Ice sheet reconstructions based on geological and geophysical information

- Geophysical modelling of glacial-isostatic adjustment (GIA) processes has long been used to reconstruct paleo-ice sheets (e.g. Tarasov et al 2012, Peltier et al 2015, Gowan et al 2016a, Lambeck et al 2017). In order to do this efficiently, it is necessary to have strict control on the geometry of the ice sheet.
- These data have limitations due to the spatial distribution (i.e. sea level indicators are only located in coastal regions, so other geological information need to be used, such as flow direction).
- Ultimately, the reconstruction should have at least a minimal amount of glaciological realism. This can be achieved using our model, ICESHEET (Gowan et al 2016b), which uses perfectly plastic rheology.

Methodology to make ice sheet reconstructions using ICESHEET

- Inputs for ICESHEET include the margin at discrete time periods, and a temporal variable basal shear stress model which controls the ice surface profile.
- Can include iterations of GIA to account for changes in basal topography from loading and sea level change. We use SELEN (Spada et al., 2012) to compute this.
- At present, we have setups for North American and Eurasian ice sheets.

North American Ice sheets at 20000 yr BP
(blue line is the margin reconstruction from Dyke, 2004 and Gowan et al. 2016a)

Eurasian Ice sheets at 20000 yr BP
(blue line is the margin reconstruction from Hughes et al. 2016)

Refining the ice sheet reconstruction

Currently, we are refining the ice sheet reconstruction for the Innuitian Ice Sheet in Northern Canada. We are revising margins and sea level indicators using updated reservoir corrected radiocarbon dates (Buitzin et al, 2017).

The Sea level data are classified based on whether they indicate that sea level was above (minimum) or below (maximum) the sample elevation, or intermediate of the sample and the local highstand position (bounded).

Sea level is calculated at the location of each sample, and a score is assigned based on the discrepancy between the observation and model (zero if there is no discrepancy). This score is used to assess the ice sheet reconstruction.

The basal shear stress or margin models are adjusted if there is a discrepancy in calculated sea level.

Ice Sheet Topography

and climate modeling

Refinement of western Laurentide ice sheet by Gowan et al (2015a,b) resulted in a ice sheet geometry that has a substantially lower profile from the reconstruction used by PMIP. The cause of this discrepancy is a result of the inclusion or exclusion of specific data in this region, and a different choice of Earth rheology for glacial-isostatic adjustment. One of the main differences is a result of fitting sea level data from southern Hudson Bay, which has been difficult to reconcile in other reconstructions (i.e. Tarasov et al, 2012 and Peltier et al, 2015). A lower profile ice sheet has profound effects on modelled climate (see concurrent tilt data). A lower profile ice sheet has profound effects on modelled climate (see concurrent tilt data).

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References

Ice sheet reconstructions based on geological and geophysical information

- Ice sheet reconstructions are based on geological and geophysical information to understand past ice sheet extent and dynamics.
- These reconstructions are crucial for understanding past climate and for validating models of future ice sheet behavior.

Methodology to make ice sheet reconstructions using ICESHEET

- ICESHEET is a program that produces paleo-ice sheet reconstructions with minimal assumptions about past ice sheet behavior.
- This program uses a combination of geological and geophysical data to reconstruct past ice sheet extent and dynamics.

Refining the ice sheet reconstruction

- Refinement of the ice sheet reconstruction involves using additional datasets and iterative adjustments to improve the accuracy of the reconstructions.
- This can include the use of additional datasets such as radiocarbon dated raised beaches and other geological indicators.

Ice Sheet Topography and climate modeling

- Ice sheet topography plays a critical role in climate modeling, as it affects the way that ice sheets interact with the atmosphere and oceans.
- Accurate reconstructions of past ice sheet extent and dynamics are essential for improving climate models and predicting future climate changes.

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