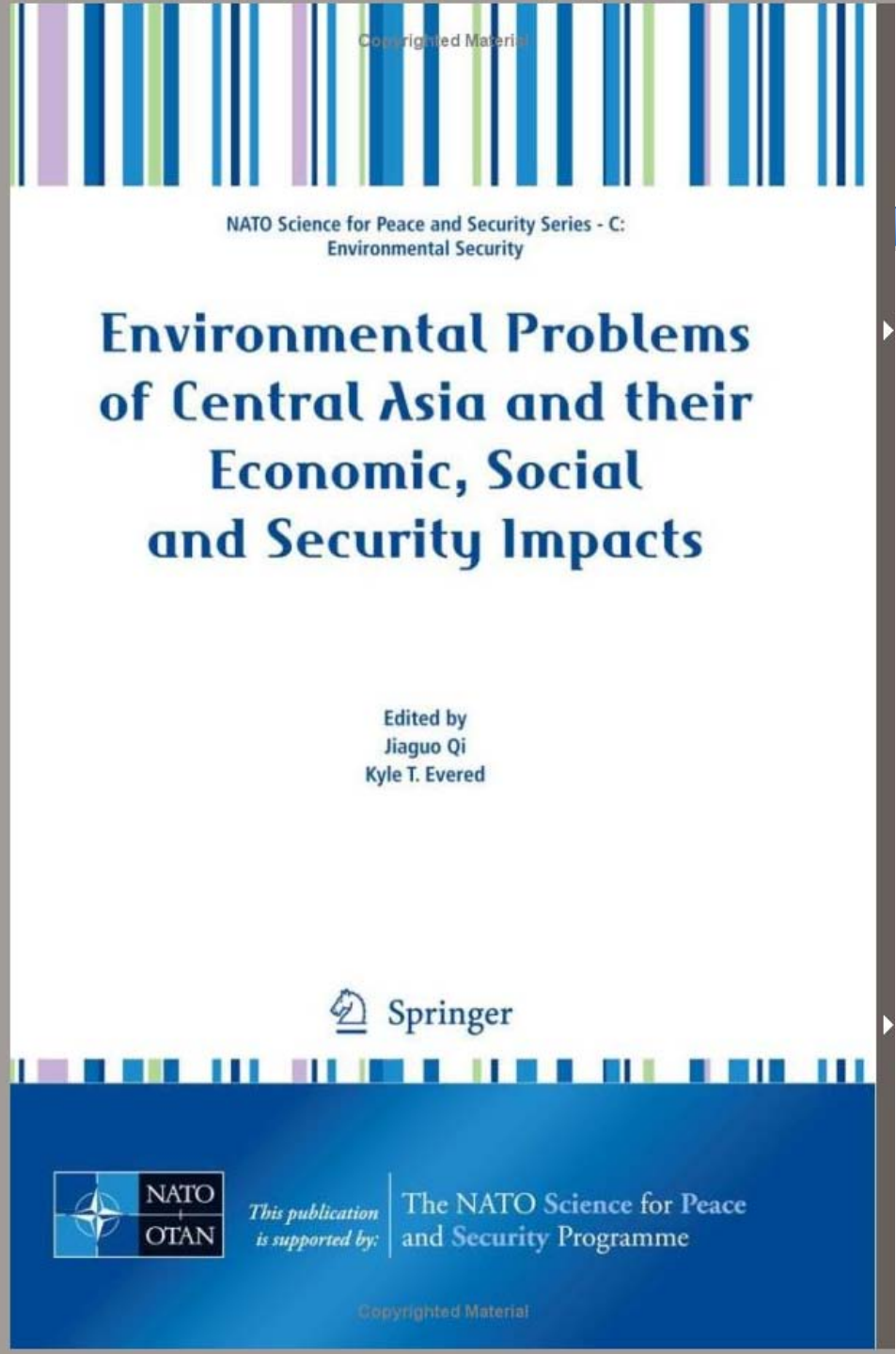
Carbon Consequences of China's Land Cover Changes -- Climate or Human Responsible?

Jiaguo Qi, Director
Center for Global Change and Earth Observations
Department of Geography
Michigan State University

Team:

Dr. Jianjun Ge (Oklahoma State University);
Dr. Haiyan Wei (USDA-ARS, Tucson, AZ);
Dr. Phil Heilman (USDA-ARS, Tucson, AZ);
Mr. Feng Zhang (Lanzhou University);
Nathan Moore (MSU and ZJU)

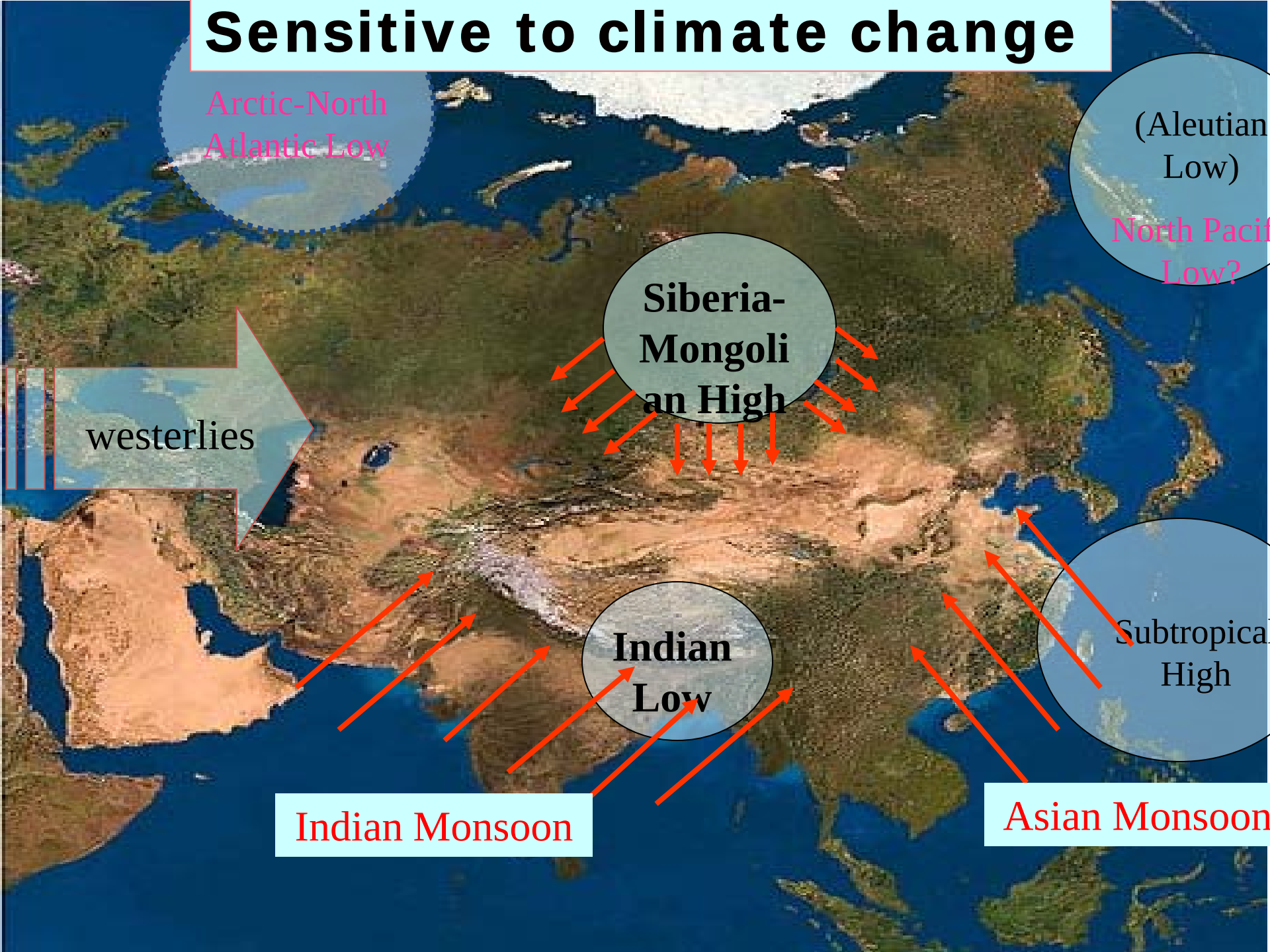
Center for GLOBAL CHANGE & Earth Observations Michigan State University

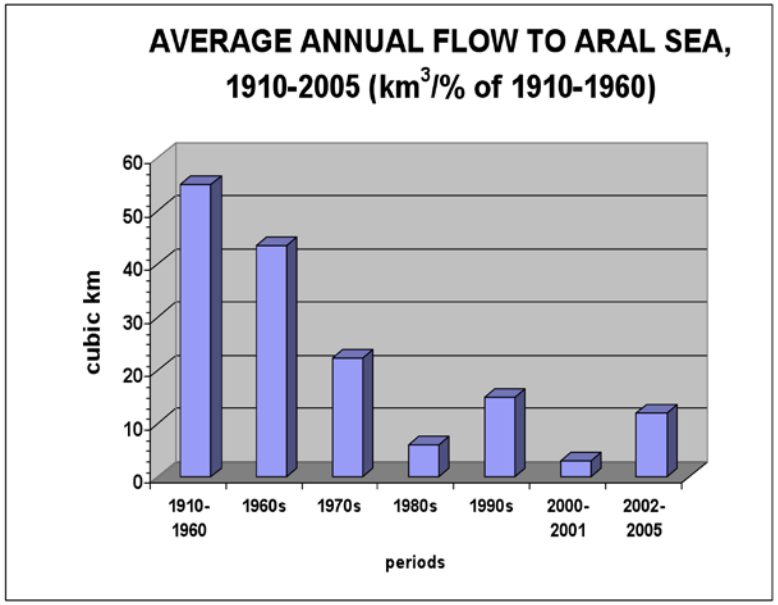


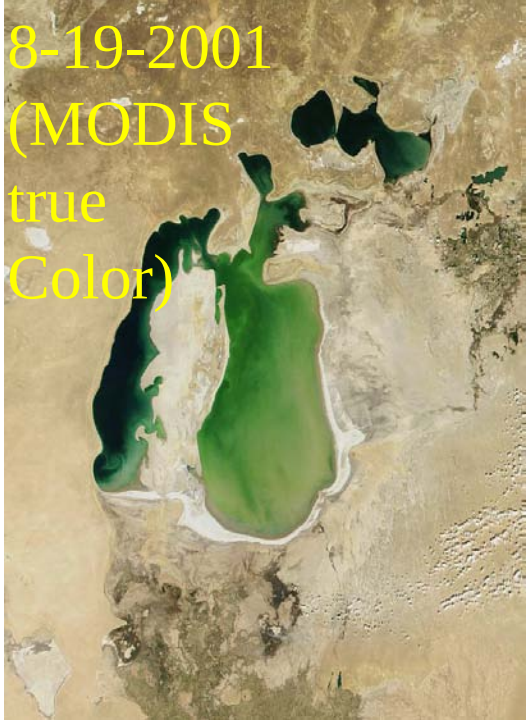
Through my research and international activities, I learned that the environmental issues in Central Asia need to be addressed urgently!

Why Central Asia?

Population Changes in Central Asia (50s-80s)（Unit：1000）


Sensitive to climate change
Arctic-North Atlantic Low
(Aleutian Low)
North Pacif
Low?
Siberia-Mongolian High
westerlies
Indian Low
Subtropical High
Indian Monsoon
Asian Monsoon


AVERAGE ANNUAL FLOW TO ARAL SEA,
1910-2005 (km3/% of 1910-1960)
cubic km
60
50
40
30
20
10
0
1910-1960
1960s
1970s
1980s
1990s
2000-2001
2002-2005
periods


8-19-2001
(MODIS
true
Color)


6-23-2003,
(MODIS
false color)


9-22-2004
(MODIS
true color)


4-8-2005
(MODIS
true
color)

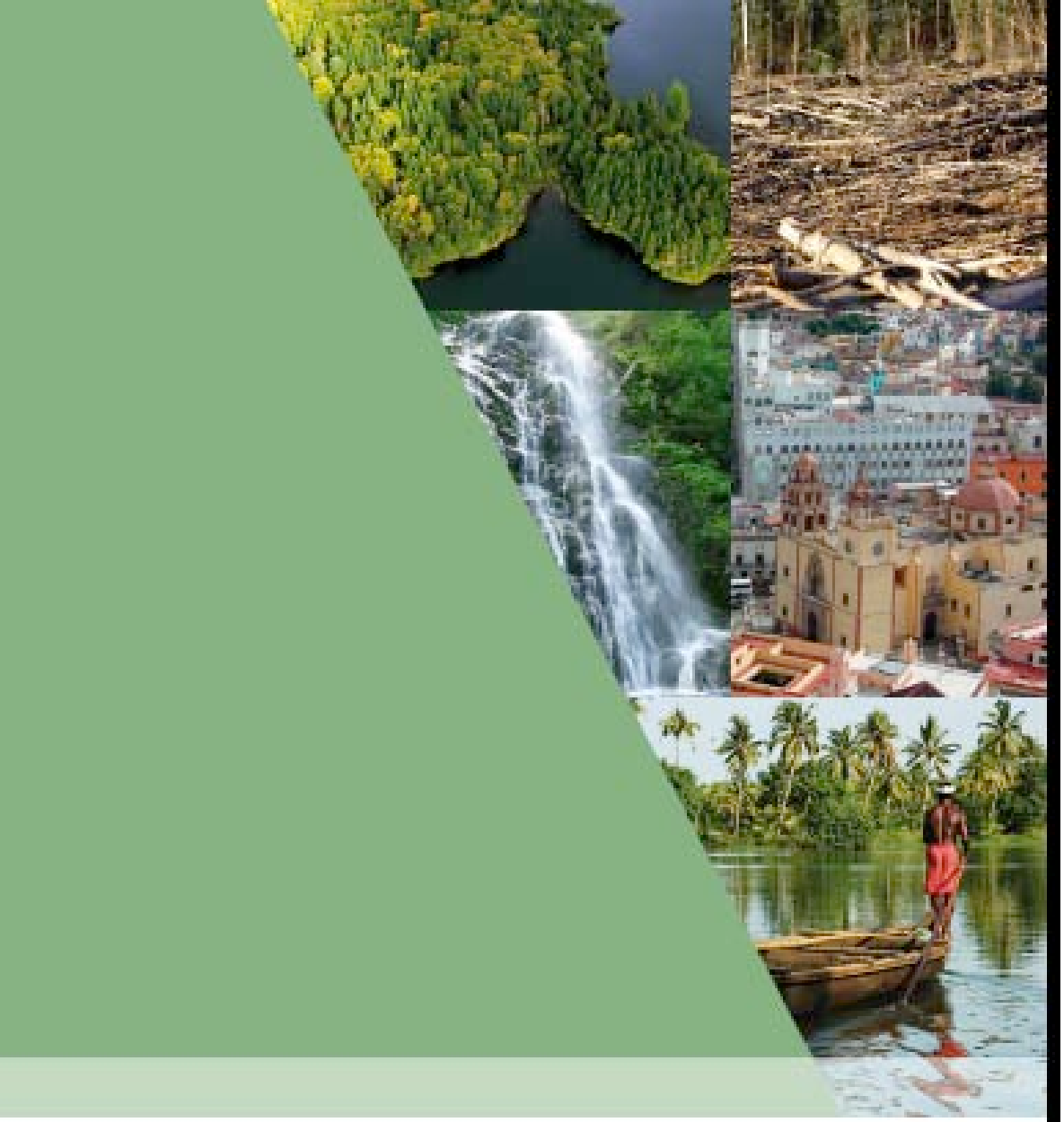

8-11-2007
(MODIS
true
color)

Agricultural Intensification


Desertification


Salinization


Degradation



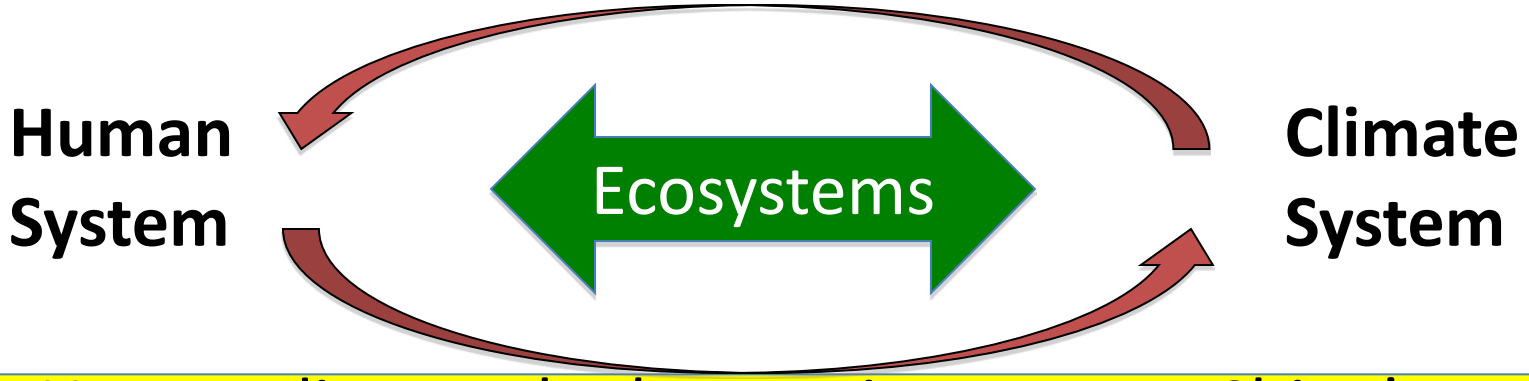
Ecosystem Change and Human Well-being

Research and Monitoring Priorities Based on the Findings of the Millennium Ecosystem Assessment

The National Research Council on March 12 released a report, *Informing Decisions in a Changing Climate, that concludes we are "unprepared, both conceptually and practically" for climate change and that it is no longer valid to base decisions on the assumption of continued climatic conditions of the past.*

Science Questions

- To what extent have human activities affected regional climate change?
- To what extent has the climate change affected ecosystems?



- How to discern the human impacts on China's ecosystem dynamics from climate impacts?

Approaches

Approach 1:
Observational and Statistical Modeling

- Remote sensing – temporal change
  - GIMMS (1982-2006) and MODIS (2000-2007) time series
  - In phenological and carbon/biomass
- Time series analysis with TIMESAT
  - Calculate the biomass
- Correlations analysis biomass – climate
  - Correlation coefficients: percentage of explanation
  - Examine residuals: percentage of explanation?

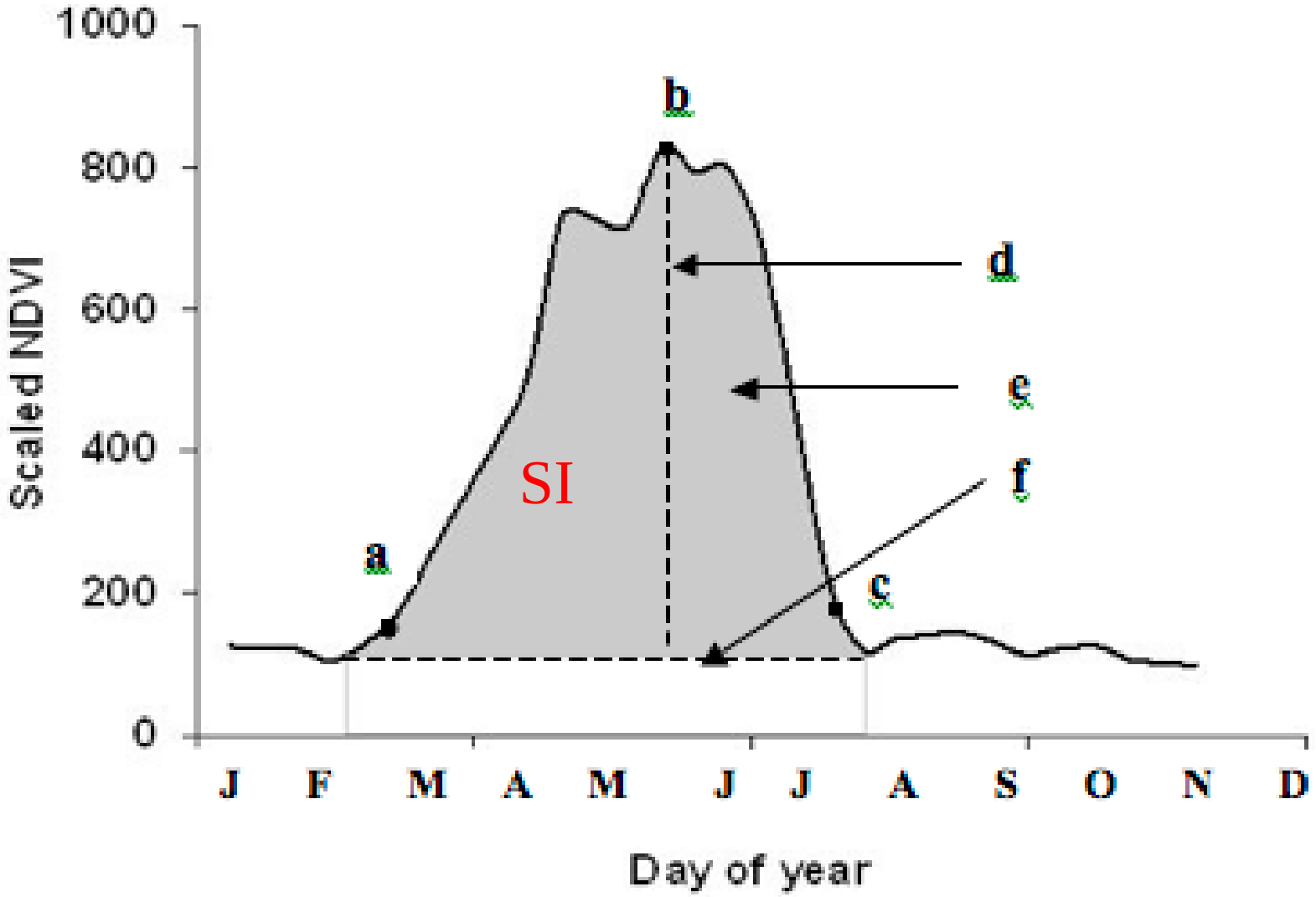
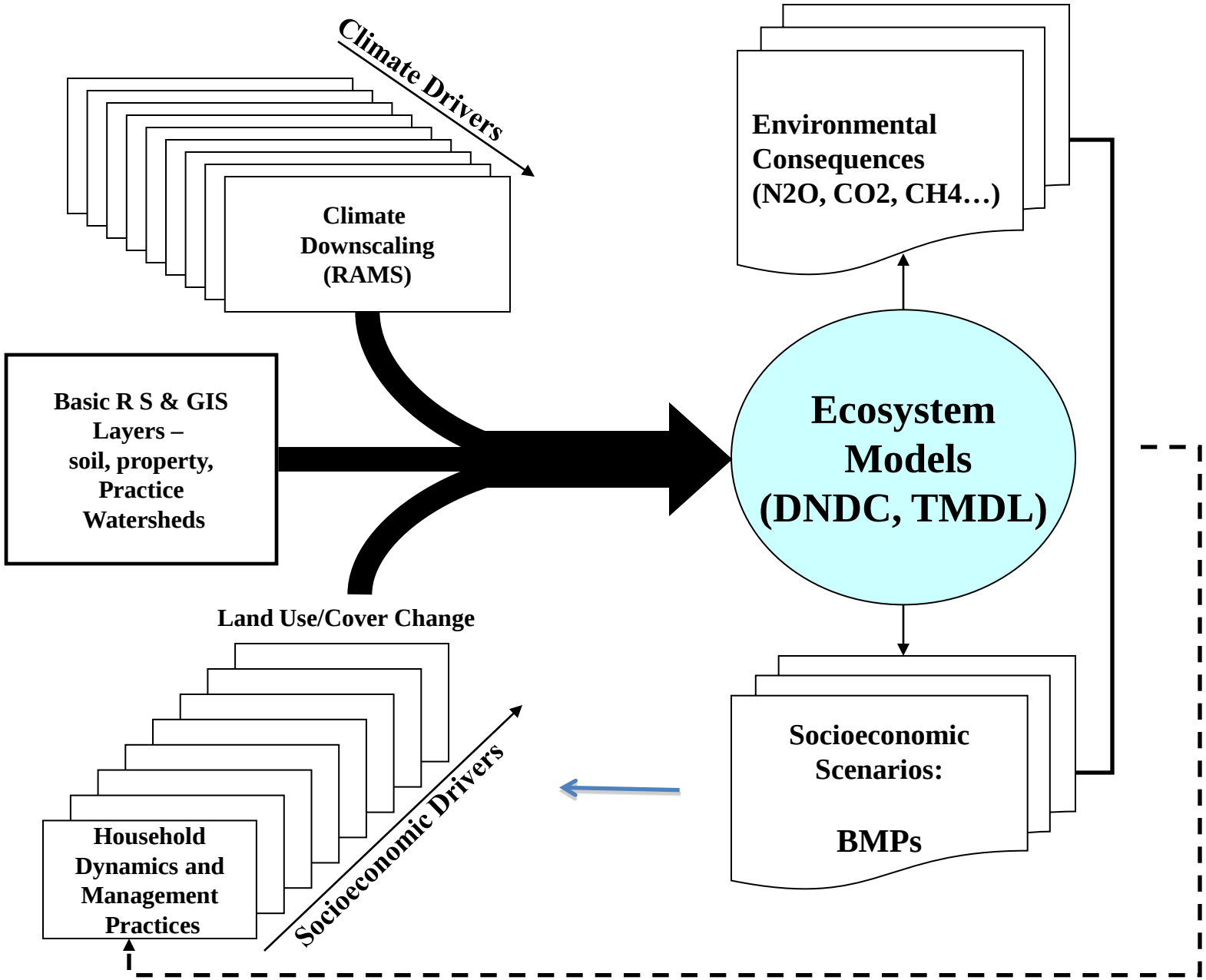
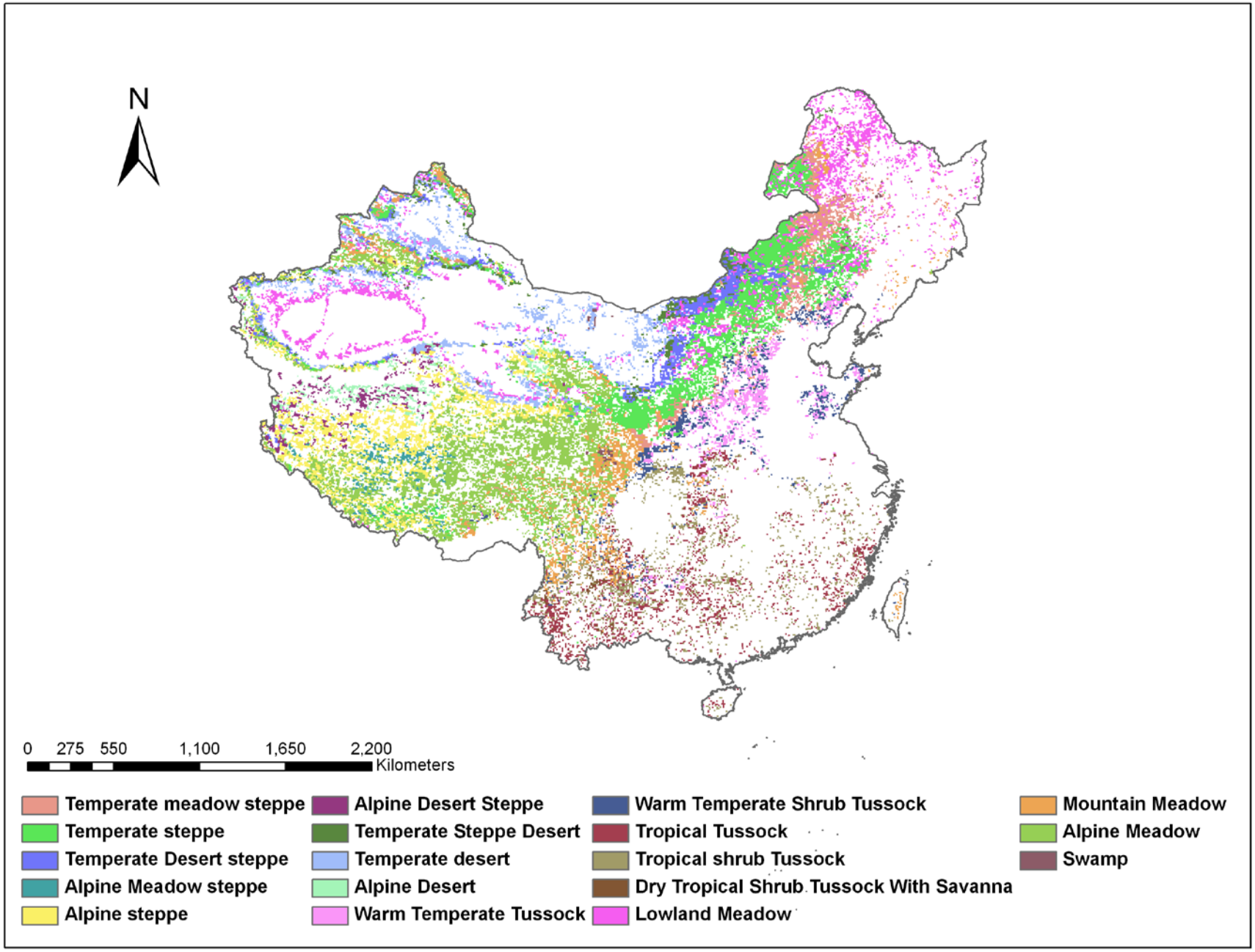


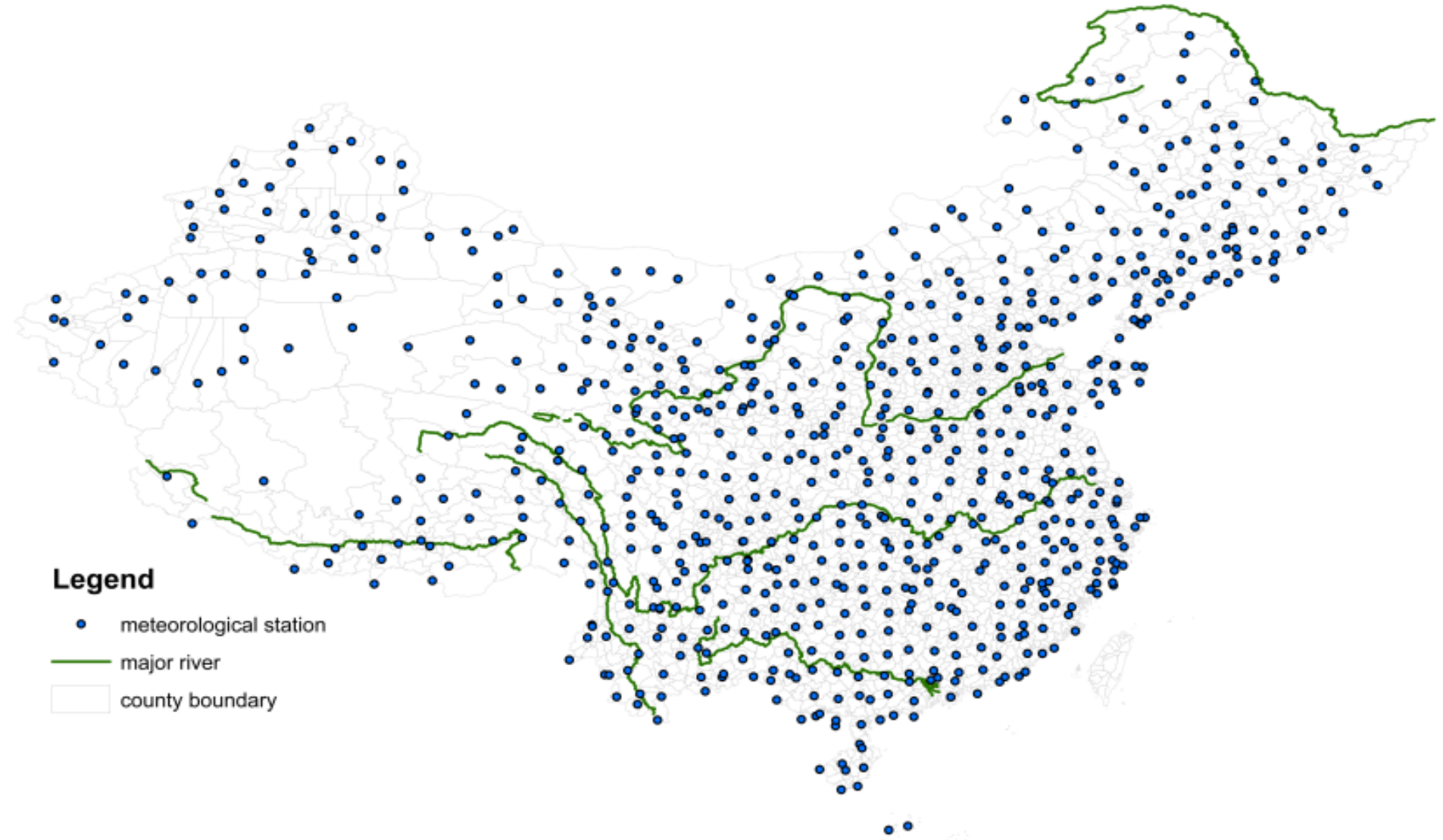
Figure 1. Seasonal parameters computed in TIMESAT: (a) beginning of season; (b) peak; (c) end of growing season; (d) amplitude; (e) small integral over the growing season, area between NDVI curve and zero level; (f) base value; (Adapted from Jönsson and Eklundh, 2004)

Approach 2: System Modeling




N
0 275 550 1,100 1,650 2,200
Kilometers
Temperate meadow steppe
Temperate steppe
Temperate Desert steppe
Alpine Meadow steppe
Alpine steppe
Alpine Desert Steppe
Temperate Steppe Desert
Temperate desert
Alpine Desert
Warm Temperate Tussock
Warm Temperate Shrub Tussock
Tropical Tussock
Tropical shrub Tussock
Dry Tropical Shrub Tussock With Savanna
Lowland Meadow
Mountain Meadow
Alpine Meadow
Swamp

Climate data

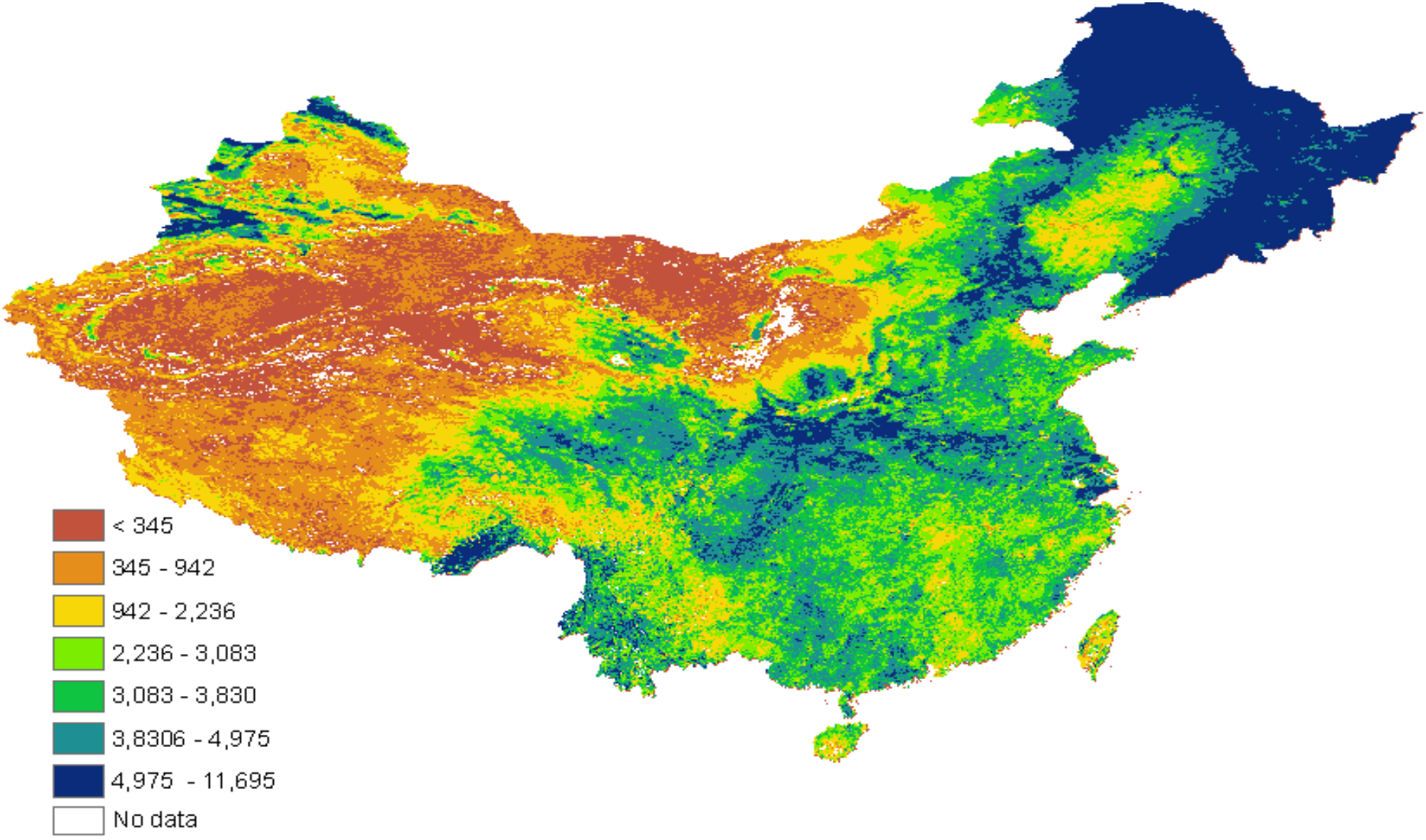


738 meteorological stations across China

To answer the question:

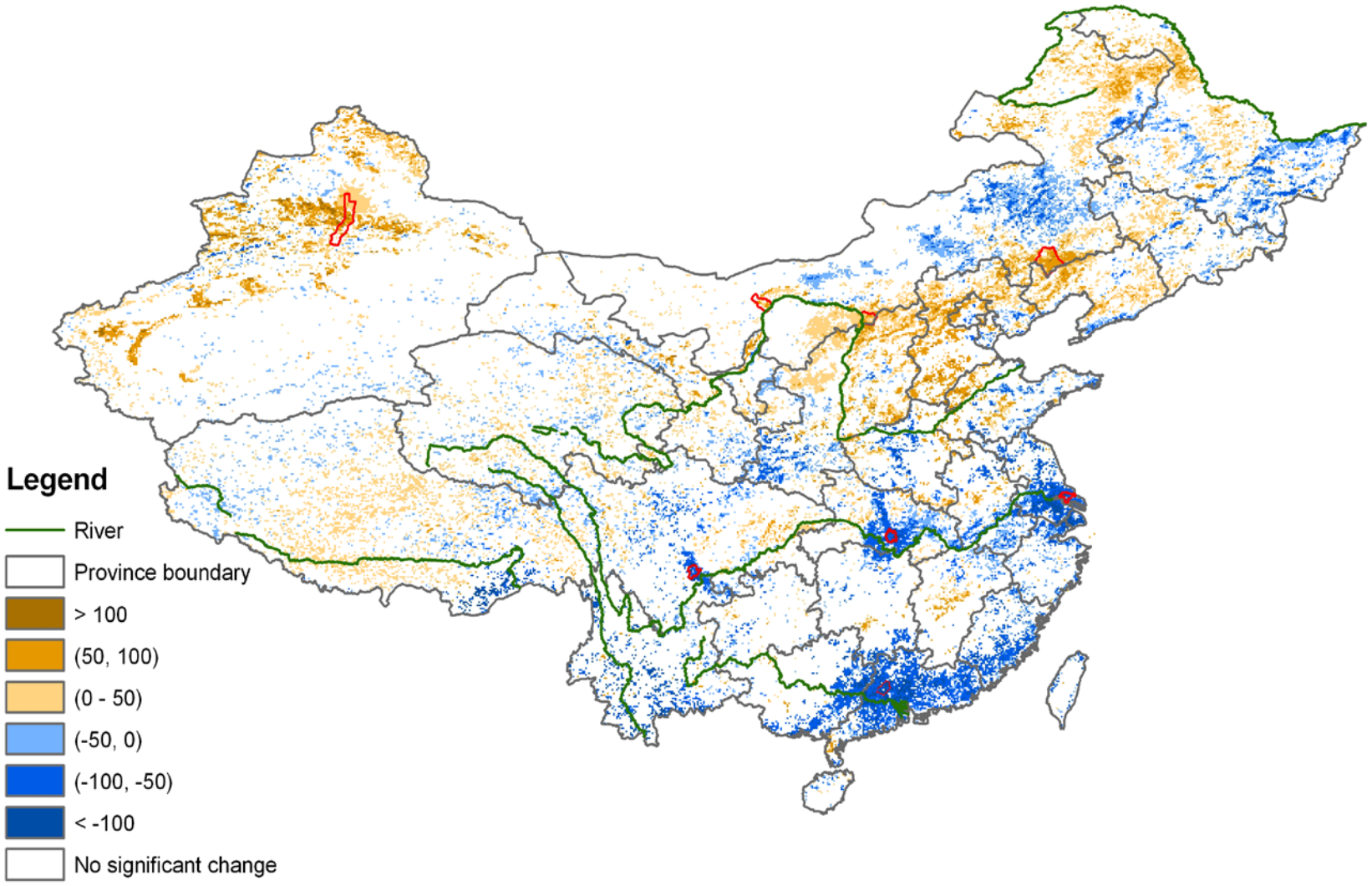
How to discern climate impact from human disturbance?

Example map of Small Integral (SI)

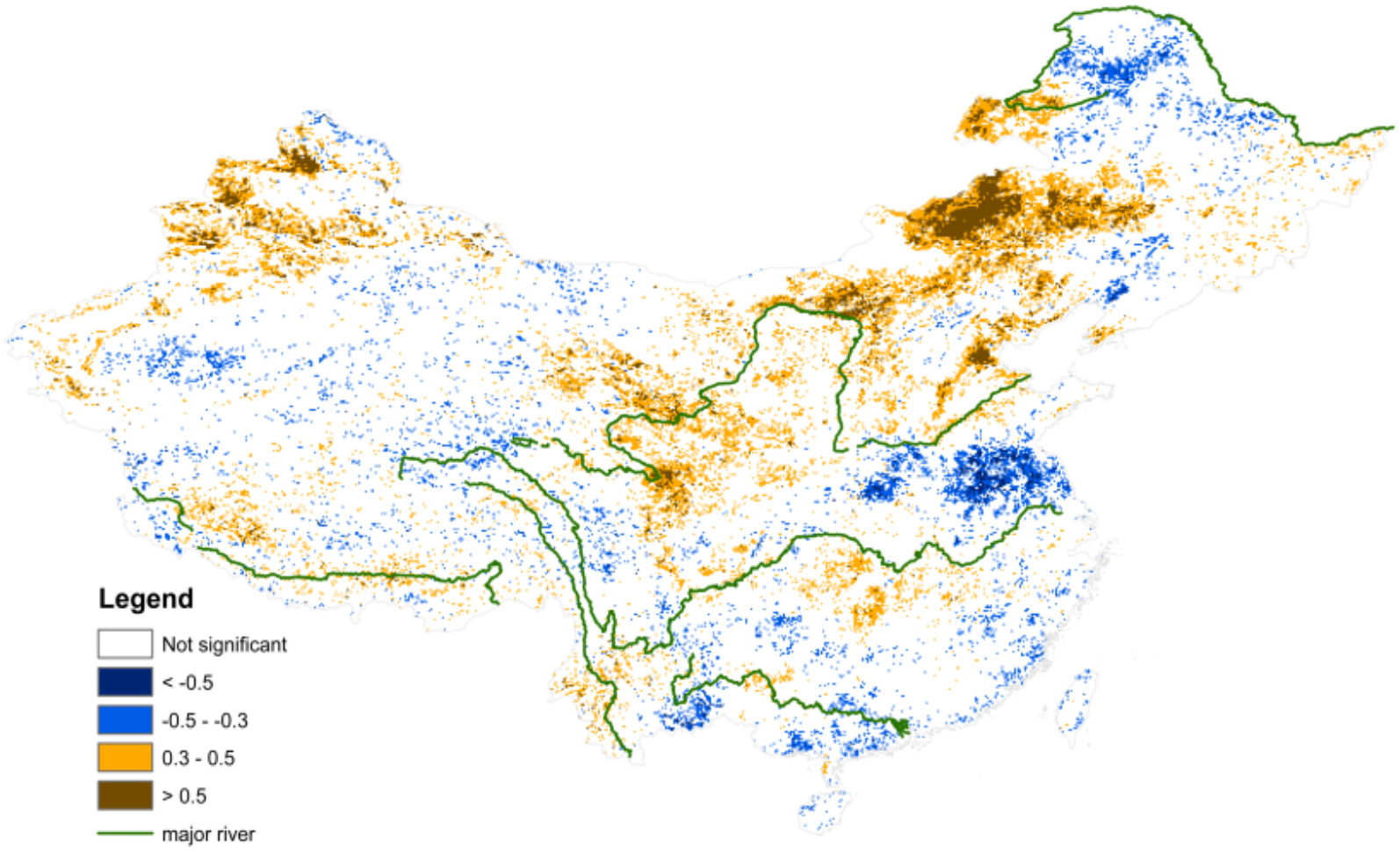


The SI over the growing season in 1982 across China

Slope of linear temporal trend of small integral across China from 1982 to 2006 (p<=0.05)

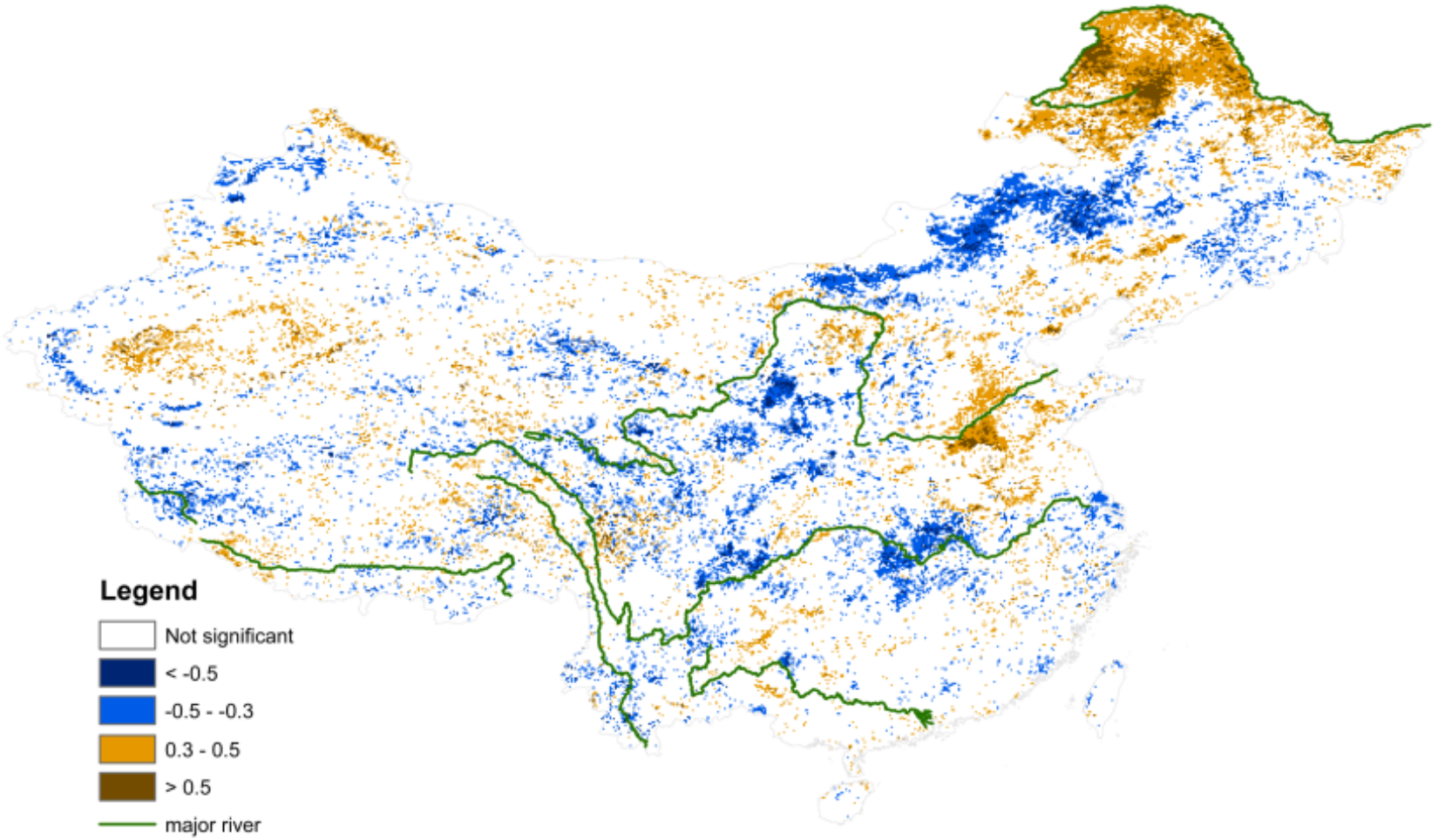


Correlation between SI and and climate factors



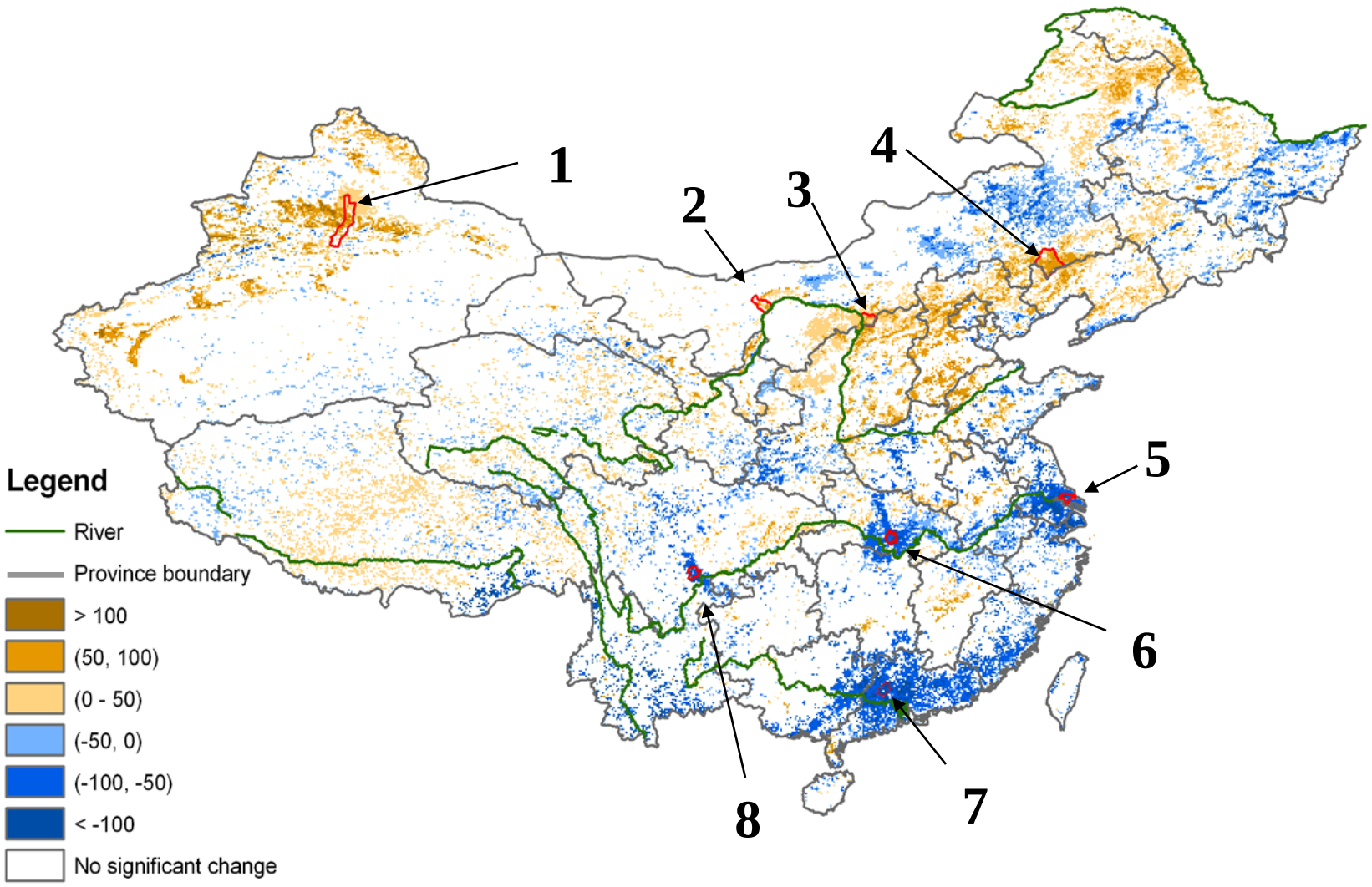
Correlation coefficient between SI and P_{July}

Correlation between SI and and climate factors



Correlation coefficient between SI and T_{July}

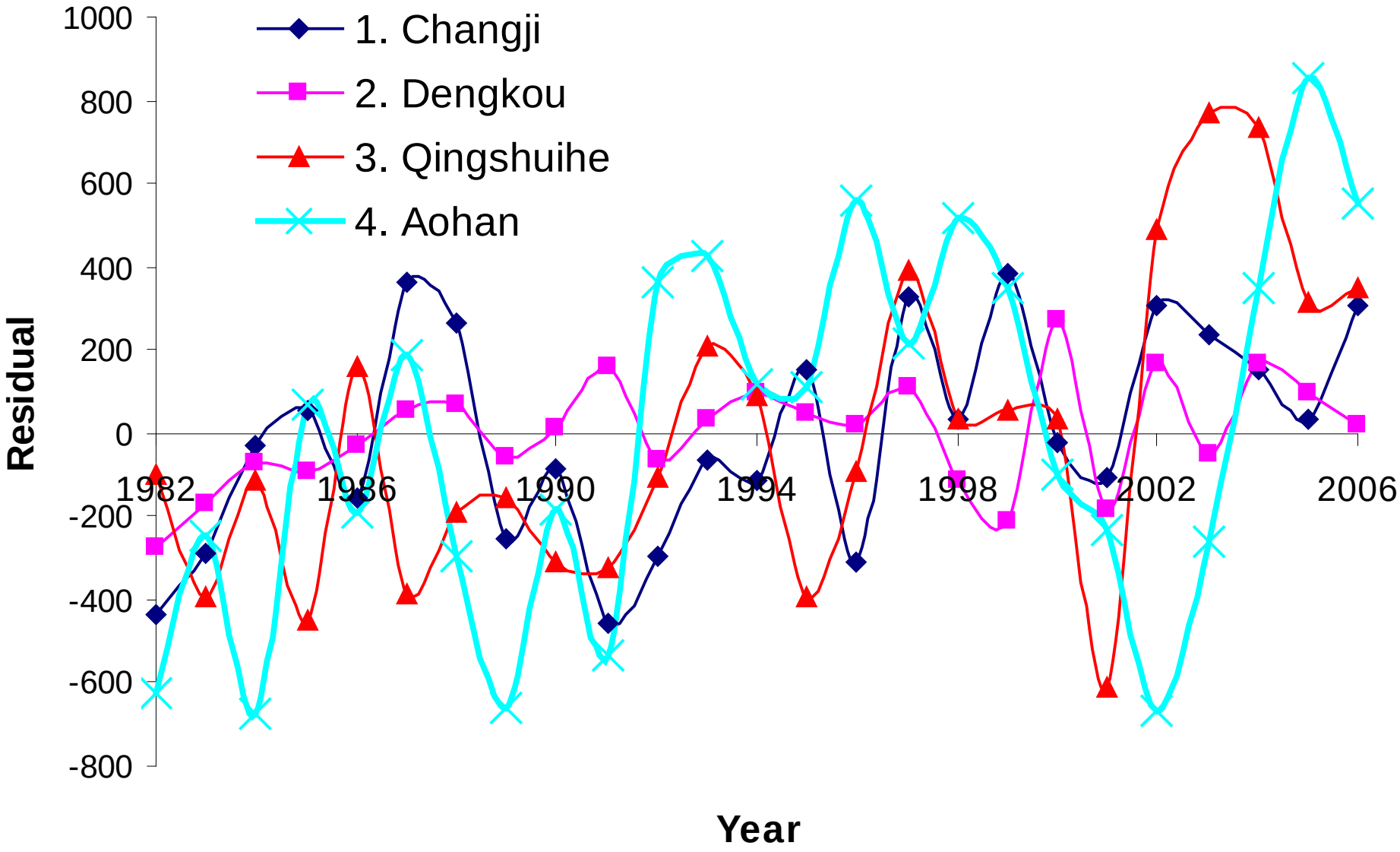
Taking the 8 counties as an example:



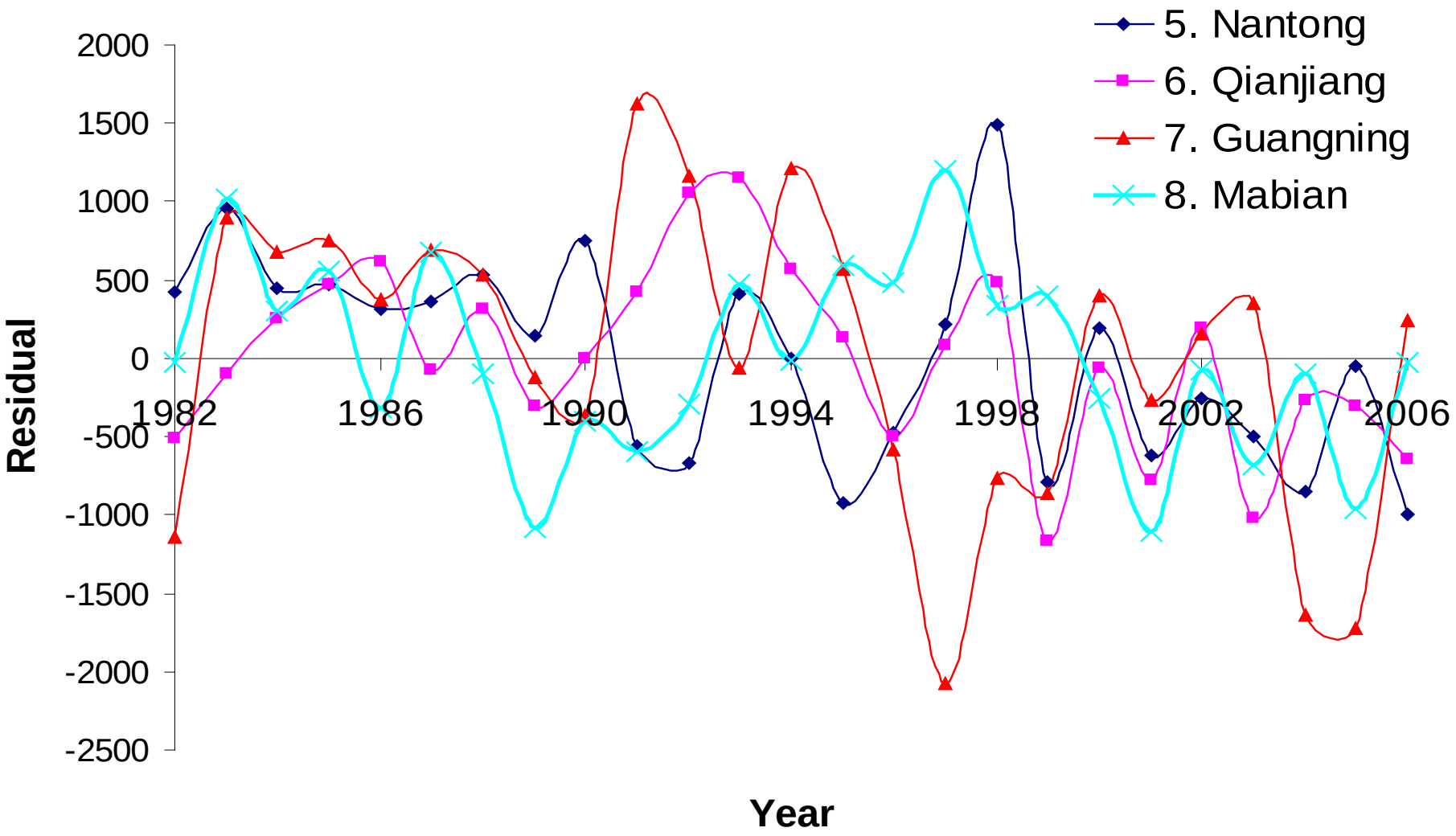
Results, residual trend

#	County	Relationship between small integral and selected climate factors		linear temporal trend of residual	
		Equation	r^2	Equation	r^2
1	Changji	SI = -7620.44 + 9.17 P_{July} + 233.10 T_{June} + 201.21 T_{July}	0.59	y=15.96x-31818	0.22
2	Dengkou	SI = -1565.08 + 6.11 P_{July}+ 46.56 T_{April} + 104.22 T_{June}	0.67	y = 6.96x - 13879	0.15
3	Qingshuihe	SI = -114.95 + 5.21 P_{July} -225.19 T_{May} + 243.94 T_{July}	0.39	y = 30.06x - 59938	0.37
4	Aohan	SI = -1289.97 + 6.81 P_{June} + 85.22 T_{Feb} + 171.14 T_{July}	0.34	y = 29.2x - 58225	0.24
5	Nantong	SI = 16702.14 - 4.28 P_{July} - 531.22T_{April} - 192.21 T_{July}	0.52	y = -48.94x + 97576	0.31
6	Qianjiang	SI = 14460.55 - 109.6 T_{Feb}- 170.42T_{April} - 317.50 T_{June}	0.42	y = -31.33x + 62472	0.16
7	Guangning	SI = 47614.52 - 7.11 P_{July} - 222.17T_{April} - 1286.47 T_{July}	0.38	y = -51.85x +103380	0.16
8	Mabian	SI = 5623.69 + 4.15 P_{July} - 157.61 T_{Feb} - 166.95 T_{April}	0.44	y = -23.68x + 47222	0.08

Linear temporal trend of residual



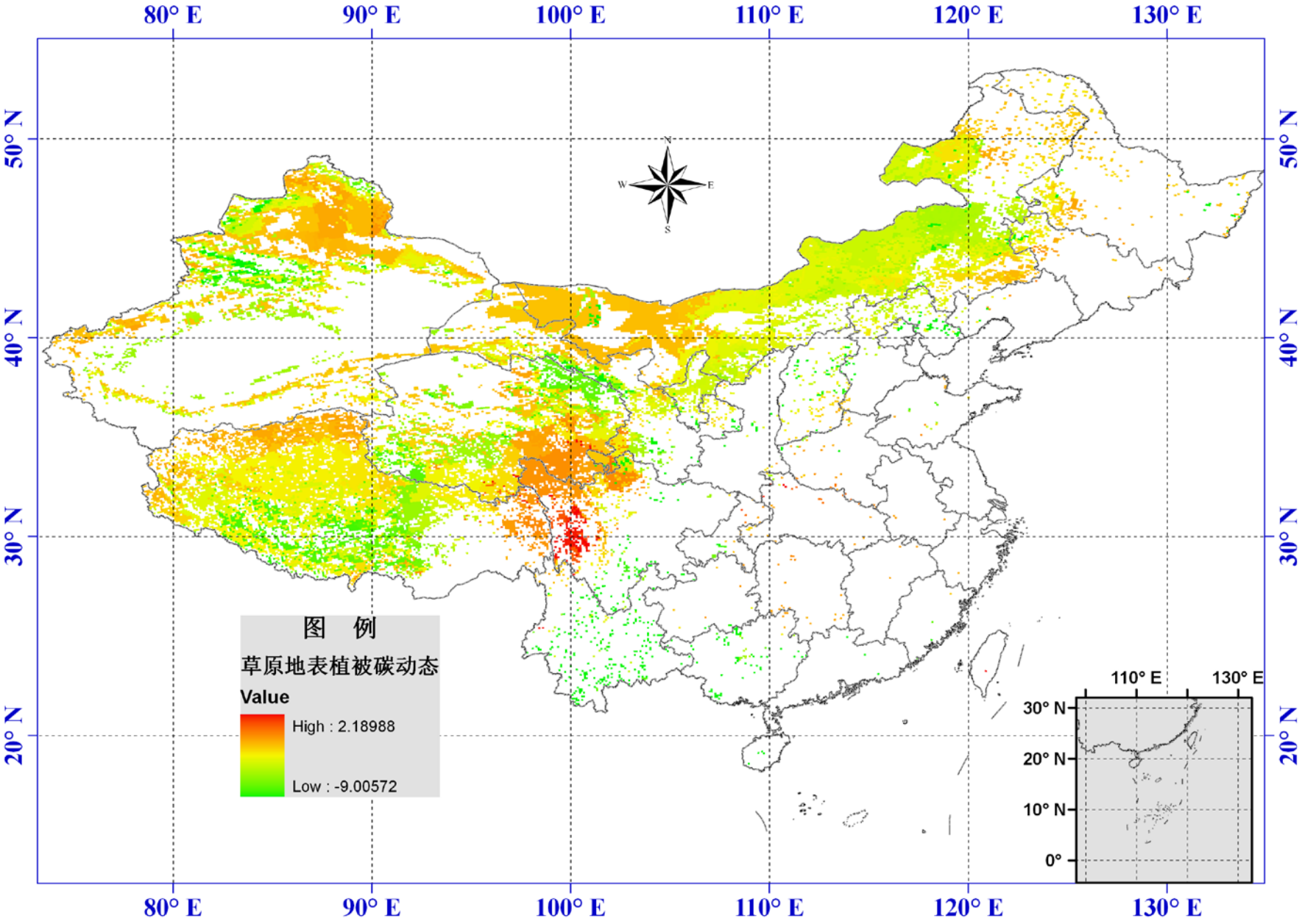
Linear temporal trend of residual



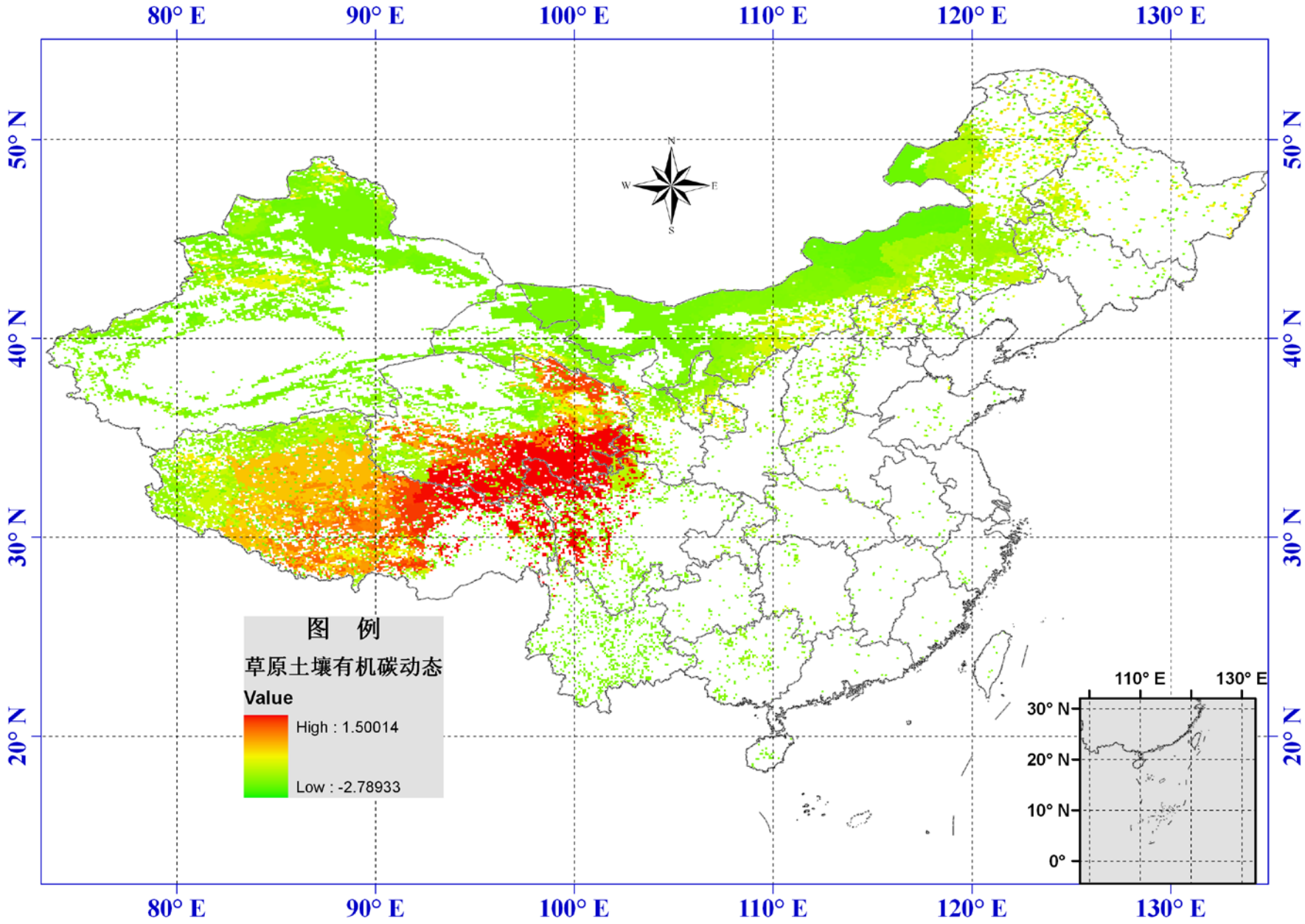
To answer the question:

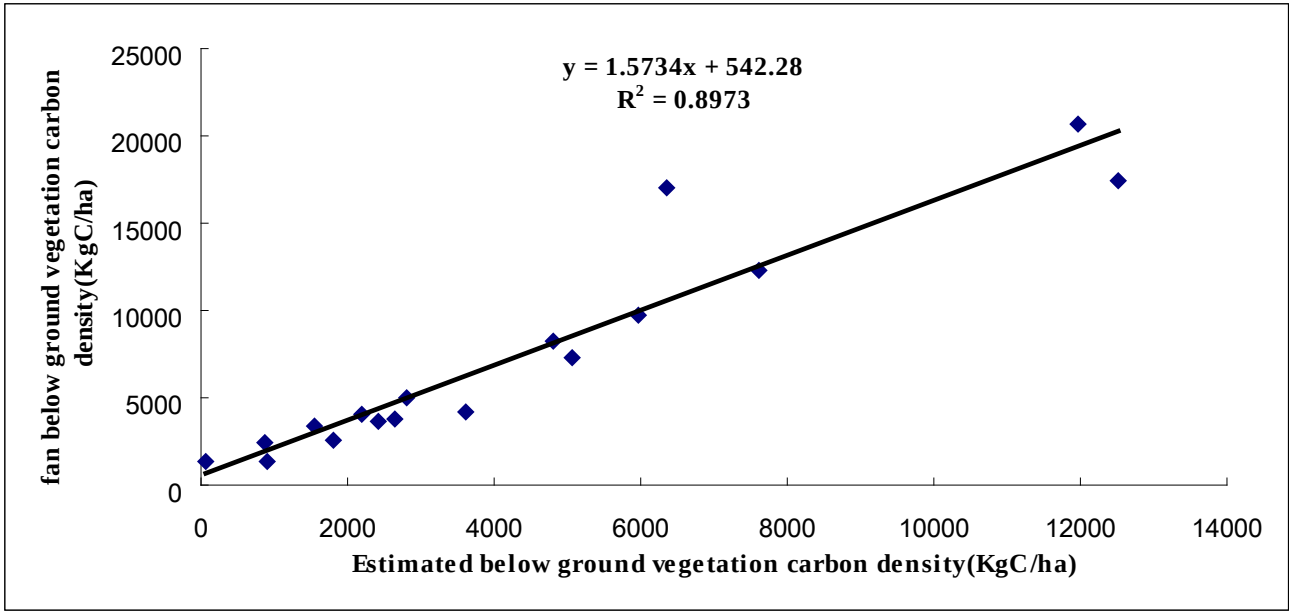
How has the climate change impacted the carbon sequestration of China grassland?

Grassland above ground carbon change trend from 2000 to 2007



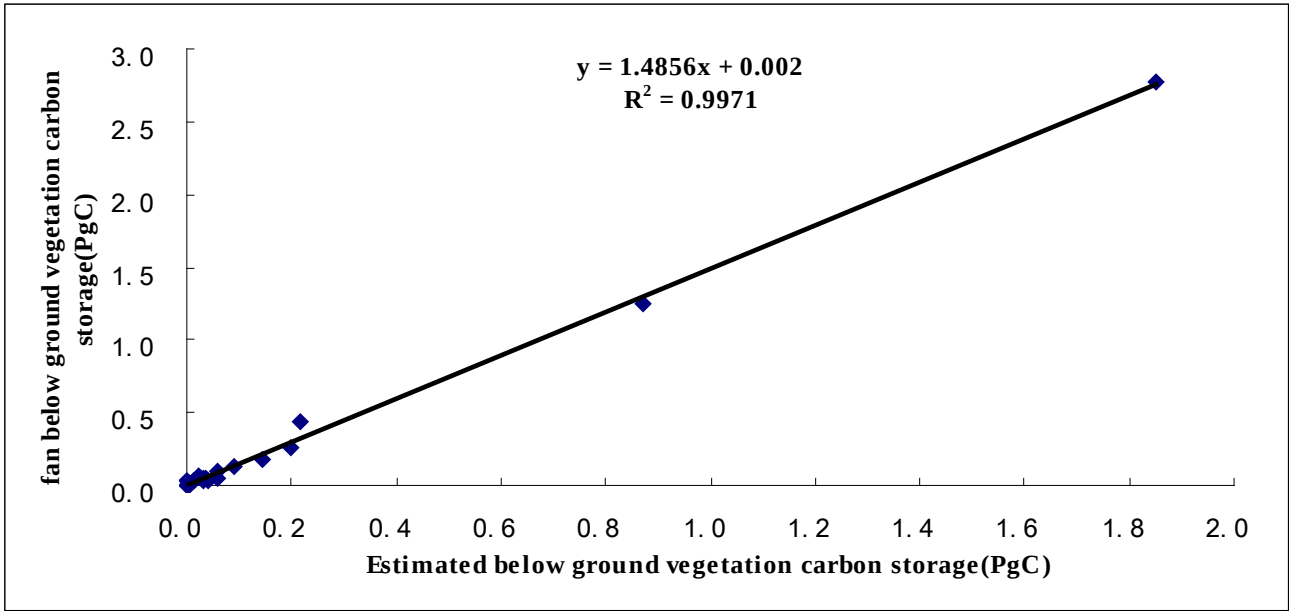
Grassland soil carbon storage change trend from 2000 to 2007



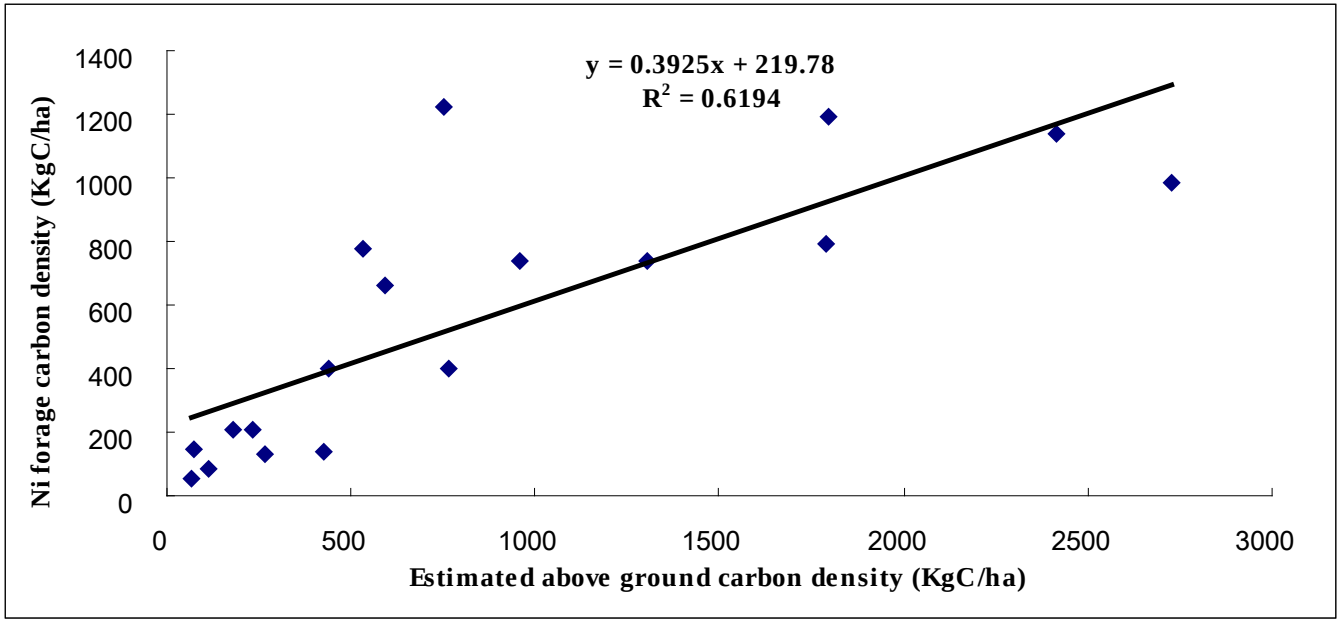


C density (PgC/ha)

Below ground carbon results compare with Fan's results

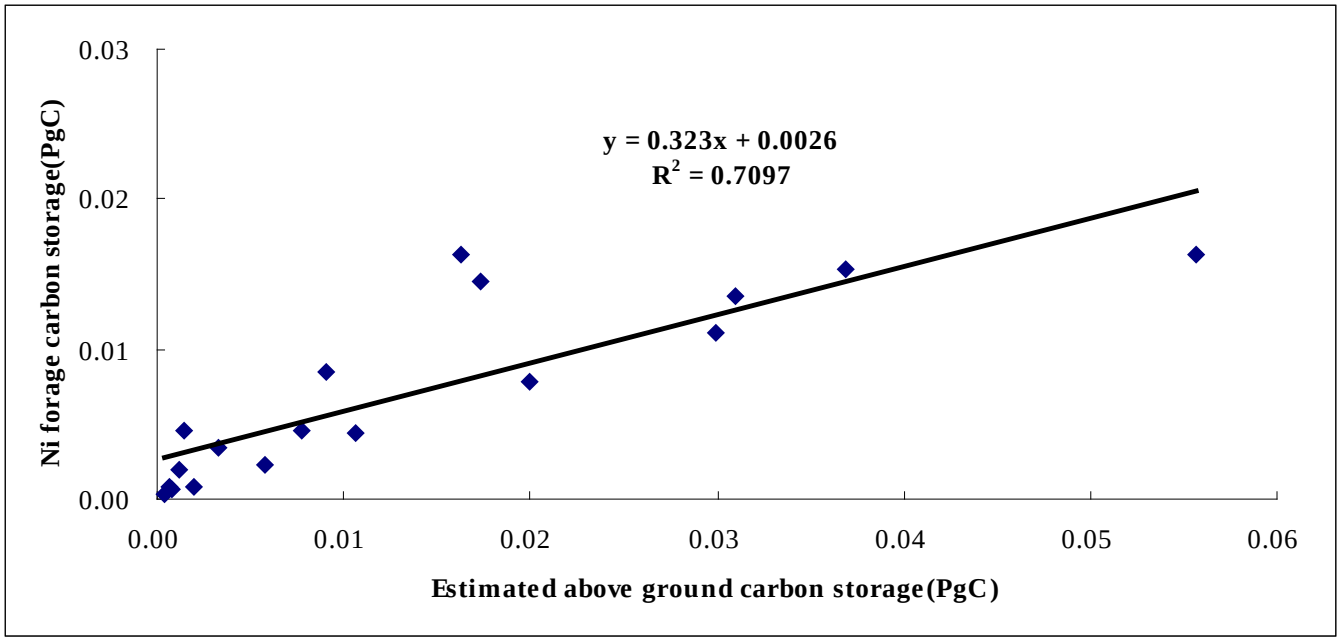


C storage (PgC)



C density (PgC/ha)

Above ground carbon result compare with Ni's results



C storage (PgC)

Conclusions

- Remote sensing, long term monitoring data can be very useful to study ecosystem changes
- Statistical approaches are useful in understanding the drivers of changes (discern climate cause from human impacts)
- Biogeochemical models (DNDC) incorporate human and climate into a system to quantitatively assess ecosystem responses to both climate and human drivers
- More research is needed to investigate the change patterns and their linkages to specific policy implementations (on going)
- On-going research focuses on fine resolution MODIS type data for other land cover types

Acknowledgment

- NASA and NSF funding
- Chinese MOST funding through CAS