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Optimized atmospheric inversion for methane flux quantification in Eurasia

Antoine Berchet (1), Isabelle Pison (1), Frédéric Chevallier (1), Philippe Bousquet (1), Sébastien Conil (2), Michael Geever (3), Tuomas Laurila (4), Jost Valentin Lavric (5), Morgan Lopez (1), John Moncrieff (6), Jarslaw Necki (7), Michel Ramonet (1), Martina Schmidt (1), Martin Steinbacher (8), and Jérome Tarniewicz (1)

(1) Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS-UVSQ, IPSL, Gif-sur-Yvette, France (antoine.berchet@lsce.ipsl.fr), (2) Andra, DRD/OS, Observatoire Pérenne de l'Environnement, France, (3) National University of Ireland, Galway, Ireland, (4) FMI, Finnish Meteorological Institute, Helsinki, Finland, (5) Max Planck Institute for Biogeochemistry, Jena, Germany, (6) University of Edinburgh, Edinburgh, United Kingdom, (7) AGH University of Science and Technology, Krakow, Poland, (8) Empa, Laboratory for Air Pollution/Environmental Technology, Duebendorf, Switzerland

Distinguishing between the various natural and anthropogenic sources contributing to methane surface fluxes is a prerequisite for closing the methane budget in Eurasian Boreal environments. Regional atmospheric inversions at a high resolution provide a mean for improving the inventories of methane emissions and the process-based models for land surface exchanges. Though promissing, the atmospheric approach relies on performant chemistry-transport models and a network of precise in-situ observation sites. The inversion then suffer from all the uncertainties within the model and the observations. In the Bayesian inversion framework, an advanced and objective understanding of the statistics of the errors in the inversion system (such as the transport, representation, aggregation or observation errors) is required. Acquiring such an understanding rises many theoretical and practical difficulties. In most previous inversion studies, the statistics of the errors are built relying on expert knowledge on the behaviour of the models and the inversion systems. In this work, optimal matrices of error covariances are computed using general statistical methods.
The error statistics are optimally estimated with a minimal set of physical hypotheses on the patterns of errors. Complex patterns and correlations of errors are then entirely retrieved. The reliability of our method was first tested on a well-documented European domain with numerous observations and precise inventories. We assimilated the data from 13 observation sites with quasi-continuous measurements to infer the European anthropogenic fluxes during a period of two weeks in March-April 2012. Errors caused by mis-representations in the transport model or by its inability to reproduce the situations of steep gradients in the air mass composition were retrieved. An analysis of the sensitivity of the inversion to each individual observation suggested guidelines for the selection of data in regional inversions. With this simple but efficient and optimal inversion system applied to a domain covering most of Siberia and Scandinavia, we inquire into the possibility of retrieving improved knowledge on the Eurasian Boreal methane fluxes.