SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2023……………………………………………….……
Project Title:	Extend and improve CH_4 flux inversions at global and European scale based on ERA5 reanalyses ……………………………………………………….…… ……………………………………………………….……
Computer Project Account:	ECJRC…………………………………………….……
Principal Investigator(s):	Dr. Francesco Graziosi (EC-JRC), Dr. Giovanni Manca (EC-JRC)……………….…… ……………………………………………………….……
Affiliation:	European Commission, Joint Research Centre (EC-JRC) Directorate for Energy, Mobility and Climate Clean Air and Climate Unit ……………………………………………….……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	……………………………………………………….…… ……………………………………………………….……
Start date of the project:	2022……………………………………………….……
Expected end date:	2024……………………………………………………..…

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)	3.200.000	25.476.963	3.200.000	3.754.748
Data storage capacity	(Gbytes)	1500	1000	1500	1300

Summary of project objectives (10 lines max)

- Extend and improve estimates of global CH_4 emissions. Assess the global methane emissions applying global inversion system (TM5-4DVAR) , and determine the regional methane emissions using flexinvert+ model inversion chain.
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Summary of problems encountered (10 lines max)

No major problems encountred………...

Summary of plans for the continuation of the project (10 lines max)

Extend the application of the TM5-4DVAR inversions up to 2022 with the aim to assess the methane emissions from global domain. Perform a set of sensitivity tests experiments to determine the best bias correction, and determine the best model setting to retrieve the methane emissions over north hemispheric wetlands. Apply the flexinvert+ inversion system to estimate the hotspot methane emissions over regional domain.

List of publications/reports from the project with complete references

Report in preparation.
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Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

The preliminary results reported here are generated adopting the TM5-4DVAR inversion system [Bergamaschi et al., 2013; Meirink et al., 2008; Segers and Houweling, 2017a; 2017b]. This model chain is based on the atmospheric transport model TM5 [Krol et al., 2005] and its adjoint and uses a 4DVAR variational technique that iteratively minimises the cost function. The model inversion chain has been run for the period 2018 to 2020 to assess the methane fluxes over the global domain. The TM5 chemical transport model was driven by ECMWF ERA5 meteorological fields. The model system generates the 3D methane model fraction fields taking in-to account a priori information on emissions from wetlands, rice, biomass burning, other (mainly anthropogenic) sources, and

atmospheric photochemical sinks in the troposphere (reacting with OH) and in the stratosphere (OH, Cl and O1(D)). The inversion system ingests the surface based measurements and satellite retrievals as observational constraints to optimise fluxes in the grid cells taking into account the four source categories. The inversion procedure consists of two inversion steps.
As the first step, we performed an yearly inversions (including 6-months of spin up and 6 months of spin down) at coarse resolution (6° x 4° lat lon and 25 vertical levels) using surface based measurements from NOAA Earth System Research Laboratory (ESRL) [Segers and Houweling, 2017a; 2017b], covering the period from 2018 to 2020. This first inversion stream generates the 3D optimized methane mole fraction fields, ingested as initial concentration fields by the second iteration inversions. The fig 1 shows the optimized methane mole fraction fields, used as initial concentration fields by the second iteration runs.

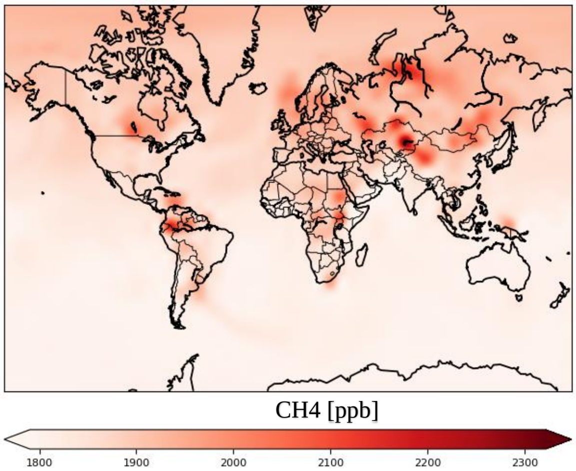
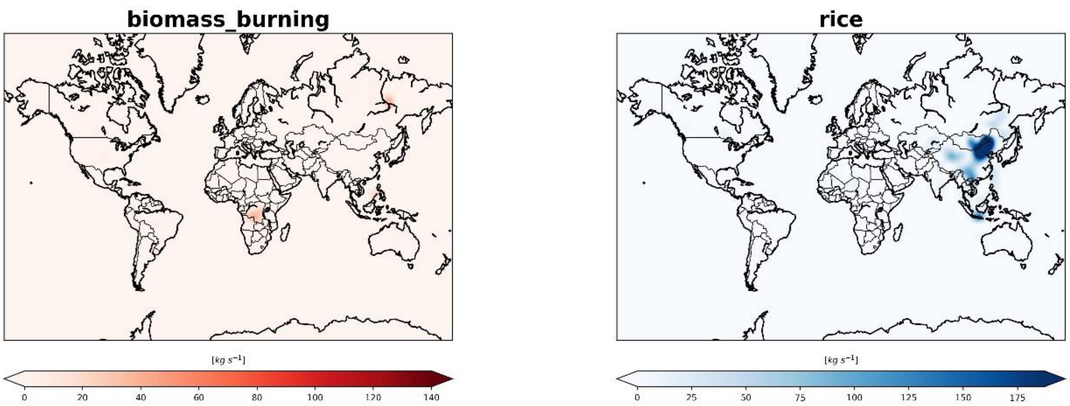


Figure 1. January of 2019 methane optimized concentration fields generated by the first inversion stream.

The second step consists in a yearly (plus 6 months of spin-up and 6 months of spin-down) high resolution (3° x 2° lat lon and 34 vertical layer) inversion runs covering all the investigated period. We performed two different high resolution inversion streams, 1) using surface based measurements from NOAA only, and 2) adopting satellite retrievals from GOSAT satellite and surface based measurements from NOAA. For the last high resolution inversion stream, a bias correction is applied. Fig. 2 reports an optimized methane emission fields of wetland, biomass burning, rice and other, generated by the high resolution inversion stream, for the year 2018.



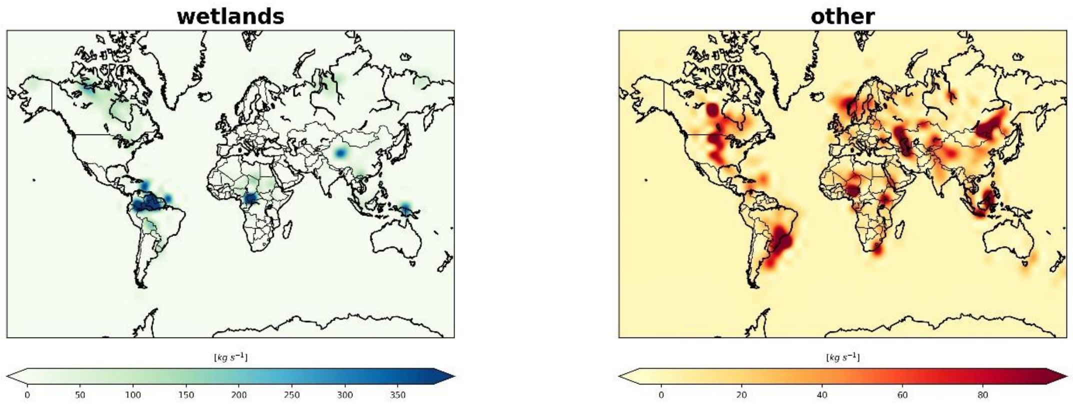


Figure 2. Methane emissions maps of different source categories generated by inversions using GOSAT satellite retrievals and surface based measurements from NOAA, for the year 2019.

References

Bergamaschi, P., S. Houweling, A. Segers, M. Krol, C. Frankenberg, R. A. Scheepmaker, E. Dlugokencky, S. C. Wofsy, E. A. Kort, C. Sweeney, T. Schuck, C. Brenninkmeijer, H. Chen, V. Beck, and C. Gerbig, Atmospheric CH4 in the first decade of the 21st century: Inverse modeling analysis using SCIAMACHY satellite retrievals and NOAA surface measurements, J. Geophys. Res.-Atmos., 118(13), 7350-7369, doi:10.1002/jgrd.50480, 2013.

Krol, M., S. Houweling, B. Bregman, M. van den Broek, A. Segers, P. van Velthoven, W. Peters, F. Dentener, and P. Bergamaschi, The two-way nested global chemistry-transport zoom model TM5: algorithm and applications, Atmos. Chem. Phys., 5, 417-432, doi:10.5194/acp-5-417-2005, 2005.

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Segers , A., and S. Houweling, Description of the CH4 Inversion Production Chain, https://atmosphere.copernicus.eu/sites/default/files/FileRepository/Resources/Validationreports/Fluxes/CAMS73_2015SC2_D73.2.5.5-2017_201712_production_chain_v1.pdf, 2017a.

Segers, A., and S. Houweling, Validation of the CH4 surface flux inversion - reanalysis 2000-2016, CAMS73_2015SC2_D73.2.4.4-2016_201712_validation_CH4_2000-2016_v1, 2017b.
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