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CO_2 and CH_4 flux estimates in Central Siberia from a 2-step transport inversion system

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The boreal ecosystems in Siberia contribute significantly to the global terrestrial carbon sink. Climate change has particular impacts on this region: increasing temperature lengthens the vegetation period, enhances the permafrost thawing, and changes local hydrological conditions and forest fire occurrences. Long-term biogeochemical trace gas measurements in the middle of the continent help to improve the knowledge about those impacts on the carbon source/sink processes. Therefore, the Zotino Tall Tower Observatory (ZOTTO, 304 m, 60°N, 89°E, www.zottoproject.org) was built near the village of Zotino at the Yenisei River in the perspective to monitor and determine variability and trends in the carbon balance of central Siberian forests. Since April 2009 we measure CO_2 and CH_4 from six height levels reaching from 4 to 301 m. The height of the tower allows regular probing of the mixed part of the boundary layer, which is – unlike the surface layer – only moderately influenced by diurnal variations of local surface fluxes and thus representative on regional to continental scales (~1000 km). We use the data in a two-step scheme for a high-resolution regional atmospheric trace gas inversion. The results of the model are surface flux patterns, which optimally represent the observed mixing ratio data series. Within the first step, a global model (TM3 inversion) provides the boundary conditions for the Central Siberian domain. The second step uses the same inverse model framework but replacing the coarse transport model (TM3) by the Lagrangian transport model (STILT) with a higher resolution of 0.25°x0.25° in the Central Siberian domain. It is the first time that a regional inversion is set up for CO_2 and CH_4 flux estimates for the Central Siberian region. To estimate the CO_2 surface fluxes we make use of the ZOTTO data in combination with monthly aircraft data from Novosibirsk and Surgut. With this data our a-priori flux of 0.01 $\pm$ 0.21 PgC in the boreal zone of the Ob lowlands can be constrained to a mean annual flux of 0.04 $\pm$ 0.11 PgC in the year 2009. With the CH_4 data from ZOTTO and three additional stations from the 9-tower network in the West Siberian lowlands, we determine a mean annual flux of 8.4 $\pm$ 1.1 TgC from CH_4 emissions in the boreal zone of the Ob lowlands in the year 2009 (a-priori flux: 5.2 $\pm$ 1.3 TgC). The model results also allow insights in the alterations of the seasonal cycle in comparison to the model forecasts. In conclusion, the regional two-step inversion model applied to representative atmospheric observations is an important source of information for future carbon cycle studies in Central Siberia.