Effective Radiative Forcing Estimates of Anthropogenic Aerosols in MRI-ESM2

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The effective radiative forcing (ERF) of anthropogenic gases and aerosols in present-day conditions (year 2014) relative to preindustrial conditions (year 1850) is estimated using the Meteorological Research Institute Earth System Model version 2.0 (MRI-ESM2.0) as part of the Radiative Forcing Model Intercomparison Project (RFMIP) and the Aerosol and Chemistry Model Intercomparison Project (AerChemMIP), endorsed by the sixth phase of the Coupled Model Intercomparison Project (CMIP6). The global mean total anthropogenic net ERF estimate at the top of the atmosphere (TOA) is 1.96 W m^{-2}, and is composed mainly of positive forcings due to carbon dioxide (1.85 W m^{-2}), methane (0.71 W m^{-2}), and halocarbons (0.30 W m^{-2}) and of negative forcing due to total aerosols (-1.22 W m^{-2}). The total aerosol ERF consists of approximately 25% from aerosol-radiation interactions (-0.32 W m^{-2}), 80% from aerosol-cloud interactions (-0.98 W m^{-2}), and slightly from surface albedo changes caused by aerosols (0.08 W m^{-2}). The ERFs due to aerosol-radiation interactions consist of opposite contributions from light-absorbing black carbon aerosols (0.25 W m^{-2}) and from light-scattering sulfate (-0.48 W m^{-2}) and organic aerosols (-0.07 W m^{-2}) and is pronounced over the emission source regions. The ERFs due to aerosol-cloud interactions are prominent over the source and downwind regions, caused by increases in the number concentrations of cloud condensation nuclei and cloud droplets in low-level clouds. Concurrently, increases in the number concentration of ice crystals in high-level clouds caused by anthropogenic aerosols, particularly over the tropical convective regions, cause both substantial negative shortwave and positive longwave ERFs in MRI-ESM2.0. These distinct forcings can largely cancel each other out in terms of the radiation budget at the TOA; however, significant longwave radiative heating of the atmosphere caused by high-level clouds suggests the importance of further studies on the interactions of aerosols with ice clouds.

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