ESTIMATION OF REGIONAL SOURCES AND SINKS OF CO_2 USING MIXING RATIO DATA FROM THE RING OF TOWERS IN NORTHERN WISCONSIN

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ABSTRACT

The WLEF TV tower in northern Wisconsin is instrumented to take continuous measurements of CO_2 mixing ratio at 6 levels from 11 to 396m. During the spring and summer of 2004 additional CO_2 measurements were deployed on five 76 m communication towers forming a ring around the WLEF tower with a 100-150 km radius.

The data from the ring of towers are being used to estimate regional fluxes of CO_2. The inversion framework developed for this purpose is based on RAMS (Regional Atmospheric Modeling System) and the Lagrangian Particle Dispersion (LPD) model. The LPD model is used in its adjoint mode to trace particles backward in time to derive influence functions for each concentration sample. The influence functions provide information on potential contributions both from surface sources and inflow fluxes that make their way through the modeling domain boundaries into the CO_2 concentration sample. Then the Bayesian inversion technique is applied in an attempt to estimate unknown surface emissions. CO_2 flux is treated as a sum of respiration flux and assimilation. The influence functions are used not only for inversion calculations but also as a tool to analyze CO_2 tower data during specific episodes.

Different configurations of source areas within 500 km radius from WLEF tower and different assumptions concerning expected model-data mismatch error were investigated. The data from the ring of towers significantly reduce uncertainty of estimated regional CO_2 fluxes in comparison with inversion calculations utilizing the WLEF tower data alone. The results of inversion calculations are very promising as long as the inflow CO_2 flux is known or if its good a-priori estimation is available.

In order to eliminate the inflow flux problem, the LPD model was linked to SiB-RAMS, a new version of RAMS where surface processes including CO_2 exchange between vegetation and atmosphere are simulated by Simple Biosphere (SiB) model. In this RAMS version CO_2 is also transported in the atmosphere as a passive tracer. CO_2 concentrations fields and CO_2 surface fluxes are extracted from SiB-RAMS within a mesoscale domain used by the LPD model. Using the influence function approach the CO_2 concentrations at the towers are calculated as a sum of contributions from CO_2 surface fluxes, initial CO_2 field and CO_2 inflow flux across lateral boundary of the mesoscale domain. Figure 2 presents the comparison of observed and simulated CO_2 in the summer of 2004 using a preliminary SiB-RAMS run on two nested grids with horizontal spacing of 40 and 10 km. The current research focuses on improving this simulation and further model validation using all data available from the ring of towers.

In the next step, the CO_2 fluxes simulated by SiB-RAMS will be used as the initial estimates for inversion calculations based on the influence functions derived from the LPD model and CO_2 data from the towers. This approach will be tested first with the aid of model generated pseudo-data and, then, applied to real CO_2 observations to obtain better estimations of regional CO_2 fluxes than provided directly by the forward in time SiB-RAMS simulation.

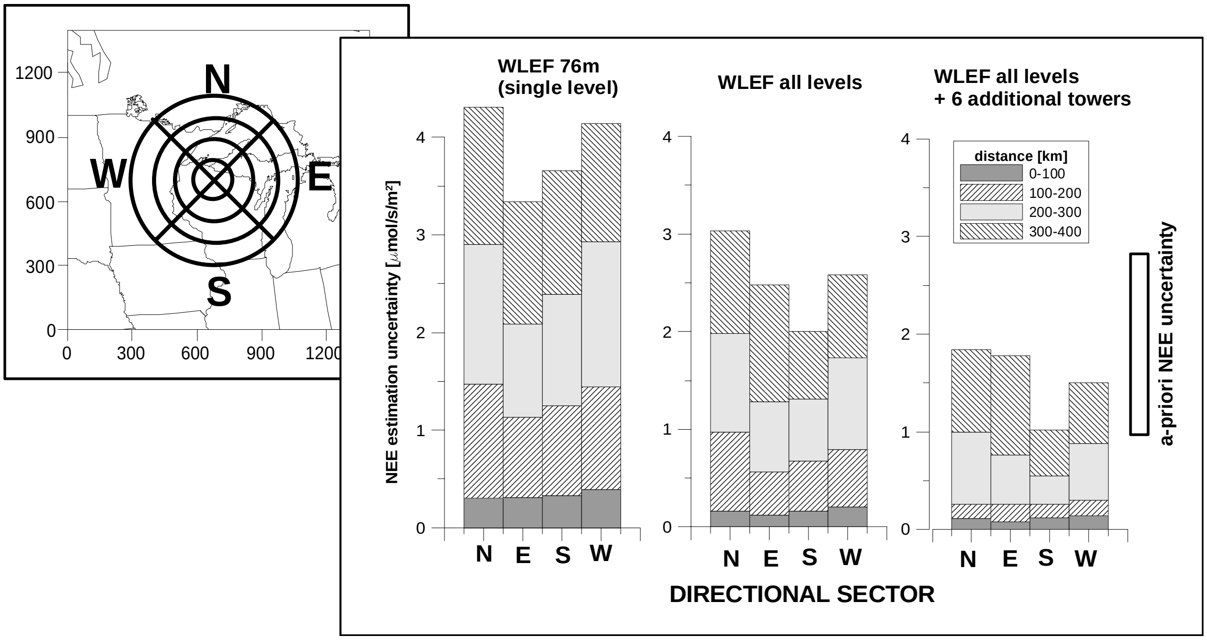

Fig. 1. Configuration of source areas in polar coordinated around the WLEF tower and the uncertainty of CO_2 flux (NEE) estimated for August of 2000 using different amount of concentration pseudo-data from the WLEF and ring of towers (initial uncertainty assumed to be 2 ppm for all sources).

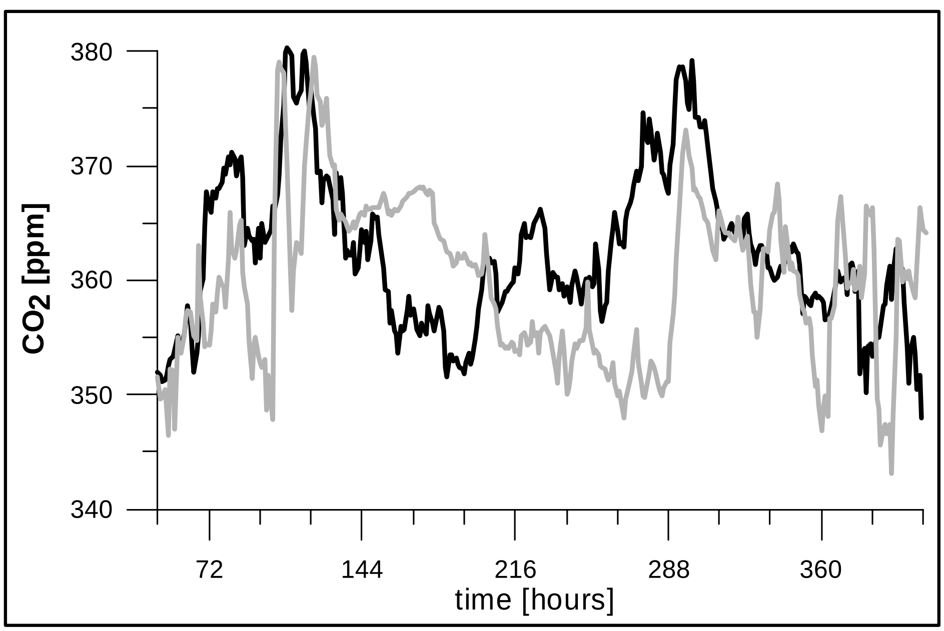

Figure 2: Comparison of CO_2 mixing ratio observed at 396m level of WLEF tower (black line) and simulated by LPD model linked to SiB-RAMS (gray line) for summer of 2004 (0 hour corresponds to July 17, 00:00)