

Weekly cycle of aerosol- meteorology interaction over China: indication of human impact on weather/climate

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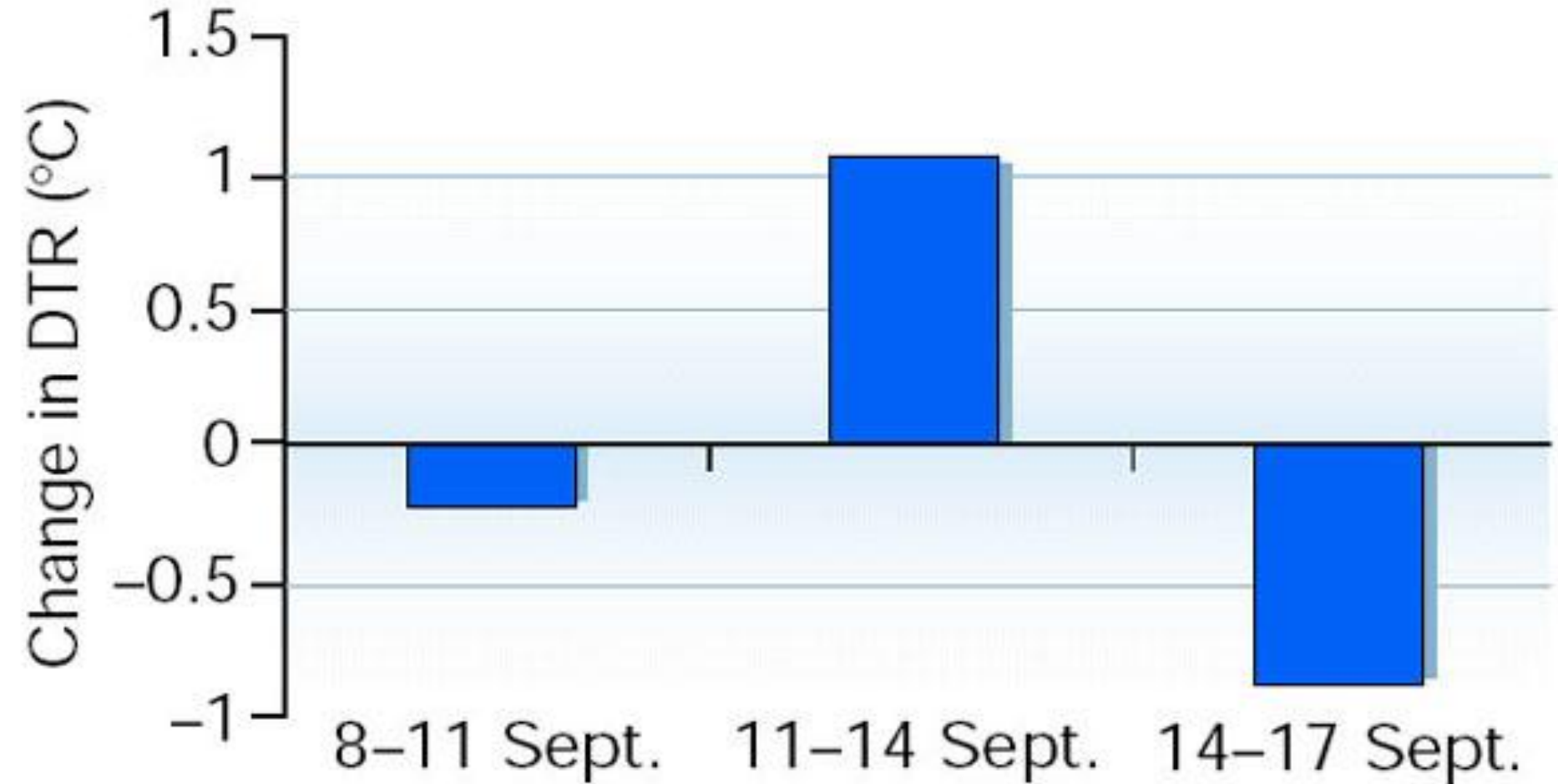
What happened after that?



All the contrails disappeared!



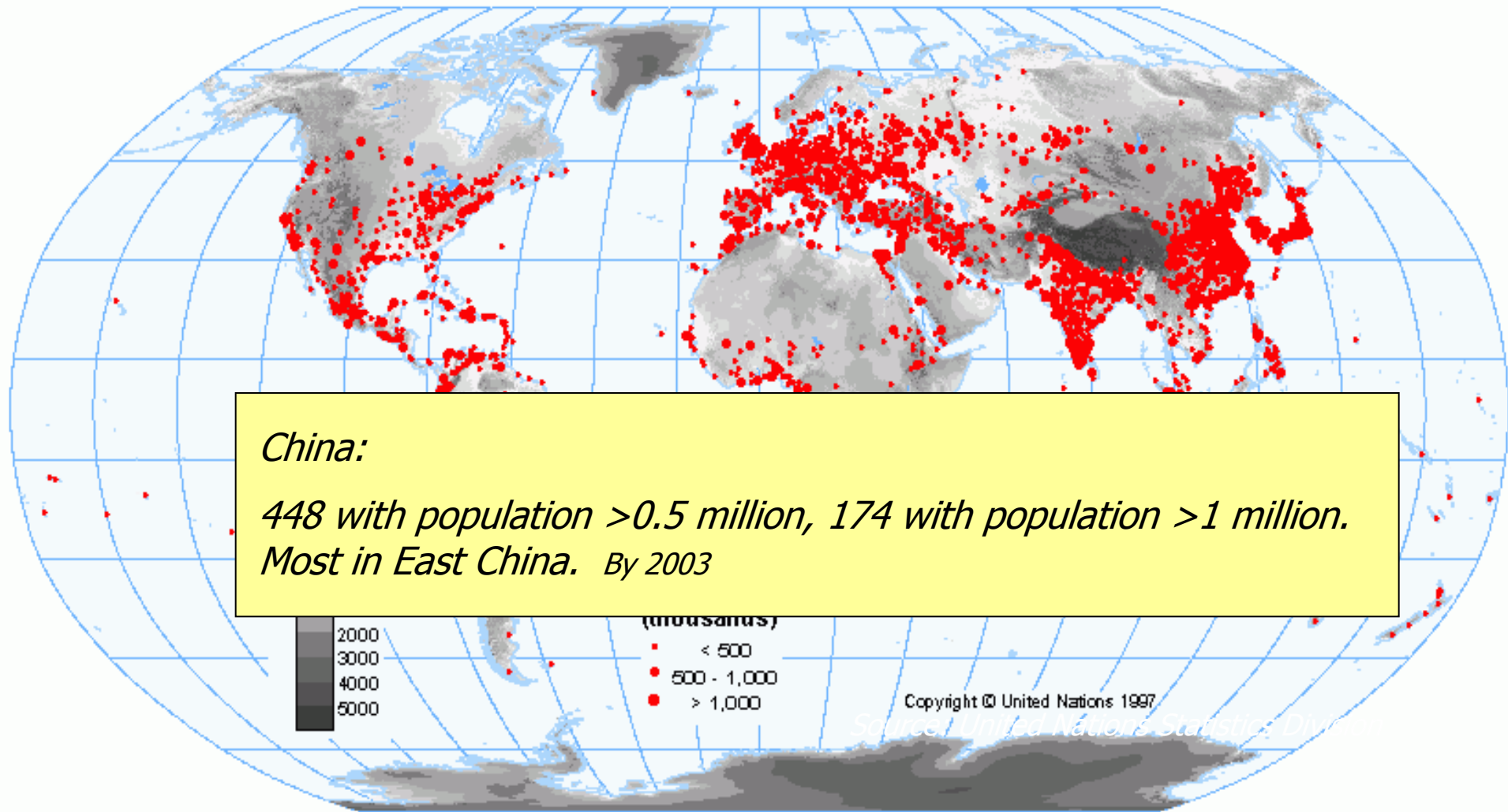
DTR: daily temperature range (the maximum-the minimum)



Travis et al. (2002)'s Nature paper concluded that

- because persisting contrails can reduce the transfer of both incoming solar and outgoing infrared radiation, there was an anomalous increase in the mean DTR for the period 11–14 September 2001, which makes them to conclude that at least a portion of this anomaly can be attributed to the absence of contrails over this period.

Globe: Cities with more than 100,000 people in 1997



Urban air quality is strongly influenced by human activity



Emission from traffic is a factor..



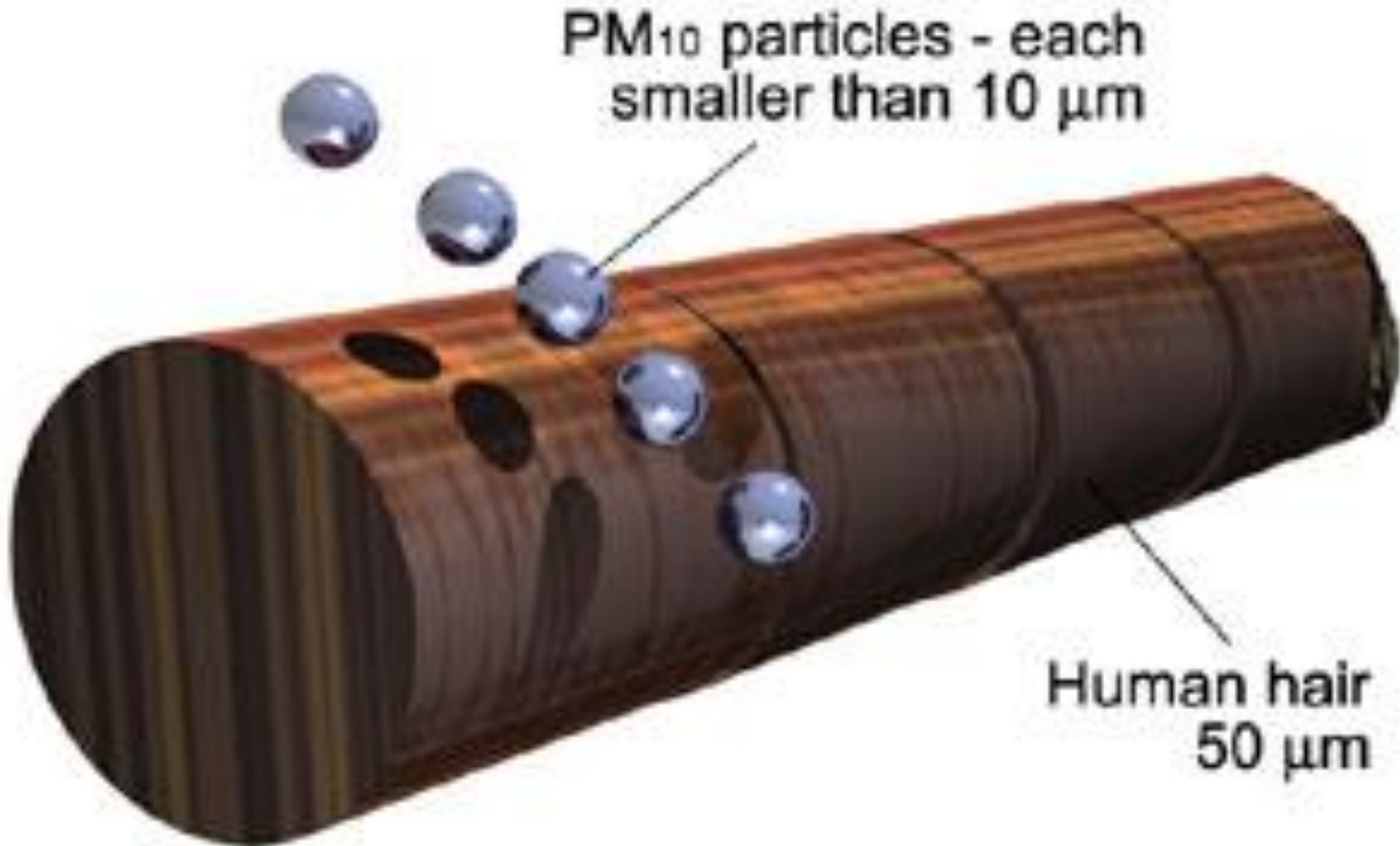
Particulates and air pollution

- **Particulates**, alternatively referred to as **particulate matter (PM)**, **aerosols** or **fine particles**, are tiny particles of solid (a smoke) or liquid (an aerosol) suspended in a gas.



Aerosol pollution over Northern India and

PM10 are particles which result mainly from combustion processes (< 10 microns in diameter).



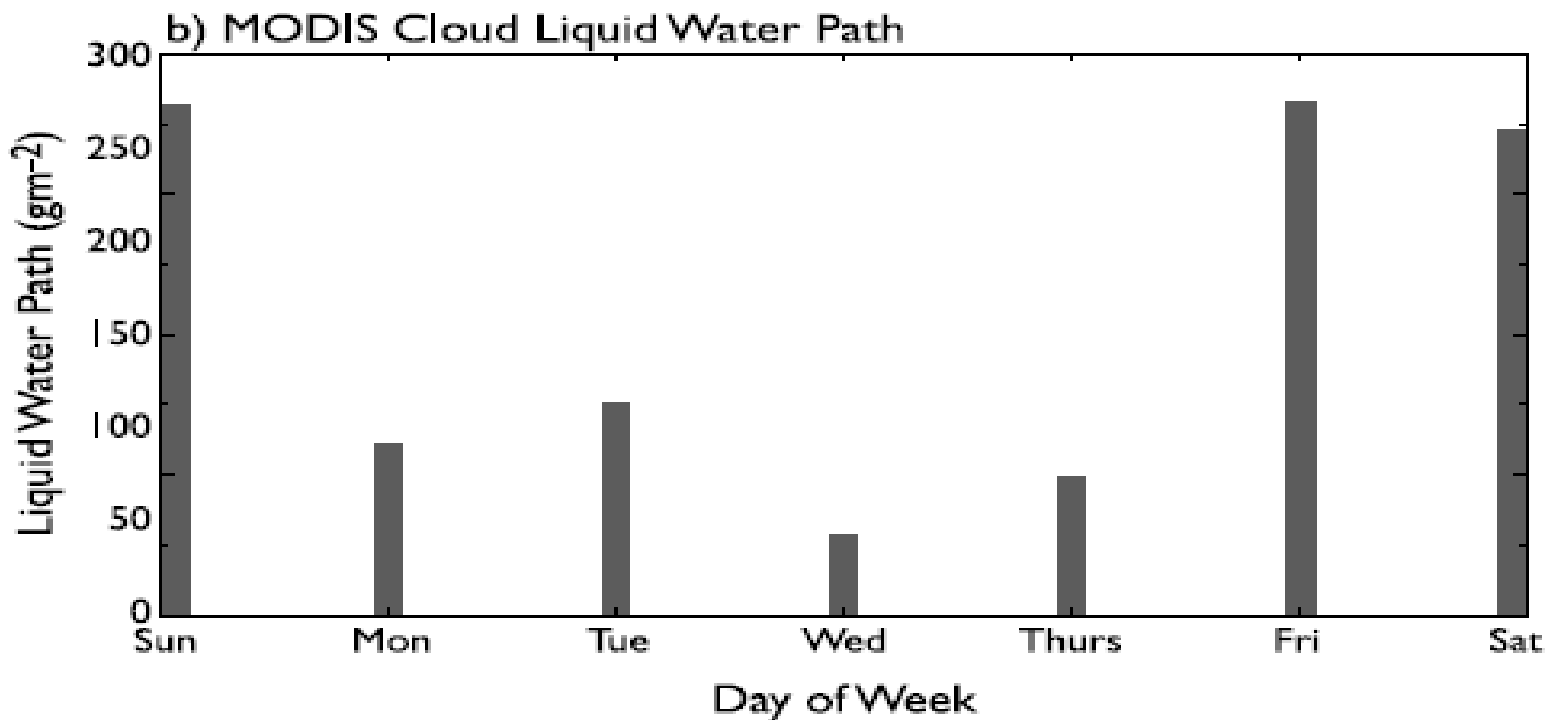
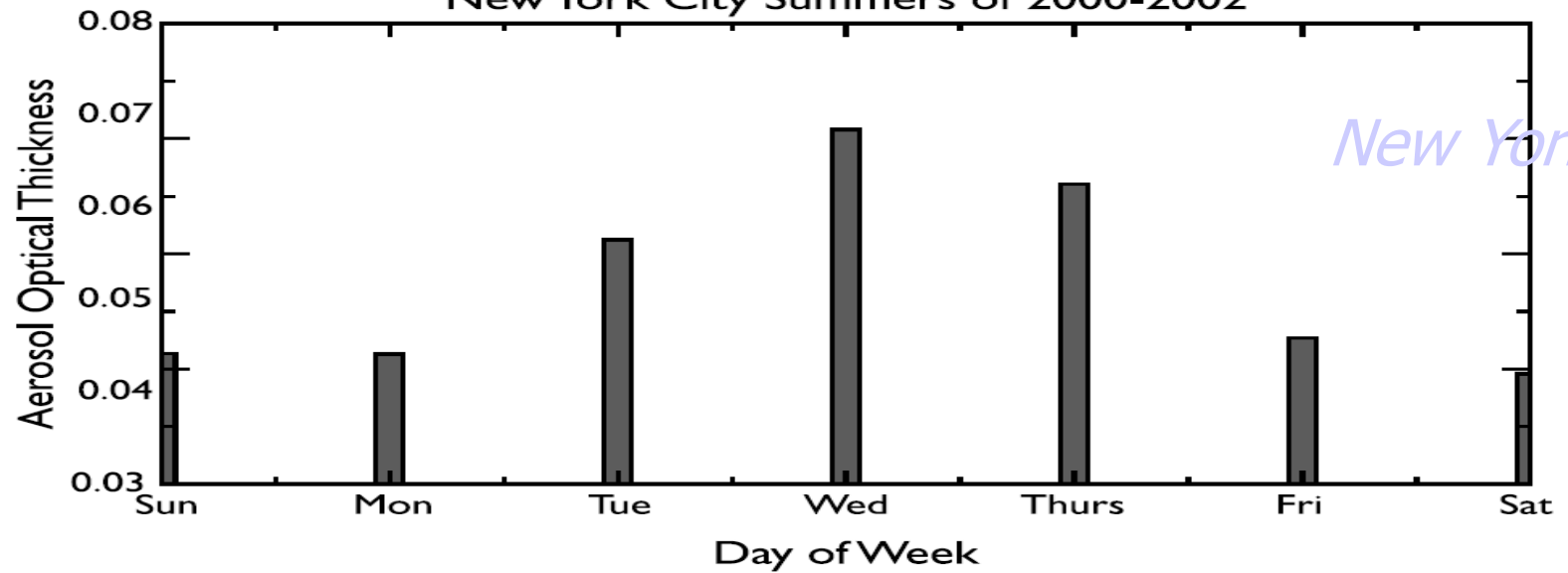
Why study aerosols?

- Reduce/Increase GHG's warming,
- **Affect cloud and rain,**
- Interfere with Remote Sensing of EAS,
- Active in Atmospheric Chemistry,
- Supply Minerals to Ocean Biosphere,
- Affect Well- Being of Organisms on both Land and Sea:
 - Contain Spores, Microbes and Viruses, Acids and other stuff.

Human activities have a distinctive weekly cycle!

- There is a clear difference between weekdays and weekends,
- But, are all the weekdays have similar air quality and statistics of weather conditions?
- If not, how does the weekly cycle look like? What causes the shape of the weekly cycle?

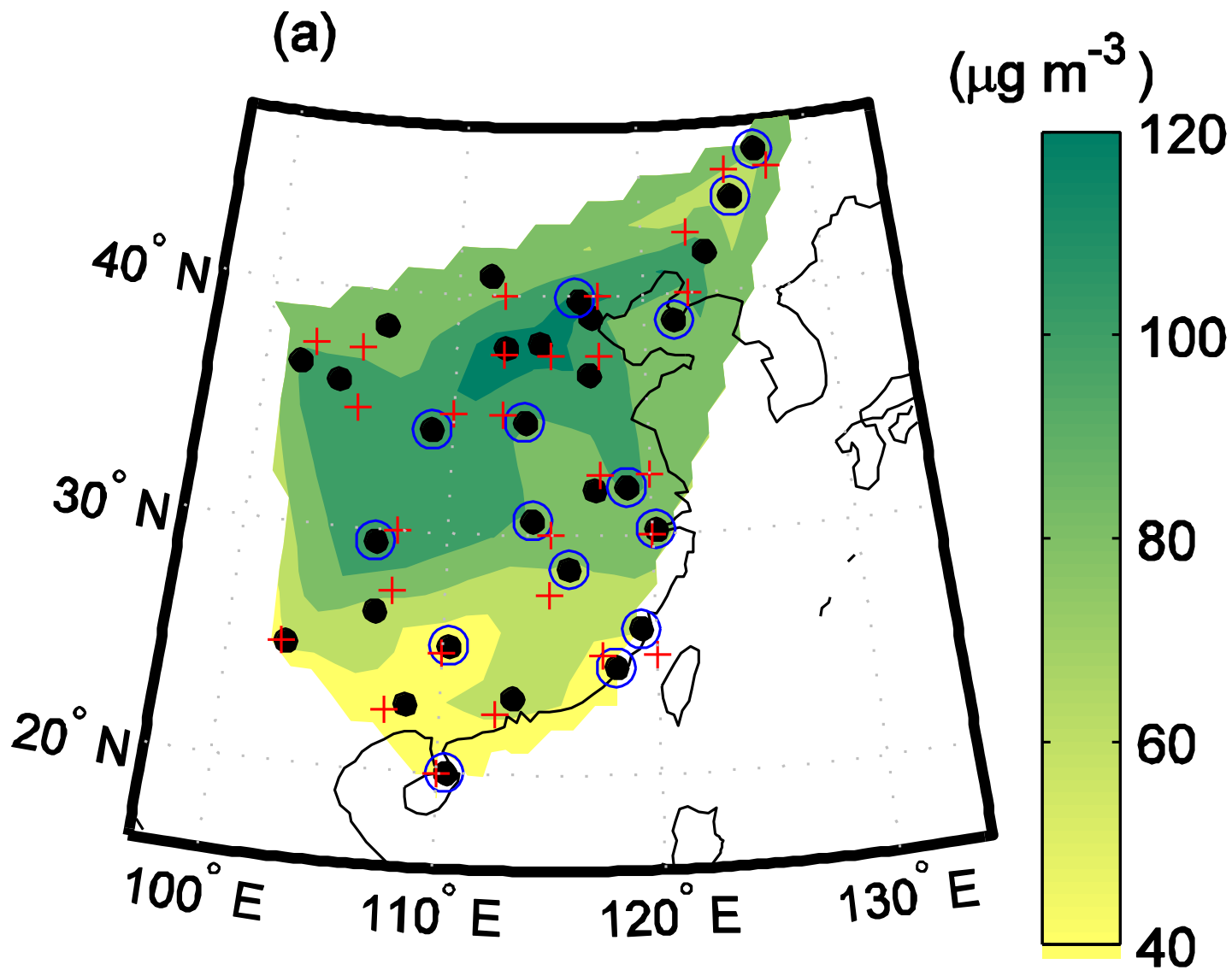
New York City Summers of 2000-2002



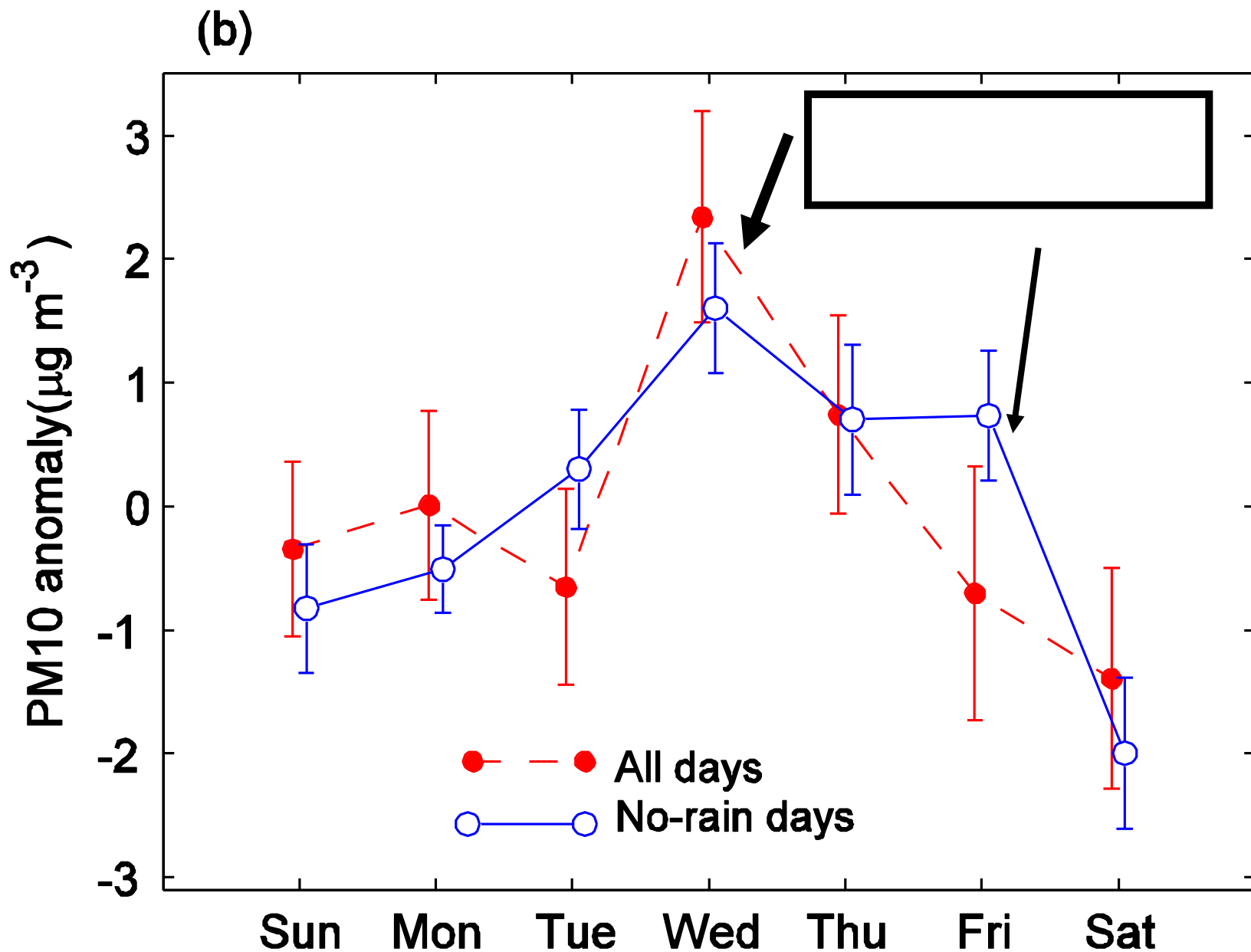
Objectives

- To identify weekly cycles of the PM10 in 29 Chinese cities (middle to mega cities) during summer
- To relate the PM10 weekly cycle to changes in meteorological variables over the cities
- To test the hypothesis that human activity through via PM10 has an impact on local weather/climate at the weekly time scale.

Data used for the analysis: Time: JJA, 2001-2006.
'•' : PM10 stations, '+' : R2 (NCEP reanalysis, 4 time daily) grids, 'O' : radio-sounding stations (2 times daily)



PM10 concentrations from Sunday through Saturday. JJA, 2001-2006.
Error bars are ± 1 standard error about the 29-sample mean.



Climate effects of Aerosol

Direct: back scattering and absorbing, reducing net incoming solar radiation. **Net cooling** (Tegen et al., 1996, Nature, 380, 419-422)

Semi-direct: absorbing radiation, heating, resulting in either local reduction of cloud cover or can inhibit new cloud-formation (Hansen et al., 1997, J.G.R., 102, 6831-6864) **Net warming ?**

Indirect: related to changes of the cloud droplet spectrum [more aerosols act as CCN, resulting in more and smaller cloud droplet] **Either net cooling or net warming.**

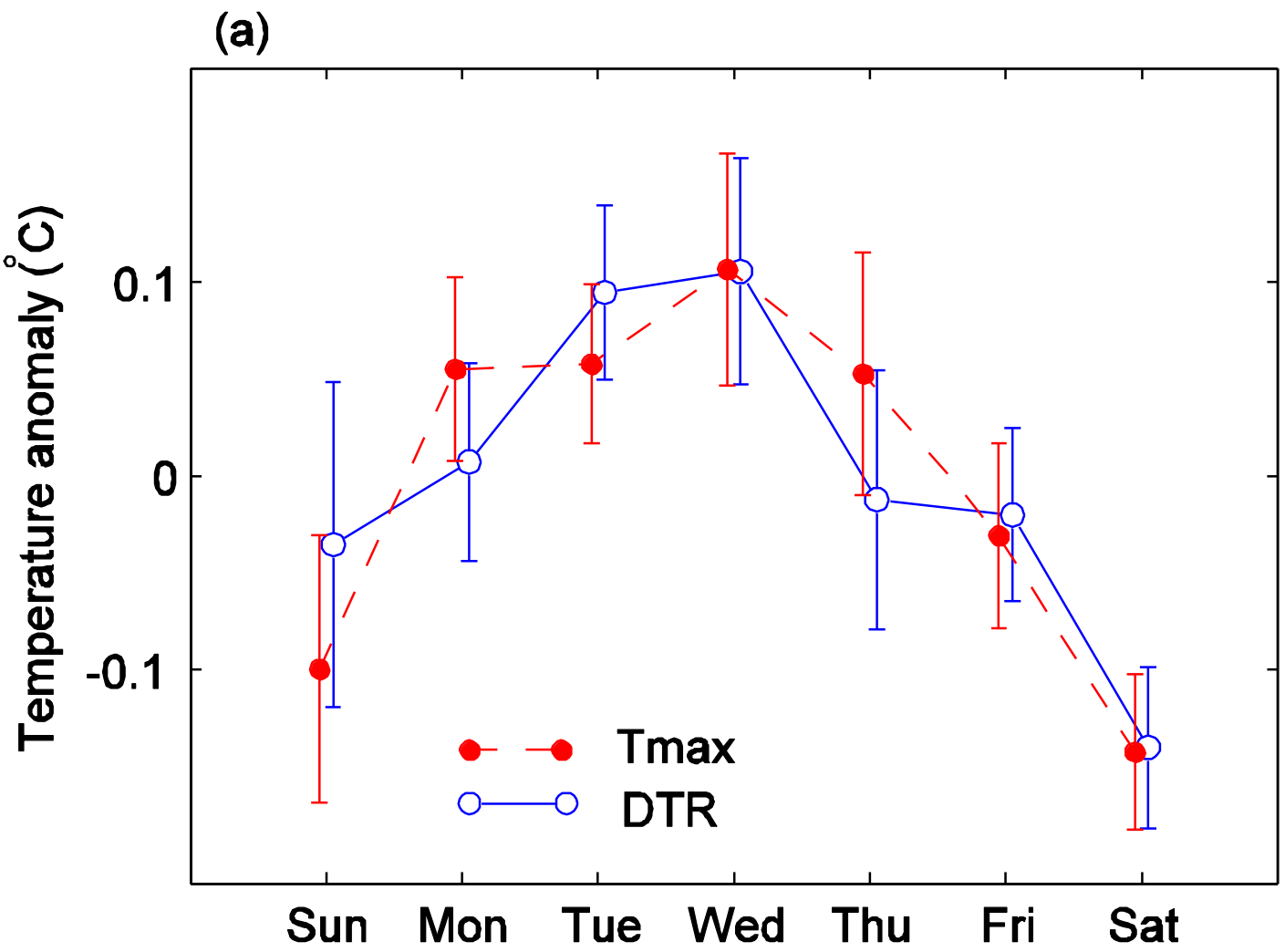
First indirect: cloud albedo (Twomey, 1977, J.A.S., 34, 1149-1152)

Second indirect: cloud lifetime, and precipitation-formation (Albrecht, 1989, Science, 245, 1227-1230; Rosenfeld, 2000, Science, 1793-1796)

In addition, chemical process ?

Local mechanisms through which PM10 influences light rain occurrence:

- Heating the atmosphere (circulation!), reduce relative humidity/rain occurrence
- Changing atmosphere stability
- Influencing cloud formation by increasing the number of small CCN, reducing Collision-Coalescence and rain occurrence



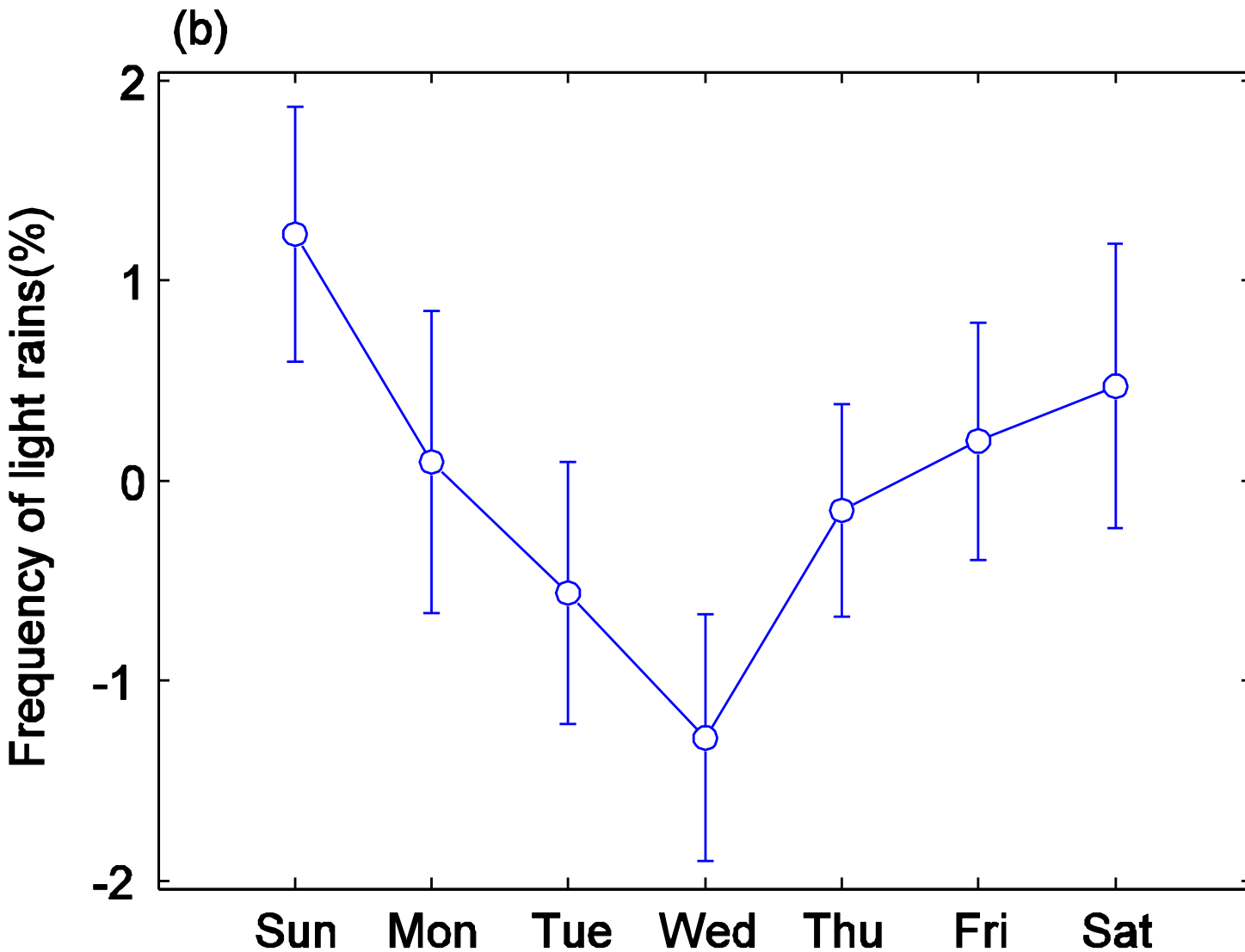
Heating effect

Mainly day effect

Anomalies of temperature from Sunday through Saturday at 29 stations, JJA, 2001-2006.

Error bars are ± 1 standard error about the 29-sample mean.



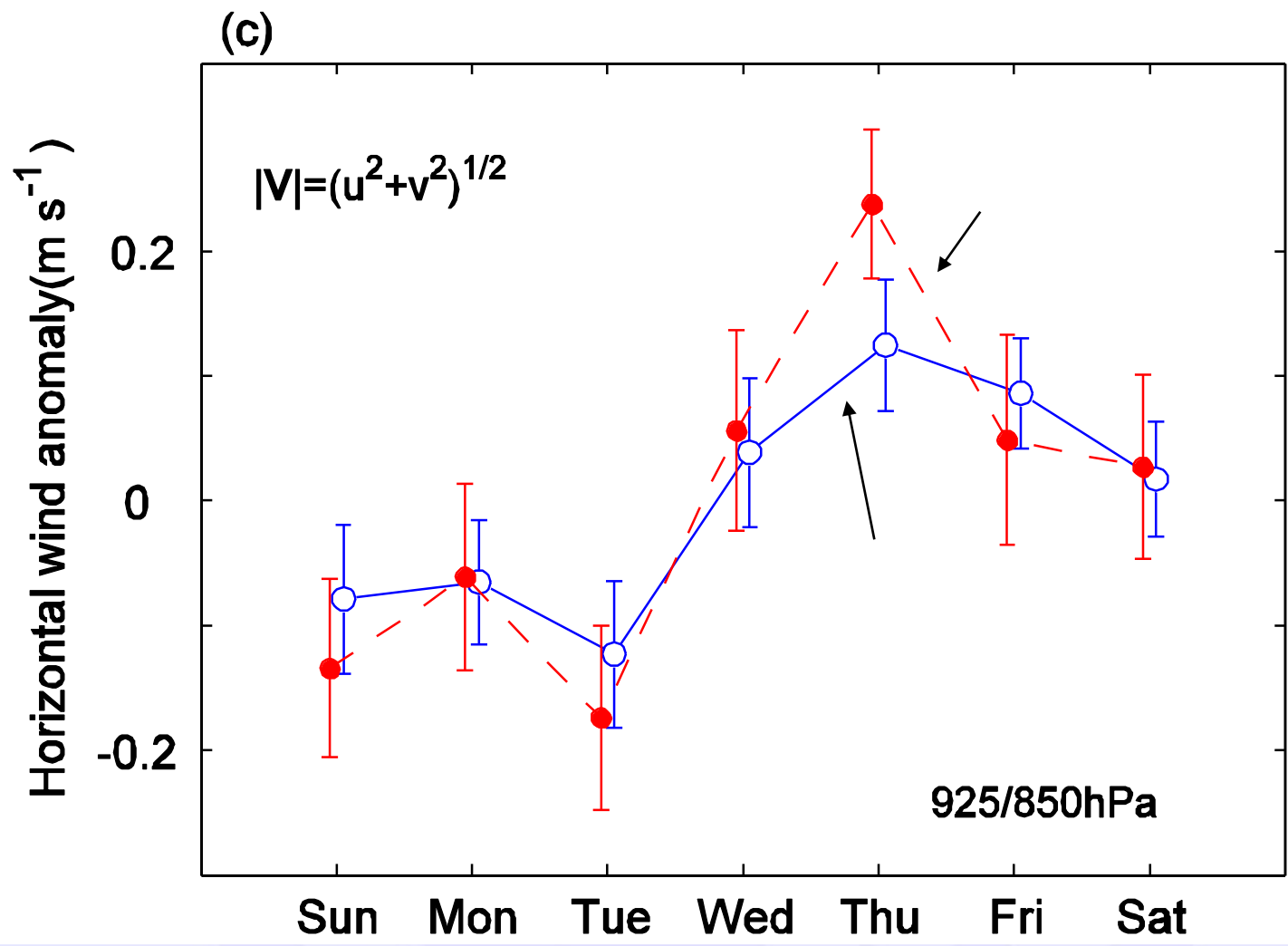


**Reducing
clouds?!!**

Anomalous frequency of light rains from Sunday through Saturday.

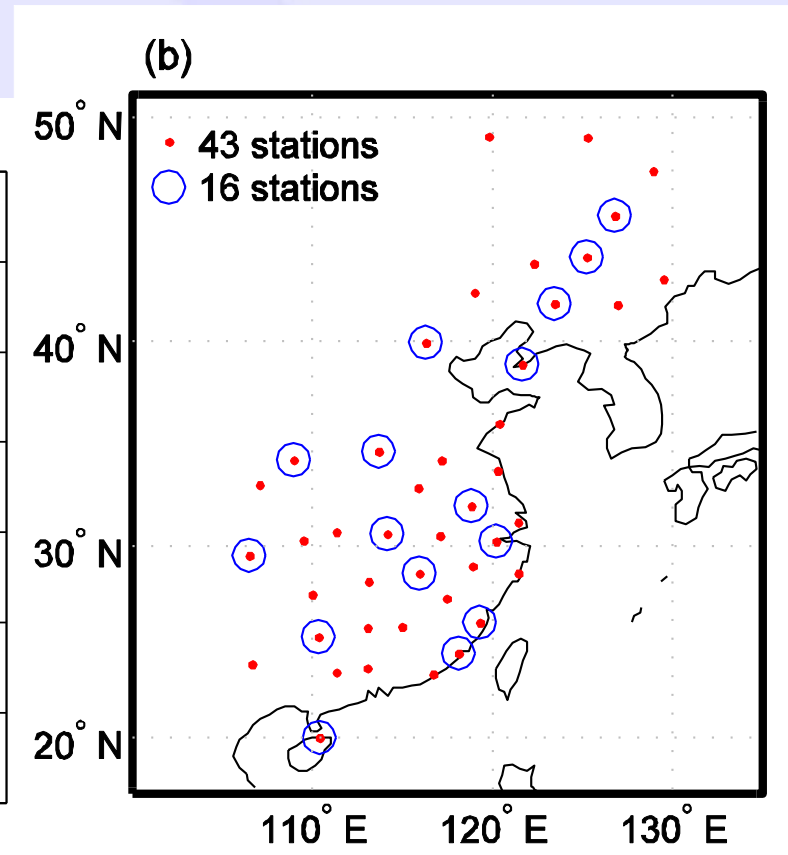
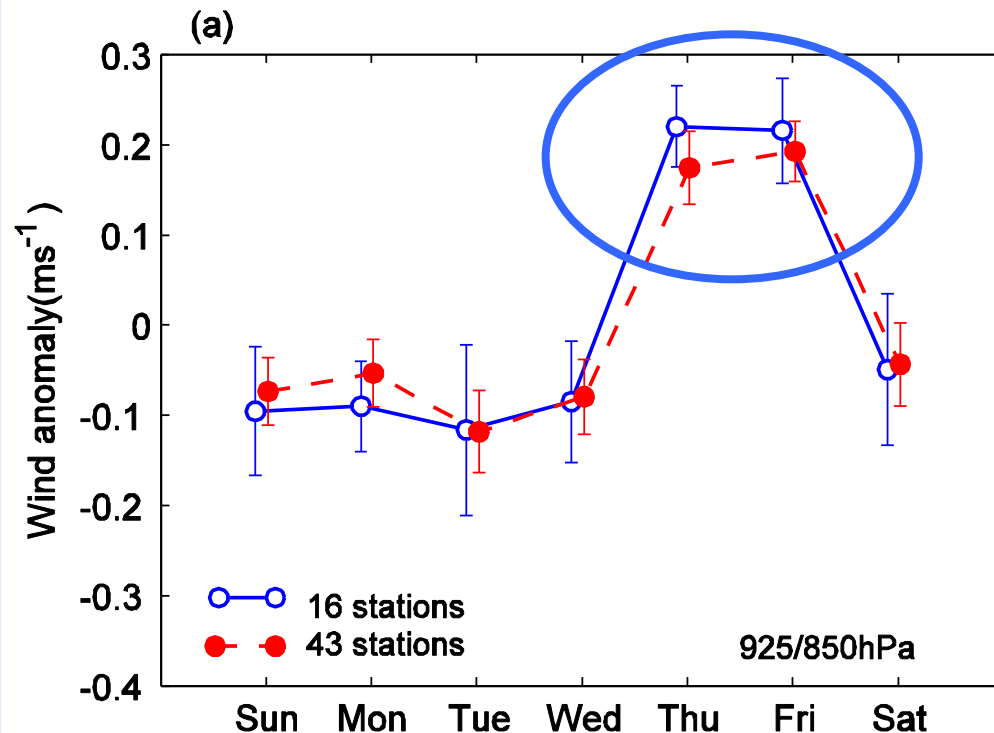
$P \leq 5\text{mm/day}$, 29 stations, JJA, 2001-2006

Error bars are ± 1 standard error about the 29-sample mean.



Anomaly of the horizontal wind velocity in lower troposphere between 925 and 850hPa levels, shown as the average from 29 R2 grids. Error bars are ± 1 standard error about the 29-sample mean.

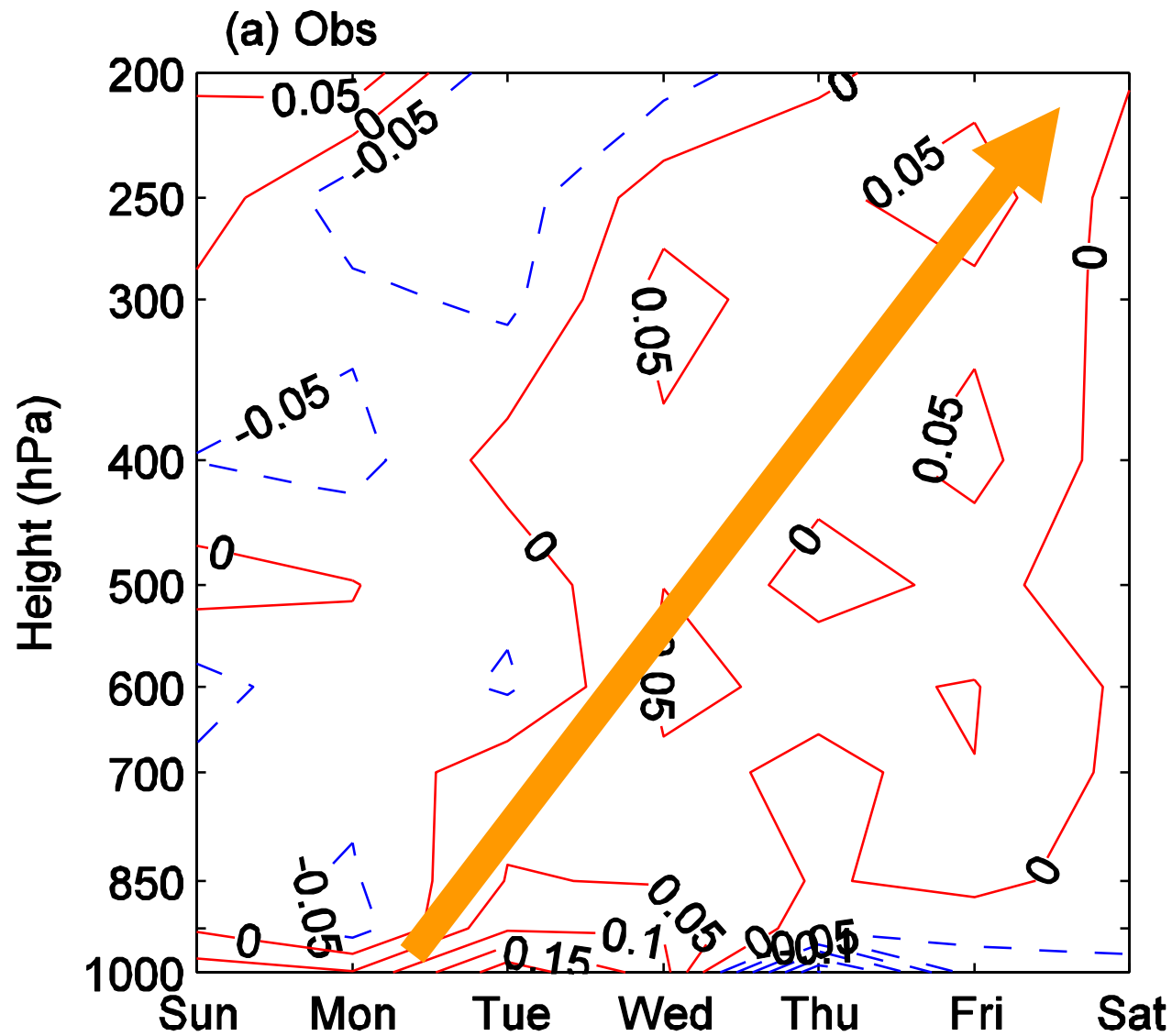
Can we confirm this by radiosoundings?



Anomaly of the horizontal wind velocity in lower troposphere between 925 and 850hPa levels, shown as the average from radiosonde observations. Error bars are ± 1 standard error about the sample mean. 1100UTC, data availability >90%.

Data sources: Durre et al., 2006. *J. Climate*, 19, 53-68

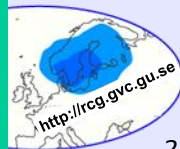
Department of Earth Sciences

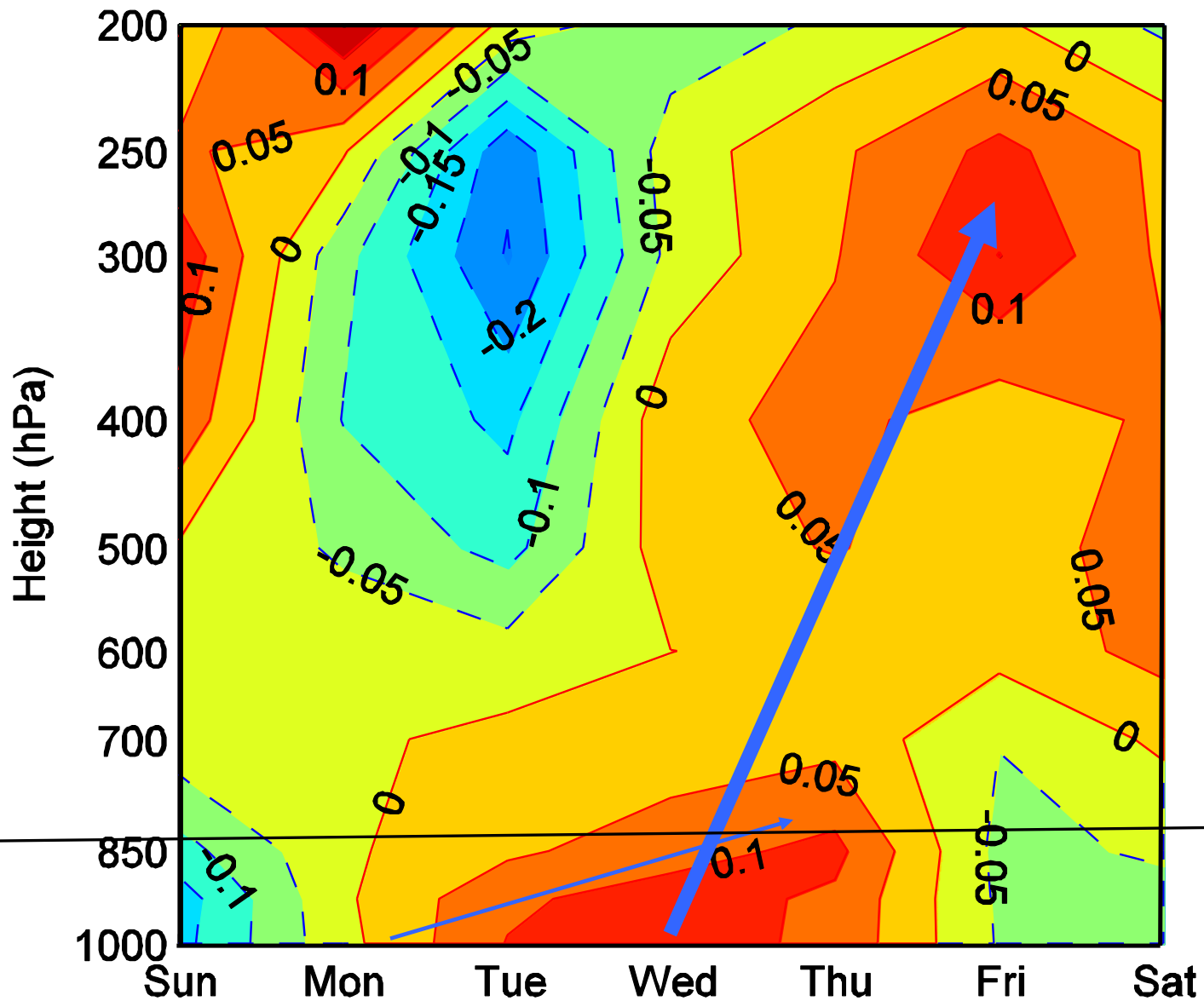


Profile of temperature anomaly in troposphere. Shown here is the mean of 15 radiosonde observations. Unit: °C.

Data sources: Durre et al., 2006. J. Climate, 19, 53-68

1100UTC.





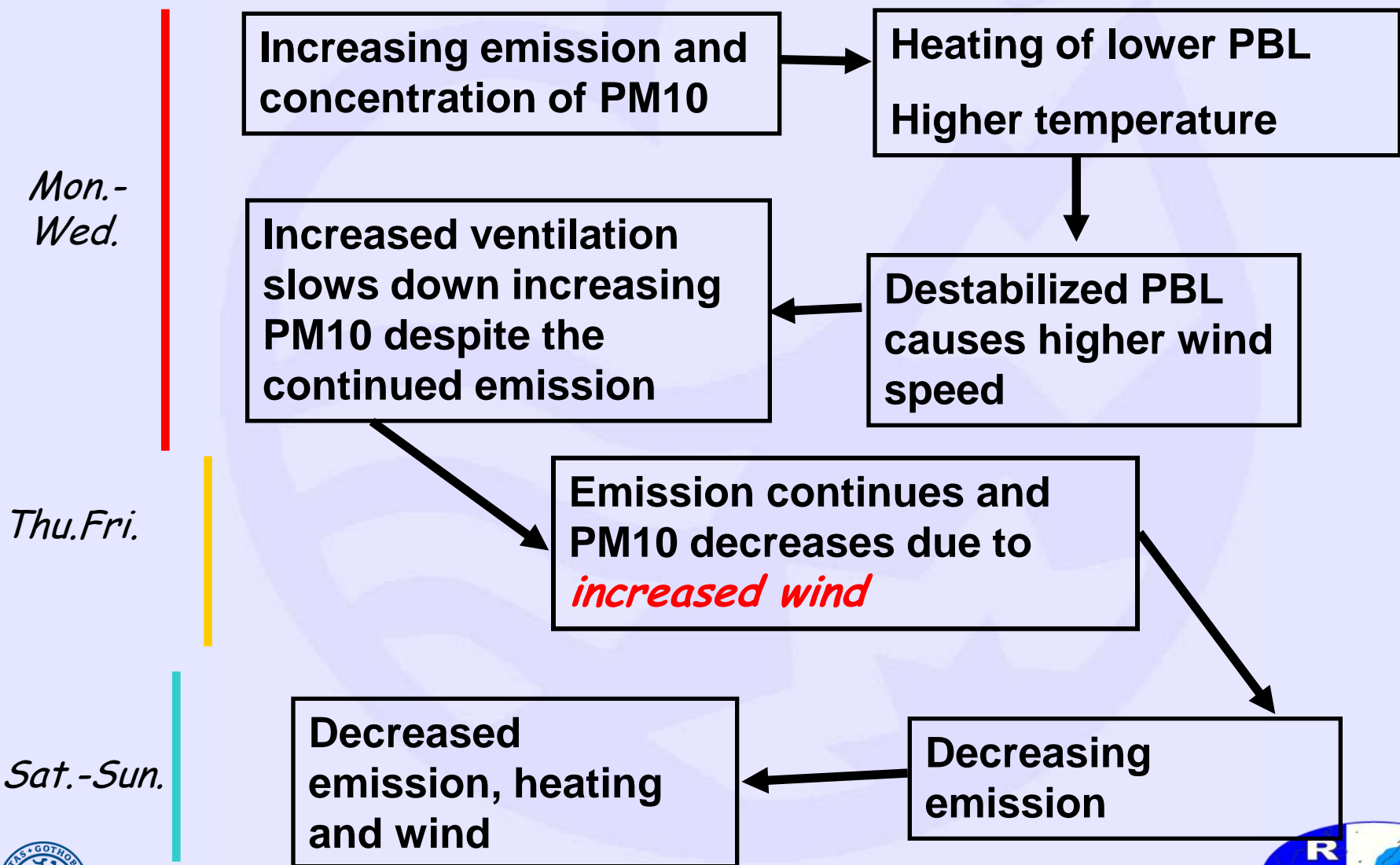
T, R2

PBL

Profile of temperature anomaly from Sunday through Saturday in troposphere. Shown here is the mean of 29 R2 grids. Unit: °C.



Summary



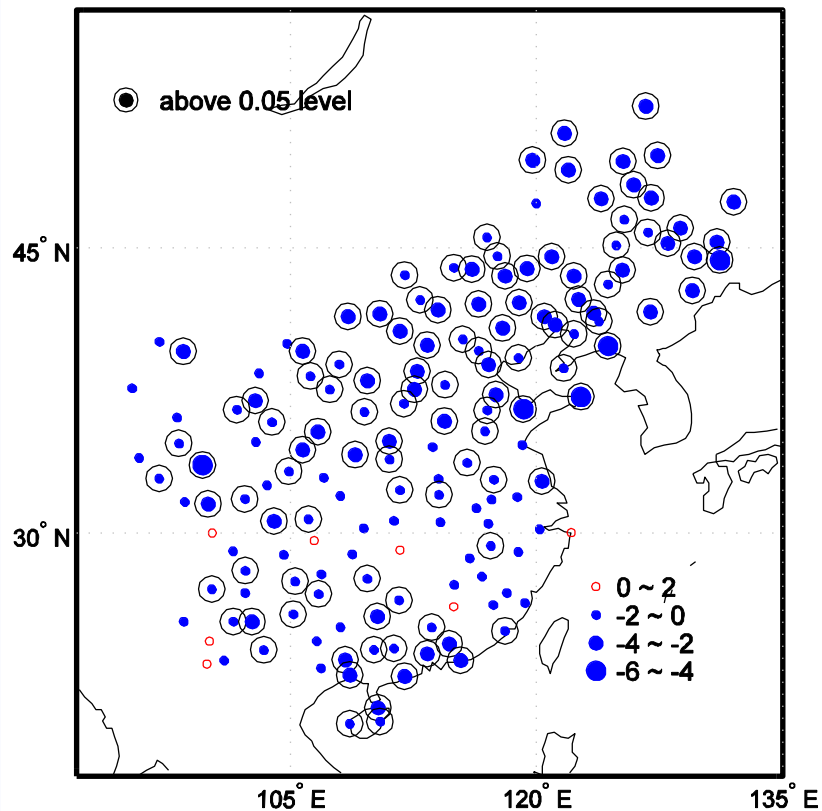
Conclusions

- There is a clear weekly cycle in surface air temperature, PBL wind speed, and light rain occurrence over the 29 cities in China, which is consistent with the PM10 concentrations.
- The maximum of the concentration of PM10 and its impact on other meteorological variables on the weekly scale can be explained in a physically plausible way, which indicates the existence of the human influence on weather!

Future directions

- Relation to long term climate changes in the regions
- Processes associated with cloud microphysics
- Chemical processes?!

(a) $p \leq 10\text{mm/day}$, 1956-2005, days/10yr

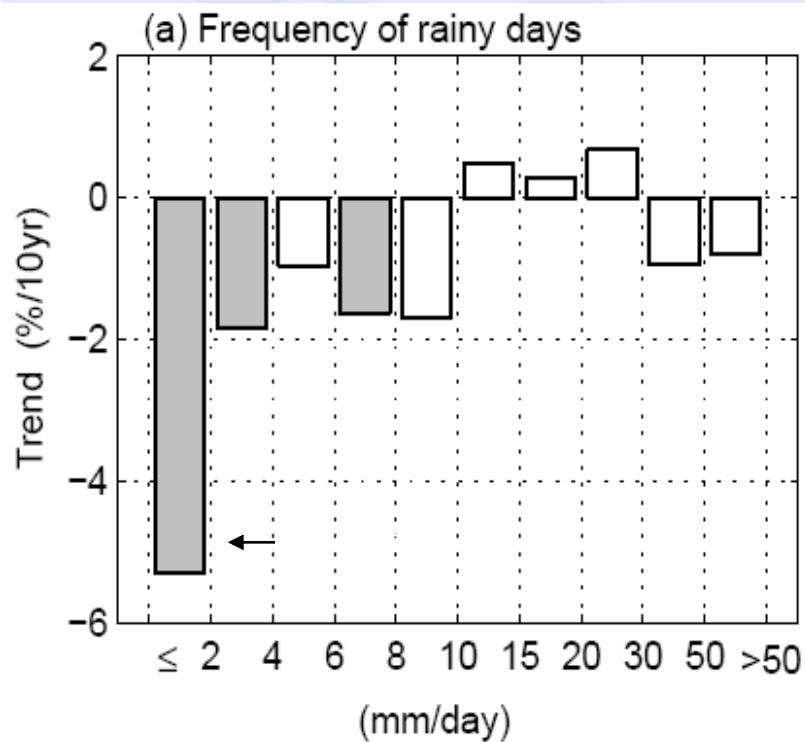


Linear trend of the number of light rain days during the time period 1956-2005. Unit: days/10yr. **JJA.**

Regional mean trends [10mm/day]:

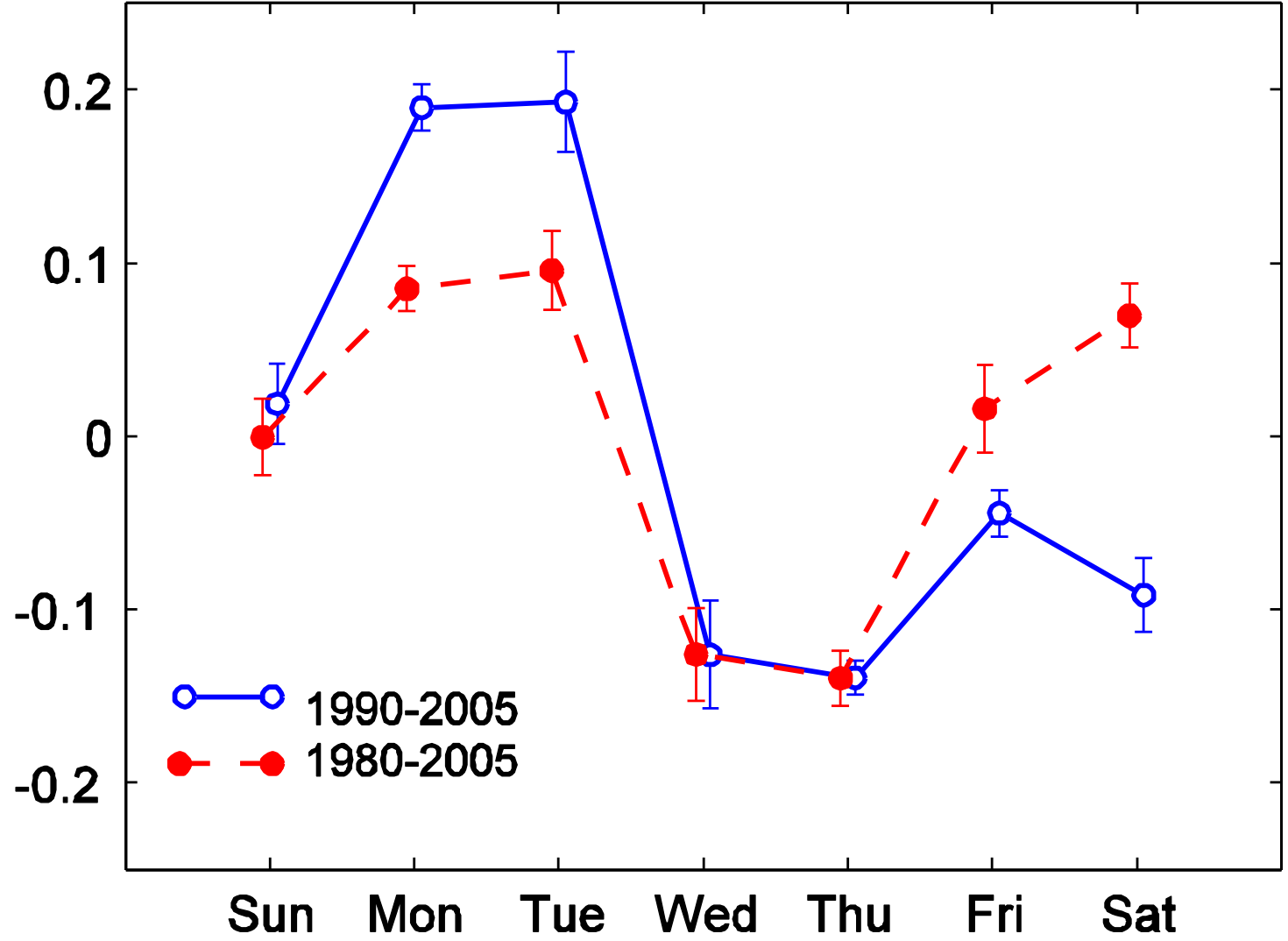
1956-05: -1.7days/10yr [*~20%*]

1980-05: -2.4days/10yr, 0.01 level



Sea level pressure

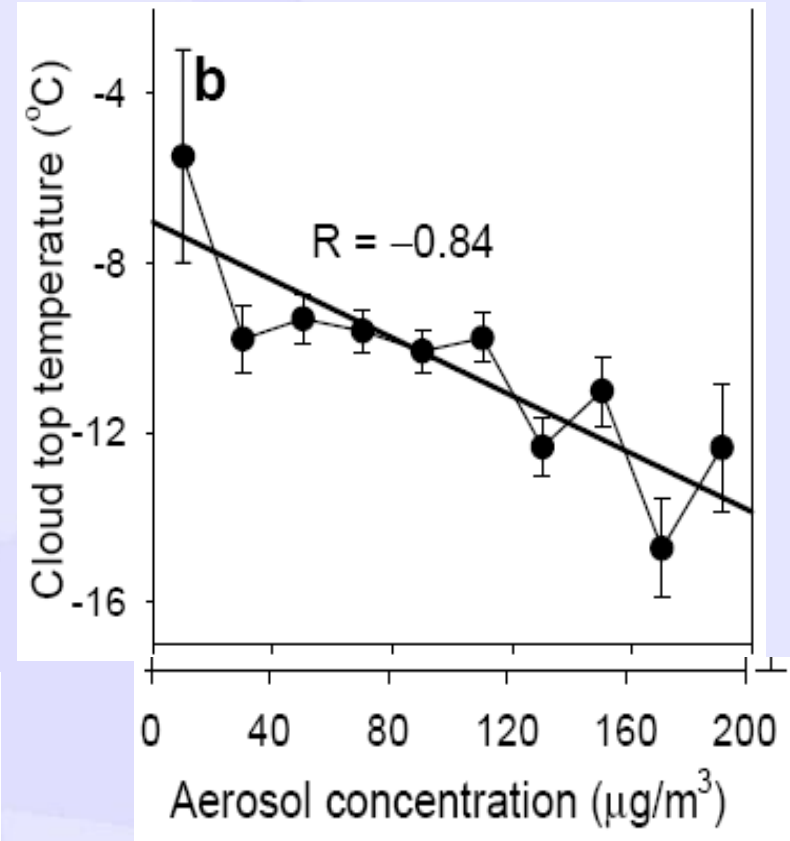
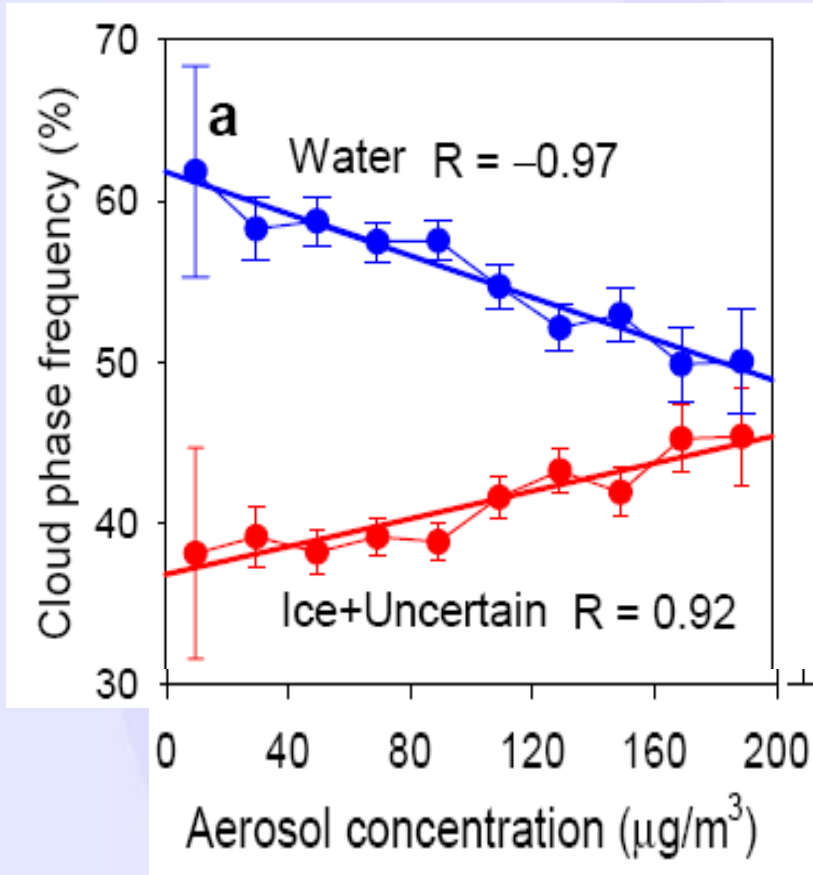
Pressure anomaly (hPa)



Weekly changes in surface pressure anomalies shown as the average of the 28 stations. Error bars are ± 1 standard error about the 28-sample mean. Results for two time periods are plotted together for comparison.



In addition to influencing the precipitation process in warm-cloud, is there any other mechanisms, such as in cold cloud ?



Satellite-retrieved cloud properties as a function of aerosol concentrations.

a, Cloud phase frequency is obtained by the ratio of the number of ice (or liquid) phase to that of total cloudy pixels in a given domain. **b**, Cloud top temperature is an average of mean values corresponding to aerosol concentration bins. The error bar plotted in **a** and **b** corresponds to ± 1 standard error. MODIS data.

