Copernicus and Cultural Heritage in the Eastern Mediterranean under the 'ATHENA' Project

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Abstract

Copernicus European Union Programme aiming at developing European information services based on satellite Earth Observation and in situ (non-space) data, is coordinated and managed by the European Commission. Several Copernicus services are currently provided from the Sentinel satellites and other supporting missions. Sentinel-1 and Sentinel-2 can provide systematic radar and optical data worldwide with a high temporal resolution. This paper focuses on the potential use of these sensors for Cultural Heritage applications, providing in this way valuable information to stakeholders and other end-users as well as the archaeological community. Examples include the exploitation of the satellite products for the detection of damaged archaeological sites in the cities of Palmyra and Nimrud, CH sites in Syria and Iraq, as well as to examine potential soil marks in the UNESCO World Heritage Site of “Nea Paphos” in Cyprus. Looting marks have been based on supporting WorldView-2 products, are also presented. The overall results, expose the potentialities of Earth Observation data and the promising use of the Copernicus Programme as a European service for World Heritage applications. This study was carried out under the H2020 ATHENA project.

ATHENA Center

“ATHENA” H2020-TWINN-2015 project aims at improving and expanding the potentialities of the existing Remote Sensing and Geo-environment Research Lab of the Cyprus University of Technology, by involving experts dealing with remote sensing technologies for supporting CH sector. These are the National Research Center of Italy (CNR) and the German Aerospace Centre (DLR). The envisage ATHENA center will be devoted to the development, introduction and systematic use of advanced remote sensing science and technologies in the field of archaeology and built cultural heritage, the multi-temporal analysis and interpretation and the distant monitoring of their natural and anthropogenic environment in the area of Eastern Mediterranean.

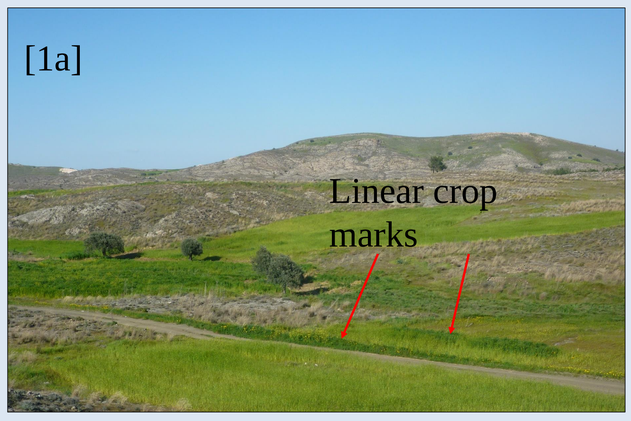
Copernicus

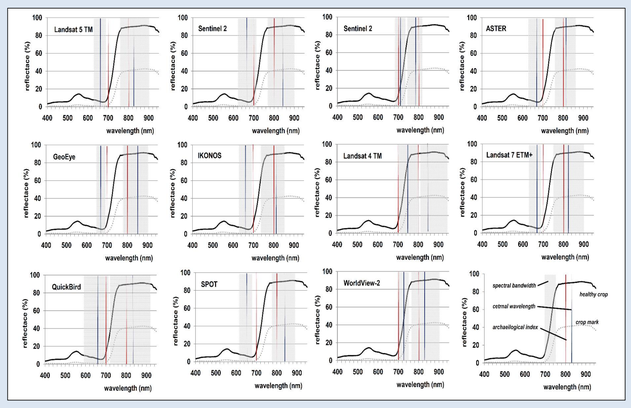
Copernicus is the European program for observing and monitoring the Earth. Copernicus consists of a complex set of systems which collect data from multiple sources, namely earth observation satellites (such as the Sentinels) and ground sensors (such as ground stations, airborne and sea-borne sensors). It processes these data and provides users with reliable and up-to-date information through a set of services related to environmental and security issues. Based on the Copernicus services and on the data collected through the Sentinels and the contributing missions, many value-added services can be tailored to specific public or commercial needs, resulting in new business opportunities. In fact, several economic studies have already demonstrated a huge potential for job creation, innovation and growth .

Amplitude Change Detection (18-29 April 2016) based on the ratio of the backscattering coefficient using TerraSAR-X SSC ST geometrically corrected to ground range images (yellow – no change in backscatter, green - increased backscatter) [4a]. RGB Image showing corresponding areas of minimum change in backscatter intensity [4b]. RGB Image showing the outline geometrical patterns of the features identified [4c].

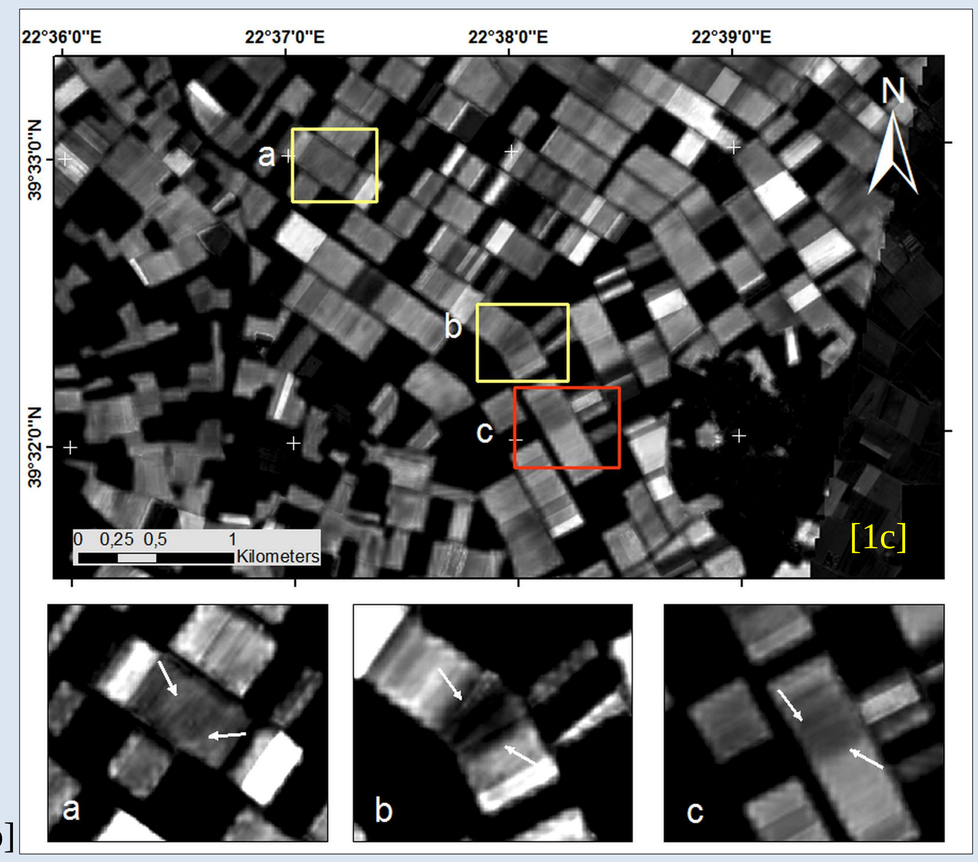
[4]:Kouhartsiouk, D.; Agapiou, A.; Lysandrou, V.; Themistocleous, K.; Nisantzi, A.; Hadjimitsis, D. G.; Lasaponara, R.; Masini, N.; Brcic, R.; Eineder, M.; Krauss, T.; Cerra, D.; Gessner, U.; Schreier, G.; Active Satellite Sensors for the needs of Cultural Heritage: Introducing SAR applications in Cyprus through ATHENA project, Geophysical Research Abstracts Vol. 19, EGU2017, Vienna, Austria

Exploitation of Earth Observation for Cultural Heritage





[1b]

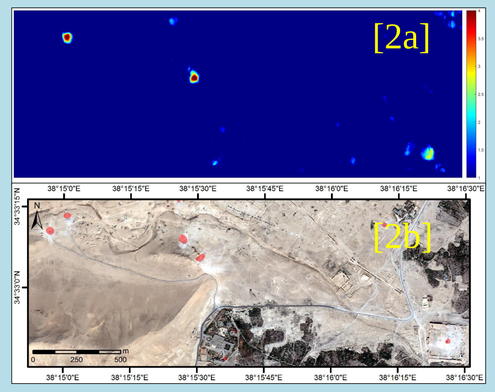


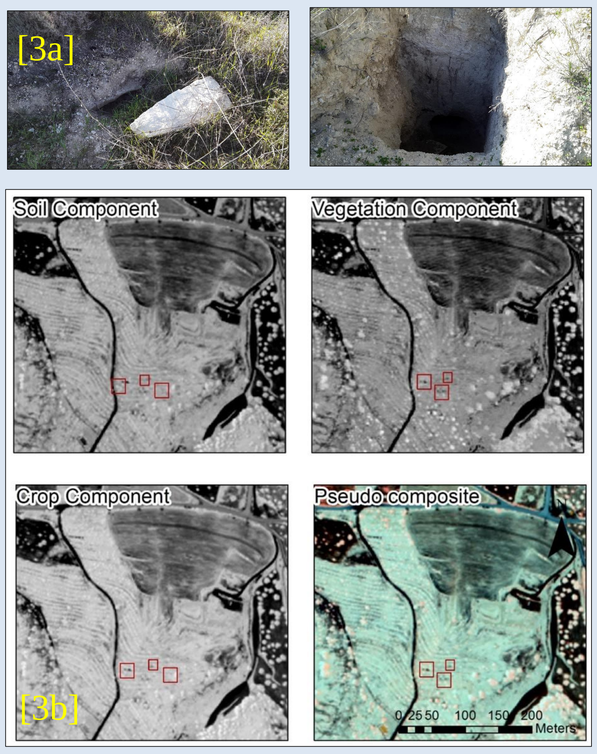
The potentials of Sentinel-2 sensor for archaeological research was evaluated prior to its lunch in [1]. The evaluation included an extensive spectral library from crop marks (i.e. vegetation stress due to the presence of buried archaeological remains, see [1a]), acquired through numerous spectroradiometric campaigns. The ground measurements, have been resampled according to the spectral characteristics of Sentinel-2. In addition, other existing satellite sensors have been also evaluated (Landsat 5 Thematic Mapper (TM); Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER); IKONOS; Landsat 4 TM; Landsat 7 Enhance Thematic Mapper Plus (ETM+); QuickBird; Satellite Pour l’Observation de la Terre (SPOT); and WorldView-2). The simulated data have been compared with the optimum spectral regions for the detection of crop marks (700 nm and 800 nm) (see [1b]). As it was found, the spectral characteristics of Sentinel-2 are able to better distinguish crop marks compared to other existing satellite sensors. Indeed, as it was found, using a simulated Sentinel-2 image, not only known buried archaeological sites were able to be detected, but also other still unknown sites were able to be revealed in the Thessalian plain in Cenral Greece [1c]

[1]: Agapiou, A.; Alexakis, D.D.; Sarris, A.; Hadjimitsis, D.G.Evaluating the Potentials of Sentinel-2 for Archaeological Perspective. Remote Sens. 2014, 6, 2176-2194.

Another example of the use of Earth Observation data (Copernicus supporting missions) was the automatic damage detection for two archaeological sites in Syria and Iraq. The study [2] included fast and robust change detection techniques, based on the extraction of textural information and robust differences of brightness values related to pre- and post-disaster satellite images. A map highlighting potentially damaged buildings was derived, which could help experts at timely assessing the damages to the Cultural Heritage sites of interest. Encouraging results were obtained. In the right [2a], change maps derived from differences of Gabor features were mapped. The results were confirm with the post-processed changes overlaid on the 2 September 2015 WorldView-2 image with the damaged areas indicated with red colour [2b].

[2]: Cerra, D.; Plank, S.; Lysandrou, V.; Tian, J. Cultural Heritage Sites in Danger—Towards Automatic Damage Detection from Space. Remote Sens. 2016, 8, 781.





Illegal archaeological activity, namely looting, is considered as a major anthropogenic threat for cultural heritage, entailing undesirable and irreversible damage in several levels such as landscape disturbance, heritage destruction and adverse social impact. In the last years, the exploitation of remote sensing technologies using ground-based and/or space-based sensors inverted this issue. Novel remote sensing techniques may tackle heritage destructions enacted in war conflicted areas, as well as illicit archeological activity in vast areas of archaeological interest upon limited surveillance means. The damage performed by these illegal activities, as well as the scarcity of reliable information are some of the major concerns that local stakeholders are facing today. Copernicus supporting missions were used to study the potential use of remote sensing technologies based on the results obtained for the archaeological landscape of Ayios Mnason in Politico village, located in Nicosia district, Cyprus. In this area, more than ten looted tombs (shown in [3a]) have been recorded in the last decade, indicating small-scale, but still systematic attempts by looters. The results (see looted tombs highlighted by red square in [3b]) indicated that earth observation can be used by stakeholders as an early warning system, in an effort to establish a systematic monitoring tool for archaeological areas in Cyprus facing similar threats.

[3]: Agapiou, A.; Lysandrou, V.; Hadjimitsis D. G., Remote sensing potentials for looting detection, Geosciences, (2017, under review)

….more info

ATHENA Remote Sensing Science Center for Cultural Heritage

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Consortium

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