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What Can We Learn about Aerosol–Cloud Interactions from Degassing Volcanic Eruptions?

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Aerosol-cloud-interactions and climate sensitivity continue to be the two key uncertainties in our understanding of climate change. These are inter-related problems because models with a strong/weak aerosol cooling effect and a high/low climate sensitivity respectively are both able to represent the historic global mean temperature record. Aerosol-cloud-interactions operates via microphysical impacts reducing the size of cloud droplets (Twomey effect) and subsequent impacts on rain formulation which has been postulated to change the overall physical properties of clouds (Albrecht effect). The representation of the Twomey and Albrecht effects remain highly uncertain in climate models indicating they are poorly understood and poorly parameterised.

The major problem in reducing these uncertainties is the lack of suitable observations at globally relevant spatial scales with which to challenge the models. The fissure eruption at Holuhraun in 2014-2015 in Iceland emitted sulphur dioxide at a peak rate of up to 1/3 of global emissions, creating a massive aerosol plume across the entire North Atlantic [Gettelman et al., 2015]. In effect, Iceland became a significant global/regional pollution source in an otherwise unpolluted environment, creating an almost perfect analogy for anthropogenic emissions of sulphur dioxide. Analysis reveals that the strength of the Twomey effects varies between models, but strong Albrecht effect is likely in error [Malavelle et al., 2017].

While the eruption at Holuhraun was ideal because of the on/off nature of the emissions, there are other volcanic systems in remote environments that can also provide evidence that the Albrecht effect is very weak. This work analyses data from the world's most consistent degassing volcanoes including Kilauea (Hawaii) and Ambrym (Vanuatu). The results show conclusively that, on average, the Albrecht effect is near-zero. While this conclusion might suggest that aerosol-cloud-interactions climate models could be significantly simplified and that those with a strong Albrecht effect should be re-evaluated, there may be impacts on individual clouds and precipitation extremes, which suggest that further work is necessary using the suite of models with different resolutions and the suite of in-situ and remote sensing observations that are now available to the aerosol and climate modelling communities.