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Forecasting the climate response to volcanic eruptions

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The last major volcanic eruptions, the Agung in 1963, El Chichon in 1982 and Pinatubo in 1991, were each associated with a cooling of the troposphere that has been observed over large continental areas and over the western Pacific, the Indian Ocean and the southern Atlantic. Simultaneously, Eastern tropical Pacific temperatures increased due to prevailing El Niño conditions. Here we show that the pattern of these near-surface temperature anomalies is reproduced with decadal simulations of the EC-Earth model initialised with climate observations and forced with an estimate of the observed volcanic aerosol optical thickness. Sensitivity experiments highlight that the post-eruption cooling is mainly due to the volcanic forcing, whereas El Niño events following the eruptions would have occurred even without volcanic eruptions. Focusing on the period 1961-2001, the main source of skill of this decadal forecast system during the first two forecast years is related to the initialisation of the model. The contribution of the initialisation to the skill becomes smaller than the contribution related to the volcanic forcing after two years, the latter being substantial in the Western Pacific, the Indian Ocean and the Western Atlantic. This study investigates two protocols to account for the volcanic forcing in real-time forecasts: applying a two-year exponential decay to the initial stratospheric aerosol load observed at the beginning of the forecast allows to simulate the aerosol forcing in the Tropics after tropical volcanic eruptions, but causes forecast deficiencies at high latitudes. Using the forcing of a past eruption with a similar magnitude to forecast the climate response to a future eruption is appropriate if both have similar spatiotemporal characteristics of the forcing.