UNIVERSIDAD DE ALMERÍA
Vicerrectorado de Internacionalización

Programas de Internacionalización

Study Abroad 2018

Geospatial information technologies in land planning and natural resources management.

Period: **from July 2 to July 26, 2018.**

Teaching hours: **80**

Coordinators: Fernando J. Aguilar Torres, Andrés M. García Lorca, Manuel A. Aguilar Torres

1. INTRODUCTION

Emerging space information technologies (Geospatial Information Technologies: GIT) can be considered as a new paradigm of geospatial information processing where the digital technology of georeferenced data acquisition and the computer processing of raw information allow to efficiently address many of the standard phases related to a myriad of scientific and technical disciplines: i) data collection, ii) storage, iii) administration, iv) analysis, v) modeling and vi) application of results. Currently, the GIT have become an irreplaceable tool for obtaining and analyzing spatio-temporal and multi-scale information that constitutes a high added value for the improvement of decision-making in areas such as environmental management and integrated land planning. Indeed, many of GIT applications have arisen from the concept of increasing business competitiveness linked to the term "do more for less", repeatedly demonstrating that they can increase the performance of companies in different fields such as construction and civil engineering , urban planning, forestry, monitoring and managing of natural resources, energy and resource transport systems, integrated land management, waste management, tourism and services, agriculture and livestock, conservation of artistic heritage, etc.

The disciplines included in this summer course proposal, i.e. Physical Geography, Remote Sensing and Information and Territorial Planning, offer a set of tools and technologies very valuable for monitoring, at multiple scales and with great precision, the dynamics of what happens in our "Digital Earth". The team of professors who make up this course lays up a valuable background, accumulated by our teaching group over many years and research projects, that has permitted to design an attractive and transversal course conceived from the development of case study cases. In this way it has been devised to transmit to the students a sufficient base in order to improve their capacities headed up to implement these monitoring systems as a continuous methodology to support decision making through what could be described as an Integrated and Sustainable Policy for Land and Natural Resources Management.

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2. GOALS

1. To present the most up-to-date spatial information technologies for the capture and production of 2D and 3D georeferenced digital cartography from digital photogrammetry (aerial photography, drones and satellite images), laser altimetry (LIDAR: Light Detection and Ranging), Terrestrial Laser Scanning (TLS) and Mobile Mapping (SLAM: Simultaneous Localization and Mapping).

2. To show the general procedures to obtain geo-referenced products such as multiband orthophotos, digital terrain models and digital surface models, 3D point clouds and vector data, bearing the idea of selecting the techniques that best suit to the problem to solve (spatial and temporal scales, accuracy, required information, etc.).

3. To train students in the use of software platforms for the integration and analysis of geo-referenced information such as ArcGIS and QGIS, thus learning to use geo-referenced data from various sources, both local and remote, integrating them into the skeleton of various projects (e.g. environmental, agricultural, spatial planning, etc.), editing, analyzing data and finally obtaining the requested results and derived maps.

4. To extract high-added-value meaningful information from 2D/3D geospatial data by using the concept of data fusion and specific software as tools to improve the monitoring and management of natural resources. For example, forest mass monitoring and biomass inventory, estimation of biophysical variables (chlorophyll content, plant water, vegetation indices), urban planning studies, etc.

5. To introduce knowledge and know-how about Natural Resources Management and Integrated Land Planning within the framework of sustainable development.

3. CONTENTS

Modules	Description
MODULE 1: *Geomatics. General concepts and applications in land planning and natural resources management*	• Introduction to Geomatics. Elements supporting Geomatics (Remote sensing, GNSS, photogrammetry, GIS, geodesy, cartography, laser scanner and expert systems & spatial information). • Passive optical sensors. Satellite images. Electromagnetic spectrum. Physical principles (visible radiation and color, radiance, reflectance and spectral response, effects of atmosphere). • Active sensors. Laser scanner and Radar. • Analysis of digital images. Preprocessing, improvement, transformations, classification and integration. • Applications in land planning and natural resource management. • Invited conference: Priority lines of the Mediterranean Program (International Union for Conservation of Nature) aimed at promoting and

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	supporting a governance model of effective and equitable natural resources management
MODULE 2: *Aerial digital photogrammetry, drones and satellite images*	• Digital photogrammetry. Aerial images. General characteristics. Digital cameras. Geometric basis of photogrammetry. External and internal orientation. Structure from Motion Multi-View Stereo Algorithms (SfM MVS). • Very high resolution satellite images (VHR). Introduction to very high resolution satellite images. Fundamentals of pushbroom systems (linear arrays). GeoEye-1 and WorldView-2/3 satellites. Orientation models based on rational functions. • Digital photogrammetric flow. Flight planning, digitization, preparation of pyramidal images and orientation. Ground control and ground check points. Aerotriangulation. Vision and stereoscopic edition. Epipolar images. • Generation of orthophotos and digital elevation models (surface models and terrain models). • Case study: practical applications with OrthoEngine from PCI Geomatica for images of conventional aerial flights and VHR satellite images. Production of digital elevation models and orthoimages. • Case study: processing of images taken with drones (RPAS) for coastal erosion monitoring. Generation of colored point clouds, digital elevation models and orthoimages. Obtaining the digital terrain model by automatically filtering non-terrain points.
MODULE 3: *Optical images of medium ground resolution (Landsat 8 and Sentinel-2 A & B)*	• Characteristics of medium-high ground resolution optical sensors with free access. Download sites. • Relevant indices which can be derived from the spectral information of Landsat 8 and Sentinel-2 A & B. • Importance of previous atmospheric corrections. • Time series. Examples. • Practical applications on vegetation mapping, burned areas and Land Use/Land Cover (LULC) classification using the "SNAP" software from the European Space Agency. • Supervised classification. Practical examples by means of different classifiers. • Invited conference: Systems and procedures for capturing, processing and publishing geo-referenced data. The Environmental Information Network of Andalusia
MODULE 4: *Fundamentals and applications of airborne LiDAR systems*	• Basis of airborne LiDAR systems. Integration of laser scanner, inertial navigation system and kinematic GPS. • Flight parameterization. Correction of strips and transformation of ellipsoidal into orthometric heights. • Lightweight LiDAR borne on drones (RPAS). Capabilities and limitations. • Filtering and classification of point clouds to obtain digital terrain models, digital surfaces models and normalized digital surface models.

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	• Display and processing of LiDAR point clouds using the open source CloudCompare software. • Case study: Complete workflow using Lastools software (quality control, classification of points and generation of digital terrain models, surface models, normalized surface models and buildings delineation). • Case study: Workflow for carrying out forestry inventories using the open source FUSION software.
MODULE 5: *Fusion and processing of multi-temporal and multi-source information for monitoring and analyzing natural and environmental resources*	• Integration of multi-source and multi-temporal geo-referenced data. • OBIA image analysis techniques (Object Based Image Analysis) vs. pixel-based traditional methods. • Image segmentation. Generation and optimization of the features vector (color, shape, area, texture and context of each object). • Supervised classification of objects through non-parametric classifiers (Nearest Neighbor, SVM and Random Forest). • Importance of training samples and validation of the classifier. Measuring classification accuracy. • Case study: complete workflow by using the eCognition (Trimble) software to help in urban planning and forest management.
MODULE 6: *Physical geography for land planning and natural resources management*	• Introduction to Physical Geography. • Elements that structure the physical environment (relief, surface waters, seas and oceans, climate, vegetation, fauna and soil). • Patterns and processes. • Applications of Physical Geography for the integrated management of land and natural resources. • Guided tour through the Maritime-Terrestrial Natural Park of Cabo de Gata-Níjar.
MODULE 7: *Spatial analysis with ArcGIS*	• Models and data structures in Geographic Information Systems (GIS). • Introduction to spatial analysis. • Functions and techniques of spatial analysis from vector models. Queries based on attributes and locations and measurement functions (distances, perimeters, areas, etc.). Inclusion and selective extraction of information (Classifications). Neighborhood functions (buffer). Overlay functions. Cartographic production (maps, legends, etc.). • Digital Elevation Models. Extraction of topographic variables (slope, orientation, shading, area of contribution, extraction of basins, insolation, etc.). • Spatial analysis from raster models. Selective extraction of information (Classifications). Neighborhood functions (buffer) and overlay functions (LSF factor and other secondary topographic attributes).
MODULE 8 *Urban Planning*	• General concepts regarding Urban Planning. • Territorial Information needed by Local Administrations. • Information Systems of Urban Planning. • Sustainable urbanism in Municipal Planning. • Case study: Transformations and recent changes regarding land use on

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	the "Levante Almeriense" coast.
MODULE 9: *Building Information and Modeling (BIM), Terrestrial Laser Scanning (TLS) and Simultaneous Location and Mapping (SLAM)*	• Technology Information Building and Modeling (BIM) concept. • Phases of a BIM procedure. Software and hardware of utility. • Introduction to the Terrestrial Laser Scanner (TLS). • Types of terrestrial laser scanners and measurement methodology. • Applications in 3D documentation, engineering, forestry, mining, etc. • Processing of laser point clouds using the FARO Scene software. • Practical case of laser survey. Full flow including GPS-RTK geo-referencing. • Introduction to Simultaneous Location and Mapping (SLAM) procedures. • Metric and topological maps. • Sensors used to navigate and update maps in real time. Most common algorithms (Kalman filters, etc.). • Case study: Mobile Mapping survey with a LiDAR system and stereo camera borne on a car.
MODULE 10: *Web Mapping applications*	• Distribution of spatial information through the internet. Web Mapping Applications. • Technology: HTML and Javascript. • Spatial data bases: PostGIS. • Architecture: Open Source Libraries for Web Mapping (OpenLayers and Leaflet). Introduction to BaseMaps (Google Maps and OpenStreetMaps). Open Source map servers (GeoServer). • Importing and publishing spatial data through Geoserver. Web Map Service (WMS), Web Feature Service (WFS) and GeoJSON. • Connection with the GIS open source QGIS. • Case study: Web Mapping project.

4. METHODOLOGY

The teaching methodology of this course should be adapted to the profile of the participant student, initially presenting a very diverse academic origin (Engineering, Geography, Environmental Sciences, Architecture, etc.) with both master and degree levels. These would be students who take the summer course as enrichment of their original academic training, so their motivations and expectations will be very heterogeneous. In general, and according to the experience of the teaching staff, very motivated, mature and responsible students are expected. If they are sufficiently motivated, they strive a lot and do not usually raise problems related to collaborative work (team work) because they assume that it will be a constant in the development of their future professional career. In general, a main asset for the motivation of this type of students would consist of finding specific applications from all the knowledge and know-how acquired.

From this perspective, this course focuses on eminently practical or procedural sessions, aimed

at highlighting the importance of the techniques and procedures that students learn for their future professional career. For example, the transversal relevance of the know-how related to capturing, processing, analyzing and extracting meaningful information from geo-referenced data of diverse nature and its application in several disciplines such as architecture, engineering, landscape analysis, management of natural resources, etc.

It is therefore essential to work in the computer classroom with geomatics tools (mainly case studies and project-based learning) through specialized software, preferably open source. This type of procedural knowledge will be complemented by field visits (Physical Geography and Environmental knowledge) and invited lectures or seminars given by professors of widely recognized expertise and extensive professional experience outside the University of Almeria. Likewise, and to address the first two phases of conceptual maturation, i.e. phases of comprehension and analysis, the course should provide sufficient theoretical knowledge to facilitate its understanding and assimilation in order to get students ready and motivated to perform a further deepening work through procedural or practical teaching (phases of application and synthesis). The component of preliminary learning and understanding will be carried out through participatory lectures through PowerPoint presentations and online teaching platform.

Coming from the methodological characteristics of this course, the coordination and synchronization of the practical and theoretical classes in order to facilitate the development and assimilation of the applied component, thus increasing its effectiveness, will be a priority.

The teaching languages of the course will be both English and Spanish.

5. PROFESSIONAL VISITS AND COMPLEMENTARY ACADEMIC ACTIVITIES

*Activity 1. Invited lecture given by **Antonio Troya**, Director and Coordinator of the Mediterranean Programme of the International Union for Conservation of Nature. One of the priority lines of the Mediterranean Programme is related to promoting and supporting an effective and equitable governance model of natural resources management. (https://www.iucn.org/es/regions/mediterr%C3%A1neo).*

*Activity 2. Invited lecture given by **Juan José Vales Bravo**, Head of Earth Observation in REDIAM (Environmental Information Network of Andalusia), belonging to the Environment and Water Agency of Andalusia, which will offer information on capturing, processing and web mapping publishing of geo-referenced data used by REDIAM (http://www.juntadeandalucia.es/medioambiente/site/rediam).*

*Actividad 3. Visit to the Maritime-Terrestrial Natural Park of Cabo de Gata-Níjar. A guided visit will be accomplished by the Professor of Physical Geography **Andrés M. García Lorca** and the Director-Conservator of the Park. Students will know, in addition to a description of the patterns and geographic processes of the Natural Park, the current General Plan for Natural*

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Resources Management (comprising natural and cultural heritage and areas subject to different degrees of protection), the Master Plan for Use and Management (guidelines to ensure the conservation of natural and cultural values) and the Sustainable Development Plan (prevention of risks and proposals to solve existing problems).

6. EVALUATION

The assessment of students achievement will be carried out through the following tools:

The conceptual component will have a weight of 20% in the final grade, being evaluated through a multiple choice test to individualize the assimilation of the theoretical contents.

The procedural and attitudinal component will have a weight of 80% in the final grade, being evaluated in a continuous way throughout the course by using the following tools:

a) *Evaluation of student reports concerning several case studies developed in class and proposed by the academic staff.*

b) *Attendance at face-to-face activities and active participation in all teaching activities. On time delivery of the works proposed by the academic staff will be also valued.*

7. ACADEMIC STAFF

Fernando J. Aguilar Torres *obtained his Ph.D. in Agriculture Engineering from the University of Córdoba in 1997. He is currently* ***Full Professor of Geomatics Engineering and Computer Aided Design in the Engineering Department of the University of Almeria****. It has a total of 60 scientific publications in journals with relative quality index, 45 of which are included in the Journal Citation Reports of the "Science Citation Index", with around 1500 citations in Google Scholar (h-index = 20). He has obtained numerous mentions for the quality of contributions to international conferences, in which he has presented more than 100 communications. The internationalization of his scientific activity has led to his performance as a regular reviewer of 15 international journals JCR (SCI) related to the discipline of Remote Sensing, as well as belonging to several international scientific committees and the collaboration, as external evaluator, of the Italian Research and University Evaluation Agency for the periods 2004-2010 and 2011-2014 (Evaluation of Research Quality VQR 2004-2010 and VQR 2011-2014). Finally, he has been the principal researcher and has participated in several projects obtained in competitive public calls at national and international level, as well as he has participated in several research contracts of knowledge transfer to the business sector.*

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Andrés M. García Lorca *obtained his Ph.D. in Geography from the University of Murcia in 1990. He is currently* ***Full Professor of Regional Geography at the University of Almeria****. With regards to the quality and dissemination of his research activity, a total of 113 scientific and technical publications stand out, from which 35 are included in the Journal Citation Reports of the "Science Citation Index". He has obtained numerous mentions for the quality of contributions to national and international congresses, in which he has presented more than 65 communications, also participating as a scientific-technical coordinator and member of the organizing committee of more than 8 international congresses. He has acted as a member of the editorial board of several scientific journals (e.g. Cuadernos de la OICI, Parallel 37º Magazine of Geographical Studies, NIMBUS, etc.). He has also participated as a representative of the General State Administration in the Board of Directors of the Port Authority of Almeria, has chaired the Andalusian Regional Science Association, being also a founding member and member of the Board of Directors of the Ibero-American Institute of Local and Municipal Law, academic number of the Andalusian Academy of Regional Science and President of the academic section of the Society of Knowledge. Finally, he has led 14 research projects and has collaborated in several others, all of them obtained in competitive public calls at national and international level, also highlighting his participation in numerous research contracts of knowledge transfer to the business sector.*

Manuel A. Aguilar Torres *obtained his Ph.D. in Agricultural Engineering from the University of Córdoba in 2001. He is currently* ***Full Professor at the University of Almeria, working at the Engineering Department****. He has a total of 55 scientific publications in journals with a relative quality index, 44 of which are included in the Journal Citation Reports of the "Science Citation Index", with 677 citations in SCI (h-index = 15). He has obtained several mentions for the quality of contributions to international congresses, in which he has presented more than 80 communications. The internationalization of his scientific activity has led to the performance as a regular reviewer of up to 18 international journals JCR (SCI). He has been the main researcher and has participated in several projects obtained in competitive public calls at national and international level, as well as he has participated in many research contracts for the transfer of knowledge to the business sector. Further information can be found in the following website: https://w3.ual.es/personal/maguilar/*

Jorge Delgado García *obtained his Ph.D. in Geological Sciences from the University of Granada in 1993. He is currently* ***Professor at the University of Jaen in the Department of Cartographic, Geodetic and Photogrammetric Engineering****. His research activity focuses on the application of geostatistical and geomatics techniques for the extraction of information from the territory, both in urban and rural environments, having published more than 30 papers in international journals, and having participated as a speaker in more than 100 scientific conferences, also achieving several international recognitions. He is a regular reviewer of international journals*

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related to Geomatics Engineering and the application of photogrammetric techniques for the extraction of information from the territory and its modeling. He has participated as main researcher in several research projects funded by competitive public calls (PROFIT, AVANZA, Iberoeka, CDTI, Interreg, CTA) with a special focus on collaborative research and technology transfer to the business sector. He has also collaborated in different contracts for providing services both in Spain and in Ibero-American countries (Ecuador, Colombia, Costa Rica, Bolivia, etc.), taking part in the Follow-up Committee of the Multipurpose Cadastral Project of Colombia since 2016 as an expert in Mapping. He is the responsible of the research group "Photogrammetric and Topometric Systems" of the Andalusian Plan for Research and Development and Innovation. He is currently a member of the Advisory Board of the Agency for the Quality of the University System of Galicia (ACSUG).

Abderrahim Nemmaoui *obtained his Ph.D. in Territorial Planning and Remote Sensing from the University of Almeria in 2011. He is currently a* ***researcher hired in the Engineering Department****. It has a total of 19 scientific publications in journals with a relative quality index, 13 of which are included in the Journal Citation Reports of the "Science Citation Index". The internationalization of his scientific activity has meant his performance as a reviewer of several international journals JCR (SCI) mainly related to the discipline of Remote Sensing. He has participated in several research projects whose main subject is related to the study of data capture with terrestrial laser scanner (TLS), spatial planning, geographic information systems (GIS) and remote sensing from satellite images of medium, high and very high ground resolution.*

Mª Yolanda Cantón Castilla *started her research career in the Arid Zones Experimental Station (CSIC), where she developed her doctoral thesis defended in 1999. She is currently* ***Professor at the Department of Agronomy of the University of Almería*** *where she teaches in the Degree in Environmental Sciences, mainly in the subject "Geographic Information Systems and Remote Sensing". Her research activity has focused on surface hydrology and soil degradation processes in semi-arid ecosystems, for which he has constantly applied GIS and Remote Sensing tools. She has published numerous works among which 52 indexed articles stand out, 47 of them published in journals indexed in the JCR, the majority (70%) located in the first quartile. Her Google Scholar h-index is 21, counting on amore than 1400 citations. She has presented 150 contributions to congresses, most of them international. She has participated in many competitive research projects funded by the European Union, the National Plan or the Junta de Andalucía and has coordinated as Principal Investigator 3 of these projects. She has been part of different organizing and scientific committees of international congresses, as well as other scientific evaluation committees such as the experts panel of the MINECO Research Projects Subdirectorate and research staff evaluation committees (Ramón and Cajal and Juan de la Cierva). She is currently Associate Editor of the journal Ecohydrology and has recently been*

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invited to be Consulting Editor of the Journal of Arid Environments. He has directed 4 doctoral theses. She is regular reviewer of numerous journals in the areas of Remote Sensing and Soil Science, among others.

Juan Martín García *holds a degree in Architecture and a PhD in Geography from the University of Almería. He is currently* ***Director of the Assistance Area for Municipalities of the Diputación de Almería****, in charge of technical assistance in urban planning, architecture and building to the municipalities of the province of Almeria. He also develops his teaching work as an associate professor at the Polytechnic School of Cartagena (Degree in Architecture). He has developed research stays in Montevideo (Uruguay) and Puebla (Mexico), currently collaborating in research lines related to urban and territorial planning (information systems for urban planning) with the University of Almería, Puebla, Montevideo and Montreal.*

Juan José Vales Bravo *is Engineer in Geodesy and Cartography from the University of Jaén, where he also obtained the Diploma of Advanced Studies in the doctoral program Science and Technology of Geodetic and Cartographic Engineering. Previously he obtained the degree of Technical Engineer in Topography from the University of Extremadura. He began his professional career working as an external consultant in the field of Photogrammetry, Airborne Sensors, Geodesy and Cartography for the Ministry of Environment and Territory Planning of the Junta de Andalucía. In 2007, he joined EGMASA, which in 2011 became the Environmental and Water Agency of Andalusia, where* ***he currently works as the Territory Observation Manager of the Environmental Information Network of Andalusia (REDIAM)****. Since the beginning of its professional stage, the main activities developed have been headed up to project management and the development of regional (Andalusia) and national Earth Observation Plans (PNOA, PNOA-LiDAR, PNT), mainly on Orthophotography coverage, Digital Elevation Models, satellite imagery and LiDAR data, but also working on the development of support work for environmental and emergency management. Other aspects of interest:*
It belongs to the Research Group Photogrammetric and Topometric Systems of the University of Jaén.
Member of the National Association of Engineers in Geodesy and Cartography.
Member of the Spanish Association of Remote Sensing.
Activity in Working Groups: PNOA, PNT, Andalusian Cartographic Plan, RPAS (AMAYA), AET, Users Forum COPERNICUS, CODIIGE (Orthoimages and Elevations).

José Luis Blanco Claraco *has been an intense researcher since 2004, going through different work phases at the Universities of Malaga (until 2012) and currently* ***at the University of Almería as a Professor at the Department of Engineering****. The targeted research focuses on the fields of computer vision and multibody dynamics. He has done and is doing a work intensely focused on research in mobile robotics and the development of innovation projects for companies through several national research projects, European and OTRI contracts with national companies. As notable examples of transfer, it can be highlighted the utility model "Roadbot", an electric vehicle to automate the topographic survey, currently in operation by*

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SACYR S.A.U. in different infrastructures (airport runways, works of the Las Pedrizas motorway, etc.). He collaborates with the American company InTouch Health, Inc. since 2016 as robotic software engineer of a new range of mobile robots. It should be noted that he is the main developer of the set of C ++ MRPT libraries (http://www.mrpt.org), used in research groups and companies from different countries, accumulating more than 44,000 downloads since its launch in 2007. In addition, it was one of the projects selected in the Google Summer of Code (GSoC) 2016 and 2017. In terms of scientific dissemination for the general public, he is publishing the blogs Science-Explained and Mapping Ignorance (http://mappingignorance.org/), having received in 2012 the first prize "Nikola Tesla of scientific divulgation".

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