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Volcanic super eruptions, a challenge for Earth system models ?

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Very large volcanic eruptions (super eruptions) produce extremely strong radiative forcing, which can affect the Earth system for longer times than the pure atmospheric residence time of the volcanic aerosol. Applying such forcing provides a wide range of possibilities to investigate the complex feedback mechanism of the Earth System, e.g. which processes will be activated, how stable will the system be, are positive or negative feedback mechanisms dominant. The super eruption simulations are therefore an ideal test bed for the quality and performance of the Earth System model (ESM). Here we present and discuss MPI-M ESM simulations of a very large Northern Hemisphere mid latitude eruption (Yellowstone) and a very large tropical one (Toba) for different seasons of the eruption. Our ESM simulations show that the climate system is disturbed over more than a decade. A strong cooling signal is found in the first years after the eruption in particular over the Northern Hemisphere mid and high latitudes land masses with maximum cooling of more than -10 K in the annual average. This strong cooling leads to a decrease in precipitation in particular in the tropical region. Tropical precipitation and temperature anomalies are modulated by changes in the tropical ocean dynamics. After 75 years the climate has completely recovered however anomalies in the ocean heat content still persist. Following a short increase in the first 3 years after the eruption atmospheric CO_2 concentration declines quite rapidly during the next 3 years before reaching a minimum and starting to increase slowly towards the pre-eruption level. The atmospheric CO_2 signal is explained mainly by changes in land carbon storage in the initial phase. In the longer term, the ocean compensates for the carbon loss from the atmosphere to the land by increased After 150 years the carbon cycle has reached equilibrium again.