Effects of Land Use Change on the Energy and Water Balance of the Semi-Arid Region of Inner Mongolia, China

OBJECTIVES:
1. Mechanistically explain the variability of energy and water fluxes in semi-arid grassland through a network of in-situ USCCC eddy flux towers and a mobile flux tower for three representative landscapes along a gradient of climate and land use in Inner Mongolia.
2. Partition whole ecosystem water flux (ET) into evaporation and transpiration through analyzing stable isotope compositions of vapor and associated water sources ($\delta^{18}O$ and $\delta^D$);
3. Develop and validate satellite-based models to estimate water fluxes;
4. Evaluate and improve process-based SiB model for regional simulations of water and energy fluxes at multiple spatial and temporal scales.

BACKGROUND
The combined changes in the frequency of extreme weather events, intensified grazing and extensive land development have led to the decline of native ecosystems, more severe soil erosion and more frequent sandstorms, which in turn adversely affect the native as well as agricultural ecosystems on which the region depends. In this study we will analyze current and historic patterns of land cover and land use, shifts in biome boundaries and changes in soil-vegetation-atmosphere water and energy balance, and their importance to ecosystem function across the region of Inner Mongolia. We hypothesize that the spatial and temporal variability of energy fluxes ($R_n$, $G$, $L$, and $H$) has increased as the result of increasing land use intensity and climatic variability.

CONCEPTUAL FRAMEWORK

This study is developed with collaborations with the following on-going investigations:
1) Carbon, water, and energy exchanges of disturbed ecosystems in Northern China (J. Chen, S. McNulty, G. Lin, et al., funded by CAS & SGCP).
2) Land use and land cover dynamics of China (Jiguo Qi et al, Michigan State Univ., funded by the NASA Carbon Cycle Science).
4) Moisture Isotopes in the Biosphere and Atmosphere (MIBA) (G. Lin et al., Institute of Botany, CAS, funded by the International Atomic Energy Agency).
5) Mesoscale carbon data assimilation for NACP (Scott Denning et al., Colorado State Univ, funded by NASA Carbon Cycle Science Program).

RESEARCH COMPONENTS.
Our research is developed along four tasks paralleling the study objectives.

Task 1: Quantifying water and energy fluxes of dominant ecosystems across land use and climate gradients. Up to 9 eddy covariance towers will be used to directly measure water and energy fluxes.

Task 2: Estimating transpiration (Tr) from stable isotope mixing ratios. Stable isotope compositions of vapor along a height profile and their possible water sources (precipitation, plant, soil, and ground water) will be analyzed to partition water sources that contribute to ET for each of 9 ecosystems in the Stable Isotope Laboratory for Ecological & Environmental Research at IBCAS following the MIBA protocols.

Task 3: Developing and evaluating satellite-based models for estimating water flux (ET, Tr, EF, LSWI). We plan to employ two complementary approaches to address the complex issue of scaling-up of water fluxes. One approach is to use the existing algorithms to estimate evaporative fraction. The other approach is to explore the potential of coupled photosynthesis and transpiration mechanism at leaf level for estimating transpiration.

Task 4: Refining the SiB3 for improving regional estimation of waters and energy flux. SiB3 will be used for comparing water and energy fluxes of different ecosystems of the region to examine the effects of land use and climate on 9 ecosystems. Landsat (cover type) and MODIS, and GOES (climatic input) as input parameters for a cell-based SiB3.

DATA DISSEMINATION
This study is built upon the integration of diverse disciplines (modeling, ecosystem processes, micrometeorology, GIS, and image processing) that will provide valuable research data for the broader community. A webpage will be developed on the LEES server to ensure widespread dissemination of the findings and broader uses for the data. All the raw and processed data will be posted immediately after quality control. The webpage will include a project description and progress updates, as well as an interactive version of the SiB3 model and field data. Our intensive in situ measurements of surface data for model parameterization and validation is only possible because of the existing flux towers (total 9), stable isotope infrastructure, and other ongoing projects of our collaborators. Data produced from this project, organized after NEESPI format, will be openly shared with the scientific community and general public through the web database (http://research.eecscience.utoledo.edu/lees/data/).

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