# Supplementary Information

## 1 Supplementary Tables

Table S1: Summary table of the set-up for the experiments presented in the study (see methodology for full details).

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| --- | --- | --- | --- | --- |
| **Name** | **Initial ice Thickness** | **Surface mass balance** | **Sub-shelf melt** | **Basal Friction** |
| *SPINUP* | Plastic thickness | 26 ka BP | 26.3 m/y | Standard (Fig. 4a) |
| *RETREAT* | *SPINUP* | 26 ka BP + 1.5 K | 47.1 m/y | Standard |
| *RETREAT\_ATMOS* | *SPINUP* | 26 ka BP + 1.5 K | 26.3 m/y | Standard |
| *RETREAT\_OCN* | *SPINUP* | 26 ka BP | 47.1 m/y | Standard |
| *READVANCE\_xxxxyr* | Retreat at model year xxxx yr (800 yr intervals) | 26 ka BP | 26.3 m/y | Standard |
| *RETREAT\_NOSHELF* | *SPINUP* | 26 ka BP + 1.5 K | 100 m/y | Standard |
| *READVANCE\_COOLING* | Stable READVANCE\_8000yr | 26 ka BP – 1.5 K | 26.3 m/y | Standard |
| *SPINUP\_MAXFRICT* | Plastic thickness | 26 ka BP | 26.3 m/y | Standard x 1.5 |
| *SPINUP\_MINFRICT* | Plastic thickness | 26 ka BP | 26.3 m/y | Standard x 0.5 |

## 2 Supplementary Figures

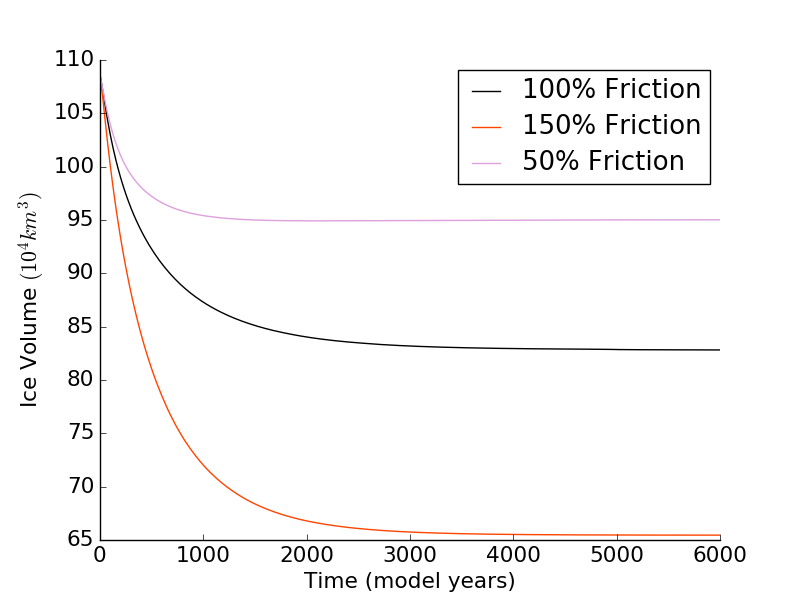
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Figure S1: Sensitivity of equilibrium ice volume to bed friction. The original bed friction coefficient map used in SPINUP (100%, used in the experiments) is increased and decreased by 50%.

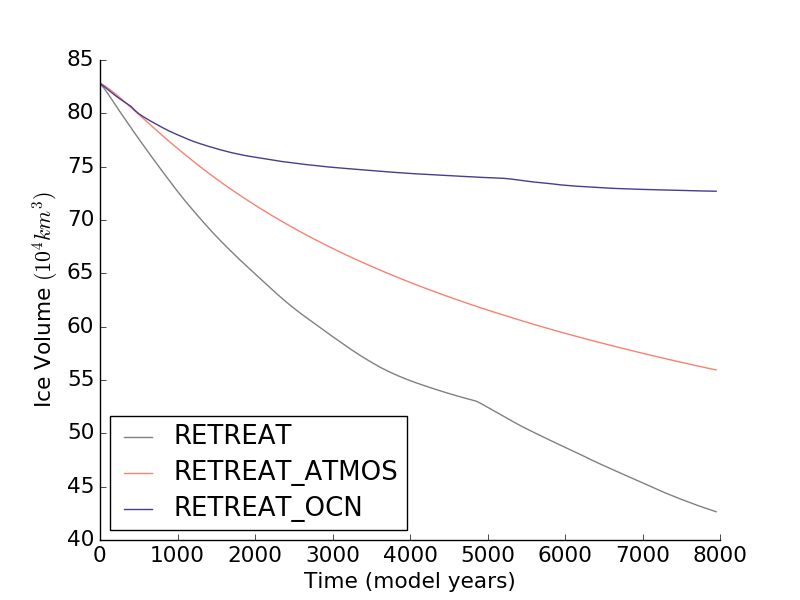
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Figure S2: A comparison of the volume response when simulating deglaciation of the ice stream with only Surface Mass Balance forcing (RETREAT\_ATMOS), only ocean forcing (RETREAT\_OCN), and both forcings combined (RETREAT).

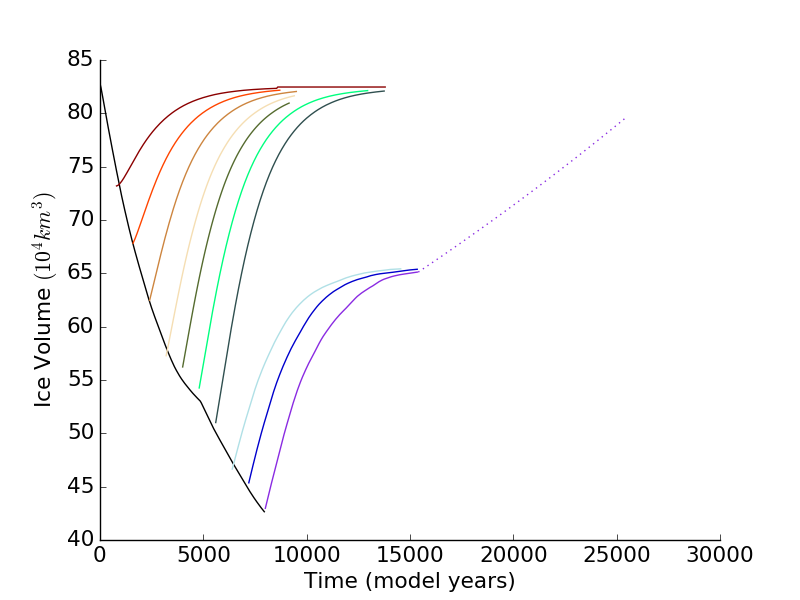


Figure S3: The original result of experiment READVANCE, with the READVANCE\_COOLING experiment (dotted line). This experiment starts from the “collapsed” state and is forced with a constant surface air temperature from 26 ka BP cooled by 1.5K, causing recovery from the collapsed state (dotted line).

Video S4: Animation of ice velocity during experiment *RETREAT. [Attached file Minch\_retreat.mp4]*

## 3 Basal Friction Coefficient Map

The basal friction coefficient map was produced first by grouping regions of similar bed friction, then prescribing values to those regions based on bed friction coefficient values from other studies. Regions of similar basal friction were classified into the following five groups based on observable surface morphological features in satellite imagery and DEMs, and from the glacial map of Britain (Clark et al., 2018) as well as reference to superficial geology maps:

1. Palaeo-ice streams, based upon the presence of mega-scale lineations, convergent flow-patterns from subglacial bedforms and previous reporting in the literature (Margold et al., 2015; Stokes and Clark, 1999). As the main outlets for ice-flow and fastest flow regions, these regions were assigned the lowest basal friction coefficients.
2. Marine-sediments, defined based upon geological maps and the presence of characteristic marine bedforms. These are highly deformable, and were therefore assigned the second lowest basal friction coefficient values.
3. Subglacial lineations or drumlins, identified on the glacial map and elevation models. Lineations are thought to represent reasonably fast ice flow and be the product of subglacial bed deformation (Ely et al., 2016). These were assigned an intermediate basal friction coefficent.
4. Subglacial ribs or ribbed moraines, identified from previous mapping and elevation models. These are thought to be characteristic of slower ice flow than that of subglacial lineations, and were thus assigned a higher basal friction coefficient.
5. Exposed bedrock was assigned the highest basal friction coefficient. These high roughness areas were defined by their characteristic surface morphology and from geological maps.

Clark, C.D., Ely, J.C., Greenwood, S.L., Hughes, A.L.C., Meehan, R., Barr, I.D., Bateman, M.D., Bradwell, T., Doole, J., Evans, D.J.A., Jordan, C.J., Monteys, X., Pellicer, X.M., Sheehy, M., 2018. BRITICE Glacial Map, version 2: a map and GIS database of glacial landforms of the last British-Irish Ice Sheet. Boreas 47, 11-e8. doi:10.1111/bor.12273

Ely, J.C., Clark, C.D., Spagnolo, M., Stokes, C.R., Greenwood, S.L., Hughes, A.L.C., Dunlop, P., Hess, D., 2016. Do subglacial bedforms comprise a size and shape continuum? Geomorphology 257, 108–119. doi:10.1016/J.GEOMORPH.2016.01.001

Margold, M., Stokes, C.R., Clark, C.D., 2015. Ice streams in the Laurentide Ice Sheet: Identification, characteristics and comparison to modern ice sheets. Earth-Science Rev. 143, 117–146. doi:10.1016/J.EARSCIREV.2015.01.011

Stokes, C.R., Clark, C.D., 1999. Geomorphological criteria for identifying Pleistocene ice streams. Ann. Glaciol. 28, 67–74. doi:10.3189/172756499781821625