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GLOBAL AIR POLLUTION MAP:

RANKING THE WORLD'S WORST SO_2 AND NO2 EMISSION HOTSPOTS

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SUMMARY

Greenpeace's updated analysis of a full year of TROPOMI NO2 satellite data and other scientific datasets confirms that the coal-fired power plant and industrial cluster in Mpumalanga is the world's worst hotspot for power plant NO2 and SO_2 emissions, and overall ranks 4th for NO2 and 3rd for SO_2 emissions in the world. It is the only place in the world that ranks among the top five for both of these dangerous pollutants. The finding is corroborated by analyses by NASA, Netherlands meteorological institute KNMI and Eskom's own published emissions data.

The satellite-based identification of hotspots is a proxy for emissions rather than local ground-level pollutant concentrations. The vast volume of SO_2 and NOx emissions from Mpumalanga affects health over a large area, including the neighboring Gauteng City Region. SO_2 and NOx are converted through chemical processes into PM2.5, the air pollutant with the largest public health impact.

With PM2.5 air pollution causing the premature deaths of over 20,000 South Africans every year, it is essential for the country's decision-makers to require Eskom, Sasol and other major polluters in the area to comply with the country's Minimum Emission Standards (MES).

INTRODUCTION

It is estimated that ambient PM2.5 air pollution caused 3.4 million deaths worldwide in 2017 and over 20,000 in SA every year[1]. SO_2 and NO_x emissions from the burning of coal and oil are the key sources of this pollution.

The largest concentration of emitters in Africa is the Highveld/Mpumalanga region in South Africa (SA), just 100-200 km from the Gauteng City Region, the largest population center in SA, implying the risk of major public health damage.

A Greenpeace ranking based on three months of data, from June to August 2018, had found that Mpumalanga had the highest atmospheric NO2 level in the world over this period, making it one of the worst hotspots of NOx emissions in the world. After the publication of this ranking, a full year of NO2 data, from February 2018 onwards, has become available, as ESA has processed and released data retrieved before June.

Based on a similar approach Greenpeace has for the first time also identified and ranked SO_2 hotspots globally.

[1] Stanaway JD et al., 2018. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 392(10159):1923-1994. https://doi.org/10.1016/S0140-6736(18)32225-6

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UPDATED METHODOLOGY

With a full year of data, from Feb 2018 to Jan 2019, more systematic validation is possible.

We have validated the comparison of NOx emissions sources against monthly NO2 emissions data for all large point sources in the U.S.A – this is the only set of emitters for which high-quality monthly emissions data is available in near-real time. We built a regression model that takes into account average monthly wind speeds, temperatures and background NO2 concentrations around the emission source to quantify emissions. The emissions dataset stretches the continent and the period Feb-Dec 2018, covering a wide range of temperature and wind conditions.

After applying the regression model to the global gridded dataset to get predicted NOx emissions for each point in the grid, we identify the largest emission hotspots in the world using a diameter of 50km. Choosing a specific radius is inevitably arbitrary to an extent, but at the same time this approach is more consistent and objective than ranking based on country or provincial boundaries. The group of the 'top 10' of largest polluters presented here is largely unchanged using any diameter from 25 to 100km, with the ordering changing.

FULL-YEAR RANKING OF NO2 HOTSPOTS

The updated full-year data puts the power plant and industrial cluster in Mpumalanga, centered on Nkangala, at the fourth spot in the world, after Tehran and Dubai, two Middle Eastern locations with very high oil consumption in power plants, industries and transport, and Seoul in South Korea with a large concentration of transport and industrial emissions. These locations had very high seasonality with higher NO2 levels in the northern hemisphere winter, and consequently rank lower in the southern hemisphere winter, when the original analysis was made.

Mpumalanga remains the highest-emitting non-urban and the highest-emitting power plant hotspot in the world, at par with the Sonbhadra coal mining and power plant cluster in India, according to the full-year data.

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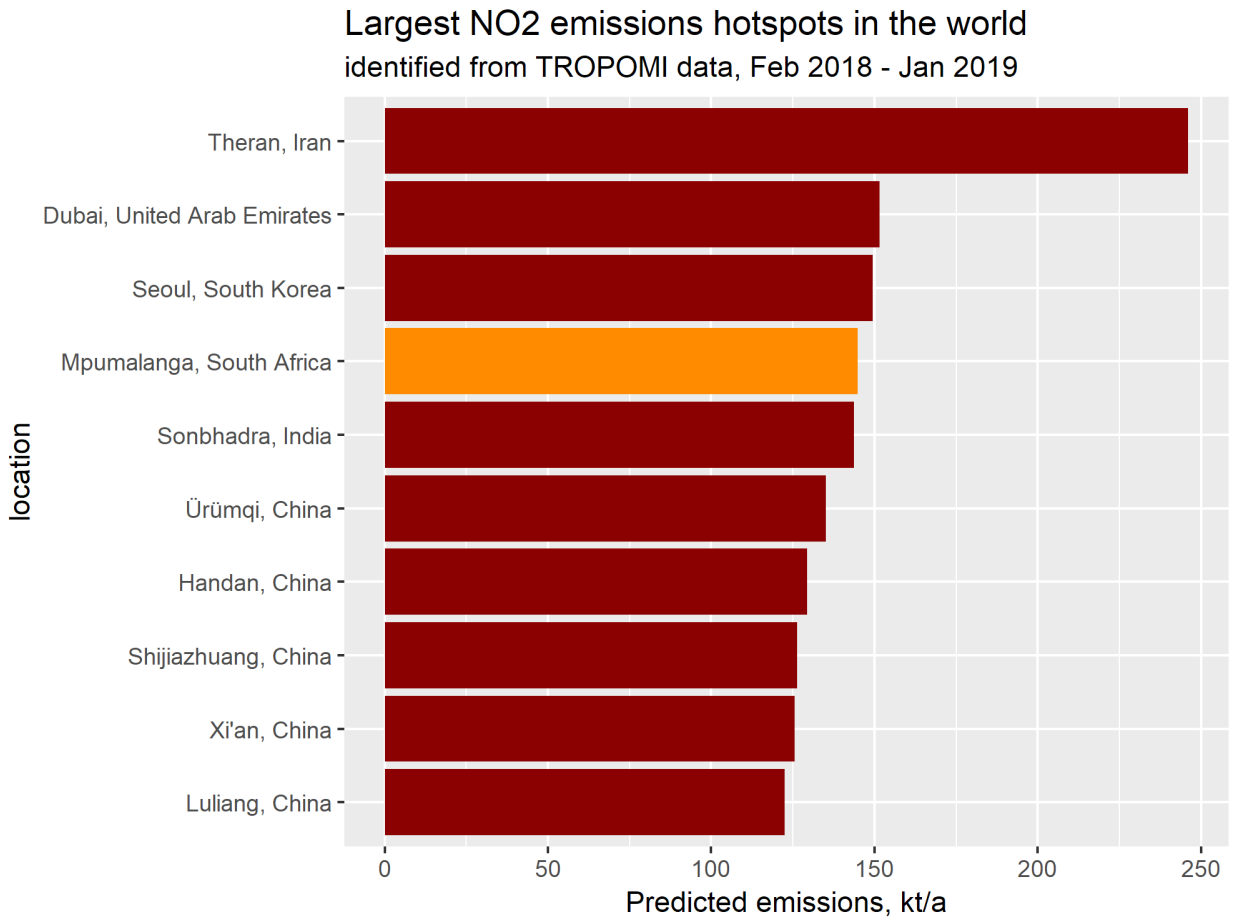
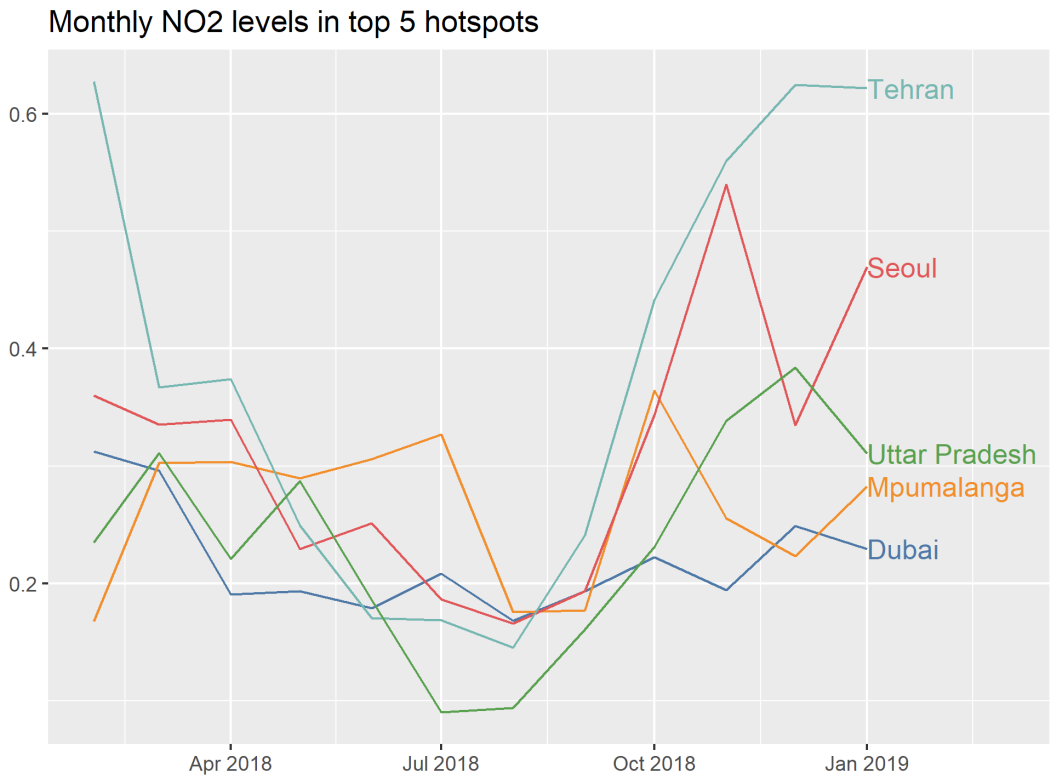
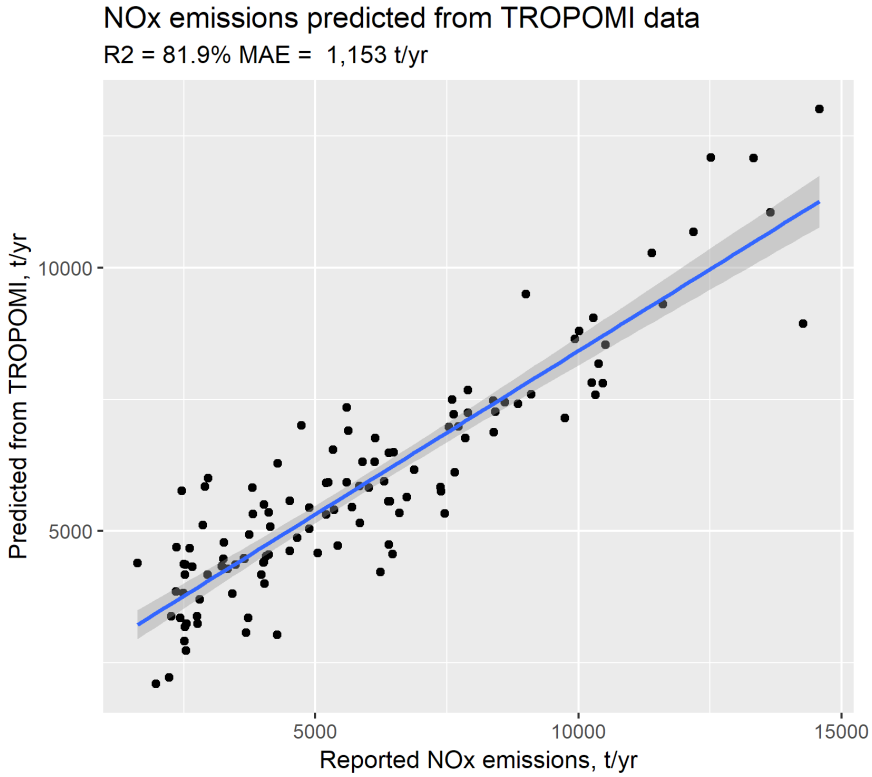

Largest NO2 emissions hotspots in the world
identified from TROPOMI data, Feb 2018 - Jan 2019
location
Theran, Iran
Dubai, United Arab Emirates
Seoul, South Korea
Mpumalanga, South Africa
Sonbhadra, India
Ürümqi, China
Handan, China
Shijiazhuang, China
Xi'an, China
Luliang, China
0
50
100
150
200
250
Predicted emissions, kt/a





Performance of TROPOMI-based emissions estimates against U.S. EPA-reported emissions for large point sources, Feb-Dec 2018.

RANKING SO_2 HOTSPOTS

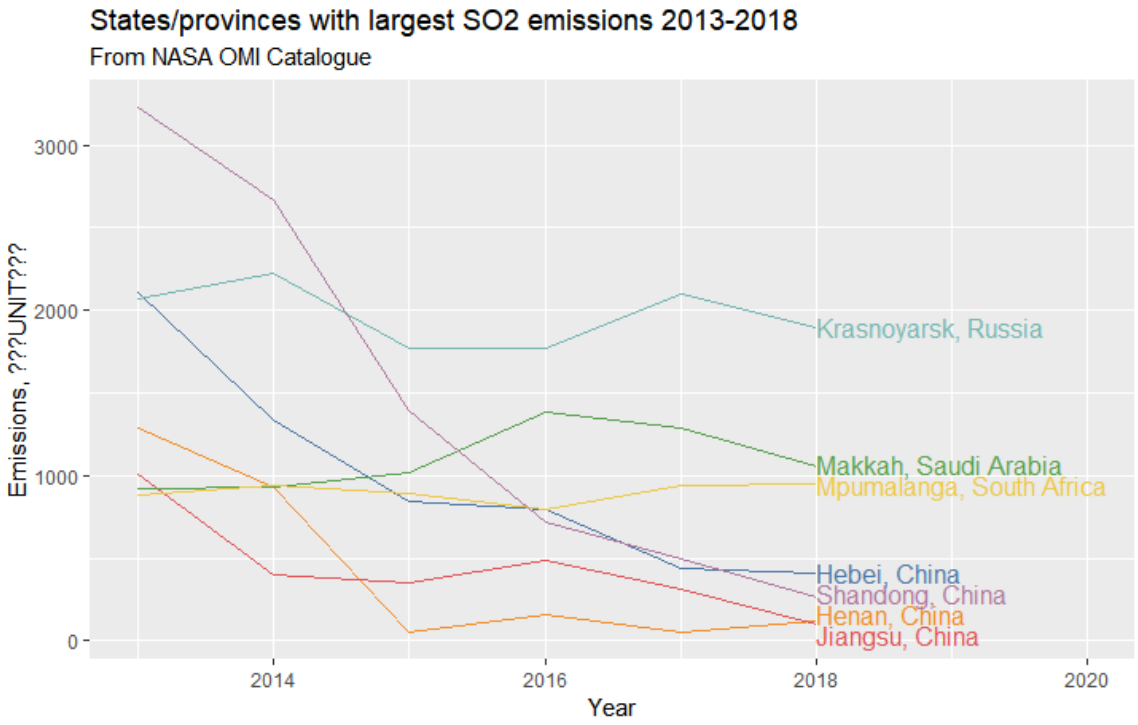
Greenpeace analysed the NASA MEaSUREs SO_2 source emission catalogue data[2] to identify countries and states/provinces with the largest man-made SO_2 emissions.

The NASA SO_2 monitoring team has recently updated their annual emissions estimates for large SO_2 emissions sources for 2018, using data from the NASA OMI satellite instrument. The methodology is based on comparing SO_2 levels measured by satellites upwind and downwind of identified point sources, and has been validated against measured SO_2 emissions in the U.S. and the EU.[3]

The analysis finds that Mpumalanga ranked third in the world for SO_2 emissions in 2018 for the second year, after strict emissions standards brought emissions from highest-emitting Chinese provinces down dramatically.

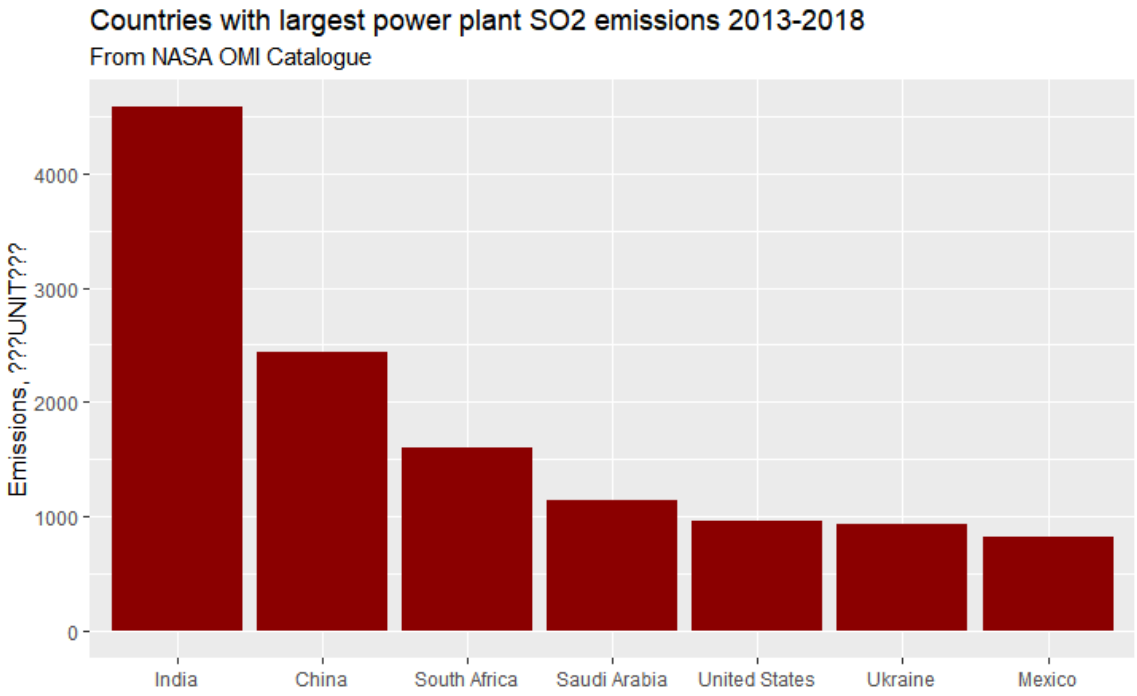
The only places in the world with even higher emissions were Krasnoyarsk in Russia, with the Norilsk industrial cluster with tremendously polluting smelters, power plants and factories, and the Saudi region of Makkah (Mecca) with oil refineries and oil-fired power plants. Both of these regions have a larger land area than Mpumalanga.

South Africa also ranks third in the world for power plant SO_2 emissions in 2018, after India and China, and followed by Saudi Arabia and the United States.



[2] excluding volcanic sources

[3] Fioletov, V., McLinden, C. A., Kharol, S. K., Krotkov, N. A., Li, C., Joiner, J., Moran, M. D., Vet, R., Visschedijk, A. J. H., and Denier van der Gon, H. A. C. (2017): Multi-source SO2 emissions retrievals and consistency of satellite and surface measurements with reported emissions, Atmos. Chem. Phys., 17, 12597-12616, DOI: 10.5194/acp-17-12597-2017.



OTHER DATASETS

The Greenpeace findings are by no means an outlier, but rather well in line with earlier, publicly available data. Besides using the NASA SO_2 emission data, we compared our NO2 estimates to two other sources: the Dutch meteorological agency's (KNMI) monthly NOx emissions estimates based on NASA OMI satellite data, and official emissions statistics from China and Eskom.

KNMI DECSO ALGORITHM FOR NO2

The Dutch Royal Meteorological Institute (KNMI) has developed a sophisticated approach to estimating NOx emissions combining satellite-based NO2 measurements with a detailed atmospheric model to relate atmospheric levels to emission sources and rates[4].

DECSO data was available for eastern China and South Korea until 2017, the Middle East until 2014 and South Africa until 2011. Estimates for India were only available for 2008 and were discarded as too old, given the rapid growth in the country's fossil fuel use and emissions in the past decade.

Within this limited dataset, the coal power plant and industrial cluster in Mpumalanga ranks as the third largest NO2 hotspot in the world, after two locations in the Middle East with very high oil consumption in transport, industries and power plants.

[4] Ding, J., van der A, R. J., Mijling, B., Jalkanen, J.-P., Johansson, L. and Levelt, P. F., Maritime NOx emissions over Chinese seas derived from satellite observations. Geophysical Research Letters, 45. https://doi.org/10.1002/2017GL076788. Mijling, B. and R. van der A (2012). Using daily satellite observations to estimate emissions of short-lived air pollutants on a mesoscopic scale. J. Geophys. Res. 117, D17, https://doi.org/10.1029/2012JD017817.

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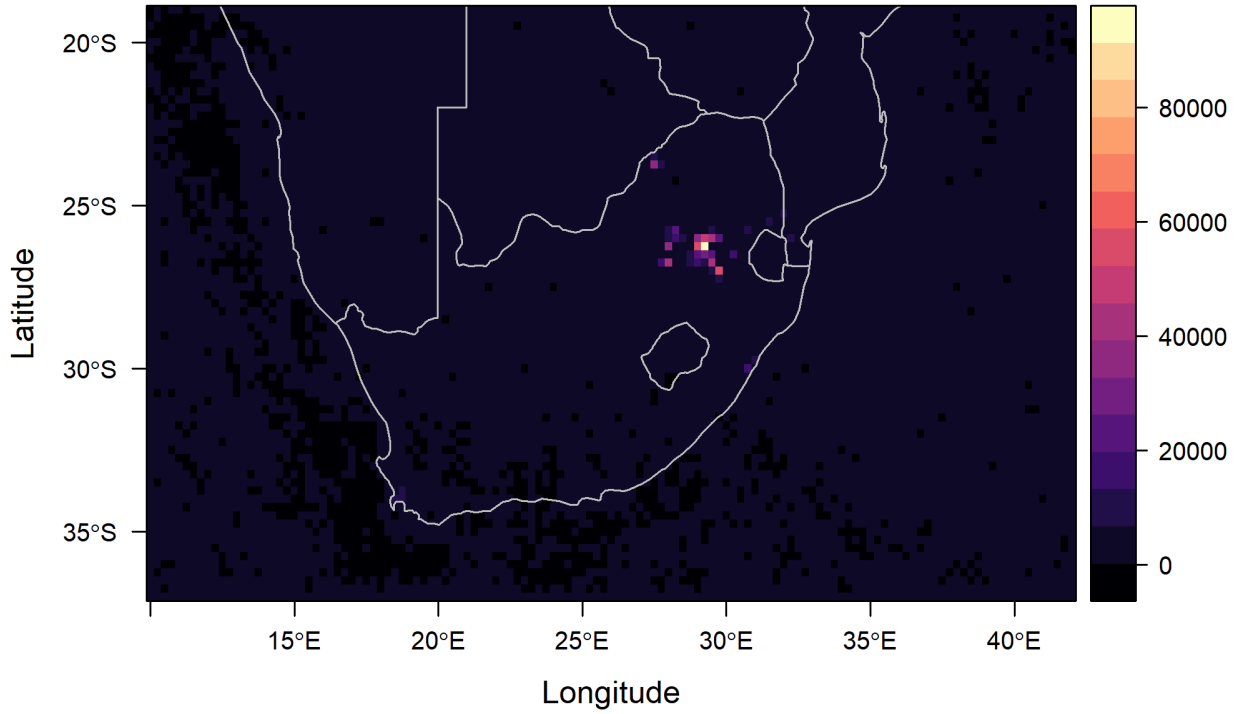
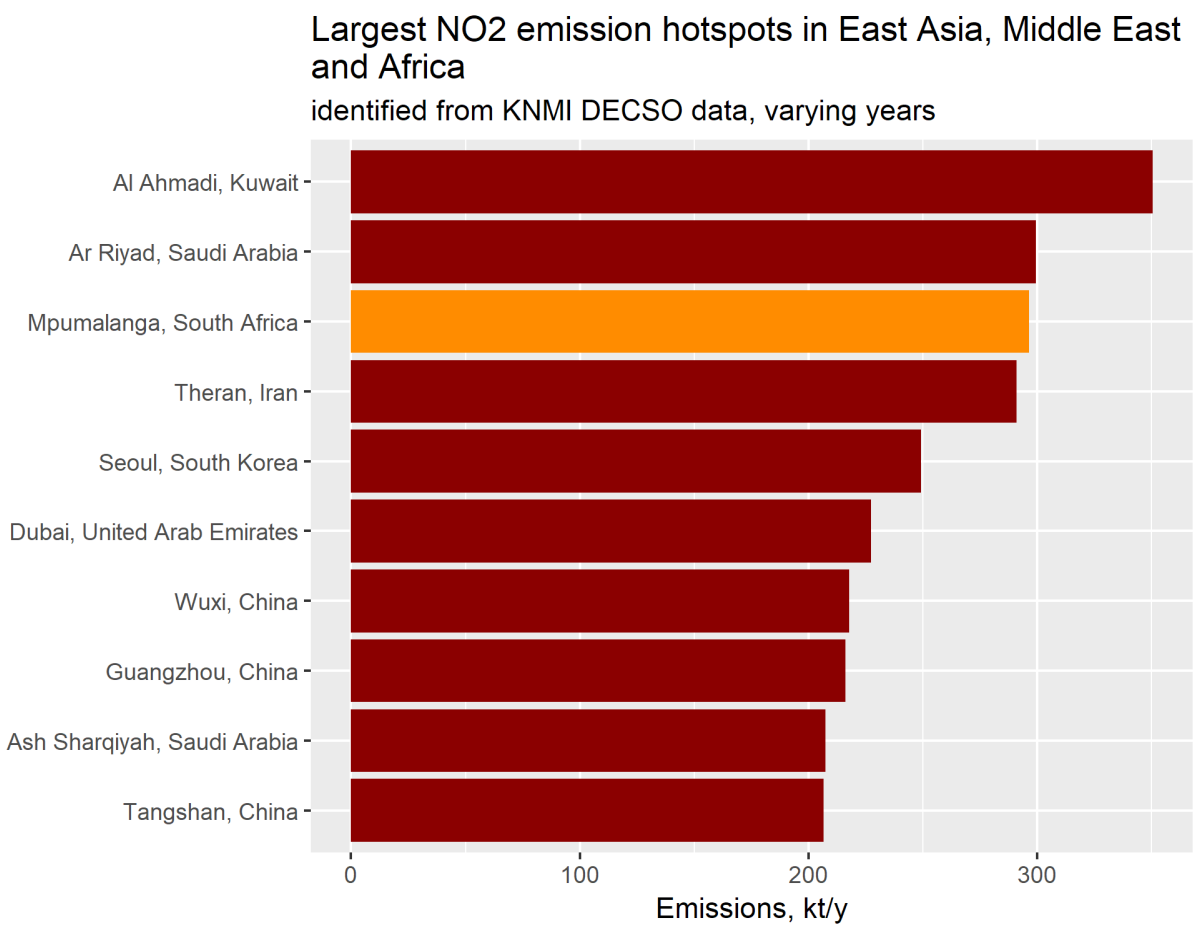
KNMI DECSO NOx emissions for South Africa (kt/yr)





EMISSION STATISTICS

Another approach corroborating our results is comparing annual emission volumes reported by Eskom as a part of its applications[5] for suspension of compliance with South Africa's Minimum Emission Standards with province-level statistics on industrial emissions in China.

Eskom's Highveld plants emit more SO_2 and almost as much NO_x as all the industrial emitters in the largest emitting province in China, Shandong. Shandong's area is twice as large as Mpumalanga's. Eastern China and Shandong have reduced NOx emissions by 24% and 31% respectively from 2012 to 2017. SO_2 emissions have fallen by more than 80% in China and more than 90% in Shandong from 2012 to 2018.

[5] http://www.naledzi.co.za/public-documents-naledzi.php

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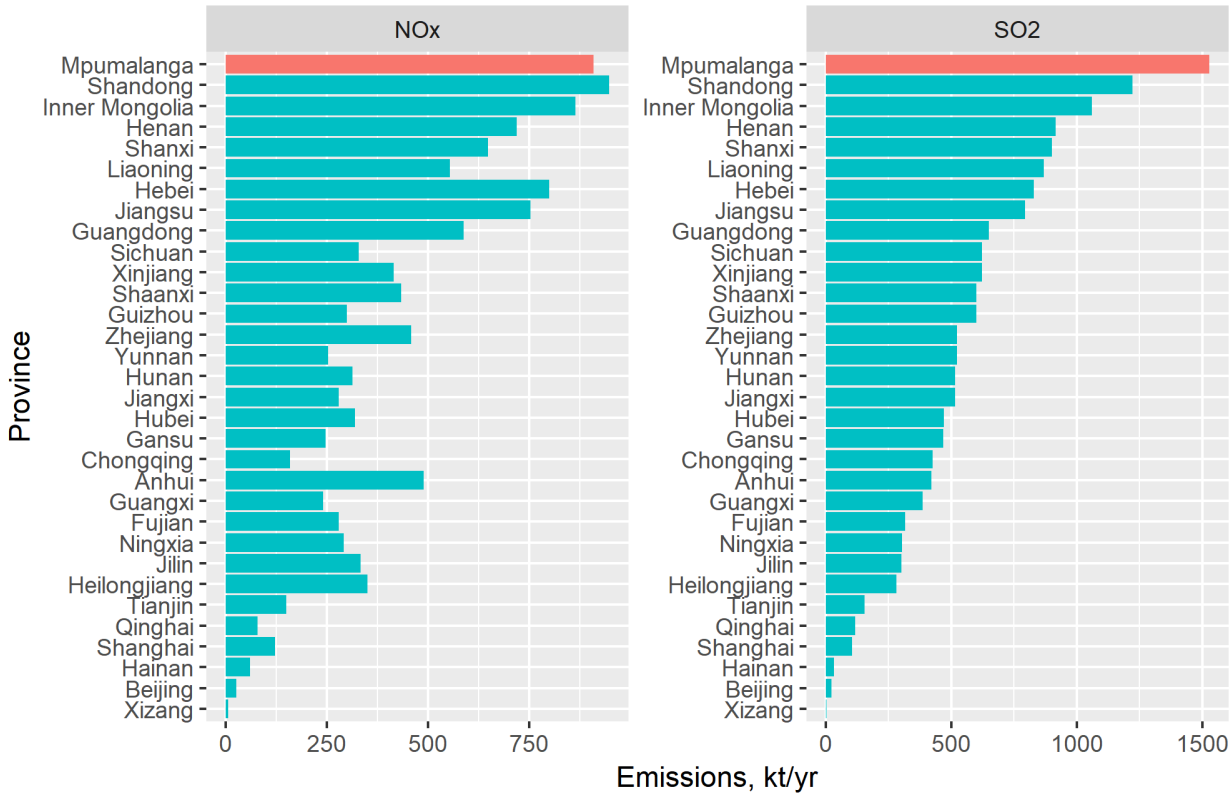
Eskom's reported emissions compared to total industrial emissions in Chinese provinces (2015)



Source: China Environment Statistical Yearbook 2016

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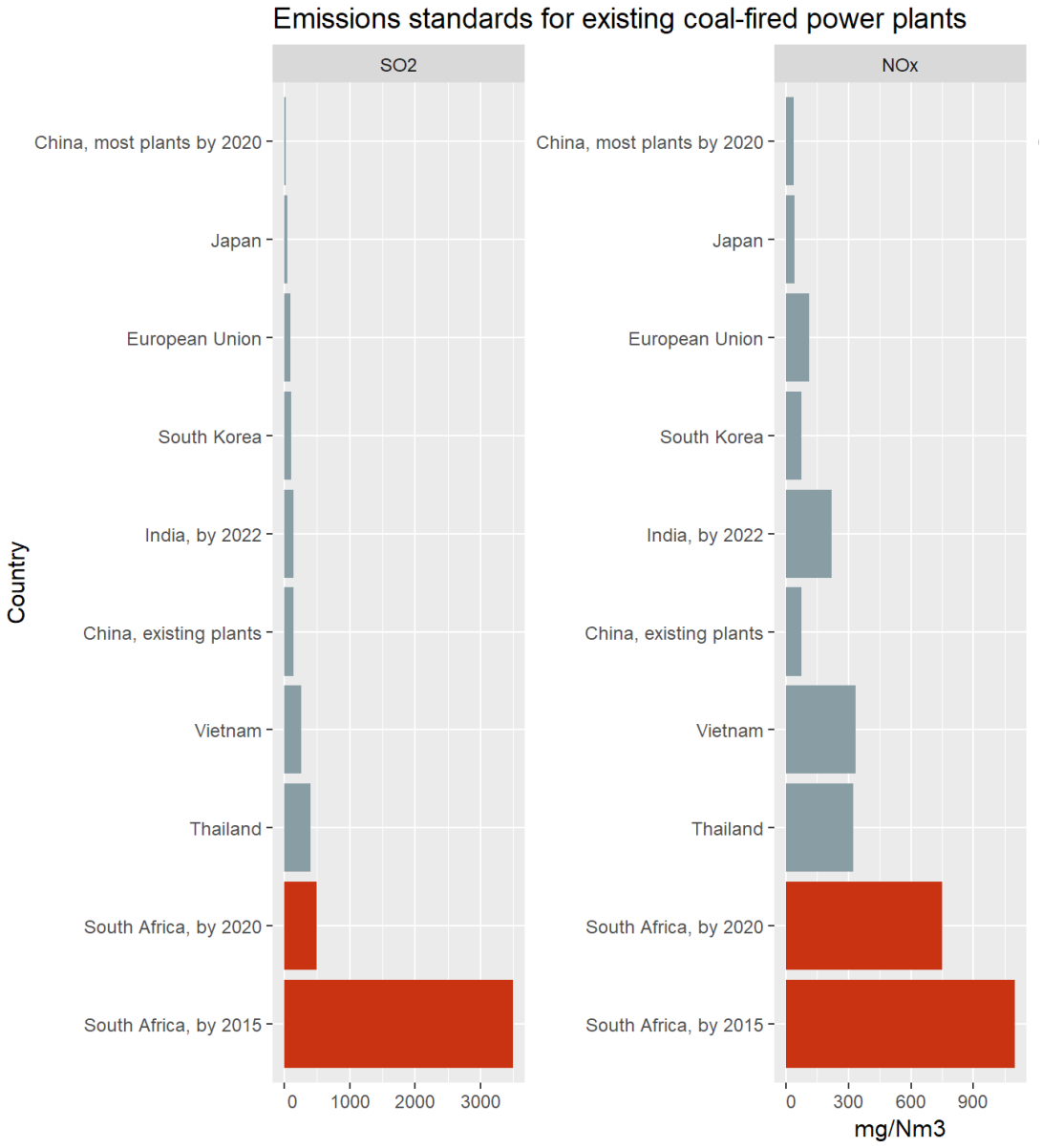
WHY COAL POWER EMISSIONS IN MPUMALANGA ARE THE HIGHEST IN THE WORLD

There is a clear reason why Highveld ranks as the world's largest power plant SO_2 and NO2 emission hotspot – besides having a large concentration of coal-fired power generating and industrial capacity, the emission control performance of the coal-fired boilers is dramatically worse than in other countries. Eskom's coal-fired power plants are allowed to emit more than 20 times as much SO_2 and 15 times as much NOx as Chinese and European coal-fired plants.



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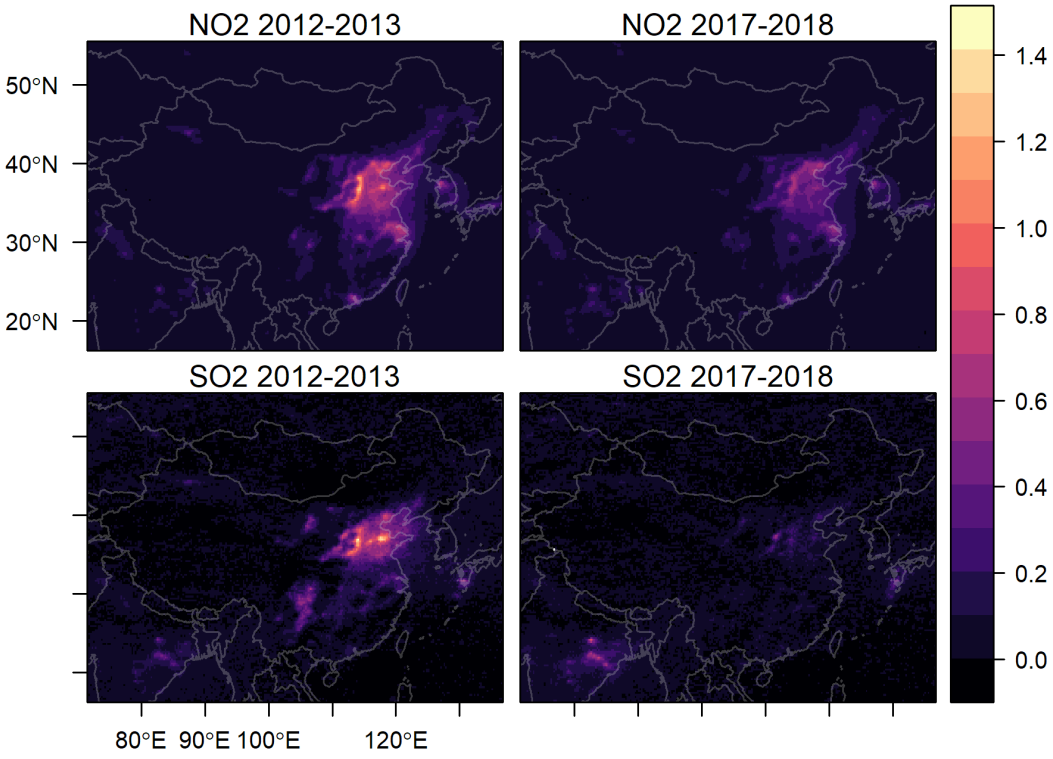
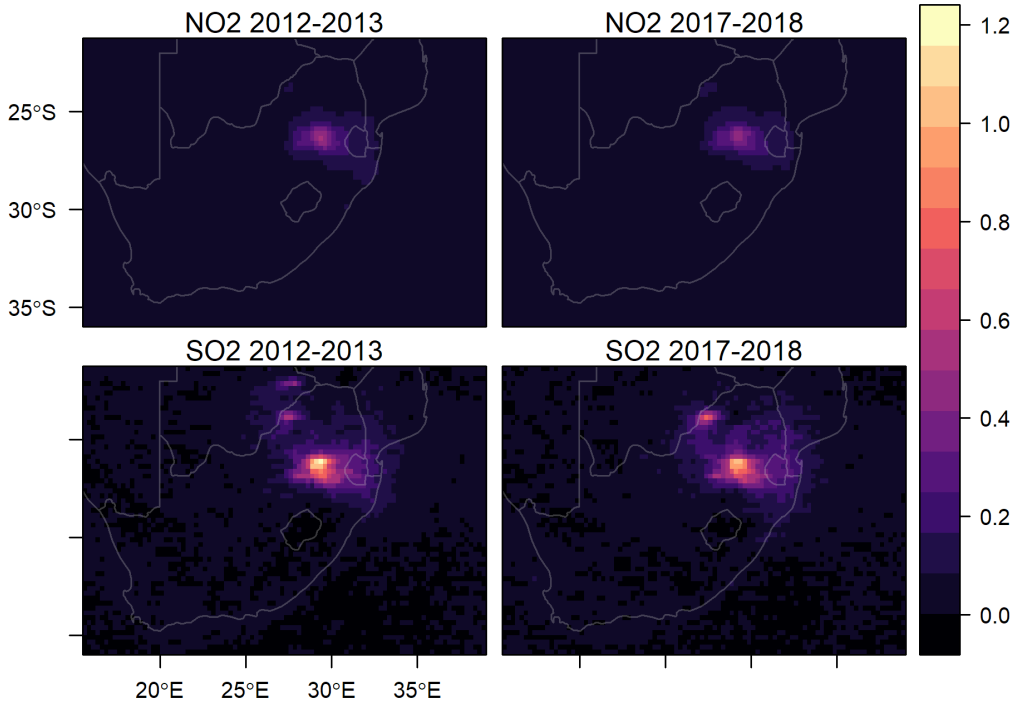
HOW CHINA HAS CUT EMISSIONS FROM COAL-BURNING

Satellite-based SO2 and NO2 levels in China



Satellite-based SO2 and NO2 levels in South Africa



After public opinion reached a boiling point during disastrous smog episodes in winter 2011-12, later known as China's "Airpocalypse", the government reacted forcefully and published a "National Air Pollution Prevention Action Plan", which set detailed targets for improving air quality, reducing emissions and reducing coal consumption in the country's key regions by 2017. The action plan period also saw new emissions standards for coal-fired power plants enter into force in 2014, requiring steep reductions in SO_2 and NOx emissions from the power sector, and a new environmental law become effective at the start of 2015, strengthening the enforcement of emission limits and increasing fines for violators.

Over the five-year period from 2012 to 2017, China achieved dramatic reductions in power plant and industrial emissions and equally dramatic improvements in air quality.

China retrofitted approximately 250 gigawatts of existing coal-fired capacity with Flue Gas Desulphurisation (FGD) between 2005 and 2011, bringing the share of capacity with SO_2 controls from 14.3% to 89.1% in six years. These installations were in response to the national emission standards introduced in 2004. Similarly, after the emission standards were updated in 2011 to levels that required selective catalytic NOx controls (SCR), these retrofits were carried out on approximately 480 GW of capacity by 2015, raising penetration from 18.2% to 84.5% in four years.[6]

Subsequently China has been retrofitting existing power plants to meet so-called ultralow emission standards, which are 100 times as strict as South Africa's Minimum Emissions Standards for SO_2 (26mg/Nm3 in China vs. 3500mg/Nm3 in South Africa[7]).

China remains the world's largest emitter of NOx (and CO2) and one of the largest emitters of SO_2, and air pollution levels remain hazardous despite dramatic improvement. However, China's success in reducing emissions and improving air quality rapidly over this decade shows how much can be achieved with a coordinated action plan that requires major polluters to comply.

[6] Data summarized from annual editions of China Association of Environmental Protection Industry: Annual Report on China Desulfurization and Denitrification Industry. See e.g. 赵雪,程茜,侯俊先 (2018): 脱硫脱硝行业2017年发展综述.中国环保产业,2018(07):10-24.
http://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2018&filename=ZHBY201807006&v=MTE2NThSOGVYMUx1eFlTN0RoMVQzcVRyV00xRnJDVVJMT2ZadVJtRkNybVdyM0lQeVhKZDdHNEg5bk1xSTlGWW8=

[7] The Chinese standard is 35mg/Nm3 at 6% oxygen which converts to 26mg/Nm3 at the 10% reference oxygen level used in South African standards.

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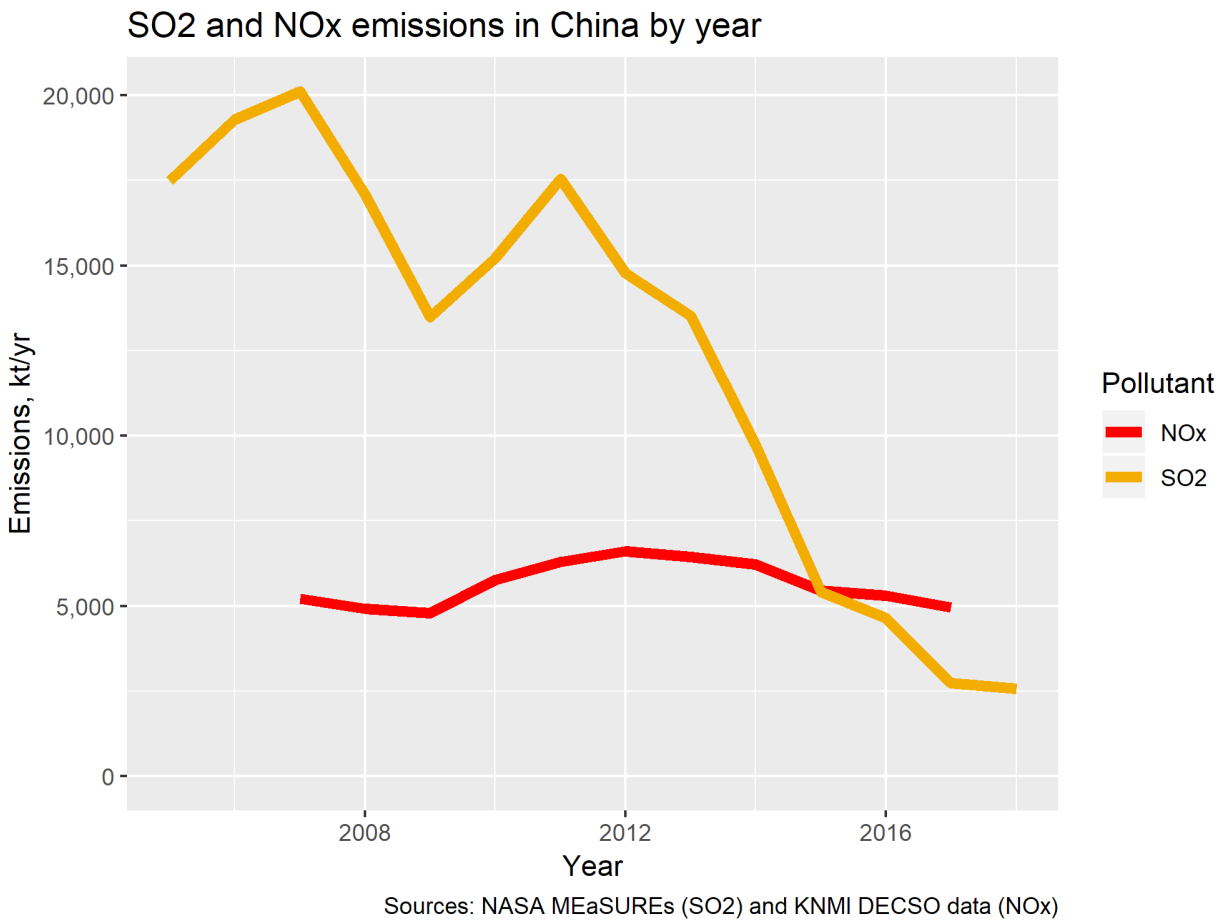
SO2 and NOx emissions in China by year
20,000
15,000
10,000
5,000
0
Emissions, kt/yr
2008
2012
2016
Year
Pollutant
NOx
SO2
Sources: NASA MEaSUREs (SO2) and KNMI DECSO data (NOx)