Exploring the Importance of Promoting Earth Observation in Education

Diofantos G. Hadjimitsis [ab], Phaedon Kyriakidis [ab], Chris Danezis [ab], Evangelos Akylas [ab], Nicholas Kyriakides [ab], Christiana Papoutsa [ab], Kyriacos Themistocleous [ab], Rodanthi Mammouri [ab], Argyro Nisantzi [ab], Athos Agapiou [ab], Christodoulos Mettas [ab], Marios Tzouvaras [ab], Maria Prodromou [ab], Eleni Loulli [ab], George Melillos [ab], Vasiliki Lysandrou [ab], Dimitris Antoniades [ab], Andreas Christofe [ab], Haris Kontoes [c]; Gunter Schreier [d], Albert Ansmann [e]; Silas Michaelides [ab] Anastasis Evagorou [ab], Elpidoforos Anastasiou [ab], Thomaida Polydorou[ab], Kyriacos Neocleous [ab] Milto Miltiadou [ab], Evagoras Evagorou [ab], Christos Theocharides [ab], Georgios Leventis [ab], Andreas Anayiotos [b,f], Stelios Tzortzis [g], George Komodromos [g]

[a] Department of Civil Engineering and Geomatics, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus

[b] ERATOSTHENES Centre of Excellence, Limassol, Cyprus

[c] National Observatory of Athens, BEYOND Ctr. of Excellence, Greece

[d] German Aerospace Center, Germany

[e] Leibniz Institute for Tropospheric Research, Germany

[f] Department of Mechanical Engineering and Materials Science and Engineering, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus

[g] Department of Electronic Communications, Deputy Ministry of Research, Innovation and Digital Policy, Cyprus Government, Cyprus

ABSTRACT

This paper presents the significance and importance of promoting the benefits of Earth Observation when implemented in 'secondary' and 'higher education' in Cyprus schools. Firstly, examples of how Earth Observation is exploited for secondary education in other countries, such as Germany and China, are presented, and in particular how ESA's Earth Observation education materials are used to promote STEM education. Secondly, the 'EXCELSIOR for Schools' & 'SOFIA ESA' initiatives for promoting Earth Observation education in Cyprus are also presented. Examples of how Earth Observation is presented through seminars, workshops, science cafes, researcher's night, from Earth Observation experts in schools in Cyprus are also described and analysed. Examples of how Earth Observation is used in the existing curriculum for undergraduate, postgraduate courses for surveying and civil engineers are demonstrated for monitoring and providing solutions for civil and geomatics engineering issues at the Cyprus University of Technology through the EXCELSIOR H2020 Teaming project.

Keywords: Remote Sensing, Earth Observation, school, curriculum, satellite images, data, educational platforms, STEM education

1. INTRODUCTION

In our modern-day society, where children and teenagers are more than keen towards using new technologies and new software, such as social media platforms, Google Earth, geo-caching, and navigation systems[1], the use of remote sensing data in the classroom appears easier than ever. By incorporating such data and activities into the classroom, schools contribute to the development of future highly qualified professionals in the field of Earth Observation (Remote Sensing). The examples of Remote Sensing implementation within the school curriculum that follow, showcase the countless possibilities of problem-solving oriented instruction, in which Remote Sensing is used as a modern medium and tool for teaching different fields of study.

Earth Observation (EO) has been used in higher education through the activities of the Department of Civil Engineering and Geomatics at the Cyprus University of Technology, both in research and teaching activities. Indeed, this paper presents the significance and importance of promoting the benefits of Remote Sensing when implemented in higher education in Cyprus's schools along with some examples of its integration within the curriculum. Examples of how Earth Observation is presented through seminars, workshops, science cafes, researcher's night, from Earth Observation experts in schools is also described and presented. Examples from other countries of how Earth Observation is promoted in secondary education are also presented.

2. BENEFITS OF REMOTE SENSING

Remote sensing along with its characteristics and features can be described as a vehicle that can provide immense opportunities for school education[2]. Remote Sensing uses an interdisciplinary approach (see Table 1) because it involves a combination of aspects of different fields, such as Geography, Mathematics, Physics, Biology, Computer Sciences and requires various tasks and skills[2]. Essentially, Remote Sensing holds an interdisciplinary component that enables students to use cross-linked thinking to deal with a range of curriculum-specific topics in a problem-solving manner[3], [4]. In natural science classes like Math, Physics or Computer Sciences, the basic principles of Remote Sensing can be introduced, while in Geography or Biology which are considered as applied sciences, satellite data can be analyzed for further comprehension[3]. In applied sciences classes, the teacher can pose environmental questions that require students to answer via the use of Remote Sensing data[3].

Table 1. Interdisciplinary Approach.

Classes	Math, Physics, and Computer Science	Geography and Biology
Content	Students can be introduced to the basic principles of Remote Sensing	For further comprehension of Remote Sensing, satellite data can be analyzed and interpreted

In this environment where students are required to observe, ask, collect data, associate, and communicate all through Remote Sensing, they will[4]:

1. Develop an understanding of science topics related to the local and global environment.
2. Develop methodological skills in the area of data processing, general computer work, and digital image processing.
3. Be motivated because satellite images can draw student attention thus making them more engaged in the classroom.
4. Work on up-to-date and dynamic problems.
5. Acquire a new view of certain problems that provide a high degree of vividness.

3. EXAMPLES OF INSTRUCTION IN GERMANY

A new concept of teaching was developed within the "Fernerkundung in Schulen" (Remote Sensing in schools) project at the Geographical Institute of the University of Bonn, sponsored by the German Federal Ministry of Economics and Technology to encourage the use of Remote Sensing in schools[5]. This new didactical concept is based on the use of digital, interactive, and interdisciplinary learning modules, aiming to promote the methodological and media competence of students and develop their independent study skills[5]. In what follows, it is shown how digital learning modules were used in Geography and Physics lessons. It is important to note that for the successful integration of Remote Sensing in the class, the learning modules were linked with existing topics in the curriculum.

Geography lesson

The Geography curriculum for secondary schools in the German state of North Rhine Westphalia includes the teaching unit “Tsunami” (see Figure 1). Based on this subject area, a lesson was designed with the purpose to familiarize year seven students with the endangerment of habitats (natural disasters) so they can acquire an understanding of spatial cognition and perform a spatial assessment. Students also had an opportunity to learn about the possibilities that remote sensing has with regards to damage assessment. The learning module was divided into two parts. In the first one, students were familiarized with natural disasters, more specifically tsunamis. After acquiring sufficient knowledge on this topic, they continued to the second part of the modular unit (see Figure 2). Students were given two satellite images by a virtual professor, one before the tsunami and one image displaying the aftermath. The students had to use an interactive controller to compare the two images and answer the following questions:

1. name the structures that were destroyed by the tsunami,
2. reflect on the effect the damage had on the residents,
3. consider the value of satellite images in in the case of natural disasters and how these images can be used during these disasters.

For the last question, the students could also use the information box in which more details regarding the process of change detection was explained through a short film. After understanding the concept of change detection, students could use their newly acquired knowledge to classify specific land surfaces and assess how much of the land surface displayed in the picture was flooded or even how much of the agricultural area was destroyed by the tsunami.

Figure 1. Learning Module: Tsunami [5].

Physics lesson

The Physics curriculum for secondary schools in the German state of North Rhine Westphalia includes the subject field of physical optics which is divided into 3 subgroups: light on the surface, optical lenses, and the slight procedure and optical instruments. Based on that subject area, a lesson was designed with the purpose of using satellite images so a link between these three subgroups can be created. The related teaching unit aimed to help students comprehend the connections between the electromagnetic spectrum, absorption, exposure, reflectance, and development of satellite images. The learning module was divided into two parts. In the first part, students were introduced to the concept of reflectance. A playful experiment was carried out with their virtual professor regarding reflectance on various objects.

Figure 2. Learning Module: On the Trail of the Invisible [5].

The purpose of the experiment was to help students determine the features of the objects with regard to their reflectance attributes. After understanding the concept of visible light in the electromagnetic spectrum they moved to the second part which is "how a satellite works". The students were required to use their newly acquired knowledge from the virtual lab to a satellite. The main focus of attention was on how a satellite converts the reflectance signal it receives into a color image information.

4. EXAMPLES OF INSTRUCTION IN CHINA

One of the main objectives of the New Senior Secondary curriculum that was integrated in schools in 2009 was to help teachers integrate GIS and satellite remote sensing in their classrooms. "Knowing that GIS and RS can be very effective tools in the NSS curriculum" [6,p.1] a project was funded by the Quality Education Fund of the Hong Kong SAR Government to help achieve this goal. The main focus of the project "was to develop a pedagogy of implementing GIS&RS in ordinary classrooms" [6,p.7]. With that in mind, teachers were supported in developing appropriate teaching materials. Furthermore, teacher and students were encouraged "to explore spatial relations among spatial data and practice spatial thinking skills freely"[6]. Thus, the Project team developed the KML Utility software to help them carry out various forms of explorations and identify the underlying spatial relations among data[6].

Lesson plan 1

The first implementation of the platform is visualizing and exploring geospatial data in 3 dimensions (location, conditions, connections). An example of an implemented lesson involved students required to explain the causes behind the constant flooding of river Tai O (see Figure 3). With the help of a geospatial data platform students were able to perform 3-dimension visualization (location, conditions, connections) and answer what if questions such as "What if the level of water reaches 4m? (see Figure 4). Another similar analysis was conducted to comprehend the visual impacts of flooding if a building or urban plan is built.

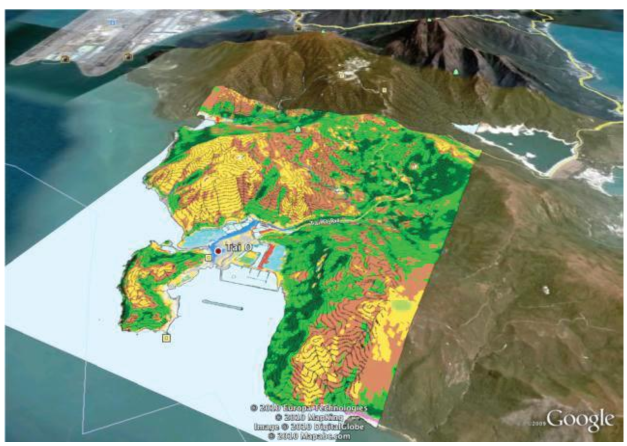


Figure 3. Tai O as seem in 3D Visualizations [6].

Lesson plan 2

In this example, students are asked to suggest possible causes of landslides and to search the web and textbooks for relevant geospatial information. Students could suggest several causes that may be hypothetical or sensible for the occurrence of landslides. The technical challenge here is that the data have different origins, and their spatial relationships can barely be distinguished. Thus, all related information was geo-referenced and analyzed integrally in a common geospatial data platform.

Lesson plan 3

One more example of a lesson was that of Spatial Pattern Analysis. In addition to field data gathered, students used geospatial data to figure out the pattern of urban growth in Southern China (see Figure 5a). Another application of spatial pattern analysis required students to use satellite photos of a road network to discover that the development of the new cities actually matched the road network pattern in the region (see Figure 5b).

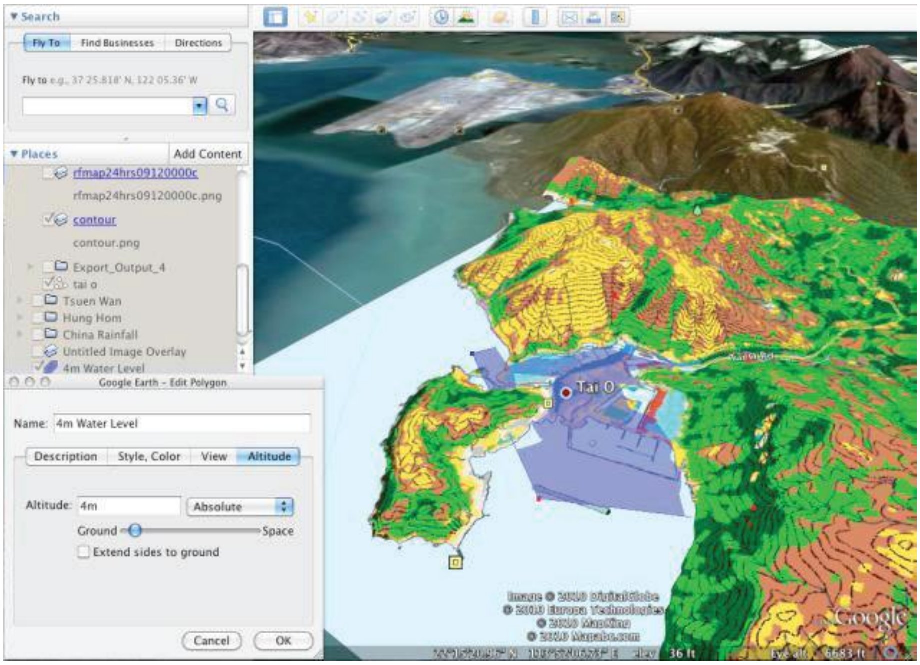
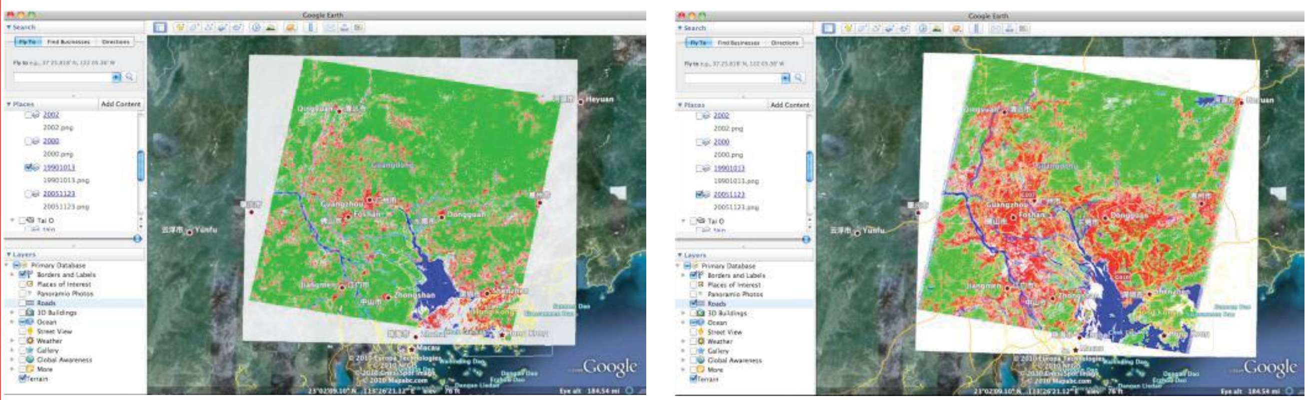


Figure 4. What-if analysis: What if the level water reaches 4m? [6].



(a) (b)

Figure 5. (a) Urban areas in Pearl River Delta in 90s' (b) in 2000s' and the transportation network [6].

5. ESA'S CONTRIBUTION TO STEM EDUCATION

STEM education is based on the idea of teaching and learning in four specific disciplines: science, technology, engineering, and mathematics in an interdisciplinary and applied approach across all grade levels, from pre-school to post-doctorate, and in both formal and informal classroom settings[7]. Unfortunately, the lack of student interest in STEM education is evident. To tackle this issue and help students develop skills that are crucial for today's society and for the labor market, Vocational Education and Training (VET) and Life-Long Learning (LLL) are used.

Vocational Education and Training (VET)

VET is education that prepares students for work in a specific trade, a craft or a position in engineering (mechanical, electrical, civil, and architectural), computer science, safety-related professions, agriculture, social sciences, medicine, law, etc.[8]. VET can be used in secondary education or at a postsecondary level which is usually the case for technological institutes or colleges[8]. Vocational education is sometimes referred to as career and technical education. It is evident that the public and private sector invests in VET due to the high demand of the labor market to hire qualified professionals. “VET comprises all skill transfers, formal and informal, which are required in the improvement of productive activities of a society”[9, p.1].

Life-Long Learning (LLL)

Lifelong Learning (LLL), on the other hand, “involves the provision of education and training possibilities for everyone, regardless of their age”[8, p.1654]. Lifelong learning (LLL) covers the entire scope of learning that incorporates formal, informal, and non-formal learning[10]. LLL is a continuously supportive process that aims at the development of skills and knowledge throughout the life of an individual[10]. It not only enhances social inclusion, active citizenship, and personal development, but also competitiveness and employability[11].

Earth Observation education materials

Earth Observation education materials can be incorporated in VET and LLL with the aim to promote STEM education as well as for the development of green and geospatial skills. This would be to the mutual benefit of both ESA and the EU. Topics on space, the environment as well as geospatial information seem to draw student attention. “ESA undertakes a wide range of activities in the field of Earth Observation education, training, and capacity building. The scope of these activities ranges from high level training in state-of-the-art processing for the next generation of Principal Investigators to more general outreach activities and Earth Observation education for schools. The ESA Earth Observation Education & Training website is an all-in-one portal that supplies information about these activities and enables access to resources provided in their framework”[8, p.1657] (see Figures 6-14). It is worth noting that a lot of the material uploaded to the website is readily accessible and available in several languages at no cost. Without a doubt, ESA stands at the frontline of space education and with the use of its educational materials it can ensure the future employment of a highly qualified workforce for both itself and the European Industry. There are countless of employer organizations that offer people the opportunity to work in the fields of Earth Observation/Remote Sensing data and techniques, along with Geographic Information Systems (GIS), Global Navigation Satellite Systems (GNSS) and Cartography and Surveying[8].

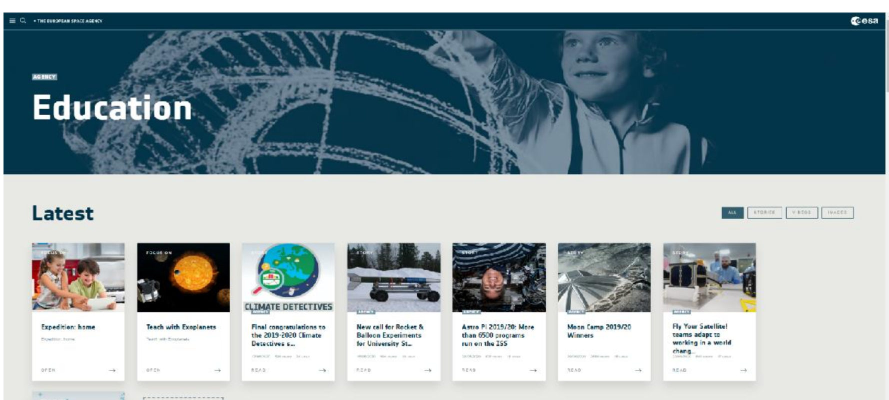


Figure 6. Main page of ESA Earth Observation Education & Training Website which includes or gives links to all the online material such as lectures, data and exercises developed for ESA Earth Observation courses: http://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Education.

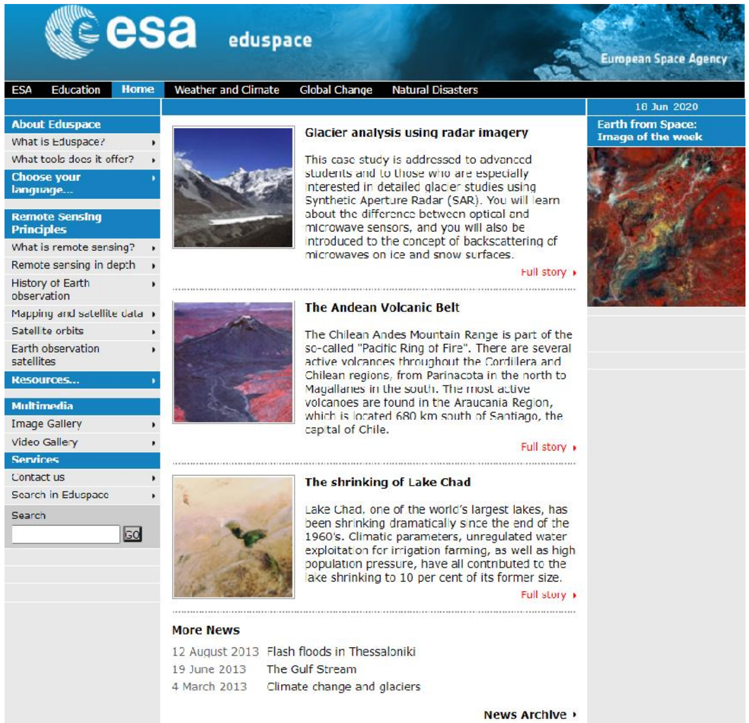


Figure 7. Eduspace: Website that provides learning and teaching tools to secondary school students and teachers across the various educational systems in Europe: http://www.esa.int/SPECIALS/Eduspace_EN/.

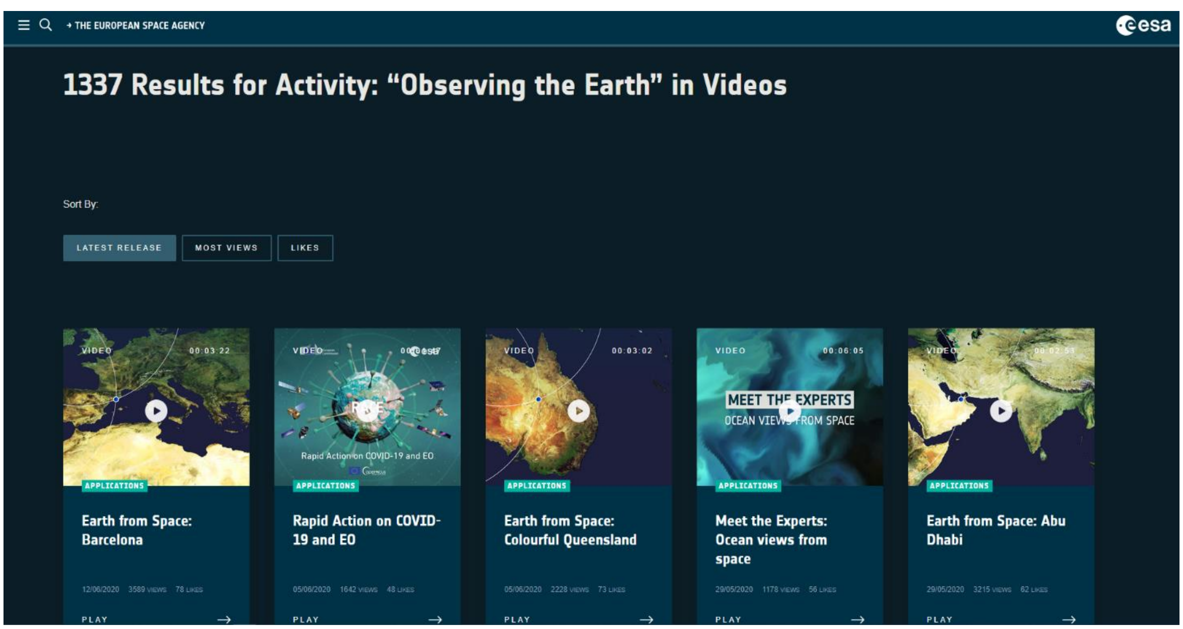


Figure 8. The ESA multimedia gallery contains the best visual material such as images, videos, and animations of the ESA portal, along with many Earth Observation and environment-related subjects:

http://www.esa.int/ESA_Multimedia/Directorates/Observing_the_Earth/(class)/image?collection=Observing+the+Earth&type=I.

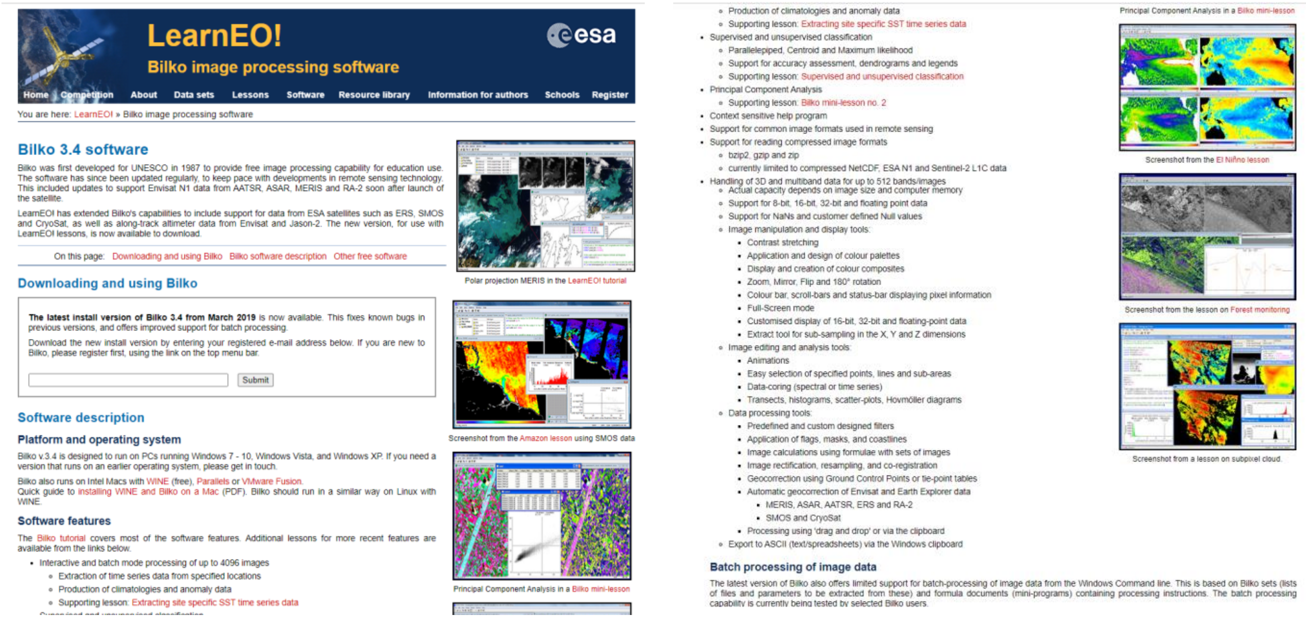


Figure 9. The Bilko software which is supported by UNESCO and ESA is accompanied by a variety of tutorials, lessons and modules that show different applications of remote sensing: https://www.learn-eo.org/software.php.

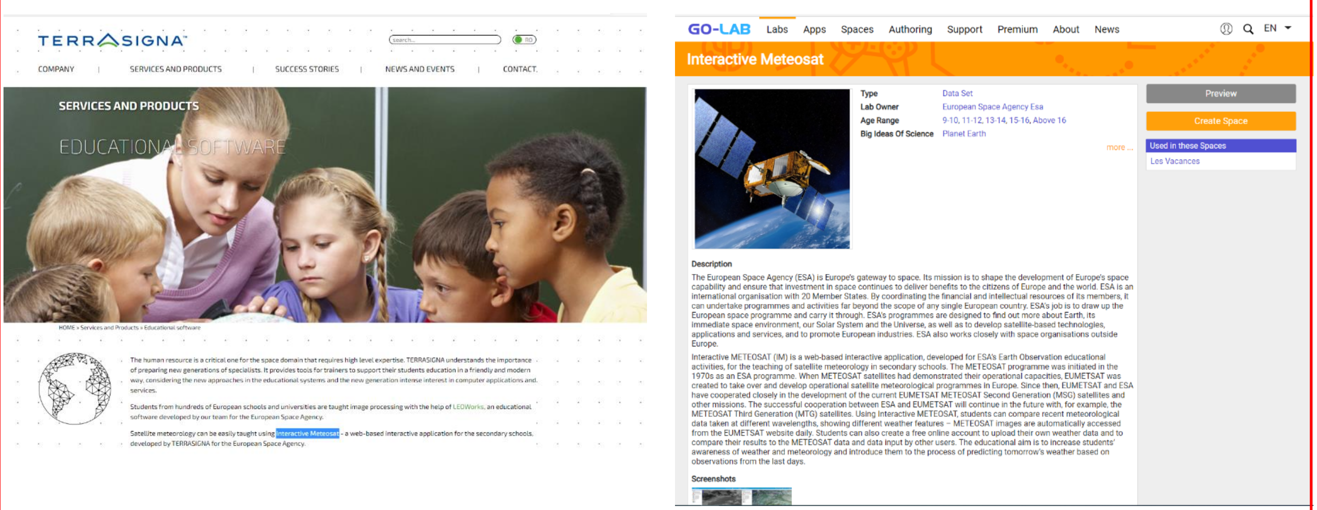


Figure 10. Interactive METEOSAT (IM) is a web-based interactive application, developed for ESA's Earth Observation educational activities, for the teaching of satellite meteorology in secondary schools: http://www.terrasigna.com/interactive-meteosat-esa-educational-software-for-meteorological-applications.html.

Figure 11. Leoworks is an educational open source software for inspecting and analysing satellite images. It represents the main tool for showing Earth Observation techniques at secondary or post-secondary level. It is used in relation to Eduspace or in the frame of ESA training courses for teachers and learners: http://leoworks.terrasigna.com/.

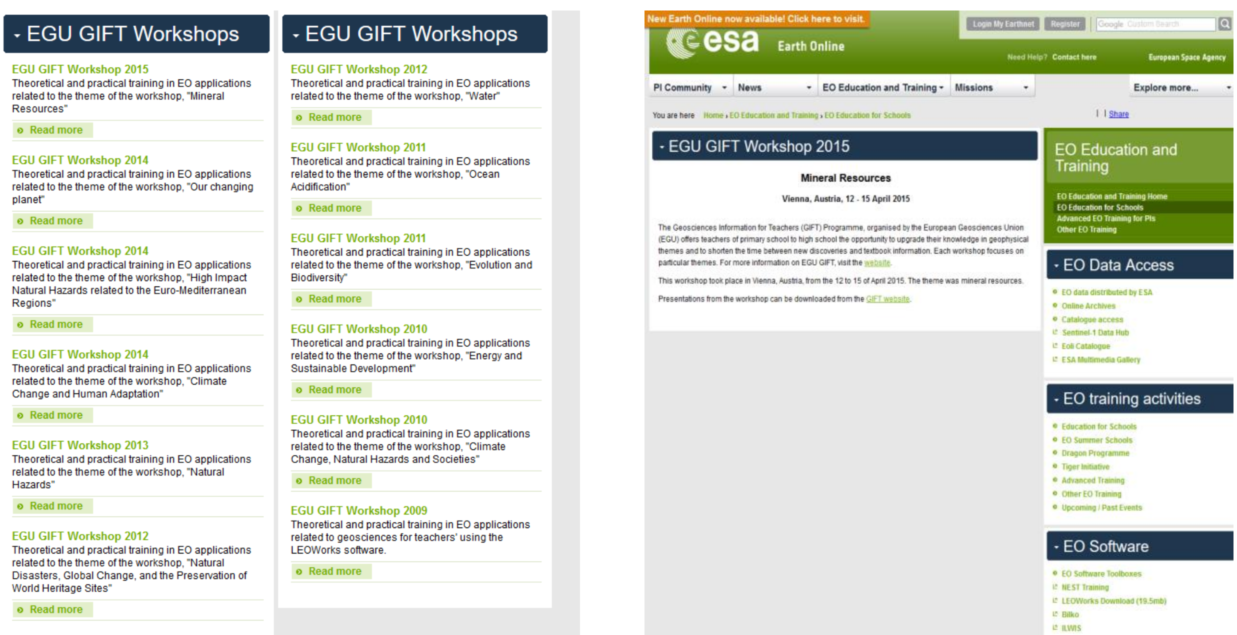


Figure 12. ESA provides and contributes to training courses, workshops, and other events where teachers are given instruction in the use of tools that will enable them to incorporate Earth Observation into the curricula of their subject. ESA also organizes outreach events where students and teachers are made aware of ESA's activities in Earth Observation: https://earth.esa.int/web/guest/eo-education-and-trainingweb/eo-edu/education-for-schools.

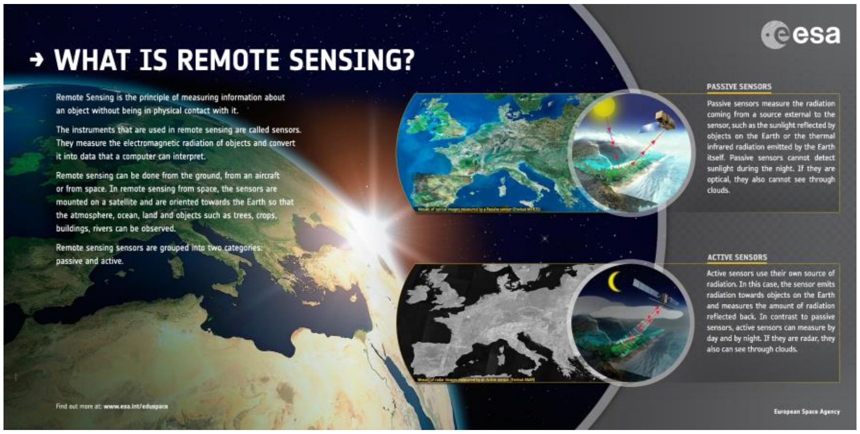


Figure 13. Several educational posters on remote sensing principles and applications for beginners which can be used in schools are available for download at the ESA website. They are available in a number of languages, including English (EN) – Spanish (ES) – Greek (GR) – Czech (CZ) – German (DE) – Italian (IT): https://eo4society.esa.int/resources/educational-posters/.

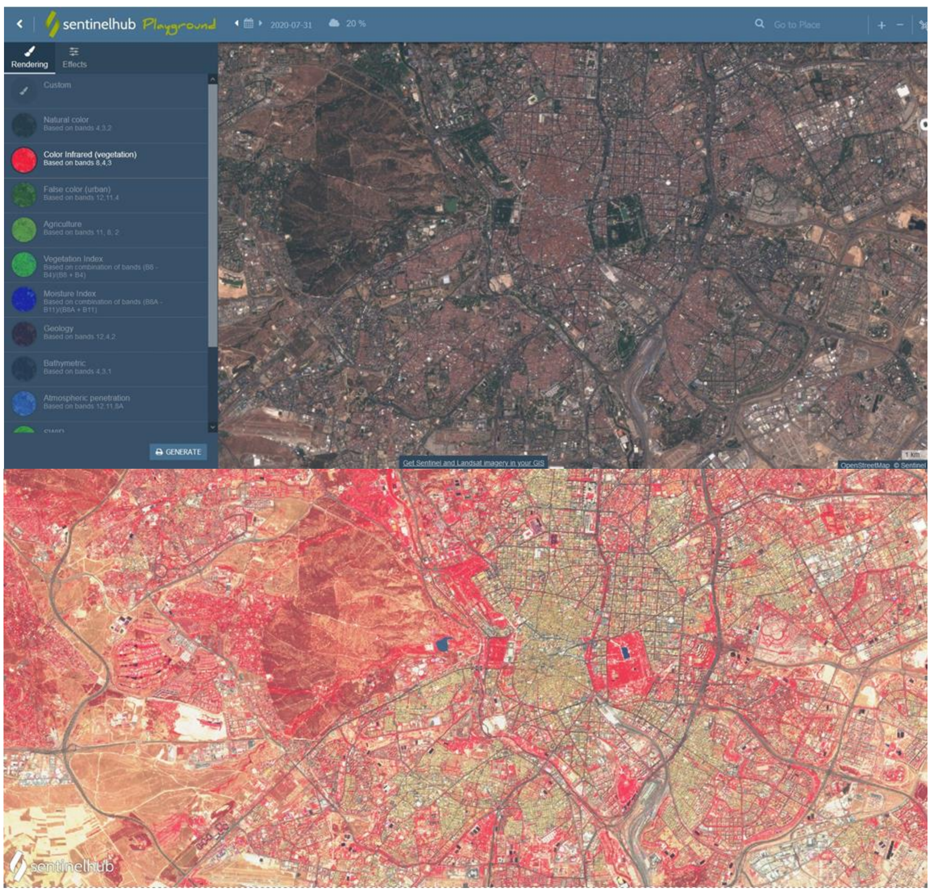


Figure 14. Even though Sentinel Playground was not developed by ESA it is worth mentioning. It utilizes Sentinel Hub technology to enable easy-to-use discovery and exploring of full-resolution Sentinel-1, Sentinel-2, Landsat 8, DEM and MODIS imagery, along with access to the Earth Observation data products. It is a graphical interface to a complete and daily updated Sentinel-2 archive, a massive resource for anyone interested in Earth's changing surface, natural or manmade. The application is perfect for someone, who wants to find the latest available images of current events (such as forest fires), observe droughts, download a nice looking poster, or simply understand how Earth Observation products are built: https://www.sentinel-hub.com/explore/sentinelplayground/.

6. CASE STUDIES AT THE CYPRUS UNIVERSITY OF TECHNOLOGY (CUT)

6.1 THE 'EXCELSIOR' H2020 TEAMING PROJECT

The Cyprus University of Technology (CUT) is a public University founded in Limassol in 2003 and consists of six faculties. The Times Higher Education World University Rankings for 2018/19 ranked the Cyprus University of Technology in the top 301-350 universities of the world; the University also received the highest score among all universities in Cyprus and Greece. The Cyprus University of Technology enrolled its first students in 2007. With its orientation towards applied research, the University aspires to establish for itself a role in support of the state and society in their efforts to confront problems, which cover all areas of science and technology. CUT is equipped with the most modern infrastructures and technological equipment which makes it possible to be the strongest on the island in research, with specialized units directed by distinguished professionals.

The 'Remote Sensing and Geo-Environment Lab'/ ERATOSTHENES Group has received the biggest funding within CUT and through "EXCELSIOR" H2020 (Excellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment; TEAMING Grant no. 857510), has been upgraded to ERATOSTHENES Centre of Excellence (CoE). ERATOSTHENES CoE activities are strengthened by an extended network of international partners.

Through the 'EXCELSIOR' H2020 Teaming Project (2019-2026) the ERATOSTHENES CoE aspires to become an excellence Digital Innovation Hub for Earth Observation and Geospatial Information by offering education, responsible research, open innovation and application services capable of sustaining Cyprus's development. The ERATOSTHENES CoE aspires to actively contribute to the European Research Area (ERA) priorities in Atmosphere and Climate, Resilient Societies and Big Earth Data Analytics, as well as to become the reference Earth Observation/Geoinformation Centre for research and innovation in the Eastern Mediterranean, Middle East and North Africa (EMMENA) region. The ERATOSTHENES CoE is a continuation of the Remote Sensing and Geo-Environment Lab/ERATOSTHENES Group [12].

The main concept behind the ERATOSTHENES CoE (ECoE) is to be a fully functional Digital Innovation Hub and a Research Excellence Centre for Earth Observation in the EMMENA region, creating an ecosystem where state-of-the-art sensing equipment, cutting-edge research, targeted education services and entrepreneurship come together. It is based on the paradigm of Open Innovation 2.0 (OI2.0), which is based on the Quadruple Helix Model, where government, industry, academia and society work together to drive change by taking full advantage of the cross-fertilisation of ideas.

The ECoE as a Digital Innovation Hub (DIH) adopts a two-axis model. In line with the ECoE Vision, the horizontal axis consists of three Thematic Clusters for sustained excellence in research of the ECoE, namely: Environment and Climate, Resilient Societies and Big Earth Data Analytics (see Figure 15).

The ECoE will exploit the networks that the EXCELSIOR partners are members of to facilitate capacity building, knowledge transfer, research partnerships, etc. Specifically,

The Infrastructure Area will be responsible for the seamless use of the existing and future ECoE infrastructure, their proper operations and the unobstructed access to Earth Observation data by the ECoE staff and stakeholders.

The Research Area will be responsible for the development of science and research which later on will lead into the development of ECoE services.

The Education Area will sustain the development and operation of ECoE as a Regional Digital Innovation Hub. The specific activities of the Education area include the ***MSc & PhDs hosting programme***, a ***Skills Development Centre*** and a ***Professional Training Programme***.

The Entrepreneurship Area will be responsible for ensuring the sustainability of the ECoE and stimulating national and regional growth, through the exploitation of the IPR, licensing of innovation and market uptake of new EO-based products, services and solutions generated by the ECoE and the Strategic Partners.

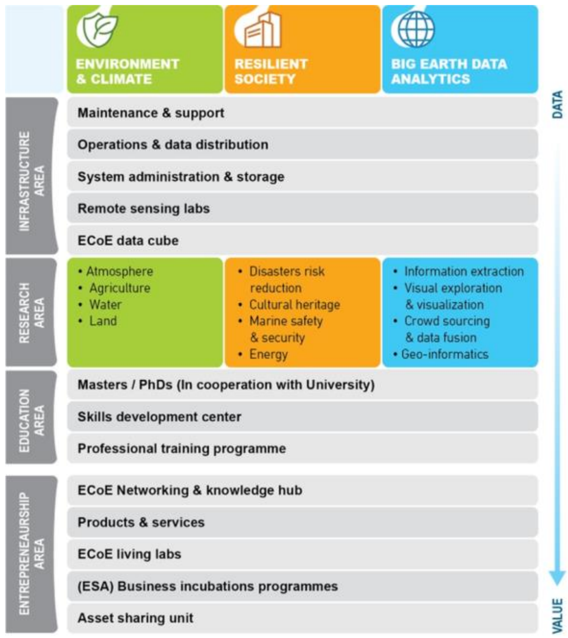


Figure 15. ERATOSTHENES as a Digital Innovation Hub; https://excelsior2020.eu/.

6.2. EXCELSIOR for Schools

Since 2007, the ERATOSTHENES Research Centre at the Cyprus University of Technology supports schools participating in national and European research competitions. One of the aims of the ‘EXCELSIOR’ project and ERATOSTHENES Centre of Excellence (ECoE) is to support students during their first contact with research, science and technology and encourage them to become young researchers. This can be achieved through presentations, seminars, workshops, science cafes and researcher's night. Students participate in research competitions by forming working groups and are guided by their teachers. In addition, researchers from the ‘EXCELSIOR’ & ERATOSTHENES Centre of Excellence are also involved to guide the group through meetings and communication and assist them during all stages of their research work. These include the study of relative publications (literature review), set the question/hypothesis, design the experimental methodology, observation and analysis of the results and finally, conclusions and dissemination of the outcomes of the study[12]. An excellent example of how students from secondary education have been involved in Earth Observation is the study conducted in Limassol coastal area in Cyprus in which plastic bottles were employed in order to determine if plastic litter can be detected through Sentinel-2 satellite images with excellent feedback[13] (see Figure 16). The ERATOSTHENES Centre of Excellence participated also at the European Researchers Night (see Figure 17).

6.3. SOFIA: Schools’ encouragement in educatiOn and outreach oF Earth surveIllance And remote sensing: Secondary Schools in Cyprus

‘SOFIA’ is one of the ongoing projects of the ‘EXCELSIOR’ and ERATOSTHENES Centre of Excellence (ECoE) in collaboration with CyRIC and is funded by the European Space Agency (ESA) (see Figures 18 and 19). This project aims to promote Earth Observation/Remote Sensing in the student community of Cyprus through educational activities, to encourage and promote education in Earth Observation and space-related topics in secondary schools, to raise awareness of students on Earth Observation (European Space Agency's satellite telescopes), to inform students on remote sensing techniques through presentations and educational workshops and finally to contribute to the effort in the development of future highly qualified professionals in the field of Earth Observation (Remote Sensing). The project has

3 stages. In the first stage, presentations must be conducted to numerous schools in Cyprus to inform students about SOFIA and to introduce them to the concept of Remote Sensing. Before and after the presentation is conducted, the researchers hand out questionnaires to students as well as teachers in order to collect data so they can evaluate the effectiveness of the presentation. In the second stage, workshops will be organized for practical training in which students will use and program a real copy of an Astro-Pi platform. The teams will also be trained to use NoIR cameras and in simulating satellite measurements. Researchers from the ERATOSTHENES Centre of Excellence as well as CyRIC will be involved to guide the students through meetings and assist them during all stages of their research work. For the final stage, a national school competition related to space technologies will be held in which teams from several schools in Cyprus will have the opportunity to participate. The winning team will be awarded a prize determined by ESA itself.

Figure 16. Researchers from the ERATOSTHENES Centre of Excellence helping students with their project for the Stockholm Junior Water Prize: https://excelsior2020.eu/excelsior-for-schools/.

Figure 17. ERATOSTHENES Centre of Excellence at the European Researchers Night.

Figure 18. SOFIA Banner: Schools' encouragement in educatiOn and outreach oF Earth surveIllance And remote sensing.

Figure 19. On the 12th of February 2020, a presentation was given to 175 students of the Drosia Gymnasium in Larnaka on the SOFIA funded project.

6.4. Earth observation at the Department of Civil Engineering and Geomatics of the Cyprus University of Technology & EXCELSIOR H2020 Teaming activities in higher education

Within the Department of Civil Engineering and Geomatics of the Cyprus University of Technology-CUT, the following educational programmes are offered:

- two BEng Degrees: BEng in Civil Engineering & BEng in Surveying Engineering (> 4 modules in remote sensing),
- two MSc: MSc in Civil Engineering with Sustainable Design (Remote Sensing module plus options for remote sensing for civil engineering purposes in dissertations) & MSc in Geoinformatics & Geospatial Technologies (including 2 remote sensing modules plus specialization in geoinformatics modules in which Earth Observation is used and dissertation)

- and a PhD in Civil Engineering & Geomatics (e.g., Earth Observation activities)

Through the Excelsior H2020 activities, virtual workshops have been organized in collaboration with the strategic partners DLR, TROPOS and NOA for the existing CUT PhD students and researchers by providing the opportunity to all to come across with CUT research activity on Earth Observation and geospatial analysis using the CUT Bigbluebutton Platform (see Figure 20). An international workshop through the Excelsior H2020 teaming project has been organized in collaboration with the strategic partners DLR, TROPOS and NOA and CUT & DEC partners using the Zoom platform and attracted more than 520 participants (see Figure 21).

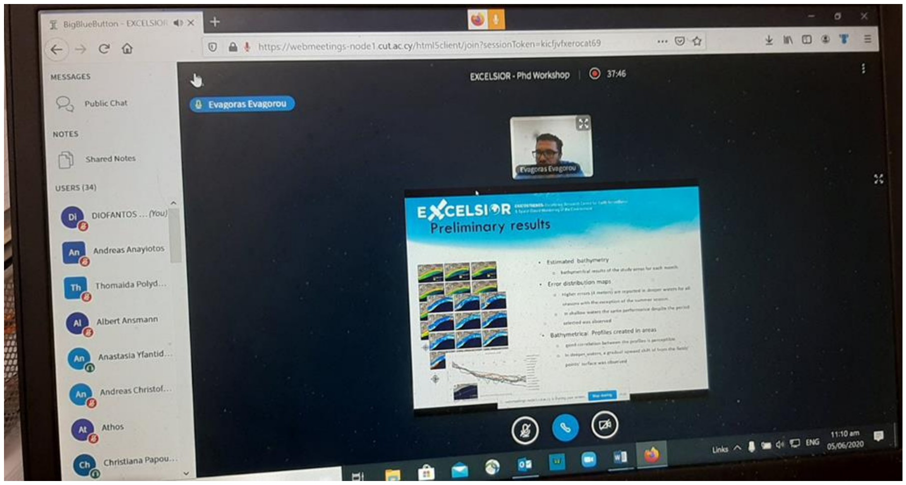


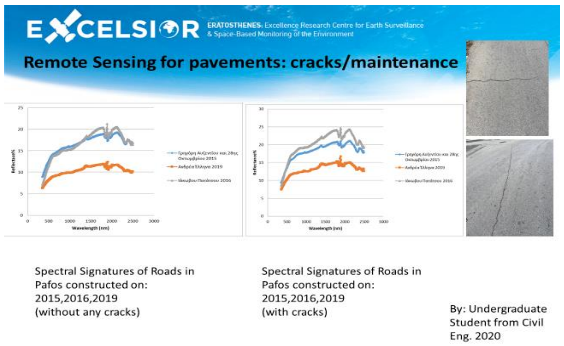
Figure 20. Virtual PhD Workshop through Excelsior H2020 Teaming Project (Bigbluebutton of the Cyprus University of Technology).

Figure 21. Virtual Workshop through Excelsior H2020 Teaming Project (Zoom Platform).

Through the existing MSc in Geoinformatics & Geospatial Technologies modules, several interactive examples of how Earth Observation is used to provide solutions for engineers have been presented through the 'Moodle platform' such as the following key examples that are of common interest for both geomatics and civil engineers, using 'EXCELSIOR' H2020 Teaming working examples/applications (e.g., see Figure 22):

- Integrated use of GIS and remote sensing for monitoring landslides in transportation pavements: the case study of Paphos area in Cyprus [14]
- Use of Earth Observation to support the detection of cracks in transport pavements [15]
- Use of Earth Observation flood risk assessment (hydraulics analysis) [16, 17, 21]

- Water quality monitoring in dams using Earth Observation [18, 21]
- Irrigation demand through Earth Observation [19, 21]
- Air quality monitoring through space / Air pollution and Climate change [20]
- Water leakage detection from space [21]
- Cultural Heritage Applications from space [22, 23]
- Preparing business plans for remote sensing companies etc.



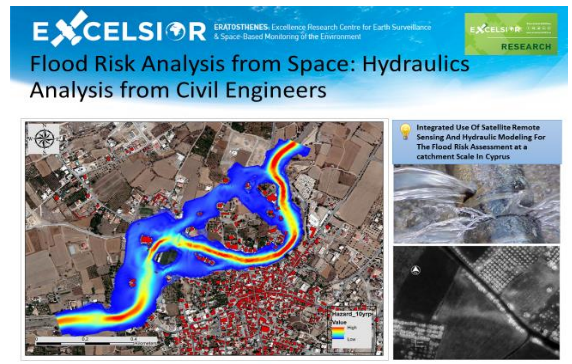


Figure 22a. Interactive examples through Moodle. How Earth Observation is used to solve problems (Teaching lecture notes).

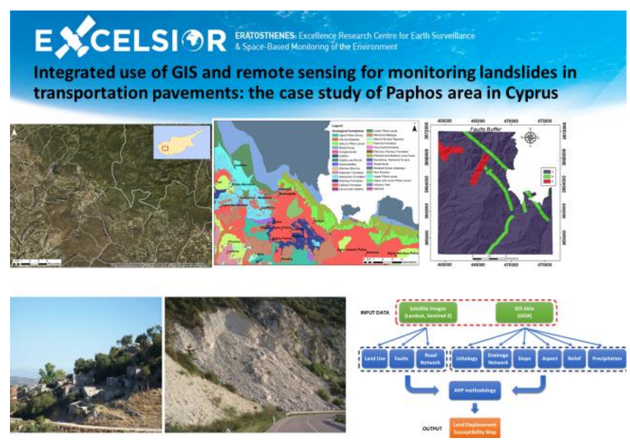


Figure 22b. Interactive examples through Moodle. How Earth Observation is used to solve problems (Teaching lecture notes).

How remote sensing can be used from the Civil Engineers through the BEng & MSc courses? Through the

- The existing knowledge of Civil Engineering within the Department of Civil Engineering & Geomatics at CUT has been capitalized.
- The Integration with Remote Sensing for solving engineering problems.
- Use of the Civil Engineering Labs for the benefit of Geomatics / Excelsior and vice –versa. Testing-Calibrating results from Satellite Remote Sensing.
- The use of remote sensing module in the curriculum of the Civil Engineers (e.g. dissertation and final year projects).

Figure 22c. Interactive examples through Moodle. How Earth Observation is used to solve problems (Teaching lecture notes).

Business Model Canvas of your company

Key Partners	Key Activities	Key Resources	Customer relationships	Customer Segments
• .... • Partnering Organizations (6)	• International knowledge transfer and capacity building • Data management, • Publish scientific papers • Infrastructure maintenance • Educational activities • Living Labs	• Personnel (30) • Infrastructure (10 Million euros) • Buildings and offices (3 Additional Buildings)	• Specialized EO applications • Education • End-user • Scientific Community	• Government Departments Semi-government Agencies Utility Companies SMEs • Spin-offs Professional organizations • Academia • Individual End-users

EXAMPLE OF BUSINESS CANVAS FOR A REMOTE SENSING COMPANY

Figure 22d. Interactive examples through Moodle. How Earth Observation is used to solve problems (Teaching lecture notes).

7. DISCUSSION & PRELIMINARY RESULTS

Within the context of education, 'monitoring' is defined as the continuous process of gathering information about teaching for practical judgment and decision making [24], whereas 'evaluation' is the periodic assessment of the overall process and final results of a course or academic program or a structured short course. The results of evaluations should be used to demonstrate to teaching institutions, funding agencies, and national authorities to what extent the resources invested in teaching produced the expected effect. There are four main types of evaluations. These are the evaluation of the process, final outcomes, effectiveness, and impact [24]. Based on the existing activities as described in section 6, a preliminary assessment of the methods used to promote Earth Observation benefits to the secondary and higher education in Cyprus have been conducted up to now using the above four types of evaluations. Indeed, at this stage the following qualitative assessment has been made based on the existing experience using the 'effectiveness' evaluation process for comparing different methods for promoting Earth Observation in education in the secondary and higher education (preliminary results) as shown in Table 2. Effectiveness assesses the ability of students to apply knowledge, skills, and attitudes.

Table 2: Evaluation results.

Method	**SECONDARY EDUCATION ‘EFFECTIVENESS’**	**HIGHER EDUCATION ‘EFFECTIVENESS’**
stage presentations		**X**
hand out questionnaires & leaflets	**X**	
workshops	**X**	**X**
On-site meetings	**X**	**X**
Seminars		**X**
competitions	**X**	
science cafes	**X**	**X**
researcher's nights	**X**	
Demonstration projects (e.g., detection of plastics in the coastal areas using Earth Observation)	**X**	
Use of remote sensing in the curriculum of engineering courses (undergraduate & postgraduate courses)	**NOT APPLICABLE**	**X**
On-line seminars, lectures, workshops using Moodle or zoom platforms through worked examples and applications		**X**
‘**X**’=refers to the more effective method		

8. CONCLUSIONS

If Remote Sensing is successfully integrated into education and teachers have the appropriate training and materials to work with, then the school curriculum can be enriched with new innovative concepts regarding space technology. Furthermore, multidisciplinary and active learning can be promoted due to the nature of Remote Sensing. Finally, teachers are provided with an opportunity to explain and teach science topics in a more enjoyable and motivating way, thus helping students learn but also informing them about this fast-growing technology and its industry which is in need for highly qualified employees. Examples of how Earth observation is used in secondary education in other countries have been presented; as well as examples in Cyprus through the ‘EXCELSIOR for Schools’ & SOFIA ESA funded projects. Also, examples of how Earth Observation is used in higher education are presented. Finally, interactive examples of how Earth Observation is used in the existing curriculum for undergraduate, postgraduate courses for surveying and civil engineers are demonstrated for monitoring and providing solutions for civil and geomatics engineering issues.

The benefits of Earth Observation are promoted in Cyprus for the secondary education through different methods such as: stage presentations, hand out questionnaires, workshops, meetings and competitions, seminars, science cafes and researcher's nights; and for the higher education through: use of remote sensing in the curriculum of engineering courses both on undergraduate and postgraduate level, workshops, seminars using on-line platforms or conventional methods. Preliminary results regarding the effectiveness of each educational method have been demonstrated for both secondary and higher education in Cyprus. The campaign is still running, and more results will be published soon.

ACKNOWLEDGEMENTS

The authors acknowledge the 'EXCELSIOR': ERATOSTHENES: EXcellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment H2020 Widespread Teaming project (www.excelsior2020.eu). 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. Thanks are given also to ESA for funding the ESA PECS project in Cyprus 'SOFIA': Schools' encouragement in educatiOn and outreach oF Earth surveIllance And remote sensing.

REFERENCES

[1] S. Naumann, Siegmund, A., Ditter, R., Haspel, M. Jahn, M., Korea, S. "Remote Sensing in School – Theoretical Concept and Practical Implementation," *Earth*, no. June 2014, 2009.

[2] W. Hassenpflug, L. Riechelmann, and W. D. John, "Promotion of remote sensing in school education in Germany," *Int. Geosci. Remote Sens. Symp.*, vol. 5, pp. 2714–2716, 1999, doi: 10.1109/igarss.1999.771627.

[3] K. Voss, R. Goetzke, F. Thierfeldt, and G. Menz, "Integrating applied remote sensing methodology in secondary education," *Int. Geosci. Remote Sens. Symp.*, pp. 2167–2169, 2007, doi: 10.1109/IGARSS.2007.4423264.

[4] L. Somantri and Nandi, "Learning Methods of Remote Sensing in the 2013 Curriculum of Secondary School," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 47, no. 1, 2016, doi: 10.1088/1755-1315/47/1/012045.

[5] K. Voss, R. Goetzke, and H. Hodam, "Learning Modules – A Way to Integrate Remote Sensing Methods in School Education," *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.*, 2006.

[6] Y. Cheung, M. Pang, H. Lin, and C. K. J. Lee, "Enable spatial thinking using GIS and Satellite Remote Sensing - A teacher-friendly approach," *Procedia - Soc. Behav. Sci.*, vol. 21, pp. 130–138, 2011, doi: 10.1016/j.sbspro.2011.07.014.

[7] T. J. Kennedy and M. R. L. Odell, "Engaging Students In STEM Education," *Sci. Educ. Int.*, vol. 25, no. 3, pp. 246–258, 2014.

[8] A. Mouratidis and M. Koutsoukos, "Use of Esa Earth Observation Educational Resources in Vocational Education and Training - Lifelong Learning: Towards Stem Promotion and Development of Skills," *Bull. Geol. Soc. Greece*, vol. 50, no. 3, p. 1652, 2017, doi: 10.12681/bgsg.11888.

[9] T. Agrawal, "Vocational education and training programs (VET): An Asian perspective," *Asia-Pacific J. Coop. Educ.*, vol. 14, no. 1, pp. 15–26, 2013.

[10] M. Laal and P. Salamati, "Lifelong learning; Why do we need it?," *Procedia - Soc. Behav. Sci.*, vol. 31, no. 2011, pp. 399–403, 2012, doi: 10.1016/j.sbspro.2011.12.073.

[11] Wikipedia, "Lifelong learning," [Online]. Available: https://en.wikipedia.org/wiki/Lifelong_learning.

[12] "Excelsior2020," [Online]. Available: https://excelsior2020.eu/the-project/overview/.

[13] Themistocleous, K.; Papoutsa, C.; Michaelides, S.; Hadjimitsis, D. Investigating Detection of Floating Plastic Litter from Space Using Sentinel-2 Imagery. *Remote Sens*. 2020, 12, 2648.

[14] Alexakis, D. D., Agapiou A., Tzouvaras M., Neocleous, K., Michaelides, S., Themistocleous, K., Hadjimitsis, D.G., (2013). Integrated use of Remote Sensing and GIS for monitoring Landslides in transportation pavements: risk assessment study of Paphos area in Cyprus, Natural Hazards, Journal of the International Society for the Prevention and Mitigation of Natural Hazards, 72(10), 119-141, DOI10.1007/s11069-013-0770-3.

[15] Mettas, C.; Themistocleous, K.; Neocleous, K.; Christofe, A.; Pilakoutas, K.; Hadjimitsis, D.; Engineering, S. Monitoring Asphalt Pavement Damages Using Remote Sensing Techniques. In Proc. SPIE 9535, Third International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2015); 2015.

[16] Alexakis, D., Hadjimitsis, D.G., Agapiou A., Themistocleous K., Retalis A. Monitoring urban land cover in Yialias catchment area in Cyprus using satellite remote sensing techniques and field spectroradiometric measurements, *Appl. Remote Sen*., SPIE (2012) DOI: 10.1117/1.JRS.6.063603

[17] Alexakis, D.D., Hadjimitsis, D.G. Agapiou, A. (2013). Integrated use of Remote Sensing, GIS and Precipitation Data for the Assessment of Soil Erosion Rate in the Catchment Area of "Yialias" in Cyprus. *Atmos. Res.*, 131, pp. 108-124.

[18] Papoutsa, C., Akylas, E., Hadjimitsis, D. Trophic State Index derivation through the remote sensing of Case-2

water bodies in the Mediterranean region. cent.eur.j.geo. 6, 67–78 (2014). https://doi.org/10.2478/s13533-012-0161-4.

[19] Papadavid G., Hadjimitsis D. G., Toulios L., Michaelides S. A Modified SEBAL Modeling Approach for Estimating Crop Evapotranspiration in Semi-arid Conditions. *Water Resources Management*, 27: 3493-3506, July 01, 2013 (2013) DOI10.1007/s11269-013-0360-x., http://link.springer.com/article/10.1007/s11269-013-0360-x.

[20] Mamouri R., Albert Ansmann, Hadjimitsis D.G., Nisantzi A, Johannes Bühl, Silas Michaelides, Patric Seifert, Ronny Engelmann, Ulla Wandinger, Charalampos Kontoes, Gunter Schreier, Georgios Komodromos, and Kyriacos Themistocleous "Strategic positioning of the ERATOSTHENES Research Centre for atmospheric remote sensing research in the Eastern Mediterranean and Middle East region", Proc. SPIE 10429, Lidar Technologies, Techniques, and Measurements for Atmospheric Remote Sensing XIII, 1042906 (4 October 2017); https://doi.org/10.1117/12.2281777.

[21] Hadjimitsis D.G. 'Remote Sensing of Environment – Integrated Approaches', Edited by Diofantos G. Hadjimitsis, ISBN 978-953-51-1152-8, Hard cover, 211 pages, Publisher: InTech, DOI: 10.5772/3337, 2013.

[22] Agapiou, A.; Lysandrou, V.; Alexakis, D.D.; Themistocleous, K.; Cuca, B.; Sarris, A.; Argyrou, N.; Hadjimitsis, D.G. Cultural heritage management and monitoring using remote sensing data and GIS: The case study of Paphos area, Cyprus. CEUS Comput. Environ. Urban Syst. (2015), 54, 230–239.

[23] Agapiou, A.; Lysandrou, V.; Themistocleous, K.; Hadjimitsis, D.G. Risk assessment of Cultural Heritage Sites Clusters Using Satellite Imagery and GIS: The case study of Paphos District, Cyprus. Nat. Hazards (2016), 83, 5–20

[24] https://www.cdc.gov/std/Program/pupestd/Types%20of%20Evaluation.pdf.