This package is the submitted version of code extending the *iceberg* package for MITgcm which can be found here (Davison et al. (2020), https://zenodo.org/records/3979647)

Key additions in this package:
- Addition of iceberg physical blocking based on parameterizations from Hughes (2022) (https://doi.org/10.1029/202 including new diagnostic fields for iceberg drag in X and Y directions.
- Acceleration of the thermodynamics code and streamlining of configuration files (all berg geometries now in 3 binary files)
- Per iceberg statistics are off by default for faster run time, but available as build time option
- Addition of diagnostic for Iceberg surface area
- New check of global configuration files to ensure hFac values are not reset
- Iceberg melting can now be controlled with a mask as a runtime parameter

This work is still pending review, and will be updated to this zenodo DOI repository once finalized. Any questions can be directed to Paul Summers (paul.summers@rutgers.edu)

Main development was run on MITgcm checkpoint 68z, last run for compatibility on checkpoint69c, last tested Jan 27 2025.

Installation is similar to any non-standard MITgcm package
- Copy '/pkg/iceberg' directory and contents into the 'MITgcm/pkg' directory
- Copy files in 'code' to the code folder of your local experiment directory (recommended), or overwrite the version in the existing 'MITgcm/pkg' or 'MITgcm/src' directories of your main MITgcm folder (be careful with this option)
- Use 'pythonMakeBergs.py' to generate files needed in the 'input' directory.
- Use the data.iceberg file in the 'input' directory of your experiment directory

# 1 inputs

| Option | Unit | Default | Description |
|---|---|---|---|
| ICEBERG_OPTIONS.h | | | |
| ALLOW_PER_BERG_DIAG | | undef | Build-time option to include per-berg diagnostics |
| ICEBERG_SIZE.h | | | |
| maxBerg | Integer | 500 | maximum number of icebergs per cell |
| PARM01 | | | |
| ICEBERGmaskFile | Filename | none | XY file specifying where icebergs are in the domain |
| ICEBERGmaskNumsFile | Filename | none | XY file specifying unique IDs for each cell with icebergs. Used for per-berg statistics |
| ICEBERGnumPerCellFile | Filename | none | XY file specifying total number of icebergs per cell, can be 0 |
| ICEBERGdriftFile | Filename | none | XY file specifying where cells where iceberg melt rate is caluclated using drift velocity |
| ICEBERGbarrierFile | Filename | none | XY file specifying which cells have iceberg blocking/drag effects |
| ICEBERGopenFracFile | Filename | none | XYZ file specifying volume faction of ocean (0-1 values) |
| ICEBERGareaFile | Filename | none | XYZ file specifying submerged area of icebergs ($m^2$) |
| ICEBERGlengthFile | Filename | none | (maxBerg)XY file specifying iceberg lengths. 0 is fill for slots beyond last iceberg |
| ICEBERGwidthsFile | Filename | none | (maxBerg)XY file specifying iceberg widths. 0 is fill for slots beyond last iceberg |
| ICEBERGdepthsFile | Filename | none | (maxBerg)XY file specifying iceberg depths. 0 is fill for slots beyond last iceberg |

| | | | |
|---|---|---|---|
| icebergRho | kg $m^{-3}$ | 917 | iceberg ice density |
| brg_iceTemp | C | 0 C | iceberg ice temperature |
| icebergBGvel | m $s^{-1}$ | 0.06 | Minimum velocity for melt parameterization |
| brg_lambda1 | C $psu^{-1}$ | -.0573 | Freezing point slope |
| brg_lambda2 | C | 0.0832 | Freezing point offset |
| brg_lambda3 | C $m^{-1}$ | 0.000761 | Freezing point depth |
| brg_GamT | | 0.022 | Thermal turbulent transfer coefficient |
| brg_GamS | | 0.00062 | Salt turbulent transfer coefficient |
| brg_c_w | J $kg^{-1}$ $C^{-1}$ | 3974.0 | Heat capacity of water |
| brg_c_i | J $kg^{-1}$ $C^{-1}$ | 2000.0 | Heat capacity of ice |
| brg_L | J $kg^{-1}$ | 334000 | Latent heat of melting |
| brg_Cd | | 0.0025 | Iceberg drag coefficient for melt parameterization |
| brg_DragForm | | 0.0025 | Iceberg drag coefficient for drag parameterization |
| brg_SelectDrag | | 3 | selection for drag parameterization $\alpha$ value |
| brg_SelectFill | | 3 | selection for drag parameterization $\beta$ value |

# 2 Diagnostics

There are two sets of *iceberg* diagnostics. One set are at the grid-cell scale and another set at the iceberg scale (off by default). All diagnostic output are assigned zeros where no iceberg melting occurred. The former (grid-cell scale) set of diagnostics requires pkg/diagnostics to be compiled and enabled in data.pkg. The available grid-cell scale diagnostics are:
- BRGfwFlx : grid-cell total freshwater flux ($m^3$ s-1)
- BRGhtFlx : grid-cell total heat flux ($W/m^2$)
- BRGmltRt : grid-cell melt rate (m $s^{-1}$)
- BRGarea3D: grid-cell total submerged area (not yet implemented)
- BRG_TauX: grid-cell total drag, zonal direction (Pa)
- BRG_TauY: grid-cell total drag, merid direction (Pa)

The iceberg scale diagnostics are created when the *iceberg* option ALLOW_PER_BERG_DIAG is defined. These are the same as the previous version of *iceberg*. Description of Davison et al. (2020) is repeated below:
These are in the form of text files for each plan-view cell, numbered (NUM) using ICEBERGmaskNumsFile. Six text files are produced per plan-view cell. Each of these text files contains a variable of interest (e.g. iceberg melt rate) along with metadata. The available files are:
- iceberg_mltRt_NUM.txt : contains iceberg melt rate (m d-1)
- iceberg_fwFlx_NUM.txt : contains iceberg freshwater flux (m3 s-1)
- iceberg_htFlx_NUM.txt : contains iceberg heat flux (W m-2)
- iceberg_spdla_NUM.txt : contains relative current velocity parallel to the iceberg long-axis (m

s-1)
- iceberg_spdsa_NUM.txt : contains relative current velocity parallel to the iceberg short-axis (m s-1)
- iceberg_spdba_NUM.txt : contains relative current velocity parallel to the iceberg base (only at the row corresponding to the iceberg base) (m s-1)
Each row in these text files corresponds to a model vertical level. If there are multiple icebergs within a cell, these are appended sequentially. If nt $> 1$, data for sequential output time steps (corresponding to those set in data.diagnostics) as also appended. We provide a .m file (combine_iceberg_profiles_v3.m), which can read these text files and create 3-D matrices of each variables (nz, numIcebergs, nt) along with corresponding iceberg dimension data (length, width, depth) and location (x,y) vectors to identify the position of each iceberg.

# 3 Using *iceberg*

Recommended structure for running MITgcm with *iceberg*:

```
MITgcm
|--experiment
   |--build
   |--code
       | copy contents of code directory here.
   |--input
       | copy contents of input directory here
        execute 'pythonMakeBergs.py' here.
        *MUST* update domain size in this script to
        agree with your model domain.
   |--results
|--pkg
   | copy entire 'iceberg' directory here.
```

In this new version of *iceberg* the drag enabled cells assume the icebergs are not drifting (i.e. locked in a mélange). This implies that the driftFile should be set to false for these cells, but this is not enforced as a requirement. We also note that the melt parameter values here ($\Lambda, \Gamma, C_d$ are the same values set as defaults in Davison et al. (2020), and not the values used by the Summers, et al. manuscript currently under consideration. Iceberg drag default values (brg_DragForm, brg_SelectDrag, brg_SelectFill) are those used by Summers, et al.

# References


Davison, B. J., Cowton, T. R., Cottier, F. R., and Sole, A. J. (2020). Iceberg melting substantially modifies oceanic heat flux towards a major Greenlandic tidewater glacier. *Nature Communications*, 11(1):1–13.

Hughes, K. G. (2022). Pathways, Form Drag, and Turbulence in Simulations of an Ocean Flowing Through an Ice Mélange. *Journal of Geophysical Research: Oceans*, 127(6):1–17.