Project: **1251**

Project title: **Computational approaches to Final Palaeolithic/earliest Mesolithic climate change**

Principal investigator: **Claudia Timmreck**

Report period: **2022-11-01 to 2023-10-31**

Summary:

Work during the reporting period focused on the impact of volcanic eruptions on storm track dynamics. This has emerged from the fact that proxy data clearly indicate increased storminess following volcanic eruptions in the study period (around 13 ky BP, Dreibrodt, 2020) and from strong indications that the hunter-gatherer societies prevalent at the time may have been susceptible to stormy conditions (Nelson, 1972, Riede, 2014).

From the completed experiments we find clear suggestions using a variety of different methods, that volcanic eruptions can indeed alter the storm tracks both under pre-industrial and glacial climate. Furthermore, we have linked the changes in the storm tracks to changes in the thermal structure of the atmosphere (Andreasen et al; to be submitted).

Unfortunately, the simulations of the Allerød period planned for 2023 could not be carried out and will be postponed to the next project year. The main reason for this is the six months of parental leave taken by project member Laurits Andreasen in 2023.

Simulated changes in the storm tracks

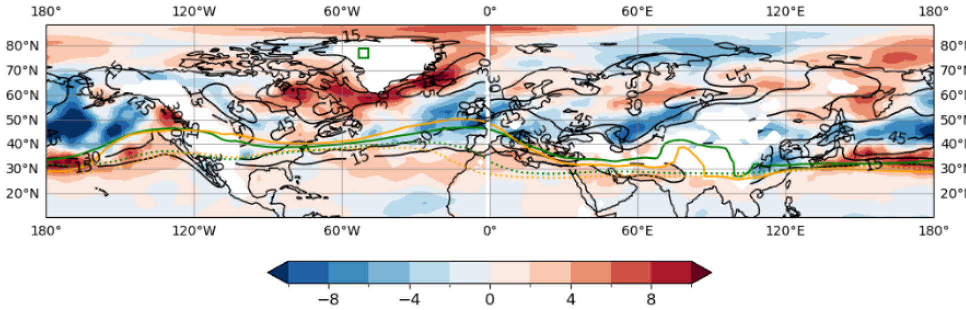

Figure 1: Five years mean of changes in the number of passing cyclones post-eruption. Black contours indicate unperturbed values. The green (yellow) dotted line indicates the subtropical jet in the unperturbed (perturbed) scenario. The green (yellow) solid lines indicate the eddy-driven jet in the unperturbed (perturbed) scenario.

We perturbed a preindustrial (PI) configuration of MPIESM 1.2LR with volcanic forcing similar to the Laacher See Eruption (LSE) from palaeolithic period. We implemented several routines for studying storm tracks on Levante (e.g., Hodges, 1995, 1997) and used them to compare the frequency of cyclonic maxima and curvature (common indicators of extratropical storms) and location of jets between the perturbed and unperturbed simulations. As seen in figure 1, we observe several changes: Increased storminess around Greenland, decreases in for example Northern Europe and increases in the subtropics.

We have linked the storm track changes to a combination of changes in the thermal structure of the lower troposphere (figure 2) and changes in the tropopause height (figure 3). The changes in the thermal structure are linked to increasing near-surface temperature gradients, whereas the changes in the tropopause height are linked to a contracting Hadley cell in combination with a warming stratosphere (due to aerosol heating). Together the thermal and tropopause changes explain the bulk of the changes in the storm tracks.

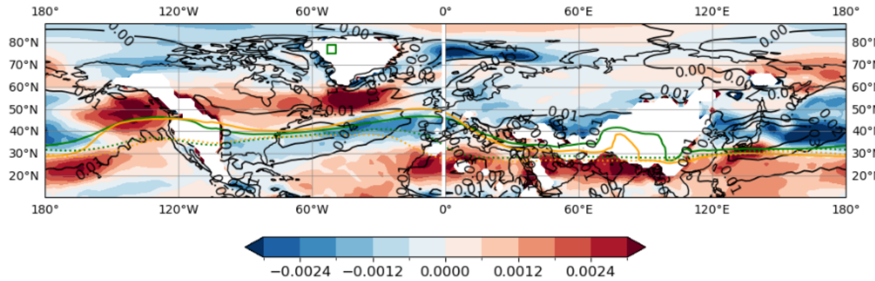

Figure 2: As figure 1, but showing changes in the isentropic slope (hPa/degree) at the 850 hPa surface.

The linking of storm track changes to thermal and tropopause changes has been done through a series of simulations, where both the location of the volcanic eruptions has been shifted and the radiative interaction of the forcing with the atmosphere has been altered to include only e.g., shortwave, or longwave forcing.

A surprising outcome of our simulations are the shifts of the jets: The subtropical jet shift southward with the contracting Hadley cell as is known from colder climates, but the eddy-driven jet in the North Atlantic migrates northward as seen under global warming scenarios. Hence volcanically perturbed climates may provide an interesting hybrid between cold and warm climates useful for understanding storm patterns general dependency on the background climate.

Furthermore, results related to the storm track changes dependency on the background climate (Pre-industrial vs Glacial vs Allerød) are emerging.

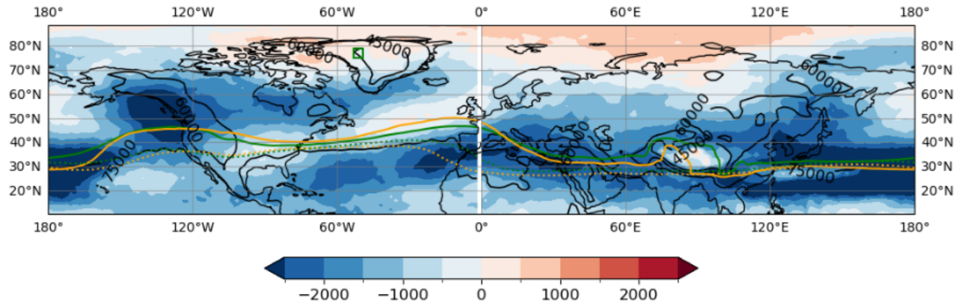

Figure 3: As figure 1, but showing changes in the tropopause height (hPa).) at the 850 hPa surface.

Understanding societal consequences of storm track changes

The experiments done on Levante are part of the larger CLIOARCH project https://cas.au.dk/en/erc-clioarch, which concerns environmental influence on human populations around the end of the last glacial periods. To provide a link between storm patterns and hunter-gatherer populations we have explored an earlier suggested connection between the disappearance of the so-called Greenlandic North and storms during the Little Ice Age period (Dawson et al, 2007). Our simulations indicate that increases in near-costal storms in Western and Southern Greenland could have hindered a meaningful connection between the Greenlandic North and their relatives in Iceland.

References

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