

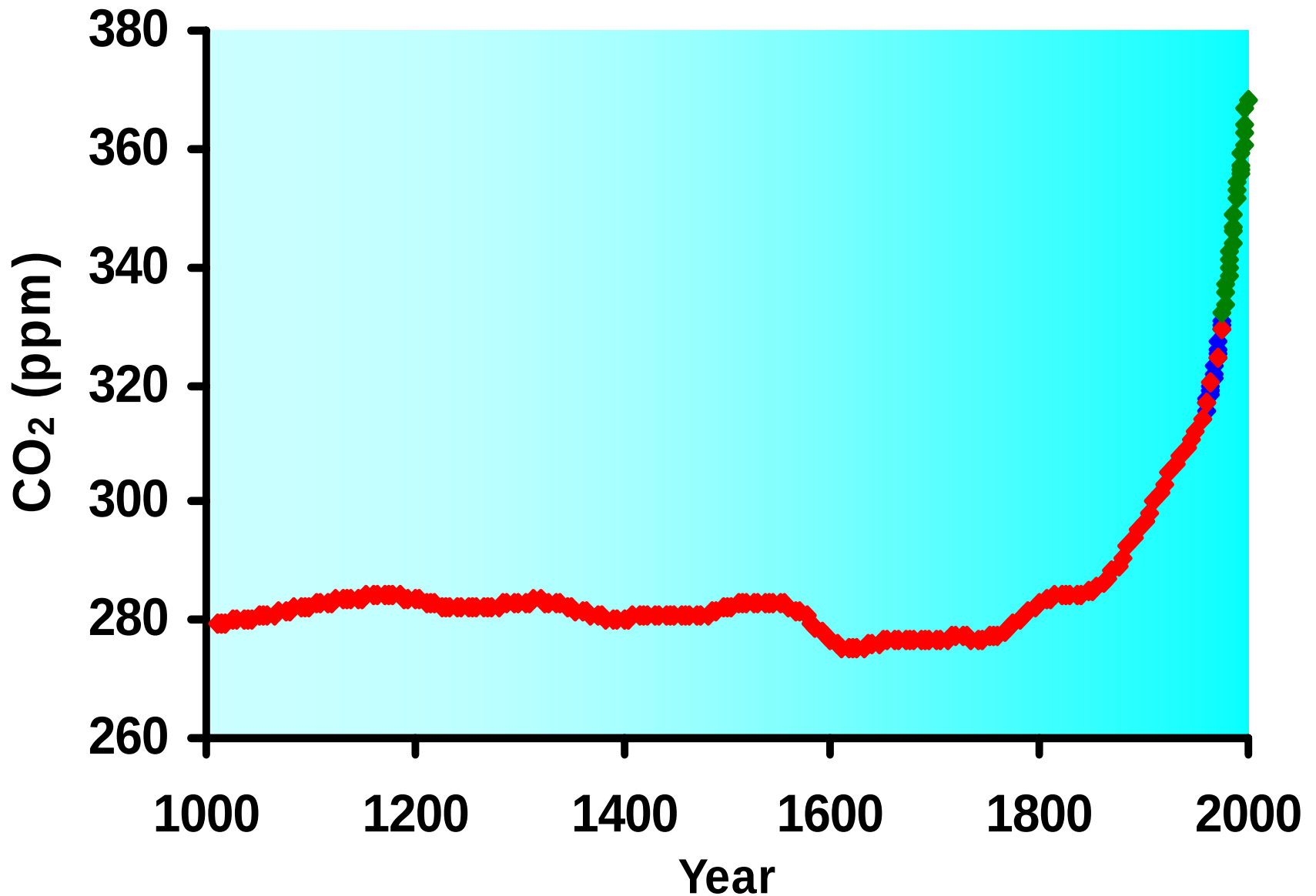
Human-Induced Change in Biogeochemical and Hydrological Cycles: Regional Analysis and Synthesis

Hanqin Tian (田汉勤)

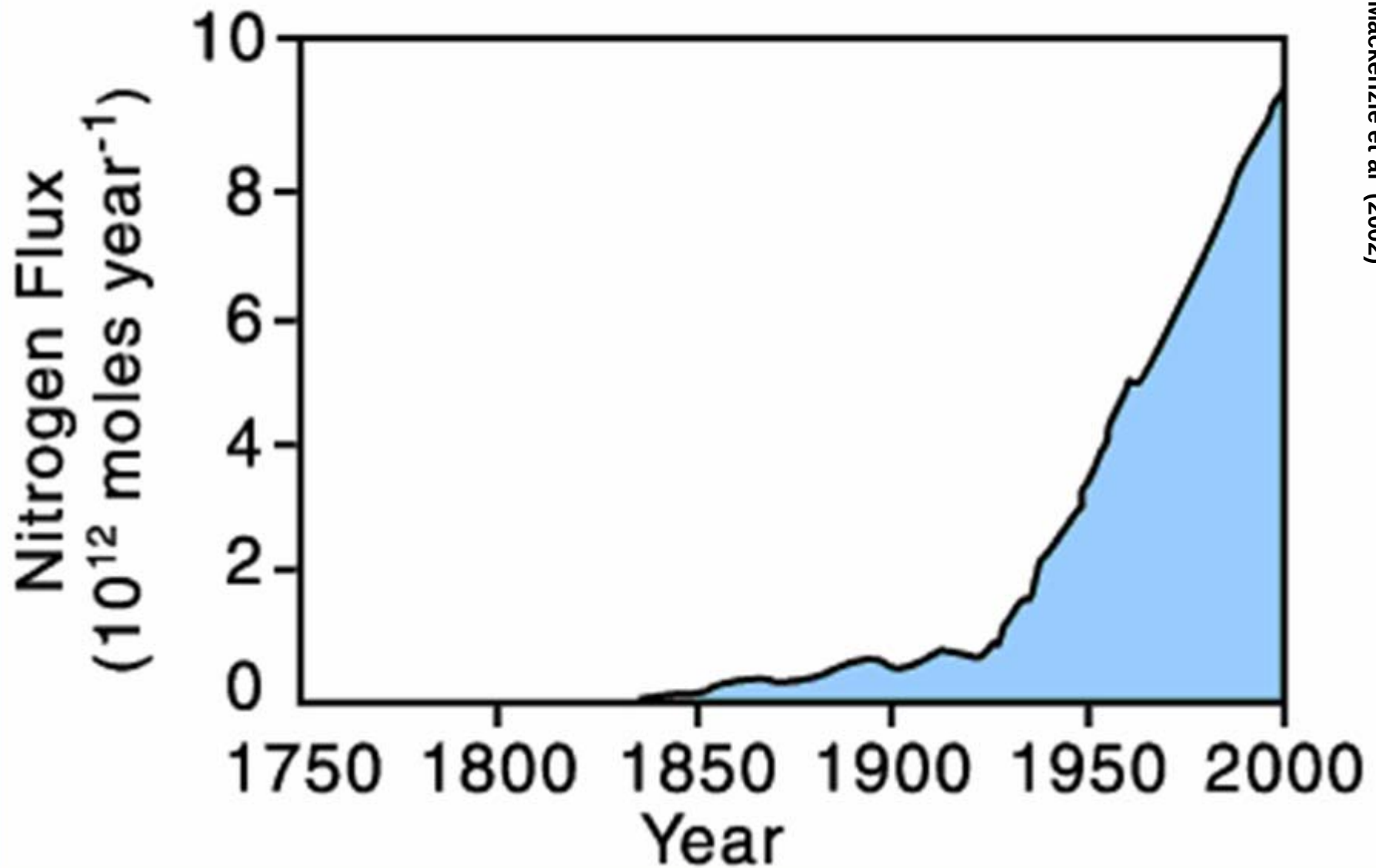
AUBURN UNIVERSITY
School of Forestry and Wildlife Sciences
Auburn, AL 36849, USA

Human-Induced Changes in the Global Environment

1000 year history of Atmospheric CO₂ concentration

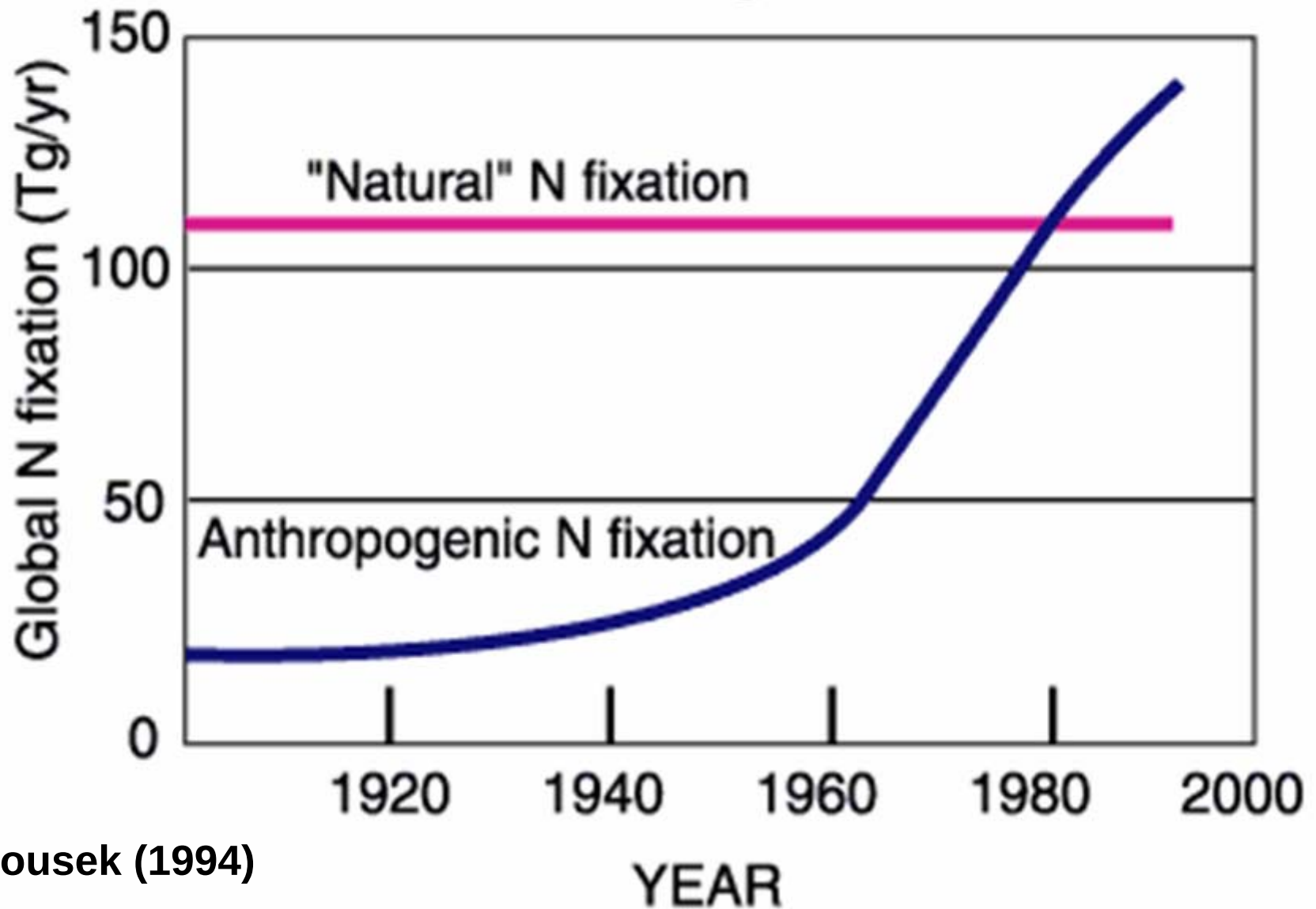


Nitrogen Flux to Coastal Zone



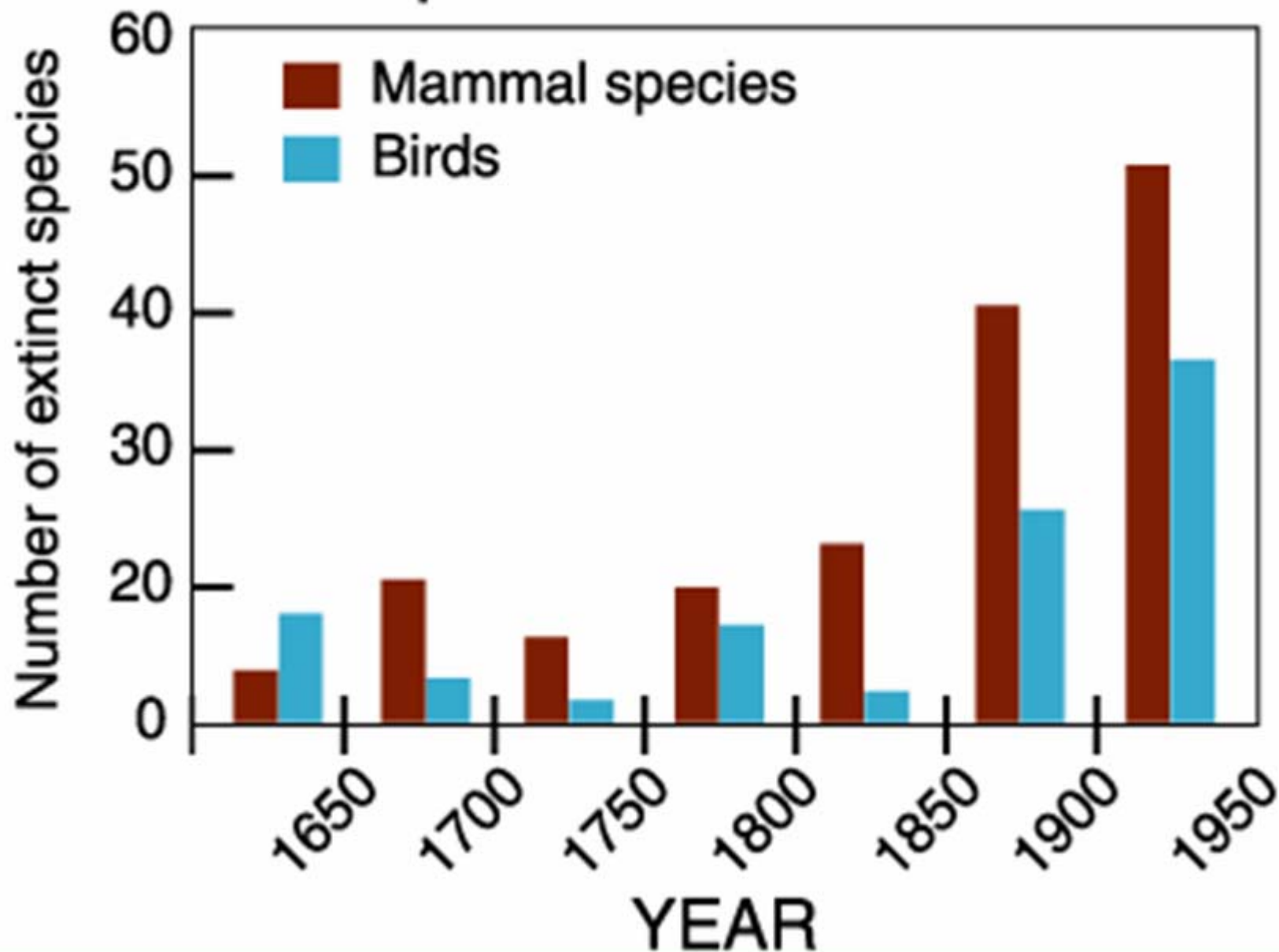
Mackenzie et al (2002)

Nitrogen

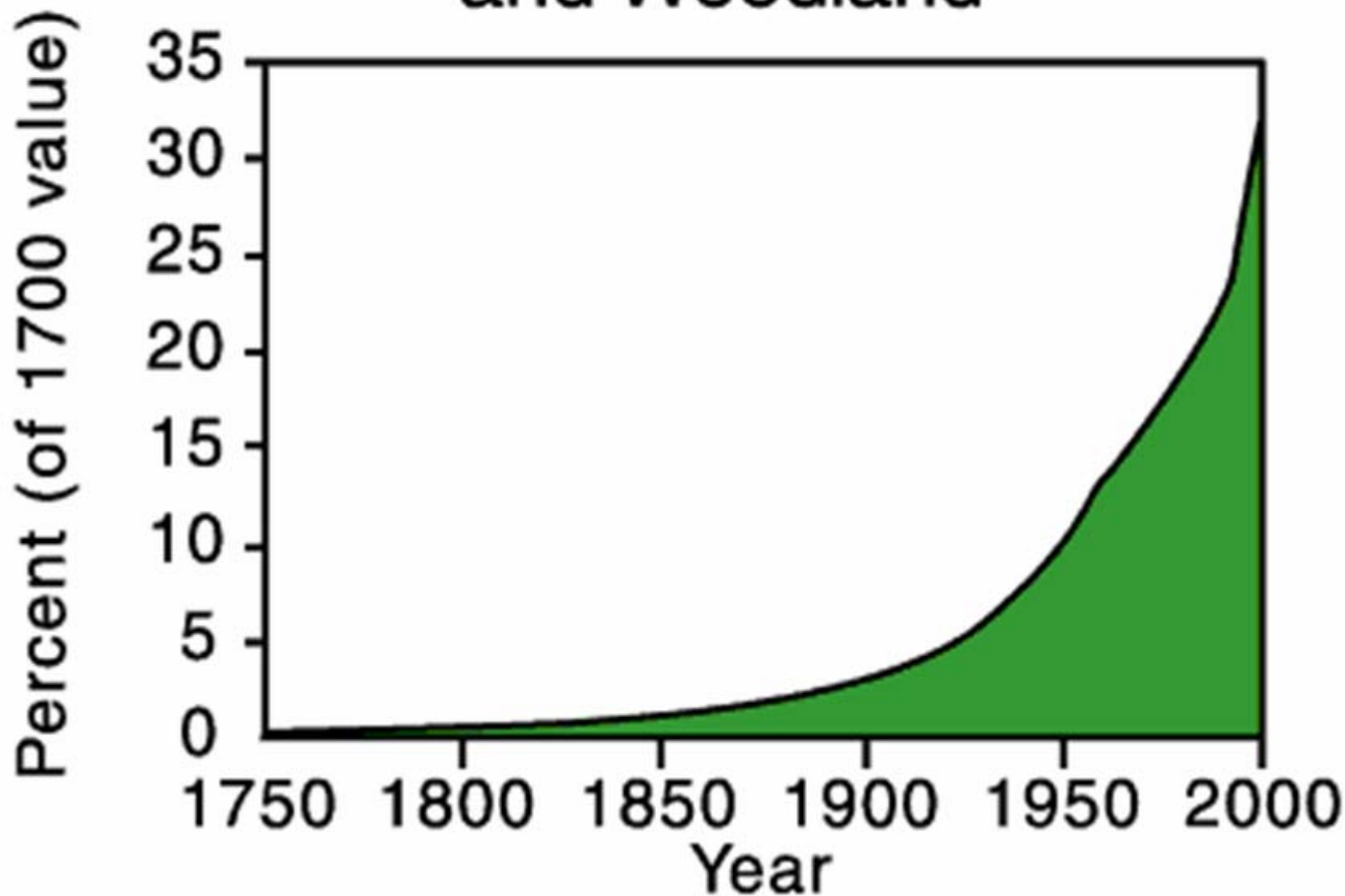


Vitousek (1994)

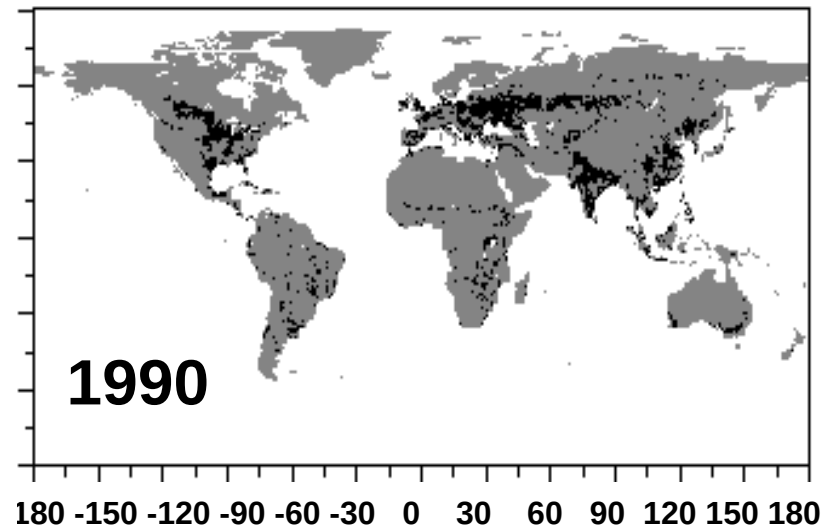
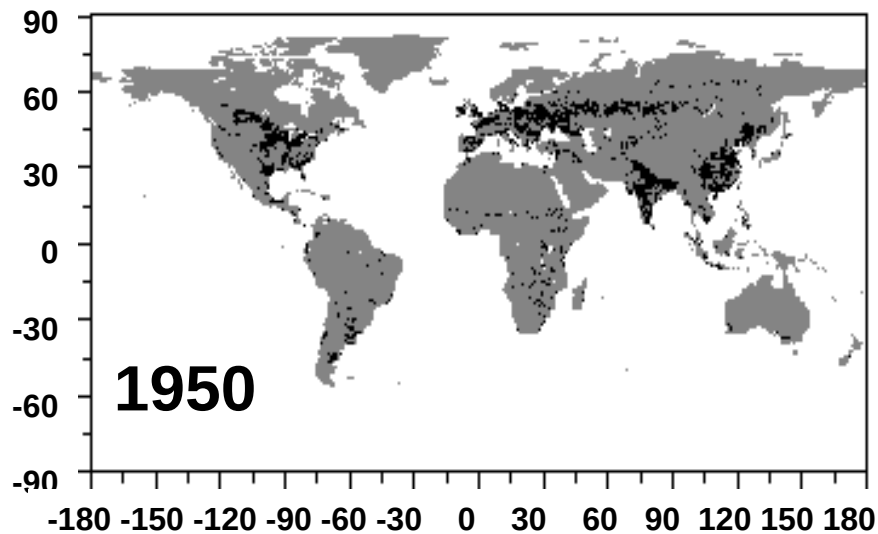
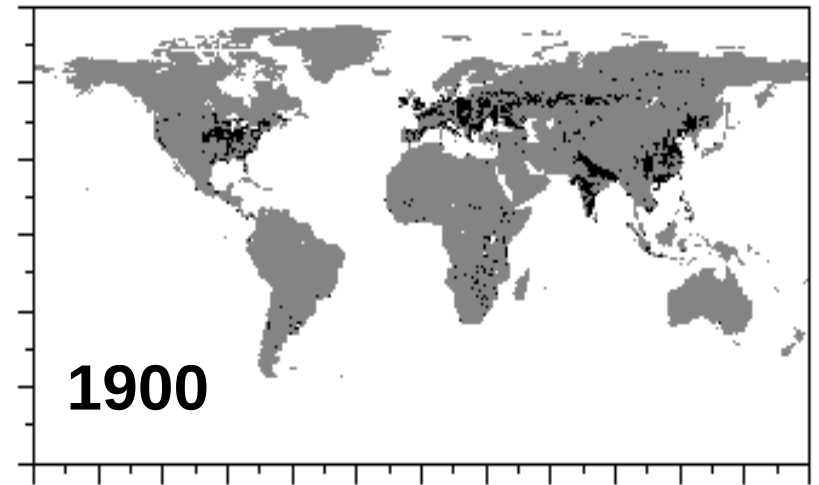
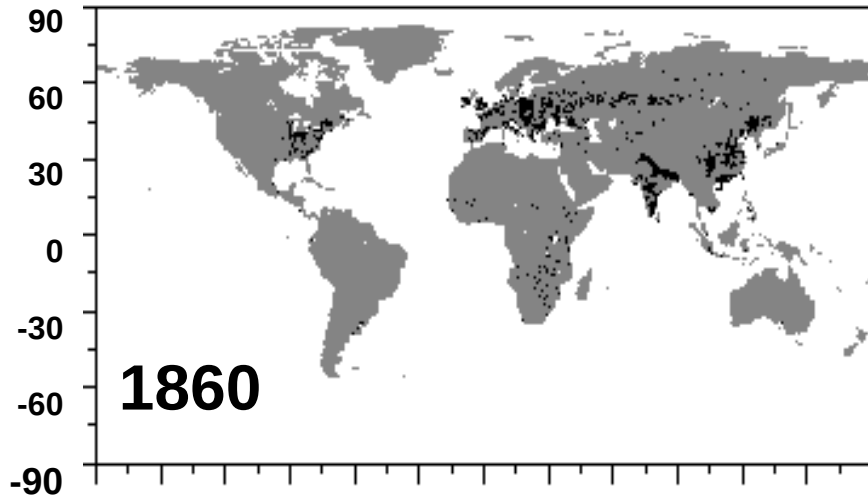
Species Extinctions



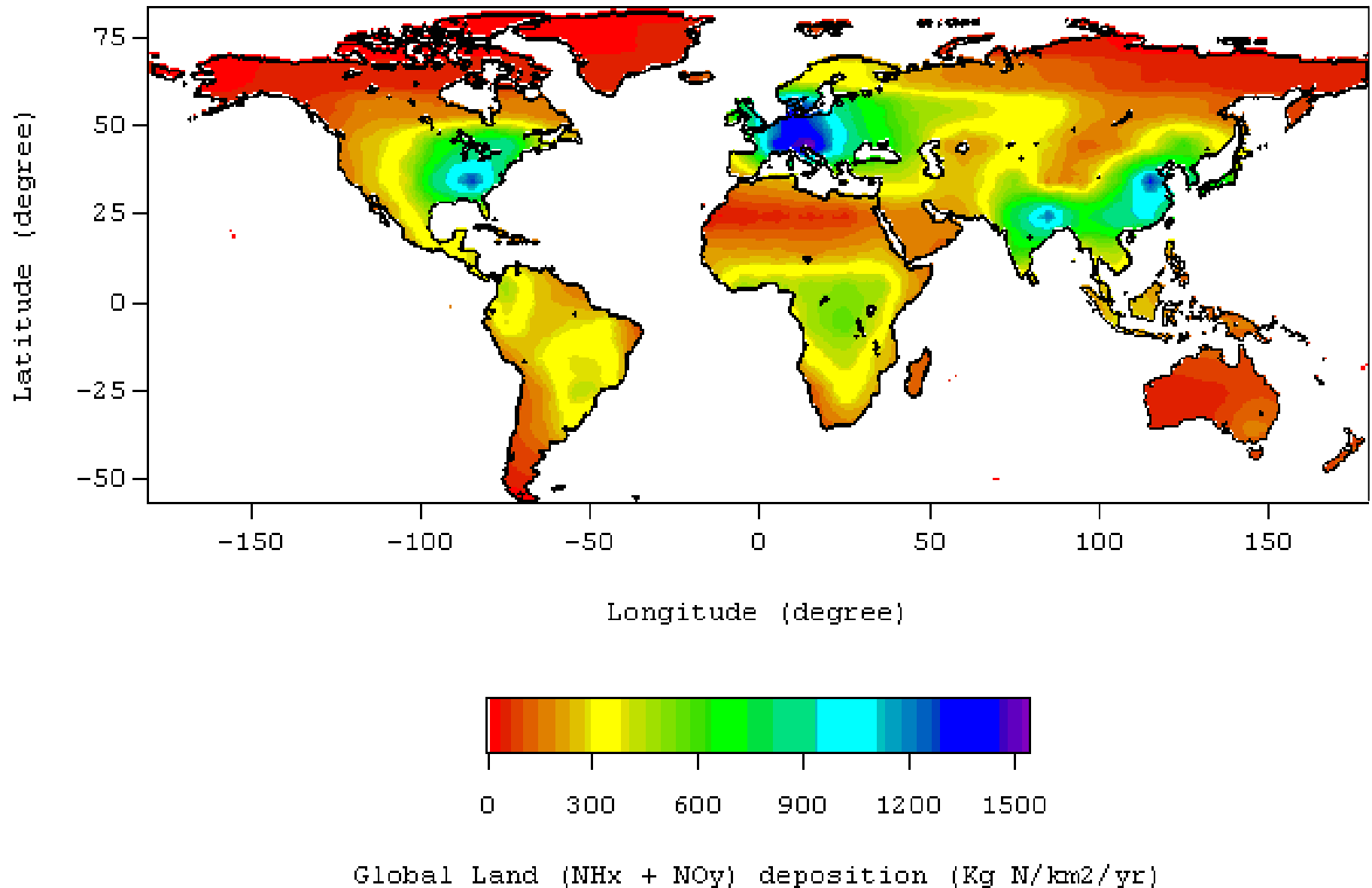
Loss of Tropical Rain Forest and Woodland

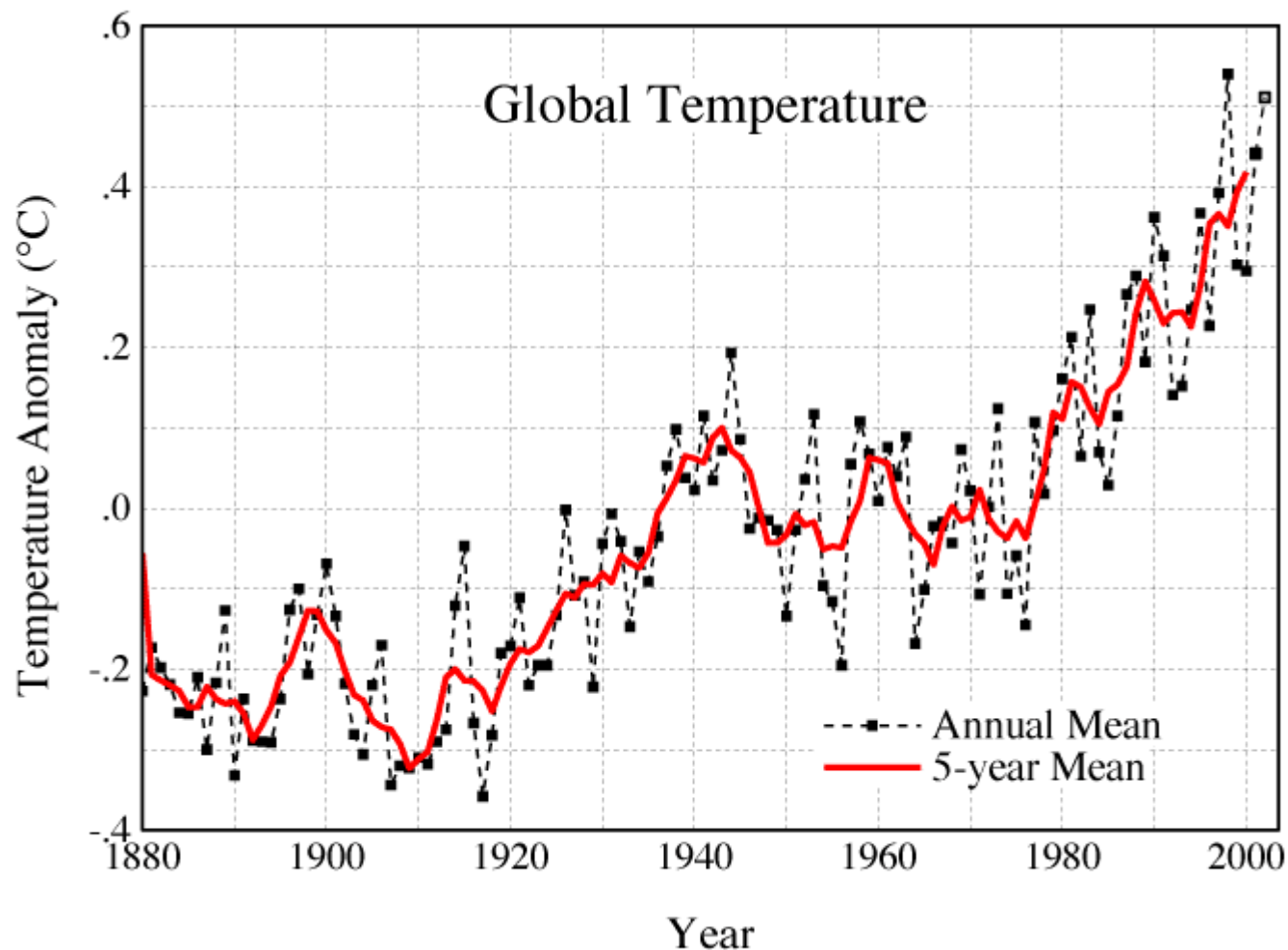


Global Expansion of Cropland



Global Pattern of Nitrogen Deposition

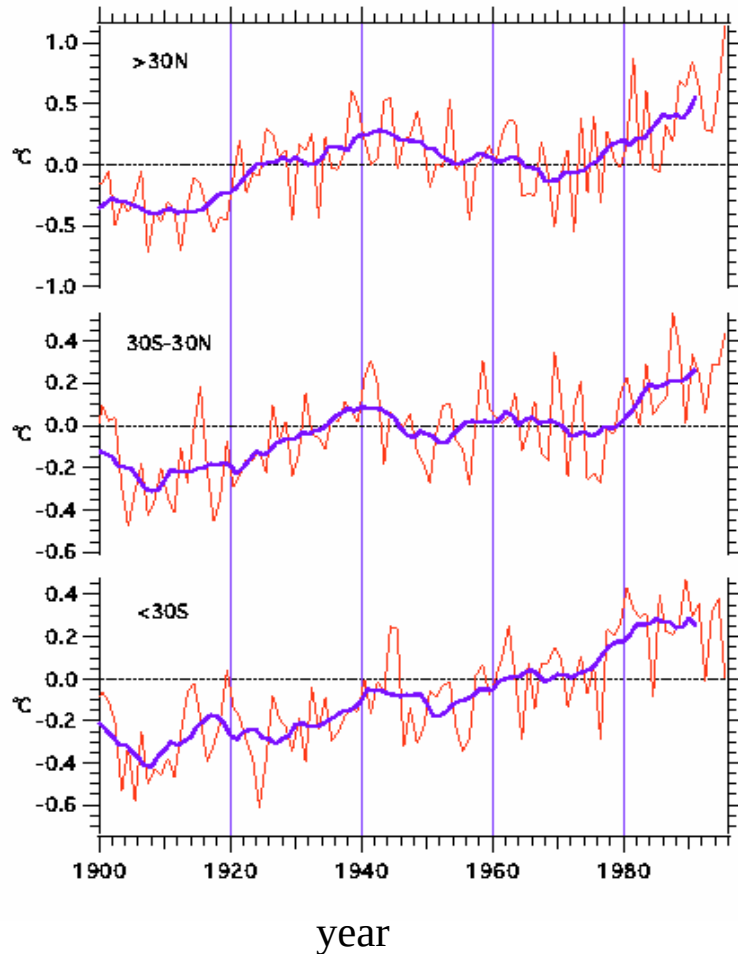




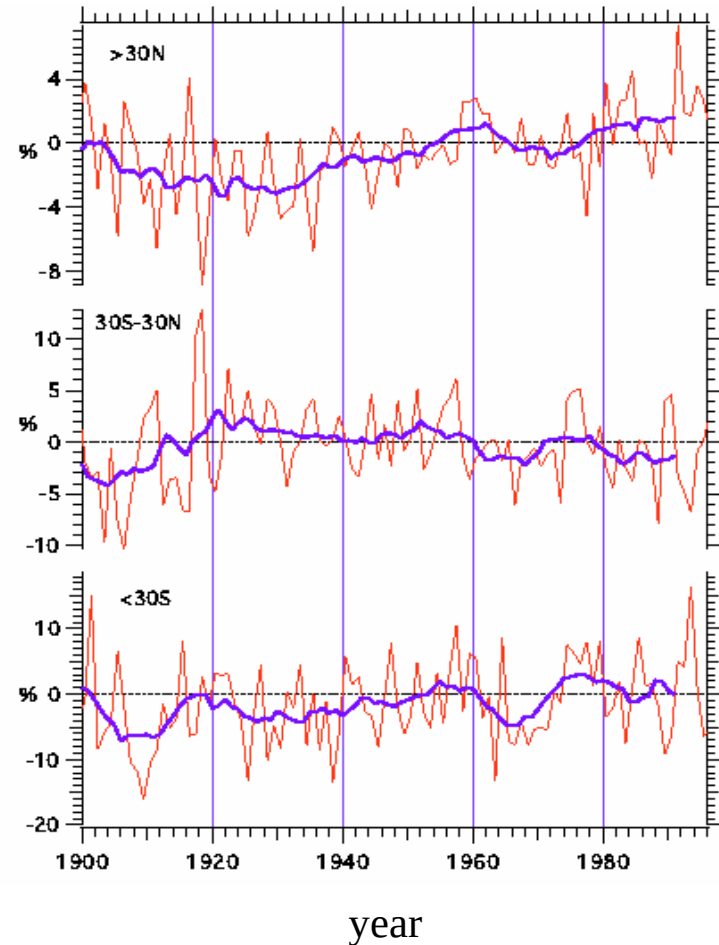
The global surface temperature for 12 months from December 2001 through November 2002 is **0.51° C** above the climatological mean (1951-1980 average) in the GISS analysis, which uses meteorological station measurements over land and satellite measurements of sea surface temperature over the ocean.

Climate Change and Variability

Temperature



Precipitation



Annual (Red) and 10 Year Running Mean (Purple) Temperature and Precipitation Anomalies in 3 Latitude Bands (1900 to 1995)

To understand human-ecosystem interactions, we need
Integrated Regional Studies

The Importance of A Regional Approach

- Different regions may manifest significantly different responses to various Earth-System dynamics, which may in turn produce considerable consequences for the global Earth System.
- Regions may function as choke or switch points and small changes in regional systems may affect the two-way linkage between regional and global change, as well as the way in which the Earth System operates.
- Irreversible changes to the regional biogeochemistry, and terrestrial and marine ecosystem functioning brought about by increase in population, intensified land use, urbanization, industrialization and economic development may have global as well as regional consequences.
- Similarly, effects of global change have a significant impact on sustainable development at both regional and national levels.

Earth System Questions

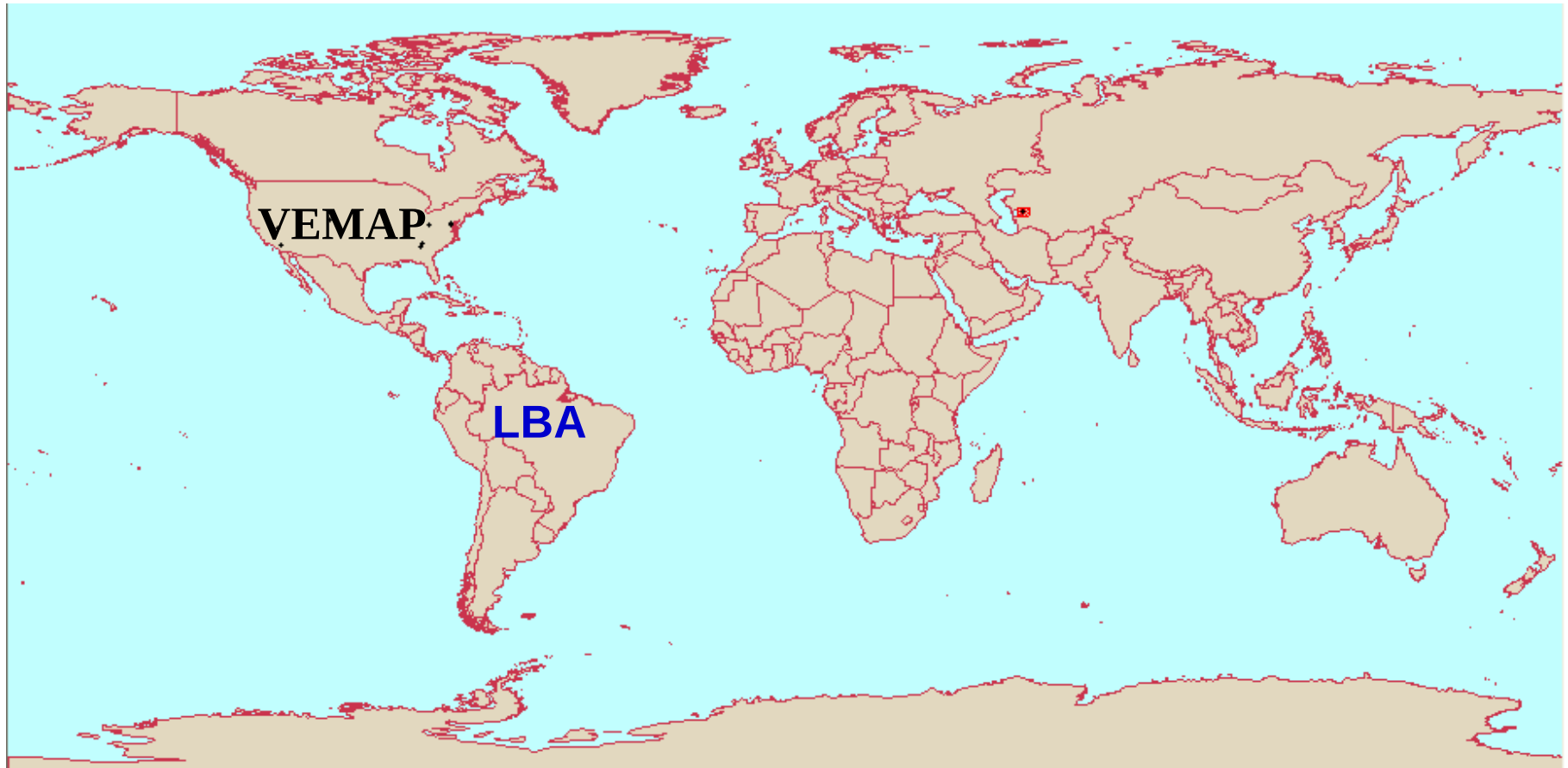
e.g. What are the critical thresholds/ switches/ hot spots in the Earth System?



The Overall Objectives of IRS

- To better understand how human activities in regions are interacting with and altering natural regional variability of the atmospheric, terrestrial, and marine components of the environment;
- To contribute to the provision of a sound scientific basis for sustainable regional development; and,
- To develop a predictive capability of estimating changes in global-regional linkages in the Earth System and to recognize on a sound scientific basis the future consequences of such changes.

Integrated Regional Studies (IRS)



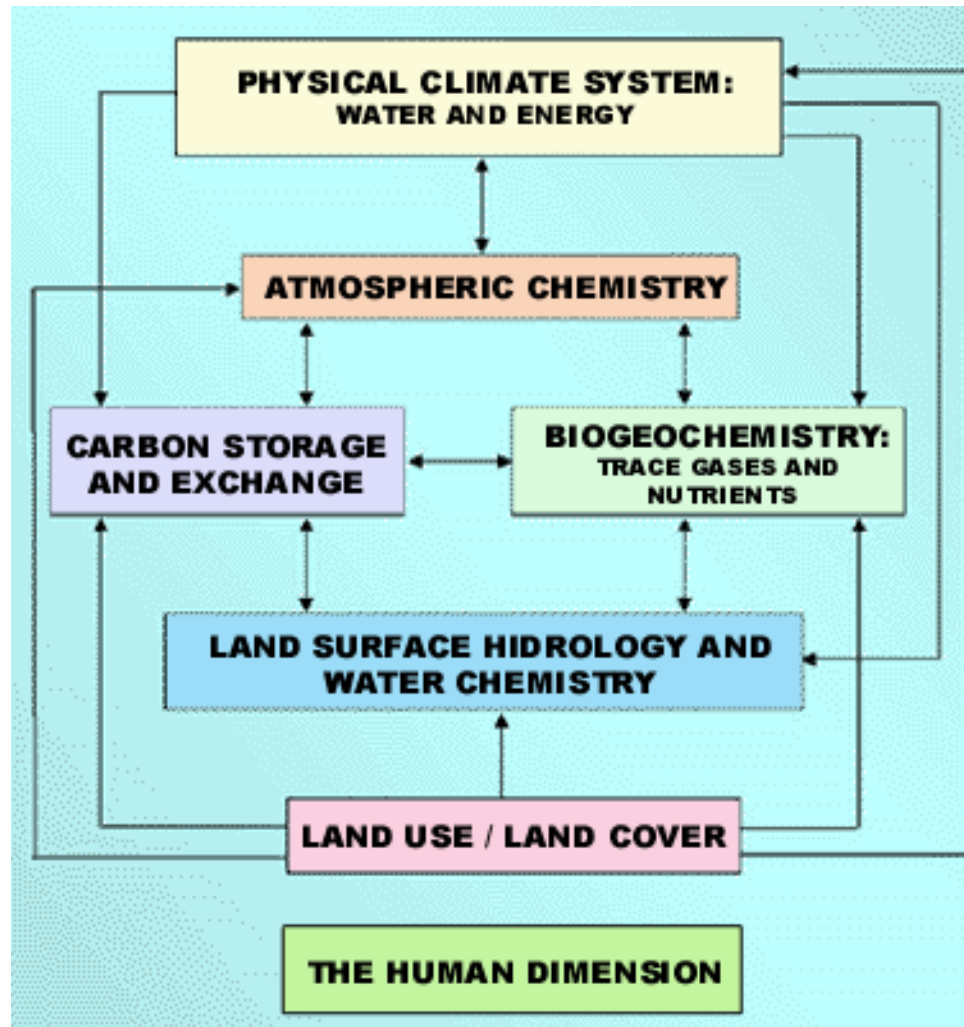
LBA – Large-scale Biosphere-Atmosphere Experiment in Amazon Basin

VEMAP – Vegetation/Ecosystem Modeling and Analysis Project

Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)

- 80 research groups - 600 scientists
- How does Amazonia function as a regional entity (e.g., natural cycles of water, energy, aerosols, carbon, nutrient and trace-gases)?
- How will changes in land use and climate affect the biological, chemical and physical functioning of Amazonia, including its sustainability and influence on global climate?





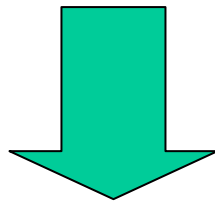
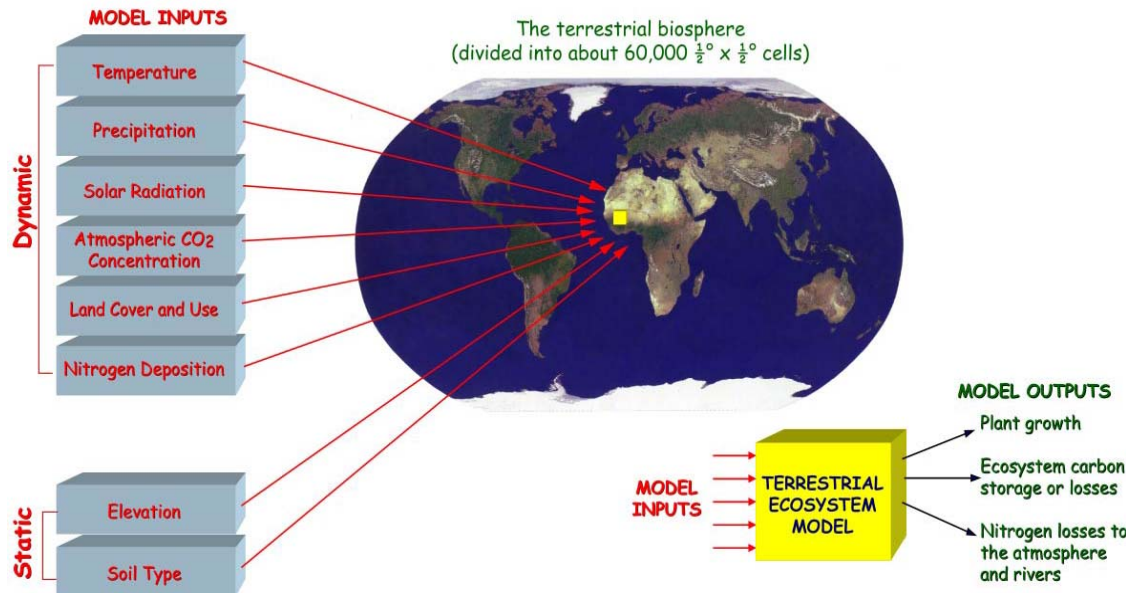
Framework for LBA

The Integrated/Systems Approach

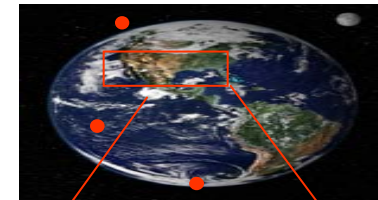
Modeling



Measuring



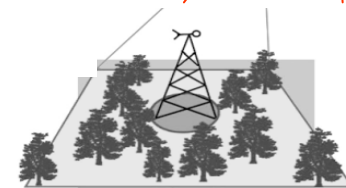
Synthesis



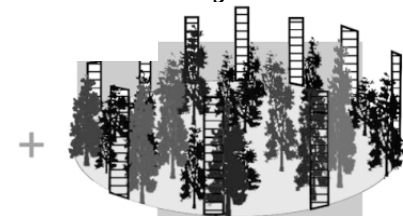
Flask Data



Satellite Data



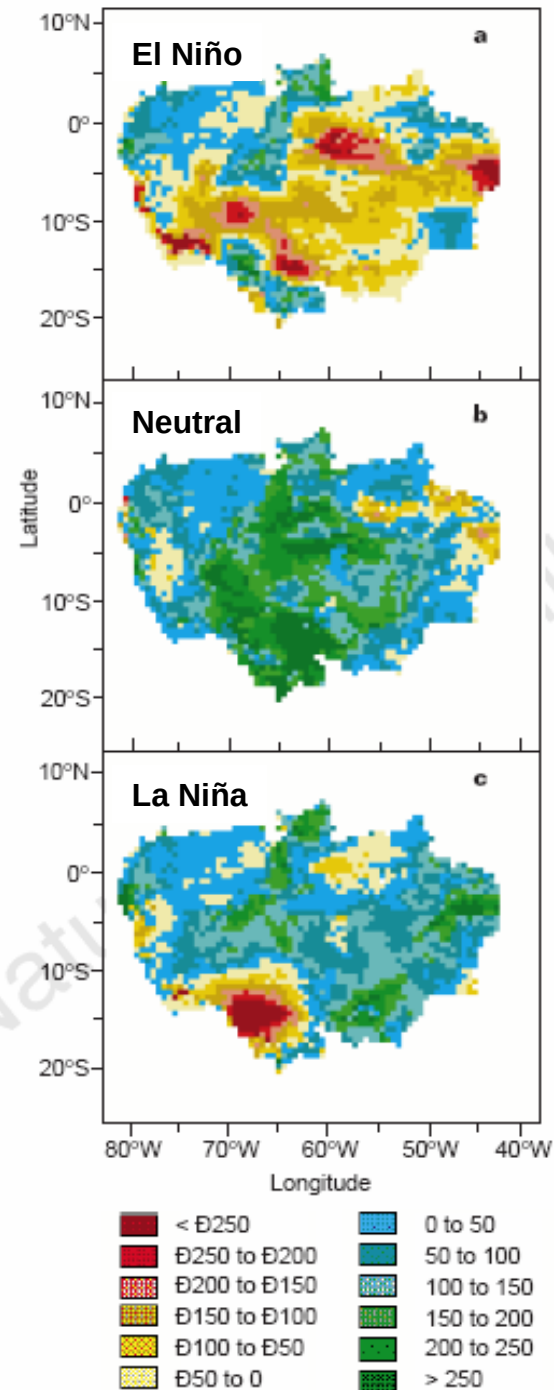
Eddy Flux



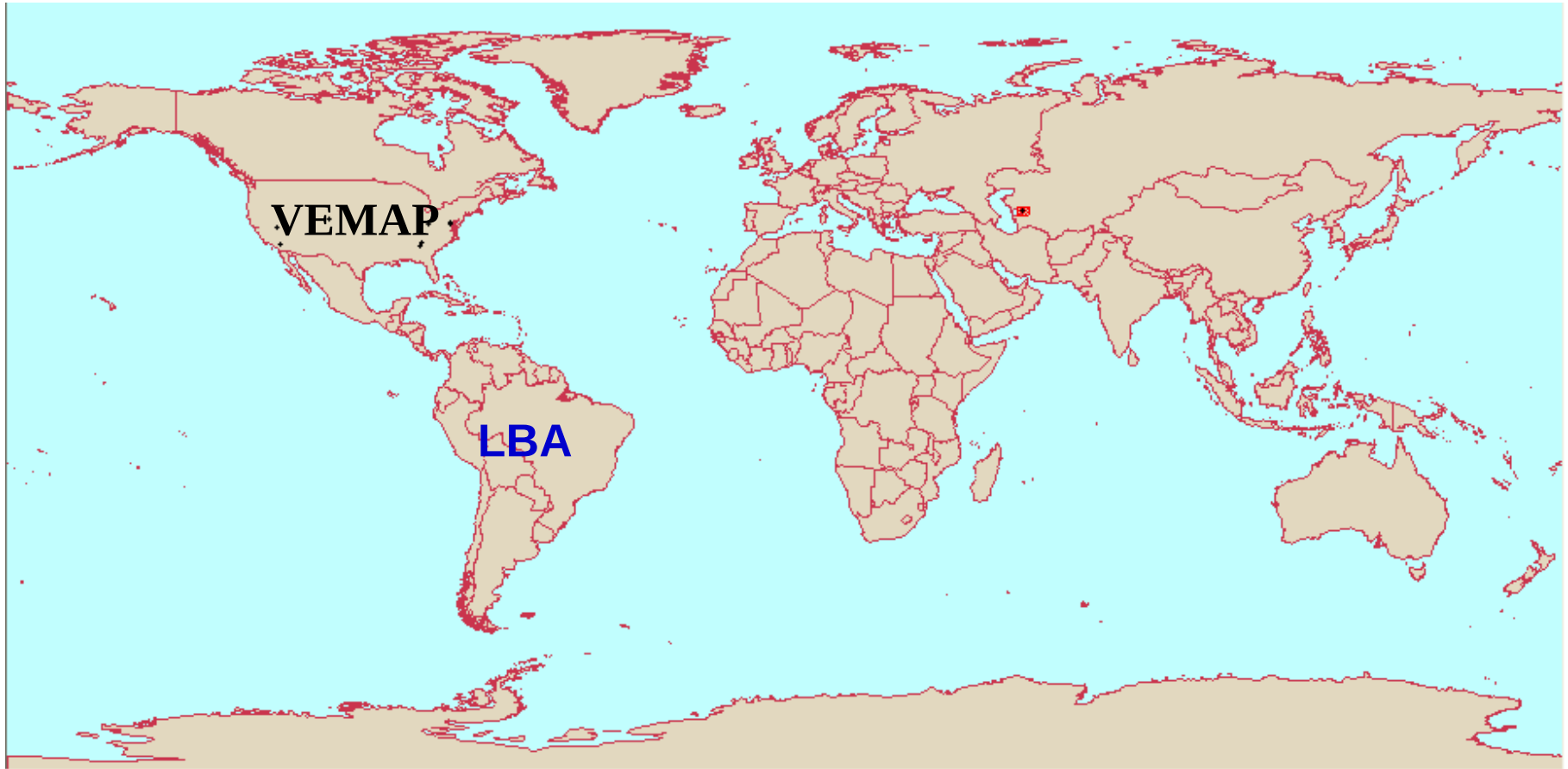
Ecosystem Experiments

Climate-Induced Spatial and Temporal Variability in Net Ecosystem Production Across the Amazon Basin

Tian H. et al. ***NATURE*** 396:664-667

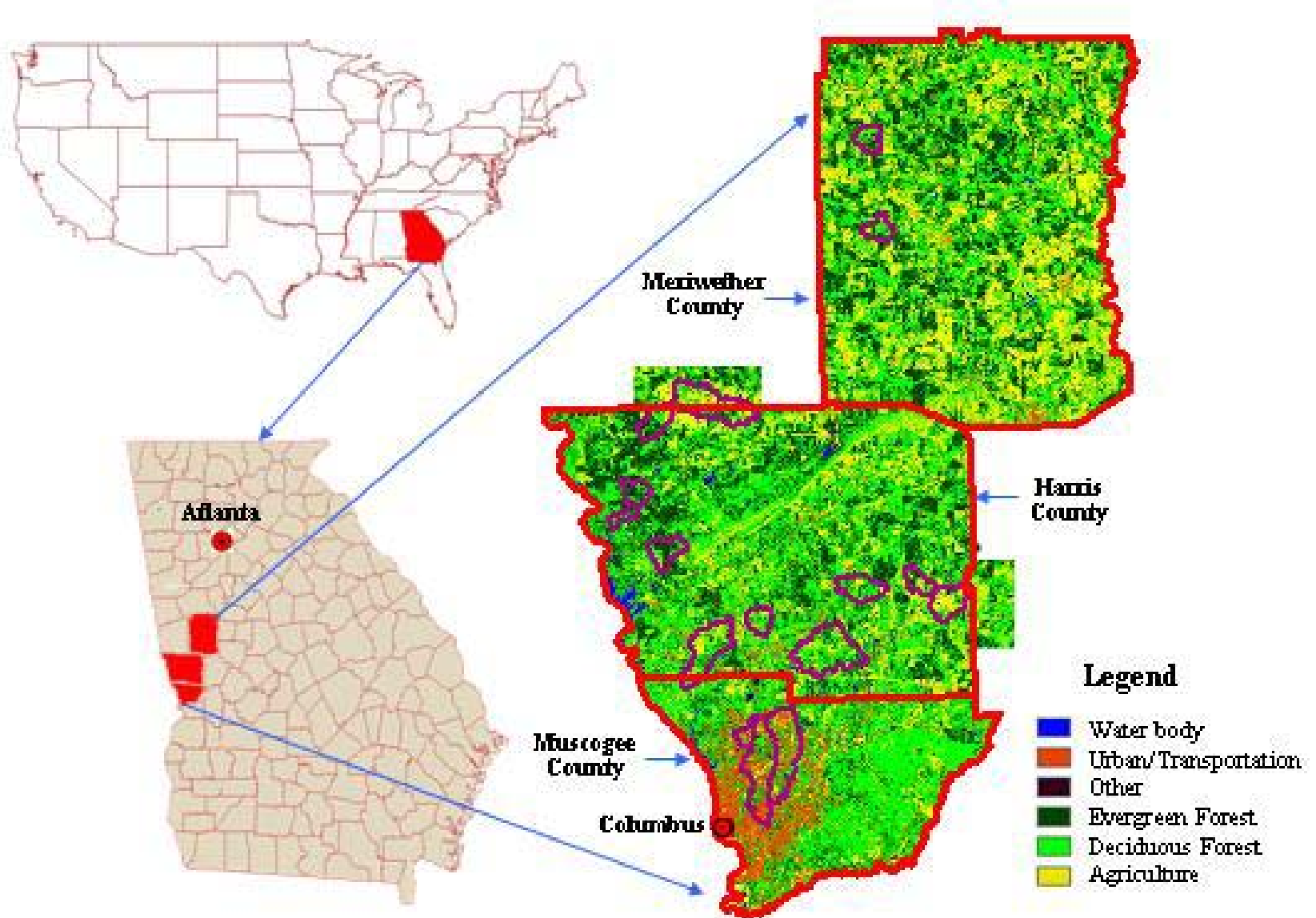


Integrated Regional Studies (IRS)



VEMAP – Vegetation/Ecosystem Modeling and Analysis Project

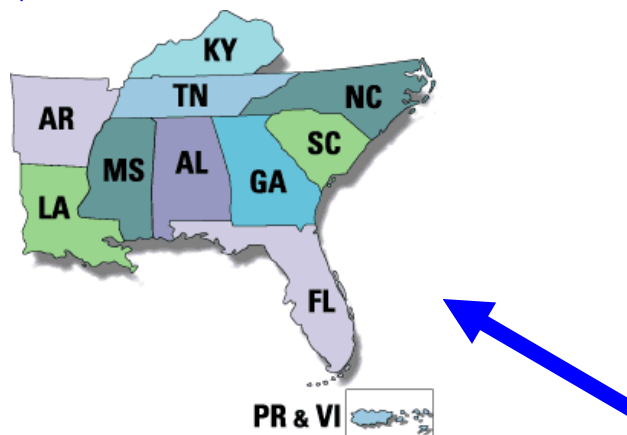
Rural-Urban Interface in Western Georgia



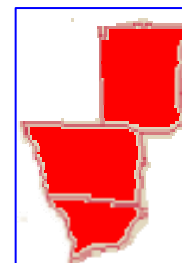
National



Southeast



WestGA

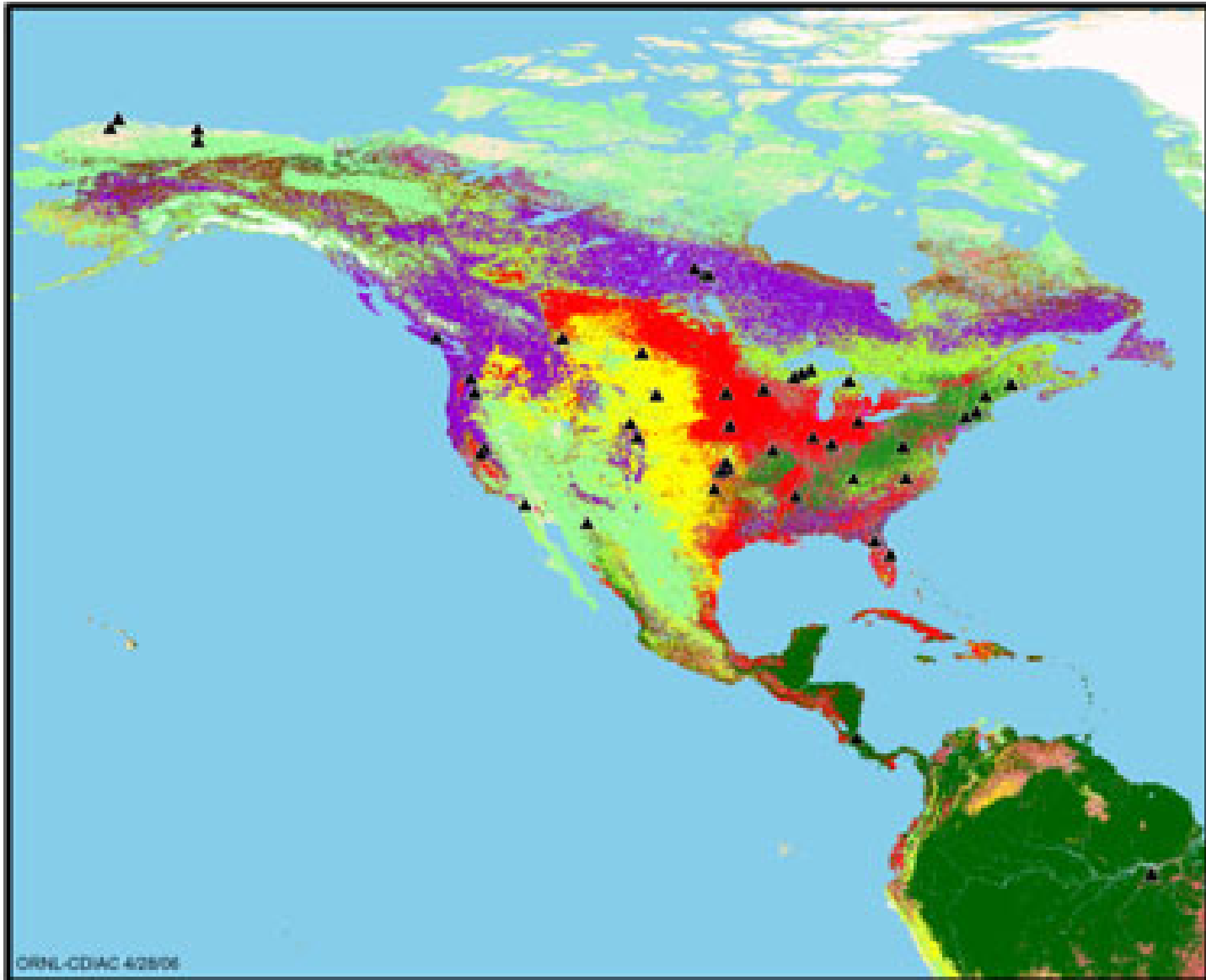


Scaling up



Model Calibration and Validation

The AmeriFlux network



Schimel D., Melillo J. and **Tian H.**, et al. 2000. Contribution of Increasing CO₂ and Climate to Carbon Storage by Ecosystems in the United States. ***SCIENCE*** 287:2004-2006.

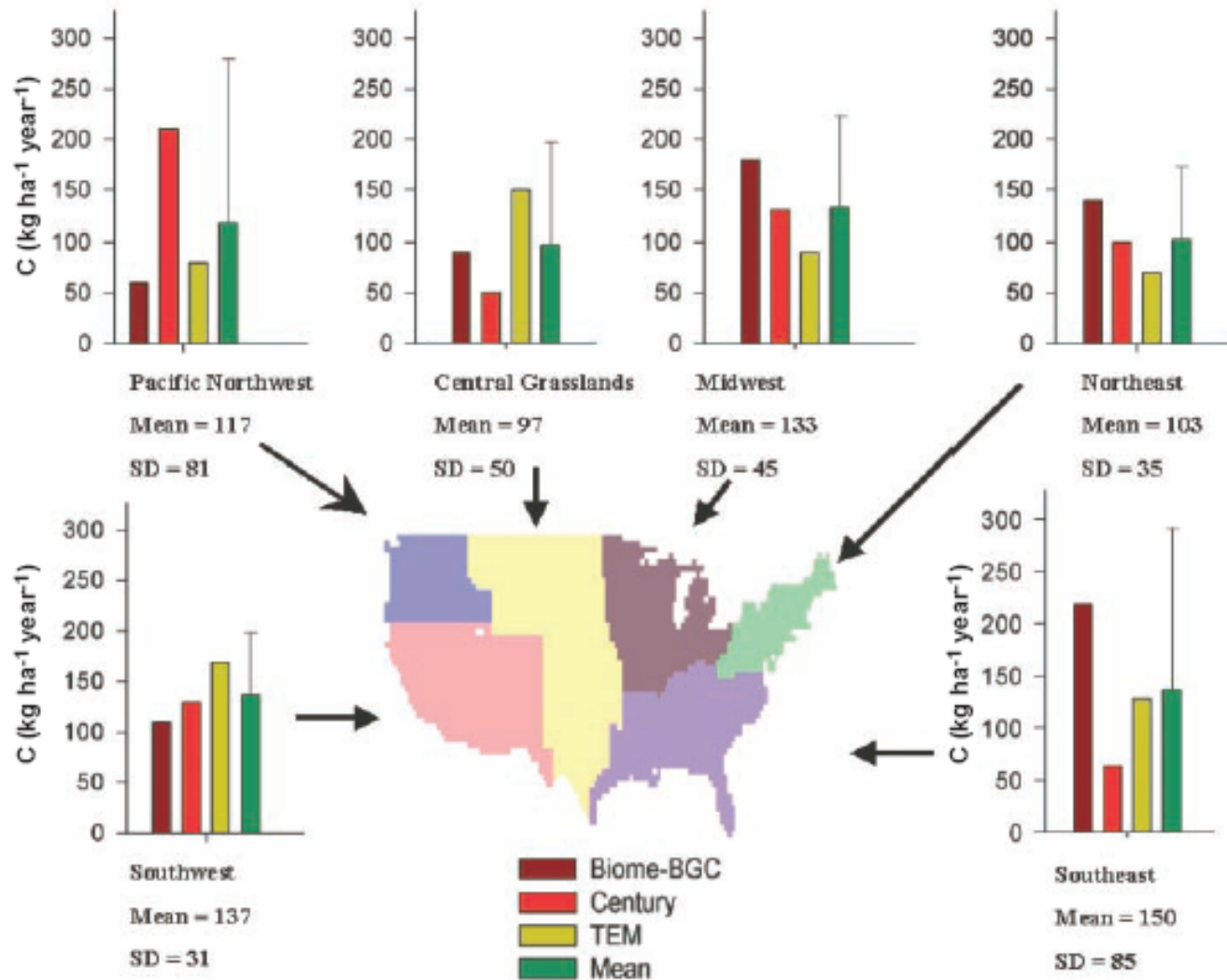
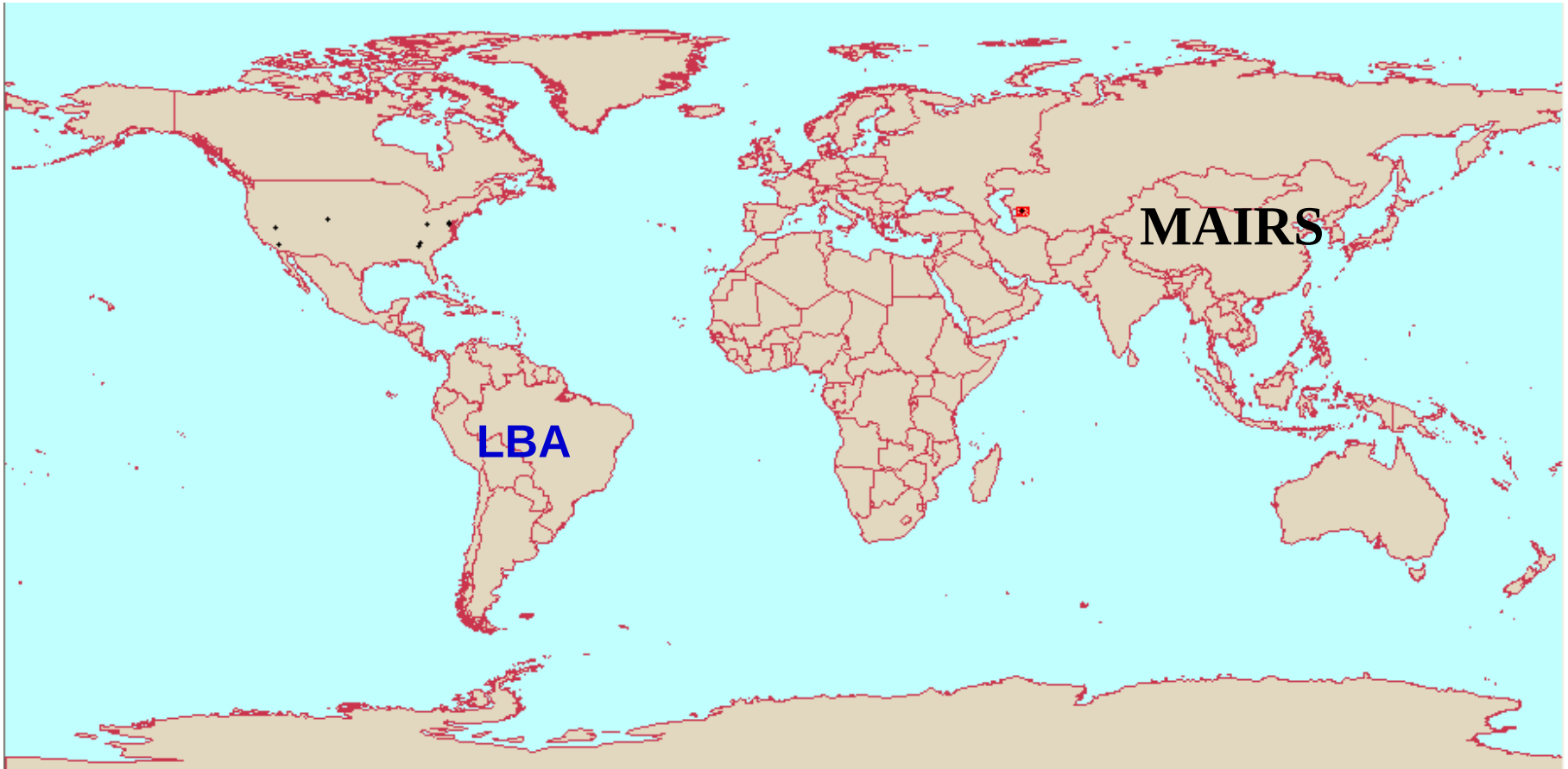


Fig. 1. Net carbon storage for different bioclimatic regions of the United States estimated with all three models for natural ecosystems, with Century results applied in agricultural cells. Histograms show specific model results and the mean (95% confidence interval).

MAIRS – Monsoon Asia Integrated Regional Studies

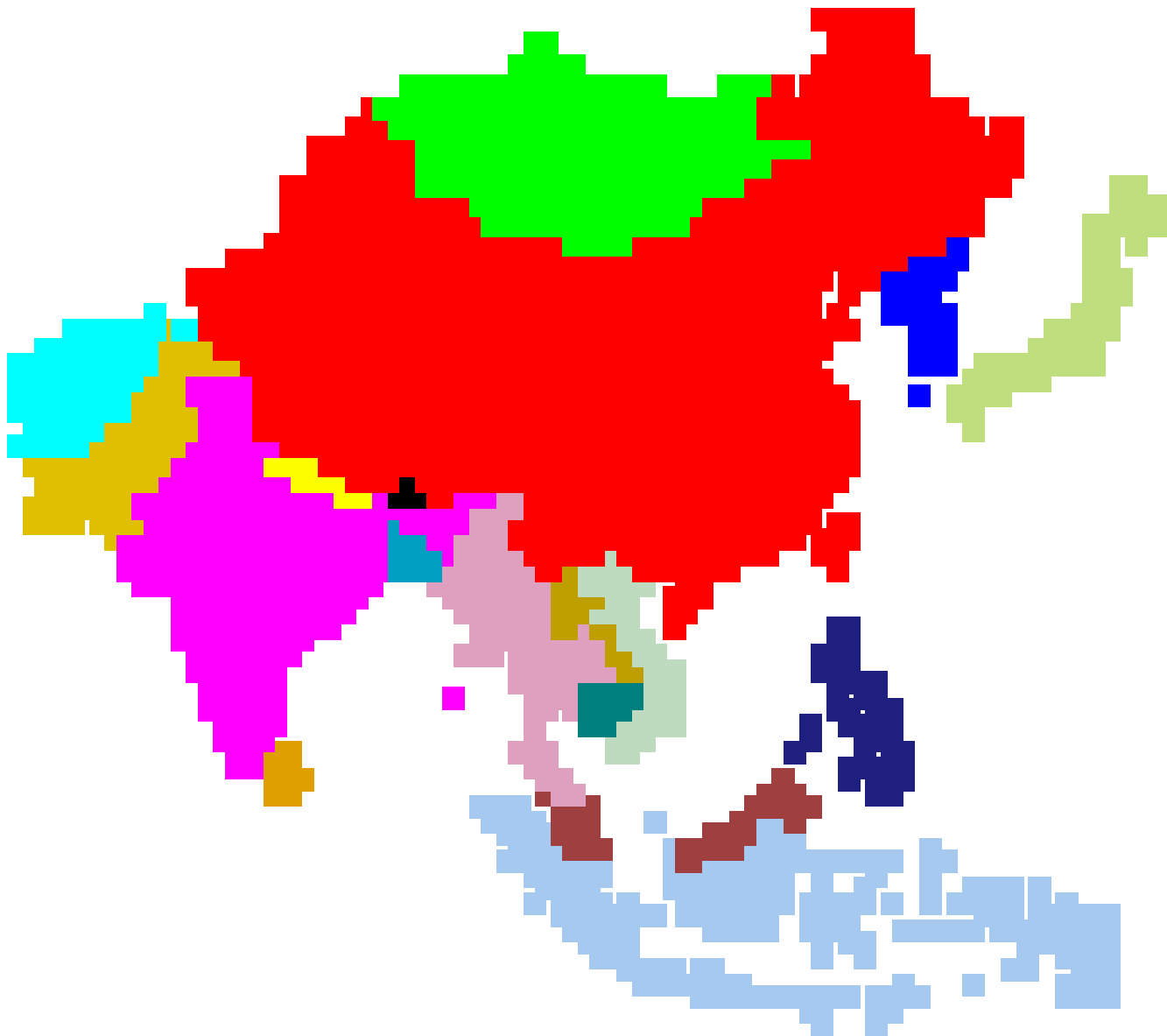


Land Area and Human Population

(Monsoon Asia vs. the World)

	Globe	Monsoon Asia	% of global
Area (10^{12} m ²)	133.6	21.4	16
Population in 1998 (million)	5,901	3,585	61

Monsoon Asia



E. Asia

- China
- Japan
- Korea
- Mongolia

S. Asia

- Afghanistan
- Bangladesh
- Bhutan
- India
- Nepal
- Pakistan
- Sri_Lanka

S. E. Asia

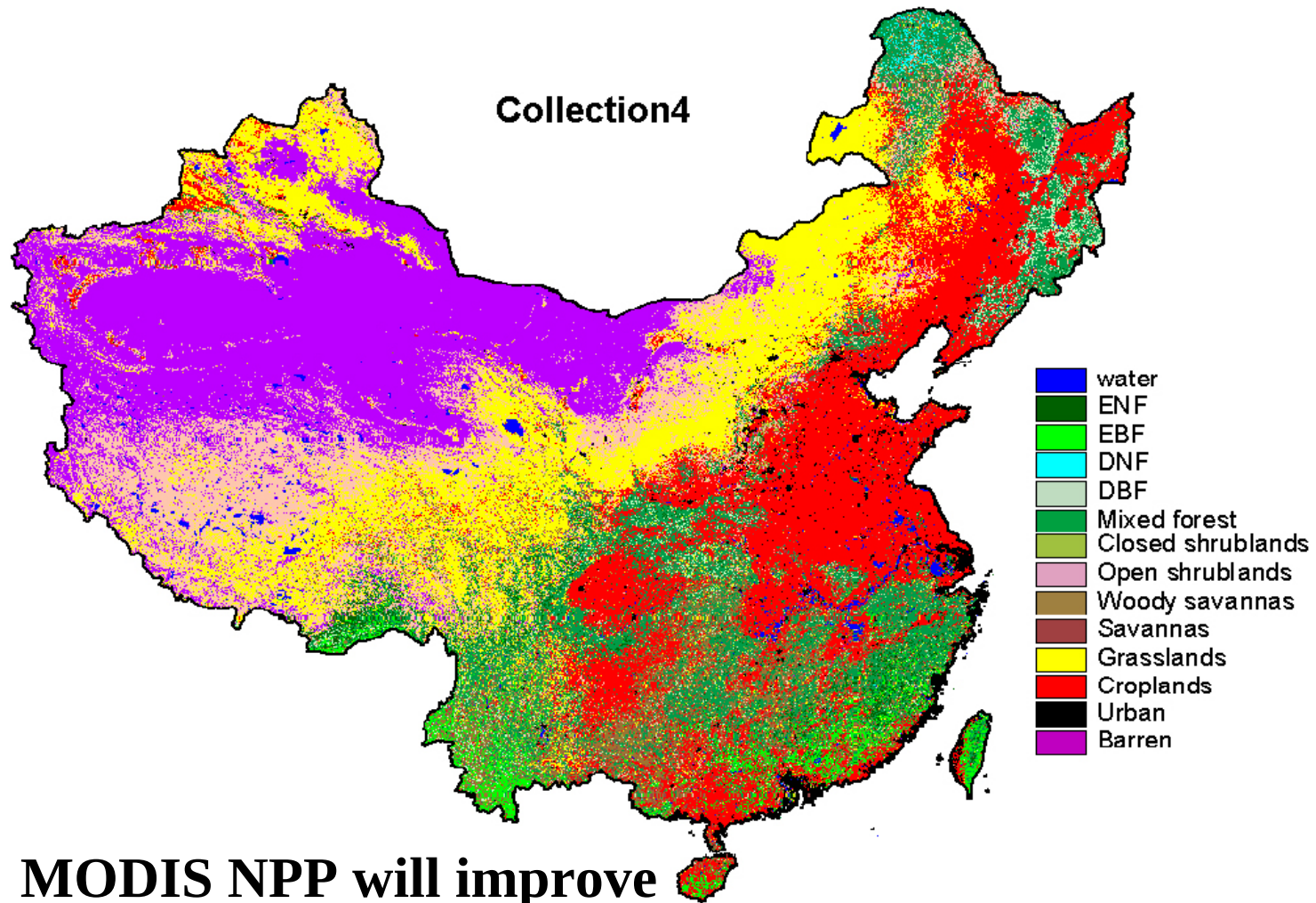
- Brunei
- Burma
- Indonesia
- Kampuchea
- Laos
- Malaysia
- Philippines
- Thailand
- Vietnam

Toward

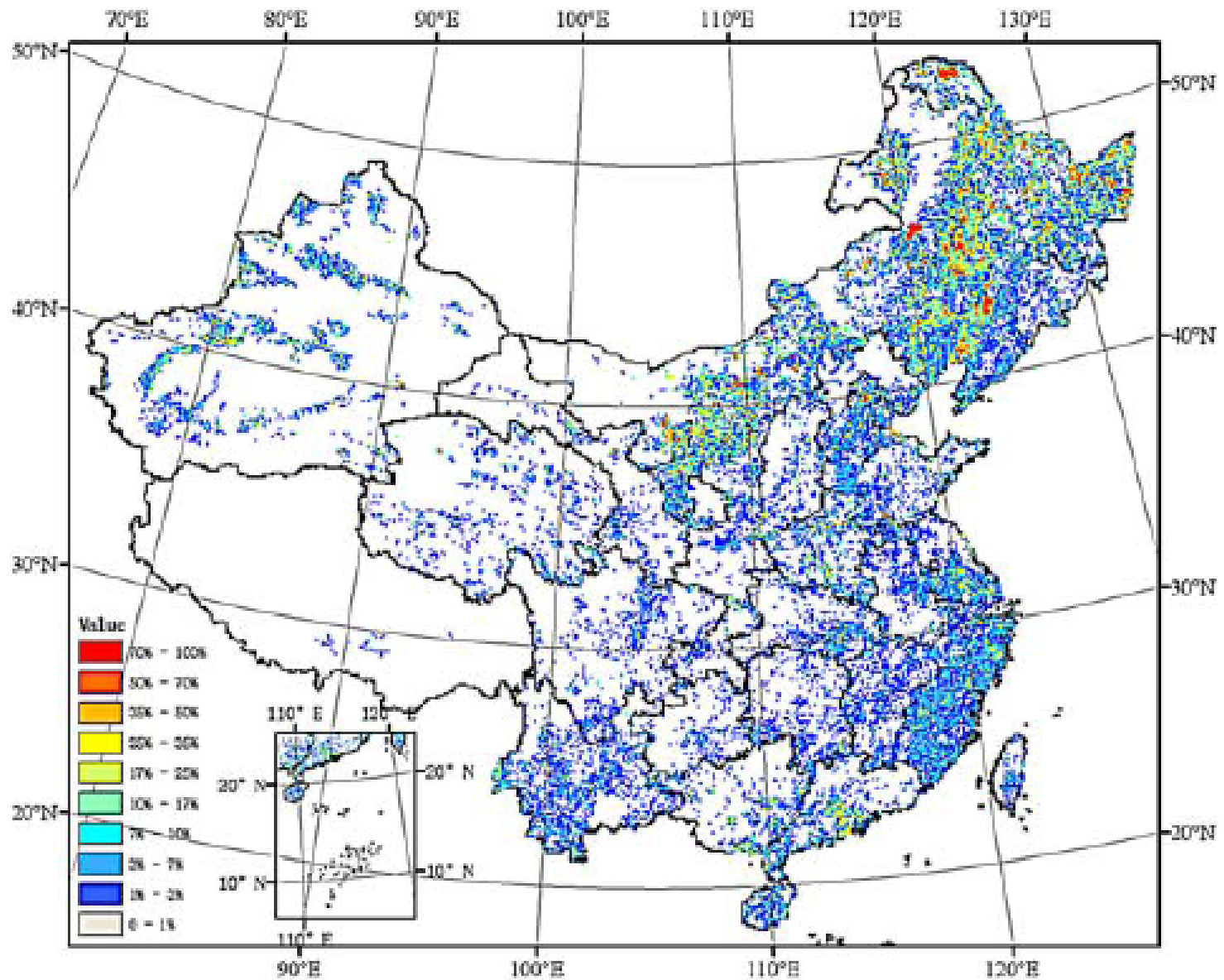
Interdisciplinary Research of

Terrestrial Ecosystems and Global Change

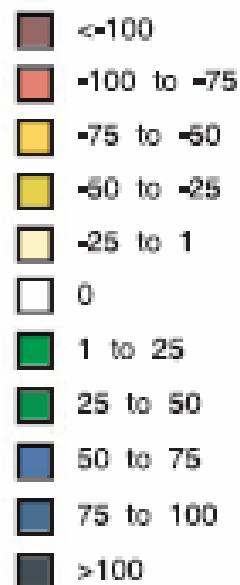
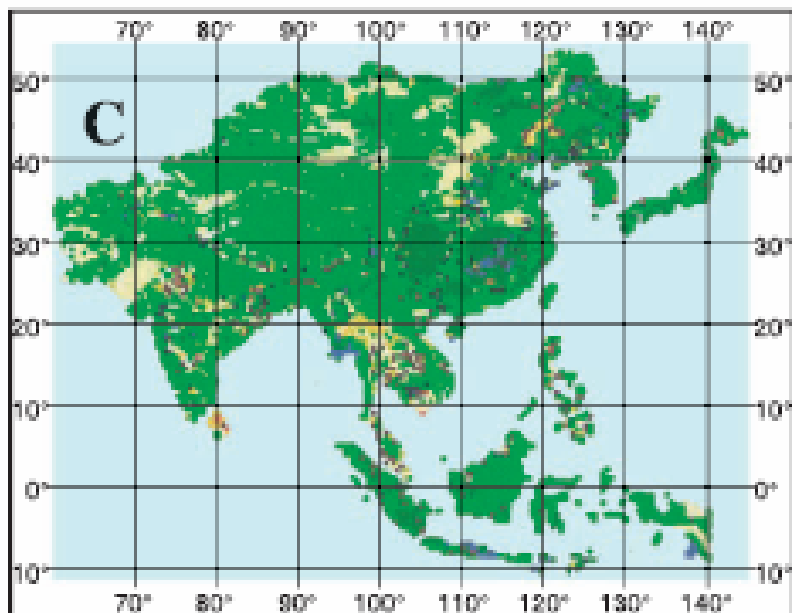
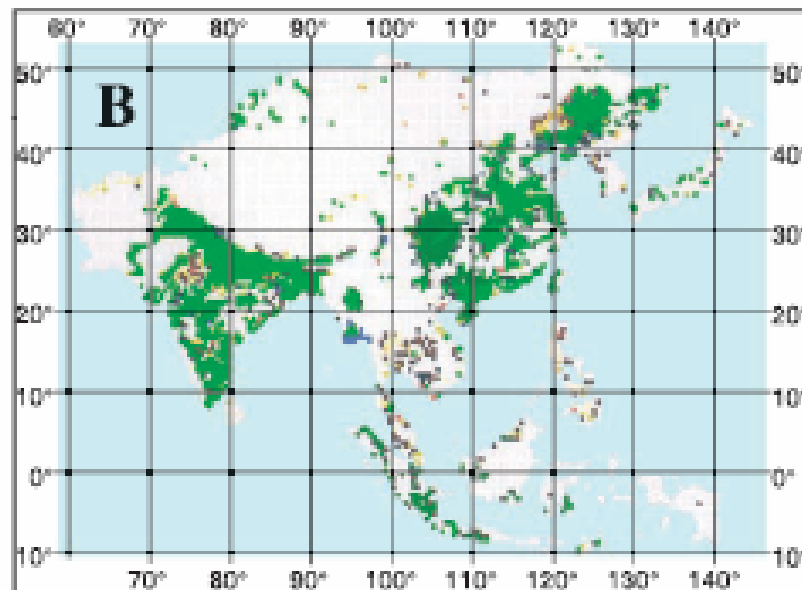
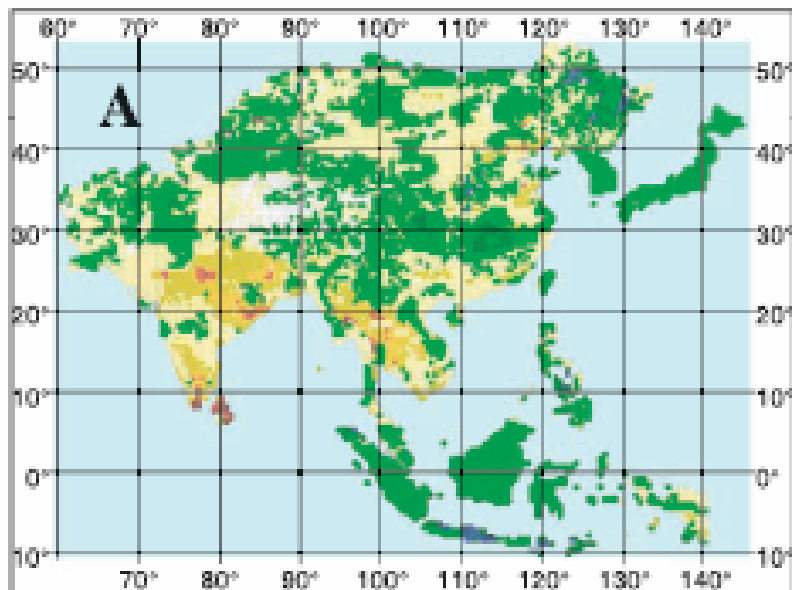
MODIS Land Cover



**MODIS NPP will improve
its accuracy with the the
latest Collection4 land cover**

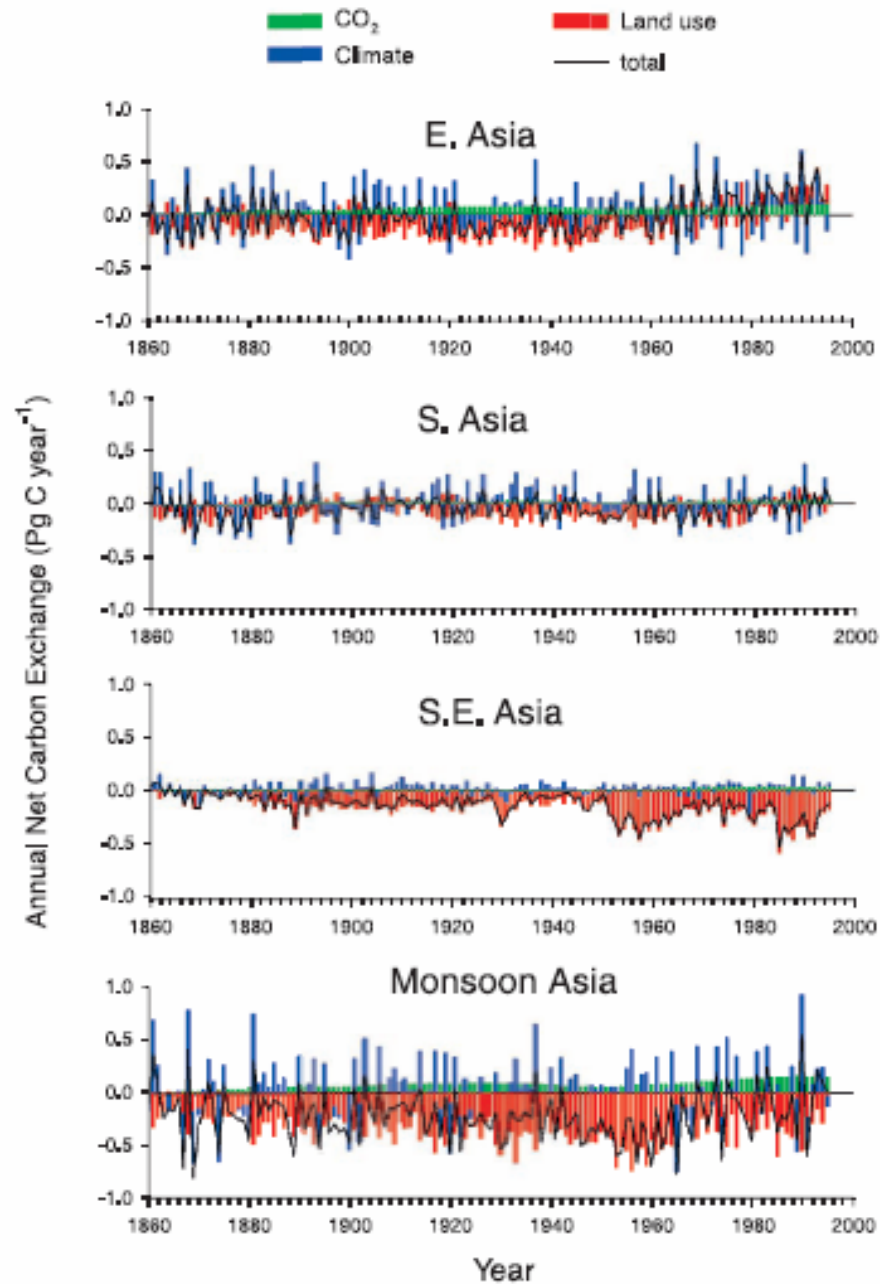


Land use change in China in 1990s (Liu et al. 2005, GRL)

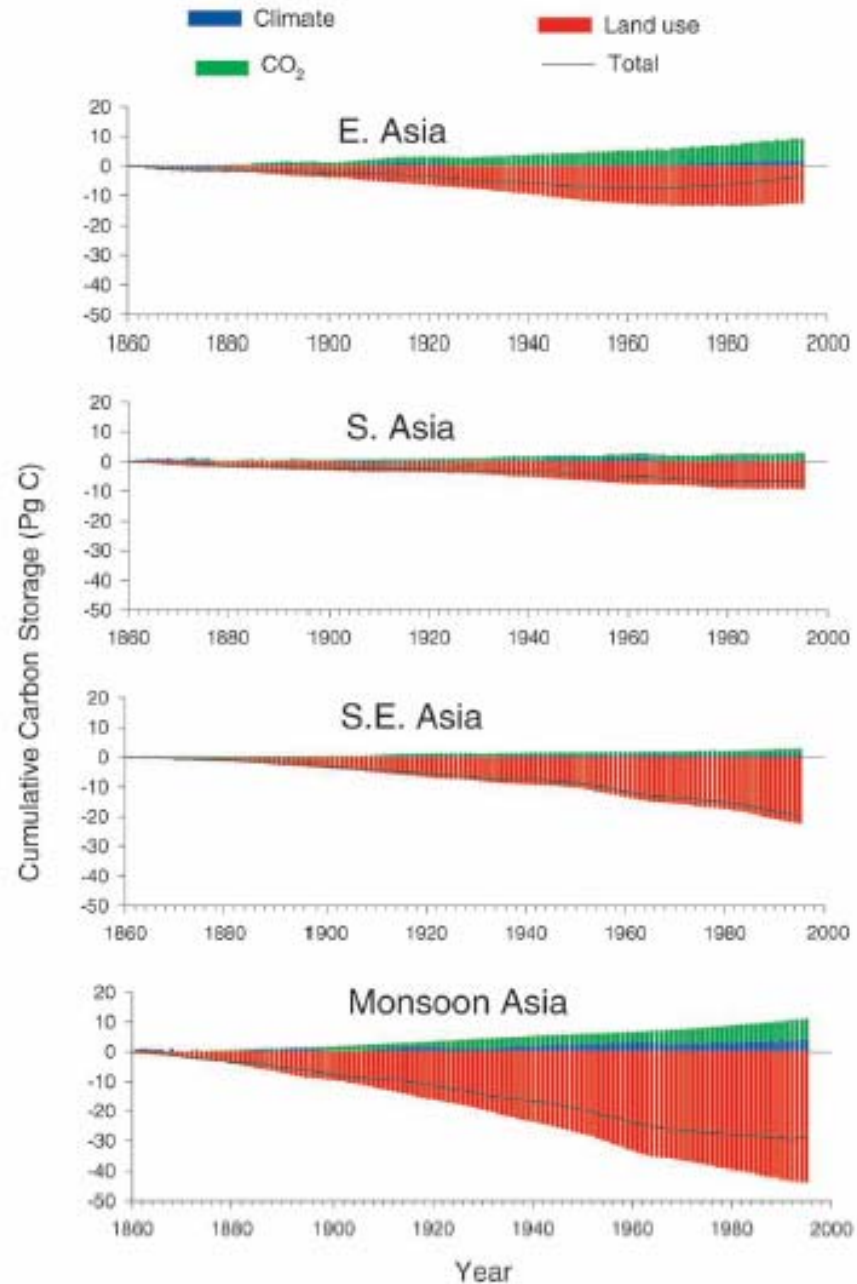


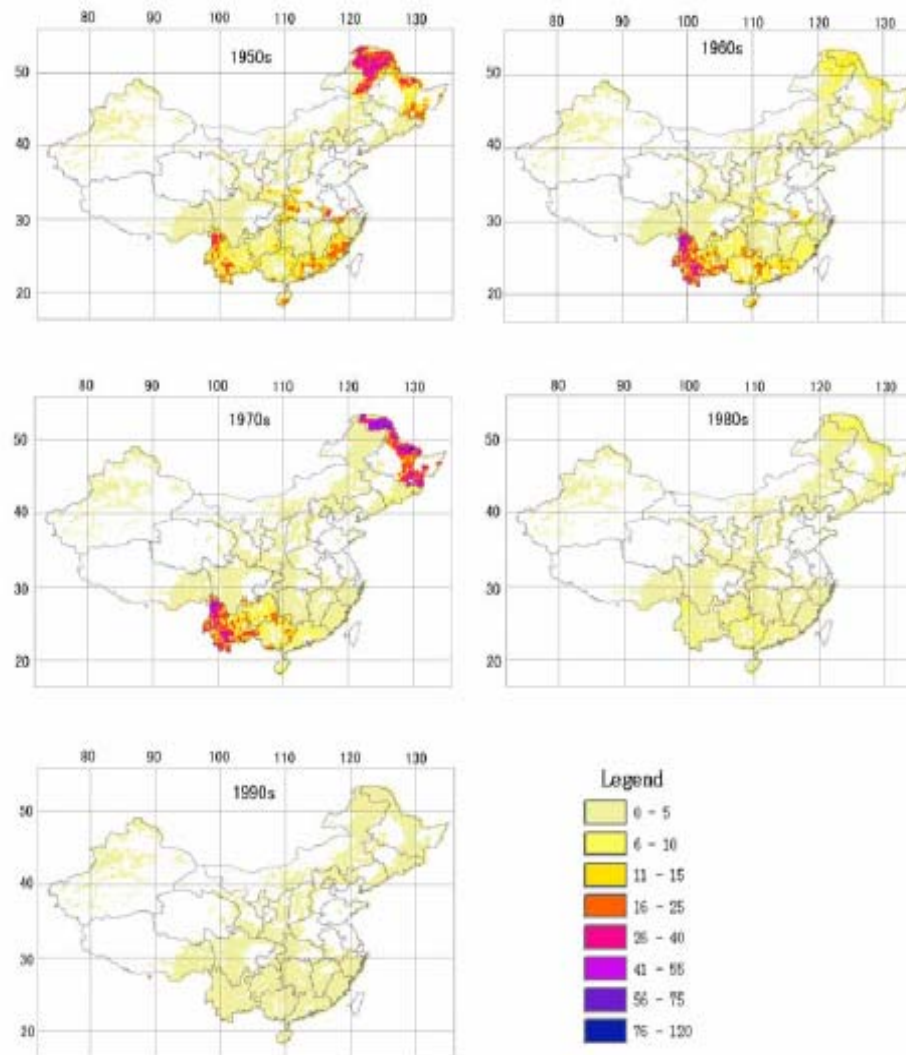
$\text{g C m}^{-2} \text{ yr}^{-1}$

Annual Net Carbon Storage in Monsoon Asia



Cumulative Carbon Storage in Monsoon Asia since 1860





ton carbon per year

Decadal variations in carbon emission induced by forest fires across China (Lü et al. 2006, JGR)

Research Challenge

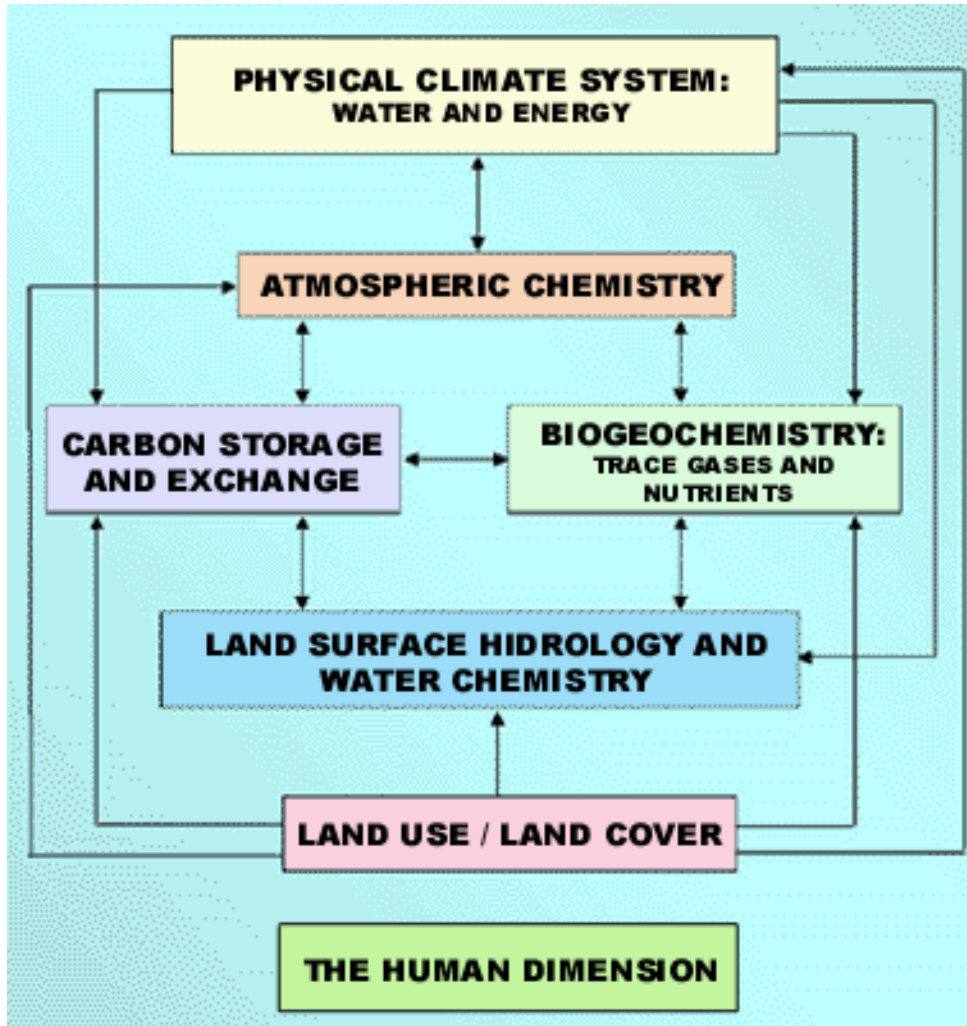
- **Data needs for large-scale ecosystem analyses**
- **Mechanistic links between small- and large-scale processes**
- **Coupled biogeochemical cycles (e. g. C-N-P interactions, multiple gases including CO₂, CH₄, N₂O, etc)**
- **Potential consequence of vegetation redistribution and plant migration on ecosystem processes**
- **Theoretical and experimental consideration of indirect effects such as plant-herbivory interactions**
- **Climate-Ecosystem-Human Activity Interactions**
- **Integrated Assessment: Linking Ecosystem Model with Economic Model**
- **Carbon Sequestration: From Science to Policy**

The Limitations of Data and Model

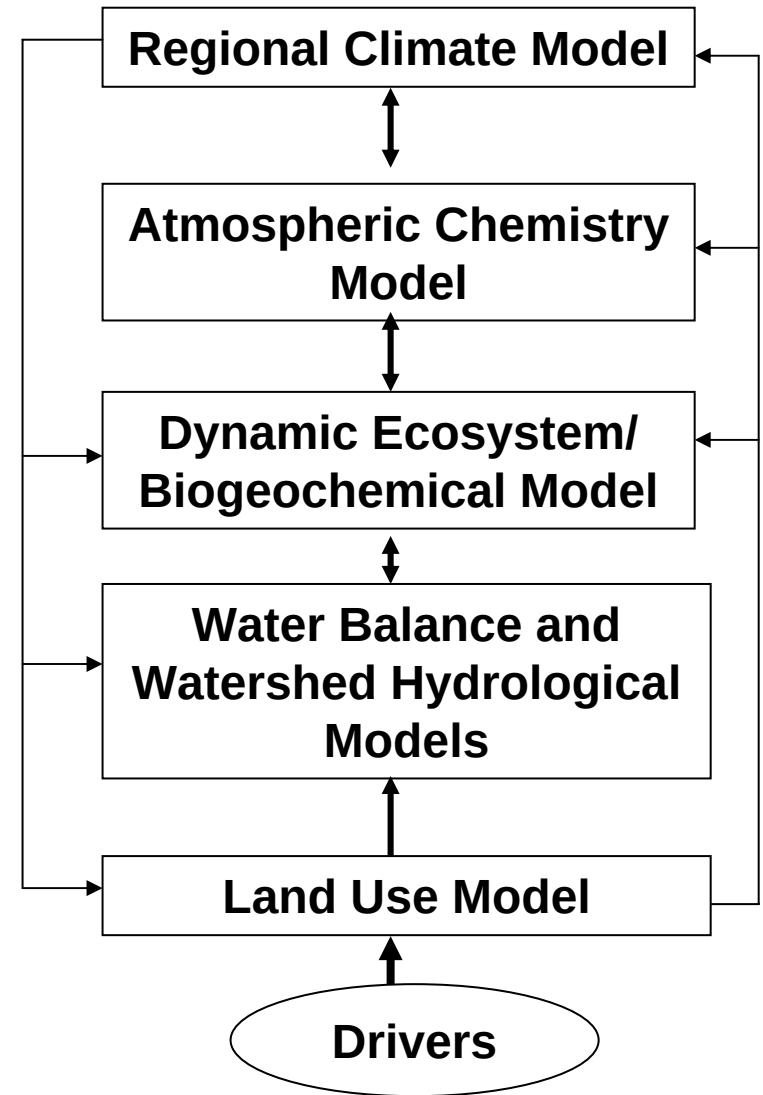
MODEL:

- Coupling
- Validation

The Coupled Land System



Conceptual Linkages

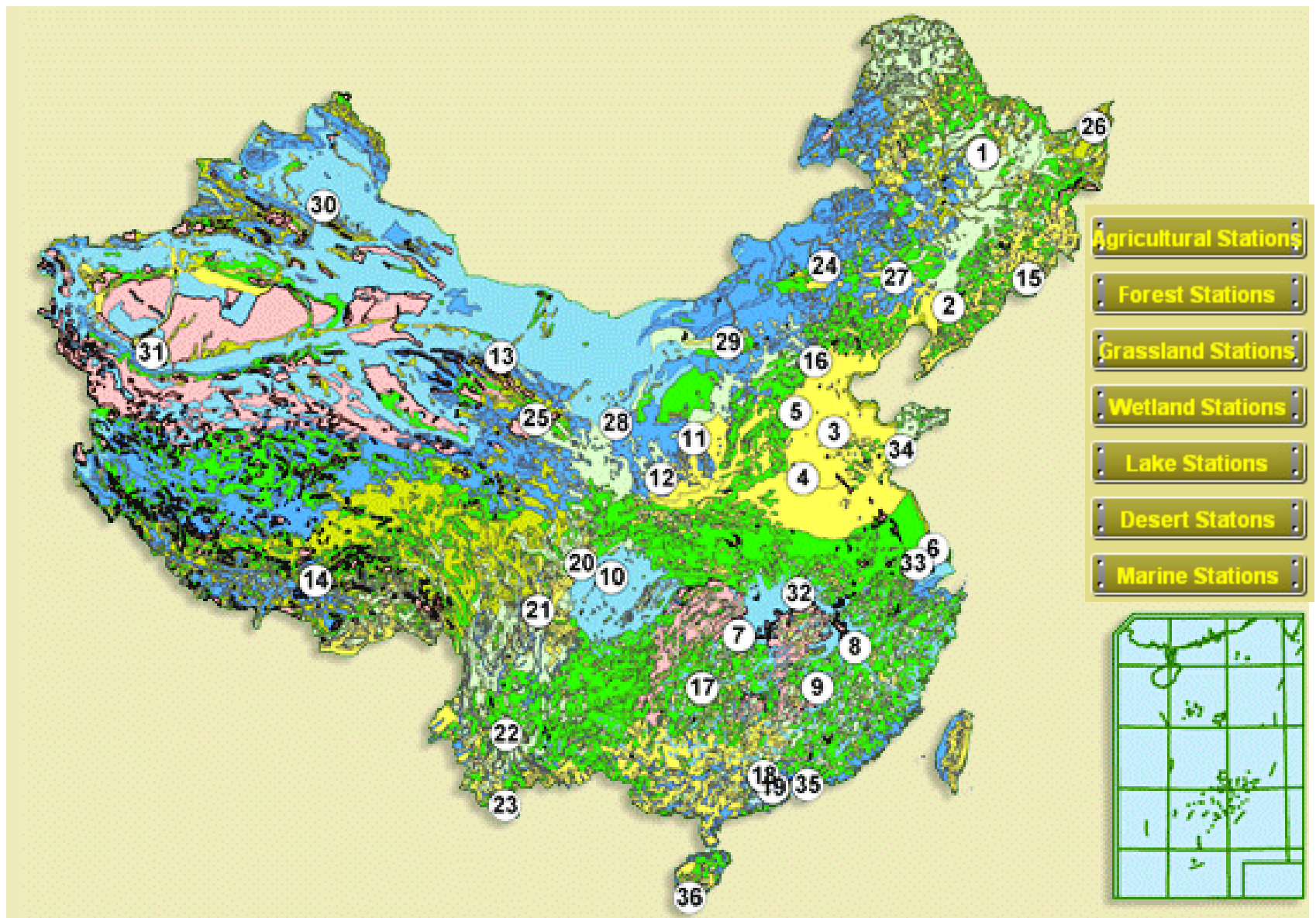


Integration System Model

The Limitations of Data and Model

DATA:

- Data standard
- Data share



Chinese Ecosystem Research Network (CERN)

Distribution of ChinaFLUX stations

Flux Observation Site of Inner Mongolia Grassland



Flux Observation Site of Changbaishan Temperate Deciduous Broad-leaved and Coniferous Mixed Forest



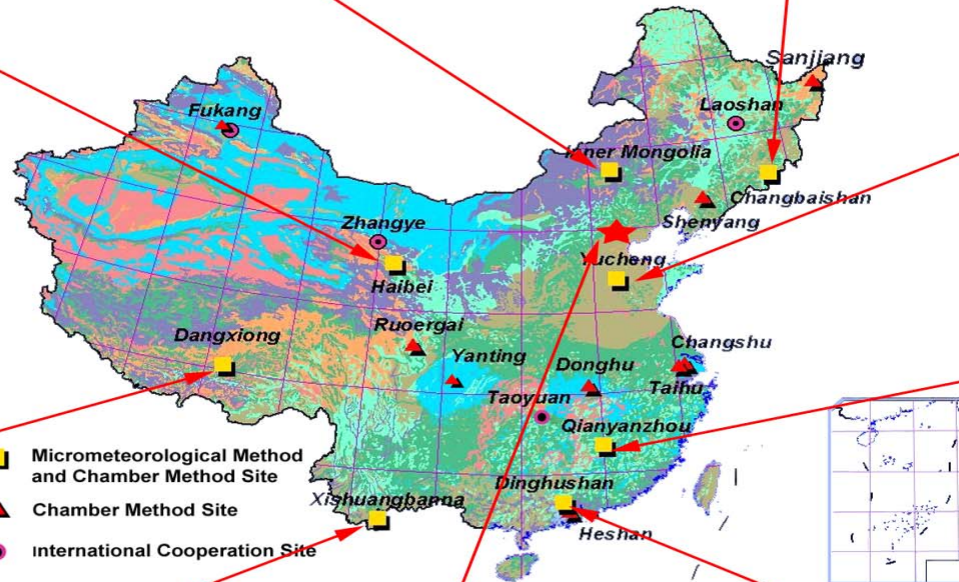
Flux Observation Site of Haibei Highland Frigid Meadow



Flux Observation Site of Dangxiong Alpine Meadow



Flux Observation Site of Xishuangbanna Tropic Seasonal Rainforest



Flux Observation Site of Yucheng Warmer Temperate Dry Farming Cropland



Flux Observation Site of Qianyanzhou Man-planted Forest on Red Soil Hill Region



Flux Observation Site of Dinghushan Sub-tropic Typical Tropical Evergreen Broad-leaved Forest



CERN
ChinaFLUX Office

Thank you