SPATIALLY DISTRIBUTED CO_2, SENSIBLE, AND LATENT HEAT FLUXES OVER THE SOUTHERN GREAT PLAINS

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ABSTRACT:
Vegetation strongly influences the spatial distribution of sensible and latent heat fluxes, and also controls ecosystem-atmosphere CO_2 exchange. We describe here a methodology to estimate surface energy fluxes and Net Ecosystem Exchange (NEE) of CO_2 continuously over the Southern Great Plains, using (1) data from the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) program in Oklahoma and Kansas; (2) meteorological forcing data from Mesonet facilities; (3) U.S. Geological Survey (USGS) soil database; (4) MODIS NDVI at 250 meters resolution; and (5) a tested carbon and isotope land-surface model (ISOLSM, based on LSM1.0 [*Bonan* 1996]). The need for distributed ecosystem modeling was demonstrated by the large spatial variability in CO_2 fluxes across the region, which is typically modeled as homogeneous cropland. This work addresses U.S. national goals of estimating regional CO_2 sources and sinks, and provides inputs to forward and inverse models.

METHODS:
We have developed a methodology [based on *Doran et al*., 1998] to incorporate meteorological data from over 120 Oklahoma and Kansas Mesonet sites into a distributed Land Surface Model (ISOLSM) of fluxes between ecosystems and the atmosphere. These meteorological datasets are compiled by ARM and contain fields for precipitation, radiation, wind speed, air temperature, and atmospheric pressure. The interpolation procedure provides the required meteorological input for ISOLSM at a user-specified resolution. The simulations shown here use a 10×10 km grid resolution centered over the ARM Climate Research Facility (ACRF) domain. All data ingested in the interpolation have been quality controlled by the groups responsible for the data collection.

LSM is a "big-leaf" land surface model that simulates aboveground fluxes of radiation, momentum, sensible heat, and latent heat; energy and water fluxes below ground; and coupled CO_2 and H_2O exchange between soil, plants, and atmosphere. We modified the surface types in LSM to correspond to the dominant land cover in the ARM-SGP domain. Soil hydraulic characteristics are determined from sand, silt, and clay content provided by the USGS STATSGO 1 km resolution soil map. LSM has been tested in the dominant crop (winter wheat) in this area by Riley et al. (2003).

We compared simulated and ongoing measurements of land surface-atmosphere exchanges of CO_2 and energy as well as ancillary data from pasture (C_3/C_4 grass mix), wheat (winter C_3 crop), and sorghum (C_4 crop) fields, which are the dominant crop types in the ARM-SGP domain (Fischer et al., 2004). These measurements are made with portable systems comprised of a sonic anemometer, an open-path infrared gas analyzer (IRGA), and a set of meteorological instruments that monitor net and photosynthetically active radiation, air temperature, relative humidity, precipitation, soil heat flux, and soil moisture and temperature (http://www.arm.gov/instruments/carbon.stm).

RESULTS:

Our results show that the interpolated meteorological fields are in good agreement with independent measurements in the area's dominant vegetation types (using four portable meteorological stations). We compare site-level modeled NEE to measurements made with (1) four portable eddy correlation flux systems located in the dominant vegetation covers and (2) ten permanent eddy correlation flux systems distributed throughout the Southern Great Plains domain. Predicted CO_2, latent heat, and sensible heat fluxes were in good agreement with measurements (Fig. 1).

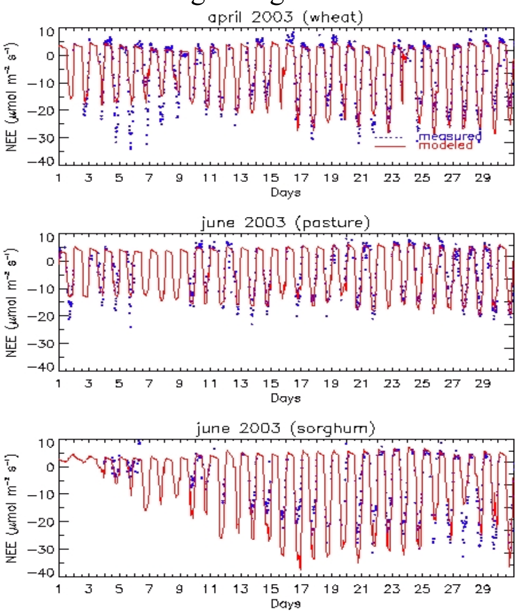

Fig. 1. Time series of measured and simulated NEE of wheat (April 2003), pasture, and sorghum (June 2003). Red lines and blue dots correspond to simulated and measured CO_2 fluxes, respectively.

We also performed a sensitivity analysis for NEE in which we varied spatial and temporal resolution of land cover and meteorological inputs. Typical midday NEE variations across the ARM-SGP domain can be large (up to 25 µmol m^{-2} s^{-1}), implying that estimating regional NEE requires accurate characterization of spatial heterogeneity in vegetation characteristics and meteorological forcing (Fig. 2).

Currently, in regional and global models the region is typically modeled as homogeneous cropland. Our approach allows us to quantify uncertainty in regional flux estimates associated with uncertainties in vegetation type, soil types, and spatial and temporal scaling of surface characterization and meteorological forcing.

Our approach will allow us to estimate fluxes in periods and areas where meteorological forcing data are unavailable and will benefit both 'bottom-up' and 'top-down' approaches to quantifying regional-scale surface CO_2 and energy exchanges.

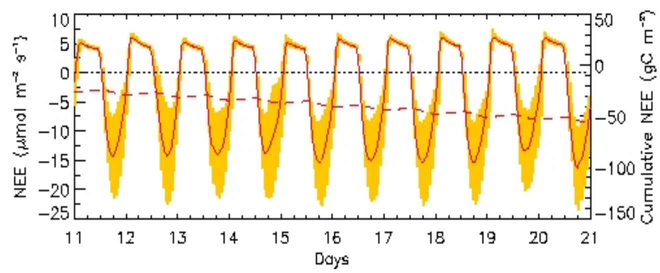

Fig. 2. Regional NEE (solid red line) and cumulative carbon assimilation (dashed red line) across the ARM-SGP domain in June 2003. Orange color corresponds to plus or minus one standard deviation around average NEE.

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