Spatial and Seasonal Diversity of BC Sources to the Himalayas and the Tibetan Plateau: an Analysis Using the GEOS-Chem Adjoint Model

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We investigate the spatial and seasonal diversity of black carbon (BC) sources that contribute to BC concentrations and deposition in the snow-covered areas of the Himalayas and the Tibetan Plateau. In addition, we estimate the resulting radiative forcing due to direct and snow albedo effect of BC. To identify the origin of BC we use the recently developed adjoint of the GEOS-Chem global chemical transport model (CTM). In comparison to a standard CTM, the receptor-oriented adjoint model efficiently computes sensitivities of chemical concentrations at receptors to sources of emissions. It is therefore ideally suited to identify the locations and magnitudes of contributions of widely distributed sources to particular receptor region. We compute the sources and the radiative forcing of BC at five glacier sites (receptor regions) that are distributed throughout the region.

We find that the Himalayas are mostly affected by BC transported from China, India and Nepal, and our preliminary results suggest that Chinese emissions could be contributing as much as Indian emissions or more. During the dry season (winter) we find that BC from biomass burning in western Africa also makes a significant contribution to the Himalayas. Tibetan Plateau receives BC emissions from many countries and regions, whose dominant contributions vary with seasons. North-western Tibetan Plateau is affected overwhelmingly by Chinese BC emissions and to smaller extent by BC from Pakistan, Iran and India (in descending order). South-eastern Tibetan Plateau receives most of its BC from India and China, but the dominant source changes with season. Overall, there is a large spatial and temporal variation of the sources contributing to the Himalayas and the Tibetan Plateau, and we elaborate on the variations as well as their effect on the resulting radiative forcing.