NO_x emission estimates during the 2014 Youth Olympic Games in Nanjing

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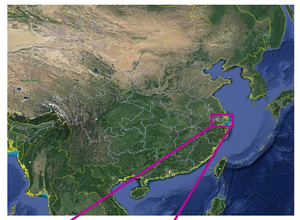
Abstract: The Nanjing Government has taken temporary environmental regulations to guarantee good air quality during the Youth Olympic Games (YOG) in 2014. We study the effect of those regulations by applying the emission estimate algorithm DECSO to measurements of the Ozone Monitoring Instrument (OMI). We improved DECSO by updating the chemical transport model CHIMERE from v2006 to v2013 and by adding an Observation minus Forecast (OmF) criterion to filter outlying satellite retrievals due to high aerosol concentrations. Despite the cloudy conditions during the YOG we could still see a decrease of tropospheric NO_2 column concentrations of about 32% in the OMI observations as compared to the average NO_2 concentrations from 2005 to 2012. The results of the improved DECSO algorithm for NO_x emissions show a reduction of at least 25% during the YOG period.

Introduction

- **Nanjing:** Capital of Jiangsu province, located in the east part of China with a population of 8.2 million.
- **Youth Olympic Games (YOG):** 16 August to 24 August, 2014.
- Regulations taken by the local government to guarantee good air quality.



Air quality regulations

Period	Regulations
1st May - 30th Jun.	The local government started to shut down the coal-burning factories.
1st Jul.- 15th Jul.	All coal-burning factories have been shut down.
16th Jul. - 31st Jul.	The work on one third of construction sites was stopped. The parking fees in downtown increased sevenfold.
1st Aug.– 15th Aug.	Work on 2000 construction sites was stopped. Heavy-industry factories reduced manufacturing by 20%. Vehicles with high emissions were banned from the city. Open space barbecue restaurants were closed. 900 electric buses and 500 taxis have been put into operation.
16th Aug.-31st Aug.	The work at all construction sites was put on hold.

We use the DECSO (Daily Emission estimates Constrained by Satellite Observation) algorithm with OMI satellite data to study how the environmental regulations affect the NO_x emissions in Nanjing during the 2014 YOG .

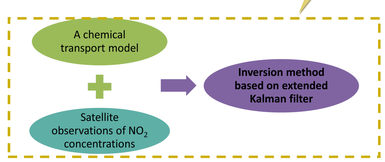
Methods

CHIMERE model

- Domain: East Asia (18 – 50° N, 102 – 132° E).
- Horizontal resolution: 0.25° x 0.25°; Vertical resolution: 8 layers up to 500 hPa.
- Initial emission inventory: MEIC (2008) for China, INTEX-B outside China.
- Meteorological data: ECMWF.

Satellite observations: OMI

- Overpass time: 13:30 local time.
- Spatial resolution: 24 x 13 km² in nadir till 150 x 28 km² at the end of swath.
- Filter: Cloud radiation fraction larger than 70%; Surface albedo larger than 20%; Clouds below 800 hPa; 4 pixels at either side of the swath.



Ground measurements

- Location: Nanjing People's government (centre of Nanjing).
- From aqicn.org based on China National Urban air quality real-time publish platform.

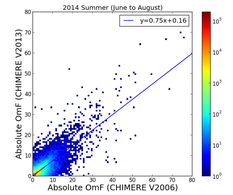
Improvements of DECSO

1. **Model improvement**

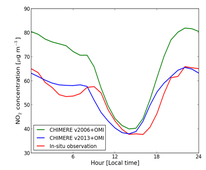
CHIMERE v2013 instead of CHIMERE v2006

CHIMERE V2013 => Biogenic emissions added, new transport schemes, secondary organic aerosol chemistry, updated chemical reaction rates.

New land use data: GlobCover Land cover (2009).



Comparison of the absolute OmF (10^{15} molec.cm²) of CHIMERE v2006 and v2013.

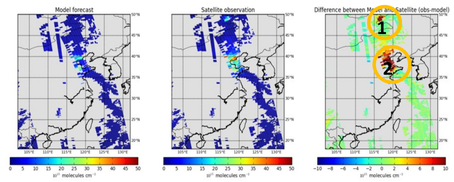


Diurnal cycle in Nanjing from Jan.to Aug. 2014.

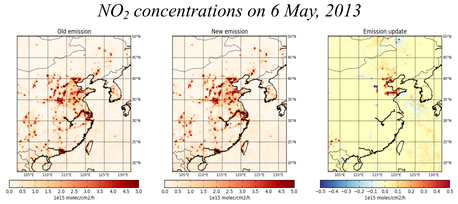
* CHIMERE v2013 gives better results during night time.
* The absolute OmF (Observation minus Forecast) from assimilation using CHIMERE v2013 is lower than that of CHIMERE v2006 indicating a better performance of CHIMERE v2013 in summertime.

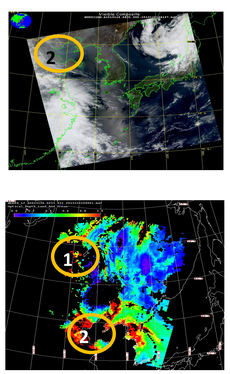
2. Improvement of the satellite data

Unrealistic emission updates in our initial results were always related to extreme OmF values (out of the interval [-5, 10] 10^{15} molecules cm^{-2}) in case of high aerosol concentrations.



NO_2 concentrations on 6 May, 2013





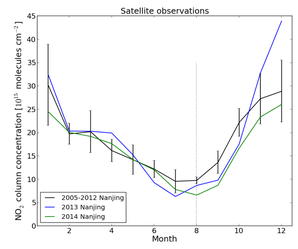
Unrealistic update of emissions over the Hulunbuir sand land (area 1) and around Bohai Bay (area 2) on 6 May, 2013 with high OmF values.

High aerosol concentrations can affect the NO_2 retrieval and results in over- or under-estimated NO_2 concentrations .

To solve these problems, we applied an **OmF filter criterion** to filter out satellite observations with these extreme OmF. We filter out negative OmF values lower than $5 \cdot 10^{15}$ molecules/cm² and positive OmF values higher than $10 \cdot 10^{15}$ molecules/cm².

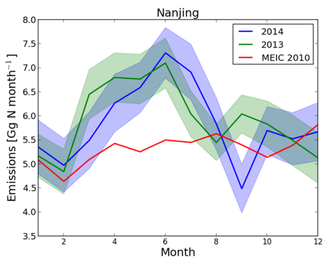
Emission analysis for the Nanjing Youth Olympic Games

The monthly averages of OMI satellite observations of tropospheric NO_2 concentrations in Nanjing.



* The **NO_2 concentration** seasonal cycle: higher in winter and lower in summer.
* A small decrease of NO_2 concentration in February due to the Spring Festival.
* Compared to the averaged NO_2 concentration in August from 2005 to 2012, NO_2 concentration of August 2014 **decreases with 32%**.

The monthly NO_x emission estimates by DECSO in Nanjing for 2013 and 2014 and the monthly NO_x emission of the MEIC inventory of 2010.



- The **NO_x emissions** have a different seasonal cycle compared to the NO_2 concentrations of satellite observations. The difference is caused by the use of air conditioning in summer and no heating in winter.
- A drop of NO_x emissions in February due to the reduced industrial activities during the Spring Festival.
- A **reduction of 25%** in September 2014 due to the air quality regulations for the **YOG**.

Conclusions

- CHIMERE v2013 is better performing than CHIMERE v2006.
- An OmF filter criterion is necessary to avoid unrealistic emission updates in case of high aerosol concentrations.
- During the YOG period, the NO_2 concentration decreased with 32% in Nanjing.
- The results of DECSO show an emission reduction of 25% during the YOG.
- DECSO has the capacity to capture changes of NO_x emissions on a monthly scale.
- DECSO provides information about emission changes on a spatial scale of 50 km.

Reference

Ding, J., van der A, R. J., Mijling, B., Levelt, P. F., and Hao, N.: NO_x emission estimates during the 2014 Youth Olympic Games in Nanjing, Atmos. Chem. Phys. Discuss., 15, 6337-6372, doi:10.5194/acpd-15-6337-2015, 2015.