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Volcanoes and ENSO in millennium simulations: global impacts and regional reconstructions in East Asia

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Impacts and co-operative effects of volcanic eruptions and ENSO (El Niño/Southern Oscillation) are determined in millennium simulations for 800-2005AD using the earth system model (ESM) ECHAM5/MPIOM/JSBACH subject to anthropogenic and natural forcings. The simulation comprises two ensembles, one with weak (E1, five members) and a second with strong (E2, three members) variability total solar irradiance (TSI). The 21 most intense eruptions are selected in each ensemble member. The ENSO index is defined by the principal component of the first EOF of the tropical Pacific sea surface temperature (SST) variability in winter (DJF). The impacts of volcanoes are analyzed at a global scale and the simulated temperature and drought indices are further compared with various reconstructions in East Asia. Volcanoes with neutral ENSO states during two preceding winters cause a global cooling in the year after eruptions up to –2.5°C. In the winter after an eruption warming is mainly found in the Arctic Ocean, the Bering, Siberia and central Asia. The recovery times for the volcano induced cooling vary globally between one and 12 years. In China, volcanoes cause a dramatic cooling in West China (–2°C) and a drought in East China during the year after the eruption. The reconstructions show similar a cooling pattern in China (with smaller magnitudes) and a dryness pattern in East China. El Niño events in the winters after eruptions compensate the cooling caused by volcanoes in most regions of China (consistent with reconstructions), while La Niña events intensify the cooling (–2.5°C). The simulated impact of the Tambora eruption in 1815, which caused the ‘year without summer’ 1816 in Europe and North America and a three-year famine in the China, depends crucially on the ENSO state of the coupled model.