Air Pollution and Climate

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What is Particulate Matter?

A mixture of solid particles and liquid droplets. The size of the particles can range in size from microscopic to easily visible to the naked eye. Two basic ranges of particles are considered when examining 'pollution'

- 10 μm inhalable particles, 2.5 μm to 10 μm
- 2.5 μm Fine inhalable particles that are less than 2.5 μm

The particles impact health, visibility and radiative forcing. Critically, the particles less than 10 μ m have longer lifetimes of days to weeks (and even longer in the Stratosphere), which will enhance transport and global impacts

What is Particulate Matter?

Examples of various atmospheric contaminants that are suspended in the atmosphere.



Particulate Pollution Sources

Sources of Pollution

Because of the multitude and various numbers of particulate pollution, it is easier to break the the particulate matter into several general categories. These categories can include, but not limited to:

- Sulfates
- Nitrates
- Organic Carbon
- Elemental (Black) Carbon
- Sea salt
- Soil or Crustal material



Sources of Pollution

Direct (Primary) emissions - Construction, dirt roads, smokestacks, fires.

- <u>Black carbon</u> formed only from combustion.
- <u>Brown carbon</u> carbonaceous particles formed from inefficient (incomplete) combustion of hydrocarbons. (typically less light absorbing than black carbon, but more than organic carbon)

<u>Atmospheric Formation (Secondary)</u> - Reactions with Sulfur Dioxides and Nitrogen Oxides from emissions of power plants, industries, and automobiles.

Sources of Pollution



Climatic Impacts

Light (shading) Particulates

- Increased albedo generates a reflective layer that reduces the total energy reaching the planet.
- Possible geoengineering solution?



Brown and Black Carbon

- Low albedo creates local absorption and heating in the atmosphere, but cooling effects at the surface (assuming the carbon is high enough in the atmosphere) (Ban-Weiss, et al. 2011).
- Another danger is increased ozone loss due to thermal decomposition from the higher temperatures (Kravitz, et al., 2012).



Mitigation Strategies

Trees?

Trees have shown potential for removal of particles, particularly ones smaller than 2.5 μ m. Studies are being conducted to determine the best trees for the job. (Yang, Chang, and Yan. 2015)

Other studies how a more limited use of trees (Yli-Pelkonen, Setala, Viippola. 2017), showing little potential for removal of pollutants at a local level, but there was evidence that particulate matter is reduced by trees over time.

The tree leaves surfaces give a location for particulates to land and stick to the surface. Which can, over time reduce those particulates.

Scrubbing

A more proven strategy is to remove or 'scrub' particulate matter at the source. Filters can trap particles before they are released into the general environment. Additionally, additional methods have been developed to use high temperature filters to better remove particulates at high temperatures (~300 to ~500 C). These high temperature ceramic candle filters have become so effective that they have begun replacing wet scrubbers for particulate removal.

Wet scrubbers use the particulate matter as nucleation sites to precipitate the solid matter out and into a liquid form. That liquid is then treated to separate out the particulate matter for disposal (US Dept of Energy).

Geoengineering

There is some speculation that injecting sulfur dioxide into the lower stratosphere could be a solution to reverse the effects of the increasing levels of carbon dioxide.

Unfortunately, the levels of sulfur dioxide required to make a significant impact seems extremely large (5 Tg(S)/yr) to generate cooling around 1.2 K. There are also strong indications that global precipitation would also decrease with the injection of sulfur (Laakso, et al., 2017).

Additional consideration about the potential for acid rain from the sulfur dioxide, is the risk worth the benefit?

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