A CASE STUDY IN REGIONAL INVERSE CARBON MODELING

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ABSTRACT

In order to facilitate future decision-making regarding regional carbon fluxes, it is essential to better quantify uncertainty in inverse carbon flux models. At Colorado State University, research is being performed in order to better quantify sources and sinks and associated uncertainties on a mesoscale level, through a coupled atmospheric (RAMS and PCTM) and terrestrial carbon flux (SiB3) model (Denning, 2003). Carbon-dioxide flux and mixing ratio data were collected from a ring of towers (WLEF tall tower and nearby smaller towers) in northern Wisconsin over the summer of 2004. The fully coupled terrestrial-atmospheric model, SiB/RAMS, will be forced with 2004 reanalysis data to predict fine scale weather in the vicinity of these towers for the summer of 2004. Relevant portions of this simulated weather, including wind fields and pertinent turbulence components, are extracted and used to create backward-in-time Lagrangian Particle Dispersion Modeled (LPDM) influence functions. Pseudo spatial carbon-dioxide mixing ratio and flux data created by SiB/Rams is then used as input to several different estimation routines in order to try and predict pseudo tower data at different heights. Different temporal and spatial aggregation lengths are considered as means of data reduction. Particular attention will be paid to Ensemble Kalman Filter (EnKF) techniques as well as geo-statistical methods as a means of estimation.

METHODS

Steps to Flux Estimation

1. Construct a SiB-RAMS (Simple Biosphere - Regional Atmospheric Modeling System) model to simulate fine-scale transport in the region of interest as well as create modeled pseudo-data of CO_2 flux and transport. Fig. 1 is an example of an hourly predicted flux for our area of interest.

2. Develop diagnostics to analyze differences between SiB-RAMS simulated weather, transport, and pseudo-fluxes, and actual observations.

3. Once satisfied with step 2, use a backwards-in-time Lagrangian particle dispersion model, in conjunction with *very* fine scale simulated RAMS transport, to build fine scale influence footprints that exist in both space and time. Fig. 2 is a plot of an example influence function for our area of interest.

4. Aggregate influence footprints in such a way as to maximize statistical power in detection while maintaining as fine of a time-space sampling interval as possible.

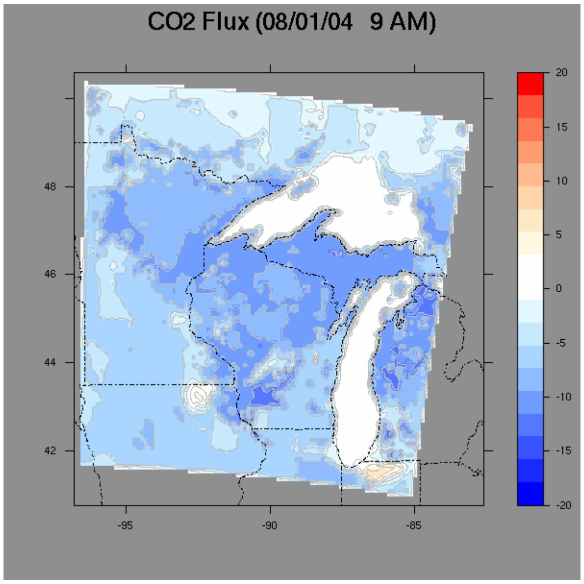

Fig 1: Sib-RAMS CO_2 flux estimate

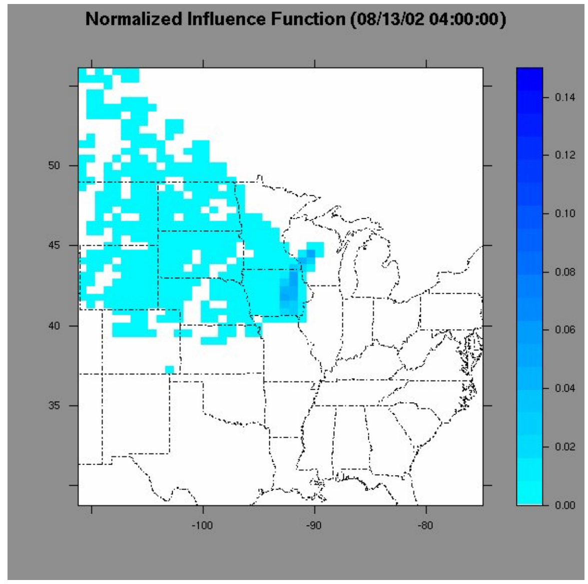

Fig 2: Surface Influence Footprint

RESULTS

Results will be presented indicating the effectiveness of the *influence footprints* and the tower observations in predicting the SiB-RAMS generated CO_2 concentrations. Ensemble Kalman Filter Methods [*Evensen*, 2003], such as the Maximum Likelihood Ensemble Filter (MLEF) will be used as a flux estimation tool as well as some variation of the general geo-statistical method as discussed in Michalak, 2004. In both methods, a form of the following classical Bayesian cost function is minimized.

$$J(x) = \frac{1}{2}(x - x_b)^T Q^{-1}(x - x_b) + \frac{1}{2}(y - H(x))^T R^{-1}(y - H(x))$$

Here, x represents the estimated flux, x_b the prior flux estimate, Q the estimate-prior covariance matrix, H the observation operator, y the observations, and R the observation-error covariance matrix. One key part of these methods will be an accurate estimation of flux correlations in both time and space. Results will be presented for flux estimates at several different temporal and spatial scales.

REFERENCES

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