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Understanding the surface temperature response and its uncertainty to CO2, CH4, black carbon, and sulfate

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Regional climate change is what people will experience on their daily lives. However, the regional temperature changes in response to changing greenhouse gases and aerosols vary between current climate models. The origin of these inter-model differences is poorly understood . Here we relate temperature changes in response to different anthropogenic climate forcing agents to changes in atmospheric and oceanic energy fluxes.

We use climate model simulations forced by idealized perturbations in four major anthropogenic climate forcing agents (CO_2, CH_4, sulfate, and black carbon aerosols) from Precipitation Driver Response Model Intercomparison Project (PDRMIP) climate experiments for six climate models (CanESM2, HadGEM2-ES, NCAR-CESM1-CAM4, NorESM1, MIROC-SPRINTARS, GISS-E2). We decompose the regional temperature change to its different energy budget components: change in longwave and shortwave fluxes under clear-sky and cloudy conditions, surface albedo changes, and oceanic and atmospheric energy transport. We also analyze the regional model-to-model temperature response spread due to each of these components.

The main physical processes driving global temperature responses vary between forcing agents, but for all forcing agents the model-to-model spread in temperature responses is dominated by differences in modeled changes in effective longwave clear-sky emissivity. Furthermore, in polar regions for all forcing agents, the differences in surface albedo change are a major contributor to temperature response and its spread between models. Our results provide valuable information on what is causing the spread between climate models' response to various forcing agents.