ESA's Earth Observation Programmes: recent achievements and perspectives

ICES Biennial Workshop
Geneva, 12 November 2013

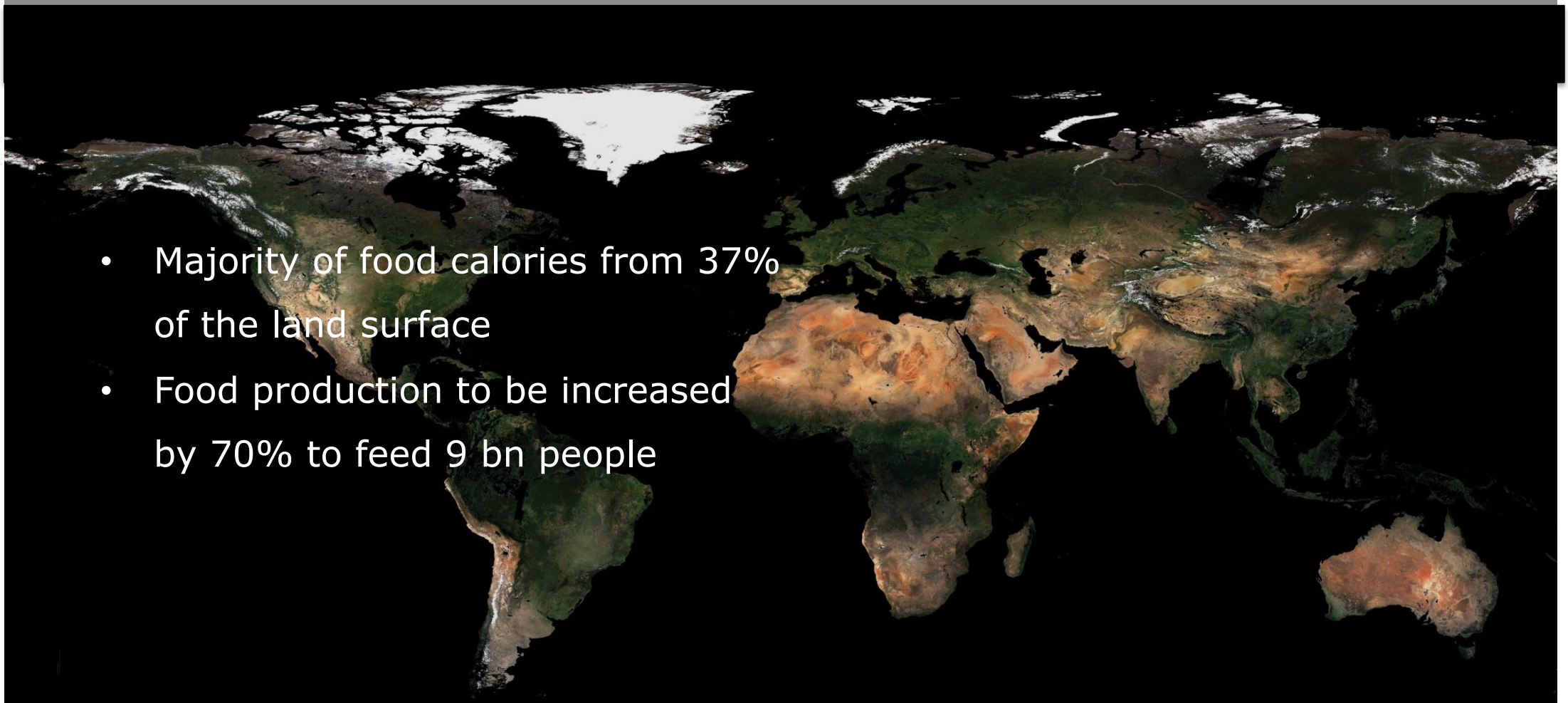
Michael Rast, ESA-ESRIN

21st Century: New Societal Challenges

- Population Growth
- Food Security
- Energy
- Pollution
- Geo-Hazards
- Climate Change

Challenge Population Growth

Challenge Population Growth – Food Security



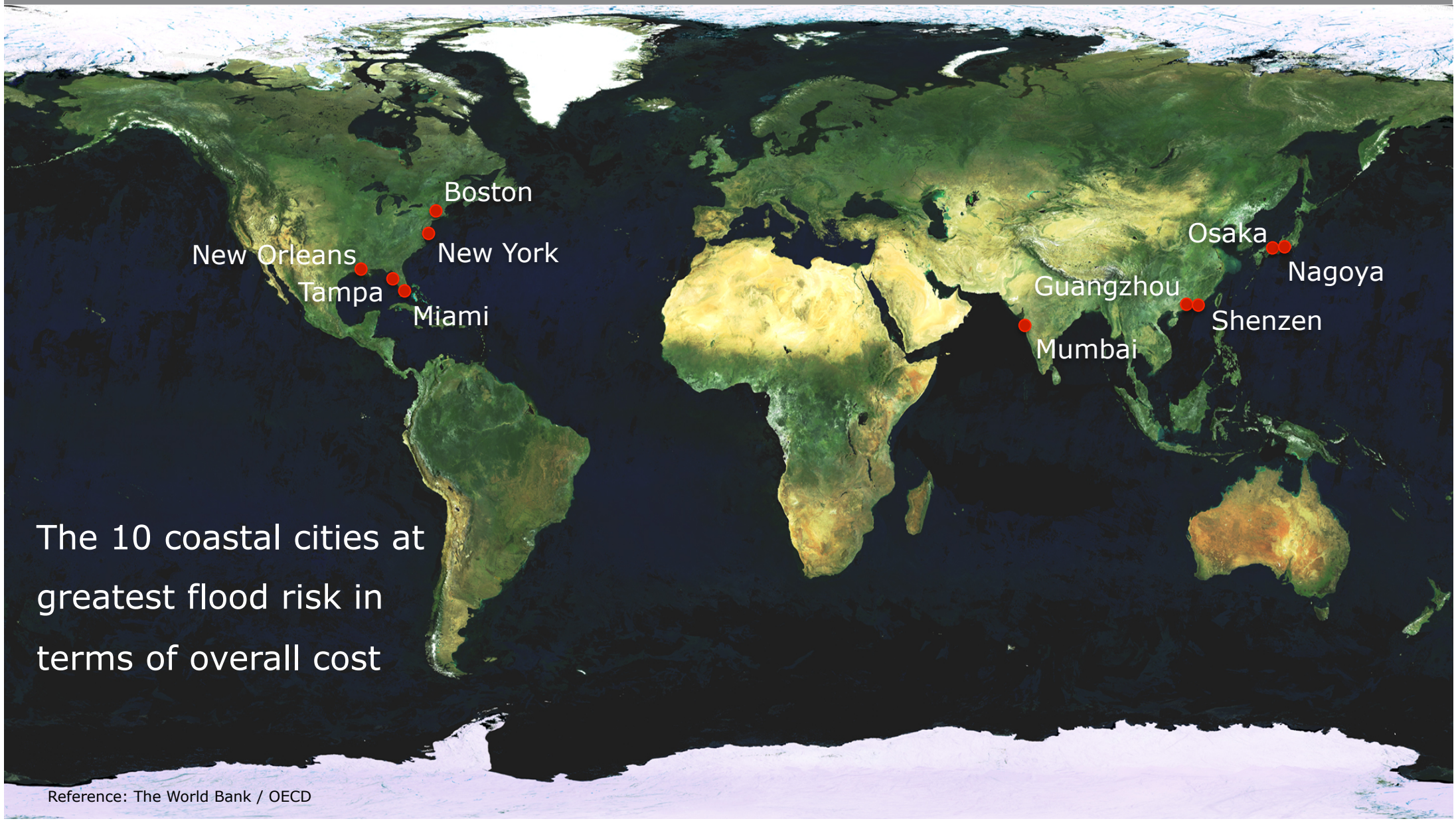
- Majority of food calories from 37% of the land surface
- Food production to be increased by 70% to feed 9 bn people

Source: FAO "The State of the World's Land and Water Resources for Food and Agriculture", 2011 (adapted)

Challenge Population Growth: Mega-Cities

- Rapid increase: 2 Mega-Cities in 1979, up to 37 in 2025
- Cities will hold most of population increase
- 3 Mio people move to cities each week in developing countries
- Mega-Pollution, Mega-Stress, Mega-Risks

Challenge Population Growth: Vulnerability



New Opportunities – The Information Age

New boundary conditions for gathering, processing, exploiting, searching and storing data:

- Crowd Sourcing/Crowd Mapping
- Sensor Web/Internet of Things
- Cloud Computing
- Big Data
- New Generation Mapping Tools
- Social Networks

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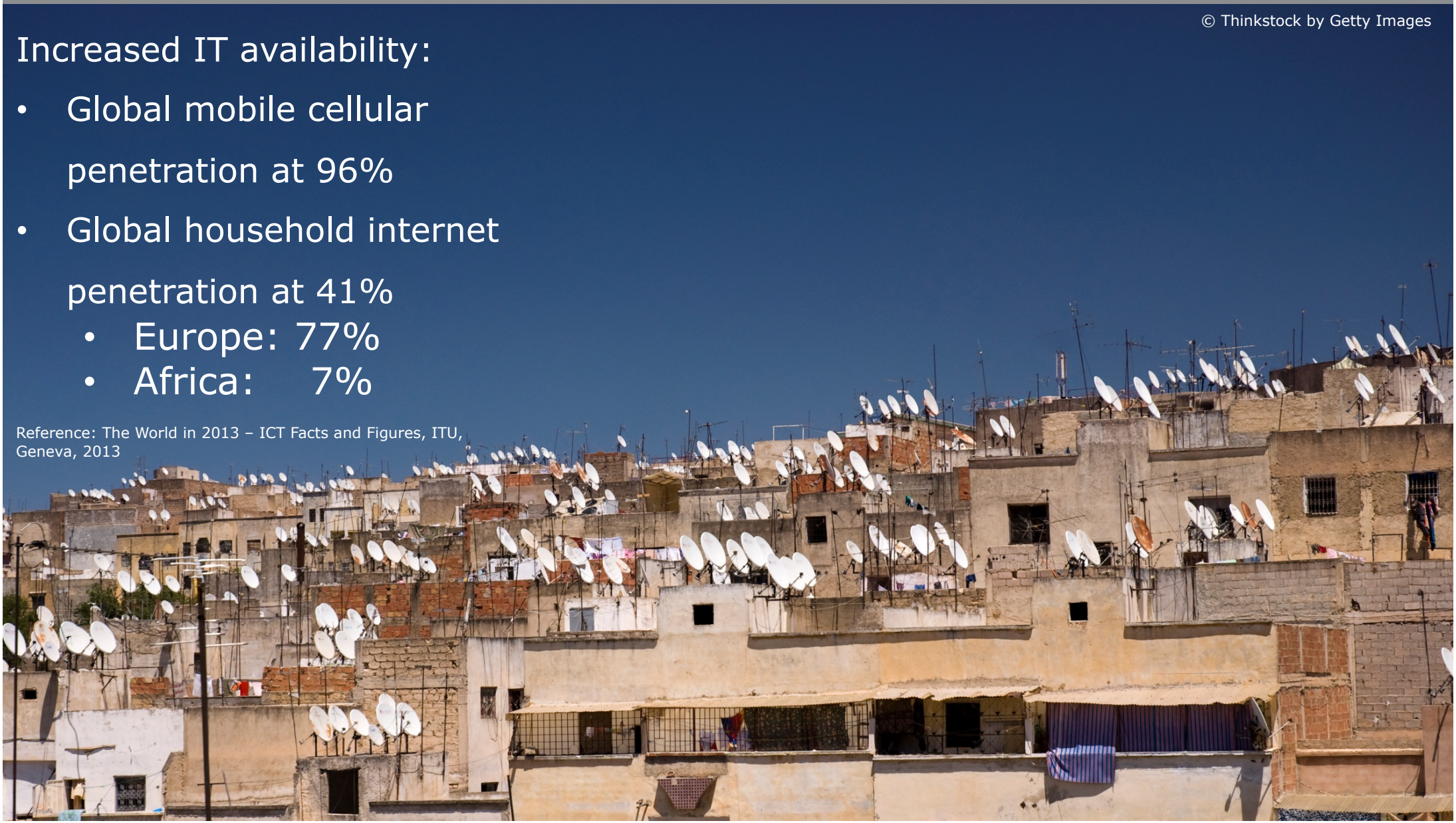
New Opportunities – The Information Age



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Increased IT availability:

- Global mobile cellular penetration at 96%
- Global household internet penetration at 41%
  - Europe: 77%
  - Africa: 7%

Reference: The World in 2013 – ICT Facts and Figures, ITU, Geneva, 2013

Space Based Earth Observation

Essential tool to tackle global challenges

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

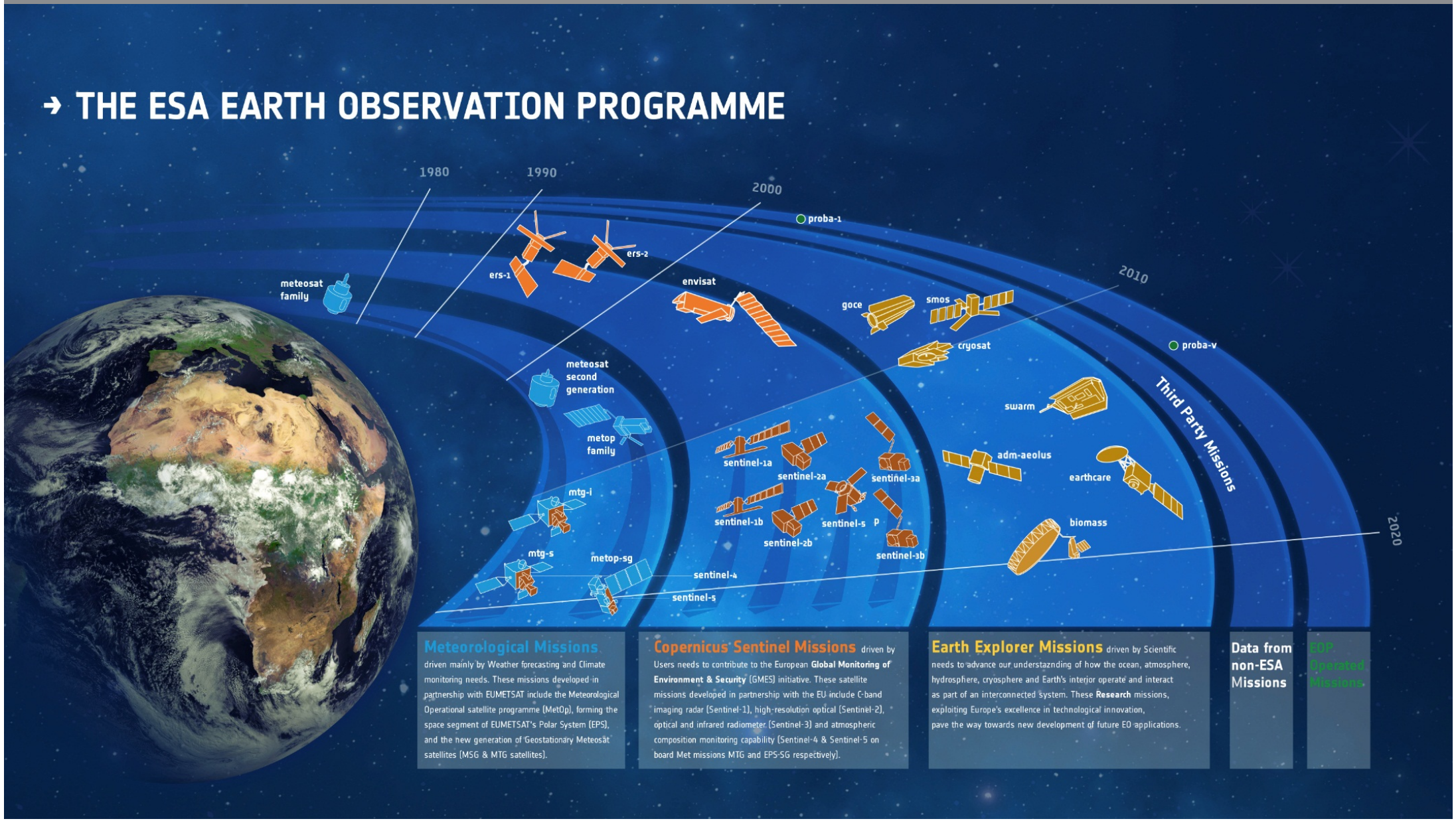
First EO Revolution:

- WWW, broadband data networks, GIS, desktop processing

Second EO Revolution:

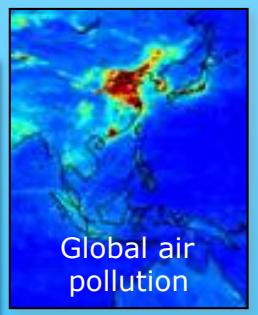
- cloud computing, crowd sourcing, big data, new generation mapping tools
- Coverage over space and time
- Long observation intervals
- Large scale observations

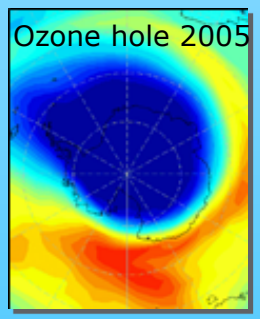
What is at our hands?

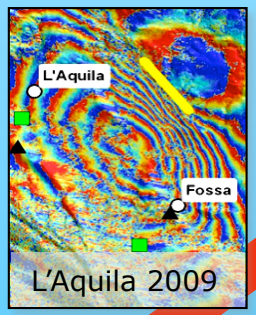


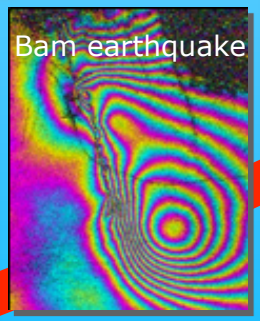
Ten Years of Envisat Science

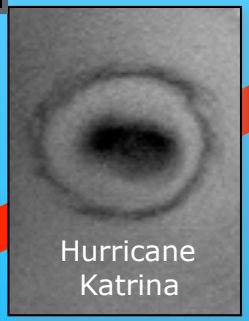
5000 scientific projects using Envisat data

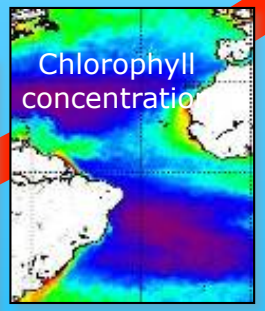


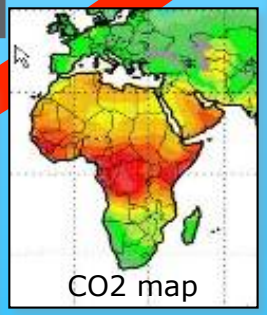


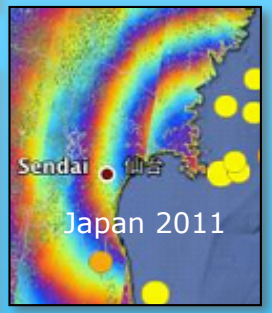












Numerous presentations based on Envisat data during the Symposium

Envisat was the Sentinel "precursor" for many operational users

Envisat Symposium Salzburg (A) — Sep 04

Envisat Symposium Montreux (CH) — Apr 07

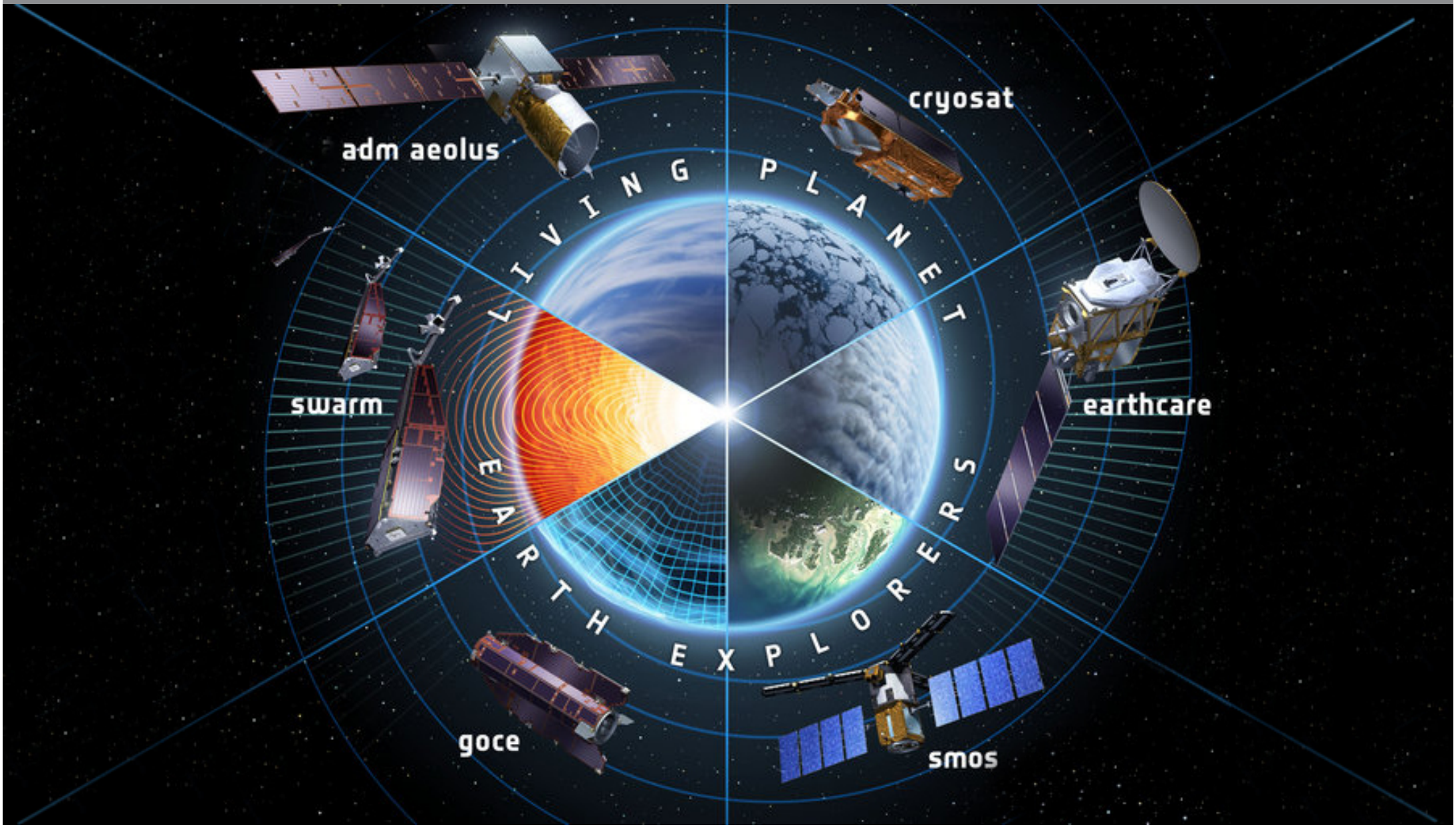
Living Planet Symposium Bergen (N) — Jun 10

Living Planet Symposium Edinburgh (UK) — Sep 13

Mar 02

and many workshops dedicated to specific Envisat user communities

Science – the Earth Explorers



GOCE: A Wealth of Applications

Geoid

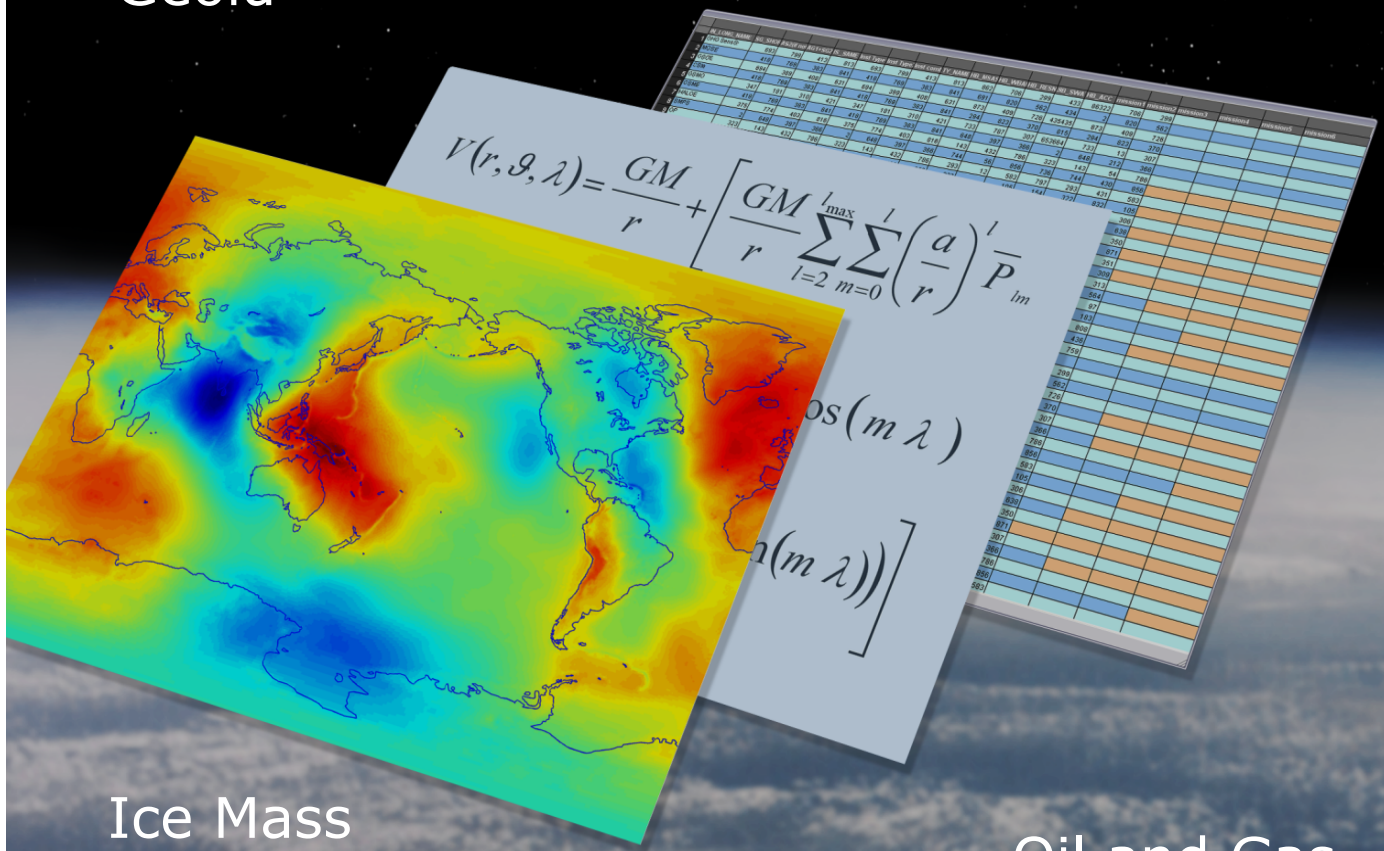
Gravity Anomalies

Topography

Altimetry

Positioning

Unified Height Systems



Ice Mass Balance

Mean Ocean Circulation

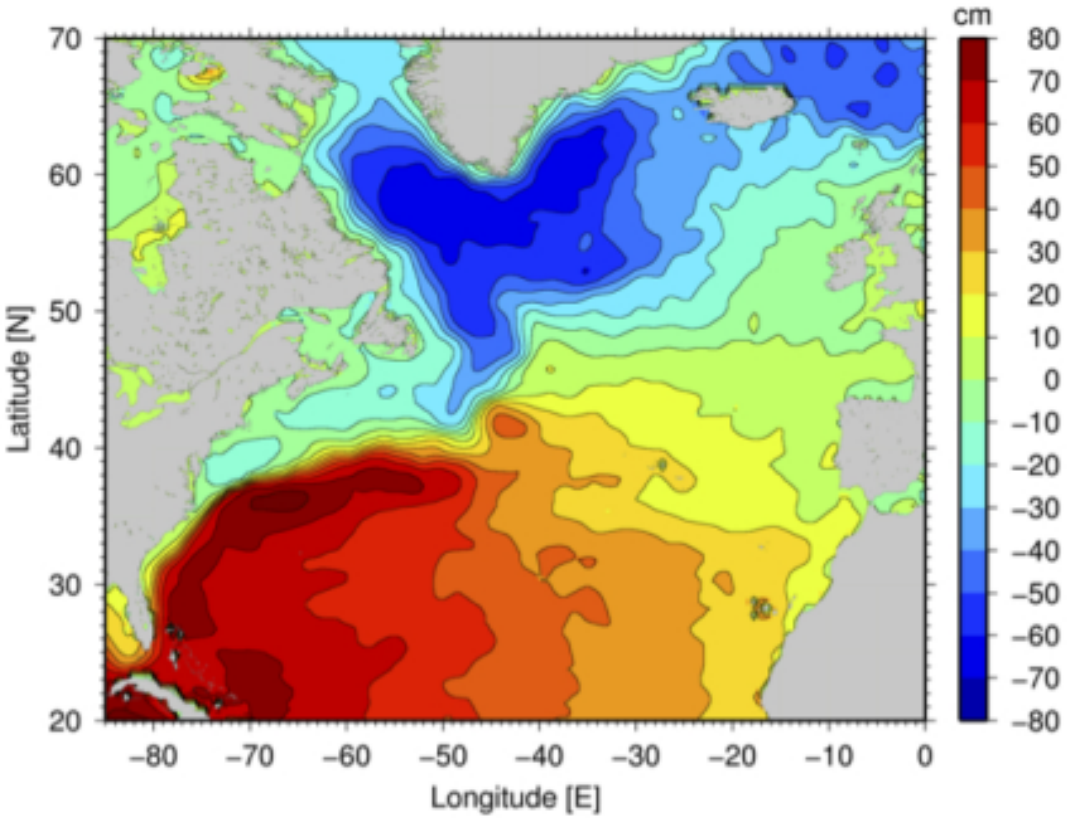
Oil and Gas Exploration

Post Glacial Rebound

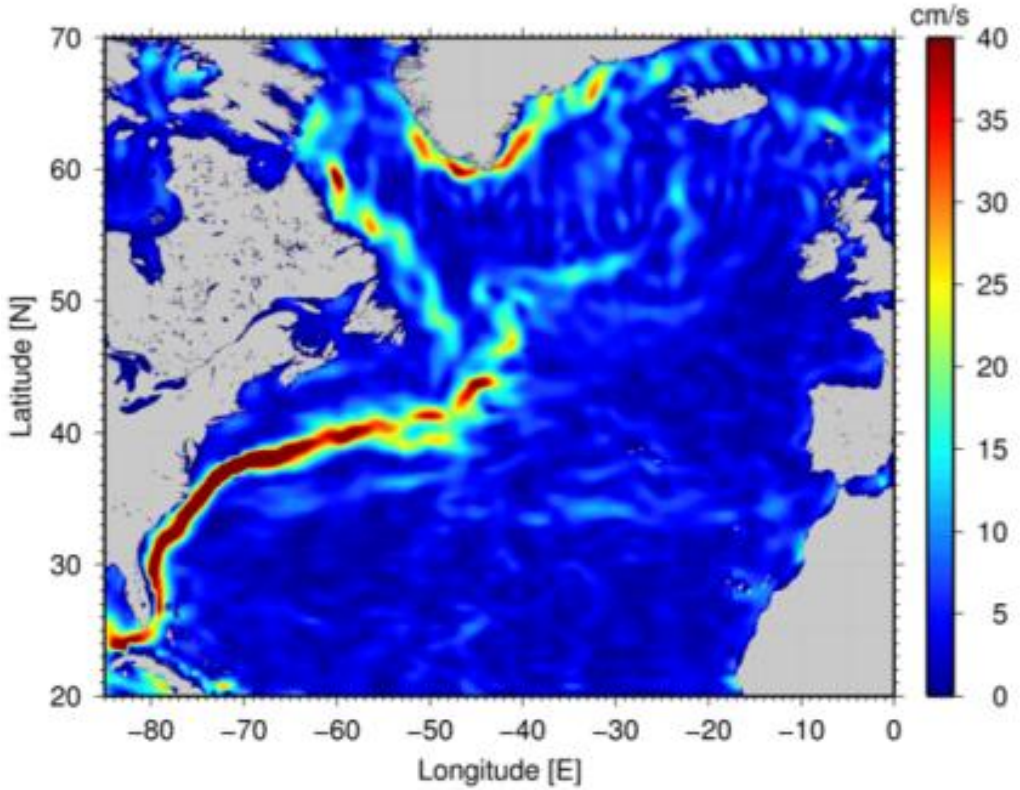
GOCE: accurate ocean currents map

- With GOCE geoid, for the first time, global currents can be extracted directly from satellite altimetry data.

Ocean Dynamic Topography

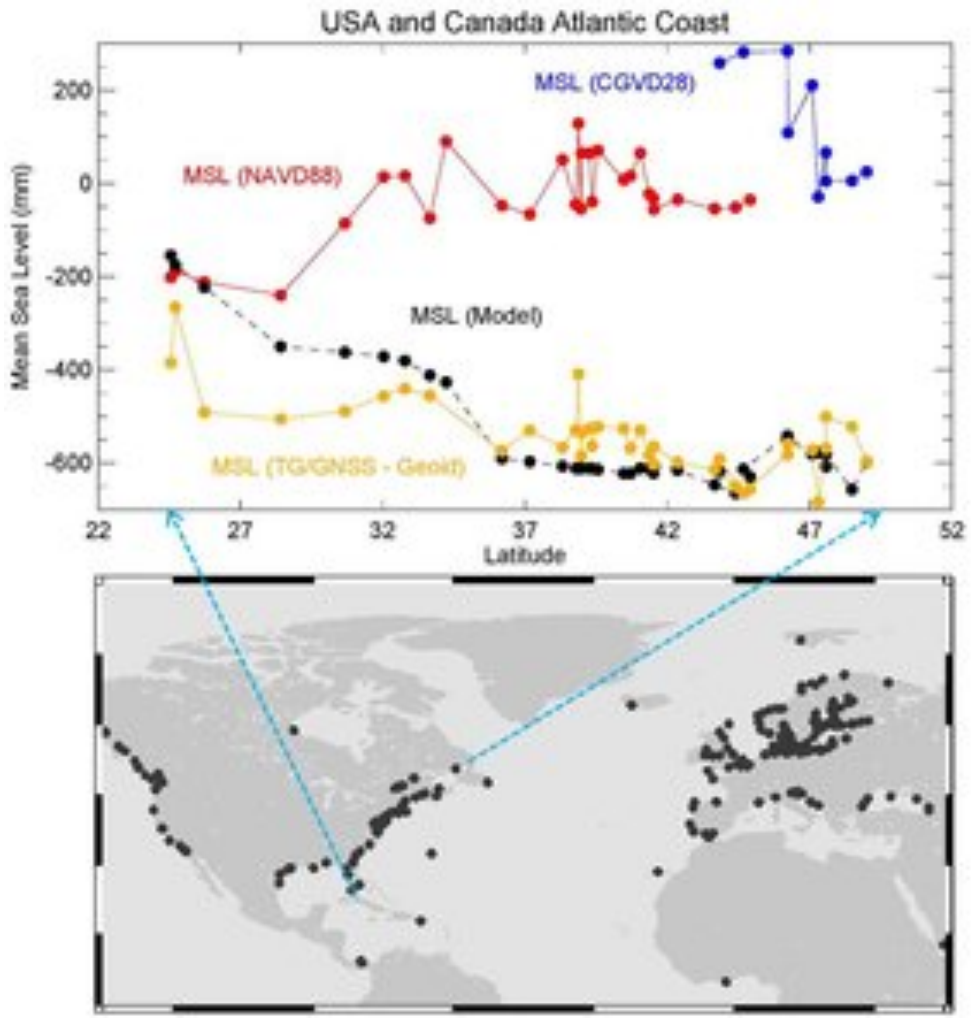


Water Surface Velocity

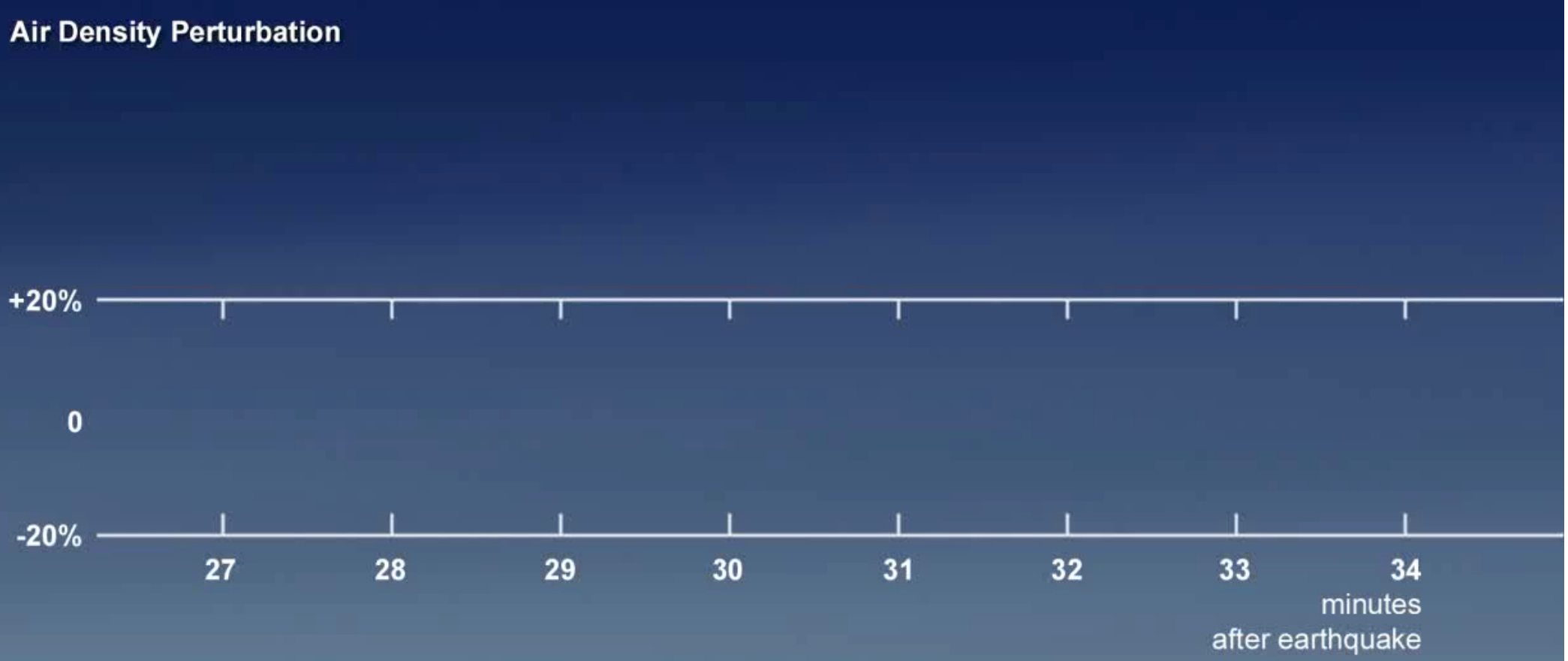


GOCE: Debate on Sloping Sea

- Science has been dealing with the question whether the sea is higher or lower heading north along the east coast of North America
- Wind, currents, tides and different temperatures cause seawater to pile up in some regions and dip in others
- GOCE measurements, together with GPS heights, showed that the sea level decreases going north along the North American coastline
- Through ESA's Support to Science Element programme, new reference level surfaces have been determined

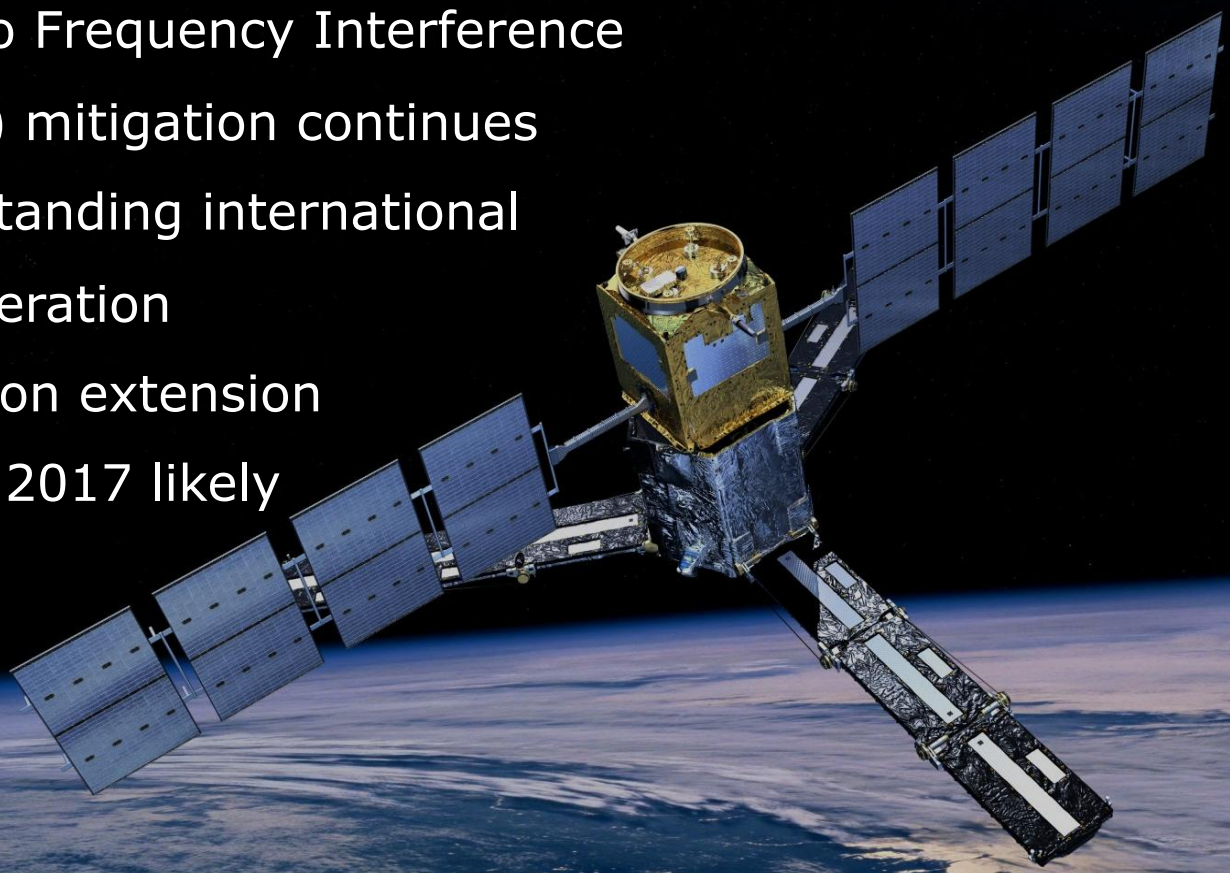


GOCE – Tohoku Earthquake

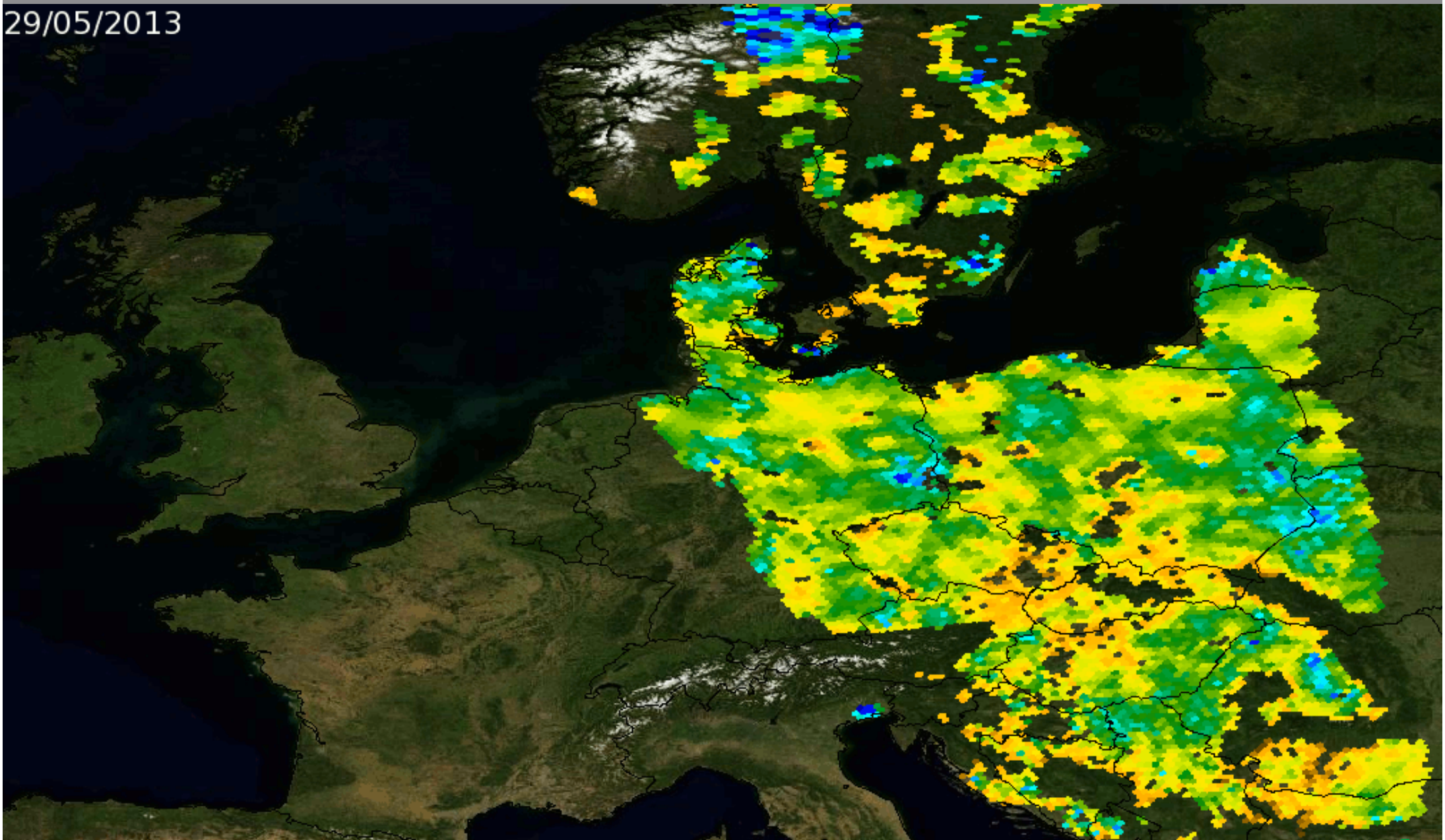


SMOS – Soil Moisture and Ocean Salinity

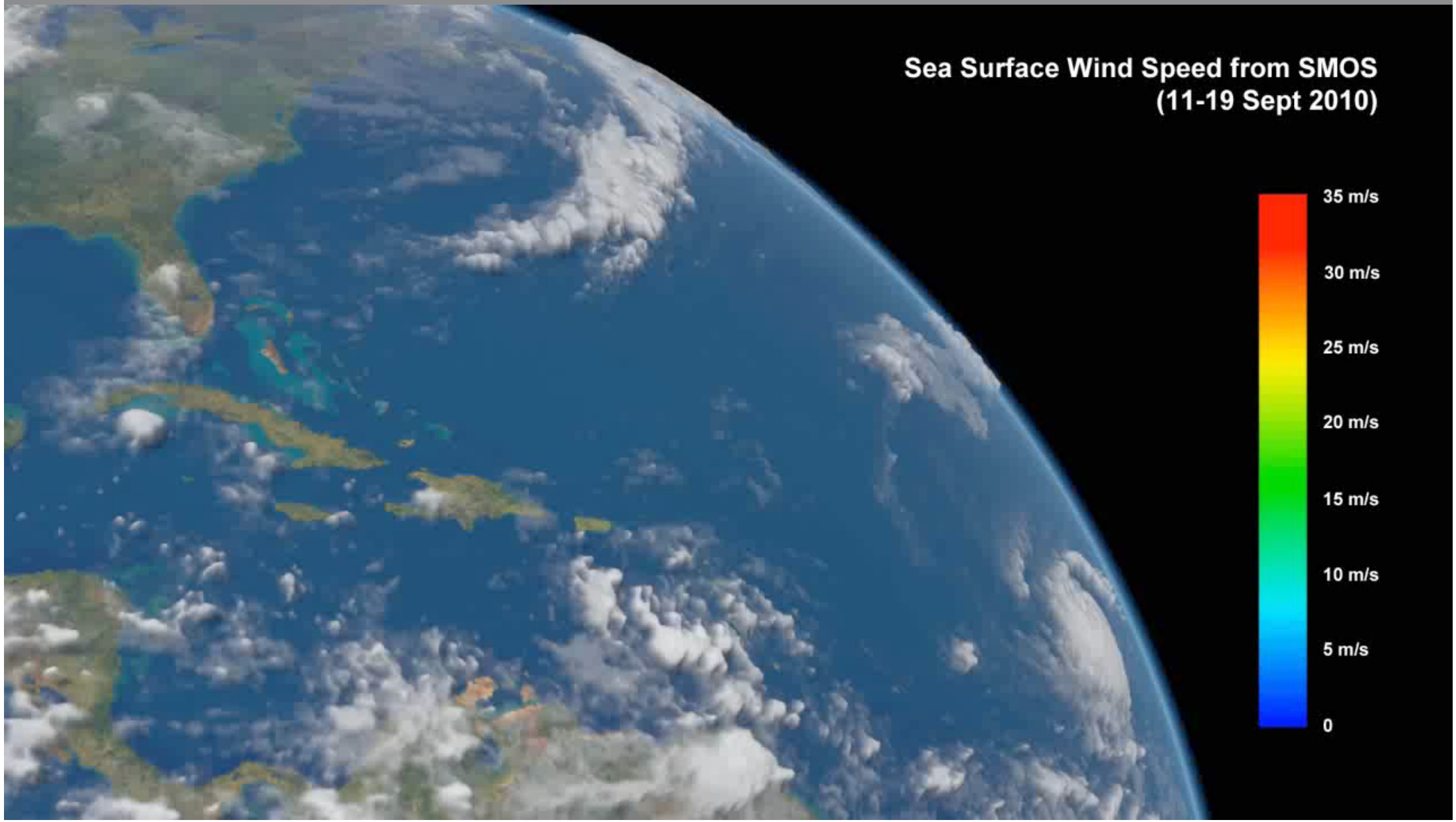
- Complete Earth coverage within three days
- Radio Frequency Interference (RFI) mitigation continues
- Outstanding international cooperation
- Mission extension until 2017 likely



SMOS AND HYDROLOGY:
Floods in Europe May/June 2013

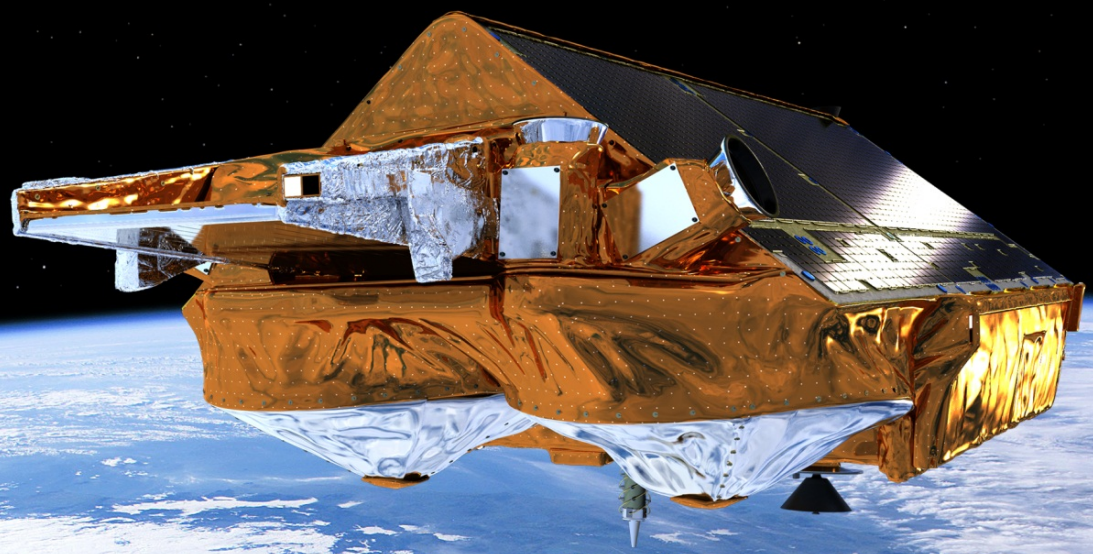


SMOS - Hurricane Igor

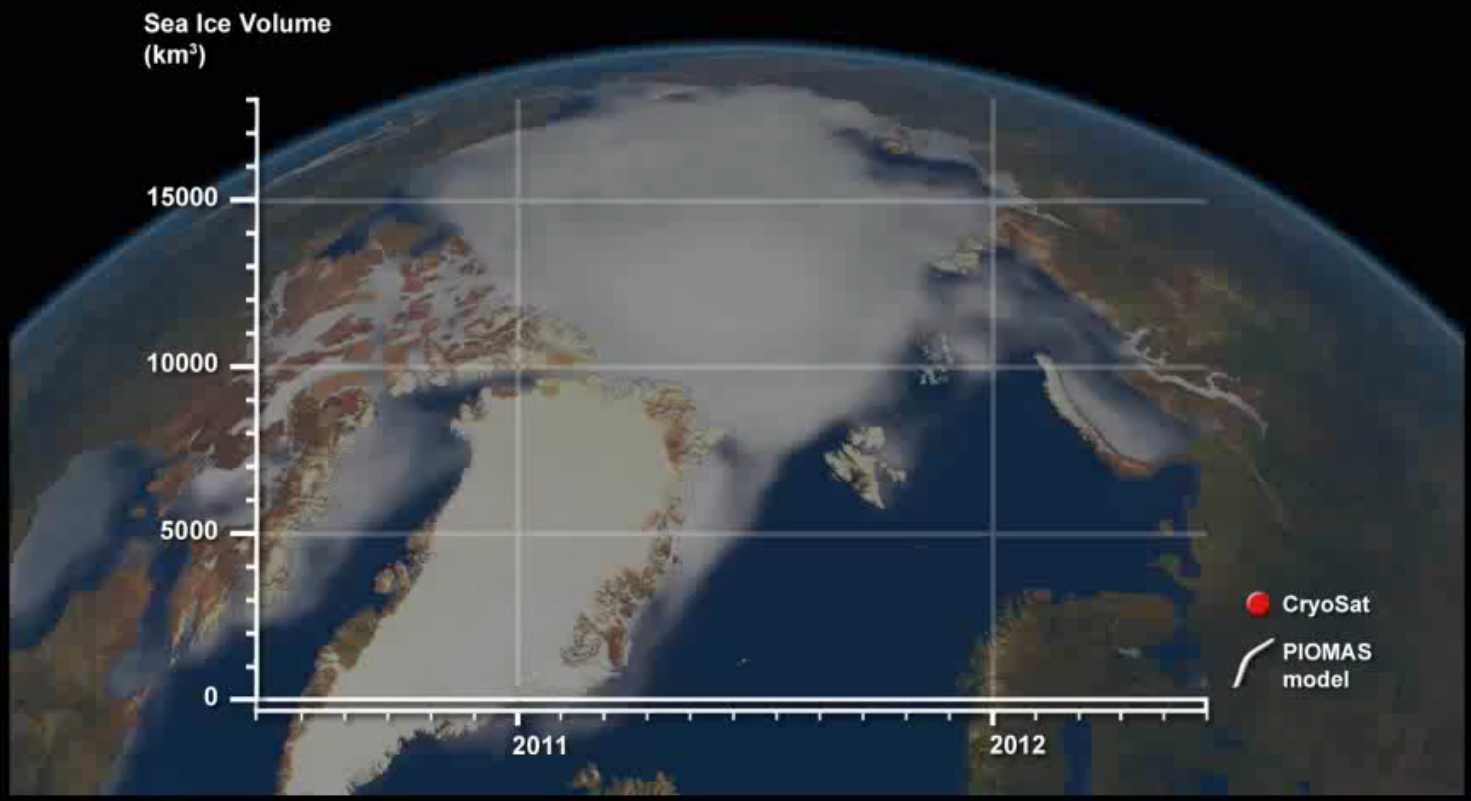


CryoSat: The Ice Mission

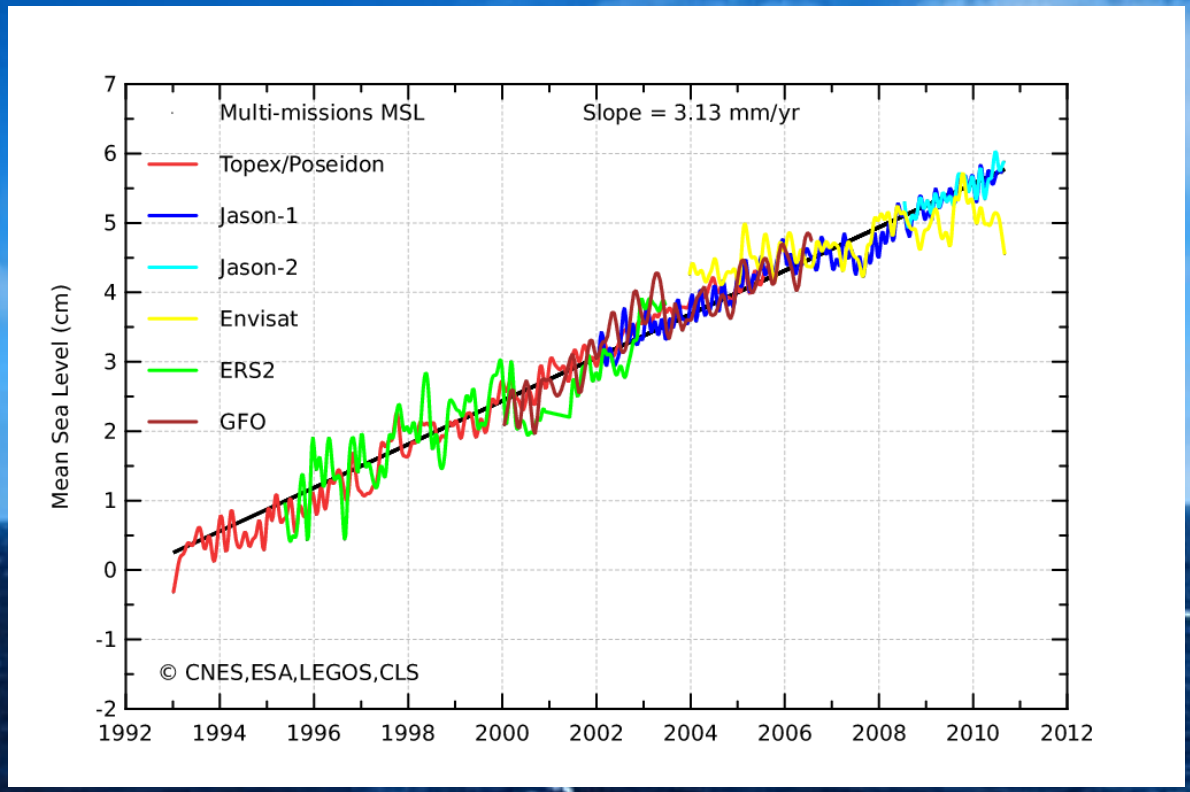
- First interferometric altimeter in space
- Global sea ice thickness measurements
- Data used for ice research, but increasingly also for oceanography
- Mission extension until 2017 likely

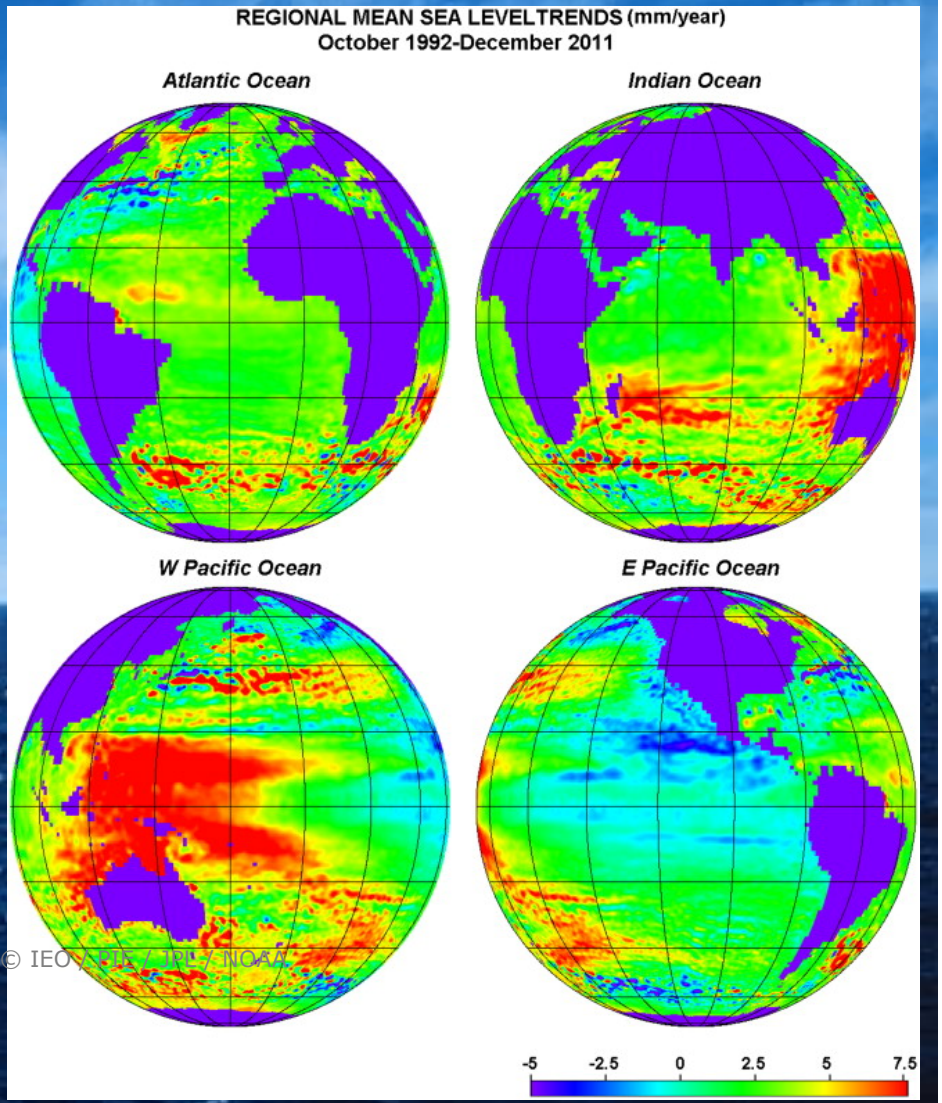


CryoSat – Arctic Sea Ice Volume



Satellites show global sea-level rise: 20 year-trend

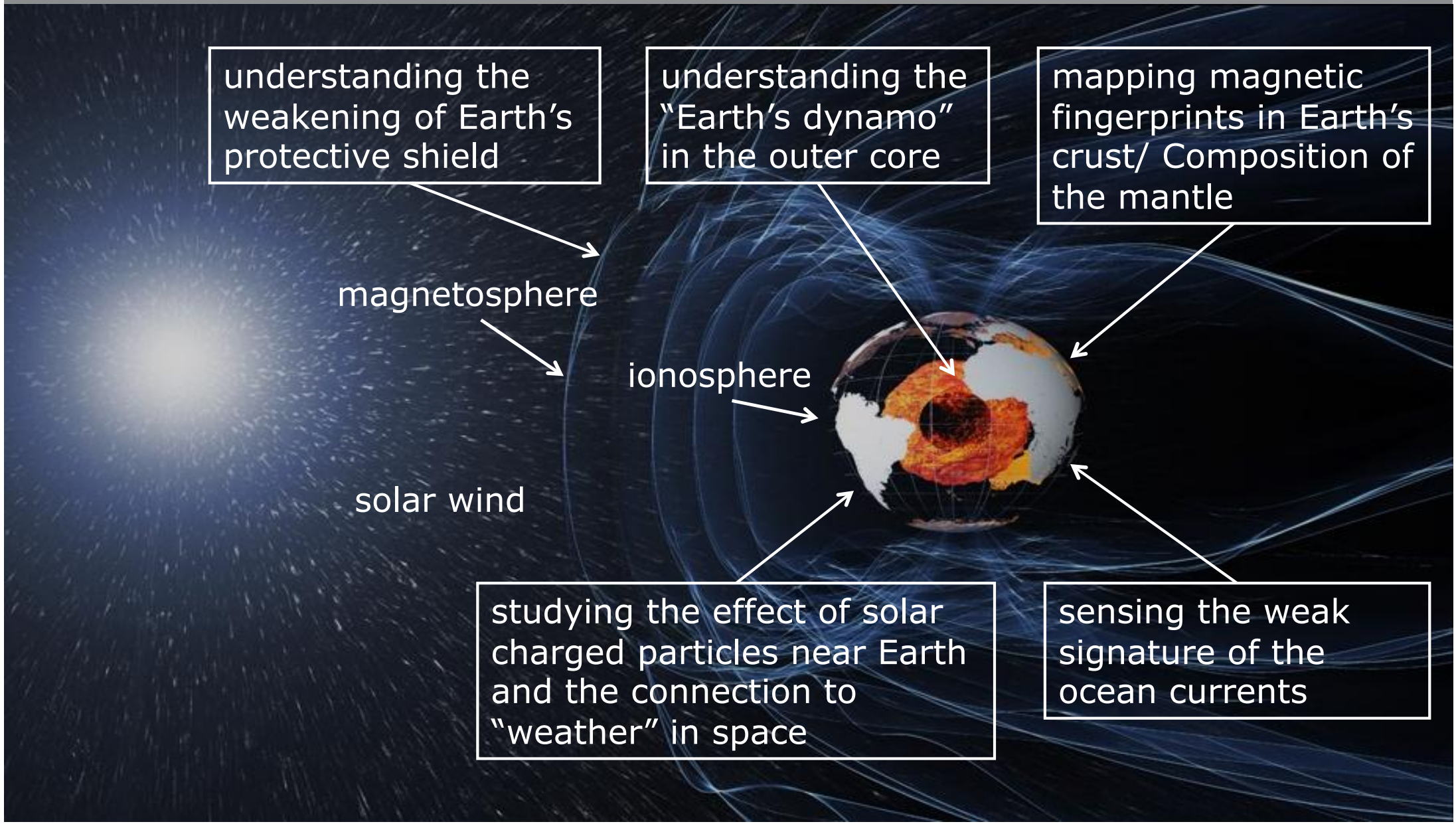




Next in line: Swarm

- Swarm will provide the best-ever survey of the Earth's geomagnetic field and its variation in time
- Swarm will allow to gain new insights into the Earth's interior and climate
- Launch 22 November 2013

Swarm Science Objectives



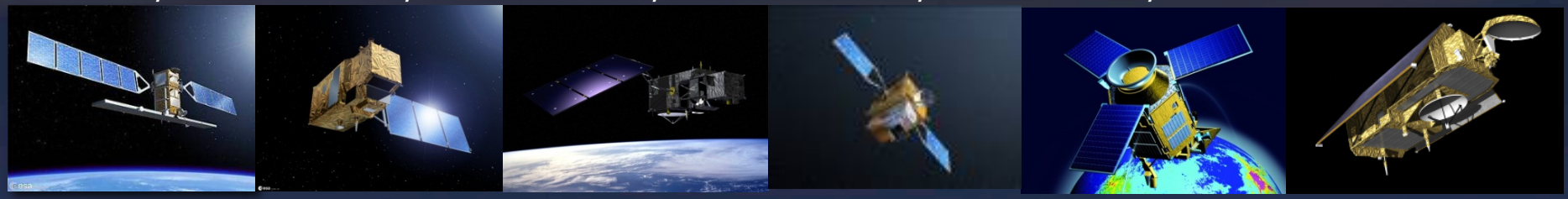
Meteorological missions

- Cooperation model: ESA is developing and launching the European meteorology missions, EUMETSAT is operating them
- Currently Meteosat Second Generation (MSG) missions in GEO and MetOp missions in LEO
- Two successful launches in 2012: MSG-3 and MetOp-B
- MeteoSat Third Generation (MTG) and MetOp Second Generation under development

First image of Europe's "youngest" meteorological satellite, MSG-3 (7 August 2012)

Copernicus: A New Generation of Data Sources

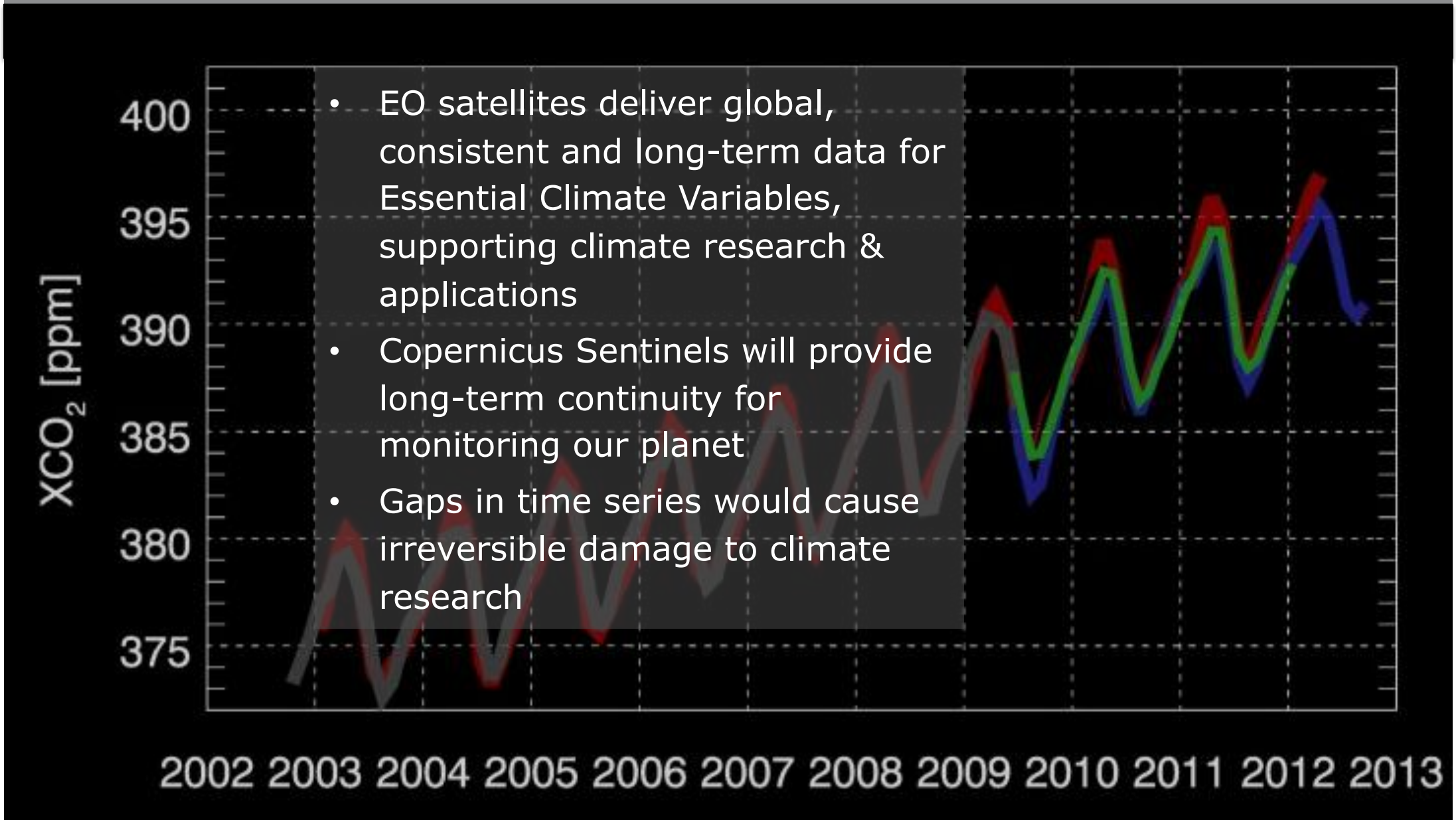
Sent-1A/B | Sent-2A/B | Sent-3A/B | Sent-4A/B | Sent-5/5P | Jason-CS



- 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

opernicus
The European Earth Observation Programme

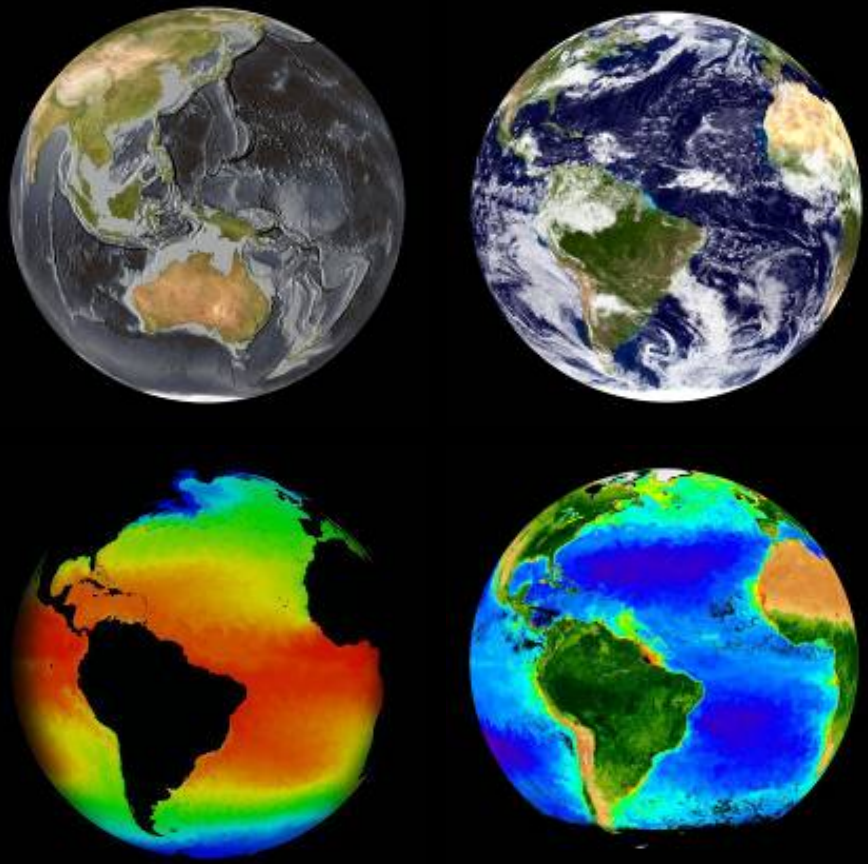
The ESA Climate Change Initiative (CCI)



- EO satellites deliver global, consistent and long-term data for Essential Climate Variables, supporting climate research & applications
- Copernicus Sentinels will provide long-term continuity for monitoring our planet
- Gaps in time series would cause irreversible damage to climate research

CCI: Essential Climate Variables

- Cloud Properties
- Carbon Dioxide, Methane & other GHGs
- Ozone
- Aerosol properties
- Sea Surface Temperature
- Sea Level; Sea Ice
- Ocean Colour
- Glaciers and ice caps
- Land cover
- Fire disturbance
- Soil moisture



The Big EO Data challenges

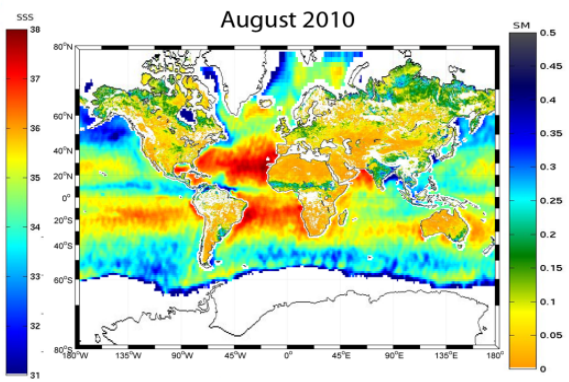
Definition of BIG DATA includes:

1. The ***size*** (volume) of the data sets
2. The degree of ***diversity*** and ***complexity*** within the data sets
3. The *amount of* ***value*** that can be derived from innovative analysis techniques applied to diverse and complex data sets

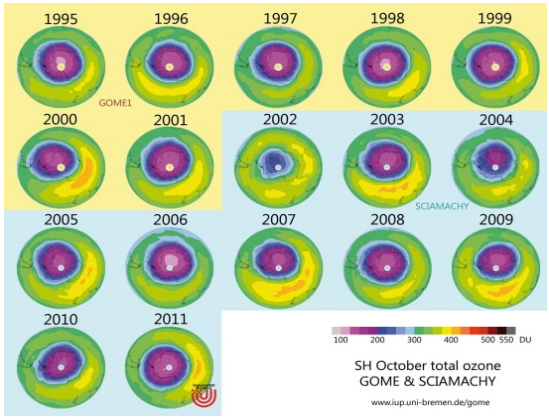
Aspects relevant for Earth Observation :

A. Increasing ***amount*** of ***EO space data*** (past, current and new satellite data)
B. Increasing ***diversity*** of ***EO space data*** (in media, formats and processing)
C. Increasing ***amount and diversity*** of ***non-space data*** used in conjunction with EO space data (e.g. ground GPS measurements, marine buoys measurements, atmospheric plane measurements, etc…)

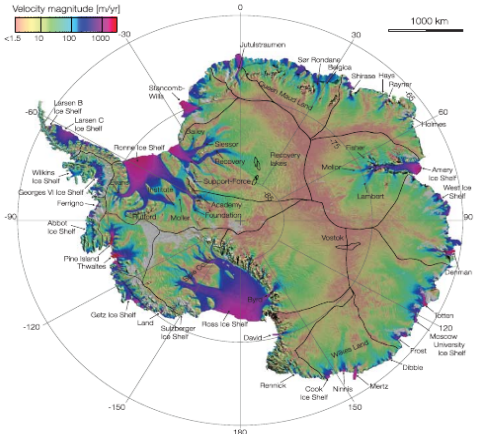
Variety of EO Data Challenges



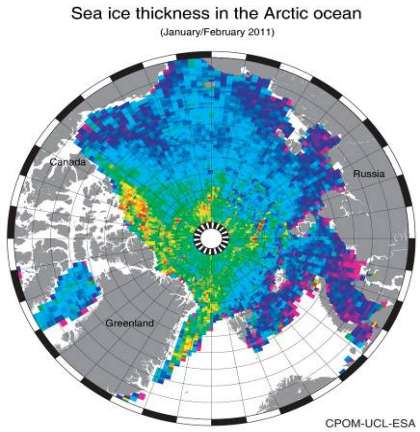
Data volume



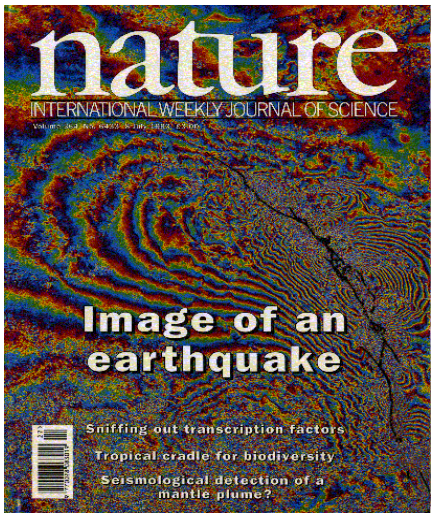
Data continuity



Data sharing

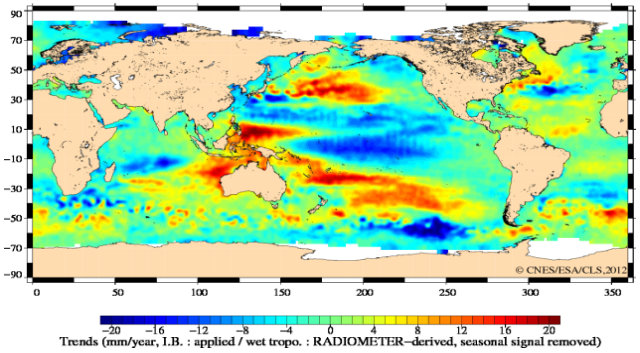


Data quality

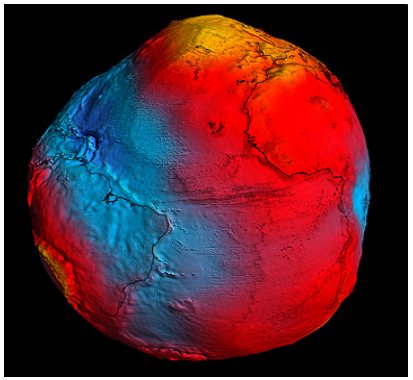


Innovation

Timeliness

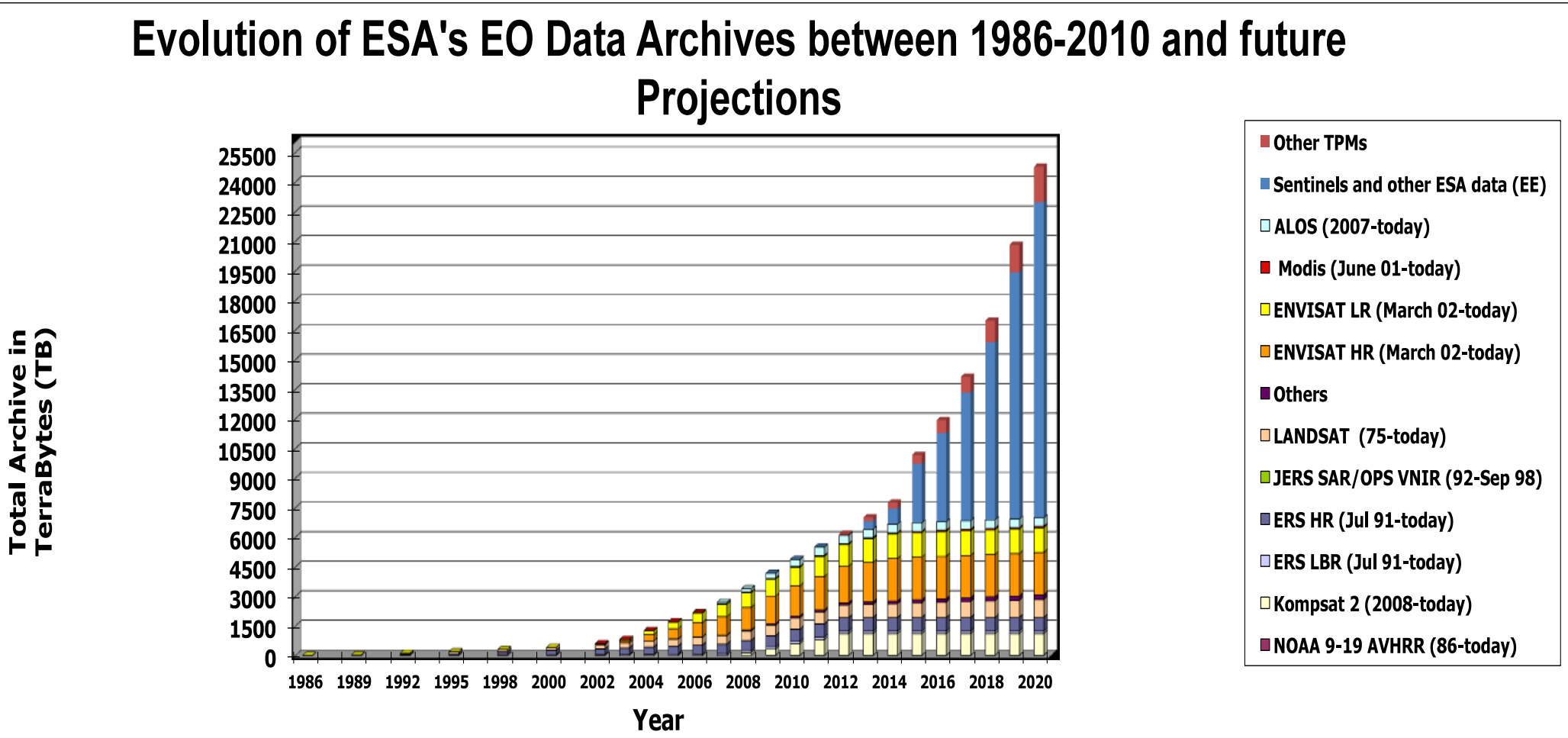


Synergy with other missions



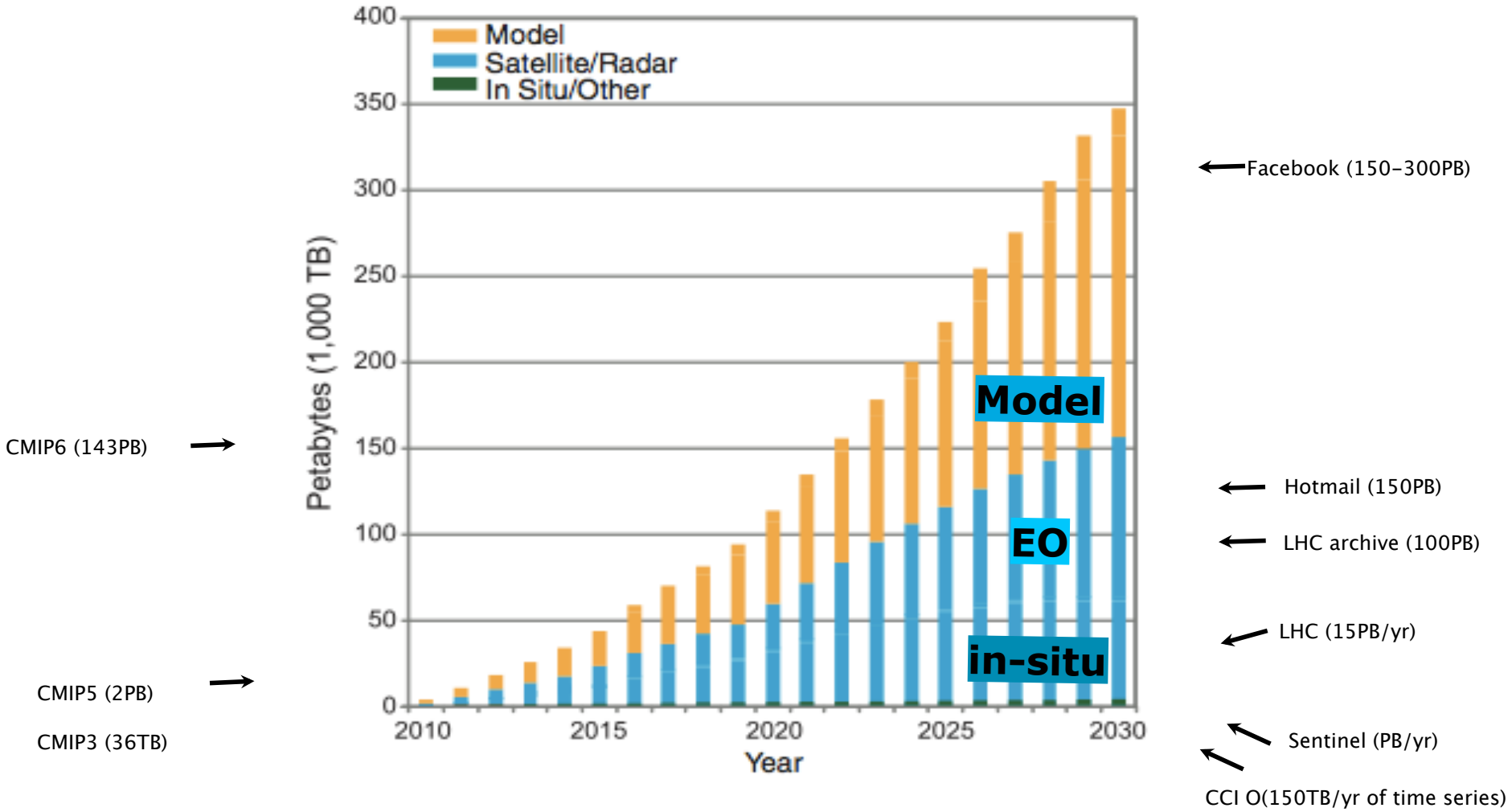
Uniqueness

Increasing Volume of EO space data



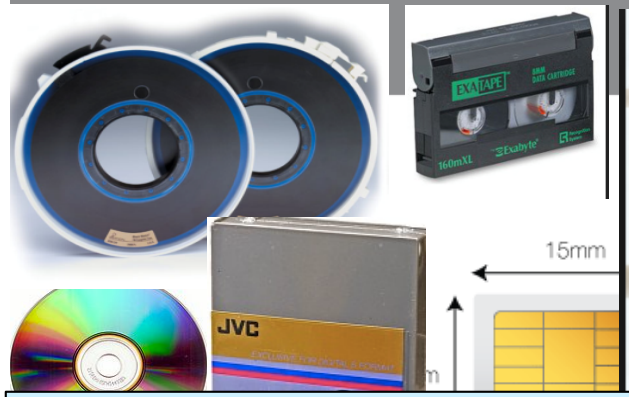
→ New data volume increasing fast
→ Old data gaining value (e.g. climate change studies)

Climate Data Deluge



Source: Overpeck et al., 2011, Climate Data Challenges in the 21st century. Science Mag http://promo.aaas.org/ema/booklets/data.pdf

Increasing diversity of EO data media



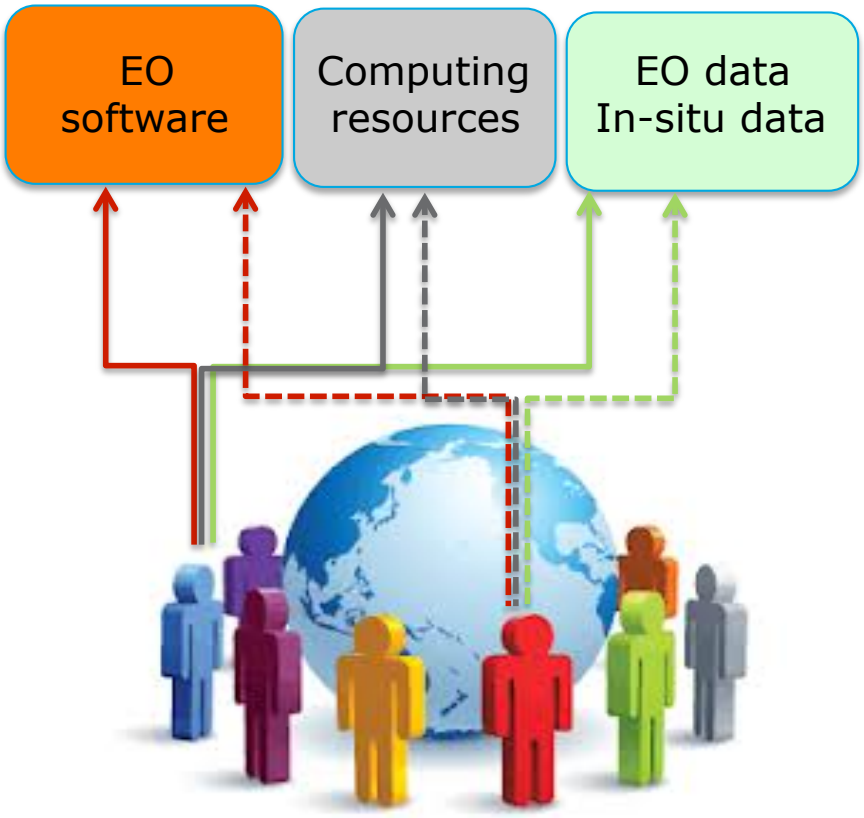
Data from some 30 different EO missions from 15 owners for >50 instruments

Transcription
Reformatting
Reprocessing

→ Diversity of Historical Data is the challenge not new data

New Paradigm of Exploitation Platforms

Legacy model: Move the data to users' computers

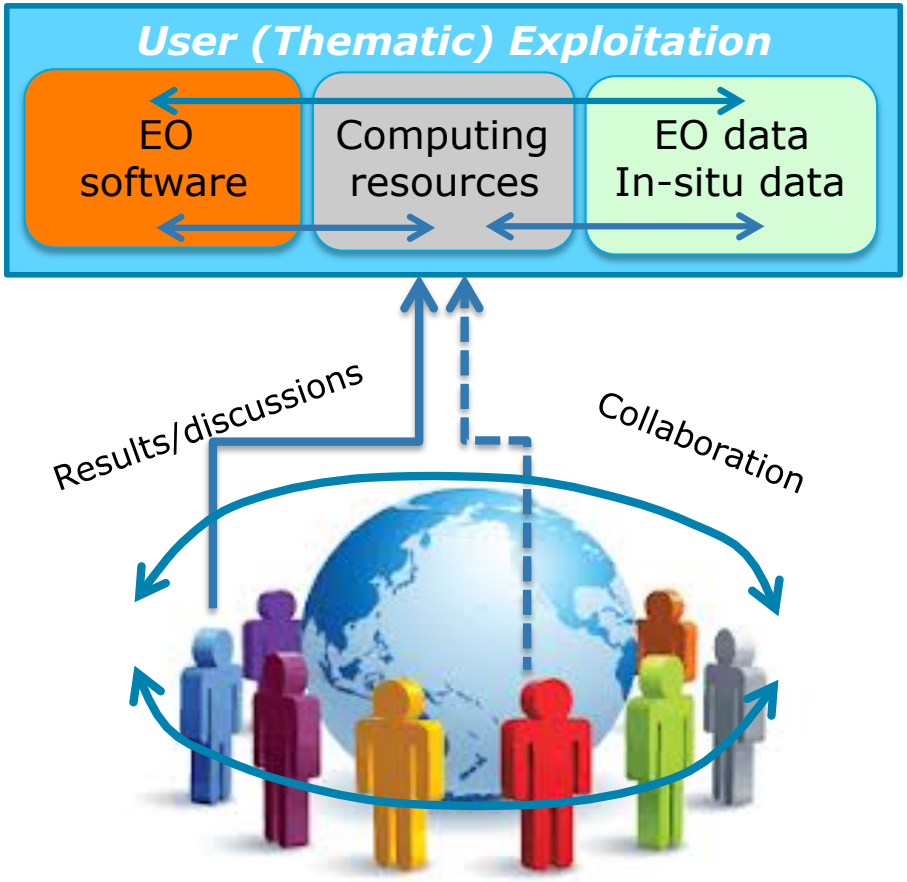


Legacy model: data and software distributed to users. Transferred many times; replicated in many places; loose user network.

But usage of large amount of data opens big opportunities for research and requires new approaches and services (e.g. exploitation platforms for e-collaboration)

New Paradigm of Exploitation Platforms

New model: Move the users' computers to the data



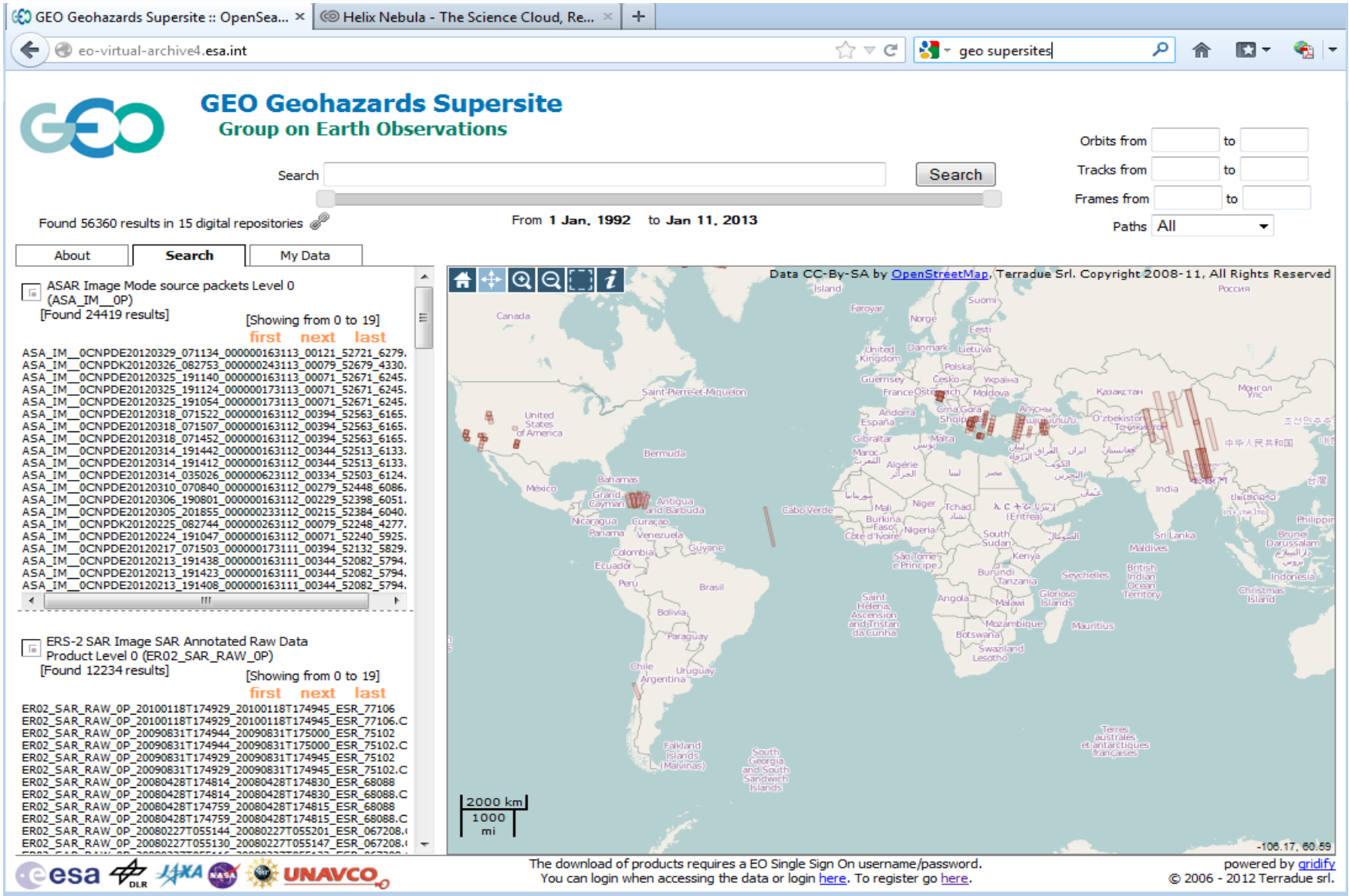
Legacy model: data and software distributed to users. Transferred many times; replicated in many places; loose user network.

New model: users access a platform work environment containing the data and resources required, as opposed to downloading and replicating the data 'at home'.

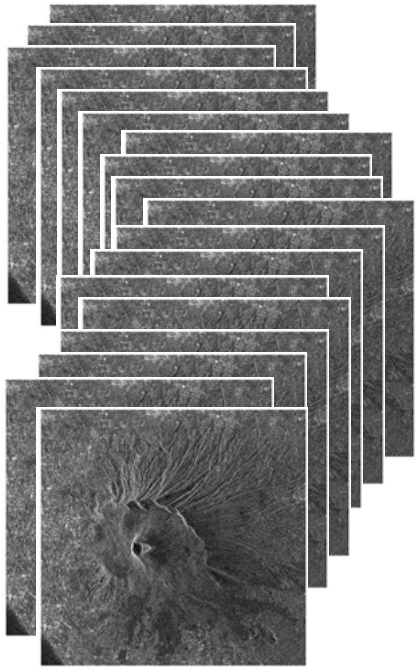
A scenario for data intensive scientific exploration (but not only) - complementing – but not replacing – the traditional model.

Exploitation Platform = Virtual Environment bringing together Data Center + Computing Resources + Third Party Tools + Workflows + Integrated User Interface + Documentation + Collaborative Tools + Help desk (social network) around a thematic domain.

ESA Super Sites Exploitation Platform - archive

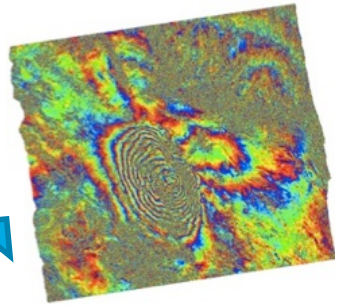


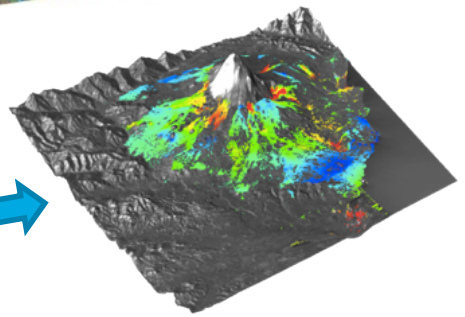
ESA Super Sites Exploitation Platform - processing

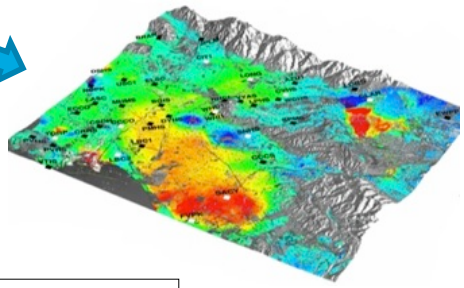


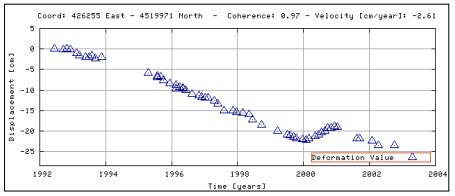
Cloud
Processing

~150 Satellite images/250 GB (per area)









Earthquakes

Volcanoes

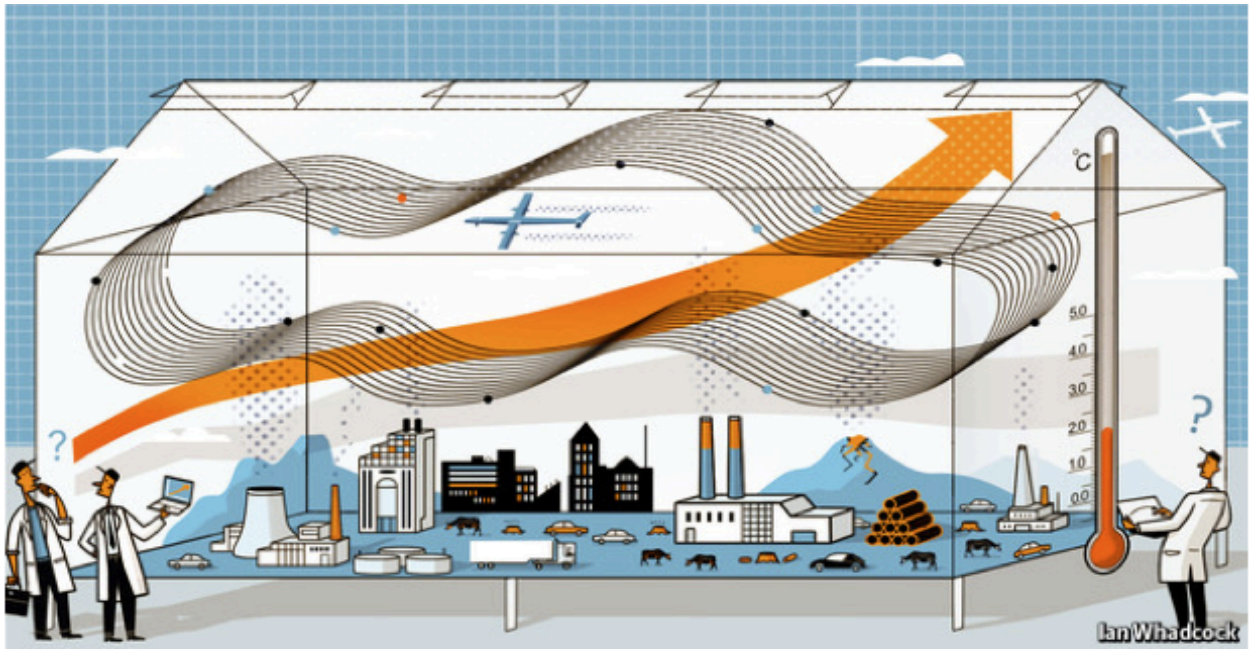
Oil & Gas

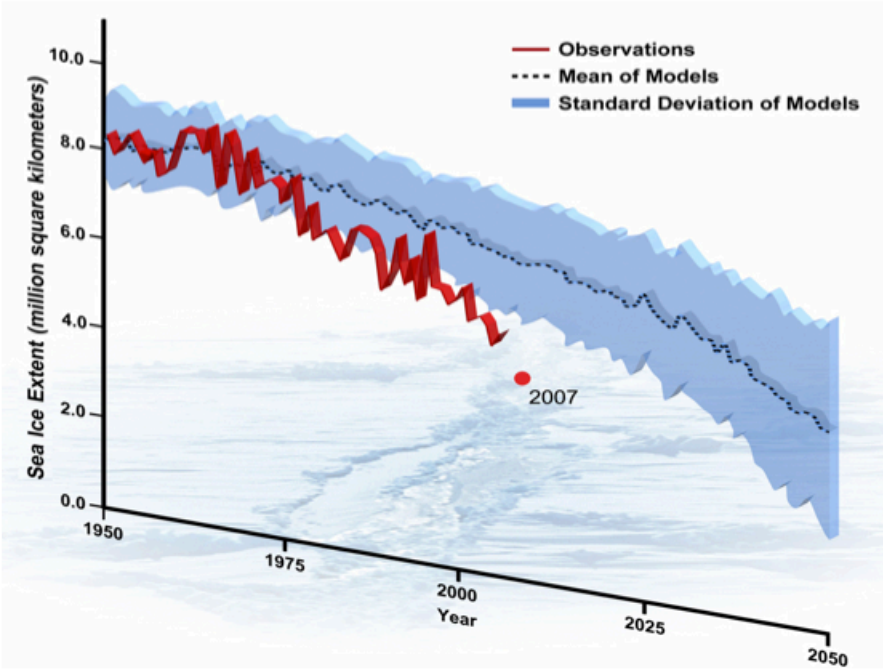
Water Resources

Confronting Data & Models

Climate science

A sensitive matter





Source: The Economist

"Data can be equated with money that has value only if it is used and circulated. As the different currencies can be stored in the globally interrelated bank infrastructures, we need persistent, highly available and compatible data infrastructures where data from various disciplines can be stored and fetched from."

PARADE - Partnership for Accessing Data in Europe14.