SPATIAL DATA SERVICE OPERATIONS FOR METOP/GOME-2 ATMOSPHERIC COMPOSITION PRODUCTS

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Abstract

In order to promote the use of atmospheric composition products derived from MetOp/GOME-2 in a wider community, DLR operates processing and delivery systems as well as spatial data services based on Open Geospatial Consortium (OGC) standards. Through the Web Map Service (WMS) and the Web Coverage Service (WCS) different data layers, projections and views can be portrayed for interactive inspection and the full resolution primary data can be downloaded for further processing. Complementary to the data delivery services provided by DLR in the framework of the Ozone and Atmospheric Chemistry Monitoring Satellite Application Facility (O3M-SAF), DLR operates spatial data services for total and tropospheric column products for a number of trace gases (O_3, NO_2, BrO, SO_2, H_2O, OClO and HCHO) as well as cloud properties (cloud fraction, cloud-top pressure and cloud optical thickness) derived from GOME-2. These products are available in near-real-time (less than 2 hours after sensing) and offline.

During more than one year of test and productive operations for a continuously growing number of product types, DLR gained practical experience with operational and configuration aspects of providing atmospheric composition datasets through standard business-to-business spatial data services. Taking into account the various data species (trace gases and cloud properties), product quality information, different levels of temporal and spatial aggregation and assimilation, as well as different data timeliness, the spatial data services were configured, optimized and presented with the goal of best serving a wide range of applications ranging from short-term air quality monitoring and chemical weather forecasting to long-term climate research.

This contribution gives an overview of the full GOME-2 operational data processing chain from reception to the access service front-ends. The focus is on operational experience gained in the configuration, optimization, presentation and performance of atmospheric data access services. In addition we introduce the EOWEB® GeoPortal, the new DLR multi-mission web portal for interactive access to earth observation data. EOWEB® GeoPortal integrates the classical catalogue-and-order services with the novel browse-and-download data access paradigm. Finally, a short outlook on future developments planned by DLR to extend the spatial data services is presented.

OPERATIONAL DATA PROCESSING IN O3M-SAF

Two main processing workflows characterize the operational environment of the SAF on Ozone and Atmospheric Chemistry Monitoring O3M-SAF: the near-real-time workflow and the offline workflow. As shown in figure 1, DLR as well as KNMI receive the GOME-2 L1b data via EUMETCast and generate L2 total column and profile products. Based on assimilations processed at KNMI, DMI derives a clear sky UV index product still in near-real-time. In the offline workflow, the near-real-time L1b data is aggregated to full orbit products and processed to L2 total column, profiles and other derived products such as the surface UV index (FMI) and the absorbing aerosol index (KNMI).

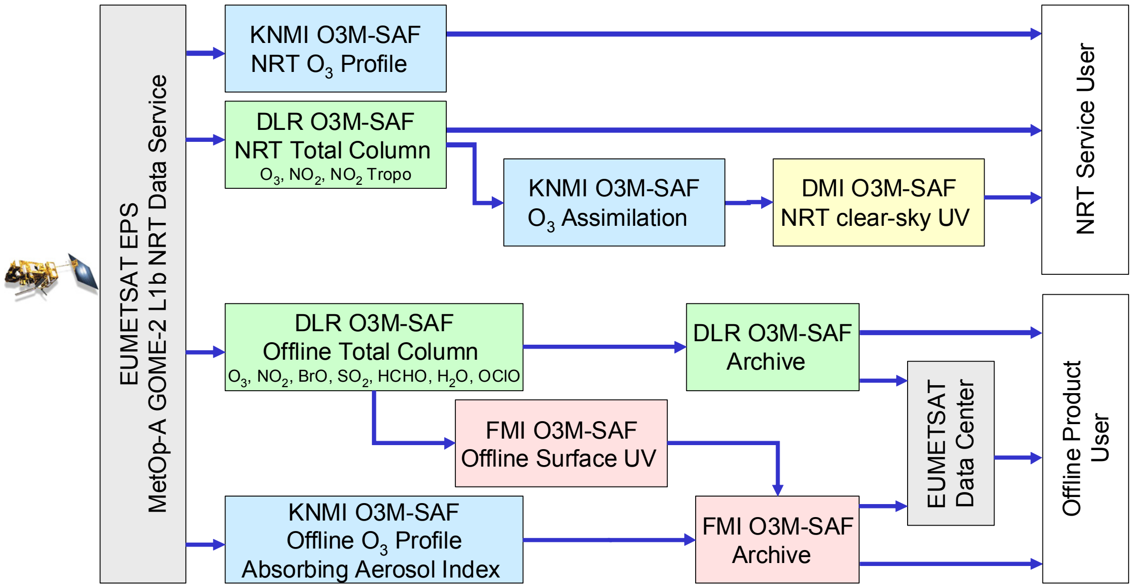

Figure 1: **Overall Operational Product Data Flow of the Satellite Application Facility for Ozone and Atmospheric Chemistry Monitoring.**

The offline products are stored in the archive facilities at FMI and DLR before being propagated (metadata and browse images) to the EUMETSAT Data Center, from where users can order them.

METOP/GOME-2 ATMOSPHERIC COMPOSITION PRODUCTS AND SERVICES AT DLR

In addition to the O3M-SAF catalogue and order service provided through the EUMETSAT Data Center, DLR provides complementary dissemination and access services as well as different data formats. The following table gives an overview on how DLR disseminates near-real-time products and how users can access near-real-time and offline products. We thereby not only distinguish near-real-time and offline, but also the composite products which contain accumulated L2 data of one day. These composite products are the main data source for web mapping services.

NRT – PDU	**NRT – Composite latest/previous**	**Offline – Full Orbit**	**Offline – Daily Composite**
O3, NO2, NO2 Tropo		**O3, NO2, NO2 Tropo, BrO, SO2, HCHO, H2O, OClO CloudFraction, CloudTopPressure CloudOpticalThickness**	
EUMETCast: HDF5, BUFR	WMS, WCS: GeoTIFF	EOWEB: cat. and order	WMS, WCS: GeoTIFF
FTP server: HDF5, BUFR atmos.caf.dlr.de	FTP server: NetCDF-CF atmos.caf.dlr.de	FTP server HDF5 atmos.caf.dlr.de	FTP server: NetCDF-CF atmos.caf.dlr.de
WMO GTS: BUFR	ATMOS web server: PNG atmos.caf.dlr.de/gome2	EUMETSAT Data Center: cat. and order	ATMOS web server: PNG atmos.caf.dlr.de/gome2

Table 1: **Overview of GOME-2 Products, Dissemination/Access Services and Data Formats Provided by DLR.**

The preliminary work with web mapping services for atmospheric data has been presented in [1]. A more general discussion of the setup of services in DLR's spatial data infrastructure has been published in [2].

EXPERIENCES WITH THE SETUP OF CATALOGUE AND WEB MAPPING SERVICES

As part of the DLR EOWEB® user service system, standard catalogue and ordering service interfaces are provided. The catalogue interface implements the OGC CSW/ebRIM standard [3] with EO application profile. This EO profile includes specific extensions for SAR, optical and atmospheric product metadata. As can be expected, a standard has to generalize from concrete mission specimen and needs to be simple in order to be widely applicable.

However this makes it difficult to map the original GOME-2 product metadata, as defined in the product user manual [4], to the standard metadata and moreover to specific metadata models such as the EUMETSAT Data Center metadata definition [5]. In certain cases the semantics do not exactly match (also due to sometimes imprecise specification in the standard), in other cases several origin metadata parameter values need to be combined or their values need to be mapped to match allowed values and data types. There are also cases where standard metadata parameters have no source in the origin product, because the information is contained in the product user manual. This is the case for the “atm:unit” parameter (denoting the physical unit of the data) listed as one of a few examples for the mappings of atmospheric product metadata in the following table.

GML Application Schema for EO Products OGC 06-080/10-157	**Parameter in GOME-2 HDF5 META_DATA group**	**Parameter in EUMETSAT Data Center (UMARF)**
eop:imageQualityDegradation	DegradedRecordPercentage	Degraded Record Percentage (QDRP)
eop:method / methodVersion atm:algorithmName / algorithmVersion	ProductAlgorithmVersion + InitializationFileVersion	Product Algorithm Version (AVPA)
eop:processorVersion	BaseProductAlgorithmVersion	Base Algorithm Version (AVBA)
atm:specy	ProductContents (csv)	Spectral Band Ids (ABID)
atm:unit	-	-
eop:operationalMode	ScanMode	Instrument Mode (SMOD)

Table 2: **Examples of Mapping Metadata Parameters Relevant for Atmospheric Composition Products.**

Two major issues have to be tackled for the setup of web mapping and web coverage services: the definition of the data layers which get finally exposed to the user, and the handling of the time dimension.

As discussed earlier in [1], the original level 2 product files which contain all species processed in the same retrieval step would suggest defining the species as a dimension within one single data layer for the chemical atmospheric composition. Because different users typically want to access different species and for technical reasons we decided to handle species not as a dimension but to define distinct data layers for each species. The WMS/WCS layer naming for GOME-2 data follows the convention

{mission}.{sensor}.{code}.{species}.{temporalAggregate}

e.g.

metop.gome2.tc.comp.no2.latest
metop.gome2.tc.comp.o3.daily
ers.gome.tc.comp.o3.daily

The mission, sensor and code fragments are suffixed to the layer name in order to allow adding other related data layers (e.g. ERS GOME-1) to the same service.

The temporal aggregate allows to distinguish the near-real-time data “latest” containing the most up-to-date data of the current day only, the “previous” layer containing the data of yesterday and the “daily” layer containing the offline data, which becomes available around 24 hours after sensing. New layers for e.g. monthly aggregates may be added later.

Historical offline data (e.g. “daily”) support the temporal selection as the sensing time is explicitly mapped as a dimension in the WMS/WCS (see “6.7.6 Temporal CS” in WMS 1.3.0 Specification). Therefore the time constraint can be specified as a filter parameter in the HTTP get request URL (or in the body of a HTTP post request), e.g. in the form “…&TIME=2004-10-12/2004-10-14&...” for a period of three days.

The near-real-time “latest” and “previous” data layers do not support the temporal selection, because they always show the most recently acquired datasets and the last full earth coverage respectively.

The download service provided by DLR (through WCS version 1.0) currently supports GeoTIFF (single-banded, 32bit floating point), and it uses the nearest neighbour interpolation method during re-projection to other non-native reference systems such as Polar Stereographic or Mercator. In future we intend to support the WCS 2.0 specification with EO profile and the download in NetCDF-CF format.

ACCESSING WEB MAPPING SERVICES

In the following some examples of accessing the web mapping services are provided. Of course the data images served by the WMS can be visualized with any client software which supports the standard WMS protocol: a web embedded client, a thick client such as GoogleEarth, a desktop GIS client or a larger GIS system. The following two figures show the visualisation of GOME-2 level 2 vertical column data in the open source desktop GIS tool uDig [6]. As with most GIS clients, other data layers such as basic map information or other spatial data can be under- or overlaid.

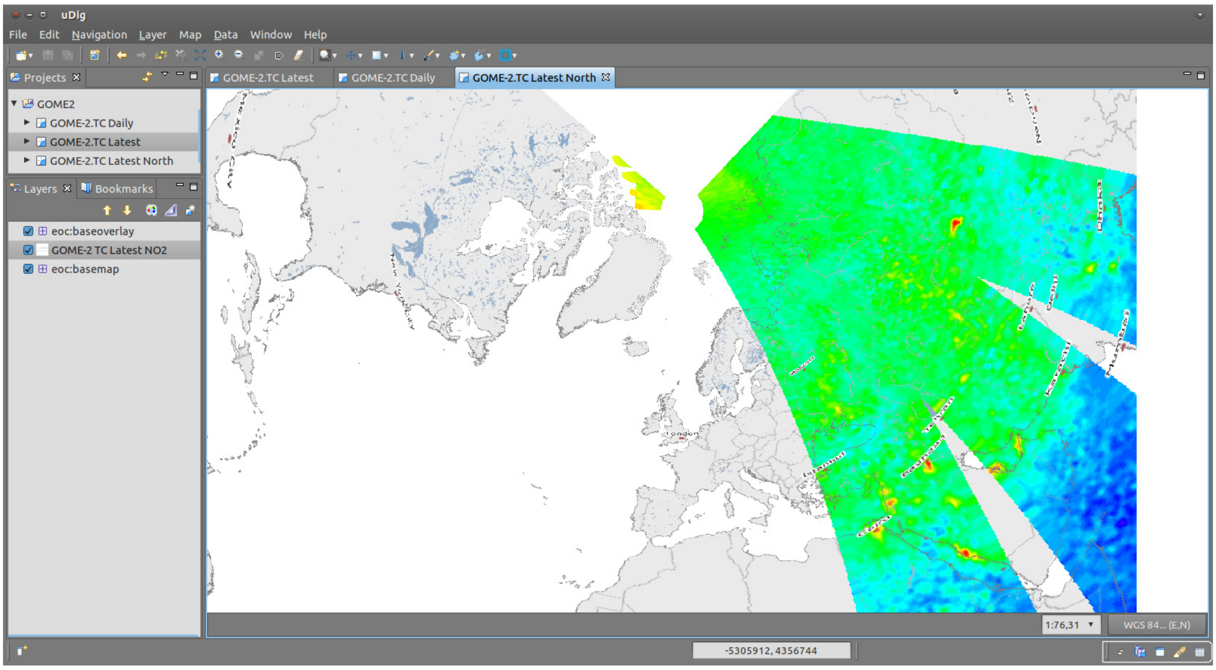

Figure 2: **GOME-2-derived Near-real-time Tropospheric NO2 Data Visualized in the uDig Desktop GIS Tool.**

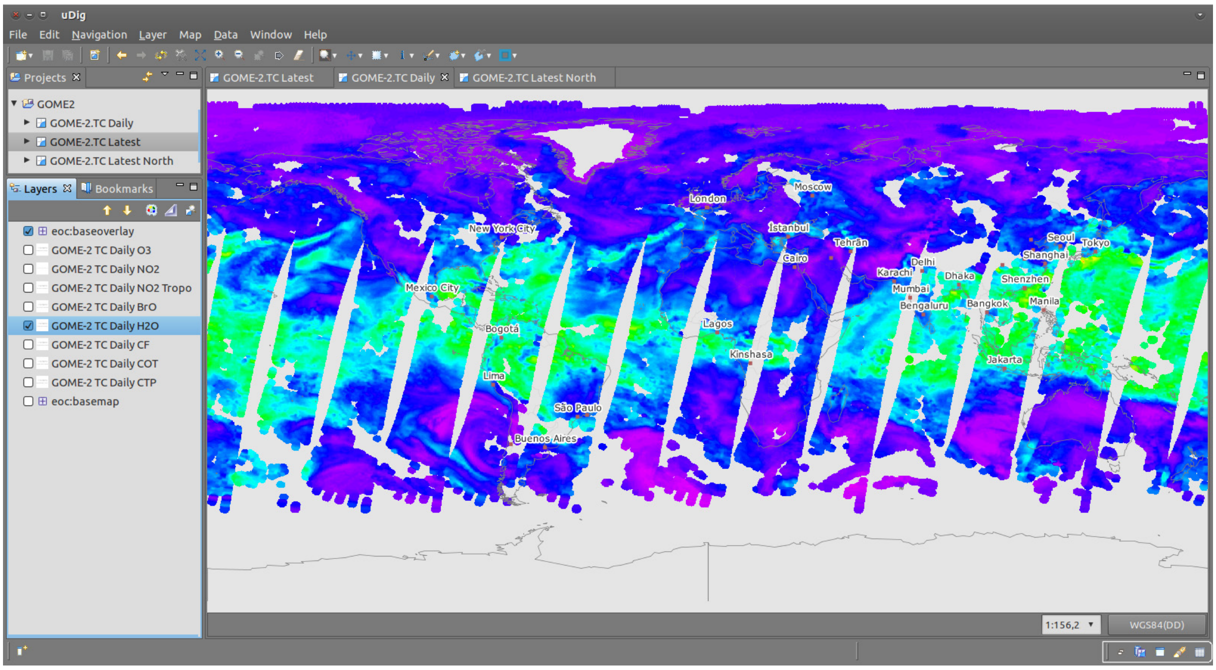

Figure 3: **GOME-2-derived Offline Total Column H2O Data Visualized in the uDig Desktop GIS Tool.**

EOWEB® GEOPORTAL

The EOWEB® GeoPortal is the new DLR multi-mission web portal for interactive access to earth observation data. It combines the classical catalogue-and-order services with new browse-and-download features for data available via DLR's OGC services. With these new features it is possible to generate individual maps by adding, removing and altering data layers. Furthermore layers providing temporal information can be visualized for certain points in time. In addition, the download of data subsets and whole layers is also supported. The OGC services used for browsing are the WMS (incl. WMS-T), the Web Feature Service (WFS), the Web Map Tile Service (WMTS) and the Tile Map Service (TMS), whereas the download is based on OGC's WCS protocol. Finally, the modular structure of the EOWEB® GeoPortal allows the fast integration of additional services and protocols.

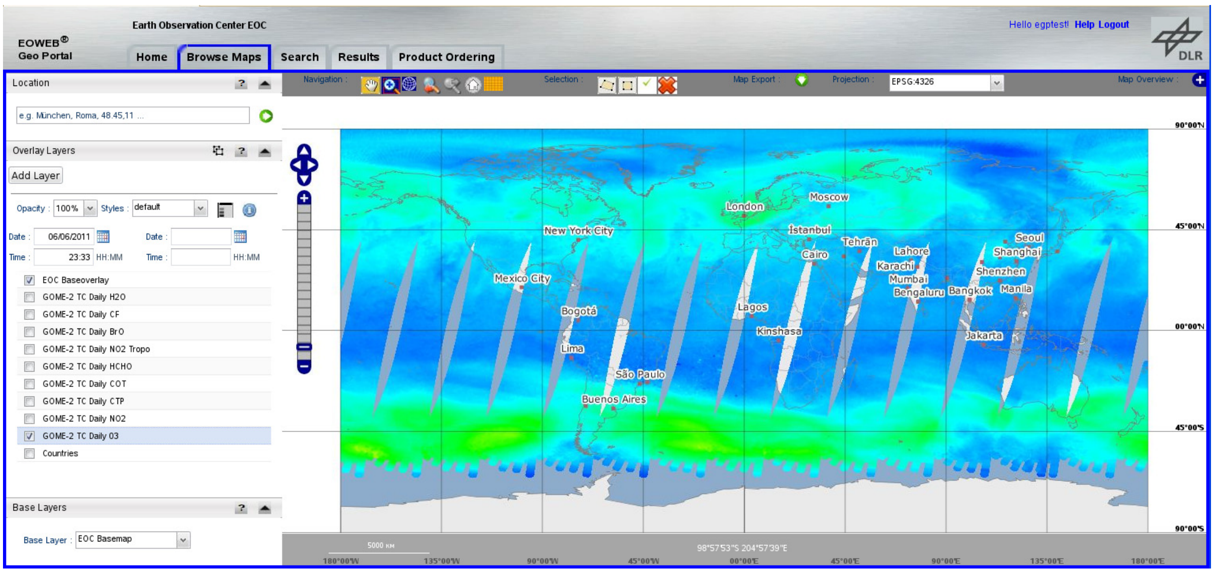

Figure 4: **GOME-2-derived Offline Total Column O3 Data Visualized in the EOWEB® GeoPortal Browse View.**

The EOWEB® GeoPortal is implemented using the Google Web Toolkit (GWT) [7]. For the map views OpenLayers is used [8]. The result is an interactive web application based on HTML, CSS and JavaScript only. From the user perspective a standard web browser without any additional plug-ins is sufficient to access the EOWEB® GeoPortal. Special emphasis is put on the intuitive usability to give the user the feeling of a desktop-like application. Figure 4 shows the display of the offline total ozone WMS layer in the data browse view. The other tabs are used to search the original products in the catalogue, inspect metadata and quicklooks, and place and follow product orders.

OPERATIONS STATUS AND FUTURE WORK

The spatial data access services for GOME-2-derived atmospheric products are backed by the data reception, processing and dissemination facility which has a high level of service with respect to timeliness and availability. Figure 5 shows the evolution of the timeliness and availability of DLR's operational system as reported within the O3M-SAF project. The timeliness measures the time duration between sensing and provision of level 2 data to the user, and the availability is the percentage of products delivered within the required timeliness (3 hours for near-real-time, 14 days for offline).

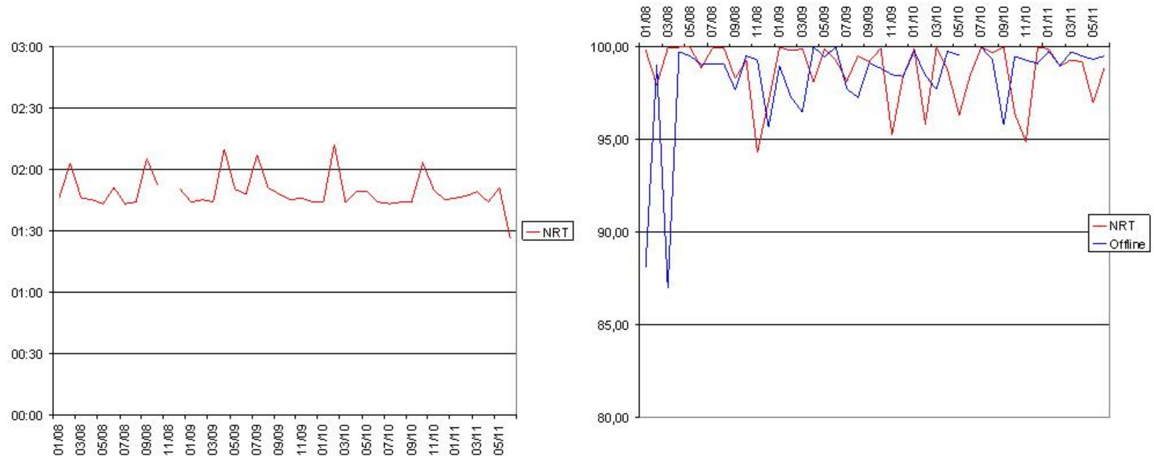

Figure 5: **Average NRT Timeliness (Hours:Minutes from Sensing, left) and System Availability (Percent, NRT and Offline, right) of O3M-SAF System at DLR.**

Although the service level requirements are met in most cases, the operational system is regularly maintained in order to react on observed incidents and it will be migrated onto new server hardware until end of 2011 to achieve better performance and thus enable the simultaneous support of MetOp-A and MetOp-B as well as reprocessing tasks.

The spatial data access services will be made online under the web address geoservice.dlr.de. Currently this service is in transition to operations. The validation environment, which is accessible under the web address geotest.caf.dlr.de, can be used for test purposes. However it must be noted that this environment is not continuously monitored and maintained, that it does not contain complete data sets and that its performance is low. Once transferred into operations the geo services shall fulfil as high service level requirements as the production systems in the background.

The EOWEB® GeoPortal is currently in development and the first releases are in beta-testing by selected pilot users. A first version of the EOWEB® GeoPortal will become operational in early 2012. Meanwhile the GOME-2 L2 products can be searched and ordered through the current EOWEB®-NG gateway under the web address eoweb.dlr.de.

DLR intends to follow the evolution of OGC web mapping standards. Especially the WCS/EO 2.0 version shall be adopted, and a focus for future developments is the inherent support of time series within web mapping services.

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