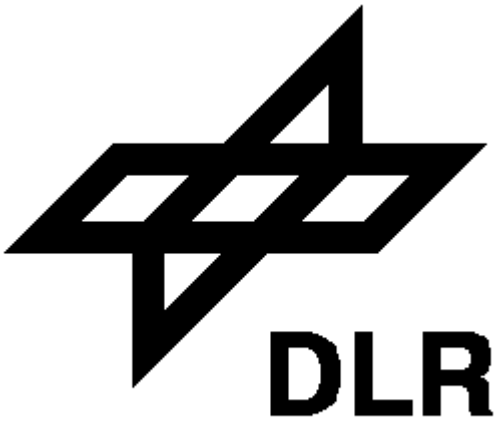
Significant Events since last Plenary

Report of the German Space Agency (DLR)

26th CEOS Plenary meeting, Bengaluru, India

October 2012



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1. General

Highlights in the German Earth Observation Programme of DLR since the last CEOS plenary meeting in November 2011 were:

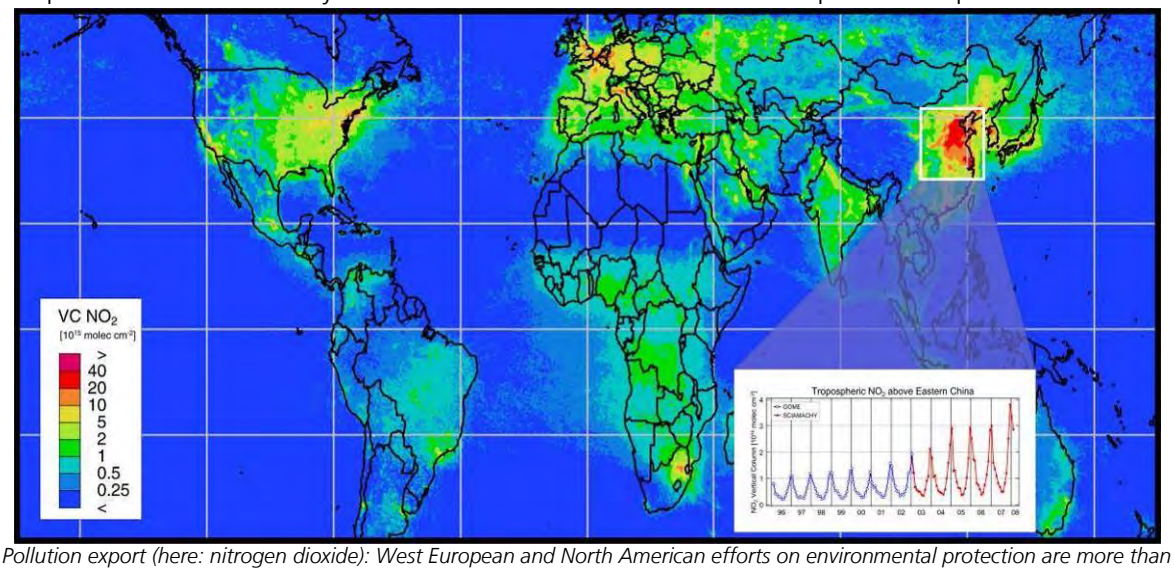
- continuous successful operation of the
  - SCIAMACHY instrument on board ENVISAT
  - GRACE-mission
  - TerraSAR-X
  - RapidEye
  - TanDEM-X
- continuous preparation of:
  - EnMAP
  - MET*Image*
  - MERLIN
- positive decision of Germany and NASA to develop a GRACE-FO mission
- running the data utilization programme for new applications in agriculture, forestry, monitoring of the environment, atmospheric chemistry, early warning of catastrophic events and humanitarian aid, including scientific and application oriented data utilization projects for TerraSAR-X, TanDEM-X, ENVISAT, RapidEye and preparatory work for future missions like EnMAP, MERLIN and scientific missions within ESA´s Earth Explorer Envelope Program as well as GMES Sentinel missions regarding data validation and utilization. Special emphasis is given to "GMES interface projects", which will link the GMES Core services with the specific requirements of German national regional authorities, responsible for land cover services, natural hazards relief and coastal zone management. Other key activities are devoted to the research on synergetic use of high resolution SAR and Optical data and the preparation of the scientific use of hyperspectral remote sensing data from EnMAP.

The progress made in national programme activities is described in the following chapters. For detailed technical information please look at the regularly updated CEOS Earth Observation Handbook (http://www.eohandbook.com) or the different dedicated web-links within the following chapters.

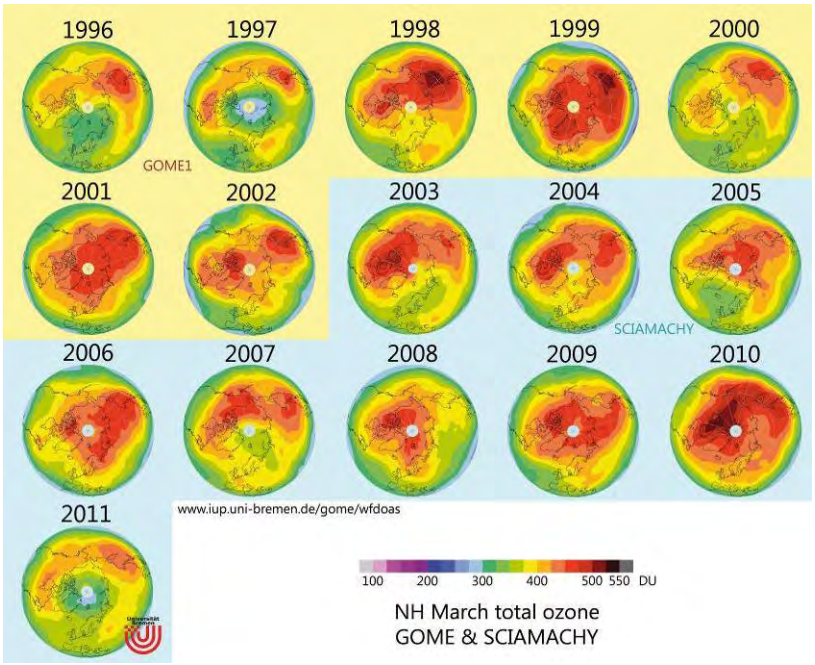
2. Space Segment
2.1 Running Missions

SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric Chartography)

The SCIAMACHY instrument was a German/Dutch/Belgian contribution to the ESA ENVISAT mission. SCIAMACHY had been launched on ENVISAT with an Ariane-5 at 1st March 2002. Since the successful finalization of the Commissioning Phase in December 2002 SCIAMACHY had been operated nominally until the fatal ENVISAT failure on 8th April 2012 ending the mission. Measuring trace gases of environmental importance, SCIAMACHY helped to improve our knowledge about the greenhouse effect, the stratospheric ozone chemistry, the global impact of tropospheric pollution, the exchange between the stratosphere, the troposphere, the stratospheric ozone chemistry and the natural modulations of atmospheric composition.



Pollution export (here: nitrogen dioxide): West European and North American efforts on environmental protection are more than outweighed by the deterioration over Eastern Asia



SCIAMACHY, together with GOME on ERS-2 and now continued by GOME-2 on the MetOp series provide a unique data set of atmospheric trace gases (here: ozone over the northern hemisphere in early spring between 1996 and 2011, showing some rare occurrences of an Arctic ozone hole in 1997 and 2011).

More detailed information (including scientific and application results) can be found under:

http://www.sciamachy.de/#english
http://atmos.caf.dlr.de/projects/scops
http://www.iup.physik.uni-bremen.de/sciamachy/index.html
http://earth.esa.int/object/index.cfm?fobjectid=1671
http://wdc.dlr.de/sensors/sciamachy/index.html

GRACE (Gravity Recovery and Climate Experiment)

GRACE was selected as an "Earth System Science Pathfinders" (ESSP) mission under US/German leadership. The mission consists of two polar-orbiting satellites in a loosely controlled tandem formation. Variations in the Earth's gravity field are causing a variation of the distance between the two satellites. This variation is measured with an accuracy of about 100 nm/s using a microwave inter-satellite link. Since its launch on March 17, 2002, the satellites are operated by the German Satellite Operations Centre (GSOC) at DLR Oberpfaffenhofen. The mission provides regularly updated models of the Earth's gravity field. GRACE provides unique information on temporal and spatial gravity variation. For example GRACE measures the mass reduction of the melting polar ice caps and of ground water drain on sub-continental scale. Accurate gravity models are provided to support geophysics and global climatic studies. GRACE-type measurements are indispensable for global seal level forecast.

Participants in the project are:

- University of Texas, USA (PI)
- Geo-Research Centre Potsdam, Germany (CoPI)
- Jet Propulsion Laboratory, USA (Technical Management)
- DLR, Germany (Launcher, Mission Operation)
- Astrium GmbH, Germany (Satellites)

The payload consists of:

- Dual One-Way Tracking System (K/Ka band) (USA)
- GPS Turbo-Rogue Receiver (JPL, USA)
- Ultra-Stable Oscillator (USA)
- SuperSTAR Accelerometer (ONERA, France)

Both GRACE satellites were launched on a single Rockot launch vehicle from Plesetsk (Russia). All instruments are still working nominally, however instrument switch-on times had to be reduced due to weakening battery cells. The satellites are estimated to be useful until 2018 or longer and will be operated until their technical end of life. NASA together with their German partners are currently developing a a follow-on mission

For more information, please visit:
http://www.gfz-potsdam.de/grace or http://www.csr.utexas.edu/grace

Gravity model displays are also available at:
http://photojournal.jpl.nasa.gov/catalog/PIA04652

TerraSAR-X

The German radar satellite, TerraSAR-X, is continuing to deliver high quality radar date of Earts surface. TerraSAR-X was launched on 15 June 2007 from the Russian Space Centre in Baikonur in Kazakhstan into a near-Earth orbit at 514 km altitude. After just four days the German Remote Sensing Data Centre in Neustrelitz recorded the first data. Shortly afterwards these were successfully converted into the first images at the DLR Remote Sensing Technology Institute in Oberpfaffenhofen. The successful processing of that first image demonstrated the outstanding functional capability of the satellite on the one hand and the operability of the ground segment on the other hand. The entire processing chain including ordering, scheduling, commanding, data acquisition, ground data reception, SAR processing and archiving of the images has been validated by this first picture.

Since then the German Space Operations Centre in Oberpfaffenhofen has taken on the role of mission control. Thousands of high-quality images have been acquired, processed and delivered to the scientific and commercial customers. All three basic image products - Spotlight, Stripmap and ScanSAR - have been released and the image performance is of exceptional quality. To be noted are especially the high radiometric accuracy and stability of the sensor as well as the very good geo-location-accuracy of the products. Besides the basic image products also higher level products have been successfully acquired. This includes

* The highest resolution 300 MHz product,
* The multi-polarization images and
* The interferometric data.

TerraSAR-X is the first German satellite to be manufactured under what is called a public-private partnership (PPP) between the German Space Agency and Astrium GmbH in Friedrichshafen.

DLR is responsible for using TerraSAR-X data for scientific purposes. It is also responsible for planning and implementing the mission as well as controlling the satellite. Astrium built the satellite and shares the costs for developing and using it. The Infoterra GmbH, a subsidiary company founded specifically for this purpose by Astrium, is responsible for marketing the data commercially.

The data/products of TerraSAR-X will also be used to support public interests and the performance of governmental tasks as there are: environmental monitoring, air traffic control, mobile telecommunication services by provision of digital elevation models, regional planning by provision of large scale topographic maps as well as disaster management supported by high resolution data. TerraSAR-X data is also supporting the European GMES-Programme.

After nearly five years of operational lifetime the satellite is still in excellent shape. An extension of the operational phase is envisaged to cover also the TanDEM-X mission goals..

For more detailed information regarding TerraSAR-X please refer to:

http://www.dlr.de/tsx

http://www.dlr.de/en/desktopdefault.aspx/tabid-4219/

http://www.infoterra.de/terrasar-x.html

TanDEM-X

TanDEM-X is Germany's first national X-band SAR interferometry mission based on the TerraSAR-X satellite (TSX) already launched in 2007 and a modified rebuilt named TanDEM-X (TDX) launched this year on the 21 st of June from Baikonur Cosmodrome on a Dnepr launcher at 02:14:08 UTC. For a period of at least five years the mission will supply high-resolution radar data and a global DEM of the Earth for scientific and commercial purposes. The project is realized in a public private partnership between the German Aerospace Centre (DLR) and EADS Astrium GmbH.

The Mission

The TanDEM-X mission (TerraSAR-X add-on for Digital Elevation Measurement) will survey all 150 million square kilometers of the Earth's land surface several times within a mission duration of three years. Besides high measuring-point density (twelve meters apart) and high vertical accuracy (better than two meters), the elevation model generated by TanDEM-X will have another outstanding advantage to offer: being entirely homogenous, it will serve as a basis for globally consistent maps. Conventional maps are often fragmented, along national borders, for example, or they are difficult to reconcile because they are based on different survey methods, or because of time lags between survey campaigns. Mapping the entire earth for several times for generating some intermediate products, the final high precision global DEM will be available in 2014.

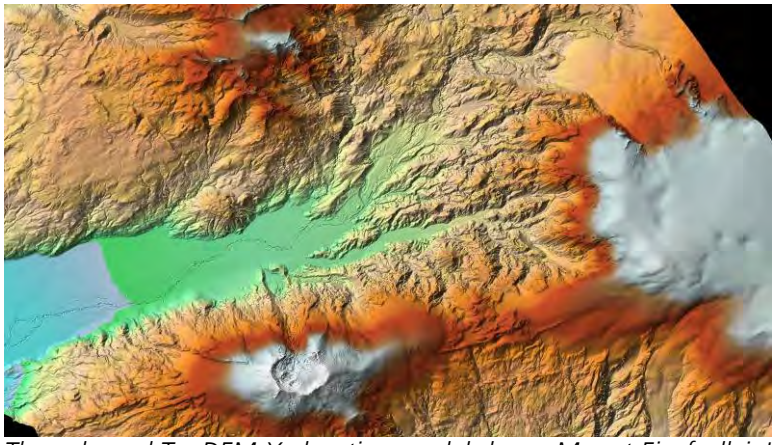
Besides the primary goal of the mission, several secondary mission objectives based on new and innovative methods as for example along-track interferometry, polarimetric SAR interferometry, digital beamforming and bistatic radar have been defined and represent an important asset of the mission.

The TanDEM-X satellite is as much as possible a rebuild of TerraSAR-X with only minor modifications like an additional cold gas propulsion system for constellation fine tuning and an additional S-band receiver to enable a reception of status and GPS position information broadcast by TerraSAR-X. The TanDEM-X satellite has been designed for a nominal lifetime of five years and has a nominal overlap with TerraSAR-X of three years. TerraSAR-X holds consumables and resources for up to seven years of operation, allowing for a potential prolongation of the overlap and the duration of the TanDEM-X mission.

Mission Status

After more than two years in space both the Space Segment and the Ground Segment are in very good shape. In the meantime the global land mass is covered nearly twice being baseline for the global DEM. Processing of the tremendous amount of data is running excellent. First local DEMs showing the high quality to be expected final product.

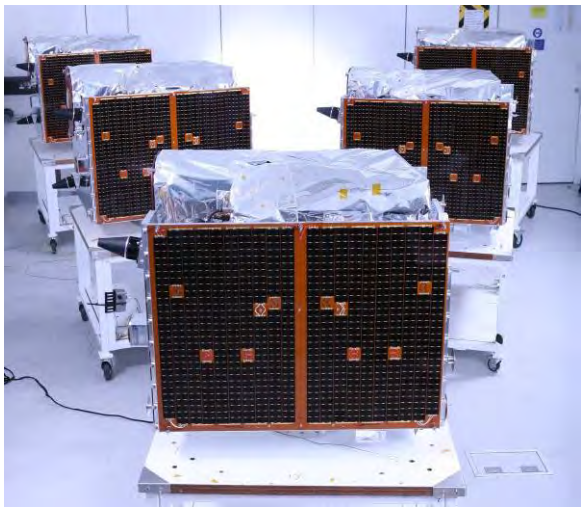
For more detailed information please refer to:
http://www.dlr.de/hr/tdmx
http://www.dlr.de/blogs/desktopdefault.aspx/tabid-5919/
http://www.infoterra.de/terrasar-x/tandem-x-mission.html



The coloured TanDEM-X elevation model shows Mount Ejyafyallai, Island2011, Credit: DLR.

RapidEye

The launch of the RapidEye fleet/flotilla on 29th of August 2008 on top of a DNEPR rocket from spaceport Baikonur was successful, each stage of the launch was on schedule. First images have been unveiled on 21th of October 2008. Since then the satellites are successfully operating and deliver commercial and scientific data. The latter are stored in the RapidEye Science Archive (RESA) at DLR / Neustrelitz and can be delivered on request. According to the scientific users the data quality is outstanding.



The RapidEye Fleet: source RapidEye AG

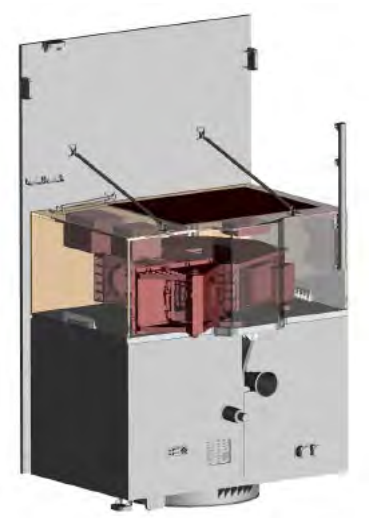
The RapidEye constellation of five satellites stands apart from other providers of satellite-based geospatial information in their unique ability to acquire high-resolution, large-area image data on a daily basis. The RapidEye system is able to collect an unprecedented 4 million square kilometers of data per day at 6.5 meter nominal ground resolution. Agricultural insurance companies, farmers, food companies, government agencies as well as national and international agencies are the main users of these information products and services. In addition RapidEye offers on demand up-to-date maps and digital elevation models of every region on earth.

To be able to serve the identified market segments the RapidEye system allows image capture of the earth surface in five spectral bands, including the red edge, with a resolution of 6.5 m. The five satellites each carry a camera payload with 80 km swath and a rotation capability of up to +/- 20° off-track allowing for large area data takes as well as daily revisit. The start-up financing of the project was provided by the State of Brandenburg, the German government via the German Space Agency DLR, Bonn, and several strategic partners. End of August 2011 the Blackbridge Group, Canada, acquired the assets of RapidEye AG, Germany.

More information is available on the Web under: http://www.rapideye.com.

2.2 Missions in preparation

EnMAP



Sketch of the EnMAP satellite (source: OHB System AG)

The **En**vironmental **M**apping and **A**nalysis **P**rogram (EnMAP) is Germany's first national hyperspectral satellite mission. EnMAP's emphasis lies on the in-orbit demonstration of a new technology and the development of the corresponding techniques, algorithms and products and the scientific use of these products. In more detail the objectives are:

- To provide high-spectral resolution observations of bio-geochemical and geophysical variables
- To observe and develop a wide range of ecosystem parameters in agriculture, forestry, soil/geological environments and coastal zones/inland waters
- To enable the retrieval of presently undetectable, quantitative diagnostic parameters needed by the user community
- To provide high-quality calibrated data and data products to be used as inputs for improved modelling and understanding of biospheric/ geospheric processes

The combination of unprecedented features of the hyperspectral instrument is:

- Dedicated imaging pushbroom hyperspectral sensor mainly based on modified existing or pre-developed technology (e.g. SWIR FPA by AIM-Infrarot Module GmbH Heilbronn)
- Broad spectral range from 420 nm to 1000 nm (VNIR) and from 900 nm to 2450 nm (SWIR) with high SNR in both spectral ranges
- High spectral resolution of 5/10 nm at SNRs >500:1 (VNIR) and >150:1 (SWIR); up to 220 channels
- 30km Swath at high spatial resolution of 30m and off-nadir (30°) pointing feature for fast target revisit (5 days)
- Sufficient on-board memory to acquire 1,000 km swath length per orbit and a total of 5.000 km per day

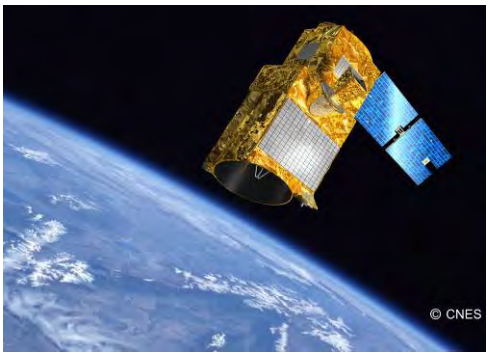
EnMAP Phase C/D started in November 2008. The space segment will be built by an industrial team which is led by Kayser-Threde GmbH. OHB-System AG is building the S/C Bus. The Launch in 2017 is planned to be performed with the Indian PSLV.

DLR-DFD is developing the ground segment, together with DLR-GSOC and DLR-IMF. A project office was installed at GeoForschungszentrum Potsdam to coordinate scientific preparations. In addition scientific advice will be given by an international expert group to DLR and GFZ.

The project will make profit from the long-term experience with the operations and scientific exploitation of hyperspectral airborne sensors in Germany like ROSIS, CASI, DAEDALUS, HYMAP and ARES, a customised version of the HYMAP instrument soon to be added to the GFZ/DLR fleet of airborne sensors. The scientific teams and these airborne sensors will be involved in the preparation and in the Calibration/Validation activities.

For more detailed information please refer to http://www.enmap.org

French/German Climate Mission (MERLIN)



The French Centre National d'Études Spatiales (CNES) and the German DLR Space Administration agreed to develop and implement in a close cooperation MERLIN (MEthane Remote sensing LIdar missioN), a small satellite dedicated to the measurements of the green house gas Methane (CH4). Mission aim is the improvement of the knowledge on anthropogenic contribution to the atmospheric Methane amount. Climate change, driven by anthropogenic activities may cause melting of permafrost soils and ocean sediments (hydrates) thus leading to enhanced Methane emissions.

It is planned to launch the satellite in the time frame 2016 with 3 years of operation in space. Germany will contribute by providing the instrument payload, a Methane Integrated Path Differential Absorption (IPDA) LIDAR. France will contribute its space-proven small satellite platform MYRIADE. Developing and operating the ground segment is shared between DLR and CNES.

Mission Definition Review (MDR) and Preliminary Requirements Review (PRR) have been passed successfully in December 2010 and in May 2012, respectively.

For more detailed information please refer to:

- http://www.dlr.de/rd/desktopdefault.aspx/tabid-2440/3586_read-31672/
- http://www.dlr.de/pa/desktopdefault.aspx/tabid-2342/6725_read-26662/

MET*image*

The evolving needs of the meteorological community concerning the EUMETSAT Polar System follow-on satellite mission (EPS-SG) require the development of a high-performance multi-spectral imaging radiometer, the so-called Visible–Infrared Imager (VII). Recognizing these needs, Jena Optronik GmbH proposed an innovative instrument concept, MET*image*. MET*image* is supposed to be the VII mission on Post-EPS.

Core item of the MET*image* instrument is a rotating telescope scanner covering the large swath width of about 2800 km which is needed for a global coverage by a polar platform. The de-rotated image facilitates in-field spectral channel separation, which allows tailoring individual channel GSD (ground sampling distance) and features like TDI (time delay and integration). State-of-the-art detector arrays and read-out electronics can easily be employed. The reflecting telescope design is able to support even demanding requirements on image quality and ground resolution.

The chosen instrument concept covers a spectral range from 430 nm to 13.3 µm and provides 20 spectral channels. The ground sampling distance is 500 m and 250 m for selected high-resolution channels.

The MET*image* instrument development is currently in phase B. Phase B1 has been completed in summer 2010. Phase B2 was kicked-off in September 2012.
MET*image* is supposed to be an in-kind contribution to the EPS-SG programme by Germany.

For more detailed information please refer to:
http://www.dlr.de/rd/desktopdefault.aspx/tabid-2440/3586_read-10140/
http://www.jena-optronik.de/de/raumfahrtinstrumente/metimage.html

For more detailed information on the EUMETSAT EPS-SG program please refer to:
http://www.eumetsat.int/Home/Main/Satellites/EPS-SG/index.htm

GRACE-FO

Stimulated by an invitation of NASA to plan for a GRACE Follow On mission, the GeoForschungsZentrum GFZ submitted a funding proposal to the German Ministry for Education and Research, which was accepted in fall 2011. The mission will have the same set-up as the first and still operating GRACE mission but with an additional experimental payload. This payload will measure the distance between the two satellites via a laser link and by this the accuracy of the measurement should be improved significantly. The activities in Germany are managed by the GFZ.

For more information please refer to:
http://www.gfz-potsdam.de/portal/gfz/Struktur/Departments/Department+1/sec12/projects/grace

New Mission Studies

To prepare for future national and European space borne Earth Observation missions, the German Space Agency funds a number of studies with scientific organisations and with support from industry.

- Concerning the next TerraSAR-X satellite InfoTerra GmbH completed their industrial phase A study and is currently conducting a industrial phase B with Astrium GmbH and DLR Oberpfaffenhofen. In discussions with the German Space Agency different options for the implementation of a TerraSAR-X next Generation mission are analysed. The framework for an implementation is planned to be finalized in 2012.
- The new owners of RapidEye started discussions with the German Space Agency concerning the future after the first Generation of the RapidEye satellite constellation.
- As an answer to a new announcement of opportunity for mission proposals in spring 2012 in preparation for a new ESA AO in EOPEP-4 several mission concepts had been submitted by the German scientific community. The three proposals selected for phase 0 grants were
    - Next Generation Satellite Gravity, a satellite concept with two GRACE-like satellites with enhanced capabilities
    - G3E, the Geostationary Emission Explorer for Europe plans to observe sources and sinks of trace gases relevant for air quality and climate and corresponding processes and
    - HiTeSEM (High resolution temperature and spectral emissivity mapping) , a proposal for a hyperspectral TIR mission for the measurement of biogeochemical key parameters in the Earth's system.

  The studies will be carried out though out 2013 in order to be prepared for the next ESA call for Earth Explorer missions.

3. Ground Segment and Application Development

Highlights at the DLR Earth Observation Center (EOC) are

3.1. Payload Data Acquisition

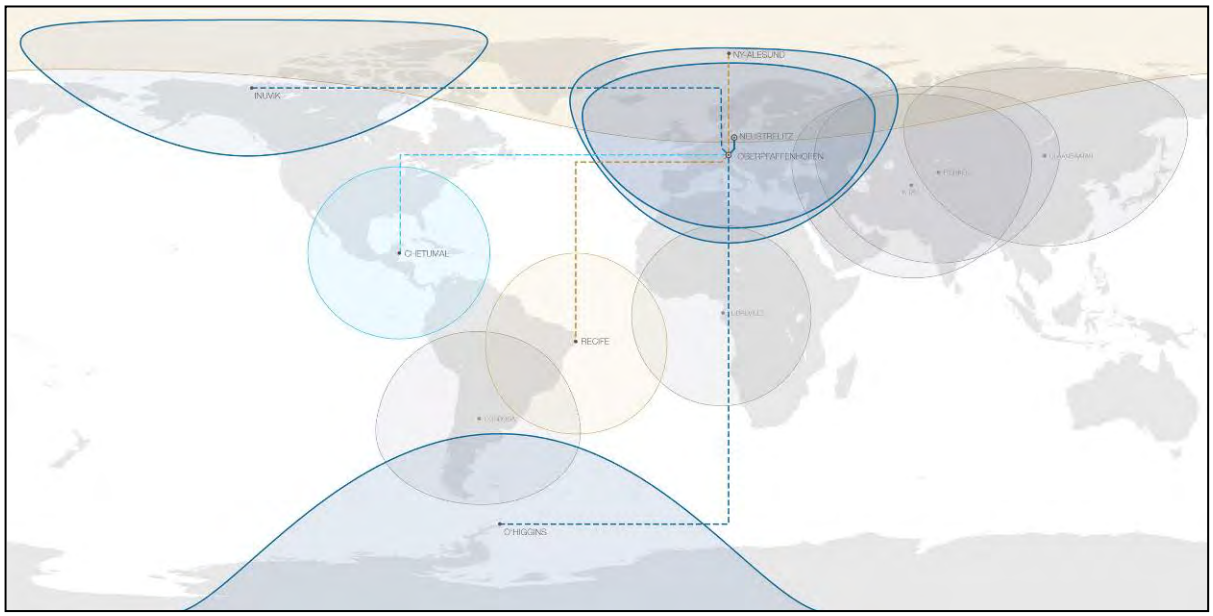


Figure 1: DLR ground segment network:
Dark blue = TanDEM-X Network: Telemetry, Tracking & Commanding, Payload Data Reception
Light blue = TanDEM-X Network: Payload Data Reception
Orange = Payload Data Reception
Gray = Former Ground Stations

DFD operates the existing reception capabilities:

Permanent

Neustrelitz (Germany)	3 LSX-band 7.3 m, LS-band 4.0 m, VHF
Oberpfaffenhofen (Germany)	X-band 3.6 m, L-band 2.4 m, L-band 4.0 m X-band (5,6 m) on behalf of European Space Imaging
O'Higgins (Antarctic)	LSX-band 9.0 m
Chetumal (Mexico)	LSX-band 9.0 m
Inuvik (Canada)	LSX-band 13.0 m

Transportable

Ny Ålesund (with GFZ, Spitzbergen)	X-band 4.0 m

Mobile

Recife (Brazil)	L-band 0.9 m

While the DLR stations in Germany (mainly Neustrelitz, Oberpfaffenhofen) carry out their duties especially in the framework of the TerraSAR-X mission and for ESA ERS-2 and ENVISAT data, the following is noteworthy for new activities and newly established stations of DFD.

GARS O'Higgins / Antarctica: the station was used for support of TerraSAR-X background mission and especially for TerraSAR-X support to the International Polar Year IPY. Furthermore the station is now working and permanently staffed for whole year round operations of the TanDEM-X mission and was therefore activated from the TanDEM-X commissioning phase-onwards, now being operational for TanDEM-X data acquisition.

Figure 2: DLR Acquisition station O'Higgins, Antarctic Peninsula

Chetumal, Mexico: The DLR transportable station was brought in 2007 to Chetumal/ Mexico for a multi-mission support of various EO satellites. This activity is performed within a MoU with the Mexican authorities and DLR. The station was inaugurated and officially named ERIS Chetumal (ERIS = Estacion para la Reception de Imagenes Satelitales). Since then the station performs normal duties with regard to capture EO data including ERS-2 from ESA, supporting the USGS Landsat-5 global land cover project and acquisition on TerraSAR-X data for the ESA MARISS project.

Neustrelitz, Germany: Neustrelitz has started in 2008 to acquire Indian CartoSAT-1 data (IRS-P5) on a regular basis under the contract with Euromap. An entire processing chain for the CartoSAT-1 data was installed and augmented by a DLR developed stereo processor to derive precise elevation models (DEM) from the in-track stereo CartoSAT-1 data.

Meanwhile the Indian Resourcesat1-data acquired in Neustrelitz under contract of EuroMap, continues to form the backbone of the European Land coverage for regular land cover mapping under European programmes (e.g. GMES). Euromap and DLR meanwhile prepare for the acquisition and processing of Resourcesat-2.

The near real time acquisition of SAR data was augmented in Neustrelitz especially to support national maritime security trials (DeMarine) and corresponding European programmes (e.g. MARISS). A special automated ship detection processor was installed (SAINT), working with TerraSAR-X, ERS-2 and other SAR data (ENVISAT, until end of operations). The processor merges the locations of identified ships with ground and satellite based AIS information (Automated Identification System) to identify non-cooperative behaviour.

The near real time services in Space weather monitoring from Neustrelitz are continuing for ionospheric monitoring based on CHAMP/GRACE and GPS/GLONASS measurements. The NOAA ACE mission (solar activity monitor) acquisition continued on an operational basis with Neustrelitz as one of the few global stations to deliver this information in near real time.

Inuvik, NWT, Canada: Driven by the challenging demands of the global data capture for the German TanDEM-X mission (Launch June 2010) DLR was in demand for an X-band acquisition station in the polar area of North America. After evaluation of several options, DLR decided to go into a partnership approach with European and Canadian partners to establish a new station site in Inuvik, North West Territories, Canada. In 2009 the 13m multiband antenna was delivered, set up and successfully test with the TerraSAR-X data acquisition and TT&C in S-Band. Meanwhile the station is in operations to support the TanDEM-X mission. The operations as such is performed remotely from DLR in Oberpfaffenhofen, while on-site support for eventual interaction is available. Meanwhile another – technically identical – antenna systems was established by Swedish Space Cooperation (SSC) and will be used for EO Misisons of CNES.

Figure 3: DLR Acquisition station O'Higgins, Antarctic Peninsula

Oberpfaffenhofen, Germany: The X-/L-Band stations in Oberpfaffenhofen continue acquisition of Aqua and Terra data for daily European coverage, serving as input for various value added products including regular fire monitoring services and input for European Commission projects.

In 2009 the licence contract for the GeoEye satellites has been awarded to e-GEOS/Telespazio. This includes the latest Geoeye-1 satellite which is received at Geoeye stations worldwide. Satellite tasking and product generation have been awarded by e-GEOS to EuroMap/DLR in Neustrelitz. IKONOS tasking and acquisition/processing has meanwhile phased out

In parallel European Space Imaging (EUSI), Munich has signed an agreement with DigitalGlobe for the exclusive rights of the WorldView-1/2 satellites (WorldView-2 was successfully launched in October 09). A new tasking and acquisition antenna, acting as WorldView Direct Acquisition Facility (DAF), established on the roof of the new Earth Observation Center (EOC) Building at DLR in Oberpfaffenhofen, is now in regular operations. The acquisition cone of Oberpfaffenhofen is complementing the other WorldView DAF in Dubai/Abu Dhabi. The agreement with EUSI also allows the EOC to use WorldView data for its own purposes.

3.2 Data Processing and Archiving

3.2.1. TerraSAR-X and TanDEM-X Payload Ground Segment

The overall TerraSAR-X system and as part of that of course the TerraSAR-X payload ground segment are fully operational servicing the commercial as well as the scientific mission goals.

The TanDEM-X ground segment was working from the very beginning of the TanDEM-X launch, incl. all existing and newly established international ground stations (such as Inuvik). Details of the progress of both missions are given in the previous chapters.

The TerraSAR-X mission is on-going without problems, despite the parallel TanDEM mission with both satellites closely aligned. Minor restrictions for TerraSAR acquisitions do occur due to the fact that the TanDEM acquisition need to be performed with high priority to achieve the global

acquisitions for the DEM within the needed timeframe. The TerraSAR mission catalogue contains in the meantime after 5 year of operation more than 100.000 L0 products available for ordering.

http://sss.terrasar-x.dlr.de/

The operational phase of the TanDEM mission for the generation of the global DEM started in December 2010 and is still ongoing. The first acquisition phase lasted until end of March 2012. In this phase most of the terrestrial Earth surface was acquired. Partially this first acquisition is already sufficient to derive the global DEM. Since April 2012 the second acquisition phase is running which aims at further improving the DEM accuracy and which is needed to have a second acquisition in "difficult" areas, like rainforests and mountainous regions. The catalogue contains currently 65.000 L0 products and more than 300.000 scenes to be used for the generation of the global DEM. Co-registered SSC products from the mission catalogue are available for ordering by users.

https://tandemx-science.dlr.de/

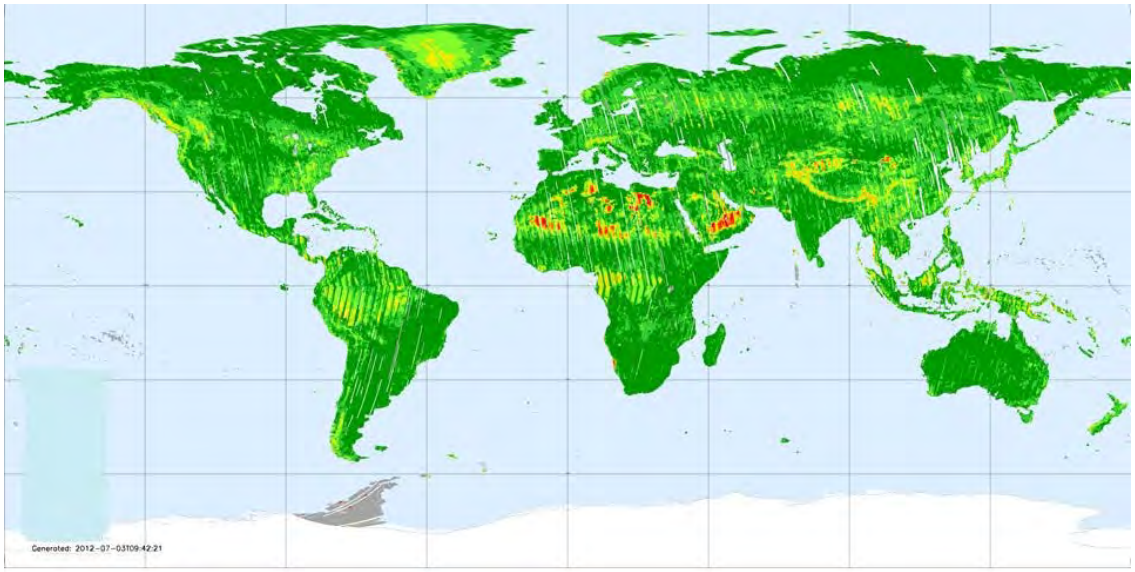


Figure 4: Progress of TanDEM-X global mapping as of end 2011

3.2.2. Data Processing and Archiving for ERS and ENVISAT

During the past 20 years the German Remote Sensing Data Centre of DLR has been involved in a multitude of ground segment collaborations with ESA. The most relevant activities are outlined hereafter:

The German Processing and Archiving Facility for ERS is operated under ESA contract as part of the ERS ground segment for the processing and archiving and user services for ERS tracking data, radar altimeter data (archive only) and SAR data, in addition since the launch of ERS 2 also for the processing and archiving of GOME total ozone columns. Within the scope of GMES activities, DLR was under contract to ESA to support the MARISS SUP project for ship detection with near real-time ERS SAR data, acquired and delivered by its Neustrelitz station. Also DLR's sensing station in Chetumal, Mexico was phased-in to deliver such service.

Through its co-operation with the GeoForschungsZentrum Potsdam (GFZ), D-PAF systematically generated preliminary and precise Orbit products for the ERS-2 spacecraft during the period 1991 through 2011.

After 16 years of successful operations, and a highly satisfactory scientific and applications output, the ERS-2 satellite was successfully de-orbited during summer 2011 with the final activation on 5 September 2011. The ERS-2 satellite acquired data until 4 July 2011, with its last months of activity dedicated to a specific Ice Phase (3-day repeat orbit). Through the data acquired at the German Antarctic Receiving Station in Antarctica DLR could contribute substantially to the outstanding results on the ERS-2 Ice Phase that were presented e. g. at last year's Fringe workshop, in particular with respect to polar glacier dynamics.

Within the Payload Data Segment of ESA's ENVISAT mission, DFD hosts the German Processing and Archiving Centre. Nominal data distribution is done both through electronic dissemination and via media distribution (e.g. CD, DVD, bulk deliveries via HDD). D-PAC especially supports the atmospheric community with products from SCIAMACHY, MIPAS and GOMOS. Higher-level atmospheric data are available permanently online for ftp access, including the GOME L1 and L2 data from ERS-2. Access is coordinated through the ESRIN Helpdesk. Major efforts are devoted to the reprocessing of the data of these sensors based on updated auxiliary data and new processor versions.

Within 2011 DLR has carried out 2 reprocessing campaigns for the entire mission data of the Sciamachy and Mipas instruments. The data are hosted within DLR's multi-mission infrastructure in support of ESA. Access can be obtained via ESA's user service Eohelp@esa.int .

Since the declaration of Envisat's end of mission in summer 2012, DLR-DFD has been streamlining the focus of its activities from systematic/routine processing to long-term data preservation and historic / bulk processing and delivery of large sets of instrument data.

ESA Multimission Facility Infrastructure Evolution

Under contract to ESA/ESRIN DLR was the Prime Contractor of a consortium to further enhance the multimission concept of ESA. The project called FEOMI (Facilities Evolution into an Open Multimission Infrastructure) provided additional capabilities in the area of data input, inventory, processing and delivery. The unification covers ENVISAT, ERS and the 3rd Party Missions supported by ESA. The implementation of the new systems at the ESA sites Frascati and Kiruna, and at the national facilities in Oberpfaffenhofen (D), Farnborough (UK), Matera (I) and Maspalomas (ES) started in October 2006 und was finished around Christmas The project was formally terminated successfully with the Final Presentation at ESA-ESRIN on March 30, 2007. The current MMFI architecture of DLR in support of ESA services is depicted hereafter:

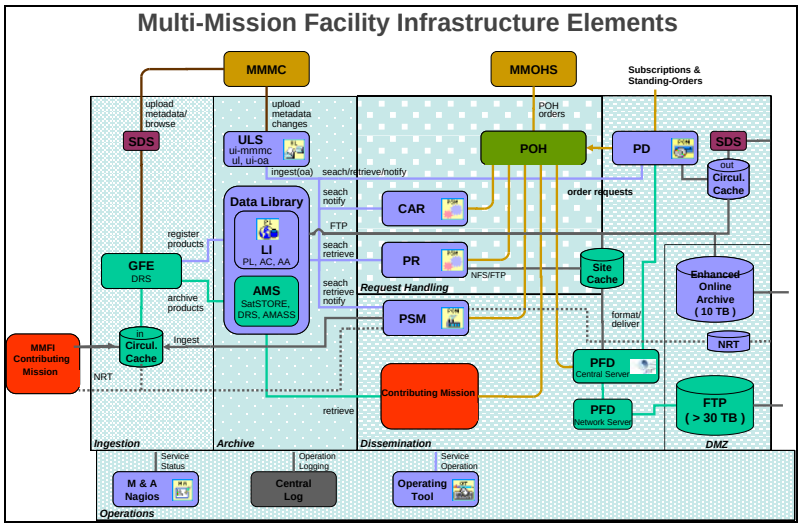


Figure 5: MMFI infrastructure elements (blue) under responsibility of DLR

GMES Sentinel PAC

Under a contract signed recently this year in July, DLR-DFD has been tasked by ESA to build up and operate the Processing and Archiving Centre for the Sentinel-1 and Sentinel-3 OLCI instrument data. Among others, the tasks will be the provision of production and dissemination services, the long-term archive and connectivity to the GMES Wide-Area Network infrastructure:

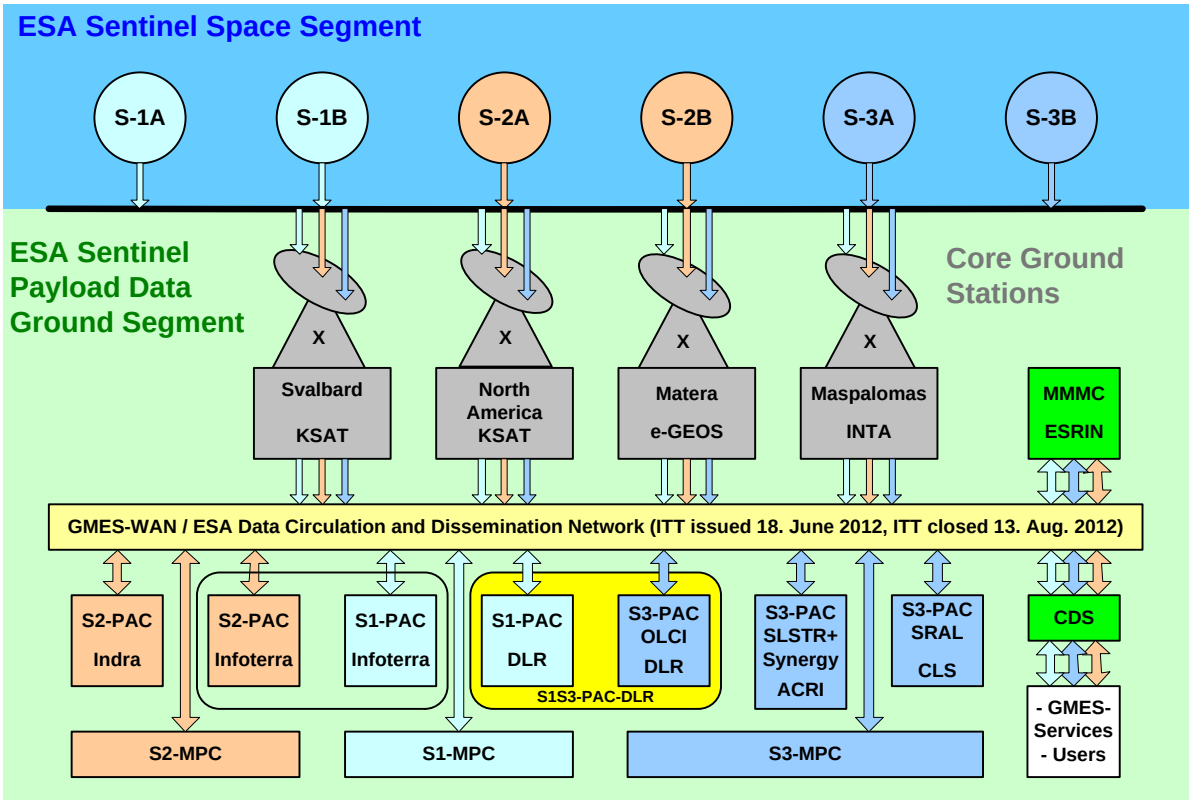


Figure 6: DLR as a partner of ESA in the GMES Sentinel context

DLR-DFD's particular specialism in the context of ground segment operations is with the maintenance of large EO data archives and with the preparation, organisation and execution of large bulk deliveries of reprocessed higher-level instrument data. This specialism is backed up by the following performance indicators:

- Total archive size: > 750 Terabyte
- Annual growth until 2012: 80 Terabyte
- Annual production and dissemination volume:
  - 130 TB electronical disseminations
  - 25000 on-request orders
  - >100000 items disseminated via diverse bulk delivery campaigns
- Reprocessing of instrument data: On average once per year the entire data volume of one selected Envisat resp. ERS atmospheric instrument dataset (GOME, SCIAMACHY or MIPAS) has been reprocessed and made distributed in the past 5 years.

3.2.3 Data Access

DLR Multimission Implementation for Heterogeneous Missions Accessibility (HMA)

To facilitate EO mission data access, EOC operates several user services which are compliant to the service standards developed in the ESA HMA initiative. Based on web mapping standards defined by the Open Geospatial Consortium (OGC), the new EO application profiles developed in HMA ensure common interpretation and interoperability of EO metadata and service requests upon all HMA partners (ESA, EUMETSAT, ASI, CNES, CSA, DLR, UK Space Agency) and all other HMA-compliant service providers, currently about 10, including commercial EO providers.

The DLR HMA Catalogue Service and Order Service interfaces are integrated in the EOWEB server layer. The catalogue interface gives access to all TerraSAR-X and IRS product collections, as well as and MetOp/GOME-2 collections. The order interface operated by DLR allows ordering of IRS products, orders are forwared to and processed by Euromap in Neustrelitz. The DLR order service implementation is also operated by Infoterra for ordering TerraSAR-X products. Within the next 2 years, DLR will serve all collections of the German Satellite Data Archive (D-SDA) through HMA service interfaces.

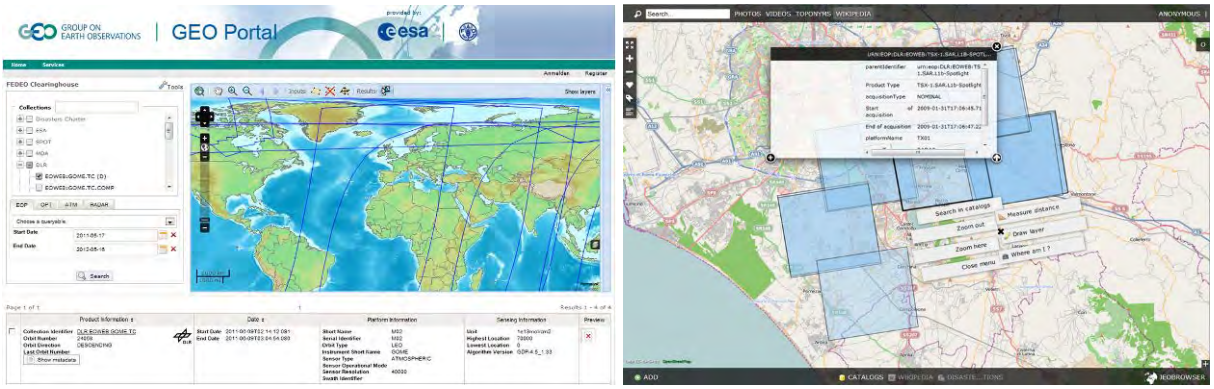


Figure 7: D-SDA EO Products Visible in GEO Portal and Other Standard Clients (e.g. jeobrowser.com)

GMES Space Component – Data Access for GMES Contributing Missions

DLR serves two GMES Contributing Missions projects by hosting TerraSAR-X and IRS data in the D-SDA, through engineering support, and by providing the operational HMA services as described above.

Evolution of Online User Service on EO Data

An initial set of D-SDA product collections have been described with ISO metadata and been published in an OGC-compliant catalog service (CSW) for integration into the German national geodata infrastructure (GDI-DE) and INSPIRE compliance. Thus the data sets can be discovered via the national Geoportal.DE as well as through the global GEO/GEOSS Portal.

The first D-SDA data sets have become available online for direct access through OGC-compliant web mapping services (WMS). Throughhe new EOC Geoservice platform geoservice.dlr.de SRTM-DEM and GOME-2 atmospheric chemistry products can be accessed. Further data sets are continuously being integrated. DLR also contributes to the standardisation of EO application profiles of web mapping and download services in the HMA context.

The renewal of the EOWEB web gateway progresses. The new EOWEB GeoPortal will extend the classic search/inspect/order approach with a data browse function allowing the Google-Earth-like display of data layers, enhanced by navigation to metadata, ordering and direct download services. The EOWEB GeoPortal will allow as a client access to HMA-compliant catalogues and OGC-compliant web mapping services served by DLR or third parties. An initial test version of the EOWEB GeoPortal is operational.

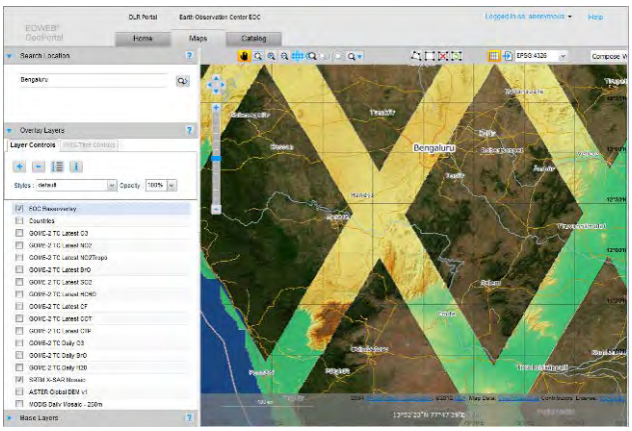


Figure 8: DLR EOWEB GeoPortal

The new ESA project EOLib conducted by DLR aims at integrating information mining functions into the EO payload data ground segment, adding a semantically assisted way of opening up Petabytes archives of EO products. Products will be systematically annotated with searchable semantic terms and users shall be able to refine searches by giving example patterns and anti-patterns. The EOLib demonstrator system developed in the project will allow to exercise these new EO data access functions upon the TerraSAR-X data set within D-SDA.

3.2.4 Long Term Data Preservation (IT)

Long term data preservation is a major task within the DLR owned/supported ground segment environments, i.e the German Satellite Data Archive (D-SDA), ESA Payload Data Ground Segment, and scientific and commercial partner facilities. This work will be intensified to improve and harmonize data archiving and access in order to guarantee long term availability and usability of EO space data. This work is of particular importance with respect to exponentially growing data volumes in the German Satellite Data Archive D-SDA.

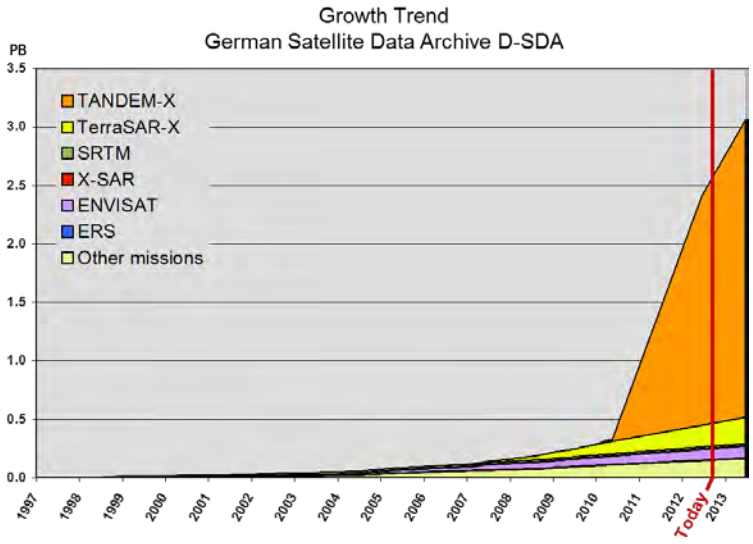


Figure 9: Growth Trend German Satellite Data Archive

DLR, together with representatives from ASI, CNES, CSA/CCRS, UK Space Agency, and ESA, is a member of the ESA-led Long Term Data Preservation (LTDP) Working Group. The LTDP working group was formed in 2007 within the Ground Segment Coordination Body (GSCB) with the objective to ensure preservation and usability of European and Canadian Earth Observation data for an unlimited timespan. This is done through cooperation and harmonization of EO LTDP approaches across ESA countries and by encouraging LTDP within EO and Earth Science communities in Europe and beyond

Within this context DLR is involved in defining and promoting the 'European LTDP Common Guidelines', as well as the 'European EO Space Data Set' to be preserved. DLR contributed to the ESA-managed Long Term Data Archive Study on New Technologies (LAST) and the definition of LTDP User Requirements and Preserved Data Set Composition Study (FIRST). Moreover, DLR supports studies on the evaluation and evolution of the Standard Archive Format for Europe SAFE and on the design of an ESA LTDP architecture.

Through the work of the LTDP working group DLR also contributes to component C1 'Evolution and Enhancement of the GEOSS Common Infrastructure' in the Infrastructure sub-task IN-03 'GEOSS Common Infrastructure' in the GEO 2012-2015 Work Plan.

DLR will continue evaluating, implementing, and shaping LTDP practices through its ongoing participation in the LTDP working group and in related projects, such as the EU project SCIDIP-ES.

3.2.5. Data Processing and Archiving for MetOp-A - Satellite Application Facility for Ozone and Atmospheric Chemistry Monitoring (O3M-SAF)

The German component of the O3M-SAF is operated at DLR on behalf EUMETSAT as part of the EPS ground segment. DLR is responsible for the processing, archiving and user services for GOME-2 total column products. The following products are already operational:

- total Ozone (O3)
- total and tropospheric Nitrogen dioxide (NO2)
- total Sulphur dioxide (SO2)
- total Bromine Oxide (BrO)
- total Formaldehyde (HCHO)
- total Water Vapour (H2O)
- cloud properties (CF, CTH, COT)

Other trace gases are continuously processed for pre-operational and demonstrational purposes.

The level 2 products are available in near-real-time, i.e. 2 hours after sensing, as well as off-line consolidated orbits. The DLR services fulfil the high EPS requirements on accuracy, availability (24/7) and reliability (97.5%). The near-real-time data products are disseminated through the satellite broadcast system EUMETCast operated by EUMETSAT and worldwide through the Global Telecommunication System (GTS) operated by the WMO and national weather services.

The next O3M-SAF project phase (CDOP-2), covering a time period of 5 years started in March 2012. DLR will continue the algorithm development and operational processing of products from GOME-2/MetOp-A and additionally of GOME-2/MetOp-B (with an expected launch September 17, 2012).

Since the switch-off of ERS-2 with the GOME sensor on-board in July 2011 and the loss of the ENVISAT platform in April 2012, the GOME-2 instruments on the MetOp series form currently the 'work horses' of DLR's involvement in spaceborne atmospheric remote sensing until the next generation of missions will become operational (Sentinel-5 Precursor, Sentinel-4, Sentinel-5, MERLIN, CarbonSat).

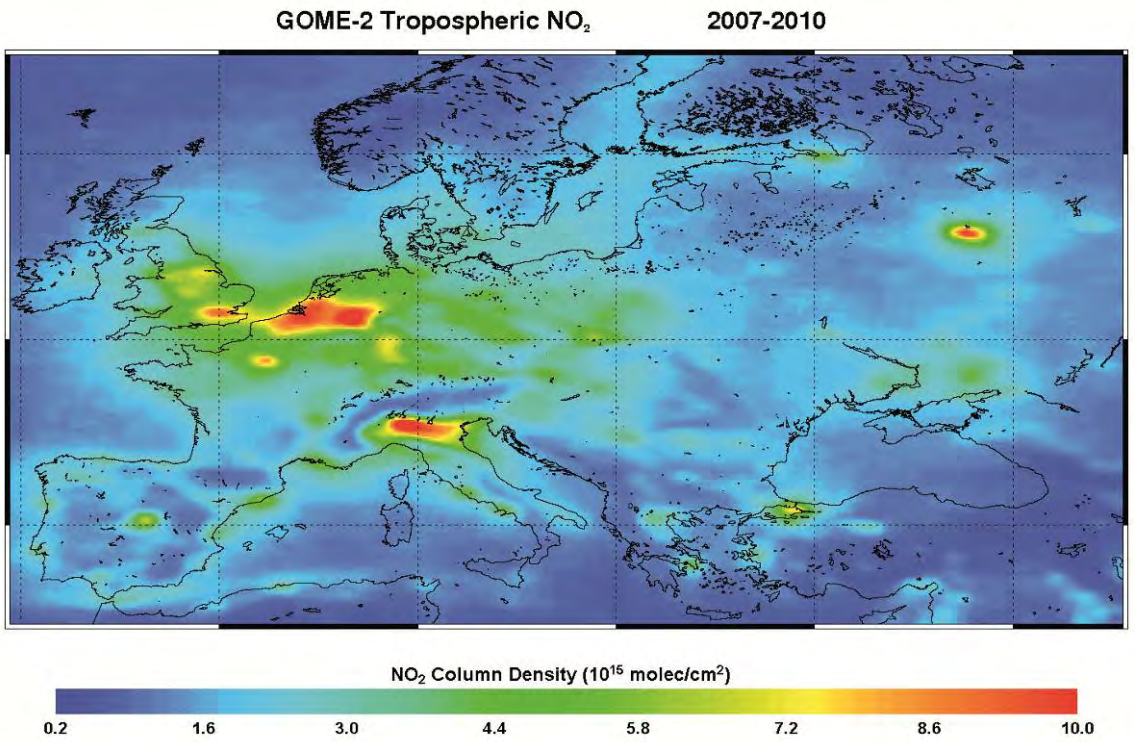


Figure 10: Average tropospheric NO2 columns measured by GOME-2 over Europe between 2007 and 2010.

SCIAMACHY Operations

Work of the SCIAMACHY Operations Support Team (SOST), a collaborative effort between DLR's Applied Remote Sensing cluster and IUP-IFE, University Bremen, continued and ensured safe and healthy operations of the instrument until the sudden loss of the ENVISAT mission on 8th April 2012. Until this unexpected event, as in all previous years, a high level of availability was achieved.

It is planned to extend the SOST activities for the duration of an at least 1-2 years spanning phase F for appropriately documenting and archiving the operations related information of the SCIAMACHY instrument. This shall be in support of long-term data preservation of the SCIAMACHY measurement data. In addition, further analyses of instrument properties, e.g. line-of-sight knowledge, temperature dependences, are envisaged for improving the instrument's characterization.

3.2.6. Algorithm Development for Atmospheric Chemistry Missions (GOME, GOME-2, SCIAMACHY, ADM)

GOME & GOME-2

Since 1995, GOME/ERS-2 measured solar and backscattered spectra in the ultraviolet and visible wavelength range. The last GOME measurements were performed in July 2011 when the ERS-2 satellite was decommissioned. The GOME Level 1-2 processor was updated to version GDP 5. In contrast to previous versions that were based on the DOAS technique, GDP 5 uses the more elaborated GodFit technique. The GDP 5 data covering the complete GOME mission was released in September 2012.

Water vapour retrievals from GOME-2 data has achieved the full operational status in the framework of the O3M-SAF based on a retrieval algorithm developed at the Max Planck Institute for Chemistry, Mainz.

In the context of the ESA DUE GlobVapour Project, DLR developed global total column water vapour data from GOME/SCIAMACHY/GOME-2 over ocean and land for 1996-2010 with weekly and monthly resolution. For more GOME/GOME-2 related information see: http://atmos.caf.dlr.de/gome/ and http://atmos.caf.dlr.de/gome2/

The GOME-2 SO2 products provided by DLR were extensively used during recent eruptions like the Grimsvoetn volcano on Iceland (May 2011), and from several volcanos in Africa, see Figure below. During the last year, DLR continued the development and validation of a new algorithm for the fast retrieval of the volcanic SO2 plume height. The GOME-2 SO2 concentration and plume height information are being used in operational services like the Support to Aviation Control Service (SACS) hosted by BIRA-IASB.

More information can be found in the dedicated GOME-2 SO2 service page
http://atmos.caf.dlr.de/gome2/service_so2.html

SCIAMACHY

DLR's level 0-1b and level 1b-2 activities occurred in the frame work of the SCIAMACHY quality working group (SQWG). The SQWG has the task to coordinate, harmonise and streamline the development of SCIAMACHY operational data processing. Members are IUP-IFE (University of Bremen) as the prime, DLR-IMF, BIRA and SRON. Additionally it cooperates with KNMI. Apart from the further evolution of the data processing, IMF-AP also provided expert support for the maintenance of the operational processors and the quality of the data products. The tasks include investigation and solution of product or processor anomalies, answering helpdesk requests and supporting ESA for the implementation of the operational processing chain.

- Level 0-1b algorithm development comprised improvement of the level 0-1b prototype processor. A new version (V. 8) of the processor is currently implemented and will be delivered at the end of 2012. Several improvements were implemented, the most important being a new model by SRON to correct the scan angle dependent degradation of the mirrors.
- Level 1b-2 work focused on the implementation of an updated processor V. 6 with a planned delivery end of 2012.
- Developments of the Level 1b-2 processor towards V6 comprise
- finalisation of the vertical column retrievals of CH4
- vertical slant columns of CHOCHO (Glyoxal)
- implementation of a NO2 tropospheric retrieval using Limb-Nadir matching.

In support of the operational SCIAMACHY data products, DLR continued the verification of the quality of the consolidated level 0 (cl0) products and maintained its cl0 master measurement data set. These products serve as the basis for each operational re-processing activity.

- Studies for the retrieval of water vapour from Limb observations have been continued.
- Nadir observations in the near infrared can be used to derive information on atmospheric carbon gases such as CO, CH4 and CO2. A study of the dependence of the SWIR retrievals on instrument and calibration features was performed to further improve the operational CO and CH4 products:

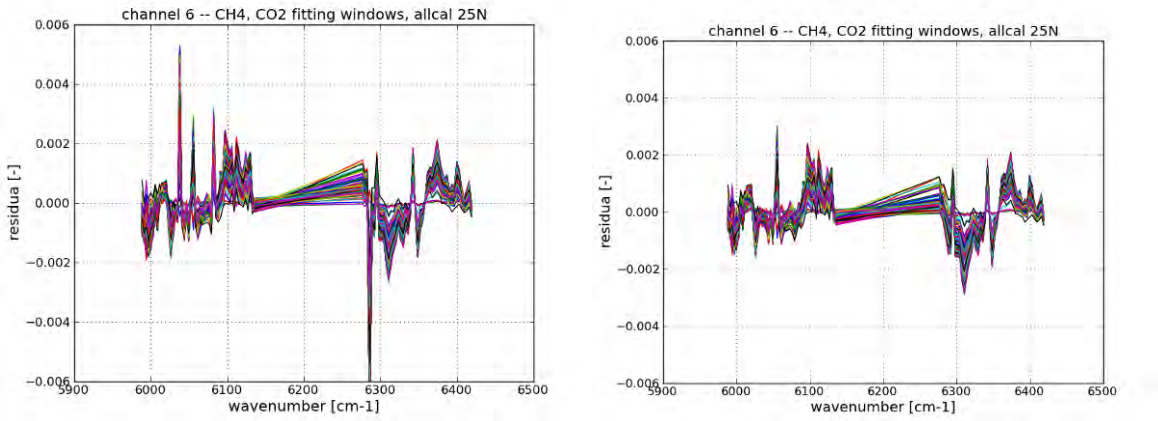


Figure 11: Identification of degraded detector pixels undetected during calibration in the CH4 retrieval. Left: Fit residual CH4 using the original pixel mask. Right: Fit residual using a mask that has additional 3 pixels masked. Different colours mark different observations.

ADM-Aeolus

In the context of the future ESA Earth Explorer Doppler wind lidar mission ADM-Aeolus with a planned launch end 2014, DLR develops the operational ground processor and is responsible for pre-launch validation of the lidar instrument by airborne campaigns.. During the ADM-Aeolus mission DLR will also be responsible for operating the long-term archive. The ADM-Aeolus mission will provide the following products:

- the line-of-sight wind velocity
- information on cloud top heights,
- the vertical distribution of cloud,
- aerosol properties.

A new global atmospheric observing system, such as ADM-Aeolus, will have a great effect upon operational weather forecasting. The provision of detailed wind profiles will also benefit scientists involved with climate research, allowing for greater accuracy in the numerical modelling of tropical regions in particular.

Contributions to ESA Climate Change Initiative

- *Ozone Essential Climate Variable (ECV):* DLR plays a central role in the consortium for the Ozone ECV within the ESA Climate Change Initiative (CCI). The Ozone CCI project is led by the BIRA institute in Belgium and DLR is responsible for ozone total column ECV parameter (based on GOME, SCIAMACHY and GOME-2 measurements) as well as the system engineering and climate modelling aspects of the project. see http://www.esa-ozone-cci.org/?q=project%20team.
- *Greenhouse Gases (GHG) Essential Climate Variable (ECV):* DLR is part of the consortium for the GHG ECV within the ESA Climate Change Initiative (CCI). The GHG CCI is led by the University of Bremen. Within the consortium DLR is responsible for Level 0-1 improvements and system engineering aspects of the prototype processor software.

- *Supplementing Activities:* The Virtual Lab (VL) continued to provide online access to modules for scattering and radiative transfer applications via a powerful web-based GUI (see http://vl.nz.dlr.de). In addition the high-quality scattering database is going to be further extended by providing cross-sections for extinction/absorption, scattering phase functions as well as polarization information for uniformly oriented spheroidal aerosol particles. This database can be used to perform radiative transfer computations in the shortwave and longwave spectral region and for interpreting lidar backscattering observations of aerosols.

Sentinel-5 Precursor Level 2 Development

- DLR started the development of S5P level 2 algorithms and the adaption of the UPAS processor. This work will be funded by national grants and an ESA contract. The corresponding proposals are in preparation. A first meeting of the level 2 working group (KNMI/DLR co-lead) took place in July 2012.

3.3 Highlights of Algorithm and Application Development at DLR Earth Observation Center

The construction of the new Earth Observation Center (EOC) at DLR in Oberpfaffenhofen was finalized and the inauguration of the Earth Observation Center took place on July 20th, 2010 in presence of the German Minister for Ecomomy, Mr. Bruederle and ESA DG, Mr. Dordain. The EOC is supported by the State of Bavaria and will host GMES ground segment facilities and GMES Services. Hence, in September 2010, the Cluster of Applied Remote Sensing was officially renamed Earth Observation Center (EOC).

Figure 10: View of the new EOC at DLR in Oberpfaffenhofen

3.3.1 Atmosphere

- The work about *Global long-term environmental satellite data for climate monitoring* by a team from DLR-IMF and DLR-IPA, based on the homogeneous long-term total ozone record from GOME, SCIAMACHY and GOME-2, received the DLR science award 2011. At the ceremony it was stated that with "The creation of long-term time series of stratospheric parameters such as ozone from homogenized satellite measurements is an extremely important and essential contribution for climate research".

Figure 111: Prof. Wörner (right), Chairman of the Board of DLR, awards the DLR science prize 2011 to Diego Loyola, Andrea Stenke, Martin Dameris and Melanie Coldewey-Egbers during the DLR annual general meeting in Stuttgart (photo: DLR).

- The homogeneous long-term total ozone record from GOME, SCIAMACHY and GOME-2 provided by DLR was used in the WMO/UNEP ozone assessment 2011.
- The new GOME level 1-2 processor version 5 using the GodFit algorithm instead of DOAS was developed and the GOME total ozone data was reprocessed.
- Water vapour from GOME-2 has reached the full operational status. This product completes the list of operational O3M-SAF products provided by DLR: O3, NO_2, tropospheric NO_2, SO_2, BrO, HCHO and H_2O.
- A new version (V6) of the SCIAMACHY level 1b-2 is prepared for delivery end of 2012
- DLR maintains, over the SCIAMACHY mission lifetime, a complete master measurement data set of consolidated level 0 products. Consolidated level 0 product availability as high as 97% has been achieved.
- A high-quality scattering database has been made available und further extended which provides cross-sections for extinction/absorption, scattering phase functions as well as polarization information for uniformly oriented spheroidal aerosol particles. This database can be used to perform radiative transfer computations in the shortwave and longwave spectral region and for interpreting lidar backscattering observations of aerosols.
- The Virtual Lab (VL) continued to provide online access to modules for scattering and radiative transfer applications via a powerful web-based GUI, see http://vl.nz.dlr.de. Web-access to a benchmark database for spherical particles is forseen for 2013.
- Successful implementation and daily provision of SCIAMACHY nadir level-2 based 4DVAR ozone analysis using the SACADA data assimilation system. SACADA is developed in cooperation with the Rheinish Institute for Environmental Research (D).
- DLR-DFD has successfully implemented air quality modelling systems for Bavaria and the Middle East and is currently developing an Alpine airshed. The systems are aiming at combining modelling capabilities and satellite observations of air pollutants (e.g. tropospheric NO2) in order to improve forecasting of air quality and health related early warning systems.

Network for the Detection of Mesopause Change NDMC:

The international Network for the Detection of Mesopause Change (NDMC) coordinated by DLR-DFD (http://wdc.dlr.de/ndmc) was launched in May 2007. Currently 51 measurement sites in 24 nations are providing measurements from ground based instruments for monitoring climate development and satellite validation. The current focus on ground-based airglow instruments in the mesopause (80 -100 km altitude) will be extended to the mesosphere including other measurement techniques such as Lidar, Radar, satellite-based and rocket-borne techniques or modelling. The World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT) serves as the data and communication platform of NDMC.NDMC became part of the international CAWSES (Climate and Weather of the Sun-Earth-System)-II program. It is further affiliated with WMO's Global Atmosphere Watch (GAW)-program and with the Network for the Detection of Atmospheric Composition Change (NDACC).The first global NDMC measurement campaign took place in September/October 2009 primarily focussing on the investigation of hemispheric asymmetries and planetary wave activities in the mesopause region. The second joint measurement period started in May 2010 lasting a full year focussing primarily on studying effects of gravity waves in the mesopause region and intercomparison.

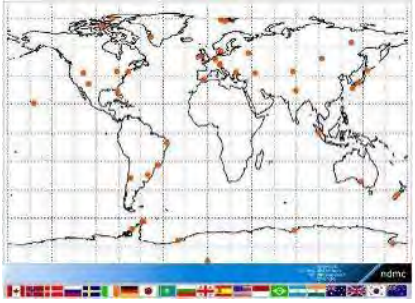


Figure 14: NDMC global station network

Hazard

The GRIPS spectrometer of DLR-DFD is also be suited for the rapid detection of natural hazards such as tsunamis, earth quakes, or volcanic activities. This is because the infrasound caused by such events should induce observable temperature fluctuations in the OH*-airglow layer. At present the feasibility of using this modulation of OH*-temperatures caused by infrasonic waves travelling through the airglow layer is analysed. Development of a volcanic fast response system in the context of the BMBF-funded project EXUPERY (http://www.exupery-vfrs.de/) has been finished. Besides established ground-based monitoring approaches, a major novelty of this mobile system is the successful inclusion of satellite based observations to deduce ground deformation, to detect hazardous gas emissions and to monitor thermal activity. For monitoring gas emissions near-real-time data of GOME-2 is utilised. Based on the data collection the actual state of activity at the volcano can be determined and alert levels set or further processing by local decision makers

Energy

- ESA Integrated Application Programme feasibility study CSP-FoSyS (Concentrating Solar Power Forecast System for Participation in the Spanish Electricity Market using EO and COM technologies) has been continued in 2011 in close cooperation between DLR and Solar Millennium AG. It showed the value of geostationary satellite-based nowcasting of solar irradiance for power plant operations and power production forecasting
- DFD-AT continues its contributions both to the International Energy Agency (IEA), Solar Heating and Cooling Programme and the GEOSS Energy Community of Practice and EN-07-01 task.
- Participation in the EU COST action ES1002 "Weather Intelligence for Renewable Energies"
- DLR is leading the radiation sub-project within the GMES component service project "Monitoring Atmospheric Composition and Climate" (MACC, started in June 2009) which is devoted to solar-energy resource information as well as surface UV quantification.
- FP7 project EnerGEO started October 2009. It evaluates the environmental impacts of coal, gas, nuclear, wind, solar and bio-energy production by using GEOSS capabilities. This is a direct answer to GEOSS task EN-07-02.
- FP7 project ENDORSE (Energy Downstream Services) focuses on service development with selected users and service providers for the downstream energy sector in the field of solar, wind, biomass energy and energy efficiency in buildings.
- DFD-AT generated a global 1984 to 2009 aerosol optical depth data set suitable to solar energy needs. This has been included in the BMU MedSolarAtlas project providing planning information for solar power plant site selection in Northern Africa (Desertec initiative).
- DFD-AT completed a major reprocessing of the Meteosat Second Generation satellite data deriving atmospheric parameters suitable for solar energy users (specific cloud parameters, water vapour, snow). This will become part of the GMES atmosphere service within the MACC-2 project

Aerosol

- The synergetic aerosol retrieval (SYNAER) from ENVISAT SCIAMACHY and AATSR of aerosol loading and composition continues to extend the time series from 2003-2009 over Europe, Africa, the Atlantic and parts of South Americaup to the end of ENVISDAT operations; new IASI products (mineral dust and volcanic ash) were demonstrated, improved and validated.
- Statistical analysis of MSG-BMDI, MODIS, and ENVISAT-SYNAER cloud and aerosol date over the West-African monsoon region and Southern Africa showed counter-acting aerosol indirect effects on cloud properties.
- Contributions to GMES atmosphere services in the field of particulate matter compliance monitoring support (MACC, PASODOBLE and MACC-2 continuation) are evolving.
- The benefit of component-wise assimilation of SYNAER-ENVISAT aerosol observations into the MATCH atmosphere model using simple and sophisticated error covariance setup was shown.

- Within ESA Climate Change Initiative DLR leads the *Aerosol Essential Climate Variable (ECV)* consortium which for the first time integrates practically all European aerosol retrieval groups in one project. The focus of the first three year project is to assess, qualify and improve a number of pre-cursor algorithms through comparison to ground-based and other (NASA) satellite datasets.

Middle atmosphere dynamics

- For functional reasons satellite and comparison measurements in general do not correspond precisely in time and space. However, dynamical effects in the atmosphere lead to temporal and spatial variability of atmospheric parameters (e.g. temperature). Already due to this effect, there exist differences in the measurements (miss-time / miss-distance error). Additionally, deviations in measurement data that are caused by differing measurement geometry of the instruments (miss-integration error) have to be taken into account. Miss-time and miss-distance errors were investigated using ERA-40 and TIMED-SABER data and a climatology on monthly base was calculated. Concepts for the estimation and first analysis of the miss-integration error were developed / performed. An internet tool providing the miss-time / miss-distance error for a given miss-time, miss-distance, time, latitude and longitude was developed and is online: http://wdc.dlr.de/ufsdaz/mismatch-tool_intro.php.
- The basic ideas were also used for the development of a validation concept for PREMIER.
- For the investigation of gravity waves and their influence on atmospheric circulation an algorithm has been developed allowing the derivation of gravity waves structures. It was applied to SABER data in the ALPINE region for 2002 to 2009.
- The change of the atmospheric's large-scale circulation within the last 30 years on the Northern Hemisphere during winter months was investigated using ozone data of TOMS (on board of Nimbus-7 & Earthprobe). Using these results the change of stratospheric ozone caused by dynamical effects has estimated to be in the same order of magnitude or at least one order of magnitude less than the chemically induced trend. Natural influence caused by the sun or the QBO for example was quantified in case studies.
- Three more places are at least for a certain time period equipped with GRIPS spectrormeters (ALOMAR (Norway), Catania (Siciliy, Iltaly), Palma (Mallorca,Spain)); the data will beneath others be used for the further development of novel validation approaches
- Simultaneous measurements of three GRIPS instruments allowed the derivation of horizontal wavelengths, periods and phase speeds of gravity waves in the mesopause region
- NDMC data were used for SABER-comparisons showing a differing results

Modelling of planetary atmospheres

The Earth Observation Center (EOC) participates in the Helmholtz Alliance Planetary Evolution and Life, led by the Institute of Planetary Research of DLR at Berlin-Adlershof. The goal of this alliance is to study in a multidisciplinary fashion the interaction of the evolution of life and its hosting planet. It comprises the entire planet – dense geosphere (core, mantle, crust), hydrosphere, cryosphere, atmosphere, biosphere and even magnetosphere. Partners of the alliance are Helmholtz centres, universities, non-university research institutes and associated groups.

For an assessment of the spectral signatures of exoplanets from high resolution spectra and the impact of clouds, a multiple scattering radiative transfer solver had been implemented in DLR-IMF's line-by-line code GARLIC. Observations of Venus obtained by SCIAMACHY on-board ENVISAT served as a unique test case. Simulations of the thermal emission spectrum of Earth-like exoplanets orbiting F, G, K, and M stars have been performed at high resolution, and the feasibility to observe biomarkers in cloudy atmosphere has been studied.

In addition, the exoplanet Gliese 581d, orbiting the nearby red dwarf Gliese 581, has been studied as a model case for characterizing the spectrum of a potentially habitable planet.

3.3.2 Land

Land Processes

DLR is leading or participating in several international research and development projects related to environmental monitoring. Some examples are:

- In the ESA CCI "Fire" project, DLR is in charge of developing an improved pre-processing chain (ortho-rectification, atmospheric and terrain correction, advanced cloud / haze masking) for MERIS, (A)ATSR and VEGETATION data. The overall project has successfully completed its first phase, and is aiming at the detection of burnt areas as an Essential Climate Variable.
- Participation in European GMES projects related to land monitoring, e.g. the EU funded FP7 project on the "Geoland 2" and the ESA funded DUP project GlobWetlands project. Participation in the GMES Initial Operation Phase (Lot 6: Grasslands, wetlands and water bodies in the EEA39) in preparation.
- Involvement in the FP7-SPACE project "SENSUM - Framework to integrate Space-based and in-situ sENSing for dynamic vUlnerability and recovery Monitoring". Start 01/2013.
- Integrated Water Ressource Management in central Asia (CAWa) integrating a climate and hydrological ground station network with remote sensing products to estimate seasonal and long term water availability and need. Aim is to install a regional water information system to support adapted water management driven by regional land use and climate changes.
- Water Related Information System for the Mekong Delta in Vietnam (WISDOM) (http://www.wisdom.caf.dlr.de/intro_en.html)
- RSSC Africa: Pre-phase to establish regional science service centers in west and the southern Africa to establish information systems for land management reacting on climate and human induced pressures.
- In the EU funded FP7 research project EOMiners the role of Earth observation in the reduction of the ecological and societal footprint reduction in the minerals sector. Industry and science partners from ten different countries are working together on three test areas in the Check Republic, Kirgizstan and South Africa.
  Continuation of the Ph.D. program "Integrated Earth Observing System" (HGF-EOS) in the framework of the Helmholtz Research Network. Members of the EOS research network include the Helmholtz Centers DLR, AWI, GFZ, GKSS, FZK and FZJ) (see: http://helmholtz-eos.dlr.de/start_en.htm)

In context of CEOS, also the following in-house developments and projects are of interest:

- Finalization and implementation of joint and agreed European standards for metadata and data quality indices for airborne hyperspectral data in the framework of FP7 EUFAR project, also taking account existing standards (ISO, INSPIRE).
- Contributing to the GEO 2012-2015 work plan in different social benefit areas (SBA), e.g. SB-04 (Global Urban Observation and information), SB-05 (Impact Assessment of Human Activities) and EN-01 (Energy and Geo-Resources Management).
- Establishment of an operational processor to derive the area of human settlements on a global scale using TanDEM-X (Global Urban Footprint). Operational processing started end of 2011; first products will be be available in early 2013.
- Implementation of ATCOR atmospheric correction in the framework of the ESA Sentinel-2 prototype processor

Photogrammetric Engineering and 3D

- Project "IMAGE2012" for GAF: Development and operations of a processing chain for IRS-P6-LISS3, AWIFS, SPOT-5 images; Input: Level 1b (systematic and radiometric correction); Output: Level 1c (ortho-rectified, including cloud mask); Status: ongoing
- Project "Operational Processor for ALOS Optical Images": Development of an operational processor for ALOS-PRISM and AVNIR image data , Input Level 1b, Output: ortho-rectified data (Level 1c) using additional reference data if available, ongoing
- Project Sentinel-2 GPP: Validation work for the development of the prototype processor for sentinel-2, Lead: ACS, Italy

- A fully automatic software for the generation of Digital Surface Models for optical stereo data for satellites like Cartosat-1, Worldview-2, GeoEye-1, Pleiades has been developed and is operated for several projects

3.3.3 Oceans

MARISS – Ship Detection Service

In the framework of the ESA project `MARISS ` - European Maritime Security Services, a ship detection software (SAINT – SAR AIS Integrated Toolbox) was installed for real time use and tested in campaigns together with the German Federal Police, the German Navy and international users. The service can be used on C-Band or X-Band SAR, e.g. TerraSAR-X and Tandem-X high resolution data, Radarsat-2 or the former C-Band systems ERS and ENVISAT ASAR.

Ship detection results are delivered via an auto-generated Email to users in less than half an hour as quick-looks, text files containing position and ship parameters, Google Earth compatible kml files (as shown below) and GIS shape files. SAR detected ships are compared to ship messages from the terrestrial or satellite based Automatic Identification System (AIS) and non-cooperating ships are identified.

The service is used in the ESA project MARISS together with data from other service providers and has shown to be very helpful in joint campaigns aiming at prevention of piracy and illegal cross border trafficking.

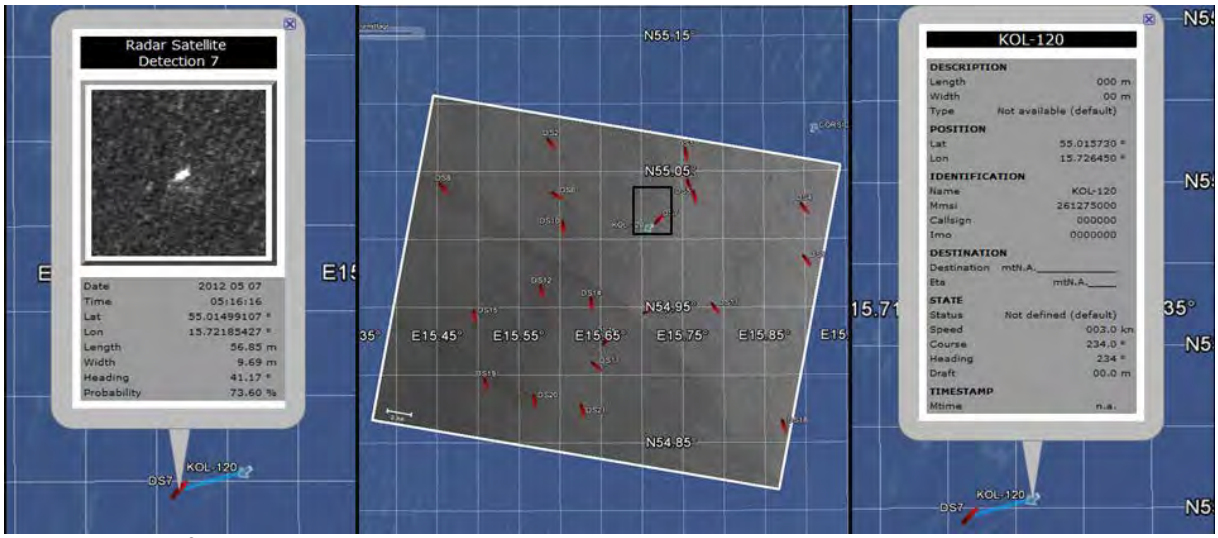


Figure15: The figure shows a 30 km x 20 km image over the North Sea, detected ships are marked with red symbols. The data are compared to terrestrial AIS messages(see the example of the KOL-120). Data were delivered in NRT in less than half an hour by auto-generated email.

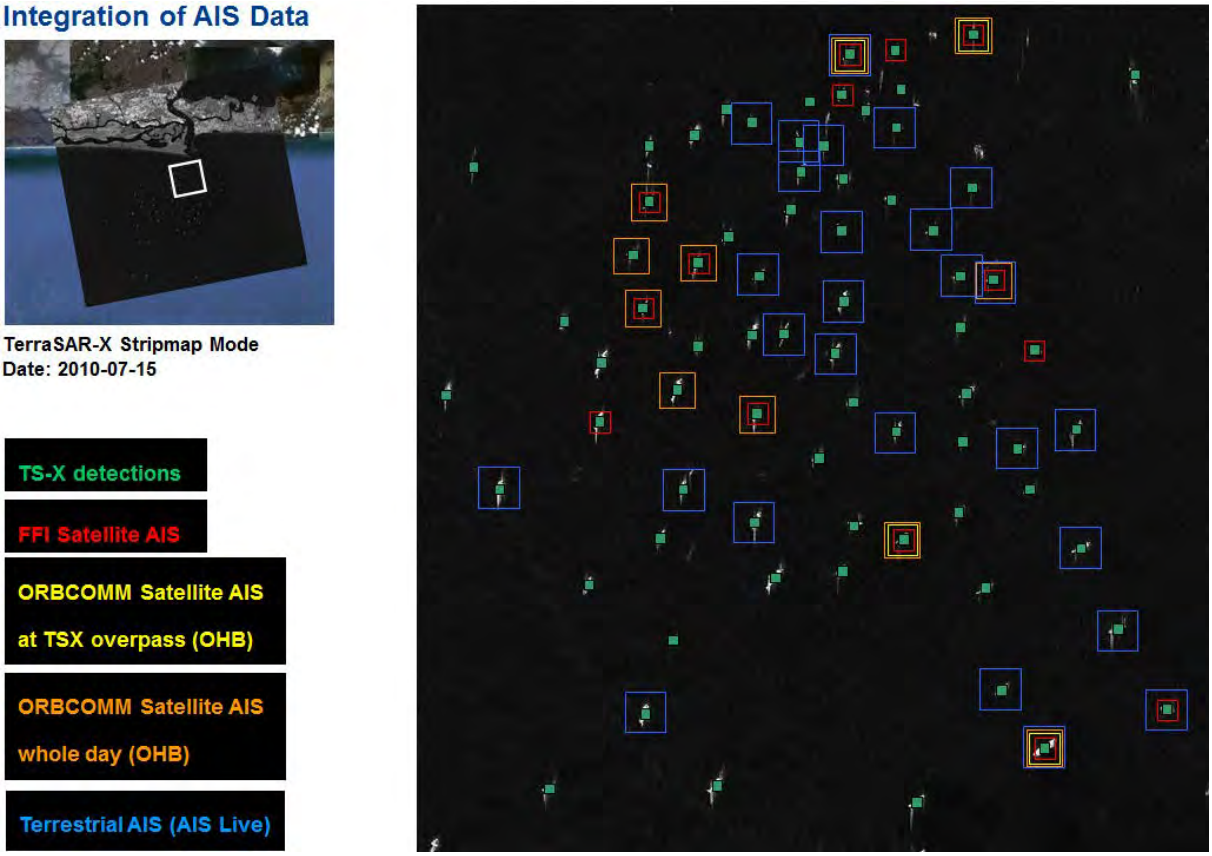


Figure 16: The TerraSAR-X image shows an area in front of Lagos, Nigeria. A large number of ships are anchoring in front of the coast. The green dots indicate TerraSAR-X ship detections. Terrestrial AIS messages are marked with blue rectangles. The captured AIS data by satellites during the over flight and whole day are marked with yellow, orange and red rectangles

Anti-Piracy Campaigns

In a series of joint anti-piracy campaigns together with the German Federal Police hijacked ships like the MV York and the Beluga Nomination were imaged (as shown below).

Near Real Time ship detection reports have been delivered in the Anti-Piracy campaigns PIRASAT which are in led by EMSA (European Maritime Safety Agency). Activities extended from joint ESA campaigns in the MARISS project to development of new techniques in the DOLPHIN EU project, which is led by E-GEOS.

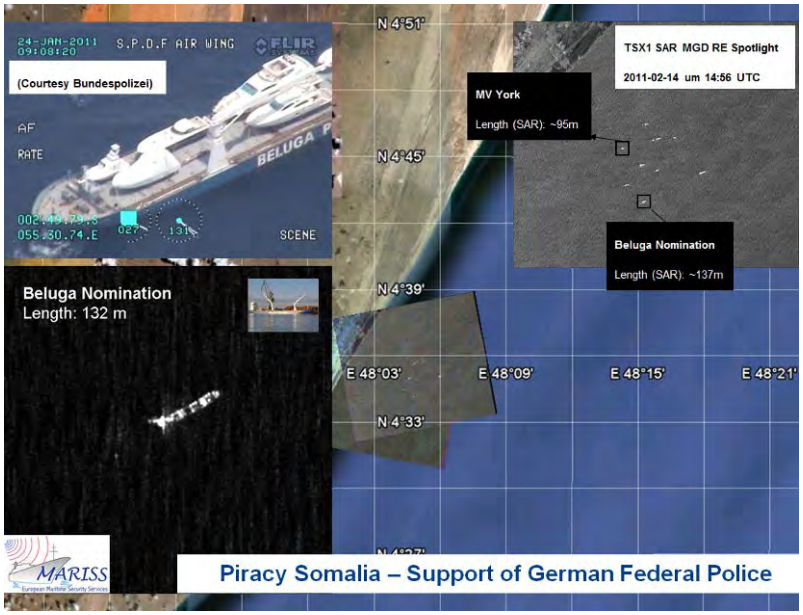


Figure 17: Anti-piracy demonstration campaign

TerraSAR-X Wind and Wave Algorithms

Using TerraSAR-X Data new algorithms, XMOD 1 & 2, were developed to determine the high resolution wind field, which is particularly interesting, e.g., for offshore wind farms in highly variable coastal areas. Sea state parameters, i.e., significant wave height, wave length and direction are derived using the XWAVE algorithm. Related parameter like underwater topography is deduced from the refraction of the waves. Finally from the streaks near to the coast the height of the breaking waves is deduced.

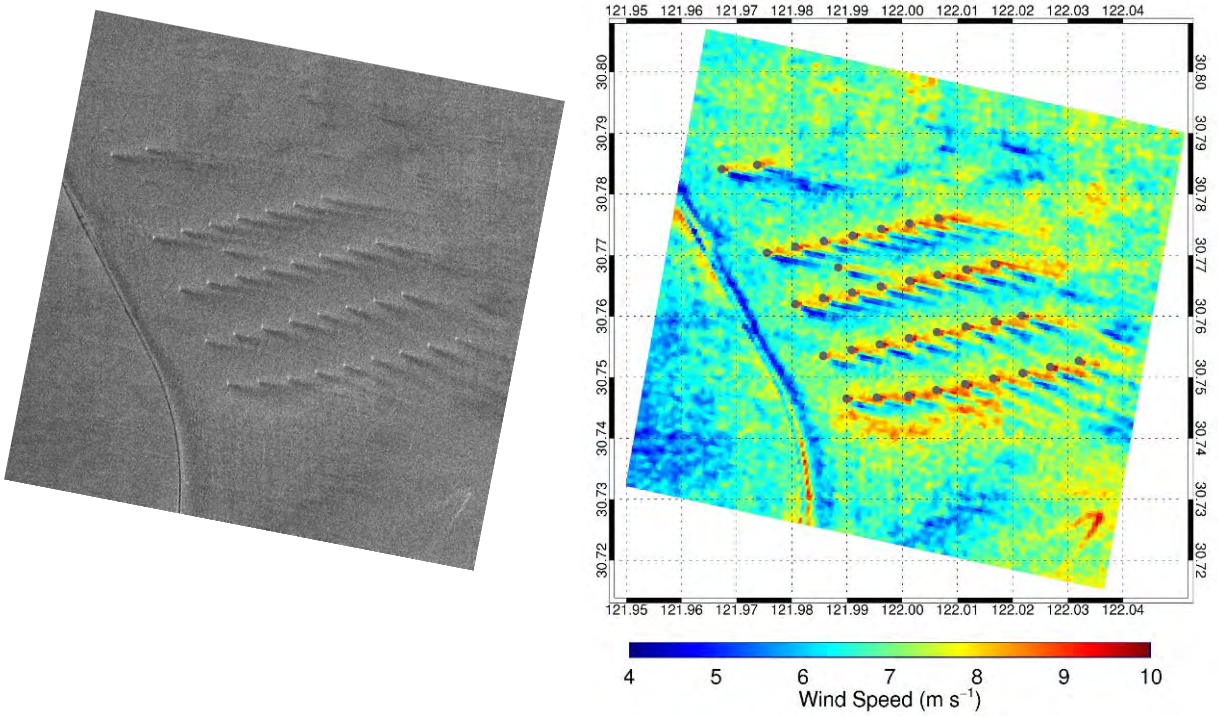


Figure 18: Wind Field from TerraSAR-X over Wind Farm in South China Sea

Storms and Storm Surges

New methods were developed to derive significant wave height from SAR Wave Mode data. ENVISAT ASAR Wave mode data are acquired on parallel tracks to the altimeter and are thus a quality criterion of wave height satellite measurements verses model results. In storms, SAR wave mode measurements are usually higher than, e.g., model results from the German Weather Service (DWD). The figure shows wave height of a North Atlantic storm as modelled by DWD with two superimposed satellite tracks from altimeter and SAR. Obviously wave height in the storm was stronger than modelled. A further focus is on derivation of wind fields from typhoons.

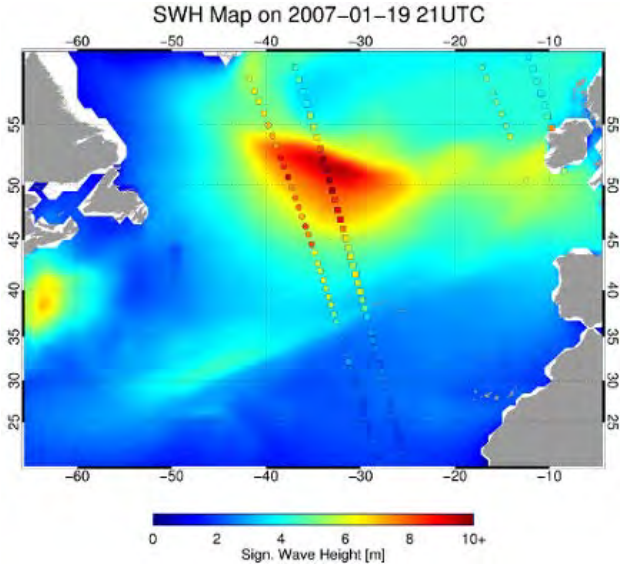


Figure 19: Significant Wave Heights from ENVISAT over North Atlantic

3.3.4 Civil Security and Georisks

Research and development activities have been focussed on the development of Earth observation based products and services to support all phases of the disaster management. This includes the support to (1) emergency response by rapid mapping of the disaster extent and damages as well as (2) post-disaster monitoring and (3) pre-disaster risk assessment. For all these phases, new methods and services have been developed and operationally implemented. Flights campaigns have been performed to further develop the capabilities in near real-time from airborne sensors.

Research activities on the field of information extraction aimed at the development of innovative methods to provide new products and services in order to further improve the monitoring and rapid mapping of crisis situations world-wide. Among several others, a new method for the detection of burnt areas based on SAR data has been developed. It is based on a SAR backscatter change analysis and implemented for TerraSAR-X data. A combined approach for burnt area detection based on optical and SAR data was implemented and applied in several rapid mapping activations. The detection of flooded areas using X- and L-band SAR was intensively investigated in the framework of the joint cooperation between DLR and JAXA. Based on the synergetic use of TerraSAR-X and ALOS PalSAR data the methods for flood mapping have been further developed

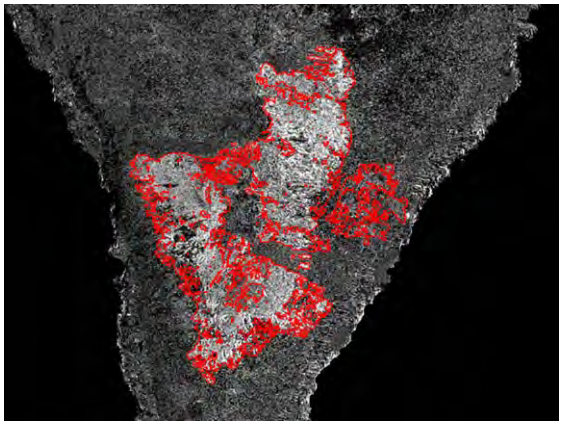


Figure 20: Burnt area mapping based on TerraSAR-X Strip Map and Spot-5 data for forest fires in La Palma

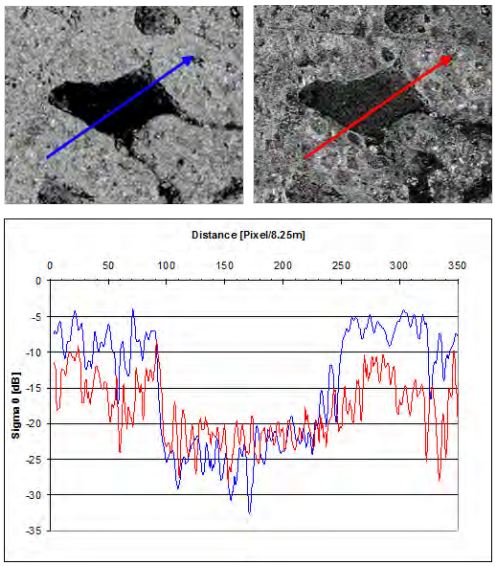


Figure 21: Backscatter profile of land and water areas in TerraSAR-X (red) and ALOS PalSAR (blue) data.

3.4 Highlights of Earth Observation Services at DLR Earth Observation Center

3.4.1. Center for satellite based Crisis Information (ZKI)

The DLR Center for satellite based Crisis Information (ZKI) continued to serve as operational interface to DLRs capacities for Emergency response. This involved different aspects of user services during all phase of the disaster/crisis cycle as well as the development of projects, training, consultancy and capacity building in this domain. A major activity of ZKI is the implementation and operation of the GMES Emergency Response Service (GMES-ERS) where DLR played a key role in the European Union FP7 funded projects SAFER and linkER.

Extensive Mapping in Support of Disaster Management, Humanitarian Relief and Emergency Response has been performed. Some of the recent activations are given below:

Date	Title	Topic	Countries
21 May 2012	UEFA Champions League final, 19 May 2012, Munich, Germany	Exercise	Germany
2 March 2012	Tropical storm in Mozambique	Severe Storm and Hurricane	Mozambique
10 February 2012	Flood in Bulgaria	Flood	Bulgaria
24 January 2012	Flood in Mozambique	Flood	Mozambique
3 January 2012	Fires in Chile	Wild Fire and Burn Scars	Chile
23 November 2011	Forest fires in Bulgaria	Wild Fire and Burn Scars	Bulgaria
8 November 2011	Forest fires in Romania	Wild Fire and Burn Scars	Romania
23 October 2011	Earthquake in Turkey on October 23, 2011	Earthquake	Turkey
27 September 2011	Parking occupancy at the NRW-Day and German Unity Day, Bonn 2011, Germany.	Exercise	Germany
14 September 2011	EU CARPATHEX exercise on CBRN threats held in the Podkarpackie Region, Poland	Exercise	Poland
13 September 2011	Floods in Pakistan	Flood	Pakistan

More detailed information about the maps provided during these activations can be found in the ZKI Web-Portal, which can be accessed under: http://www.zki.dlr.de

Exercises

Setting up exercises for other space service providers and the user domain in the frame of emergency response has been activity with high priority during the past year at DLR ZKI. For instance the EU CARPATHEX exercise which aims at improving the response of European Civil Protection Mechanisms to chemical, biological, radiological and nuclear (CBRN) threats was supported by maps for the scenarios dealing with forest fire and flooding.

Training / Capacity Building

In the frame of several projects, especially in the LinkER project, DLR conducted trainings and workshops to transfer knowledge about the services, the products, the processes and the techniques on humanitarian mapping to actors and decision makers on the user side (European Commission, UN, NGOs, relief agencies).

3.4.2. Early Warning and Crisis Information Systems

After the handover of the German-Indonesian Tsunami Early Warning System for the Indian Ocean (GITEWS) to Indonesia on 29 March 2011 the system is being fully operated by BMKG. Under the direction of the Helmholtz Association of German Research Centers and represented by the GFZ German Research Centre for Geosciences, German scientists developed the early warning system. The technical concept of GITEWS relies on the information of several sensor systems, which is aggregated at the early warning center in Jakarta. This merging is accomplished by a Decision support System (DSS), which was developed and implemented by DLR. Besides that, a system for the "Regional Tsunami Information Provider" was developed and successfully tested in the framework of the Indian Ocean Wave Exercise (IOWAVE) on 12. October 2011.

Figure 12: Indian Ocean Wave Exercise (IOWAVE), October 2011

Contacts with Chilean organisations have been established in order to initiate a joint research cooperation in the framework of multi-hazard early warning systems, satellite-based emergency response and risk assessment.

3.3.3. ICSU/WMO World Data Center for Remote Sensing of the Atmosphere

The ICSU/WMO World Data Centre for Remote Sensing of the Atmosphere (WDC-RSAT) is the most recent data center in the WMO-WDC family; in cooperation with the World Meteorological Organization (WMO), WDC-RSAT is implemented as part of the WMO-GAW Strategic Plan 2008-2015 especially in the context of IGACO within the WMO program Global Atmosphere Watch (GAW). WDC-RSAT cooperates with partners in establishing and making use of modern information technologies (e.g. Grid) in order to promote networking. It acts since 2010 as a data publication agent for data related to remote sensing of the atmosphere and is thus authorized to assign so-called 'Digital Object Identifiers' (DOI) to data sets. This allows that data sets can be cited similarly such as peer reviewed publications.

In cooperation with NASA, WDC-RSAT developed and implemented the CEOS-Atmospheric Composition (AC) Portal as envisioned by CEOS (GEO 2009-2011 Task AR-09-02b: AC Portal: Lead: NASA and DLR); the alpha version of the portal (http://wdc.dlr.de/acp) was released in May 2010. The mission of this portal is to provide an entry point to access, tools, and contextual guidance to scientists and value-adding organizations in using remotely sensed atmospheric composition data, information, and services. The AC Portal will help to foster interoperability and application of atmospheric composition data, information and services worldwide.

WDC-RSAT is currently implementing a data analysis center for the GAW global station Schneefernerhaus / Zugspitze for foster the scientist in their research by making available globally satellite-based data, data products and specific services. It is planned to connect it also with other European observatories (e.g. ALOMAR, Norway; Sonnenblick, Austria) via standardized interfaces.

3.4.4. EOC in Global Monitoring for Environment and Security (GMES)

During the reporting period, the Cluster Applied Remote Sensing took further actions to strengthen its participation in the European GMES program. Most of the GMES Service demonstration projects are being finalized by end of 2011 or in early 2012 All projects delivered results and involved primary European and national scale GMES users. DLR was actively involved in the following projects:

- Geoland2 (the GMES Land Services)
- SAFER (the GMES Disaster Mapping Services). Here DLR leads the rapid mapping and is member of the management board of the European consortium, running the service
- GMOSAIC (the GMES Civil Security Services). Here DLR delivers expertise in several applications, such as illegal activities and consequence management
- MACC (the GMES Atmosphere Service). Here DLR is a major partner for delivering atmospheric pollution information

In parallel, several FP7 GMES and ESA GMES projects are performed with DLR participation. Namely projects on atmosphere services (PASODOBLE) and maritime security (MARISS and Dolphin). Achievements of these projects are shown in previous chapters of this document.

DLR is also supporting ESA in guaranteeing the accessibility to and interoperability with national EO missions. Data of these contributing missions form a substantial part of the GMES data input. The ESA project "Heterogenous Mission Access" (HMA), DFD guarantees the interoperability of national mission data catalogues with an ESA integrated catalogue interoperability framework. DLR is amongst the first providers allowing now access to the catalogs for TerraSAR-X and the Indian Remote Sensing Satelites (IRS) (the latter acquired and archived by DLR under contract of EuroMAP, Neustrelitz). DLR has enabled its partners to supply mission data to the various GMES demonstration and initial services. DLR is also involved in the further development of HMA as described in previous chapters of this report.

DLR takes an active part in an ESA member coordination group (Ground Segment Coordination Body; GSCB) to harmonize the compatibility of national developments with ESAs developments of the GMES ground segment. Several issues with regard ground segment interoperability; long term data preservation (LDTP) and product harmonisation and phase-in of national collaborating ground segments have been addressed and concluded in specific working groups. A specific action of GSCB was the description of national requirements to GMES in the framework of an GMES collaborative ground segment. Therein, DLR compiled a document describing the needs of national projects, science and commercial entities to have special access to GMES data either with a direct acquisition capacity or special interfaces to the GMES Processing and Archiving Centers (PAC).

Responding to a competitive call for tender in 2011, the EOC responded in offering ESA to host GMES Processing and Archiving Centers (PAC). After a European wide evaluation, DLR-EOC was awarded to set-up, commission and operate a PAC for the Sentinel-1 and a PAC for the Sentinel-3 (OCLI-Instrument). The other PACs assigned to operate PACs are located in UK (Sentinel-1 and Sentinel-2), France (Sentinel-3 SLSTR and ALT-instruments), Spain (Sentinel-2). As defined in an agreement between ESA and EUMETSAT, the ocean and atmosphere products of Sentinel-3 are generated at a PAC located at EUMETSAT, Darmstadt, Germany.

The signature of the GMES PACs contracts at DLR took place on July 24th, 2012 in Oberpfaffenhofen. The technical Kick-off meetings with ESA have been performed in September and the preparation of the installations will start in 2012 in order to have the PAC ready for Sentinel-1 and Sentinel-3 operations from 2013 onwards.

Figure 13: Signature of the GMES PAC contract with ESA, 24th July 2012: Prof. Dech, DLR, Prof. Liebig, ESA, Prof. Dittus, ESA

The Cluster Applied Remote Sensing of DLR contributed to the formulation of a national GMES strategy, a European GMES data policy and is actively involved in a public-private interest group (i.e. research institutes and industry) in the German federal free state of Bavaria and the federal state of Mecklenburg-Vorpommern to organise the participation in GMES. Therein, the concept of GMES Centers is currently under implementation and has achieved an important milestone with the establishment of the GMES PACs in Oberpfaffenhofen and the formulation of a national research programme on maritime security with a DLR maritime safety and security lab in Neustrelitz.

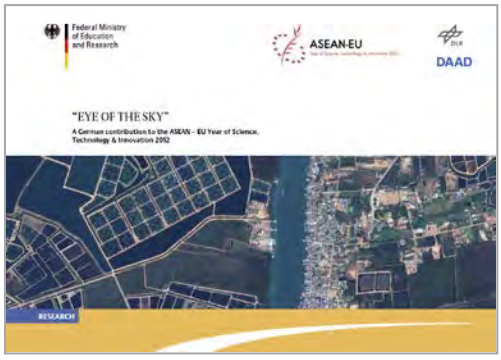
3.4.5 Outreach activities

Events and exhibitions during the reporting period:

- International Aerospace Exhibition ILA – Berlin, 2012: Demonstration of the ability of Earth Observation techniques in general and radar remote sensing in particular in the frame of a DLR showcase.
- International Geoscience and Remote Sensing Symposium IGARSS- Munich 2012: Demonstration of the ability of Earth Observation techniques in general and radar remote sensing in particular in the frame of a DLR showcase.
- "EYE OF THE SKY": Touring exhibition in the frame of the ASEAN – EU Year of Science, Technology & Innovation 2012 (Vietnam, Singapore, Indonesia, Malaysia, Laos, Thailand, Germany, Ireland, Belgium) funded by the Federal Ministry of Education and Research
- "Terra Blue": Support of touring exhibition about Earth Observation. The exhibition was shown 69 times in 2012 in stations and shopping centres.

Earth Observation as central theme at ILA 2012- Berlin

DLR-ESA Booth: IGARSS- Munich 2012



"Eye of the Sky" touring exhibition