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

Nan Hao and Dragon 3 Project team

NRSCC

esa

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

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NANJING UNIVERSITY 1902

LATMOS

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學

Outline

- Introductions
  - Air pollution over China
  - East Asian Monsoon
- Measurements of air pollutants over China
  - Satellite measurements
  - 11 years Ozonesonde over Hongkong (2000-2010)
  - Ground-based measurements over Nanjing from 2011
- Impact of East Asian Monsoon on air quality over China

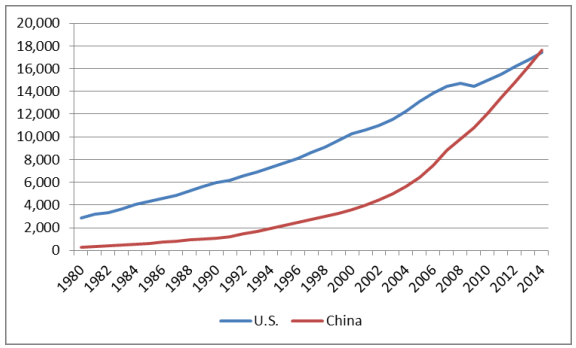
Nan.hao@dlr.de

Air pollution in East China

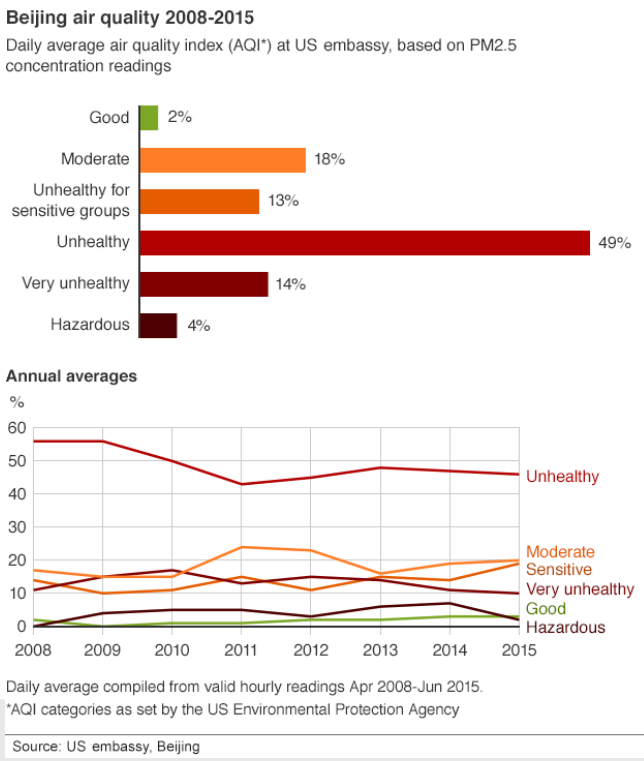
- Industrial development and urbanization result in tremendous increases in energy consumption and air pollutants emission.
  - Increasing production of harmful pollutants
  - Creating significant health problems
  - Causing urban and regional haze
  - Potential to contribute significantly to climate change

- Important to study the anthropogenic impact on atmospheric composition over East China

Chinese and U.S. GDP on a PPP Basis: 1980-2014



Source: IMF world economic outlook



Photos and figures from BBC

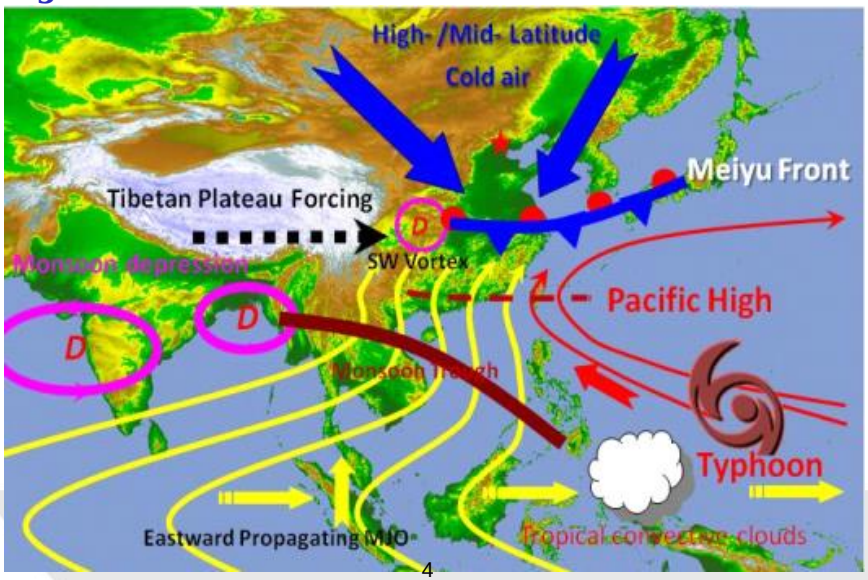
East Asian Monsoon Over China

➢https://www.youtube.com/watch?v=We4ss7xUlKM

➢The **East Asian monsoon** is a monsoonal flow that carries moist air from the Indian Ocean and Pacific Ocean to East Asia.

➢**East Asian monsoon** plays a significant role in characterizing the temporal variation and spatial patterns of **air pollution**, since monsoon is a major atmospheric system affecting air mass transport, convection, and precipitation.

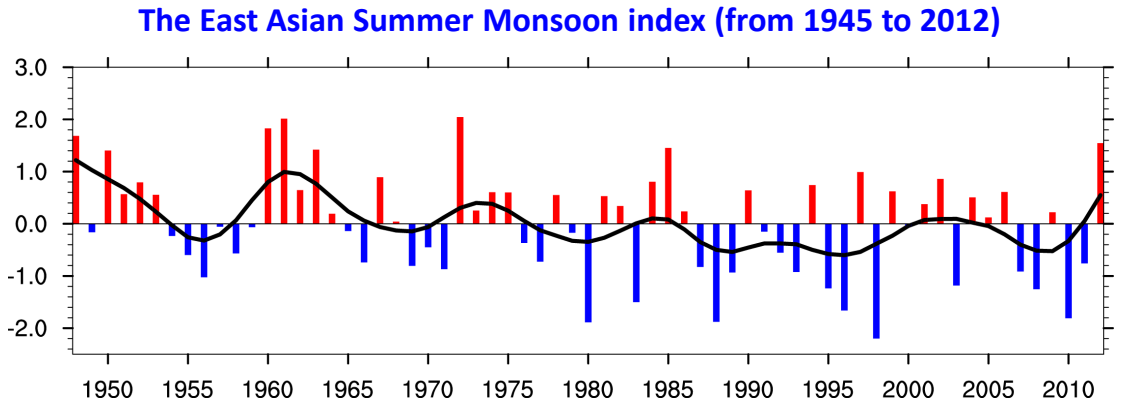
➢Monsoon climate controls air pollution transport in East Asia, especially for "long-life" species like O_3



East Asian Monsoon Over China

- The dynamically normalized seasonality monsoon index (**DNSMI**) defined by Li and Zeng (2002)
  - Using monthly NCEP/NCAR Reanalysis data

- The East Asian summer monsoon (**EASM**) index is defined as an area-averaged seasonally (JJA) dynamical normalized seasonality (DNS) at 850 hPa within the East Asian monsoon domain (10-40° N, 110-140° E).



Li and Zeng, 2002, 2003, 2005

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- **Measurements of air pollutants over China**
  - Satellite measurements & validation
  - 11 years Ozonesonde over Hongkong (2000-2010)
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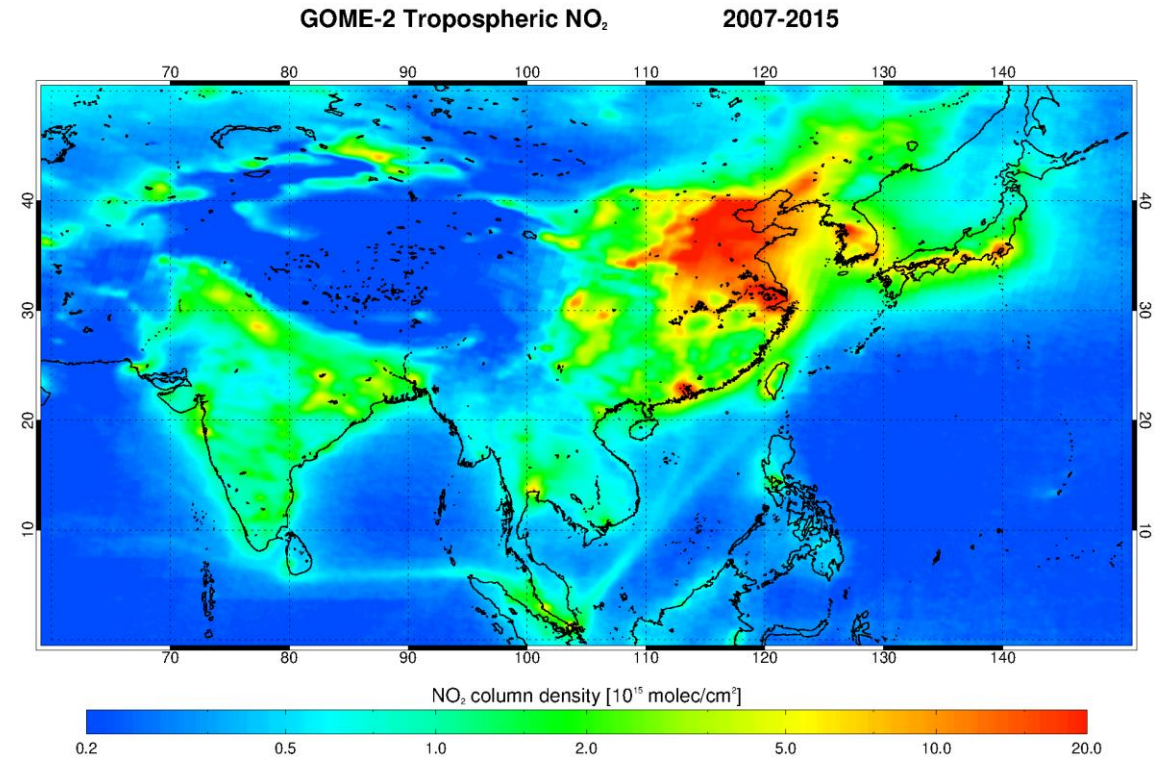
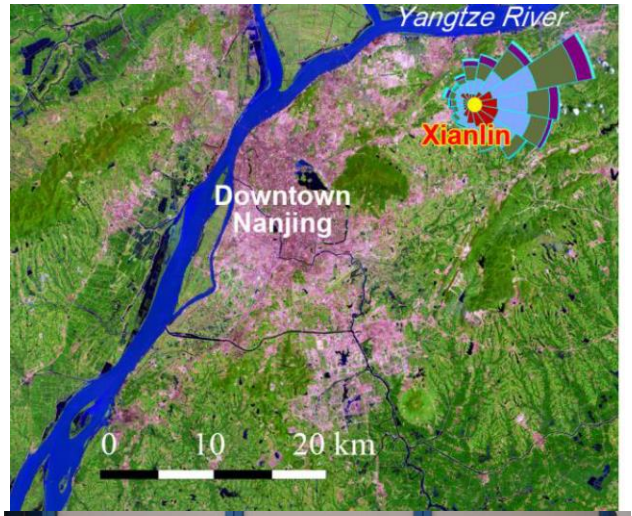
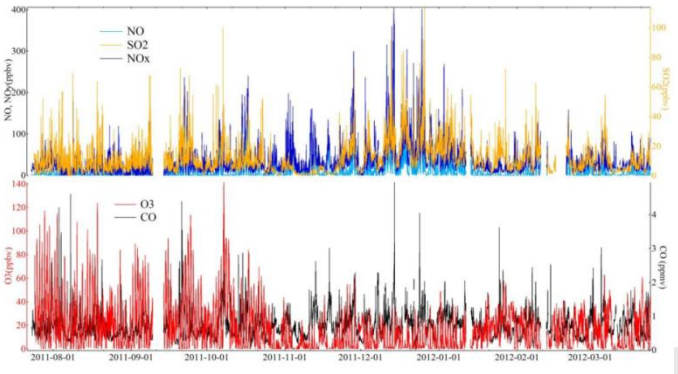
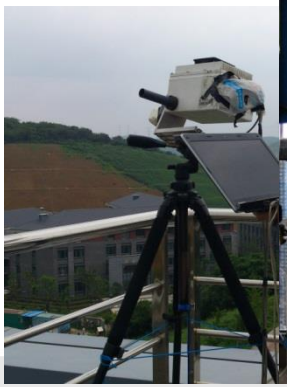
Observations of NO_2 over China



Station for Observing Regional Processes in the Earth System of Nanjing University (**SORPES-NJU**)
Location and Height: **E118.9°, N32.1°,43 m**



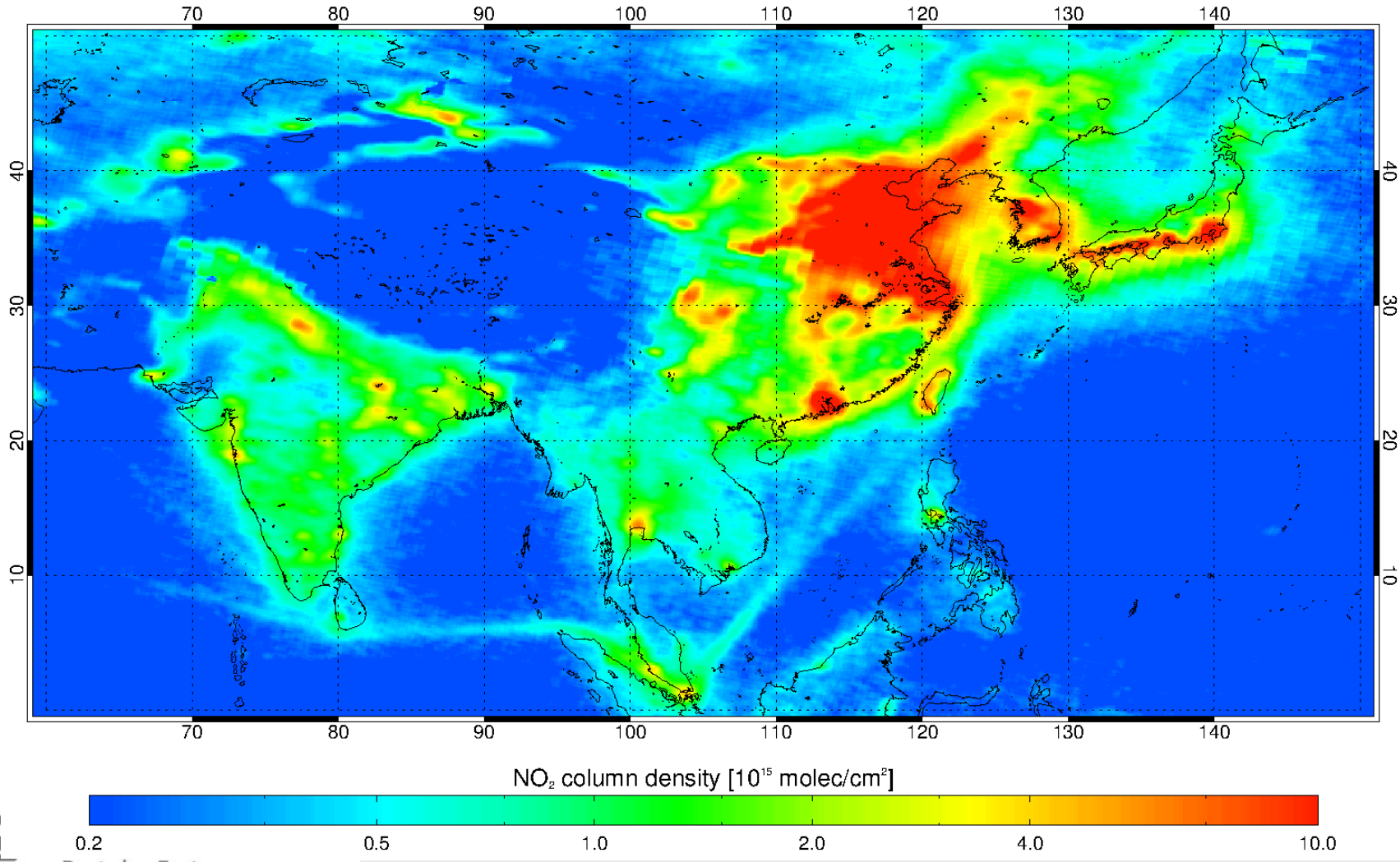




Deutsches für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Ding et al., ACP, 2013

Tropospheric NO_2 trends over East China



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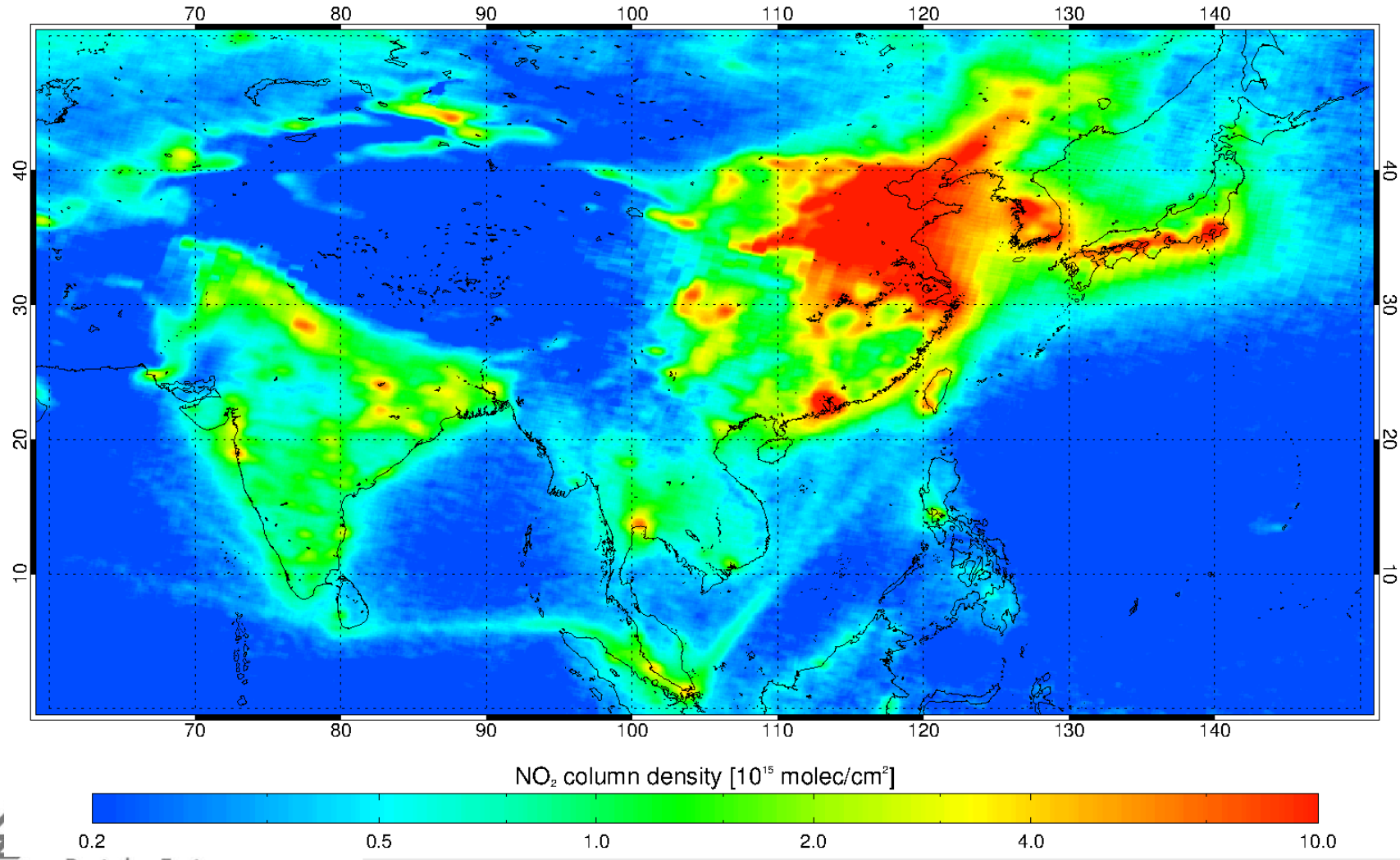

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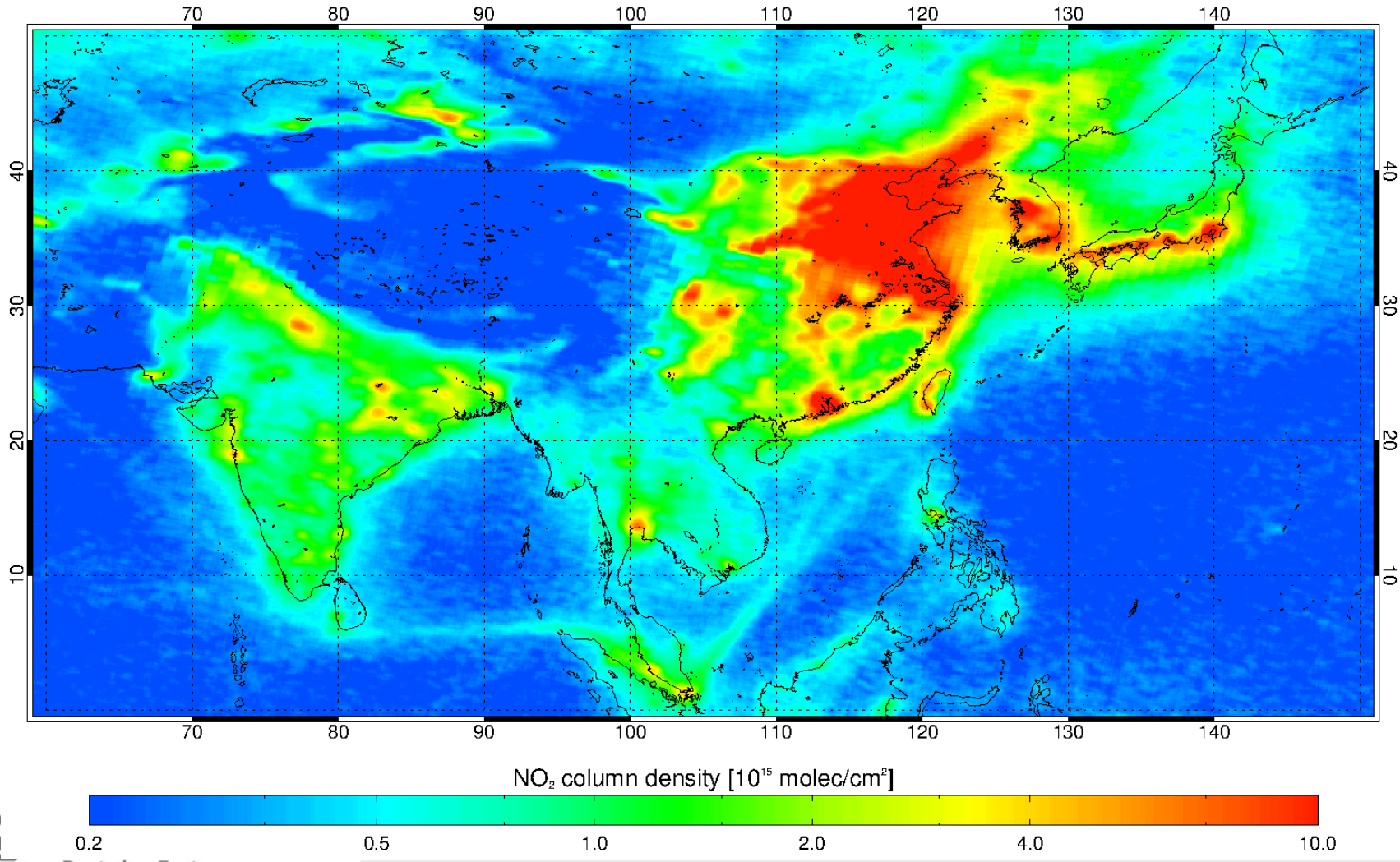

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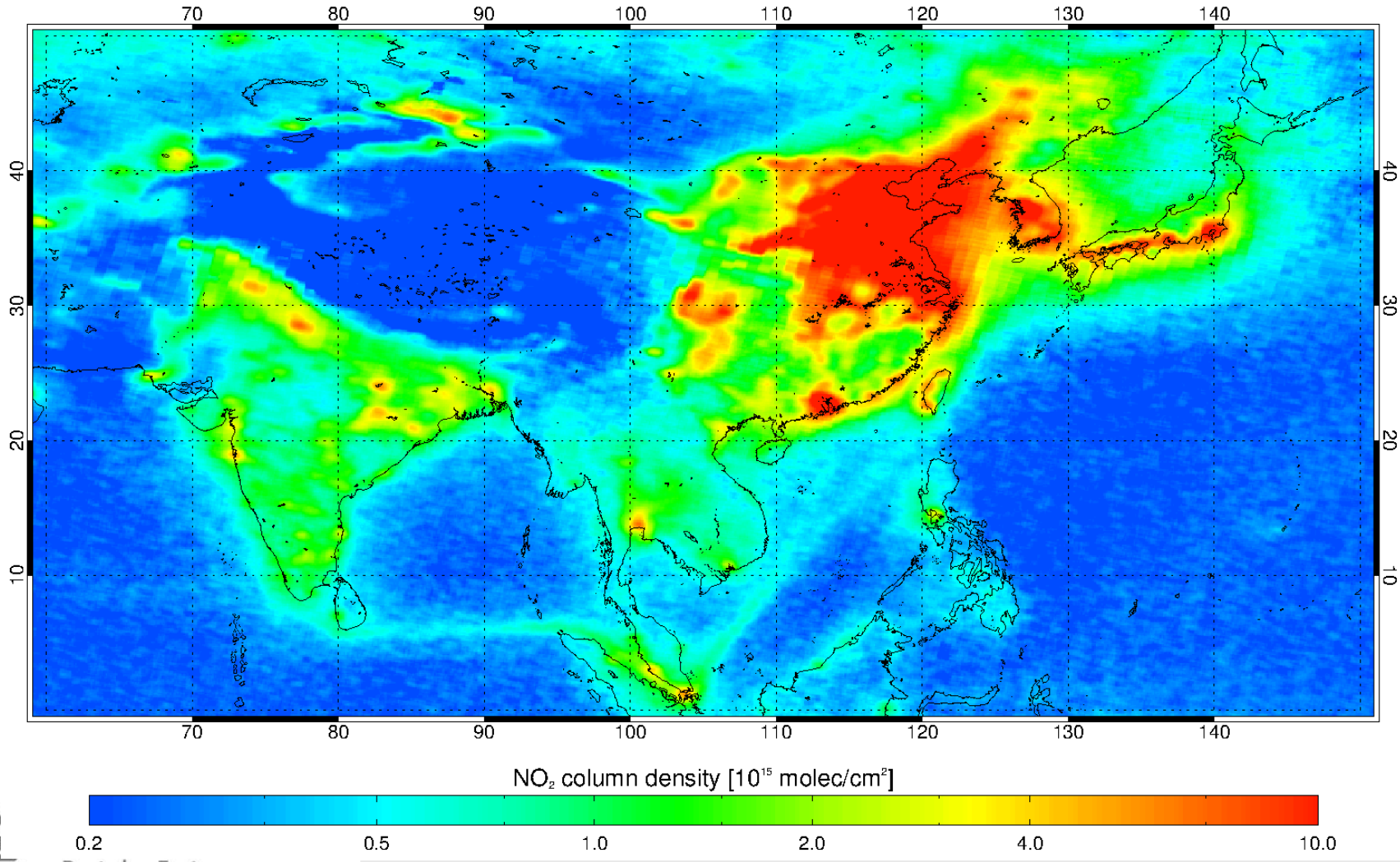

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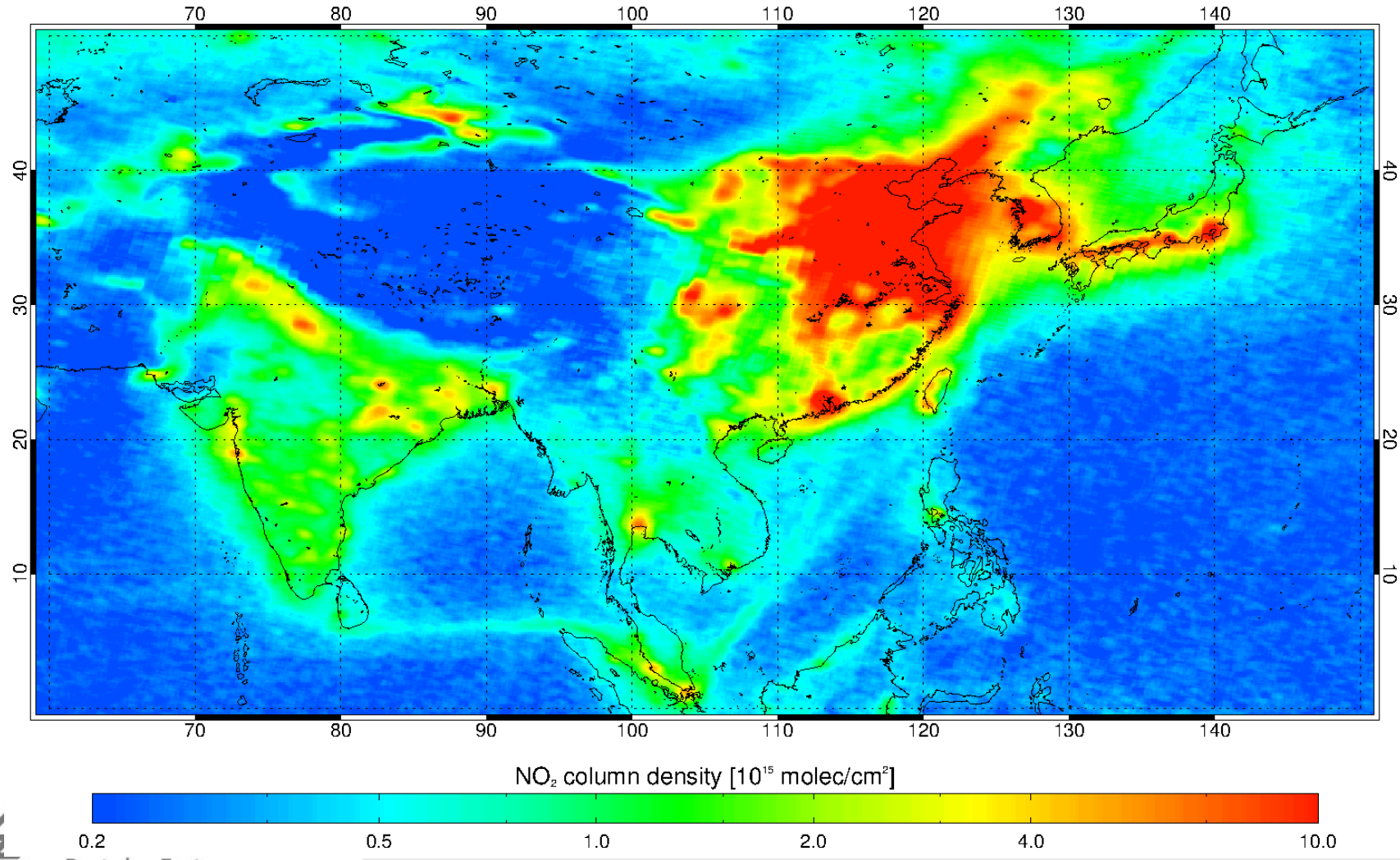

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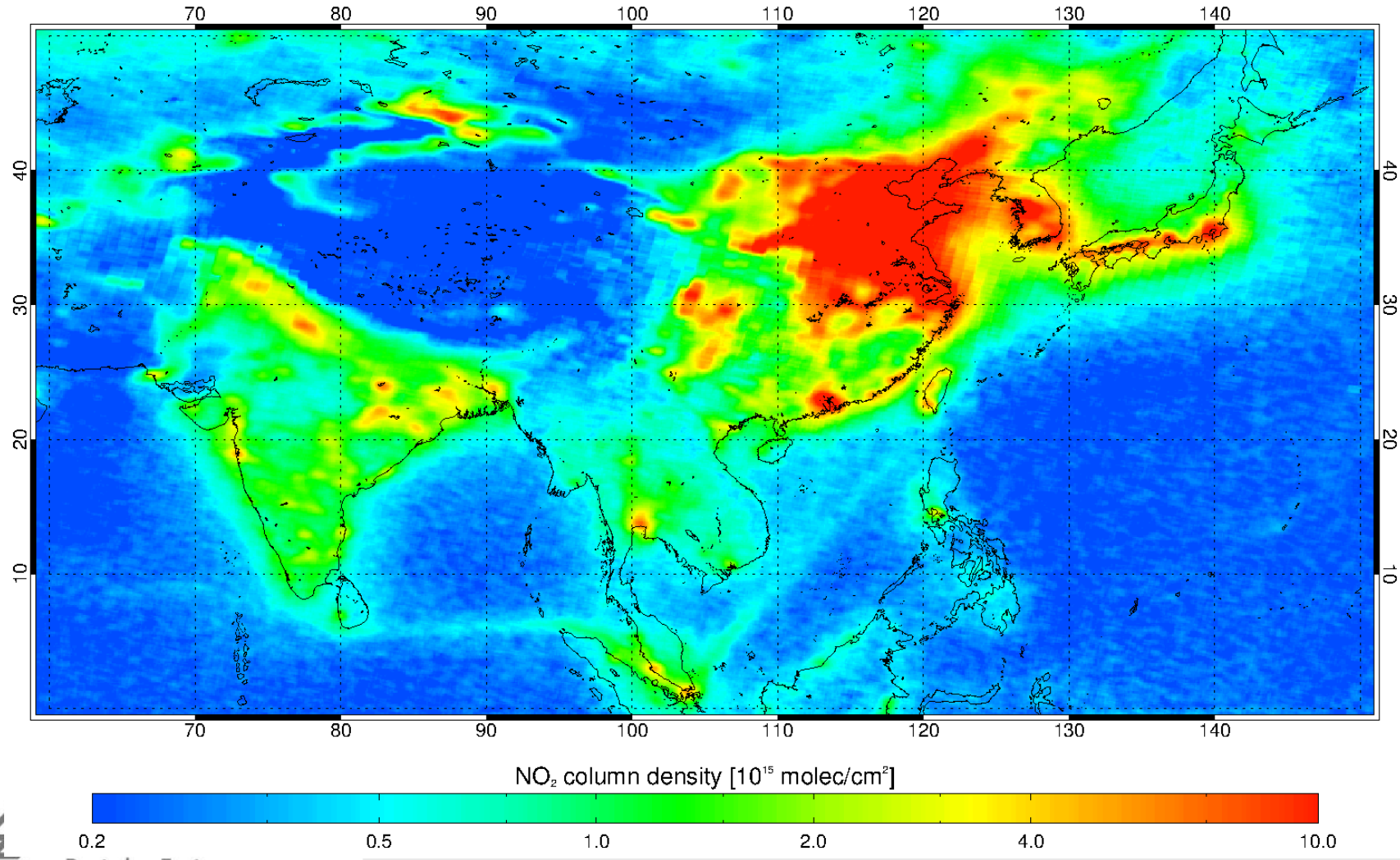

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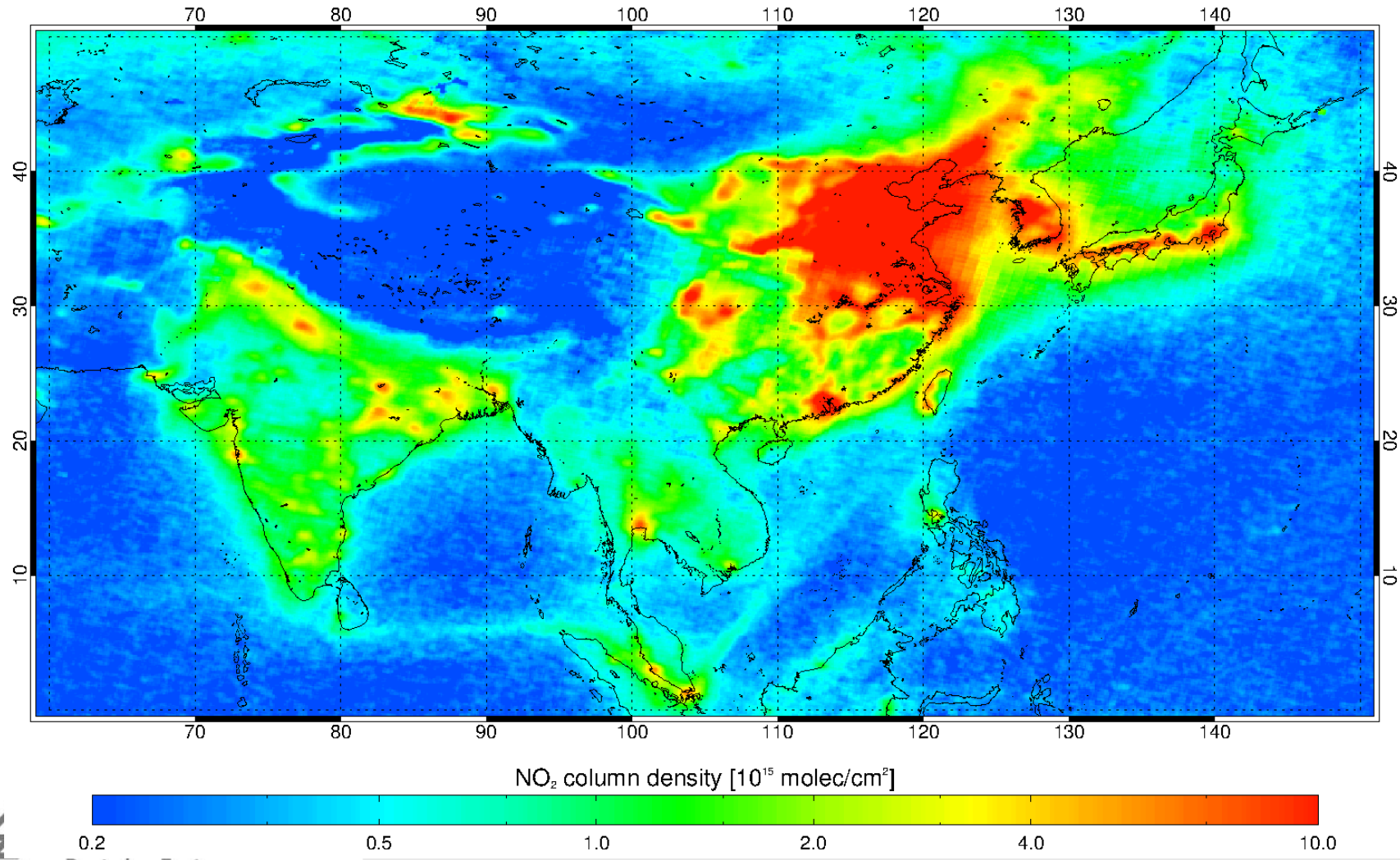

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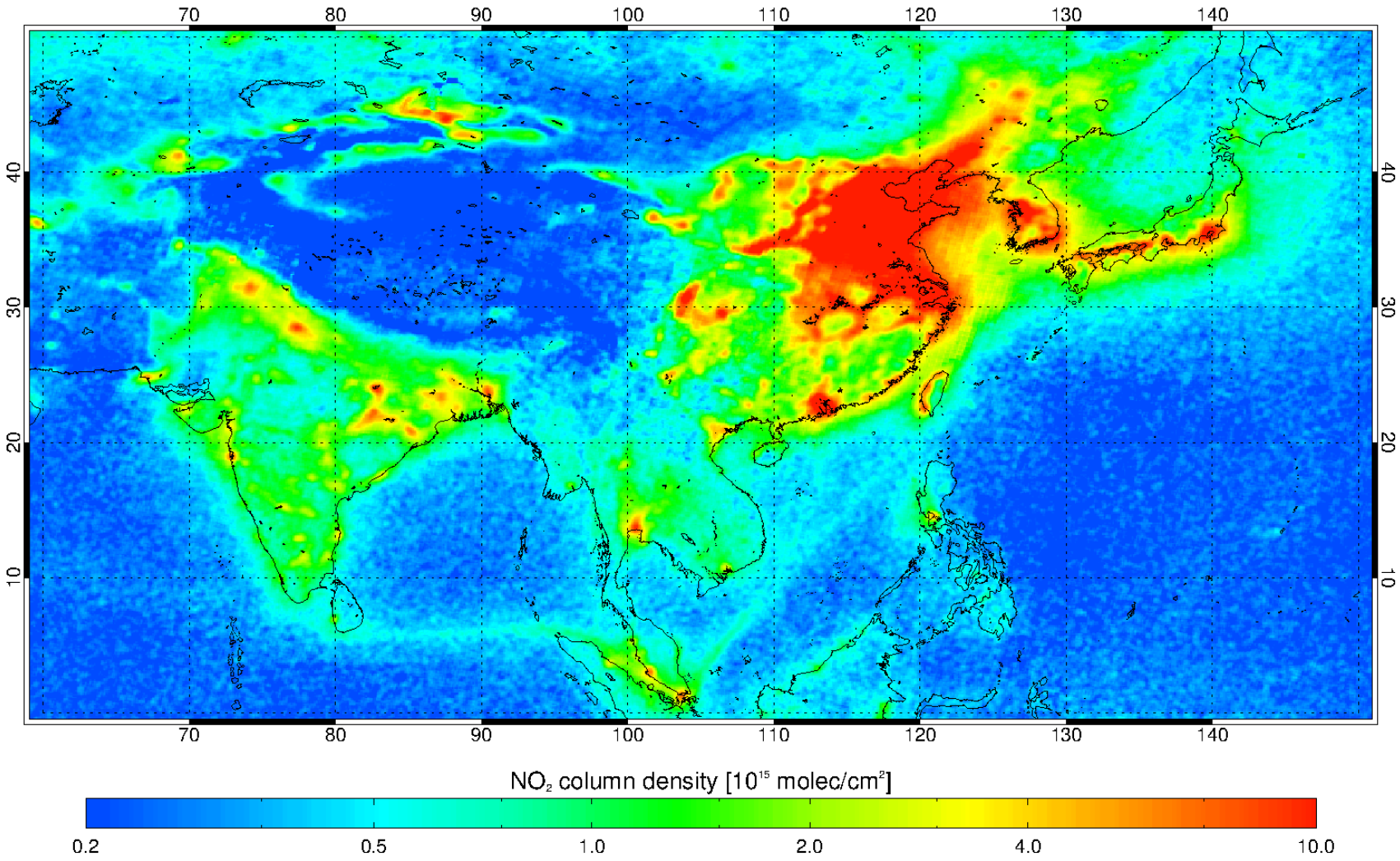

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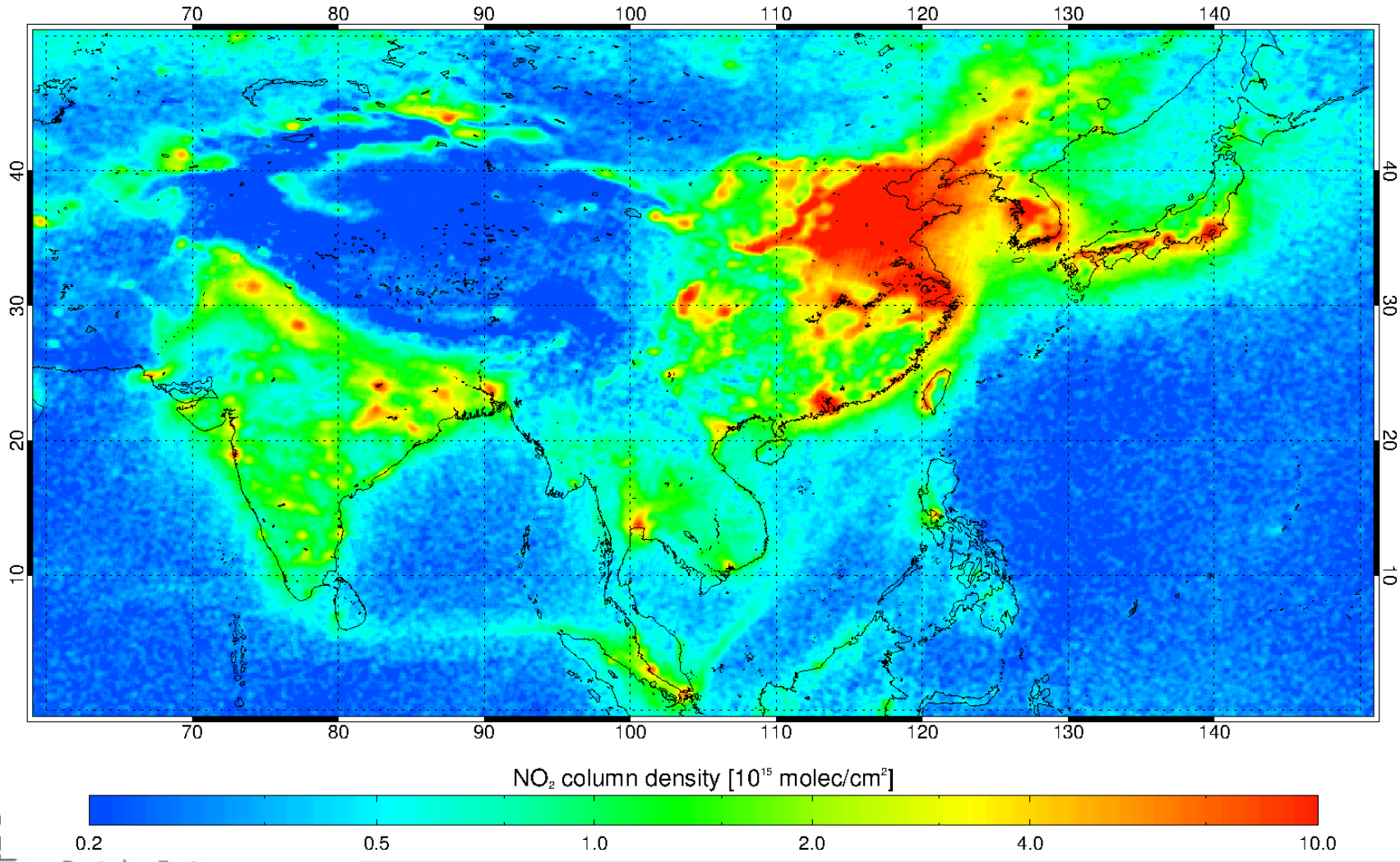
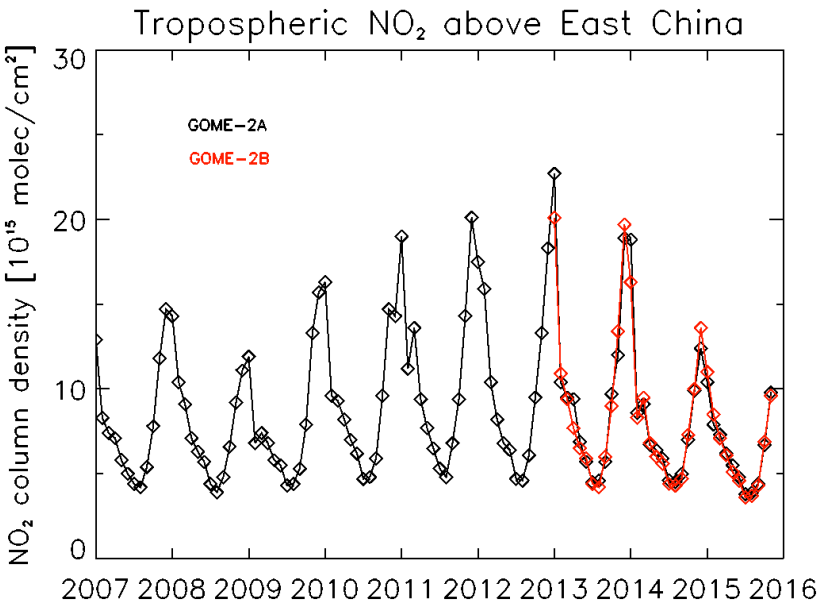
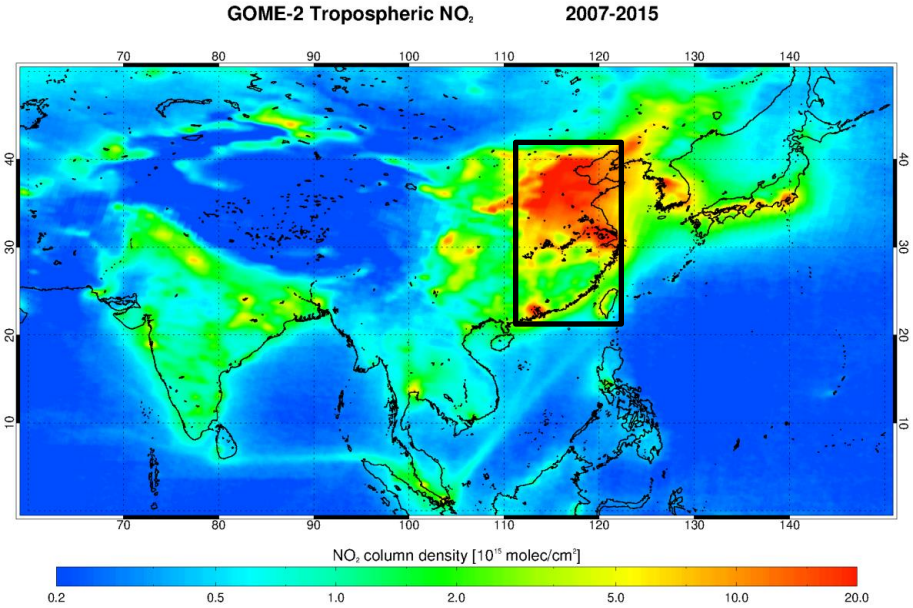


Tropospheric NO_2 trends over East China

Latitude: 21.5-41 N, Longitude: 112-122 E



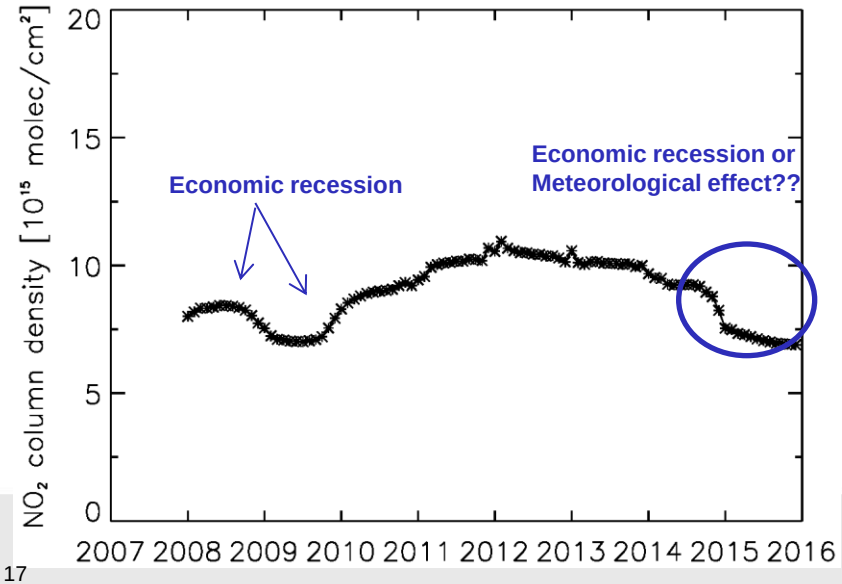


A **significant increase** of NO_2 over China from 1994 to 2006 observed by GOME and SCIAMACHY

Richter A, et al., Nature 2005;

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

A 12-month moving average



Hao N et al., 2012

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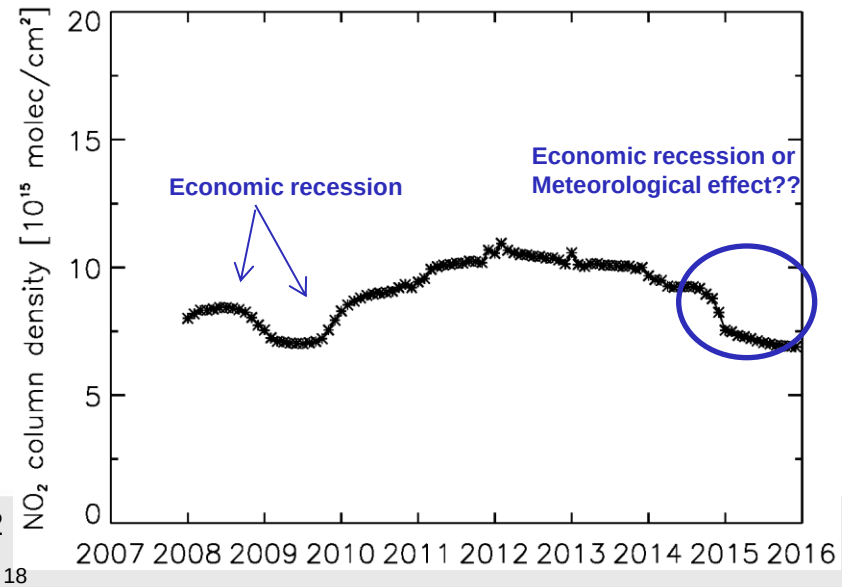
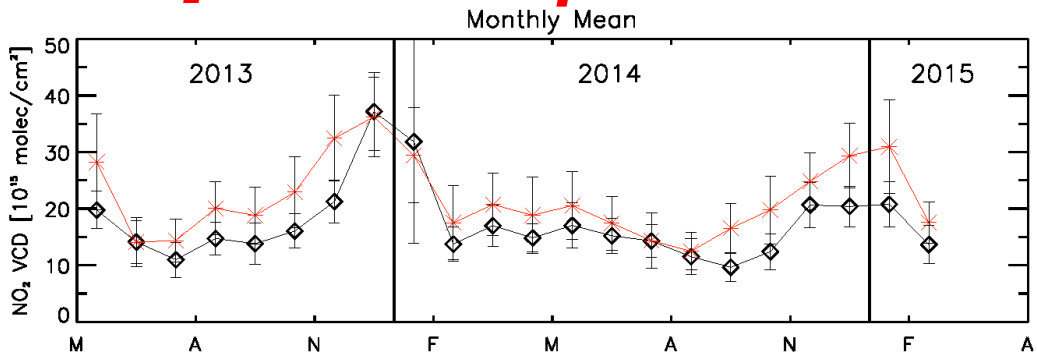


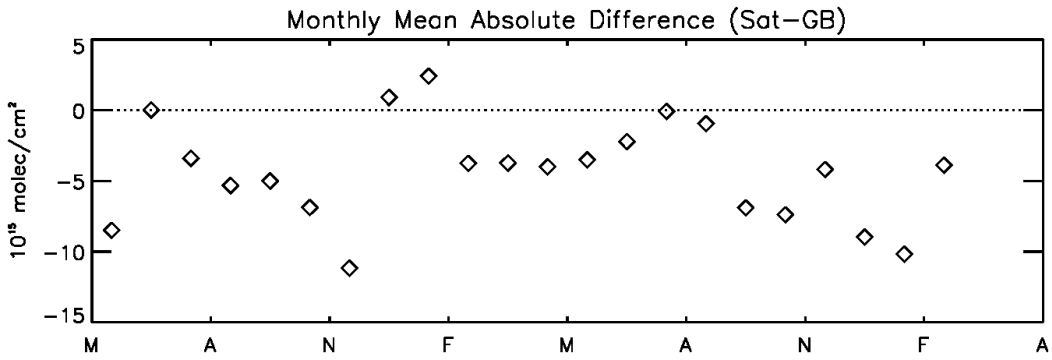
Hao N et al., 2012

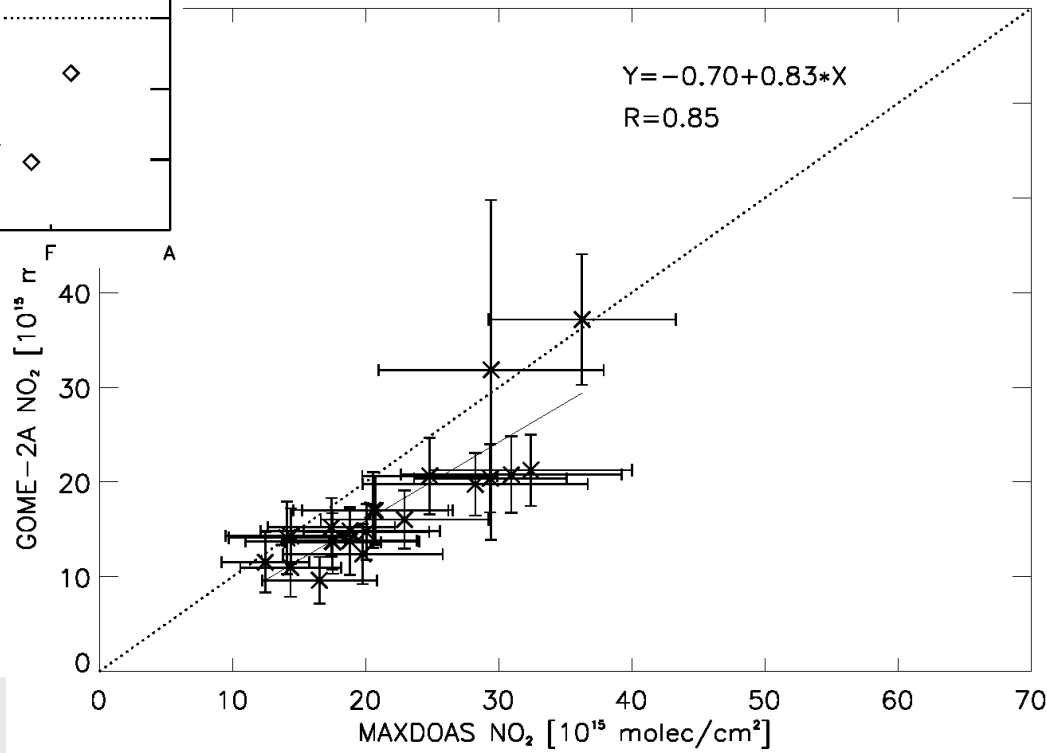
NO_2 VCD-comparison with satellite



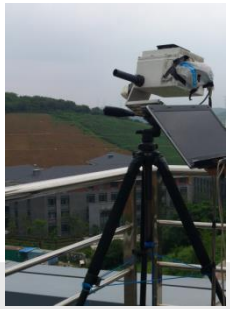
◊ **GOME-2A**

* MAXDOAS





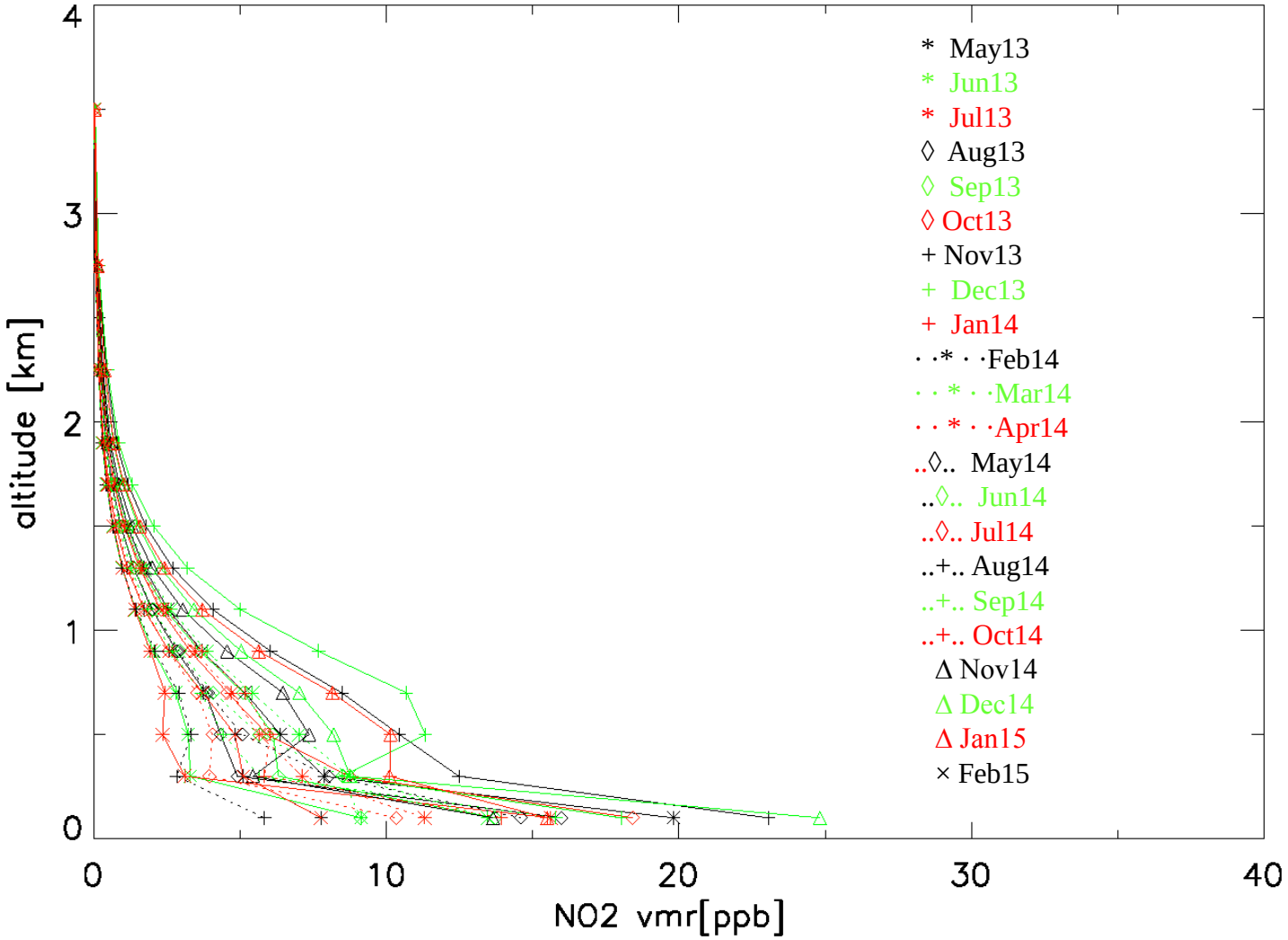
Satellite: 50 km radius



NO_2 Profile Retrieval

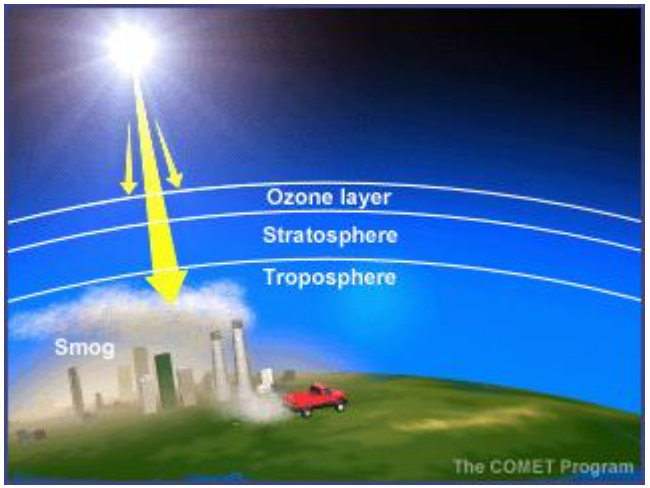
Monthly Mean

Nanjing May, 2013 – Feb., 2015



Most profiles peak at surface. Three layers can be distinguished: 0-200 m, 200-400m and above 400 m.

Stratospheric and Tropospheric ozone



Stratospheric ozone: '**good**'

Tropospheric ozone: '**Bad**'

Ozone overtakes PM2.5 to become top pollutant of Beijing air

(Ecns.cn) 15:37, May 27, 2015

Email|Print 0

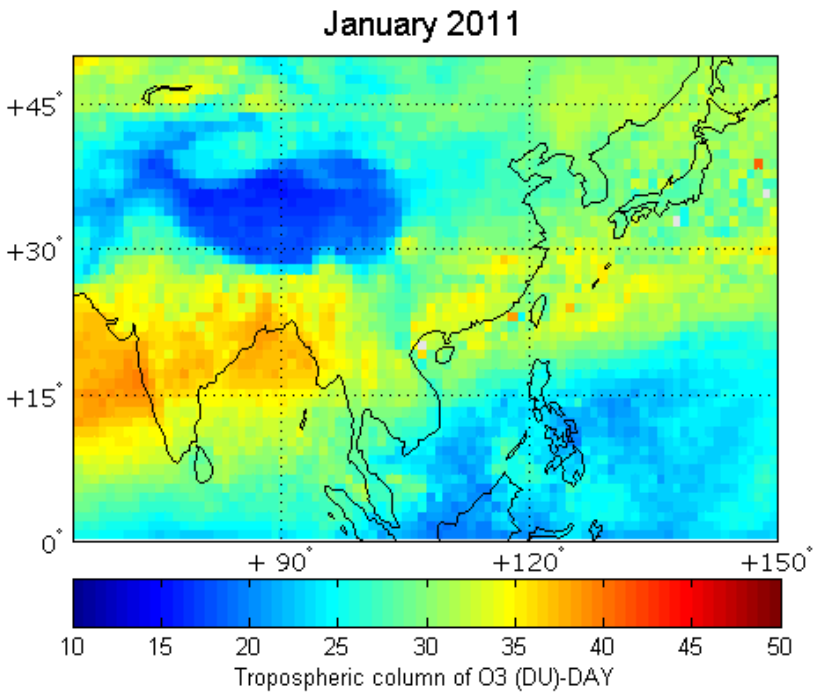
People hold umbrellas in the sun. Ozone has overtaken PM2.5 as the top pollutant of Beijing's air. (Photo/Chinanews.com)

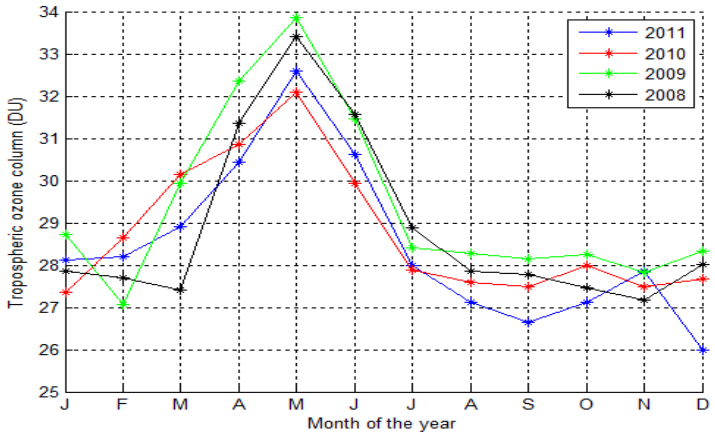
Ozone has overtaken PM2.5 as the top pollutant of Beijing's air, according to the municipal environmental monitoring center.

The center said it expected "moderate pollution" influenced by a high density of ozone, which began Monday, to last till Thursday, and the city's air quality may be deemed "good" by Friday.

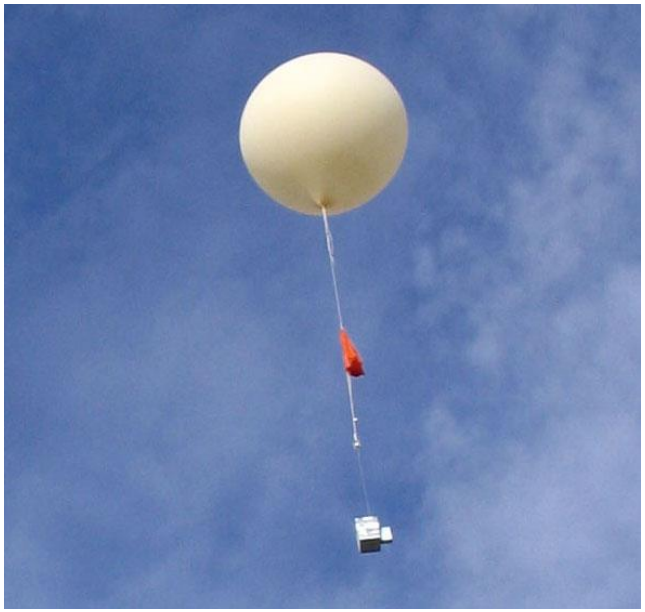
Observations of tropospheric ozone over China

IASI Tropospheric ozone



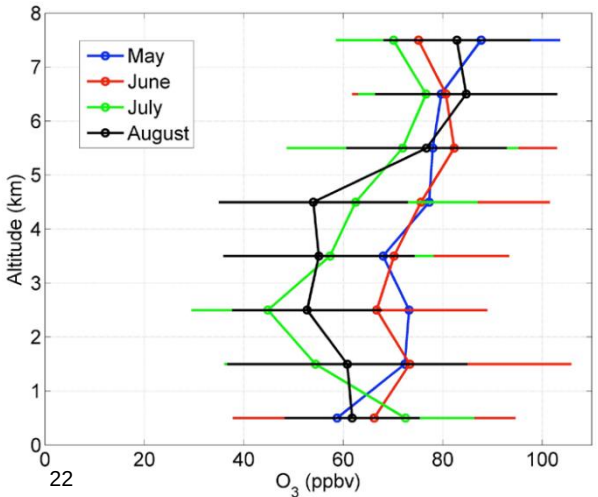


Ozonesonde at Hong Kong



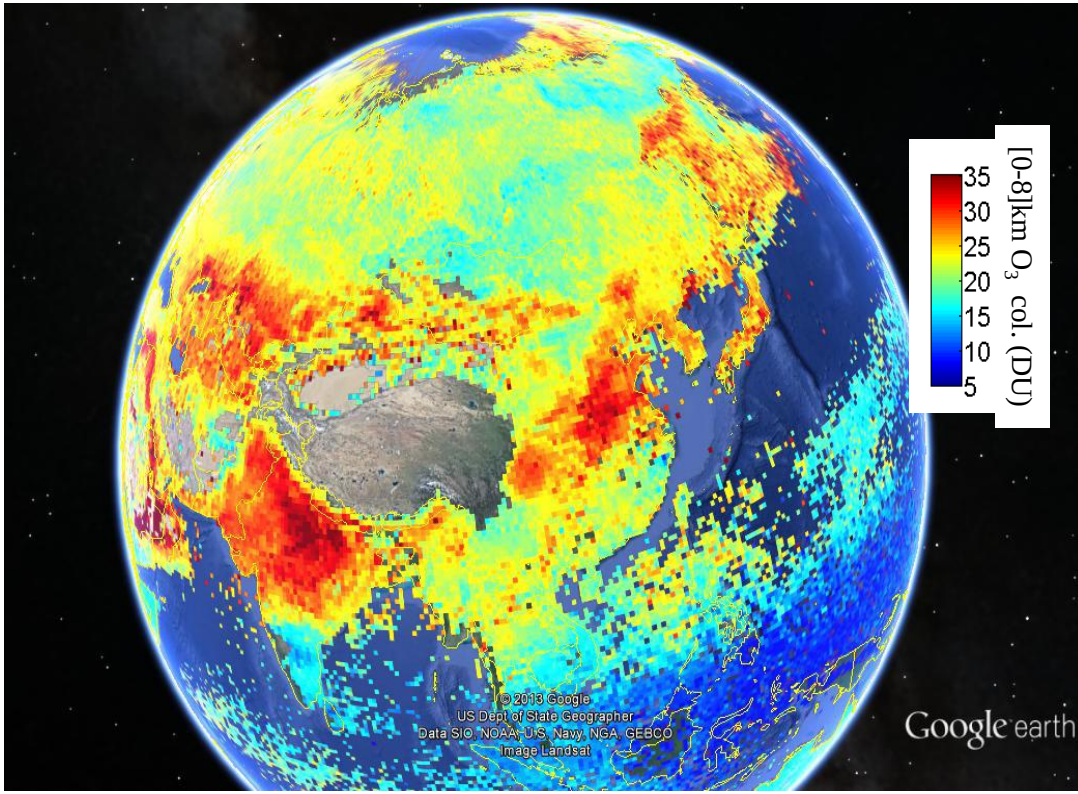
Period: 2000-2010
Frequency: Weekly at LT13-14:00

Ozone Profiles over Nanjing

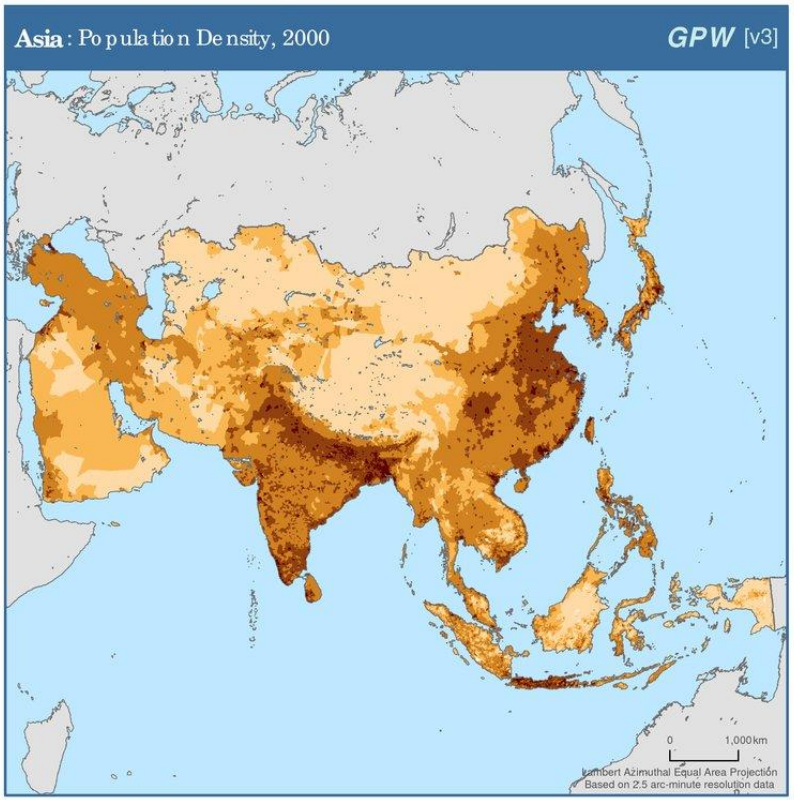


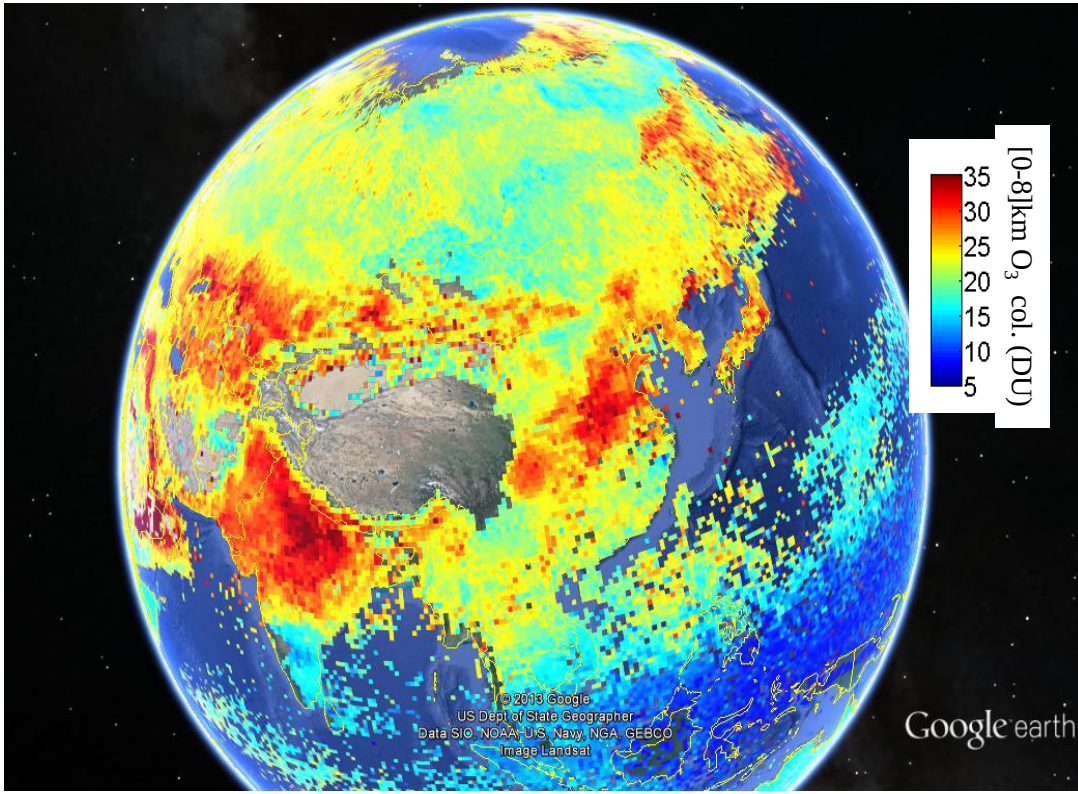
Monthly average Trop. Ozone profiles from MOZAIC during May-August, 2011
http://www.iagos.fr/web/

East Asian Tropospheric ozone

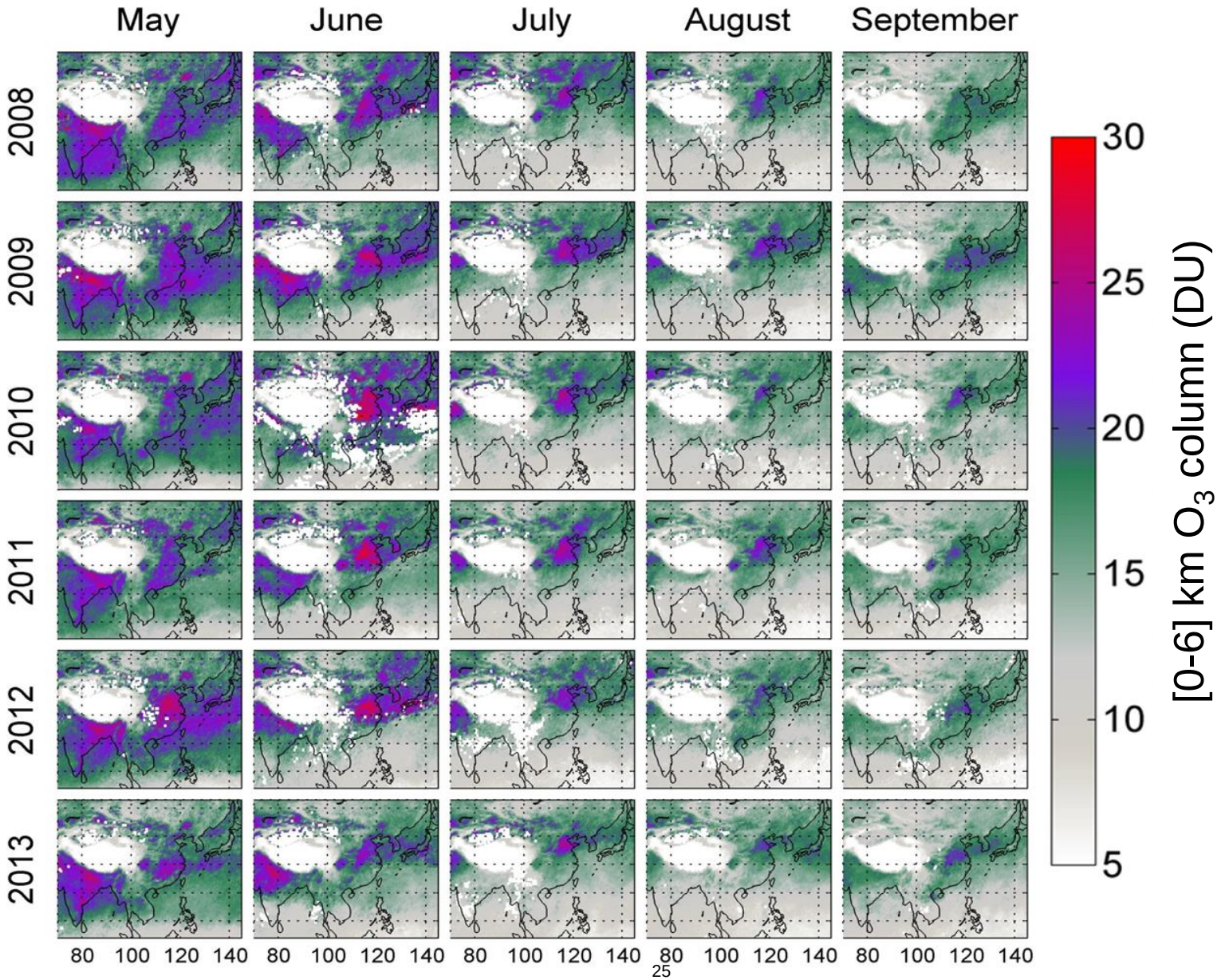


East Asian Tropospheric ozone





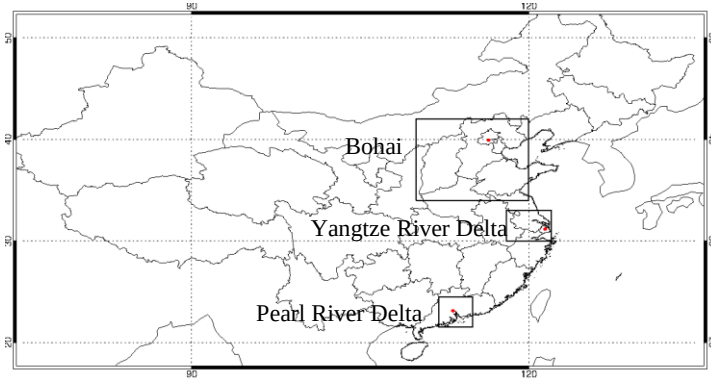
East Asian summer monsoon From IASI



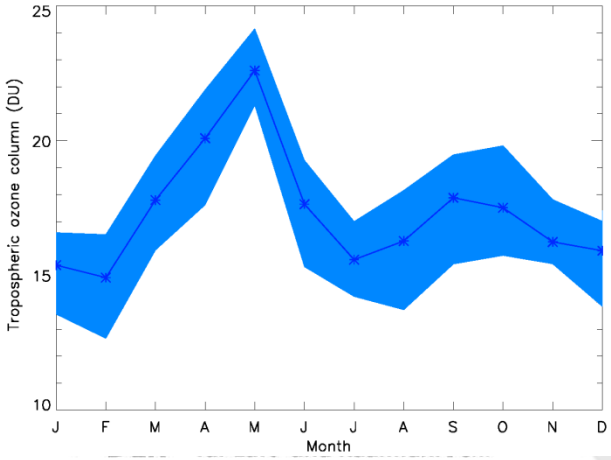
Impact of East Asian Summer Monsoon on tropospheric ozone over China

➢The **seasonal march** of East Asian Summer monsoon displays a distinct stepwise **northward** and **northeastward** advance, with two abrupt northward and three stationary periods.

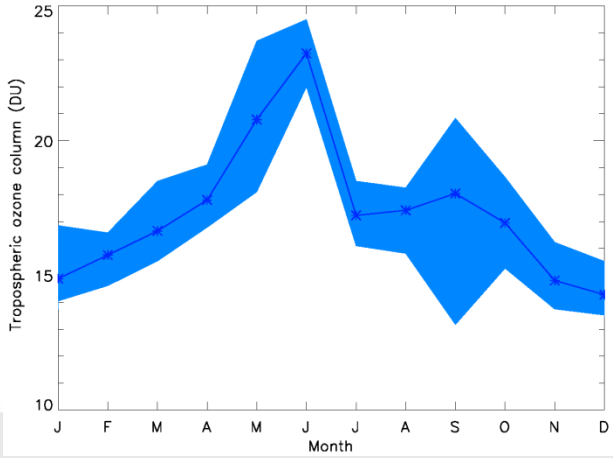
➢**East Asian summer monsoon** affects ozone concentrations over East China by bringing in **clean oceanic air masses** and reducing the photochemical productions of ozone in the troposphere **partly related to clouds**.



Guangzhou Average 2008-2012



Shanghai Average 2008-2012



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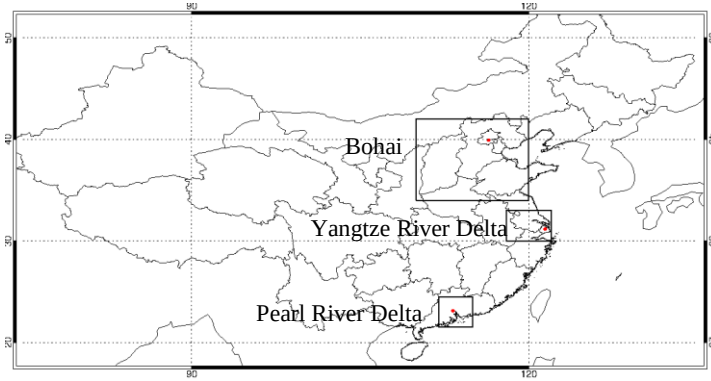

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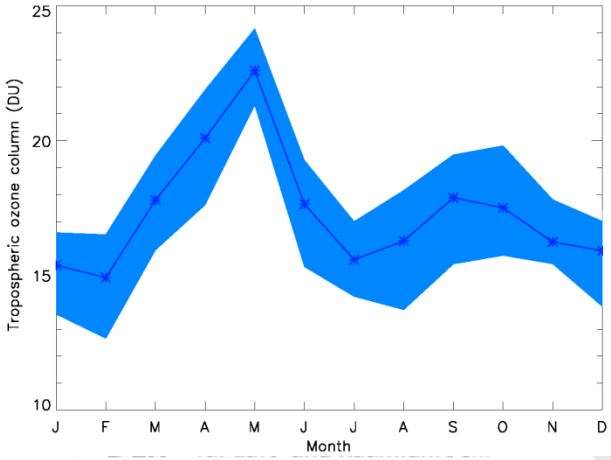

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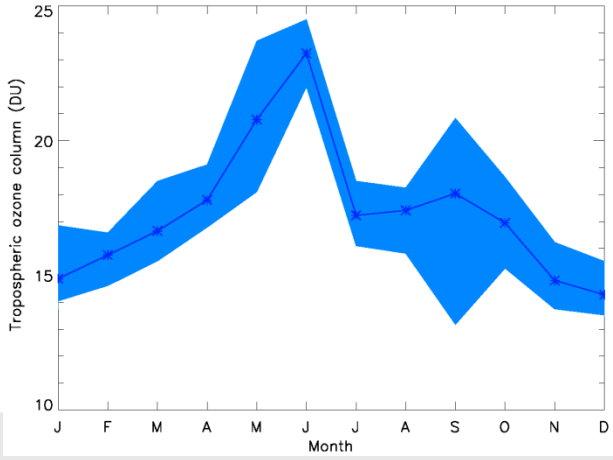
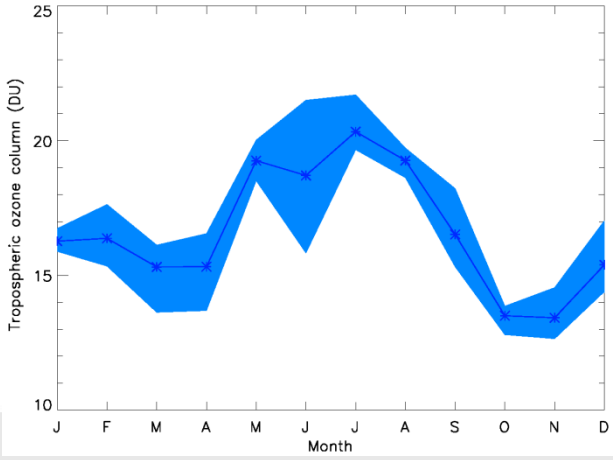
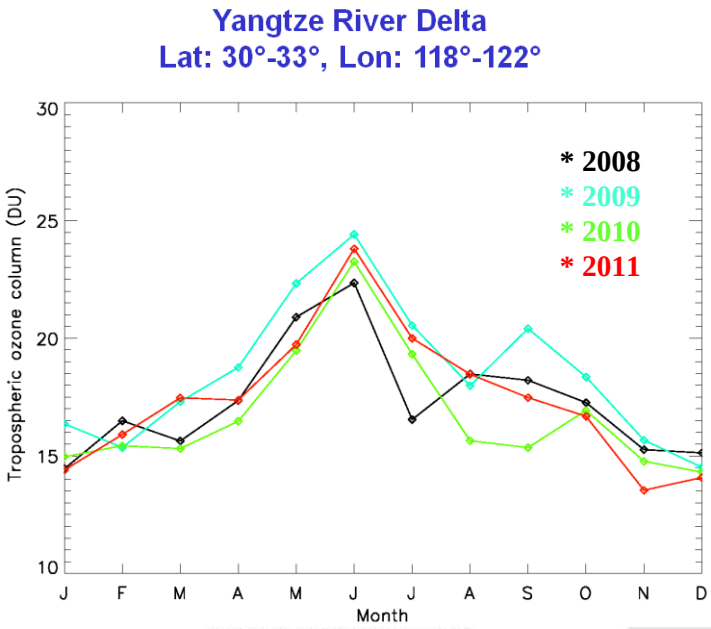


Beijing Average 2008-2012

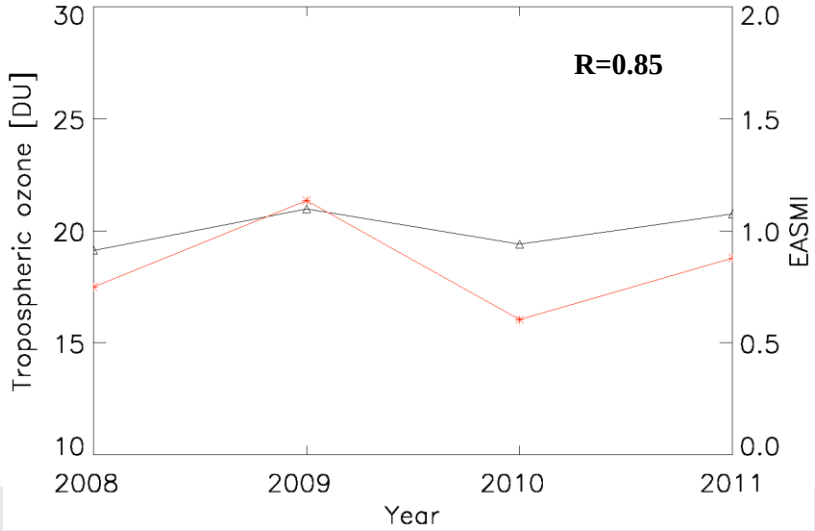


Impact of Asian Summer Monsoon Strength on interannual variation of ozone

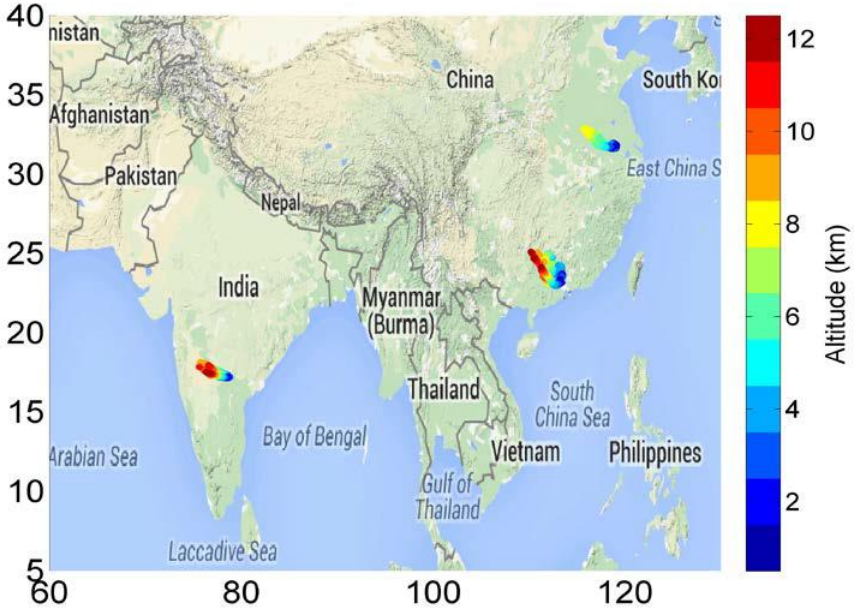
- The **strength** of the Asian Summer Monsoon shows large **interannual** variations as a result of the interactions between atmosphere and oceans.
- According to the EASM index, year **2009** is a strong monsoon year and year **2010** is a weak monsoon year.
- These interannual variations can **affect ozone** over China by influencing transport, chemical reactions, and deposition of ozone.



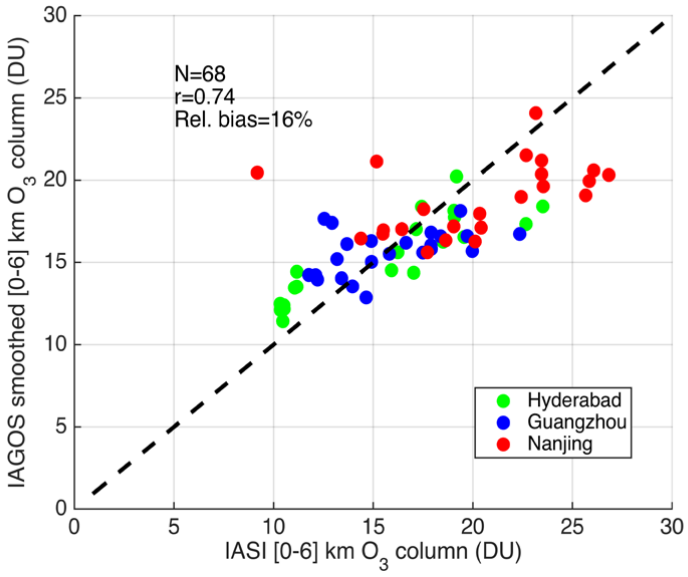
Over Yangtze River Delta, the average tropospheric ozone concentrations (JJA) in the strong summer monsoon year 2009 are about **9%** higher than those of in weak monsoon year 2010.



East Asian summer monsoon from aircraft data

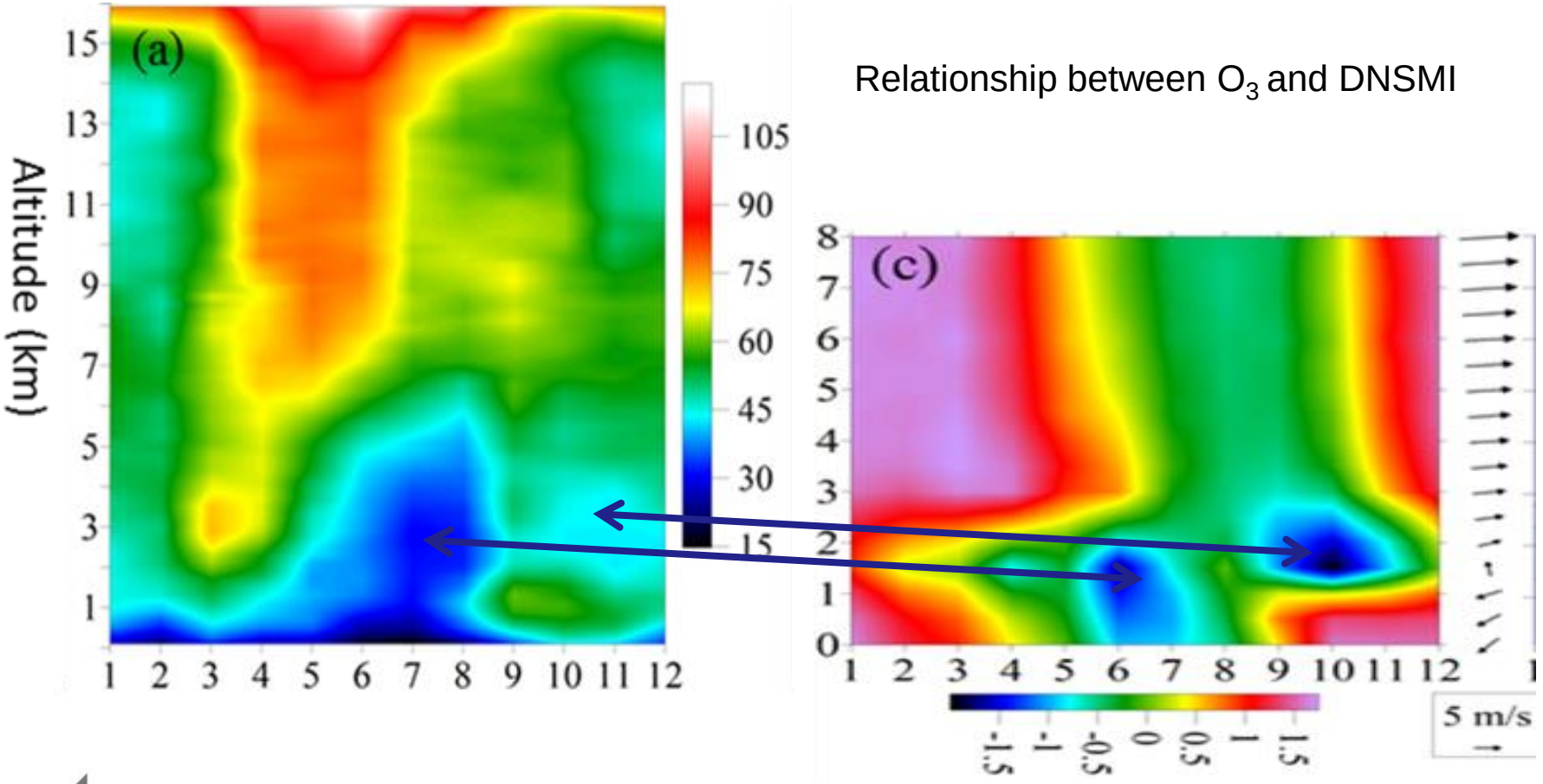


IASI validation with aircraft data



Safieddine et al., ACPD, 2015

Impacts of the East Asian Monsoon on Lower Tropospheric ozone over Hongkong

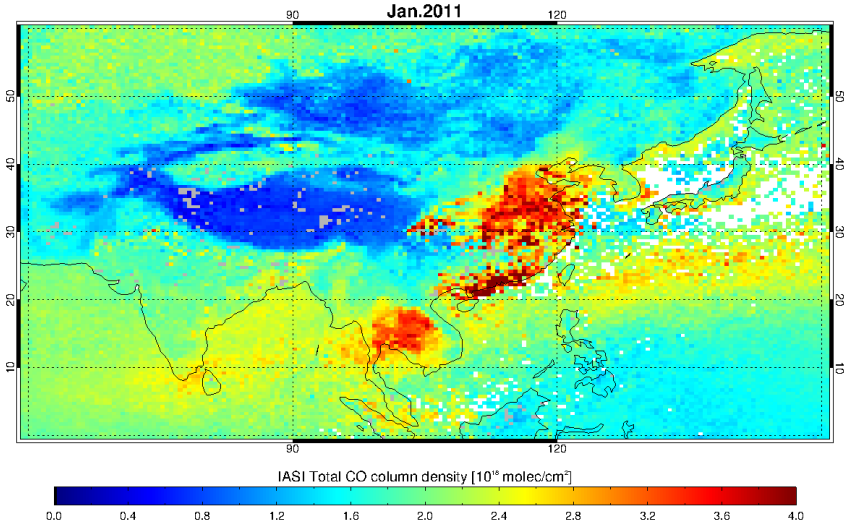


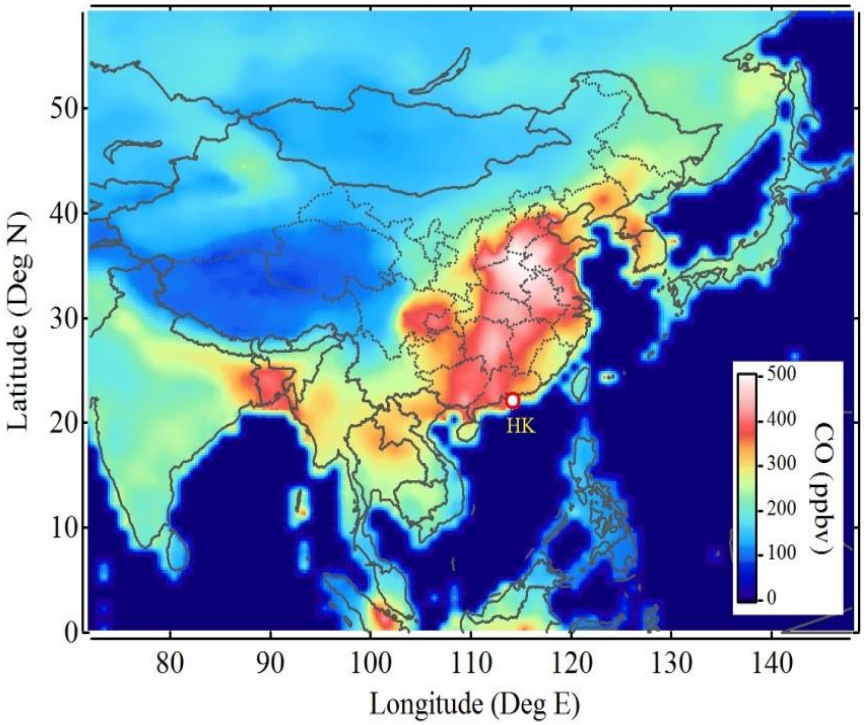
Relationship between O_3 and DNSMI

Zhou et al., ERL, 2013

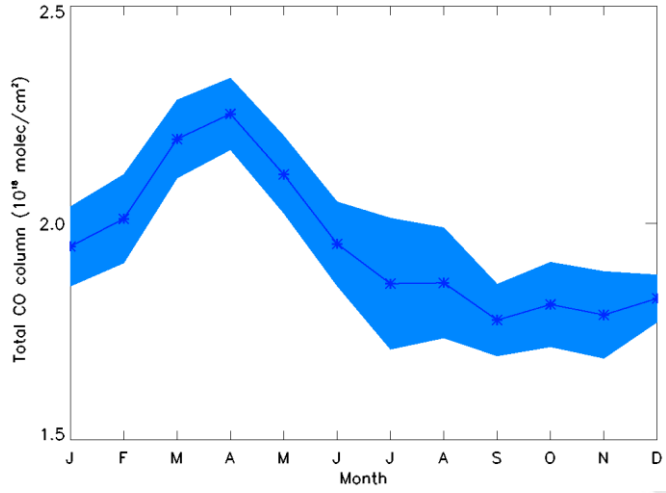
Observation of CO over China

IASI CO





East China CO 2008-2012

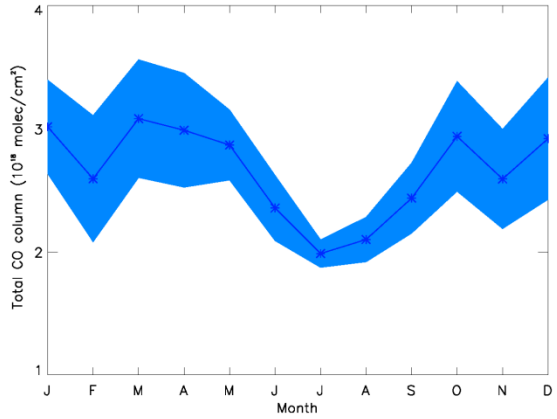


Climatology of surface **MOPITT CO** during 2000-2010 in East Asia

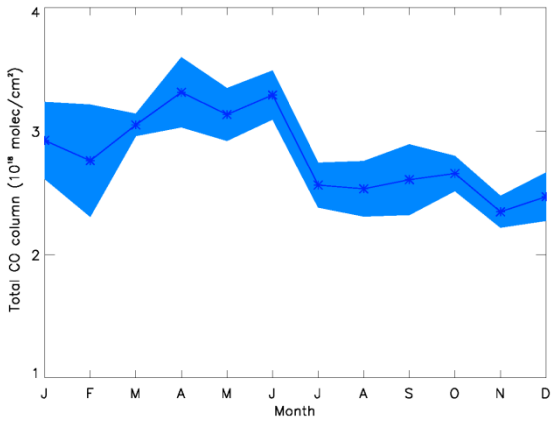
Impact of East Asian Summer Monsoon on CO over China

IASI Total CO column

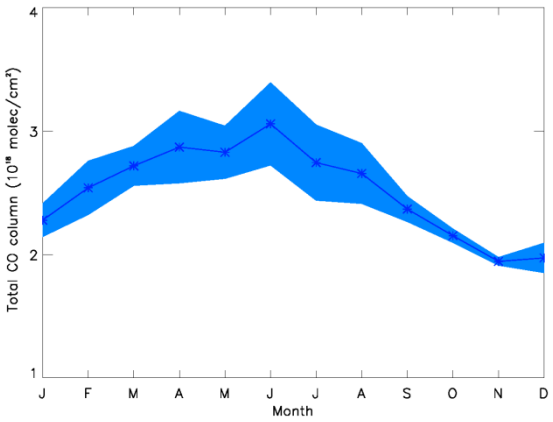
Pearl River Delta
Average 2008-2012



Yangtze River Delta
Average 2008-2012

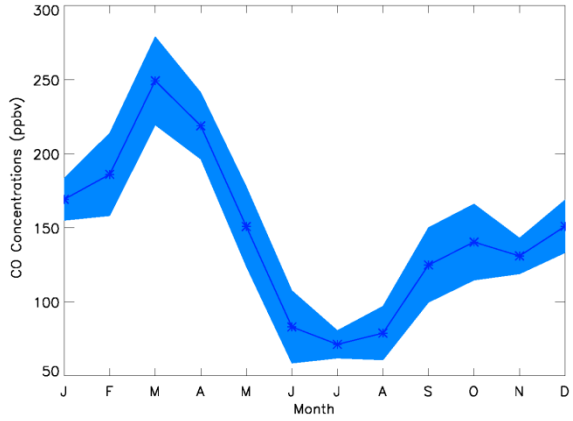


Bohai
Average 2008-2012

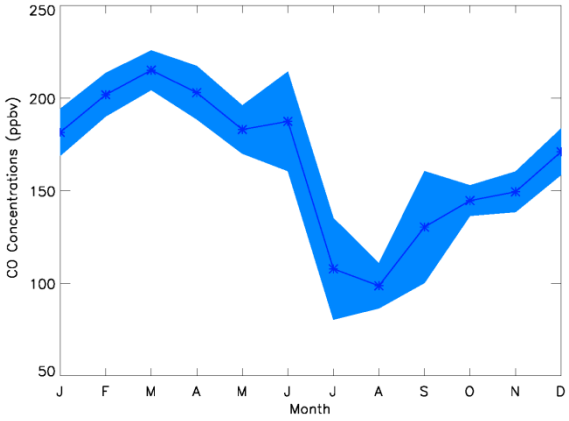


MOPITT CO concentrations (700 hPa)

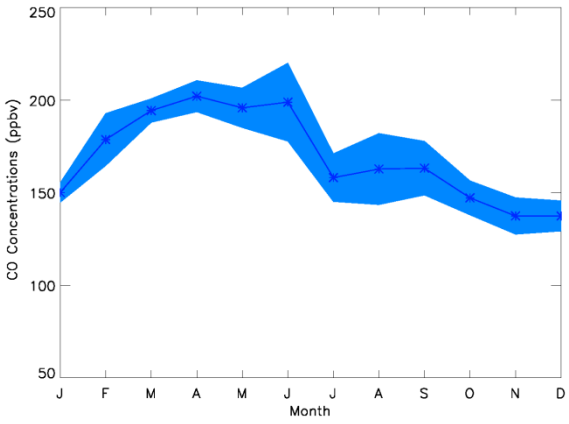
Average 2007-2012



Average 2007-2012



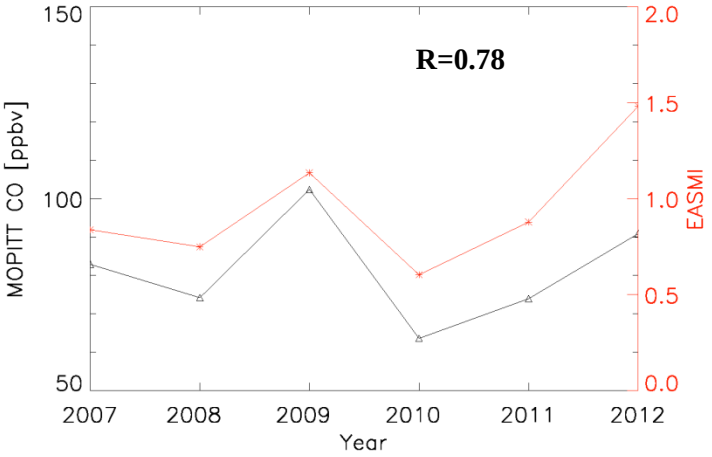
Average 2007-2012

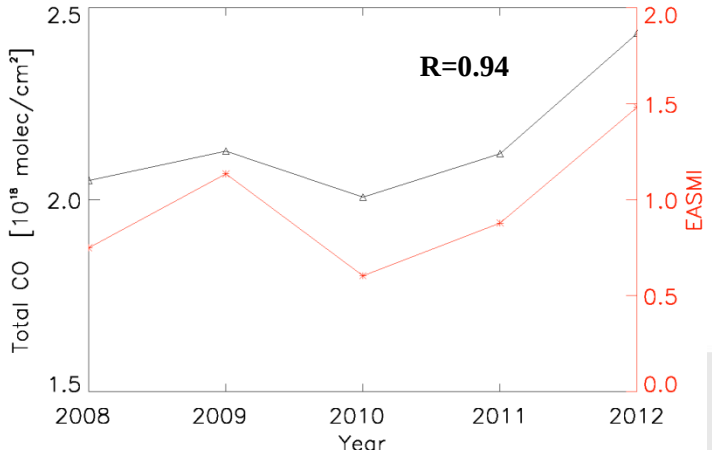


Impact of Asian Summer Monsoon Strength on interannual variation of CO

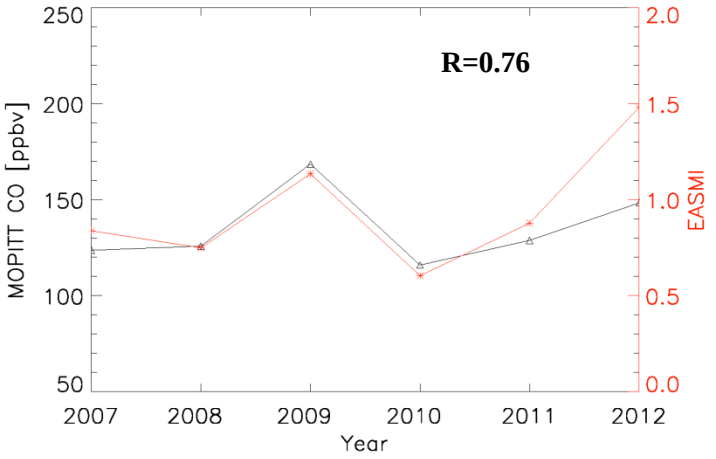
- These interannual variations can **affect CO** over China by influencing transport and deposition .

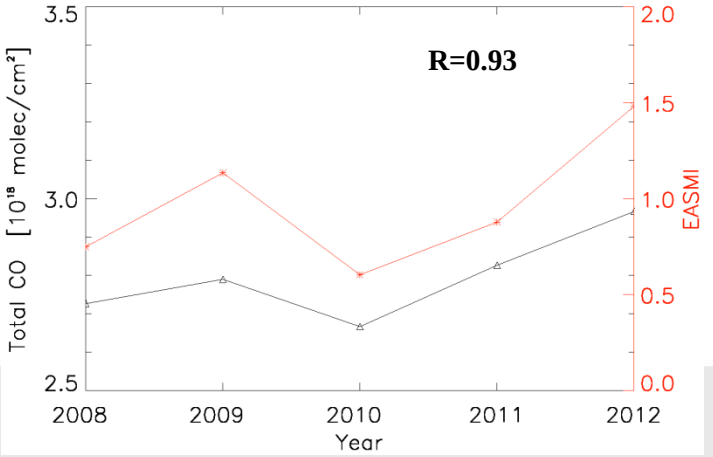
Pearl River Delta
Lat: 21.5-24.5, Lon: 112-115





Yangtze River Delta
Lat: 30-33, Lon: 118-122





Hao et al., in preparation

Summary

- Satellite observations are capable of capturing the monsoon-associated variation of tropospheric ozone and CO over China
- A close link between tropospheric ozone and the East Asian Monsoon on seasonal scales over East China
- Ozone and CO show strong inter-annual variability in the lower troposphere, particularly because of the intensity of the monsoon.
- This study highlights the important impact of climate change on air quality over China

http://www.dlr.de/eoc/en/desktopdefault.aspx/tabid-6608/10836_read-37309/

o3msaf.fmi.fi
http://atmos.caf.dlr.de/gome2