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Radiative adjustments after a 4%-reduction of the solar constant, based on data from the abrupt-solm4p experiment (CFMIP from CMIP6)

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So-called “radiative" or "rapid" adjustments describe the surface-temperature-independent response of the climate state to an instantaneous radiative forcing. However, the term “rapid” can be misleading since various processes are considered adjustments, which appear on timescales of hours (e.g. aerosol-cloud-interactions) to month (e.g. stratospheric temperature change) or even longer timescales (e.g. adjustments of biosphere and cryosphere). On time scales of months and longer, differentiating between adjustments and feedbacks becomes increasingly difficult. Depending on the scientific method the definition of “adjustments” and which processes are considered can vary. Nevertheless, a good understanding of these processes is crucial for improving climate models and advance our general understanding of how the Earth climate system reacts to a forcing.

The abrupt-solm4p experiment from CFMIP (Cloud Forcing Model Intercomparison Project) from CMIP6 (Coupled Model Intercomparison Project phase 6) simulates an instantaneous reduction of the solar constant by 4% branching from a pre-industrial control run on 01/01/1850. We analysed changes in geographical distribution as well as global mean temporal development of various climate variables (e.g. surface and atmospheric temperature, precipitation, humidity), different cloud properties (e.g. cloud cover, column integrated liquid and ice water), as well as radiative fluxes at top of atmosphere and the cloud radiative effect. The different variables were evaluated on timescales of hours, days, months and up to 150 years after the onset of forcing, in order to learn more about the timing of different adjustment processes. Four different models participated in the abrupt-solm4p experiment. Their outputs were compared and possible source of differences discussed. During the first hours all models unanimously simulate decreasing surface and atmospheric temperature, especially strong in the Antarctica, which experiences 24hr irradiation at the onset of forcing. In the beginning, the stratospheric cooling is strongest. The moderate cooling of the troposphere leads to increased condensation and thereby increased cloud cover, even in Northern latitudes, that do not directly experience the forcing, and strengthened precipitation in the tropics.

In a next step, we plan to compare the results from abrupt-solm4p (CFMIP) to simulations of a homogeneous stratospheric sulfate scattering-layer and to the volc-pinatubo-full-experiment (VolMIP). We expect some similarities between the simulated adjustments in these experiments, because in all three cases, incoming solar radiation is reduced in the troposphere and at surface level. However, more realistic experiments, like the volc-pinatubo experiment are expected to show more complex adjustments and the comparison to more simplified experiments like abrupt-solm4p might provide valuable insights to adjustment processes after volcanic eruptions.