

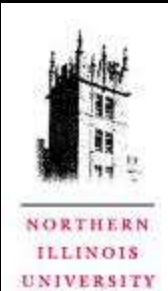
Impact of Preindustrial to Present-day Changes in Urbanization and Pollutant Emissions on the East Asian Summer Monsoon (EASM)

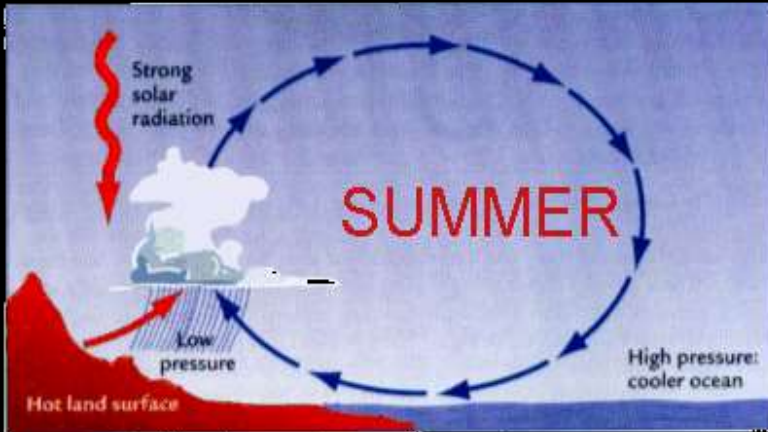
Jie Song, Northern Illinois University, DeKalb, IL, USA
Hongyun Ma, and **Zhihong Jiang**, Nanjing University of Information Science and Technology, Nanjing, China



Outline

1. Observed changes in the EASM;
2. Hypothesis of possible impact by human activities;
3. Sensitivity experiment with numerical model:
 - (0) control run
 - (a) urban land cover
 - (b) pollution emission
 - (c) urban land cover and pollution emission;
4. Result analysis;
5. Summary and conclusion



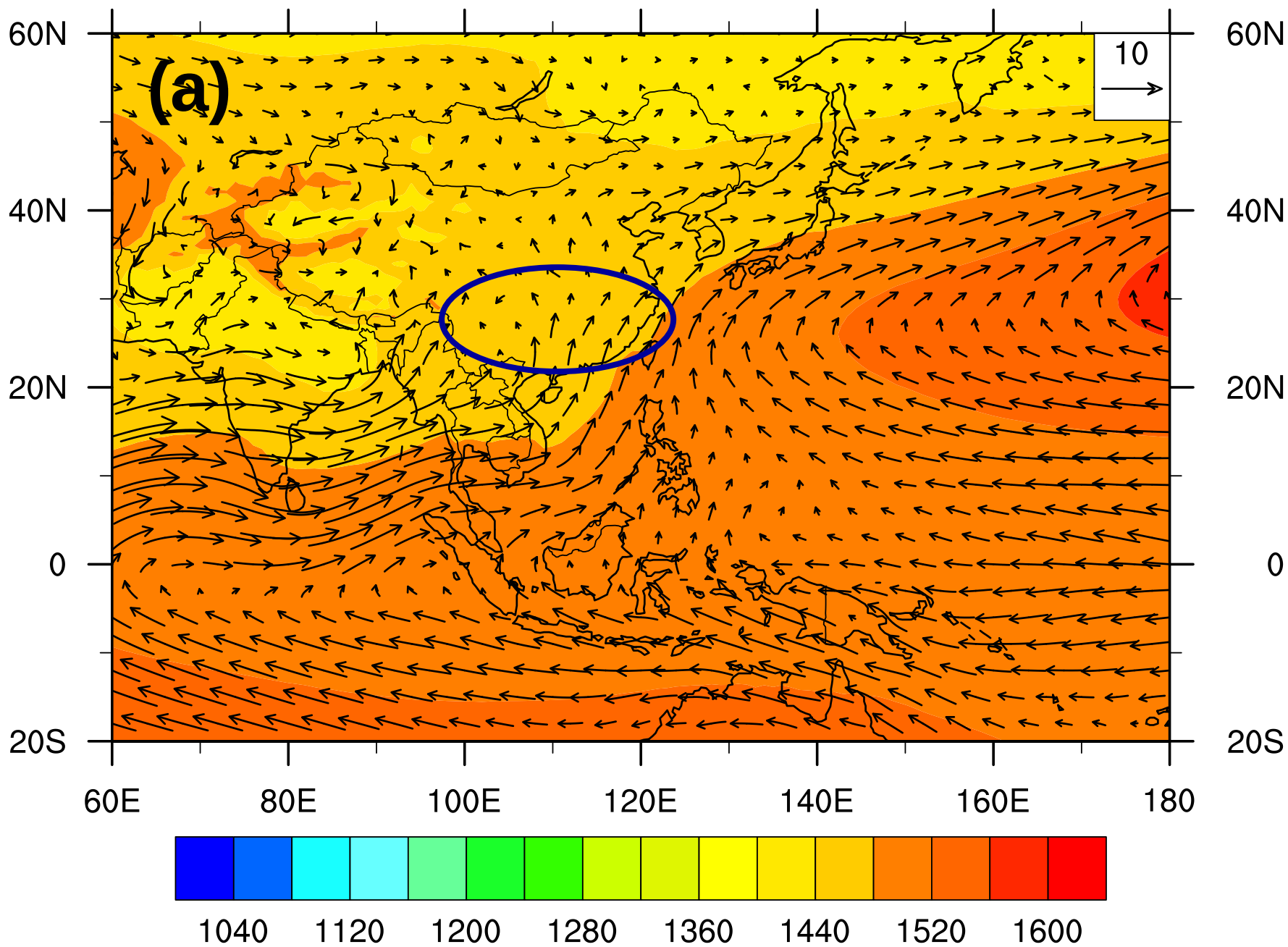


- Monsoons are a response of the coupled atmosphere-ocean-land system to annual variation of solar forcing

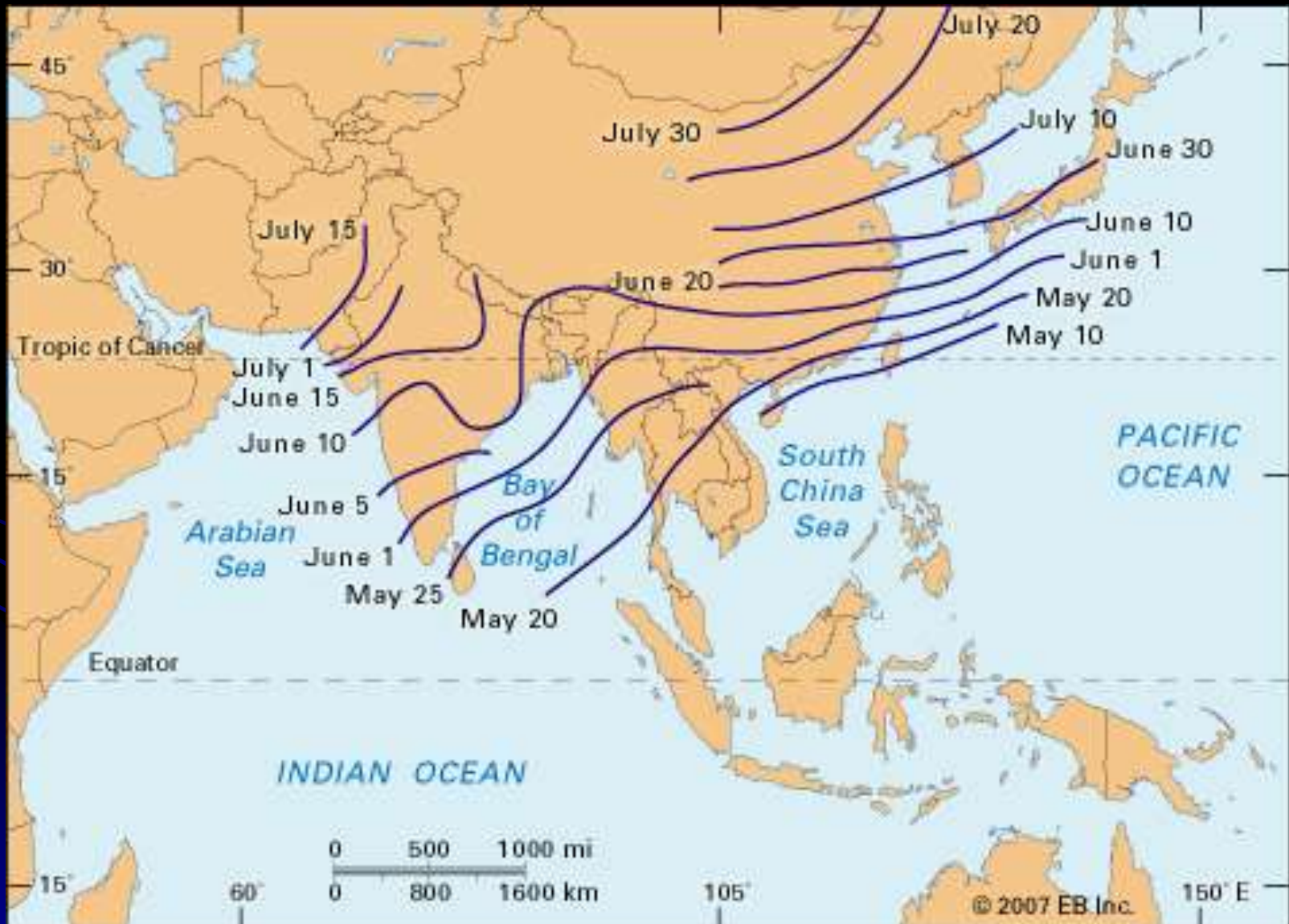


JJA

850hPa

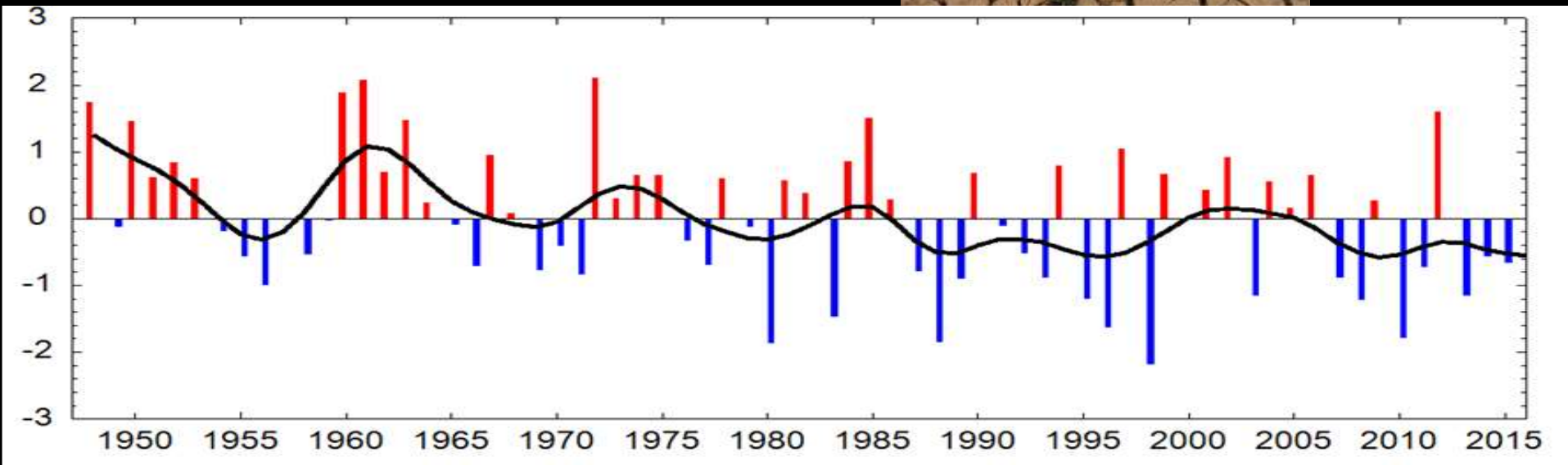


- Mean onset date of the Asian summer monsoon



East Asian Summer Monsoon is weakening

Strong EASM (+): wetter north, **drier south** →

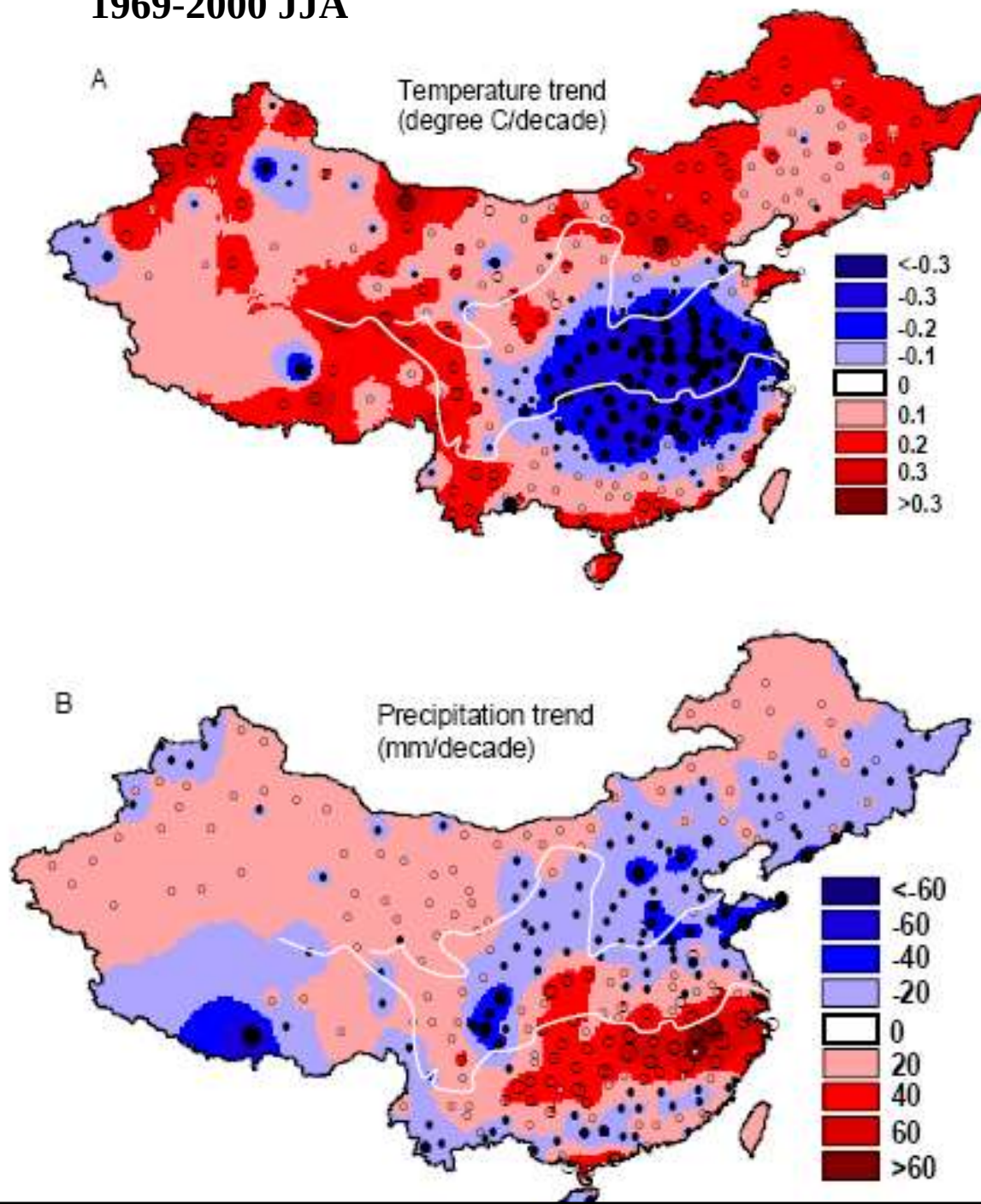


EASM indices from Dr. Jianping Li

Weak EASM (-): drier north, **wetter south** →



1969-2000 JJA



Observed wind declining trend of about 0.2 m/s per decade
by Xu et al. (2006), JGR

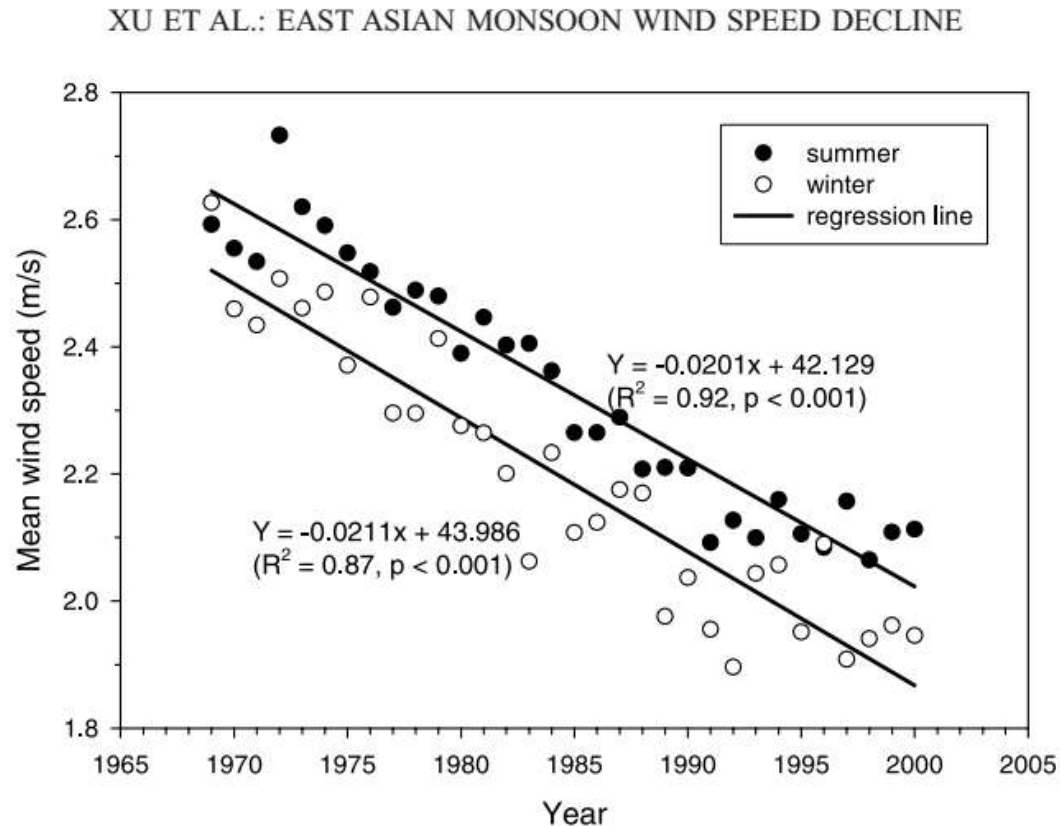


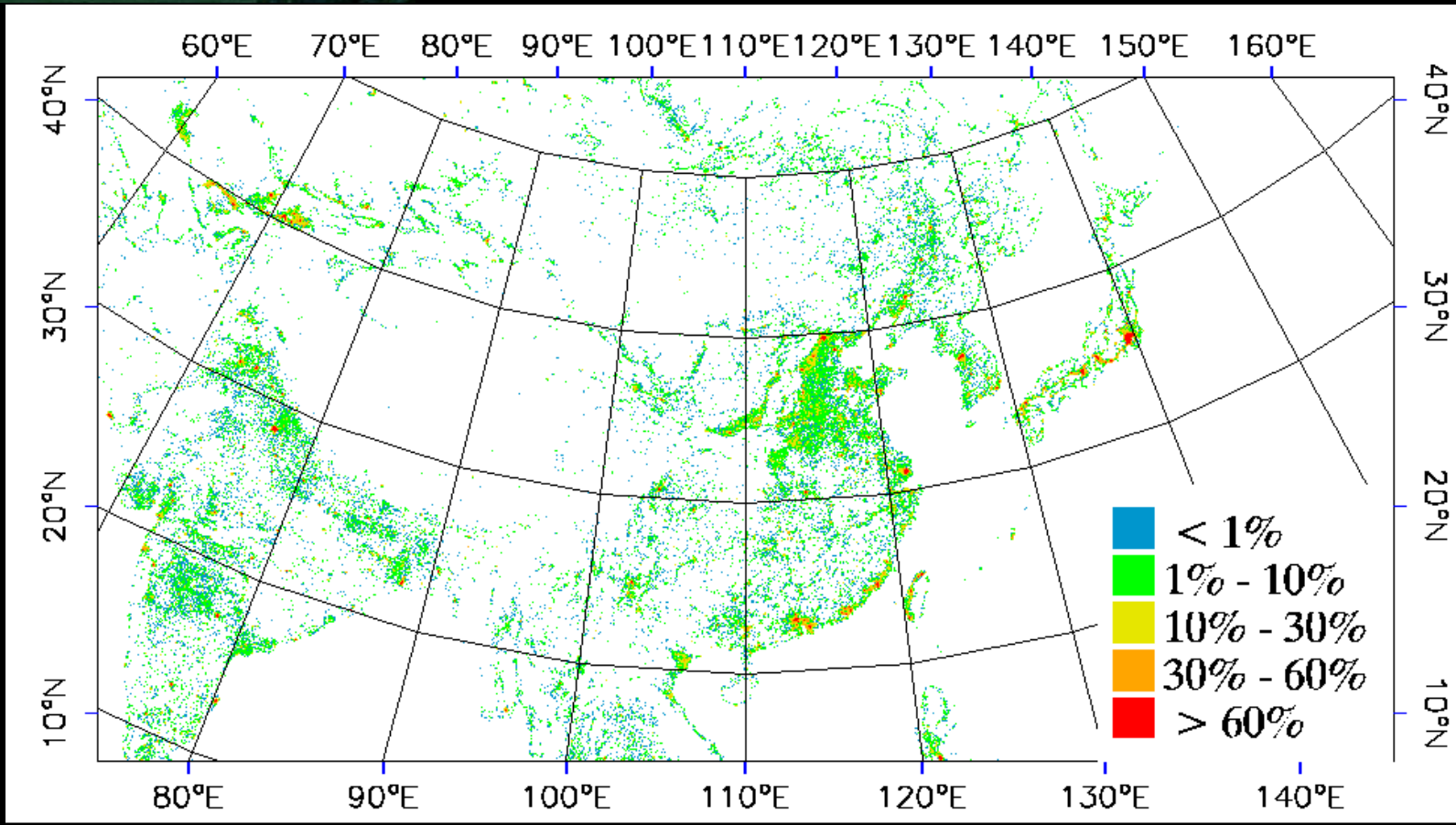
Figure 6. Declining trend of approximately 0.2 m/s per decade, which is quite similar in winter (NDJF) and summer (JJA).



Hypothesis: Anthropogenic Impact I:

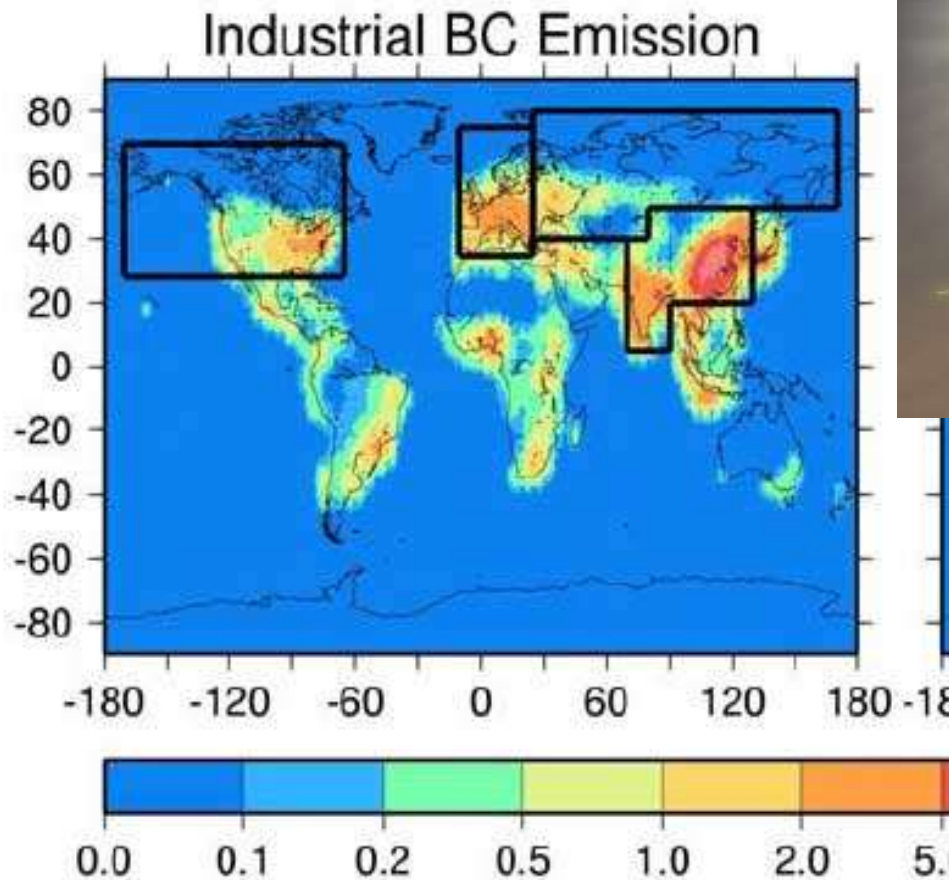
“The great migration” to the Eastern China caused the large-scale land cover change

Fraction of Urban land use



Hypothesis: Anthropogenic Impact II:

East Asia is a global hotspot for BC as well as sulfate emission. Air pollutants in eastern China influence solar radiation directly by scattering and absorption, and indirectly by “brightening” clouds and extending cloud life.



(Koch et. al. 2011. *J. Climate*)



Sensitivity Experiment with Numerical Modeling

- Community Atmosphere Model (CAM5.1)
- Community Land Model + Urban (CLMU)
- Simulation period: 1988-2007
- Results analysis period: 1993-2007

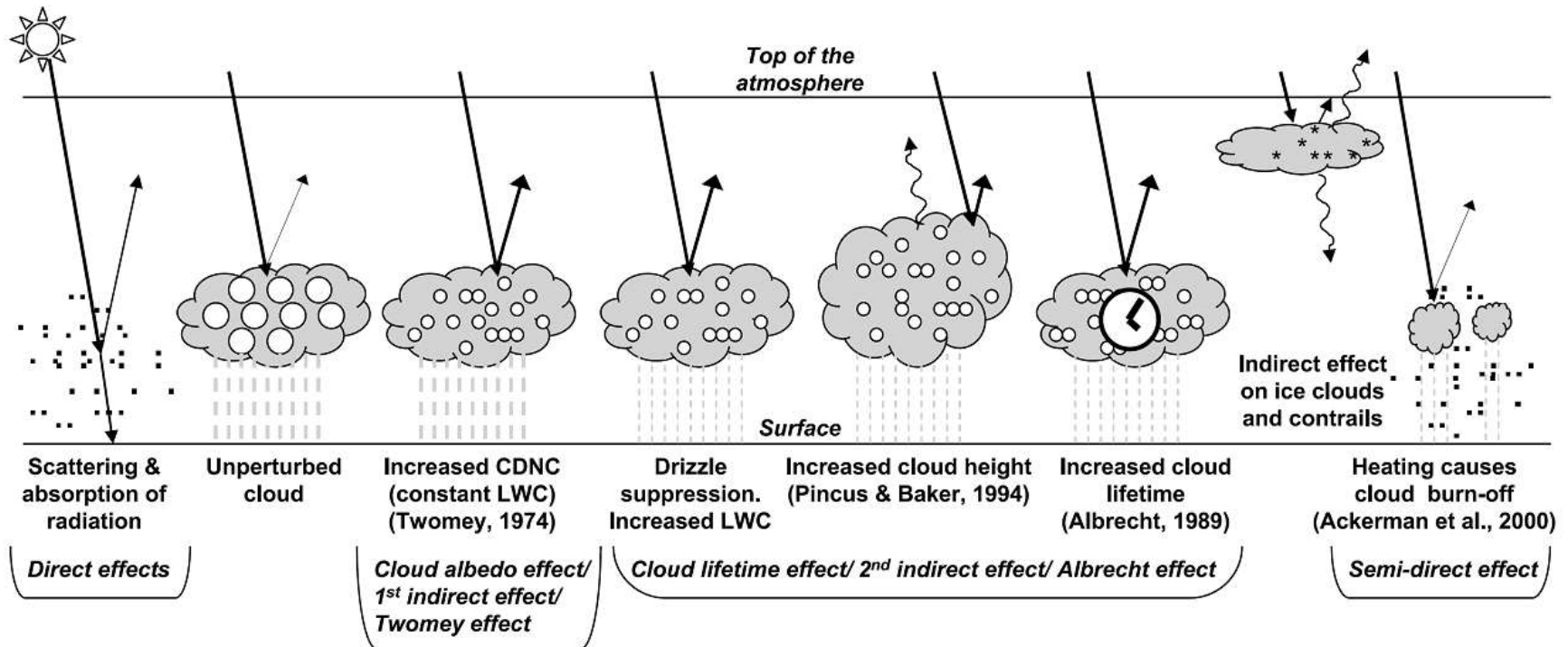
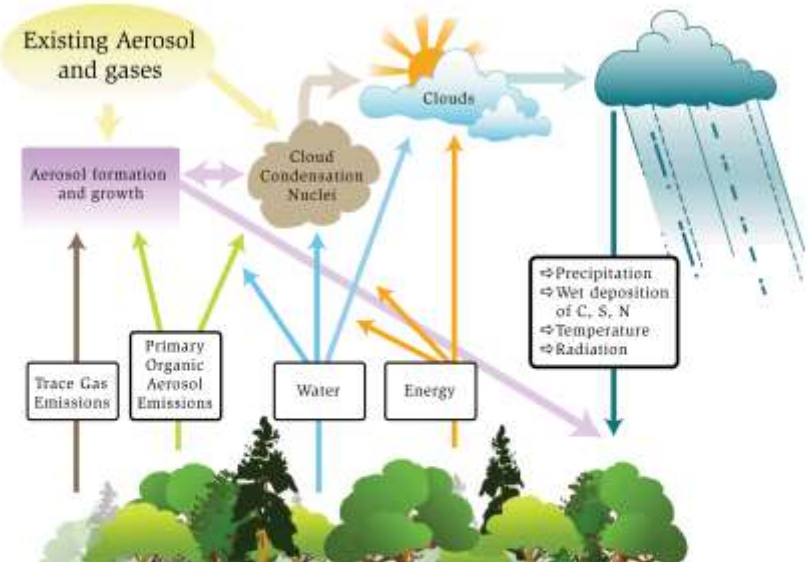
(0) Control run

(1) urban land cover

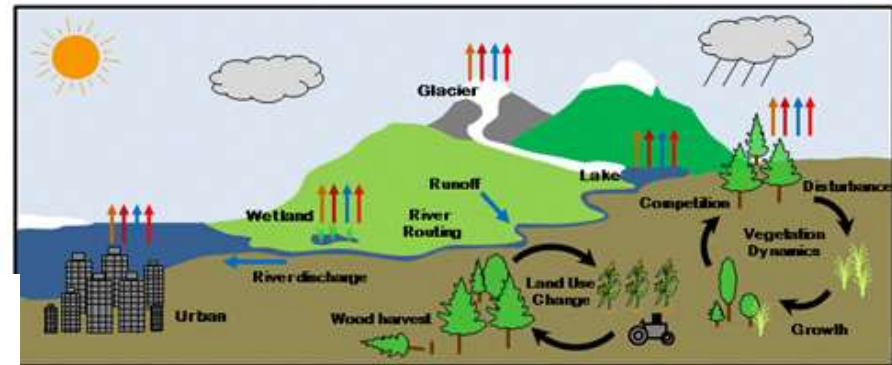
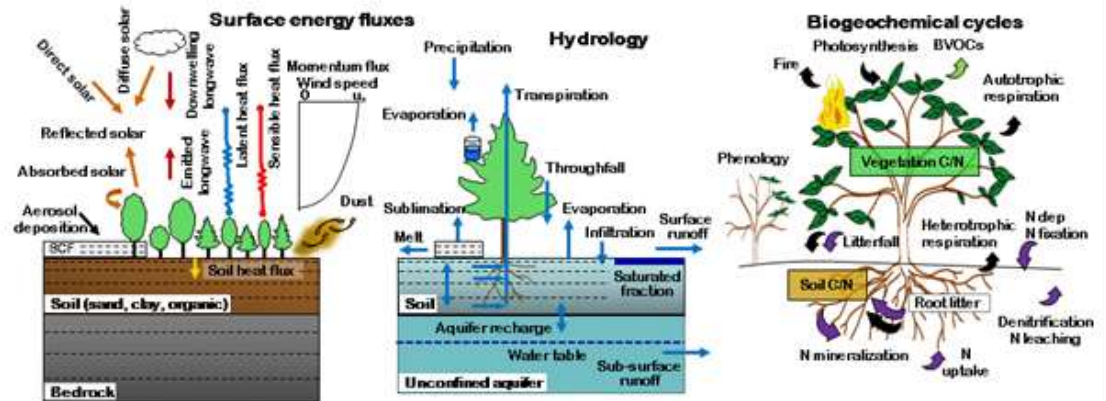
(2) pollution emission

(3) urban land cover and pollution;

Aerosols' direct and indirect effect



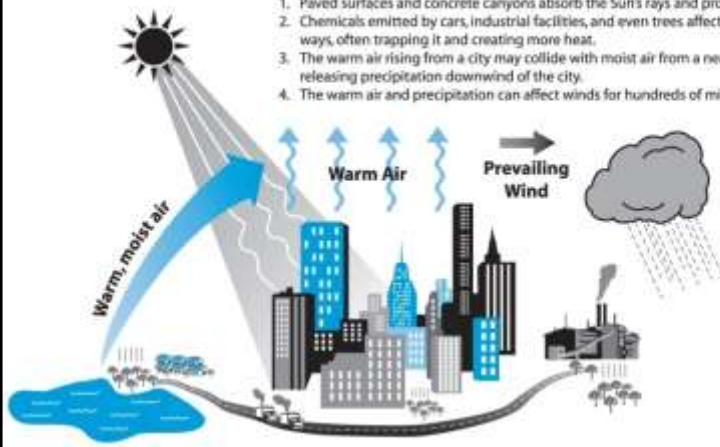
Land model coupled with urban model



Urban Heat Island Effect

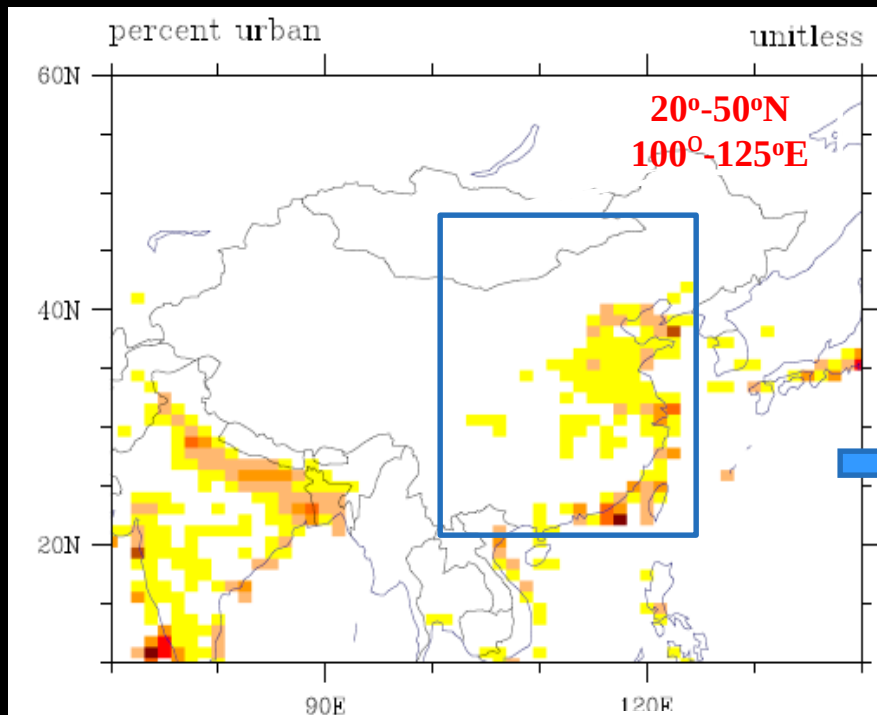
Urban areas influence the atmosphere through a number of processes:

1. Paved surfaces and concrete canyons absorb the Sun's rays and produce heat.
2. Chemicals emitted by cars, industrial facilities, and even trees affect sunshine in different ways, often trapping it and creating more heat.
3. The warm air rising from a city may collide with moist air from a nearby body of water, releasing precipitation downwind of the city.
4. The warm air and precipitation can affect winds for hundreds of miles.

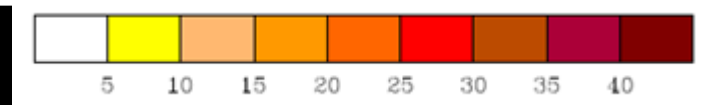
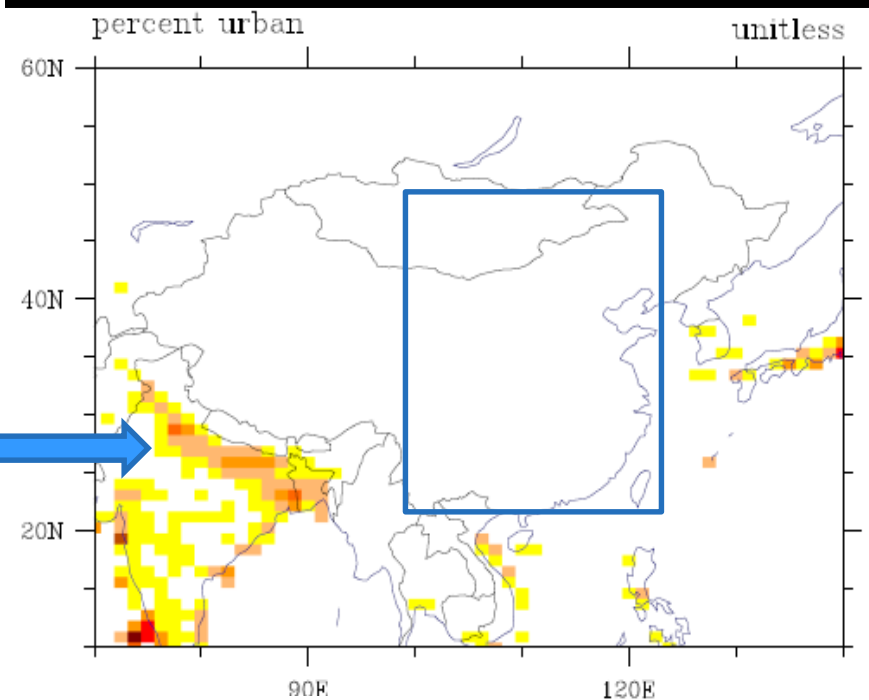


Experiment with urban land cover

Original (CTL)



Modified (NOURBAN)

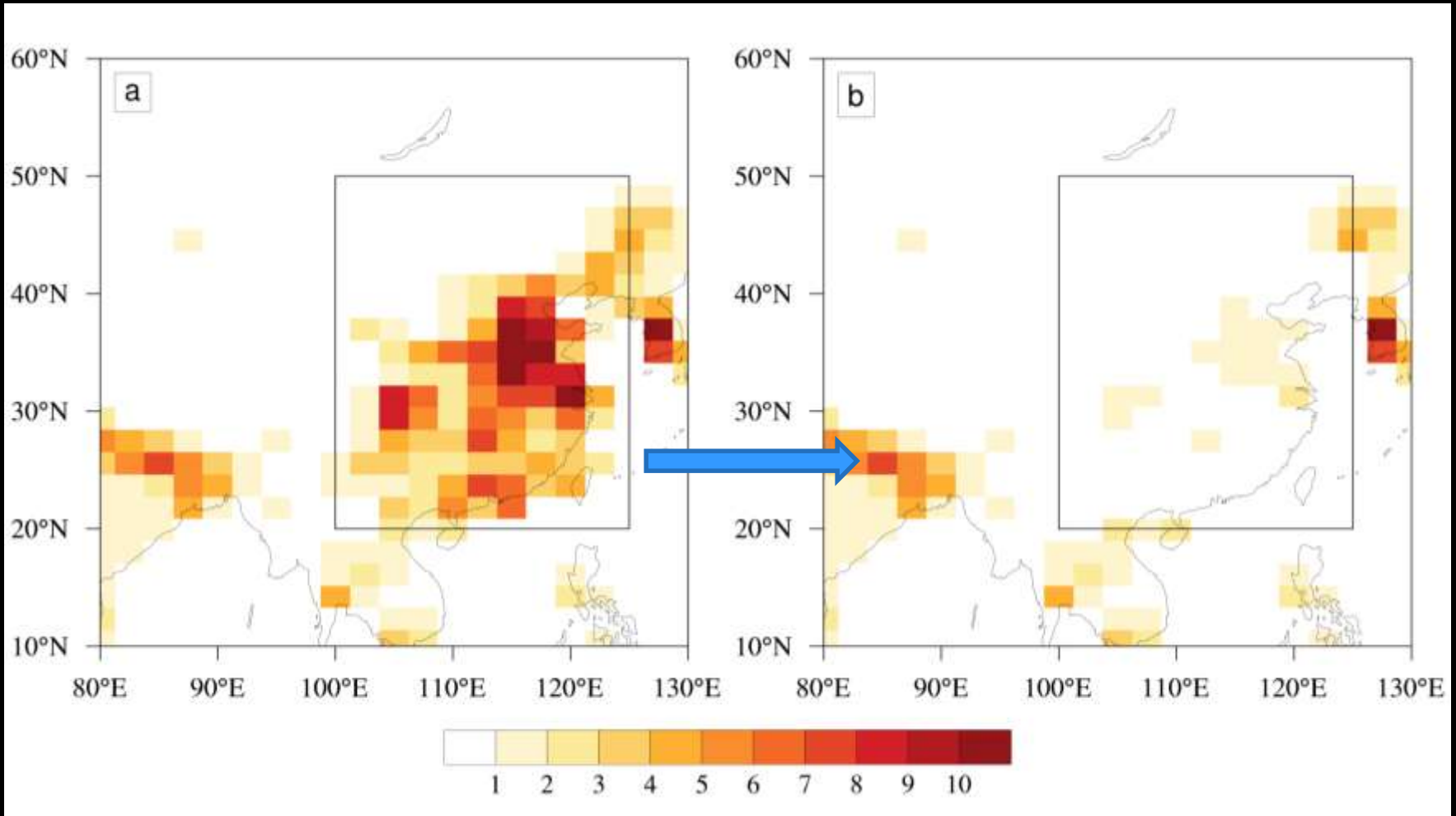


Percentage of urban fraction distribution

Experiment with anthropogenic emission: e.g. Black carbon emission (10^{10} molecules $\text{cm}^{-2} \text{s}^{-1}$)

Original (CTL)

Modified (NOAERO)



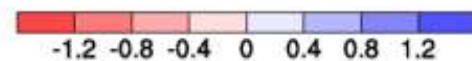
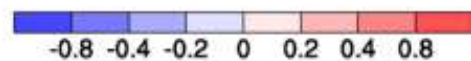
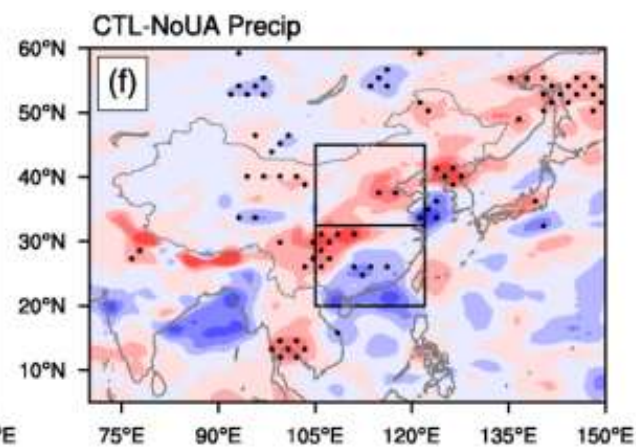
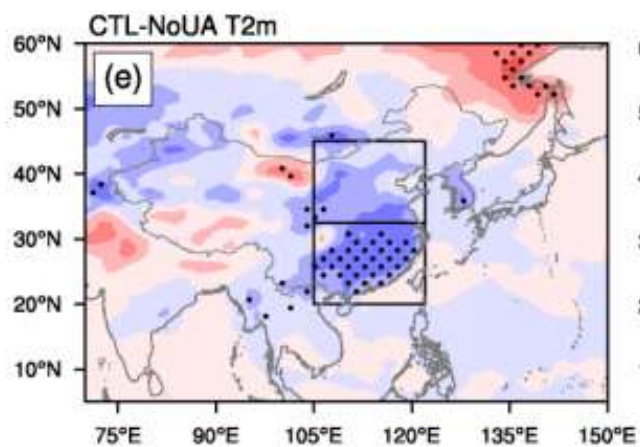
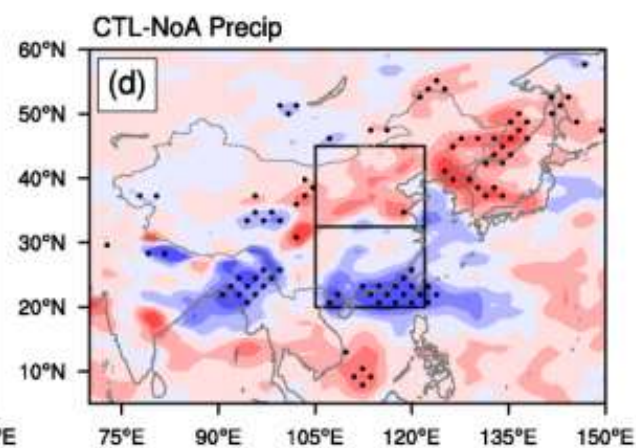
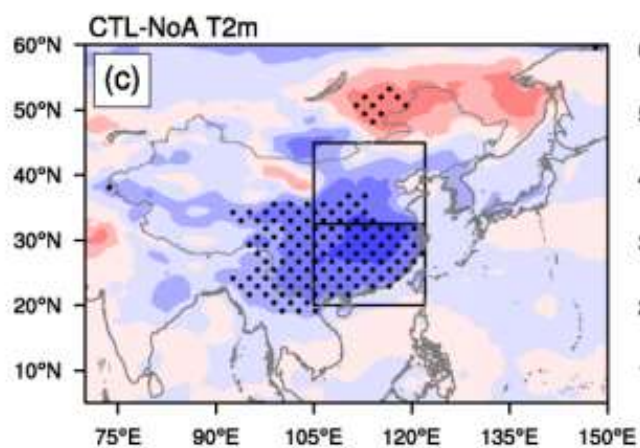
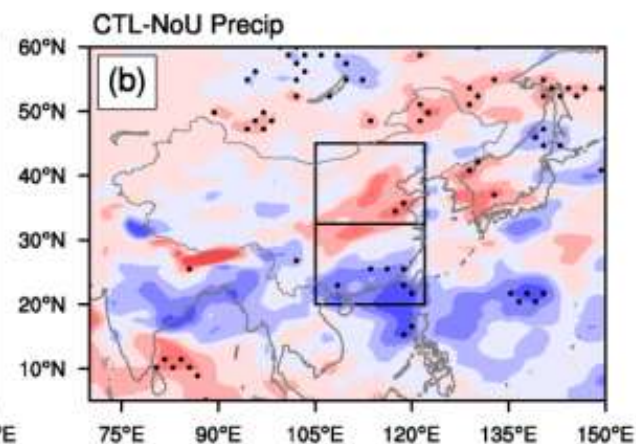
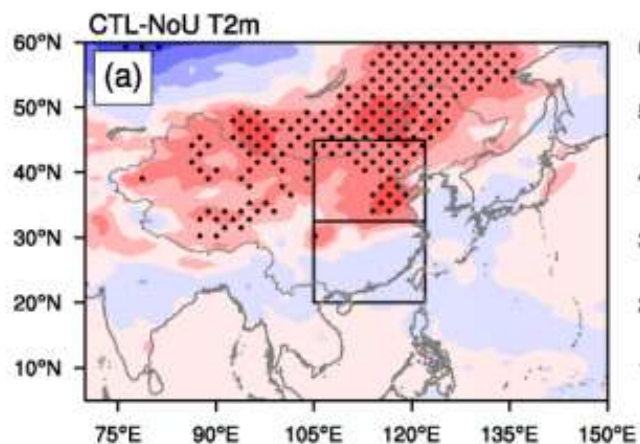
Model Result Evaluation

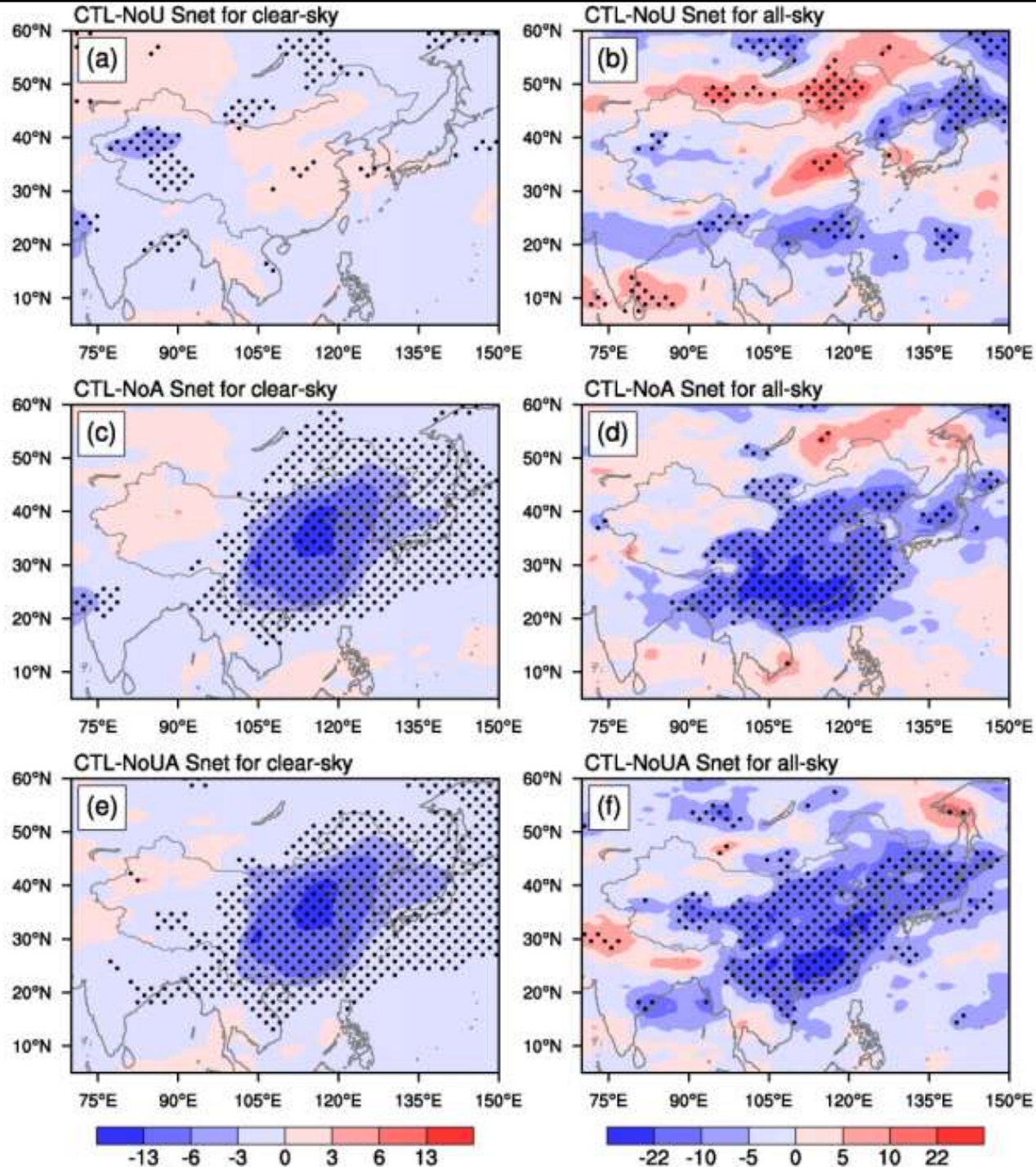
➤ Evaluation of Sensitivity Experiment

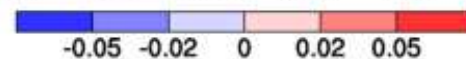
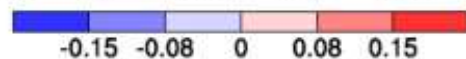
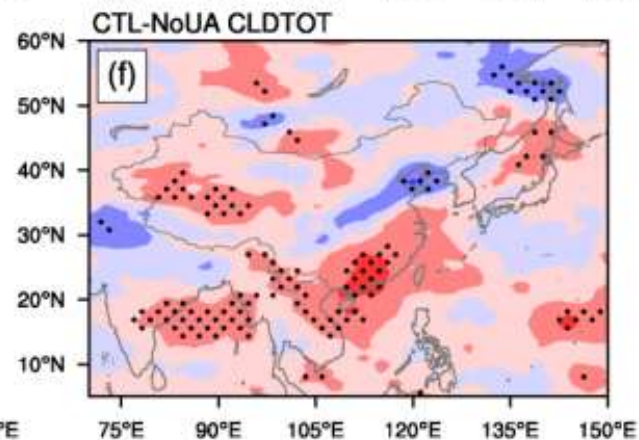
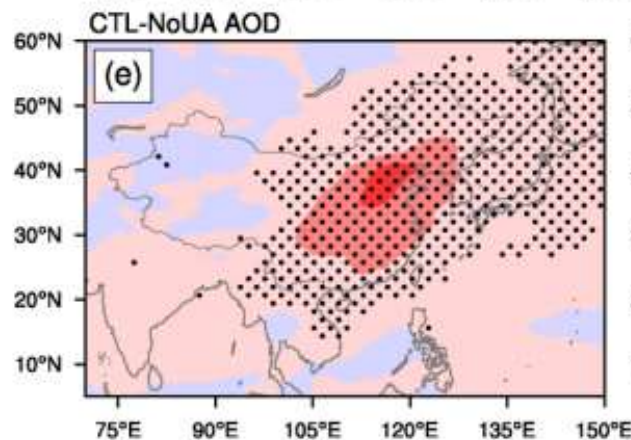
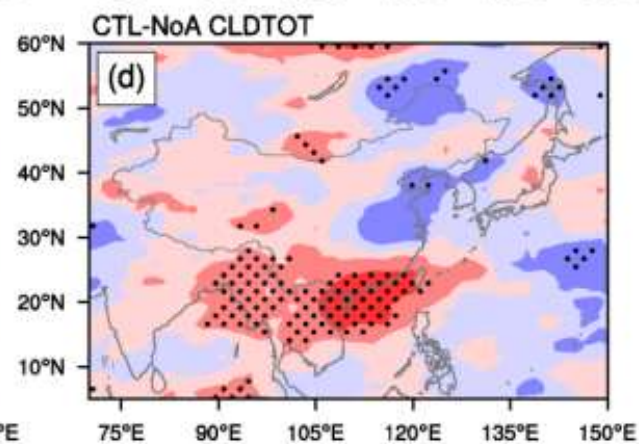
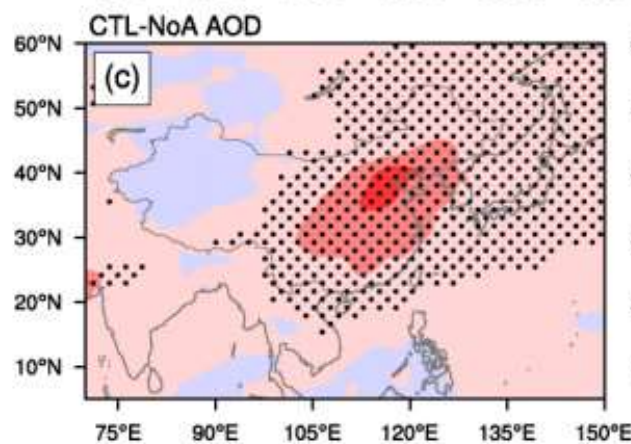
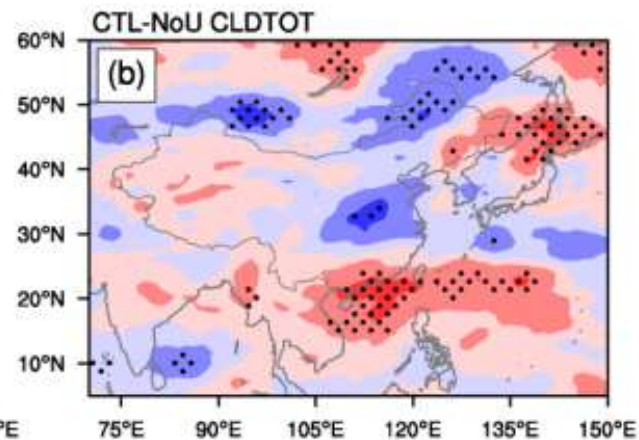
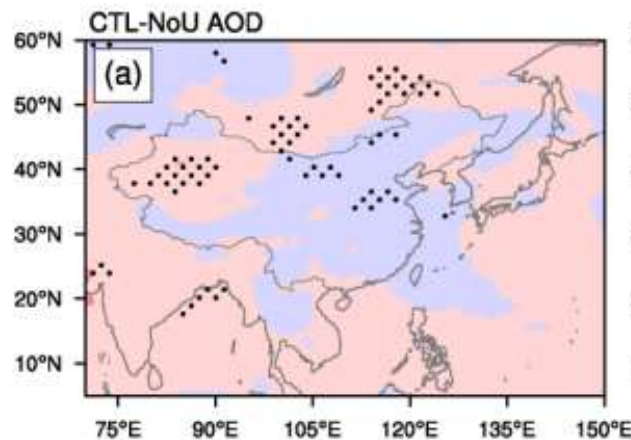
(1) CTL-NOURBAN: urban land cover effect

(2) CTL-NOAERO: aerosol emission effect

(3) CTL-NOUA: urban and aerosols effect

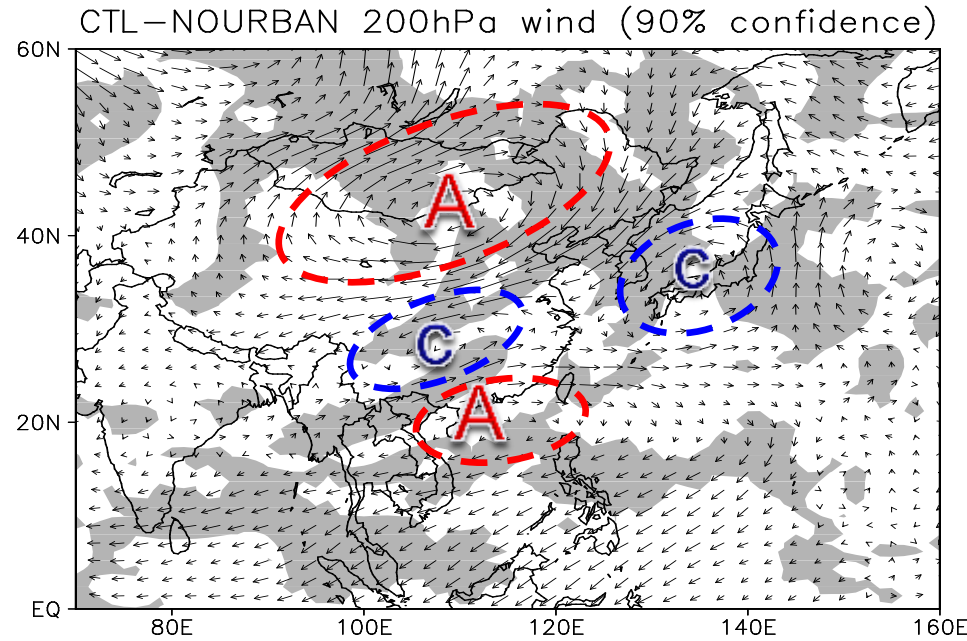




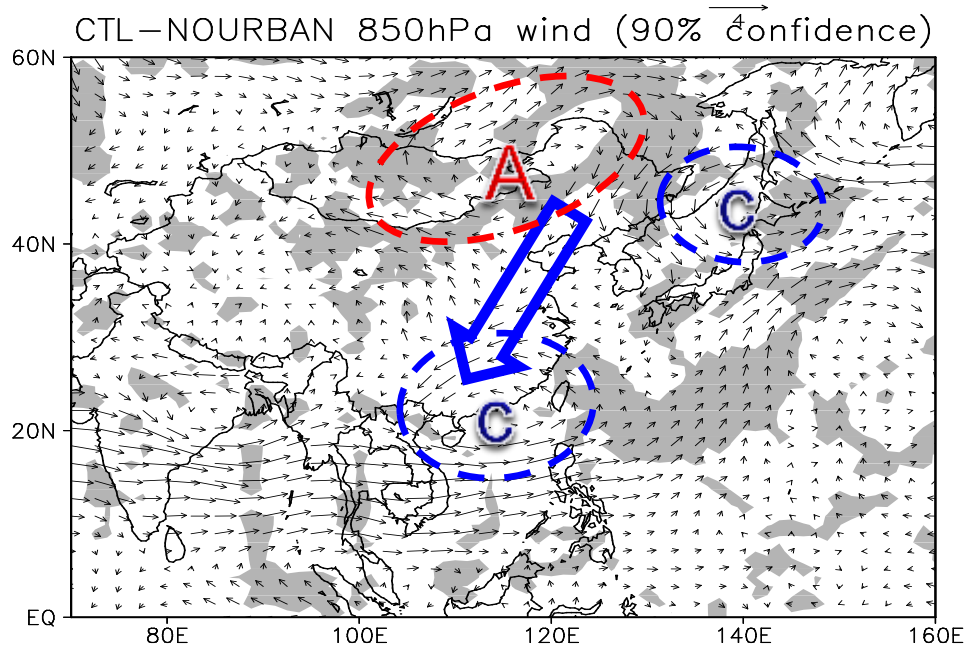


(1) CTL-NOURBAN: urban land cover effect

**Wind field diff.
200 mb**



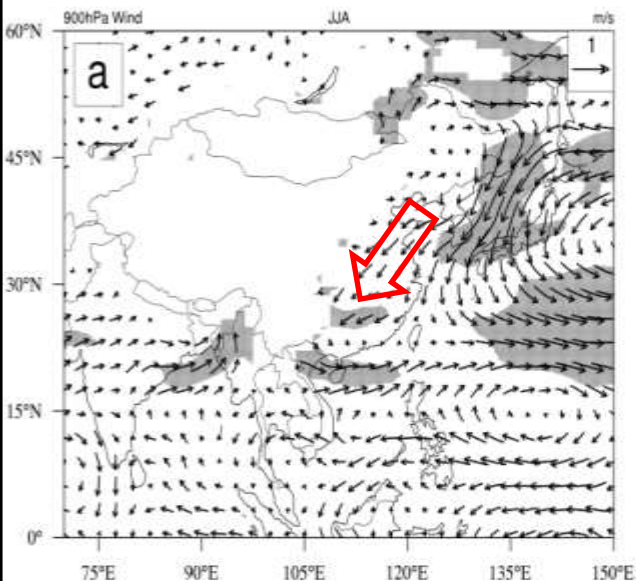
**Wind field diff.
850 mb**



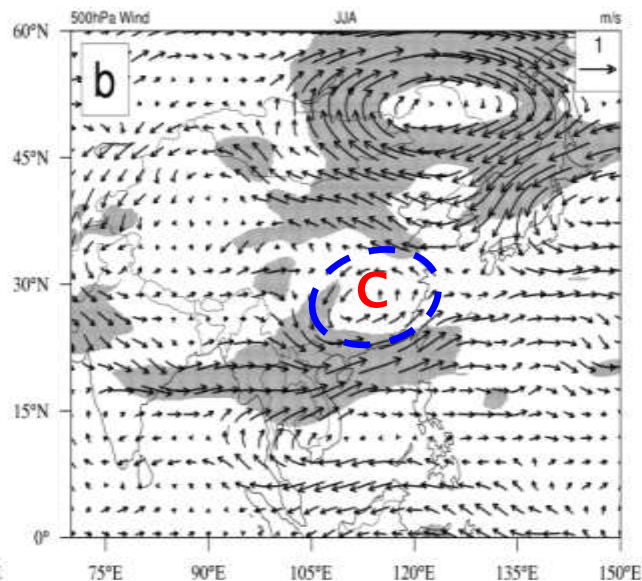
(2) CTL-NOAERO: aerosol emission effect

Wind Field Difference

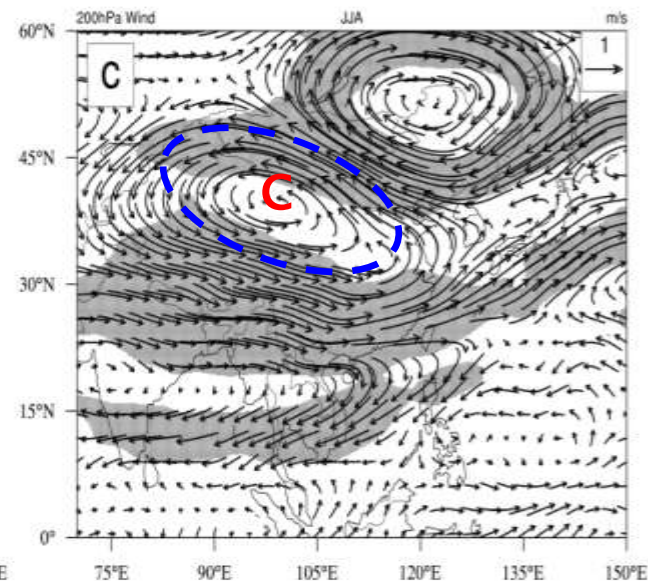
900hPa



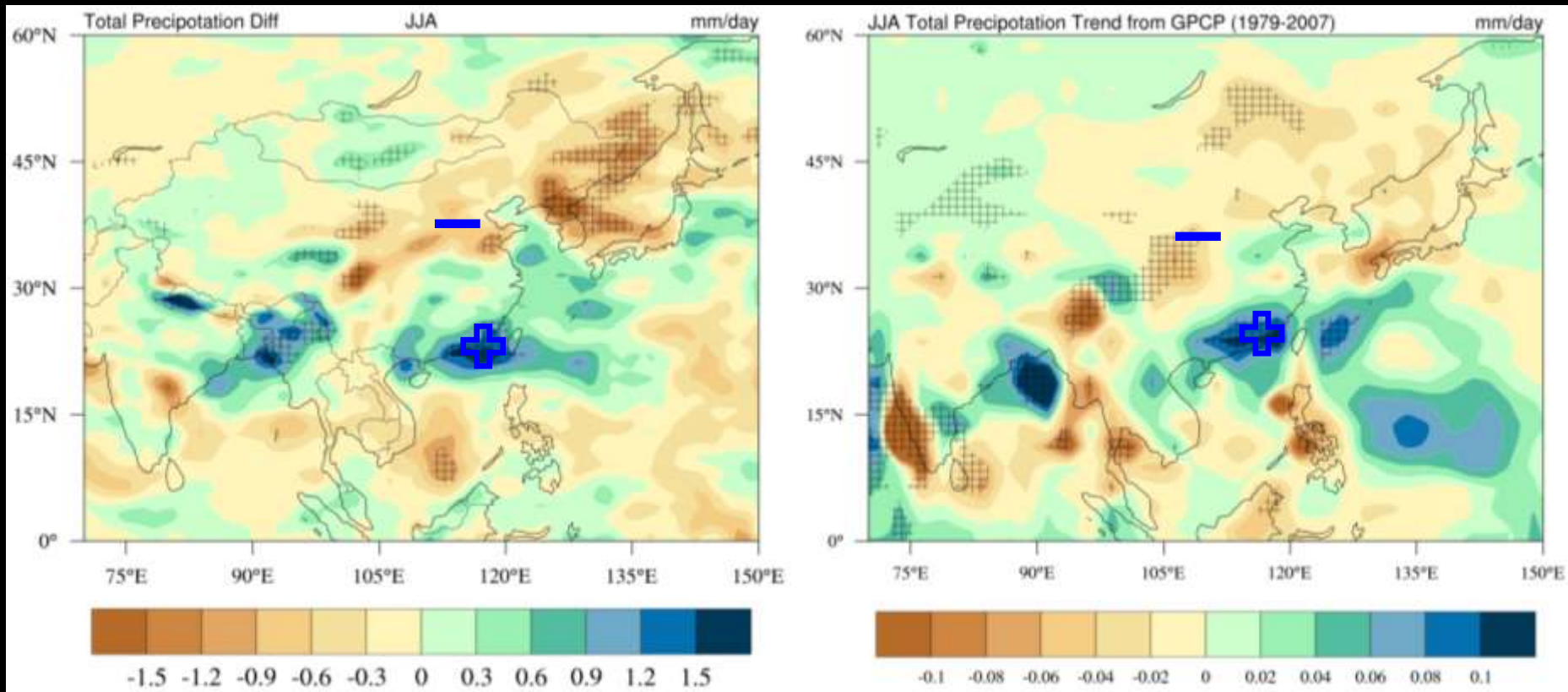
500hPa



200hPa

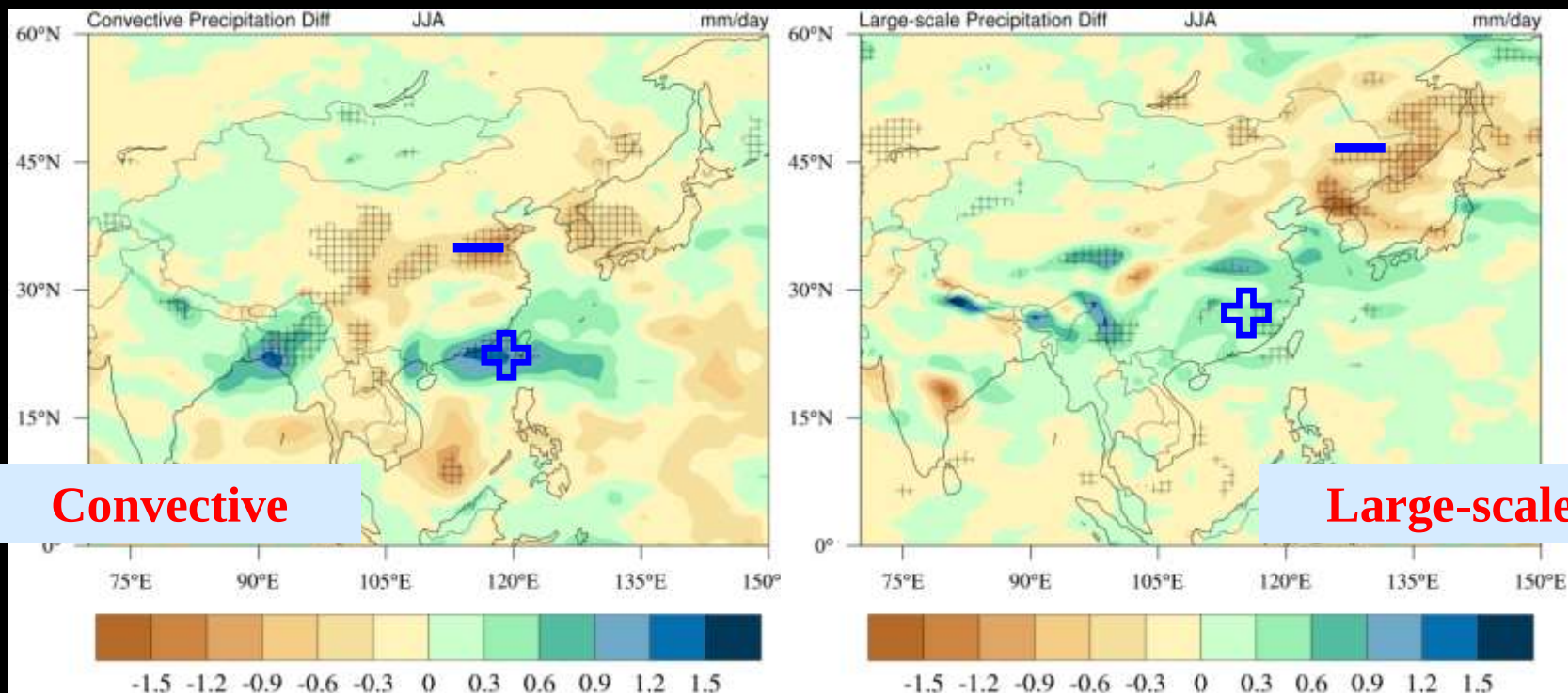


(2) CTL-NOAERO: aerosol emission effect



Diff. in Precipitation

GPCP Precipitation Trend



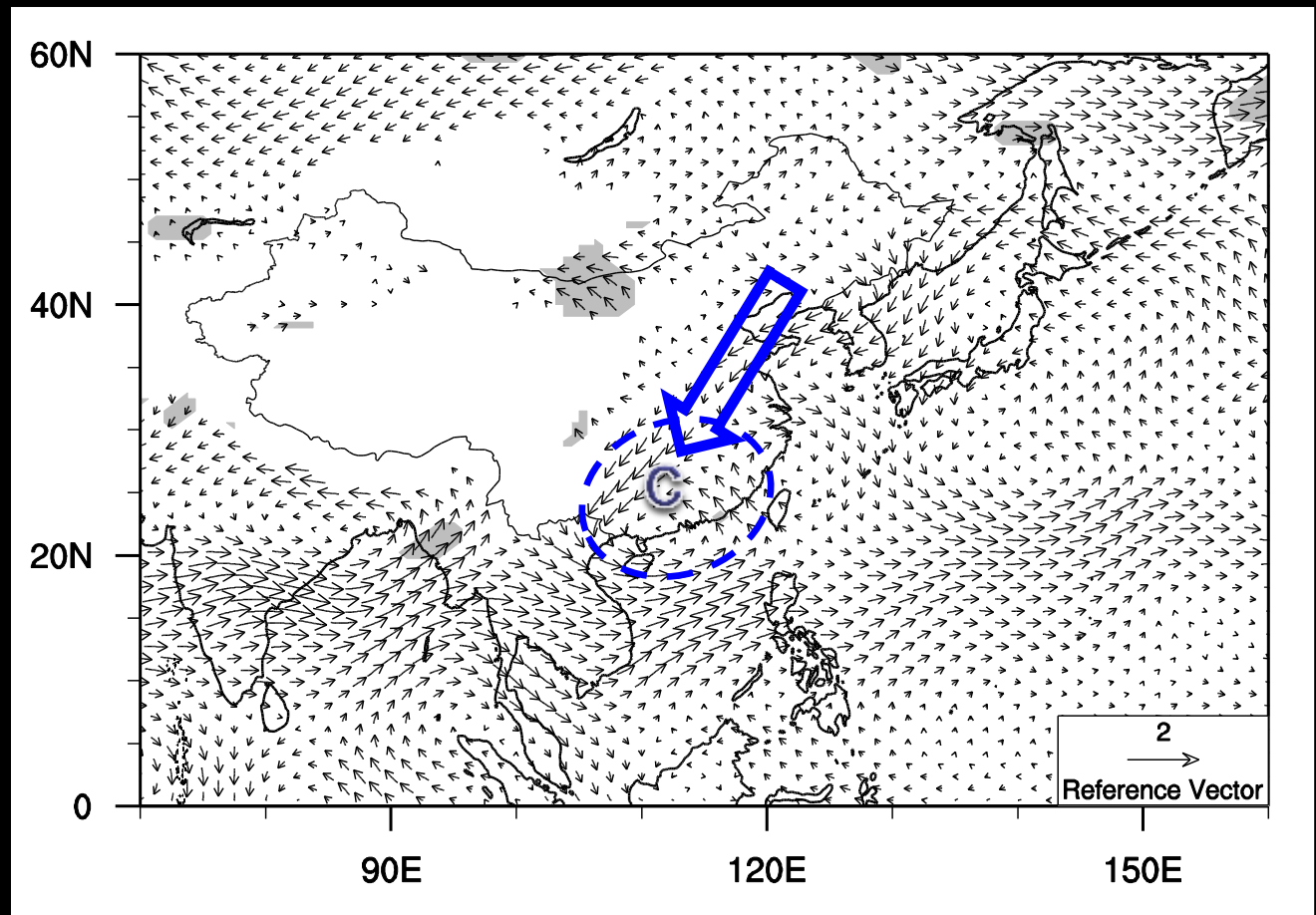
Diff. in regional mean precipitation (mm/day)

	Total Precip	Convective	Large-scale
North (32.5-45N, 110-120E)	-0.40	-0.30 ✓	-0.10
South (20-32.5N, 110-120E)	0.62	0.31 ✓	0.31 ✓
Eastern (20-45N, 110-120E)	0.09	-0.01	0.10 ✓

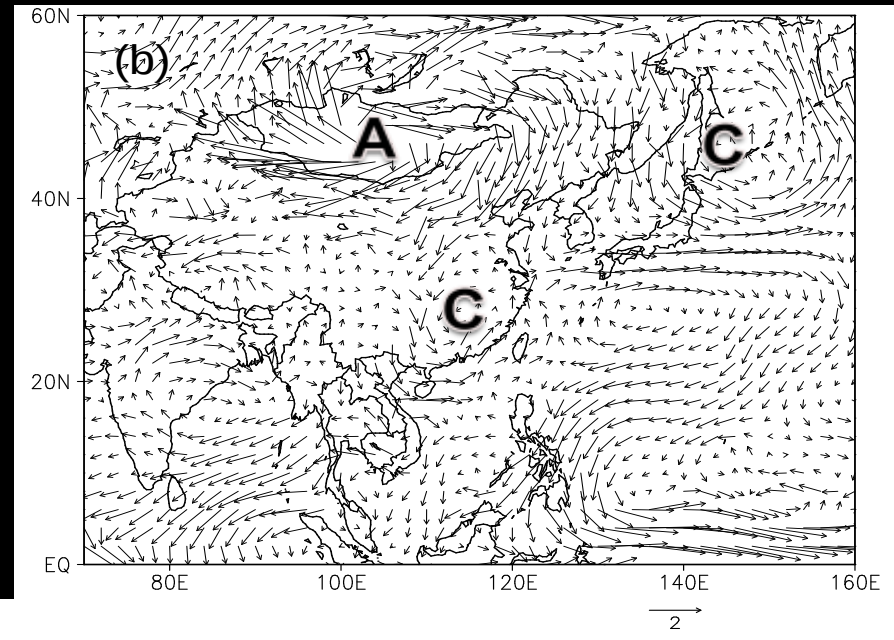
Wetter South, Drier North

(3) CTL-NOUA: Eastern China urban + aerosols effect

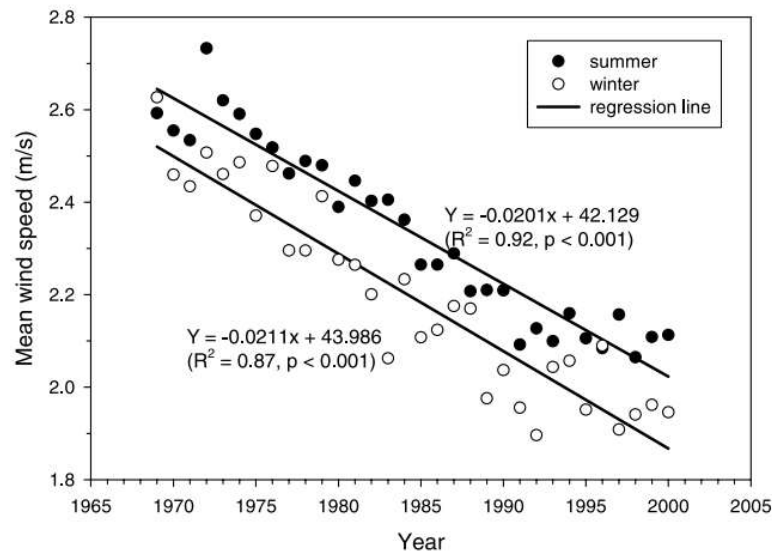
850hPa wind diff.
(CTL-NOUA)



Observed Wind Variation (1993-2007) – (1982-1992)

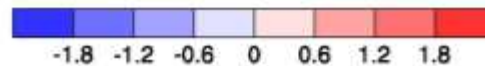
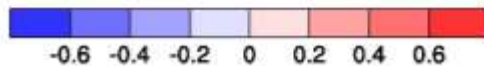
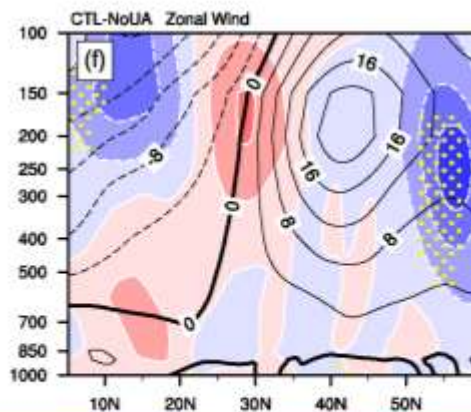
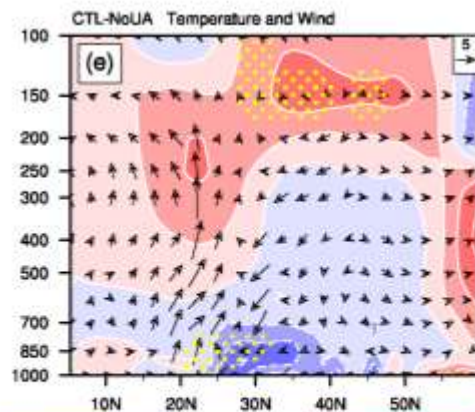
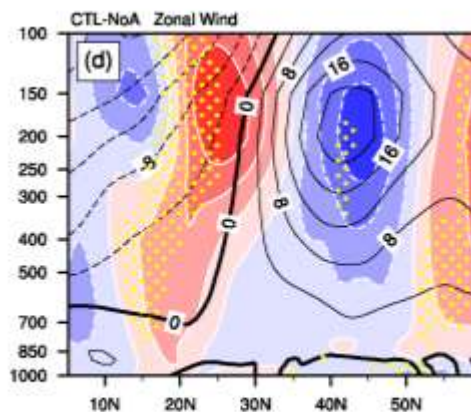
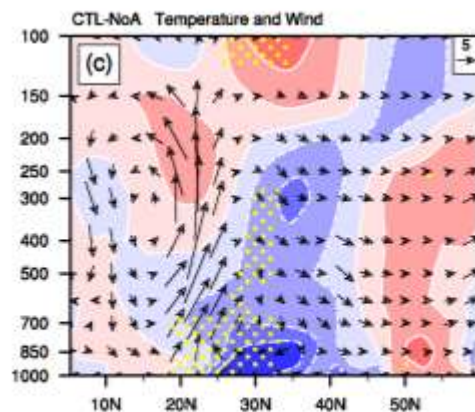
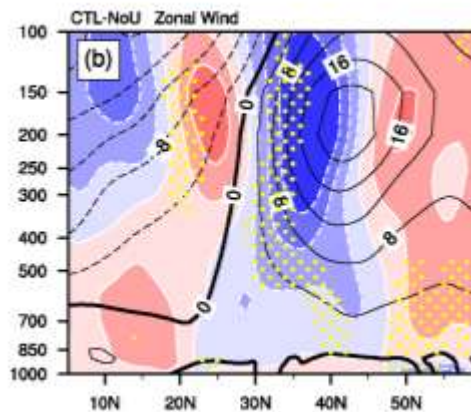
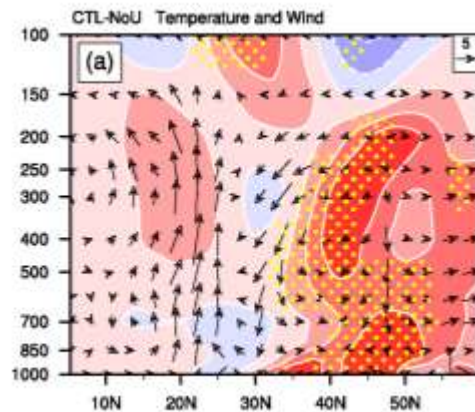


XU ET AL.: EAST ASIAN MONSOON WIND SPEED DECLINE



850hPa

Figure 6. Declining trend of approximately 0.2 m/s per decade, which is quite similar in winter (ND and summer (JJA).



5. Summary and Conclusion

- CAM5.1 could simulate well the EASM circulation, surface temperature and rainfall pattern;
- *Urban land use* change in eastern China led to changes in the EASM circulation, weaken the southerly monsoon wind; dynamic and thermal adjustment enhance each other, resulting in wetter south/drier north rainfall pattern;

- ***Anthropogenic aerosols*** (dominated by sulfate aerosols in the summer) caused cooling throughout the atmosphere in the EASM region, leading to the increase in sea level pressure over land, decrease in pressure gradient between ocean and land. The thermal effect caused weakening in the EASM circulation;
- ***The combined effect*** of changed urban land cover and aerosols to the EASM show that cooling occurred in the EASM region, abnormal northeast wind component weakened the monsoon wind, rainfall pattern was wetter south but drier north.