ESA Climate Change Initiative (CCI)

Product User Guide Version 4 (PUGv4) for the XCO_2 SCIAMACHY Data Product BESD

for the Essential Climate Variable (ECV)

Greenhouse Gases (GHG)

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Change log:

Version Nr.	Date	Status	Reason for change
Version 1, draft 0	5 October 2012	Template version for input by project partners Author: O.Hasekamp	
Version 1, draft 1	25 February 2013	Make one PUG per product, data examples in first section	Drafting of the PUG for BESD XCO2
Final Version 1	21 June 2013	Final Version	
Final Version 2	10 June 2014	Final Version	Adaptation to new and common data format described in PSDv3
Final Version 3	27 October 2015	Final Version	Adaptation to BESD v02.01.01 (CRDP#3)
Final Version 4	31 August 2016	Final Version	Adaptation to BESD v02.01.02 (CRDP#4)

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1 Summary

This document is the Product User Guide Version 4 (PUGv4), which is a deliverable of the ESA project GHG-CCI. The GHG-CCI project started on 1st September 2010. The GHG-CCI project is one of several projects of ESA's Climate Change Initiative (CCI). The GHG-CCI project delivers the Essential Climate Variable (ECV) Greenhouse Gases (GHG). State-of-the-art retrieval algorithms for remote sensing of the ECV "Greenhouse Gases" (GHGs) are developed further in the frame of this project. Multi-year Carbon Dioxide (CO2) and Methane (CH4) data sets are generated and validated.

Two existing satellite sensors are used to produce the core GHG-ECV products (XCO2 and XCH4): SCIAMACHY on ENVISAT and TANSO-FTS on GOSAT. Both instruments measure NIR/SWIR spectra of reflected solar radiation and are sensitive to CO2 and CH4 concentration changes close to the Earth's surface. Consequently, they carry information on regional surface fluxes. The accuracy requirements for such an application are demanding, especially for CO2 but also for CH4.

Table 1 provides a short overview about our core data products which are generated with so-called "ECV Core Algorithms" (ECAs) . These products are near-surface-sensitive dry-air column-averaged mole fractions (mixing ratios) of carbon dioxide (CO2) and methane (CH4), denoted XCO2 (in ppmv) and XCH4 (in ppbv) generated from SCIAMACHY on ENVISAT and TANSO-FTS onboard GOSAT.

Typically, we have generated the same product (e.g., XCO2 from GOSAT) using different retrieval algorithms. We encourage users of our data products to make use of the fact that typically several different methods are available to generate a given product. This gives users the possibility to find out if important conclusions drawn by using one product are robust with respect to the method used to generate that product. This however may require significant effort and is therefore not always possible.

For users who only want to use one product but do not know which one to choose, we aimed at defining one recommended baseline product generated with a baseline algorithm (see Table 1). The other products are called alternative products. Note that the quality of an alternative product may be equivalent to the corresponding baseline product.

This document describes the BESD XCO2 data products so that it will be clear for the user how to use the products. The description includes quality flags and metadata, data format, product grid and geographical projection, known limitations, available tools for decoding and interpreting the data, and the product (column) averaging kernels and a description how to use them.

Table 1: GHG-CCI ECV XCO_2 Core Algorithms

Product	Competing Algorithms	Baseline Algorithms
XCO_2 SCIA	WFMD (Weighting Function Modified DOAS, IUP-Bremen) BESD (BESD Bremen optimal EStimation Doas, IUP-Bremen)	BESD
XCO_2 GOSAT	OCFP (OCO Full Physics, UoL) SRFP (SRON Full Physics, SRON)*	not yet defined
XCO_2 merged („EMMA“)	N/A	N/A

2 Introduction

2.1 The SCIAMACHY Instrument

The SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY, **/Burrows et al., 1995/**, **/Bovensmann et al., 1999/**) instrument started its operation in 2002 with the launch of the ESA (European Space Agency) satellite ENVISAT (Environmental Satellite) on March 1st, 2002. Roughly one decade later on May 9th, 2012 ESA declared end of the mission due to the unexpected loss of ENVISAT.

SCIAMACHY was the first and during seven years the only satellite instruments which was able to measure the CO_2 mixing ratio (XCO_2) with large sensitivity also in the boundary layer where the signals from the sources and sinks at the surface are largest.

ENVISAT was in a sun synchronous descending orbit with an equator crossing time of 10:00. SCIAMACHY measured simultaneously the radiance in 8 spectral channels in the range from 240-2400nm each consisting of 1024 spectral points. BESD uses SCIAMCHY measurements within two spectral bands, namely the O_2-A absorption band at around 760nm and the weak CO_2 absorption band at around 1580nm. The spectral resolution of these bands was 0.42nm and 1.45nm, respectively. The measurements in these bands had a ground pixel size of approximately 60km across track and 30km along track. The swath width of SCIAMACHY was about 960km.

2.2 The BESD XCO_2 Full Physics Product

The Bremen Optimal Estimation DOAS (BESD) algorithm is designed to analyze SCIAMACHY sun normalized radiance measurements to retrieve the column-average dry-air mole fraction of atmospheric CO_2, i.e., XCO_2. BESD is a so called full physics algorithm which uses measurements in the O_2-A absorption band to retrieve scattering information of clouds and aerosols. This information is transferred to the CO_2 absorption band at 1580 nm by simultaneously fitting the spectra measured in both spectral regions. The explicit consideration of scattering by this approach reduces potential systematic biases due to clouds or aerosols. More details on BESD can be found in the publications of **/Reuter et al., 2010/** and **/Reuter et al., 2011/** and the Algorithm Theoretical Basis Document **/Reuter et al., 2014/**. As an example, Figure 2-1 shows a global map of the long term seasonal anomaly April/May/June (top) short before the growing season with largest values on the northern hemisphere and July/August/September (bottom) during the growing season with lowest values on the southern hemisphere.

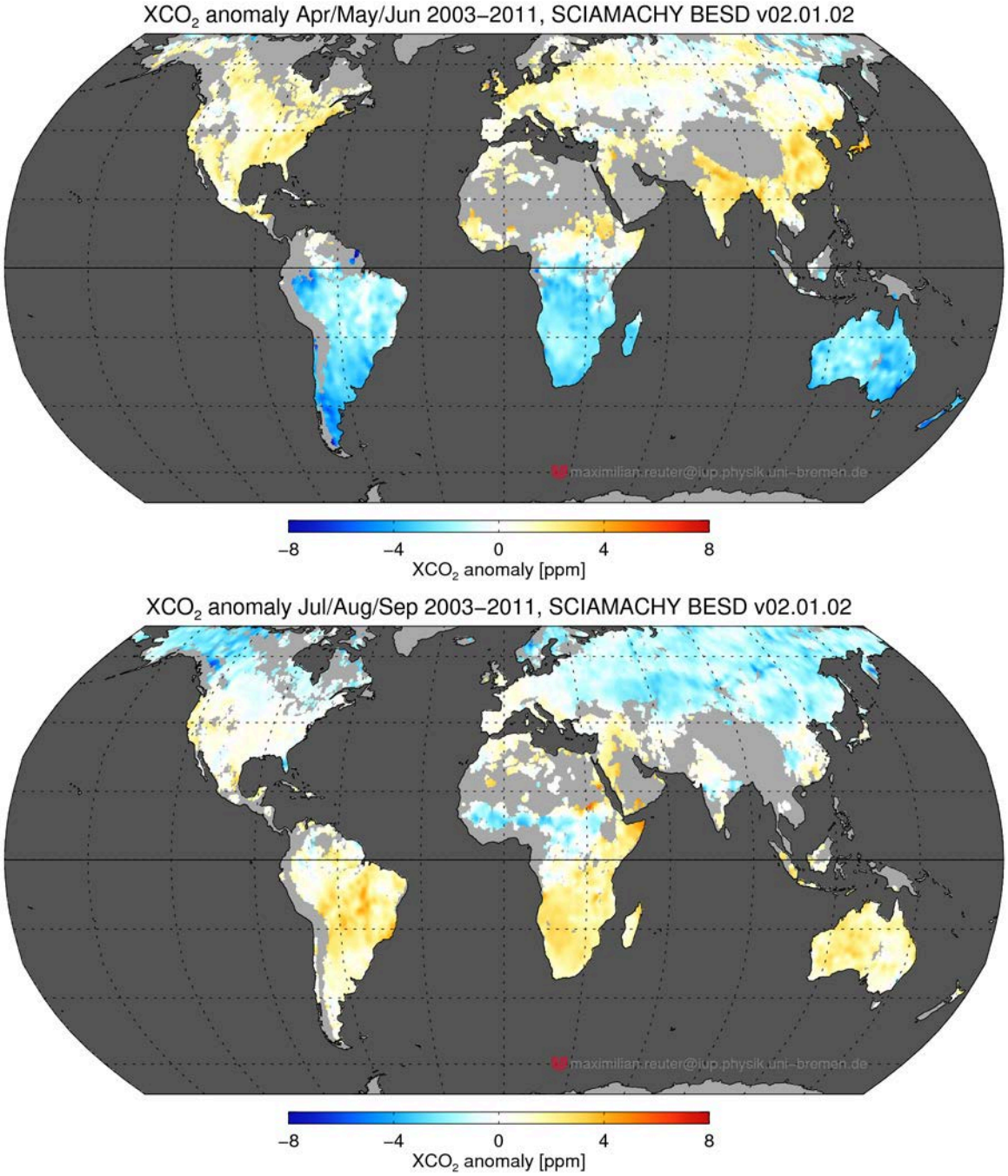

Figure 2-1: Long term seasonal anomaly of XCO_2 retrieved with BESD. Top: April/May/June. Bottom: July/August/September.

3 Product Description

3.1 Algorithm Description

Algorithm specific information can be found in the Algorithm Theoretical Basis Document Version 5 (ATBDv5, **/Reuter et al., 2016/**). The ATBD describes in detail the mathematical and physical bases and methods used to generate the data product. It is available at the GHG-CCI website (http://www.esa-ghg-cci.org/webfm_send/338).

3.2 Validation

Some initial validation results are shown in the Algorithm Theoretical Basis Document Version 5 (ATBDv5, **/Reuter et al., 2016/**). Results of more comprehensive validation analyses will be made via the GHG-CCI website (http://www.esa-ghg-cci.org).

3.3 Product Specification

The Product Specification Document Version 3 (PSDv3, **/Buchwitz et al., 2014/**) describes in detail the product content and format and advises the user how to use our data. It is available at the GHG-CCI website (www.esa-ghg-cci.org/index.php?q=webfm_send/160).

4 Known Limitations and Issues

Due to instrument issues data earlier than April 2003 are less reliable.

5 References and Further Reading

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