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Balancing a quadrupling of CO_2 by a reduction of solar irradiance: Climate responses simulated by four Earth system models

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We compare the climate response of four state-of-the-art Earth system models to climate engineering under scenario G1 of the Geoengineering Model Intercomparison Project(GeoMIP). In G1, the radiative forcing from an instantaneous quadrupling of the CO_2 concentration, starting from the preindustrial level, is balanced by a reduction of the solar constant. Model responses to the two counteracting forcings in G1 are compared to the preindustrial climate in terms of global means and regional patterns and their robustness. While the global mean surface air temperature in G1 remains almost unchanged compared to the control simulation, the meridional temperature gradient is reduced in all models, i.e polar regions still warm while the tropics cool slightly. However, in comparison to the climate response to a quadrupling of CO_2 alone, the temperature responses are small in experiment G1. Another robust response is the global reduction of precipitation under G1. This means that the global increase of precipitation under increased CO_2 is overcompensated by the reduction of the solar irradiance. Strong reductions of precipitation are simulated in all four ESMs in particular for North and South America and northern Eurasia. Globally averaged the magnitude of the precipitation response to G1 is about half of the response to increased CO_2 alone. Regionally, precipitation responses may even be larger in G1 than for quadrupled CO_2. The stratospheric response is very different to the tropospheric response. As the CO_2 concentration remains unchanged through the climate engineering in G1 about the same stratospheric global mean temperature response is simulated as for increased CO_2.