

## **GHG-CCI QSR April-June 2015**

### **1. GHG-CCI major achievements and considerations for CCI follow-on activities (“CCI+”)**

Until now GHG-CCI has achieved the following:

- Generation of improved data products with higher quality and extended time coverage: As planned GHG-CCI has released in March 2015 the 2<sup>nd</sup> version of the CRDP (CRDP#2) based on re-processing of SCIAMACHY and GOSAT nadir spectra to generate an improved version of the GHG-CCI core products generated with ECV Core Algorithms (ECAs). A comparison of the achieved performance w.r.t. GCOS and GHG-CCI CRG user requirements is shown in validation document PVIRv3.2 ([http://www.esa-ghg-cci.org/?q=webfm\\_send/251](http://www.esa-ghg-cci.org/?q=webfm_send/251), Table S-3). As can be seen, several user requirements have been met, but not all. For example, the comparison with the TCCON reference data indicate that the GCOS XCO<sub>2</sub> accuracy requirement of better than 1 ppm (target) has been met but not the more demanding 0.5 ppm requirement (threshold) of the GHG-CCI CRG. CRDP#2 has also been assessed by the GHG-CCI CRG, see CARv2 ([http://www.esa-ghg-cci.org/?q=webfm\\_send/256](http://www.esa-ghg-cci.org/?q=webfm_send/256)). Furthermore, significant progress has been made on the non-core (i.e., Additional Constraints Algorithm (ACA)) products. For example, new CH<sub>4</sub> and CO<sub>2</sub> stratospheric profile time series have been generated from the SCIAMACHY solar occultation measurements and the long-standing high bias of MIPAS CH<sub>4</sub> profiles in the lower stratosphere has been significantly reduced. For details please see <http://www.esa-ghg-cci.org/> -> CRDP (Data)
- Data usage and publications: GHG-CCI data products are used by many users (see below). A large number of publications have been written for which GHG-CCI data products have been used. 39 peer-reviewed publications exist with GHG-CCI funding explicitly acknowledged (but note that not all users explicitly acknowledge GHG-CCI). Also several other important documents have been written and are periodically updated such as the GHG-CCI User Requirements Document (please see <http://www.esa-ghg-cci.org/> -> Documents and -> CRDP (Data)).

Until end of Phase 2 the following will have been achieved:

- Generation of improved data sets (using improved algorithms) with extended time coverage including better error characterization, validation and user assessments: Two major re-processings are foreseen: CRDP#3 will be available in April 2016 and CRDP#4 in February 2017 (end of Phase 2). The final data sets will cover the time period mid/end of 2012 – end of 2015.

Considerations / recommendations for CCI+ (after February 2017) and potential transfer to operational service:

- Continuous, long term data sets are especially important for climate research where the timescales are decades. With new instruments on the horizon (S5p, S5, GOSAT-2, ...) it is possible to produce long term GHG data sets covering decades. However, to ensure that all data are consistent and suitable for carbon and climate related applications including trend analyses it is important to involve retrieval experts and to keep the expertise: the new measurements likely require further evolution of existing algorithms to generate high quality products and to explore the opportunities that these new missions provide.
- It is therefore highly recommended to continue GHG-CCI within CCI+. The GHG-CCI products are currently essentially generated “operationally” in the ongoing Phase 2 as data products are generated according to a pre-defined schedule incl. documentation etc. The data products are generated to a large extent automatically but due to the demanding user requirements combined with changing (see below) instruments, a significant amount of work needs to be carried out by retrieval experts to make sure that the to be delivered products are of sufficient quality.
- Transfer to an operational service in the sense of handing over specifications / software to non-experts to generate the GHG-CCI products is not recommended as this will not result in data products meeting the user needs. It is considered mandatory that the GHG-CCI retrieval experts

continue to generate the GHG-CCI products. There are several important reasons for this, in particular:

- Not all user requirements have been met yet for all products (see above).
  - Aiming at maintaining and/or meeting the demanding user requirements for the ECV GHG requires continuous expert involvement in particular to assess and minimize the impact of instrument changes (e.g., two major GOSAT instrument/satellite issues needed to be dealt with in 2014/2015 and also not all SCIAMACHY degradation issues for methane are solved yet). Dealing with these problems typically requires several re-processings of all or a large fraction of the data, i.e., an iterative approach which needs to be carried out by experts, until a new improved and extended data set is ready and can be released.
- Nevertheless, operational services such as the Copernicus services can plan an important role, e.g., providing additional resources (financial and/or technical, e.g., along the lines as recommended in the GHG System Requirements Document (SRDv1, [http://www.esa-ghg-cci.org/?q=webfm\\_send/264](http://www.esa-ghg-cci.org/?q=webfm_send/264))). For the reasons explained above this requires that the products need to be generated by the experts, i.e., it is important that the GHG-CCI retrieval experts have full control over the generation of the products. Only after the experts have carefully assessed the quality of a new data set and if no major problems have been identified, the data products shall be used for operational services. This activity may be carried out as part of an operational service (assuming that appropriate resources are available for all tasks that need to be carried out) or via projects such as GHG-CCI generating products which will be delivered to an operational service.
    - Note that GHG-CCI team members are / were also involved in the pre-operational MACC-III project and also plan to be involved in the operational CAMS project. However in CAMS focus is on quasi NRT delivery (currently 4 days after satellite data acquisition at the latest), whereas the GHG-CCI focus is on meeting climate research / service needs, i.e., on meeting the GCOS ECV requirements, which implies the generation of consistent high-quality long-term data sets (with approximately annual updates as currently foreseen for GHG-CCI). MACC/CAMS is therefore highly complementary to GHG-CCI. To what extent C3S will be able to provide resources for the generation of the ECV GHG, as currently only done within GHG-CCI, is an open issue.

## 2. Overall progress during reporting period

The GHG-CCI project proceeds as planned. A successful 1<sup>st</sup> GHG-CCI Phase 2 Annual Review Meeting (ARM1) has been held at ESRIN, 31<sup>st</sup> of March to 1<sup>st</sup> of April 2015. No major problems have been identified. During the reporting period focus was on the following:

- Presentation of project results at various conferences (EGU, 36<sup>th</sup> ISRSE, ESA ATMOS 2015, IWGGMS-11, etc.) and participation at project meetings (ARM1, CMUG Integration Meeting).
- Publications (see below)
- Preparation for the generation of the 3<sup>rd</sup> version of the GHG-CCI CRDP (to be delivered in April 2016 incl. documentation and validation)
- Several other activities (Newsletter, website improvements, specific figures, animations, etc.).

## 3. Recent publications

Buchwitz, M., M. Reuter, O. Schneising, H. Boesch, S. Guerlet, B. Dils, I. Aben, R. Armante, P. Bergamaschi, T. Blumenstock, H. Bovensmann, D. Brunner, B. Buchmann, J. P. Burrows, A. Butz, A. Chédin, F. Chevallier, C. D. Crevoisier, N. M. Deutscher, C. Frankenberg, F. Hase, O. P. Hasekamp, J. Heymann, T. Kaminski, A. Laeng, G. Lichtenberg, M. De Mazière, S. Noël, J. Notholt, J. Orphal, C. Popp, R. Parker, M. Scholze, R. Sussmann, G. P. Stiller, T. Warneke, C. Zehner, A. Bril, D. Crisp, D. W. T. Griffith, A. Kuze, C. O'Dell, S. Oshchepkov, V. Sherlock, H. Suto, P. Wennberg, D. Wunch, T. Yokota, Y. Yoshida, The Greenhouse Gas Climate Change Initiative (GHG-CCI): comparison and quality assessment of near-surface-sensitive satellite-derived CO<sub>2</sub> and CH<sub>4</sub> global data sets, *Remote Sensing of Environment*, 162, 344-362, doi:10.1016/j.rse.2013.04.024, 2015.

Buchwitz, M., M. Reuter, O. Schneising H. Boesch, I. Aben, M. Alexe, R. Armante, P. Bergamaschi, H. Bovensmann, D. Brunner, B. Buchmann, J. P. Burrows, A. Butz, F. Chevallier, A. Chedin, C. D. Crevoisier, S. Gonzi, M. De Maziere, E. De Wachter, R. Detmers, B. Dils, C. Frankenberg, P. Hahne, O. P. Hasekamp, W. Hewson, J. Heymann, S. Houweling, M. Hilker, T. Kaminski, G. Kuhlmann, A. Laeng, T. T. v. Leeuwen, G. Lichtenberg, J. Marshall, S. Noel J.

Notholt, P. Palmer, R. Parker, M. Scholze, G. P. Stiller, T. Warneke, C. Zehner, The greenhouse gas project of ESA's Climate Change Initiative (GHG-CCI): Overview, achievements and future plans, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-7/W3, 36th International Symposium on Remote Sensing of Environment, 11–15 May 2015, Berlin, Germany, 2015.

Buchwitz, M., M. Reuter, O. Schneising, H. Boesch, I. Aben, M. Alexe, R. Armante, P. Bergamaschi, H. Bovensmann, D. Brunner, B. Buchmann, J. P. Burrows, A. Butz, F. Chevallier, A. Chedin, C. D. Crevoisier, M. De Maziere, E. De Wachter, R. Detmers, B. Dils, C. Frankenberg, S. Gonzi, P. Hahne, O. P. Hasekamp, W. Hewson, J. Heymann, S. Houweling, M. Hilker, T. Kaminski, G. Kuhlmann, A. Laeng, T. T. v. Leeuwen, G. Lichtenberg, J. Marshall, S. Noel, J. Notholt, P. I. Palmer, R. Parker, P. Somkuti, M. Scholze, G. P. Stiller, T. Warneke, C. Zehner, THE GREENHOUSE GAS PROJECT OF ESA'S CLIMATE CHANGE INITIATIVE (GHG-CCI): PHASE 2 ACHIEVEMENTS AND FUTURE PLANS, ESA ATMOS 2015 conference proceedings (ESA SP-735), Heraklion, Greece, 8-12 June 2015, 2015.

Feng, L., P. I. Palmer, R. J. Parker, N. M. Deutscher, D. G. Feist, R. Kivi, I. Morino, and R. Sussmann, Elevated uptake of CO<sub>2</sub> over Europe inferred from GOSAT XCO<sub>2</sub> retrievals: a real phenomenon or an artefact of the analysis?, Atmos. Chem. Phys. Discuss., 15, 1989-2011, 2015.

Heymann, J., M. Reuter, M. Hilker, M. Buchwitz, O. Schneising, H. Bovensmann, J. P. Burrows, A. Kuze, H. Suto, N. M. Deutscher, M. K. Dubey, D. W. T. Griffith, F. Hase, S. Kawakami, R. Kivi, I. Morino, C. Petri, C. Roehl, M. Schneider, V. Sherlock, R. Sussmann, V. A. Velasco, T. Warneke, and D. Wunch, Consistent satellite XCO<sub>2</sub> retrievals from SCIAMACHY and GOSAT using the BESD algorithm, Atmos. Meas. Tech. Discuss., 8, 1787-1832, 2015.

Kulawik, S. S., D. Wunch, C. O'Dell, C. Frankenberg, M. Reuter, T. Oda, F. Chevallier, V. Sherlock, M. Buchwitz, G. Osterman, C. Miller, P. Wennberg, D. W. T. Griffith, I. Morino, M. Dubey, N. M. Deutscher, J. Notholt, F. Hase, T. Warneke, R. Sussmann, J. Robinson, K. Strong, M. Schneider, and J. Wolf, Consistent evaluation of GOSAT, SCIAMACHY, CarbonTracker, and MACC through comparisons to TCCON, Atmos. Meas. Tech. Discuss., 8, 6217-6277, doi:10.5194/amtd-8-6217-2015, 2015.

Full publication list please see: <http://www.esa-ghg-cci.org/> -> Publications (note that publications with GHG-CCI funding explicitly acknowledged are marked with (\*) on that website).

#### **4. Downloads of GHG-CCI data products**

Since mid 2011 GHG-CCI is recording the number of users of the GHG-CCI core (ECA) data products (the number of downloads has not been recorded). This includes users who registered via the GHG-CCI website and some other (e.g., maintained historical) websites. The number of users is (status 2-July-2015): 384.

\*\*\* End of Report \*\*\*