

# Environmental Monitoring from Space & Geoinformation through the Excelsior H2020 Teaming Project

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**Abstract.** The "EXCELSIOR" H2020 Widespread Teaming Phase 2 Project titled ERATOSTHENES: EXcellence Research Centre for Earth SurveiLlance and Space-Based MonItoring Of the EnviRonment is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 857510 for a 7-year project period to establish a Centre of Excellence in Cyprus. The Government of the Republic of Cyprus is providing additional resources to support the establishment of the ERATOSTHENES Centre of Excellence (ECoE). The ECoE seeks to fill the gap by carrying out spaceborne Earth Observation (EO) activities in the Eastern Mediterranean and becoming a regional key player in the Earth Observation sector. The ECoE as a Digital Innovation Hub adopts a two-axis model, where the horizontal axis consists of three Thematic Clusters for sustained excellence in research of the ECoE in the domains of Atmosphere and Climate, Resilient Society and Big Earth Data Analytics, while the vertical axis consists of four functional areas: Infrastructure, Research, Education, and Entrepreneurship. This paper presents existing state of the art research examples within the Centre that deals with the integration of earth observation and geoinformation for monitoring systematically the environment in the areas of Agriculture monitoring, Atmospheric monitoring and Disaster risk reduction in terms of earthquakes and landslides, fires and floods.

**Keywords:** EXCELSIOR, ERATOSTHENES Centre of Excellence, Environmental Monitoring, Earth Observation, Geoinformatics

## 1. Introduction

Earth Observation technologies are critical in providing in a continuous manner, reliable and up-to-date information required to observe, monitor, and predict environmental factors in relation to land, water and air. EO-based data play an important role in the environmental programs in

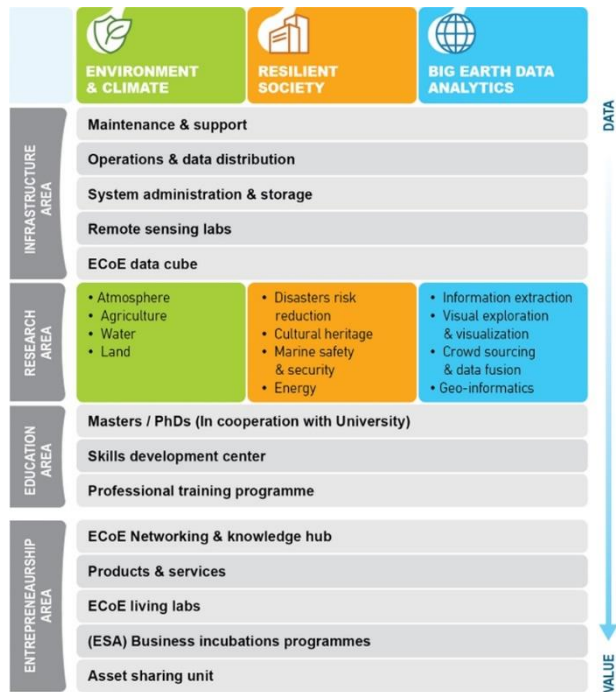
many countries, assessing the current environmental information, being part of the decision-making process for sustainable development through the involvement of stakeholders. Climate change, air and water quality, floods, earthquakes, fires, erosion, landslides and other issues are some of the aspects that should be considered in environmental studies (Hadjimitsis *et al.*, 2017).

A new, autonomous and self-sustained Centre of Excellence, namely the ERATOSTHENES Centre of Excellence (ECoE) will be created through the EXCELSIOR Horizon 2020 Widespread Teaming Phase 2 project, by upgrading the existing Remote Sensing and Geo-Environment Lab, operating within the Department of Civil Engineering and Geomatics, Faculty of Engineering and Technology, of the Cyprus University of Technology (CUT) since 2007.

The establishment of the ECoE in Cyprus is advantageous for several reasons, such as the unique geo-strategic position, being the most southern and most eastern EU member state; Cyprus' prime location for the establishment of a satellite EO data receiving station; Weather and climatic conditions providing 300 days of sunshine a year, favoring cloud-free satellite acquisitions and specific atmospheric research activities; Underdeveloped but emerging geo-information market in the Eastern Mediterranean, Middle East and North Africa (EMMENA) region due to public and governmental as well as private sector needs in timely information; and Collaboration with European and International EO players and access to an active network of EO stakeholder in EMMENA (Hadjimitsis *et al.*, 2020).

The EXCELSIOR project vision is fully aligned with the Smart Specialization Strategy (S3Cy) for Cyprus (Hadjimitsis *et al.*, 2017, 2018), that has been established by the Government of Cyprus, based on priority sectors that were selected for future sustainable economic growth in Cyprus. Within the next 7 years, the ECoE is expected to become a world-class Digital Innovation Hub (DIH) for

EO and Geospatial Information becoming the reference Centre in the EMMENA region (*Figure 1*). In line with the ECoE vision, the three Thematic Clusters, of Environment and Climate, Resilient Society and Big Earth Data Analytics, and their sub-categories, are defined for sustained excellence in the areas of infrastructure, research, education and entrepreneurship.



**Figure 1.** The ERATOSTHENES Centre of Excellence as a Digital Innovation Hub and its thematic clusters

In the next section of the present paper, emphasis is given on the research areas of Atmospheric monitoring, Agriculture monitoring, and Disaster risk reduction in terms of earthquakes and landslides, fires, and floods. These are some of the research areas that the ECoE team has proven track record through scientific publications and involvement in numerous research projects and activities.

## 2. Atmospheric monitoring

The Cyprus Atmospheric Remote Sensing Observatory (CARO) of the ECoE will be the core of the sector of Atmosphere, enabling research and innovation in the fields of aerosol and cloud research. CARO utilizes the 10 years' experience of the Atmospheric Remote Sensing group of CUT on atmospheric studies related to aerosol, clouds and aerosol-cloud interactions (ACI) conducted mainly during research projects (Nisantzi *et al.*, 2015; Mamouri *et al.*, 2016; Ansmann *et al.*, 2019). Extensive research was carried out during 2015-2016 in the framework of large EU projects of BACCHUS and ACTRIS with the participation of CUT, corroborating that Cyprus is one of the hot spot regions of atmospheric and climate research. The most recent project SIROCCO (<https://sirocco.cut.ac.cy/>), funded by the Research and Innovation Foundation (2019-2021), focuses on the Study of precipitation aeROsols and Clouds in a Coastal areas of Cyprus. Its overall objective is to provide new knowledge in the field of aerosol-cloud-

precipitation interaction based on synergy of different remote sensing techniques. SIROCCO acts as a Research Capacity Demonstrator for the Atmospheric Sector capabilities of the ECoE. The ECoE will run the National facility that will consist of the Aerosol Remote Sensing and the Cloud Remote Sensing Observational Platforms of Aerosol Cloud and Trace gases Research Infrastructure (ACTRIS). The range of measurements provided at this facility and the key point position of the station make it an ideal site for cloud/aerosol interaction field campaigns for the vertical resolved separation of the different aerosol types (Mamouri and Ansmann, 2017) as well as for long range aerosol transport (Nisantzi *et al.*, 2015; Mamouri *et al.*, 2016).

## 3. Agriculture monitoring

ECoE's personnel have previous experience in the field of agriculture monitoring using both field spectroscopy and remote sensing techniques. Previous knowledge has been gained through the preparation of doctoral dissertations and funded research projects. Specifically, the ECoE team have extended knowledge in the estimation of evapotranspiration which can support the estimation of irrigation (Papadavid *et al.*, 2011). Since agriculture counts as one of the main water resources consumers, it is important to adopt measures for water conservation especially in areas that are facing water scarcity problems like Cyprus. One of the recent funded projects of the team is the SWSOIP project (<https://www.swsaip.com/>) entitled 'Smart Watering System for Optimizing Irrigation Process' which is funded by ESA through ESA-PECS. SWSOIP aims to develop a smart watering system for the irrigation process based on the estimation of evapotranspiration using both in-situ data (spectroradiometric, LAI, CH and meteorological) and Sentinel satellite data (Papoutsas *et al.*, 2020).

## 4. Disaster risk reduction

### 4.1. Earthquakes and landslides

The identification of areas vulnerable to ground movements and the systematic monitoring of land displacement at areas with critical infrastructure, areas of Cultural Heritage interest and other urban areas, can be carried out through Earth Observation techniques and space technologies. Nowadays, Copernicus satellite data such as those from the Sentinel missions as well as image processing software are freely available.

Coherent Change Detection (CCD) and Differential Interferometric SAR (DInSAR) methods, exploiting a series of Sentinel-1 SAR images have been used for monitoring ground movement caused by earthquakes and landslides, affecting different areas in Cyprus. These methods have been applied successfully by the ECoE team in several case study areas, that were selected based on the site geology and the risk that land movements can cause to the general public and to critical infrastructure (Tzouvaras *et al.*, 2019; Tzouvaras *et al.*, 2020).

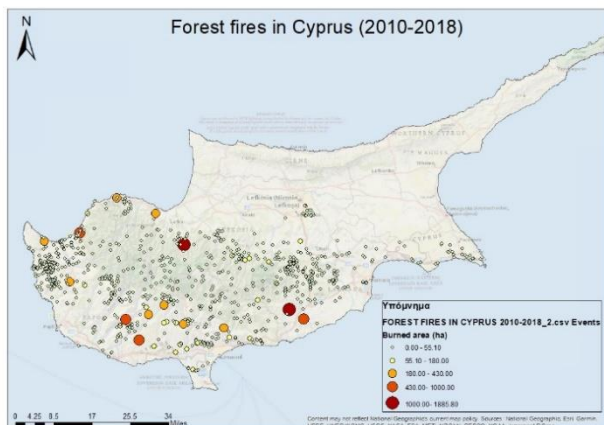


**Figure 2.** The wider area of the landslide (left) and a picture of the landslide (right)

The integration of these techniques for the systematic identification of areas susceptible to these specific natural hazards, and their continuous monitoring based on the analysis of optical and SAR satellite data, can lead to a systematic way of monitoring land displacement on a larger scale. Rapid detection and more detailed products have been developed using the proposed Earth Observation methodologies, for the detection and monitoring of natural hazards and their impact on critical infrastructure resilience. This information can be used by stakeholders in the decision-making process as well as for updating the landslide inventory.

#### 4.2. Fires

Mediterranean ecosystems are significantly affected by forest fires. This is due to the features of the Mediterranean ecosystems that relate to climate and vegetation. Cyprus is located in the Eastern Mediterranean, which is an area where forest fires frequently occur, especially during the summer period (Figure 3). Several factors contribute to the increased risk of forest fires, such as prolonged drought, hot summers, strong winds, large slopes of forests and flammable dry vegetation.





environment by enhancing the scientific and R&I capabilities of the existing center. The ECoE will provide new job opportunities and encourage future developments of EO products and services in Cyprus, the EMMENA region, and the European and global EO arena. Moreover, capacity building and training activities by the EXCELSIOR strategic partners will be carried out on the three Thematic Clusters of the ECoE, and their sub-categories, throughout the duration of the EXCELSIOR project, filling the gaps on the existing ECoE team knowledge and thus, ensuring the accomplishment of the ECoE's ultimate target, excellence in research.

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## ACKNOWLEDGEMENTS

The authors acknowledge the 'EXCELSIOR' (ERATOSTHENES: EXcellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment) project. The 'EXCELSIOR' project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 857510 and from the Government of the Republic of Cyprus through the Directorate General for the European Programmes, Coordination and Development.