Application of Influence Functions to Analyze CO_2 Tower Data

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We have been developing a set of techniques to combine the use of numerical models with regional CO_2 measurements. The regional inversion framework is built around the Colorado State University Regional Atmospheric Modeling System (RAMS) and the Lagrangian Particle Dispersion (LPD) model. The LPD model is used in adjoint mode to trace particles backward in time to derive influence functions for each concentration sample. The influence function provides information on potential contributions from both surface sources and inflow fluxes that make their way through the modeling domain boundaries into the CO_2 concentration sample. Therefore, they provide not only necessary information for inversion calculations but also allow us to analyze and interpret observational data. In addition to the influence functions, another atmospheric transport characteristics can be determined from backward particles, e.g., travel time between a source area and a receptor.

Applications of the influence function technique will be presented with the aid of two examples. In the first one, a climatology of influence functions is derived for 2 years, 1996 and 2003, for CO_2 observations at the WLEF tower in northern Wisconsin. Contributions of different source areas to the tower observations are analyzed and a distinct signature of Lake Superior in CO_2 data is demonstrated.

In the second example, the influence functions are applied to the episode of frontal passage across the WLEF tower and the ring of towers on April 30, 2004 (Figure 1). A sequence of influence functions is helpful to explain a jump in the observed CO_2 concentrations when the front hits particular towers. The influence functions indicate different vertical exchange as well as different source areas affecting towers before and after the front passage.

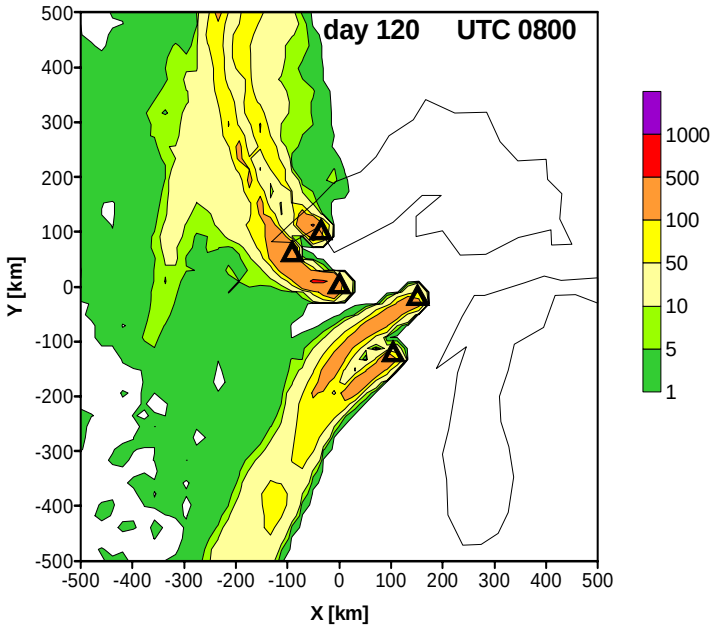

Figure 1. The influence functions (10^{-10} s m^{-3}) derived for the WLEF tower and the ring of towers during the frontal passage episode of April 30, 2004.