

The European Space Agency Earth Observation missions

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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



1- THE EUROPEAN SPACE AGENCY

www.esa.int

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 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 ESA Earth Observation missions | 9/2013 (Pag. 5)



2- EARTH OBSERVATION



esa

→ THE ESA EARTH OBSERVATION PROGRAMME



Meteorological Missions driven

mainly by Weather forecasting and Climate monitoring needs. These missions developed in partnership with EUMETSAT indude the Meteorological Operational satellite programme (MetOp), forming the space segment of EUMETSAT's Polar System (EPS), and the new generation of Geostationary Meteosat satellites (MSG & MTG satellites). GMES Sentinel Missions driven by Users needs to contribute to the European Global Monitoring of Environment & Security (GMES) initiative. These satellite missions developed in partnership with the EC include C-band imaging radar (Sentinel-1), high-resolution optical (Sentinel-2), optical and infrared radiometer (Sentinel-3) and atmospheric composition monitoring capability (Sentinel-4 & Sentinel-5 on board Met missions MTG and EPS-SG respectively).

Earth Watch

Earth Explorer Missions driven by Scientific needs to advance our understanding of how the ocean, atmosphere, hydrosphere, cryosphere and Earth's interior operate and interact as part of an interconnected system. These Research missions, exploiting Europe's excellence in technological innovation, pave the way towards new development of future EO applications.



3 – ERS-1 and ERS-2 missions



European Space Agency

SAR interferometry: the Breathing of ETNA





Terrain displacement of Mount Etna [ERS-2 data - 1992-2000] © ESA, JPL CCBC 20 years of ers

DRAGON Forest cover and biomass maps for South China courtesy Prof. C Schmullius Univ. Jena & Prof. LI Zengyuan CAF

Forest Cover ERS InSAR ILU



Forest Biomass ERS SAR coherence



SCATTEROMETER: SOIL WATER INDEX

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20 years of ers



Wide Area Product (WAP) for Greece

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The future of ESA's Terrafirma project (<u>www.terrafirma.eu.com</u>), a Pan-European ground motion hazard information service.

20 years of ers

-10 [mm/year] 10

Cesa 20 years of ers

European Space Agency

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.



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4 – ENVISAT



ENVISAT mission: 10 years

Iceland

L'Aquila

2010



and many workshops dedicated to specific Envisat user communities

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 Icemonitoring



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) staring from Jan 2011. Increased seismic activity and gas emissions inside th.e 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

GLOBCOVER: NEW PORTRAIT OF EARTH SHOWS LAND COVER AS NEVER BEFORE





→ GLOBCOVER 2009 | MERIS 300m

Multi-Mission Sea Surface Temperature



(ESA Medspiration project)

ODYSSEA / 2011-12-15



SWELL PROPAGATION (CLS-Brest)





Evolution of Ground Displacements (2011-2012)





Rift Valley Dynamic from INSAR Univ of Bristol)





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





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

esa

Water Surface Velocity

SMOS – The ESA water mission



In space since 2 November 2009

Applications:

First <u>global</u> 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

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

CryoSat-2 – ESA's ice mission





CryoSat



Primary Mission Goals:

- Determination of regional and basinscale 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.







SAR Altimeter vs classical altimeter Norwegian Sea: SSH accuracy (July 2010-Feb 2011)





Factor of ~1.5 improvement of Cryosat-2 SAR versus Jason-2 LRM

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

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.



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 space Agency reforestation

A single P-band satellite can provide both polarimetric and interferometric coverage





Biomass product requirements



<image/> <text></text>	Forest height Upper canopy height (meter)	<image/> <text></text>
 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 	 200 m resolution 1 map every 6 months for 4 years global coverage of forested areas accuracy of 20-30% 	 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

A single P-band satellite can deliver 3 independent types of information for biomass





5 – EARTH EXPLORERS IN SELECTION



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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Global Monitoring for Environment and Security



6 -THE SENTINELS

opernicus

What is Copernicus?







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Copernicus Services Component







Competences







Copernicus Space Component -Status





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

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





Arctic ice extent August 2009 (Credit: MyOcean)



Larsen ice shelf loss between 2002 and 2009 (Credit: Polar View)

support a wide range of

applications



Oil spill detection and Surveillance (Credit: EMSA)

Ship detection (Credit: ESA)



Land use

(Credit: ESA)



Emergency management: flooding Credit: SAFER, DLR)



Mean wind speed from 2005 to 2009 (Credit: CLS)





Subsidence map 1992-2006 (Credit: Terrafirma)





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

A variety of applications will be served by S2



URBAN ATLAS - IT001L-Roma



every second, a slice of rainforest the size of a football field is moved down



Forests & Carbon, Vegetation monitoring/change Credit: GEO-FCT/Tropforest project)



European, African coverages for land cover classification/CORINE IMAGE2006, IMAGE2009 etc. (Credit: Euromap, DMCii-Deimos, USGS)

Optical observations with 13 spectral bands at 10-60m resolution Support a wide range of applications

Emergency management: flooding Credit: SAFER, DLR)



Geology (Credit: USGS)





Repetitive coverages/change detection: Urban Atlas (Credit: EUSI, SIRS)

Global Land cover Land use (Credit: GLOBCover ESA)



Coastal zones/bathymetry

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

Sentinel-3 Applications



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





Chlorophyl and Vegetation





Global Topography and Bathymetry







7 – The ESA Climate Change Initiative







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







Mean Sea Level (cm)



Annual average sea-level rise, 1993-2010



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

IMBIE



INSTE ON

Change in Ice Sheet Thickness Per Year



- 50 cm

IMBIE





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						



Se m scientific exploitation of operational missions

ACTION LINES



Research and Development Studes

Scientific Toolboxes development

Science Users Consultations

Training Next Generation of Earth Observation Scientists

Promoting Science Data use and Results Launching state-of-the-art R&D studies for scientific exploitation of operational missions

Developing, validating and maintaining open-source, multi-mission, scientific software toolboxes

Organising a series of regular international thematic workshops for science users consultation and gathering science users feedback

Offering a multi-year programme of advanced international training courses, summer schools and educational materials

Promoting scientific use of data and ensuring a responsive ESA channel for regular, timely, highquality scientific publications



living planet symposium 2013

EDINBURGH INTERNATIONA

European Space Agency

living planet symposium 2013






living planet symposium 2013

European Space Agency

The *size and diversity of the ESA Earth Observation programme* is reflected in the *Living Planet 2013 Symposium*:

- ✓ Record number of participants:
 → 1700 participants
- ✓ Numerous themes, covering both science and applications:
 - \rightarrow 9 parallel sessions over 5 days
 - → 740 oral presentations
 - → 920 poster presentations

✓ Significant presence of *our partners*:
 → ESA Member States, in particular
 UK Space Agency

- → European Commission
- → Industry exhibitors

Oceanography



Ocean Circulation Sea Level & Dynamic Topography Wind and Wave/Sea State Modelling Ocean Colour Sea Surface Temperature Sea Surface Salinity Coastal Zones Oil Spills/Ship Detection

Climate and Meteorology



Climatology Carbon Cycle Water Cycle (rainfall, evapotranspiration) Sea-Land-Atmosphere Interaction

Interaction Near Earth Environment Land



Magnetic Field (core, lithosphere, ionosphere, magnetosphere) Electric field and current systems, plasma studies Thermospheric density and high-latitude winds



Gravity field

Geodynamics

Height Systems

Mass transport

Cryosphere

Glaciology

Permafrost

Snow

Lithosphere and mantle

extent Landslides Subsidence Earthquakes Volcanoes Floods Fires Hurricanes

Land applications



Soil Moisture Land Cover and Land Use Agriculture Forestry Wetland Urban areas Geology and Geomorphology Global Vegetation and Biogeophysical Products Inland Waters (resources, runoff, aquifer, quality, level) Albedo



Products

Methodologies and

Calibration and Validation Results New Products and Algorithms Orbit Determination Data Assimilation Interferometry Polarimetry Tomography Atmospheric Corrections Data Visualisation

Solid Earth/Geodesy Atmosphere



Troposphere/Air Quality Greenhouse Gases Stratosphere Upper Atmosphere Clouds/Aerosols Atmospheric Applications

Hazards



A large effort for **attracting students**:

- ✓ Grants from EU and ESA financially support the attendance of 90 European students at the symposium
- ✓ School Lab for 105 students aged 16-18 and 90 educators from the UK, organised in cooperation with UK Space Agency and German Space Agency (DLR)
- ✓ Tutorials by European lead scientists this morning with 500+ participants



The ESA **User Satisfaction Survey**, regularly performed by the ESA EO User Services, this year with the support of a Romanian company (ACRS) → special emphasis on Earth Explorers data users



living planet symposium 2013

European Space Agency

Tools for symposium participants:✓ **Ips application** for Iphone/Ipad



Poster QR code for Android & Iphone:

→ Extended contents on poster



The excellent collaboration for the Symposium organisation with the UK Space Agency



European Space Agency





THANKS

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