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

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Taikan Oki, Tokyo University
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**Abstract**

The project is using 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. The project seeks to characterize land-cover, simulate LCLUC and measure climate/hydrological variables across a range of scales. The project is focused in two study watersheds, each approximately 100 $km^2$, in the southern part of China's Yunnan Province, and in northern Thailand. 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.

Key words:
Research Fields:
Geographic area/biome:
Remote sensing:
Methods/scales:

**Research Questions:**

1. How has LCLU changed in recent decades and what hydrologically-significant LCLUC is likely to occur in MMSEA in the coming decades? (NASA ESE question (a) on changes in land cover and or land use)
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? (NASA ESE question (c) on the consequences of LCLUC)
3. To what degree and over what spatial extent will these LCLUC in MMSEA affect changes in atmospheric circulations and climate? (NASA ESE question c)
4. What are the separate and combined effects of LCLUC and global warming on the regional and local hydrology? (NASA ESE question c)

**Goals and Accomplishments in Year 1:**

1. To develop a comprehensive, high-resolution database of recent and current land cover in MMSEA and to develop scenarios of future LCLUC in the region.
    a. Scenario development is being assisted by a grant of $550,000 from NSF which is devoted approximately 80% social science. This NASA grant has 0% social science. See our website for more details on the NSF grant: http://www2.eastwestcenter.org/environment/MMSEA/
    b. Our goal in Year 1 was to develop an extensive digital geospatial database for the MMSEA highway corridor and study watersheds. Accomplished. See Figure NASA_NSF_database.jpg
2. To make field measurements of key hydrological variables within two representative watersheds for the purposes of calibrating and validating hydrological and climatological models for the region.
    a. The project is approximately 75% devoted to water.
    b. Our goal in Year 1 was to install an 11-station climate/hydrological network in each of two study watersheds. Accomplished. See http://webdata.soc.hawaii.edu/hydrology/projects/res_NASA/data.htm
3. To model hydrological processes within each study watershed to establish the role of land-cover change in altering watershed function.
    a. Our goal in Year 1 was to select watershed hydrology model and identified needs for modifying model. Accomplished.
4. To simulate the climate and hydrology of the greater East and SE Asia region under scenarios of land-cover and climatic change. Accomplished.
    a. Our goal in Year 1 was to start development of cellular automata (CA) approaches to simulate future land-cover changes. Accomplished.
5. To use climate model output to drive simulations of the watershed model to predict the effects of both land-cover and climatic change, including feedbacks, on MMSEA hydrology.
    a. Our goals in Year 1 were to select and test regional climate model; and to adapt MODIS-IGBP land cover product to accommodate model requirements. Accomplished. See Figure MODIS-BATS_sm.jpg

**Approach Adopted:**

Multi-disciplinary, field and modeling approach in involving four teams: (1) LCLU Team; (2) Field Hydrology Team; (3) Watershed Modeling Team; and (4) Regional Climate Modeling Team.

**Most significant results**

In Year 1 we accomplished most of the goals we set out to meet. Our most significant results were as follows:

- Acquired extensive geospatial database;
- Installed an 11-station climate/hydrological network in each of two study watersheds;
- Established data retrieval, screening, archival system; data available via internet; see http://webdata.soc.hawaii.edu/hydrology/projects/res_NASA/data.htm
- Selected watershed hydrology model and identified needs for modifying model;
- Selected and tested regional climate model; adapted MODIS-IGBP land cover product to accommodate model requirements.

**Future steps**

In Year 2 we will seek to meet the following goals:

- Continue to build capability for LCLUC simulation using CA approach;
- Continue to develop and provide necessary geospatial datasets as required by watershed modeling and regional climate modeling teams;
- Continue to obtain field climate/hydrological data and soil, vegetation, and physical parameters for forcing, parameter setting, and calibration of watershed and climate models;
- Collect soil moisture transects to allow comparison with model simulations and to evaluate the possibility to use canopy water content as an indicator of soil moisture status (see new potential);
- Implement the distributed hydrological model DHSVM for the two watersheds;
- Simulate climate and hydrology of East-SE Asia region for present and future land cover and present and future global climate scenarios;
- Use regional climate output to drive simulations of hydrological processes in study watersheds under future land-cover and climate conditions.

**New Potential**

- We are investigating the utility of Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) for synthesizing and quantifying the knowledge of local and regional experts, researchers, and policy-makers about the drivers of LCLUC and their relative importance for decision-making and observed land cover transitions in the region. If successful this promises to be an exciting new way of using, collecting and quantifying social science data for modeling land-cover change.
- In collaboration with Greg Asner (Carnegie Institution/Stanford University), we will evaluate the possibility to relate high resolution, Hyperion-derived canopy water content images to soil moisture status. Our working hypothesis is that even approximate information on the spatial distribution of soil moisture status will help constrain our partially distributed watershed model. This hypothesis will be tested theoretically in collaboration with Jasper Vrugt (LANL). This spatial information would complement the point observations made at our meteorological sites.

**New Products**

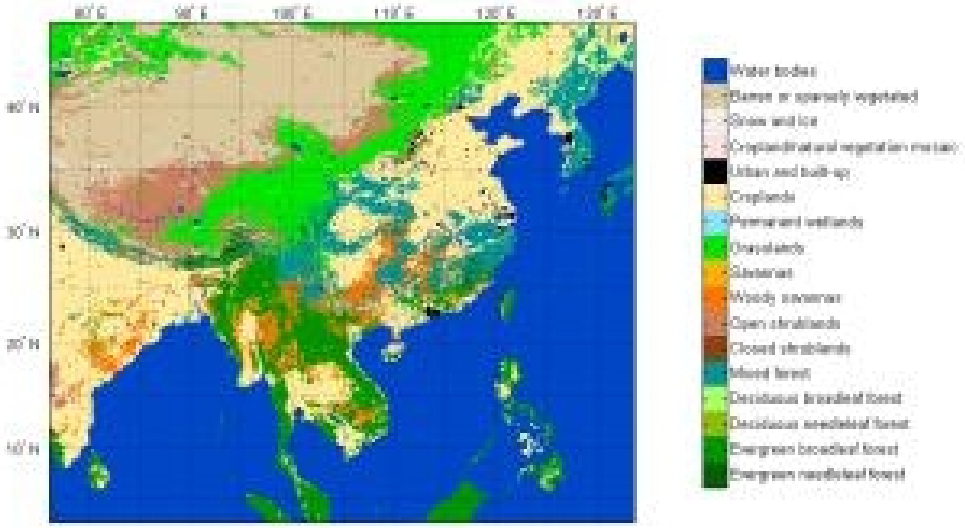
We developed a MODIS-based BATS land cover/vegetation classification map for the regional climate model (see Figure MODIS-BATS_sm.jpg).

**Conclusions**

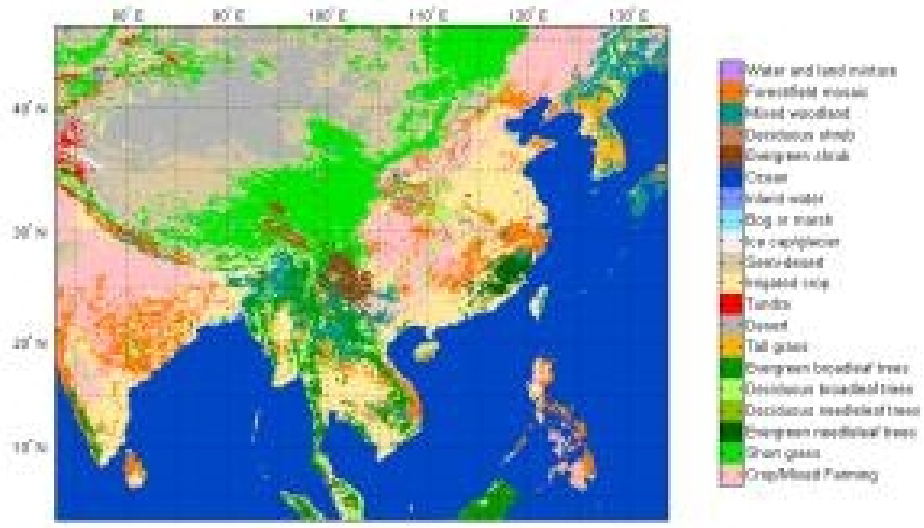
This project is progressing nicely. We accomplished the goals we set out to achieve in Year 1. We do not currently have any major gaps or problems that we feel that we cannot resolve. Modeling land-cover change to the year 2050 for all of MMSEA region will be challenging. However, we should be able to produce plausible scenarios based on the detailed information we are collecting along the highway corridor running between Chiang Mai, Thailand, and Kunming, China. The NSF grant greatly strengthens this NASA funded project by making it possible to explore in greater depth how resource management systems in MMSEA are changing in the wake of commodification of resources and to examine how these changes may affect sustainable resource use, landscape transformation, and land cover. This project is still in its early stage and we do not yet have any significant results and we have not published any results of the research funded by this grant.

# Land cover/vegetation map

## MODIS-IGBP

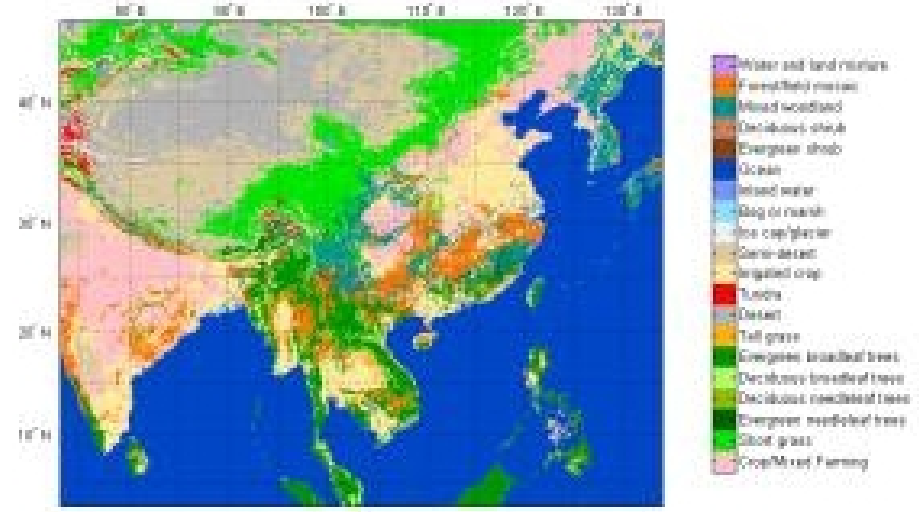


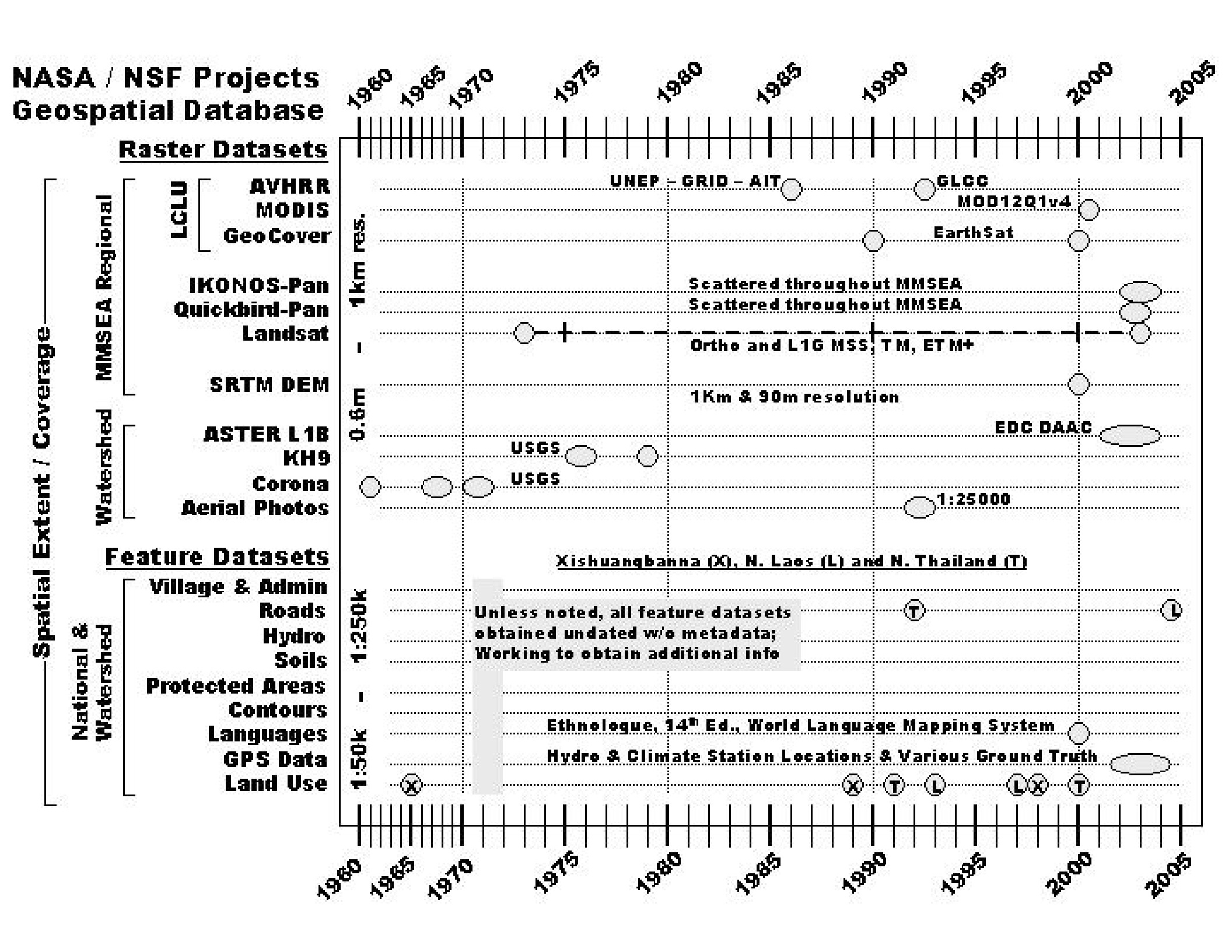
## AVHRR-BATS



- **MODIS-IGBP obtained at 0.008333 degree**
- **Upscaled to 0.08333 degree (~9.26 km) using dominant landscape approach**
- **IGBP vegetation classes were then translated to corresponding BATS classes**
  - **Incorporated some attributes from AVHRR-BATS when MODIS-IGBP class was too broad ("Grassland" in IGBP could be translated to "Short grass" or "Tall grass" in BATS)**

## MODIS-BATS




NASA / NSF Projects
Geospatial Database
Raster Datasets
Feature Datasets
Spatial Extent / Coverage
MMSEA Regional
Watershed
National & Watershed
LCLU
AVHRR
MODIS
GeoCover
IKONOS-Pan
Quickbird-Pan
Landsat
SRTM DEM
ASTER L1B
KH9
Corona
Aerial Photos
Village & Admin
Roads
Hydro
Soils
Protected Areas
Contours
Languages
GPS Data
Land Use
1km res.
0.6m
1:250k
1:50k
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
UNEP – GRID – AIT
GLCC
MOD12Q1v4
EarthSat
Scattered throughout MMSEA
Scattered throughout MMSEA
Ortho and L1G MSS, TM, ETM+
1Km & 90m resolution
EDC DAAC
USGS
USGS
1:25000
Xishuangbanna (X), N. Laos (L) and N. Thailand (T)
Unless noted, all feature datasets obtained undated w/o metadata; Working to obtain additional info
Ethnologue, 14th Ed., World Language Mapping System
Hydro & Climate Station Locations & Various Ground Truth