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

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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 δD);
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 (Rn, G, L, and H) has increased as the result of increasing land use intensity and climatic variability.

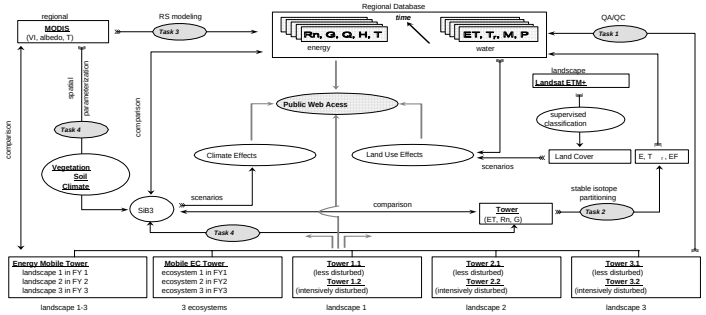
Major abbreviations used in this proposal

E :	Evaporation
EC :	Eddy-covariance
ET :	Evapotranspiration
EF :	Evaporotranspiration fraction
EVI:	Vegetation index
G :	Soil heat flux
H :	Sensible heat
L :	Latent heat, equivalent to ET
LAI:	Leaf area index
LSWI:	Land surface water index
M :	Soil moisture
P :	Precipitation
PAR :	Photosynthetically-active radiation
Q :	Available energy (Rn-G)
h :	Relative humidity
Rn :	Net radiation
SLW :	Specific leaf weight
T :	Air temperature
T_r :	Transpiration
VI:	Vegetation index
VPD :	Vapor pressure deficit
W_{leaf}:	Leaf water content

CONCEPTUAL FRAMEWORK

Proposed activities to quantify the water and energy cycles in the semiarid Inner Mongolia is based on a combination of direct flux measurements, stable isotope technique, remote sensing products, and SiB3 modeling. Our central focus will be developing public-domain webpage for accessing spatial data and comprehensive predictions of major water and energy terms to support NEESPI initiative.

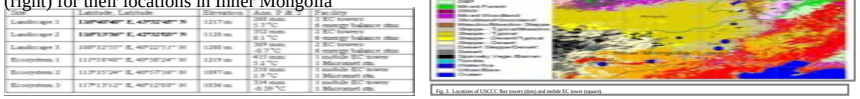
Conceptual flow chart for quantifying water and energy cycles in the semiarid Inner Mongolia



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 (Jiaguo Qi et al, Michigan State Univ., funded by the NASA Carbon Cycle Science).
3) Northern Eurasian C-land use-climatic interactions in the semi-arid regions (D. Ojima et al., Colorado State Univ., funded by NASA Carbon Cycle Science Program).
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).

Characteristics of ecosystems/landscapes for intensive field campaigns in this study (USCCC EC towers, IAEA stable isotope analysis). See figure (right) for their locations in Inner Mongolia



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 evaporation fraction. The other approach is to explore the potential of coupled photosynthesis and transpiration mechanism at leaf level for estimating transpiration.

Table 2. A comparison of three approaches in estimating ET.

Methods	Field Observation	RS Modeling	SiB Modeling
Major objectives	In situ direct measurements (i.e. EC)	Regional to global scale quantifications	Extrapolation of short term observation and understanding processes
Advantages	High accuracy in time and space; Most reliable	Large scale coverage; less costly for large area	Essential tools for data synthesis and underlined responses; Less costly for large area and long term
Disadvantages	High cost for large	Less accurate; Low	Generally not reliable in

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.eeescience.utoledo.edu/lees/data/).

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