

ESA Earth Observation: Current status and latest results

Meeting of the European Space Sciences Committee
30 November 2021

Maurice Borgeaud

Head of the Earth Observation Department
"Science, Applications and Climate"

ESA UNCLASSIFIED – For ESA Official Use

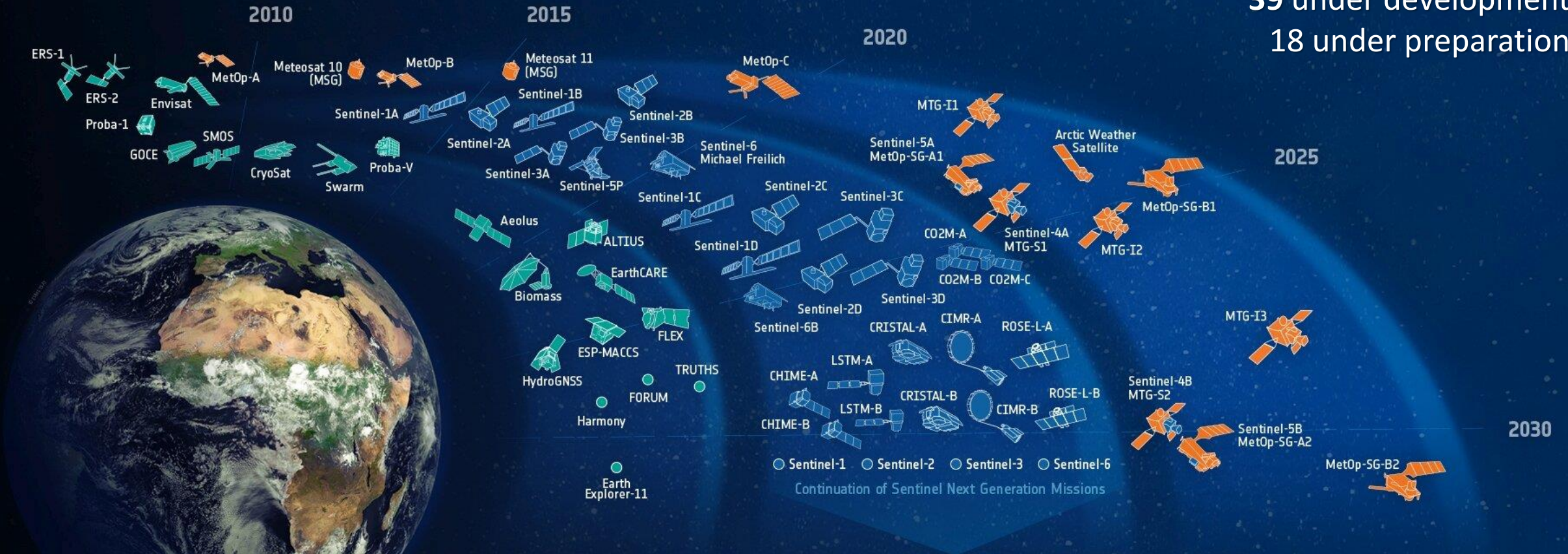


ESA-Developed Earth Observation Satellites



Satellites

15 in operation
39 under development
18 under preparation



Science



Copernicus



Meteorology



Strengthening EO



FFPA signed with EU on 22 June including Contribution Agreement on Copernicus



ESA-NASA Earth Sciences Partnership Joint Statement of Intent signed 13th July



Joint EC DG-RTD/ESA Earth System Science Initiative - Coordinated Calls



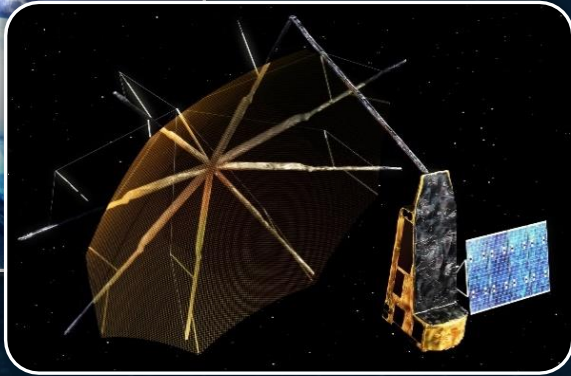
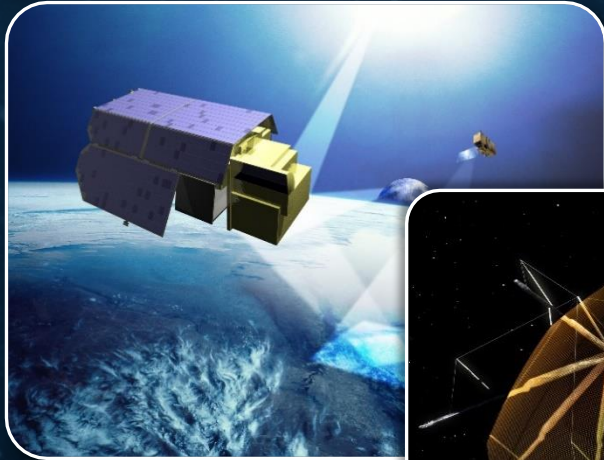
Contribution Agreement with DG Connect on DestinE in progress



EO Successfully Represented at COP26



TRUTHS and BioMass at COP26



ESA's climate data interactive 3D visualisations shown at COP26



Climate from Space



CCI supporting the Paris Agreement presented at Earth Information Day

ESA and GHGSat support new International Methane Emissions Observatory



SCO promoted at Space solutions for climate action event



Biggest Φ -week ever!



- EO innovators addressing some of society's biggest challenges, "**the climate crisis**" and "**the SDGs**" while boosting economy through transformative New Space technologies, artificial intelligence, quantum and cognitive cloud computing in space.

Notable participants

EC, EIB, ICEYE, AIRBUS, THALES, SHELL, SAP, SCOR, Satlantis, AEROSPACE LAB, Ubotica, Unibap, SPIRE, OpenCosmos, ArianeSpace, Primo Space, Seraphin, NASA, Microsoft, CERN, ECMWF, and more.

3000+
attendees



91
countries



17
sessions

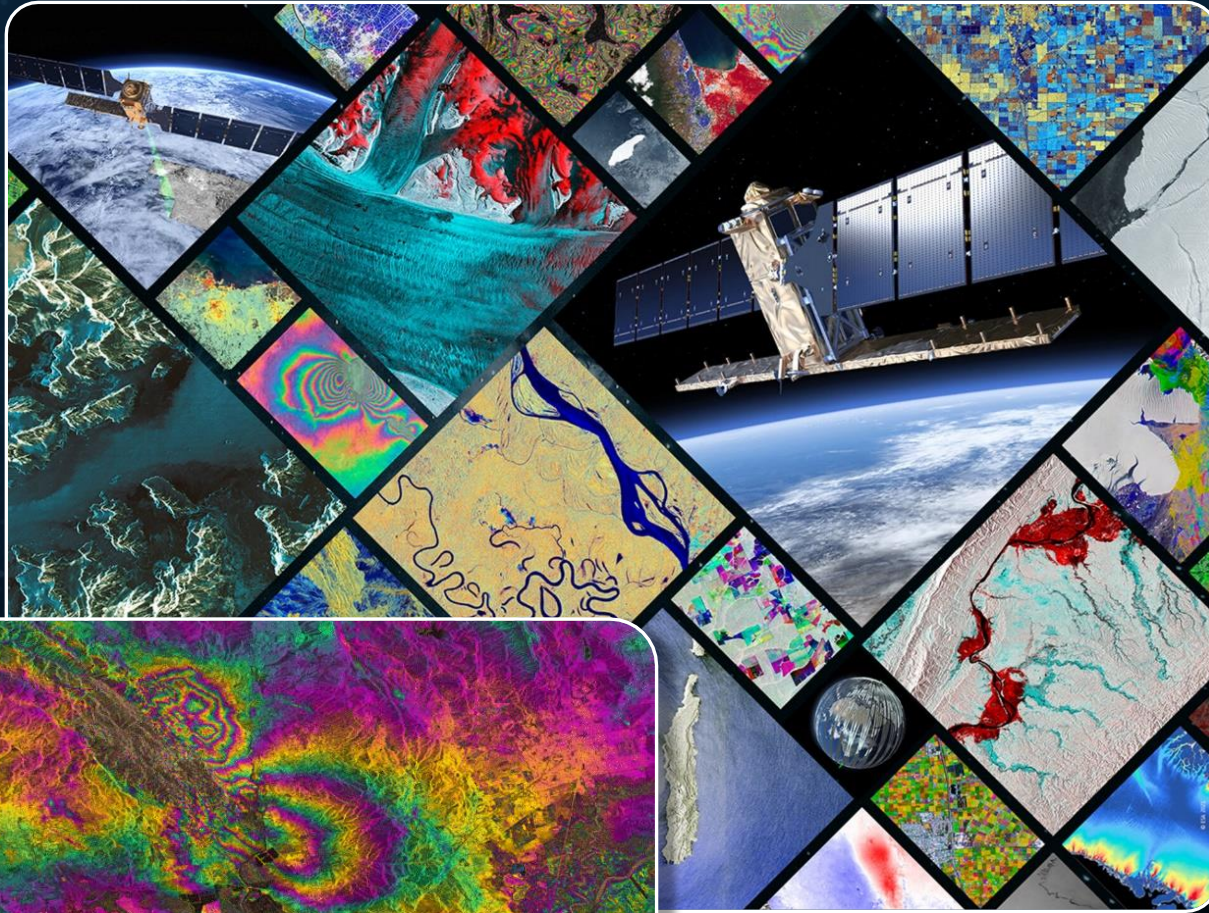


150
e-posters &
e-exhibitions



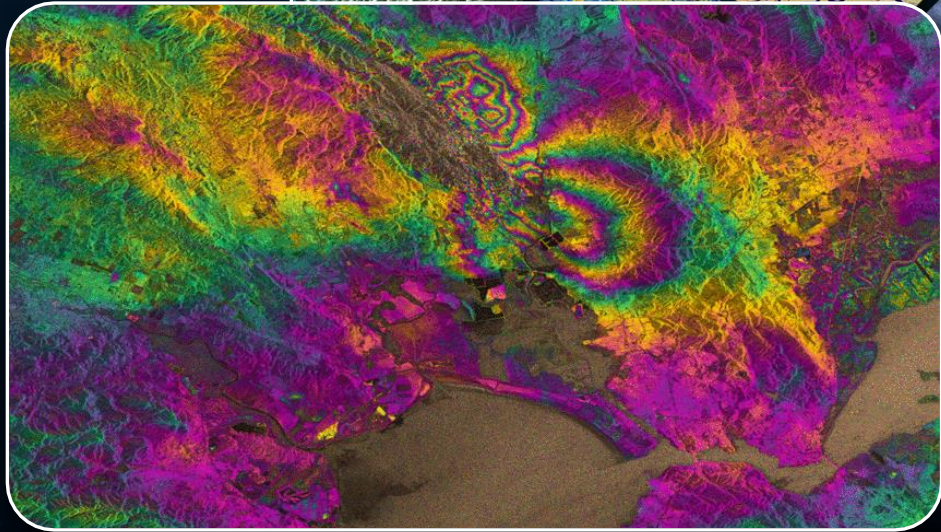
29
side events





SENTINEL-1A

- Launched on 3 April 2014, Sentinel-1A has exceeded its design lifetime of 7 years of operations, providing a wealth of worldwide SAR data.
- The satellite is foreseen to continue its operations until Sentinel-1C is fully operational in 2023



Prof. Klaus Hasselmann Receives Physics Nobel Prize 2021



(Max Planck Institute for Meteorology, Hamburg, Germany)



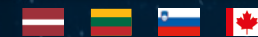
Together with Syukuro Manabe and Giorgio Parisi, Hasselmann received the prize...

“...for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming”

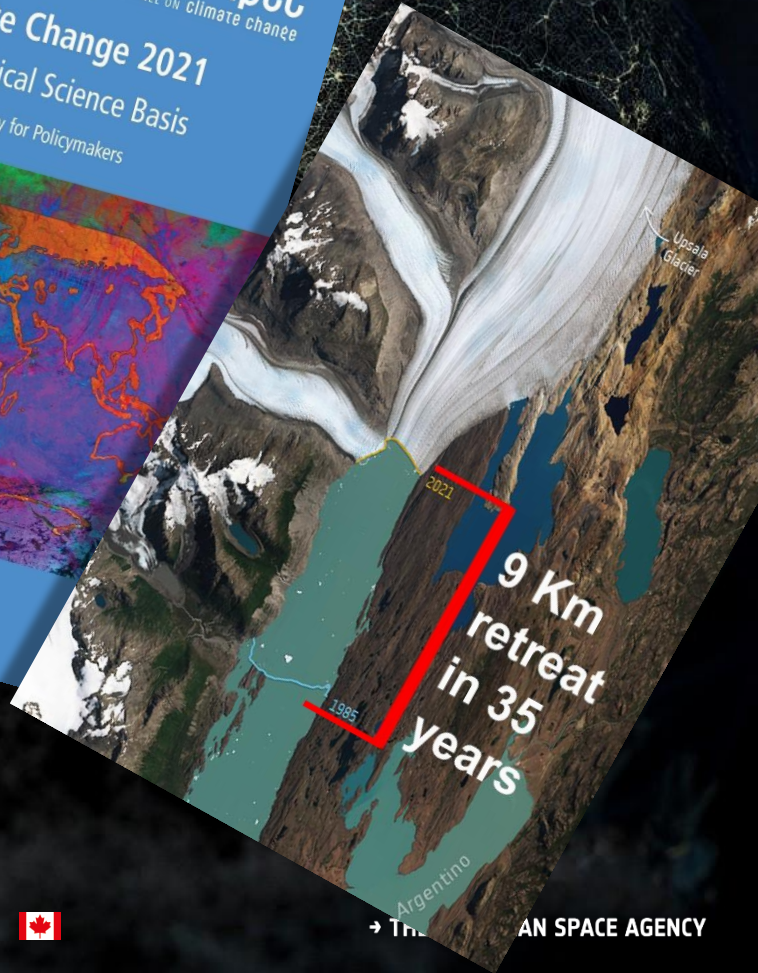
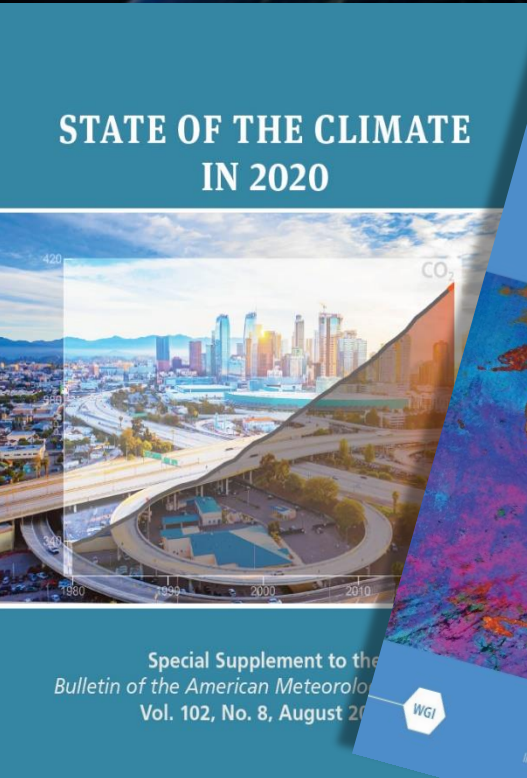
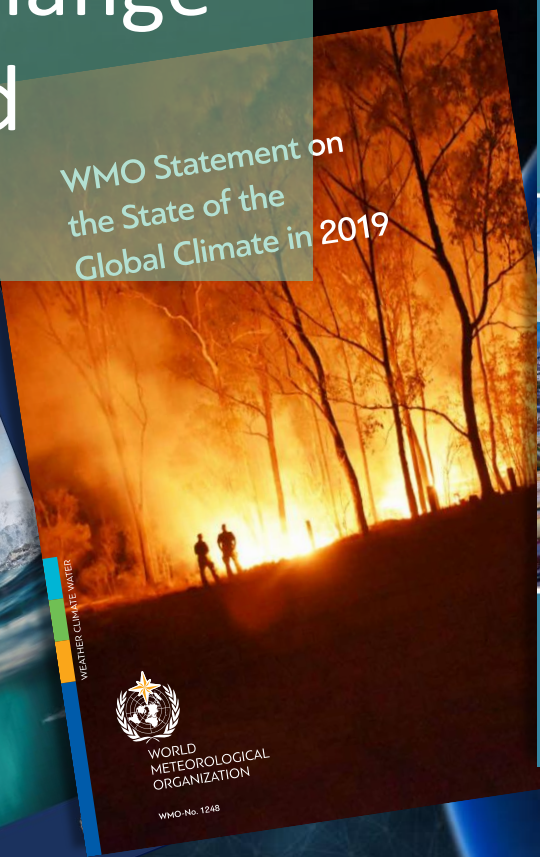
The ERS SAR Wave Mode: A Breakthrough in Global Ocean Wave Observations 165

K. Hasselmann, B. Chapron, L. Aouf, F. Ardhuin, F. Collard, G. Engen, S. Hasselmann, P. Heimbach, P. Janssen, H. Johnsen, H. Krogstad, S. Lehner, J.-G. Li, X.-M. Li, W. Rosenthal & J. Schulz-Stellenfleth

Considered as “one of the fathers of ERS-1”, he made key contributions to its objectives, the orbit scenario and payload.



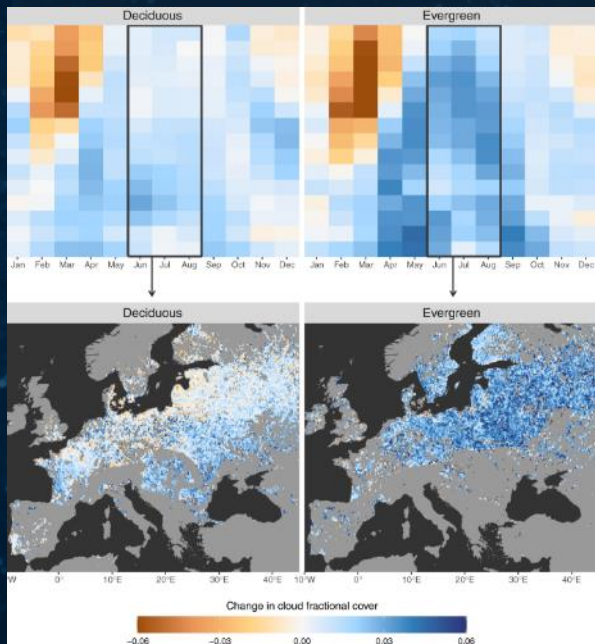
EO Data Invaluable for Climate Change Reporting and Monitoring



Satellite EO Data in Research



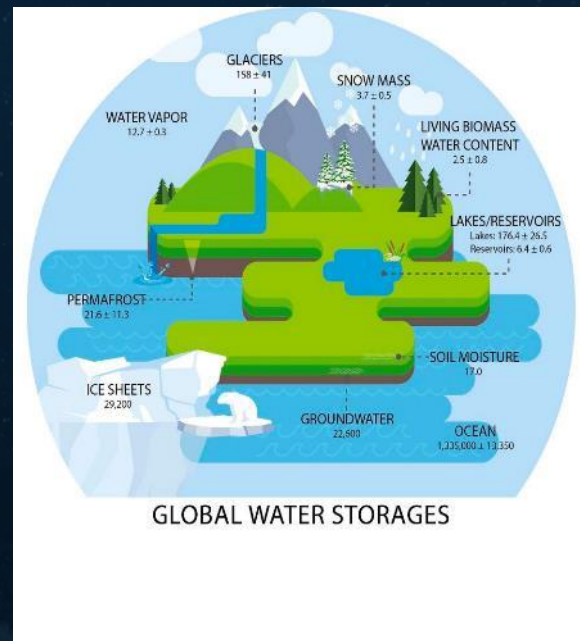
Forests cool climate



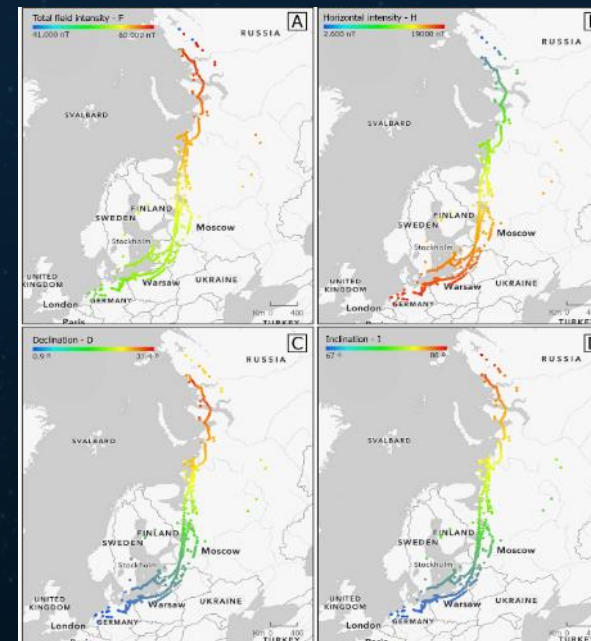
CO2 in Russia's Forests



Accounting Earth's water cycle



Bird migration



CCI Cloud products



CCI Biomass product



CCI Water/Ice products

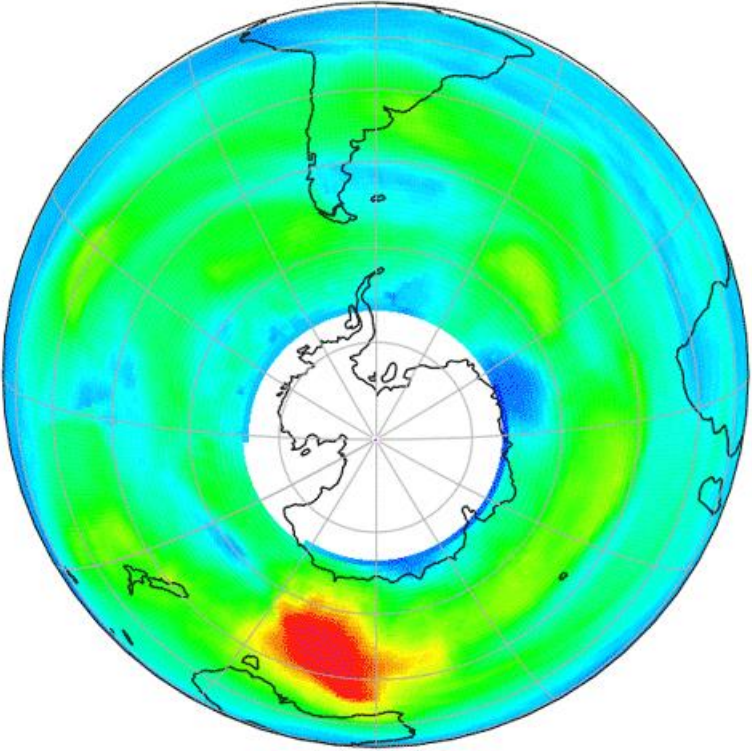


Swarm data

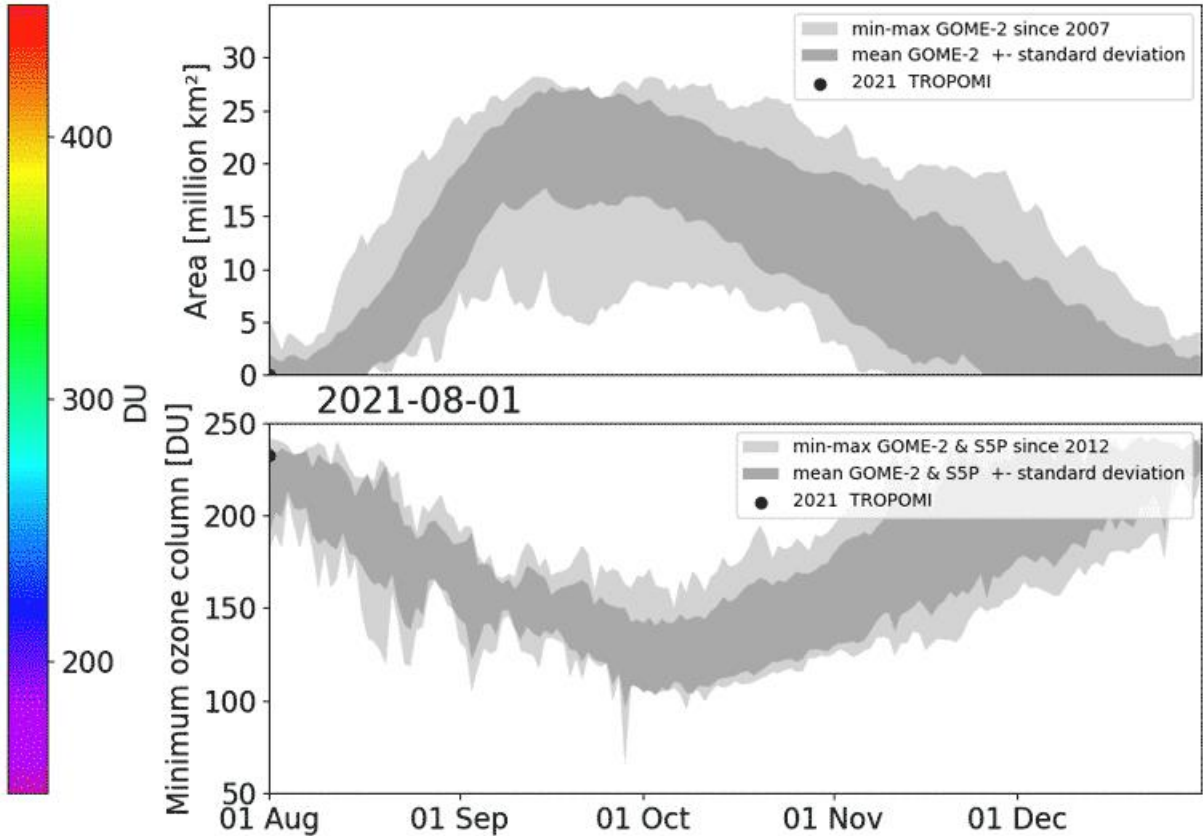


Satellite EO Data in Research - New Insight in the Antarctic Ozone Hole

Sentinel-5P data



Data for AUG-SEP

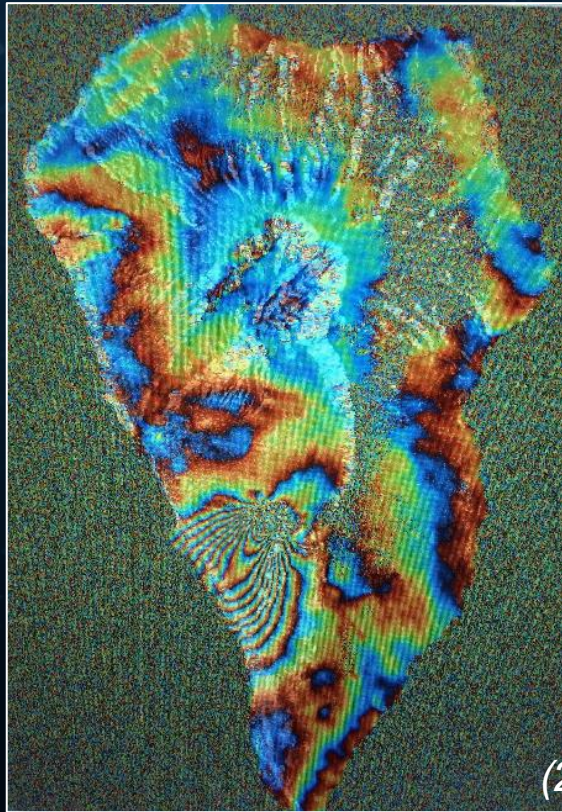


Copyright: contains modified Copernicus Sentinel data (2021)



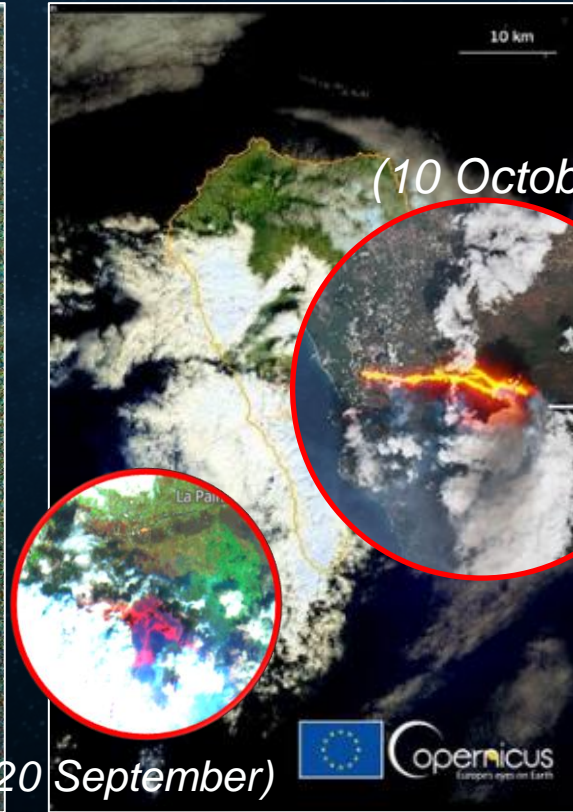
Volcano on La Palma – Eruption Monitored by Copernicus

Before the eruption

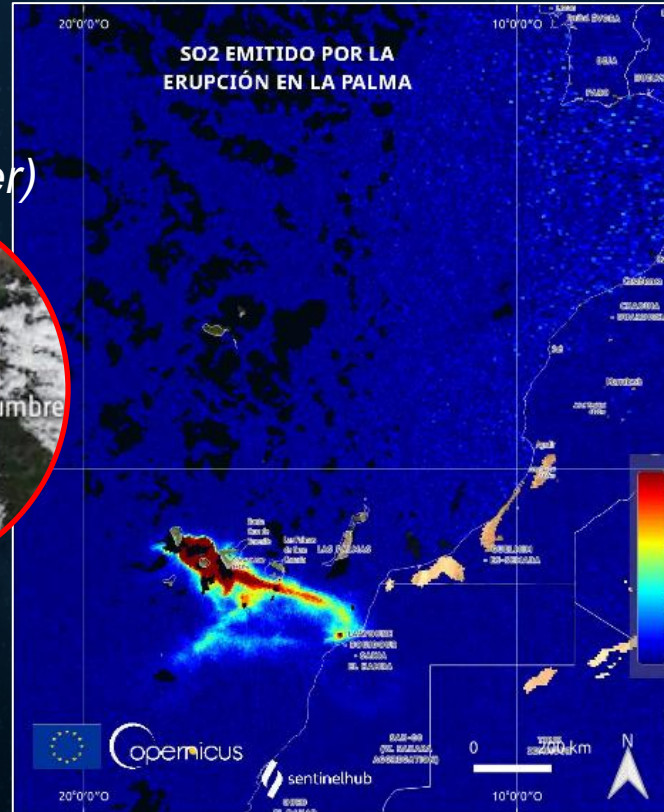


Sentinel-1 interferogram (14-20 Sep)
[courtesy Pablo J. González]

Eruption started on 19 September 2021

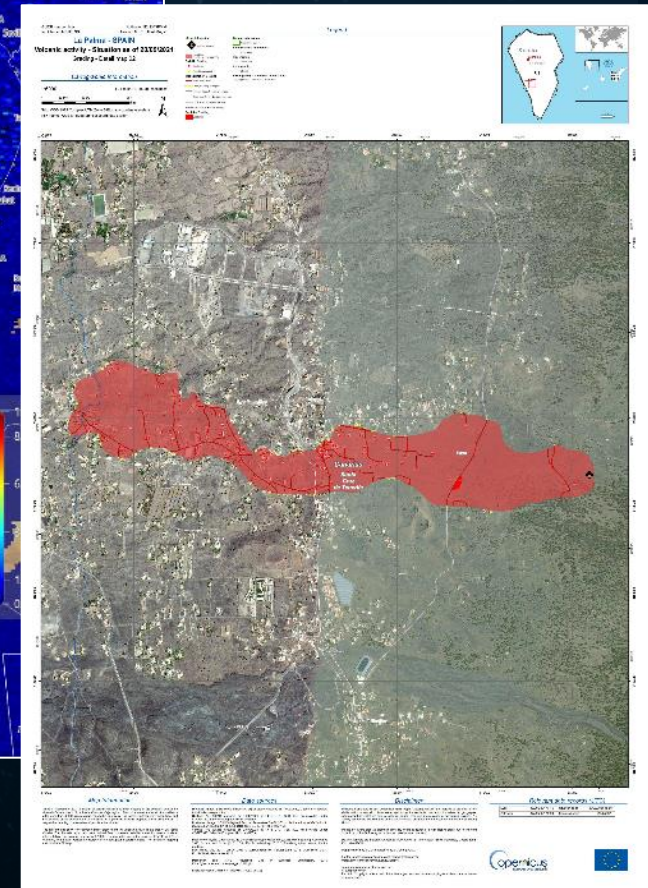


Sentinel-2
(20 September)



Sentinel-5P (SO₂, 20 September)

First lava map produced by Copernicus Emergency Management Service



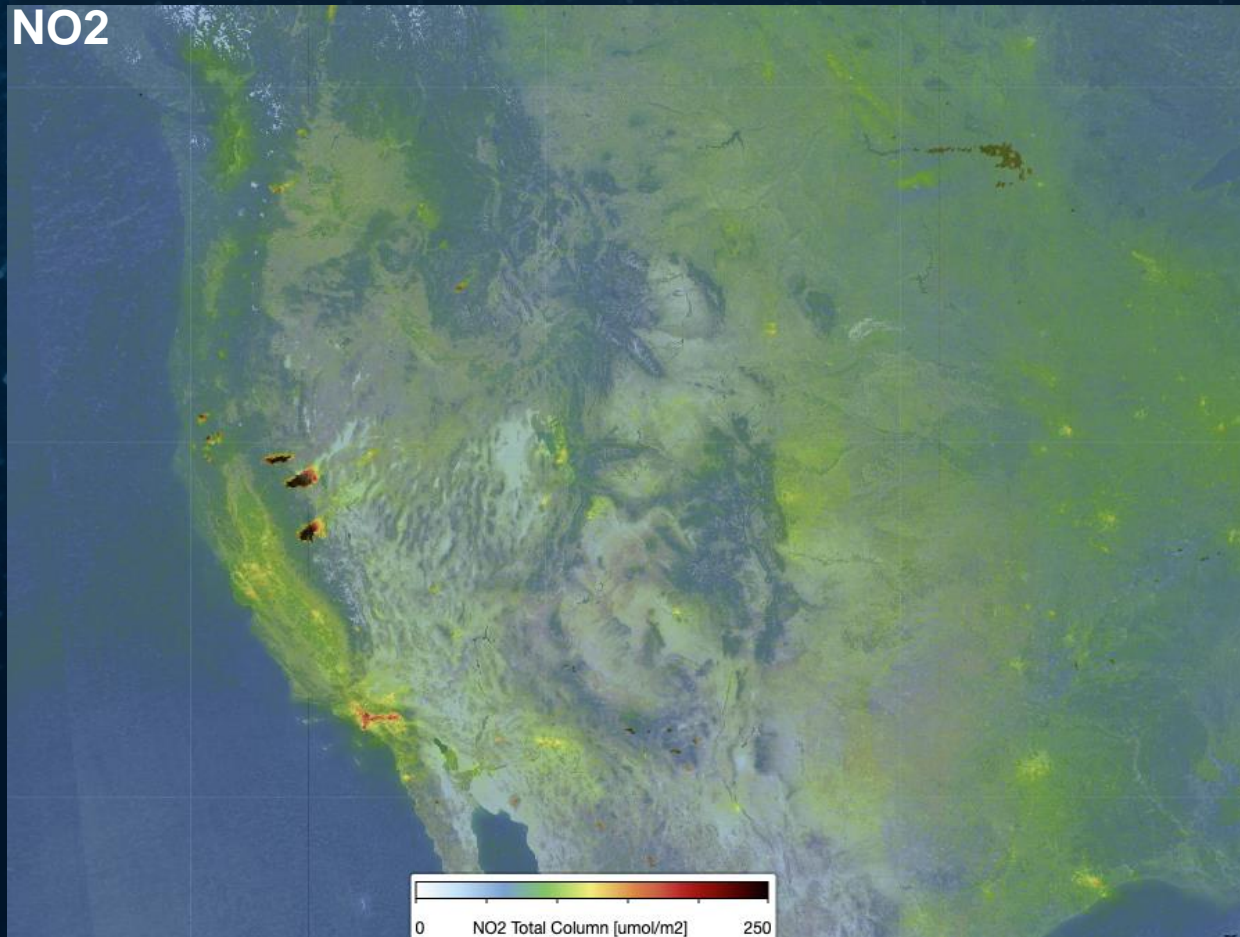
Based on **Sentinel-1** and **Cosmo-Skymed** data

Copyright: Contains modified Copernicus Sentinel data (2021)

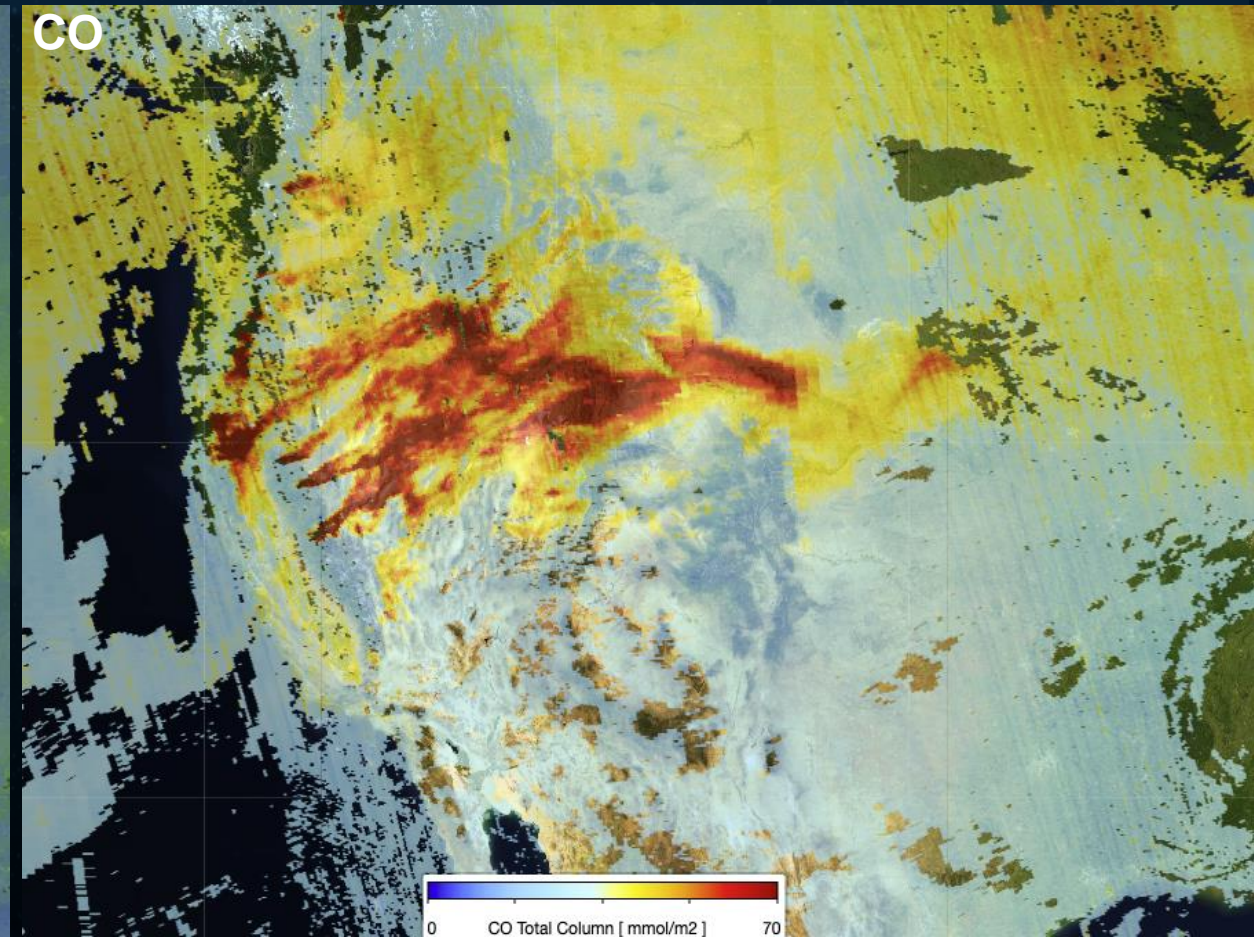


Wildfire emission measurements over Western USA (30 Aug 2021)

NO2



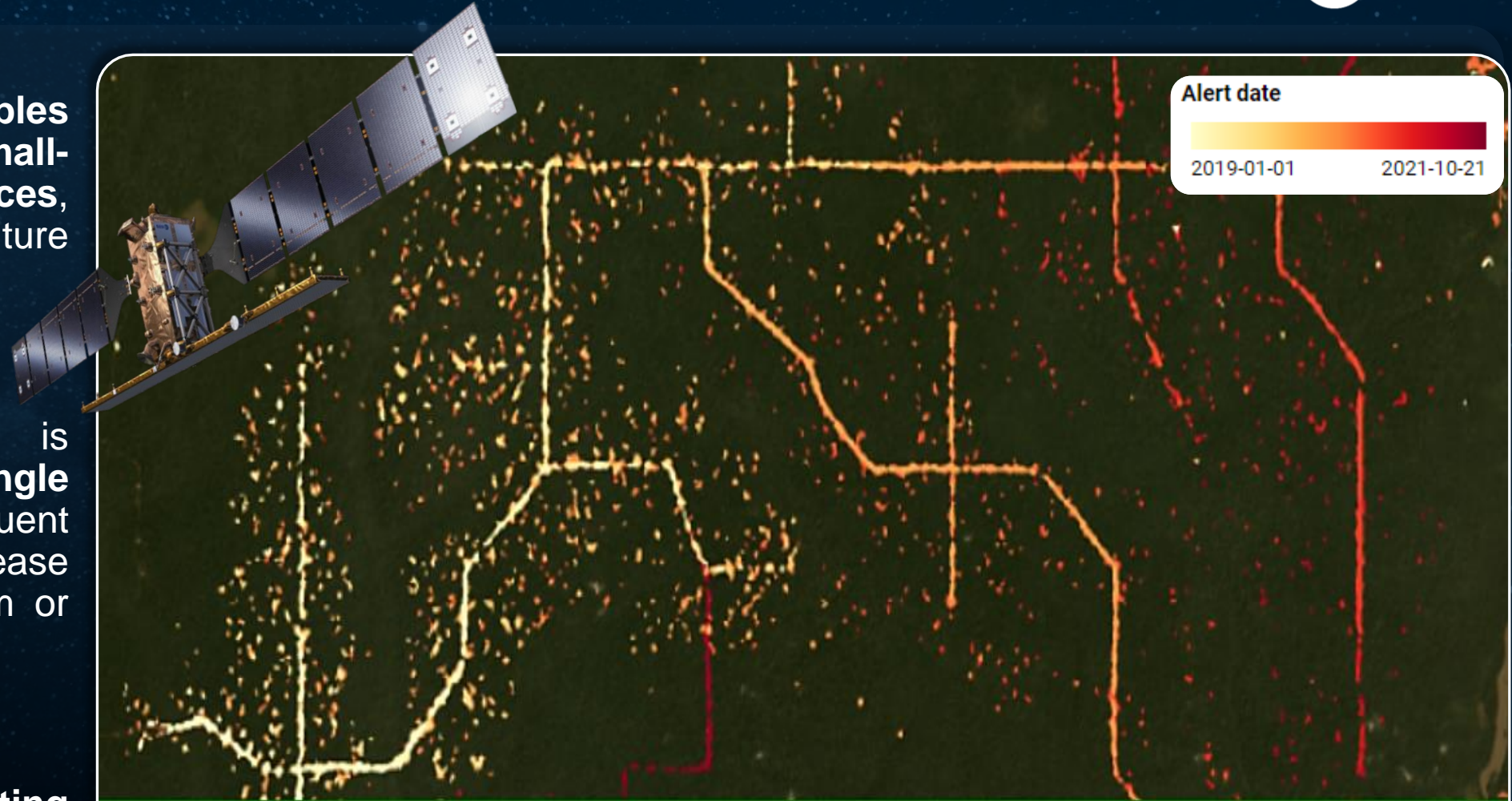
CO



Copyright: contains modified Copernicus Sentinel data (2021), processed by KNMI

Mapping RADD Forest Alerts with Sentinel-1 Data

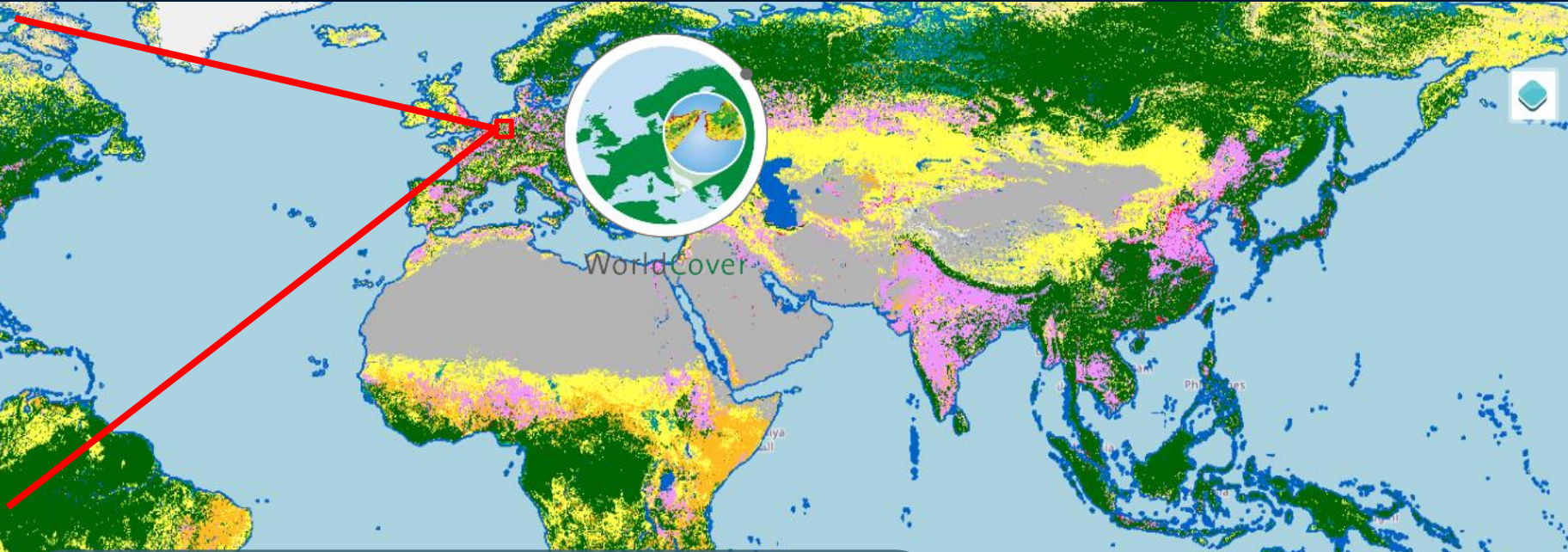
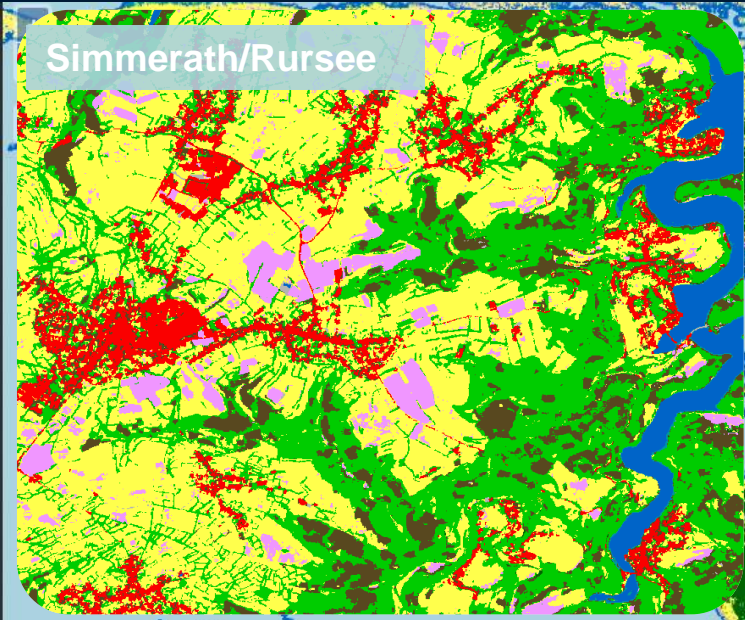
- Sentinel-1 data enables rapid detection of small-scale forest disturbances, e.g. subsistence agriculture and selective logging.
- A disturbance alert is triggered based on a single observation with subsequent observations used to increase confidence and to confirm or reject the alert.
- RADD (Radar for Detecting Deforestation) alerts are available on the Global Forest Watch platform



Forest disturbance alert in primary humid tropical forest (44 countries)

RADD Forest Disturbance Alert

Mapping Land Cover - ESA WorldCover 2020 Viewer and Downloader Released



- | | |
|--|------------------------|
| | Tree cover |
| | Shrubland |
| | Grassland |
| | Cropland |
| | Built-up |
| | Bare/sparse vegetation |
| | Snow and ice |
| | Permanent water bodies |
| | Herbaceous wetland |
| | Mangroves |
| | Moss and lichen |
- o 11 classes based on LCCS
 - o Cfr 10% prototype + Mangroves - Leaf types
 - o Annual cropland (no oil palm/olive trees or pastures)
 - o Swamp forest € tree cover

Released on 20th October 2021

- New Global Land Cover map at 10m resolution based on S1/S2
- Year 2020, 11 classes, ≈74% overall accuracy
- Independent data validation
- Highly robust for phenology
- Copernicus DEM used as auxiliary data

Involved stakeholders

- 5 key users
 - United Nations Convention to Combat Desertification
 - WORLD RESOURCES INSTITUTE
 - CIFOR
 - OECD
 - Food and Agriculture Organization of the United Nations
- Associate users
 - AVIA G/S
 - CSIRO
 - GEOBON
 - GEOGLAM Global Agricultural Monitoring
 - INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
 - Swiss Re
- European Directorates General (DG's)
 - AGRI; CLIMA; DEVCO; EEA; ENV; JRC

World Settlement Footprint (WSF) suite

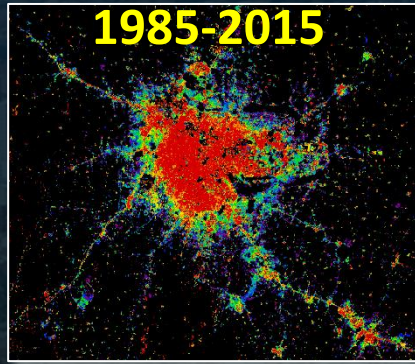
A collection of novel **open-and-free global datasets** produced by **DLR** in collaboration with **ESA** and **Google Earth Engine** for advancing the understanding of urbanization at high detail and accuracy.

WSF 2015



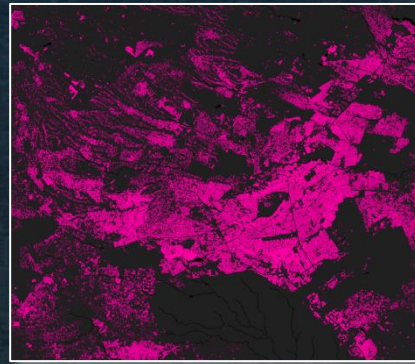
10m resolution

WSF evolution 1985-2015



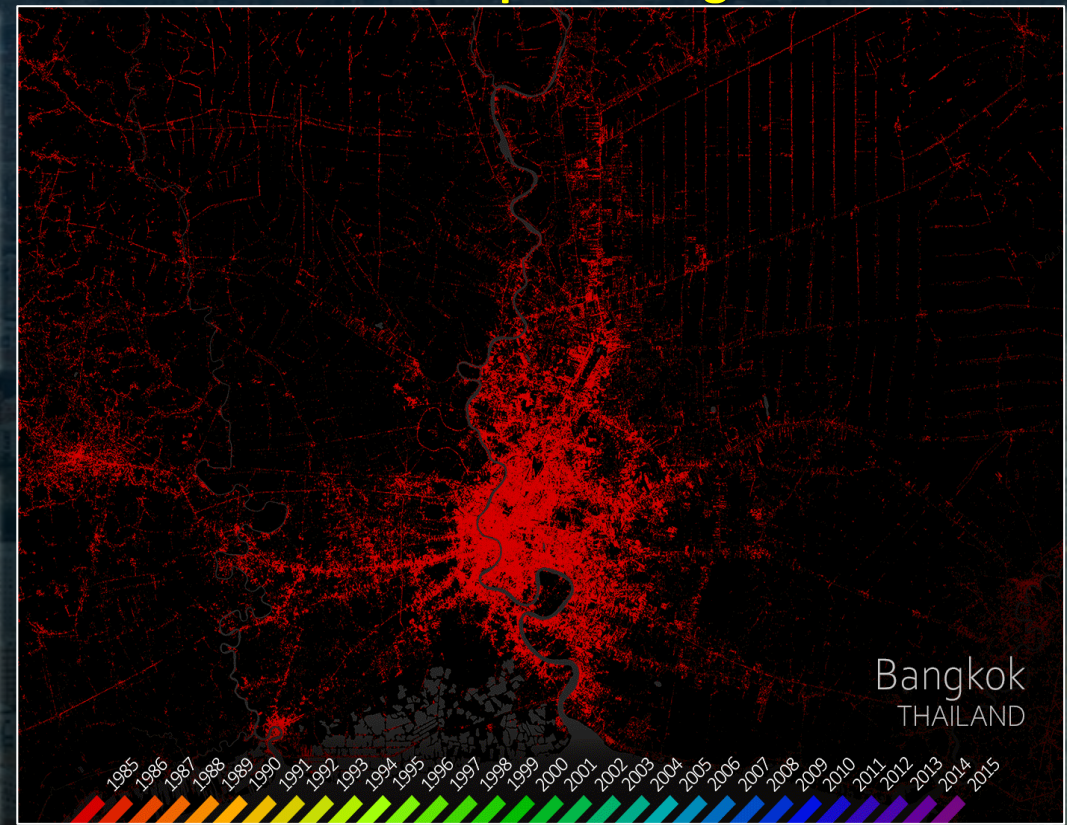
30m resolution

WSF 2019



10m resolution

WSF evolution example: Shanghai 1985-2015



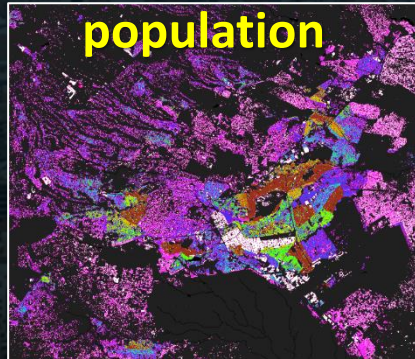
30m resolution

WSF 2019 imperviousness



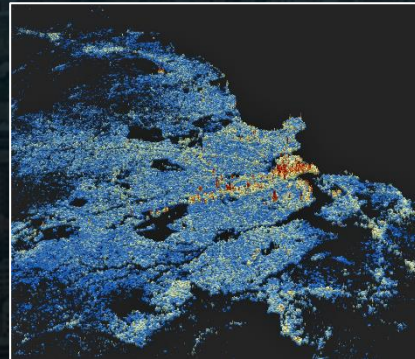
10m resolution

WSF 2019 population



10m resolution

WSF3D



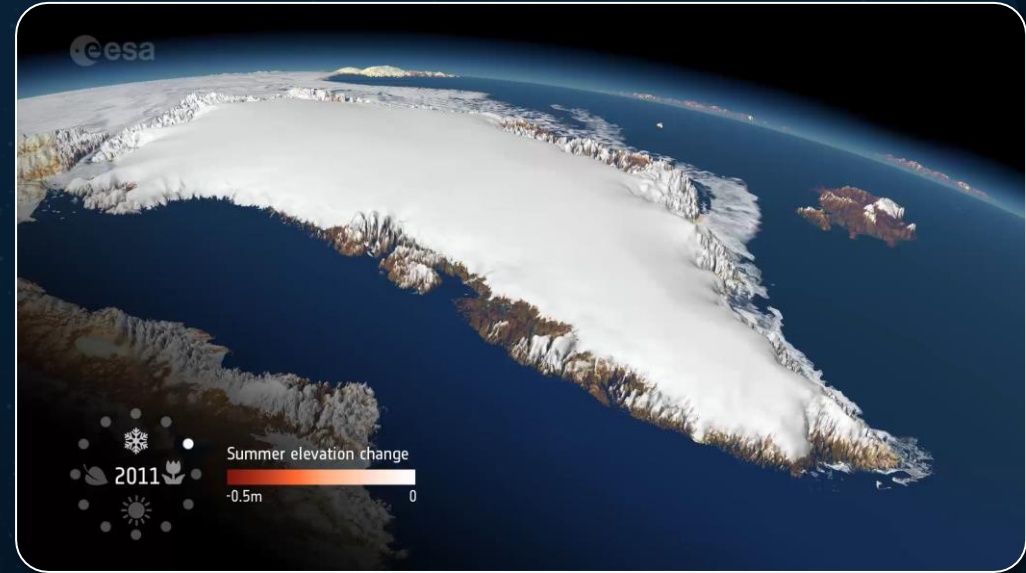
90m resolution



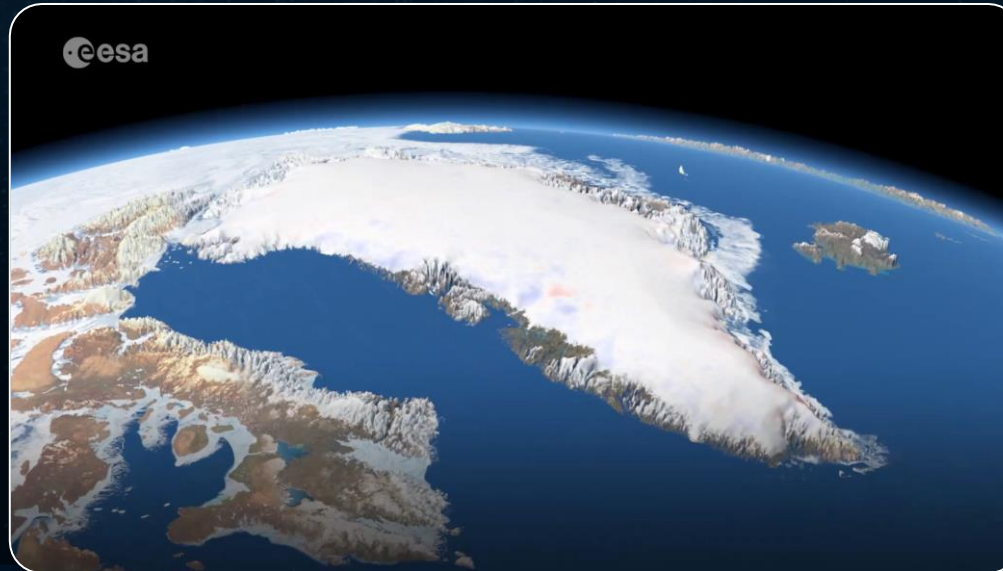
Satellites Measuring the Changing Cryosphere



Arctic Ocean Ice Free by Summer 2050

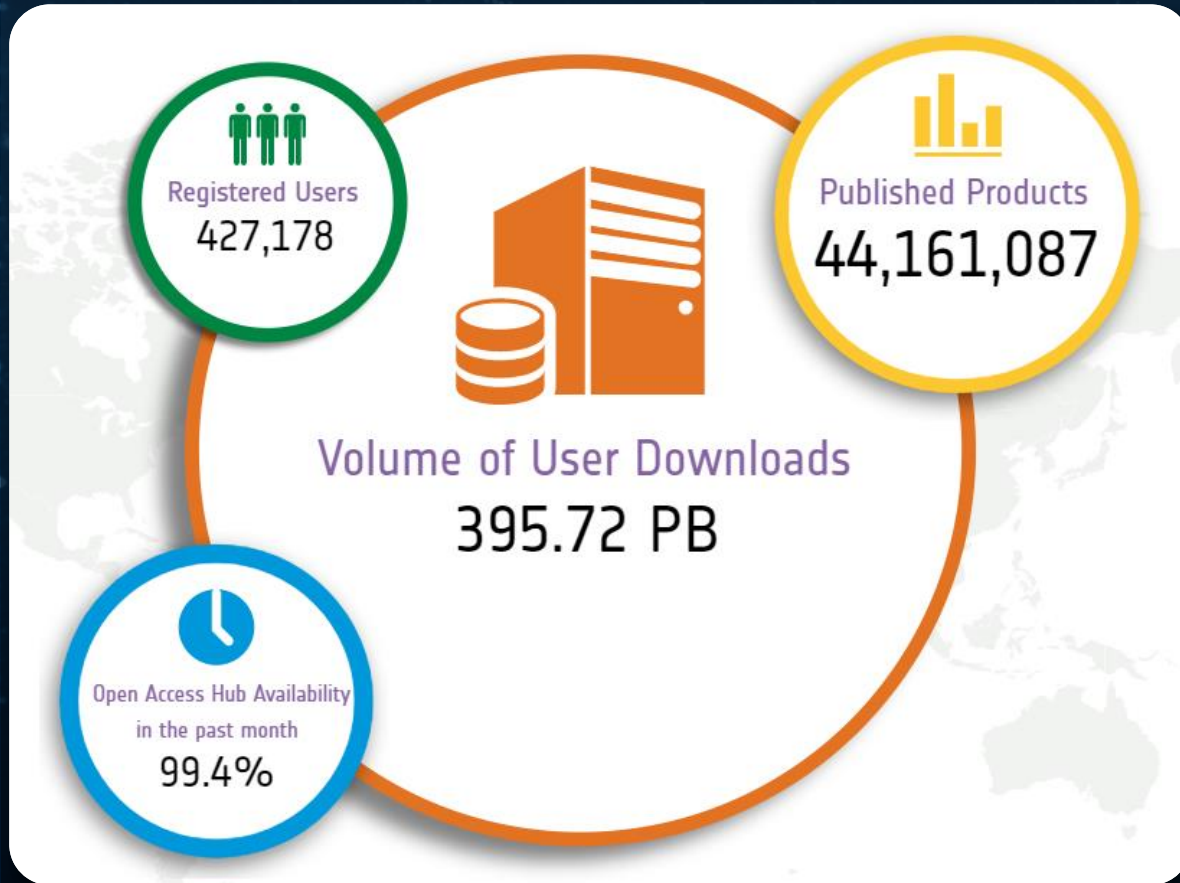


Meltwater runoff from Greenland becoming more erratic

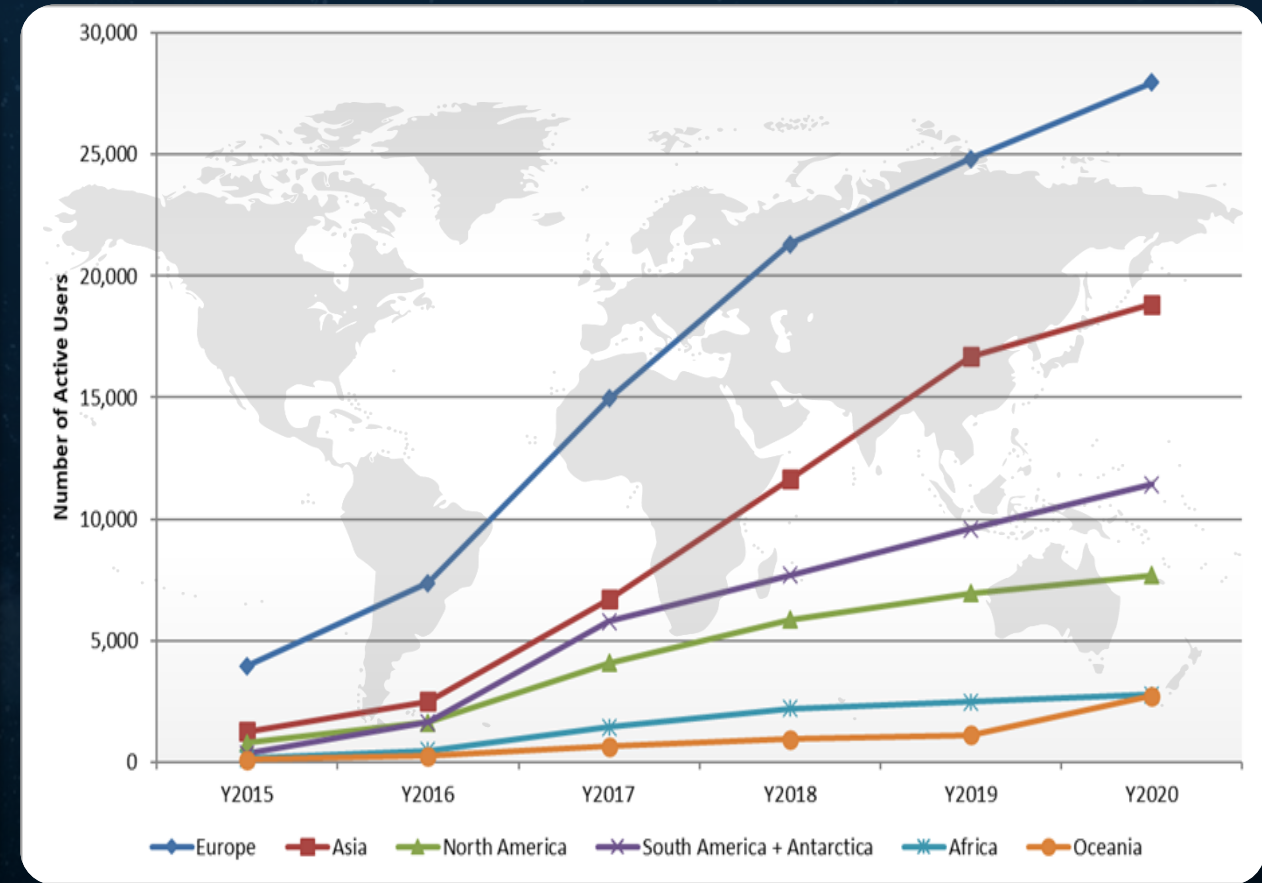


Greenland losing more ice per year than gained from snowfall

Copernicus Data Users Keeps Growing (Status Early Nov. 2021)



Registered Users, total data download and published products since start of operations



Active Users per continent on Copernicus Open Access Hub from 2015 to 2020

Strong Growth in European Downstream EO Industry

- 6th survey on the state & health of the EO services industry, prepared by EARSC with the support of ESA
- 2nd survey in new series of annual updates
- Direct research on over 600 companies; survey sample of 150 companies



EARSC Industry Survey 2021 for 2019-2020



713 Companies
up from
572 (+24%*)



11,600 Employees
up from
9800 (+17%*)



€1.71b Revenues
up from
€1.38b (24%*)



10% CAGR**
Sustained

* Year on year
** Over 5 years

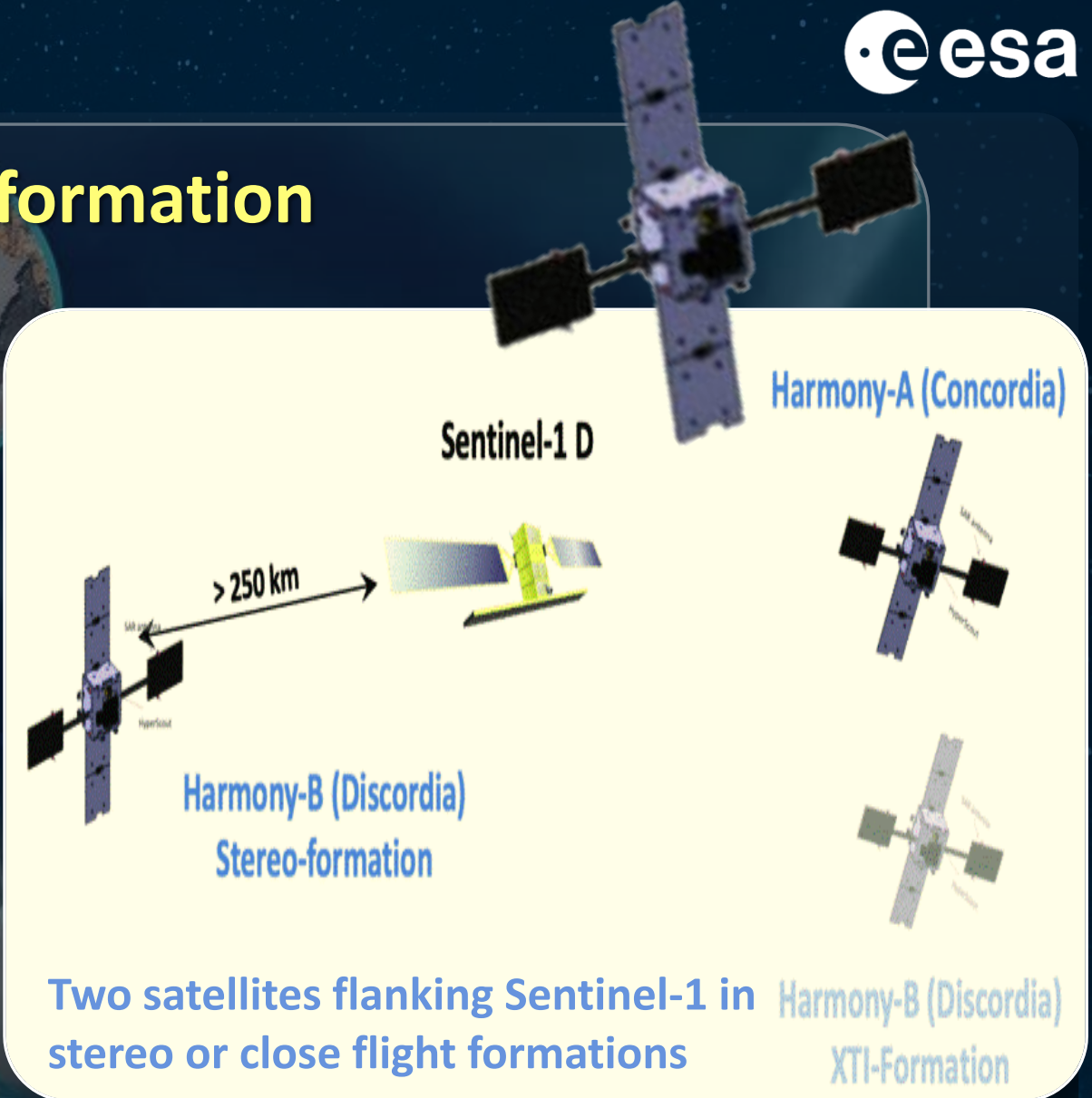
Studying small-scale motion & deformation fields

Mission for data-driven representations of processes in Earth System models

- Observing displacements in ocean, solid Earth & cryosphere
- Better understanding of: Ocean sub-mesoscale circulation patterns, Ice dynamics and mass balance, 3D deformation fields in land topography, Ocean-atmosphere boundary layer

Two passive receiving antenna satellites

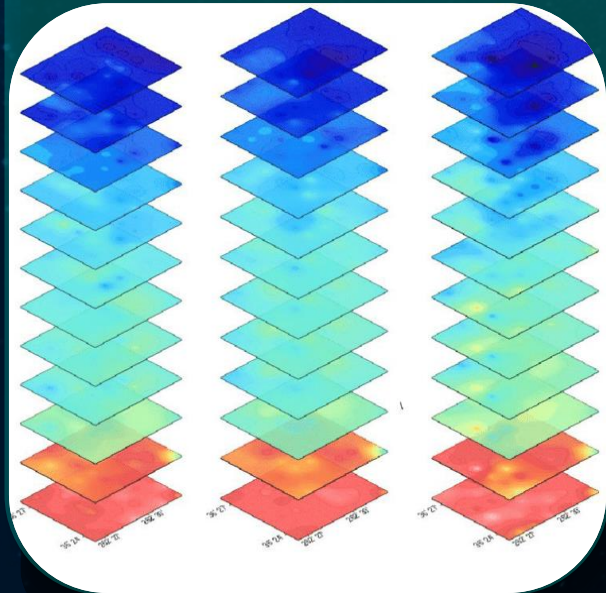
- Bi-static SAR, in stereo and close formation with Copernicus Sentinel-1
- ~250 Km baseline for along- and cross-track interferometry
- 3D Doppler/backscatter measurements +TIR



CAIRT

Understanding the links between CC and atmospheric chemistry and dynamics at 5 to 120 km

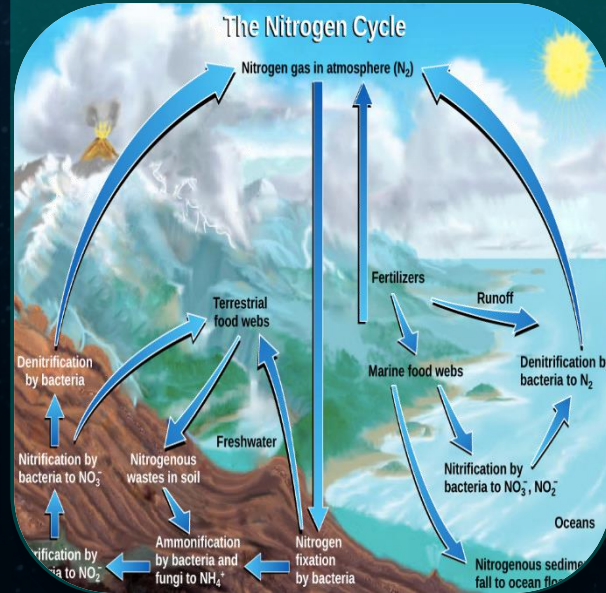
First limb-sounder with imaging Fourier-transform infrared technology in space



Nitrosat

Understanding the links between CC and the natural carbon and nitrogen cycles

Measurement of nitrogen dioxide and ammonia, two important reactive nitrogen compounds in the atmosphere



WIVERN

Improving the prediction of high-impact weather and hazard warnings

Dual-polarisation, conically scanning 94 GHz Doppler radar for measuring wind in clouds and delivering profiles of rain, snow and ice water



Seastar

Understanding air-sea interactions using two-antenna along-track interferometry radar

Providing ocean surface current & wind vectors at 1 km resolution for all the coastal ocean, shelf seas and marginal ice zones



EO at CM22



An ambitious CM22 package but our house is burning



Deadly flooding in Germany, Belgium fuelled by climate change, study finds

Issued on: 24/08/2021 - 01:10



Climate crisis made deadly German floods 'up to nine times more likely'

Europe's deadly floods leave scientists stunned

By Warren Cornwall | Jul. 20, 2021, 3:30 PM



World | Africa | Asia | Australia | Europe | Latin America | Middle East | US & Canada

Greece wildfires spread, causing mass evacuations



Greece: The BIGGEST fire of all time, up to 700,000 acres have been burned

by ATHENS BUREAU

NSW floods break 120-year-old rain records during March rain event, BOM says

ABC Weather / By Ben Deacon

Posted Mon 19 Apr 2021 at 10:24pm, updated Tue 20 Apr 2021 at 12:56am

The entire New South Wales coast experienced its wettest week ever

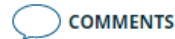
NEWS DEFEND THE PLANET

Deadly Heatwaves & Floods: UK Failing to Prepare for Impact of Climate Crisis Say Experts

Hot weather, wildfires, and more flooding are likely, but the country isn't adapting, says report.



'Lucifer' could see Italy shatter Europe's heat record as temperatures near 49°C in Sicily



By AP with Euronews • Updated: 12/08/2021



Climate change: US-Canada heatwave 'virtually impossible' without warming

By Matt McGrath
Environment correspondent | 8 July | Comments

Greenland experienced 'massive' ice melt this week, scientists say

July 30, 2021

7:13 PM CEST

Last Updated a month ago

By Kate Abnett

VANCOUVER | News

Metro Vancouver saw 15 times more heat wave deaths than estimated during unprecedented alert



© Sebastien Bozon, AFP



“EO IS KEY” to Understanding Our Planet



“EO IS KEY”

- To understand our natural world and its complexity
- To address critical and urgent European and Global challenges & threats

Expanding Europe’s leadership in EO

Earth Explorer 9 FORUM <small>Far-infrared-Outgoing-Radiation Understanding and Monitoring</small>	Copernicus <small>6 ESA-funded Sentinels (+ 6/7 EU-funded recurrent)</small>	TRUTHS <small>Phase A/B1</small>
Small Missions <small>1-2 SCOUTS and 2-4 Φ-sats</small>		ARCTIC WEATHER
	Prepare future Missions <small>Sentinels NG Phase AB1 in FutureEO Aeolus follow-on, Earth Explorer-10, Next Generation Gravity Mission with NASA</small>	ALTIUS <small>Phase E</small>
		Proba-V <small>Exploitation + 2 Smallsat</small>

Measure, model and predict the climate & biodiversity crises

Building the future with next gen EO missions & systems

- Push frontiers of tech & scientific knowledge
- Maintain European EO leadership
- System of systems architecture

Support Policy

- European Green Deal
- Climate neutrality in 2050
- UNFCCC Paris Agreement
- New laws on circular economy, building renovation, biodiversity, farming and innovation

Fulfilling the 5 ESA Agenda 2025 Priorities

- Strengthen ESA-EU relations
- Boost green and digital commercialization
- Develop space for safety and security
- Address critical programme challenges
- Complete the ESA transformation

Multiply societal & economic value of EO

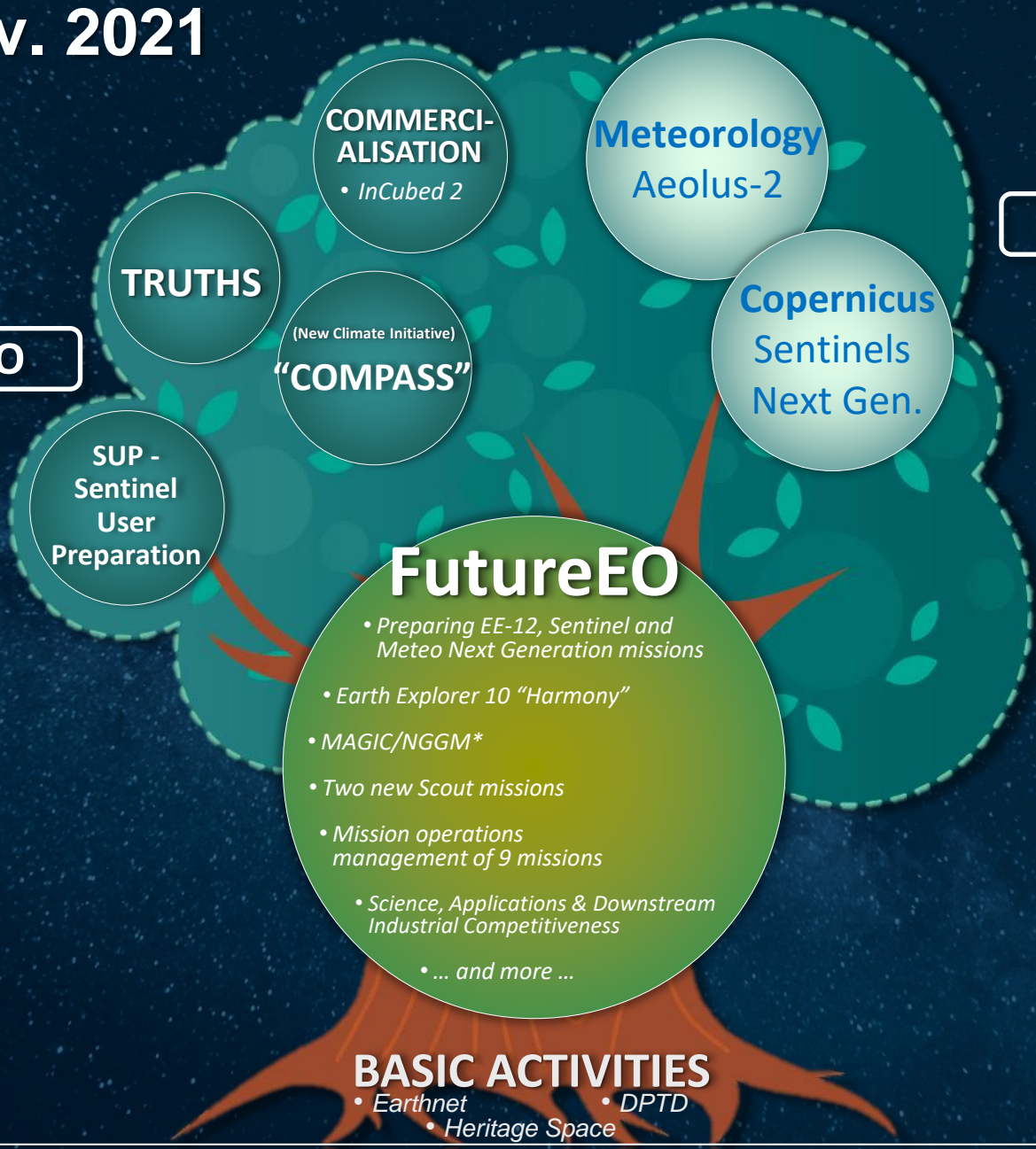
- Deploy disruptive innovation & boost EO economy
- Support disaster mgmt.



EO Programme in Nov. 2021

CUSTOMISED EO

OPERATIONAL EO



MULTI-DOMAIN ACTIVITIES WITH EO INVOLVEMENT



Digital Twin Earth & Universe



Civil Security from Space

BASIC ACTIVITIES

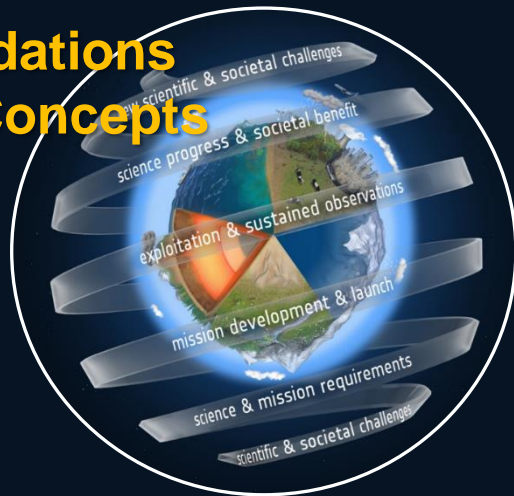
- Earthnet
- DPTD
- Heritage Space

* NGGM (Next Generation Gravity Mission) is a Mission of Opportunity in cooperation with NASA to enable the Mass change and Geosciences International Constellation (MAGIC)



Earth Science, Preparation of EO future and World-class EO Research Missions

Foundations and Concepts



Research Missions



Mission Mgmt. & Ground Segment



Earth Science for Society



Harmony

Scout 3 & 4

EE-11

MAGIC/NGGM

earthcare

hydrognss

swarm

cubema p

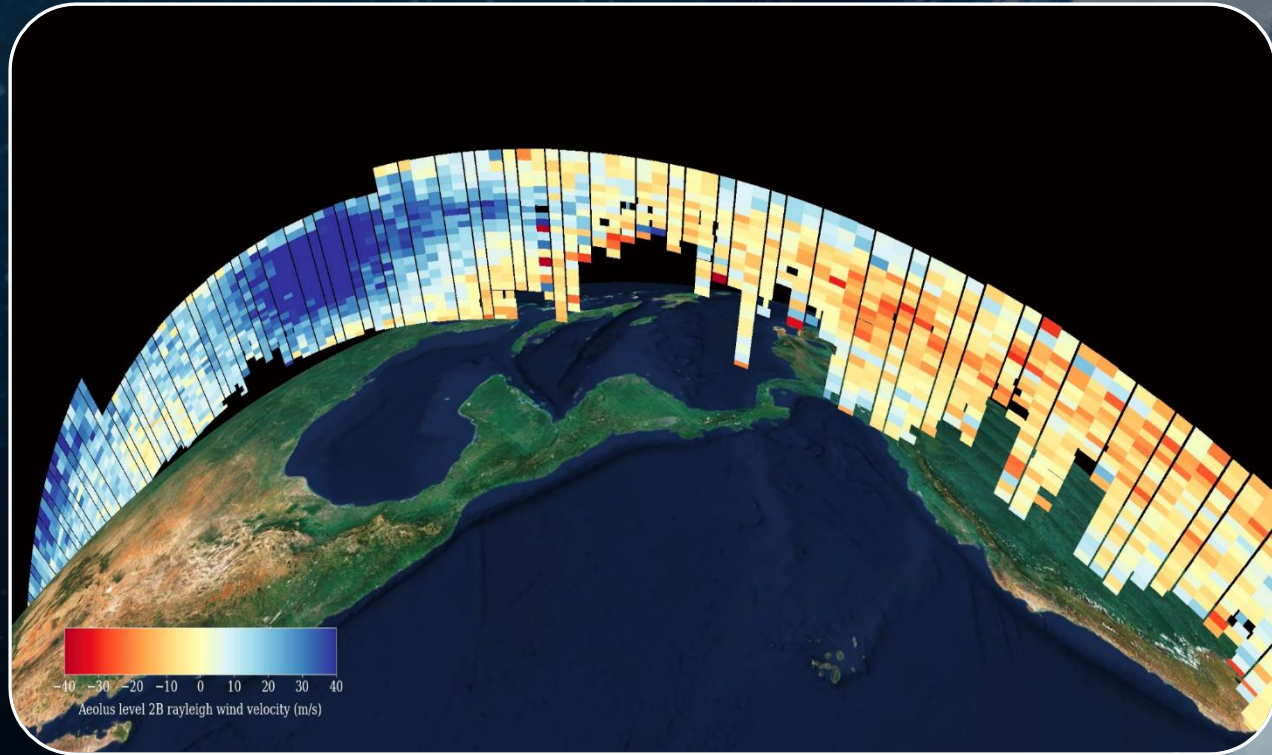
cryosat

flex

smos

biomass

Securing the long-term continuation of Europe's eyes on our planet



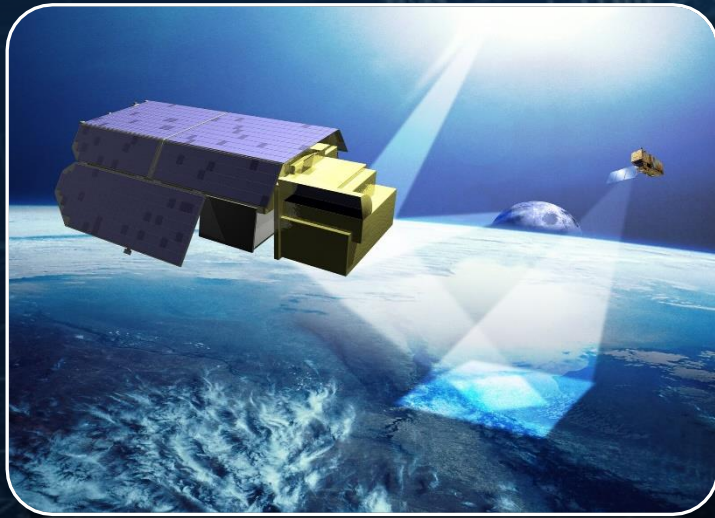
Meteorology - Aeolus-2

Copernicus Sentinels Next Generation



Customised EO

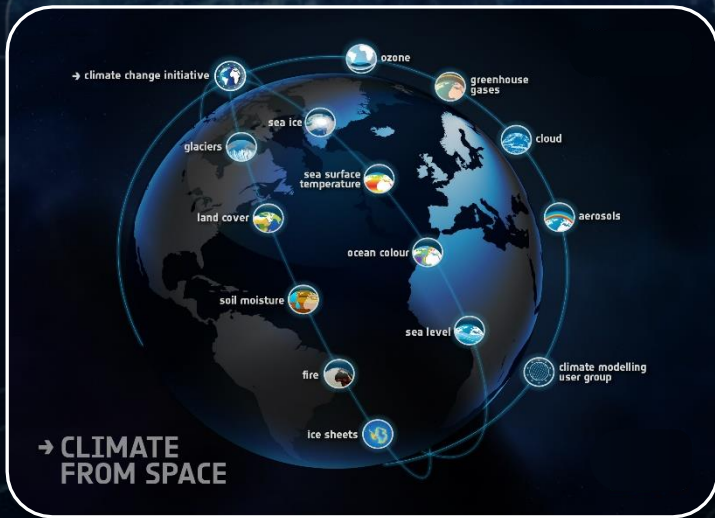
Pre-operational activities answering demands from user communities, industry, Member States



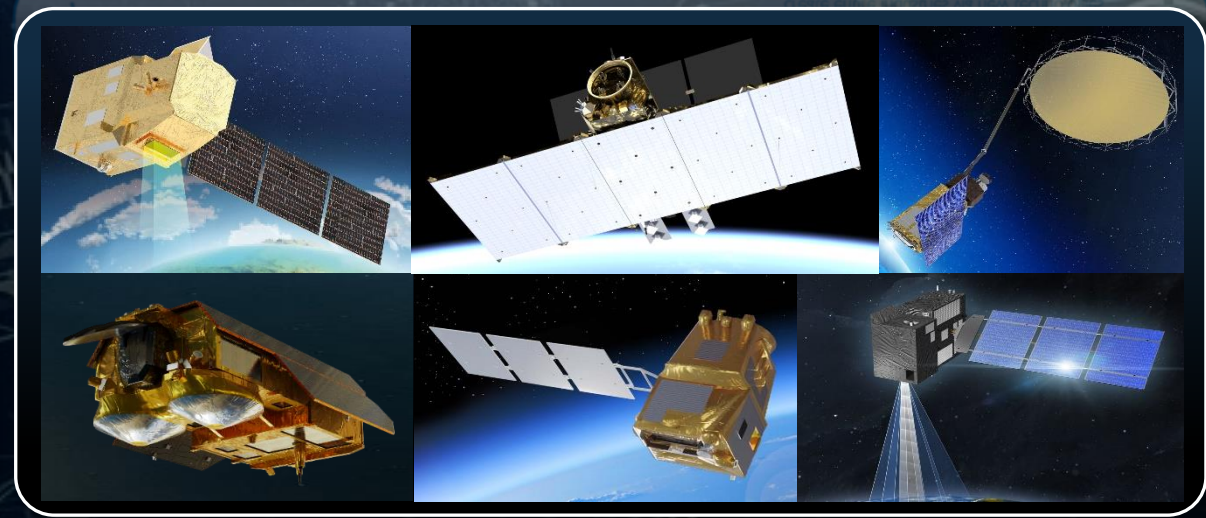
Truths



Incubed-2



New Climate Initiative: COMPASS

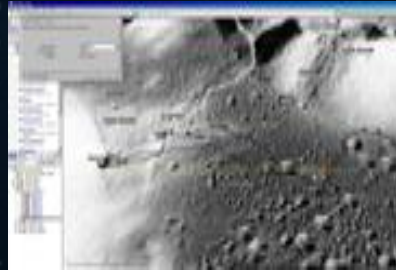


SUP: Sentinel User Preparation

Basic Activities

Worldwide data and a walk in the past to better understand the present and the future

Heritage Space



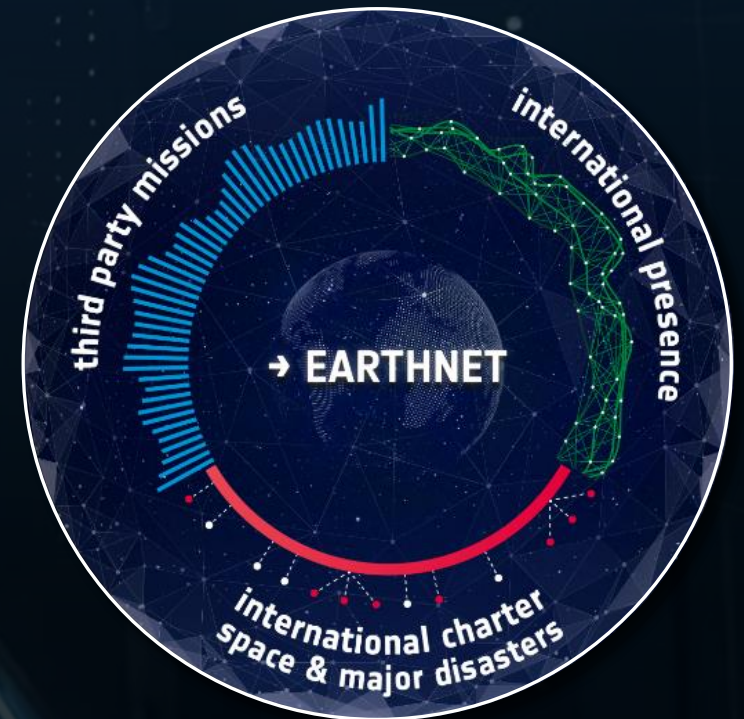
PRESERVE AND KNOW THE PAST

UNDERSTAND THE PRESENT

SHAPE AND ENABLE THE FUTURE



Earthnet



Two Multi-domain Activities with EO involvement

Digital Twin of the Earth and Universe



Civil Security from Space



Going beyond the borders of Earth Observation



Ambitious Vision for Accelerating Space in Europe



Presented and endorsed by ministers at the recent IMM



ACCELERATING



Space for a Green Future

ACCELERATING



Rapid & Resilient Crisis Response

ACCELERATING



Protection of space assets



Role of ESSC to support ESA/EOP

- Chris Rapley is member (ex officio) of ACEO (EOP/EOP Advisory Committee for Earth Observation)
- Important role of ESSC to provide a position wrt to the ESA programmes proposed at CM-22, including for EO
- ESA/EOP will start the update the EO science strategy. If interested, potential role of ESSC to support this task
- ESA-EGU EO award : If interested, ESSC could organise the science (external) panel to evaluate the nominations of potential awardees

living planet symposium

BONN
23-27 May
2022

TAKING THE PULSE
OF OUR PLANET
FROM SPACE

**Abstracts deadline extension:
~~26 Nov. 2021~~ => 10 Dec 2021**

MAKE SPACE FOR EUROPE

www.esa.int