Co-funded by the Erasmus+ Programme of the European Union

SDI and EO Education and Training for North Africa

Project ref. number:
No. 610328-EPP-1 -2019-1-BE-EPPKA2-CBHE-JP

D3.1 Localised curricula at partner universities

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Work Package / Task:

WP3 - Implementation of SDI and EO courses

T3.1 - Localisation of curriculum

Short Description:

This report presents the outcomes of task 3.1 on the localisation of the SEED4NA curricula at the partner universities. In this report, an overview is provided of all the SEED4NA courses, i.e. the SDI and EO courses at the partner institutions in which components of the SEED4NA curriculum are introduced.

Keywords:

Curriculum, localisation, SDI, EO, North Africa

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1. Introduction

1.1. The SEED4NA project

For many of the societal and environmental challenges that governments are facing, decision-makers strongly rely on spatial and earth observation data, to better target, monitor, and assess their actions and interventions. These data are now becoming more and more available, through the establishment of data infrastructures and platforms, which aim to improve the access to, sharing and use of data. The effective use of these data requires that professionals in the public, private and academic sector have the relevant knowledge and skills on spatial data infrastructures (SDI), earth observation (EO) and related technologies. This means that higher education institutions must have the knowledge and capacities to provide modern education to their students and offer professionals the right training programmes to raise the overall level of expertise in SDI & EO.

Initiatives to promote and coordinate the sharing of EO and spatial data are also emerging in the region of Northern Africa, at the local, national and regional level. Despite the growing availability and accessibility of data, there still are several barriers and challenges hindering the uptake and use of these data in policy making and implementation. Among these barriers and challenges is a lack of skills and knowledge on SDI and EO among practitioners, decision makers and other key stakeholders. Therefore, it is essential that academic institutions in the North African countries raise their capacities regarding SDI and EO.

The main objective of SEED4NA is to improve the quality of higher education in North Africa in the fields of SDI and EO, and to enhance its relevance for the labour market and society through the development of new and innovative SDI/EO curricula. The SEED4NA project aims to: 1) develop the required knowledge, skills and competencies on SDI & EO within partner universities; 2) help introducing modern SDI & EO courses in engineering and agriculture/forestry studies; 3) implement supporting relevant vocational training programmes; 4) help partner universities to support the development of SDI in their country and 5) promote a European approach to SDI & EO.

SEED4NA will result in the establishment of capable, well trained pools of experts within the involved North African academic institutions which will introduce a modern approach in academic and VET education on SDI & EO in their respective countries, thereby becoming promotors of SDI development and EO use.

1.2. Localization of curricula at the partner universities

One of the main goals of the SEED4NA project is the introduction of new and/or revised courses on SDI, EO and related topics at the partner universities. Building further on the project curriculum defined and specified in the first stages of the project, several updated and/or new courses on SDI and EO are implemented at the eight partner universities of the project.

In the SEED4NA project, the implementation of SDI and EO curricula at the partner universities was structured around four main tasks:

- Task 3.1 – Localisation of curricula, which entails the preparation of the courses and related teaching materials
- Task 3.2 – Implementation of local curricula, which entails the formalization of the courses in the institutional study programs of the partner universities

- Task 3.3 – Running courses to students, which entails the delivery of courses to students, and teaching them about key SDI and EO topics
- Task 3.4 – Evaluation of implementation, which entails the evaluation of the courses

This report presents the outcomes of task 3.1 on the localisation of curricula at the partner universities. The aim of this task is to localise and integrate (parts of) the SEED4NA project curriculum into relevant study programs at the eight partner institutions. This is done through the revision of existing courses or the introduction of new courses. In this report, an overview and discussion is provided of all SEED4NA courses, i.e. the SDI and EO courses at the partner institutions in which components of the SEED4NA curriculum are introduced. The discussion of the courses focuses on these new components, i.e. new topics and learning objectives introduced in the course. For each course, we also describe the newly developed teaching activities and materials, and how these related to existing SEED4NA trainings and materials.

1.3. Structure of the document

This report is structured as follows. After this introductory chapter, the second chapter provides an overview of the SDI and EO courses at the partner institutions that were revised or created in the context of the SEED4NA project. The third chapter provides a more detailed discussion of each of these courses, looking at the newly introduced subjects and learning objectives, and the newly developed teaching activities and teaching materials. The fourth and final chapter provides some key conclusions on the localisation of the curricula at the partner institutions and discusses the next steps in the implementation of the SEED4NA courses.

2. Overview of the SDI and EO courses

The table below gives an overview of the SDI and EO courses implemented at the eight partner universities in the context of the SEED4NA project. These include 14 revised courses and 13 fully new courses. Courses are provided at different study levels, as they include Bachelor (7), Master (15), Postgraduate (2), Phd (1) and Engineering (2) courses.

University	Courses	Study level	Update/New
Alexandria University (2)	Introduction to Remote Sensing and Earth Observation	MSc	Update
	Spatial Analysis, Modelling and Applications: Simulation in Urban Studies	MSc	New
Fayoum University (5)	Geographic Information System 1	BSc	Update
	Remote sensing in Agriculture	BSc	Update
	GIS and Spatial Database	MSc	Update
	Spatial Web Applications	PG	Update
	Mapping and Surveying	PG	Update
Ibn Zohr University (2)	Geoinformatics	BSc	Update
	Spatial Data Infrastructure	MSc	New
Institut Agronomique et Vétérinaire Hassan II (2)	Spatial Data Management	BSc	Update
	Advanced Photogrammetry	BSc	Update
University of Carthage (4)	Measurement and mapping of water resources using EO and advanced tools	MSc	New
	Hydrological sciences using Earth Data and Advanced Tools	MSc	New
	Smart water resources Management using EO data, ICT and the Internet of Things	MSc	New
	Assessment of sediment and surface water pollution using Earth Data and Advanced Tools	MSc	New

University of Jendouba (3)	Application of Remote sensing & ICT in water management	MSc	New
	AI for remote sensing applications	Eng.	New
	Geostatistics	Eng	Update
University of Oran 1 Ahmed Ben Bella (4)	Spatial Big Data	MSc.	Update
	Application of Machine Learning to Satellite Imagery	PhD.	New
	Remote Sensing	BSc	New
	Global Navigation Satellite Systems	BSc	New
University Of Science And Technology Houari Boumediene (5)	Remote sensing and satellite imagery processing	MSc	Update
	Cartographic synthesis	MSc	Update
	GIS and remote sensing	MSc	Update
	GIS and data analysis I	MSc	New
	Space Geodesy	MSc	New

The aim of this report is to explain how different components of the SEED4NA project curriculum have been introduced into these various courses. For each of these courses, information will be provided on the selection and introduction of new topics and learning objectives to the course, and the development of new teaching activities and teaching materials.

3. Localization of SEED4NA components

In this chapter a more detailed discussion is provided on how components of the SEED4NA curriculum were introduced into study programs at the eight partner universities. The chapter is structured around the revised and/or new courses of each partner university. For each course a short overview is given of some key characteristics and of the newly added components, i.e. the new subjects and learning materials and the newly developed teaching materials.

3.1. Alexandria University (P6 - Egypt)

Course	**Introduction to Remote Sensing and Earth Observation**
Study program	Master of Science
Credits	3 credit hours
Teacher(s)	Hany Ayad (Professor), Sarah Abougendia (Assistant Lecturer)
Language(s)	English
New or revised	Revised
New subjects	LM1: Introduction to remote sensing and its process - Definitions, remote sensing process, and applications. LM2: Basic principles of RS - Electromagnetic energy and its interactions with the atmosphere and earth's surfaces. - Sensors and platforms and data acquisition. - Mapping cameras, imagery resolution, and band combination. LM3: Preprocessing techniques of remotely sensed data - Image preprocessing and enhancement. - Image Interpretation. LM4: Processing of satellite imageries:: Digital Image Classification - Introduction to machine learning and digital image classification. - Unsupervised and supervised Classification (explained with different algorithms). - Accuracy assessment of image classification. - Change detection.
New learning objectives	1. To illustrate the remote sensing process and its components.

	2. To recognize electromagnetic energy and its interactions with the atmosphere and earth's surfaces. 3. To distinguish among several types of sensors and platforms of earth observations, their usage, and application. 4. To differentiate among various mapping cameras, imagery resolution, and band combination. 5. To select the appropriate type of remotely sensed data for the field of interest. 6. To implement pre-processing techniques of the raw satellite imageries. 7. To distinguish between radiometric, geometric, and atmospheric corrections to satellite imageries. 8. To distinguish among various types of digital image classification with their applications for the field of interest. 9. To perform digital image classification using the associated algorithms. 10. To apply change detection workflow using remotely sensed data.
Source materials	SEED4NA materials used as a starting point University of Twente (ITC) materials: - Geospatial Data – Concepts, acquisition and management - Geospatial Analysis and Interpretation - VET Introduction to Geoinformatics EO4Geo Body of Knowledge: http://www.eo4geo.eu/tools/bok-visualization-and-search/ ITC Living Textbook: https://www.itc.nl/about-itc/organization/resources-facilities/living-textbook/ Other materials used as a starting point - Tempfli K, G.C. Huurneman, W.H. Bakker, and L.L.F. Janssen, (2009) Principles of Remote Sensing, University of Twente Faculty of Geo-Information and Earth Observation (ITC). - Campbell, James B., (2011) Introduction to remote sensing, A Division of Guilford Publications, Inc. - Qihao Weng, Dale Quattrochi, Paolo Gamba (2018), Urban Remote Sensing, 2nd Edition, CRC Press. - Thomas Lillesand, Ralph W. Kiefer, Jonathan Chipman (2015), Remote Sensing and Image Interpretation, 7th Edition, Wiley. - Pawan Gupta, and Melanie Follette-Cook, Fundamentals of Satellite Remote Sensing, NASA's Applied Remote Sensing Training Program. AREST (NASA's Applied Remote Sensing Training Program)
Teaching materials developed	- **Lecture 1: Definitions, Remote Sensing Process, and Applications**, which introduces the definition of remote sensing, a historical overview of milestones starting from the beginning of the practice of photography in the

19th century until the generation of Landsat sensors and the development of hyperspectral sensors in the 20th century. In addition, it discusses the comparison between satellite observations and aerial photography and defines earth observation. This lecture gives an introductory step to remote sensing as a process and differentiates between its main components in this process. A list of applications is presented afterward, highlighting its common usage in research and urban studies.

- **Lecture 2: Electromagnetic energy and its interactions with the atmosphere and earth's surfaces**, in which electromagnetic radiation is explained, beginning with an introduction about the energy sources and the electromagnetic spectrum. In addition, its interactions with the atmosphere and the Earth's surface are illustrated as well as the spectral signature of different components of the Earth's surface.

- **Lecture 3: Sensors and platforms and data acquisition**; a major topic in remote sensing is differentiating the platforms and sensors, including orbits, energy sources, type of sensors, resolution, and possible applications. Specifically, the types of orbits are explained in depth by their purpose and characteristics, the eccentricity, the inclination angle, orbit step, and sun-synchronization. Then, the satellite revisits time, coverage, and energy sources are discussed.

  In this lecture, an exercise and an assignment are given, first, data exploration using Earth Explorer (USGS), and second, individual work on an assignment to compare different satellite missions.

- **Lecture 4: Mapping cameras, imagery resolution, and band combination,** as a continuous explanation of the last lecture's topic, digital and analog photography, multispectral scanners, and image resolution are included. Image resolution is defined by four different types: spatial resolution, spectral resolution, radiometric resolution, and temporal resolution, followed by the different attributes of a selected set of sensors (Landsat 8, Sentinel-2, and Planet Scope), and band combination work for different purposes/applications.

  In this lecture, an exercise on the band combination work is conducted by the students, further applications and a short explanation of which is requested as an assignment.

- **Lecture 5: Image preprocessing and enhancement,** this lecture gives important milestones in the remote sensing work, explaining the preprocessing phase that is generally conducted to improve image quality. First, this includes the radiometric preprocessing, de-striping algorithm, and geometric corrections. then, the product of this phase is presented by the processing levels. Second, image enhancement is an important step to

improve the visual interpretability of an image, which includes Gray-Level Thresholding, Level Slicing, and Contrast Stretching.

In this lecture, an exercise on image enhancement is conducted as a practical session.

- **Lecture 6: Image Interpretation;** it is about the three kinds of knowledge forming the image interpretation task: Subject, geographic region, and RS system. The task is introduced by several points: classification, enumeration, mensuration, and delineation. Specifically, ground sample distance (GSD) is defined, together with elements of image interpretation such as image tone, image texture, shadows, pattern, shape, size, association and context, and collateral information.

  By this lecture, the students are given an introduction to the term paper by selecting a particular application of interest and start working on the preprocessing techniques followed by the application of digital image classification by the next lectures.

- **Lecture 7: Introduction to machine learning and digital image classification.** It is introduced by the topic of Machine Learning (ML), its definition, application, and different broad categories: unsupervised learning, supervised learning, and reinforcement learning, followed by the linkage between ML and remote sensing, its relation to some basics of last introduced concepts, specifically the spatial signature and class frequency distribution. An application is explained based on image classification, which applies two different methods and workflows: supervised and unsupervised classification. These two methods are explained in detail by their algorithms, steps, and training process.

  In this lecture, practical work on image classification is conducted in two sections, followed by continuous work on the term paper. Throughout this, guidance is given to the students about reporting and writing a research paper and its workflow and technical points.

- **Lecture 8: Accuracy assessment of image classification.** A continuous explanation and conduction of unsupervised and supervised methods for image classification, in which the accuracy assessment is introduced with its basic rules, inputs, and outputs, and sampling methods. The reference data and its acquisition techniques are given a brief introduction. Lastly, the confusion matrix, as an output, is clarified and constructed by the user's and producer's accuracy, overall accuracy, and the Kappa coefficient.

  In this lecture, an exercise is conducted based on the work conducted in the term project.

- **Lecture 9: Change detection**, in which the change detection in remote sensing is given a specific understanding of its procedures, data

	acquisition, and workflows (post-classification change detection and spectral change detection).

Course	**Spatial Analysis, Modelling and Applications: Simulation in Urban Studies**
Study program	Master of Science
Credits	3 credit hours
Teacher(s)	Hany Ayad (Professor), Manar Talal (Lecturer), Esraa Othman (Demonstrator)
Language(s)	English
New or revised	Revised
New subjects	LM1: Introduction to GIS &SDI and the benefits of spatial analysis - Introduction to GIS &SDI. - The benefits of spatial analysis and Principles of spatial analysis. LM2: Introduction to spatial analysis: the language of spatial analysis - The importance of spatial data. - Understanding location maps, mapping variations and patterns, comparative maps, and mapping changing conditions in urban areas. - Different types of data and query of data within database. - Summarizing, interpreting data, and spatial join and relate work. LM3: Data exploration and working with query operations. - Model Builder - Exercises on spatial modelling LM4: Spatial analysis operations and tools - Basics in geoprocessing: (Extraction: clip, split, select, erase; overlay; proximity: buffer/multi-ring buffer, near, point distance; statistics: frequency, summary statistics). - Conceptualization of Spatial Relationships. - Proximity Analysis: geographic distributions and point patterns. - Overlay Analysis LM5: Spatial statistics - Global tools and Local Clusters. - Classical Correlation, Spatial Autocorrelation. - Density Estimation and Hot Spot Mapping.

	LM6: Network Analysis - Service Area solver. - Choosing optimal locations for services in cities. LM7: Advanced Network Analysis - The closest facility and OD cost matrix solvers. LM8: Spatial modelling & visualization: Workflows & applications - Spatial models classified by the purpose (Descriptive Model, Explanatory Model, Predictive Model, Normative Model). - Different types of spatial models, such as Binary model, Weighted models, Regression models, and Process models. LM9: Application on spatial analysis within a methodological context - The spatial analysis as a process and steps of analytical methodology of specific problems concerned with urban areas, through the PPDAC model (Problem, plan, data, analysis, and conclusions).
New learning objectives	1. To recognize the basic topics and terminologies of spatial analysis and modelling and their applications for urban planning. 2. To list several spatial analysis techniques, basic technologies, and concepts associated with the field of urban planning and the related decision-making process. 3. To apply spatial analytical methods for different spatial problems. 4. To interpret spatial analysis in a process using the appropriate tools and datasets. 5. To detect spatial patterns, clusters, and spatial relationships. 6. To illustrate spatial data using techniques of spatial statistics and quantitative analysis using GIS. 7. To evaluate and explain results of spatial statistics. 8. To plan, develop and implement spatial models for predefined spatial problems, validate and evaluate model results. 9. To identify spatial components of a problem, preparing criteria for selection with the appropriate tools and datasets. 10. To experience using the model builder, processing results and interpretation of maps, and drawing conclusions and evaluation of results.
Source materials	<u>SEED4NA materials used as a starting point</u> University of Twente (ITC) materials: - Geospatial Data – Concepts, acquisition and management - Geospatial Analysis and Interpretation - VET Introduction to Geoinformatics

	EO4Geo Body of Knowledge: http://www.eo4geo.eu/tools/bok-visualization-and-search/ ITC Living Textbook: https://www.itc.nl/about-itc/organization/resources-facilities/living-textbook/ Other materials used as a starting point - Michael J. de Smith, Michael F. Goodchild, Paul A. Longley. (2015). Geospatial Analysis: A Comprehensive Guide to Principles, Techniques and Software Tools (http://www.spatialanalysisonline.com/). - Mozgeris, G., & Dumbrauskas, A. (Eds.). (2008). Training material, Spatial Analysis and Modeling (GII-07). - ESRI. (2013). The language of spatial analysis. ESRI Press. - Training material, Spatial analysis and modeling "(GII-07) © National Land Service under the Ministry of Agriculture, 2007 - Grekousis, G. (2020). Spatial analysis methods and practice: describe–explore–explain through GIS. Cambridge University Press.
Teaching materials developed	- **Lecture 1: Principles of spatial analysis & modeling**, which is designed to introduce different topics of applications that concerned with problems emerged in cities, such as urban sprawl, social segregation, quality of the urban environment, interdependence of urban and rural areas, transport flow and congestion, urban heat island, loss of biodiversity and natural areas, environmental protection, and risk management. - **Lecture 2: Workflows and Applications**, which introduces the spatial analysis and identifies the importance of spatial data through several topics addressed by ESRI, categorized as follows: First, understanding where which concern with location maps, mapping variations and patterns, comparative maps, and mapping changing conditions in urban areas. Second, measuring size, shape, and distribution of features. Third, determining how places are related. Fourth, finding the best locations and paths. Fifth, detecting and quantifying patterns and making predictions. In this lecture's exercise, Students experience a flow of steps to identify features affected by a problem of their choice in the city of Baltem. They utilize the model builder in building their queries. - **Lecture 3: Proximity Analysis – 1,** which contains tools that are used to determine the proximity of features within one or more feature classes or between two feature classes. These tools can identify features that are closest to one another or calculate the distances between or around them (Esri, 2022). In this lecture's exercise, students will continue to understand different proximity approaches to analyze data.

- **Lecture 4: Proximity Analysis – 2,** as a continuous explanation of the last lecture's topic, spatial relationships of distance operations are explored. This required investigating geographic distributions and point patterns through centrography principles. Also, Spatial relationships include the modelling of the relationships and interactions between features across space. It mathematically defines the terms near, far, adjacent, contiguity, neighbourhood, neighbouring and distance for a set of spatial objects by using specific values or functions. The difference between global tools and local cluster tools marks a milestone in any analysis. Also, one of the aiding tools is the spatial autocorrelation tool that evaluates whether the pattern expressed is clustered, dispersed, or random.

  In this lecture's exercise, students investigate the spatial relationships in a regional context between cities in Egypt within the zone of Sadat new city. The analysis includes finding mean centres, median canters, central features, standard directional distributions, box plots, finding outliers, average nearest neighbours and kernel density tools.

- **Lecture 5: Overlay Analysis,** this lecture explores both spatial and attribute characteristics of combined data layers. More specifically data is overlaid to answer questions about which geographic features are on top of each other's features.

  In this lecture's exercise, students use overlay tools to locate customers based on their spatial relationships with the drive time polygon They will use spatial Analyst tool to summarize the length of streams in watersheds and calculate amount of each land-use classification in a raster.

- **Lecture 6: Spatial Statistics;** introduces the classical and spatial statistics through the techniques used for explanation and presentation of data.

  By this lecture, using optimized hot spot analysis help to examine clusters of counties of the US according to usage of social media percentage. Followed by using optimized outliers' analysis. These tools are also applied on point features to experience data aggregation techniques in the case of tornados events for example.

- **Lecture 7: Network Analysis.** Given locations of fire stations, hospitals, public transit stations etc. this analysis helps to identify what areas can be served from these locations by either amount of distance traveled or by time taken using the Service area solver.

  In this lecture, practical work is considering adding a new bus route, where it is not yet decided where it is most needed. This exercise help to map the area served by existing bus stops and compare it with demographic data to assess which part of the city is in greatest need of access to public transit.

	- **Lecture 8: Advanced Network Analysis.** A continuous explanation and conduction of network analysis given the spatial distribution of demand for a service. it is a type of optimization model created to determine the optimal location for service provision across a city or region. For example, demand from the neighborhood is distributed to a facility or set of facilities in one form of interaction model. The facilities may be commercial ones, like distribution centres for grocery shops or facilities used for package delivery, or they may be public ones that provide a service, like fire stations, schools, or libraries. In this lecture's exercise, the student is going to solve three different problems for three different case study: adding a second distribution facility which will cut down on the amount of driving required to deliver goods to clients, proposing a seven-minute trip to a hospital emergency room, establishing whether firemen in reach 95% of the city's residents in less than four minutes and Which fire station serves which census tract. - **Lecture 9: Advanced Network Analysis**, in which the closest facility and OD cost matrix solvers are performed to Determine the best route for a group of facilities. In this lecture's exercise, the students investigate the impact of time in the analysis through assigning time windows and comparing results of different solvers.

3.2. Fayoum University (P7 - Egypt)

Course	**Geographic Information System 1**
Study program	Undergraduate- BSc. Agriculture (Soils and Water)
Credits	Credits in ECTS: 4
Teacher(s)	Prof. Mahmoud A. Abdelfattah Dr. Ali G. Mahmoud Dr. Ahlam S. Saber
Language(s)	Arabic / English
New or revised	Revised
New subjects	Geodatabases, Geostatistics, Simulation models
New learning objectives	*New learning objectives:* • Understand some basics of Building and the benefits of Geodatabase. • Understand some basic concepts of statistics • Understand what spatial statistics is. • Describe the differences between spatial and non-spatial statistics • Understand the surface interpolation technique • Understand the Kriging technique and geostatistical process for surface interpolation. • Understand Spatial Modeling with GIS and the importance and reasons for modeling. • Describe the differences between Spatial Models and Data Models • Describe different types of models and technology for modeling
Source materials	• BoK Visualization and Search tool, http://www.eo4geo.eu/tools/bok-visualization-and-search/ • SEED4NA materials: VET - Introduction to Geoinformatics\ VET-Introduction to Geoinformatics Module 2 - Principles of GIS. • ESRI: Using ArcGIS™ Geostatistical Analyst. • ESRI: Geostatistical analyst tutorial. • ESRI: Spatial Analysis tutorial. • Ali G. Mahmoud, Lectures on Spatial Statistics, and Modeling and Programming Courses, Institute of Strategic Research and Studies for Nile Basin Countries, Fayoum University, Fayoum, Egypt.

Teaching materials developed	- Lecture/presentation about Geodatabases, in which the students are introduced to the definition of GDB and the main characteristics, benefits, and advantages of using GDB. in addition to GDB types, GDB Elements, types of relationships, and GDB design. - Lecture/presentation about Geostatistics, in which the students are introduced to spatial and non-spatial data analysis, statistics and spatial statistics, applications of spatial statistics, point data transformation and surface modeling, and Kriging techniques. - Lecture/presentation about simulation models, in which the students are introduced to spatial modeling with GIS, spatial models vs. data models, reasons and benefits of using models, types of models, and technology for modeling. - Exercise on geodatabases, geostatistics, and modeling, in which some practical examples were applied to get familiar with these topics. - Assignment on the upgraded topics, in which students were asked to perform some tasks on GDB, geostatistics, and modeling.

Course	**Remote sensing in Agriculture**
Study program	Undergraduate- BSc. Agriculture (Soils and Water)
Credits	Credits in ECTS: 4
Teacher(s)	Prof. Mahmoud A. Abdelfattah Dr. Ali G. Mahmoud Dr. Ahlam S. Saber
Language(s)	Arabic / English
New or revised	Revised
New subjects	• Applications of some models to track changes in agriculture and the environment, and application models in the field of land and water. • Basics of Google Earth Engine (GEE). • Applications of Google Earth Engine GEE.
New learning objectives	• Identify the basis of modeling to monitor the change in natural and environmental phenomena • Interpret the results of the tracking spatial change models. • Apply practically how to track the spatial changes of agricultural and ecological systems.

	• Understand the basics of Google Earth Engine (GEE) and GEE Benefits and limitations. • Describe the main components of GEE. • Describe data categories in Earth Engine • Understand the Computation Engine • Applying different examples on GEE
Source materials	• BoK Visualization and Search tool, http://www.eo4geo.eu/tools/bok-visualization-and-search/ • SEED4NA materials. • Google Earth Engine, https://earthengine.google.com/ • Mahmoud M. Shendi, Remote Sensing Courses, Institute of Strategic Research and Studies for Nile Basin Countries, Fayoum University, Fayoum, Egypt.
Teaching materials developed	- Lecture/presentation about change detection models, in which the students are introduced to the definition and basics of land use/land cover change detection and the methods of monitoring such changes. - Lecture/presentation about Google Earth Engine (GEE), in which the students are introduced to the basics of GEE and the main components of GEE, the benefits and limitations of using the GEE, and different data sources/categories in GEEE. - Lecture/presentation about applications of Google Earth Engine GEE, in which the students are introduced to the applications of GEE in agriculture. - Exercise on change detection and GEE applications, in which some practical examples were applied to get familiar with these topics. - Assignment on the upgraded topics, in which students were asked to perform some tasks on GEE and change detection.

Course	**GIS and Spatial Database**
Study program	Master - Information Systems
Credits	Credits in ECTS: 4
Teacher(s)	Prof. Mohmed Helmy Khafagi Dr. Mostafa Ali Mahmoud
Language(s)	English

New or revised	Revised
New subjects	• Fundamentals of simulation models • Using Model Builder in simulation modelling. • Using Python programming language in simulation modeling. • Artificial Intelligence in GIS
New learning objectives	• Understand basic concepts of modeling • Describe the differences between Spatial Models and Data Models • Describe the importance and reasons for modeling • Understand Spatial Modeling with GIS • Describe different types of models and technology for modeling • Understand the basics of "model builder" in spatial modeling. • Understand the basics of Python programming in spatial modeling. • Understand the basics of artificial intelligence in GIS. • Use Automated workflows using Model-Builder and Python programming language • Apply simulation models and automated workflows in various fields of applications
Source materials	• BoK Visualization and Search tool, http://www.eo4geo.eu/tools/bok-visualization-and-search/ • SEED4NA materials: VET - Introduction to Geoinformatics\VET-Introduction to Geoinformatics Module 2 - Principles of GIS. • ESRI: Spatial Analysis tutorial
Teaching materials developed	- Lecture/presentation about the Fundamentals of simulation modeling. - Lecture/presentation about Model Builder in simulation modeling. - Lecture/presentation about Python programming language in simulation modeling. - Lecture/presentation about Artificial Intelligence in GIS. - Exercises in Geodatabases, Geostatistics, and modeling, in which some practical examples are applied to get familiar with these topics. - Assignment on these topics, in which students are asked to perform some tasks on GDB, geostatistics, and modeling.

Course	**Spatial Web Applications**
Study program	GIS Postgraduate Diploma
Credits	Credits in ECTS: 4
Teacher(s)	Dr. Hassan M. Hassona Dr. Ahmed Harby Mohamed
Language(s)	Arabic / English
New or revised	Revised
New subjects	▪ Mobile Web Applications. ▪ Dynamic Web-GIS interface developed using ArcGIS online. ▪ Geocoding. ▪ Programming languages for Web-GIS.
New learning objectives	▪ Learn and understand the basic concepts of Mobile Web Applications ▪ Learn and understand the Dynamic Web-GIS interface developed using ArcGIS online ▪ understand the basic concepts of Geocoding ▪ Learn and understand Programming languages for Web-GIS ▪ Understand Web-GIS advantages and recognize Web-GIS Application Components. ▪ Identify different platforms of Web-GIS. ▪ Realize the capabilities of Web-GIS in different fields
Source materials	• BoK Visualization and Search tool, https://bok.eo4geo.eu/ • SEED4NA curriculum development: Approaches and application areas • Fundamentals of Geospatial Information in SDI: overview and teaching approaches • ESRI sources • Course material and PPTs by the teacher: Dr. Ahmed Harby Mohamed • Other web resources
Teaching materials developed	- Lecture/presentation about Mobile Web Applications. - Lecture/presentation about Dynamic Web-GIS interface developed by using ArcGIS online. - Lecture/presentation about Geocoding. - Lecture/presentation about Programming languages for Web-GIS.

	- Exercise on the updated topics, in which practical examples are applied to get familiar with these topics. - Assignment on the upgraded topics, in which students are asked to perform some tasks on the updated topics.

Course	**Mapping and Surveying**
Study program	GIS Postgraduate Diploma
Credits	Credits in ECTS: 4
Teacher(s)	Dr. Nasser A. Abd El-Hady Mr. Ahmed Mostafa Gomaa Abdelwahed
Language(s)	Arabic / English
New or revised	Revised
New subjects	▪ Use of AI in surveying and mapping. ▪ Advanced techniques in map production
New learning objectives	• Understand some basic concepts of AI • Understand what AI can provide in the field of geoscience. • Describe different techniques of AI in surveying and map production. • Describe the importance of AI in cartography ▪ Understand the advanced techniques in map production
Source materials	• BoK Visualization and Search tool, https://bok.eo4geo.eu/ • SEED4NA curriculum development: Approaches and application areas • Fundamentals of Geospatial Information in SDI: overview and teaching approaches
Teaching materials developed	- Lecture/presentation about the Use of AI in surveying and mapping. - Lecture/presentation about the advanced techniques in map production. - Exercise on the updated topics, in which practical examples are applied to get familiar with these topics. - Assignment on the upgraded topics, in which students are asked to perform some tasks on the updated topics.

3.3. Ibn Zohr University (P8 - Morocco)

Course	**Geoinformatics**
Study program	Bachelor
Credits	2
Teacher(s)	Adnane Labbaci
Language(s)	French
New or revised	Revision
New subjects	Identify Vector/Raster Data Illustrate data into GIS and RS software. Master the use of spatial extensions into GIS and RS.
New learning objectives	Apply spatial analyse tools suitable for modelling data. Manage GIS and RS projects. Explain opportunities given by Spatial Analysis Data in different fields (Geology, hydrogeology, …).
Source materials	Various SEED4NA materials
Teaching materials developed	GIS I- Notions of digital image II- Spatial reference systems III- Geographic information systems RS I- For digital images II- Satellite and drone imagery interpretation

Course	**Spatial Data Infrastructure**
Study program	Master
Credits	2
Teacher(s)	Pr. Adnane Labbaci
Language(s)	French/English
New or revised	New course
New subjects	• Definition of SDI and concepts; • Web services for spatial data; • Distribution and publication of spatial data on the Web. • Languages for spatial data description. • Markup languages and digital cartography. • Digital map creation and web-based publication.
New learning objectives	Knowledge - knowledge resulting from the course: • distinguish and describe the specifics of GIT on the web • define requirements for creating GIT on the web • get acquainted with the appropriate norms and standards • define accessibility and usability parameters Skills - skills resulting from the course: • create a web map • program code in Java script • process data in JSON format • process data in XML format • work with virtual 3D scenes on the web
Source materials	Open SDI Summer School and several other meetings
Teaching materials developed	1. Computer networks essentials; 2. Architecture of network GIS; 3. Data interoperability and semantics; 4. SDI definition and its applications;

	4. Accessible and open applications, web services; 5. Development of web applications focused on spatial data and maps

3.4. Institut Agronomique et Vétérinaire Hassan II (P9 – Morocco)

Course	**Spatial Data Management**
Study program	Surveying an Geomatics Engineer degree
Credits	2 ECTS
Teacher(s)	Hajji Hicham
Language(s)	French
New or revised	Revised
New subjects	Spatial Big Datasets Approaches for Spatial Big Data Management Approaches for Spatial Big Data Computing Approaches for Spatial Big Data Visualization
New learning objectives	Distinguish the difference between Spatial Database Systems and Spatial Big Data systems Investigate the use of Spatial Partitioning techniques for spatial datasets storage Using Parallel Computing techniques for accelerating Spatial Queries and Analyses Constructing Spatial Big Data architecture using dask geopandas
Source materials	SEED4NA Training: Summer School Duborvnick Mainly: Spatial Data Science: Carsten Kessler (Bochum University of Applied Sciences, Germany); SEED4NA Summer School Dubrovnik May 9–13, 2022 All Other SEED4NA online trainings SEED4NA Materiels: Spatial Data Science: Carsten Kessler (Bochum University of Applied Sciences, Germany); SEED4NA Summer School Dubrovnik May 9–13, 2022 BIG DATA SOLUTIONS DISTRIBUTED COMPUTING , Mahdi Farnaghi, ITC, Twentee University (Thanks Lucas)
Teaching materials developed	- Lecture/presentation about Spatial Big Data: how we define spatial big data, how is it different from traditional Big Data…

	- Lecture/presentation about Spatial Big Data Management: why plain spatial data management approach cannot handle Spatial Big Data, what's the main constraints, and how modern and parallel approaches can be efficient when dealing with Spatial Big Data - Lecture/presentation about Spatial Big Data Computing: We give here a presentation of recent Spatial Big Data Library that can handle spatial big data computing named :dask-geopandas. - Exercise on using dask Exercise on using dask-geopandas Exercise on Executing spatial queries over spatial big dataset Exercise on testing spatial partitioning techniques over spatial big data to accelerate spatial queries - Assignment on dask-geopandas (notebook) - Reading material : Spatial Big Data Science; Zhe Jiang, Shashi Shekhar; Springer ISBN-13 978-3319601946

Course	**Advanced Photogrammetry**
Study program	Surveying an Geomatics Engineer degree
Credits	3 ECTS
Teacher(s)	Prof. Prof. Imane Sebari Prof. Kenza Ait El Kadi
Language(s)	French
New or revised	Revised
New subjects	Photogrammetry and Lasergrammetry integration: Opportunities Integration levels Integration approaches Applications

New learning objectives	Experiment the fusion/combination of photogrammetry and lasergrammetry at different levels, data, process and products; Differentiate the opportunities given by photogrammetry/lasergrammetry integration
Source materials	SEED4NA Training: Summer School Dubornick All Other SEED4NA online trainings SEED4NA Materiels: Photogrammetry: geometry from images and laser scans Kraus, K. Walter de Gruyter. 2007 Digital photogrammetry: theory and applications Linder, W. Springer Science & Business Media.2013
Teaching materials developed	- Lecture/presentation about Opportunities and Integration Levels of Photogrammetry and Lasergrammetry Intergation - Lecture/presentation about Integration approaches and Applications - Exercise on Integration levels - Exercise on Integration approaches

3.5. University of Carthage (P10 – Tunisia)

Course	**Measurement and mapping of water resources using EO and advanced tools**
Study program	MSc Water Governance and Sustainable Development
Credits	2
Teacher(s)	Prof. Jamila Tarhouni
Language(s)	French
New or revised	New
New subjects	• Water Resources: Role of GIS and Earth Observation • GIS in Water Resources • Earth observation for Water Resources • Examples at large and local scales
New learning objectives	1. Explain how GIS and Earth Observation is used to characterize water resources at basin level 2. Retrieve and to organize relevant data to WRM 3. Produce WR maps at different temporal and spatial scales
Source materials	SEED4NA Summer School Zagreb + various other SEED4NA materials
Teaching materials developed	Lectures + practical exercises on the abovementioned topics

Course	**Hydrological sciences using Earth Data and Advanced Tools**
Study program	MSc Water Governance and Sustainable Development
Credits	2
Teacher(s)	Dr. Anis Chekirbene
Language(s)	French
New or revised	New

New subjects	- basics of hydrology, water budget and hydrological parameters - hydrological modelling concept and flow equations - hydrological model construction
New learning objectives	- Students will be able to characterize a hydrological system - Students will understand the water dynamics within a hydrological system - Students will have the necessary knowledge to ensure the sustainable use of water resources of a hydrological system
Source materials	SEED4NA Summer School Zagreb + various other SEED4NA materials
Teaching materials developed	Lectures + practical exercises on the abovementioned topics

Course	**Smart water resources Management using EO data, ICT and the Internet of Things**
Study program	MSc Water Governance and Sustainable Development
Credits	2
Teacher(s)	Prof. Issam Nouiri
Language(s)	French
New or revised	New
New subjects	- Formulation of water resources management - Implementation of optimal solutions for water resources management - Intelligent management of water resources
New learning objectives	1. Describe and characterize a mode of water resources management based on DS, ICT and IoT, 2. Design and implement an intelligent water resources management system based on DS, ICT and IoT, 3. Initiate intelligent water resources management projects.
Source materials	Various SEED4NA materials
Teaching materials developed	Lectures + practical exercises on the abovementioned topics

Course	**Assessment of soil and surface water pollution using Earth Data and Advanced Tools**
Study program	MSc Water Governance and Sustainable Development
Credits	2
Teacher(s)	Dr. Layla Ben Ayed
Language(s)	French
New or revised	New
New subjects	- Introduction and kind of pollutions (non-points and points sources) - Pollution parameters and indicators in water and in soil - Assessment of the pollution using earth data observation and remote sensing - Calibration/validation and sensitivity analysis - Case study: Gafsa mining basin.
New learning objectives	1. Collect data related to the soil and water quality from earth observation data supplied via the world wide web (i.e., Google Earth Engine platform) and through available national web portals 2. Process and visualize earth observation data in QGIS 3. Apply a validation/calibration protocol for quantitative accuracy assessment of derived pollution state variables.
Source materials	Various SEED4NA materials
Teaching materials developed	Lectures + practical exercises on the abovementioned topics

3.6. University of Jendouba (P11 – Tunisia)

Course	**Application of Remote sensing & ICT in water management**
Study program	MSc Climate Change & Water Management
Credits	2 ECTS
Teacher(s)	Assoc. Prof. Fatma Trabelsi
Language(s)	French
New or revised	New
New subjects	Presentation of Application cases of RS, GIS, ICT and IoT for water management: floods, droughts, groundwater recharge, irrigation Overview of the principles of RS and GIS tools Overview of the principles of smart sensors, IoT, Cloud, ICT Concept and use of open data sets and geospatial platforms in water sector Project study: Irrigated areas mapping and water abstraction estimation from time series Sentinel-2 imagery
New learning objectives	- Assess the water remotely data and distinguish their utilities - Manipulate open satellite images and downscaling spatial data - Perform time series processing for irrigation monitoring - Choose and apply appropriate software tool for water management - Summarize results obtained for the selected problem and its solution
Source materials	/
Teaching materials developed	**Lectures:** - Presentation of Application cases of RS, GIS, ICT and IoT for water management: floods, droughts, groundwater recharge, irrigation - Overview of the principles of RS and GIS tools - Overview of the principles of smart sensors, IoT, Cloud, ICT - Concept and use of open data sets and geospatial platforms - Project_Part 1: Irrigated areas mapping and water abstraction estimation from time series Sentinel-2 imagery - Project_Part 2: Irrigated areas mapping and water abstraction estimation from time series Sentinel-2 imager - Presentation of student's projects **Exercises:**

	- Download and image analysis of Sentinel-2 from Earth Explorer portal - Calculation of the reflection index (NDVI) and estimation of Evapotranspiration coupled with NDVI time series - Calibration / Validation of the satellite estimate of Evapotranspiration - Simulation of the water balance at the plot scale - Calculation of groundwater recharge though estimated Evapotranspiration - Groundwater potential recharge mapping - Groundwater potential recharge mapping

Course	**AI for remote sensing applications**
Study program	Eng. Topography & Geomatics
Credits	2 ECTS
Teacher(s)	Salsebil Bel Hadj Ali
Language(s)	French
New or revised	New
New subjects	- Google Earth Engine Basics and General Applications - Land Cover Classification and Accuracy Assessment in Google Earth Engine - Time Series Analysis and Change Detection in Google Earth Engine
New learning objectives	- Recognize the GEE functionalities - Apply initial skills for python Algorithms and JavaScript commands - Distinguish cloud-based raster computing for land management applications, APIs .. - Apply Landcover Classifications using algorithms and classifiers - Derive a time series of environmental parameters and calculate differences between years to detect landscape changes
Source materials	/
Teaching materials developed	**Lectures:** - Introduction to JavaScript for Google Earth Engine ('Hello World', Variables, Arrays, Dictionaries, Functions) - Google Earth Engine Datasets and Image Collection - Google Earth Engine Datasets (Feature Collection) - Linear Regression NDVI - Charts

	- Land Cover Classification and Accuracy Assessment Overview - Supervised Land Cover Classification (Random Forest Classification Algorithm) - Overview of Time Series and Change Detection - Environmental Parameter Calculations - Time Series Display of Environmental Data - Change Detection Calculation and Mapping **Exercises:** - Image Collection - Linear Regression NDVI - Charts - Supervised Land Cover Classification (Random Forest Classification Algorithm) - Change Detection Calculation and Mapping

Course	**Geostatistics**
Study program	Eng Hydraulic & Planning
Credits	2 ECTS
Teacher(s)	Slaheddine Khlifi
Language(s)	French
New or revised	Revised
New subjects	- Application of geospatial krigeage models to predict precipitation datasets - Presentation of case study (filling gaps and missing data processing) and comparaison to other several techniques
New learning objectives	- Compare interpolation techniques related to watershed monitoring
Source materials	/
Teaching materials developed	**Lectures:** - Precipitation time series and IDF curves - Spatial interpolation of precipitation - Interpolation of continuous variables - Variogram

	- Kringing **Exercises:** - Application of spatial and temporal interpolation - Application of variogram models to data set of precipitation - Application of kringing models to data set of precipitation - Presentation of case study (filling gaps and missing data treatment)

3.7. University of Oran 1 Ahmed Ben Bella (P13 – Algeria)

Course	**Spatial Big Data**
Study program	MSc "Networks and Distributed Systems"
Credits	1 ECTS
Teacher(s)	Mejdi Kaddou, Professor, Department of CS, UORAN1
Language(s)	French/English
New or revised	Revised
New subjects	- Introduction/review of GIS and spatial data management: spatial reference framework (datum, map projections, coordinate transformation), spatial data models, spatial data acquisition systems, spatial data analysis, and geo-visualization. - Spatial databases: extended data models and spatial queries. - Spatial data Analytics: principal methods and business applications, spatial autocorrelation, proximity and accessibility, spatial Interpolation, spatial categorization, hotspot analysis, network analysis - Spatial Big Data with Apache Sedona.
New learning objectives	After completion of the course students should be able to: - Explain the fundamentals of geographic information systems (GIS) and spatial data models - Design a spatial database schema from a set of requirements - Create spatially enabled tables in Postgres/PostGIS and retrieve data using SQL spatial queries - Compare the requirements and tasks related to spatial big data analytics and traditional spatial data analytics - Conduct spatial big data analyses on Apache Sedona involving advanced operations such as RDD such as spatial data queries - Combine various storage, databases and processing platforms (QGIS, Postgres/PostGIS, Apache Spark, Apache Sedona) to implement end-to-end big spatial data solutions for real-world problems
Source materials	SEE4NA trainings: - Teaching tips for an introductory GI course: Notes and examples, Lucas De Oto/Faculty ITC, University of Twente, SEED4NA Virtual Summer School 18-27th May 2021. - Spatial data models -A content overview, Lucas De Oto/Faculty ITC, University of Twente, SEED4NA Online training 9-11th March 2022.

	- Spatial data analysis - A content overview, Lucas De Oto/Faculty ITC, University of Twente, SEED4NA Online training 9-11th March 2022. - Spatial Data Science, Carsten Kessler/Bochum University of Applied Sciences, SEED4NA Summer School Dubrovnik, May 9–13, 2022 <u>SEED4NA Materiel:</u> - Vector Analysis, Mahdi Farnaghi/Faculty ITC, University of Twente, Master's Core Course, GIS & RS for Geospatial solutions, Course 3 - Geospatial Analysis and Interpretation. - Introduction to Spatial Analysis, Lucas De Oto/Faculty ITC, University of Twente, VET - Introduction to Geoinformatics, Module 2 - Principles of GIS. - Big data solutions Distributed computing, Hadoop, Spark and Dask, Mahdi Farnaghi, Raúl ZURITA-MILLA/ Faculty ITC, University of Twente.
Teaching materials developed	- Lecture on Geographical Information Systems: applications, components, data models, spatial reference framework (datum, map projections, coordinate transformation), cartography. - Lecture on Spatial Analysis and Estimation: Introduction, Spatial Analysis Operations (examples, scope), Selection operations, Classification operations, Dissolve operations, Proximity functions, Overlay operations, Network analysis, Raster analysis, Spatial interpolation. - Lecture on Spatial Databases: spatial data models and query languages (spatial SQL), spatial index structures, geohash indexing, spatial join operators, introduction to PostGIS - Lecture on Spatial Big Data Processing /Apache Sedona: Apache Sedona architecture, Spatial RDD, Spatial indexing, Spatial queries, Examples of use cases. - Exercise on Spatial databases: Postgres/PostGIS installation and Setup, spatial dataset import, execution of spatial queries - Exercise on Hadoop/HDFS: installation and setup on a cluster of Linux virtual machines, common file system operations, monitoring HDFS cluster through command line and web interface - Exercise on Spark processing engine: implement and run simple programs in Scala or Python. - Exercise on Sedona distributed spatial engine: installation and setup, creating Geometry attributes, loading spatial data into RDDs (GeoJSON), executing spatial queries

Course	**Application of Machine Learning to Satellite Imagery**
Study program	PhD, Computer Science Department, Faculty of Exact and Applied Sciences, UORAN1
Credits	/
Teacher(s)	Mejdi Kaddour, Professor, Department of CS, UORAN1
Language(s)	English
New or revised	New
New subjects	- **Introduction to Remote Sensing:** definition and main sensing steps; energy and illumination sources, properties of electromagnetic waves, atmosphere and Interaction with targets; sensor types: active/passive; digital images: multispectral, panchromatic, color, thermal, hyperspectral; satellite platforms: Landsat, Sentinel, Ikonos, Worldview; preprocessing of images: geometric and radiometric distortion, spatial indices, vegetation indices. - **Review of Deep Leaning:** deep neuronal networks; convolutional neuronal networks; recurrent neuronal networks; auto-encoders, generative adversarial networks; optimization (gradient descent); hyperparameters and algorithm tuning: dropout, batch normalization, vanishing gradients; performance and error analysis; ensemble and transfer learning - **Applications of DL in Remote Sensing:** feature engineering; spatial and geometric features on remote sensing dataset; supervised deep feature extraction: pre-trained networks, fine tuning, full-trainer networks; image classification: pixel-wise, spectral feature, spatial feature, spectral-spatial feature, patch-based approach, classification of deep features; semantic segmentation (FCN, SegNet, U-Net, etc); object detection (Faster-RCNN, YOLO, etc); instance segmentation (Mask R-CNN); multimodal fusion; change detection; challenges and opportunities for DL in RS.
New learning objectives	After completion of the course students should be able to: - Organize advanced methodologies for the analysis of remote sensing images acquired by satellite systems. - Explain both the geometric and spectrum characteristics of common remote sensing data - Express the theoretical concepts behind deep neural networks - Design and apply deep learning techniques to solve EO problems. - Explore relevant case studies of ML-based applications, such as land-cover maps generation, land-cover maps updating, biophysical parameter estimation, image search and retrieval, and change detection.

	- Engage relevant knowledge into Ph.D. research topics.
Source materials	SEED4NA Training - Earth Observation and Remote Sensing, Andrija Krtalić/University of Zagreb, SEED4NA Online Training, December 2021. - Remote Sensing & GIS, Andrija Krtalić/University of Zagreb, SEED4NA Algiers Training, 25-26 October 2022.
Teaching materials developed	- Lecture on Introduction to Earth Observation and Remote Sensing - Lecture on Introduction to Deep Learning - Lecture on Deep Learning for Remote Sensing

Course	**Remote Sensing**
Study program	Bachelor's program in Precision Agriculture (for second-year students)
Credits	3 ECTS
Teacher(s)	Noureddine Aribi, Associate Professor, Department of CS, UORAN1
Language(s)	French and English
New or revised	New course
New subjects	– History and basic concepts in remote sensing – Physics of Remote Sensing – Spectral Signature, In-situ measurements and Visual image interpretation – Sensors and Remote Sensing Systems – EO satellites and their optical and radar sensors – Image acquisition, resolution types and data collection techniques in the electromagnetic spectrum – RS data errors, geometric distortions and transformations of the geospatial data – Pre-processing and digital image processing – Incorporating geospatial data into a GIS – Geovisualization and cartographic aspects – Machine learning algorithms and data structures for geospatial data – Use of multispectral images in precision agriculture
New learning objectives	– Define and describe remote sensing and explain its applications and history. – Define and describe basics of electromagnetic spectrum and interactions with various types of media. – Describe sensors and data acquisition methods of remote sensing (collection, processing, and presentation). – Introduce the different types of remote sensing bands (visible, hyperspectral, thermal, radar) – Describe basic characteristics of remote sensing imagery (spatial, spectral resolution, pixel values, etc.). – Critical thinking about methodologies for data collection, pre-processing and digital image processing, such as image filtering, calibration, correction, classification, and calculation of spectral indices. – Develop the necessary skills for managing and using proper methods for solving problems within remote sensing, with applications to precision agriculture-specific image sources.

	– Develop the skills required for the written presentation of findings from quantitative and qualitative data analysis and digital images processing.
Source materials	**I. Online trainings** **1. Basics of Earth Observation and Remote Sensing technical training, December 13th –15th, 2021.** – Speaker: Andrija Krtalić from the Faculty of Geodesy University of Zagreb **2. Lifelong learning through high-quality teaching, February 21-23, 2022** – Covered topics: Quality Assurance in Higer Education; Bologna Process For Curriculum Develoment. – Speakers: Željko Bačić, Ana Kuveždić Divjak, University of Zagreb; Anders Östman (Novogit) **3. Fundamentals of Geospatial Information in SDI: Overview and Teaching Approaches, University of Twente Faculty of GeoInformation Science and Earth Observation (UT-ITC), March 9–11, 2022** – Covered topics: Spatial data analysis; Spatial data models; Teaching tips for an introductory GI course – Speakers: De Oto & Rolf de By – Faculty ITC, University of Twente **II. In-person trainings** **4. Dubrovnik (CRO) Summer school, May 9th – 13th, 2022** – Covered topics: Spatial Datna Science; SDI establishment; AI for EO - GIS applications ; Drone usage – Speakers: Željko Bačić, Zvonimir Nevistić, UNIZG, Anders Östman (Novogit AB), Lucas de Oto, Dr. Khodadadzadeh, U Twente, Carsten Kessler, HSBO, Glenn Vancauwenberghe, KU Leuven **5. Open SDI Summer School", Zagreb, Croatia, August 22-26, 2022** – Covered topics: Introduction to the concept of open SDI; Introduction to assignments; Finding open datasets in Croatia; how easy and how open?; Encoding standards and semantics. – Speakers: Carsten Kessler, Hrvoje Tomić, Željko Bačić, Vesna Poslončec Petrić, Bastiaan von Loenen, Glenn Vancauwenberghe, Ali Mansourian – Case Studies, lecture & exercises: Crowdsourced noise map: Collecting data yourself; Interoperability and interface standards + QGIS demonstration. Quiz & Exercise **6. National training Algiers, October 23rd – 26th, 2022** – Covered topics: Space Geodesy & Cartographic Synthesis, GIS & data analysis, Remote Sensing, Remote Sensing & GIS; Satellite Altimetry: Principles and basics Mean sea level determination – Speakers: Željko Bačić, Vesna Poslončec-Petrić, Marijan Grgić, Andrija Krtalić, UNIZG, Croatia – Case Studies, lecture & exercises: Noise mapping & visualization & processing ; Remote Sensing & GIS (Spectroscopy; Digital Images; Spectral Indices; Spatial Interpretation)

Teaching materials developed	**1. Lecture/presentation about the Electromagnetic Spectrum** ▪ Learning objectives: – Understand the fundamental concepts of the electromagnetic spectrum, including the different ranges of wavelengths and frequencies. – Explain how electromagnetic waves are generated and the relationship between wavelength, frequency, and energy. – Identify and describe the various regions of the electromagnetic spectrum, such as radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. – Understand the applications and uses of different regions of the electromagnetic spectrum in various fields, including communication, astronomy, medicine, and technology. – Analyze the interaction of electromagnetic waves with matter, including absorption, reflection, refraction, and diffraction. – Describe the principles and technologies behind various devices that utilize the electromagnetic spectrum, such as antennas, lasers, optical fibers, and imaging systems. – Explore the historical development of our understanding of the electromagnetic spectrum and its significance in scientific discoveries and technological advancements. – Apply knowledge of the electromagnetic spectrum to solve problems, make predictions, and evaluate real-world scenarios. **2. Practical work about NDVI Change Analysis in QGIS** ▪ Educational objectives: – Find and download NDVI satellite images from the web – Perform a visual change analysis – Perform a mathematical change analysis with management of pixels not representing NDVI – Connect the analysis of NDVI satellite images with climate data – Choose a relevant raster symbology in relation to the data to be represented ▪ Data & QGIS Project: The data necessary to carry out this exercise (~ 170 MB) essentially corresponds to: – 2 low resolution NDVI images over Africa for January and September 2006 – An image expressing the change in NDVI between the 2 dates – A 0/1 binary mask image that identifies invalid/valid pixels in the NDVI change image ▪ Goal: analyze the evolution of vegetation in Africa between January and September 2006 **3. Practical work about Hyperspectral data manipulations in QGIS** ▪ Educational objectives:

	– Better understand the notion of hyperspectral image – Distinguish the variation of spectral signatures for different land cover – Analyze various graphic forms of spatial information representation (spectral signature, 2D point cloud, hyperspectral cube) ▪ Data & Applications: – The data necessary to carry out this exercise (~ 50 MB) essentially corresponds to: (i) A CHRIS-PROBA hyperspectral satellite image; (ii) Hyperspectral field data – QGIS, Temporal/Spectral Profile Tool &Raster Data Plotting plugins, ViewSpecPro, **4. Practical work about the Analysis of SAR SENTINEL-1 (active remote sensing) data for flood mapping in SNAP** ▪ Educational objectives: – Become familiar with the use of the SNAP software, the reference software of the European Space Agency (ESA) for processing data from the Sentinel satellite constellation. – Explore specific processing techniques for RADAR data. – Learn how to get Subseted, Multilooked and Radiometrically Calibrated Sentinel-1 images – Learn how to correct for distortion due to the mountainous terrain – Utilize multi-date RADAR data for flood mapping. ▪ Data: – The required data consists of two Sentinel-1 images (~1.09 GB). **5. Assignment about Remote Sensing, which includes:** – Multiple Choice Questions (MCQs) on basic concepts in remote sensing, such as reflectance, spectral signature, spectral bands, spectral indices, and vegetation states (Healthy, Stressed, or Dead). – Classification and confusion matrix. – Different types of image resolution. **6. Assignment about Crowdsourced Data of a GreenSeeker Handheld NDVI Sensor for Generating an NDVI Map** ▪ Educational objectives: – Use GreenSeeker Crop sensor and Mobile application to collect geodata in the selected area – Process and interpolate measurement data (using QGIS) – Create a NDVI Map – Use the provided GreenSeeker workflow to Estimate Fertilizer Rate – Create a Fertilizer Rate Map **7. Reading material on Fundamentals of Remote Sensing**

Course	**Global Navigation Satellite Systems**
Study program	Third year of Bachelor in Precision Agriculture, Biology Department, Faculty of Life Sciences, UORAN1
Credits	4 ECTS
Teacher(s)	Mejdi Kaddour, Associate Professor, Department of CS, UORAN1 Noureddine Benaissa, Professor, Department of Biology, UORAN1
Language(s)	English
New or revised	New
New subjects	- Fundamentals of global navigation satellite systems - GPS architecture, components, signals, and navigation message - Estimation and representation of satellite orbits (Keplerian parameters) - Geodetic reference systems and time systems - Pseudo-ranging and dilution of precision - Estimation of positions with GNSS satellite observations, Resolution of navigation equations, Error sources and budgets - GNSS positioning modes - GNSS augmentation systems - GNSS data formats - GNSS in precision farming and agricultural technology
New learning objectives	After completion of the course students should be able to: - Describe the principles of GNSS based positioning methods, the main components in a satellite navigation system and their functions - Apply transformations of GNSS-related coordinate systems - Implement basic algorithms for estimation of GNSS based positions - Analyse and estimate the influence of different error sources on the positioning precision - Plan, perform and process precise GNSS measurements - Prepare data to be shared and integrated with GIS - Recognize GPS augmentation systems such as WAAS - Exemplify the role of GNSS, or GNSS based products and services, in precision farming
Source materials	<u>SEED4NA Materiel:</u> - GNSS, Introduction to Satellite Positioning, Željko Bačić, University of Zagreb, Geomatics Institute, Academic year 2021/22.

	- GNSS, Reference Systems, Željko Bačić, University of Zagreb, Geomatics Institute, Academic year 2021/22.
Teaching materials developed	- Lecture on Fundamentals of Satellite Navigation: Definition, GNSS applications, Performance characteristics, Development timeline, Introduction to GPS (history, constellations, architecture), GPS orbits and Kepler's laws, GPS signals, A first intuition on receiver location and navigation equations. - Lecture on Coordinate Reference Systems and Time: Cartesian/Spherical coordinates, Global Coordinate Systems (ECEF, ECI), Geoid and Datums, Heights, Fundamentals of Time References, GPS Time. - Lecture on Coordinate Frame Transformations: Transformation between Cartesian coordinate frames, From Keplerian parameters to ECEF frame, Decoding the navigation message - Lecture on GPS Performance and Analysis: Navigation equations, Solution of the navigation equations, Dilution of Precision, Error Budget. - Lecture on GNSS Positioning Modes: Positioning Modes, Differential GNSS, Carrier-phase measurements, Static/Fast Surveying, RTK, Dual-frequency GNSS, Satellite Based Augmentation System (SBAS) - Exercises on GNSS Fundamentals: quizzes, geometry of ellipses, Keplerian parameters, GPS frequencies and signals - Exercises on Coordinate transformations: DMS/DD notations, WGS84 ellipsoid model, geoid height calculation, GPS time - Lab on GNSS raw measurement from Phones: presentation of GNSS Logger App for Android. - Lab on GNSS Logger App: pseudo-range measurements - Lab on GNSS data analysis: presentation of GNSS Analysis Matlab software, mission planner, Receiver C/No comparison, - Lab on GNSS data analysis: analysis example, driving by car data - Lab on GNSS data analysis: analyzing ionosphere and troposphere errors - Labs on Garmin GPS receiver: collecting waypoint coordinates on an agricultural parcel

3.8. University Of Science And Technology Houari Boumediene (P14 – Algeria)

Course	**Remote sensing and satellite imagery**
Study program	Master 1
Credits	3
Teacher(s)	Hourizi Ratiba
Language(s)	French
New or revised	Revised
New subjects	For this existing course, we have added the following: 1- Signal disturbances and cuts in spectral signatures 2- The concept of hyperspectral satellite images and the use of radiometric sensors on board satellites, planes and drones. 3- Presentation of certain satellite image acquisition sites: EarthExlorer, Eosda_LandViewer; Copernicus 4- Integration of the concept of telecommunications satellites (positioning satellites). 5- Integration of the concept of GNSS positioning system and its importance in cartography and positioning of geographic information. With this in mind, we have put together a short practical course on using TOPCON. 6- Introduction to the concept of artificial intelligence and machine learning and its importance in the processing of satellite images, particularly hyperspectral images. 7- Presentation of Python programming software in an anaconda environment and demonstration and its importance in satellite image processing. 8- In the GIS course, I introduced the notion of SDI (definition of SDI and importance).
New learning objectives	1- Know the effect of disturbances in modifying the recording of information on satellite images. 2- Know the value of hyperspectral images to better discern the spectral properties of objects, particularly those whose reflectances are very close, such as the mapping of the canopies of the different forest species dominant in a forest ecosystem.

	3- Teach students that they can choose which data to download for free based on their purpose and data availability. - The objectives of points (4) and (5) are to understand the importance of the positioning of information in spatial analyzes and to become aware of all the technologies deployed for this purpose. Let them know the difference between a GNSS and a GPS. and the use of TOPCON as a field positioning system. - That students understand what artificial intelligence is and that machine learning is a branch of artificial intelligence, so that they can use machine learning methods to monitor certain ecological phenomena by processing satellite images . Teach students that artificial intelligence is also part of our daily lives (example: use of Google Map). Know SDI and their importance in the homogenization of information, particularly in the environment, and their use in understanding complex and continuous ecological phenomena, without borders.
Source materials	**"**SEED4NA Virtual Summer School", May 2021 (online) "Basics of Earth Observation and Remote Sensing", December 2021 (online) "Basics of Spatial Data Infrastructures (SDI)", January 2022 (online) "SPIDER Summer School on Open SDI in Zagreb", August 2022 (online) "Agadir training", September 2022 (online) "Algiers National training", October 2022 (face to face)
Teaching materials developed	1- On the subjects covered in points 1, 2 and 3 of the "new subjects" section (signal disturbance, hyperspectral images and satellite image download sites), I used 5 presentations on remote sensing made within the framework SEEDNA4 training. Two presentations made during the Workshop organized National training Algiers, from October 23 to 26, 2022 at the USTHB: • Remote Sensing, Remote Sensing & GIS Presenter: Andrija Krtalić, UNIZG, Croatia. Spectroscopy. • Remote Sensing & GIS Presenter: Andrija Krtalić, UNIZG, Croatia: Spectroscopy – Exercises (For the exercises we mainly used the histograms displayed in imageJ) 3 presentations of the online courses from 13-14 and 15/12-2021 presented by Andrija Kralić. - Regarding GNSS, I used the presentation made in the Altelier presented in Algeria 2022:

	• Space Geodesy & Cartographic Synthesis Presenter: Željko Bačić, UNIZG, Croatia: Positioning modes (absolute, relative, startic and kinematic) and GNSS error sources. - For the SDI introduction theme, I used the following two presentations from the 2021 SEED4NA Virtual Summer School: • Joep Crompvoets, KU Leuven (18 May 2021): Spatial Data Infrastructures in academic education • Željko Bačić, UNIZG (May 18, 2012): SDI curriculum developed by BESTSDI project. And consulted this publication found on the SEEDNA4 site: • Crompvoets, J., Poslončec-Petrić, V., & Bačić, Ž. (2020). Academia-Business survey on needs and cooperation in field of Spatial Data Infrastructure. EuroSDR & BESTSDI project, 1-34. - For the theme of the spectral signature of vegetation and the study of water stress, I consulted the publications cited in the articles published on the SEEDNA4 site: • Greimeister-Pfeil, I., Wagner, W., Quast, R., Hahn, S., Steele-Dunne, S., & Vreugdenhil, M. (2022). Analysis of short-term soil moisture effects on the ASCAT backscatter-incidence angle dependence. Science of Remote Sensing, 5, 100053. From this publication I was also able to consult other publications on different aspects of the study of vegetation, such as: • Konings, A. G., Rao, K., & Steele-Dunne, S. C. (2019). Macro to micro: microwave remote sensing of plant water content for physiology and ecology. New Phytologist, 223(3), 1166-1172. Konings, A. G., Holtzman, N. M., Rao, K., Xu, L., & Saatchi, S. S. (2021). Interannual variations of vegetation optical depth are due to both water stress and biomass changes. Geophysical Research Letters, 48(16), e2021GL095267 • Jones, M. O., Jones, L. A., Kimball, J. S., & McDonald, K. C. (2011). Satellite passive microwave remote sensing for monitoring global land surface phenology. Remote Sensing of Environment, 115(4), 1102-1114.

Course	**Cartographic synthesis**
Study program	Master 2
Credits	2
Teacher(s)	Hourizi Ratiba
Language(s)	French
New or revised	Revised
New subjects	To existing course, the following points have been added : 1- The integration of the concept of GNSS positioning system and its importance in cartography and positioning of geographic information. With this in mind, we have put together a short practical course on using Topcon GNSS. 2- I introduced the notion of SDI (definition of SDI and importance). 3- New case studies such as Forest Fire Modelling
New learning objectives	The objectives of points (1) are to understand the importance of the positioning of information in spatial analyzes and to become aware of all the technologies deployed for this purpose. Let them know the difference between a GNSS and a GPS. and the use of TOPCON as a field positioning system. Introduce SDI and their importance in the homogenization of information, particularly in the environment, and their use in understanding complex and continuous ecological phenomena, without borders.
Source materials	"SEED4NA Virtual Summer School", May 2021 (online) "Basics of Earth Observation and Remote Sensing", December 2021 (online) "Basics of Spatial Data Infrastructures (SDI)", January 2022 (online) "SPIDER Summer School on Open SDI in Zagreb", August 2022 (online) "Agadir training", September 2022 (online) "Algiers National training", October 2022 (face to face) SEED4NA repository
Teaching materials developed	1- To enhance GIS courses, I used 5 presentations related to GIS within the framework SEEDNA4 training. Two presentations made during the Workshop organized National training Algiers, from October 23 to 26, 2022 at the USTHB:

	• Remote Sensing, Remote Sensing & GIS Presenter: Andrija Krtalić, UNIZG, Croatia. Spectroscopy. • Remote Sensing & GIS Presenter: Andrija Krtalić, UNIZG, Croatia: Spectroscopy – Exercises (For the exercises we mainly used the histograms displayed in imageJ) Online courses from 13-14 and 15/12-2021 presented by Andrija Kralić. - Regarding GNSS, I used the presentation made in the Altelier presented in Algeria 2022: • Space Geodesy & Cartographic Synthesis Presenter: Željko Bačić, UNIZG, Croatia: Positioning modes (absolute, relative, startic and kinematic) and GNSS error sources. - For the SDI introduction theme, I used the following two presentations from the 2021 SEED4NA Virtual Summer School: • Joep Crompvoets, KU Leuven (18 May 2021): Spatial Data Infrastructures in academic education • Željko Bačić, UNIZG (May 18, 2012): SDI curriculum developed by BESTSDI project. And consulted this publication found on the SEEDNA4 site: • Crompvoets, J., Poslončec-Petrić, V., & Bačić, Ž. (2020). Academia-Business survey on needs and cooperation in field of Spatial Data Infrastructure. EuroSDR & BESTSDI project, 1-34.

Course	**GIS and remote sensing**
Study program	Master 1
Credits	5
Teacher(s)	Hourizi Ratiba
Language(s)	French
New or revised	Revised
New subjects	To existing course, the following points have been added : 1- Signal disturbances and cuts in spectral signatures 2- The concept of hyperspectral satellite images and the use of radiometric sensors on board satellites, planes and drones. 3- Presentation of certain satellite image acquisition sites: EarthExlorer, Eosda_LandViewer; Copernicus 4- Integration of the concept of telecommunications satellites (positioning satellites). 5- the integration of the concept of GNSS positioning system and its importance in cartography and positioning of geographic information. With this in mind, we have put together a short practical course on using Topcon GNSS. 6- Introduction to the concept of artificial intelligence and machine learning and its importance in the processing of satellite images, particularly hyperspectral images. 7- Presentation of Python programming software in an anaconda environment and demonstration and its importance in satellite image processing. 8- In the GIS course, I introduced the notion of SDI (definition of SDI and importance).
New learning objectives	Understand the effect of disturbances in modifying the recording of information on satellite images. Know the value of hyperspectral images to better discern the spectral properties of objects, particularly those whose reflectances are very close, such as the mapping of the canopies of the different forest species dominant in a forest ecosystem. Teach students that they can choose which data to download for free based on their purpose and data availability.

	The objectives of points (4) and (5) are to understand the importance of the positioning of information in spatial analyzes and to become aware of all the technologies deployed for this purpose. Let them know the difference between a GNSS and a GPS. and the use of TOPCON as a field positioning system. That students understand what artificial intelligence is and that machine learning is a branch of artificial intelligence, so that they can use machine learning methods to monitor certain ecological phenomena by processing satellite images . Teach students that artificial intelligence is also part of our daily lives (example: use of Google Map). Introduce SDI and their importance in the homogenization of information, particularly in the environment, and their use in understanding complex and continuous ecological phenomena, without borders.
Source materials	"SEED4NA Virtual Summer School", May 2021 (online) "Basics of Earth Observation and Remote Sensing", December 2021 (online) "Basics of Spatial Data Infrastructures (SDI)", January 2022 (online) "SPIDER Summer School on Open SDI in Zagreb", August 2022 (online) "Agadir training", September 2022 (online) "Algiers National training", October 2022 (face to face) SEED4NA repository
Teaching materials developed	1- On the subjects covered in points 1, 2 and 3 of the "new subjects" section (signal disturbance, hyperspectral images and satellite image download sites), I used 5 presentations on remote sensing made within the framework SEEDNA4 training. Two presentations made during the Workshop organized National training Algiers, from October 23 to 26, 2022 at the USTHB: • Remote Sensing, Remote Sensing & GIS Presenter: Andrija Krtalić, UNIZG, Croatia. Spectroscopy. • Remote Sensing & GIS Presenter: Andrija Krtalić, UNIZG, Croatia: Spectroscopy – Exercises (For the exercises we mainly used the histograms displayed in imageJ) Online courses from 13-14 and 15/12-2021 presented by Andrija Kralić. - Regarding GNSS, I used the presentation made in the Altelier presented in Algeria 2022: • Space Geodesy & Cartographic Synthesis Presenter: Željko Bačić, UNIZG, Croatia: Positioning modes (absolute, relative, startic and kinematic) and GNSS error sources.

	- For the SDI introduction theme, I used the following two presentations from the 2021 SEED4NA Virtual Summer School: • Joep Crompvoets, KU Leuven (18 May 2021): Spatial Data Infrastructures in academic education • Željko Bačić, UNIZG (May 18, 2012): SDI curriculum developed by BESTSDI project. And consulted this publication found on the SEEDNA4 site: • Crompvoets, J., Poslončec-Petrić, V., & Bačić, Ž. (2020). Academia-Business survey on needs and cooperation in field of Spatial Data Infrastructure. EuroSDR & BESTSDI project, 1-34. - For the theme of the spectral signature of vegetation and the study of water stress, I consulted the publications cited in the articles published on the SEEDNA4 site: • Greimeister-Pfeil, I., Wagner, W., Quast, R., Hahn, S., Steele-Dunne, S., & Vreugdenhil, M. (2022). Analysis of short-term soil moisture effects on the ASCAT backscatter-incidence angle dependence. Science of Remote Sensing, 5, 100053. From this publication I was also able to consult other publications on different aspects of the study of vegetation, such as: • Konings, A. G., Rao, K., & Steele-Dunne, S. C. (2019). Macro to micro: microwave remote sensing of plant water content for physiology and ecology. New Phytologist, 223(3), 1166-1172. Konings, A. G., Holtzman, N. M., Rao, K., Xu, L., & Saatchi, S. S. (2021). Interannual variations of vegetation optical depth are due to both water stress and biomass changes. Geophysical Research Letters, 48(16), e2021GL095267 • Jones, M. O., Jones, L. A., Kimball, J. S., & McDonald, K. C. (2011). Satellite passive microwave remote sensing for monitoring global land surface phenology. Remote Sensing of Environment, 115(4), 1102-1114.

Course	**GIS and data analysis I**
Study program	Master 1
Credits	4
Teacher(s)	Dr Saci Kermani
Language(s)	French
New or revised	New course
New subjects	-GIS features -Data Editing and Topology -Database management -Handling and treatment methods in GIS -Compatibility of GIS with other applications and software.
New learning objectives	- Acquire basic principles of spatial data acquisition and analysis - Be able to use and apply different methods of classification, extraction and processing spatio-temporal data. - Know how to display and visualise maps and graphs of spatial data. - Master data processing using spatial queries - Learn how to export and import external data to the GIS environment. - Know how to import and link non-spatial datasets with spatial data using the georeferencing.
Source materials	Advances in Cartography and Geographic Information Engineering, Jiayao Wang Fang Wu, 2021. La dimension géographique de système de formation, Henri Pornon, 2015. SEED4NA Virtual Summer School", May 2021 (online) "Basics of Earth Observation and Remote Sensing", December 2021 (online) "Basics of Spatial Data Infrastructures (SDI)", January 2022 (online) "Algiers National training", October 2022 (face to face) SEED4NA material : Mainly based on VET : Introduction to geo-informatics RICHARD KNIPPERS courses of February 2022 provided by ITC Twente University

Teaching materials developed	Course slides and course materials

Course	**Space Geodesy**
Study program	Geodesy and cartography
Credits	5
Teacher(s)	Assoc. Prof. Mohammed Chikh-Baelhadj
Language(s)	French
New or revised	New
New subjects	Artificial Satellite - an overview Classification of satellites, orbits GNSS Principles and Basics Types of measurements (code, phase and doppler) Positioning modes (absolute, relative, DGPS and PPP) Satellite Altimetry: Principles and Basics Mean sea level determination Satellite Gravimetry: Principles and Basics Space gravity missions (CHAMP, GRACE and GOCE) Gravity field recovery approaches
New learning objectives	This course objectives are to : - Introduce the general principle of satellite orbit mechanics and different types of orbits. - Explain the relationship between Earth's geometric and physics proprieties and satellite orbit - Explain how to obtain geodetic information from satellites. - Introduce the principle of ascending and descending satellite systems - Introduce the principle of positioning, and explain the different modes and assassinated class of precision.

	- Introduce the principle of Satellite altimetry and explain the mean sea level and marine geoid determination - Introduce the principle of satellite gravimetry and different approach of gravity recovery. - Develop skills for proccessing geodetic satellite data.
Source materials	"SEED4NA Virtual Summer School", May 2021 (online) "Basics of Earth Observation and Remote Sensing", December 2021 (online) "Basics of Spatial Data Infrastructures (SDI)", January 2022 (online) "Lifelong learning through high-quality teaching", February 2022 (online) "Fundamentals of Geospatial Information in SDI: Overview and Teaching Approaches", March 2022 (online) "Algiers National training", October 2022 (face to face) SEED4NA repository: AGIV/AIV (2004-2019), Edited by:Jos Van Orshoven (04/2019) & Sam Ottoy (11/2019)
Teaching materials developed	Slides. New course material available Cours GPS M1 USTHB - 2023-09-29.pptx

4. Conclusion and next steps

After the design and development of the SEED4NA curriculum in the previous stages of the project, an important step was the localisation of this curriculum into the relevant study programs at the eight partner universities participating in SEED4NA. This localisation could take place to the revision of existing courses or through the introduction of new courses into the study programs. This report summarized the localisation processes at the eight North African universities, which resulted into 14 revised courses and 13 fully new courses, which are provided at different study levels (Bachelor, Master, Postgraduate, Phd and Engineering).

Localisation included the identification of new subjects, the definition of relevant learning objectives related to these subjects and the design of appropriate and effective teaching activities to support students in achieving these objectives. For each of these elements (subjects, learning objectives & teaching activities) the SEED4NA partners could build upon existing teaching materials as well as the training they received as part of the project. The aim of this report was to provide an harmonized description of the localisation process for all courses developed/revised under SEED4NA. Using a common template, detailed descriptions are provided for all courses, in which the different elements of localisation are covered.

The next step in the process of modernising education on SDI and EO at the partner universities is the execution of the courses, i.e. the delivery of these courses to the students at the partner institutions. Prior to this also the formal approval of the curriculum projects is needed, i.e. the approval of the modifications to the educational programs. Finally, it is important to also evaluate this modernisation processes, and the extent to which they resulted into improvements in the relevance, quality and impact of higher education on SDI, EO and related topics at the eight partner universities in North Africa. Each of these steps will be documented for all partner universities involved in SEED4NA and their curriculum projects.