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ENSO response to volcanic forcing: the interplay between ITCZ shift and ocean dynamical thermostat mechanism

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Early work suggested that the El Niño-like response to tropical volcanic forcing was caused by reduced surface radiation, which weakens the zonal SST gradient along the equatorial Pacific (thermostat mechanism). Recent studies have suggested the shift of the Inter-tropical convergence zone (ITCZ) due to asymmetrical cooling between the Northern (NH) and Southern Hemisphere (SH) as a key driver of ENSO response to volcanic forcing. Here we use an Earth System Model to investigate the potential interplay between the two proposed mechanisms. We perform a set of ensembles to simulate two NH and SH tropical eruptions injecting 60 Tg of SO_2 to mimic the Tambora eruption, the strongest tropical eruption of the last 200 years. In the NH tropical eruptions most of the volcanic aerosol is confined north of 20°S and for the SH eruptions it is mostly concentrated south of 20°N. If the ITCZ shift is the primary driver of the ENSO response, one should expect an El-Niño response for NH eruptions (due to the cooling of the NH and consequent southward shift of the ITCZ) and a La-Niña response for SH eruptions. On the other hand, if the thermostat mechanism were the only driver of ENSO response after tropical volcanic eruptions, an El Niño response should be expected both for NH and SH tropical eruptions.
Our experiments show that Tropical NH eruptions always trigger an El Niño-like response whereas the ENSO response to Tropical SH eruptions seems to depend on the initial ENSO state. Our results show that both the ocean dynamical thermostat mechanism and the ITCZ shift work in synergy to alter the ENSO state: for Tropical NH eruptions the ITCZ shift and the thermostat mechanism act together towards triggering an El Niño response. On the contrary, for Tropical SH eruptions the thermostat and the ITCZ-shift mechanisms work against each other, with the former favoring a La Niña-like and the latter favoring an El Niño-like response.