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Modelling the 10th century Eldgjá eruption in Iceland and revisiting evidence of its climatic and environmental impacts

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The episodic eruption of Eldgjá in the 10th century stands as the largest basaltic flood lava eruption on Earth during the Common Era. The eruption released an estimated 200 Tg of sulphur dioxide into the atmosphere, a substantial emission that likely had severe impacts on the climate and environment. Various sources, including observations of haze over Europe, a minimum in tree ring temperature reconstructions, and suppressed flow of the Nile, suggest that the eruption had both regional and global effects.

Petrological evidence from Iceland quantifies the sulphur and halogen emissions from the eruption site, and subsequent deposition is recorded in high-resolution Greenland ice cores. Additionally, recent analyses of Greenland cryptotephra have shed light on the eruption's date and duration (Hutchison et al., JGR under revision).

In combination, these constraints provide valuable information about the nature of the eruption, but they do not directly quantify its climate forcing or environmental effects. Furthermore, reconciling the petrological and ice core constraints with proxies of Eldgjá's impacts presents a puzzle.

To bridge this gap, we constructed a plausible volcanic forcing, combining the most recent and available volcanology and ice core records, and used a fully-coupled Earth system model to simulate the Eldgjá eruption. We simulate the volcanic aerosol and atmospheric composition changes resulting from long-lasting, stratospheric and tropospheric emissions of sulphur, chlorine, bromine, and fluorine in a pre-industrial Earth system.

Our results help improve our understanding of the climate effects of prolonged Icelandic eruptions, and offer clues about the potential effects of the Eldgjá eruption on the population and environment at the time. Finally, we discuss the model results with regard to uncertainties in the volcanic forcing, experimental set-up, and the available proxy data.