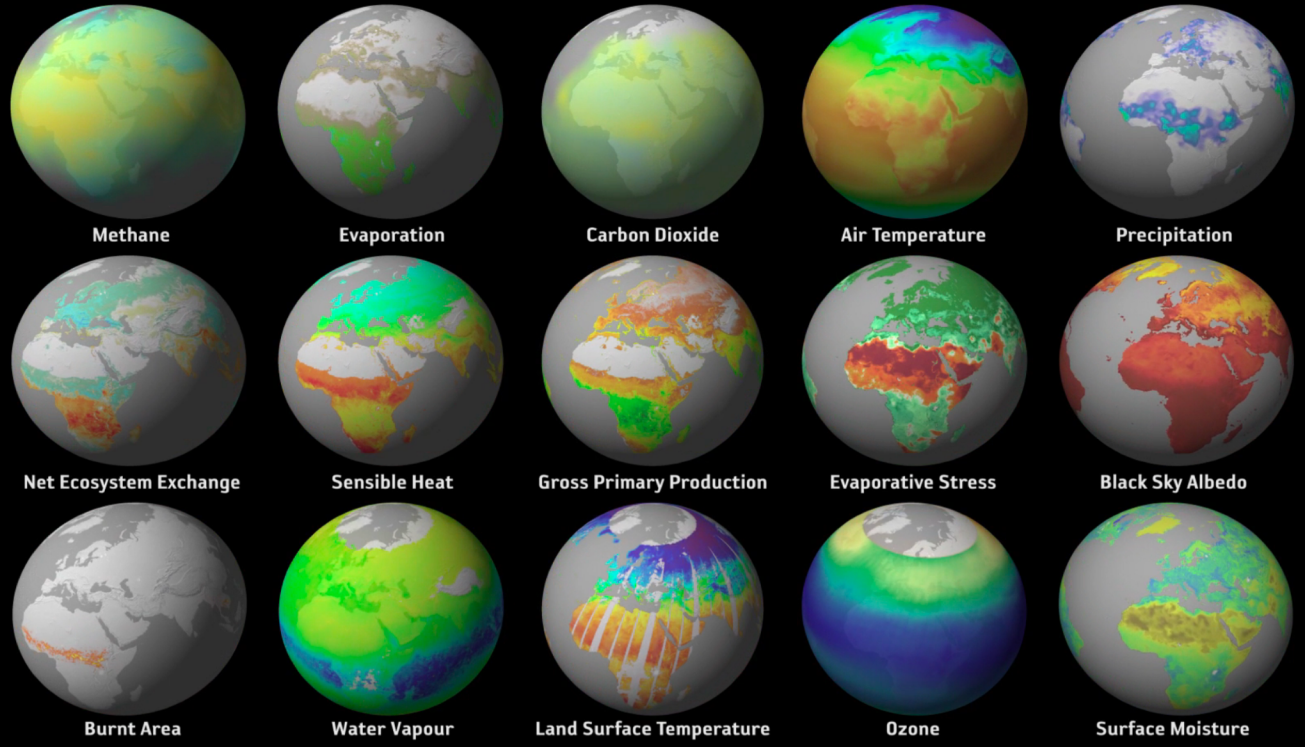
ESA Earth Observation Programs and Missions

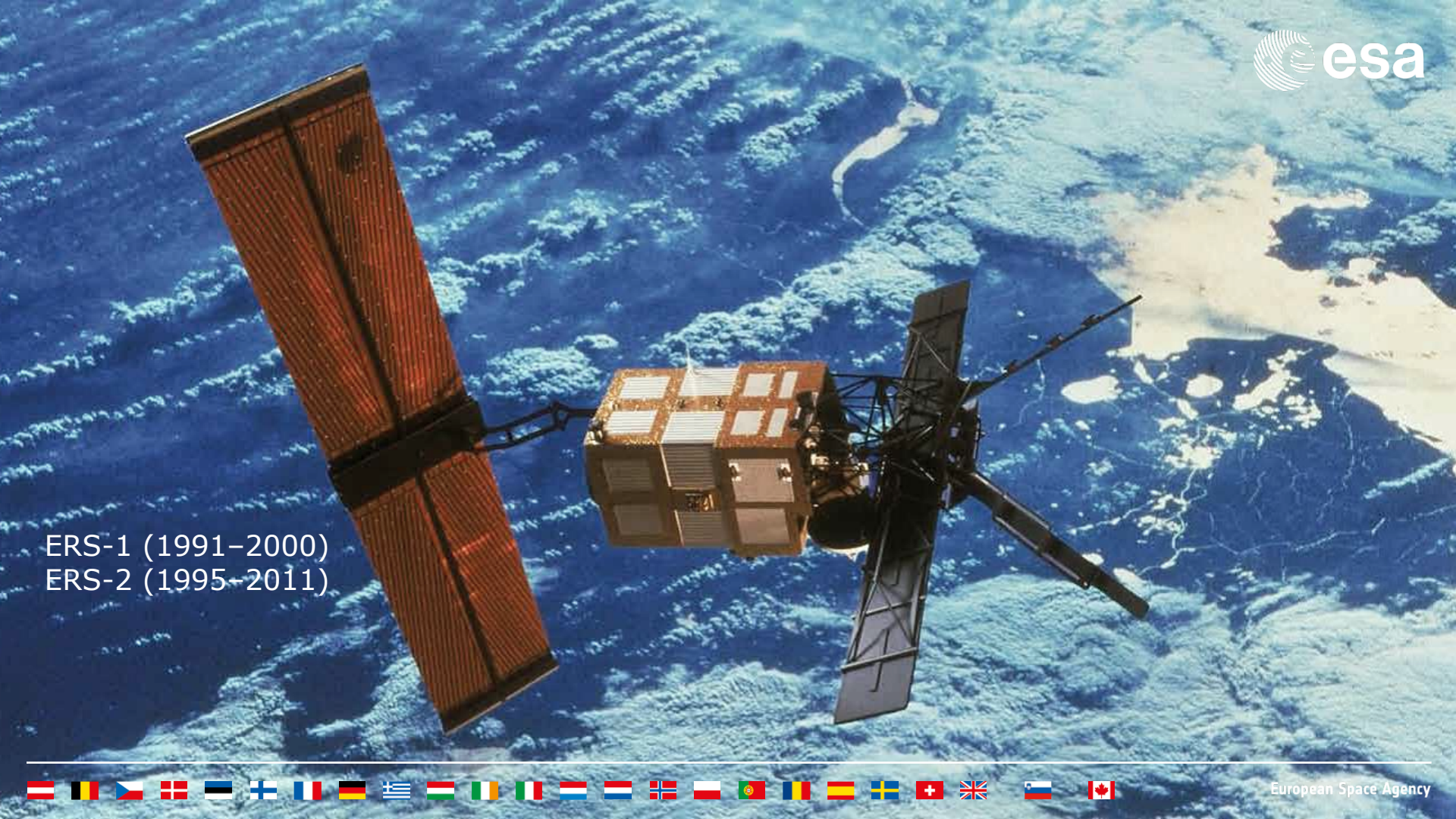
Dragon 4
18 Nov 2019 Chongqing China
2019年11月18日 中国重庆

Eric Doyle, ESA
Science, Applications and Climate Department
Directorate of Earth Observation Programmes

Our Mission is to develop world class Earth observing systems addressing scientific and societal challenges with European and global partners

ESA Monitors the Health of the Planet




esa
ERS-1 (1991–2000)
ERS-2 (1995–2011)
European Space Agency

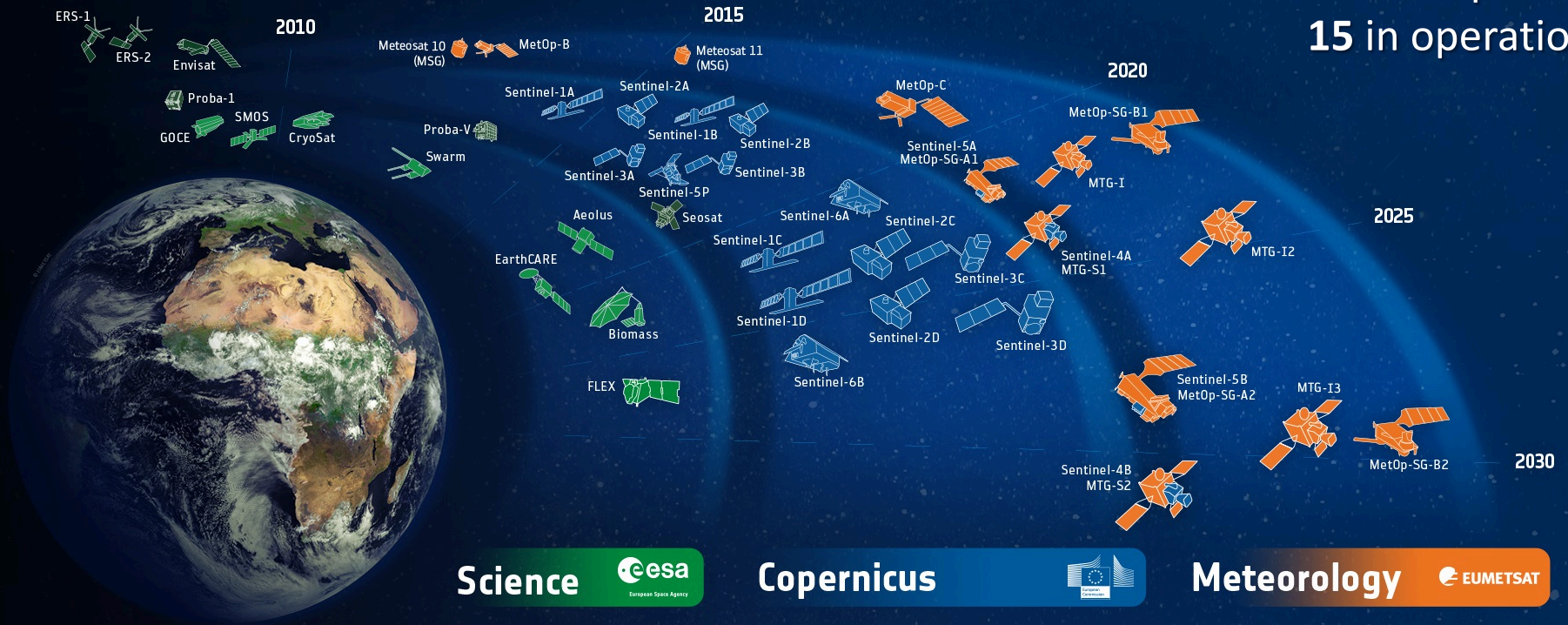

esa
Envisat (2002–2012)
European Space Agency

ESA-Developed Earth Observation Missions

Satellites

25 under development

15 in operation



ESA-Developed Earth Observation Missions

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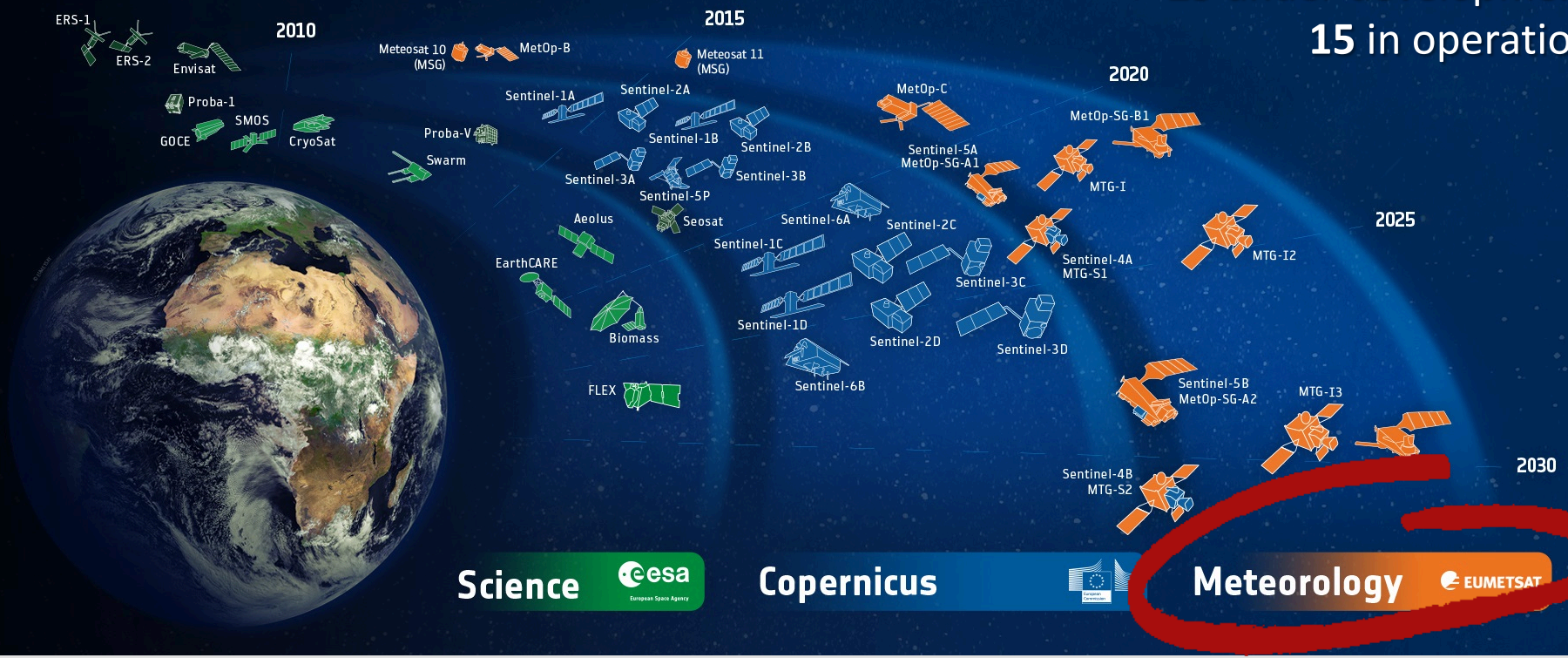
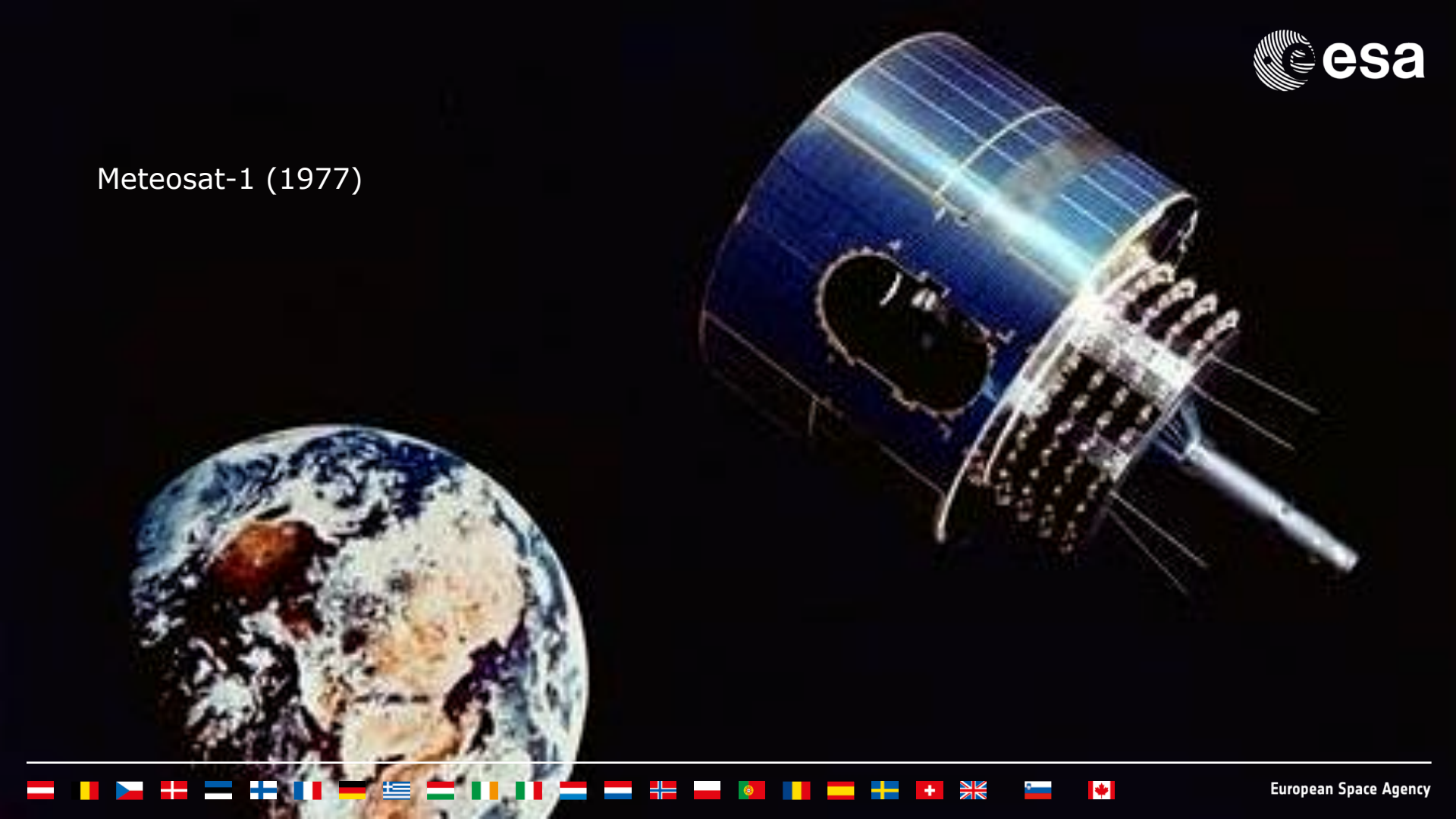
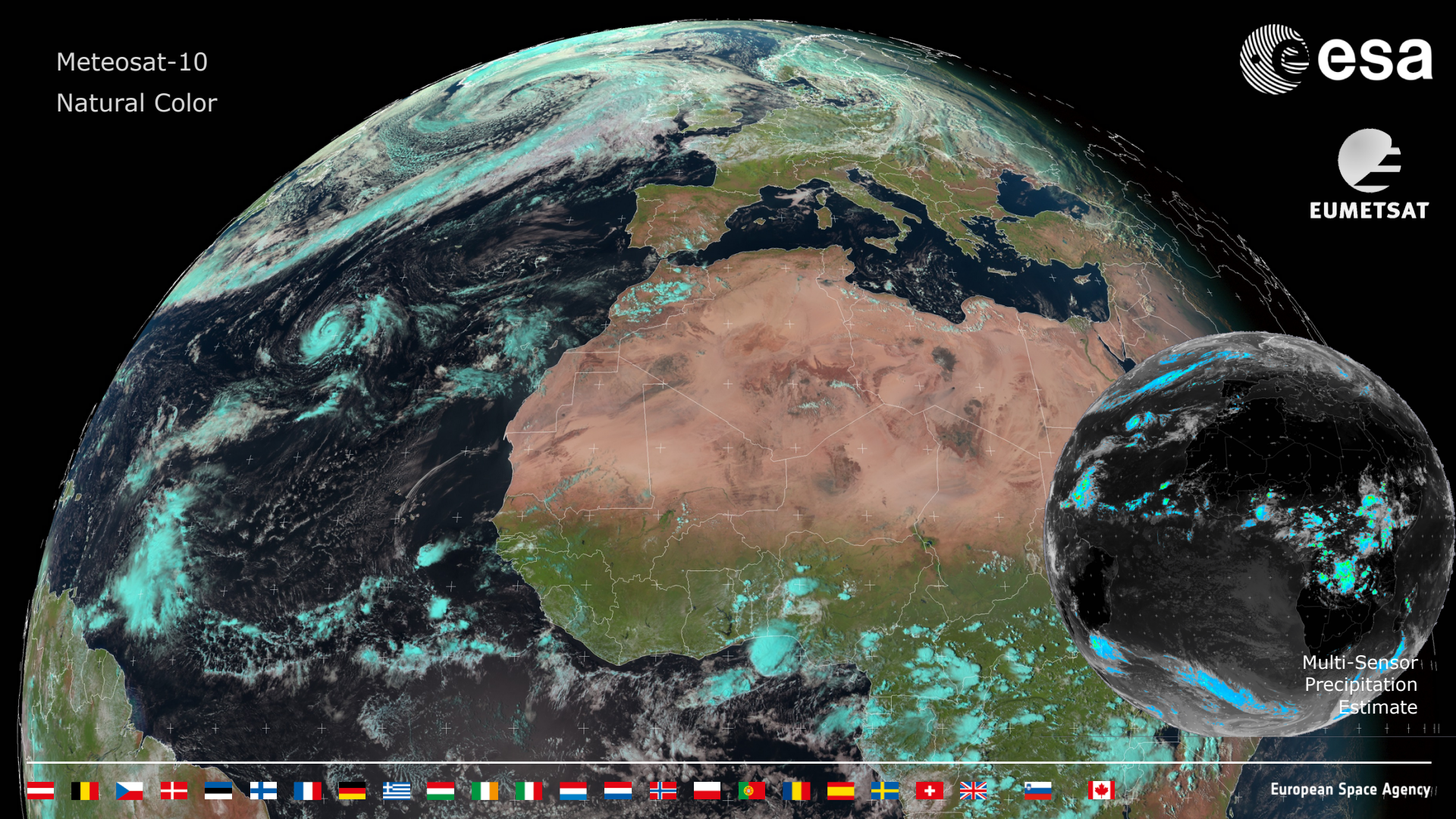


Meteosat-1 (1977)



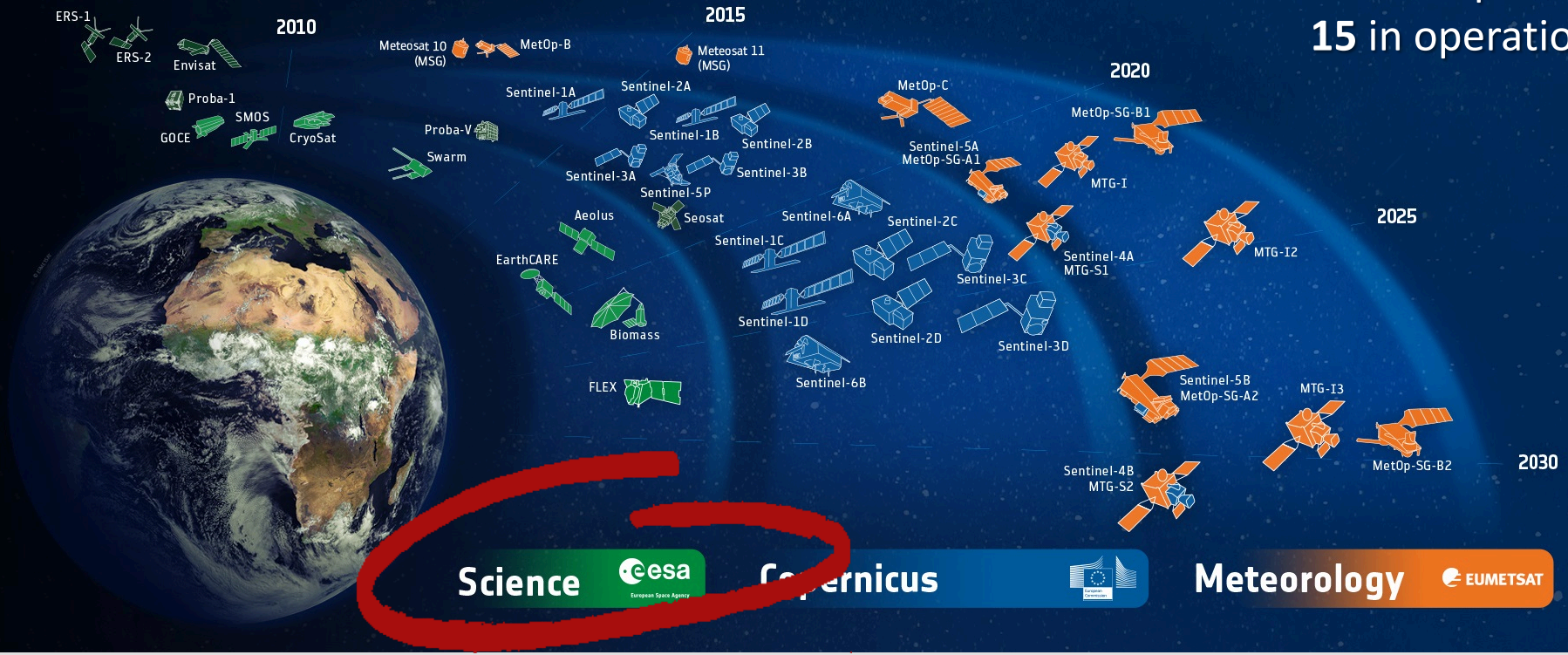

Meteosat-10
Natural Color
esa
EUMETSAT
Multi-Sensor
Precipitation
Estimate
European Space Agency

ESA-Developed Earth Observation Missions

Satellites

25 under development

15 in operation



The Earth Explorers Missions

- Science driven programme
- Mission selection proposed by a peer committee "Advisory Committee for Earth Observation"
- Financed through the Earth Observation Envelope Programme (EOEP)
- On average one mission every 2 years

Explorer Core Missions

Major missions covering primary research objectives

Fast Track Missions

Smaller research and demonstration missions

Earth Explorers

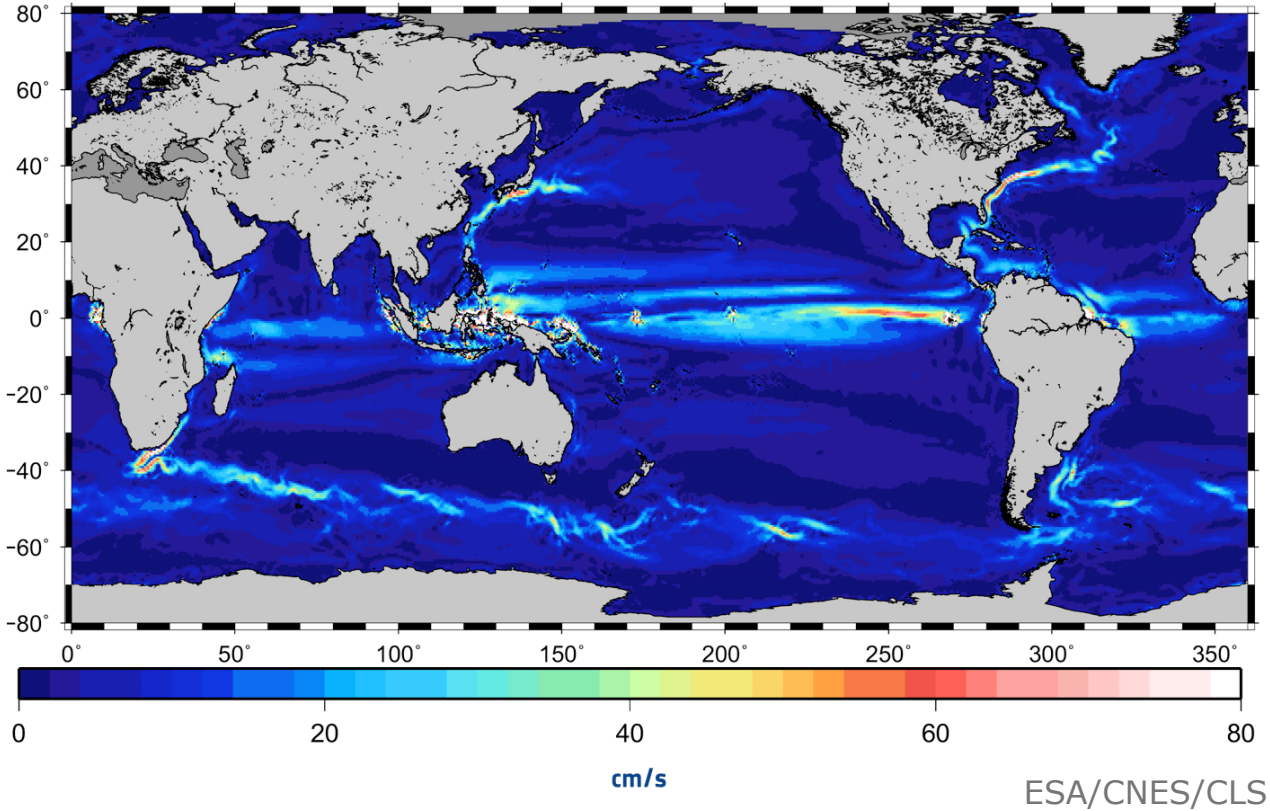
- **GOCE** (2009–13) studying Earth's gravity field
- **SMOS** (2009–) studying Earth's water cycle
- **CryoSat-2** (2010–) studying Earth's ice cover
- **Swarm** (2013–) three satellites studying Earth's magnetic field
- **ADM-Aeolus (2018)** studying global winds
- **EarthCARE (2022)** studying Earth's clouds, aerosols and radiation (ESA/JAXA)
- **Biomass** (2022) studying Earth's carbon cycle
- **FLEX** (2024) studying photosynthesis
- **Forum (2026)** measure radiation emitted from the Earth
- Earth Explorer 10 to be selected (3 candidates)


esa
GOCE Mission
European Space Agency

GOCE: ESA's Gravity Field and Steady-state Ocean Circulation Explorer

- First gradiometer in space launched 17 March 2009
- Best ever static geoid
- Various versions of the geoid have been released including all GOCE measurements
- End of mission declared 21 October 2013 following depletion of Xenon fuel
- Re-entry 11 November 2013

GOCE & Altimetry: Global Mean Ocean Currents



ESA/CNES/CLS

Altimetry derived mean sea surface when combined with GOCE geoid gives the "mean dynamic topography" (MDT)

MDT is the relief or shape of the ocean surface corresponding to mean ocean circulation

GOCE geoid contributing to the fundamental understanding of role of global ocean circulation in distributing heat and freshwater/salt.

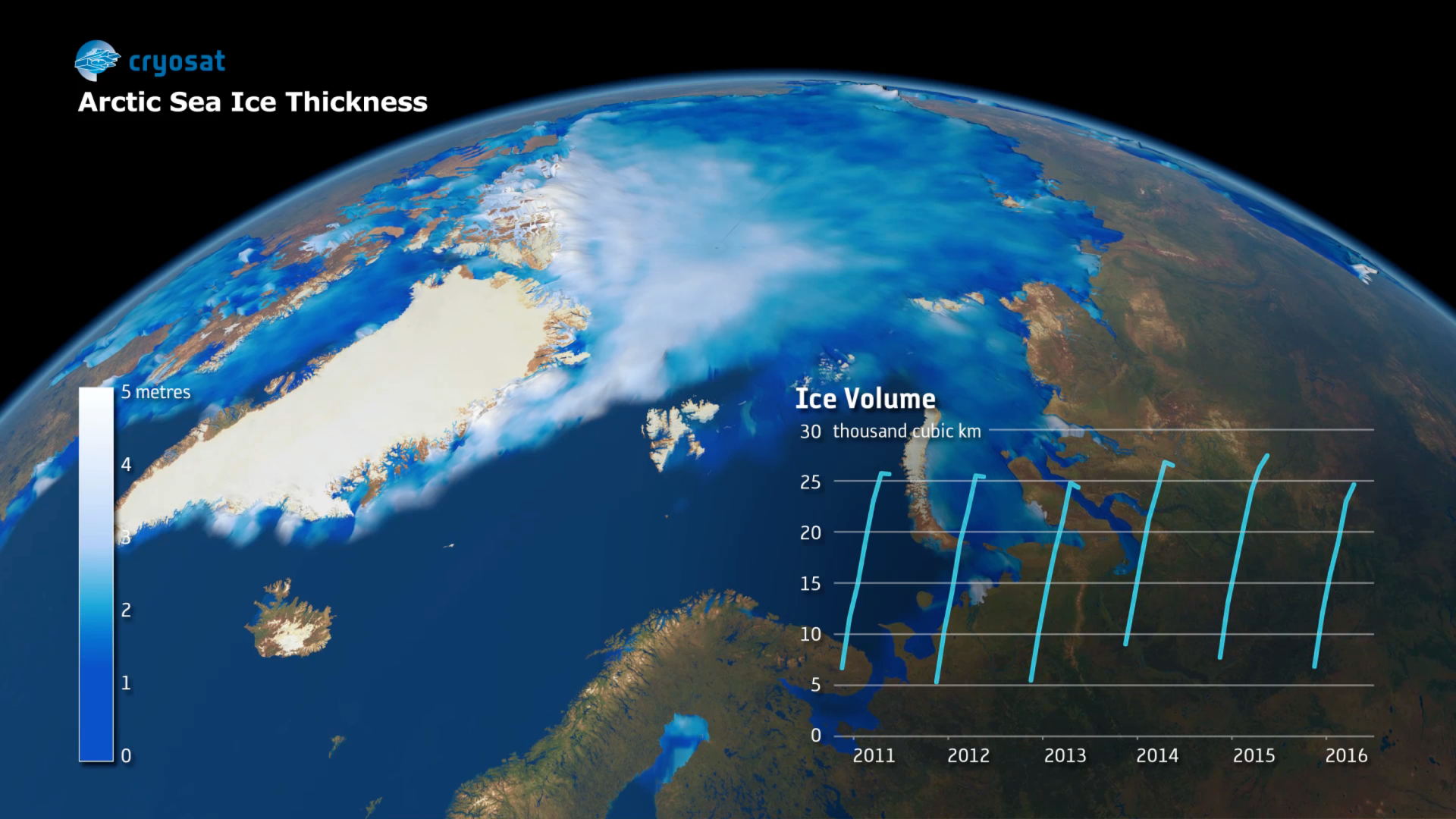
CryoSat Mission

CryoSat: ESA's Ice Mission

- Launched 8 April 2010
- First interferometric altimeter in space
- Global ice elevation & thickness change measurements
- Data used for ice research, but increasingly also for mountain glaciers/ice caps, oceanography, river & lakes, and bathymetry

cryosat

Arctic Sea Ice Thickness

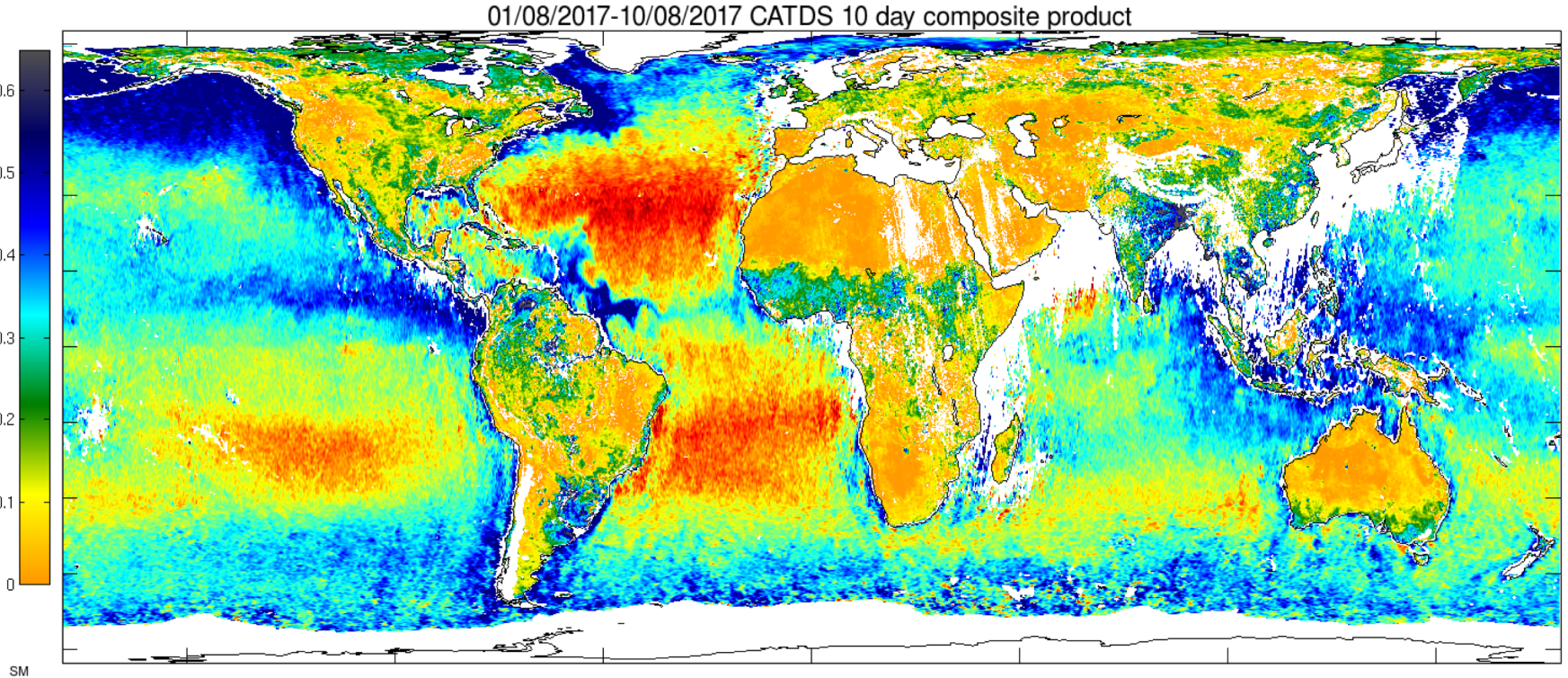



esa
SMOS (Soil Moisture and Ocean Salinity)
European Space Agency

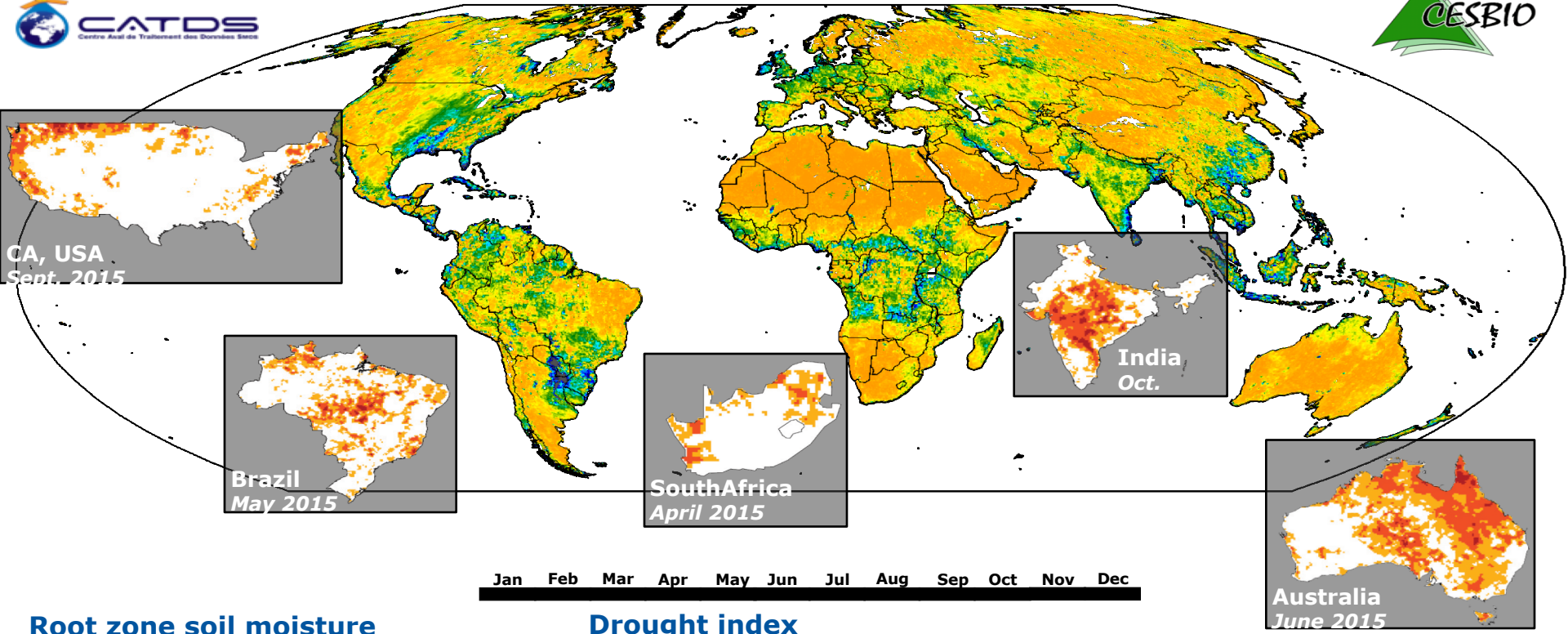
SMOS: Soil Moisture & Ocean Salinity Mission

- Launched 02 November 2009
- Data delivery since February 2010
- Complete Earth coverage within three days
- Radio Frequency Interference (RFI) mitigation continues
- Outstanding international cooperation

SMOS Measurements

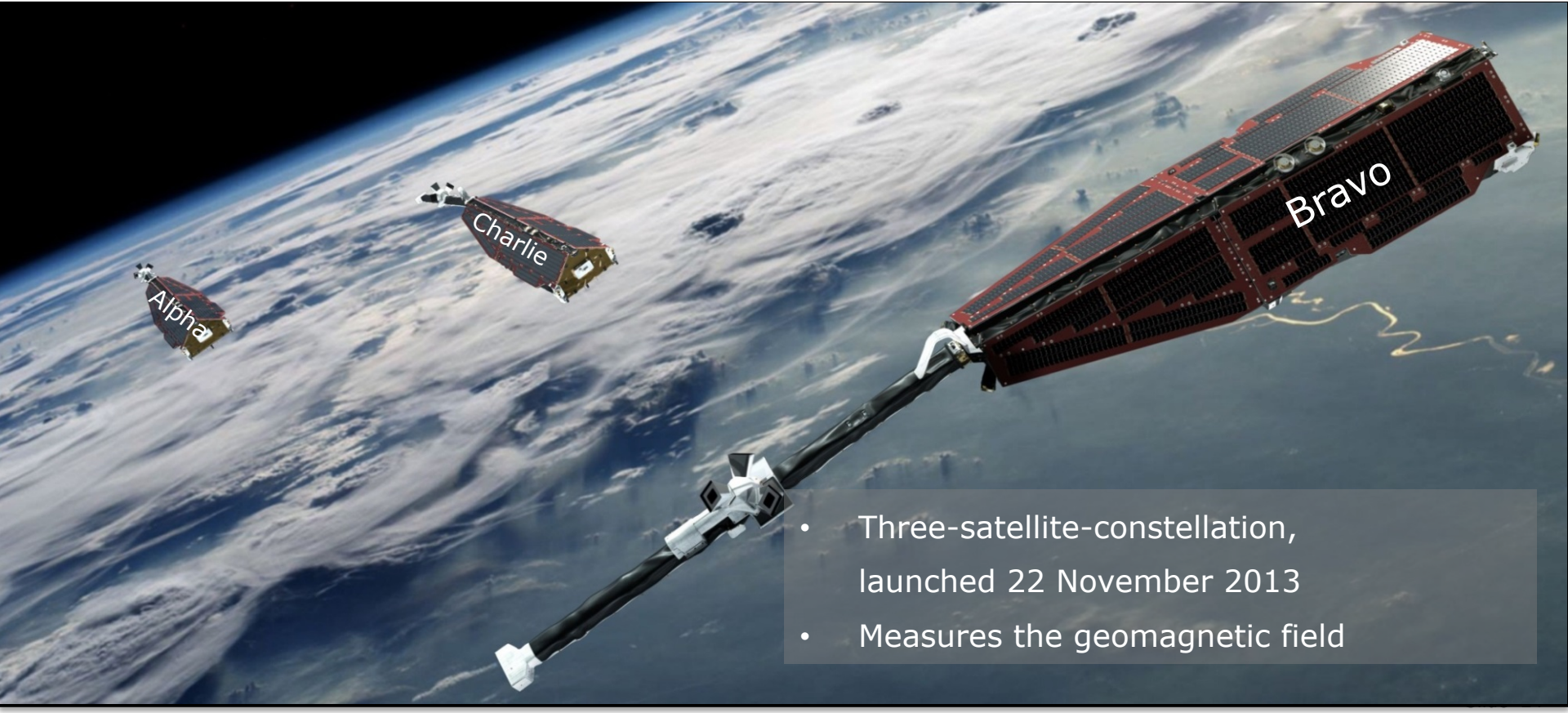


SMOS monitoring major droughts in 2015



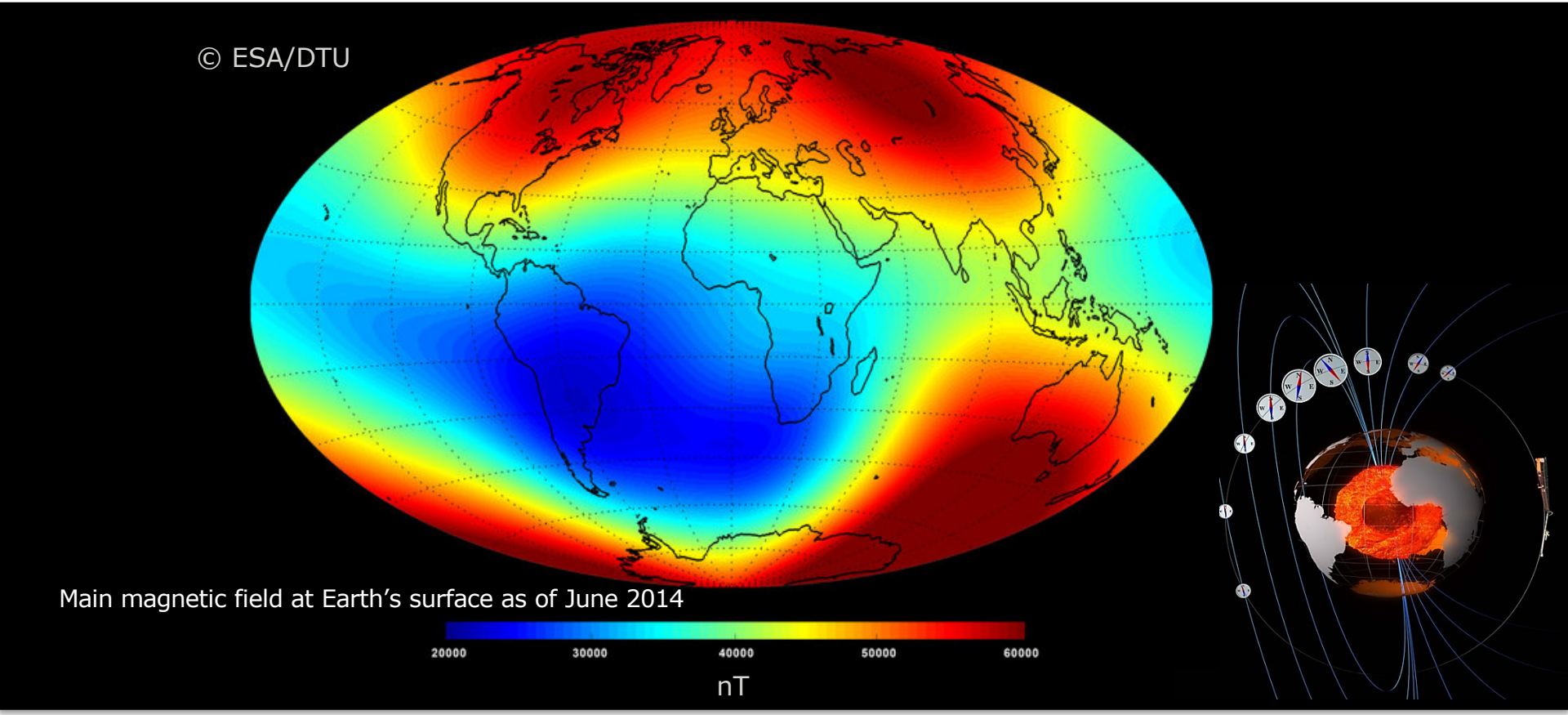
SWARM Mission

Swarm: ESA's Magnetic Field Mission

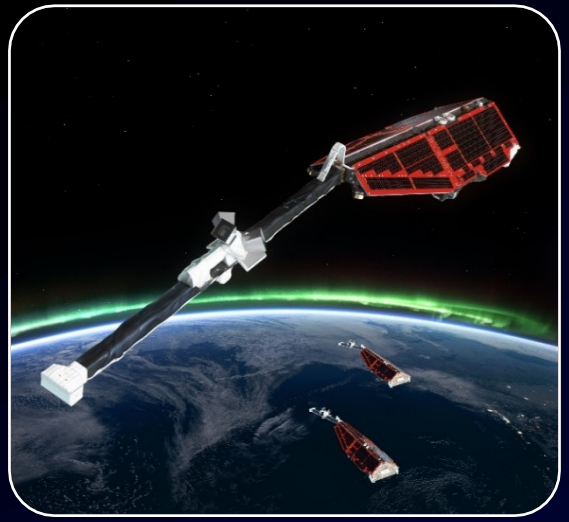


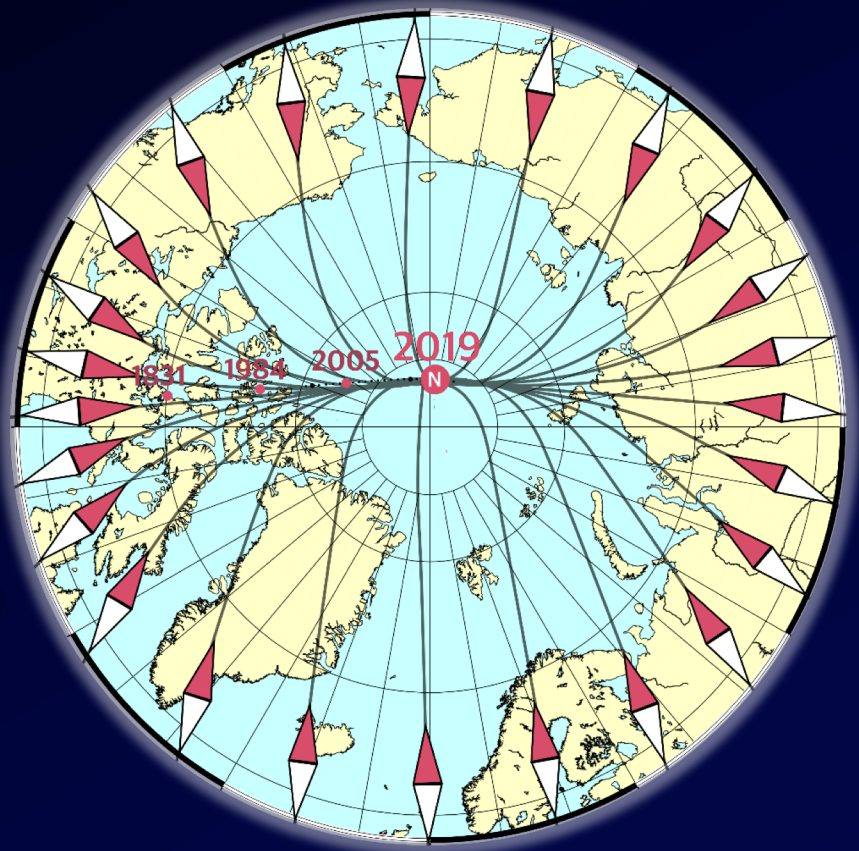
- Three-satellite-constellation, launched 22 November 2013
- Measures the geomagnetic field

Swarm: Earth's Magnetic Field



Swarm tracking magnetic north





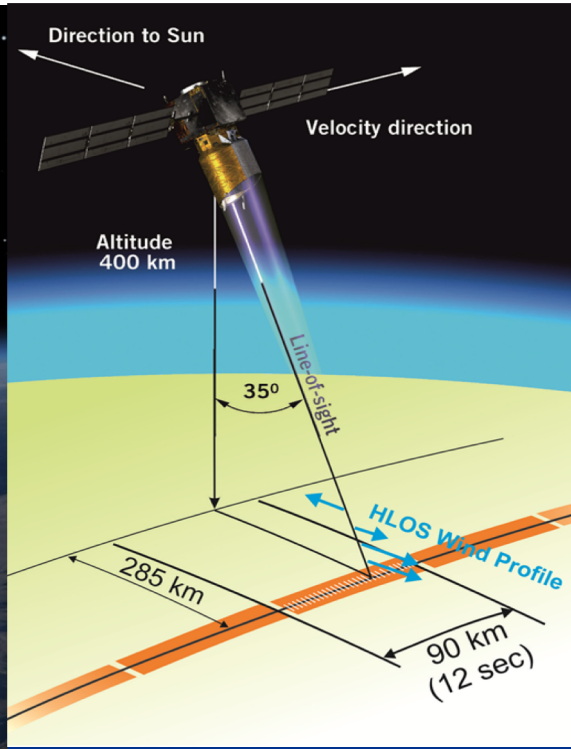
- Swarm tracks wandering magnetic north
- Now moving at 55 km per year
- Data crucial for daily applications: ships, google maps on smartphones

ADM-Aeolus Mission

ADM-Aeolus: ESA's Wind Profiling Mission

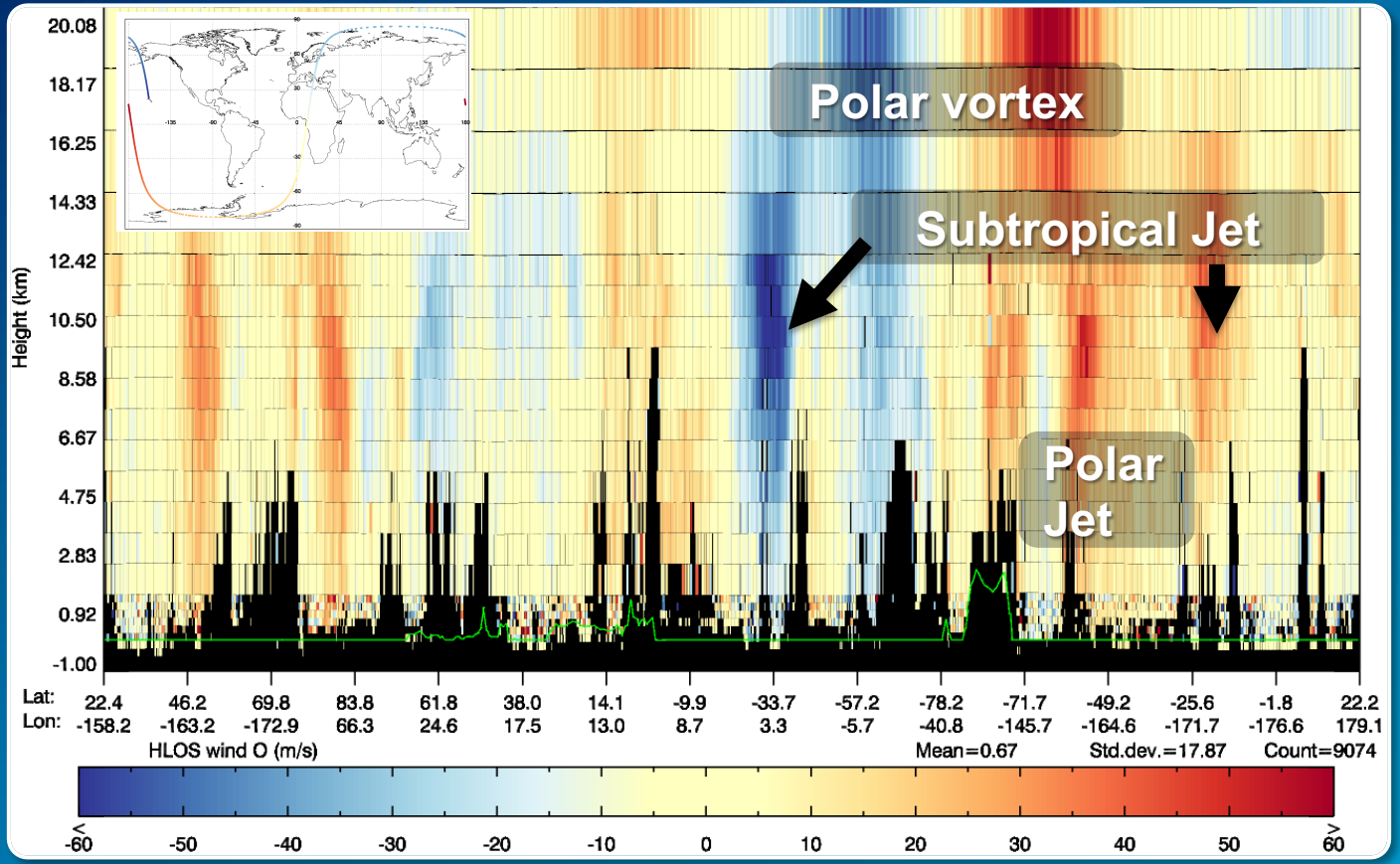
- Observations of wind profiles for analysis of global wind field
- Understanding of atmosphere dynamics and climate processes
- Improved weather forecasts and climate models

- First UV (λ = 355nm) Doppler wind lidar (ALADIN)
- Laser transmitters qualified for flight
- Launched 2018



- UV lidar (355 nm) with Mie and Rayleigh receivers
- Doppler shift used to retrieve Horizontal Line of Sight component of wind velocity

Aeolus



L2B Rayleigh-clear and Mie-cloudy HLOS winds

15 Sept. 2018

ECMWF

Next Earth Explorers

2022: EarthCare

- Clouds and Aerosols

2022: Biomass

- Above Ground Biomass

2023: Flex

- Plant Health

2026: Forum

- measure radiation emitted from the Earth

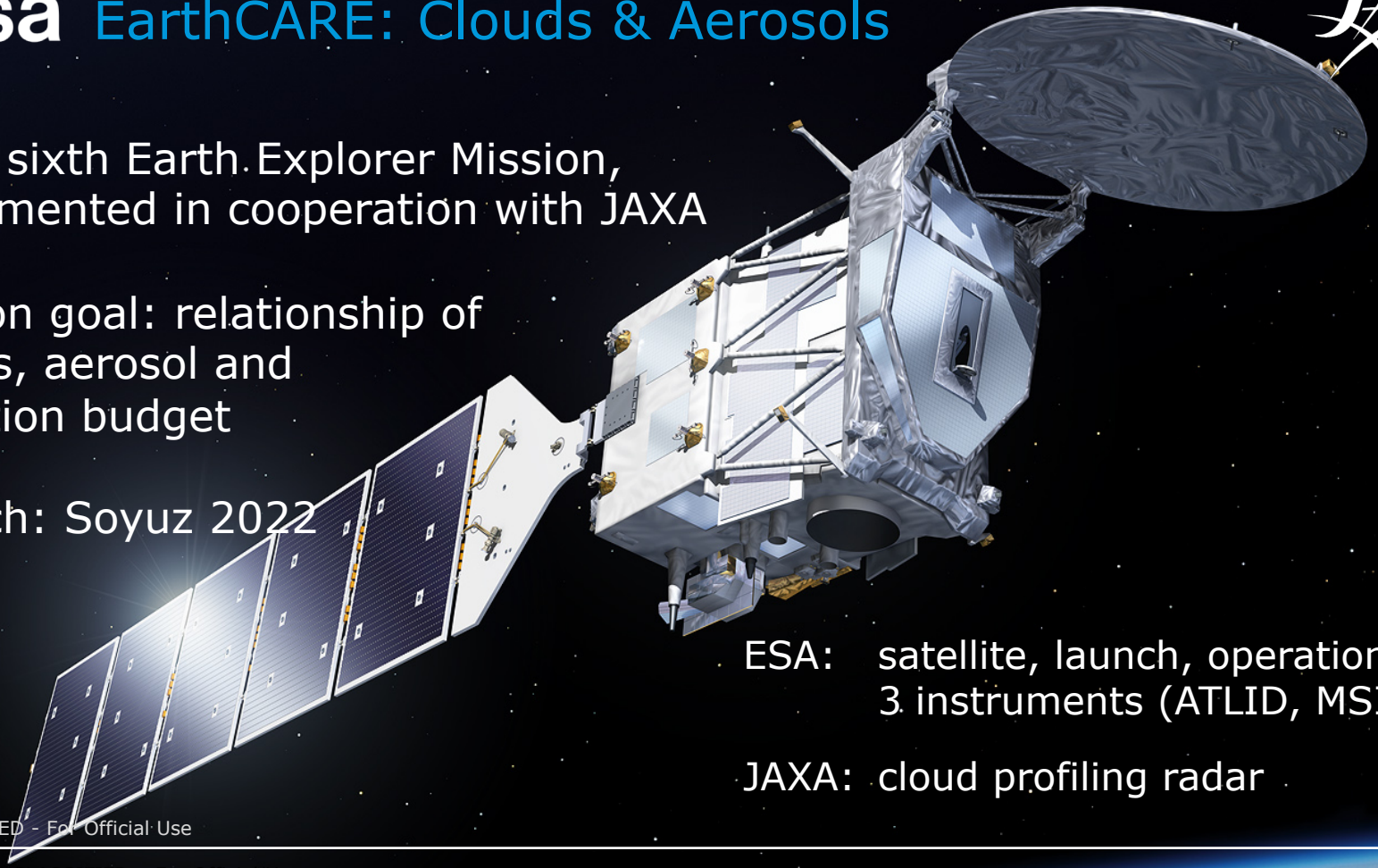
EarthCARE Mission

EarthCARE: Clouds & Aerosols

ESA's sixth Earth Explorer Mission, implemented in cooperation with JAXA

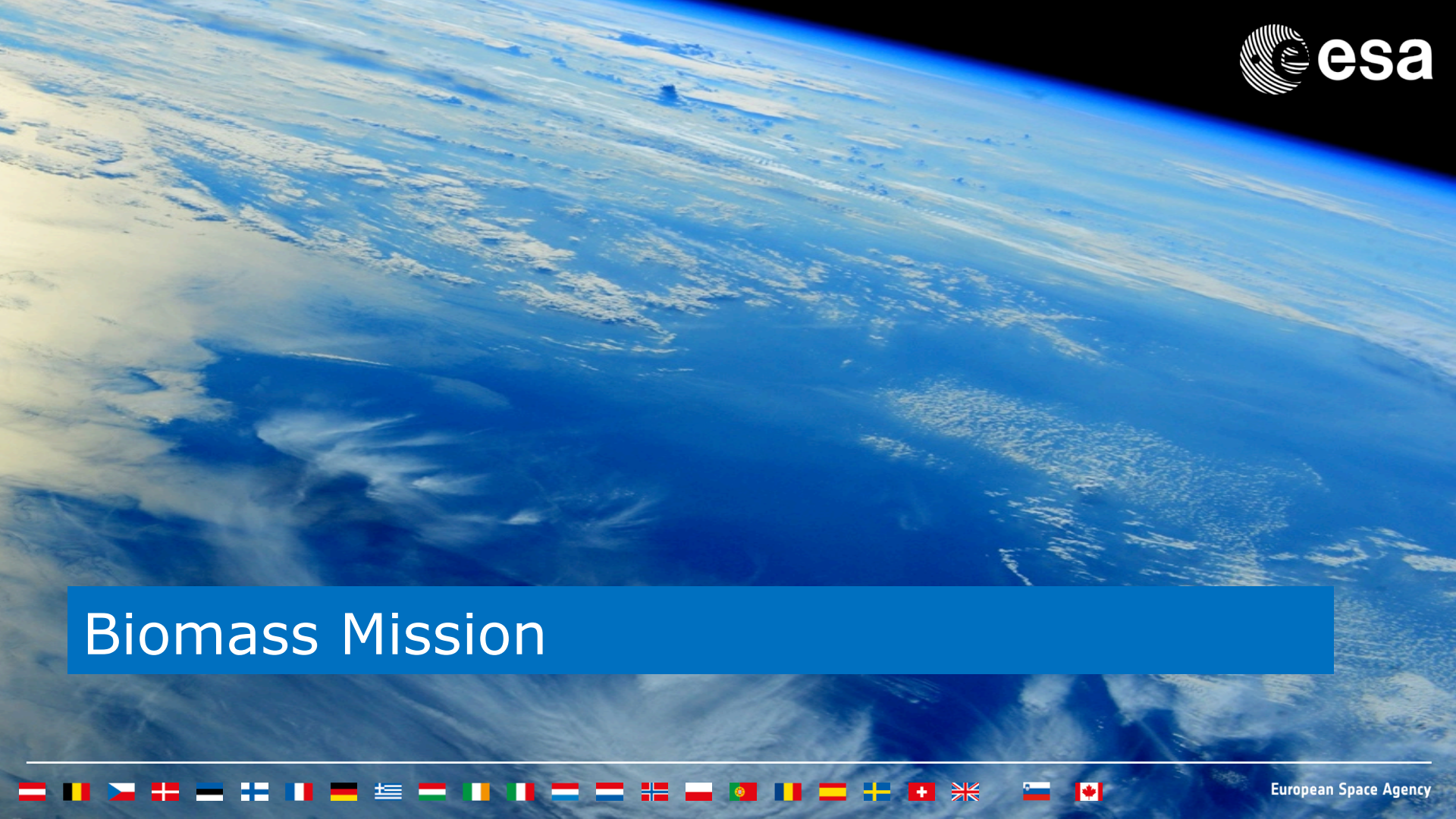
Mission goal: relationship of clouds, aerosol and radiation budget

Launch: Soyuz 2022



ESA: satellite, launch, operations, 3 instruments (ATLID, MSI, BBR)

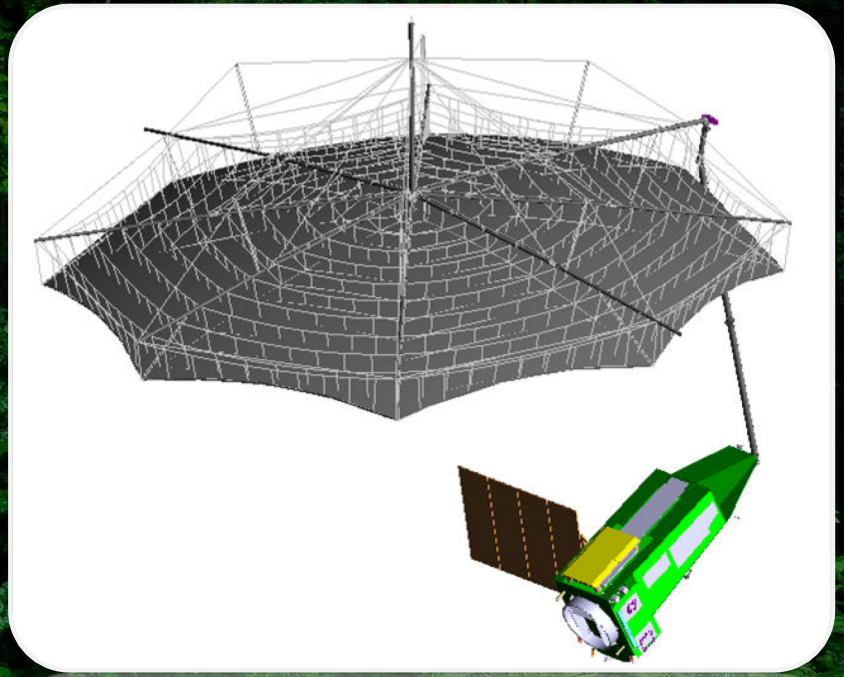
JAXA: cloud profiling radar



Biomass Mission

BIOMASS

Mission	Measure of forest biomass and height (200 m. pixel resolution)
Payload	P-Band radar
Orbit	SSO, alt: 666 km; LTAN: 6h00
Satellite	1250 Kg
Consortium	Prime: ADS-UK, Instrument: ADS-DE
Launch date	2022
Lifetime	5.5 years



FLEX (Fluorescence Explorer) Mission

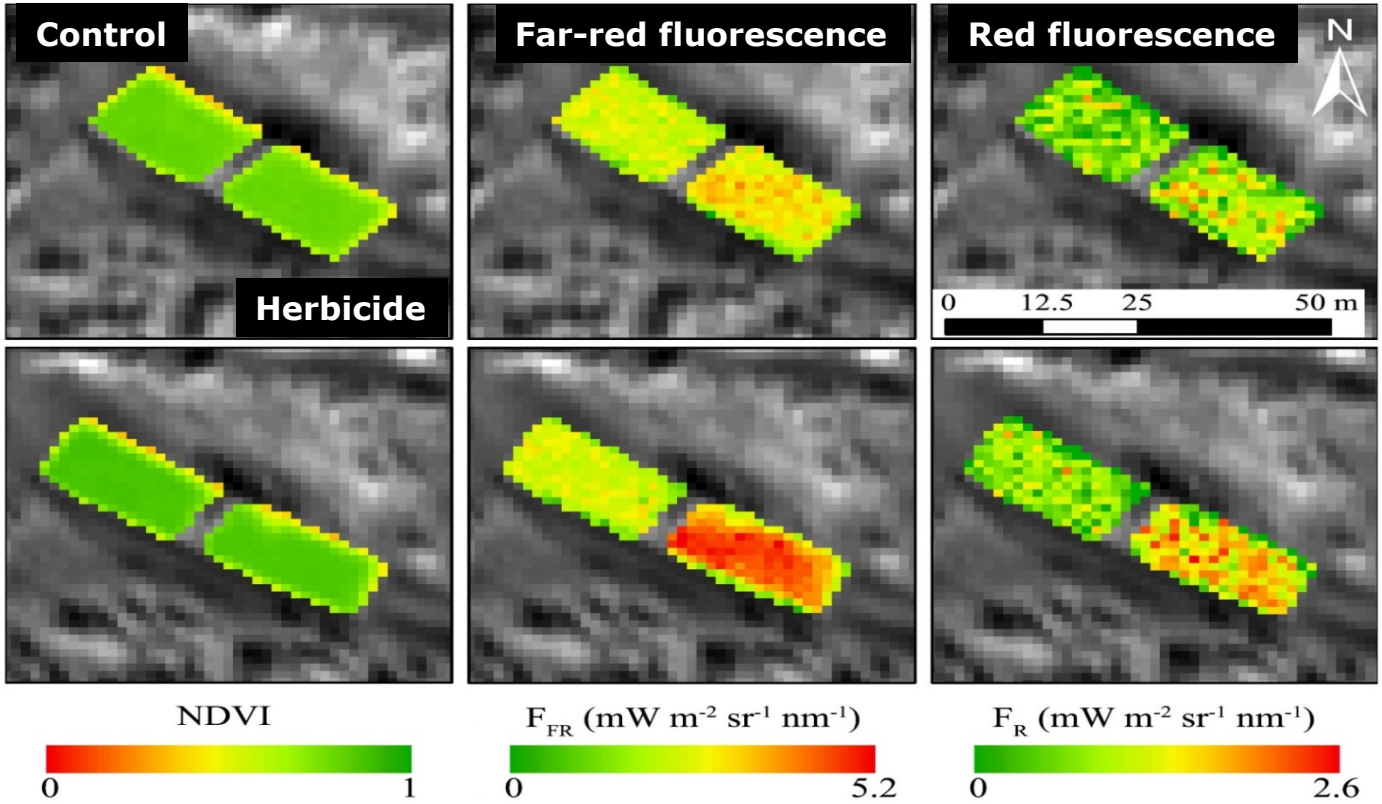
FLEX

Mission	Study & monitoring of fluorescence signal linked to vegetation stress; pixel 300m.
Swath	150 km
Payload	FLORIS, 2 channels spectrometers (O_2 lines)
Orbit	SSO, alt: 814 km; LTDN: 10h00
Satellite	470 Kg
Consortium	Prime: TAS Instrument: Leonardo
Launch date	2023
Lifetime	3.5 years

FLEX: Fluorescence tracks photosynthetic change

Low concentration

Higher concentration

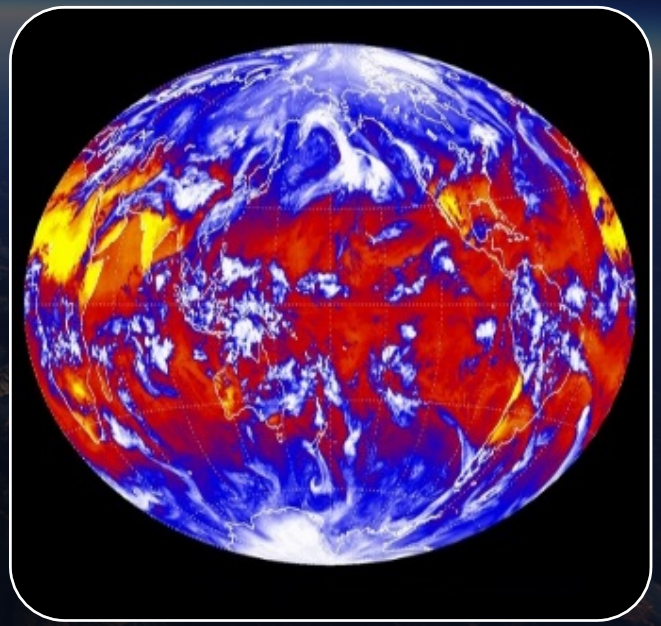


Rossini et al. (2015) *Geophysical Research Letters, 42, doi:10.1002/2014GL062943.*

Forum (Earth Explorer 9)

Earth Explorer 9 - FORUM

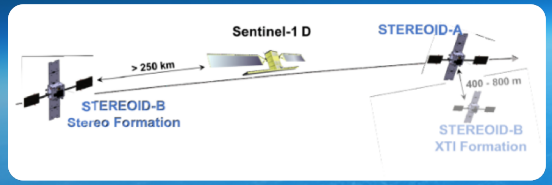
- Far-infrared Outgoing Radiation Understanding and Monitoring
- Benchmark measurements will improve our understanding of the greenhouse effect and contribute to climate change assessments accuracy
- Launch 2026




esa
Earth Explorer 10
European Space Agency

Earth Explorer 10 – Three Candidates

STEREOID

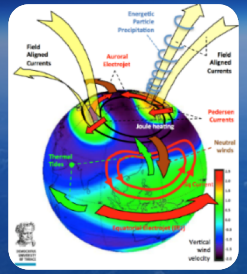


Bistatic SAR as passive followers of Sentinel-1
Two <500kg spacecraft

Applications

- Cryosphere
- Oceanography
- Geosphere

Daedalus



Explore mesosphere, lower thermosphere & Ionosphere

Four cubesats at 120 km altitude

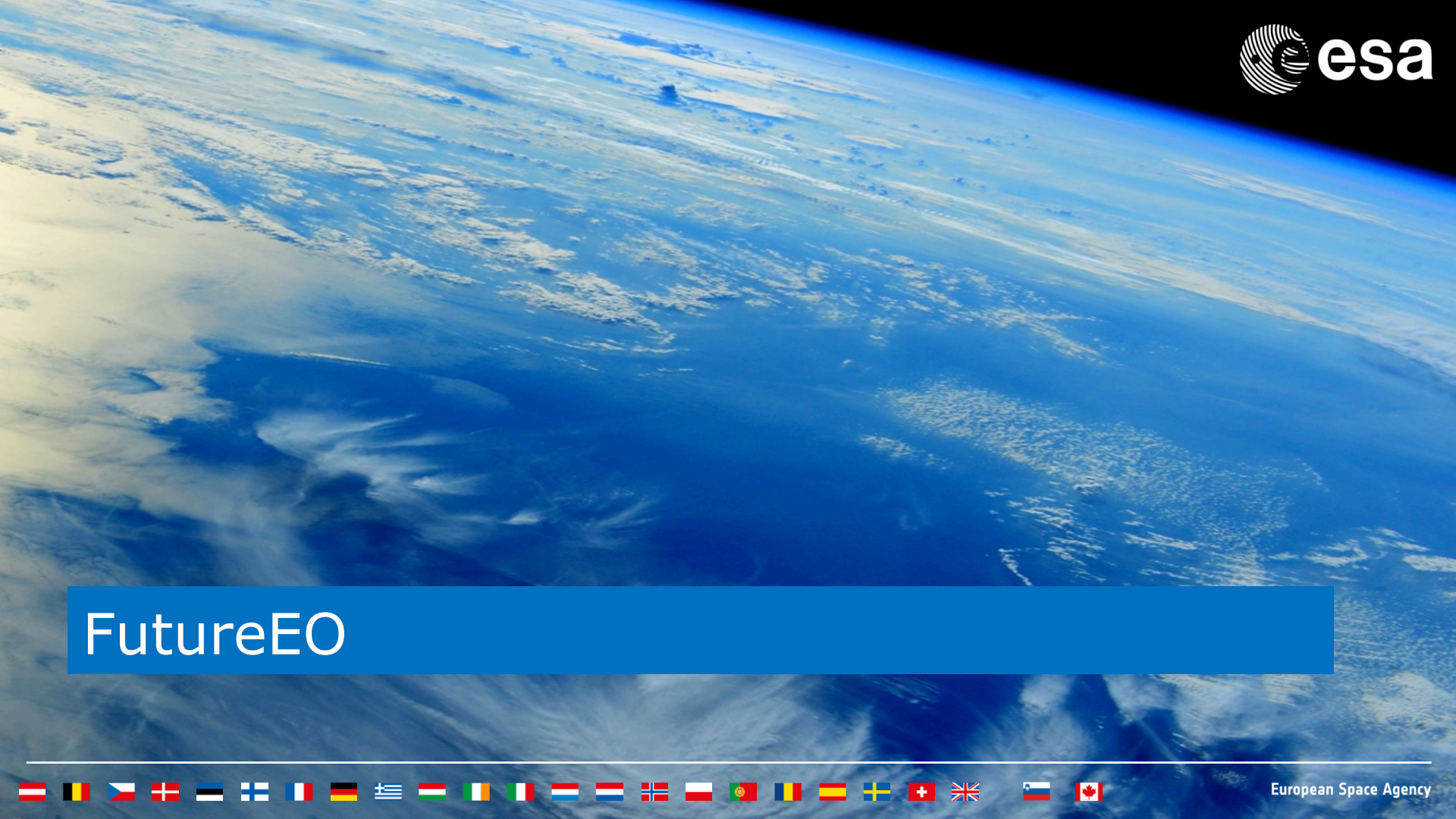
Focus on temperature, heating processes & composition structure

G-CLASS: H_2O

Science on daily water cycle

Geostationary C-band SAR

Benefits for weather forecasting, hydrology, mountain cryosphere



FutureEO

FutureEO – Earth Explorers as S&T Flagships

Flying Missions

GOCE
2009-2013

SMOS
2009

Cryosat
2010

Swarm
2013

Aeolus
2018

Future Missions

EarthCare
2022

Biomass
2022

FLEX
2023

Forum
2026
Just selected

EE-10
2027
3 Cand.

Science & Innovation

4.700+ Reg. Users

300+ Publ. per Year

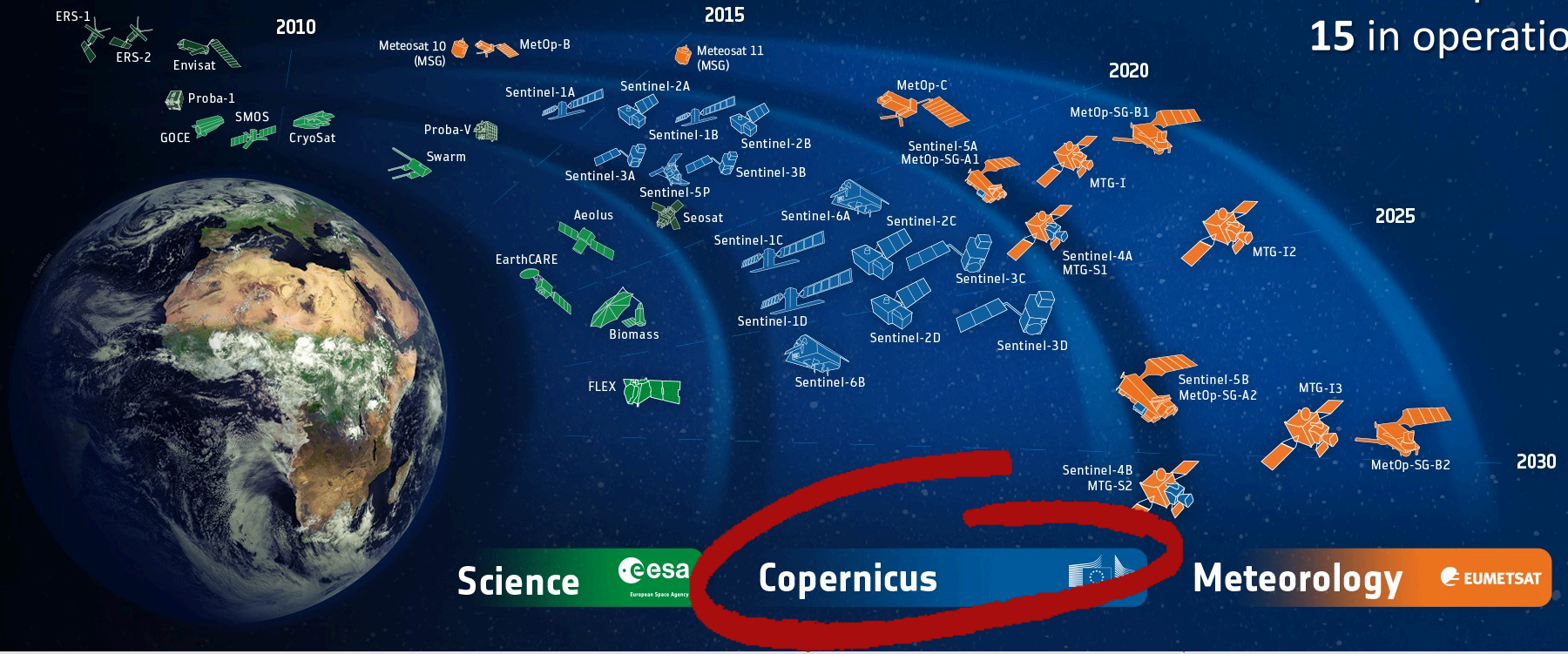
High Risks for Great Rewards

ESA-Developed Earth Observation Missions

Satellites

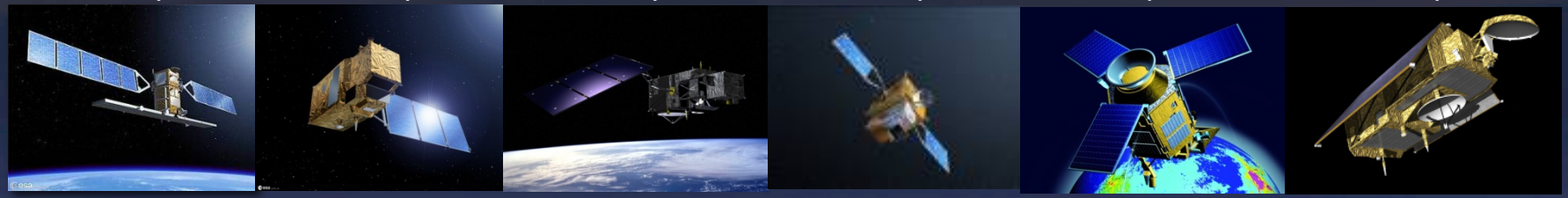
25 under development

15 in operation



Sentinels: A New Generation of Data Source

Sent-1A/B | Sent-2A/B | Sent-3A/B | Sent-4A/B | Sent-5/5P | Sent-6A/B



- Copernicus - European space flagship programme, led by the EU
- ESA is responsible for space component, Sentinel development, operation of some Sentinels, data buy from other partners, system evolution
- Sentinels – designed to monitor various elements of the Earth System in a fully operational manner
- Free and open data policy

Current Approved Sentinel Missions

S1A/B: Radar Mission

S2A/B: High Resolution Optical Mission

S3A/B: Medium Resolution Imaging and Altimetry Mission

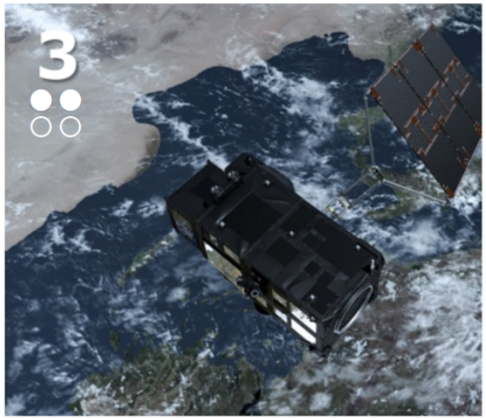
S4A/B: Geostationary Atmospheric Chemistry Mission

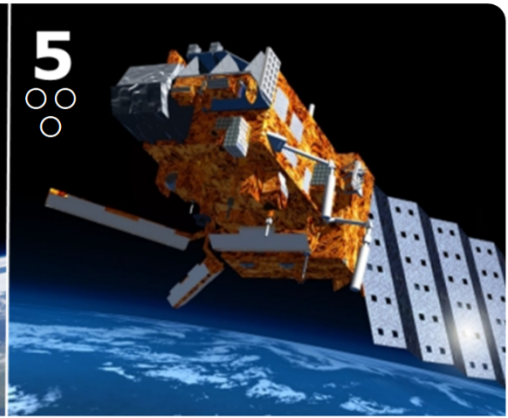
S5P: Low Earth Orbit Atmospheric Chemistry Mission

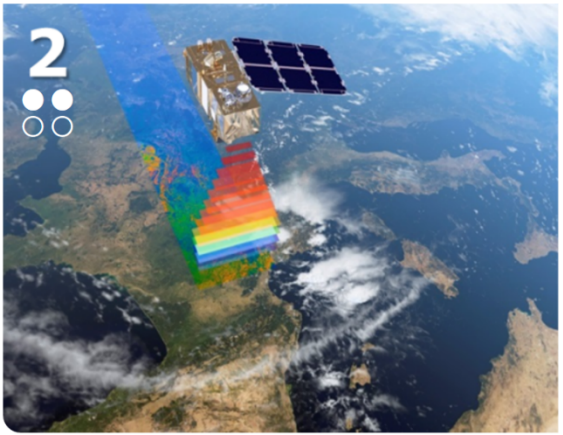
S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission

S6A/B: Altimetry Mission

Copernicus – European Leadership in EO



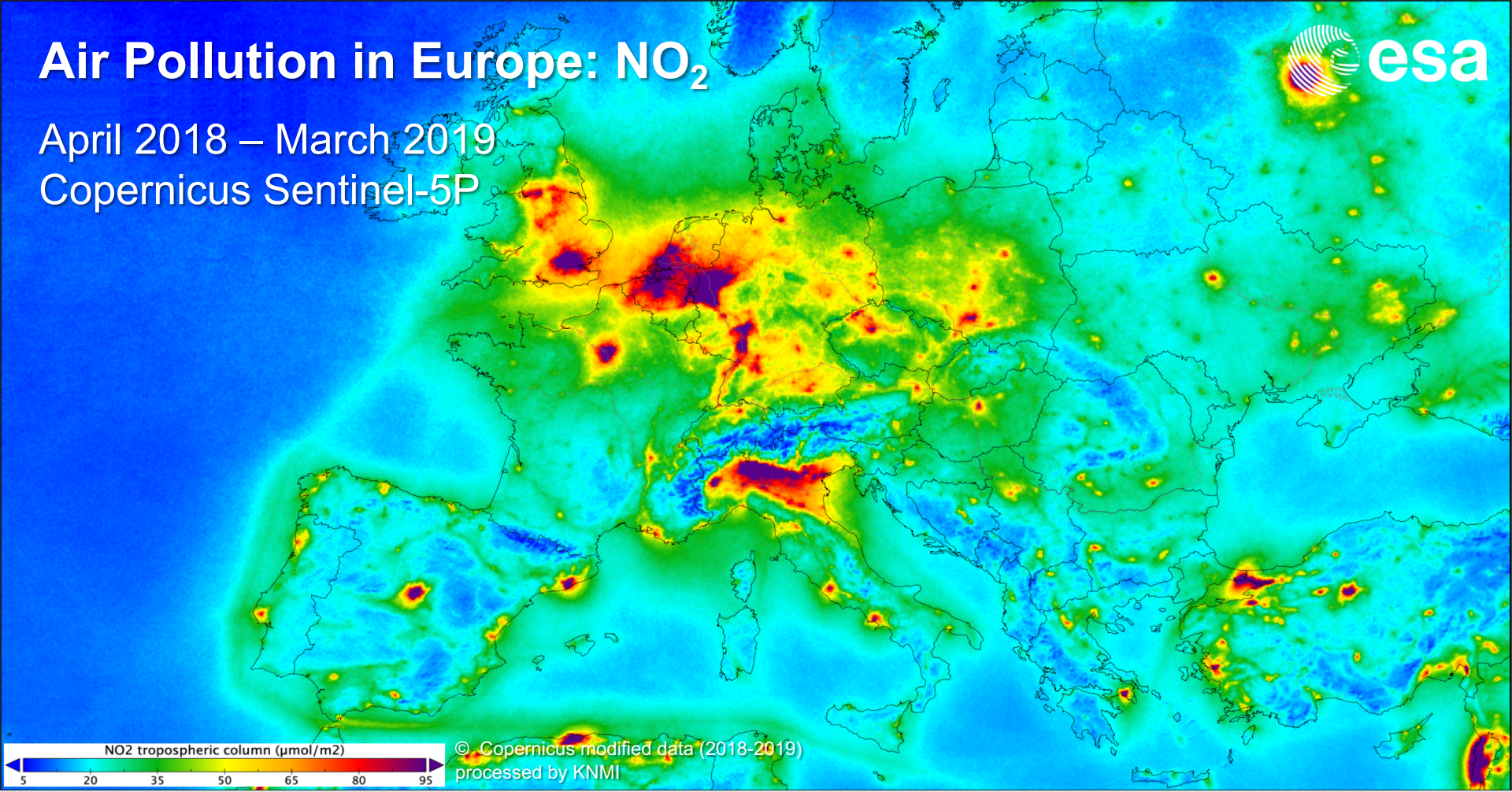




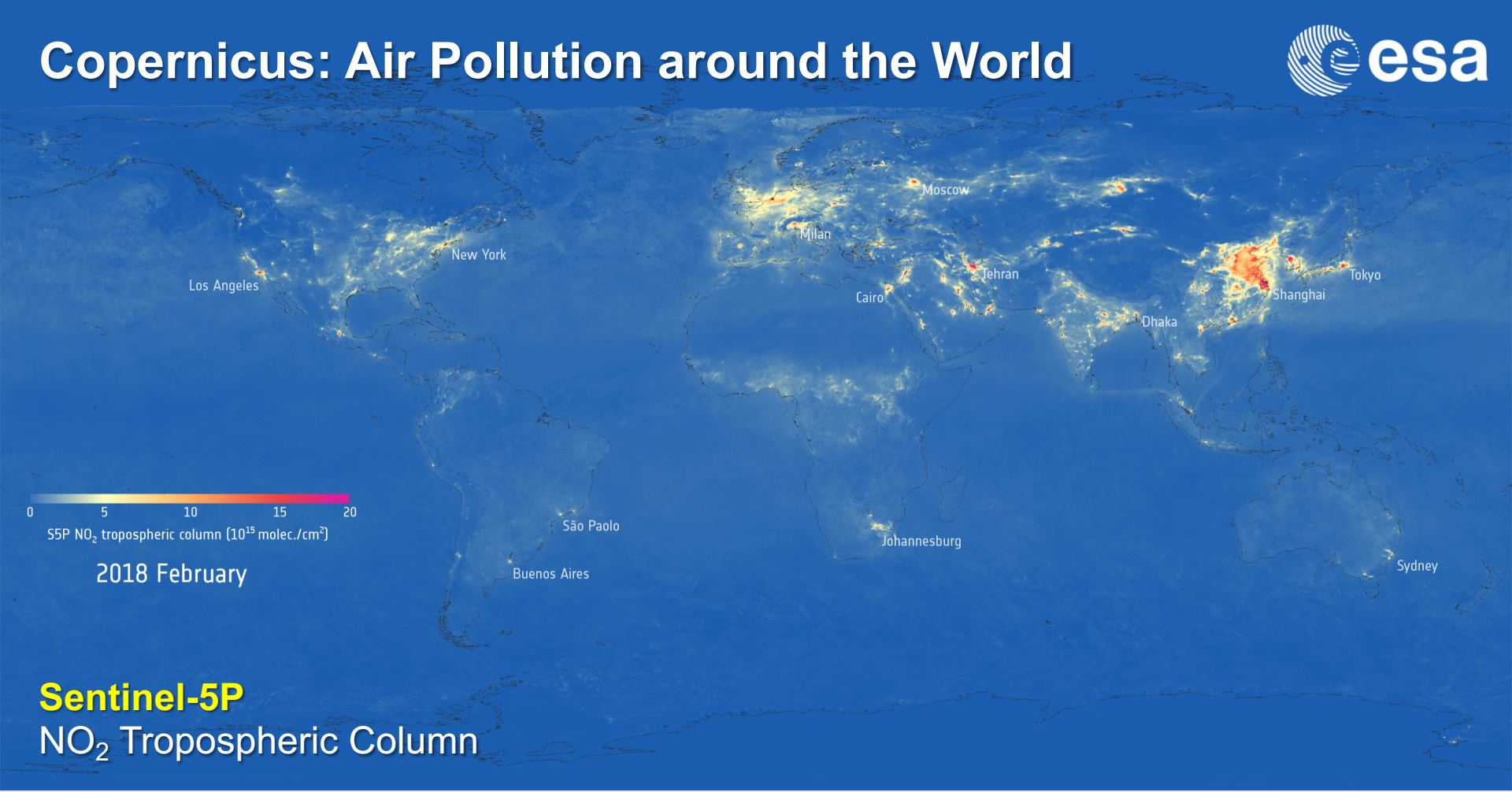

esa
Sentinel 5p
European Space Agency

Air Pollution in Europe: NO_2

April 2018 – March 2019
Copernicus Sentinel-5P



Copernicus: Air Pollution around the World



Sentinel-5P

NO_2 Tropospheric Column

Copernicus: Global European Leadership in EO

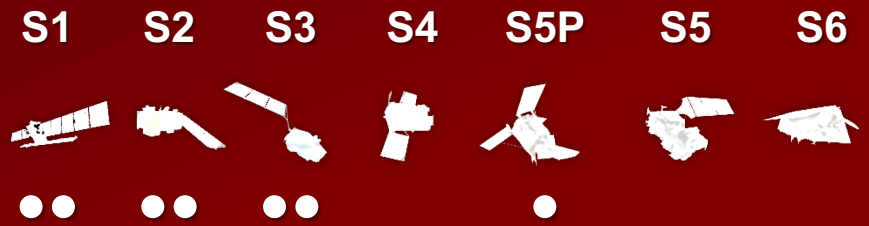
> 235.000
registered users
= tip of the iceberg

6 operational services

250 TB satellite data distributed per day

full, free & open data policy

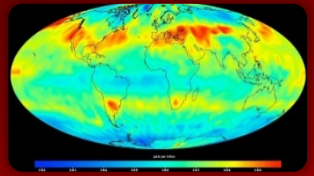
7 satellites flying



preparing Copernicus 4.0

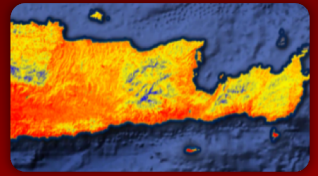
Copernicus 4.0 – Six new Monitoring Missions

Anthropogenic CO_2 Mon. Mission



Causes of
Climate Change

LST – Land Surface Temperature Mission

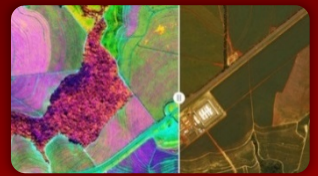


Agriculture & Water
Productivity

CRISTAL – Polar Ice & Snow Topography

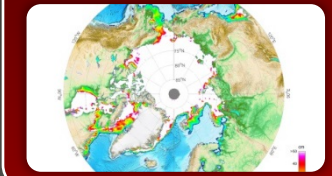
Effects of
Climate Change

CHIME – Hyperspectral Imaging Mission



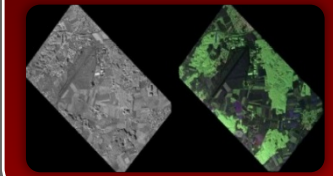
Food Security, Soil,
Minerals, Biodiversity

CIMR – Passive Microwave Radiometer

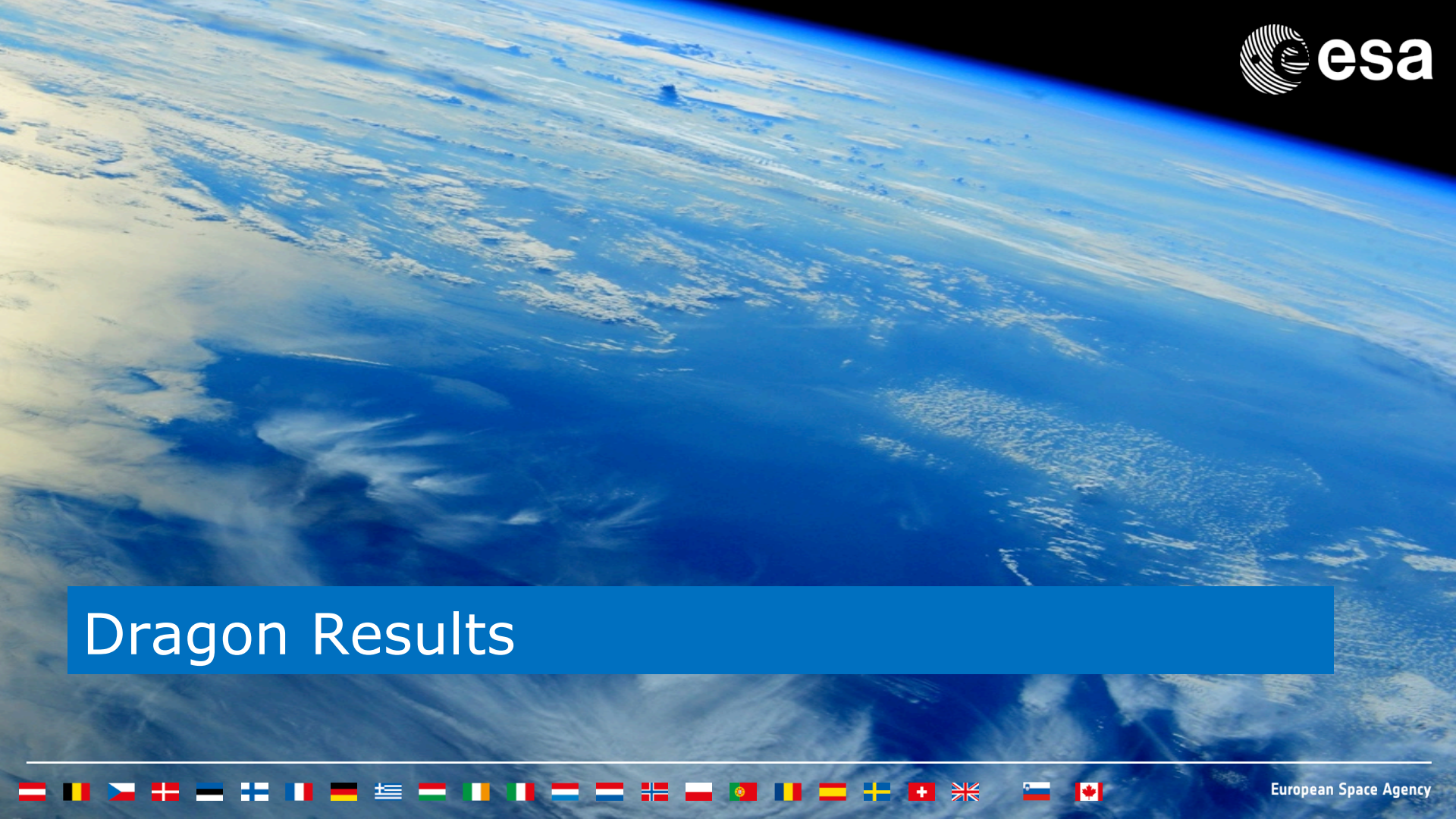


Sea: Surface Temp.
& Ice Concentration

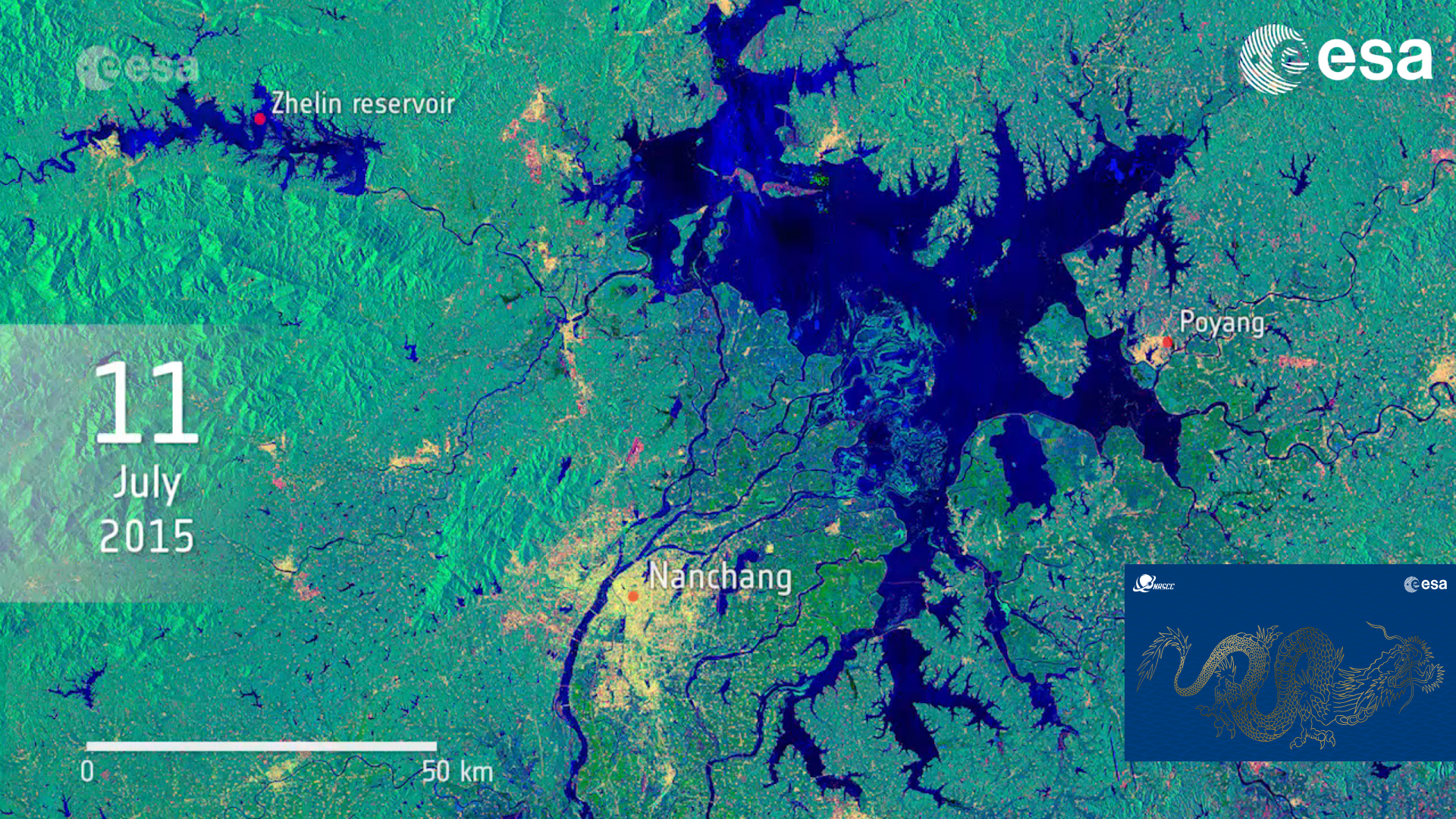
Rose-L – L-band SAR Mission



Vegetation & Ground
Motion & Moisture

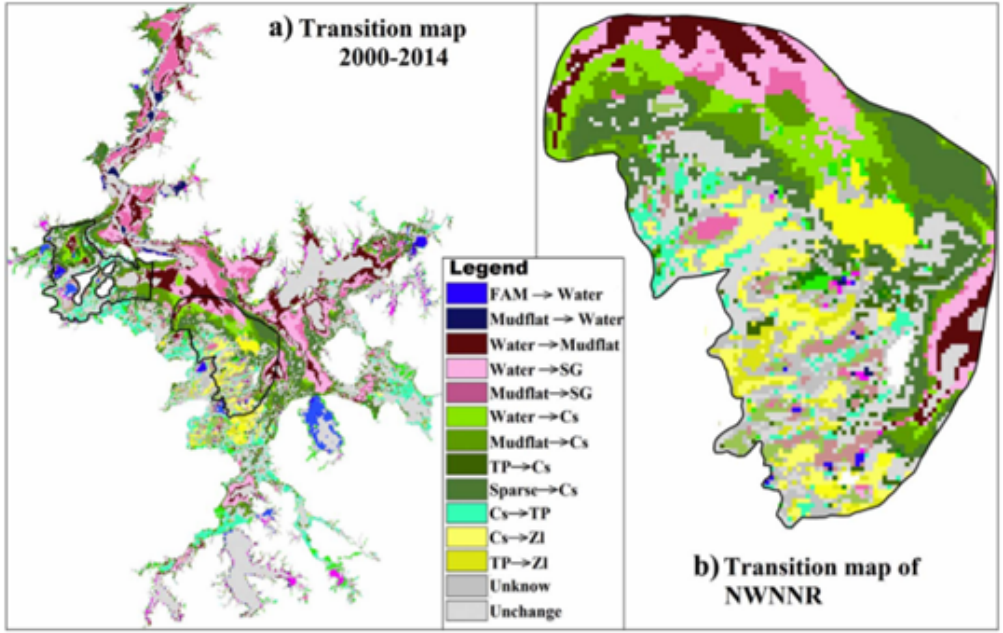


Dragon Results

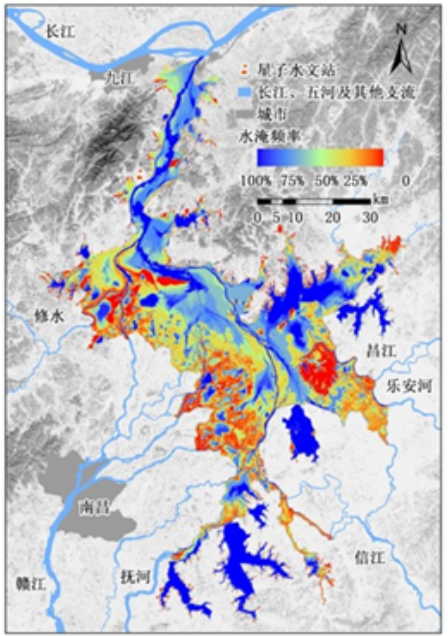

Zhelin reservoir
Poyang
Nanchang
11
July
2015
0
50 km

Hydrology Poyang Lake ID. 32442

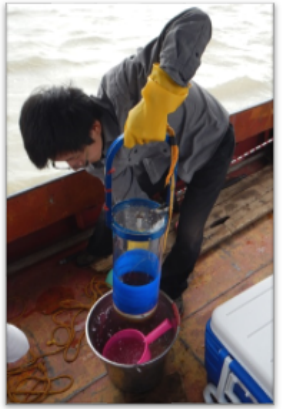
1. EO derived vegetation transition maps 2000 to 2014
Change to drier land species in the period



2. Annual **wetland inundation conditions**
Blue longer inundation, red shorter (GF-1 data)



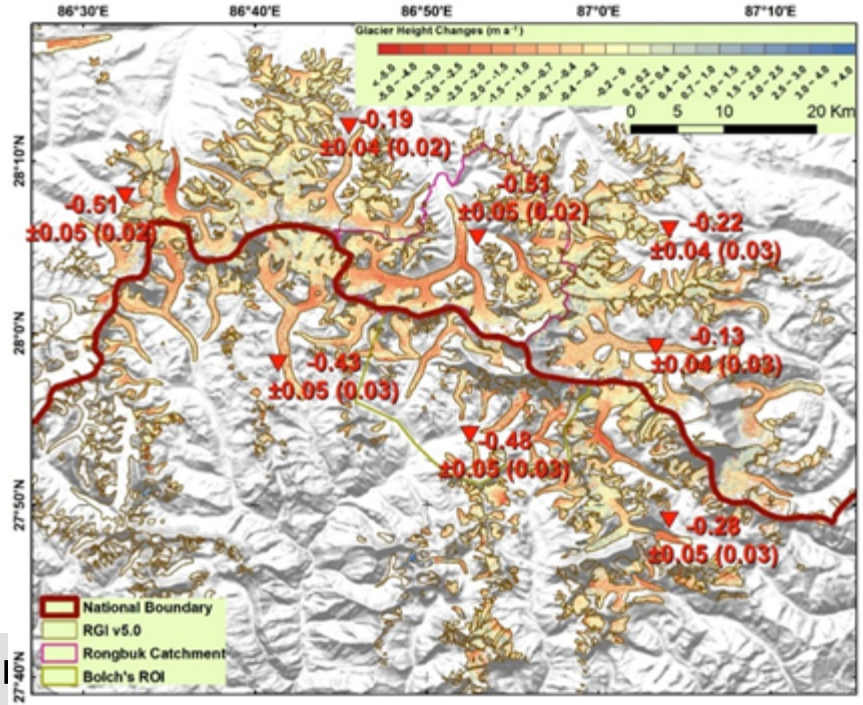
3. **Water colour,**
monitoring & calibration



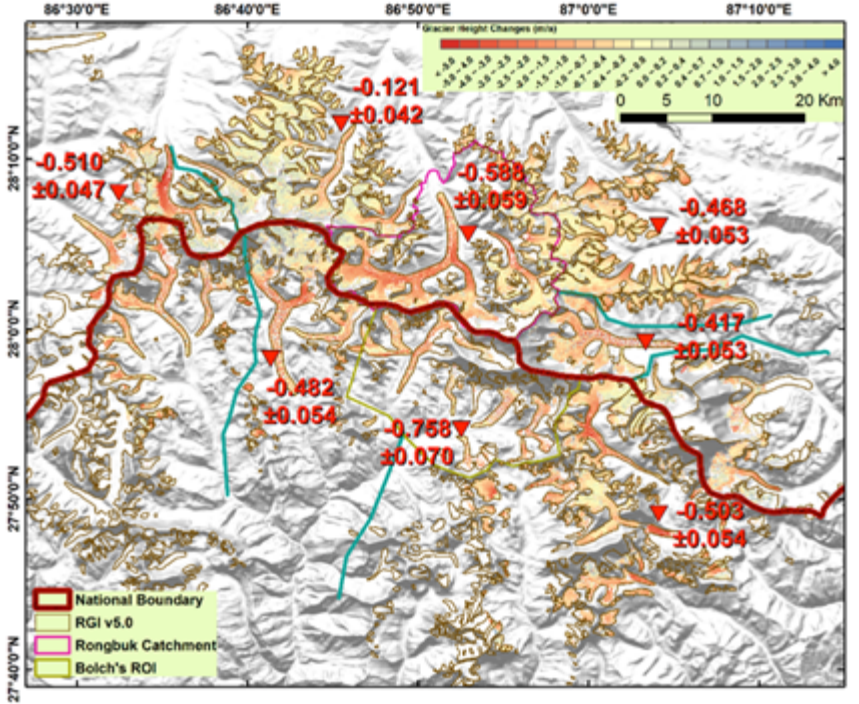
Mt. Everest glacier change ID. 32388

Glaciers **mass lost rate has speeded up** (faster mass lost rate during 2012-2017 compared to 2000-2012). In both periods, glaciers **mass balance was spatially heterogeneous**.

Glacier height changing rates for 2000 to 2012

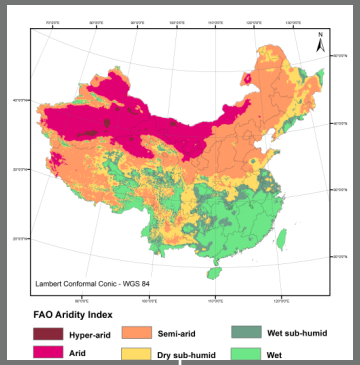


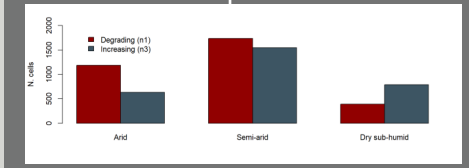
Glacier height changing rates for 2012 to 2017



Project ID 32396 Land Degradation vs Regeneration Trends

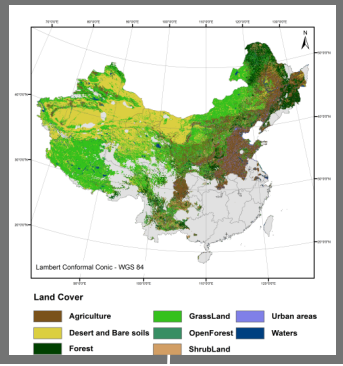
Distribution of land classes – FAO classification

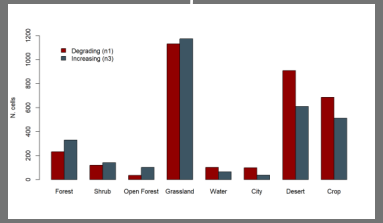




Significant Time-coefficients for FAO climate classes in China drylands

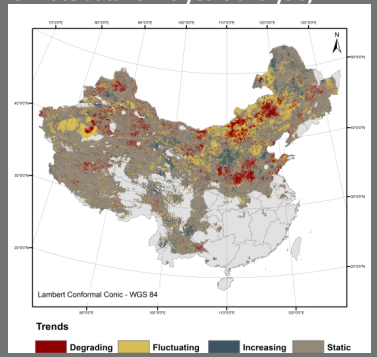
Land-uses in China Drylands





Significant Time-coefficients frequency for land-uses in China drylands

Land condition trends based on Vegetation fraction trend analysis (combining EO and climate data for 10 years analysis)



Degrading: 282,384 km2 (11.5%)
Fluctuating: 511,344 km2 (20.8%)
Increasing: 165,280 km2 (6.7%)
Static: 1,503,360 km2 (61.1%)

Objective

Gain insight about the magnitude of the processes of degradation and regeneration. Analyze these trends by land-uses and climatic FAO classes.

Produce a low-cost exportable methodology

Generate data to support alternative paths for degradation and regeneration processes.

Methodology

Land condition trends using a stepwise regression to isolate the effects of time on vegetation, a proxy of the impact of human activity on land

→ EO SCIENCE FOR SOCIETY

EOEP5–Block4 Introduction

Scientific Exploitation

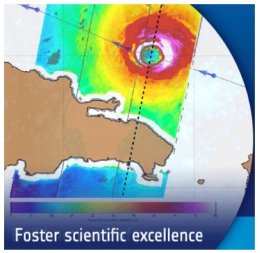
EO Science for Society #EO4society

EO Science for Society (EOEP5 Block 4) built on successes of previous ESA exploitation activities:

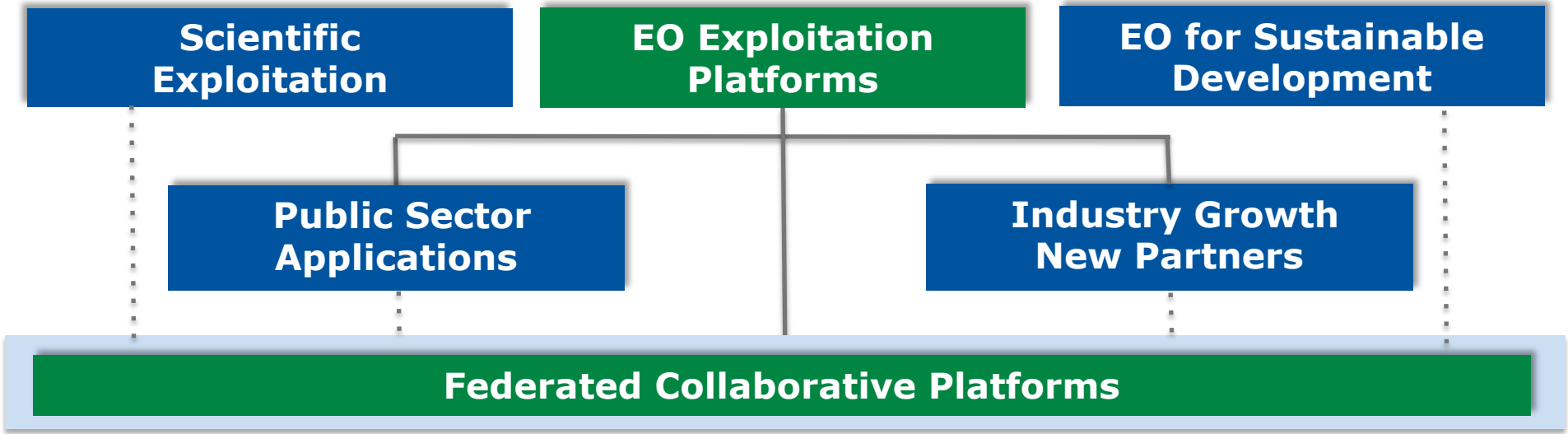
- adapting them to the new European EO context
- responding to recommendations of programmatic and scientific review.

MAIN OBJECTIVES

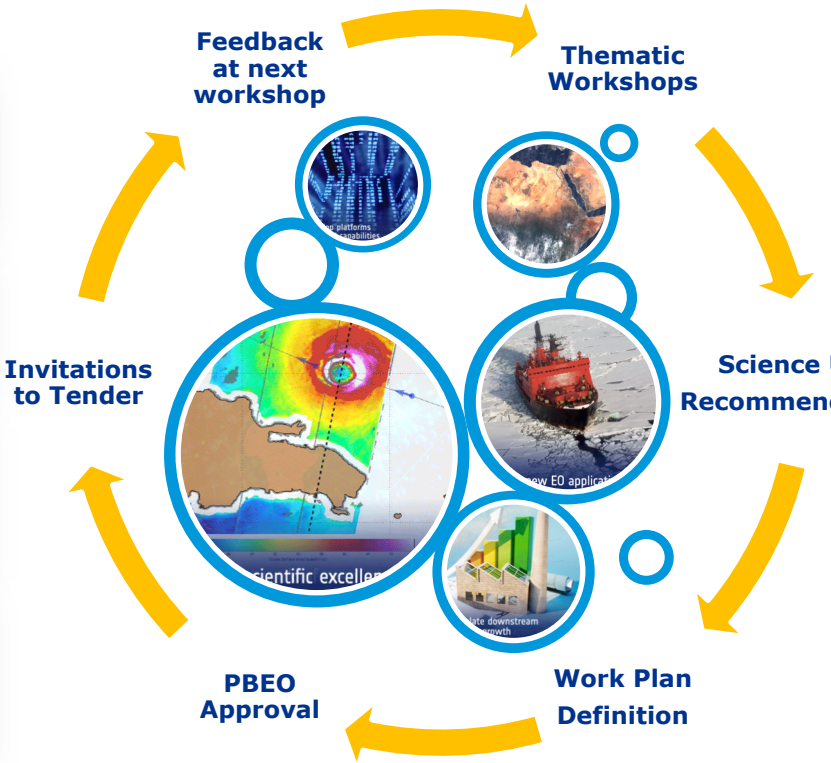
- Foster scientific excellence
- Pioneer new EO applications
- Stimulate downstream industry growth
- Support international responses to global societal challenges
- Develop platforms technical capabilities
- Build network of resources



#EO4society – Components



#EO4society – Consultations



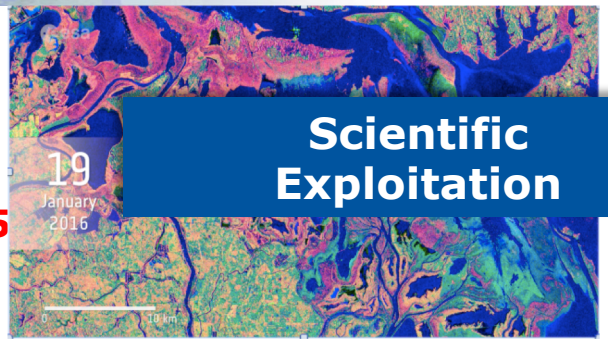
SNAP open source toolbox

for Radar/Optical/Thermal data exploitation

used in 190 countries

more than 440,000 downloads since June 2015

http://step.esa.int/main/download



Scientific Exploitation

STEP (Science Toolbox Exploitation Portal)

EO science collaborative portal

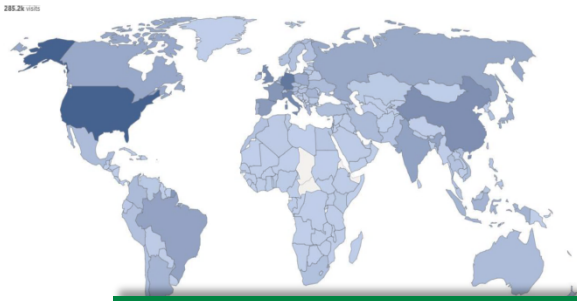
Technical forum and community animation

Gathering user feedback and usage

Communicating on results

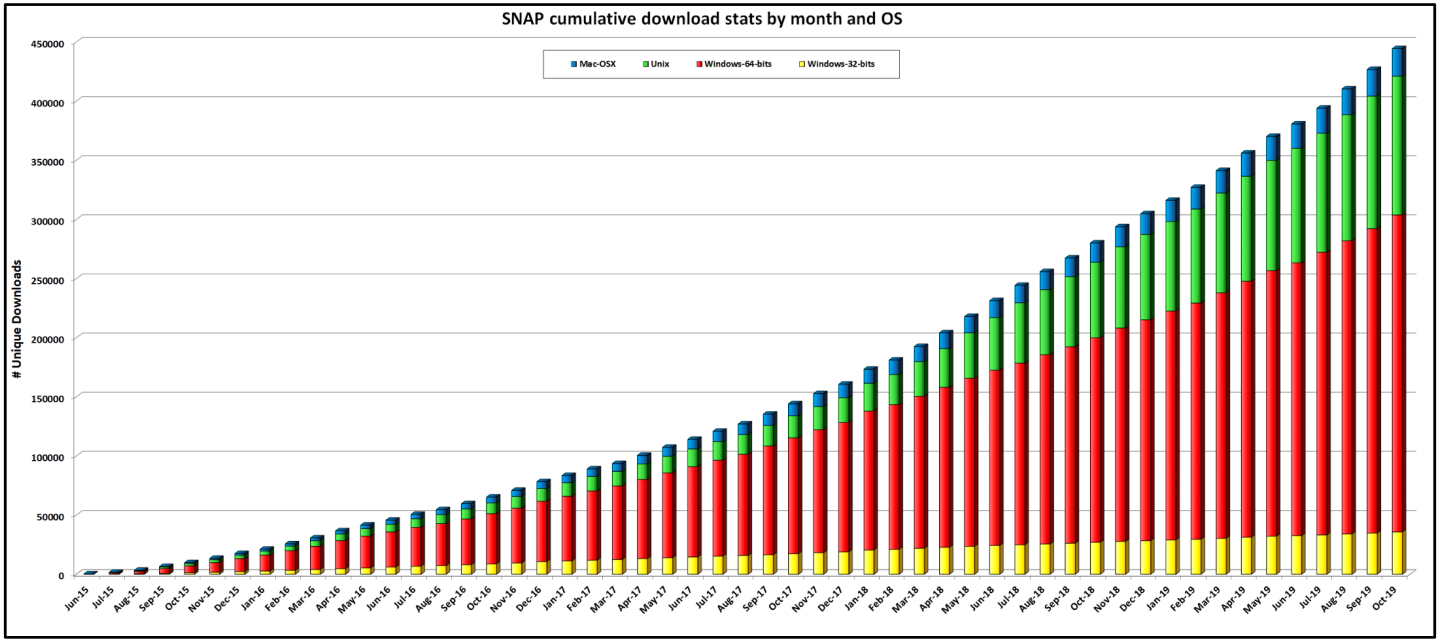
On line tutorials

880 000+ visitors

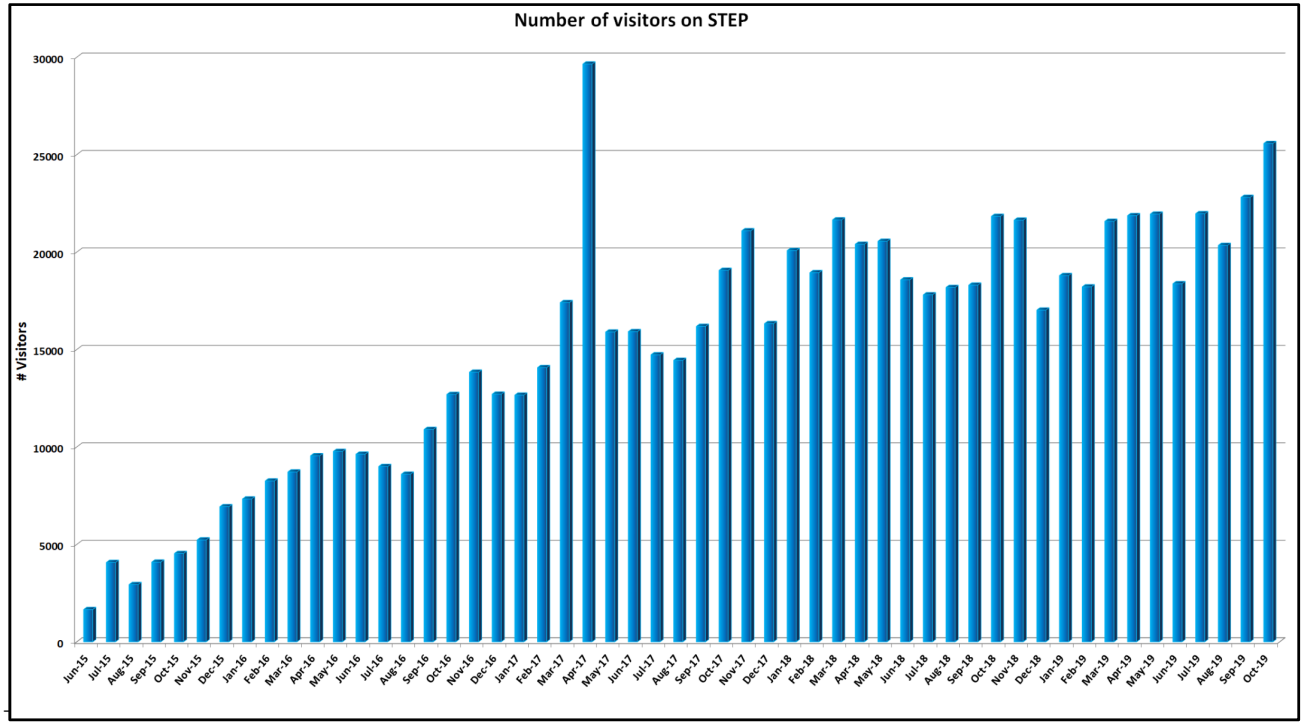


EO Exploitation Platforms

SNAP cumulative download by month and OS
(2015/06/15 – 2019/10/31)



Number of Monthly visits on STEP (2015/06/15 – 2019/10/31)



ESA facts and figures

- Over 50 years of experience
- 22 Member States
- Eight sites/facilities in Europe, about 2300 staff
- 5.6 billion Euro budget (2018)
- Over 80 satellites designed, tested and operated in flight

ESA ESRIN Establishment

Activities

- Earth Observation
- Vega Launcher
- Corporate Informatics
- ESA Security Office
- Contracts, Personnel
- Site Management
- Communication

50.000 visitors per year

813 personnel on the site


esa
Thank you for your attention!
谢 谢
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