Evaluation of model-data mismatch errors in the CarboScope-Regional Inversion System

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Introduction

The mesoscale Jena CarboScope-Regional (CSR) inversion system is applied to atmospheric data over Europe at 0.25 x 0.25 deg. spatial resolution using a-priori anthropogenic fluxes from the EDGARv4.3 inventory combined with BP stastistical report, and a-priori biosphere fluxes from the diagnostic model VPRM.

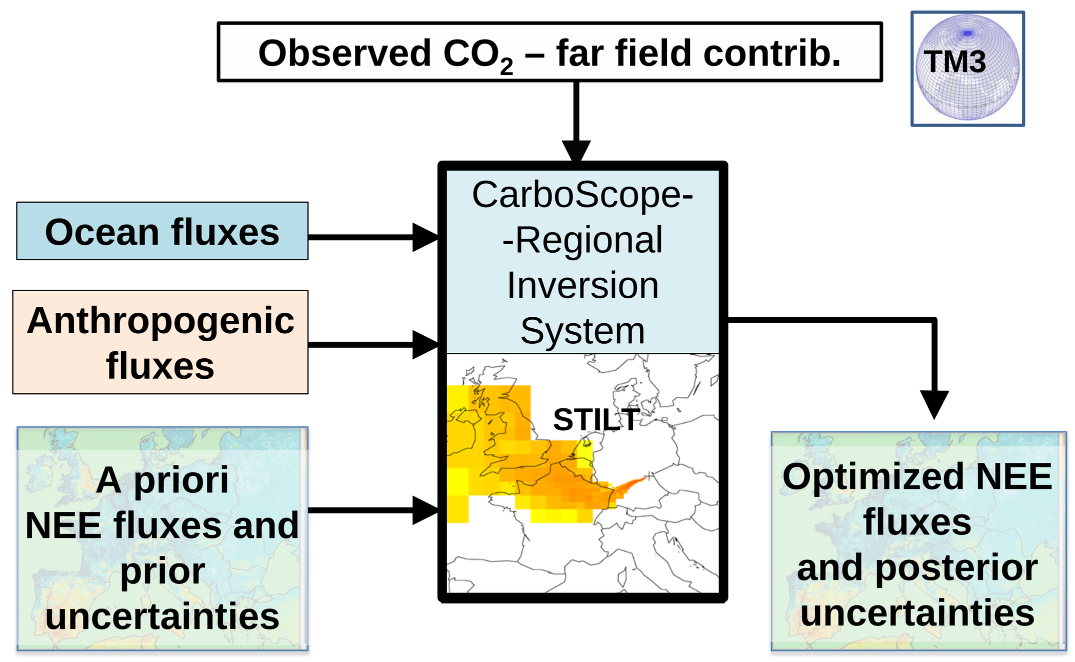
The state space consists of additive corrections to the net ecosystem exchange (NEE), while anthropogenic fluxes are assumed as perfectly known.

We optimize 3-hourly biogenic (NEE) fluxes using hourly CO_2 mixing ratio measurements on 44 , 40, and 15 stations for the target period 2006 – 2018.

To evaluate the assumed model data mismatch a leave-one-out cross validation is applied for the single year 2018 using all stations except one for the inversion, and comparing posterior concentrations predicted for the omitted station with the observed concentrations.

Method

CarboScope-Regional (TM3-STILT two-step inversion) [1] combines the global transport model TM3 and the regional Stochastic Time-Inverted Lagrangian Transport Model STILT [2]. The two-step scheme uses results from a global inversion to determine the far-field contribution of the fluxes outside the regional domain.



Prior error:
- diagonal elements: 2.27 μmol/m²/s
- temporal correlation: 30 days
- spatial correlation: 100 km or 200 km (hyperbolic decay)

Observations

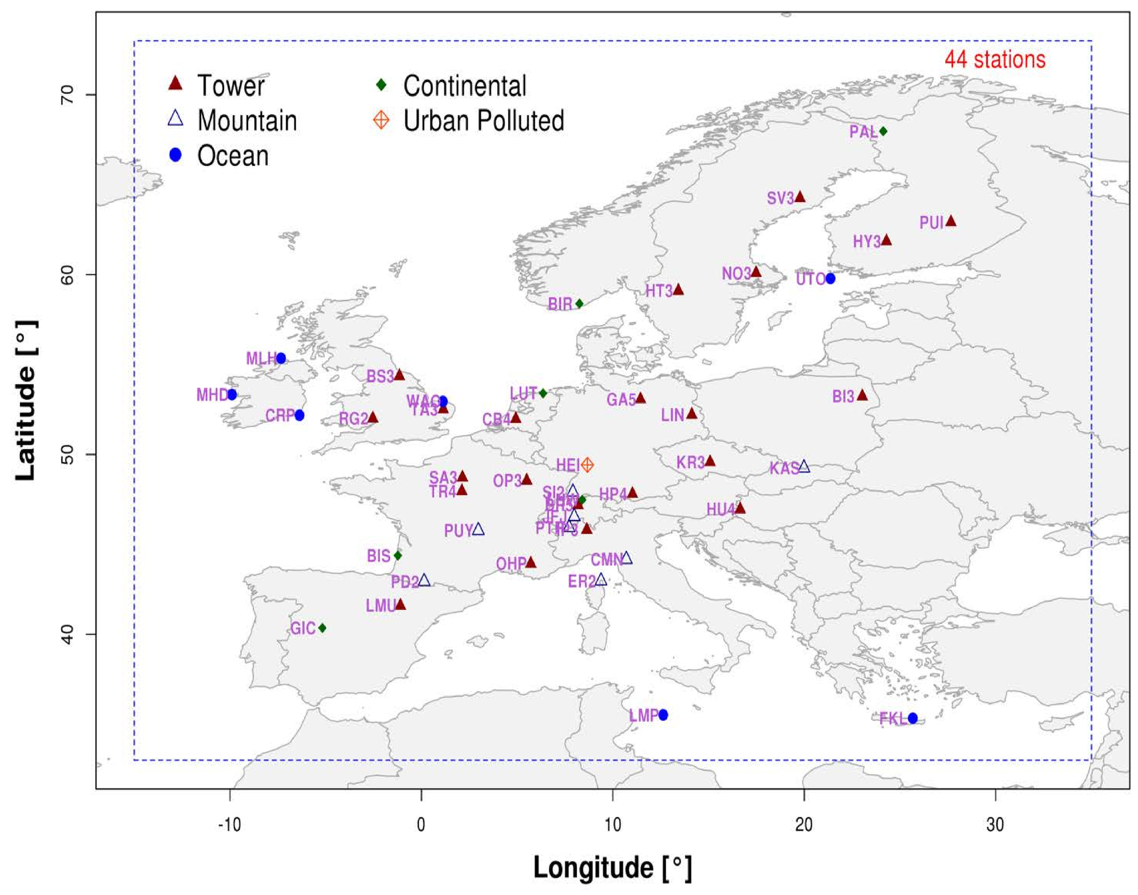


Fig 1: Locations of the 44 sites used in the inversions

Three different inversions using a station network of 44, 15 and 40 atmospheric sites:

44 stations: all available sites

15 stations: only core sites: BIK, BIR, CBW, HEI, HUN, LUT, MHD, PAL, WAO, BIS, MN, JFJ, KAS, PRS, SSL

40 stations: validation run without the 6 validation sites: BRM, LMP, TAC, FKL, OHP, UTO

23:00 -04:00 UTC used mountain stat.
11:00 -16:00 UTC used all other stat.

assumed Model-data mismatch in ppm on weekly scale

S	C	M	T	UP
1.5	2.5	1.5	1.5	4

S: Near shore
C: Continental (surface)
M: Continental (Mountain)
T: Continental (Tall tower)
UP: Urban polluted

Results

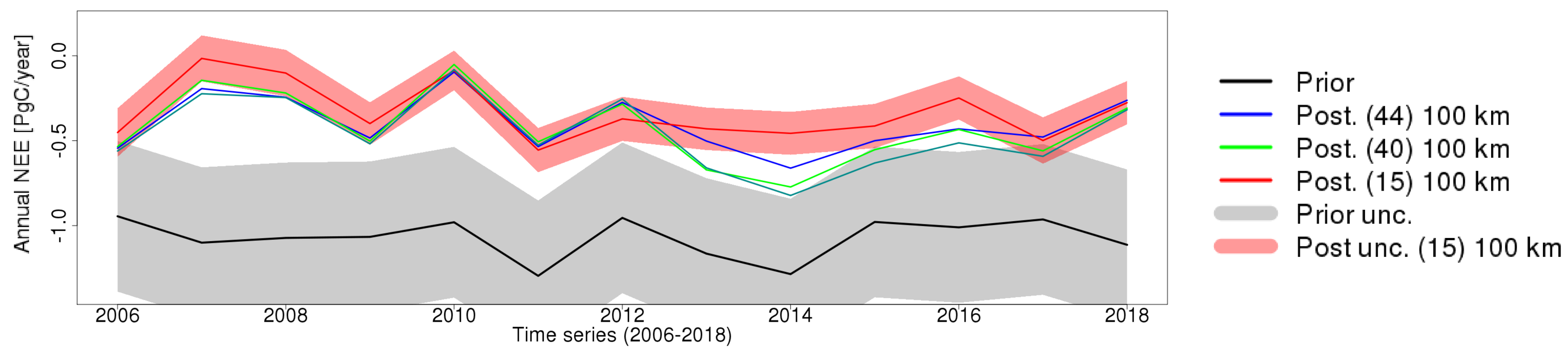


Fig 2: Annual prior and posterior NEE budget over Europe 2006 – 2018 using 44 , 15, or 40 atmospheric sites with 100 km spatial correlation length

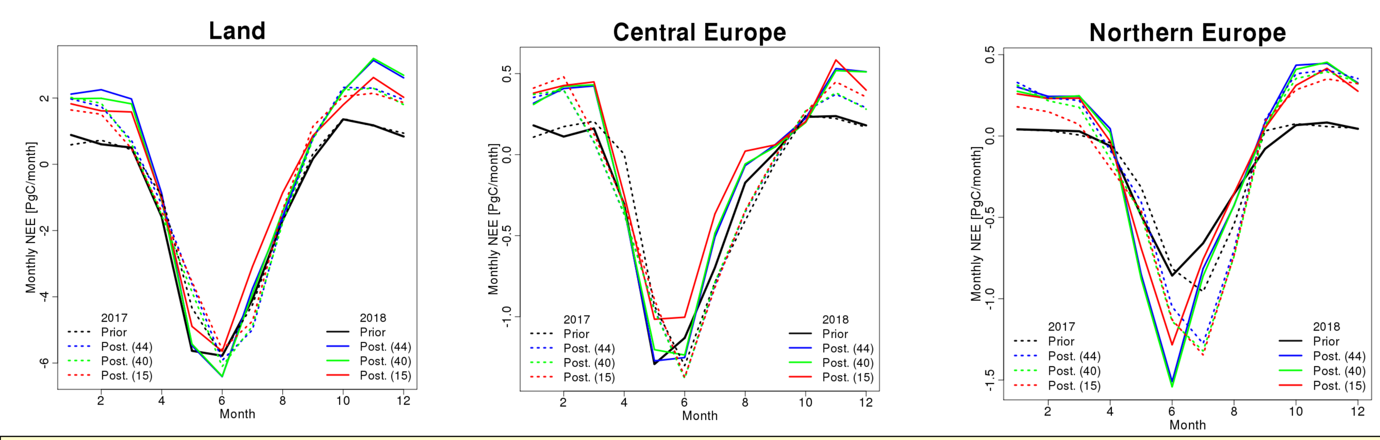


Fig 3: Prior and posterior monthly mean NEE for 2017 (dashed lines) and 2018 (solid lines) for the EUROCOM full domain, Central Europe, and Northern Europe from different inversion runs (44: all stations , 15: core stations , and 40: validation run)

Model-data error evalution

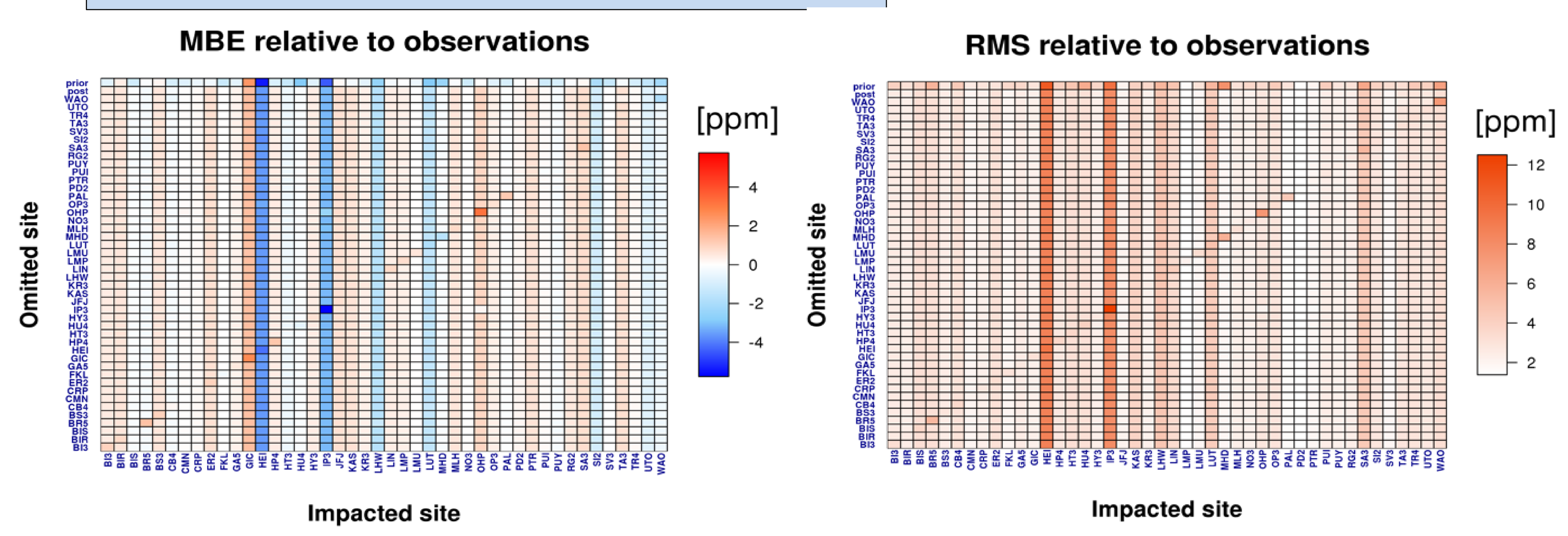


Fig 5 : Mean bias error and root mean square error relative to the observations (2018). Diagonals indicate the errors where the exclusion of omitted site reflects the impact caused on the site itself within the set of stations used in the inversion. Top two rows contains evalution against prior and posterior conc.

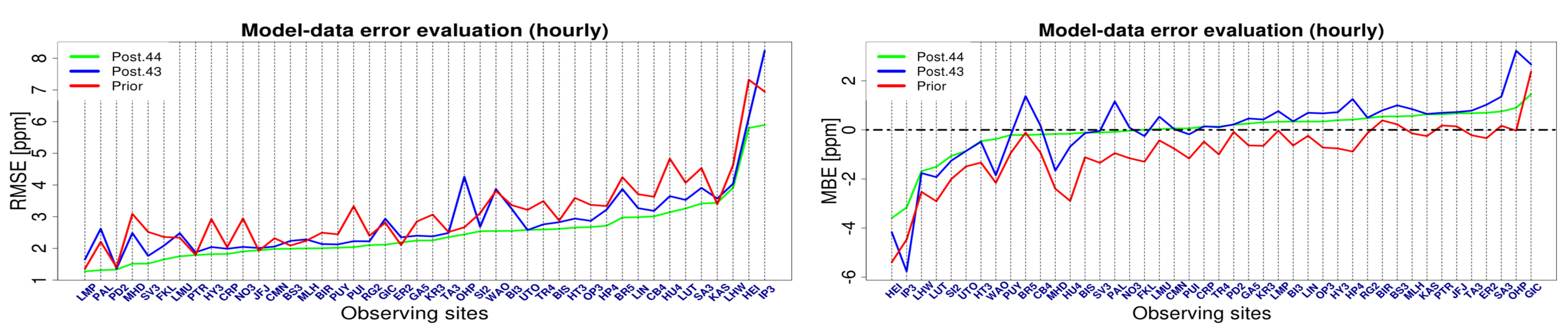


Fig 6 : Model-data error evalution of hourly standard derivation, root mean square error, and mean bias error for the prior and posterior concentrations for 44 stations, and one-leave-out (43) station run

Conclusions

CarboScope-Regional (CSR) inversion results show a significant positive correction to the VPRM fluxes throughout the 2006-2018 period. The NEE monthly mean flux shows significant differences between the year 2017 and 2018 in the Central Europe and Northern Europe sub-domain due the impact of the drought in 2018.

The root mean square error (RMSE) relative to the observations varies up to 12.5 ppm on hourly scale for 2018. This is consistent with the assumed model data mismatch on weekly scale.

- assumed for tall towers, sea sites, mountain sites: 1.5 ppm * sqrt(6 obs/day * 7 day/week) = 9.7 ppm
- assumed for continental sites : 2.5 ppm * sqrt(6 obs/day * 7 day/week) = 16.2 ppm

References :

[1] Rödenbeck, C., Gerbig, C., Trusilova, K., Heimann, M. (2009), A two-step scheme for high-resolution regional atmospheric trace gas inversions based on indepentent models, Atmos. Chem. Phys, 9, 5331-5342

[2] Lin, J.C., C. Gerbig, S.C. Wofsy, A.E. Andrews, B.C. Daube, K.J. Davis, and C.A. Grainger (2003), A near-field tool for simulating the upstream influence of atmospheric observations: The Stochastic Time-Inverted Lagrangian Transport (STILT) model, Journal of Geophysical Research- Atmospheres, 108 (D16)

[3] P. Kountouris, C. Gerbig, C. Rödenbeck, U. Karstens, T. Koch, and M. Heimann (2016), Atmospheric CO2 inversions at the mesoscale using data driven prior uncertainties. Part2: the European terrestrial CO2 fluxes, Atm. chem. phys. doi:10.5194/acp-2016-578, 2016,

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ICOS INTEGRATED CARBON OBSERVATION SYSTEM

Max Planck Institute for Biogeochemistry