Utilizing land surface models for gap-filling energy and CO_2 exchange rates

Tilden Meyers, Jesse Miller, Tim Wilson, John Kochendorfer, Mark Heuer, NOAA/OAR/ARL

Objectives

• To provide continuous gap-filled dataset of energy, water, and CO_2 fluxes for representative ecosystems in the major climate zones of the United States, using ensemble averages from common land surface models.

•To work with the various land-surface schemes, become familiar with various sub-models and parameters, and become more aware of model parameters sensitivities and inputs.

•To improve the current suite of land-surface model parameterizations by assessing strengths and weaknesses from comparisons with in-situ air-surface exchange data for a variety of important ecosystems.

Methods

Scientists at NOAA's Atmospheric Turbulence and Diffusion Division are using land surface models to gap-fill heat, water and CO_2 fluxes taken at various tower sites that comprise the Surface Energy Budget Network. Currently, three models are being utilized and tuned for the gap-filling procedure. The models are:

The Joint UK Land Environment Simulator (JULES) model is based on MOSES (Met Office Surface Exchange System), which is used in United Kingdom Met Office, and is known for its hydrologic forecast skill.

The Advanced Canopy-Atmosphere-Soil Algorithm (ACASA)is a multi-layer model that uses a detailed higher-order closure solutions for predicting fluxes. The model has been successfully used to predict energy and mass fluxes between the vegetation and atmosphere over numerous ecosystems for annual cycles and has state of the art parameterizations for estimating carbon fluxes.

The Atmosphere-Land Exchange (ALEX) model is a two-source model (soil/canopy) that was developed as for estimating energy and carbon surface fluxes over various landuse types using general atmospheric forcing data. The strength of the model lies in the soil moisture/temperature routines

With any long-term monitoring effort, and especially when using micrometeorological methods to obtain fluxes of energy and CO_2, gaps in measurements of fluxes are inevitable. Statistical methods are typically used to fill gaps in data records. Recent modeling intercomparison studies such as the Project for Intercomparison of Land Surface Parameterization Schemes (PILPS) have demonstrated that using an ensemble average of all model results consistently compares well with observations. We have selected these three models, all which have been extensively evaluated against observations obtained from similar land-use types in the SEBN network.

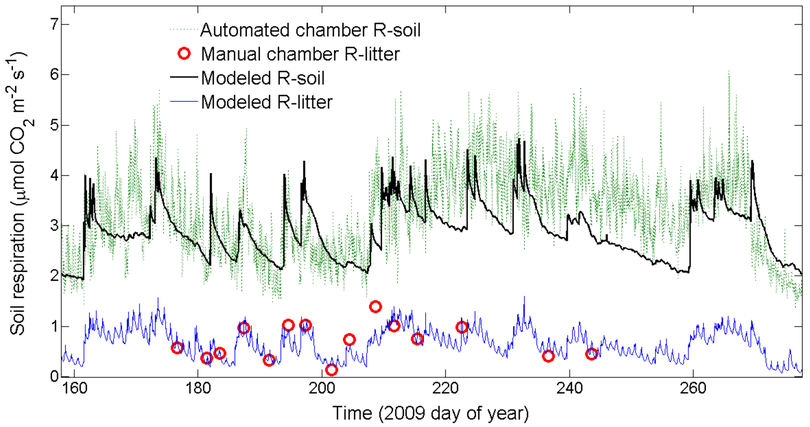

Figure 1. A time series comparison of modeled and measured soil and litter CO2 respiration rates. Observations were obtained at the Chestnut Ridge Forest Research tower in Oak Ridge, Tennessee.

During a recent experiment at the Chestnut Ridge Forest Research facility in Oak Ridge, TN, the water content in the litter layer was shown to be a major factor affecting the CO_2 respiration rate from the litter. By incorporating these results into the soil respiration module of the ALEX model by adding a second term for litter, the trends and magnitudes in predicted respiration rates are well matched with observations and explains many of the day to day observed variations (Figure 1).

Not only did the same model reproduce the observed energy fluxes at the Chestnut Ridge site, but the overall canopy model performed better (Figure 2) when a litter layer was added as a component of the soil sub-model. This layer acts as a temporary storage for water, and also is shown to have a more dynamic response in respiration rates with rain events.

Accomplishments

•Familiarity with operating various land surface models over various ecosystems for an entire annual cycle including both the "green" and senescent part of the annual cycle.

•Excellent agreement between in-situ measurements and model predictions of above canopy energy fluxes for initial tests using data obtained from the Chestnut Ridge Research Facility at Oak Ridge, Tennessee.

•Adapted a land surface model to reflect the role of the forest litter layer towards total ecosystem evapotranspiration and CO_2 respiration rates.

•Improvements in gap-filling procedures using ensemble model averages over standard statistical methods using bootstrap methods

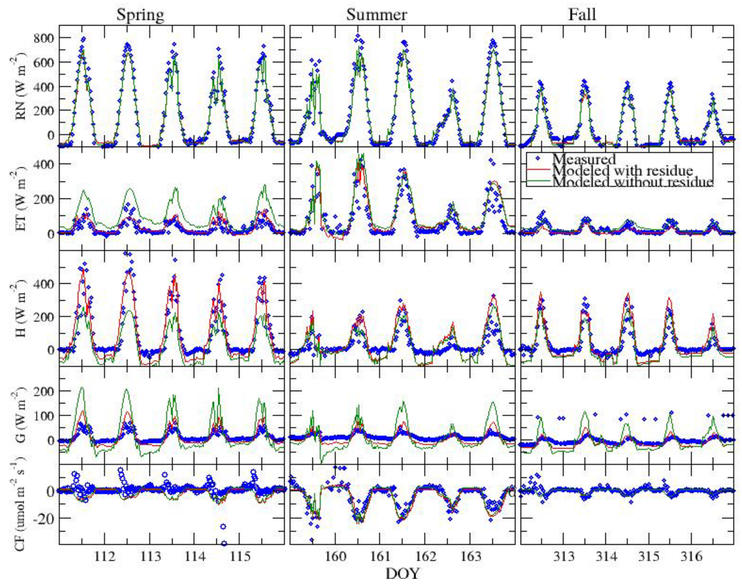

Figure 2. Observed and predicted fluxes of net radiation (Rn), sensible heat flux (H), evapotranspiration (ET) , ground heat flux (G), and CO2 flux (CF) for spring, summer and fall periods at the Chestnut Ridge Forest Research Facility near Oak Oak Ridge, TN.

Collaborators and Partners

- NOAA/NCEP
- USDA/ARS
- UK Met Office
- University of California-Davis

Future Direction

- Refine techniques for deriving model site specific parameters
- Possible inclusion of additional land surface models