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The climate impact of very large volcanic eruptions

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Very large volcanic 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. In case of a very large eruption, volcanic aerosols persist in the stratosphere for several years changing the radiative balance of the atmosphere. This leads to large negative temperature anomalies at the surface and significant warming of the aerosol containing layers altering substantial atmospheric and ocean circulation and composition.
Here we present and discuss Earth system model (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 two decades. A strong cooling signal is found in the first years after the eruption in particular over land masses of northern hemisphere mid and high latitudes 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. The ocean heat content is reduced and the anomalies persist for decades. Dominantly cooler surface temperatures over the Northern Hemisphere continents lead also to a decrease in netto primary production in the first years after the eruption. This increases the atmospheric CO2 content in contrast to findings for the 1991 Pinatubo eruption and the 1258 eruption. After 5 years the up take of CO2 due to tropical soil becomes important and the atmospheric CO2 content decreases for a couple of years.