Constraining radiative forcing of Asian carbonaceous aerosols with Observations and CESM1/CAM5

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Abstract

Carbonaceous aerosols, including black carbon (BC) and organic carbon (OC), are significant contributors to the anthropogenic climate change. BC is considered as the second largest warming agent. However, the direct radiative forcing of carbonaceous aerosols is still quite uncertain, in particular over Asia. To better constrain the present-day Asian carbonaceous aerosol forcing, we utilize both a top-down approach that is primarily based on ground-based and satellite observations over the first decade of 21^{st} century, as well as a bottom-up approach that is based on the latest global climate model coupled with an interactive chemistry and aerosol module (CESM1/CAM5/MAM3). (1) By making the comparisons of top-down observational estimates with bottom-up model simulations, we show that the model considerably underestimates atmospheric heating of BC. The major source of discrepancy between observations and models are speculated to be emission inventory, which is developed from emission of BC due to limited economic activity data reported by developing countries. A series of sensitivity tests of model simulations, in which BC anthropogenic emission are increased by different factors are conducted, and these tests suggested BC emission sources are underestimated by a factor of three to five over Asia. (2) By applying a new partitioning scheme to the observed aerosol optical properties, we show that OC can contribute up to 20% of atmospheric heating, and thus the overall TOA cooling of OC is previously overestimated. The biases

of OC forcing simulated by the model can be attributed to the model assumptions of BC and OC refractive indexes primarily developed from laboratory measurements, rather than from ambient environment observations. In particular, the model currently cannot sufficiently account for OC absorption, leading to a factor-of-two underestimation of its atmospheric heating and consequently an overestimation of TOA cooling. The adjustment of the OC refractive index to match the empirically derived single scattering albedo improved the observation-model agreement.