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An efficient use of a Lagrangian transport model for atmospheric inversions using satellite observations: case study using TROPOMI to estimate CH4 emissions over Siberia

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We present a novel and efficient method for atmospheric inversions of satellite observations using a Lagrangian Particle Dispersion Model (LPDM) and demonstrate its use for a case study in Siberia. LPDMs have several advantages over Eulerian models. First, they can more precisely represent an observation since calculations are independent of a computational grid and second, LPDMs can be run in a backwards in time mode, which allows the computation of the sensitivity of an observation to fluxes and in this way are sometimes said to be “self adjoint”. The LPDM used in our study is FLEXPART.

In our method, FLEXPART is run in a backwards-in-time mode to determine total column source-receptor relationships (SRRs), which describe the relationship between a total column observation (such as from a satellite) and fluxes. The SRRs are used in the Bayesian inversion framework, FLEXINVERT, to optimize fluxes over a nested domain. Background mixing ratios for the total column observations are determined by coupling FLEXPART backward trajectories with the outputs of an optimized global Eulerian model (TM5).

We demonstrate the method in a case study, determining CH4 emissions over Siberia using observations from the TROPOspheric Monitoring Instrument (TROPOMI) onboard Sentinel 5P. Siberia was chosen as it is a region with important emissions from oil/gas facilities and coal mining, as well as abundant natural sources from wetlands. The posterior fluxes obtained using TROPOMI XCH4 are evaluated by comparing to inversions using observations from the ground-based network, JR-STATION.