New Greenpeace analysis finds Mpumalanga is the second worst sulphur dioxide (SO_2) pollution hotspot in the world

South Africa relies on coal, one of the dirtiest fossil fuels, for almost 90% of its electricity and primary energy production.[1] Eskom and Sasol are the two biggest emitters in the country. The burning of coal, a carbon-rich rock found in the Earth's surface, is associated with heavy outputs of pollutants and airborne toxins such as fine particulate matter (PM), nitrogen oxides (NO_x), including nitrogen dioxide (NO_2), sulfur dioxide (SO_2), lead, mercury, and other heavy metals.

A new analysis of NASA OMI Satellite data adds to the body of research highlighting the extent of the global air pollution crisis by mapping the world's worst SO_2 pollution hotspots around the world. Once again, this analysis of satellite data puts a spotlight on South Africa. In 2018/2019, the analysis of satellite data made it clear that South Africa has an air pollution crisis related to nitrogen dioxide (NO2) emissions, with Mpumalanga being among the very worst NO2 pollution hotspots in the world, and the worst NO2 pollution hotspot from power generation alone.

Key findings

The latest analysis of satellite data reveals that the world's second worst SO_2 hotspot is the Kriel area in Mpumalanga province: the province is the world's worst SO_2 hotspot from power generation alone, and it is the world's worst NO2 hotspot from power generation alone. The province has a cluster of 12 coal fired power stations owned and operated by Eskom, with a capacity of more than 32 Gigawatts[2].

This latest analysis once again confirms that South Africa has the most polluting cluster of coal-fired power stations in the world. The satellite data corroborates existing data which indicates that Mpumalanga is a deadly global air pollution hotspot, both in terms of NO2 and SO_2. The location of these coal based power plants is just 100-200km from South Africa's largest populated area, the Gauteng region, which is a particular health concern.

There is a clear reason why the Highveld ranks as the world's worst 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 as Chinese and European coal-fired plants. SASOL, one of the largest industrial users of coal in the world, hasn't been required to mitigate its

[1] https://www.theigc.org/blog/the-cost-of-air-pollution-in-south-africa/

[2] https://en.wikipedia.org/wiki/Mpumalanga

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SO_2 emissions in any meaningful way either. Eskom's Highveld plants emit more SO_2 and almost as much NOx as all the industrial emitters in the largest emitting province in China, Shandong. Shandong's area is twice as large as Mpumalanga's. SO2 emissions have fallen by more than 80% in China and more than 90% in Shandong from 2012 to 2018.

SO_2 is one of the main contributors to human death and disease from air pollution across the planet. The ranking of global SO_2 emission hotspots demonstrates the need for stronger emission standards for power plants and industry and a rapid transition away from fossil fuels. Transitioning to cleaner air in South Africa is stunted by a massive reliance on coal, weak emission standards and a lack of enforcement to ensure compliance. South Africa's Minimum Emission Standards are already weak by international standards, and the National Air Quality Officer from the Department of Environment, Forestry and Fisheries is currently considering whether to further weaken SO_2 limits by doubling the amount of allowable SO_2 emissions.

Air pollution is a public health emergency, yet few of the countries and regions with the worst air quality have comprehensive inventories of the sources of the pollution. This analysis of satellite data enables us to reveal the worst emitters of pollution regardless of their location.

This briefing analyses NASA data on the largest point sources of SO_2, one of the key pollutants contributing to deaths from air pollution worldwide. To accompany the briefing there is an online interactive map[3] of the world's worst sources of SO_2 pollution, which allows further exploration of emission hotspots across different regions.

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3 https://bit.ly/30inNie

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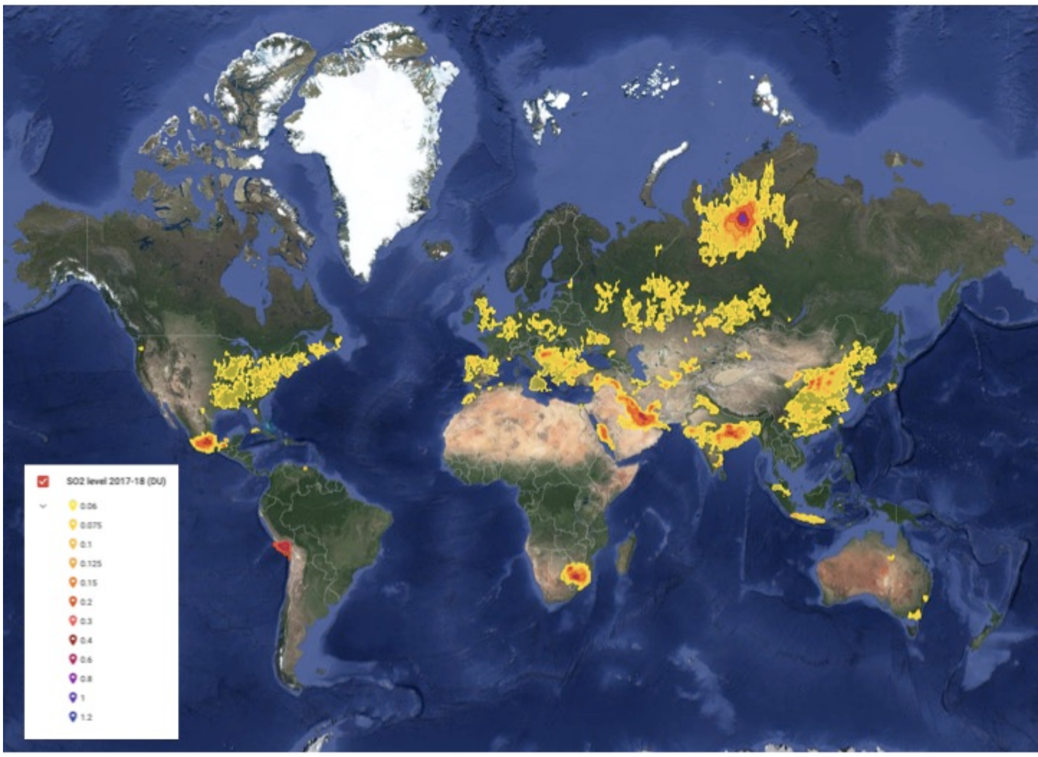

Figure 1: Presence of SO_2 emission hotspots detected by NASA OMI. Please refer to the interactive map at https://bit.ly/30inNie

Power plants burning coal and oil are responsible for two-thirds of the anthropogenic emission hotspots tracked by NASA. Oil refineries and metals smelters are the other major sources worldwide.

The world's worst SO_2 emission hotspots are found in Russia, **South Africa**, Iran, Saudi Arabia, India, Mexico, United Arab Emirates, Turkey and Serbia.

In Russia, **South Africa**, Mexico and Turkey, emissions are currently not increasing but there is not a lot of progress in reducing them either. Transitioning towards cleaner air in South Africa is stunted by a very high reliance on coal, weak emission standards and a lack of enforcement/compliance.

Out of the major emitters of SO_2, China and the United States of America have been able to reduce emissions rapidly. They have achieved this by switching to clean energy sources and, particularly in China, dramatically improved their emission standards and enforcement.

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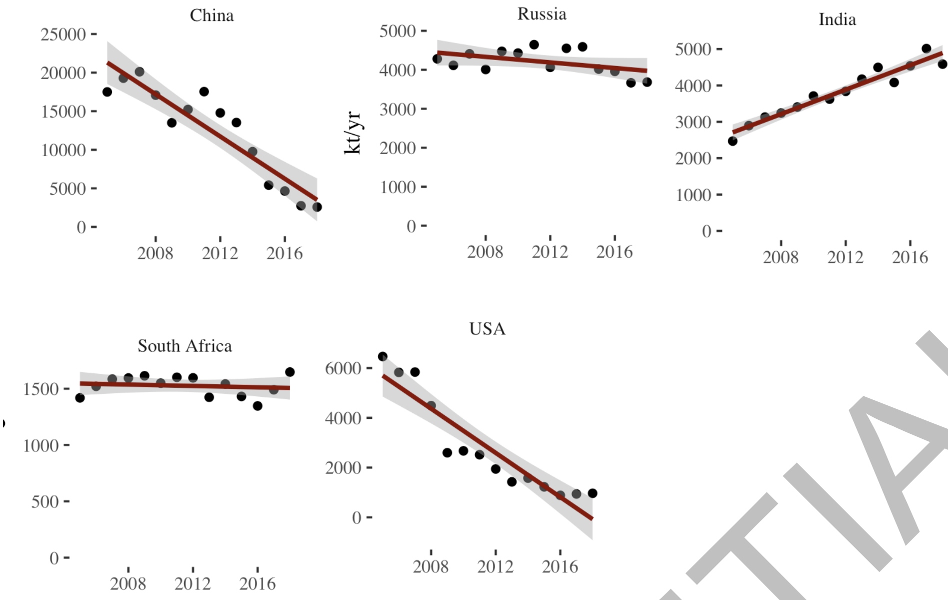

Figure 2: Trends in anthropogenic SO_2 emissions in China, Russia, India, **South Africa** and USA since 2005

SO_2 pollution and its health impacts

SO_2 is a gas which contaminates the air we breathe. Emissions of SO_2 are a significant contributor to air pollution and SO_2 is created when burning materials that contain sulfur, which is found in all types of coal and oil across the world in varying proportions. Once in the air, it can also react with water and other substances to form harmful compounds, such as sulfuric acid (H_2SO_4), sulfurous acid (H_2SO_3) and sulfate particles (SO_4^{2-}). SO_2 irritates the nose, throat, and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest.

The health impact of SO_2 derives both from direct exposure to SO_2 and exposure to fine particulate matter[4] (PM2.5) produced when SO_2 reacts with other air pollutants to form sulfate particles. PM2.5 is the air pollutant with the largest public health impact because it is a cocktail of all different kinds of pollution ranging from heavy metals to secondary gaseous pollutants such as sulfates and nitrates. These pollutants are so small that they can penetrate deeper into our organs and cells harming every organ in our body, causing everything from dementia and fertility problems to reduced intelligence and heart and lung disease[5].

The greatest source of SO_2 in the atmosphere is the burning of fossil fuels in power plants and other industrial facilities. Smaller sources of SO_2 emissions include industrial processes

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[4] Particles with aerodynamic diameter of around 2.5 µm (roughly speaking)
[5] http://www.rapidshift.net/air-pollution-is-slowly-killing-us-all-new-global-study-claims/

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such as extracting metal from ore; natural sources such as volcanoes; and locomotives, ships and other vehicles and heavy equipment that burn fuel with a high sulfur content. To tackle this problem adequately, it is important to understand both its extent and its causes. Where are pollution hotspots, what are their contributing sources, the history of their buildup and how do their emissions disperse over regions across the globe?

Methodology

The NASA OMI satellite has been monitoring air quality from space since 2004 with high consistency. Its worldwide observation coverage enables us to identify pollution hotspots which are not listed in emission inventories. Furthermore, by comparing upwind and downwind SO_2 levels, NASA has quantified emissions of large point sources and validated their results against in situ measurements in the U.S. and the European Union (EU).[6,7]

We use their MEaSUREs SO_2 source emission catalogue[8] to identify countries, administrative domains and the point sources with the largest anthropogenic SO_2 emissions. We refined this data set, by breaking down the sources of a hotspot's emissions into several categories ie. coal, oil and gas and smelters (modified from NASA original classification). We also added details of smaller industries as well as the largest emission source in the region. This way, we better represent the contributions of individual emitters within a cluster, rather than just that of the biggest. The names for hotspots were adapted from NASA database by us to represent the region as hotspots instead of just the biggest polluter in the region. An interactive map showing the raw OMI SO_2 column amounts together with the locations of the retrieved emission sources is available (Fig. 1 depicts a screenshot of that map).

Data and analysis

NASA OMI satellite data captured more than 500 major point sources of SO_2 emissions across the globe including natural sources such as volcanoes. Excluding all natural sources from our analysis and only investigating anthropogenic sources of SO_2, we found a close correlation of high SO_2 emission levels within regions that have high fossil fuel consumption i.e., geographies with high coal burning, oil refining and combustion as well as smelters.

Sixty percent of the total emissions detected by the satellite are anthropogenic. Regions with high capacity of coal combustion for power generation and industries, smelters, oil and gas refining/combustion contributed 31%, 10% and 19% respectively (Figure 2). In many cases, the total emissions for a region cannot be attributed to an exact source because emissions from large sources may obscure those of other smaller nearby contributors. Therefore, in

6 Fioletov, et al.,. Multi-source SO2 emissions retrievals and consistency of satellite and surface measurements with reported emissions, Atmos. Chem. Phys., 17, (2017), 12597-12616, DOI: 10.5194/acp-17-12597-2017.

7 A global catalogue of large SO2 sources and emissions derived from the Ozone Monitoring Instrument, https://docserver.gesdisc.eosdis.nasa.gov/public/project/MEaSUREs/Krotkov/README.MSAQSO2L4.pdf

8 Excluding volcanic sources, NASA original database https://so2.gsfc.nasa.gov/kml/OMI_Catalogue_Emissions_AMF_S20km_2005-2018_T1.xlsx (10 May 2019)
Fioletov et al., Multi-Satellite Air Quality Sulfur Dioxide (SO2) Database Long-Term L4 Global V1, Greenbelt, MD, USA, Goddard Earth Science Data and Information Services Center (GES DISC), (2019) https://doi.org/10.5067/MEASURES/SO2/DATA403

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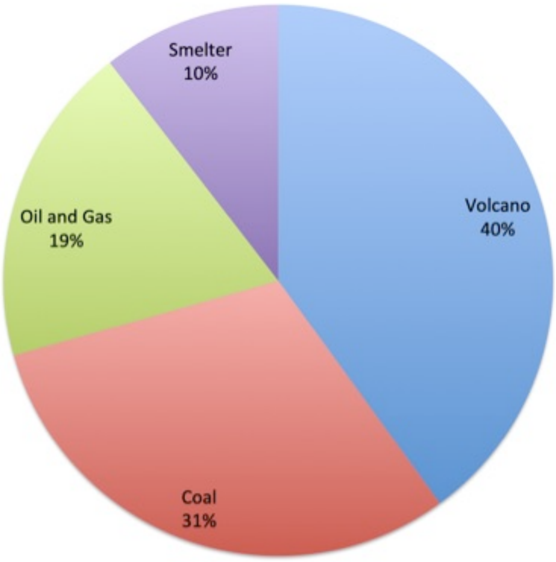
cases where multiple industries are present in the cluster, we take the largest sources as representing all other sources.



Source	Emission 2018 (kt/yr)
Volcano	19868
Coal	15217
Oil and Gas	9385
Smelter	5216

Figure 3: Sources identified by NASA OMI for SO_2 emissions (kt/yr) across the world in 2018

The Norilsk (Норильск) smelter site in Russia continues to be the largest anthropogenic SO2 emission hotspot in the world, followed by the Kriel area in Mpumalanga province of South Africa and Zagroz in Iran (Figure 3).

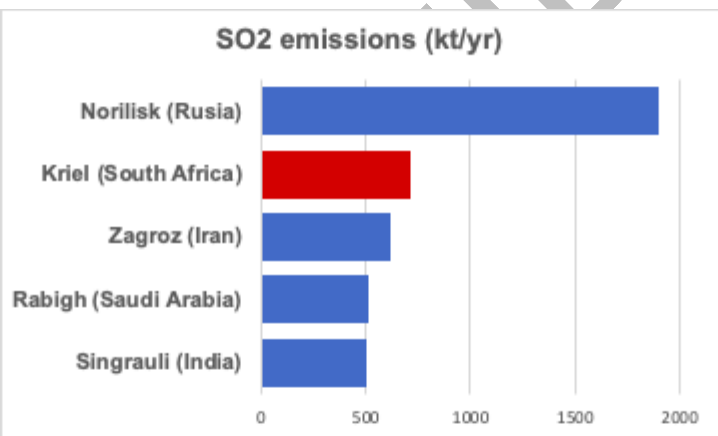


Figure 4: Top five SO_2 emission hotspots (kt/yr) across the world in 2018

Table 1: Country wise anthropogenic SO_2 emissions in 2018 estimated by NASA from identified point sources - Top 10 emitter countries

Country	**SO_2 emissions from hotspots in 2018 (kt/yr)**

1. India	4586
2. Russia	3683
3. China	2578
4. Mexico	1897
5. Iran	1820
6. Saudi Arabia	1783
7. South Africa	**1648**
8.Ukraine	979
9. U.S.A	967
10. Turkey	919

Mpumalanga has the second worst SO_2 pollution hotspot in the world, and South Africa is ranked seventh overall in terms of total SO_2 emissions.

Weakening the SO2 limits in South Africa

The Department of Environment, Forestry and Fisheries is currently considering whether to weaken the SO_2 MES limit from 500mg/Nm3 to 1000mg/Nm3 - the result of industry lobbying to avoid compliance. Greenpeace Africa has made a full submission objecting to the weakening of these standards, and as part of this submission, Greenpeace Africa included a health study[9] by Lauri Myllyvirta, the lead analyst for the Greenpeace Global Air Pollution Unit, which analyses the potential health impacts of weakening these limits. Based on atmospheric modeling results in this study, doubling the SO_2 emissions limit would increase population exposure to PM2.5 caused by Eskom's coal-fired power plants by 70%, as most of the PM2.5 exposure is due to secondary sulfate formation.

We project that, over time, the higher SO_2 MES limit of 1000mg/Nm3 will lead to the following avoidable health impacts, compared with compliance with the current (already weak) regulation:

[9] 'Air quality and health impacts of doubling the South African standards for SO_2 emissions from power plants', Lauri Myllyvirta, 2019. Available here: https://storage.googleapis.com/planet4-africa-stateless/2019/08/77d3e161-annexure-1_air-quality-and-health-impacts-of-so2-doubling.pdf

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- 950 premature deaths due to increased risk of lower respiratory infections, including in young children
- 350 premature deaths due to increased risk of stroke
- 320 premature deaths due to increased risk of death from diabetes
- 560 premature deaths due to increased risk of chronic obstructive pulmonary disease
- 720 premature deaths due to increased risk of ischaemic heart disease, and
- 520 premature deaths due to increased risk of lung cancer associated with chronic PM2.5 exposure

In total, an estimated 3,300 premature deaths (95% confidence interval: 3,000 to 3,500 deaths) would be caused by doubling the SO_2 emissions limit.

Compared against a scenario of full compliance with the current limit of 500mg/Nm3, the weakened emissions standard would allow Eskom to emit an excess 280,000 tonnes of SO_2 per year, for a total of 5.5 million tonnes over the lifetime of the plants. The failure to install SO_2 scrubbers would increase mercury emissions by an estimated 15,000 kilograms per year or 200,000 kilograms over the remaining operating life. These estimates are based on the assumption that all units retire after 50 years of operation - a longer operating life would mean larger excess emissions.

Greenpeace Africa is strongly opposed to the proposed weakening of the SO_2 limits, and believes that compliance with the already weak Minimum Emission Standards should be non-negotiable.

The solution

Air pollution and the climate emergency share the same solution. Emission hotspot regions across the world owe it to citizens to stop investing in fossil fuels and shift to safer, more sustainable sources of energy while reducing the impact of existing polluting facilities by adopting stricter emission standards.

Governments across the world owe it to citizens to stop investing in fossil fuels and shift to safer, more sustainable alternatives.

They can:

- Stop thousands of deaths by enforcing stricter emissions standards on their power plants
- Install flue-gas desulfurization (FGD) in power plants, to remove SO_2 from exhaust flue gases of fossil-fuel power plants
- Stop investing in fossil fuels and join the global transition to renewable energy

The country's electricity plan

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South Africa is in the process of finalising the country's heavily delayed Integrated Resource Plan (IRP) and the draft IRP2018 currently includes standard decommissioning rates for the coal-fired power stations, an assumption that Eskom complies with MES, and new coal investments. The release of this global SO_2 map, and the revelation that Mpumalanga is the world's largest NO2 and SO_2 emission hotspot from power generation in the world means that South Africa must take urgent steps to avoid the substantial health impacts of coal and the IRP2018 cannot allow the status quo to continue. The health toll from these emissions shows the need for an urgent just transition that eliminates our reliance on fossil fuels and instead focuses on renewable power generation combined with energy efficiency.

Greenpeace Africa demands:

South Africa is clearly in the midst of an air pollution emergency. The Department of Environment, Forestry and Fisheries has an important opportunity to play a strong role as an advocate for our constitutional right to a healthy environment by abandoning the proposed weakening of the SO2 limits, and instead seeking compliance with the existing MES from both Sasol and Eskom, and all other polluters. We believe that this should be followed by the rejection of both Sasol and Eskom's applications to postpone compliance with the MES.

Greenpeace Africa believes that these are the key actions that must be taken:

- *Absolutely no further postponements from complying with Minimum Emission Standards for Eskom's coal-fired power stations in South Africa can be granted. If coal-fired power stations don't comply, they need to be decommissioned.*

- *South Africa's National Air Quality Officer, Dr Thuli Khumalo, must ensure that there is full compliance with South Africa's Minimum Emission Standards by both Eskom and Sasol, the country's two biggest emitters.*

- *Under no circumstances should the SO_2 limits be weakened. Dr Khumalo should instead be looking to strengthen our Minimum Emission Standards.*

- *An Air pollution action plan for Mpumalanga, Johannesburg, Pretoria and all other high priority areas, that:*
    - *follows the guidelines and maximum air pollution levels of the World Health Organization (WHO) and international emission standards for coal-fired power stations*
    - *sets up concrete measures and steps to improve the air pollution levels in those regions and makes sure that they comply with the air pollution standards within 5 years*

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- *introduces independent, regular and reliable air pollution monitoring, which is available to the public and informs decision-making (including transparent data)*

- *No new coal-fired power stations* in the national electricity plan (IRP 2018), the *cancellation of unit 5 and 6 in Kusile coal power plant* in Mpumalanga and the *decommissioning of 50 percent of current coal-fired power stations by 2030 in line with the latest Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C*[10].

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[10] http://www.ipcc.ch/news_and_events/pr_181008_P48_spm.shtml