Land Cover and Land Use Change in Temperate East Asia: Impacts on Carbon Fluxes and Land Productivity

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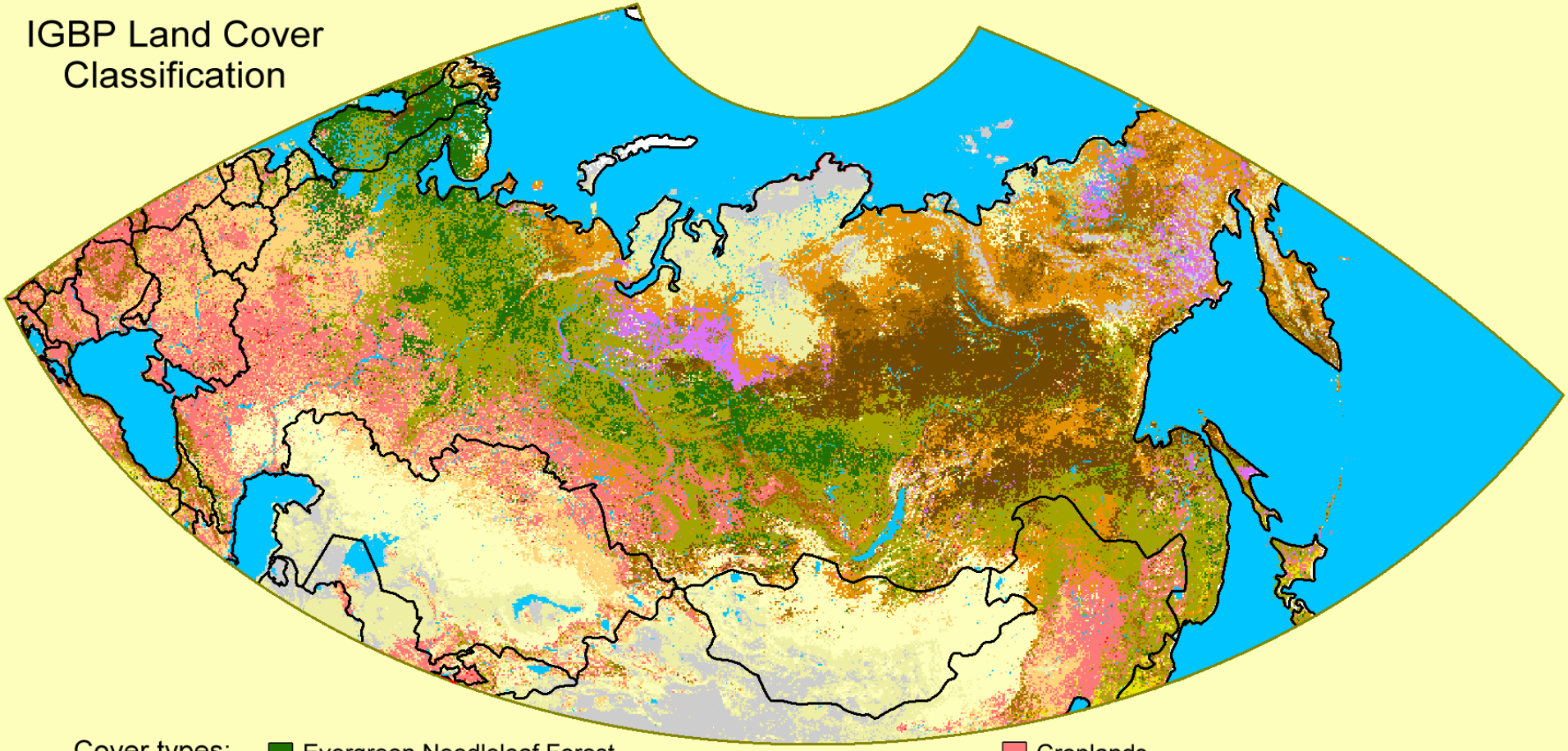
2001 – 2004

NASA LCLUC Science Meeting, January 19-22, 2004

IGBP Land Cover Classification



Cover types:

- Evergreen Needleleaf Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Decidous Braodleaf Forest
- Mixed Forest
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up
- Cropland/Natural Vegetation Mosaic
- Snow and Ice
- Barren or Sparsely Vegetated
- Water Bodies

MAJOR DRIVERS

- ECONOMIC LIBERALIZATION
- URBAN GROWTH
- POPULATION GROWTH
- ENVIRONMENTAL POLICY
- CLIMATE CHANGE

LUTEA INTEGRATED ANALYSIS

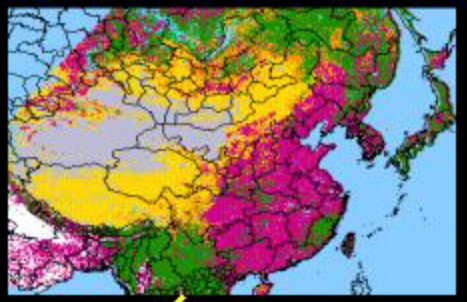
CLIMATE

- RADIATION
- TEMPERATURE
- PRECIPITATION

ENVIRONMENT

- WATER
- TOPOGRAPHY
- SOIL

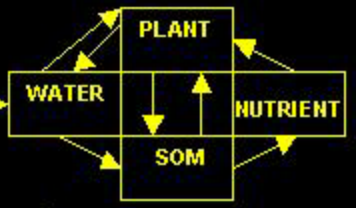
TEMPORATE EAST ASIA LANDCOVER (TEAL)



LAND USE MANAGEMENT

- CROPS
- GRAZING
- LIVESTOCK
- FOREST
- URBAN

ECOSYSTEM

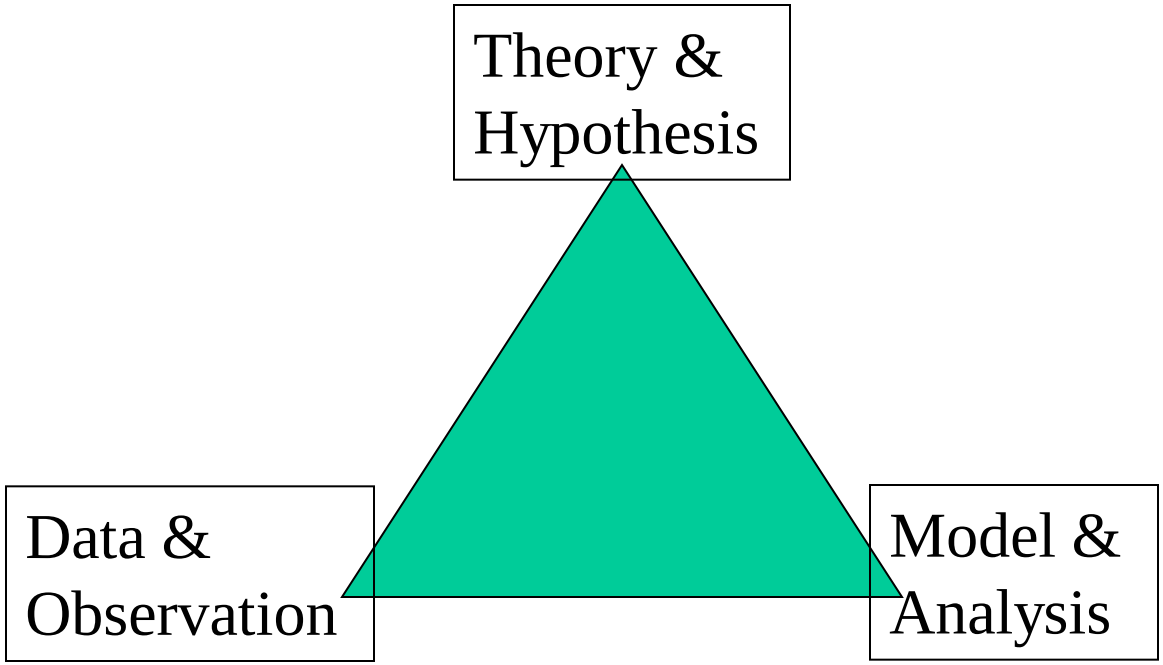


REGIONAL ASSESSMENT

SOCIAL SCIENCE

- CULTURE
- DEMOGRAPHY
- ECONOMICS
- POLICY

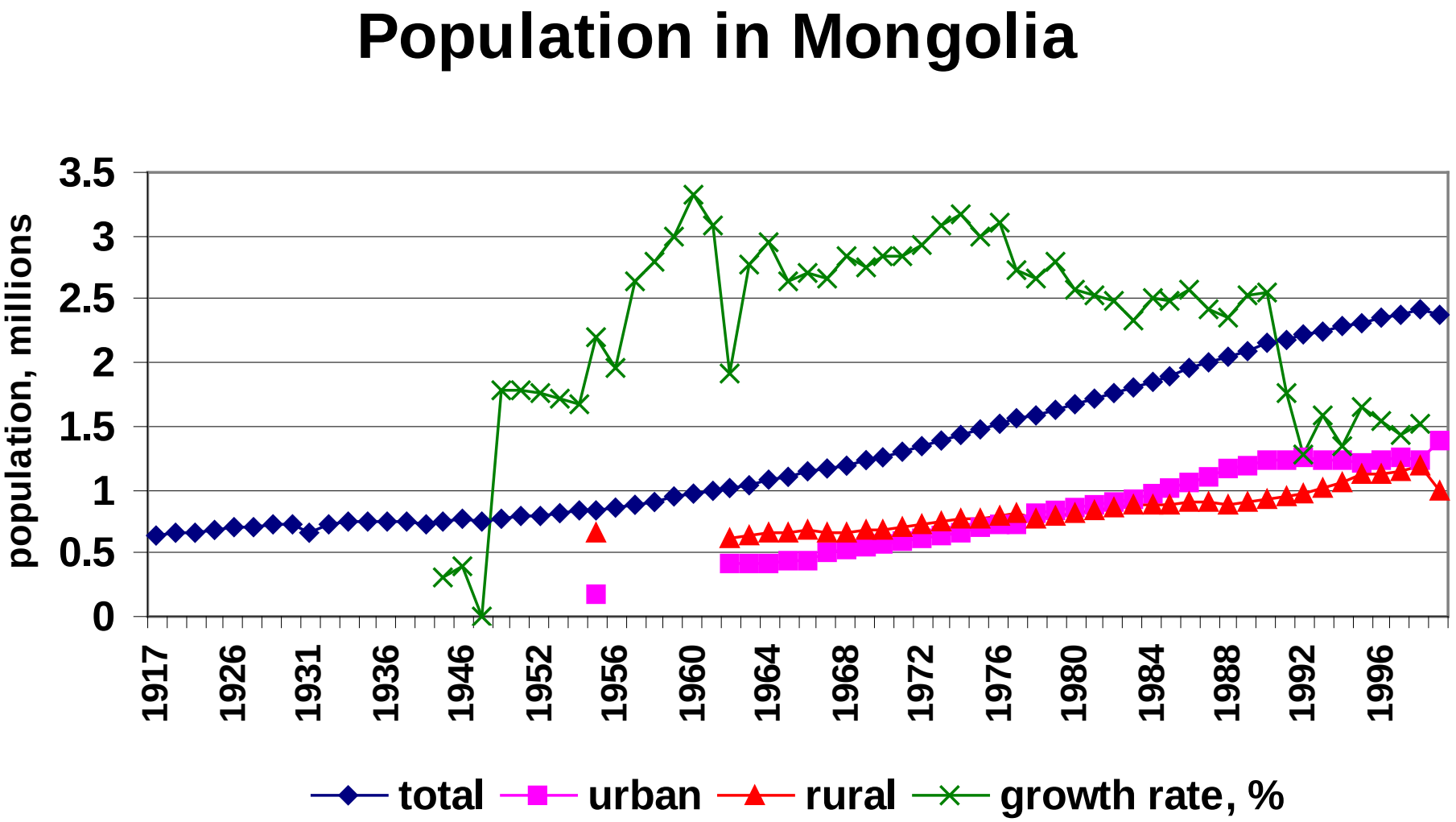
Organization chart for the presentation



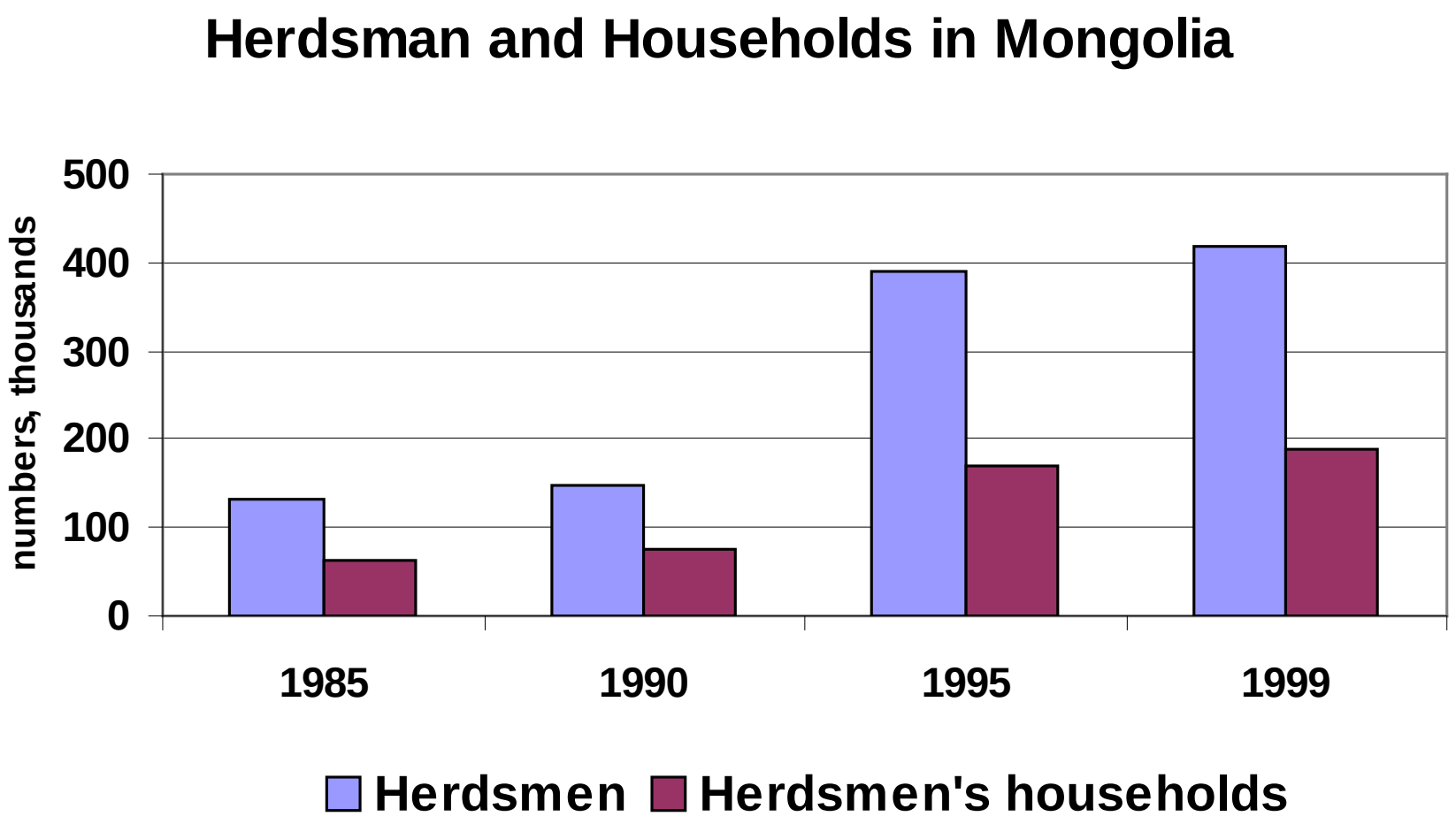
Data and Observation

	Rangelands million ha	Croplands million ha	Collectivization	Privatization
Mongolia	123	1.35	Late 1950's	Early 1990's
Inner Mongolia	63	8	In 1950's	Early 1980's
Central Asia	246	43	In 1930's	Mid 1990's

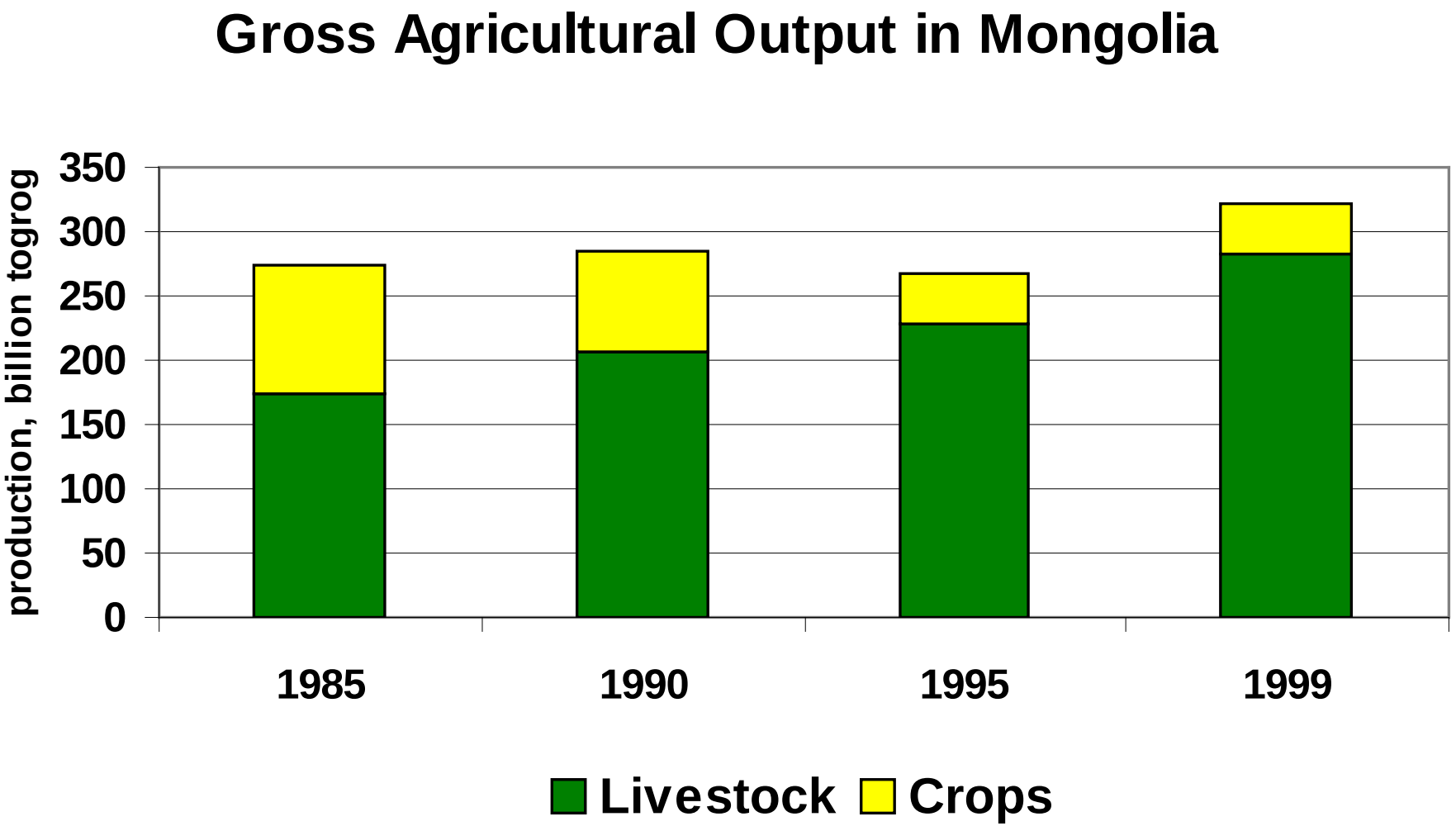
Data and Observation



Data and Observation



Data and Observation

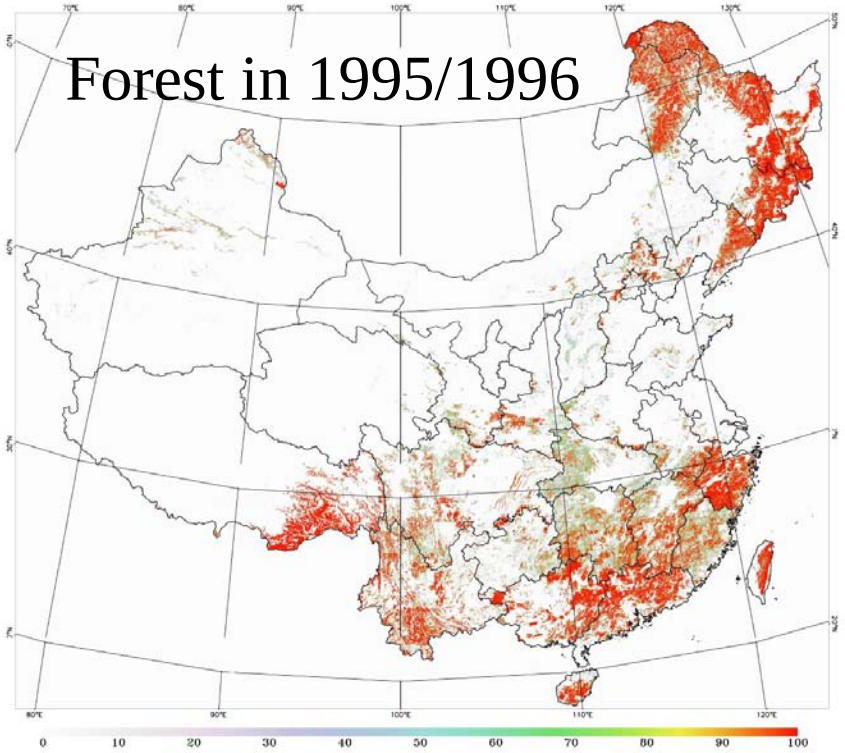


Data and Observation

National Land Cover Dataset in 1995/1996, 1999/2000, -- China

from classification of Landsat TM and ETM+ images

% land cover with 1-km pixels, 25 land cover types



From LIU, Jiyuan, Institute of Geographical Science and Natural Resources, Chinese Academy of Sciences, Beijing, China

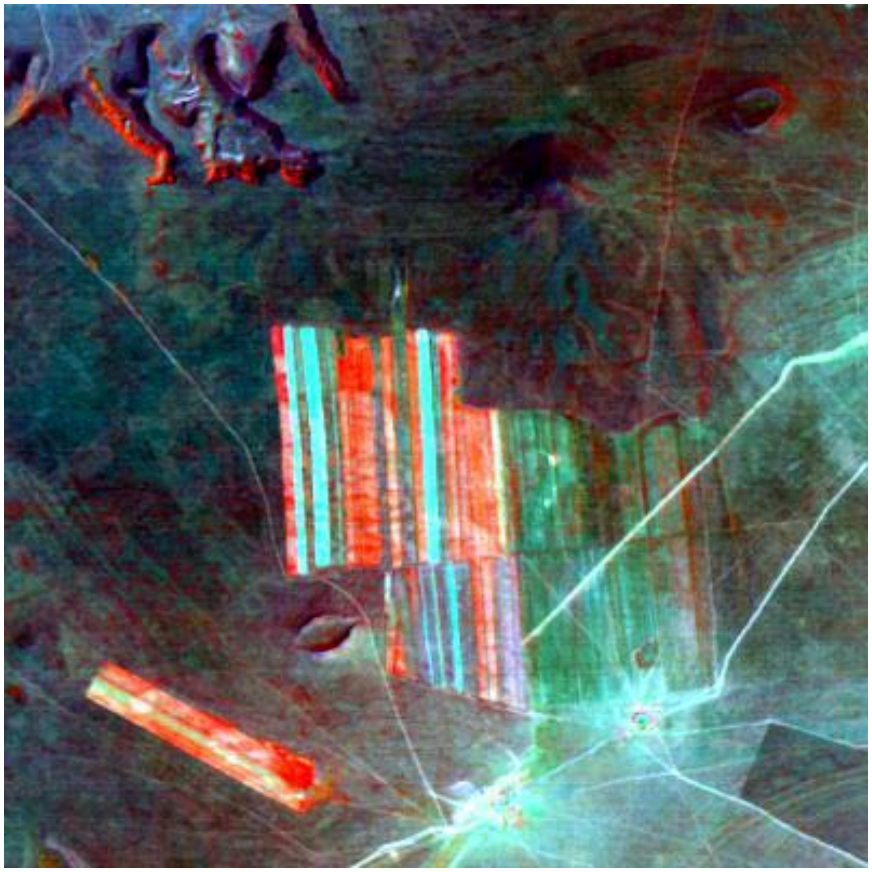
Data and Observation

Land use and land cover change

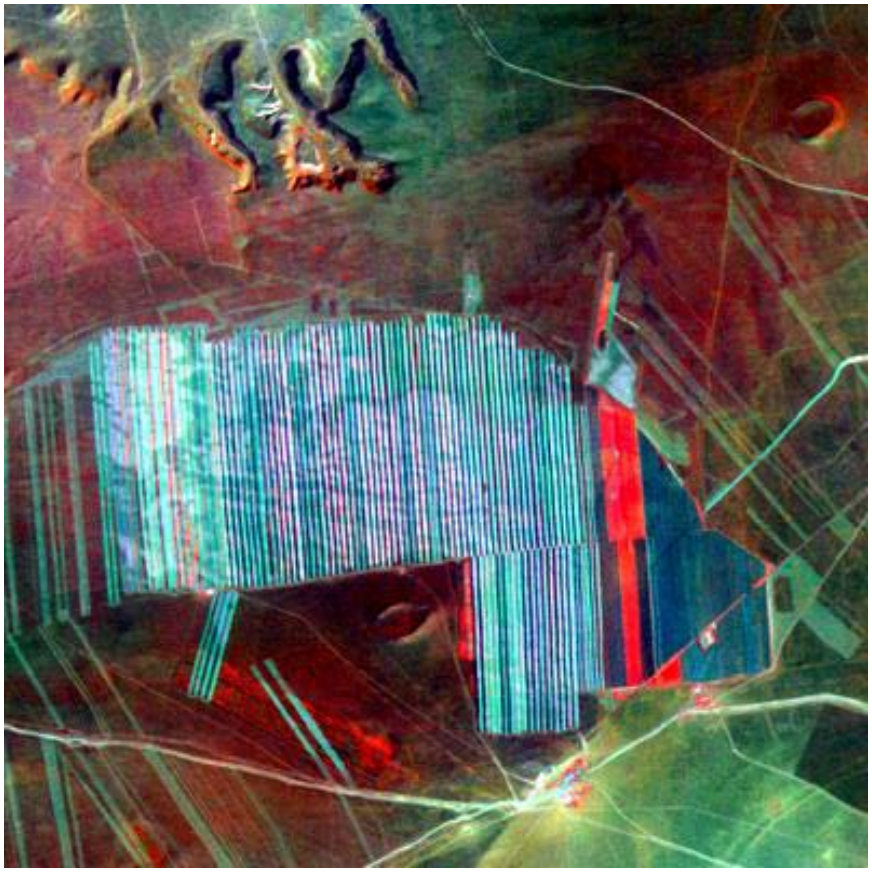
land cover conversion ----- grassland → cropland

Xilin River Basin, Inner Mongolia, China

(a) Landsat TM image on 7/31/1987

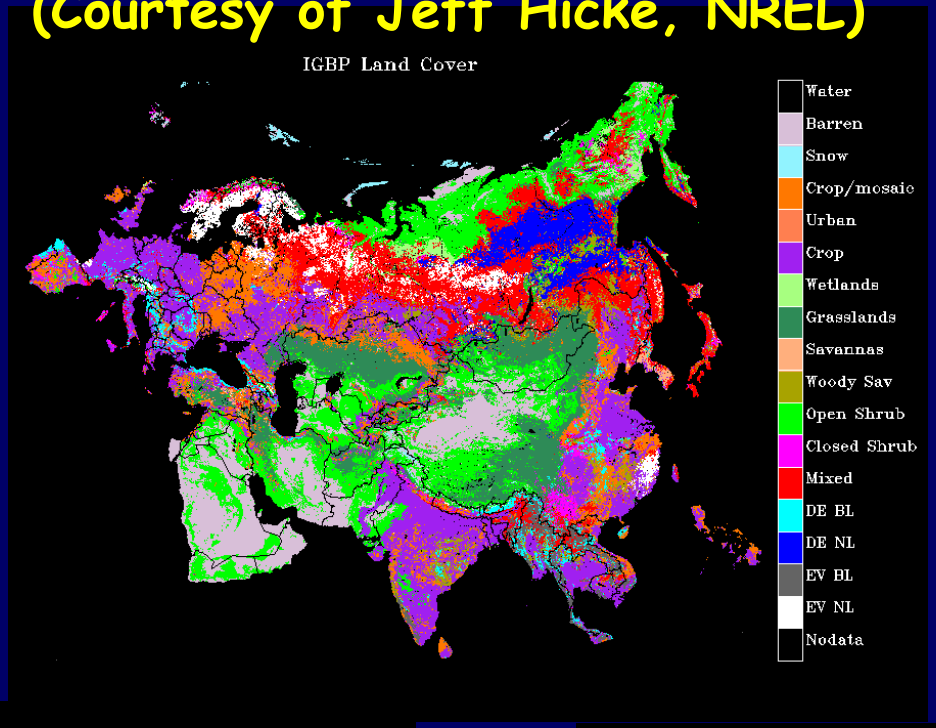


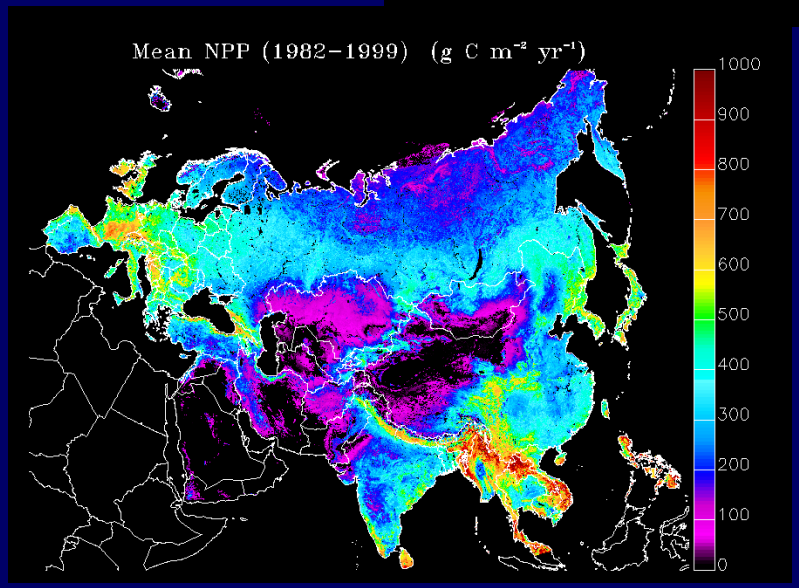
(b) Landsat TM image on 8/27/1997

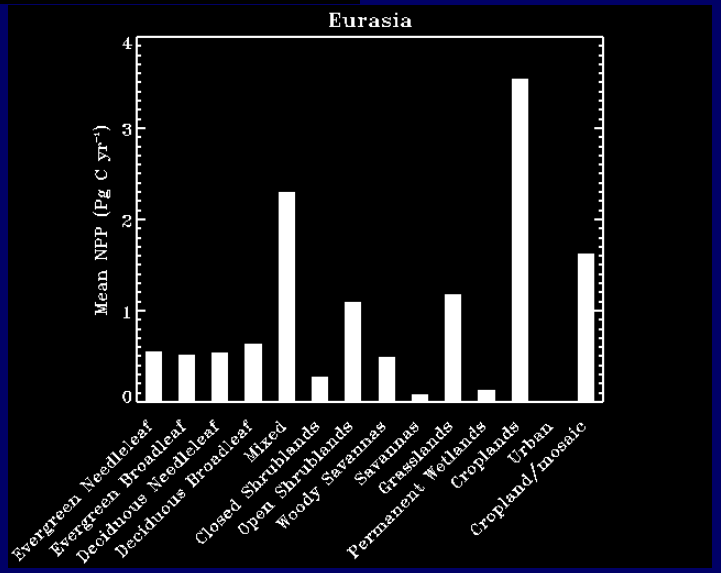


Biome distribution and mean NPP

(Courtesy of Jeff Hicke, NREL)

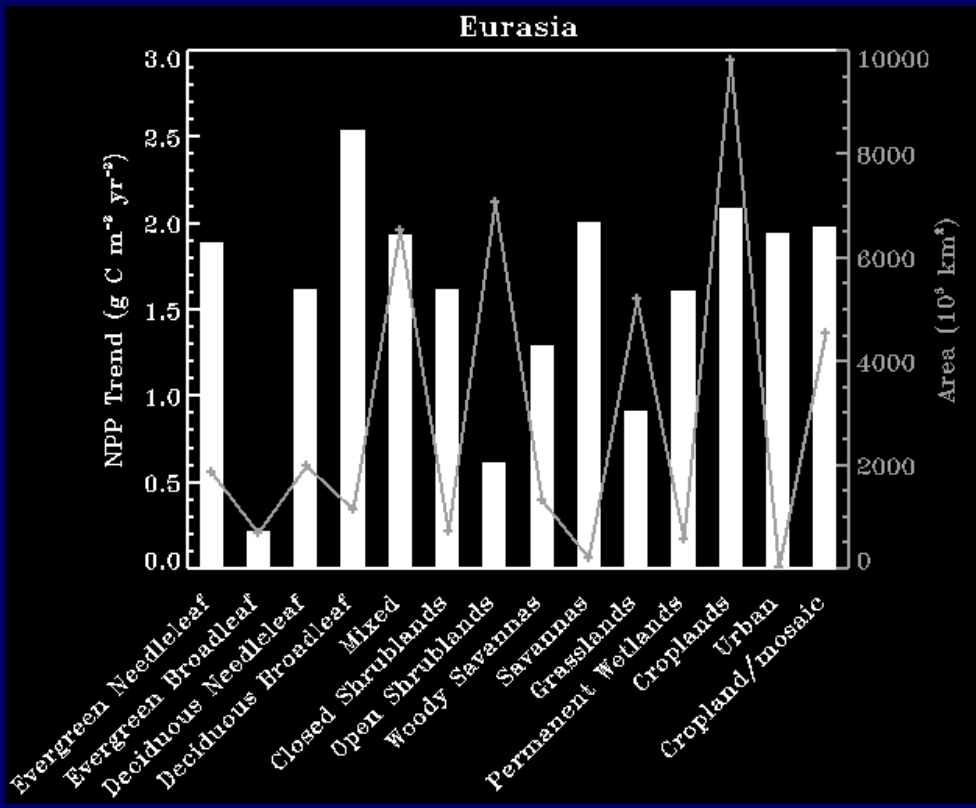




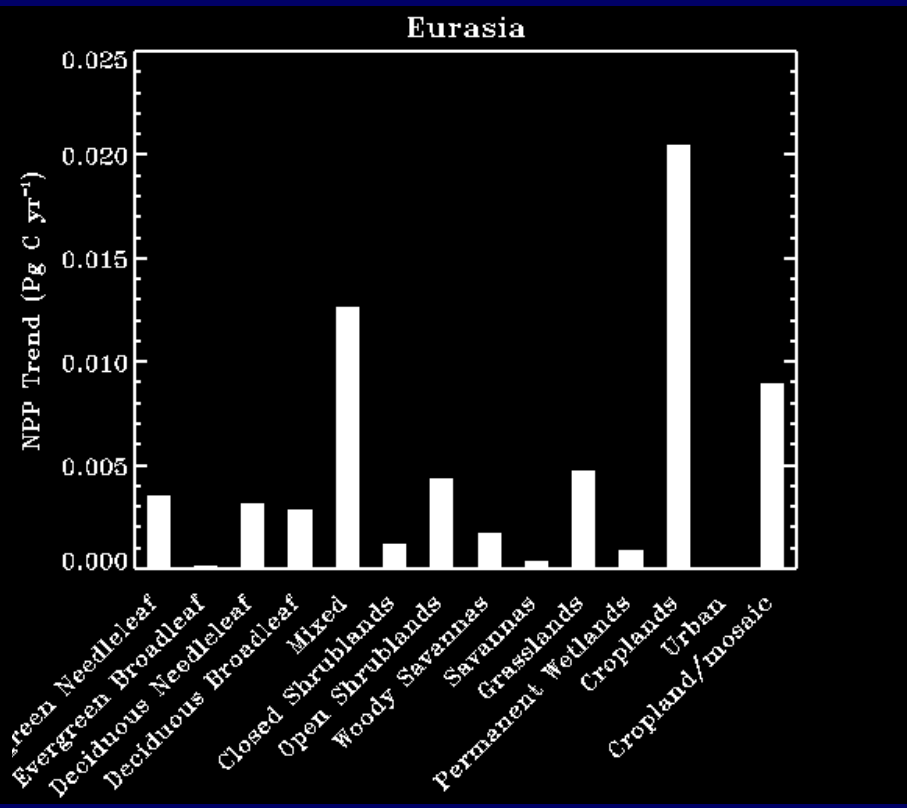


NPP trends by IGBP biome
(Courtesy of Jeff Hicke, NREL)

Mean NPP trend per unit area



NPP trend across biome area



Data and Observation

Improved vegetation indices datasets

Greenness-related vegetation indices

$$NDVI = (NIR - RED) / (NIR + RED)$$

$$EVI = G \times (NIR - RED) / (NIR + C1 \times RED - C2 \times BLUE + L)$$

Water-related vegetation index (Land Surface Water Index)

$$LSWI = (NIR - SWIR) / (NIR + SWIR)$$

Global datasets: from VEGETATION sensor onboard SPOT-4 satellite that has 4-spectral bands (blue, red, NIR, SWIR) and 1-km spatial resolution.

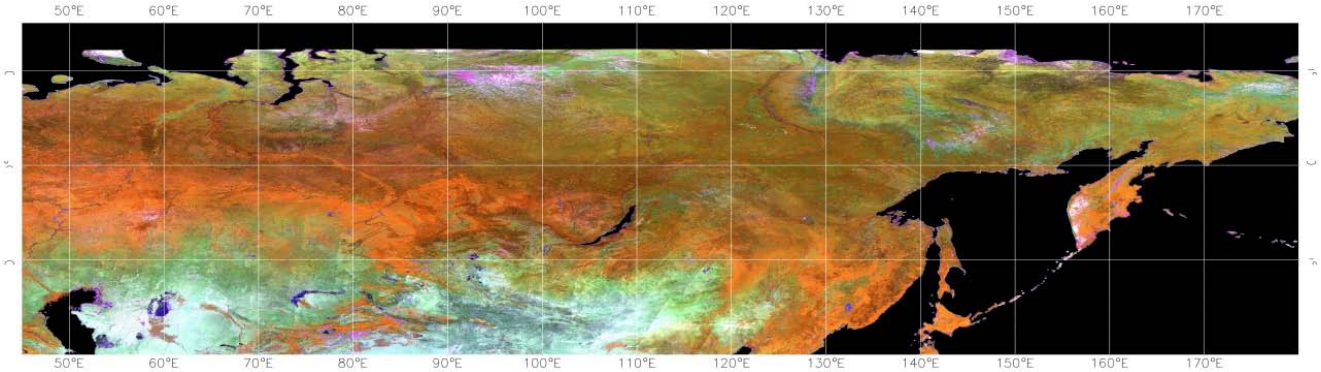
10-day composites from 4/1998 – 12/2002 (available)

Regional datasets for Asia: from MODIS 8-day composites (MOD09A1)

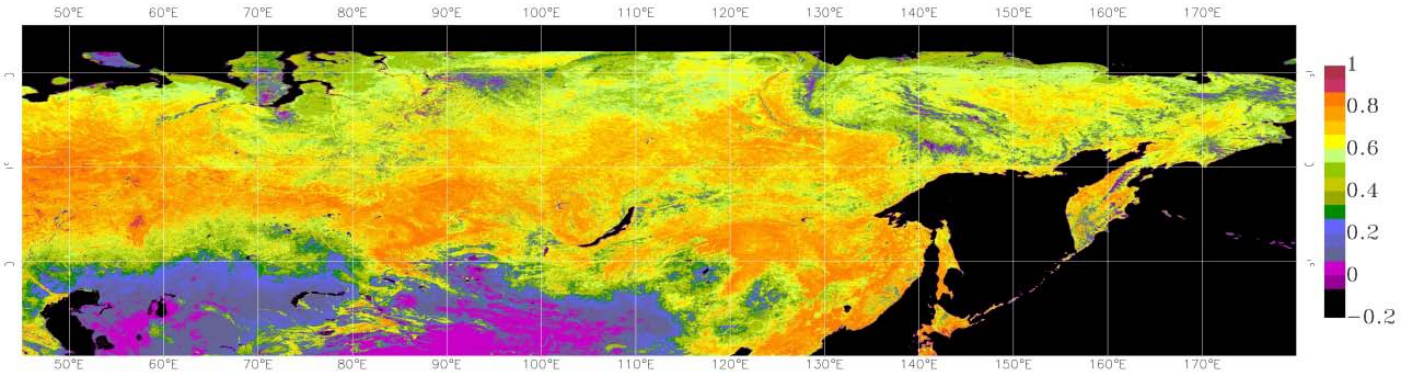
8-day composites from 1/2002 – 12/2002 (available).

Data and Observation

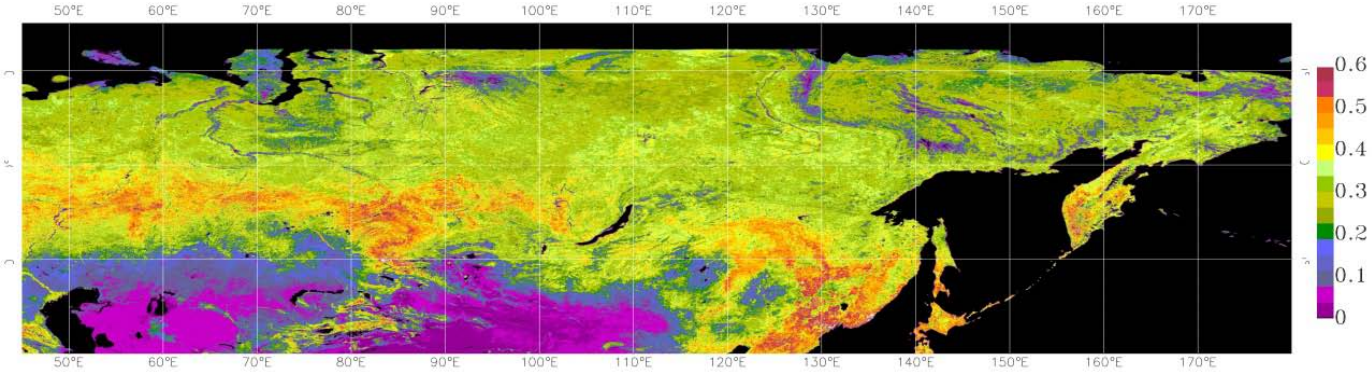
(a) False color composite (NIR-SWIR-Red), July 1-10, 2000



(b) NDVI, July 1-10, 2000



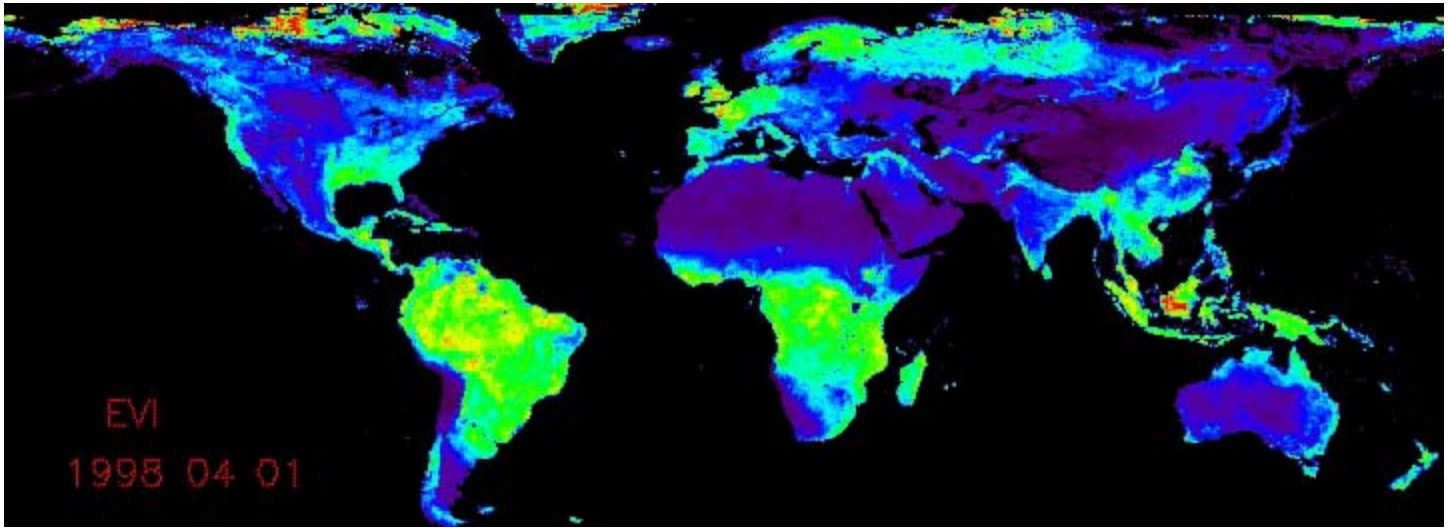
(c) EVI, July 1-10, 2000



Data and Observation

Spatial patterns and temporal dynamics of **Enhanced Vegetation Index (EVI)** at the global scale

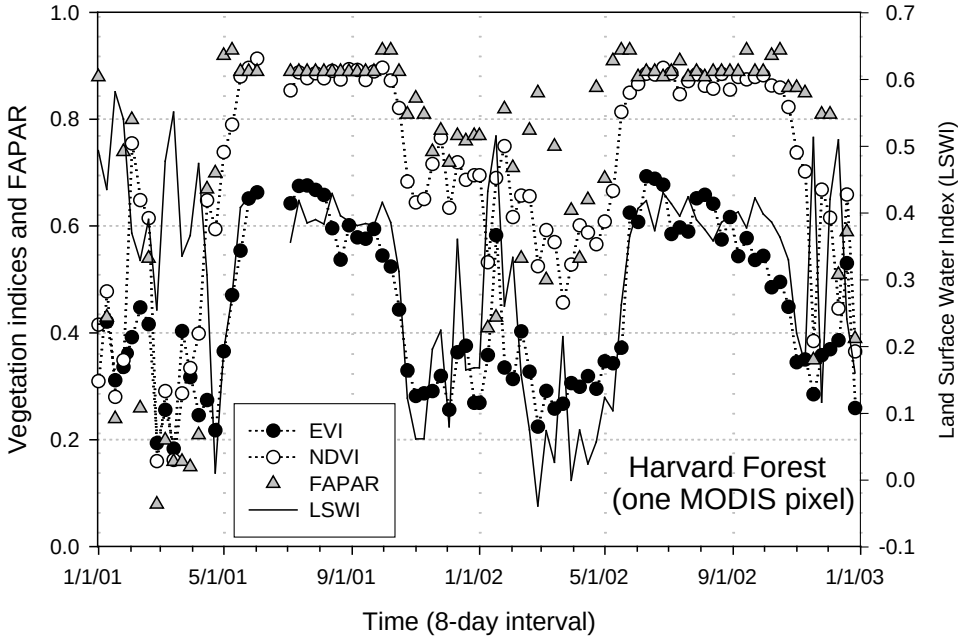
starting at 4/1-10, 1998, (strong La Nina in 1998/1999, after strong El Nino in 1997/1998)

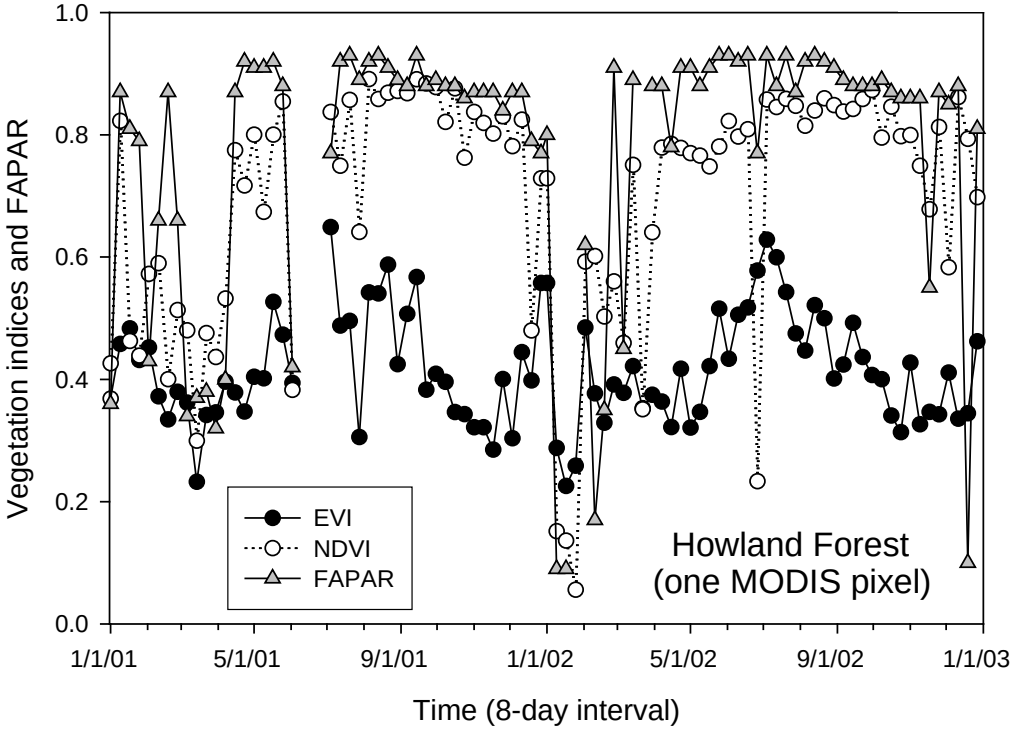


Theory and Hypothesis

Hypothesis #1.

Advanced vegetation indices (e.g., EVI, LSWI) will improve land cover characterization, e.g., phenology, classification.





Greenness and LAI

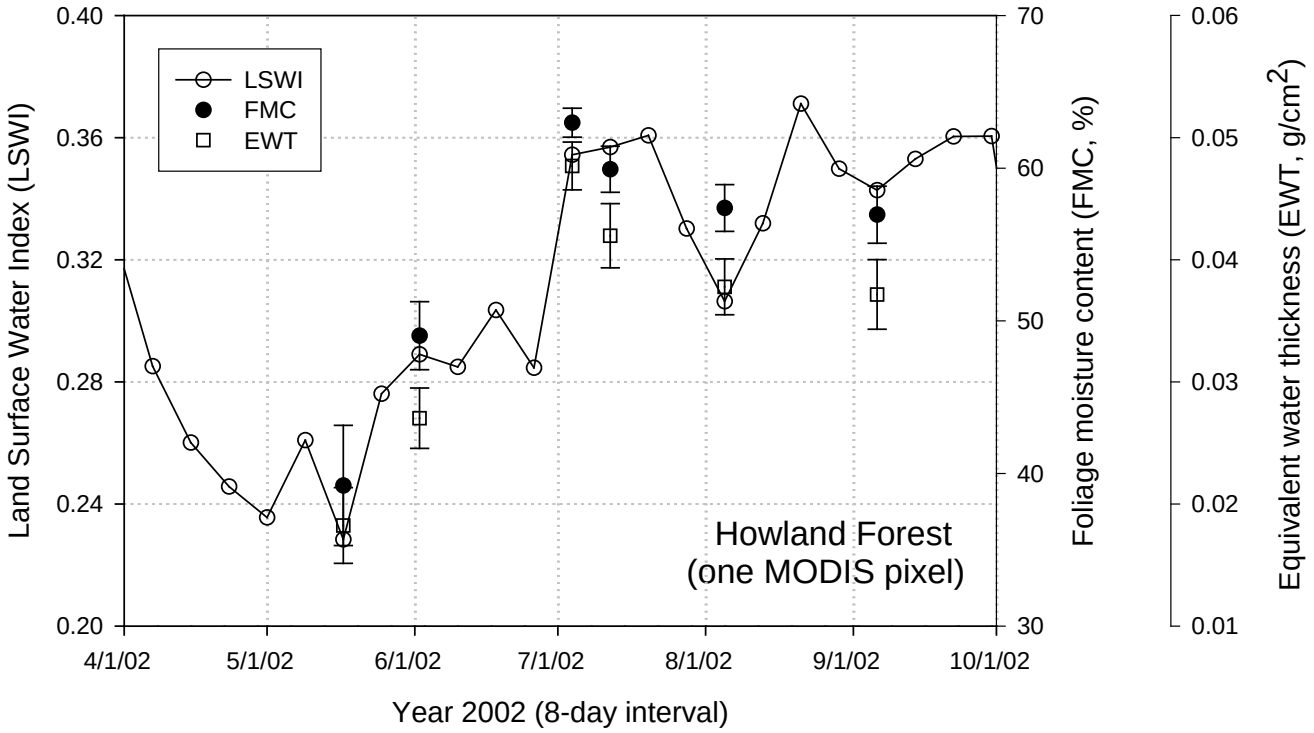
EVI, NDVI

Hypothesis #1 (continue).

Advanced vegetation indices (e.g., EVI, LSWI) will improve land cover characterization, e.g., phenology, classification.

Leaf and canopy water content

LSWI



Model and Analysis

Hypothesis #1

Advanced vegetation indices (e.g., EVI, LSWI) will improve land cover characterization, e.g., phenology, classification.

Land cover classification in Northeastern China

Time series input data: NDVI + LSWI versus NDVI

Xiao, X., *et al*., 2002, Remote Sensing of Environment, 82, 335-348

Regional-scale comparison between NDVI and EVI

Xiao, X., *et al*., 2003, Remote Sensing of Environment, 84, 385-392.

Land cover classification in temperate East Asia

Time series input data: EVI + LSWI versus NDVI

Boles, S., Xiao, X., *et al*., 2004, Remote Sensing of Environment, (in revision)

Hypothesis #2.

Advanced vegetation indices (e.g., EVI, LSWI) will improve modeling of land productivity.

LAI-centered algorithms

$GPP = \varepsilon_g \times FAPAR \times PAR$

$NPP = \varepsilon_n \times FAPAR \times PAR$

$FAPAR = f(NDVI)$

$NDVI = f(LAI)$

$FAPAR = a \times (1 - e^{-k \times LAI})$

CASA

Glo-PEM

MODIS-PSN

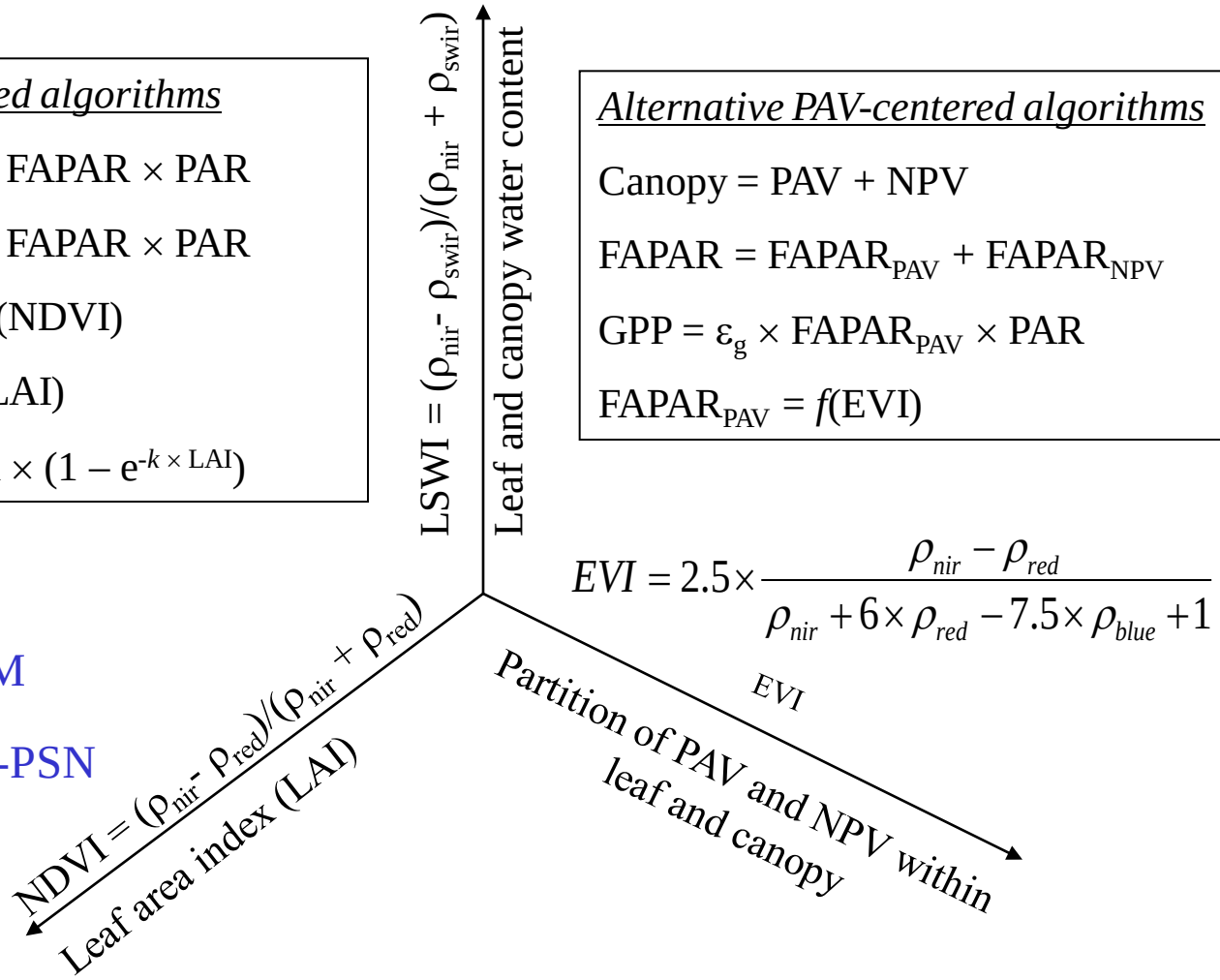
Alternative PAV-centered algorithms

$Canopy = PAV + NPV$

$FAPAR = FAPAR_{PAV} + FAPAR_{NPV}$

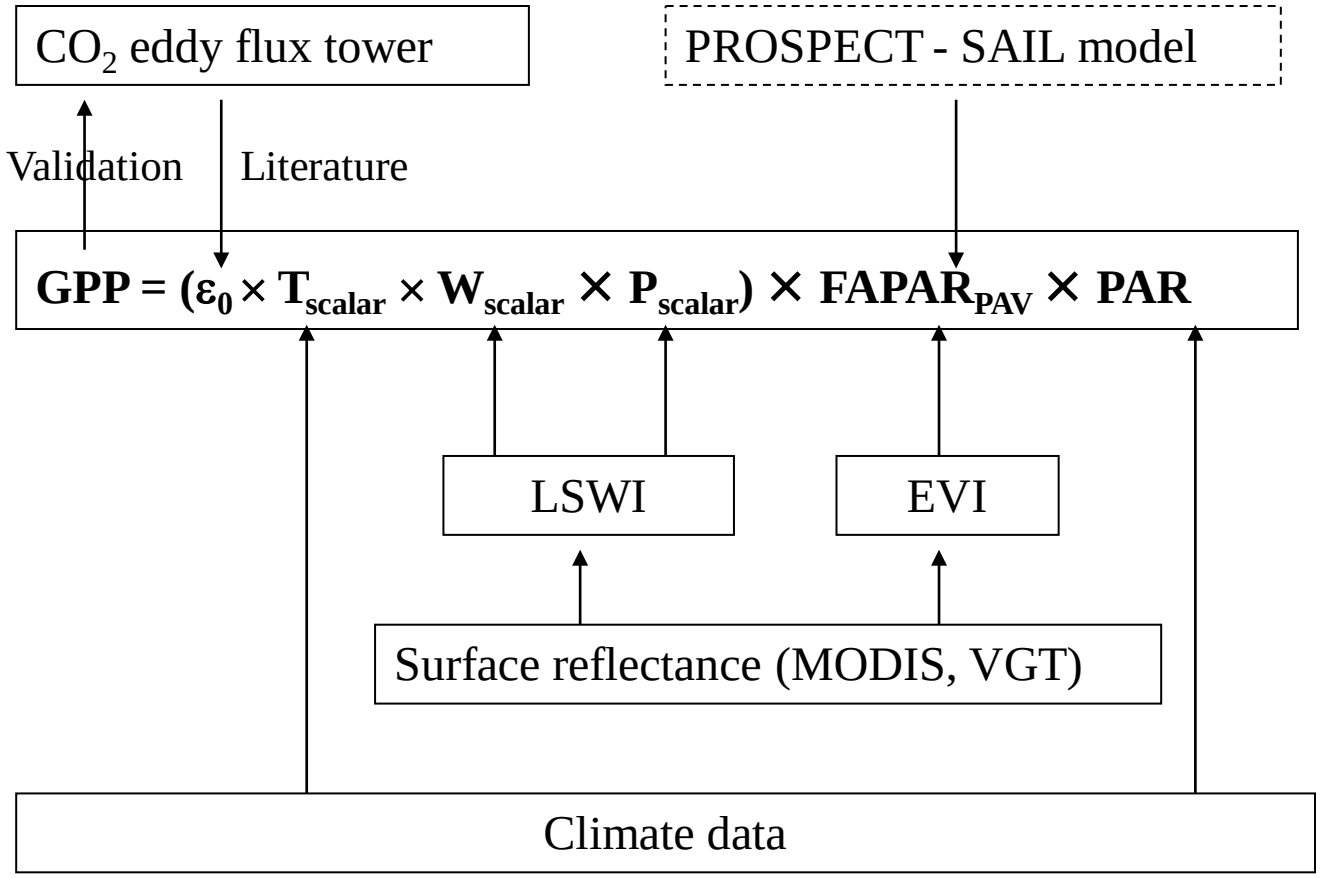
$GPP = \varepsilon_g \times FAPAR_{PAV} \times PAR$

$FAPAR_{PAV} = f(EVI)$



Model and Analysis

Model structure of **Vegetation Photosynthesis Model (VPM)**

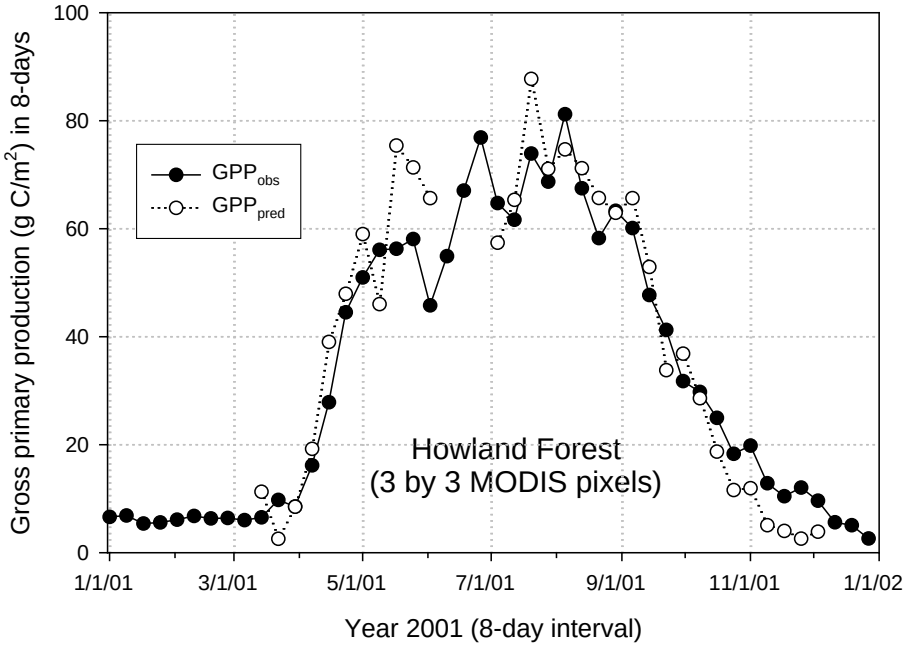


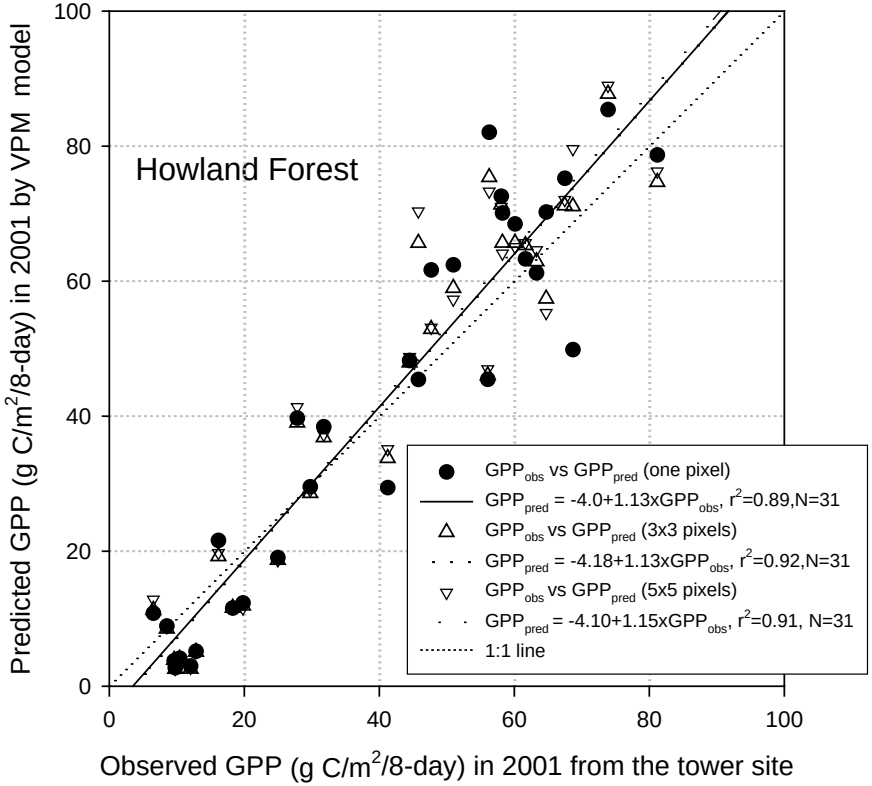
Major advantages: (1) VPM model does not need a soil water model, precipitation and vapor pressure deficit, which have large spatial heterogeneity, e.g., soil depth, soil texture.

(2) VPM model is largely driven by satellite-data and serves as an independent diagnostic tool, e.g., for evaluating process-based biogeochemical models.

Validation of VPM for evergreen needleleaf forest

site-specific CO_2 flux and climate data (from David Hollinger)



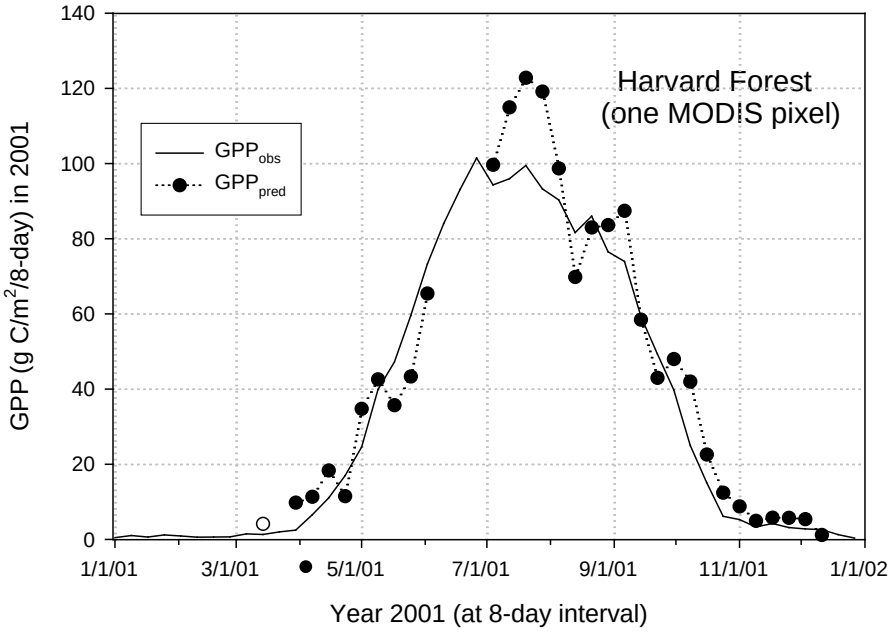


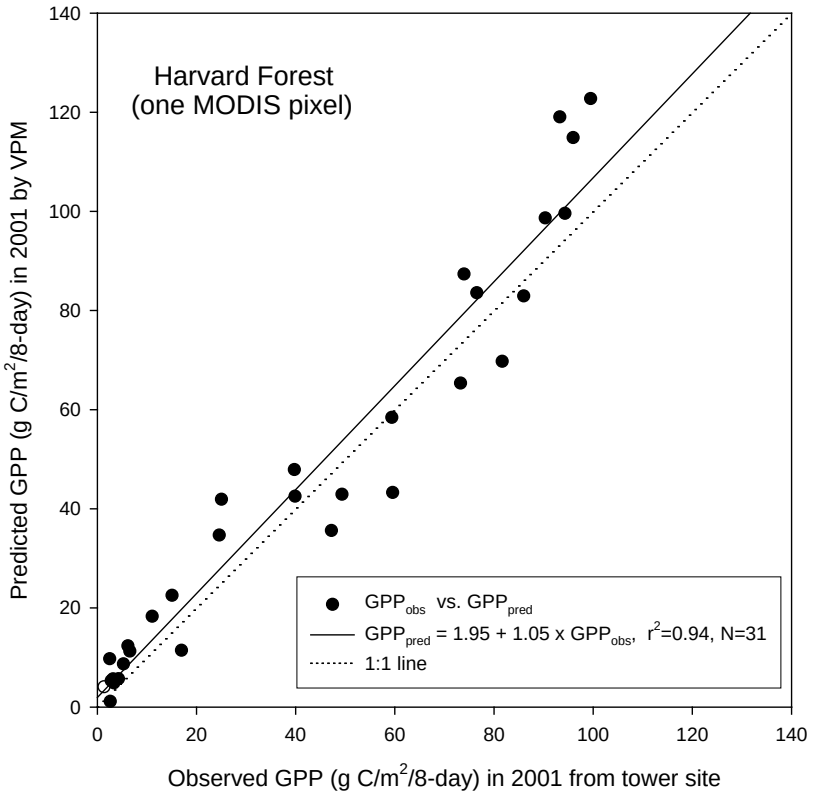
Xiao, X., *et al*., 2003, Remote Sensing of Environment, (in press)

Xiao, X., *et al*., 2004, Journal of Geophysical Research - Atmosphere, (in revision)

Validation of VPM model for deciduous broadleaf forest

site-specific CO_2 flux and climate data (from Stephen Wofsy)



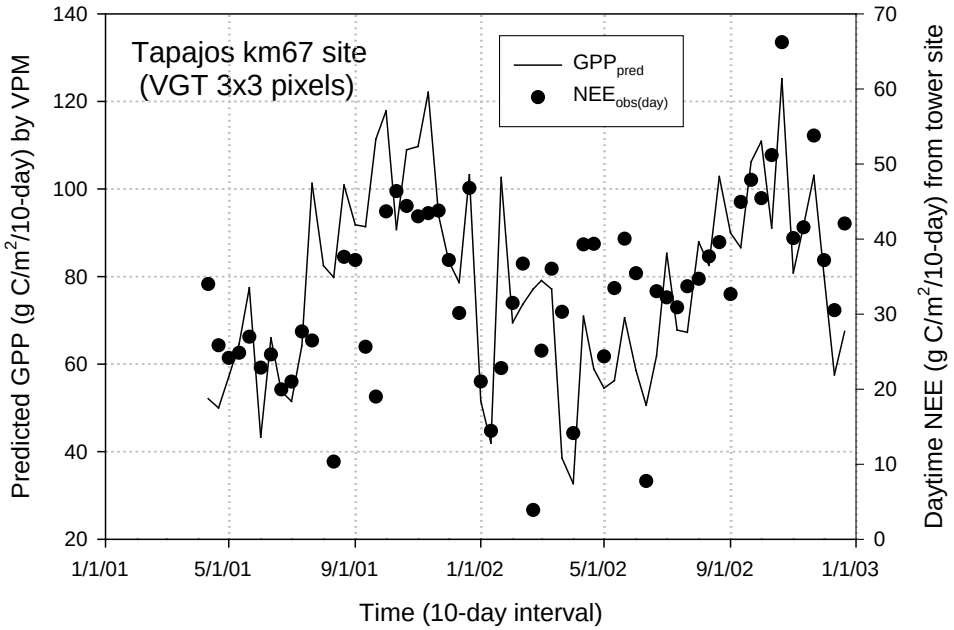


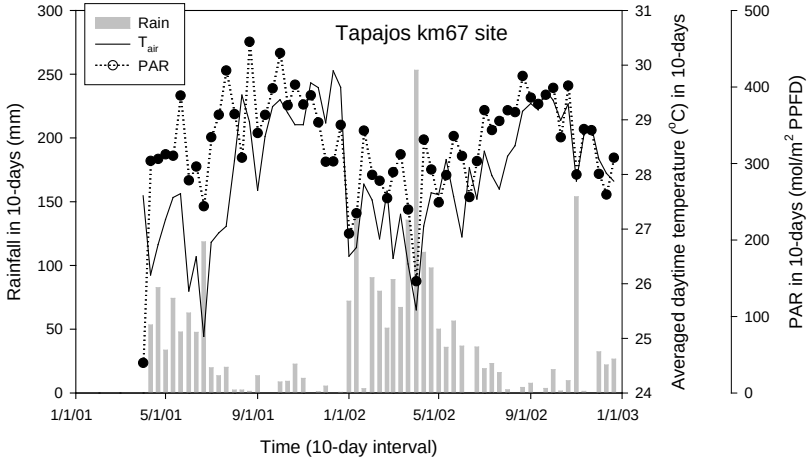
Xiao *et al*., 2003, Remote Sensing of Environment, (in review)

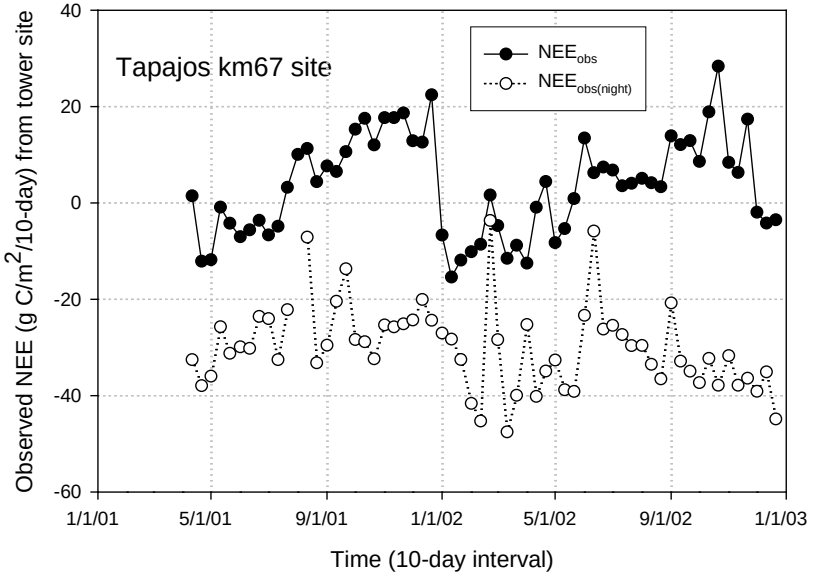
Model and Analysis

Validation of VPM model for evergreen tropical forest

site-specific CO_2 flux and climate data (from Saleska, S., *et al.*, *2003*)



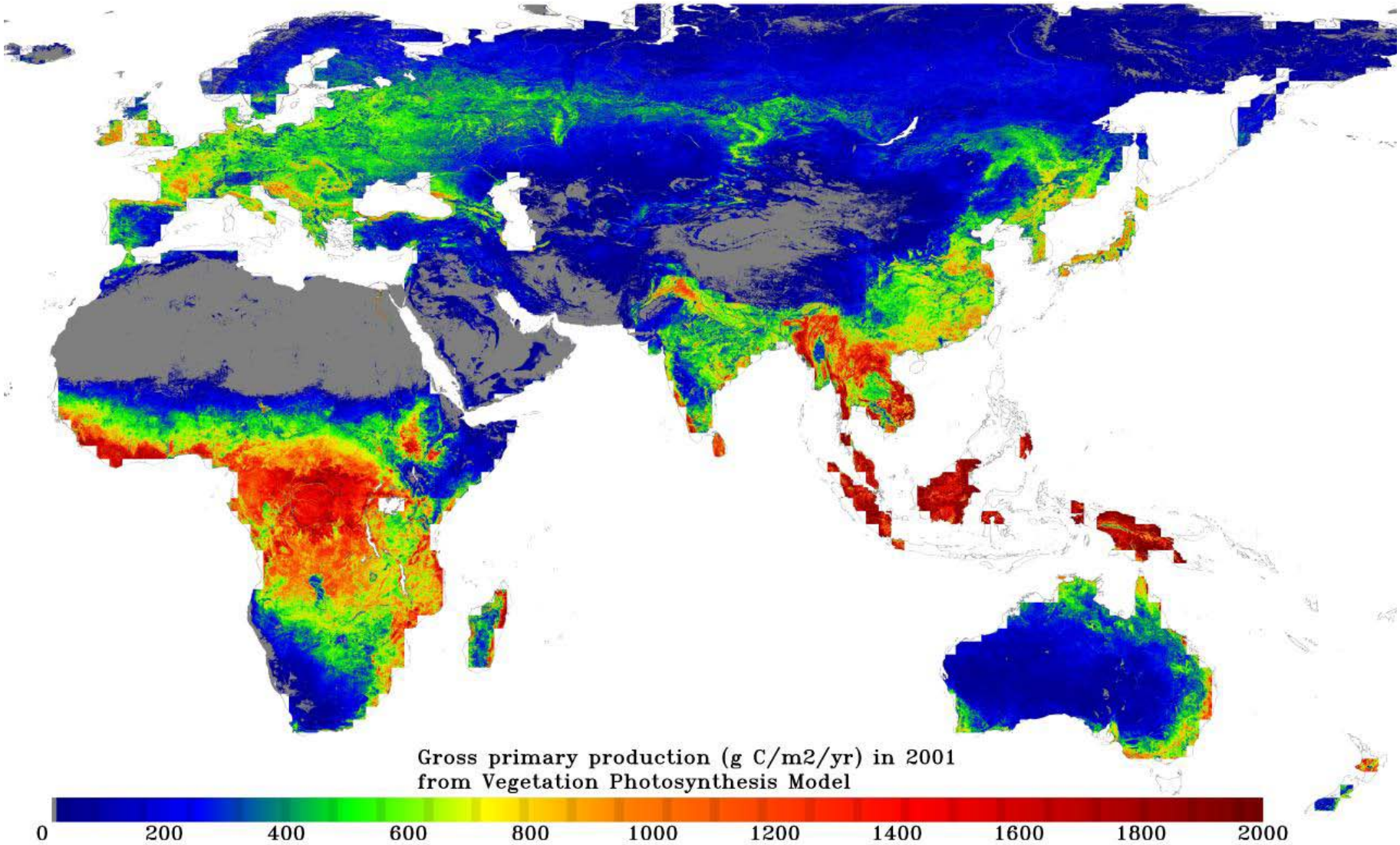




Xiao, X., *et al.*, in preparation

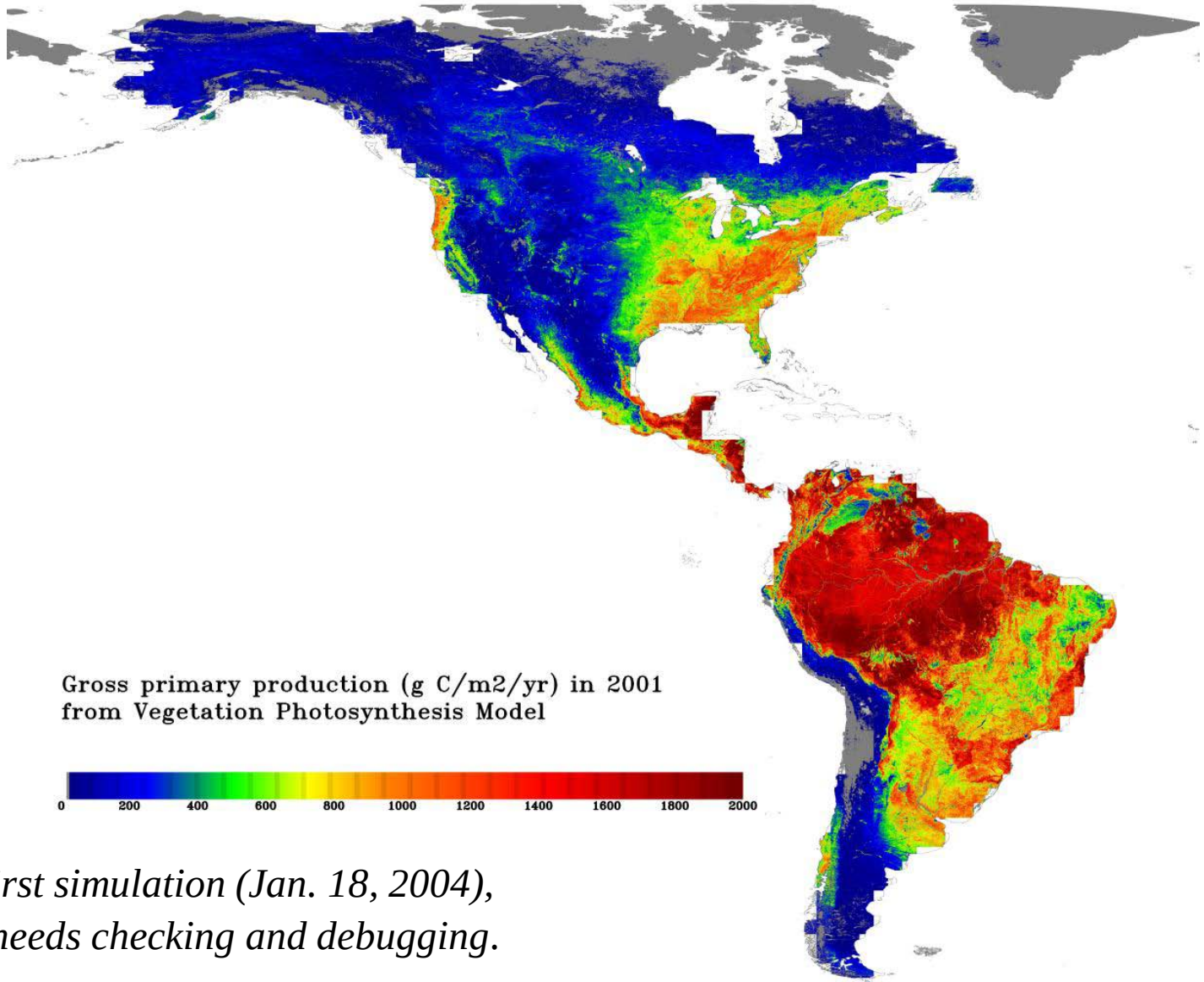
Model and Analysis

Global simulation of **Vegetation Photosynthesis Model**



Model and Analysis

Global simulation of **Vegetation Photosynthesis Model**



It is the first simulation (Jan. 18, 2004),
and still needs checking and debugging.

Future actions

1. Continue validation of VPM model for non-forest biomes (e.g., grassland, shrubland, tundra);

2. Regional simulations of VPM model for temperate East Asia – Diagnostic analysis;

3. Integration of VPM model and Century model --- Diagnostic analysis;

4. Regional simulations of Century model for future scenarios – Prognostic analysis.

SUMMARY OF PROGRESS

- Partnerships with Mongolian Ministry of Nature and Environment and with Chinese Academy of Sciences
- Ecosystem parameterization of major land use systems
- Land use change analyses through AVHRR, SPOT-Vegetation, MODIS, and TM
- Regional Land Productivity relative to climate variability and land use change
- Specific products associated with desertification and degradation of land resources