

A high-resolution photograph of Earth from space, showing a curved horizon with a thin blue atmosphere. The surface is covered in white clouds and brownish-yellow landmasses. The sun is visible as a bright, glowing arc along the horizon, creating a lens flare effect.

The ESA Earth Observation Programmes Status and Perspectives

**Meeting of the Space Studies Board's Committee
on Earth Science and Applications from Space (CESAS)**

**Washington DC
4 March 2014**

**Dr. Maurice Borgeaud
Head of the Department "Sciences, Applications and Future Technologies"
ESA Earth Observation Programmes**

- Introduction on the European Space Agency (ESA)
- Overview of ESA Earth Observation activities
- International cooperation ESA-NASA in Earth Observation
- Decadal survey and impact on ESA planning
- Conclusions
- Q&A

20 MEMBER STATES AND GROWING



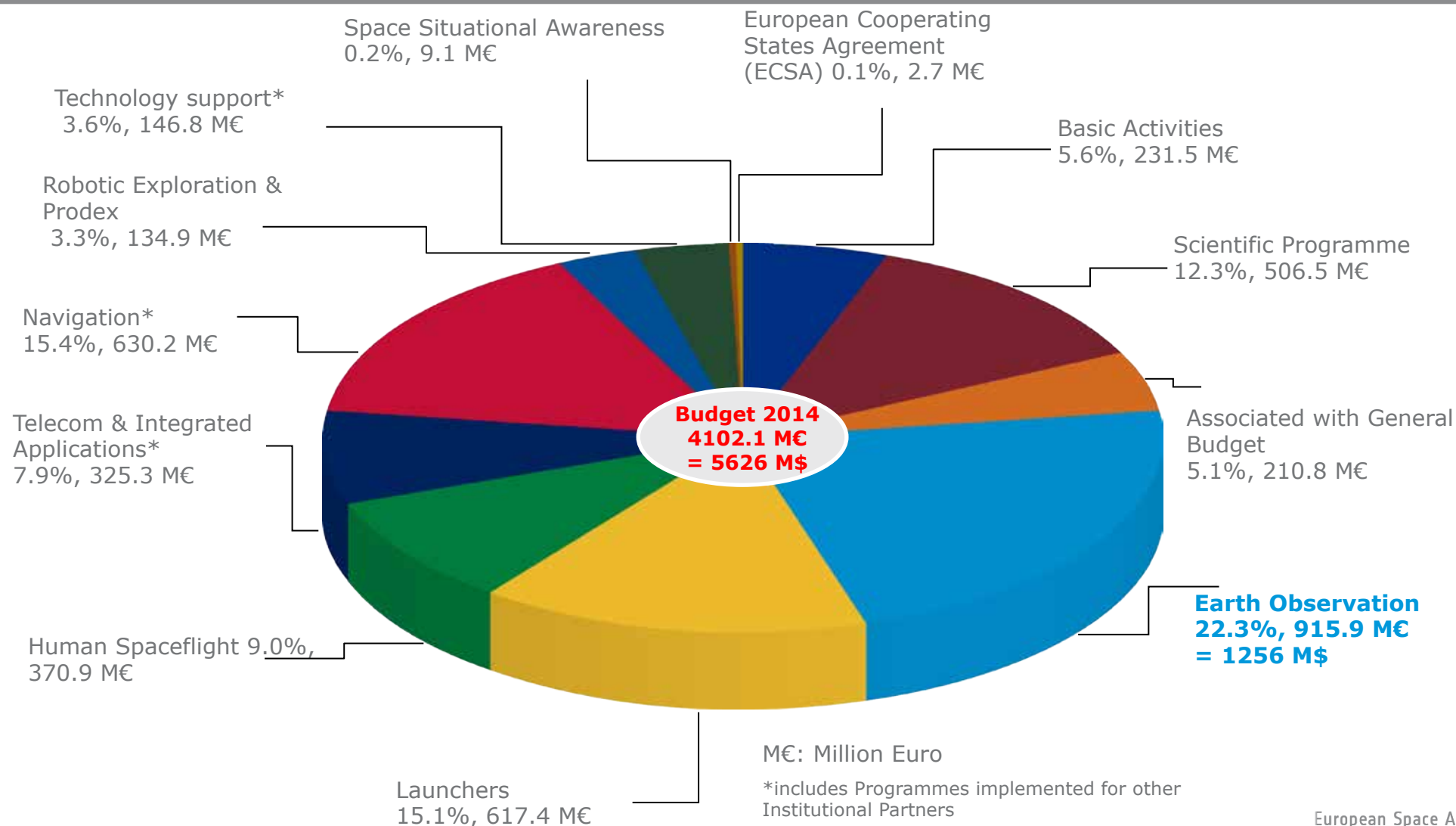
ESA has 20 Member States: 18 states of the EU (AT, BE, CZ, DE, DK, ES, FI, FR, IT, GR, IE, LU, NL, PT, PL, RO, SE, UK) plus Norway and Switzerland.

Eight other EU states have Cooperation Agreements with ESA: Estonia, Slovenia, Hungary, Cyprus, Latvia, Lithuania, Malta and the Slovak Republic. Bulgaria is negotiating a Cooperation Agreement. Discussions are ongoing with Croatia.

Canada takes part in some programmes under a long-standing Cooperation Agreement.



ESA 2014 BUDGET BY DOMAIN



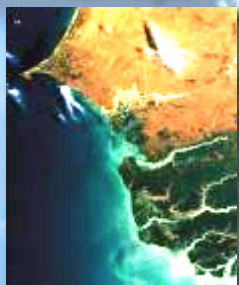
ESA Earth Observation Programmes



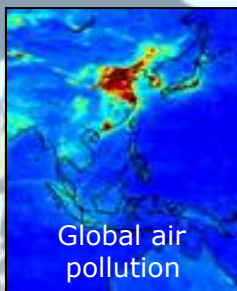
ENVISAT mission: 10 years



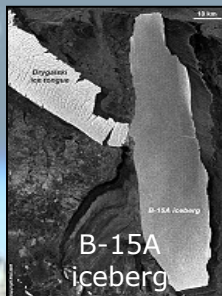
First images



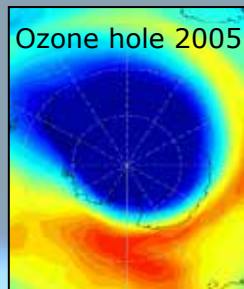
Global air pollution



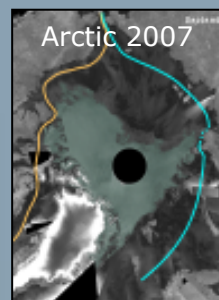
B-15A iceberg



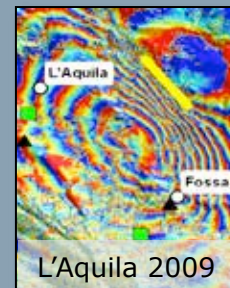
Ozone hole 2005



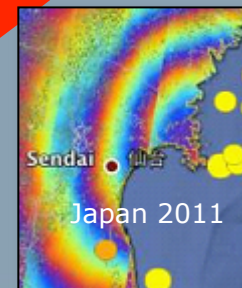
Arctic 2007



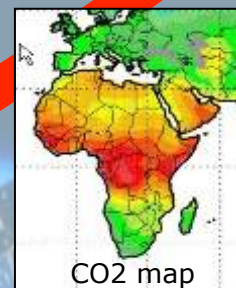
L'Aquila 2009



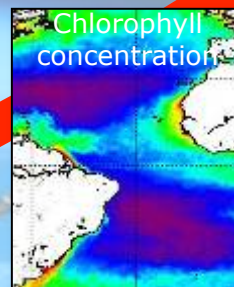
Japan 2011



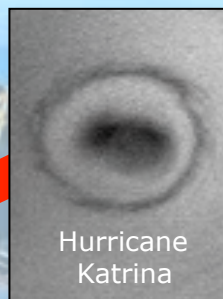
CO2 map



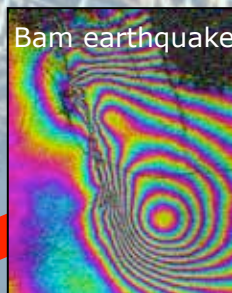
Chlorophyll concentration



Hurricane Katrina



Bam earthquake



Prestige tanker oil slick



Launch



Envisat
Symposium
Salzburg (A)

Envisat
Symposium
Montreux (CH)

Living Planet
Symposium
Bergen (N)

Living Planet
Symposium
Edinburgh (UK)

2002

2004

2007

2010

2013

and many workshops dedicated to specific Envisat user communities

© ESA 2013

**more than 4000
science projects**

Newly in orbit: Swarm



Providing the best-ever survey of the Earth's geomagnetic field and its variation in time

Gaining new insights into the Earth's interior and climate

Launch 22 November 2013

Commissioning phase on-going

Products up to L2 available after June 2014

European Space Agency
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Swarm Science Objectives



understanding the
weakening of Earth's
protective shield

understanding the
"Earth's dynamo"
in the outer core

mapping magnetic
fingerprints in Earth's
crust/ Composition of
the mantle

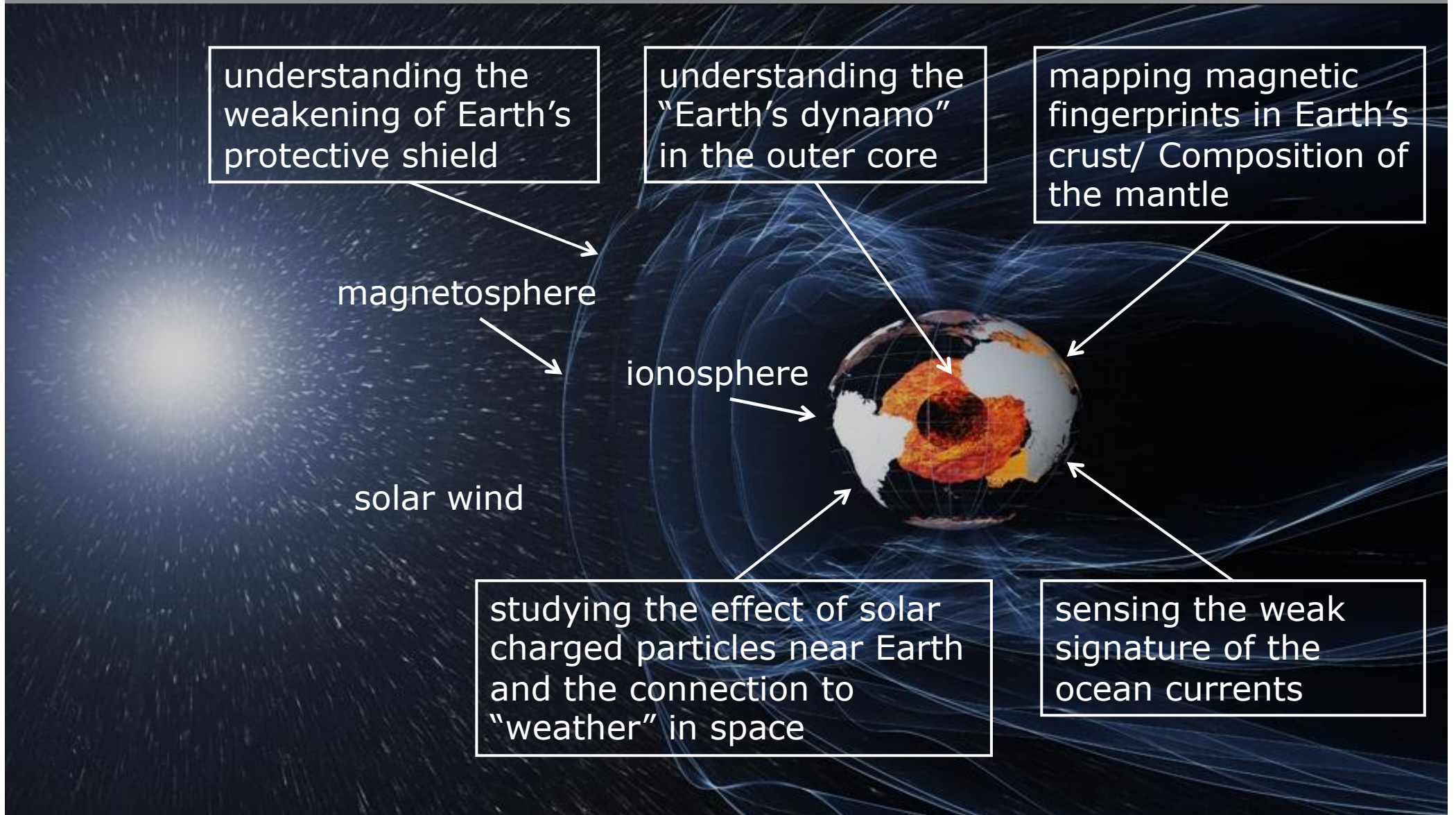
magnetosphere

ionosphere

solar wind

studying the effect of solar
charged particles near Earth
and the connection to
"weather" in space

sensing the weak
signature of the
ocean currents



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 very likely



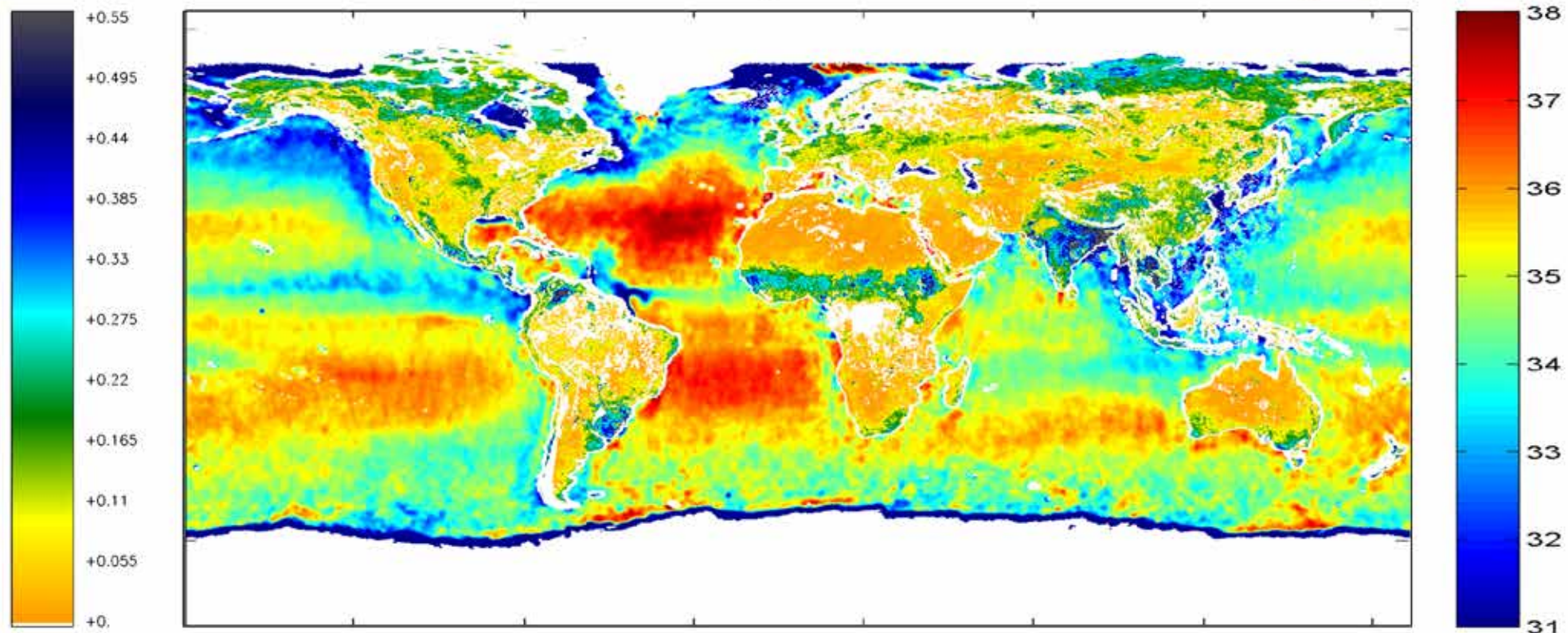
SMOS : Global Map



Soil Moisture
August 2011

Ocean Salinity
August 2010

Morning orbits



CryoSat: The Ice Mission



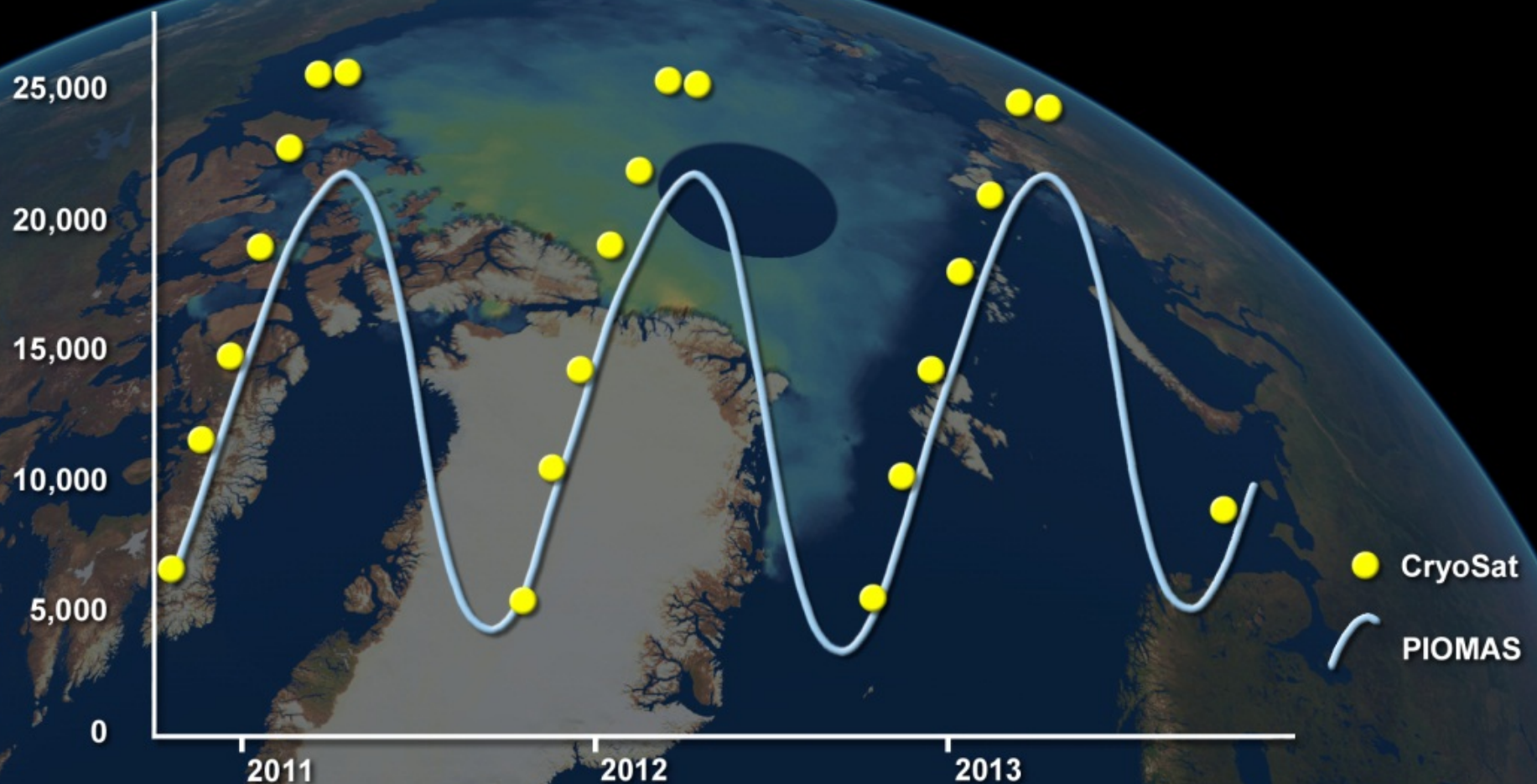
- First interferometric altimeter in space
- Global sea ice thickness measurements
- Data used for ice research, but increasingly also for oceanography
- Mission extension until 2017 likely



CryoSat: The Ice Mission



Arctic Sea Ice Volume
(cubic km)



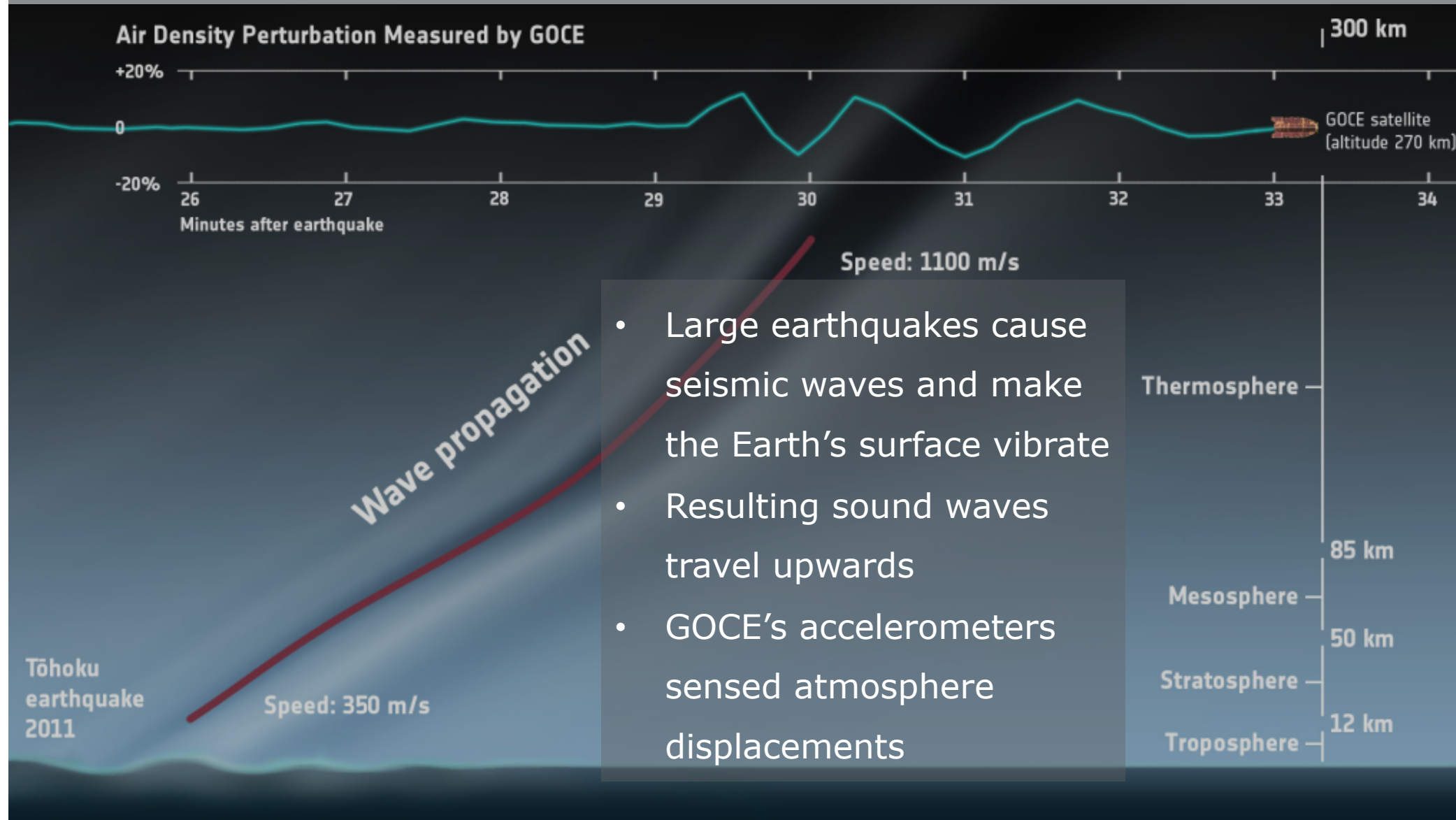
GOCE: Gravity and Ocean Circulation



- First gradiometer in space
- Best geoid ever
- 4th version of geoid released in March 2013
- 5th version of geoid foreseen in mid 2014, including all GOCE measurements
- End of mission declared 21 October 2013 following depletion of Xenon fuel
- Re-entry 11 November 2013



GOCE: Seismometer in Space

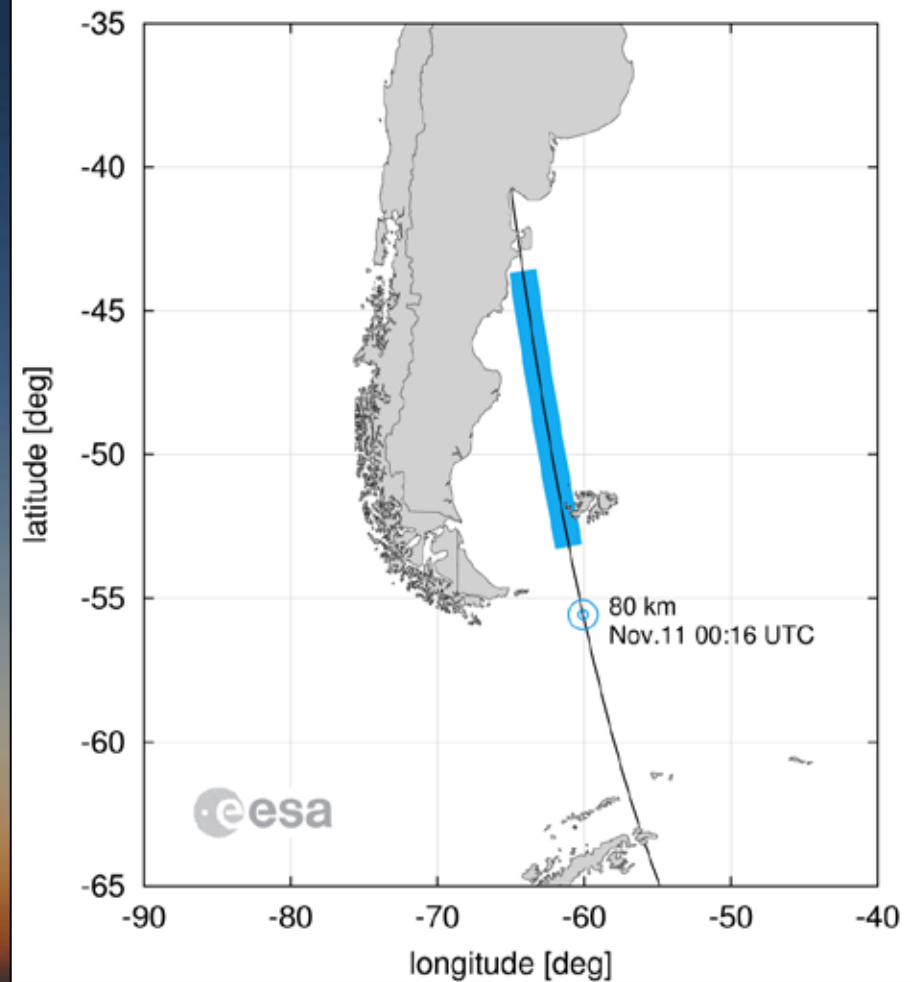


- Large earthquakes cause seismic waves and make the Earth's surface vibrate
- Resulting sound waves travel upwards
- GOCE's accelerometers sensed atmosphere displacements

GOCE Re-Entry 11 November 2013



- As seen from the Falkland Islands...

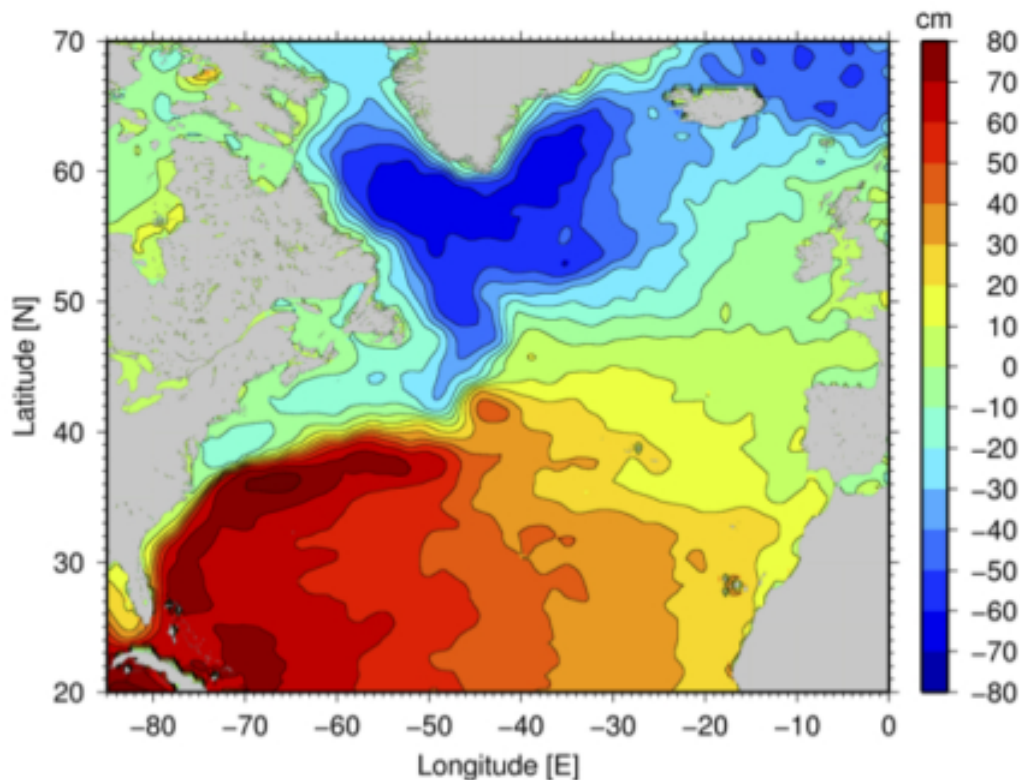


GOCE: accurate ocean currents map

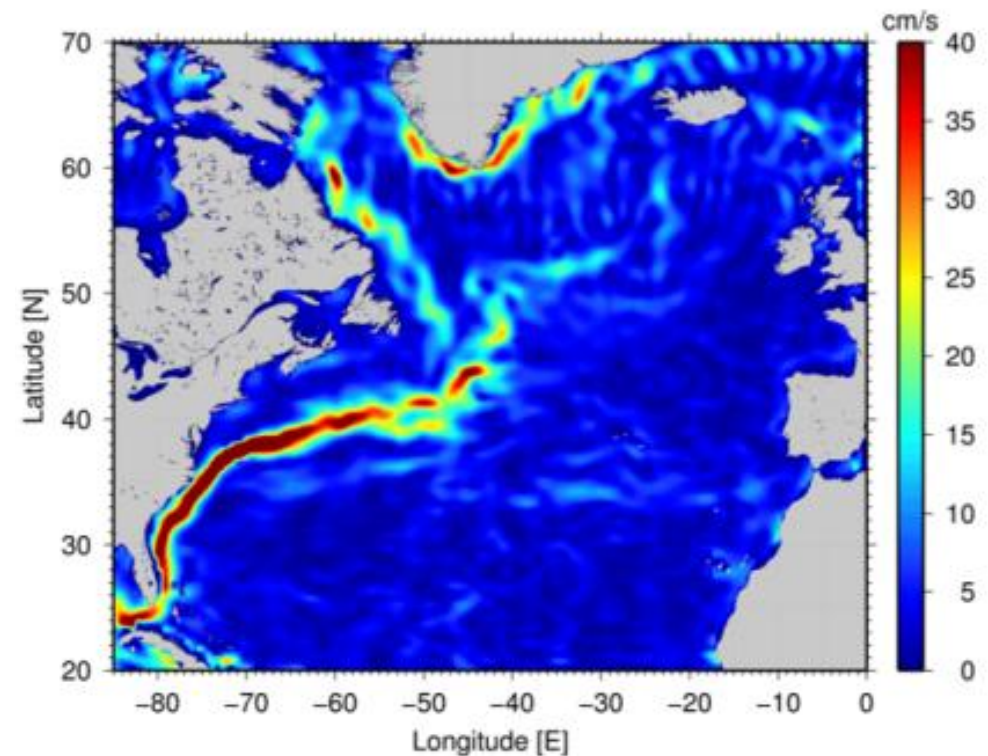


- With GOCE geoid, for the first time, global currents can be extracted directly from satellite altimetry data.

Ocean Dynamic Topography



Water Surface Velocity



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
- 
- A detailed illustration of the ADM-Aeolus satellite in orbit above Earth. The satellite features a central body with a large, circular instrument bay and two long, rectangular solar panel arrays extending outwards. The Earth's surface, showing clouds and landmasses, is visible below the satellite, while the blackness of space is above.
- Laser transmitter of Lidar has passed operational qualification tests
 - Launch planned for 2015

EarthCARE – ESA's Aerosol Mission



- Global observations of clouds, aerosols and radiation
- Scientific instruments:
 - First UV Lidar
 - First Doppler Cloud Profiling Radar (JAXA contribution)
 - Multispectral Imager
 - Broadband Radiometer
- Clouds-aerosols-radiation closure
- Launch planned for 2016

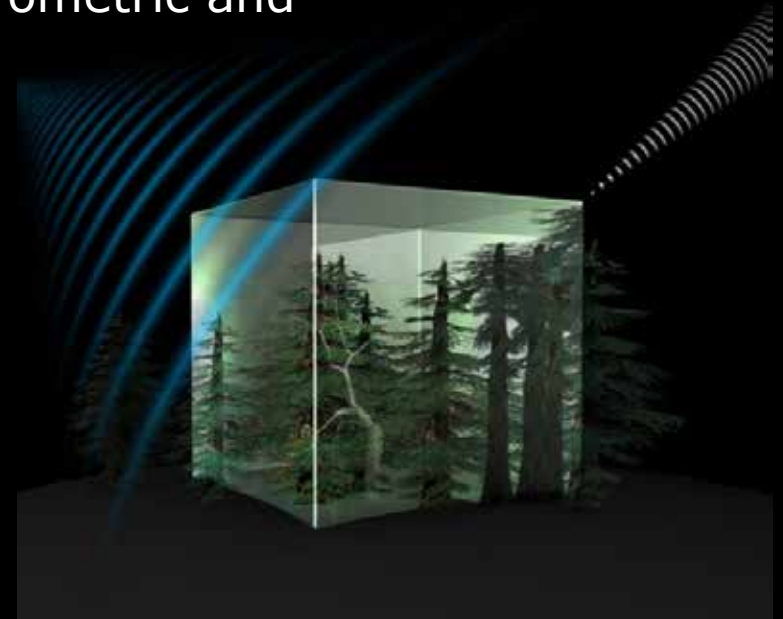


Future Earth Explorer Missions



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
- Biomass could fill the gap of the DesdynI

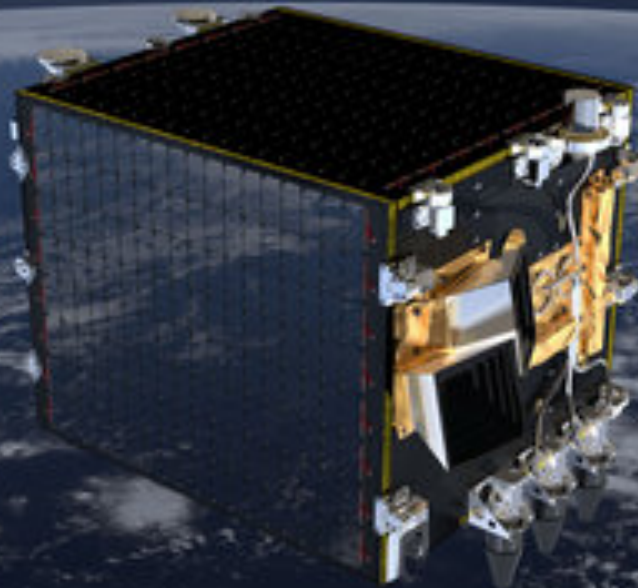


Candidate missions for 8th Earth Explorer: Flex and CarbonSat, launch in ~ 2022

Proba-V



- Minisatellite tracking global vegetation growth
- Observation on an “always on” basis
- Launched May 2013 on 2nd VEGA flight as part of the VERTA programme
- Multiple guest payloads
- Routine data delivery since December 2013



Copernicus: A New Generation of Data Sources



Sent-1A/B



Sentinel-2A/B



Sentinel-3A/B



Sentinel-4A/B



Sentinel-5/5P



Sentinel-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 (Multi-Year Financial Framework) foresees 3.783 billion Euro (5.2 B\$) for Copernicus operations and recurrent satellites
- Delegated Act on Data Policy approved (free and open)



Sentinel-1 A launch scheduled on 3 April 2014

Meteorological missions



- ESA develops prototype satellites and, on behalf of EUMETSAT, procure recurrent satellites
- EUMETSAT procures launchers and LEOP services
- EUMETSAT operates the satellites
- Currently Meteosat Second Generation (MSG) missions in GEO and MetOp missions in LEO
- MeteoSat Third Generation (MTG) and MetOp Second Generation under development



The ESA Climate Change Initiative



- **EO satellites deliver global, consistent and long-term data for Essential Climate Variables**, constituting the foundation supporting Climate Research & Applications
- **Copernicus (GMES) Sentinels will provide long-term continuity for monitoring our planet**
- Gaps in time series => irreversible damage to the foundation underpinning Climate Research



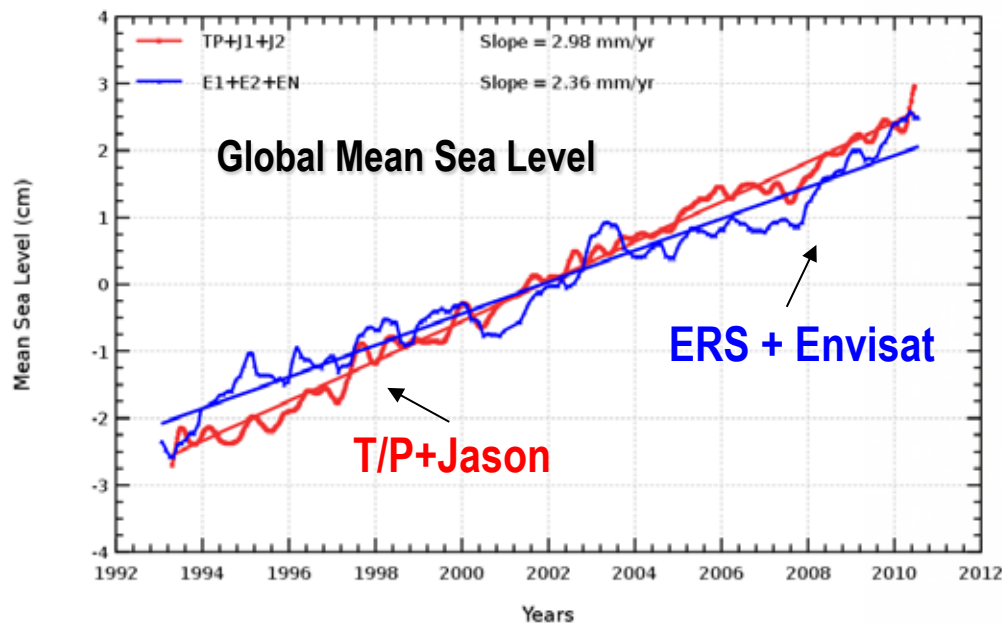
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European Space Agency
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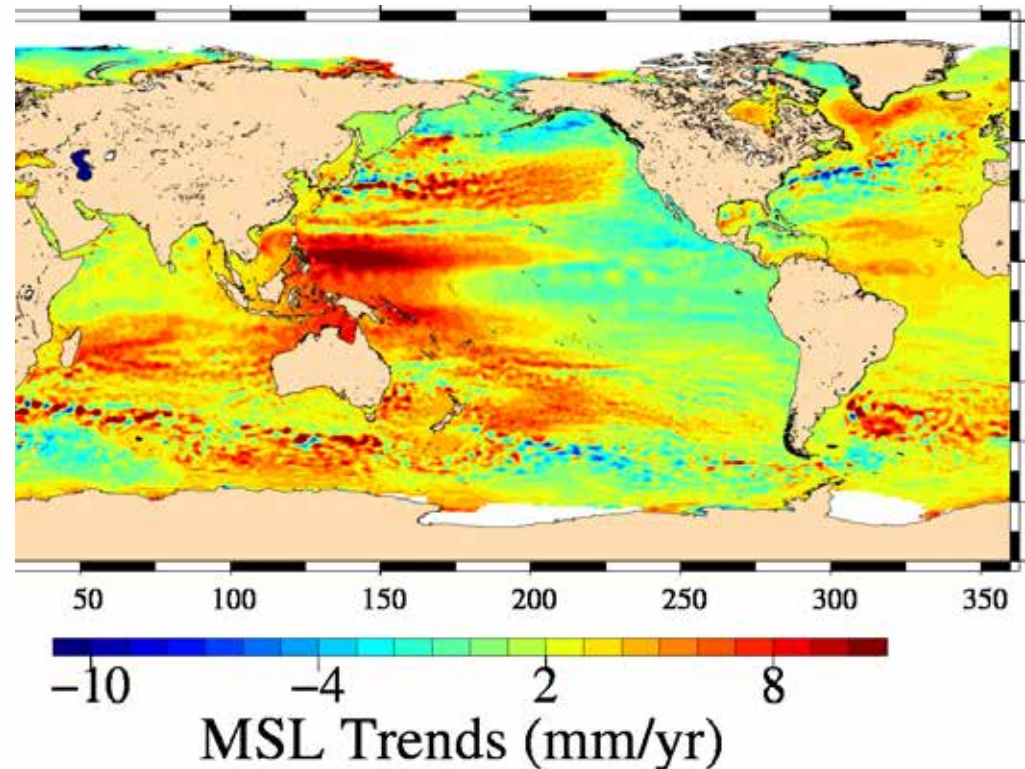
Sea Level CCI



RELEASE of the NEW
Sea Level ECV PRODUCT
18 years from 1993 to 2010



Thanks to the SLCCI project



International cooperation ESA-NASA in Earth Observation (1)



- Formal ESA/NASA Earth Science and Observation Framework for Cooperation signed on 7 September 2010
- Setup of a joint NASA-ESA Earth Science **Joint Program Planning Group (JPPG)** to enhance cooperation in the area of Earth sciences, observation techniques, and applications including global climate change
- Annual joint meetings held dealing with three main collaboration domains:
 - WG-1: Mission and Technology
 - WG-2: Cal/Val and Field Campaigns
 - WG-3: Ground segment and data

International cooperation ESA-NASA in Earth Observation (2)



- Some major achievements of NASA-ESA JPPG:
 - Joint Arctic campaign for ICEBridge and CryoVex
 - Approved the exchange of the LDCM and S2 pre-launch calibration hardware
 - Bulk exchanges of MERIS/MODIS/SEAWIFS data sets
 - Set up International Science Working Group for joint gravity monitoring initiative (GRACE-2 from Decadal Survey plus ESA's post-GOCE gravity mission)
 - Coordination and cross-participation in the on-going international constellation developments constellation/convoy effort

International cooperation ESA-NASA in Earth Observation (3)



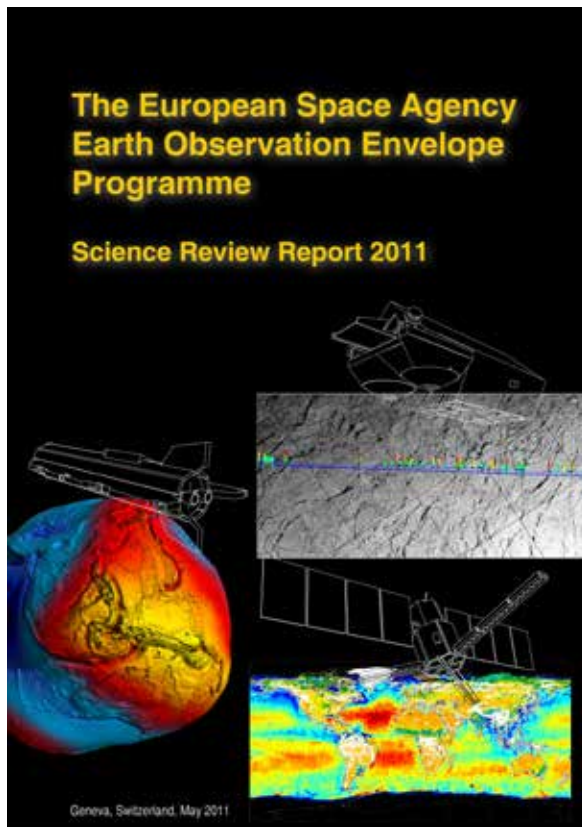
- Potential for future cooperation
 - Use of Sentinel-2 in the NASA Sustained Land Imaging (LI) within joint effort on future global land monitoring (extendable to multi-spectral imaging in VNIR/SWIR/TIR, hyper-spectral imaging, persistent imaging,...)
 - Cal/Val & cross-calibration activities (e.g. SMOS/Aquarius/SMAP, CryoSat/IceSat-2, S-2/LDCM, EarthCare/Caplisio/Cloudsat)
 - Biomass (just approved at ESA, possible collaboration with NASA)
 - Define scenarios with satellites in constellation/formation (each Agency contributing with its own missions) towards common objectives
 - Flight opportunities to embark one each other's instrument
 - Joint (or at least coordinated) Calls for missions
- Cooperation to be based on
 - Complementarity, unless strategic for a partner
 - Realize "real constellations" besides "virtual constellations"
 - If hardware exchange, favor senior/junior partnership

2011 Science Review of the EOEP Programme



Among some of the findings:

- ESA's approach of **consulting broadly**, and in a sustained manner, with the scientific community in establishing its science strategy and priorities to have been very effective and sound
- **The balance between risk and innovation** in the Earth Explorer Programme requires continued strategic thinking and planning in the future, especially in the light of the rapidly evolving science requirements and the changing European national and other international space-based EO programmes.
- Added risk due to technology innovations in later phases of the Programme is the primary reason for prolonged development life-cycle time and increased cost => **Selection of mission after successful phase AB1 (TRL-5)**



Future Earth topics of particular relevance to ESA Living Planet Science Challenges



- Food and freshwater availability/security
- Management of the Earth's resources and energy
- Health of the planet and humankind
- Risk reduction and improvement of resilience to disaster
- Topics are relevant to society, overarching and require new approaches and understanding of cross-cutting dimensions
- Topics very likely to also influence the next version of the NASA Decadal Survey

Decadal Survey and impact on ESA planning (1)



- ESA has its own Earth science strategy setup in the mid-1990's and keeps it regularly updated (new issue in 2014)
- Next programmatic decision for ESA EOEP programme will be in 2016 for which international collaboration will be emphasized
- ESA would welcome a closer interaction with NASA on the next issue of the Decadal Survey
 - Overall science objectives
 - Programmatics
 - Options for synergistic Earth observation efforts



- Based on the 2012 Mid-term Assessment of NASA's Implementation of the Decadal Survey, a closer NASA-ESA collaboration could yield:
 - Mission harmonization and synergy
 - Improve the balance between prioritizing science objectives and constraining how those objectives are accomplished
 - Contribute to a better use of funding to develop an all-encompassing program to enhance every aspect of Earth system science
 - Foster the EO science collaboration between the US and Europe

- ESA welcome this opportunity to present the EO programmes to the SSB-CESAS Committee
- International cooperation is not only an opportunity but a “must”
 - Number of excellent and urgent proposals from science increases while the budgets stay constant
 - Cannot afford to double efforts anymore and need to work more than in the past together
 - Flying constellations (convoys) with international partners to reach a larger objective compared to a single mission
- Promising cooperation between ESA and NASA but needs to be firmed up in the future

- ESA keen in a balanced and reliable cooperation with NASA in the frame of Earth observation
- Strong synergy between the priorities of the NASA Decadal Survey and ESA's future EO plans => Obvious cooperation
- Concerns not only NASA and ESA but other Space Agencies