Project: **920**

Project title: **Early-Holocene and last glacial maximum simulations using the high resolution finite-element ocean model FESOM coupled with ECHAM6**

Project lead: **Gerrit Lohmann**

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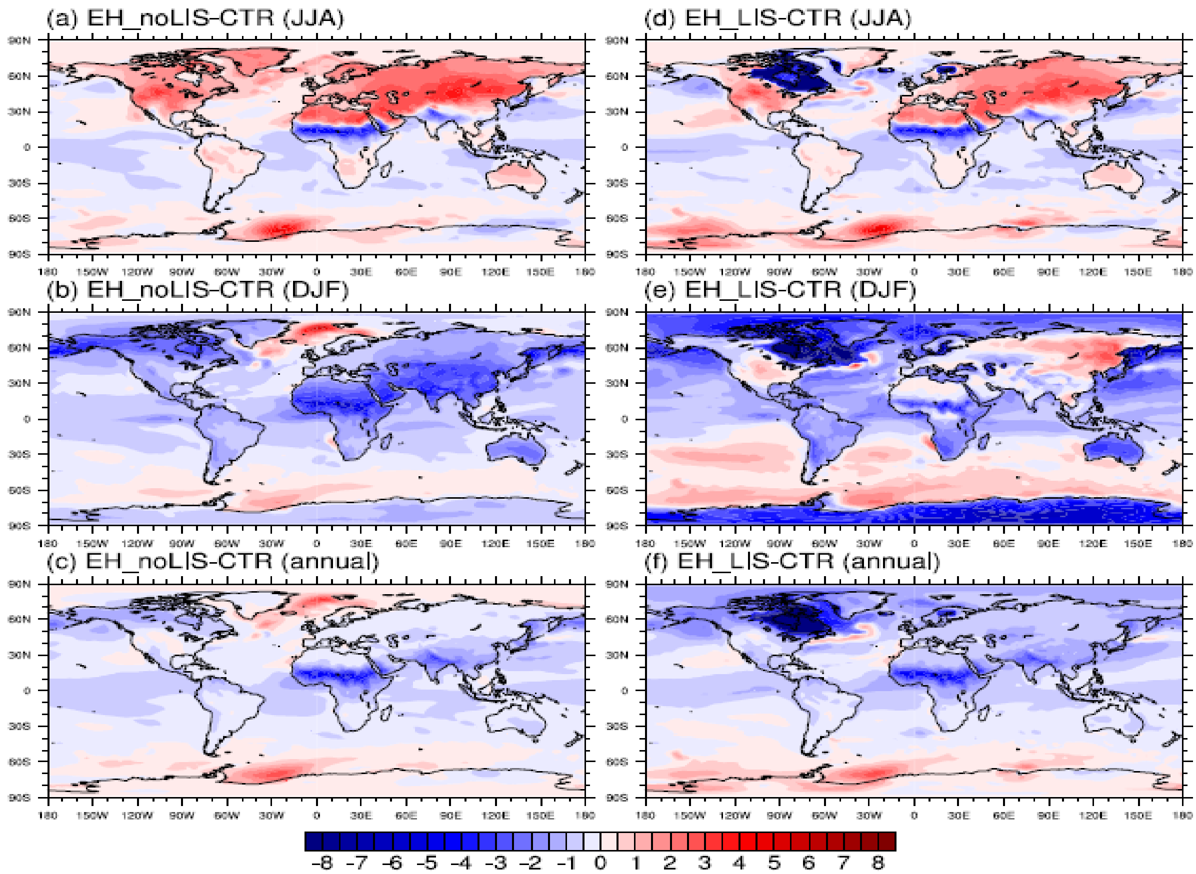
Text:

Sensitivity of the simulated climate to the early-Holocene (9k) insolation, greenhouse gases (GHGs) and topography is examined in this study by performing timeslice experiments under pre-industrial and 9k regimes using a state-of-the-art climate model ECHAM6-FESOM with unstructured mesh and high resolution. For purpose of extracting the effect of the Laurentide Ice Sheet (LIS), we also conduct a 9k simulation in which the pre-industrial topography is applied. Under the 9k orbit and GHGs, the ECHAM6-FESOM simulation shows a JJA warming and DJF cooling over mid and high latitudes compared to pre-industrial, with amplification over the continents; as well as a reduction of sea ice in the Arctic and Southern Oceans. A reduced sea ice transport through the Fram Strait leads to a stronger-than-present Atlantic Meridional Overturning Circulation (AMOC) in 9k. A change of the westerlies over the North Atlantic section, is accompanied by a positive Sea Level Pressure (SLP) anomaly over the western North Atlantic Ocean.



Including the 9k topography and continental ice sheet over North America leads to a regional cooling year-round. The resulted enhanced sea ice thermodynamic production over Baffin Bay and North Atlantic subpolar gyre is the cause for a more saline surface over the region of deep water formation. The anomalous anticyclone over the ice sheet constitutes to stronger and weakened westerlies around 50N and 30N, respectively, which further drives the upper air circulation.

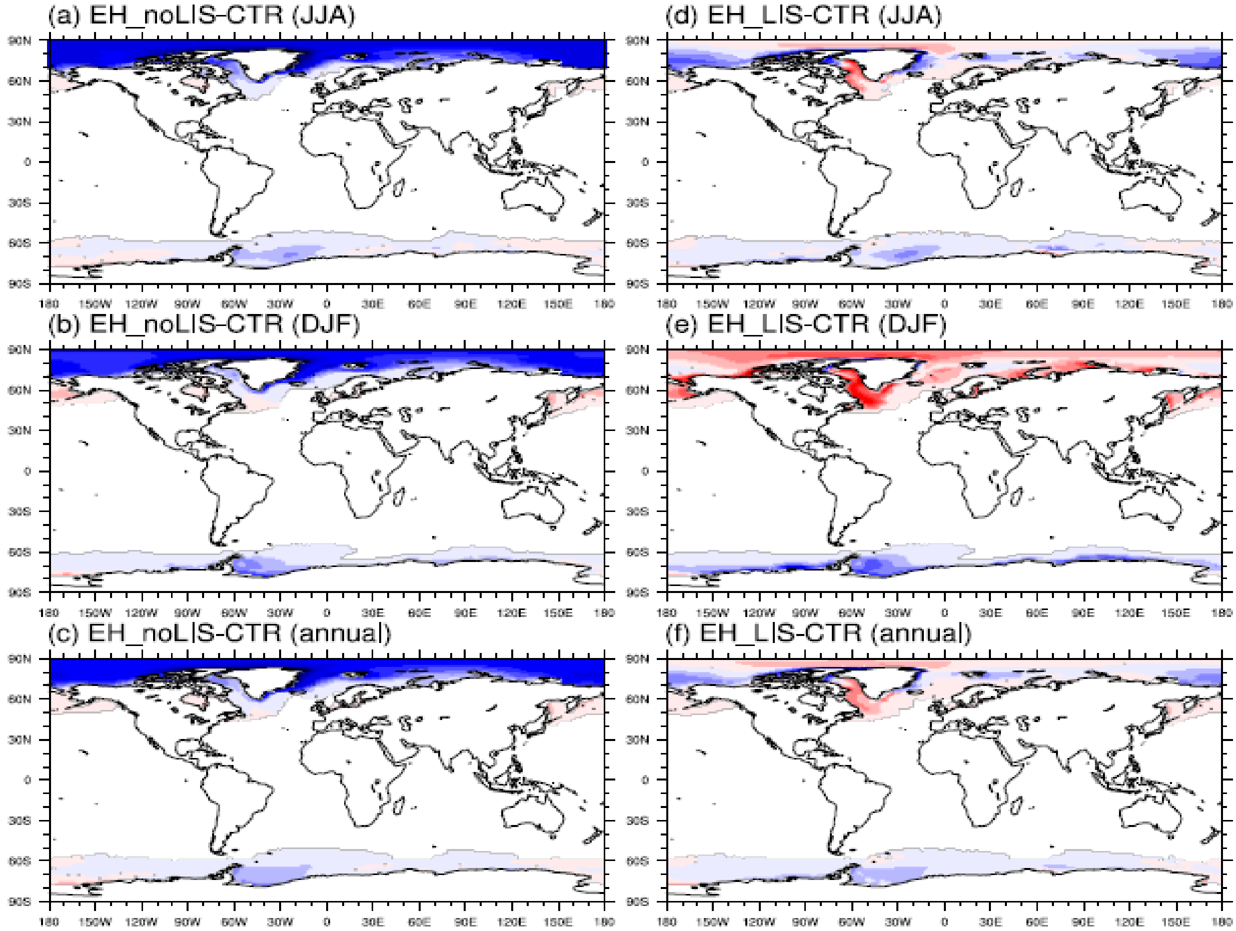


Fig. 1 Simulated surface temperature anomalies relative to pre-industrial (CTR) in (a-c) early-Holocene without LIS (EH_noLIS) and (d-f) early-Holocene with LIS (EH_LIS) for (a, d) JJA (June-August), (b, e) DJF (December-February) and (c, f) annual mean. Units are K.

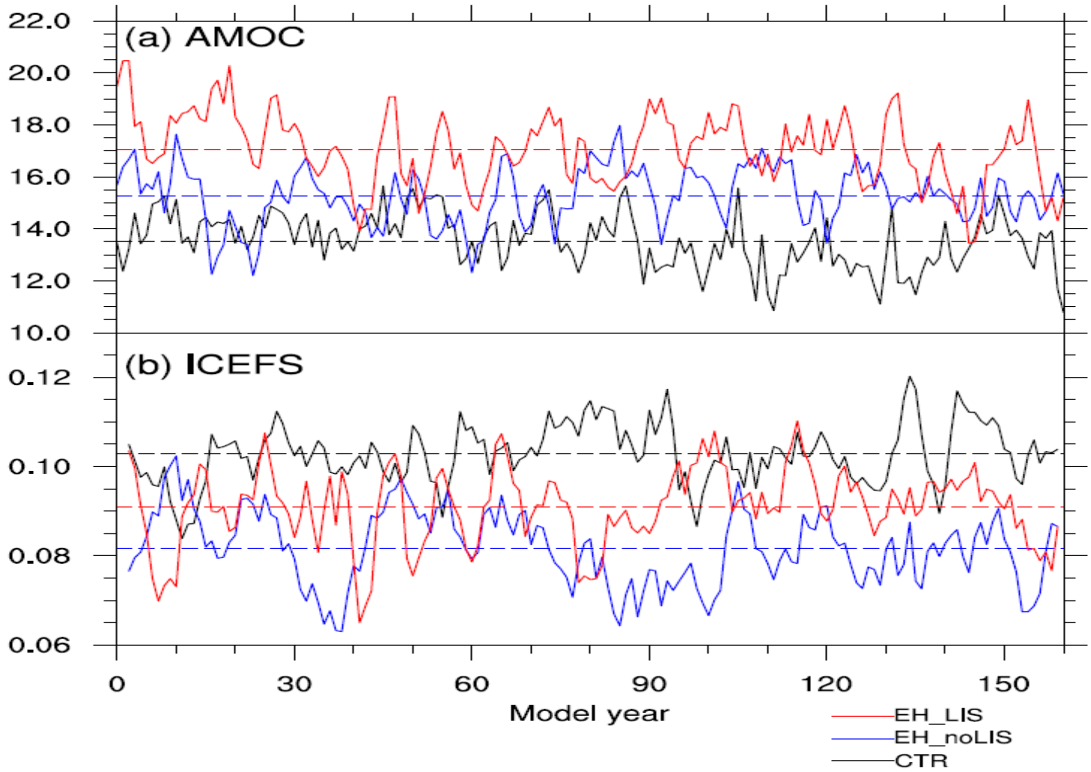


Fig. 2 As in Fig. 1, but for sea ice thickness. Units are m.

Fig.3 Indices of (a) AMOC and (b) Fram Strait sea ice mass transport in solid lines. Averaged *values are represented in dashed lines. Units are Sv.*

The model show a long-term mean overturning circulation ranging from 11 Sv to 16 Sv for the pre-industrial condition, as displayed in Fig. 3a. The EH_noLIS identifies stronger AMOC varying from 12 Sv to 18 Sv. Both CTR and EH_noLIS show a standard deviation (SD) of 1.1 Sv for the AMOC indices. With 9k topography, the AMOC indices in EH_LIS---ranging between 13.5 Sv and 20.5 Sv --- is characterized by strong variability, with a relatively larger SD of 1.4 Sv.

To examine the reason for the AMOC response, it is important to consider the ice mass transport through Fram Strait (ICEFS) for studies of the net freshwater input into the GIN Seas. The time series of the annual means of this export (Fig. 3) shows significant negative anomalies in sensitivity experiments relative to CTR, accounting for an averaged ice volume export of 666 km3/year and 375 km3/year larger in EH_noLIS and EH_LIS than the pre-industrial mean of 3242 km3/year, respectively. The reduction in ICEFS origins from decreased sea ice volume in the Arctic. This ice export anomaly represents a loss of freshwater in the GIN Sea and North Atlantic subpolar gyre.

CPU consumed in the project in 2015:

experiment	Model years	Nodes	CPUs	Wall clock time	CPUh
Early-Holocene with 0k topography	210	4	256	420h	107520
Early-Holocene with 9k topography	210	4	256	420h	107520
∑=	420			2200h	215040

Summary:

CPUh : Σ = 215040