Inverse modeling of CH_4 fluxes based on GOSAT and ground-based observations

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Expectations on changes in methane emissions in Arctic due to climate warming are high. In order to better quantify the possible climate feedback, present era CH_4 emissions should be understood better as well as their interannual variability. As the data obtained with ground based atmospheric CH_4 observations are sparse, it is important to test utility of the observations by satellites, such as GOSAT, AIRS, TES and others. Monthly CH_4 fluxes for 43 regions in 2009-2010 are estimated by an inverse model using the GOSAT SWIR Level 2 X_{CH4} data and ground-based CH_4 observations archived at WDCGG. The flux estimates and global distribution of methane concentrations in the atmosphere are prepared for a distribution as the GOSAT Level 4 research product. We used interannually varying CH_4 emissions by the GFED and VISIT ecosystem model (Ito and Inatomi, 2012) and interannually repeating the EDGAR CH_4 emissions and chemical sink fields prepared by the TransCom-CH4 project in a forward simulation by the NIES transport model. Monthly scale adjustments were applied to 4 categories of fluxes independently for each region (as in Kim et al., 2011). The inverse problem of optimizing the fluxes was solved with a fixed-lag Kalman smoother (Saeki et al., 2013). We compared the inversion results using the two different datasets to assess the utility of GOSAT X_{CH4} data in flux estimates and found good fit to the data. Mean residual misfit between simulations and GOSAT data is 5 ppb, which is smaller than difference with TCCON and GOSAT observations. The inversion using ground-based data only estimated larger uncertainty of fluxes over tropical regions, South America and Temperate Asia where the data are sparse. Adding large number of the GOSAT data to the inversion leads to decreasing the uncertainty in Temperate Asia (by 41%), northern South America (26%), Tropical Asia (24%), Europe (23%) and other regions. Monthly mean X_{CH4} simulated with fluxes estimated using the ground-based data is close to the GOSAT observations in the north of 40°N, but lower than GOSAT in southern hemisphere, and the difference can be attributed to possible biases in X_{CH4} observations and the transport model. Figure 1 shows annual maximum regional monthly flux uncertainty reduction. It is shown that the GOSAT observations are adding extra information on fluxes in the high latitudes in summer, and can be useful for constraining the surface fluxes.

References

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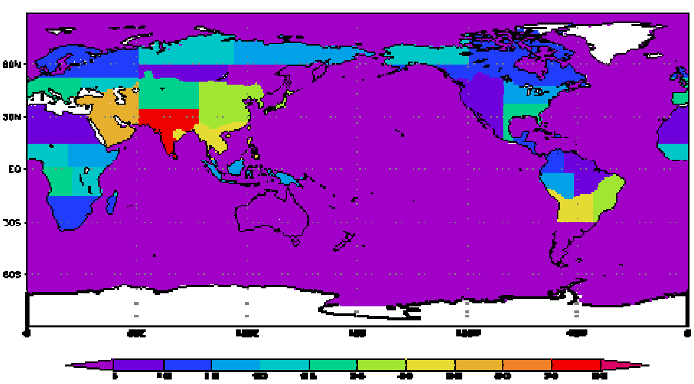

Figure 1. Reduction rate (%) of regional CH_4 flux uncertainties estimated with GOSAT to the flux uncertainties with ground-based observations during Jun 2009 – May 2010