Supplementary information for:

Arctic warming from a high latitude effusive volcanic eruption

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S.1 Temperature anomalies in the Arctic

In the ERA5 reanalysis, surface air temperatures were anomalously low over northwestern Siberia and the adjacent Arctic seas in SON 2014 compared to the 2000-2013 climatology, as well as being anomalously high over western Europe (supplementary Fig. S1a). Similar temperature anomaly patterns have been connected to the positive phase of the East Atlantic-West Russia (EA-WR) pattern (Lim, 2015), which happened to be the case for the SON mean in 2014 (NOAA, 2023). The EA-WR pattern does, however, not explain the high temperature anomalies over the Greenland Sea. We would in fact expect the opposite to be the case for a positive EA-WR index, namely surface cooling (Lim, 2015). Other modes of natural variability, such as the North Atlantic Oscillation (NAO) and the El Niño-Southern Oscillation (ENSO), are also not sufficient to explain the strong warming over the Greenland Sea on their own.

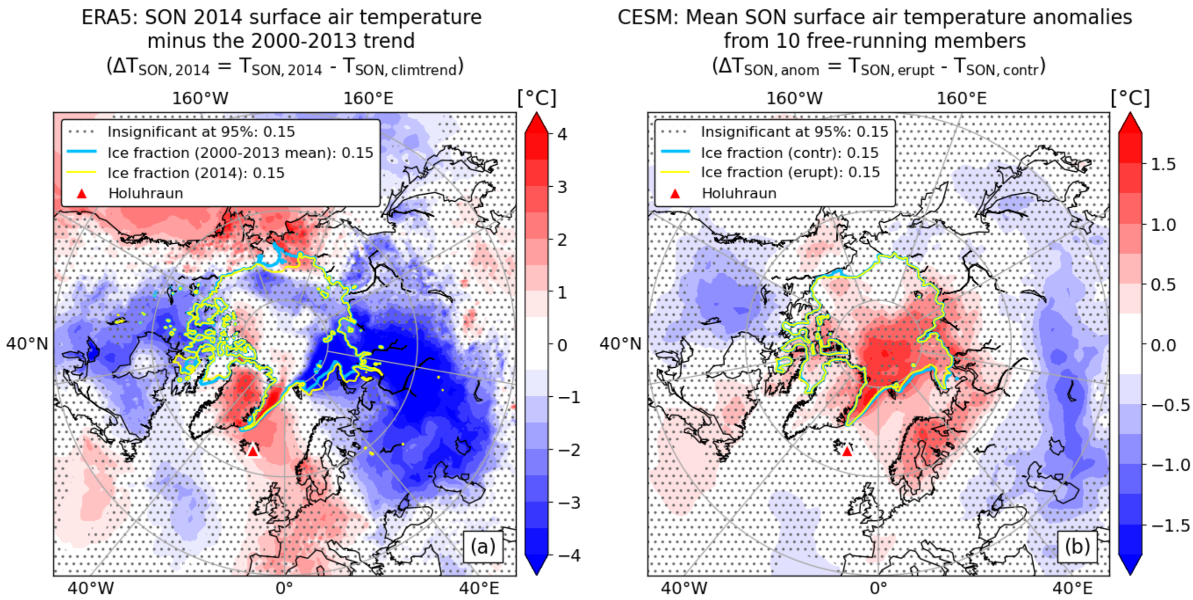

Figure S1: *(a) and (b) are the same as Figs. 1b and 1c respectively but cover the northern hemisphere north of 40°N. Sea ice edges as defined by the 15% sea ice cover have been added.*

S.2 Aerosol distribution and cloud response in nudged and free-running CESM simulations

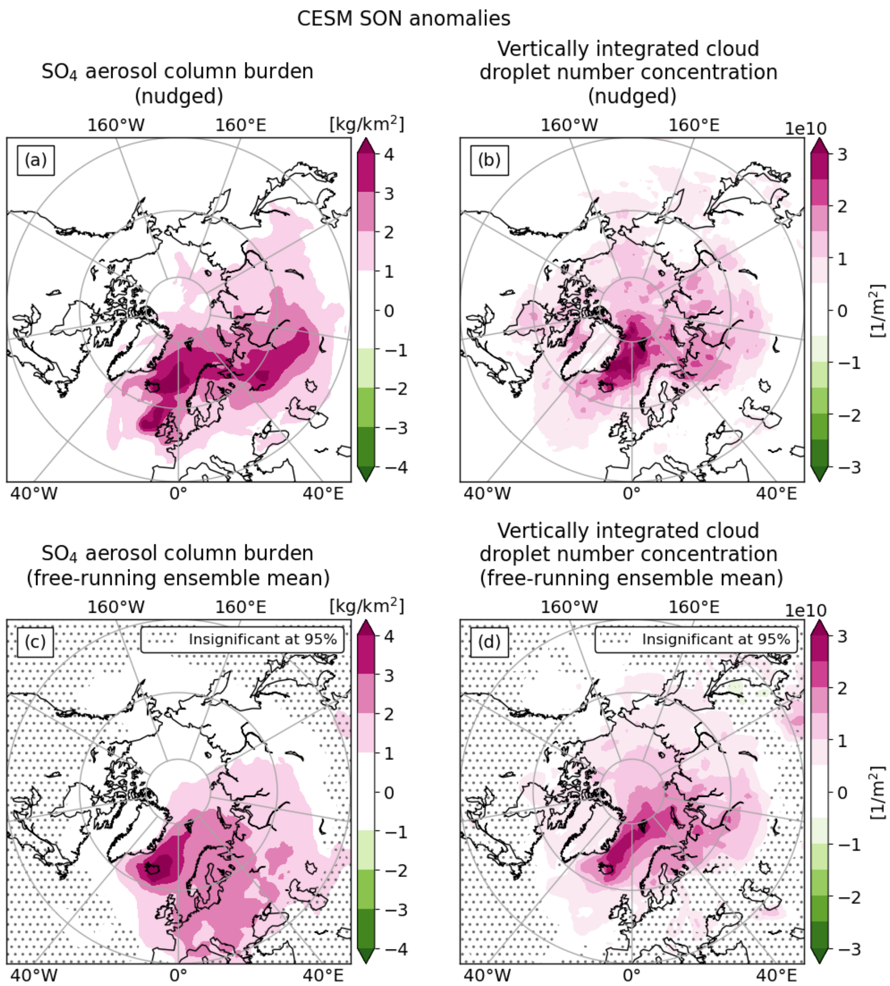

Figure S2: *SON means from CESM2(CAM6): (a)* SO_4 *aerosol column burden, nudged simulations; (b) vertically integrated cloud droplet number concentration, nudged simulations; (c)* SO_4 *aerosol column burden, free-running simulations; and (d) vertically integrated cloud droplet number concentration, free-running simulations. Dotted regions in (c) and (d) indicate insignificance at the 95% confidence level.*

S.3 Liquid water path

In their paper on the Holuhraun eruption, Malavelle et al. (2017) compared the climate response in several models to satellite observations. Among those was CAM5, CAM6's predecessor, which managed to capture observed cloud droplet effective radius anomalies but showed an excessive LWP response. Most atmospheric parametrizations have been improved in CAM6 (Danabasoglu et al., 2020), including the Morrison-Gettelman (MG) cloud microphysics scheme, from MG1 to MG2 (Gettelman and Morrison, 2015). In MG2, the LWP is less sensitive to the droplet number concentration, especially where the droplet number concentration is low as is often the case in the Arctic. Additionally, there is a positive LWP anomaly along the east coast of Greenland in the ERA5 reanalysis for SON 2014 (supplementary Fig. S3) and, although it is not significant at the 95% confidence level, it has a spatial structure similar to the one simulated by CAM6.

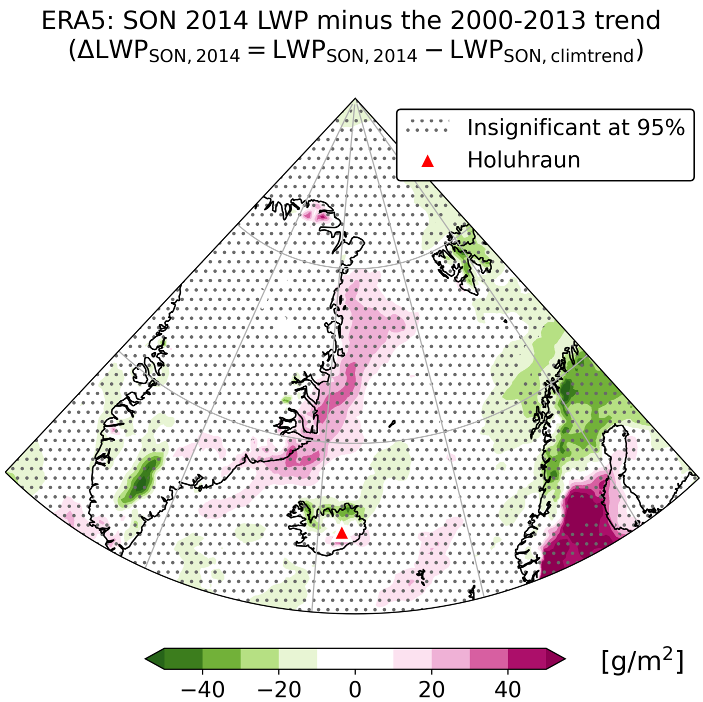

Figure S3: *Vertically integrated liquid water path (LWP) anomalies for SON 2014 relative to the 2000-2013 climatology in ERA5. Dotted regions indicate insignificance at the 95% confidence level.*

S.4 CCN in free-running CESM simulations

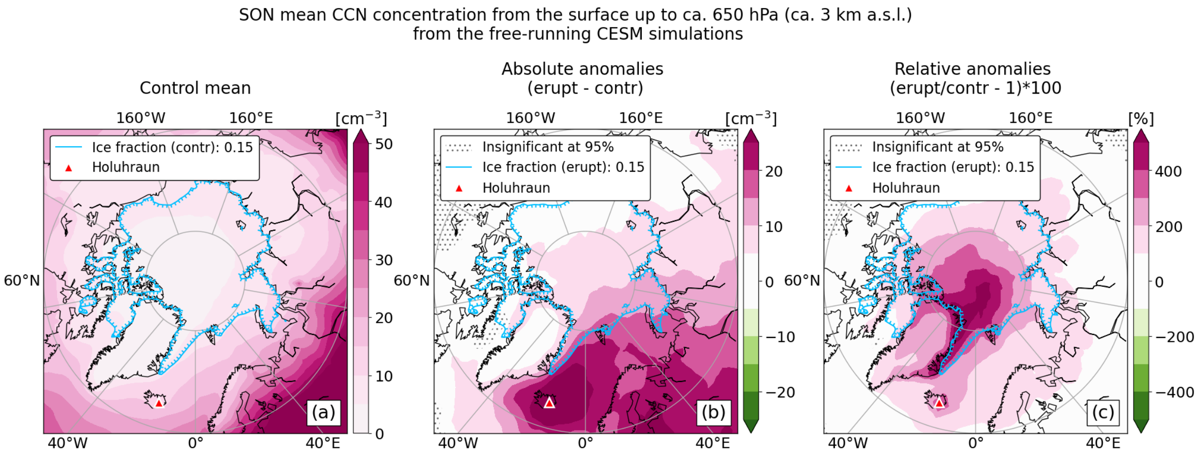

Figure S4: *SON means from the free-running CESM2(CAM6) simulations. Ensemble mean CCN quantities from the surface up to ca. 650 hPa (ca. 3 km a.s.l.): (a) Mean CCN concentration from the control run, (b) absolute CCN concentration anomalies, and (c) relative CCN concentration anomalies presented in percentage change. Dotted regions in (b) and (c) indicate insignificance at the 95% confidence level.*

References

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