THE SIGNALS FROM SYNOPTIC CO_2 VARIABILITY AND LOCAL ECOSYSTEM - A CASE STUDY

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With the increasing temporal and spatial density of CO_2 flux and concentration observations from worldwide tower networks, the importance of interpreting the data is becoming more conspicuous. Previous work shows that tower observations might be able to catch synoptic, regional, and local signals of CO_2 simultaneously. Thus a study that can explain CO_2 transport and the response of the ecosystem to the weather change simultaneously is necessary and will help the development of the regional inverse modeling technique in the future.

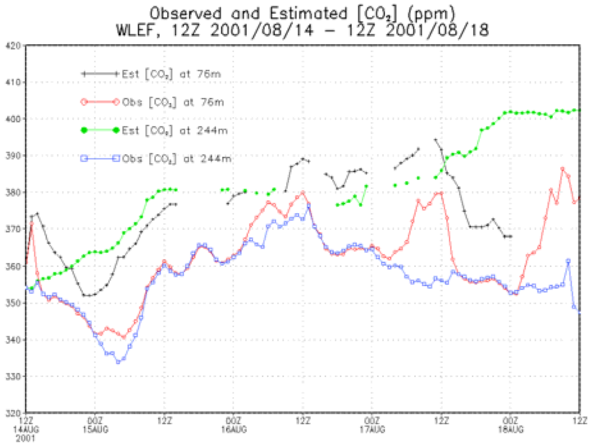

Fig. 1: Observed and estimated [CO_2] using vertical flux divergence method for WLEF, 12Z 2001/08/14 – 12Z 2001/08/18.

We have chosen a frontal case at the WLEF tower site in Wisconsin, USA, on 2001/08/16 from a case pool of 51 cold fronts during the summers of year 1997 to 2001. This frontal event on 2001/08/16 had an increasing CO_2 trend before the front arrived at the WLEF site and a decreasing trend after that. The discrepancy between the CO_2 concentrations estimated from the vertical flux divergence of the WLEF tower flux data and the observed CO_2 concentrations (see Fig.1) indicates that both the local ecosystem response to the weather change and horizontal advection determine the atmospheric CO_2 concentration. The data analysis also shows that on 2001/08/15, stronger respiration at night due to warmer air temperature and slow photosynthesis during the day due to the cloud cover might be responsible for a small part of the slow CO_2 accumulation in the lower levels in northern Wisconsin. Horizontal advection is, however, the most important mechanism to bring CO_2-rich air and increase it by more than 40 ppm.

SiB 2.5 [*Sellers et al.*, 1996] and RAMS 5.04 [*Pielke et al.* 1992, *Cotton et a1.* 2003] with a newly implemented Grell [1995] convection scheme are coupled together. We have implemented the interface of the exchange of latent heat, sensible heat, radiation, CO_2, water vapor, and momentum between the land surface and the atmosphere, and employed the latest high-resolution soil map, satellite vegetation map, and biome map. The model is designed to simulate the regional CO_2 budget, its transport, and the feedback between the ecosystem and the local weather.

Our case simulation shows that a high CO_2 concentration air mass is built up in Oklahoma and Texas on 2001/08/14 and 2001/08/15 due to very strong daytime respiration and the shut-down of photosynthesis caused by hot and dry air over that region (see Fig. 2). The leading edge of this air mass then reaches out to the north at lower levels and is responsible for the increasing trend of CO_2 concentration at the WLEF site on 2001/08/15. On 2001/08/16, a low CO_2 concentration air mass from Canada is advected into northern Wisconsin and gradually sweeps the CO_2-rich air to the southeast. The simulation results cannot, however, explain all the [CO_2] temporal variation that is detected by the WLEF tower during this frontal event. Further refinement of the coupled model is needed to simulate the rather weak photosynthesis rate on a cloudy day, such as during the daytime of 2001/08/15, and to correctly reproduce the synoptic signals that travel across North America.

This case study confirms the existence of mixing signals from at least two different scales: horizontal advection and the local ecosystem response to the weather change. Without an appropriate tool to successfully simulate CO_2 concentration spatial distributions, regional wind fields, and the correct timing and strength of the local ecosystem signal to solve the signal puzzle from different scales, it is improper to exploit tower observation data in inverse modeling to determine regional sources and sinks.

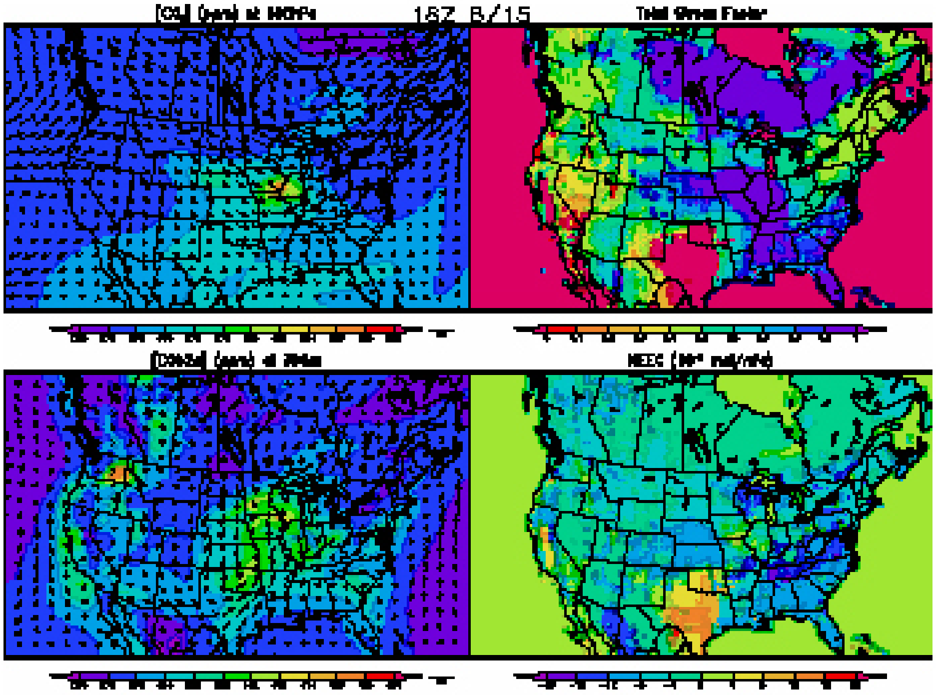

Fig. 2: [CO_2] near the surface and at the mid-troposphere, vegetation stress factor, and NEEC for North America, 18Z 2001/08/15.

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