NEW DEVELOPMENTS IN THE SCIAMACHY L2 GROUND PROCESSOR

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ABSTRACT

SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric ChartographY) aboard ESA's environmental satellite ENVISAT observed the Earth's atmosphere in limb, nadir, and solar/lunar occultation geometries covering the UV-Visible to NIR spectral range. It is a joint project of Germany, the Netherlands and Belgium and was launched in February 2002. SCIAMACHY doubled its originally planned in-orbit lifetime of five years before the communication to ENVISAT was severed in April 2012, and the mission entered its post-operational phase F.

The SCIAMACHY Quality Working Group (SQWG) was established in 2007. The group coordinates evolution of algorithms and processors, aiming at improving the quality of the operational data products. University of Bremen (IUP), BIRA, DLR-IMF, SRON (Netherlands Institute for Space Research) and KNMI (The Royal Netherlands Meteorological Institute) are the members providing expertise in this group.

In order to preserve the best quality of the outstanding data obtained by SCIAMACHY, data processors are still being updated. This presentation will highlight new developments that are currently being incorporated into the forthcoming Version 7 of ESA's operational Level 2 processor.

Key words: Cloud Detection, Data Preservation, Troposphere.

1. INTRODUCTION

During the SCIAMACHY Phase F the Version 6 of the L1b-2 processor has been delivered to ESA and become operational. It has been employed for re-processing of the entire mission. The public release of the Version 6 Level 2 data, after validation, is planned for the end of 2016. The list of products in the Version 6 is presented in Table 1.

Nadir Products	Limb Products
Absorbing Aerosol Index	Ozone profiles
Ozone total column	NO_2 profiles
Nitrogen dioxide (NO_2)	BrO profiles
Tropospheric NO_2	Limb clouds
Bromine monoxide (BrO)	
Tropospheric BrO (planned for L2v7)	
Sulphur dioxide (SO_2)	
Chlorine dioxide (OClO)	
Formaldehyde (HCHO)	
Glyoxal (CHOCHO)	
Water vapour (H_2O)	
Carbon monoxide (CO)	
Methane (CH_4)	
Cloud parameters (fraction, top height, optical density)	

Table 1. List of products in the SCIAMACHY Level 2 (Versions 6 and 7).

In the next section the latest developments of ESA's operational Level 2 processor are described. They will be part of the next Version 7 of the processor and are listed below:

1. Tropospheric BrO columns
2. Improved cloud flagging using limb measurements
3. A new file format for the Level 2 product

The Version 7 of the SCIAMACHY Level 2 Products is expected to be publicly released in 2017.

2. IMPROVEMENTS OF THE SCIAMACHY L1B-2 PROCESSOR

2.1. Tropospheric BrO

Tropospheric BrO is a new retrieval based on the scientific algorithm of [2]. This algorithm had been originally developed for the GOME-2 sensor and was later adapted for SCIAMACHY. The main principle of the new algorithm is to utilize BrO total columns (already an operational product; DOAS fit window $336-351$ nm) and split them into stratospheric VCD_{STRATO} and tropospheric VCD_{TROPO} fractions. VCD_{TROPO} is then determined simply as a difference:

$$VCD_{TROPO} = VCD_{TOTAL} - VCD_{STRATO} \quad (1)$$

Stratospheric BrO is determined from a climatological approach driven by SCIAMACHY O_3 and NO_2 observations. SCIAMACHY total O_3 columns are used as a proxy for the stratospheric dynamics, while photochemical effects are taken into account using stratospheric NO_2 columns (calculated using SCIAMACHY NO_2 limb profiles).

Both air mass facors - stratospheric and tropospheric (AMF_{STRATO} and AMF_{TROPO}) - are computed as follows: weighting functions (block $AMFs$) are read from a lookup table. They depend on five parameters including surface albedo and height, solar zenith angle and viewing geometry. For AMF_{STRATO} computation, climatological BrO profiles are taken, whereas a Gaussian profile with a maximum at 6 km hight is assumed for AMF_{TROPO}.

Since the algorithm needs total BrO and O_3 columns together with stratospheric NO_2 of the full orbit as input, it is implemented as a processing step that starts after the limb and nadir retrievals.

The integration of the scientific algorithm into the operational environment has started with the prototype implementation. The purpose of this is to fill gaps in the algorithm documentation and to clarify a sequence of the algorithm steps.

Tropospheric BrO retrieved by the prototype has been compared with the results produced by the scientific algorithm. Around 200 orbits distributed over the entire mission lifetime have been compared. An example of the comparison for 20^{th} May 2008 are presented in Figure 1. As seen in the Figure 1 all bromine explosion events are detected by both retrievals.

After the prototype verification the algorithm will be implemented into the L1b-2 processor.

2.2. Limb Clouds

In limb mode SCIAMACHY measures the light scattered along the line-of-sight. If the line-of-sight intersects a cloud at a certain height, the measurements differ from those taken under cloud free conditions. For the clouds detection, ratios of hight resolved measurements in two wavelength regions are used (at 750 nm and 1090 nm). In an ideal atmosphere, consisting only of molecules, the quotient of radiances at two wavelengths about 300 nm apart is large ($I \sim \lambda^{-4}$), while for larger particles, like cloud droplets, this difference is reduced ($I \sim \lambda^{-1}$).

The SCIAMACHY cloud detection algorithm (SCODA) [1] is already implemented in the L1b-2 operational processor since version 5.02, released in 2012. SCODA considerably improved the limb trace gas retrievals in the upper troposphere/lower stratosphere region. Since then the scientific version of SCODA has been reviewed, further improved and described in the peer-reviewed paper [1]. These latest modifications are currently being implemented into the operational processor.

SCODA distinguishes four different cloud types:

- water/ice/aerosol clouds (WCL)
- water/ice clouds (ICL)
- polar stratospheric clouds (PSC)
- noctilucent clouds (NLC).

in the new version of the operational SCODA algorithm the following changes are performed:

- geographical constraints for PSCs
- maximal solar zenith angle for which the retrievel is still done
- maximal allowed and warning heights for all types of clouds
- updated thresholds for detection of all types of clouds

In Figure 2 a global map of the annual mean cloud top height (in km) for 2006 is shown.

2.3. New Format for SCIAMACHY L2 Product

The Version 7 of the L2 SCIAMACHY data is to be released in a new more user-friendly NetCDF format, which is better suited for the long-term data preservation. The SQWG aims to align and harmonize the new format with other missions (esp. Sentinels and GOME-1). Splitting of the L2 products into profile and column products is also considered.

The first version of the new format has been already created and the test file is made available for the members of the SQWG for further suggestions and revisions. The following guidelines have been pursued when designing the new format:

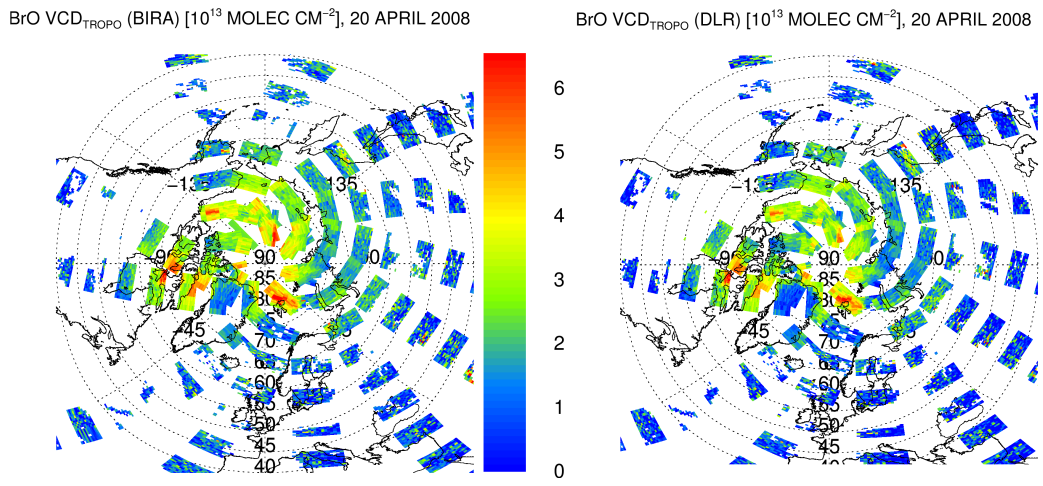

Figure 1. Tropospheric BrO for 20^{th} May 2008 as retrieved by the BIRA scientific processor and the operational prototype.

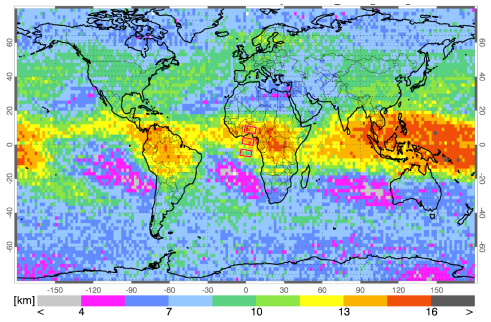

Figure 2. Global map ($2° \times 2°$) of the annual mean cloud top height (in km) for 2006. The superimposed red rectangles show the approximate size of three consecutive SCIAMACHY limb states.

- **Completeness:** All information that was contained in the old Level 2 files should be also available in the new ones.
- **Clean-up:** Elements of the old format that are no longer used, or may never be used, should not be ported to the new format.
- **Clarity:** Elements of the old format that were difficult to understand, to access, to extract, or to handle, should be reorganized and represented in a more user-friendly way within the new file format.
- **Compatibility, conformity and harmonization**
  - with data products of other instruments on ENVISAT, which have originally been delivered in the ENVISAT format, and for which a NetCDF-based format is considered;
  - with Level 2 file formats of other instruments on past or future atmospheric chemistry missions, especially TROPOMI on Sentinel 5 Precursor;
  - with climate and forecast meta data conventions.

For the verification and validation activities required L2 products will also be provided in the old ENVISAT format.

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