The role of land-cover change in montane mainland Southeast Asia in altering regional hydrological processes under a changing climate

Participants, Affiliations & Project Roles

Land Cover / Land Use: Jefferson M. Fox and John B. Vogler, East-West Center, Honolulu, Hawaii

Watershed-scale Modeling: Bart Nijssen, Hydrology, Univ. of Arizona

Regional-scale Modeling: Omer Sen and Yuqing Wang, International Pacific Research Center, Univ. of Hawaii

Field Observations: Thomas Giambelluca, Alan Zeiglar and Michael Nullet, Geography, University of Hawaii

General Circulation Model: Gerald Meehl, National Center for Atmospheric Research, Boulder, CO

Linkage with GEWEX GAME-Tropics: Taikan Oki, Institute of Industrial Science, Univ. of Tokyo, and Institute for Humanity and Nature, Kyoto

Coordination of Field Observations:
Thailand: Chatchai Tantasirin, Kasetsart University
Laos: Sithong Thongmanivong, Faculty of Forestry, National Univ. of Laos
Yunnan: Xu Jianchu, Center for Biodiversity and Indigenous Knowledge (CBIK), Kunming

Abstract

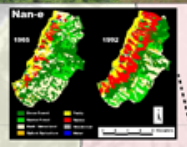
The proposed research uses multi-scale, multi-temporal remotely sensed data and derived products along with an array of ground-based, hydrological measurements and spatially-explicit, regional climate and watershed models to characterize and understand the relationships between land-cover/land-use change (LCLUC) and hydrologic processes in montane mainland Southeast Asia (MMSEA) and their interactions with the effects of global climate change. MMSEA is a region of great biological and cultural diversity that has come under scrutiny because of deforestation, land degradation, and the conversion of traditional agricultural practices to permanent agriculture. These human-induced changes have important implications for biodiversity, watershed hydrology, local and regional meteorological processes, and global climate change.

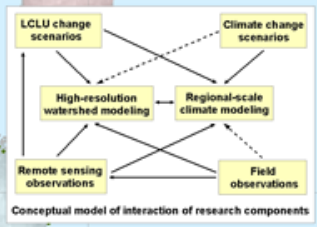
The proposed project will involve land-cover characterization, LCLUC simulation, and climate/hydrological measurement and simulation across a range of scales. We will focus our observations within three study watersheds, each approximately 100 km2, in the southern part of China's Yunnan Province, northern Thailand, and northern Laos. These sites provide a cross-section of the varied political-cultural influences on land cover and land use (LCLU) in MMSEA, and represent a range of levels of current development and trajectories of future land-cover change. Moreover, the field sites are important nodes along the corridor of the proposed Chiang Mai-Kunming Highway, a major construction project certain to initiate rapid land-cover conversion and result in profound environmental and economic change in the region.

We will use current and historical, multi-scale, multi-spectral remotely sensed data available from NASA ESE mission satellites, primarily TERRA's ASTER and MODIS sensors, Landsat 5 and 7, and NOAA's AVHRR, and other commercial satellite data and aerial photographs, where available. A spatial landscape database will be developed for the region with particular emphasis on road development. These data will be used to assess past and current LCLU and LCLU dynamics in the highway corridor and in MMSEA region. We will also project future LCLU change in MMSEA, annually, to the year 2050, using a Cellular Automata modeling approach, and giving special attention to scenarios related to the influences of the expanding international highway network in the region.

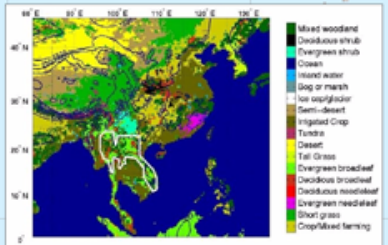
Hydrological observations in two watersheds will include monitoring of spatially distributed rainfall and evapotranspiration, and stream discharge at the watershed outlet. In addition, vegetation and soil parameters will be sampled for the principal land covers and soil types. Observations will be used to force off-line runs of the high resolution watershed model MIKE SHE, and to provide calibration/validation data. Simulations will focus on elucidating direct influences of land-cover change on hydrologic processes within each of the study watersheds.

To evaluate the influences of land-cover change and global climate change on the climate and hydrology of MMSEA and the greater East and SE Asia region, we will implement the IPRC_RegCM coupled climate model for the domain 80-135°E and 0-45°N, with a horizontal resolution of 0.25° longitude and latitude. A suite of land cover and climate scenarios will be run encompassing a range of possible future conditions.





Conceptual model of interaction of research components



Domain of IPRC regional climate model with land cover and elevation

Science Questions

How does LCLUC in MMSEA affect local and regional energy and moisture fluxes, and what are the consequences of those changes for continental-scale atmospheric circulation and climate, and local and regional hydrology, in the context of a changing global climate.

More specifically,

1) How has LCLU changed in recent decades and what hydrologically-significant LCLUC is likely to occur in MMSEA in the coming decades?

2) How do changes in LCLU alter the hydrological functioning of watersheds in MMSEA? In particular, how will LCLUC affect the moisture and energy fluxes in these basins?

3) To what degree and over what spatial extent will these LCLU changes effect changes in atmospheric circulations and climate?

4) What are the separate and combined effects of LCLUC and global warming on the regional and local hydrology?

Expected Results and Research Products

To develop a comprehensive picture of the impact of LCLUC and global climate change on local, regional and continental climate and hydrology with the following research products:

1) Baseline LCLU, biophysical, spatial database for the highway corridor;

2) Time series database and analysis of LCLUC within the highway corridor from the early 1980s to present;

3) Multi-resolution LCLU within the corridor and MMSEA region for past, present and projections to 2050;

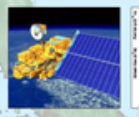
4) 1-km and 5-km surface skin temperature database for MMSEA;

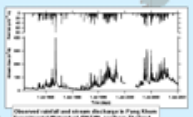
5) High resolution hydroclimate database for two representative watersheds along the highway corridor;

6) Database of ground-measured vegetation and soil characteristics keyed to land cover, topography, and soil type;

7) Comparative simulations of regional climate for present and future global climate and for current, future, and extreme LCLUC scenarios;

8) High-resolution watershed simulations based on current and projected LCLU and climate.





Remotely sensed data, mapping and field observations for generating biophysical variables, hydroclimate data, thematic layers and understanding LCLUC at multiple scales

- Remote sensing analysis and field observations for LC characterization and LCLUC dynamics
- ⟶ CA model development, implementation, validation for LCLU simulations
- Field hydrology equipment installation, calibration and field observations
- ⟶ Watershed model construction, implemention, simulation and scenario evaluation
- Development and analysis of land surface temperature (LST) time-series and model comparisons
- RegCMs using present/control/projected climates with present LCLU and extreme deforestation
- ⟶ RegCMs using present/control/projected climates with 2025 and 2050 LCLU simulations

Annual, multi-res LCLU simulations derived from LCLUC scenarios and CA modeling provide input for high-res watershed simulations (MIKE-SHE model) and regional climate simulations (IPRC-regCM) to years 2025 and 2050. Mulit-res, derived land surface skin temperatures (LST) data sets compared to watershed and regional atmospheric simulations.

1980 Landsat 5 TM — 1990 NOAA AVHRR — 2000 Landsat 7 ETM+ ASTER MODIS — 2004 — 2005 — 2006 — 2007 NASA Project Duration — 2025 — 2050 Simulation Period

Response to NRA-03-OES-03

- Cities / Towns
- Watersheds
- North-South Corridor
- MMSEA boundary (approximately)

Background: NOAA Globe ~1km gridded DEM data

MYANMAR
CHINA
Yunnan
Kunming
Mohei
Jinghong
Kengtung
Tachilek
Boten
Houayxay
LAOS
VIETNAM
Ha Noi
Gulf of Tonkin
Chiang Mai
Vientiane
Rangoon
THAILAND
Bangkok
CAMBODIA
Phnom Penh
Ho Chi Minh City
Andaman Sea
Gulf of Thailand