



## **The volcanic double event at the dawn of the Dark Ages**

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Documentary records report dimming of the sun by a mysterious dust cloud covering Europe for 12-18 months in 536-537 CE, which was followed by a general climatic downturn and global societal decline. Tree rings and other climate proxies have corroborated the occurrence of this event as well as characterized its extent and duration, but failed to trace its origin. New volcanic timeseries, based on a multi-disciplinary approach that integrates novel, global-scale time markers with state-of-the-art continuous ice core aerosol measurements, automated objective ice-core layer counting, tephra analyses, and detailed examination of historical archives, show unequivocally that the 536-540 climate anomaly was concurrent with two or more major volcanic eruptions, with the largest eruptions likely occurring in the years 536 and 540 CE.

Using a coupled aerosol-climate model, with eruption parameters constrained by ice core records and historical observations of the aerosol cloud, we reconstruct the radiative forcing resulting from the 536/540 CE eruption sequence. Comparing with existing reconstructions of the volcanic forcing over the past 1200 years, we estimate that the decadal-scale Northern Hemisphere (NH) extra-tropical radiative forcing from this volcanic “double event” was larger than that of any known period. Earth system model simulations including the volcanic forcing are used to explore the temperature and precipitation anomalies associated with the eruptions, and compared to available proxy records, including maximum latewood density (MXD) temperature reconstructions. Special attention is placed on the decadal persistence of the cooling signal in tree rings, and whether the climate model simulations reproduce such long-term climate anomalies. Finally, the climate model results are used to explore the probability of socioeconomic crisis resulting directly from the volcanic radiative forcing in different regions of the world.