# High-Resolution Model Development to Quantify the Impact of Icebergs on the Stability of the AMOC

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This project has developed a sophisticated iceberg model (MITberg) to more accurately evaluate changes in the cryosphere on ocean circulation, climate, and in particular the Atlantic meridional overturning circulation (AMOC). MITberg has been successfully coupled to MITgcm ocean-sea ice model and integrated at eddy permitting resolutions (~1/6°; 18 km). This has allowed a detailed study of the interaction between meltwater/icebergs with open ocean convection and North Atlantic Deep Water (NADW) formation. In 2013, we implemented a keel model into the iceberg model code, allowing icebergs to assume a variety of shapes both above and below the waterline. This routine was develop as a 'multilevel' drag scheme to account for water drag at different vertical levels in the water column, and was found to produce increasingly realistic iceberg drift patterns (Figure 1a). Additional simulations focused on reproducing the historic record of iceberg drift collected at 48°N that began in 1900.

A second focus of 2013 was the development of the first ever eddy-permitting ocean-sea ice-iceberg model simulation of the last ice age, 21,000 years ago (Figure1b). Using this new set up, we showed that icebergs and meltwater discharged from the Laurentide ice during glacial times would have first been transported to the subtropical gyre, not the subpolar gyre, by narrow coastal boundary currents (Figure1c). This meltwater was advected northwards by the Gulf Stream to regions of NADW formation over a period of several decades, producing a delayed, more muted response, in deepwater formation to increased high-latitude freshwater forcing, compared to the more traditional freshwater hosing experiments. A fraction of icebergs and meltwater penetrated south of Cape Hatteras and under the right forcing conditions carried massive (up to 300 m thick) icebergs to southern Florida. This transport pathway is supported by the discovery of iceberg scours in equivalent water depths along the entire US continental shelf from Newfoundland to Florida Keys (Figure 1d). This research was published in *Nature Geoscience* in October 2014.

## Recent results

- To accurately simulate iceberg drift one must account for water drag forces at all levels in the water column (not just the surface) that an iceberg keel penetrates. Moving towards higher ocean model resolutions that simulate mesoscale eddies and narrow coastal currents also help to produce increasingly realistic iceberg distributions.
- During glacial periods the Gulf Stream was more zonal, with limited transport of heat to northern Europe and the Arctic. An expansion of the cold, fresh, subpolar gyre led to increased eddying at the subpolar-subtropical gyre boundary due the larger thermal gradient in this region.
- Large meltwater floods from Hudson Bay were capable of transporting Northern Hemisphere icebergs as far south of Florida Keys. A more subtropical meltwater-iceberg pathway (compared to the traditional 50°N-70°N hosing zone) has implications for understanding how increases in high-latitude freshwater forcing from the Greenland ice sheet will influence subpolar deep water formation and the strength of the AMOC in the near-future.

## Bibliography

Hill, J. C. and A. Condron, 2014: Subtropical iceberg scours and meltwater routing in the deglacial western North Atlantic. *Nat. Geosci.*, **7,** 806-810, doi:10.1038/ngeo2267.