Climate Change in China in the Past 50 Yeas

Ming Xu

Department of Ecology Evolution & Natural Resources

Center for Remote Sensing and Spatial Analysis

Rutgers University

Email: mingxu@crssa.rutgers.edu

Collaborators:

Mark Henderson, Department of ESPM, UC Berkeley, USA
Binhui Liu, Northeast Forestry University, Harbin, China
Ye Qi, Tsinghua University, Beijing, China
Chih-Pei Chang, Alan Robock, David Robinson, Congbin Fu and Others

Acknowledgements:

National Climate Center, China Meteorological Administration

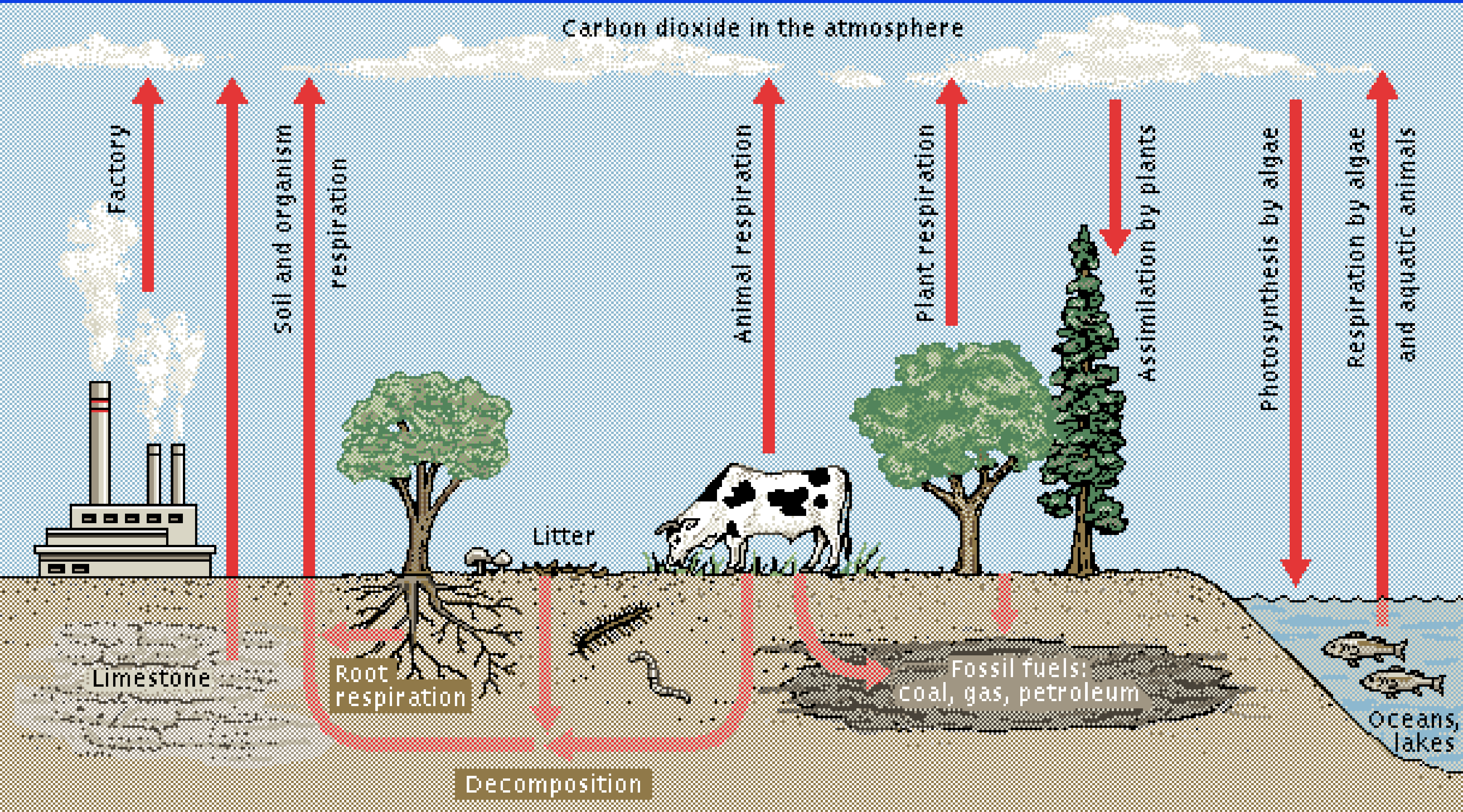
Research Interests

1. Climate and Ecosystem Interaction (especially the carbon cycle and its feedback)

2. Historical Climate Change (focusing on East Asian monsoon region)

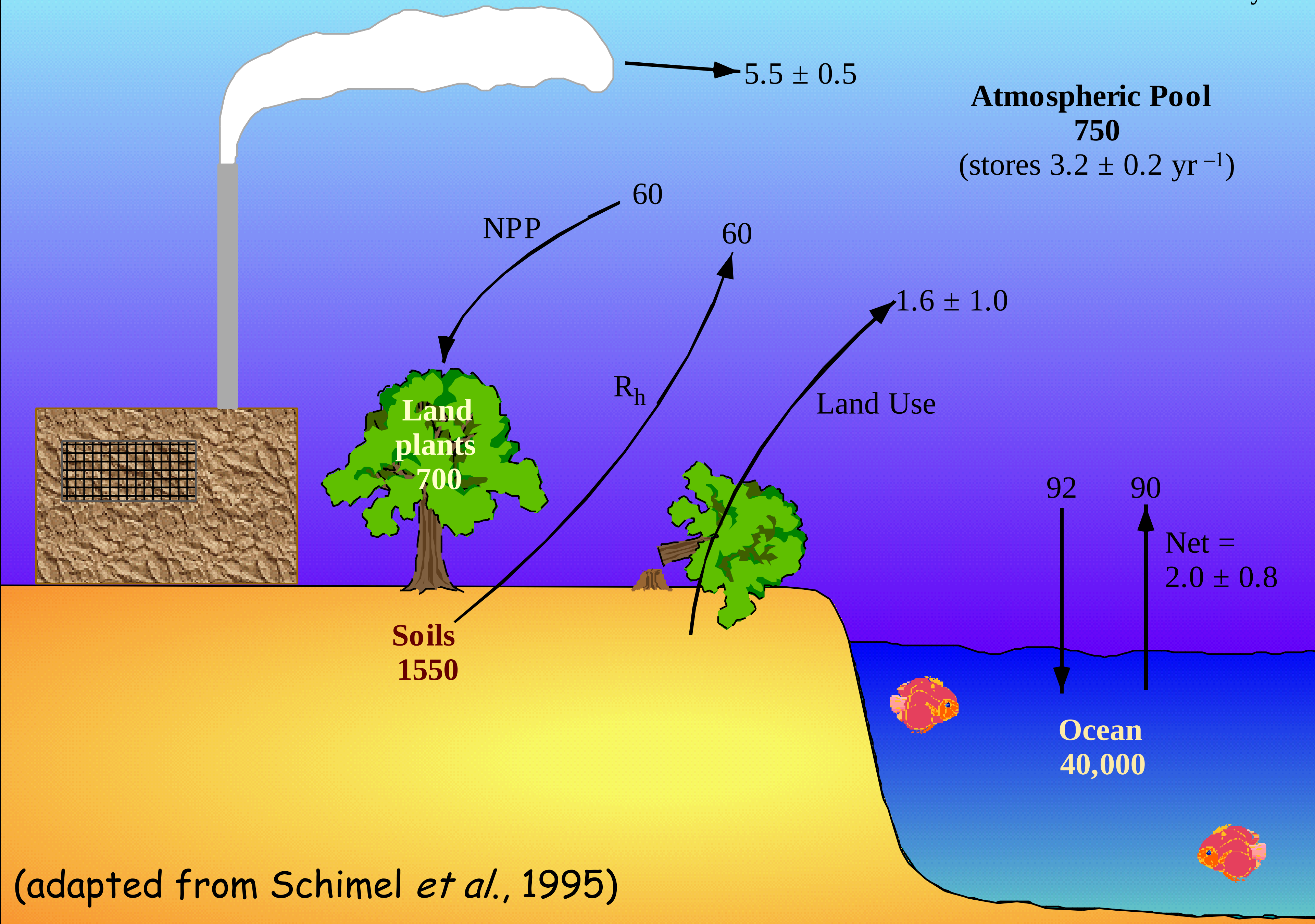
3. Coupled Climate-Ecosystem Modeling

$$CO_2 + H_2O \underset{\text{Respiration}}{\overset{\text{Photosynthesis}}{\rightleftharpoons}} (CH_2O)_n + O_2$$



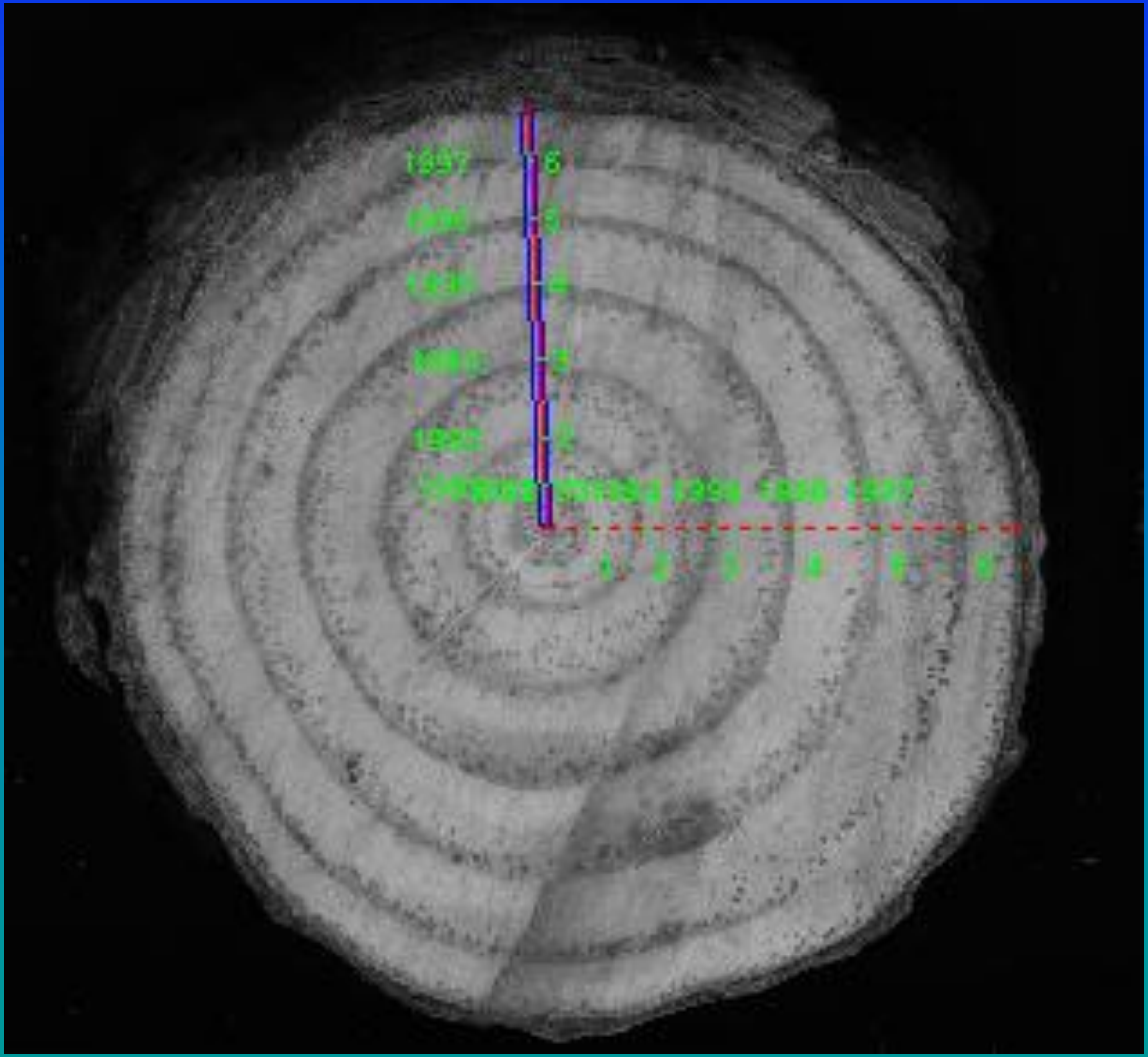
The Global Carbon Cycle

Units: Stocks - Gt-C
Fluxes - Gt-C yr^{-1}

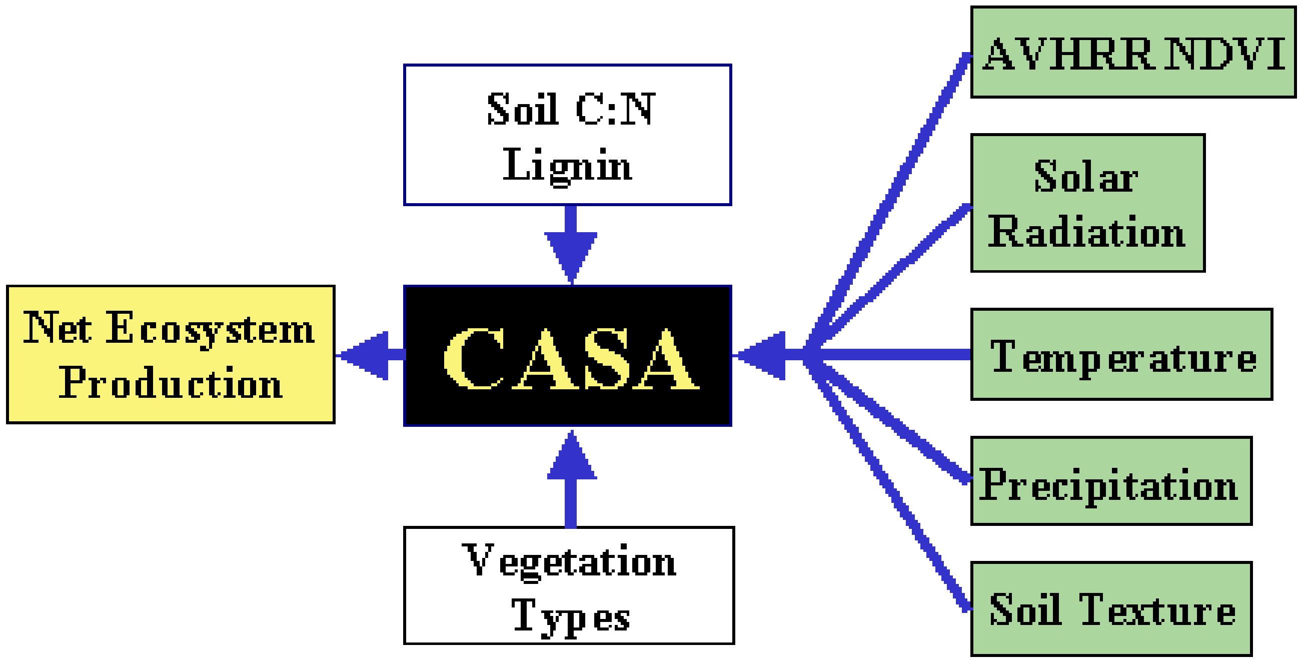


(adapted from Schimel *et al.*, 1995)

Quantifying the carbon stocks



Remote Sensing Based Approach



Climate Change in China in the Past 50 Yeas

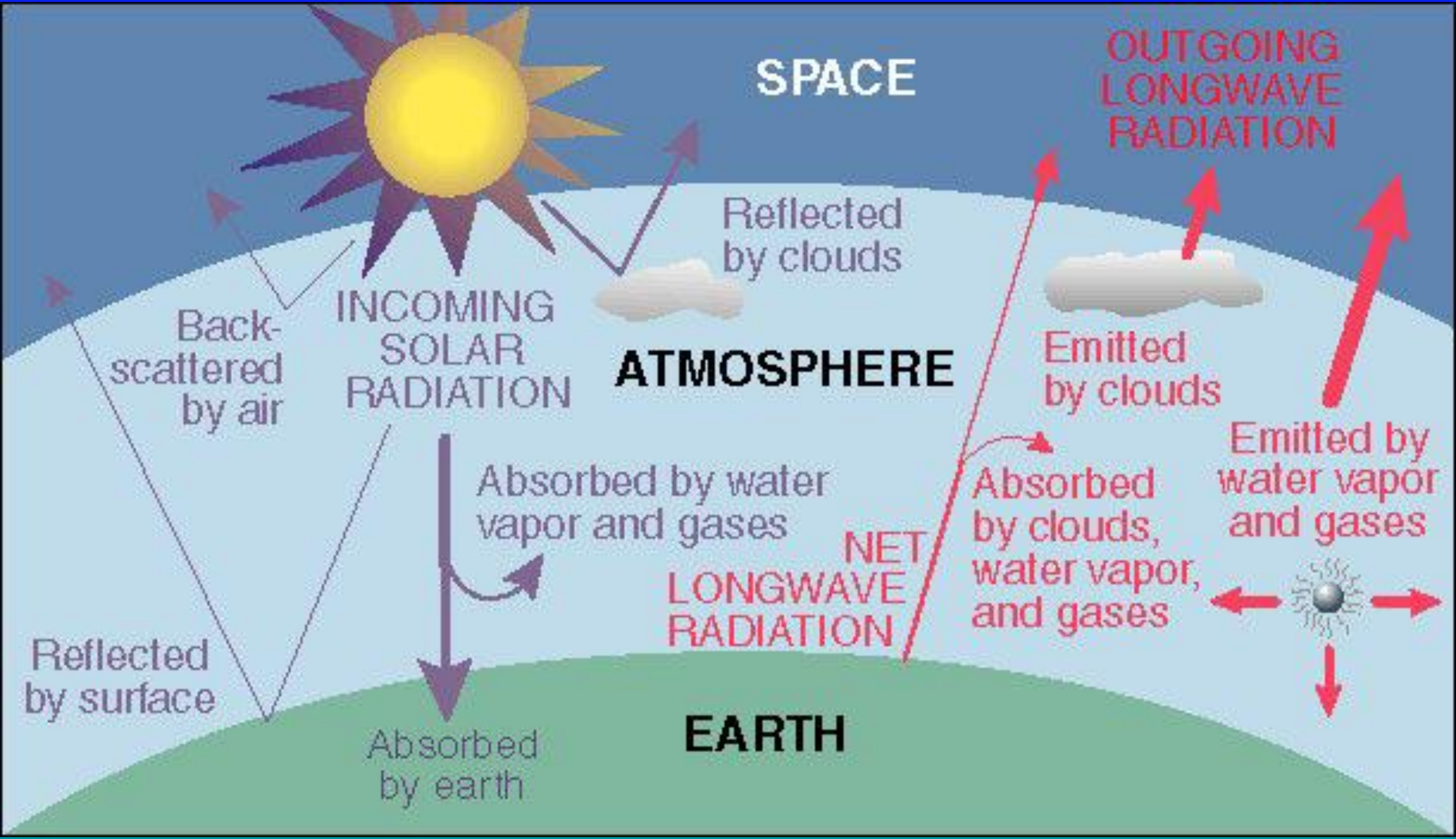
Ming Xu

Department of Ecology Evolution & Natural Resources

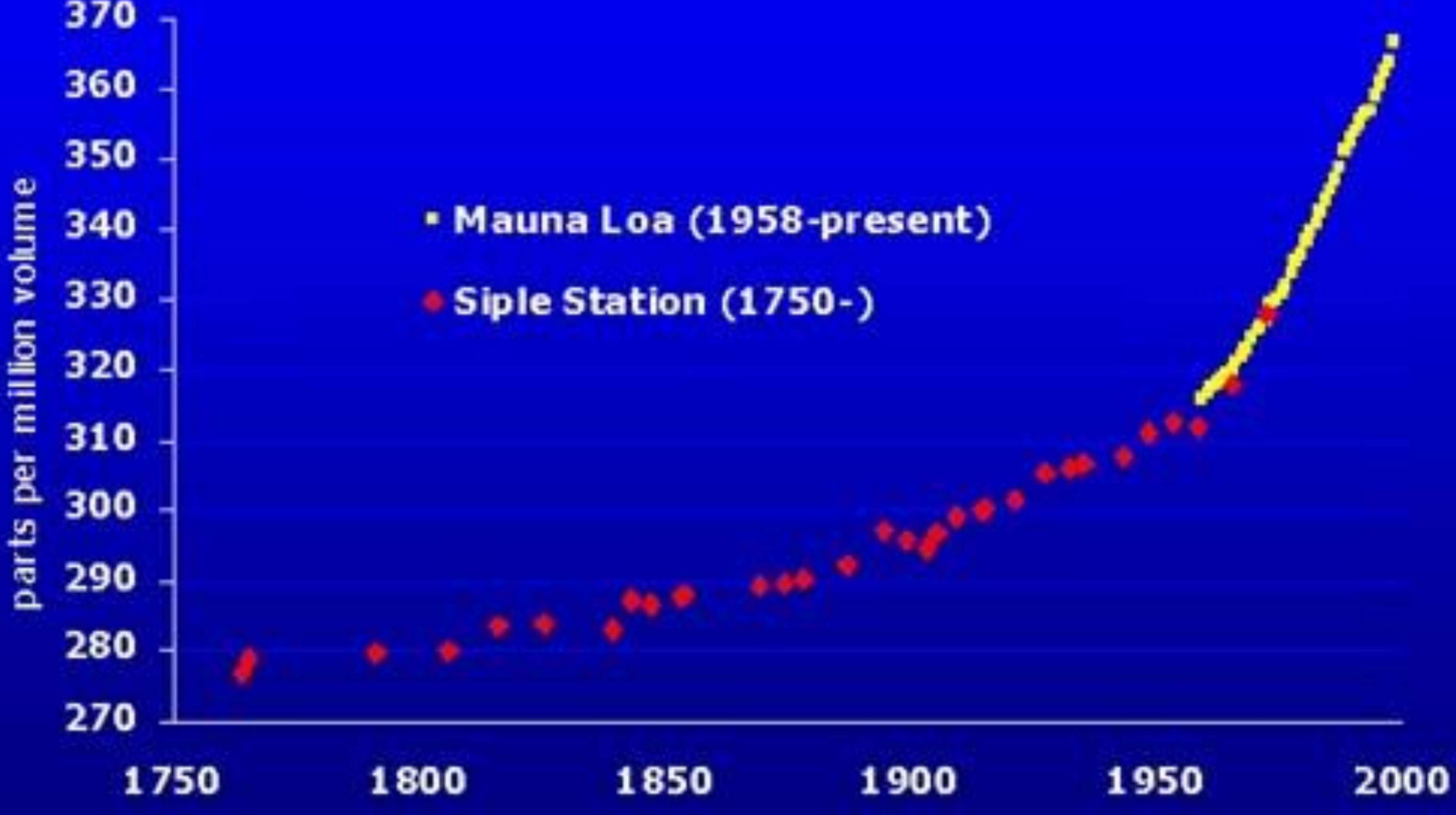
Center for Remote Sensing and Spatial Analysis

Rutgers University

Email: mingxu@crssa.rutgers.edu

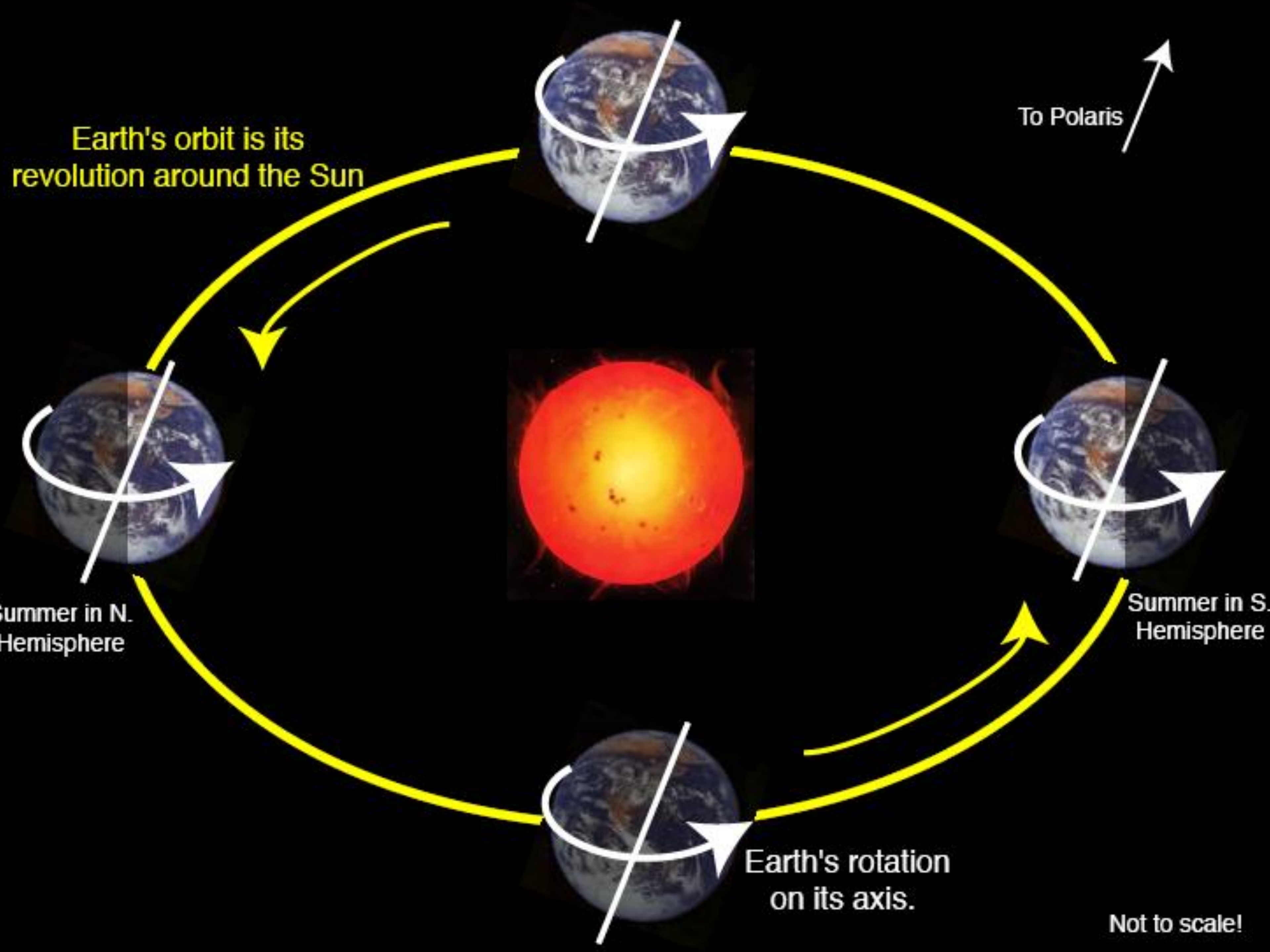

SPACE
OUTGOING LONGWAVE RADIATION
Reflected by clouds
Back-scattered by air
INCOMING SOLAR RADIATION
ATMOSPHERE
Emitted by clouds
Emitted by water vapor and gases
Absorbed by water vapor and gases
NET LONGWAVE RADIATION
Absorbed by clouds, water vapor, and gases
Reflected by surface
Absorbed by earth
EARTH

Atmospheric carbon dioxide (CO_2) concentrations (1750 to present)

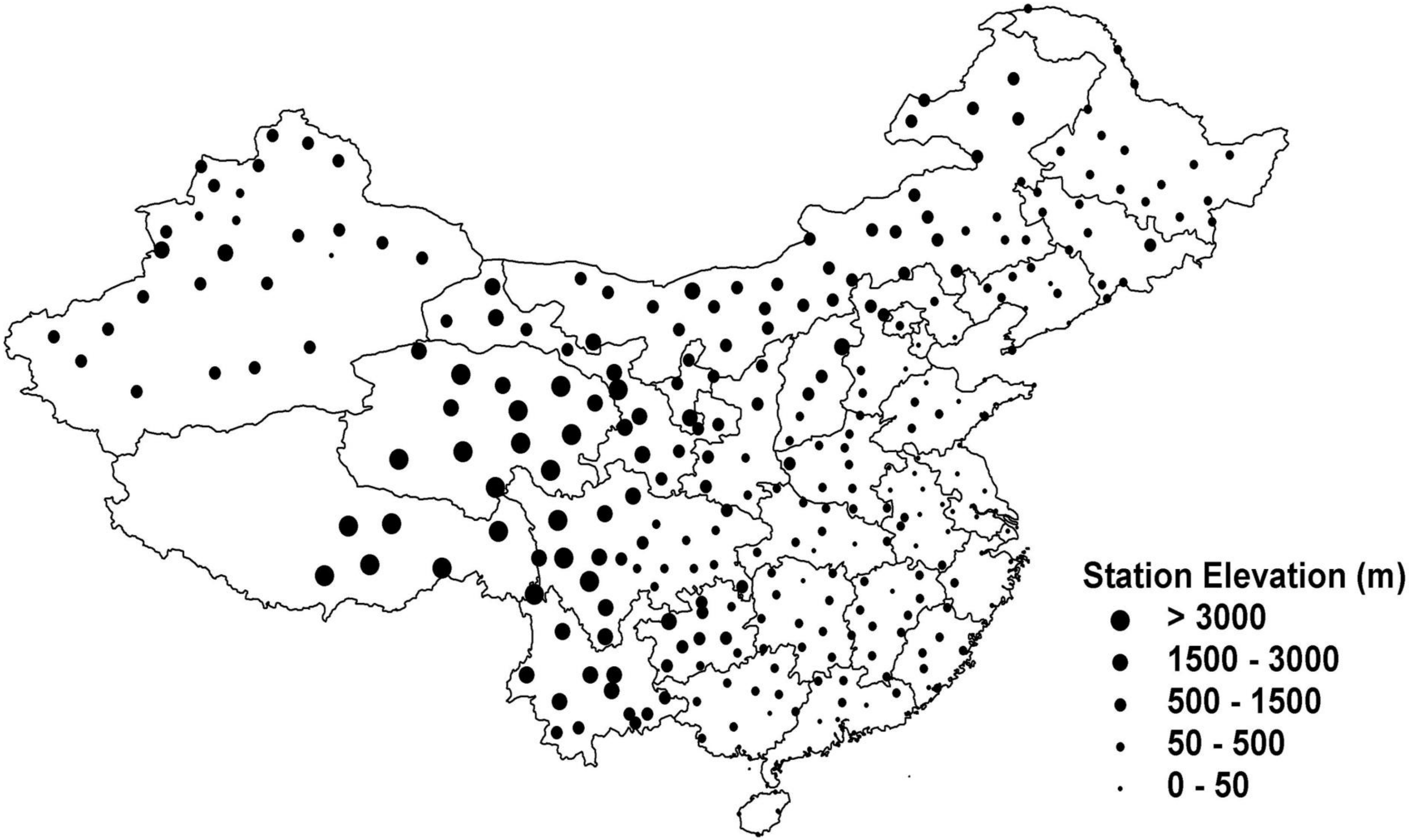


Data Source: C.D. Keeling and T.P. Whorf, Atmospheric CO2 Concentrations (ppmv) derived from in situ air samples collected at Mauna Loa Observatory, Hawaii, Scripps Institute of Oceanography, August 1998. A. Neftel et al, Historical CO2 Record from the Siple Station Ice Core, Physics Institute, University of Bern, Switzerland, September 1994. See http://cdiac.esd.ornl.gov/trends/co2/contents.htm

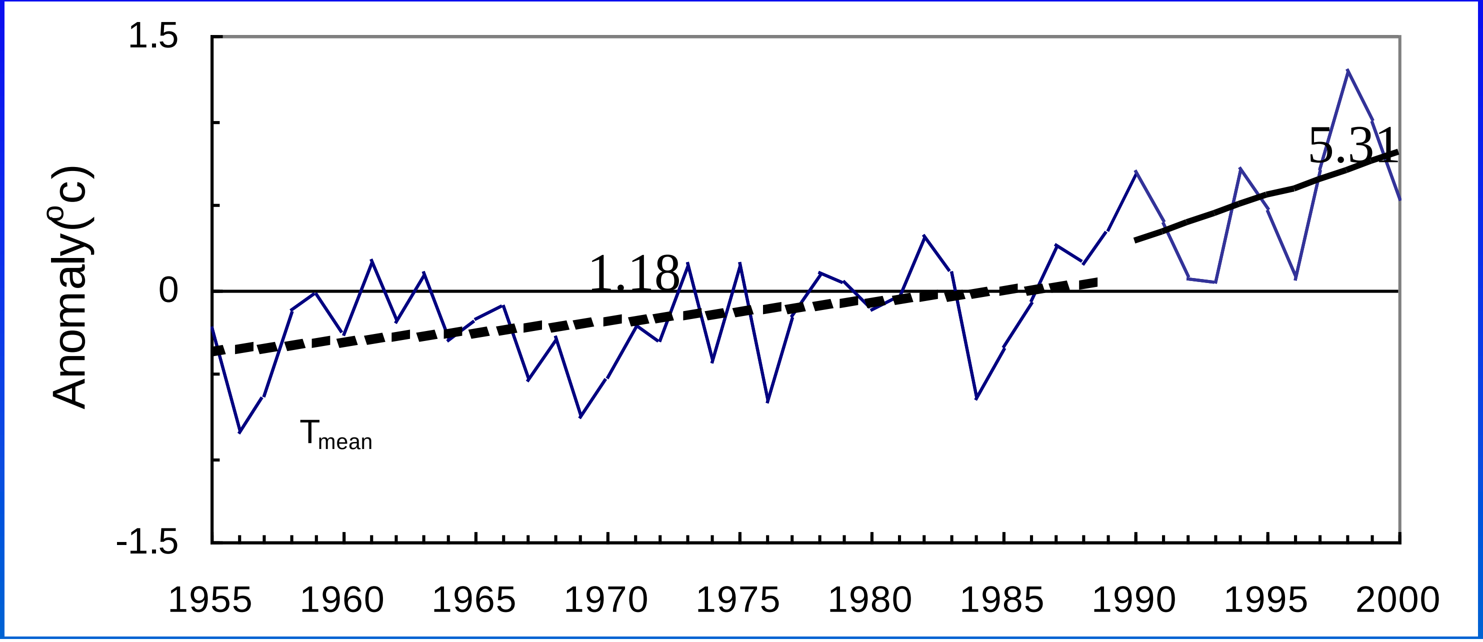
WORLD RESOURCES INSTITUTE

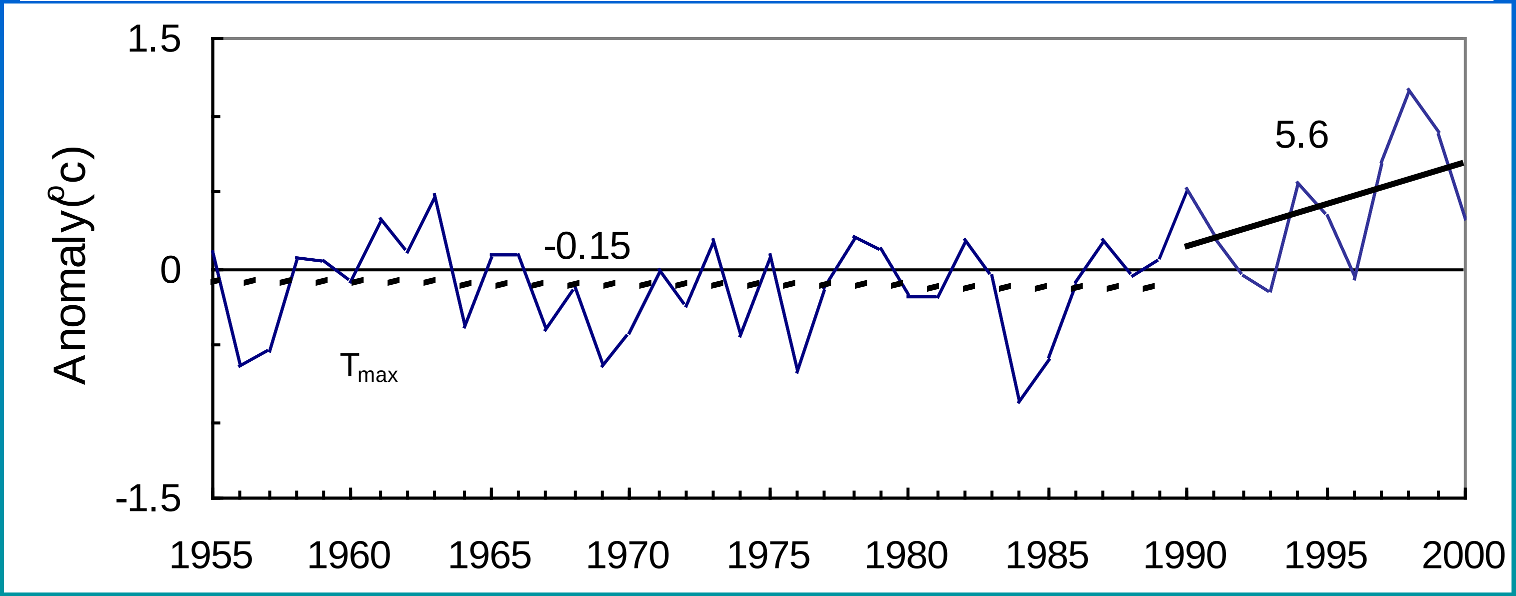


Earth's orbit is its
revolution around the Sun
To Polaris
Summer in N.
Hemisphere
Summer in S.
Hemisphere
Earth's rotation
on its axis.
Not to scale!

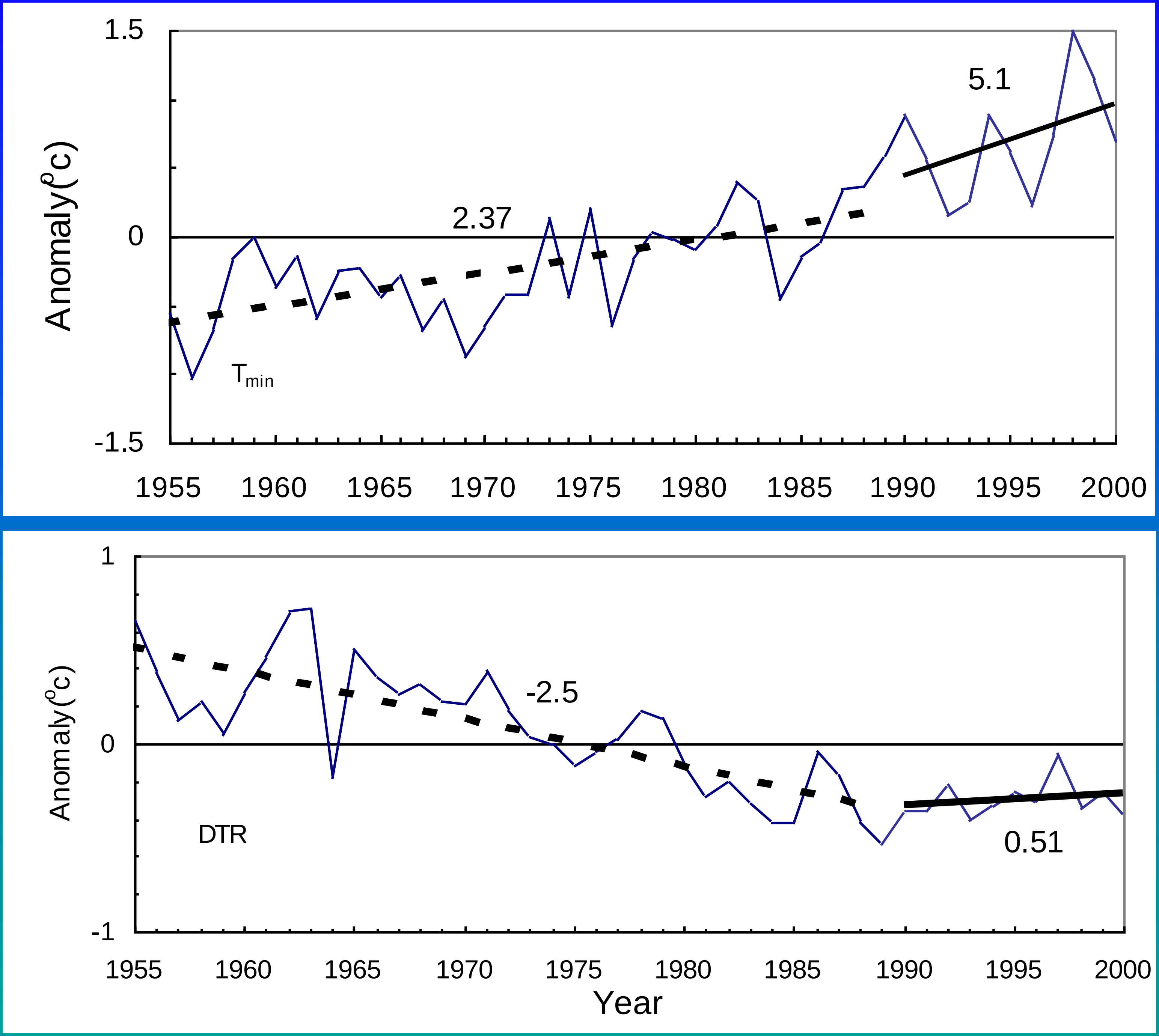



Station Elevation (m)
> 3000
1500 - 3000
500 - 1500
50 - 500
0 - 50



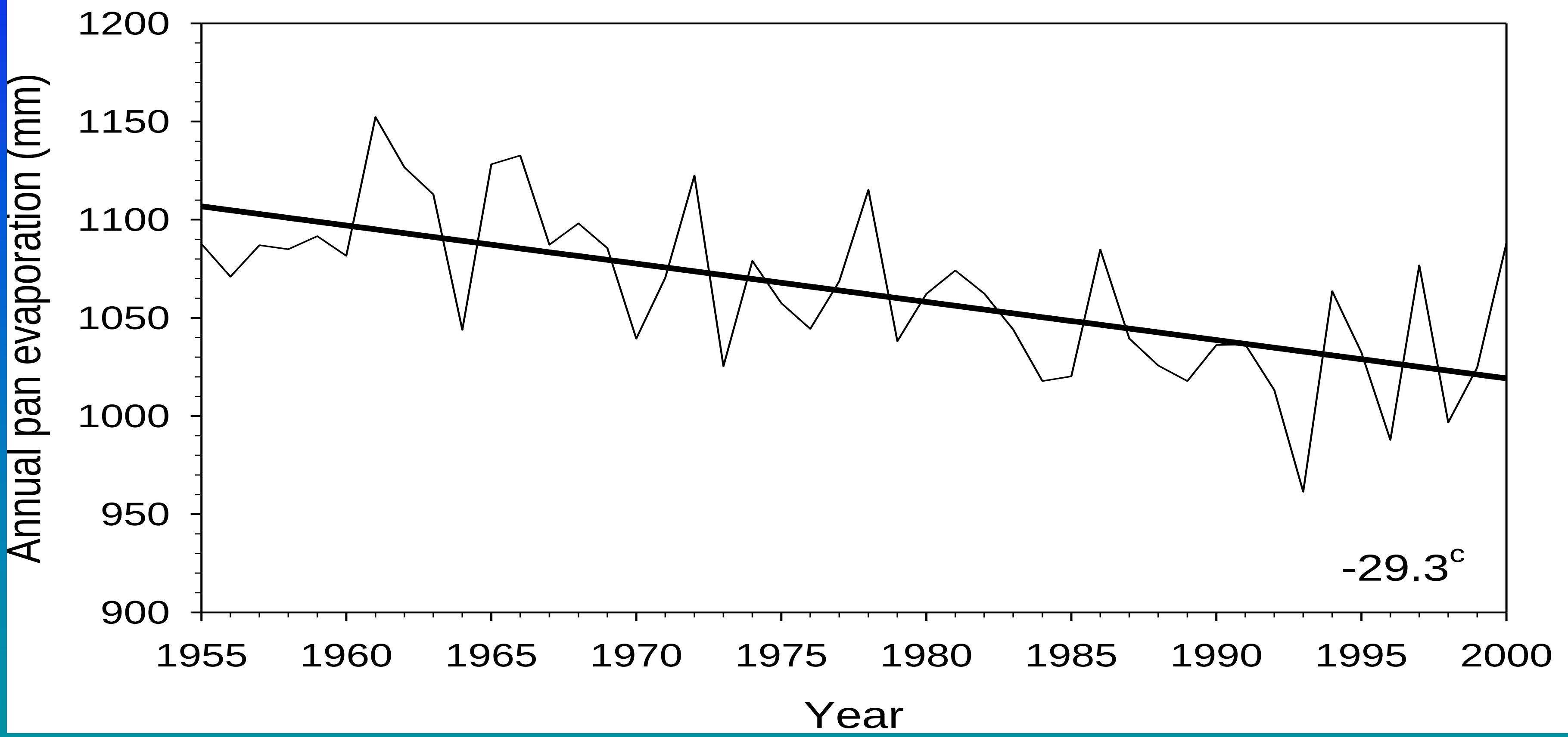


Liu et al. 2004. ***Journal of Climate*** 17: 4453-4462

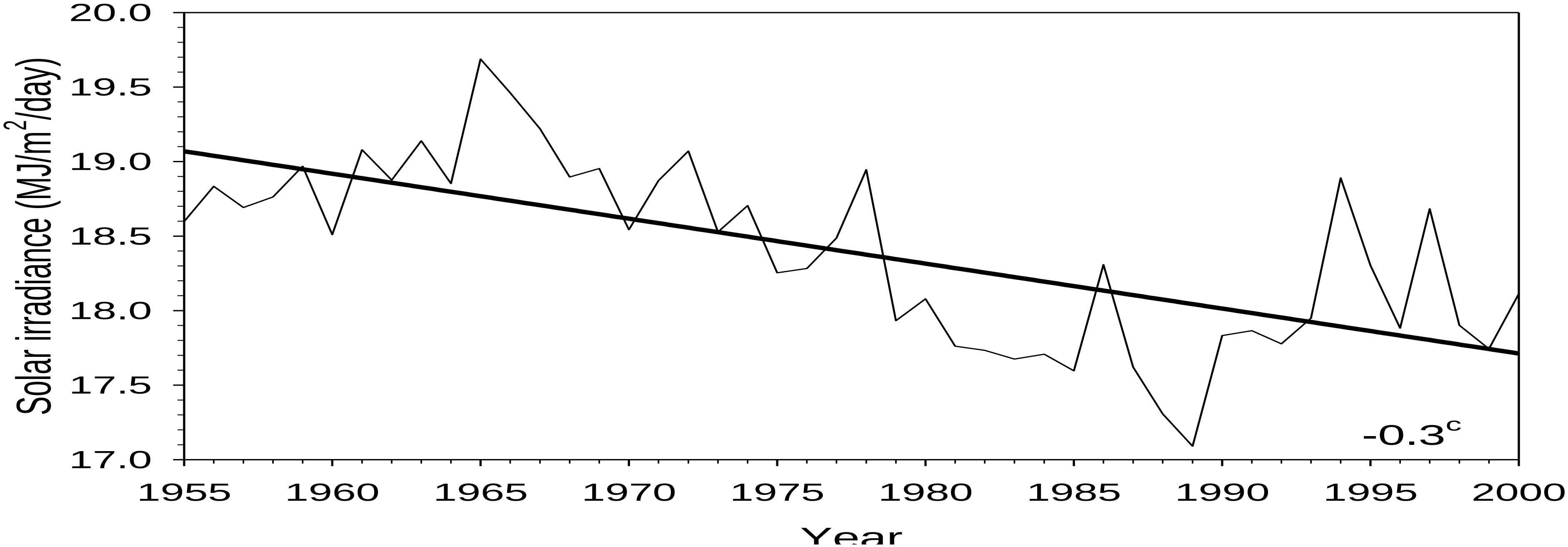


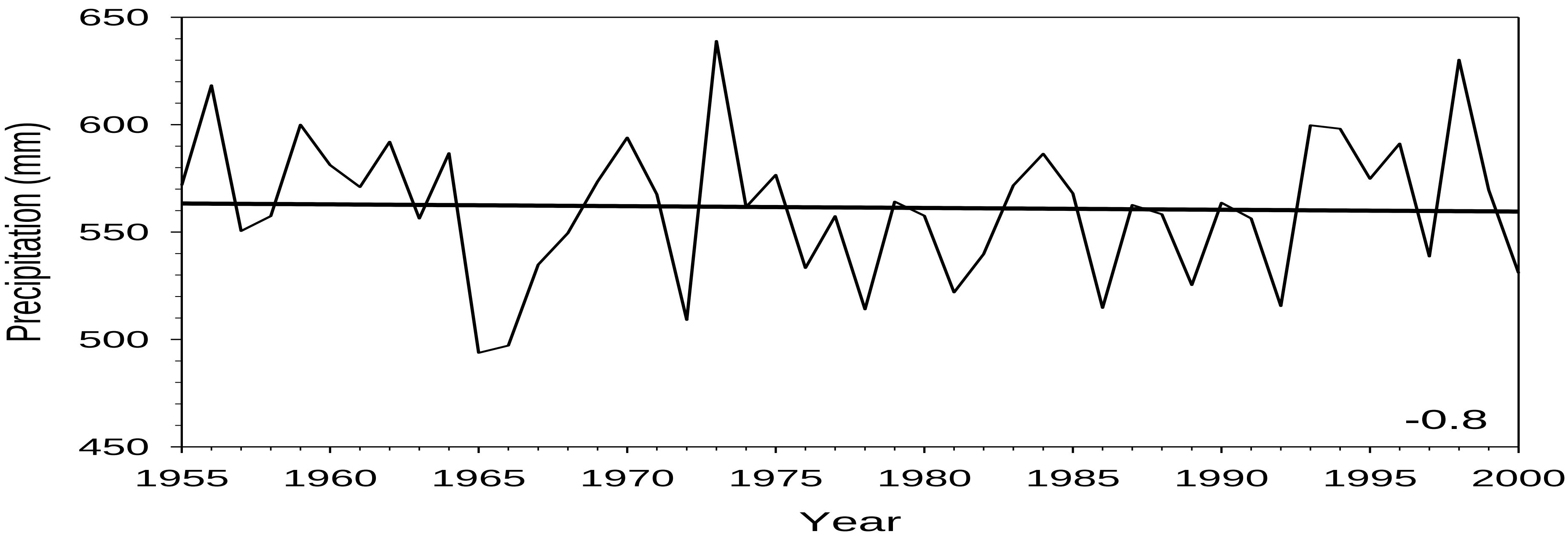
1.5
0
-1.5
Anomaly(°c)
5.1
2.37
Tmin
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
1
0
-1
Anomaly(°c)
-2.5
DTR
0.51
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

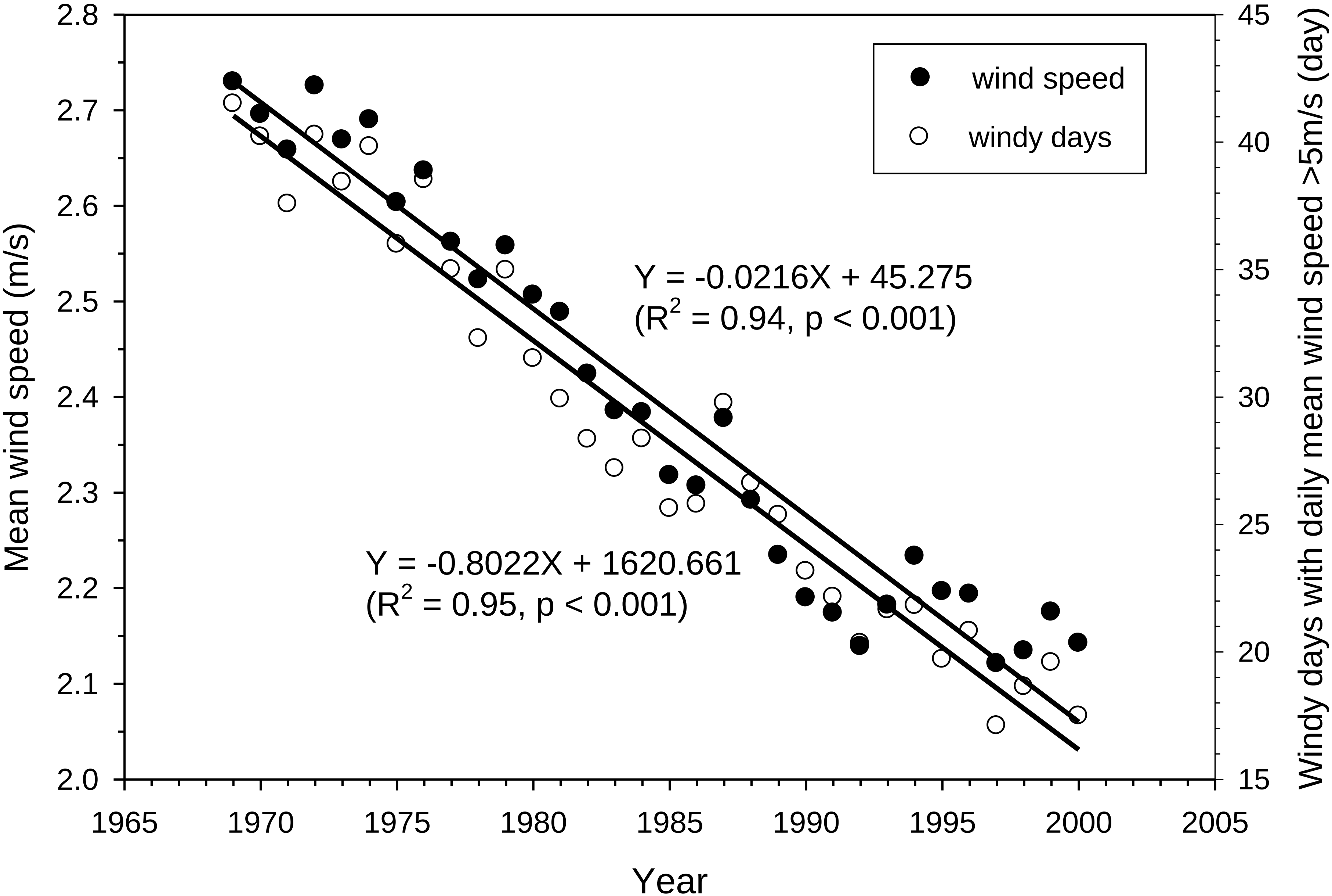
Pan evaporation in China (1955-2000)



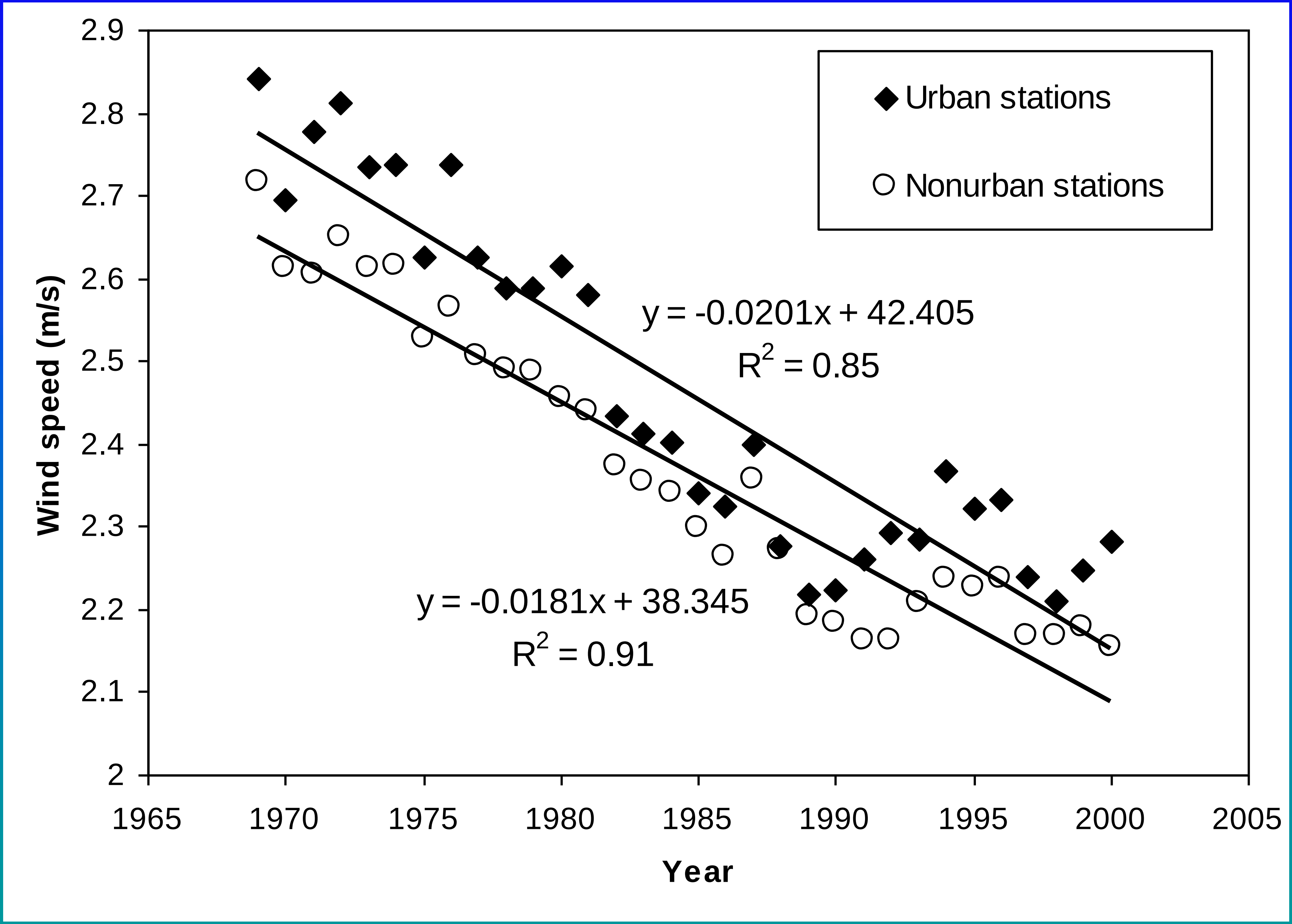
Liu et al. 2004. *Journal of Geophysical Research*, *109*, D15102, doi:10.1029/2004JD004511.


Solar irradiance (MJ/m²/day)
20.0
19.5
19.0
18.5
18.0
17.5
17.0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year
-0.3c

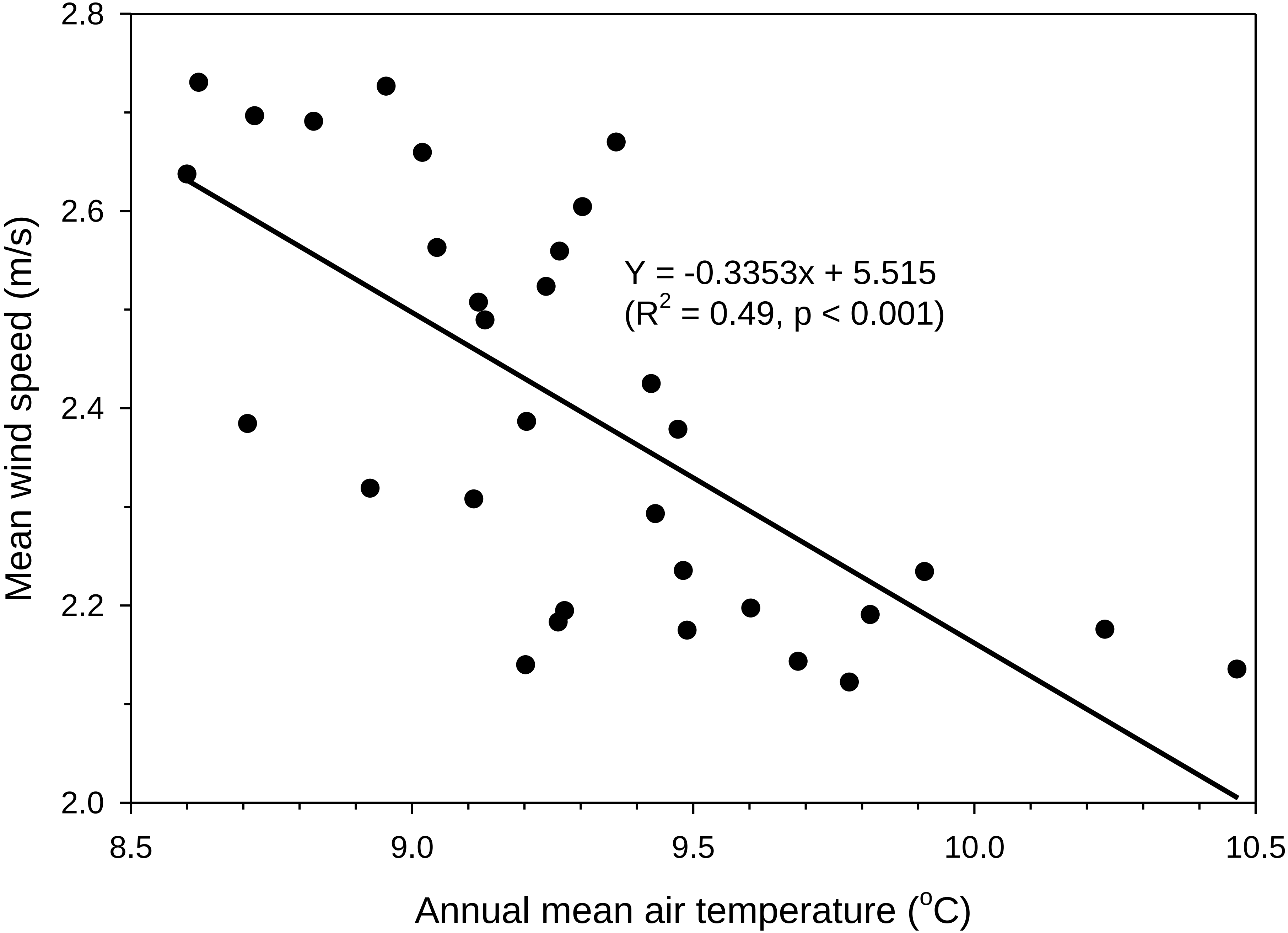

Precipitation (mm)
650
600
550
500
450
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year
-0.8



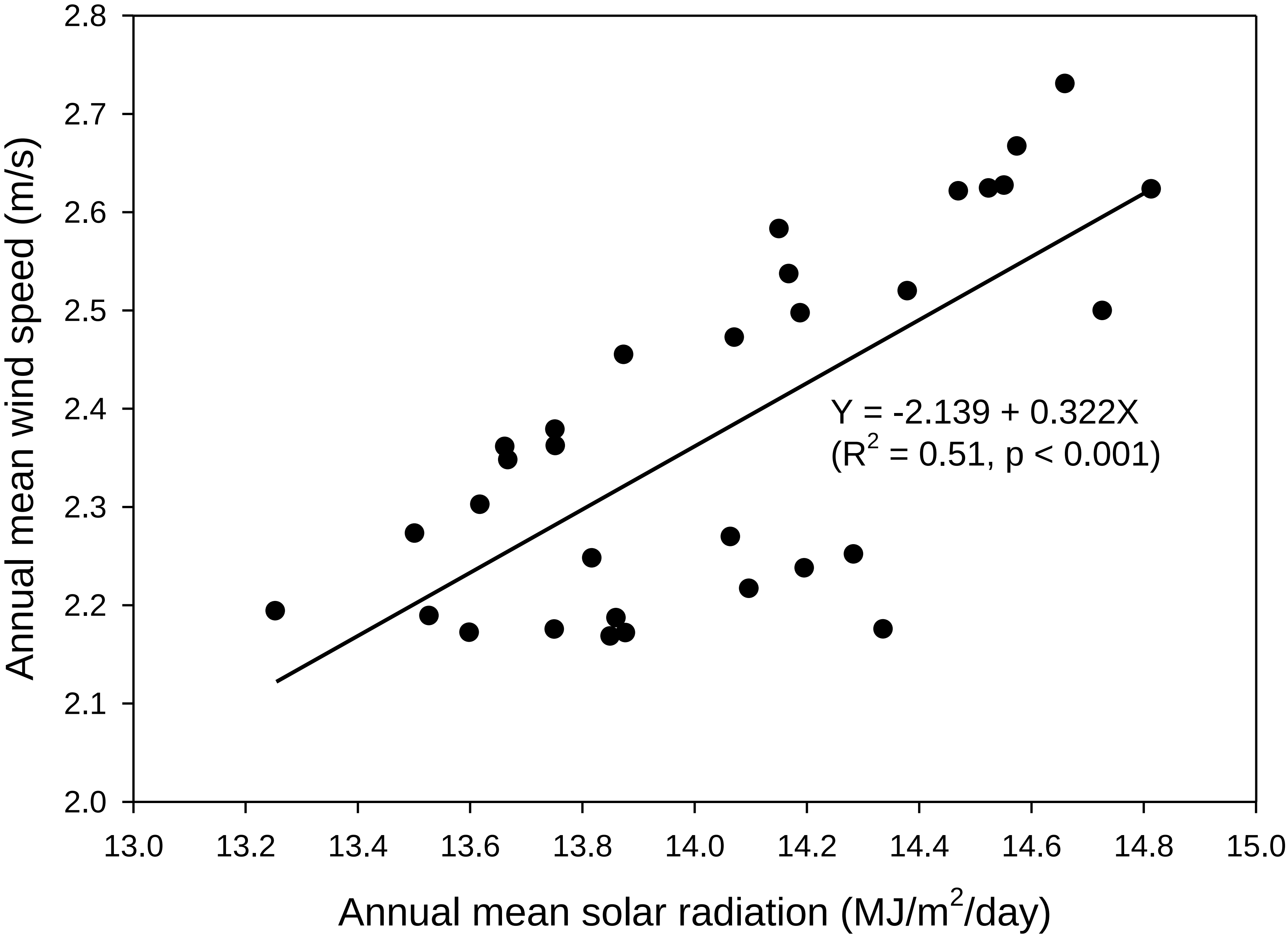
Xu et al. JGR (in press)



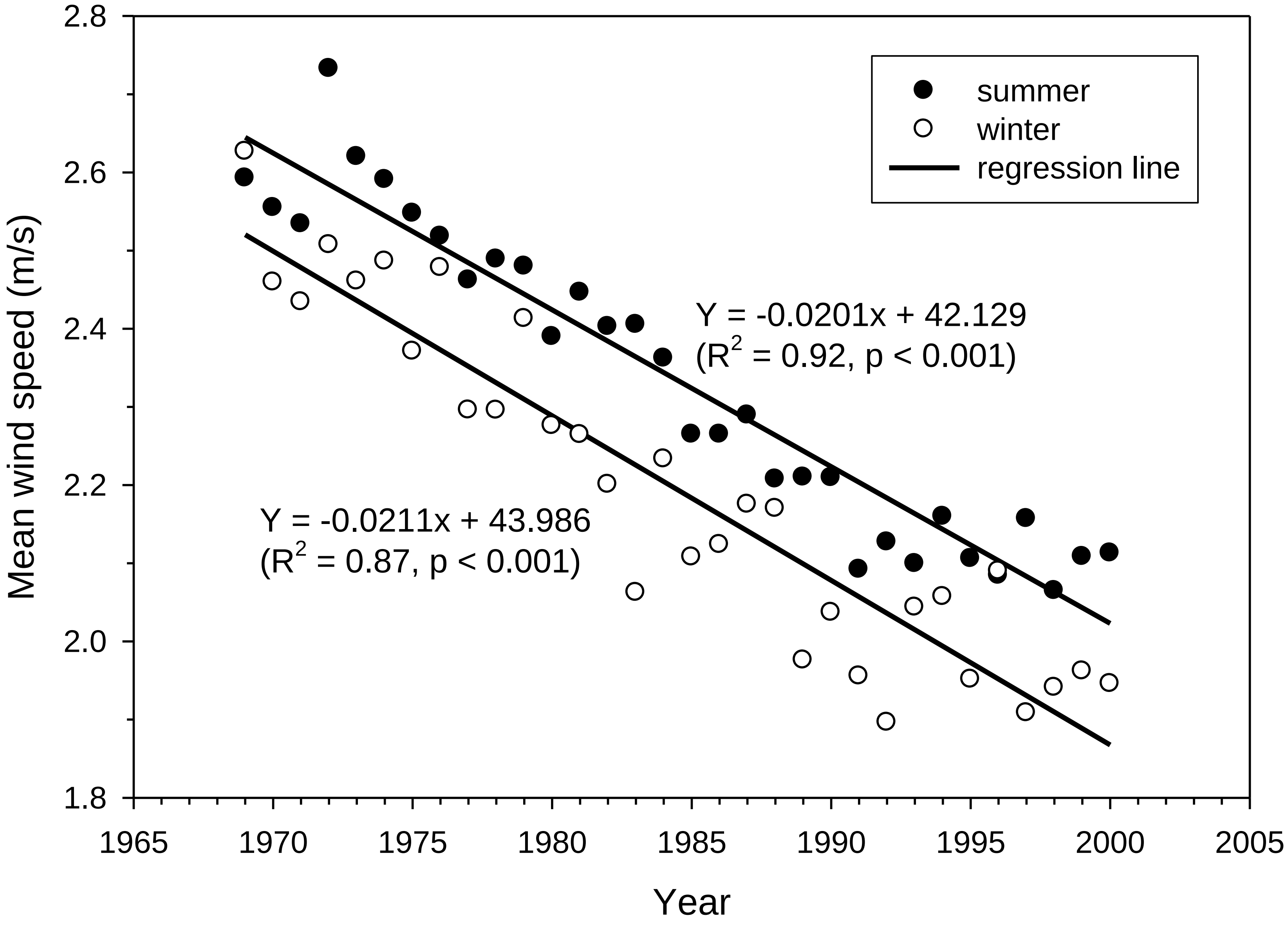
Urban stations
Nonurban stations
y = -0.0201x + 42.405
R2 = 0.85
y = -0.0181x + 38.345
R2 = 0.91
Wind speed (m/s)
Year
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1965
1970
1975
1980
1985
1990
1995
2000
2005



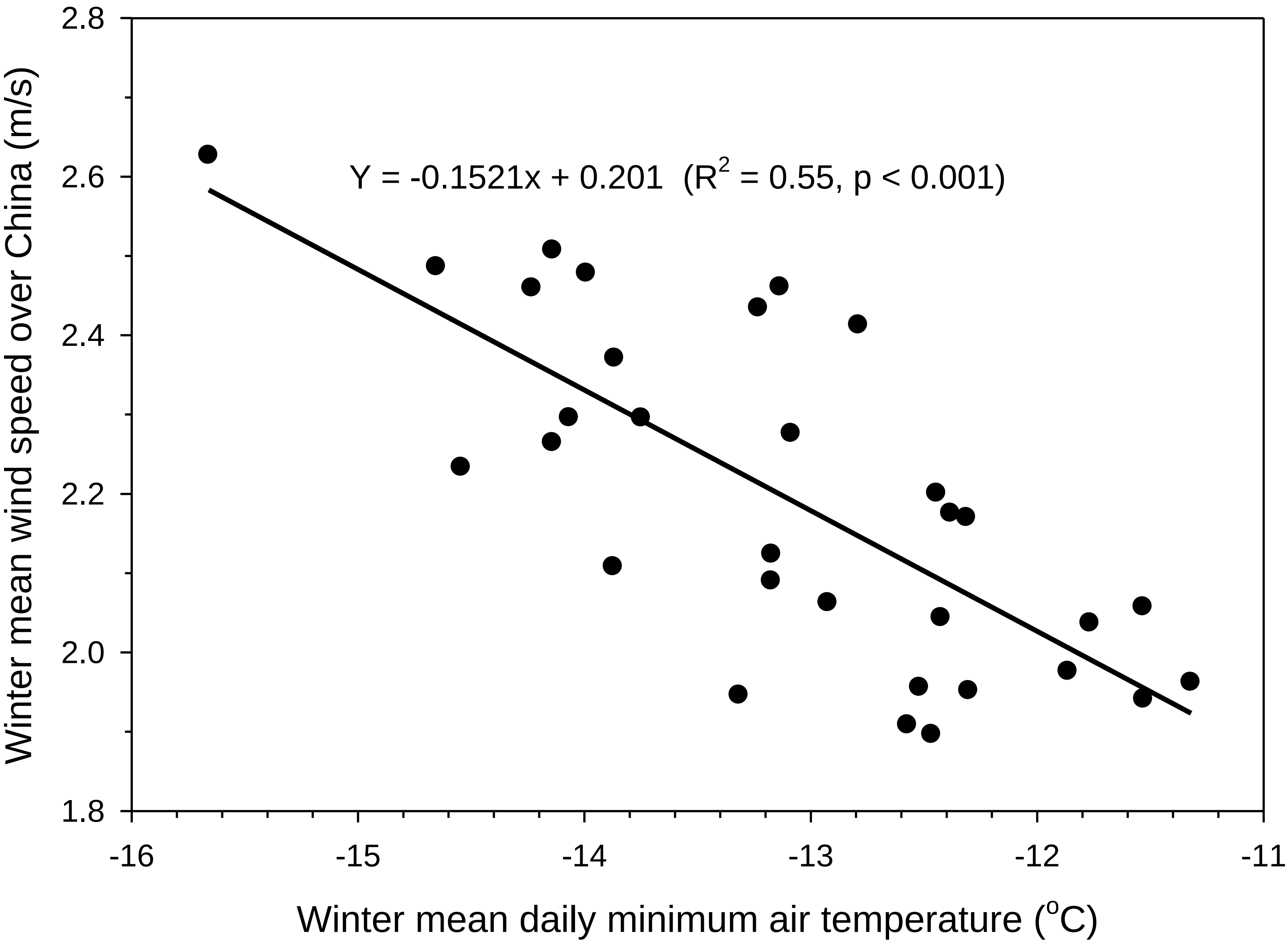
Y = -0.3353x + 5.515
(R2 = 0.49, p < 0.001)
Mean wind speed (m/s)
Annual mean air temperature (oC)
2.0
2.2
2.4
2.6
2.8
8.5
9.0
9.5
10.0
10.5

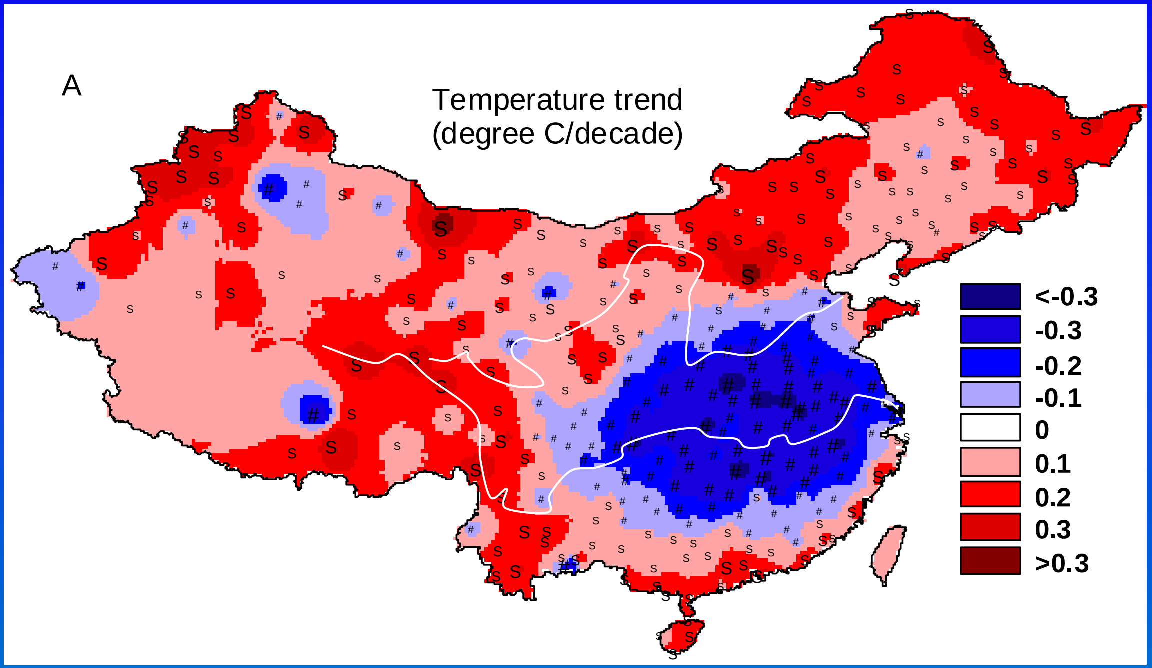


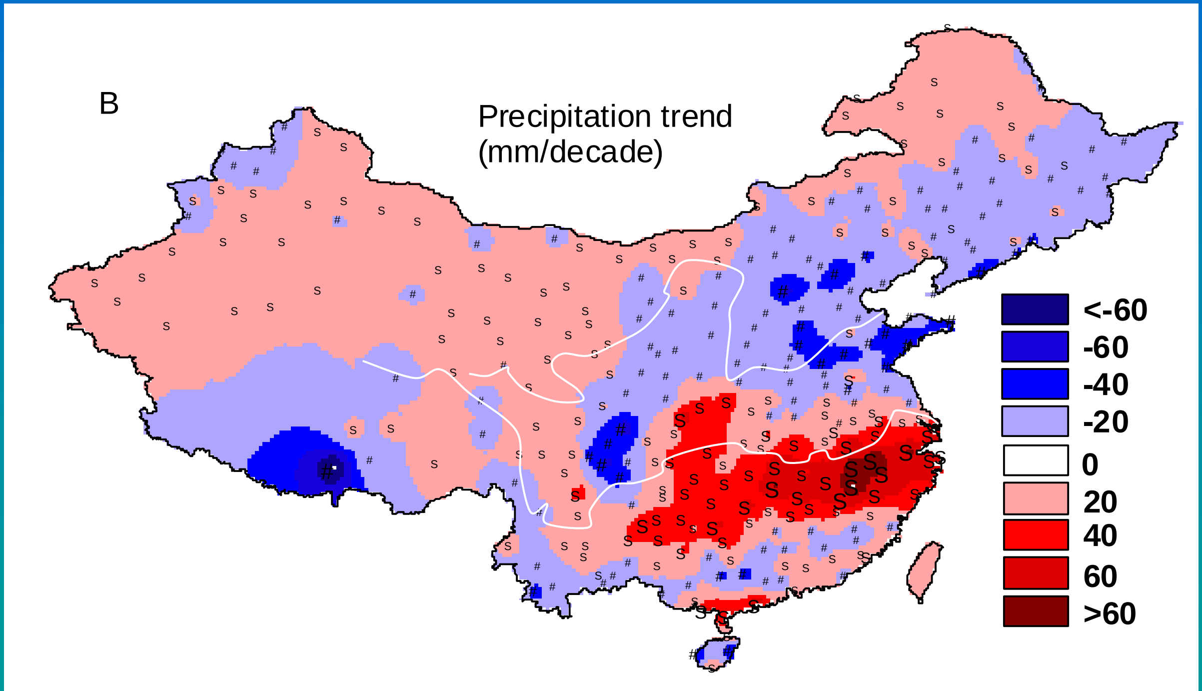
Annual mean wind speed (m/s)
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
13.0
13.2
13.4
13.6
13.8
14.0
14.2
14.4
14.6
14.8
15.0
Y = -2.139 + 0.322X
(R^2 = 0.51, p < 0.001)
Annual mean solar radiation (MJ/m^2/day)



2.8
2.6
2.4
2.2
2.0
1.8
Mean wind speed (m/s)
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year
summer
winter
regression line
Y = -0.0201x + 42.129
(R^2 = 0.92, p < 0.001)
Y = -0.0211x + 43.986
(R^2 = 0.87, p < 0.001)

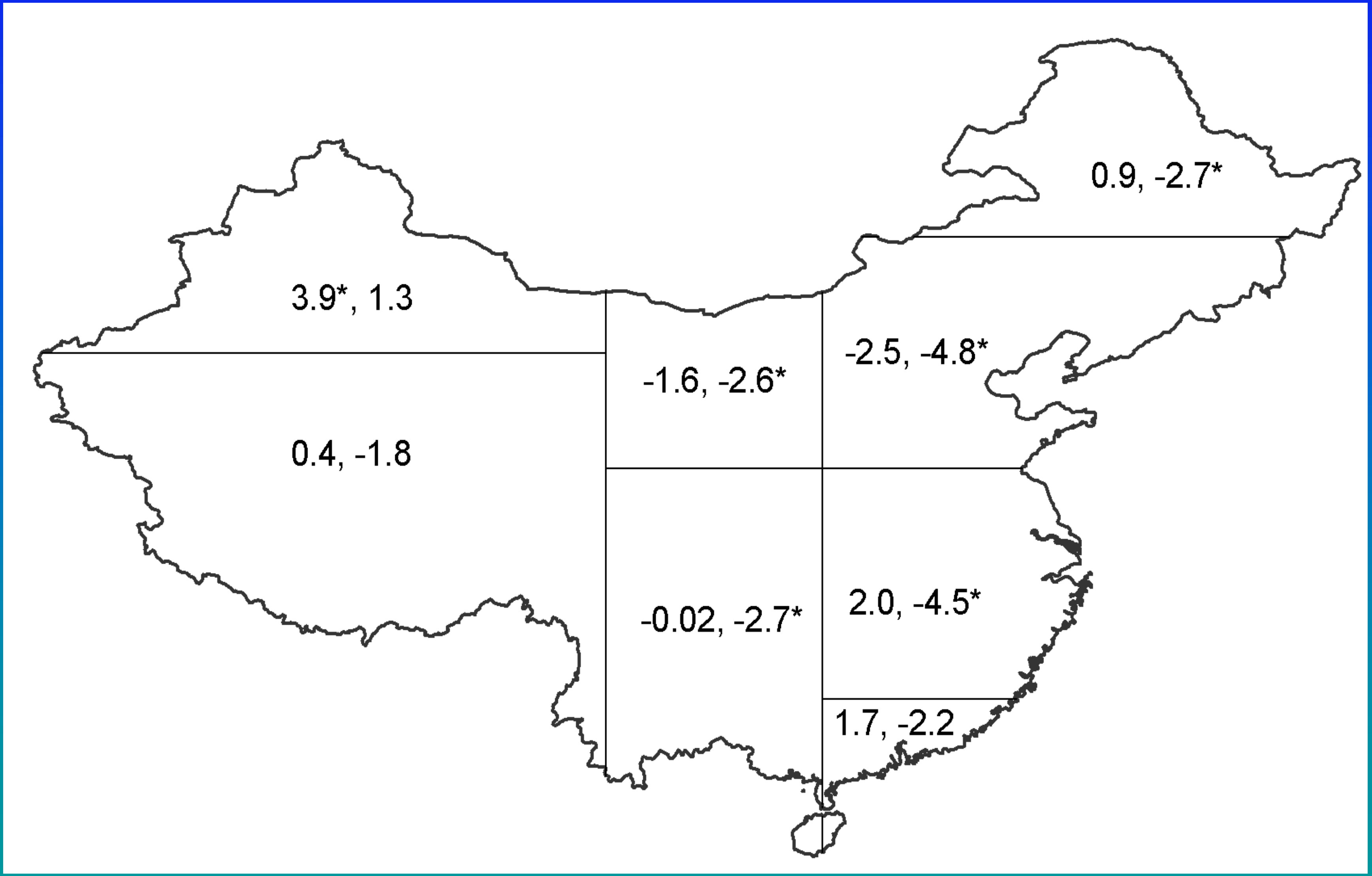

Y = -0.1521x + 0.201 (R2 = 0.55, p < 0.001)
Winter mean wind speed over China (m/s)
2.8
2.6
2.4
2.2
2.0
1.8
-16
-15
-14
-13
-12
-11
Winter mean daily minimum air temperature (oC)





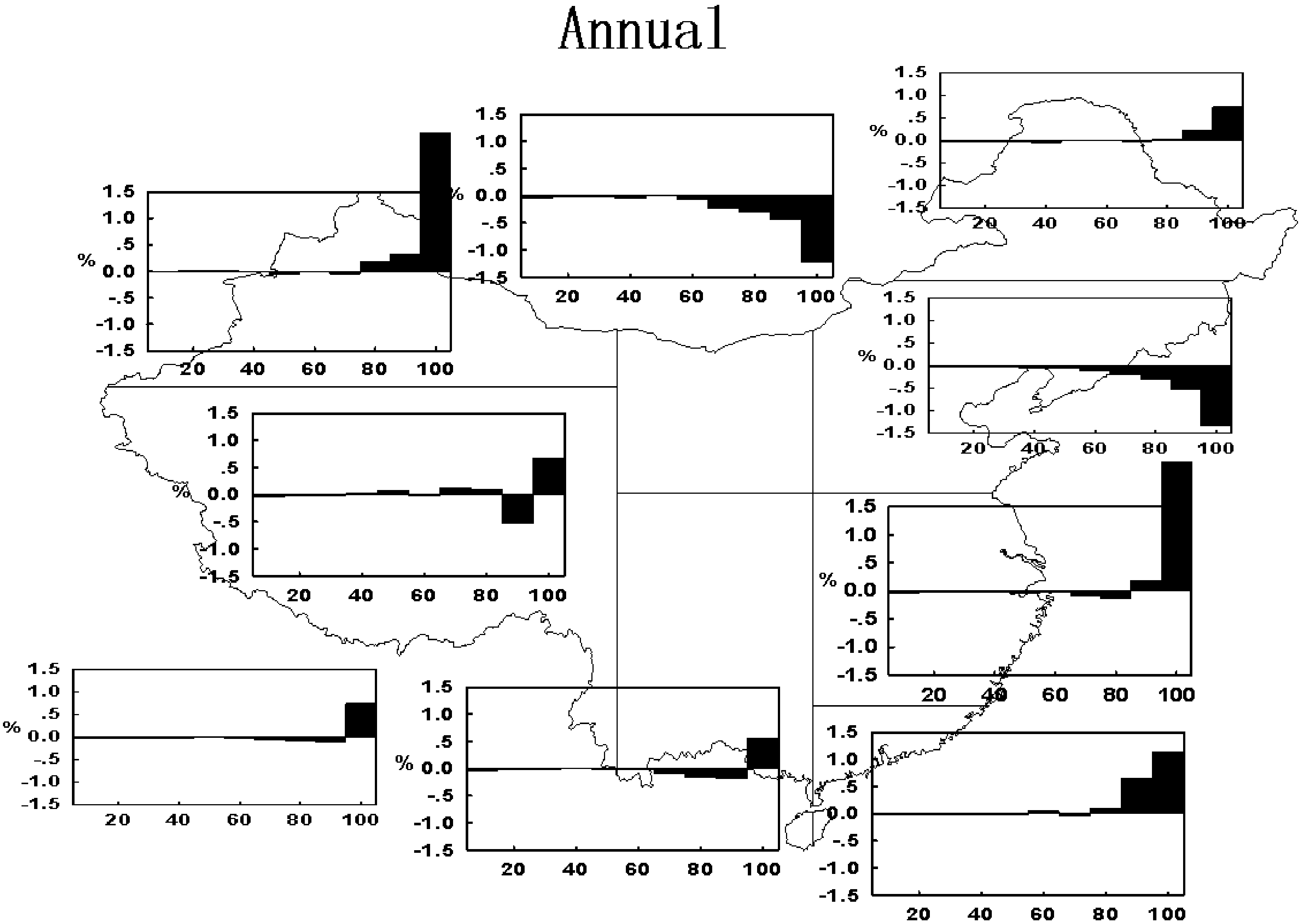
Xu et al.
JGR (in press)

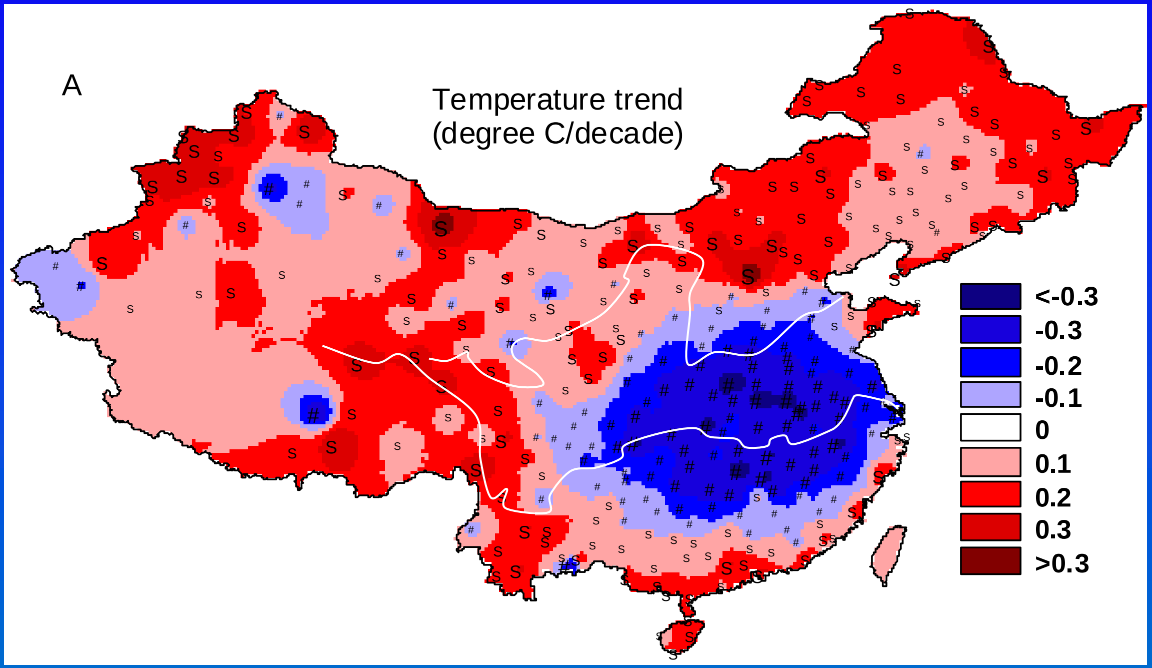
Regional precipitation trends (1960-2000)

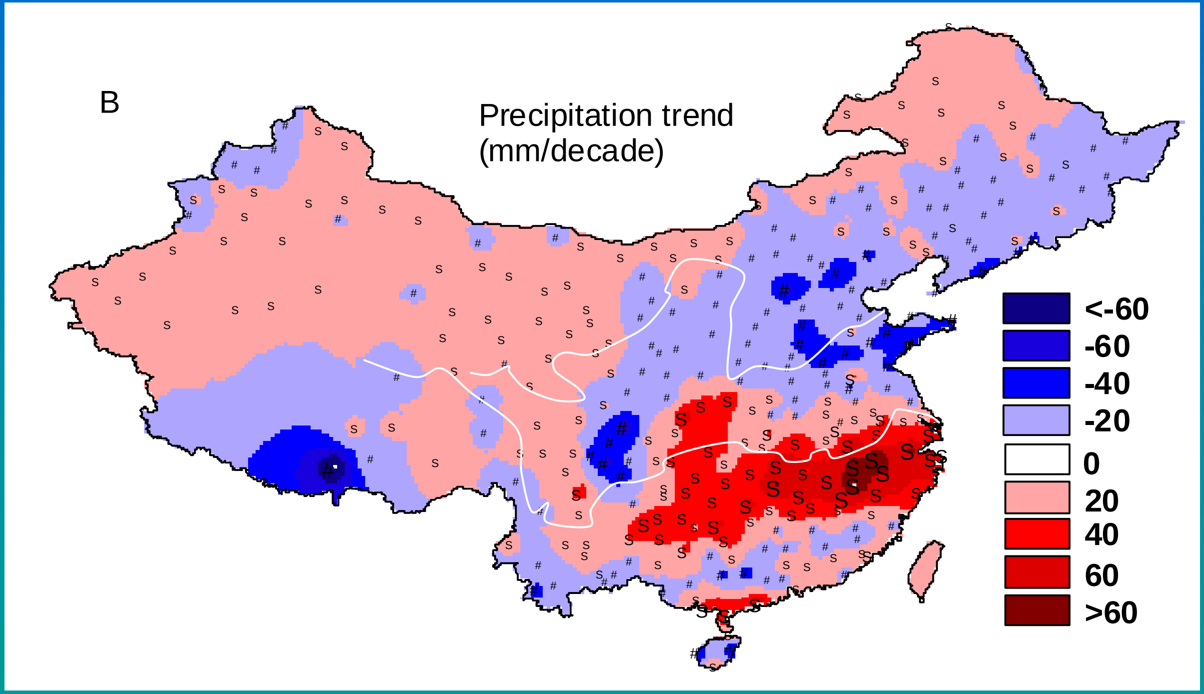


Liu et al. 2005. ***Journal of Geophysical Research*** **110**, D08103

Annual trend of precipitation by intensity categories



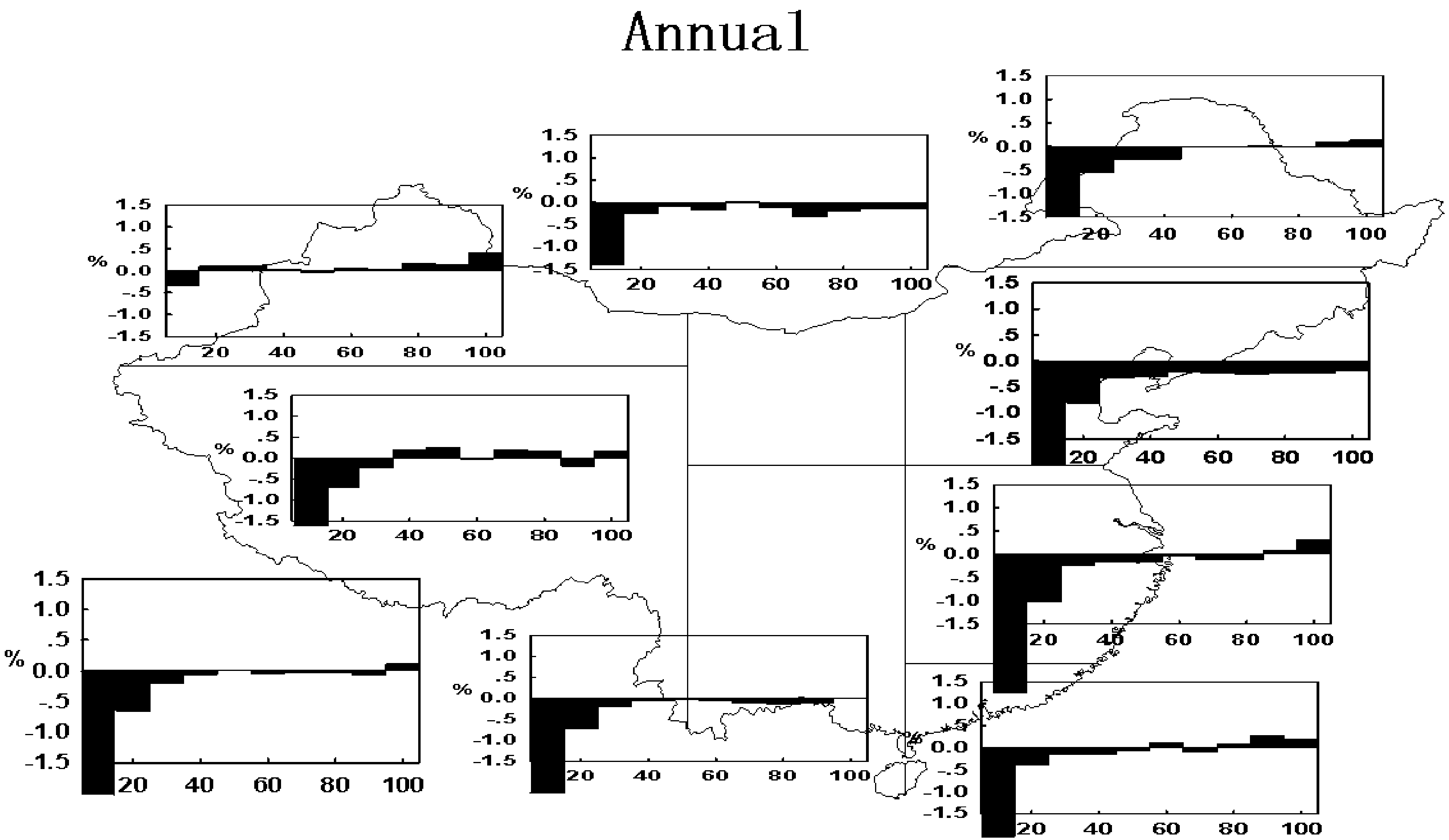




Xu et al.
JGR (in press)

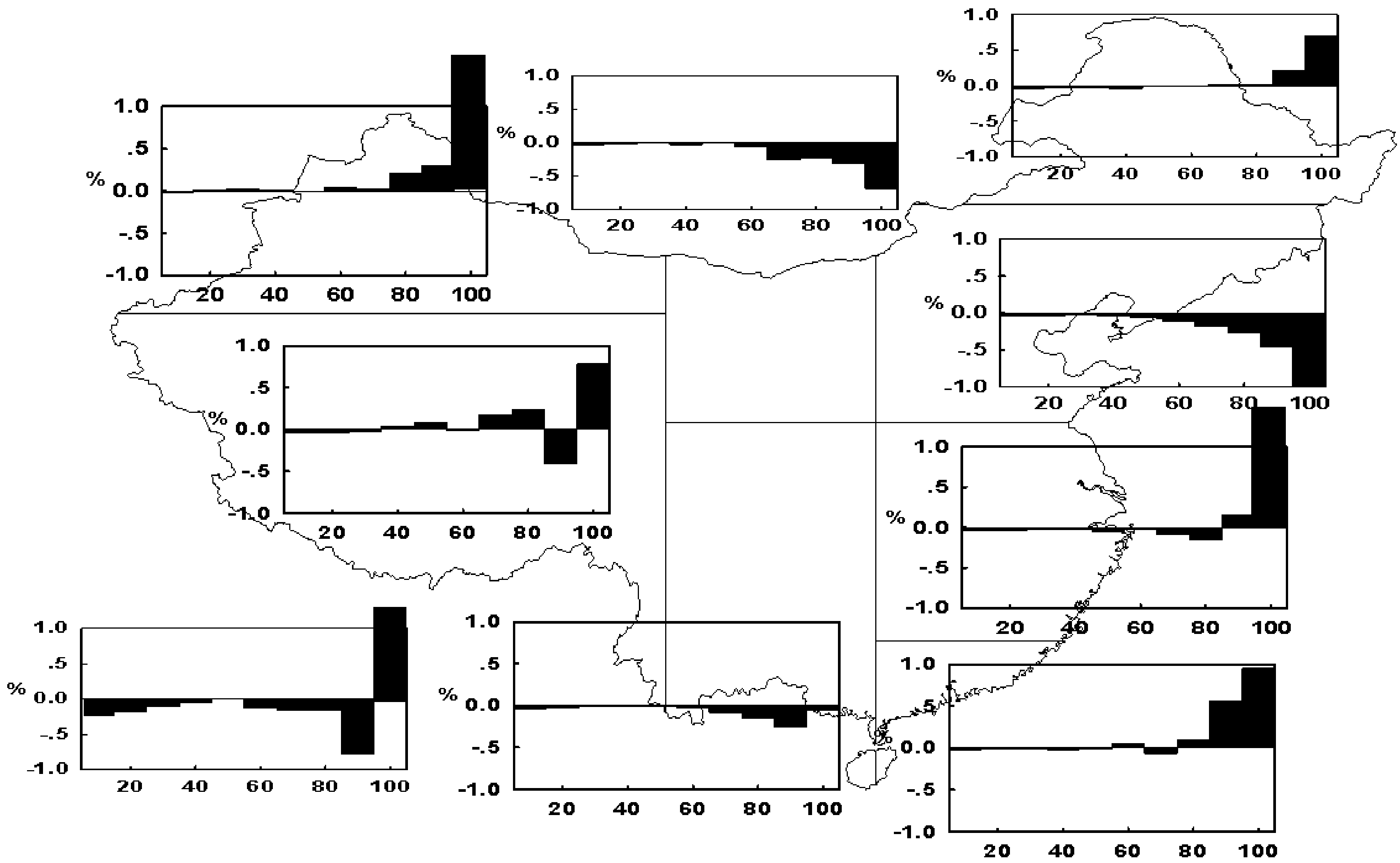
Thank you

Change of precipitation frequency by decile

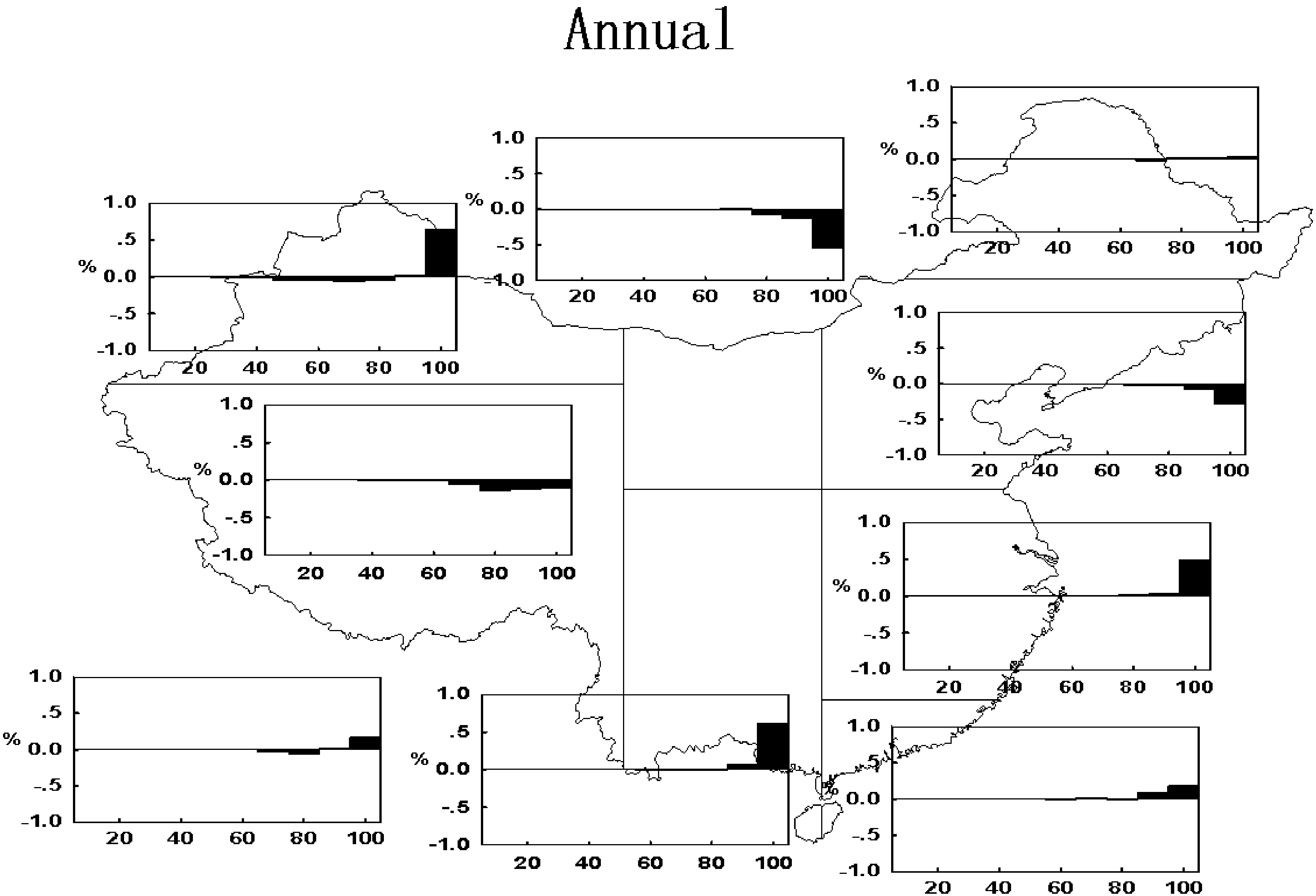


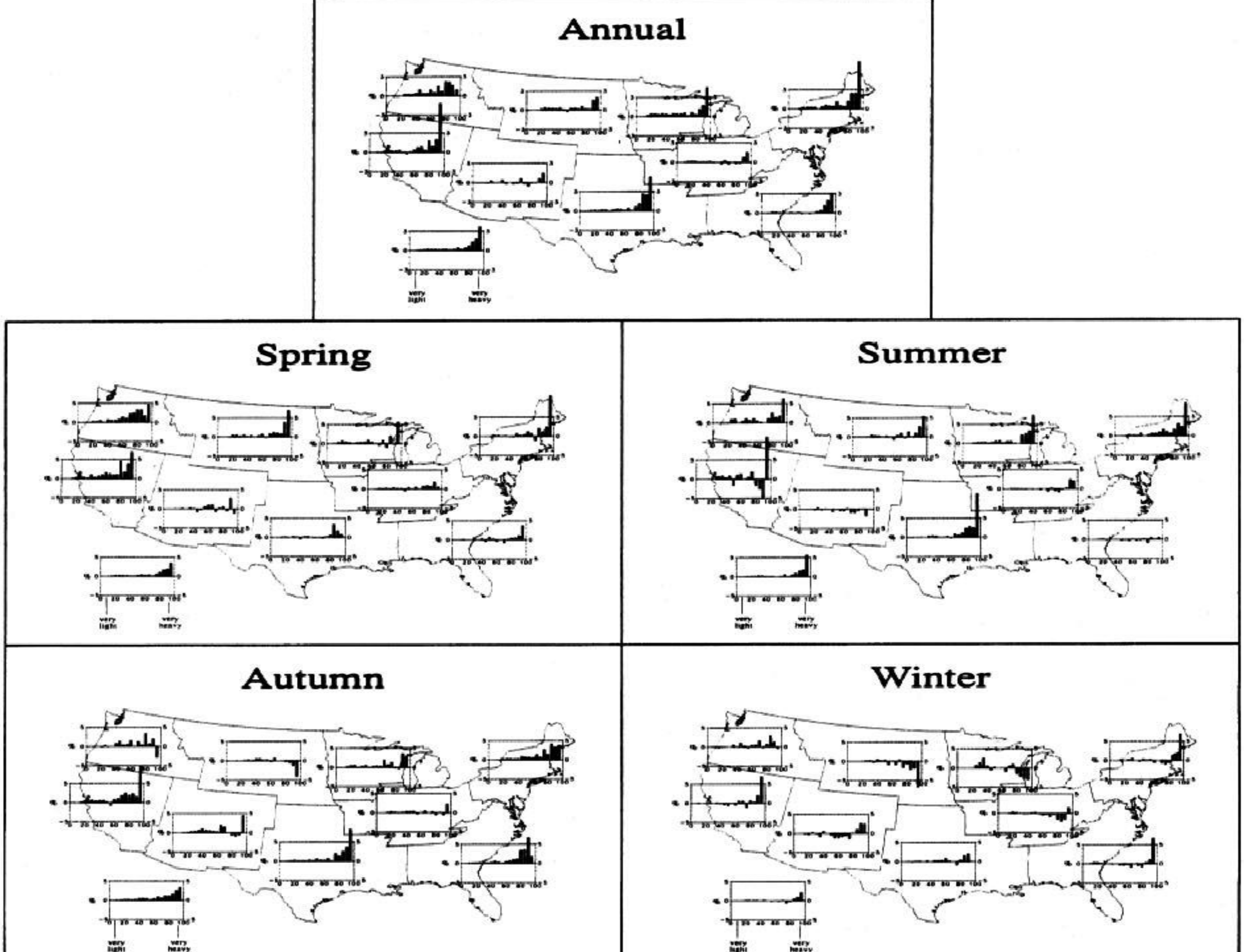
Contribution from frequency change

Annual



Contribution from intensity change




Annual
Spring
Summer
Autumn
Winter

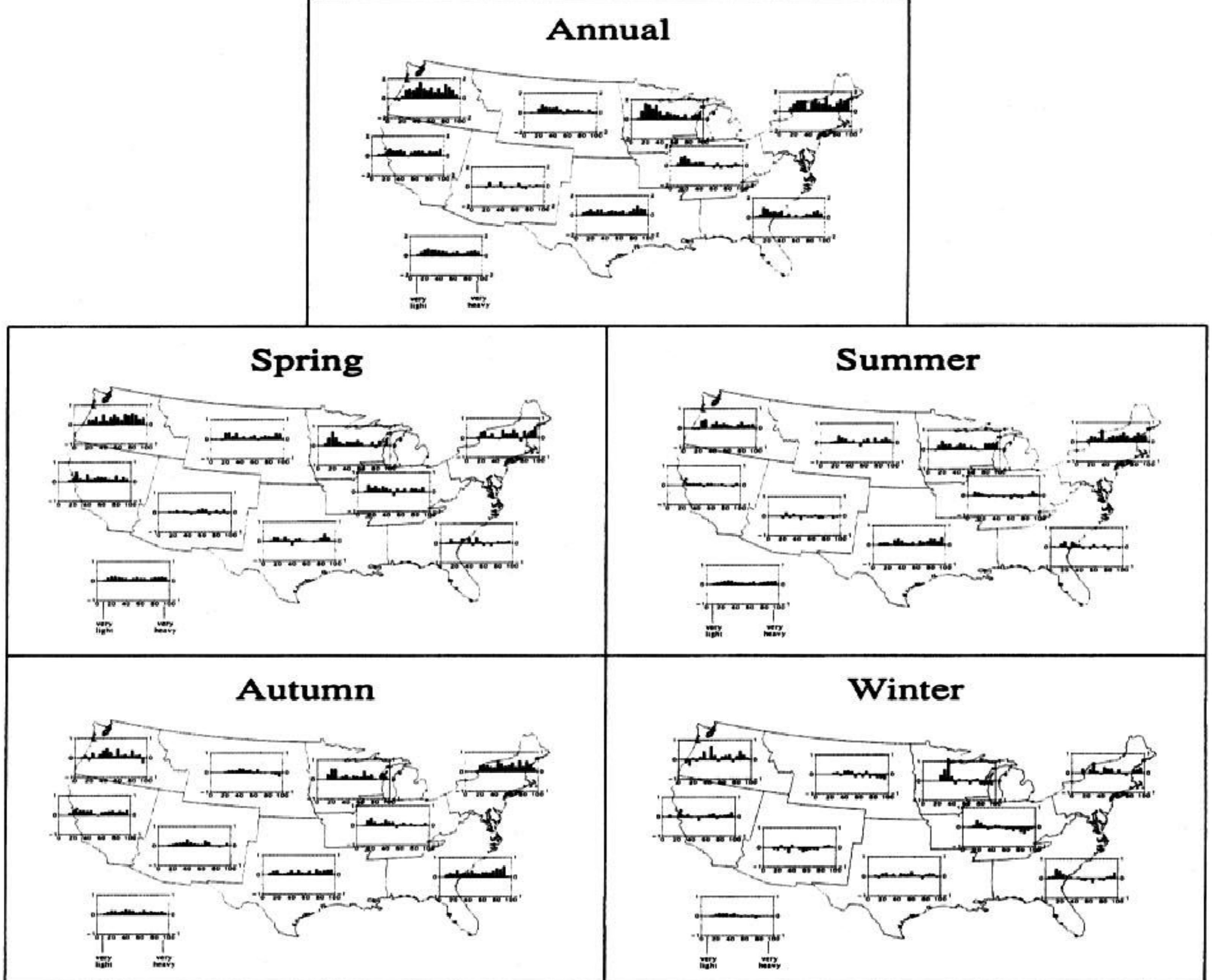


FIG. 3. The trend of the number of precipitation events expressed as events per century for the same percentiles as in Fig. 1.

moderate precipitation amounts, for example, the 50th

proportion of the total annual precipitation contributed

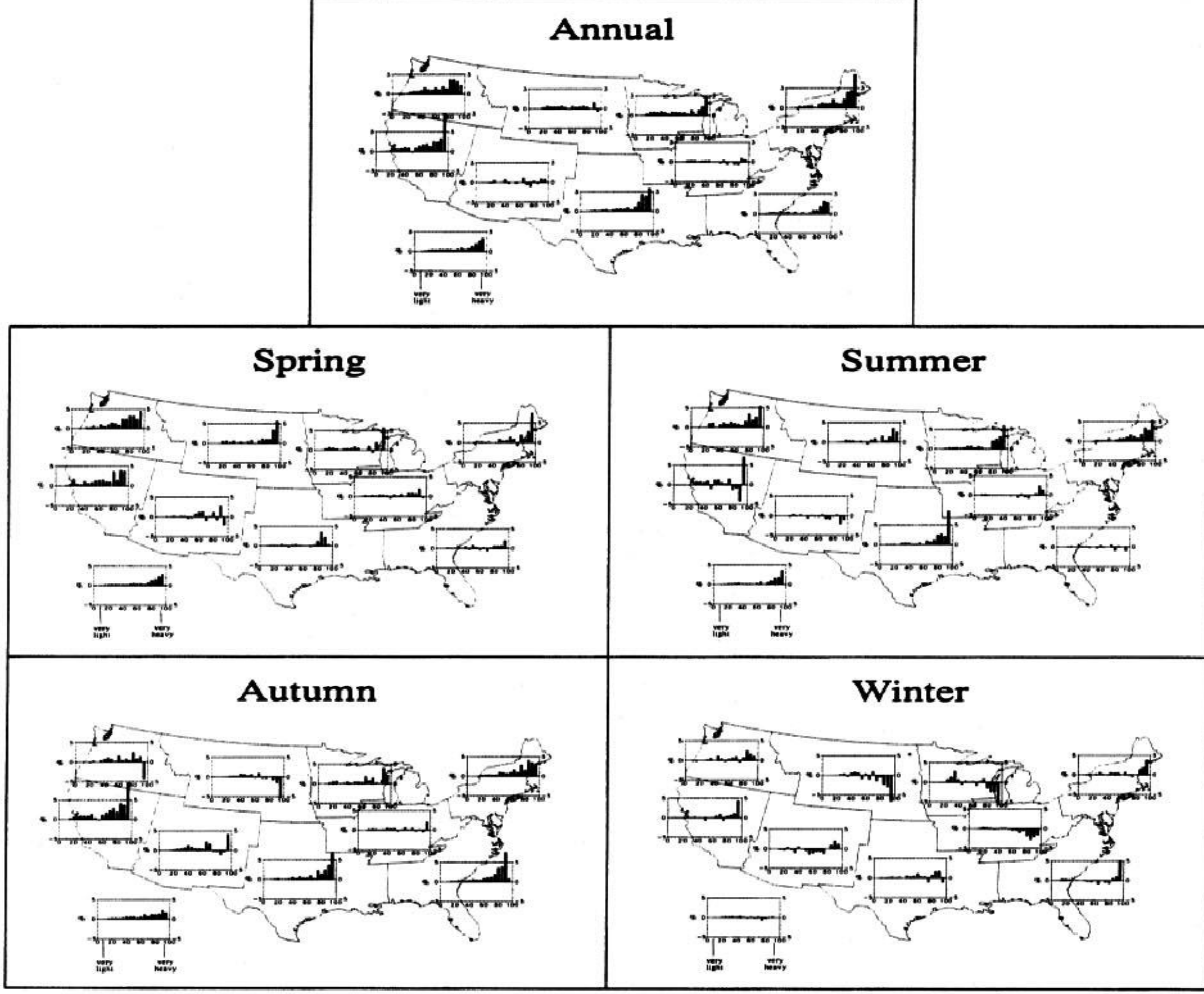


FIG. 4. The contribution to the trends in Fig. 1 attributed to trends in precipitation frequency. Trends are expressed as in Fig. 1.

a change in the precipitation distribution; for example, a crease (2%) in area affected by a much above-normal

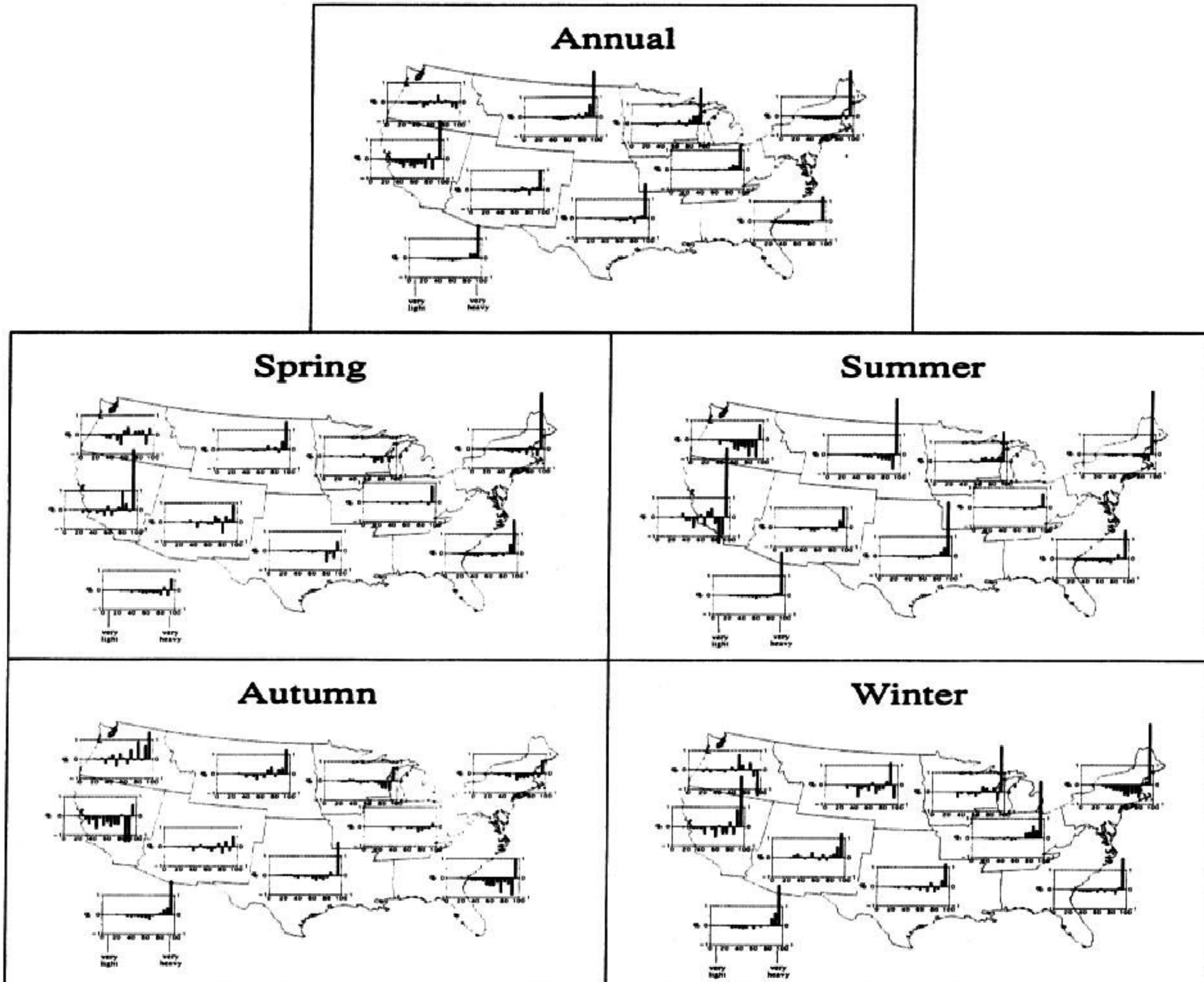


FIG. 5. The contribution to the trends in Fig. 1 attributed to trends in precipitation intensity. Trends are expressed as in Fig. 1.

5. Conclusions

changes in precipitation intensity have been shown to