# From Earth Explorers to Sentinels: ESA's Earth Observation Programmes – achievements, status and plans

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www.esa.int

# A New Era of Earth Observation

EO: Tool to tackle global challenges

- Reliable assessment of human activity
- Coverage over space and time
- Long observation intervals
- Large scale observations

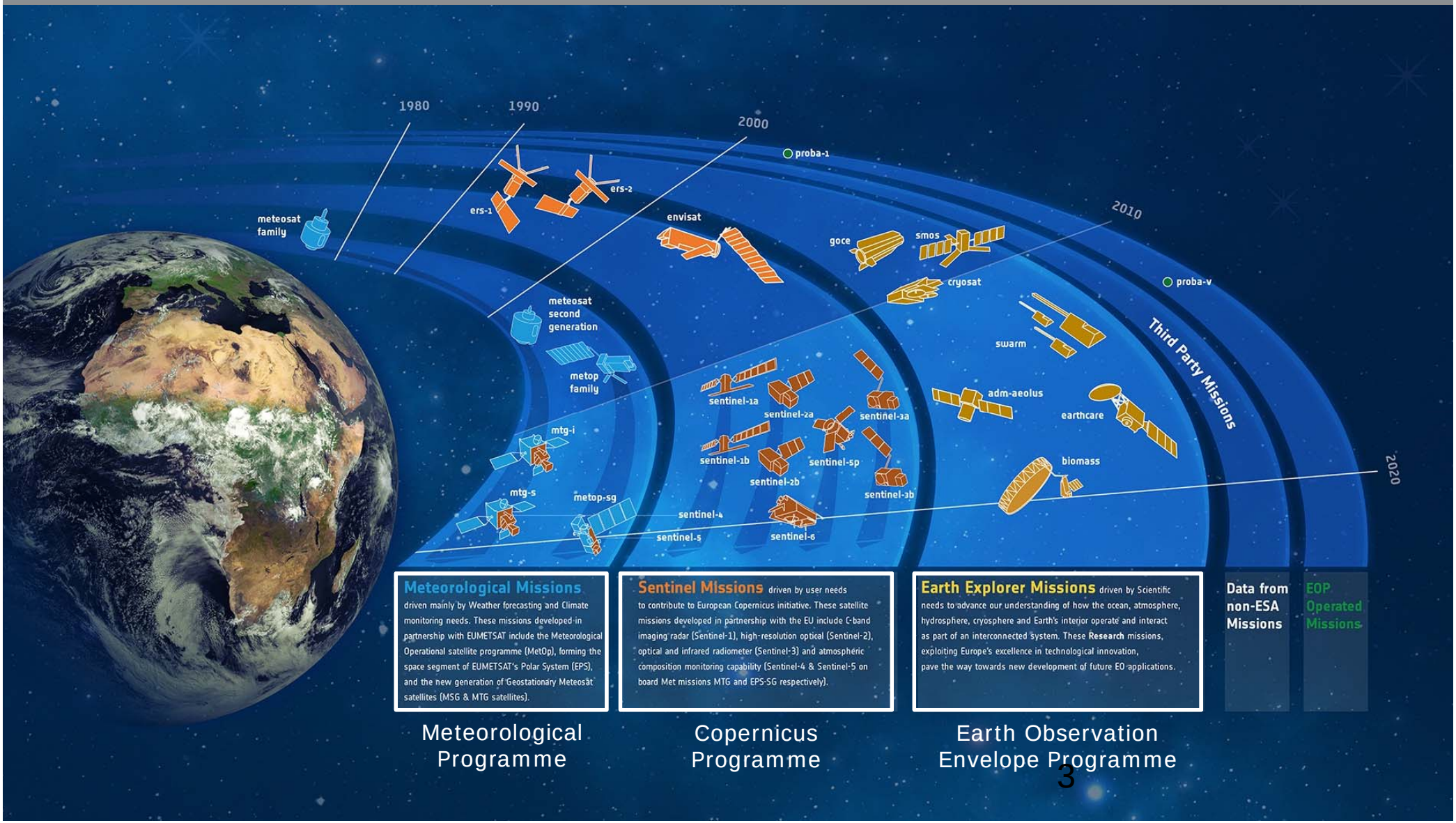
First EO Revolution:

- WWW, broadband data networks, GIS, desktop processing

Second EO Revolution:

- cloud computing, crowd sourcing, big data, new generation mapping tools

# ESA Earth Observation Programmes



# Copernicus: A New Generation of Data Sources

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

- Copernicus is a European space flagship programme led by the European Union
- ESA coordinates the space component
- Copernicus provides the necessary data for operational monitoring of the environment and for civil security

# Copernicus – Current Status

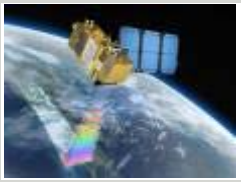
- EU MFF foresees 3.783 billion Euro for Copernicus operations and recurrent satellites
- New Long Term Scenario
- Delegated Act on Data Policy in force
- Programme Regulation in force
- Delegation Decision taken in July 2014
- EU-ESA Agreement to be negotiated
- Sentinel-1 A launch on 3 April 2014

# Facing the Future

- Third development step under way (GSC-3)
- Phase 2 decided in June 2014
- Sentinels up to D-units (First Generation) covered by current MFF
- Development of Second Generation Sentinels to start in 2016
- Division of tasks
  - ESA: R&D activities
  - EU: funding of operations and of recurrent satellites; integration of Copernicus into sectorial policies

# Copernicus dedicated missions

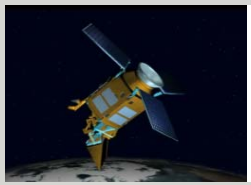
**Sentinel-1 (A/B) – SAR imaging**
All weather, day/night applications, interferometry



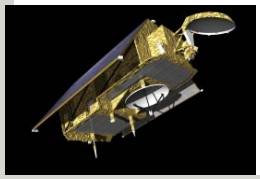
**Sentinel-2 (A/B) – Multi-spectral imaging**
Land applications: urban, forest, agriculture,…
Continuity of Landsat, SPOT

**Sentinel-3 (A/B) – Ocean and global land monitoring**
Wide-swath ocean color, vegetation, sea/land surface temperature, altimetry

**Sentinel-4 (A/B) – Geostationary atmospheric**
Atmospheric composition monitoring, trans-boundary pollution



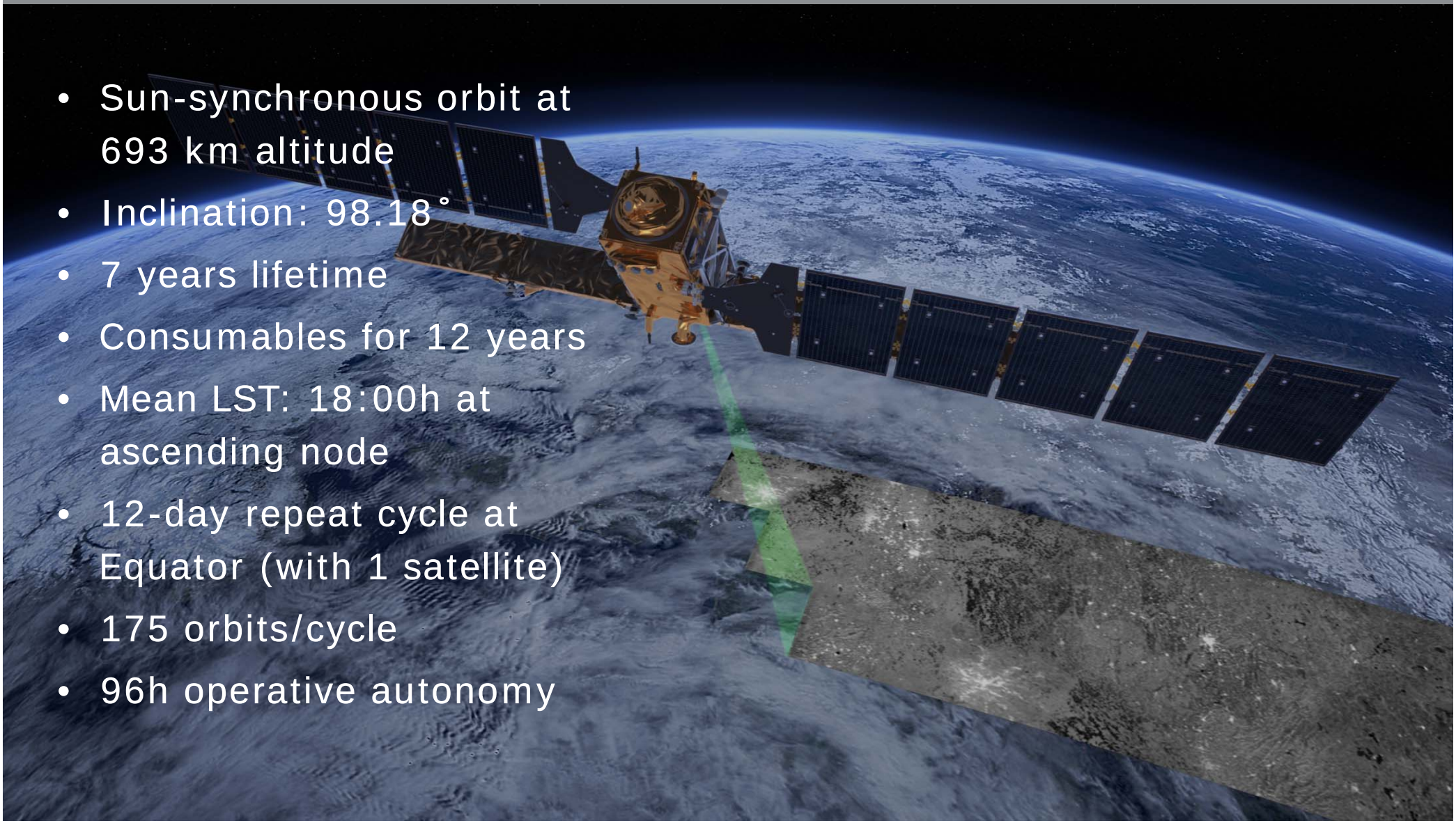
**Sentinel-5 precursor/ Sentinel-5 (A/B) – Low-orbit atmospheric**
Atmospheric composition monitoring



**Sentinel-6 [Jason-CS] (A/B) – Low inclination Altimetry**
Sea-level, wave height and marine wind speed

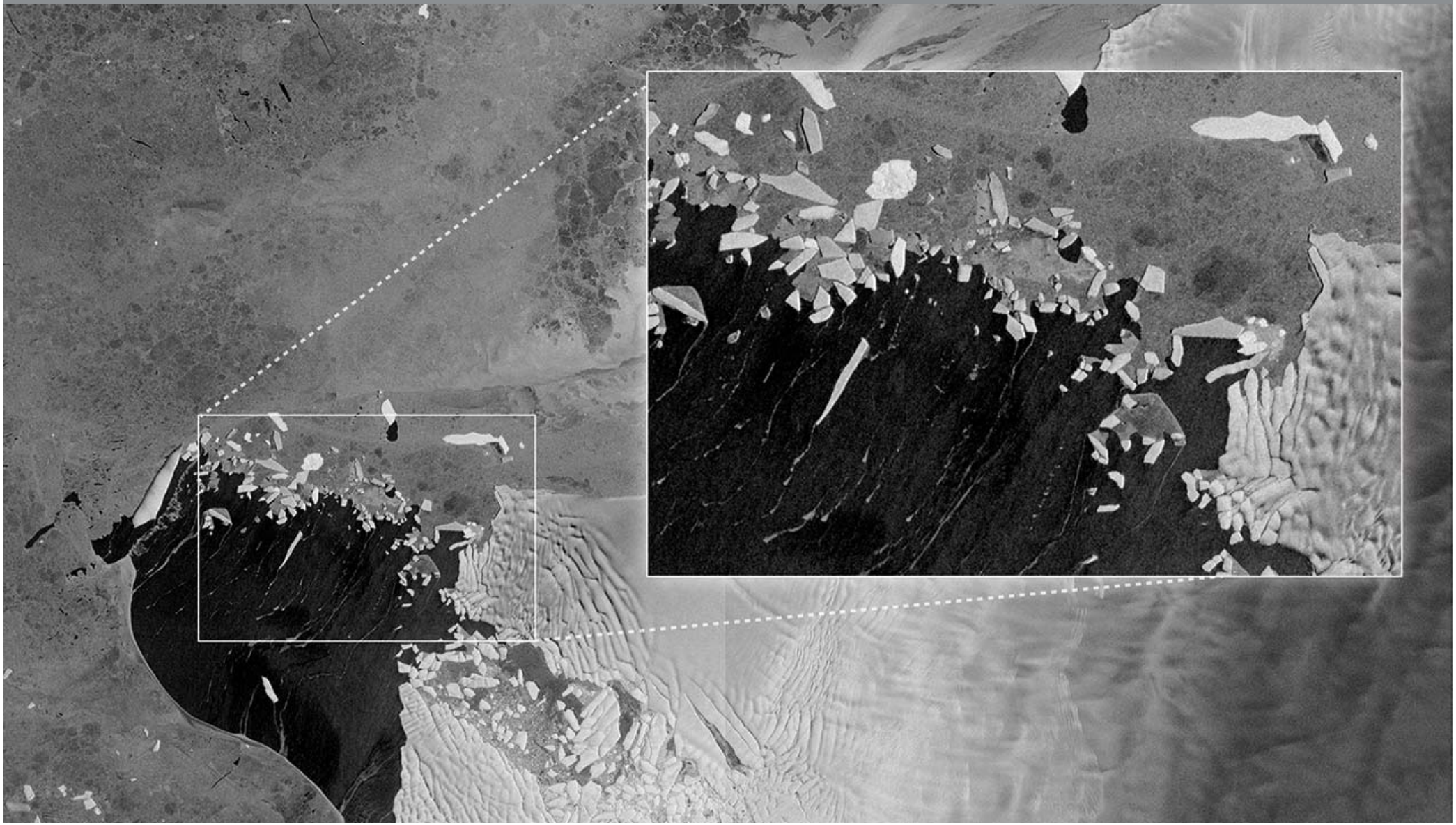
European Space Agency

# Sentinel-1: Mission Profile



- Sun-synchronous orbit at 693 km altitude
- Inclination: 98.18˚
- 7 years lifetime
- Consumables for 12 years
- Mean LST: 18:00h at ascending node
- 12-day repeat cycle at Equator (with 1 satellite)
- 175 orbits/cycle
- 96h operative autonomy

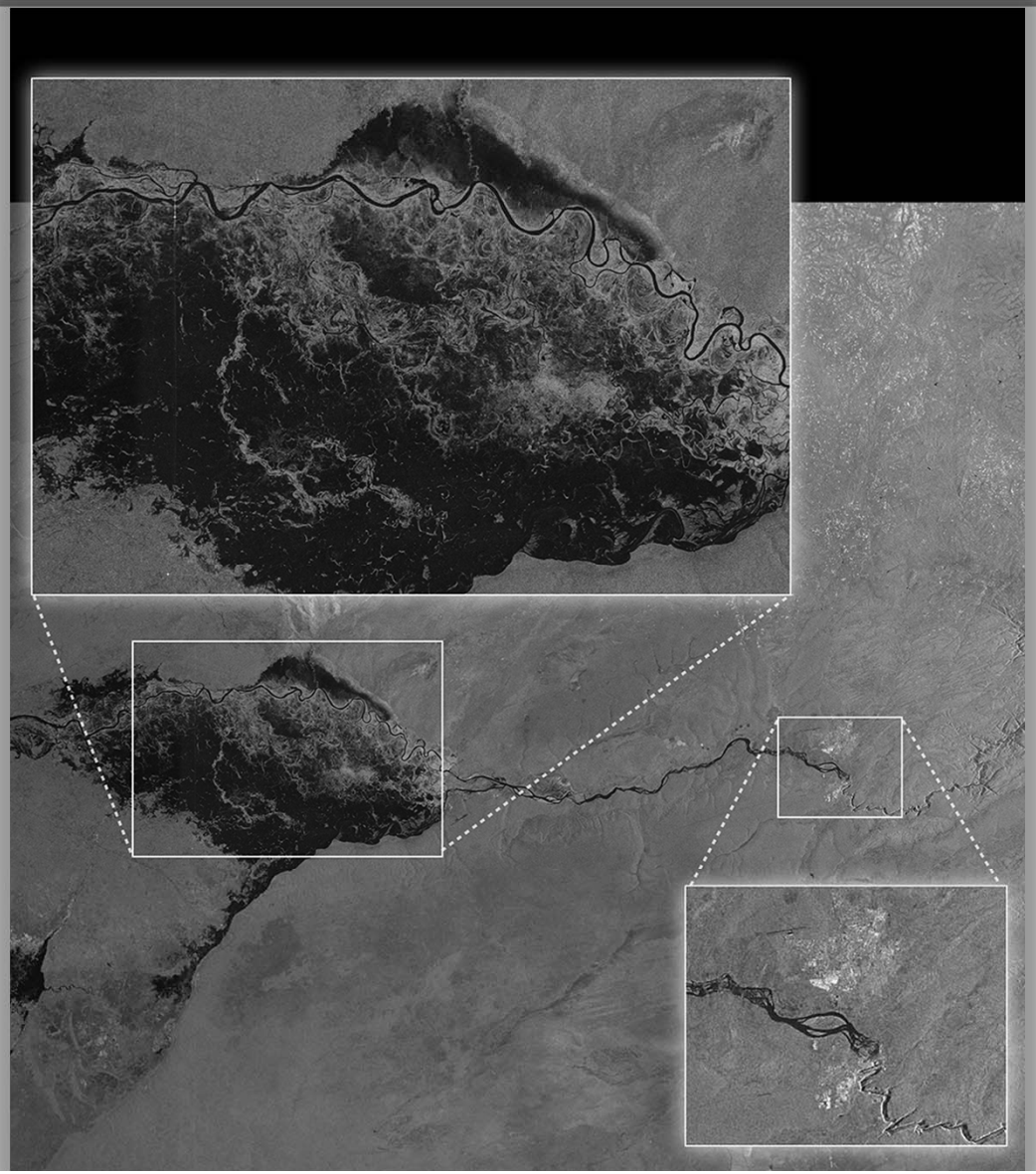
# First Images of Sentinel-1A



# First Images of Sentinel-1A

Zambezi River Flooding and Victoria Falls, Namibia

13 April 2014



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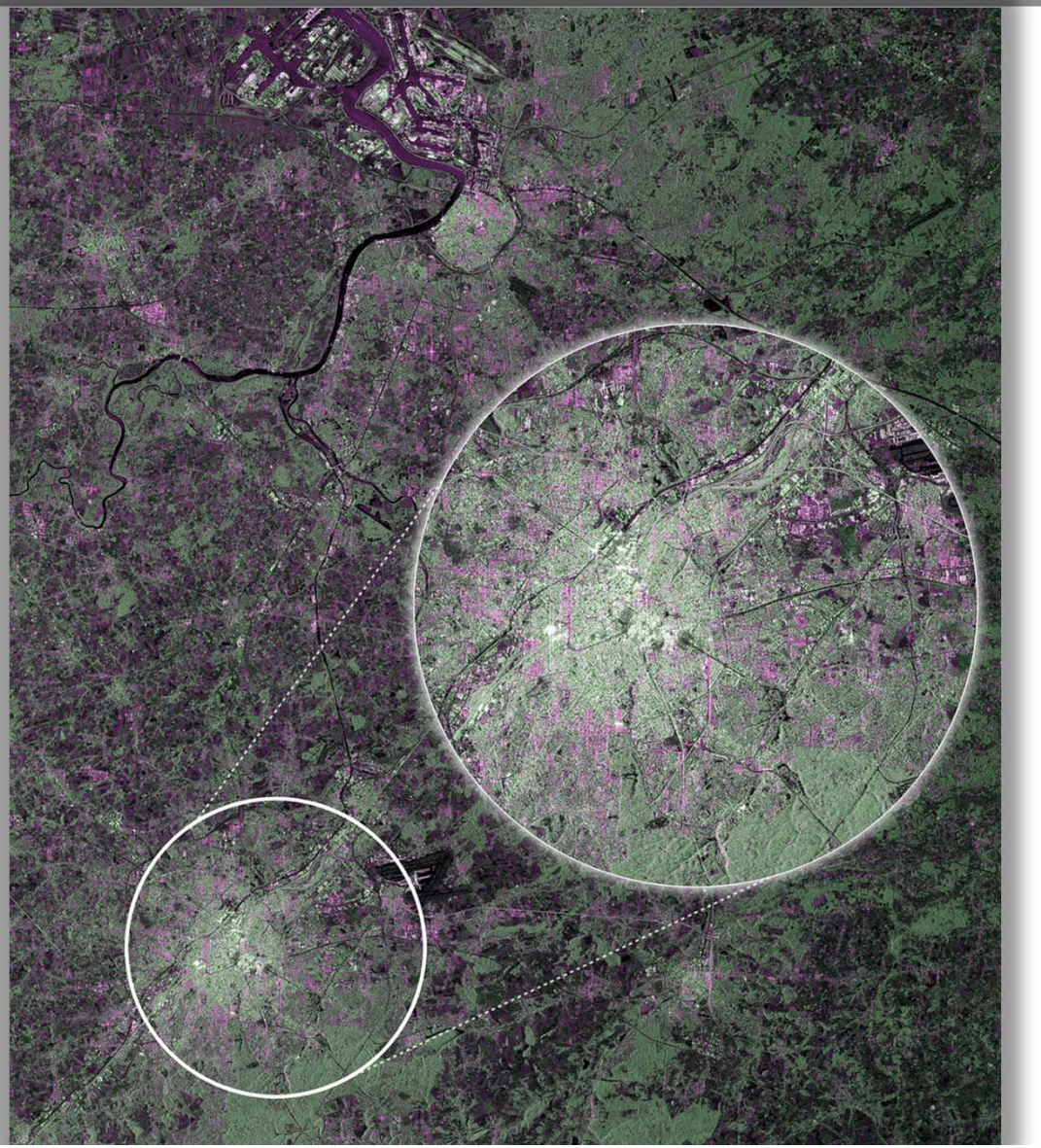
# First Images of Sentinel-1A

Brussels and Antwerp, Belgium

12 April 2014



European Space Agency

# First Images of Sentinel-1A

# Sentinel-1 Quantum Leap

## Sentinel-1

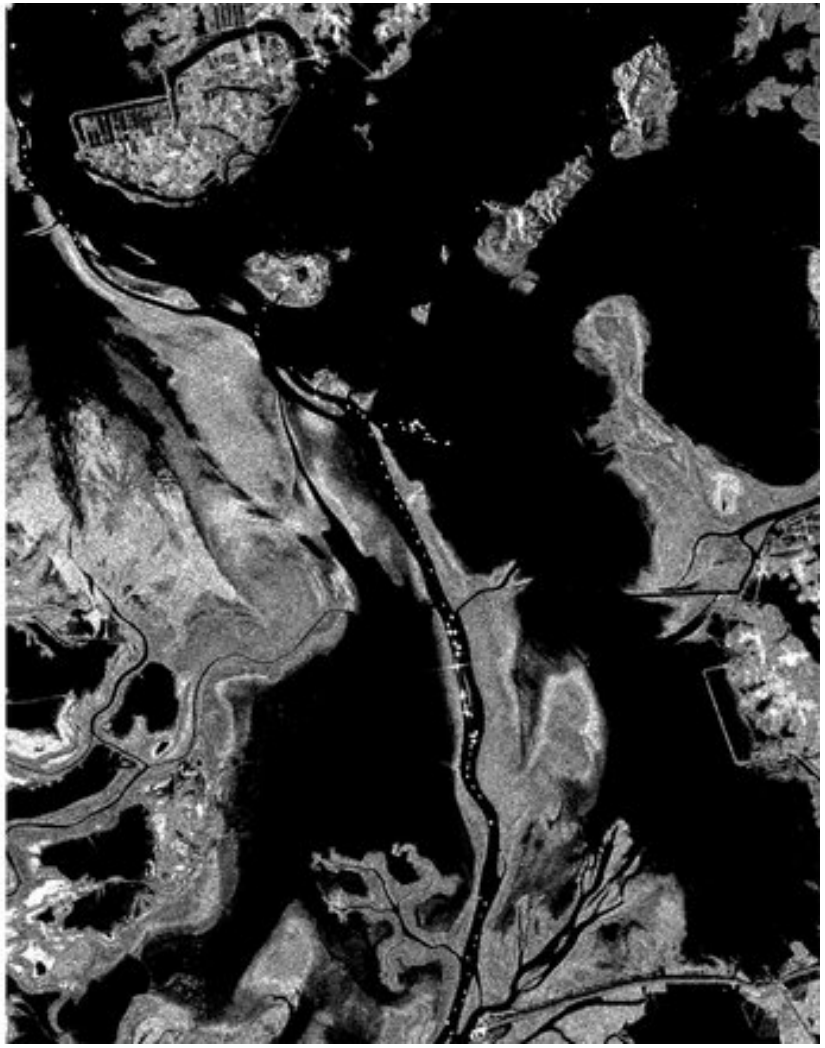
- **10** m ground range resolution (stripmap mode)
- **250** km swath width (Interferometric wide swath mode)
- **6** days repeat cycle (with 2 satellites)
- **2 x 260 Mb/s** downlink data rate
- **7** years design lifetime (consumables for 12 years)
- Optical link to downlink the data to EDRS.

## Envisat

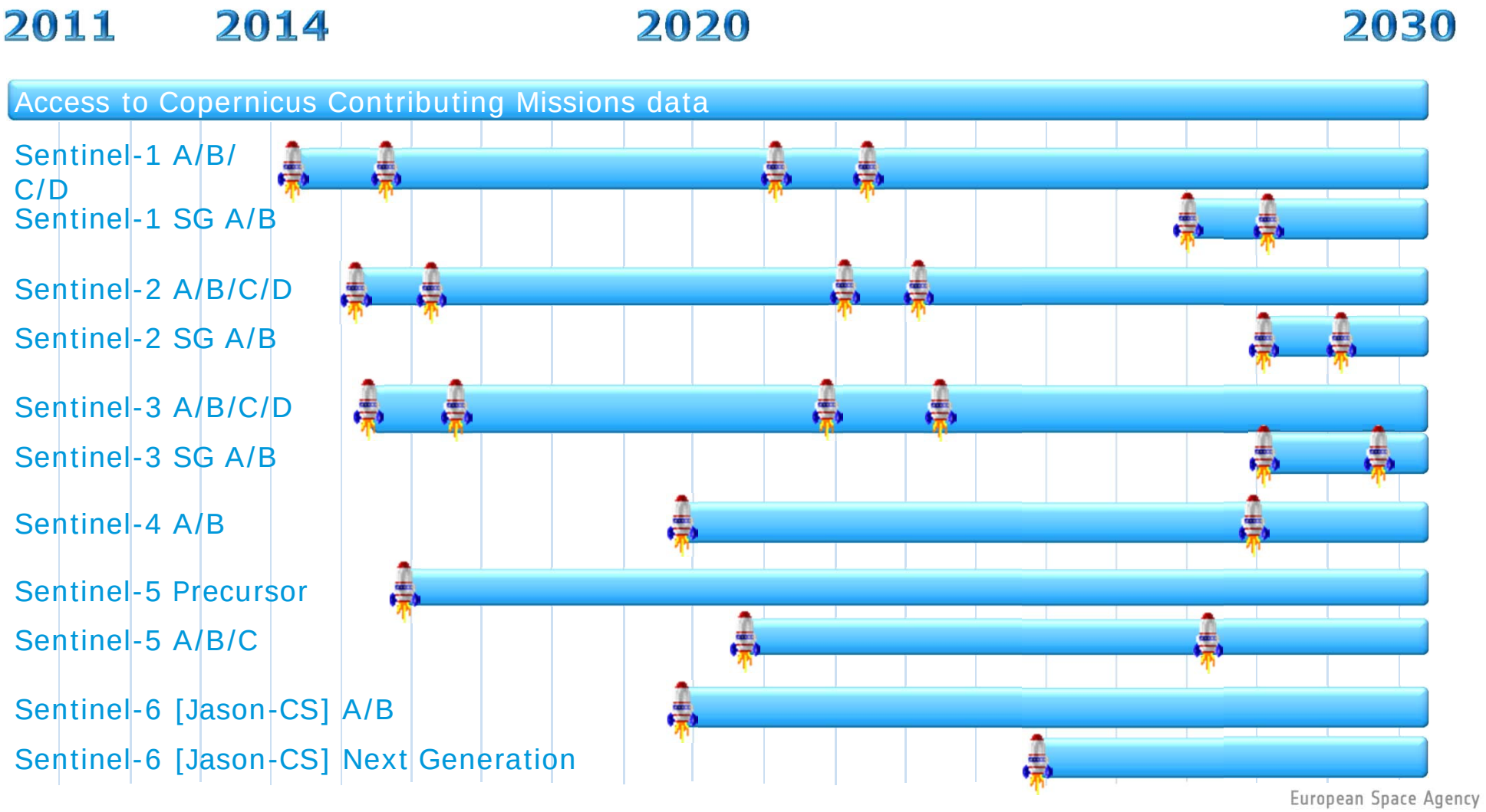
- **20** m ground range resolution
- **100** km swath width (Imaging mode)
- **35** days repeat cycle
- Up to **100 Mb/s** space to ground data rate
- **5** years design lifetime

**Sentinel-1: Twice the sensitivity and thrice the accuracy in Radar imaging quality**

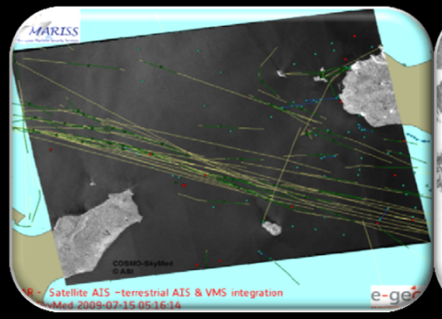
# Envisat vs. Sentinel-1



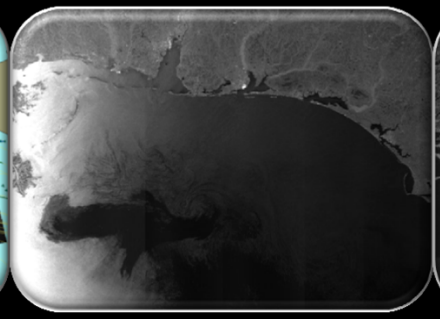
# Sentinel Deployment Schedule

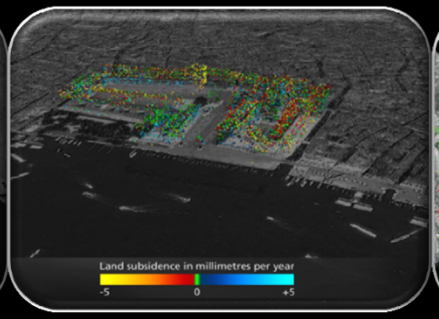


# Some Sentinel Application Areas

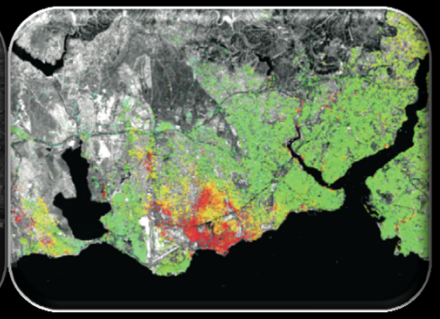


Maritime surveillance

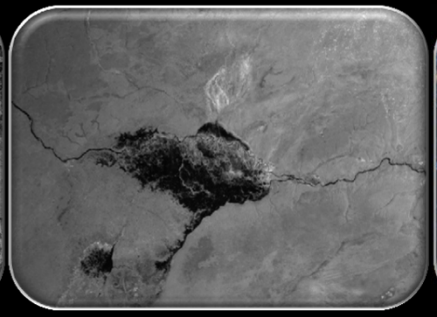

Oil spills



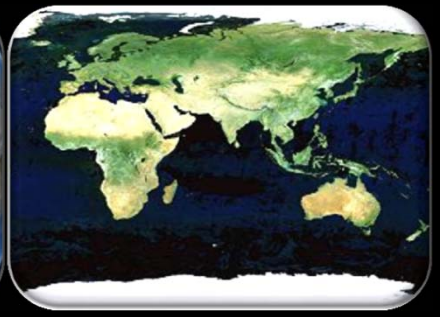
Land subsidence

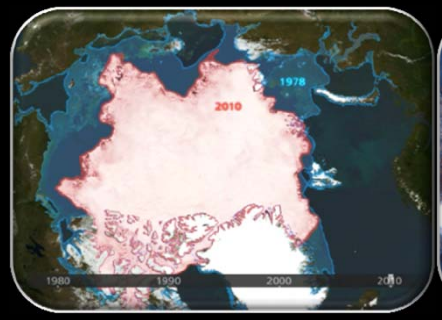

Tectonics


Volcanoes

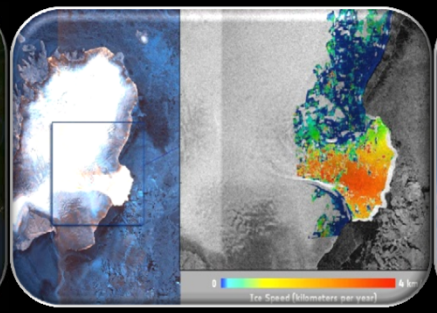

Floods


Deforestation


Vegetation



Sea ice extent

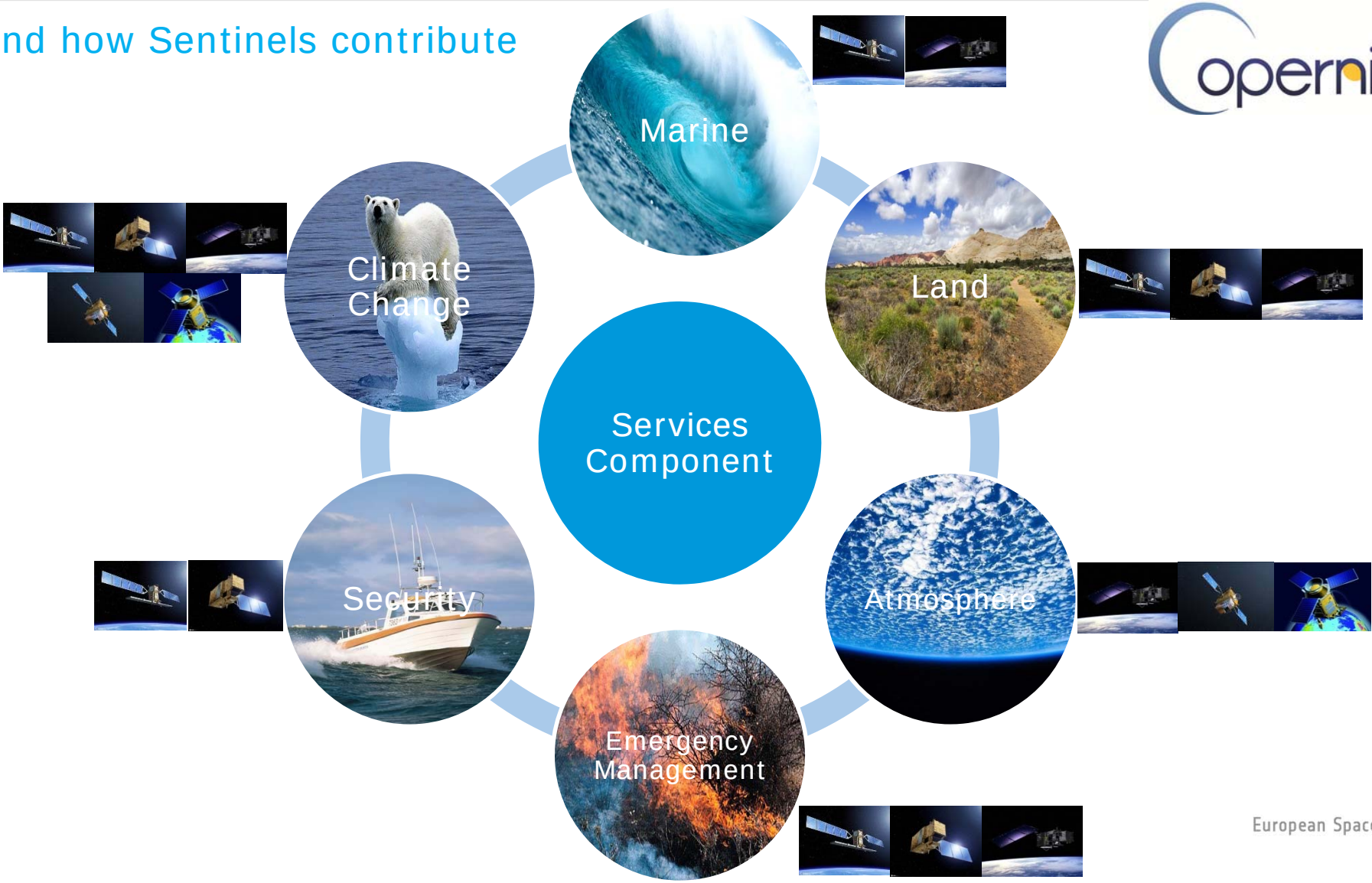

Ice speed


Atmosphere

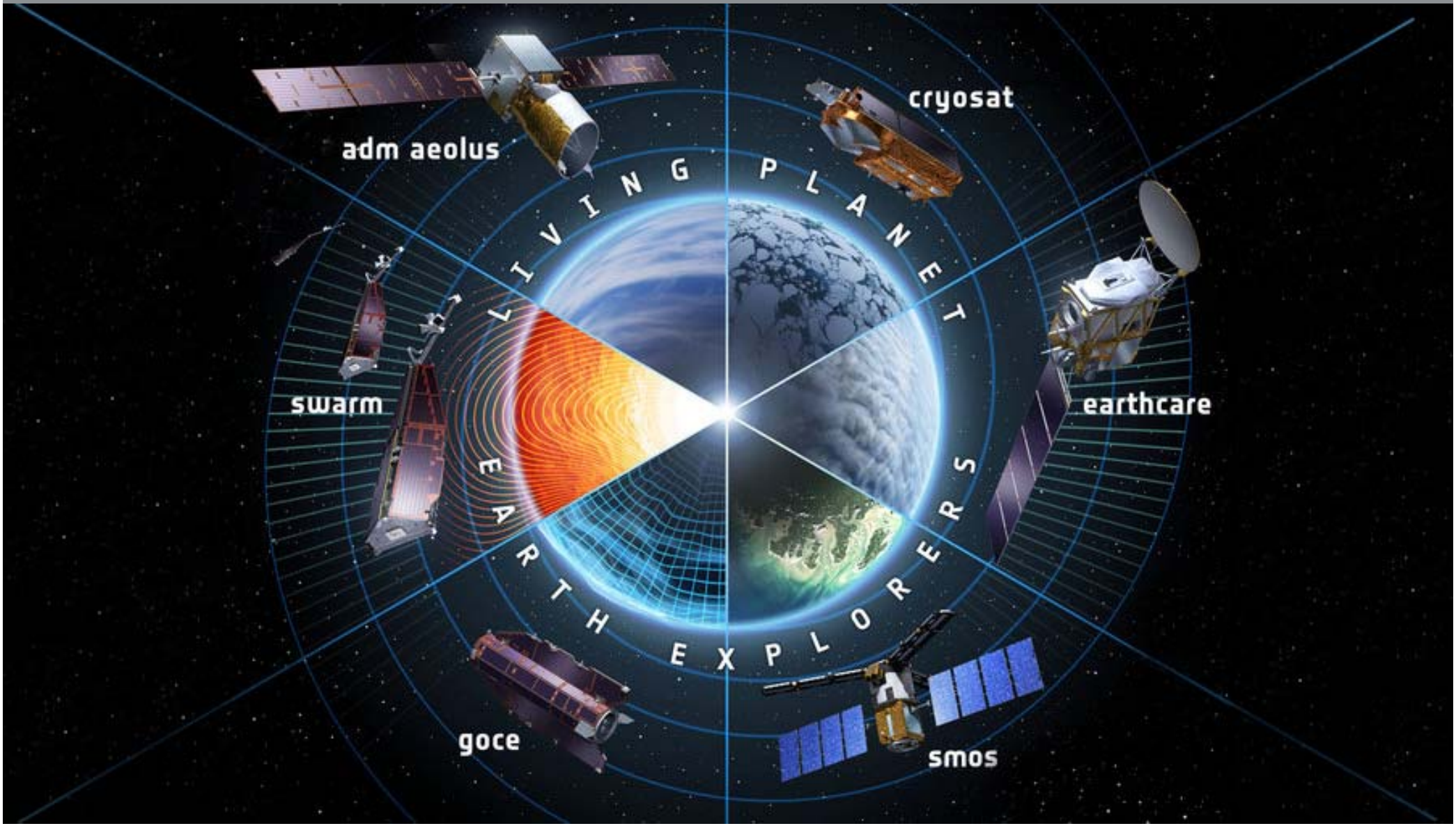

Ocean colour

# Copernicus Services Component…

…and how Sentinels contribute



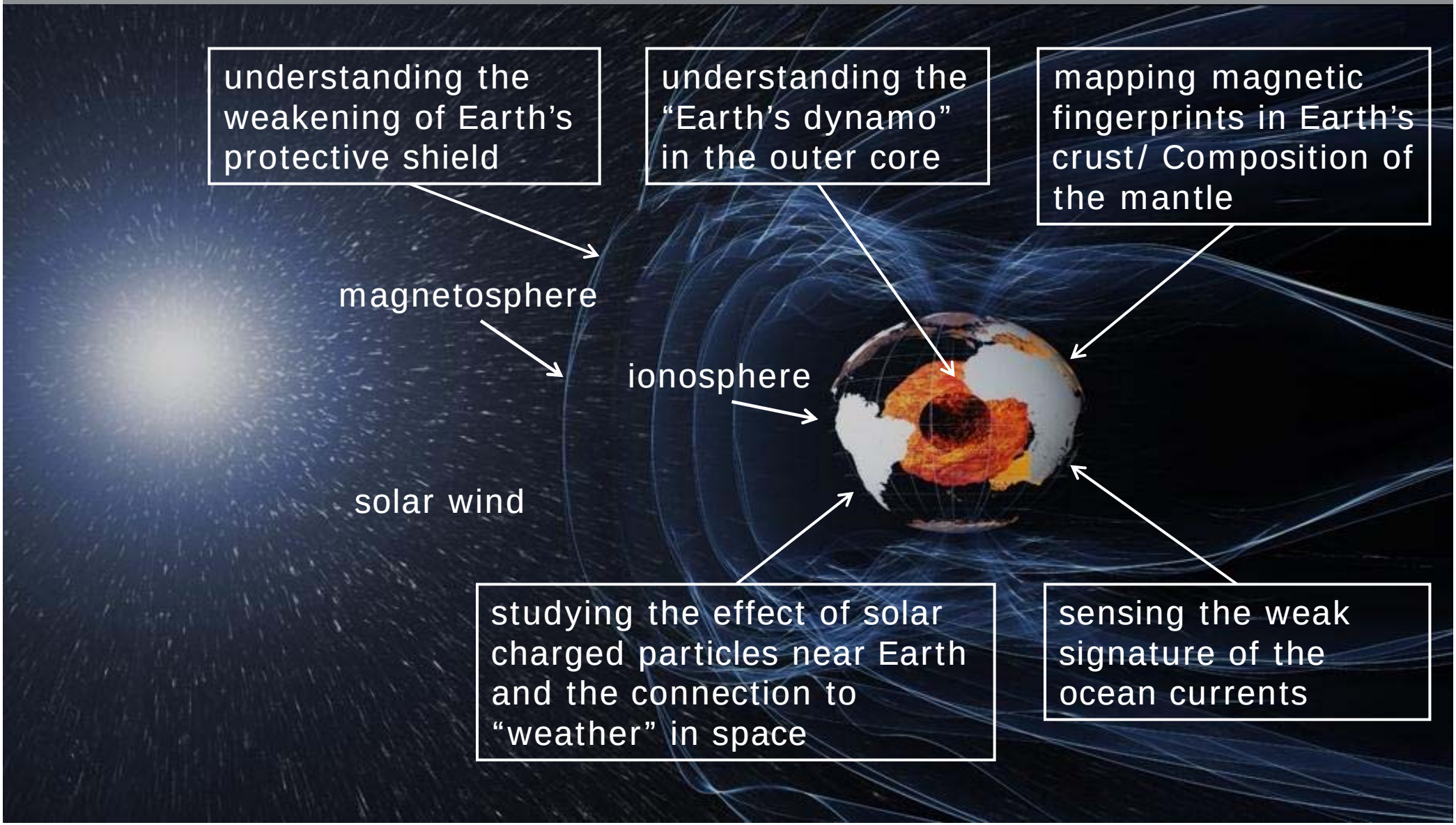
# Science – the Earth Explorers



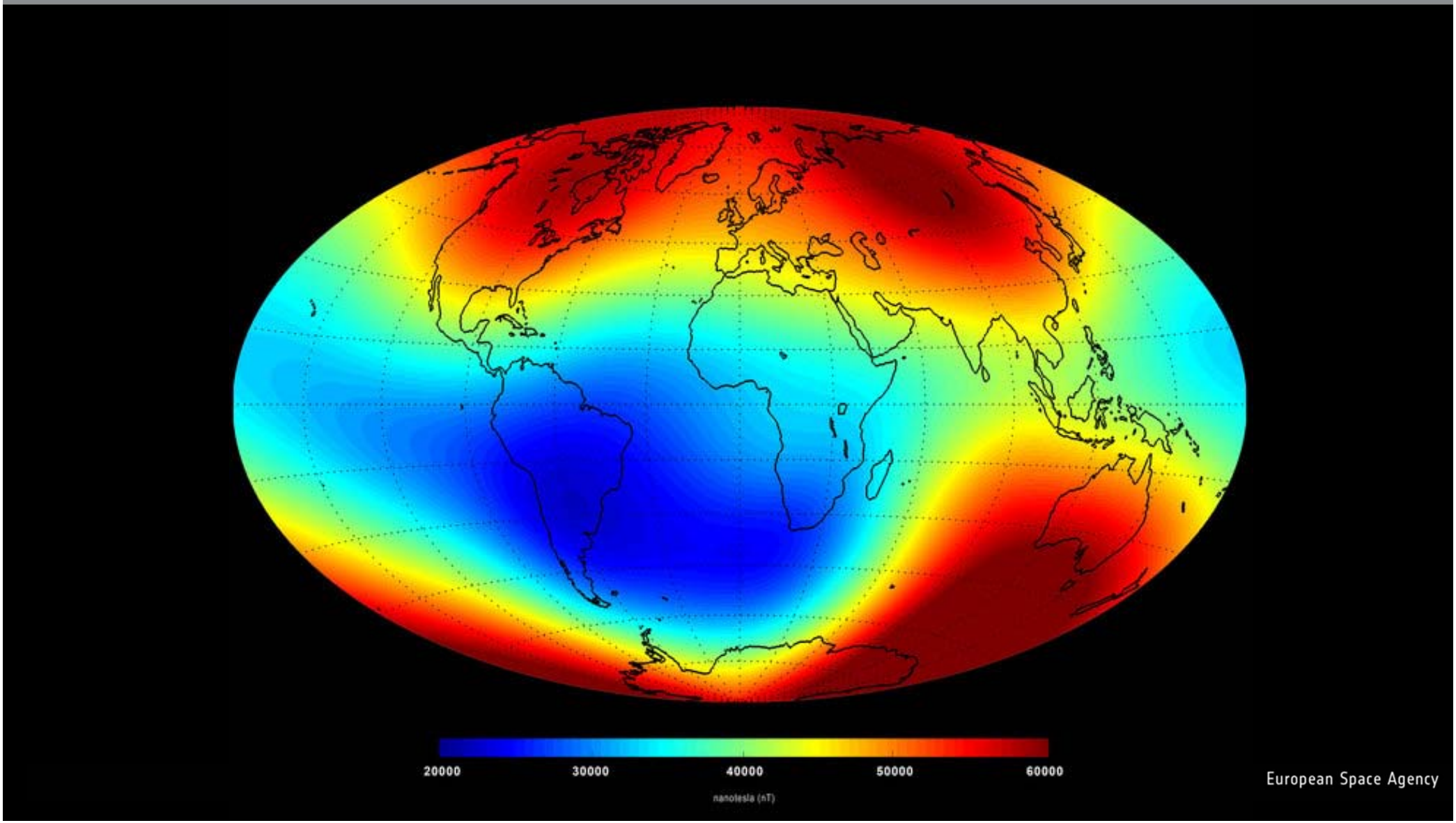
# Swarm

- Three satellite constellation
- Providing the best-ever survey of the geomagnetic field and its variation in time
- Gaining new insights into the Earth's interior and climate
- Launch 22 November 2013
- IOCR finished 19 March 2014

# Swarm Science Objectives

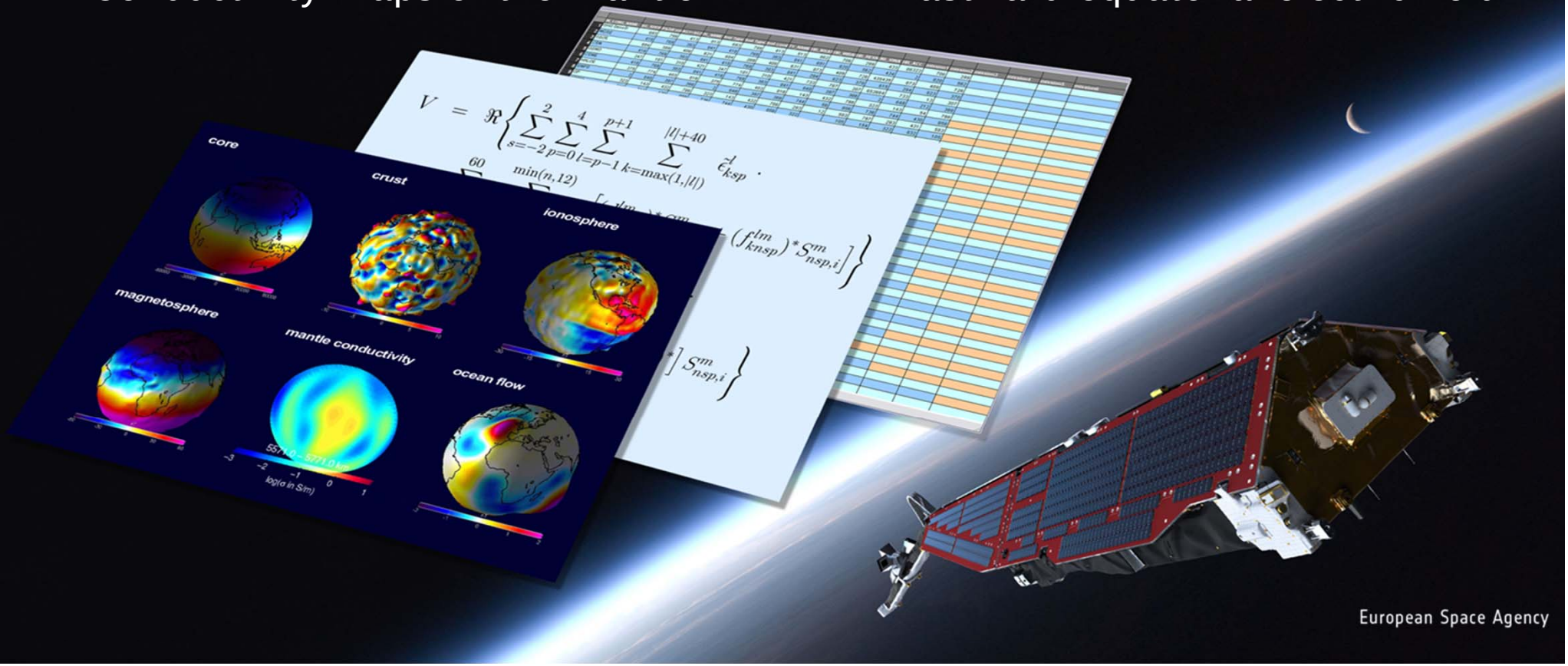


# Earth’s Magnetic Field from Swarm Data



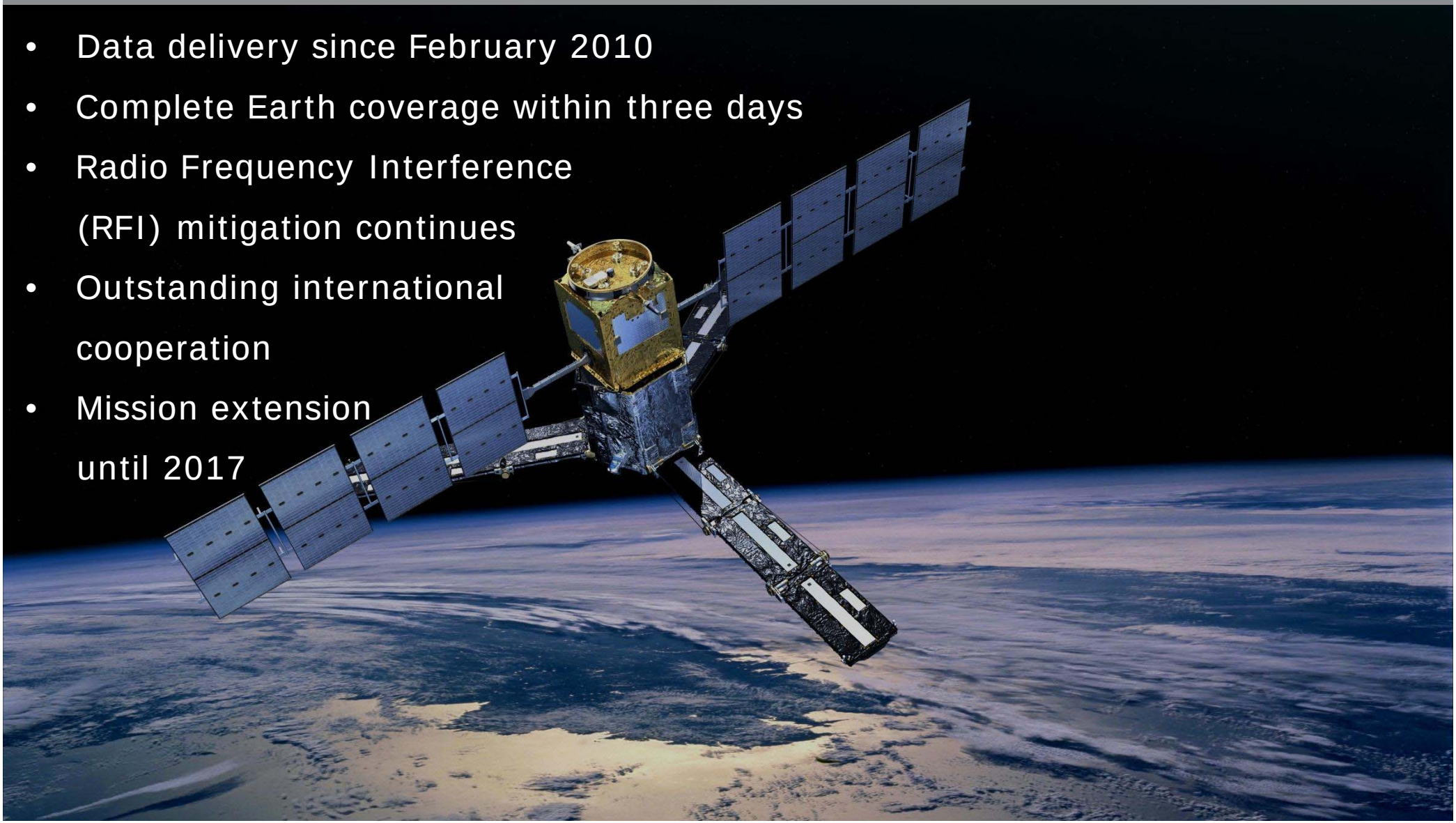
# Swarm Data

- Magnetic and electric field products
- Ion density and ion and electron temperature
- Global models of the core and crust
- Conductivity maps of the mantle
- Neutral density and wind
- Plasma bubble index and field aligned currents
- Precise orbits and accelerations
- Eastward equatorial electric field

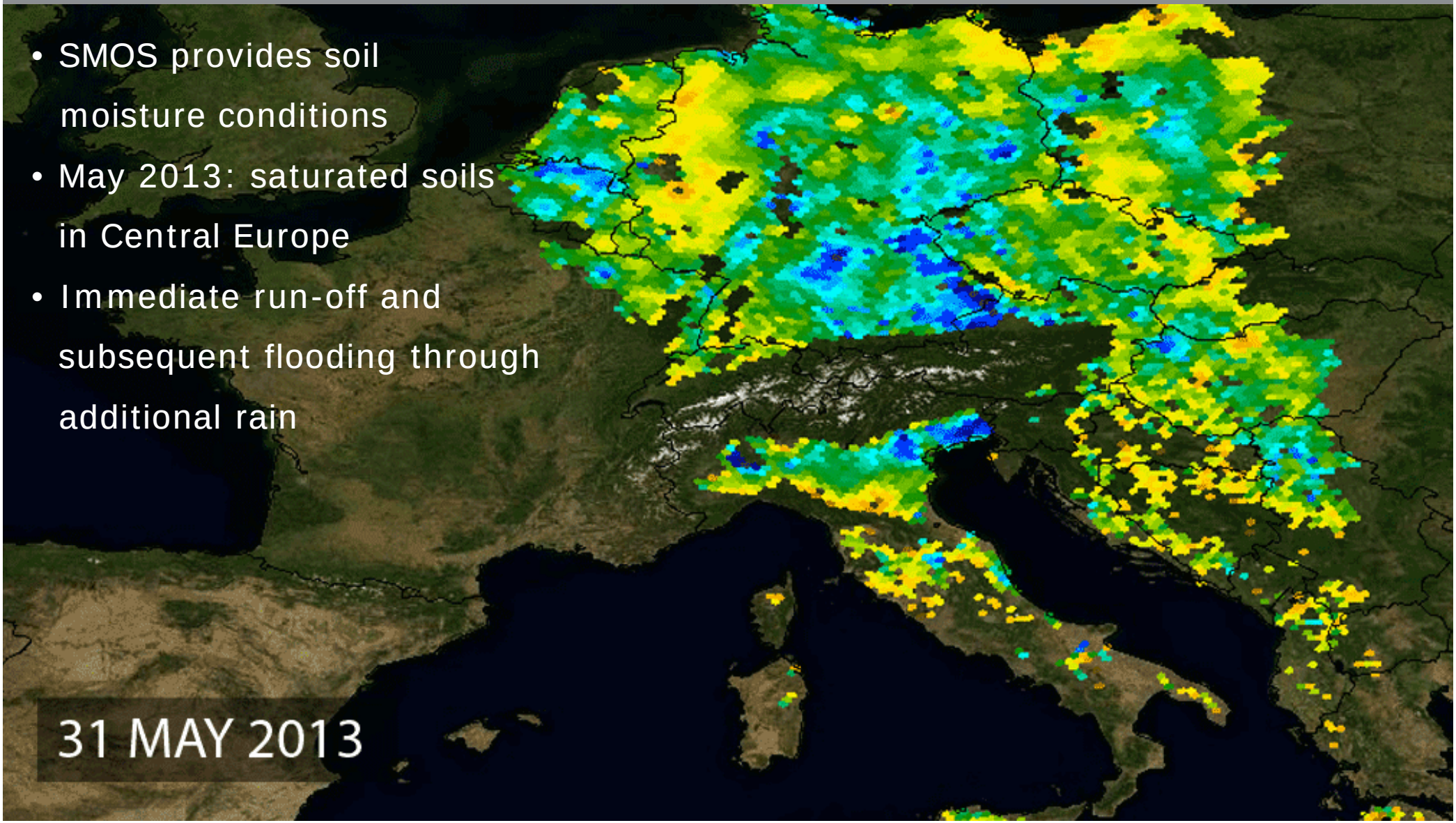


# SMOS – Soil Moisture and Ocean Salinity

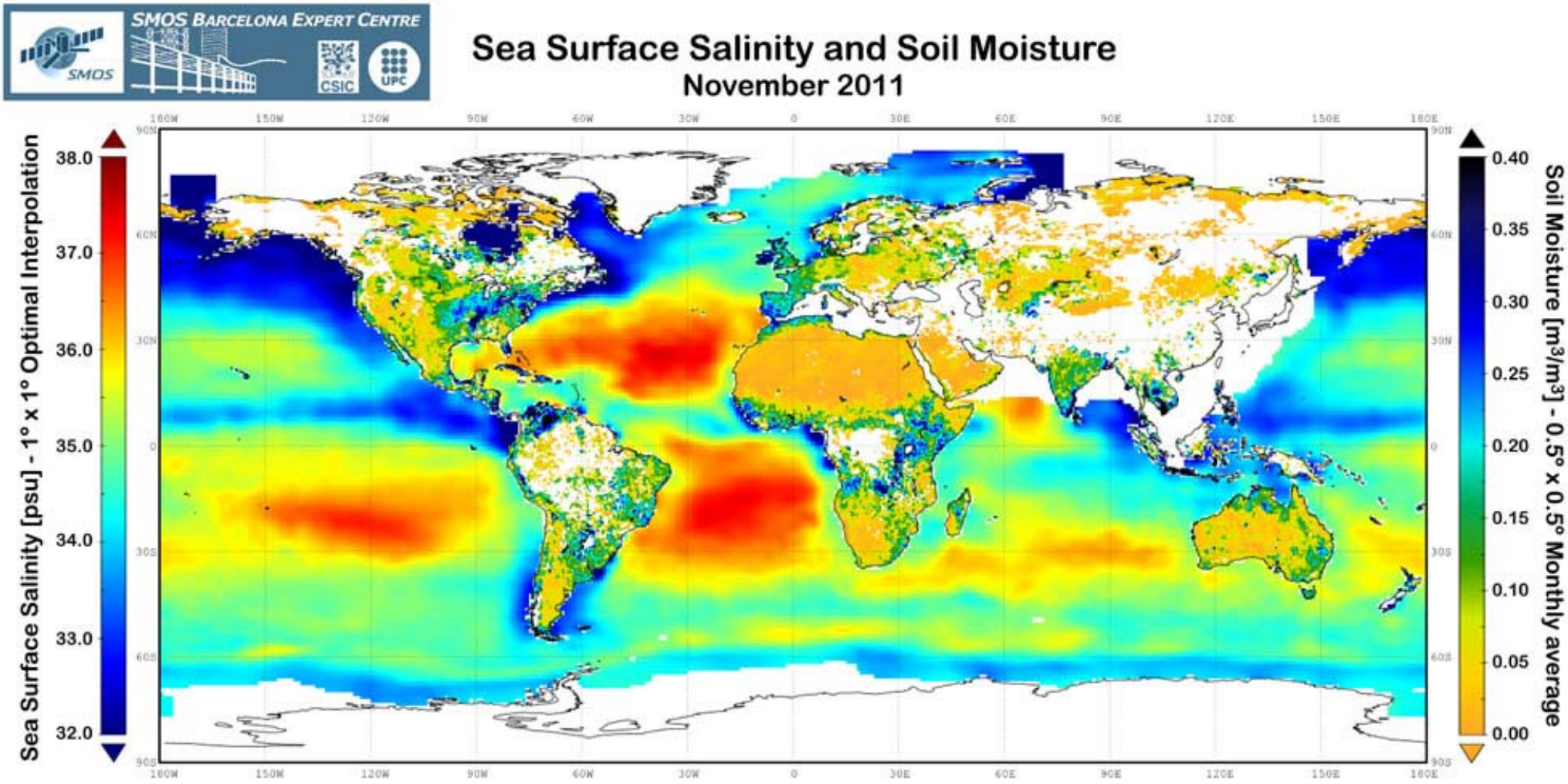
- Data delivery since February 2010
- Complete Earth coverage within three days
- Radio Frequency Interference (RFI) mitigation continues
- Outstanding international cooperation
- Mission extension until 2017



# SMOS – Hydrology

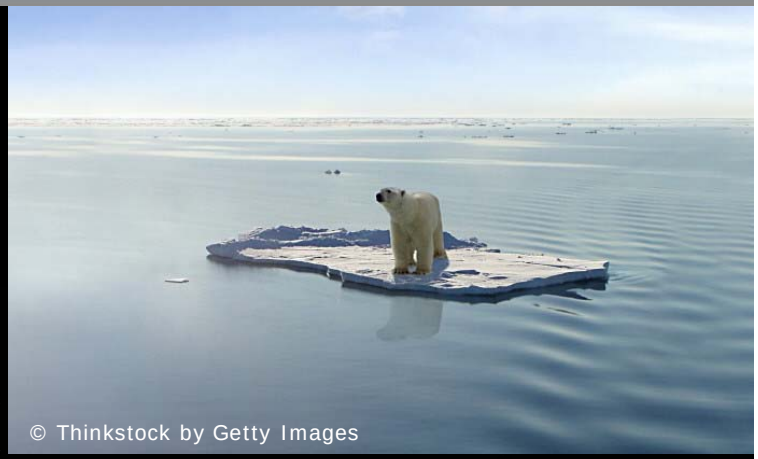


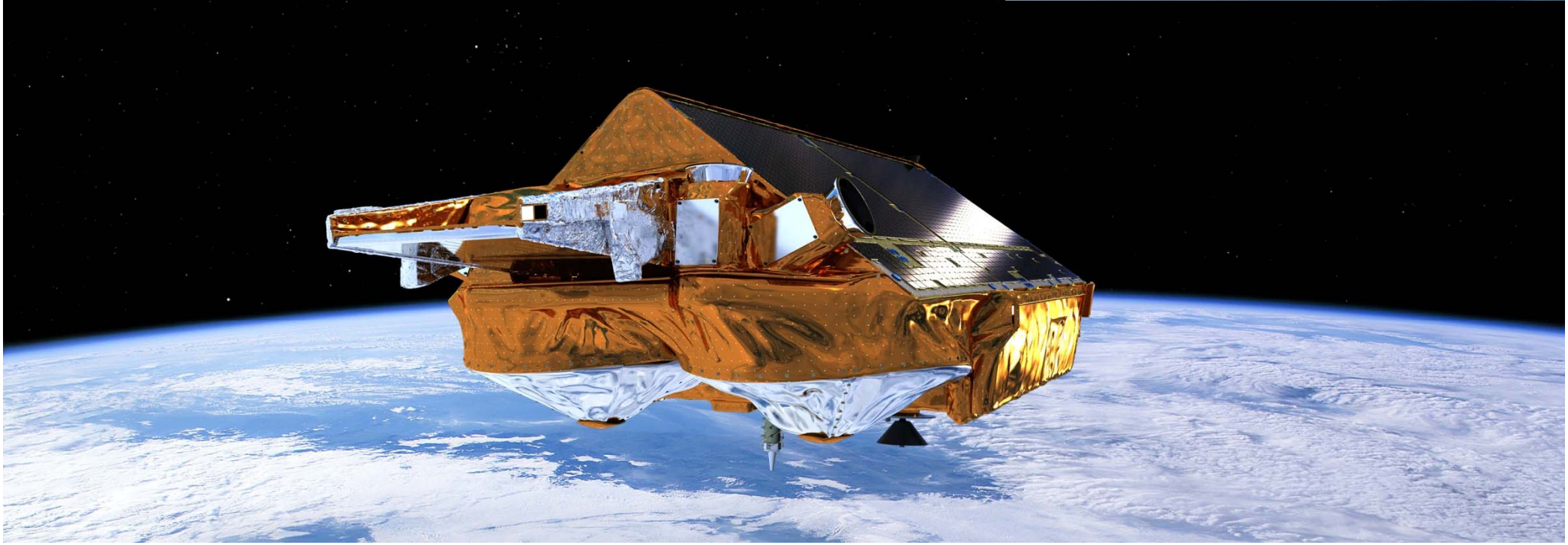
# SMOS Measurements



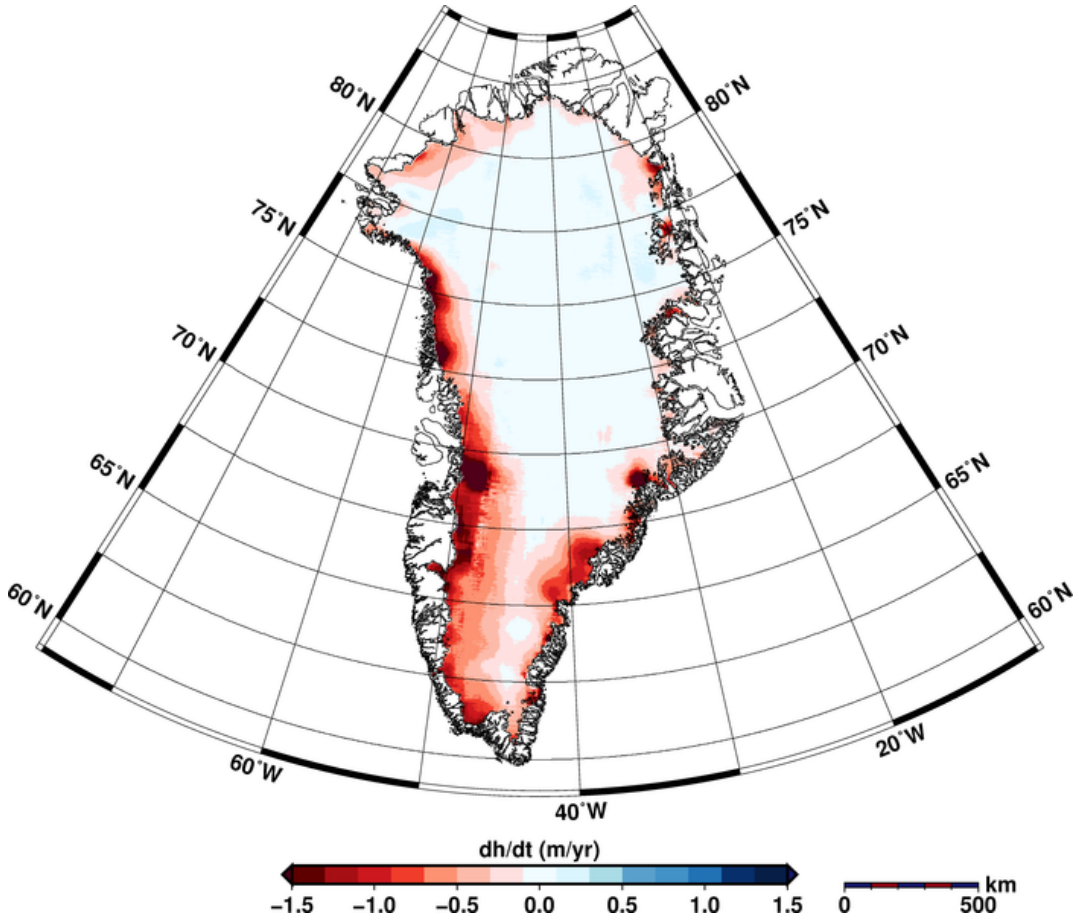
# CryoSat: The Ice Mission

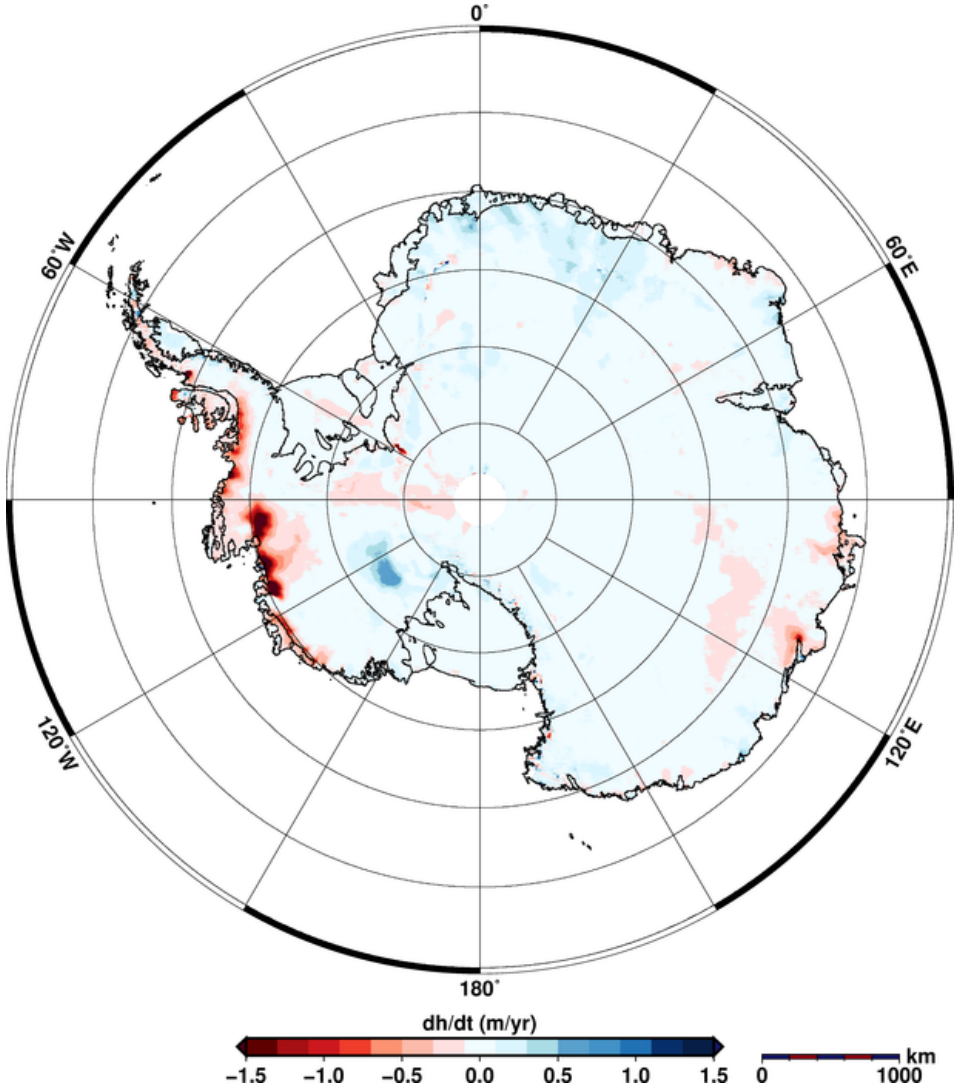
- First interferometric altimeter in space
- Global sea ice thickness measurements
- Data used for ice research, but increasingly also for oceanography
- Mission extension until 2017 [verify]



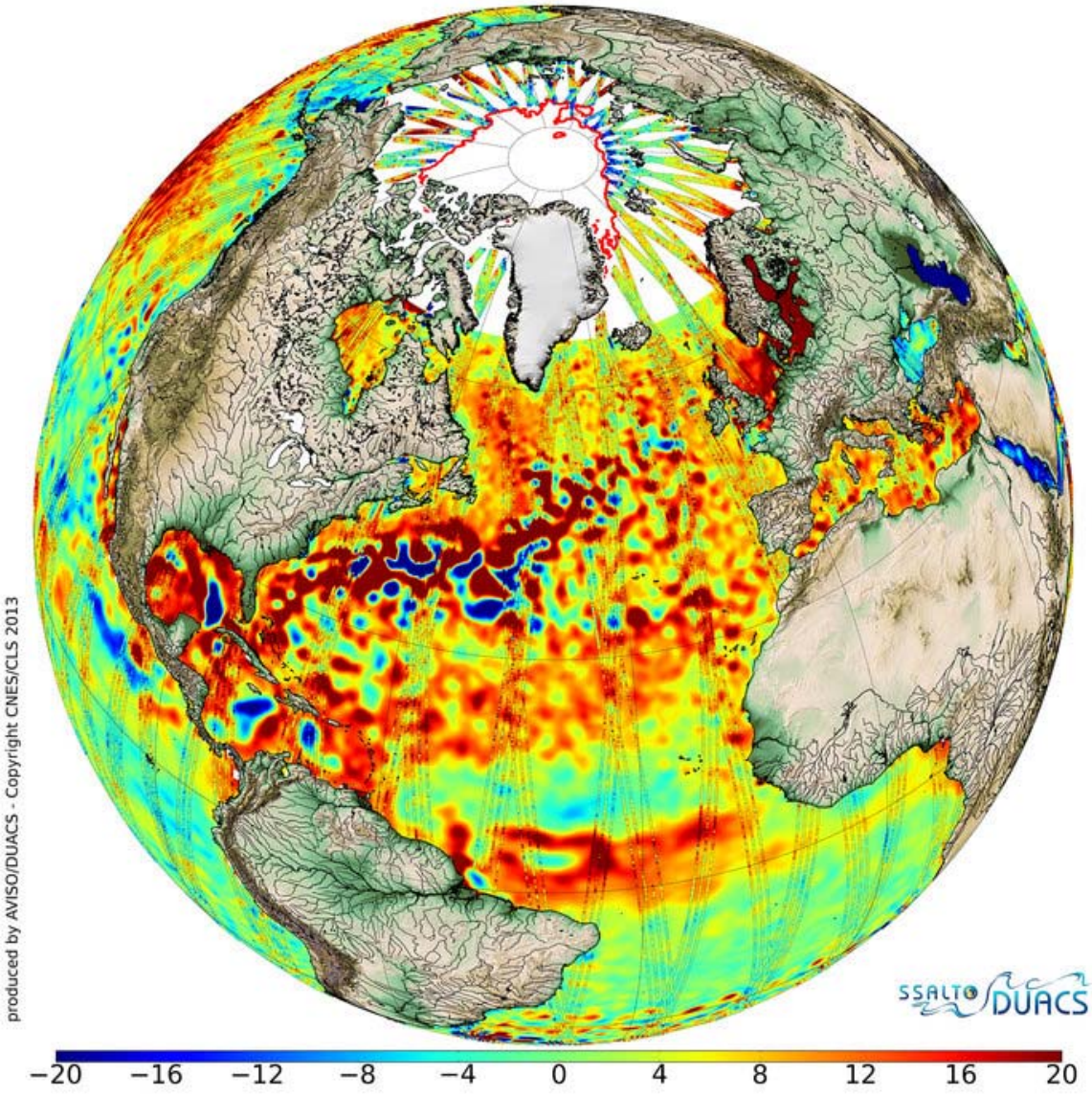



# CryoSat: Greenland Ice Sheet Change



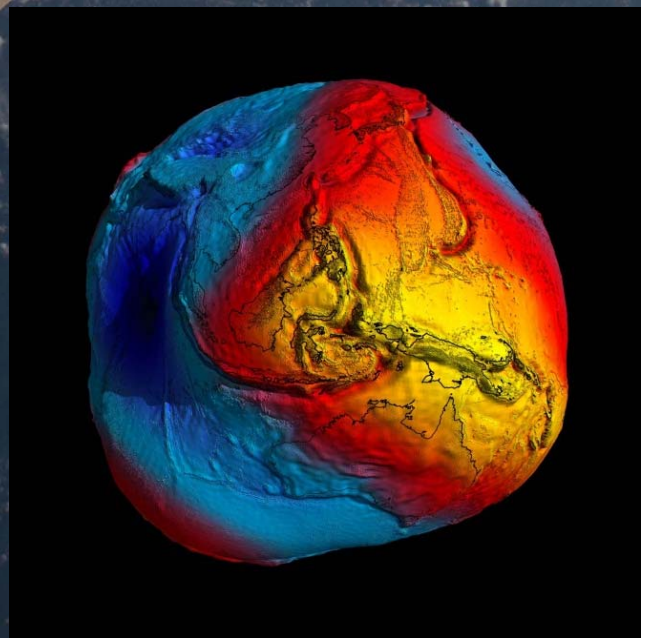



# Sea Surface Topography from CryoSat

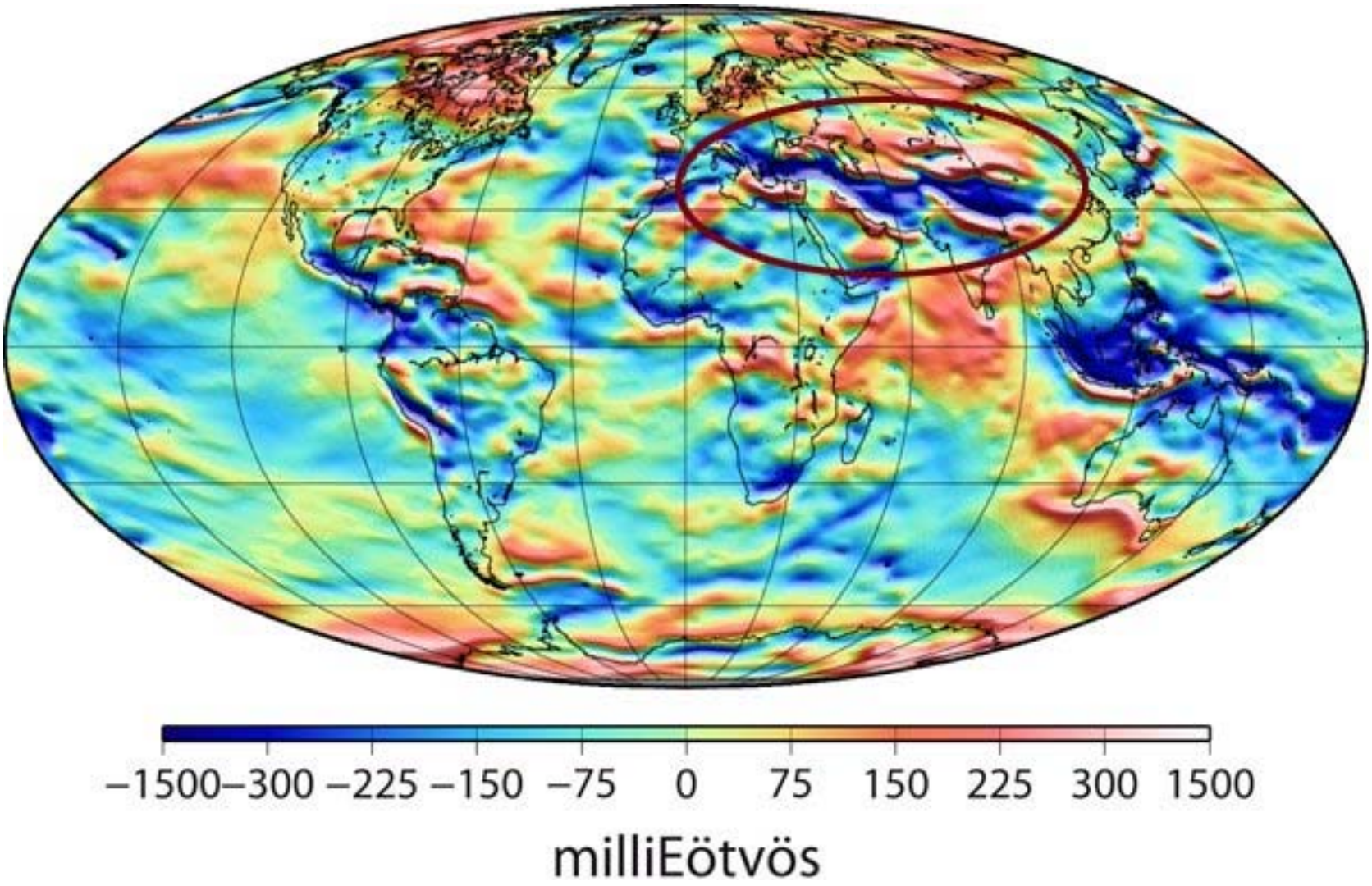


# GOCE: Gravity and Ocean Circulation

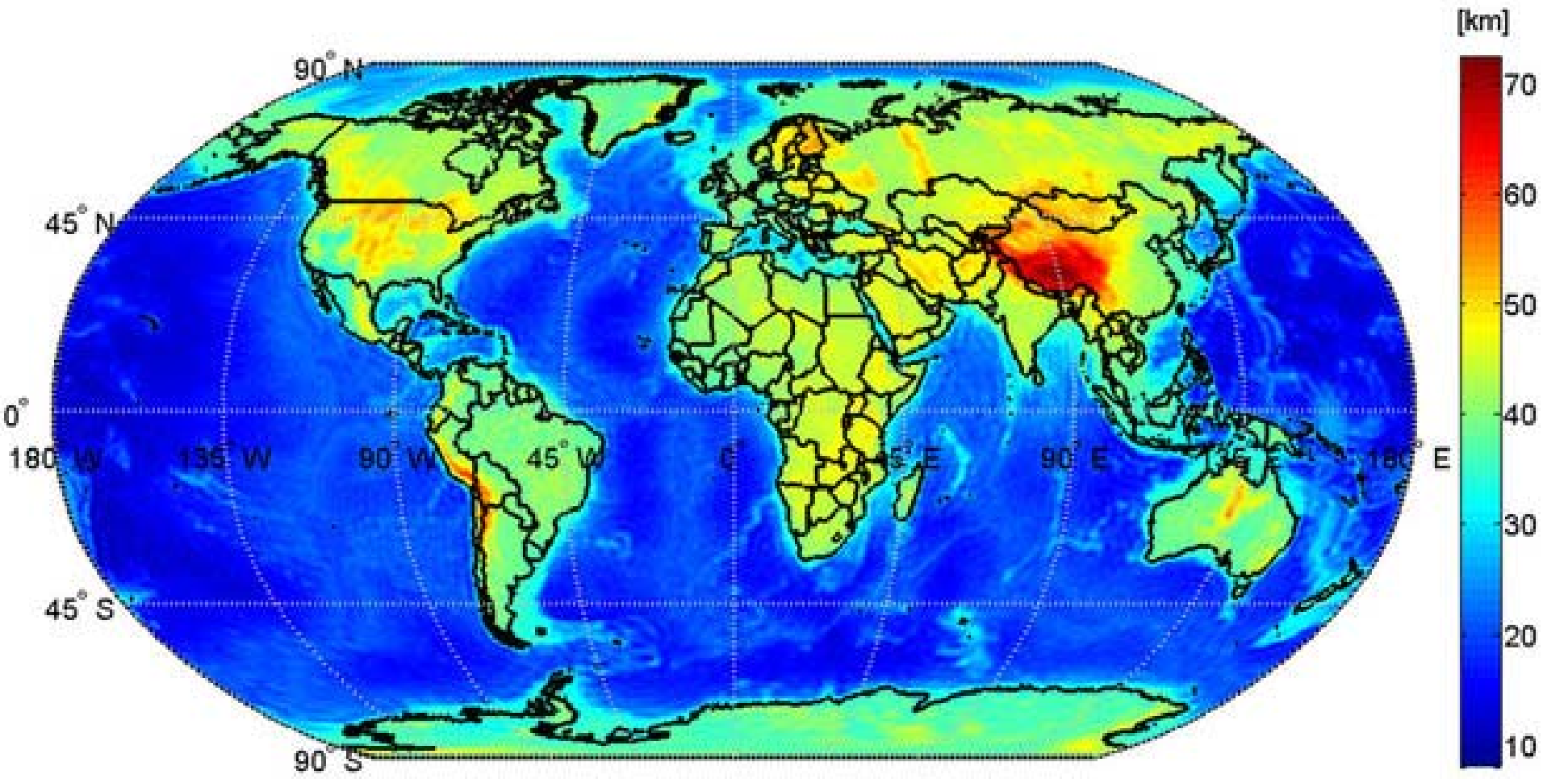
- First gradiometer in space
- Best geoid ever
- 5th version of geoid foreseen released in July 2014, including all GOCE measurements
- End of mission declared 21 October 2013 following depletion of Xenon fuel
- Re-entry 11 November 2013



# GOCE: Remnants of Tethys Ocean



# GOCE: Moho Discontinuity

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# GOCE: A Wealth of Applications

Geoid

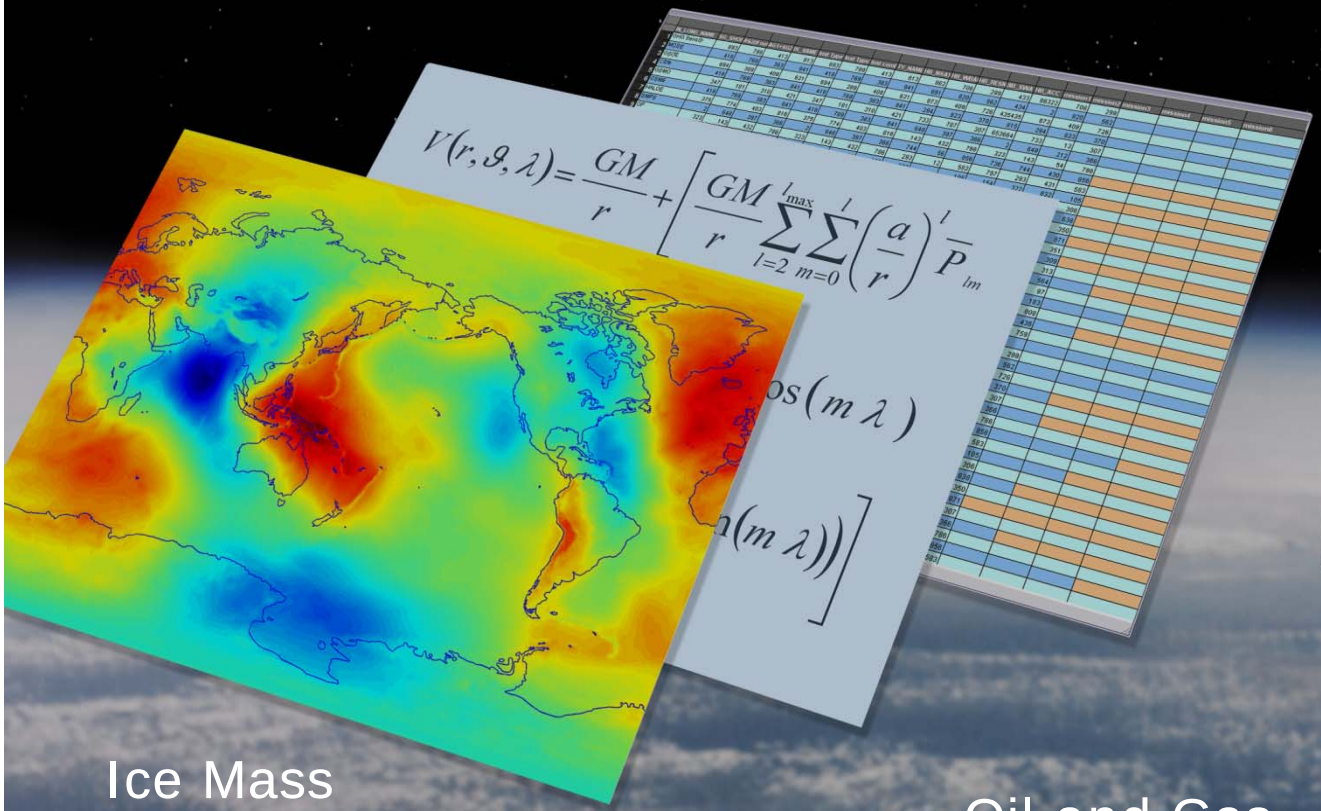
Gravity Anomalies

Topography

Altimetry

Positioning

Unified Height Systems



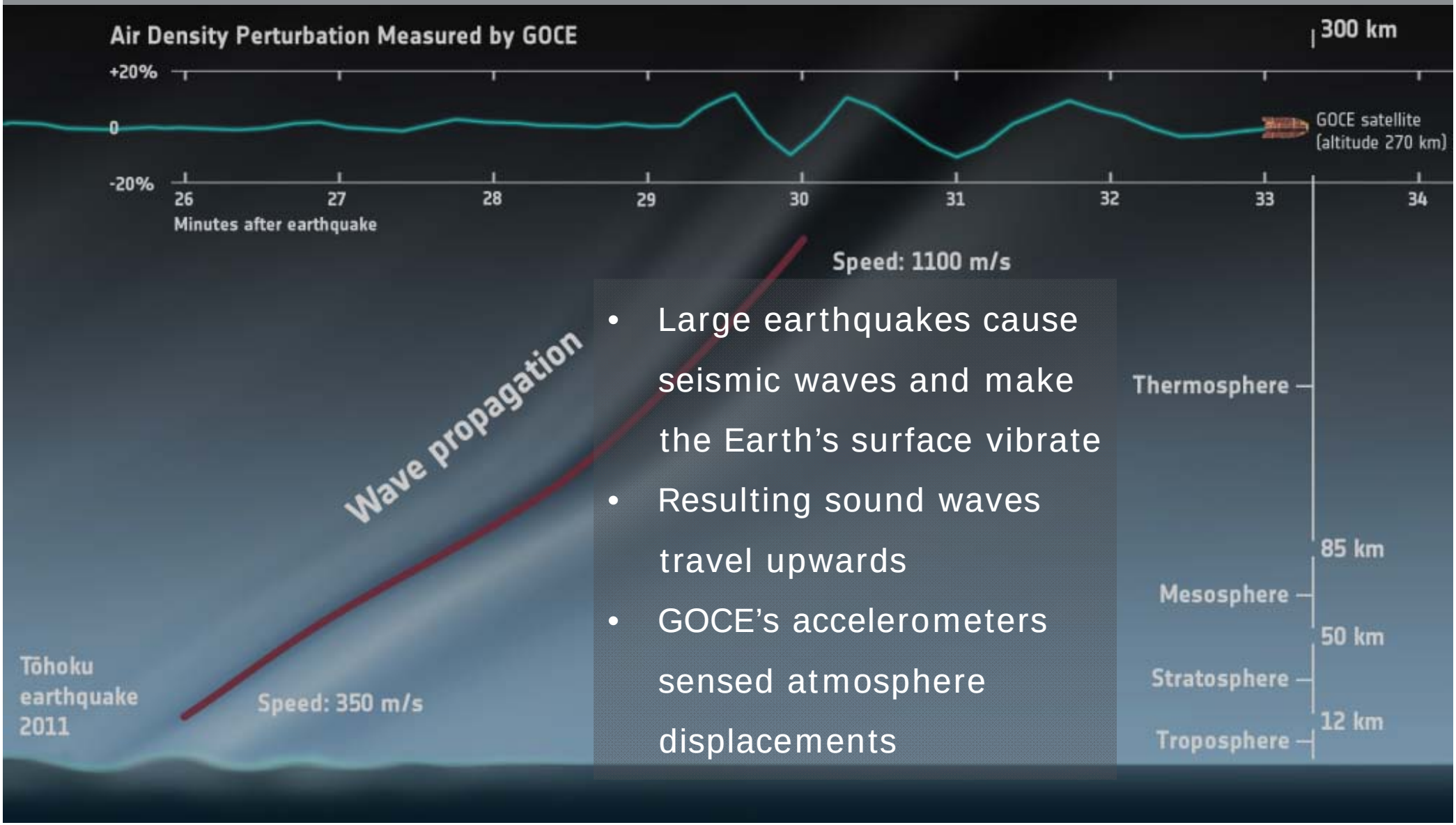

Ice Mass Balance

Mean Ocean Circulation

Oil and Gas Exploration

Post Glacial Rebound

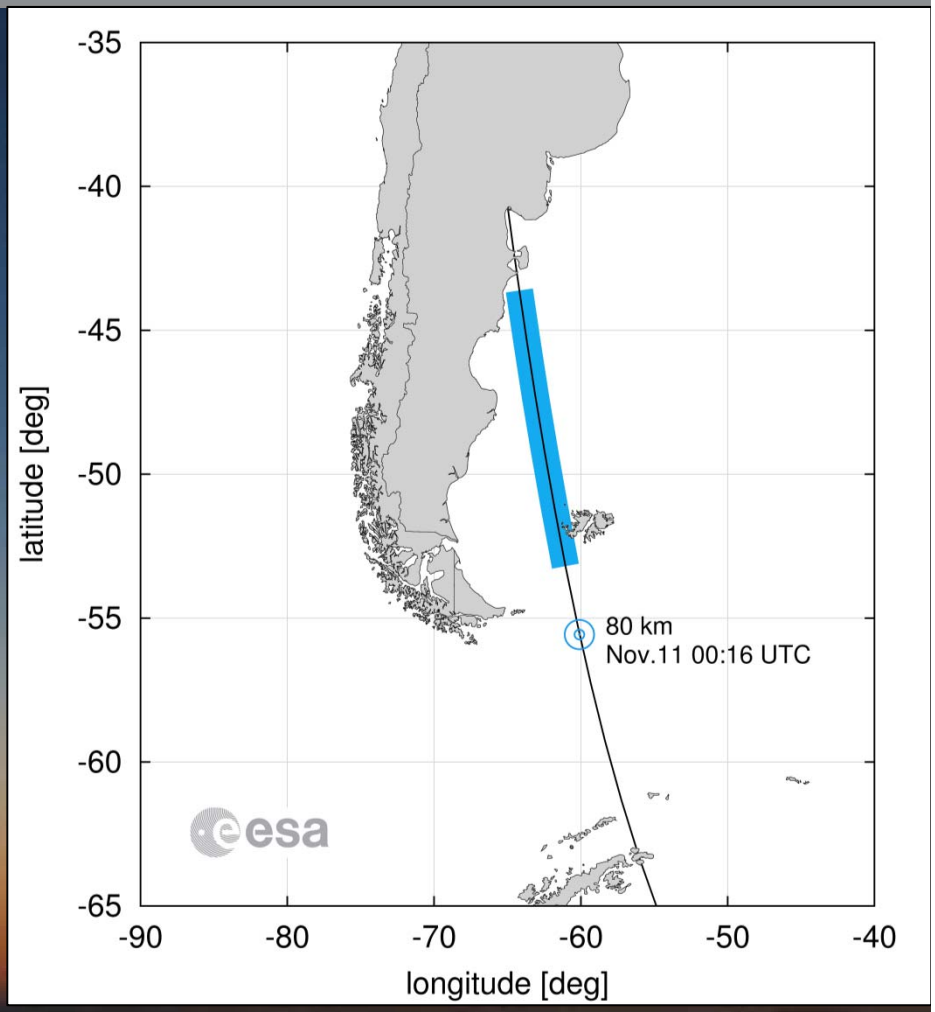
# GOCE: Seismometer in Space




- Large earthquakes cause seismic waves and make the Earth's surface vibrate
- Resulting sound waves travel upwards
- GOCE's accelerometers sensed atmosphere displacements

# GOCE Re-Entry 11 November 2013

- As seen from the Falkland Islands…

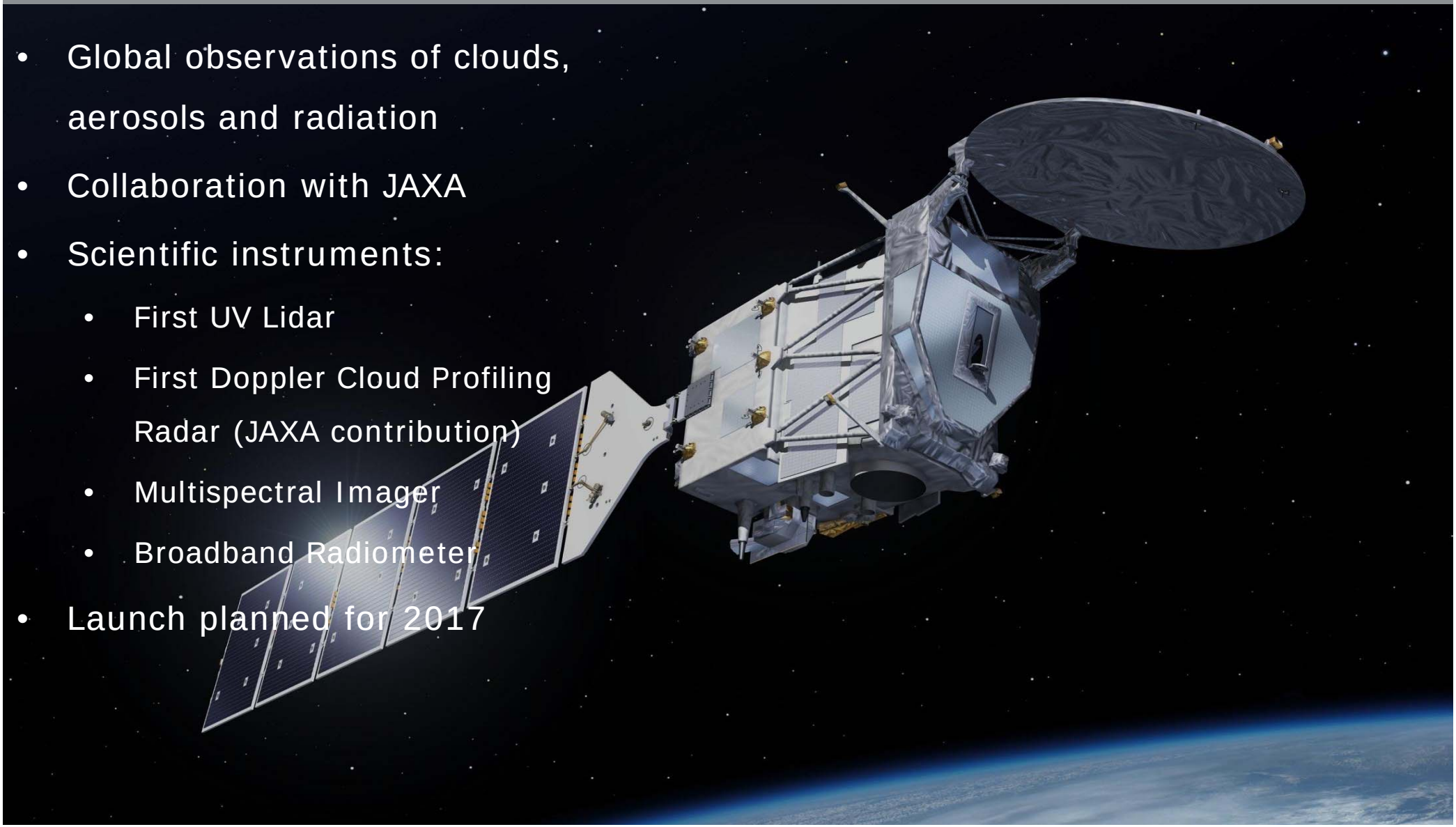


# **ADM-Aeolus** – ESA‘s Wind Mission

- Global observations of wind profiles for analysis of global 3D wind field
- Understanding of atmosphere dynamics and climate processes
- Improved weather forecasts and climate models

- Laser transmitter of Lidar has passed operational qualification tests
- Launch planned for 2016

# EarthCARE – ESA‘s Aerosol Mission

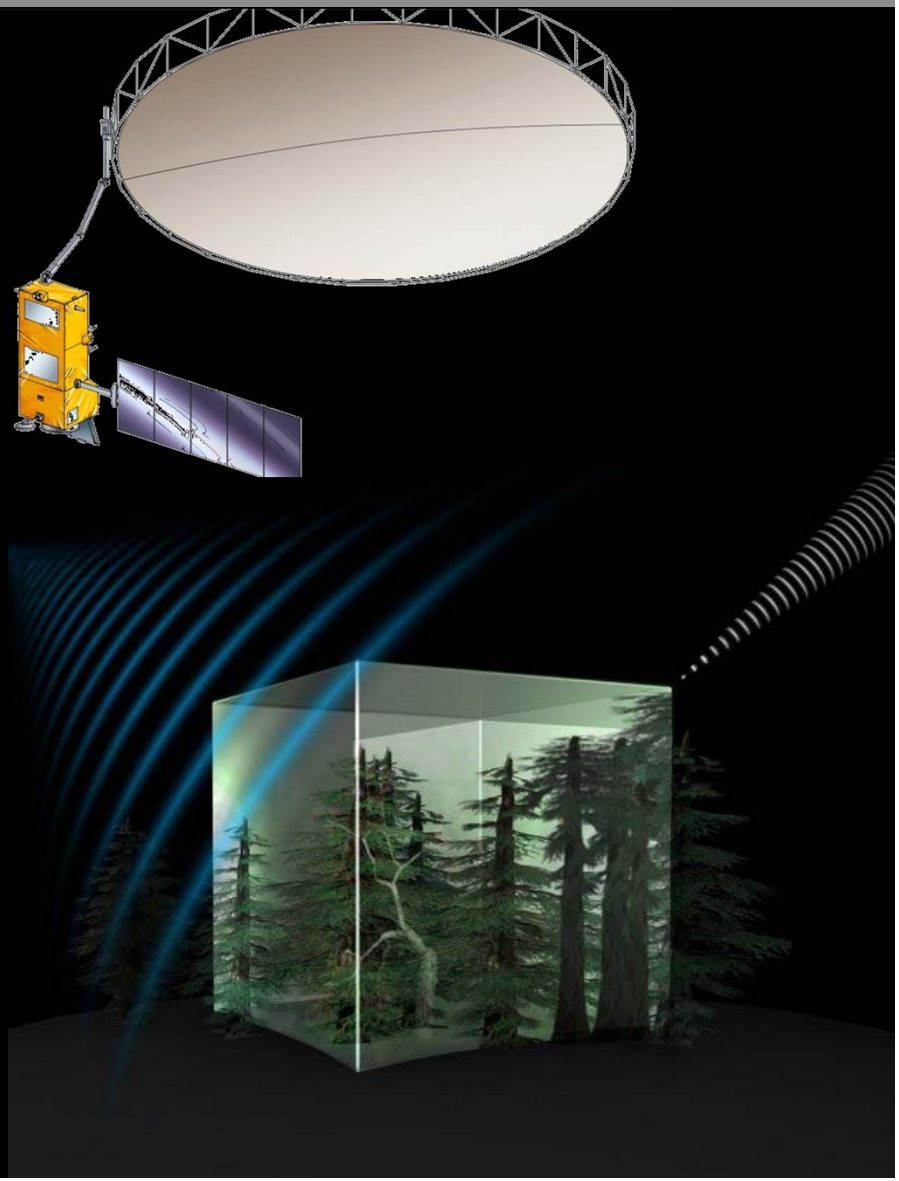


- Global observations of clouds, aerosols and radiation
- Collaboration with JAXA
- Scientific instruments:
  - First UV Lidar
  - First Doppler Cloud Profiling Radar (JAXA contribution)
  - Multispectral Imager
  - Broadband Radiometer
- Launch planned for 2017

# Future Earth Explorer Missions

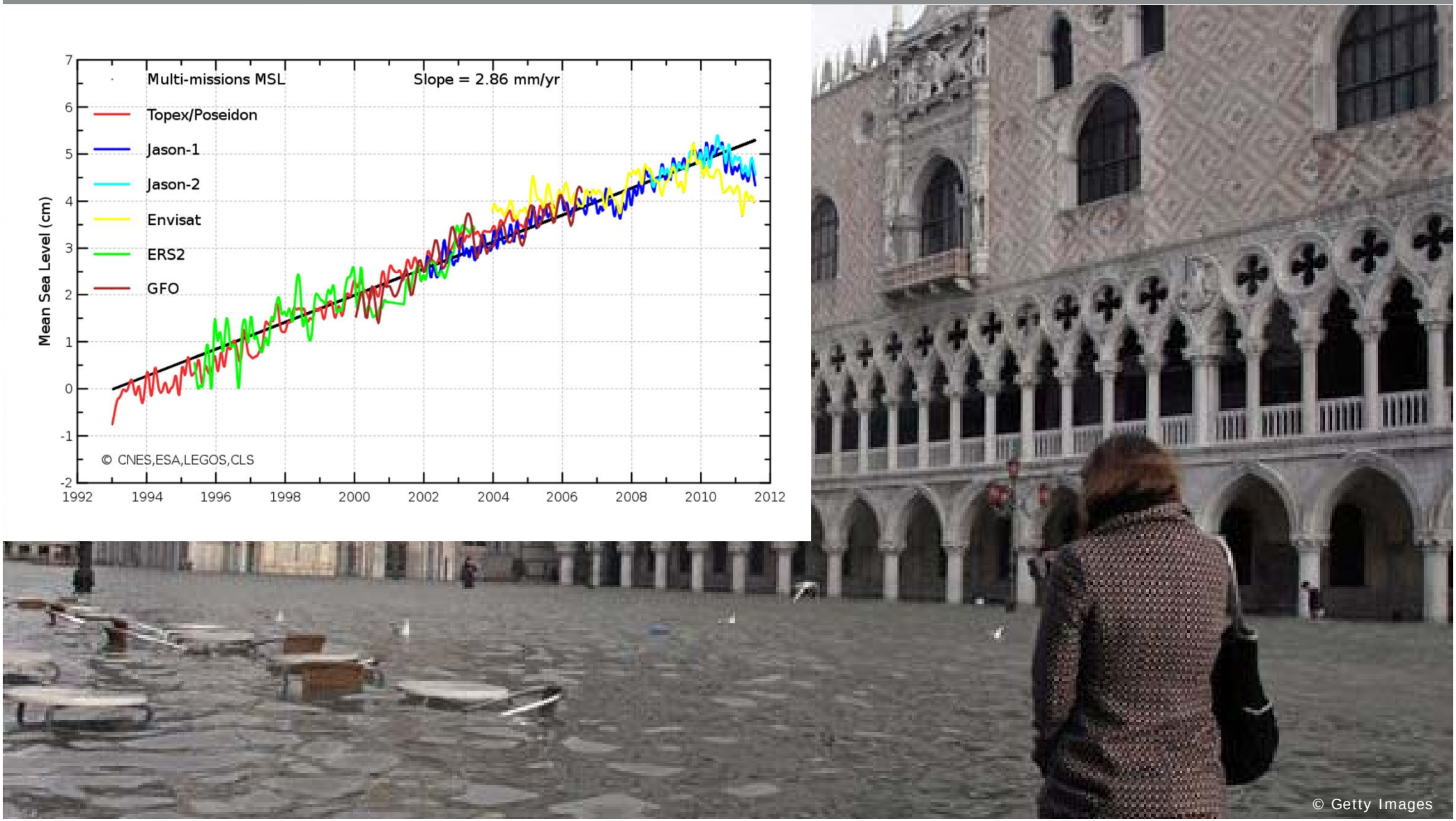
- BIOMASS will be the 7th Earth Explorer
  - Selected by ESA's Earth Observation Programme Board
  - Biomass estimates based on global interferometric and polarimetric P-Band Radar observations
  - Essential to understand the Earth's carbon cycle
  - Offers for phase B received
  - To be launched in 2020

- Candidate missions for 8th Earth Explorer: Flex and CarbonSat



# The ESA Climate Change Initiative (CCI)




Thank you for your attention
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