e-newsletter

Navigator
Copernicus Earth Observation Big Data for Cultural Heritage

This project is co-funded by the Republic of Cyprus and the Structural funds of the European Union for Cyprus under the Research and Innovation Foundation grant agreement EXCELLENCE/0918/0052, Project title: Copernicus Earth Observation Big Data for Cultural Heritage NAVIGATOR

Navigator in brief

Navigator
Copernicus Earth Observation Big Data for Cultural Heritage

The NAVIGATOR project seeks to exploit **Earth Observation** datasets in addressing **Cultural Heritage** needs, capitalising on the **European Copernicus space program**.

The NAVIGATOR project is implemented under the "**Excellence Hubs**" Programme within the "RESTART 2016-2020" funding framework for Research, Technological Development and Innovation (RTDI) administered by Cyprus's Research and Innovation Foundation. Programme "Excellence Hubs" aims at promoting, bottom-up, scientific excellence through funding frontier research projects, possibly intersectoral and interdisciplinary, in cutting-edge fields.

The NAVIGATOR proposal was ranked 2nd (score 14.82/15) out of a total of 124 proposals submitted under the "Physical Sciences and Engineering" scientific area. NAVIGATOR project has a duration of 24 months, starting as from October 2019, with an overall budget of €250k.

NAVIGATOR aims to maximise the impact of Copernicus Earth Observation data for Cultural Heritage, providing innovative solutions and methodologies.

This project is being co-funded by the Republic of Cyprus and the Structural funds of the European Union in Cyprus, under the Research and Innovation Foundation grant agreement EXCELLENCE/0918/0052

Research Promotion Foundation
2016-2020 RESTART SEARCH
Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης
Κυπριακή Δημοκρατία
Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο

Navigator consortium

Navigator
Copernicus Earth Observation Big Data for Cultural Heritage

Project coordination: Cyprus University of Technology (CUT)

The Cyprus University of Technology (CUT- https://www.cut.ac.cy) is a public university founded in 2003, and one of the three state universities in Cyprus. CUT is a dynamic university with six leading schools/faculties and 10 academic departments, able to offer education and high-level research, in primary branches of science and applied technology both in Undergraduate and Postgraduate (MA, MSc, PhD) levels. University research activities are normally accomplished through funding secured from two major sources: from the University's state funded budget and from different organizations, entities or private sources at national, European and international level. Strengthening of the research management support and infrastructure, aiming at securing externally funded projects, is another major objective of the University. Moreover, the University has adopted principles in relation to research which conform with the European Union's declarations relating to the creation of the European Research Area (ERA).

Cyprus University of Technology

Personnel involved:

Prof. Diofantos Hadjimitsis
(Project Coordinator)

Dr. Athos Agapiou
(Principal Investigators)

Dr. Vasiliki Lysandrou
(Principal Investigators)

Navigator consortium

Navigator
Copernicus Earth Observation Big Data for Cultural Heritage

German Aerospace Center (DLR)

Foreign Research Organisation: German Aerospace Center (DLR)

The German Aerospace Center (DLR - https://www.dlr.de) is Germany's national research centre for aeronautics and space. Its research in aeronautics, space, energy, transport, defence and security is integrated into national and international cooperative ventures. The German Remote Sensing Data Center (DFD) of DLR conducts research and developments in the domain of Earth Observation application and earth sciences. The research and development work being undertaken by the Geo-Risks and Civil Security department of the DFD has the goal of developing thematically relevant information products based on Earth Observation data, integrating them into IT systems, and operating and continuously optimizing customized user services. The focus is on supporting the entire disaster management cycle in cases of environmental and natural threats, humanitarian crisis situations, and civil security emergencies.

Personnel involved:
Dr.-Ing. Simon Manuel Plank (Principal Investigator)

External Quality Assurance Board:

Dr. Rosa Lasaponara, National Research Council of Italy

National Research Council of Italy

Dr. Apostolos Sarris, University of Cyprus

University of Cyprus

Supporters:
Department of Electronic Communications, Ministry of Transport, Communications and Works, Republic of Cyprus

DEC
DEPARTMENT OF ELECTRONIC COMMUNICATIONS

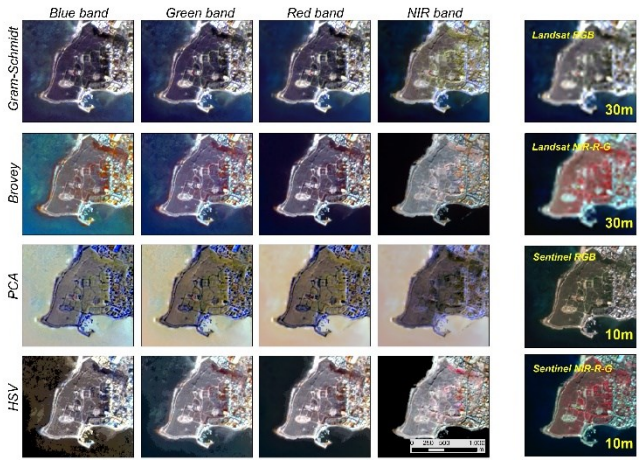
Navigator overview

Navigator
Copernicus Earth Observation Big Data for Cultural Heritage

The NAVIGATOR project focuses on improving and developing Earth Observation methodologies and strategies for Cultural Heritage applications. Towards this direction, the Copernicus Earth Observation big data technologies and cloud platforms play a vital role in addressing existing problems of built heritage management.

The use of Earth Observation and ground remote sensing non-contact technologies are suitable to support the development of an integrated approach to data usage for better decision making related to preventive interventions and for supporting site management and sustainable exploitation of its cultural assets.

The broad spectra of remote sensing techniques provide the ideal platform to undertake a wide range of practical, cost-efficient and easily programmable studies, not easily acquired with other tools. In the case of cultural landscape sites, these techniques offer the opportunity to ensure repeated monitoring of multiple parameters, in a macro and micro spatial scale, offering European broad comparisons and contrasts.



Archaeological site of Nea Paphos, Cyprus
(image source: 10.3390/rs12030579)

Navigator implementation

Copernicus Earth Observation Big Data for Cultural Heritage

The NAVIGATOR project had a duration of 24 months, starting in October 2019.

During this period, the following six work packages (WPs) were accomplished:

WP1. Project Management

WP2. Dissemination Activities

WP3. An Earth Observation approach for Cultural Heritage sites

WP4. Application of Earth Observation Copernicus Data for endangered Cultural Heritage sites

WP5. Development of novel methodologies for exploitation of Copernicus Data

WP6. Copernicus Services expansion for Cultural Heritage needs

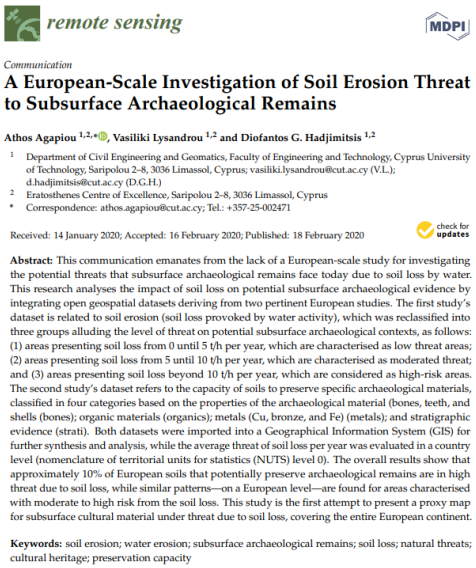
http://web.cut.ac.cy/navigator/

Scientific dissemination

Navigator

Copernicus Earth Observation Big Data for Cultural Heritage

- *Journal publications*
- *Scientific conferences*
- *Academic lectures*
- *Book chapters*



remote sensing

MDPI

Communication

A European-Scale Investigation of Soil Erosion Threat to Subsurface Archaeological Remains

Athos Agapiou [1,2,*], Vasiliki Lysandrou [1,2] and Diofantos G. Hadjimitsis [1,2]

[1] Department of Civil Engineering and Geomatics, Faculty of Engineering and Technology, Cyprus University of Technology, Saripolou 2–8, 3036 Limassol, Cyprus; vasiliki.lysandrou@cut.ac.cy (V.L.); d.hadjimitsis@cut.ac.cy (D.G.H.)
[2] Eratosthenes Centre of Excellence, Saripolou 2–8, 3036 Limassol, Cyprus
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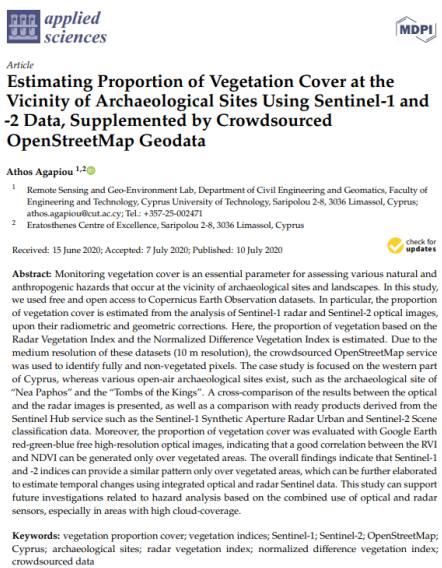
check for updates

Abstract: This communication emanates from the lack of a European-scale study for investigating the potential threats that subsurface archaeological remains face today due to soil loss by water. This research analyses the impact of soil loss on potential subsurface archaeological evidence by integrating open geospatial datasets deriving from two pertinent European studies. The first study's dataset is related to soil erosion (soil loss provoked by water activity), which was reclassified into three groups alluding the level of threat on potential subsurface archaeological contexts, as follows: (1) areas presenting soil loss from 0 until 5 t/h per year, which are characterised as low threat areas; (2) areas presenting soil loss from 5 until 10 t/h per year, which are characterised as moderated threat; and (3) areas presenting soil loss beyond 10 t/h per year, which are considered as high-risk areas. The second study's dataset refers to the capacity of soils to preserve specific archaeological materials, classified in four categories based on the properties of the archaeological material (bones, teeth, and shells (bones); organic materials (organics); metals (Cu, bronze, and Fe) (metals); and stratigraphic evidence (strati). Both datasets were imported into a Geographical Information System (GIS) for further synthesis and analysis, while the average threat of soil loss per year was evaluated in a country level (nomenclature of territorial units for statistics (NUTS) level 0). The overall results show that approximately 10% of European soils that potentially preserve archaeological remains are in high threat due to soil loss, while similar patterns—on a European level—are found for areas characterised with moderate to high risk from the soil loss. This study is the first attempt to present a proxy map for subsurface cultural material under threat due to soil loss, covering the entire European continent.

Keywords: soil erosion; water erosion; subsurface archaeological remains; soil loss; natural threats; cultural heritage; preservation capacity



applied sciences

MDPI

Article

Estimating Proportion of Vegetation Cover at the Vicinity of Archaeological Sites Using Sentinel-1 and -2 Data, Supplemented by Crowdsourced OpenStreetMap Geodata

Athos Agapiou [1,2]

[1] Remote Sensing and Geo-Environment Lab, Department of Civil Engineering and Geomatics, Faculty of Engineering and Technology, Cyprus University of Technology, Saripolou 2-8, 3036 Limassol, Cyprus; athos.agapiou@cut.ac.cy; Tel.: +357-25-002471
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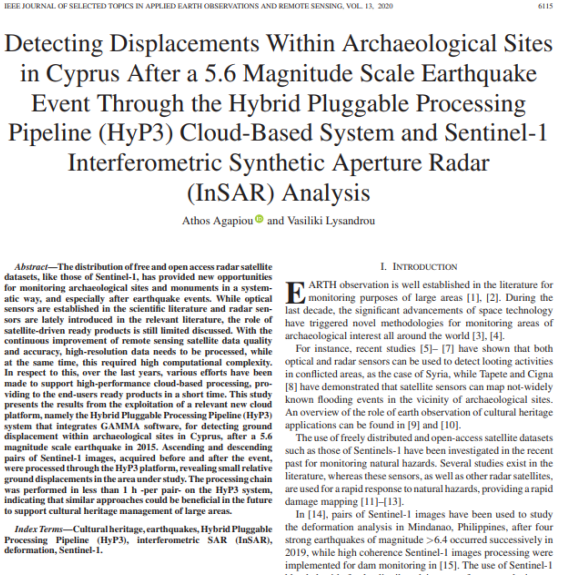
Abstract: Monitoring vegetation cover is an essential parameter for assessing various natural and anthropogenic hazards that occur at the vicinity of archaeological sites and landscapes. In this study, we used free and open access to Copernicus Earth Observation datasets. In particular, the proportion of vegetation cover is estimated from the analysis of Sentinel-1 radar and Sentinel-2 optical images, upon their radiometric and geometric corrections. Here, the proportion of vegetation based on the Radar Vegetation Index and the Normalized Difference Vegetation Index is estimated. Due to the medium resolution of these datasets (10 m resolution), the crowdsourced OpenStreetMap service was used to identify fully and non-vegetated pixels. The case study is focused on the western part of Cyprus, whereas various open-air archaeological sites exist, such as the archaeological site of "Nea Paphos" and the "Tombs of the Kings". A cross-comparison of the results between the optical and the radar images is presented, as well as a comparison with ready products derived from the Sentinel Hub service such as the Sentinel-1 Synthetic Aperture Radar Urban and Sentinel-2 Scene classification data. Moreover, the proportion of vegetation cover was evaluated with Google Earth red-green-blue free high-resolution optical images, indicating that a good correlation between the RVI and NDVI can be generated only over vegetated areas. The overall findings indicate that Sentinel-1 and -2 indices can provide a similar pattern only over vegetated areas, which can be further elaborated to estimate temporal changes using integrated optical and radar Sentinel data. This study can support future investigations related to hazard analysis based on the combined use of optical and radar sensors, especially in areas with high cloud-coverage.

Keywords: vegetation proportion cover; vegetation indices; Sentinel-1; Sentinel-2; OpenStreetMap; Cyprus; archaeological sites; radar vegetation index; normalized difference vegetation index; crowdsourced data



Detecting Displacements Within Archaeological Sites in Cyprus After a 5.6 Magnitude Scale Earthquake Event Through the Hybrid Pluggable Processing Pipeline (HyP3) Cloud-Based System and Sentinel-1 Interferometric Synthetic Aperture Radar (InSAR) Analysis

Athos Agapiou and Vasiliki Lysandrou

***Abstract*—The distribution of free and open access radar satellite datasets, like those of Sentinel-1, has provided new opportunities for monitoring archaeological sites and monuments in a systematic way, and especially after earthquake events. While optical sensors are established in the scientific literature and radar sensors are lately introduced in the relevant literature, the role of satellite-driven ready products is still limited discussed. With the continuous improvement of remote sensing satellite data quality and accuracy, high-resolution data needs to be processed, while at the same time, this required high computational complexity. In respect to this, over the last years, various efforts have been made to support high-performance cloud-based processing, providing to the end-users ready products in a short time. This study presents the results from the exploitation of a relevant new cloud platform, namely the Hybrid Pluggable Processing Pipeline (HyP3) system that integrates GAMMA software, for detecting ground displacement within archaeological sites in Cyprus, after a 5.6 magnitude scale earthquake in 2015. Ascending and descending pairs of Sentinel-1 images, acquired before and after the event, were processed through the HyP3 platform, revealing small relative ground displacements in the area under study. The processing chain was performed in less than 1 h -per pair- on the HyP3 system, indicating that similar approaches could be beneficial in the future to support cultural heritage management of large areas.**

***Index Terms*—Cultural heritage, earthquakes, Hybrid Pluggable Processing Pipeline (HyP3), interferometric SAR (InSAR), deformation, Sentinel-1.**

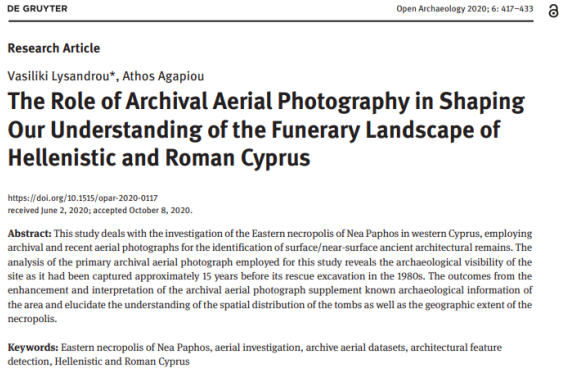
I. Introduction

EARTH observation is well established in the literature for monitoring purposes of large areas [1], [2]. During the last decade, the significant advancements of space technology have triggered novel methodologies for monitoring areas of archaeological interest all around the world [3], [4].

For instance, recent studies [5]– [7] have shown that both optical and radar sensors can be used to detect looting activities in conflicted areas, as the case of Syria, while Tapete and Cigna [8] have demonstrated that satellite sensors can map not-widely known flooding events in the vicinity of archaeological sites. An overview of the role of earth observation of cultural heritage applications can be found in [9] and [10].

The use of freely distributed and open-access satellite datasets such as those of Sentinels-1 have been investigated in the recent past for monitoring natural hazards. Several studies exist in the literature, whereas these sensors, as well as other radar satellites, are used for a rapid response to natural hazards, providing a rapid damage mapping [11]–[13].

In [14], pairs of Sentinel-1 images have been used to study the deformation analysis in Mindanao, Philippines, after four strong earthquakes of magnitude >6.4 occurred successively in 2019, while high coherence Sentinel-1 images processing were implemented for dam monitoring in [15]. The use of Sentinel-1



DE GRUYTER Open Archaeology 2020; 6: 417–433

Research Article

Vasiliki Lysandrou*, Athos Agapiou

The Role of Archival Aerial Photography in Shaping Our Understanding of the Funerary Landscape of Hellenistic and Roman Cyprus

https://doi.org/10.1515/opar-2020-0117
received June 2, 2020; accepted October 8, 2020.

Abstract: This study deals with the investigation of the Eastern necropolis of Nea Paphos in western Cyprus, employing archival and recent aerial photographs for the identification of surface/near-surface ancient architectural remains. The analysis of the primary archival aerial photograph employed for this study reveals the archaeological visibility of the site as it had been captured approximately 15 years before its rescue excavation in the 1980s. The outcomes from the enhancement and interpretation of the archival aerial photograph supplement known archaeological information of the area and elucidate the understanding of the spatial distribution of the tombs as well as the geographic extent of the necropolis.

Keywords: Eastern necropolis of Nea Paphos, aerial investigation, archive aerial datasets, architectural feature detection, Hellenistic and Roman Cyprus

Journal publications

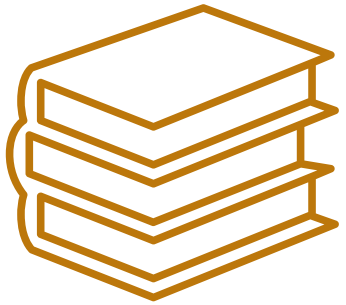
Navigator
Copernicus Earth Observation Big Data for Cultural Heritage

1. Agapiou A., Lysandrou V. Hadjimitsis D.G. Earth Observation Contribution to Cultural Heritage Disaster Risk Management: Case Study of Eastern Mediterranean Open-Air Archaeological Monuments and Sites. Remote Sens. 2020, 12, 1330, https://www.mdpi.com/2072-4292/12/8/1330
2. Agapiou A. Vegetation Extraction Using Visible-Bands from Openly Licensed Unmanned Aerial Vehicle Imagery. Drones 2020, 4, 27, https://www.mdpi.com/2504-446X/4/2/27
3. Agapiou A., Lysandrou, V. Hadjimitsis D.G. A European-Scale Investigation of Soil Erosion Threat to Subsurface Archaeological Remains. Remote Sens. 2020, 12, 675, https://www.mdpi.com/2072-4292/12/4/675
4. Agapiou A. Estimating Proportion of Vegetation Cover at the Vicinity of Archaeological Sites Using Sentinel-1 and -2 Data, Supplemented by Crowdsourced OpenStreetMap Geodata. Appl. Sci. 2020, 10, 4764, https://www.mdpi.com/2076-3417/10/14/4764
5. Agapiou A., Lysandrou V. Detecting displacements within archaeological sites in Cyprus after a 5.6 magnitude scale earthquake event through the Hybrid Pluggable Processing Pipeline (HyP3) cloud-based system and Sentinel-1 Interferometric Synthetic Aperture Radar (InSAR) analysis, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2020, 13, 6115-6123, 10.1109/JSTARS.2020.3028272, https://ieeexplore.ieee.org/abstract/document/9210771
6. Lysandrou V., Agapiou A., The role of aerial photography in shaping our understanding of the funerary landscape of Hellenistic and Roman Cyprus, Open Archaeology, 2020, 6, 417-433, https://www.degruyter.com/document/doi/10.1515/opar-2020-0117/html
7. Agapiou A., Damage Proxy Map of the Beirut Explosion on 04th August 2020 as Observed from the Copernicus Sensors, Sensors, 20(21), 6382; https://doi.org/10.3390/s20216382, https://www.mdpi.com/1424-8220/20/21/6382
8. Agapiou A., UNESCO World Heritage properties in changing and dynamic environments: change detection methods using optical and radar satellite data. Heritage Science 2021, 9, 64. https://doi.org/10.1186/s40494-021-00542-z, https://heritagesciencejournal.springeropen.com/articles/10.1186/s40494-021-00542-z
9. Agapiou A. Multi-Temporal Change Detection Analysis of Vertical Sprawl over Limassol City Centre and Amathus Archaeological Site in Cyprus during 2015–2020 Using the Sentinel-1 Sensor and the Google Earth Engine Platform. Sensors 2021, 21, 1884. https://doi.org/10.3390/s21051884, https://www.mdpi.com/1424-8220/21/5/1884
10. Agapiou A., Land Cover Mapping from Colorized CORONA Archived Greyscale Satellite Data and Feature Extraction Classification, Land, 2021, *10*, 771. https://doi.org/10.3390/land10080771, https://www.mdpi.com/2073-445X/10/8/771

Conferences – Book Chapter

Navigator
Copernicus Earth Observation Big Data for Cultural Heritage

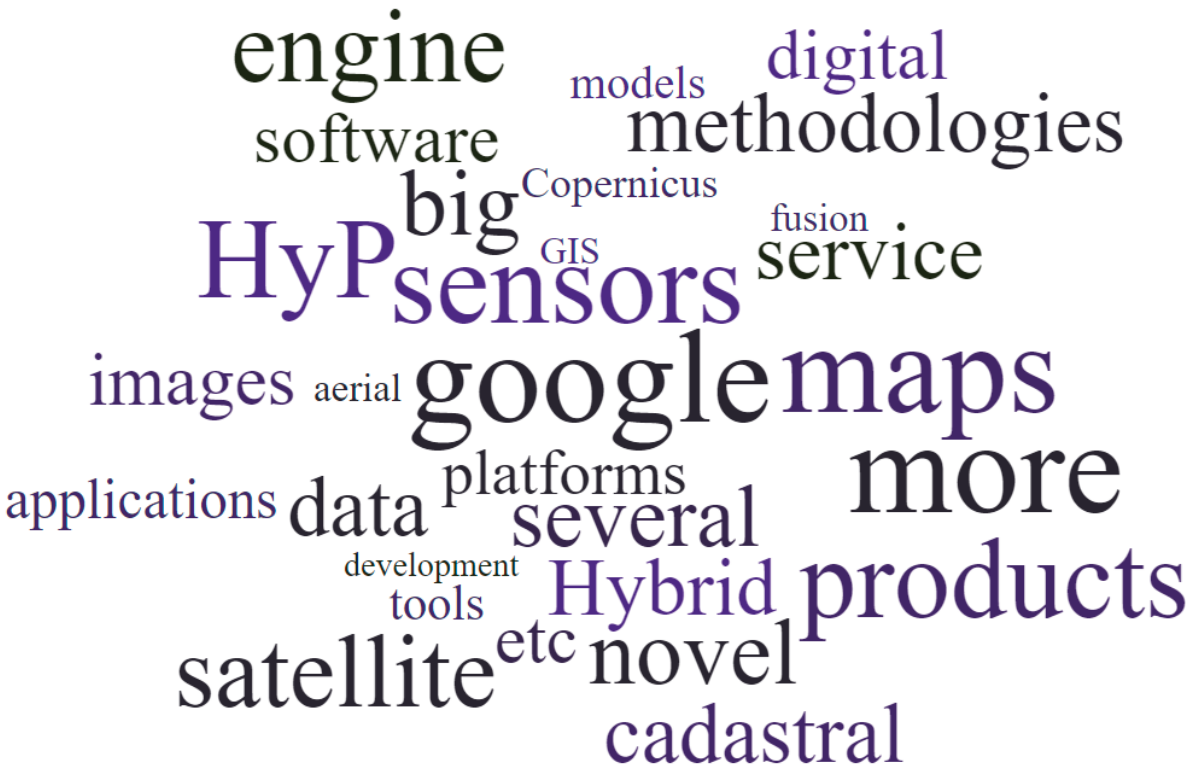
1. Agapiou A., Computational approaches to archaeological site detection and monitoring, A one day workshop to be held at the McDonald Institute for Archaeological Research, University of Cambridge 29 February 2020
2. Agapiou A., Lysandrou V., Cuca B., Copernicus earth observations for cultural heritage, Proceedings of the joint international event, 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021.
3. Agapiou A., Lysandrou V., Change Detection Analysis Using Multi-Source Satellite Imageries and Big Data Cloud Platform for Supporting Cultural Heritage Disaster Risk Management Cycle, Computer Applications in Archaeology 2021: Digital Crossroads, 14-18 June, Limassol, Cyprus.



4. Vella M.-A., Sarris A., Agapiou A., Lysandrou V., Sensing the Cultural Heritage from above. The Case from Cyprus, 2021, SAGA COST Book (under publication)
5. Agapiou A., Lysandrou V., Remote sensing applications for monitoring natural hazards over cultural heritage sites in Cyprus. In Applications of Remote Sensing on the Natural Hazards in the MENA Region (Ed. AlSaud), Springer

ΚΤΙΣΙΣ
Ιδρυματικό Καταθετήριο
Τεχνολογικού Πανεπιστημίου Κύπρου

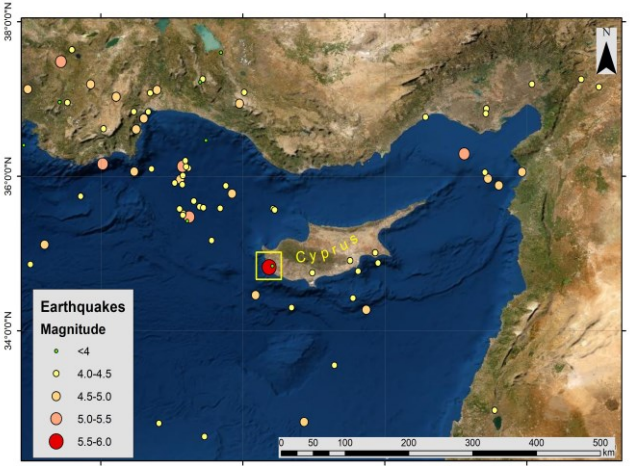
Scientific outputs

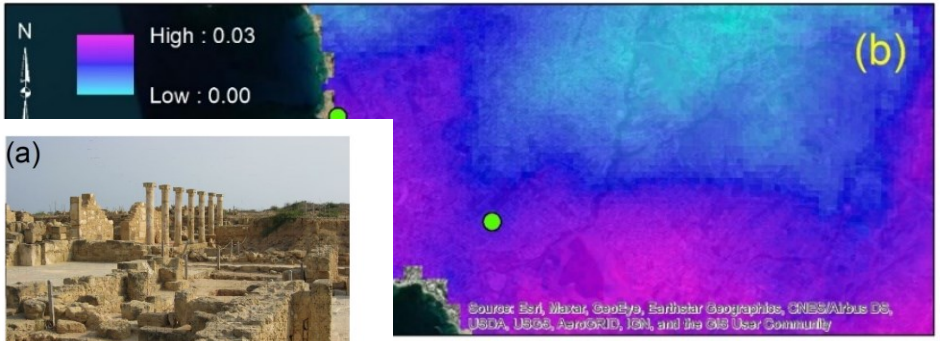


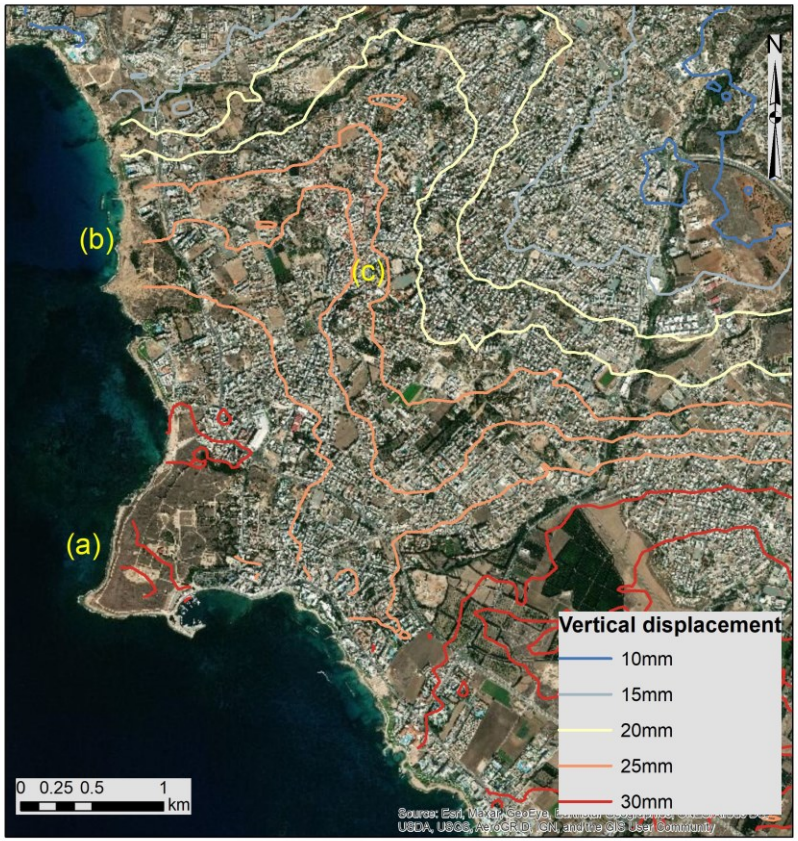
Hybrid applications; development of novel methodologies; fusion of geo-datasets: satellite images and products (several sensors, Copernicus products, etc.) & aerial photographs & conventional cadastral maps & digital elevation models & more… with tools, software, big data platforms (GIS, google engine, HyP3, etc., in the service of

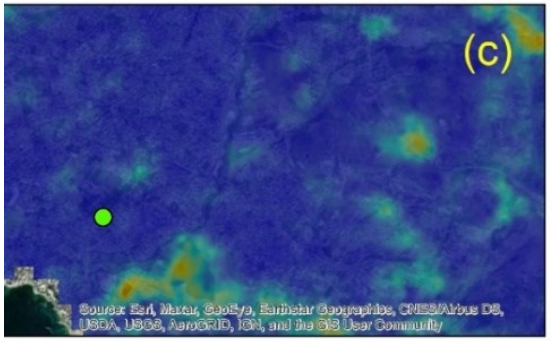
Cultural Heritage & Archaeological Research

Scientific outputs



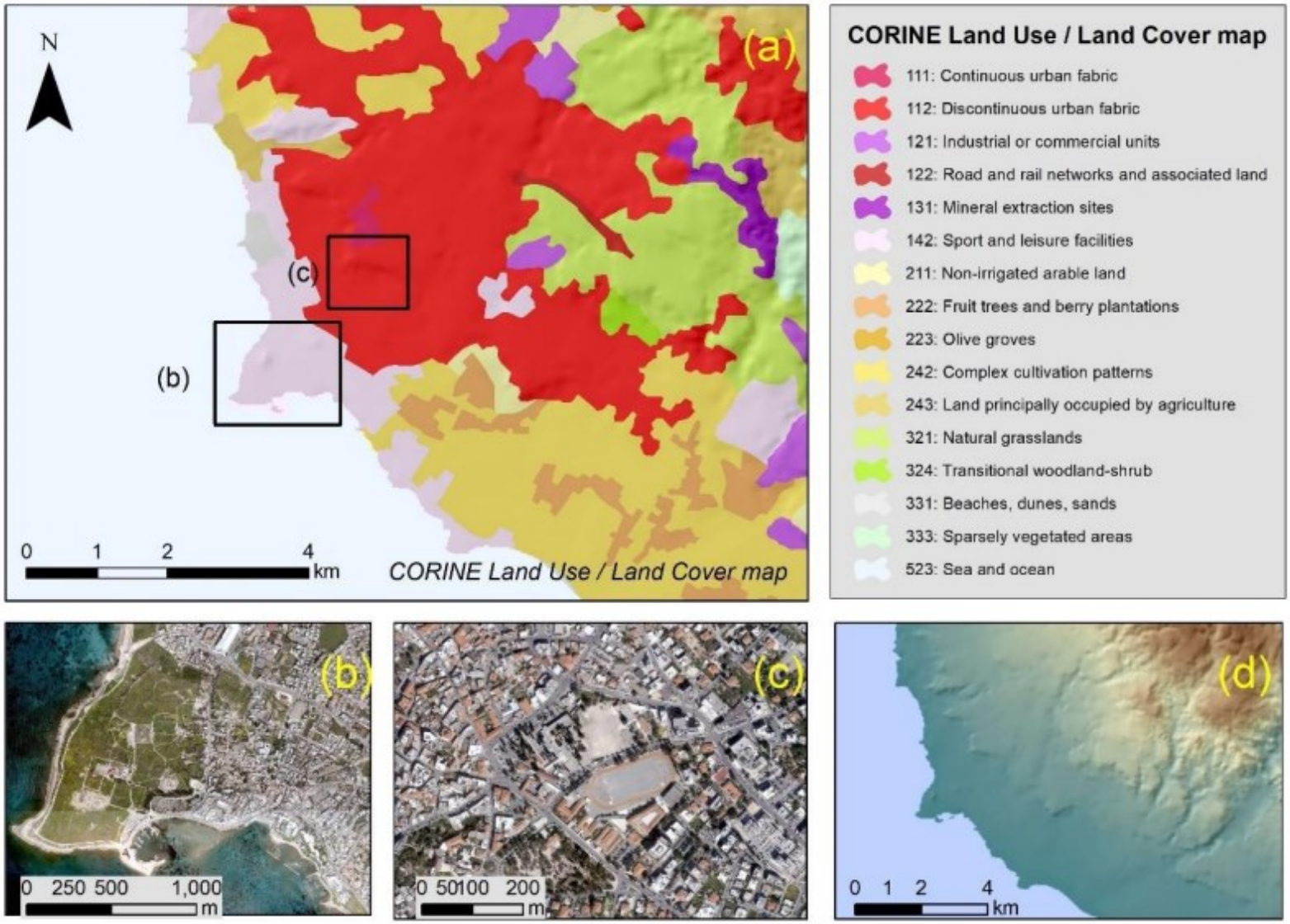






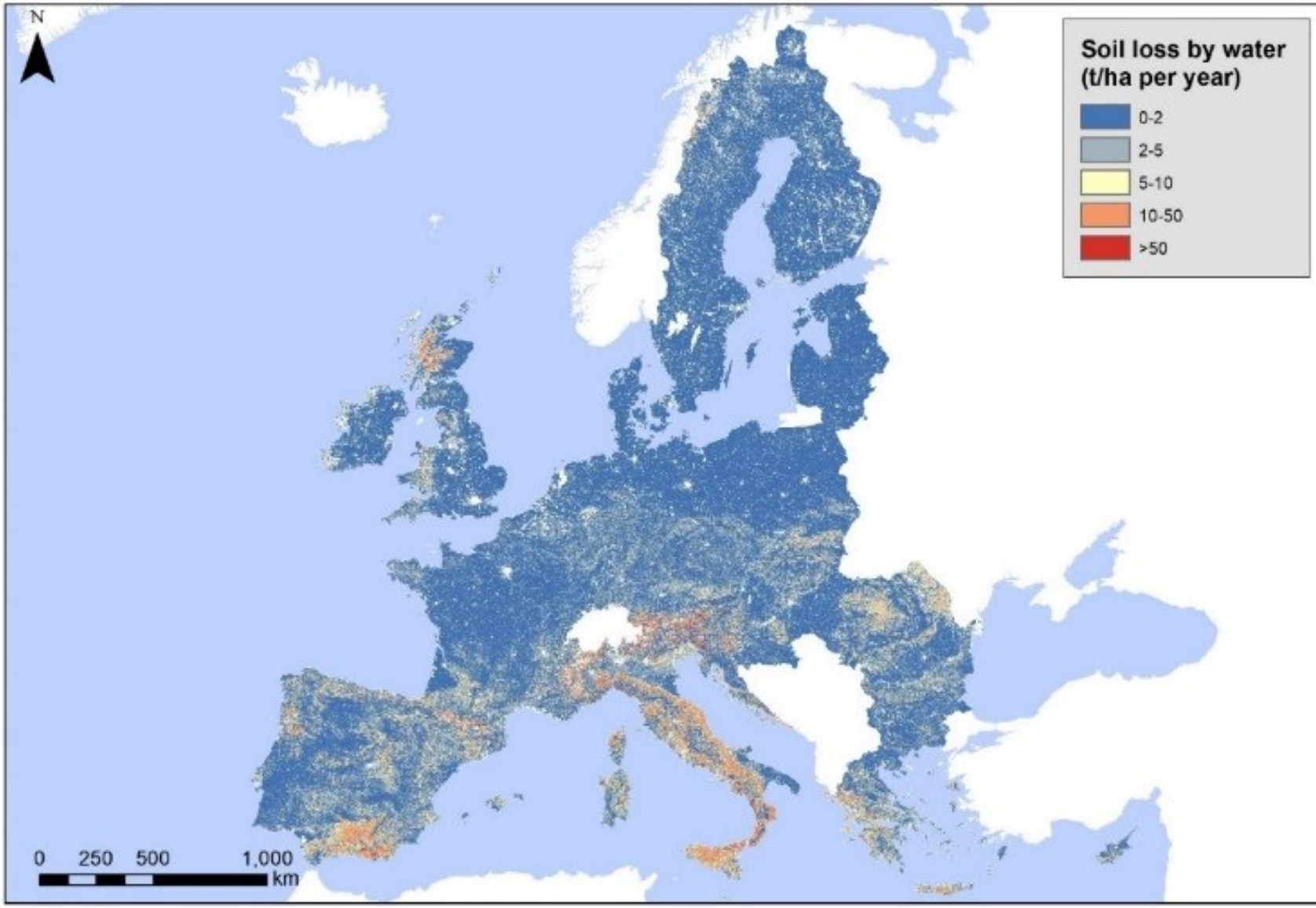
Earthquakes and displacements within archaeological sites

Scientific outputs



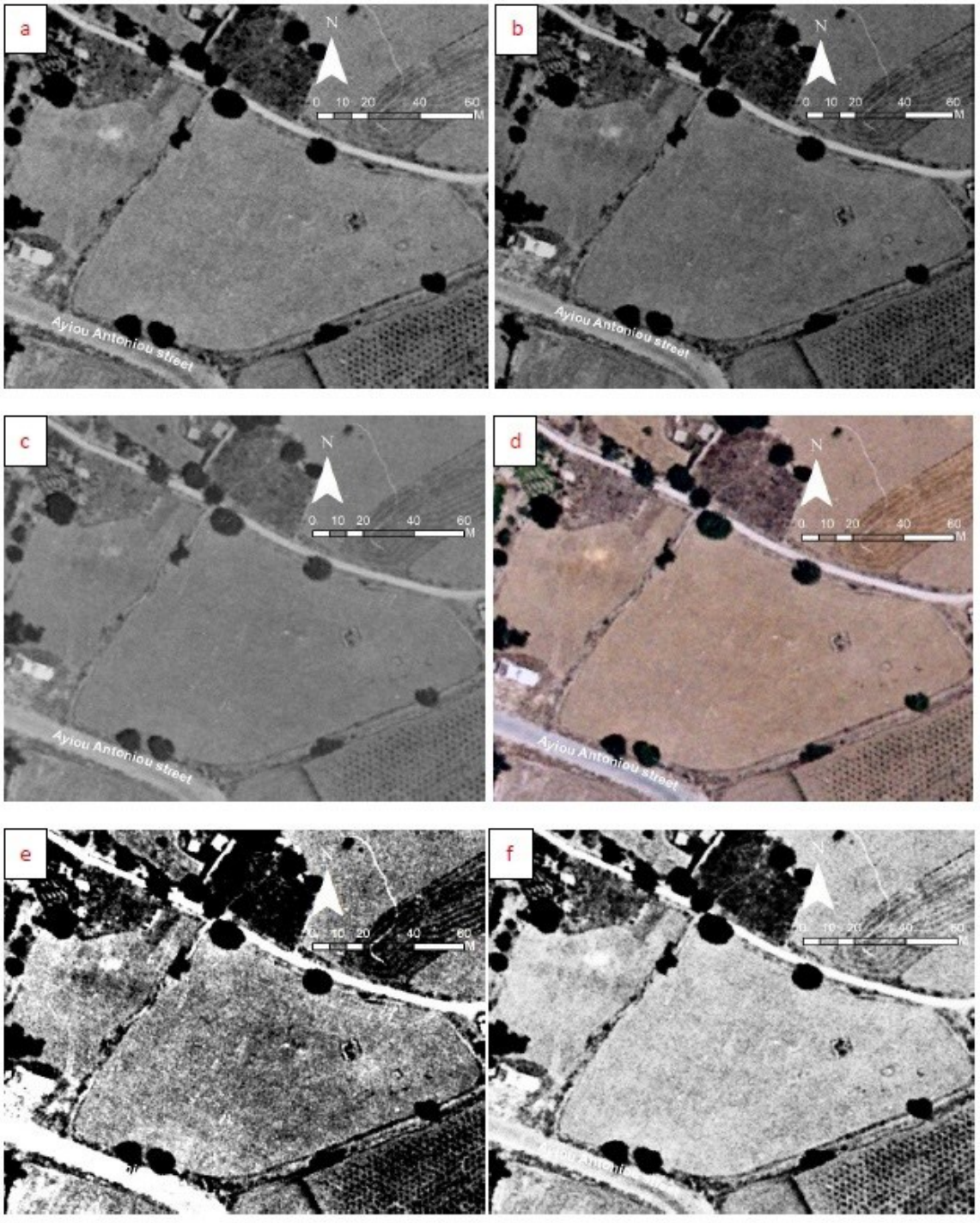
Vegetation cover over archaeological sites

Scientific outputs



Soil erosion over archaeological sites

Scientific outputs



Land use change and archaeological proxies

Copernicus Earth Observation Big Data for Cultural Heritage
NAVIGATOR

Copernicus Earth Observation Big Data for Cultural Heritage

http://web.cut.ac.cy/navigator/

Cyprus University of Technology

DLR German Aerospace Center

Research Promotion Foundation

2016-2020 RESTART SEARCH

Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης

Κυπριακή Δημοκρατία

Διαρθρωτικά Ταμεία της Ευρωπαϊκής Ένωσης στην Κύπρο

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e-newsletter

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