

ESA Advanced Training Course on Land Remote Sensing: Agriculture (LTC25)

Introduction to LTC25 & to ESA activities supporting agriculture

Espen Volden
Science Section
Green Solutions Division

Why does ESA organise LTC25?



ESA does a number of R&D activities in support of remote-sensing based application to agriculture

- Some inside ESA
- Mostly outside with European universities, research institutes, companies, user organisations, ...

⇒ Need to ensure there will be competent experts to participate in these activities in the future

⇒ More generally, need to ensure that there will be competent experts in Europe to use the data from the operating ESA and Copernicus satellites, and those we are developing and will launch in the coming years

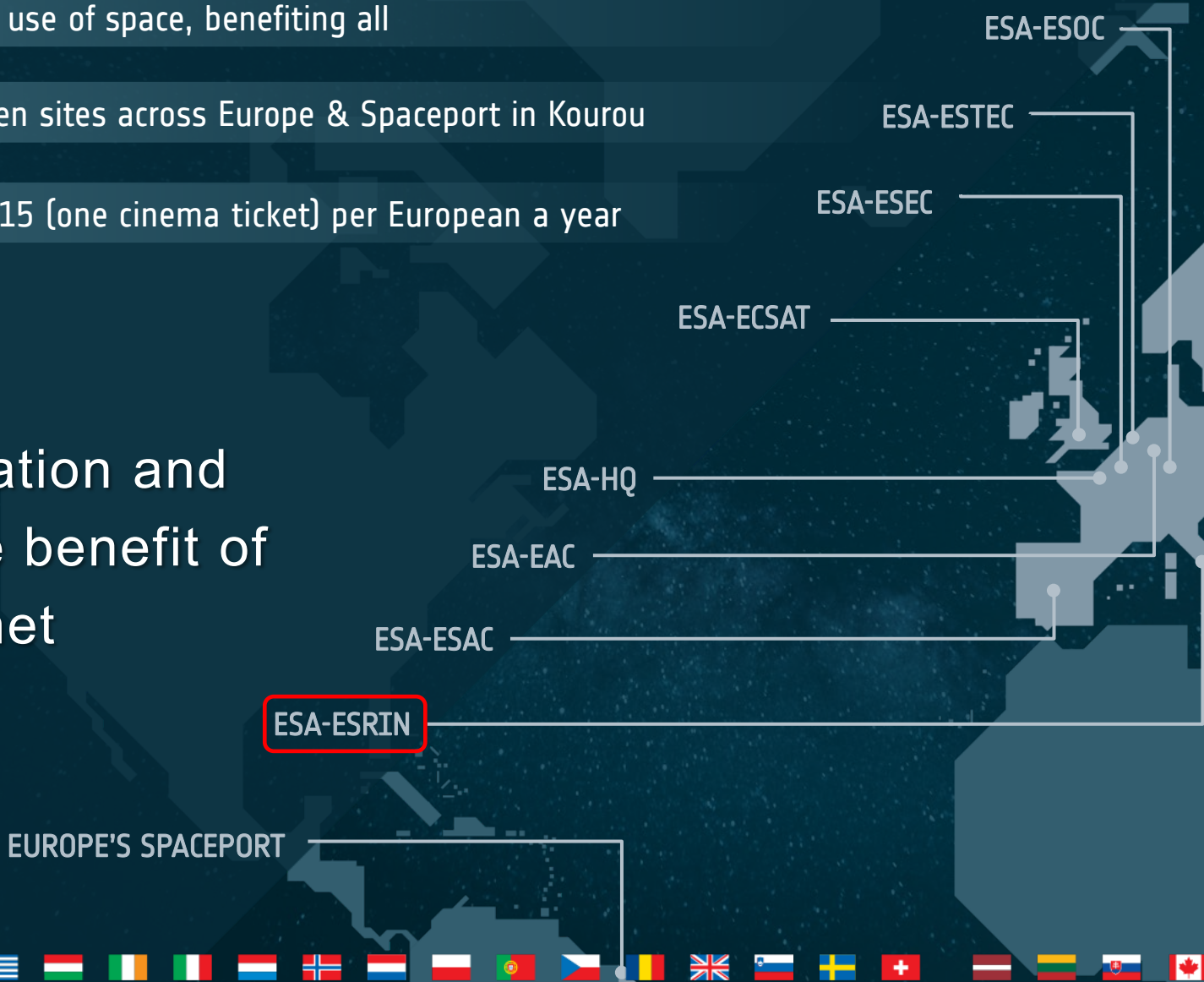
- ESA & Earth Observation
- Copernicus
- EO4Society: Developing new applications and science
- EO4Society: Opportunities for young scientists
- LTC25

ESA in a Nutshell



WHO	23 Member States, 2500+ staff members and total workforce of 6000+
WHY	For the peaceful use of space, benefiting all
WHERE	HQ in Paris, seven sites across Europe & Spaceport in Kourou
BUDGET	€7.7 billion = €15 (one cinema ticket) per European a year

ESA is committed to the peaceful exploration and use of space for the benefit of our people and planet



Satellite Design & Development



Missions Management



Cal/Val & Data Distribution



Earth System Science

Emergency Response

Digital Twins

Climate Change

Applying the Data for Earth Action

Innovation

Commercialisation

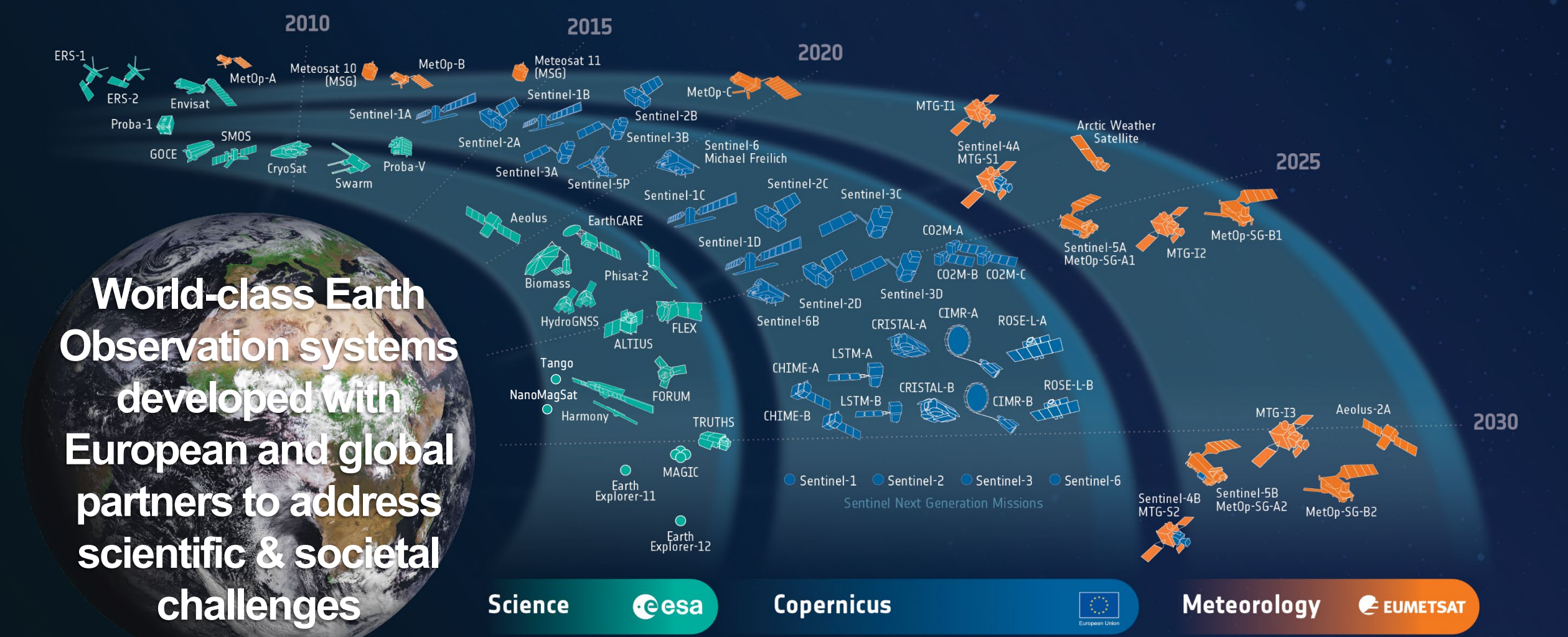
InCubed

Future Systems & Instruments activities

Accelerate the future of EO with cutting edge research

ESA's Earth Observation Missions

Satellites: Heritage **08** / Operational **16** / Developing **40** / Preparing **22** / Total **86**



World-class Earth
 Observation systems
 developed with
 European and global
 partners to address
 scientific & societal
 challenges

Copernicus Sentinel Satellites



Sentinel 1 (A/B/C/D)
SAR Imaging

All weather, day/night applications, interferometry



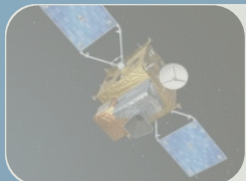
Sentinel 2 (A/B/C/D)
Multispectral Imaging

Land applications: urban, forest, agriculture, ...
Continuity of Landsat, SPOT



Sentinel 3 (A/B/C/D)
Ocean & Global Land Monitoring

Wide-swath ocean colour, vegetation, sea/land
surface temperature, altimetry



Sentinel 4 (A/B)
Geostationary Atmospheric

Atmospheric composition monitoring, pollution;
instrument on MTG satellites



Sentinel 5 (MF/B/C) & Precursor
Low-Orbit Atmospheric

Atmospheric composition monitoring; instrument on
MetOp-SG satellites



Sentinel 6
Jason CS (A/B)

Altimetry reference mission

Copernicus Space Component – Evolution



PROGRAMME OF THE
EUROPEAN UNION

co-funded with



**+ Next Generation
Sentinels for data
continuation and
enhanced observations**



PROGRAMME OF THE
EUROPEAN UNION



co-funded with



Copernicus Land Monitoring Service



Zero Pollution
Action Plan



Common
Agricultural
Policy



EU Action
to Protect
and Restore the
World's Forests



Net-Zero
Industry Act



and
others...



EU Forest
Strategy
for 2030

European
Climate Law



Copernicus supports EU policies and the Green Deal



Earth Observation Science for Society

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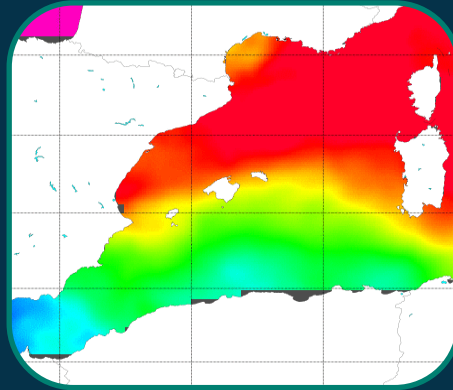


→ THE EUROPEAN SPACE AGENCY

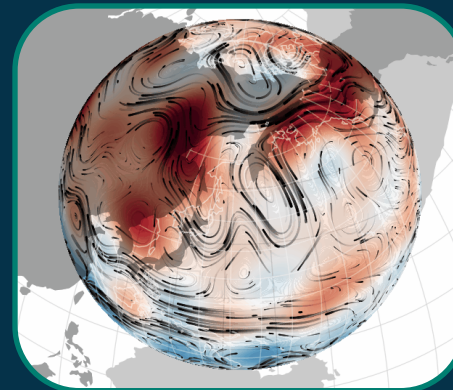
Pushing the frontiers of science



Engaging the community



New methods & observation products



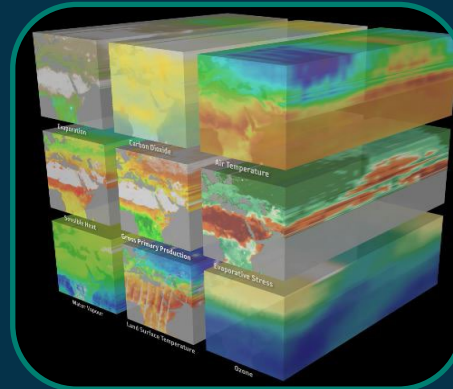
Advancing Earth System Science



Advanced simulations & predictability



Training and Education



Open Science Tools/Virtual Labs



Scientific Campaigns



Transfer to future missions

EO4CEREALSTRESS

Detecting and Monitoring Crop response to Multiple Stressors

Agriculture is subject to **multiple stressors** (heat, drought, salinity, lodging etc.,). Their combined effects can be more severe and complex, difficult to address.

This project follows a **data-centric approach**, synergistically combines multi-source EO data and machine learning techniques to monitor multiple stressors and aims to provide a **scientific roadmap** for the future development of crop stress related EO products.

Target stressors: Heat, Salinity, Toxicity, Water, Lodging
Pests, Nutrient Stress

Email us @ z.un-nisa@soton.ac.uk

Experimental Products:

- ❖ Drought Prediction maps (2018 – 2024)
- ❖ Lodging Severity and Soil Salinity maps based on field campaigns, Sentinel 2, EnMap and PRISMA archives (2023 – 2024)
- ❖ New Framework for Integrating Hyperspectral Remote Sensing with Machine Learning, Active Learning, and Sentinel-2-Based Deep Learning to monitor multiple stressors

Project Duration : August 2023 – August 2025

Consortium:



Agriculture and
Agri-Food Canada



University of Natural Resources
and Life Sciences, Vienna

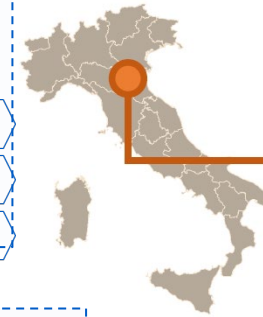
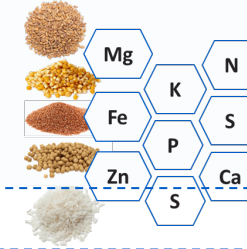


EO4Nutri - Earth Observation for estimating and predicting crop nutrients

Duration: April 2023 - September 2025

Overall goal: develop solutions that bring together the capabilities of various Earth Observation data through novel methods to estimate and predict the nutrient content of soil, crop canopy, and harvested crop

Website: <https://www.eo4nutri.nl> & <https://eo4nutri.wiki.utwente.nl>



Datasets:

Sites in **Jolanda di Savoia** and **Munich-North-Isar**

- PRISMA and EnMAP for 2023 and 2024
- Field measurements

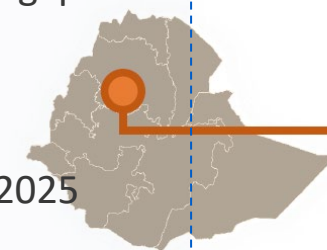
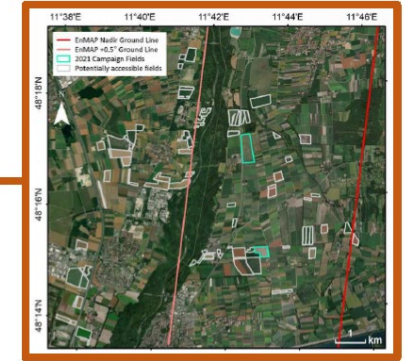
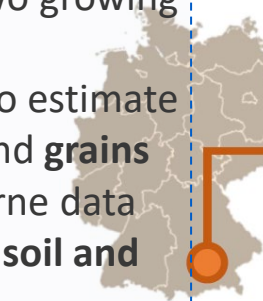
YEAR	CROPS	STAGE	MEASUREMENTS					
2023	WHEAT MAIZE RICE	SOW	X*	-	X*	-	-	X*
		VEG	X	X	-	X	-	X
		REP	X	X	-	X	-	X
		MAT	X	-	-	-	X	X
2024	WHEAT MAIZE RICE	SOW	X	-	X	-	-	X
		VEG	X	X	-	X	-	X
		REP	X	X	-	X	-	X
		MAT	X	-	-	-	X	X

*only for maize and rice

Ethiopia: crop nutrients collected by GeoNutrition project + Sentinel-2, Landsat, Modis products and other environment covariates (weather, soil etc.)

Results:

- Unique **field measurements** collected across two growing seasons (2023 and 2024)
- **Data-driven and hybrid models** implemented to estimate micro and macronutrients in **soil**, crop **plants** and **grains** using field spectra measurements and spaceborne data
- Maps showing the **spatial explicit variations of soil and crop nutrients**
- Workshop with **scientific community** and relevant **stakeholders** identify EO, methods and datasets gaps related to crop nutrients
- **Scientific outcomes:**
 - Four submissions to ESA Living Planet 2025
 - One accepted oral presentation to IGARSS 2025
 - Six scientific publications in preparations



Jolanda di Savoia, IT
Munich-North-Isar, DE
Amhara region, ETH

Crop yield forecasts are a key tool to ensure food security in a changing climate. However, often scarce input data complicates accurate crop yield forecasts.

YIPEEO aims to improve crop yield forecasts through the usage of high-resolution remote sensing data and cutting-edge deep learning techniques and tackling the issue of data scarcity.

Project
finished

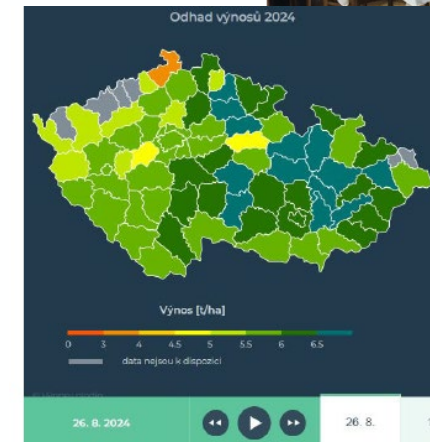
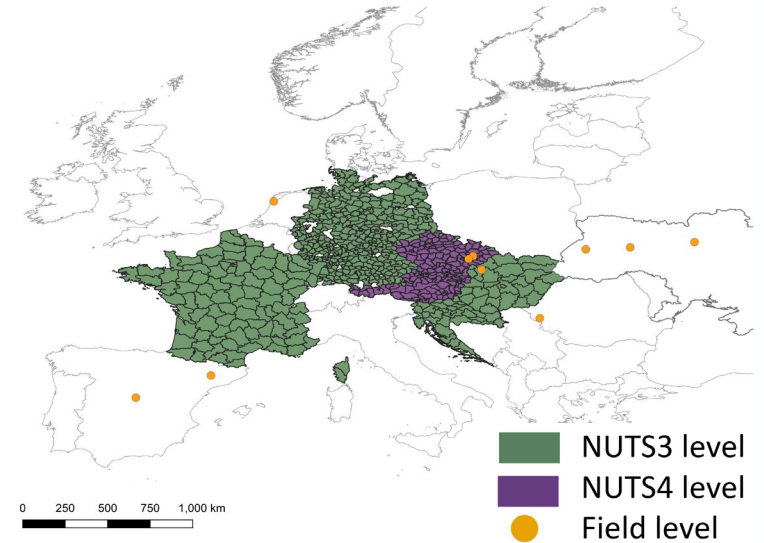


YIPEEO



Key results

- Collected much crop yield data (field and regional)
- Transfer learning for data-scarce field scale forecast
- Assessed impact of irrigation on crop yields in Spain
- Potential of soil moisture products for yield forecast
- Operational crop yield forecasts for Czechia
- Organised workshop with >100 farmers/stakeholders



Advanced Agricultural Monitoring with Copernicus Expansion Missions

Objectives:

- 1) Generate a representative dataset for the hyperspectral CHIME and the thermal LSTM mission
- 2) Develop and test advanced vegetation stress products using CHIME and LSTM

Use case: **sugar beet**

Status and results:

KO: 11/2024

Set up E2E workflow for dataset generation with SCOPE and RISE simulator

Started in-situ campaigns

Produced first test time series of L1C for one growing season

Ongoing implementation of innovative indices

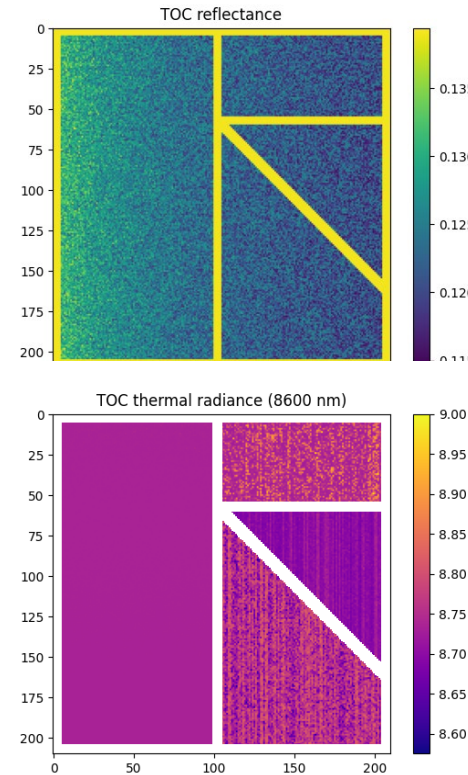


Figure 1: SCOPE top-of-canopy reflectance and radiance (4 km²)

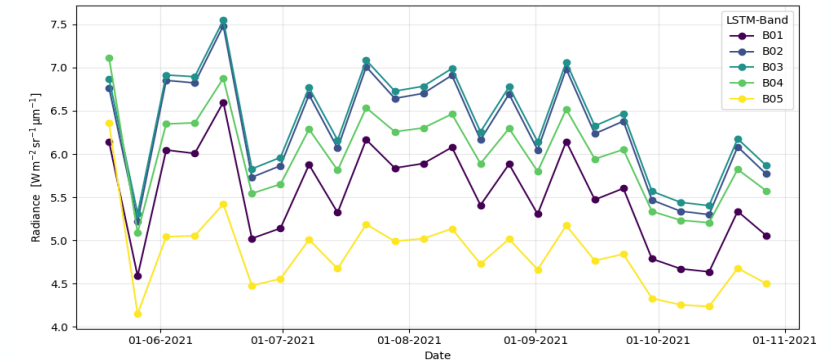


Figure 2: Average in-field LSTM L1C Band radiance over growing season

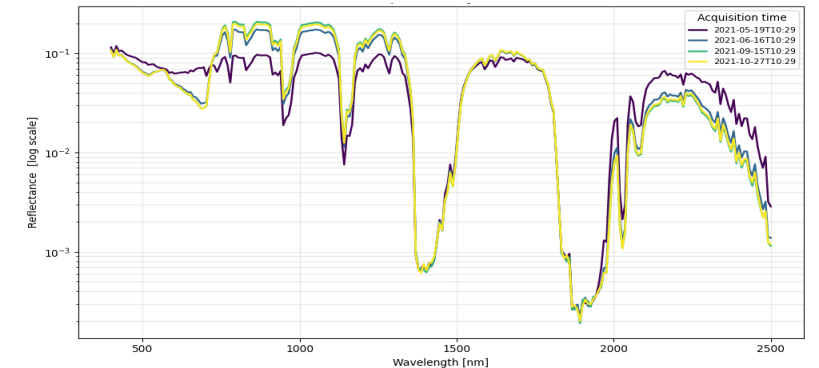
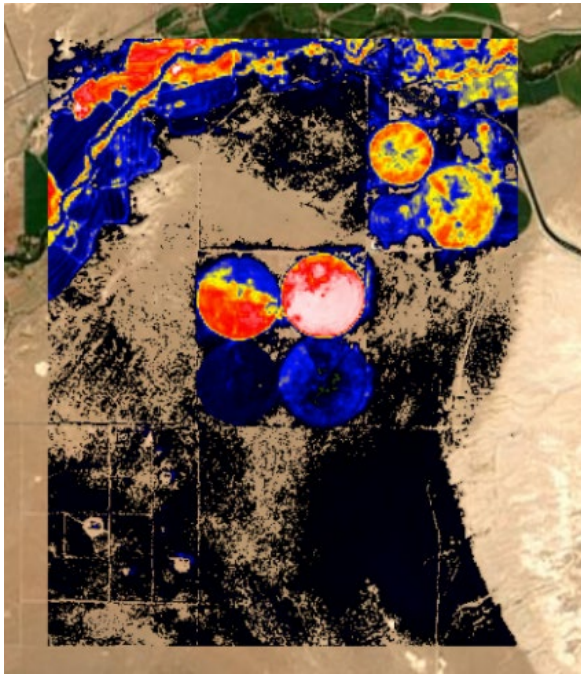


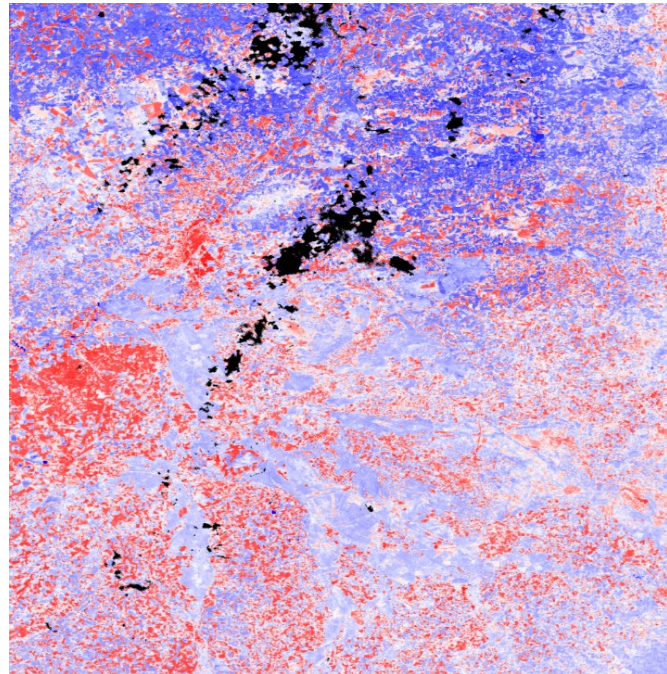
Figure 3: CHIME L1C TOA reflectance for different weeks of the season

SAVECROPS4EU | DTC DATA OUTPUTS EXAMPLES

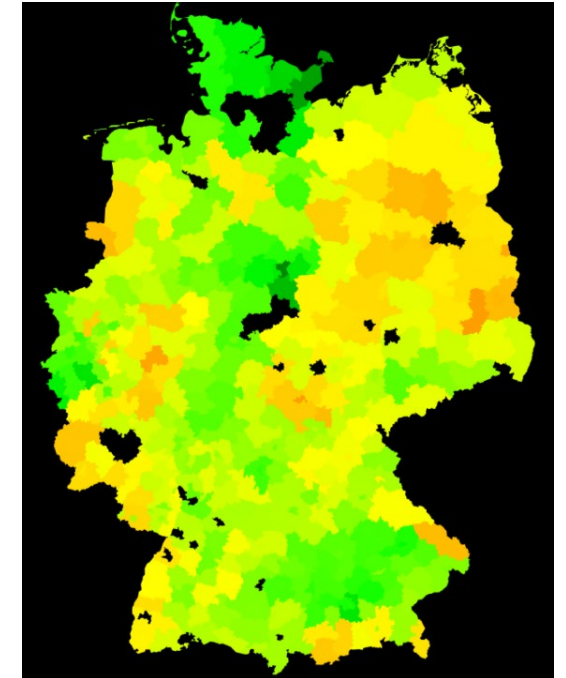
EO Enabled Canopy Nitrogen Content Monitoring Maps:



EO Enabled Crop Drought Stress Monitoring Maps using Evapotranspiration metrics:



In-season district Level Yield forecasting Maps using ML algorithms:



Field Scale scenario testing. For example, Yield optimization versus End-of Season (EoS) Nitrogen Soil Content

Under fertilization Scenario

Low Yield



Acceptable EoS
Soil Nitrogen

Over Fertilization Scenario

High Yield



Unacceptable EoS
Soil Nitrogen

Optimized Fertilization Scenario

High Yield



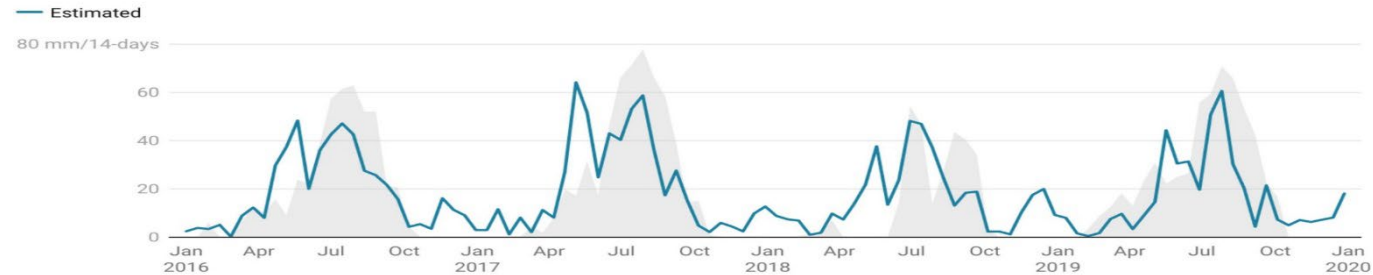
Acceptable EoS
Soil Nitrogen

How much water is used for irrigation?

Irrigation is the major water consumer (70%), but irrigation data are absent. Through Sentinel-1 first attempts to obtain irrigation water use from space have been carried out in the ESA **Irrigation+** project.

Irrigation amount

Estimated against observed amount in Algerri-Balaguer, Catalonia



<https://esairrigationplus.org/>



Cumulated irrigation amount
(May-September 2016)

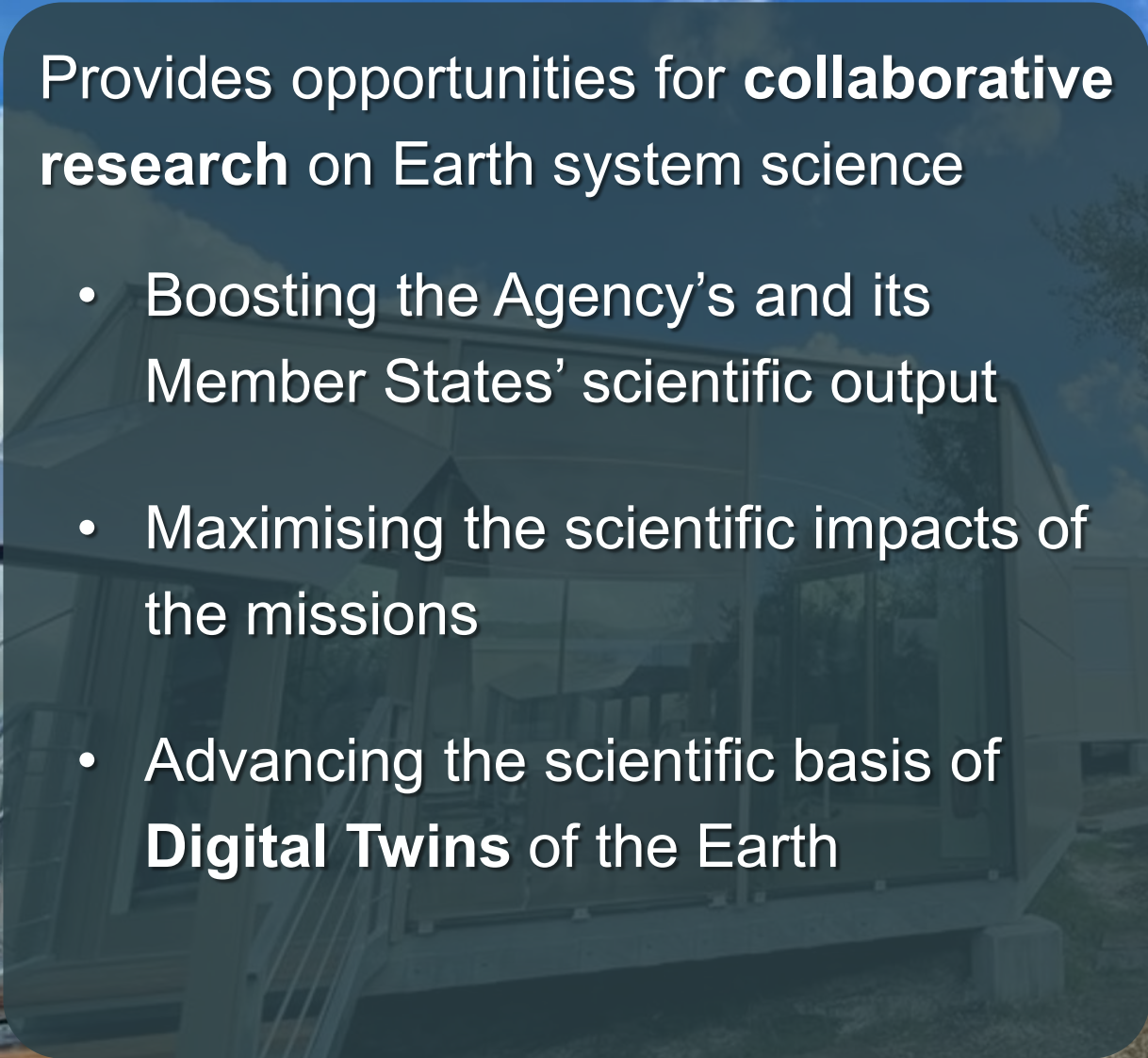


- Gathered the community: 300 attendees in person from 40 different countries + more than 500 joining online
- A comprehensive overview and discussion of the current state of the art : 10 technical sessions featuring 60 presentations selected from 175 abstracts by a scientific committee of 43 experts
- Two poster sessions complemented the technical sessions, presenting over 100 posters and offering young scientists an opportunity to network
- Six panels with scientists, policy makers, policy owners and user organizations addressed specific issues, e.g. transition from R&D to operations and integrating in-situ and EO data
- A dedicated session highlighted 20 EC and ESA projects and pre-kicked off the ESA Agriculture Science Cluster
- Participants proposed recommendations to ESA & EC regarding future R&D activities

EO for Agriculture Under Pressure

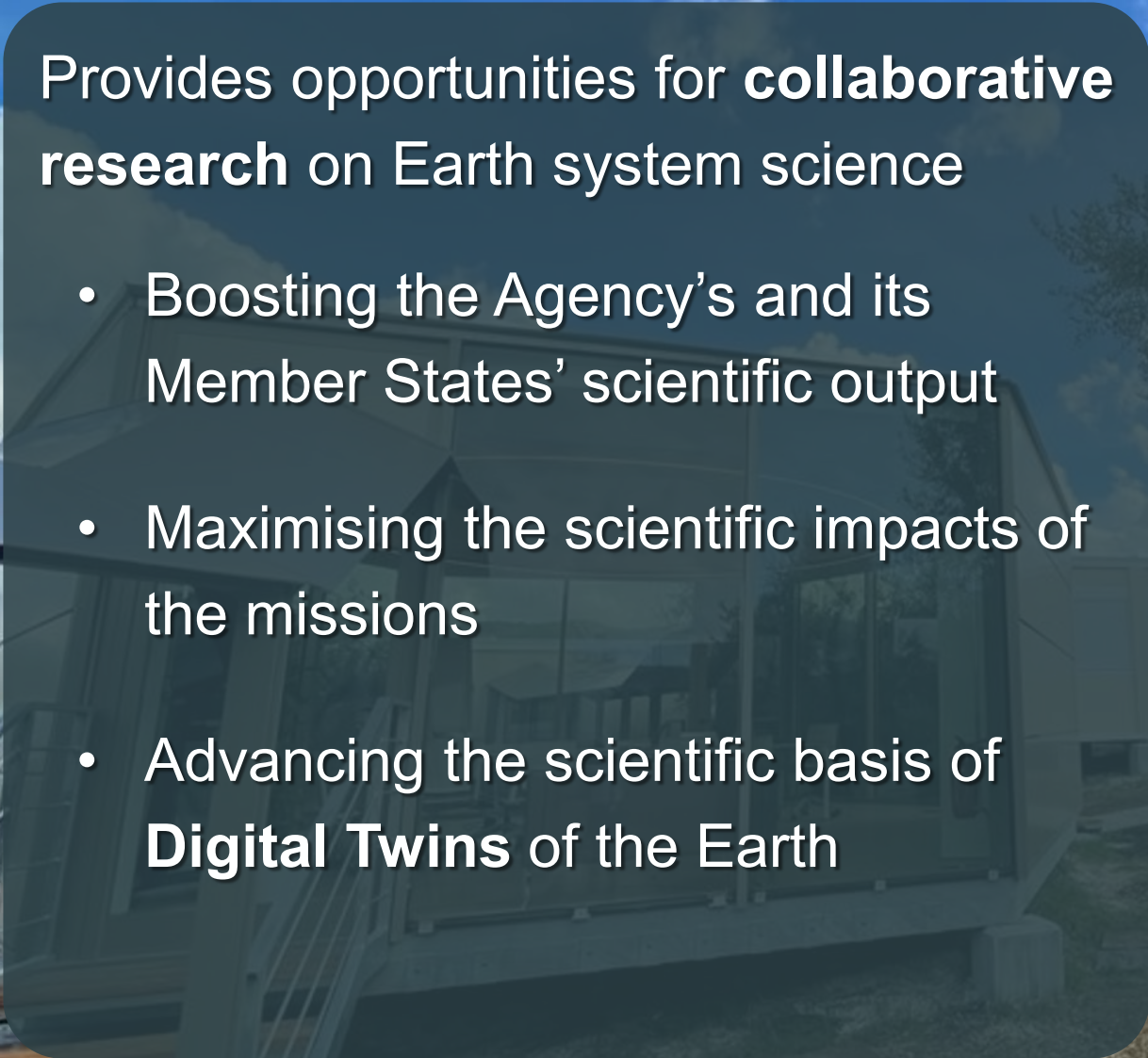
Workshop 2024

13–16 May 2024 | ESA–ESRIN | Frascati (Rome), Italy



Provides opportunities for **collaborative research** on Earth system science

- Boosting the Agency's and its Member States' scientific output
- Maximising the scientific impacts of the missions
- Advancing the scientific basis of **Digital Twins** of the Earth

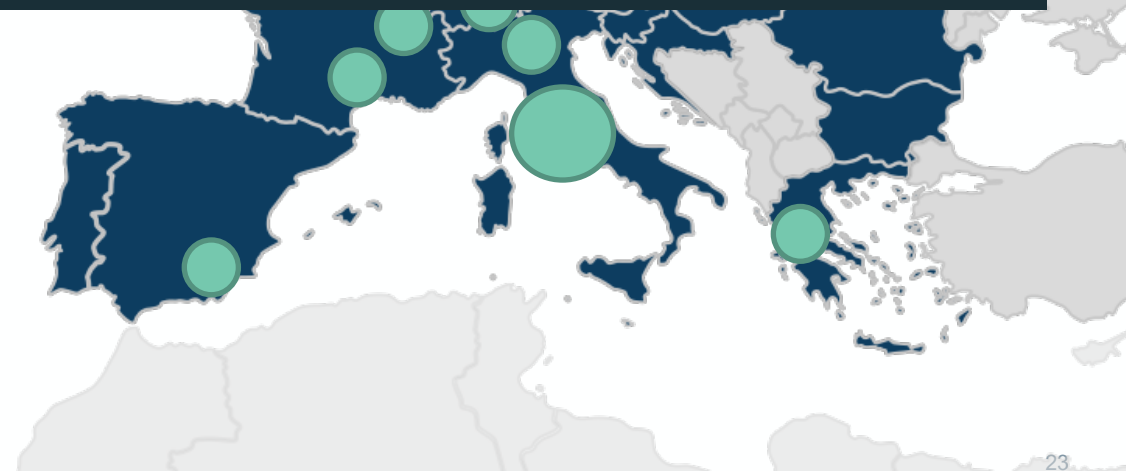
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- Provides opportunities for **collaborative research** on Earth system science
- Boosting the Agency's and its Member States' scientific output
 - Maximising the scientific impacts of the missions
 - Advancing the scientific basis of **Digital Twins** of the Earth



Living Planet Fellowship - Opportunities



*"to support young scientists, at **post-doctoral level**, to undertake cutting-edge research in **Earth Observation and Earth System Science**, maximising the scientific return of ESA and European EO missions"*



14th edition of Land Training Course



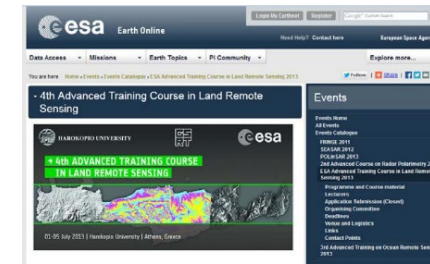
Lisbon 2007



Prague 2009



Krakow 2011



Athens 2013



Valencia 2014



Bucharest 2015



Gödöllő 2017



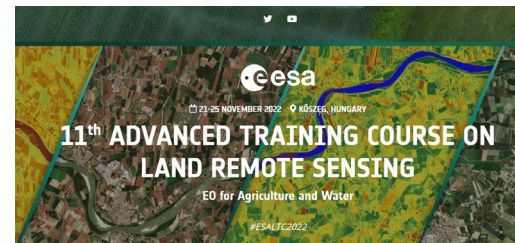
Leicester 2018



Louvain 2019



Ljubljana 2021



Kőszeg 2022



Wroclaw 2023



Innsbruck 2024



ESA 13th ADVANCED TRAINING COURSE ON LAND REMOTE SENSING: Agriculture

Espen Volden
Magdalena Fitrzyk

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- Training the **next generation of scientists and professionals** on remote sensing for agriculture
 - Explaining the **theoretical principles, processing algorithms, data products** and their **use**
 - Introducing **tools & methods** for the exploitation of EO satellite data, in particular Sentinels
 - Stimulating and supporting the use of EO data for **science and operational applications related agriculture**
- Facilitating **networking**

Organising Committee

European Space Agency (ESA)

Espen Volden

Magdalena Fitrzyk

Irene Renis

Aristotle University of Thessaloniki

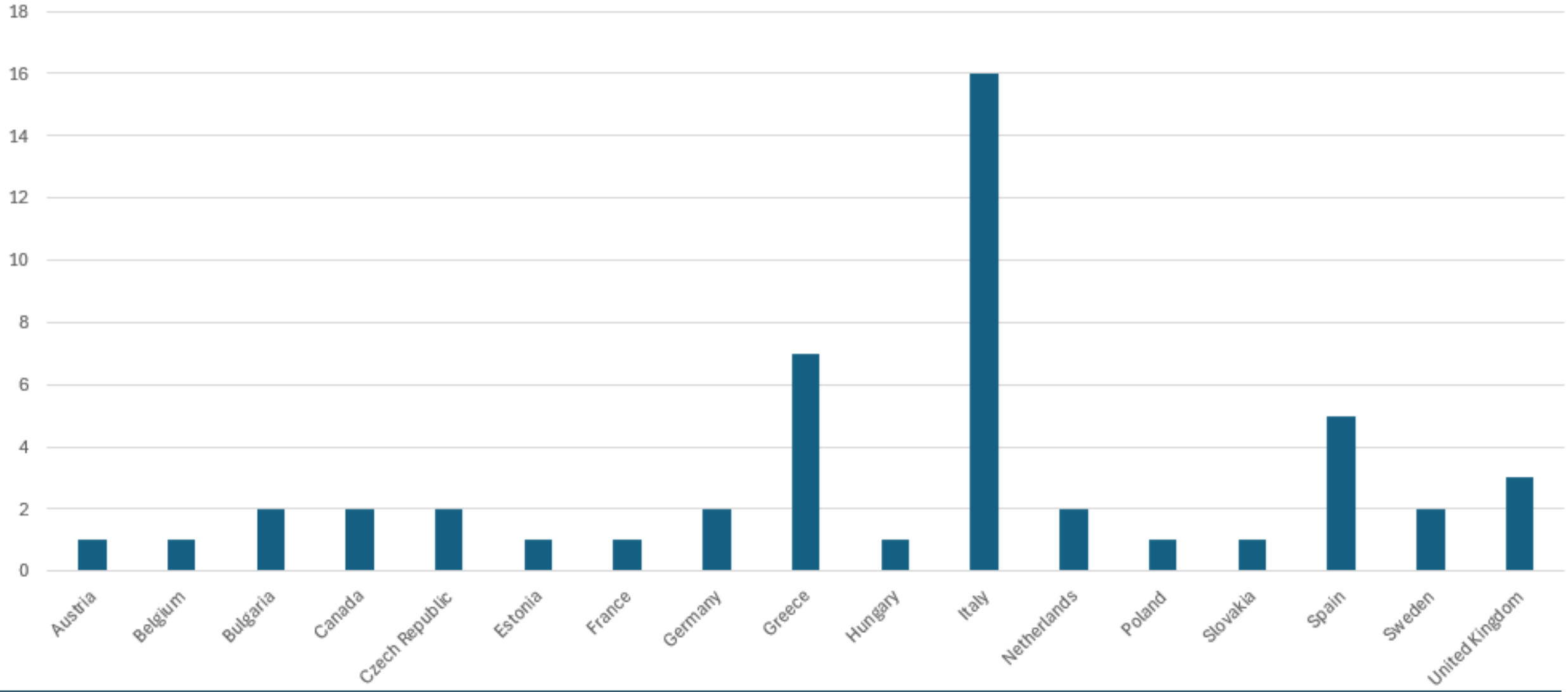


CIRI-AUTH Center for Interdisciplinary Research and Innovation

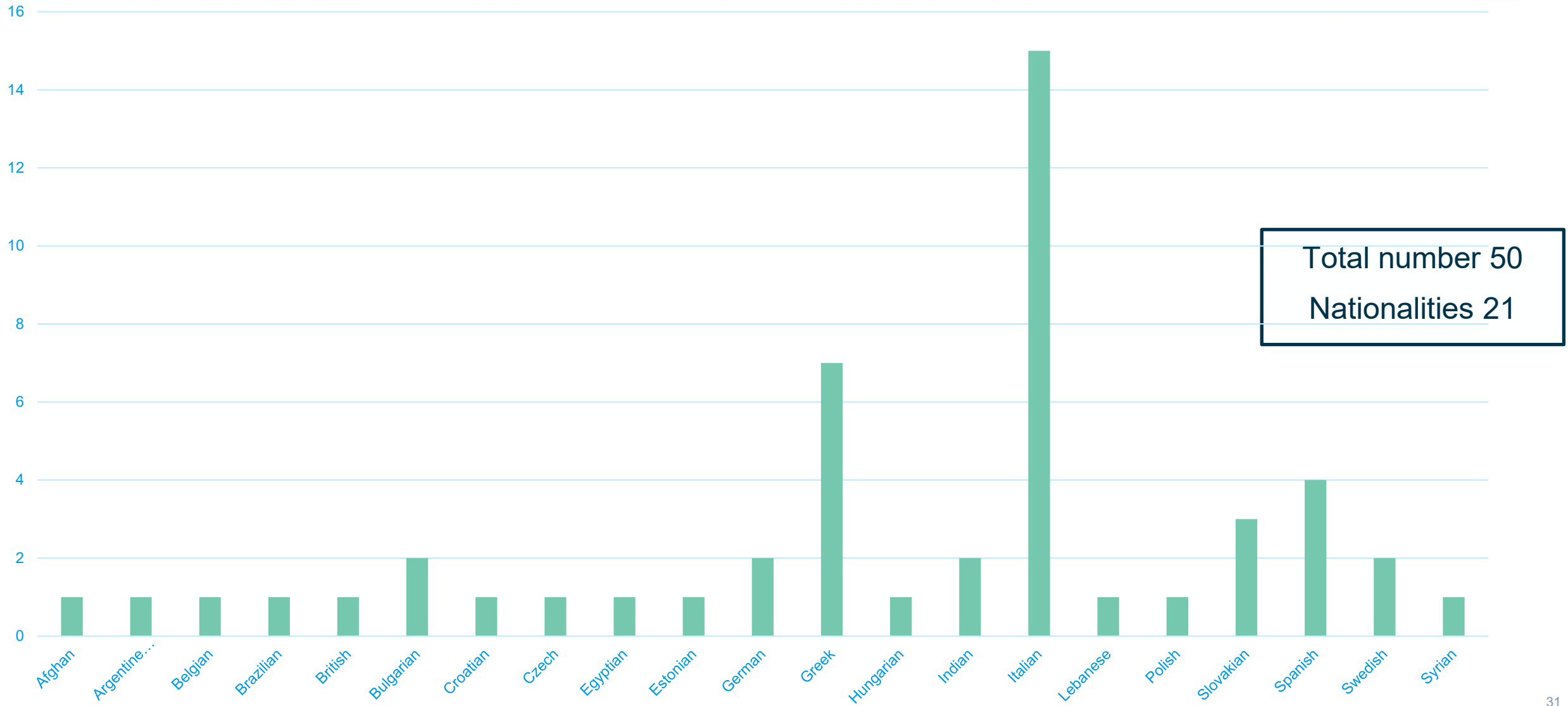


Prof. Antonios Mouratidis

Participants by country of affiliation



Participants by nationality



Programme

Morning : lectures

Afternoon : practicals

Social events:

- Ice-breaker
- Lightening talks
- Field trip and dinner

Monday 29/09	Tuesday 30/09	Wednesday 01/10	Thursday 02/10	Friday 03/10
08:00 Registration NOESIS				
09:00 Welcome speech NOESIS				
09:05 Introduction to the course and to ESA activities for agriculture Espen Volden (ESA) NOESIS				
09:25 Training course logistics Antonios Mouratidis (Univ. of Thessaloniki) NOESIS				
09:30 Earth Observation in Greece: The Greek National Satellite Space Project Christina Karakizi (Hellenic Space Center) NOESIS				
09:50 Group Photo and Coffee Break				
10:20 Status of current and future Copernicus Sentinels and ESA Earth Explorers ESA Mission Managers/Scientists NOESIS				
11:10 Data Access: Copernicus Data Space Ecosystem & Third Party Missions M. Fitzryk (RSAC c/o ESA) NOESIS				
11:30 Introduction to EO for Agriculture Jadu Dash (Univ. Southampton) NOESIS				
12:30 Lunch Break				
14:00 Optical pre-processing and hyperspectral analysis Marco Celesti (ESA) NOESIS				
15:00 Coffee Break				
15:30 SAR pre-processing, POLINSAR and agricultural monitoring Elise Colin (ONERA) NOESIS				
17:00 SNAP M. Fitzryk (RSAC c/o ESA) NOESIS				
18:30 Hosted welcome event (Ice-breaker) BUILDING A				
	09:00 Monitoring abiotic and biotic stressors Jadu Dash (Univ. Southampton) NOESIS	09:00 In-situ data sampling, accuracy assessment and phenology monitoring Gohar Ghazaryan (ZALF) NOESIS	09:00 Temperature and evapotranspiration Tian Hu (LIST) NOESIS	09:00 Yield prediction and water productivity Egor Prikazluk (UT-ITC) NOESIS
	10:30 Coffee Break	10:30 Coffee Break	10:30 Coffee Break	10:30 Coffee Break
	11:00 Biophysical variables monitoring Jochem Verrelst (Univ. Valencia) NOESIS	11:00 Crop type mapping Kristof van Tricht (VITO) NOESIS	11:00 Drought monitoring and yield prediction Piet Emanuel Büechi (TU Wien) NOESIS	11:00 Nutrients and carbon monitoring Mariana Belgio (UT-ITC) NOESIS
	12:30 Lunch Break	12:30 Lunch Break	12:30 Lunch Break	12:30 Lunch Break
	14:00 Monitoring abiotic and biotic stressors Jadu Dash (Univ. Southampton) BUILDING A	14:00 Phenology monitoring Gohar Ghazaryan (ZALF) BUILDING A	14:00 Temperature and evapotranspiration Tian Hu (LIST) BUILDING A	14:00 Yield prediction and water productivity Egor Prikazluk (UT-ITC) BUILDING A
	15:30 Coffee Break	15:30 Coffee Break	15:30 Coffee Break	15:30 Coffee Break
	16:00 Biophysical variables monitoring Jochem Verrelst (Univ. Valencia) BUILDING A	15:45 Crop type mapping Kristof van Tricht (VITO) BUILDING A	16:00 Drought monitoring and yield prediction Piet Emanuel Büechi (TUWien) BUILDING A	16:00 Nutrients and carbon monitoring Mariana Belgio (UT-ITC) BUILDING A
	17:30 Monitoring abiotic and biotic stressors Jadu Dash (Univ. Southampton) BUILDING B	17:15 Phenology monitoring Gohar Ghazaryan (ZALF) BUILDING B	16:00 Temperature and evapotranspiration Tian Hu (LIST) BUILDING B	16:00 Yield prediction and water productivity Egor Prikazluk (UT-ITC) BUILDING B
	17:30 Lightening talks BUILDING A	17:30 Field trip	17:30 Closing ceremony BUILDING A	
		19:30 Social Dinner		

Introductory lecture @ NOESIS
Lecture @ NOESIS
Exercise @ ROOM A
Exercise @ ROOM B
Social event

Certificate of Attendance

To get a certificate, attendance is mandatory for all lectures and practical classes

Attendance lists will be in circulation during the week

Certificates will be awarded during the closing ceremony on Friday

Online Course Evaluation

To provide feedback to improve for future courses

10 minutes to complete

The questionnaire is anonymous

Link to website will be provided by email (by the end of the course)

Course material will be made available on eo4society.esa.int

ECTS points – please let us know if you need it!

Thank you

FUTURE EO



<https://eo4society.esa.int>
https://twitter.com/EO_OPEN_SCIENCE