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Benchmark Global Shortwave Absorption Calculations Constrain Intermodel Spread in Aerosol Radiative Forcing and Hydrological Cycle Intensification

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A new global radiative transfer benchmarking tool has been developed and applied to evaluate the role of radiative parameterization error in the spread of climate-change relevant variables, such as aerosol radiative forcing and hydrological cycle intensification. The tool combines line-by-line spectral variation of gaseous optical properties with a multi-stream solver to create benchmark calculations of radiative transfer on a given global distribution of inputs. This allows the fluxes calculated by a GCM radiation code to be evaluated against a benchmark calculation at the native GCM resolution and using the exact same climate as seen by the GCM.

We use this tool to evaluate the impact of errors in the absorption of solar radiation by the atmosphere due to both greenhouse gases and aerosol in two GCMs. Atmospheric absorption of solar radiation is important for the hydrological cycle, as it competes with latent heat of precipitation to balance long wave cooling. Recent work has hypothesized that errors in radiative transfer calculation of the absorption of solar radiation by greenhouse gases may be the leading cause of the intermodel spread in the intensification of the hydrological cycle under a warming climate. However, for both models studied here we find that the impact of aerosol absorption is far larger than parameterization error associated with gaseous absorption. Global average radiative parameterization errors in aerosol effect on solar absorption are 20% for GFDL's AM4 and 10% for CESM 1.2.2, with larger errors regionally. However, the range in shortwave absorption by aerosols between the two GCMs is still greater than the error in aerosol or gaseous absorption. Therefore, our results suggests that the spread in hydrologic cycle intensification between models may not be primarily due to inter-model differences in gaseous radiative parameterization, as hypothesized in the literature, but instead due to a combination of errors in aerosol radiative transfer and uncertainty in how much shortwave radiation is absorbed by aerosol.