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Reducing sulfur dioxide emissions alone cannot substantially decrease air pollution

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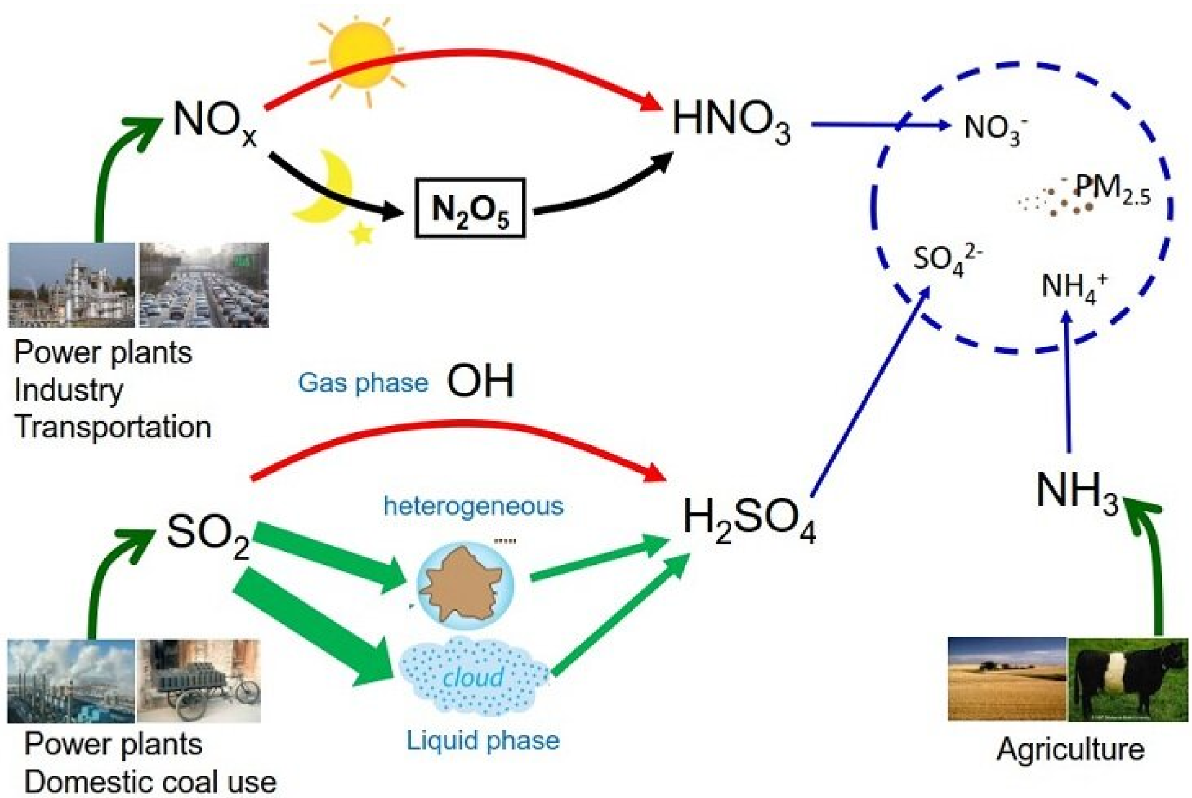

Chemical cycle of SO_2, NOx, and NH_3 in the atmosphere.

High loadings of fine particulate matter ($PM_{2.5}$) during haze are mostly produced from the chemical reactions of reactive gas precursors, including sulfur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), and volatile organic compounds. In an ideal world, air pollution would be cured by wiping clean any one of these four $PM_{2.5}$ precursors. However, in the real world, we have to go step by step, considering the technological conditions and the economic costs in the emission control strategies.

These gases are subject to a certain thermodynamic equilibrium in the atmosphere. Theoretically, NH_3 prefers to combine with SO_2 (sulfuric acid) to form ammonium sulfate, which is stable in the atmosphere. Excessive NH_3 will react with nitrogen dioxide (nitric acid) to form ammonium nitrate, which is unstable, and the formation of which is influenced by the relative abundance of NH_3 and nitrogen dioxide. Consequently, a decrease in SO_2 emissions leaves more NH_3 to form ammonium nitrate, and it may also perturb the balance between NH_3 and nitrogen dioxide.

Due to the delivery of the Air Pollution Control Action Plan, SO_2 emissions have declined dramatically since 2013. It also offers us an opportunity to examine whether a reduction in SO_2 will perturb the balance between NH_3 and nitrogen dioxide in forming ammonium nitrate, and to decide how to make emission control strategies in the future.

Professor Xingying Zhang from the National Satellite Meteorological Center and his coauthors have addressed this issue. They evaluated and compared the behavior of $PM_{2.5}$ with respect to NO_x and NH_3 emission changes in high (2013) and low (2018) SO_2 emission cases.

Prof. Zhang's group has found that, from 2013 to 2018, due to the changes in precursor emissions, the simulated annual mean $PM_{2.5}$ concentration decreased by nearly 20%, more than half of which was driven by reduced SO_2 emissions. "To evaluate the influence of a reduction in SO_2 emissions on the sensitivity of $PM_{2.5}$ to NO_x and NH_3 emissions, we conducted model sensitivity studies by separately perturbing NO_x and NH_3 emissions by 25%. Then, we calculated the relative reduction of $PM_{2.5}$ concentration caused by a 1% decrease in NO_x and NH_3 emissions," explains Professor Zhang.

According to the study of Prof. Zhang, it can be concluded that, due to the reduced emissions of SO_2, and considering the high level of NH_3 emissions in China, nitrogen dioxide emissions control is more effective in reducing the surface $PM_{2.5}$ concentration in China. This paper has been published in *Atmospheric and Oceanic Science Letters*.

More information: Guangyi XU et al, Changes in PM2.5 sensitivity to NOx and NH3 emissions due to a large decrease in SO2 emissions from 2013 to 2018, *Atmospheric and Oceanic Science Letters* (2020). DOI: 10.1080/16742834.2020.1738009

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