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ENSO response to high-latitude volcanic eruptions: the role of the initial conditions

Francesco S.R. Pausata (1), Rodrigo Caballero (1), and David S. Battisti (2)

(1) Stockholm University, Bolin Centre for Climate Research, Meteorological Institute (MISU), Stockholm, Sweden (francesco.pausata@misu.su.se), (2) University of Washington, Seattle, WA, USA

Large volcanic eruptions can have major impacts on global climate affecting both atmospheric and ocean circulation through changes in atmospheric chemical composition and optical properties. The residence time of volcanic aerosol from strong eruptions is around 2-3 years and attention has consequently focused on their short-term impacts, and in particular on tropical eruptions. The long-term, ocean-mediated response has been less studied and large uncertainties remain. Moreover, studies have largely focused on tropical eruptions; high-latitude eruptions have drawn less attention because their impacts have been thought to be merely hemispheric rather than global and no study has hitherto investigated the long-term effects of such eruptions. Here we use a climate model to show that large summer high-latitude eruptions in the Northern Hemisphere could cause an El Niño-like anomaly in the equatorial Pacific during the first 8-9 months after the start of the eruption owing to a strong hemispheric cooling. The hemispherically asymmetric cooling shifts the Inter-Tropical Convergence Zone southwards, triggering a weakening of the trade winds over the western and central equatorial Pacific that leads to an El Niño-like anomaly. However, the El Niño-like anomaly strongly depends on the initial ENSO state: a 3-time larger response is shown when the climate system is going towards a La Niña compared to when is going towards an El Niño. Finally, the eruption also leads to a strengthening of the Atlantic Meridional Overturning Circulation (AMOC) in the first twenty-five years after the eruption, followed by a weakening lasting at least 35 years. The long-lived changes in the AMOC strength also alter the variability of El Niño-Southern Oscillation.