How Does the Nature of Rain Affect the Climate? Black Carbon – Rain Interaction Over Eastern Himalaya, India

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One of the major sources of global warming is atmospheric Black Carbon (BC) which is generated by fossil fuel and biomass burning. Wet scavenging or wash-out by rain is the major process for the removal of BC from the atmosphere. This study is an attempt to investigate the effect of the intensity of rain on the removal of BC from the atmosphere and its consequent signature on the net radiative forcing over a high altitude hill station, Darjeeling (2200 m asl), Eastern Himalaya, India. The study has been made during several rain events in premonsoon (April – May) and monsoon (June – September) in the year 2009. BC had been continuously monitored using an Aethelometer, which measures the mass concentration of BC by measuring the attenuation of light transmitted through a quartz filter tape on to which the ambient particles are made to impinge. The intensity of rain was measured using a co-located optical rain gauge. The removal or wash-out of BC due to rain was determined from the BC concentrations just before and after the rain. Out of several rain events, the initial BC concentrations before rain were found to be almost equal in 11 events. Among those, 6 events were of lower intensity (less than 5 mm hr^{-1}), 3 events were of moderate intensity (5-10 mm hr^{-1}) and 2 events were of higher intensity (greater than 10 mm hr^{-1}). The wash-out of BC from the atmosphere was studied for each of intensity-classes for the equal duration (1 hr). Thus the initial BC concentrations and the duration of the rain were kept equal in order to better understand the extent of removal of BC depending on the nature of rains. It was observed that the wash-out of BC was highest for the lower-intensity rains (60-70 %) followed by moderate (40-55 %) and higher-intensity rains (20-30 %). It was also observed that to remove equal amounts of BC from the atmosphere, the time taken by higher-intensity rains was almost double than lower-intensity rains. In addition to those 11 events, four rain events were studied separately where BC, SO_4^{2-} aerosol and Aerosol Optical Depth were measured before and after the rains. The radiative forcing and the radiative heating rate were determined using SBDART model both before and after the rains. It was observed that the lower intensity rains reduced the BC to SO_4^{2-} ratio more compared to moderate and higher-intensity rains. Consequently atmospheric forcing and radiative heating rate were also found to be drastically reduced for the lower-intensity rain. Thus a light rain is much more able to cool the atmosphere by reducing the atmospheric forcing and radiative heating rate significantly and has a significant co-benefits to the climate than a heavy rain. Although this study represents the regional scenario of aerosol-rain interaction over Eastern Himalayan region, it is expected to be generally valid.

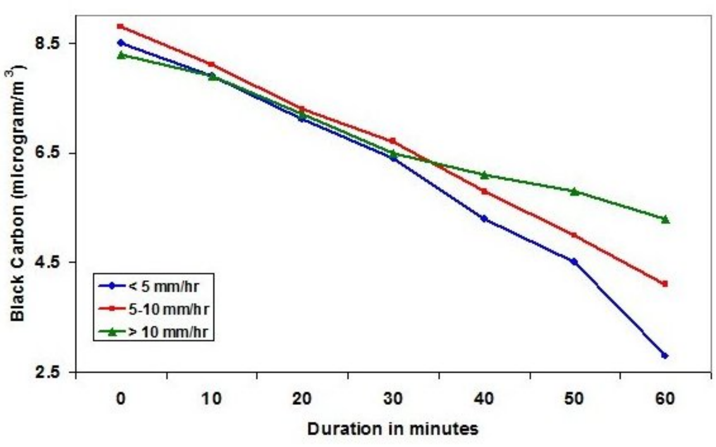

Figure 1. Wet scavenging of BC aerosol at different rain intensities.