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The influence of volcanic eruptions on growth of central European lowland trees in NE-Germany during the last Millennium

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Large and mainly tropical volcanic eruptions can have significant effects on the Earth's climate system, likely resulting in decreased summer and increased winter temperature means, as well as enhanced fractions of diffuse light lasting for one to several years after the eruptive outbreak. It has been argued that due to scattering by volcanic sulfur aerosol the more diffuse light fraction can be particularly beneficial for tree growth and more generally for ecosystems biomass productivity. However, other observations suggest decreasing tree-ring width because of the cooler conditions following large eruptions, with overall stronger fingerprints expected towards higher altitudes and higher latitudes where tree growth is mainly temperature-limited. Since tree growth in lowland temperate climate zones is dominated by various climate quantities rather than temperature alone. Thus it has been hypothesized that tree growth within the temperate zones of the mid-latitudes may not suffer from lower temperatures per se, but rather profits from increased rates of diffuse light, in tandem with reduced evapotranspiration and subsequently enhanced soil moisture availability.

Most studies so far have concentrated on the impact of volcanic eruptions on trees growing outside the temperate climate zones. This study aims at trees in temperate zones where tree growth is less temperature limited. Therefore, a comprehensive database with 1128 samples of millennium-long tree-ring chronologies of Quercus robur L. and Pinus sylvestris L. based on heterogenous archaeological material originating from three different lowland sites (Greifswald, Eberswalde and Saxony) in eastern Germany was used to test whether tree growth suffered or profited from the globally changed conditions after large volcanic eruptions. The growth relationships were tested against 49 individual large volcanic eruptions from the last Millennium. High-resolution ice core records of sulfate measurements calibrated against atmospheric observations after modern eruptions identified the timing and magnitude of the eruptions since 1000 CE.

Dendrochronological methods revealed a predominantly negative relationship of our long tree-ring chronologies to large volcanic eruptions. In two tree-ring width chronologies of oak and pine (Quercus robur L. and Pinus sylvestris L.) originating from the different sites in eastern Germany a negative influence on tree growth for up to four years after large eruptions could be detected. In comparison, the chronologies of Q. robur reveal a stronger negative (71%) response after large eruptions than those of P. sylvestris (54%). Only at the Greifswald site both tree species show a common negative response in tree growth after volcanic eruptions. For both tree species and at all three sites just the eruption years of 1586 revealed significant positive growth responses whereas significant negative tree growths was detected after the eruptions of 1800. Volcanic aerosols originating from the northern hemisphere appear to cause a greater reduction in tree growth than aerosols from volcanoes from the southern hemisphere, which probably relates to the shorter distance to the investigated tree sites. Our study clearly indicates that effects of major volcanic eruptions are less obvious in central Europe than observed for trees growing at the altitudinal or latitudinal timberlines.