Capitalize on the experience of the 'ATHENA H2020 Remote Sensing Science Center for Cultural Heritage' at the 'Eratosthenes Centre of Excellence-ECoE' through the 'Excelsior H2020' for the benefit of the East Med region

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Abstract. The "ATHENA" H2020 Twinning project seeks to establish a Center of Excellence in the field of Remote Sensing for Cultural Heritage through the development of an enhanced knowledge base and innovative methods in the areas of Archaeology and Cultural Heritage. This paper presents an overview of the ATHENA twinning project as well a review of the remote sensing in archaeology. The ATHENA stakeholder hub is presented through a WEBGIS platform. The importance of capitalizing on the experience of running the ATHENA project for the benefit of the ERATOSTHENES Centre of Excellence (ECoE) is explained. In recent years, Earth Observation (EO) techniques have been used extensively for archaeological and cultural heritage applications, which makes the ECoE a key player in EO activities in the Eastern Meditteranean region. The different areas that are under the umbrella of the remote sens- ing in archaeology sector are categorized based on the review findings. Finally, how Earth observation and remote sensing is spread out through research activities in the Eastern Meditteranean region from 1998 to 2018 is presented based on the Scopus engine.

Keywords: Remote sensing, Copernicus, Athena Centre for Cultural Heritage, Excelsior, ECoE

1 What is 'ATHENA'

The "ATHENA" H2020 Twinning project seeks to establish a Center of Excellence (CoE) in the field of Remote Sensing for Cultural Heritage through the development of an enhanced knowledge base, capacity building and innovative methods in the areas of Archaeology and Cultural Heritage (CH). The ATHENA center has been established by twinning the existing Remote Sensing and Geo-environment Research Laboratory/ Eratosthenes Research Centre-ERC. at the Cyprus University of Technology (CUT) with counterparts from other Member States of the EU, such as the Institute of Archaeological and Architectural Heritage of the National Research Council of Italy (IBAM- CNR) and the German Aerospace Centre (DLR). The close collaboration between the ATHENA CoE and other experts in the field of Remote Sensing for Cultural Heritage in the EU will form a synergic network that will enhance knowledge transfer and improve capacity building of the existing ERC staff.

The ATHENA project is expected to have direct and indirect social, scientific and economic impacts, through the creation of new jobs, increased research activity and knowledge transfer. The implementation of the project will facilitate future collaborations with experts of the Archaeology and CH sector at a European level, increase the CoE's research capabilities and enhance the research and academic profile of all participants. The location of the ATHENA CoE in Cyprus is especially important, as the region has been inhabited for thousands of years before and there is a wealth of tangible and intangible archaeological and CH remains.

During times of economic instability, national considerations overrule the process of European integration. CH is an integral element of a European set of values and respect for heritage is vital for developing a common European identity. Recently, the CH sector has undergone a number of challenges as a result of the financial crisis that hit Europe, including the decrease of public budgets, urbanization, globalization and technological changes, among others. Within this context, CH professionals are seeking to improve currently used methodologies in order to better understand, protect and valorize the common European past and common identity.

ATHENA seeks to improve and expand collaboration between low performing and leading institutions to use remote sensing technologies to support the CH sector. The ATHENA project was developed based on EU policies and international conventions related to Cultural Heritage protection, management and best practice, including the Europa Nostra policy documents; COM (2014) 477; UNESCO and EU conventions and multilateral treaties related to the protection of CH).

2 Remote Sensing in Archaeology and Cultural Heritage

EO techniques have become an indispensable tool for CH and archaeological investigation. Within the past 20 years, EO techniques have been used for the detection of cultural remains to the documentation, monitoring and preservation as found in the last 20 years. EO techniques are a non-invasive and cost-effective method for accessing data from a large area, especially in the case of archaeolandscapes. Such techniques enable CH experts to gain extremely precise results, thereby facilitating the different phases of heritage management, including survey, mapping, excavation, documentation, monitoring at diverse scales of interest, moving from small artifacts to architectural structures and landscape reconstruction and vizualization. Aerial and satellite data, in-situ data from ground sensors, databases such Geographic Information Systems (GIS) as well as augmented and virtual reality have revolutionized the archaeological and CH sector. For example, it is now possible to integrate satellite and ground archaeological and CH data to reconstruct an ancient environment, including the mapping of past flora and fauna and anthropological aspects.

There are dramatic differences in the cost and capabilities of different EO equipment. The increasing availability of free data and open access software tools can be used with in situ investigations and computer-based analysis, thereby providing new opportunities for the operational exploitation of archaeological results. The impact of EO technologies for archaeology experts [1] as well as end-users, which are currently underexploited, are expected to have a larger diffusion in the cultural heritage access and exploitation in the future, especially in the touristic sector. It is important to highlight the following areas are classified as the most important sectors of the wider area of remote sensing in archaeology research arena: (a) *airborne photography*: UAV [2, 3] and LIDAR [4]; (b) *passive satellite remote sensing* [5]; (c) *active satellite remote sensing*; (d) *ground remote sensing* that includes geophysical survey[6], magnetometry [7] and field spectroscopy [5].

Over the past two decades, the use of space technologies in archaeology and CH has increased for several reasons, including the improved spectral and spatial resolution of satellite sensors, the availability of user-friendly software and the recent trend for archaeologists to study the dynamics of human frequentation in relation to environmental changes. Indeed, EO techniques are very beneficial for archaeological and CH investigations, due to their reduced costs, time and risk associated with excavations and the creation of site strategies that focuses on conservation and preservation. In addition, the multispectral capability of satellite images can also be used to the identify the differences in texture, moisture content, roughness, topography, various types of terrain, vegetation cover, lithological and geological composition and other information used in archaeological studies. For example, crop-marks can be detected by spectral variations in specific channels more sensitive to vegetation (as near infrared) (see Fig.1) or spectral indices (i.e. mathematical combinations of different spectral channels) as NDVI, SAVI, VI etc. by using multi-spectral images. The

thirteen (13) spectral bands (443–2190 nm) and HR imaging capabilities in visible and near-infrared bands at 10 m spatial resolution have been already tested for archaeological prospection and monitoring [8-10].

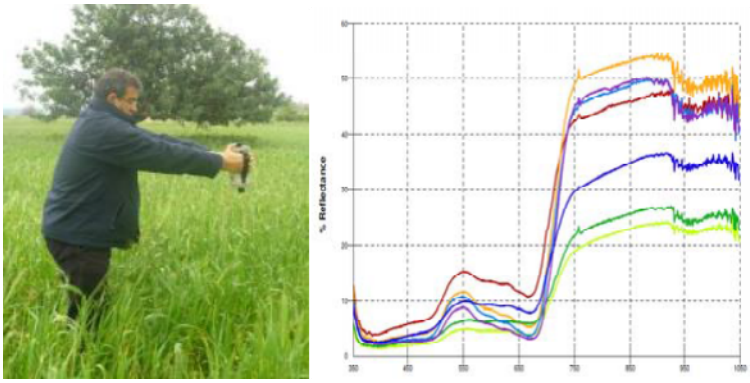

Fig.1: Field Spectroscopy in archaeological sites with typical spectral signatures of buried archaeological crops.

In addition, local changes in the drainage capability of the soil, which are referred to as damp-marks, can be identified by spectral variations in specific channels more sensitive to moisture or spectral indices (see Fig.2) as NDVI or difference in moisture in satellite SAR data [2] as in the case of Cosmo Skymed (see Fig.2) acquired for the archaeological area of Metapontum. As well, shadow marks, which are micro/medium-micro-topographic relief linked to archaeological remains, as artworks, platforms, ditches and shallow remain, can be revealed by changes in colour or texture due to the presence of shadow through the use of spectral data.

The European Commission Copernicus programme provides new opportunities in the EO sector and supports cultural heritage and cultural heritage monitoring [7]. Indeed, the Copernicus programme uses EO data and services for archaeological remote sensing [7] as highlighted during the Copernicus for Cultural Heritage Workshop (http://workshop.copernicus.eu/cultural-heritage).

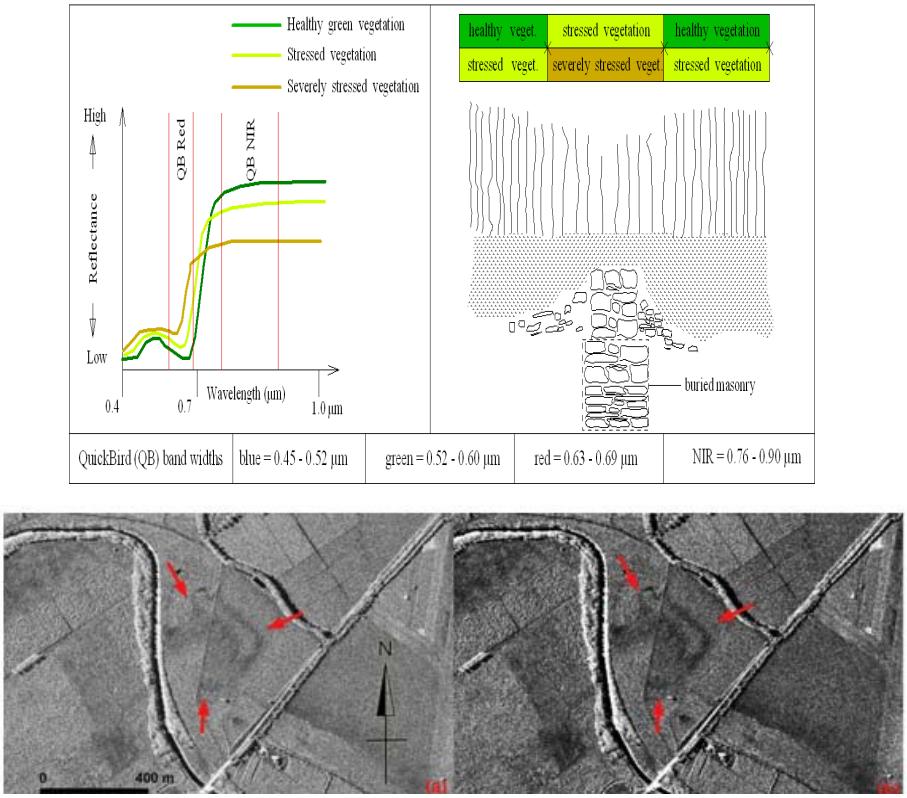

Fig.2. Up-Spectral response by QuickBird imagery of archaeological crop marks- Bottom-Cosmoskymed view of palaeochannels (Damp-marks) in Metapontum archaeological area (additional detail in [2].

The authors provide the following findings regarding a review of research activities using RS and EO techniques in cultural heritage and archaeology, focusing on the east-med region using the Scopus engine as shown in Fig. 3, from 1998 to 2018 It is important to highlight based on the Scopus results, the active participation of the ERC group in EO, also helped the pillar of cultural heritage which will be one of the pillars of the ECoE.

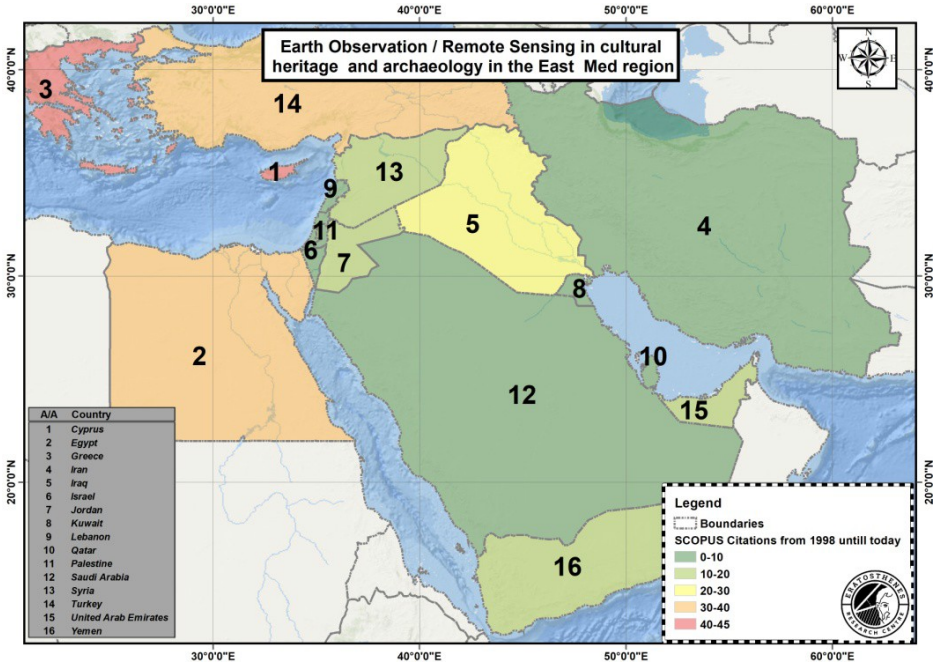

Fig.3. Research Activity in the East-MED region from 1998-2018 using Scopus engine (citations).

3 ATHENA Database: Stakeholder Hub

A relational database has been created to manage the information about the network of Institutions (laboratories, research groups) involved in Remote Sensing and Cultural Heritage. Additionally, information on Projects (including scientific expeditions and scientific missions) focused on EO tools was considered. The current database contains data information concerning **143 institutions** of different states and **14 projects** along with predefined queries to facilitate the search and use of the database (see Fig.4). Specific queries can be created for specific needs and requests. The information currently offered by the database is a fundamental starting point for the creation of networks and collaborations. It has been conceived as an open updatable tool that will be continuously enriched during and after the project by both project partners and crowd-sourcing. Therefore, a specific web interface will be defined and set in order to enable the updating of the data base, promoting the growth of the network, facilitate contacts and collaborations.

Fig.4. WebGIS Map of the existing database: Hub for collaboration.

By merging together the existing ERC hub of over 450 stakeholders that has expanded since 2007 during the EO activities with the 'ATHENA' Hub shown above, it is apparent that the region can be benefit of this available platform for future collaborations and future activities for solving societal problems.

4 How to capitalize on the experience of the ATHENA

One of the main aims of the 'ATHENA' Twinning project [11] after its completion at the end of 2018 is to secure the sustainability of the Centre. This is very challenging since the only source of funding will be competitive funding and services. Indeed, the ATHENA will be one of the pillars of the Eratosthenes Centre of Excellence (ECoE) which will upgraded through the EXCELSIOR H2020 Teaming project (www.excelsior2020.eu) as shown in Fig.5. The aim of the EXCELSIOR teaming project is to upgrade the existing ERATOSTHENES Research Centre (ERC), established within the Cyprus University of Technology (CUT) into a sustainable, viable and autonomous Centre of Excellence (CoE) for Earth Surveillance and Space-Based Monitoring of the Environment, which will provide the highest quality of related services on the National, European and International levels [12]. The ERATOSTHENES CoE (ECoE), with its extensive expertise and infrastructure, can be a hub for the Earth observation activities in the eastern Mediterranean area due to the key geostrategic position of Cyprus.

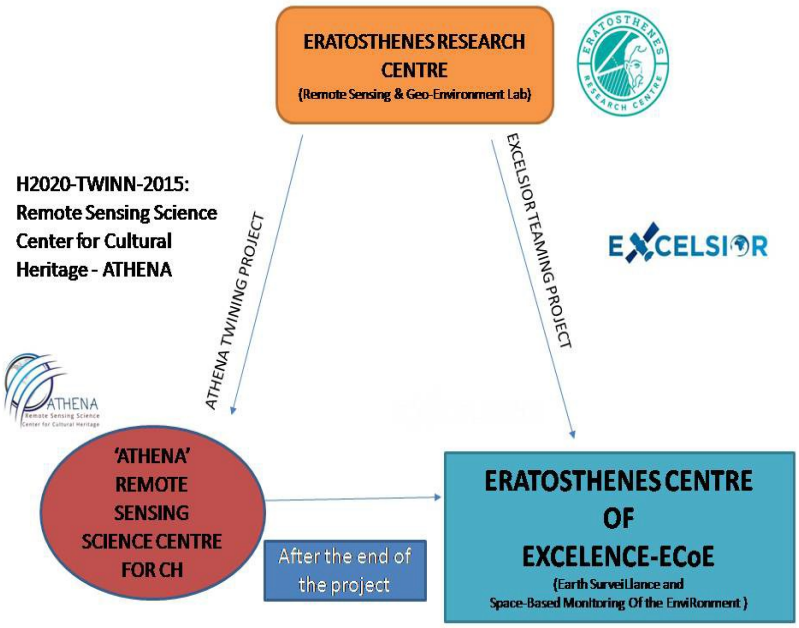

Fig.5. How to secure sustainability of the 'ATHENA'? Capitalize on the Athena experience at the Eratosthenes Centre of Excellence (www.excelsior2020.eu).

The ERC is already an existing stakeholder hub with over 400 stakeholders from Europe, USA, Asia, Africa. Through ATHENA, this hub has already expanded the potential of the Earth observation area especially in the East Meditteranean Middle East North Africa (EMMENA) region. This hub will benefit society, academia, government and industry. Through the ECoE, EO services in the natural and built environment will be offered including also the cultural heritage. The ERC is a Copernicus Academy member and this assisted the sustainability of the ATHENA cultural heritage pillar within the ECoE. The ERC has already secured some funds through the ATHENA twinning and EXCELSIOR teaming benefits. The knowledge transfer from the twining partners of ATHENA, CNR and DLR to the CUT team (ERC) in the areas of SAR, geophysical surveys has been a great benefit of the ERC.

The ERC is a member of the Copernicus Academy network and has already promoted 'ATHENA' and 'EXCELSIOR' through several stakeholders' meetings, events and workshops. Such activities have already contributed to the Network's goals for providing researchers, scientists and entrepreneurs with the skills required for accessing Copernicus data and information services through a series of trainings and the development of relevant educational material. The Copernicus Academy also works to increase the exchange of ideas and best practices across borders and disciplines while contributing to the development of the use of EO data in general

and Copernicus data and information in particular, in various public or private user organizations or industries. through ERC activities by presenting ATHENA and EXCELSIOR, new EO practices in teaching, tools and interactive workshops have been developed.

One of the significant impacts of running the '**ATHENA'** project under the umbrella of the ERC 'a pure multi-disciplinary Earth observation group' which have already been capitalized are the following: (a) merging ATHENA and ERC existing stakeholders hubs: this will be an open hub platform for the *regional* and *European* use (b) increase visibility of our group (c) applying EO techniques more efficiently for natural and built environment including cultural heritage (c) social media /networking: promotion of community engagement , fostering an 'open science' environment through the use of digital and social media (d)the use of the EO for the implementation of the *UN Sustainable Development Goals* through the application of satellite remote sensing for real practical problems (d) active participation of local stakeholders (e) securing more funds in the wider area of risk management and environment (natural and built). The implementation of a novel strategic infrastructure unit to monitor natural hazards in Cyprus and eastern-med region through a new funded project named CyCLOPS will help boost the ECoE and the region for monitor, catalogue and understand the natural hazards for any intended application including natural and built environment (e.g., heritage)

5 Conclusions

This manuscript provided a review of the different available methods and categorized within the umbrella of the remote sensing in archaeology. Through 'ATHENA' the existing ERC stakeholder hub has increased and improved for the benefit of the local and the region. One of the aims of the ATHENA Twinning project was to sustain the existing cultural heritage sector within the ERC. Indeed, such goals have been achieved and will be further boosted through the 'EXCELSIOR' H2020 Teaming project in which the existing ERC will be upgraded to a Centre of Excellence-ECoE.

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