Impact of ice sheet reconstructions on the deglacial climate in iLOVECLIM

Nathaelle Bouttes[1], Didier Roche[1,2], Fanny Lhardy[1], Aurelien Quiquet[1], Didier Paillard[1], and Hugues Goosse[3]

[1]LSCE/IPSL, Gif Sur Yvette, France (nathaelle.bouttes@lsce.ipsl.fr)
[2]Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
[3]Georges Lemaître Centre for Earth and Climate Research (TECLIM), Earth and Life Institute (ELI), Université catholique deLouvain (UCL), Louvain-la-Neuve Belgium

Introduction

The last deglaciation is a time of large climate transition from a cold Last Glacial Maximum at 21,000 years BP with extensive ice sheets, to the warmer Holocene 9,000 years BP onwards with reduced ice sheets. Despite more and more proxy data documenting this transition, the evolution of climate is not fully understood and difficult to simulate. Following the PMIP4 protocol, two ice sheet reconstructions can be used: ICE-6G_C (Peltier et al., 2015) or GLAC-1D (Tarasov et al., 2012). We evaluate the impact of using these reconstructions considering both the topography and bathymetry.

Method

We use the iLOVECLIM model of intermediate complexity (Goosse et al., 2010) and follow the PMIP4 protocol (Ivanovic et al., 2016):
- Insolation and greenhouse gas concentration
- **Ice sheet**: ICE-6G_C or GLAC-1D
- **Bathymetry**: fixed or evolving

In addition, we have run simulations with or without the Antarctic ice sheet (AIS) changes.

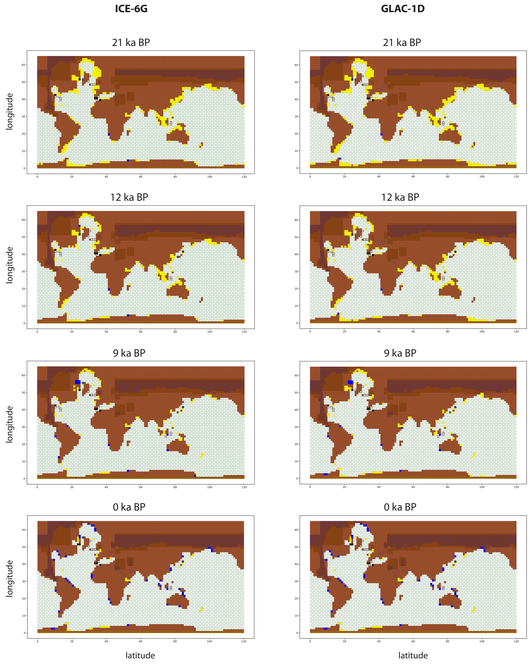
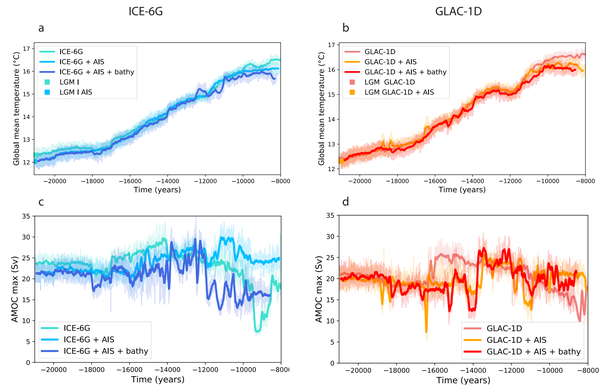


Figure 1. Land-sea mask for the two reconstructions at different times of the deglaciation. Yellow cells indicate continental cells compared to the reference (previous pre-industrial), blue cells indicate ocean.

We have generated new bathymetry and land-sea mask files:
- every 500 years for ICE-6G_C
- every 100 years for GLAC-1D

Impact on temperature and oceanic circulation



Including the Antarctic ice sheet evolution (+AIS) reduces the temperature after 11 ky BP. It also reduces the AMOC strength between 17 ky BP and 14 ky BP.
Including the bathymetry (+ bathy) decreases the AMOC strength and leads to a stalling of the warming at 12ky BP before a rapid increase for ICE-6G. It has little impact for GLAC-1D.

Figure 2. Evolution of (a,b) global mean temperature (°C) and (c,d) maximum of the meridional streamfunction in the North Atlantic (Sv) for the simulations with the two reconstructions.

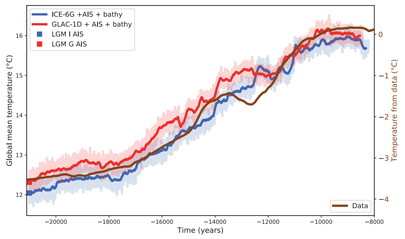


Figure 3. Evolution of global mean temperature (°C) and comparison with data from Shakun et al., 2012.

The two reconstructions result in different temperature evolution:
- the GLAC-1D simulation is warmer than with ICE-6G
- the main differences take place between 14.5 ky BP and 11.5 ky BP: with GLAC-1D the temperature increase is reduced and stalls from ~14 ky BP while it happens later with ICE-6G. Compared to proxy data the timing seems in better agreement with GLAC-1D but the temperature should decrease more strongly earlier. While the global evolution is in relatively good agreement with data, adding fresh water flux from ice sheet melting could help resolve the remaining mismatch.

The long-term evolution of the AMOC is similar in both simulations (with the two reconstructions) with a relatively stable AMOC until 14 ky BP, then an increase in strength until 12 ky BP and a decrease to lower values.
On shorter time scales the two reconstructions can result in large differences in AMOC such as at 14 ky BP with a much weaker circulation with GLAC-1D than with ICE-6G.

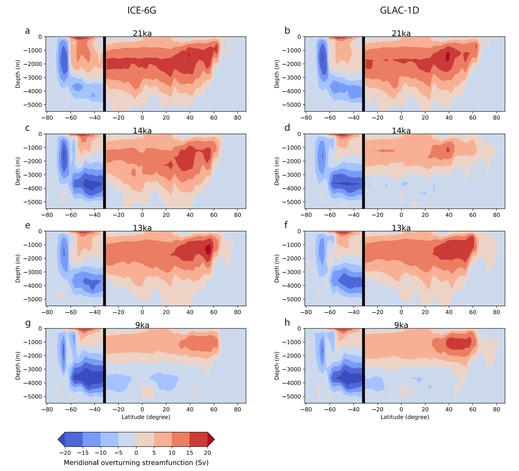


Figure 4. Meridional streamfunction (Sv) for the simulations with the two reconstructions, including the AIS and bathy evolution.

Conclusion

- The two ice sheet reconstructions lead to different temperature evolution during the deglaciation
- The temperature evolution obtained with GLAC-1D seems in better agreement with proxy data
- Even without fresh water flux from ice sheet melting the temperature evolution stalls and increase again

References

Goosse et al., 2010, GMD, https://doi.org/10.5194/gmd-3-603-2010
Ivanovic et al., 2016, GMD, https://doi.org/10.5194/gmd-9-2563-2016
Peltier et al., 2015, J. Geophys. Res.-Sol. Ea., doi:10.1002/2014JB011176
Shakun et al., 2012, Nature, doi:10.1038/nature10915
Tarasov et al., 2012, EPSL, doi: 10.1016/j.epsl.2011.09.010