→ CLIMATE CHANGE INITIATIVE

GHG CCI Newsletter

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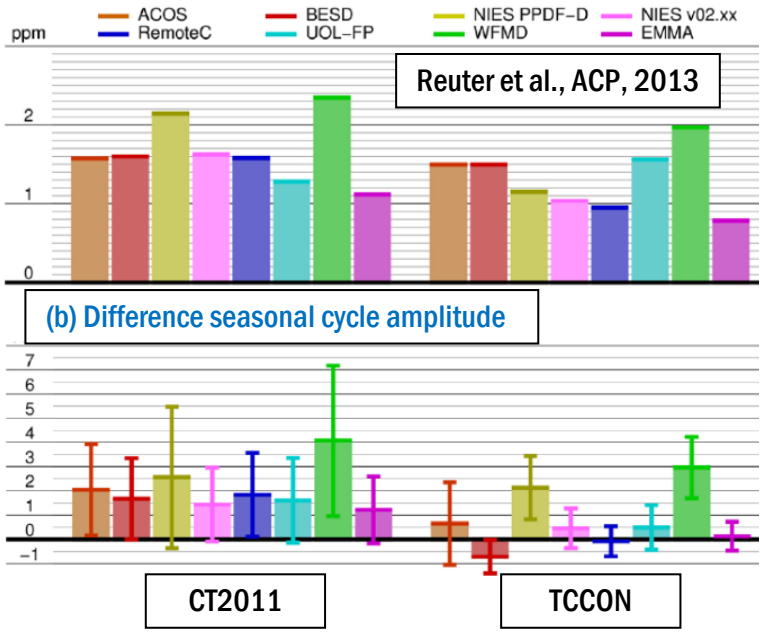
Carbon dioxide (CO_2): Comparison of satellite data with global model and ground-based observations:
(a) Standard deviation of difference



In this issue:

Round Robin successfully completed, CRDP validation & user assessment ongoing

The focus of GHG-CCI is to generate global data sets of carbon dioxide (CO_2) and methane (CH_4), which are the two most important anthropogenic greenhouse gases (GHGs). Satellite observations combined with modelling provide important missing global information on regional CO_2 and CH_4 sources and sinks required for better climate prediction. This application requires appropriate retrieval algorithms. The focus of the first 2 years of the GHG-CCI project was to improve various state-of-the-art algorithms and to compare the resulting data products with the goal to decide which methods to use to generate the CRDP ("Round Robin exercise").

The GHG-CCI "Round Robin" exercise was successfully completed as planned end of August 2012. The goal of this exercise was to improve European GHG retrieval algorithms needed to convert the radiance spectra as measured by the satellite instruments SCIAMACHY/ENVISAT and TANSO-FTS/GOSAT into the desired high quality information on atmospheric GHG distributions. The resulting GHG-CCI core data products generated with "ECV Core Algorithms" (ECAs) are column-averaged mixing ratios of CO_2 and CH_4, denoted XCO_2 (in ppm) and XCH_4 (in ppb). In addition, a number of other algorithms ("Additional Constraints Algorithms" (ACAs)) have also been improved to obtain information on upper layers of the atmosphere as derived from instruments such as IASI and MIPAS. Here we present a short overview about the key results of this activity and other ongoing activities related to the generation and analysis of the "Climate Research Data Package" (CRDP).

GHG-CCI Round Robin: Approach and results

The ultimate goal of the GHG-CCI Round Robin exercise was to identify which algorithms to use to generate the Climate Research Data Package (CRDP, see page 4), which is the first version of the "Essential Climate Variable" (ECV) "Greenhouse Gases" (GHG).

To achieve this, detailed comparisons have been conducted with ground-based observations using TCCON (see below). Due to the sparseness of the TCCON data a large number of other comparisons have also been conducted, most notably using the newly developed ensemble approach "EMMA" (Reuter et al., ACP, 2013; see page 3).

The GHG-CCI Round Robin approach and results are presented in detail in Buchwitz et al., The Greenhouse Gas Climate Change Initiative (GHG-CCI): comparison and quality assessment of near-surface-sensitive satellite-derived CO_2 and CH_4 global data sets, Remote Sensing of Environment (in press), 2013 (pdf pre-print available on http://www.esa-ghg-cci.org -> Publications). For XCO_2 from SCIAMACHY and GOSAT it has been decided to continue with all algorithms for example in order to be able to generate a merged "EMMA" ensemble product (see above). For methane it has been decided to continue with 2 (one "proxy" and one "full physics" algorithm) out of the 4 GOSAT algorithms and with 2 SCIAMACHY algorithms as it was not always possible to identify which algorithm performs best under all conditions. More research is needed to achieve this.

Algorithms & Products compared during Round Robin (RR)

Core Products	GHG-CCI ECV Core Algos. (ECAs)						For comparison	
	IUP		UoL		SRON		NIES	NASA
	BESD	WFMD	OCPR	OCFP	SRPR	SRFP	Official GOSAT & PPDF	ACOS
SCIA XCO_2	ECV?	ECV?						
SCIA XCH_4		ECV?			ECV? (IMAP)			
GOSAT XCO_2				ECV? (OCO)		ECV? (RemoTeC)	cmp	cmp
GOSAT XCH_4			ECV? (OCO)	ECV? (OCO)	ECV? (RemoTeC)	ECV? (RemoTeC)	cmp	

GHG-CCI: Key performance estimates (status @ end of Round Robin)

GHG-CCI ECV Core Data Products: Estimated data quality #)

Product	Sensor	Algorithm	Precision Single observation	Precision Regional / monthly	Relative accuracy
XCH_4 [ppb]	SCIAMACHY 2003-2005 (> 2005)	IMAP WFMD	30 (50) 30 (70)	10 (<15) 9 (13-16)	4 – 13 (2003-2009) 3 – 12 (2003-2009)
	TANSO	OCPR SRFP	14 15	5 9	3 5
	Required (URD):		< 34 (T) < 17 (B) < 9 (G)	< 11 (T) < 5 (B) < 3 (G)	< 10 (T) < 5 (B) < 1 (G)
XCO_2 [ppm]	SCIAMACHY	BESD WFMD	2.4 4.3	2.0 2.3	0.8 1.2
	TANSO	OCFP SRFP	2.5 2.6	1.3 1.3	0.8 1.0
	Required (URD):		< 8 (T) < 3 (B) < 1 (G)	< 1.3 (T) < 1.0 (B) < 0.3 (G)	< 0.5 (T) < 0.3 (B) < 0.2 (G)

#) Typical values obtained using different methods mainly based on comparisons with TCCON (esp. rel. accuracy not fully representative for all conditions). From: GHG-CCI Algorithm Selection Report (ASR, http://www.esa-ghg-cci.org/)

Figure 1: Algorithms / data products compared during the GHG-CCI Round Robin exercise (top) and estimated data quality (bottom) as obtained by comparisons with TCCON ground-based observations.

Scientific highlights

A number of scientific publications have been published since 2012 based on the GHG-CCI data products. Here we present a short overview about these recent publications.

Global CO_2 inverse modelling results based on GHG-CCI data are presented and discussed in the following paper, which is currently under review but available on-line:

Basu, S., S. Guerlet, A. Butz, S. Houweling, O. Hasekamp, I. Aben, P. Krummel, P. Steele, R. Langenfelds, M. Torn, S. Biraud, B. Stephens, A. Andrews, and D. Worthy, Global CO_2 fluxes estimated from GOSAT retrievals of total column CO_2, Atmos. Chem. Phys. Discuss., 13, 4535-4600, 2013.

This publication presents the GHG-CCI Round Robin approach and results (see also page 2):

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_2 and CH_4 global data sets, Remote Sensing of Environment, in press, 2013.

This publication presents a statistical analysis related to the interpretation and the information content of satellite CO_2 observations:

Chevallier, F., and C. W. O'Dell, Error statistics of Bayesian CO_2 flux inversion schemes as seen from GOSAT, Geophys. Res. Lett., doi: 10.1002/grl.50228, 2013.

Here a CO_2 data set derived from GOSAT is analysed using inverse modelling of CO_2 surface fluxes to study inter-annual differences in carbon fluxes for the Northern Hemisphere:

Guerlet, S., S. Basu, A. Butz, M. Krol, P. Hahne, S. Houweling, O. P. Hasekamp and I. Aben, Reduced carbon uptake during the 2010 Northern Hemisphere summer from GOSAT, Geophys. Res. Lett., doi: 10.1002/grl.50402, 2013.

The following two publications show how the SCIAMACHY WFMD XCO_2 data product has been improved:

Heymann, J., O. Schneising, M. Reuter, M. Buchwitz, V. V. Rozanov, V. A. Velazco, H. Bovensmann, and J. P. Burrows, SCIAMACHY WFM-DOAS XCO_2: comparison with CarbonTracker XCO_2 focusing on aerosols and thin clouds, Atmos. Meas. Tech., 5, 1935-1952, 2012.

Heymann, J., H. Bovensmann, M. Buchwitz, J. P. Burrows, N. M. Deutscher, J. Notholt, M. Rettinger, M. Reuter, O. Schneising, R. Sussmann, and T. Warneke SCIAMACHY WFM-DOAS XCO_2: reduction of scattering related errors, Atmos. Meas. Tech., 5, 2375-2390, 2012.

Here an overview about the entire CCI programme is presented:

Hollmann, C.J. Merchant, R. Saunders, C. Downy, M. Buchwitz, A. Cazenave, E. Chuvieco, P. Defourny, G. de Leeuw, R. Forsberg, T. Holzer-Popp, F. Paul, S. Sandven, S. Sathyendranath, M. van Roozendael, W. Wagner, The ESA Climate Change Initiative: satellite data records for essential climate variables, Bulletin of the American Meteorological Society (BAMS), 0.1175/BAMS-D-11-00254.1, 2013.

One of the most innovative achievements of GHG-CCI is the development and use of an ensemble product for satellite XCO_2. This aspect is presented and discussed in the following paper:

Reuter, M., H. Boesch, H. Bovensmann, A. Bril, M. Buchwitz, A. Butz, J. P. Burrows, C. W. O'Dell, S. Guerlet, O. Hasekamp, J. Heymann, N. Kikuchi, S. Oshchepkov, R. Parker, S. Pfeifer, O. Schneising, T. Yokota, and Y. Yoshida, A joint effort to deliver satellite retrieved atmospheric CO_2 concentrations for surface flux inversions: the ensemble median algorithm EMMA, Atmos. Chem. Phys., 13, 1771-1780, 2013.

This paper discusses a comparison of different approaches to retrieve methane from GOSAT:

Schepers, D., S. Guerlet, A. Butz, J. Landgraf, C. Frankenberg, O. Hasekamp, J.-F. Blavier, N.M. Deutscher, D. Griffith, F. Hase, E. Kyro, I. Morino, V. Sherlock, R. Sussmann and I. Aben: "Methane retrievals from Greenhouse Gases Observing Satellite (GOSAT) shortwave infrared measurements: Performance comparison of proxy and physics retrieval algorithms" J. Geophys. Res., 117, D10307, doi:10.1029/2012JD017549, 2012.

An analysis of the SCIAMACHY WFMD XCO_2 data set over major anthropogenic CO_2 source regions is presented in this publication:

Schneising, O., J. Heymann, M. Buchwitz, M. Reuter, H. Bovensmann, and J. P. Burrows, Anthropogenic carbon dioxide source areas observed from space: assessment of regional enhancements and trends, Atmos. Chem. Phys., 13, 2445-2454, 2013.

Validation of the GHG-CCI satellite data products is very important and this publication contributes to extending the number of ground-based observations useful for validation:

Sussmann, R., A. Ostler, F. Forster, M. Rettinger, N. M. Deutscher, D. W. T. Griffith, J. W. Hannigan, N. Jones, and P. K. Patra, First intercalibration of column-averaged methane from the Total Carbon Column Observing Network and the Network for the Detection of Atmospheric Composition Change, Atmos. Meas. Tech., 6, 397-418, 2013.

Status "Climate Research Data Package" (CRDP)

The CRDP has been generated as planned. Ongoing activities are the validation of the CRDP and an initial user assessment. Once these activities are completed (plan: September 2013) the CRDP along with its documentation will be made publicly available. The unvalidated data are already available via the GHG-CCI web site for interested users (http://www.esa-ghg-cci.org -> CRDP).

Overview CRDP. For details, please visit the GHG-CCI website:

GHG-CCI Climate Research Data Package (CRDP)											
Product ID	Product (Level 2, mixing ratios)	Years processed									
		2003	04	05	06	07	08	09	10	11	12
ECV Core Products (ECAs)											
XCO2_SCIA	XCO_2	■	■	■	■	■	■	■	■	■	■
XCH4_SCIA	XCH_4	■	■	■	■	■	■	■	■	■	■
XCO2_GOSAT	XCO_2							■	■	■	■
XCH4_GOSAT	XCH_4							■	■	■	■
XCO2_EMMA	XCO_2							■	■	■	■
Additional Constraints Products (ACAs)											
CO2_AIRS	CO_2 (1)	■	■	■	■	■					
CO2_IASI	CO_2 (1)					■	■	■	■	■	
CH4_IASI	CH_4 (1)					■	■	■	■	■	
CH4_SCIAOCC	CH_4 (2)	■	■	■	■	■	■	■	■		
CO2_SCIAOCC	CO_2 (2)	■	■	■	■	■	■	■	■		
CH4_MIPAS	CH_4 (2)			■	■	■	■	■	■	■	■
CO2_ACEFTS	CO_2 (2)		■	■	■	■	■	■	■		
Comments: (1) Mid / upper tropospheric column; (2) Upper tropospheric / stratospheric profile		Algorithms ECAs: XCO2_SCIA: BESD (WFMD) XCH4_SCIA: IMAP, WFMD XCO2_ GOSAT: SRFP(RemoTeC), OCFP XCH4_GOSAT: SRFP, OCPR XCO2_EMMA: Various (merged SCIA & GOSAT)									