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Modelling high-latitude explosive eruptions and their atmospheric and environmental impacts

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Large explosive volcanic eruptions inject sulphur into the stratosphere where it is converted to sulphur dioxide and sulphate aerosols. Due to atmospheric circulation patterns, aerosols from high-latitude eruptions typically remain concentrated in the hemisphere in which they are injected. Eruptions in the high-latitude Northern Hemisphere could thus lead to a stronger hemispheric radiative forcing and surface climate response than tropical eruptions, a claim that is supported by a previous study based on proxy records and the coupled aerosol-general circulation model MAECHAM5-HAM. Additionally, the subsequent surface deposition of volcanic sulphate is potentially harmful to humans and ecosystems, and an improved understanding of the deposition over polar ice sheets can contribute to better reconstructions of historical volcanic forcing. On this basis, we model Icelandic explosive eruptions in a pre-industrial atmosphere, taking both volcanic sulphur and halogen loading into account. We use the fully coupled Earth system model CESM2 with the atmospheric component WACCM6, which extends to the lower thermosphere and has prognostic stratospheric aerosols and full chemistry. In order to study the volcanic impacts on the atmosphere, environment, and sulphate deposition, we vary eruption parameters such as sulphur and halogen loading, and injection altitude and season. The modelled volcanic sulphate deposition is compared to the deposition in ice cores following comparable historical eruptions. Furthermore, we evaluate the potential environmental impacts of sulphate deposition. To study inter-model differences, we also compare the CESM2-WACCM6 simulations to similar Icelandic eruption experiments simulated with MAECHAM5-HAM.