Global Monitoring for Environment and Security (GMES)

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EOP/GS

Prague, 20 March 2009
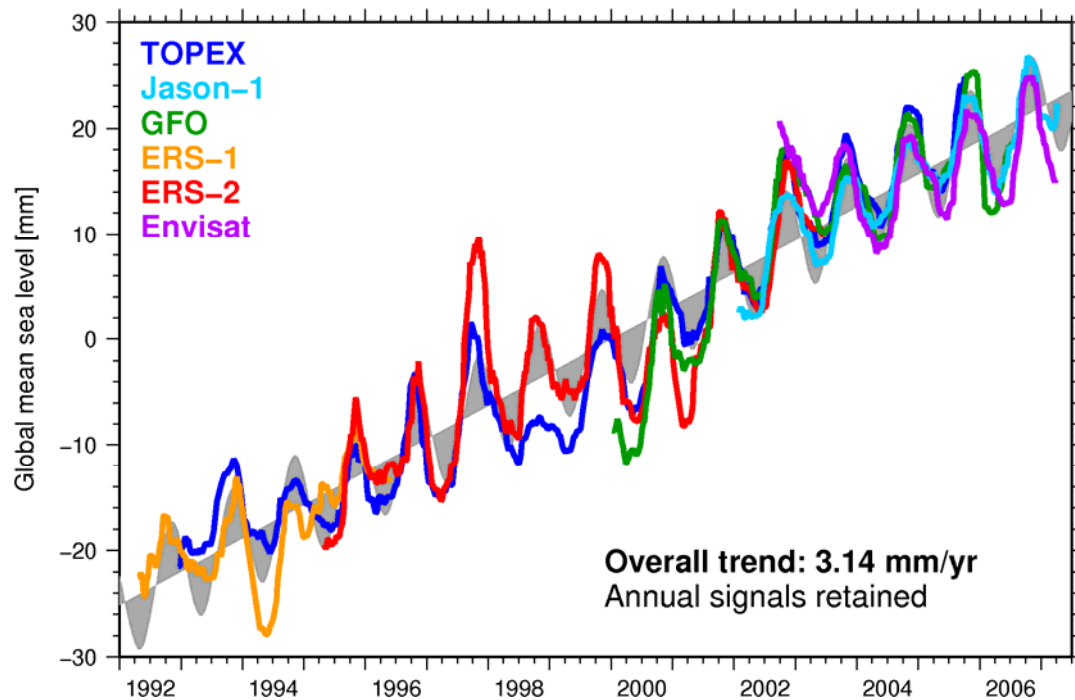

Goal of GMES

GMES aims at developing operational services,
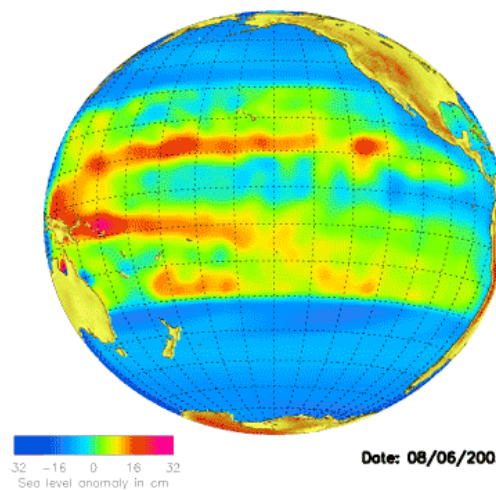
… following the example of meteorology…

… but for other domains such as emergency management, air quality monitoring, land monitoring, ocean & sea ice monitoring, etc.

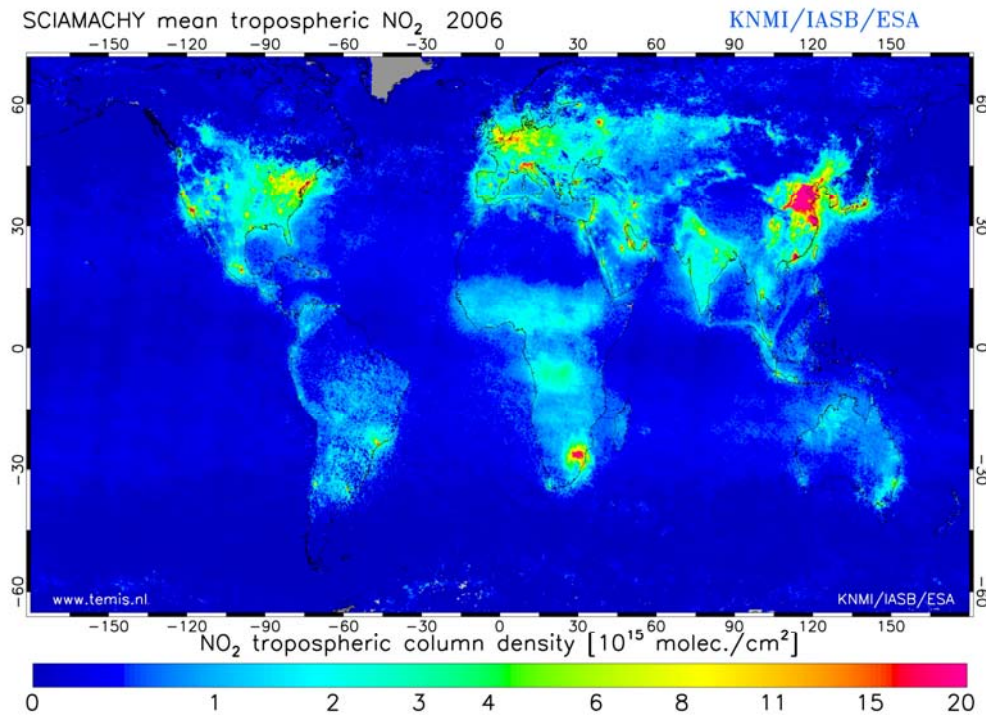**Science needed to create and continuously improve operational services**

Global sea level change from ERS-1, ERS-2 , ENVISAT altimetry
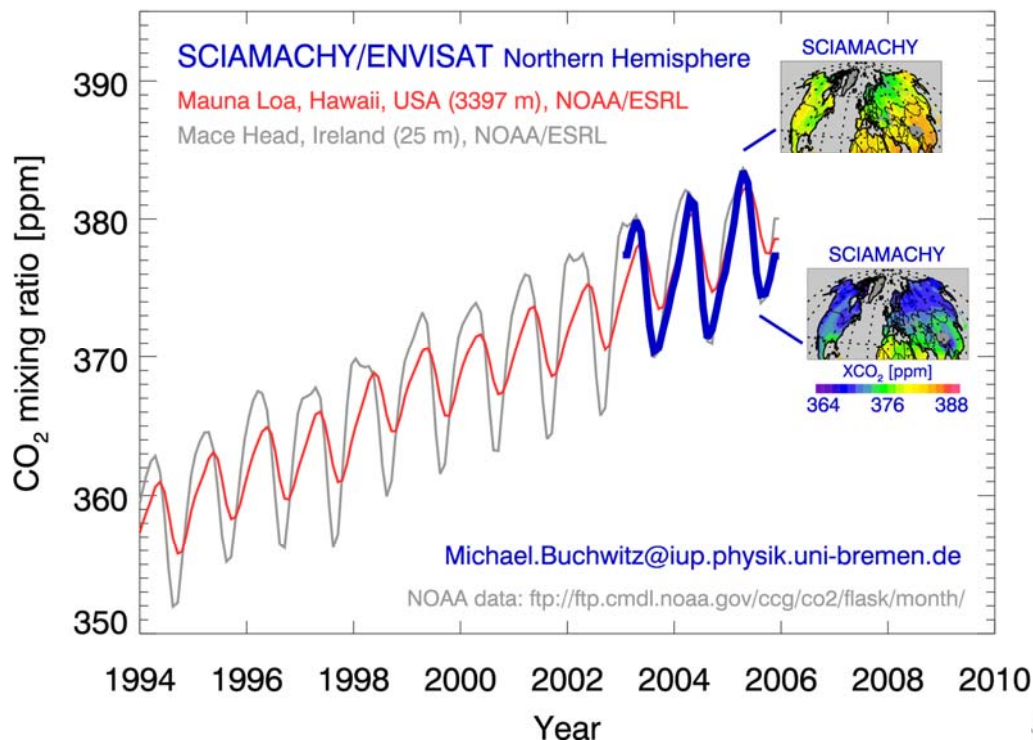*Courtesy of Remko Scharroo Altimetrics LLC, Cornish, NH*

El Niño Southern Oscillation (ENSO) ocean-atmosphere phenomenon from ERS-1, ERS-2 , ENVISAT sea level and sea surface temperature measures
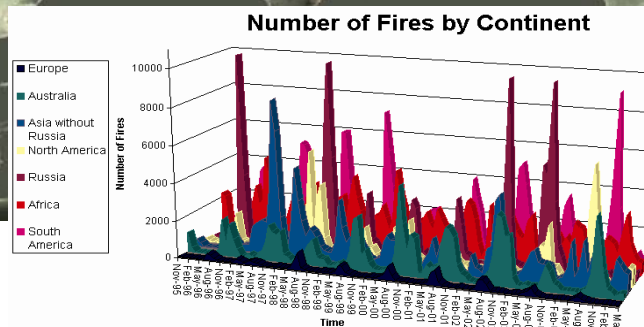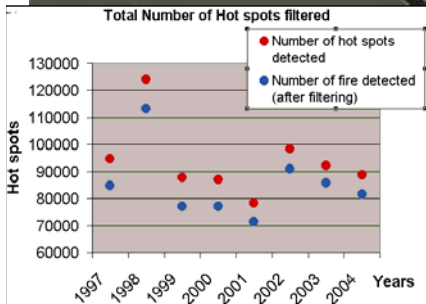*Credits: Delft University, NL and ESA/ESRIN*

SCIAMACHY mean tropospheric NO₂ 2006   KNMI/IASB/ESA

www.temis.nl   KNMI/IASB/ESA

NO₂ tropospheric column density [10¹⁵ molec./cm²]

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eesa   SCIAMACHY CO2 columns

Atmospheric Carbon Dioxide
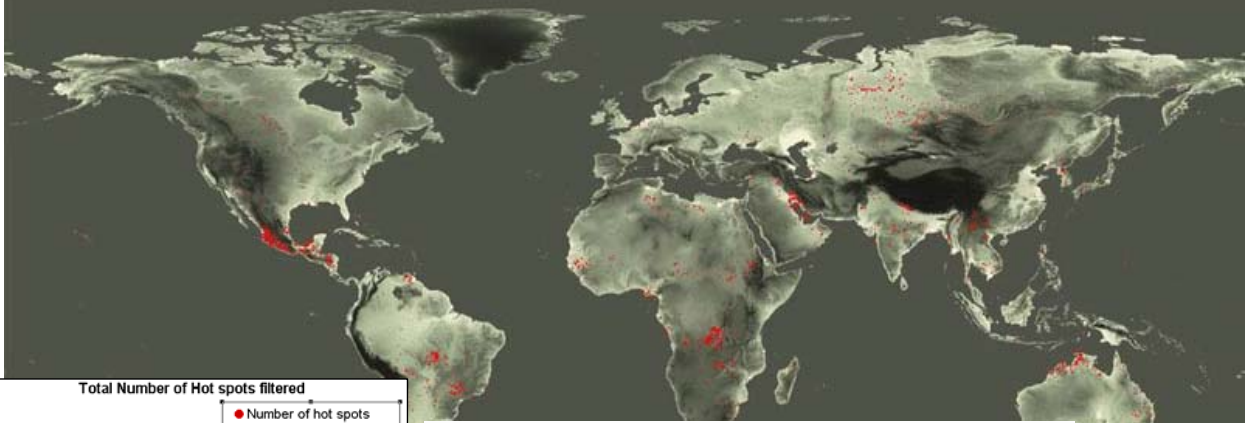
SCIAMACHY/ENVISAT Northern Hemisphere   SCIAMACHY
Mauna Loa, Hawaii, USA (3397 m), NOAA/ESRL
Mace Head, Ireland (25 m), NOAA/ESRL

CO₂ mixing ratio [ppm]

SCIAMACHY

XCO₂ [ppm]
364   376   388

Michael.Buchwitz@iup.physik.uni-bremen.de

NOAA data: ftp://ftp.cmdl.noaa.gov/ccg/co2/flask/month/

Year

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15 years global fires monitoring

Oil spill monitoring

January   1999

LAI

0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96 100
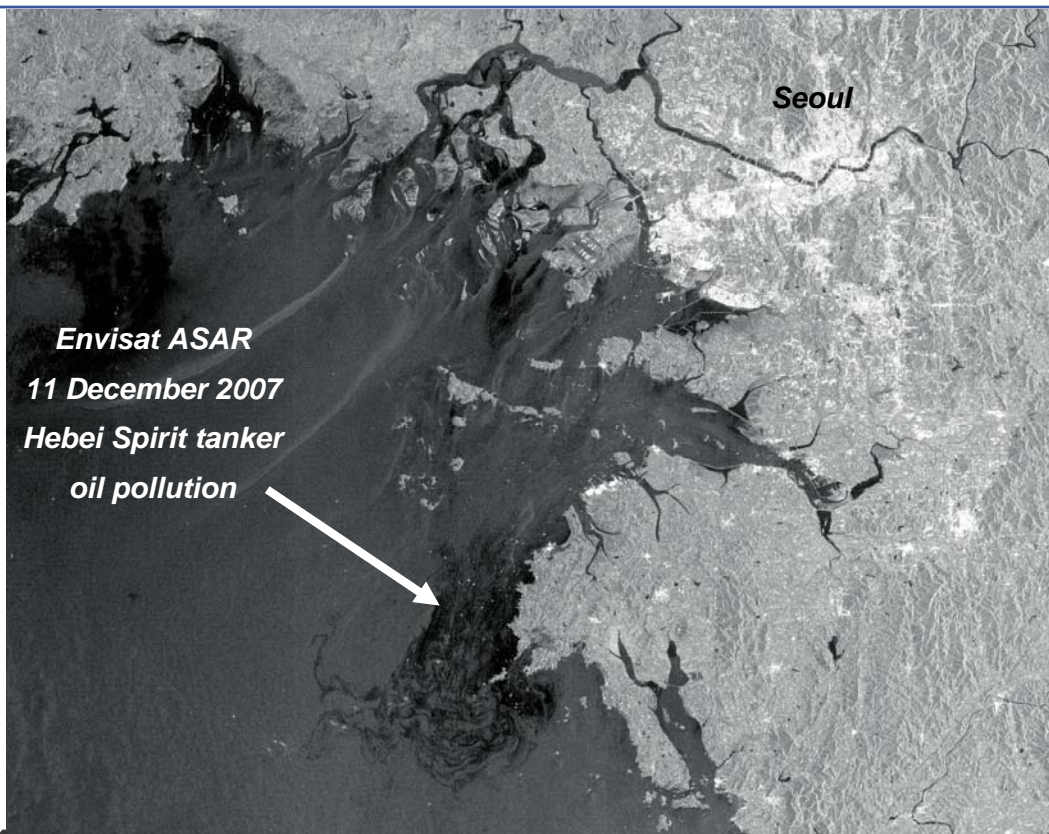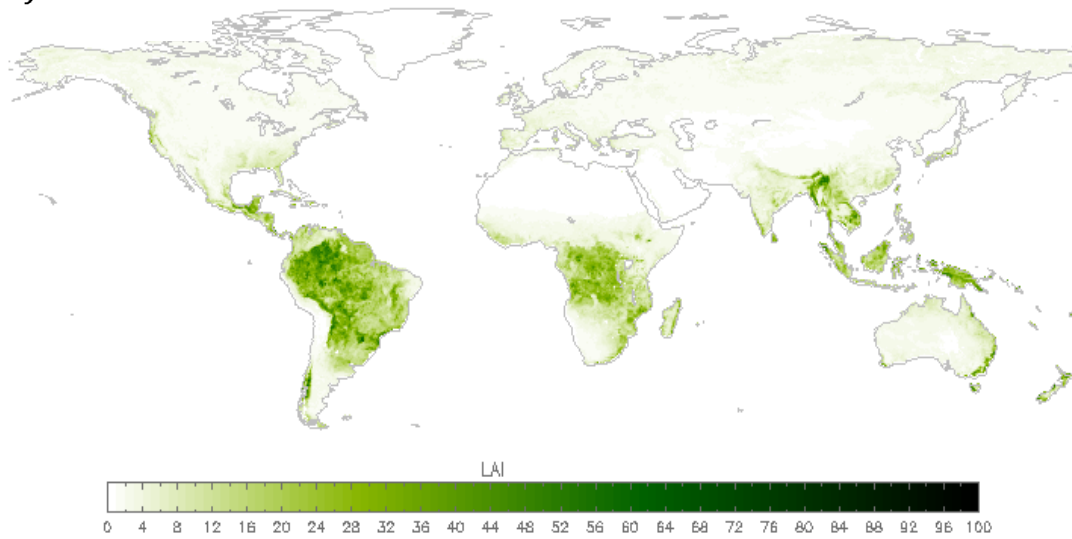
4 years 1999 to 2002 measurements with ATSR-2, AATSR, MERIS, VEGETATION
Courtesy of Deng, F. et al , 2006, **Algorithm for global leaf area index retrieval using satellite imagery,**
IEEE Transactions on Geoscience and Remote Sensing, 44(8), 2219-2229.

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Lowest Arctic ice coverage in history

Northwest Passage open (orange line) and Northeast passage only partially blocked (blue line)

Dark grey represents ice-free areas, green represents areas with sea ice

Envisat ASAR
mosaic 09/2007

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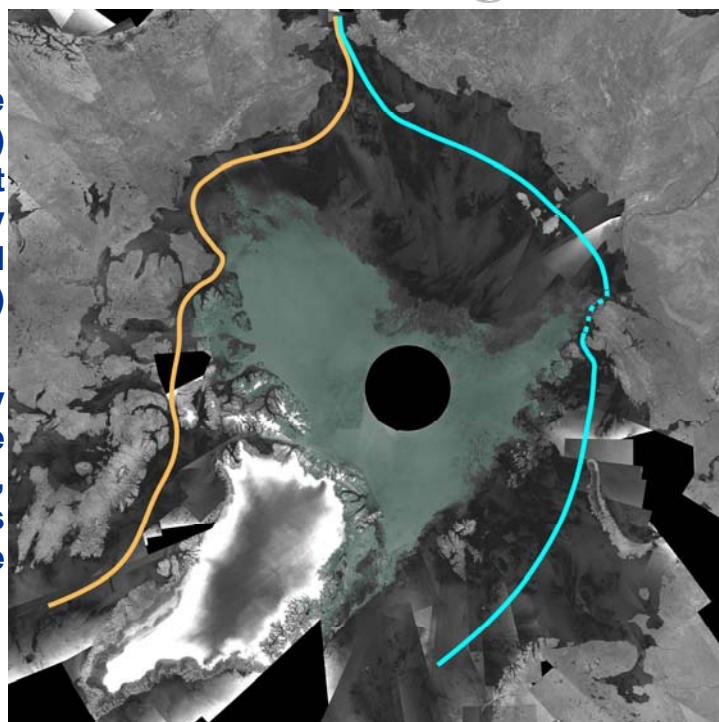
1998	**Initiation of GMES, Baveno Manifesto**
2000	**Gothenburg EU Summit "establish by 2008 an operational European capacity for … GMES"**
2001+	**Investments by ESA and EC on services**
2005	**EU initiates "Fast-track" services; GMES becomes 'flagship'** **ESA C-MIN in Berlin funds Phase-1 of GSC programme**
2007	**ESA Phase-2 approved**
2008	**EC-ESA agreement on GMES signed** **EC Fast-Track services to become operational** **ESA C-MIN in November - GSC Segment-2**
2011+	**Launch of first GMES Sentinels**

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Services Component

- Produces information services in response to European policy priorities in environment and security
- Relies on data from in-situ and space component

In-situ component

- Mostly of national responsibility, with coordination at European level

Space Component

- EO missions developed specifically for GMES (Sentinels)
- EO missions built for purposes other than GMES but offering part of their capacity to GMES (EU/ESA MSs, EUMETSAT, commercial, international)

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Services Component

- Produces information services in response to European policy priorities in environment and security

- Relies on data from in-situ and space component

In-situ component

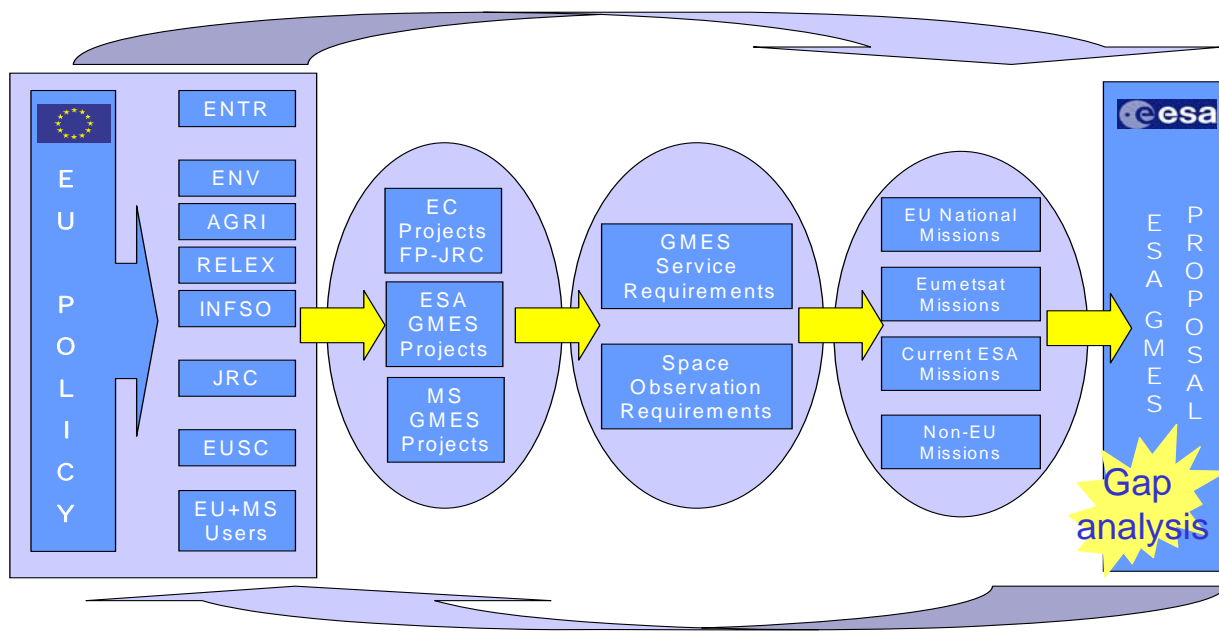- Mostly of national responsibility, with coordination at European level
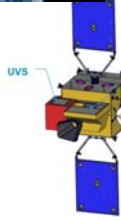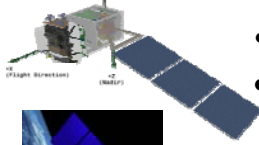
Space Component – role of ESA as

- development agency for dedicated infrastructure

- coordinator of contributions from Member States, EUMETSAT, private and commercial partners

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From EU policies to the GSC Sentinels and Data Access requirements

POLICIES → USERS → SERVICES → REQUIREMENTS → GAP ANALYSIS → SOLUTIONS

GMES dedicated missions: Sentinels

- **Sentinel 1 – SAR imaging**
- All weather, day/night applications, interferometry

- **Sentinel 2 – Multispectral imaging**
- Land applications: urban, forest, agriculture, etc
  Continuity of Landsat, SPOT data

- **Sentinel 3 – Ocean and global land monitoring**
- Wide-swath ocean color, vegetation, sea/land surface
  temperature, altimetry

- **Sentinel 4 – Geostationary atmospheric**
- Atmospheric composition monitoring, trans-boundary
  pollution

- **Sentinel 5 – Low-orbit atmospheric**
- Atmospheric composition monitoring

2011

2012

2012

2017+

2019+

Sentinel-1

Sentinel-1:

C-band

SAR mission

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:
- 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.)
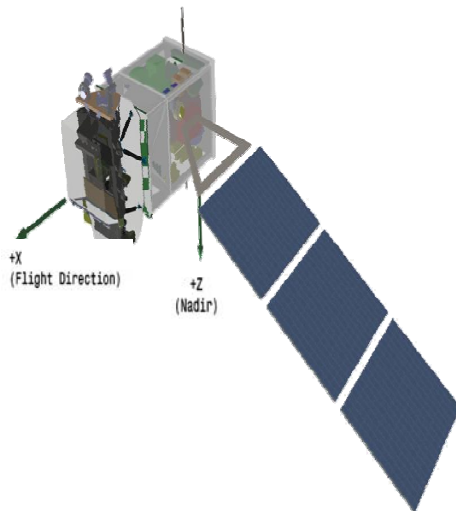- Wave (5X20 m res.)

2300 Kg spacecraft mass

Sun synchronous orbit at 693 Km mean altitude

12 days repeat cycle

7 years design life time, consumables for 12 years

Sentinel-2

Sentinel-2:
Superspectral imaging mission

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

Pushbroom filter based multi spectral imager with 13 spectral bands (VNIR & SWIR)

Spatial resolution: 10, 20 and 60 m

Field of view: 290 km

1098 kg spacecraft mass

10 days repeat cycle

Sun synchronous orbit at 786 km mean altitude

7 years design life time, consumables for 12 years

Sentinel-3

Sentinel-3:
ocean & global land mission

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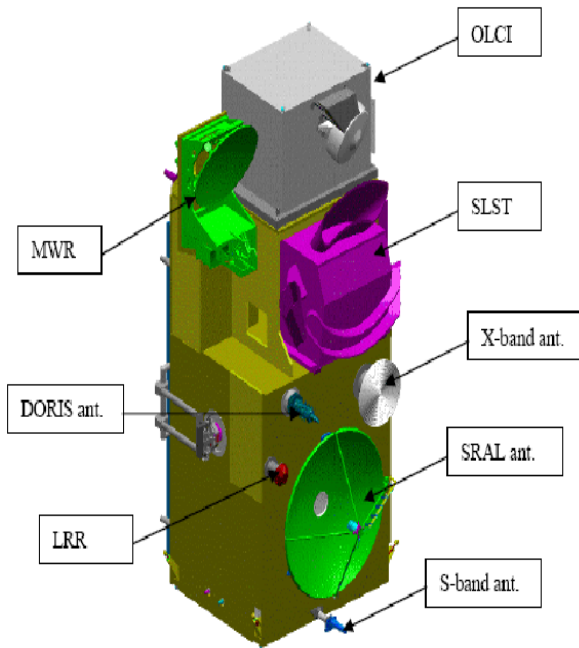- vegetation products

1198 kg spacecraft mass

Sun synchronous orbit at 814.5 km mean altitude over geoid

27 days repeat cycle

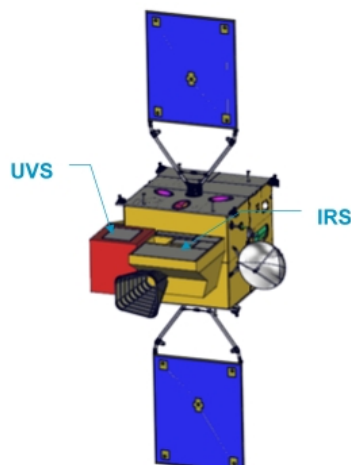7 years design life time, consumables for 12 years

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Instruments:

- **Ocean and Land Colour Instrument (OLCI) with 5 cameras, 8 bands (only VIS) for open ocean (low res), 15 bands (only VIS) for coastal zones (high res). Spatial sampling: 300m @ SSP**

- **Sea and Land Surface Temperature (SLST) with 9 spectral bands, 0.5 (VIS, SWIR) to 1 km res (MWIR, TIR). Swath: 180rpm dual view scan, nadir & backwards**

- **RA package**
  SRAL Ku-C altimeter (LRM and SAR measurement modes), MWR, POD (with Laser Retro Reflector, GNSS and DORIS)

OLCI
SLST
MWR
X-band ant.
DORIS ant.
SRAL ant.
LRR
S-band ant.

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Sentinel-4:

GEO atmospheric mission

UVS
IRS

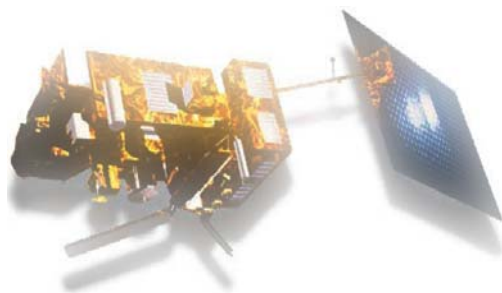| |
|---|
| **Applications:** |
| • **monitoring changes in the atmospheric composition (e.g. ozone, NO_2, SO_2, BrO, formaldehyde and aerosol) at high temporal resolution** |
| • **tropospheric variability** |
| **Narrow field spectrometer covering UV (290-400 nm), visible (400-500 nm) and near-IR (750-775 nm) bands** |
| **Spatial sampling 5-50 km and spectral resolution between 0.06 nm and 1 nm (depending on band)** |
| **Geostationary orbit, at 0° longitude** |
| **Embarked on MTG-S and operated by EUMETSAT** |

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Sentinel-5:

LEO atmospheric mission

Applications:

- **monitoring changes in the atmospheric composition (e.g. ozone, NO_2, SO_2, BrO, formaldehyde and aerosol) at high temporal (daily) resolution**
- **tropospheric variability**

Wide-swath pushbroom spectrometer suite, covering UV (270-400 nm), visible (400-500 & 710-750 nm), NIR (750-775 nm) and SWIR (2305-2385 nm) bands.

Spatial sampling 5-50 km and spectral resolution between 0.05 nm and 1 nm (depending on band)

Low Earth orbit (reference altitude of about 817 km)

Sentinel-5 precursor to fill data gaps (2013-2019). Sentinel-5 embarked on post-EPS and operated by EUMETSAT

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Potential contributions to GMES Space Component
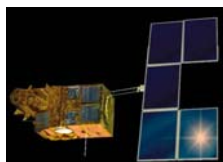
National, Eumetsat and Third Party Missions for GMES (list not exhaustive)
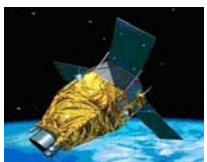
CosmoSkymed   **SPOT**   **Pléiades**   **Jason**   **Radarsat**

Terrasar-X   **Rapideye**   **DMCs**   **METOP**   **MSG**
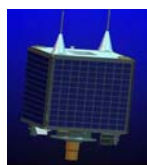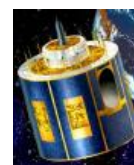
+ Seosat, Tandem-X, Enmap, Venµs, Altika, etc.

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GSC implementation schedule

GSC funding aspects
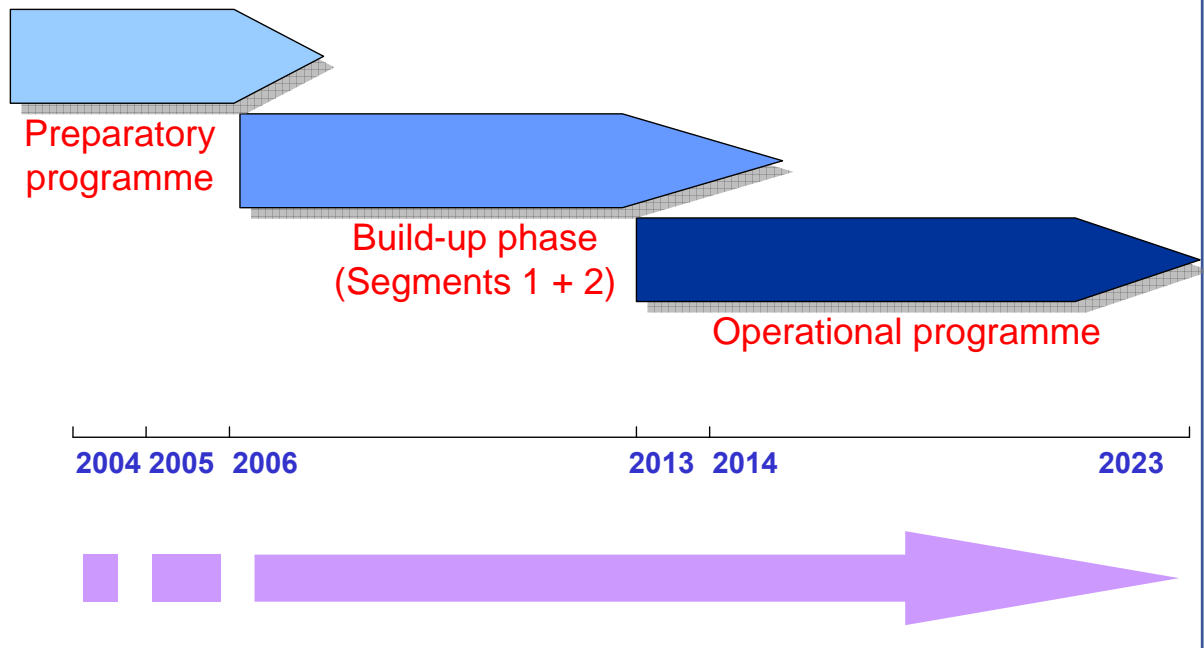
1. **Build-up phase**
   development of first generation of Sentinels, data access to MS/EUM missions, ground segment, early operations: ~ 2.4 bn€

   Financing – ESA GSC programme
   - 758 M€   Segment 1 (CMIN 2005)
   - ~ 800-900 M€   Segment 2 (CMIN 2008)

   Financing – EC FP7
   - 48 M€   FP7 Space (2007-2013) grant
   - 624 M€   FP7 Space (2007-2013) ESA – EC agreement

   Additional funding is required in ~2011 to complete build-up

2. **Operational Programme**
   development of recurrent Sentinel satellites, operational access to MS / EUM missions, GSC routine operations, evolution of GSC: ~ 450-500 M€/year (2008 e.c.), to be consolidated

GMES Ground Segment and Data Access

GMES Space Component

Sentinel-1
Sentinel-3
SENTINEL 2

TM/TC
ISPs

TT&C Stations
Acquisition Stations

FOS

GMES
Sentinels
GS

Sentinels
PDGS

GCM   GS

GSC Coordinated Data Access System

Data Access Portfolio (DAP)

GSC
Data Request

GSC
Data Provision

GMES Service Segment

Final end-user information products

USER Segment

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Coordinated Data access System

GCMs

Mission Planning
User Services
Acquisition/ Processing
Archive
Dissemination

GMES Service Projects (Coordinated Operations Interface)

Service Projects Coordinated Interface
Core Infrastructure
Reporting and Performances
Post-processing Element

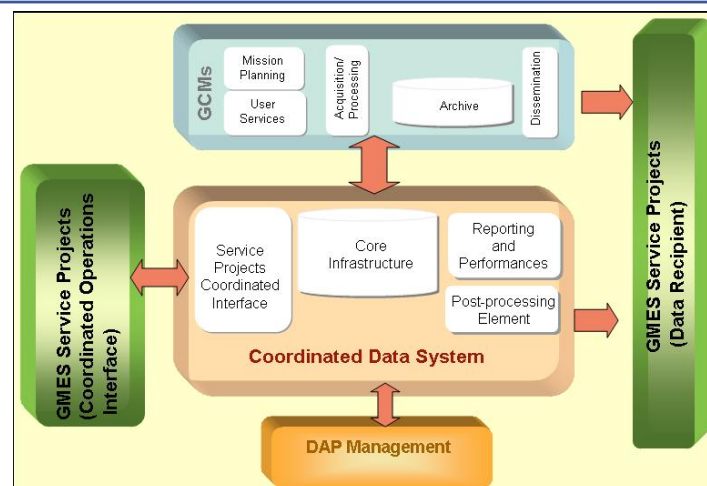**Coordinated Data System**

GMES Service Projects (Data Recipient)

DAP Management

Coordinated Data Access System components:
Service Projects Coordinated Interface:
  • Service Projects interface for data sets and operations advertisement, user management, data ordering interface
  • Data set production coordination
  • GCMs interface for mission production coordination
Core Infrastructure: Products collection and cataloguing for data sets creation
Reporting and performance: Overall performance continuous measurement

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Sentinels PDGS High Level Architecture

Sentinels System Technical Budget Overview
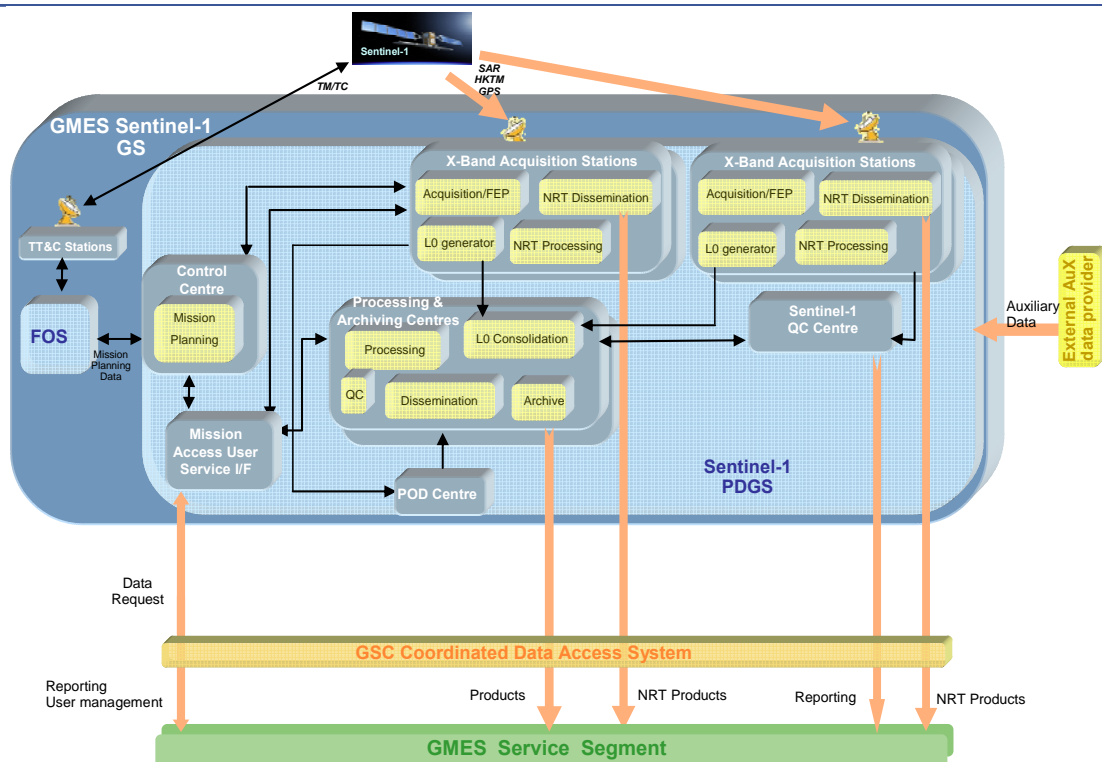
In terms of acquired data volume, the Sentinels Missions represent an increase of a factor 18 compared to the most demanding ESA EO mission (ENVISAT).
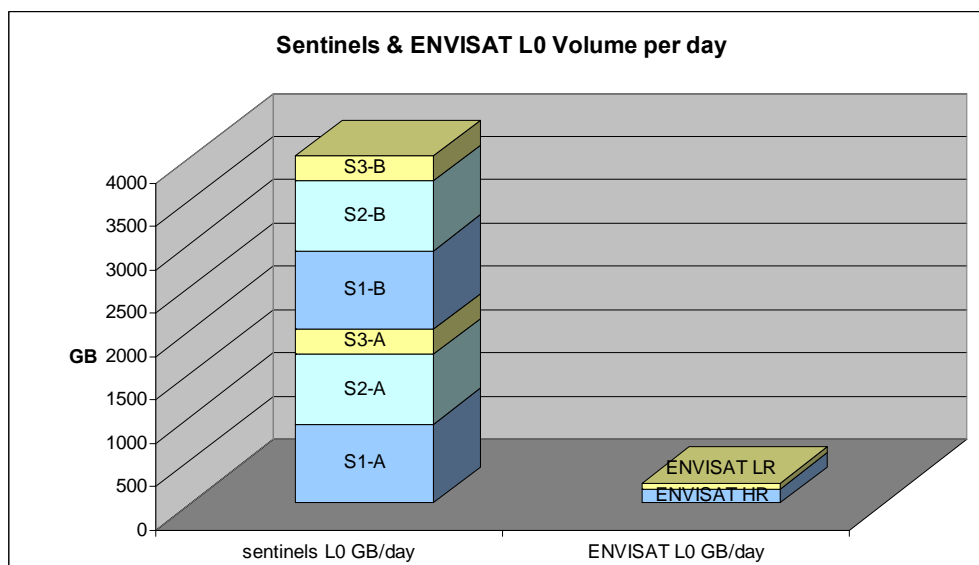
Sentinels X-Band downlink rate 260 Mbps per channel, with two independent downlink channels.

S-1 PDGS Elements Development, Integration & Testing Procurements

S-2 **S-3**

Sentinel-1 PDGS
Core Facilities Procurement & Overall Integration & Testing

- S-1 PDGS multi-mission elements configuration
- Specific elements development / upgraded
- Overall S-1 PDGS reference platform set-up, integration and testing activities (all elements)

Procurement of S-2 Multi-Mission & Mission Specific elements Ref. Platform, Integration & Testing

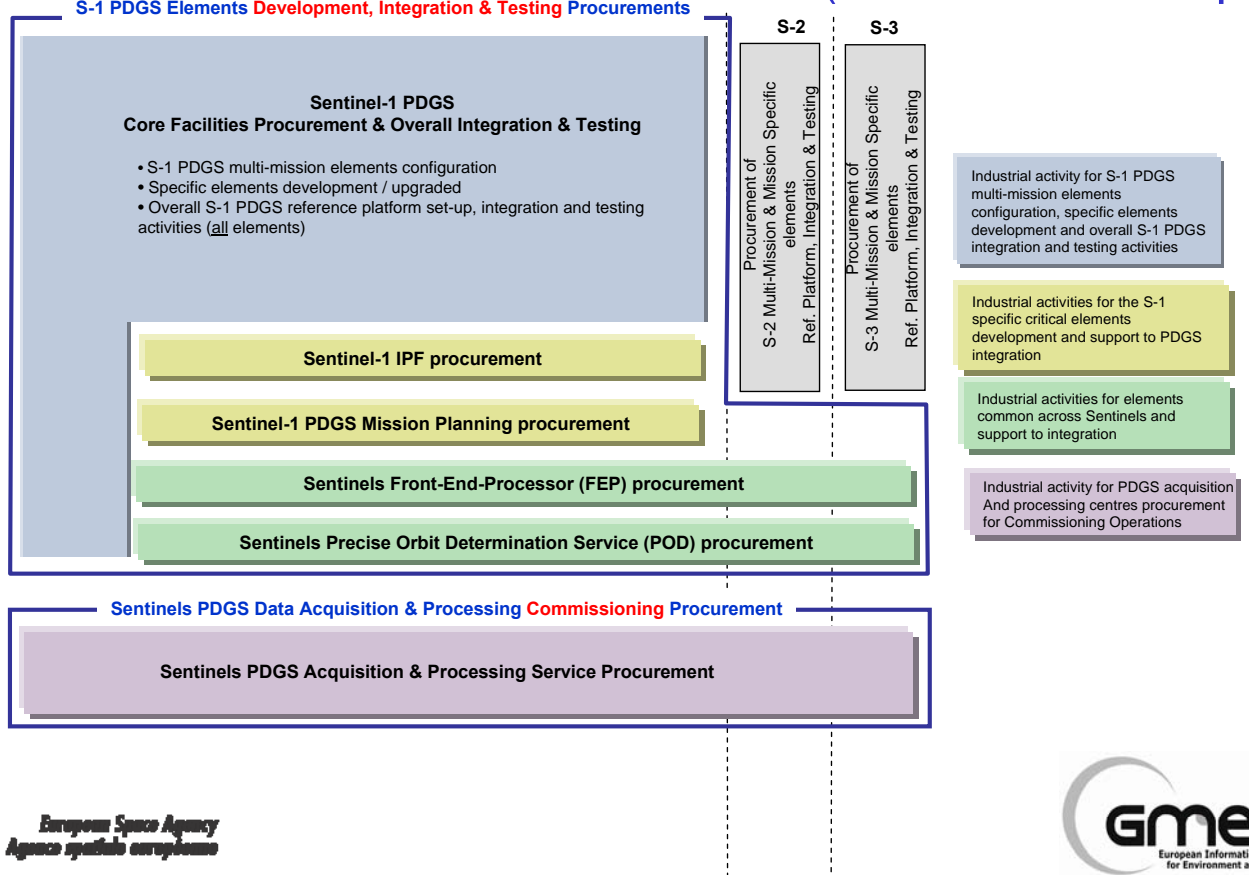Procurement of S-3 Multi-Mission & Mission Specific elements Ref. Platform, Integration & Testing

Sentinel-1 IPF procurement

Sentinel-1 PDGS Mission Planning procurement

Sentinels Front-End-Processor (FEP) procurement

Sentinels Precise Orbit Determination Service (POD) procurement

Industrial activity for S-1 PDGS multi-mission elements configuration, specific elements development and overall S-1 PDGS integration and testing activities

Industrial activities for the S-1 specific critical elements development and support to PDGS integration

Industrial activities for elements common across Sentinels and support to integration

Industrial activity for PDGS acquisition And processing centres procurement for Commissioning Operations

Sentinels PDGS Data Acquisition & Processing Commissioning Procurement

Sentinels PDGS Acquisition & Processing Service Procurement

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Currently foreseen for May 2009

Industry Day at ESA-ESRIN
Frascati (RM) – Italy

Sentinels PDGS Procurement
Approach

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Thank you