Applications of Lagrangian Particle Transport Modeling in the Top-Down Regional CO_2 Studies

M. Uliasz[1], A.S. Denning[1], L. Lu[1], K. Corbin[1], S.J. Richardson[2], N. Miles[2], and K.J. Davis[2]

[1]Department of Atmospheric Science, Colorado State University, Fort Collins, CO 80523;
E-mail: uliasz@frii.com
[2]Department of Meteorology, Pennsylvania State University, University Park, PA 16802

Atmospheric transport plays a critical role in top-down studies where observations from towers and/or aircraft are inverted to estimate net sources and sinks of CO_2 for the study area over short periods of time. Lagrangian particle dispersion models are well suited for this modeling task since they: (1) can be easily linked to any regional scale meteorological model, (2) can be run both forward or backward in time (in an adjoint model, (3) can accurately resolve any CO_2 observational system without limits of gridded transport models, and (4) can be applied to different spatial scales even across grids or domains of meteorological models. In the modeling framework developed at Colorado State University, the Lagrangian Particle Dispersion Model is linked to SiB-RAMS: Regional Atmospheric Modeling System combined with Simple Biosphere model. For our North America studies the SiB-RAMS domain extends over the entire continental U.S. with nested grids centered in the mesoscale area of interest. The CO_2 lateral boundary conditions are provided by a global transport model - PCTM (Parameterized Chemistry and Transport Model). Influence functions derived from the LPDM output allow us to quantify each CO_2 data point (e.g., concentration at a specific sampling time and tower) in terms of contributions from different sources: (1) surface fluxes, (2) inflow fluxes across domain boundaries and (3) initial CO_2 concentration in the domain at the beginning of the analysis period. The surface contributions can be further quantified by a physical process (respiration, assimilation or fossil fuel emission) and/or land cover type. Therefore, the influence function approach is very useful for interpretation of CO_2 observations and source apportionment, designing tower network and, finally, deriving source-receptor information for the inverse studies. We are going to review our modeling efforts based on the SiB-RAMS/ LPDM and the influence function approach to the meso- and regional scales from a few tens to several thousands of kilometers:

- Estimation of mesoscale CO_2 fluxes in the 300x300 km domain using the summer 2004 observations from the "ring of towers" in northern Wisconsin
- Extension of the previous work to a larger domain of the second "ring of tower" run in summer 2007 within the NACP's Midcontinental Intensive Study
- Deriving influence functions and transport characteristics for the US continental scale CO_2 inversions
- Quantifying both CO_2 concentration and flux measurements from real and hypothetical towers in the Tapajos River region in the Amazon using very high resolution SiB-RAMS simulations
- An attempt to quantify source areas for CO_2 observed at the BAO tower near Boulder, Colorado

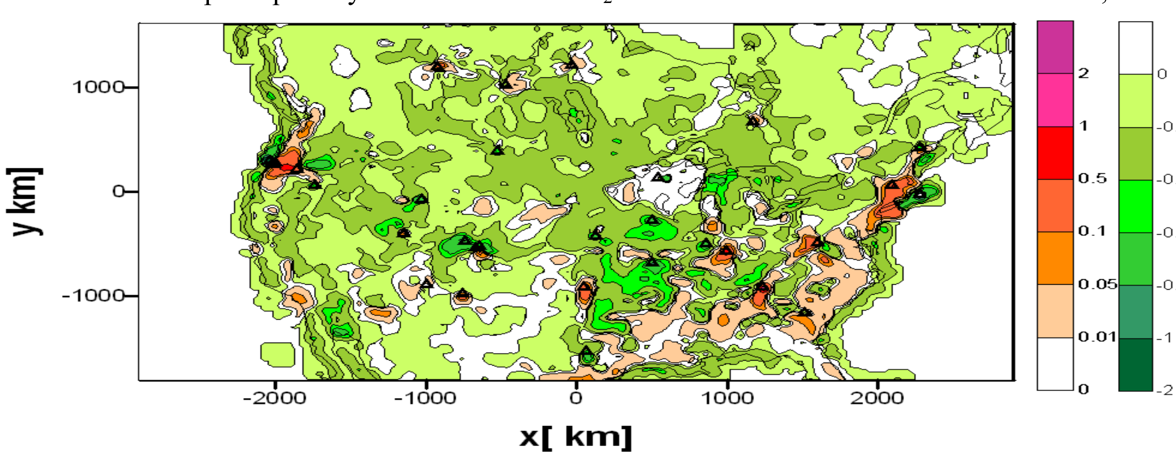

Figure 1. Influence function climatology for August 2004 showing contribution [in ppm] of surface CO_2 fluxes within the US domain into the average CO_2 concentration observed at 30 towers.