SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year

2014 (31 July 2013 - 30 June 2014)

Project Title:

Global and regional inverse modelling of atmospheric CH_4 and N_2O

Computer Project Account:

spjrc4dv

Principal Investigator(s):

Dr. Peter Bergamaschi

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Name of ECMWF scientist(s) collaborating to the project
(if applicable)

Dr. Anna Agusti-Panareda, Dr. Sebastien Massart, Dr. Richard Engelen (in the framework of the MACC-2 project)

Start date of the project:

1 January 2012

Expected end date:

31 December 2014

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	500000	441796	500000	~62000[1] (June 2014)
Data storage capacity	(Gbytes)				

[1]several larger simulations planned for the first half 2014 have been delayed but will be started soon

Summary of project objectives
(10 lines max)

1. Improve global CH_4 inversions using new satellite retrievals (contribution to MACC-II project)

2. Improve European CH_4 and N_2O inversions using in-situ observations

3. Further development of TM5-4DVAR system

Summary of problems encountered (if any)
(20 lines max)

no major problems

Summary of results of the current year (from July of previous year to June of current year)
This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

Improve global CH_4 inversions using new satellite retrievals (contribution to MACC-II project)

The MACC CH_4 inversion reanalysis over the period 2003-2010 [*Bergamaschi et al., 2013a*] has been further extended until end of 2012 (with inversions using SCIAMACHY data extended only until 2011 (due to the end of operation of ENVISAT)). As for 2007-2010, also for 2011-2012 higher global CH_4 emissions are derived compared to 2003-2005. Most of the inferred emission increase was located in the tropics and mid-latitudes of the northern hemisphere, while no significant trend was derived for Arctic latitudes (Figure 1).

Half-yearly MACC-II 'delayed-mode' CH_4 inversions for the periods 01-06/2011, 07-12/2011, 01-06/2012, 07-12/2012, and 01-06/2013 have been delivered to ECMWF and published on the MACC-II website:

http://www.copernicus-atmosphere.eu/d/services/gac/delayed/ch4_flux_inversions/

Since 01/2012 CH_4 retrievals from GOSAT (RemoteC PROXY v2.0 XCH_4 product from SRON) are now used, while the previous CH_4 inversions were based on SCIAMACHY (IMAPv5.5), which became dysfunctional beginning 2012.

In order to investigate the impact of the changing data streams on the inversions, a detailed comparison study has been performed using the different XCH_4 satellite products from SCIAMACHY and GOSAT, including additional XCH_4 products developed within the ESA GHG climate change initiative project [*Alexe et al., 2014*]. This study shows the significant improvement of GOSAT retrievals compared to SCIAMACHY, with significantly lower bias and noise of the GOSAT retrievals (RMS reduced by more than factor 3). The most important result is that the different retrieval products yield qualitatively consistent regional CH_4 emission patterns, particularly over the United States and Tropical Africa (Figure 2). The derived regional fluxes (2010-2011 average) for the TRANSCOM regions agree within ~10-15 Tg CH_4/yr [*Alexe et al., 2014*].

Improve European CH_4 and N_2O inversions using in-situ observations

A first series of European CH_4 inversions has been performed using a first dataset of improved, harmonized European CH_4 in-situ measurements, generated in the InGOS ("Integrated non-CO_2 greenhouse gas Observing Systems") project (http://www.ingos-infrastructure.eu/) for the period 2007-2011. These inversions will be updated in the coming months using an updated observations dataset (using only those InGOS data which meet the defined quality criteria, and which include estimates of repeatability and different components of the uncertainty relative to the WMO GAW mole fraction scale for CH_4).

First N_2O test inversions have been performed in preparation of the InGOS N_2O inversions. These will be performed in the coming months using the InGOS N_2O dataset (as for CH_4 including detailed uncertainty estimates).

A detailed model validation has been performed using ^{222}Rn simulations (based on a novel ^{222}Rn soil emission inventory, parameterized by soil type, porosity, moisture and water table [*Karstens et al., 2014a*]. Furthermore boundary layer height dynamics in TM5 have been compared with the NOAA Integrated Global Radiosonde Archive (IGRA) and LIDAR measurements [*Karstens et al., 2014b*].

Further development of TM5-4DVAR system

The TM5-4DVAR observations interface has been upgraded for various GOSAT retrievals products (from ESA GHG climate change intiative project [*Alexe et al., 2014*]).

Furthermore, important features of the current JRC TM5-4DVAR version have been implemented in the new TM5-4DVAR pyshell version (with enhanced modularity), including support of m1qn3, continuous surface observations and treatment of model representation errors.

List of publications/reports from the project with complete references

Bergamaschi, P., M. Corazza, U. Karstens, M. Athanassiadou, R. L. Thompson, I. Pison, A. J. Manning, P. Bousquet, A. Segers, A. T. Vermeulen, G. Janssens-Maenhout, M. Schmidt, M. Ramonet, F. Meinhardt, T. Aalto, L. Haszpra, J. Moncrieff, M. E. Popa, D. Lowry, M. Steinbacher, A. Jordan, S. O'Doherty, S. Piacentino and E. Dlugokencky, Top-down estimates of European CH_4 and N_2O emissions based on four different inverse models, Atmos. Chem. Phys. Discuss., 14, 15683–15734, 2014.

Alexe, M., P. Bergamaschi, A. Segers, R. Detmers, A. Butz, O. Hasekamp, S. Guerlet, R. Parker, H. Boesch, C. Frankenberg, R. A. Scheepmaker, E. Dlugokencky, C. Sweeney, S. C. Wofsy and E. A. Kort, Inverse modeling of CH4 emissions for 2010–2011 using different satellite retrieval products from GOSAT and SCIAMACHY, Atmos. Chem. Phys. Discuss., 14, 11493–11539, 2014

Houweling, S., M. Krol, P. Bergamaschi, C. Frankenberg, E. J. Dlugokencky, I. Morino, J. Notholt, V. Sherlock, D. Wunch, V. Beck, C. Gerbig, H. Chen, E. A. Kort, T. Röckmann and I. Aben, A multi-year methane inversion using SCIAMACHY, accounting for systematic errors using TCCON measurements, Atmos. Chem. Phys., 14, 3991–4012, 2014.

Thompson, R. L., P. K. Patra, K. Ishijima, E. Saikawa, M. Corazza, U. Karstens, C. Wilson, P. Bergamaschi, E. Dlugokencky, C. Sweeney, R. G. Prinn, R. F. Weiss, S. O'Doherty, P. J. Fraser, L. P. Steele, P. B. Krummel, M. Saunois, M. Chipperfield and P. Bousquet, TransCom N_2O model inter-comparison – Part 1: Assessing the influence of transport and surface fluxes on tropospheric N_2O variability, Atmos. Chem. Phys., 14, 4349–4368, 2014.

Thompson, R. L., K. Ishijima, E. Saikawa, M. Corazza, U. Karstens, P. K. Patra, P. Bergamaschi, F. Chevallier, E. Dlugokencky, R. G. Prinn, R. F. Weiss, S. O'Doherty, P. J. Fraser, L. P. Steele, P. B. Krummel, A. Vermeulen, Y. Tohjima, A. Jordan, L. Haszpra, M. Steinbacher, S. van der Laan, T. Aalto, F. Meinhardt, M. E. Popa, J. Moncrieff and P. Bousquet, TransCom N_2O model inter-comparison Part II: Atmospheric inversion estimates of N_2O emissions, Atmos. Chem. Phys. Discuss., 14, 5271–5321, 2014

Karstens, U., P. Bergamaschi, I. Levin, E. Koffi, M. Saunois, R. Locatelli, I. Heard, A.J. Manning, A.T. Vermeulen, M. Schmidt, R. Fisher, J. Hatakka, H.A.J. Meijer, J. Moncrieff, and C. Schlosser, Comparison of ^{222}Radon simulations based on the new ^{222}Radon inventory with observations, InGOS Deliverable D15.4, report, 2014a.

Karstens, U., P. Bergamaschi, E. Koffi, M. Saunois, R. Locatelli, I. Heard, A.J. Manning, A.T. Vermeulen, S. Pal and M. Ramonet, Comparison of simulated and observed boundary layer mixing height, InGOS Deliverable D15.5, report, 2014b.

Bergamaschi, P., S. Houweling, A. Segers, M. Krol, C. Frankenberg, R. A. Scheepmaker, E. Dlugokencky, S. Wofsy, E. Kort, C. Sweeney, T. Schuck, C. Brenninkmeijer, H. Chen, V. Beck and C. Gerbig, Atmospheric CH_4 in the first decade of the 21st century: Inverse modeling analysis using SCIAMACHY satellite retrievals and NOAA surface measurements, J. Geophys. Res., doi:10.1002/jgrd.50480, 2013a.

Bergamaschi, P., A. Segers, R. Scheepmaker, C. Frankenberg, O. Hasekamp, E. Dlugokencky, C. Sweeney, M. Ramonet, L. Rivier, J. Tarniewicz, E. Kort, and S. Wofsy, Report on the quality of the inverted CH_4 fluxes, MACC-II Deliverable D_43.3, MACC-II report, 2013b.

Kirschke, S., P. Bousquet, P. Ciais, M. Saunois, J. G. Canadell, E. J. Dlugokencky, P. Bergamaschi, D. Bergmann, D. R. Blake, L. Bruhwiler, P. Cameron-Smith, S. Castaldi, F. Chevallier, L. Feng, A. Fraser, M. Heimann, E. L. Hodson, S. Houweling, B. Josse, P. J. Fraser, P. B. Krummel, J.-F. Lamarque, R. L. Langenfelds, C. Le Quéré, V. Naik, S. O'Doherty, P. I. Palmer, I. Pison, D. Plummer, B. Poulter, R. J. Prinn, M. Rigby, B. Ringeval, M. Santini, M. Schmidt, D. T. Shindell, I. J. Simpson, R. Spahni, L. P. Steele, S. A. Strode, K. Sudo, S. Szopa, G. R. van der Werf, A. Voulgarakis, M. van Weele, R. F. Weiss, J. E. Williams and G. Zeng, Three decades of global methane sources and sinks, Nature Geoscience, 6, 813–823, 2013.

Summary of plans for the continuation of the project

(10 lines max)

European CH_4 and N_2O inversions using improved European in-situ measurements from InGOS, taking into account estimates of repeatability and different systematic error components

Update global CH_4 inversions (within MACC-II / MACC-III and ESA GHG climate change initiative second-phase project)

Improve a posteriori uncertainty estimates of inversions (implement system that can be used for non-linear inversion system).

Complete transition to new TM5-4DVAR pyshell version (with enhanced modularity); including harmonization of different versions used by TM5 modelling community and support of satellite data

Figures

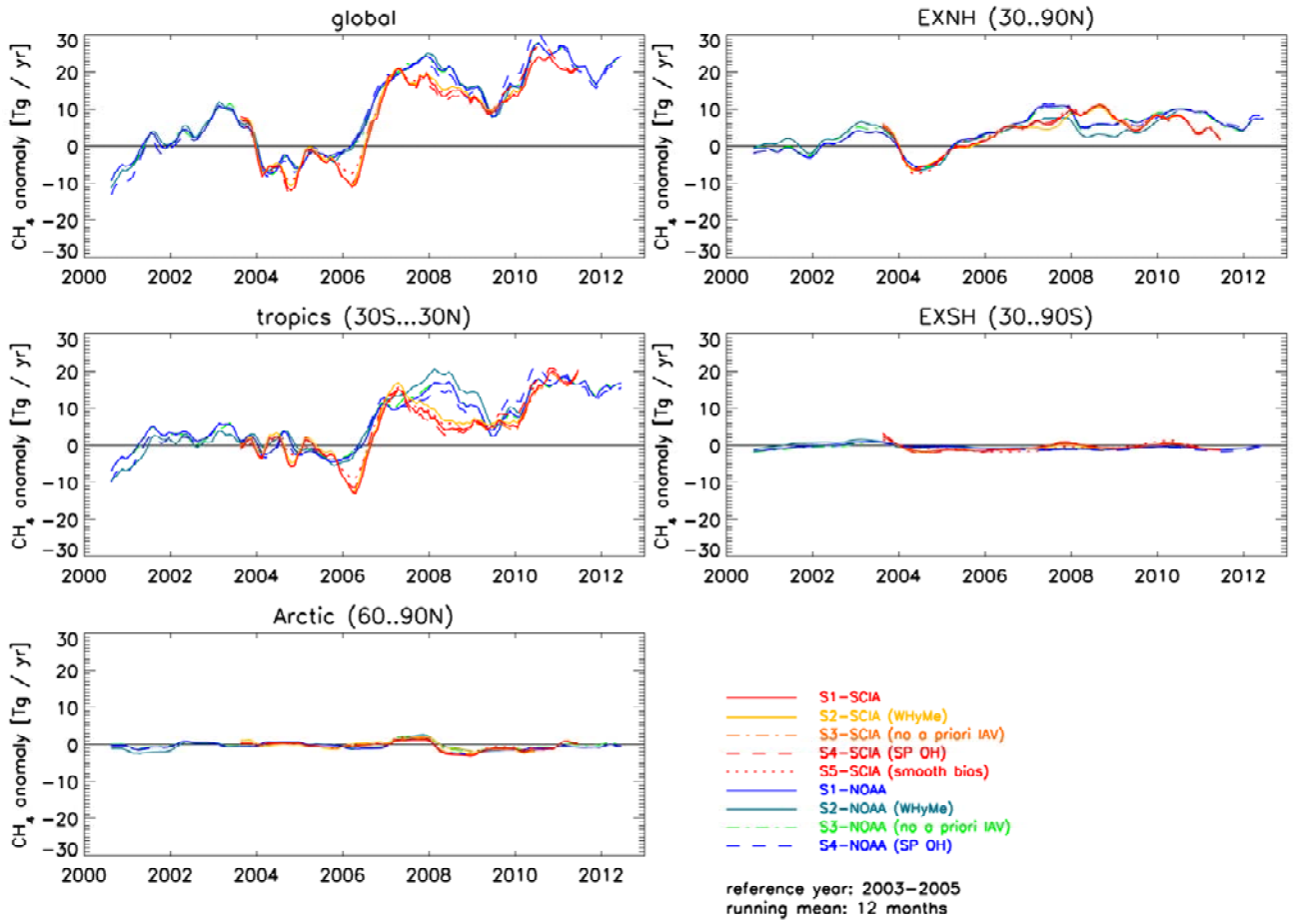

Figure 1: Extension of reanalysis of global CH_4 emissions until end 2012: CH_4 Inter-annual variation of total CH_4 emissions derived from the different inversions. The variations are shown relative to the average emissions during the reference period 2003-2005 (12-month running mean values).

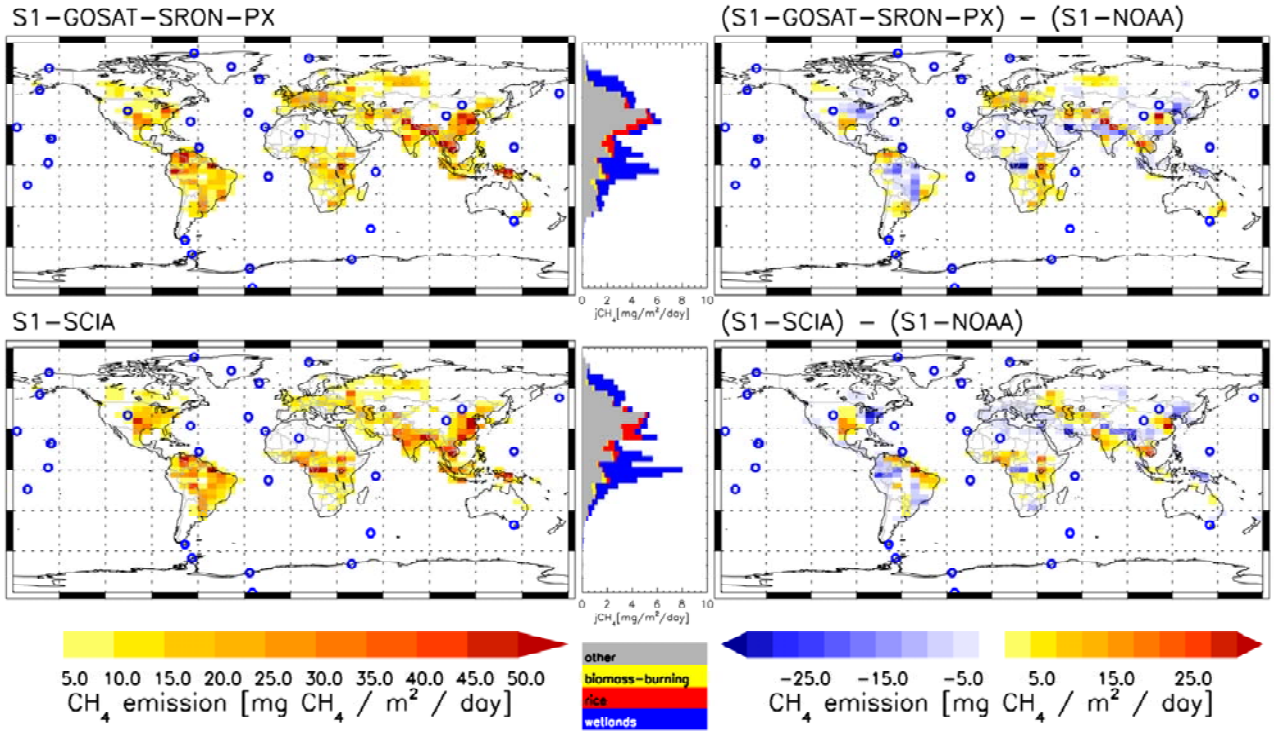

Figure 2: Comparison of derived global CH_4 emissions using the GOSAT (RemoteC PROXY v2.0) XCH_4 retrievals (top) and using SCIAMACHY retrievals (IMAPv55) (bottom) [*Alexe et al., 2014*]; the figure shows 2010-2011 average emissions (left) and difference compared to a reference inversion using only NOAA surface observations (right).