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Impact of volcanic eruptions on the climate of the 1st millennium AD in a comprehensive climate simulation

Sebastian Wagner and Eduardo Zorita
Helmholtz-Zentrum Geesthacht, Institute for Coastal Research, Geesthacht, Germany (sebastian.wagner@hzg.de)

The climate of the 1st millennium AD shows some remarkable differences compared to the last millennium concerning variation in external forcings. Together with an orbitally induced increased solar insolation during the northern hemisphere summer season and a general lack of strong solar minima, the frequency and intensity of large tropical and extratropical eruptions is decreased.

Here we present results of a new climate simulation carried out with the comprehensive Earth System Model MPI-ESM-P forced with variations in orbital, solar, volcanic and greenhouse gas variations and land use changes for the last 2,100 years. The atmospheric model has a horizontal resolution of T63 (approx. 125x125 km) and therefore also allows investigations of regional-to-continental scale climatic phenomena.

The volcanic forcing was reconstructed based on a publication by Sigl et al. (2013) using the sulfate records of the NEEM and WAIS ice cores. To obtain information on the aerosol optical depth (AOD) these sulfate records were scaled to an established reconstruction from Crowley and Unterman (2010), which is also a standard forcing in the framework of CMIP5/PMIP3. A comparison between the newly created data set with the Crowley and Unterman dataset reveals that the new reconstruction shows in general weaker intensities, especially of the large tropical outbreaks and fewer northern hemispheric small-to-medium scale eruptions. However, the general pattern in the overlapping period is similar.

A hypothesis that can be tested with the simulation is whether the reduced volcanic intensity of the 1st millennium AD contributed to the elevated temperature levels over Europe, evident within a new proxy-based reconstruction. On the other hand, the few but large volcanic eruptions, e.g. the 528 AD event, also induced negative decadal-scale temperature anomalies. Another interesting result of the simulation relates to the 79 AD eruption of the Vesuvius, which caused the collapse of the city of Pompeii and its surroundings. Despite its severe local effects the eruption does not show a clear-cut hemispheric or global cooling.

Therefore the simulation allows investigations on the effect of individual and clustered eruptions on the climate in the 1st millennium AD and its potential influence to human induced migration periods and decay of cultures in different regions.