

## Regional climate impacts of air pollutants

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We present a brief review on the regional climate impacts of air pollutants. Specifically, we focus on the role of carbonaceous aerosols that make up a large portion of particulate mass -- PM 2.5, especially over Asia, and the prevalence of these pollutants that are thought to be more important than nitrogen oxide radicals ( $\text{NO}_x$ ) or ozone ( $\text{O}_3$ ) in affecting air quality. Prior studies have shown that carbonaceous aerosols have been increasing more rapidly over Asia over the last 50 years. This is mainly due to rapid industrialization and the lack of adequate technology that results in incomplete combustions processes – the major source of these aerosols. Some of the main sources of these carbonaceous aerosols are coal combustion over China and biofuel use over India. Transportation (diesel fuel use) is also thought to be an important source in certain Asian cities.

The role of  $\text{O}_3$  and  $\text{NO}_x$  have been well documented in several previous studies due to their effects on air quality; and the role of reflective aerosols such as sulfates have been well studied due to their acid rain effects and their ability to change cloud properties via the aerosol indirect effects. However, the role of carbonaceous aerosols (organic carbon (OC) and black carbon (BC)) and their climate effects have been gaining importance only in the recent few years. Since OC is mostly reflective in the visible, their climate effects are similar to that of sulfates and other aerosols such as sea-salt and nitrates. However, since BC aerosols primarily absorb in the visible, they tend to reduce sunlight reaching the surface and absorb sunlight above, resulting in stronger atmospheric heating that in turn affect the stability of the underlying boundary layer, depending on their vertical location. The response of convection to the implied heating results in changes to precipitation patterns via changes in the large-scale convergence. These climate effects of BC have been documented based both on measurements and modeling studies and in some cases an assimilation of both. Over China, several recent studies have found large changes to precipitation trends, sunshine duration, surface radiation budgets, frequency of temperature extremes (minima and maxima), surface humidity index, etc. over the last 40-50 years. These have been correlated to the presence of aerosols in these regions that have also increased during the same time period. Some studies also indicate that the aerosol influence on these changes may be more important than the changes caused by other greenhouse gases. Similar measurements over the India subcontinent also suggest the increasingly significant role of aerosols in affecting radiative fluxes, precipitation and temperature.

Since aerosols have a short life-time (usually 4-7 days) and are spatially heterogeneous, their climate patterns are specific to locations. Smaller particles can however be readily exported to other regions and these have been observed to affect distant climates. BC deposition on sea ice and snow has also been found to influence surface albedo and melting of snow layers in the Arctic.

In this talk we will review the climate impacts of air pollutants (primarily aerosols) over China and India as discussed above. We will also examine the relative role of BC and the other pollutants ( $\text{O}_3$ ,  $\text{NO}_x$ , OC and sulfates) on future climate (2030) based on preliminary results of our recent modeling study.