GOME-2 observations of air quality in Chinese megacities

PRESCRIBE

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Outline

- GOME-2 trace gas column products provided by O3M-SAF
- Ten years trend in key air pollutants in China's megacities
  - GOME-2 SO_2, NO_2 and HCHO
- Air pollution events in East China in January 2013
- ESA-MOST Dragon 3 project
  - Impact of East Asian Monsoon on air quality over China
- Outlook for Sentinel-4 and -5

Ozone and Atmospheric Chemistry Monitoring SAF

- Part of distributed EUMETSAT ground-segment
- Operational NRT and Off-line products based on GOME-2 and IASI data
- Consortium of ~10 National Meteorological Services and research institutes

Products and services

- Ozone and minor trace gas columns
- Ozone profiles
- Aerosol properties (AAI, AOD, SSA)
- UV products (clear-sky and with clouds/albedo)
- Validation service for each product

- IASI products (O_3, SO_2, CO, HNO_3)

O3M SAF

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o3msaf.fmi.fi

GOME-2 trace gas column products

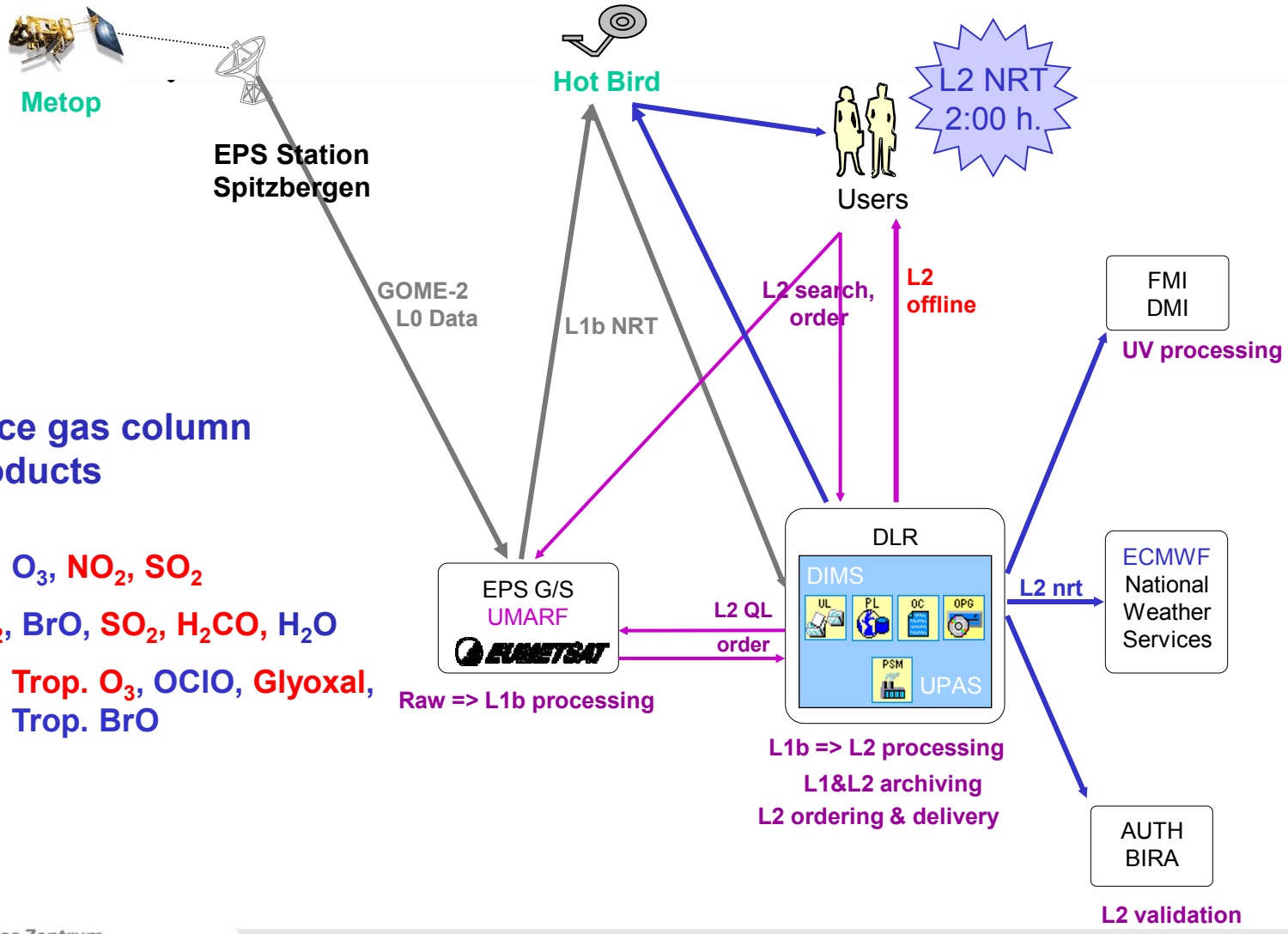
O3M SAF

GOME-2 trace gas column products

Near-Real-Time: O_3, NO_2, SO_2

Off-line: O_3, NO_2, BrO, SO_2, H_2CO, H_2O

In development: Trop. O_3, OClO, Glyoxal, Trop. BrO



Megacity and air quality

- Megacity: a metropolitan area with a total population of more than 10 million people
  - There are **26** megacities in the world, **14** megacities located in Asia and **3** in **China**
  - In China, urban population rate increase from 19.6% to 46% within the last three decades
  - Two-thirds of China's population—an estimated 64%—will live in cities by 2025

- Urbanization and industrialization have important consequences for the atmosphere
  - Increasing production of harmful pollutants
  - Creating significant health problems
  - Causing urban and regional haze
  - Potential to contribute significantly to climate change

- Important to study the anthropogenic impact on atmospheric composition in megacities

Megacities are playing a leading role for regional air pollution problem

China's Top 3 City Clusters		
Territory	354969 (km²)	3.7(%)
Population	189.24 (million)	14.1 (%)
GDP	7825.9 (billion)	40.1 (%)

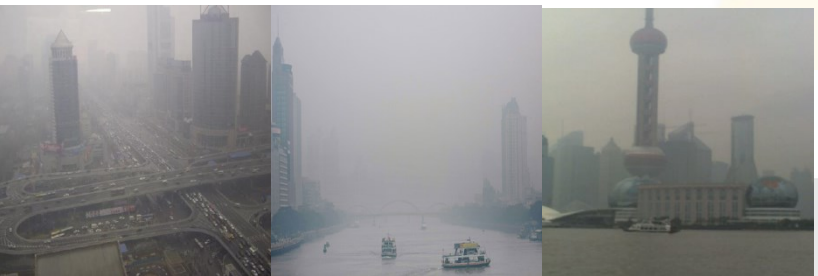
* Based on data in 2006

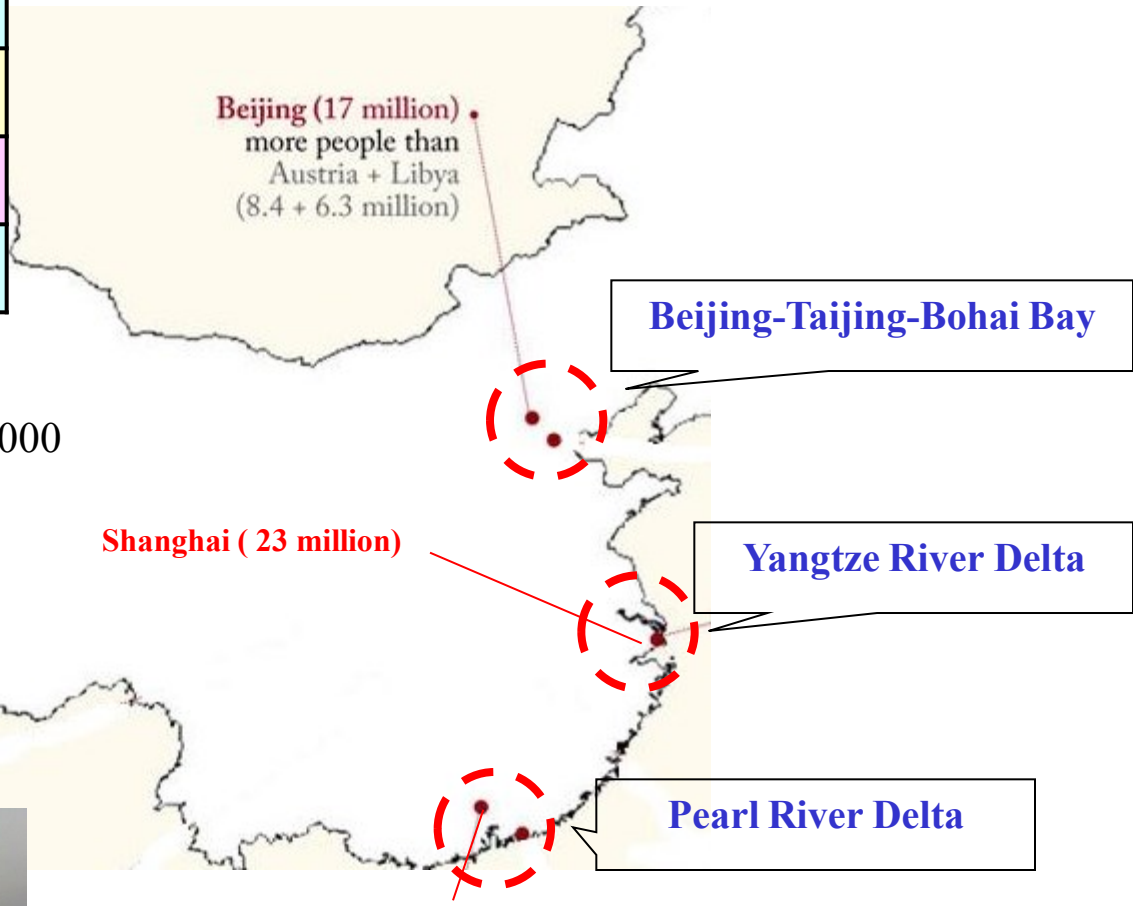
The numbers of cars (2010) compared to 2000

Beijing: 4.76 million ~200%

Shanghai: 2.85 million ~100%

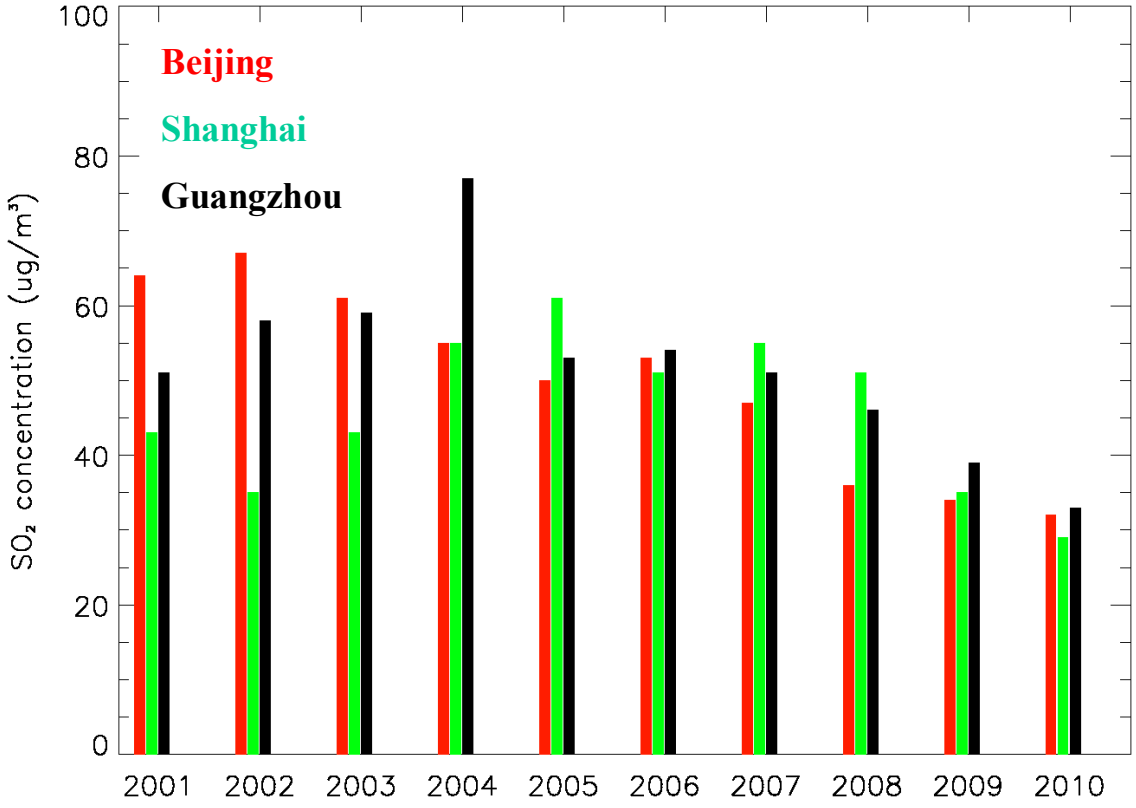
Guangzhou: 2.12 million ~170%





More than half year were haze days in **Shanghai**

Ten years trend of SO_2 concentrations



From **2000 to 2005**, SO_2 showed a clear increase in **Shanghai** and **Guangzhou,** due to increase in energy consumption (mainly from coal burning).

After **2007**, SO_2 showed a relative clear decrease in **Beijing, Shanghai** and **Guangzhou**.

SO_2 data from EPA

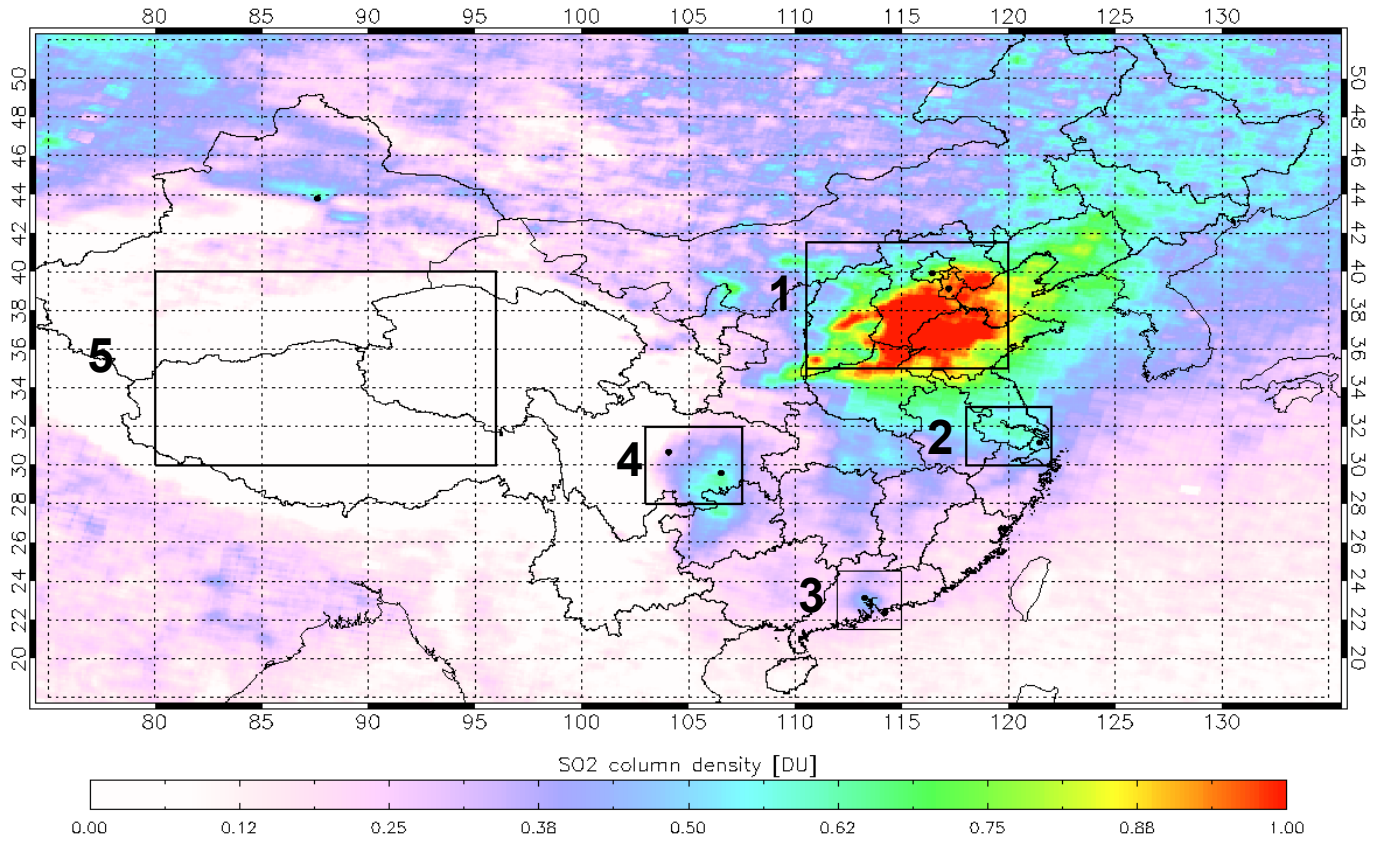
PJ	2000	2005	Increase
Industry coal use	10,178	17,053	**68%**
Electricity coal use	12,203	24,028	**97%**
On road transport	1,946	3,424	**76%**
Off road transport	1,387	2,696	**94%**

Ref: National Bureau of Statistics of China. China Statistical Yearbook

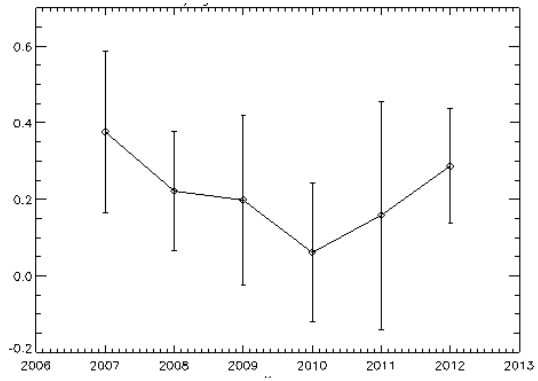
Satellite observation of SO_2 over China

2008

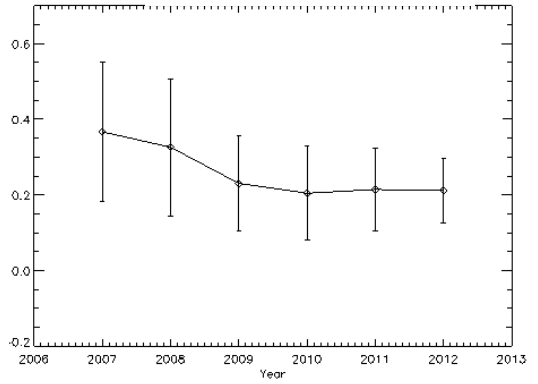
GOME-2



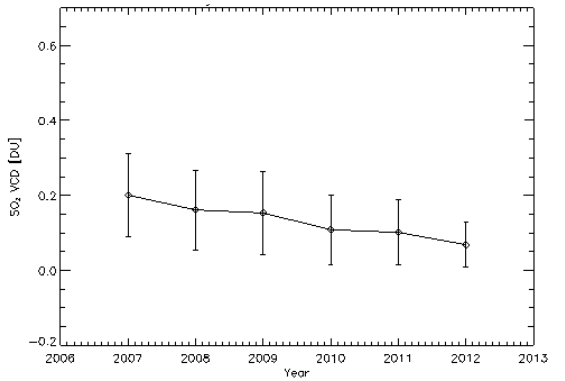
Beijing



Shanghai



Guangzhou



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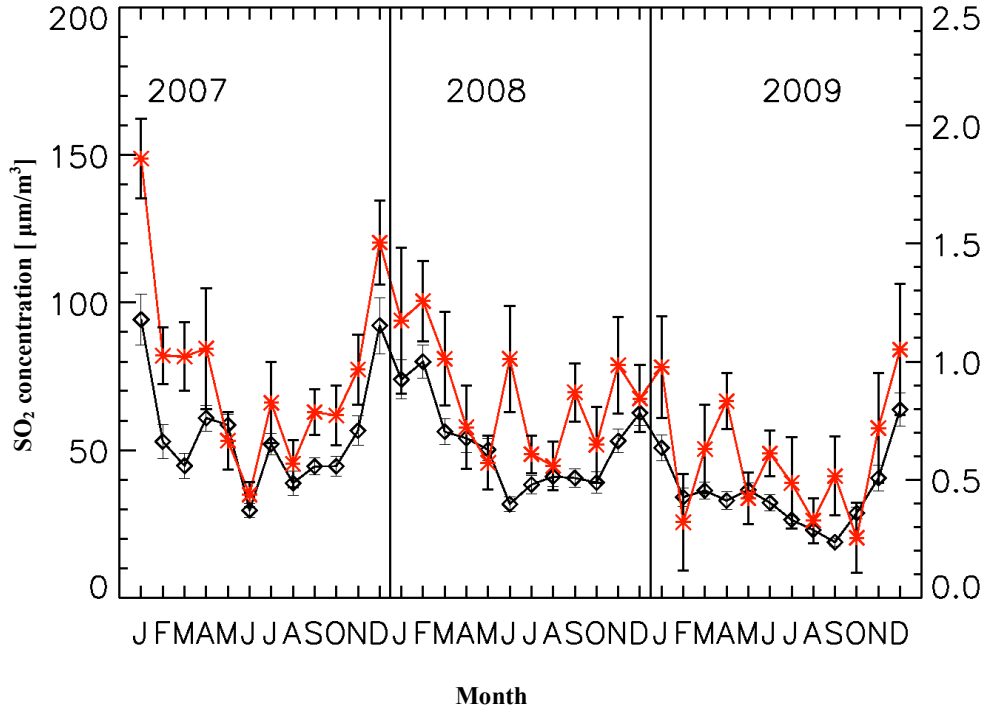
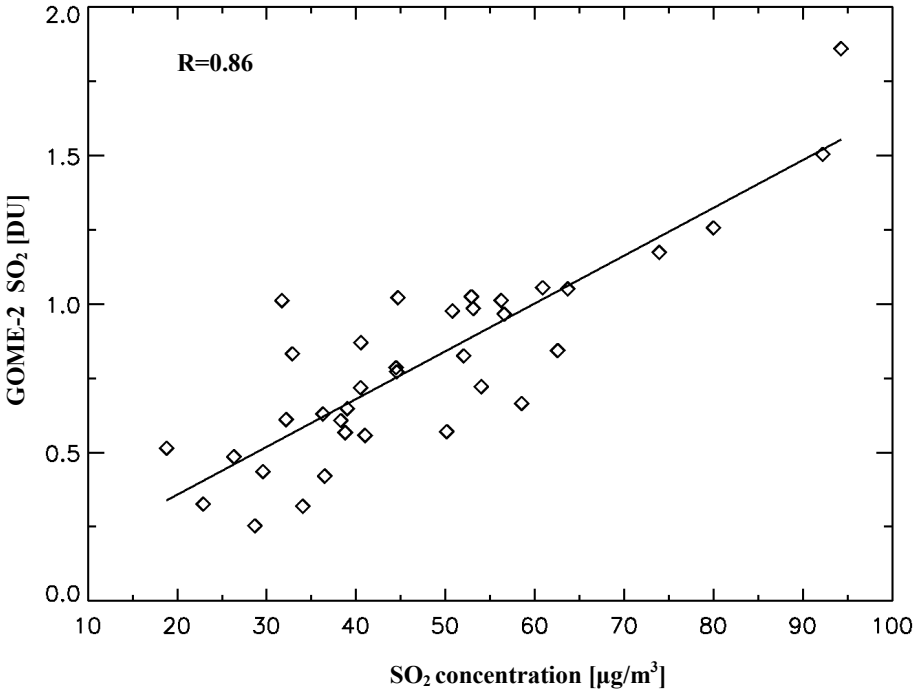
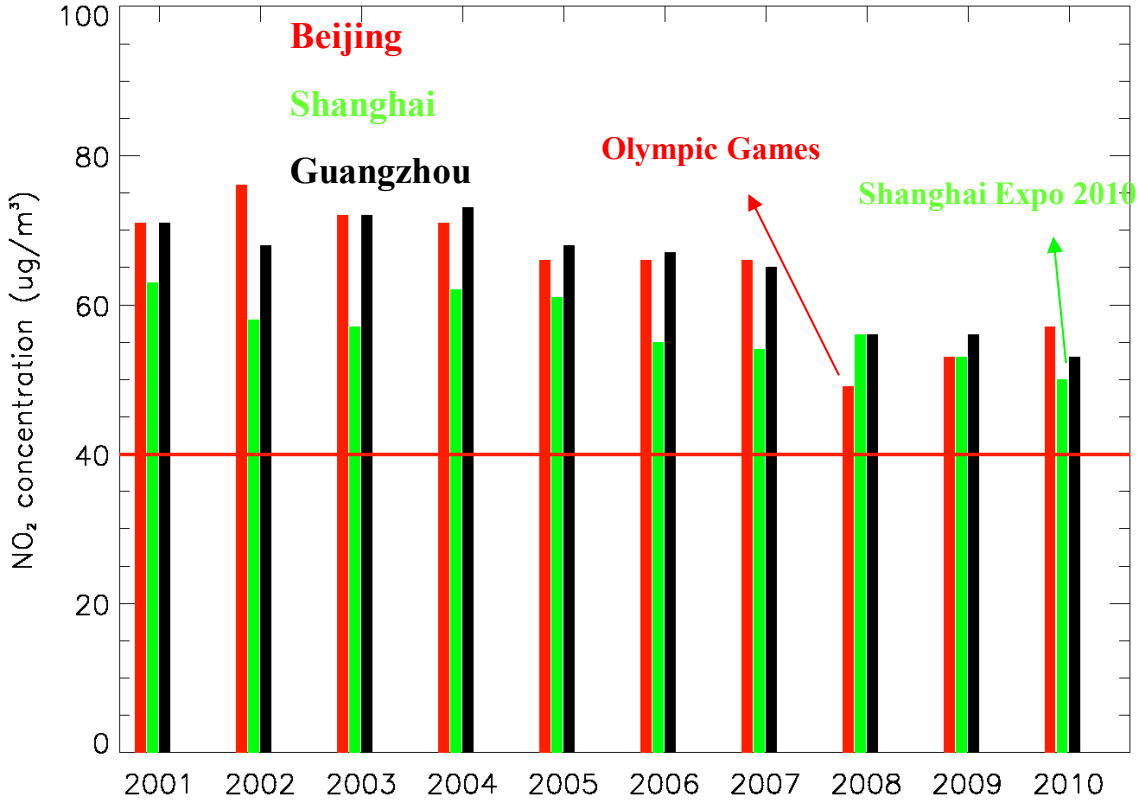
Comparison with in-situ SO_2 measurement in Shanghai





In-situ SO_2 data from Shanghai EPB

Ten years trend of NO_2 concentrations

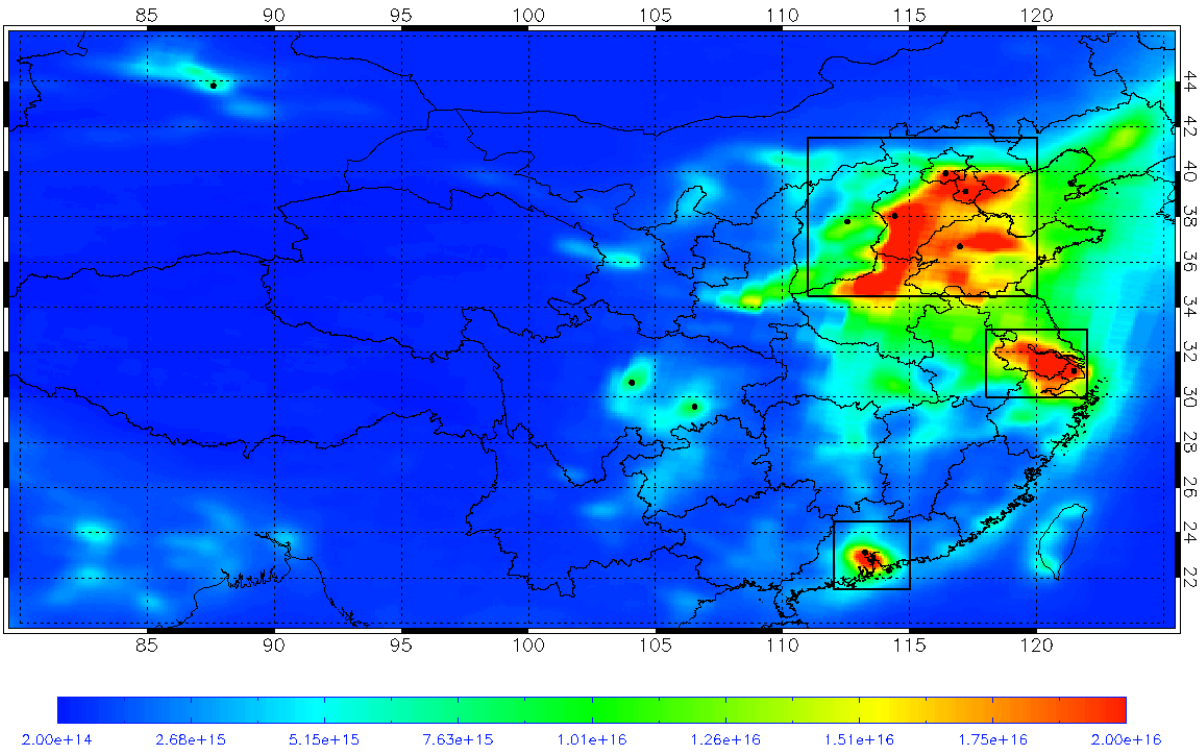


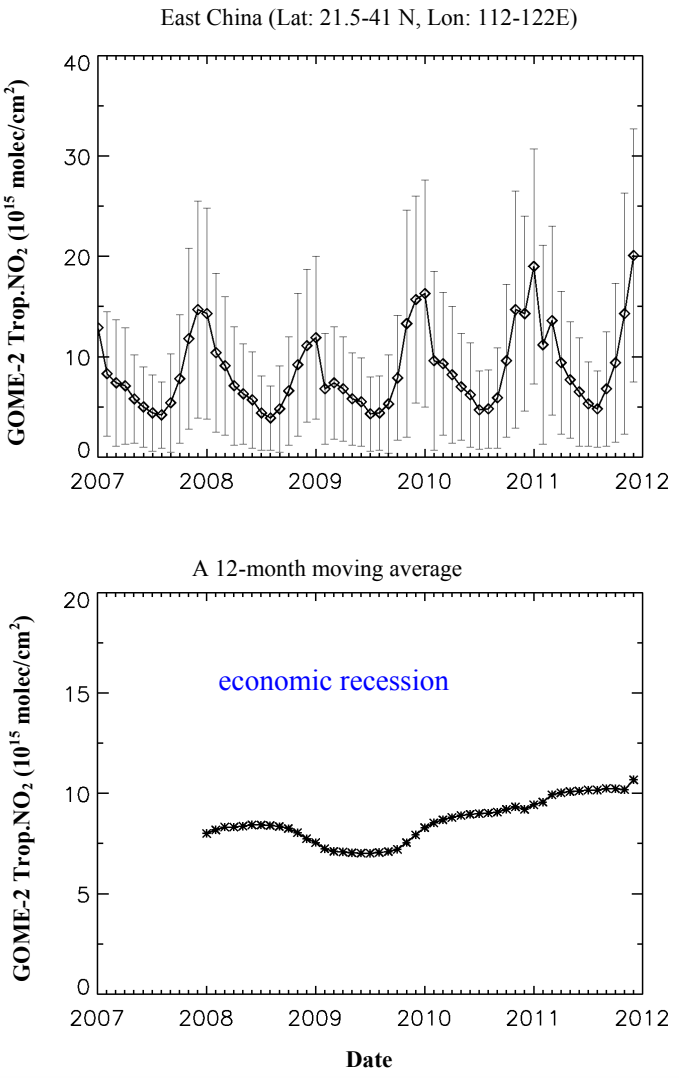
NO_2 showed no evident annual trend in Shanghai.

From 2004, NO_2 showed a decreasing trend in Guangzhou.

In 2008, NO_2 showed a clear decrease in Beijing, but increase again after 2008.

GOME-2 Tropospheric NO_2 over China (2007-2012)





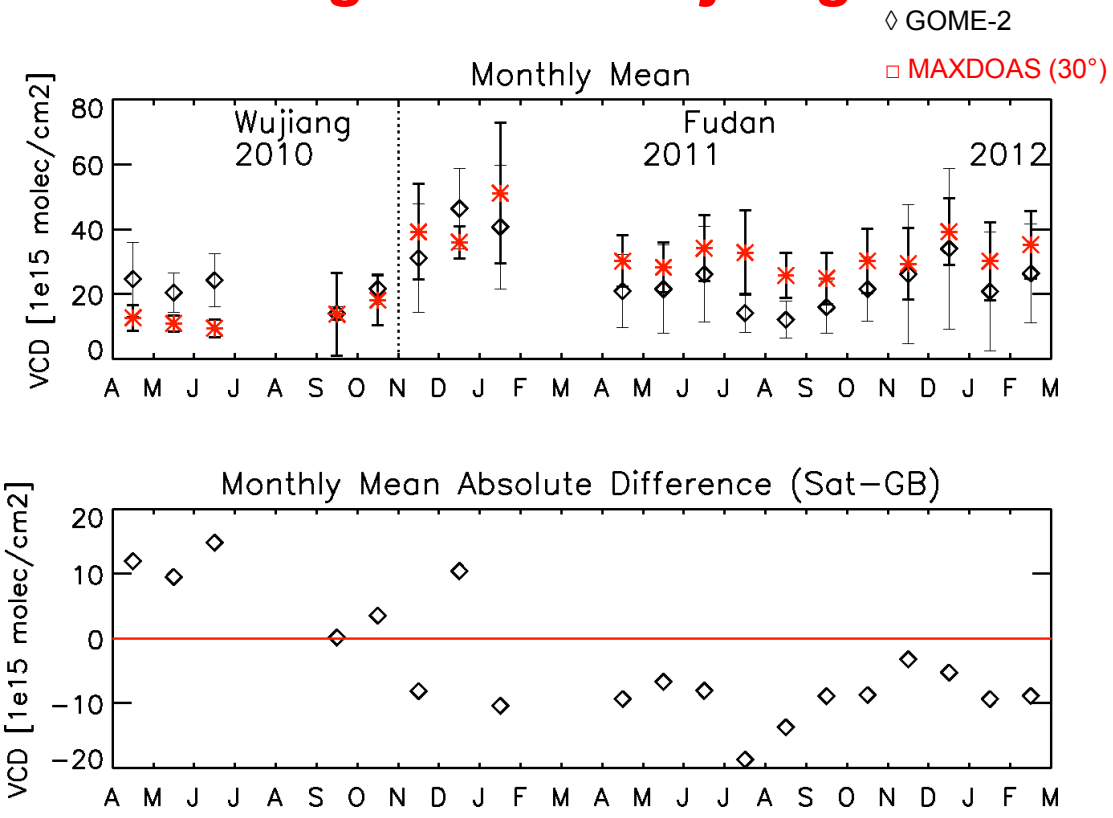
A **significant increase** of NO_2 over China from 1994 to 2006 observed by GOME and SCIAMACHY

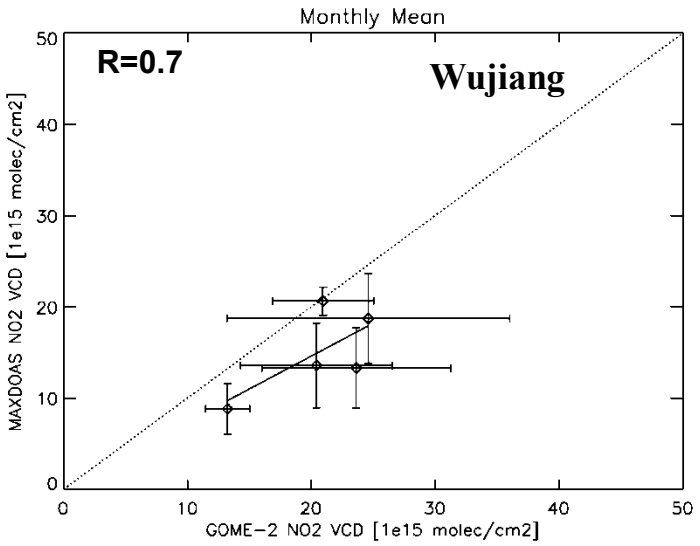
Richter A, et al., Nature 2005;

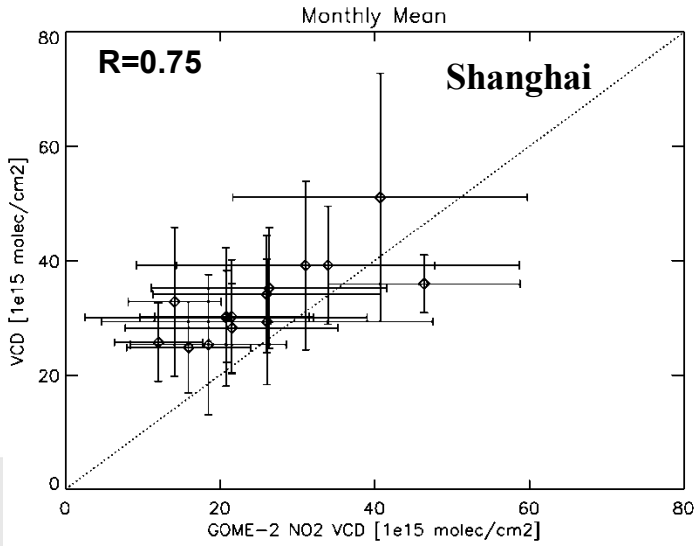
Van der A et al., J. Geophys. Res., 2006

Hao et al, Environ. Res. Lett. 6, 2011

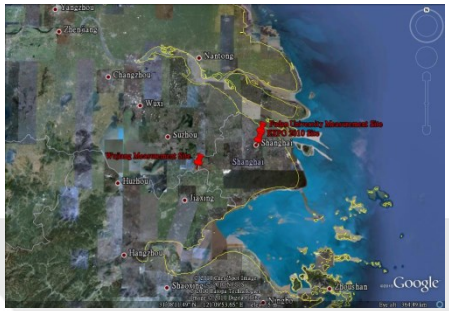
Monthly means MAX-DOAS and GOME-2 tropospheric NO_2 over Shanghai and Wujiang







GOME-2: mean values of all the pixels within 50 km around Wujiang and Fudan University



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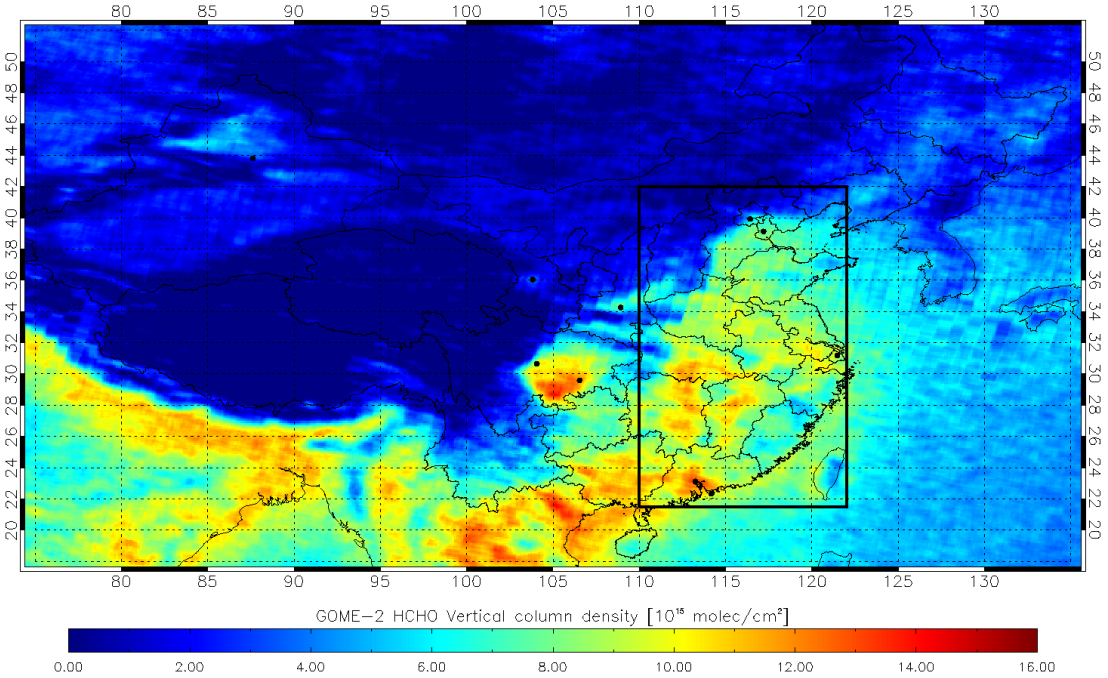
GOME-2 Tropospheric HCHO over China (2007-2012)



$HCHO/NO_2$ column ratio:

Indicator of surface ozone-NO_x-VOC sensitivity

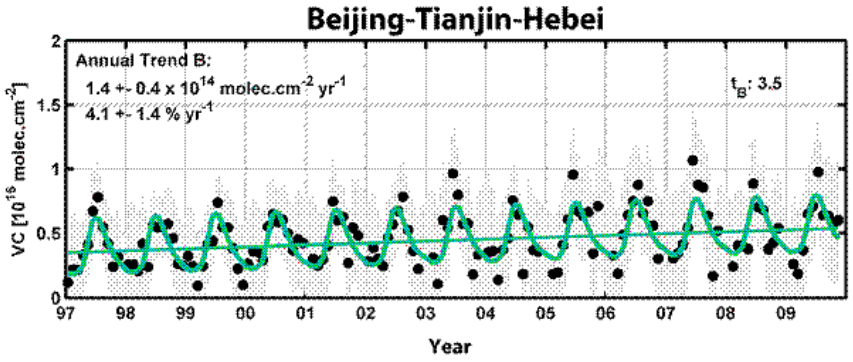
Beijing, Shanghai and Guangzhou:

VOC-limited

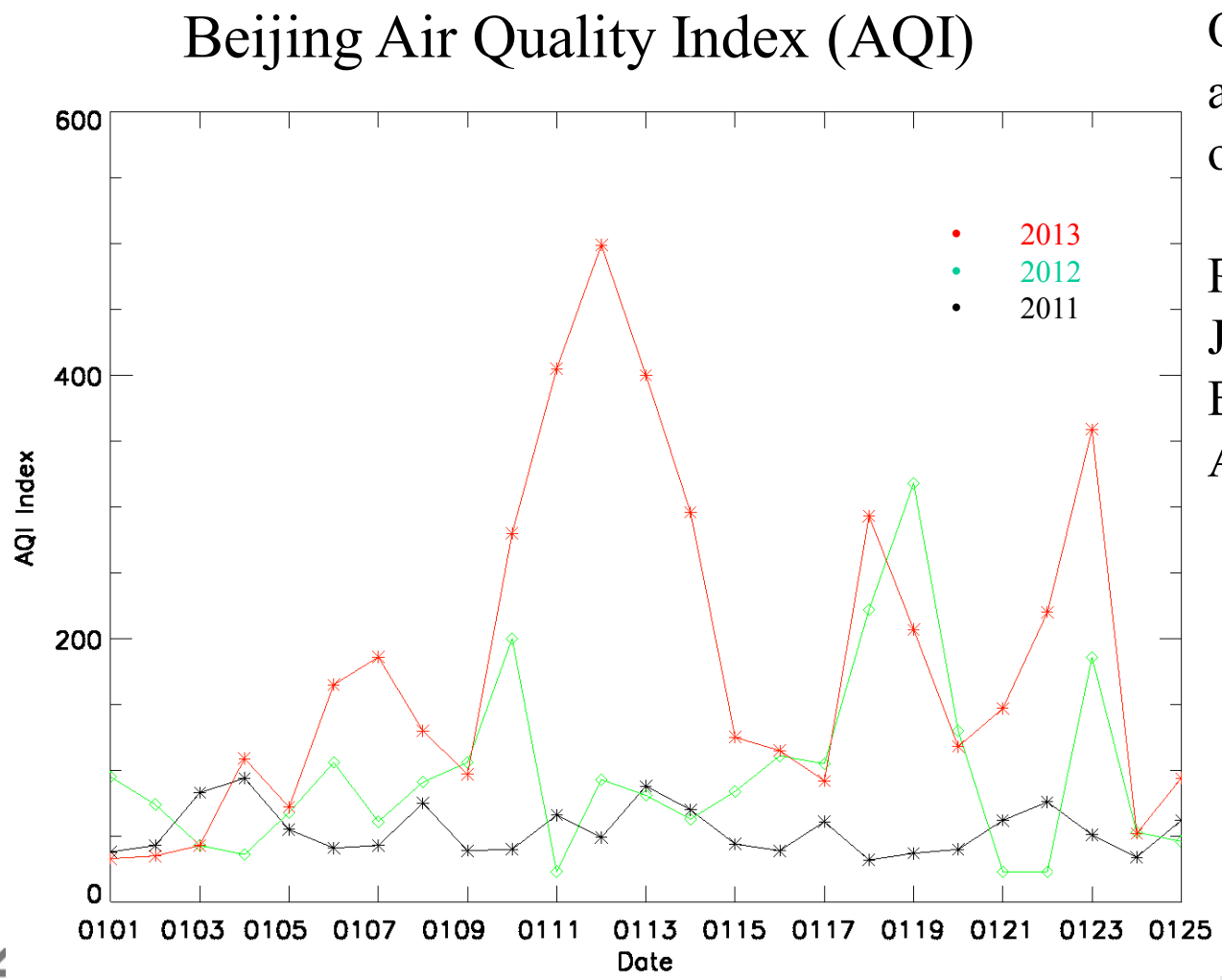
GOME and SCIAMACHY HCHO for 1997-2009

Growth rate: 4 ± 1.4% per year

De Smedt et al., 2010



Air Pollution Events in East China in mid-January 2013

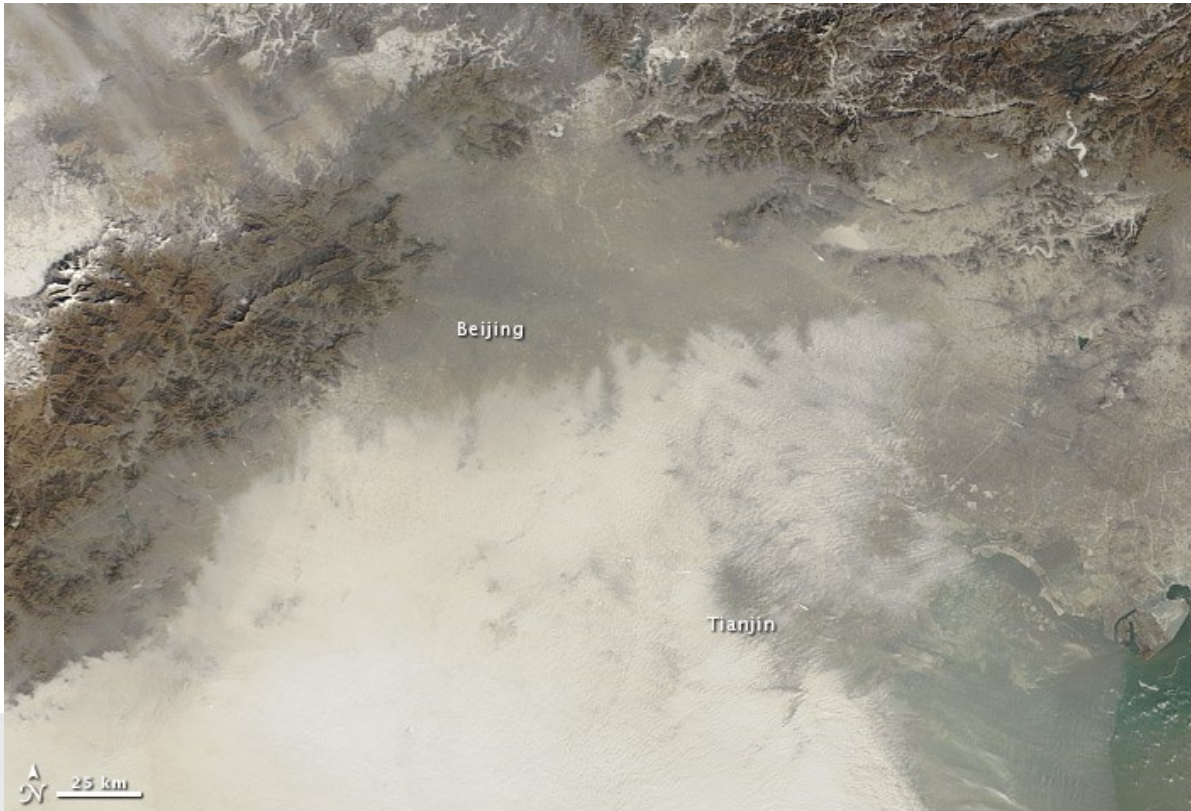


One of the worst period of air quality in Beijing and other cities in China

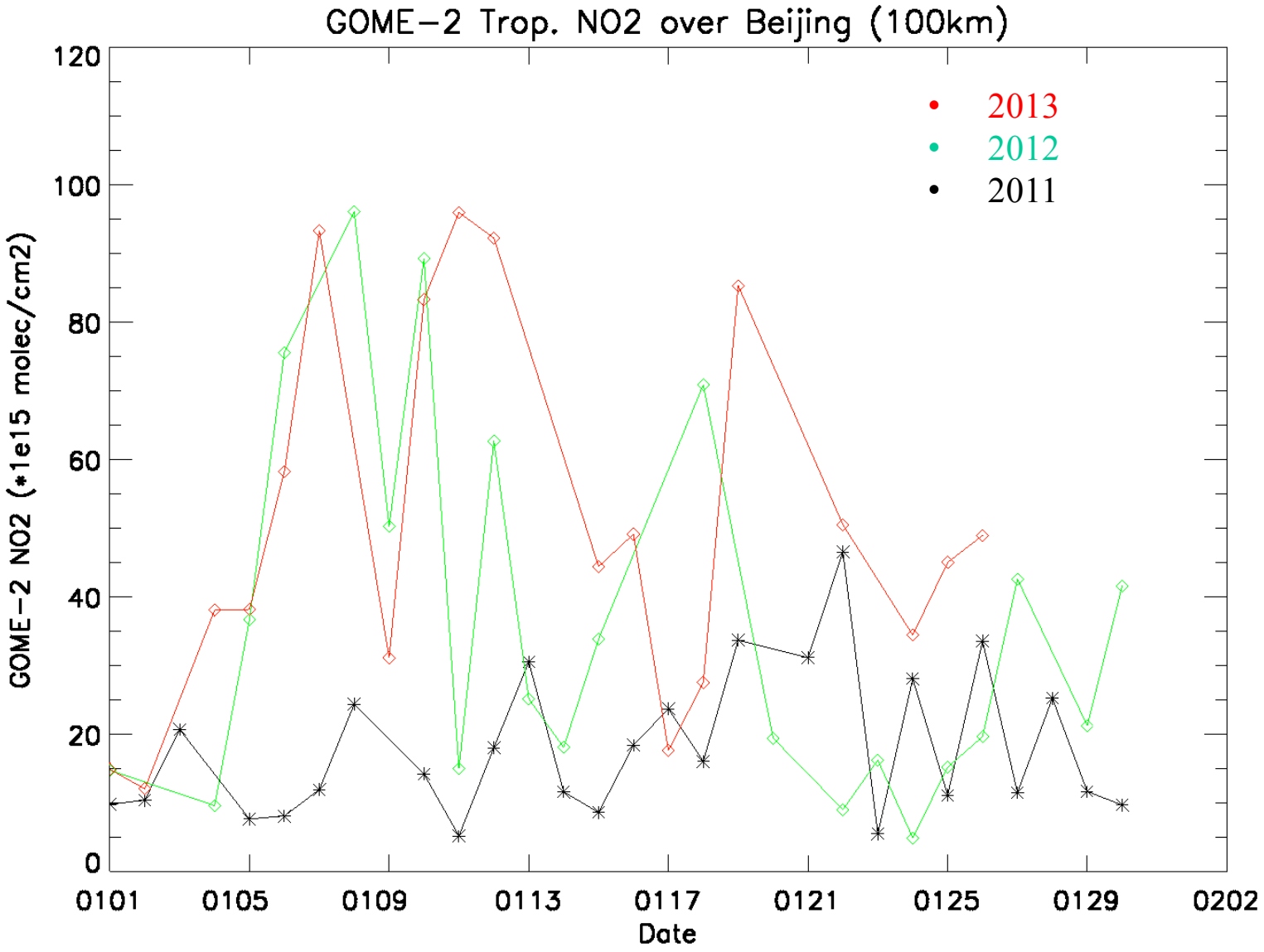
Peak of AQI is 775 on Jan. 12 – off the US. Environmental Protection Agency scale

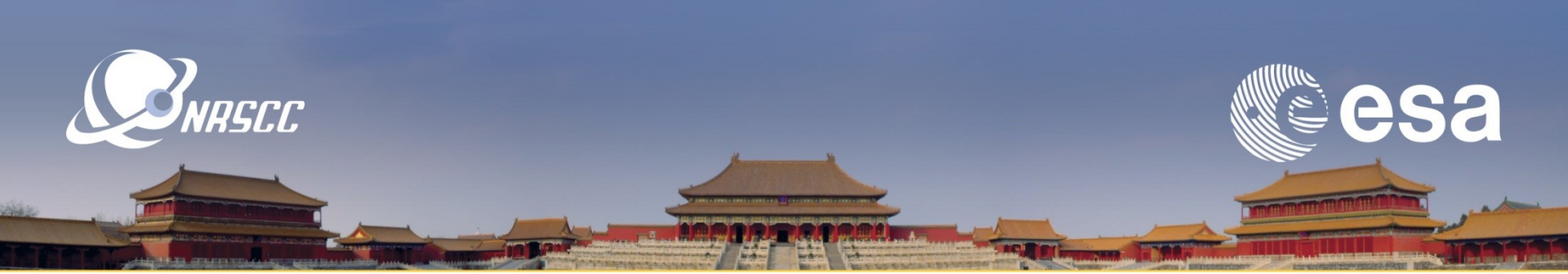
Beijing Olympic Stadium
Jan. 14, 2013

MODIS Jan. 14, 2013



Trop. NO2 over Beijing in January 2011-2013





ESA-MOST Dragon Cooperation

中国科技部-欧洲空间局合作“龙计划”

DRAGON 2 FINAL RESULTS AND DRAGON 3 KO SYMPOSIUM

“龙计划”二期总结研讨会暨三期启动会

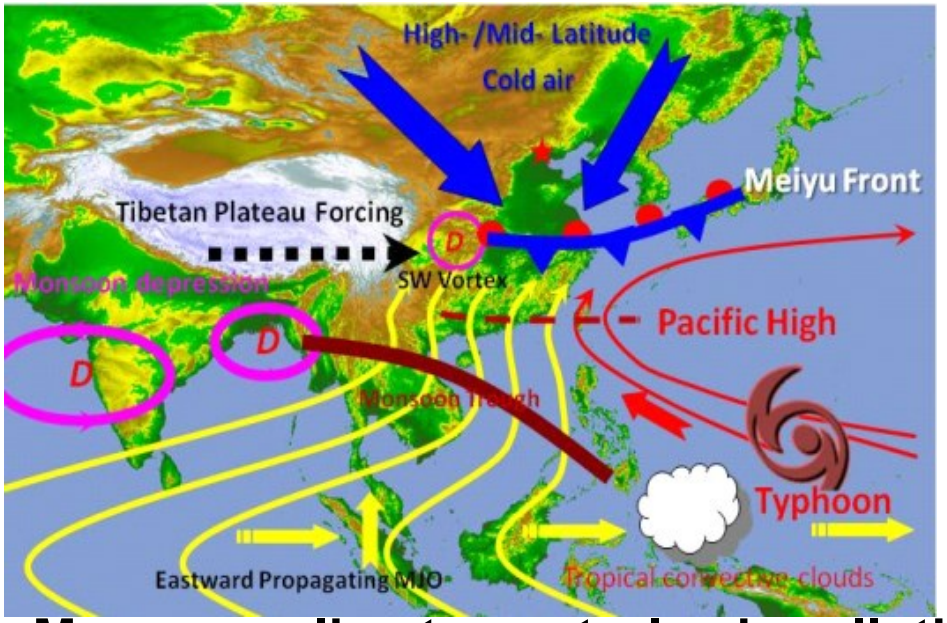
Assessment of the impact of the East Asian Summer Monsoon on the air quality over China

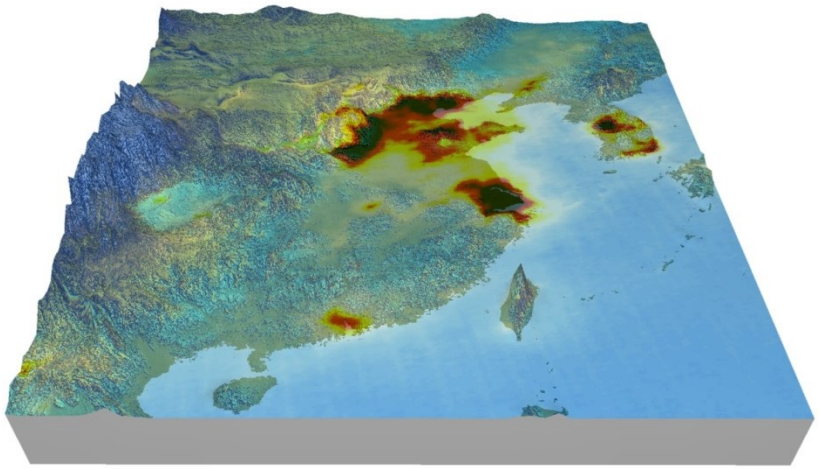
Dr 3 project Id. Number 10455

N. Hao[1], A.J. Ding[2], C. Clerbaux[3], S. Safieddine[3], T. Wang[4], T. Trautmann[1], P. Valks[1], K. Ding[2]

Background and Objectives

Provide a holistic view of the monsoon impact on tropospheric ozone and related trace gases over China





Climatology of NO_2 column (1996-2007)

Monsoon climate controls air pollution transport in East Asia, especially for "long-life" species like O3

Summary of Expected Results

- A comprehensive databank of ozone and related trace gases from various platforms

- Improved understandings of the driving mechanisms of the seasonal patterns and inter-annual variations of air pollution in different regions of China.

- A general assessment on the uncertainties of satellite products and improved retrieval algorithms of some species in the high-polluted East Asian regions

Outlook for Sentinel-4 and -5

DLR has a strong interest in S4-UVN and S5-UVNS product development and processing

Strong involvement in GOME/ERS-2, SCIAMACHY, GOME-2/MetOp and S5P

- Processor development
  - Level-1 and Level-2 processors
  - Prototype and operational
- Operational processing
  - Part of (distributed) ground-segment (ESA and EUMETSAT)

Sentinel-4/UVN

- Level-1b prototype processor development ongoing
- Level-2 prototype processors (ESA-ITT in 2013?)
- Operational processors and processing
  - Central or distributed EUMETSAT ground-segment ???

Sentinel-5/UVNS

- Prototype Level-1b and Level-2 processor development ???
- Operational processors and processing ???

Conclusions

- Ten years trend in key air pollutants in Chinese megacities
  - SO_2 emissions successfully controlled from 2007 to 2010, increase in Beijing after 2010
  - NO_2 showed a decreasing trend in Guangzhou, but not in Beijing and Shanghai
  - Particulate pollution especially $PM_{2.5}$ is the major air pollution problem

- MAXDOAS measurements in Shanghai from 2010 until now
  - Preliminary comparison results show good agreement between satellite and ground-based measurements

- Satellite observations can be used to monitor air quality in mega-cities

- Operational GOME-2 trace-gas products available at:

http://atmos.caf.dlr.de/gome2