THE ROLE OF LAND-COVER CHANGE IN MONTANE MAINLAND SE ASIA IN ALTERING REGIONAL HYDROLOGICAL PROCESSES UNDER A CHANGING CLIMATE

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Building an Asia Pacific Community

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THE UNIVERSITY OF ARIZONA

Department of GEOGRAPHY

INTERNATIONAL PACIFIC RESEARCH CENTER

Center for Biodiversity and Indigenous Knowledge
云南省生物多样性和传统知识研究会

BACKGROUND

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OVERARCHING QUESTION

How will 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 changing global climate?

SCIENCE QUESTIONS

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?

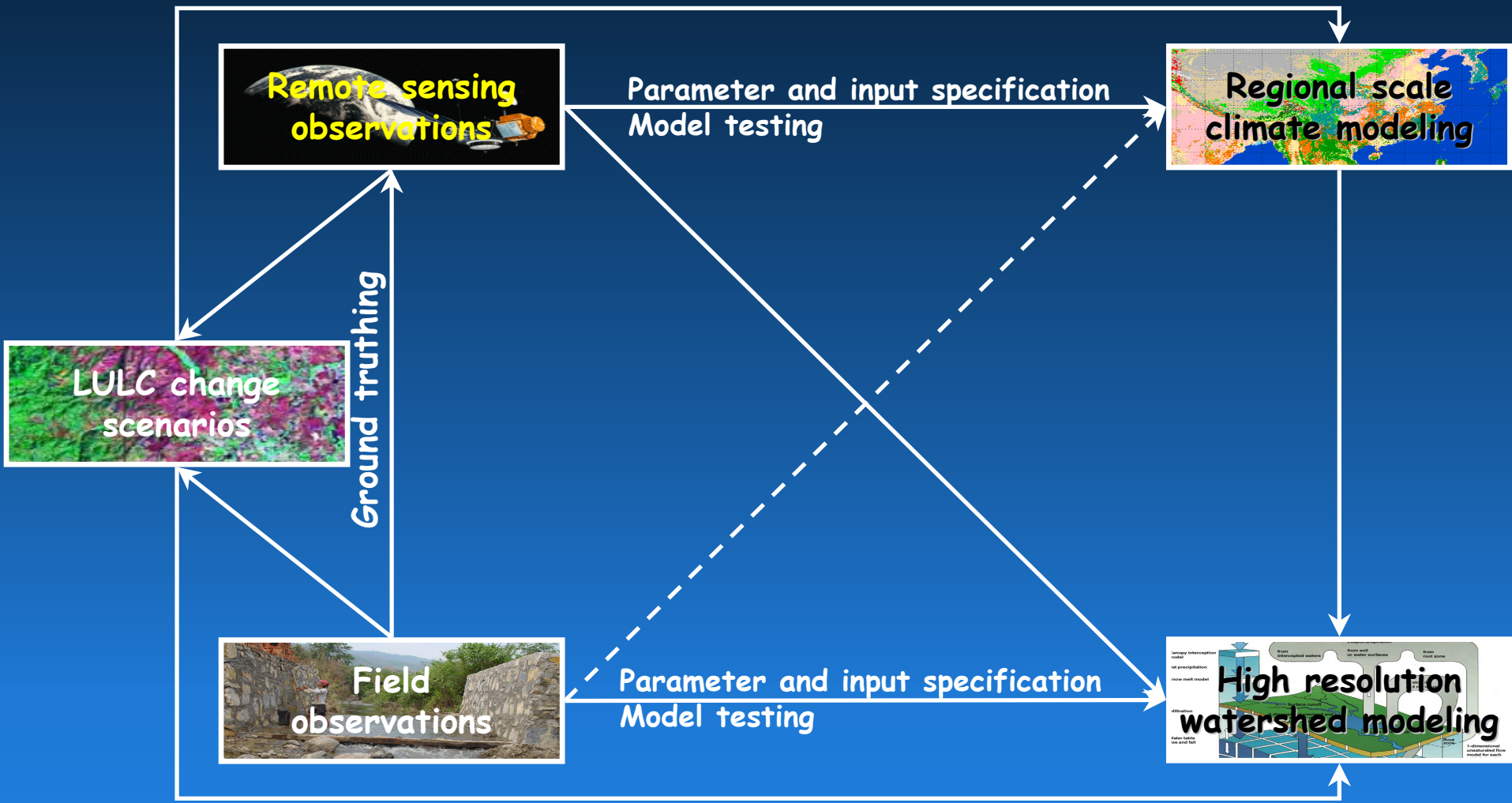
3. To what degree and over what spatial extent will these LCLUC in MMSEA effect changes in atmospheric circulations and climate?

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

MAJOR GOALS

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.
2. To make field measurements of key hydrological variables within three representative watersheds for the purposes of calibrating and validating hydrological and climatological models for the region.
3. To model hydrological processes within each study watershed to establish the role of land-cover change in altering watershed function.
4. To simulate the climate and hydrology of the greater East and SE Asia region under scenarios of land-cover and climatic change.
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.

Project components



TEAMS

Spatial Data/LCLUC (EWC)

- –Jeff Fox
- –John Vogler
- –Martin Buchert
- –Xu Jianchu
- –Khamla Phanvilay

Field Hydrology (UH-Geog)

- –Tom Giambelluca
- –Alan Ziegler
- –Mike Nullet
- –Pornchai Preechapanya
- –Chatchat

Watershed Modeling (UA)

- –Bart Nijssen
- –Maite Guardiola-Claramonte

Climate Modeling (ITU, IPRC)

- –Omer Sen
- –Yuqing Wang

COLLABORATORS

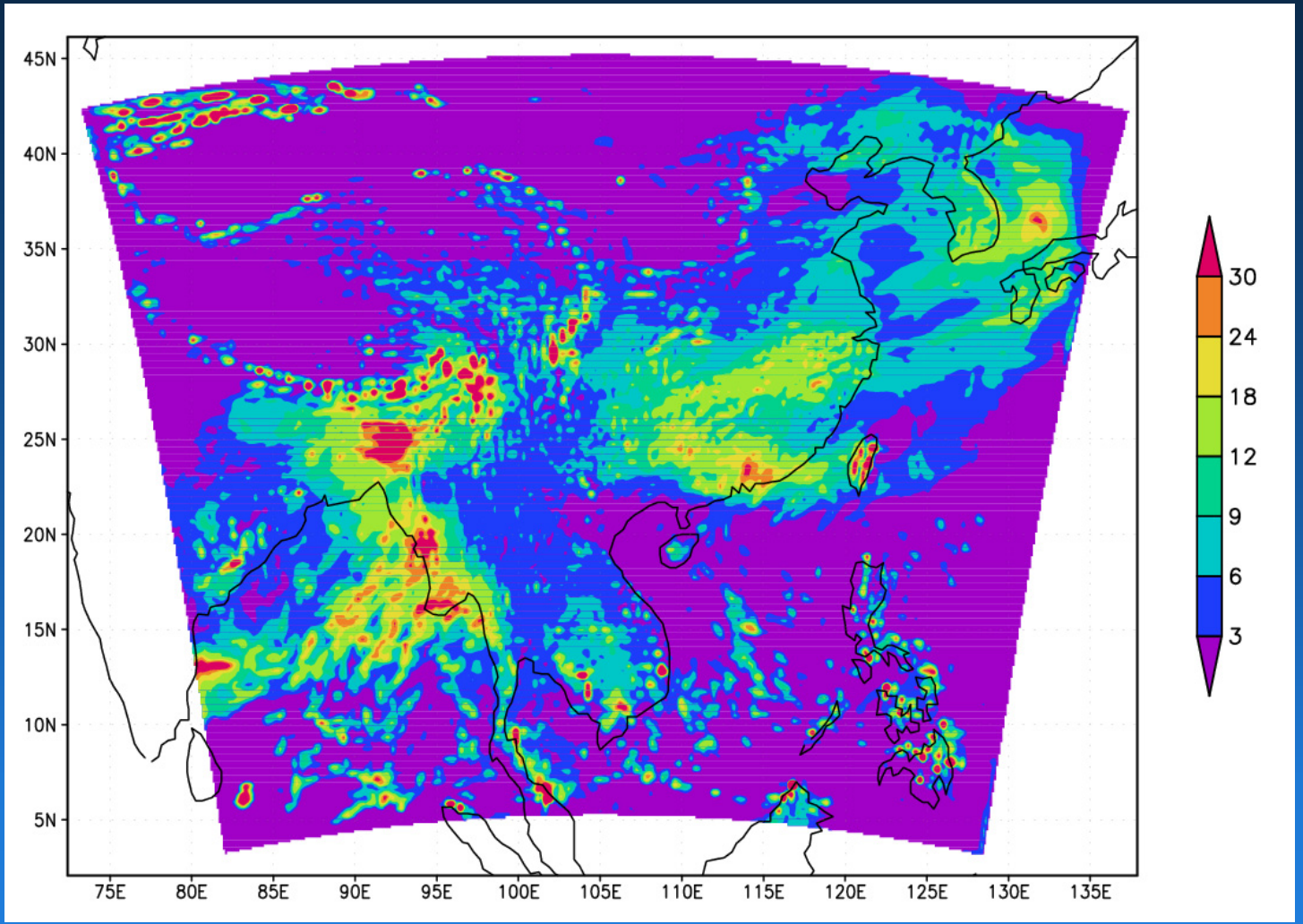
Global Data Sets

–Gerald Meehl (NCAR)

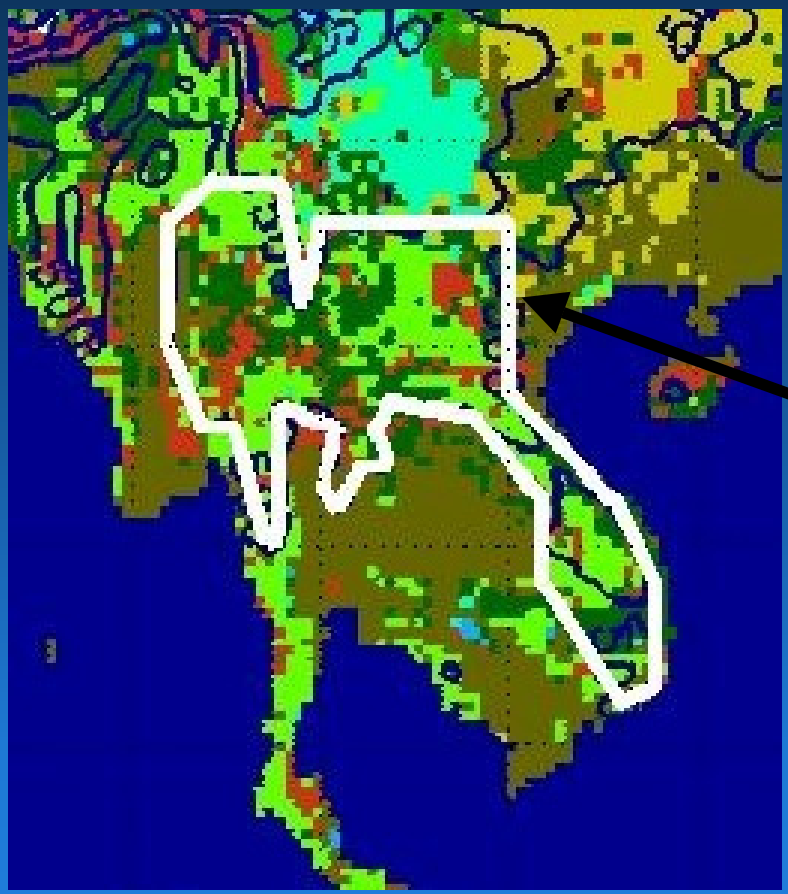
GEWEX

–Taikan Oki (University of Tokyo)

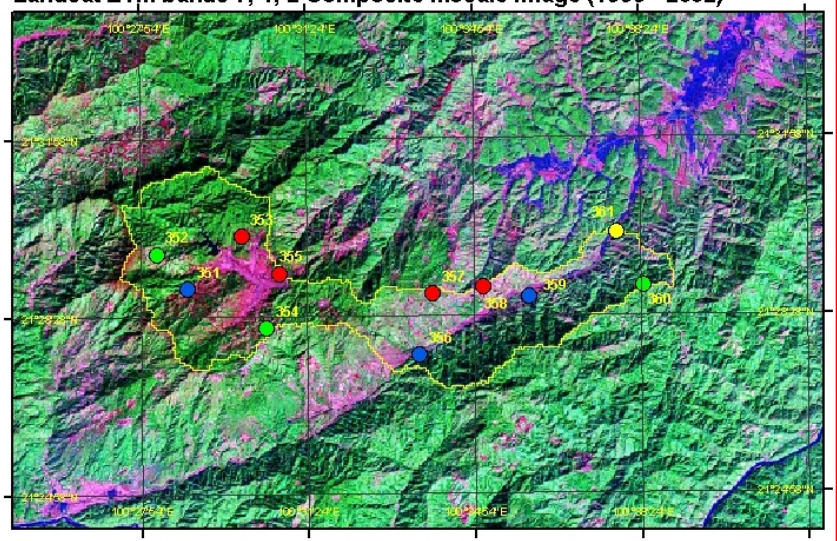
SCALES: Continental

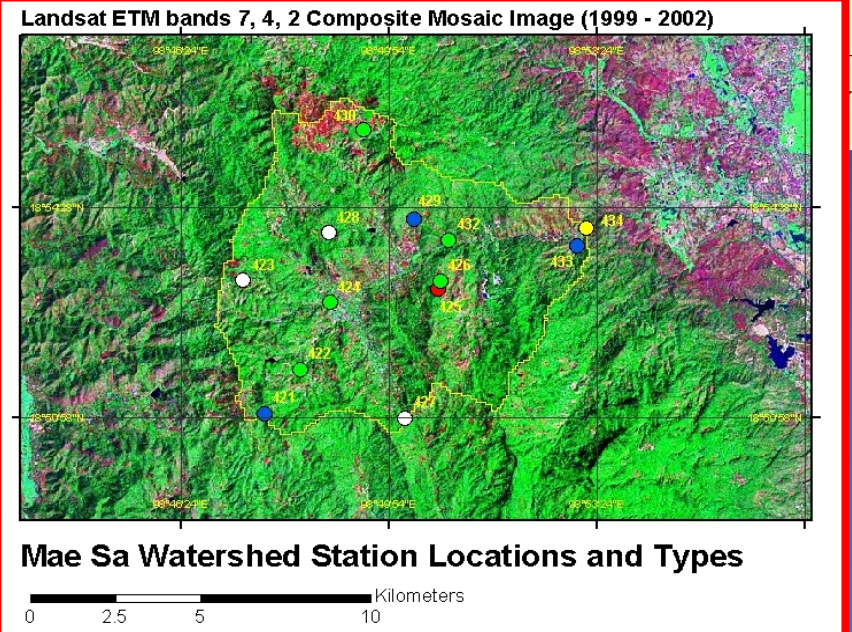


SCALES: Regional



SCALES: Watershed

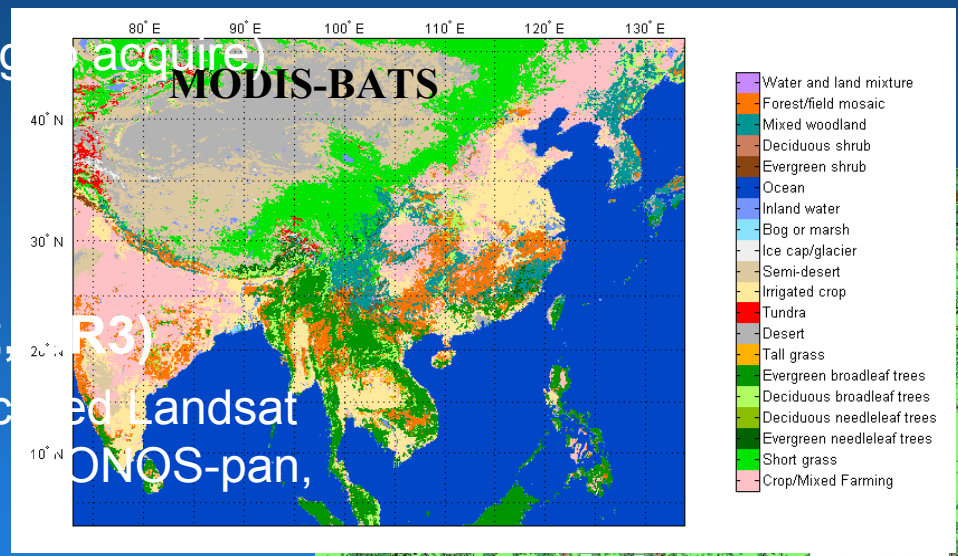




Laos Watershed Study Postponed

LCLU Team

- **Spatial database & land-cover characterization**
  - **Regional climate model domain**
    - MODIS land cover product MOD12Q1V004
    - Processed to specifications of regional climate model
  - **MMSEA Regional Data**
    - 1985/86 AVHRR (currently working to acquire)
    - 1992/93 AVHRR
    - 2000/01 MODIS
    - 1-km SRTM DEM
  - **Simulation Regions (SR1, SR2, SR3)**
    - KH-9 mapping (mid 70s), Orthorectified Landsat (mid-70s, ~1990, ~2000), ASTER, IKONOS-pan, Quickbird-pan
    - Vector data: roads, rivers, villages, admin., protected areas, etc.
    - 90-m SRTM DEM



LCLU Team

- **LCLU Change Simulation: 2025 and 2050**
  - –database development and theoretical and practical strategies for using Cellular Automata (CA)
  - –software training
  - –hiring, training assistant
  - –Jan 2005: Mobile Workshop on Land Use History in MMSEA: improve understanding of land use dynamics and drivers of change in region
  - –Feb 2005: Convert results of Mobile Workshop into sets of land cover transition rules, weights, thresholds; test rules and parameters; solve issues of data handling and programming for land cover simulation; use Analytical Hierarchy Process model to quantify relative importance of drivers based on expert knowledge (obtain weights)

Progress Report

- **Stud**
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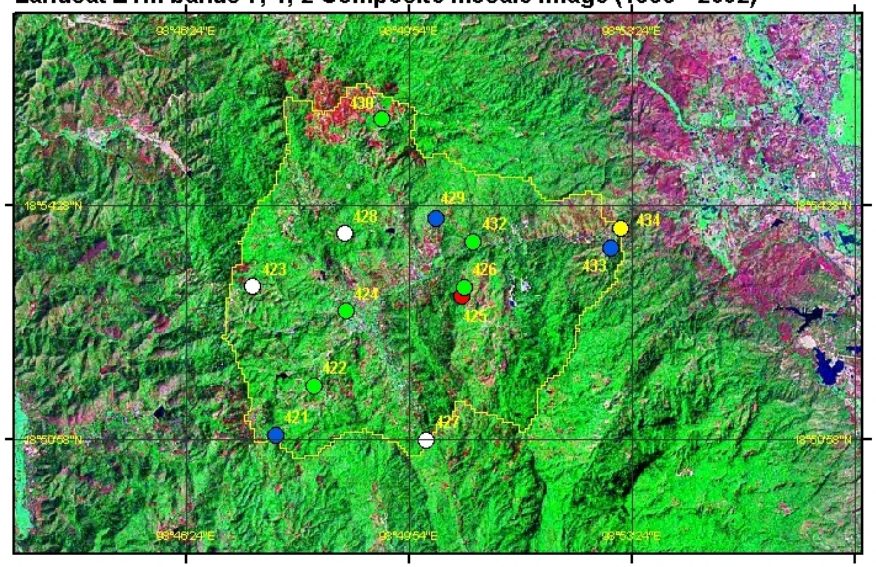
CHINA

map

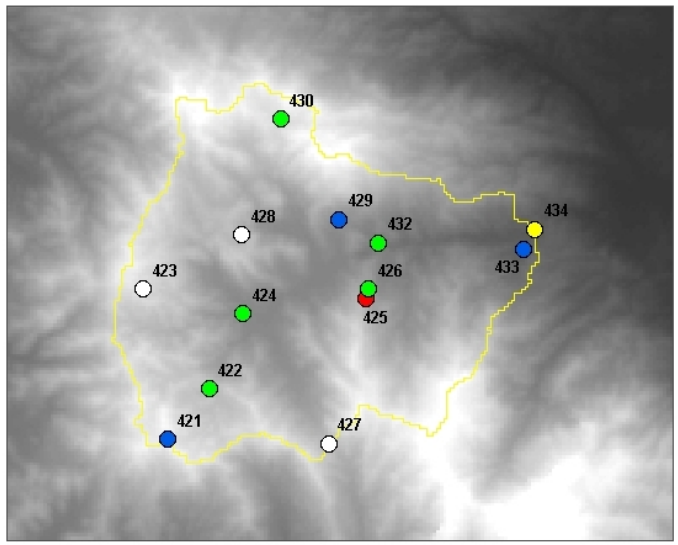
Landsat ETM bands 7, 4, 2 Composite Mosaic Image (1999 - 2002)



Mae Sa Watershed Station Locations and Types

Kilometers

0 2.5 5 10



Type

- RG/Hobo
- RG/SM
- SM
- climate station
- pressure T + level loggers

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Value

High : 1688

Low : 0

SRTM 90m Resolution DEM

Station visit notes [2004] [2005] [2006] | last update: 041124

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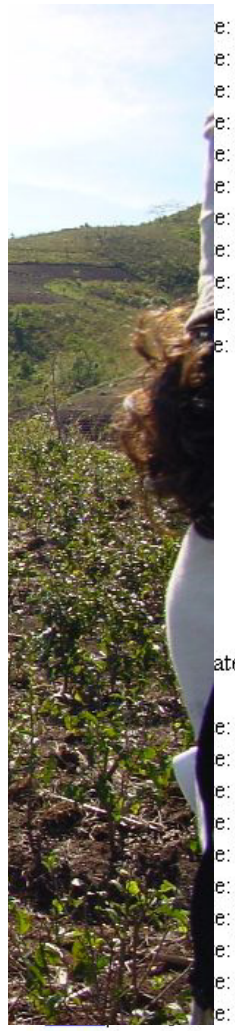

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Field Hydrology Team

Scenes from the field

Field Hydrology Team

- **Field Sites:**
- Nam Ken Watershed (China)

Tea/rice swidden →

Young secondary vegetation →

Rubber plantation →

Streamgage →

Field Hydrology Team

- **Field Sites**
  - –Mae Sa Watershed (Thailand)
    - –Agriculture
    - –Advanced secondar vegetation
    - –Lychee orchard
    - –Streamgage

Watershed Modeling Team

Rationale:

Land use / land cover (LULC) changes occur at the scale of individual hillslopes

Develop high-resolution, spatially-distributed watershed models to represent more explicitly the physical processes by which LULC changes affect hydrological fluxes

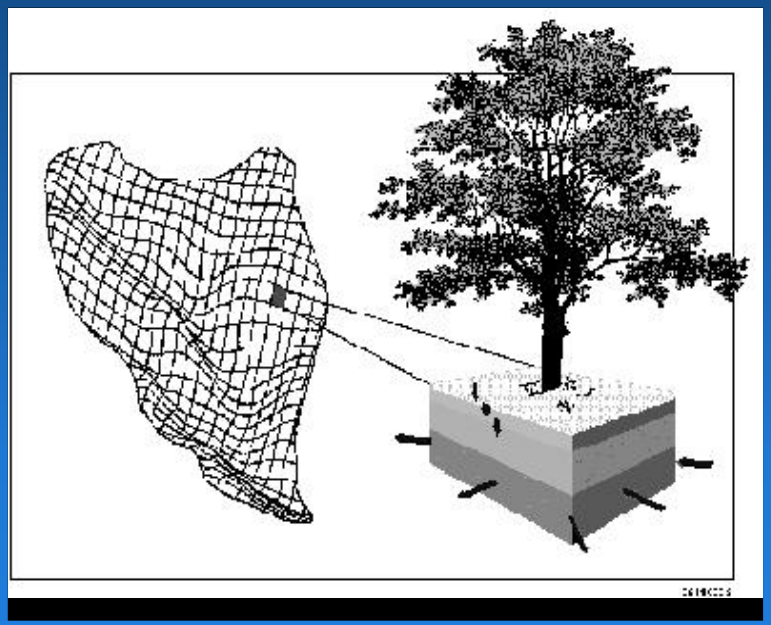
Model Simulations:

a. Current conditions
b. Altered land use and land cover
c. Altered climate
d. Combined altered LULC and altered climate

Watershed Modeling Team

Distributed Hydrology Soil Vegetation Model

DHSVM



Source: University of Washington

- Spatially distributed hydrological model
- Free and open source
- co-PI Nijssen was a co-developer of this model while at University of Washington
- Previously application of this model in Pang Khum watershed in region similar to Mae Sa watershed

Watershed Modeling Team

Data needs

Variable	Data Source	Default
Land Surface Characteristics (consta		
Topography	30 r	TOPO30 interpolated to the resolution of the watershed model
Drainage network	Der	Derived from DEM
Soil type	Loc	AO 5 minute soil map of the world
Soil hydraulic parameters	Fiel	iterature values based on soil type
Land Use Characteristics (time-v		
Land use / Land cover	AVHRRE, MODIS, TM and ETM+ remote sensing (**4.1**) Outp char	MODIS Land cover classes
Biophysical parameters (LAI, albedo, etc)	AVH Lite	
Meteorological model forcings		
Precipitation, temperature, wind speed, humidity, shortwave radiation, longwave radiation	Loca Fiel Bias clim	mental Watershed observations 3 global 0.5° monthly time series g statistics based on observations from n the region gwave radiation will be generated using s based on daily temperature ranges
Model testing and validation data		
Streamflow	Exis Gag	e available for the PKEW 1 km^2 nd. Although this basin is much smaller s watersheds, it will give us the ting our BATS implementation in MIKE SHE. Available data for PKEW include meteorological forcings as well as streamflow, soil moisture, net radiation and surface temperature
Soil moisture (point)	Fiel	
Turbulent fluxes (point)	Fiel	
Net radiation (point)	Field observations (**4.4**)	
Surface temperature (point)	Field observations (**4.4**)	
Surface temperature (spatial)	MODIS land surface temperature (**4.3**)	

Long term datasets:
- Meteorology
- Streamflow
- Etcetera

Physical attributes

Auxiliary datasets:
- Vegetation characteristics
  - Root depth, distribution
  - Leaf area index
- Soil properties
- Etcetera

Watershed Modeling Team

Required model changes

- Implement DHSVM within the Virtual Scalable Basin (VSB) a modeling framework currently under development that will allow us to link DHSVM with other models. (VSB is being developed jointly with research groups at the University of Washington)
- Change land surface scheme to be compatible with that used in the GCM
- Make changes to represent irrigation and in particular flooded rice paddies

Watershed Modeling Team

Planned activities for 2005

Model Development

- Develop VSB prototype and implement DHSVM
- Change land surface model for calculation of energy balance

Data Needs

- Together with East-West Center team develop spatial datasets needed by model (land use, etcetera)
- Develop sample forcing data set to drive the model

Summer Field Campaign

- Together with University of Hawaii team further develop soil map
- Measure spatially variable land surface states (e.g. soil moisture) to test the spatial patterns predicted by the model

Regional Climate Modeling Team

Climate questions

- *How do projected LCLU changes in MMSEA for the years 2025 and 2050 and for an extreme deforestation scenario affect the regional climate?*
  - *Present climate (1997-2001; ECMWF) with present LCLU*
  - *Present climate (1997-2001; ECMWF) with 2025 LCLU*
  - *Present climate (1997-2001; ECMWF) with 2050 LCLU*
  - *Present climate (1997-2001; ECMWF) with extreme deforestation*

Regional Climate Modeling Team

Climate questions

- *How does projected LCLU change for 2050 affect the regional climate under a warmed global climate?*
  - *Control climate (PCM 2045-55; Present CO2) with present LCLU*
  - *Control climate (PCM 2045-55; Present CO2) with 2050 LCLU*
  - *Projected 2050 climate (PCM 2045-55; SRES A2 CO2) with present LCLU*
  - *Projected 2050 climate (PCM 2045-55; SRES A2 CO2) with 2050 LCLU*

Regional Climate Modeling Team

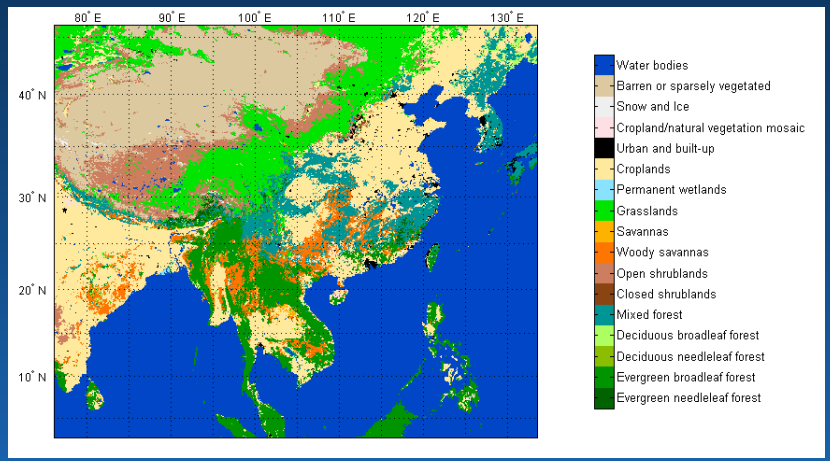
Important Changes

- *MODIS 2000-2001 instead of AVHRR 1992-1993 for land surface data*
- *ICTP-RegCM3 instead of IPRC-RegCM for dynamic downscaling*
  - *Advantages:*
    - *Computationally more efficient*
    - *Can run on PC-Linux*
    - *Sub-grid feature that give us opportunity to make the simulations at 9.26km (0.083333 degree) grid resolution to resolve the basins under study in this project. This is for land surface part only; atmosphere part works on 0.25 degree resolution as proposed in the project.*
- *1998-2002 period instead of 1997-2001 for present climate*

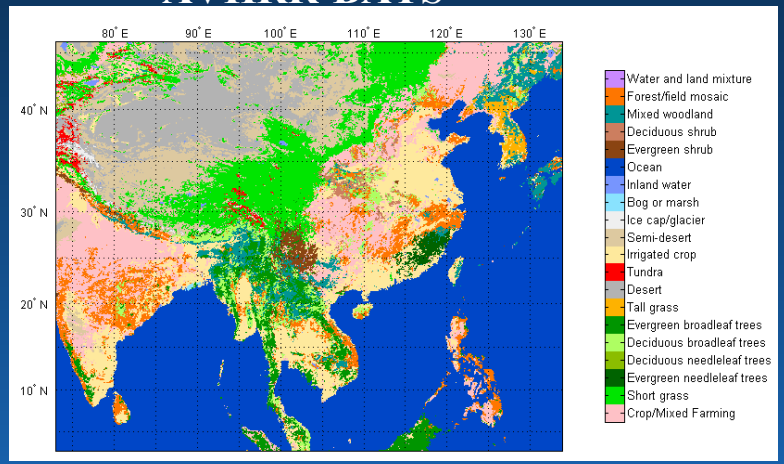
Regional Climate Modeling Team

Land cover/vegetation map

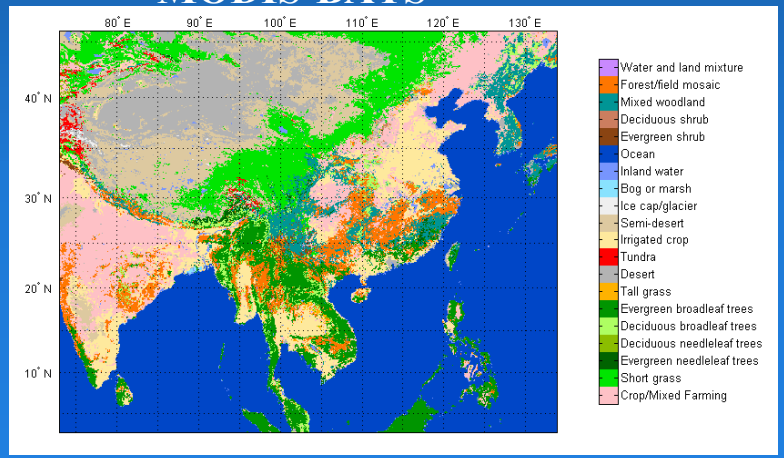
MODIS-IGBP



AVHRR-BATS



MODIS-BATS

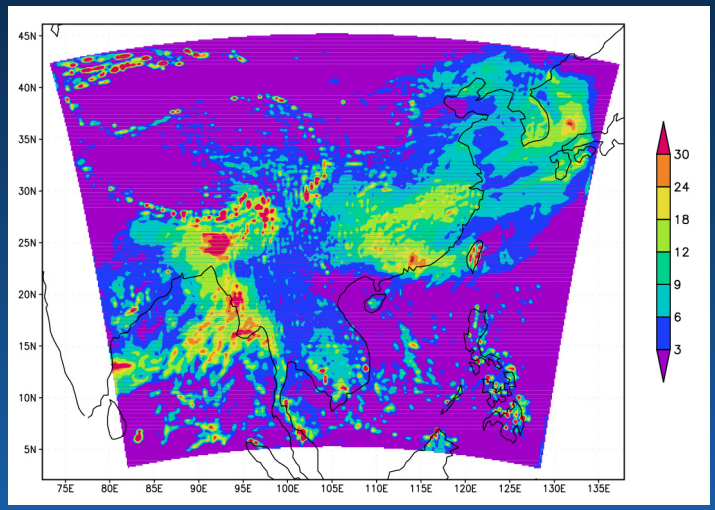


- MODIS-IGBP obtained at 0.008333 degree
- Upscaled to 0.08333 degree (~9.26 km) using dominant landscape approach
- IGBP vegetation classes were then translated to corresponding BATS classes
  - Incorporated some attributes from AVHRR-BATS when MODIS-IGBP class was too broad ("Grassland" in IGBP could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

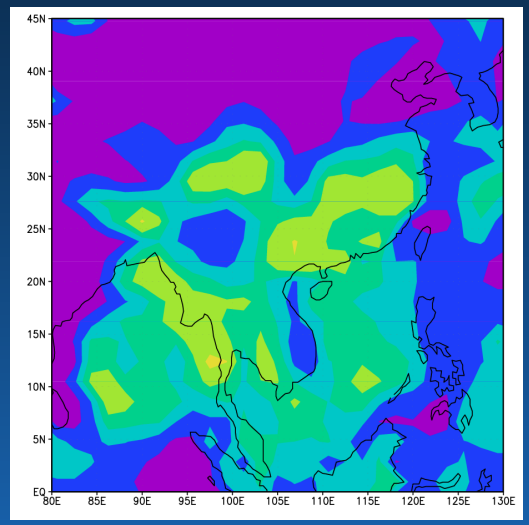
Regional Climate Modeling Team

Performance of the MODEL

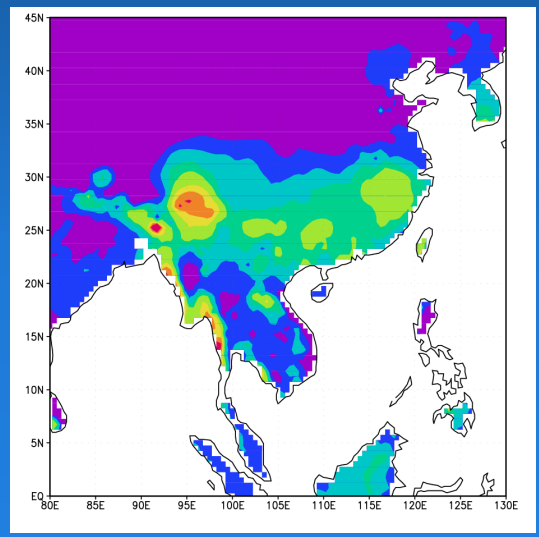
Model generated 0.25 degree rainfall for June 1998

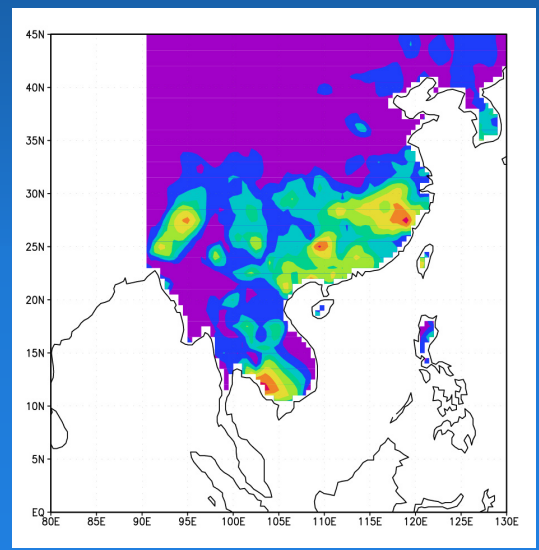


NCEP/NCAR reanalysis 2.5 degree rainfall for June 1998



University of Delaware 0.5 degree gridded rainfall for June 1998

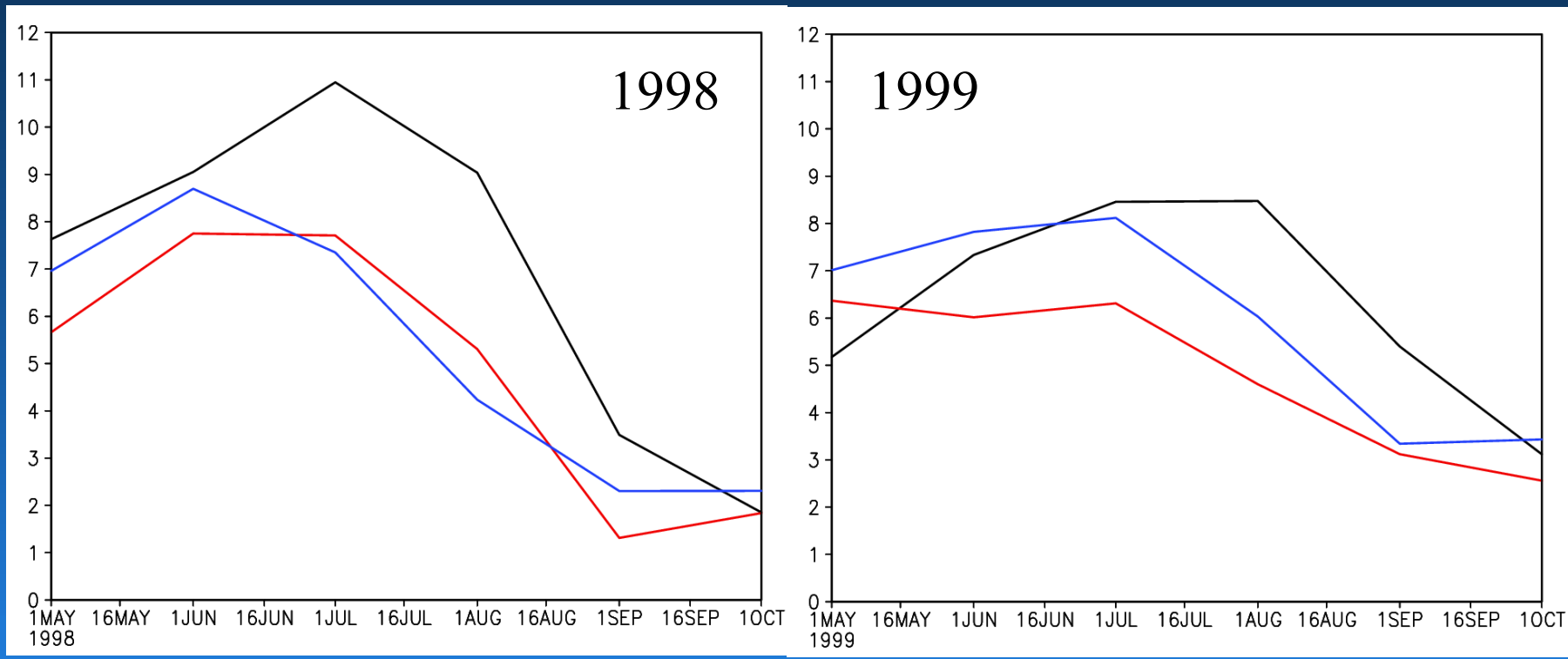




0.5 degree gridded station rainfall for June 1998

Regional Climate Modeling Team

Precipitation in the Eastern China (105-120°E & 25-35°N)



NCEP/NCAR Reanalysis precipitation (mm/month)

U. of Delaware precipitation (mm/month)

Modeled precipitation (mm/month)

Results

- A MODIS based BATS land cover/vegetation classification map was generated for the regional climate model
- A recent version of ICTP-RegCM3 with sub-grid feature was set up for the study area
- Several simulations were carried out to obtain the best performance for the physical parameterizations, especially for the cumulus schemes
- Model has been running for the control simulation

Project Progress Summary and Outlook

- Year 01 work: Everything On-schedule
- Year 02:
  - LCLU simulations
  - Watershed monitoring and characterization (summer field campaign)
  - Watershed model development and testing (DHSVM)
  - Climate model continued testing and beginning experimental runs


Thank You