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Identifying the origin and estimating the radiative forcing of BC in the Himalayas: an analysis using the global GEOS-Chem adjoint model

Monika Kopacz (1), Denise Mauzerall (1), Eric Leibensperger (2), Jun Wang (3), Daven Henze (4), Kumaresh Singh (5), and Changsub Shim (6)

(1) Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, NJ, United States (mkopacz@princeton.edu, mauzeral@Princeton.edu), (2) School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, United States (eleibens@fas.harvard.edu), (3) Department of Geosciences, University of Nebraska, Lincoln, NE, United States (jwang7@unl.edu), (4) Department of Mechanical Engineering, University of Colorado, Boulder, CO, United States (Daven.Henze@Colorado.EDU), (5) Department of Computer Science, Virginia Polytechnic Institute, Blacksburg, VA, United States (kumaresh@cs.vt.edu), (6) Jet Propulsion Laboratory, Pasadena, CA, United States (changsub.shim@jpl.nasa.gov)

The goal of this study is to identify the locations of the primary sources contributing to BC over the Himalayas and to estimate the resulting radiative forcing. To identify the origin of black carbon (BC) that contributes to warming over the Himalayas, 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 regions. We obtain the direct and snow albedo radiative forcing effect of BC at the receptor region from a broad-band delta-four-stream radiative transfer model.

To reach our goal we first, we use available ice core data from glacier drilling sites in the Himalayas and on the Tibetan Plateau to evaluate the ability of GEOS-Chem to reproduce observed BC concentrations deposited to the surface. Next, we calculate the changes in direct and snow albedo radiative forcing resulting from BC transported to the region. Finally, we use the GEOS-Chem adjoint model to obtain detailed maps, for each season, that show the locations of the BC emission sources responsible for the BC reaching the Himalayas.

Preliminary results indicate that the Himalayas are strongly affected by BC emissions from northern India and Nepal during the summer monsoon season and by emissions west of the mountains otherwise. In particular, we find that biomass burning in western Africa in winter makes an unexpectedly large contribution to BC over the Himalayas. The Tibetan plateau receives BC from both European and Asian sources, with the magnitude of contributions varying with season.