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Estimation of surface carbon fluxes with data assimilation

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The estimation of surface carbon fluxes from atmospheric measurements of CO2 is an ill-posed problem (Enting, 2002). In the real atmosphere emissions are transported and mixed, losing information; measuring atmospheric concentrations introduces further errors; and the calculation of transports with imperfect models amplifies the errors in estimating surface sources and sinks. Because of this ill-posedness, prior information on carbon surface fluxes is essential for inverse estimations (e.g., Gurney et al., 2004, Baker et al., 2006, Roedenbeck et al., 2003). Peters et al. (2007) have used instead an Ensemble Kalman Filter (EnKF) data assimilation approach where the winds are given (e.g., from ECMWF). They use a Kalman smoother with a 5-week smoother, producing the operational "Carbon Tracker" estimation of surface fluxes at NOAA. We address the ill-posedness by assimilating simultaneously every 6 hours both carbon concentrations and meteorological variables, since within this time scale changes in atmospheric CO2 concentrations should be dominated by surface fluxes rather than transport and mixing. A simulation system using the Local Ensemble Transform Kalman Filter (LETKF) to assimilate CO2 from a realistic observing system including GOSAT, AIRS and surface observations, and is able to estimate in detail the seasonal evolution of "true" surface fluxes (including fossil fuel emissions) even in the absence of prior information. These promising results (albeit simulated) suggest that with more advanced models and accurate column observations such as those expected from OCO-2 it may be possible to estimate surface carbon fluxes if the LETKF is optimized (Kang et al., 2011).