VIEWpoint 新观点

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Why is it so important to control sulphate aerosols? A complex role in a warming climate

Briefing Note

A briefing on research from the Climate Science for Service Partnership (CSSP) China for decision-makers in China No.01

Human-made aerosols, such as sulphate aerosols due to increased industrialisation, have a detrimental impact on human health and a wider influence on our climate. This affects, for example, rainfall patterns and therefore our food and water supplies. Gaining a better understanding of the role that sulphate aerosols have on climate and health is essential for better decision-making and a balanced management of climate and air quality mitigation measures.

Aerosols start as emissions from burning fossil fuels and last only a few weeks. Tropospheric sulphate aerosols act as condensation nuclei that cause cloud cover to increase. They are also a source of acid rain. When sulphate aerosols reach the stratosphere, they can remain there for months and affect global temperatures for as long as a year. Sulphate aerosols in the stratosphere scatter radiation from the sun and absorb radiation from the Earth causing a cooling effect.

Impacts of sulphate aerosols in China

Health - China has become one of the regions with the largest human-made aerosol loading due to rapid industrialisation (Lu et al. 2011). The World Health Organization (WHO) estimates that ambient air pollution caused 4.2 million premature deaths worldwide in 2016, of which 40% occurred in China (World Bank, 2020).

Food - sulphate aerosols may influence the Asian summer monsoon and regional rainfall, and induce profound impacts on food supply (Bartlett et al, 2018) given that 40% of the Chinese population directly relies on agriculture (World Bank, 2019).

Water - in cities experiencing heavy air pollution (e.g. Beijing), air pollutants, including sulphate aerosols, can also contaminate water resources via polluted rainfall, exacerbating water shortages (Kokkonen et al. 2019).

Climate - sulphate aerosols can interact with climate both regionally and globally, inducing changes in global mean temperature, weather extremes and diurnal temperature range, to name a few. (Wilcox et al. 2018).

The benefits of a better understanding of the effects of sulphate aerosols

- **Climate mitigation measures bring benefits for air quality** – reducing greenhouse gases (GHGs) can provide an additional reduction in the daily exposure of the population to high levels of air pollutants (Turnock et al. 2019).
- **Asian sulphate aerosols and drying in Northern China are linked** - the weakening of the East Asia summer monsoon was caused by increased Asian sulphate aerosols and hence the reduced precipitation over northern China during the latter half of the 20th century (Tian et al. 2018; Dong et al. 2019).
- **Near-term impacts of future sulphate emissions pathways on our climate** - sulphate aerosols emissions are expected to decrease rapidly throughout the 21st century and lead to enhanced East Asian summer monsoon over East Asia. The magnitude of changes is sensitive to the future emissions pathways (Wilcox et al. 2020).
- **Limited off-set effect of sulphate aerosols on climate warming** - sulphate aerosols partially off-set the warming of GHGs due to their cooling effect. This cooling effect can be small, localised and temporary relative to GHG warming (Luo et al 2020; Wilcox et al. 2020).

Beijing, Image: Brady Bellini, Unsplash

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Implications

China is taking important measures to tackle air pollution, greatly improving air quality while achieving rapid socio-economic development, by:

- upgrading industrial and residential energy sources (Crane and Mao 2015)
- employing advanced technologies (Xinhua Net, 2019)
- carrying out global collaborations (World Bank, 2020)

There is still much to do, however, as pollutant concentrations in some Chinese megacities are above WHO guidelines values. If the wider and complex impacts of sulphate aerosols are not taken into consideration (e.g. the competition between sulphate aerosols and GHGs, the interaction between decreasing Chinese emission and increasing Indian emission), poor decision-making may not only exacerbate haze events and food and water shortage, but also lessen the impact of the achievements already made on health via air pollution control.

Air Pollution in Shanghai Image: Photoholgic, Unsplash

China has greatly improved air quality while achieving rapid socio-economic development. Since the implementation of the "Atmospheric Pollution Prevention and Control Action Plan" in 2013, aerosol emissions have dramatically decreased, with sulphur dioxide (SO_2) reduced by 59% in 2017 compared to 2013 (Zheng et al., 2018).

Recommendations

- Continuing with **air pollution control policy**. Haze events (e.g. in Beijing) will be less intense if aerosol emissions keep coming down, even though the weather that favours haze events might be more frequent in future (Zhang et al. 2020).
- Continuing the investment in **monitoring emissions**, e.g. establishing and maintaining a national network for monitoring emissions and climate response.
- Further support and funding for **global collaborations,** e.g. World Bank Program.
- Finding a balance between **competing challenges** such as boosting the economy, improving air quality and stabilising future climate, especially for developing countries like China with a large population living around the poverty line.
- Combining **mitigation measures** – air quality control and climate mitigation measures need to work side by side.
- Considering the **limited off-set effect** of sulphate aerosols on temperature – this off-set will only impact the regional climate in the short-term therefore cannot be considered as a climate mitigation measure.
- Testing and adopting **new cutting-edge technologies** to improve the efficiency of energy usage, to monitor climate response and to control rainfall pollution.
- Engaging in the **development of climate services**, e.g. the decadal prototype climate service for air quality control with projections of haze weather index at the Met Office, to allow tailored service for downstream users.
- **Raising awareness** of the impacts of sulphate aerosols among the public to empower the population, highlighting the benefits of reducing aerosol emissions in their lives.

Further reading:

Crane K, and Mao Z. (2015). https://www.rand.org/pubs/research_reports/RR861.html

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World Bank, (2020). https://www.worldbank.org/en/results/2020/05/07/breathing-easier-supporting-chinas-ambitious-air-pollution-control-targets

Zhang et al. (2020). https://doi.org/10.5194/acp-2020-957, in review

Zheng et al. (2018). https://doi.org/10.5194/acp-18-14095-2018

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