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Efficacy of climate forcings using PDRMIP models

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Effective radiative forcing is a vital concept in predicting the surface temperature response to climate drivers. However, the feedbacks driven by different forcing agents may vary in magnitude due to the geographical distribution and characteristics of the forcing. Previous studies suggest that forcings which project more strongly on the northern hemisphere, land or polar regions are more effective in changing global temperature than CO_2. In this study we investigate the efficacies relative to CO_2 of four different forcing agents (CH4, SO4, black carbon and solar), using idealized single forcing scenarios performed by nine global climate models participating in the Precipitation Driver Response Model Intercomparison Project (PDRMIP). All four forcing agents are found to have multi-model mean efficacies of less than one. Despite the forcing being predominantly concentrated in the northern hemisphere both black carbon and SO4 drive less global temperature change per unit forcing than the more homogenously distributed CO_2 forcing. Regionally, black carbon drives a stronger temperature response over the northern Pacific, North America, Europe and Asia, but this is counteracted by weaker changes over the rest of the globe, particularly in the southern hemisphere. SO4 drives a stronger temperature response over most of the northern hemisphere, particularly over the Norwegian and Greenland Seas, but this is counteracted by the weak response in the southern hemisphere. The global climate feedback parameter is found to be nonlinear across forcing scenarios in some models, reducing in magnitude through the simulations. The extent of the nonlinearity is highly variable across models. The timescale of the climate response to black carbon is found to be much shorter than for CO_2, and therefore methodological choices can strongly affect the efficacy results.