Modeling ocean dynamics in ice-shelf rifts.

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Abstract

Ice-shelf break-up is thought to be driven by a combination of various environmental factors that can be classified as oceanographic, glaciological and atmospheric. These contribute to different phases of the ice damaging process. However, physical processes driving ice-shelf collapse and rift propagation are still poorly understood. A few studies have suggested that ice-shelf rifting can be highly influenced by the rift's infill. In particular, ice melange, a heterogeneous mixture of sea ice, marine ice, and trapped icebergs, is thought to stabilize rift evolution, potentially slowing or halting rift growth. In this study, we investigate ocean dynamics associated with rifts in ice-shelves using the Massachusetts Institute of Technology ocean general circulation model. Our goal is to estimate the effects of rifts on ice-shelf melting and freezing processes and in turn on sub-ice shelf circulation. Enhanced (reduced) melting/freezing rates induced by ice-shelf rifts affect the physical properties of the volume confined between rift's flanks. Here, we examine key hydrographic conditions on sensitivities to the cracked ice-shelf basal environment in an idealized set-up. We find that basal fractures modify the thermohaline circulation by accumulation of cold and fresh water in the rift's open volume, which potentially is a prerequisite for ice melange formation. An improved representation of ice-ocean interactions below a fractured ice-shelf is a step toward a better understanding of rifting processes and, on a larger scale, of ice-shelves collapse. To further study this, we use a more realistic regional set-up of Larsen C in the Antarctic Peninsula.

Modeling of Ocean Dynamics in Ice-Shelf Rifts

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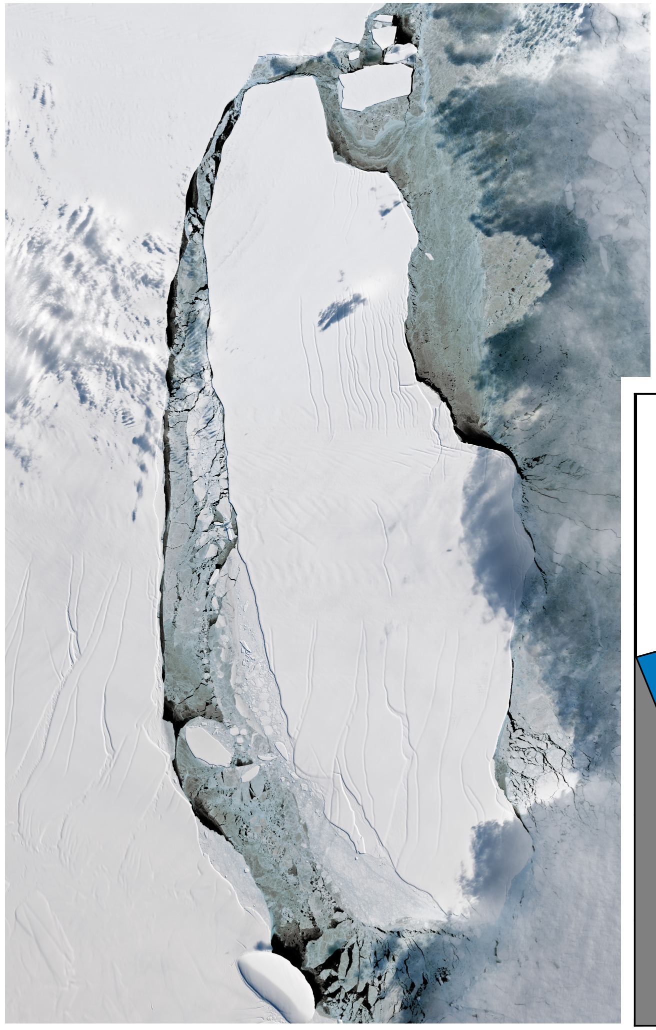
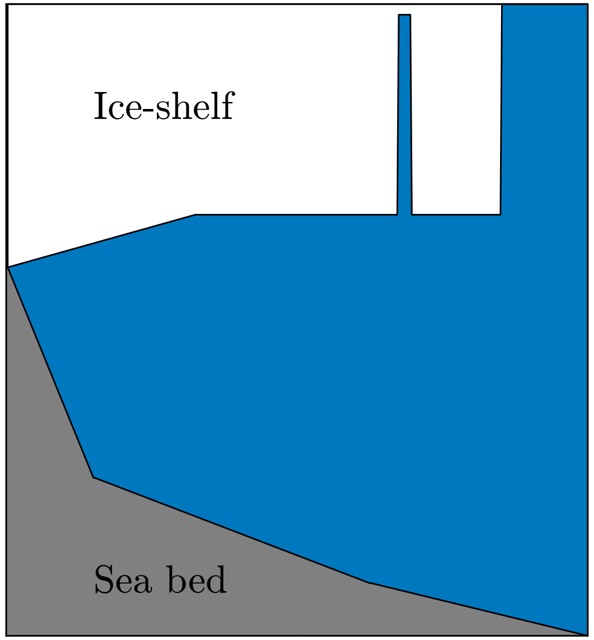
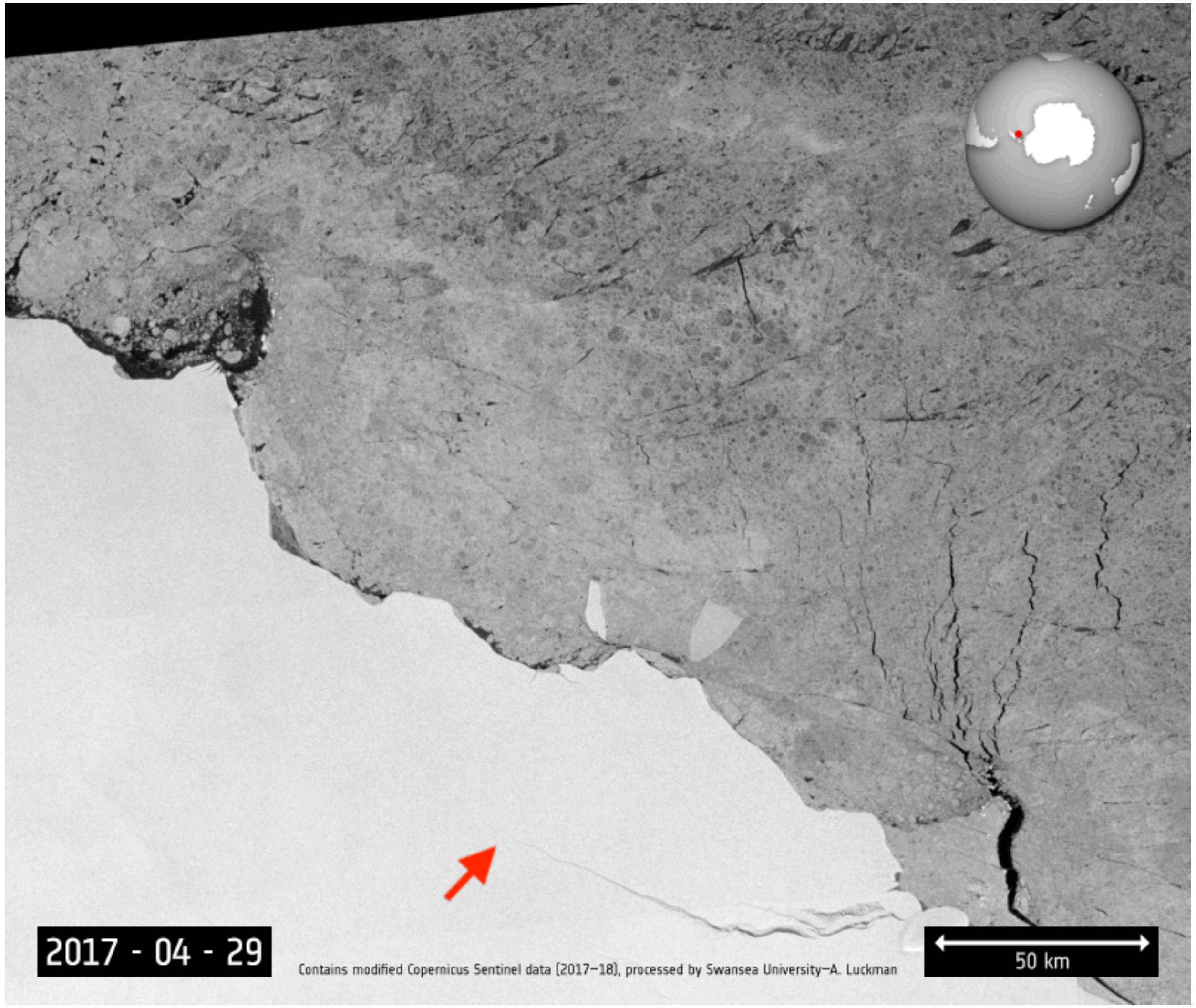


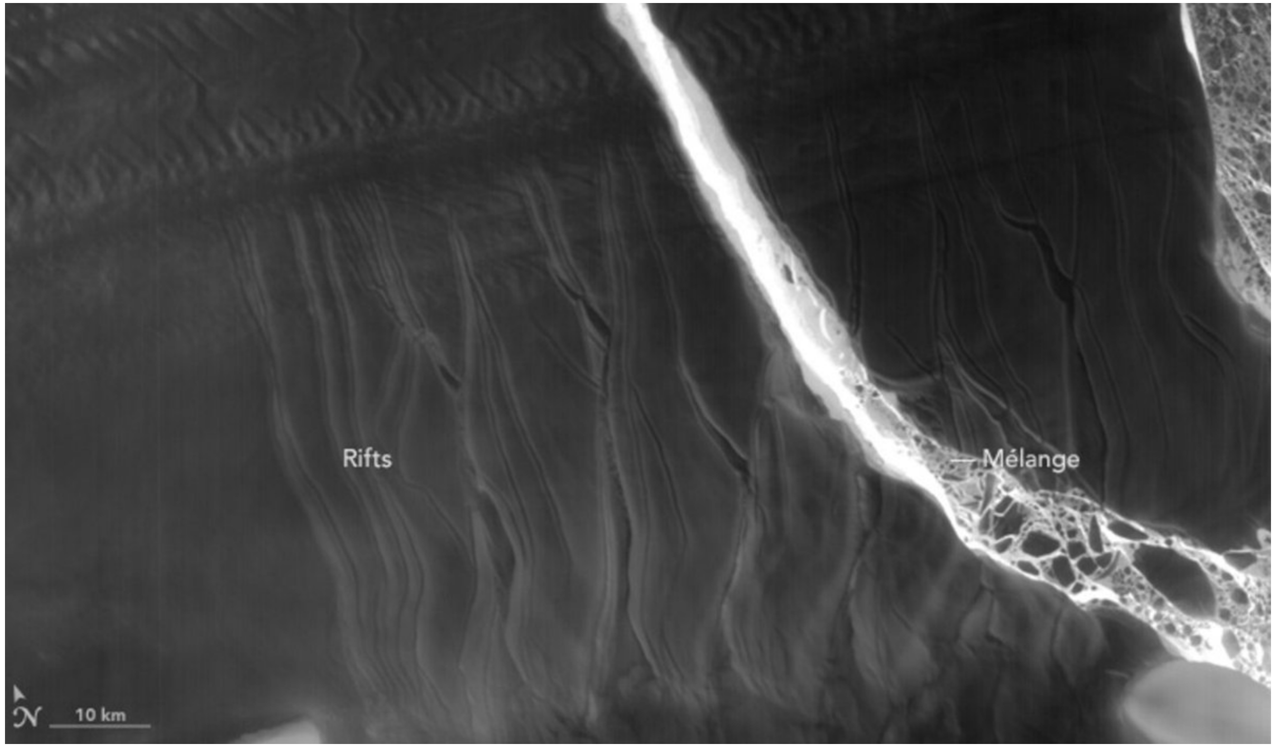
LANDSAT data processed by Stevens, J.



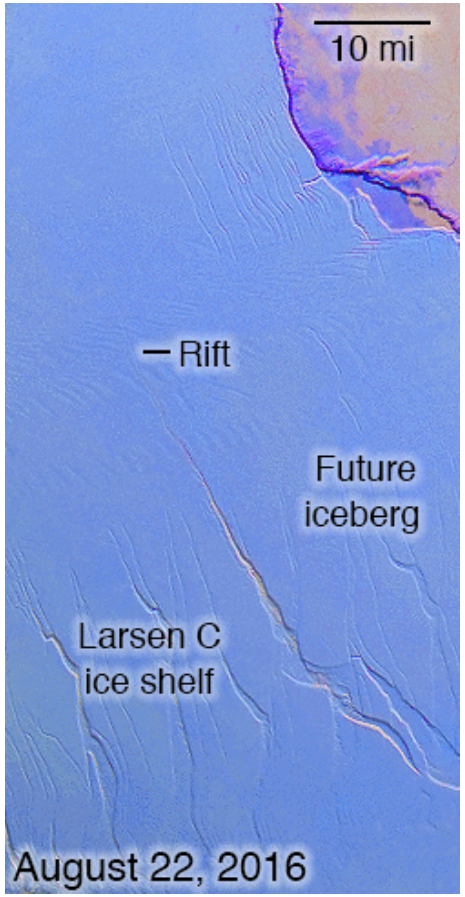
Larsen C calved the large iceberg A68 in July 2017.



Ice mélange is thought to control rift propagation.

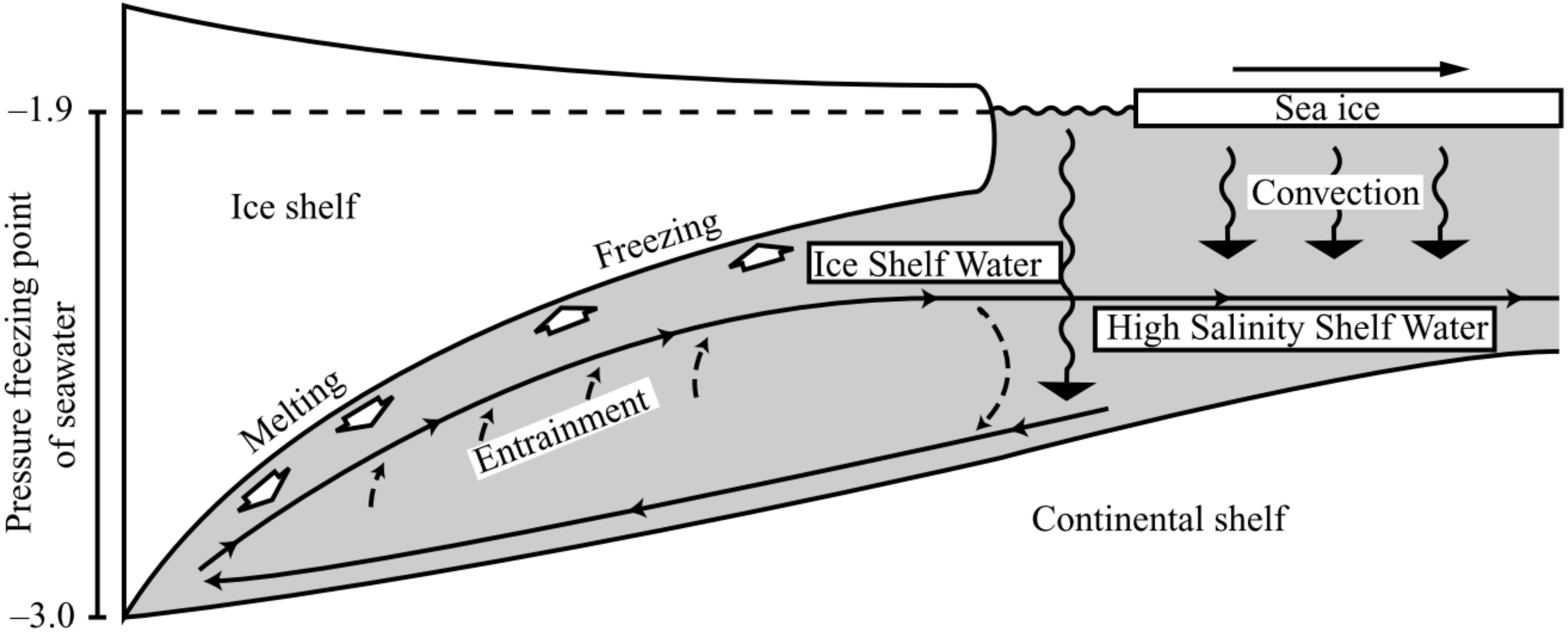


LANDSAT data processed by Allen, J.



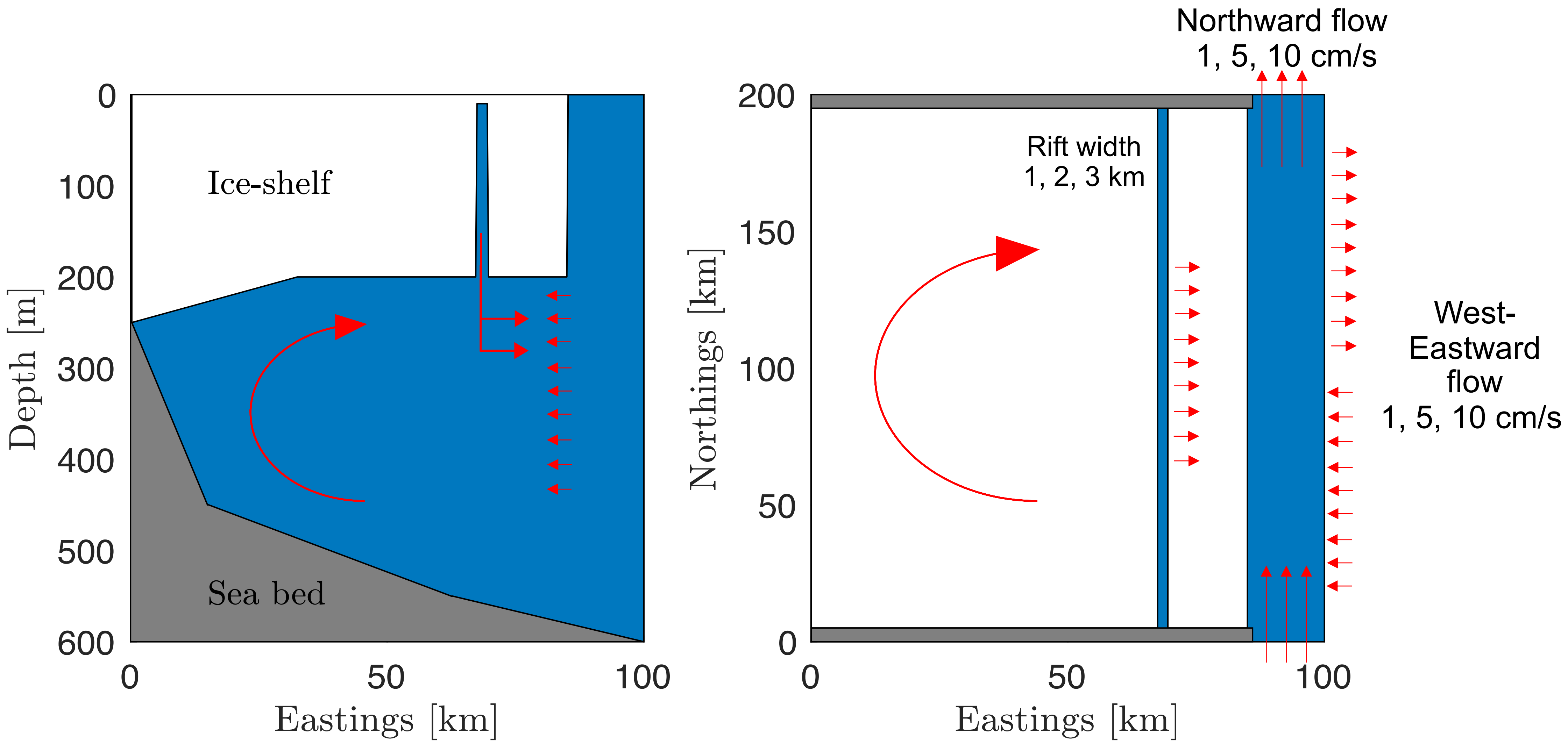
NASA Terra

Meltwater formed at depth raises along the cavity topography, accreting as frazil ice at shallower depths.

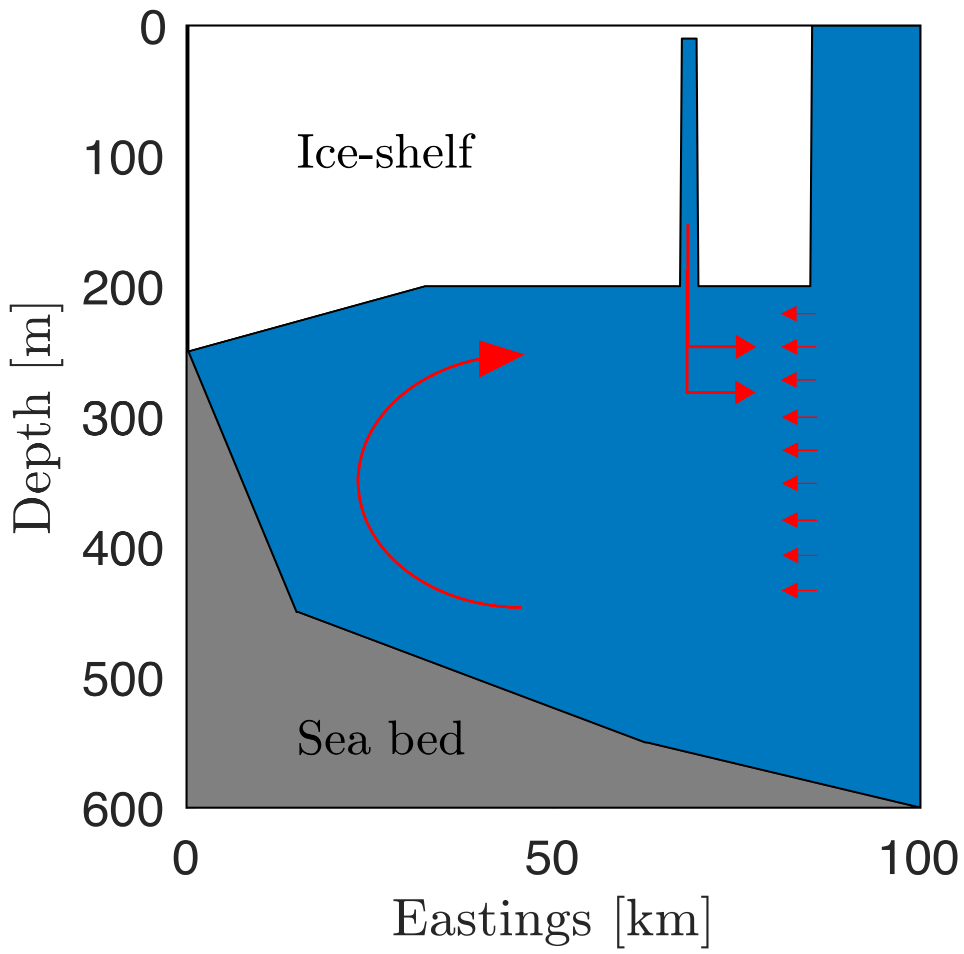


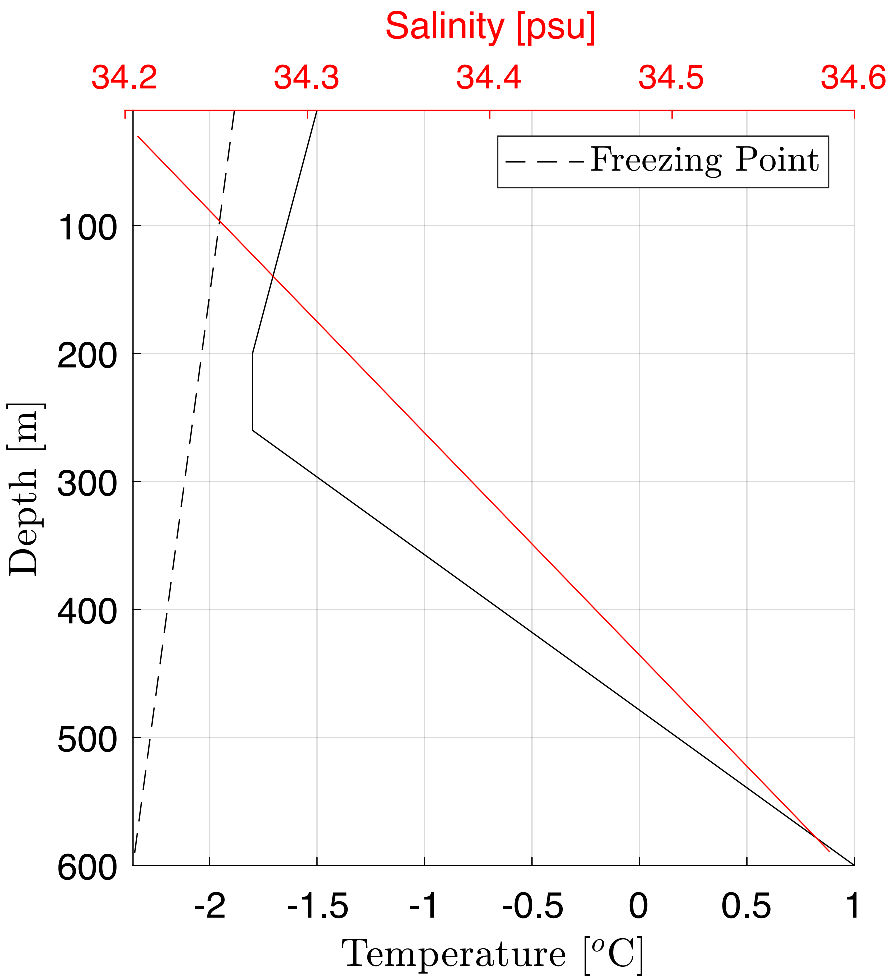
Holland & Feltham, *J. Fluid. Mech*. (2005)

We use MITgcm to study ocean dynamics below an idealized ice-shelf, tuning rift volume and current intensity.

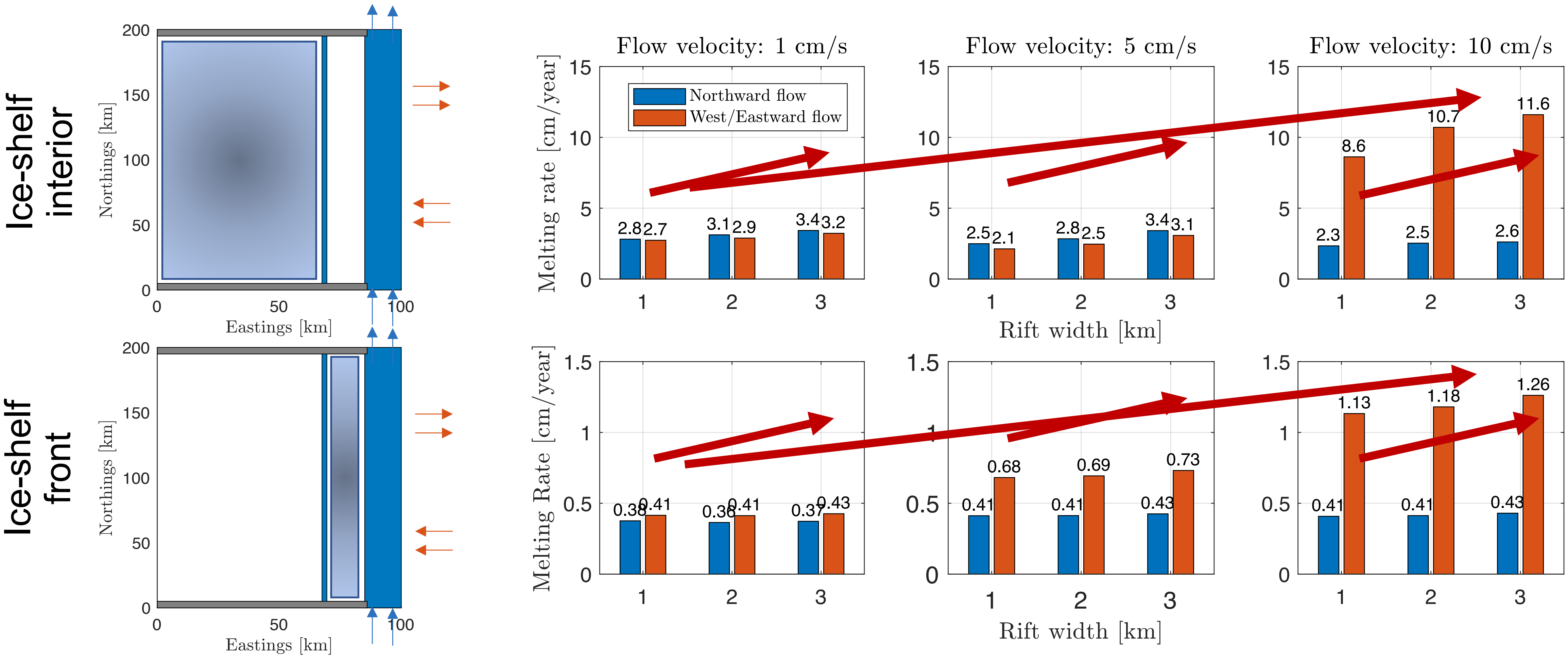


Boundary conditions represent a barotropic flow, characterized by a standard stratification vertical profile.



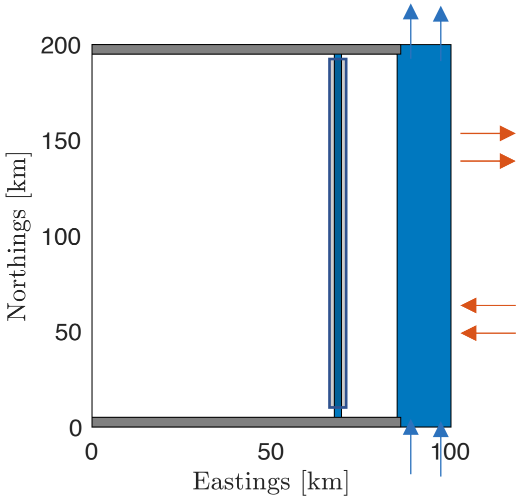


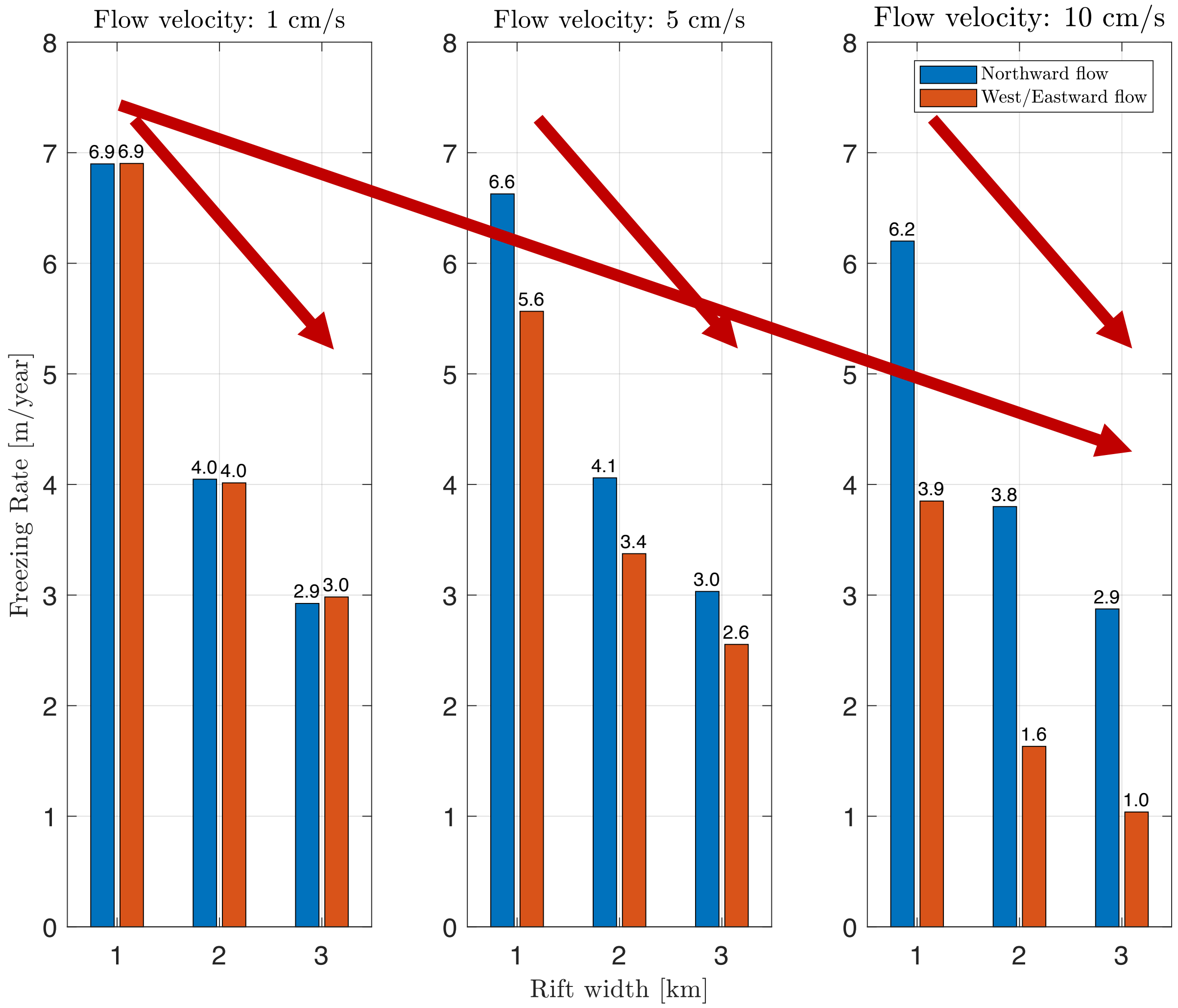
Average melting rate below the ice-shelf increases with rift widening.



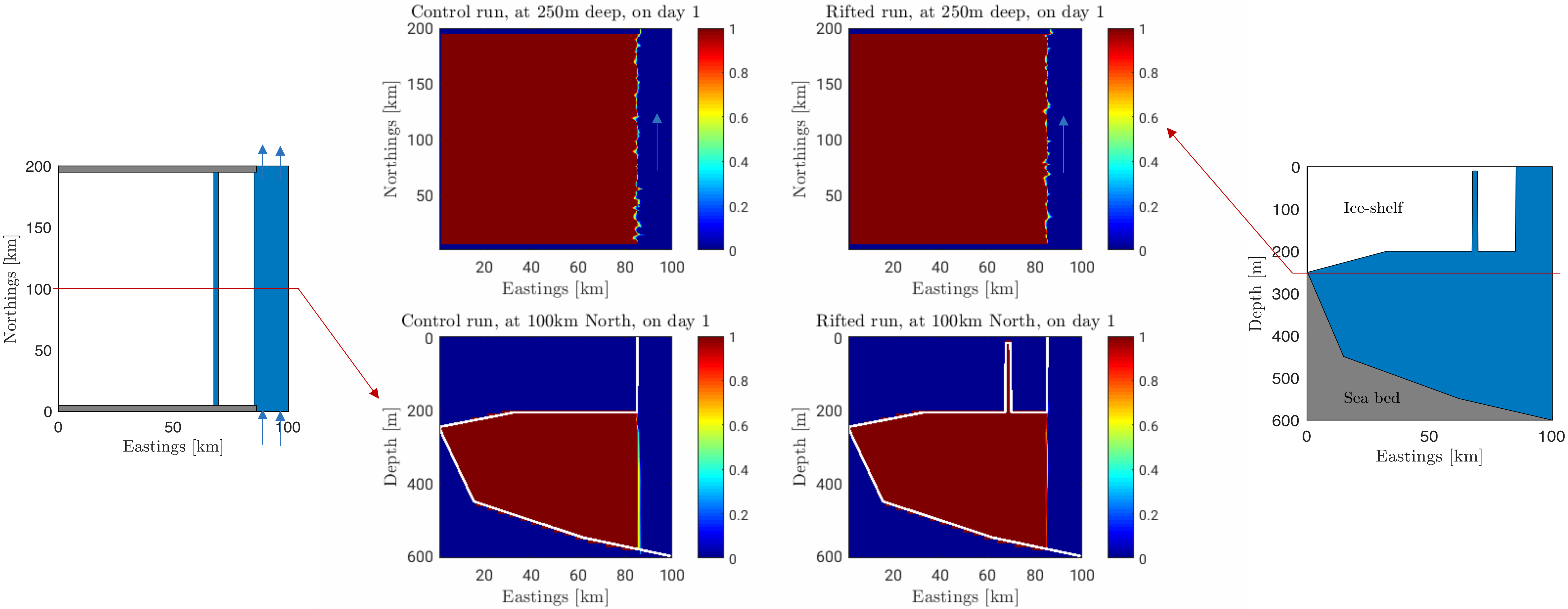
Average freezing rate inside the rift drops with rift widening.

Rift

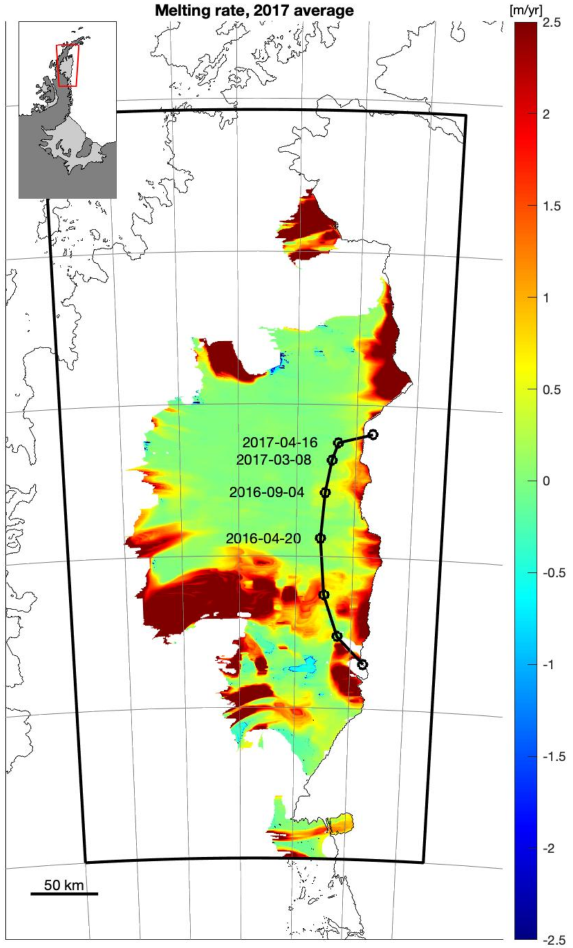


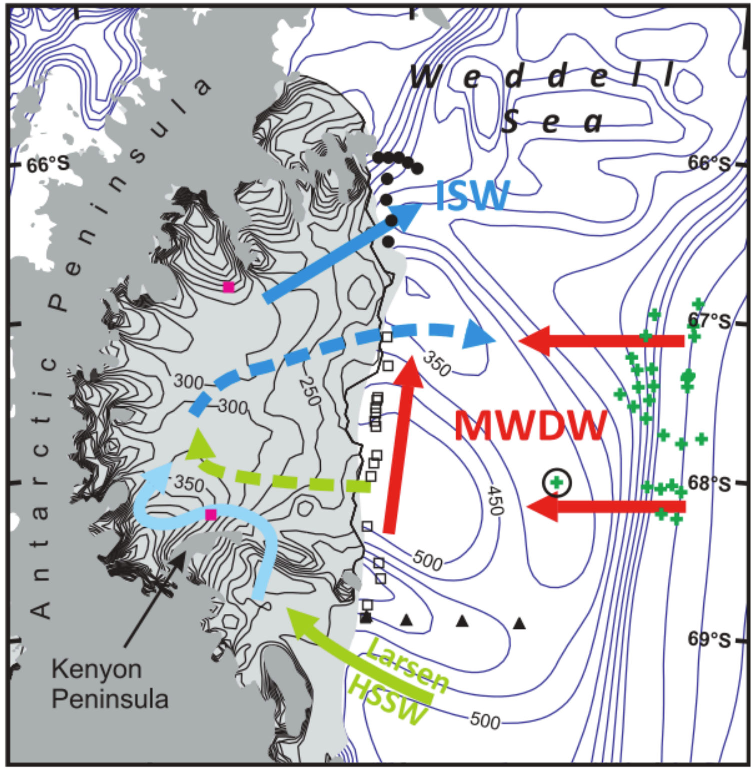


Compared to a fully intact shelf, rift presence dampens the intrusion of water masses from outside the cavity.



We aim to quantify the intrusion of water masses in the Larsen C ice-shelf during the propagation of A68 rift in 2016-2017.





After: Nicholls et al., *Geophys. Res. Lett.* (2012)

Conclusions

1. The larger the rift, the higher melting all over the ice-shelf.

2. A small volume rift, in combination with weak along-front currents imply enhanced freezing within rift flanks.

3. Freezing in between rift flanks rejects cold and salty water into the cavity, dampening the intrusion of water masses.

4. Currently, we are modeling ocean circulation on Larsen C, during the development of A68 berg, in order to quantify effects of the rift in the melting of the shelf.

Thank you!

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