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Sensitivity of a coupled climate-carbon cycle model to large volcanic eruptions during the last millennium

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The sensitivity of the climate-biogeochemistry system to volcanic eruptions is investigated using the comprehensive Earth System Model developed at the Max Planck Institute for Meteorology. The model includes an interactive carbon cycle with modules for terrestrial biosphere as well as ocean biogeochemistry. The volcanic forcing is based on a recent reconstruction for the last 1,200 years. To reduce the influence of internal variability on the experimental outcome, an ensemble of 5 members is performed and the averaged response of the system is analyzed in particular for the largest eruption of the last millennium in the year 1258. After this eruption, the global annual mean temperature drops by about 1 K and recovers slowly during 10 years. Atmospheric CO2 concentration declines during 4 years after the eruption by ca. 2 ppmv before reaching the minimum and starting to increase towards the pre-eruption level. This CO2 decrease is explained mainly by reduced heterotrophic respiration on land in response to the surface cooling, which leads to increased CO2 storage in soils, mostly in tropical and subtropical regions. The ocean acts as a weak carbon sink, which is primarily due to temperature induced solubility changes. This sink saturates two years after the eruption, earlier than the land uptake.