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Wet scavenging of black carbon and sulphate depends on the nature of the rain; effect on the climate and global change

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Global aerosol distribution is largely controlled by the rate of removal of aerosol by wet removal processes. In Indian atmospheric conditions, wet removal is mainly effective during the monsoon period (June–September) when more than 90% of annual rainfall occurs. There are several dry days between the rain events even during monsoon. Thus, several natural and anthropogenic aerosol species are built-up in the atmosphere before the rain, scavenged during the rain and again they start building up after the rain.

Two such climatically important aerosol species in the atmosphere are black carbon (BC), which is anthropogenic in nature, and sulphate aerosol, which is emitted both from natural and anthropogenic sources. BC is a strong absorber of solar radiation in the visible and near IR part of the spectrum, where most of the solar energy is distributed and thus is a major source of global warming. On the other hand, sulphate aerosol strongly reflects the solar radiation and cools the atmosphere. Thus, the net radiative forcing is determined by the relative amounts of BC and sulphate i.e. the BC to sulphate ratio.

The wet removal of aerosol species is strongly dependent on the rain intensity also. However, most studies till date have concentrated on the total aerosol wash-out but species-specific scavenging has not been studied in any detail. This study is an attempt to find answers to the following questions: 1) How the atmospheric removal of BC and sulphate dependent on the rain intensity. In other words, which kind of rain (light, moderate or heavy) is more efficient to remove those species from the atmosphere and 2) how their removals (relative concentrations) affect the net radiative forcing from before to after the rain?

This study has been performed at a high-altitude station Darjeeling over eastern Himalaya in India during monsoon in the year 2008. Four rain events were studied where aerosol components were measured just before, during and after the rain. Aerosol optical depth (and radiative forcing) was also measured before and after the rain as clear and cloud-free skies were available.

It was observed that the rain of lower intensity and of longer duration is more efficient in removing absorbing type BC aerosols from the atmosphere and minimizing its concentrations. As, this type of light rain is not efficient to remove scattering type sulphate aerosols (abundant mostly in coarse-mode during monsoon), BC to sulphate ratio is drastically reduced. Thus a light rain is better able to cool the atmosphere by reducing atmospheric forcing and radiative heating rate significantly and has significant co-benefits to the climate than a heavy rain of shorter duration.

Thus this study was conducted at a high altitude station in eastern Himalaya but the result should be of universal validity.