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1. SUMMARY

As a virtual training, different unit materials have been prepared within each of the 4 topics covered in the Advanced Course and they are available through the virtual learning platform. Each course and unit will be freely programmed so the CBK PAN staff is able to follow the course at their own availability rhythm. Please note that the Moodle Platform and its courses are planned to be managed and maintained by CBK PAN beyond the end of the project, thus any CBK PAN researcher or student will be able to enrol in the courses after the project ends.

Other important aspect in the Advanced Course is that, as a difference from the Standard Course, which was open to anyone registering to the Moodle platform, even from outside the CBK PAN, the Advanced course is open only for the CBK PAN authorized members and staff. The purpose of this restriction is to keep the knowledge inside the organization since this is a more advanced and specialized course. For this reason, the course is not open for self-registration, but under permission.

Each unit is composed of different educational resources: presentations, video-tutorials, unit reports and scientific bibliography, practical exercises, a Questions and Answers section and a Self-Evaluation Quiz so that students can evaluate the level of their knowledge acquisition.

2. COURSE DESCRIPTION, CONTENT DETAILS AND LEARNING OUTCOMES

The advanced course is formed by 4 courses based on 4 main topics related to Ecosystem research: Remote Sensing (AR), Ecosystem Research (AE), Modelling (AM), Computer Science (AC). Each course includes different sections: several theoretical subjects, a practical exercise part and a Questions and Answers and Self Evaluation Quiz part. The outline is the following:

COURSE TITLE	CODE	TITLE	ORGANIZER
Remote Sensing	AR1	Generation of Reflectance products	CREAF
	AR2	Long time series geoprocessing	CREAF
Ecosystem Research	AE1	Generation of Ecosystem Functional Types	CREAF
	AE2	Future ecosystem scenarios and related uncertainties	CNR
Modelling	AM1	Novel approaches to ecosystem modelling and services assimilating EO information	CNR
	AM2	Climate modelling	CREAF
Computer Science	AC1	Massive geoprocessing (2nd part)	CERTH
	AC2	OGC services for viewing, querying, downloading and processing	CREAF

AR REMOTE SENSING

AR1 GENERATION OF REFLECTANCE PRODUCTS

AR1 Generation of Reflectance products				CREAF	
COURSE CONTENT					
Code	**Title**	**Resp.Team**	**Time**	**Format / Software**	**Learn.Out (Code)**

AR1.1	Optical radiometric correction
	
	   a) Concepts and objectives of the radiometric correction
	   b) Methods of atmospheric correction
	   c) Methods of topographic correction
	   d) Processors
		CREAF	40'	PDF	ARO1.1, ARO1.2, ARO1.3

AR1.2	Thermal radiometric correction
	
	   a) Basic concepts of thermal radiance
	   b) Apparent brightness temperature obtention
	   c) Emissivity obtention
	   d) Surface temperature obtention
		CREAF	40'	PDF	ARO1.4
					
					ARO1.5

AR1.3	Practical exercise - optical images	CREAF	50'	MiraMon /SNAP	ARO1.1, ARO1.2, ARO1.3
AR1.4	Practical exercise - thermal images	CREAF	40'	MiraMon	ARO1.4 ARO1.5
AR1.5	Self-Evaluation Test	CREAF	10'	MOODLE TEST	
LEARNING OUTCOMES					
Code	**Title**			**Course Content (Code)**	
ARO1.1	Understand the purpose of radiometric correction			AR1.1	
ARO1.2	Understand the different capabilities and functionalities of atmospheric and topographic correction			AR1.1	
ARO1.3	Learn about the different methods and main processors of radiometric correction.			AR1.1	
ARO1.4	Learn to assess and improve the quality of thermal imagery by correcting various atmospheric and sensor-induced distortions			AR1.2/AR1.4	
ARO1.5	Gain knowledge of atmospheric effects on thermal images and techniques to compensate for these effects.			AR1.2/AR1.4	

AR2 LONG TIME SERIES GEOPROCESSING

AR2 Long time series geoprocessing					CREAF - CNR - CERTH

COURSE CONTENT

Code	Title	Resp.Team	Time	Format / Software	Learn.Out (Code)
AR2.1	Change detection: how Remote Sensing is evolving in studying change	CNR		PDF	ARO2.1
AR2.2	Phenology Metrics and Changes	CERTH	25'	PDF	ARO2.2
AR2.3	Practical exercise – Phenology Metrics and changes	CREAF	90'	WEkEO, Jupyter Notebook	ARO2.2
AR2.5	Self-Evaluation Test	CREAF	10'	MOODLE TEST	

LEARNING OUTCOMES

Code	Title	Course Content (Code)
ARO2.1	Understand the concepts underlying time series data, including seasonality or trend analysis and trajectories.	AR2.1
ARO2.2	The course introduces participants to the fundamental concept of Land Surface Phenology (LSP) and the Bfast module. Additionally, participants gain insights into Phenology Metrics and Phenology Changes algorithms.	AR2.2 AR2.3

AE ECOSYSTEM RESEARCH

AE1 GENERATION OF ECOSYSTEM FUNCTIONAL TYPES

AE1 Generation of Ecosystem Functional Types					CREAF

COURSE CONTENT

Code	Title	Resp.Team	Time	Format / Software	Learn.Out (Code)
AE1.1	Concepts	CREAF	10'	PDF	AEO1.1, AEO1.2
AE1.2	Model workflow description	CREAF	10'	PDF	AEO1.3
AE1.3	Practical exercise EFT batch processing	CREAF	60'	MiraMon	AEO1.3
AE1.5	Self-Evaluation Test	CREAF	10'	MOODLE TEST	

LEARNING OUTCOMES

Code	Title	Course Content (Code)
AEO1.1	Understand the EFT and EFA concepts	AE1.1

AEO1.2	Differentiate the PFT and EFT approaches	AE1.1
AEO1.3	Learn to generate EFAs and EFTs maps	AE1.2, AE1.3
AEO1.4	Understand the characteristics of processing in the Cloud	AR2.4

AE2 FUTURE ECOSYSTEM SCENARIOS AND RELATED UNCERTAINTIES

AE2 Future ecosystem scenarios and related uncertainties					CNR - CREAF	
COURSE CONTENT						
Code	Title	Resp.Team	Time	Format / Software	Learn.Out (Code)	
AE2.1	Uncertainty, errors, chaos: what is what?	CNR	15'	PDF	AE02.1	
AE2.2	The sources and measurement of uncertainty in future ecosystem scenarios-Part I (uncertainty quantification in mapping and modelling)	CNR	30'	PDF	AE02.2	
AE2.3	The sources and measurement of uncertainty in future ecosystem scenarios-Part II (uncertainty quantification in climate modelling)	CNR	30'	PDF	AE02.2, AE02.3	
AE2.4	Spatialization and uncertainty quality indicators	CREAF	30'	PDF	AEO2.4 AEO2.5	
AE2.5	Practical exercise - Uncertainty	CREAF	20'	PDF		
AE2.6	Self-Evaluation Test		10'	MOODLE TEST		
LEARNING OUTCOMES						
Code	Title				Course Content (Code)	
AEO2.1	Basic concepts on uncertainty and related terminology				AE2.1	
AEO2.2	The course summarizes the sources of uncertainty in ecosystem mapping and in modelling and the issues related to Uncertainty Quantification (UQ). It also describes the use of Monte Carlo methods for UQ in modelling				AE2.2 AE2.3	
AEO2.3	Role of uncertainty in climate models and how to tackle and quantify it.				AE2.2 AE2.3	
AEO2.4	Develop a comprehensive understanding of uncertainty in data and its importance				AE2.4	
AEO2.5	Reflect about different approach of compute error propagation				AE2.4	

AM MODELLING

## AM1 NOVEL APPROACHES TO ECOSYSTEM MODELLING AND SERVICES ASSIMILATING EO INFORMATION

AM1 Novel approaches to ecosystem modelling and services assimilating EO information				CNR-CREAF-CERTH	

COURSE CONTENT

Code	Title	Resp.Team	Time	Format / Software	Learn.Out (Code)
AM1.1	Models and methods for ecosystem management	CNR	60'	PDF	AMO1.2
AM1.2	Fusion of S-1 and S-2 data for inundation mapping	CERTH	40'	PDF	AMO1.3
AM1.3	Models and methods for ecosystem management-exercise	CNR	30'	PDF	AMO1.2
AM1.4	Self-Evaluation Test	CNR	10'	MOODLE TEST	AMO1.2

LEARNING OUTCOMES

Code	Title	Course Content (Code)
AMO1.1	Gain proficiency in using remote sensing data to assess and monitor biodiversity across different ecosystems, including forests, wetlands, grasslands and marine environments.	AM1.1 AM1.3
AMO1.2	The course identifies modelling needs in ecosystem management and briefly describes examples of mechanistic modelling of species distribution, showing how to incorporate control action to serve management needs. It focuses in particular on invasive species and how to use modelling techniques in support of control actions to minimize their spread.	AM1.1 AM1.3
AMO1.3	The course covers the advantages and limitations of utilizing Sentinel data for estimating Hydroperiods. Focused on study areas such as Doñana and Camargue, participants will explore both Sentinel-1 and Sentinel-2 approaches for calculating inundation maps and the fusion approach.	AM1.2

AM2 CLIMATE MODELLING

AM2 Climate modelling				CREAF-CNR	

COURSE CONTENT

Code	Title	Resp.Team	Time	Format / Software	Learn.Out (Code)
AM2.1	Generation of spatialized climate variables	CREAF	25'	PDF	AMO2.1, AMO2.2
AM2.2	Downscaling of climate variables	CREAF	25'	PDF	AMO2.3, AMO2.4
AM2.3	Practical exercise map generation of monthly precipitation/mean temperature	CREAF	60'	MiraMon	AMO2.2
AM2.4	Self-Evaluation Test	CREAF	10'	MOODLE TEST	
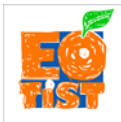
LEARNING OUTCOMES		
Code	Title	Course Content (Code)
AMO2.1	Understand spatial concepts: autocorrelation, interpolation, geostatistics, etc.	AM2.1
AMO2.2	Acquire theoretical and practical skills in multivariate methods for the generation of spatially continuous climate variable maps	AM2.1, AM2.3
AMO2.3	Learn about Global and Regional climate models	AM2.2
AMO2.4	Acquire knowledge about different downscale methods	AM2.2

AC COMPUTER SCIENCE

AC1 MASSIVE GEOPROCESSING (SECOND PART)

AC1 Massive Geoprocessing (second part)					CERTH - CREAF	
COURSE CONTENT						
Code	Title	Resp.Team	Time	Format / Software	Learn.Out (Code)	
AC1.1	Ontology-based approaches	CERTH	10'	PDF	ACO1.1	
AC1.2	Computational complexity	CERTH	5'	PDF	ACO1.2	
AC1.3	Big Geospatial Data Analysis with Google Earth Engine	CERTH	10'	PDF	ACO1.2	
AC1.4	Digital Twins	CERTH	10'	PDF	ACO1.3	
AC1.5	Geospatial ML Ops	CERTH	15'	PDF	ACO1.4	
AC1.6	FAQS	CERTH	5'	PDF		
AC1.7	Self-Evaluation Test		10'	MOODLE TEST		
LEARNING OUTCOMES						
Code	Title				Course Content (Code)	
ACO1.1	Understanding ontologies and their relevance				AC1.1	
ACO1.2	Computational complexity and how Google Earth Engine tackles it				AC1.2 AC1.3	
ACO1.3	Understanding Digital Twins				AC1.4	
ACO1.4	Knowing MLOps and MLOps platforms				AC1.5	

AC2 OGC SERVICES FOR VIEWING, QUERYING, DOWNLOADING AND PROCESSING

AC2 OGC services for viewing, querying, downloading and processing	CREAF-CERTH

COURSE CONTENT

Code	Title	Resp.Team	Time	Format / Software	Learn.Out (Code)
AC2.1	Geospatial Web Services a) Visualization Services b) Data Exchange Services c) Processing Services d) Discovery Services	CREAF	15'	MP4	ACO2.1
AC2.2	Integrated Geospatial Client	CREAF	5'	MP4	ACO2.1
AC2.3	Deploying Web Services	CREAF	5'	MP4	ACO2.2
AC2.4	The Emergence of APIs e) WebMapViewerAPIs f) OpenAPIs	CREAF	5'	MP4	ACO2.3
AC2.5	API design and data processing pipeline development	CERTH	35'	PDF	ACO2.3
AC2.6	Practical exercise	CREAF	20'	DOC	ACO2.1, ACO2.2, ACO2.3
AC2.7	Self-Evaluation Test	CREAF	10'	MOODLE TEST	All

LEARNING OUTCOMES

Code	Title	Course Content (Code)
ACO2.1	Know the main operations of the different categories of geospatial services in a very practical way	AC3.1, AC3.2
ACO2.2	How to deploy a web service	AC3.3
ACO2.3	Learn the basics of an emerging new type of geospatial standards	AC3.5
ACO2.5	The course covers key concepts and technologies for building robust systems. Participants will become familiar with API design principles, task queue implementation for asynchronous processing, understand the role of message broker systems, and optimize data processing pipelines. Additionally, the course imparts expertise in satellite data processing, covering acquisition, processing, and analysis of satellite datasets.	AC2.5