EGU24-19839, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-19839
EGU General Assembly 2024

Modelling the climate response following idealized long-lasting high latitude volcanic eruptions: The stratospheric response and resulting implications for North Atlantic surface weather

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Given the fact that many Icelandic volcanic systems are on the verge of an eruption, producing some of the largest volcanic eruptions over the past millennia, e.g., O□ræfajo□kull, Bárðabunga, Grímsvötn and the Katla system, it is important to be able to predict potential changes in Northern Hemisphere (NH) climate variability in the following years after an NH eruption in due time. Recent volcanic activity in Iceland, e.g., Holuhraun 2014-2015 and Reykjanes/Geldingadalur 2021-2023, further demonstrates this urgency.

With the aim to contribute to improving the forcasting and adaptation strategies for the North Atlantic region we, as a first step, forced an Earth System Model (CESM1.2.2) with an idealized long-lasting high-latitude volcanic eruption to quantify i) the response within the stratospheric polar vortex and ii) the resulting response within the coupled climate system in the Northern Hemisphere (NH) by assessing the first 15 years following the eruption focusing on the winter (DJF) response. Here results will be presented showing evidence of sudden stratospheric warming events and a deceleration of the stratospheric polar vortex occurring in the second and third post-volcanic winter. This is identified in the temperature and zonal winds at 50hPa as a result of the large modelled surface cooling in the NH where Eliassen-Palmer wave flux calculations further support these findings. The strong stratospheric response identified further influences surface climate throughout the continental NH in the first 5 years following this event via the NAO. Our result suggest that two competing mechanisms are at work during these first years, partly explaining this long-lasting short-term response. The long-term impact is identified as a change in regional surface temperature and sea ice variability as well as a general strengthening of the AMOC, reaching a maximum in winter 2 and remaining positive throughout the run.