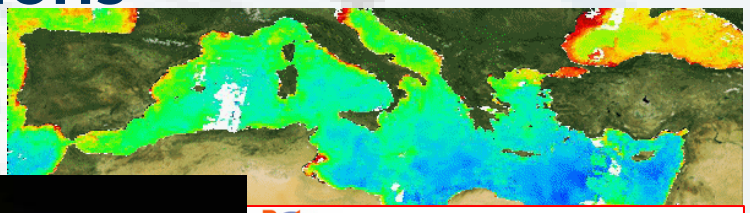
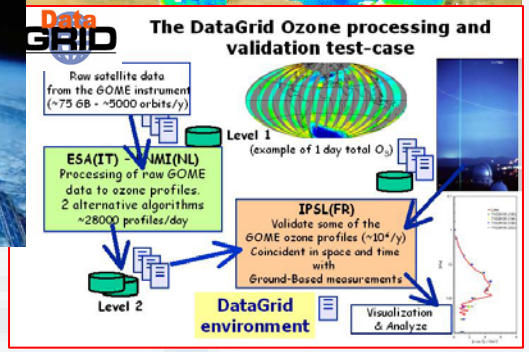
Earth Science and Space Applications on the Grid:

Community, requirements, experiences and future directions





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NEW GRID COMMUNITIES PROGRAM TRACK

Space-related Grid Applications

esa THE VOICE Diligent eGee

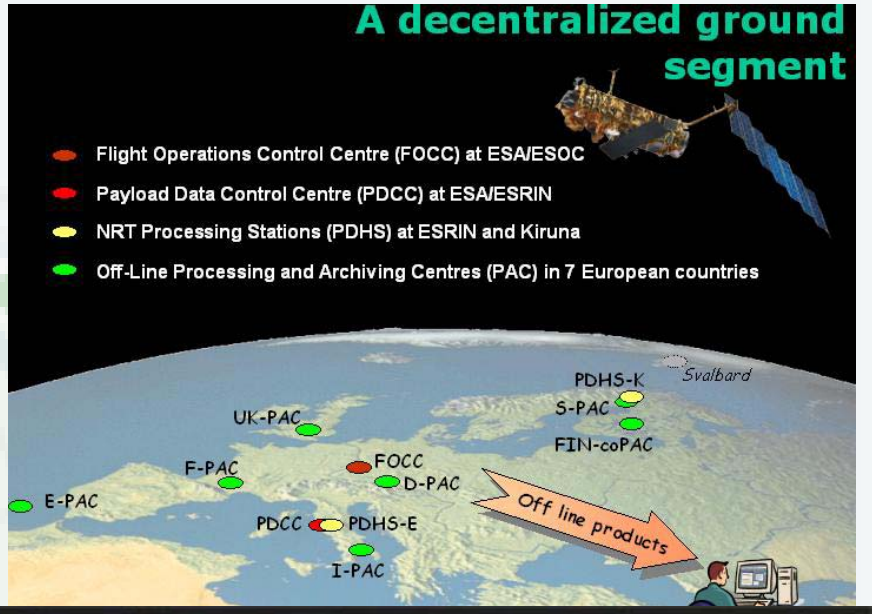
Outline

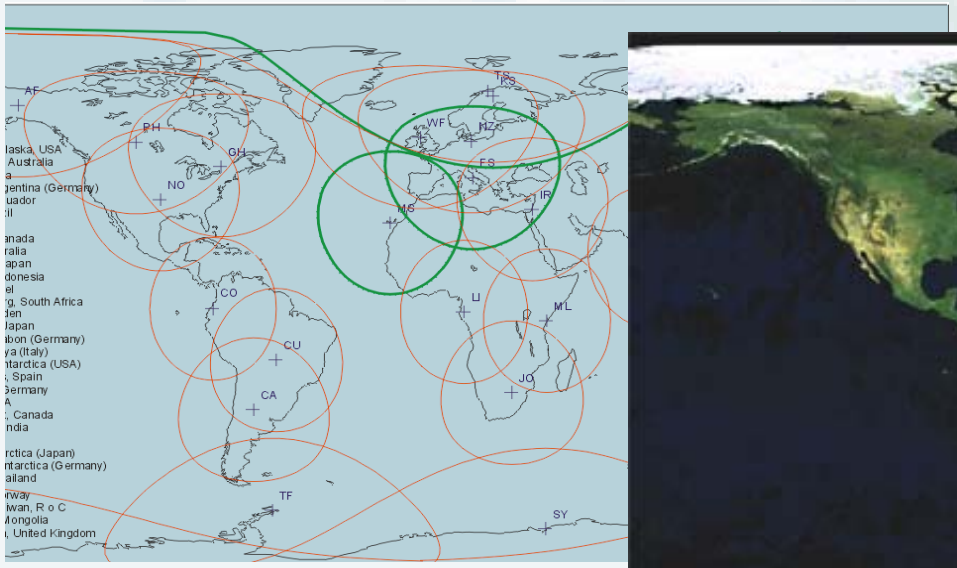
- ✓ **GMES, GEOSS, ESA and the Earth Science community**
- ✓ Earth Science Applications & requirements
- ✓ Grid Dev ents & Activities
- ✓ Conclusions & Future Wor

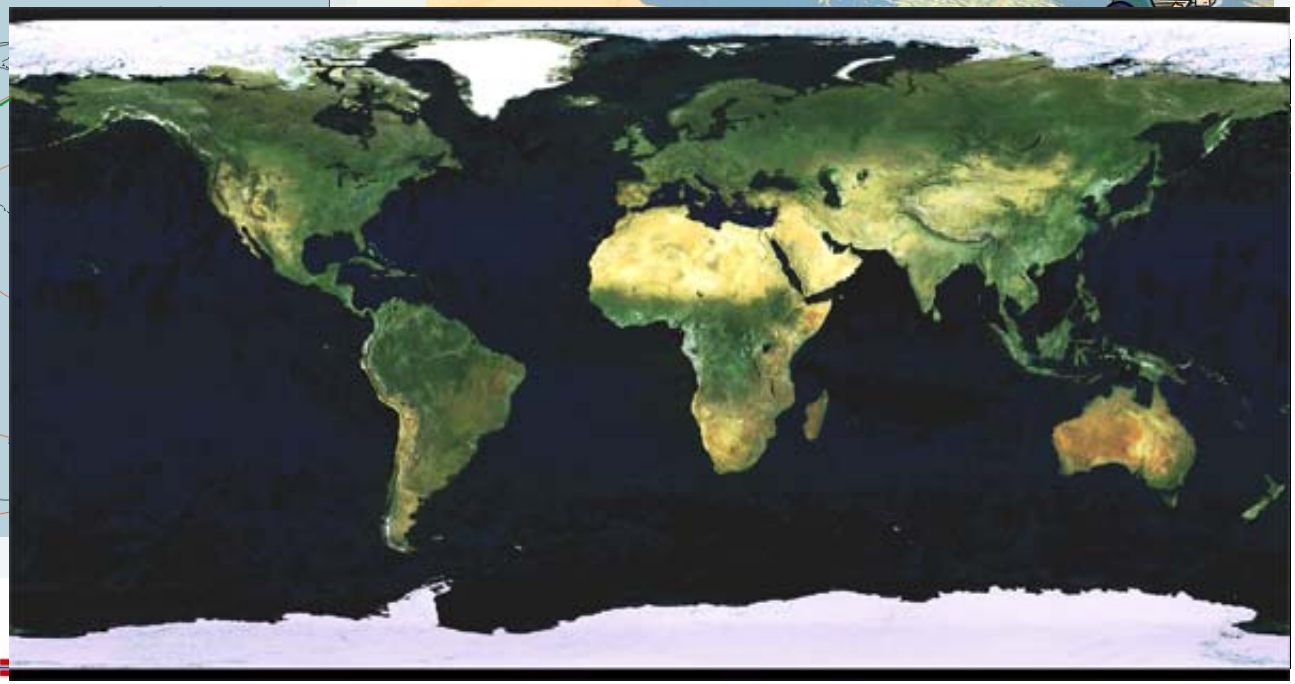
This presentation describes only the Earth Science Community!!

The Earth Observation scenario

- ✓ Wide distributed system environment:
  - ✓ multi-satellites
  - ✓ multi-facilities
- ✓ Large user community
  - ✓ multi-discipline
  - ✓ research, institutional, commercial and operational
  - ✓ Large international partnership







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GMES - the European initiative

Global Monitoring for Environment and Security

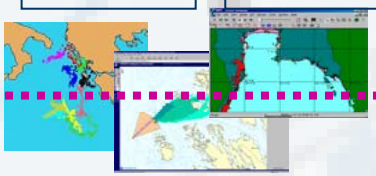
Governments, EU
International Organisations
Regulatory Bodies
Industry
General Public

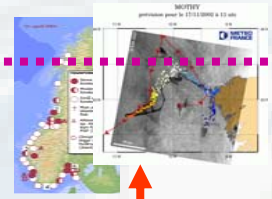
http://www.gmes.info

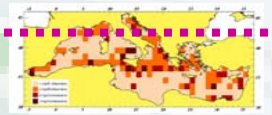
GMES Marine & coastal overall architecture

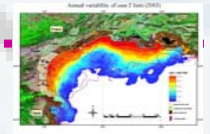
EMSA | EU DGs | EEA | Int'l conventions secretariats OSPAR, Helsinki, MAP

Coast guards | Port authorities | Coastal Environment managers | environment agencies | Health & safety agencies | Food/ fisheries agencies









Airborne surveillance operators

AIS

VDS

VTMS operators

Systematic monitoring and detection for ALERT

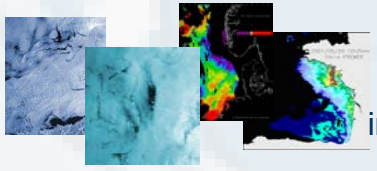
Decision support information

Reference DB administration

Coastal Management information

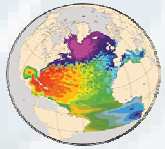
In-situ data collection networks

NRT radar imagery



NRT optical imagery

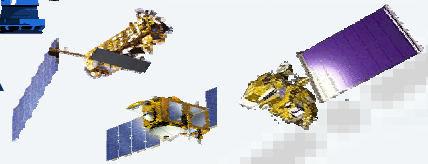
Meteo forecast



Ocean state forecast

GS operators

Satellite operators

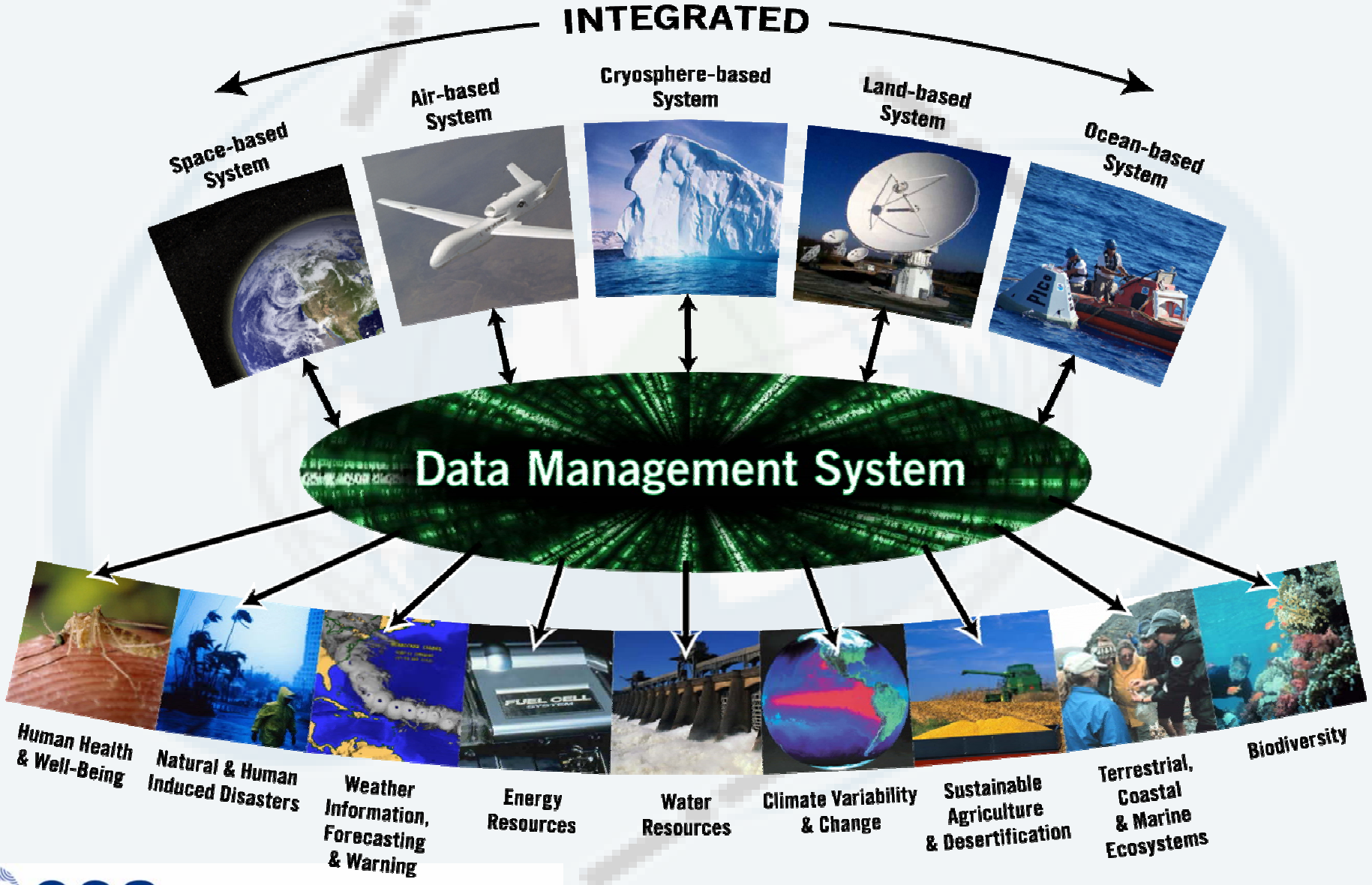


Meteo models operators

Ocean model operators

GEOSS - the wider view

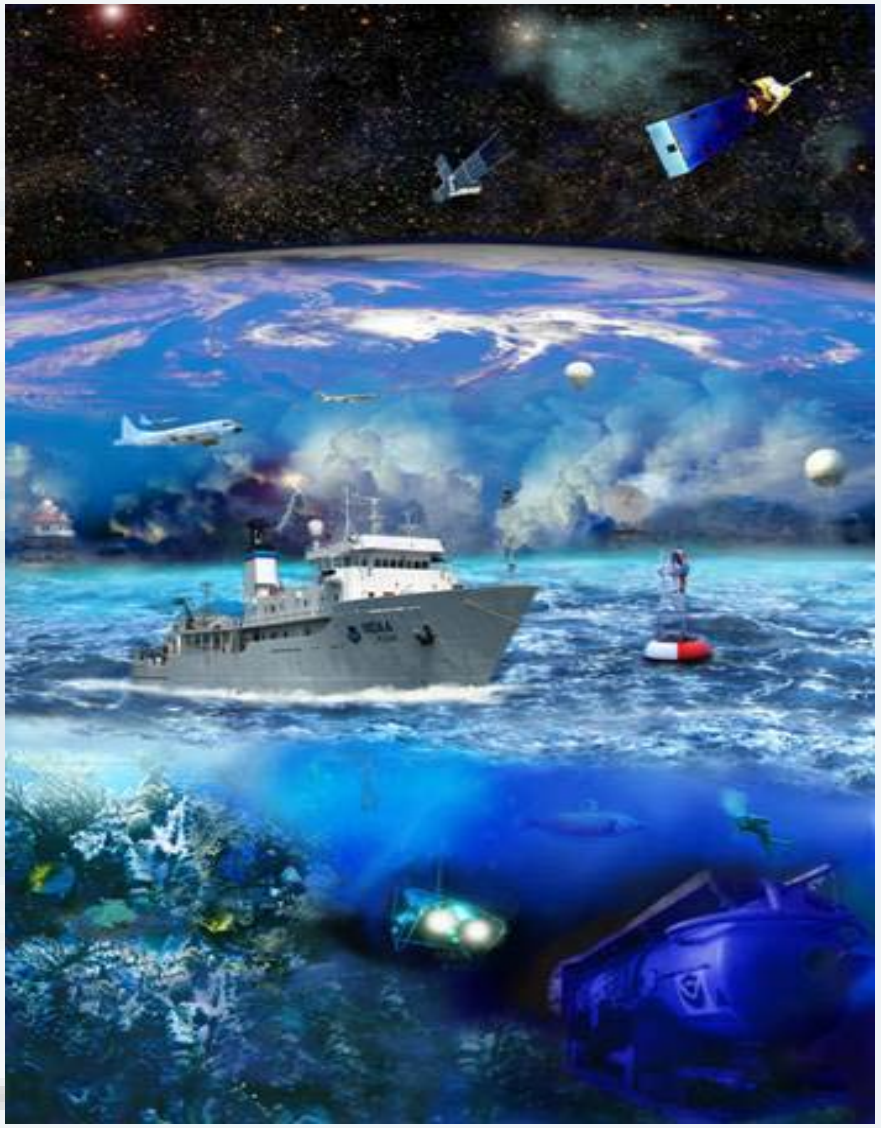
Global Earth Observation System of Systems



GEOSS: The Global Earth Observation Interoperability Framework

A distributed system of systems

- ✓ Improves coordination of strategies and observation systems
- ✓ Links all platforms: in situ, aircraft, and satellite networks
- ✓ Identifies gaps in our global capacity
- ✓ Facilitates exchange of data and information
- ✓ Improves decision-makers' abilities to address pressing policy issues



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Example of GEOSS interoperability plans

- **GEOSS implementation plan**
  - facilitate the development and availability of data, metadata and products (incl. base maps and common socio-economic data)
  - facilitate improved related data management approaches encompassing a broad perspective of the earth observation data life cycle, from input through data acquisition through processing and archiving, until dissemination of data and related products.

The role of CEOS

Committee on Earth Observation Satellites

- **CEOS:**
  - **Established by Space Agencies**
    - Some 20 years ago
    - Involving large International Earth Science programmes as users
- **CEOS WGISS:**
  - **Working Group on Information Systems and Services**
    - Active on Interoperability, GRID, Standards, Applications …
    - Task Teams members work together on the common issues
  - **Example of interoperability activities**
    - GCMD – Global Change Master Directory
    - CIP – Catalogue Interoperability Protocol
    - Open GIS Standards and WEB Services

CEOS

Committee on Earth Observation Satellites

Working Group on Information Systems and Services

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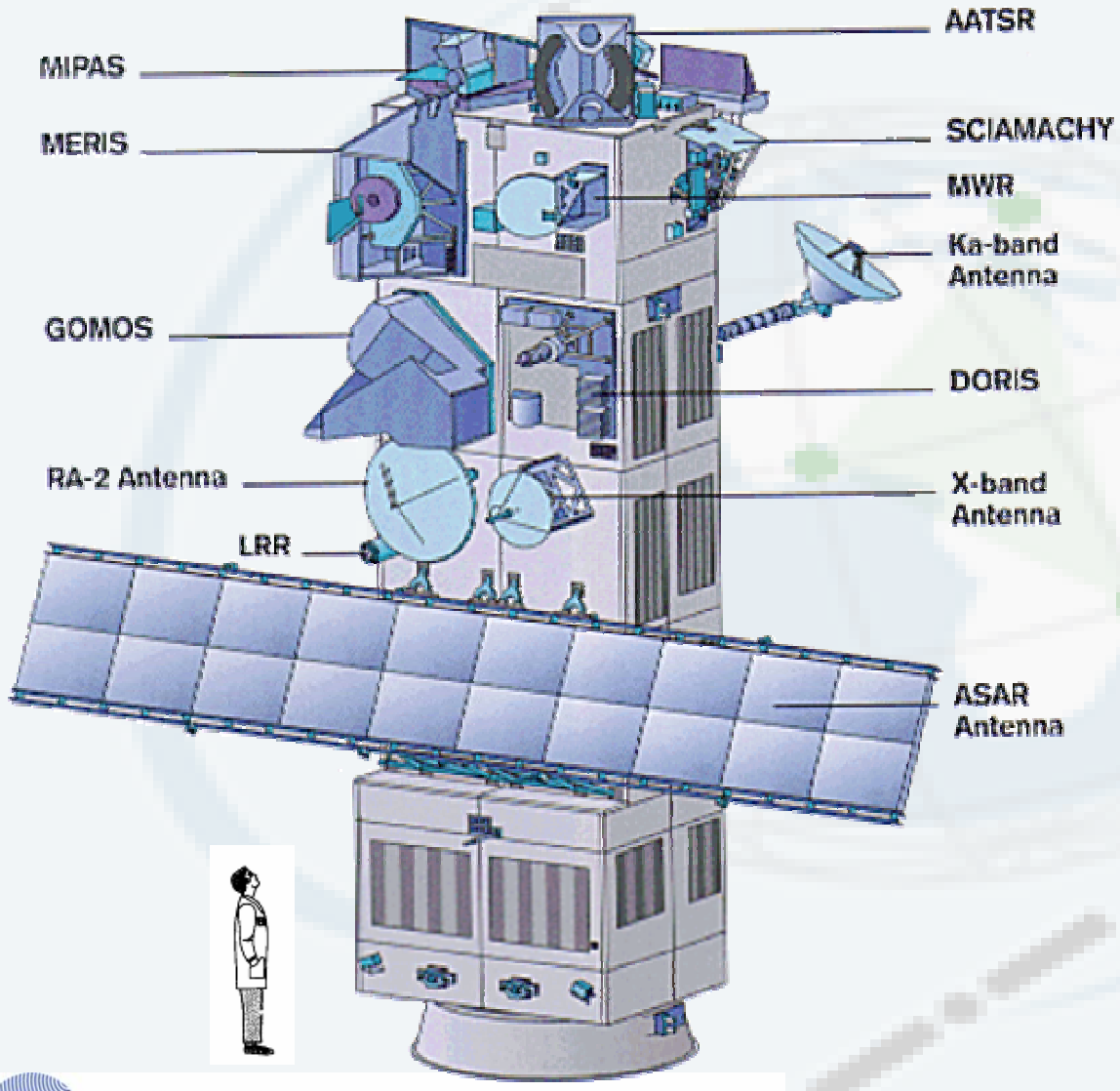
ENVISAT: the most complex civil satellite for monitoring the state of our planet



- ***Dimensions***
  Launch configuration:
  length 10.5 m
  envelope diameter 4.6 m
  In-Orbit configuration:
  26m x 10m x 5m

- ***Mass***
  Total satellite **8140 Kg**
  Payload 2050 Kg

- ***Power***
  Solar array power:
  6.5 kW (EOL)
  Average power demand:

	Sun (watts)	Eclipse (watts)
Payload	1700	1750
Satellite	3275	2870

- ***Orbit***
  800 km, sun synchronous 10:00 hours local

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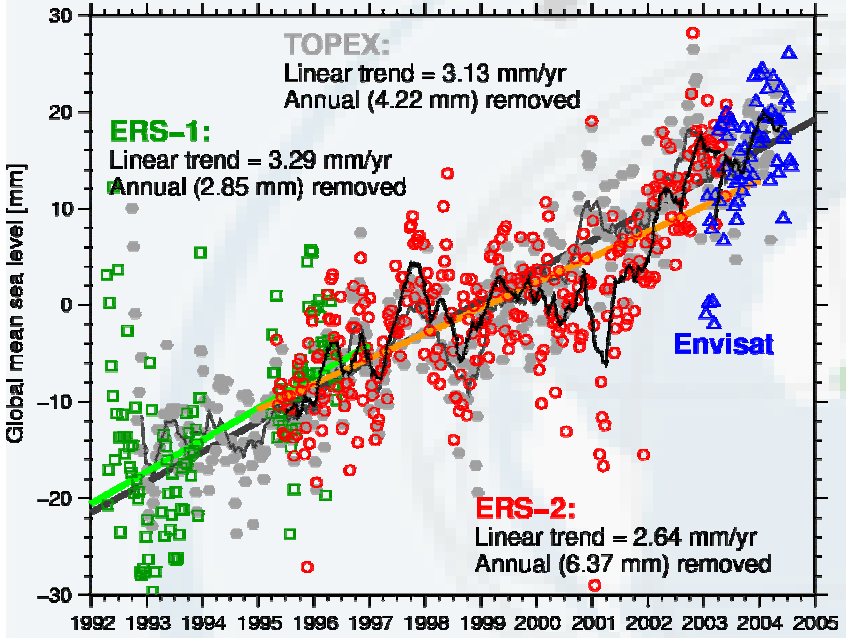
Envisat & Global Climate Change

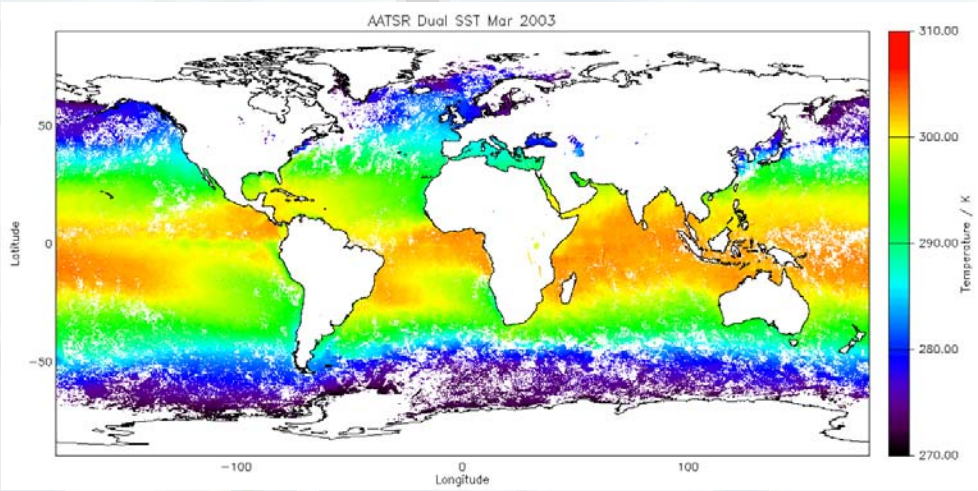
Sea Level rise



Altimetry measurements
Trend +3 mm/yr

Courtesy of Remko Scharroo, NOAA,US

Sea Surface temperature rise

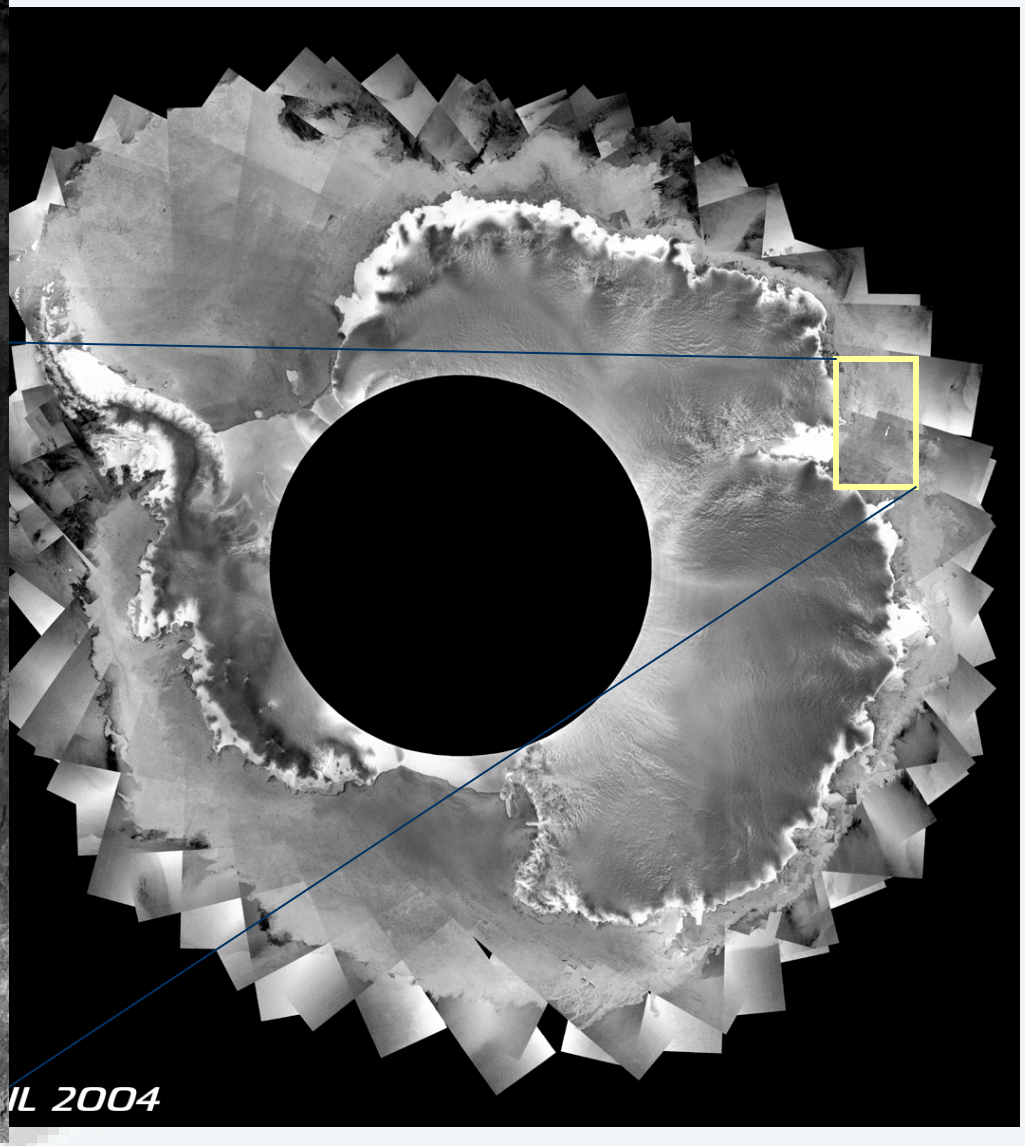


ATSR/AATSR measurements
Trend 0.13±0.03°C/decade

Courtesy of David Llewellyn Jones, Univ. Leicester, UK

Envisat & Ice-Sea Ice in Antarctica

Envisat Radar monitoring Antarctica Ice and Sea-Ice extent (April-to June 2004)



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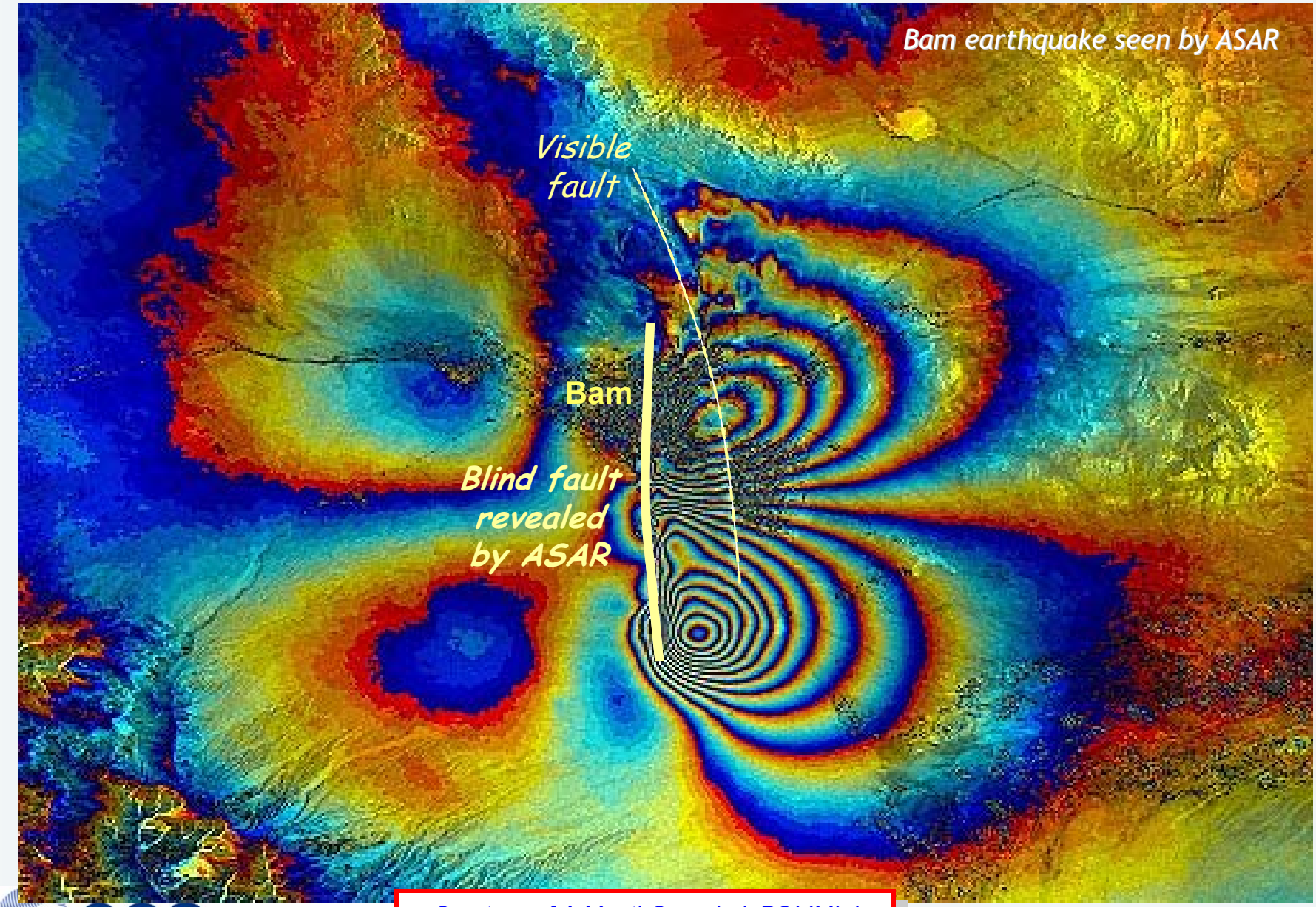
Envisat identifies blind Tectonic Faults



Courtesy of A.Monti-Guarnieri, POLIMI, I

The Breathing of ETNA

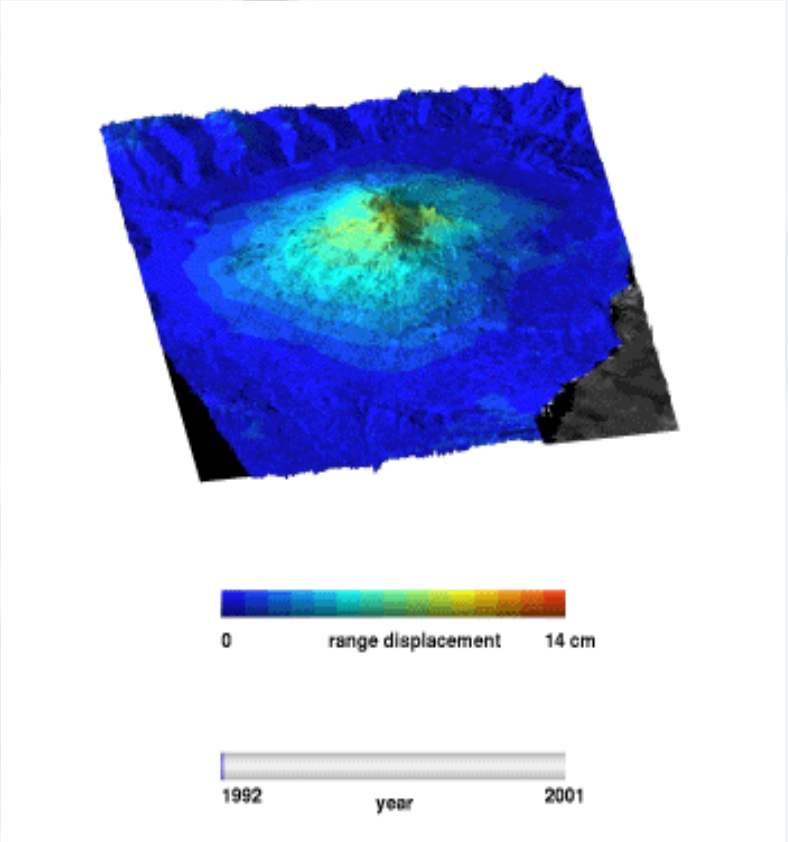
ERS SAR images spanning the period 1992-2000 have been used to reconstruct the line of sight deformations of Etna.

Inflation and deflation episodes are shown by changes in the color scale.

Work performed under
ESA Category-1 project 1127

PI Paul Lundgren JPL,USA

CoI Riccardo Lanari CNR Napoli, Italy



Envisat observations of Hurricane Frances

ASAR observes ocean roughness

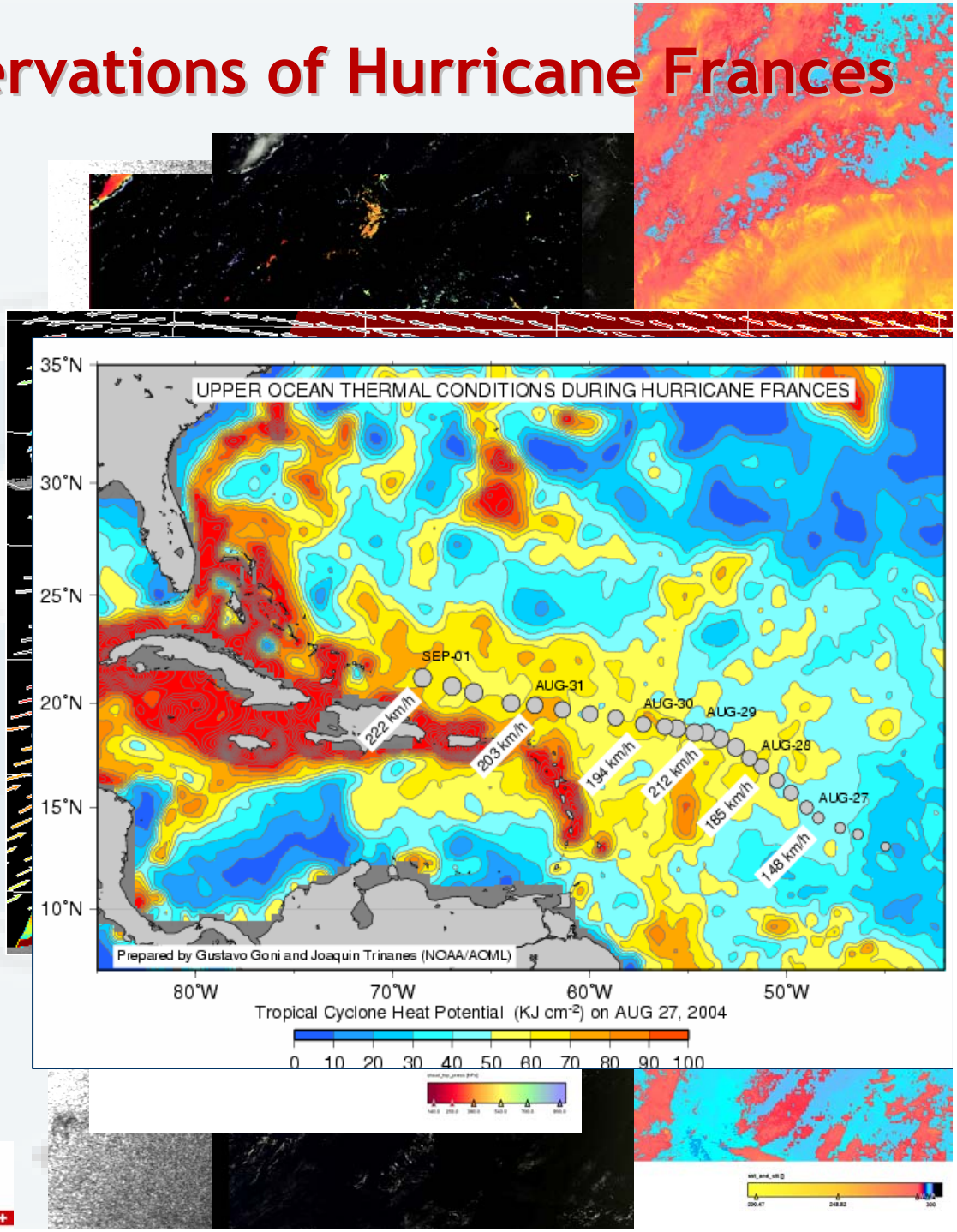
MERIS cloud view

AATSR Sea surface and cloud temperature

MERIS derived cloud top pressure

Wind speed from ASAR

RA2 used in models to derive heat potential



Outline

- ✓ GMES, GEOSS, ESA and the Earth Science community
- ✓ **Earth Science Applications & requirements**
- ✓ Grid Developments & Activities
- ✓ Conclusions & Future Work

Earth Science Issues & general requirements

- Global, regional, local applications
  - Alternative use of the data at different resolution
- Large historical distributed archives
  - Long term data and knowledge preservation issues
- Near real time access to data
  - For processing, value adding and dissemination
- Integration with models to provide forecast
  - Data assimilation
- Need to integrate different data sources
  - Standardisation, Virtual Organisation, …

Earth Science & emerging technologies

- **GRID has large potential**
  - Common environment for data access and processing (Move algorithms to data)
  - Integration of **user tools** - dynamically create high level products
  - Ease reprocessing of large historical archives (e.g. ENVISAT)
  - **e-collaboration** environment
  - Allow more complex applications (data assimilation, fusion/mining, modelling …)
  - Support for industry and SME competitiveness
- **Earth Science Research e-infrastructure**
  - Across national centres and facilities (thematic)
  - new cooperation paradigm for science application (European Research Area)
- **When?**
  - Step-wise approach, need stability, security, …
  - Build confidence in operational people

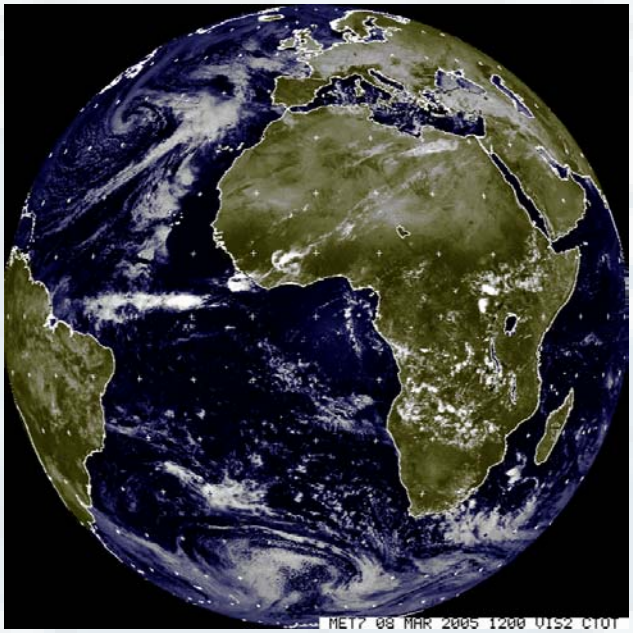
EGEE Earth Science Community

Earth Observations by Satellite

Seismology

Hydrology

Climate



Geosciences

Meteorology, Pollution…

Mars upper atmosphere…..

EGEE Earth Science Community

- Earth Science Research Virtual Organization
- Ongoing since 2000 in Eu-DataGrid
- Large experience gathered on gridification & deployment of Grid applications
- Requirements gathering, middleware testing and feedback
  - To science community
  - To middleware & infrastructure developers
- Ongoing dissemination to new ES communities
  - Increasing Grid awareness and usage needed for critical mass

Community Specific EGEE Requirements

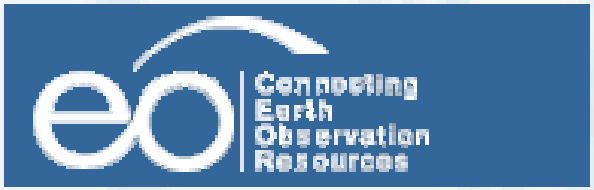
- ✓ Secure and controlled access to data and metadata: on going with gLite
- ✓ Filtered access to license server
- ✓ Natural risk for prediction and analysis needs many CPUs (>100) without reservation.
- ✓ MPI: many simulation and model need MPI
- ✓ Accounting
- ✓ Web service: on going with gLite
- ✓ Difficulty to add resources to EGEE
- ✓ Different platform : Sun Grid Engine batch queue system

DILIGENT: Digital Library on GRID

- Digital Library (DL) technology
  - A DL is seen as a bunch of functions and services, including storage, discovery, retrieval, and conservation of data.
  - DLs are seen as an essential element for communication and collaboration among scientists and disciplines:
    - data management, info retrieval, library sciences,
    - info systems, the web,
    - human-computer interaction…

Present DL limits and examples

- DLs have collections which
  - are large, and persist over time, are well organised and managed, contain many formats, contain digital objects
- Most DLs however,
  - run in a single organisation,
  - handling textual and limited multimedia documents
- Examples



Diligent

will overcome these limits!

Diligent

DILIGENT:
an opportunity for Earth Science

- DILIGENT intends to develop the DL environment over a GRID infrastructure
- At present many efforts have been made in providing Earth System related material (satellite products, forecast models, specific applications and tools) to a wide range of users. *Earth System related digital libraries* as Alexandria and DLESE are already in operation, as well as several applications and tools able to process Earth Observation data or to provide e-learning facilities
- What these systems still lack are:
  - the availability of the computing power of a Grid
  - workspaces where users can put/publish their work results (i.e. retrievals from searches, ad-hoc processing, reports)

Diligent

One DILIGENT User Community:
Implementing Environmental Conventions

- ✓ **The 21 Coastal States of the Mediterranean Sea and EU**
- ✓ **Ministries of Environment** and selected European **coast-guard** offices;
- ✓ **ITOPF**, International Tanker Owners Pollution Fed. Ltd. and MOIG, Mediterranean Oil Industry Group;
- ✓ **ICRAM**, Central Institute for scientific and technological Research Applied to the Sea
- ✓ **WWF**
- ✓ **REMPEC**
- ✓ **UNESCO-IOC**
- ✓ Many science partners

REMPEC

ICRAM
Istituto Centrale
per la Ricerca scientifica
e tecnologica

esa

Diligent

ESA & the Environmental Conventions

Important stakeholder of GMES are the International Environmental Organisations

- ✓ **ESA supports:**
  - ✓ World Heritage Convention;
  - ✓ Ramsar Convention on Wetlands;
  - ✓ UNCCD (desertification)
  - ✓ UNFCCC (forest, global change)
  - ✓ **Barcelona Convention (Med sea)**
  - ✓ …
- ✓ **ESA contributes to events:**
  - ✓ World Summit, Johannesburg, SA, 2002;
  - ✓ COP 8 of the UNFCCC, New Delhi, India, 2002;
  - ✓ COP 8 of the Ramsar Convention, Valencia, Spain, 2002;
  - ✓ ….

DILIGENT
selected test case

esa

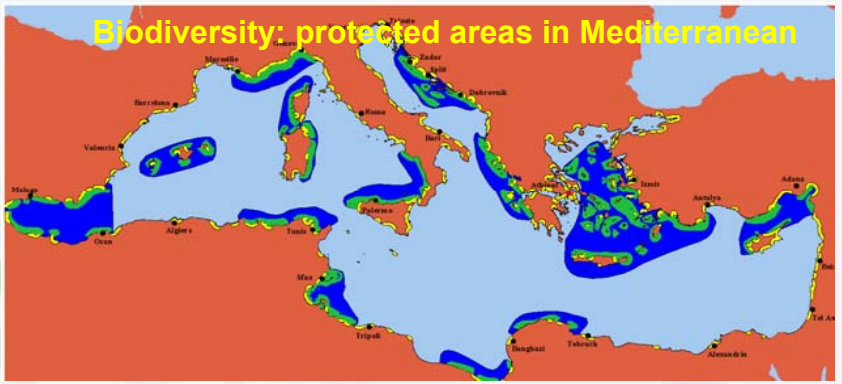
Issues in Barcelona Convention

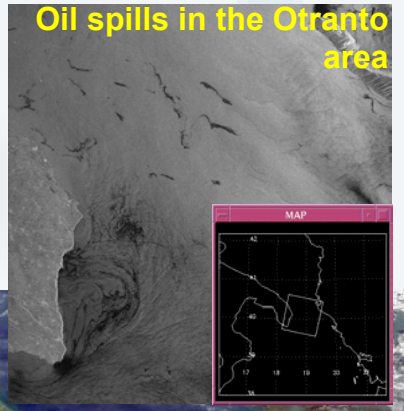
User community tasks:

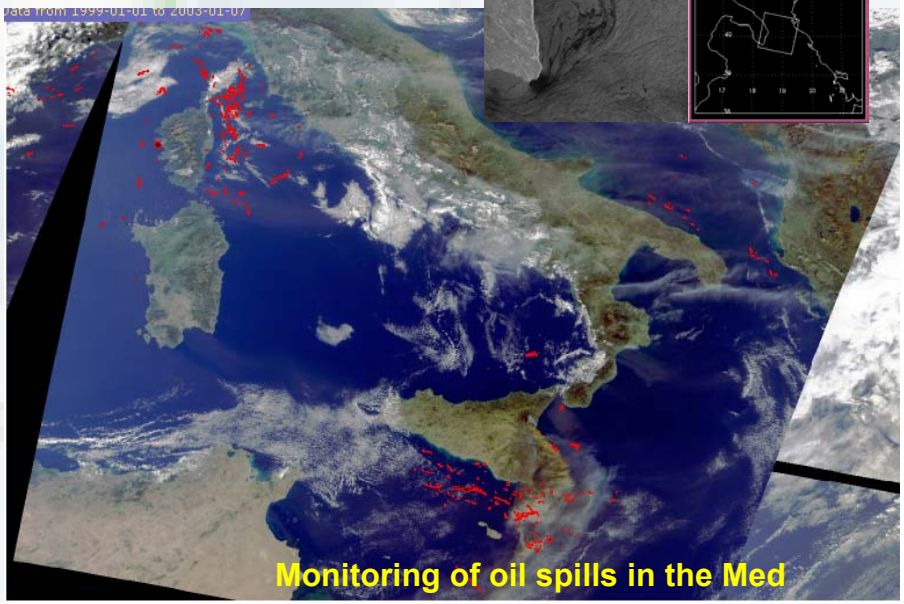
- ✓ Environmental Impact Assessment Studies
  - ✓ coastal environmental protection …
- ✓ Reporting-activities
  - ✓ Periodical review of status (countries), Oil and chemical pollution, accidents at sea …
- ✓ Adoption and formulation of Med Sea protocols
  - ✓ Sharing objectives
  - ✓ Definition of common standards, dissemination

DILIGENT challenges:

- ✓ How to support this community







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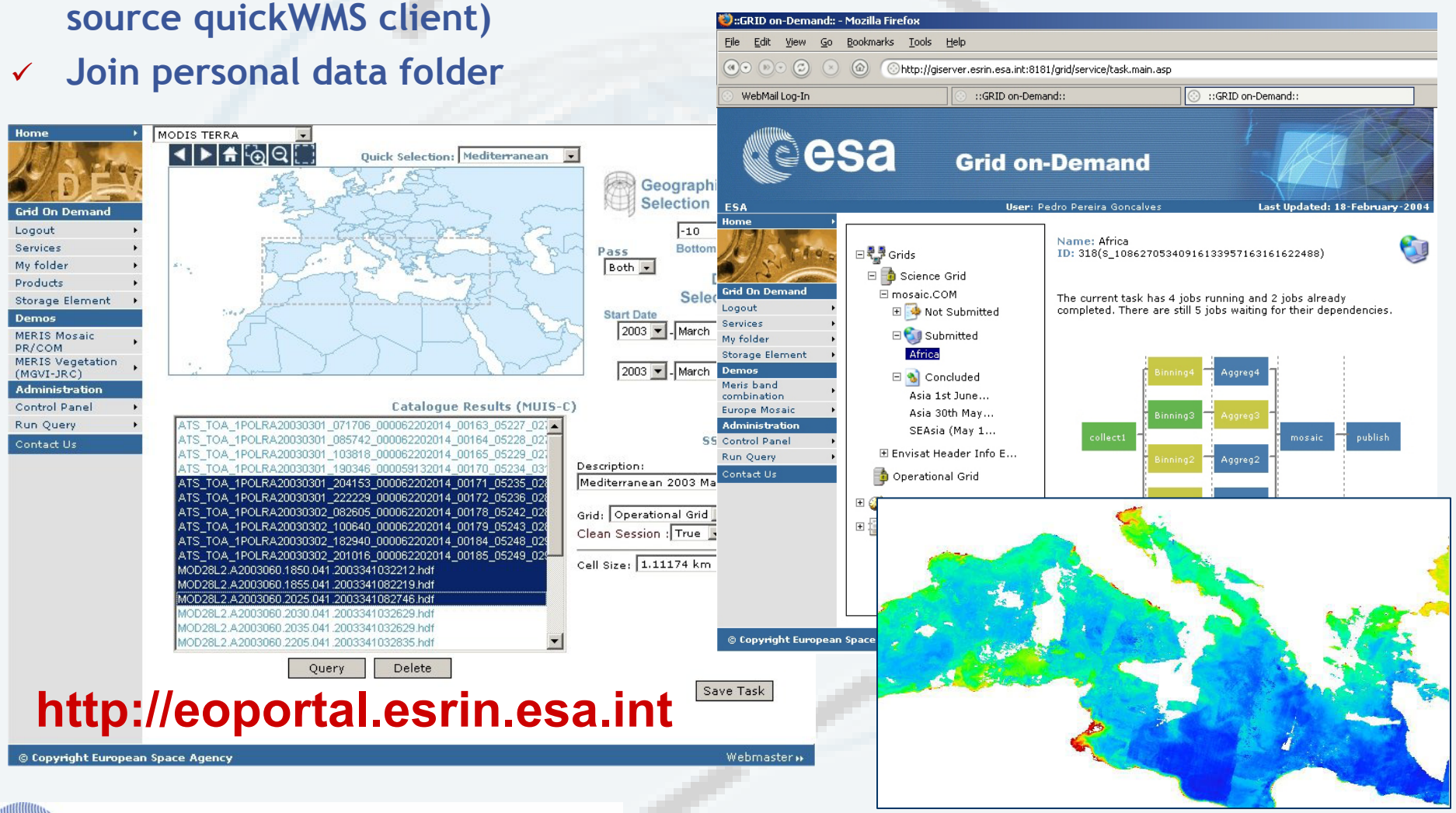
Earth Science in EGEE / LCG

- Building on EU-Datagrid experiences & infrastructure
- ESR Virtual Organization (Earth Science Research)
  - 30 persons from Science & Industry in 8 countries
  - 1,153 CPUS distributed in 12 sites
- Earth Observation: validation of the whole dataset (time and space) and several algorithms
- Seismology and Hydrology: possibility to fulfill in real or quasi real time the Civil Society requests.
- Seismology: example of prediction on alert
- Geocluster: initiative R&D de la Compagnie Générale de Géophysique – nearly completely ported
- Success rate (90-100%) – cf Earth Observation
- Interactive Collaboration of the teams around a project

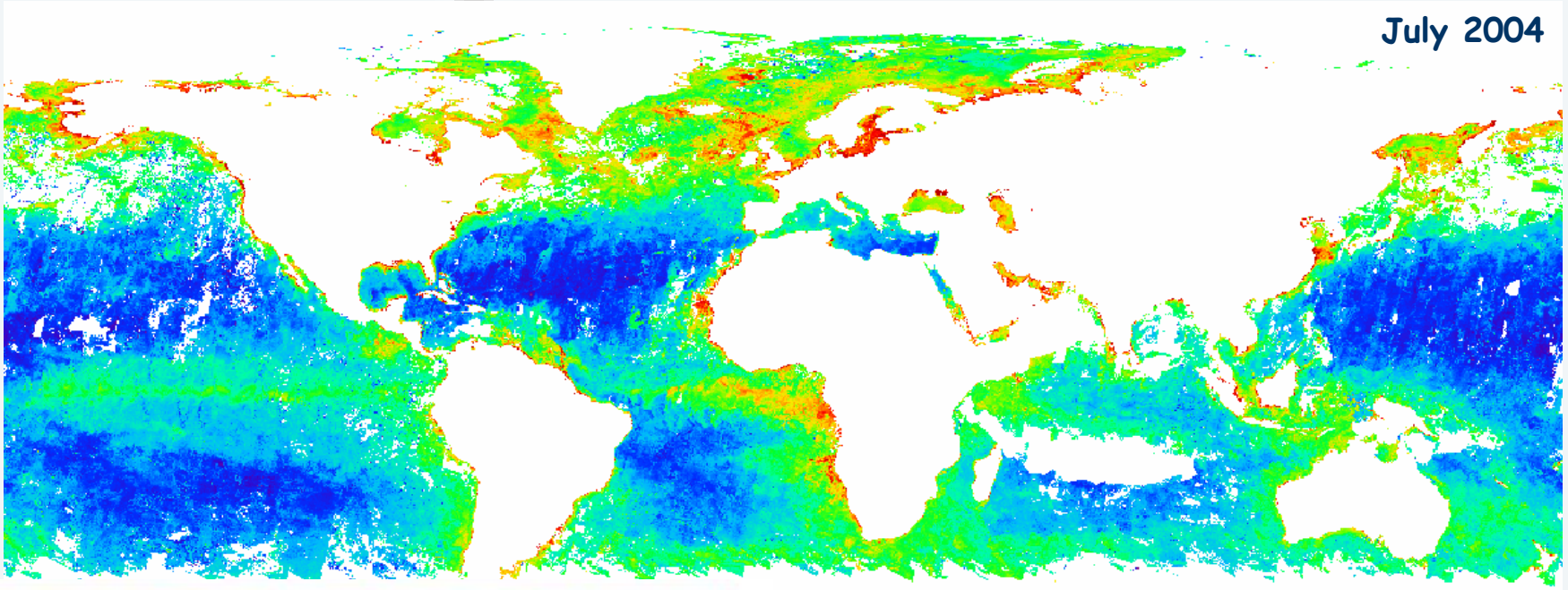
ESA Portal for Earth Science Grid Services

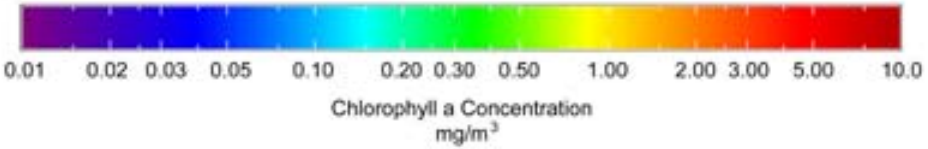
- ✓ Job selection, chaining, launching and live status
- ✓ Direct result visualization in WMS (using open source quickWMS client)
- ✓ Join personal data folder



http://eoportal.esrin.esa.int

Chlorophyll BEAM processing on ESA GRID





Input Data:

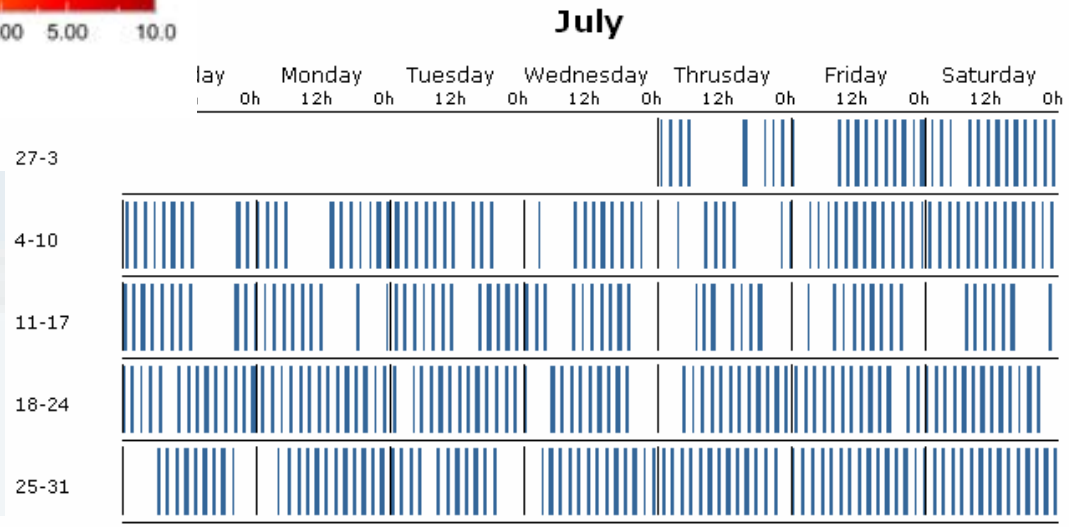
178.92 Gb in 1828 files

Output Files:

700 Kb (JPEG)

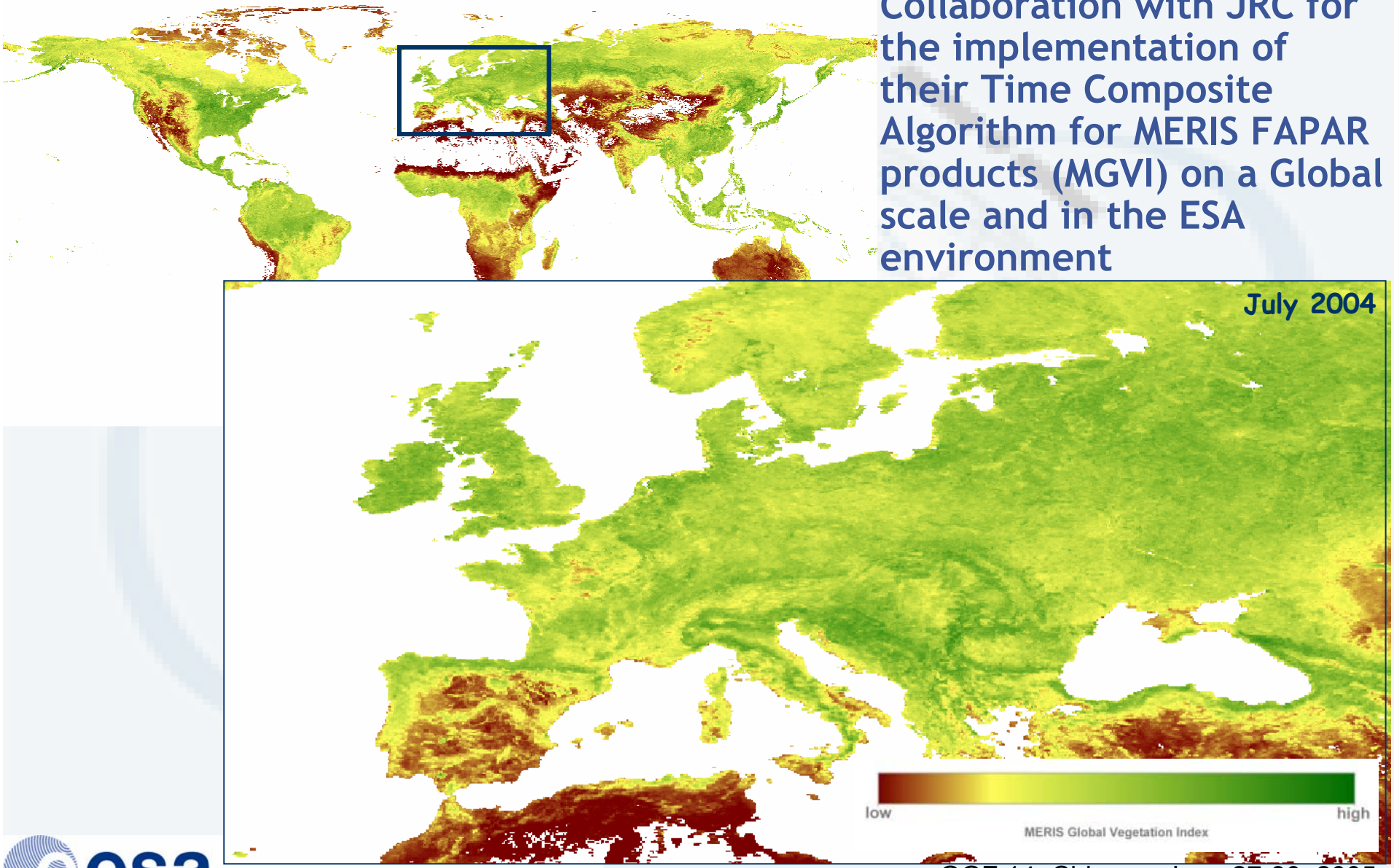
28 Mb (TIFF)

36 Mb (DIM-MAP)



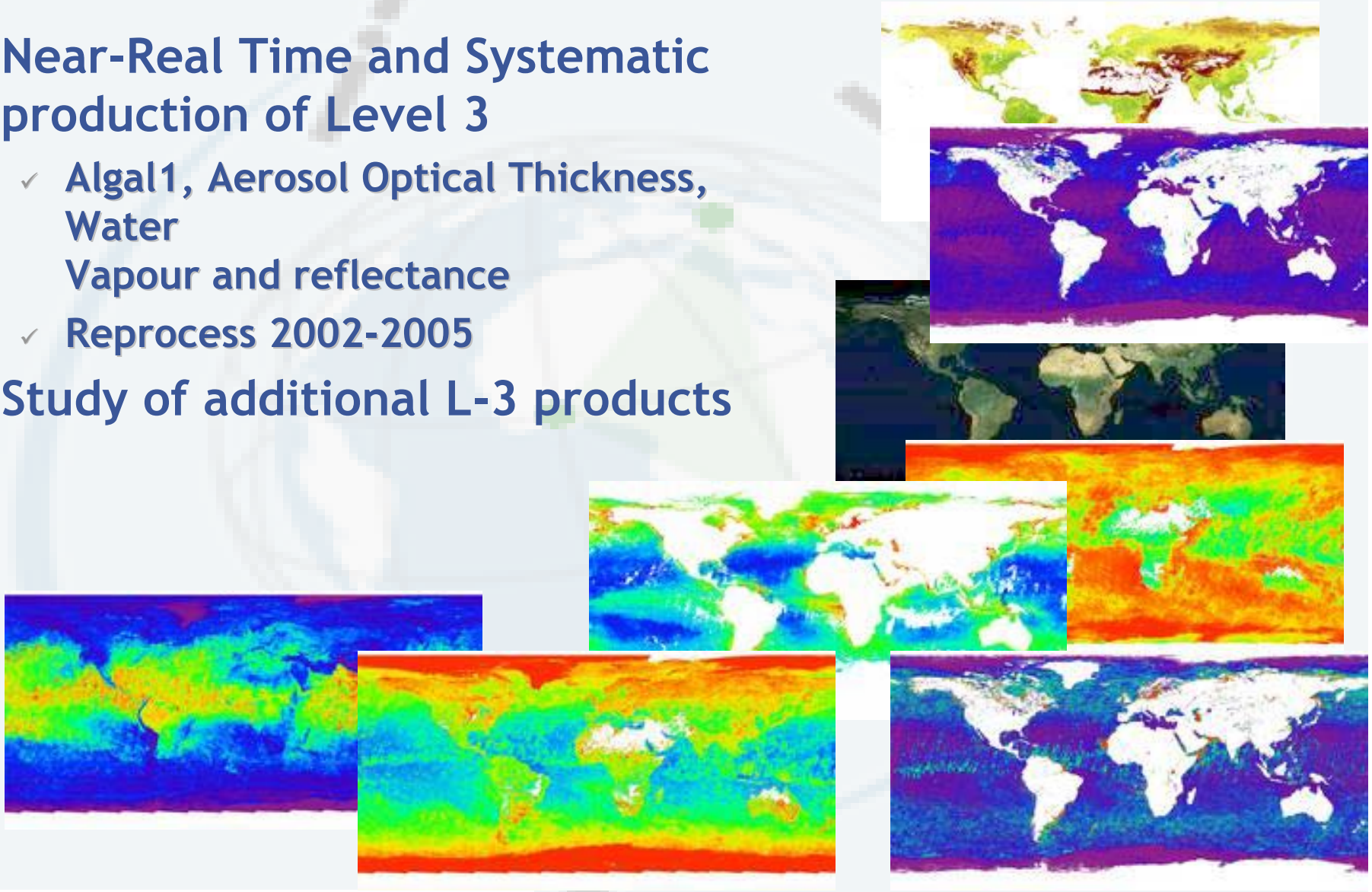
MERIS MGVI: support to new science

Collaboration with JRC for the implementation of their Time Composite Algorithm for MERIS FAPAR products (MGVI) on a Global scale and in the ESA environment



GRID Support to MERIS Level 3 reprocessing

- ✓ Near-Real Time and Systematic production of Level 3
  - ✓ Algal1, Aerosol Optical Thickness, Water
    Vapour and reflectance
  - ✓ Reprocess 2002-2005
- ✓ Study of additional L-3 products



ESA e-collaboration environment

based on "The VOICE" project

- e-collaboration platform - interoperability at 3 levels:
  - Communication layer
  - Infrastructure for sharing of data/tools
  - Collaboration at application environment
- Based on Virtual Organisation for:
  - the science and /or the industry communities
- Technologies of interests:
  - The Internet and improved communication
  - Sensor Web, Wireless Technologies, Web-Services, Grid
  - Semantic Technologies and Ontologies
  - Workflow Management Technologies
  - Virtual Reality or Augmented Reality
  - Standards (eg OGC, W3C) … and more

Example of e-collaboration

GMES Prototype multi-tiered Architecture

Client Tier

Browser

Web Tier

GMES prototype Web Application

E-collaboration layers

WMS

WFS

GMES Business Logic

Security

Email service

Other Environment services

Service Tier

Map Data

GIS Layers

Catalogue

Data metadata

Persistence Tier

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Perspectives & Added Values

- EGEE is a truly Global infrastructure reaching beyond Europe
- EGEE working groups benefit from a large international collaboration effort
- Several successful applications have shown that EGEE testbed works
- The high success rate of LCG2 has increased confidence and more applications are being ported on EGEE
- New gLite middleware is expected to provide ES users with vital functionalities that were missing in LCG2
  - migration to gLite : critical to ensure stability and continuity for the production testbed
- Continued support of EGEE needed to ensure ESR users & applications will increase in future

New Applications to be ported

- ✓ Direct Monte Carlo simulation of non thermal sources of hot oxygen in the upper atmosphere of Mars (IPSL): long job (48-60h)
- ✓ Data mining on meteorological data NCEP
- ✓ Space Physics Interactive Data Resource (SPIDR)
- ✓ Institute of Computational Mathematics and Mathematical Geophysics Russian Academy of Sciences, Novosibirsk : projet nwo-grid
- ✓ Large scale air pollution model on EGEE, for evaluation of the concentrations of a large variety of chemical species, responsible for the air pollution
- ✓ Geant4(HEP) under study for earth and planet atmosphere (IPSL)
- ✓ Earthcare : simulation of physical radiative transfer from satellite observations