

Welcome to the 10th TAT Course on Earth Observation, 2023

Jointly organised by ESA, NASA, Charles University

27 June -1 July 2023, Prague & Brno

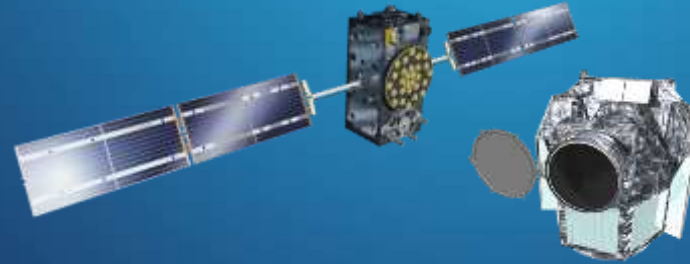
F. Sarti, ESA Earth Observation Programme Data Applications EOP-SD

Day1 (Prague)	Day2 (Prague)	day3	Day4 (Brno)	Day5 (Brno)
<p>ESA EO introduction</p> <p>Machine learning and EO (ESA Phi-Lab)</p>	<p>(Follows) SAR for Land Cover, Practical (Uni Thessaloniki).</p> <p>SAR Polarimetry, Theory and Practice (Uni Stirling)</p> <p>Optical and SAR RS for Forestry, with Machine learning. Theory and practice (Charles University)</p>	<p>Field trip to Brno, with two stops</p>	<p>NASA EO introduction</p> <p>Land Cover from space, Theory and Practice (Masaryk university)</p> <p>Hydrology applications of RS, Theory and Practice (Grand Valley State uni)</p>	<p>RS applications to Agriculture Land Cover mapping with Machine Learning (uni of Maryland)</p> <p>Hyperspectral RS for Environmental studies (NASA and uni Maryland)</p>
<p>SAR for Soil Moisture (Uni Vienna)</p> <p>SAR for Land Cover, Theory and Practice (Uni Thessaloniki)</p> <p>SAR Polarimetry intro (Uni Stirling)</p>				<p>Closing ceremony & feedback collection</p>
<p>Ice-breaker</p>	<p>Almost 40 participants from many different countries</p> <p>The course includes Theory & Practice (different tools, including machine learning, as from 2022 TAT feedback)</p>			

What is the European Space Agency, ESA



Make Space
for Europe



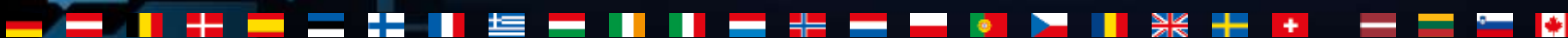
Pushing the limits of
what is possible in
space since 1975



5 500+
ESA Workforce

22 Member States
(+ associated and
cooperating states)

2023-2025 Budget
16.9 billions €



EUROPE'S GATEWAY TO SPACE

WHAT

22 Member States, 5000 employees

WHY

Exploration and use of space for exclusively peaceful purposes

WHERE

HQ in Paris, 7 sites across Europe and a spaceport in French Guiana

HOW MUCH

€16.9 billions for 2023-2025



ESA Activities and Achievements



All of this is possible thanks to the collaboration of Member States

ESA is active across every area of the space sector

World leader in science and technology

Over 80 satellites developed, tested, and operated since 1975

More than 220 launches from Europe's Spaceport in Kourou



ESA Membership



22 Member States

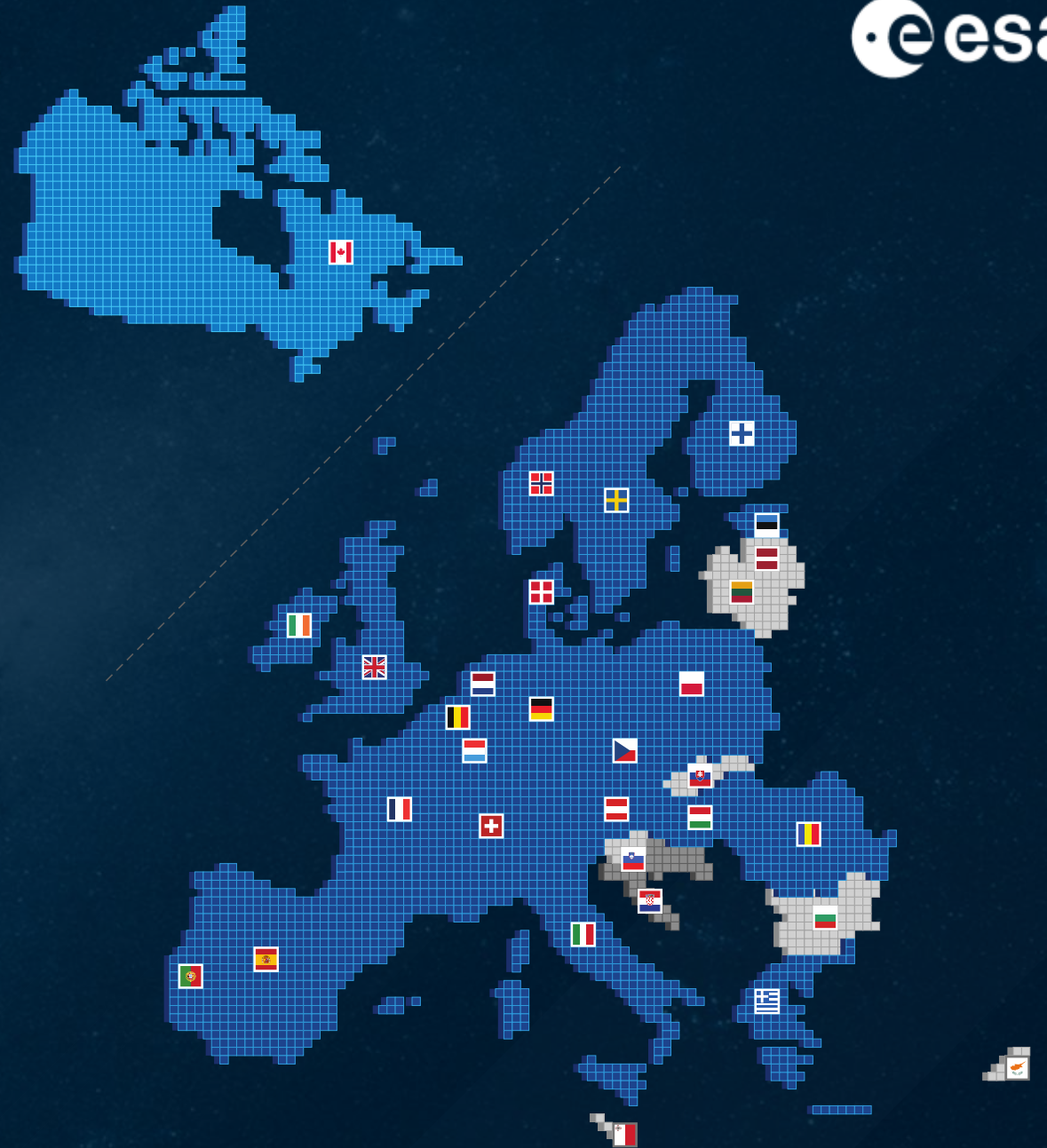
Austria	Italy
Belgium	Luxembourg
Czech Republic	Netherlands
Denmark	Norway
Estonia	Poland
Finland	Portugal
France	Romania
Germany	Spain
Greece	Sweden
Hungary	Switzerland
Ireland	United Kingdom

4 Associate Members

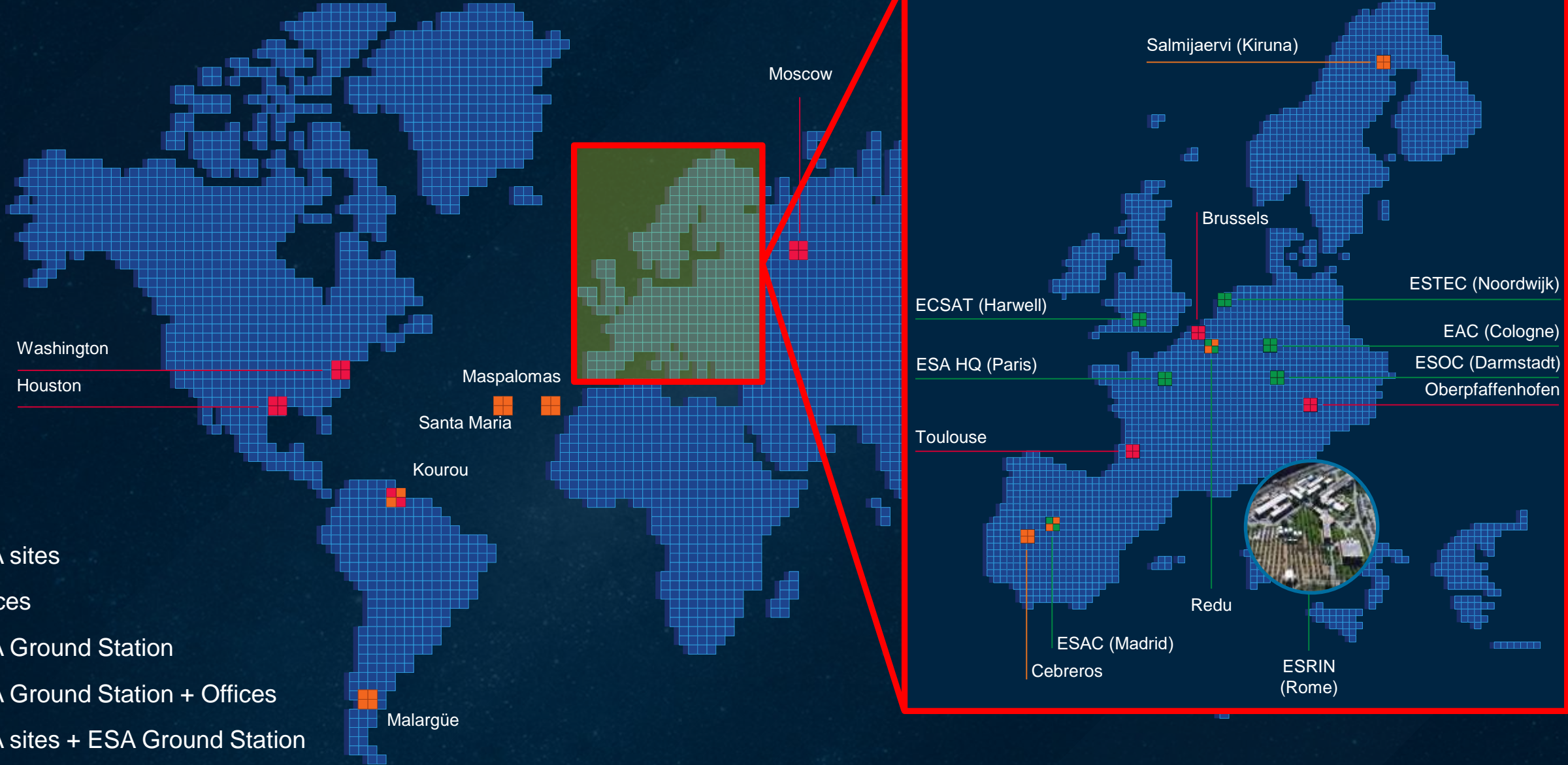
Slovenia, Slovakia, Latvia, Lithuania

Cooperation Agreements

4 other European States (Bulgaria, Croatia, Cyprus and Malta) + Canada



ESA Locations



ESRIN does much more than Earth Observation



- Earth Observation
- Space transportation
- NEO Coordination Centre
- Disaster Charter Coordination Centre
- Corporate IT
- Communication
- Archives
- ESA Security Office
- Contracts, Personnel
- Site Management

850+ personnel
on site (pre-Covid)

50.000 visitors
per year (pre-Covid)



ESRIN – ESA's EO and European Small Launcher Programmes



Copernicus – Largest Global EO Provider



- Over 427.178 registered users
- 25 terabyte new EO data per day
- 365.23 PB of download volume

[Status 13 July 2021]

Earth Explorers



Groundbreaking Earth Science satellite missions

International Charter Space & Major Disasters



ESRIN hosts a 24-hour call operator to deal with requests for assistance from civil protection authorities

Home to ESA Φ -lab



Accelerate the future of EO

ESRIN hosts the VEGA European small Launcher Project Team



ESA Directorate of EOP



A large, semi-transparent image of the Earth as seen from space, showing clouds and continents, centered behind the main title.

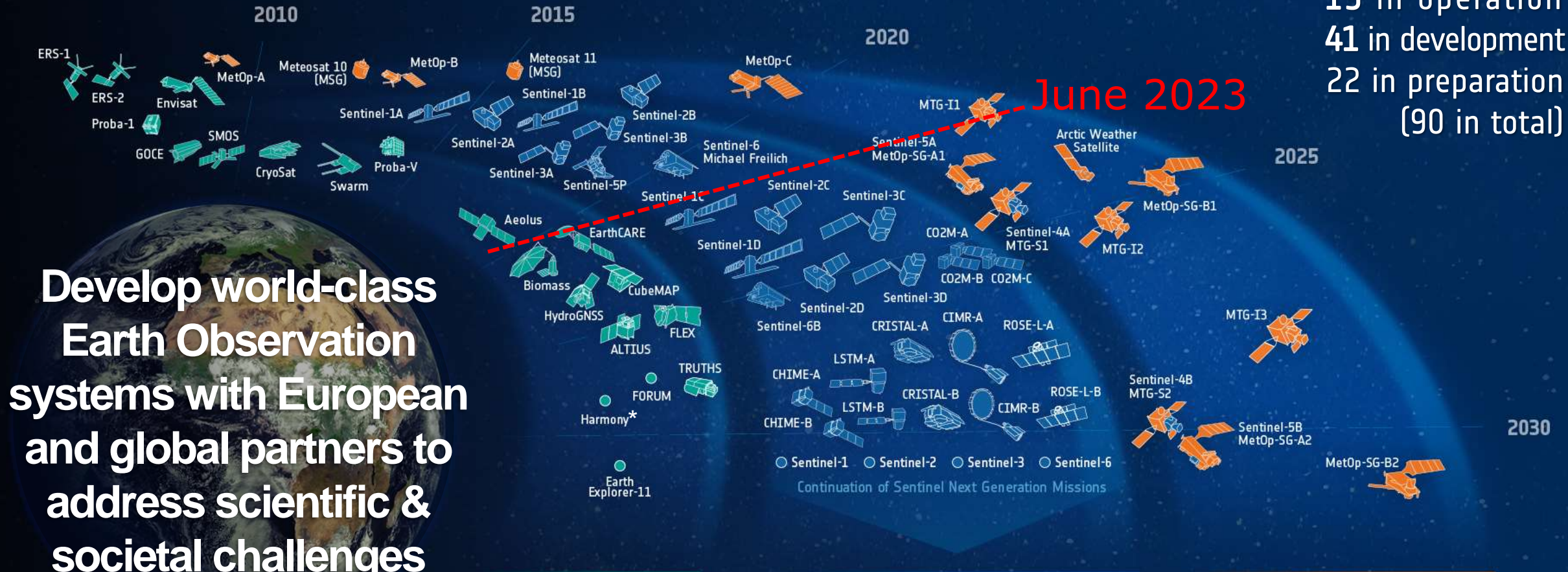
ESA's Earth Observation Vision

Taking the Pulse of our Planet

ESA's Earth Observation Mission

Satellites

12 in heritage
 15 in operation
 41 in development
 22 in preparation
 (90 in total)



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

Science Copernicus Meteorology

*Pending final mission selection



> 425.000

registered users
= tip of the iceberg



Land



Atmosphere



Ocean



Climate



Disaster



Security

6 operational services



250 TB satellite data
distributed per day



full, free & open
data policy

8 Copernicus Sentinels flying

S1



S2



S3



S4



S5P



S5



S6



preparing Copernicus 4.0

ESA and Copernicus EO Data access



On top of **Copernicus data** (free and open) via the Copernicus data hubs (and others), you can access freely also:

- **ESA EO Data** (Earth Explorers, ERS and ENVISAT archives, ...)
- **ESA Third Party Mission (TPM) Data** (<https://earth.esa.int/eogateway/missions/third-party-missions>), including some Polarimetric SAR data: ALOS-1 PalSAR, Radarsat-2 and airborne campaigns.

Since 2023, ESA and CONAE make available polarimetric data of the **L-band SAOCOM mission via a series of AO's (PUMAS initiative)**

<https://earth.esa.int/eogateway/activities/pumas-initiative>



S1B end of mission (failure on 23 Dec 2021) and next S1C replacement

Sentinel-1B experienced an anomaly related to the instrument electronics power supply (impossibility to deliver radar data).

Launch of Sentinel-1C targeted end of 2023 (new Vega-C launcher)

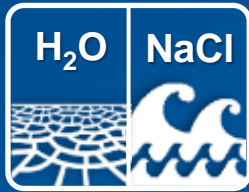


Flying Missions

GOCE
2009-2013



SMOS
2009



Cryosat
2010



Swarm
2013



Aeolus
2018



Science & Innovation



1.200+
Active Users

Future Missions

EarthCARE
2024



Biomass
Q1-2025



FLEX
2025



FORUM
2027



Harmony*
2029



400+ Publ.
per Year

High Risks for Great Rewards

*Pending final mission selection¹⁷

Earth Explorers Putting together the puzzle Earth Since 2009



EE-1

EE-2

EE-3

EE-4

EE-5

EE-6

EE-7

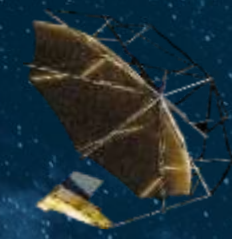
EE-8

EE-9



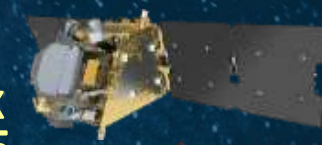
Clouds,
aerosol &
radiation

Earthcare
2024



Forest
mission

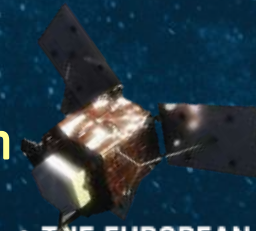
Biomass
Q1-2025



Flex
2025

Photosyn-
thesis

Forum
2027



Thermal
radiation

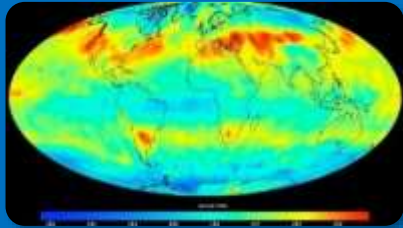
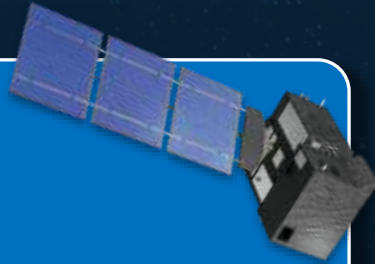
Geoid
Ocean Salinity & Soil Moisture
Thickness of ice
Magnetic Field
Wind mission



Sentinel Expansion Missions

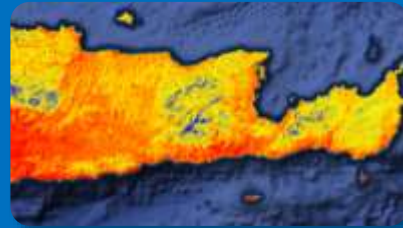


CO2M - Anthropogenic CO₂ Monitoring



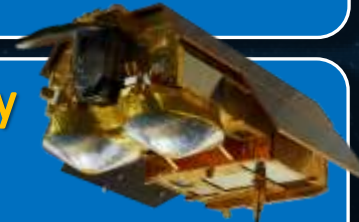
Causes of Climate Change

LST - Land Surface Temperature Mission



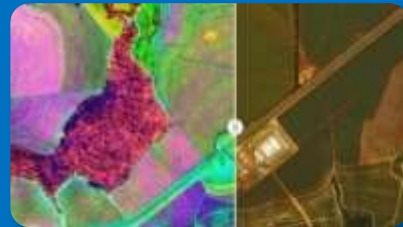
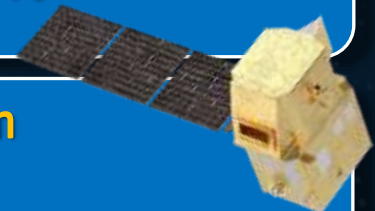
Agriculture & Urban Management

CRISTAL - Polar Ice & Snow Topography



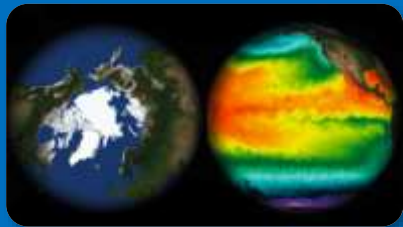
Effects of Climate Change

CHIME - Hyperspectral Imaging Mission



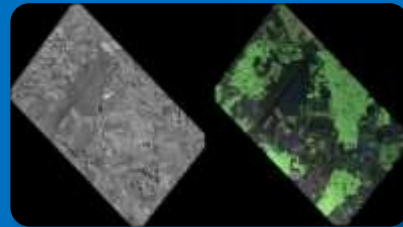
Food Security, Soil, Minerals, Biodiversity

CIMR - Passive Microwave Radiometer



Sea: Surface Temp. & Ice Concentration

ROSE-L - L-band SAR Mission



Vegetation & Ground Motion & Moisture





Scientific Advances & Impact

Building on Europe's EO ecosystem to address societal needs and global challenges;

ESA LPS 2022 Bonn May 2022

https://www.esa.int/ESA_Multimedia/Videos/2022/05/Living_Planet_Symposium_opens_LPS_2022

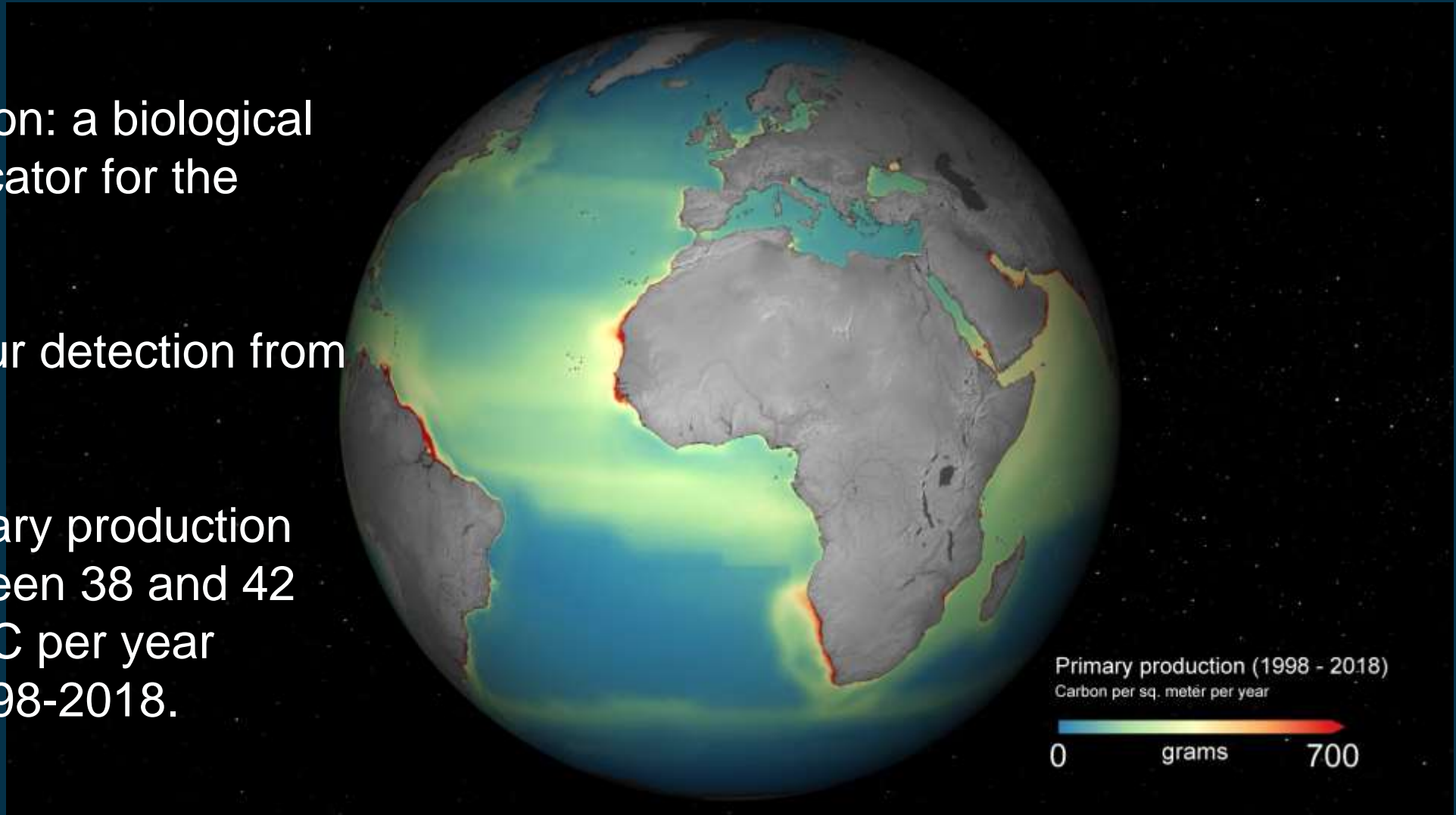
SAR: ESA PolinSAR/Biomass 2023 (last week, Toulouse)
ESA Fringe 2023 (11-15 Sept, Leeds)

TRACKING THE OCEAN'S LIVING CARBON PUMP

Phytoplankton: a biological climate indicator for the oceans.

Ocean colour detection from space

Global primary production varied between 38 and 42 gigatonnes C per year between 1998-2018.



CRYOSAT measures changes of Antarctica Ice Sheets



CRYOSAT Swath Altimetry to monitor World Glaciers



Glaciers provide crucial energy resources and are a major component of the world's land ice cover.

Glacier ice loss can now be measured frequently and in detail from space using satellite radar altimetry



Climate: Sentinels add to 3 decades of ice sheet & sea level data

11 satellites including ESA's ERS-1, ERS-2, Envisat and CryoSat, S-1 and S-2

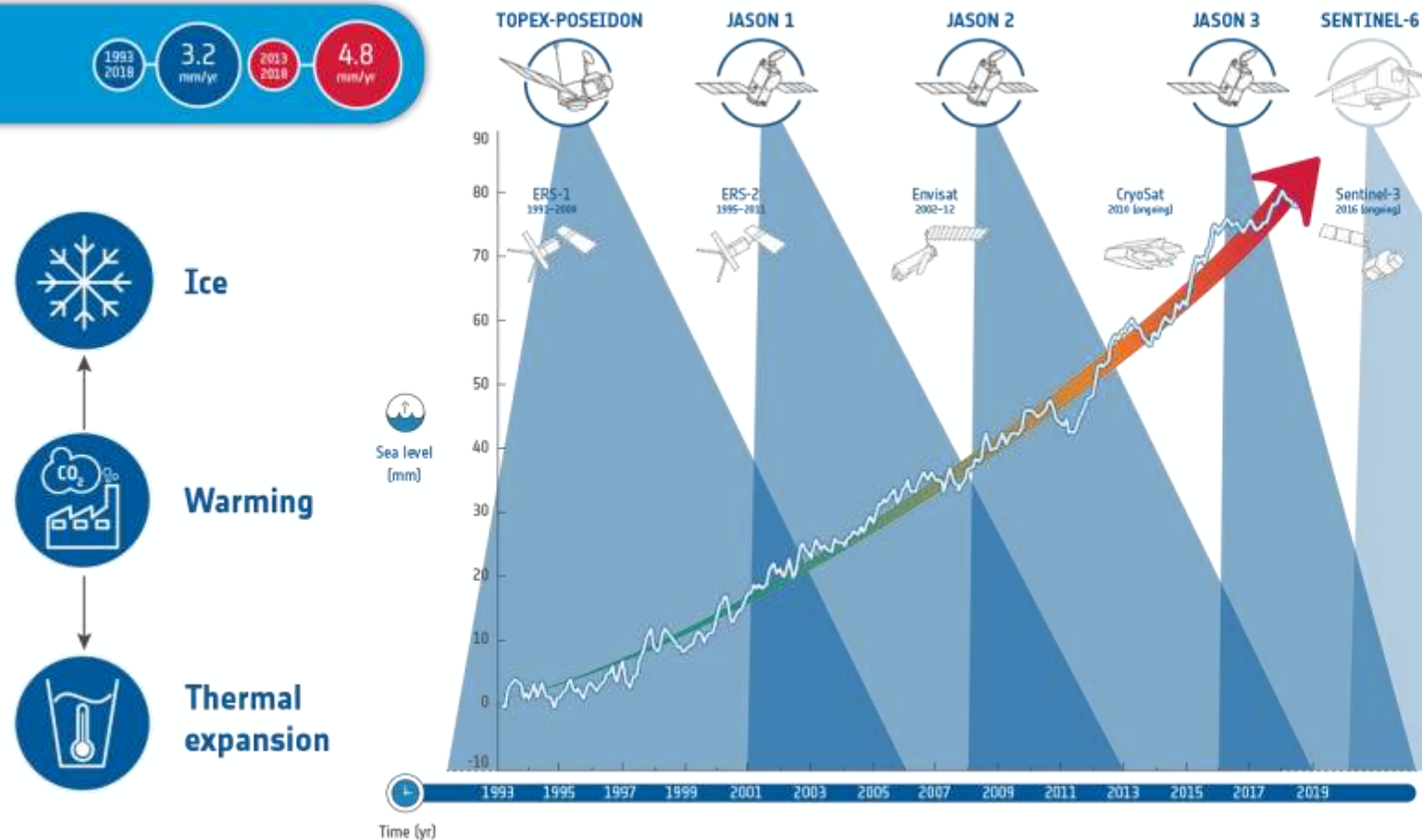


Greenland and Antarctica are losing ice six times faster than in the 1990s.

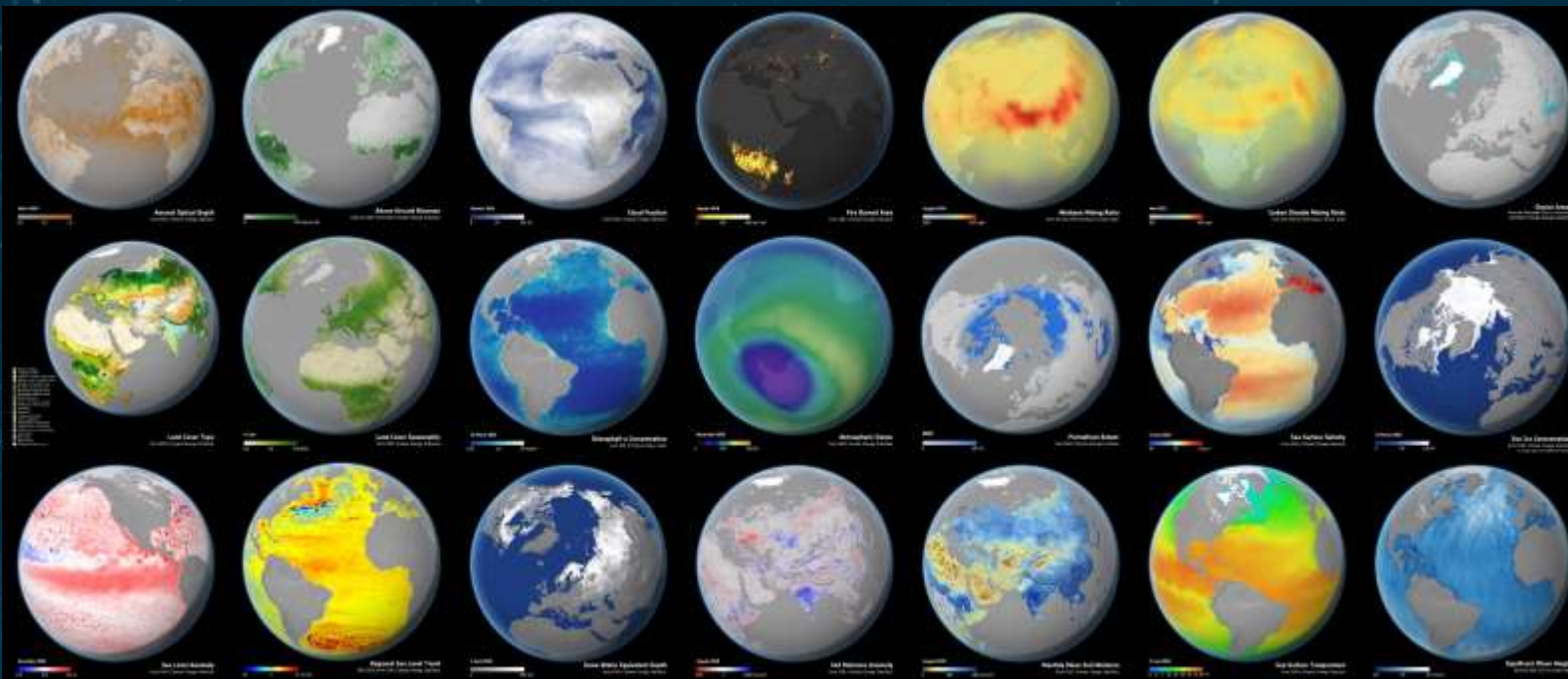
Polar ice sheets are now responsible for a third of all sea level rise.

Losses are on track with the IPCC's worst-case climate warming scenario.

OBSERVING SEA LEVEL FROM SPACE

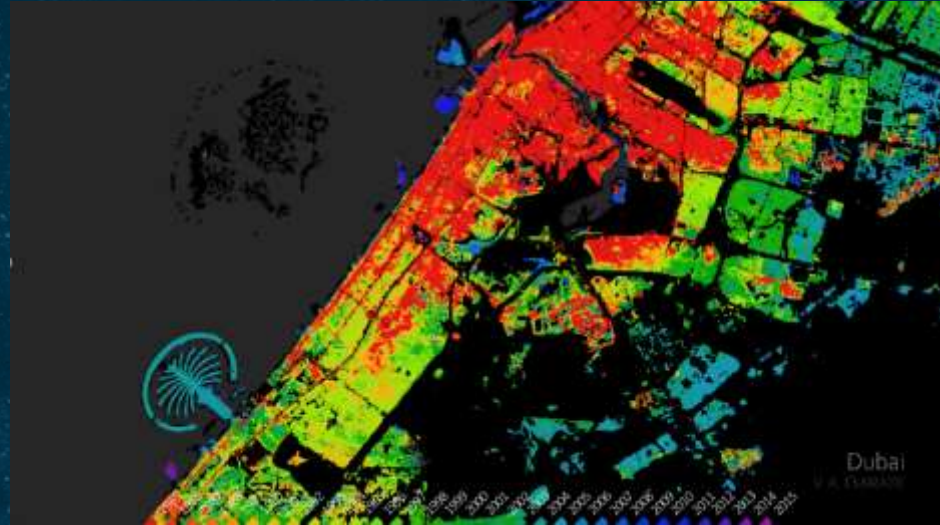


- Rate of sea level rise is accelerating (towards 4.5 mm/year)
- Sea level rise is not uniform
- ESA generating long term observation record
- Copernicus Sentinel-6, extending record
- Current area of focus on coastal sea level



Climate Change Initiative

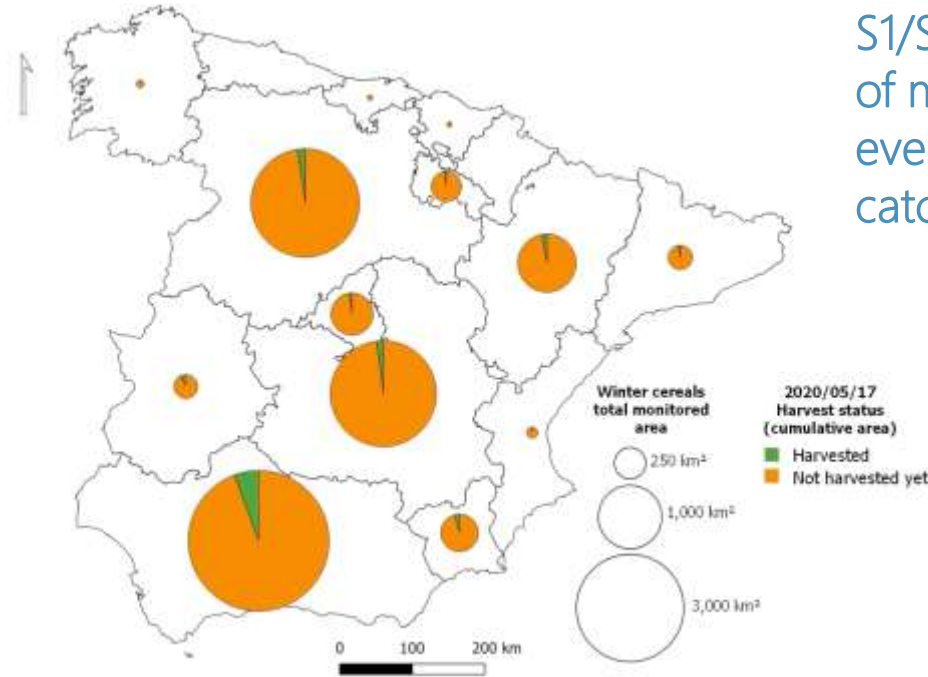
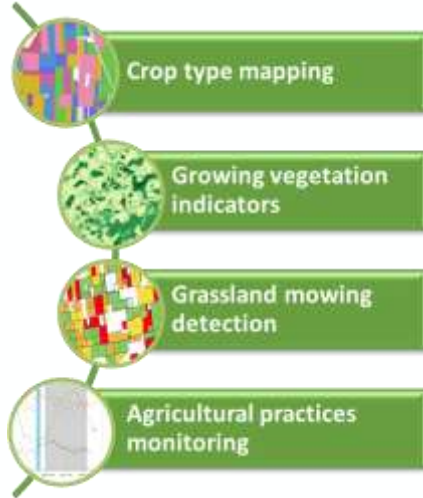
The ESA CCI develops robust, global long term satellite datasets for 21 Essential Climate Variables as defined by the Global Climate Observing System.



Earth Science for Society – Applications

*Extending Europe’s World-leading EO expertise and competitive advantage
Support international responses to global societal challenges*

Enabling Agriculture monitoring and policies



S1/S2 Detection of mowing events, harvest & catch crops

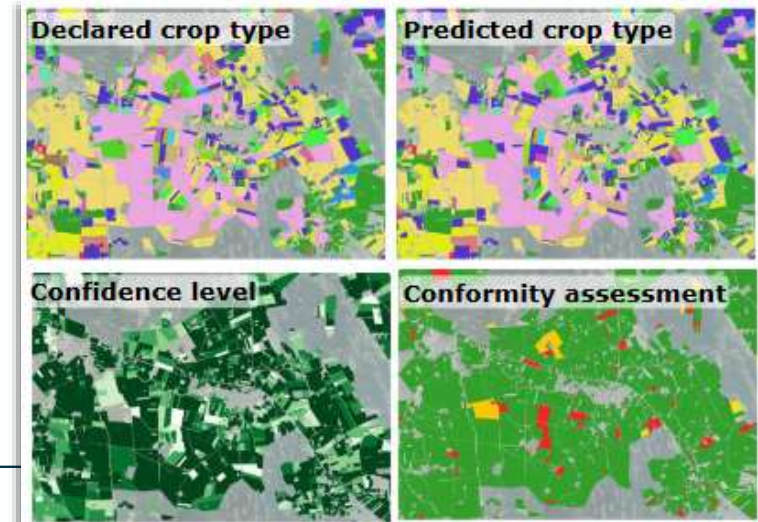
Involved stakeholders

Sen4CAP > 20 Paying Agencies are early adopters and integrating these EO-based solutions for monitoring.
Sen4Stat four National Statistical Offices involved as early adopters.

International stakeholders are collaborating:



Accuracy:
80% (crop type) &
88% crop group



Worldwide Land Cover Mapping at 10m



WorldCover

→ a freely accessible global land cover product at 10 m resolution for 2020, based on Sentinel-1 and Sentinel-2 data

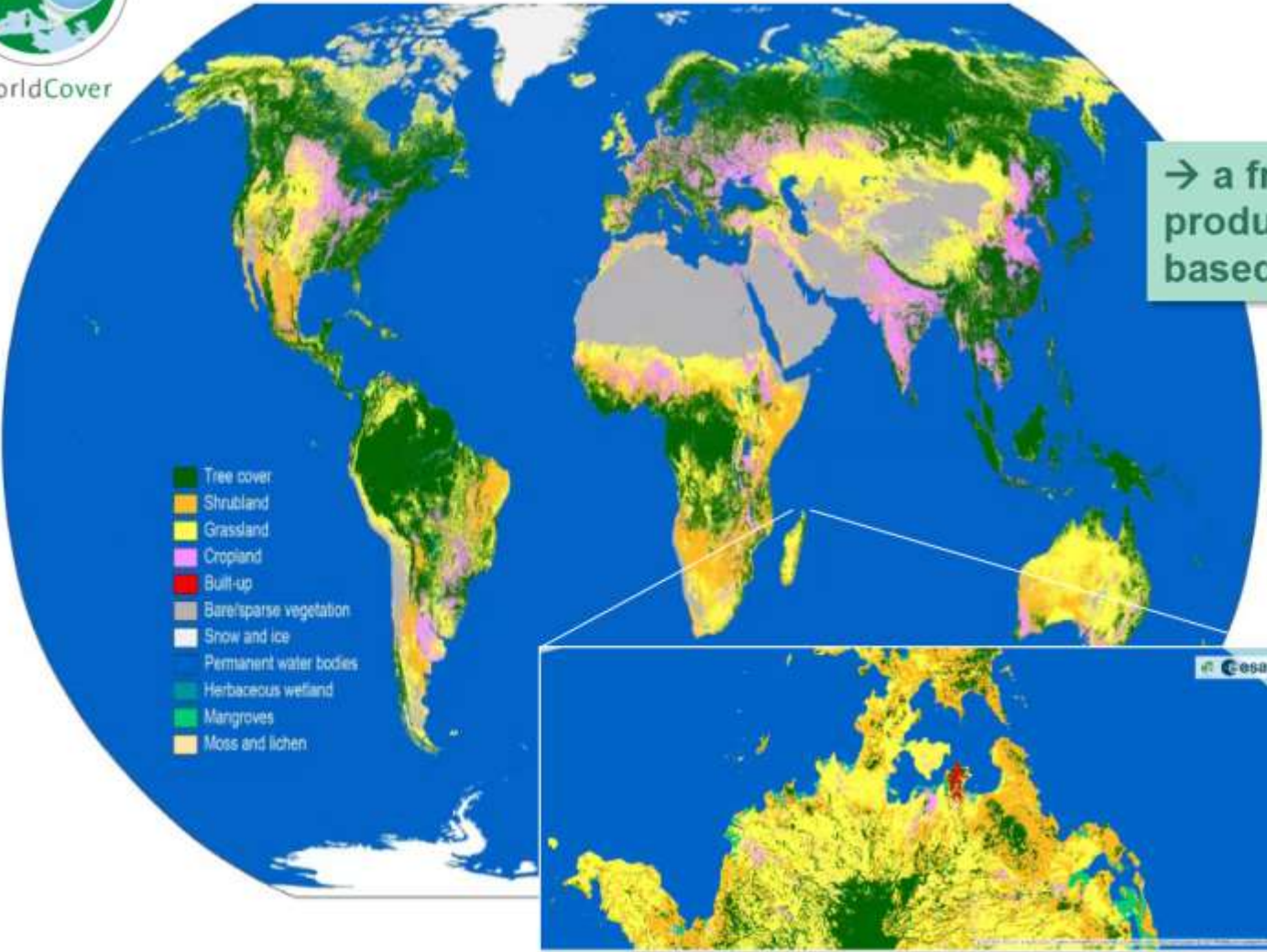
WorldCover 2021 released on Oct 28, 2022. Overall accuracy 76.7%

- ✓ Released on 20th October 2021
- ✓ **11 classes, ≈74%** overall accuracy
- ✓ Independent data validation, highly robust for phenology, Copernicus DEM used as auxiliary data
- ✓ **Part of ESA EOEP-5** (Block 4 – EO Science for Society)

<https://esa-worldcover.org/>



WorldCover



© ESA WorldCover project 2020
© Contains modified Copernicus Sentinel data (2020), processed by ESA WorldCover consortium



OBSERVER: Mapping ground motion at European Scale: from dream to reality

Thu, 02/06/2022 - 12:00

[Print to pdf](#)

<https://www.copernicus.eu/en/news/news/observer-mapping-ground-motion-european-scale-dream-reality>

In May 2022 the Copernicus Land Monitoring Service launched the European Ground Motion Service. In this article we look at the making of the service and its significance to users.

<https://egms.land.copernicus.eu/>



Left image: landslide and subsidence in mountainous area east of Lyon, France - Basic Product; central image: bradyseism in Campi Flegrei, Naples - Basic product; right image: metropolitan area of Rome- Basic product; credits: EEA/Copernicus Land Monitoring Service/EGMS

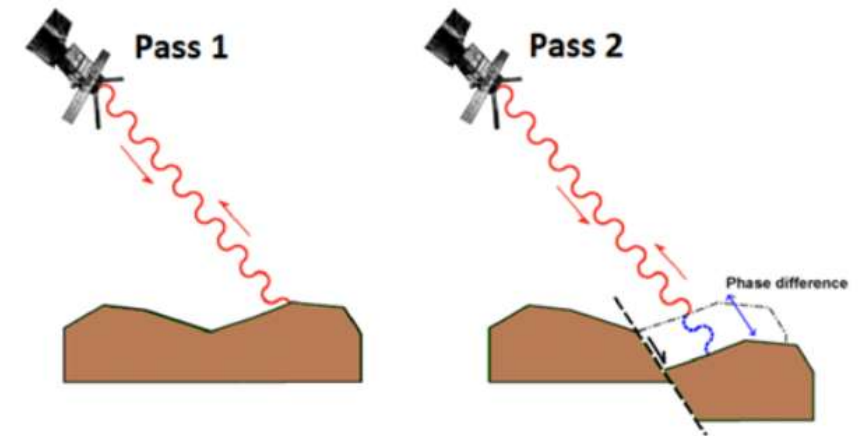


Figure 6: Principle of the InSAR techniques: sketch of phase-shift (Δr) detection by comparing two SAR images, produced by a ground deformation.



Earth Science for Society - Digital Platforms

Access and utilization of EO data shall be massively enhanced and democratized by accelerated use of ICT, bringing users to data and scalable hosted processing

The Rapid Action coronavirus Earth observation dashboard presents the results of the Joint cooperation between ESA and the European Commission on Covid 19 and EO.

The **platform** demonstrates how the use of **Earth observation** data can help shed new light on societal and economic changes currently taking place owing to the coronavirus pandemic.



RACE Project Summary

race.esa.int





532
INDICATORS


39
COUNTRIES
(EUROPE)


WEEKLY
UPDATES

 CHL-A & TOTAL SUSPENDED MATTER

 NO2, CO, PM2.5, PM10, O3

 TEMPERATURE, HUMIDITY, WIND

 PRODUCTION, HARVESTING

 WORKERS AVAILABILITY

 FREIGHT TRANSPORT

 PORTS & SHIPPING

 MANUFACTURING, MATERIALS

 AIR TRAVEL

 URBAN MOBILITY

 HEALTH



OPEN
SOURCE



114.710
VISITS



40
COMPANIES



REPRODUCIBLE
SCIENCE



EDUCATIONAL
RESOURCES



3 COMMUNITY
CONTRIBUTIONS



2 months



Deep Earth System Data Lab (DeepESDL)

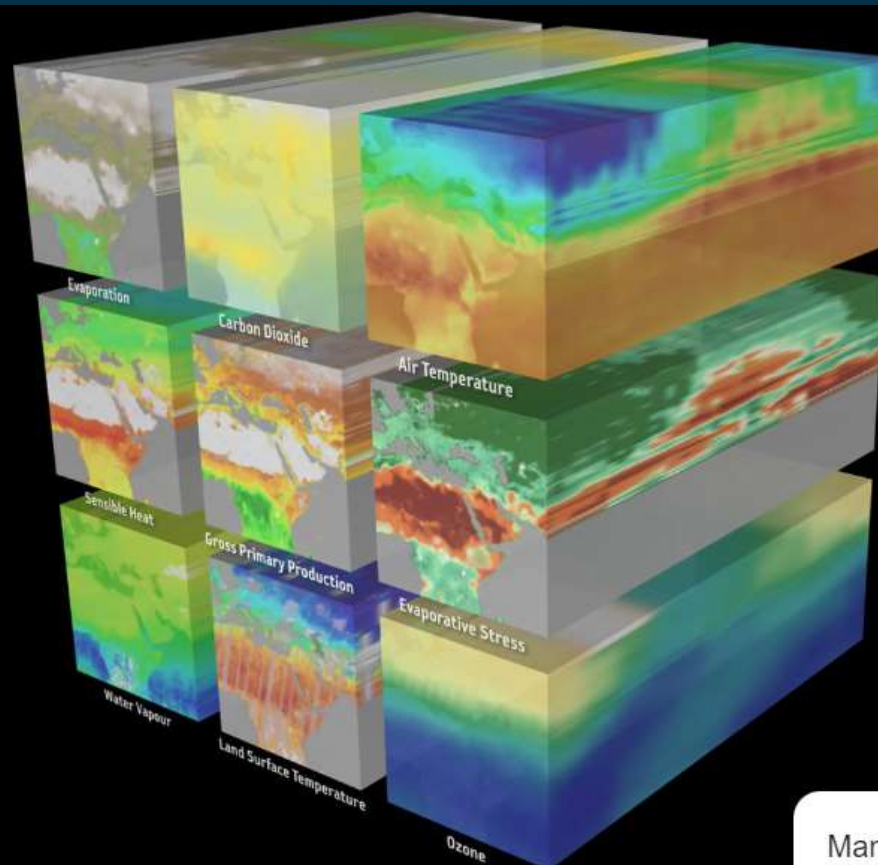
<https://www.earthsystemdatalab.net>

Earth in a Box

The Earth System Data Lab (ESDL) offers analysis-ready Earth System data together with the tools to collaboratively exploit, share and publish them.

SCIENTIFIC BACKGROUND

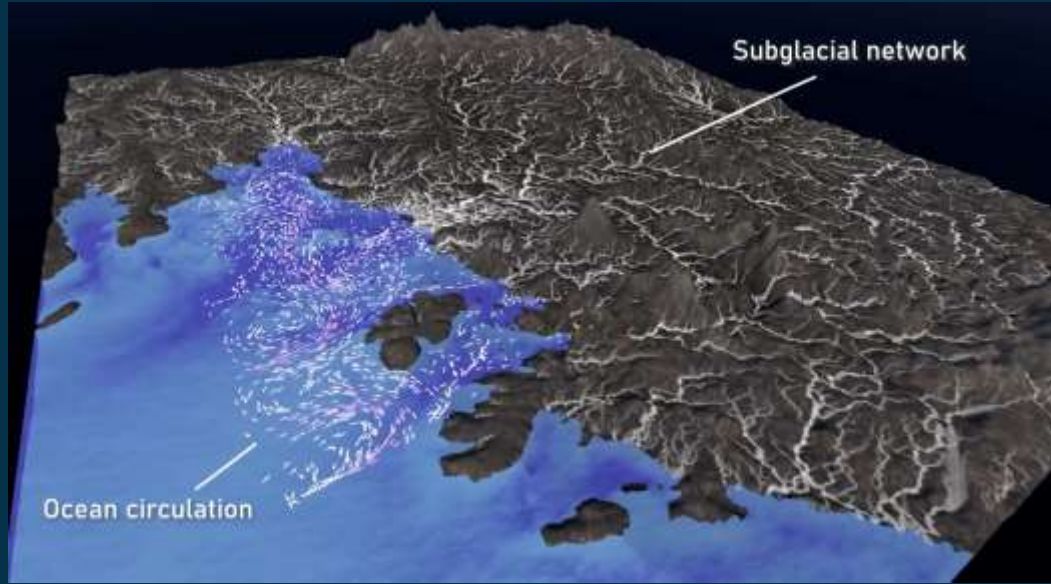
CONTACT US!



Manage consent

FutureEO Block 4 Digital Twin Earth (DTE) – HPC Demonstrators

- Two fast DTE demonstrator projects on going showing the potential of an HPC capability in ESA.
- Activities based on the scaling up of DTE Precursors projects over Antarctica and the Mediterranean.



DTE-Antarctica will provide a first 4D reconstitution of the Antarctic system including the ice sheets-ocean and atmosphere interactions with focus on ice shelves dynamics, stability and risks of collapse under different scenarios



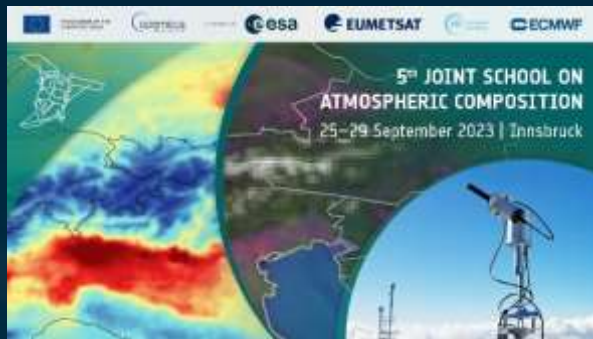
DTE-Hydrology will provide the first full Mediterranean remonstration of the hydrological cycle at 1Km resolution and 1 hour based on an effective integration of state of the art EO datasets, hydrological and hydraulic models.

ESA EO Education/Training activities: opportunities and tools

Upcoming Training Courses



- **13th ESA Training Course on Earth Observation 2023** in Osijek, Croatia, September 18-22.
 - *Intermediate* training covering a broad range of *land and marine applications* using optical and SAR data.
 - Mainly for students in Croatia, with some from other countries.
- **5th ESA/EUMESAT/ECMWF Joint Atmospheric Composition Training Course** in Innsbruck, Austria, September 25-29.



- *Advanced* training on *atmospheric remote sensing* and calibration and validation of satellite data and scientific models using in-situ measurements.
- **12th ESA Advanced Training Course On Land Remote Sensing** in Wroclaw, Poland.
 - *Advanced* Land RS training with a focus on *hydrology and related hazards*; irrigation, drought, etc., using optical and SAR.

More trainings are added often! See our website <https://eo4society.esa.int/>

All materials from past courses incl. lecture recordings can be found here too.



- **Just finished: 7th ESA Advanced Polarimetry Training Course** in Toulouse, France.
 - *Advanced* Polarimetric SAR training covering TomoSAR, PolSAR, PolInSAR, and more.
 - Materials from the course are available online now!

Massive Open Online Courses (MOOCs)

Free online courses covering theory and practical tutorials you can follow at home!

Will be updated this year with new materials and systems to make it simpler, more relevant, and fun to complete.

- **Land in Focus** – new content and more interactivity
 - Online course with a focus on EO for land applications, including large basics module for students new to RS.
 - 8 parts covering RS basics, agriculture, forests, hazard mapping, cities, dry and wet ecosystems, and sustainability.
- **Echoes in Space** – adding content on X, L, and P-band and Multi-Frequency Synergy
 - Complete intro to SAR RS including principles of SAR, agriculture, ship detection, flooding.
- **Towards Zero Hunger** – ongoing
 - MOOC made from content from many agencies and institutions including ESA and DLR.
 - Detailed theory and practicals on using EO to study and monitor food security.



More MOOCs can be found on <https://eo-college.org/>

Opportunities for Young Scientists

• Student Internship

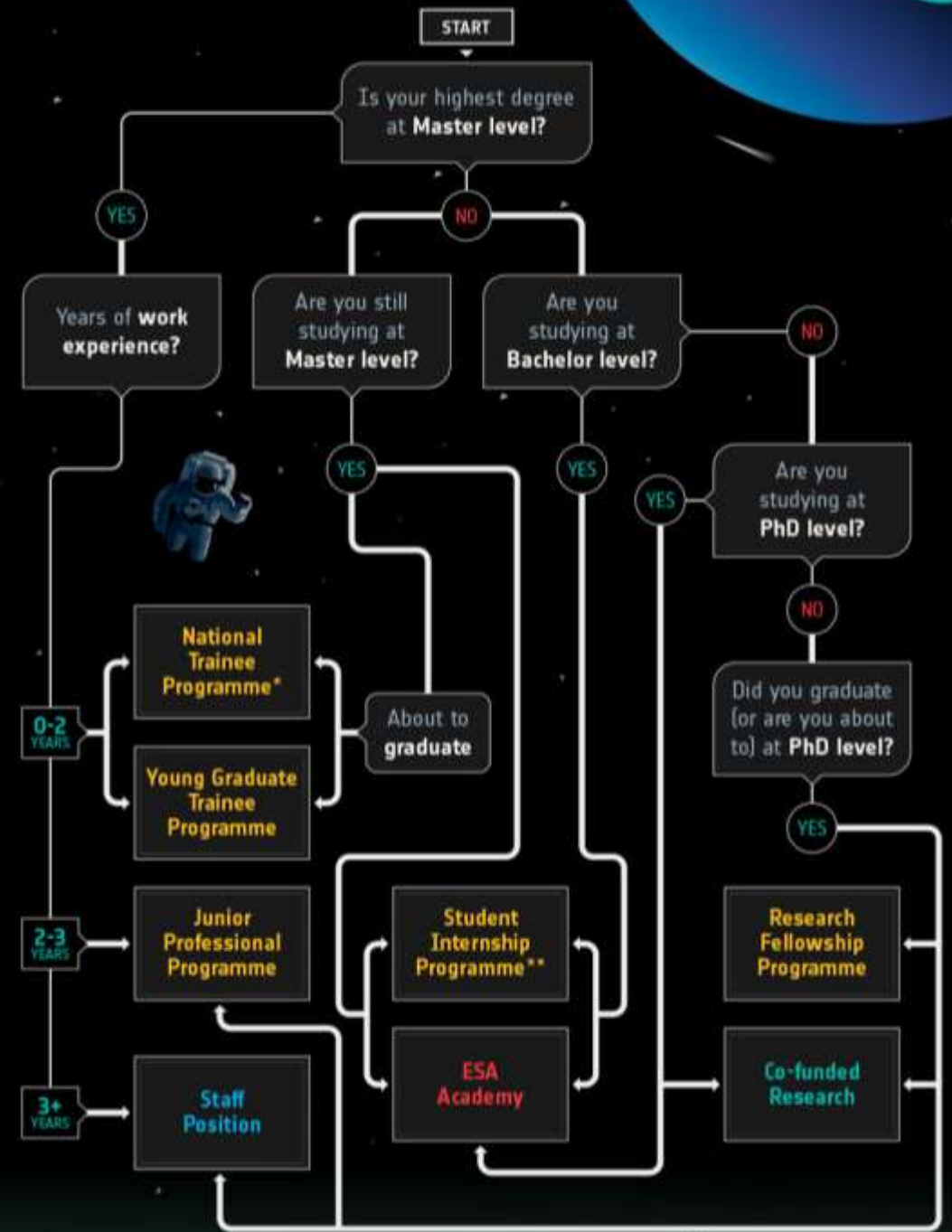
- For MSc Students in last years – learn more about ESA and our opportunities, and gain valuable experience
- Unpaid with an allowance. 3-6 months.
- Positions are posted in November each year.

• National trainees

- MSc graduates – gain practical experience at ESA in a specific field
- Programmes are handled by the participating member states only (Belgium, Estonia, Germany, Ireland, Luxembourg, Portugal, and Switzerland).

• Junior professional programme

- MSc graduates with 2-3 years of professional experience.
- 3-year contract – entry level job working in space science, engineering, or business → maybe permanent position!
- Positions posted online in November-December, next in late 2024!



LINKS!



Opportunities for Young Scientists

• Young Graduate Trainee scheme

- MSc Graduates: ESA's graduate programme.
- Stay for 1 year at ESA and gain experience in your field!
- Positions are posted 1 time per year in February.

LINKS!

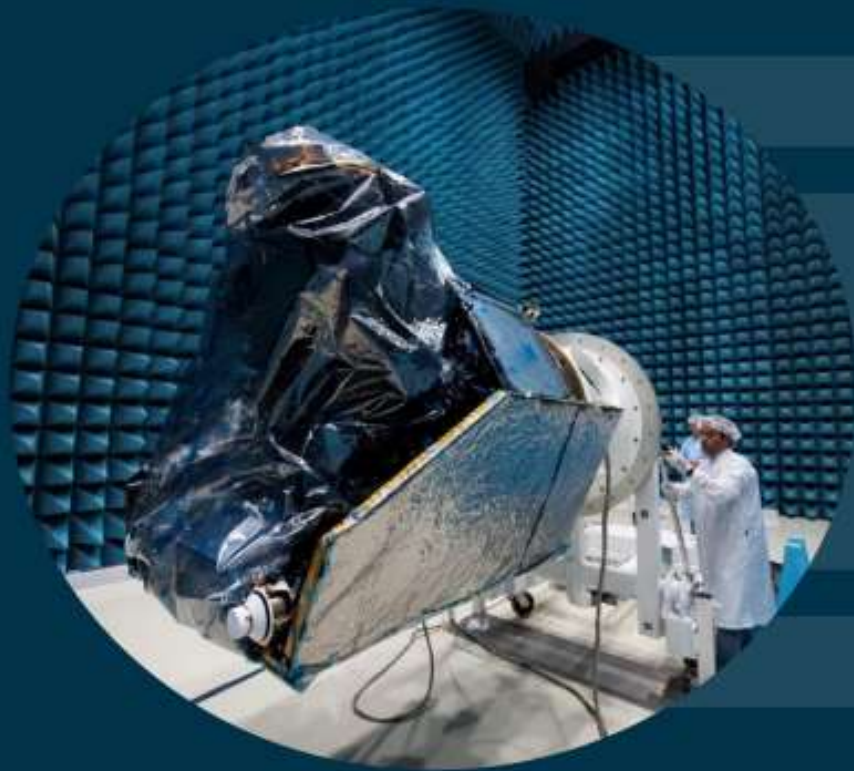
• Research fellowship

- For post-docs – two years at ESA to carry out research.
- Positions are posted online, or you can be referred if part of another post-doc programme.
- At ESRIN:
 - **Φ-lab**: Focus on AI and EO.
 - **ESA Science hub**: Focus on Earth System Science and EO.

• Visiting researcher

- For different levels - MSc, PhD, or Post-Docs.
- Stay at ESA and work on your own research project.
- Flexible opportunities – vacancies are not posted but are created in dialogue with the researcher.





Applied mathematics

Earth observation & environmental science
(geophysics, meteorology, climatology)

Planetary & space science
(astronomy, astrophysics, solar physics)

Life & material sciences

Mechanical engineering

(optical, propulsion, thermal, mechanisms, structures, materials, robotics)

Electrical engineering

(RF, power & data systems, antennas, microelectronics, EMC, components)

System engineering

Telecom & integrated applications

Software engineering & IT

Ground segment systems & operations

Product/quality assurance & safety



The new ESA Earth System Science Hub

Opportunities for Visiting Scientists...

Contacts at: EOscience@esa.int

A new science facility in ESRIN to boost the scientific output of ESA and its MSs through networking and partnerships, offering ESA as a hub for scientific cooperation, exchange of ideas and promoting a community response to major science challenges





We work on



Φ -lab Explore innovation cycle:

- Focus on a meaningful problem
- Connect expert partners
- Build solution developing capacity
- Experiment “fail and recover fast” on use cases

Opportunities for visiting researchers (Phd, postdoc, professors, industry) for 2 - 3 months.

Contact sabrina.ricci@esa.int

USE CASES
Prototyping

OUTREACH
Ecosystem Building

**CONNECTING
TALENTS
IDEAS
CAPACITY**

CAPACITY
BUILDING

Thanks for your attention!

<https://eo4society.esa.int/training-education/>