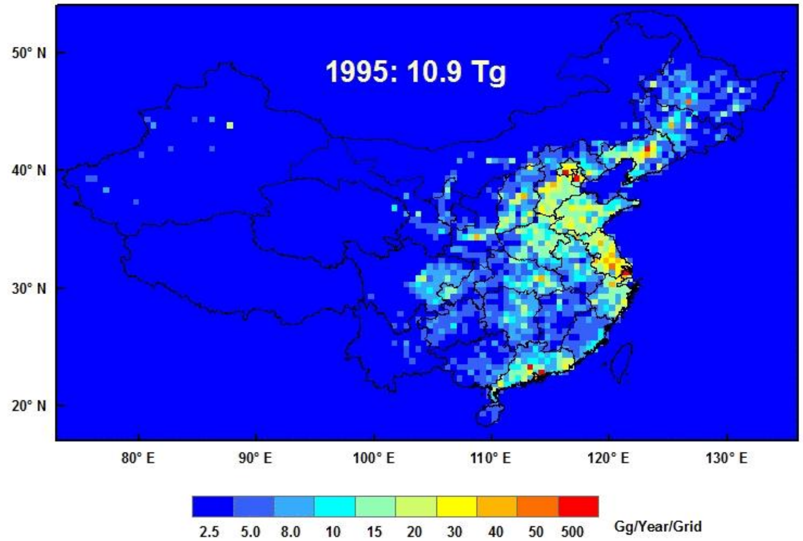
Fast update of NO_x emission trend for China: synthesis of bottom-up method and satellite observations



Evolution of NO_x emissions in China: 1995-2010

Qiang Zhang

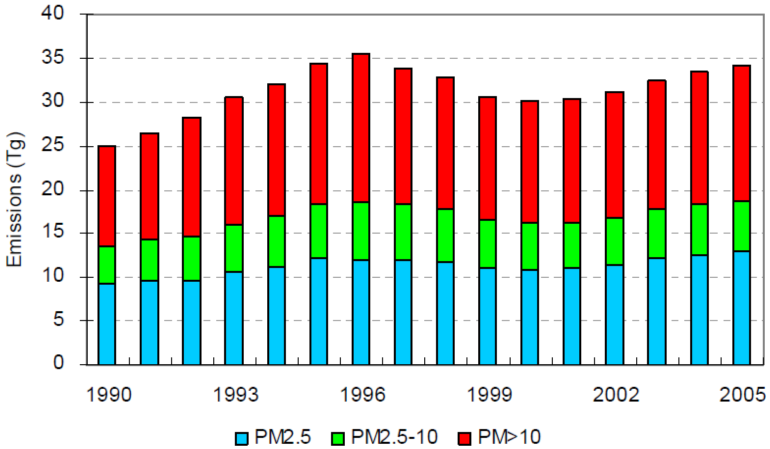
Center for Earth System Science, Tsinghua University

With Sicong Kang, Siwen Wang, Hong Huo and Kebin He (Tsinghua U), David Streets (ANL), and Randall Martin and Lok Lamsal (Dalhousie)

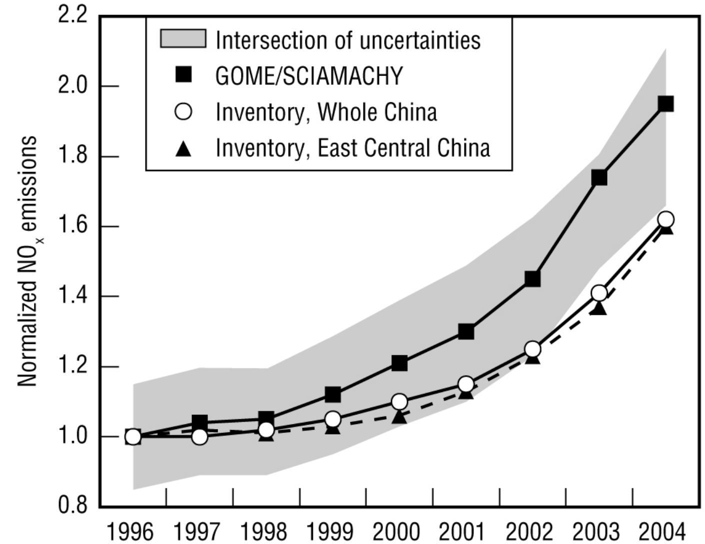
Presented at 5th international GEOS-Chem meeting

May 2-5, 2011, Harvard University, Cambridge, MA

Anthropogenic emissions in China are changing dramatically



Primary aerosol, Lei et al., ACP, 2011

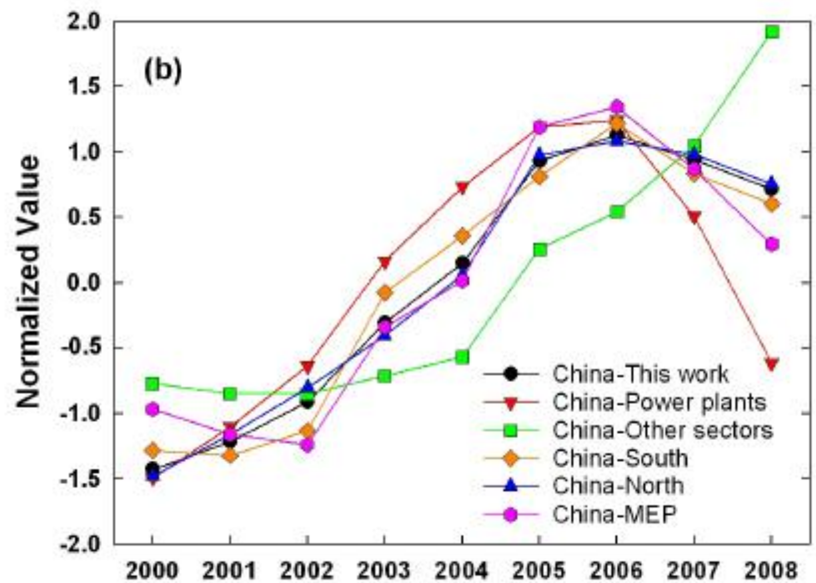


NO$_x$, Zhang et al., JGR, 2007

Primary aerosol: two peaks, reflecting the impacts of both economy increase and emission control

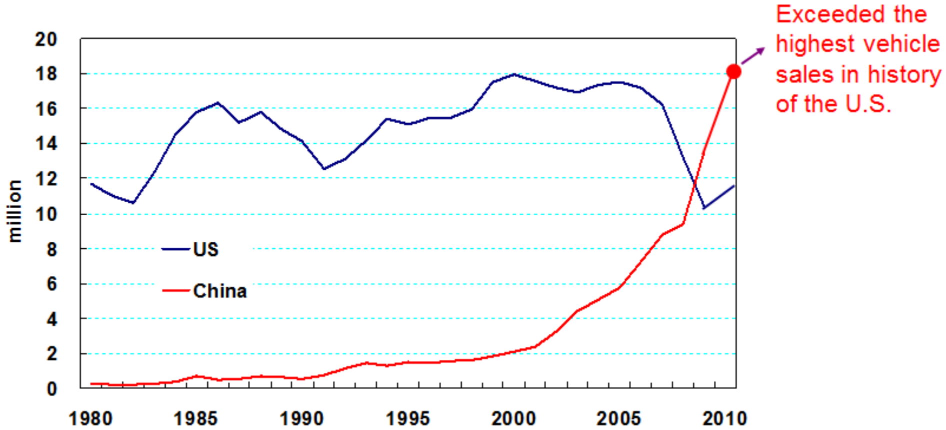
SO_2: increasing until 2006, driven by new power plants and industrial facilities, and decreasing after 2006, through installations of FGD devices

NO_x: continuously increasing driven by new power plants and increased vehicle populations

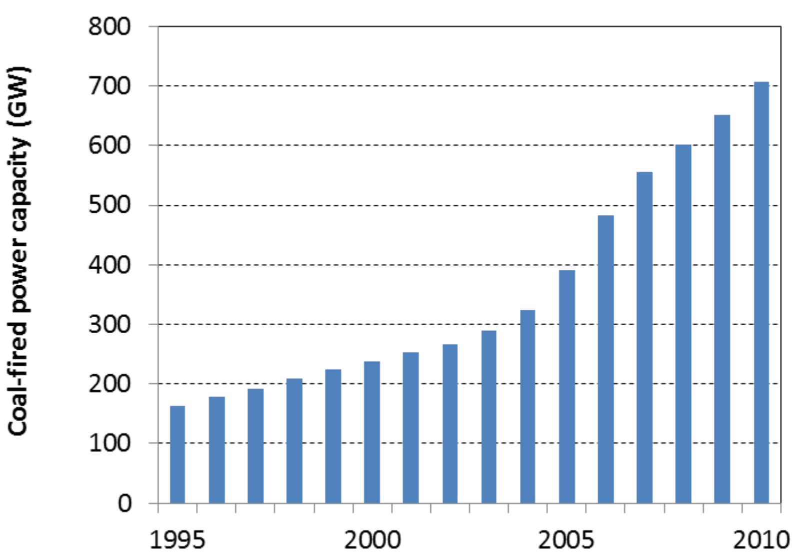


SO_2, Lu et al., ACP, 2010

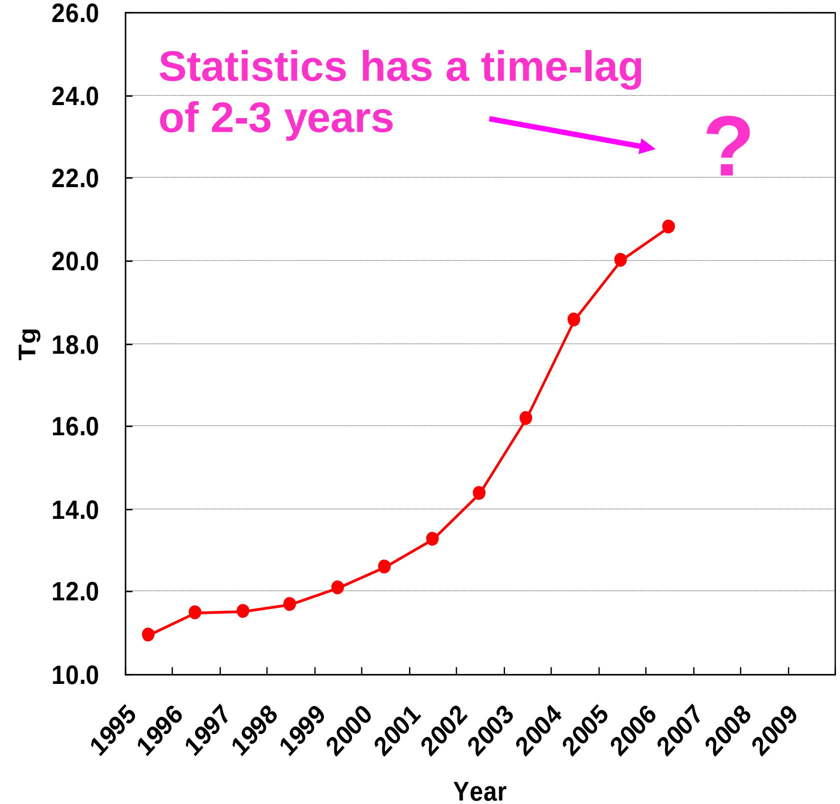
Developing up-to-date emission inventory is a challenging work…



Vehicle sales in China



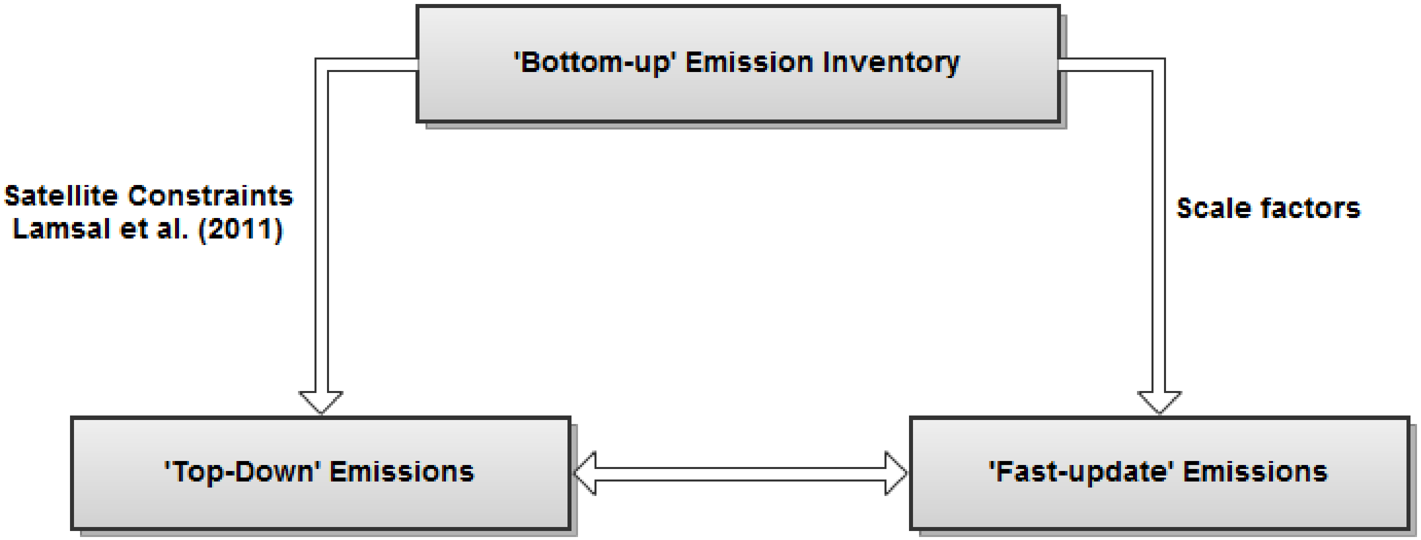
Coal-fired power capacity in China



NO_x emission trends in China

(Zhang et al., 2007, 2009)

Fast update of NO_x emissions by using bottom-up method and satellite constraints



E_i Base Year

E_j Projected year

$$E_j = (1 + \beta \frac{(\Omega_j - \Omega_i)}{\Omega_i}) E_i.$$

$$E_j = \frac{A_j}{A_i} \times \eta \times E_i$$

β → Local sensitivity of column changes to emissions changes (calculated by nested GC model)

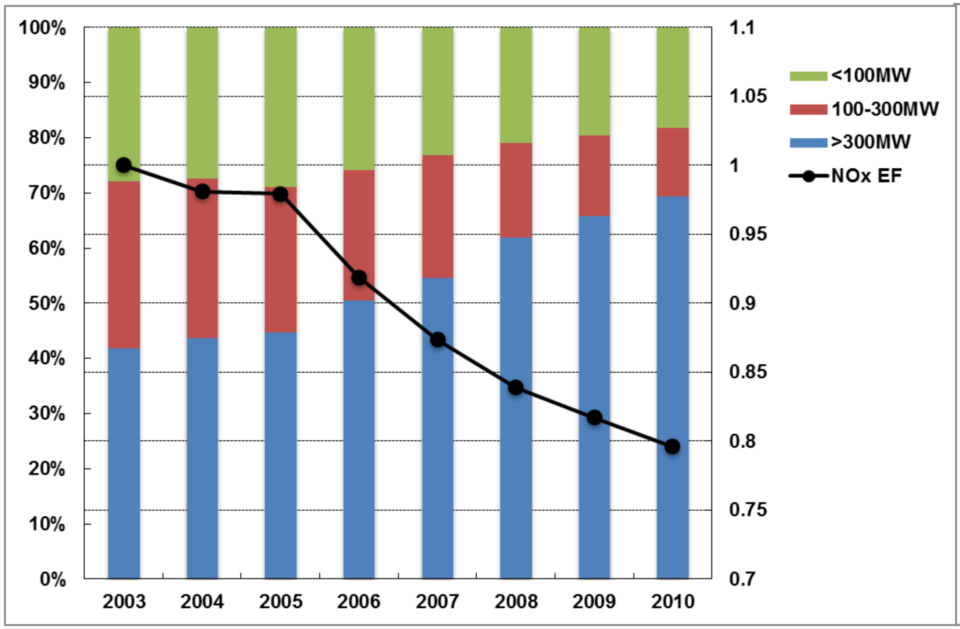
Ω → Trop NO_2 columns

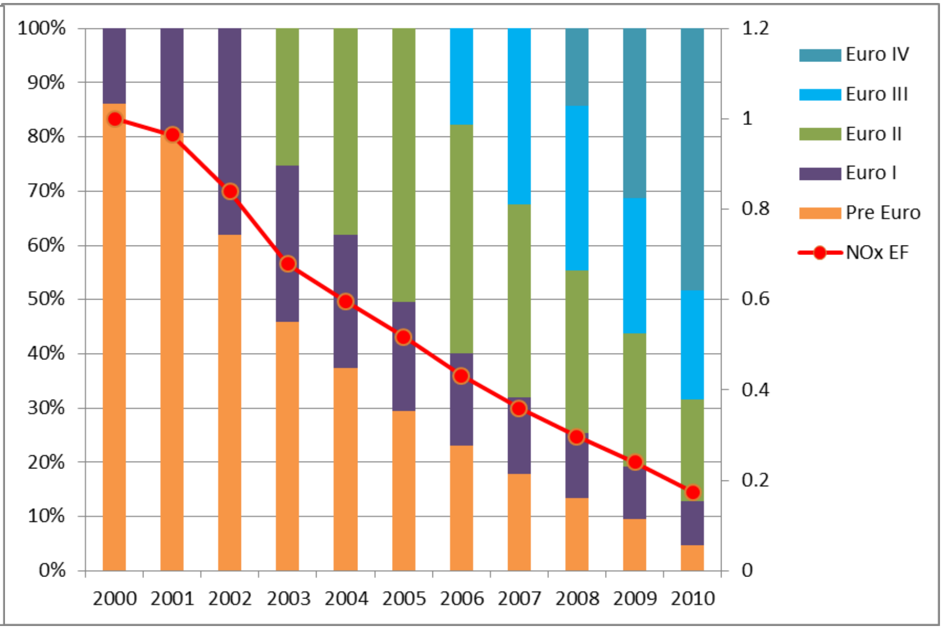
Lamsal et al., 2011, GRL

A → activity scale factor
e.g., power generation, vehicle population

η → Relative changes in emission factors

Changes in technology penetrations and their impacts on NO_x emission factors





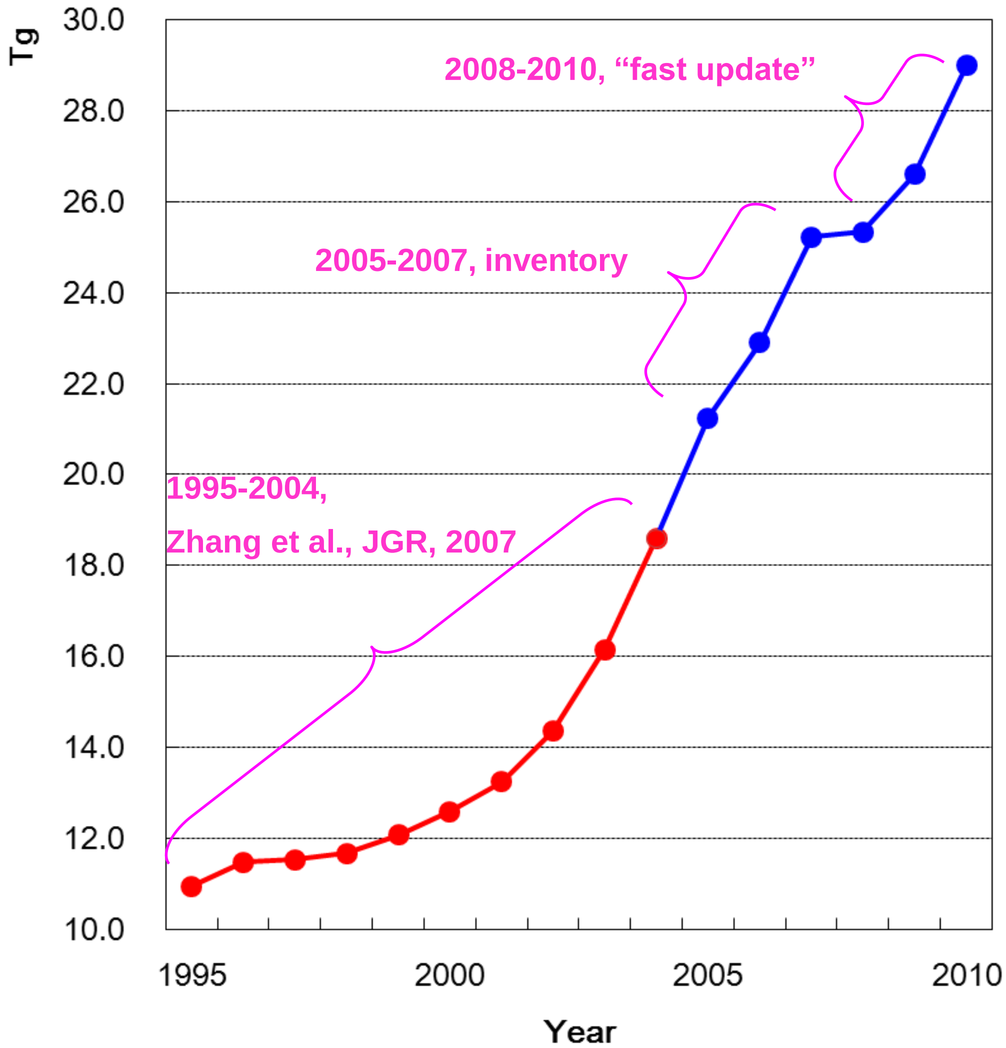
Coal Power Plants

Cars in Beijing

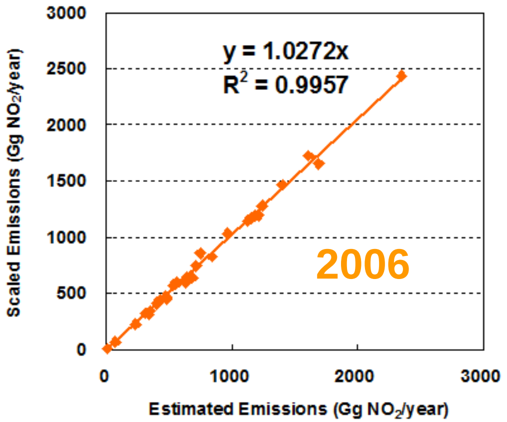
EF decreased by 20% in seven years

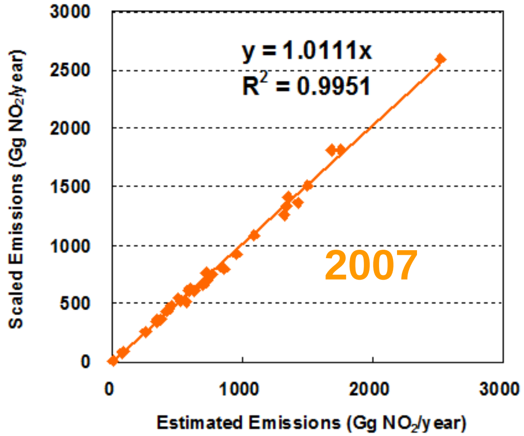
EF decreased by 85% in ten years

NO_x emission trends for China: 1995-2010



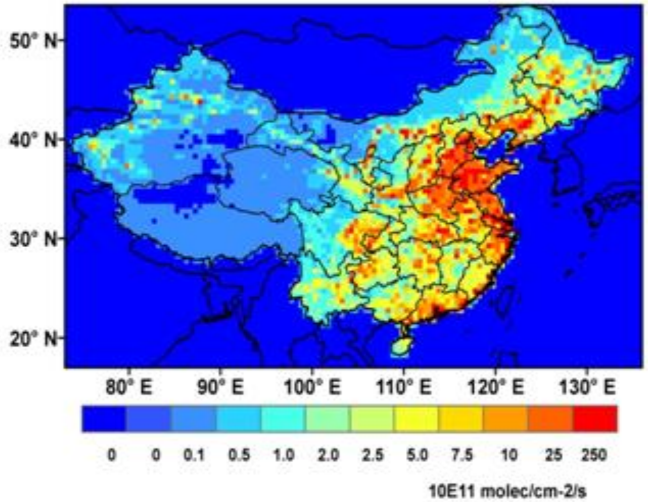
160% increase in 15 years





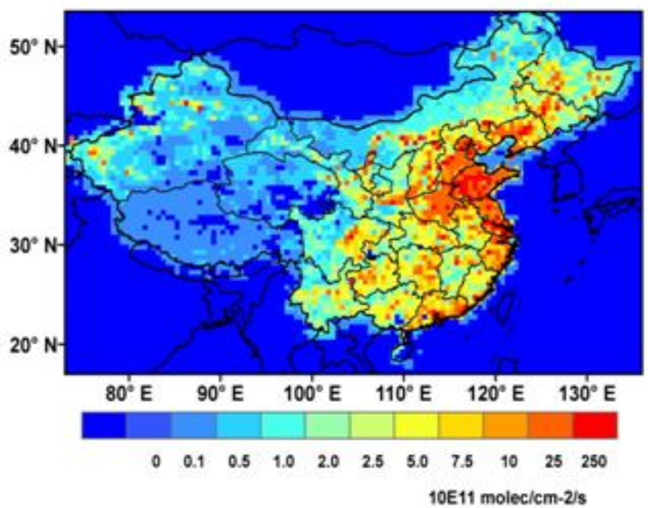
Comparison of "fast update" and "traditional inventory" approach

Comparison of bottom-up and top-down estimates: magnitudes, distributions, and trends

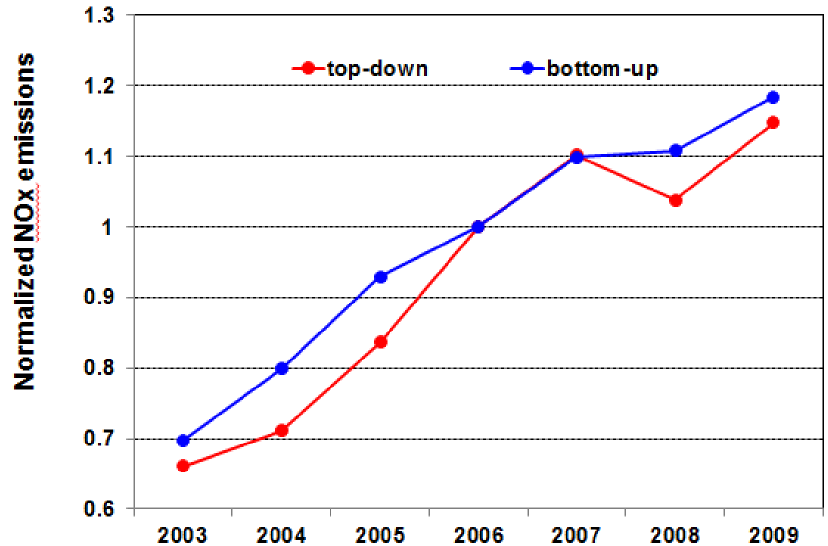


Bottom-up, 2009, 8.4 Tg N

R^2=0.93



Top-down, 2009, 8.1 Tg N



2003-2009 change:

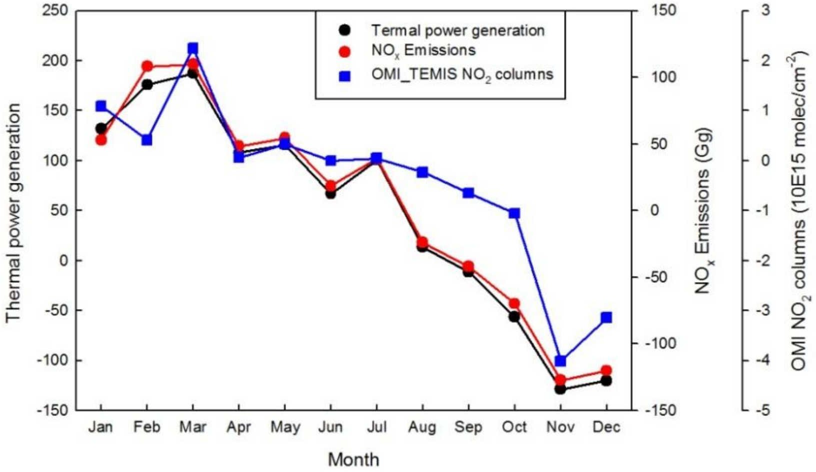
Top-down: 73 % increase

Bottom-up: 70 % increase

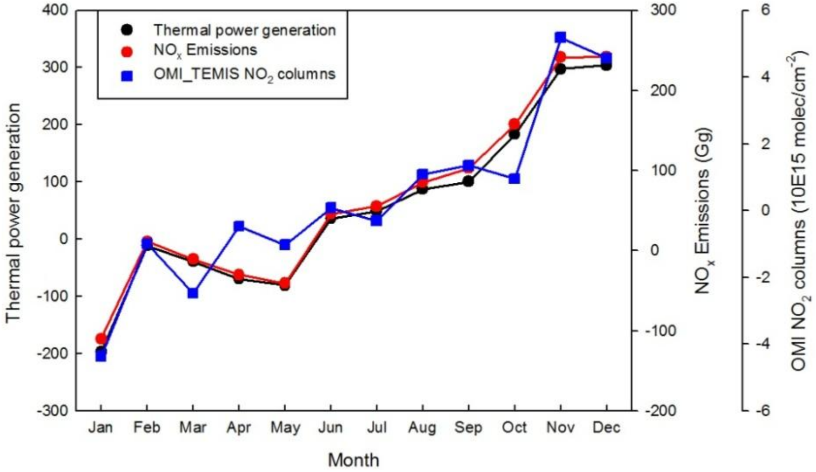
SCIAMACHY data from TEMIS

Emission anomaly in 2008 and 2009

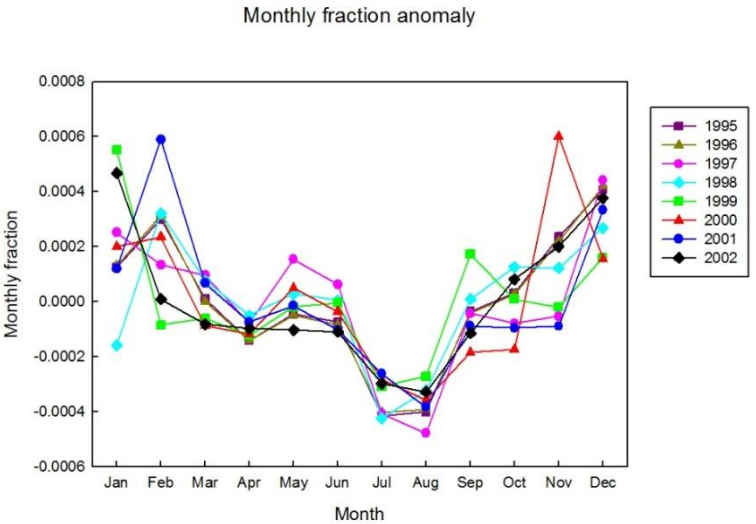
2008 minus 2007

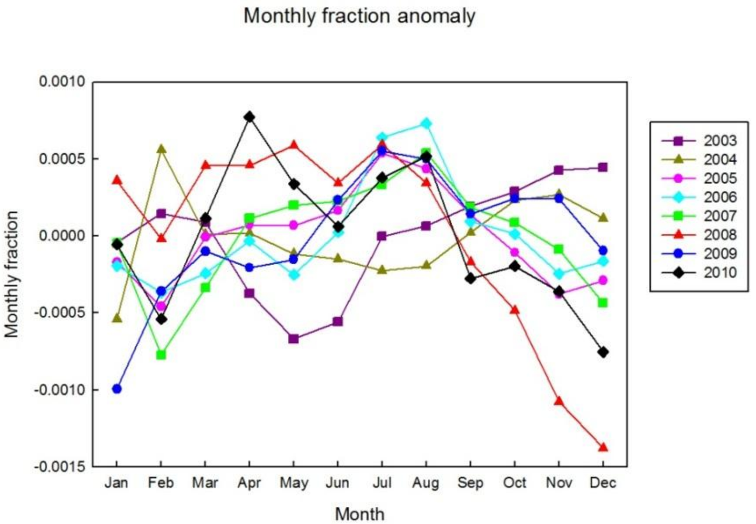


2009 minus 2008



Changes in power generation, NO_x emissions, and OMI NO_2 columns





Emission monthly fraction anomaly to the average of 1995-2010

Acknowledgements

This work was funded by

> *Project of Monitoring and Management on Emission Reduction, managed by the Ministry of Environmental Protection of China*
>
> *And the National Aeronautics and Space Administration's Program on Decision Support through Earth Science Research Results*

SCIAMACHY and OMI data used in this work were produced by KNMI in the Netherlands in collaboration with NASA (www.temis.nl)

Application of Satellite Observations for Timely Updates to Emission Inventories

Use GEOS-Chem to Calculate Local Sensitivity of Changes in Trace Gas Column to Changes in Emissions

$$\frac{\Delta \mathrm{E}}{\mathrm{E}} = \beta \times \frac{\Delta \Omega}{\Omega}$$

Fractional Change in Emissions

Local sensitivity of column changes to emissions changes

Fractional Change in Trace Gas Column

$$\mathrm{E_j} = (1 + \beta \frac{(\Omega_\mathrm{j} - \Omega_\mathrm{i})}{\Omega_\mathrm{i}})\mathrm{E_i}.$$

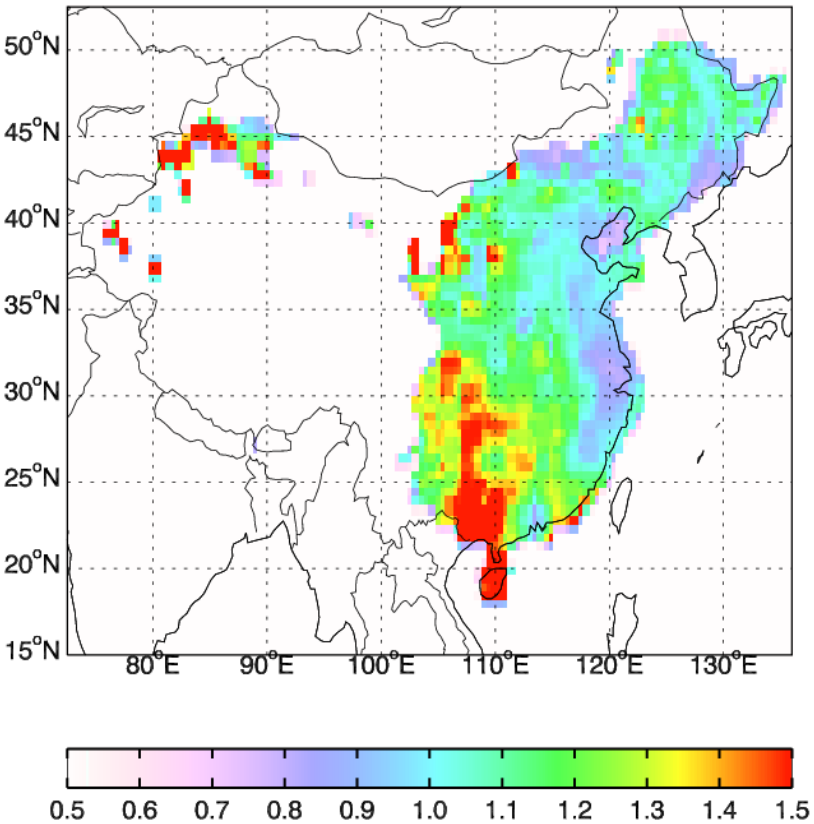
Projected emissions

Satellite columns

Base year emissions

Walker et al., ACP, 2010, Lamsal et al., GRL, 2011

Annual average value of β over China calculated by nested GEOS-Chem model (0.5 x 0.666)



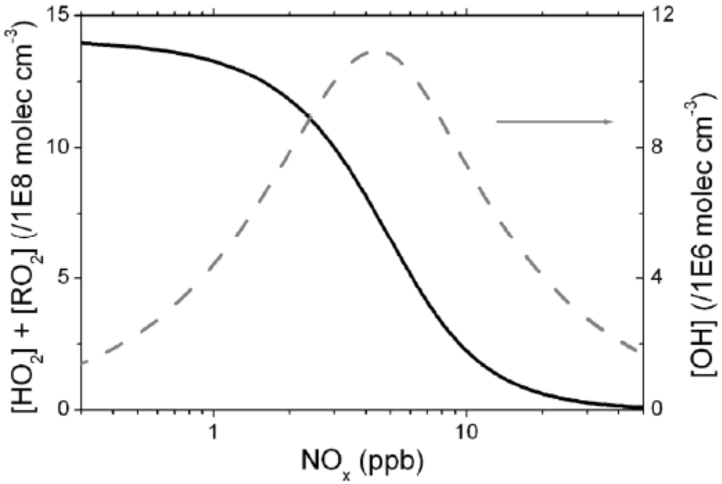


Fig. 7. NO_x dependence of the concentration of odd hydrogen radicals, [OH] (- - -) in units of (10^6 molecules cm^{-3}) and [HO_2 +RO_2] (—) in units of (10^8 molecules cm^{-3}).

Murphy et al., ACPD, 2006

Apply to regions where anthropogenic emis sions dominate (>50%)

ß tends to

- *>1 in remote regions where an increase in NOx emissions decreases the NOx lifetime*
- *<1 in polluted regions since an increase in NOx emissions consumes OH and increases the NOx lifetime*