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27-29 April 2026 - Paphos, Cyprus

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12th International Conference

on Remote Sensing and Geoinformation of Environment

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ERATOSTHENES Centre of Excellence
EXCELSIOR H2020 Teaming Project
Cyprus Remote Sensing Society

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Preface

The Organizing Committee, Scientific Committee, and Editors extend their sincere appreciation to all authors and participants attending the 12th International Conference on Remote Sensing and Geoinformation of Environment (RSCy 2026), held in Paphos, Cyprus, from 27–29 April 2026. RSCy 2026 addresses emerging challenges and advances in remote sensing and geoinformation of the environment. The conference is structured around three core thematic areas: Environment and Climate, Resilient Society, and Big Earth Data Analytics.

Through keynote lectures and a diverse technical program, the conference fosters the exchange of ideas and supports the development of future collaborations and innovations. The conference is organized by the ERATOSTHENES Centre of Excellence, the EXCELSIOR H2020 Teaming Project (funded by the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 857510 and supported by the Government of the Republic of Cyprus and the Cyprus University of Technology), and the Cyprus Remote Sensing Society, under the auspices of the Deputy Ministry of Research, Innovation and Digital Policy and the Cyprus Presidency of the Council of the European Union. We are honored to welcome experts from around the globe representing a wide range of disciplines within remote sensing and geoinformation. The conference provides an excellent platform for knowledge exchange, networking, and the advancement of collaborative research. Participants are encouraged to engage with the latest state-of-the-art developments and applications in the field. The abstracts included in this volume have been peer-reviewed and accepted by the Scientific Committee, reflecting ongoing advancements in remote sensing and geoinformation. The program comprises oral and poster presentations organized across more than 20 thematic areas, including hazards, fires, forestry, marine and coastal environments, cultural heritage, SAR, atmosphere, meteorology, agriculture, water resources, hydrology, floods, land use and land cover, urban studies, artificial intelligence, and big data, among others. With contributions from more than 200 authors representing more than 20 countries, this volume highlights significant scientific achievements and contributions to the field.

The awards for best paper and best poster will be presented during the conference closing ceremony, based on peer review and eligibility criteria including submission to the SPIE Proceedings and presentation at the conference. We gratefully acknowledge the support of all sponsoring organizations. Special thanks are extended to the Conference Chairs, the ERATOSTHENES Center of Excellence staff, the members of the Cyprus Remote Sensing Society, and the SPIE team for their valuable contributions to the successful organization and publication of the proceedings.

The Editors of the RSCy 2026 Proceedings: Diofantos Hadjimitsis, Andreas Christofi, Silas Michaelides, Kyriacos Themistocleous, George Papadavid, Andreas Anayiotos, Georgios Christodoulou, Ioannis Theodorou, Marios Tzouvaras, Christodoulos Mettas, Michalis Mavrovouniotis, Christiana Papoutsa.

Events organized under the auspices of the Cyprus Presidency of the European Council

Under the auspices of the Council of the European Union during the Cyprus EU Presidency in 2026, the ERATOSTHENES Centre of Excellence is organising a series of high-level flagship events that highlight the role of research, innovation, and space-based technologies in addressing European and global challenges. These include international conferences and thematic forums bringing together policymakers, research organisations, industry leaders, and innovators to advance topics such as Earth observation, ocean science, climate resilience, cultural heritage protection, and the translation of research into market-ready solutions. The events aim to strengthen collaboration across Europe and position Cyprus as a regional hub for scientific excellence, innovation, and policy dialogue, contributing to the broader priorities of the EU Presidency.

The following events are (co-)organized by ERATOSTHENES Centre of Excellence under the auspices of the Cypriot Presidency of the Council of the EU:

- International Symposium Cultural Property Protection, 20 - 21/04/2026 (https://cpp-cyprus-2026.eratosthenes.org.cy)
- Twelfth International Conference on Remote Sensing and Geoinformation of the Environment, 27 - 29/04/2026 (https://rscy2026.com)
- Riding the Wave: Advancing the EU Ocean Pact through Science, Innovation and Cooperation, 11 - 12/05/2026 (https://www.cmmi.blue/events/riding-the-wave-advancing-the-eu-ocean-pact-through-science-innovation-and-cooperation)
- 2026 General Assembly of the EU Space Networks, 27–28/05/2026, scheduled back-to-back with the EU Space Days 2026 organized by the European Commission under the auspices of the Cypriot Presidency of the Council of the EU (https://defence-industry-space.ec.europa.eu/eu-space/eu-space-days-2026-nicosia-cyprus_en)
- From Space to Solutions, Leveraging Space Tech, Earth Observation & AI for Real-World Impact, 8/06/2026 (https://space2solutions.com).

EXCELSIOR H2020 Teaming Project – ERATOSTHENES CENTRE OF EXCELLENCE

The integration of advanced Earth Observation technologies, including space-based and ground-based systems, plays a critical role in enabling sustainable environmental monitoring, supporting economic growth, and enhancing the detection and analysis of natural and anthropogenic hazards.

The ERATOSTHENES Centre of Excellence, established through the EXCELSIOR Horizon 2020 Teaming project, is dedicated to advancing multidisciplinary research in Earth Observation. Its mission is to improve the understanding, monitoring and sustainable management of natural resources and infrastructures, while providing high-quality services and innovative solutions based on cutting-edge geospatial technologies. The Centre aims to become a leading Digital Innovation Hub and a reference institution in the Eastern Mediterranean, Middle East, and North Africa (EMMENA) region.

The Centre collaborates closely with key strategic partners, including the Cyprus University of Technology, the German Aerospace Centre (DLR), the National Observatory of Athens (NOA), the Leibniz Institute for Tropospheric Research (TROPOS), and national authorities, alongside affiliated partners such as Cyprus Research and Innovation Centre (CyRIC) and Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center (PMOD/WRC). These collaborations support Cyprus's transition toward innovation-driven growth in the Earth observation sector.

The ERATOSTHENES Centre of Excellence operates as a comprehensive Digital Innovation Hub, integrating research, infrastructure, education, and entrepreneurship. Its activities are structured around three main thematic clusters:

- **Environment and Climate**, focusing on atmospheric monitoring and calibration/validation infrastructure,
- **Resilient Society**, addressing disaster risk reduction and societal challenges,
- **Big Earth Data Analytics**, enabling the extraction of valuable insights from complex datasets.

The Centre is committed to fostering innovation through state-of-the-art infrastructure, high-impact research, advanced education and training programs, and the promotion of entrepreneurship. It actively supports start-ups, technology transfer, and the commercialization of research outcomes, contributing to the development of a dynamic space and Earth observation ecosystem in Cyprus and the wider EMMENA region. Through initiatives such as the Digital Innovation Hub, Living Labs, and the Networking and Knowledge Hub, the Centre promotes collaboration among researchers, industry, policymakers, and society. It also emphasizes social responsibility by engaging with the public and addressing critical challenges related to climate change, environmental protection, disaster management, and cultural heritage.

Figure 1: Left: Earth Observation Satellite Data Acquisition Station (DAS). Right: Ground-based Remote Sensing Station (GBS).

The four value-adding areas of the Digital Innovation Hub include **Infrastructure, Research, Education and Entrepreneurship:**

- The **Infrastructure Area** ensures the efficient operation and optimal use of the Centre's existing and future facilities, while providing seamless access to Earth observation data for researchers and stakeholders. Key assets include a state-of-the-art ground-based atmospheric remote sensing supersite for aerosol and cloud monitoring, as well as a satellite data direct receiving station enabling Near Real-Time access to Earth observation data, supporting timely analysis and decision-making across Eastern Europe, North Africa, and the Middle East.
- The **Research Area** drives the development of high-quality, multidisciplinary scientific outputs that underpin the Centre's services and solutions. Its activities aim to generate impactful results that benefit not only the scientific community but also policymakers, industry stakeholders, and society at large.
- The **Education Area** focuses on capacity building in Earth observation through postgraduate training, including MSc and PhD programmes, as well as specialized professional training and skills development initiatives.
- The **Entrepreneurship Area** supports the long-term sustainability of the Centre by fostering innovation, promoting intellectual property exploitation, and facilitating the market uptake of Earth observation-based products and services. Through incubation and acceleration initiatives, including the Space BIC programme, the Centre actively contributes to the development of a dynamic space technology ecosystem in Cyprus and the wider region. Complementary initiatives, such as the Office of Innovation and Living Labs, further promote collaboration, technology transfer, and the co-creation of solutions.

The Centre also strengthens stakeholder engagement through its Networking and Knowledge Hub, enabling collaboration, knowledge exchange, and the dissemination of research outcomes across the EMMENA region. Committed to social responsibility, the ERATOSTHENES Centre of Excellence actively engages with society to address key challenges such as climate change, environmental protec-

tion, disaster risk reduction, and cultural heritage preservation, leveraging advanced Earth observation technologies.

By integrating research excellence with innovation and stakeholder engagement, the ERATOSTHENES Centre of Excellence aims to deliver impactful solutions that enhance decision-making and improve quality of life at regional and international levels.

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This project has received funding from the Government of the Republic of Cyprus through the "Directorate General for European Programmes, Coordination and Development."

This project has received funding from the European Union's "Horizon 2020 Research and Innovation Programme" under Grant Agreement No. 857510.

This project is co-funded by the Cyprus University of Technology.

Keynote Speakers

The keynote speakers at RSCy 2026 bring together a diverse group of internationally recognized experts from academia, research institutions, and industry, offering deep insights into remote sensing, Earth observation, geoinformation, and related technologies. Their expertise spans areas such as environmental monitoring, climate and atmospheric studies, geospatial innovation, and the application of advanced data analytics, reflecting the conference's strong focus on cutting-edge research and real-world impact. Together, they provide a multidisciplinary perspective that supports knowledge exchange, collaboration, and the advancement of solutions for global environmental and societal challenges.

RSCy 2026 Keynote Speakers

Mrs. Eleni Paliouras, Directorate of Earth Observation Programmes, Head of the Strategy, Programme & Coordination Office (EOP-C)

Mrs. Barbara Ryan Earth Observation Advocate

Dr. Nektarios CHRYSOULAKIS, Director of Research at the Foundation of Research and Technology Hellas (FORTH)

Dr. Haris Kontoes, Research Director of National Observatory of Athens (NOA)

Dr. Michael Falkowski, Earth Fire Alliance

Prof. Lena Halounova, Department of Geomatics, Czech Technical University of Prague

Dr. Dirk Roland Haupt, Minister Counselor and Deputy Chief of Mission, Embassy of Germany, Nicosia

Mr. Lóránt Czárán, Chief of the Vienna Branch, UN-SPIDER

Prof. Rosa Lasaponara, CNR-IMAA & University of Basilicata, Italy

Dr. Vincent G. Ambrosia, Department of Applied Environmental Sciences, College of Science, California State University – Monterey Bay

Mr. Marcello Maranesi, founder GMATICS

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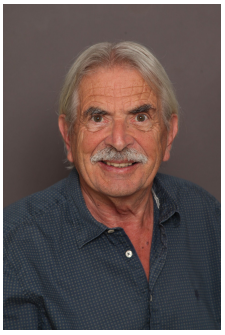
Dr. Peter Zeil, Senior consultant & Co-founder Spatial Services Ltd



Mrs. Usue Donezar, Leader of the Copernicus project at the European Environment Agency

Abstracts

0135. Revolutionizing Shallow-Water OFG and SGD Research: The Role of Drones and UAS-Borne Sensors

Iliyan Kotsev[1,2], Bogdan Prodanov[2,3]

[1]Professor Fridtjof Nansen Institute of Oceanology/Strashimir Dimitrov Geological Institute, Bulgaria, [2]Bulgarian Academy of Sciences. Bulgaria, [3]Professor Fridtjof Nansen Institute of Oceanology, Bulgaria

Keywords: UAS and airborne geophysics, offshore freshened groundwater (OFG), fresh submarine groundwater discharge (FSGD), inshore-offshore aquifers, geospatial data fusion

Unmanned aerial systems (UAS) equipped with the latest sensors represent advanced technologies that are transforming the existing traditional airborne and marine geophysical methods for the detection, mapping, and characterization of fresh submarine groundwater discharge (FSGD) and offshore freshened groundwater (OFG) systems. Traditional survey techniques often fail to capture the full spatial extent of FSGD and OFG systems related to aquifers extending from inshore to nearshore and even offshore due to the complexity of coastal and marine environments. In contrast, the development and evolution of UAS-mounted sensors provide high-resolution, non-invasive alternatives for comprehensive and flexible surveys.

Beyond commonly employed airborne techniques like thermal, multi-, and hyperspectral imaging, photo- and LiDARgrammetry, UAS-based geophysical methods like electromagnetic and magnetometric surveys, water-penetrating radar (WPR), and gravimetric surveys represent highly promising tools for the detection and characterization of FSGD and OFG systems. These methods offer complementary surface and subsurface information that optical, laser scanning, or thermal techniques alone cannot resolve.

The resulting geospatial datasets, when integrated within geographic information systems (GIS) platforms, allow the complex analysis and subsequent compilation of composite maps and marine charts that combine thermal, geophysical, and bathymetric data, thereby providing a comprehensive representation of FSGD and OFG systems. By employing UAS technology, researchers can efficiently survey extensive coastal and nearshore areas with minimal environmental impact, improving the accuracy of FSGD/OFG assessments while reducing the reliance on labor-intensive and costly field and at-sea surveying campaigns. These multi-sensor, multi-scale, and data fusion approaches significantly improve existing conceptual models of coastal aquifers and increase awareness about coastal groundwater systems and how they extend offshore while also supporting sustainable water resource management in freshwater-stressed littoral regions.

0137. Urban Heat Island Impacts on Residential Energy Costs and CO_2 Emissions in Ten Greek Regional Units

Paraskevi Gkatzioura[1], Olga Christopoulou[1], Konstantinos Perakis[1]

[1] University of Thessaly, Greece

Keywords: Urban Heat Island, Residential Energy Consumption, Carbon Footprint, Urban Resilience, Google Earth Engine

Urban Heat Island (UHI) climate phenomenon constitutes a multifactorial global process that tends to increase air temperatures in urban areas by up to 15°C compared to their surrounding rural environments. The intensification of the climate crisis, combined with the increasing frequency of extreme thermal events, renders not only the understanding but also the quantitative assessment of UHI impacts essential for urban energy planning, urban and climate resilience.

The primary driver of the Urban Heat Island effect is extensive urbanization, which is intrinsically linked to increasing anthropogenic heat emissions and associated socio-economic dynamics. The intensity of the phenomenon is not limited to temperature increases but is closely related to energy consumption patterns, quality of life, and the overall resilience of cities. Depending on seasonality (winter and summer), the UHI exerts multiple and often contrasting effects, as it may reduce heating demand during winter while significantly increasing cooling demand during summer months.

The present study focuses on the monetary quantification of UHI-related impacts across ten selected regional units in Greece for the period 2020–2025. To establish the relationship between thermal stress, energy consumption, and CO_2 emissions, satellite-based air temperature data from ERA5-Land (reanalysis data) and land surface temperature data from MODIS (LST) were employed through the Google Earth Engine (GEE) cloud-based geospatial analysis platform. The energy impact of the UHI phenomenon was assessed using the thermal indices Heating Degree Days (HDD) and Cooling Degree Days (CDD), allowing for the representation of seasonal variations in heating and cooling demand as well as the comparative evaluation among the study areas. In addition, the contribution of the UHI effect to CO_2 emissions and the associated energy-related costs was quantitatively isolated at the regional unit level.

The results reveal pronounced spatial heterogeneity in UHI impacts, strongly influenced by local topographic and urban structural characteristics. Increased summer cooling demand represents the dominant energy burden for household, while winter heating savings remain insufficient to compensate for the overall energy and economic impact. The findings highlight that urbanization constitutes a significant, yet not exclusive, driver of UHI-related costs. These outcomes support the development of targeted mitigation and adaptation policies, contributing to a better understanding of building energy behavior and enabling the reduction of the energy and environmental footprint of urban areas.

0138. Association Between Spread-F and Spread-Es in the Midlatitude Ionosphere

Krishnendu Sekhar Paul[1], Haris Haralambous[1]

[1]Frederick Research Center, Cyprus

Keywords: Midlatitude Ionosphere; Spread F; Spread Es

Nighttime midlatitude F-region ionosphere occasionally exhibits diffuse plasma irregularities that persist from several minutes to several hours, commonly termed midlatitude spread F (SF) (Paul et al., 2019). These irregularities arise from spatial electron-density perturbations frequently generated by the upward and downward motions associated with atmospheric gravity waves (GWs) (Kelley 2009). As these waves modulate ionospheric layer heights, they induce localized current divergences along

the inclined midlatitude geomagnetic field. The resulting polarization electric fields can initiate plasma instabilities in the F region, including gradient–drift and Perkins instability mechanisms, which contribute to the formation of small-scale (0.1–10 km) structure (Miller, 1997; Kelley, 2009).

Comparable structuring also develops within the sporadic-E (Es) layer, where spread-Es (SEs) signatures exhibit pronounced diurnal and directional characteristics (Bowman, 1985). Early ionosonde and VHF observations demonstrated that SEs structures are predominantly frontal, possessing horizontal scales on the order of 1̃0 km and frequently propagating toward the northwest (Clarke, 1965). Off-vertical or specular reflections from these organized Es-layer ionization fronts can generate echo distortions resembling SF at midlatitudes, indicating that perturbations in the Es region may influence F-region reflections. Recent studies indicate that patchy Es layers can influence the overlying F region through electrodynamic coupling, primarily via Hall-current-driven polarization, with the resulting electric fields mapping along geomagnetic field lines to modify F-region plasma dynamics (Haldoupis et al., 2003; Cosgrove and Tsunoda, 2004). These associations indicate that the nighttime E and F regions operate as an electrodynamically coupled system, in which initial structuring within the Es layer can facilitate conditions favourable for the growth of F-region irregularities.

Although several works have suggested a link between SEs and SF, the extent to which SEs occurrence can statistically predict SF formation at midlatitudes has remained uncertain. To address this gap, the present study applies the height–time–intensity (HTI) technique (Oikonomou et al., 2014) to simultaneously detect SEs and SF signatures. We analyze long-term Digisonde observations from Nicosia, Cyprus, covering the interval 2009–2017, focusing on nighttime periods when the E–F coupling pathways are most effective. Our results show a consistently high association between SF and SEs, ranging from 72% to 89% depending on solar activity, season and local time. This strong statistical association supports the framework in which gradient–drift instability produces small-scale field-aligned irregularities (FAIs) in both layers (Bowman 1985). Furthermore, the analysis indicates that SEs signatures may serve as precursors or indicators of F-region structuring under certain dynamical conditions.

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0139. Large-Scale Ionospheric Disturbances During the November 2025 Geomagnetic Storm from Swarm and TEC Observation

Krishnendu Sekhar Paul[1], Haris Haralambous[1]

[1]Frederick Research Center, Cyprus

Keywords: Geomagnetic Storm; Ionosphere; LSTIDs; Swarm; dTEC Maps

This study investigates storm-time Large-Scale Travelling Ionospheric Disturbances (LSTIDs) during the geomagnetic storm of 12–13 November 2025 (minimum Dst ≈ –238 nT) using a combination of Swarm A and B satellite observations and regional detrended total electron content (dTEC) maps across the Japanese, European, and North American longitude sectors. Major geomagnetic storms, driven by Earth-directed coronal mass ejections (CMEs), deliver substantial energy into the auroral ionosphere through particle precipitation and enhanced electric fields. Ionization occurring in regions with elevated neutral density increases electrical conductivity and intensifies ionospheric currents. Under disturbed conditions, the coupled solar wind–magnetosphere–ionosphere system behaves analogously to a voltage source, with the solar wind providing the driving potential and field-aligned currents (FACs) closing the circuit between the magnetosphere and ionosphere. A significant fraction of magnetospheric energy is dissipated in the auroral zone through conductivity enhancements and particle precipitation, producing magnetic perturbations detectable at ground level (Lu et al., 2016; Prölss, 2004). Storm-time variability in Joule heating and energetic particle input strongly modulates the ionosphere–thermosphere system, affecting plasma densities, electrical conductivities, and thermospheric temperatures (Wilson et al., 2006). Energy carried by FACs is partially converted into neutral wind motion via ion–neutral drag (Richmond & Lu, 2000). Sudden high-latitude heating launches large-scale travelling atmospheric disturbances (TADs) that propagate equatorward, producing their ionospheric signatures as LSTIDs (Bruinsma & Forbes, 2007). Thus, LSTIDs provide a direct manifestation of coupled magnetospheric energy input, current intensification, and thermospheric dynamics. In this study, Swarm A and B in-situ electron density (Ne) measurements were examined to detect storm-time plasma fluctuations and depletions indicative of LSTID activity. Observed signatures were subsequently analyzed using regional dTEC maps to confirm the presence of LSTIDs and track their equatorward propagation. This integrated satellite–ground approach enables a coordinated assessment of LSTID development, revealing spatial and temporal characteristics across multiple longitude sectors. Results indicate that during the first storm phase, pronounced Ne fluctuations at high latitudes corresponded to strong dTEC fluctuations over Japan and Europe, signalling the onset of large-scale equatorward-propagating LSTIDs. Throughout the main and early recovery phases, additional plasma density irregularities and depletion features were observed over North America, confirmed by regional dTEC maps, demonstrating persistent LSTID activity. Sector-to-sector differences were evident, with earlier onset in Japan and more extended responses over North America. These observations illustrate that combining Swarm low-altitude plasma measurements with regional dTEC imaging provides a reliable approach for detecting storm-time LSTID signatures, tracking their equatorward propagation, and characterizing their spatial and temporal evolution, offering a comprehensive view of ionospheric variability during the 12–13 November 2025 geomagnetic storm.

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0140. Seeing Without Touching, Cleaning Without Owning: Remote Sensing Law as a Launchpad for Active Space Debris Remediation

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Keywords: Remote sensing law; active space debris remediation: legal aspects; data governance for "data-to-deorbit"

Satellites have become the planet's nervous system. They reveal coastlines eroding, crops failing, cities overheating, and storms rewriting borders—often in near real time. Yet the orbital highways that make this environmental intelligence possible are steadily filling with hazardous fragments. This presentation argues that the legal questions discussed in the context of remote sensing and geoinformation of the environment and the legal questions surrounding active space debris remediation are two halves of one governance challenge: keeping the space environment usable so that Earth-observation (EO) services can continue to inform climate policy, disaster management, and economic resilience.

The legal baseline for "seeing" is still the 1986 United Nations Principles on Remote Sensing of the Earth from Outer Space. The International Law Association (ILA) has repeatedly revisited those Principles in light of today's commercial EO reality and found a framework that has aged better than many expected. At the same time, the ILA's work highlights the pressure points that matter most: unclear definitions, the politics of "reasonable cost" access for sensed States, the distribution and commercialization of data, the practical meaning of consultations and international cooperation, and the growing salience of privacy and the evidentiary use of satellite data.

That debate is no longer confined to climate science. The European Space Agency (ESA) is positioning EO as resilience infrastructure—rapid tasking, frequent revisit, low latency, and secure access to imagery that supports civilian response while also meeting heightened security requirements. Programmatic moves such as the European Resilience from Space initiative and preparatory work toward Earth Observation Governmental Services (EOGS) make the point vividly: Geoinformation is becoming an operational capability, with major downstream economic value and correspondingly high expectations of continuity and trust. The physical prerequisite for this geoinformation economy is under strain. In low Earth orbit (LEO) and in geostationary Earth orbit (GEO), debris populations continue to grow; current policy discussions often cite ESA estimates of roughly 40,500 objects larger than 10 cm, around 1.1 million objects between 1 and 10 cm, and about 130 million fragments down to millimeter scale. With collision dynamics associated with the Kessler syndrome, congestion can become a self-reinforcing risk rather than a linear increase in hazard.

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) has built real negotiating capital around prevention: After sustained work in its Scientific and Technical Subcommittee, the Space Debris Mitigation Guidelines (SDMG) were adopted and then endorsed and promoted through the United Nations system as voluntary guidance for national implementation. In practice, the SDMG have become a widely used due-diligence benchmark—incorporated into licensing practice and relied upon by insurers and investors—yet their scope is largely mitigation, not active remediation.

Hence the growing inevitability of active space debris remediation (ADR). Technically, the remediation menu is expanding—robotic capture, drag-enhancement devices, laser-based mo-mentum transfer, and deorbit "kick modules," among others—but every option depends on precise tracking, target characterization, and safe proximity operations. Economically, the sector remains constrained: Early demand is largely public-sector driven; revenue models are still emerging; and legal and regulatory uncertainty

is a first-order market failure. Europe is also investing programmatically in “space safety” capabilities, including debris-related missions and enabling technologies, underlining that remediation is moving into the mainstream of institutional planning.

This is where remote sensing law becomes part of the remediation solution rather than a neighboring discipline. Debris remediation is an information problem before it is a propulsion problem: What exactly is the object; who has jurisdiction and control; which data must be shared for safety; and how much transparency can be required without compromising legitimate security interests? When remediation involves another actor’s object, the continuing jurisdiction and ownership logic of Article VIII of the Outer Space Treaty, and uncertainties in the Liability Convention’s handling of fault and environmental effects, turn engineering risk into legal and insurability risk.

Building on COPUOS’s demonstrated soft-law pathway—SDMG—and on the ILA Committee on the Legal Aspects of Space Debris Remediation’s mandate to produce implementable guidance for legislators, this presentation outlines a “data-to-deorbit” approach: treat environmental remote sensing rules and debris remediation rules as one normative stack. The aim is to design tiered transparency, notification, and consultation procedures—paired with licensing and supervision expectations—that make remediation operationally safe, commercially bankable, and politically acceptable, while preserving the public-good function of environmental geoinformation. This is the punchline: The satellite imagery and environmental geoinformation that shape public policy are only as reliable as the orbital environment that keeps those satellites alive. Remote sensing law helped the world accept “seeing” as normal. Active space debris re-mediation now needs a comparable legitimacy architecture for “touching,” so the geoinformation economy can grow without turning LEO into the tragedy of a commons.

0141. Assessment of Galileo Single-Frequency Positing Algorithm over Nicosia Under March 2023 Geomagnetic Storm Conditions

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Keywords: Geomagnetic storm, Space weather, Galileo, single-frequency positioning

Under the context of a research project, single frequency positioning service of Galileo has been proposed to be improved, by incorporating regional ionospheric characteristics into an ionospheric error mitigation algorithm. As part of the Global Navigation Satellite System (GNSS), Galileo uses NeQuick-G algorithm to provide ionospheric correction to single frequency user. For such corrections, NeQuick-G uses global CCIR (International Radio Consultative Committee) file coefficients to estimate ionospheric parameters such as M(3000)F2 and foF2. In the modified algorithm, the global CCIR coefficients are adjusted by using local measurement of M(3000)F2 and FoF2 and therefore provides improved ionospheric corrections. The algorithm can operate in both short-term and long-term modes. In the short-term mode, ionospheric conditions observed at a station on the previous day are used to estimate the ionospheric error for the following day. In the long-term mode, the CCIR coefficients are locally adjusted using data from representative low- and high-solar-activity years, and the coefficients for intermediate solar activity levels are obtained through linear interpolation.

In this study, we evaluated the algorithm during a significant space weather event. A G3-class geomagnetic storm occurred on 23–24 March 2023, during which the Dst index reached -163 nT. A sudden storm commencement (SSC) was recorded at 05:00 UT on 23 March, followed by the storm’s main phase beginning at 12:00 UT. The recovery phase started at 04:00 UT on 24 March. During this interval, the algorithm produced significantly different results in short-term and long-term modes when compared with the global CCIR operation over Nicosia. Under storm conditions, the largest discrepancies between estimated and measured TEC (up to 40 TECU) were observed for the long-term and global CCIR modes. The global CCIR mode tended to underestimate TEC during the storm, while the long-term mode overestimated TEC during the recovery phase. This behavior is expected, since both

global CCIR and long-term coefficients are derived from solar-activity dependent climatology and cannot capture short-lived space weather disturbances. In contrast, the short-term mode closely followed the measured TEC values, including during the recovery phase on 25 March, demonstrating better performance out of all, during the space weather event.

0142. Dynamics of Amplitude and Phase Scintillation Through Multi-Year Observation from Cyprus

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Keywords: Amplitude scintillation, Phase scintillation, Ionosphere, Satellite

Modern technology heavily depends on satellite-based communication and navigation, driving global efforts to improve signal reliability and accuracy. Trans-ionospheric radio signals can encounter irregular plasma densities, causing rapid fluctuations in signal amplitude and phase, known as amplitude and phase scintillation (Aarons et al., 1971; Kintner et al., 2007). These scintillations can degrade GNSS positional accuracy (Aquino et al., 2009; Vadakke Veettil et al., 2020) and, in aviation, may lead to signal loss-of-lock, posing safety risks (Biswas et al., 2019; Biswas & Paul, 2021). This study investigates the occurrence of scintillation events over a middle latitude station Nicosia, Cyprus, using multiyear data from 2012-2015. The aim is to study the correlation between amplitude scintillation (S4) and phase scintillation ($\sigma\phi$) indices, focusing on genuine ionospheric scintillation events and distinguishing pseudo-phase scintillation phenomena.

Genuine scintillation events are characterized by stochastic effects caused by ionospheric irregularities smaller than the Fresnel scale, leading to fluctuations in both amplitude and phase of trans-ionospheric radio signals. Pseudo phase scintillation events are characterized by high $\sigma\phi$ and low S4 values. The analysis reveals strong Pearson correlation coefficients (0.4–0.8) between S4 and $\sigma\phi$ across different seasons, with the highest correlation observed during summer and vernal equinoxes. Pseudo phase scintillation events are found to be primarily linked to signals from geostationary Earth orbit (GEO) satellites belonging to the Satellite-Based Augmentation System (SBAS). Pseudo-phase scintillation is attributed to receiver-induced noise, such as Phase Lock Loop (PLL) jitter, and large-scale ionospheric variations. These phenomena are found to be more frequent during solstices, particularly the June solstice, suggesting a significant ionospheric contribution rather than solely receiver-related effects. Factors such as fixed ionospheric pierce points (IPPs), low Doppler shift, and low carrier-to-noise ratio (C/NO) in GEO satellite signals can also contribute to artificially elevated $\sigma\phi$ values. Additionally, long slant paths through the ionosphere for GEO links can accumulate large-scale ionospheric variations, leading to slow phase changes that standard detrending filters fail to remove, further enhancing pseudo-phase scintillation. Findings of this study highlights the importance of distinguishing between genuine and pseudo-phase scintillation for accurate characterization of ionospheric dynamics and their impact on satellite-based communication systems.

0143. GPR misinterpretations and how AI mitigates and exacerbates these issues

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Keywords: GPR, Interpretation, Artificial Intelligence

Ground-penetrating radar (GPR) is widely applied in geosciences, archaeology, civil engineering,

and environmental studies due to its non-destructive nature and high spatial resolution. Despite its broad adoption, GPR data interpretation remains highly susceptible to misinterpretation, particularly when conducted without sufficient understanding of electromagnetic wave behavior, site-specific subsurface conditions, and acquisition limitations. Common sources of error include the misidentification of hyperbolic reflections, incorrect velocity assumptions, confusion between geological features and anthropogenic objects, and the overinterpretation of noise, multiples, and clutter as meaningful subsurface targets. These issues are often amplified by heterogeneous materials, variable moisture content, complex stratigraphy, and inadequate survey design.

In recent years, artificial intelligence (AI) and machine-learning techniques have been increasingly introduced to assist GPR data processing and interpretation. Automated feature extraction, pattern recognition, and anomaly detection promise faster and more consistent analysis compared to traditional manual interpretation. However, the integration of AI also introduces new risks of misinterpretation. Poorly curated training datasets, limited generalization across geological settings, and the “black-box” nature of some deep-learning models may lead to false positives, overlooked targets, or unjustified confidence in algorithmic outputs. When AI systems are trained on synthetic or site-specific datasets, their applicability to real-world and unseen conditions may be significantly constrained.

This abstract highlights the most frequent misinterpretations encountered in conventional GPR analysis and critically examines how AI-based approaches can both mitigate and exacerbate these issues. Emphasis is placed on the importance of combining domain knowledge with data-driven methods, transparent model validation, and human-in-the-loop interpretation strategies. Rather than replacing expert judgment, AI should be viewed as a complementary tool that enhances interpretation reliability when used responsibly. Clear understanding of GPR physics, rigorous data preprocessing, and cautious deployment of AI models are essential to reduce interpretational bias and improve the robustness of subsurface investigations.

0144. Bridging the Scale Gap in Earth Observation: Using Particle Detector Networks as a Novel Remote Sensing Data Source for Atmospheric Monitoring

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Keywords: Muon detector, Atmospheric monitoring, Earth observation, Data fusion, Geographic Information Systems

Two extremes are currently being experienced in the operation of Earth observation systems: broad geographic coverage is provided by satellites but at coarse resolution and infrequent revisit times , whereas continuous detailed measurements are offered by meteorological ground stations but only at sparse, isolated locations. The creation of a fundamental gap is due to the lack of continuous observations at intermediate spatial scales. This is necessary to improve our understanding of atmospheric phenomena and extreme weather events.

While underground detectors have shown the ability to monitor atmospheric conditions through muon flux measurements for many years, their systematic incorporation into routine Earth observation processes is still limited. The creation of standardized data pipelines has been suggested. These pipelines would integrate muon measurements with satellite data and Geographic Information System maps. They will adhere to common data-sharing standards, enabling seamless collaboration between muon data, satellite observations, and climate models. This approach proposes the use of a prototype for the continuous validation of meteorological models and real-time operational observations.

Prior to conducting an analysis, we suggest a framework that illustrates the integration of detector measurements into a pre-existing multi-source data analysis system. This framework is applicable to detector facilities like the CMS experiment at CERN’s LHC. We have incorporated the following elements: (1)

readings from particle detectors, (2) satellite remote sensing images, and (3) data from ground-based weather stations. We propose a method for examining these diverse data streams using geographic information systems to determine when and how atmospheric disturbances generate detectable signals across all three types of observations. Various patterns that differentiate normal atmospheric conditions from extreme events, such as thunderstorms, sudden pressure shifts, and temperature anomalies, were utilized.

Muon detectors can fill the gap between satellite observations (which require clear skies and view large areas) and ground stations (which are detailed but measure only one point). Networks of detectors at research facilities, combined with portable stations, operate 24/7 in any weather and measure the entire atmosphere. Our plan for testing using CMS detector data demonstrates that these measurements provide considerable atmospheric information suitable for climate monitoring. Following the initial proof-of-concept, we suggest that further work be conducted to test the differences between other CERN detectors. We can use this to determine how to create a test above ground. We can base detectors on a proof of concept and combine meteorological and satellite data with ground-based pilot studies if these can be arranged.

0146. Land consolidation and LLMs: implications for statutory interpretation and governance

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Keywords: land consolidation, statutory reasoning, large language models, legal AI, land governance, Cyprus, risk-aware deployment

This study examines the behaviour of large language models (LLMs) when applied to codified, procedure-heavy land consolidation legislation, using Cyprus as a representative civil law case. Land consolidation reduces fragmentation and supports rural investment; however, statutory execution depends on the precise interpretation of interdependent articles, circulars and sequential steps. Building on an earlier journal study, we present an expanded conference version framed as a complexity-stratified benchmark for statutory reasoning in land governance. A 100-question corpus was constructed from the national land consolidation legal framework and organised into four tiers, from factual recall to abstract interpretation and exception handling. Responses were graded using a practitioner-oriented rubric that captured correctness, completeness, and statutory coherence. The benchmark revealed a systematic decline in performance as legal complexity increased, with severe failures arising from jurisdictional misfits, missed procedural dependencies and unsupported assertions. We translated these patterns into a risk-aware deployment model for public-sector land governance by defining safe assistance functions, identifying high-risk statutory tasks that must remain human-led, and specifying safeguards, including retrieval-augmented generation, controlled prompts, and audit logging, aligned with EU regulatory expectations. This study offers guidance for agencies designing trustworthy AI support for land-administration workflows and a reusable benchmark structure for comparative studies across jurisdictions.

0147. InSAR-Derived Surface Deformation and Damage Assessment of the 2019 Mirpur Earthquake

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Keywords: InSAR, Sentinel-1 SAR, Co-seismic deformation, Interferometric coherence, Earthquake damage assessment, Mirpur earthquake 2019, Urban damage detection

The 24 September 2019 Mirpur earthquake (Mw 6.0) in Azad Jammu and Kashmir, Pakistan, caused noticeable surface deformation and structural damage in urban areas. Rapid and reliable assessment of such impacts is essential for effective disaster response and future risk mitigation. This study investigates co-seismic surface deformation and urban damage patterns using Sentinel-1 Synthetic Aperture Radar (SAR) data and interferometric processing techniques.

Differential Interferometric SAR (DInSAR) analysis was performed to estimate line-of-sight surface displacement associated with the earthquake. In addition, interferometric coherence was analyzed to identify potential damage within the built-up environment, as coherence reduction is commonly linked with structural disturbance and ground surface changes. Processing was carried out using standard SAR interferometric workflows, including precise orbit correction, co-registration, interferogram generation, phase filtering, terrain correction, and coherence estimation.

The results reveal measurable ground deformation concentrated near the epicentral region and along the active fault zone. Coherence analysis indicates spatial patterns consistent with reported urban damage, demonstrating the usefulness of SAR-based indicators for rapid post-earthquake assessment in areas where field surveys are limited. The study highlights the capability of freely available Sentinel-1 data to support timely disaster monitoring and infrastructure damage evaluation in tectonically active regions.

Overall, the research confirms that integrated deformation and coherence analysis provides an effective remote sensing approach for earthquake impact assessment and can contribute to improved hazard response and resilience planning in northern Pakistan.

0148. Hyperspectral unmixing and bio-optical classification for inland water quality monitoring: a multi-cube AVIRIS-NG analysis of Lake Trasimeno

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Keywords: Imaging spectroscopy; Spectral unmixing; Bio-optical classification; Inland water quality; AVIRIS-NG

This study aims to develop and demonstrate a hyperspectral unmixing framework for spatially resolved water quality monitoring of eutrophic lakes using airborne imaging spectroscopy. Lake Trasimeno, Italy's fourth-largest lake and a shallow eutrophic system (mean depth 4.7 m, 128 km^2), experiences seasonal phytoplankton blooms, agricultural nutrient loading, and sediment resuspension dynamics typical of Mediterranean shallow lakes, making it representative of optically complex inland waters requiring adaptive retrieval strategies. We process six AVIRIS-NG flight cubes acquired over Lake Trasimeno (central Italy) on 4 June 2021, covering the full 128 km^2 lake surface at 5.5 m spatial resolution with 425 spectral bands (377–2501 nm). A two-stage sunglint management strategy first applies a broad water mask (SWIR < 0.12) to retain all water pixels for unmixing, then screens glint-affected pixels ($R_{1240} > 0.005$) from the endmember extraction pool, preventing the extraction algorithm from expending its endmember budget on glint intensity gradients rather than water quality variability. Minimum Noise Fraction transformation and Vertex Component Analysis on glint-free pixels

identify five spectrally distinct water endmembers, supplemented by a synthetic glint spectrum for Fully Constrained Least Squares unmixing across all 4.67 million water pixels. A key contribution of this work is the coupling of spectral unmixing with an optically informed bio-optical decision tree that classifies endmembers into water types (eutrophic, CDOM (Colored Dissolved Organic Matter)-rich, turbid resuspension, floating vegetation) and enables per-water-type algorithm selection for chlorophyll-a (Chl-a) and TSM (Total Suspended Matter) retrieval, an approach less tractable with conventional per-pixel methods. A hybrid retrieval strategy applies the three-band model where the phytoplankton signal dominates, falling back to the NDCI (Normalized Difference Chlorophyll Index) polynomial in CDOM-rich waters, and selects Nechad (2010) retrieval wavelength (708 vs. 560 nm) based on endmember optical type to avoid fluorescence contamination. Lake-wide abundance-weighted estimates (Chl-a $8.5 \mu g L^{-1}$; TSM $14.9 mg L^{-1}$) are consistent with long-term monitoring statistics reported by ARPA Umbria (2002–2008 mean Chl-a $8.5 \mu g L^{-1}$; TSM $10.4 mg L^{-1}$; Giardino et al., 2010), indicating physically realistic retrievals. The resulting maps reveal coherent spatial gradients: elevated Chl-a and CDOM nearshore from agricultural runoff, wind-driven sediment resuspension in the shallow southern basin, and localized macrophyte beds consistent with documented recent expansion. This research was enabled by the environmental monitoring expertise and remote sensing capabilities of our research group, including satellite data processing, UAV-based monitoring, atmospheric parameter retrieval, and ML applications for environmental assessment.

0149. Spatial Patterns of Urban Sprawl in the Larnaca Metropolitan Area Using Landscape Metrics and the GLAD Global Land Cover and Land Use Change dataset

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Keywords: Urban sprawl, Landscape metrics, Qgis, Fragstats, Shannon's diversity index, Larnaca-Cyprus

Urban sprawl is a key land-use trend in Mediterranean coastal cities, frequently leading to fragmented urban forms, loss of agricultural land, and a significant pressure on ecologically sensitive coastal regions. This manuscript explores the spatial patterns and morphological characteristics of urban expansion in the Larnaca Metropolitan area over a two decade timeframe, utilizing the Global Land Analysis & Discovery (GLAD) products and a GIS-based landscape metrics approach. Built-up areas were extracted from the GLAD dataset for 2000 and 2020, enabling a temporal assessment of urban growth dynamics at medium spatial resolution. In the Qgis software, landscape metrics were derived through the use of the Fragstats spatial analysis tool, focusing on both class and landscape levels. Among the indicators computed are the total urban growth rate (UGR), number of patches (NP), patch density (PD), mean patch size (MPS), largest patch index (LPI), edge density (ED), and Shannon's diversity index (SHDI).

Our analysis shows a notable expansion of built-up surfaces, alongside a rise in PD and ED, which signifies increasing fragmentation and a discontinuous urban landscape. The MPS suggests a growth in smaller, dispersed communities, particularly situated along major transport corridors and coastal areas. Our findings suggest that in the wider metropolitan area, a gradual evolution from urban development characterized by relative compactness to more dispersed, low-density patterns - focused on edge expansion, has been noted between the years 2000 and 2020.

Ultimately, integrating multi-temporal land cover data with a thorough set of landscape metrics effectively diagnoses the intensity, directionality, and morphology of urban sprawl. This manuscript, aside from quantitatively presenting reliable metrics regarding the urban sprawl, aims to facilitate evidence-based urban planning and sustainable land management strategies across coastal Mediterranean cities.

0150. Data-driven and intelligent modeling of atmospheric processes: review of contemporary methods

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Keywords: Earth observation, Atmospheric processes, System dynamics, Monte Carlo simulation, Neural networks, Extreme learning machines, Genetic algorithms and Genetic programming, LLMs

A review of contemporary methods for the intelligent modelling and analysis of atmospheric processes has been conducted, with a focus on their application in the study of atmospheric pollution and the extraction of data for simulating atmospheric conditions and scenarios. Earth System Digital Twins (ESDTs) are defined and discussed as dynamic virtual replicas that can simulate and predict the development of atmospheric conditions. Approaches to modelling system dynamics to capture complex interrelationships and processes are presented. Monte Carlo simulations are employed to address uncertainties in 'what if' scenarios and risk assessment. The analysis covers genetic algorithms for model optimisation, as well as genetic programming and symbolic regression for extracting interpretable dependencies in atmospheric data. The predictive accuracy and real-time efficiency of neural networks and extreme learning machines are compared. Additionally, the capabilities of large language models (LLMs) and multimodal base models — including those developed by NASA and IBM — for integrating heterogeneous Earth observation data into intelligent atmospheric analysis are examined. Together, these methods support the development of modern approaches to processing and interpreting data from satellite and ground-based observations.

0151. Digital Readiness and Innovation Attitudes as Determinants of Farmers' Training Needs in Remote Sensing and Geoinformatics: A Case Study of Imathia Prefecture, Greece

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Keywords: Remote Sensing, Agricultural Education, Agriculture 4.0, Digital Divide, Geospatial Literacy, Prefecture of Imathia

The rapid development of Remote Sensing technologies and Geographical Information Systems (GIS) is substantially influencing the design and delivery of agricultural education across all sectors of rural production. Despite the significant potential these tools offer, their widespread adoption remains hindered by the so-called "digital divide," which is not exclusively related to infrastructure but mostly to the lack of specialized digital skills. In the Greek context, this issue is further intensified by the aging rural population and the limited familiarity of producers with Information and Communication Technologies (ICT).

The present study examines the level of digital readiness among farmers in Imathia Prefecture, aiming to identify educational needs related to the effective integration of geospatial technologies into the production process. For this purpose, a quantitative methodological approach was adopted through a structured questionnaire, which explored producers' perceptions and degree of readiness regarding the adoption of innovative tools. The analysis focuses on the correlation between age and educational level with attitudes toward technological innovation and the willingness to pay for specialized consulting services. Simultaneously, the critical institutional and technical barriers hindering the integration of geoinformatics into the production process are investigated.

The research findings demonstrate that existing agricultural education is insufficient for the substantive utilization of geospatial technologies in practice. Therefore, the need to redefine the educational approach toward a more interdisciplinary model that enhances geospatial literacy is highlighted. In this

context, education is called upon to transcend the boundaries of traditional agronomic knowledge and focus on the management and interpretation of digital data, while upgrading the role of the agronomist as a mediator between technology and the producer. The development of a specialized technical culture appears to be a critical prerequisite for producers to perceive remote sensing and Artificial Intelligence (AI) applications as practical decision-making tools rather than abstract or inaccessible technologies.

0152. Calibration, Validation and Implementation of a WRF-Hydro Flash-Flood Forecasting System over the Koiliaris Basin (Crete, Greece)

Vassiliki Kotroni[1], Christos Giannaros[2], Kostas Lagouvardos[1], Antonis Bezes[1], Christina Oikonomou[2], Haris Haralambous[2]

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Keywords: WRF-Hydro, Flash-flood forecasting, Mediterranean catchments

Flash floods constitute one of the most damaging hydrometeorological hazards across Mediterranean catchments, where complex terrain, short response times and intense convective precipitation frequently result in high-impact runoff events. Within this context, the MedGIFORS (Medicane GNSS-based Impact Forecasting and Emergency Management System) project aims to develop an integrated hydrometeorological forecasting framework to support fluvial flood in 2 basins in the southeastern Mediterranean region (in Pedieos River basin in Nicosia, Cyprus and in Koiliaris River basin in western Crete, Greece). This study presents the calibration, validation and implementation of a high-resolution WRF-Hydro modelling system over the Koiliaris River basin.

The modelling framework is based on the fully distributed WRF-Hydro system, operating in both offline and fully coupled atmosphere–hydrology modes. The atmospheric component (WRF) is configured using a two-way nesting approach at 10 km and 2 km spatial resolution, while the hydrometeorological downscaling over the broader Chania region is performed at 400 m. Hydrological processes are explicitly resolved over the Koiliaris watershed using an ultra-high-resolution 80 m routing grid. Static physiographic inputs are derived from MODIS land-use and SRTM/HydroSHEDS topographic datasets, while ERA5 reanalysis provides atmospheric initial and boundary conditions for the calibration and validation experiments. Automated calibration of key soil, runoff and channel routing parameters was performed using the Parameter ESTimation (PEST) framework under singular value decomposition regularization, targeting high-flow conditions relevant to flood early warning applications. The calibration period focused on February 2019, encompassing the high-impact “Chioni” and “Oceanis” storm events, which produced daily rainfall totals exceeding 60–100 mm and peak discharges above 100 $m^3 s^{-1}$. Independent validation was conducted for the 31 December 2014 – 5 January 2015 period. Results indicate substantial improvement in both the timing and magnitude of simulated hydrographs following calibration, with the system successfully reproducing observed peak flows and providing reliable indication of high-discharge events under extreme precipitation forcing. Building upon the calibrated configuration, the WRF-Hydro system has been implemented in an operational forecasting chain driven by GFS forecasts, enabling daily 48-hour streamflow predictions triggered by rainfall thresholds (> 15 mm h^{-1} or > 30 mm in 6 h).

This work is conducted within MedGIFORS project
(Project Protocol Number: BRIDGE2HORIZON/0823D/0011) in the framework of the
“RESTART 2016-2020”Programmes for Research, Technological Development and Innovation (RTDI) which is co-financed by the Republic of Cyprus and the European Regional Development Fund.

0153. Statistical modelling of urban objects from noisy and low resolution satellite imagery

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Keywords: WorldView, Pléiades, Sentinel-2, Noisy and blurred data, Statistical urban Modelling, Urban Digital Twins

In this work we present a new approach for modelling urban areas based only on high resolution satellite stereo data of lesser quality like oblique Pléiades or WorldView scenes or old Ikonos and Quickbird scenes with ground sampling distances (GSD) of 50 cm to 1 m. In such stereo scenes the derived digital surface models (DSMs) are rather noisy with a vertical resolution of also about 50 cm to 1 m. Orthorectification of the satellite imagery to the noisy DSM creates also blurred and smeared out ortho images. In the presented approach we introduce different methods for extracting urban objects from such noisy and blurred data based on statistical approaches for e.g. trees, buildings and roads. Since also the acquisition date of the single stereo scene is often in a season where trees and other vegetation can barely be detected by using the normalized difference vegetation index (NDVI) first a time series of Sentinel-2 scenes of the area is used to derive vegetated areas. Based on this derived vegetation information, the DSM derived from the panchromatic stereo images and the blurred ortho image in a first step a combined spectral and height classification to the classes road, soil, vegetation and water (all low) as well as trees and buildings (high) is made. In combination with the DSM trees can be detected and modelled using a statistic approach based on the local maxima of the DSM in the classified tree areas by setting up and refining a Voronoi diagram on such areas. The buildings are modelled by deriving statistical main directions from slope and aspect of the DSM and also the outlines of different separable building levels together with detected ridges, flat roofs and break lines. For extraction of the roads the digital terrain model derived from the digital surface model is used in combination with a spectral classification from the projected ortho image to detect flat road segments and their boundaries. Combining these in a statistical model together with a network graph gives the road network. The method is applied to different scenes of different sensors and manually evaluated and compared to existing ground truth data using random sampling.

0154. A Geospatial Framework for High-Resolution Coastal Mapping: Insights from the COASTLINE Project

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Keywords: Coastal monitoring, Spatiotemporal Mapping; Geospatial technologies; Unmanned Aerial Vehicles (UAVs); Drone LiDAR: Coastal change detection

The confluence of climate change, sea-level rise, and anthropogenic pressure presents a threat to global coastal habitats. To effectively manage these vulnerable areas, we need decision-making frameworks that rely on accurate, trustworthy, and long-term data. The COASTLINE project, an initiative supported by the European Union's Horizon 2020 Marie Skłodowska-Curie Actions, represents a multidisciplinary effort to revolutionize the monitoring, assessment, and management of European coastal zones through state-of-the-art geospatial technologies. The initiative focuses on generating

high-resolution, multi-temporal datasets critical for analyzing complex coastal dynamics, such as accelerated erosion, ecological shifts, and human-induced environmental degradation.

This objective is realized through the strategic integration of Earth Observation (EO) data with Unmanned Aerial Vehicles (UAVs) equipped with LiDAR, multispectral, and hyperspectral sensors, complemented by terrestrial ground penetration radars and rigorous in-situ measurements. COASTLINE prioritizes the development of an intuitive analytical platform that empowers stakeholders, policymakers, and the scientific community to access and visualize multidimensional data on coastal evolution and environmental stress. This repository will be populated by diverse streams, including the Copernicus program, advanced LiDAR data, and proprietary datasets, facilitating proactive monitoring and the rapid identification of systemic changes within coastal ecosystems.

Additionally, the project employs advanced 2D and 3D visualization techniques to visualize physical transformations and measure the specific pressures applied to coastal margins. COASTLINE uses machine learning to predict and detect coastal changes and geohazards. Establishing a resilient, user-centric platform enables interactive, real-time cartographic queries. The COASTLINE project constitutes a pivotal advancement in creating a holistic framework for coastal diagnostic assessment by synthesizing multi-source data with frontier geospatial innovations. Its methodology—harmonizing satellite imagery, aerial surveys, and ground-truth data—is engineered to provide a comprehensive perspective on shoreline retreat, habitat fragmentation, and the preservation of coastal cultural heritage sites.

0155. Enhancing High-Impact Rainfall Forecasts through Multi-Sensor Data Assimilation in WRF: Insights from the CYGMEN Project

Vassiliki Kotroni[1], Antonis Dimitrelos[1], Athanasios Karagiannidis[1], George Gragkoulidis[1], Christos Giannaros[1,2], Kostas[1], Christina Oikonomou[3], Haris Haralambous[3]

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Keywords: Rainfall forecasting, Radar, Data Assimilation

Reliable short-range forecast of high-impact precipitation remains a big challenge for operational meteorology, particularly in regions prone to intense convective activity. Within the framework of the CYPRUS GNSS METEOROLOGY ENHANCEMENT (CYGMEN) project an integrated data assimilation strategy has been developed to strengthen the representation of mesoscale processes in numerical weather prediction systems.

This contribution presents the implementation and evaluation of a multi-observation assimilation framework in the Weather Research and Forecasting (WRF) model, incorporating ground-based Global Navigation Satellite System (GNSS) zenith total delay estimates, weather radar reflectivities, and in situ surface meteorological measurements. The three-dimensional variational (3D-Var) scheme is employed to ingest heterogeneous datasets and to improve the initial atmospheric state prior to short-term forecasts.

The methodology is assessed for a severe precipitation episode associated with the “BORA” storm (November 2023), a prolonged event driven associated to (or driven by) a deep low-pressure system over the Ionian Sea that generated widespread and intense rainfall over the region. A set of sensitivity experiments is performed to isolate the contribution of each observational component and to examine the influence of alternative initialization approaches, including cycling (“warm start”) and non-cycling (“cold start”) configurations with varying assimilation frequencies.

Forecast performance is evaluated using both conventional categorical verification metrics derived from contingency tables and object-based diagnostics via the Method for Object-Based Diagnostic Evaluation (MODE). This dual verification strategy enables a comprehensive assessment of rainfall intensity, spatial displacement, and structural characteristics.

This work is realized within the CYGMEN project (Project Protocol Number: STRATEGIC INFRASTRUCTURES/1222/0198) in the framework of the “RESTART 2016-2020 ”Programmes for Research, Technological Development and Innovation (RTDI) which is co-financed by the Republic of Cyprus and the European Regional Development Fund.

0156. GNSS-Derived Water Vapor as a Precursor to Fluvial Flooding in Cyprus: A Case Study of Storm Byron and the Pedieos River Basin

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Keywords: GNSS Precipitable Water Vapour; Fluvial Flood Nowcasting; Storm; WRF-Hydro

Cyprus – one of the most prominent climate change hot spots in Eastern Mediterranean – has in recent years been characterized by a climatological paradox: while the region experiences record-low reservoir levels and chronic drought, there has been a simultaneous significant increase in high-intensity, short-duration flood events. Data from the last 5 years reveals that urban and flash floods now constitute 37% and 20% of the island’s flood incidents, respectively, with fluvial flooding accounting for an additional 16%. These events have caused substantial socio-economic disruptions, impacting critical infrastructure such as highways, airports, urban areas, agriculture and tourism. A primary challenge in mitigating these impacts is the limitations of standard Numerical Weather Prediction (NWP) models, which often fail to precisely localize extreme precipitation due to insufficient high-resolution data on lower-atmosphere water vapor distribution. This study analyses the evolution of regional vulnerability to fluvial floods, by comparing the socioeconomic impacts of 2020 flood events with the 2025 flood event in Pedieos River, Nicosia Cyprus, that occurred during the storm Byron (a barometric low that triggered an Orange Weather Alert by Cyprus Department of Meteorology, with rainfall intensities exceeding 55 mm/h). During this event, the Pedieos River – a high-risk urban catchment running through Nicosia – reached overflow levels, leading to the closure of major urban arteries, flooding of neighbourhoods in northern Nicosia, and triggered landslides and rock falls in rural areas of Troodos. Moreover, this work aims to evaluate the relationship between Precipitable Water Vapor (PWV) and the subsequent rainfall during Byron event, using GNSS (Global Navigation Satellite System) data from stations near the Pedieos basin. By examining the critical window between December 7th and 9th, this work aims to assess whether PWV peaks could have provided a several-hour early warning before the physical overflow occurred on December 10th. While the current work focuses on proving the direct link between atmospheric water vapor and historical flood damage, it establishes the empirical baseline for the MedGIFORS project. Proving that PWV is a reliable precursor of extreme rainfall, it can be used as o local index helpful for the nowcasting of sudden local flood events. Assimilating PWV data into the WRF model, can serve as a tool to validate WRF-Hydro prediction of floods. This data integration is essential for transitioning Cyprus from a reactive emergency response toward a proactive, impact-based forecasting system. This work is conducted within MedGIFORS project (Project Protocol Number: BRIDGE2HORIZON/0823D/0011 in the framework of the “RESTART 2016-2020 ”Programmes for Research, Technological Development and Innovation (RTDI) which is co-financed by the Republic of Cyprus and the European Regional Development Fund.

0157. An Unsupervised Autoencoder pipeline for Coastal and Reservoir change detection using Sentinel-2 Multispectral Imagery

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Keywords: Unsupervised Learning, Autoencoder, Sentinel-2, Change Detection, Land-Water Segmentation, Reservoir Monitoring, Coastal Erosion, Remote Sensing

Monitoring land–water dynamics in coastal zones and inland reservoirs is essential for environmental management, climate adaptation, and infrastructure planning. This work presents a fully automated, unsupervised deep learning pipeline for detecting coastal modifications and reservoir water-level changes using Sentinel-2 multispectral imagery. The system is designed to operate without manual thresholding or pixel-wise labels, instead learning the underlying spectral behaviour of land and water directly from data. The proposed method uses Sentinel-2 Level-2A Surface Reflectance imagery (12 bands) from different time periods and preprocesses it into a large, normalized pixel dataset. A compact autoencoder architecture compresses each 12-band pixel into a one-dimensional latent variable, which acts as a self-derived Water/Land Probability Index. To convert this latent space into an operational land-water mask, the pipeline performs automatic threshold calibration using ESA WorldCover as reference data.

Change detection is then performed by applying the calibrated threshold to these time periods, inverting the masks to focus on land, and differencing them to identify land gain, land loss, and stable terrain. Morphological filtering is used to remove small, noisy detections and enforce spatial coherence, ensuring that only contiguous changes larger than a few hectares are retained. The pipeline is demonstrated on several coastal and reservoir test sites, successfully capturing reservoir surface expansion of $+0.45\ km^2$. The results highlight that unsupervised latent-space learning, coupled with data-driven calibration, can deliver robust, scalable, and sensor-specific change detection without any manual tuning. The approach is directly transferable to regions where Sentinel-2 or similar multispectral data and basic land-water reference maps are available.

0158. GIS-Based Digital Transformation: A Methodology for Bureaucratic Burden Reduction

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Keywords: Digital Transformation, Geospatial Technologies, Bureaucratic Burden, Methodology, Urban

The strategic adoption of emerging technologies to modernize and streamline workflows within public administration has emerged as a focal point in European regulatory directives. Meanwhile, public sectors are called to change their traditional way of operation with the integration of new tools that improve efficiency and Decision-Making on complex matters. In this landscape the need for the reduction of excess bureaucratic burdens has come to the centre of attention for all sectors involved. As a result, administrations can benefit from immediate, fast, and effective tools that streamline their processes, improve the productivity and efficiency of employees, and reduce bureaucratic burdens that hinder their ability to act in a timely manner and make critical decisions quickly. Geographical Information System platforms have been used to access spatial information and speed up workflow and spatial planning procedures. Since they can easily and immediately be updated, they can pave the way for integration into all kinds of organizational workflows.

While tools like these can improve D-M and minimize centre bureaucratic burdens, it is obvious that they

cannot completely remove burdens but also create new ones. This is possible because of the learning curve an employee must go through to be familiar with the new tools. These types of burdens are a point of interest and through a bibliographic review three main types have been identified:

- Learning costs, effort or expense to learn about a new tool
- Compliance costs, needed documentation for access to services
- Psychological costs, stigma, frustration and stress when applying to services

So, there is a clear need to ensure that such tools improve decision-making processes in local administration while removing unnecessary burdens from bureaucratic processes. This paper's aim is to showcase a methodology that proves weather GIS are a viable, sustainable, and effective tool that boosts employee productivity and reduces bureaucratic burdens in local administrations. In order to prove such argument, the paper will follow the case study of the municipalities of Limassol, Cyprus. In this instance the municipalities are in the process of adapting a GIS platform into their workflows. So, there is clear interest in this study to find and test a methodology that answers the question "can a GIS platform reduce bureaucratic burdens and if so by how much in money and time?". The main tool that will be used to quantify such a measure are questionnaires that have been internally validated for consistency and reliability. Employees will be asked about their previous experience with digital tools, the time they spend on processes that will be digitized by a GIS, and the psychological impact that these processes produce. The information system of the municipalities is under reform and modernization. One of the main tools that is being implemented is the GIS platform that aims to ease and streamline workflows in tasks that involve spatial information. So, it is important to receive questionnaire data before and after the implementation so that a realistic and accurate understanding of the platform's impact can be measured. Through this process a step-by-step methodology emerges. Part of this process is the quantification of bureaucratic burdens and the impact that they can have in time and money to local administration.

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0159. UAV Remote Sensing of Watermelon under Different Irrigation Regimes: Non-Parametric Modelling of Crop Biophysical Variables

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Keywords: UAV remote sensing, Precision irrigation, Vegetation indices, Crop biophysical variables, Non-parametric modelling

Very high–resolution imagery was acquired using a DJI Phantom unmanned aerial vehicle (UAV) platform at 30 m altitude to derive remote sensing indicators of watermelon crop status. The field measurements were collected to monitor crop biophysical properties, including leaf area index (LAI), fraction of intercepted photosynthetically active radiation (fIPAR), fractional vegetation cover (fCover), and chlorophyll content index (CCI). These in situ observations were used to support the analysis and modelling of UAV-derived vegetation indices. Field experiments were conducted during the 2025 growing season at the Maritsa Vegetable Crops Research Institute, Bulgaria. Three observation

campaigns were carried out across the season in experimental plots including three watermelon cultivars subjected to two irrigation regimes (optimal and reduced). In total, 21 plots were monitored, with 12 plots receiving optimal irrigation and 9 plots under reduced irrigation. The complete dataset is analysed using non-parametric modelling approaches to quantify relationships between UAV-derived indicators and measured crop biophysical parameters, and to evaluate their sensitivity to irrigation treatments and cultivar variability. The results contribute to the development of high-resolution crop monitoring methods and support precision irrigation management in watermelon production systems.

0160. FPGA-Accelerated Neural Network for Wildfire Pixel Classification

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Keywords: Wildfire detection; FPGA; Fixed-point neural network; Multilayer perceptron; VHDL

This research paper presents an alternative approach to the application of machine learning algorithms for fire detection systems, forming insights for the implementation of such systems. Real-time wildfire detection on edge devices requires millisecond-scale inference with minimal power consumption. Yet many modern computer-vision solutions that integrate machine learning algorithms rely on GPUs or cloud processing, which introduce latency, increase energy costs, and limit deployment in remote areas. This work presents an FPGA-based approach for detecting early wildfire indicators from RGB imagery using a compact multilayer perceptron (MLP) that classifies each pixel as fire or non-fire within a streaming pipeline. An end-to-end methodology is presented, which starts with dataset preparation and training in Python and concludes with a synthesizable VHDL inference core integrated in Xilinx Vivado, targeting the Zynq UltraScale+ FPGA device. A reproducible software flow prepares a wildfire dataset containing fire and non-fire images paired with segmentation masks, enabling pixel-level supervision rather than coarse image-level labels. After training and evaluating neural-network accuracy in Python, the neural-network is quantized and exported in fixed-point format, allowing direct use in hardware. The FPGA architecture is implemented in VHDL using fixed-point multiply-accumulate operations and a Look Up Table-based (LUT-based) sigmoid activation to avoid floating-point overhead while preserving nonlinearity. Compared to prior FPGA neural-network efforts that often focus on generic classification or simplified activations, this work targets wildfire segmentation specifically with a fixed-point MLP with LUT-based sigmoid designed for per-pixel wildfire detection in a VHDL architecture that handles continuous data processing. Results show that the fixed-point implementation maintains competitive predictive performance while having a small hardware footprint: the design reaches approximately 80% test accuracy and uses only about 4850 of LUTs and about 71 of DSPs while achieving a frequency of 74.25 MHz, latency of 121 ns, and 1.782 Gbit/s throughput in steady state inference. These measurements demonstrate the efficiency of deploying neural inference in constrained FPGA fabrics alongside additional system logic (e.g., video interfaces and control). Overall, the proposed workflow enables low-latency, low-power wildfire detection at the sensor, supporting rapid, local, low-cost fire alerts for distributed remote monitoring networks in opposition to existing systems. Key contributions include: (i) dataset preparation and a reproducible training pipeline, (ii) fixed-point export flows and an activation LUT generation methodology, (iii) a streaming VHDL architecture for inference with resource/performance measurements, and (iv) experimental evaluation on test imagery and comparison to floating-point baselines.

0161. Earth observation–based monitoring and early-warning system for vegetation stress and drought conditions

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Keywords: Drought monitoring, Vegetation stress, Early warning, Europe, Remote Sensing

Climate change is intensifying drought risks across Europe, particularly affecting vegetation, which is highly sensitive to climatic conditions. Consequently, climate change poses severe risks to agricultural production and food security in Europe. Earth observation (EO) data enable effective monitoring of vegetation conditions and near-real-time assessments of vegetation stress and drought development, thereby supporting informed agricultural decision-making and climate adaptation strategies.

Within the EU Horizon project NOSTRADAMUS (Data Cube and Copernicus Data for Food Security and European Independence), a drought monitoring and early warning system is being developed. The application exploits multi-source EO data and derived products to provide spatially explicit information on vegetation stress and drought conditions. The monitoring framework is based on a Combined Drought Indicator (CDI) approach that integrates anomalies from several complementary variables. These include the Normalized Difference Vegetation Index (NDVI) derived from Copernicus Sentinel-2, Land Surface Temperature (LST) from Sentinel-3, Surface Soil Moisture (SSM) from the Copernicus Global Land Service (CGLS), and the Standardized Precipitation Index (SPI) derived from Climate Hazards Center Infrared Precipitation with Stations (CHIRPS) data. In addition, short-range to seasonal meteorological forecasts will be incorporated to support the prediction of drought evolution.

A first prototype has been implemented and evaluated for a test site in Germany. The application generates drought status maps at 10 m spatial resolution with multiple severity levels, using Sentinel-2-derived vegetation indicators as the spatial backbone. Given the temporal resolution of the input data, drought conditions can be updated at 5-day intervals. Evaluation of the model performance has been conducted against established drought monitoring products to assess plausibility, spatial agreement and temporal consistency in drought pattern evolution.

Future work will focus on extending the system to additional project regions and integrating forecast products to support the prediction of drought development and strengthen early warning capabilities. The resulting EO-based information products aim to support agricultural decision-making, including crop management, irrigation planning, and implementation of appropriate adaptation measures.

0162. Multiple Exposures in Cabo Delgado, Mozambique: How Civil Conflict and Cyclones Alter Cultivated Land Use Patterns

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Keywords: Agriculture, remote sensing, climate change, climate adaptation, civil conflict

Armed conflict alters agricultural land use through displacement and constraining access to land and other assets. Since 2017, a conflict in Cabo Delgado, Mozambique—linked to socioeconomic grievances over gas extraction—has displaced approximately 1 million people. In the past decade, Mozambique has also been impacted by three of the worst cyclones in African history, including Cyclone Kenneth which made landfall in Cabo Delgado in 2019. In the context of these shocks, this study used Dynamic World land cover data to correlate agricultural land use change in Cabo Delgado from 2016-2025 with conflict event data from the Armed Conflict Location Events Database and local news sources. We found that conflict produced mixed patterns of land abandonment and expansion, consistent with migration away from conflict zones to safer locations within the Cabo

Delgado and bordering Nampula. Short-term cultivated land change exceeded long-term change, which aligned with reference data on displacement. Increased cultivation loss along the Rovuma and Lurio Rivers indicated the impacts of cyclone-induced flooding. Local Indicators of Spatial Analysis showed significant positive spatial autocorrelation, conveying that drivers operate at regional scales rather than as isolated local events. We argue that near-real-time Dynamic World data offers significant underused potential for conflict studies.

0163. A Hybrid Disaster Victim Dataset Using AI-Generated and Simulated Images for Victim Detection in Collapsed Buildings

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Keywords: Victims Detection; Disaster Response; AI image; Search and Rescue

Rapid identification of trapped victims in collapsed structures is one of the most critical challenges in post-disaster search-and-rescue operations. Earthquakes, explosions, and structural failures often leave victims partially buried under debris, where only small portions of the body, such as a hand, foot, or head, may be visible. Computer vision systems deployed on drones, ground robots, or handheld devices have the potential to support first responders by automatically detecting human presence in such complex environments. However, the development of reliable victim-detection algorithms is hindered by the limited availability of annotated datasets that represent realistic disaster scenarios. Collecting images of real disaster victims is ethically sensitive and rarely feasible, while existing datasets often lack sufficient diversity in occlusion conditions, viewpoints, and environmental complexity. To address this challenge, this paper presents a new dataset designed for victim detection in collapsed building environments. The proposed dataset combines two complementary data sources: synthetic images generated using diffusion-based generative models and simulated real-world images captured in controlled rubble environments. The synthetic component is produced by first generating realistic disaster backgrounds and then introducing partially occluded victims through guided image-to-image generation. These images simulate various rescue scenarios, including victims partially buried under debris, individuals trapped in collapsed corridors, and cases where only limited body parts are visible. In parallel, a simulated data collection process is conducted in which mannequins are placed within artificially constructed rubble scenes, and images are captured from multiple viewpoints to mimic the perspectives of drones or robotic platforms used in search-and-rescue missions. This approach allows the dataset to include realistic lighting conditions, occlusions, and environmental textures while avoiding the ethical and safety issues associated with photographing real disaster victims. The resulting dataset comprises a diverse range of victim-detection scenarios, from clearly visible victims to heavily occluded cases in which only a small body part is visible. All images are annotated with bounding boxes corresponding to the presence of victims, enabling the dataset to be used for training and evaluating object detection models. To demonstrate the usefulness of the dataset, a series of experiments is conducted using a modern object detection architecture. Models are trained under different data configurations, including training on synthetic images only, simulated images only, and a combination of both sources. The models are then evaluated on simulated test scenes representing realistic collapsed-structure conditions. Experimental results indicate that synthetic data generated using diffusion models can significantly increase the diversity of training samples and help improve detection performance when combined with simulated real-world data. Although models trained exclusively on synthetic images exhibit a noticeable domain gap when evaluated on real scenes, hybrid training substantially improves robustness to occlusion and complex backgrounds. These findings highlight the importance of combining generative and simulated data sources when building datasets for safety-critical computer vision applications.The proposed dataset contributes a practical resource for research on victim detection in disaster environments and provides a foundation for developing more robust AI-based search-and-rescue systems capable of operating in highly cluttered and partially

occluded scenes.

0164. Large Language Model Driven Named Entity Recognition for Soil and Land Information Extraction in the EMMENA Region

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Keywords: Large Language Models; Named Entity Recognition; Soil Information Extraction; Agricultural NLP; EMMENA Region

To achieve effective, sustainable agriculture and climate-resilient land management in the East Mediterranean, Middle East, and North Africa (EMMENA) region, soil and land data must be accurate, well organized, and easily accessible. A lot of information about regional soils is still stored in unstructured text files, such as soil survey reports, agricultural extension bulletins, scientific papers, and government archives. Because there are no automated extraction methods, it is hard to convert these text-based resources into structured, machine-readable data usable by digital agriculture platforms and decision-support systems. Most Named Entity Recognition (NER) research in agriculture today uses standard Machine Learning models such as Conditional Random Fields (CRF) and Support Vector Machines (SVM), as well as early Deep Learning frameworks such as BiLSTM-CRF. These methods are limited by extensive manual feature engineering, a lack of understanding of contextual semantics, a lack of ability to generalize across domains, and a lack of ability to adapt to regional agricultural vocabulary. Additionally, there are no publicly available benchmark datasets for soil-text NER in the EMMENA region, making it hard to reproduce results and conduct standardized tests. This research introduces a Large Language Model (LLM) driven NER framework specifically designed for the extraction of soil and land information within the EMMENA context. The proposed study introduces the first benchmark annotated soil-text corpus for the region and outlines a domain-specific entity schema comprising soil property, soil value, soil type, land use, land degradation, management practice, and location entities. The methodology includes gathering data from regional agricultural documents, preprocessing and tokenization, Begin–Inside–Outside (BIO) tagging. A comprehensive comparative evaluation is conducted across three model categories: classical machine learning models (CRF, SVM), deep learning models (BiLSTM-CRF, CNN-BiLSTM), and fine-tuned transformer-based LLM token categorization architectures. To make contextual extraction more effective, domain adaptation techniques like ongoing pre-training on soil-specific datasets and fine-tuning that is sensitive to terminology are used. To evaluate a model, we use Precision, Recall, and F1-score at the token and entity levels. We also use micro- and macro-averaging, confusion matrix analysis, and cross-validation stability metrics. Technology turns unstructured soil descriptions into structured records, making it easier to connect with digital soil intelligence systems, geospatial platforms, and AI-driven tools for agricultural advice. The suggested method provides a standardized way to evaluate agricultural Natural Language Processing (NLP) research in the EMMENA region and demonstrates how well LLM-based domain adaptation performs at extracting soil-text information. Future work will expand the framework to include multilingual settings (English, Greek, and Arabic), add remote sensing and geospatial datasets, and use AI to create soil advisory systems that will help farmers, researchers, and policymakers.

0165. Climate-informed spatial prioritization for the conservation of Emys orbicularis in Greece

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Keywords: Climate-informed conservation planning, Habitat suitability modelling, Emys orbicularis, MaxEnt, species distribution model

Freshwater biodiversity is increasingly threatened globally by climate change and intensified human pressures, requiring conservation strategies that remain effective under changing environmental conditions. Notably, the European pond turtle (Emys orbicularis), a protected native species in Greece, has been assessed as near threatened due to the fragmented habitat and anthropogenic aggressions. This study aims to delineate priority conservation areas for the European pond turtle under present and future climate conditions (SSP370, 2041–2060) by integrating habitat suitability mapping, a human-pressure cost surface, and optimization-based systematic conservation planning. Habitat suitability maps were generated using a maximum-entropy species distribution modelling approach (MaxEnt), in which remote sensing variables and climate scenarios were used as key parameters integrated into the species distribution model (SDM). Conservation priorities were then identified through minimum-cost planning-unit optimization on a $5 \times 5\ km^2$ grid, targeting at least 30% representation of suitable habitat while minimizing conservation cost, quantified based on a spatial global human modification (gHM) index threshold. Identified hotspots for current and future conditions were then intersected with the Natura 2000 map to determine the coverage and identify gaps.

Results revealed a clear shift in suitability patterns and conservation priorities under future conditions, with a declining trend observed in the current northern strongholds. While maintaining the current protected areas, new zones (22% of the delineated suitable areas) have been identified in the southern and southeastern coastal regions, necessitating the implementation of conservation plans.

0166. Detecting Illegal Water Abstractions Using Earth Observation and Artificial Intelligence: Challenges, Research Gaps, and Future Directions

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Keywords: Earth Observation, Water Resources Management, Illegal Water Abstraction, Artificial Intelligence, Environmental Monitoring

Water scarcity and unsustainable water withdrawals constitute major global challenges, particularly in semi-arid and Mediterranean regions where agricultural activities exert significant pressure on limited hydrological resources. Illegal or unreported water abstractions further exacerbate these pressures, threatening ecosystem stability, food security, and policy compliance. Despite advances in Earth Observation (EO) technologies and data-driven environmental monitoring, the detection of unauthorized water use remains a complex and insufficiently addressed research problem. Existing monitoring mechanisms rely primarily on administrative reporting, field inspections, or indirect hydrological indicators, which are often costly, delayed, or spatially incomplete.

Recent literature demonstrates substantial progress in EO-based irrigation monitoring, evapotranspiration estimation, soil moisture retrieval, and crop classification through machine learning and remote sensing techniques. Satellite-based sensors such as ESA's Sentinel-2 Multi-Spectral Instrument and NASA's Moderate Resolution Imaging Spectroradiometer have enabled large-scale environmental observation with increasing temporal and spatial resolution, while artificial intelligence approaches have improved predictive capabilities for agricultural and hydrological applications. However, the majority of existing studies focus on estimating water consumption patterns rather than identifying anomalous

or potentially unauthorized behavior. Moreover, current methodologies often lack integration between geospatial analysis, temporal dynamics, and contextual environmental variables, limiting their effectiveness in operational governance scenarios. Challenges such as data heterogeneity, uncertainty propagation, limited ground truth validation, and interpretability constraints further hinder the deployment of reliable detection systems.

This literature-based analysis highlights a critical research gap: the absence of robust, scalable frameworks capable of proactively identifying abnormal water use patterns across heterogeneous landscapes. Addressing this gap is essential for supporting sustainable water governance, improving compliance monitoring, and enabling data-driven policy interventions aligned with international environmental objectives. The findings indicate that future research should move beyond descriptive analytics toward integrated spatiotemporal intelligence capable of combining multi-source EO data, environmental indicators, and advanced learning paradigms.

Building upon these observations, this work outlines a conceptual research direction that leverages recent advances in artificial intelligence and remote sensing to support the detection of irregular water abstraction behaviors. The proposed perspective emphasizes the importance of integrating spatial and temporal modeling, anomaly detection strategies, and context-aware environmental analysis within a unified framework. Such approaches have the potential to transform water monitoring from reactive assessment toward proactive decision support, contributing to sustainable resource management and environmental resilience.

0167. Creating Accurate Annotation Datasets from EO and SAR imagery for Defence Applications

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Keywords: EO/SAR Imagery, Artificial Intelligence, Image Annotation, GIS, Defence

The expansion of Artificial Intelligence applications in defence increasingly depends on the availability of large, high-quality annotated datasets derived from Earth Observation (EO) imagery. While numerous benchmark datasets exist for civilian remote sensing tasks, defence-oriented datasets remain limited due to secrecy, operational constraints, complex object classes, and the challenges associated with interpreting multi-sensor satellite imagery. In particular, the integration of optical EO and Synthetic Aperture Radar (SAR) data introduces additional complexity related to sensor physics, geometric inconsistencies, and object appearance variability.

This paper presents a methodology and empirical findings from an evaluation study aimed at developing reliable multimodal annotation datasets from optical and SAR satellite imagery for defence-related AI applications. The study examines the practical challenges of annotating high-resolution EO/SAR datasets and evaluates the consistency and reliability of annotations produced under realistic operational conditions. The workflow starts with a data model based on NATO STANAGs for the identification and classification of defence-relevant entities. Several image packages containing both optical and SAR imagery were analysed to assess how effectively defence-related objects and infrastructure could be detected, classified, and spatially delineated. Empirical observations revealed that certain objects visible in optical imagery could not be consistently mapped to predefined classes, indicating limitations in the original schema. These findings required iterative refinement of the data model based on empirical interpretation results and operational experience, highlighting the importance of adaptable ontologies for defence intelligence datasets.

The incorporation of SAR imagery into the annotation workflow introduces further challenges. SAR images exhibit speckle noise, geometric distortions, and backscatter patterns that depend strongly on acquisition geometry, system characteristics (e.g. frequency, polarization), surface material, and object

orientation. Consequently, objects clearly visible in optical imagery may appear distorted or partially obscured in SAR data. Small targets such as helicopters, UAVs, or ground vehicles are particularly difficult to identify reliably. Additionally, geometric misalignments between optical and SAR products may introduce spatial offsets that complicate cross-modality annotation transfer. Temporal differences between acquisitions may also result in the appearance or disappearance of objects, reducing the reliability of direct EO/SAR comparisons.

To support scalable annotation campaigns involving multiple operators, a dedicated GIS-based workflow was developed using open geospatial technologies. A custom tiling tool partitions large satellite scenes into manageable tiles that can be distributed among annotators, enabling parallel annotation while maintaining spatial consistency and preventing overlaps. The workflow also facilitates systematic metadata management and monitoring of annotation progress. Furthermore, a structured digitization process leveraging a spatial database environment was implemented to generate geometrically consistent oriented bounding boxes, even for irregular shaped objects. Annotators digitize objects within the GIS, while spatial database functions enforce orientation constraints, validate geometries, and store annotation attributes, enabling automated quality control.

The results demonstrate that the creation of defence-grade EO/SAR annotation datasets requires deep understanding of remote sensing principles, robust geospatial data engineering workflows, and adaptable data models. The proposed approach supports the development of scalable and reproducible annotation pipelines that can contribute to the generation of reliable benchmark datasets for AI-driven defence intelligence systems.

0168. AI-driven multi-satellite orbit prediction model for improved Earth Observation and disaster response

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Keywords: Satellite orbit prediction, TLE, Deep learning, Earth observation, Disaster response, Space situational awareness

Accurate satellite orbit prediction is fundamental for Earth observation (EO) planning, constellation management, and rapid disaster response. Most operational orbit forecasts rely on Two-Line Element (TLE) sets propagated with analytical models such as SGP4. While computationally efficient, these models often exhibit decreasing accuracy as prediction horizons increase, particularly when TLE updates are sparse or irregular.

This study introduces the Multiple Satellites Deep Learning TLE prediction model (MS-DL-TLE), a data-driven framework designed to improve long-term satellite position forecasting using historical TLE sequences. The model combines sequence-learning techniques with attention mechanisms to capture temporal dependencies in irregular orbital data and predict future satellite positions at user-defined horizons.

The approach was evaluated using a benchmark dataset of 63 Earth-observation satellites and thousands of historical TLE samples, with input sequences of thousands data samples, and prediction horizons extending up to 30 days. Experimental results demonstrate that the proposed method maintains stable prediction accuracy of approximately 93–96% across long prediction horizons, while the accuracy of classical SGP4 propagation declines significantly over the same interval.

Beyond improving orbit prediction performance, the method enables more reliable planning of satellite acquisitions and coverage assessments. Such capabilities are particularly valuable in time-critical applications such as disaster monitoring, where accurate knowledge of satellite availability can accelerate the delivery of actionable Earth-observation data to emergency responders. The results highlight the potential of integrating artificial intelligence with orbital data analysis to support next-generation space

operations, space situational awareness, and EO-driven disaster resilience.

0169. Detecting Unauthorized Constructions from Aerial Imagery Using Deep Learning Model and Cadastral Data

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Keywords: Aerial imagery; unauthorized construction; U-Net; cadastral mapping; GIS

The rapid expansion of unauthorized construction poses significant challenges to land management and cadastral governance. In Armenia, detecting illegally constructed buildings remains largely dependent on manual field inspection, resulting in incomplete enforcement of spatial planning regulations. This study presents a methodology for automated building detection using high-resolution aerial imagery and its comparison with existing cadastral maps to identify unauthorized structures in the Ayntap community of Ararat Province, Armenia.

Aerial imagery with a ground sampling distance of 6 cm were acquired through low-altitude aerial survey, providing submeter spatial resolution that satisfies the technical requirements established for cadastral mÍapping under Armenian national standards. The high geometric accuracy of the imagery ensures reliable correspondence between detected features and real-world cadastral boundaries, making the dataset suitable for official cadastral applications.

Building footprints were extracted automatically using a deep learning model based on a convolutional neural network (CNN) with U-Net architecture, trained on labeled samples from the study area. Model performance was evaluated using Intersection over Union (IoU) and F1-score metrics. The deep learning model achieved an IoU exceeding 0.85 on the test subset, confirming the reliability of the automated detection results. Post-processed vectorized building polygons were overlaid with the cadastral layer. Spatial analysis performed in a GIS environment identified discrepancies between detected footprints and registered cadastral objects. Structures present in the aerial-derived layer but absent from the cadastral database were flagged as potentially unauthorized constructions.The comparison procedure identified a notable proportion of unregistered structures within the study area, underscoring the practical value of integrating remote sensing and cadastral data for land monitoring.

The proposed workflow constitutes an effective and scalable approach for illegal construction monitoring and is directly applicable to other communities across Armenia. Integration into the national spatial data infrastructure would enable evidence-based enforcement by relevant state authorities, supporting more transparent and efficient land governance. Future work will focus on multi-temporal change detection and automated administrative reporting.

0170. Evaluating EarthCARE's MSI and ATLID Aerosol Products Against Ground-Based Sunphotometer and Lidar Observations

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Keywords: EarthCARE, AERONET, PollyNET, Aerosol Optical Thickness, Validation

Assessing the accuracy of spaceborne aerosol retrievals is essential for advancing atmospheric research, air-quality monitoring, and climate modelling. This study evaluates the performance of ESA-JAXA EarthCARE (Earth Cloud, Aerosol, and Radiation Explorer) satellite mission, launched on 28 of May 2024, focusing on MSI (Multi-Spectral Imager) Aerosol Optical Thickness and ATLID (ATmospheric LIDar) extinction, backscatter and depolarisation retrievals of baseline BA (MSI_AOT_2A and ATL_EBD_2A). Validation is conducted using ground-based measurements from AERONET and, in some cases, PollyNET stations. For Limassol in Cyprus, data are provided by the CIMEL CE318-N sunphotometer and the PollyXT lidar at the ACTRIS National Facility of the Cyprus Atmospheric Remote-sensing Observatory (CARO), which also contributes to the EarthCARE calibration and validation activities through the CORAL (Cyprus Observations for EarthCARE vALidation) project.

The methodological approach involves precise spatial and temporal matching of satellite overpass timestamps with lidar profiles and sunphotometer measurements. PollyXT-derived AOT is calculated by vertically integrating extinction coefficients, applying different height averaging and quality control filters including cloud masking and signal-to-noise thresholds. Satellite data are evaluated using closest-point measurements, along-track spatial averaging (± 25 km and ± 50 km), distance thresholds (< 50 km and < 60 km) from the station, and multi-point averaging based on standard deviation criteria. Ground-based data are assessed using both instantaneous measurements during satellite overpass and temporal averaging windows (±30 minutes and ± 1 hour). Special consistency between the datasets is achieved by addressing wavelength differences using the Ångström exponent 440-675 nm and 340-440 nm from AERONET.

Comparisons between satellite and surface observations are performed via linear regression analysis and evaluated using multiple statistical indicators, to assess the agreement between AOT values from MSI, ATLID, AERONET, and PollyNET observations. Notably, MSI and AERONET operate only during the daytime, while ATLID and PollyNET provide measurements both day and night. Therefore, comparisons are made using available data for each instrument.

In Limassol, the strongest agreement is observed for MSI AOT within a 60 km radius of the station, for ATLID using the nearest footprint, with $\pm 30-$minute temporal averaging for AERONET and PollyNET, and extinction profile integration up to 10 km for both ATLID and PollyXT. The best agreements are found between ATLID and AERONET, and between MSI and AERONET, with MSI showing a slight overestimation. These results demonstrate the strong performance and value of satellite observations. Applying the same statistical methodology to additional ACTRIS stations further validates and assesses EarthCARE's performance.

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0171. Causal Machine Learning for Agricultural Yield Analysis with Earth Observation: Systematic Review and a Framework for Mediterranean Rainfed Systems

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Keywords: Causal inference; Earth observation; yield proxies; Double Machine Learning

Understanding whether agricultural practices cause yield gains is central to evidence-based policy and precision agriculture. However, much of the EO-driven yield literature remains dominated by predictive, correlational models that can be biased by confounding from weather, soils, and terrain. This contribution synthesizes the emerging intersection of causal machine learning (CML) and Earth observation (EO) for yield analysis through a systematic review of studies published between 2018 and 2025, and uses the review to motivate a practical framework for Mediterranean rainfed systems.

The review maps the methodological landscape from association to causation, with emphasis on estimators suited to high-dimensional EO covariates, including Double Machine Learning, causal forests, and meta-learners. Preliminary findings suggest that studies simultaneously combining explicit causal identification strategies, satellite-derived treatments or confounders, and agricultural outcomes at field scale remain relatively scarce. The review also examines how identification assumptions, treatment-effect heterogeneity, and reproducible open-source causal tooling are addressed across the literature.

Building on these findings, we outline a Cyprus-focused framework for rainfed wheat/barley systems that integrates parcel-scale Sentinel-2 phenology features with multi-source confounders (reanalysis climate, soils, terrain) and yield proxies (e.g., HR-VPP seasonal productivity, subject to known phenology-detection limitations for winter crops). The goal is a transferable blueprint for estimating heterogeneous treatment effects of management proxies (e.g., sowing timing, rotation indicators) under water-limited conditions while explicitly accounting for fragmented landscapes and data-access constraints.

This work is part of a sub-project that has indirectly received funding from the European Union's Horizon Europe programme via an Open Call issued and executed under the ENFIELD project (Grant Agreement No. 101120657).

0172. Quantum Fourier Transform for velocity estimation in Multi-Temporal SAR Interferometry: validation on Sentinel-1 data

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Keywords: SAR interferometry, Multi-Temporal Interferometry, Quantum Fourier Transform, ground deformation, Sentinel-1

Multi-Temporal Interferometry (MTI) is a well-established technique for monitoring ground deformation from stacks of Synthetic Aperture Radar (SAR) acquisitions, achieving millimetre-level accuracy in line-of-sight displacement velocity estimation. In standard operational pipelines based on Persistent Scatterer Interferometry (PSI) or Small Baseline Subset (SBAS) methods, the velocity at each measurement point is extracted by identifying the dominant frequency in the wrapped interferometric phase time series, typically via the Fast Fourier Transform (FFT). With the growing interest in quantum computing for Earth Observation applications, highlighted by the ESA QC4EO study and national programmes such as the ASI-funded Qu4EO (Quantum Computing for Earth Observation) project, it is relevant to investigate whether quantum algorithms can serve as viable alternatives for spectral estimation within existing SAR processing chains. Yet, to date, no quantum-based approach has been

validated against operational Earth Observation products derived from real satellite data.

This work presents a hybrid quantum-classical pipeline in which the FFT-based velocity estimation kernel is replaced by a Quantum Fourier Transform (QFT) circuit followed by repeated quantum measurements. The interferometric phase history of each measurement point is amplitude-encoded into a quantum register, transformed via the QFT, and sampled multiple times in the standard measurement basis. Each measurement returns a probabilistic sample of the output spectrum, from which the dominant frequency and the corresponding displacement velocity must be inferred statistically. Three estimators are developed and compared: the mode (with parabolic interpolation), a windowed median, and a windowed mean, each designed to extract robust velocity estimates from the discrete measurement histogram produced by the quantum circuit. Convergence analysis shows that both mode and median estimators achieve sub-millimetre-per-year accuracy with 5,000–10,000 measurement repetitions.

The methodology is validated on real Sentinel-1 C-band data from the Cazzaso test site (Friuli Venezia Giulia, Italy), comprising 2,005 persistent scatterer signals derived from 245 SAR acquisitions and processed by operational PSI/MTI chains managed by GAP s.r.l. The QFT-derived velocities are compared directly against the operational FFT-based reference products. On the full dataset, the median estimator achieves a mean absolute error of 0.405 mm/yr, with over 90% of estimates within ± 1 mm/yr of the reference; the mode estimator yields comparable performance (MAE 0.563 mm/yr, 83.4% within the same threshold). These results are consistent with the velocity precision targets of the Copernicus European Ground Motion Service (EGMS). Residual outliers are concentrated among low-coherence signals with ambiguous spectral peaks, in line with standard quality control practice in operational MTI processing.

All quantum circuits were executed using a noiseless simulator; the interferometric input data are entirely real. This design allows validation of algorithmic performance independently of current hardware limitations, establishing a reference baseline for future tests on near-term quantum processors. To our knowledge, these results represent the first end-to-end validation of a quantum-based spectral estimator against operational satellite MTI velocity products. They contribute to the roadmap for quantum computing applications in Earth Observation and identify practical requirements for integrating quantum processing modules into established SAR interferometric chains.

0173. Evaluating the Lead Time of GNSS-derived Precipitable Water Vapor Jumps as a Potential Predictor for Heavy Rainfall Events in Cyprus

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Keywords: Water Vapour; GNSS Precipitable Water Vapour; Extreme Rain Events

Implementing high-resolution technological systems for the nowcasting and early warning of convective storms – including Mediterranean hurricanes (Medicanes) – is essential for safeguarding public safety, agricultural sector, and critical infrastructure against small-scale, short-term extreme weather events. Precipitable Water Vapor (PWV) serves as a critical indicator for heavy rainfall potential. Its accurate estimation is essential for near-real-time extreme weather forecasting, offering the capacity to significantly enhance Numerical Weather Prediction (NWP) models and short-range nowcasting accuracy. This study investigates the potential of GNSS-derived Precipitable Water Vapor (PWV) as an indicator of abrupt heavy rainfall across Cyprus. The present study focuses on the evolution of PWV during both short-duration flash events and longer-lasting heavy rain events to determine if distinct moisture (PWV) patterns prevail for different event types. To achieve this, we specifically examine the lead time – the interval between a sharp increase in PWV and the actual onset of precipitation – during heavy and extreme rainfall events, and the rate of PWV change ($\Delta PWV/\Delta t$) in the 0-6 hour window. Moreover, we compare the atmospheric response across coastal, inland, and mountainous regions to evaluate how moisture intensification varies as systems move inland and whether PWV thresholds can

provide a reliable warning window. To ensure robustness, GNSS derived PWV values are validated against respective Radiosonde and ERA5 reanalysis data. This work serves as a localized pilot for the EURTISS (Southeastern Europe Real-Time Severe Weather System) initiative, demonstrating how ground-based GNSS networks can be integrated into a “System of Systems ”to improve regional resilience through enhanced nowcasting capabilities. This work is conducted within EURTISS project (Project Protocol Number: BRIDGE2HORIZON/0823E/0039) in the framework of the “RESTART 2016-2020”Programmes for Research, Technological Development and Innovation (RTDI) which is co-financed by the Republic of Cyprus and the European Regional Development Fund.

0174. LST extraction using machine learning and SDGSat-1 high resolution thermal data

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Keywords: Land surface Temperature, Machine Learning, Thermal remote sensing, Urban planning

Conventional methods for estimating Land Surface Temperature (LST) from thermal satellite data involve complex procedures and require several auxiliary atmospheric parameters. In this study, a machine learning approach is investigated as an alternative method for LST retrieval and is applied to thermal data from the SDGSat-1 satellite. First, LST is estimated using a conventional single-channel method and validated against the Landsat 9 LST product acquired during an almost concurrent overpass, showing strong agreement. Subsequently, a machine learning model based on the XGBoost model is applied using the three thermal bands of SDGSat-1 as input. The results show that the XGBoost model can efficiently estimate LST without the need for external atmospheric parameters, providing a promising approach for high-resolution urban thermal mapping.

0175. A Novel MATLAB algorithm for rapid sea surface objects detection, counting and classification in SAR images

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Keywords: SAR, Sentinel-1, Shipping, Detection, Counting, Classification, MATLAB

This article presents preliminary results from the development of a novel algorithm for rapid sea surface objects counting and classification in SAR images. Data from the Sentinel-1 satellite constellation were used for the algorithm development and the research activities. The proposed algorithm has been tested on SAR images covers various regions of the Earth’s surface, such as approaches to heavy loaded traffic straits (Strait of Hormuz, Strait of Gibraltar, Bosporus Strait, etc.), polar regions (Bransfield Strait, Antarctic Sound, etc.) and open sea aquatories. Tools for exporting the output data for visualization in popular applications such as GoogleEarth, SNAP Toolbox, SeaDas, QGIS, etc. was developed.

0176. Application of satellite data for monitoring dynamics of the Huron glacier on Livingston island over a period of 40 years

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Keywords: Satellite data, Normalized Difference Snow Index (NDSI), TCT-wetness, ice shelf, change detection

Optical satellite images obtained from Landsat 5 TM, Landsat 8-9 OLI TIRS and Sentinel-2 MSI covering a period of 40 years were used in the present study. The optical imagery are selected from the austral summer on Livingston island, Antarctic, encompassing the period from December to March for each of the selected years. Normalized Snow Difference Index (NDSI) and Tasseled Cap Transformation (TCT) wetness component were generated and the spatial distribution of ice/snow covered areas was estimated using the values derived from the applied NDSI index and TCT-wetness component. Individual threshold values of each generated index were determined by visual analysis and applied to mask the glacier areas, change detection was performed and the ice shelf area loss was estimated over the entire time period. The results obtained in the presented study can be applied and integrated for ongoing observations, studies and scenarios regarding the impact of climate change and global warming on ice shelves, ice sheets and ice caps melting in Antarctic etc.

0177. Forest Status Monitoring in Vrachanski Balkan Nature Park, Bulgaria

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Keywords: Monitoring, forest ecosystems, remote sensing, dNDVI, NDVI, NDWI, Tasseled cap Greenness component (TCG)

This paper examines the application of Remote Sensing and Geographic Information Systems (GIS) for aerial monitoring of forest ecosystem dynamics. The main objective of the study is to develop a model for monitoring changes in forest ecosystems, which can be used to support the updating of forest management plans and policies. A test spatial profile with 100 Research points (SPRP) was used to analyze forest dynamics over a 35-year period. Vrachanski Balkan Nature Park (VBNP), located in Bulgaria, was selected as the study area due to the presence of anthropogenic pressure. The results were obtained through spatial analysis of optical satellite imagery acquired from the Sentinel and Landsat missions. From these data, the Normalized Difference Vegetation Index (NDVI), differenced Normalized Difference Vegetation Index (dNDVI), Normalized Difference Water Index (NDWI), and the Tasseled Cap Transformation (TCT), specifically its Greenness component (TCG), were calculated. A detailed methodology and analysis were developed to assess the degree of correlation between different optical indices, between time series from the same satellite, and between data acquired by two different satellites on the same day. This analysis enabled the implementation of a so-called synchronous approach, which successfully validated historical data for the period 1990–2025. The results obtained provide an assessment of the dynamics and condition of forest vegetation within VBNP and can be applied to activities related to forest monitoring, mapping, and forest management.

0178. Spatiotemporal Soil Erosion Assessment Projections on the Cultural Heritage Sites under Different Climate Change Scenarios: The Case Study of Amathus, Cyprus

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Keywords: RUSLE; soil erosion; climate change; cultural heritage

Soil erosion is widely recognized as one of the most critical and widespread threats to cultural heritage sites, particularly in Mediterranean environments. Changes in temperature and rainfall driven by climate change impose additional stress on built heritage and cultural artefacts. This study evaluates the current and future state of soil erosion at the archaeological site of Amathus in Cyprus using the Revised Universal Soil Loss Equation (RUSLE). Future changes in rainfall erosivity and their subsequent impact on soil erosion patterns were analyzed using CMIP5 Global Climate Model (GCM) simulations under three different future emission scenarios (RCP2.6, RCP4.5, and RCP8.5) for the period 2061–2080. Preliminary results indicate a consistent decline in soil erosion attributed to reduced rainfall erosivity across the representative emission scenarios, with erosion remaining slightly higher under RCP2.6. This work underscores the necessity of continuous monitoring of future climate and the timely detection of the projected risk of damage for structures in order to facilitate the development and implementation of policies and strategies for the effective and sustainable management of cultural heritage sites.

0179. From Historical Maps to Satellite Data: A Methodology for Coastal Change Analysis in the CHANGES Project

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Keywords: Coastal change, Remote sensing, Shoreline reconstruction, Cypriot archaeology, Climate Change

Understanding long-term coastal dynamics is essential for reconstructing past climate variability and assessing risks to cultural heritage. Within the framework of the CHANGES Project, this study presents an integrated remote sensing and GIS-based methodology for reconstructing multi-decadal shoreline change in the eastern Mediterranean, with a focus on the coastal zones of Enkomi–Alasia (Late Bronze Age, ca. 1600–1050 BC) and Salamis–Constantia (11th c. BC–8th c. AD) in Cyprus.

The methodology combines multi-temporal satellite imagery (Landsat 5, Landsat 8, Collection 2 Level-2 products) with declassified KH-9 Hexagon imagery and archival aerial photographs from the Cyprus Department of Lands and Surveys (1963 onward). This dataset enables the construction of a continuous ca. 62-year shoreline time series (1963–2025), bridging the gap between historical cartography and contemporary Earth Observation. Pre-processing procedures include geometric and radiometric corrections, reprojection to a unified coordinate reference system, and the generation of summer median composites to reduce wave and turbidity effects.

Shoreline extraction is performed in ArcGIS Pro using the Normalized Difference Water Index (NDWI) and Modified NDWI (MNDWI) to enhance water–land discrimination. Binary classification and morphological filtering refine coastal boundaries, which are subsequently converted into vector shorelines with attributed metadata (date, source, positional uncertainty). Shoreline change is quantified using the Digital Shoreline Analysis System (DSAS), generating transects perpendicular to a defined baseline and calculating key metrics such as Net Shoreline Movement (NSM), End Point Rate (EPR), and Linear Regression Rate (LRR). The LRR metric, incorporating all temporal shoreline positions, provides robust

long-term erosion and accretion trends and minimizes sensitivity to short-term anomalies.

Validation procedures include cross-comparison with aerial photography and geomorphologically stable sectors, as well as manual digitization checks. In addition, reconstructed shorelines are compared with historical cartographic sources, notably Kitchener's Survey of Cyprus, to evaluate positional deviations and assess the reliability of nineteenth-century mapping. This integration enables extension of shoreline reconstructions further back in time while distinguishing between cartographic distortion and genuine environmental change. The outputs include georeferenced shoreline datasets, erosion–accretion maps, transect-based statistical tables, and hazard classification layers suitable for GIS dissemination.

This research contributes to broader questions of human–environment interaction by contextualizing coastal transformations within archaeological settlement patterns and long-term climatic variability. By linking past coastal dynamics to present-day vulnerability, the study provides spatially explicit data to support heritage risk assessment, coastal management, and climate adaptation strategies. The proposed workflow is scalable and transferable to other Mediterranean coastal regions, offering a reproducible framework for interdisciplinary coastal change analysis.

The authors acknowledge the Erasmus+ CHANGES project: Cultural Heritage and Archaeology for the study and dissemination of Natural, Geological, Environmental and Social events due to climate changes in antiquity: learning from the past for a better awareness in the future [Project 2024-1-CY01-KA220-HED-000256266]. It is funded by the European Union.

0180. Single Ionogram Detection of Ionospheric Irregularities

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Keywords: Ionospheric irregularities, Travelling ionospheric disturbances, ionogram

Travelling ionospheric disturbances (TIDs) represent an ionospheric manifestation of the effect of gravity waves on the ionosphere. There is an interest in understanding the correlation between various forms of such irregularity signatures on ionograms such as spread F with the actual characteristics and severity of TIDs and therefore these signatures provide an important tool for TID identification and monitoring. In the existing literature there is evidence that tilted surfaces generated by TIDs at mid-latitude regions are the reason for supplementary nighttime traces appearing on ionograms which are satellites of the main ionogram traces. Therefore the term "satellite" traces signifies the formation of oblique echoes which are the reflecting patterns of the tilt manifested at the F-layer bottomside. In turn, these satellite traces (STs) are apparently associated with spread F traces. Another form of characteristic signature/irregularity on ionogram traces is the fork trace. This presentation will discuss recent results from typical (5-min) but also high-time resolution ionogram datasets suggesting that the identification of such ionogram signatures can be used as an indicator of MSTID activity over ionosonde stations.

0181. Ionospheric signatures excited by recent earthquakes

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Keywords: Earthquake, co-seismic ionospheric disturbances, Tsunami

In this presentation we will demonstrate multi-instrument evidence of co-seismic ionospheric disturbances (CSIDs) excited by earthquakes and tsunami from recent events including Kuril–Kamchatka and Myanmar 2025. We will highlight the anisotropic propagation of earthquake-driven ionospheric

disturbances and underline the benefit of adopting a multi-instrument approach in resolving both horizontal and vertical aspects of CSIDs. We will also discuss the limitations and the strengths of various ionospheric monitoring techniques, that are typically used to monitor the ionosphere, focusing primarily on co-seismic waves as they manifest on various ionospheric characteristics provided by these techniques.

0182. Who Owns What You See from Space? Remote Sensing and Data Rights

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Keywords: Data Rights, IPR, Licensing, Data Restrictions, EU law

Satellite remote sensing has become essential across scientific disciplines, yet the legal frameworks governing satellite data remain poorly understood by many researchers. This presentation aims to help scientists understand who owns satellite data, what they can legally do with it, and how to navigate data rights in the European Union.

Scientists routinely download imagery, process it through algorithms, and produce insights that advance knowledge. However, beneath this workflow lies a complex web of legal rights and restrictions that may create challenges, e.g. collaborators unable to share data internationally, researchers discovering they cannot meet journal requirements for open data, startups finding their business models violate licensing terms, and scientists inadvertently breaching contracts by publishing imagery.

The presentation will map the satellite data landscape, distinguishing between public programs like the EU's Copernicus (offering free, open data, with unrestricted use and redistribution), commercial providers (imposing significant constraints on sharing and publication), and derivative products created by scientists. The main EU legal instruments governing remote sensing will be briefly outlined, alongside their major practical consequences. These instruments regulate issues, such as the Copernicus data policy (Regulation 2021/696), copyright protection (Directive 2001/29/EC and Directive (EU) 2019/770), protection of databases (Directive 96/9/EC), export control and dual-use items (Regulation 2021/821). The presentation will also touch upon challenges regarding AI/ML applications and will conclude with a list of practical recommendations for researchers.

0183. Efficient Tile-Computing YOLOv8 Model for Near-Real-Time Ship Detection in a High-Dimensional SAR Imagery

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Keywords: SAR, Ship Detection, Smart Computing, YOLO, GEE

Synthetic Aperture Radar (SAR), with the advancement of Machine Learning (ML) techniques in remote sensing, has become a topic of interest for automatic SAR Ship Detection (SSD). In this paper, a fine-tuned YOLOv8 model is used via transfer learning with an update in pretrained weights for autonomous ship detection in SAR imagery. The model is primarily trained and tested with epochs (80, 90, and 100) and batch sizes (8, 16, and 32) to generalize and validate. The standard evaluation shows that the model achieves great mAP (89%), precision (93.5%), recall (98%), and F1-score (91%) using the iVision-MRSSD dataset. Practically, the SAR scene is High-Dimensional (HD) compared to the images in the dataset used for model training and testing. To tackle this, we proposed a technique

to achieve Near-Real-Time (NRT) SSD. This is accomplished by acquiring a Sentinel-1 SAR image (for this instance, with the size of 35546 $\times$ 21389 Pixels) nearby Cyprus. Then by using fine-tuned YOLOv8 to detect ships in the live SAR image by Tile-Computing with a moving window (e.g., a tile of 512 $\times$ 512 Pixels) over the HD SAR scene. This method offers great accuracy and helps preserve local information. The SAR scene results are compared with the Benchmark and also with the Adaptive Threshold algorithm in Google Earth Engine (GEE). Compared to a benchmark, this pixel-level method obtained 100% accuracy for VV polarization SAR images and 95% for VH polarization in terms of ships detected.

0185. Cloud Vertical Structure and Regimes from EarthCARE CPR over the Eastern Mediterranean

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Keywords: EarthCARE, Cloud Profiling Radar, Cloud Vertical Structure, Cloud Regime Classification, Eastern Mediterranean

Cloud vertical structure remains one of the dominant sources of uncertainty in radiative flux estimation and cloud–climate feedback assessment, particularly in regions characterized by strong dynamical variability. The launch of the EarthCARE (Earth Cloud, Aerosol and Radiation Explorer) mission provides vertically resolved observations of clouds and precipitation through its 94 GHz Cloud Profiling Radar (CPR), enabling detailed investigation of cloud macrophysical properties and regime-dependent variability.

This study analyzes Level-2 radar products over the Eastern Mediterranean, using Cyprus as the geographic center of analysis. A total of 159 EarthCARE overpasses are included, corresponding to the common baseline (BA) product release and spanning July 2024 to November 2025. This transition zone experiences strong seasonal and convective variability, ideal for regime analysis.

CPR Feature Mask (CPR-FMR) is used to derive cloud geometrical properties, including cloud top height (CTH), cloud base height, total geometrical thickness, and number of layers. Cloud regimes are defined by utilizing cloud geometrical characteristics and the CPR Target Classification (CPR-TC) product, which provides physically consistent identification of convective and non-convective structures based on radar reflectivity and vertical continuity.

The CTH distribution exhibits a pronounced bimodal structure, with a lower-tropospheric maximum near 2–3 km and a dominant upper-tropospheric peak between 8 and 11 km. Cloud geometrical thickness is strongly right-skewed: most clouds are thinner than 3 km, while only a small fraction exceeds 6 km. The mean vertical cloud fraction profile mirrors the bimodal CTH distribution, with maxima in the upper and lower troposphere.

A regime-dependent analysis is performed classifying clouds into single-layer low (CTH $<$ 2km), mid (2 $<$ CTH $<$ 6km), high (CTH $\geq$ 6 km), deep convective (from CPR-TC), and multi-layer non deep. Single-layer clouds account for 89% of all cloudy profiles, with high level clouds representing 65%, mid level 19%, and low level 5%. Deep convective systems comprise 3%, and multi-layer non-deep clouds 8%.

Overall, the results demonstrate the capability of EarthCARE CPR to resolve regime-dependent cloud vertical structure over the Eastern Mediterranean. These observational constraints are essential for evaluating cloud-resolving and climate models and for improving representation of cloud morphology and vertical distribution in radiative transfer and climate simulations.

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0186. Monitoring the Phenological Cycle of Olive (cv. 'Koroneiki') Using High-Resolution Satellite Time Series: A Region-Specific Transferable Approach

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Keywords: Olea europaea L., Phenology detection, Algorithm transferability, Remote sensing, Precision agriculture

Olive (Olea europaea L.) cultivation constitutes one of the most important pillars of the agricultural economy in Mediterranean countries. Accurate knowledge of olive grove phenology is essential for the transition to precision agriculture, as it enables the optimal scheduling of critical agricultural interventions such as irrigation, fertilization, and pruning. This study presents an approach for monitoring olive orchards (cv. 'Koroneiki') using high-resolution satellite time series. The approach focuses on utilizing spectral signatures as a baseline to identify key phenological stages, enabling the early detection of biotic or abiotic stress at the field level and guiding targeted in-situ inspections by agronomists. Preliminary results suggest that vegetation indices such as the Normalized Difference Vegetation Index (NDVI), Green Chlorophyll Index (CIgreen), Normalized Difference Red Edge (NDRE), and Enhanced Vegetation Index (EVI) show potential for detecting key phenological stages. Particular emphasis is placed on the transferability of the approach, ensuring that it can be applied effectively across different olive groves and provide a scalable tool for decision-making. The proposed methodology lays the groundwork for future research aimed at establishing a phenological signature for the 'Koroneiki' variety, which could serve as a reference baseline for monitoring crop development and identifying deviations associated with biotic or abiotic stress.

0187. Automating Urban Planning Workflows with LLMs: The Case of Nork-Marash, Yerevan

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Keywords: LLM; Workflow Automation; Construction Permitting; Urban GIS

Construction permit assessment in densely built urban districts represents one of the most epistemically demanding procedural tasks within municipal spatial governance. The process requires systematic multi-criteria reasoning across heterogeneous regulatory layers, including cadastral boundary conditions, utility infrastructure load thresholds, road network setback requirements, courtyard area normatives, and floor-area-ratio ceilings, while simultaneously producing formally auditable justification documentation under institutionally defined temporal constraints. The cumulative cognitive load imposed by this procedural architecture constitutes a structural bottleneck in urban administrative capacity that scales adversely with increasing application volumes and regulatory complexity.

This paper presents a prototype decision-support module designed to automate urban planning spatial analyses for the Nork-Marash district of Yerevan, operating natively in Armenian and aligned with the regulatory framework of the Republic of Armenia's construction norms. The system accepts natural language permit queries in Armenian, decomposes them into formally ordered sequences of spatial operations, executes these against authoritative Yerevan urban geodatasets, and returns results with

explicit chain-of-thought reasoning traces constituting verifiable analytical provenance. An Armenian urban planning terminology layer is integrated natively into the reasoning pipeline, enabling semantically accurate processing of domain-specific regulatory language without translation preprocessing.

A hierarchical constraint enforcement mechanism, implemented through structured chain-of-thought prompting, operationalizes the normative priority ordering embedded in RA construction regulation. Absolute regulatory prohibitions are resolved prior to suitability scoring, preventing categorical violations from being obscured by aggregate compliance metrics. This architecture enables effective integrated analysis across multiple spatial data layers simultaneously, combining cadastral, infrastructural, and normative datasets within a single coherent analytical workflow.

The proposed architecture relies exclusively on open-source components and is designed for direct governmental deployment in resource-constrained institutional contexts. The system is positioned not as a substitution for professional planning expertise, but as an instrument for redistributing expert cognitive capacity toward higher-order interpretive tasks for which domain expertise remains genuinely irreplaceable.

0188. Monitoring Cropland Recovery After Flooding Using Multi-Sensor Satellite Time Series: Case Study for the Lake Karla Basin, Greece

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Keywords: Remote Sensing; Cropland Recovery; Flood Impact; Agricultural Monitoring; Food Security

Extreme flooding events can significantly disrupt agricultural production and threaten food security by delaying or preventing the cultivation of cropland. In September 2023, Storm Daniel caused severe flooding across the Thessaly region in Greece, leading to prolonged inundation of large agricultural areas in the Lake Karla basin. Many fields remained waterlogged for more than a year following the event, creating uncertainty regarding the resumption of farming activities and the potential abandonment of cropland, in a region of which its contribution to the national agricultural production is deemed important.

This study presents a preliminary remote sensing analysis aimed at monitoring post-flood cropland recovery using multi-sensor satellite imagery. Time-series observations from Sentinel-2 and Landsat 8 optical data are used to examine the vegetation dynamics through spectral vegetation indices, capturing seasonal variability and crop growth patterns before and after the flood event. These observations are complemented by Sentinel-1 Synthetic Aperture Radar (SAR) data, which provide additional information on surface moisture conditions and flood persistence independent of cloud coverage. High-resolution PlanetScope imagery (3m spatial resolution) is further used for cross-validation, allowing detailed comparison with Sentinel and Landsat observations and supporting the interpretation of cropland recovery patterns.

By analyzing vegetation trajectories and multi-sensor signals across the periods before and after the flooding event, the study investigates how differences in crop phenology and surface conditions can reveal whether agricultural parcels have returned to active cultivation or remain unused. The analysis also explores the spatial extent of flood-affected cropland and examines patterns of recovery in selected agricultural fields across the Lake Karla basin. Attention is given to identifying parcels that show delayed vegetation recovery, or persistently low vegetation activity, which may signal prolonged disruption of agricultural practices.

The results provide an initial framework for monitoring post-disaster agricultural activities using Earth Observation time series and establish the foundation for future data-driven methods aimed at automated

parcel-level detection of cultivation dynamics following extreme events. Such information can support the assessment of flood impact on agricultural land use and contribute to understanding how extreme climatic events may influence regional food production and long-term food security.

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0189. Uncertainty and information content of satellite-observed tropospheric NO_2 in earth system digital twins: a monte carlo and information-theoretic framework

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Keywords: Earth Observation, Sentinel-5P TROPOMI, Monte Carlo Simulation, Uncertainty Quantification, Sobol Sensitivity Analysis, Earth System Digital Twins, Air Quality, Complex Terrain, Bulgaria

Earth System Digital Twins (ESDTs) are emerging as operational platforms for environmental monitoring and decision support, yet their effective use of satellite observations requires robust quantification of both uncertainty and information content. While uncertainty propagation is increasingly addressed through ensemble modelling, the informational value of satellite observations within digital twin frameworks remains insufficiently characterized.

This study introduces an integrated Monte Carlo and information-theoretic framework for analysing uncertainty propagation and information content in satellite-observed atmospheric pollution fields. The approach combines Monte Carlo simulation, Latin Hypercube Sampling, and Sobol global sensitivity analysis with entropy-based metrics to evaluate how uncertainties in key inputs propagate into tropospheric nitrogen dioxide (NO_2) vertical column densities retrieved from Sentinel-5P TROPOMI observations.

Uncertain inputs include emission inventories, planetary boundary layer height derived from ERA5 reanalysis, satellite retrieval bias associated with air mass factor estimation, and chemical transformation parameters. Ensemble experiments (n $\approx$ 500–2000) generate probabilistic NO_2 distributions over complex terrain representative of the Sofia metropolitan region. Variance-based sensitivity indices are complemented by information-theoretic diagnostics, including Shannon entropy and mutual information, enabling quantitative assessment of the relative information contribution of meteorology, emissions, and retrieval uncertainties.

Results indicate that meteorological variability associated with boundary-layer dynamics can dominate uncertainty propagation during winter inversion conditions, while information-theoretic metrics reveal spatially heterogeneous observational information content across the domain. The proposed framework provides a computationally efficient methodology for diagnosing both uncertainty and information value of satellite observations within Earth observation–driven digital twin systems. By linking ensemble uncertainty analysis with information diagnostics, the approach contributes a practical methodological basis for uncertainty-aware environmental monitoring using Copernicus satellite data.

0190. Decision support systems for water scarcity management in Semi-arid regions: A review of AQUATOOL Applications and Implications for Cyprus

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Keywords: Decision Support Systems, AQUATOOL, WEAP, Water Management, Water Scarcity, Mediterranean water management, Cyprus Water policy, Water simulation

Water scarcity is one of the most critical issues affecting semi-arid regions worldwide, emerging because of the combined effect of increasing water demand, overexploitation of water resources, and a plethora of climate and anthropogenic factors. To address these challenges, effective water resources management should be designed based on solid scientific evidence and long-term motoring of hydrometeorological factors. This information is integrated into decision support systems (DSS) capable of integrating complex hydrological operational and policy frameworks.

This study presents an integrative literature review of common practices and established decision support systems applied to water scarcity management globally between 2000 and 2025, with a particular focus on AQUATOOL DSS. A comparative thematic analysis is conducted between the AQUATOOL DSS and alternative DSS tools, such as WEAP, to evaluate their capabilities in supporting integrated water resource management.

The results of this review revealed the need to integrate traditional water supply solutions-such as dams, desalination and water transfers, within advanced decision-making tools to optimize the water allocation among end-users. While WEAP DSS is proven to be effective for demand-side scenario analysis, the AQUATOOL DSS provides a more comprehensive environment for integrated surface water and groundwater system management. In particular, its modular structure enables the combined simulation and optimization of reservoirs, aquifers and non-conventional resources.

Successful applications of this tool are reported in several Mediterranean countries (Spain, Portugal, Italy, Turkey and Morocco), demonstrating its efficacy in dams' management and policy evaluation. Despite these advances, important limitation remains in the literature, including: a) High data requirements and the need for specialised technical expertise, which limit the practical implementation of DSS in many water management institutions. b) Limited applications of integrated DSS frameworks in small island water systems, particularly in simi-arid regions. c) Insufficient integration of climate change projections into operational water management models reducing their capacity to support long-term adaptive planning. d) In Cyprus specifically, the limited use of integrated predictive decision support systems despite substantial investments in physical water infrastructure such as dams and desalination plants.

This review highlights the vital role of integrated DSS framework such as AQUATOOL in supporting more proactive and resilient water management strategies for Cyprus and other semi-arid regions.

0191. From Multispectral to Hyperspectral: A Benchmarking Study of Crop Mapping Consistency between Sentinel-2 and PRISMA

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Keywords: PRISMA, Sentinel-2, Crop mapping, Accuracy assessment, Remote sensing

Accurate crop-type mapping is essential for agricultural monitoring, food security, and sustainable land management. While multispectral satellite data, such as Sentinel-2, provide high spatial and temporal resolution, their limited spectral sampling often results in significant inter-class confusion among crops with similar phenological profiles. This study evaluates the added value of hyperspectral data from the PRISMA mission compared to Sentinel-2 multispectral imagery for single-date crop

type classification in the complex agricultural landscape of South-Central Bulgaria. To ensure data consistency, both datasets were spatially harmonized and clipped to their mutual overlapping extent. The PRISMA imagery was subjected to a comprehensive pre-processing workflow, which included the exclusion of redundant and noisy bands, followed by Principal Component Analysis (PCA) to extract the most significant spectral components. To eliminate boundary noise, the datasets were masked to agricultural parcels using buffered IACS (Integrated Administration and Control System) vectors. The classification models were trained and validated using ground-truth polygons across five representative crop classes: Alfalfa, Pastures, Sunflower, Wheat, and Maize. Accuracy assessment was performed using confusion matrices and Kappa coefficients. The results demonstrate that PRISMA achieved superior classification performance with an Overall Accuracy (OA) of 88.15% and a Kappa coefficient of 0.8121, compared to Sentinel-2's OA of 85.06% and Kappa of 0.7655. While both sensors accurately identified dominant crops like Wheat (User's Accuracy ¿ 95%), a significant "hyperspectral advantage" was observed in discriminating complex summer crops. Specifically, PRISMA improved the Producer's Accuracy for Maize by over 21%, effectively mitigating the spectral "bleeding" and confusion with Sunflower that heavily impacted the Sentinel-2 results (where 55.39% of Maize was misclassified). Conversely, Sentinel-2 showed slightly better performance in Alfalfa and Pasture categories, likely due to its dedicated red-edge bands. These findings underscore the critical role of contiguous hyperspectral bands in resolving spectral overlaps in agricultural monitoring, suggesting that hyperspectral missions can significantly enhance the precision of secondary crop identification where multispectral sensors reach their thematic limitations.

0192. A GIS-Based Geoheritage Inventory for Greece: Development and Applications

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Keywords: Geoheritage, Geographic Information Systems (GIS), Geosite Inventory, Geotourism, Alternative tourism

Greece is characterized by remarkable geological diversity resulting from its complex geodynamic evolution. This diversity is reflected in numerous geological features of scientific, educational, cultural, touristic, and aesthetic value, which together constitute the country's geoheritage. Systematic documentation and promotion of these sites are essential for effective management and for supporting research, education and alternative tourism. This study presents the development and potential applications of a national GIS-based geoheritage inventory aimed at systematically recording geosites across Greece. The inventory enables the organization, management, and spatial visualization of geoheritage elements at a national scale. Identification and documentation of sites involve bibliographic research, collection of geological and geographical data, precise spatial localization, and verification of both well-known and lesser-known locations. Each geoheritage element is verified to ensure data accuracy and reliability. A classification system was established to represent the wide variety of geological features, including caves, fossil sites, tectonic structures, geomorphological formations, and volcanic features. Both the database and classification system are dynamic tools, continuously updated and enriched as new data become available or further research is conducted. The geosites have not been evaluated based on any criteria; the primary objective is to create a comprehensive digital inventory encompassing as many known and lesser-known sites as possible. This inventory can serve as a reference for researchers, educators, planners, and the public, facilitating knowledge dissemination and supporting scientific, educational and alternative tourism-related activities.

Furthermore, GIS enables the development of thematic georoutes connecting sites with similar geological characteristics. For example, a "Caves of Greece" route could link significant cave systems, while geoheritage sites can be integrated into existing tourist routes to enhance visitors' understanding of the

geological landscape. Overall, the national GIS-based geoheritage inventory represents a significant step toward documenting, promoting, and sustainably utilizing Greece's rich geological heritage.

0193. A Method for Reconstruction of Leaf Area Index Time Series Using Sentinel-2 Data and the Canopy Structural Dynamic Model

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Keywords: Leaf Area Index (LAI), Sentinel-2, CSDM, Times series reconstruction, Winter wheat

Continuous time series of crop biophysical variables are essential for monitoring crop development and supporting agricultural modelling. However, satellite observations are often incomplete due to cloud cover and revisit limitations. This study presents an approach for reconstructing daily Leaf Area Index (LAI) dynamics using the Canopy Structural Dynamic Model (CSDM). The method integrates LAI estimates derived from Sentinel-2 imagery with accumulated effective temperature as a predictor of crop development. The approach was tested for winter wheat in a test area near Kneja, Bulgaria, during the 2017–2018 growing season. Satellite-based LAI values derived from vegetation indices were used to calibrate the model, while meteorological data from the JRC MARS database were used to compute effective temperature sums. The proposed workflow enables the reconstruction of temporally continuous LAI information from sparse satellite observations.

0194. Comparative Analysis of EnMAP and Sentinel-2 Data for Crop Type Mapping

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Keywords: EnMAP, Sentinel-2, Crop Classification, IACS, Bulgaria

Accurate crop type mapping is essential for agricultural monitoring and the administration of subsidies under the Integrated Administration and Control System (IACS). This study evaluates the potential of the hyperspectral EnMAP mission, compared to the multispectral Sentinel-2 satellite, for classifying primary crop types in Northeastern Bulgaria (Shumen and Varna municipalities). An EnMAP L2A scene and a Sentinel-2 L2A image, acquired on June 7 and 10, 2024, were processed using a Support Vector Machine (SVM) classifier. The EnMAP data underwent rigorous pre-processing, including the removal of overlapping and noisy bands, followed by dimensionality reduction via Principal Component Analysis (PCA) to isolate highly informative spectral features. Both datasets were spatially masked to agricultural parcels using buffered IACS boundaries. Training and validation were conducted using ground truth polygons for five classes: sunflower, maize, wheat, alfalfa, and pastures. Both sensors achieved high overall accuracies (EnMAP: 87.35%, kappa: 0.813; Sentinel-2: 87.89%, kappa: 0.822). Wheat was identified with near-perfect precision (>98%) by both platforms. Their differences emerged within the complex classes, where Sentinel-2 exhibited a massive commission error (79.51%) for pastures, frequently misclassifying row crops as grassland. In contrast, EnMAP's hyperspectral data significantly improved thematic purity, yielding a user's accuracy of 50.67% for pastures, 30% increase over Sentinel-2. Both sensors faced "green-on-green" confusion between sunflower and maize, though EnMAP provided higher reliability (user's accuracy: 98.73%) for sunflower identification. The results demonstrate that while Sentinel-2 benefits from higher spatial resolution, EnMAP's hyperspectral capabilities, combined with FPCA dimensionality reduction, offer superior spectral discrimination for transitionary land covers like alfalfa and pastures. This study highlights the value of hyperspectral missions for enhancing the reliability of national agricultural monitoring systems.

0195. Comparing Pearson and Spearman Correlations to Detect Decadal Drought Impacts on semi-arid forests

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Keywords: Tree mortality, forest decline, climate change, remote sensing, drought

Mediterranean evergreen woodlands increasingly show canopy deterioration under prolonged drought, yet satellite–climate linkages depend strongly on the temporal scale used to summarize hydroclimate. We evaluated drought–canopy coupling in Cyprus woodlands dominated by Juniperus phoenicea, Pinus brutia, and the endemic Quercus alnifolia over 1990–2020. Using Landsat 5/7/8/9, we derived eight canopy-condition indicators spanning greenness, moisture status, and disturbance-related change (NDVI, EVI, SAVI, NDMI, NDWI, NBR, LAI, GPP). Hydroclimatic stress was characterized with SPI, SPEI, and PDSI. To emphasize persistent forcing and reduce the influence of short-lived extremes, all satellite and drought time series were expressed as 10-year running means. Across sites, sustained precipitation deficits and prolonged drought severity aligned with persistent declines in canopy condition, indicating tighter sensitivity to multi-year hydroclimatic persistence than to interannual variability. Relationships were quantified with both Pearson's r and Spearman's ρ; differences between them highlighted cases where responses were monotonic but not strictly linear, supporting the value of reporting both metrics when interpreting satellite–drought coupling. Overall, a decadal running-mean perspective clarifies species- and habitat-specific drought sensitivity near xeric range limits.

0196. Short-Term Effects of Air Pollution and Temperature on Arterial Stiffness: Findings from the DEpICT Study

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Keywords: Arterial stiffness; pulse wave velocity; air pollution; ambient temperature; cardiovascular risk

Exposure to ambient air pollution has been consistently associated with increased cardiovascular morbidity and mortality in epidemiological studies. Proposed mechanisms include promotion of atherosclerosis, systemic inflammation, and vascular dysfunction, which may contribute to the development of cardiovascular disease. Arterial stiffness, commonly assessed by carotid–femoral pulse wave velocity (cfPWV), is an established marker of vascular dysfunction and an independent predictor of cardiovascular events. Although both long- and short-term exposure to air pollutants have been linked to vascular alterations, findings regarding their association with arterial stiffness remain inconsistent. In addition to air pollution, ambient temperature may influence vascular tone and arterial function through thermoregulatory and hemodynamic mechanisms.

This study aimed to investigate the short-term effect of air pollution and ambient temperature with arterial stiffness measured by carotid–femoral pulse wave velocity (cfPWV) in an adult population sample.

Data were derived from 303 volunteers in the DEpICT study conducted in Limassol, Cyprus between 2018 and 2023. Participants underwent anthropometric and cfPWV measurements (Complior Analyse,Alam Medical). Daily concentrations of major air pollutants (PM_{10}, NO_2, O_3, CO and SO_2) and meteorological data were obtained from official environmental monitoring sources. Exposure levels were classified according to established air quality categories. Linear regression models were used to examine associations between pollution exposure levels and cfPWV. Multivariable models were adjusted for age, sex, body mass index (BMI), smoking status, and mean daily temperature (lag0: day

of measurement; MA3: 3-day moving average). Additional models further adjusted for systolic blood pressure (sBP).

Among all pollutants examined, due to limited variability and collinearity among pollutants, only PM_{10} was included in the final analysis. In multivariable linear regression models, age was positively associated with cfPWV ($\beta = 0.047$, 95% CI: 0.025–0.069, $p < 0.001$), while female sex was associated with lower cfPWV values ($\beta = -1.02$, 95% CI: -1.40 to -0.64, $p < 0.001$). Higher ambient temperature was significantly associated with lower cfPWV. Each 1^oC increase in mean temperature was associated with a decrease in cfPWV at both lag0 (β = -0.057, 95% CI: -0.090 to -0.024, p=0.001) and the 3-day moving average (β = -0.056, 95% CI: -0.088 to -0.023, $p = 0.001$). After further adjustment for systolic blood pressure, the association between temperature and cfPWV remained significant, although attenuated, indicating that the effect on cfPWV was over and above the effect of sBP (lag0: β = -0.038, 95% CI: -0.070 to -0.005, p=0.024; MA3: β = -0.036, 95% CI: -0.068 to -0.004, p=0.028). BMI and smoking status were not significantly associated with PWV. Short-term exposure to PM_{10} was not associated with arterial stiffness in either lag0 or the 3-day moving average.

Short-term ambient temperature was associated with arterial stiffness, with higher temperatures linked to lower cfPWV values, suggesting a possible acute vasodilatory effect. In contrast, short-term PM_{10} exposure was not associated with cfPWV in this population. These findings highlight the importance of considering environmental and meteorological factors when evaluating determinants of cardiovascular health, both long-term and acutely.

0197. Associations Between Neighborhood Disadvantage and Arterial Stiffness: Neighborhood Visualization Using GIS in the DEpICT Study, Cyprus

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Keywords: Arterial stiffness; carotid–femoral pulse wave velocity(cfPWV); neighborhood socioeconomic disadvantage; built environment; geographic information systems (GIS);

Arterial stiffness, commonly assessed by carotid–femoral pulse wave velocity (cfPWV), is a well-established marker of vascular aging and a strong predictor of cardiovascular morbidity and mortality in the general population. Increasing evidence indicates that cardiovascular risk is influenced not only by individual clinical and behavioral factors but also by broader social and environmental determinants. In particular, characteristics of the residential neighborhood, including socioeconomic conditions and features of the built environment, have been linked to disparities in cardiovascular health. Area-level deprivation and unfavorable built environments may influence cardiovascular risk through multiple pathways, such as limited access to health-promoting resources, reduced opportunities for physical activity, and chronic psychosocial stress. Using previously developed census-based indices of socioeconomic disadvantage (SED) and demographic and built environment (DBE) characteristics, together with Geographic Information Systems (GIS) for spatial mapping, this study examines their associations with arterial stiffness within the DEpICT Study in Cyprus.

The DEpICT Study is a cross-sectional study including adults aged over 40 years who had been residing in the same neighborhood for at least five consecutive years in Limassol, Cyprus. Arterial stiffness was assessed by measuring cfPWV using the Complior Analyse (Alam Medical, France). Two neighborhood-level indices were used: the socioeconomic disadvantage (SED) index and the demographic and built environment (DBE) index. Both indices were derived from national census data aggregated at the residential postal code level. GIS tools were applied to visualize spatial patterns of neighborhood characteristics across the study area. Multivariable linear regression models were used

to examine associations between these census-based indices and cfPWV after adjusting for age, sex, blood pressure, and anti-diabetes medication.

A total of 303 participants were included in the analysis (55.1% men; mean age 55.58 years (SD = 8.35)). In unadjusted models, neither the built environment disability score (dbscore) nor the socioeconomic disadvantage score (sescore) were statistically significant predictors of cfPWV (p = 0.088 and p = 0.140, respectively). After adjustment for age, sex, blood pressure, and anti-diabetes medication, both indices showed associations with arterial stiffness. The DBE score demonstrated a marginal association with cfPWV (β = -0.21; 95% CI: (-0.43, 0.02); p = 0.071), while the SED score was significantly associated with cfPWV (β = -0.23; 95% CI: (-0.45, -0.005); p = 0.045). The magnitude of the associations was similar for both indices.

These findings suggest that census-based area-level socioeconomic disadvantage and built environment characteristics are associated with arterial stiffness after accounting for key individual cardiovascular risk factors. The results highlight the importance of the residential environment in shaping vascular health and support the integration of spatial and neighborhood-level data in cardiovascular research and public health planning.

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0198. GIS in Strategic Health Service Planning: A Systematic Review of Access-Oriented Applications in Primary Care

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Keywords: Primary health care; Geographic Information Systems; Spatial accessibility; Health service planning; Health equity;

Equitable access to primary health care (PHC) is a cornerstone of effective health systems and a key objective of universal health coverage. Despite global efforts to strengthen PHC delivery, geographic and spatial inequalities continue to limit access to essential health services, particularly in rural, remote, and socioeconomically disadvantaged communities. Geographic Information Systems (GIS) have increasingly been used as powerful analytical tools to measure, visualise, and model spatial accessibility to health services. By integrating geographic, demographic, and health system data, GIS-based analyses can identify underserved areas and support evidence-based planning. However, existing studies vary substantially in methodological approaches and geographic contexts, making it difficult to draw general conclusions about the most effective methods and their implications for health service planning.

This systematic review aims to synthesise international evidence on the application of GIS methods for measuring and analysing spatial accessibility to primary health care services. Specifically, it seeks to identify commonly used methodological approaches, summarise key findings on geographic inequalities in access, and highlight the potential role of GIS in informing equitable health service planning and resource allocation.

A systematic literature search was conducted in PubMed, Embase, and Scopus for studies published between 2015 and 2025. Studies were eligible if they applied GIS-based methods to analyse, model, or

optimise geographic access to health services. Inclusion criteria were limited to peer-reviewed English-language articles focusing on human health services. Two independent reviewers screened titles, abstracts, and full texts according to predefined criteria. Extracted data included study setting, year, population, GIS analytical methods, and outcomes related to spatial accessibility or health service planning.

Twenty-three studies met the inclusion criteria, representing diverse settings across Africa, Asia, Europe, North America, and Oceania. The most frequently applied analytical approach was the floating catchment area (FCA) method (n = 12), including enhanced two-step FCA models. Network-based travel-time analyses were used in six studies, while three studies applied location–allocation optimisation models to identify optimal facility placement. Two studies used patient-centred or realised-access approaches linking spatial accessibility with health service utilisation. Across most settings, consistent geographic disparities in PHC access were observed, with urban populations demonstrating higher accessibility than rural or peripheral communities. Reported coverage gaps ranged from approximately 12% of residents lacking adequate PHC access in urban Algeria to more than 65% of rural populations in Ethiopia living beyond a one-hour travel threshold. Studies incorporating optimisation modelling suggested that strategic relocation or addition of PHC facilities could increase service coverage by 10–60%. Patient-centred analyses further indicated that perceived service quality and affordability may influence utilisation beyond geographic proximity alone.

GIS-based approaches provide robust tools for identifying spatial inequalities in primary health care accessibility and informing evidence-based health system planning. Integrating travel-time modelling, facility capacity, and population needs within GIS frameworks can support more equitable distribution of primary care services and strengthen policy decision-making.

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0199. Fusion of Oil Spill Detection Results from Thresholding and Deep Learning Using Landsat Data over the North Sea

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Keywords: Optical Remote Sensing, Oil Spill Detection, Thresholding, CNN, U-Net

The contamination of marine and coastal environment by oil pollution has a considerable impact on the surrounding ecosystems. It is therefore imperative that oil spills are identified at the earliest possible stage in order that the relevant monitoring frameworks can be put in place and appropriate response measures initiated. The timely and accurate detection of oil is of great benefit in the prevention of pollution and the facilitation of clean-up operations, which serve to minimise the negative impact on the environment and identify the source of the pollution. In particular, the use of Synthetic Aperture Radar (SAR) has been established as an effective method for monitoring large marine areas for many years.

This paper presents the fusion results of two complementary approaches for automatic oil spill detection in optical satellite imagery using Landsat data. The first approach is a traditional thresholding analysis, while the second employs a convolutional neural network (CNN) in the type of a U-Net architecture. The study evaluates the fusion on two datasets: a larger set of 48 Landsat-8 images to analyse general detection performance, and a subset of 15 images for which manually labelled binary oil masks are available enabling quantitative validation. The aim of this study is to improve detection accuracy and

reduce false positive detections under the assumption that the two methods produce different types of errors.

The results demonstrate that the combination of both methods thresholding and deep learning partially optimizes detection accuracy by reducing false positive detections, although some false positives remains and certain oil spills are reduced in size or they are lost.

0200. Optimizing Sentinel-2 Spectral Bands for Marine Debris Detection with Random Forests

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Keywords: Marine Debris, Sentinel-2, Feature Selection, Random Forest, Spectral Indices

Marine debris poses a persistent threat to coastal and open-ocean ecosystems, yet operational monitoring remains challenging due to the subtle and variable spectral signatures of floating materials. In this work, we use the MADOS Sentinel-2 dataset to systematically investigate how Random Forest (RF) performance for marine debris detection depends on the number and choice of spectral bands. Starting from the full 11-band Sentinel-2 configuration, we perform a feature sweep in which RF models are trained and evaluated with the top N bands (N=1...10), as ranked by RF feature importance, plus the full 11-band baseline. Experiments are conducted in a one-vs-rest setting (marine debris vs all other annotated classes) with stratified cross-validation at the scene–crop level to avoid spatial leakage. Our results show that RF performance, measured by Matthews Correlation Coefficient (MCC) and balanced accuracy, improves rapidly as the first 5–6 bands are added and then plateaus around 8–9 bands. The best configuration reaches an MCC of approximately 0.76 with nine bands, while an eight-band model retains more than 98% of this performance relative to the 11-band baseline. Analysis of the learned feature importances reveals a consistent dominance of short-wave infrared bands, complemented by selected visible and near-infrared channels, in agreement with the known radiative properties of floating debris and seawater. These findings indicate that high debris-detection skill can be achieved with a reduced subset of Sentinel-2 bands, offering practical benefits for model deployment, sensor design, and future multi-sensor harmonization efforts.

0201. Mapping Heritage Vulnerability in Limassol, Cyprus: An Unsupervised Learning Approach to Quantifying Spatial and Environmental Conflict Between Commercial Gentrification and Cultural Preservation Using Sentinel-5P

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Keywords: Cultural Heritage Management, Sentinel-5P, K-Means Clustering, Urban Gentrification, Limassol

The rapid growth of large-scale urbanization, as well as commercial development, in many historic Mediterranean cities has created an extreme risk of the loss of the integrity of these sites (Guzman et al., 2017). The traditional model of urban planning relies heavily on static “conservation zones” that do not account for the dynamic or time-sensitive nature of the spatial pressure from the real estate market (van Oers & Pereira Roders, 2012). The deficiency of this model is especially pronounced in post-crisis economies where the accelerated pressure to develop leads to increased displacement of heritage. This study introduces a GeoAI-based method for quantifying and visualizing the spatial conflict between the commercial gentrification of areas and their use as heritage sites in Limassol,

Cyprus, which addresses the long-standing need for data driven monitoring methods to be used in the field of heritage management (Agapiou et al., 2015).

The methodology uses multiple types of data, from various sources to generate a multi-step process based on Geographic Information Science (GIS), and Machine Learning (ML) (Janowicz et al., 2020). The methodology also addresses the fact that many real estate databases are proprietary by building a georeferenced database with 600 commercial properties and processing them with a Python-based parsing tool, which was built with aim to extract structured data (JSON-LD) from archived repositories. (Boeing, 2020) has shown the efficacy of this method that can be used for Urban Data Mining.

Subsequently, a spatial proximity analysis was conducted to calculate the density of protected heritage monuments within a 400-meter isochrone of each commercial property, adhering to established urban walkability metrics (Talen, 2003). The 400-meter radius is a common metric used to determine the proximity of heritage areas to commercial properties (van Oers & Pereira Roders, 2012). Based upon these results, the data were then analyzed using an unsupervised machine learning technique (K-Means clustering) to identify similar patterns in the data and create distinct zones within the city (Jain, 2010). The analysis revealed three statistically significant clusters (p ¡ 0.01). These clusters include a Peripheral Expansion Zone, with a mean listing price of €476.922, and a low density of heritage monuments (¡ 0.5 monuments per 400m. radius); a Historic Core, with a mean listing price of €509.303, and a high density of heritage monuments (¿ 1.5 monuments per 400m. radius); and a Conflict Zone, with a mean listing price of €749.136, and a high density of heritage monuments (3.6 monuments per 400m. radius). It is the latter cluster that indicates the neighbourhoods, where increased development pressures pose immediate risks of heritage displacement, including parts of the Limassol Old Town and the transitional areas immediately adjacent to the commercial downtown area (El Faouri & Sibley, 2022). The abovementioned economic-spatial model was enriched with Earth Observation data - extracting Tropospheric NO_2 column density from the Copernicus Sentinel-5P satellite (Jan. 2025 – Dec. 2025 data) - and OpenStreetMap major traffic network centrality to serve as proxies for localized exhaust emissions and potential chemical weathering of the proximate CH sites.

These results indicate that GeoAI pipelines may provide an evidence base for quantitative and geographically specific measurements of heritage 'at risk' (i.e. drive of heavy vehicular traffic directly through historical buffer zones) that can be used by policymakers and heritage managers on a near real time basis. This provides a scalable, replicable methodology to proactively manage heritage through proactive heritage management even when data is limited (Couclelis, 2003). The framework fills significant gaps within cultural heritage informatics by integrating computational geography, cultural economics, and machine learning to facilitate evidence based urban conservation strategies.

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0202. Satellite data and GIS in monitoring air pollution and respiratory diseases

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Keywords: Satellite Data, GIS, Medical Geography, Respiratory Diseases, Air Quality

This study reviews and synthesizes scientific literature on the use of satellite observations and

geographic information systems (GIS) for remote monitoring of atmospheric pollution with fine particulate matter (PM) and its association with respiratory diseases. Advances in health and medical geography, driven by rapid technological development, have strengthened their role as interdisciplinary fields integrating spatial analysis with public health, epidemiology, and the social sciences. Understanding the spatial dimensions of health is essential for addressing contemporary public health challenges and supporting evidence-based decision-making. Satellite-derived spatial and temporal data, when analyzed within GIS platforms, provide valuable tools for assessing air quality, tracking the movement of dust and pollution plumes, and identifying environmental risk factors linked to respiratory morbidity. These data sources enable health authorities to detect deteriorations in air quality, anticipate increases in respiratory disease incidence, and develop early warning systems aimed at protecting vulnerable populations.

GIS technologies further support the creation of detailed maps of respiratory disease incidence across regions, facilitating spatial comparisons, risk assessment, and the identification of disease clusters. By integrating environmental, demographic, and epidemiological datasets, GIS allows for the development of health models that improve understanding of population-level exposure and vulnerability. Such models contribute to more effective management of respiratory disease burdens and mitigation of adverse health outcomes.

The combination of satellite data and GIS also enhances the capacity to monitor the spatio-temporal dynamics of respiratory diseases, offering insights into how environmental conditions influence disease patterns over time. Working within a GIS environment enables the visualization of results in graphical, tabular, and cartographic formats, including thematic maps that provide critical information for epidemiologists and public health practitioners. These maps support multidimensional analyses and can be used to evaluate the social impacts of respiratory diseases.

Overall, the integration of satellite observations with GIS-based spatial analysis represents an indispensable approach for conducting geographically informed health research. This combined methodology supports early warning systems, strengthens public health surveillance, and improves the ability of health authorities to manage respiratory morbidity. As technological capabilities continue to expand, satellite data and GIS will remain essential tools in medical geography for modeling disease processes and addressing complex health challenges.

0203. Early detection of foliar diseases in wheat using UAV-based NDVI remote sensing

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Keywords: Remote sensing, NDVI, disease detection, precision agriculture, advisory, ICT

Foliar diseases of wheat are among the most economically significant threats to crop yield and quality worldwide, causing substantial losses under favorable environmental conditions. Early detection of these diseases is crucial for effective management; however, conventional monitoring methods based on field scouting and visual assessment are labor-intensive, time-consuming, and often fail to detect infection at early stages. Recent advances in precision agriculture and remote sensing technologies offer new opportunities for rapid and non-destructive monitoring of crop health. Unmanned aerial vehicles (UAVs) equipped with multispectral or RGB sensors enable the acquisition of high-resolution imagery and frequent observation of crop conditions over large agricultural areas.

The Normalized Difference Vegetation Index (NDVI) is widely used to evaluate plant vigor, canopy density, and stress levels. Variations in NDVI values are associated with changes in chlorophyll content and photosynthetic activity, which can be affected by foliar disease infection. This study investigates the potential of UAV-derived NDVI for the early detection of foliar diseases in wheat. The research was

conducted in an experimental wheat field near Farsala in Thessaly, Greece. A widely cultivated winter wheat variety, Maestrale, was monitored using UAV-based imaging, and NDVI values were extracted from the acquired aerial imagery to evaluate the relationship between spectral reflectance and disease severity. The data workflow was designed for integration into ICT-based Decision Support Systems (DSS), ensuring NDVI outputs are compatible with Farm Management Information Systems (FMIS) for scalable advisory use. The results indicate that wheat areas affected by foliar diseases tend to exhibit lower NDVI values compared with healthy plants due to chlorosis, necrosis, and reduced photosynthetic efficiency caused by pathogen infection. The NDVI showed a moderate correlation as an indicator of disease-induced stress, demonstrating moderate predictive capability for assessing infection severity. Although NDVI alone cannot fully capture the complexity of disease development, it provides useful information for identifying potentially infected zones before severe visual symptoms become evident.

The findings highlight that UAV-based NDVI monitoring can serve as a practical, cost-effective, and scalable tool for early detection of foliar diseases in wheat. Such approaches can support precision agriculture practices by enabling more timely and targeted disease management strategies, contributing to improved crop protection and sustainable wheat production. This enables digital advisory services to translate raw spectral data into site-specific 'prescription maps,' bridging the gap between remote sensing and actionable on-farm decision-making.

0204. Modeling hydrological impacts of wildfires in the Kouris catchment

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Keywords: Wildfire; hydrology; post-fire runoff; catchment response; watershed modelling; hydrology simulation

Wildfires influence a watershed's functioning by altering vegetation cover, soil characteristics, and runoff conditions. These alterations affect the essential hydrological response of a watershed by impacting infiltration ability, soil moisture dynamics, evapotranspiration, surface runoff generation, and streamflow response. The Kouris catchment is a crucial watershed in Cyprus, given its hydrological importance and its contribution to regional water resource management. This study examines the hydrological effects of the July 2025 wildfire in the Kouris basin through hydrological modelling using QSWAT. The analysis focuses on post-fire changes in runoff generation, infiltration, and streamflow response at the watershed scale, while hydraulic simulations are considered a subsequent step for assessing flood hazard. The fire was one of the most severe wildfire events recorded in Cyprus in recent years, burning approximately 105 km2 and causing deaths, evacuations, and extensive damage to homes, infrastructure, and natural ecosystems in the Limassol area. The main objective is to examine how fire-induced changes in land cover and soil conditions can affect the hydrological modelling system. The methodology integrates geographical, meteorological, and hydrological data, including digital elevation models (DEMs), land use/land cover, soil data, and precipitation data, to represent the hydrological behaviour of the watershed. Supplementary data on the spatial extent of the burned region are integrated to define the post-fire scenario within the basin and to enable a comparison between pre-fire and post-fire hydrological simulations. The modelling process encompasses watershed delineation, stream network identification, and subdivision into sub-basins, the creation of Hydrologic Response Units (HRUs), based on land cover, soil and slope characteristics In the post-fire simulation, the burned area is integrated into the land cover input used for HRU definition, allowing the model to represent fire changes in watershed properties. The analysis focuses on changes in the burned area and their impacts on hydrological parameters, including surface runoff, infiltration, evapotranspiration, and streamflow. Special emphasis is placed on evaluating the impacts of vegetation

loss and fire-induced changes in soil conditions by comparing simulated hydrological outputs under pre-fire and post-fire watershed scenarios. This approach enables comparison of the catchment's hydrological response under pre-fire and post-fire land-cover conditions. The model compares the watershed's hydrological response before and after the fire. This research contributes to a better understanding of the post-fire hydrological behaviour of the Kouris catchment area and supports flood risk management and the protection of natural resources. Moreover, the study can facilitate future watershed monitoring initiatives, post-fire management strategies, and the identification of regions necessitating prioritized intervention. Furthermore, it underscores the use of hydrological modelling methods to assess the effects of extreme events on watershed systems and to support environmental management and risk-informed decision-making. This method can also be applied to other watersheds with areas highly prone to wildfires, where understanding post-fire hydrological response is important.

0205. A Socio-Economic Decision-Support Tool for Sustainable Agricultural Policy

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Keywords: Data-driven agriculture; food systems; socio-economic modelling; socio-economic data; policy; informed decision making; farm management

Sustainable agricultural policy increasingly depends on timely, integrated socio-economic evidence that extends beyond traditional global statistical systems. While such systems provide extensive datasets, they rarely offer operational tools capable of translating data into structured, standardized, decision- and policy-ready insights. This paper presents a socio-economic decision-support tool developed within the Horizon Europe project Nostradamus, designed to strengthen evidence-informed policymaking in agricultural sustainability governance.

The tool forms part of the broader Nostradamus Data Cube infrastructure, which integrates environmental, agricultural and socio-economic data within an analytical environment across five countries (Cyprus, Germany, Serbia, Slovenia, Switzerland). Within this ecosystem, the socio-economic module provides a structured analytical layer that translates large-scale indicator datasets into standardised, policy-related outputs.

The tool operationalises more than 16,000 World Bank socio-economic indicators spanning 1960 to the present. Through automated bulk processing implemented in R, indicators of agricultural and non-agricultural relevance are harmonised, grouped by country and systematically evaluated using reproducible statistical routines. For each indicator and territory, the tool generates: (1) the most recent available value, (2) historical minimum and maximum values, (3) long-term averages, and (4) short-, medium-, and long-term trend estimations based on linear regression analyses (one-, five- and ten-year horizons). These outputs enable rapid assessment of structural socio-economic developments relevant to rural resilience, agricultural productivity, governance capacity and market dynamics.

Going beyond data aggregation, this work establishes a operational, policy-aligned analytical framework within the Nostradamus data infrastructure. The tool supports alignment with major sustainability frameworks, including the Common Agricultural Policy (CAP), the EU Biodiversity Strategy 2030, the Farm-to-Fork Strategy, and international biodiversity and climate commitments. By enabling systematic comparison of socio-economic trajectories across countries and over time, it facilitates anticipatory governance rather than retrospective reporting. In doing so, the approach contributes to emerging research on digital sustainability governance, integrated policy analytics and early detection of structural socio-economic shifts.

Methodologically, the tool emphasises reproducibility, scalability and interoperability within digital policy infrastructures. Its modular architecture allows integration into dashboards, monitoring systems and

analytical workflows used by policymakers and advisory bodies. By linking socio-economic trends with environmental and agricultural indicators within the Nostradamus platform, the tool facilitates cross-sectoral policy analysis and supports coherent sustainability governance.

In practice, the socio-economic decision-support tool enhances policymakers' capacity to detect emerging socio-economic shifts through structured and regular multi-horizon trend monitoring assess long-term development patterns, and calibrate policy interventions accordingly. It demonstrates how socio-economic modelling can be embedded within integrated data ecosystems to provide structured, transparent and actionable information for sustainable agricultural policy.

This abstract contributes a transferable framework for operationalising socio-economic trend analytics within integrated sustainability data platforms, helping to bridge the persistent gap between data availability and effective policy application.

0206. Land-Use Change and Socio-Economic Outcomes: A Global Longitudinal Assessment

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Keywords: Land-use change; land governance; socio-economic modelling; socio-economic data; longitudinal analysis; sustainability policy

Land-use change does not only transform landscapes; it reshapes labour markets, economic structures and social outcomes, yet these socio-economic dynamics remain insufficiently researched at a global scale. Existing literature on land-use management largely focuses on short-term effects, specific policies, limited geographical areas or environmental consequences, leaving long-term cross-country socio-economic dynamics underexplored. This work addresses this gap through a large-scale longitudinal analysis of land-use and socio-economic indicators from 1960 to the present across 213 countries.

Drawing on more than 16,000 World Bank indicators, we analyse whether land-use change predicts changes in socio-economic indicators. We focus on the relationship between changes in forest, agricultural and arable land and a broad spectrum of socio-economic outcomes. Growth rates are calculated for each indicator and country, followed by time-series regression analyses incorporating lag structures of up to ten years. Granger causality tests complement the modelling approach to assess directional relationships.

The findings show systematic, heterogeneous and statistically significant associations between land-use dynamics and socio-economic development. Changes in forest land use show particularly broad correlations with indicators related to consumption, communication, employment, GDP, health and price-related indicators. Agricultural and arable land-use changes also demonstrate significant associations, though across a narrower set of socio-economic domains. The results further indicate differentiated gender-related effects in employment and health outcomes, as well as evidence of both positive and negative externalities. For example, certain land-use changes are associated with labour market shifts and fiscal indicators, while others correlate with health and demographic variables.

Particularly in countries covered by the LandShift project – France, Greece, Italy, Poland, Ukraine – forest land-use changes exhibit statistically significant correlations with inclusive socioeconomic indicators, whereas agricultural land-use changes display correlations with more diverse and context-specific socioeconomic indicators. Overall, the results expand existing empirical evidence and broaden the range of socio-economic indicators shown to respond to land-use change.

By systematically identifying observable macro-level socio-economic patterns associated with land-use dynamics, our study complements existing work on non-market valuation of agriculture and forestry

while highlighting both market-driven adjustments and ecosystem-service-related externalities. By providing a globally comparable, long-term assessment of socio-economic responses to land-use change, this study contributes to integrated land governance research and sustainability policy analysis. Our findings underline the importance of systematically incorporating socio-economic trajectories into land-use planning and policy design.

0207. Land-Use Composition and Socio-Economic Dynamics in Sub-Saharan Africa: Evidence from the AfroGrow Project Countries

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Keywords: Agroforestry; land-use change; socio-economic modelling; land governance; Sub-Saharan Africa

Forests and agricultural lands are central not only to environmental sustainability but also to economic development and social wellbeing. The AfroGrow project investigates agroforestry systems in Botswana, Côte d'Ivoire, Ethiopia, Kenya, Senegal, and Zambia – countries that we call AfroGrow countries. Agroforestry, understood as the intentional integration of trees and shrubs into crop and livestock systems, is widely promoted for environmental and livelihood benefits. Yet systematic evidence on broader macro-level socio-economic associations of Agroforestry remains limited. This study attempts to fill this gap, examining how variations in forest and agricultural land shares relate to socio-economic outcomes. Forest and agricultural land shares serve as proxies for agroforestry dynamics, albeit at a country level. This approach allows to discover to what extent are land-use compositions associated with agroforestry-related transitions systematically linked to macro-level socio-economic dynamics in Sub-Saharan Africa.

Drawing on World Bank data, this study analyses how variations in forest and agricultural land shares relate to selected socio-economic indicators across the six AfroGrow countries. Using regression analysis and country-level time-series data, we identify statistically significant associations between land-use composition and economic, demographic and health-related outcomes.

The findings reveal heterogeneous but systematic patterns. In several countries, changes in forest share are associated with labour market participation, mortality indicators, demographic structure and rural population dynamics. Agricultural land shares correlate with macroeconomic variables including trade flows, financial indicators and sectoral value added. While some associations suggest potential market-driven adjustments, others point to ecosystem-service-related externalities. Notably, correlations are frequently gender-differentiated, with certain employment, mortality and life-expectancy indicators showing distinct patterns for women and men.

Country-level results differ in magnitude and direction. Ethiopia exhibits more limited observable associations due to data constraints, whereas Kenya, Côte d'Ivoire, Zambia, Botswana and Senegal display broader linkages between land-use composition and socio-economic indicators. Across countries, both positive and negative correlations emerge, underscoring the complexity of land-use transitions and their societal implications. These findings underscore that land-use change and forestry strategies (LULUCF) are closely intertwined with socio-economic structures beyond traditional macroeconomic measures. Shifts in forest and agricultural land shares are associated not only with GDP and sectoral value added, but also with demographic change, labour force participation and health outcomes. Ignoring these linkages risks overlooking unintended distributional effects or reinforcing existing inequalities.

By systematically mapping macro-level socio-economic responses to land-use dynamics in Sub-Saharan Africa, this study contributes to integrated land governance research and evidence-informed agroforestry policy design. The results underline the importance of incorporating gender-sensitive and socio-economic perspectives into land-use planning to ensure that agroforestry and forestry

interventions promote equitable and sustainable development.

0208. Assessing the spatial transferability of GEDI–AlphaEarth Embedding-based biomass models from Kenya to AfroGrow Living Lab Landscapes

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Keywords: Above-ground biomass density, AlphaEarth embeddings, GEDI LiDAR, spatial generalization, spatial cross-validation

Accurate mapping of above-ground biomass density (AGBD) constitutes a critical step in enabling the spatial assessment of several ecosystem services associated with different landscape components that are essential for environmental management and climate policy. Its large-scale estimation relies heavily on global spaceborne lidar missions like GEDI, which provides discontinuous measurements, hindering challenges during its spatial extrapolation. With the recent groundbreaking harmonization of Earth Observation datasets into high-resolution numerical embeddings, this study aims to evaluate the use of AlphaEarth embeddings associated with structural canopy height and SAR-derived backscatter to extrapolate GEDI AGBD measurements to continuous regional estimations and assess their spatial generalization.

Serving as a proof-of-concept for AfroGrow Living Labs-wide assessment, an ensemble of random forest and gradient tree boosting regression models was trained on multi-year GEDI measurements (2019–2022) trained on GEDI measurements and 64-dimensional satellite embeddings in order to assess the model performance over Kenya, maintaining a spatial block cross-validation (10-folds) for independent accuracy estimations. The resulting Embedding-driven biomass was then compared with the inverse distance weighting (IDW) GEDI-driven prediction and served to generate ensemble-based uncertainty maps.

Preliminary results of spatial block cross-validation across Kenya reflect a consistent performance with an overall R^2 of over 0.65, an RMSE of 19.8 Mg/ha and a mean bias of $+4.2$ Mg/ha. In log-transformed space, the model achieves R^2 of 0.64, indicating stronger predictive consistency when back-transform amplification is accounted for. These outputs demonstrate a reasonably stable geographic generalization under heterogeneous woody-vegetation landscapes. The highest recorded errors, with an RMSE of approximately 44 Mg/ha, were observed in the densest forest areas, highlighting common challenges in high-biomass regions. The variable-importance analysis indicates that the ten most important components jointly explain only about 28% of the total importance, with a maximum individual contribution of roughly 3.9%. The Kenya pilot findings provide a preliminary indication that AlphaEarth embeddings-based biomass mapping achieves spatially consistent performance across different landscapes. The observed challenge in dense canopies emphasizes the need for continued evaluation and extension across additional countries to assess its robustness under broader ecological conditions.

0209. Wildfire Impact on Agricultural Vegetation and Post-Fire Recovery: A Remote Sensing and GIS Approach in Fokida, Greece

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Keywords: Remote Sensing; Cropland Recovery; Fire Impact; Agricultural Monitoring; Food Security

Wildfires are a major environmental hazard in Mediterranean regions, often causing significant impacts on natural vegetation and agricultural land. Ass essing the spatial extent of burned areas and monitoring post-fire vegetation recovery are important for understanding ecosystem response and supporting effective land management.

This study examines the wildfire that occurred on 6 August 2021 in the region of Fokida, Greece, focusing on its impact on tree crops, particularly olive groves and vineyards. The main objective is to map the burned area and evaluate the effects of the fire on agricultural vegetation, while also exploring the potential relationship between vegetation recovery and precipitation.

Satellite imagery from Sentinel-2 was used to analyse vegetation conditions before and after the wildfire event. Vegetation changes were assessed using the Normalized Difference Vegetation Index (NDVI), enabling the identification and mapping of the burned area. The analysis was carried out in a GIS environment (QGIS), where spatial processing techniques were applied to identify the extent of the fire-affected area. Additional spatial analysis with Corine Land Cover data was performed to identify affected land-use categories and estimate the extent of burned agricultural areas, with particular emphasis on tree crops such as olive groves and vineyards.

The study also examines precipitation data in order to explore patterns of vegetation recovery following the wildfire. The findings are expected to contribute to a better understanding of wildfire impacts on agricultural landscapes and the role of rainfall in post-fire vegetation recovery.

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0210. Long Life Learning Courses building Advanced Skills for Climate-Resilient Land Management: Insights from the GPSEducation Project

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Keywords: Long Life Learning Courses, Advanced Skills, Earth Observation, LULUCF, Sustainable Land Management

The "Green & Pink for Sustainable Education" TNE-GPSEducation project is a multidisciplinary project created to strengthen international cooperation between 10 Italian Universities and foreign universities, promoting training and education on the topic of sustainability, addressed from different perspectives and lines of research. The WP4 "Advanced Skills (AS) courses – Positioning skills for health and green digital paths" represent the core of the transdisciplinary project, integrating socioeconomics, Earth Observation (EO) technologies, Nature-Based Solutions (NBS) design, and health.

Five (n. 5) Long Life Learning Courses addressing the Advanced Skill project program (AS-LLLC) have been modularized at Politecnico di Milano, precisely: (A.) “Remote Sensing Techniques and Methods For Earth Observation (LLLC-EO); (B.) “SCAN - to - BIM – to - XR Process: from 3D Survey and Modeling to the Development of Immersive VR And WebXR for Sustainable Built Environment (LLLC BIM-XR)”; (C.) “Nature Based Solutions. Principles of Environmental Design and Digital Tools for Climate Change Adaptation (LLLC-NBS)”; (D.) PNRR TNE EDU GPSEducation - “From Land Degradation to Regeneration: EO monitoring within LULUCF Frameworks (LLLC-EO LULUCF)”; (E.) PNRR TNE EDU GPSEducation - “Decarbon and NBS (CO2 computation: from vegetation, CO2 equivalent from water infiltration, retention, energy). Methods and tools (LLLC-Decarbon)”. The participation of researchers from the International University of Rabat (UIR) in the Long Life Learning Courses (LLLCs) at Politecnico di Milano (POLIMI), delivered within the PNRR TNE framework, strengthened collaboration between the École d’Architecture de Rabat and the Department of Architecture, Built Environment and Construction Engineering at POLIMI. The LLLC-EO LULUCF course enabled the exchange of methodologies in Earth Observation (EO) applied to LULUCF monitoring and land degradation assessment, covering data processing, indicator interpretation, and decision-oriented reporting. The acquired expertise shows strong potential in African contexts, where land degradation and climate change represent a challenge. EO-based tools introduced—such as Collect Earth, Open Foris Arena, QGIS Trends.Earth, Google Earth Engine, and Restor—enable scalable monitoring of land-use change, vegetation dynamics, and climate-related indicators. These approaches are relevant for Morocco, following recent flood events (February 2026), which caused agricultural losses and landslides in northern mountainous regions. EO tools support both emergency response and long-term land management strategies. Furthermore, the integration of digital twin approaches, sensor data, GIS modelling, and 3D visualization enhances decision-support systems for ecosystem restoration. The collaboration between UIR and POLIMI establishes a foundation for future research cooperation, linking EO monitoring with applications in vulnerable landscapes and supporting sustainable land management.

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0211. Human Capital, AI Readiness and STEM Capability in Earth Observation Centres of Excellence: Towards a Talent and Skills Framework for Organisational Excellence

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Keywords: Earth Observation, AI readiness, Human Capital, STEM Capability, Organisational Excellence

Earth Observation and geoinformation ecosystems increasingly depend not only on advanced sensing technologies, geospatial data infrastructures, and scientific excellence, but also on the ability of organisations to attract, develop, and retain highly skilled people. In STEM-based environments, Centres of Excellence perform better when they have people able to work across disciplines, are

equipped for digital technology, and have effective people-related systems. At the same time, Artificial Intelligence is transforming Earth Observation by providing new analytical tools, increasing the need for data processing, and requiring new skills. This creates even more pressure on organisations to strengthen their workforce's readiness and skills development.

Even though Artificial Intelligence has become increasingly important in Earth Observation, not much consideration has been given to the human capital and organisational environment that need to be built in order to ensure this change occurs effectively. In particular, it is necessary to develop a deeper understanding of how talent, skills, AI readiness, and organisational capability influence staff capability, performance, and organisational effectiveness within research- and innovation-driven environments, such as Centres of Excellence.

This PhD research bridges this gap by examining how human capital, AI readiness, and STEM competence come together in Earth Observation Centres of Excellence. The goal is to develop a talent and skills framework that can help Centres of Excellence strengthen staff capability, AI readiness, cross-disciplinary collaboration, and the organisational conditions that support research excellence and innovation performance. The study is initially grounded in the ERATOSTHENES Centre of Excellence, which was established through HORIZON funding in a Widening country, and uses it as the primary empirical setting. It is designed as a mixed-methods project. The first phase includes a focused literature review, followed by a structured questionnaire addressed to employees in order to examine perceptions related to critical skills, talent development, AI awareness, organisational readiness, and enabling conditions for excellence. Where feasible, comparative insights from collaborating Centres of Excellence established through Horizon funding in other Widening countries may also be considered. Indeed, the proposed framework could be used by other CoEs to strengthen talent development, AI readiness, and overall organisational effectiveness.

The anticipated contribution of the study is both academic and practical. It aims to strengthen discussion on the human dimension of AI-enabled Earth Observation ecosystems and to propose a transferable framework that supports talent, skills, and organisational excellence in research- and innovation-driven environments.

0212. Mitigating Coastal Erosion and Beach Flooding with Environmentally Friendly Solutions Under Climate Change

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Keywords: Coastal erosion, monitoring, soft measures, 3D-printing

Coastal erosion, as a result of natural or human factors, poses a significant threat to shoreline stability, leading to the: loss of land, degradation of coastal ecosystems, disruption of tourism and increased vulnerability of coastal infrastructure and communities.

The ECO-BEACHTECH project aims to create environmentally friendly coastal management solutions to address some of these challenges. Specifically, the project is designed on experimental, pilot-scale monitoring and risk assessment of coastal regions in the Republic of Cyprus. Within a two-year period, the plan is the mapping of the pilot beaches, compilation of their characteristics using satellite data and the construction of a database. Coastal flood-risk prediction will be assessed under specific sea-level scenarios using a suite of 1D morphodynamic simulation models. Watershed analysis of the pilot beaches is taking place through geomorphological, hydrodynamic and biodiversity measurement and assessment. An innovative aspect of the research effort is considered the engineering design and deployment of artificial reef 3D-printed units alongside concrete manufactured reef units which can be

reconfigured in the future to accommodate sea-level rise. The deployment of artificial reefs is considered an important milestone for the reduction of tidal and wave impact, whilst providing a natural habitat for benthic organisms and fish populations.

Finally, the installation and operation of monitoring systems is expected to contribute to the sustainable promotion of coastal tourism and ecosystem conservation. The significance of the undergoing work is considered to be the introduction of low-impact measures to enhance coastal resilience while preserving biodiversity.

Planned analyses involve the generation of high-resolution coastal maps, shoreline change detection, and the application of quantitative metrics related to coastal morphology and habitat distribution. The project is currently in the data collection phase, with field measurements and satellite data processing ongoing. Preliminary mapping outputs and initial model simulations are under development, with comprehensive results expected by the end of the project timeline.

0213. Remote sensing for archaeological site monitoring in Africa: Barriers and solutions

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Keywords: Archaeology, Monitoring, Change detection, Risk analysis, African Heritage

Africa's archaeological heritage is under unprecedented pressure. Climate change is reshaping coastlines, intensifying erosion, driving vegetation change, and increasing the frequency and severity of flooding and drought, all of which directly threaten the physical integrity of archaeological sites and monuments. Alongside these environmental stressors, land use change, urban expansion, agricultural encroachment, and conflict compound the risk to sites that are irreplaceable and often poorly documented. Remote sensing offers one of the most powerful available means of monitoring these threats at scale. Translating satellite and aerial data into actionable heritage management decisions, however, remains a significant challenge, particularly for agencies operating without in-house geospatial expertise.

This paper highlights the principle barriers to effective remote sensing-based heritage monitoring in Africa and charts possible solutions. Ranging from a lack of infrastructure, capacity, and policy frameworks to the variety of landscapes and spatial and temporal resolutions of threats, these barriers operate at technical, institutional, ethical and infrastructural levels. We draw on work from the Mapping Africa's Endangered Archaeological Sites and Monuments (MAEASaM) project to illustrate both the scale of these challenges and viable pathways forward. The first phase of the MEASaM project developed metadata and geospatial accuracy standards for documenting archaeological sites and monuments in close collaboration and consultation with its in-country members. GIS and remote sensing training on open-access tools such as QGIS and Google Earth Pro have begun to equip heritage professionals across the region with the skills needed to monitor and document their own archaeological sites and monuments independently. Results in remote sensing monitoring, including diachronic shoreline analysis across coastal Kenya, Tanzania, and Senegal using Landsat-derived MNDWI via the Digital Earth Africa Datacube (Ochungo et al. 2025) and land-use/land-cover analysis in semi-arid East Africa using Random Forest classification (Ochungo et al. 2022), demonstrate that scalable, open-source remote sensing pipelines can generate heritage-relevant risk intelligence cost-effectively. Making such pipelines accessible and sustainable in the long-term remains the central challenge. Outputs must be interpretable by heritage professionals whose expertise lies in historical significance rather than GIS, systems must function in low-connectivity, low-resource institutional environments, and governance frameworks must ensure local ownership.

We argue that solutions lie in open-source spatial analysis environments, the automation of monitoring pipelines around freely available Earth observation products, interface design that renders complex outputs as clear actionable risk indicators, and sustained investment in local capacity that goes beyond singular training events. Comprehensive documentation and user guides, as well as supporting policy frameworks, are equally essential if technical solutions are to translate into durable, locally-owned heritage management practice. We actively invite dialogue with the remote sensing community about existing data products, pipelines, and methodological approaches that could advance these goals and extend their regional reach.

0214. Monitoring Land Use and Land Cover Change in the Coastal Region of Burgas (Bulgaria) Using Copernicus Data

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Keywords: Change detection, LULC, MSPA, Sentinel-2, environmental and urban transformations

Monitoring Land Use and Land Cover (LULC) changes is critical for sustainable development, particularly in highly dynamic coastal regions. This study aims to quantify and analyse LULC transformations in metropolitan areas, in 7 municipalities like Burgas, Kameno, Nessebar, Pomorie, Primorsko, Sozopol, Tzarevo, located within Burgas district for the period 2018-2023 by leveraging high-resolution data from the European Union's Copernicus Land Monitoring Service (CLMS). The Morphological Spatial Pattern Analysis (MSPA) was conducted using the GUIDOS Toolbox on land cover maps derived from Sentinel-2 multispectral imagery, supplemented by CORINE Land Cover (CLC) and Urban Atlas datasets. Change detection is performed through supervised machine learning algorithms, such as Random Forest to classify key land types including artificial surfaces, agricultural land, and coastal wetlands. Variety of morphological patterns were examined for structural changes in time on the thematic classes of interest. Research results show a correlation of vegetation area and built-up area development. Preliminary analysis of the investigated areas in Burgas region indicates a trend of urban expansion and industrial growth against decrease in agricultural lands and natural grasslands. Change detection analysis suggests for different interactions which are crucial for decision-making in territorial planning and the conservation of the district's diverse ecosystems. The findings demonstrate that Copernicus data provides a robust, cost-effective framework for regional authorities to implement environmental monitoring on the areas.

0215. Spatiotemporal Dynamics of Reservoir Water Volumes Using Satellite Data: A Case Study of Studena Dam (Bulgaria)

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Keywords: Remote Sensing, IEM on dams, watershed crisis management, Sentinel

Dams in Bulgaria constitute a critical component of the national hydro-economic system. They function as artificial impoundments designed for the accumulation and regulation of water volumes. These facilities are operated under a regulated discharge regime, whereby water release is strictly controlled to meet diverse sectoral demands, including irrigation, potable water supply, and hydroelectric power generation. Concurrently, their effective management is of paramount importance in the context of intensifying climate change. The present study aims to develop a model for monitoring the

spatio-temporal dynamics of reservoir storage through the utilization of satellite-derived data. Radar and optical imagery from the Sentinel-1 and Sentinel-2 constellations for the 2018–2025 period were analyzed, with a primary focus on the “Studena dam” Reservoir. Significant seasonal fluctuations in water levels are identified within the reservoir’s operational management framework. The results are validated against in-situ inflow and outflow data, as well as official records from the Ministry of Environment and Water. The proposed methodology demonstrates the efficiency of remote sensing (RS) for the operational monitoring of water resources, early warning systems, and adaptive reservoir management under conditions of escalating water stress.

0216. RECHBib: Bibliographic database for Remote Sensing and Cultural Heritage studies in the Eastern Mediterranean, Middle East, and North Africa (EMMENA)

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Keywords: Remote Sensing; Cultural Heritage; Earth Observation; Bibliographic Database; EMMENA

The increasing use of Earth Observation (EO) and Remote Sensing (RS) technologies in archaeology and cultural heritage has generated a rapidly expanding body of literature, spanning applications such as site detection, landscape reconstruction, condition assessment, damage mapping, risk monitoring, and heritage management. However, this growing scholarship remains highly fragmented across disciplinary journals, regional publications, conference proceedings, technical reports, and other forms of grey literature, limiting its accessibility and broader analytical use. In response to this challenge, this paper presents RECHBib (Remote Sensing and Cultural Heritage Bibliography), a specialized bibliographic database developed to consolidate, organize, and facilitate exploration of research at the intersection of EO, RS, archaeology, and cultural heritage.

RECHBib has been designed as a structured and searchable research tool focusing on the Eastern Mediterranean, Middle East, and North Africa (EMMENA) region, an area of archaeological richness and environmental vulnerability, where remote sensing applications have become increasingly relevant for documentation, monitoring, and protection. The database is anticipated to host over 5,000 bibliographic records and will enable users to explore publications through multiple filters, including geographic focus, chronological scope, thematic category, and remote sensing technique. These include, among others, satellite-based observation, aerial and UAV imaging, SAR applications, LiDAR, photogrammetry, and multi-temporal change detection approaches.

Developed within the broader cultural heritage cluster of the Eratosthenes Centre of Excellence and presented here in the context of the REVITALISER Project, RECHBib contributes to ongoing efforts to strengthen digital infrastructures for cultural heritage research and innovation. Beyond its function as a bibliographic tool, the database aims to support researchers, heritage professionals, and project developers by improving discoverability, fostering interdisciplinary exchange, and providing a foundation for future analytical, collaborative, and community-driven expansion.

0217. Accuracy evaluation of Transformer-based 3D Reconstruction Compared to Photogrammetry for the 3D survey of Archaeological Sites

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Keywords: Transformer-based 3D reconstruction; Photogrammetry; Depth estimation; Accuracy evaluation; Archaeological documentation

Recent advances in Artificial Intelligence have introduced new possibilities for the 3D documentation of archaeological sites. In particular, transformer-based approaches for depth estimation and 3D reconstruction enable the derivation of geometric information directly from images through learned geometric reasoning (Wang et al., 2025). These methods present new opportunities for documentation and analysis in cases where only a limited number of images exist or where architectural elements have been severely damaged or lost, requiring reconstruction to rely primarily on photographic records.

Pan et al. (2020) developed a monocular depth estimation model based on a single-scale fully convolutional network using ResNet-50 to derive depth maps and point clouds from archived photographs, achieving approximately 95% accuracy in reconstructing the Borobudur reliefs. More recent approaches employ transformer-based models, such as DINOv2 (Oquab et al., 2024) and the Visual Geometry Grounded Transformer (VGGT) by Wang et al. (2025), which improve accuracy by learning global image relationships. While DINOv2 utilizes self-supervised learning, VGGT leverages transformer-based architectures to process single or multiple RGB images, estimating depth and recovering 3D scene information with an overall error of approximately 0.382 in multi-view depth estimation and 0.677 in point cloud reconstruction.

In this study, a methodology is developed to evaluate the accuracy and applicability of transformer-based 3D reconstruction for archaeological surveys. To achieve this, point cloud data are derived from the depth estimation of a transformer-based 3D reconstruction using the VGGT model. Subsequently, these data are aligned with a point cloud from a conventional photogrammetric survey to perform a deviation analysis, quantifying reconstruction accuracy and spatial consistency. Two reconstruction scenarios are investigated through a case study at the Amathous Archaeological Site: (1) monocular depth estimation derived from a single image and (2) multi-view reconstruction using bundle adjustment when multiple images are available.

The proposed framework successfully achieves both monocular and multi-view depth estimation. An initial accuracy evaluation is made to the monocular depth estimation results in comparison to the photogrammetric model with an average deviation of 30mm. This provides promising results for the use of transformer-based 3D reconstruction in scenarios with limited visual data, particularly for lost heritage elements.

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0218. Fishing Zone Suitability Index using Multi-Parameter Remote Sensing and Biogeochemical Analysis for the Arabian Sea

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Keywords: Fishing Zone Suitability Index (FZSI), Marine Geoinformation Systems, Biogeochemical Modelling, Satellite Oceanography, Climate Change and Fisheries

This study presents a novel multi-parameter Fishing Zone Suitability Index (FZSI) for the Ratnagiri coastal region of the Arabian Sea, developed through the integration of satellite-derived and model-based oceanographic variables, combining net primary production (NPP), dissolved oxygen (O_2), nitrate gradients (NO_3), chlorophyll-a, salinity, and sea surface temperature (SST) to capture complex biogeochemical–thermal interactions governing fish habitat distribution; a weighted composite index (35% NPP, 30% oxygen, 20% nutrient gradients, 15% thermal suitability) was formulated to quantify spatiotemporal fishing potential, revealing strong seasonal variability driven by monsoon dynamics with peak suitability during January–February and July and reduced suitability during late monsoon due to thermal–oxygen habitat compression, alongside significant statistical relationships such as a negative correlation between SST and productivity ($r = -0.608$) and strong coupling between nutrient gradients and oxygen dynamics highlighting the dual role of upwelling in enhancing productivity while constraining habitable depth; validation against independent fisheries landing datasets from Indian Council of Agricultural Research – Central Marine Fisheries Research Institute (ICAR–CMFRI) (≈ 3.53 million tonnes marine production in India, 2023) shows strong agreement with observed spatial and seasonal landing patterns, including pelagic species dominance and monsoon-driven variability, thereby supporting the predictive reliability of the model, while the proposed FZSI framework advances existing potential fishing zone methodologies by explicitly incorporating thermal habitat constraints and oxygen dynamics, offering improved predictive capability under climate-driven ocean variability and providing actionable insights for sustainable fisheries management, climate adaptation, and resource optimization through integrated remote sensing and geoinformation techniques.

0219. Protecting Cultural Heritage from Space: The SATCULT Project

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Keywords: Remote Sensing, Cultural Heritage, Earth Observation, Vocational Training, Capacity Building

Cultural heritage across Europe is increasingly exposed to accelerating risks associated with climate change, extreme weather events, environmental degradation, armed conflicts, and illicit activities. These pressures require monitoring approaches capable of detecting changes across large spatial and temporal scales. Satellite-based Earth Observation (EO) and geoinformation technologies provide important capabilities in this respect, supporting applications such as environmental monitoring, deformation analysis, early warning of hazards, and post-disaster damage assessment. Previous research has also demonstrated the potential of satellite imagery for identifying archaeological looting and monitoring threats to heritage landscapes [1, 2, 3]. Despite these demonstrated capabilities, the

systematic integration of satellite-based information into cultural heritage management remains limited.

The SATCULT project, funded by the Erasmus+ Programme, investigates the conditions required to facilitate the effective uptake of satellite-based data within the cultural heritage sector. In particular, the project examines how EO-derived information can be translated into operational knowledge relevant to heritage professionals and decision-makers. A central challenge concerns the disciplinary divide between cultural heritage management and geoinformation sciences. These communities often employ different terminologies, methodological frameworks, and operational priorities, which can limit knowledge transfer and collaboration.

To address these challenges, SATCULT adopts an integrated approach combining needs assessment, analysis of existing applications, and the development of recommendations for training and institutional capacity building. The project synthesises current practices in the use of satellite data for heritage monitoring and evaluates their relevance across different risk contexts, including preventive conservation, environmental monitoring, landscape change detection, and post-disaster damage assessment.

A key component of the project is the identification and documentation of twelve representative Good Practices illustrating the use of satellite data in cultural heritage protection. These cases demonstrate how EO data can support monitoring of environmental pressures, detection of structural or landscape changes, assessment of disaster impacts, and identification of human-induced threats such as looting. The selected examples cover a range of geographical and thematic contexts, illustrating both preventive and reactive applications of remote sensing technologies.

Finally, SATCULT's survey-based needs assessment, involving respondents from both heritage and geoinformation sectors, provides robust empirical evidence. The results indicate a strong demand for training opportunities and practical guidance on the use of satellite-derived information. At the same time, respondents report several barriers to implementation, including limited institutional resources, insufficient technical expertise within heritage organisations, and difficulties integrating geospatial data into existing workflows.

The findings suggest that awareness of remote sensing technologies within the heritage sector is higher than often assumed. Several respondents report previous experience with EO data, indicating that the primary challenge lies in structured knowledge transfer, operational integration, and long-term institutional and financial capacity. Strengthening cooperation between heritage professionals and geoinformation specialists is therefore essential for translating Earth Observation capabilities into effective heritage management tools.

In conclusion, SATCULT highlights the strong potential of satellite-based Earth Observation for cultural heritage monitoring, while emphasizing that its effective use depends on bridging disciplinary gaps and strengthening institutional capacity. The main challenge lies not in data availability, but in its translation into operational knowledge. Targeted training, improved collaboration, and better integration into workflows are therefore essential to fully exploit EO for heritage protection.

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0220. Grid-Based Machine Learning for Forecasting Accident Risk and Supporting EMS Planning in Cyprus

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Keywords: Machine Learning, Road traffic accidents, Hotspot detection, Grid-based spatial modelling, Population exposure (GeoTIFF), Geospatial Analysis; Emergency Medical Services (EMS); Risk Mappin

Effective planning of Emergency Medical Services (EMS) requires accurate identification of accident risk hotspots and the ability to forecast future incidents, including scenarios where ground-truth data are unavailable. This study proposes a new grid-based framework using Machine Learning (ML) to accurately forecast spatial accident risks within the region of Cyprus and provide future location-based accident predictions. Cyprus is discretised into a uniform grid-based model of approximately 1 km resolution to ensure consistency throughout the region. Historical accident records are aggregated to provide monthly counts of accidents within each grid cell, with annual population counts used as a proxy to provide exposure estimates. The model framework combines spatial position, seasonality, and temporal persistence of past accidents to forecast future risks. Three advanced tree-based ML models are evaluated: HistGradientBoostingRegressor with Poisson loss, RandomForestRegressor, and XGBoostRegressor with a Poisson count objective. Validation using the most recent ground-truth data demonstrates very high spatial agreement between predicted and observed accident distributions (Pearson correlation ≈ 0.98) and strong identification of high-risk areas (Top-200 hotspot overlap ≈ 0.91). For forecast years without observed data, consistency across models indicates robust and stable predictions. The framework provides yearly risk maps and probabilistic locations for accidents up to the year 2030. The proposed system is a viable tool for EMS authorities, enabling optimized resource deployment, hotspot monitoring, and planning those accounts for population dynamics. Beyond emergency response, the methodology has broader applications in road safety policy, urban planning, and disaster management in Cyprus and other regions facing similar data limitations.

0221. Low-Interaction Post-Disturbance Mapping for UAV/Satellite Optical Imagery Using Tile Scoring and Prompted Segmentation

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Keywords: Post-disturbance mapping, Optical imagery, Prompted segmentation, Tile-level classification, Georeferenced GIS outputs

The Rapid post-disturbance mapping for wildfires, floods, windthrows, and deforestation has georeferenced extent and severity layers with strict response timelines. Manual digitizing of UAV/Satellite GeoTIFF scenes is computationally intensive in terms of analyst time and leads to inter-operator variability in results, whereas fully trained segmentation pipelines require event-specific dense labels, which are typically unavailable in the early response setting and are generally insignificant in cross-site, cross-sensor, and cross-domain settings. This study introduces a prompt-efficient workflow based on a promptable foundation segmentation model and a lightweight, trained tile-level classifier that generates scene-wide disturbance products from georeferenced optical imagery collected by UAV or satellite, in RGB or multispectral setups. The workflow first divides each scene into overlapping tiles, trains a binary classifier on labelled tiles to determine whether the content is affected, and identifies the type of disturbance and the conditions under which it was acquired by a specific satellite type. An operator then creates sparse point or box prompts within representative areas of the affected areas (e.g., burn scars, inundation extents, or areas of storm damage), and the segmentation model creates an initial

mask on the prompted tile. The classifier then scores all tiles in the full scene, locates high-probability candidate locations, and the segmentation model draws boundaries only within the candidate tiles using simple box/seeds prompts. The workflow merges tile masks into a georeferenced scene mask with overlap-consistent stitching, preserving coordinate reference system metadata throughout the raster-to-vector conversion. Multispectral index–guided refinement (for example, NDWI for inundation and NBR or dNBR for burn severity) and optional auxiliary structure layers reduce confusion from shadows, haze, and mixed land cover and support hazard-specific consistency. GIS-oriented post-processing produces georeferenced raster masks, vector polygons, severity zones, and summary statistics suitable for operational decision support. The contribution addresses the label-scarce early-response regime through a prompt-to-product propagation and geospatial integration methodology that couples tile-level candidate discovery with prompt-based boundary delineation rather than introducing a new segmentation architecture.

0222. Applications of UAV-Based Multispectral Techniques in Archaeology

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Keywords: UAV-based multispectral imaging, Archaeological remote sensing, Vegetation indices / crop marks, Cultural heritage monitoring, Non-invasive archaeological survey

In recent years, unmanned aerial vehicles (UAVs) have seen increasing adoption in archaeological research, driven by rapid technological advances and decreasing costs. One of the principal advantages of UAVs is their ability to provide rapid and precise acquisition of high-resolution spatial data. They are particularly useful for investigating archaeological features that are not visible from the ground surface, as well as for surveying areas or with limited accessibility. Furthermore, UAVs can be employed not only for research purposes but also for the preservation and management of cultural heritage, including site monitoring, digital documentation, and the 3-D reconstruction of monuments.

In addition to standard aerial imaging within the visible spectrum (RGB photography), recent technological advances have enabled UAVs to be equipped with a variety of sensors capable of multispectral imaging, thermal scanning, and LiDAR measurements. These technologies enable the acquisition of data with higher spatial and temporal resolution compared with satellite or manned aerial platforms. Moreover, UAV-based surveys allow greater flexibility in flight planning, an improved ability to avoid cloud cover, reduced atmospheric interference, and generally lower operational costs.

Over the past decade, the number of studies employing UAVs equipped with multispectral sensors in archaeological research has increased. Multispectral remote sensing records electromagnetic radiation reflected from the Earth's surface across several spectral bands in both the visible and non-visible parts of the electromagnetic spectrum, typically including the near-infrared (NIR) region. In addition to enabling the analysis of signals that cannot be detected through conventional photography, a key advantage of multispectral data lies in the possibility of combining information from different spectral bands to calculate various spectral indices. Because buried archaeological features frequently influence soil moisture, vegetation growth, and the reflectance properties of the ground surface, these indices can enhance the visibility of anomalies in soil or vegetation that may be associated with subsurface archaeological structures. Vegetation indices are particularly useful for detecting archaeological anomalies in areas covered by vegetation. Such anomalies in vegetation cover are commonly referred to as crop marks. Crop marks occur because the presence of massive stone structures beneath the soil can cause vegetation stress, as a shallow soil horizon restricts root development and limits water retention. Conversely, areas where structures have been excavated and backfilled in the past may retain greater soil moisture, thereby enhancing vegetation growth. While crop marks of large archaeological structures

may be visible to the naked eye or captured through conventional aerial photography, those of smaller or less prominent features are frequently subtle and can only be reliably identified using multispectral remote sensing techniques. For this reason, multispectral UAV-based remote sensing holds considerable potential to enhance the capabilities of non-invasive archaeological research. Although the results obtained are generally less detailed than those provided by geophysical surveys, UAV-based multispectral surveys enable the investigation of much larger areas. Linear archaeological features, such as ancient roads, may, for example, be traced over distances of several tens of kilometres.

0223. Next-Generation Remote Sensing: Leveraging 5D Spatio-Temporal Data and Integrated Intelligence for Cultural Heritage Protection in Greece

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Keywords: Archaeology; Remote Sensing; Artificial Intelligence; Neolithic settlements; Crop marks

This research, advances archaeology by enhancing non-invasive Remote Sensing through high-precision computational architectures. Utilizing a 5D framework, the proposed methodology includes the collection of multi-temporal and multi-scale data of the Copernicus program, historical maps and Digital Elevation Models (DEMs) to produce highly probability patterns as training data for AI Algorithms. By automating the identification of anthropogenic signatures, the project optimizes monitoring for expansive or inaccessible terrains. Ultimately, this approach provides a systematic protocol for detecting buried remains and protecting cultural heritage against urban encroachment, looting, and environmental threats.

Remote sensing can help detect mounds, tombs and crop marks. Crop marks represent differential vegetation growth patterns reflecting subsurface archaeological features. It can further detect the presence of objects of archaeological interest (pottery fragments, flint tools, etc). Such detections are particularly valuable for archaeologists, as they suggest areas worth excavating.

Our focus lies in the regions of Thessaly (Northern Greece), Chalkidiki (Northern Greece) areas rich in archaeological mounds/tells created by layers of habitation during the prehistoric period. There are different types of settlement; magoulas in Thessaly and toumbas in Chalkidiki. The Thessalian magoulas are characterized by their low and elliptical profiles resulting from vertical buildup, whereas the toumbas in Chalkidiki exhibit a conical geometry with steep gradients. Each settlement type exhibits distinct characteristics, reflecting different social and environmental adjustments to local terrain and climate.

To identify the crop marks, satellite images from Sentinel-2 were analysed in Google Earth Engine environment with monthly sequence for the whole 2024. The data were Harmonized for Top of Atmospheric correction-TOA (Level-1C). Spectral vegetation indices such as NDVI, EVI, DVI, GNDVI, RVI, OSAVI and SR were applied to the multi-temporal satellite images as well as Tasseled Cap Transformation and Principal Component Analysis. By dividing the reflectance values of specific bands, the result was ratio images with 10 m spatial resolution.

The methodology employed a statistical analysis within 20m and 50m buffer zones surrounding each target. Calculating the percentage difference in vegetation reflectance values between these zones, potential archaeological targets were isolated from the surrounding landscape.

The study evaluated the effectiveness of each index across the diverse study areas. The analysis revealed that environmental and morphological features significantly influence detection rates. Notably, the highest detection performance was observed in the region of Chalkidiki, attributed to the morphology of the toumbas, which creates distinct pattern. Preliminary results demonstrate the effectiveness of Sentinel-2 multi-spectral sensors in detecting crop marks, particularly during the dry season, by lever-

aging vegetation indices to enhance growth and color contrasts.

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0224. High-Resolution Satellite Mapping of Citrus Orchards: Tree Detection and Canopy Cover Assessment

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Keywords: Citrus orchards, Tree detection, SkySat, NDVI, Remote Sensing

Accurate information on tree distribution and canopy characteristics is essential for efficient orchard management and precision agriculture. In this study, an automated method for detecting citrus tree centers and estimating canopy cover was developed using high-resolution SkySat satellite imagery. The approach combines NDVI-based canopy segmentation with a Euclidean distance transform and local peak detection to identify individual tree centers within citrus orchards. Two citrus plantations located in the agricultural region of Phassouri, Limassol, Cyprus were used as study areas to evaluate the method under different canopy conditions.

For the first study area, 500 ground-truth trees were manually annotated, of which 353 were located within the NDVI-derived canopy mask and considered valid for evaluation. The proposed method detected 237 tree centers, achieving a precision of 0.84, recall of 0.56, and an F1-score of 0.68. In the second study area, 424 ground-truth trees were annotated, with 420 falling within the canopy mask. The algorithm detected 505 tree centers, resulting in a precision of 0.74, recall of 0.89, and an F1-score of 0.80. These results demonstrate that canopy structure and spectral variability influence detection behavior, leading to either conservative or more exhaustive detection patterns.

In addition to tree detection, the algorithm produced useful orchard metrics such as tree density, canopy area, and canopy cover percentage. The proposed workflow provides a simple and efficient approach for extracting structural information from high-resolution satellite imagery and can support large-scale orchard monitoring, crop management, and agricultural planning.

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The authors would like to thank The Cyprus Phassouri Plantations Co. Limited (CPPC) for providing access to the citrus plantation used in this study.

0225. Wildfire smoke cases detected by the PollyXT Lidar at the CARO Limassol station: EarthCARE capabilities for detecting Smoke

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Keywords: Biomass-burning aerosols; CARO; lidar; EarthCARE; ATLID products

Wildfires are large, uncontrolled fires that often occur in rural or sparsely populated areas. The main causes of wildfires can be attributed to either human activity or natural factors. When key conditions such as heat, drought, and fuel availability reach critical thresholds, wildfires can ignite or become more intense. Climate change affects these parameters by lowering the critical values required for fire activity to occur. Smoke particles play a significant role in the climate system, affecting it directly by absorbing solar radiation and indirectly by influencing cloud formation as cloud condensation nuclei (CCN) and ice-nucleating particles (INPs). They also impact air quality, visibility, and pose health risks. Therefore, it is of great importance to improve our understanding of smoke properties, especially under mixed-aerosol conditions in climatically sensitive region such as Cyprus.

Cyprus, the third-largest island in the Mediterranean, provides a strategic location for investigating the vertical distribution of aerosols, with biomass-burning particles being a common feature detected over the island. Multiwavelength polarization Raman lidar, PollyXT (POrtabLe Lidar sYstem), operated at the Cyprus Atmospheric Remote Sensing Observatory National Facility (CARO NF), detects smoke plumes originating from different sources. These sources include local wildfire events, wildfires from neighboring areas such as Greece and Turkey, as well as smoke plumes transported over long distances, including Canada and other parts of North America.

For the first two cases, smoke layers are usually observed at heights between 1-4 km, while North American smoke plumes are detected at altitudes between 3.5 and 8 km, with aged smoke also observed at heights of 10-12 km. This study presents selected cases of fresh and aged smoke, with emphasis given to their optical properties and their potential differences. Additionally, the capabilities of the joint European Space Agency (ESA)–Japan Aerospace Exploration Agency (JAXA) Earth Clouds, Aerosol and Radiation Explorer (EarthCARE) satellite mission are examined, as EarthCARE satellite captured some of these events, enabling a comparison of the ground-based lidar data with the ATLID L2a aerosol product A-EBD.

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0226. Investigating the cooling efficiency of drought-tolerant vegetation as a Nature Based Solution (NBS) for urban heat resilience: The case study of Paphos, Cyprus

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Keywords: Urban heat island, NDVI, NDMI, mitigation strategy, remote sensing

The Urban Heat Island (UHI) effect poses significant threats to public health, energy consumption, and environmental quality in cities across the Mediterranean. Urban vegetation offers a promising strategy for mitigating this phenomenon. However, the effectiveness of urban greening in hot and arid environments against the UHI effect depends not only on cooling capacity but also on the efficient use of water resources that maintain the urban vegetation. Therefore, the sustainability of urban greening rests critically on selecting vegetation that can withstand prolonged drought periods while still offering adequate cooling benefits. This study investigates the cooling efficiency of drought-tolerant vegetation as a Nature-based Solution (NBS) strategy in the city of Paphos, Cyprus, by integrating remote sensing techniques with spatial analysis to identify, characterize, and evaluate the thermal performance of plant communities adapted to water-limited conditions.

The methodology employed a multi-step approach using satellite imagery acquired during both the summer dry season, to capture peak thermal stress and vegetation water status, and the winter wet season, to establish baseline conditions for comparison. Landsat 8 and 9 OLI/TIRS imagery were processed to derive land surface temperature (LST) and Sentinel-2 to produce the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Moisture Index (NDMI). NDVI served as an indicator for vegetation greenness and density, while NDMI was used to assess plant water content, which consists of a critical indicator of drought tolerance. To identify drought-tolerant vegetation, a conditional classification approach was applied during the hot and dry summer period, selecting pixels that maintained moderate-to-high NDVI values (indicating healthy canopy cover) alongside very low to low NDMI values (indicating sustained tissue moisture stress tolerance without irrigation). Winter season imagery was subsequently analysed to validate these classifications by comparing seasonal shifts in vegetation indices and confirming the resilience patterns of identified drought-tolerant zones. LST retrieved from thermal bands was employed to evaluate the cooling capacity of the identified drought-tolerant vegetations serving as a cross-validation mechanism to assess the thermal efficiency of these areas during peak summer conditions.

This research contributes to the broader advancement of urban climate mitigation strategies with the drought-tolerant vegetation, serving as a Nature-based Solution (NBS) in water-scarce environments. The integrated methodological framework developed here by combining NDVI, NDMI, and LST analyses across seasonal timescales, offers a replicable model for cities in the Mediterranean and other arid to semi-arid regions. By prioritizing vegetation which requires minimal irrigation while still delivering measurable cooling benefits, urban planners and policymakers can implement adaptive measures that simultaneously address the Urban Heat Island effect and the imperative of water conservation under global climate change. As extreme heat events and water scarcity intensify, the approach presented in this study provides a cost-effective, ecologically appropriate pathway toward urban heat resilience.

0227. SAR-Based Change Detection of the February 2026 Evros Floods (Greece) in Google Earth Engine with PlanetScope Integration for Agricultural Impact Assessment

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Keywords: Flood mapping, Sentinel-1, PlanetScope, Food security, Evros

In February 2026, the Evros region in northeastern Greece experienced a major flood episode associated with sustained transboundary river pressure and overflow conditions along the Evros/Maritsa river system. Early warnings and preparedness measures were already reported on 7 February 2026, while the event escalated during the second half of the month; the Copernicus Emergency Management Service activated rapid mapping for the Evros River basin on 20 February 2026, with the event time reported as the night of 18 February 2026. By 24–27 February 2026, civil protection authorities maintained heightened emergency readiness as floodwaters continued to threaten settlements, infrastructure, and productive lowland areas. News reporting during the peak phase of the event highlighted extensive impacts on cultivated land, underlining the relevance of this flood not only as a hydrometeorological disaster, but also as a food-security concern for the wider agricultural plain of Evros.

This study presents a multi-sensor Earth Observation approach for mapping the February 2026 floods in Google Earth Engine (GEE) using Sentinel-1 SAR and PlanetScope imagery. Sentinel-1 data form the core of the flood detection workflow because C-band SAR supports day-and-night, all-weather imaging, making it particularly suitable for flood monitoring under cloudy winter conditions. Flooded areas are identified through a pre-event/post-event change-detection framework applied to Sentinel-1 imagery acquired before and during the flood period. The derived inundation layer is subsequently refined and intersected with land-cover information to quantify impacts on agricultural areas. In parallel, PlanetScope analysis-ready surface reflectance imagery is used to provide higher spatial detail (3 m) for the interpretation of inundated field patterns and localized flood impacts where cloud conditions permit, complementing the synoptic and weather-independent SAR observations.

The scientific contribution of the study lies in linking rapid flood detection with the assessment of agricultural exposure in a region where cropland dominates the floodplain landscape. Rather than treating flood extent as an isolated hazard metric, the proposed framework evaluates inundation in relation to cultivated land in order to better capture potential consequences for crop loss, production disruption, and short-term pressure on local agri-food systems. This is especially important in lowland river basins such as Evros, where repeated winter flooding can directly affect sowing cycles, standing crops, field accessibility, and the economic stability of rural communities.

Overall, the study demonstrates how cloud-based processing of SAR and very-high-temporal-resolution optical data can support rapid and scalable flood-impact assessment, while also contributing to the broader discussion on food security under increasing hydroclimatic extremes. The proposed methodology is intended as a transferable framework for operational flood monitoring and agricultural damage assessment in transboundary and highly cultivated river basins.

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0228. The influence of agrometeorological factors on irrigated Citrus trees

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Keywords: Citrus trees; sap velocity; vapor pressure deficit; soil moisture; irrigation

Sap flow, which represents the movement of water through a plant's vascular system, is a key indicator of plant transpiration (T). Understanding sap flow dynamics is essential for investigating plant physiological processes, hydraulic functioning, water budgets, and plant responses to environmental stressors such as drought. These dynamics are particularly important in semi-arid Mediterranean regions, which are characterized by limited water availability and high evaporative demand.

The aim of this study was to investigate the influence of different agrometeorological factors on sap velocity responses in Citrus trees located at the Cyprus Phassouri Plantations Co. farm in Limassol, Cyprus. The research was conducted between 1 February 2025 and 31 July 2025. Meteorological data, including air temperature, relative humidity, solar radiation, wind speed, and vapor pressure deficit (VPD), were obtained from a meteorological station situated in an open area within the study site. Sap velocity was measured using heat ratio method sap flow sensors installed on the trunks of six representative Citrus trees. Additionally, soil moisture and soil water potential sensors were installed at different soil depths around the selected trees. Irrigation commenced at the end of April, and irrigation amounts were recorded throughout the study period.

The results show an overall increasing trend in sap velocity from February to July, accompanied by clear diurnal patterns. Soil moisture remained relatively high throughout most of the study period, although some trees experienced temporary water stress during the transition between the end of rainfall events and the onset of irrigation in April. In certain cases, irrigation clogging on specific dates resulted in reduced sap velocities. However, the primary driver of sap velocity responses across all trees was vapor pressure deficit. As an indicator of atmospheric evaporative demand, VPD strongly influenced sap velocity, suggesting that tree water use was primarily controlled by atmospheric conditions rather than soil water availability. These findings indicate that Citrus orchards in the study area may be receiving more irrigation than necessary.

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0229. A Satellite-Based Validation of Reservoir Water Capacity at Mavrokolympos Dam: A Follow-Up Study

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Keywords: Reservoir monitoring, water capacity, satellite remote sensing, NDWI, PlanetScope, Sentinel-2, Water Development Department, Cyprus, dam

This study builds upon previous work carried out on the Mavrokolympos Dam (Paphos, Cyprus) in the framework of an extraordinary draining event that occurred in January 2025. The latter investigated the current storage capacity of the reservoir using Terrestrial Laser Scanning (TLS), Unmanned Aerial Vehicles (UAV) photogrammetry and the PlanetScope satellite constellation. Once the mechanical problems were successfully addressed, the dam was returned to operation and the extension of the reservoir surface was monitored throughout the winter period of 2025 to 2026 through a series of multispectral (PlanetScope: 3 m; Sentinel-2: 10 m) satellite images. The Normalised Difference Water Index (NDWI) was used for water surface mapping and its applicability across different water storage levels is herein assessed. The derived surfaces were then translated into water storage volume by using the high-resolution elevation, area, and volume hypsometric curve obtained from the 2025 TLS/UAV Digital Elevation Model (DEM), which identified a current storage capacity of $\sim$ 1.87106 m^3 (15% below original design capacity, due to sediment deposition). The water volumes obtained from satellite data are validated against corresponding gauge-based water level measurements and storage volumes currently provided by the Water Development Department (WDD) of Cyprus, such as the storage volume of 1,577,415 m^3 and a water level of 108.69 m on 27 March 2026. This work aims to validate the current satellite-based methodology as an efficient alternative or complementary tool to the in situ gauging method for water storage monitoring, which can be easily extended to the rest of the Cypriot reservoirs, which are becoming increasingly vulnerable to climate-related changes.

0230. Assessing Aquatic Vegetation from Satellite Imagery Using Drone Derived Reference Data: A Case Study at Lake Maschsee

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Keywords: Lake Monitoring, UAV, Satellite Data, Water Plants, Synthetic Ground Truth

Excessive aquatic vegetation in inland water bodies such as lakes can compromise water quality, ecosystem balance, management operations, and recreational accessibility. For efficient human intervention, a good understanding of vegetation development is necessary. To enable scalable and routine monitoring based on publicly available satellite data, we present a pixel wise detection workflow for the lake Maschsee in Hanover, Germany. The study area was partially mapped during three drone campaigns, providing high resolution imagery both for generating detailed ground truth (GT) and for evaluating the overall workflow.

First, we analyze how the high resolution drone imagery relates to PlanetScope and Sentinel 2 data, considering their differing spatial resolutions and spectral band configurations. We define regions of interest according to flight coverage, manually label the RGB drone data, and classify the imagery using a simple Random Forest to produce a dense, high resolution map of aquatic vegetation. We then aggregate labels to satellite scale through majority voting within each satellite pixel footprint, yielding a GT raster at Sentinel 2 (10m) resolution that serves both as the basis for classifier training and as an independent evaluation standard. To better understand the limits and possibilities of vegetation detection from satellite data, we examine (i) band level spectral separability between classes, and (ii)

how mixed pixel conditions affect detectability by relating accuracy to vegetation fractions derived from the drone based synthetic GT.

Additionally, we quantify how well spectral indices such as the Aquatic Plant and Algae (APA) composite index reproduce the drone derived GT. Beyond this baseline, we experiment with a lightweight machine learning model operating on per pixel spectral vectors to test whether data driven spectral combinations provide meaningful improvements given the limited sample size. Evaluation is based on accuracy metrics and qualitative map comparison.

This work narrows the gap between information needs and the practical availability of suitable data. It clarifies in which situations a compact index may be sufficient and where learned spectral information offer potential advantages for continuous detection and operational planning, supporting practitioners who require explainable and transferable monitoring of (invasive) aquatic vegetation.

0231. Estimating Diffuse Fraction under Dust Conditions in Cyprus

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Keywords: Diffuse Fraction Modelling, Dust Aerosols, Solar Irradiance, Clearness Index

Accurate estimation of the diffuse fraction of solar radiation is essential for solar energy applications, photovoltaic (PV) performance modeling, and atmospheric radiative studies. This is due to the model inability to accurately represent the diffuse radiance distribution under dust conditions. With major related issues linked with the complex optical properties of dust (shape, spectral dependence), size distribution determination, cloud-dust interactions and all related model simplifications and assumptions. However, the performance of commonly used models under dust-prone conditions remains insufficiently assessed, particularly in the Eastern Mediterranean.

This study evaluates the behavior of established diffuse fraction models in Cyprus, a region frequently affected by desert dust events. High-resolution (1-minute) measurements of global horizontal irradiance (GHI), diffuse horizontal irradiance (DHI), and direct normal irradiance (DNI) collected in Limassol were analyzed for 18 months. Dust aerosol conditions were identified using AERONET aerosol optical depth and Ångström exponent. The performance of the Erbs model and the Engerer2 model was assessed against observations, while CAMS aerosol and radiation products were used to provide additional atmospheric inputs and evaluate their consistency with in situ measurements. Results show a clear non-linear relationship between clearness index (Kt) and diffuse fraction (Kd), with increased variability at intermediate and high Kt values due to the combined influence of clouds and aerosols. Dust events are associated with a systematic increase in diffuse fraction, indicating enhanced scattering effects.

The Erbs model captures the overall trend but fails to reproduce observed variability, while Engerer2 improves performance under clear-sky conditions but exhibits a negative bias at intermediate Kt values. Differences between CAMS-based and ground-based estimates further highlight the challenges in representing aerosol effects under dust-laden conditions.

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0232. Spatio-Temporal Vegetation Dynamics and Climate Drivers in Cyprus: A Multi-Decadal Analysis Using Remote Sensing and Causal Inference

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Keywords: Vegetation index anomalies; Drought monitoring; PCMCI causal inference; MODIS time series

The Mediterranean region is highly vulnerable to climate change, with increasing drought frequency, declining precipitation, and rising temperatures posing major threats to ecosystems, water resources, and agriculture. Cyprus, located in the eastern Mediterranean faces particular pressure, holding the highest Water Exploitation Index among all EU member states. Its unique ecosystems, including maquis and phrygana vegetation, are increasingly threatened by changing climatic conditions, while socioeconomic consequences of drought, including water scarcity and reduced agricultural productivity, underscore the urgent need for improved understanding of vegetation-climate interactions.

This study investigates spatio-temporal patterns of vegetation index anomalies across Cyprus and their climatic drivers over a 25-year period from March 2000 to December 2025. Vegetation dynamics are analyzed using the MODIS MOD13Q1 V6.1 product (250 m, monthly composites), with the analysis stratified by stable land-cover and land-use (LULC) classes derived from the ESA Climate Change Initiative (CCI) land cover dataset (available for the years 2000-2022). Trend analysis is performed to characterize inter- and intra-annual variability of vegetation indices across different LULC types. To identify causal climate drivers and potential time-lag effects, the PCMCI causal inference framework is applied using TerraClimate data, incorporating variables including precipitation, temperature, soil moisture, vapor pressure deficit, and surface solar radiation. The analysis is conducted across 34 hydrological subbasins, with causal graphs aggregated seasonally to reveal dominant land-atmosphere interactions.

Results reveal marked seasonal and spatial heterogeneity in vegetation responses to climate variability. Analysis of the significant drought year 2007-2008 illustrates the utility of the approach: negative Enhanced Vegetation Index (EVI) anomalies were already detectable in winter months, with the most pronounced negative deviations occurring in March, primarily in the districts of Nicosia and Larnaca and the Mesaoria valley. Causal analysis identifies water availability (expressed through soil moisture and atmospheric demand) as the dominant driver of vegetation dynamics across nearly all seasons and subbasins, consistent with findings from comparable Mediterranean studies. Seasonal causal graphs reveal a strong negative coupling between solar radiation and EVI in winter, while precipitation exerts a strong positive influence on soil moisture in all seasons except summer, where this relationship reverses. Soil moisture, in turn, positively influences EVI particularly in spring and summer, with time lags of up to three months captured in the analysis. These findings contribute to a deeper understanding of vegetation-hydrology-climate interactions in Cyprus and provide a robust methodological framework applicable to other water-scarce Mediterranean environments, ultimately supporting evidence-based land and water management under ongoing climate change.

0233. Delineation of Geological Basement and Marine Geohazards Using Subbottom Sensing Technology at Kokkari, Samos Isl., Greece

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Keywords: Marine geophysical survey, subbottom profiler, offshore works, marine geohazards, Samos Isl.

On October 2020, a 7.0 R earthquake struck Samos Island in the mid-eastern Aegean Sea causing casualties and injuries, important structural damage, numerous small-scale landslide phenomena and a small tsunami. Significant rockfalls were observed in Kokkari village to the north, along with notable damages to the quay wall of the homonymous fishing shelter. The surrounding onshore area consists of alluvial deposits, Neogene sedimentary rocks, and Upper Miocene volcanics. Main active faulting in the coastal-offshore region comprises the WNW-ESE Vathy-Kokkari and the E-W North Samos offshore fault, the latter being responsible for the destructive earthquake. The scope of this study is to investigate recent sediment thickness, the stratigraphic position of the geological basement and potential marine geohazards near the shelter for repairing and safely extending the quay wall so as both to prevent wave erosion in the land-based area inside the fishing shelter and improve mooring facilities. The study was carried out in 2025 with a Humminbird multi-parametric sonar for the acquisition of general bathymetric and morphological information and an Applied Acoustics Boomer subbottom profiler along a grid of crossing lines. Positioning was by an RTK-GNSS. SonarWiz and QGIS software were used for data acquisition, processing and analysis.

Six main seismic facies (SF) were identified in the seismic profiles. SF1 and SF2 corresponds to the acoustic basement, each one further distinguished to two sub-facies. The remaining SF are attributed to sedimentary deposits, with SF3 related to surficial very loose/soft Holocene materials. Three onshore and two offshore boreholes within the fishing shelter verified the stratigraphic interpretation of SF1 to SF3. Fault mapping indicated that the identified faults are synthetic to each other, as well as to the onshore fault systems and the main North Samos offshore fault, striking NW–SE to WNW–ESE. Small-scale antithetic faults are also observed north of the western margin of Kokkari Bay, whilst to the north faults are generally oriented N–S, suggesting a rotation of the faulted formations.

Within Kokkari Bay, seismic profiles revealed a considerable thickness (2-21m) of recent unconsolidated/soft sediments and the complex distribution of geological formations comprising the acoustic basement within and around the bay. The isopach pattern exhibits an elongated trend of thinning toward the central coastal sector, whilst adjacent to the existing pier, sediment thickness is significant. The inner part of the bay probably corresponds to a palaeo-valley that favoured the accumulation of alluvial sediments. The presence of faults in the wider area appears to have modified the palaeo-valley morphology and contributed to variations in sediment thickness. It is suggested that the study area is controlled by regional tectonics, palaeo-morphology, and Late Pleistocene–Holocene sea-level fluctuations. These factors led to the accumulation of substantial sediment thickness in the coastal zone, particularly in Kokkari Bay. No other geohazards, such as sediment instabilities, fluids in sediment pores or erosional features were detected in the seismic profiles. Yet, it appears that the extension of the quay wall represents an engineering challenge due to the thick loose/soft surficial sedimentary cover.

0234. BorderForce: Flexible system extending automated border surveillance by increased situational awareness adaptable to uncertain times with unforeseen events

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Keywords: Real-time threat assessment, Satellite based monitoring, UAV based monitoring, OSINT, C2 station

BorderForce overarching objective is to develop a scalable and deployable real-time threat assessment system to automatically provide geo-referenced threat indicators based on an autonomous and adaptable smart transportable Command and Control C2 Station for border surveillance integrating versatile sensing platforms and Open-Source Intelligence (OSINT) information. The threat indicators will be fused and shown on an immersive and responsive user interface. BorderForce (trans)national uptake will be promoted for planning and operation with sustainable collaborative technologies and interactive trainings. All research activities will be designed, demonstrated, and evaluated in close cooperation with the project partners concentrating on critical and validated tactical and operational border guarding and customs needs and accommodating pertinent ethical and legal considerations by design. The BorderForce solution for monitoring people, flow of goods and border relevant information will be replicable across European external land borders and shorelines as well as third countries in the context of CSDP missions. Robust land border surveillance (including shoreline) allows authorities to deter illegal activities effectively and re-orient capacity and resources while at the same time encouraging border crossings through authorised border control points.

State of the Art and Beyond in UAV-based and Satellite-based Monitoring: The use of UAS in law enforcement, has exponentially grown in recent years, including border management. In the military domain, the Russian invasion of Ukraine represents “the first large-scale, high intensity war where both sides have extensively deployed military and commercial drones”. Despite widespread use, the performance of standard UAVs remains constrained for example by limited monitoring and communication distances, high energy consumption, weather conditions and limited night-time operations. Similar to UAVs, the interest towards satellite-based monitoring has likewise intensified. However, satellite imagery has also several limitations e.g. relating to the consolidation of real-time operational needs with satellite revisit times over an area of interest and adverse weather conditions. Copernicus Satellites and Copernicus Contributing Missions provide good coverage, regardless of weather conditions but they lack flexibility in the data delivery time potentially extending to several days. Synthetic Aperture Radar technology allows satellites to penetrate clouds and capture images regardless of weather conditions or time of day making it particularly useful for continuous monitoring. Within Borderforce the satellite monitoring coverage will be broadened by integrating high-revisit microsatellites/ cubesats with tasking capabilities, enabling targeted camera adjustments to specific geo-locations and areas of interest, and facilitating night-time image acquisition capabilities.

The BorderForce project responds to evolving threats by enhancing real-time surveillance capabilities. It introduces a dynamic system, featuring self-sufficient, transportable C2 Stations with configurable and extendable capabilities. These stations incorporate versatile surveillance towers with anti-drone features, integrating data from autonomous monitoring sensors and UAV systems. BorderForce will enrich operator situational awareness through integration of AIsupported satellite image intelligence from satellite resources acquiring imagery at high-risk spots and with frequent revisits to critical areas. To enable early threat assessment, BorderForce leverages OSINT, processing online data for border security threats. The project emphasizes ethical, legal, and social aspects, safeguarding fundamental rights in border surveillance capability development.

0235. The Golden Twins

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Keywords: Multi-source EO data, Civil security, Maritime and border security, AI-driven analytics

Mainland, coastal and island regions face a convergence of security risks that affect civil protection, economic stability, and border integrity. Lately, increasingly frequent wildfires and extreme precipitation events threaten human life, tourism infrastructure, and critical services, while rapid-onset floods can disrupt transport networks and overwhelm emergency response capacity. At the same time, maritime zones present complex security challenges, including undocumented vessel movements, illegal activities conducted by ships operating without AIS transponders ("dark vessels"), port congestion risks, and pollution incidents such as oil spills. These threats are compounded by fragmented situational awareness, delayed reporting, and limited monitoring coverage across remote coastal areas and sea borders.

The Golden Twins, an ESA Earth Observation (EO) project, addresses these vulnerabilities through a near real-time satellite-powered digital platform designed to enhance situational awareness and security across mainland, coastal and maritime environments. By integrating multi-source EO data, including Greek national CubeSats, the Copernicus Missions, and commercial Copernicus Contributing Very High Resolution constellations with SAR and optical data, such as ICEYE and PleiadesNeo, the platform delivers reliable mapping and AIdriven analytics that support rapid detection and response.

For civil security, the system enables near real-time wildfire detection, burned-area mapping, and damage assessment, achieving high accuracy and providing emergency responders with timely intelligence for evacuation planning and resource deployment. Flood and extreme precipitation mapping delivers rapid delineation of inundated areas and infrastructure impacts, supporting civil protection authorities, insurers, and local administrations in minimizing damage and accelerating recovery. In addition, the platform provides fire danger assessments on both a seasonal basis and short-term forecasts for the upcoming 1-2 days, while also identifying flood-prone areas to support preventive planning and risk mitigation.

For maritime and border security, The Golden Twins enhances maritime domain awareness through automated vessel detection and dark vessels identification via correlation with AIS data. With detection accuracy exceeding 85% for relevant vessel sizes, the platform supports coast guard operations, border surveillance, and port safety management. Oil spill detection capabilities further strengthen environmental security by enabling early identification of marine pollution events and facilitating rapid mitigation.

Delivered through a secure web-based portal, the platform provides interactive dashboards, alerts, and standardized reports, ensuring that public authorities and private stakeholders receive actionable intelligence in near real time. By bridging space-based observation and operational decision-making, the Golden Twins strengthens civil protection, environmental resilience, and maritime border security in vulnerable island, coastal and mainland regions.

0236. Sat4Gaia: A land monitoring service for the Hellenic National Small-Sats Project

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Keywords: Greek National Satellite Space Project (GNSSP), Earth Observation, Land Use/ Land Cover and Change Mapping, Land Deformation, Urban Analytics

Sat4GAIA is a land monitoring service developed within Axis 3 of the Small-Satellites Project, within the framework of the Greek National Satellite Space Program, an initiative of the Ministry of Digital Governance with a total budget of approximately €130 million, funded by the National Recovery and Resilience Plan “Greece 2.0”, coordinated and supported of the Hellenic Space Center and the European Space Agency (ESA). The aim of this program is the deployment of a fully Greek-owned microsatellite constellation consisting of 13 satellites equipped with thermal, multispectral, hyperspectral, and SAR sensors, enabling near-daily coverage of the entire Greek territory. Sat4GAIA is one of the five thematic services of the program and focuses on the systematic monitoring of Land Use/ Land Cover (LULC) and Change, Land Deformation processes, and Urban Analytics based on Earth Observation data. The Land Use/ Land Cover Classification Module is based on state-of-the-art deep learning semantic segmentation methods (U-Net/FCNN-type architectures) to produce classification rasters delivered at 10 m for the historical annual series (2015–2024) and 5 m for the semiannual series from 2025 onward. The Change Analysis service uses as an input the multitemporal land cover maps and produces change analysis maps both systematically and ondemand. The service performs post-classification, pixel-level “from-to” comparison to generate detailed change maps and transition statistics, strengthened by a Markov chain transition model that filters out low-probability transitions to reduce noise and highlight meaningful change.

The Land Deformation module provides InSAR time-series deformation maps. By utilizing InSAR methodologies, it delivers millimetre-scale Line-of-Sight (LOS) displacementsusing Persistent Scatterer Interferometry (PSI) and SBAS time-series analysis. The operational concept targets reliable multi-year velocity estimation, enabling consistent mapping of slow movements (land subsidence, landslides, and tectonic movements). The module expands also into an on-demand landslide tracking service, generating a landslide raster map accompanied with a quantification report from pre-/post-event SAR imagery.

The Urban Analytics Service delivers actionable, city-level products based on Earth observation and in-situ data, focused on three highly impactful domains. The Urban Heat Islands service utilizes images from thermal imagery and other EO data to produce Land Surface Temperature maps and Air temperature maps. Finally, the service produces high resolution UHI and SUHI maps. The Urban & Public Health product combines EO-data with demographic/socioeconomic data to generate Urban and Public Health Index maps for cities on a hexagonal grid. The Air Quality service scales Copernicus information to city scale using the AI-downscaling methodologies, which employs the results of the CAMS forecast data, by combining also, data from in-situ sensors to generate near-real-time air quality index maps on a 100×100-meter grid per pollution component (PM2.5, PM10, NO_2, SO_2, CO_2, O_3), based on severity legends according to WHO recommendations.

The Sat4GAIA Land Monitoring Service demonstrates how national EO services can move from research pipelines to operational, high-end products that can be utilized from academia, the public and industrial sector. All services are integrated into the Governmental HUB serving as a one stop shop for

EO related products.

Disclaimer: The project is being carried out under an ESA Contract in the frame of the Greek National Satellite Space Project. The Project: Small-Satellites (Measure ID 16855) is implemented by the Hellenic Ministry of Digital Governance with the European Space Agency (ESA) Assistance in the Management and Implementation. The project is part of the National Recovery and Resilience Plan 'Greece 2.0', which is funded by the Recovery and Resilience Facility (RRF), core programme of the European Union-NextGenerationEU. Views expressed herein can in no way be taken to reflect the official opinion of the European Union/European Commission/European Space Agency/ Greek Ministry of Digital Governance. Views and opinions expressed are those of the author(s) only and the European Union/European Commission/European Space Agency/ Greek Ministry of Digital Governance, cannot be held responsible for any use which may be made of the information contained therein.

0237. Sat4Φorest : A forest monitoring service for the Hellenic National Small-Sats Project

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Keywords: Greek National Satellite Space Project (GNSSP), Earth Observation, MircoSatellites, Forest Ecosystems Monitoring, Forest Mapping

Sat4Φorest is a forest monitoring service developed within Axis 3 of the Small-Satellites Project, within the framework of the Greek National Satellite Space Program, an initiative of the Ministry of Digital Governance with a total budget of approximately €130 million, funded by the National Recovery and Resilience Plan "Greece 2.0", coordinated and supported of the Hellenic Space Center and the European Space Agency (ESA). The aim of this program is the deployment of a fully Greek-owned micro-satellite constellation consisting of 13 satellites equipped with thermal, multispectral, hyperspectral, and SAR sensors, enabling near-daily coverage of the entire Greek territory. Sat4Φorest is one of the five thematic services of the program and focuses on the systematic monitoring of forest ecosystems based on Earth Observation data. The project started in August 2024 and will be completed in July 2026. The project is led by the Laboratory of Forest Management and Remote Sensing of the Aristotle University of Thessaloniki, in collaboration with Geosystems Hellas, the National Observatory of Athens, Nerco, and MPLegal.

The service exploits multi-source data derived from passive micro-satellite systems, to generate geospatial products across five thematic domains: (1) forest species mapping, (2) wild-land fuel type mapping, (3) forest health monitoring, (4) biodiversity mapping, and (5) detection and monitoring of forest threats, including urbanization, deforestation, forest diseases, and droughtrelated pressures. Most of the products are produced at a national level and at very high spatial resolution (mostly 5m, although some products have a slightly lower resolution of 10m). Sat4Φorest aims to maximize the potential of the emerging Greek space ecosystem by delivering timely, cost-effective, and regularly updated remote sensing-based information to the national authorities. These products support forest management, wildfire prevention, and the long-term safeguarding of natural resources, contributing to the resilience and sustainability of Greek forest ecosystems under increasing climate change pressures.

Disclaimer: The project is being carried out under an ESA Contract in the frame of the Greek National Satellite Space Project. The Project: Small-Satellites (Measure ID 16855) is implemented by

the Hellenic Ministry of Digital Governance with the European Space Agency (ESA) Assistance in the Management and Implementation. The project is part of the National Recovery and Resilience Plan 'Greece 2.0', which is funded by the Recovery and Resilience Facility (RRF), core programme of the European Union-NextGenerationEU. Views expressed herein can in no way be taken to reflect the official opinion of the European Union/European Commission/European Space Agency/ Greek Ministry of Digital Governance. Views and opinions expressed are those of the author(s) only and the European Union/European Commission/European Space Agency/ Greek Ministry of Digital Governance, cannot be held responsible for any use which may be made of the information contained therein.

0238. Alternative crops and sustainable agriculture

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Keywords: Alternative agriculture, conventional agriculture, producers, CAP

The promotion of alternative crops which have special features and provide significant prospects for exploitation and adaptation to domestic soil and climate conditions, providing adequate profit to producers, is part of the wider framework of reshaping the agricultural model, based on the principles of sustainability. Aim of the paper is to investigate the views and attitudes of producers of the Prefecture of Drama, regarding the possibilities of cultivation and promotion of alternative crops to achieve the national goals of sustainable production in Greece. For the conducting of the research, a special questionnaire was distributed to 100 active producers in the prefecture of Drama and then a statistical analysis of the data was performed. The vast majority of producers is involved with conventional crops, while their expectations for the future of alternative crops are quite negative. The main obstacles for their promotion and adoption were highlighted the lack of information and training by the official bodies, the lack of appropriate machinery and the low profit margin, particularly during a transition period. The domestic agricultural development continues to be based on the conventional agriculture models and varieties, although the new favorable investment conditions that are emerging can be a trigger for the promotion of alternative crops in Greece.

0239. THEIA: Enhancing Copernicus Security services – EU governmental crisis management hub for forced population displacement

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Keywords: Copernicus Security, IMINT, RF, OSINT, High velocity transnational data

The Copernicus service for Security applications (CS) aims to support European Union policies by providing information in response to Europe's security challenges. It improves crisis prevention, preparedness and response in four key areas: Border surveillance; Maritime surveillance; Support to EU External and Security Actions; and R&D for EO Security. One of the most critical problems as cutting-edge challenge has to do with population displacements due to conflicts, including the impact of climate change or extreme weather phenomena and food shortages, as well as poverty, since the war's devastation and the withdrawal of many men from agricultural pursuits lead to food shortages.

The boundaries between displacement and migration are blurred, the reasons for both are varied; yet all cases refer to 'forced displacement': wars, violent conflicts, climate change and natural disasters, destroy the livelihoods of whole populations.

Earth Observation (EO) technologies are advanced significantly, both in terms of observation and data processing capacities, allowing for narrowing the gap between user expectations and service delivery. It became key to incorporate new technologies into operational services, rendering them more fit for the purpose they were designed for, Crisis and Conflict. Enlarging current CS service scope through the inclusion of new, complementary elements regarding population displacement is of major interest to several communities of users and shall support a better governance.

Fast data acquisition designed not only to acquire data but to act/process on it as well includes, but is not limited to:

- Very-High-Resolution imagery and Low orbit Earth Observations
- Use of Space-based video
- Use of micro and cube national systems
- Space-based Radio Frequency analytics
- Use of UAS with different sensors
- Use of terrestrial cameras
- Crowdsourcing, Open-source data from social networks, media
- Statistical, Economic and other demographic data, and
- High velocity transnational data.

THEIA uses Space-Based Earth Observation with existing and New ICT, Cloud Computing, AI to deliver enhanced models and predictions with capability that allows to securely share imagery and Image intelligence (IMINT) products to support situational awareness and decision-making processes at strategic level. Following the guidelines of the Copernicus Security Services Strategic Research Agenda recognizing the potential benefits of aligning with the developments and the progress of the New Space (micro/cube) in National and EU level, including the Commercial EU satellite assets along the existing CS environment, THEIA addresses new challenges. Due to the complexity of the management and efficient exploitation of such a huge amount of satellite data, to select or acquire the proper satellite imagery in a fast and accurate manner and while at the same time offering a strategic approach for the exploitation, development of algorithms for automated processing of information (AI models), also taking account of OpenSource Intelligence (OSINT), need for validation and standardization, THEIA aims the solution adaptation to the specific security application's cases. Dedicated AI solutions applied to specific users' needs, where satellite data will allow a better result success in a shorter time is a need that THEIA will study and support.

0240. DigiFarm: Assessing Digital Training Needs of Agricultural Advisors in Europe

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Keywords: Digital agriculture, agricultural advisors, smart farming, training needs assessment, digital skills

DigiFarm aims to strengthen the digital competencies of agricultural advisors in order to support farmers in adopting smart farming technologies and data-driven decision-making tools. Though the development and delivery of open e-learning training suite tailored to the specific needs of agricultural advisors, the project aims to enhance advisors' capacity to support farmers and the wider digital and sustainable transition of European agriculture. A cross-country needs assessment was conducted to identify the profiles, expectations, and training needs of potential learners. A structured questionnaire survey targeting agricultural advisors and related professionals was distributed across participating countries of Cyprus, Greece, Italy, and Ireland. The survey collected 121 responses of identified agricultural advisors across the four countries and examined participants' professional background, current use of digital tools, knowledge gaps on key smart farming technologies such as Earth Observation and precision agriculture, as well as perceived potential barriers to technology adoption. Overall, the results reveal a diverse learner pool with predominantly basic-to-intermediate digital competencies and relatively limited adoption of advanced smart farming tools. While technologies such as mobile applications and GPS systems are already used by a portion of advisors, the use of more advanced tools such as temperature or soil moisture IoT sensors, farm management information systems (FMIS), and satellite-based data remains comparatively low. Based on the analysis of responses, four distinct learner groups were identified, reflecting different levels of digital readiness and training needs. These profiles provide the foundation for the next stage of the project – the development of modular training pathways tailored to advisors' competencies and needs.

The present work was carried out in the framework of DigiFarm Erasmus+ project (project number: 2025-1-CY01-KA220-VET-000363436) that has received funding from the European Union. The authors also acknowledge the 'EXCELSIOR': ERATOSTHENES: Excellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment H2020 Widespread Teaming project. The 'EXCELSIOR' project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 857510, from the Government of the Republic of Cyprus through the Directorate General for the European Programmes, Coordination and Development and the Cyprus University of Technology.

0241. A GEE-Based Causal Machine Learning Pipeline for EO-Driven Yield Effect Estimation: Geophysical Confounding and Spatial Heterogeneity in Cyprus

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Keywords: Causal machine learning; EO pipeline; geophysical confounding; Sentinel-2; CATE; Cyprus

Standard EO-driven yield models conflate environmental constraints with management effects, producing biased estimates unsuitable for policy. Terrain, soil, and climate shape both crop development and farmer decisions simultaneously, a geophysical confounding structure that must be explicitly modelled rather than ignored.

We present a fully operational, open-source pipeline that integrates Google Earth Engine (GEE) feature engineering with Double/Debiased Machine Learning (DML) for spatially explicit causal yield effect estimation. The pipeline ingests Sentinel-1/2, ERA5/CHIRPS, Copernicus DEM, and SoilGrids, derives harmonic phenology features per pixel at user-defined resolutions (10m–1000m), and assembles a multi-band causal covariate stack per growing season. Five management treatment proxies, viz. irrigation, sowing date, cover cropping, fertilisation, and crop rotation, are conditioned on the full geophysical confounder set using geographic cross-fitting over a regular spatial grid, producing Average Treatment Effects (ATE) and spatially explicit Conditional Average Treatment Effects (CATE) with infinitesimal jackknife uncertainty bands.

Applied to the Paphos agricultural district, Cyprus (2020–2023), preliminary results identify fertilisation proxy as the most causally credible treatment, with a consistent positive effect on peak vegetation indices across the AOI. CATE maps reveal spatially structured heterogeneity in treatment response consistent with known soil and terrain gradients. Robustness is assessed via four pre-registered tests: placebo permutation, random confounder invariance, subset stability, and E-value sensitivity bounds. Full-resolution analysis at 10/100 m is ongoing, with prototype runs completed at 1000 m to validate the end-to-end workflow.

The pipeline is transferable to any Copernicus-covered region and directly implements the ENFIELD proposal's causal identification strategy, including explicit causal graph specification, overlap diagnostics, and sensitivity analysis. Code and outputs are released openly to support reproducibility across EU Member States.

0242. GEORGIA: Advancing Sustainable Irrigation and Soil Health through AI-Driven Water Management and Circular Resource Use

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Keywords: GEORGIA, CUT, Sustainable irrigation, Water resource management, Data-driven agriculture

The GEORGIA project is a Horizon Europe initiative that addresses critical challenges in water management and soil health by transforming them into opportunities for sustainable agricultural growth and innovation. Fully aligned with the European Green Deal, GEORGIA promotes a transition toward environmentally sound, socially equitable, and economically viable agricultural systems. By integrating agricultural expertise with advanced digital technologies—including artificial intelligence (AI), data analytics, and smart irrigation systems—the project seeks to enhance water-use efficiency, promote the safe reuse of alternative water sources, and improve soil health, thereby strengthening resilience to climate change.

GEORGIA adopts a holistic, multi-actor approach to address irrigation and resource management chal-

lenges across diverse European agroecosystems. Its objectives include identifying societal, regulatory, and technological barriers to innovative irrigation practices; advancing the safe use of biowaste and nutrient recycling; optimizing water management at both farm and catchment levels; and developing novel tools for the combined use of water and fertilizers. The project further aims to demonstrate and validate innovative irrigation schemes, assess their environmental and socio-economic impacts, and promote their uptake through targeted dissemination, exploitation, and policy recommendations.

Within this framework, the Cyprus University of Technology (CUT) plays a key role by contributing expertise in data analytics, modelling, and pilot implementation. CUT is actively involved in the analysis of irrigation mechanisms and soil–crop interactions (Work Package 1), where it supports the development of comprehensive datasets and factsheets on non-conventional water use, nutrient circularity, and soil properties. These activities include the investigation of predictive models for soil moisture dynamics and the design of frameworks that underpin advanced tools such as Crop Digital Twins.

CUT also contributes to pilot deployment and evaluation (Work Packages 6 and 7), including the development of data management plans, benchmarking indicators, and monitoring methodologies to assess water savings, crop performance, and ecosystem benefits. A major contribution is its participation in Pilot 5 in Cyprus, which focuses on the use of recycled water and salinity management in large-scale agricultural systems. In this context, CUT provides technical solutions for data-driven irrigation optimization in semi-arid and land-degraded environments, supporting efficient resource use and improved agricultural productivity.

Furthermore, CUT is engaged in dissemination, exploitation, and policy-oriented activities (Work Packages 8 and 9), contributing to stakeholder engagement, knowledge transfer, and the development of policy recommendations that facilitate the adoption of sustainable irrigation practices across Europe.

Overall, GEORGIA demonstrates how the integration of technological innovation, circular resource management, and stakeholder collaboration can drive a resilient and sustainable agricultural future. CUT's contributions highlight the importance of data-driven approaches and real-world pilot validation in bridging research and practice, ultimately supporting the transition toward climate-smart agriculture.

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0243. Deployment of Remote Sensing Databases in High Fidelity Forensic Spatio-temporal Reconstruction of WUI wildfires

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Keywords: Wildfire, Reconstruction, Remote Sensing, GIS, Rate of Spread

An advanced methodology for high-fidelity forensic spatio-temporal reconstruction of wildfire front propagation has been developed to support comprehensive technical analysis of incidents posing significant threats to public safety and property. The primary objectives of this reconstruction framework are to identify the governing factors influencing observed fire front propagation patterns and to quantify the temporal windows available for wildfire management interventions, including both suppression actions and the safe evacuation of exposed populations.

The methodology is founded on the identification of discrete fire front propagation milestones and the interpolation of isochronous fire front curves across the spatial domain between these points. This process explicitly integrates the principal determinants of Rate of Spread (RoS), including wind speed and direction (and gust dynamics), topographic influences, and spatial fuel distribution.

Empirical evidence regarding the precise spatial position of advancing fire fronts at specific time instances is compiled through a multi-source data fusion approach. This includes data derived from

remote sensing platforms, social media content, conventional media reports, and structured or semi-structured interviews with incident responders and eyewitnesses.

A substantial proportion of the required input data is obtained through remote sensing technologies. These include satellite imagery and processed products (e.g., active fire hotspots), as well as proximal sensing systems such as unmanned aerial vehicles (UAVs), fixed webcams, wildfire detection systems, and closed-circuit television (CCTV) networks operating within private or public domains.

The core datasets supporting the reconstruction process include:

(a) Classification and spatial distribution of natural vegetation derived from pre-incident high-resolution satellite imagery, categorized according to their influence on fire propagation (e.g., acceleration versus barrier effects), with classification schemes adapted to local landscape characteristics.

b) Characterization of agricultural land status prior to the incident, distinguishing between active and abandoned plots, and further differentiating cultivation types (e.g., woody versus non-woody), particularly within Mediterranean environments where these distinctions significantly influence fire behaviour.

c) Spatio-temporal mapping of active fire hotspots detected during the incident, utilizing satellite-based services such as NASA FIRMS.

d) Detailed topographic analysis based on Digital Elevation Models (DEM), with slope gradients evaluated relative to the direction of fire spread to quantify their effect on propagation dynamics.

(e) High-resolution delineation of burned areas (fire scars) derived from post-incident satellite imagery.

(f) Identification of previously burned areas using historical satellite data, enabling assessment of fuel availability and potential correlations with recurrent ignition patterns, including those associated with anthropogenic activity.

By integrating identified propagation milestones with spatially distributed RoS-driving factors, isochronous fire front curves are constructed within a GIS environment (QGIS). The resulting reconstruction is delivered as a time-resolved animation of wildfire progression. This framework enables detailed quantitative analyses, including high-resolution (e.g., 10-minute interval) RoS calculation and the assessment of burned area proportions across different land-use and vegetation categories.

0244. A Low-Code Paradigm for Rapid Development of Cyber-Physical Applications in the Food Security Domain: The Nostradamus Approach

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Keywords: Smart Agriculture; Food Security; Cyber-Physical Systems; Domain-specific Languages; Low-code development

The Nostradamus initiative uses digital technologies to focus on food security, sustainability and agricultural resilience in the EU. Funded by Horizon Europe, the project aligns with key EU frameworks such as the European Green Deal and the Common Agricultural Policy. The project has two main goals; first, to create a robust, data-driven foundation to support the EU food security and self-sufficiency directions, and second, to develop open-source digital applications using low-code approaches that are specifically designed to tackle the complex challenges of modern agriculture.

Ensuring European food security and agricultural resilience requires the rapid deployment of data-driven digital solutions. However, developing complex cyber-physical applications is a multidisciplinary process that requires the integration and fusion of several data sources, such as Earth observation (EO) data, real-time Internet of Things (IoT) streams and cloud-native analytics. This can present a significant

technical challenge for agricultural domain experts. This paper presents the Nostradamus Low-Code Platform (LCP), which is a core component of a hybrid Edge-to-Cloud architecture designed to make agricultural application development more accessible. Using the Model-Driven Engineering (MDE) approach, the platform enables citizen developers and domain experts (such as farmers, agronomists, and policymakers) to develop customized solutions without requiring in-depth programming knowledge. The LCP provides graphical and textual Domain-specific Languages (DSLs) that facilitate the automated generation of three application tiers: a) Edge Components for sensory acquisition, b) Logic components for cloud-deployed data pipelines, supporting aggregators and filtering, and c) GUI Components for interactive dashboards.

A key innovation of the Nostradamus Low-Code Platform is its AI assistant, which is supported by a multi-agent system. This assistant enables domain experts to create models and, consequently, full applications through natural language descriptions. This further democratizes the technology, enabling farmers and agronomists to describe desired monitoring workflows in plain text, which the AI then translates into formal DSL models for the generation engine. Furthermore, leveraging DSLs (rather than GPLs) and automated Model-to-Model (M2M) and Model-to-Text (M2T) transformations significantly reduces the latency and technical burden traditionally associated with programming complex cyber-physical systems.

By shifting from manual coding to an AI-assisted Low-code approach, fostering the ”vibe coding” paradigm, the Nostradamus LCP enables domain experts to rapidly build applications that are secure by design, interoperable, semantically valid, and precisely tailored to the agricultural sector’s unique socio-economic and biogeographical conditions.

0245. A Cloud-Native, Multi-Sensor Remote Sensing Pipeline for Regional Geothermal Reconnaissance: Joint Detection of Thermal Anomalies, Hydrothermal Alteration Zones, and Structural Corridors via Google Earth Engine and Causal Confound Removal

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Keywords: Geothermal reconnaissance, Google Earth Engine, thermal anomaly detection, hydrothermal alteration mapping, structural corridor mapping, probabilistic Hough transform, Isolation Forest, multi-sensor remote sensing, causal confound removal

Geothermal energy represents a critical baseload renewable energy source and also a valuable resource for battery metals like lithium (from geothermal brine) in the transition away from fossil fuels, yet its exploration remains disproportionately dependent on expensive, spatially limited ground-based geophysical campaigns, viz. magnetotellurics, active seismic reflection, passive seismic and self-potential surveys, which are rarely feasible at the regional screening stage. Remote sensing offers continental-scale spatial coverage and decades of multi-sensor archives, but existing workflows tend to treat individual data streams, viz. thermal infrared, synthetic aperture radar, and multispectral imagery, in isolation, without a systematic framework for their joint interpretation or integration with established exploration models.

We present a fully automated, cloud-native three-stage pipeline for regional geothermal reconnaissance that addresses this gap. The first stage, implemented entirely within Google Earth Engine, ingests and preprocesses six sensor streams: ASTER L1T thermal and shortwave infrared; Sentinel-1 GRD SAR backscatter; Sentinel-2 SR multispectral imagery; Sentinel-3 SLSTR land surface temperature; NASA-DEM terrain derivatives; and MODIS Aqua nighttime land surface temperature. Sensor-specific quality masking, temporal compositing, and feature engineering are applied across all streams to assemble an approximately 60-band geothermal feature stack at a user-configurable spatial resolution. The second stage converts this stack to a pixel-wise tabular feature matrix, applying a key preprocessing step

borrowed from the causal inference literature: elevation-based detrending of land surface temperature to remove the dominant lapse-rate confound that systematically masks geothermal thermal anomalies in topographically complex terrain. The third stage implements a cascaded detection framework with three parallel proxy streams: (i) thermal anomaly detection via unsupervised multivariate Isolation Forest across the full ASTER TIR, Sentinel-3 SLSTR, and MODIS Aqua nighttime LST feature space, exploiting the complementary spatial resolutions and overpass timings of each sensor to improve detection robustness; (ii) hydrothermal alteration zone classification from ASTER SWIR band ratios targeting argillic, propylitic, silicic, and iron oxide assemblages, augmented by Sentinel-2 clay and ferrous mineral indices and principal component analysis; and (iii) structural corridor mapping through probabilistic hough transform based lineament extraction, azimuth-weighted rose diagram analysis, and fault intersection density estimation from SAR-enhanced edge surfaces. The three proxy streams are ultimately integrated into a weighted multi-criteria prospectivity index that reflects the fundamental geothermal play concept: anomalous heat, fracture-controlled permeability, and hydrothermal fluid pathways must spatially converge to define a viable reservoir target.

Critically, we frame elevation detrending not merely as a preprocessing step but as an instance of causal confound removal, analogous to the nuisance model stage in Double/Debiased Machine Learning, where the objective is to recover the geothermal signal orthogonal to the dominant topographic driver. This framing connects geothermal remote sensing methodology to a broader statistical tradition and enables principled refutation testing: placebo anomaly labels, subset stability analysis, and alteration-thermal concordance scoring are applied to quantify the robustness of detected targets rather than simply reporting their locations.

The pipeline is currently being evaluated across geologically distinct settings spanning the principal geothermal play types encountered in Europe and globally. Within the European context, evaluation targets four contrasting settings: (i) Iceland, the pre-eminent European geothermal model; (ii) the Italian volcanic province, including Larderello in Tuscany, the site of the world's first geothermal power plant (1904); (iii) sedimentary and fault-bound intraplate systems in Germany, viz. the Southern Molasse Basin, the Upper Rhine Graben, fault-controlled hydrothermal systems in the Saxony crystalline basement, and the Northern German Basin including prospective areas of Lower Saxony; and (iv) the Eastern Mediterranean, encompassing the Cyprus and Aegean extensional province. Beyond Europe, the framework is being assessed against well-documented producing fields in the Basin and Range province of the western United States, like The Geysers, Salton Sea, and Dixie Valley; the East African Rift System; and arc-related hydrothermal systems in Japan and Indonesia. Across all settings, the pipeline is evaluated for its ability to reproduce known surface manifestations, viz. fumarole fields, hydrothermal alteration corridors, and fault-controlled upflow zones, and to identify additional candidate targets for ground-based follow-up, with the ultimate aim of demonstrating transferability across enthalpy regimes, tectonic contexts, and data-availability conditions.

All code is implemented in Python using publicly available libraries and is fully configurable via runtime prompts, requiring no proprietary data or local computing infrastructure beyond standard geospatial tools.

This work presents a satellite-based regional screening framework that provides the exploration industry with a rigorous, reproducible first-look prospectivity assessment at continental scale, analogous to a helicopter survey that systematically narrows the search space before committing to investment in detailed airborne and ground-based geophysical campaigns. By integrating open satellite archives and cloud computing, the pipeline delivers a ranked, spatially explicit set of priority corridors and anomaly clusters that are directly actionable as targets for the next stages of exploration zoom-in, viz. regional scale passive seismic, magnetotelluric and gravity transects, detailed airborne electromagnetics, and ultimately active seismic, CSEM and temperature gradient drilling programmes. The framework is particularly valuable in data-sparse and economically constrained regions where the cost and logistics of deploying ground-based surveys across large areas without prior satellite-based screening represent a prohibitive barrier to entry for both the geothermal and mineral exploration industries.

0246. UAS-Based Assessment of Beach-Dune Systems along the South Bulgarian Black Sea Coast: the MapBGBeachDune Project

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Keywords: Coastal geomorphology, airborne methods, geospatial data gaps, dune effacement, dune habitats preservation

Beach-dune systems along the Bulgarian Black Sea Coast (BBSC) represent vital natural infrastructure, providing essential ecosystem services and acting as an environmental defense against climate change-related hazards, e.g., sea-level rise, storm-induced inundation, coastal erosion, and beach retreat. Despite hosting sensitive NATURA 2000 habitat types, these important depositional landforms face escalating threats from high anthropogenic pressure, habitat degradation, and urban encroachment. Consequently, the cited vulnerabilities compromise the regional resilience and long-term viability of the Sustainable Blue Economy (SBE) in tourism-dependent regions in Bulgaria.

To address these challenges, the MapBGBeachDune project unites the capacity of several Bulgarian academic institutions to undertake comprehensive drone photogrammetry and LiDAR surveys coupled with extensive geomorphological, phytocoenological, and ecological investigations of the beach-dune systems along the southern Bulgarian Black Sea Coast (BBSC). Efforts are focused upon the coast from the city of Burgas to the north and the Turkish-Bulgarian border to the south, utilizing high-resolution drone and field data to perform systematic mapping and assessment of the sensitive dune formations and their ecological integrity.

Previous geomorphological and phytocoenological studies by the project team have identified 46 beach-dune systems along the entire BBSC, covering approximately 14% of its aggregate length. Twenty-nine of them are located south of the city of Burgas—a region that is undergoing drastic anthropogenic alterations and high levels of man-driven coastal landscape dynamics. In terms of coastal geomorphology, dune formations therein are classified into primary dunes directly influenced by wave activity (i.e., embryonic and foredunes) and secondary dunes formed by coastal progradation (blowouts, parabolic, and transgressive dunes being most common). Concerning nature conservation, results from phytocoenological studies confirm the above-mentioned coastal depositional landforms correspond to a number of sensitive NATURA 2000 habitats of critical EU importance, e.g., embryonic, white, grey, wooded dunes, and humid dune slacks. Accordingly, all mentioned dune habitat types are also listed in the Red Data Book of the Republic of Bulgaria.

A critical finding of the MapBGBeachDune project is the significant regulatory gap in existing geospatial data and records by executive authorities governing the BBSC.

A concerning number of dune fields (Burgas-South, Poda protected area, Kavatsite-Smokini locality, Butamyata Beach, and many others) remain inaccurately depicted or entirely absent from the specialized and cadastral maps and registers in Bulgaria, maintained in compliance with the Bulgarian Black Sea Coast Spatial Development Act. Without legal inclusion in cadastral records, dune habitats associated with the corresponding depositional landforms remain threatened by destruction due to anthropogenic factors, varying from beach grooming and trampling to resort construction and infrastructure development. Our studies emphasize that timely, high-accuracy mapping is imperative for shifting coastal governance from reactive responses to proactive, evidence-based coastal spatial planning. By formulating policy recommendations and landscape-scale guidelines, the project supports the implementation of Ecosystem-Based Adaptation (EBA) strategies. Integrating UAS technology and remote sensing provides a framework for ongoing monitoring, ensuring the sustainability of these conservationally important dune landscapes. Ultimately, securing them via informed governance and precise documentation is essential to balancing natural heritage preservation with human needs, safeguarding the southern BBSC for future generations.

0247. Layer-Resolved Retrieval of 3-Mode Aerosol Optical and Microphysical Properties Using GRASP Lidar-photometer synergy in Limassol, Cyprus

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Keywords: Aerosols, Desert Dust, Remote Sensing synergy, GRASP algorithm, Eastern Mediterranean

Cyprus is an island in Eastern Mediterranean basins which is frequently influenced by mineral dust air masses originating from the Saharan Desert and Arabian Peninsula, often mixing with anthropogenic pollution and maritime aerosols. Retrieving the optical and microphysical characteristics of these complex aerosol mixtures is essential for in-depth climate studies, accurate radiative forcing assessments, and policy making for the protection of the environment.

The primary objective of this study is to present the layer-resolved retrieval of optical and microphysical properties of aerosols over Limassol, Cyprus using the Generalized Retrieval of Atmosphere and Surface Properties (GRASP) Inversion algorithm. The analysis is based on a high-quality collaborative dataset from Cyprus Atmospheric Remote Sensing Observatory (CARO), a National Facility operated by the ERATOSTHENES Centre of Excellence. CARO as an integral part of the ACTRIS (Aerosol, Clouds, and Trace Gases Research Infrastructure), which provides quality-assured, continuous observations of aerosol and cloud vertical structure. The main input of the GRASP algorithm consists of PollyXT Raman-Polarization lidar measurements and Cimel sun-photometer observations from the CUT-TEPAK site (part of the Aerosol Robotic Network, AERONET). Lidar provides elastic backscatter signals at 355, 532 and 1064 nm and volume depolarization ratios at 355 and 532 nm, while the sun-photometer offers total optical depths and total scattered radiances at four wavelengths (440, 675, 870 and 1020 nm).

A key feature of this study is the implementation of a 3-mode aerosol model within the GRASP framework. The categorization is implemented into Fine (F), Coarse Non-Spherical (CNS), and Coarse Spherical (CS) modes. This configuration setup is effective for analyzing heterogeneous atmospheric mixtures. Specific case studies where elevated desert dust layers (CNS) coexist or mix with maritime aerosols (CS) or/and pollution (Fine) observed by CARO instruments are analyzed.

The results demonstrate that the GRASP Lidar-photometer synergy successfully analyzes the atmospheric column, providing vertical profiles of optical, microphysical properties, and volume concentrations of aerosols in each mode (F, CNS, CS). Separation between spherical and non-spherical particles can distinguish the aerosol mixtures in a layer and determine better the source of the particles. This work highlights the capabilities of the CARO station to provide advanced aerosol characterization vertically in the Eastern Mediterranean area.

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0248. High-Resolution Validation of MONARCH Dust forecasts during strong dust episodes: Leveraging EarthCARE ATLID and CARO NF measurements

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Keywords: MONARCH; Dust modelling; EarthCARE; ATLID; EMMENA region

The Eastern Mediterranean lies at a cross point of frequent mineral dust intrusions from Northern Africa's deserts, as well as from the deserted areas of the Middle East, something that subsequently, influences regional climate dynamics through the alteration of the radiation budget, and affects cloud formation processes and local air quality. This study evaluates the performance of the Multiscale Online Nonhydrostatic AtmospheRe Chemistry (MONARCH) model by comparing its dust forecasts against high-resolution observations from the Earth Cloud, Aerosol, and Radiation Explorer (EarthCARE) satellite, specifically utilizing the Level 2a data products of Baseline BC. The research is conducted within the framework of the calibration and validation (cal/val) activities of the satellite through EVID39 CORAL project and in the framework of the ATARRI project, following the knowledge transferred through dedicated trainings on the MONARCH model, both coordinated by the ERATOSTHENES Centre of Excellence. Additional to the satellite's measurements, the analysis also leverages the capabilities of the Cyprus Atmospheric Remote-Sensing Observatory (CARO) National Facility, which is a ground-based station located in Limassol, Cyprus. Thus, by including EarthCARE overpasses within the broader area of Cyprus, the study can integrate the station's data to facilitate a multi-perspective validation.

The evaluation methodology involves extracting the Dust Optical Depth (DOD) at 550 nm, the dust concentration, dust load, as well as the dust extinction coefficient from MONARCH model, while comparing them against the corresponding retrievals from the satellite and the ground-based lidar. This includes comparing the time-height cross-sections of dust concentration, as well as the vertical profiles of the dust extinction coefficient provided from the ground-based PollyXT lidar with the temporal and vertical evolution simulated by MONARCH, while simultaneously assessing vertical cross-sections from the model against the corresponding cross-sections retrieved along the satellite track. In order to achieve this, EarthCARE's ATLID L2a products, including the Extinction, Backscatter and Depolarization (A-EBD), the Aerosol Layer Descriptor (A-ALD), and the Target Classification (A-TC) are used to retrieve the dust parameters. More specifically, the identification of pure dust layers from A-TC products, enables the extraction of the specific dust extinction coefficient from the A-ALD and A-EBD products, which are then converted into dust mass concentration and load using established mass-extinction conversion factors. Moreover, in order to align the satellite's 355 nm extinction profiles with the model's 550 nm reference, spectral conversions are performed using vertically-resolved Ångström exponent profiles from the PollyXT lidar or the columnar exponent from the CIMEL sun-photometer of the CARO station. Consequently, this work provides an objective assessment of MONARCH model's ability to predict the vertical distribution and mass load of mineral dust in the dust-prone region of Eastern Mediterranean, Middle East, and Northern Africa (EMMENA).

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0249. Carbon Farming Practices in Cereal Crops: Effects of Compost and Straw Application on Soil Health

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Keywords: Carbon Farming, Carbon Sequestration, Cereals, Cyprus, Soil Health

According to the European climate law, the European Union is required to transition to a climate-neutral economy by 2025. Approximately 27% of global greenhouse gas emissions are produced by the agricultural sector. Carbon farming is a technique that can enhance carbon sequestration in the soil, contributing to CO_2 reduction. The CARBONICA project evaluates and promotes carbon farming practices in three carbon farming ecosystems in Cyprus, Greece, and North Macedonia. Within the Cyprus ecosystem, five crops of high economical value are currently evaluated: cereals, potato, olive, vine and citrus. The current abstract presents the evaluation of carbon farming practices in cereals.

In Cyprus, cereals occupy 24.583 hectares of cultivated land, of which wheat is the most widespread crop with 14.127 hectares, followed by barley with 9.494 hectares [1]. The wheat variety selected for this study is “Ourania” durum wheat (Triticum turgidum L. ssp. durum), a commonly cultivated and recommended variety due to its adaptability and resilience under the agroclimatic conditions of Cyprus1 [2]. Carbon farming practices examined in cereals are compost application and straw incorporation into the soil. The effects of these practices are evaluated during the growing seasons using in-situ soil measurements, including topsoil CO_2 flux, water infiltration, pH, temperature, soil moisture, and electrical conductivity (EC). These field measurements are complemented by laboratory analyses of key soil physicochemical properties, including granulometric composition, pH, electrical conductivity (EC), total nitrogen (TN), and total organic carbon (TOC).

The results of this study are expected to contribute to the promotion and adoption of these practices by farmers, with the objective of contributing to the reduction of the carbon footprint of the agricultural sector.

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0250. Disentangling landscape-specific drivers of fire severity using remote sensing and machine learning techniques

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Keywords: Fire severity, object-based image analysis (OBIA), Remote Sensing, variable importance, 2019-2020 Australian Black Summer bushfire

Accurate prediction of fire severity is essential for effective landscape-scale fire management. While numerous studies have identified meteorological, topographic, and fuel-related drivers of fire severity, their influence often varies considerably across different landforms and vegetation types. Most existing modelling approaches often consider these drivers uniformly across space, overlooking how their relative importance shifts with changing topographic and fuel structures. This study addresses this limitation by examining how fire severity drivers vary across distinct landform–vegetation scenarios, with the aim of improving both model understanding and the development of context-specific mitigation strategies. We use remote sensing and machine learning (ML) methods to explain the complex behaviour of fire severity drivers across different landform and vegetation scenarios.

The study was conducted in southeastern Australia, covering the areas affected by the 2019–2020 Black Summer bushfires. To capture environmental variability, the study area was stratified into nine landform–vegetation scenarios: one overall region, four landform classes (peaks and hilltops, upper slopes, lower slopes, and plains/valleys), and four dominant vegetation groups (rainforests and vine thickets, eucalyptus forests and woodlands, other forested woodlands, and shrubland–heathland systems). We integrated multi-source dataset including ERA5-Land meteorological reanalysis, and topographic variables derived from the 30m SRTM Digital Elevation Model. Fuel-related predictors were primarily derived from Landsat imagery, including vegetation moisture indices and spectral indicators of fuel condition. Cloud-free pre-fire and post-fire images were used to extract these variables and generate the fire severity response variable.

Fire severity, used as the response variable, was mapped using an object-based image analysis (OBIA) framework. Unlike traditional single-index approaches, this method integrates multiple severity indices - differenced Normalised Burn Ratio (dNBR), relativised dNBR (RdNBR), and relativised burn ratio (RBR) - along with spectral and statistical features, to improve the accuracy of severity response variable for subsequent prediction. Image segmentation was performed using the Simple Non-Iterative Clustering (SNIC) algorithm in Google Earth Engine, followed by supervised Random Forest (RF) classification. Scenario-specific predictive modelling was then conducted using RF, with variable interpretation performed using the explainable AI framework SHapley Additive exPlanations (SHAP).

The OBIA-based RF classification achieved strong accuracy (F1-score = 0.93, Overall Accuracy = 93.2%), confirming the reliability of the severity response variable. SHAP-based interpretation revealed strong scenario-specific variability in driver importance. Fuel variables, including canopy height and moisture indicators, were the most influential across most scenarios. High-severity fires were consistently associated with shorter canopies and low fuel moisture. Topographic drivers, especially curvature and elevation, showed strong context-specific effects, with convex slopes and upper elevations being more prone to high-severity fire. While meteorological variables were important, they had a more stable influence across scenarios, suggesting that fuel–terrain interactions primarily determine fire severity patterns. By combining remote sensing-derived variables with interpretable ML, this study provides improved insight into the spatial variability of fire drivers and supports the development of more targeted and effective fuel management strategies under diverse environmental settings.

0251. Translating Remote Sensing Research into Commercial Opportunity: The RustAlertSystem Case

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Keywords: Remote sensing; technology commercialization; infrastructure monitoring; corrosion assessment; intellectual property

Corrosion of critical infrastructure is a major challenge for asset management, especially in coastal and urban areas where exposure conditions accelerate material deterioration and increase maintenance demands. Current inspection practices rely mainly on visual assessment and periodic manual surveys, which are often resource-intensive and limited in their ability to detect early-stage damage. These limitations create a strong case for the development of remote sensing–based approaches that can support more efficient and proactive monitoring.

RustAlertSystem is a remote sensing–based technology concept developed for corrosion-related infrastructure assessment through the integration of spectral information and geospatial analysis. Although the technology originates from hyperspectral remote sensing research, this paper focuses on a different dimension of the work: the process through which a research concept begins to move toward commercialization.

Using RustAlertSystem as a case study, the paper examines key stages in this transition, including the recognition of market need, the articulation of a value proposition, the role of patenting and intellectual property considerations, and the initial engagement with stakeholders and potential end-users. Attention is also given to the contribution of the Cyprus Seeds programme in supporting the maturation of the technology and encouraging a more structured exploration of its business potential.

In addition, the paper reflects on the challenges of translating remote sensing research into an applied and commercially relevant solution. These include the need to align innovation with user requirements, operational contexts, and adoption barriers in the infrastructure sector. The discussion highlights commercialization not only as a business objective, but also as a process of making research outcomes more usable, transferable, and impactful.

Overall, the RustAlertSystem case illustrates how remote sensing research can begin to evolve beyond academic output and toward practical and commercial relevance. It also provides a useful example of the opportunities and challenges associated with bridging scientific innovation, intellectual property, and early-stage market development.

0252. Coral Bay: A test bed for nature-based solutions against beach erosion

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Keywords: Nature-based solutions, submerged concrete units, coastal protection, soft measures, Cyprus

In recent decades, Cyprus has emerged as a major tourist destination in the eastern Mediterranean, driven by its favourable climate and natural beauty. However, its “sun, sea, and sand” model is increasingly threatened by coastal erosion due to exposure to open sea conditions. Despite the implementation of costly coastal defenses, several beaches -some of high ecological value- remain vulnerable. Coral Bay (west Cyprus) is a typical pocket beach occasionally experiencing erosion/flooding during storm events, with more severe impacts observed in its northwestern section, where a coastal wall was constructed to protect overhanging residential properties. These challenges

are expected to intensify under climate change and sea level rise. This study tests the effectiveness of porous submerged concrete units (artificial reefs), commonly used to promote biodiversity and enhance recreation, as engineered nature-based solutions to reduce wave energy, mitigate erosion, and promote beach accretion.

In the framework of Eco-Beachtech project (Interreg Greece-Cyprus, 2021-2027) Coral Bay was studied in detail, acquiring a set of various high resolution field measurements (topo-bathymetry, sediments, waves and currents) that aided to set up, calibrate and evaluate an advanced model that solves high order Boussinesq equations to describe coastal hydrodynamics and morphodynamics and design an experimental-pilot coastal protection structure. The pilot structure consists of 200 submerged concrete units, arranged in four parallel lines, for a total length of 100m, forming a reef-type breakwater. The width of the structure's area will be about 8m and the minimum crest level 2m. Marine-grade concrete will be used to resist environmental degradation and provide stable attachment surfaces, ensuring long-term ecological benefits. The structure is considered to be placed $\sim 130m$ from the coastline, in water depths of $\sim 4m$, taking into account beach width fluctuations and swim zone regulations. Basal concrete jags on each unit will help anchor the whole structure to the seafloor, thereby increasing its overall stability. The design took into account main beach exposure to southwestern winds and the worst-case scenario of significant wave heights of 5.6m (including the effect of climate change) and a period of 9 sec. Stability was tested against sliding and overturning and it was found that the safety factors in both cases are very satisfactory (1.73 and 2.56, respectively). It must be noted that all calculations were made for a single unit. Since the submerged concrete units will be in contact with each other, the stability/resistance of the structure is expected to significantly increase.

The use of submerged concrete units for the protection of beaches against erosion remains under scientific investigation and evaluation in very few pilot areas where they have been placed, with no internationally published results yet available regarding their effectiveness. For this reason, the present pilot effort acquires additional interest, as it aims not only to utilize submerged concrete units as a means of mitigating coastal erosion and/or enhancing biodiversity, but also to apply them for the protection of ecologically sensitive coastal areas where the implementation of hard engineering protection measures is prohibited.

0253. Bridging Field Data and Decision-Making: A Municipal GIS Platform for Asset and Process Management

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Keywords: Geographic Information Systems (GIS), Smart Cities, Municipal Asset Management, Web GIS, Mobile GIS, Geospatial Data Integration, Field Data Collection

In order for public entities to monitor their ongoing processes, which involve a massive volume of data, they must systematically record, monitor, and manage their assets and related operational processes. More specifically, municipalities must create their digital twin within a unified management environment. This article presents the design and implementation of an integrated Geographic Information System (GIS) that will serve the municipalities of the Limassol region, with the aim of managing their assets. One of the main objectives is to organize geospatial and non-spatial information in a unified manner, avoiding fragmented and unconnected data across different departments and ensuring interdepartmental coordination.

The methodology was based on an iterative design and development approach, starting with the collection of user requirements and data, through the modeling of processes and data, up to the development of the end user applications. In the cases where the processes were not fully supported by the GIS

system, the corresponding external systems were designed and integrated.

During implementation, the basic principle for organizing this information was to group it by topic and link it to the relevant processes. In this context, it was deemed necessary to organize users into groups based on departments and to distribute functions and data through these groups. Thus, working groups were created for Technical Services, Financial Services, the Health Department, the Green Space Management Department, etc. At the same time, data management and collection-recording procedures are implemented either in the office or in the field. In this context, two working environments were created:

- Web GIS applications, which support the management, visualization, processing, reporting, and monitoring of data processes through user-friendly interfaces.
- Mobile GIS applications, which enable data collection, inspection, and validation in the field e.g. a mobile application for collecting and verifying real estate information, which allows field operators to record georeferenced data (e.g., building numbers, property attributes, and real estate characteristics) using GPS-enabled devices and structured forms.

Furthermore, the necessary automations for data synchronization were established to ensure that all municipal systems receive updates in real time or near real time from all the developed components. To support these mechanisms, all necessary interoperability infrastructure was implemented via APIs and web services.

The system's design and implementation covers standardized data management and operational coordination. Mainly field data collection processes, were previously manual and provided either digital but fragmented information from department to department, or analog data. In the GIS system the field users have the ability to produce directly digital information linked to the central geodatabase, improving accuracy and completeness while ensuring that up-to-date information is always available.

The administrative part of processes that focuses on data management and provides decision-makers with real-time access to spatial and descriptive data, enabling asset tracking, process monitoring, and report generation, is covered by the Web GIS applications.

The way in which the information and applications were designed and structured enables data exchange between departments, as well as the appropriate integration with cetrnal government systems, reducing duplication and improving consistency.

The implemented approach constitutes a framework that can be used and extended to other municipalities planning to modernize their geospatial infrastructure and adopt integrated, process-oriented GIS solutions within the broader context of smart cities and digital governance.

0254. An Integrated Geospatial Information System for Asset and Process Management in Local Government: Design and Implementation for the Limassol District

Themistoklis Roustanis[1], Petros Patias[1,2], Neophytos Stylianou[1], Evagoras Evagorou[1], Georgios Konstantinos Nestoras[1], Christina Papadopoulou[3], Eleni Mappouridou[3], Christodoulos Mettas[1]

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Keywords: Geographic Information Systems (GIS), Smart Cities, Asset Management, water supply and sewer and drainage networks, Process Monitoring, Local Government, Decision Support Systems

The transition to smart city support systems depends on the existence of a digital infrastructure capable of managing assets and processes. Geographic Information Systems (GIS) have evolved into

essential platforms that support urban functions. This article addresses the design and implementation of a GIS system for the Limassol District Local Government Organization, which will serve as a central infrastructure for managing utility networks, assets, and monitoring processes.

Public services consist of individual departments and divisions responsible for managing public utility networks, issuing permits, conducting inspections, and providing services to citizens. These administrative processes often generate a large volume of fragmented and heterogeneous information, which can lead to data inconsistencies, duplication, and limited interoperability. In this context, the relationship between asset registries and operational workflows remains a challenge, which in turn leads to difficulties in the decision-making process. The proposed approach addresses these limitations by designing a GIS as a central operational system that integrates geospatial assets with process-oriented data models and workflows.

With this approach in mind, a multi-tier, service-oriented architecture has been designed, which separates the data, application, and presentation layers. The main component of the system is the central corporate geodatabase, which supports both spatial entities (e.g., water supply and sewer and drainage networks, infrastructure) and process-related datasets (e.g., inspections, permits, maintenance activities).

To implement this, the following methodological approach is followed, starting by modeling use cases for all departments of the organization based on comprehensive documentation of the existing workflows, followed by the creation of a unified geospatial data model that integrates assets with process entities and temporal characteristics, the implementation of interoperability mechanisms for integrating external systems and datasets, as well as the development of web and mobile applications to serve different user roles. A unified geospatial information environment that supports the continuous recording, updating, and monitoring of municipal assets and related processes. The integration of spatial and non-spatial data ensures full traceability of operational activities, including maintenance, inspection, and permitting workflows.

The designed system will establish a unified geospatial information infrastructure enabling continuous recording, updating, and monitoring of utility networks assets and processes. The integration of spatial and process-oriented data enhances data consistency, traceability, and communication across different departments, while supporting real-time monitoring and improved decision-making.

0255. Assessment of Post-Wildfire Changes in Soil Physicochemical Characteristics in Burned and Unburned Vineyard Soils in Limassol, Cyprus

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Keywords: Post-fire Soil Dynamics; Vineyard Soils; Soil Physicochemical Properties, CARBONICA toolbox

Viticulture in Cyprus is firmly combatting new threats posed by climate change resulting in rising temperatures, increased winds and droughts, consequently creating favorable conditions for wildfires. Unfortunately, such an even occurred in Limassol region, Cyprus in July 2025 resulting in 125 km2 of burned land, including agriculture areas mostly consisting of grapevine cultivations. Wildfire induced changes in soil's physical, chemical, and biological properties due to high temperatures and ash incorporation in the soil matrix making the need for environmental restoration and regeneration essential.

Several impacts such as decreased clay content and weakened soil stability, higher pH, reduced EC, differences in soil respiration, decline of soil microorganisms, and an overall decline in soil structure are provoked in fire-affected sites. The aim of the present study is to provide a preliminary evaluation of these wildfire-induced changes regarding soil physicochemical characteristics by comparing selected

burned and unburned soil samples.

Implementing a comparative sampling design, two vineyards within the affected region with burned points and nearby unburned control points representing similar soil and environmental conditions were selected, located in the villages of Agios Ambrosios and Potamiou, cultivating the Lefkada and Xinisteri variety respectively. Samples were collected 50 days post-fire from burned (B1-5) and unburned (U1-5) points from each site. Soil texture was determined by the hydrometer method, while soil pH was determined with a pH meter in a 1:5 sample-to-water suspension. The same suspension was used for soil EC measurements using a benchtop conductivity meter. Field measurements were conducted using the field diagnostic CARBONICA Toolbox. On-field measurements including ΔCO_2 estimations were conducted using a chambered CO_2 data logger in 30 minutes intervals; soil temperature and water content were measured with a high accuracy pocket tester. For the infiltrations, two intervals of 500 ml of water each were applied in-situ, using the single-ring infiltration method.

Results indicate notable differences between burned and unburned vineyard soils across several measured parameters. Burned soils exhibited a decrease in the percentage of clay particles in the soil matrix. The presence of ash rich in basifying cations led to a slight increase on burned surfaces' pH and a decline in EC values compared to unburned surfaces. There was a trend of higher ΔCO_2 values in burned than unburned replicates. Soil Temperature spikes in burned replicates owed to direct sunlight and elimination of vegetation interception and plant evapotranspiration.

Preliminary insights of the post-fire dynamics underscore the importance of monitoring soil responses following wildfire disturbances, since their acknowledgment is essential for evaluating soil recovery processes and apprising management strategies in fire-prone regions. Future research analyses with expanded sampling will bestow on to a more comprehensive understanding of wildfire impacts on agricultural soils in Cyprus.

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0256. From Multispectral to Hyperspectral EO: Detecting Early Stress in Olive Groves with EnMAP

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Keywords: Hyperspectral Imaging; Sentinel-2; EnMAP; Xylella fastidiosa; Physiological Monitoring

Mediterranean agroecosystems are strongly characterized by high-value evergreen crops, particularly olive groves, which are central to regional economies and agricultural heritage. Despite their importance, monitoring their physiological status and phenological dynamics remains a major challenge in Earth Observation (EO). Unlike deciduous vegetation, olive trees show little seasonal change in canopy structure, so greenness does not reflect photosynthetic activity. As a result, widely used satellite multispectral sensors, such as Sentinel-2, primarily capture stable canopy structure and fail to detect subtle physiological changes, especially during early stages of stress.

Recent advances in hyperspectral remote sensing are reshaping EO capabilities by enabling the detection of biochemical and physiological signals through hundreds of narrow, contiguous spectral bands.

This shift will further be supported by emerging satellite missions such as Copernicus CHIME, which will provide systematic hyperspectral observations at large scales. These developments mark a transition from structural to physiological monitoring of vegetation, particularly relevant for evergreen systems. In this study, we present a preliminary assessment of hyperspectral EO for detecting disease-induced stress in olive groves in in the Salento region (Apulia, Southern Italy), focusing on Xylella fastidiosa. We utilize hyperspectral imagery from EnMAP alongside multispectral data from Sentinel-2 to evaluate their respective sensitivities to crop variability and early stress signals. The analysis compares spectral responses between healthy and infected trees, with emphasis on the visible and near-infrared regions. Initial results indicate that in the visible spectral range, infected trees exhibit higher reflectance compared to healthy ones, consistent with chlorophyll degradation reported in previous studies. Sentinel-2-derived vegetation indices largely reflect stable structural canopy properties, limiting their effectiveness in detecting these early physiological changes. In contrast, hyperspectral data demonstrate enhanced sensitivity to stress-related physiological changes, enabling the detection of early-stage plant stress before the onset of visible structural symptoms. The high spectral resolution of hyperspectral imagery allows the identification of narrow-band features linked to pigment composition and stress-related processes, revealing physiological dynamics that remain inaccessible to multispectral observations.

This work highlights the emerging advantage of hyperspectral EO in Mediterranean agriculture and underscores its potential for early disease detection in evergreen systems. As hyperspectral data availability continues to expand through missions such as CHIME and commercial providers, these approaches are expected to play a key role in next-generation agricultural monitoring systems.

0257. Deep Learning-Based Building Change Detection from Very High Resolution Orthophotos in Urban and Peri-Urban Environments

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Keywords: Remote Sensing, Deep Learning, Building spatiotemporal changes, GIS, Urban Monitoring

The rapid development of the building's coverage in tourist and peri-urban areas created the need to design and develop an effective methodologies and the corresponding tools to monitor spatial changes. This paper presents a methodology for identifying newly constructed buildings by analyzing orthophotos and very-high-resolution satellite imagery, using artificial intelligence and deep learning techniques within a geographic information system environment.

The study was applied to two different areas in Greece, with significant differences in landscape morphology and the architectural characteristics of the built environment. The aim of the research was to identify new buildings between two temporal instances (t0 and t1) and to characterize their spatiotemporal differences by comparing the buildings' footprints extracted from remote sensing images using automated processes, at the two time instances.

For the first area, two prediction models were developed using an instance segmentation approach (object-based classification), employing the Mask R-CNN deep learning model within the ArcGIS Learn framework. The models were trained using building data that were digitized from aerial photographs and high-resolution satellite images with resoution of 25–30 cm. The results achieved a satisfactory location accuracy, with an Intersection o Union (IoU) index (Area of Overlap/Area of Union) of approximately 0.74.

In the second area, where the availability of reliable training data was limited, a semantic segmentation approach was applied using the U-Net model, combining manual digitization techniques, digital elevation models (DEM/DSM) and spectral indices such as NDVI for vegetation removal. At the same time, the open model Segment Anything (SAM) was also examined, which produced particularly accurate

building footprints during image segmentation.

Analysis of the results showed that comparing polygons between time instances can identify a significant number of newly constructed buildings, especially in areas outside designated urban zones or with sparse development. However, the models' accuracy is affected by the complexity of the architectural design, the buildings' area density, and the quality of the training data.

The proposed methodology establishes proof of concept for the automated detection of changes in the built environment using modern remote sensing and AI algorithms, supporting applications in spatial planning, urban monitoring, and large-scale geospatial data management.

0258. Development of a Solar Cadastre Application for Rooftop Photovoltaic Potential Assessment and Optimal System Sizing

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Keywords: Solar cadastre; Photovoltaics (PV); GIS; Rooftop solar potential; Energy optimization

Urban decarbonization strategies increasingly rely on the large-scale deployment of rooftop photovoltaic (PV) systems. However, a major barrier to adoption is the lack of accessible, high-resolution information on building-level solar potential and appropriate system sizing. This work presents the use of a web-based solar cadastre application developed by the Centre for Observation, Impacts, Energy (O.I.E.) from Mines Paris – PSL university to quantify rooftop PV potential and how it could be leveraged into an operational service supporting the Cyprus energy system.

The proposed platform combines Geographic Information Systems (GIS), satellite data, in-situ measurements from the Central Radiation Monitoring Station of Eratosthenes Centre of Excellence and solar radiation modelling to estimate the spatial distribution of solar energy across urban rooftops. High-resolution datasets are used to extract key roof characteristics, including orientation, tilt, and usable surface area. Shading effects from surrounding buildings and vegetation, as well as seasonal solar variability, are incorporated into the analysis. These parameters enable the estimation of solar irradiation and potential electricity generation from photovoltaics (PV) at the building scale.

Additionally, by coupling simulated PV timeseries with electricity demand profiles, the analysis can be extended to self-consumption and PV system sizing can be optimized (enhancing techno-economic performance). Furthermore, the application can be adjusted to accommodate for policy developments, such as the recent transition from net metering to net billing schemes, enabling more accurate assessment of financial returns.

The application is implemented as an interactive web interface, allowing users to visualize solar exposure, expected energy yield and recommended PV configurations at multiple spatial scales, ranging from city-wide analysis to individual buildings. If this application is leveraged to support the Cyprus energy system, it has the potential to support various stakeholders, including citizens, urban planners, companies and policymakers in making informed decisions regarding renewable energy investments.

0259. Exploring the Relationship Between Sentinel-2 Vegetation Indices and Microclimate Variability in a Citrus Orchard

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Keywords: Sentinel-2, Vegetation Indices, Citrus Orchard, Microclimate Monitoring, Canopy Stress

Monitoring spatial variability of orchard conditions is a crucial step toward precision agriculture and early stress detection in crops. Remote sensing provides consistent observations of the canopy reflectance, allowing vegetation indices (VIs) to be used as indicators of crop physiological state. The main aim of this work is to investigate if there is a relationship between satellite-derived indices and field-based environmental conditions, by combining temperature and humidity measurements with remote sensing observations. This study develops a Sentinel-2-based framework to investigate the relationship between satellite derived VIs and on-site environmental conditions (air temperature and humidity) within a citrus orchard, using VIs selected based on their correlation analysis with in-situ soil measurements and microclimate observation with in-situ smart traps.

To assess how soil conditions are reflected in canopy spectral responses, soil moisture, soil temperature, and electrical conductivity of a saturation extract (ECe) were measured at a citrus orchard (in Plot 1) located nearby the study area (in Plot 2), in the area of Phassouri in Limassol, Cyprus, with both plots being within the same agro-climatic region. These measurements were temporally aligned with Sentinel-2 acquisitions and used to validate correlations between soil parameters and a set of twenty VIs linked with plant water status, pigment dynamics, and canopy structure. Based on the applied correlation analysis, the three indices that were strongly associated with the soil conditions mentioned above, were: the Normalized Difference Moisture Index (NDMI), Normalized Difference Red Edge index (NDRE), and Enhanced Vegetation Index (EVI2).

The selected VIs were calculated and further analysed at Plot 2, directly from individual Sentinel-2 acquisitions at 10 m spatial resolution, and index values were extracted at the locations of seven smart traps, installed within a smart trap network. This network provides microclimate observations with regard to air temperature and relative humidity at five-minute intervals and distributed across the orchard. This approach preserves the instantaneous relationship between canopy reflectance and environmental conditions at the time of satellite overpass.

The extracted values were analysed to explore possible relationships between in situ temperature and humidity variability and satellite-derived indices. After aligning in-situ measurements with index values extracted at the trap locations, this analysis revealed consistent inverse relationships between air temperature and VIs. In particular, NDMI showed the strongest response to temperature variations for the total amount of traps, with strong negative correlations ($r \approx -0.76$), followed by EVI2 ($r \approx -0.59$) and NDRE ($r \approx -0.55$), indicating a reduction in canopy water content under higher temperature conditions. In contrast, relative humidity exhibited weaker and less consistent relationships with the spectral indices.

This complementary perspective supports the exploring and understanding of spatial patterns observed in the satellite-derived stress indicators and highlights the potential contribution of local environmental variability to canopy reflectance dynamics.

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16- HORIZON Research and Innovation Actions, under Grant Agreement No 101134878. The authors would like to thank The Cyprus Phassouri Plantations Co. Limited (CPPC) for providing access to the citrus plantation used in this study.

0260. Remote Sensing and GIS-Based Diagnostic Framework for Post-Fire Landscape Assessment in Limassol, Cyprus

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Keywords: Post Fire restoration, burn severity, Mediterranean agroecosystems, GIS, Cyprus

In July 2025, a mega fire affected approximately 116 km² in the mountainous region of Limassol, Cyprus. The affected region is predominantly characterized by agroecosystems, including vineyards, grazing lands, terraced slopes, abandoned agricultural parcels, and a heterogeneous mosaic of semi-natural vegetation, while smaller patches of forested vegetation are also present within the affected perimeter. In response, a multi-institutional scientific team was established to support the post-fire assessment and restoration process. Within this framework, a spatially explicit diagnostic methodology was developed to systematically evaluate the structural, ecological, and geomorphological impacts of the fire and to delineate priority intervention and non-intervention zones based on biophysical vulnerability and regeneration potential.

The diagnosis was structured around the development of an integrated geospatial database (geodatabase) within a GIS environment, incorporating harmonized vector and raster datasets derived from national authorities, institutional repositories, and satellite image analysis. The database integrates administrative boundaries, burned area perimeters, burn severity classes, Natura 2000 zones, agricultural parcels (2010–2024), livestock units, geological formations, soil properties, hydrological networks, topographic derivatives extracted from a Digital Terrain Model, and critical landscape elements.

Burn severity was quantified using Sentinel-2 imagery through the differenced Normalized Burn Ratio (dNBR). Results indicate that 48% of the burned area corresponds to moderate-low severity, 29% to moderate-high severity, and 22% to low severity. Fire recurrence analysis using EFFIS data (2008–2025) revealed that 11% of the affected area had experienced previous fire events, indicating increased ecological disturbance and potential limitations to natural regeneration.

Topographic parameters derived from a 5 m resolution LiDAR-based Digital Terrain Model were used to calculate slope, elevation and aspect. Approximately 38% of the burned area exhibits slopes between 25–50%, while 19% exceeds 50%, indicating significant erosion susceptibility. Soil depth mapping showed dominance of shallow to moderately shallow soils (10–50 cm), increasing vulnerability to post-fire degradation.

A critical component of the diagnosis involved the identification of high-value agroecological landscape elements, including dry-stone terraces, isolated tree lines, riparian corridors and unburned habitat islands. These features were spatially assessed for ecological connectivity and biodiversity support functions. Particular emphasis was given to areas adjacent to forest ecosystems and Natura 2000 sites, as well as habitats relevant to priority avifauna species.

A multi-criteria spatial analysis framework was applied to integrate burn severity, slope thresholds, soil

depth, fire recurrence, ecological sensitivity and land-use type. This allowed the classification of areas into: (a) priority intervention zones (high severity, shallow soils, steep slopes, repeated fire exposure), (b) controlled management zones, and (c) non-intervention zones where natural regeneration potential remains high. The diagnostic approach moves beyond simple burned-area mapping by integrating biophysical vulnerability, landscape structure and ecological functionality. The resulting spatial synthesis provides a scientifically grounded basis for post-fire ecological assessment and territorial regeneration planning in fire affected Mediterranean agroecosystems.

This work was carried out within the framework of the Action Plan for the Regeneration of the Fire-Affected Areas of Limassol, Cyprus, an initiative supported by the A.G. Leventis Foundation in the context of its long-term commitment to Cyprus and, in particular, to the sustainable development and resilience of its mountain regions, under the scientific coordination of MountMed Institute. The authors acknowledge the support of the A.G. Leventis Foundation for the environmental and socioeconomic recovery of fire-affected landscapes in Cyprus. The authors also acknowledge the 'EXCELSIOR': ERATOSTHENES: Excellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment H2020 Widespread Teaming project. The 'EXCELSIOR' project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 857510, from the Government of the Republic of Cyprus through the Directorate General for the European Programmes, Coordination and Development and the Cyprus University of Technology.

0261. Fuel Type Mapping Using Multi-Source Earth Observation and Machine Learning: A Case Study in Cyprus

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Keywords: Fuel type mapping, Earth Observation, Random Forest, Sentinel, Cyprus

Accurate characterization of fuel types is essential for understanding wildfire behavior and supporting effective fire management strategies, particularly in fire-prone Mediterranean ecosystems. This study presents a novel framework for fuel type mapping in Cyprus by integrating multi-source Earth Observation (EO) data with machine learning techniques. Building upon an existing habitat classification approach, dominant forest habitats were reclassified into ecologically meaningful fuel types based on vegetation structure, biomass, and expected fire behavior, following the classification systems of Scott and Burgan. The analysis was conducted in Google Earth Engine, where Sentinel-2 multispectral imagery, Sentinel-1 SAR data were retrieved, spectral indices (e.g., NDVI, NDMI, NBR), topographic variables, and tree density layers were combined to capture both structural and biophysical properties of vegetation. A Random Forest classifier was employed due to its robustness and generalization capability, using a stratified training dataset derived from high-resolution imagery and expert interpretation. Model performance was evaluated using k-fold cross-validation and standard accuracy metrics. The results demonstrate that the integration of optical, radar, and ancillary data significantly improves the discrimination of fuel types compared to habitat-based classification alone. The produced fuel type map reveals distinct spatial patterns associated with vegetation structure and moisture conditions, highlighting areas of potentially higher fire susceptibility. Furthermore, the proposed approach provides a scalable and transferable framework for fuel characterization, supporting applications in wildfire risk assessment, fire behavior modeling, and post-fire management planning. This study contributes to bridging the gap between remote sensing-based land cover mapping and fire-relevant fuel characterization, offering a practical tool for enhancing wildfire preparedness and ecosystem resilience in Mediterranean environments.

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0262. AI-based downscaling framework that combines the complementary strengths of CAMS and satellite observations

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Keywords: Machine Learning, U-Net, Air quality, Downscaling, satellite observations

Cyprus is located at the intersection of Europe, Asia, and Africa, and is therefore susceptible to complex air pollution mechanisms due to long-range dust transport, regional emissions, and local anthropogenic activities. The complex nature of these mechanisms is such that air quality is highly variable in space and time. Such variability is a major obstacle for air assessment and monitoring. The Copernicus Atmosphere Monitoring Service (CAMS) is a reliable source of atmospheric composition data with high temporal resolution but limited spatial detail ($\sim$ 10 km), while satellite observations from Sentinel-5P offer enhanced spatial resolution but lower temporal consistency. Bridging this gap between temporal and spatial representation is essential for improving air quality monitoring, particularly in regions such as Cyprus where local variability plays a critical role. In this study, we propose an AI-based downscaling framework that combines the complementary strengths of CAMS and satellite observations to generate high-resolution air quality fields.

The proposed methodology is based on a convolutional neural network architecture (U-Net) which is particularly designed to detect non-linear relationships between low-resolution atmospheric fields and high-resolution spatial patterns. The framework incorporates a multi-source feature stack, which includes CAMS products, satellite data, meteorological variables, and static geographical information such as topography (Digital Elevation Model, DEM). A key component of the proposed methodology is the use of transfer learning. The framework is trained on data-rich regions in Central Europe—where dense observational networks allow robust learning—and subsequently adapted to Cyprus-specific conditions. The framework is applied to ozone (O_3), and other key pollutants, including particulate matter ($PM_{2.5}$, PM_{10}), and nitrogen dioxide (NO_2), with training datasets are developed by performing harmonization and bias correction of the data over ground-based observations. The framework can improve CAMS outputs by capturing local-scale variability, producing high-resolution air quality maps at approximately 5 km, with a long-term objective of achieving $\sim$ 3 km resolution. The expected results demonstrate improved spatial representation of pollution patterns and enhanced agreement with ground-based measurements, supporting national environmental monitoring, regulatory reporting, and future health-related applications in Cyprus.

0263. A Methodological Framework for Monitoring Burial Sites using Remote Sensing and Geostatistical Data Fusion Within the EXCALIBUR Project

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Keywords: Cultural Heritage Preservation, Earth Observation, Digital Twins, Geostatistical Data, Fusion, Burial Sites

Human remains recovered through archaeological excavations provide valuable insights into past populations; however, their integration into coherent, accessible, and actionable cultural heritage narratives remains limited. At the same time, burial sites are increasingly exposed to environmental and anthropogenic pressures. These combined challenges highlight the need for holistic approaches that simultaneously enhance data accessibility and interpretation while enabling systematic monitoring and long-term risk assessment.

In this context, the EXCALIBUR project develops a comprehensive framework that provides innovative tools and methods for the enhanced study, conservation, and understanding of cultural heritage assets, with a particular focus on burial excavations, human remains, and associated findings. The framework promotes the use of Digital Twins as integrative digital representations, supported by interoperable, open-source, and cost-effective toolkits delivered through a human-centered platform aligned with the European Collaborative Cloud for Cultural Heritage (ECCCH) infrastructure and validated through real user needs.

Within this broader context, this paper presents a novel methodological framework developed under EXCALIBUR for the monitoring and preservation of burial sites through the integration of Earth Observation (EO) and geostatistical data fusion techniques. EO and geospatial analysis act as key enabling components, providing continuous, multi-temporal, and multi-scale data streams that support the detection of environmental changes, risk assessment, and ongoing monitoring of vulnerable cultural heritage sites. The proposed methodology leverages the Copernicus Data Space Ecosystem, combined with Python-based automated workflows, to generate consistent multi-year time series datasets derived from Sentinel-1 (SAR), Sentinel-2 (optical), and Sentinel-3 (thermal) imagery. These datasets are complemented by high-resolution UAV acquisitions, incorporating LiDAR and multispectral sensors, enabling detailed assessment of structural conditions. To effectively integrate these heterogeneous data sources, advanced geostatistical data fusion techniques—such as Gaussian Process Regression, hierarchical Bayesian models, and spatial autoregressive models—are employed to derive robust geospatial indicators for monitoring and risk evaluation.

The framework is demonstrated through Use Case 1 at the Tombs of the Kings in Paphos, Cyprus, a UNESCO World Heritage Hellenistic–Roman necropolis exposed to multiple and interacting risks, including soil erosion, coastal processes, urban encroachment, and climate change impacts. The results illustrate how the proposed methodology supports the systematic assessment of these threats and provides the necessary inputs for the future development of a Digital Twin, ultimately enabling informed decision-making and strengthening long-term cultural heritage preservation strategies.

0264. AfroGrow transforming AU agroforestry systems through Living Labs and FNSSA-driven business model innovation

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Keywords: Living Labs; Agroforestry; Climate Resilience; Food and Nutrition Security; Business Model Innovation

AfroGrow is an AU–EU collaborative project advancing multi-functional, climate-resilient agroforestry systems across six AU countries through interconnected Living Labs. Addressing climate change, biodiversity loss, and food insecurity, AfroGrow adopts a systems-based and Planetary Health approach to support Climate Change Adaptation and Mitigation and Food and Nutrition Security and Sustainable Agriculture (FNSSA). The project combines Earth Observation, AI, field experimentation, and indigenous knowledge to develop a data-driven Agroforestry Hub, digital decision-support tools, and participatory, harmonized monitoring frameworks to assess environmental, socio-economic, and human health impacts.

A key innovation is the business-oriented Living Lab Canvas, which builds on the PREPSOIL Business Model Canvas framework and is adapted to AU agroforestry systems. The AfroGrow Canvas expands traditional business models by embedding FNSSA objectives, ecosystem services, and social equity into value creation. It integrates system-level objectives, agroecological and land-use contexts, governance conditions, inclusive user segments, value-chain actors, and co-creation mechanisms, while addressing climate risks and gender inequalities. Unlike conventional models, AfroGrow introduces learning-oriented metrics, long-term impact pathways, and sustainability-driven revenue streams, including carbon farming and ecosystem service payments. It also incorporates scaling and adaptive strategies to ensure replication across diverse AU contexts. By linking innovation, business viability, and policy through Living Labs and Policy Labs, AfroGrow strengthens AU–EU cooperation and enables inclusive, economically viable agroforestry systems, contributing to resilient food systems, biodiversity conservation, and equitable rural development.

0265. Nemesis Soil Health Living Labs for Combating Desertification in Mediterranean Landscapes

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Keywords: Desertification; Soil Health; Living Labs; Mediterranean; EU Soil Mission; Soil Health Descriptors

Achieving land degradation neutrality across the Mediterranean requires integrated approaches that address the complex interactions between soil, water, biodiversity, and socio-economic systems. Under the Mission “A Soil Deal for Europe”, the Nemesis project advances a systemic, innovation-driven framework to combat desertification through co-created, place-based solutions. The project establishes five interconnected Living Labs (LLs) in Cyprus, France, Italy, and Spain, and a cross-border Tunisia-Algeria ecosystem, supported by 60 pilot experimental sites that function as real-world environments for testing and demonstrating sustainable land management practices. Nemesis operates as a multi-actor platform where diverse stakeholders jointly co-design and implement solutions tailored to diverse pedoclimatic and socio-economic conditions. These LLs address soil-centred challenges linking water management, biodiversity restoration, agriculture, and land use, while fostering co-governance structures and co-eco-business models that enable long-term sustainability and replication. A core

innovation of Nemesis is its harmonized Digital Ecosystem, integrating a Mediterranean Data Cube, standardized Soil Health Descriptors, and a Digital Twin framework. This infrastructure enables consistent monitoring, scenario simulation, and comparative evaluation of solutions across regions, supporting evidence-based decision-making and alignment with emerging EU and global soil policies. Complementary mechanisms, including vocational training, policy co-creation platforms, and innovation support instruments, further strengthen adoption pathways. By combining technological integration, participatory governance, and scalable experimentation, Nemesis delivers a replicable Mediterranean model that accelerates soil restoration, enhances ecosystem resilience, and supports climate adaptation and sustainable land use transitions.

0266. Nostradamus enabling data-driven sustainable agriculture in Europe through interoperable Data Cubes and multi-actor digital innovation

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Keywords: Data Cubes; Digital Agriculture; Decision Support Systems; Earth Observation; IoT; Interoperability; Open Data; Multi-Actor Approach

Nostradamus addresses key challenges in European agriculture, including food security, reliance on agrochemical imports, and limited adoption of digital solutions, particularly in areas with weak connectivity. The project delivers an integrated, open-source digital ecosystem enabling data-driven decision-making for farmers, advisors, and policymakers. At its core, Nostradamus develops interoperable Data Cubes that consolidate multi-source data (Earth Observation, IoT, agricultural markets, and socio-economic data) into scalable, country-level one-stop shops. These are combined with analytical core modules (drought monitoring, crop suitability, soil fertility, pest management), a user-friendly graphical interface, and an application generation engine supporting cloud, edge, and hybrid solutions. A key innovation is the external needs-based data requirements framework, which establishes a structured, iterative, and policy-aligned methodology to identify, prioritise, and integrate evolving data needs from Multi-Actor Platforms, EU initiatives, AKIS ecosystems, and policymakers. Using defined suitability criteria (e.g., relevance, interoperability, timeliness, integrity) and a ranking matrix, the framework systematically validates and aligns all data inputs with EU strategies (e.g., CAP, Green Deal, Data Strategy), while remaining technically feasible within the Data Cube architecture. Through a multi-actor approach, cascade funding, and targeted capacity building, Nostradamus accelerates innovation and adoption of digital applications across diverse agro-climatic contexts. The project contributes to sustainable agriculture, climate resilience, and strengthened science-policy interfaces, delivering measurable impacts, including reduced input use, improved yields, and enhanced decision-making. By promoting open data, interoperability, and replicability, Nostradamus supports a competitive EU data economy and a resilient, autonomous food system.

0267. An Event-Driven AI Architecture for Transforming Heterogeneous Food System Data into Policy Intelligence

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Keywords: Food Systems Monitoring; Event-Driven Architecture; Big Data Infrastructure; Earth Observation Data; AI-Assisted Decision Support

In recent years, the governance of food systems has become a major priority for the European Union, particularly in light of climate change, biodiversity loss, and geopolitical disruptions that affect food supply chains. Addressing these challenges requires integrating knowledge from multiple domains, including environmental monitoring, agricultural production, and socio-economic indicators. However, the effective use of such information remains limited due to what can be described as a complexity gap: while large volumes of environmental and agricultural data are continuously generated, through Earth Observation (EO), statistical services, and market monitoring systems, these datasets often remain fragmented across infrastructures and formats, making the extraction of coherent, policy-relevant insights difficult.

To address this challenge, we present an AI-enabled Observatory platform developed in the context of EU-funded project ECO-READY, designed to integrate heterogeneous food-system datasets within a unified analytical environment. The platform combines diverse data streams, including satellite-derived indicators, environmental measurements, market statistics, and regional production data, enabling continuous monitoring of food system dynamics across Europe. In addition to aggregating data from institutional repositories and public datasets (e.g. EU agricultural statistics and climate data services), the Observatory can incorporate localized information originating from regional stakeholders and Living Labs, supporting multi-scale analysis of environmental and socio-economic factors affecting food security.

The underlying infrastructure follows an event-driven architecture that supports scalable ingestion, storage, and analysis of heterogeneous datasets. Data streams are processed through an Apache Kafka cluster that enables real-time event streaming and reliable integration of diverse data sources. Each incoming record is treated as an event and organized within a flexible hierarchical data model consisting of Projects, Collections, and Events, allowing organizations and data providers to structure their datasets within a unified schema. Processed data are stored in a distributed data store implemented using Apache Cassandra, which provides high availability and scalability for large-scale time-series and observational data.

A key advancement introduced in this work is the integration of an AI-assisted reasoning layer within the event-driven pipeline. Moving beyond traditional dashboards, this component enables natural-language interaction with the underlying datasets and supports automated synthesis across heterogeneous data streams. By operationalizing a Data – Insight – Decision workflow, the system can generate structured analytical outputs such as regional risk assessments, cross-dataset comparisons, and scenario-based impact analyses. Such capabilities allow policymakers and analysts to explore cross-domain relationships, detect emerging risks, and rapidly synthesize complex datasets into interpretable policy-relevant insights. As a result the Observatory is not only a monitoring system but also, and mainly, a proactive decision-support environment capable of assisting policymakers in navigating complex food system dynamics.

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ships, detect emerging risks, and rapidly synthesize complex datasets into interpretable policy-relevant insights. As a result the Observatory is not only a monitoring system but also, and mainly, a proactive decision-support environment capable of assisting policymakers in navigating complex food system dynamics.

Overall, the proposed architecture demonstrates how event-driven big data infrastructures combined with AI-based reasoning can bridge the gap between fragmented monitoring data and actionable policy intelligence, supporting evidence-based governance for resilient and sustainable food systems.

0268. Towards an AI-driven framework for predictive maintenance of reinforced concrete bridges using remote sensing data

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Keywords: Remote Sensing, Artificial Intelligence, Predictive Maintenance, Reinforced Concrete Bridges, Infrastructure Monitoring, Geoinformatics, Structural Deterioration

Reinforced concrete (RC) bridges are increasingly exposed to environmental factors and climate related impacts, making effective maintenance planning more critical. Current approaches are mainly based on periodic inspections and limited datasets, which often fail to capture the complexity of deterioration processes or support timely decision making.

This study proposes a conceptual framework for the predictive maintenance of RC bridges, integrating remote sensing data with geoinformatics and engineering knowledge. Artificial intelligence is introduced as a key component, enabling the extraction of useful information from geospatial data, the identification of relationships between environmental conditions and structural deterioration, and the prediction of future performance. The framework outlines the main steps from data acquisition and processing to analysis and decision support, supporting a transition towards more proactive and data driven maintenance strategies.

0269. Integrating MRR 2 Radar Observations and High Resolution WRF Simulations to Investigate Cloud and Precipitation Structure over Athens, Greece

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Keywords: Micro Rain Radar (MRR-2), Weather Research and Forecasting model (WRF-ARW), Reflectivity, Liquid Water Content, Athens

This study explores the synergistic integration of a ground-based Micro Rain Radar (MRR-2) with high-resolution simulations from the Weather Research and Forecasting model (WRF-ARW) to investigate cloud vertical structure and microphysical characteristics over the greater Athens area. Athens, Greece, represents a naturally diverse environment where land–sea interactions, complex topography, frontal passages, and episodic aerosol intrusions, such as Saharan dust outbreaks and enhanced marine sea-salt concentrations, modulate cloud development and precipitation processes.

The MRR-2 is a 24-GHz vertically pointing micro-rain radar profiler capable of measuring Doppler spectra of hydrometeors and retrieving vertical profiles of precipitation parameters up to approximately 6 km in height. It provides continuous, high-resolution vertical profiles of radar reflectivity, fall velocity, and rain rate, enabling detailed characterization of stratiform and convective cloud regimes as well as retrievals

of liquid water content, melting-layer height, and echo-top structure. These observations are systematically compared against convection-permitting WRF-ARW simulations employing state-of-the-art microphysics and aerosol-aware parameterizations. Representative case studies include frontal systems, orographic convection, sea-breeze-driven storms, and dusty atmospheric conditions.

The combined observational–modeling framework enables a robust evaluation of model performance in representing vertical cloud development, hydrometeor distribution, precipitation intensity, and the structure of the melting layer. By comparing MRR 2 retrievals with simulated cloud fields, the study assesses WRF's ability to reproduce key reflectivity signatures and precipitation processes under varying dynamical and aerosol conditions. Particular emphasis is placed on quantifying how aerosol loading modifies cloud microphysical pathways, influences droplet and particle size distributions, and affects observed radar reflectivity patterns.

Results highlight the sensitivity of convective vigor and stratiform organization to both dynamical forcing and aerosol perturbations. Overall, this work demonstrates the added value of integrating MRR-2 observations with high-resolution modeling to improve our understanding of cloud processes and enhance forecasting in complex coastal urban environments like Athens.

0270. Soil Salt Dynamics Under Treated Wastewater and Conventional Water Irrigation in Mediterranean Citrus Orchards: A Continuous Sensor-Based Monitoring Approach

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Keywords: Pore water EC; salt flushing efficiency; treated wastewater

Water scarcity is a critical challenge in Mediterranean regions, where agriculture accounts for the majority of freshwater consumption. Treated wastewater (TWW) is increasingly used by the majority of agricultural farms in Cyprus as an alternative to conventional supplies. However, TWW impact on soil salinity and root zone health in crops sensitive to salt, like citrus orchards, continue to raise concerns. The objective of the current study is to characterize and compare soil salt dynamics of Mandora citrus orchard irrigated with conventional water source (Kouris dam) and TWW in Akrotiri, Limassol, Cyprus, over a 17-month monitoring period (October 2024 – March 2026) using high-resolution in situ soil sensors. Continuous 15-minute measurements of volumetric water content (VWC) and bulk electrical conductivity (bEC) were obtained at 10, 30, and 50 cm depth using TEROS 12 sensors in two plots of mandora citrus orchards: one under a 2-day conventional sprinkler cycle and one under weekly TWW sprinkler irrigation. Pore water EC (pwEC) was derived using the Hillhorst (2000) dielectric mixing model with bulk permittivity estimated via numerical inversion of the Topp (1980) equation. Irrigation events were detected from VWC time series using a prominence-based peak algorithm (prominence = 0.005 m^3/m^{-3}). Salt flushing efficiency was computed as the pwEC reduction within 24 hours post-event relative to a 2-hour pre-event baseline. Contrary to expectations, the conventionally irrigated field exhibited substantially greater root zone salinization. Mean pwEC at 30 cm reached 8–12 mS/cm^{-1} during summer in the conventional field versus 4–5 mS/cm^{-1} in the TWW field. The TWW field showed consistently higher salt flushing efficiency at all depths (W/C ratio: $2.2\times$ at 10 cm, $1.9\times$ at 30 cm, $3.4\times$ at 50 cm). This is attributed to the high-frequency, low-volume conventional schedule generating insufficient leaching fraction to counteract evapotranspiration-driven salt concentration, while weekly TWW applications delivered sufficient per-event volumes to maintain active profile leaching. Irrigation water source EC alone is an insufficient predictor of root zone salinity. Application frequency and per-event volume play a decisive role in salt accumulation or leaching under semi-arid Mediterranean conditions. TWW, when properly scheduled, may be a viable and agronomically safer alternative for

citrus irrigation in coastal Cyprus.

0271. The MAR agreements: A new governance approach for advancing the MAR implementation

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Keywords: Managed Aquifer Recharge, Water Governance, Participatory management, Mediterranean case studies

Arid and semi-arid regions are increasingly grappling with water supply shortages, a problem expected to intensify due to the impacts of climate change. To address this challenge, the paper introduces a new governance approach for advancing the implementation of managed aquifer recharge (MAR): the MAR agreements for benefits sharing. The approach is centered on a participatory and comprehensive methodology to assess and enable the feasibility of MAR as a key climate change adaptation measure. The main components of the methodology include: 1) Designing and demonstrating a broader feasibility mapping framework that combines aquifer-dependent service demand, hydrological assessments of conventional and non-conventional water sources for MAR, and GIS-based multi-criteria decision analysis; 2) Creating a general, stakeholders-centered framework for participatory governance; 3) Assessing the reliability, vulnerability, and resilience of MAR through web-based numerical modelling; 4) Involving a broad range of stakeholders in a participatory, multi-actor process to ensure diverse societal engagement; 5) Establishing location-specific, binding or non-binding and agreements for MAR implementation. This study will present the results from the AGREEMAR project with successful application and demonstration of the approach at different scales across four case studies in Spain, Portugal, Cyprus, and Tunisia. The resulting solutions are anticipated to help close gaps in the hydrological cycle, ensuring optimal water availability for domestic use, food security, and the protection of natural ecosystems throughout the Mediterranean region and beyond.

0272. HeritEdge-AI: A Cultural Heritage–Centered, Audit-Ready Mobile–Web Workflow for Municipal Exposure Inventories and Seismic Vulnerability Mapping

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Keywords: Seismic vulnerability; rapid visual screening; mobile inspection; AI; ESRM20

The preservation of cultural heritage in seismic-prone regions depends on reliable and updatable building-scale exposure data. In historic urban environments, however, municipal inventories are often incomplete, non-standardized, and difficult to audit. Conventional field surveys remain labor-intensive and prone to inconsistencies, limiting their scalability and long-term applicability for risk-informed heritage management. This study introduces HeritEdge [1], a cloud-enabled mobile–web platform designed to support cultural heritage–aware exposure data collection and seismic vulnerability mapping. HeritEdge was developed through project Earthquake Risk plAtform For European Cities Cultural Heritage Protection (ERA4CH), HORIZON-MSCA-2021-SE-01 grant agreement No. 101086280.

The system integrates structured in-situ inspections with geotagged photographic documentation, centralized governance through role-based review and revision tracking, and GIS-based visualization and export. A key component is the incorporation of human-in-the-loop artificial intelligence modules[2,3,4] that assist inspectors by suggesting building attributes—such as structural material, construction period, building use, façade characteristics, and number of storeys—derived from inspection imagery. The platform was deployed in the historic center of Chania (Crete, Greece) and Narni (Italy)), where 243 and 45 buildings respectively were surveyed and AI performance was evaluated on an independent dataset of 163 buildings in Strovolos (Nicosia, Cyprus).

The Chania case study reveals a complex exposure profile in which heritage assets coexist with a dominant stock of mid-to-late 20th-century reinforced concrete buildings. AI-assisted inspection achieved high accuracy in façade material classification (95%), storey estimation (99%, F1 = 0.93), and building use identification (94.4%). Façade opening detection reached 83.3% exact agreement, increasing to 94.4% under tolerance criteria. Construction period classification was more challenging (66.7% accuracy), although most discrepancies occurred between adjacent temporal classes. The platform produces GIS-ready exposure datasets and vulnerability-informed outputs, including damage probability maps aligned with ESRM20 fragility models. HeritEdge-AI provides a scalable and audit-ready workflow that bridges digital inspection, artificial intelligence, and cultural heritage risk management. By integrating AI within a human-supervised process, the platform enhances data consistency while preserving expert judgment. The results demonstrate its potential to support municipal-scale, continuously updated exposure inventories and to enable risk-informed strategies for the protection of cultural heritage.

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0273. Cross-Border Cooperation for Monitoring and Evaluation of Maritime Spatial Planning

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Keywords: Marine Spatial Planning (MSP), Monitoring indicators, Marine observatories, Geospatial database, Remote sensing, Greece, Cyprus

Marine Spatial Planning (MSP) has emerged as a key policy instrument for the sustainable management of marine and coastal areas, aiming to balance environmental protection with economic development and social needs. Within the European Union framework, MSP supports ecosystem-based management and contributes to achieving the objectives of the Blue Economy. However, despite significant progress in the design and implementation of maritime spatial plans, important challenges remain in terms of systematic monitoring, evaluation, and adaptive management, particularly due to the lack of integrated tools, harmonized indicators, and interoperable data systems.

In this context, the THAL-CHOR III project aims to strengthen MSP implementation in Greece and Cyprus through the development of comprehensive methods, tools, and indicators for monitoring and evaluation. The project supports competent authorities by integrating environmental, economic, social, and cultural parameters into a unified decision-support framework. By integrating environmental, economic, social, and cultural parameters into a unified decision-support framework, the project supports competent authorities in making informed and effective decisions related to MSP.

Within this framework, a centralized database will be established based on validated statistical and geospatial datasets from national and international organizations. At the same time, remote sensing technologies will be utilized to monitor key marine environmental parameters, such as biodiversity, sea surface temperature, ocean color, and coastal changes. The integration of these datasets into an updated Geographic Information System (GIS) will enable a comprehensive understanding of marine ecosystems, enhancing adaptive management and the early detection of environmental threats.

Furthermore, the project includes analysis, development, and evaluation of monitoring and evaluation indicators, building on existing national practices as well as best practices from other European Union Member States. The database will support the periodic calculation and updating of these indicators.

The project also foresees the development of MSP observatories in Greece and Cyprus, which will combine data infrastructure within situ coastal monitoring facilities. These observatories will contribute to continuous monitoring and support early warning systems for environmental and maritime activities.

The work presented highlights the progress achieved so far in database development, indicator framework design, Earth Observation data integration, and observatory planning. The results demonstrate the added value of combining geospatial technologies, monitoring infrastructures, and policy-oriented indicators to support more effective and evidence-based MSP in the Eastern Mediterranean.

0274. Urban Heat adaptation through earth observation for supporting planning policies in Cyprus

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Keywords: Earth osbervation, planning, urban heat, Cyprus, policies

Urban areas and cities face increasing challenges in adapting to the impacts of climate change, particularly concerning heat impacts. Urban centers, are particularly vulnerable to extreme heat, leaving millions at risk of heat stress. Previous studies show several heat-related deaths in Europe. Indeed, in the summer of 2022, an estimated 61,672 heat-related deaths occurred, with the highest mortality rates in Italy, Greece, Spain, and Portugal (Ballester et al, 2023). It is important to highlight that one of the important steps of implementing a complete spatial planning study to any region or municipality, a key aspect is to track previous urban heats and existing ones. Earth observation is a key tool to support such studies. A key aspect of achieving of any policy objectives is using knowledge derived from Earth Observation (EO) to enable smarter, faster, and more systemic adaptation. For example, any spatial planner that is interested to adopt the principles of the New European Bauhaus (NEB), it is important to address urban heat impacts through integrating the three NEB pillars of sustainability, beauty and inclusivity in its implementation. Moreover EO can support any EU policy such as the European Green Deal, EU Climate Adaptation Strategy, and European Climate Law. This study shows the results obtained for a global application of Urban heat detection for the four main cities of Cyprus using Sentinel and Landsat image data (e.g. 2003-2025). Adaptation of these results with SWOT analysis as a part of the proposed strategic spatial plan of selected cities. Indeed, an example of the Pafos city is presented as case study by taking into consideration a previous study for 'Raising Awareness of Urban Heat Island' through a structured questionnaire in Pafos High school and the results of Urban heat outcomes from satellite images in a proposed city spatial plan.

0275. Vegetation Dynamics Analysis Using Semantic Classification and the Cyprus Earth Observation Data Cube

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Keywords: Earth observation data cubes; machine learning; remote sensing; vegetation; semantics

The Mediterranean region is among the most climate threatened areas globally, with Cyprus experiencing recurrent droughts, prolonged dry seasons, and progressive land degradation that collectively threaten both agricultural productivity and environmental stability. Systematic, long-term monitoring of vegetation dynamics is therefore essential for evidence-based decision-making towards environmental management. Earth Observation Data Cubes have emerged as a powerful paradigm for handling the increasing volumes of satellite data, enabling standardized, analysis-ready processing at national scale. However, their application to vegetation monitoring in the Mediterranean context remains limited, and the integration of machine learning within such infrastructures for anomaly detection has not been thoroughly explored.

This study presents a comprehensive vegetation dynamics analysis for Cyprus, developed entirely within the Cyprus Earth Observation Data Cube (CEODC). The framework builds on the spatially generalized semantic classification approach introduced for water resource monitoring, extending it to vegetation analysis. Vegetation and water indices derived from Sentinel-2 Level-2A surface reflectance, including the Normalized Difference Vegetation Index, the Normalized Difference Moisture Index, the

Moisture Stress Index, and the Normalized Difference Water Index, serve as proxies for vegetation greenness, canopy water content, and drought stress. Those proxies are fused with three MODIS biophysical products for evapotranspiration and gross primary productivity. All variables are aggregated to monthly time series spanning 2015 to 2025, forming a multi-source dataset that characterizes vegetation status, stress, productivity, and land cover at the island scale.

Anomalous vegetation states are identified through an unsupervised Isolation Forest model, applied independently per calendar month group across years. This stratification ensures that the model learns what is typical for a given month across the historical record, so that flagged observations reflect genuine inter-annual deviations rather than expected seasonal patterns. Each anomalous month is subsequently characterized through z-score profiling of its feature vector relative to the corresponding month group, connecting the statistical detection to a physically interpretable vegetation signal.

Results demonstrate the operational capacity of CEODC to support systematic, multi-source vegetation monitoring at the national scale when integrated with unsupervised machine learning techniques and provide a replicable semantic-based framework that can be directly transferred to other Mediterranean countries where Sentinel-2 Level-2A data are available.

0276. Mapping Potential Carbon Emission Interactions Within Cities: A Comparative Gravity-Based Network Analysis of Hotspot Spatial Structure in Beijing and Shanghai

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Keywords: CO2 emissions; gravity model; collaborative governance

Urban areas account for approximately 70% of global energy consumption and over two-thirds of anthropogenic CO_2 emissions, making cities central to climate mitigation efforts. While a growing body of literature has characterized the spatial distribution of intra-urban carbon emissions at increasingly fine resolutions, the interaction structures among emission hotspots within cities — and their relationship with urban morphology — remain largely unexamined. Existing network studies predominantly operate at the inter-city or regional scale, treating each city as a single node, thereby obscuring the structural complexity of emission linkages within urban systems. This study addresses this gap by constructing and comparing intra-urban carbon emission interaction networks for Beijing and Shanghai — two megacities embodying contrasting spatial configurations — through an integrated gravity-based network framework.

The methodological framework proceeds in three sequential stages. First, high-emission pixels are extracted from a 1 km resolution gridded carbon emission dataset derived from the downscaled GRACED dataset, using a one-dimensional convolutional neural network within the Socioeconomic–Environmental (SEE) framework. Hotspot nodes are then delineated through a two-scale constrained spatial clustering algorithm that distinguishes functionally independent emission clusters while avoiding the artificial merging of adjacent areas. This yields 82 valid nodes for Beijing and 147 for Shanghai. Second, a gravity model is applied to quantify potential spatial interaction strength between each pair of identified nodes, with sensitivity analysis conducted across three distance decay exponents (β = 1.0, 1.5, 2.0) to assess structural robustness. Third, the resulting networks are analyzed through the Gini coefficient of node strength distribution and the continuous core–periphery fitness model, enabling systematic cross-city comparison of spatial polarization and hierarchical organization.

The results reveal structurally divergent interaction patterns corresponding to each city's spatial form. Beijing's network exhibits pronounced centralization, with a Gini coefficient of 0.6241 on effective links and a core–periphery fitness of ρ = 0.6874, confirming a hierarchical organization in which tourism, commercial, and transport hub nodes anchored within the inner ring dominate interaction potentials,

while peripheral nodes remain structurally subordinate. Shanghai, by contrast, displays a dispersed and horizontally coupled configuration, with a Gini coefficient of 0.2314 and ρ = 0.3739, wherein multiple functionally differentiated nodes operate as structurally parallel components without a single dominant core. Notably, when analytically extended to encompass adjacent Yangtze River Delta municipalities, cross-boundary interaction potentials between Shanghai and industrial nodes in Kunshan and Suzhou prove comparable in magnitude to certain intra-urban linkages, underscoring the role of regional functional integration in shaping metropolitan emission networks. Spearman rank correlations consistently exceeding 0.96 across all β values confirm that these structural findings reflect intrinsic properties of spatial emission configuration rather than modeling artifacts.

These findings carry both theoretical and policy significance. Theoretically, this study extends the application domain of the gravity model from the interurban to the intra-urban scale and enriches classical monocentric urban theory — notably the Alonso–Muth–Mills framework — by demonstrating that the degree of spatial polarization in carbon emission interaction networks is positively associated with urban monocentricity, mediated by hierarchical functional organization rather than emission magnitude alone. Methodologically, the integrated hotspot–gravity–network framework offers a transferable analytical approach for intra-urban emission interaction research. From a governance perspective, the findings advocate for a paradigm shift in urban carbon management from ”spatial unit control” toward ”spatial linkage regulation,” with differentiated strategies: targeted node- and corridor-level interventions in hierarchically structured monocentric cities, and systemic cross-jurisdictional coordination in polycentric metropolitan regions.

0277. Mapping Greece’s Forests: The National Satellite Space Project (GNSSP)

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Keywords: Greek National Satellite Space Project (GNSSP); Earth Observation; Cubesats; Forest species mapping; Wildland fuels mapping

Sat4Φorest is the forest monitoring service developed under Axis 3 of the Greek National Satellite Space Project (GNSSP), an initiative of the Ministry of Digital Governance aimed at deploying a fully Greek owned microsatellite constellation of 13 satellites equipped with thermal, multispectral, hyperspectral, and SAR sensors, enabling near daily coverage of Greece. Sat4Φorest is one of five thematic services of the programme and focuses on the systematic monitoring of forest ecosystems using Earth Observation data.

Two of the service’s modules provide systematic national scale forest mapping. The Forest Types Mapping (FTM) module identifies the most important forest species, while the Wildland Fuel Mapping (WFM) module produces wildland fuel type and fuel model maps. Both services use yearly time series of monthly cloud free composite mosaics. In operational mode, inputs are provided by the optical micro satellites (multispectral and hyperspectral) of the so called Axis 2 component of GNSSP. Monthly multispectral and quarterly hyperspectral cloud free composites at 5m spatial resolution are derived from the original images. The FTM module employs a hierarchical classification procedure based on multiple Random Forest (RF) models to produce detailed forest species maps and a Tree Cover Density (TCD) product at 5m pixel size. These outputs feed into the WFM module, which uses additional RF models to derive fuel type maps across Greece. Fuel types follow the FirEUrisk scheme (a consistent pan-European fuel type scheme recently developed), whereas a fuel model map according to the Scott and Burgan Fire Behavior Fuel Models (FBFM40) scheme is also produced. All products are generated

twice a year, before and after the fire season.

A simplified version of the service, based on cloud free mosaics from Sentinel 2 fused with Sentinel 1, has produced a historical archive of yearly products for 2017–2025 at 10m resolution. Additionally, a variant currently uses PlanetScope analytical monthly basemaps to derive the 5m products semi operationally until Axis 2 imagery becomes available. Validation is performed using independent datasets from the Land Use/Cover Area frame Survey (LUCAS) and the Greek National Forest Inventory (NFI). All products achieve an overall accuracy exceeding 80%. These validated, high resolution services provide critical operational support for pre fire management, fire behavior simulation, and conservation planning across Greece.

The Sat4Φorest project is being carried out under an ESA Contract in the frame of the Greek National Satellite Space Project. The Project: Small-Satellites (Measure ID 16855) is implemented by the Hellenic Ministry of Digital Governance with the European Space Agency (ESA) Assistance in the Management and Implementation. The project is part of the National Recovery and Resilience Plan 'Greece 2.0', which is funded by the Recovery and Resilience Facility (RRF), core programme of the European Union-NextGenerationEU.

0278. Interannual Dynamics of Vegetation and Environmental Quality in Mediterranean Coastal Ecosystems Using Remote Sensing Indices

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Keywords: Remote sensing, vegetation indices, environmental quality, Mediterranean ecosystems, interannual variability

Mediterranean ecosystems are highly sensitive to environmental pressures, including climate variability, land-use change, and increasing anthropogenic activity. These pressures can significantly affect vegetation dynamics and overall ecosystem condition, particularly in regions characterized by seasonal climatic extremes. Within this context, the EU-funded TOPIO Project aims to develop tools and methodologies for monitoring and assessing ecosystem condition and supporting sustainable management across diverse environmental settings.

This study investigates seasonal and interannual dynamics of vegetation and environmental quality in two case study areas of the TOPIO Project: Falasarna (Crete, Greece) and the Akamas Peninsula (Cyprus). These regions represent ecologically important Mediterranean landscapes with differing levels of anthropogenic influence, making them suitable for comparative analysis. Remote sensing techniques were employed to derive four widely used indices: The Normalized Difference Vegetation Index (NDVI), the Soil-Adjusted Vegetation Index (SAVI), the Enhanced Vegetation Index (EVI), and the Remote Sensing Ecological Index (RSEI). Each index captures distinct aspects of vegetation condition and ecosystem quality, enabling a more comprehensive assessment when used in combination. All processing and analysis were conducted using Google Earth Engine, utilizing Sentinel-2 imagery as the primary data source. Land use information was derived from European Space Agency datasets and complemented with custom classification and analysis to better represent local conditions. Satellite data were analysed for all seasons (autumn, winter, spring, summer) over a six-year period (2020–2025). Seasonal datasets were subsequently integrated into annual composites, enabling robust interannual analysis while minimizing the influence of seasonal variability. This approach allows for the identification of longer-term trends and reduces noise associated with short-term fluctuations. To further enhance the assessment of environmental quality, Principal Component Analysis (PCA) was applied to the set of indices, enabling dimensionality reduction and the integration of multiple environmental variables into a composite representation of ecosystem condition. Statistical analysis was performed using zonal

statistics within a GIS environment, enabling spatially explicit comparisons across land use classes and between the two study areas. The results reveal distinct differences in ecosystem response, with Akamas exhibiting relatively stable ecological conditions over time, while Falasarna shows greater variability. These differences are likely linked to variations in land-use intensity, environmental pressures, and local climatic conditions.

The combined use of multiple vegetation and ecological indices, together with advanced statistical and geospatial analysis, allows for a more comprehensive evaluation of ecosystem condition compared to single-index approaches, particularly in heterogeneous Mediterranean environments. This study highlights the value of integrated, multi-temporal remote sensing methodologies within the framework of the TOPIO Project and contributes to improved long-term monitoring, environmental assessment, and decision-making strategies for Mediterranean ecosystems.

This research was funded by the European Union's Horizon Europe MSCA Staff Exchanges 2022 (HORIZON-MSCA-2022-SE-01), project "Towards Democratic Landscape Observation Through Geoinformatics and Public Participation (TOPIO)", under grant agreement No 101131109.

0279. Climate-Resilient Protection of Cultural Heritage on Unstable Terrain: The case study of Choirokoitia, Cyprus

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Keywords: Cultural heritage, climate change, Earth observation, InSAR, UAV photogrammetry, risk assessment, decision support, Choirokoitia, Cyprus

Climate change is increasing the exposure of cultural heritage sites to compound stressors, including heat, intense rainfall, and seismic activity, which interact with local geology to accelerate deterioration and trigger sudden failures. This study presents Choirokoitia, a UNESCO World Heritage Neolithic settlement in Cyprus, as a pilot case for protecting heritage on unstable terrain through innovative, heritage-compatible interventions that link monitoring, modelling, decision support, and on-site action.

The TRIQUETRA approach integrates multi-source Earth observation and in situ data with targeted physical mitigation measures. Satellite InSAR products from the European Ground Motion Service, UAV photogrammetry, point-cloud change detection, and on-site environmental sensing are integrated within a digital modelling framework to identify deformation hotspots and relate hazard dynamics to climatic triggers. Local seismic response analysis further refines regional hazard estimates and highlights zones of amplified ground motion that should be prioritised for preventive conservation and long-term monitoring. These risk outputs are translated into management actions through the TRIQUETRA decision-support workflow, which applies risk-severity indicators and a mitigation-selection module that ranks measures according to effectiveness, feasibility, and compatibility with heritage values.

Protection is implemented through low-impact, site-specific interventions designed to reduce rockfall and landslide risk while preserving visitor access. These measures include selective removal of progressively unstable blocks, mechanical stabilisation of retainable fractured rock using bolts or anchors, local surface support where small fragments may detach, crack treatment to reduce water infiltration, and drainage improvements to lower pore pressure and rainfall-driven triggering. Public engagement also forms part of the intervention strategy. A visitor-oriented augmented reality application, supported by QR markers, strengthens site monitoring and enables crowdsourced photo reporting that feeds back into the site model to flag possible climate-related damage.

The results show how digital tools and Earth observation can support timely, proportionate interventions to safeguard cultural heritage from the pressures of natural hazards. The Department of Antiquities of Cyprus, in collaboration with the ERATOSTHENES Centre of Excellence through the EXCELSIOR

Project, will continue monitoring the site during and after the proposed mitigation actions.

0280. Enhancing Earth Observation Capacity in Cyprus with a 9 m S/X/Ka-Band Antenna

Kyriacos Themistocleous[1,4], Nikos Christoforou[1,2], Egbert.Schwarz[3], Christos Dimou[1], Valentinos Evripidou[1], Neal Beckett[1], Sotiris Alexandrou[2], Costas Agrotis[2], Gunter Schreier[1,3]

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Keywords: Earth Observation, S/X/Ka Band Ground Station, Remote Sensing, Cyprus, Infrastructure Development, Ground Segment Operations, security applications

The Eratosthenes Centre of Excellence, in collaboration with Cyta and under the operational guidance of DLR, has established a 9 m S/X/Ka-band Earth Observation ground station in Cyprus. This initiative marks a major step forward in the region's ability to support satellite communications, data reception, and near-real-time Earth Observation applications. The antenna serves as critical infrastructure for scientific research, environmental monitoring, security, and commercial use, improving regional and international access to EO data.

The ground station is housed in high-quality, high-security premises designed to meet strict operational and security requirements, ensuring uninterrupted functionality under both routine and extreme conditions. A dual-redundant fiber link has been implemented to provide high-speed, secure, and resilient data transmission between the ground station and downstream processing centers. This redundancy is vital for preventing data loss, maintaining high availability, and enabling seamless integration with international EO networks.

This strategic initiative strengthens Cyprus's role as a regional hub for satellite data reception and dissemination while promoting scientific collaboration, technology transfer, and industry partnerships. It also enhances the region's capacity to support missions related to climate monitoring, disaster response, maritime security, and environmental sustainability, in line with global priorities in space and Earth Observation applications.

As part of Cyprus's national strategy to strengthen the use of space assets in support of civil protection and security applications, and to address a specific national capability gap, the consortium of the Eratosthenes Centre of Excellence, Cyta, and DLR is establishing a near-real-time data reception service. This service, developed under the ESA project Enabling Cyprus for the European Earth Observation Ground Segment Operation, Contract No. 4000150577/25/NL/MH/yd, will deliver maritime security analysis in line with user requirements.

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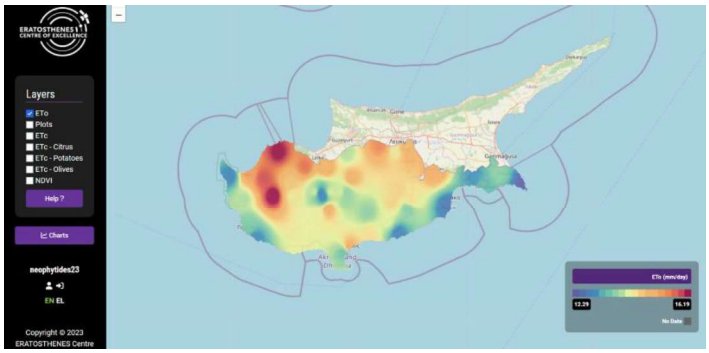

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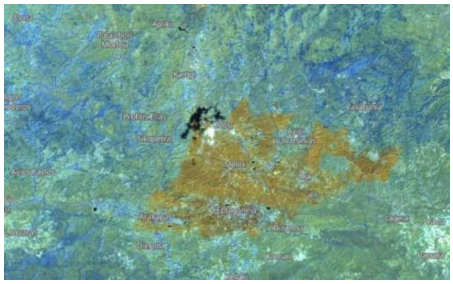

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