

# Scientific Exploitation Programme Element Science for Society

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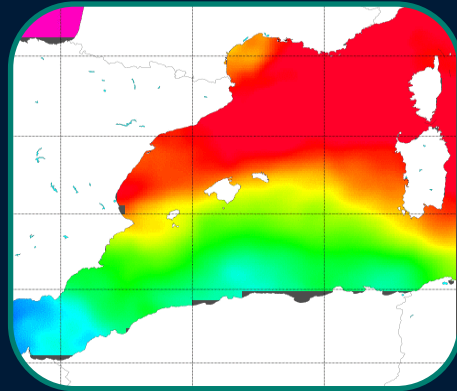
**Belgian EO Day 2023**

**Diego Fernandez & Espen  
Volden**

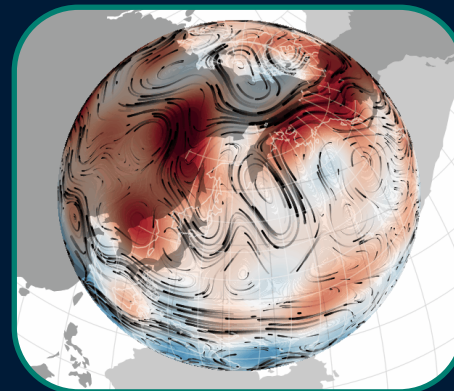
# Pushing the frontiers of science



**Engaging the community**



**New methods & observation products**



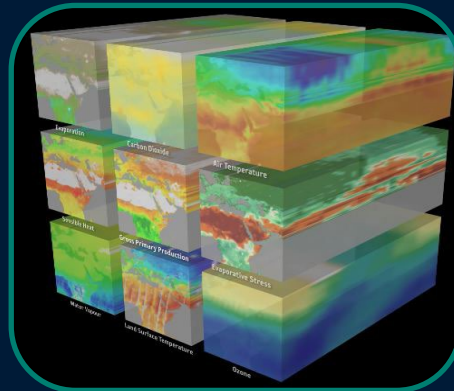
**Advancing Earth System Science**



**Scientific Campaigns**



**Training and Education**



**Open Science Tools/Virtual Labs**



**Networking & partnerships**



**Transfer to future missions**

## Strategic Activities



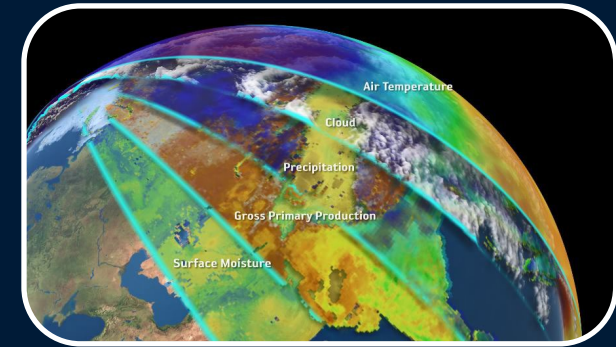
**Joint ESA-EC Earth System Science initiative strategic partnership with DG-RTD fostering an ambitious European and international scientific collaboration between FutureEO and Horizon Europe**



**ESA Science Clusters fostering a community open science approach to scientific exploitation bringing together different teams and projects to work together towards common ambitious goals addressing all major scientific domains**



**ESA Science Hub a new facility in ESA fostering partnerships with academia and collaborative research with centres of excellence in MSs focusing on EO and Earth system science priorities**



**Advance observations and understanding of the Earth system establishing solid scientific grounds for Digital Twin Earth: advanced digital reconstruction of the Earth system based on the integration of the latest ESA data sets, numerical simulations and science results**



# A strong partnership in Earth Sciences



ESA



## FutureEO

ESA new Science and Innovation Earth Observation Programme



EC-R&I

## Horizon Europe

New EU Research and Innovation Framework Programme



**A common goal "... to jointly advance Earth system science and its contribution to respond to the global challenges that society is facing in the onset of this century"**

The European Commission's Deputy Director General for Research and Innovation, Patrick Child and ESA's Director General, Josef Aschbacher at the signing ceremony, January 2020.



# Common Priorities



Kick-off in pilot phase (2020-2022)



In preparation full im

Horizon Europe WP 2023-2024  
Published 6 December 2022  
"Applicants are encouraged to coordinate with the relevant ESA projects ..."



# Horizon Europe related calls



Knowledge gaps



polar science



carbon cycle



biodiversity



ocean health



food systems



geo-hazards



extremes

- HORIZON-CL5-2023-D1-01-04 Improved knowledge in cloud-aerosol interaction
- HORIZON-CL5-2024-D1-01-02 Inland ice, including snow cover, glaciers, ice sheets and permafrost, and their interaction with climate change
- HORIZON-CL5-2024-D1-01-07 Quantification of the role of key terrestrial ecosystems in the carbon cycle and related climate effects
- HORIZON-CL5-2024-D1-01-01 Enhanced quantification and understanding of natural and anthropogenic methane emissions and sinks
- HORIZON-CL6-2023-BIODIV-01-3 Interdisciplinary assessment of changes affecting terrestrial and freshwater ecosystems, building on observation programmes
- HORIZON-CL6-2023-CLIMATE-01-3 Ocean and coastal waters carbon- and biodiversity-rich ecosystems and habitats in Europe and the Polar Regions
- HORIZON-CL6-2023-CLIMATE-01-8 Closing the research gaps on Essential Ocean Variables (EOVs) in support of global assessments
- HORIZON-CL6-2023-GOVERNANCE-01-11 Reducing observation gaps in the land-sea interface area.
- HORIZON-CL6-2023-GOVERNANCE-01-16 Digital technologies supporting plant health early detection, territory surveillance and phytosanitary measures
- HORIZON-CL3-2024-DRS-01-02 Harmonised / Standard protocols for the implementation of alert and impact forecasting systems as well as transnational emergency management in the areas of high-impact weather / climatic and geological disaster
- HORIZON-CL3-2024-DRS-01-03 Hi-tech capacities for crisis response and recovery after a natural-technological (NaTech) disaster



# From this year onwards

- The ESA-EC cooperation would enable supporting **complementary collaborative projects, funded on the EC side through Horizon Europe and on the ESA side through the FutureEO programme**
- It will result in a group/cluster of complementary projects pursuing a common objective in the domain of Earth System Science (*e.g.*, biodiversity, healthy ocean, polar science, carbon, extreme events, water cycle science, and science for sustainable agriculture)
- The EC projects would support wide R&I actions eligible under Horizon Europe (*e.g.*, modelling, in-situ data collection) while ESA projects would support EO-based science and developments based on EO space assets



- Selected ESA ITT and EC Horizon Europe calls will include dedicated provisions fostering collaborative activities between ESA science cluster projects and Horizon Europe activities
- Additional opportunities for existing projects will be launched to propose additional collaborative work packages across ESA and EC projects bridging toward results, data and knowledge addressing new more ambitious common goals beyond original objectives of the projects

# ESA Science Clusters: A community approach

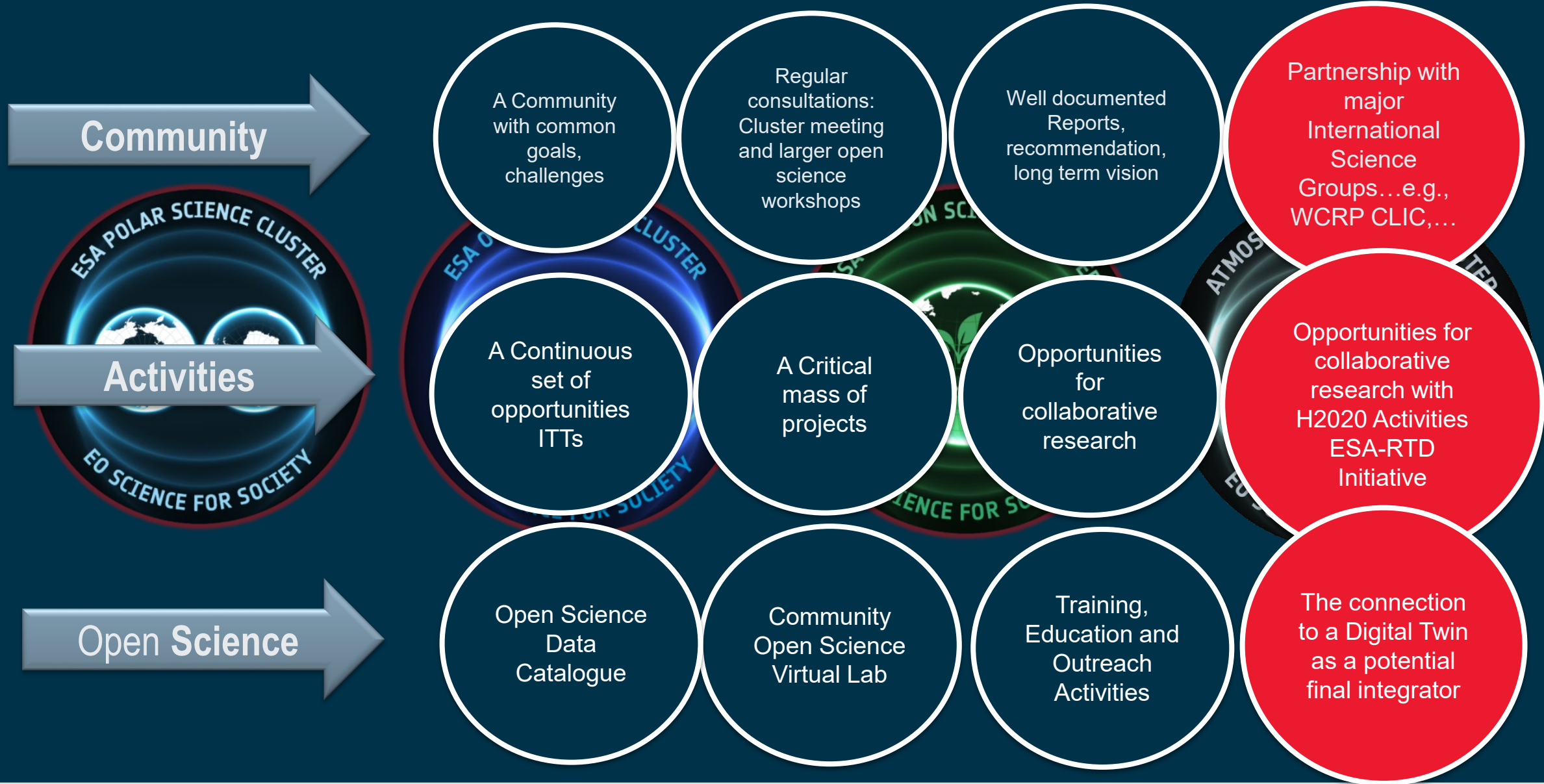


- *Promote a community approach to ESA science activities towards common and more ambitious goals*
- *Promote collaborative research across projects and teams (also non ESA projects: e.g., Horizon Europe)*
- *Promote a coordinated approach to science, through networking and partnerships*
- *Maximise the scientific impact of ESA science activities by exploiting synergies and different expertise across domains*
- *Based on a continuous dialogue with the scientific community and joint science agendas*





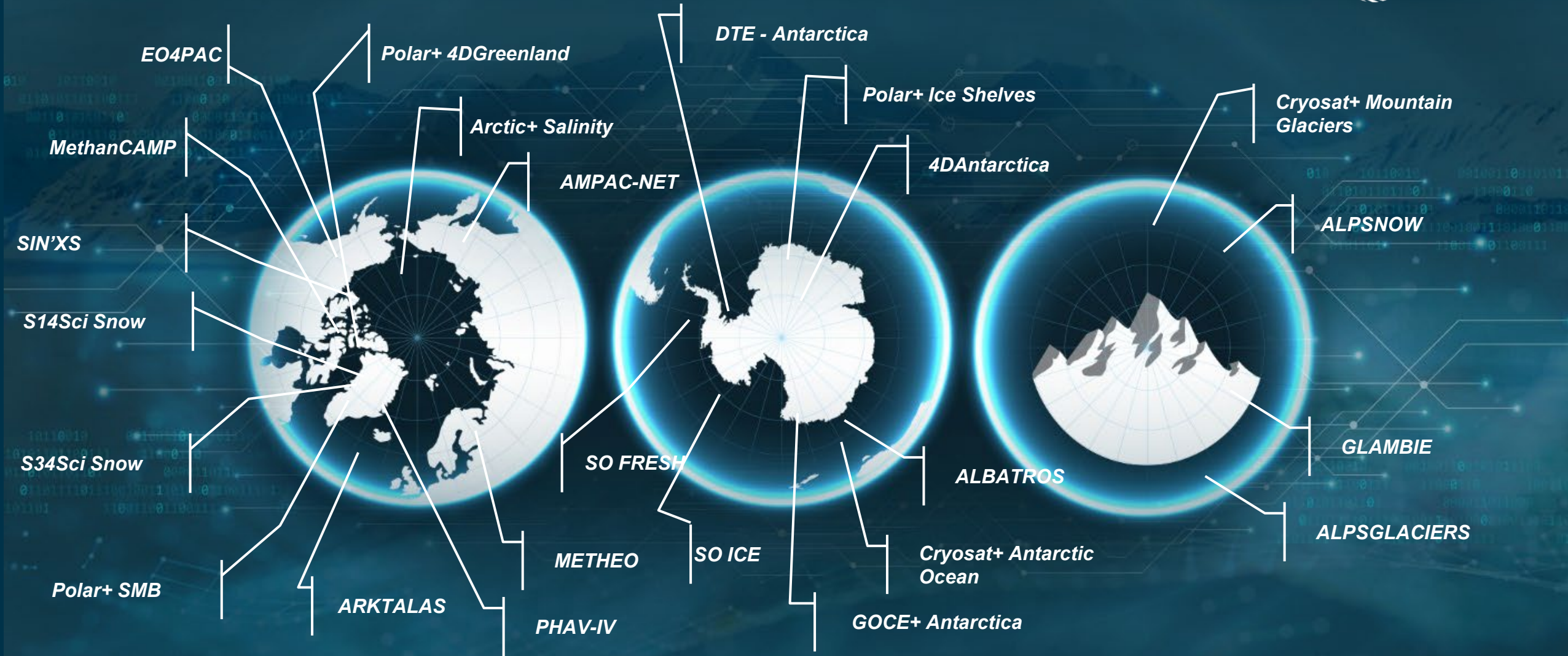
# Science Cluster Elements



# *Polar Science Cluster – An example*



# ESA Polar Science Cluster Activities



# New and unprecedented set of observation and products

SMOS very thin sea ice below 0.5 m  
SMOS + Cryosat sea ice thickness  
Snow on sea ice  
Sea ice with dynamic snow accumulation  
Daily multi-mission radar freeboard  
Dedicated Antarctic sea ice thickness products    Antarctic SSH, MDT

Cryosat Swath elevation and elevation change over ice sheets  
Cryosat Swath elevation and elevation change over mountain glaciers and ice caps  
Cryosat Swath based sub-glacial lakes  
Active sub-glacial lakes volume discharge  
Glaciers an ice cap mass change and attribution  
Ice Sheet Basal melting

Ice shelves thickness  
Ice shelves surface and basal melting  
Ice shelves fractures  
Calving fronts

3D Surface velocities  
S1 TOP based velocities  
Combined INSAR + Offset tracking velocities  
Grounding line

Ice thickness temperature profiles

Snow extend  
Snow albedo  
Snow grain size  
Snow melting/wet

Supra-glacial lakes coverage  
Supra-glacial lakes volume

SMB    Run-off

Sea Surface Salinity Arctic  
Sea Surface salinity Antarctica  
Bathymetric and tides Arctic  
Bathymetry and tides Antarctica

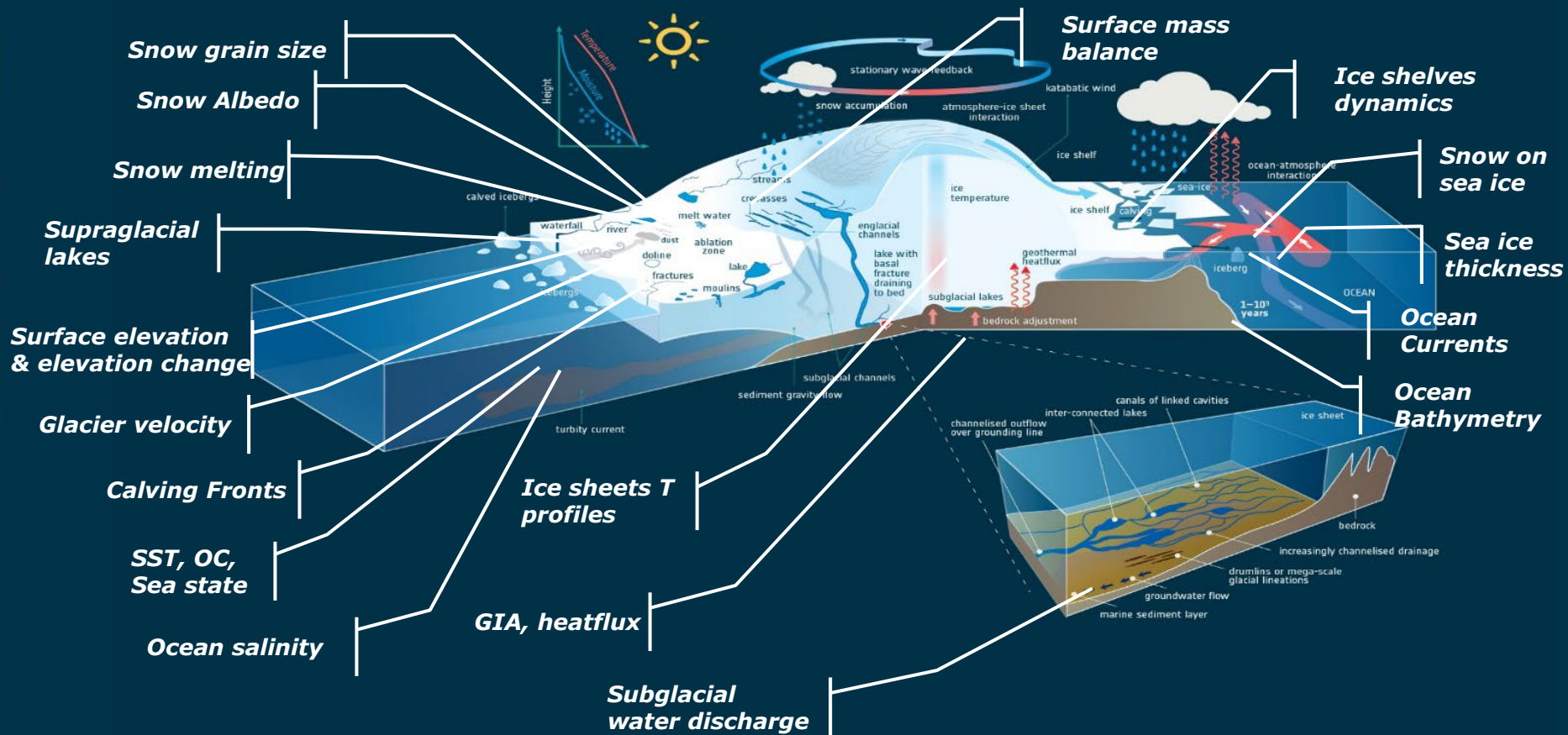
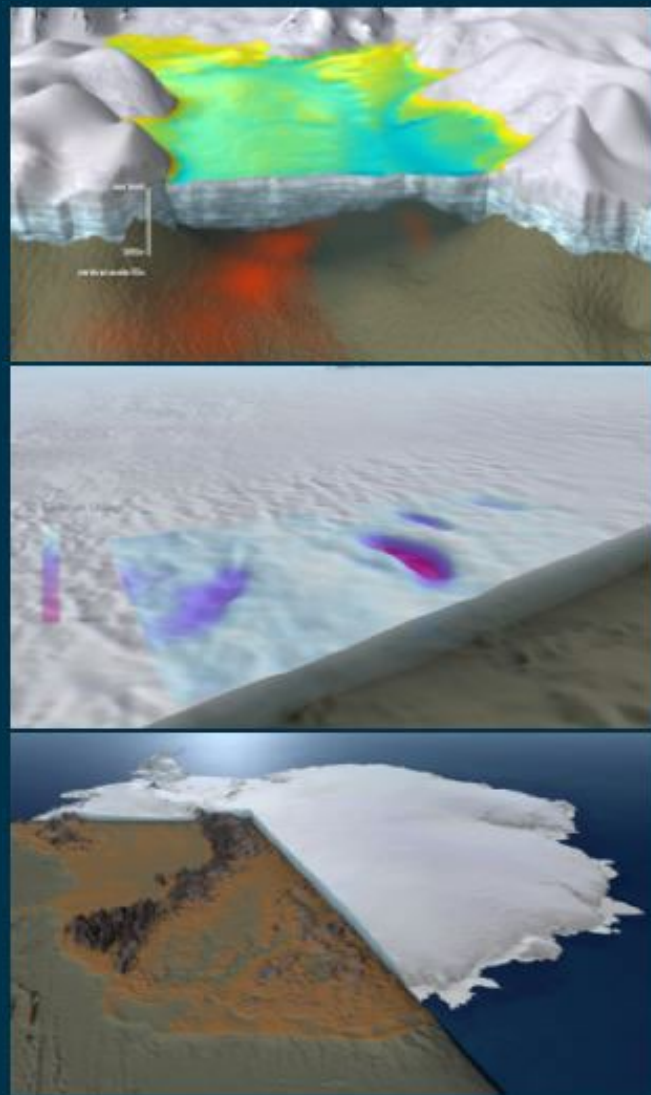
Antarctic lithosphere model  
Arctic/Greenland lithosphere model  
Arctic heat-flux and GIA  
Antarctica heat-flux and GIA

Greenland integrated hydrology assessment  
Antarctica integrated hydrology assessment  
Arctic ocean process studies  
Antarctic ocean ice shelves interactions  
Antarctic ocean sea ice and

Cryosphere



# An integrated approach to Polar sciences



# The new ESA Earth System Science Hub

*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*



# First Visiting Scientists...



Lisa Küchelbacher  
German Aerospace Center (DLR) | DLR · Department: Atmosphere



Sonia Ponze de Leon  
Marine Environment Group, CENTEC, Instituto Superior  
Técnico, Lisboa - Ocean



Nicole Biebow  
Unit for International Cooperation, Alfred Wegener Institute,  
Germany – Polar science



Marco Bellacico  
Italian National Research Council | CNR · Institute  
Science ISMAR - Ocean



Kristin Bottcher  
SYKE, FIN – Cryosphere-Carbon li

Opportunities for collaboration in ESA ITTs  
Come to visit us....  
Contacts at: [EOscience@esa.int](mailto:EOscience@esa.int)

Responding to the recommendations of the European Polar Science week and Polar Science Collocation meetings ([eo4polar.esa.int](http://eo4polar.esa.int)):

- Integrated multi-mission assessment of Antarctic dynamics with focus on dynamic regions and marginal zones (ice shelves)
- Arctic sea-ice drift, formation and sea- ice-wave interactions
- Advancing Sea ice products in the Southern Ocean and multi-mission integrated study

Activities will include opportunities for collaborative work packages with dedicated Horizon Europe activities.



# Ocean Science Cluster 2023

Dedicated  
collaborative  
Horizon Europe  
calls in WP  
2023-2024

Responding to the recommendations of the Ocean Science Cluster Collocation meeting ([eo4society.esa.int/event/ocean-science-cluster-2021](https://eo4society.esa.int/event/ocean-science-cluster-2021)) and Ocean Carbon Workshop:

- Land-Ocean interactions including coastal carbon budget (ocean shelves) and coastal dynamics
- Gaps in Ocean Essential Variables with focus on (multi-mission) ocean circulation, novel 4Dlight penetration products, advance functional types and SIF for ocean (in preparation for FLEX) and Ocean Health including HR Coastal biology and Ocean Extremes impacts on ocean ecosystems

Activities will include opportunities for collaborative work packages with dedicated Horizon Europe calls

Responding to priorities of the carbon from space workshop (4thcarbonfromspace.esa.int) with a major focus on the terrestrial carbon:

- Novel HR multi-mission (S1, S2, S3, BIOMASS, FLEX, NISAR, GEDI) terrestrial carbon budget with focus on impacts on land use dynamics (e.g., agriculture)
- Terrestrial carbon benchmarking exercise toolbox & dataset
- S5P SIF for vegetation stress impacts on terrestrial carbon quantification
- Arctic Carbon – Land HR dynamics and impacts on emissions in support of ESA-NASA AMPAC

Activities will include opportunities for collaborative work packages with dedicated Horizon Europe calls

Responding to the recommendations of ATMOS ([atmos2021.esa.int](https://atmos2021.esa.int)):

- Community effort to better characterize and understand methane emissions at both medium-resolution and HR from hot spots and point sources to large scale global emissions and understanding of latest increases in CH<sub>4</sub>
- Advancing in cloud-aerosol interactions and impacts on the radiation budget and rainfall in preparation for EarthCARE
- Integrated multi-scale air quality experiment

Activities will include opportunities for collaborative work packages with dedicated Horizon Europe calls

# Water Cycle and Hydrology Science 2023



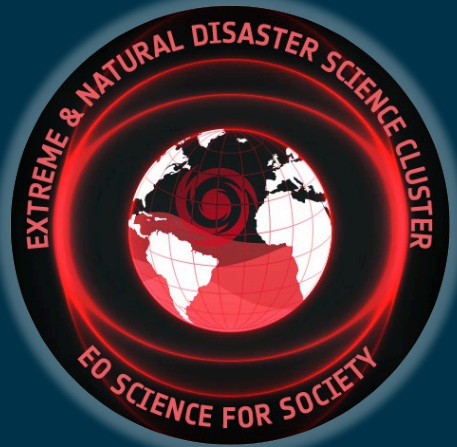
Launching a new cluster on Water Cycle and Hydrology

*New generation of space based hydrological variables for enhance hydrology*

- Advanced Hyper-resolution hydrology: European/Global HR Benchmarking dataset & Community benchmarking tool
- Global first space-based run-off assessment
- Global Altimeter SAR-in/SWOT river discharge assessment
- *See also EarthCARE and Extremes/Hazards planned activitie*

Activities will set up the basis for a launching a dedicated science cluster on water cycle and hydrology





# Extremes and Natural Hazards 2023

Dedicated collaborative Horizon Europe call in WP 2023-2024



Addressing the major lack of understanding of multi-hazards, compound and cascade effects of multiple inter-dependent hazards (e.g., hydro-climatic extremes) that jointly contribute to multiply societal or environmental risk

- Multi-hazards compound and cascaded events
- Advancing the integration of novel EO products and geo-hazard modelling with focus on volcanoes and earthquakes
- Hydro-climatic extremes

# Soils and agriculture science 2023



Dedicated collaborative Horizon Europe call in WP 2023-2024

Advancing in observations and process understanding in key domains of food systems and agriculture:

- Assessment of vegetation/crop stress under multiple stressors - disentangle biotic and abiotic stresses, and advance towards early detection of the impact on plants of pests and of hydro-climatic stressors (combined multi-mission/sensor/scale)
- Impact of Agriculture in Atmosphere carbon/CH<sub>4</sub> and nitrogen multi-mission study (FLEX SIF in 2025)
- Crop water balance (multi-mission VHR assessment of full water budget on agricultural areas at field level)

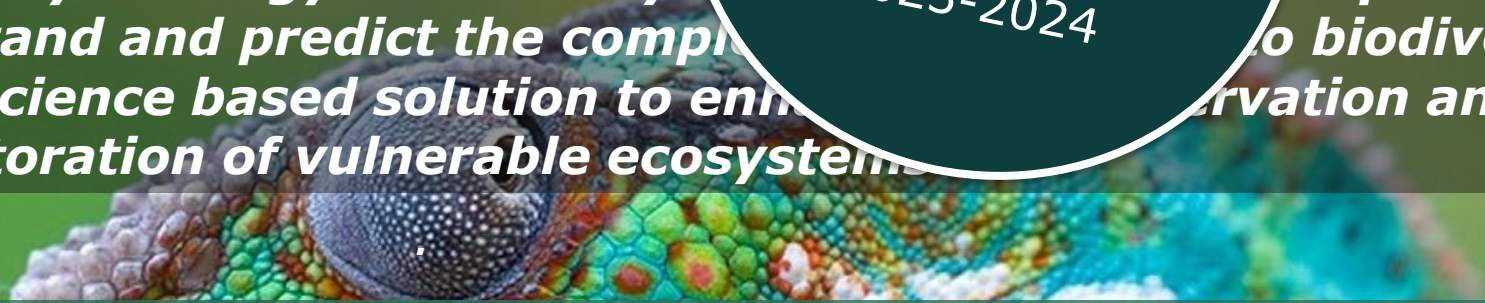


# Biodiversity



Dedicated collaborative Horizon Europe call in WP 2023-2024

**Contribute to EU Biodiversity Strategy for 2030 by increasing our capacity to observe, understand and predict the complexity of biodiversity loss and develop novel science based solution to enhance conservation and restoration of vulnerable ecosystems**



- Advanced multi-mission assessment of ecosystems change, vulnerability and response to natural and anthropogenic pressures in:
  - Terrestrial Ecosystems and
  - Freshwater Ecosystems
- See also Ocean Cluster activities



Terrestrial Ecosystems



Freshwater Ecosystems



Coastal Ecosystems



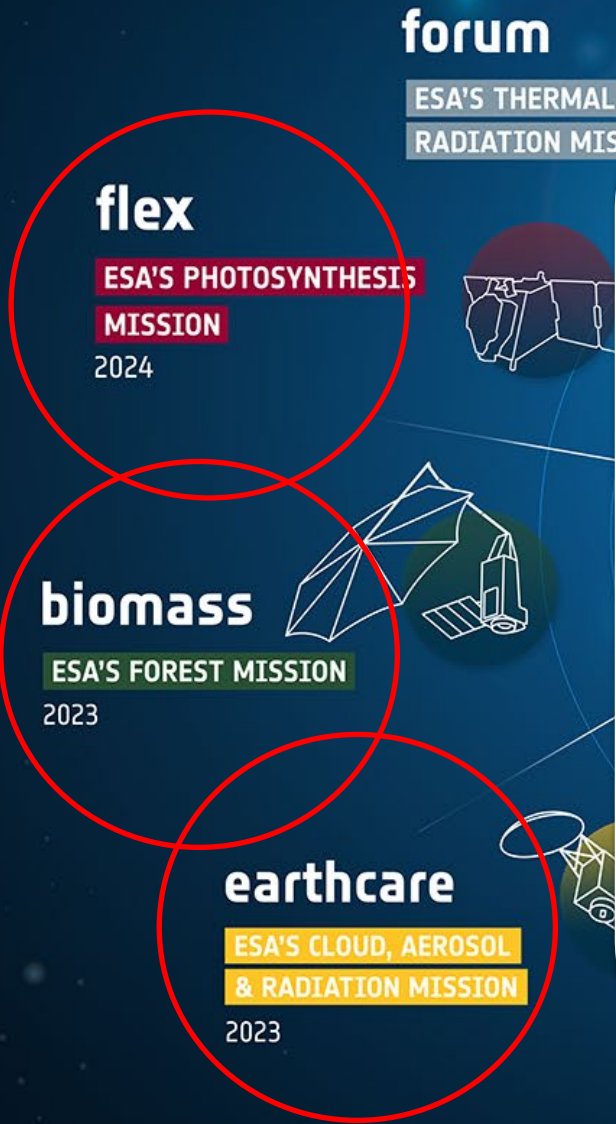
## Responding to some of the main recommendations from Swarm+ Science Workshop 2021

- Quiet ionosphere
- Hemispheric Asymmetries,
- Irregularities
- Ionosphere- thermosphere coupling
- Swarm + Cluster Ionosphere- magnetosphere coupling
- Swarm for ocean (salinity retrievals)





# Supporting Mission Science



- Supporting mission science activities (with focus on Earth Explorers and Sentinels) is a primary goal of the programme
- Main goal is to maximise the impact of the mission in terms of new methods, new products and new scientific results beyond its core objectives
- Results contribute to expanding the mission product portfolios and scientific impact and scope
- Mission specific developments are also fully integrated in the framework of “Thematic” Science Cluster activities, promoting a wider uptake of mission results by a wider community



# Priorities in early preparation for fast exploration of the Earth Explorers

- Early development of a BIOMASS DTM product algorithm and early demonstration in the TOMO Phase
- Evolution of S5P SIF over the ocean and assessment of the priority areas for FLEX ocean acquisitions
- Multi-frequency study on distributed scatterers and InSAR coherence (for natural targets, including canopies and sub-surface) in preparation for BIOMASS

How to access the new datasets:  
<https://opensciencedata.esa.int>



## Open Science Data Catalogue

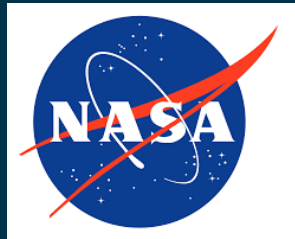
- **Science for society activities result in a wide variety of new prototype methods, algorithms and experimental products and datasets.**
- **Those assets are of interest for the scientific community to evaluate and test new data and for scientific use before even before transfer to an operational production.**
- **Today data results are available through the different project web sites and accessible via [eo4society.esa.int](http://eo4society.esa.int).**
- **In order to further facilitate the discoverability and access of this wide range of information and knowledge a dedicated tool is under development....**

# Training the Next Generation of EO and Data Scientists



New Trainings on:  
Land,  
Cryosphere,  
Atmosphere  
and Ocean

Contribution to joint trainings with CEOS partners



Maintain and expand MOOCs



ESA UNCLASSIFIED - For ESA Official Use Only

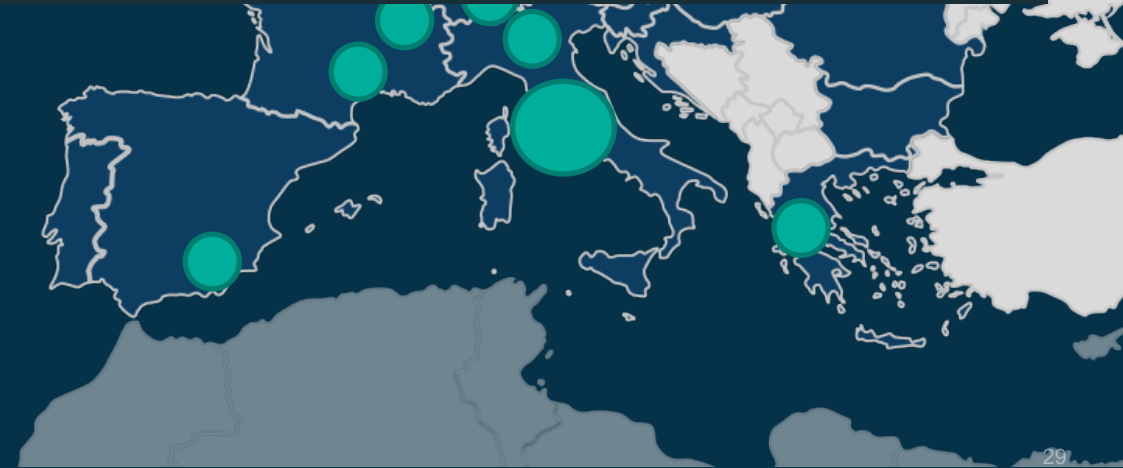


# Living Planet Fellowship



New call  
in 2023

*"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**"*



## Campaigns and benchmarking reference datasets/sites

Set of dedicated reference sites and datasets (proxy missions, in-situ, airborne, synthetic datasets) addressing different thematic areas to support collaborative research and development of algorithms and validation of products

## Training/Toolboxes and open science support

Set of activities to support the community to prepare for the coming missions including dedicated tools, training and education actions with major focus on young generations

## Fundamental research and algorithm/products developments/validations

Set of dedicated calls for the early development of algorithms products with focus on synergic aspects and additional priorities beyond core mission objectives

- Polar/Cryosphere
- Atmosphere
- Land/Vegetation Carbon & Agriculture
- Ocean
- HYDROLOGY & LST
- Dedicated SAR studies

# EO Science for Society Info Days 2023

📅 March 15 - March 16

📍 Online

<https://eo4society.esa.int/event/eo-science-for-society-info-days-2023/>



**Presentations:  
15 March 2023  
09:00-13:00  
Webex Events  
(link provided to  
registered participants)**

## Introduction and Objectives

The European Space Agency, ESA, is organising the EO Science for Society Info Days to introduce activities in FutureEO-1 Segment 2 Block 4 “EO Science for Society”. The main goals of these Info Days will be to present the upcoming opportunities for European entities to participate in the activities of the ongoing programme.

# ADDITIONAL SLIDES





1<sup>st</sup>  
High  
Resolution  
SIF

Launch  
in  
2025

Major  
contribution to  
Carbon cluster,  
biodiversity and  
agriculture –  
Partnership  
with EC-RTD

- Enhancing crop growth models and yield prediction
- Assessment of agriculture under multiple stressors
- Enhancing crop water balance
- Plant Functional Diversity and status of terrestrial ecosystems
- Advancing terrestrial carbon quantification
- Assessment of extremes impacts on vegetation stress

Impact of Agriculture in Atmosphere carbon/CH4 and nitrogen

Ocean retrievals and impacts on carbon and ocean biology

FLEX, OLCI, SLSTR experimental synergistic products

1<sup>st</sup>  
High  
Resolution  
SIF

Launch  
in  
2024

Major  
contribution to  
Atmosphere  
science cluster  
– Partnership  
with EC-RTD

- Long-term datasets for aerosol and aerosol-cloud-interaction research
- Global influence of smoke in the stratosphere
- Change of particle scattering properties by water uptake at high relative humidity
- Impact of aerosol conditions and vertical air motion on supercooled liquid clouds
- Studies on aerosol-cloud interactions from the synergy between space- and ground-based instruments
- Study of precipitation initiation processes
- Characterisation of convection with synergistic GEO and LEO satellite observations
- Light precipitation and Low-level oceanic clouds
- Global estimates of hydrometeors sedimentation rates