The 1257 eruption of Mt. Samalas was one of the largest eruptions of the last Millennium. With a VEI of 7, the eruption is estimated to have ejected 119 Tg of SO2 into the stratosphere, ten times that of the 1991 Mt Pinatubo eruption. Tree ring chronologies suggest a Northern Hemisphere (NH) summer cooling on the order of -0.7 to -1.2°C, although previous attempts to model the impact of the eruption have tended to overestimate the radiative forcing with a global surface cooling of up to -4°C. Proxy data suggest significant regional heterogeneities in temperature and precipitation anomalies, with the eruption’s climatic impact being invoked to account for a range of 13th century historical phenomena. However, uncertainties remain over the precise timing of the eruption, with dates being suggested between May 1257 to January 1258.

Using the UK Earth System Model, simulations were run for the eruption starting in January or July with initial conditions that sampled different states of the Quasi-Biennial Oscillation (QBO) and El Niño Southern Oscillation (ENSO). The climatic impact was investigated through analysis of global mean and regional stratospheric aerosol optical depth, surface temperature, and precipitation anomalies. A proxy database, including tree ring chronologies, stalagmite records, ice core data, and historical sources, has been complied and utilised to place additional constraints on key eruption parameters and climatic impact.

The climatic effects of the eruption show a strong dependency on the eruption season and initial phases of the ENSO and QBO. Simulated mean NH land summer temperature best matches the tree-ring and historical records if the eruption occurs in July 1257, with Easterly/El Nino ensembles best replicating spatially constrained temperature anomalies. This work highlights the potential of model-multi-proxy frameworks through which to investigate the impact and key parameters of historical eruptions.