

# TRENDS IN NOX EMISSIONS AND SO<sub>2</sub> CONCENTRATIONS IN CHINA

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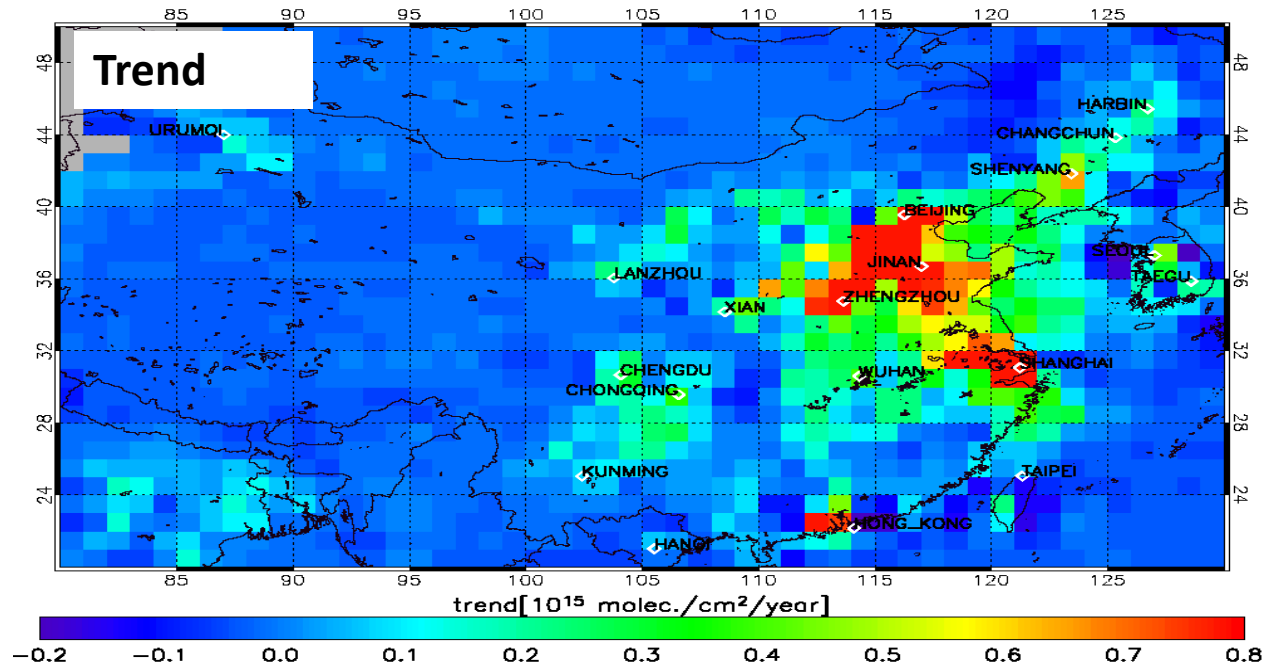
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<sup>4</sup> Aristotle University Thessaloniki

<sup>5</sup> Royal Belgian institute for Space Aeronomy

# Trends in 1996-2006 (GOME/SCIA)

## DRAGON 1-2

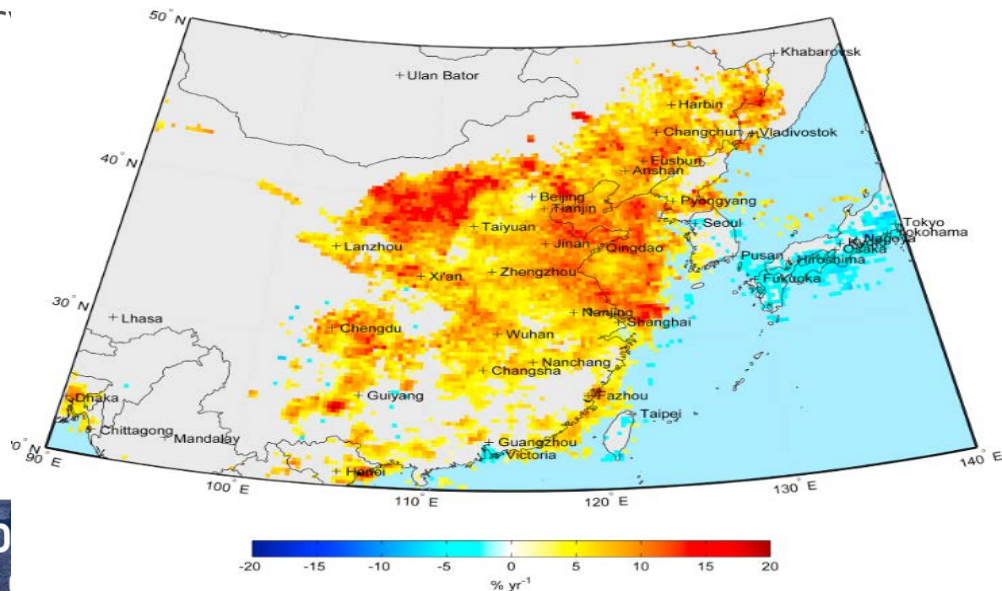


*First trend analysis of  
NO<sub>2</sub> from satellites*

## Linear NO<sub>2</sub> trend 2002-2011

NO<sub>2</sub> trend over China based on SCIAMACHY

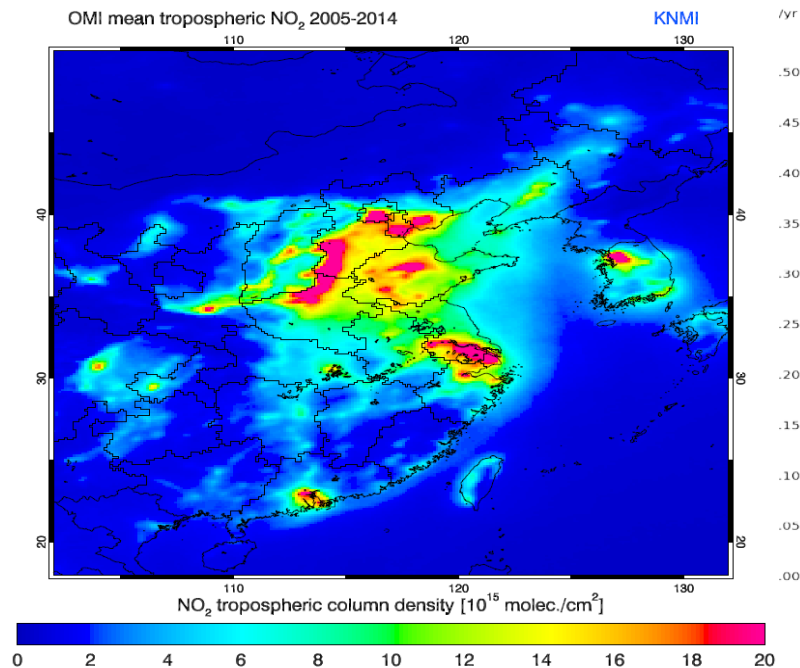
Schneider, P. and R.J. van der A, A global single-sensor analysis of 2002–2011 tropospheric nitrogen dioxide trends observed



# From concentrations to emissions

## DECSO:

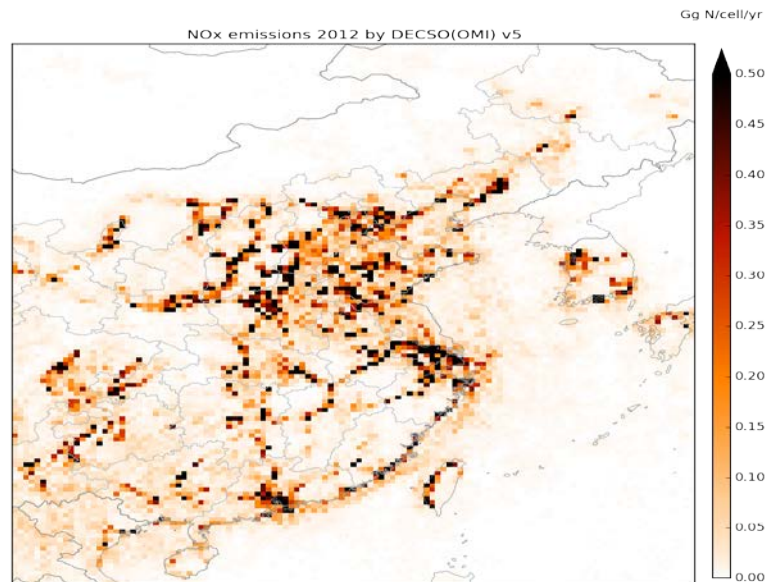
- Data assimilation of emissions using satellite observations and CTM.
- CTM is Chimere adapted to the region of China.
- Monthly mean emissions on a 0.25 degree resolution



# From concentrations to **emissions**

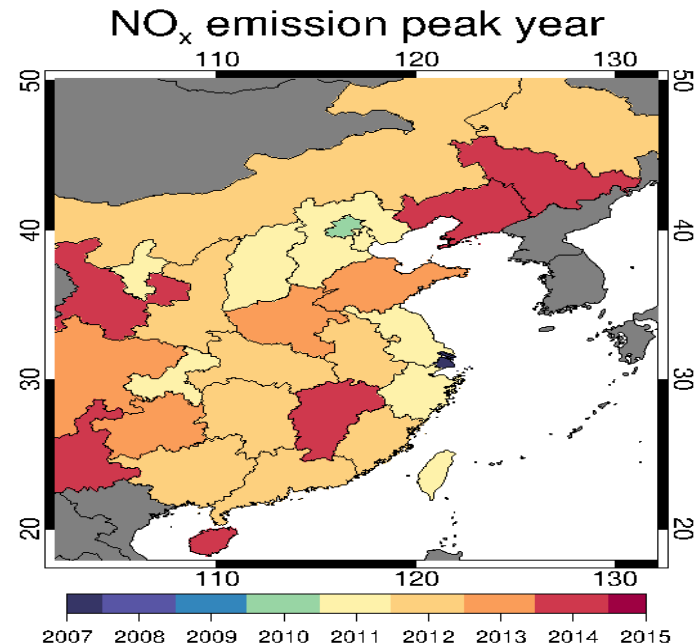
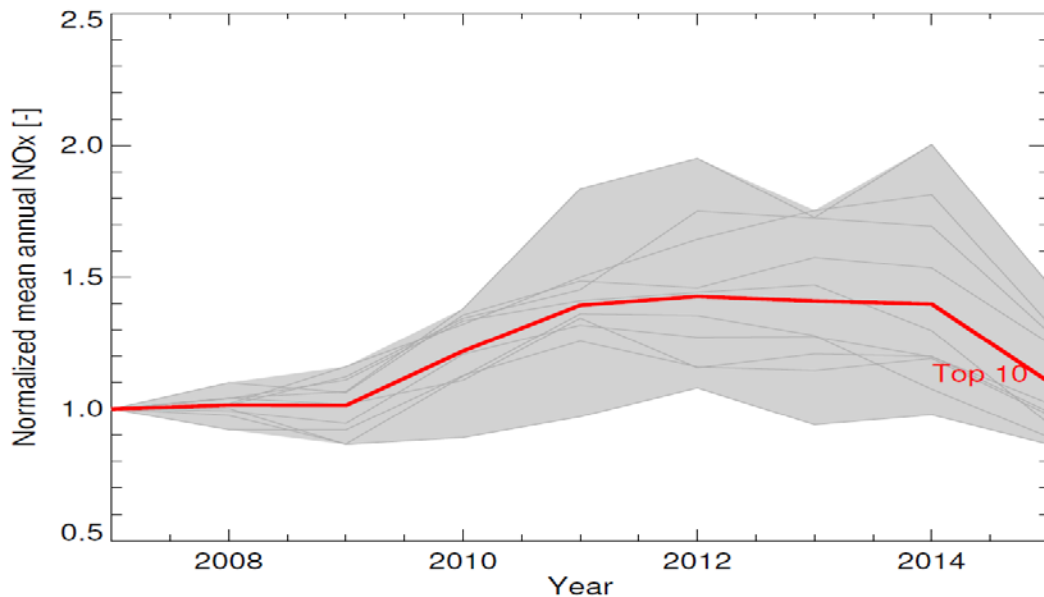
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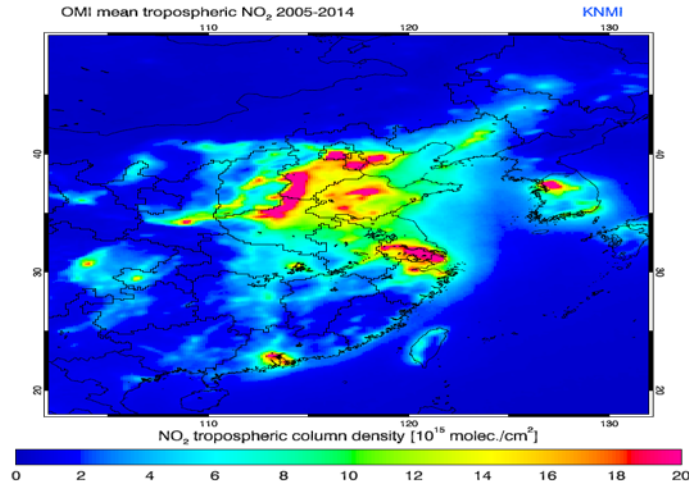
# Normalized $\text{NO}_x$ emissions per province in China 2007-2015



# What can we learn from SO<sub>2</sub> ?

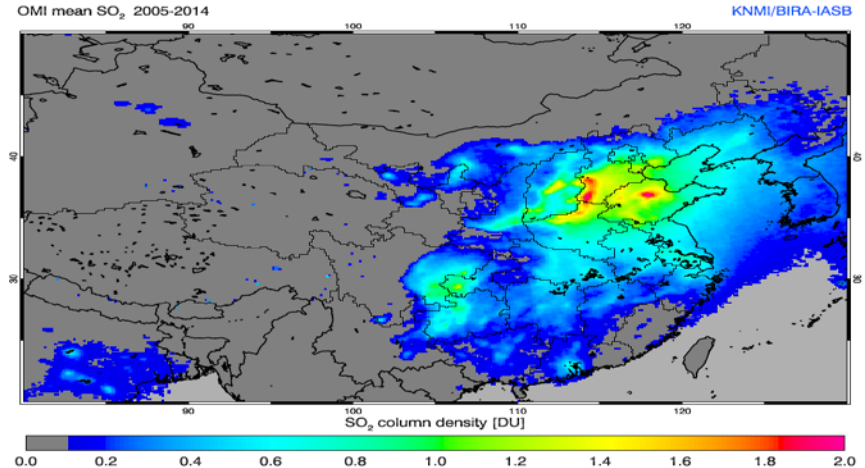
## Main NO<sub>x</sub> sources

- Thermal Power plants
- Coal-intensive Industry
- Traffic

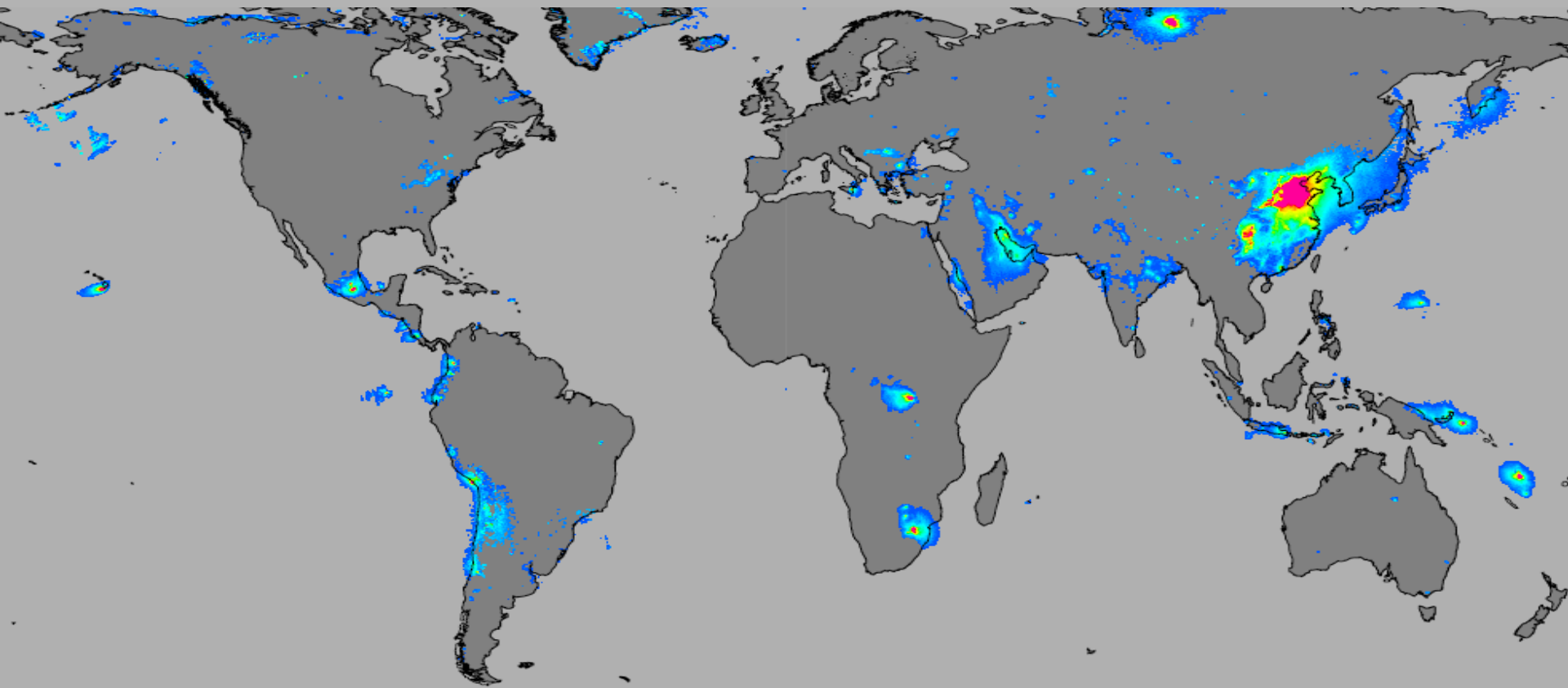


## Main SO<sub>2</sub> sources

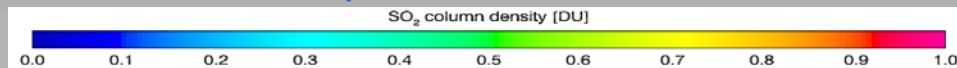
- Thermal power plants
- Coal-intensive Industry



# World map SO<sub>2</sub>



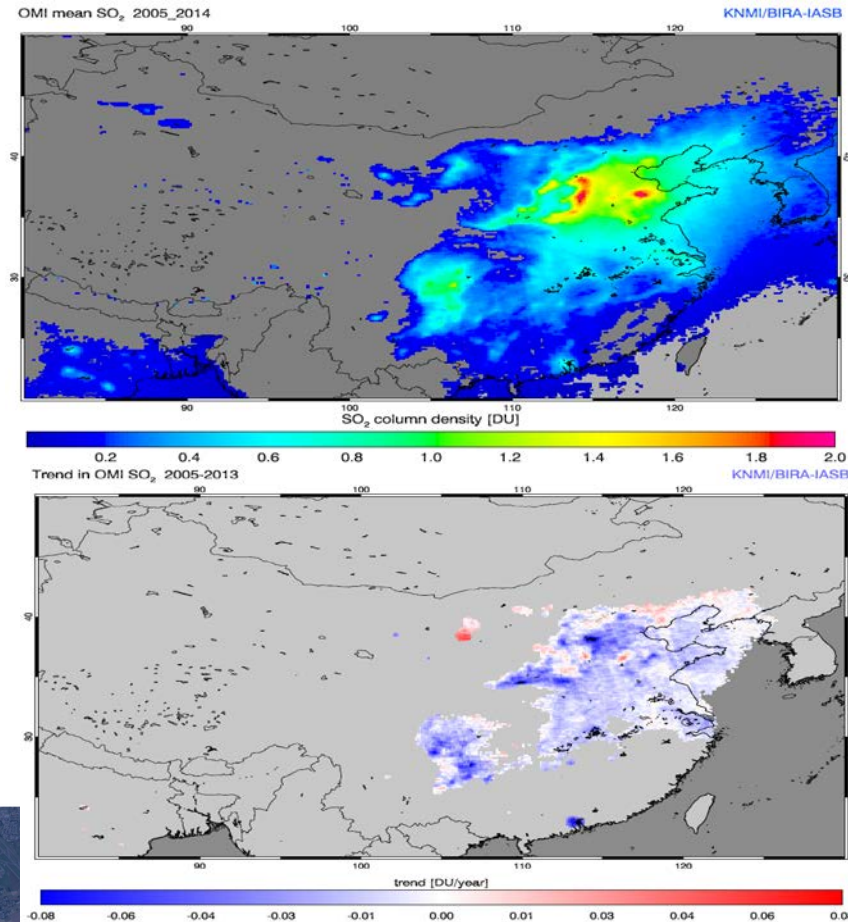
New data set  
(Theys et al., 2015)  
by BIRA-IASB



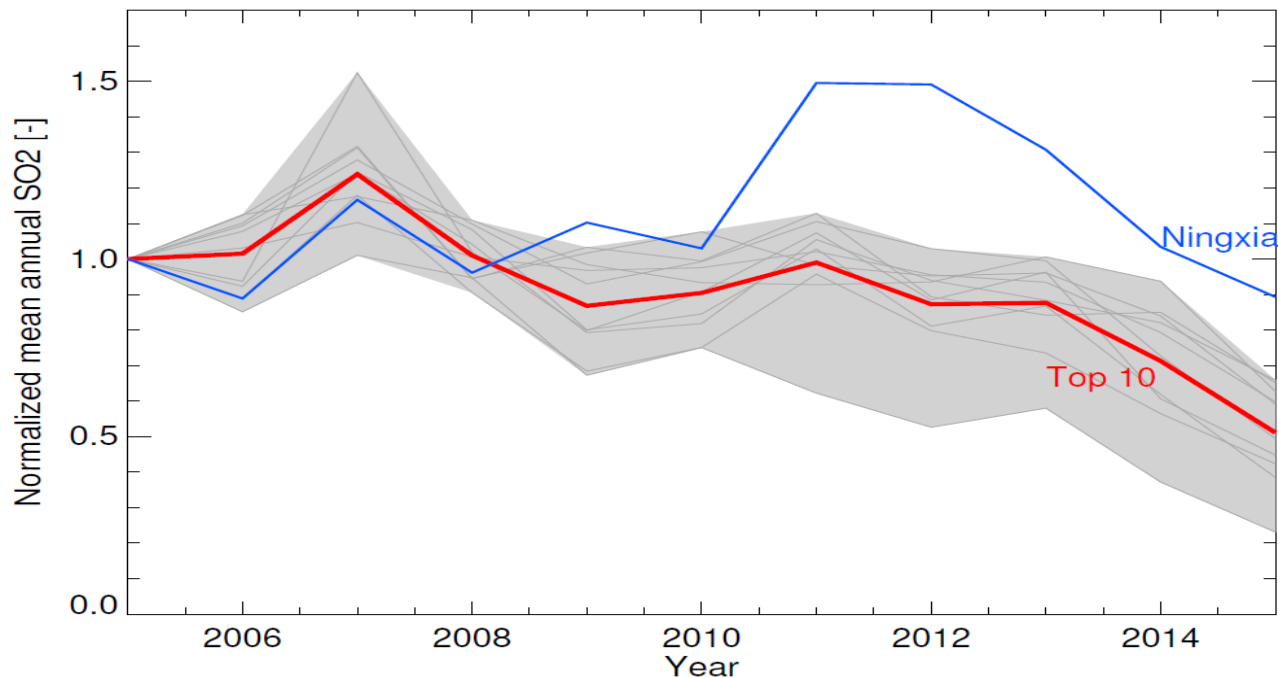
OMI 2005-2014



- Filtered for clouds (>50%), viewing angle (<50°) and solar zenith angle (<75°)
- Gridded to monthly means (1/8 degree resolution)
- Linear fit of SO<sub>2</sub> over the years 2005-2014
- Grid cells with less than 0.1 DU on average are not plotted and grid cells less than 0.5 DU are not fitted.

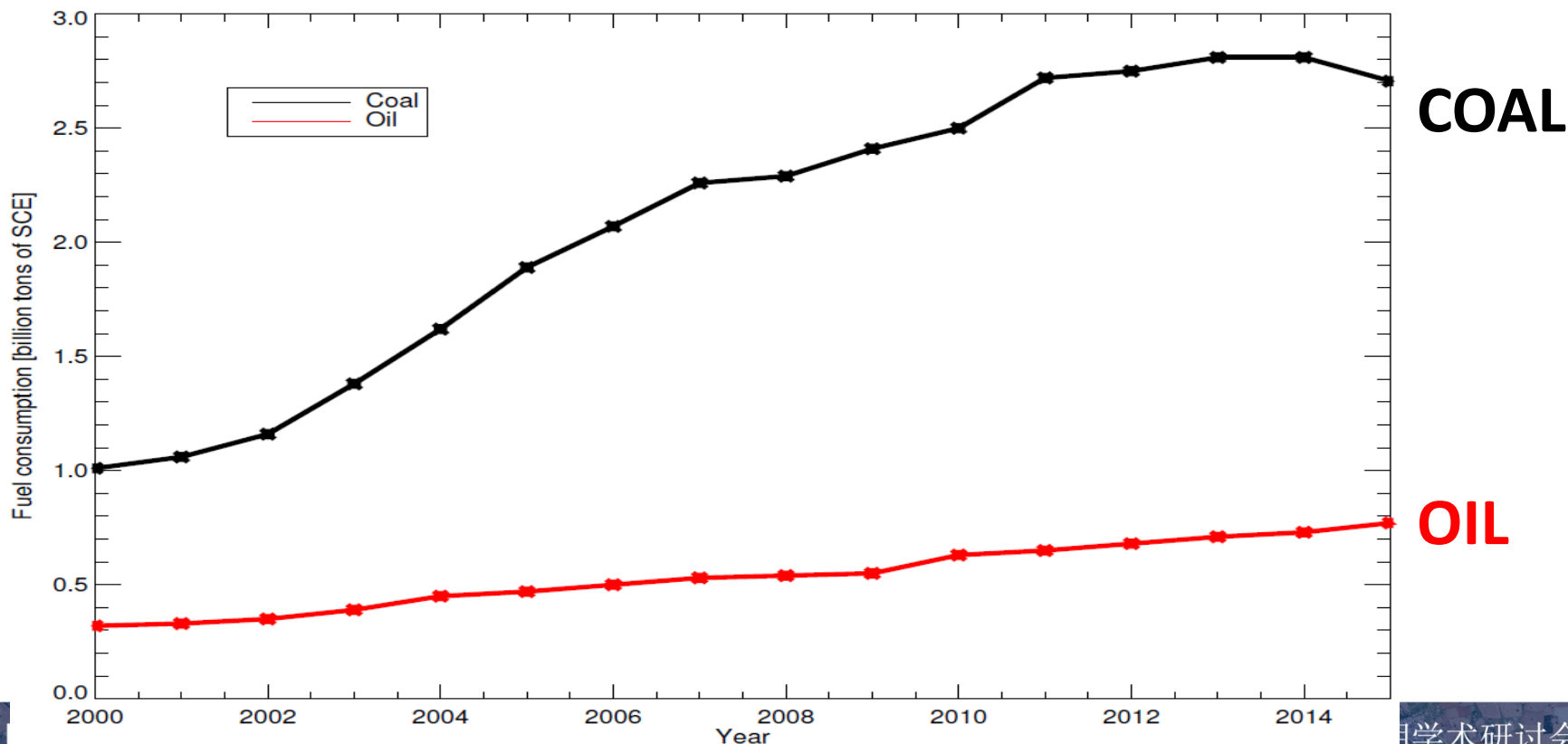


Annual means for the most polluted provinces (Normalized to 2005)



Year of implementation	Regulation	Reference
2005-2006	Desulphurization techniques in power plants. Closure of several of the most polluted power plants	Li et al, 2010, ChinaFAQ, 2012
2008	Stricter control of implementation of desulphurization in power plants	Xu et al, 2011
2011	Use of more gas and renewable energies instead of coal	NBSC, 2015
2012	New emission standard of air pollutants for thermal power plants were implemented on 1 January 2012	MEP, 2015
2013	SO <sub>2</sub> filtering of small-scale coal-fired industry	Zhang, 2013, NDRC, 2013
End 2013	Stricter control of environmental policy	CAAC, 2013, State Council, 2014
End 2013	Further desulphurization in industry	CAAC, 2013, NDRC, 2013
2014	Phasing out small-scale coal-fires boilers	CAAC, 2013, State Council, 2014
2014	Closure of 2000 small-scale coal mines	Zhu, 2013
End 2014	Use of low-sulphur coal	State Council, 2014
End 2014	Cap on coal consumption	State Council, 2014

1. Traffic regulations by (local) government
  - 2007: China 3 (Euro 3) standard for cars
  - 2011: China 4 (Euro 4) standard for gasoline cars
  - 2015: China 4 (Euro 4) standard for diesel cars
2. NO<sub>x</sub> filtering (SCR) in power plants started only from 2011/2012. In 2015 86% of the power plants had SCR equipment.

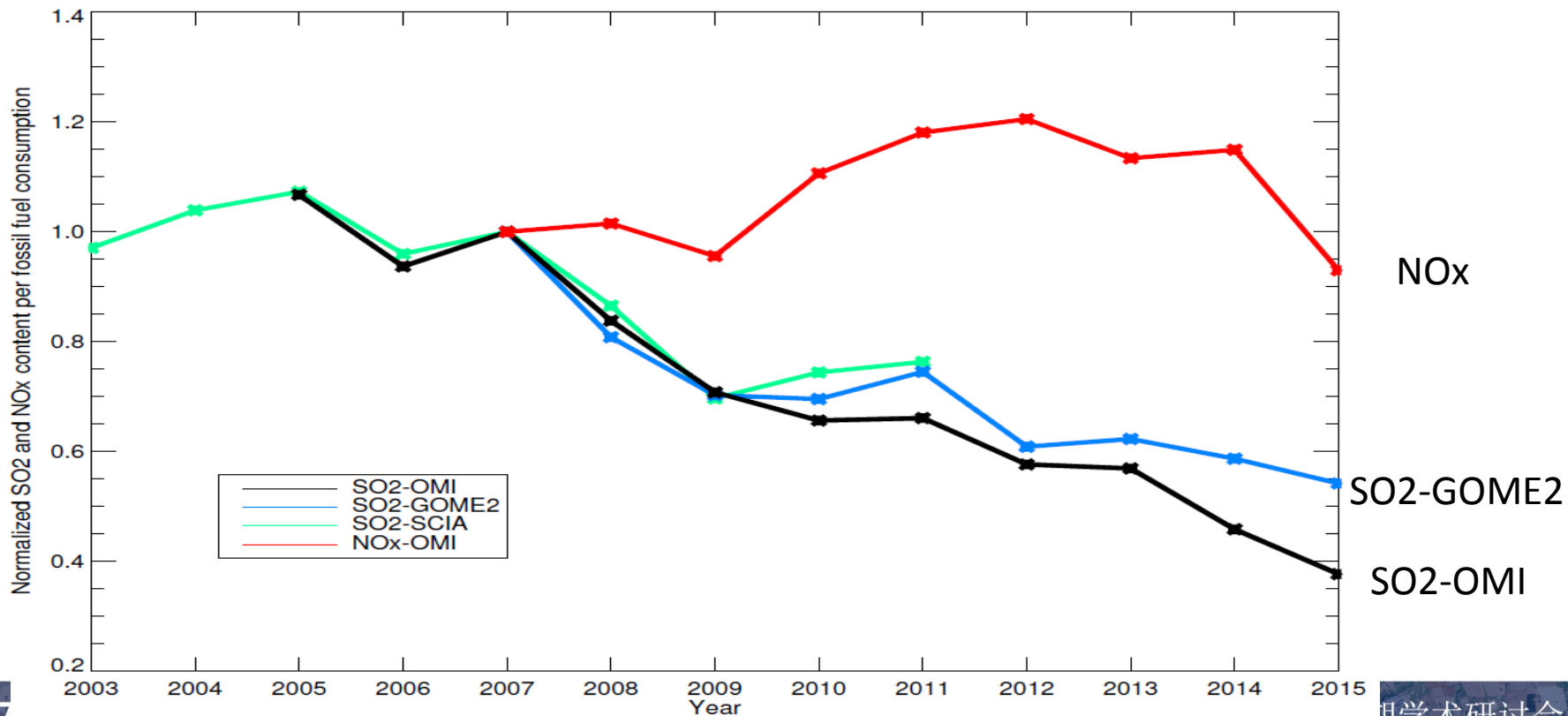


To calculate the efficiency of air quality measures:

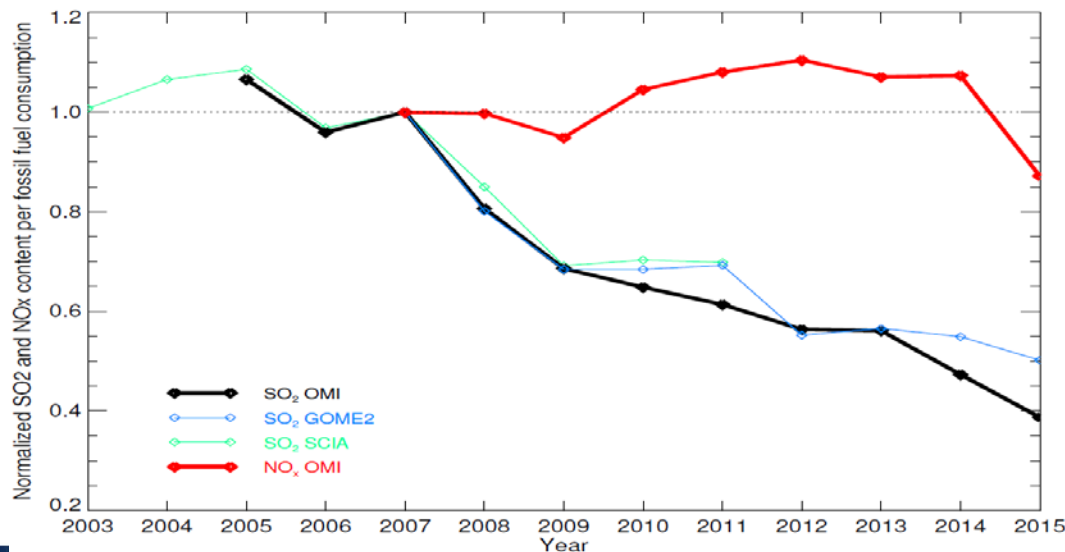
- Annual emissions (NO<sub>x</sub> or SO<sub>2</sub>) divided by the annual energy consumption (coal and oil)
- Gas and renewables are ignored
- Normalized at the year 2007

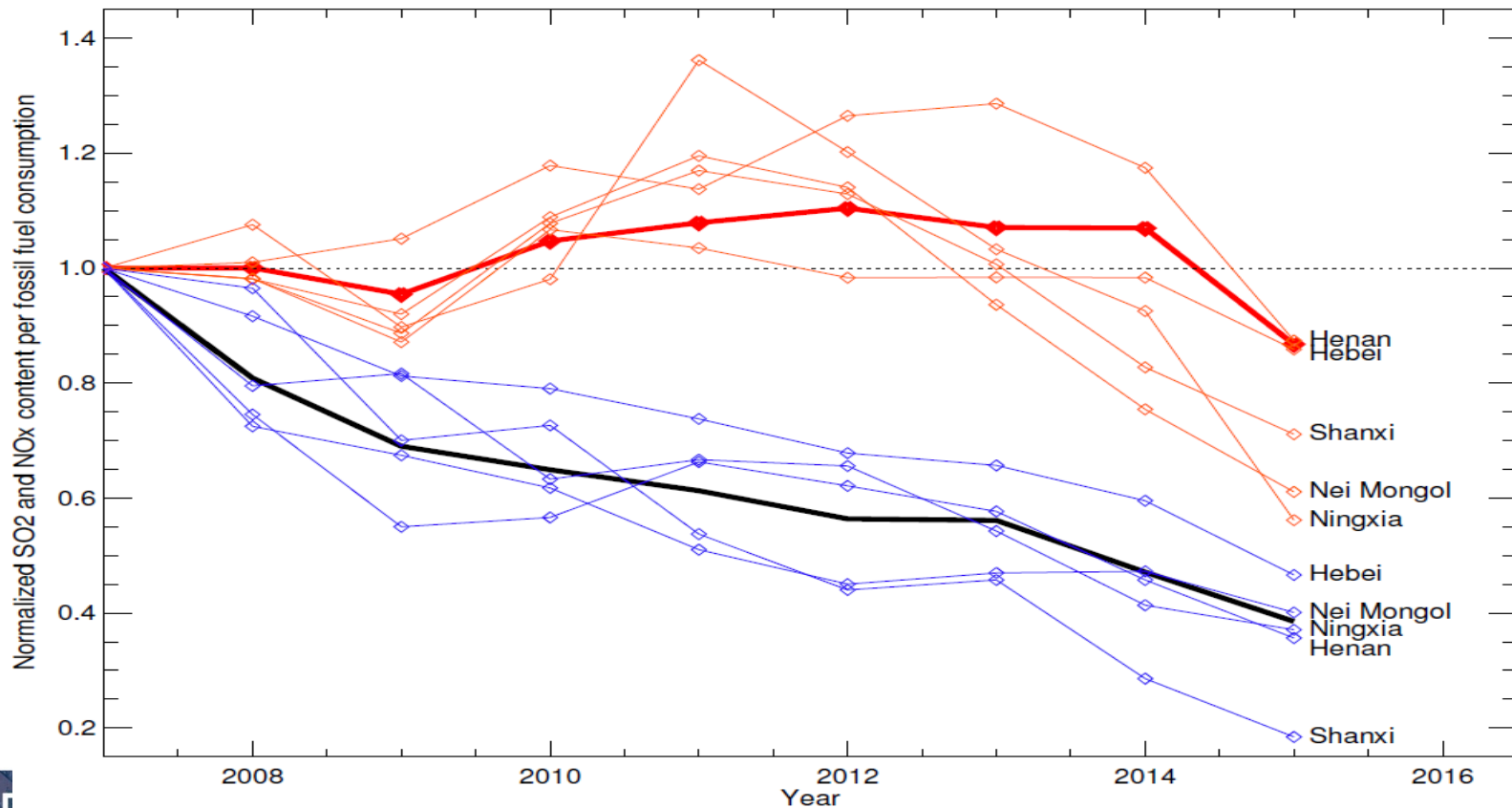


# SO<sub>2</sub>/NO<sub>x</sub> per fossil fuel consumption (normalized)



- NO<sub>x</sub> per FFC is 30% lower in 2015 than in 2012
- SO<sub>2</sub> per FFC is in 2015 about a third of the level in 2005
- GOME-2 shows less reduction after 2009, which is the year that degradation started to become worse.





- Linear fit is not very useful in China
- Effect of air quality regulations for SO<sub>2</sub> and NO<sub>x</sub> can be shown on a provincial level using the current satellites...
- ...and divide the concentration by fossil fuel consumption.
- Without air quality regulations in China:
  - NO<sub>x</sub> emissions would be at least 25% higher
  - SO<sub>2</sub> concentrations would be 2.5 times higher

**Thanks for your attention**

**Questions ?**