

The European Space Agency Earth Observation missions

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ESRIN, FRASCATI, ITALY

OVERVIEW

1. Introduction to ESA
2. Earth Observation at ESA
3. ERS-1 and 2 missions
4. Envisat mission
5. Explorers (scientific) missions
6. Sentinels (operational)missions
7. Climate Change Initiative





PURPOSE OF ESA



“To provide for and promote, for exclusively peaceful purposes, cooperation among European states in **space research** and **technology** and their **space applications**.”



Article 2 of ESA Convention

ESA Earth Observation missions | 6/2013 | Pag. 4

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ESA Facts and Figures



Over 40 years of experience

19 Member States in 2012

Cooperation Agreements with eight other EU states: Estonia, Slovenia, Poland, Hungary, Cyprus, Latvia, Lithuania and the Slovak Republic

Six establishments in Europe, about 2200 staff

Launch base in French Guiana and ground/tracking stations in various parts of the world

€4020 million budget in 2012

Over 70 satellites designed, tested and operated in flight

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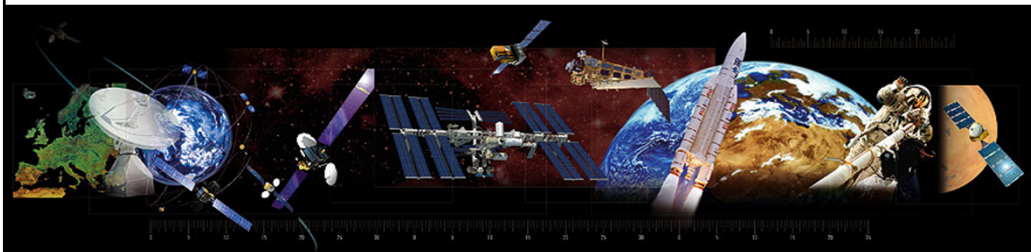


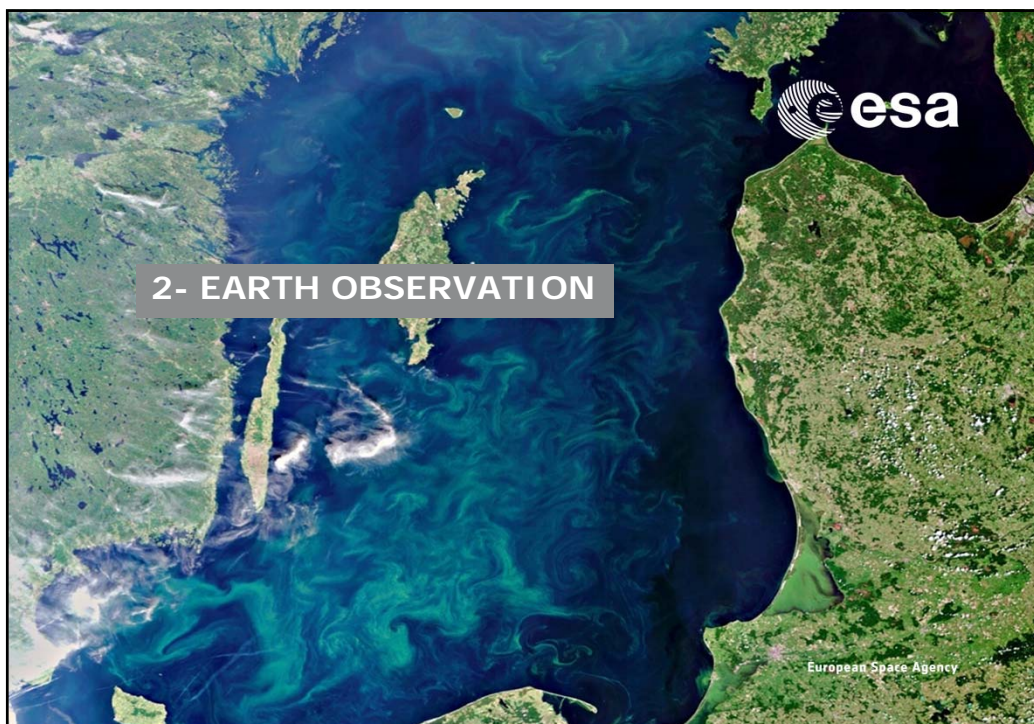
ACTIVITIES



ESA is one of the few space agencies in the world to combine responsibility in nearly all areas of space activity.

- Space science
- Human spaceflight
- Exploration
- Earth observation
- Launchers
- Navigation
- Telecommunications
- Technology
- Operations





PIONEERS IN EARTH OBSERVATION



Meteosat (1977–) ESA has been dedicated to observing Earth from space ever since the launch of its first meteorological mission.

ERS-1 (1991–2000) and **ERS-2** (1995–2011) providing a wealth of invaluable data about Earth, its climate and changing environment.

Envisat (2002–12) the largest satellite ever built to monitor the environment, it provided continuous observation of Earth's surface, atmosphere, oceans and ice caps.



EARTH EXPLORERS



These missions address critical and specific issues raised by the science community, while demonstrating the latest observing techniques.

- **GOCE** (2009–) 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** (2014) studying global winds
- **EarthCARE** (2015) studying Earth's clouds, aerosols and radiation (ESA/JAXA)



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METEOROLOGICAL MISSIONS



Missions dedicated to weather and climate.

Meteosat Third Generation – taking over from Meteosat 11 in 2018, the last of four Meteosat Second Generation (MSG) satellites. MSG and MTG are joint projects between ESA and Eumetsat.

MetOp is a series of three satellites to monitor climate and improve weather forecasting, the space segment of Eumetsat's Polar System (EPS).

MetOp-A (2006–) Europe's first polar-orbiting satellite dedicated to operational meteorology. **MetOp-B** launched in 2012.



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OBSERVING OUR PLANET FOR A SAFER WORLD



A joint ESA/European Commission initiative, **Global Monitoring for the Environment and Security (GMES)** is the response to Europe's need for geo-spatial information services. It will provide autonomous and independent access to information for policy-makers, particularly for environment and security issues.

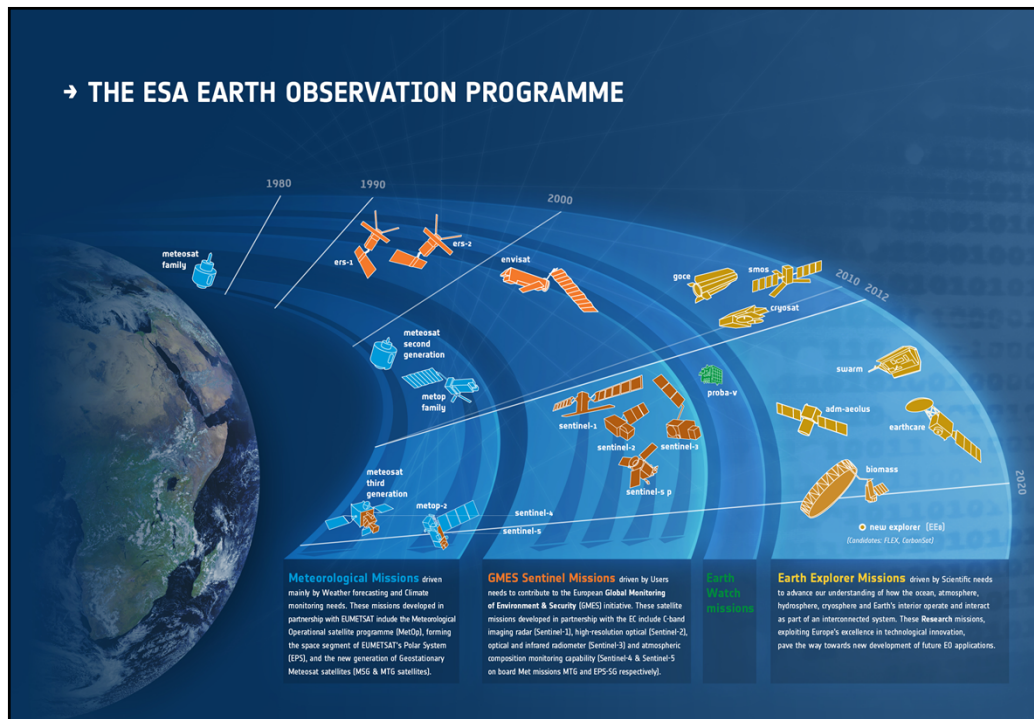
ESA is implementing the space component: developing the **Sentinel** satellite series, its ground segment and coordinating data access.

ESA has started a **Climate Change Initiative**, for storage, production and assessment of essential climate data.



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→ THE ESA EARTH OBSERVATION PROGRAMME





The first image of an Earthquake

Image of an earthquake

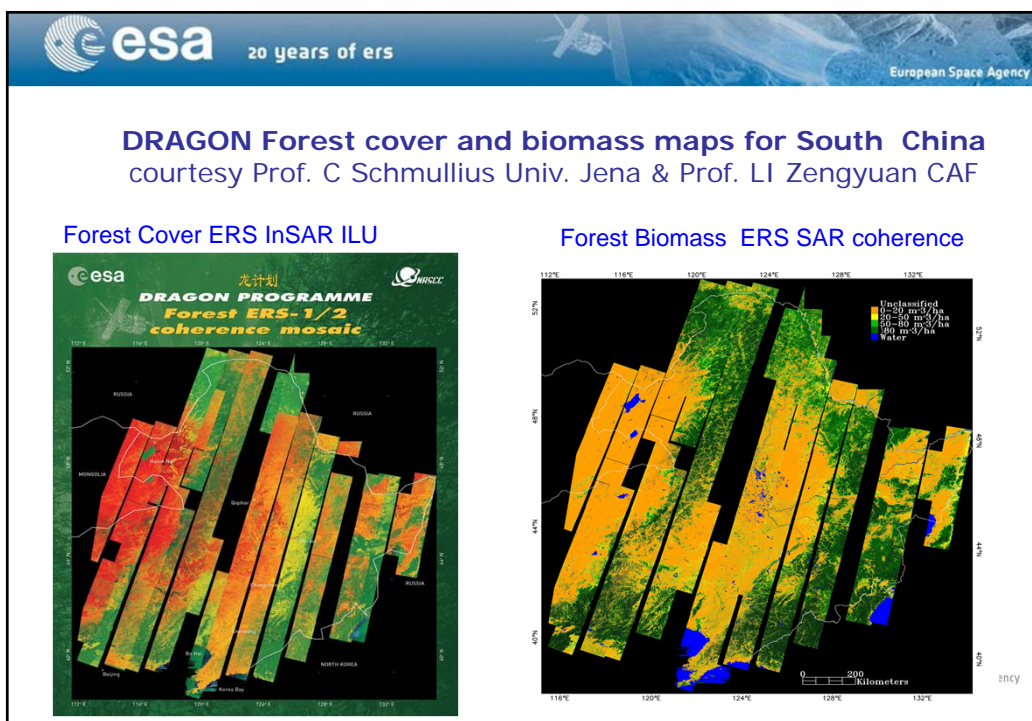
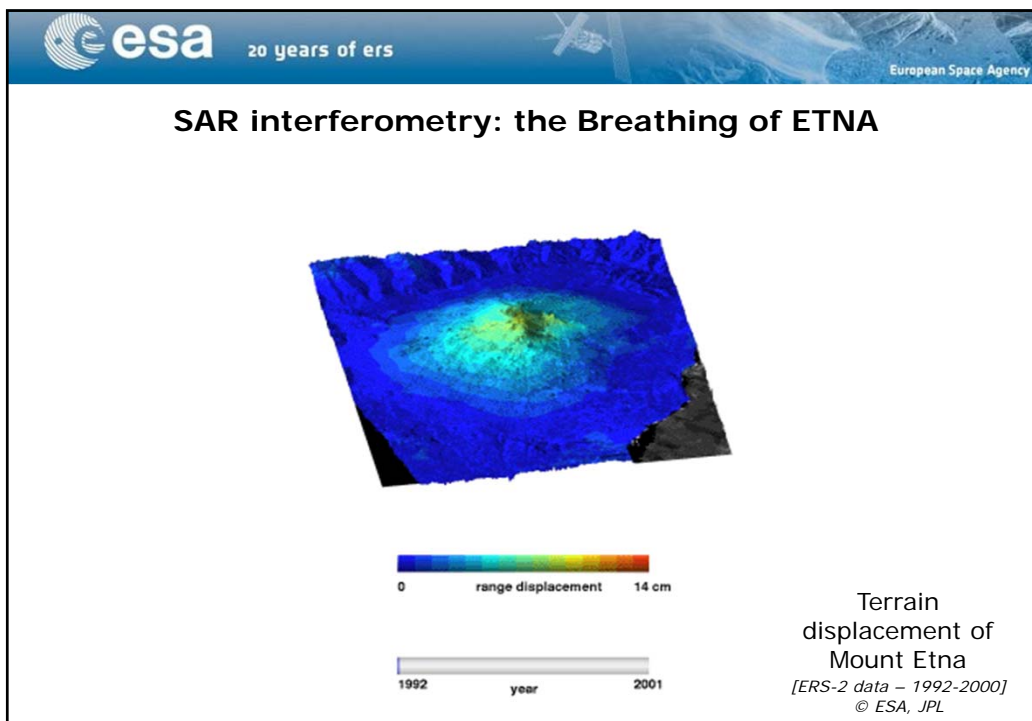
Sniffing out transcription factors
Tropical cradle for biodiversity
Seismological detection of a mantle plume?

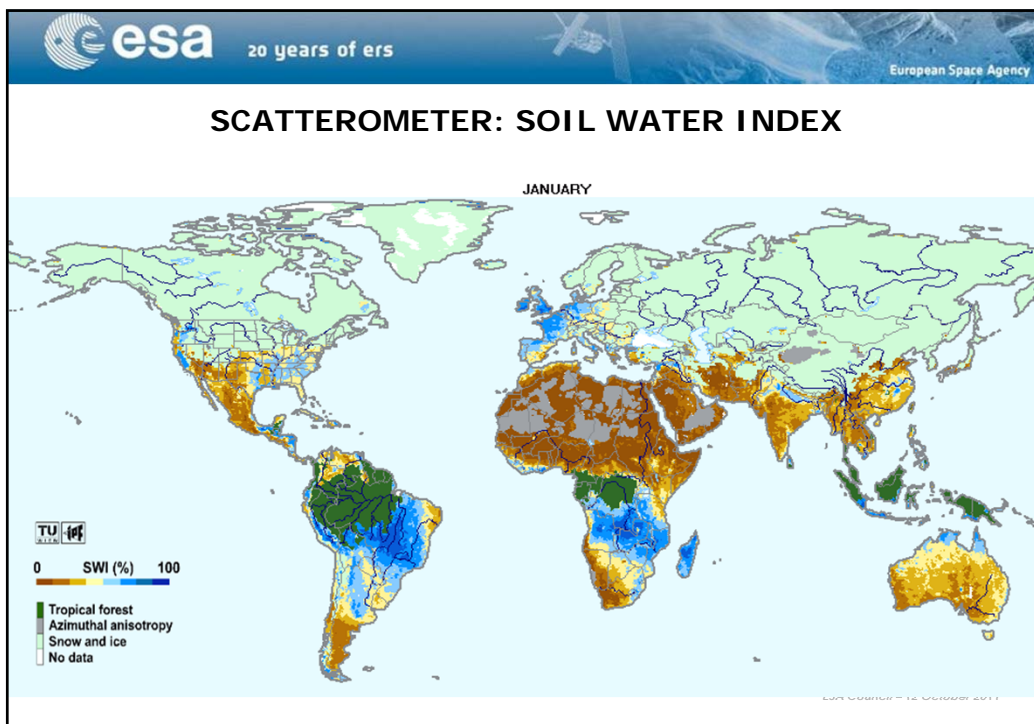
ESA Earth Obs


July 1993
Landers

Didier
Massonnet
CNES

European Space Agency








20 years of ers

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SAR last image: Ice Stream Tracking from 1992 and 2011

Kangerdlugssuaq Ice Stream



ERS-1 1st Ice-Phase


• 07 Feb 1992 (SAR)

ERS-2 Ice-Phase


• 11 Mar 2011 (SAR)

Calving front receded by ~5.5km

Notable thinning of glaciers and ice streams in the area.




OVERVIEW



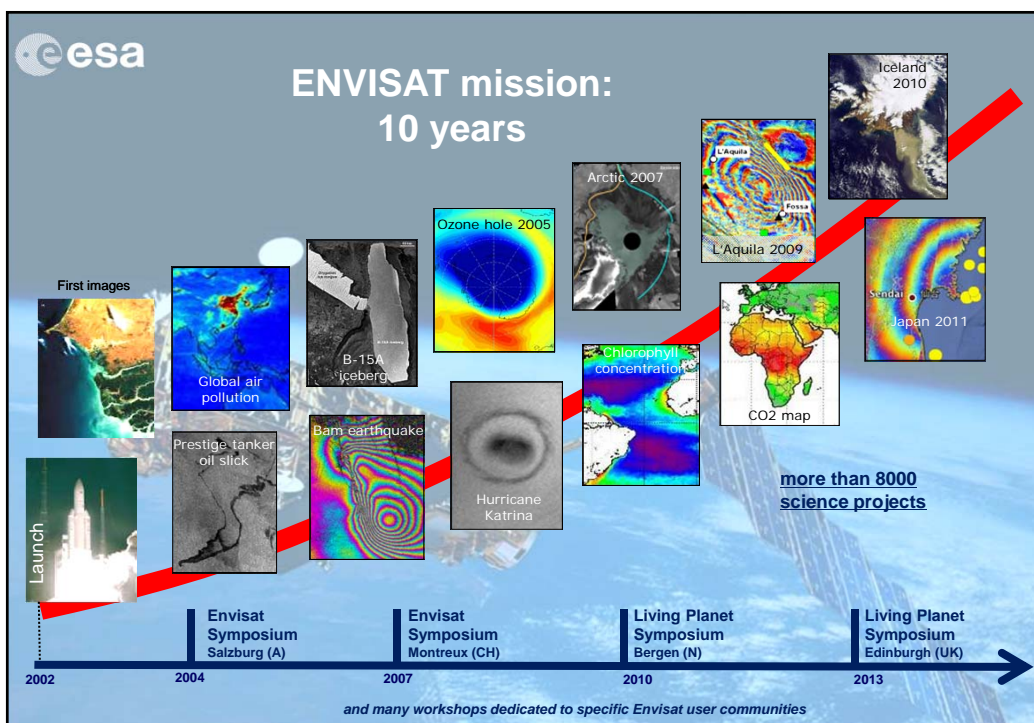
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SOYOUZ



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10



Envisat monitors Ice-Sea Ice in Antarctica

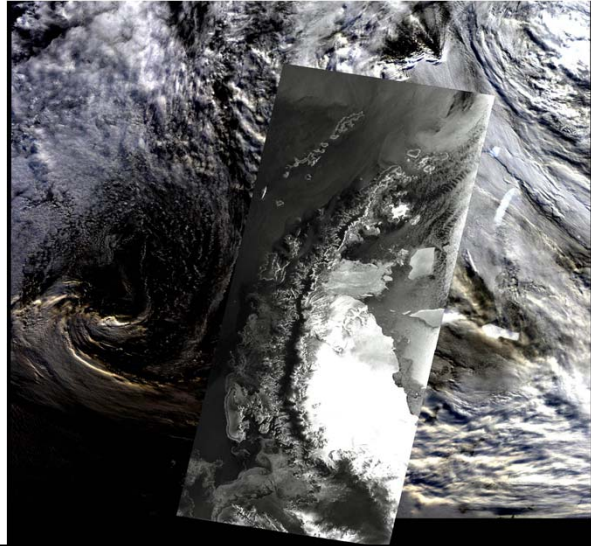


LARSEN B collapse observed
in 2002 by ERS /Envisat



Courtesy of H.Rott, Univ Innsbruck, AU

Envisat Radar monitoring Antarctica Ice)



ENVISAT/ERS SAR Antarctic Ice monitoring



Ice Flow of the Antarctic Ice Sheet

E. Rignot et al., Science, September 2011

=> A result of the coordination
between SAR satellite operators
(CSA, ESA, JAXA) during the
International Polar Year 2007-2008

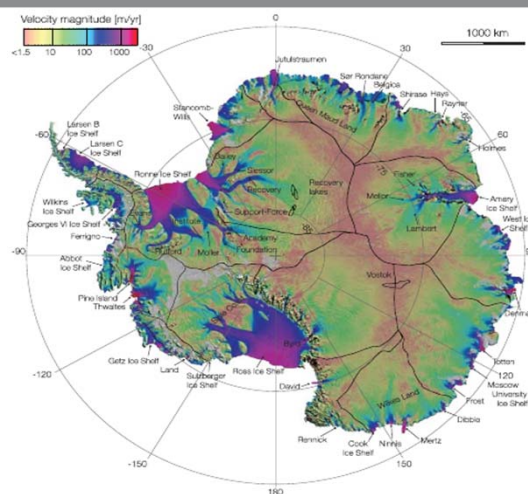
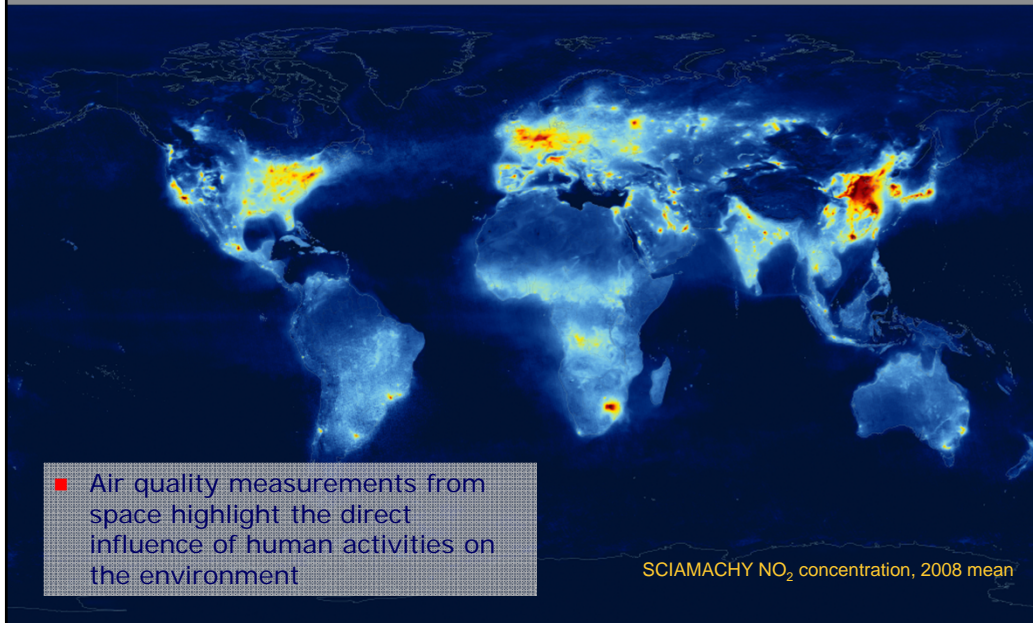


Fig. 1. Antarctic ice velocity derived from ALOS PALSAR, Envisat ASAR, RADARSAT-2, and ERS-1/2 satellite radar interferometry, color-coded on a logarithmic scale, and overlaid on a MODIS mosaic of Antarctica (22), with geographic names discussed in the text. Pixel spacing is 300 m. Projection is polar stereographic at 71°S secant plane. Thick black lines delineate major ice divides (2). Thin black lines outline subglacial lakes discussed in the text. Thick black lines along the coast are interferometrically derived ice sheet grounding lines (23).

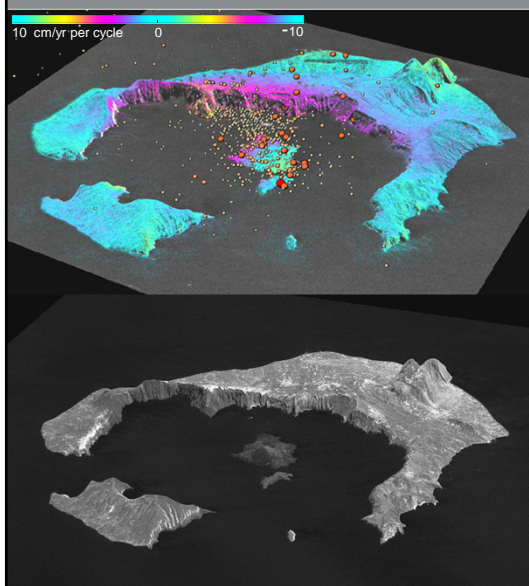
Air Pollution Monitoring from Space:



■ Air quality measurements from space highlight the direct influence of human activities on the environment

SCIAMACHY NO₂ concentration, 2008 mean

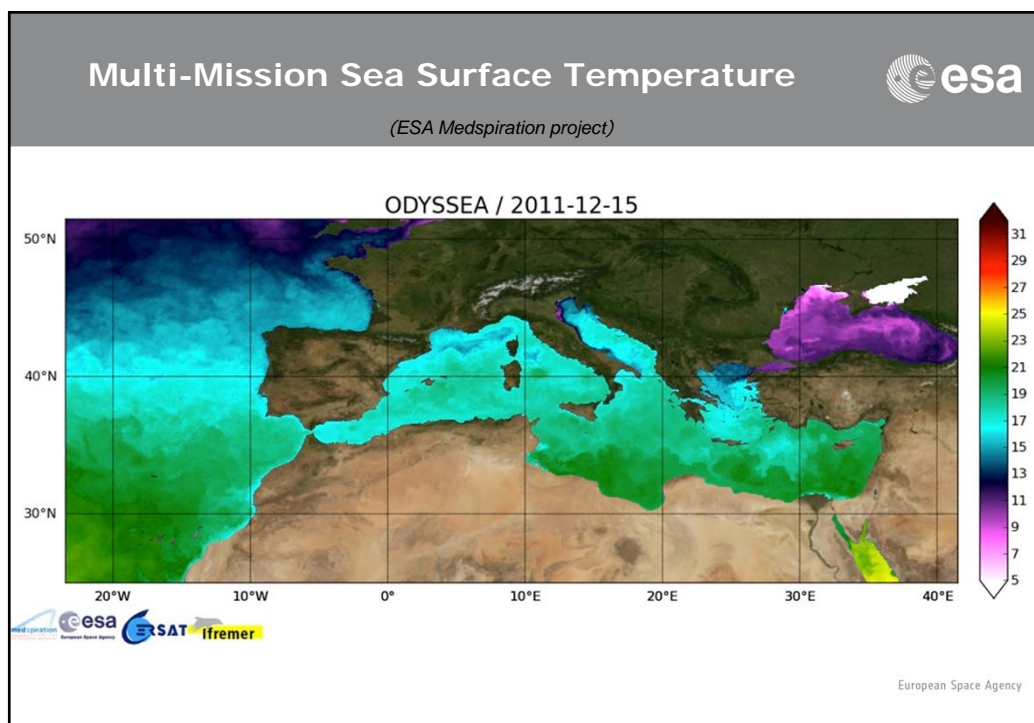
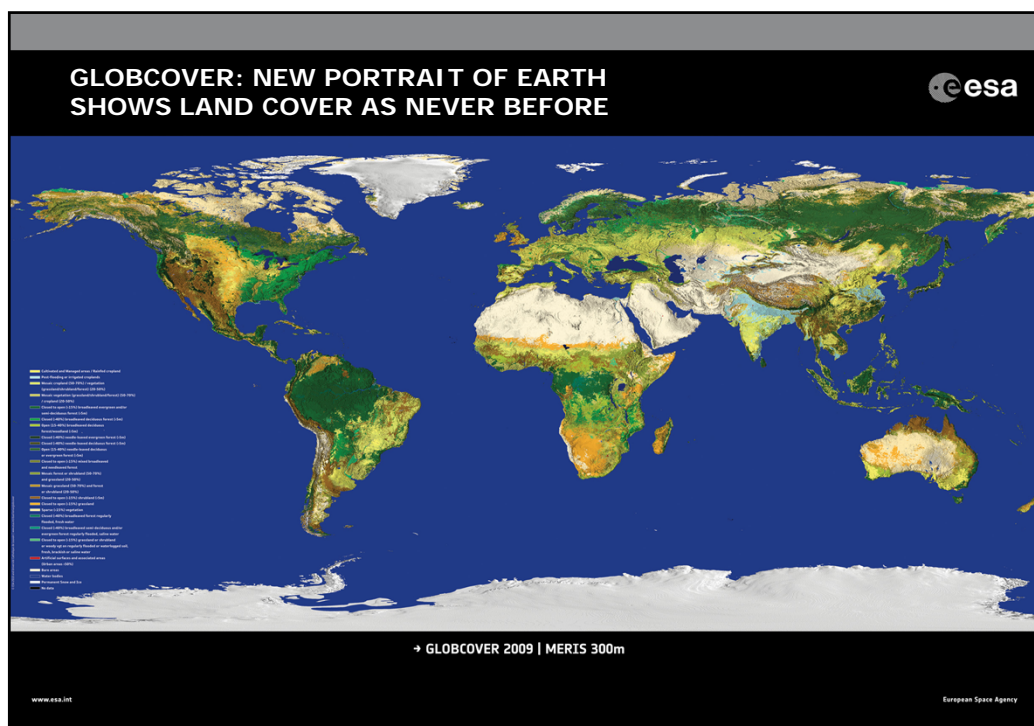
Volcanic Activity Detected by InSAR

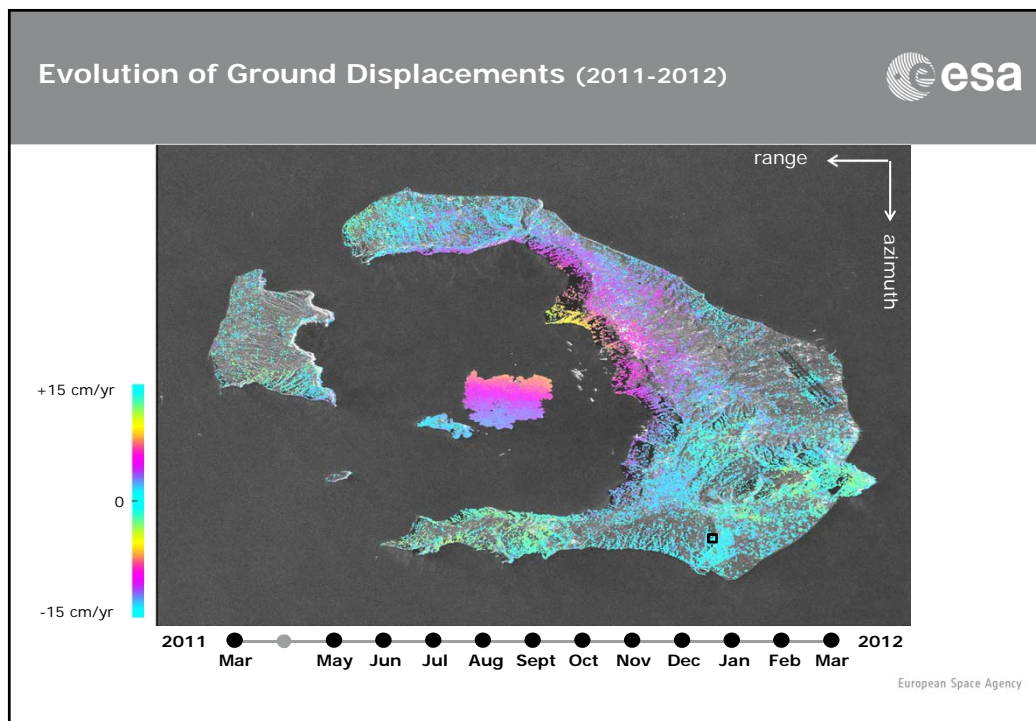
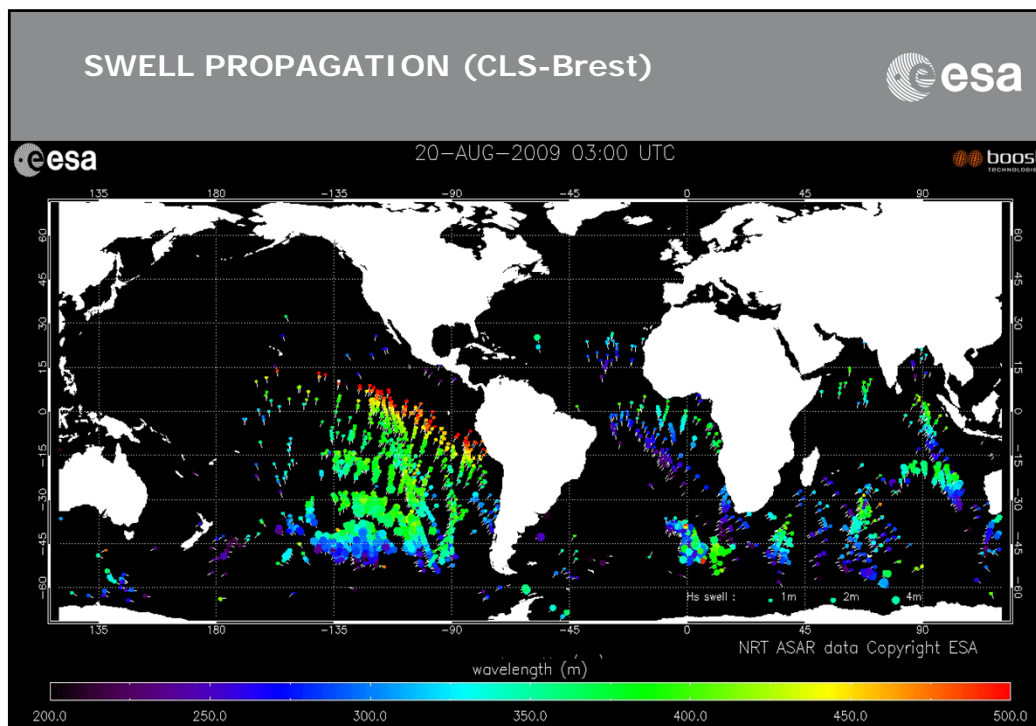


Unrest episode in Santorini Volcano (Greece) starting from Jan 2011. Increased seismic activity and gas emissions inside the caldera (Nea Kameni Is.)

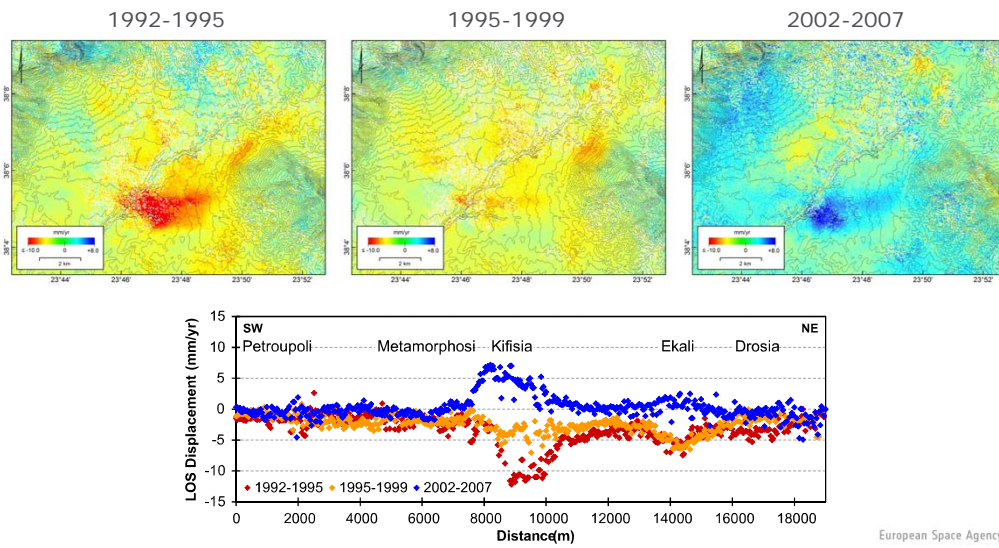
Ground deformation indicating uplift of 5 cm in less than a year was measured by InSAR techniques using ENVISAT data within the frame of ESA's TerraFirma project

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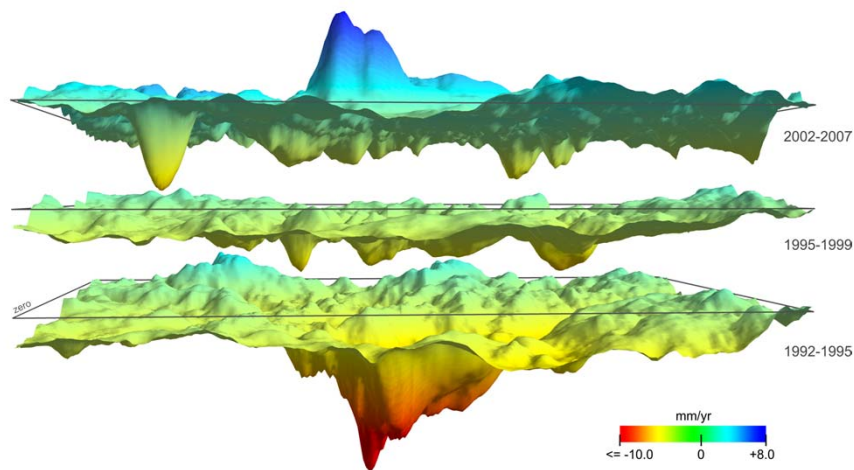




Ground Deformation over Athens



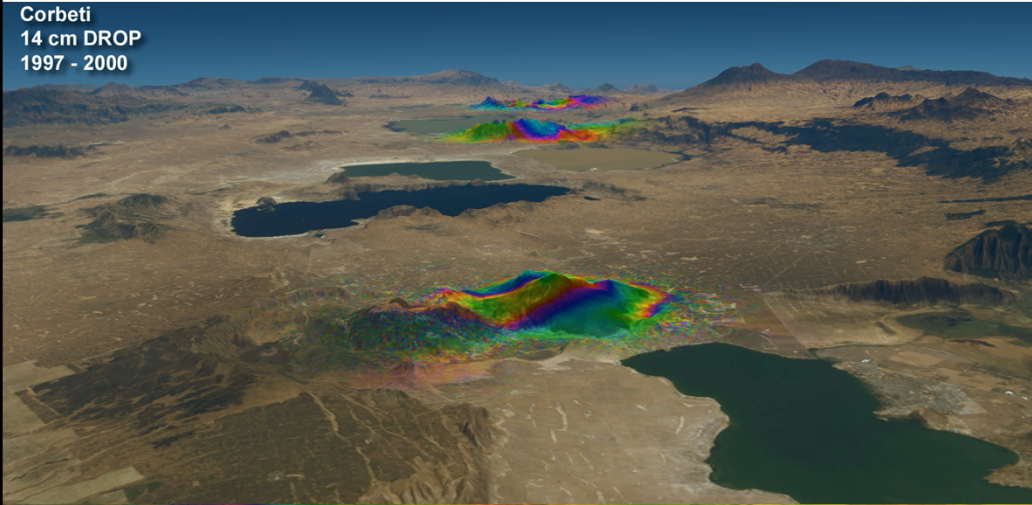
3D Overview of Ground Displacement Field



Rift Valley Dynamic from INSAR Univ of Bristol)



Corbeti
14 cm DROP
1997 - 2000



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5 –Earth Explorers: Scientific missions



GOCE – *the gravity mission*



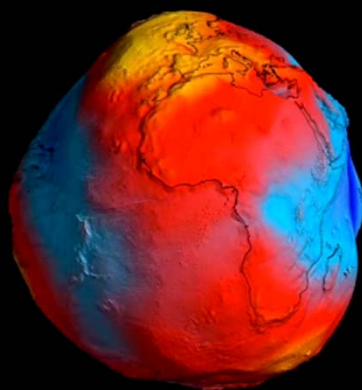
- Launched in March 2009
- GOCE successfully finished its nominal mission in March 2011

A unique mission:

- First gradiometer in space
- Very low orbit (255 km)
- Active air drag control (ion engine)
- Perfectly quiet environment

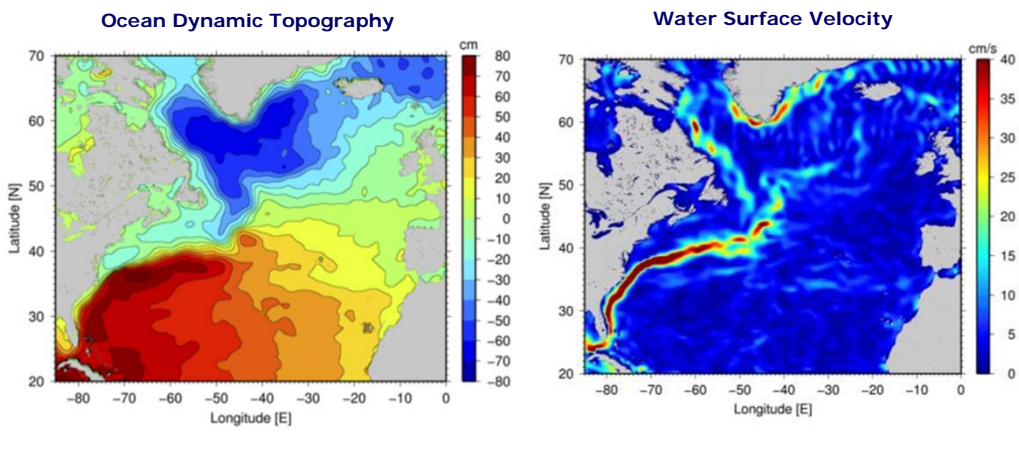


ESA's GOCE mission has delivered the most accurate model of the 'geoid' ever produced



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



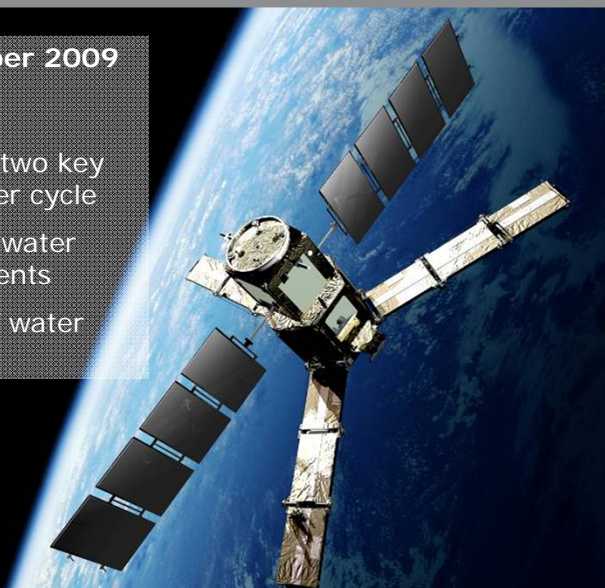
SMOS – The ESA water mission

In space since 2 November 2009

Applications:

First global observations of two key variables of the Earth's water cycle

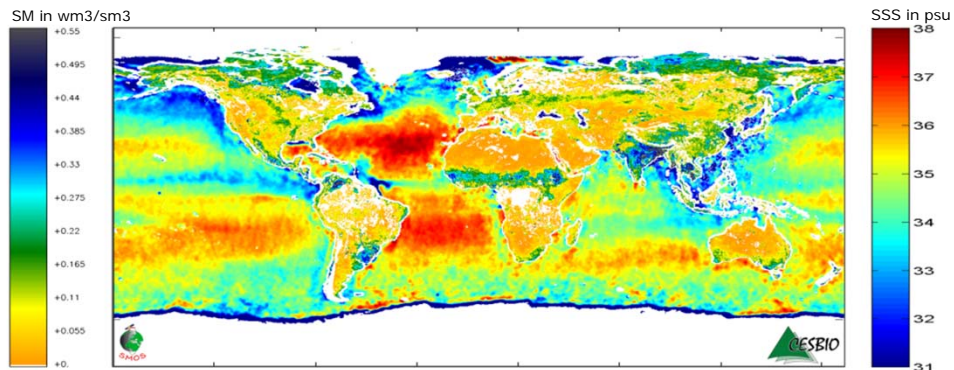
- Improve *models* of global water cycle and global ocean currents
- Improved management of water resources



ESA's SMOS mission provides global measurements of soil moisture and ocean salinity



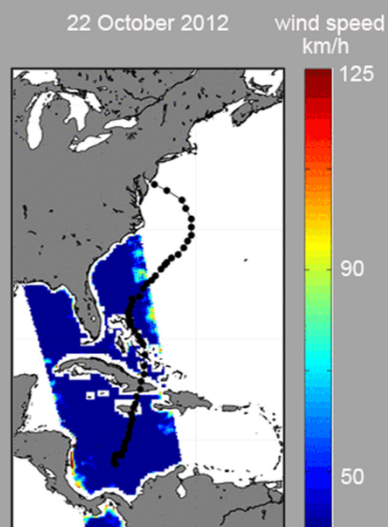
- **SMOS provides the first global measurements of two key variables in the water cycle – soil moisture and ocean salinity**



Merged global maps of soil moisture (August 2011) and sea surface salinity (August 2010), morning orbits. © CESBIO, IFREMER, CATDS

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Hurricane Sandy



- Left side: Estimates of surface wind speeds (km/hr) from SMOS data along the track of Hurricane Sandy
- Spanning 1800 km, this super storm is the largest Atlantic hurricane on record, devastating parts of the Caribbean and northeastern US in October 2012.
- ESA's SMOS microwave radiometer (L-band) provided reliable estimates of surface wind speeds in this intense storm

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CryoSat-2 – ESA's ice mission



- monitoring precise changes in the thickness of the polar ice sheets and floating sea ice, reaching latitudes of 88°
- Launch **8 April 2010**

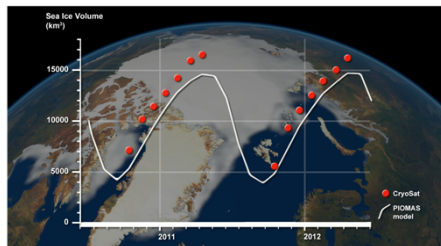
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CryoSat




Primary Mission Goals:

- Determination of regional and basin-scale trends in perennial Arctic sea ice thickness and mass.
- Determination of regional and total contributions to global sea-level of the Antarctic and Greenland ice sheets.

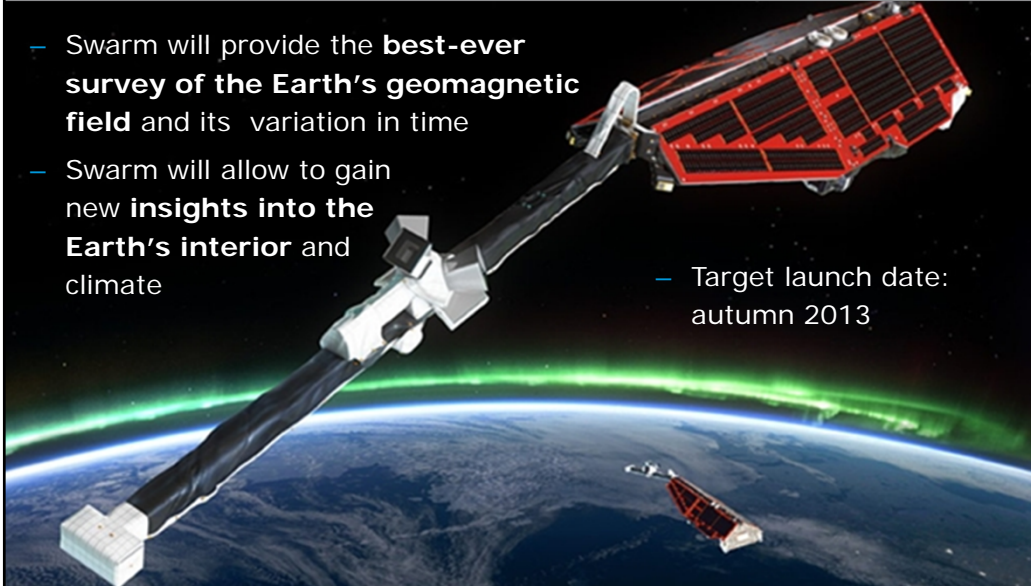


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5 – EARTH EXPLORERS IN PREPARATION

SWARM – ESA's magnetic field mission 

- 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
- Target launch date: autumn 2013



ADM-Aeolus – ESA's wind mission



- to provide **global observations of wind profiles** from space
- to **improve the quality of weather forecasts** and our understanding of atmospheric & climate processes
- **Status:**
 - Scientific impact studies regarding 80mJ laser transmitter energy are running, indicating at the moment no show-stopper
 - Laser integration completed for IR section of 1st flight laser
 - Shock characterisation test planned for mid-2013

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EarthCARE – ESA's aerosol mission



- To provide a better understanding of the **interactions between cloud, radiative and aerosol processes** that play a role in climate regulation
- **Status:**
 - S/C detailed design phase proceeding nominally
 - MSI test campaign running
 - JAXA: mechanical qualification of CPR initiated
 - Launch in November 2016



BIOMASS will be the 7th Earth Explorer

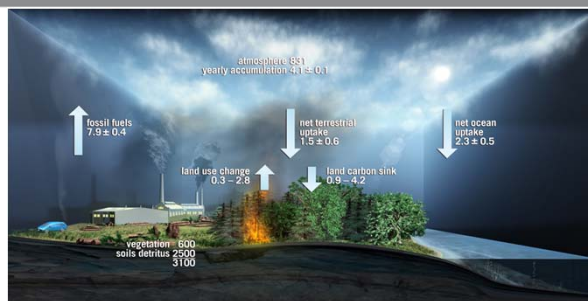


- **BIOMASS** has been selected by ESA's Earth Observation Programme Board.
- It will provide **continuous global** interferometric and polarimetric **Radar observations of forested areas**.
- Essential to the understanding of the role of forests in Earth's **carbon cycle** and in **climate change**.



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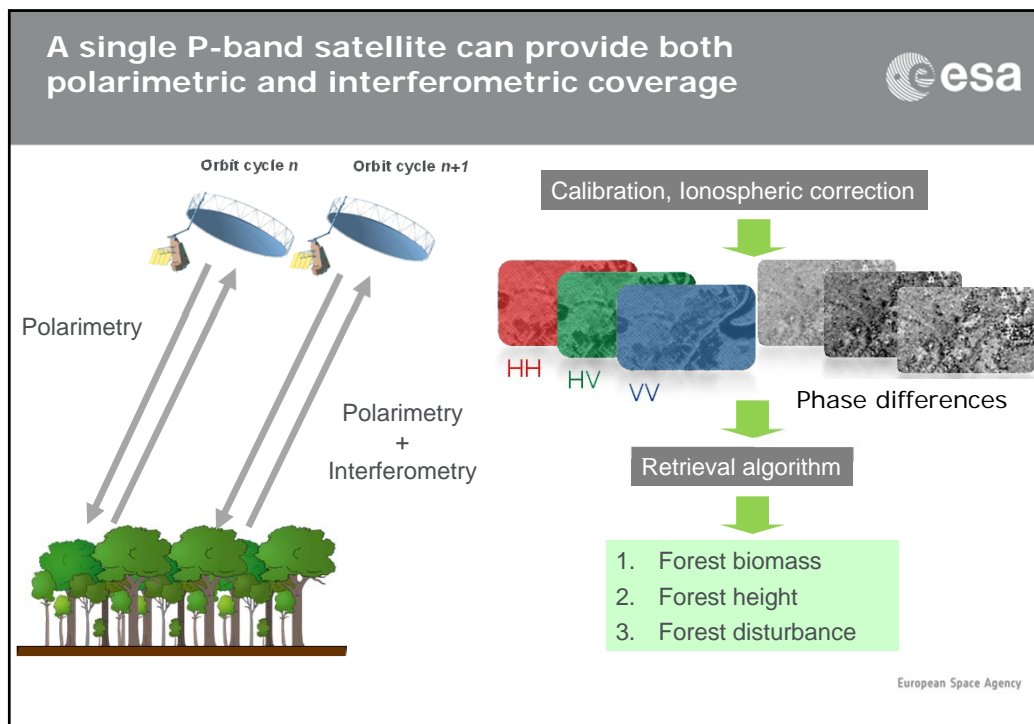
BIOMASS Science Objectives




BIOMASS aims to observe forests biomass and height globally for a better understanding of the carbon cycle to




1. Improve current estimates of forest carbon stocks
2. Reduce uncertainty in deforestation emissions to a level comparable to uncertainty in net ocean flux
3. Improve estimates of terrestrial carbon sinks from regrowth and reforestation

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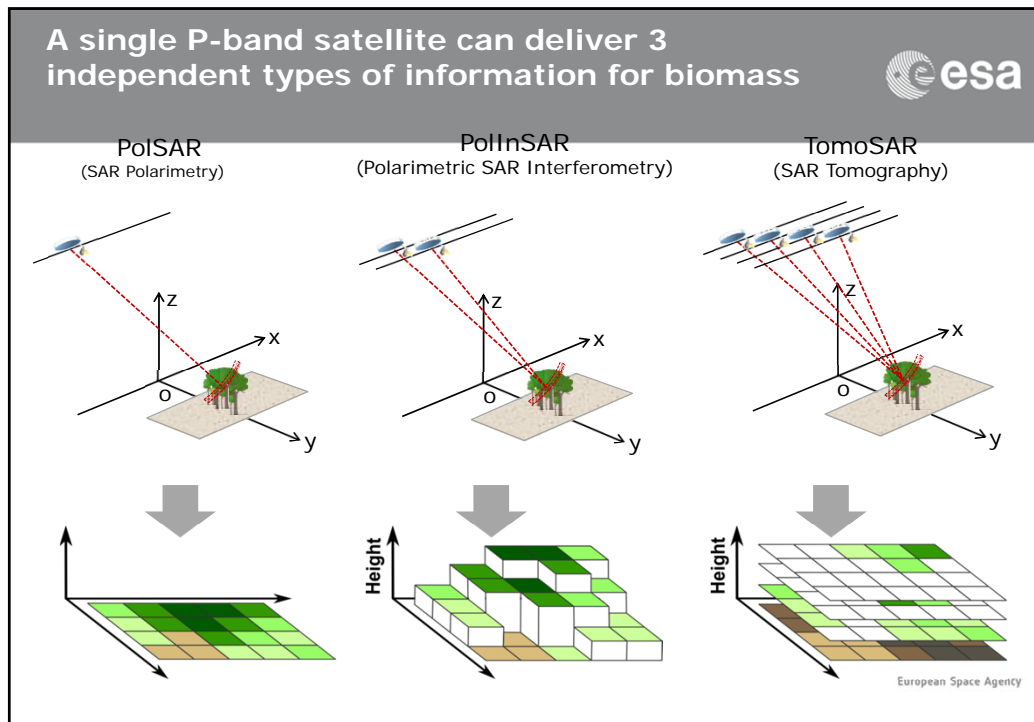
Biomass product requirements



 <p>Forest biomass</p>	 <p>Forest height</p>	 <p>Disturbances</p>
<p>Above-ground biomass (tons / hectare)</p>	<p>Upper canopy height (meter)</p>	<p>Areas of forest clearing (hectare)</p>
<ul style="list-style-type: none"> • 200 m resolution • 1 map every 6 months for 4 years • global coverage of forested areas • accuracy of 20%, or 10 t ha⁻¹ for biomass < 50 t ha⁻¹ 	<ul style="list-style-type: none"> • 200 m resolution • 1 map every 6 months for 4 years • global coverage of forested areas • accuracy of 20-30% 	<ul style="list-style-type: none"> • 50 m resolution • 1 map every 6 months for 4 years • global coverage of forested areas • 90% classification accuracy

Urgently required for IPCC, UNFCCC, REDD, national forest planning

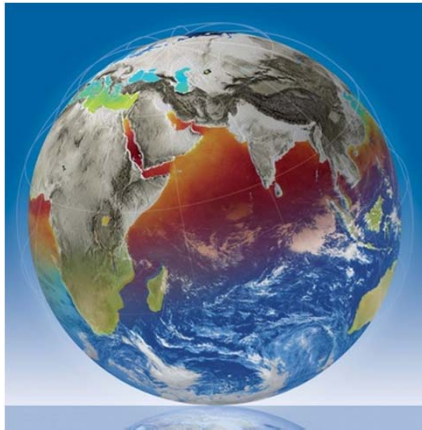




ESA, together with the science community, selects the next Earth Explorer missions



- Phase A/B1 studies for two **Earth Explorer 8** candidate missions have been kicked off.



- **FLEX:** to provide global maps of vegetation fluorescence, which can be converted into an indicator of photosynthetic activity -> to improve our understanding of how much carbon is stored in plants and their role in the carbon and water cycles
- **CarbonSat:** to quantify and monitor the distribution of carbon dioxide and methane -> for a better understanding of the sources and sinks of these two gases and how they are linked to climate change.

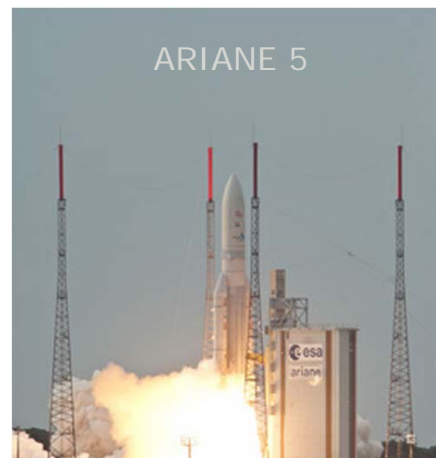
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ESA Earth Observation Programme | p. 53

OVERVIEW



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Global Monitoring for Environment and Security



6 –THE SENTINELS



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What is Copernicus?



Space
Component



In-Situ
Component



Services
Component

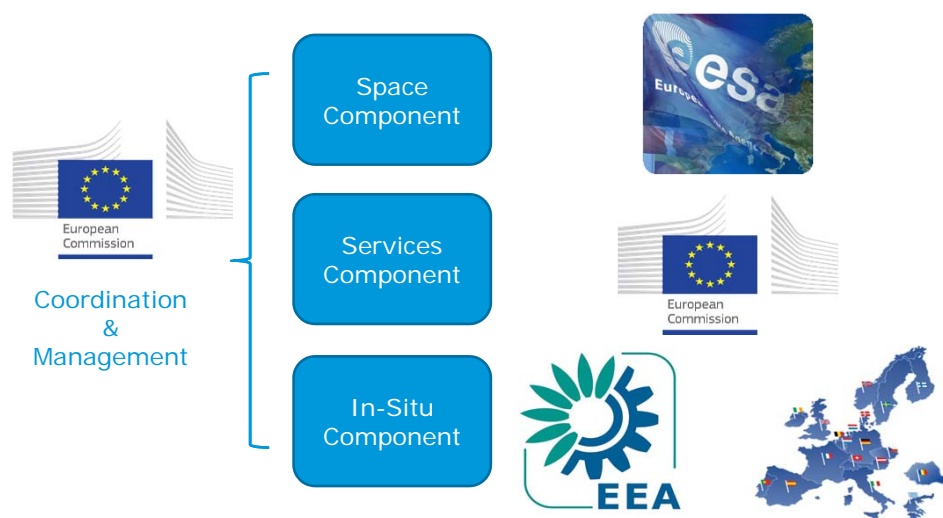
56

Copernicus Services Component



57

Competences



58

Copernicus Space Component - Status



S1A/B: Radar Mission; Launch S1A beginning 2014/end 2015



S2A/B: High Resolution Optical Mission; Launch 2014/2016



S3A/B: Medium Resolution Imaging and Altimetry Mission; Launch 2014/2017



S4A/B: Geostationary Atmospheric Chemistry Mission; Launch 2019/2027



S5P: Low Earth Orbit Atmospheric Chemistry Mission; Launch 2015



S5A/B: Low Earth Orbit Atmospheric Chemistry Mission; Launch 2020/2027



Jason-CS: Altimetry Mission; Launch beginning 2019/2025



59

Sentinel-1 Mission Highlights



C-band SAR Mission



Launch : January 2014

Applications:

- monitoring sea ice zones and the arctic environment
- surveillance of marine environment
- monitoring land surface motion risks
- mapping in support of humanitarian aid in crisis situations

4 nominal operation modes:

High Bit Rate Modes

- strip map (80 km swath, 5X5 m res.)
- interferometric wide swath (250 km swath, 20X5 m res.)
- extra wide swath (400 km swath, 25X100 m res.)

Low Bit Rate Mode

- Wave (5X5 m res.)

Duty Cycle: 25 min in HR mode per orbit in HBR mode & rest of the orbit in LBR

Sun synchronous orbit at 693 Km mean altitude

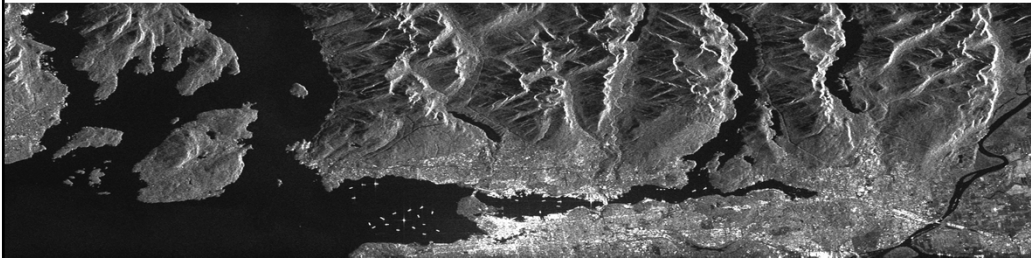
12 days repeat cycle

7 years design life time, consumables for 12 years

7/23/2013

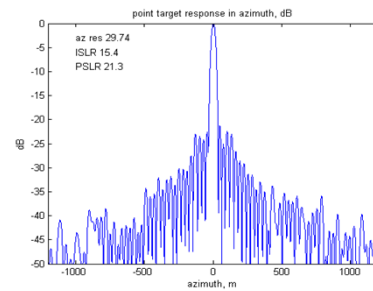
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Sentinel 1 simulated products First Radarsat 2 image in TOPS

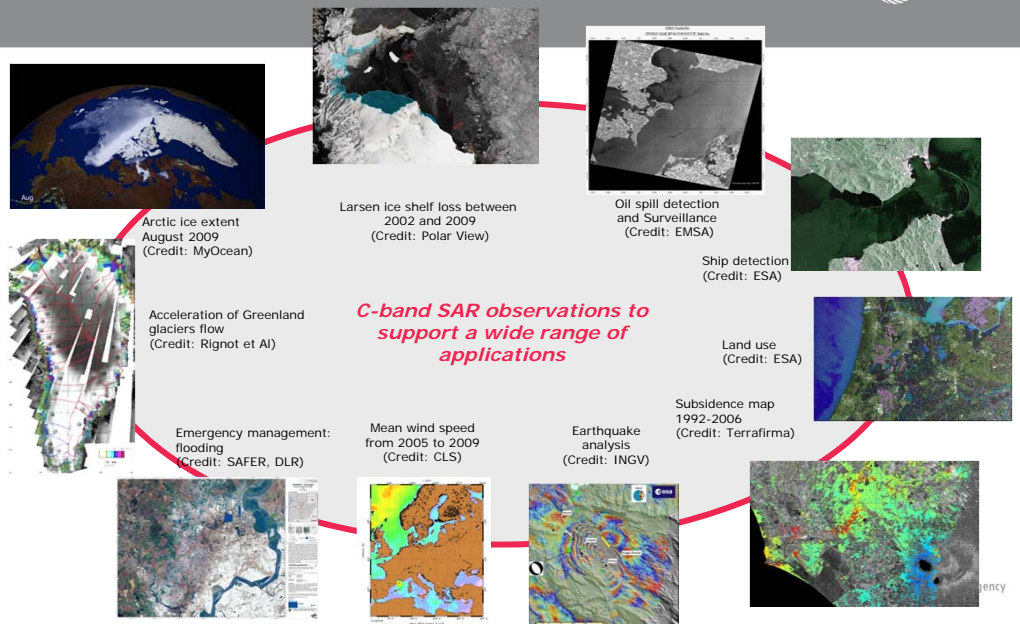


The first RADARSAT-2 TOPS mode over
Vancouver. (courtesy Radarsat 2 / MDA ,P. LIM)

point target analysis of a
bright point around the
airport



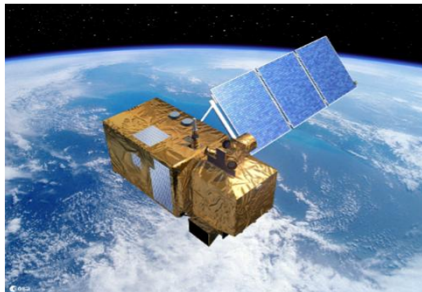
A wide range of applications



Sentinel-2 Mission Highlights



Super-spectral Imaging Mission



Launch : Q3 2014

Applications:

- Generic land cover maps
- Risk mapping and fast images for disaster relief
- generation of leaf coverage, leaf chlorophyll content and leaf water content

Push-broom filter based multi spectral imager
with 13 spectral bands (VNIR & SWIR)

Spatial resolution: 10, 20 and 60 m

Field of view: 290 km

2 x 280Mbps concurrent channels
~18 min downlink required per orbit for data playback

5 days repeat cycle (in twin spacecraft configuration)

Sun synchronous orbit at 786 km mean altitude

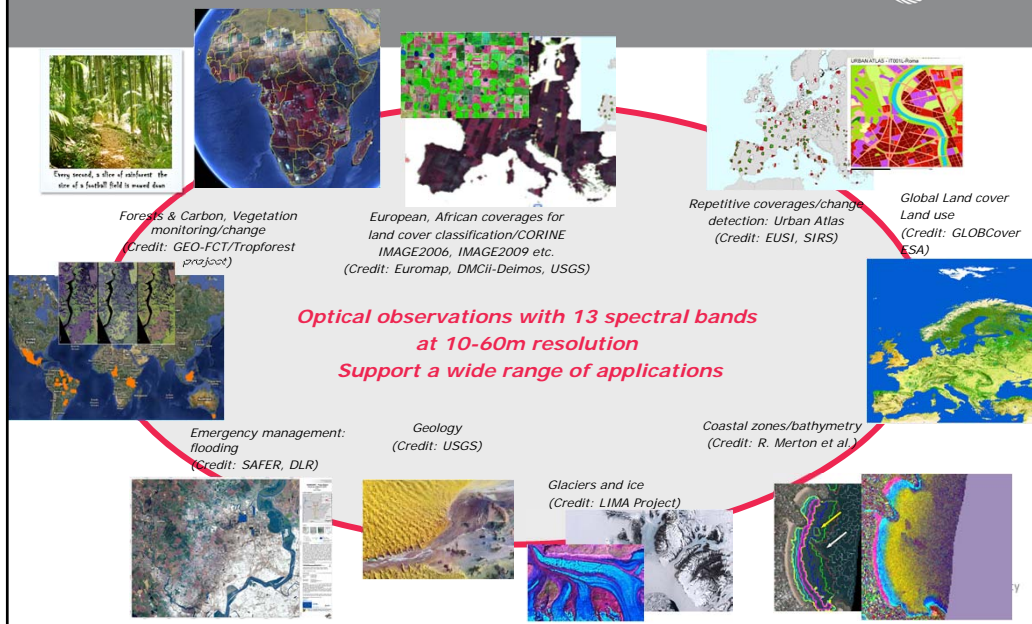
7 years design life time, consumables for 12 years

7/23/2013

Sentinels EOP-GG reference slides

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A variety of applications will be served by S2



Sentinel-3 Mission Highlights



Launch : Q4 2014

Applications:

- Sea/land colour data and surface temperature
- sea surface and land ice topography
- coastal zones, inland water and sea ice topography
- vegetation products

1198 kg spacecraft mass

Sun synchronous orbit at 814.5 km mean altitude over geoid

27 days repeat cycle

7 years design life time, consumables for 12 years

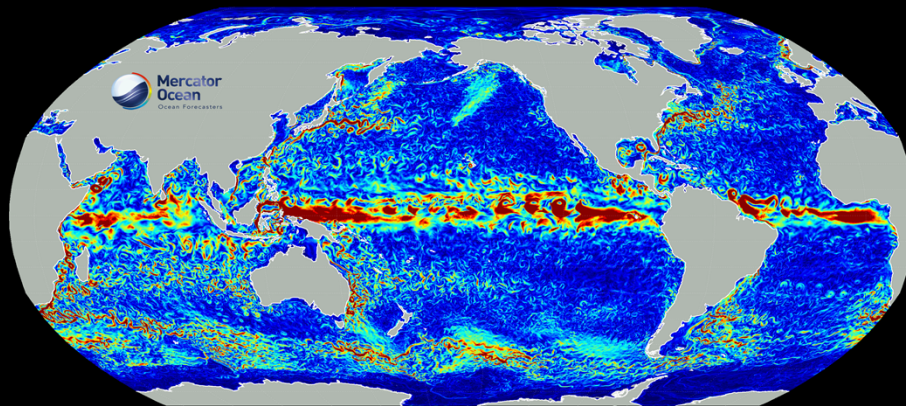
7/23/2013

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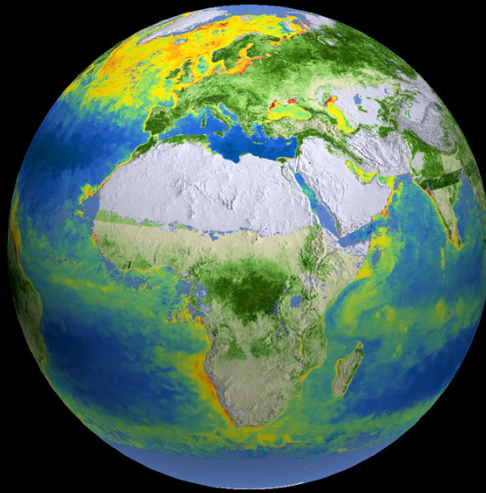
Sentinel-3 Applications



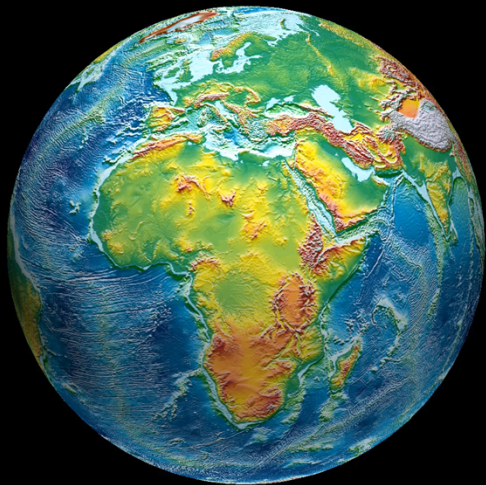
○ Mercator Global 1/12 Nov 2011 (6 day forecast) Surface Velocity m/s



Chlorophyll and Vegetation




Global Topography and Bathymetry






CCI objectives



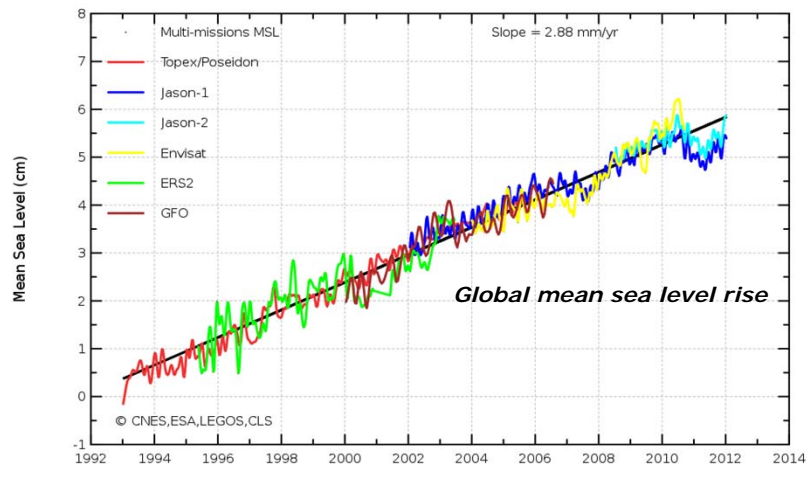
Realize the full potential of the long-term global EO archives that ESA, together with its Member states, has established over the last thirty years.....

..... as a significant and timely contribution to the ECV databases required by the United Nations Framework Convention on Climate Change



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Radar Altimeter: Monitoring Global Mean Sea Level

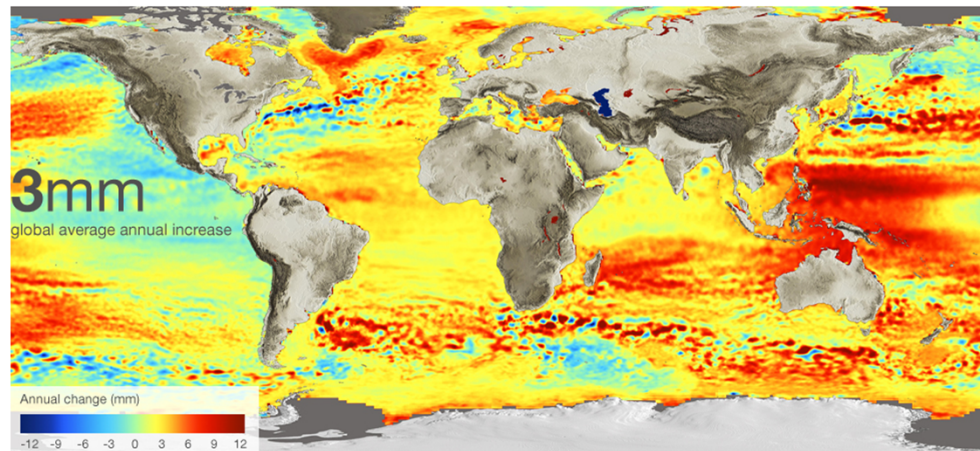


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Monitoring Global Sea Level Trend



Annual average sea-level rise, 1993-2010



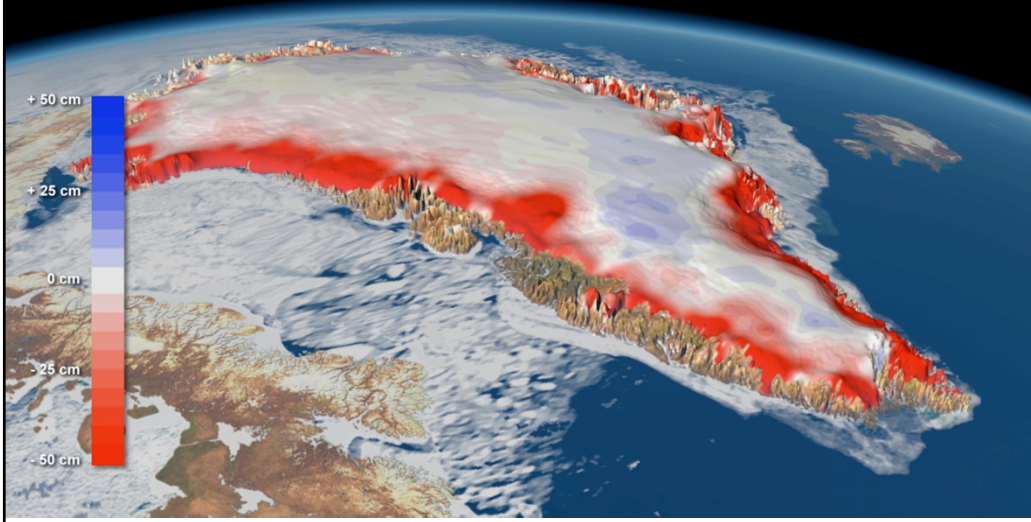
<http://www.bbc.co.uk/news/science-environment-19702450>

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IMBIE



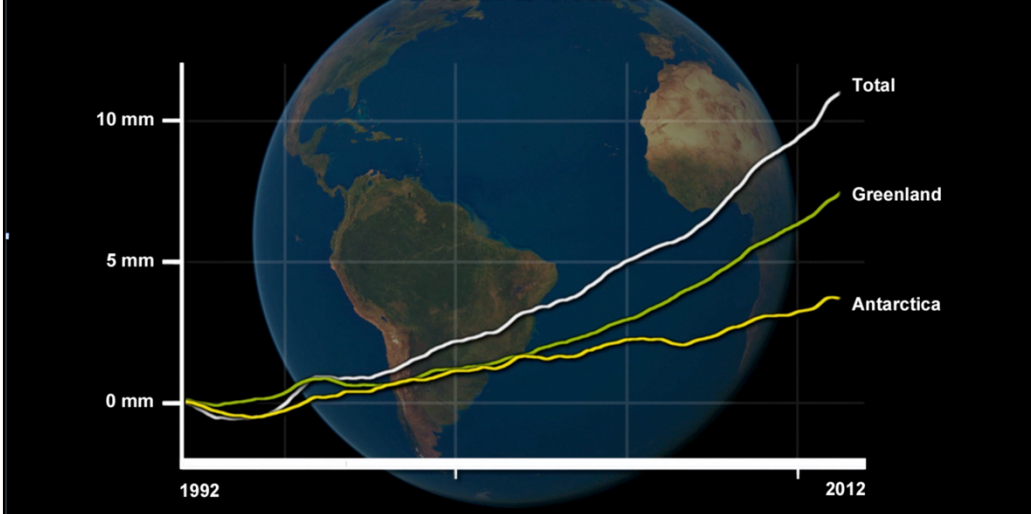
Change in Ice Sheet Thickness Per Year



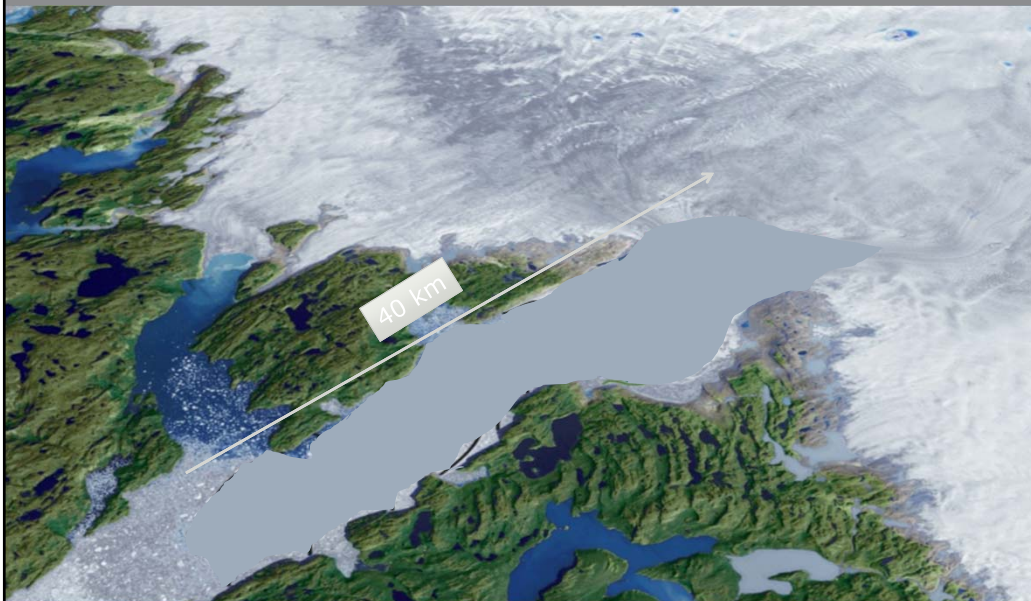
IMBIE



Total Ice Sheet Contribution to Global Sea Level



Jacobshaven glacier 1851 – 2009
Greenland's largest outlet glacier



GCOS ECV and Sentinels



ECV	S-1	S-2	S-3 (Opt/Topo)	S-4	S-5P	S-5
Cloud						
Ozone						
Aerosol						
GHG						
Sea Ice						
Sea Level						
SST						
Ocean Colour						
Glaciers						
Land Cover						
Fire						
Soil Moisture						
Ice Sheets						

in Space Agency

Upcoming Events





living planet symposium


EDINBURGH
09.13 september

2013

FIRST ANNOUNCEMENT AND CALL FOR PAPER

European Space Agency

European Space Agency



THANKS

Yves-Louis.Desnos@esa.int
European Space Agency ESRIN

