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The effect of volcanic eruptions on the hydrological cycle

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Large explosive volcanic eruptions inject sulphur dioxide into the stratosphere where it is oxidised to sulphate aerosols which reflect sunlight. This causes a reduction in global temperature and precipitation lasting a few years. We investigate the robust features of this precipitation response, comparing climate model simulations from the Coupled Model Intercomparison Project Phase 5 (CMIP5) archive to three observational datasets, including one with ocean coverage. Global precipitation decreases significantly following eruptions in CMIP5 models, with the largest decrease in wet tropical regions. This also occurs in observational land data, and ocean data in the boreal cold season. In contrast, the dry tropical ocean regions show an increase in precipitation in CMIP5 models. Monsoon regions dry following eruptions in both models and observations, whilst in response to individual eruptions, the ITCZ shifts away from the hemisphere with the greater concentration of aerosols in CMIP5. The ocean response in CMIP5 is longer lasting than that over land, but observational results are too noisy to confirm this. We detect the influence of volcanism on precipitation in the boreal cold season, although the models underestimate the size of the response, whilst in the warm season the volcanic influence is marginally detectable.

We then examine whether the influence of volcanoes can be seen in streamflow records for 50 major world rivers. Significant reductions in flow are found for the Amazon, Congo, Nile, Orange, Ob, Yenisey and Kolyma amongst others. When neighbouring rivers are combined into regions, informed by climate model predictions of the precipitation response to eruptions, decreases in streamflow can be detected in northern South American, central African and high-latitude Asian rivers and increases in southern South American and SW North American rivers.

An improved understanding of how the hydrological cycle responds to volcanic eruptions is valuable in predicting the response of precipitation and streamflow to future eruptions and to geoengineering schemes that seek to counteract global warming based on the same principals.