Towards global inverse modeling of anthropogenic methane emissions with high spatial resolution based on ground-based monitoring and GOSAT satellite retrievals

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We perform a global high-resolution methane flux inversion based on a Lagrangian-Eulerian coupled tracer transport model to estimate global methane emissions using atmospheric methane data collected at global in-situ network, which is archived at WDCGG, and GOSAT satellite retrievals. For better accounting of anthropogenic emissions, localized around large cities, we use the Lagrangian particle dispersion model FLEXPART to model local tracer transport at 0.1º spatial resolution. FLEXPART is coupled to a global atmospheric tracer transport model (NIES-TM). The adjoint of the coupled transport model is used in an iterative optimization procedure. High-resolution prior fluxes were prepared for anthropogenic emissions (EDGAR), biomass burning (GFAS), and wetlands (VISIT). High resolution wetland emission dataset was constructed using a 0.5º monthly emission data simulated by VISIT model and wetland area fraction map by Global Lake and Wetlands Database (GLWD). The inverse model optimizes corrections to two categories of fluxes: anthropogenic and natural (wetlands). Biweekly methane emissions at high spatial resolution are estimated for 2009 to 2012. The inverse model optimizes a fit to the ground-based observations around the globe. Notably, the coupled transport model manages to better reproduce ground based continuous observations in mid- and high-latitudes in winter, due to resolving both anthropogenic emission plumes and near-surface transport in the shallow boundary layer. Forward simulation with surface fluxes optimized by assimilating ground-based observations is used to reduce the mismatch with GOSAT Level 2 X_{CH4} data. The monthly mean difference between GOSAT retrievals and the optimized forward simulation is estimated for each 10ºx10º latitude-longitude box is subtracted from GOSAT retrievals before including them in the inversion. Inverse modeling combining ground-based observations and GOSAT retrievals shows the bias correction scheme is successful in retaining a good fit to the ground-based observations. The suggested correction removes large scale biases in GOSAT retrievals with respect to the model simulation, while retaining local scale variability that contains most information on anthropogenic emissions, so it favors information on localized high emissions of anthropogenic origin over large scale atmospheric signals from natural fluxes.

Keywords: anthropogenic emissions, methane, inverse modeling, data assimilation, remote sensing

