# Cultural heritage:

# The "missing layer" of the Space Programme

ESA Webinar: Space for Twin Cities - Cultural Heritage

10<sup>th</sup> Dec. 2020

Dr. Athos Agapiou<sup>1,2</sup>

<sup>1</sup> Cyprus University of Technology

<sup>2</sup> Eratosthenes Centre of Excellence

athos.agapiou@cut.ac.cy

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Scientific literature: Publications related to remote sensing and



Density map indicating clusters according citations for remote sensing archaeology in European level. Red colour indicates areas with high density of institutions received a high number of citations. Regions with no colour indicate that the citation number was very poor.

Agapiou A. and Lysandrou V., 2015. Remote sensing archaeology: Tracking and mapping evolution in European scientific literature from 1999 to 2015, Journal of Archaeological Science: Reports, 4, 192-200.



IKONOS,

the first high resolution commercial

earth observation sensor --1999

### An overview of the most common remote sensing technologies in use today for archaeology and cultural landscape investigations



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eo-spatial data metadata	sky-view factor spatial database	3d animation	extraction hypers	pectral remote sensing	g high resolution images environmental technolo	Jgy
Scientific li	terature overv	iew techniques	conventional method image classification	aerial archaeolog <sup>s</sup> arct	y naeological-marks logical posi ontol ho	apsat project tivism ogy lism
auxiliary da optical projectors agent 2 -	ta da laser applications dimensional mobile 3d point cloud	ata handling cutting digital instruments photogrammetry <sub>fusion</sub>	resol resol remote sensing ar vision atm hist	chaeology <sub>silk</sub> cer orical periods	outsourcing erpretation archaeological survey airborne rada ntral europe airborne sar i poxides cemetery	r agricultural intensification I <sup>mage</sup> hawaiian islands
cities poi ality urban soils atching 3d fdtd <sup>search o</sup> pipelines	ecology nt cloud internet co engines comparative study sentinel-1 tls bistoria	imaging systems mputer graphics landscapes tandscapes tandscapes cultural	dtm gital terrain model airborne laser scar ocessing <sub>city</sub> ectral heritage cyprus bolivia	anomalies fo Ining lida spectral resolution light detection and ran landscap	orest henan agricultural lan Ir soil chemistry t Iging settlement e archaeology africa	d fire hailand rape airborne sensor aerial prospection
rcraft components software engineering nagement artificial intel design algorith	ndt surve g laser scanner ligence laser beams ms unmanned aer	eying image analysis geographic informa ial vehicles (uav)	aerial photo ve tion systems panchromatic image	graphy spectral a egetation canals h spot phenology r	nalysis social change typerion ikonos cro econstruction ro iowa hum	crete p ad historical geograp an settlement
nondestructive exam aerial imagery stu small area chmarkingpermittivity	idents radar i risk analysis curricula <sup>eirev</sup> an	maging aerial I maging architecture m geology ground control rchaeological site	sentinel-2 northern apulia	aeology earthw	onia irrigation spatial dis eurasia nd bedrock orks field surv	tribution asia eastern hemisphere drou rey aerial pictures axios ri iddle east venice lagoon
icies bandwidth active lo nautical archaeology geo	earning applications teaching cost effe ological surveys	excavation orthoima ctive radiometers greenland computer	age nazca topographic mapp rapplications soil peru	satellite c climate c alluvia	data archaeological e change geoarchaeology china	vidence archaeological maya adi
frequency radar radar ant g sonar	tennas deep ocean cameras uhf/vht	heritage sites mining stratigraphy ethics developed co	magnetic su aerial	rvey sir geophysic survey flc	ndscape italy cal survey ood mexico	<mark>i holocene</mark> arabia <sup>basin</sup> kelshi gujara
"Remote sensing a	rchaeology co-occurren	geophysicsmagnetometry	dam turkey	b bos lav cheology	va flow landslide artifac	accipitridae canada t yuma t seismicity hunter-g
keywords based on th	ne Scopus engine.		y geographic inforr	nation system las croe	antiquity ser genetics esus	alogical manufact

# Natural hazards as observed from Sentinel-1



Coherence map as derived from the Sentinel-1 SAR images in ascending orbit and descending orbit



(a) Unwrapped interferogram. (b) Vertical displacements. (c) Coherence map, enveloping important archaeological sites of the area.

Deformation fringes related to the earthquake of 15th of April 2015, as derived from the Sentinel-1 SAR images in ascending orbit (top) and descending orbit (bottom). The location of the earthquake is shown with the red dot.

Source: A. Agapiou and V. Lysandrou, "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," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 13, pp. 6115-6123, 2020, doi: 10.1109/JSTARS.2020.3028272.

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# Anthropogenic hazards as observed from legacy satellite data



Paphos" and the "Tombs of the Kings". (c) CORINE Land Use Land

Cover dataset over the area from the 2000 campaign. Urban areas are

shown with red colour. (d) a closer look of the CORINE dataset as

before. (e) Classification results of the Sentinel-2 image taken in 2020.

Urban areas are shown with red colour and (f) a closer look of the

change detection methods using optical and radar satellite data, Springer Nature, Heritage Science, (under review)

Agapiou A., Alexakis D.D., Lysandrou V., 💉 Sarris A., Cuca B., Themistocleous K., Hadjimitsis D.G., 2015, Impact of Urban Sprawl to archaeological research: the case study of Paphos area in Cyprus, Journal of Cultural Heritage. 16(5). 671-680. http://dx.doi.org/10.1016/j.culher.2014.12.006

Increase of 300% in urban areas around cultural heritage sites



(a) High-resolution satellite image over the UNESCO World Heritage Examples of buildings to be site of "Paphos". (b) a closer look at the archaeological sites of "Nea investigated during the lifetime of the project, from Limassol case study area (photograph sources: Municipality of Limassol<sup>©</sup>).

> Agapiou A., Lysandrou V., Hadjimitsis D., Analysing the thermal conditions of historic buildings in Cyprus using archive Landsat satellite data and Google Earth Engine big data cloud platform, 2020 IMEKO TC-4 International Conference on Metrology for Archaeology and Cultural Heritage Trento. Italy. October 22-24. 2020.

#### Three levels of observation Target Sensor Macro-scale municipality Semi-macro scale UAV / aerial sensors neighbor Micro scale buildings ground sensors



Levels of observation





Source: Agapiou A., UNESCO World Heritage properties in changing and dynamic environments: Semi-automatic 

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classification results of Figure 7e as before.

the Kings

Nea Paphos



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## Trends observed in the recent year in the domain of space-based applications

- Big-data cloud platform earth observation platforms
- Increased spatial resolution



• Video frames!









DIAS platform

Google Earth Engine

Amazon

webservices

### 15cm HD Imagery! (European Space Imaging)

...is achieved through a process that intelligently increases the number of pixels in a native 30 cm resolution image, resulting in an improved visual experience. Not limited to any certain resolution, HD technology can also be applied to native 40-60 cm imagery, rendering a 30 cm HD image and thus, increasing the availability of 30 cm resolution imagery across the historical archive.



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### Copernicus programme and Cultural heritage



Disaster risk management (DRM) cycle steps represented by blue circles, while other accepted components of the DRM cycle used beyond cultural heritage applications are shown in the outer circle.

Disaster Risk Management (DRM) for Cultural Heritage



The potential contribution of satellite observation within the various steps of the risk management plan proposed by the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) is highlighted in the green rectangle.

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.

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### Copernicus programme and Cultural heritage: future perspectives



Favorable characteristics of satellite observation datasets for Disaster risk management of cultural heritage.

Source: 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.

#### "Copernicus services in support to Cultural Heritage"

- Only a small percentage (7.5%) of the cultural heritage user requirements are already fully covered by Copernicus core services products.
- An additional 19.0% of user requirements have mentioned that are partially covered by existing Copernicus core services products without adaptation.
- Adding to the Copernicus mission the Contributing Missions capabilities, these numbers increased by a 50% of the user requirements (for fully covered), while an additional 14% could be partially covered.
- Therefore a 64% of cultural heritage end-user requirements could be covered.
- Nonetheless, a 36% of end user requirements, as recorded in that report, indicated that these could not be covered by the Copernicus programme including also the Contributing missions.



#### The six thematic Copernicus-based services



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