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Global Line-by-Line Calculations of Aerosol Radiative Forcing: A Demonstration of the RFMIP Aerosol-IRF Protocol

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The large range in aerosol radiative forcing across CMIP5 GCMs may be the result of either a true range in aerosol climatology or radiative parameterization errors. The main aim of the Aerosol Instantaneous Radiative Forcing (A-IRF) component of the Radiative Forcing Model Intercomparison Project (RFMIP) is to better quantify these radiative parameterization errors.

Traditionally, errors in GCM aerosol radiative forcing have been estimated using a small number of idealized cases. However, these few cases are not sufficient to capture the wide range of aerosol optical properties seen in a GCM. The protocol for RFMIP A-IRF solves this problem by performing benchmark 16 stream line-by-line calculations over the entire globe on each participating model's native grid using the actual meteorological and aerosol optical property fields seen by the GCM radiation code. Therefore, for each GCM participating in RFMIP we will provide a benchmark aerosol forcing that can be directly compared to the forcing calculated by the GCM at every gridpoint.

For this study we apply the RFMIP Aerosol-IRF protocol to both GFDL's AM4 and NCAR's CESM. This involves performing over 1 million 16 stream line-by-line calculations on the native grid of both GCMs for numerous time-steps. A unique aspect of this study is the ability to show the spatial pattern of aerosol radiative forcing errors. Our results demonstrate errors in fluxes as high as 30%, for which the magnitude and sign are heavily dependent on the aerosol optical properties. This suggests that errors in radiative transfer parameterizations most likely play a key role in the large range of CMIP5 aerosol forcing.