The Estimation of CO_2 Fluxes with a Coupled Meteorological and Tracer Transport Model

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An important component of transport model error that is neglected in typical flux inversion systems is due to uncertain wind fields. However with a coupled meteorological and tracer transport model, this component of model error can be accounted for. In this work, we use an operational weather forecast model with coupled greenhouse gas transport as the basis for an ensemble Kalman Filter (EnKF) assimilation system in order to directly simulate all the sources of error: initial states of constituents, meteorological states, fluxes, model formulation and observations. The model is based on the Canadian Global Environmental Multi-scale - Modelling Air quality and Chemistry (GEM-MACH) model with a grid of 400x200 with 74 vertical levels and includes extensions for carbon dioxide (CO_2) simulation (Polavarapu et. al. 2016).

In this work, progress on the adaptation of the EnKF (Houtekamer et. al. 2014) for CO_2 assimilation is reported. The variable localization of Kang et al. (2011) was implemented and simulated flask, tower and aircraft observations of CO_2 are ingested. The meteorological state is constrained with conventional observations and an ensemble size of 64 members is used. Observing System Simulation Experiments (OSSEs) are performed with simulated CO_2 observations in order to determine whether, in the ideal case, true fluxes can be recovered. The OSSEs are also used to tune key parameters of the assimilation system such as localization radius for the CO_2 state and its fluxes as well as inflation factors. In particular, we determine the dependence of localization radius for CO_2 and flux covariances on observation density.

The observations are assimilated every 6 hours. The spread of 6 hours forecast CO_2 ensemble at a particular time is shown in figure 1.

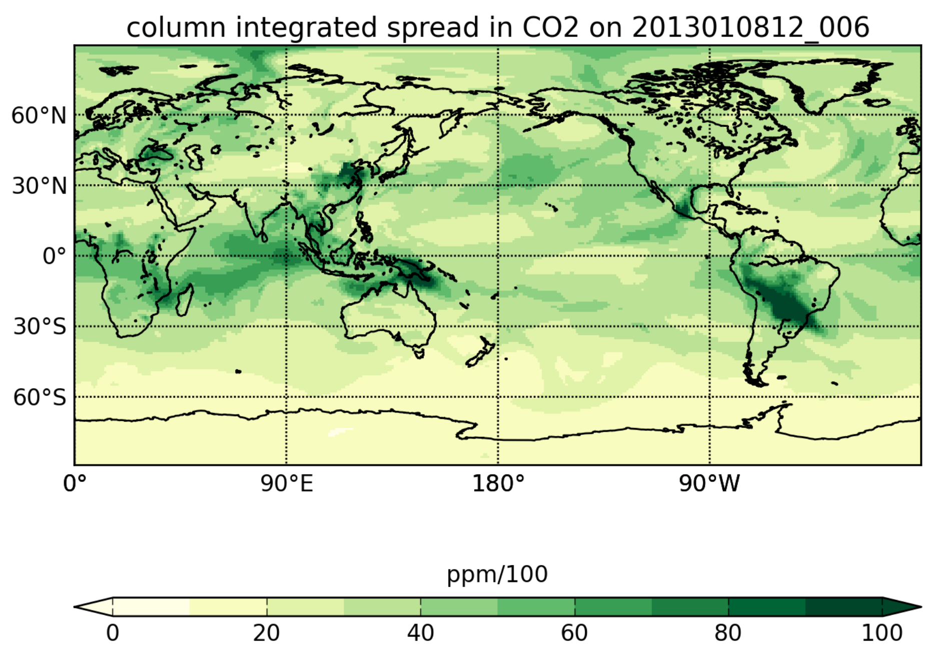

Figure 1. Spread of forecast CO_2 estimated by standard deviation after 48 cycles.