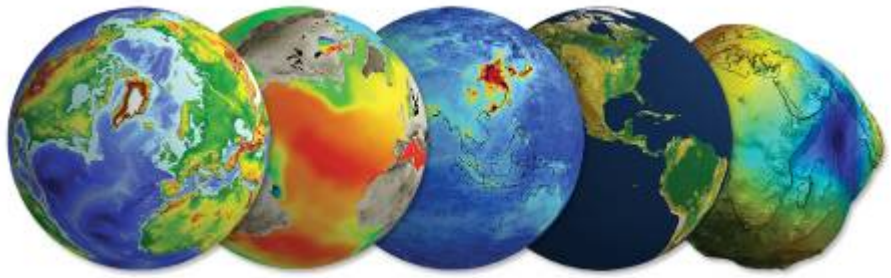
EOEP REVIEW SEMINAR

Ground Segment Management and Mission Operations

15-16 June 2011



CONTENT

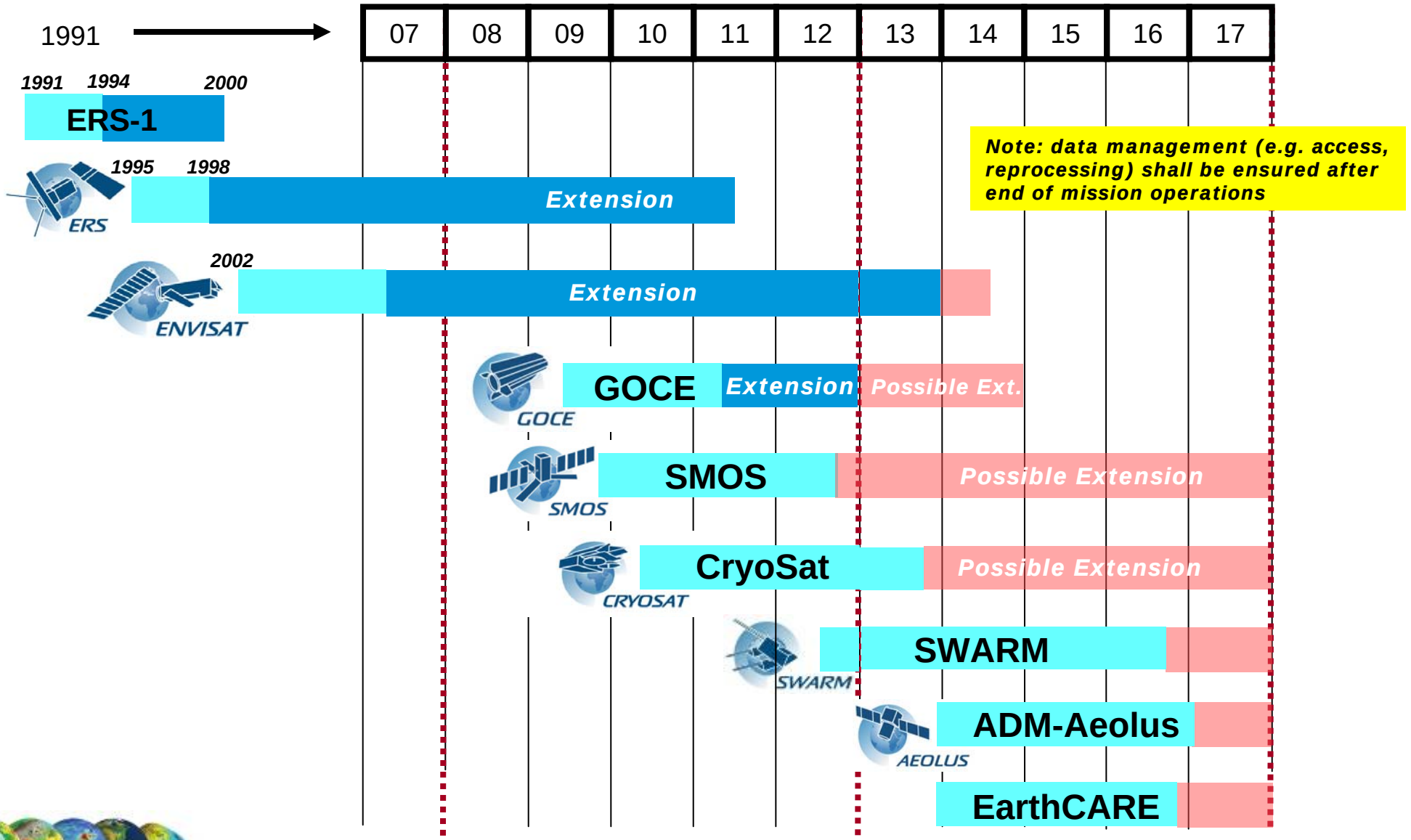
1. **What this presentation covers**

    i. Missions in operations in EOEP-3
    ii. The supporting ESA operations concept

2. **Points that will be addressed**

    i. Fulfilment of mission requirements & high quality scientific output
    ii. Operations concept supporting running of EO missions and enabling their scientific exploitation, in orbit and off-line
        – Multi-Mission Ground Segment approach: Cooperation with ESA member states and competiveness of European industry
        – Ensuring provision of high quality data
        – EO data access
        – Supporting evolving scientific and operational requirements
    iii. Standardisation and harmonisation in the international context and mechanisms for implementation in ESA
    iv. Long-term approach for data continuity, availability and preservation

FOCUS OF THIS PRESENTATION:
1. MISSIONS IN OPERATIONS IN EOEP-3

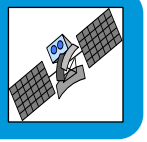


FOCUS OF THIS PRESENTATION:
2. SUPPORTING ESA OPERATIONS CONCEPT

Functionalities to be covered

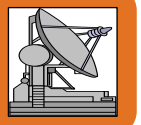
Mission Management and User Consultation

Satellite Control Payload Operations and Programming

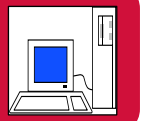


Plan Data Acquisition

Receive Satellite Data



Process and Archive Satellite Data Products Quality Assurance



Disseminate Data Products User Interface and Support Services

The mission operations are based on a multi-functional ground segment: a unified structure, developed to meet the user requirements of ESA and Third Party missions, both individually and collectively by:

- **Integrating national capabilities and facilities into a common European framework**
- **Providing benefits to Member States through access to ESA technology and systems**
- **Responding to increasing data volumes and evolving requirements for more sophisticated products**
- **Ensuring the highest quality of Earth Observation data products**
- **Facilitating data access to stimulate applications development, science and downstream industry**

PROGRAMMATIC FUNDING …

… available in EOEP-3 [2008-2012] by:

1. ***Earth Explorer component***: nominal Phase E period (~ 2.5 years)
2. ***Continuity of Missions***: Phase E beyond nominal lifetime (ERS-2, Envisat, GOCE) and CryoSat
3. ***Ground segment evolution and operations***: support science with appropriate ground segment infrastructure
4. ***Level 2 Element***: support development of higher level products and validation activities for Earth Explorer missions in development and in operations

   In addition, Envisat mission operations were co-funded through a dedicated Envisat funding line

Further support is available from:

5. ***EARTHNET:*** *Third party missions, generic ground segment elements and international presence*
6. ***LDTP:*** *long-term data preservation*

POINTS THAT WILL BE ADDRESSED

1. Fulfilment of mission requirements & high quality scientific output
2. Operations concept supporting running of EO missions and enabling their scientific exploitation, in orbit and off-line
   - Multi-Mission Ground Segment approach: Cooperation with ESA member states and competiveness of European industry
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   - EO data access
   - Supporting evolving scientific and operational requirements
3. Standardisation and harmonisation in the international context and mechanisms for implementation in ESA
4. Long-term approach for data continuity, availability and preservation

SCIENTIFIC EXCELLENCE
GOCE: ESA'S GRAVITY MISSION

1. GOCE has strongly improved our knowledge about the Earth's gravity field at medium to high spatial resolution.

2. The geoids derived from the first 6 months of data, in combination with a state-of-the-art altimetric mean sea surface, provide the sharpest-ever view on ocean dynamic topography and current systems at spatial scales 400 km and smaller

3. Gravity anomalies from GOCE are showing strong correlation with areas of high signal dynamic. GOCE reveals problems with in-situ data in many parts of the world

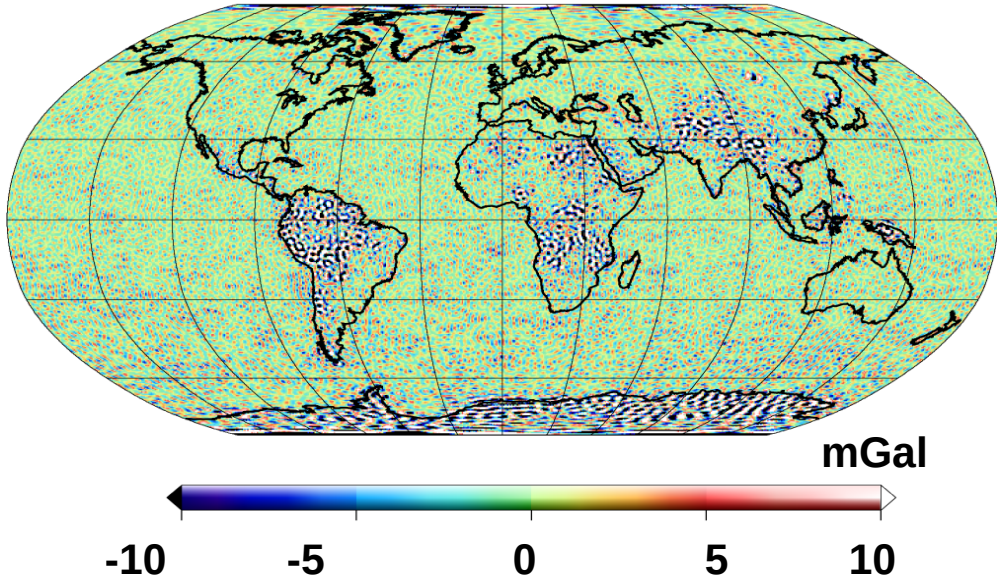
Some facts: Achievements versus mission objectives

4. Mission is well under way to achieve all its mission objectives.

5. 100 km spatial resolution requirement has already been met in full, i.e. GOCE delivers gravity fields (geoid and gravity anomaly functionals) with a spatial resolution 100 km or smaller at SNR > 1

6. Estimated present status:

gravity anomalies: approx. 1.3 mGal vs 1 mGal objective
geoid: approx. 4 cm vs. 1-2 cm objective



GOCE gravity field anomaly differences at 100 km resolution between GOCE and previous state-of-the-art model EGM 2008

Courtesy: GOCE HPF

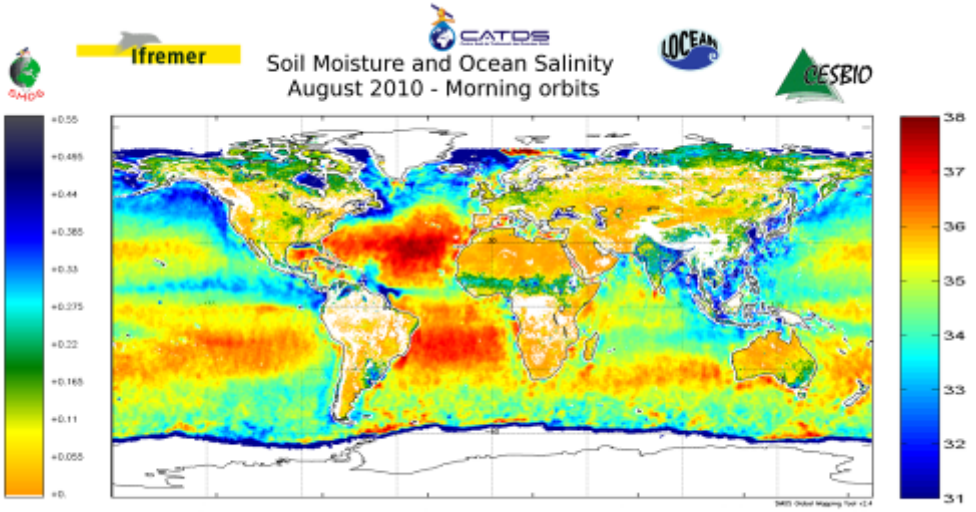
Note: it is difficult to assess and quantify the true quality if the best-ever gravity field measurements from space given the scarcity of validation data of sufficient quality

SCIENTIFIC EXCELLENCE
SMOS: ESA'S WATER MISSION

1. SMOS has provided the first global measurements of two key variables in the Earth's water cycle – soil moisture and ocean salinity

After one year of operations …

2. The SMOS instrument MIRAS has proven to be compliant to the system requirements
3. Level 1 data products: SMOS brightness temperatures observations are in good agreement with ground truth and the instrument model, proving measurement accuracy
4. Promising results have been achieved for soil moisture level 2 data products but mission requirements not yet reached on a global scale (but for individual sites)
5. Global comparisons between SMOS level 2 ocean salinity and in-situ data provide promising results (error 0.4 psu global and in the Tropical Pacific 0.3 psu) but mission requirements of 0.1 psu not yet reached

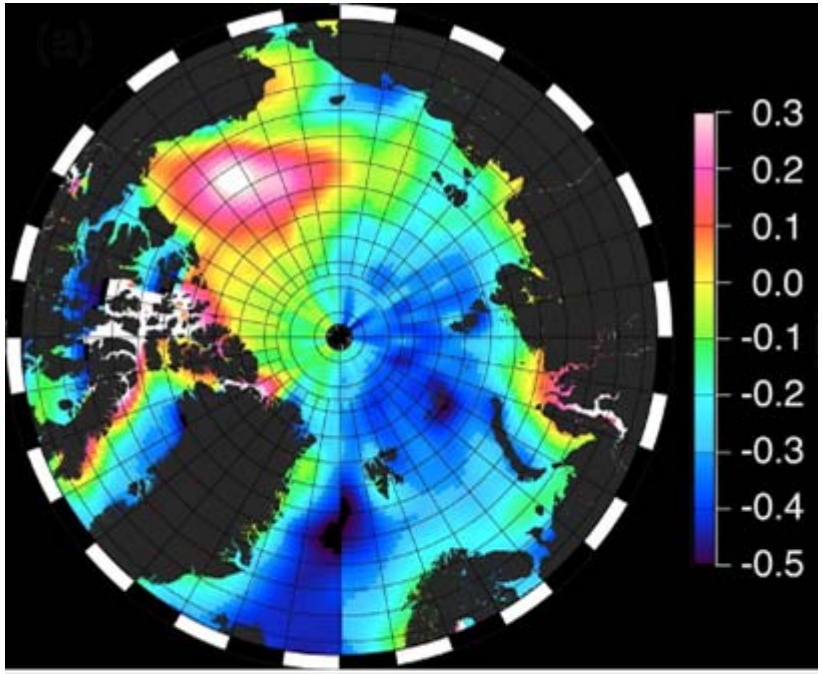


SMOS first global map of soil moisture and ocean salinity, August 2010

© CESBIO, IFREMER, CATDS

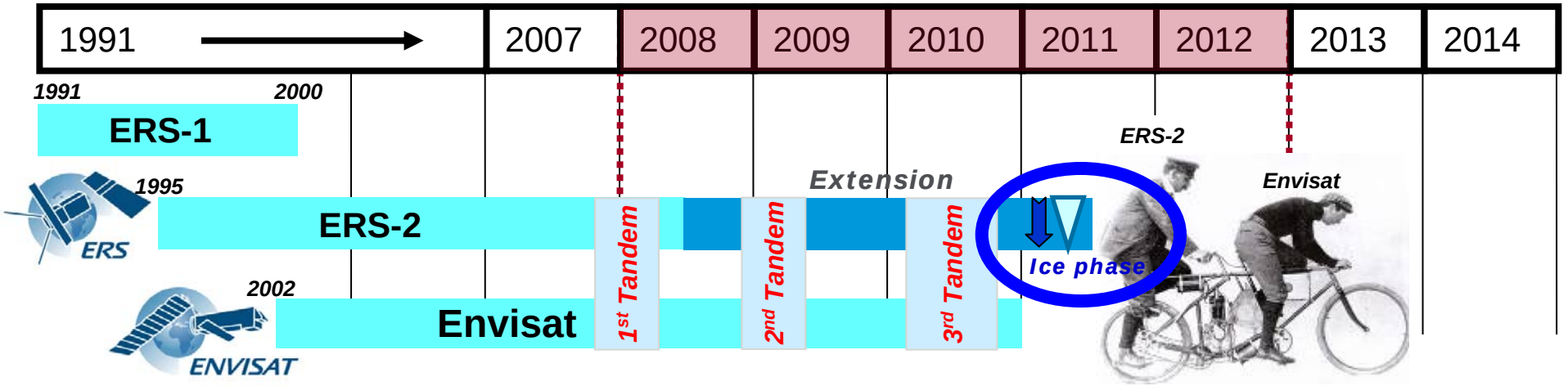
Achievements versus Mission Objectives

- Pre-launch system tests of SIRAL exceeded systems requirements
- SIRAL and DORIS are very stable and exceeding expectations
- Preliminary measurements are confirming the scientific capacity of the SIRAL high-resolution altimeter (250m along-track) not only over sea-ice but also over open oceans. CryoSat is rightly considered the precursor of Sentinel-3
- Preliminary measurements have improved our understanding of the dynamic topography over Arctic regions not reached before by former altimetry missions and started to provide details topography of ice-sheet margins
- Ground systems are constantly delivering 3 GB per day to all registered users. Data available to users only since February 2011
- All mission objectives will be met in full at the end of the first three years of operations when the density of crossovers have reached the required value and the planned in-situ measurements have contributed to bring down the errors.



CryoSat dynamic topography over the Arctic up to 88 degree lat

SCIENTIFIC EXCELLENCE
ERS-2 MISSION



The EOEP-3 proposal included the provision for operating ERS-2 until mid-2008.

However the ERS-2 mission lifetime was ***extended by 3 years*** in 2008 thanks to:

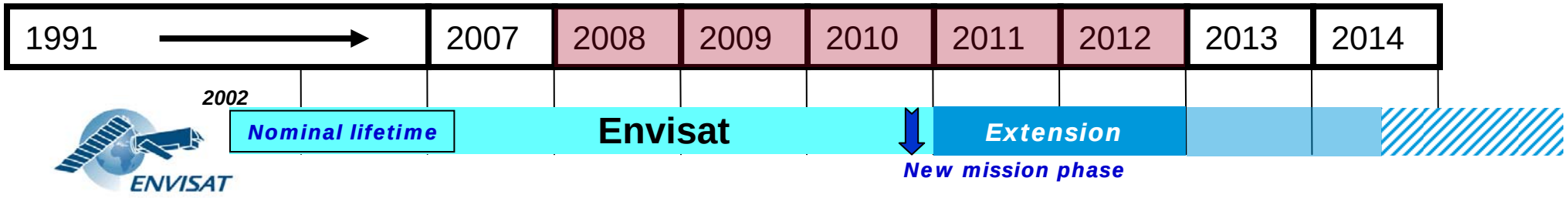
- the flexibility of the Envelope Programme
- the overall satisfactory status of the satellite
- the scientific demand (in particular InSAR) as well as demand for operational application

Amongst the benefits of the ERS-2 mission extension:

- Three ***ERS-2 / Envisat SAR tandem campaigns***, exploiting the synergy between the 2 missions (30 min. time interval on the same orbit) until Envisat orbital change at end 2010

- ***ERS-2 Ice Phase*** (February to May 2011) is a 3-day repeat cycle addressing sea-stream dynamics, ice caps, synergy with CryoSat, tectonics, volcanology, InSAR coherence

After 16 years of operations, ERS-2 mission will complete its prolonged mandate at mid-2011 and will be de-orbited.

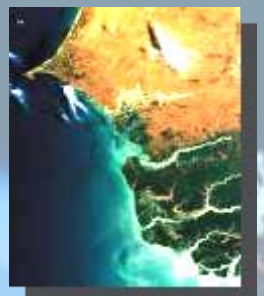


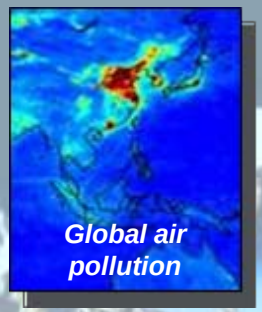
Similarly to ERS-2, the Envisat mission was extended by 3 years in 2010 (2 years extension within EOEP-3) thanks to:

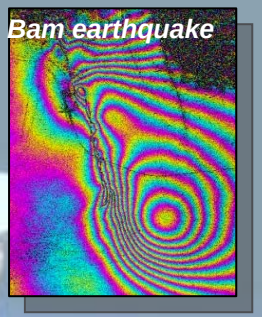
- the very large scientific and operational demand
- the flexibility of the Envelope Programme
- the satisfactory status of the satellite
- the technical possibility to operate the satellite with reduced hydrazine consumption on a different orbit

☐ the extension required a massive mission reconfiguration, including major efforts for maintaining data quality.

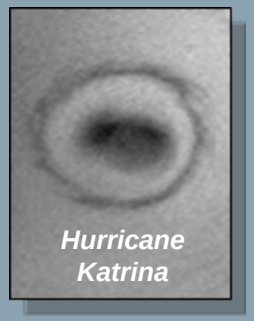
ENVISAT mission: 9 years


First images

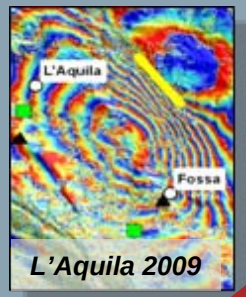

Global air pollution


Bam earthquake


Tectonic uplift (Andaman)

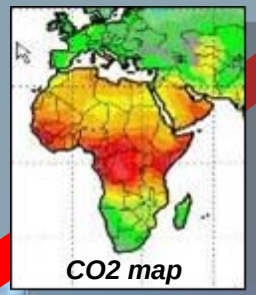

Hurricane Katrina

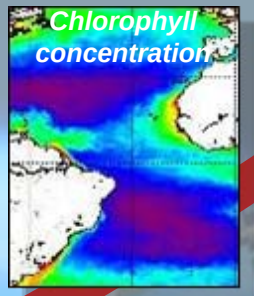

Arctic 2007



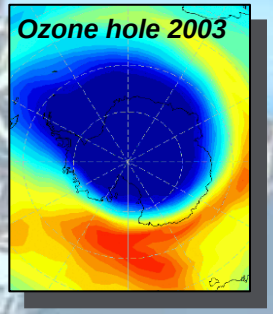
L'Aquila 2009


Iceland 2010


CO2 map


Chlorophyll concentration


B-15A iceberg


Ozone hole 2003


Prestige tanker oil slick

Serving 3000+ scientific projects and many operational users

Launch
Mar 02

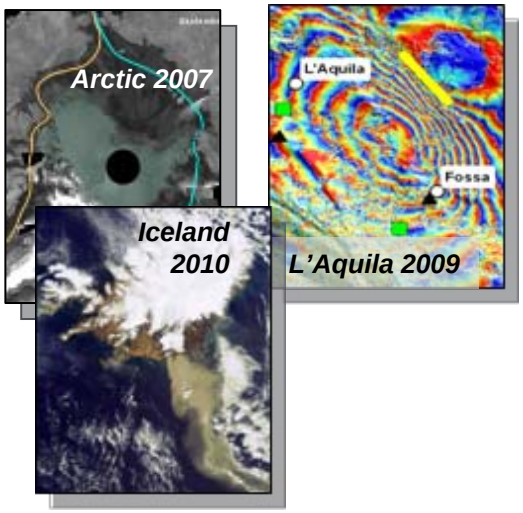
Envisat Symposium
Salzburg (A)
Sep 04

Envisat Symposium
Montreux (CH)
Apr 07

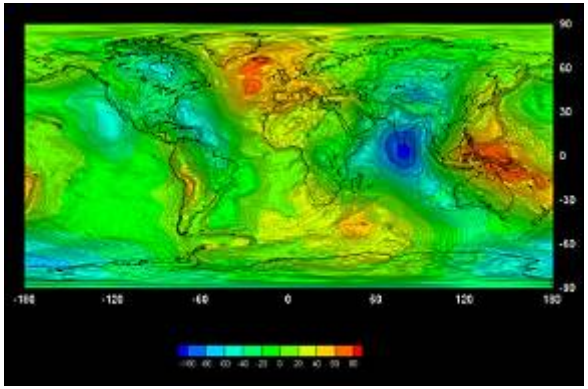
Living Planet Symposium
Bergen (N)
Jun 10

and many workshops dedicated to specific Envisat user communities

LESSONS LEARNT FOR EOEP-4
MISSION EXTENSION



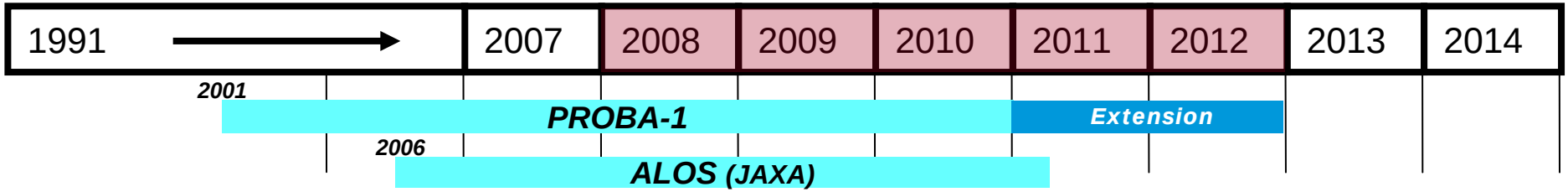
Scientific results from extended ERS and Envisat missions



The first global gravity model based on GOCE satellite data, now extended to end of 2012

1. **Many scientific results based on data from the ERS and Envisat missions have been achieved thanks to the extended mission life time**
2. **Mission extensions have been possible thanks to the flexibility of the EO Envelope Programme, the robustness and reliability of the spacecrafts and instruments and the careful planning of the mission exploitation and operations**
3. **At present a procedure for mission extension is developed by ESA FOR EOEP-4 based on the experience of other space agencies and in discussion with the community**
4. **Points to consider**
   - **a multi-annual horizon for data continuity versus an annual planning, beneficial to users**
   - **a more stable planning horizon for the Agency to anticipate mission extensions in a financial, contractual and technical context**

SCIENTIFIC EXCELLENCE
THIRD PARTY MISSIONS IN EOEP-3: PROBA-1 and ALOS

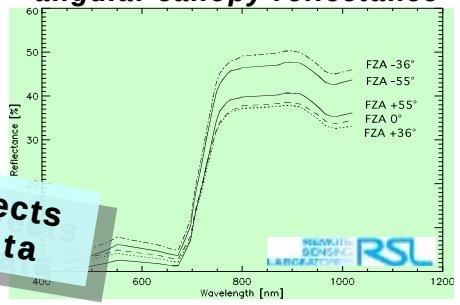


PROBA-1 (ESA)

- Proba-1 was developed as a technology demonstrator mission, then handed over to ESA EOP for operations and scientific exploitation
- CHRIS: Compact High Resolution Imaging Spectrometer is a hyperspectral instrument, collecting BRDF (Bidirectional Reflectance Distribution Function) data for a better understanding of surface reflectances
- Proba-1 has proven to deliver data of high scientific relevance thus supporting the development of a dedicated user community

370 scientific projects using PROBA-1 data

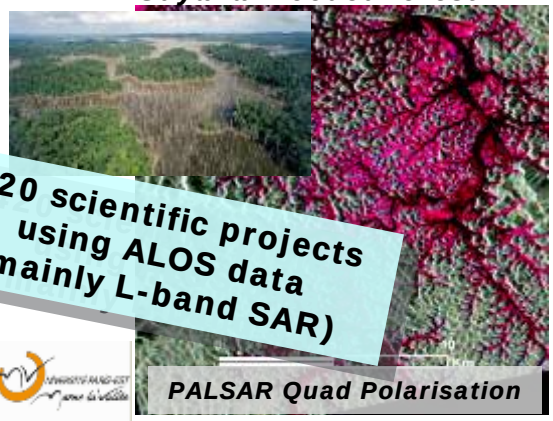
angular canopy reflectance



ALOS (JAXA)

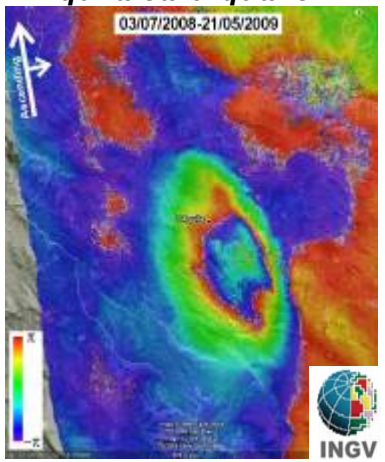
- JAXA multi-sensor satellite: L-band SAR and 2 optical sensors
- ESA operated the ALOS European/African node; mission ended in April 2011
- Many applications: SAR polarimetry and interferometry, forestry, land cover/land use, oceanography, sea ice, ice and glaciers, …

Guyana: flooded forest

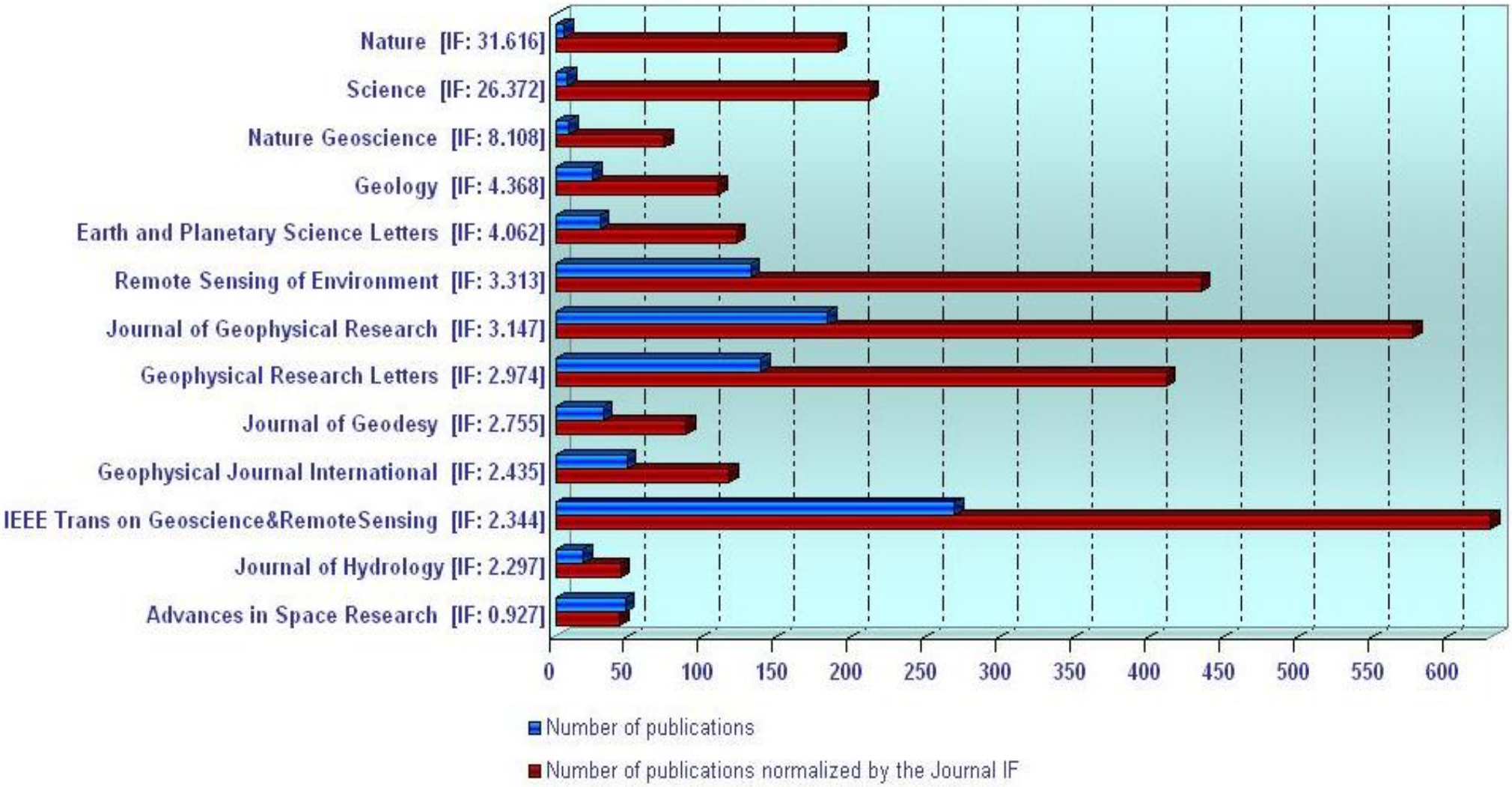


420 scientific projects using ALOS data (mainly L-band SAR)

L'Aquila earthquake

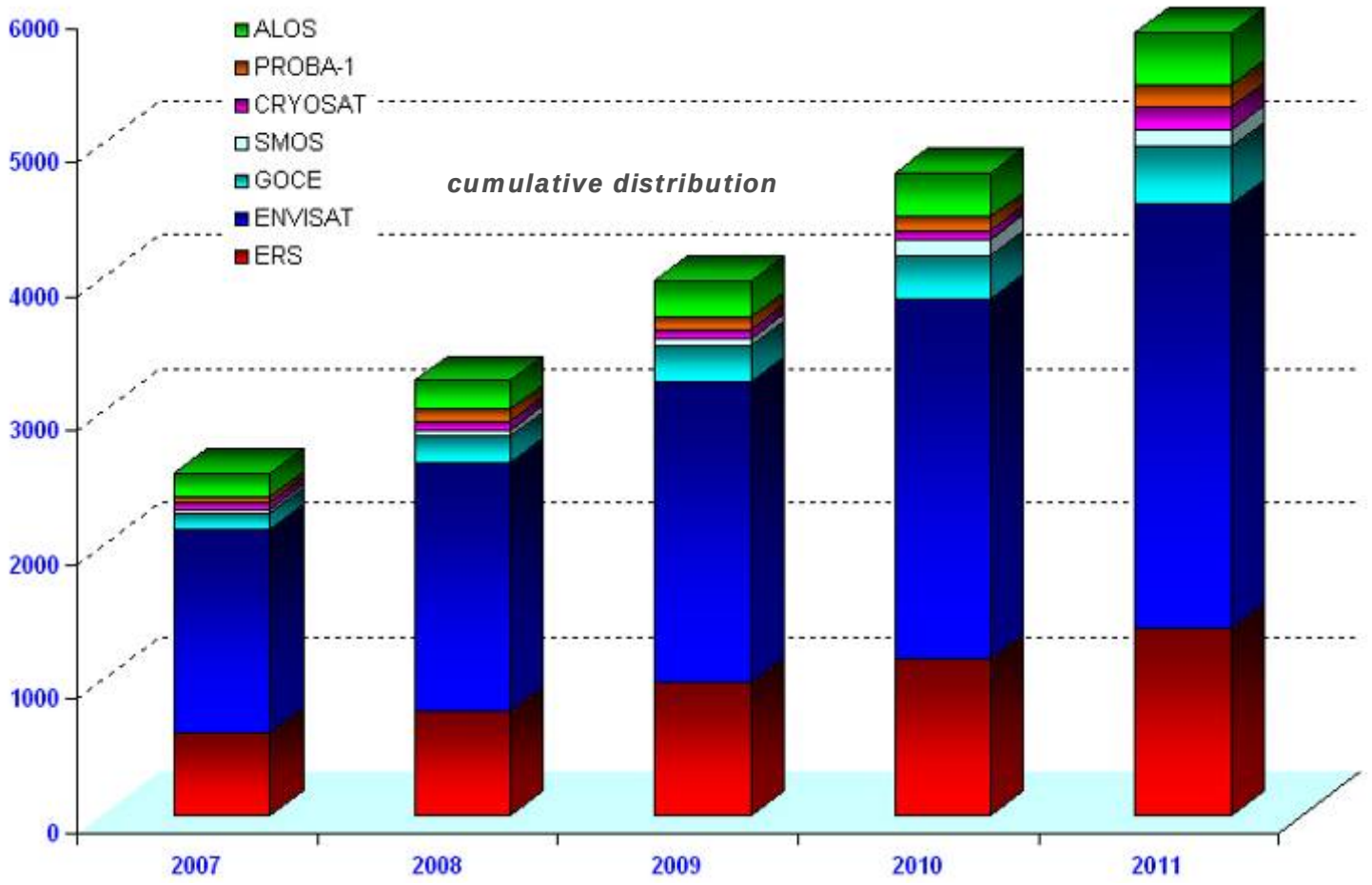


SCIENTIFIC EXCELLENCE
PEER REVIEWED PUBLICATIONS: LAST 4 YEARS

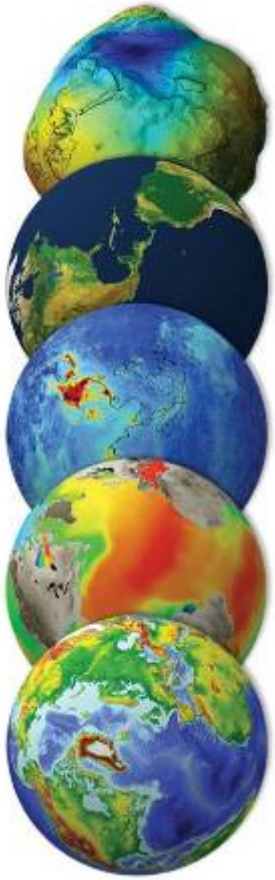


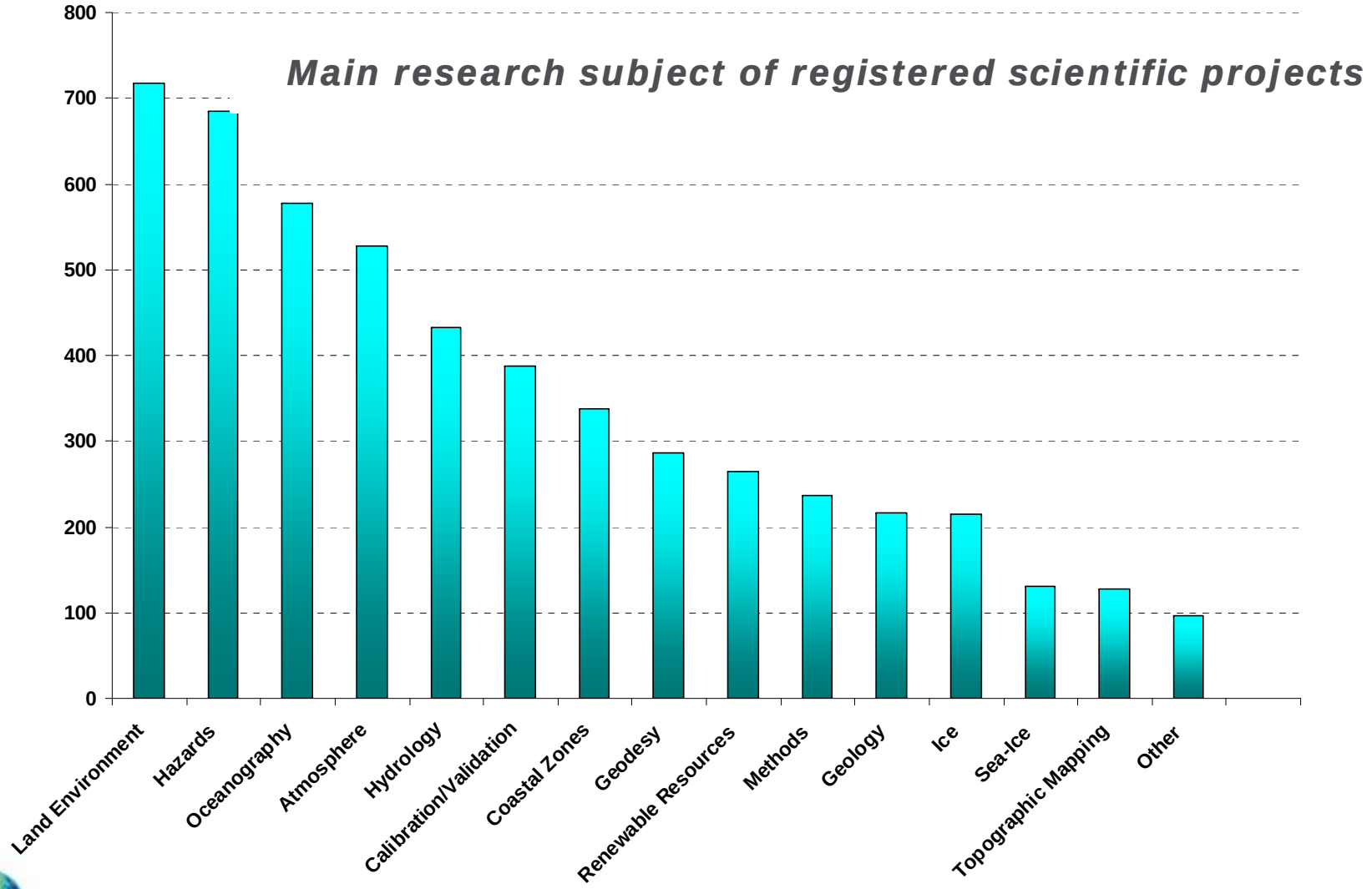
Number of scientific projects registered by ESA

- **There are currently *5000* registered scientific projects (projects use data from several missions)**
- **Scientific projects can be single-user or multi-user**



SCIENTIFIC EXCELLENCE
SCIENTIFIC USERS: HOW MANY & WHERE & WHAT II





POINTS THAT WILL BE ADDRESSED

1. Fulfilment of mission requirements & high quality scientific output
2. Operations concept supporting running of EO missions and enabling their scientific exploitation, in orbit and off-line
   - Multi-Mission Ground Segment approach: Cooperation with ESA member states and competiveness of European industry
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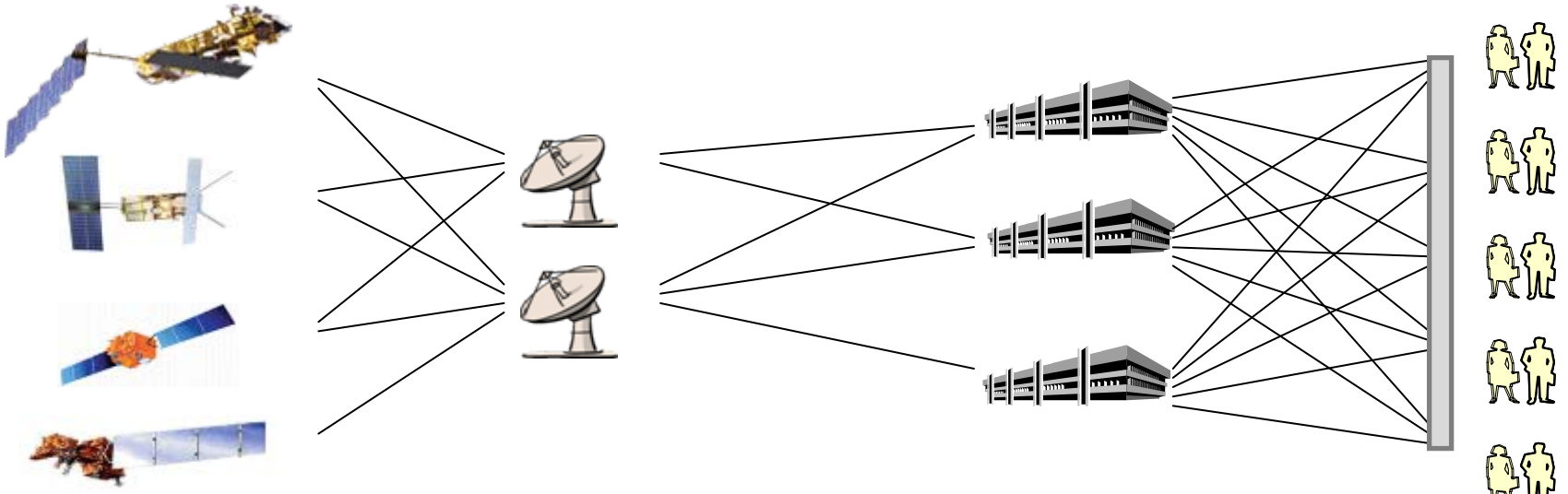
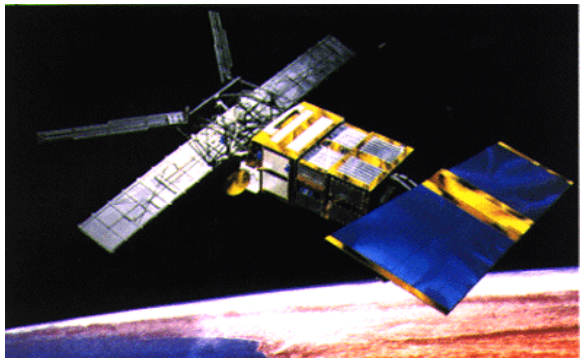
ESA MISSION OPERATIONS CONCEPT
THE ESA MULTI-MISSION GROUND SEGMENT (MMGS): THE PRINCIPLE

1. **Evolution into a single, distributed and shared Ground Segment**
2. **Consist of a network of Centres providing data reception, processing, distribution, data quality control and archiving services to the missions operated by ESA and member states**
   - Reusing Member States' ground segment technology and infrastructure (for acquisition, processing, archiving etc)
   - Developing joint standards and new technologies in collaboration with Member States (through GSCB or CEOS)
   - Supporting spin-off of ESA developed ground segment and user support technology into Member States' national initiatives



Satellites (6 ESA + 17 TPM) | **Receiving Stations (38)** | **Facility Sites and Centres (10)** | **Portals (7)** | **Users**

Heritage of sensors throughout sequence of ESA EO missions also enables common approach for mission operations and ground segment design



1991 **ERS 1** → 1995 **ERS 2** → 2002 **ENVISAT**

→ **Earth Explorers**

→ **Sentinels / GMES**

The ground segment, first established to service for the ERS-1 satellite in 1991, has been developed and enlarged to accommodate the requirements for ERS-2 and the Envisat mission. Smaller missions such as the Earth Explorers are now being supported, with major expansion taking place for the Sentinels/GMES.

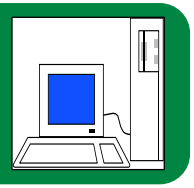
ESA MISSION OPERATIONS CONCEPT
MMGS: THE PRACTICAL SET-UP

De-centralised functions

ESA & TPM Satellite Flight Control Centres

De-centralised functions

10 Processing and Archiving Facilities
+ small thematic archives

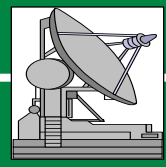


23 Expert Support Laboratories

ECMWF & Meteorological Network

10 National Ground Stations

28 Foreign Stations worldwide



Ground & Satellite Data Dissemination Networks and Data Flow

ESA ESRIN - Management Centre for Distributed Facilities

Centralised Functions

- **Development, Management and Maintenance of a distributed Ground Segment**
- **User Services**
- **Multi-mission Mission Planning**
- **Instrument Performance Monitoring, Product Development & QC**
- **Exploitation Development and Management**
- **Technology Development Standardisation & Technology Transfer**
- **Mission Management, Data Policy**

6 Commercial Data Distributors

200 VAC and Service GSE Companies

11000 Science Users

GMES Services

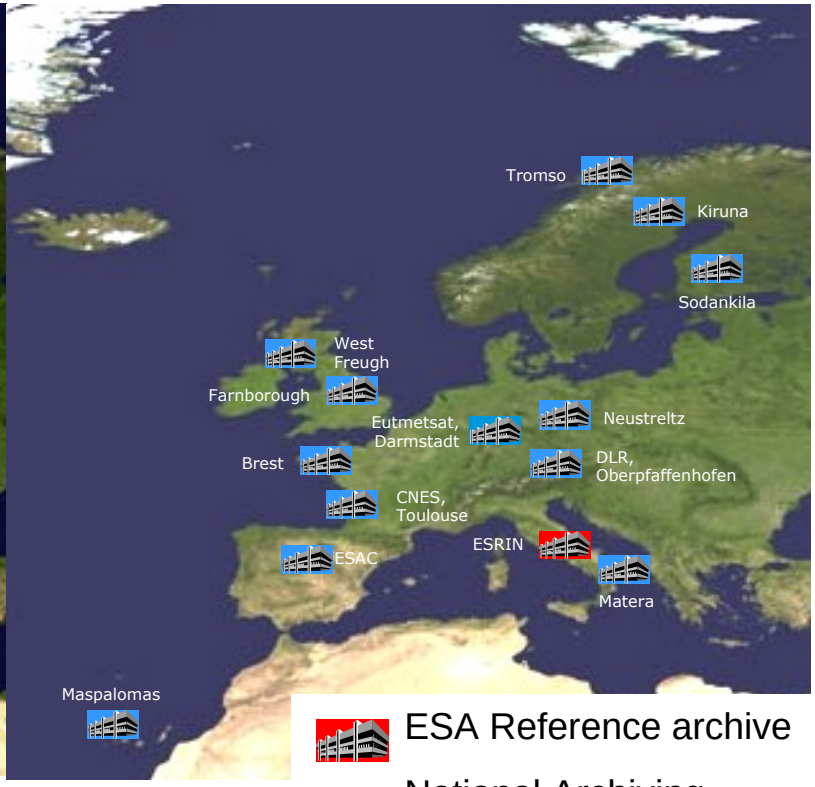
De-centralised functions

DATA RECEPTION
European Receiving Stations

ESA station

Non ESA station

PROCESSING AND ARCHIVING
EO Data Archives Network



ESA Reference archive

National Archiving centres shared by ESA

ENVISAT: ESRIN, F-PAC, E-PAC, D-PAC, UK-PAC, Fin-coPAC, I-PAC

ERS: ESRIN, F-PAF, D-PAF, UK-PAF, I-PAF

PROBA: Kiruna, ESRIN

SMOS: ESAC, CNES, Svalbard, Kiruna

...

ESA MISSION OPERATIONS CONCEPT
ACHIEVEMENTS I

1. Improvement on EO Missions Data Access

- Data available on-line through on-demand ftp or direct access to archives.
- Multi-mission data catalogues improved (EOLi, DESCW) including direct data download.
- Web registration and PI project submission: on-going.
- Multi-Mission Facility Infrastructure developed for archiving, processing and disseminating data / products.

→ see detailed slides

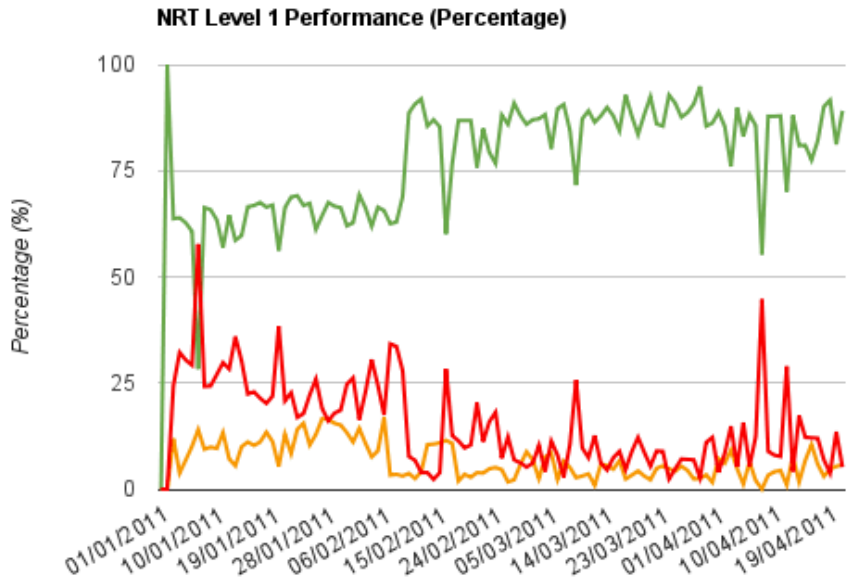
2. Technological enhancement of the ground segment elements

- User Services Next Generation.
- Charter tools for mission activation: SaVoir.
- Cal/Val Portal: supporting cooperation and coordination across missions.
- Upgrading of Multi-mission User Services Infrastructure to latest technology for disaster recovery and higher availability (Blade, Virtualization)

3. Coordination and standardisation

- Ground segment coordination body (GSCB): cooperative projects with Member states for interoperability standards, long-term data preservation, joint technology development

→ see detailed slides



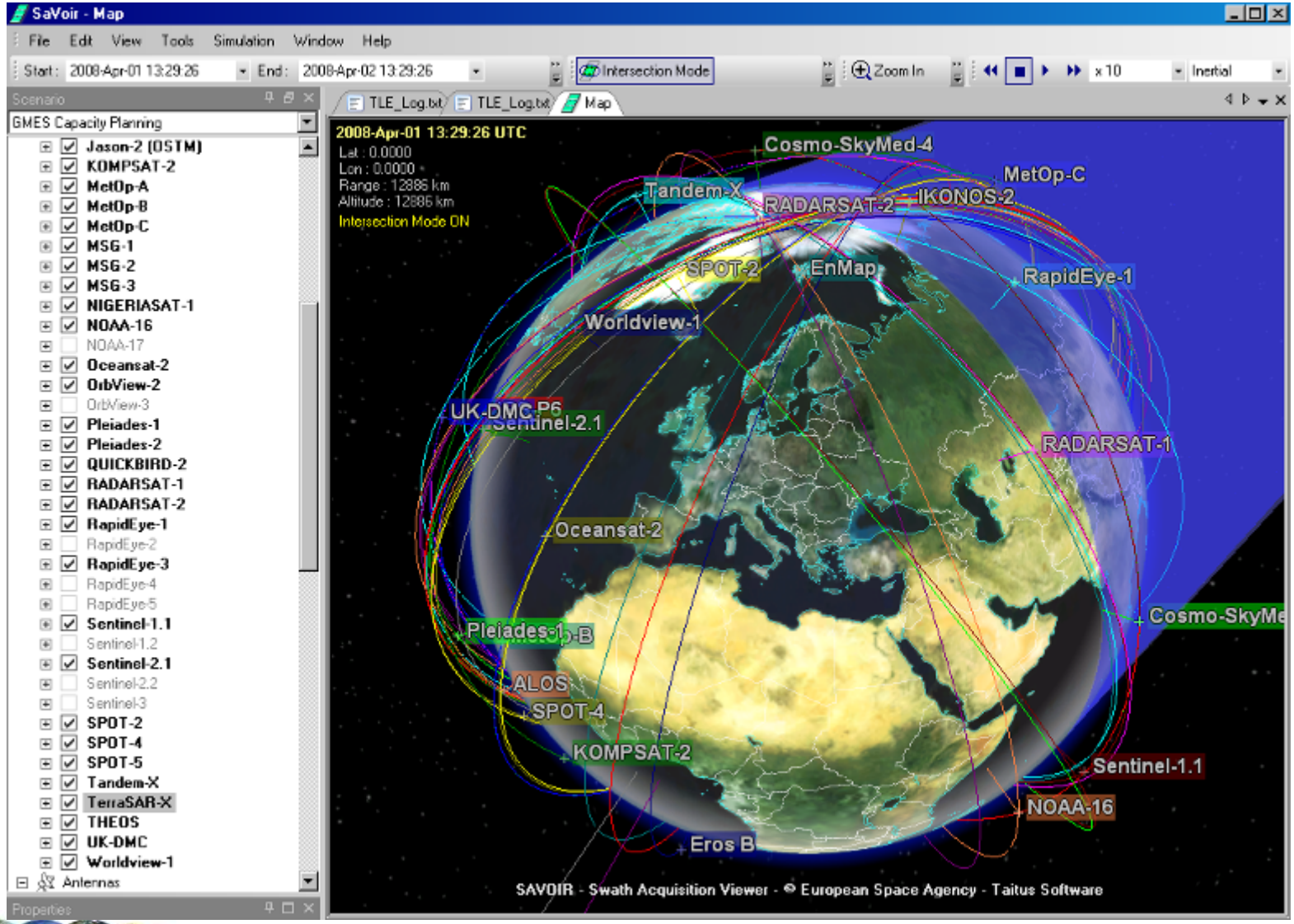
SMOS NRT data product delivered to operational users within their requirements, performance constantly improving

☐ within 165 min from sensing
☐ between 165 – 200 min from sensing
☐ beyond 200 min from sensing

4. Extended mission objectives for Earth Explorers

- Introduce generic multi-mission operational concepts in the EEs: Long-term data preservation and NRT services (SMOS, SWARM)
- Unified end-to-end mission monitoring and data Q/A with similar to other ESA managed missions (Envisat, ERS, TPM)

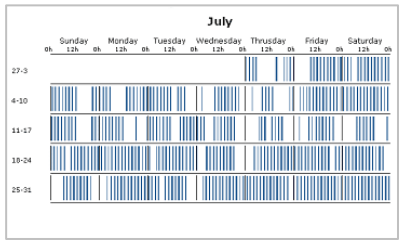
ESA MISSION OPERATIONS CONCEPT
ENHANCED USER SERVICES: SaVoir



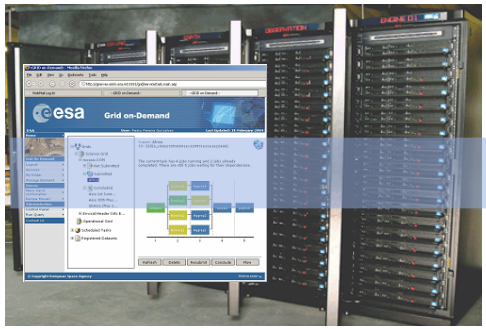
5. Technology spin-off in PDGS and user support infrastructure

Grid *Processing-on-Demand* (G-POD)

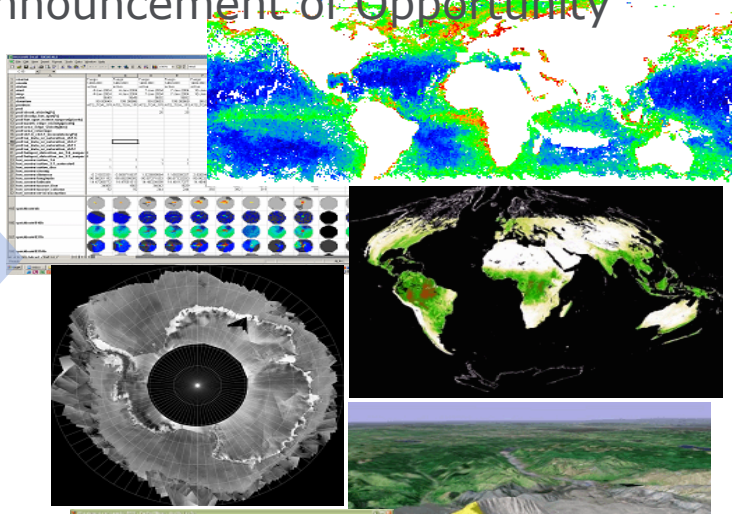
1. Promote the development of new algorithms requiring large data and computing resources: "***bring the user's algorithms to the data***"
2. The service makes available to EO PIs processing capacity, such as a grid environment with online access to EO data from ESA and non-ESA missions
3. G-POD users can test a new algorithm on large datasets, improve and validate it, re-iterating this process until the scientific goal is achieved.
4. Many projects supported through - always open - Announcement of Opportunity



on-line data archives



user triggers and controls from the G-POD website its own processor running on eogrid computers

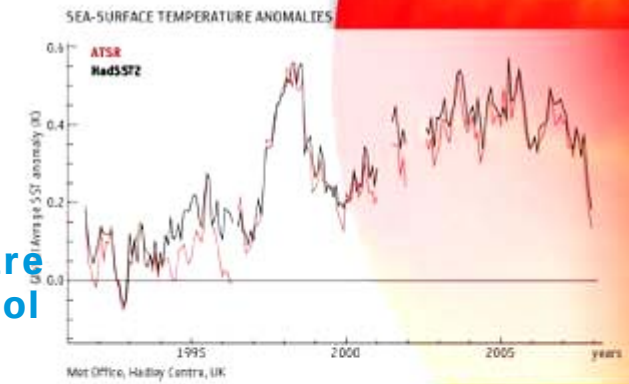


user results

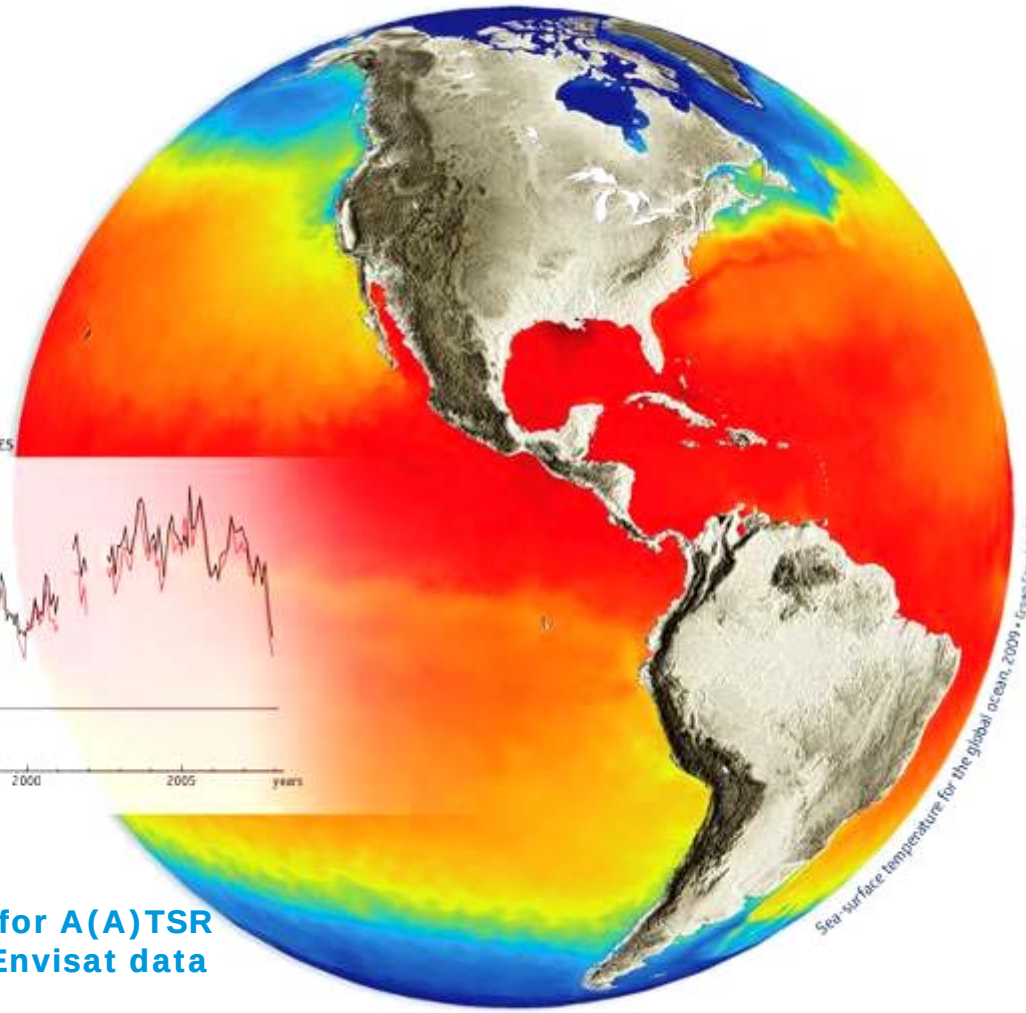
http://gpod.eo.esa.int

6. Operations of Long-Term Archive and all off-line services

- Covers at present off line operations for ERS-1, including archiving, reprocessing and data access
- Detailed approach for long-term data preservation in future tb explained in later slide
- We have now collected about 20 years of continuous measurements from space for many geophysical parameters (even 30 years for some parameters)



Earth Observation data are becoming an essential tool for Earth Science



Long-term series of SST for A(A)TSR including ERS-1, -2 and Envisat data

Benefits to ESA member states

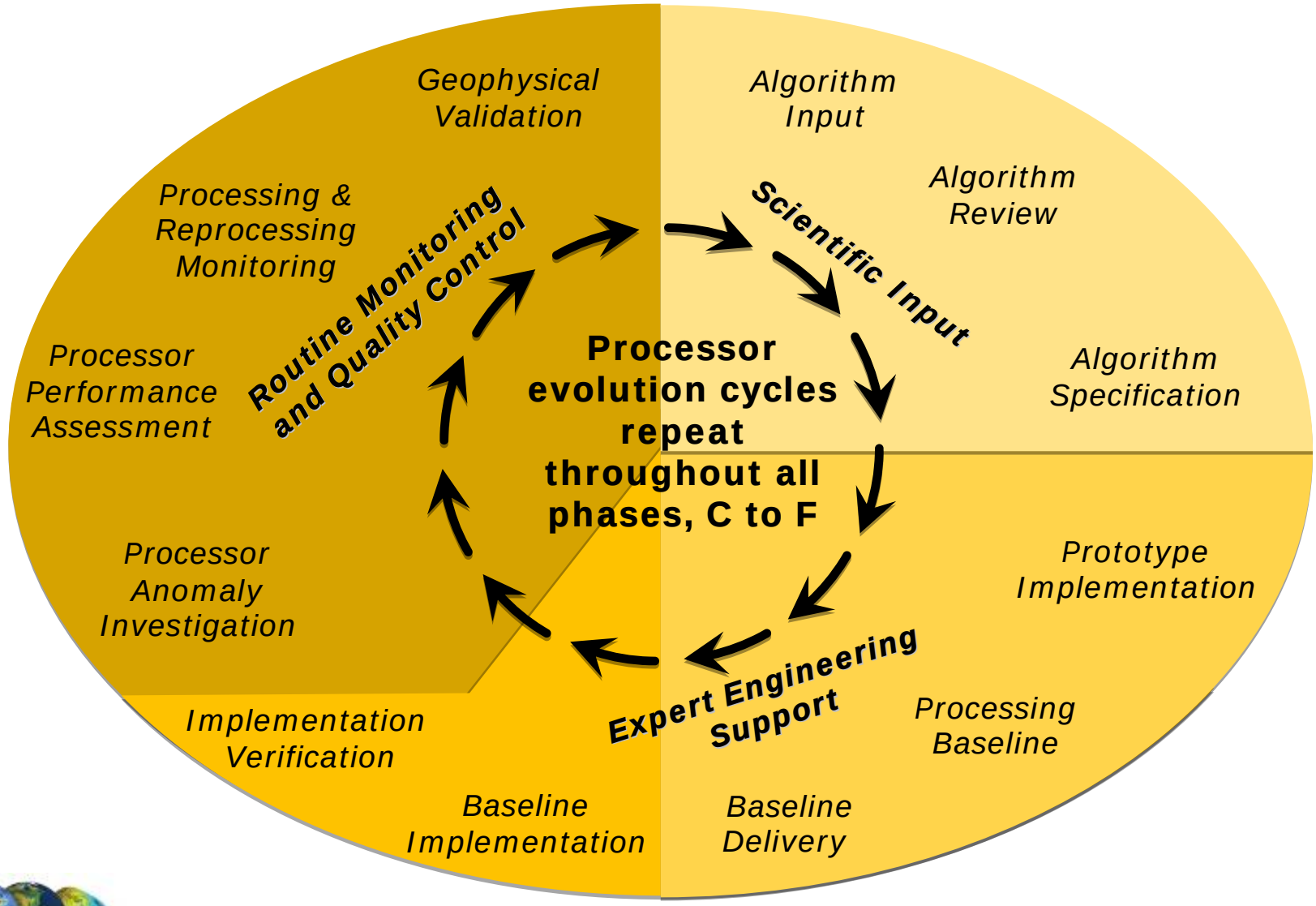
1. Procurement through ITTs with large number of SMEs, industrially complements the contracts with satellite Primes

2. Develops industrial capabilities in ESA member states

3. Supports development of industrial skills also in smaller, sometimes under-returned countries

4. Enables Member states to establish a long term architecture for own missions/facilities and to cooperate in future ESA programmes, thanks to the cooperation and joint interface standardisation efforts.

HOW TO ENSURE HIGH DATA QUALITY?
PROCESSOR EVOLUTION CYCLE



HOW TO ENSURE HIGH DATA QUALITY?
AN EXAMPLE: MIPAS DATA QUALITY EVOLUTION

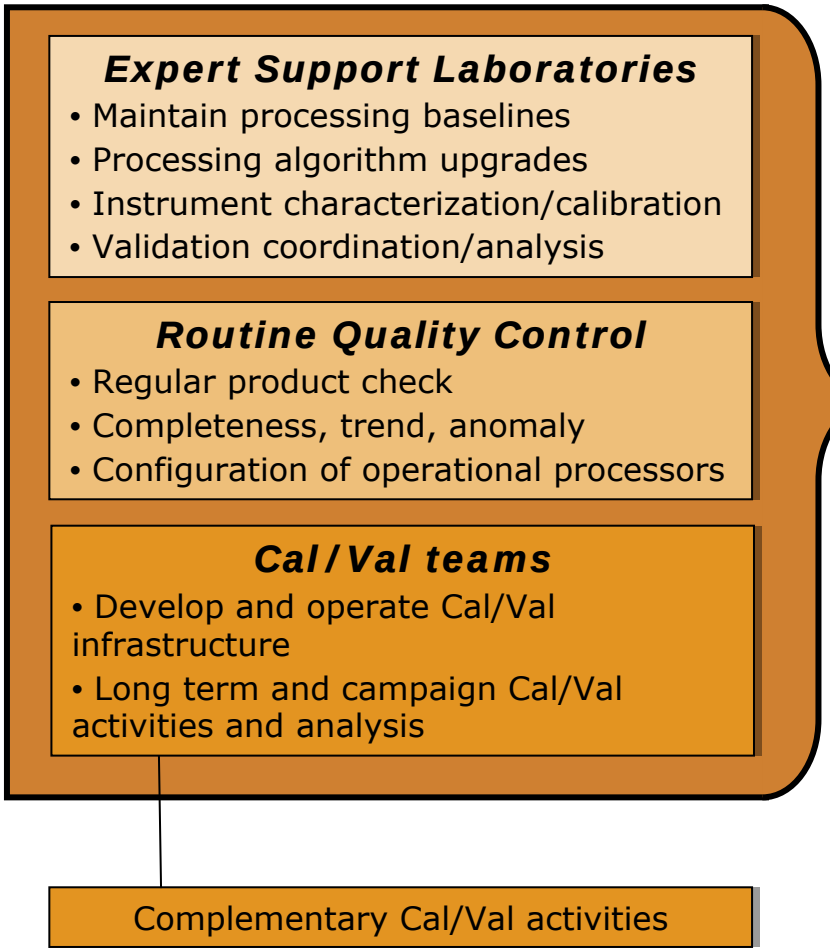
Performance improvement is a process

During mission exploitation, the data quality gradually improves thanks to the efforts put in processing algorithm upgrades, in validation and in reprocessing.

In the case of MIPAS, the process of data quality improvements had also to cope with several instrument on-board anomalies.

MIPAS			Pre Launch	2007	2010
Temperature	Bias	18-40km	2K	2 K	1 to 2 K
		40-65km			2 K
	Precision	18-40km	1K	5 K	<1 K
		40-65km			2 K
O_3	Bias	18-23km	5%	<10%	20 to 50 %
		23-52km			~0 %
	Precision	18-23km	1%	<10%	15 to 30 %
		23-52km			2 to 5 %
NO_2	Bias	23-35km	Not specified	10-20%	~0 %
		35-50km			10%
	Precision	23-35km		5-15%	10%
		35-50km			10%
HNO_3	Bias	17-34km	5-20%	<10%	10 to 15 %
	Precision	17-34km	4%	<10%	20 to 30 %
N_2O	Bias	12-40km	20%	5-30%	~0 %
	Precision	12-40km	10%	10-28%	< 20 %
CH_4	Bias	12-40km	8%	5-20%	-10 ? 2 %
	Precision	12-40km	5%	5-18%	< 20 %

HOW TO ENSURE HIGH DATA QUALITY?
MANAGEMENT OF DATA QUALITY IN OPERATIONS PHASE



Instrument or Mission

Quality Working Group

- *Regular meetings for discussion on quality issues or quality improvements*
- *Public availability of reports (monthly reports, validation reports)*
- *Regular reports on data quality to DOSTAG / PB-EO (and ESAC)*

HOW TO ENSURE HIGH DATA QUALITY?
AN EXAMPLE: SMOS CALIBRATION & VALIDATION ACTIVITIES

1. **Close collaboration with key scientific groups: Expert Support Laboratories (ESL)**
2. **Working with international teams on calibration & validation (approx. 40 PIs) covering a variety of climate zones**
3. **Support core validation sites through**
   - **Operations of three ground-based L-Band radiometers**
   - **Airborne campaigns**
4. **Support multiyear ground-based L-Band radiometer measurements at DOME-C in 2010 and beyond**
5. **Support to international in-situ soil moisture network**
6. **Collaboration with NASA's Aquarius and SMAP teams**

*Higher level Earth Explorer product development and Cal/Val activities are supported by **Level 2** programme element*

A constant ESA objective:
- ease access to Earth Observation data

1. **Revised ESA EO data policy:**
   - most of the data is now open and free of charge

2. **Constant upgrade of ground segment for easier access to data through Internet for Near Real Time (NRT) data and for archived data**

3. **Development of alternative ways to provide data (e.g. processing on demand, data / algorithm toolboxes)**

4. **Large effort in maintaining data quality (processing algorithms and subsequent reprocessing)**

5. **Need to preserve "old" data for future use (LTDP)**

ACCESS TO EO DATA
REVISED EO DATA POLICY

FREE DATASET:

- For data collections available on-line

- open and free of charge
- user registration done electronically
- for all uses (i.e. science and operational applications)

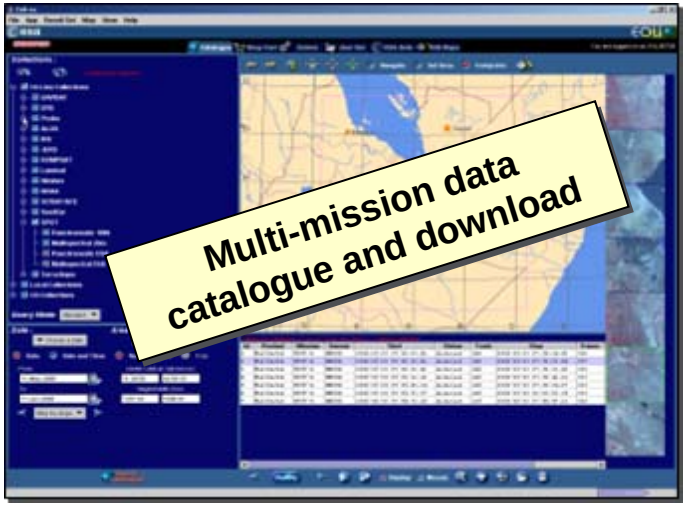
RESTRAINED DATASET (subset of ASAR):

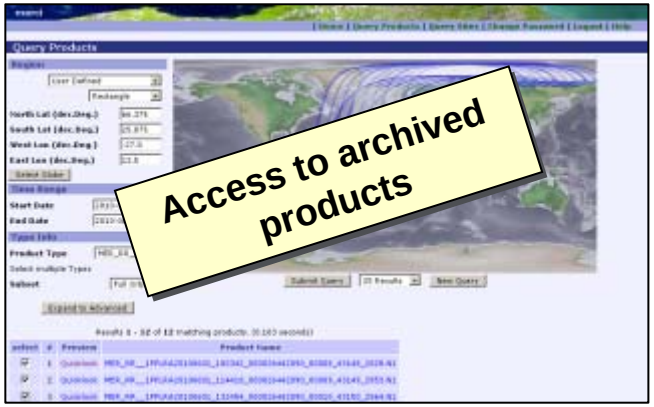
- For all other datasets still to be made available on-line

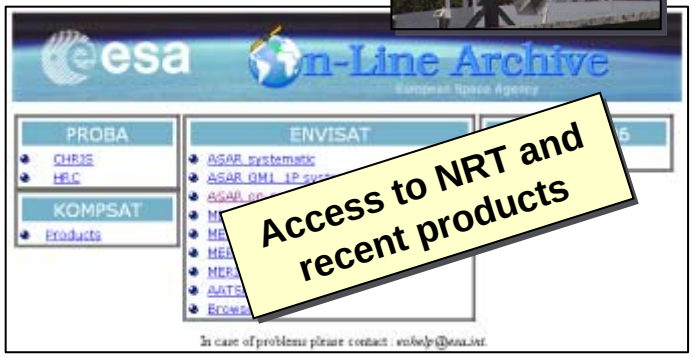
- project proposals received by ESA with data free of charge but with data quota limit related to processing or acquisition constraints,
- for operational SAR applications, possibility to have higher level of priority through SAR value adding services (or through ESA for GMES Services).

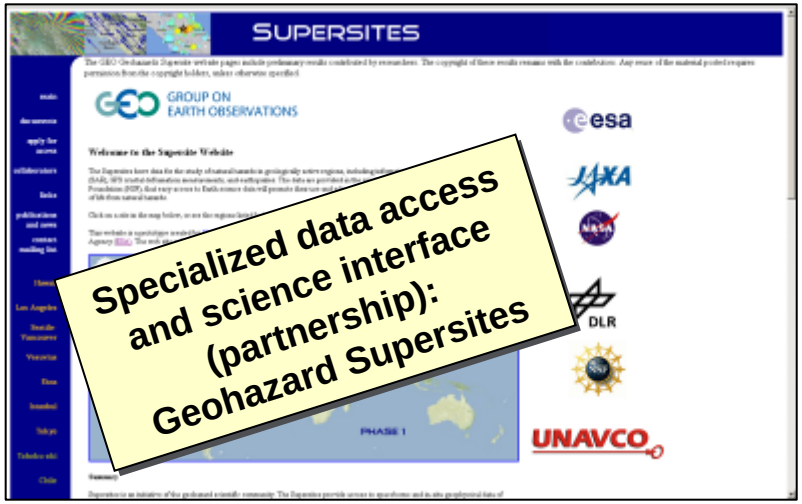
ACCESS TO EO DATA
DATA AVAILABILITY ON LINE

Ensuring seamless EO data flow from satellites to users





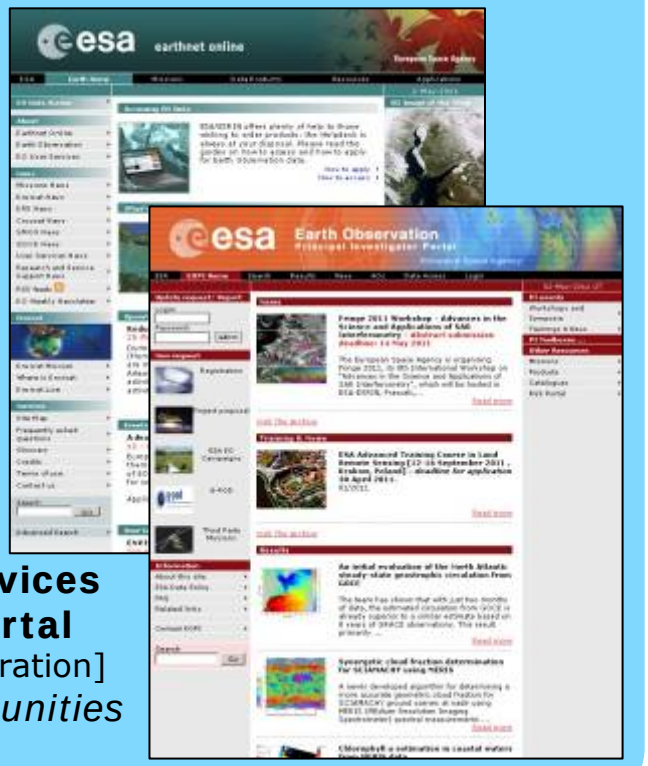




ACCESS TO EO DATA
ESA (supported) PORTALS

ESA portals

ESA Portal
- for media and general public



EO Data and Services Information Portal
[new version in preparation]
- for EO user communities

Portals in support to other organisations

GEO Portal

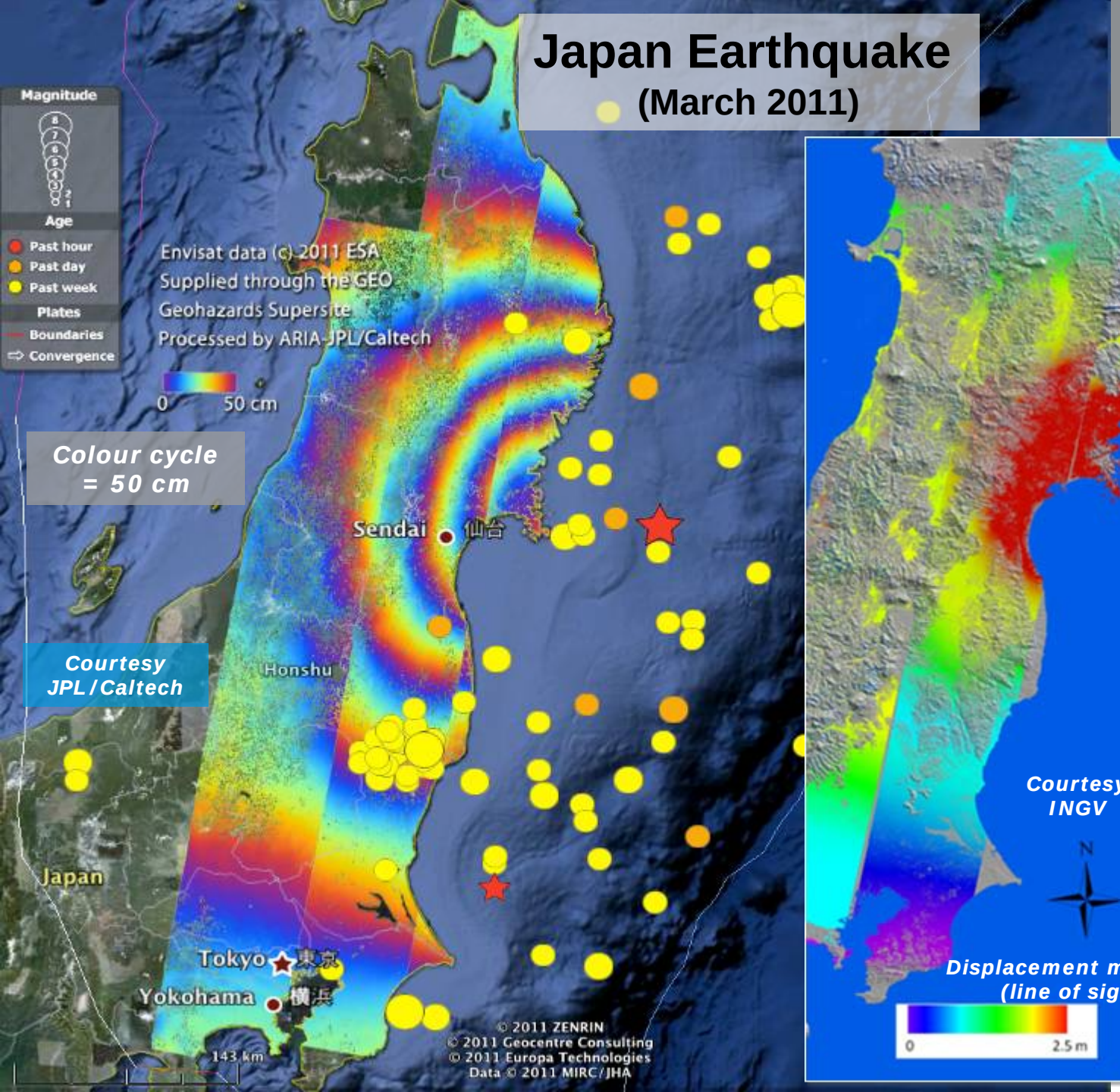
Charter Space & Major Disasters

CEOS Cal/Val Portal

ACCESS TO EO DATA
TIMELY DATA AVAILABILITY FOR EARTH EXPLORERS

	Launch	Data provided to cal/val users	Data released to science community
GOCE 	17 March 2009	Data available to cal/val team ca **= 2 weeks after launch**	Validated Level 1b data available to all users since May 2010 and validated Level 2 data available to all users since June 2010 **= 14 and 15 months after launch**
SMOS 	2 Nov 2009	Data available to ESLs ca **=1.5 months after launch** First Level 1C products (and some data sets for level 2) officially released to cal/val PIs mid April **= 6 months after launch**	Official release of level 1C products in July 2010 and Level 2 products in Oct 2010 **= 9 and 11 months after launch**
CryoSat 	8 April 2010	Data available to cal/val teams from July 2010 **= 3 months after launch**	All CryoSat L1b & L2 data are available on-line since Feb 2011 **= 11 months after launch**

Japan Earthquake
(March 2011)



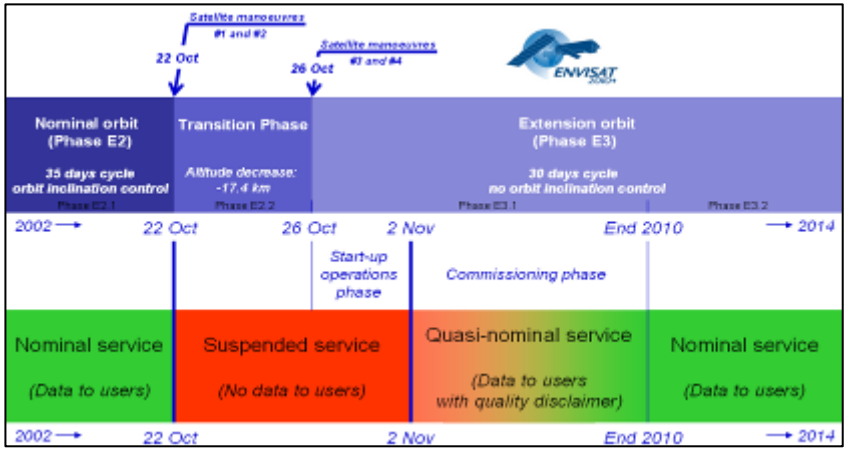
Thanks to the background data acquisitions (pre-seismic acquisitions in February 2011), it is possible to generate a mosaic derived from many Envisat ASAR interferograms (combining with post-seismic acquisitions in March 2011).

The mosaic provides a detailed estimation of the terrain movement on a very large scale.

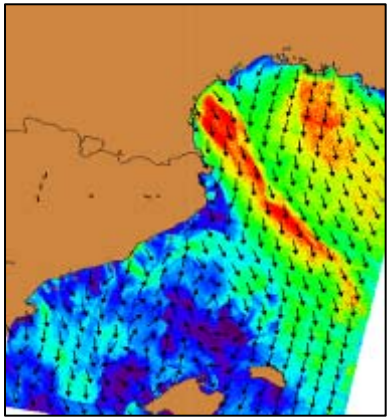
Colour cycle: 50 cm (line of sight)

SUPPORTING EVOLVING USER REQUIREMENTS
ENVISAT ORBIT CHANGE IN OCTOBER 2010

• The Envisat orbit change in October 2010 was a **major** modification of the mission. The change was needed to ensure a longer mission lifetime, well beyond the limits imposed by the amount of hydrazine available on-board after 8 years of operations (5 years nominal lifetime).



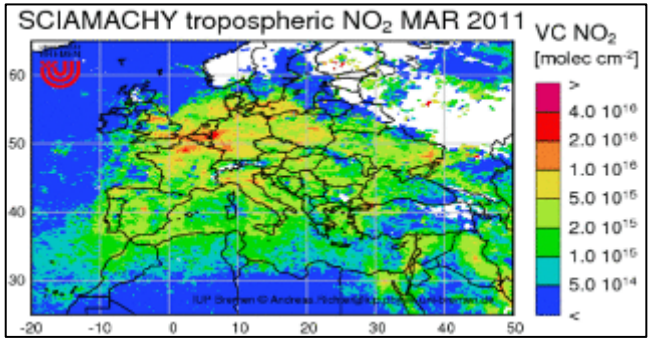
• All ground segment components (designed 10+ years ago) had to be modified, without impacting user communities.



ASAR wind field
(Tramontana storm – 2nd Jan 2011)

• The Envisat orbit change went flawlessly, exactly according to plans. The services to users was suspended for about 10 days. The subsequent short commissioning phase confirmed quickly that all 80 different types of Envisat products were of the same quality level as before the orbit change.

• The cost of all the implemented changes have been absorbed by the nominal operations budget.



MERIS
Etna eruption
(January 2011)

DEALING WITH NEW CHALLENGES
SMOS RADIOFREQUENCY INTERFERENCE

RFI = Degradation of SMOS brightness temperature observations over land and ocean likewise through interfering active sources emitting in same spectral band

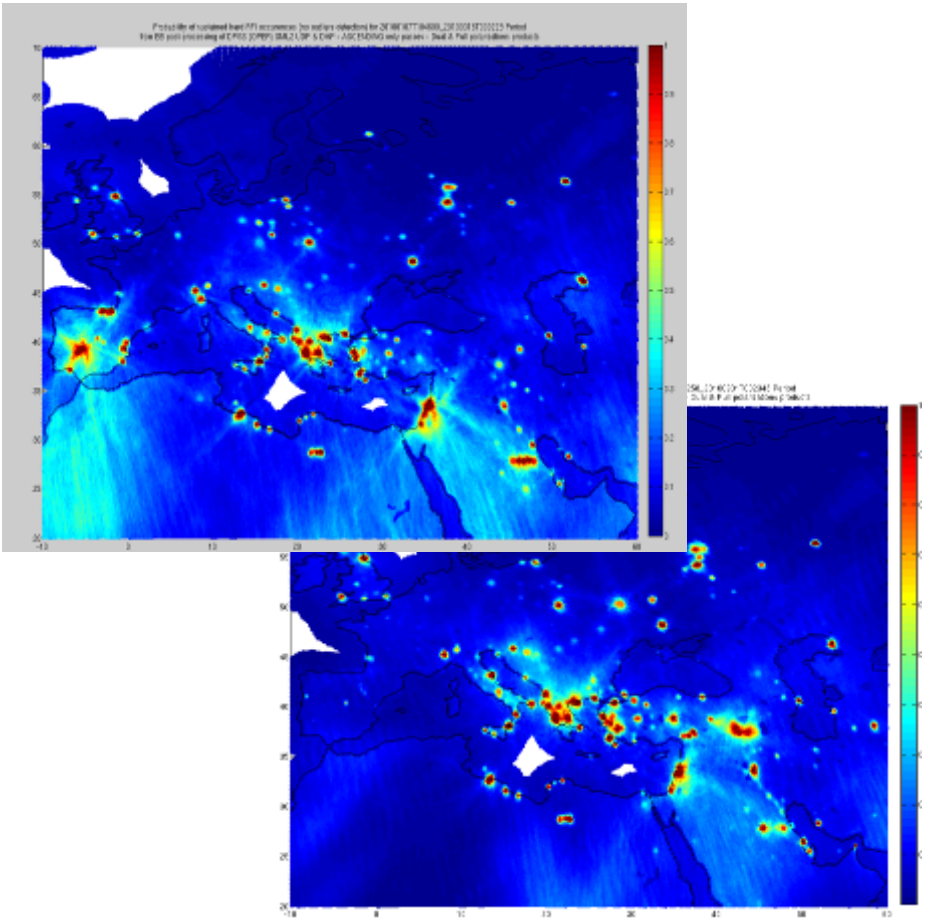
ITU and WRC resolutions were adopted to protect the passive L-Band (1400-1427 MHz) and prohibit all emissions in this band.

Nevertheless strong interference sources have been detected worldwide, especially in Southern Europe, China, Southern Asia and the Middle East.

ESA's and the SMOS scientists' instant reaction to the RFI occurrence has significantly improved the overall situation

- ESA is in contact with European and International National Frequency Management Authorities to investigate the RFI sources and initiate actions to cancel (or mitigate) these interferences.

- **Major improvement of RFI situation over Europe: From March to April 2011, approx. 85 interferers were successfully located and switched-off.**

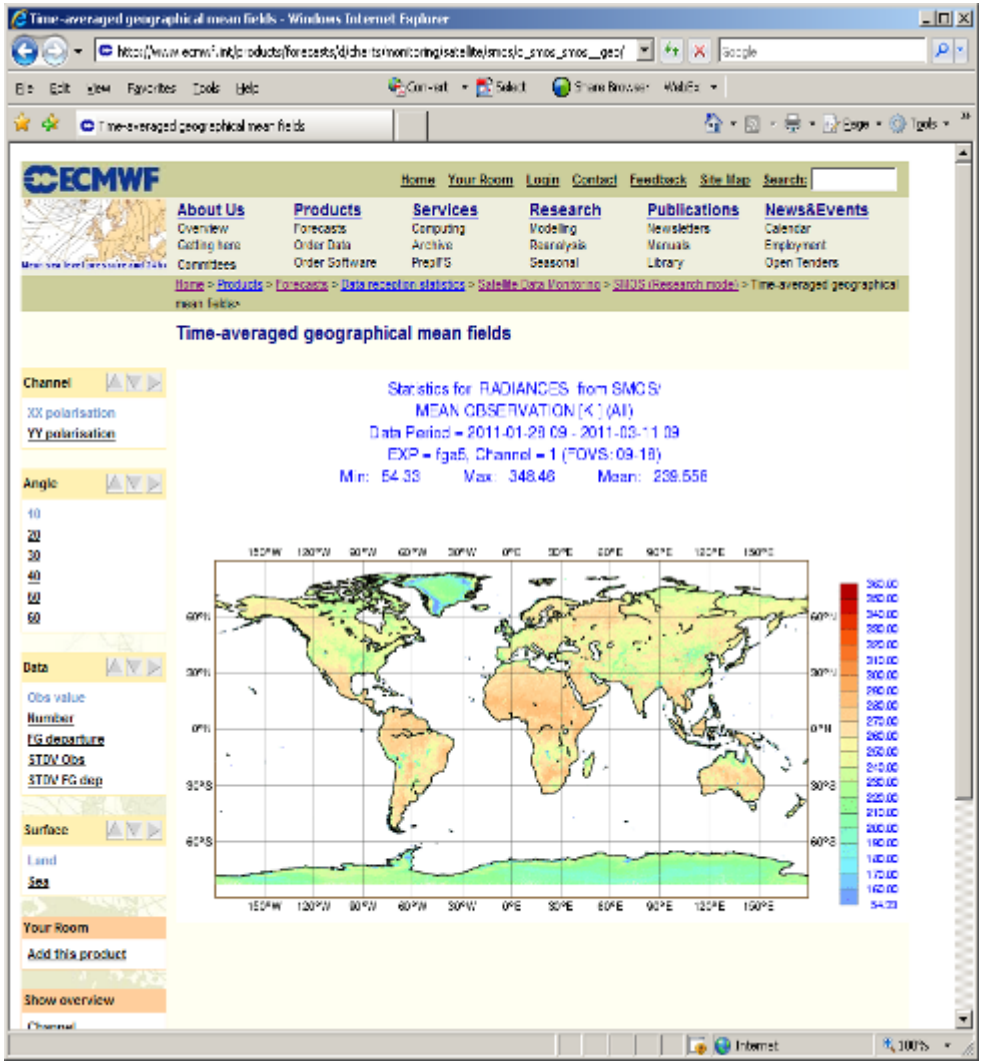


Probability of RFI occurrences over Europe in March (top) and August (bottom) 2010, showing effect of switching OFF several strong interferers. Strong RFI sources can contaminate large areas of SMOS data - A single interferer over Spain could contaminate about 75% of Western Africa!

©CESBIO

SUPPORTING NEW USER REQUIREMENTS
SMOS NRT – SCIENCE TO OPERATIONS

1. ECMWF is using SMOS data for global monitoring of brightness temperatures in NRT since launch.
2. The aim is to quantify the impact of SMOS data on the forecast skill.
3. The SMOS ground segment provides the NRT product to ECMWF within 3 hours from sensing (presently in 87% of time).
4. Excellent example of support to potential operational applications based on Earth Explorer data.
5. Aim should be to establish NRT facility for all relevant Earth Explorer missions from proposal stage.



ESA supports and coordinates multi-mission satellite tasking requests in support of emergencies and crisis management

- Allocation of satellite and processing resources to best serve the needs of the user
- Highest priority of data acquisition overrides previous planning
- Fast-track processing and delivery for use in customised image map products to be sent into the disaster zone

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Sub-totals		Total
Solid Earth	*Earthquake*		3	1	3	5	3	2	5	4	3	5	3	37	**69**	**302**
	Landslide	1	1	2	2			1			4	2	1	14		
	Volcano		1	1	2	2	1	1	2	3	3	2		18		
Weather / Atmospheric	*Storm/hurricane***			1	2	3	6	1	8	8	8	11	1	49	**216**	
	Ice/snow hazard								1			1	1	3		
	*Flood/ocean wave**		3	8	4	9	13	16	22	23	18	25	4	145		
	Fire				5	1	2		4	2	4	1		19		
Technological	*Oil spill*		3	2				4	3			1		13	**17**	
	Others					1						3		4		
	Total / year	**1**	**11**	**15**	**18**	**21**	**25**	**25**	**45**	**40**	**40**	**51**	**10**			

*includes solid earth related phenomenon of a tsunami

**includes all wind type storms (hurricane, cyclone, typhoon and tornado)

Charter activation cases

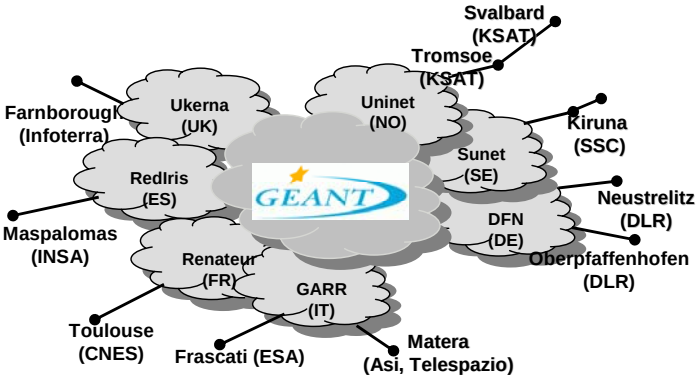
As of April 5, 2011

ADAPTING TO NEW IT TECHNOLOGY: NETWORKS

- EO Data Distribution **initially over media** (Exabyte, CD-ROM) could evolve **over Internet** thanks to the network services evolution in the user consumers market.
- Most powerful networks allowed easing the data access and improve the data timeliness
- The EO Multi-mission PDGS infrastructure evolved introducing the HiSEEN (High Speed ESA EO Network)
- HiSEEN targets high speed, performances and cost-effectiveness connecting all the EO Facilities for all managed missions.
    1. In 2005 relaying in the National Research Networks and the GEANT Backbone
    2. In 2010 evolved towards a commercial provider (Interoute) with SLA and possibility to explore other advance services like cloud and hosting.

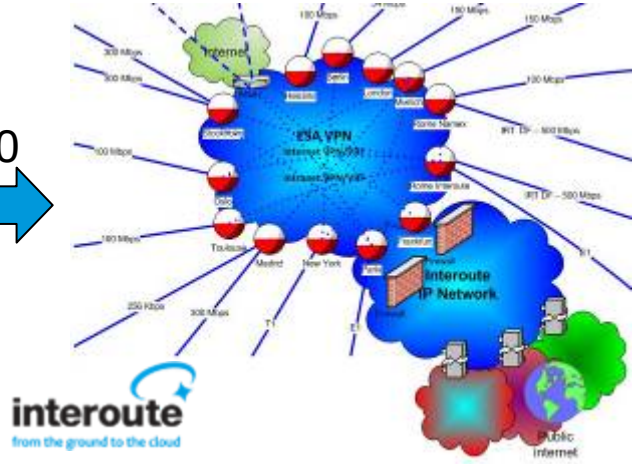
PAST: 1st HiSEEN: 50 Mbps average bandwidth

2005



PRESENT: Interoute: 150 Mbps average bandwidth per site

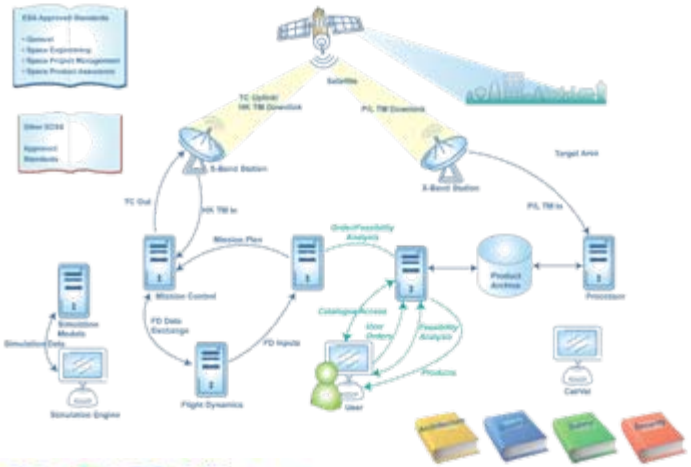
2010



POINTS THAT WILL BE ADDRESSED

1. Fulfilment of mission requirements & high quality scientific output
2. Operations concept supporting running of EO missions and enabling their scientific exploitation, in orbit and off-line
   - Multi-Mission Ground Segment approach: Cooperation with ESA member states and competiveness of European industry
   - Ensuring provision of high quality data
   - EO data access
   - Supporting evolving scientific and operational requirements
3. Standardisation and harmonisation in the international context and mechanisms for implementation in ESA
4. Long-term approach for data continuity, availability and preservation

STANDARDISATION AND HARMONISATION
GROUND SEGMENT COORDINATION BODY



1. Since 2005 focal point led by ESA for coordination and standardisation
2. ESA-led, GSCB (http://earth.esa.int/gscb)includes agencies from Members States that manage EO data ground segments and also involves users and industry
3. Created to determine a common, coordinated and cost effective approach to harmonise the activities of ground segments supporting different satellite systems
4. Major initiative has been the Heterogeneous Mission Accessibility (HMA) study (see next slide)
5. GSCB works with other standardisation entities such as CEOS (Committee on Earth Observation Satellites), OGC (open Geospatial Consortium) and CCSDS (Consultative Committee for Space Data Systems)
6. Bilateral discussion with NASA and EC

STANDARDISATION AND HARMONISATION
CONTRIBUTION TO GEO: GEONET & GEOPORTAL & LTDP

GEONET – Communication

1. A global communication network of interconnected networks by which GEOSS (Global Earth Observation System of Systems) related information, data and products can be circulated and distributed in response to the needs of users and providers
2. Based on the sharing of national, regional and global telecommunications networks using communication network typologies, satellite and terrestrial, considered most suitable to meet the service requirements

GEOportal - Access

http://geoportal.org/

1. Entry point to access EO information and services: It connects to a system of existing portals, addressing the GEO Societal Benefit Areas globally while also providing national and regional information to enhance understanding.
2. Derived from ESA's Earth Observation Community Portal www.eoportal.org, this contribution to GEO will put the accent on remote sensing, geospatial-static and in-situ data, information and services.

GEO Sub-task DA-09-01C: Long Term Preservation of EO Data

Develop a GEO strategy for the long term preservation of EO data starting with space-based data and possibly evaluating expansion to in-situ data. The strategy will be based on a set of GEO LTDP guidelines, being

- **A basic reference for the long term preservation of EO space data within GEO and GEOSS.**
- **Recommended for application by EO space data owners and archive holders**

STANDARDISATION AND HARMONISATION

CONTRIBUTION TO CEOS: QA4EO

1. QA4EO, proposed by ESA, is a set of quality guidelines based on one key principle:

   "All data and derived products must have associated with them a Quality Indicator (QI) based on documented quantitative assessment of its traceability to community agreed (ideally SI) absolute reference standards."

2. Within ESA EOEP-3, QA4EO guidelines are being put in place through the CEOS Cal/Val portal: Calibration Validation protocols, Reference Test Sites, Inter-comparison exercises and workshops (http://calvalportal.ceos.org)

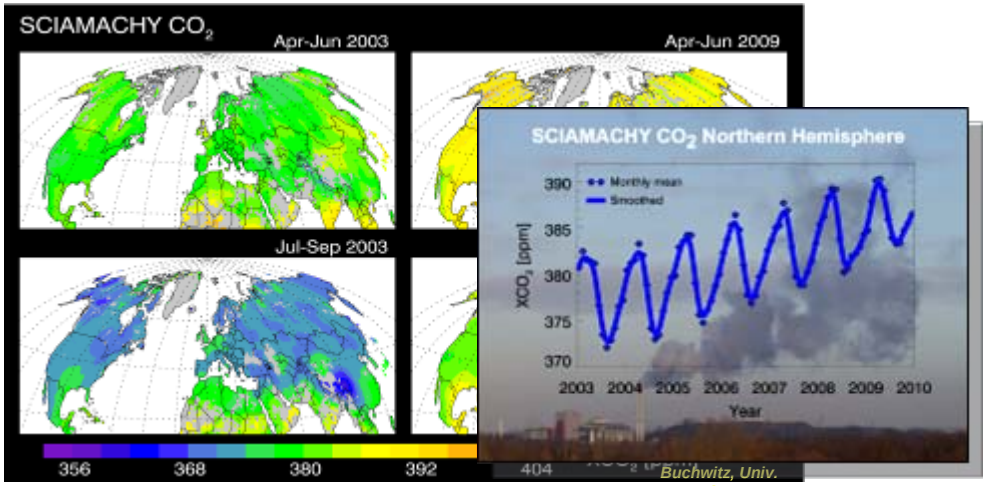
3. QA4EO is endorsed by CEOS as a contribution to facilitate the GEO vision. In GEOSS, both data providers and value adding entities are discussing the implementation of QA4EO w.r.t. assuring full meteorological and processing traceability (http://qa4eo.org)

→ Science will benefit of this effort in QA standardisation

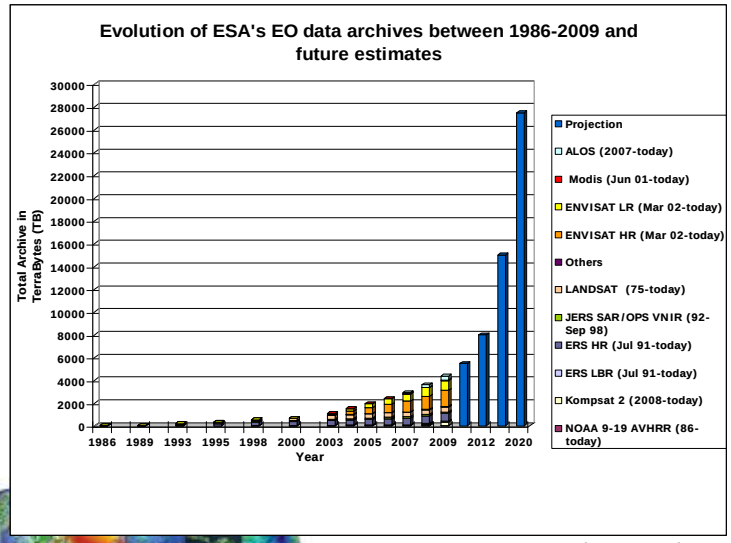
POINTS THAT WILL BE ADDRESSED

1. Fulfilment of mission requirements & high quality scientific output
2. Operations concept supporting running of EO missions and enabling their scientific exploitation, in orbit and off-line
   - Multi-Mission Ground Segment approach: Cooperation with ESA member states and competiveness of European industry
   - Ensuring provision of high quality data
   - EO data access
   - Supporting evolving scientific and operational requirements
3. Standardisation and harmonisation in the international context and mechanisms for implementation in ESA
4. Long-term approach for data continuity, availability and preservation

LONG-TERM DATA PRESERVATION
WHY?



Time series of carbon dioxide: The preservation of EO data (the "bytes") is useless without the preservation of the knowledge associated with the data (the "quality")



Valorise the past for future needs

- Increasing number of applications, scientific and commercial, need long-term data series
- In particular important for Changing Earth/Climate change research (IPCC recommendations, GCOS report on ECVs as contribution to international initiatives)
- Support to relevant ESA initiatives such as CCI
- Continuously increasing amount of data and metadata need to be preserved and readily accessible for exploitation
- Economic value of long-term data sets relevant for climate research (Stern report)

LONG-TERM DATA PRESERVATION
PAST, PRESENT AND FUTURE

2003 - 2007 | **2008 – 2012 = NOW** | **2013 – 2017 = FUTURE**

Earthnet Programme

- TPM
  ops
- Long
  GS t
- Inter

For ope
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EOEP Programme

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LTDP Preliminary Programme (2009-2011)

LTDP Programme

- LTDP architecture implementation and evolution
- Data loss prevention and recovery for all historical missions
- Operations of ground segment and off-line services for historical missions (ESA: ERS-1 and -2 (after ~2016) and TPMs).

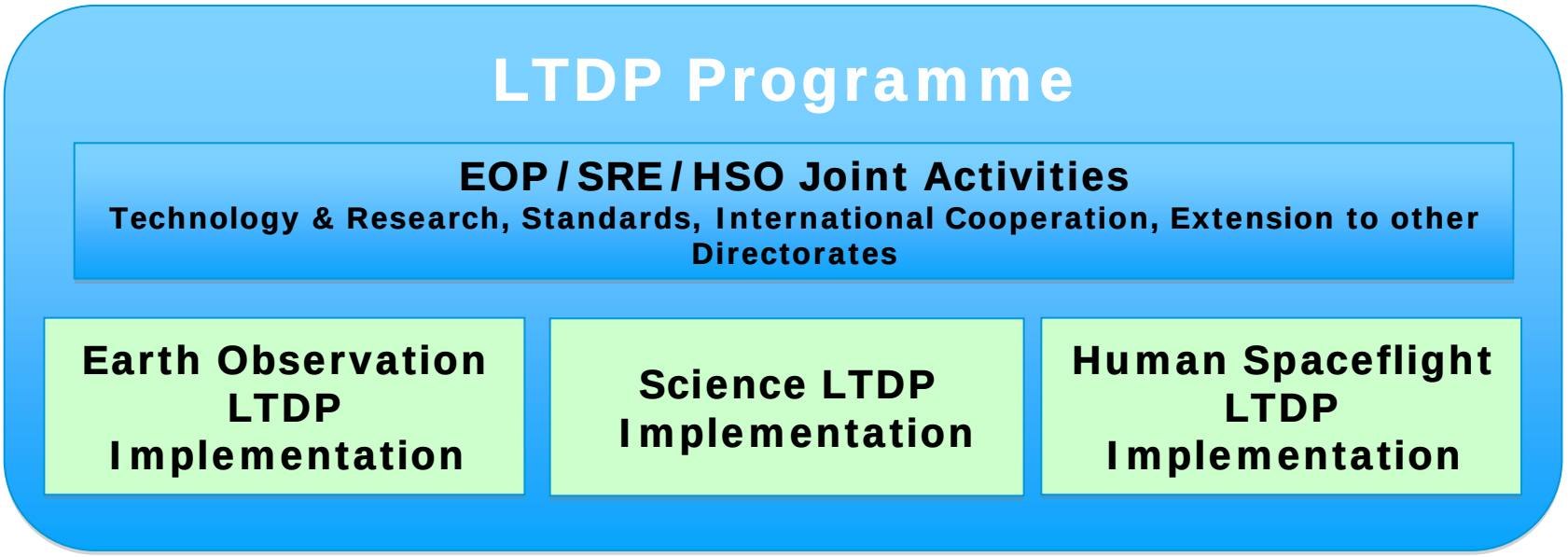
In summary

1. Need for long-term preservation in future addressed through dedicated programme: LTDP under general budget
2. In the past disparate approach to long-term data preservation but with more missions going off-line increased need for clear approach
   - Operational and post-operational missions in Earthnet and EOEP respectively for TPM and ESA missions
   - Historical missions in LTDP

Note: commonly shared ground segment facilities to be developed in coordination between these three funding lines

DEFINITIONS
1. **Operational mission: active mission**
2. **Post-operational mission: up to 5 years after end of life (EOL) or end of agreement (EOA) for TPMs**
3. **Historical mission: more than 5 years after EOL or EOA**

LONG-TERM DATA PRESERVATION
PLANNED LTDP PROGRAMME IMPLEMENTATION



MISSION OPERATIONS & GROUND SEGMENT ACTIVITIES
CONCLUDING REMARKS I

1. **Delivery of science goals: We are providing high quality EO data for scientific applications and exploitation on a long-term basis**

2. **There is an increasing number of (extended) missions in operations - thanks to robustness of sensors and carefully planned operations and exploitation leading to wider exploitation opportunities and longer operations phases**

3. **The operations concept based on multi-mission ground segment successfully delivers science goals and provides advantages technically and financially:**

   - Same concept for operations for all ESA EO missions: ERS, Envisat and EEs, leading to GSC and TPM operations concepts
   - Development & Provision of generic ground segment elements for Explorers (User Services, Long Term Archive, QC tools, networks) complementing the mission specific developments of the EE budgets
   - Development and Operations of GS Standardised Building Blocks and Interfaces (HMA, LTDP guidelines) which are now the basis for the GSC operations concept and the collaboration with 'GMES Contributing Missions' and for the Long-Term Data Preservation programme.

MISSION OPERATIONS & GROUND SEGMENT ACTIVITIES
CONCLUDING REMARKS II

4. **Multi-mission ground segment provides opportunities for ESA member states:**

   - Develops industrial capabilities in ESA member states
   - Enables Member states to establish a long term architecture for own missions/facilities and to cooperate in future ESA programmes
   - Technology development leverage: GS Technology developments for ESA missions and being made available for Member States and Industry's own missions (managed cooperatively through the Ground Segment Coordination Body with all European Space Agencies). (http://earth.esa.int/gscb)

5. **Open and easy access to EO data ensured**

6. **Operations concept has flexibility to support new and evolving data user requirements and adheres to new technology developments**
   - new science subjects > demanding new products
   - wider (global subjects) > demanding large data volumes
   - better underlying science infrastructure > different access mechanisms, shared processing, cooperative environments

CONCLUDING REMARKS III

7. **Data quality standardisation and harmonisation increasingly dominant topic internationally for comparability of sensors, combined time series etc**

8. **Science and applications doesn't start and end with a single mission cycle - this also means we need to ensure long-term approach for data continuity, availability and preservation (EOEP-4 and LDTP)**

9. **EOEP is the core EO programme leading also from science up to other programmes (GMES, Meteo)**

   - National missions and technology
   - European Cooperation
   - Establish a longer leading architecture and view
   - Supporting other ESA programmes, for example CCI

THANK YOU