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Carbon budget estimation by inverse modeling with atmospheric CO_2 concentrations from surface and CONTRAIL measurements

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A great deal of understanding of the global and regional carbon budget helps us to perform a reliable prediction of future climate with an earth system model. However, the accuracy of CO_2 source/sink estimation by inverse modeling, which is one of the leading methods to estimate regional carbon budget, is not very high because of sparse observational data coverage. The recent evolving aircraft measurements of CO_2 in a three-dimensional view are expected to provide new constraints on the estimation of surface CO_2 fluxes.

In this study, regionally divided carbon budgets are estimated by inverse modeling using surface measurement networks and aircraft measurements from Comprehensive Observation Network for Trace gases by Airliner (CONTRAIL). The CONTRAIL project has started since late 2005 and a huge amount of atmospheric CO_2 data has been obtained covering altitudes between the earth's surface to the upper-troposphere and lower-stratosphere, latitudes between the boreal high-latitudes to the austral mid-latitudes. Monthly mean observational data from GLOBALVIEW-CO_2, which mostly consists of surface measurements, and CONTRAIL are used in this inverse analysis. The CONTRAIL data measured both vertically over each airport and horizontally at the cruising altitude are used. The inversion method is based on the Bayesian statistics and the approach of the TransCom 3 is used. To relate atmospheric concentrations to surface fluxes, a three-dimensional transport model is employed. In this study, Nonhydrostatic ICosahedral Atmosphere Model (NICAM)-based transport model (NICAM-TM) is used with prescribed CO_2 flux data of fossil fuel emission, respiration/photosynthesis in terrestrial biosphere and atmosphere-ocean exchange. The transport simulations of atmospheric CO_2 are performed by low-resolution version of NICAM; the horizontal grid interval is about 240 km. The analyzed period is five years during 2005—2009 and meteorological fields in each year are used to drive the transport model with the nudging method. The inversion setup is similar to TransCom 3, but number of flux regions to be estimated is 42. Land regions are divided into 31 according to vegetation types and the same 11 ocean regions as TransCom 3 are used.

A preliminary result of forward simulation with the prescribed fluxes shows that the transport model has good performance for reproducing general features of three-dimensional structure of CO_2 observed by CONTRAIL. However, some discrepancies between the simulation and CONTRAIL are found in horizontal gradient even in the upper-troposphere during summer, indicating that aircraft measurements have significant impacts on flux estimates when vertical transport is efficient. The inversion results will be discussed in the presentation.