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	2018 (01 January 2018 - 30 June 2018)
Project Title:	Improve European and global CH_4 and N_2O flux inversions
Computer Project Account:	spjrc4dv
Principal Investigator(s):	Dr. Peter Bergamaschi
Affiliation:	European Commission Joint Research Centre (EC-JRC) Directorate for Energy, Transport and Climate Air and Climate Unit TP 124 I-21027 Ispra (Va) Italy
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Dr. Anna Agusti-Panareda (in the framework of the Copernicus / CAMS project)
Start date of the project:	01 January 2018
Expected end date:	31 December 2020

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)			400000	18376 (22 June 2018)
Data storage capacity	(Gbytes)			400	

Summary of project objectives

(10 lines max)

1. **Improve estimates of global CH_4 emissions using new satellite retrievals**

2. **Improve estimates of European CH_4 and N_2O emissions using in-situ observations**

3. **Develop coupled global / regional inversion system with high spatial resolution**

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 estimates of global CH_4 emissions using new satellite retrievals

A series of global CH_4 flux inversions at higher horizontal resolution ($3^o \times 2^o$ instead of $6^o \times 4^o$) (which was started in the previous ECMWF special project ("Improve estimates of global and regional CH_4 and N_2O emissions based on inverse modelling using in-situ and satellite measurements" (2015-2017)) has been finalized and is used also for validation of the Copernicus Atmosphere Monitoring Service (CAMS) CH_4 products [*Koffi and Bergamaschi*, JRC technical report in preparation, 2018]. Since the JRC TM5-4DVAR inversion system was used as prototype of the operational CAMS inversion system, the comparisons of the CAMS and JRC CH_4 inversions provides a benchmark to evaluate the specific model setup and further model updates of the CAMS TM5-4DVAR system. Figure 1 shows the derived CH_4 emissions from the CAMS inversions (provided by TNO; left) and JRC inversions (right) for inversions using only NOAA surface observations (top) and for inversions including both NOAA surface observations and XCH_4 satellite retrievals from GOSAT (bottom). The evaluation of the different inversions (by comparison with comprehensive independent observational data sets from surface monitoring stations, ship cruises, various aircraft programmes, AirCore soundings up to the middle stratosphere, and total column measurement) shows overall similar performance of the CAMS CH_4 flux inversions and the JRC TM5-4DVAR inversions.

Improve estimates of European CH_4 and N_2O emissions using in-situ observations

Within the H2020 project VERIFY ("Observation-based system for monitoring and verification of greenhouse gases") CH_4 and N_2O inversions will be performed. The setup of these inversions is currently discussed and prepared with the VERIFY project. A first series of inversions will be performed in the second half of 2018.

Develop coupled global / regional inversion system with high spatial resolution

First CH_4 inversions have been performed using a regional 4DVAR prototype inverse modelling system based on the Lagrangian particle dispersion model FLEXPART, coupled to the TM5-4DVAR inverse modelling system (main model development: Arjo Segers, TNO; FLEXPART simulations: Dominik Brunner, EMPA). The FLEXPART version used is driven by meteorological fields from the COSMO-7 numerical weather prediction system at a horizontal resolution of 7 km.
Figure 2 shows the derived CH_4 emissions, using measurements from the monitoring station Ispra, Italy (for year 2011). The inversion shows moderate enhancements of regional CH_4 emissions around the monitoring station Ispra. First sensitivity experiments revealed a significant dependence of derived emission increments on the assumed observation errors (including measurement and model errors). In the example shown in Figure 2 relatively large model errors are assumed (based on the comparison of a priori simulations with measurements [*Henne et al.*, 2016 [1]]. Assuming smaller model errors results in significantly larger inversions increments.

[1] Henne, S. et al., Validation of the Swiss methane emission inventory by atmospheric observations and inverse modelling, Atmos. Chem. Phys., 16, 3683-3710, https://doi.org/10.5194/acp-16-3683-2016, 2016

List of publications/reports from the project with complete references

Bergamaschi, P., U. Karstens, A. J. Manning, M. Saunois, A. Tsuruta, A. Berchet, A. T. Vermeulen, T. Arnold, G. Janssens-Maenhout, S. Hammer, I. Levin, M. Schmidt, M. Ramonet, M. Lopez, J. Lavric, T. Aalto, H. Chen, D. G. Feist, C. Gerbig, L. Haszpra, O. Hermansen, G. Manca, J. Moncrieff, F. Meinhardt, J. Necki, M. Galkowski, amp, apos, S. Doherty, N. Paramonova, H. A. Scheeren, M. Steinbacher, and E. Dlugokencky, Inverse modelling of European CH_4 emissions during 2006–2012 using different inverse models and reassessed atmospheric observations, Atmos. Chem. Phys., 18(2), 901-920, doi: 10.5194/acp-18-901-2018, 2018.

Koffi, E.N. and Bergamaschi, P., Evaluation of Copernicus Atmosphere Monitoring Service methane products, JRC technical report, in preparation, 2018.

Summary of plans for the continuation of the project

(10 lines max)

A next series of global CH_4 flux inversions will be performed in the second half of 2018. These inversions will contribute to the next round of the Global Carbon Project (GCP) - CH_4, and will be performed according to the new GCP-CH_4 protocol.

CH_4 and N_2O inversions will be performed in the second half of 2018, contributing to the VERIFY project.

The coupled FLEXPART-COSMO / TM5 4DVAR inversion system will be further developed. Further sensitivity experiments will be performed (e.g. investigating further different approaches to estimate the model representation errors).

Figures

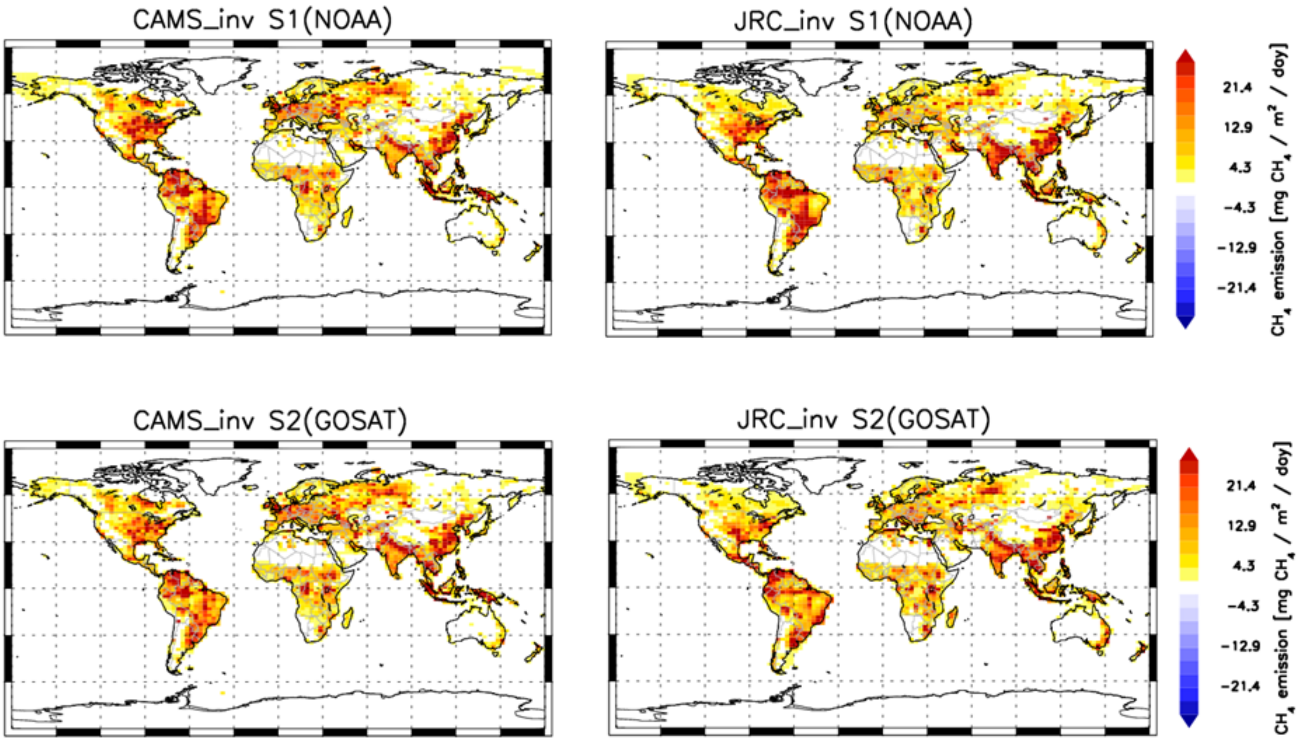

Figure 1: Comparison of derived CH_4 emissions (average 2010-2015) from CAMS inversions (left) and JRC inversions (right). Top: inversions using only NOAA surface observations; bottom: inversions including both NOAA surface observations and XCH_4 satellite retrievals from GOSAT.

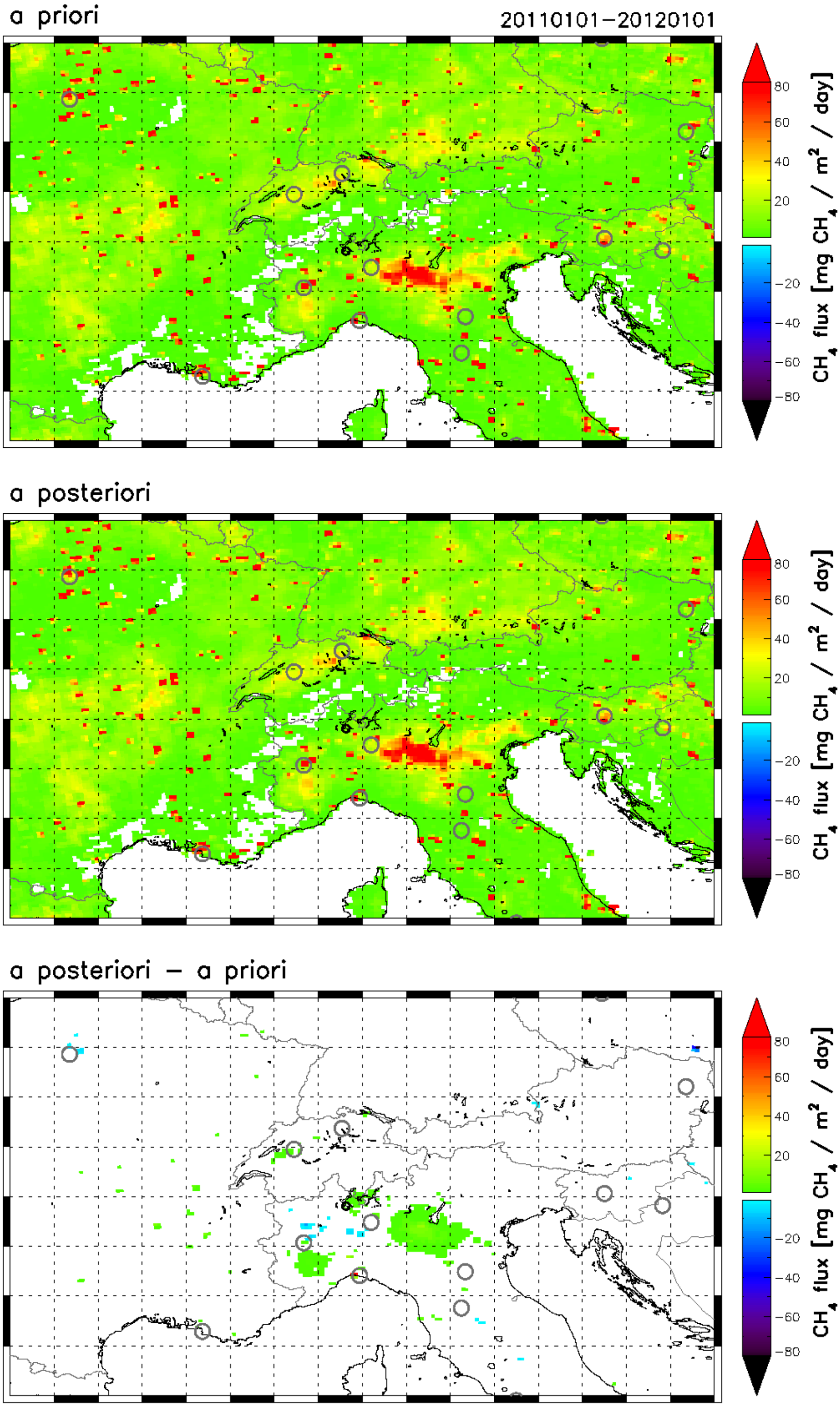

Figure 2: Derived CH_4 emissions using the new FLEXPART / COSMO inversion system coupled to the TM5-4DVAR inverse modelling system and using measurements from the monitoring station Ispra, Italy (small black circle at Lake Maggiore; grey circles show locations of larger cities (e.g. Milano, Torino, Genova, Bern, Zürich). Top: a prior emissions; middle: a posteriori emissions; bottom: inversion increments.