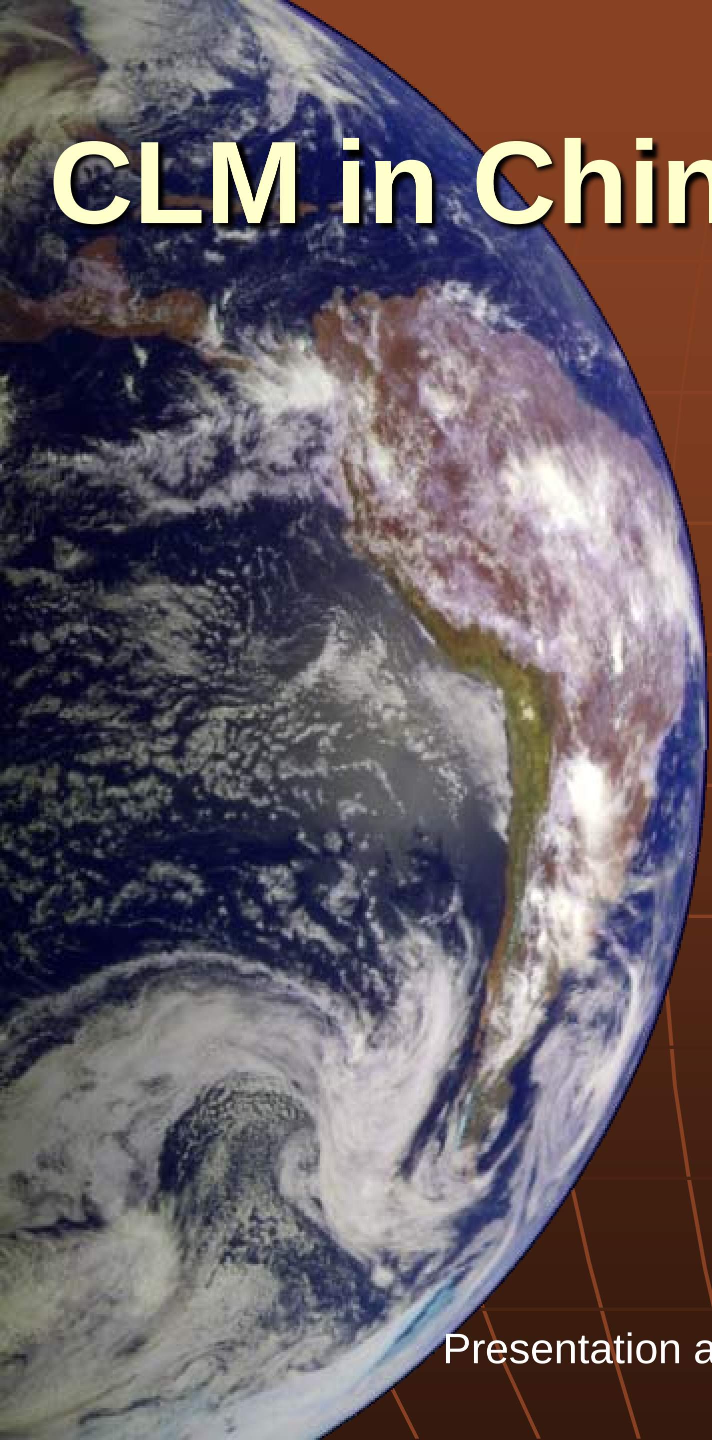

CLM in China: Past, Present and Future

Zong-Liang Yang
(杨宗良)

Acknowledgements: H.S. Chen, Y.J. Dai, J.J. Ji, M.X. Li, W.P. Li, Z.G. Ma, S. F. Sun, Z.H. Xie, A.H. Wang, and X.D. Zeng

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Presentation at the NCAR CESM Annual Workshop, Breckenridge, 21 June 2011

Milestones of Land Surface Modeling Research in China

- 1980s, TC Yeh: two papers in *Mon. Wea. Rev*. on the climatic/hydrologic impacts of snow and soil moisture anomalies
- 1980s, Xinanjiang rain-runoff model was developed for hydrologic modeling in humid and semi-humid regions → basis of VIC
- 1990s, Shufen Sun: snow–atmosphere-soil transfer (SAST) model
- 1990s, Jinjun Ji: atmosphere–vegetation interaction model (AVIM) [see a Land Working Group poster by Zhang et al.]
- 1990s, Haishan Chen: multi-layer snowpack model
- 1990s, Yongjiu Dai developed IAP94; participated in PILPS 1–2; visited Univ Arizona and Georgia Tech (1997–2002); developed the Common Land Model (CoLM) → basis of CLM
- 2000s, Zhenghui Xie developed schemes for groundwater, frozen soil, crops, studied the impacts of water use (e.g., three-gorge project), and developed a global soil moisture data assimilation system

Some Research Highlights

Yongjiu Dai, Beijing Normal University

Aihui Wang, Nansen-Zhu International Research Center, Institute of Atmospheric Physics, Chinese Academy of Sciences

Mingxing Li, Key Laboratory of Regional Climate & Environment for East Asia, IAP/CAS

Weiping Li, National Climate Center, China Meteorological Administration

Xiaodong Zeng, International Center for Climate and Environmental Sciences, IAP/CAS

Xin Li, Cold and Arid Regions Environmental and Engineering Research Institute, CAS

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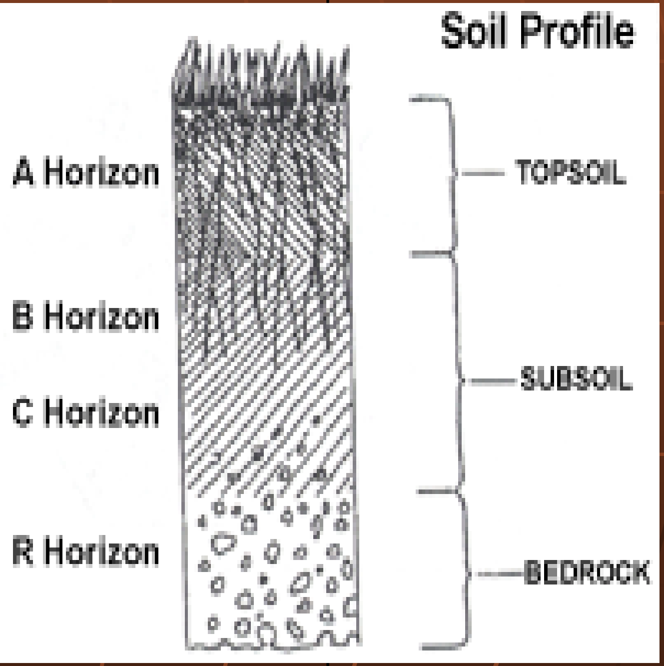
China Soil Dataset

- 9000 soil profiles vs 60 in FAO soil dataset
- Soil profiles and attributes were digitized and synthesized from county /regional soil surveys.
- Soil Map of China (1:1 000 000).

Dai et al., 2011

Dai Y, Shangguan W, Liu B, and Coauthors, 2011: **A China dataset of soil properties for land surface modeling.** (to be submitted to Global Biogeochemical Cycles)

1	Horizon Thickness (cm)
2	Soil Texture
3	Bulk Density
4	Particle-Size Fraction % (0.05 - 2.0 mm)
5	Particle-Size Fraction % (0.002 - 0.05mm)
6	Particle-Size Fraction % (< 0.002 mm)
7	Organic Matter Fraction (%)
8	Total N (%)
9	Total P (%)
10	Total K (%)
11	Available P (mg/kg)
12	Available K (mg/kg)
13	pH Value (H_2O)
14	Exchangeable H^+ (me/100g)
15	Exchangeable Al^{3+} (me/100g)
16	Exchangeable Ca^{2+} (me/100g)
17	Exchangeable Mg^{2+} (me/100g)
18	Exchangeable K^+ (me/100g)
19	Exchangeable Na^+ (me/100g)
20	Cation Exchange Capacity (CEC) (me/100g)
21	Color
22	Structure
23	Consistence



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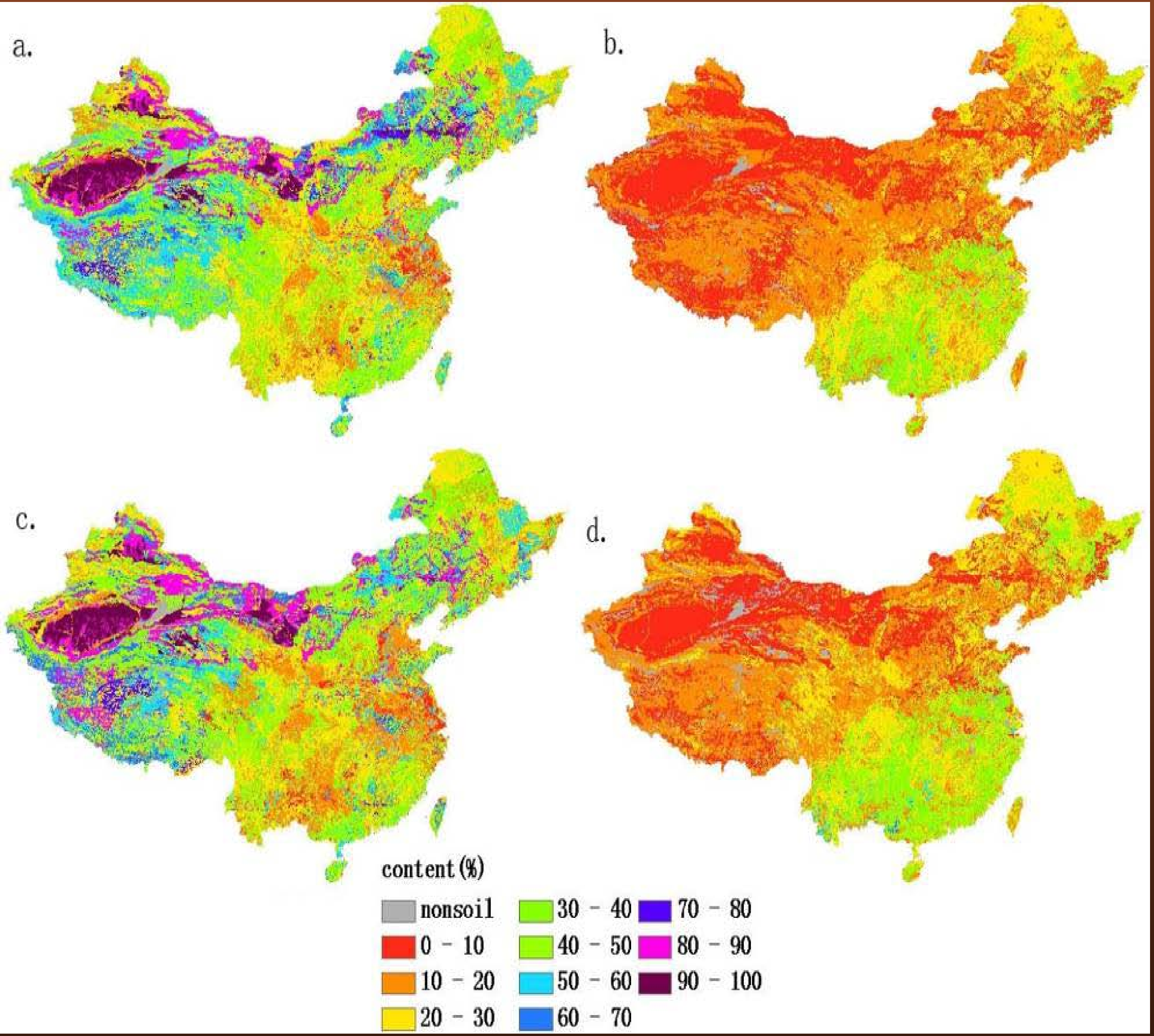
Dai et al., 2011

sand fraction of the topsoil (0–30 cm)

clay fraction of the topsoil (0–30 cm)

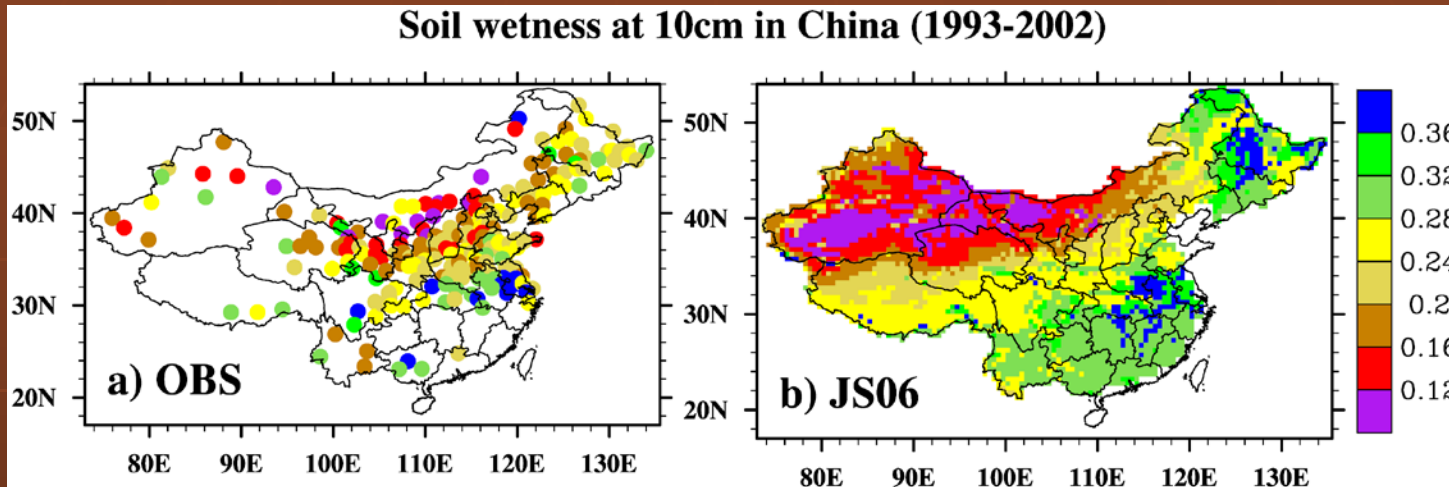


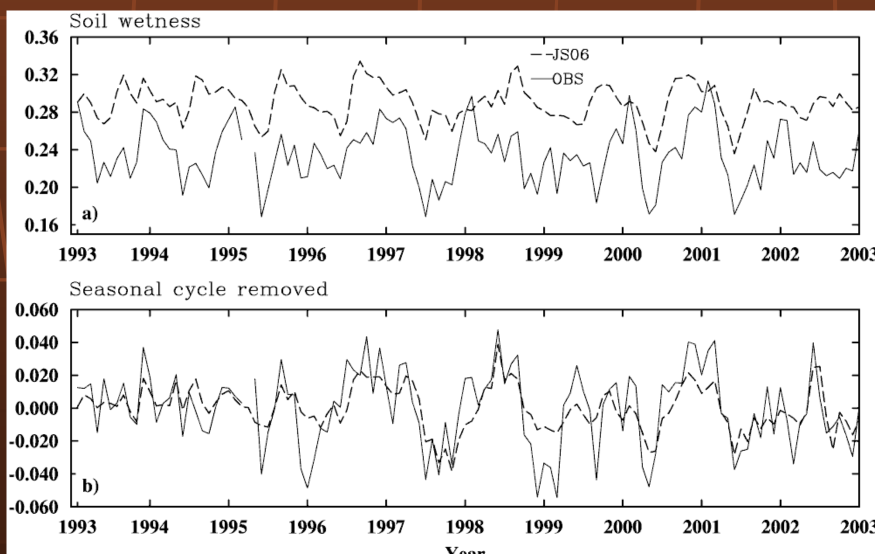
sand fraction of the subsoil (30–100 cm).

clay fraction of the subsoil (30–100 cm).

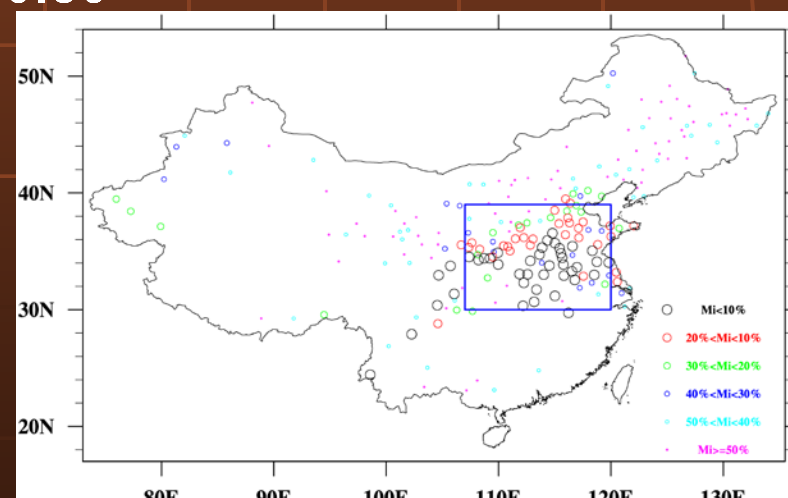
Dai et al., 2011

CLM3.5 simulations versus observed soil moisture





Correlation coefficient 0.56 and 0.59



Wang A. and X. Zeng, 2011: Sensitivities of terrestrial water cycle simulations to the variations, *J. Geophys. Res*, D116,D02107, doi:10.1029/2010JD014659

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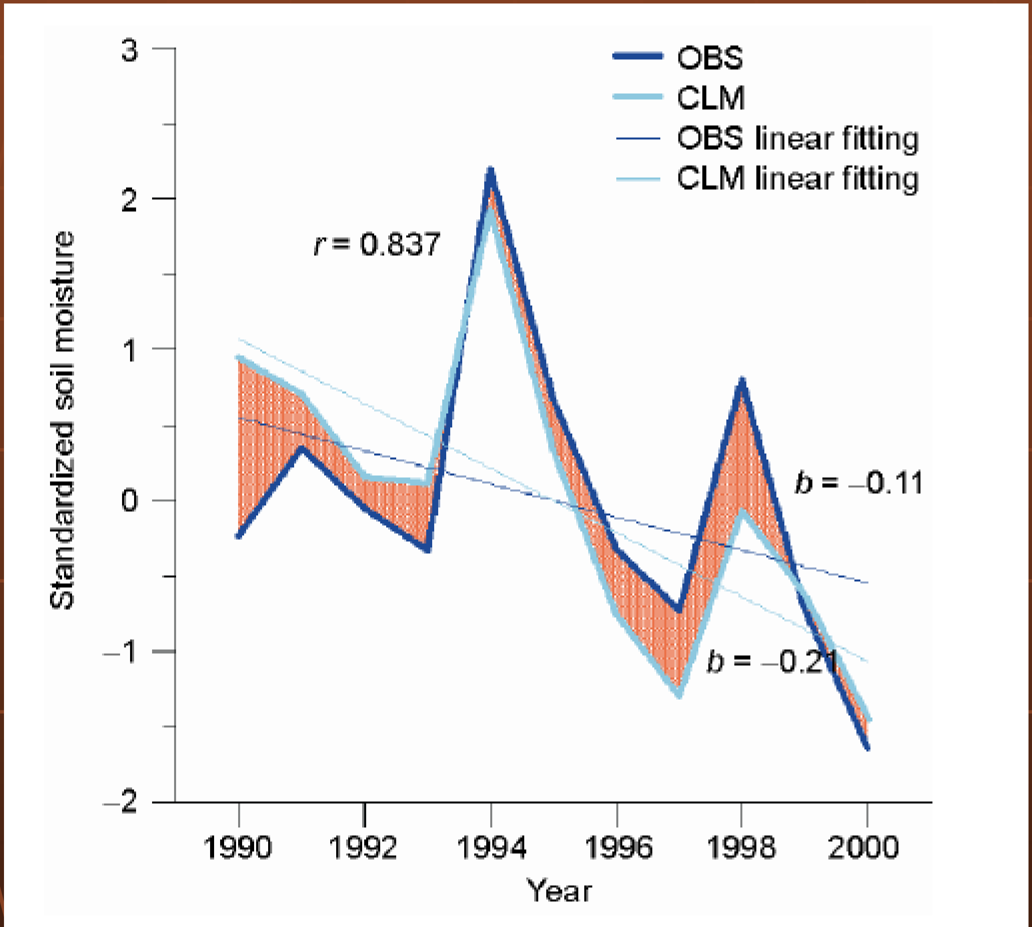
Soil Moisture Trend in China



Soil moisture is decreasing in northeast China

Li, Ma, and Niu, 2011

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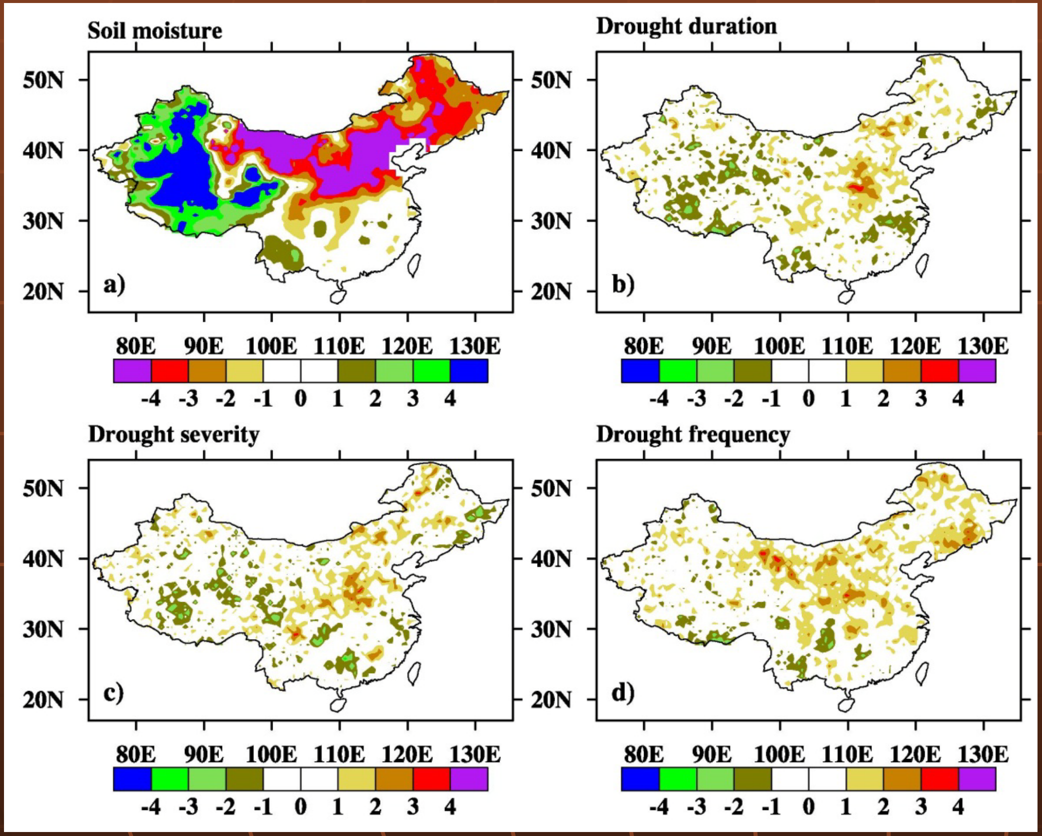
1950–2006 China Drought Reconstruction From Ensemble Soil Moisture Simulations (CLM3.5, VIC, NOAH, CLM-VIC)



Annual trends in a) soil moisture percentile; b) drought severity; c) drought duration; and d) drought frequency for 1950-2006.

The trends were computed using the seasonal Mann-Kendall algorithm. The different colors represent the magnitudes of the statistics.

Wang A., Dennis P. Lettenmaier, and J. Sheffield, 2011: Soil moisture drought in China, 1950-2006, *J. Climate*, DOI:10.1175/2011JCLI3733.1 (in press).

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Application and Development of Dynamic Global Vegetation Model in IAP/CAS

Xiaodong Zeng, Fang Li, Dongling Zhang, Pu Shao, Xiang Song, Dongxiao Tian, Hao Chen, Jiawen Zhu

International Center for Climate and Environment Sciences

Institute of Atmospheric Physics, Chinese Academy of Sciences

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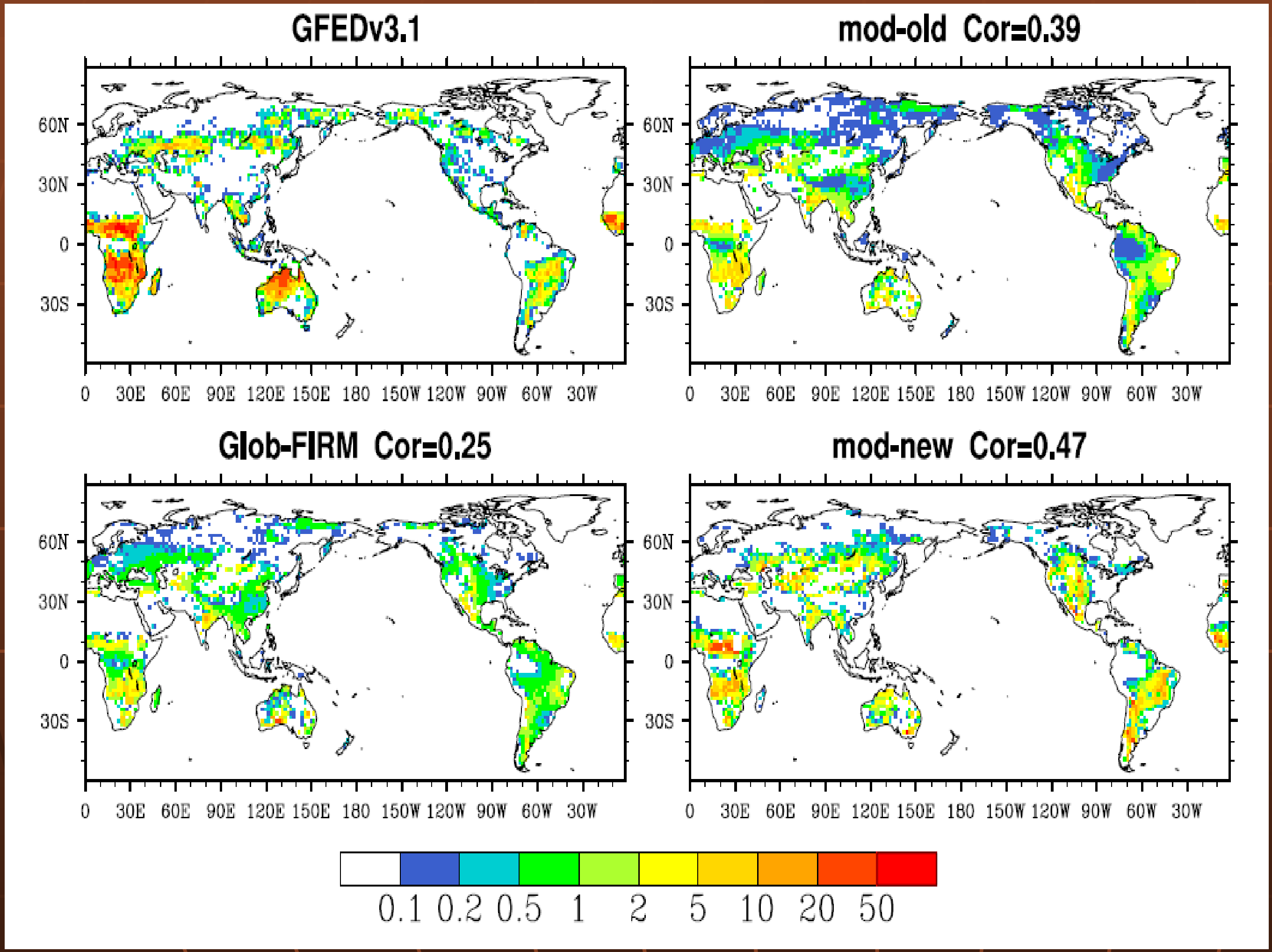
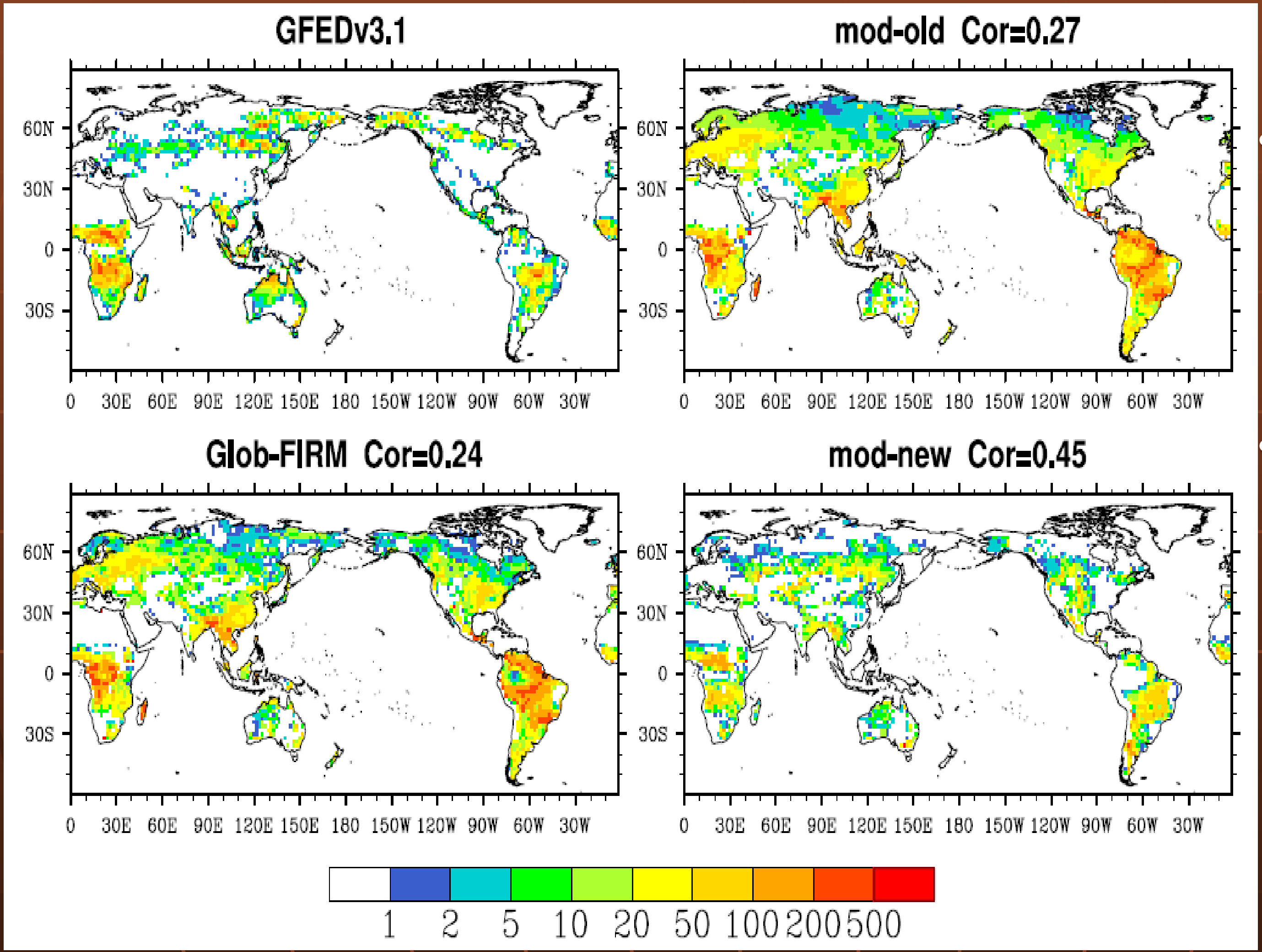
Burned Area Fraction



- **Mod-new successfully reproduces the global spatial distribution of annual burned area fraction**
- **Mod-new is more skillful than mod-old** (Levis et al. 2004) **and Glob-FIRM** (Thonicke et al. 2001), **especially in the tropics and in the middle-high latitude**

F. Li, X.D. Zeng

Fire Carbon Emission ($gC/m^2/year$)



- Mod-new successfully reproduces the global spatial distribution of annual fire carbon emissions
- Mod-old and Glob-FIRM overestimate fire carbon emissions

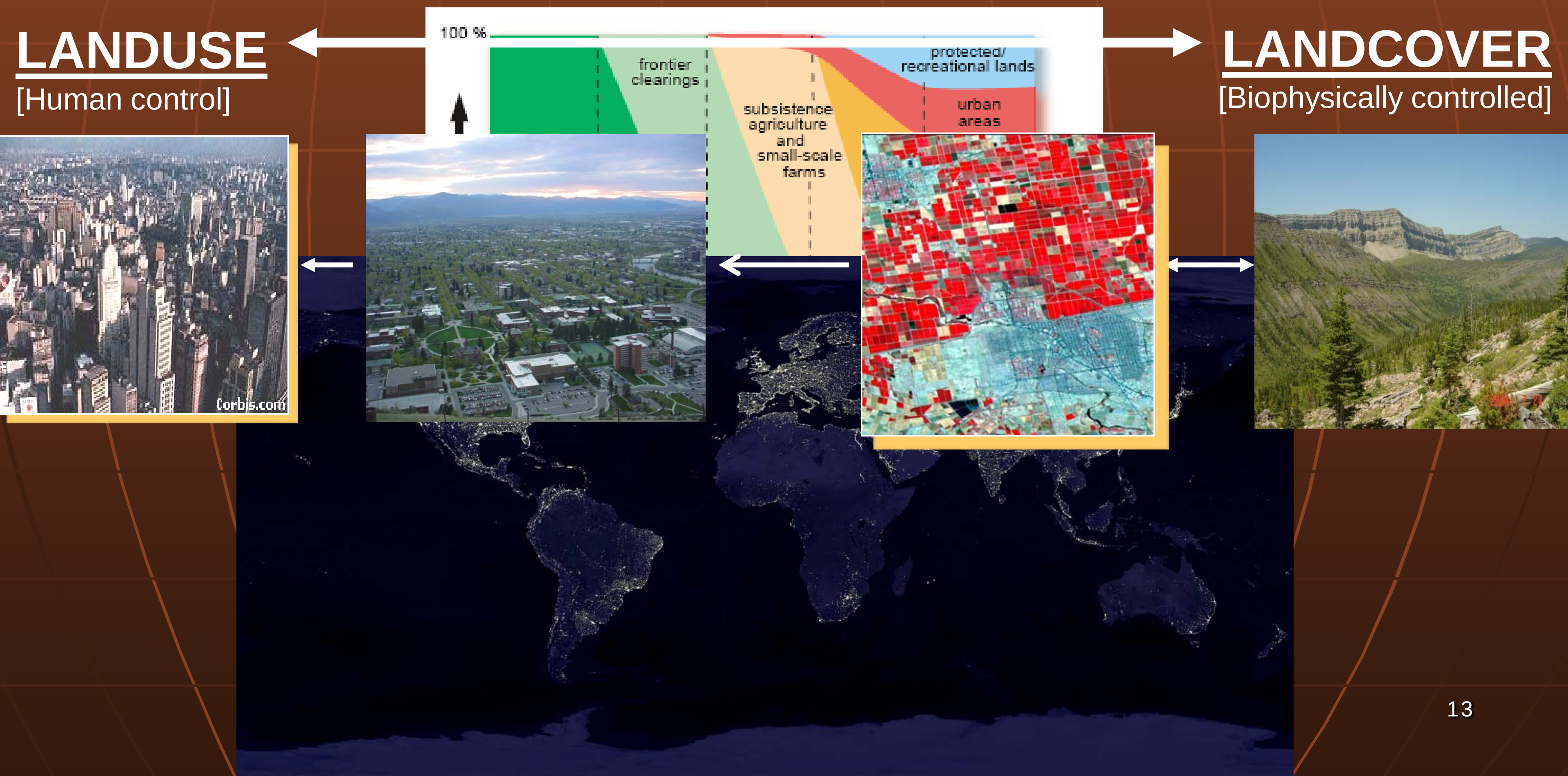
F. Li, X.D. Zeng

Research Challenges (1)

- Rapid Transformation of Landscapes
  - Land surface as a complex system
  - Natural and managed components, and multi-scale interactions
  - Deforestation, Reforestation, Urbanization, Agriculture and Irrigation
  - Living organisms

LANDUSE
[Human control]

LANDCOVER
[Biophysically controlled]



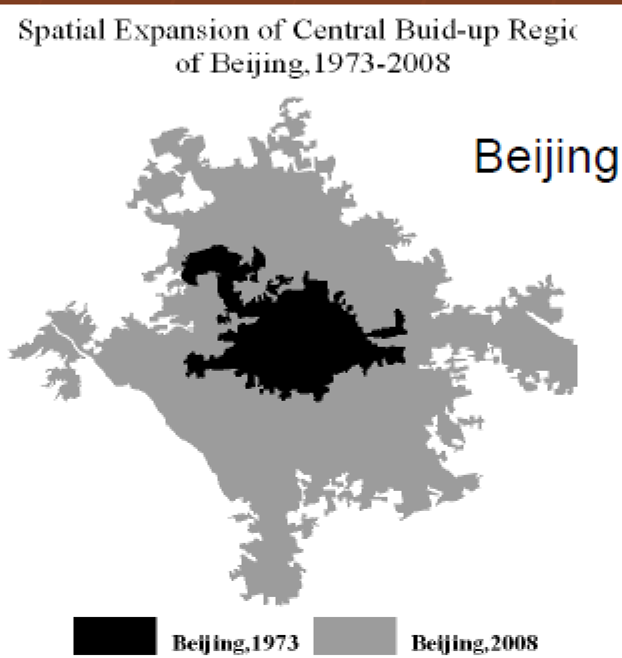
Rapid Urbanization in China

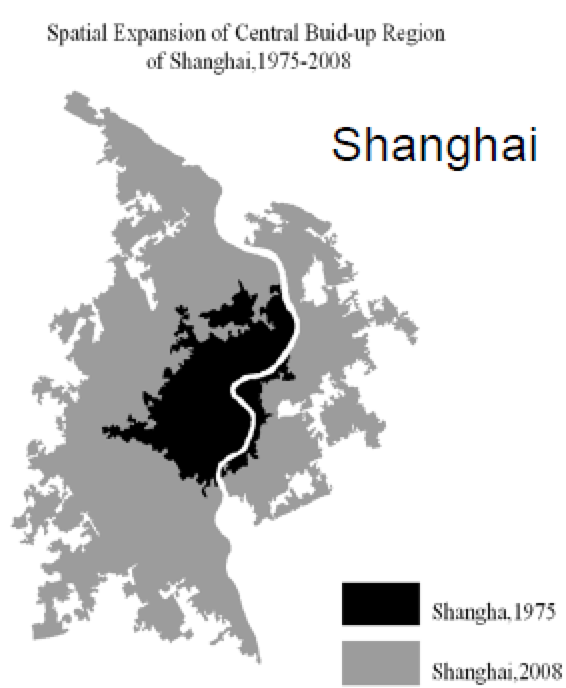
	2005	2010	2020	2030	2040	2050
Population	1307.56	1360.00	1440.00	1470.00	1470.00	1440.00
Urbanization rate	43%	49%	63%	70%	74%	79%
Urban Population	562.12	666.40	907.20	1029.00	1087.80	1137.60
Person per Household	2.96	2.88	2.80	2.75	2.70	2.65
Urban Household	189.91	221.94	288.00	336.76	364.78	380.38
Rural Population	745.44	693.60	532.80	441.00	382.20	302.40
Person per Household	4.08	3.80	3.50	3.40	3.20	3.00
Rural Household	182.71	189.68	181.03	159.97	151.59	144.00

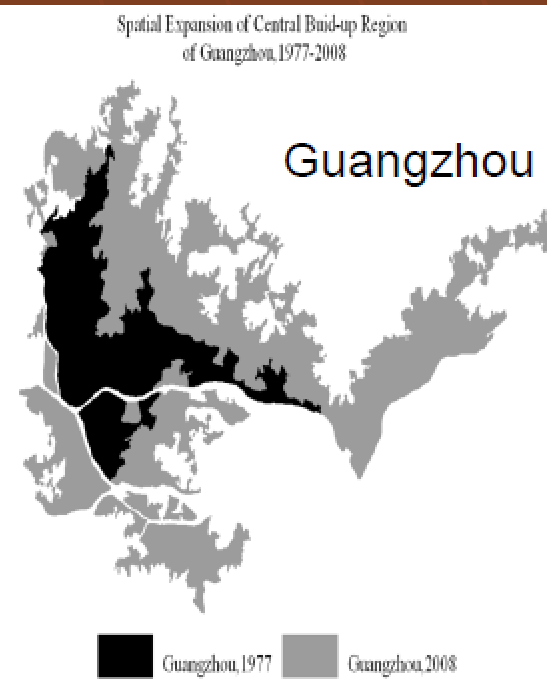
Ailikun (2011)

Megacities in China

Ailikun (2011)





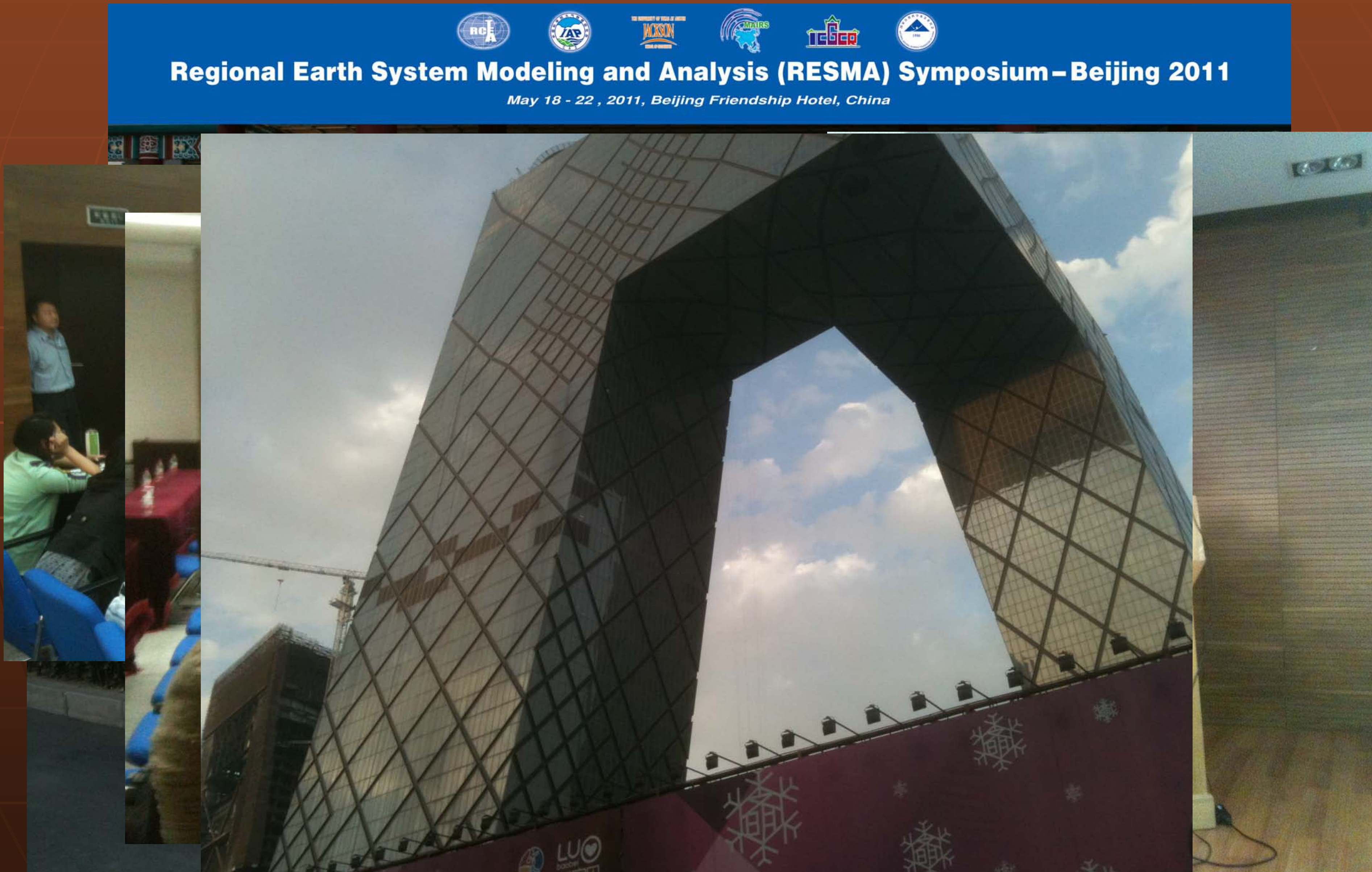


1973-2008, urban area in Beijing increased 5.56 times

1975-2008, urban area in Shanghai increased 4.88 times

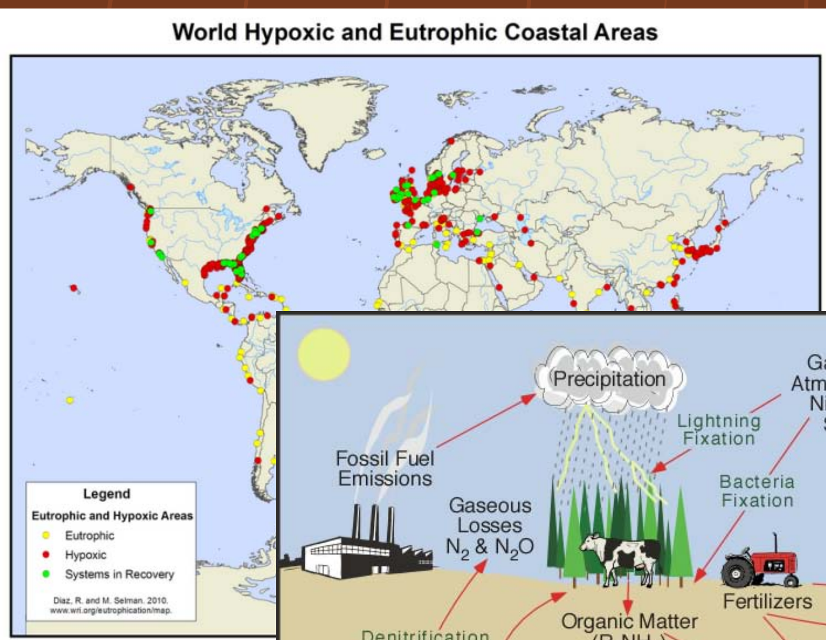
1977-2008，urban area in Guangzhou increased 2.75 times

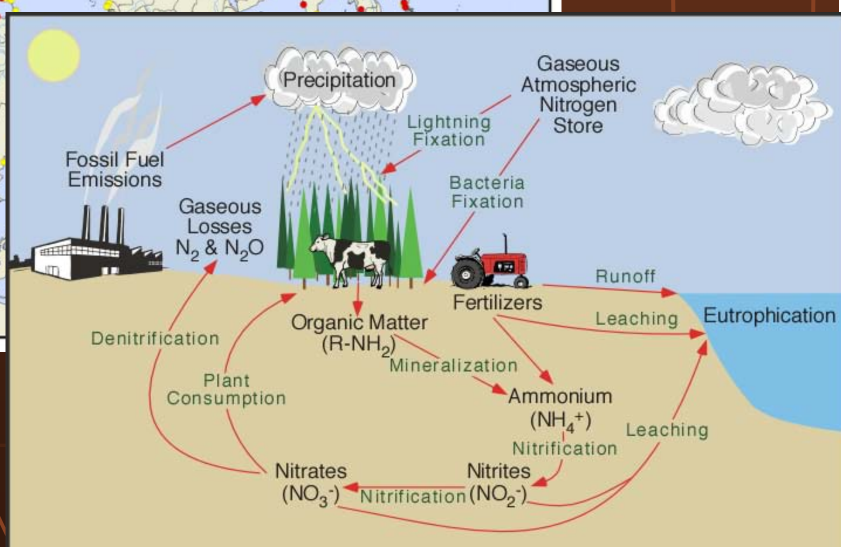
Modeling Urbanization in RESM

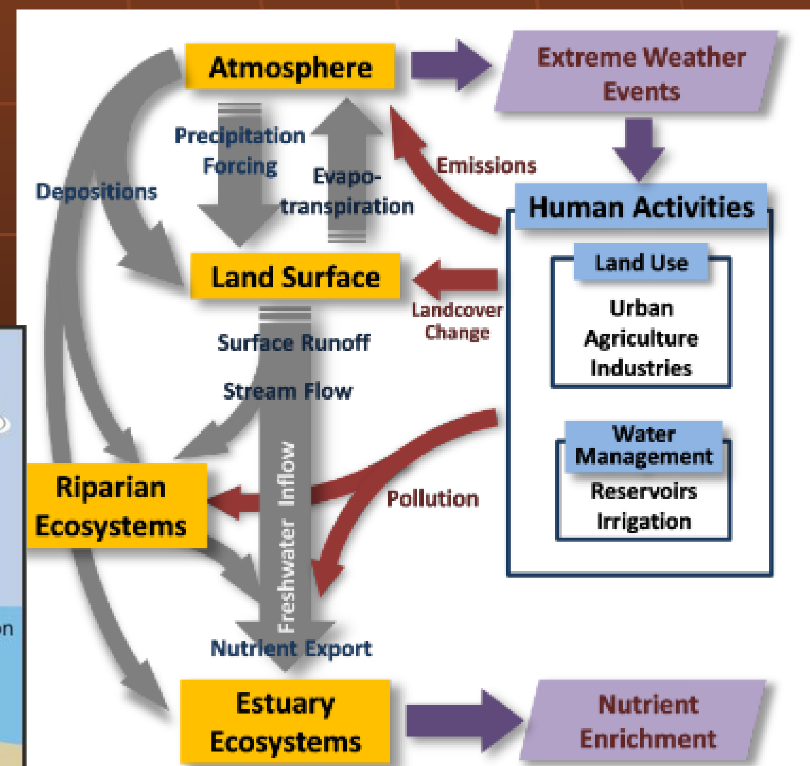


New Challenges (2)

- Increasing Frequency of Hydrologic Hazards
  - Flood and drought
  - Water resources
  - Watershed–coast coupling (runoff, riverine nutrient exports, coastal ecosystems)







Yang (2011)

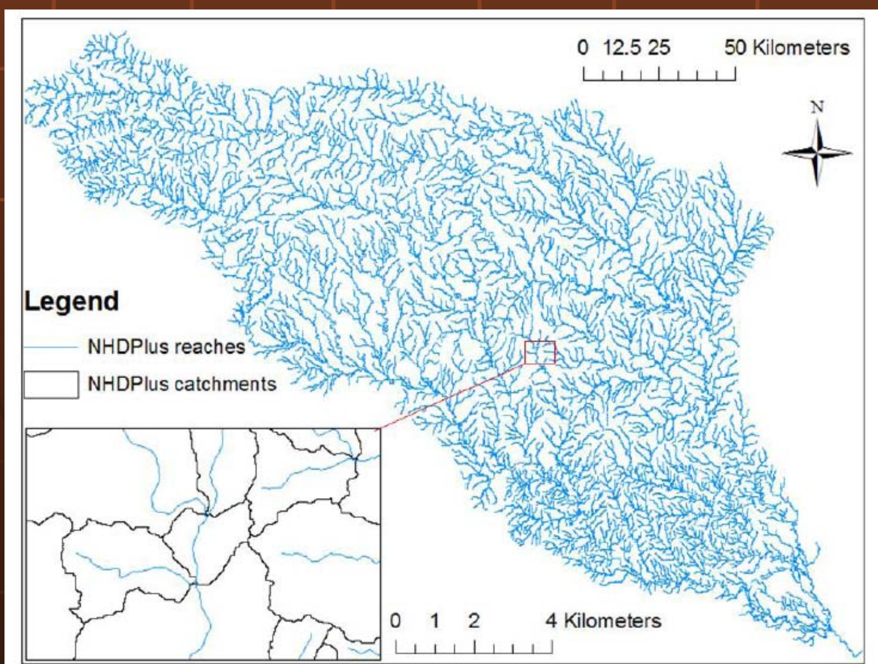
River network model: RAPID

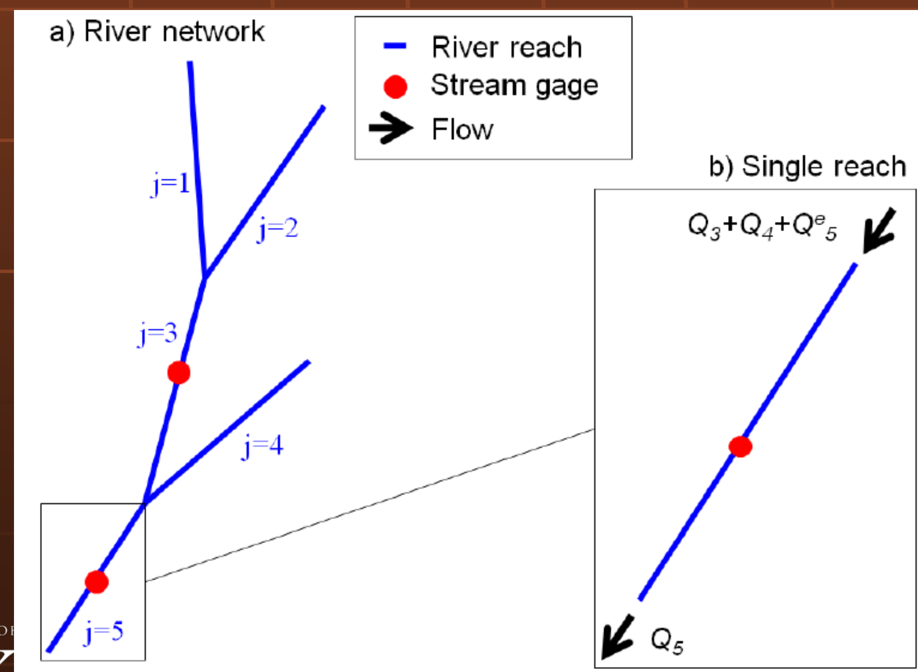
- Routing Application for Parallel computatIon of Discharge

$$(\mathbf{I}-\mathbf{C}_1\cdot\mathbf{N})\cdot\mathbf{Q}(t+\Delta t)=\mathbf{C}_1\cdot\mathbf{Q}^e(t)+\mathbf{C}_2\cdot\left[\mathbf{N}\cdot\mathbf{Q}(t)+\mathbf{Q}^e(t)\right]+\mathbf{C}_3\cdot\mathbf{Q}(t)$$

$$\mathbf{V}(t+\Delta t)=\mathbf{V}(t)+\left[\mathbf{N}\cdot\mathbf{Q}(t)+\mathbf{Q}^e(t)\right]\cdot\Delta t-\mathbf{Q}(t)\cdot\Delta t$$

http://www.geo.utexas.edu/scientist/david/rapid.htm





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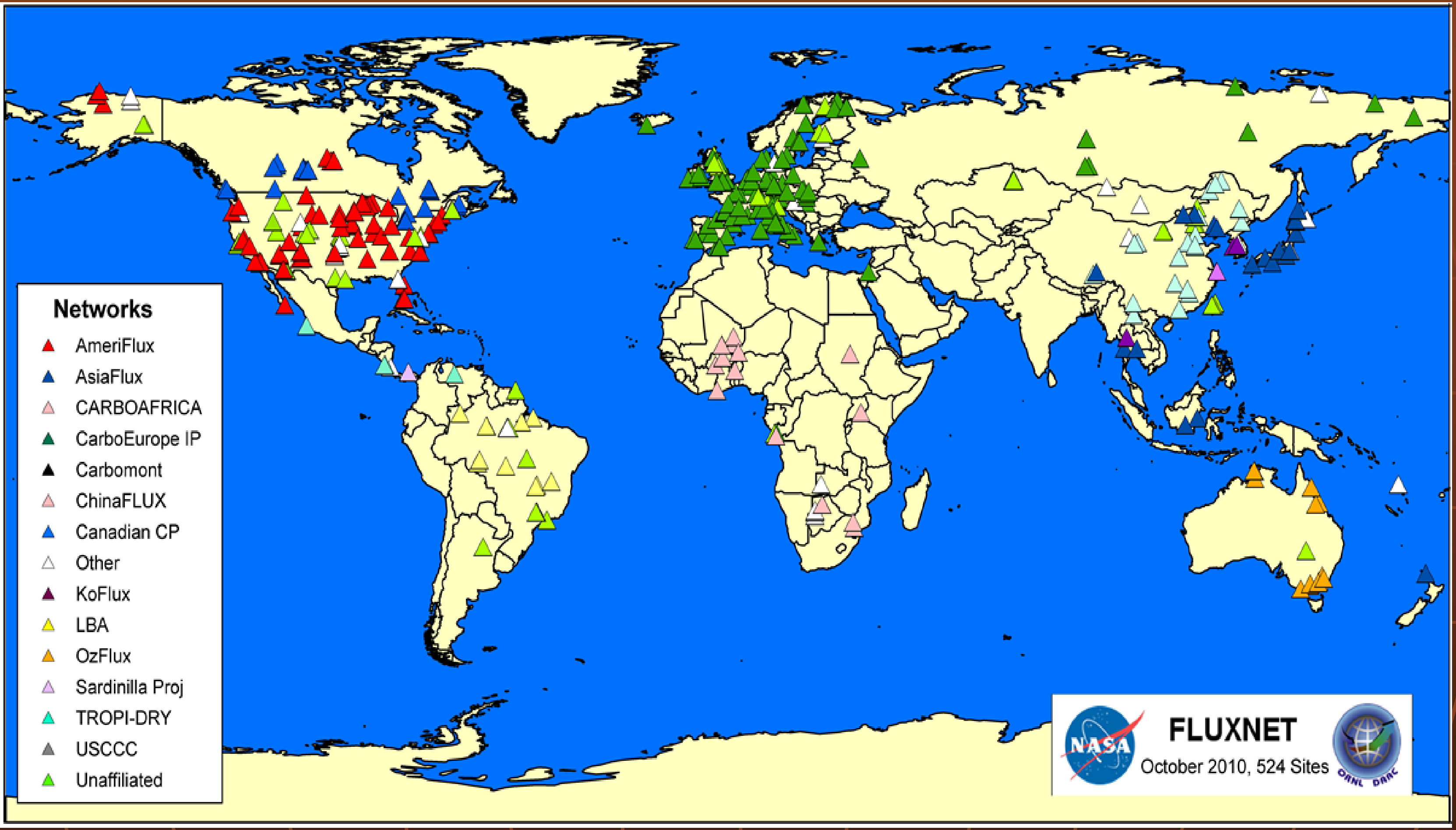
David et al. (2011)

RAPID River Routing Model Training Course
Beijing, May 24 –26, 2011

http://www.geo.utexas.edu/scientist/david/rapid.htm

Surface Flux Measurements in China



As of October 2010, 524 sites globally. A large number of sites have merged in China.

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Heihe Watershed Allied Telemetry Experimental Research (Hi-WATER)

Region: Northwest China (38–43°N, 96–104°E)

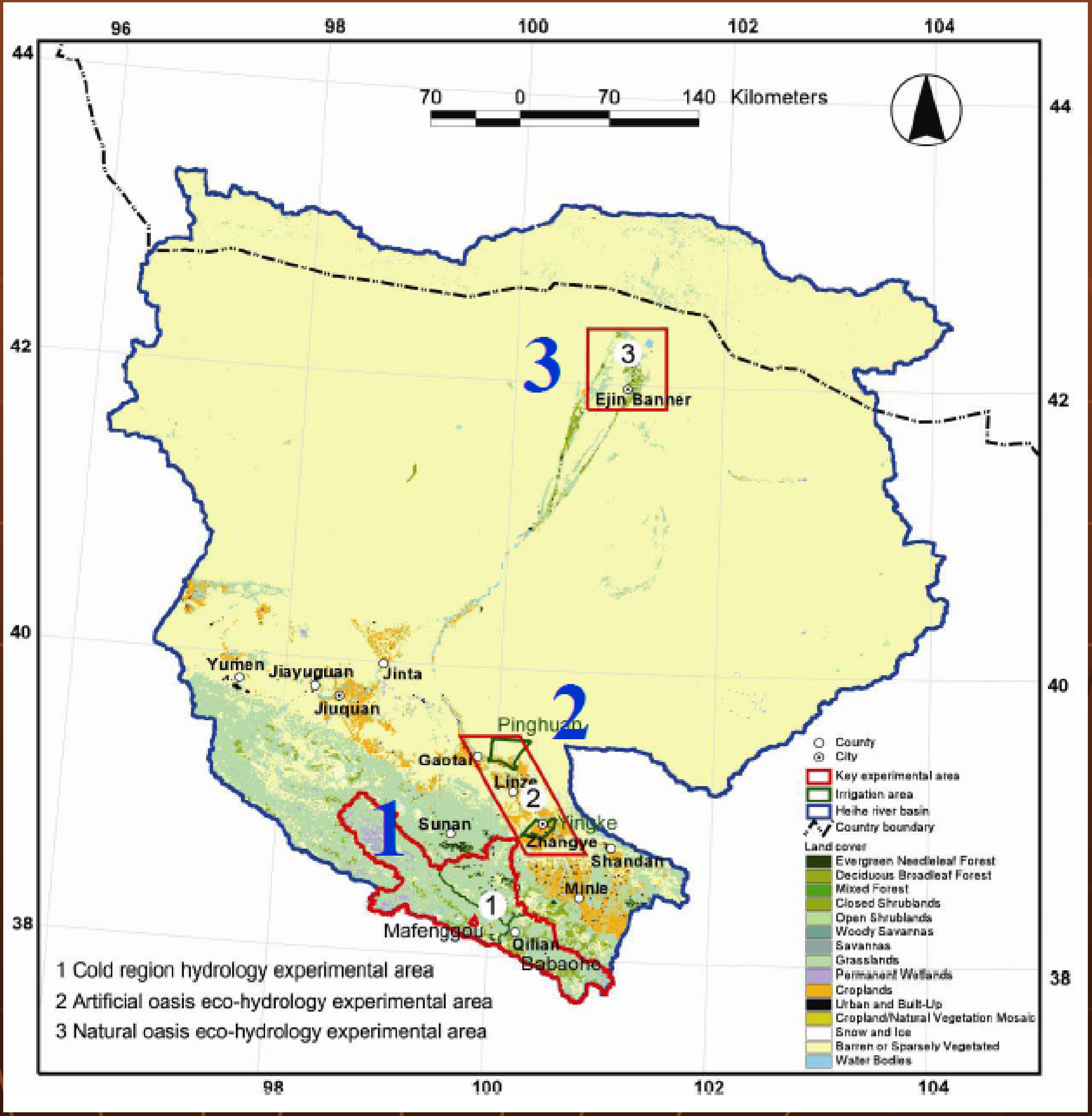
Key processes: semi-arid hydrometeorology, cold region hydrology, oasis

Intensive Observation Period (IOP): 2012–2014

Measurements: airborne remote sensing, eco-hydrological wireless sensor network, surface flux network

Funding: National Natural Science Foundation of China

Chief scientist: Xin Li



Summary

- Land surface modeling has been a key research component in China since late 1970s.

- Tremendous funding is available in the area of land surface modeling and observation, because of
  - Rapid economic growth
  - An increasing number of extreme climatic and hydrologic hazards in China.

- There are potentially a significant number of CLM developers and users.
  - A CLM tutorial in China could easily attract 200+ attendants.

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