
New satellite data reveals world's largest NO₂ air pollution emission hotspots - Greenpeace Media Briefing

The global air pollution crisis and the role of NO₂

Air pollution is a global public health crisis, with up to 95% of people across the world breathing unsafe air, and several million deaths per year attributable to it.

Unprecedentedly detailed satellite data generated by the European Space Agency's new satellite and analyzed by Greenpeace reveals the location of the globe's worst NO₂ emissions sources.

NO₂, and NO_x¹ more generally, are dangerous air pollutants, causing respiratory symptoms and lung damage on acute exposure, increasing the risk of chronic diseases in long-term exposure.

Long-term exposure to NO₂ is associated with increased mortality rates world-wide². In the European Union, exposure to NO₂ is linked to an estimated 75,000 premature deaths per year³. In China, there is growing scientific evidence that indicates significant increases in respiratory and cardiovascular mortality as a result of exposure to NO₂^{4 5 6}.

Furthermore, NO₂ and NO_x in the atmosphere lead to the formation of PM_{2.5} and ozone, two of the most important air-borne pollutants in terms of public health damage across the world⁷.

The new Sentinel 5P satellite

The TROPOMI instrument onboard the European Space Agency Sentinel 5P satellite has been providing unprecedentedly detailed and accurate data on NO₂ levels in the atmosphere since June 1, 2018⁸. The satellite passes over every location on earth once a day around noon local time. With new satellite technology, polluters will have nowhere to hide. We have unprecedented ability to identify emissions sources damaging air quality and public health, even when regulators are not doing their job.

¹ Note, NO_x is the general name for all nitrogen oxides, including gases like NO₂ and NO.

²

https://journals.lww.com/epidem/Fulltext/2018/07000/Long_term_Concentrations_of_Nitrogen_Dioxide_and.2.aspx

³ <https://www.eea.europa.eu/highlights/improving-air-quality-in-european/premature-deaths-2014>

⁴ <https://www.nature.com/articles/srep38328>

⁵ <https://www.nature.com/articles/jes201621#ref2>

⁶ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5486332/>

⁷ <https://www.who.int/airpollution/ambient/pollutants/en/>

⁸ <https://earth.esa.int/web/guest/missions/esa-eo-missions/sentinel-5p>

Revealing the largest hotspots

As NO₂ levels are highest right around major sources, averaging the NO₂ levels over a period of time enables us to reveal the biggest sources of NO₂ emissions. NO₂ is formed whenever fuel is burned at a high temperature or if the fuel itself contains nitrogen. Coal, oil, gas and biomass burning all contribute to NO₂ emissions. We used the EDGAR global emission database to identify the likely main sources of emissions within each hotspot.⁹

The findings of this analysis cover the three month period 1 June to 31 August. Annual or longer term trends may show slightly different results from this three month snapshot of hotspots. For example weather patterns may change during different seasons, while emissions may increase in winter. The source of the emissions is identified using the EDGAR global emissions database¹⁰, a comprehensive peer-reviewed map of emissions sources. However, some anomalies may exist between the database, which is was last updated in 2012, and the present day reality on the ground.

In addition, the data from the Sentinel satellite measures the amount of NO₂ across the full height of the troposphere (from the Earth's surface up through several kilometers of the atmosphere). This means that although most NO₂ is found close to the ground, the satellite data is not directly comparable to ground level measurements. The satellite provides data points that are several kilometers apart which may not coincide exactly with the location of ground level monitors.

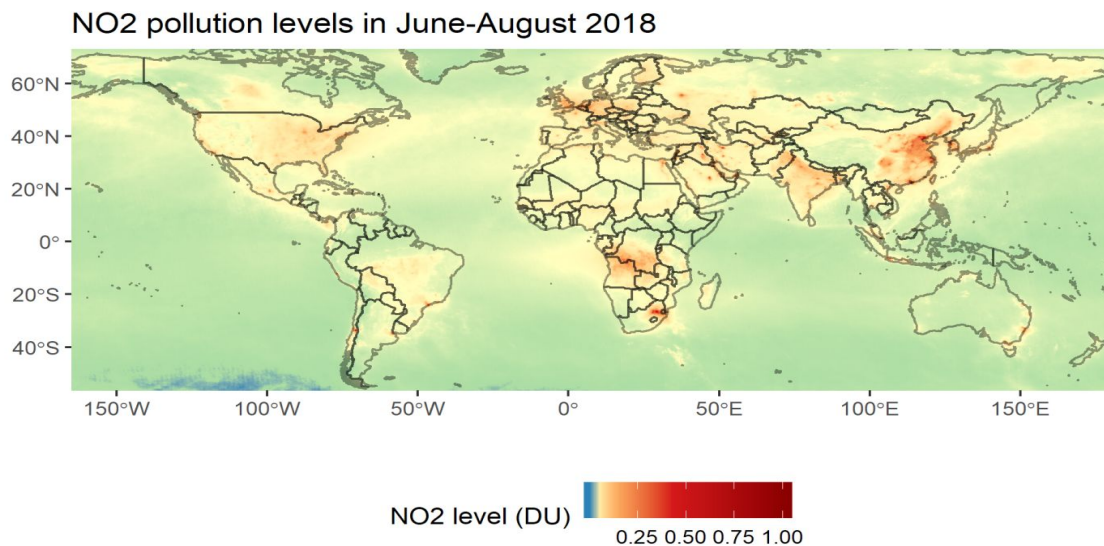
Nonetheless, the unprecedentedly detailed imagery from the Sentinel 5P satellite gives us a powerful "eye in the sky" from which polluters cannot hide.

⁹ http://edgar.jrc.ec.europa.eu/overview.php?v=432_AP

¹⁰ <https://www.earth-syst-sci-data-discuss.net/essd-2018-31/>

Key Findings

Figure 1.



The list of the largest emissions hotspots includes several coal-fired power plants in India, South Africa and Germany, 10 power plant and industrial clusters in China, 14 megacities with very high transport-related emissions, including Santiago de Chile, Tehran, Dubai, London and Paris; as well as agricultural burning in Congo and Angola. Some hotspots, such as Seoul, Jakarta and New Delhi, have a mix of contributing sources, including transport, coal power plants and manufacturing.

The world's biggest hotspot is Mpumalanga in South Africa, home to a cluster of a dozen coal fired power plants with a total capacity of over 32 gigawatts owned and operated by Eskom.

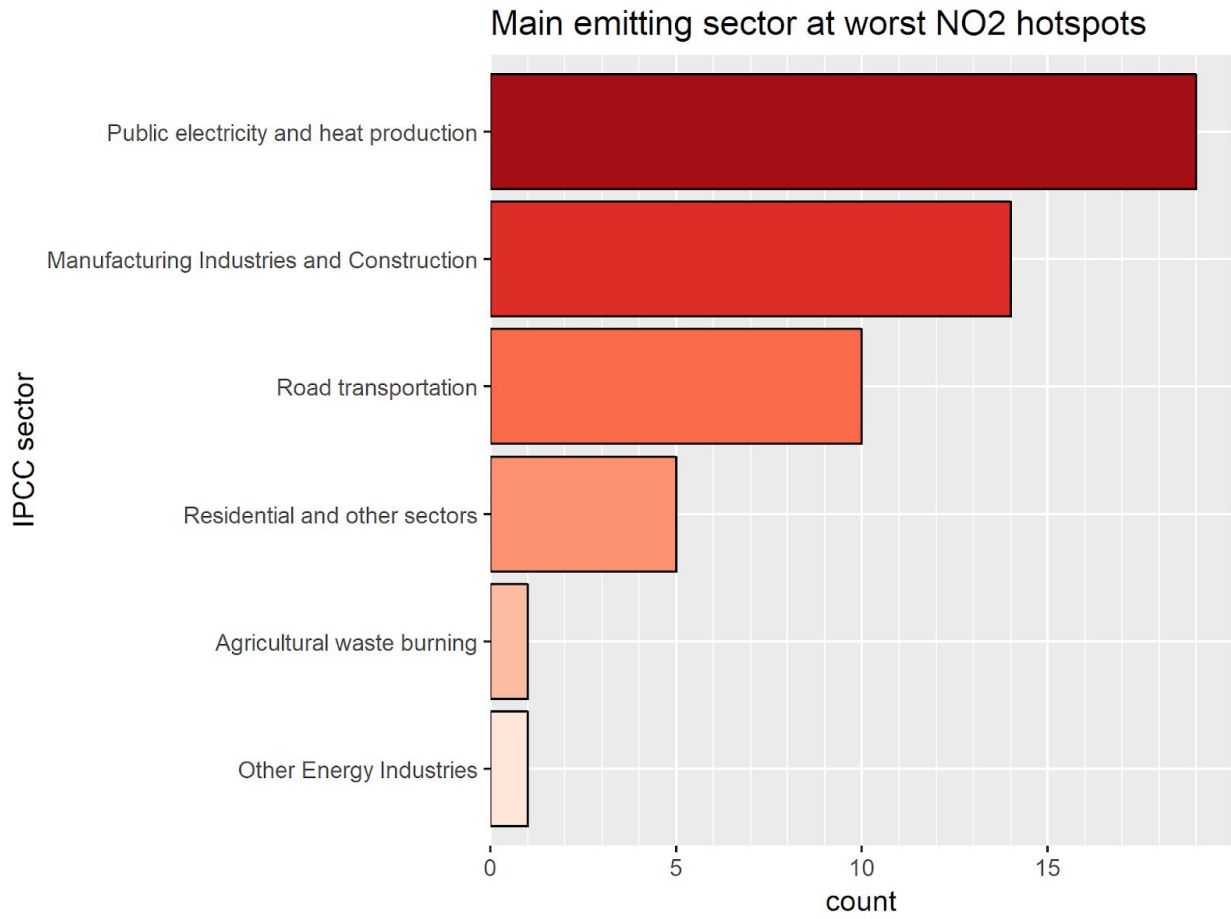
The data covers the period from 1 June to 31 August 2018.

The largest number of hotspots, a total of 10, is found in China, eight in the Arab world, four in the EU and three in India, the U.S. and DR Congo.

Power generation from coal and oil is the main source of emissions at 19 out of the 50 largest number of hotspots, followed by manufacturing industries (14), most notably steel plants in China, and transport (10)¹¹.

¹¹ This sources are identified via the global EDGAR gridded emissions inventory http://edgar.jrc.ec.europa.eu/overview.php?v=432_AP

Figure 2. (Sources are identified via the global EDGAR gridded emissions inventory)



Power Plant Hotspots

For the power plant hotspots, the main source of emissions is also readily visible from images generated from daily snapshots of NO₂ levels in the atmosphere – these images show plumes originating from specific power plants.

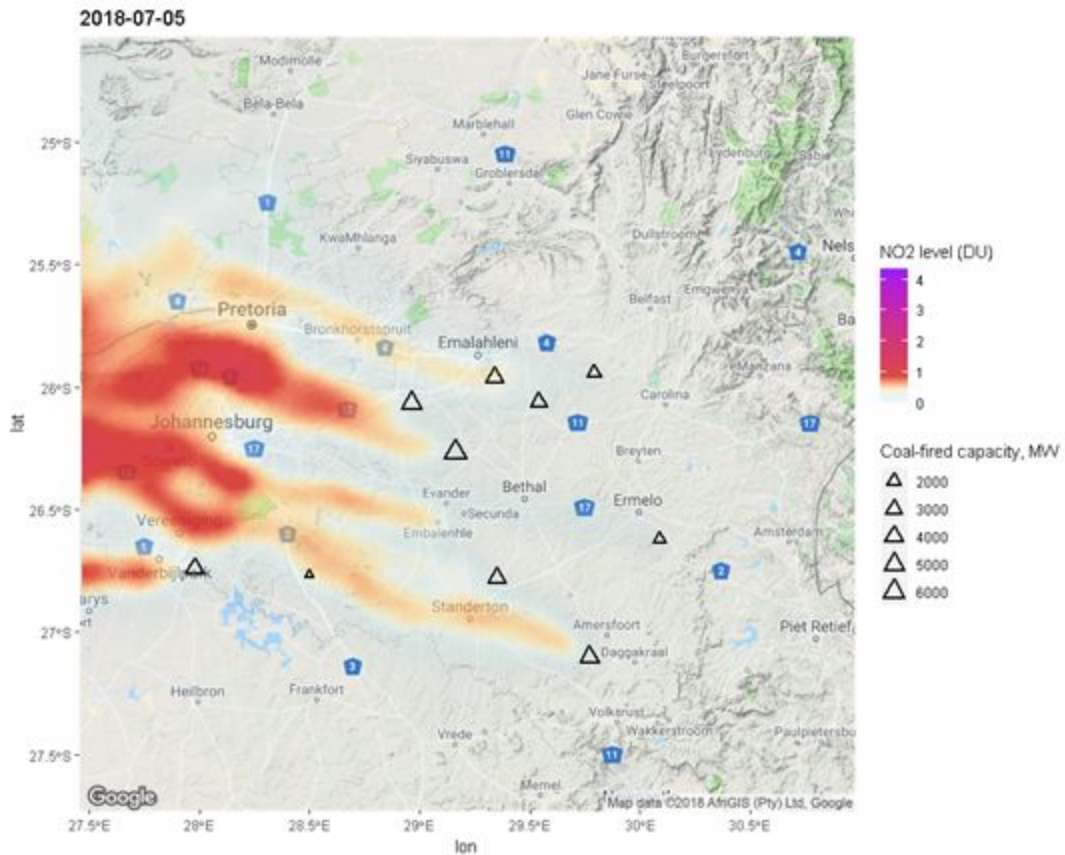


Figure 3. Power plant pollution plumes detected by Sentinel 5P on Jul 5, 2018, transported by winds from Eskom’s coal-fired power plants in South Africa to Johannesburg.

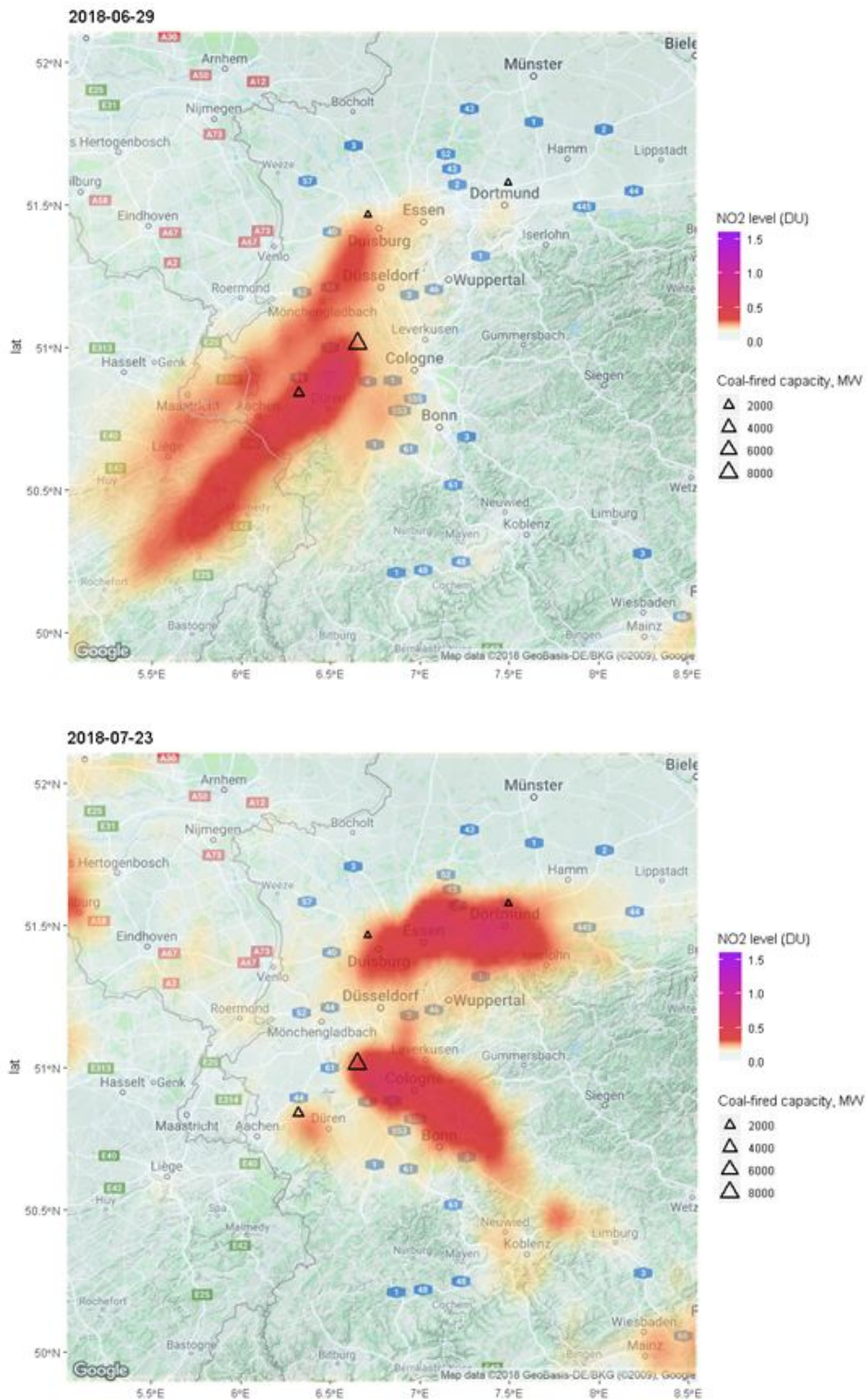


Figure 4. Pollution plumes transported from the Niederaussem power plant and from coal power plants and industry in Duisburg across the French border on Jun 29, 2018, and to Cologne, Bonn, Essen and Dortmund on Jul 23, 2018.

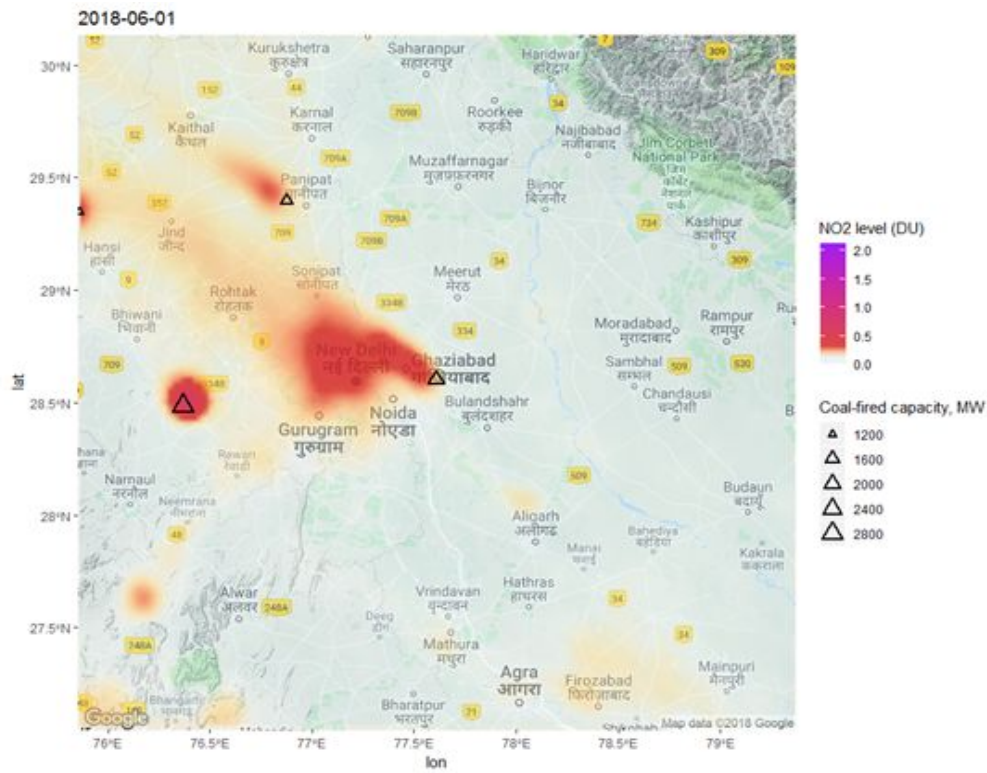


Figure 5. Pollution hotspots captured around the coal-fired power plants surrounding New Delhi in India. The pollution plume from Dadri National Capital Power Plant is getting blown right into Delhi.

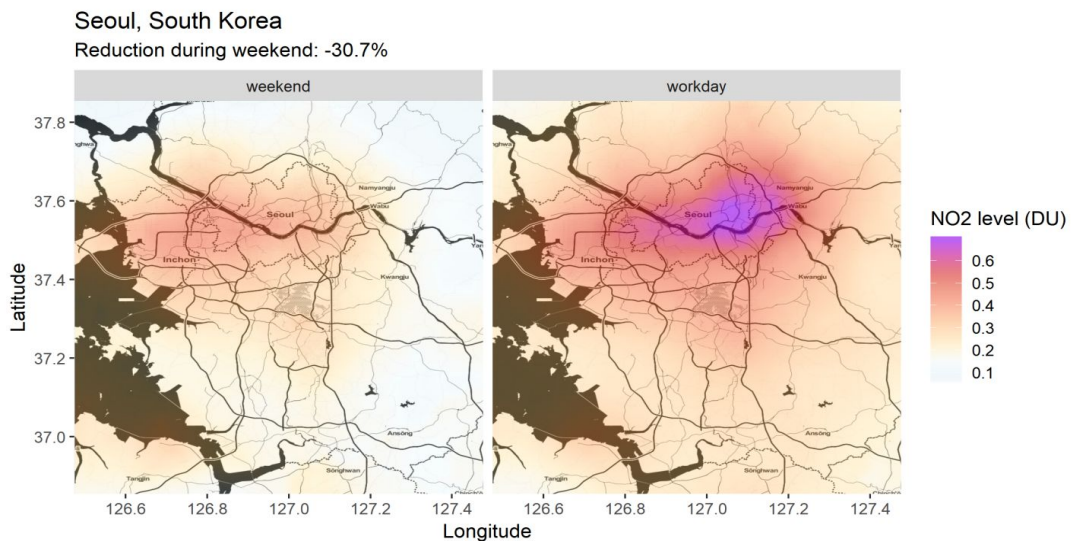


Figure 6. Weekend effect: comparing pollution levels during weekends and workdays reveals the impact of less cars on the road.¹²

¹² Recognizing that some Middle Eastern and North African countries that had traffic-related NO₂ hotspots have weekends on Friday or Friday-Saturday, workdays are taken to be Mon-Thu and weekend is either Sunday or Friday, whichever is lower.

Solutions

The vast majority of the identified hotspots threatening air quality and health are related to fossil fuel burning - coal and oil fired power plants and factories as well as unsustainable transport systems. Yet others are related to unsustainable forestry and farming practices. The health toll from these emissions shows the need for an energy revolution that eliminates our reliance on fossil fuels: renewable power generation, energy efficiency, transport and mobility systems that rely less on private cars, as well as electric vehicles.

Weak emission regulation for power plants is also a major reason for high air pollutant emissions at these hotspots around the world - there is an urgent need to strengthen standards:

- In power plants, low-NOx burners and filters using Selective Catalytic Reduction can substantially reduce NOx pollution. Most of the countries where pollution hotspots are found around coal and oil fired power plants have weak emissions standards that allow these plants to emit multiple times more pollution than best practice. For example, South Africa, with the most prominent power plant hotspot, allows 10 times more NOx from coal-fired power plants than China and Japan. German lignite plants feature as the worst NO2 hotspots in the European Union in part because their emissions standards also lag behind international best practice.
- Diesel vehicles emit far more NOx than gasoline vehicles, and recent industrial scandals show how this motor technology gained a large market share, especially in Europe, through fraud. Diesel is, nevertheless, part of a larger problem: the internal combustion engine. Private cars burning oil based fuels are a major factor causing air pollution and are also damaging for the climate. We therefore need comprehensive plans to move away from combustion engine vehicles all together, with an immediate focus on diesel, and towards electric powered public transportation; and to radically reduce the number of passenger cars on our roads in favour of active and shared mobility.

Methodology

The daily data was downloaded and processed using the R statistical computing software with the sp and raster spatial libraries. Offline processed data from TEMIS¹³ was used until Aug 14 and near-real time data from ESA Copernicus¹⁴ platform was used for Aug 15-31 as offline data was not available yet. Pixels with quality assurance (qa) value below 0.5 were ignored as recommended in the Product User Manual¹⁵.

¹³ http://www.temis.nl/airpollution/no2col/no2regio_tropomi.php

¹⁴ <https://s5phub.copernicus.eu/>

¹⁵

http://www.tropomi.eu/sites/default/files/files/S5P-KNMI-L2-0021-MA-Product_User_Manual_for_the_Sentinel_5_precursor_Nitrogen_dioxide-1.0.0-20180613.pdf

The data for each day was gridded to 0.025x0.025 degree (1'30") latitude-longitude grid according to the cell center coordinates. The daily data was interpolated using inverse distance weighted interpolation with a maximum distance of 0.05 degrees to fill in gaps between valid observations but avoiding extrapolation outside areas with valid observations. After interpolation, the daily observations were averaged over time to obtain June-August average NO₂ levels.

The unit used in the data, Dobson unit (DU), is a unit of measurement of the amount of a trace gas (e.g. NO₂) in a vertical column through the full height of the Earth's atmosphere. The Dobson Unit is defined as the thickness (in units of 10 μm) of a layer of pure gas (e.g. NO₂) which would be formed by the total amount in the column (at standard temperature and pressure).

Hotspots were identified by selecting locations with elevated NO₂ concentrations seen in the satellite data, the average of NO₂ levels at all data points within 25km of each satellite grid cell was calculated and local maxima were identified. Hotspots are a circle with a radius of 25km, centered on the cell with the highest NO₂ concentration. The choice of radius was based on observing the size of NO₂ hotspots around isolated sources with no other major emission sources in the area. When there were hotspots less than 100km apart, only the one with the highest NO₂ level was included to avoid including multiple locations within the same hotspot.

The global EDGAR gridded emission inventory¹⁶ was used to identify main NO_x emissions source sectors within that radius - the total emissions by sector within 25km of the hotspot were calculated from the emissions inventory and the share of different sectors was determined.

¹⁶ http://edgar.jrc.ec.europa.eu/overview.php?v=432_AP

Appendix I:

List of global NO₂ hotspots, 1 June to 31 August 2018.

Country / Region	Province / City	Location
Angola	Malanje	Quela
Argentina	Ciudad de Buenos Aires	Buenos Aires
Australia	New South Wales	Sydney
Bangladesh	Dhaka	-
Belgium	Vlaanderen	Antwerpen
Brazil	São Paulo	-
Chile	Región Metropolitana de Santiago	Santiago
China Mainland	Hebei	Tangshan
China Mainland	Jiangsu	Suzhou-Changzhou-Wuxi
China Mainland	Guangdong	Pearl River Delta
China Mainland	Hebei	Handan
China Mainland	Liaoning	Liaoyang
China Mainland	Shandong	Jinan-Zouping
China Mainland	Chongqing	-
China Mainland	Shaanxi	Xi'an
China Mainland	Hubei	Wuhan
China Mainland	Inner Mongolia	Baotou
Democratic Republic of the Congo	Kwango	Kahemba
Democratic Republic of the Congo	Haut-Lomami	Kamina
Democratic Republic of the Congo	Kasaï-Central	Luiza

Egypt	Cairo Governorate	Cairo
France	Île-de-France	Paris
Germany	Nordrhein-Westfalen	-
India	Delhi-NCR	Delhi-NCR
India	Uttar Pradesh and Madhya Pradesh	Sonbhadra and Singrauli
India	Odisha	Talcher-Angul
Indonesia	Jakarta	-
Iran	Tehran	Theran
Iran	Isfahan	Isfahan Metropolitan area
Iraq	Baghdad Governorate	Baghdad
Iraq	Erbil Governorate	Erbil
Japan	Tokyo	Tokyo
Japan	Osaka	Osaka
Kuwait	Al Ahmadi	-
Lebanon	Keserwan	Jounieh
Mexico	México	Mexico City
Pakistan	Punjab	Lahore
Qatar	Doha	-
Russia	Moscow City	-
Saudi Arabia	Riyadh Province	Riyadh
Singapore	Singapore	-
South Africa	Mpumalanga	Gert Sibande
South Korea	Seoul	-

Taiwan	Taichung	-
United Arab Emirates	Dubai	Sector 2
United Kingdom	England	Greater London
United States	New York	New York City
United States	California	Los Angeles
United States	Illinois	Chicago
Uzbekistan	Tashkent	

Appendix II:

Greenpeace archive photos from a selection of the identified hotspots and download link.

Mpumalanga, South Africa, [DOWNLOAD](#)



Hebei, China, [DOWNLOAD](#)



Neurath, Germany, [DOWNLOAD](#)



New Delhi, India, [DOWNLOAD](#)



Singrauli, India, [DOWNLOAD](#)



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