The Role of Satellite Remote Sensing in Understanding Emissions in China

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Why do we care emissions from China?


COMMENT

Rapid economic growth means that the air in some Chinese cities, such as Beijing, contains more fine particles than the World Health Organization recommends.

Cleaning China's air

To reduce airborne soot, organics and sulphates, tailored strategies for each must be established and coal use limited, say **Qiang Zhang**, **Kebin He** and **Hong Huo**.

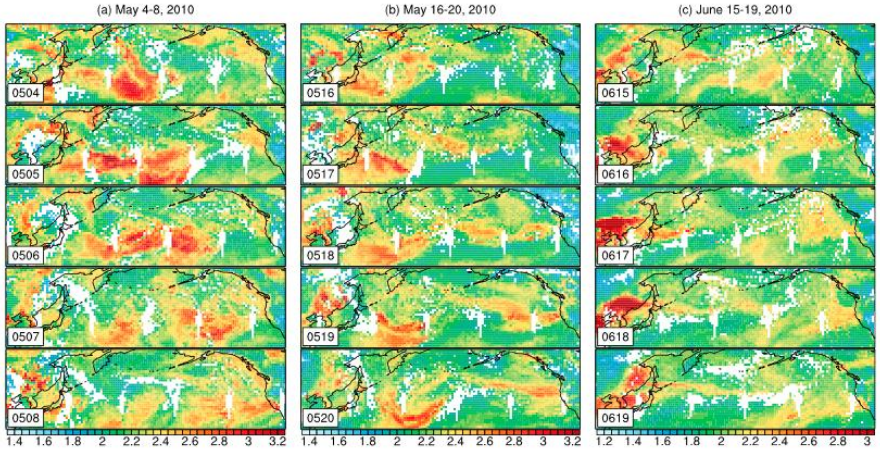
On 29 February this year, China's State Council approved its first national environmental standard for limiting

undue influence to local officials who favour economic development.

Controlling air quality in China will

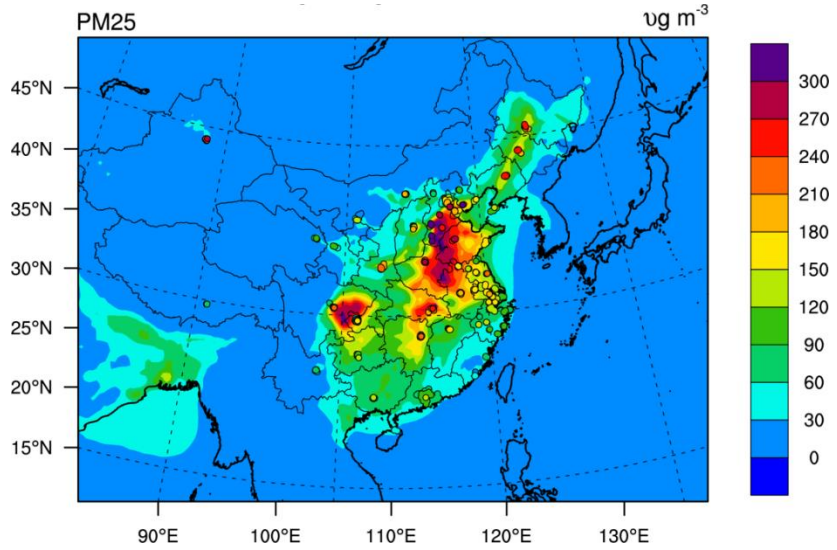
detrimental effect on climate[3]. Thought is therefore needed as to how the various pollutants and sources should be best con-

Intercontinential transport of air pollution

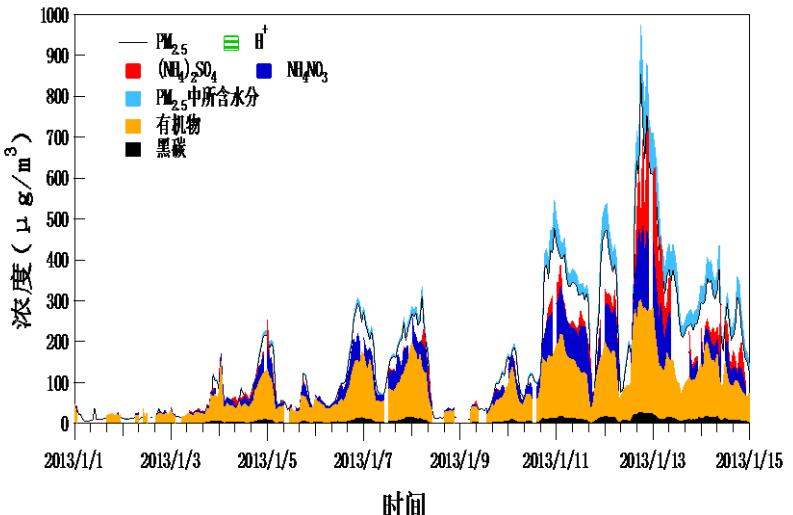


Lin et al., JGR, 2012

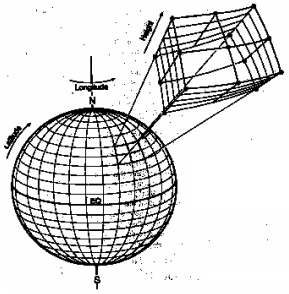
CMAQ $PM_{2.5}$ concentration, Jan 2013



$PM_{2.5}$ concentration in Beijing, Jan 2013



Approaches for quantifying emissions



Palmer et al., JGR, 2003

Kopaz et al., ACP, 2010

Inverse model

Richter et al., Nature, 2005

Beirle et al., Science, 2011

Satellite

Bottom-up

Top-down

Emissions

Biomass

Anthropogenic

Natural

Andreae and Merlet, GBC, 2001

van der Werf, ACP, 2006

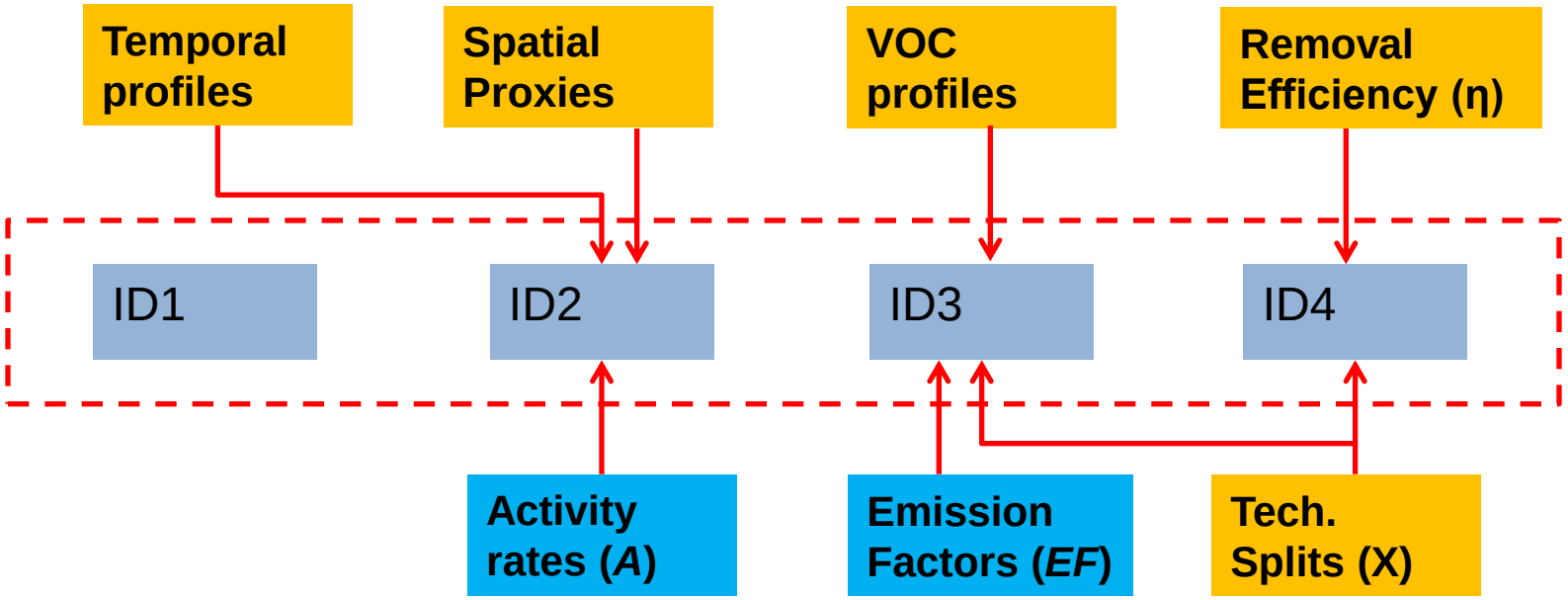
Streets et al., JGR, 2003

Smith et al., ACP, 2011

Guenther et al., AE, 2000

Guenther et al., ACP, 2006

Framework of the bottom-up emission inventory model



ID1: sectors

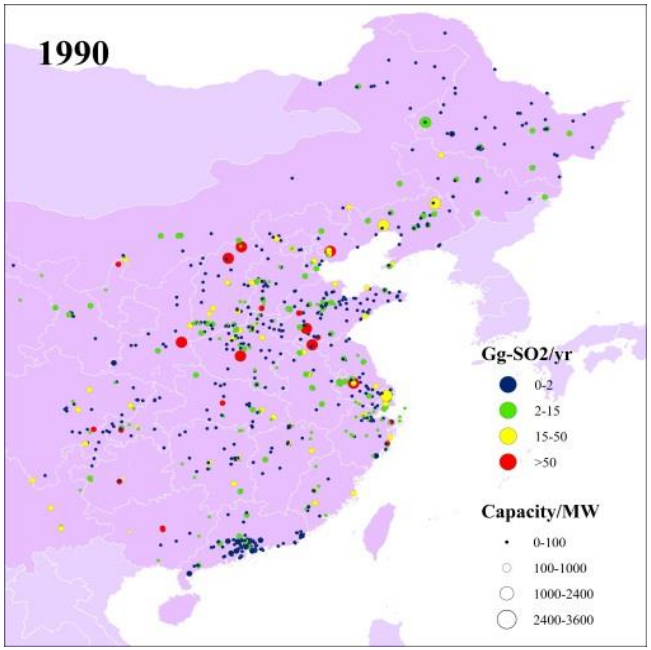
ID2: fuel/product

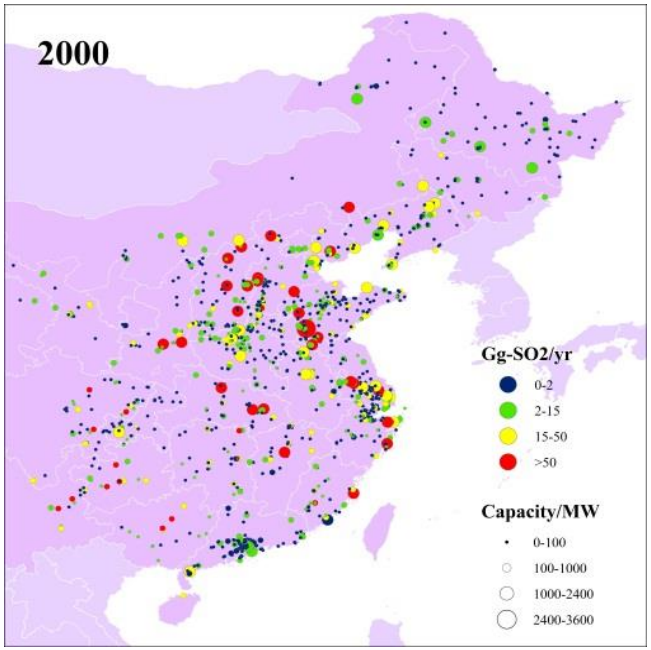
ID3: technology

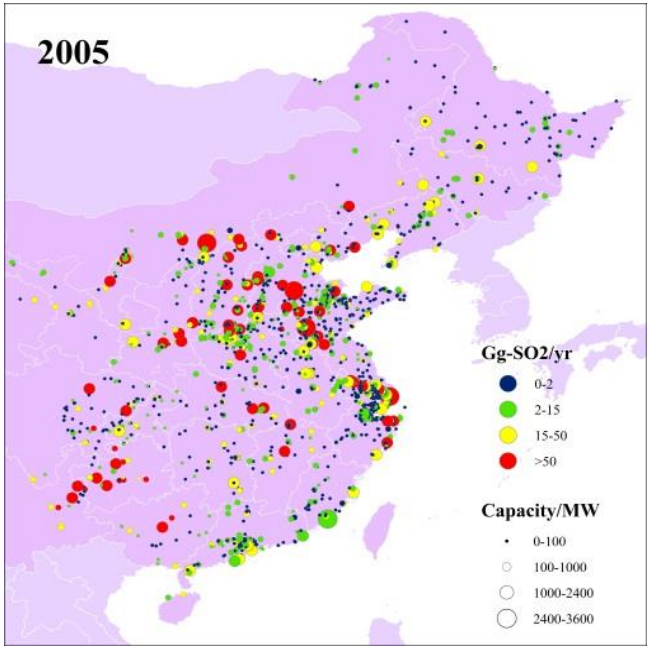
ID4: emission control

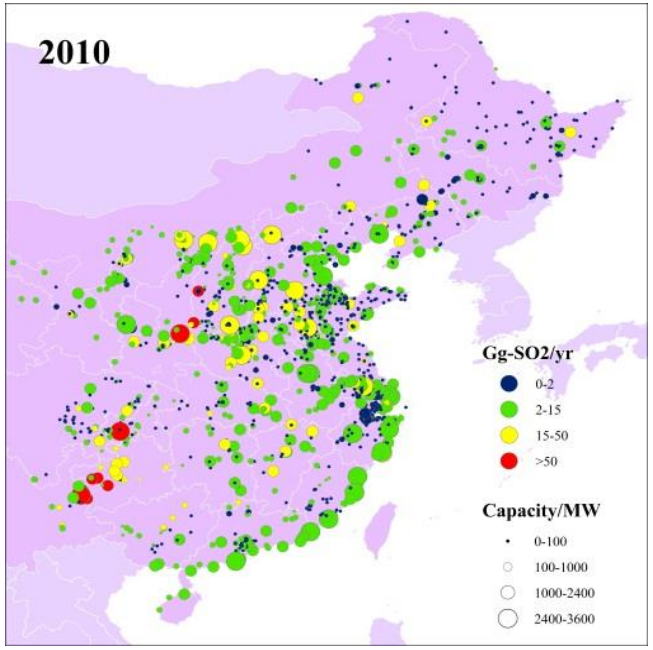
$$\text{Emissions} = A \times X \times EF \times (1-\eta)$$

A spatially resolved, unit-based emission inventory for power plants



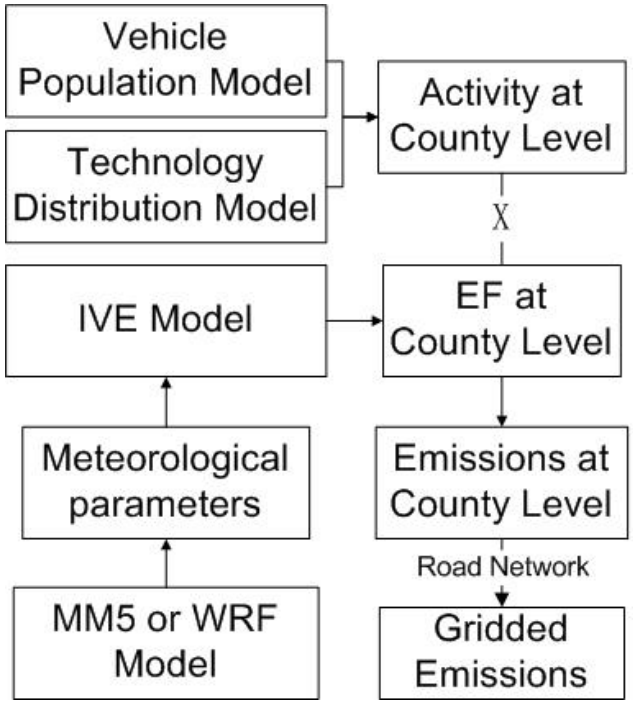


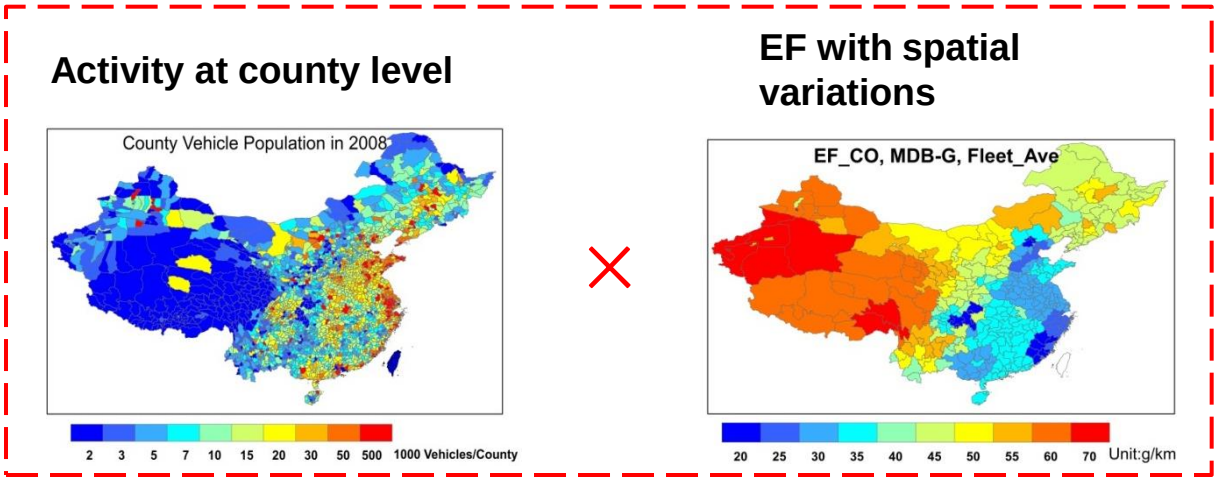


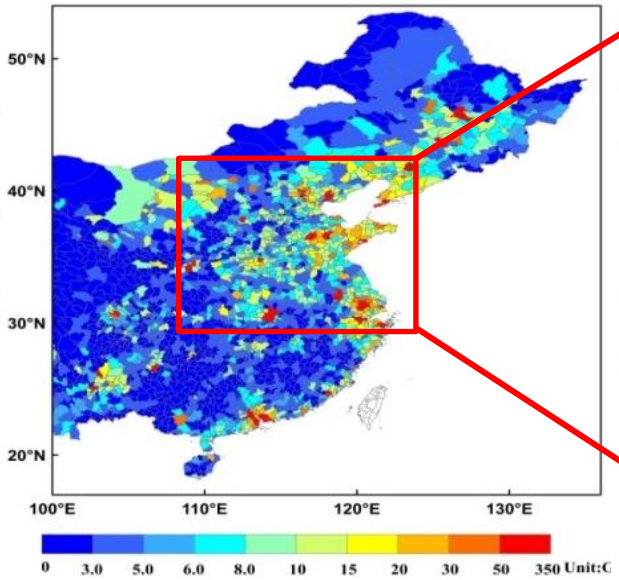


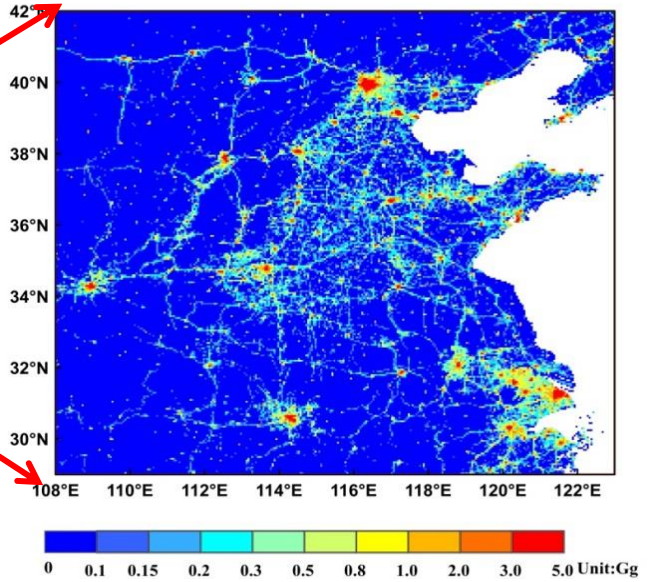
SO_2

Approach for a high spatial resolution vehicle emission inventory

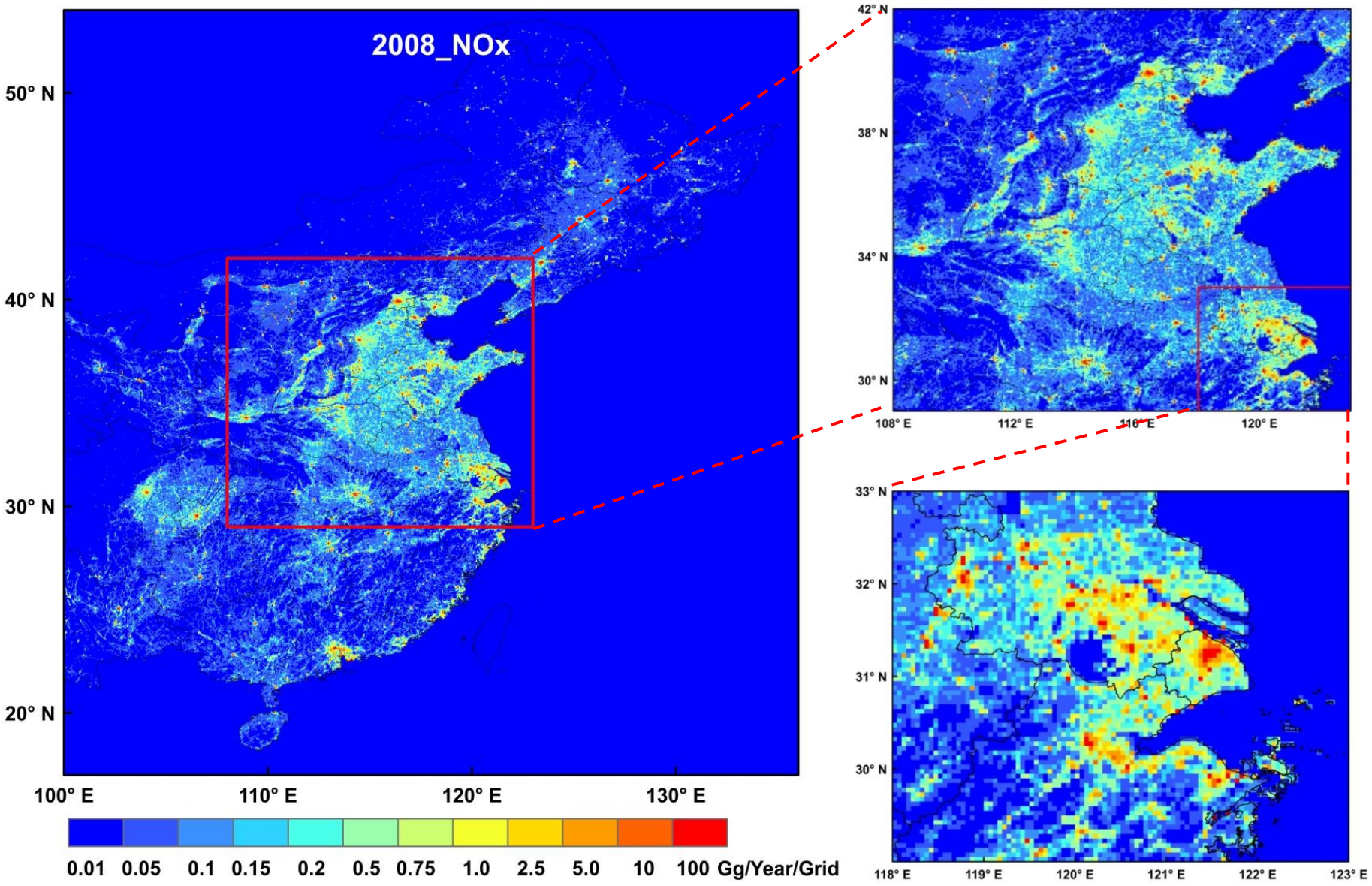








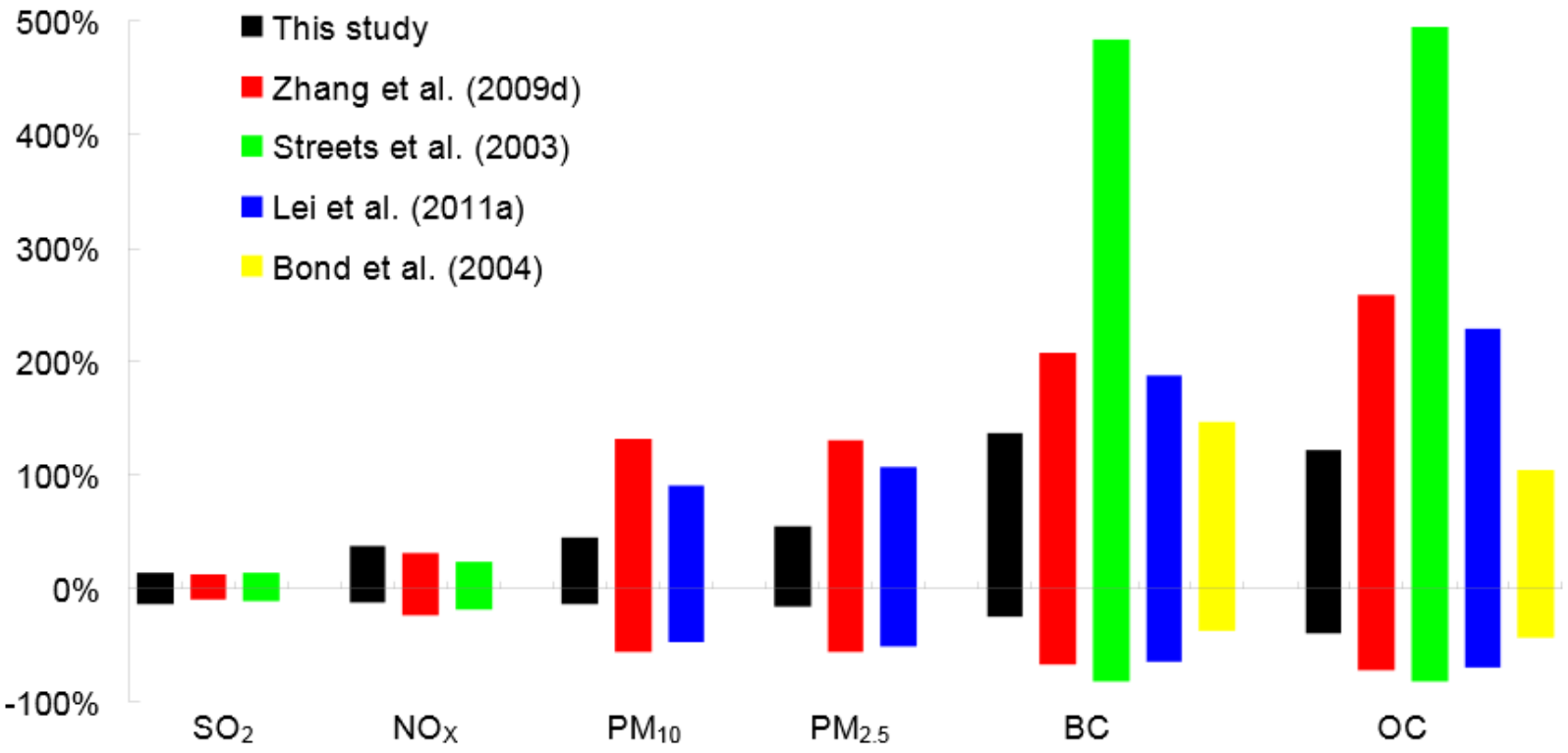
High resolution data in MEIC database: 2008 NO_x emissions at 0.05 x 0.05 degree (Not every species can get such high resolution!)



Bottom-up inventories are thought to be highly uncertain

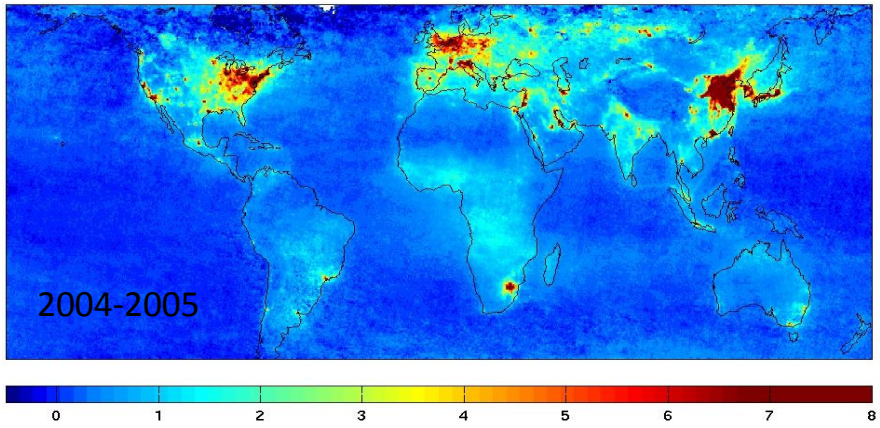
$$E_{i,n,y} = \sum_{j,k,l} A_{i,j,k,l,y} \sum_{m} [ef_{i,j,k,l,n}(1 - \eta_{i,k,m,n})X_{i,j,k,l,m,y}]$$

Klimont et al., 2009

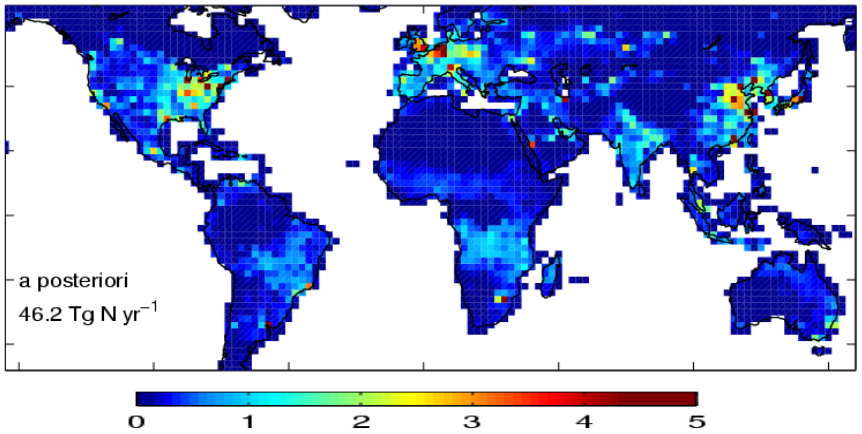


Zhao et al., ACP, 2011

Top-Down Estimates of NOx & SO2 Emissions

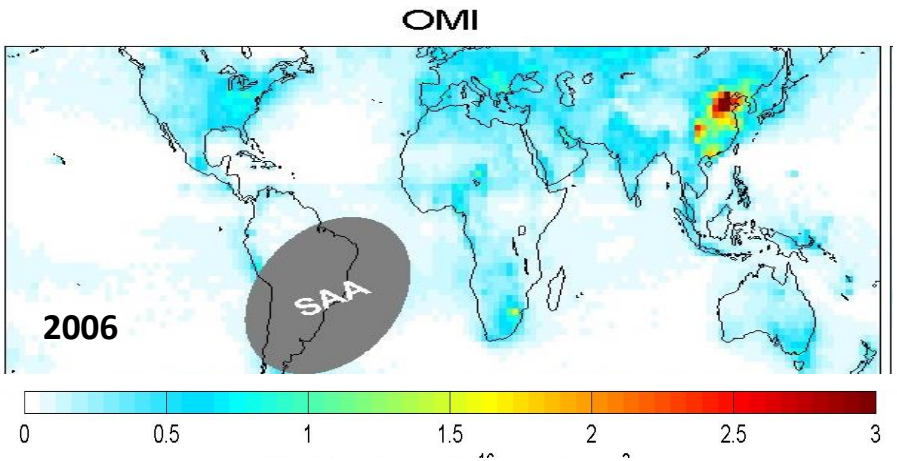


SCIAMACHY Tropospheric NO_2 (10^{15} molec cm^{-2})

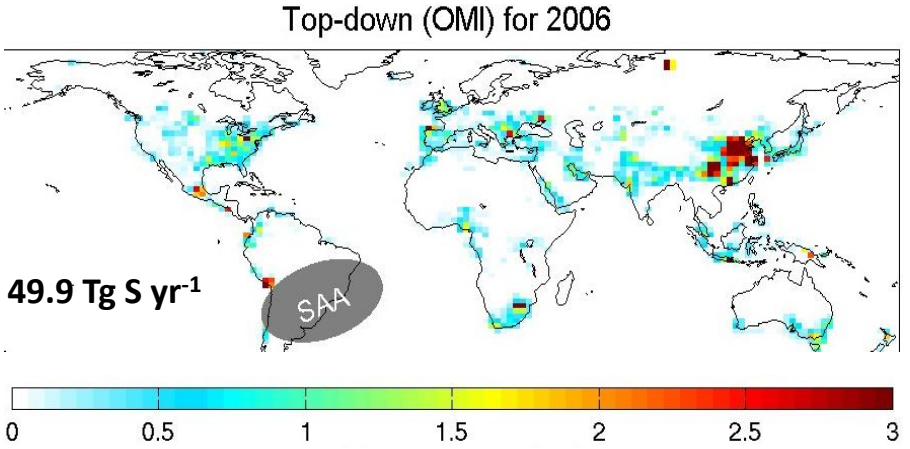


NO_x emissions (10^{11} atoms N cm^{-2} s^{-1})

Martin et al., 2006



OMI SO_2 (10^{16} molec cm^{-2})

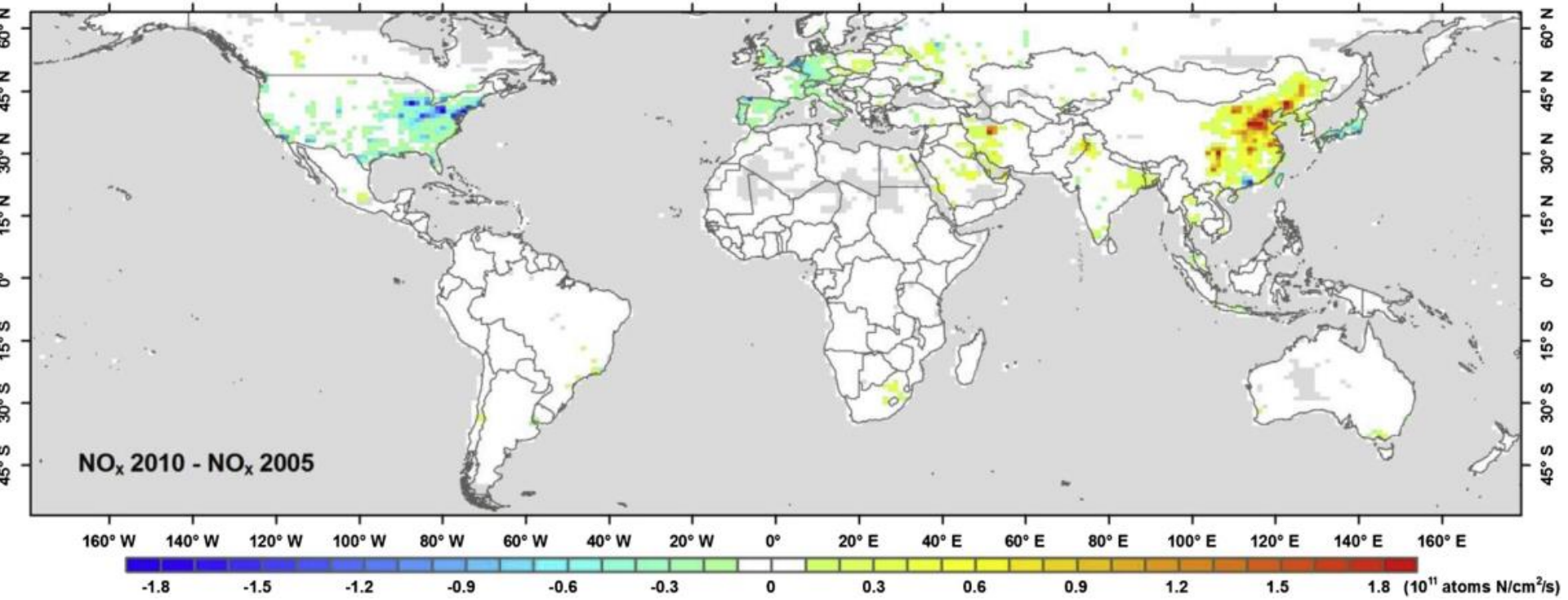


SO_2 emissions (10^{11} atoms N cm^{-2} s^{-1})

Lee et al., 2011

Application of Satellite Observations for Timely Updates to NOx Emission Inventories

Forecast Inventory for 2010 Based on Bottom-up for 2005 and Monthly OMI NO_2 for 2005-2010



2.5% increase in global emissions

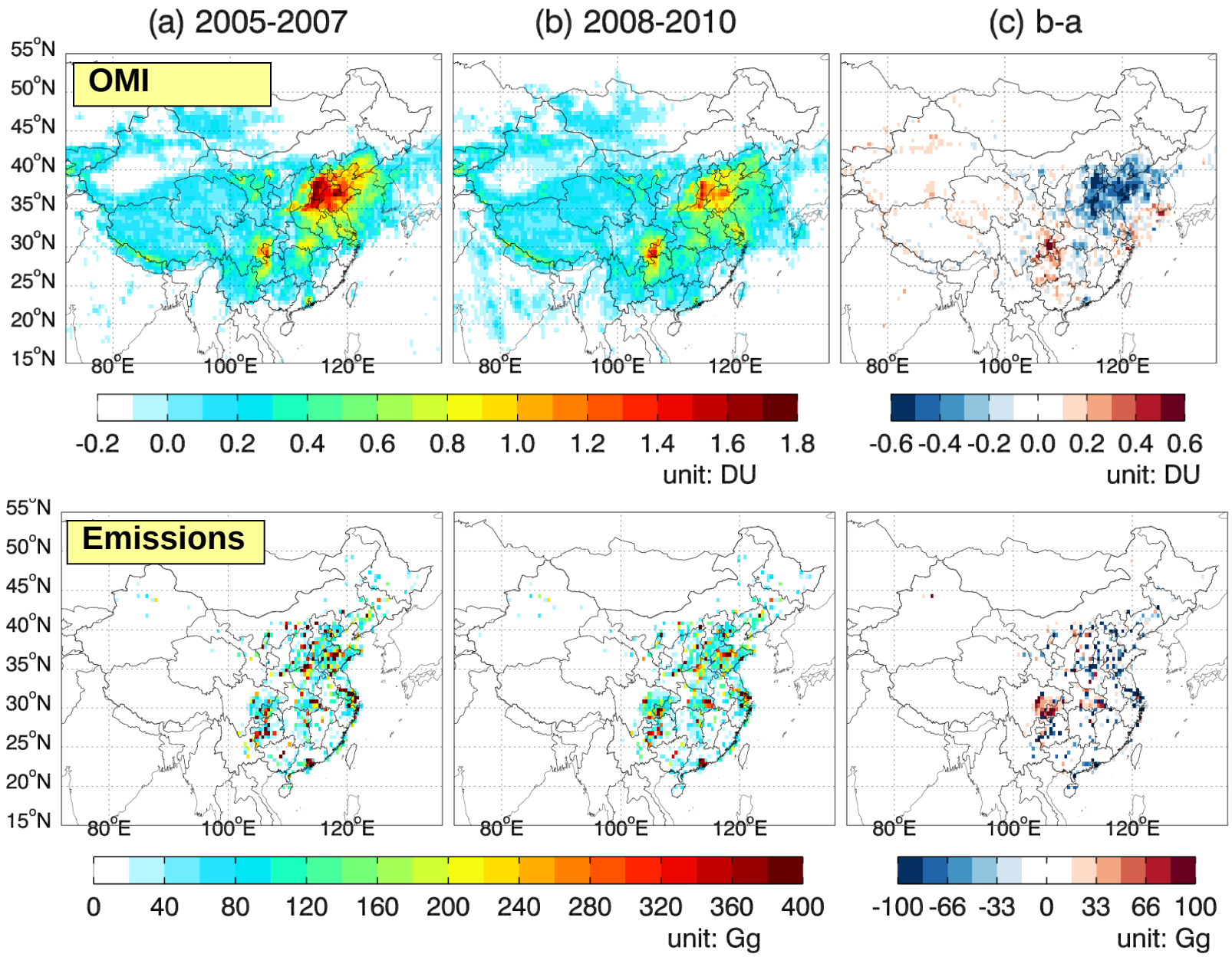
27% increase in Asian emissions

23% decrease in North American emissions

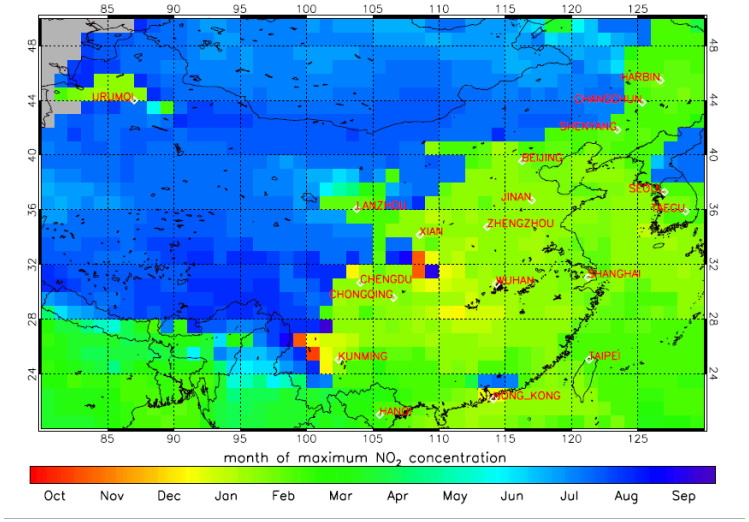
Lamsal et al., GRL, 2011

Streets et al., AE, 2013

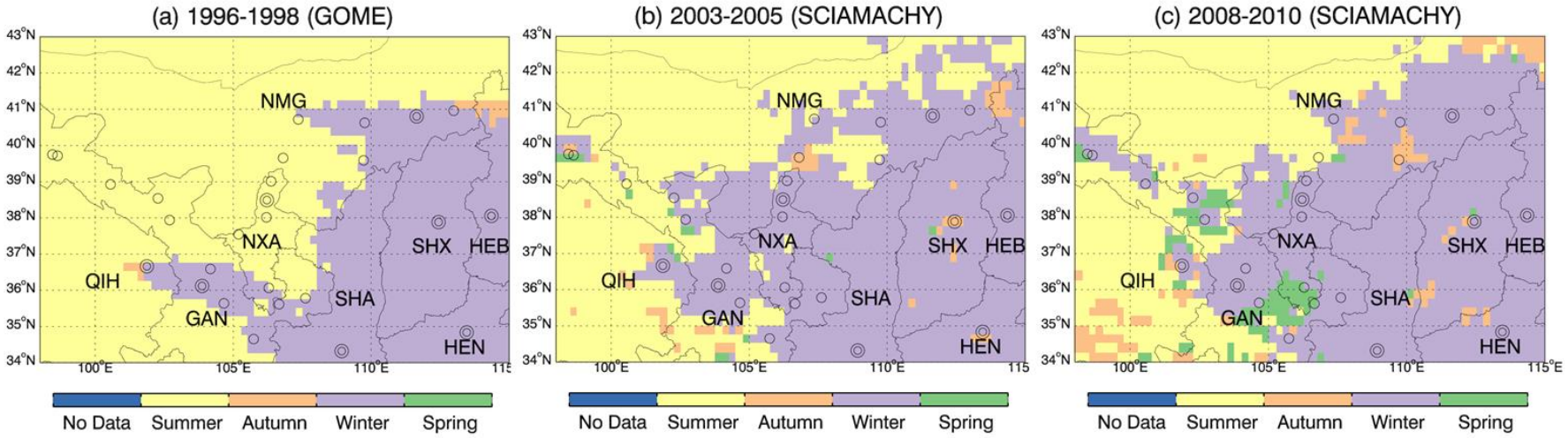
OMI proved the decreases of SO_2 over Central Eastern China after 2007



Detection of anthropogenic footprint using seasonality in NO_2 columns

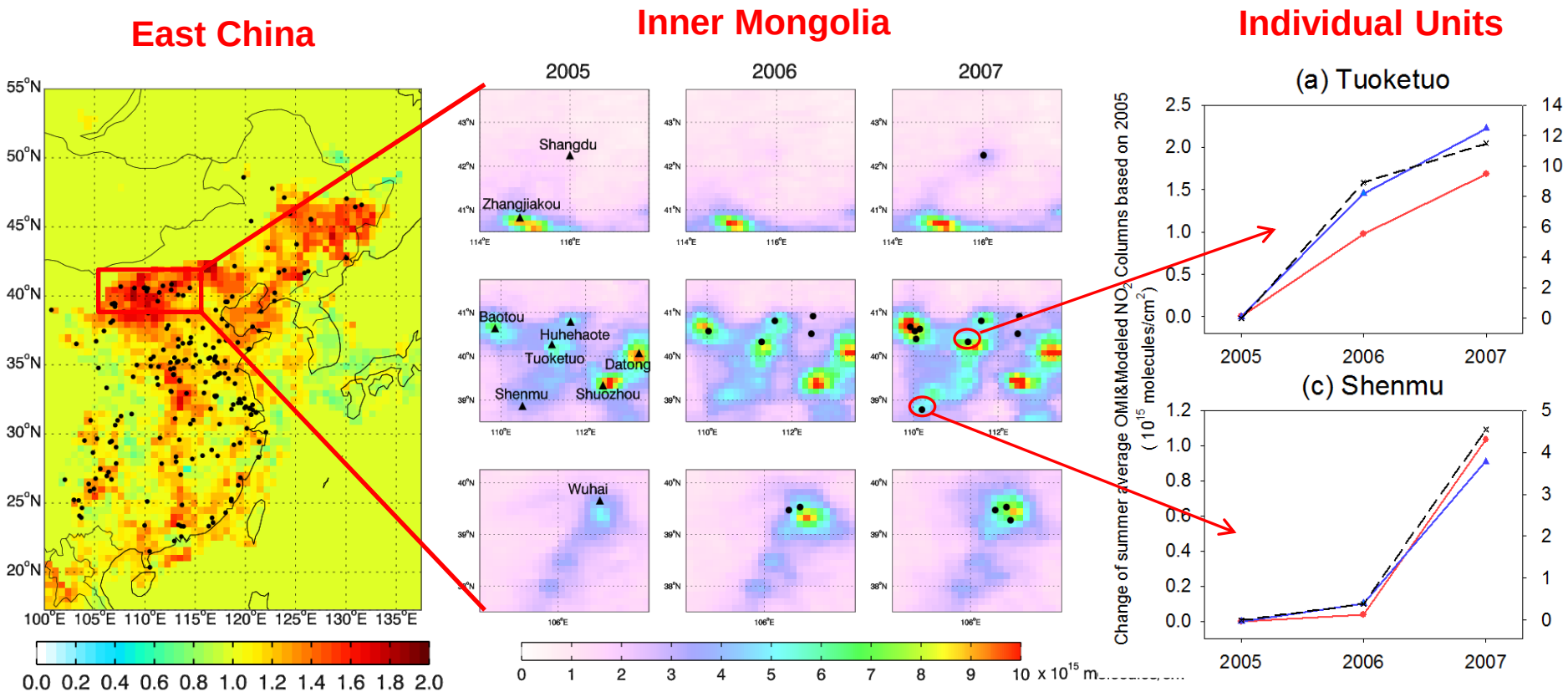


van der A, et al., JGR, 2006



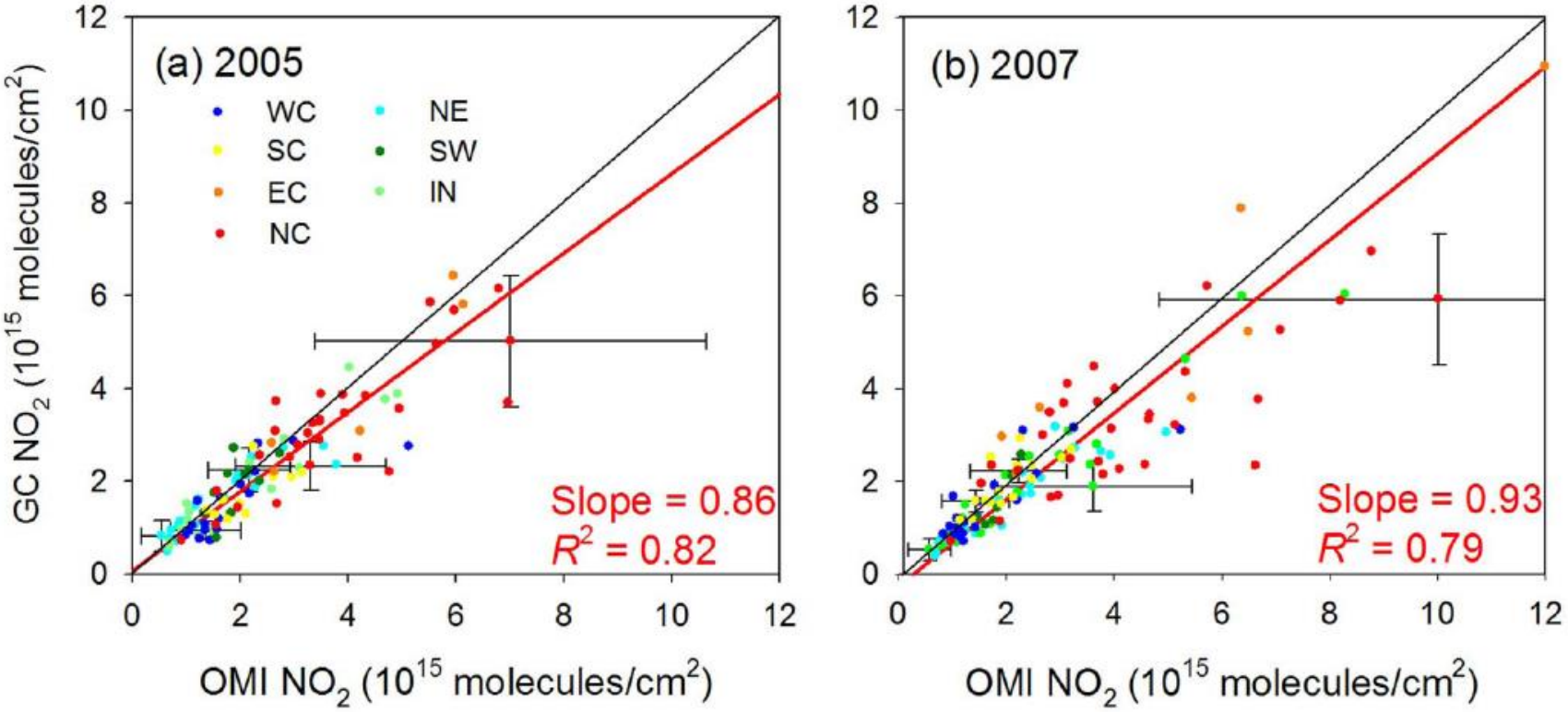
Zhang, et al., Chin. Sci. Bull., 2012

We have demonstrated that OMI is able to identify newly added NOx emissions from power plants in China



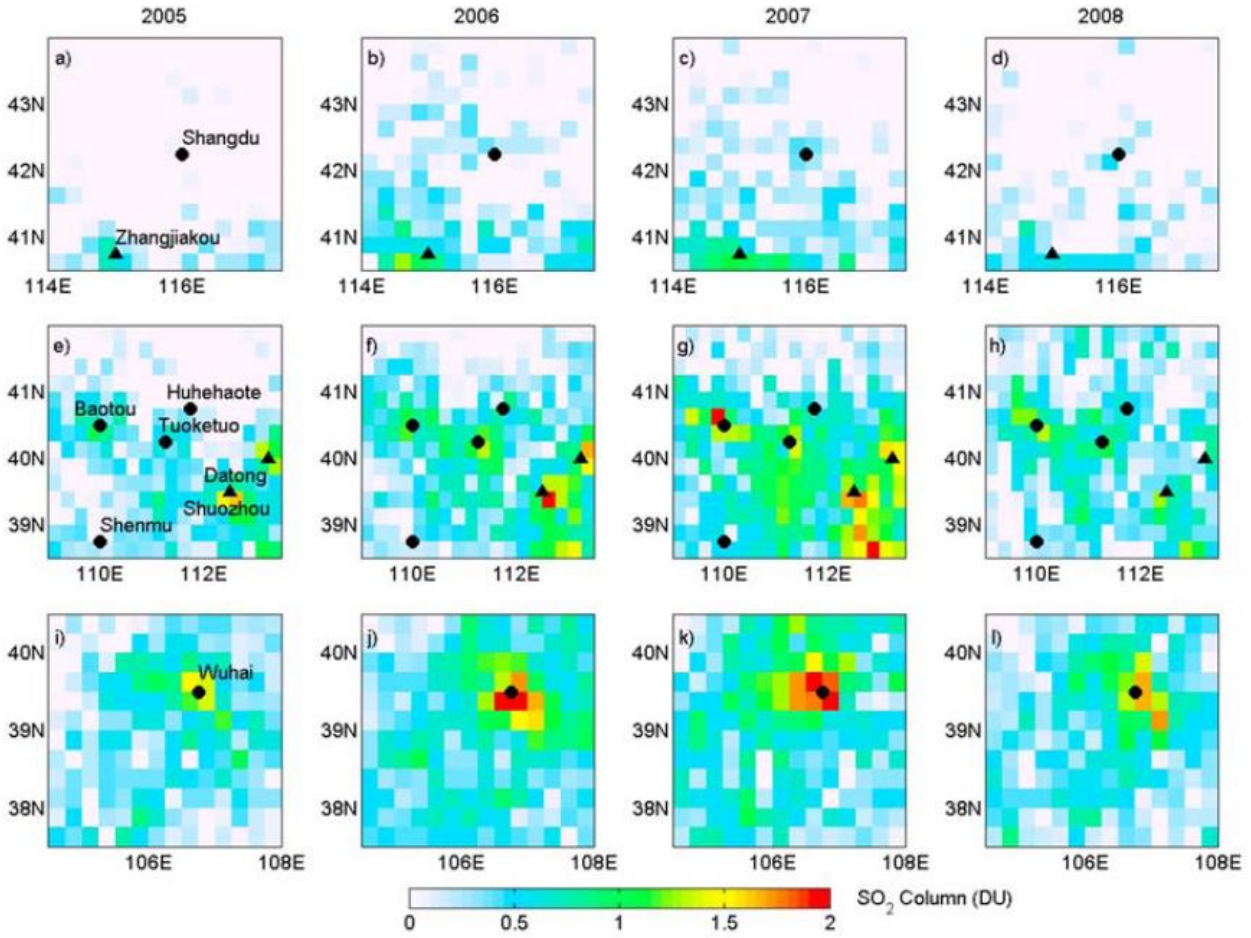
Validation of the unit-based power plant NOx emissions

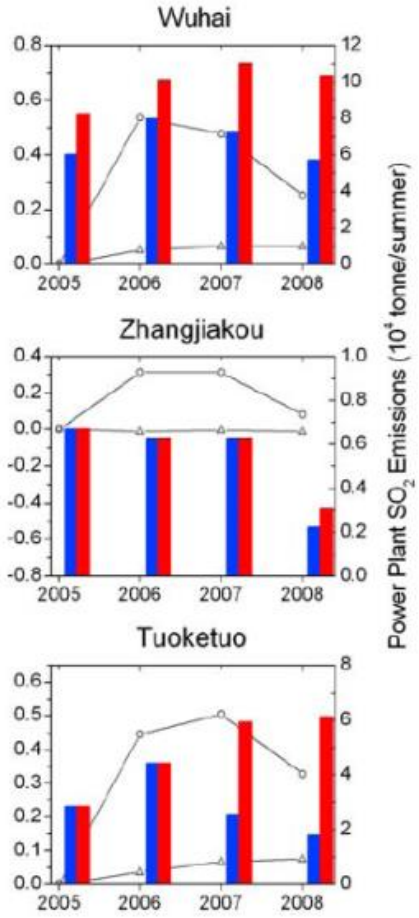
- We compared the modeled and observed NO_2 columns for grids dominated by power plant NO_x emissions, which means grids with urban population <0.5 million and power plant NO_x emissions exceed 60% of the total NO_x emissions.



Wang, et al., ACP, 2012

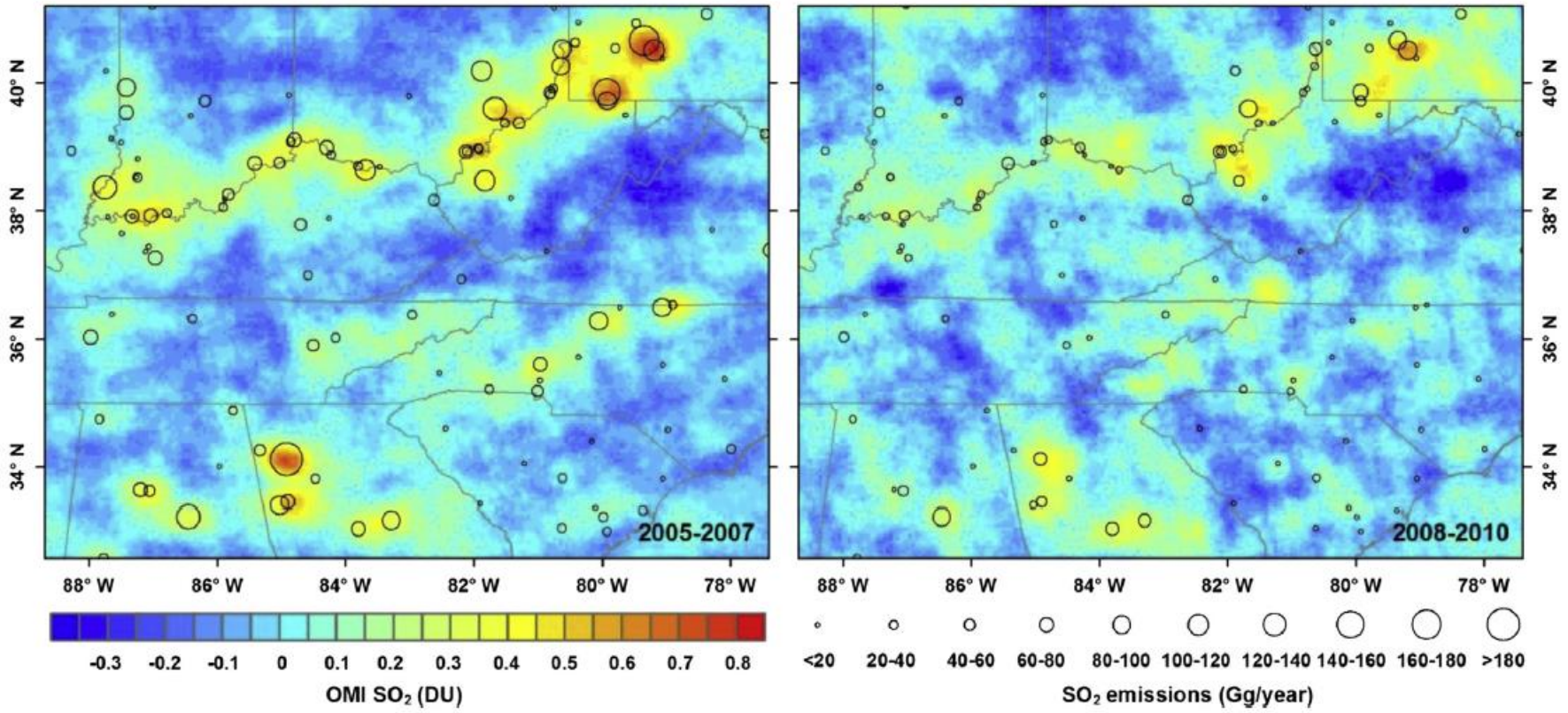
Evaluation of the effectiveness of emission control measures on power plants





Li et al., GRL, 2010

Satellite observation of power plant emissions by oversampling OMI data

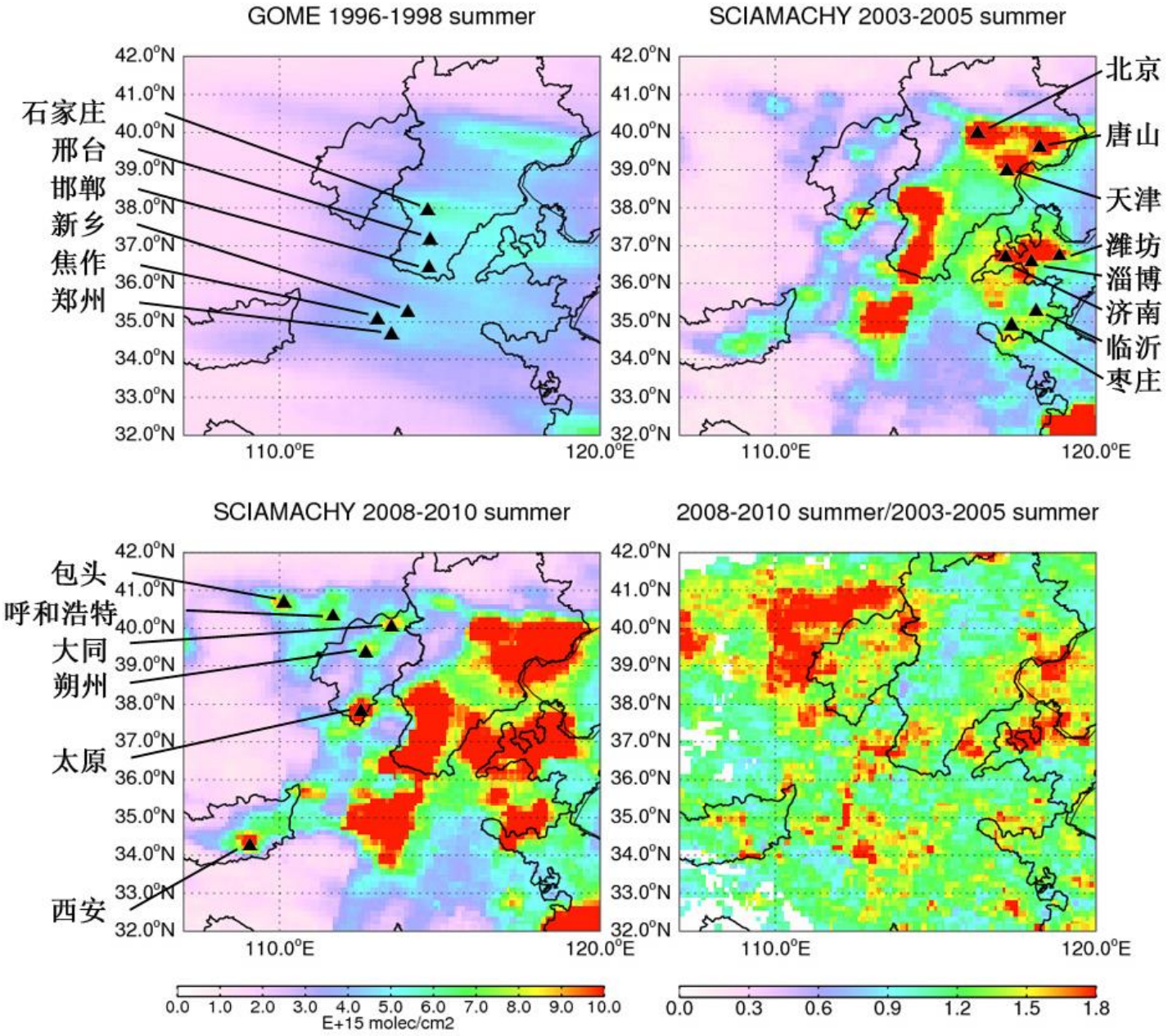


Fioletov et al., GRL, 2011

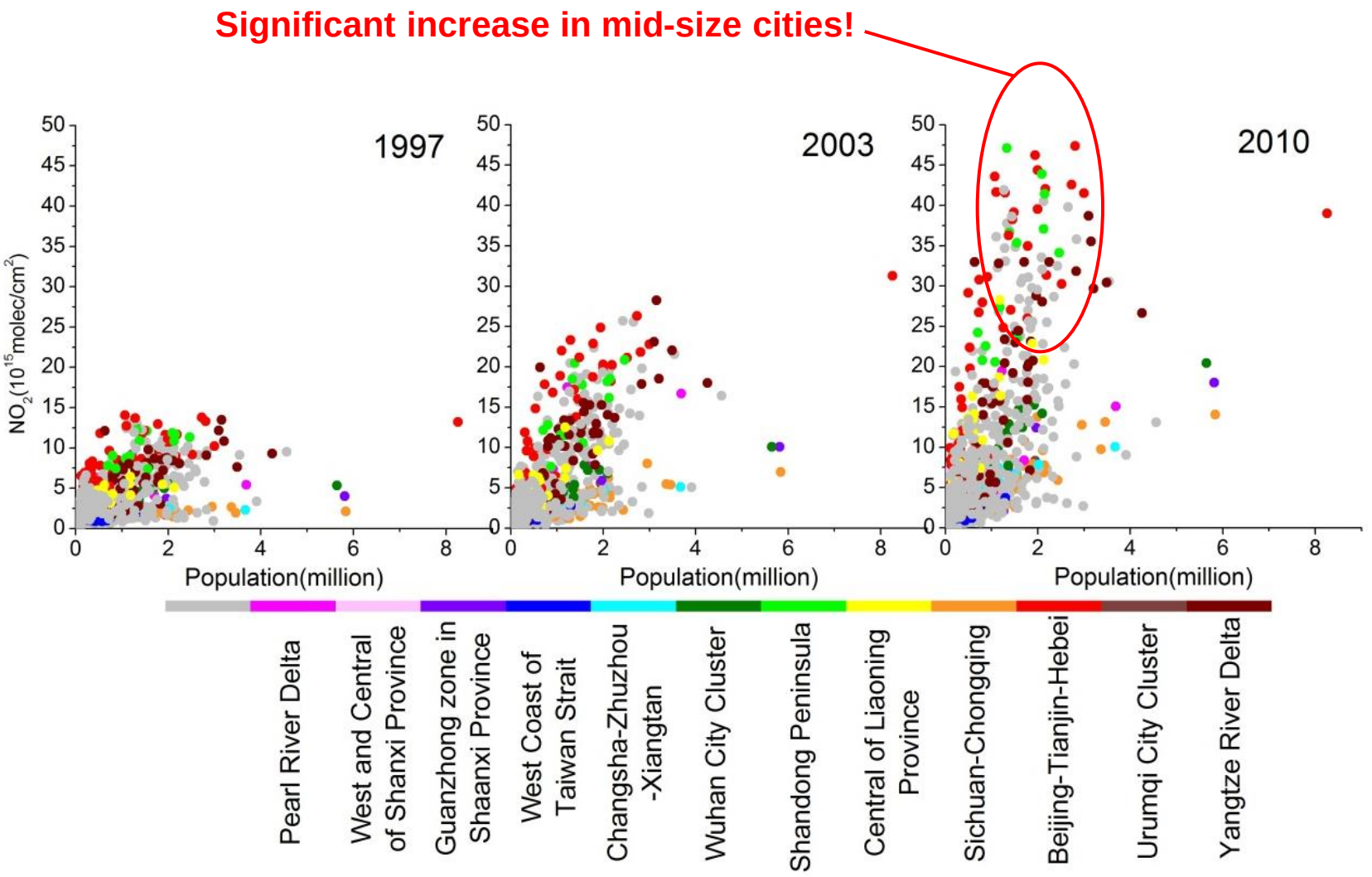
Streets et al., AE, 2013

Fine spatial resolution of GEMS can enhance this capability!

Satellite observed changes in NO_2 columns in North China during 1996-2010

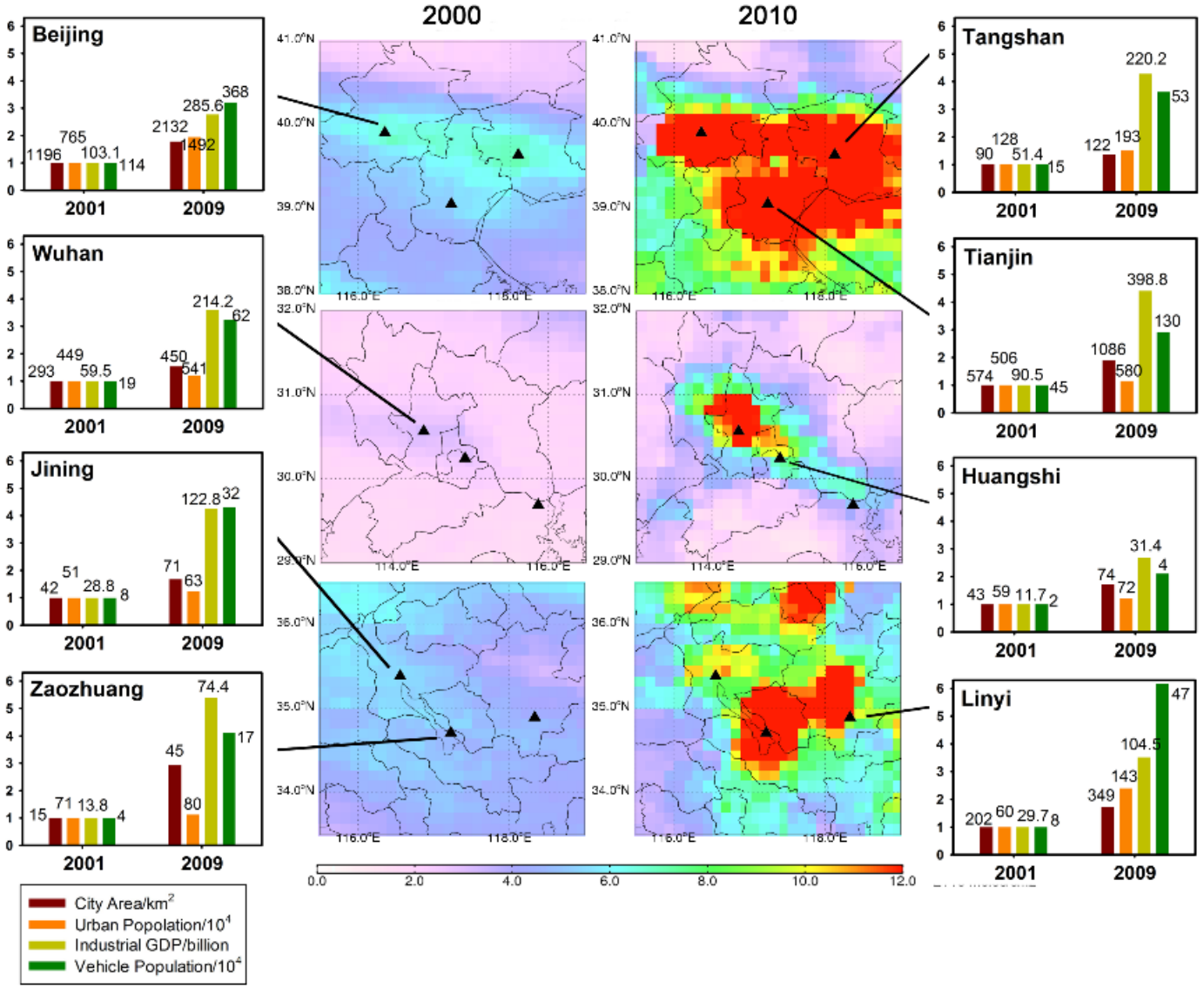


Correlations between NO_2 columns and population density



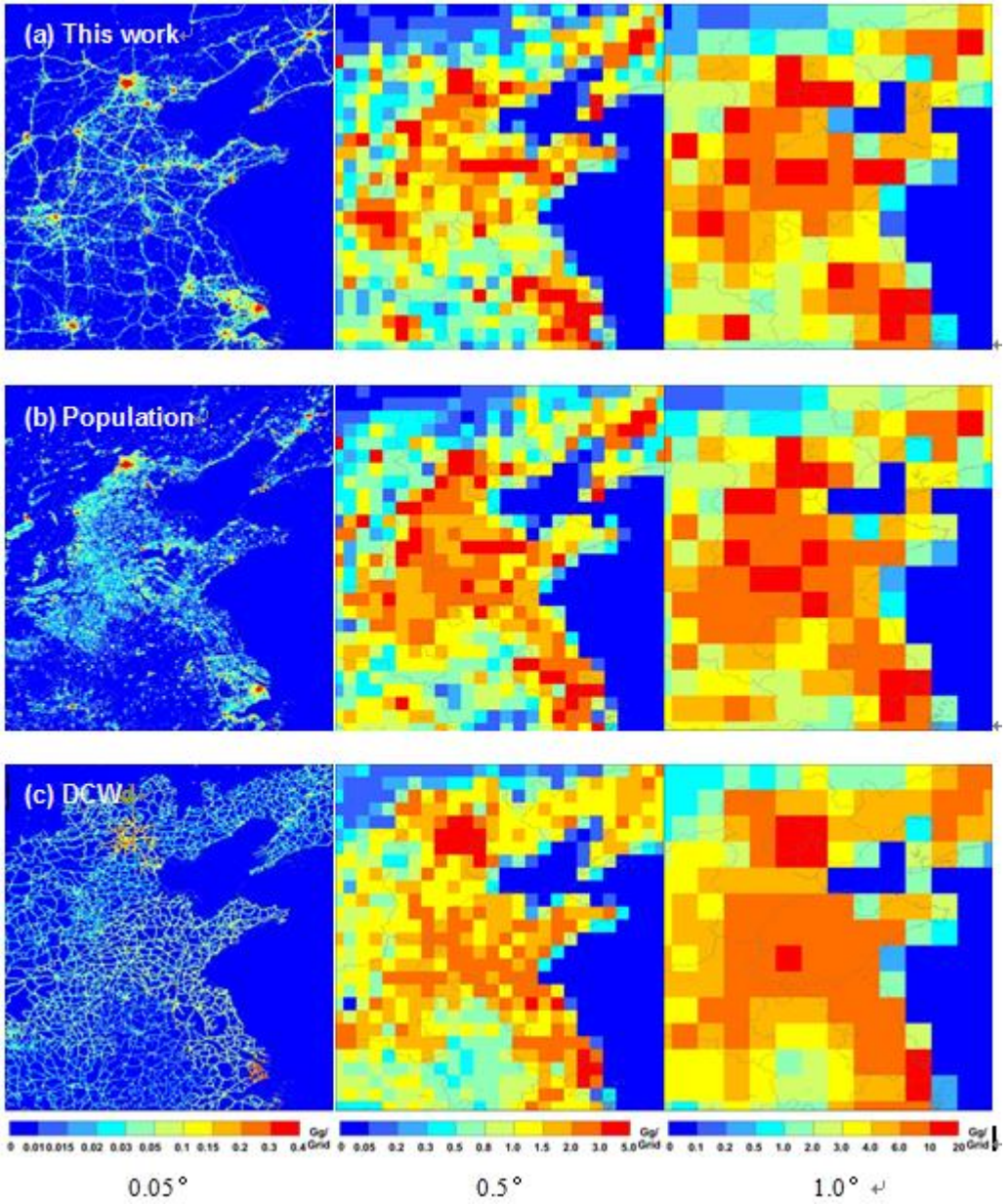
Zhang, et al., Chin. Sci. Bull., 2012

Growth of NO_2 columns in different city clusters

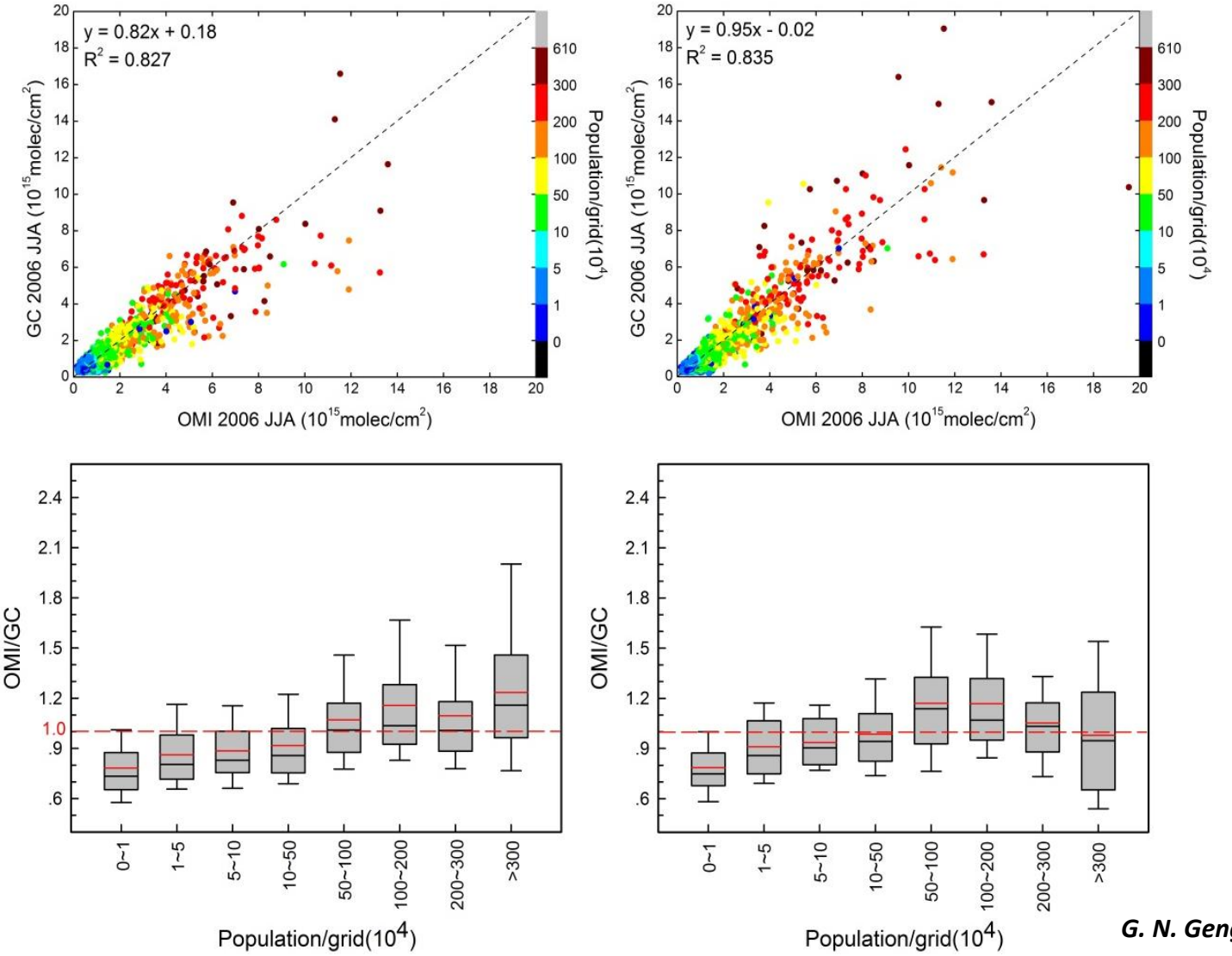


Zhang, et al., Chin. Sci. Bull., 2012

Emissions at high resolution are very sensitive to spatial proxies



Evaluation and Improvements of Spatial Proxies by OMI NO_2 observations



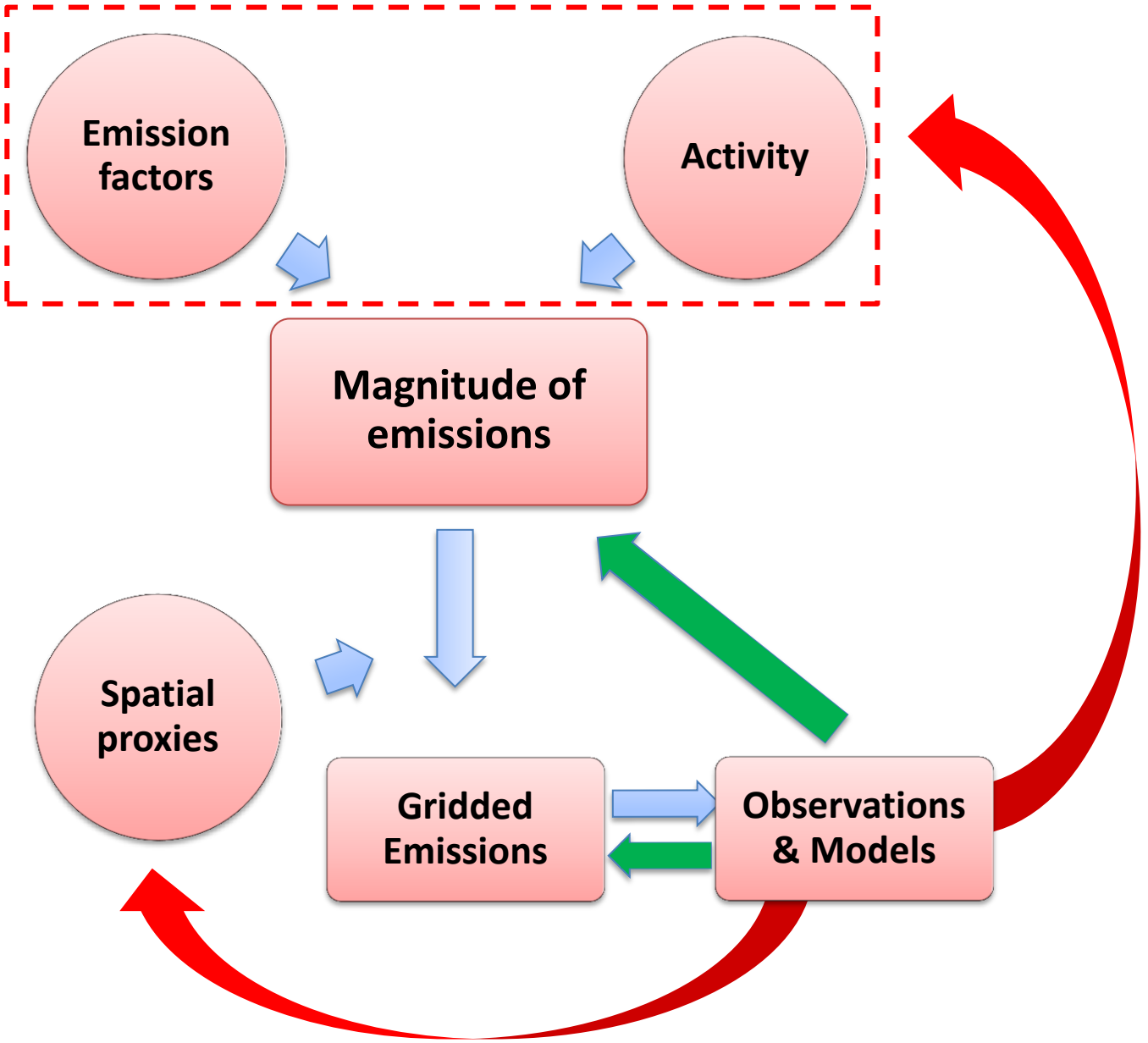
G. N. Geng, in prep

Spatial Proxies

Population, outdated road network

Industrial GDP, new road network

Perspective: Integration of Top-down Information In Bottom-up Approach



Thanks for your attention!