# Is the Last Interglacial Warm Period a Good Analog for Future Greenland Mass Balance?

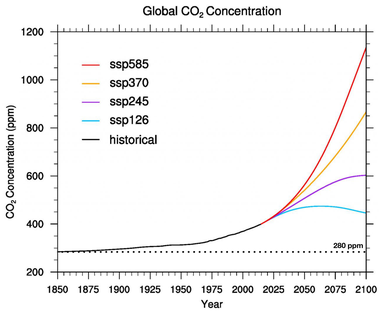
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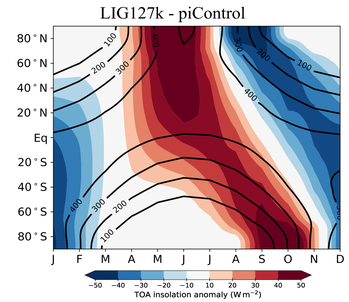
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## Goals & Motivations

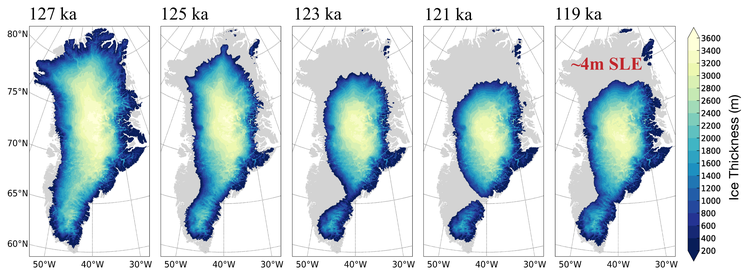
**Primary Goal**: Explore the climate system response in the North Atlantic and over the Greenland Ice Sheet (GrIS) to insolation versus greenhouse gas concentrations in climate model simulations from the Community Earth System Model, version 2 (CESM2)

**Motivating Question**:
Is the Last Interglacial (LIG127k) a good analog for future warming?




**Simulated GrIS Deglaciation in the Last Interglacial Warm Period**




Sommers et al. 2021
(Paleo Ocn. Paleo Clim.)

***Could a similar deglaciation and corresponding rise in sea level (SLE) occur under anthropogenic climate change?***

## Models & Methods

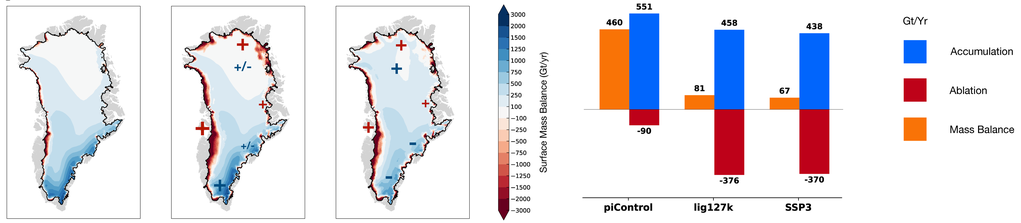
**Model Data**
3 simulations from CESM2

- **piControl** (pre-industrial control simulation) - run for 1200 years; last 200 years analyzed
- **LIG127k** (Last Interglacial Warm Period, 127,000 years before present) - 100 year climatology for equilibrium simulation
- **SSP3** (Shared Socioeconomic Pathway 3 - Regional Rivalry as defined in the AR6 IPCC report) - Climate over 2080-2100 CE averaged over 3 ensemble members

**Methods**

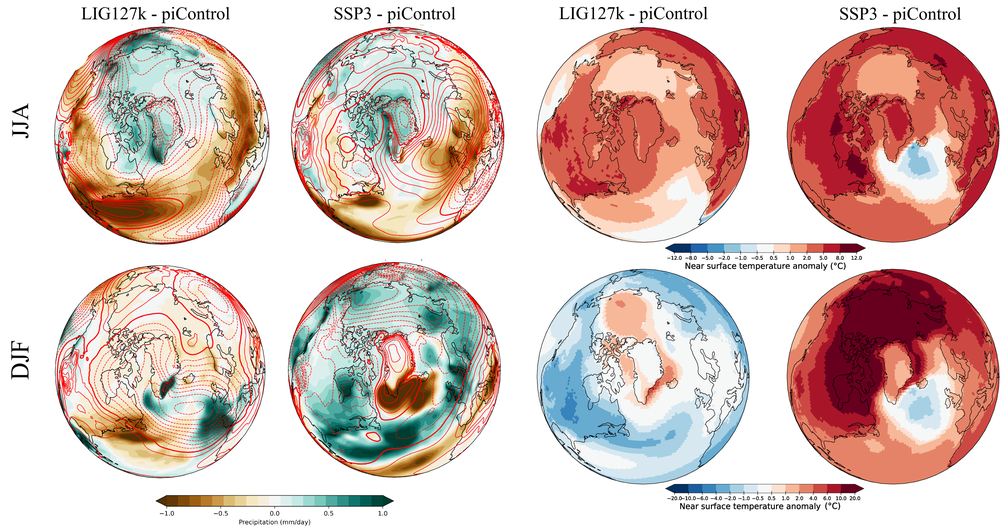
- Seasonal climatologies - Winter (DJF), Summer (JJA)
- Empirical Orthogonal Function (EOF) analysis of DJF sea level pressure (PSL)
  - Precipitation regressed onto the leading mode (PC1) timeseries

## Surface Mass Balance



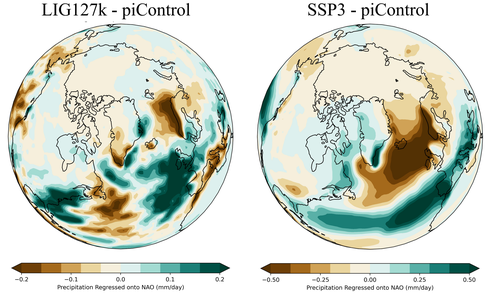

Similar mass balance integrals between LIG127k and SSP3, but different spacial signatures of melt. SSP3 is melting faster in the South and slower in the North.

## Regional Precipitation and Temperature Anomalies



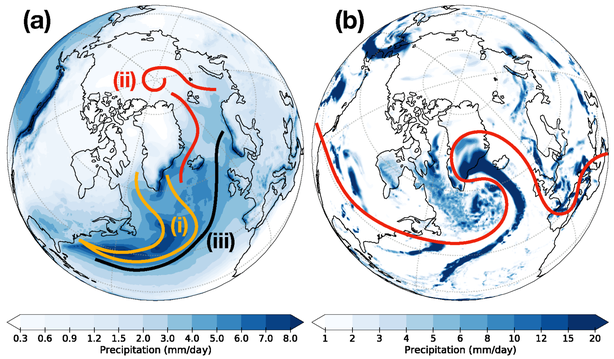

**LIG:** Stronger seasonal cycle; DJF Precipitation patterns look similar to those associated with the negative phase of NAO
**SSP3:** Dry anomaly in SSP3 DJF attributed to equatorward shift and narrowing of the storm track, as well as the cold anomaly in the North Atlantic

## EOF Analysis & Regression




- Difference in precipitation in mm/day per 1 standard deviation change in PC1 timeseries (corresponding to positive phase of NAO)
- The LIG127k shows positive precipitation anomalies in southeast Greenland, western Europe, and southwest of Greenland
  - Similar to the patterns of seasonal mean precipitation anomaly for LIG127k
  - Shift toward a more negative phase of NAO

## Wavebreaking Events




**Example of Cyclonic Wavebreaking from the ERA5 Reanalysis**

- Poleward advection of water vapor
- Equatorward momentum flux convergence
- Zonalization of the extratropical jetstream and storm track

## Conclusions

- The spatial signature of melt is different: GrIS melts faster in the North in SSP3 simulation compared to LIG127k
- In the SSP3 simulation, the decreased precipitation surrounding Southern Greenland in the winter season is controlled by both an equatorward shift and narrowing of the North Atlantic storm track, as well as the North Atlantic Warming Hole (related to weakening of Meridional Overturning Circulation)
- In LIG127k simulation, the increased precipitation southeast and southwest of Greenland appears to be controlled by different processes: one possibility is a shift toward a more negative phase of NAO, related to change in frequency of cyclonic wave breaking events

## Next Steps

- Apply wavebreaking detection algorithm to understand LIG127k winter season
- Expand analysis beyond CMIP6 CESM2, including data from other climate models

## References

Rahmstorf, S., Box, J., Feulner, G. et al. Exceptional twentieth-century slowdown in Atlantic Ocean overturning circulation. Nature Clim Change 5, 475–480 (2015). https://doi.org/10.1038/nclimate2554
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Voldoire, A., Saint-Marten, D. (July 16, 2020), Climate models, Encyclopedia of the Environment, Accessed March 24, 2023 [on- line ISSN 2555-0950] url : https://www.encyclopedie-environnement.org/en/climate/climate-models/.