中国科学院遥感与数字地球研究所
Institute of Remote Sensing and Digital Earth ,CAS

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Satellite view of the widespread haze pollution in eastern China: formation, variation, and connection with atmospheric circulation

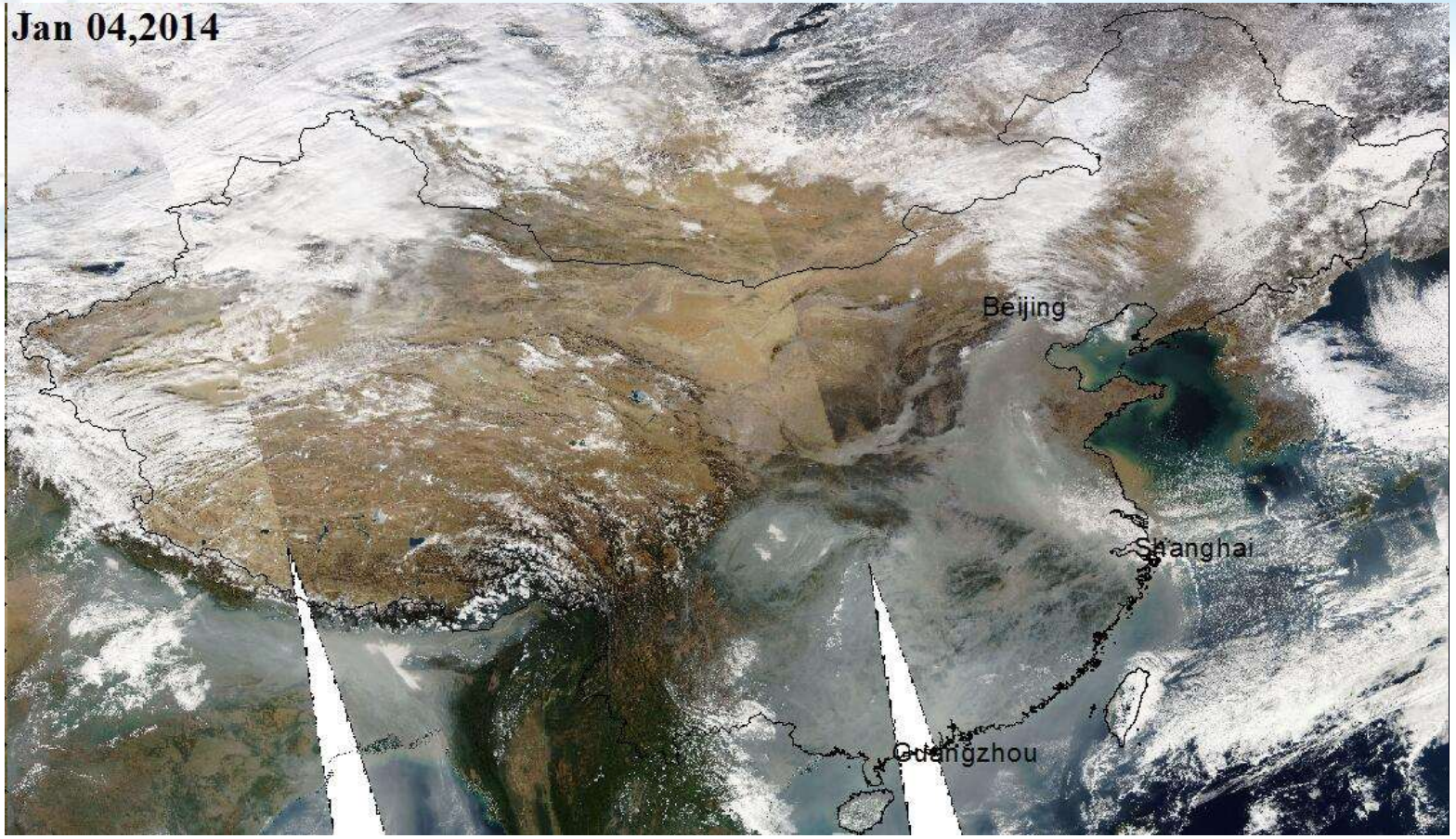
Liangfu Chen, Minghui Tao, Zifeng Wang, Jinhua Tao, Lin Su

State Key Laboratory of Remote Sensing Science

Institute of Remote Sensing and Digital Earth (RADI), Chinese Academy of Sciences

taomh@radi.ac.cn

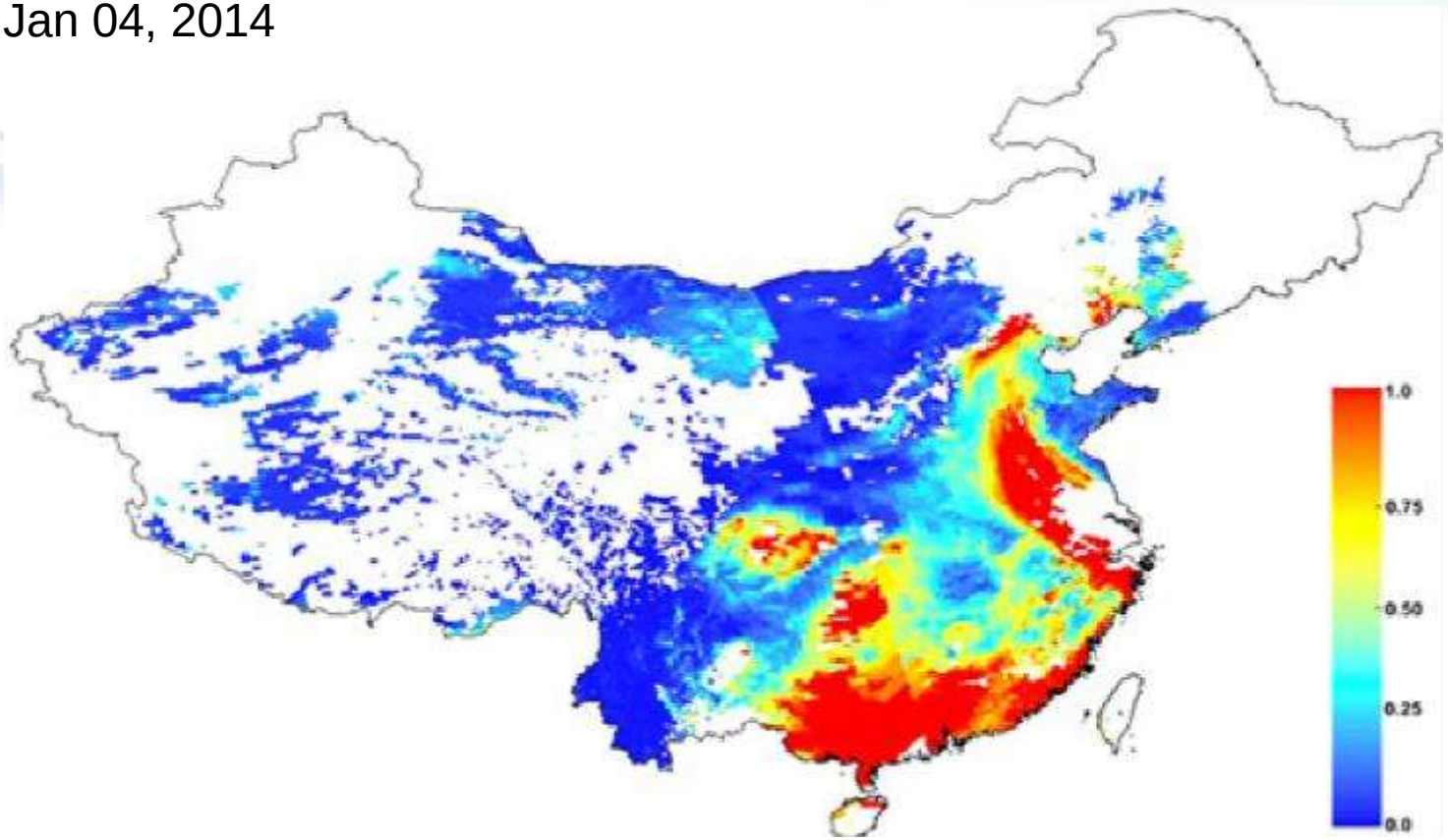
Why remote sensing from satellites



- The haze pollution is not concentrated in urban/industrial areas?
- Why dense haze plumes appear over southern China?
- Where the widespread haze pollution come from?

Why remote sensing from satellites

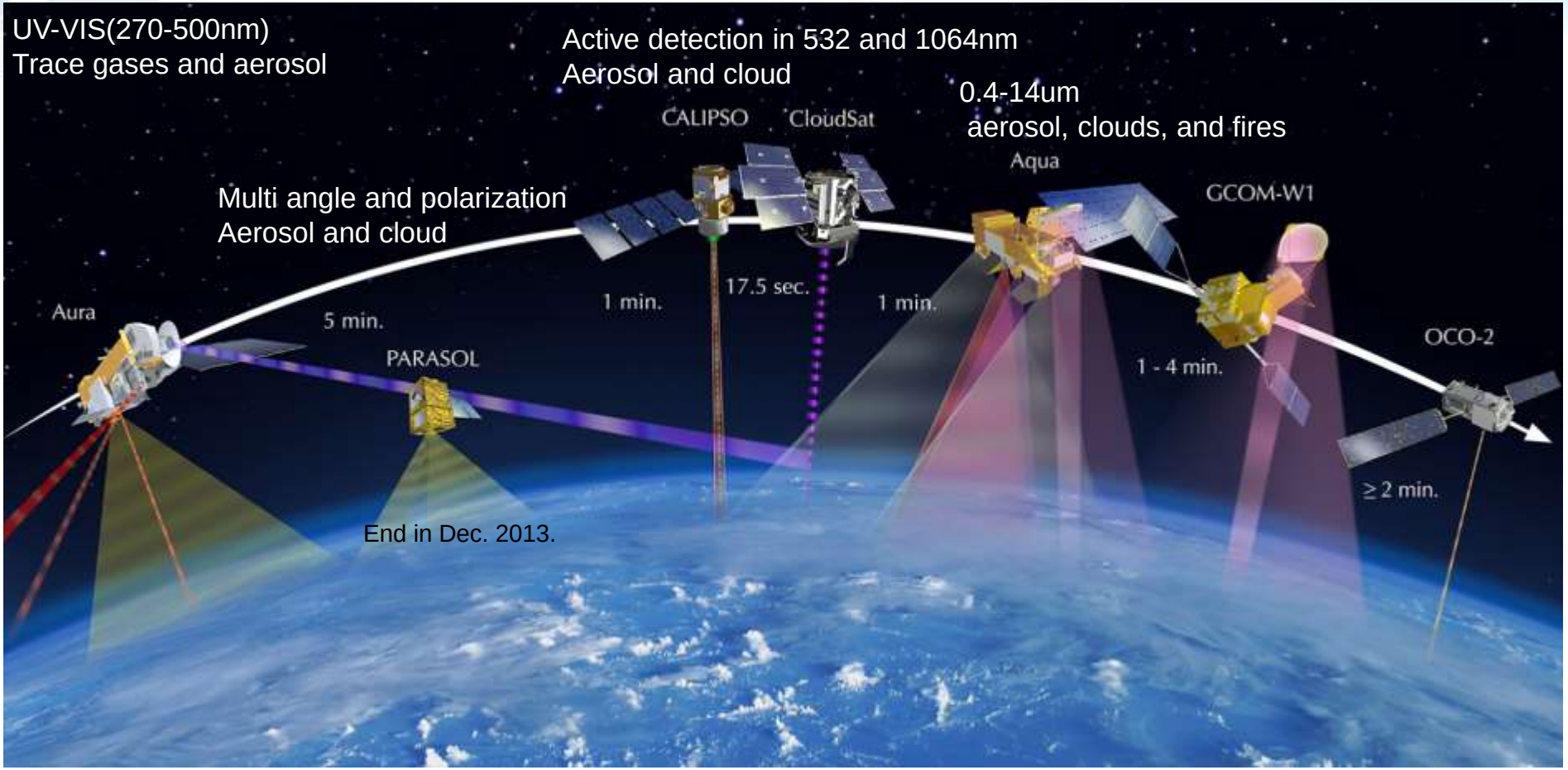
Jan 04, 2014



MODIS Deep Blue aerosol optical depth (AOD) at 550nm

The heavy haze pollution is characterized by high AOD (>1.0 mostly).

Why remote sensing from satellites



The A-Train satellite constellation across the equator each day at around 1:30 p.m. local time, enables simultaneously observe changes in atmospheric components and process from numerous perspectives.

Satellite observation of regional haze pollution over the North China Plain

Minghui Tao,[1,2] Liangfu Chen,[1] Lin Su,[1] and Jinhua Tao[1]

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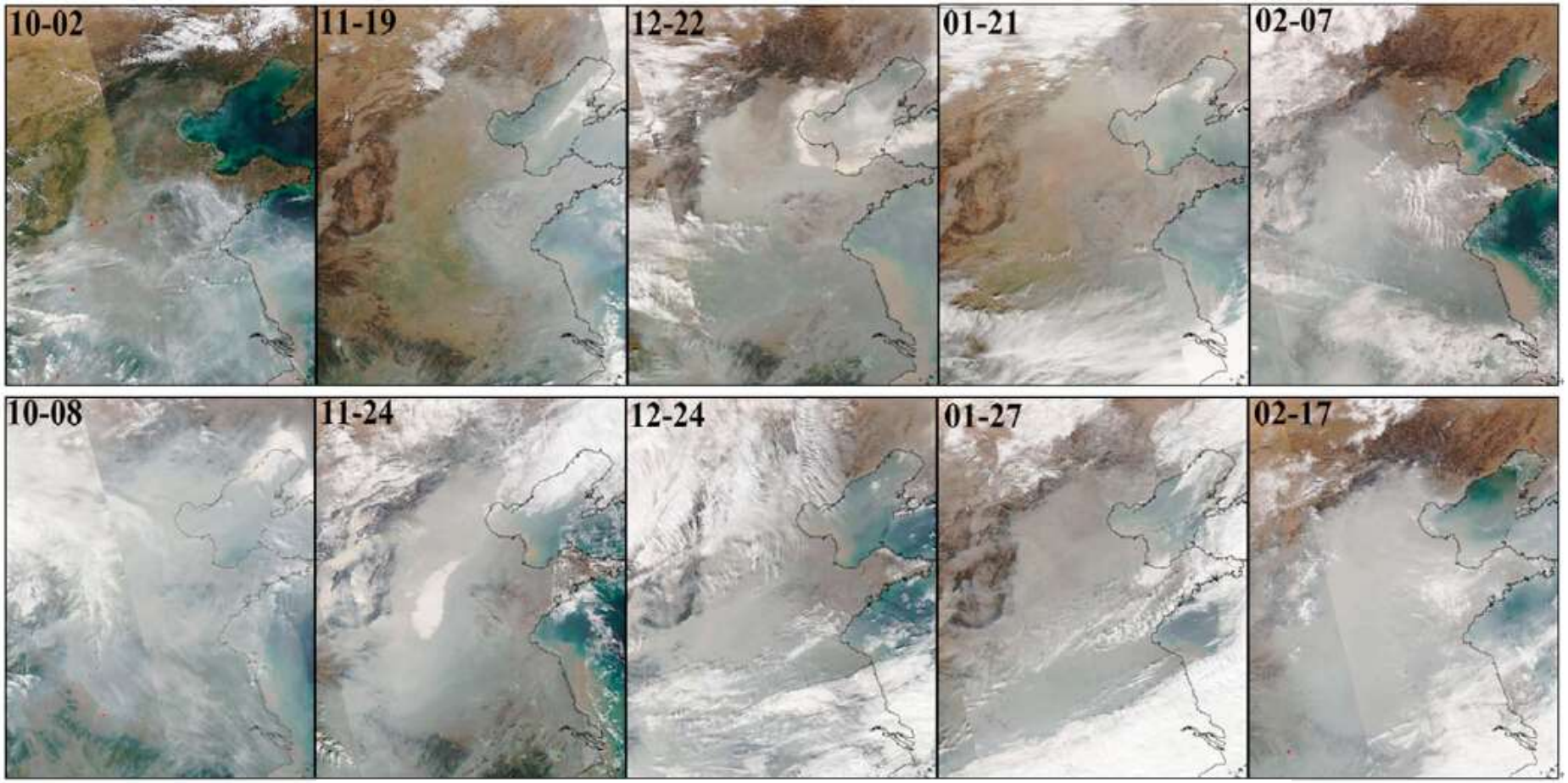
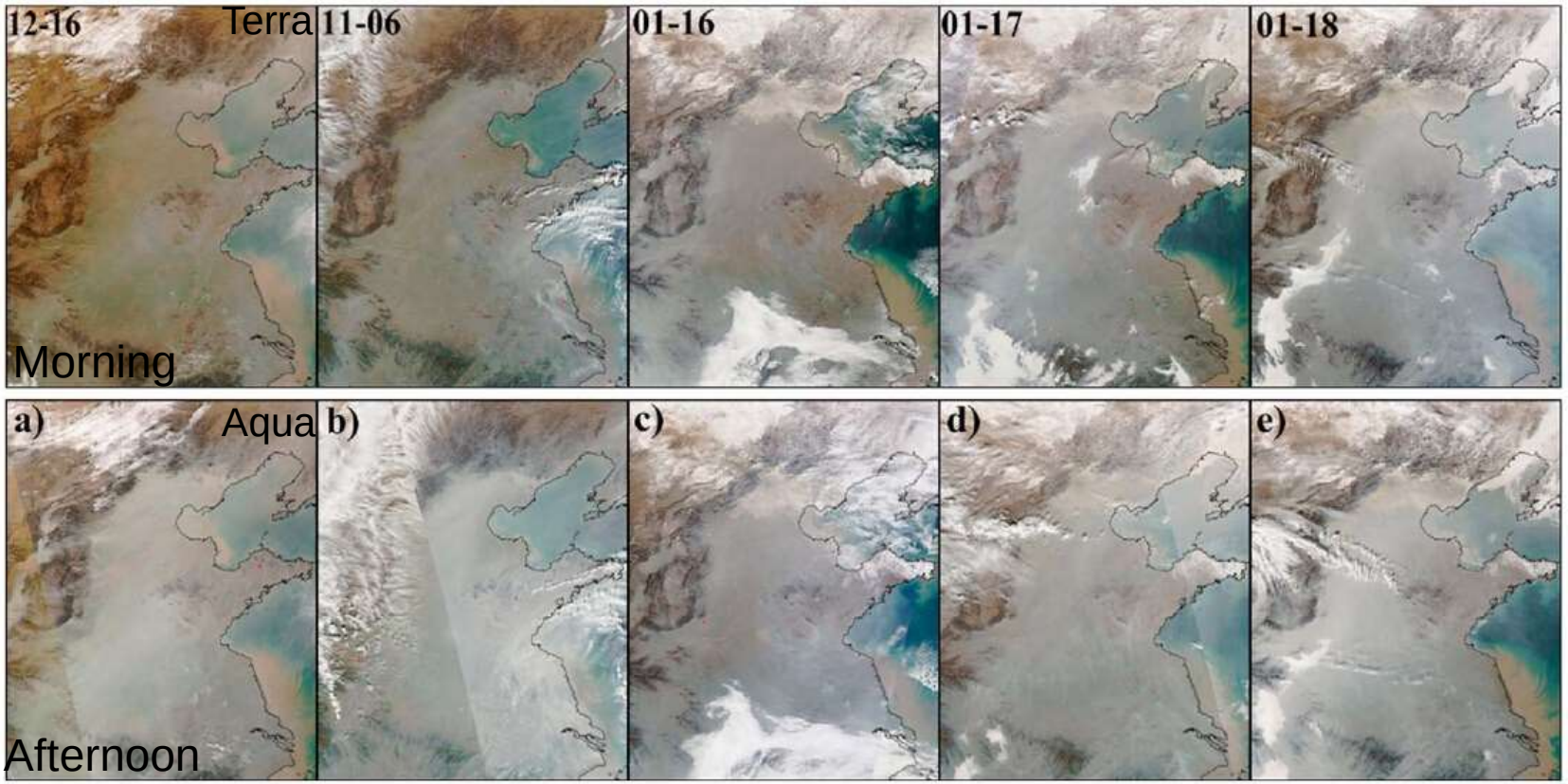


MODIS true color images of typical haze pollution over northern china

(Tao et al., JGR. 2012)

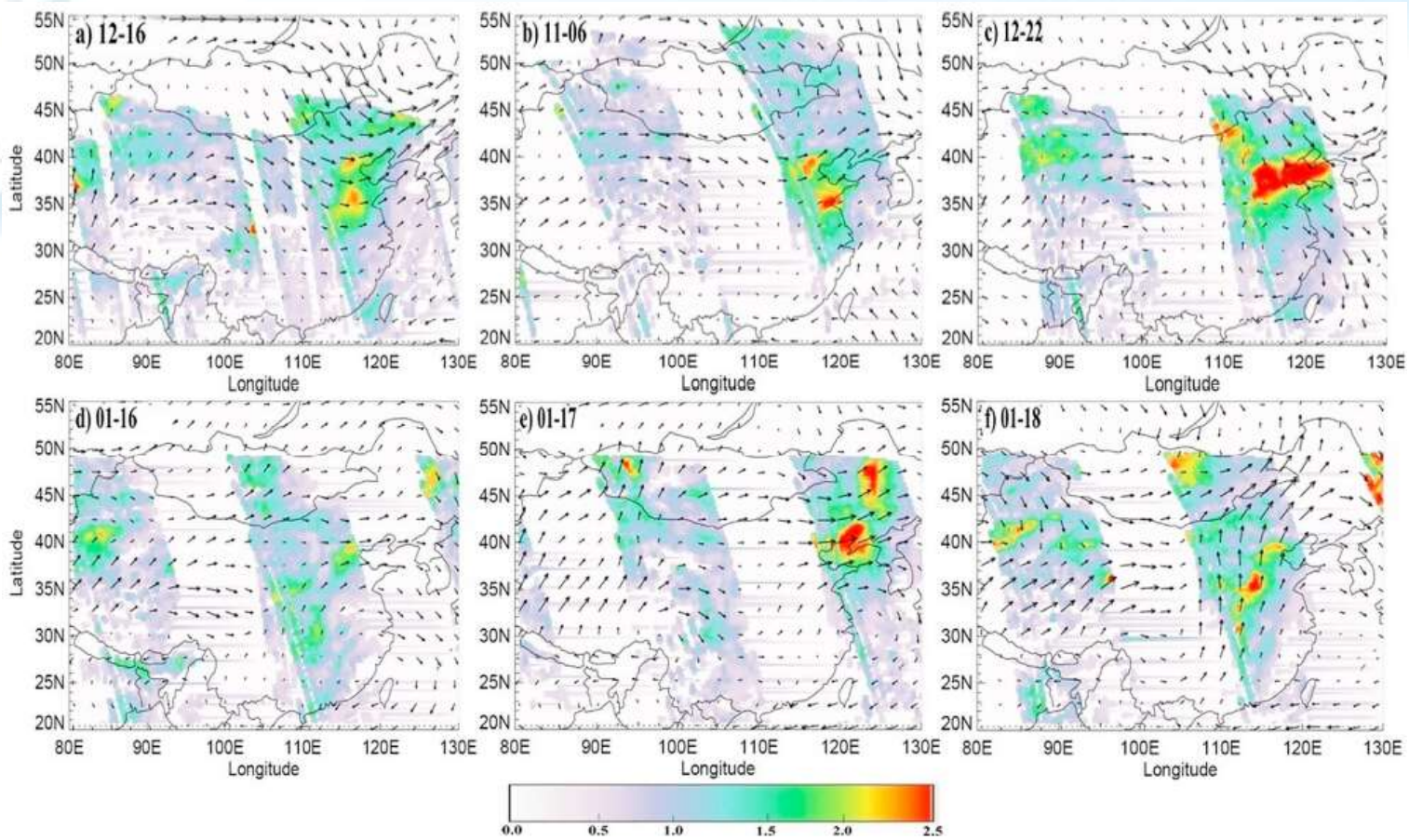
Typical haze pollution in northern China



True color image of MODIS on Terra (top) and Aqua (bottom) satellite pass eastern China around 11:00 and 13:30 of local time respectively, which can provide twice view of the atmospheric conditions.

- It was found that regional haze pollution can form within one day;
- Durative regional haze pollution can last for several days over northern China;

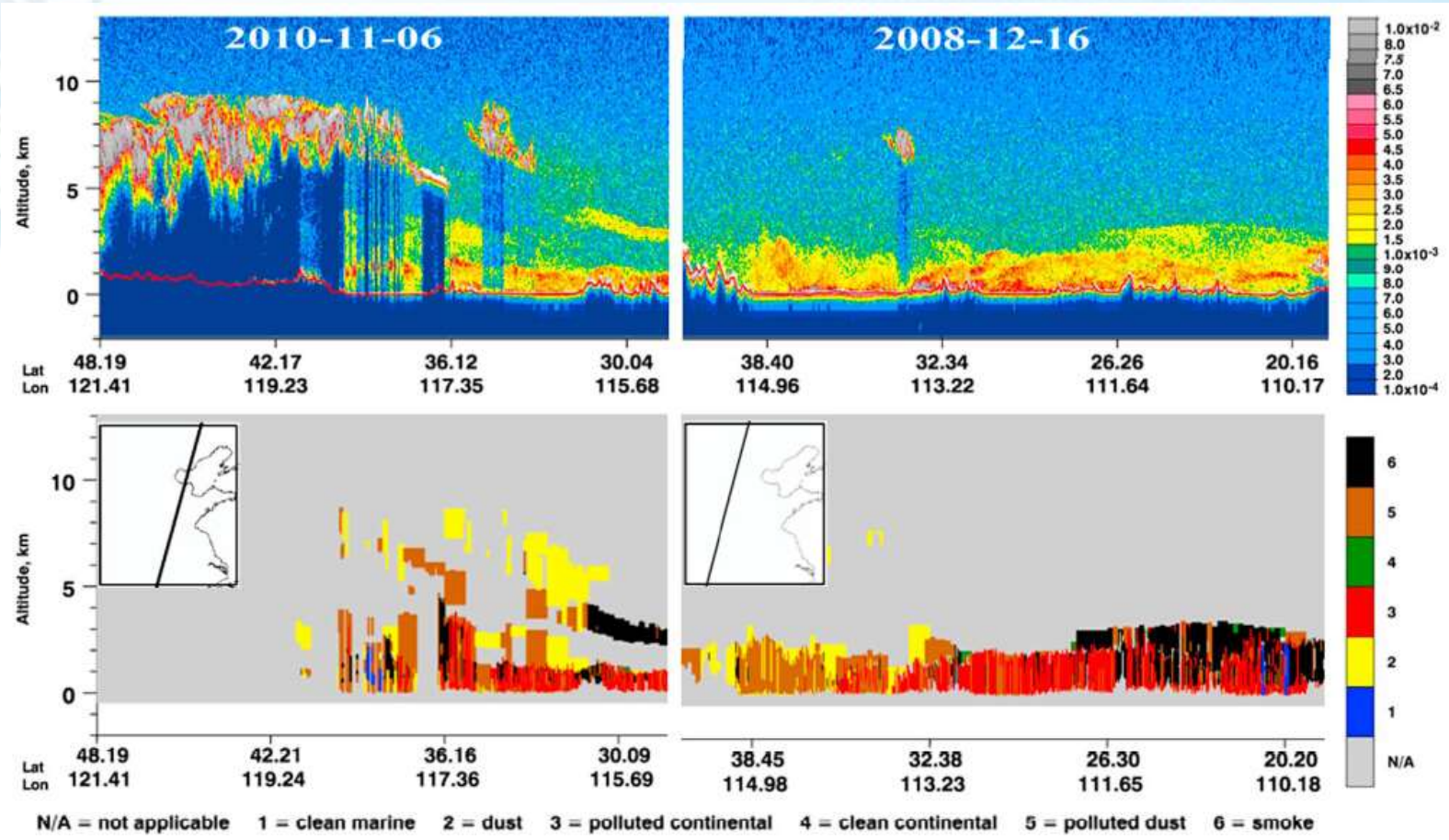
Typical haze pollution in northern China



OMI UV Aerosol Index (UVAI) with NCEP wind fields at 850 hPa

- High values of UVAI indicate prevalent UV-absorbing aerosols such as dust and smoke over northern China;
- Northwesterly winds can bring floating dust in the deserts downstream to eastern China;

Typical haze pollution in northern China



CALIPSO 532nm total attenuated backscatter and aerosol subtypes

- Floating dust layers were observed over northern China during the haze period;
- The dust particles can mix with local anthropogenic pollutants and form regional pollution in short time;

Typical haze pollution in northern China

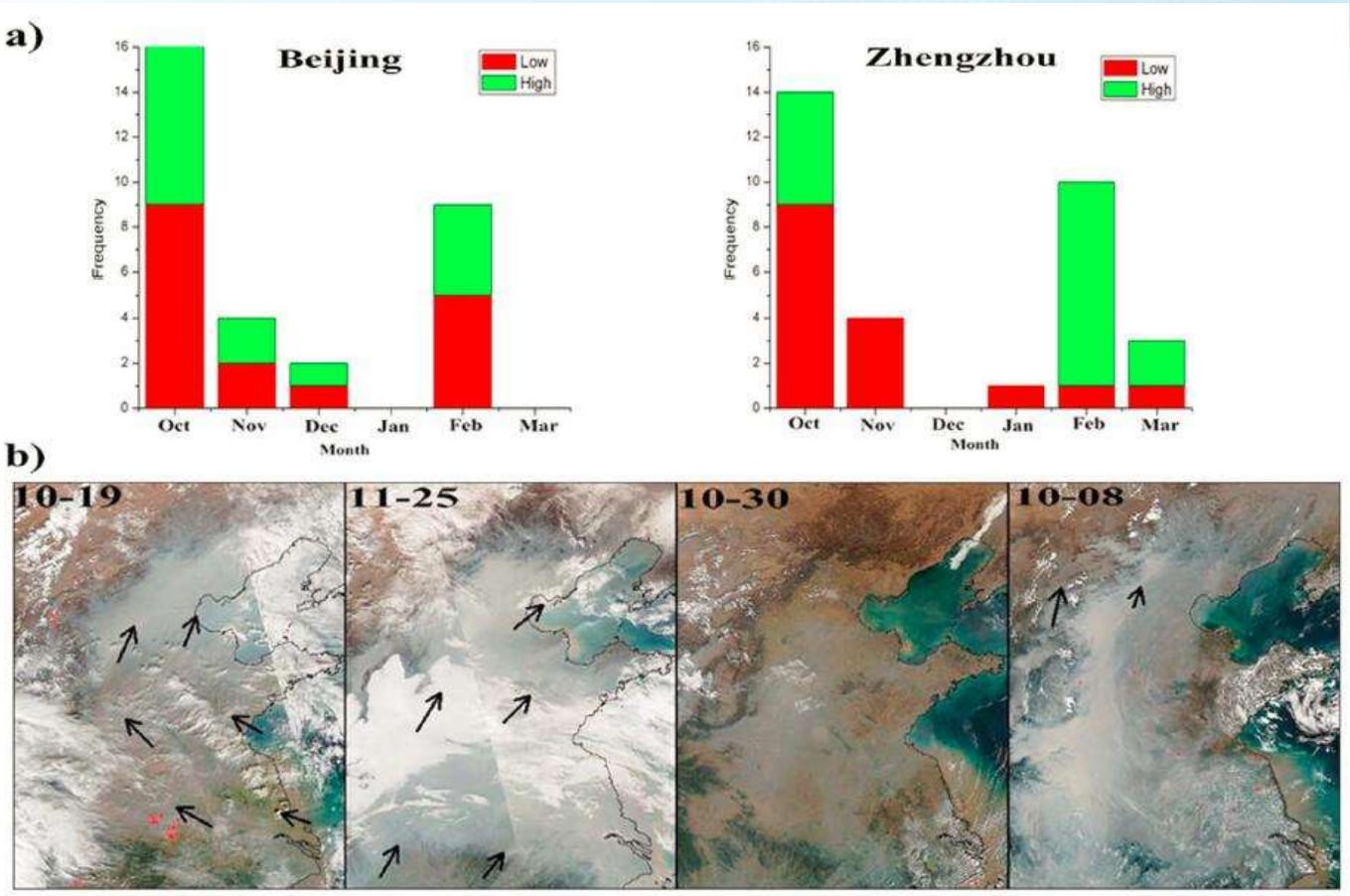
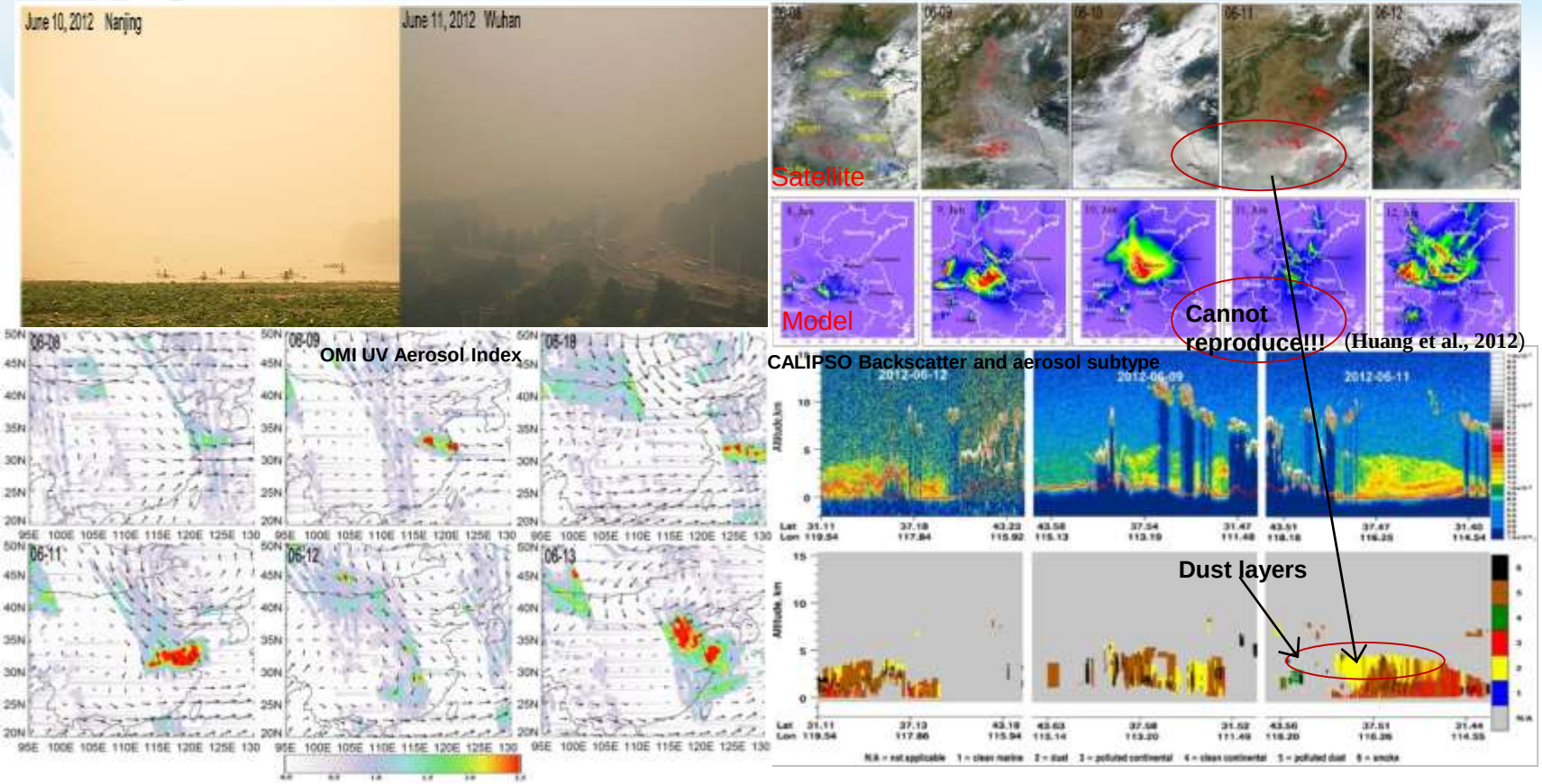


Figure 13. (a) The frequency of different fog events in Beijing and Zhengzhou between October 2010 and March 2011. (b) Regional pollution followed by different fog events over the NCP. Arrowhead denotes general wind direction of wind fields at 850 hPa.

- Durative and regional haze pollution is closely connected with fog and moist flows;
- Floating dust and moist airflows enhanced formation of widespread haze pollution;

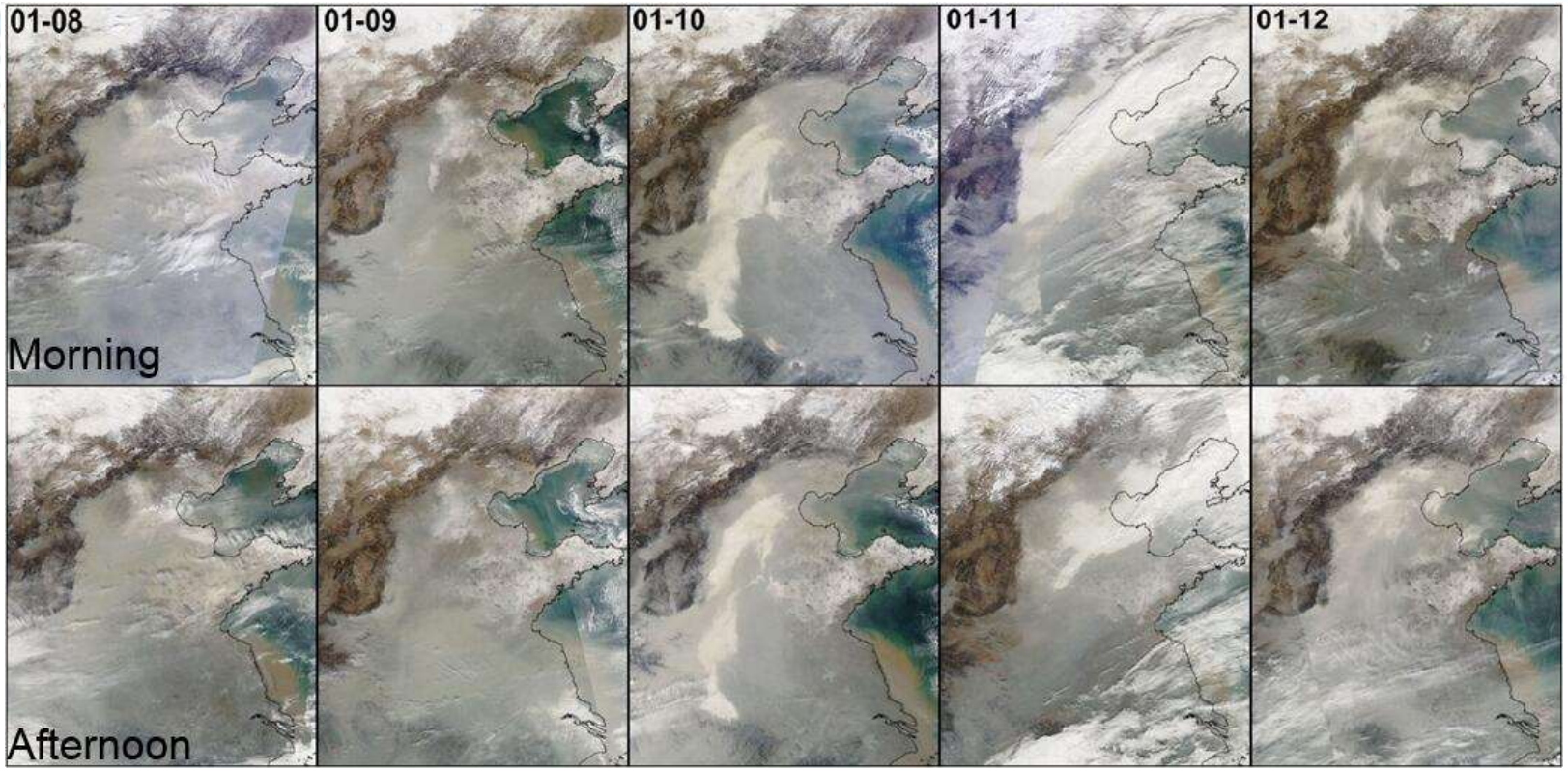
Abnormal yellow haze pollution in central China



Mixing of floating dust plumes, crop biomass burning and local pollution caused the abnormal yellow haze pollution in June, 2012.

(Tao et al., AE. 2013)

Spatial view of the extreme haze pollution during winter

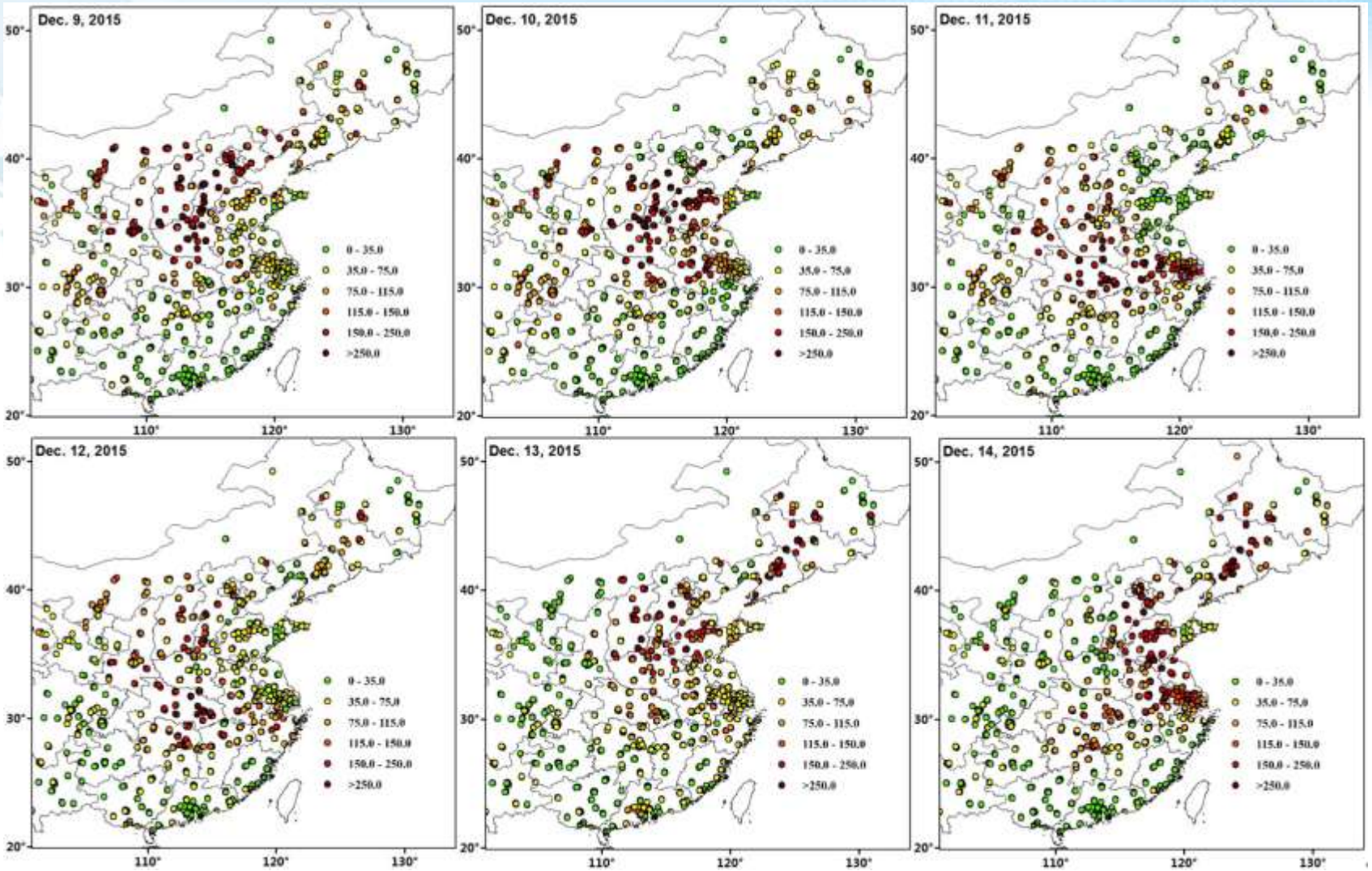


Satellite true color images from Terra (top) and Aqua (bottom) MODIS during January 8-12, 2013.

The haze plumes did not move out of northern China but wandered, overlapped, and transported!

(Tao et al., AE. 2014)

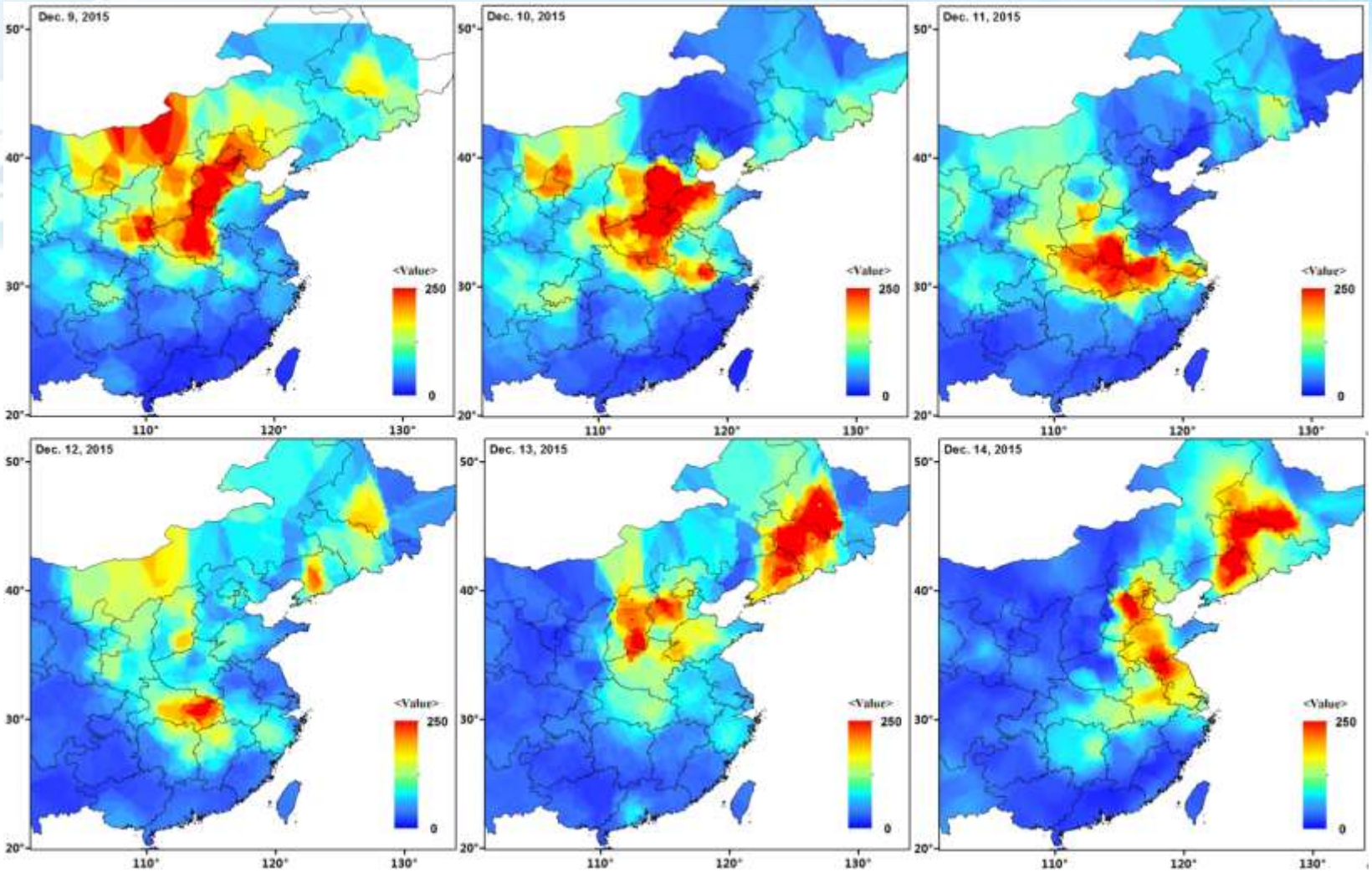
Spatial view of the extreme haze pollution during winter



Number of enhanced national ground network sites for air pollution monitoring in China increased to about 1500 .

(Tao et al., AE. 2016)

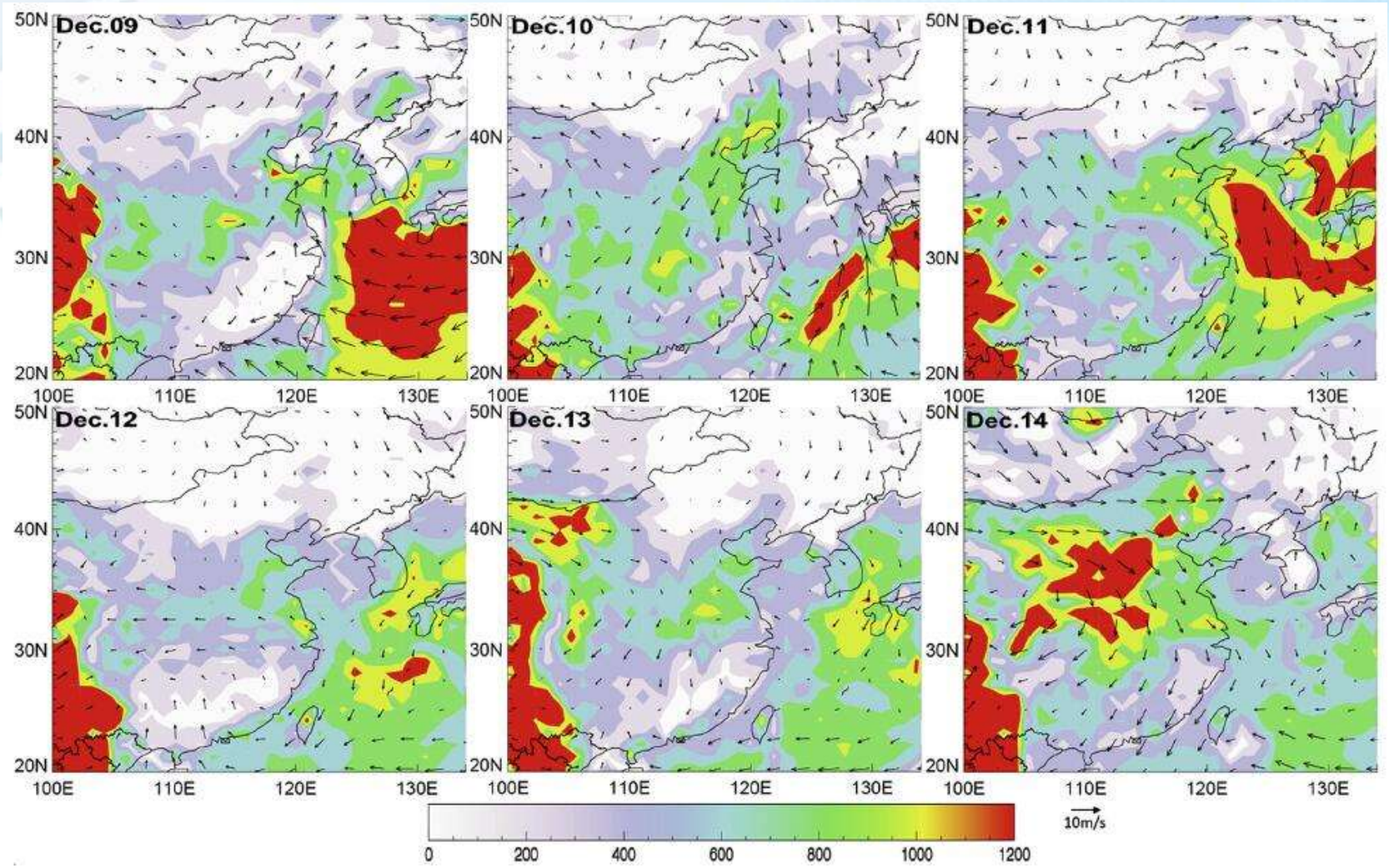
Spatial oscillation of the particle pollution during winter



Estimated concentration of $PM_{2.5}$ by satellite AOD and interpolation at 14:00 local time on Dec. 9-14, 2013.

Obvious spatial oscillation phenomenon of the particle pollutants was found in eastern China

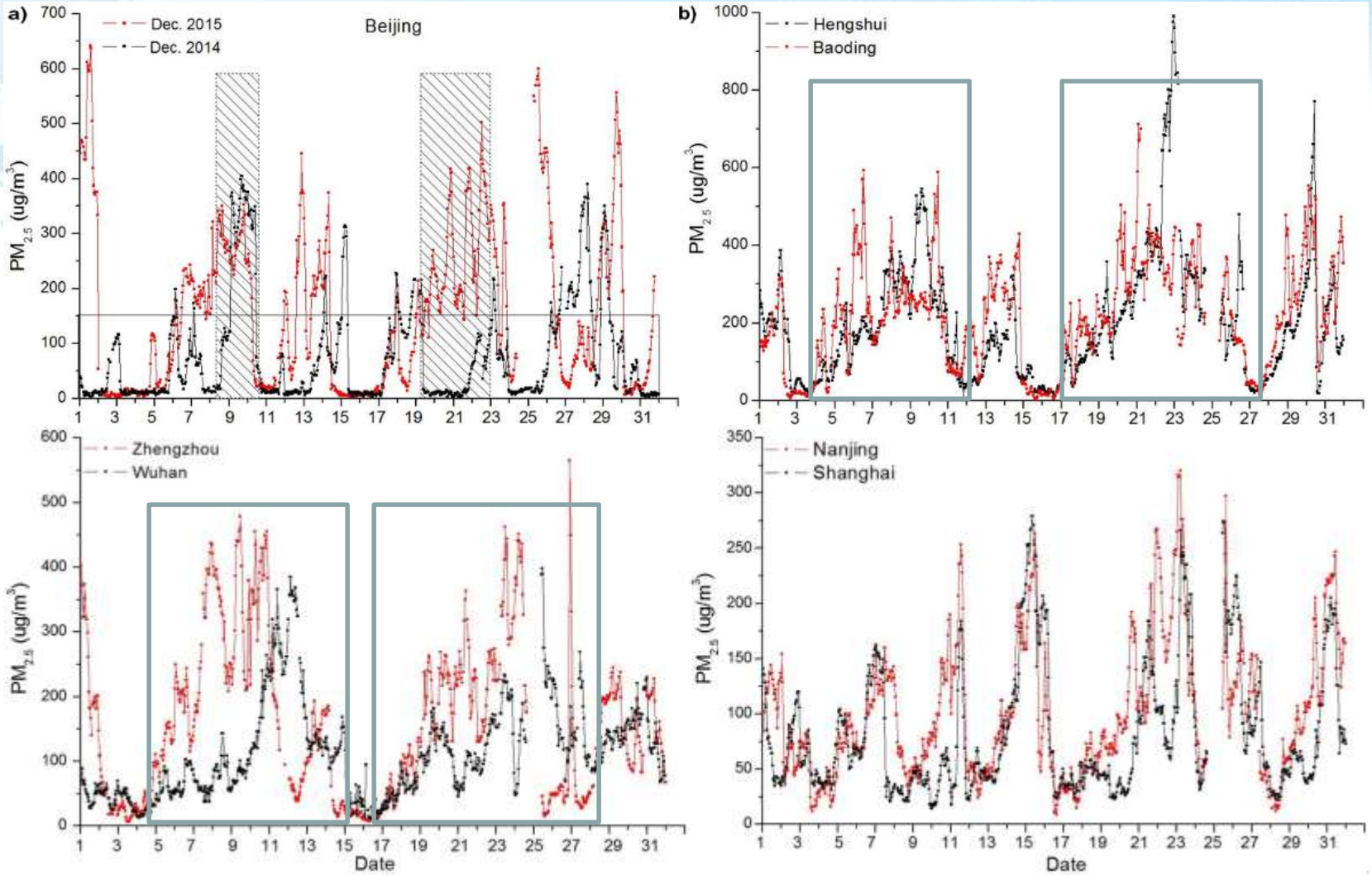
Spatial oscillation of the particle pollution during winter



Height of PBL with wind fields at 925 hPa from NCEP in eastern China at 14:00 local time during Dec. 9-14, 2013.

The wind direction changed day by day within the PBL during winter in eastern China

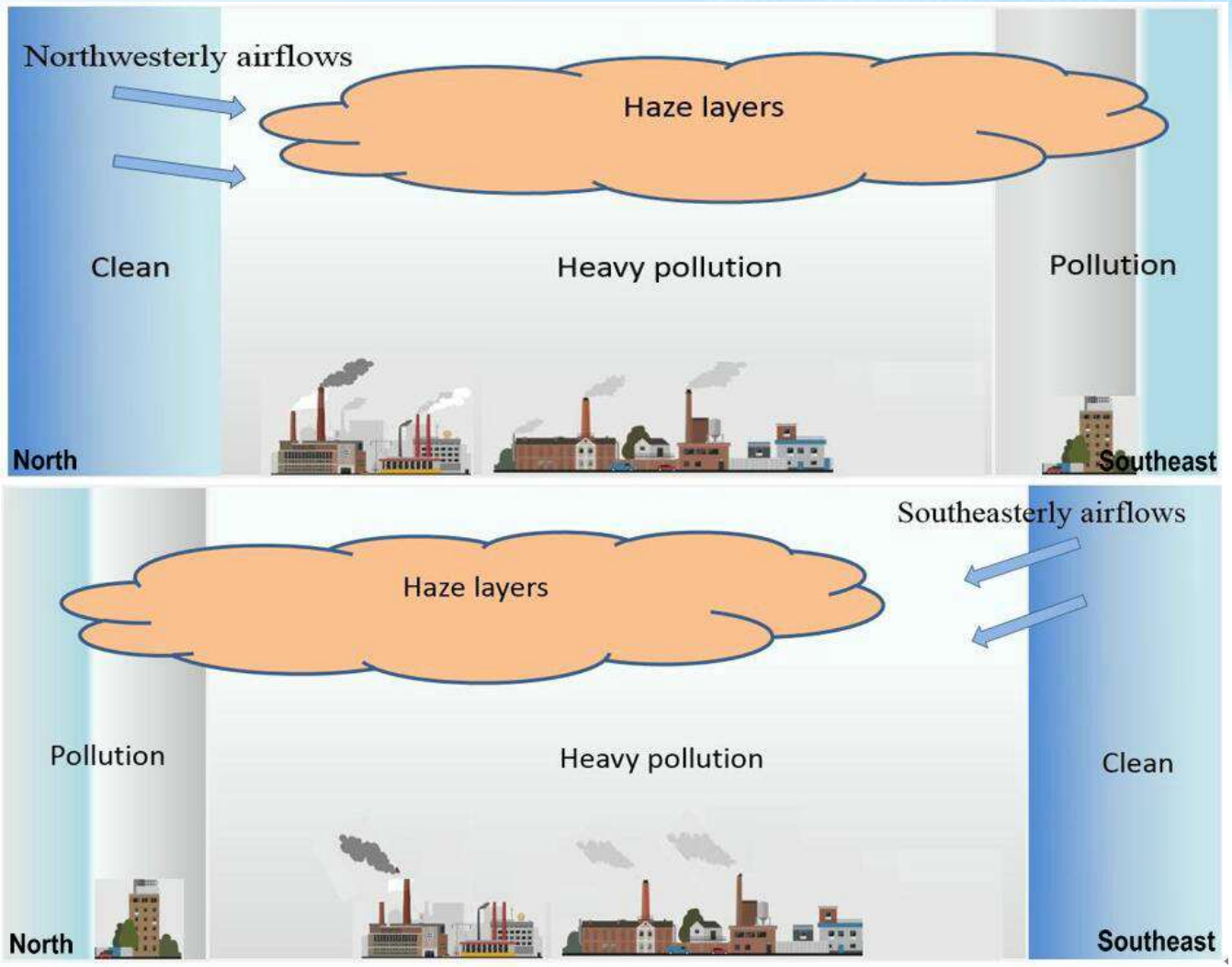
Spatial oscillation of the particle pollution during winter



Hourly concentration of $PM_{2.5}$ in megacities of eastern China during December 2013.

- Two distinct change processes of $PM_{2.5}$ existed in eastern China
- How did these variations connect with the spatial oscillation of the particle pollutants?

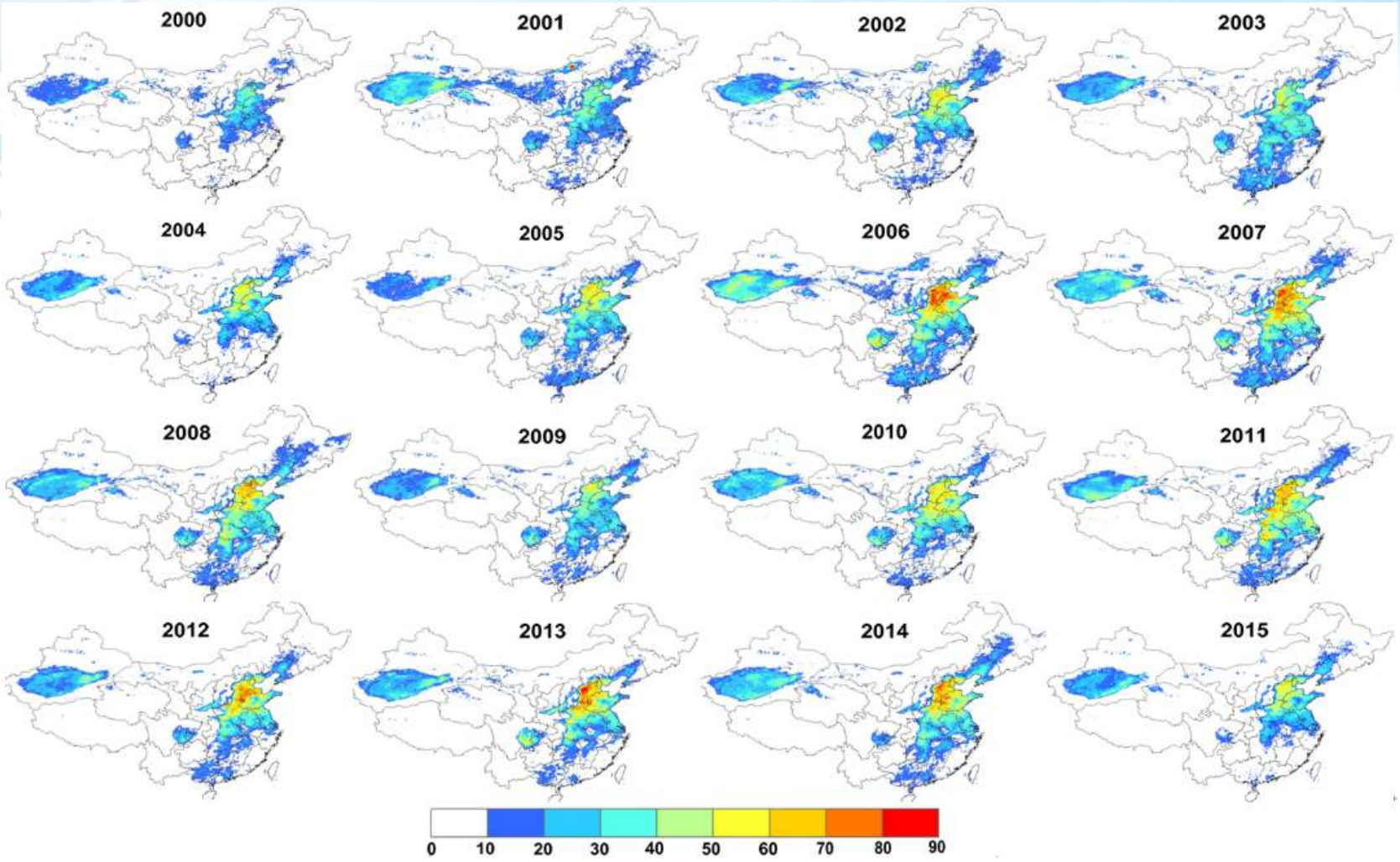
Spatial oscillation of the particle pollution during winter



Schematic diagram of spatial oscillation of the particle pollutants in eastern China

- Spatial oscillation leads to frequent abrupt heavy pollution for megacities in fringe areas
- Weakening of the atmospheric circulation can raise the possibility of extreme pollution

Decadal trends of the regional haze pollution in eastern China

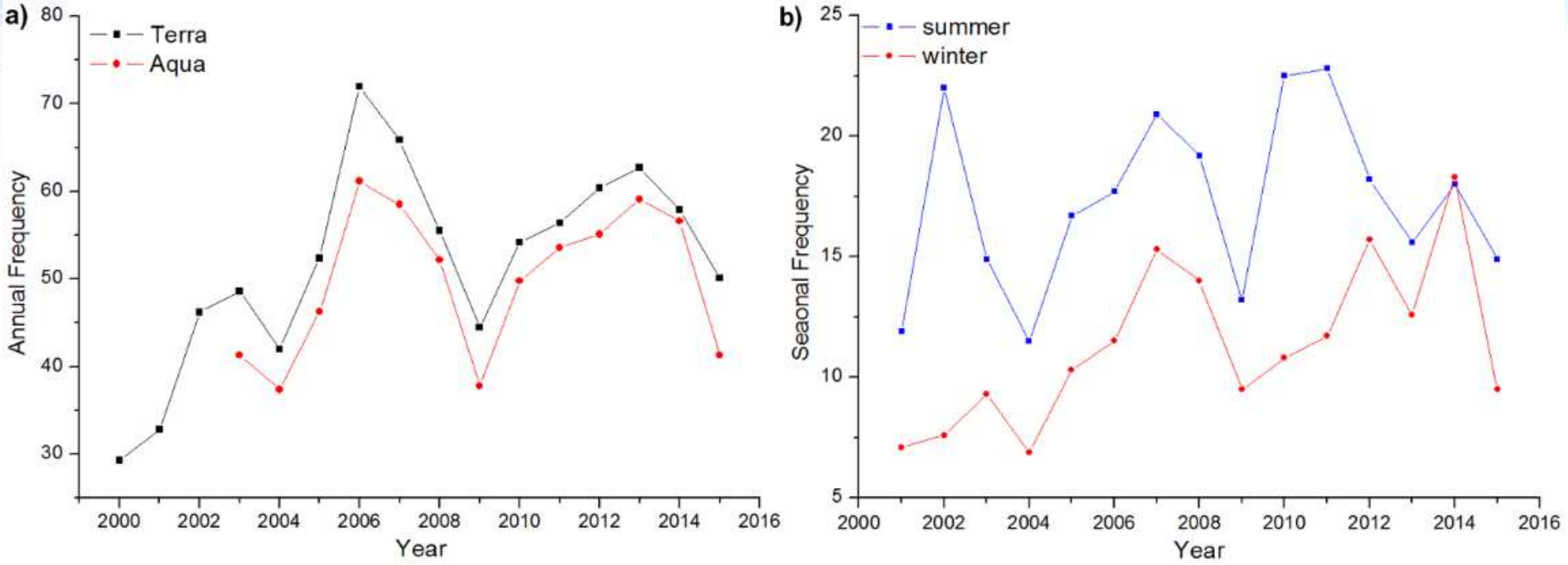


Annual frequency of MODIS Deep Blue AOD >1.0 in eastern China

Frequency of AOD>1.0 can exceeds 90 in northern China, about half the cloud-free days.

(Tao et al., ERL. 2016)

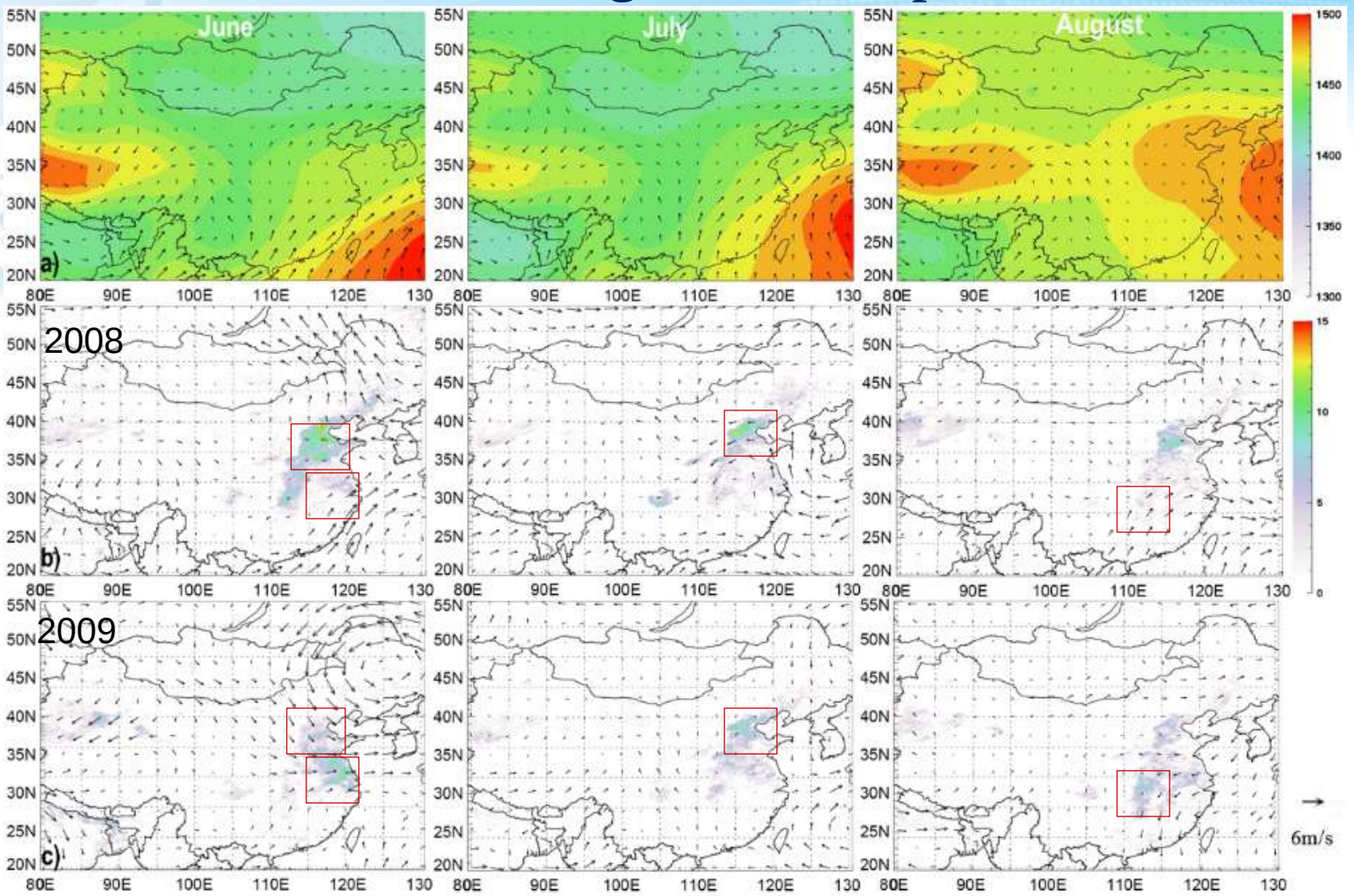
Decadal trends of the regional haze pollution in China



Mean annual and seasonal frequency of MODIS Deep Blue AOD >1.0 in northern China

- Winter haze pollution exhibited general increasing trend with occasional influence from emission control and meteorological conditions;
- Summer haze pollution is much more sensitive to the Asian monsoon

Decadal trends of the regional haze pollution in China



- Variations of the atmospheric circulation changed spatial distribution of the air pollutants;
- Besides the intensity, direction and position of the changes is also important;

Summary

- Regional haze pollution is common over China with complicated characteristics such as the very inhomogeneous optical properties in both vertical and horizontal scale
- Natural factors play a significant driving effect in formation of regional haze clouds
- Variation of regional haze pollution closely connect with the atmospheric circulation
- Much work to do in different spatial scales and their interactions

Thanks !






中国科学院遥感与数字地球研究所

地址：北京市海淀区邓庄南路9号（100094）

电话：86-10-82178008 传真：86-10-82178009

邮箱：office@radi.ac.cn

网址：www.radi.cas.cn