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A decadal inversion of carbon dioxide using the Global Eulerian-Lagrangian Coupled Atmospheric model (GELCA)

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A decadal estimate of global CO_2 flux distribution for the period of 2001-2010 was conducted using an atmospheric inversion modeling system called GELCA (Global Eulerian-Lagrangian Coupled Atmospheric model) with Kalman smoother inversion technique. The use of Lagrangian particle dispersion model (LPDM) to simulate the transport in the vicinity of the observation points enables us to avoid numerical diffusion from which Eulerian models suffer, and is suitable to represent observations at high spatial and temporal resolutions. An Eulerian model is run to generate the global background concentrations to be used as the boundary conditions for an LPDM that performs backward simulations from each receptor point (observation location). In GELCA, National Institute for Environmental Studies-Transport Model (NIES-TM) version 8.1i was used as an Eulerian global transport model coupled with FLEXPART version 8.0 as a LPDM. Two-day backward transport by FLEXPART was combined with the background CO_2 levels 2 days prior to the observations simulated by NIES-TM. The meteorological data for driving both models was taken from JMA Climate Data Assimilation System (JCDAS) with a spatial resolution of 1.25^o x 1.25^o and a temporal resolution of 6 hours. Our prior CO_2 fluxes consist of the following four types: daily terrestrial biospheric fluxes generated by the VISIT model (Vegetation Integrative SImulator for Trace gases); monthly oceanic fluxes generated by an ocean pCO_2 data assimilation system; monthly biomass burning emissions taken from the Global Fire Emissions Database (GFED), version 3.1; and monthly fossil fuel emissions combining the high-resolution Open source Data Inventory of Anthropogenic CO_2 emission (ODIAC) version 3.0 dataset. We employed a Kalman Smoother inversion technique with fixed lag of 3 months, solving for 42 land and 22 ocean regions.

The purpose of the present study is to evaluate the performance of the GELCA inversion system with rather long period (10 years) CO_2 flux estimation and to examine the impact of observation network. We tested several different sets of observation datasets starting by using the NOAA flask network ground based observations as a control case. The sensitivity of the inversion to the choice of CO_2 observation dataset was discussed using the footprint of each observation dataset. The CO_2 flux estimate was examined in terms of observation network/coverage and also compared with previous studies.

Keywords: CO2, sources/sinks, inverse modeling, coupled model