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Integration of satellite, air quality, and emissions data: progress for China and preliminary applications to the 2008 Beijing Olympics

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with

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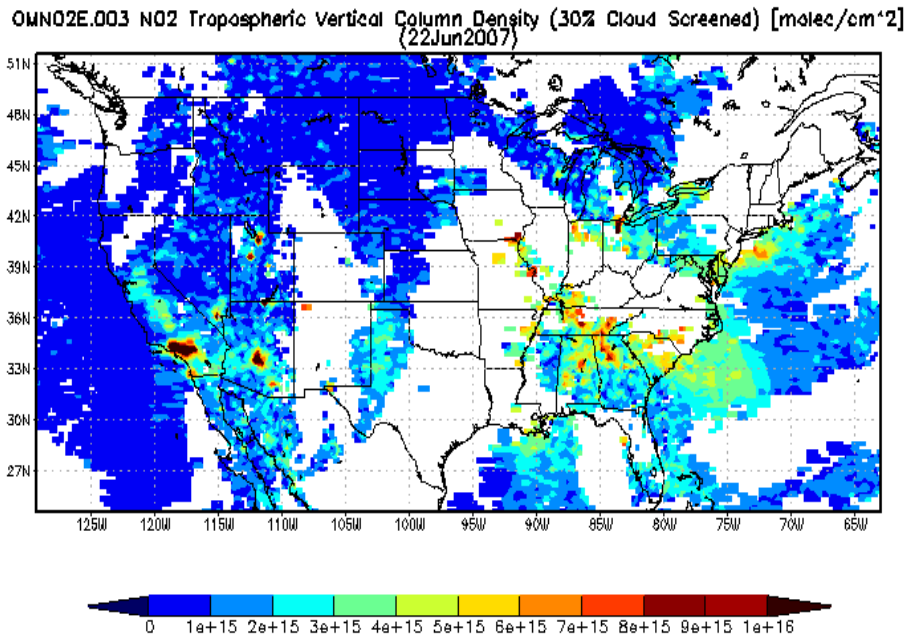
OMI observation of tropospheric NO_2 columns is well-developed; OMI is sensitive in the PBL and shows good agreement with high NOx regions (urban areas) *[source: Ana Prados, NASA]*



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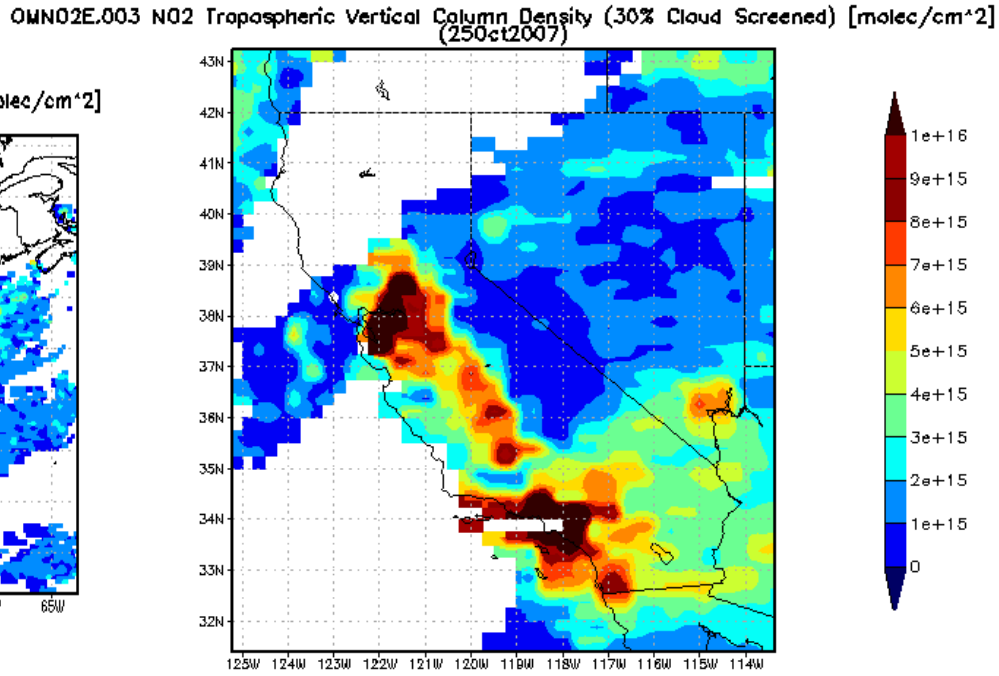


California

AURA's Ozone Monitoring Instrument (OMI) can detect smaller amounts of SO_2 at higher spatial resolution than any previous satellite instrument. Man-made sources can be compared with natural sources (volcanoes)

Source: B. Schoeberl and N. Krotkov (NASA)

Man-made

Norilsk Nickel Smelter,

Natural

Anatahan Volcano, 2004-2005

Norilsk Nickel Smelter

Anatahan Volcano

Oil Refineries

Soufriere Hills Volcano

Coal Power Plants, China

Sierra Negra Volcano

Coal Power Plants, South Africa

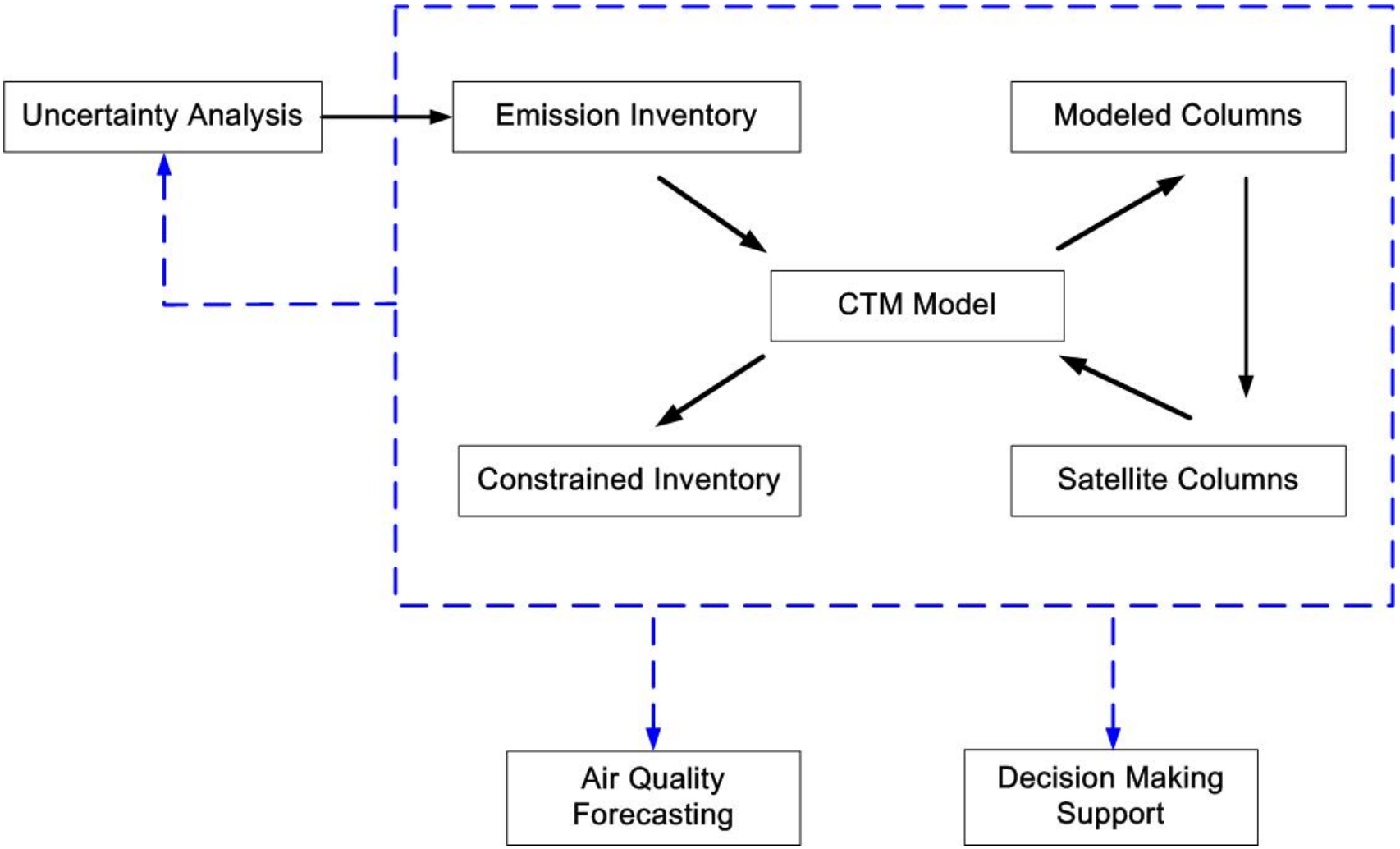
Nyiragongo Volcano, DR Congo

Ambrym Volcano, April 23, 2006

Ambrum Volcano

Designed by B. Schoeberl

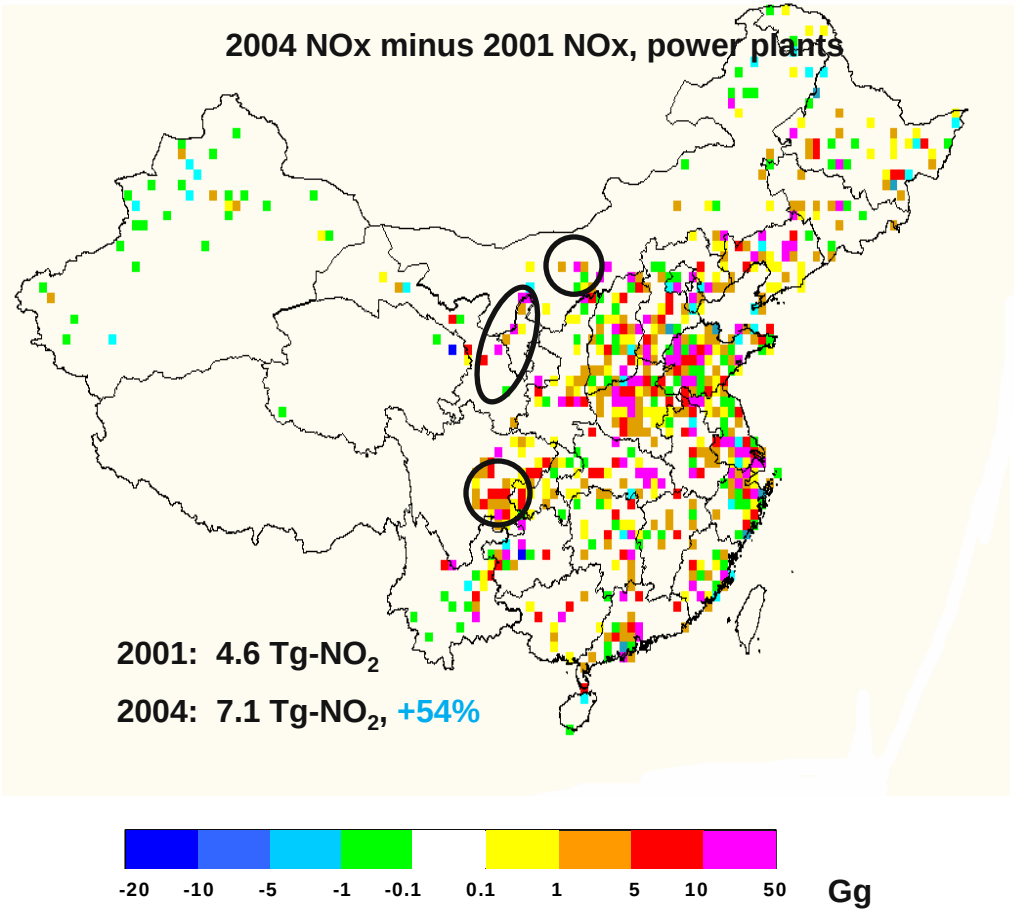
We are developing new approaches to integrate satellite data with chemical transport models and emission inventories for improved air quality management

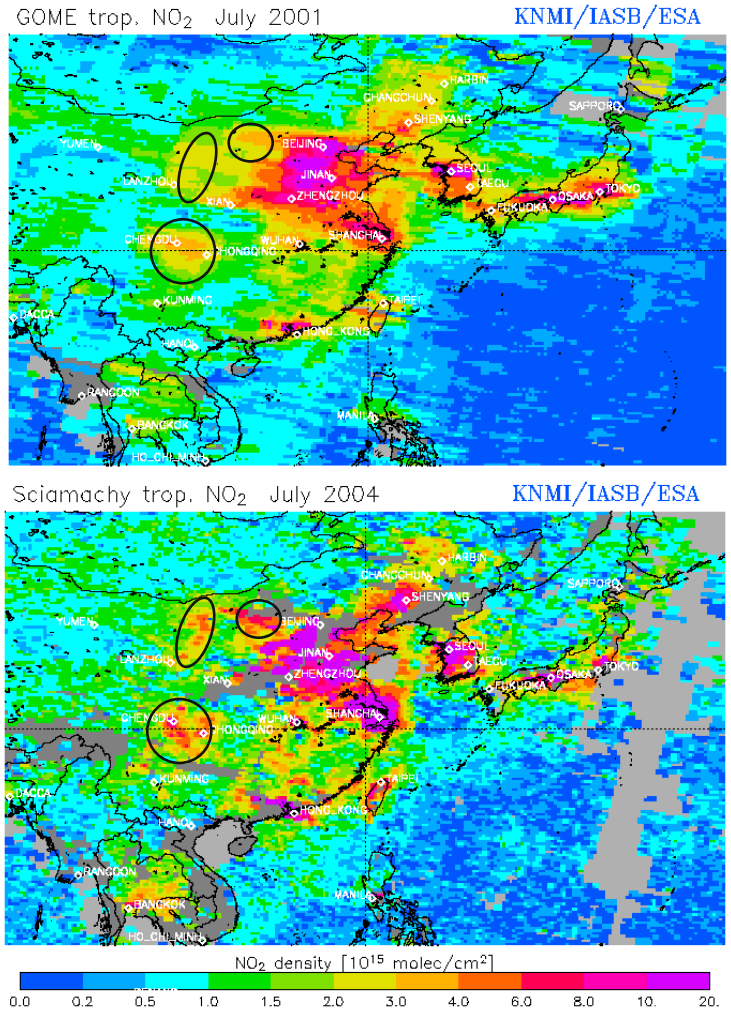


Topics for this presentation

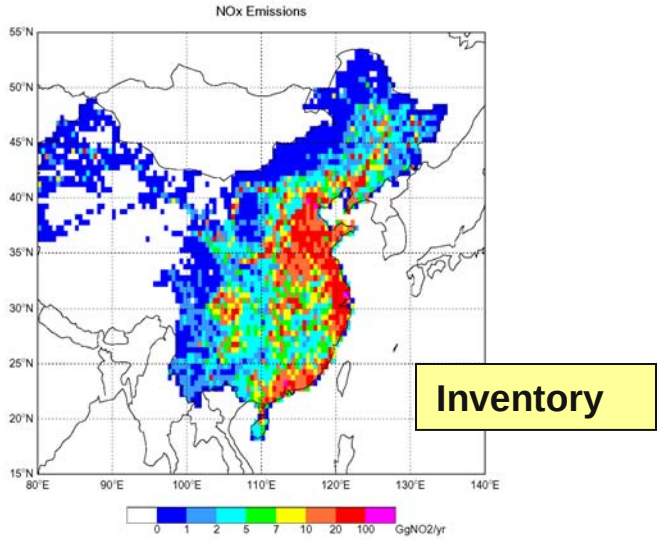
- Detection of NO_2 from new power plants (in Inner Mongolia) and beginnings of quantification of emissions
- Preliminary work to study the period of the 2008 Beijing Olympic games (NO_2 and SO_2)
- Preliminary work to quantify annual SO_2 emission reductions in China since 2006

In previous work, we found that satellites have observed new power-plant construction in China in recent years (2001-2004), through detection of their NOx emissions

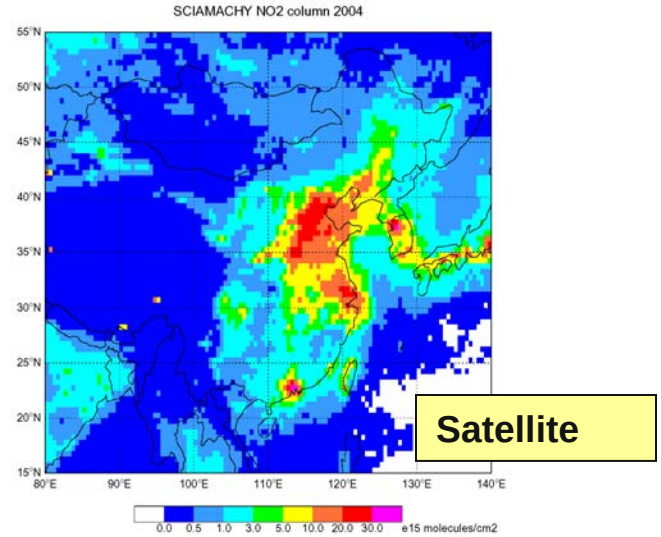




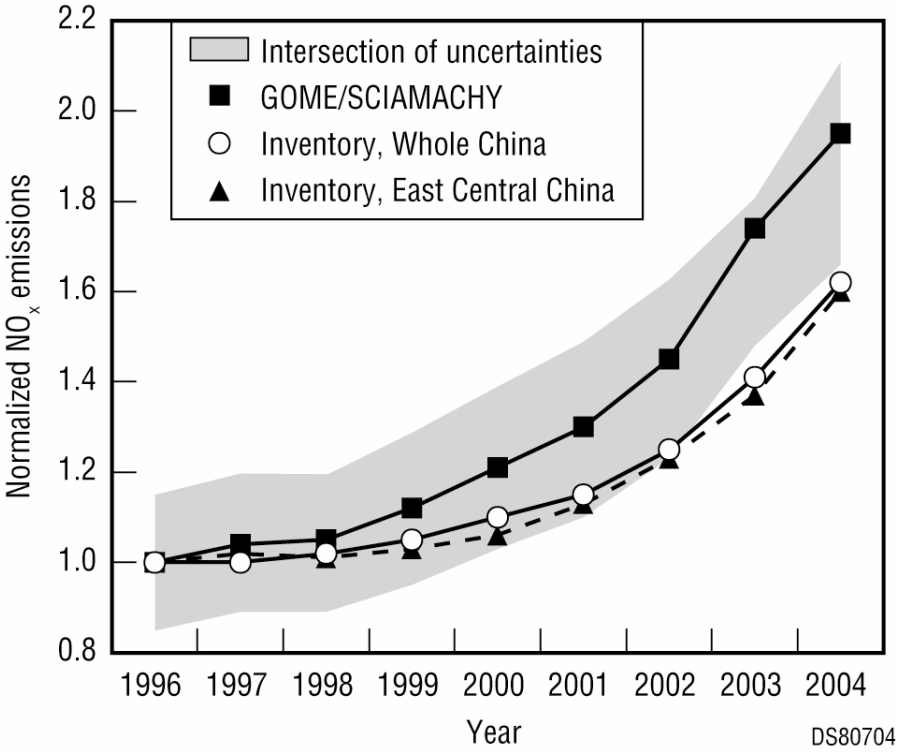
We have also reported on a new bottom-up NOx emission inventory for China and comparison with satellite observations



Inventory

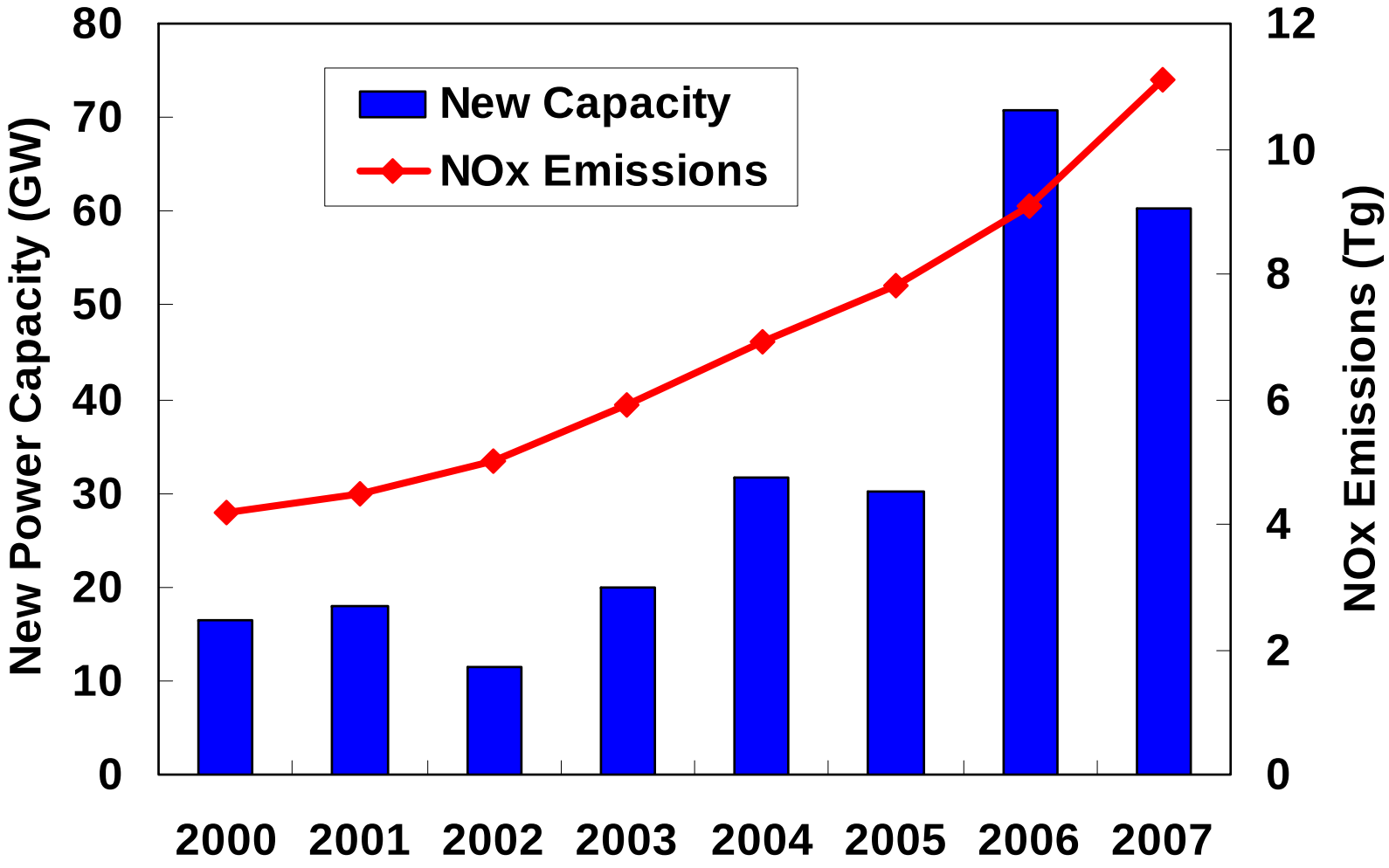


Satellite

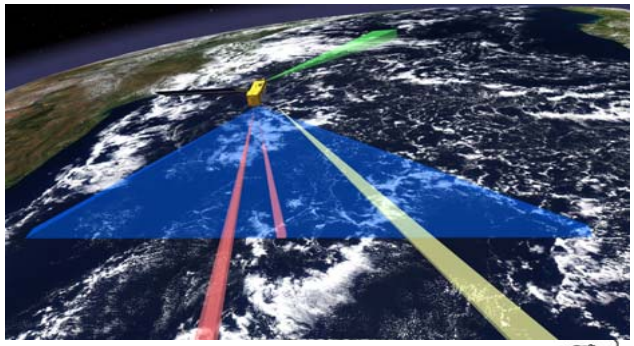


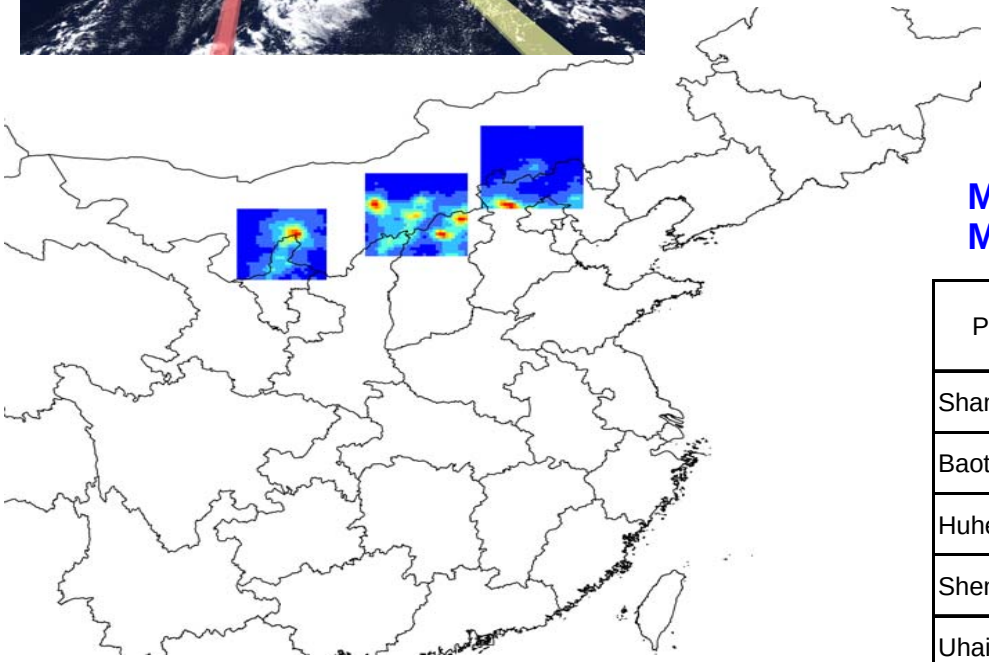
Zhang et al., JGR, 2007

The recent rapid increase of NOx emissions in China is largely attributed to the construction of new power plants



We are exploring the potential of monitoring the change of power plant emissions in China from space





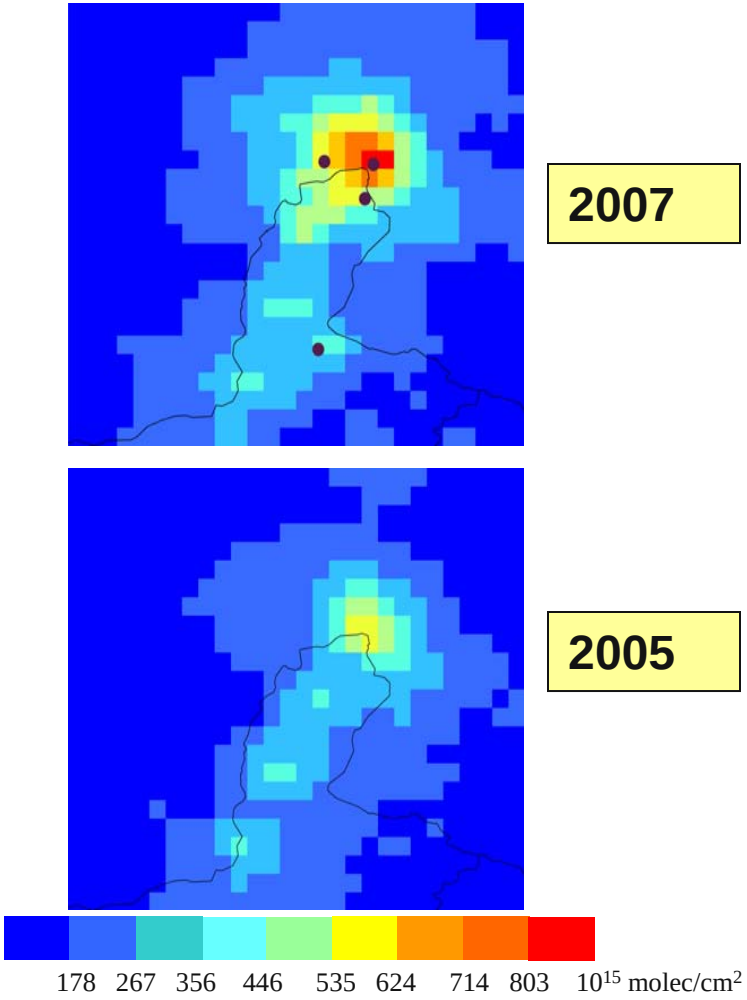
We selected Inner Mongolia for a case study

We compared the inventory and satellite data by pixel in the region where new power plants are located

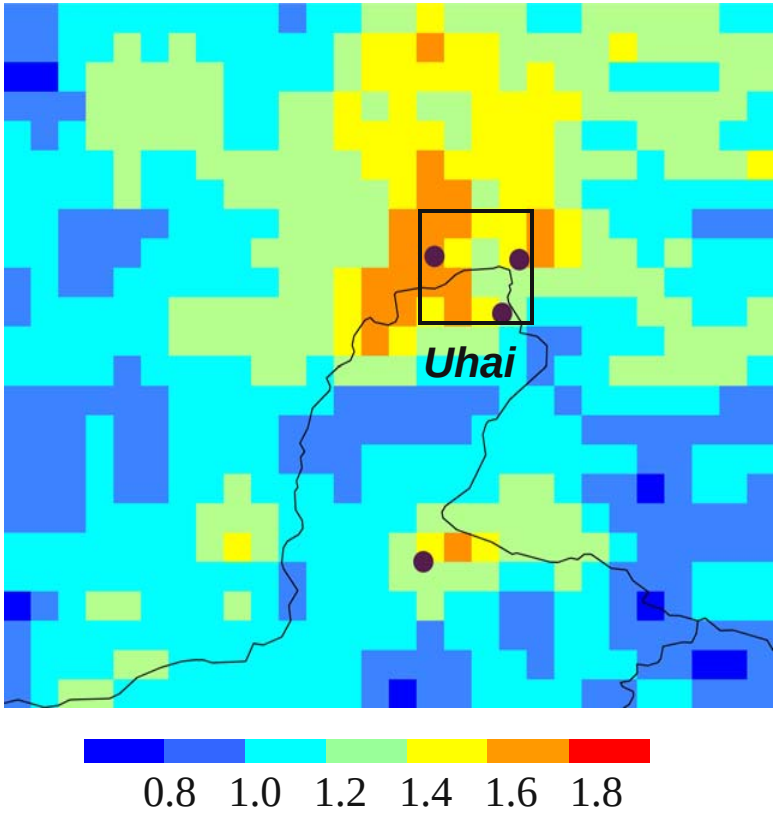
Major new large power plants built in Inner Mongolia in 2006 and 2007

Power plant name	Capacity (MW)	Year of build	NOx emissions (ton/month)
Shangdu	1800	2006-2007	1726
Baotou power cluster	2825	2006-2007	3310
Huhehaote	2400	2005-2006	2803
Shenmu (in Shaanxi)	1200	2006-2007	1465
Uhai power cluster	1870	2005-2006	2610

Satellite-observed NO_2 columns near new power plants (shown by ●) show significant increases between 2005 and 2007



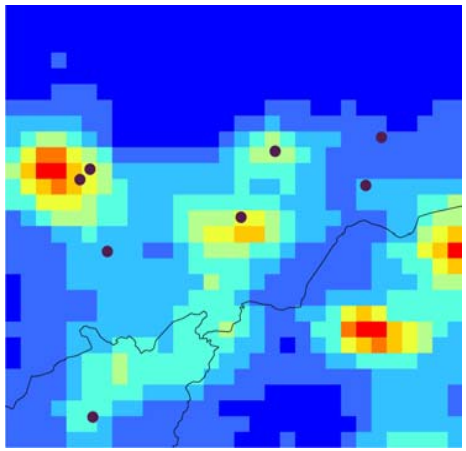
OMI NO_2 columns



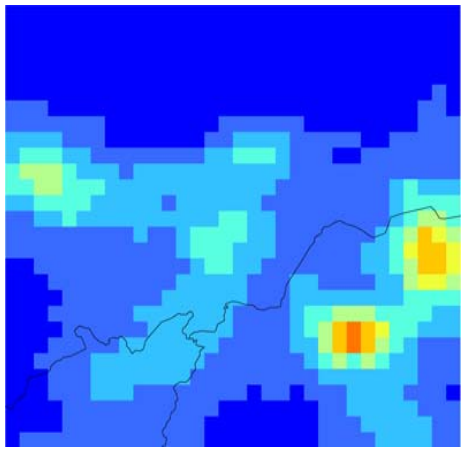
Ratio of OMI NO_2 columns between 2007 and 2005

[pixel size = 0.125° (~12 km)]

Central Inner Mongolia

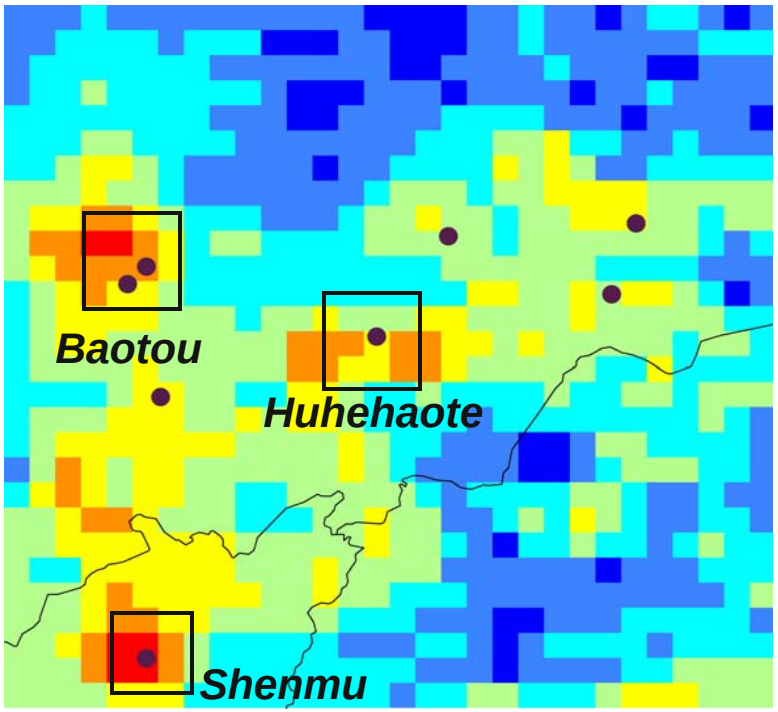


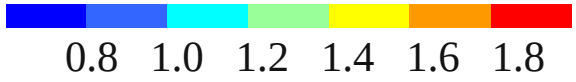
2007



2005

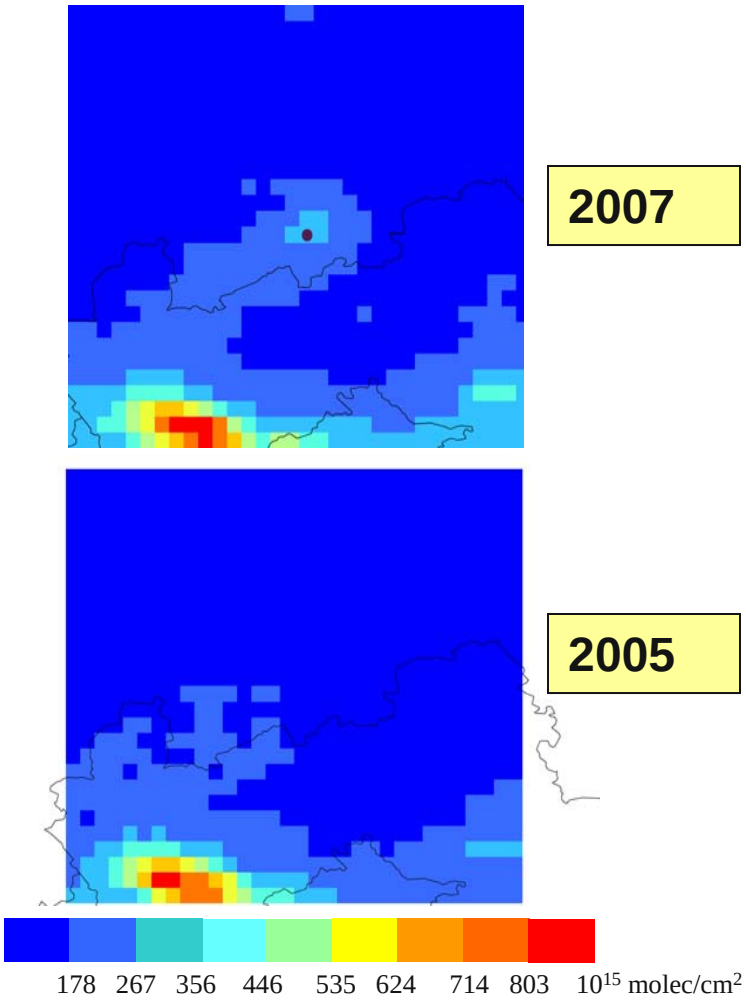
OMI NO_2 columns



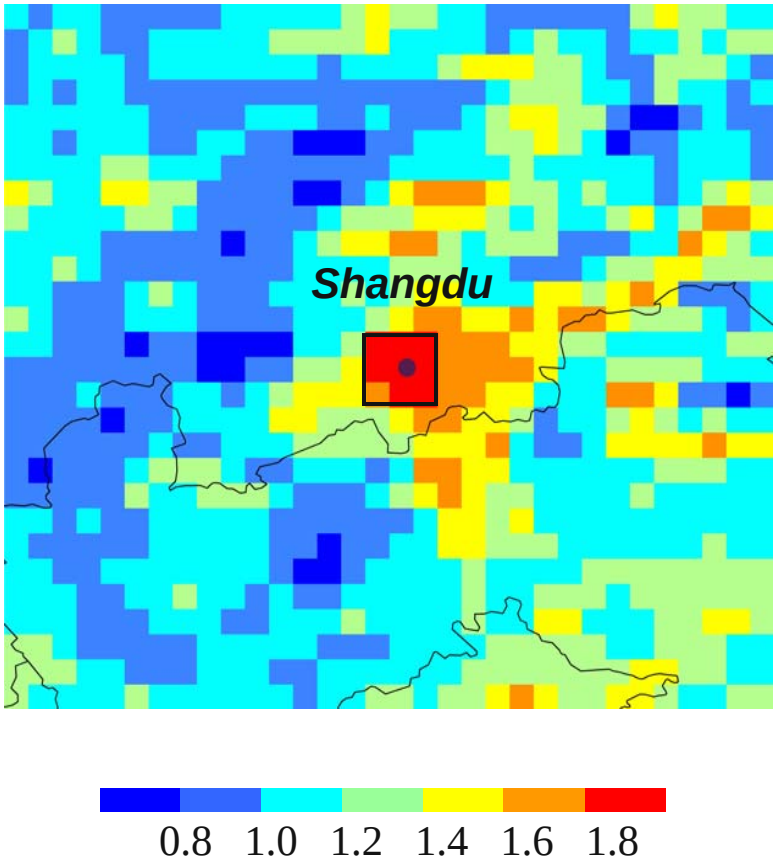


Ratio of OMI NO_2 columns between 2007 and 2005

Eastern Inner Mongolia

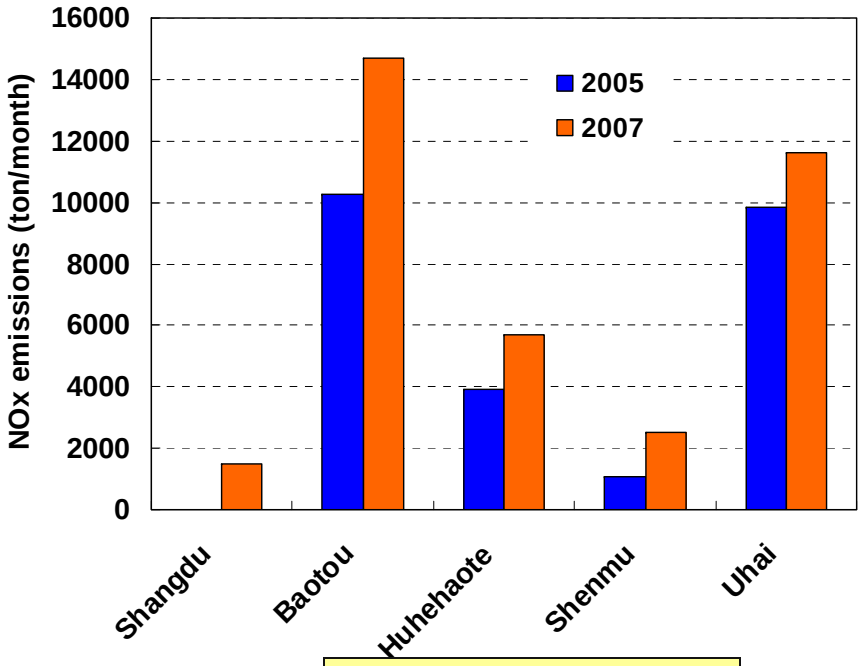


OMI NO_2 columns

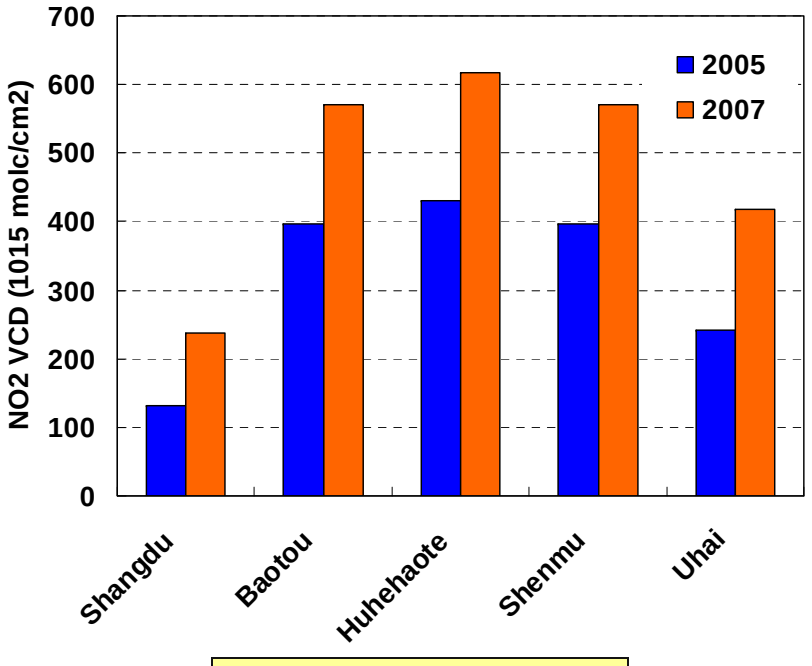


Ratio of OMI NO_2 columns between 2007 and 2005

Trends in emission inventory and satellite agree well even at this fine spatial resolution



NOx Emissions

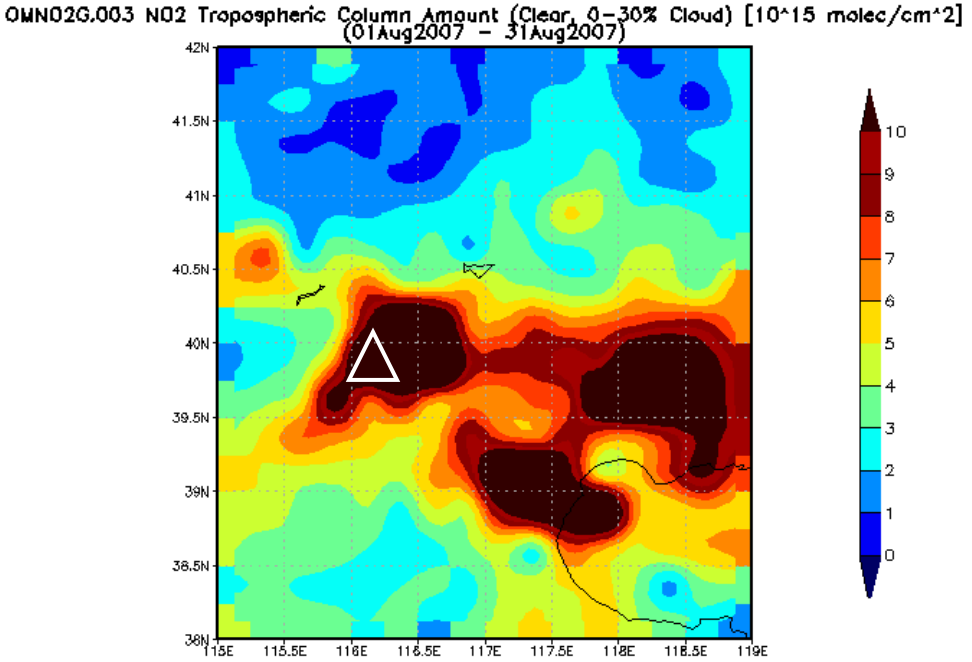


NO_2 Columns

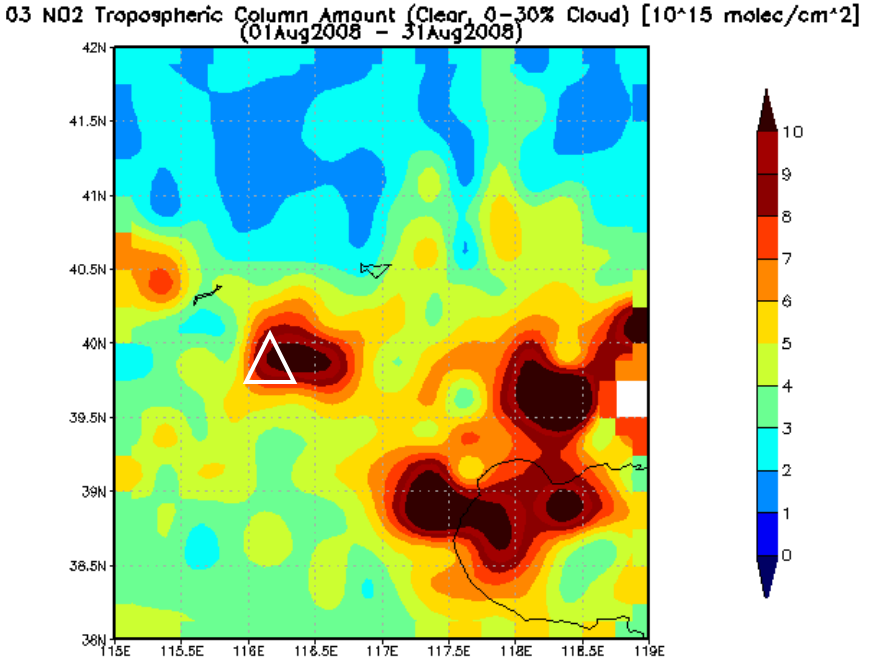
The increase rates of NOx emissions and NO_2 columns agree very well in the two urban regions (Baotou and Huhehaote).

In the regions where emissions from power plants are dominant, NOx emissions show a larger increase rate than NO_2 columns (Shangdu and Shenmu). This is probably due to absence of dispersed NO_2 in rural areas in 2005 in the inventory.

Satellites observed significant NO_2 decreases during the period of the Olympic Games (OMI NO_2 tropospheric columns processed by NASA)

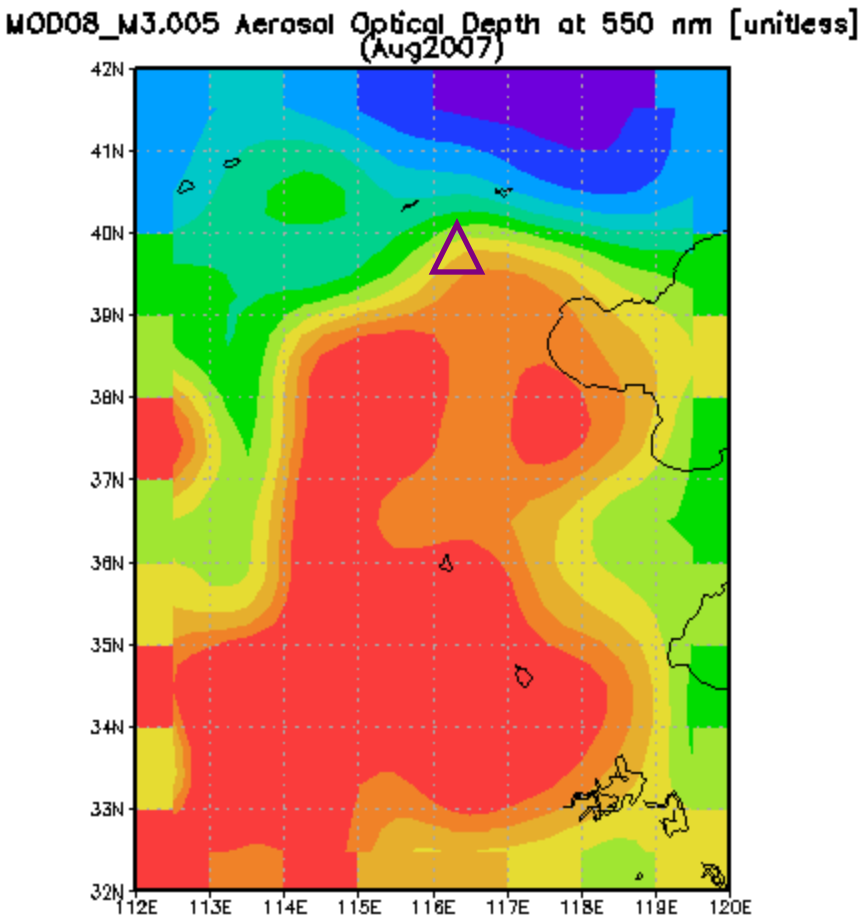


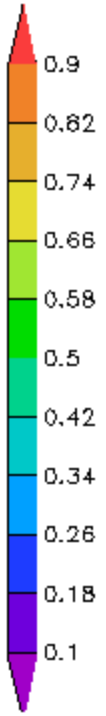
August 2007

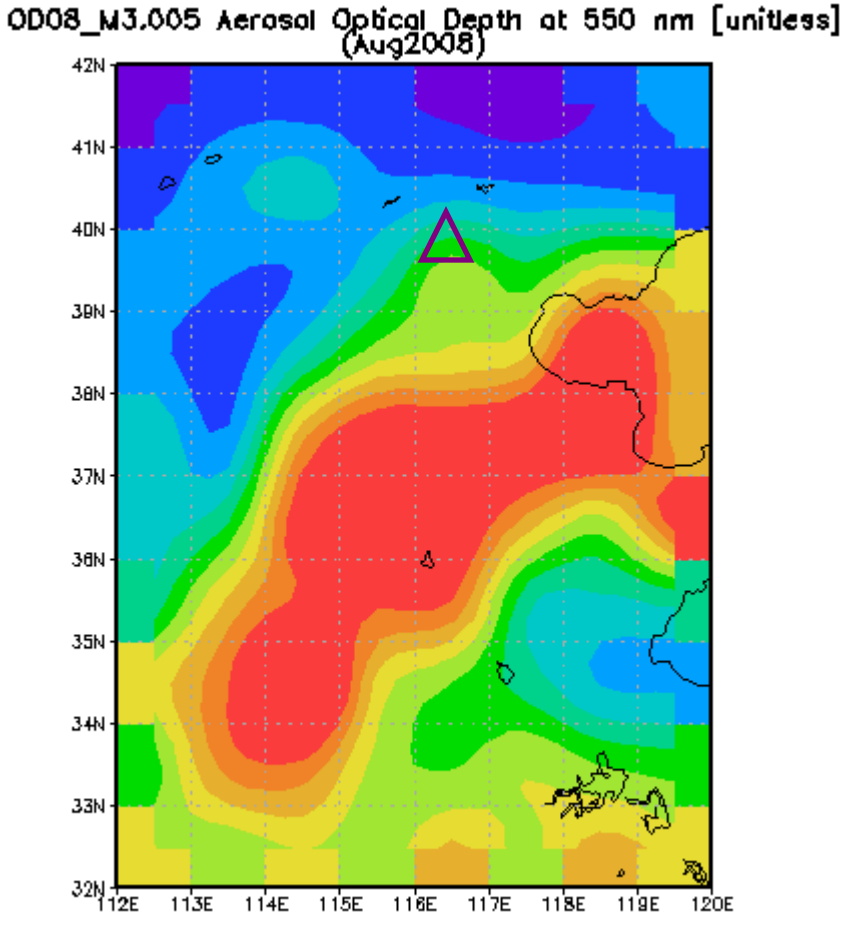


August 2008

Satellites also observed significant AOD decreases during the Olympic Games (MODIS AOD processed by NASA)



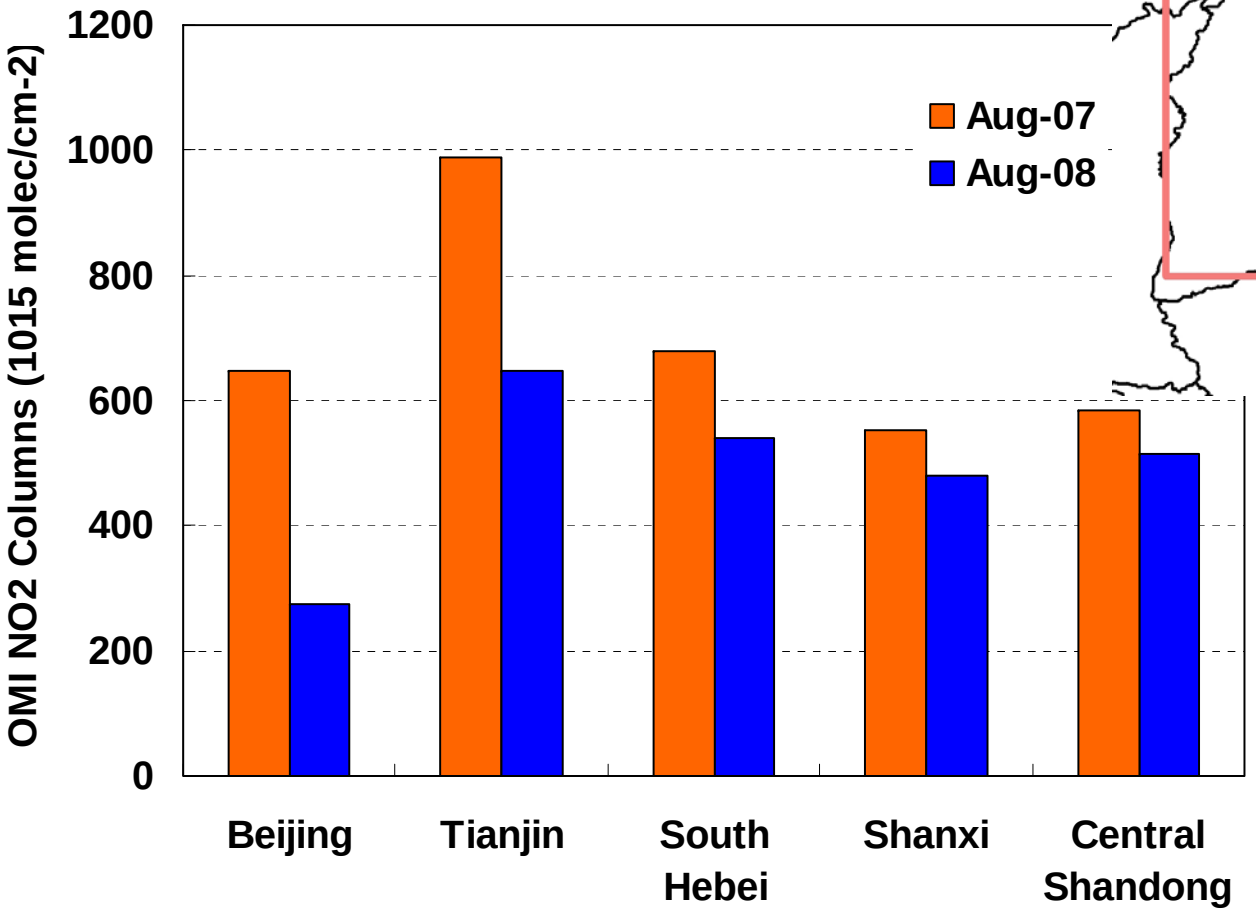


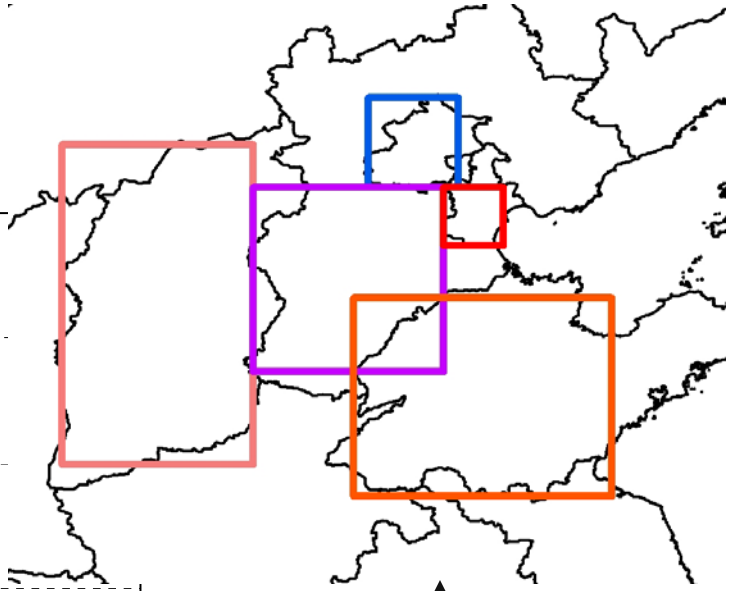


August 2007

August 2008

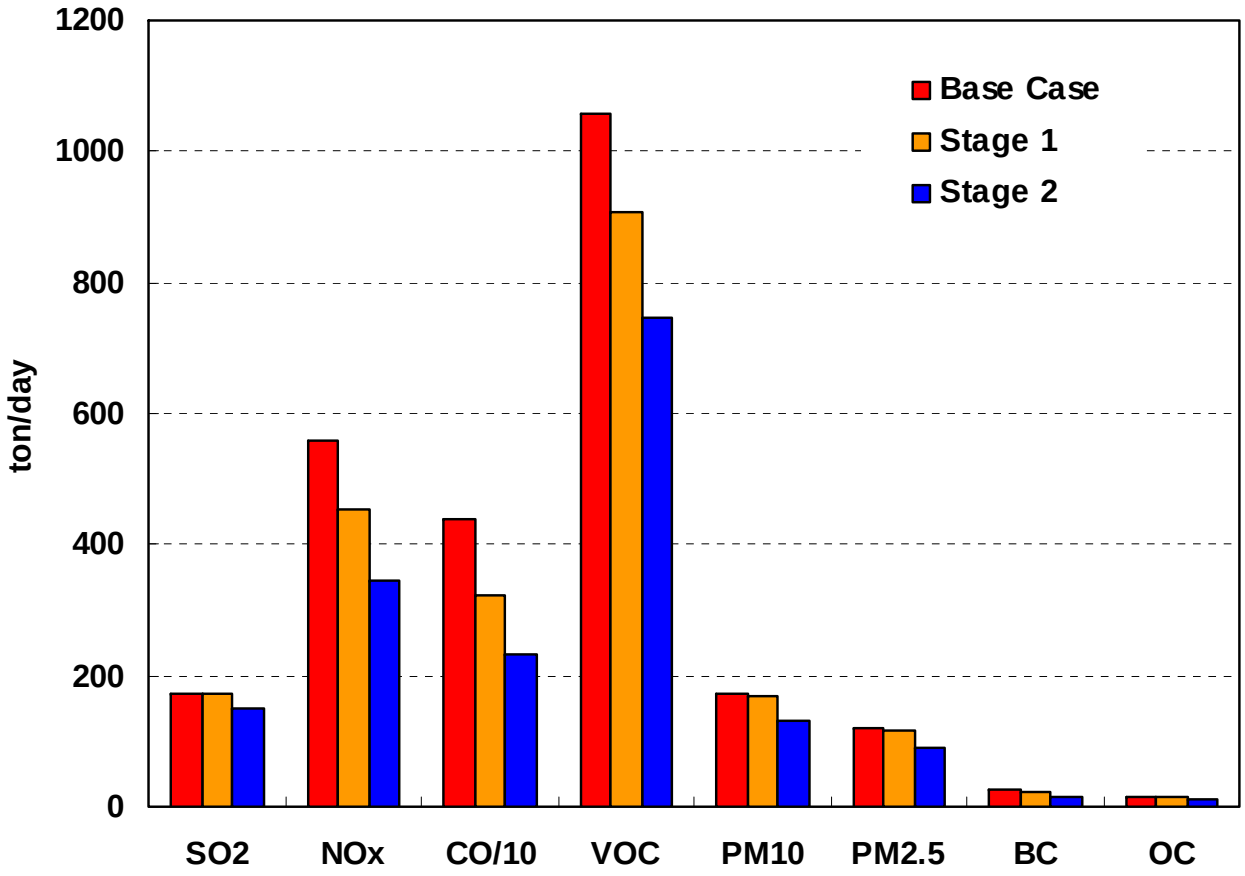
NO_2 decreases were observed in Beijing as well as all its neighboring provinces





We processed OMI NO_2 columns in these boxes for August 2007 and 2008

Daily emissions during the Beijing Olympic Games are being prepared by Argonne and Tsinghua for use in CTM modeling

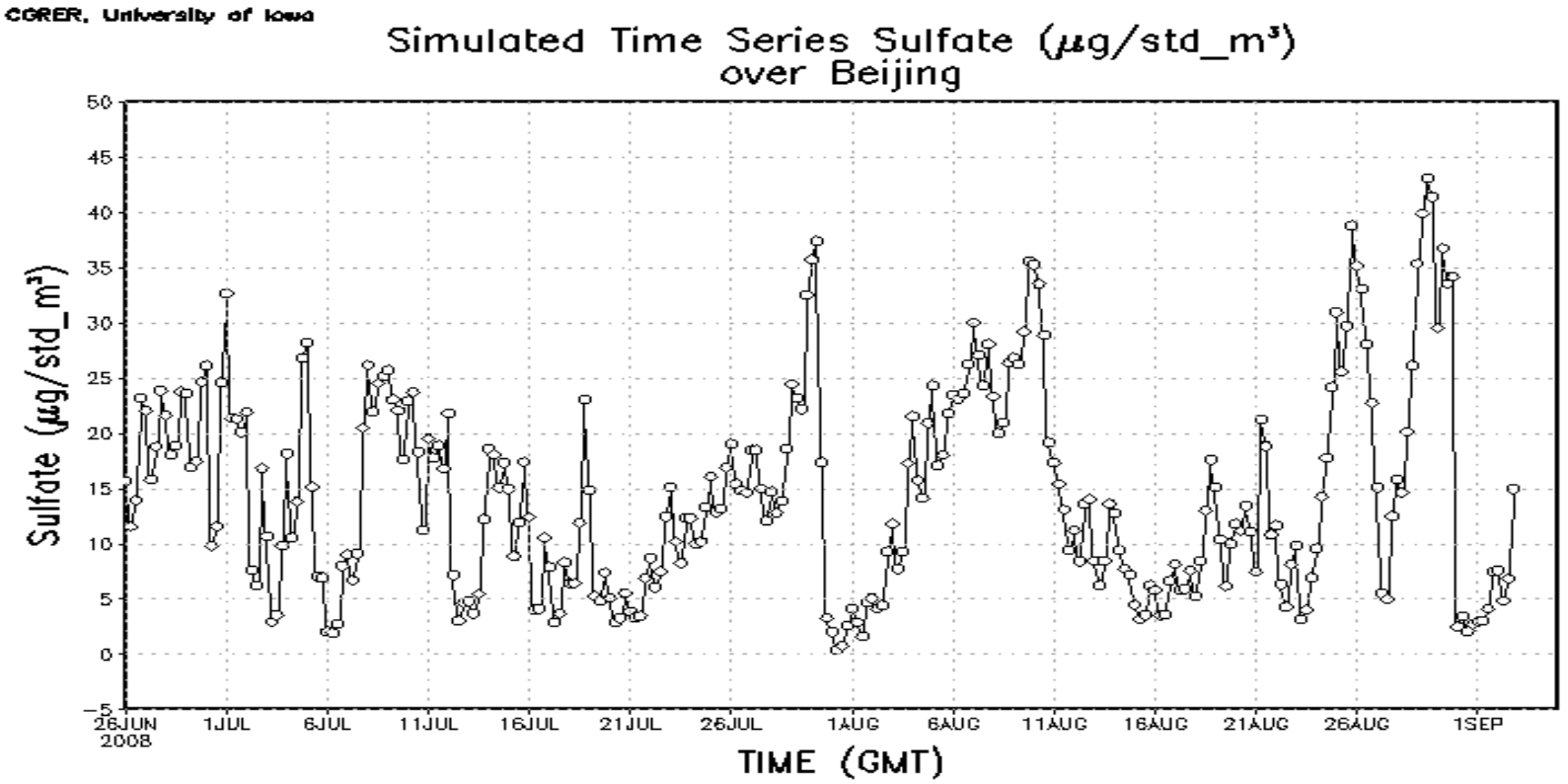


Base Case: Before July 1

Stage 1 controls: July 1-20

Stage 2 controls: After July 20

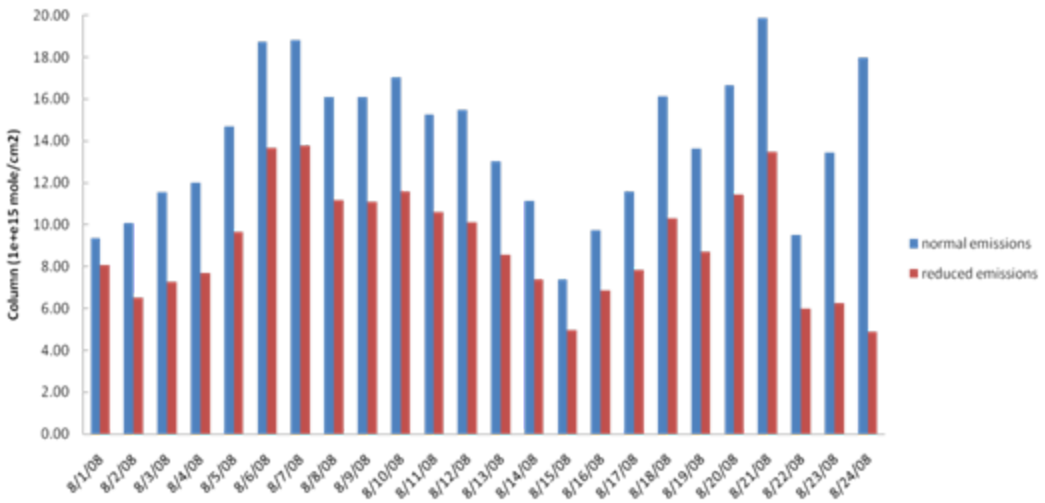
The University of Iowa is running the STEM model with normal and reduced emissions for Beijing (ongoing work)



Can we successfully model NO_2 and SO_2 columns?
Over what scales can we detect the signal?
To what extent can we attribute the signal?

Modeling of NO_2 and SO_2 columns over Beijing

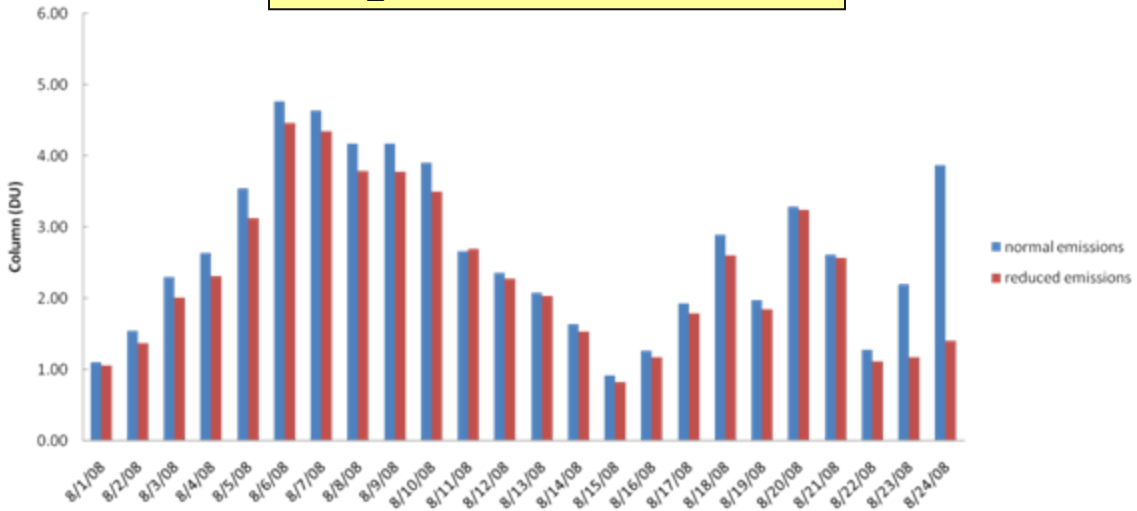
NO_2 for August 1-24



Normal emissions

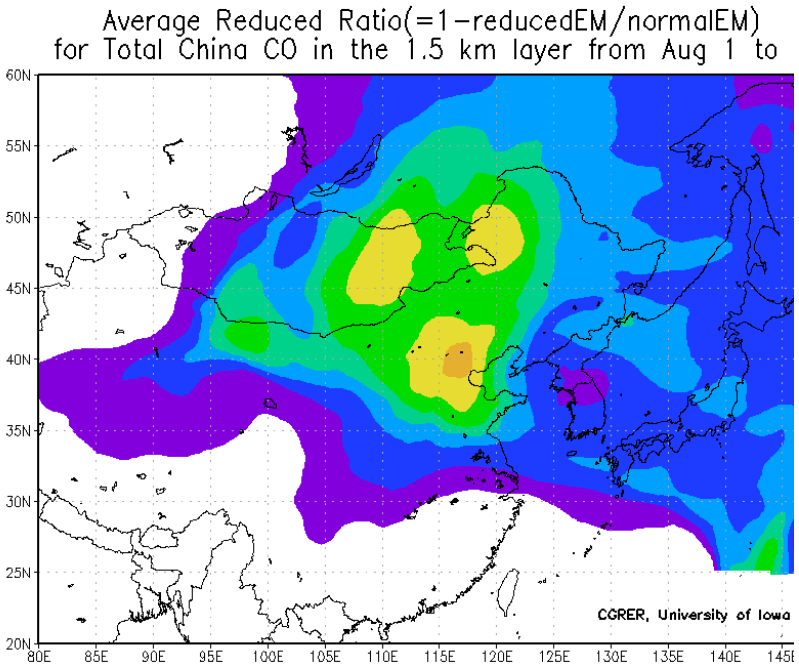
Reduced emissions

SO_2 for August 1-24

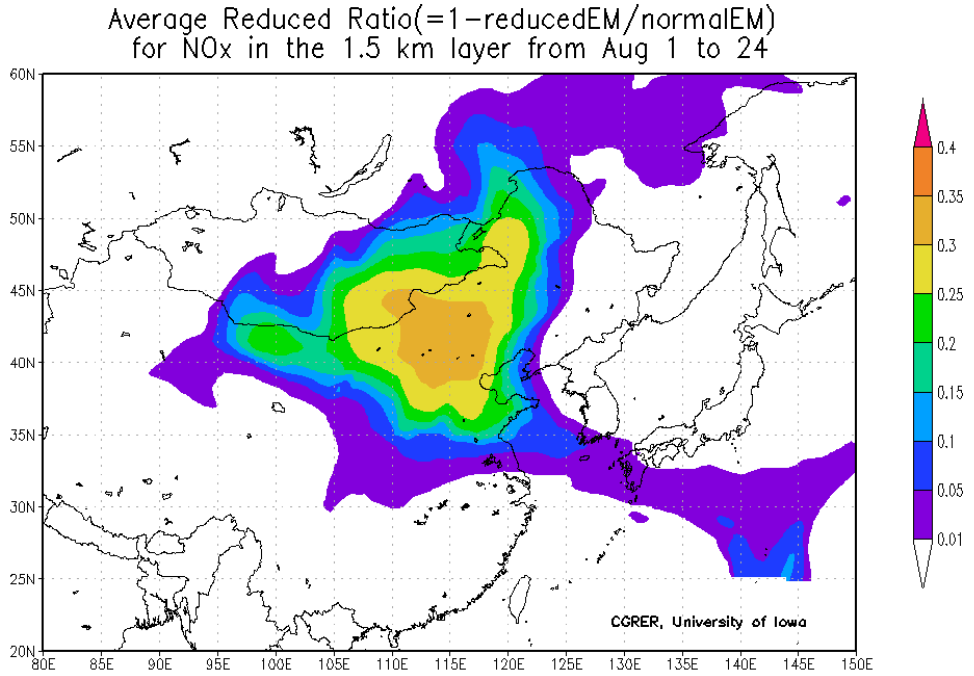


Meteorology and chemistry modulate the relationship between emissions and columns. (The summer of 2008 was much wetter than 2007.)

Predicted footprints of the Olympic Games emission controls (average changes for August 2008 in the 1.5 km layer)

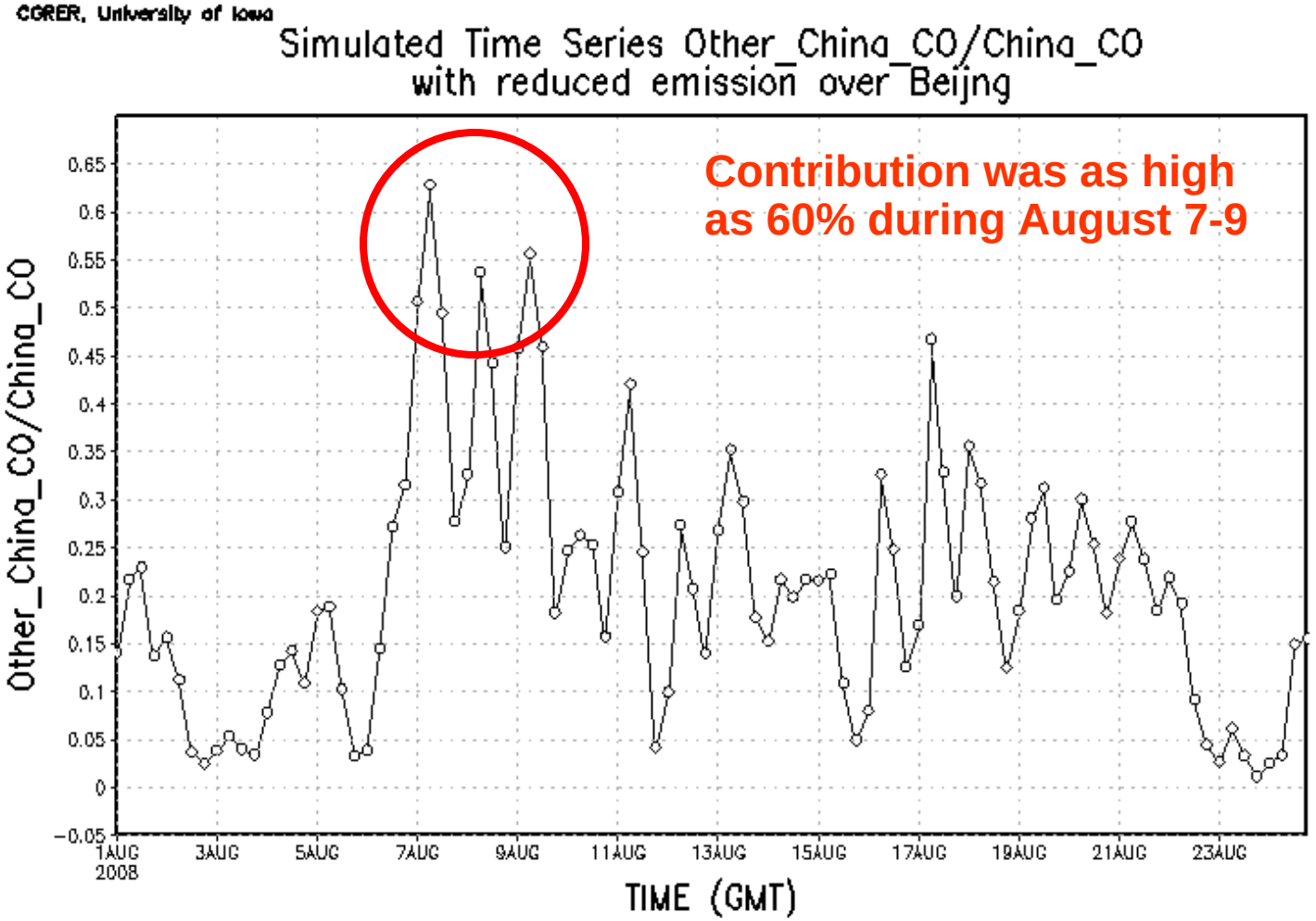


CO

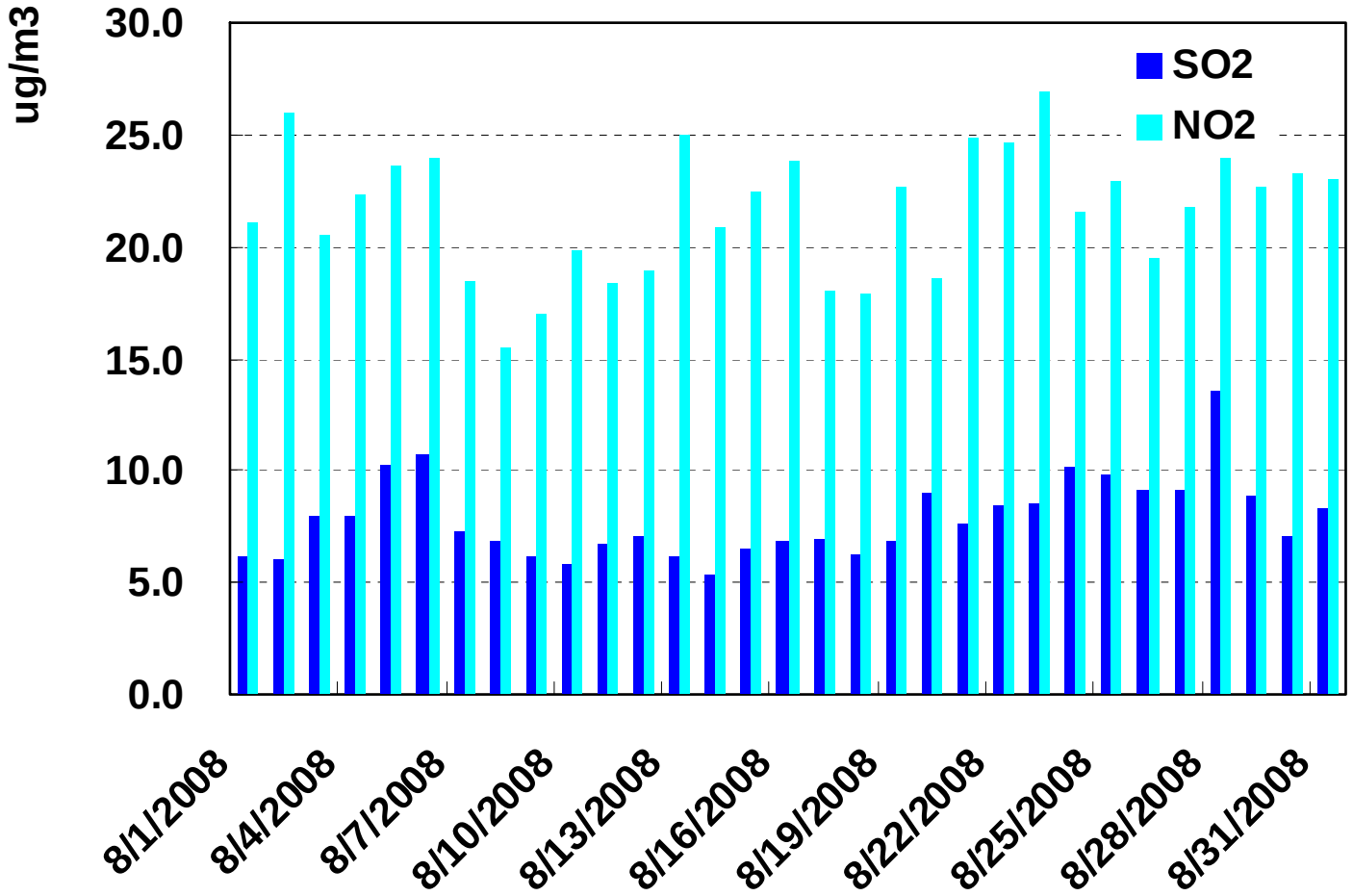


NOx

Contribution of sources outside Beijing during Olympic Games

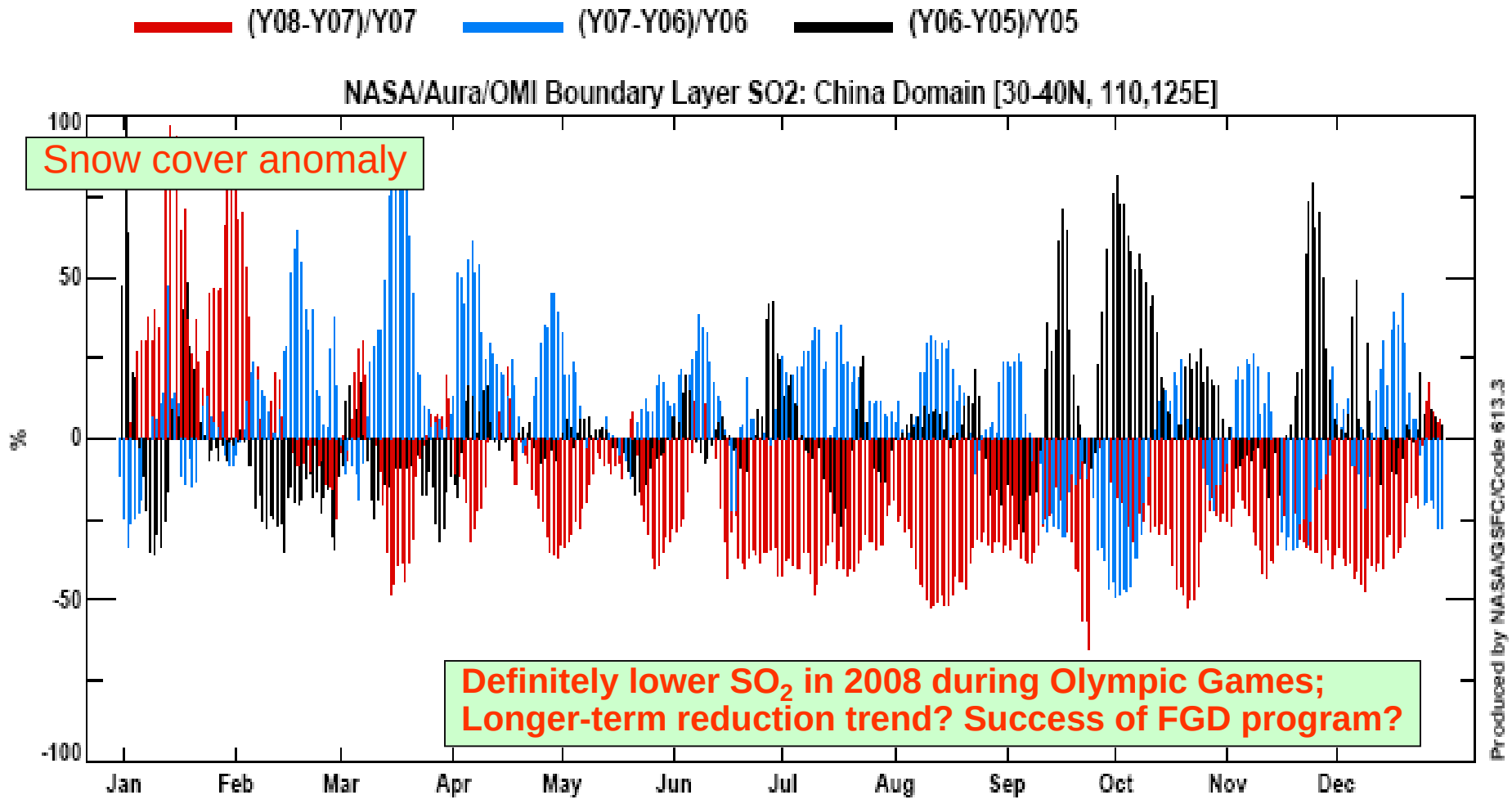


Daily SO_2 and NO_2 concentrations in Beijing in August 2008



Concentration data from http://www.bjepb.gov.cn, average concentrations from 27 monitoring stations around Beijing

Differences in OMI SO_2 retrievals around Beijing, 2005-2008



Conclusions and future work

- Satellite observations of chemical species in the boundary layer offer great prospects for informing regional air quality management
- For NO_2, the techniques are quite mature; but for SO_2 the signal is much weaker and requires sophisticated retrieval processing
- We can already identify groups of sources with confidence and some strong individual sources
- We can quantify monthly/annual emission trends over large regions, but cannot yet be quantitative for small regions and individual sources
- The integration of CTM columns in the future should greatly improve analytical power by incorporating the effects of meteorology and transport on emissions

Acknowledgments

This work is funded by NASA's Program on Decision Support through Earth Science Research results (Lawrence Friedl) and by US EPA's ICAP program (Carey Jang)