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The unidentified volcanic eruption of ~1809: why it remains a climatic cold case

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The "1809 eruption" is one of the most recent unidentified volcanic eruptions with a global climate impact. Even though the eruption ranks as the 3rd largest since 1500 with an eruption magnitude estimated to be two times that of the 1991 eruption of Pinatubo, not much is known of it from historic sources. Based on a compilation of instrumental and reconstructed temperature time series, we show here that tropical temperatures show a significant drop in response to the ~1809 eruption, similar to that produced by the Mt. Tambora eruption in 1815, while the response of Northern Hemisphere (NH) boreal summer temperature is spatially heterogeneous. Here, we present the sensitivity of the climate response simulated by the MPI Earth system model to a range of volcanic forcing estimates constructed using estimated volcanic stratospheric sulfur injections (VSSI) and uncertainties from ice core records. Three of the forcing reconstructions represent a tropical eruption with approximately symmetric hemispheric aerosol spread but different forcing magnitudes, while a fourth reflects a hemispherically asymmetric scenario without volcanic forcing in the NH extratropics. Observed and reconstructed post-volcanic surface NH summer temperature anomalies lie within the range of all the scenario simulations. Therefore, assuming the model climate sensitivity is correct, the VSSI estimate is accurate within the uncertainty bounds. Comparison of observed and simulated tropical temperature anomalies suggests that the most likely VSSI for the 1809 eruption would be somewhere between 12 -19 Tg of sulfur. Model results show that NH large-scale climate modes are sensitive to both volcanic forcing strength and its spatial structure. While spatial correlations between the N-TREND NH temperature reconstruction and the model simulations are weak in terms of the ensemble mean model results, individual model simulations show good correlation over North America and Europe, suggesting the spatial heterogeneity of the 1810 cooling could be due to internal climate variability.