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Ice-sheet-ocean interactions in Greenland fjords

2017 ECCO Meeting

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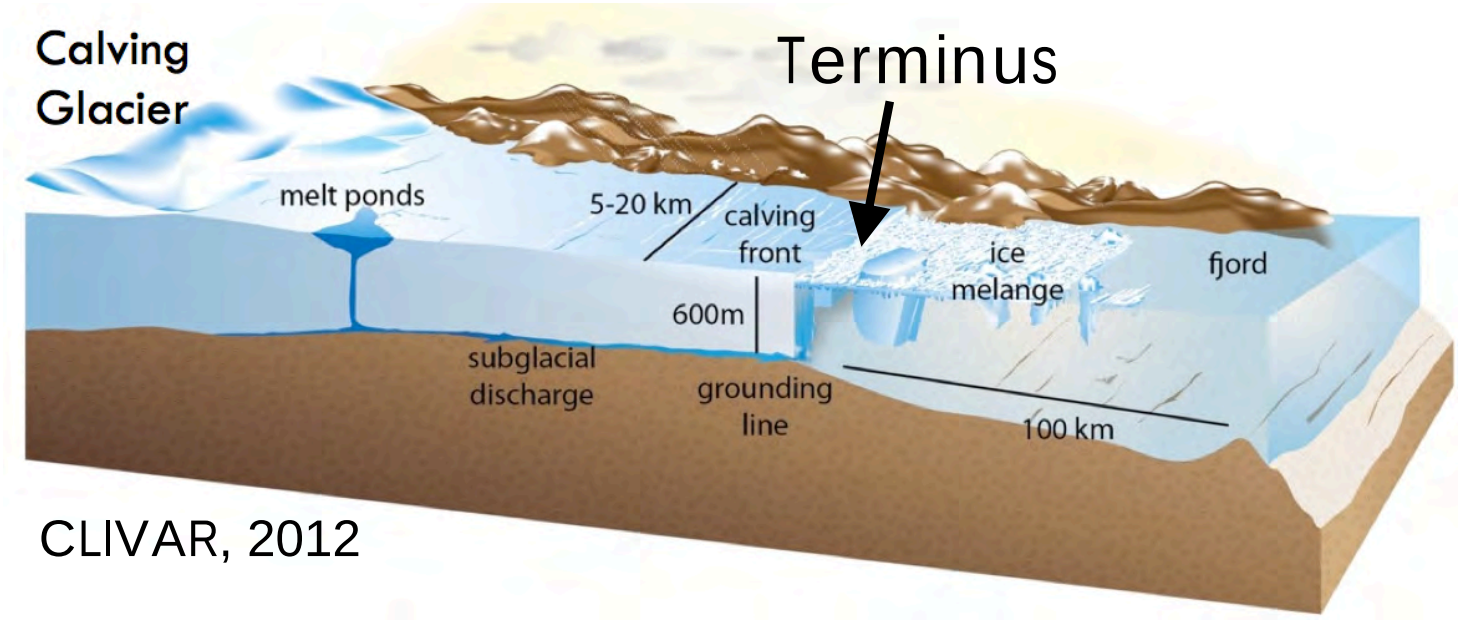
Greenland Fjords

- Greenland tidewater glaciers discharge into fjords
- Near-synchronous glacier retreat coincided with atmospheric and oceanic warming
- Dynamic mass losses (calving and melting) originated at termini, suggesting glacier sensitivity to ocean forcing

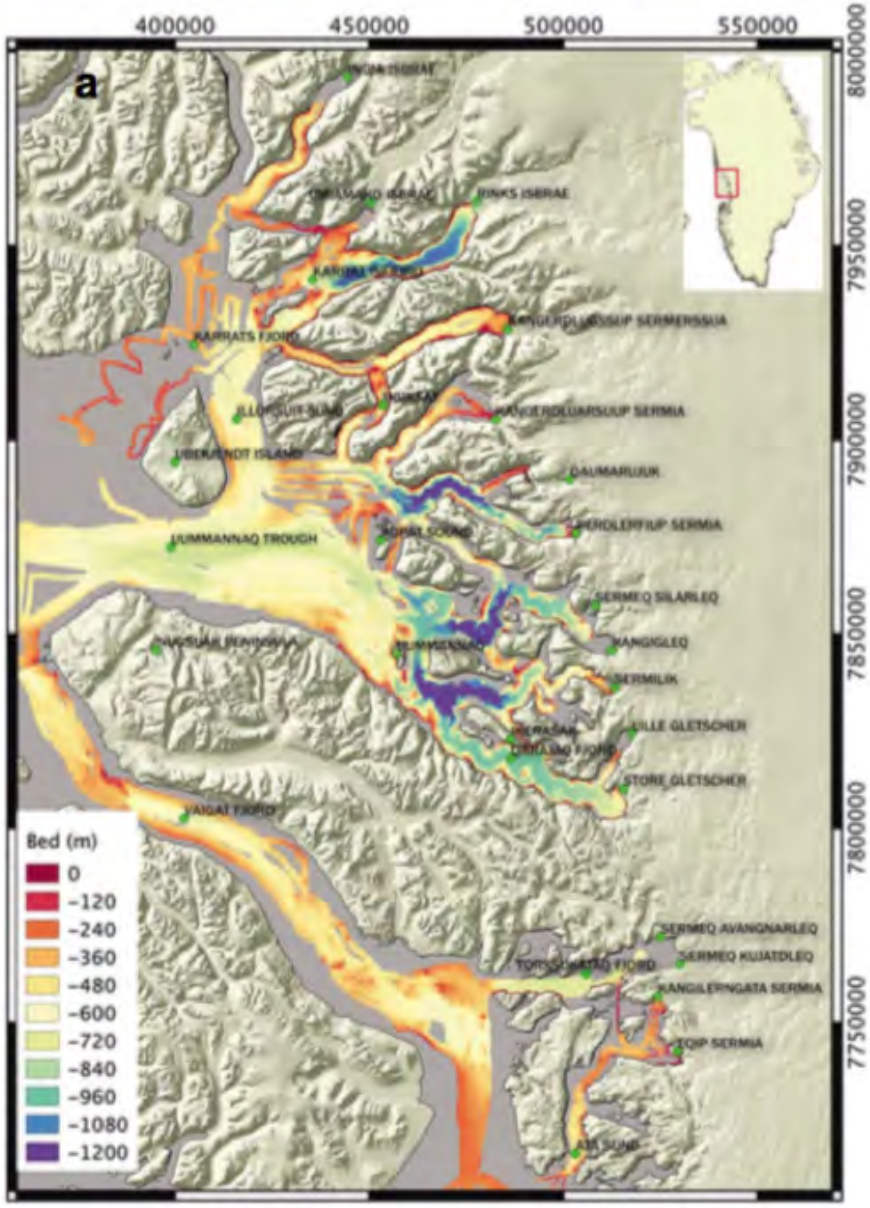
Straneo et al., 2016



CLIVAR, 2012

Bathymetric Pathways

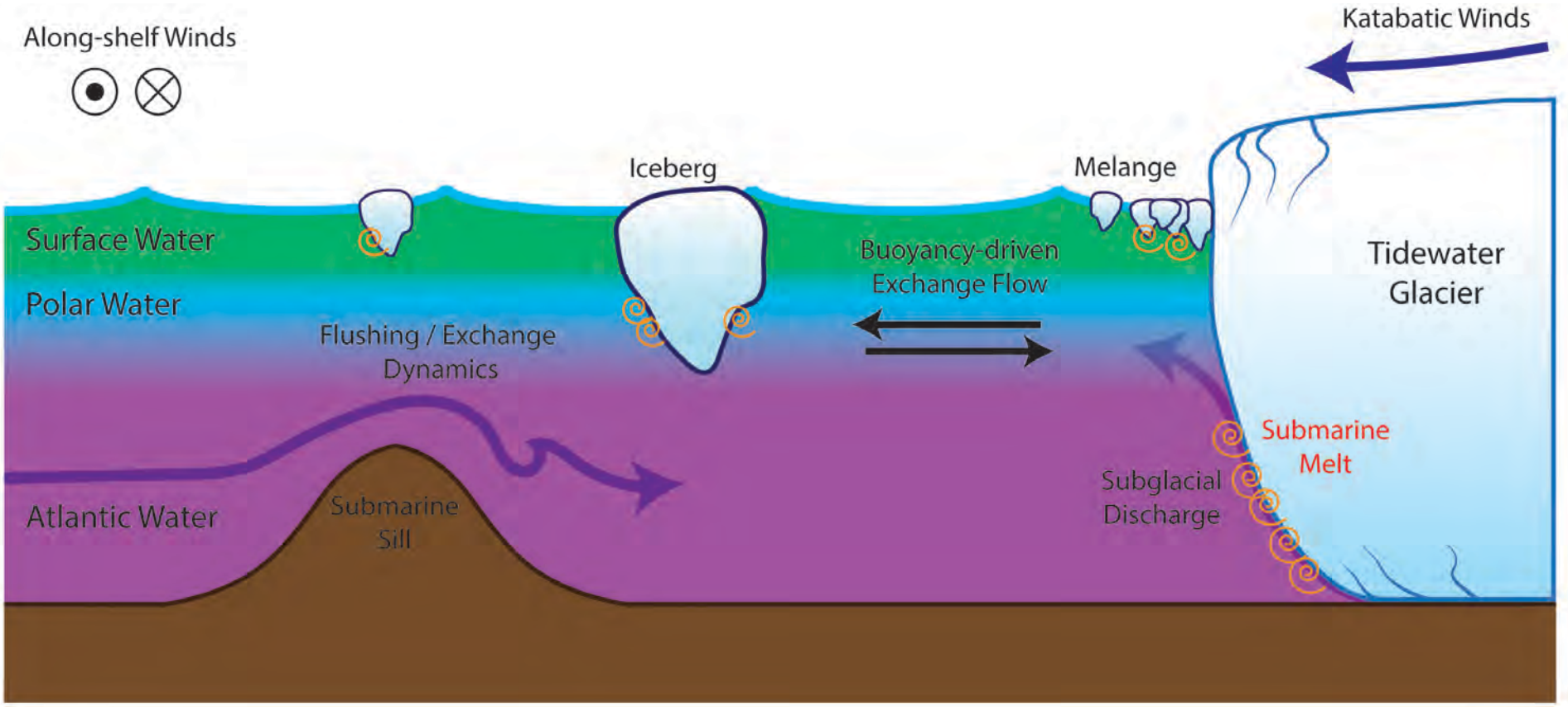
- Bathymetry is O(1)
- Inflow of warm shelf waters and export of glacially-modified waters is modulated by submarine topography
- Need to characterize the relative magnitude and timing of fjord-scale processes across Greenland



Rignot et al., 2016

Fjord-scale Processes

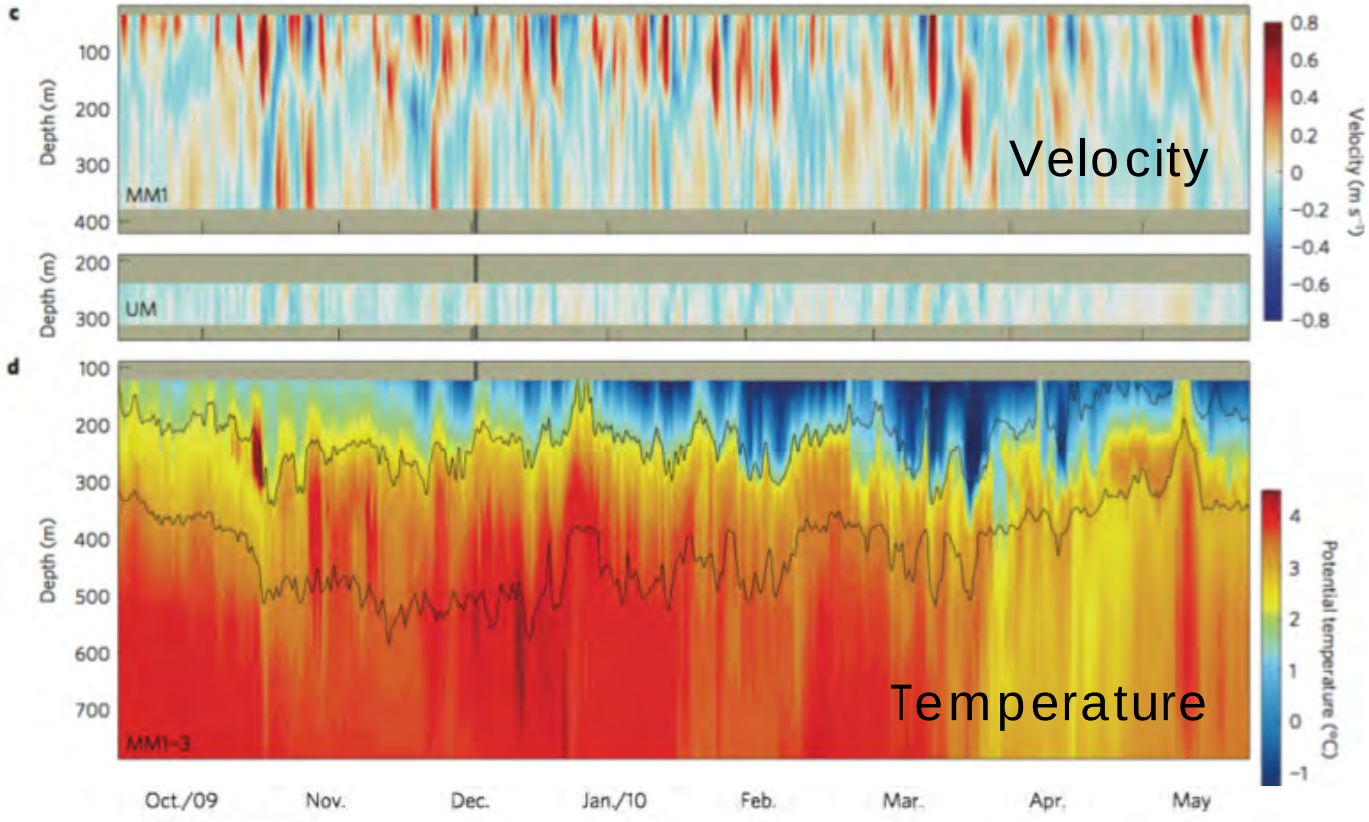
- Greenland fjords act as mixing zones



Forcing: shelf winds and inflows, buoyancy, tide-sill mixing

Forcing: Shelf Winds

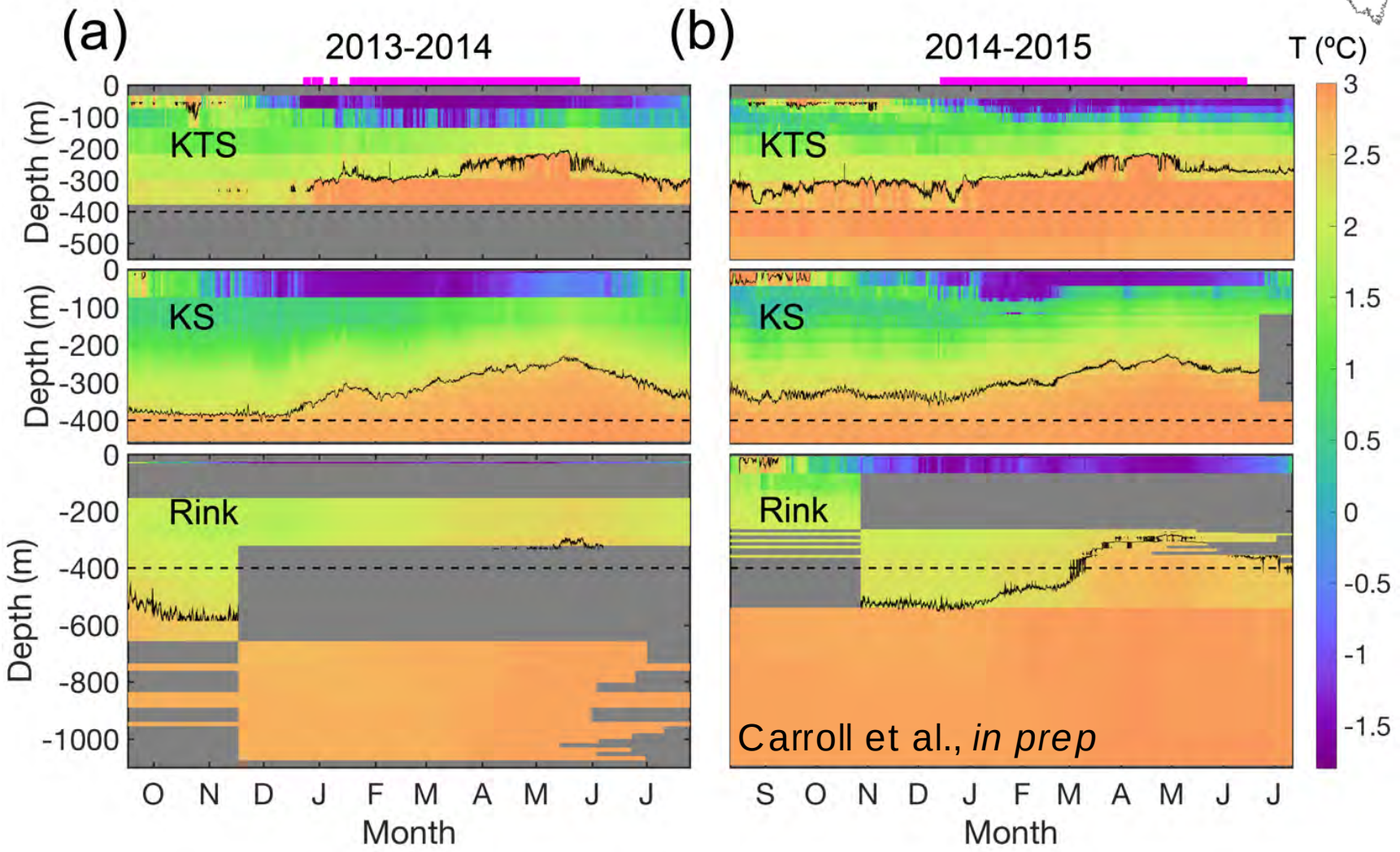
Sermilik Fjord, SE Greenland, Oct-May



Jackson et al., 2014,2016
Sutherland et al., 2014
Sutherland and Straneo 2012
Straneo et al., 2010

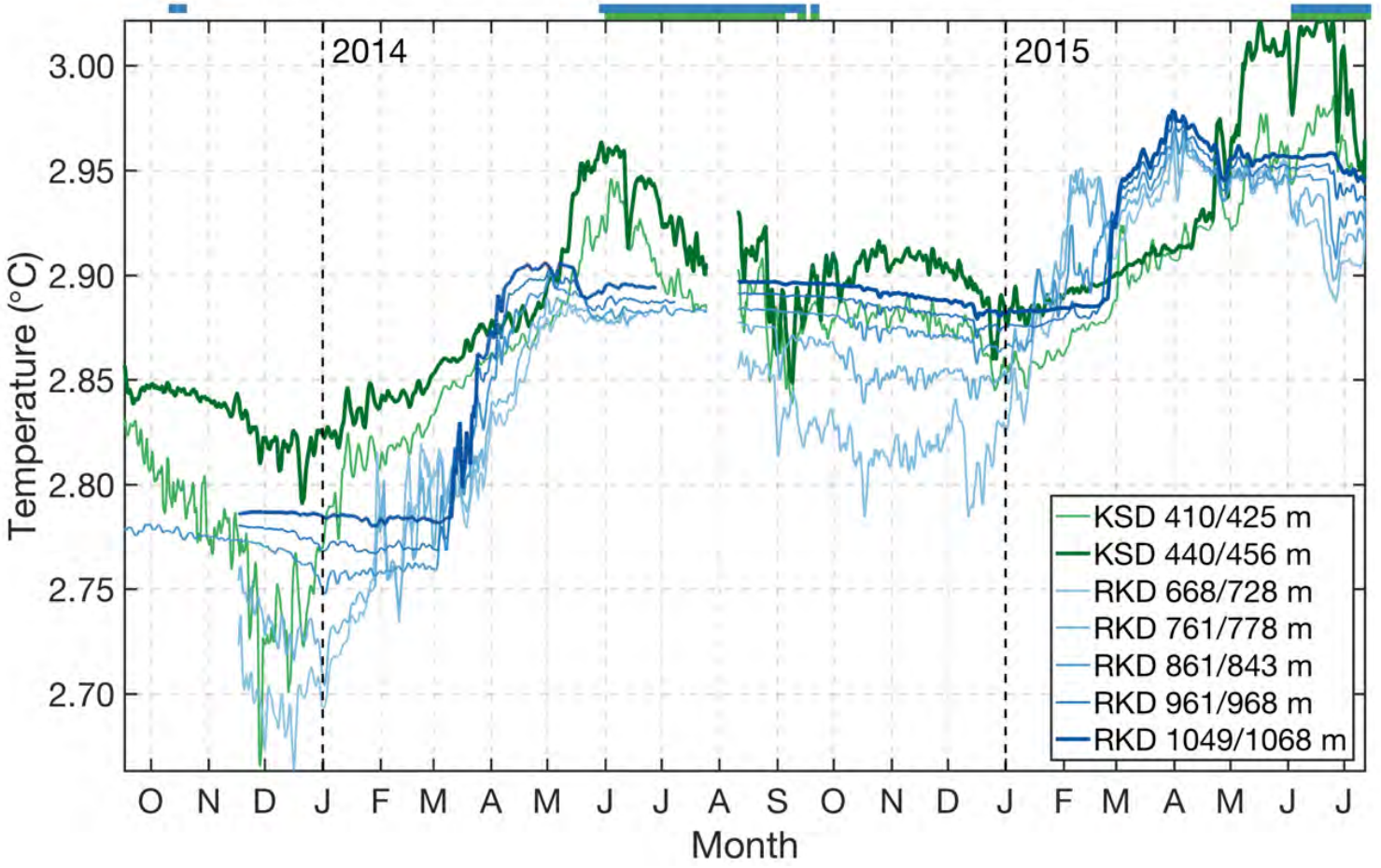
- Driven by density gradients between fjord and shelf, “intermediary circulation”
- Strongly sheared flows that reverse on synoptic timescales.
- Dominant mode of circulation in SE Greenland during non-summer months

Forcing: Shelf Inflows



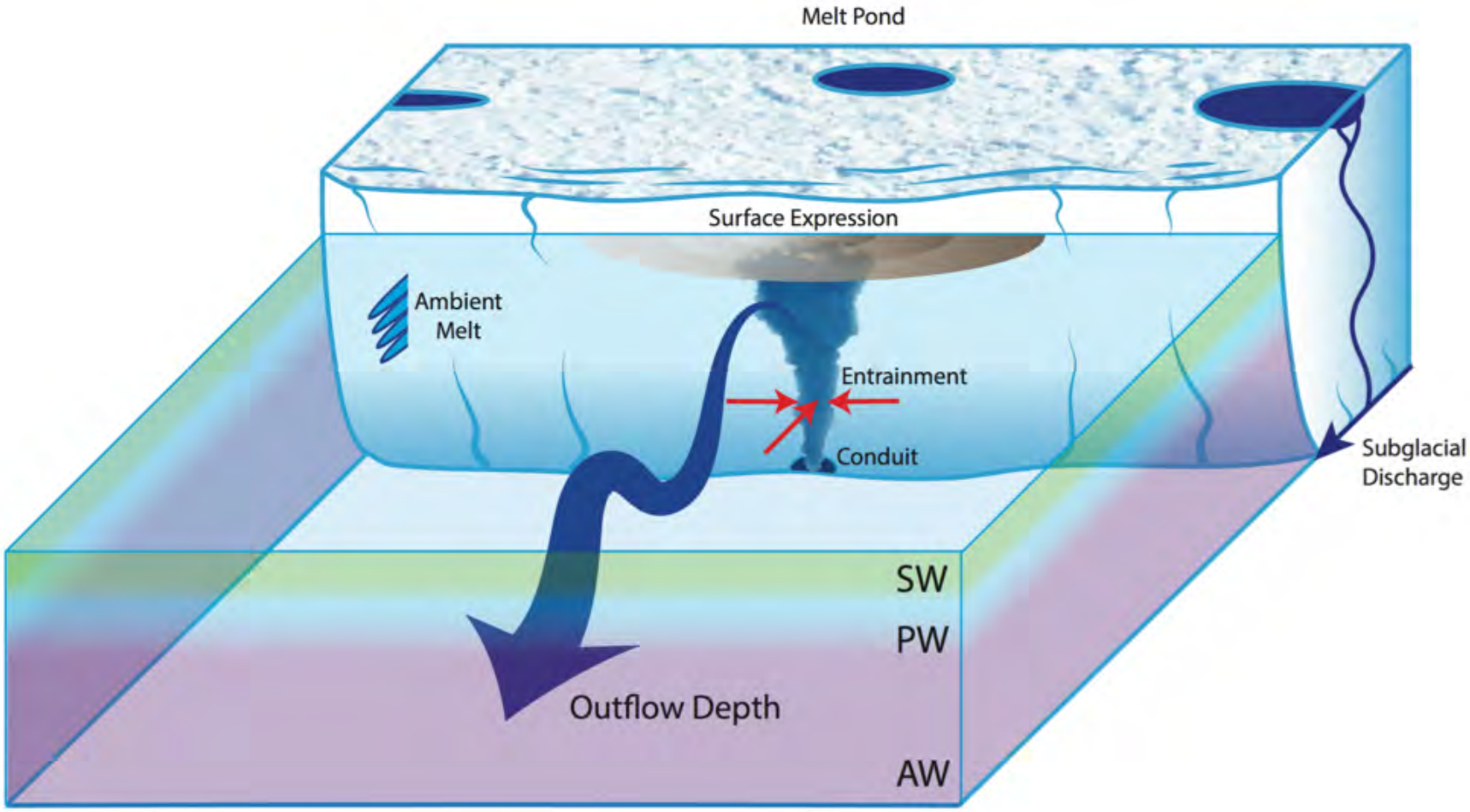
- Seasonality dominates hydrographic variability in Uummannaq Bay, west Greenland

Forcing: Shelf Inflows



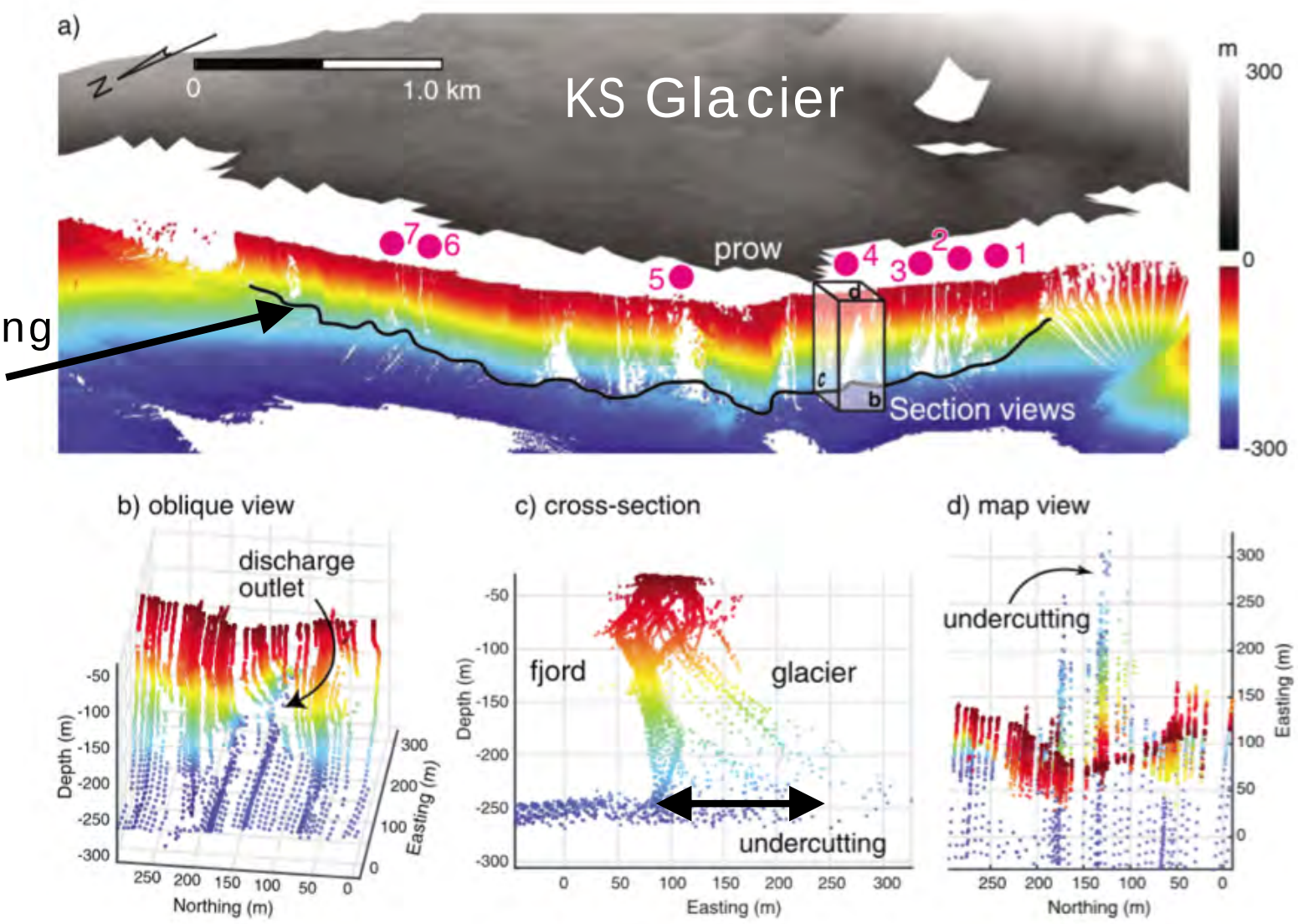
- Renewal of deep fjord waters triggered by inflow of dense shelf AW
- Deep offshore trough results in close coupling between fjords and West Greenland boundary current

Forcing: Buoyancy



Xu et al., 2013, 2014
Sciascia et al., 2013
Carroll et al., 2015, 2016
Slater et al., 2015, 2016

Feedbacks on Calving

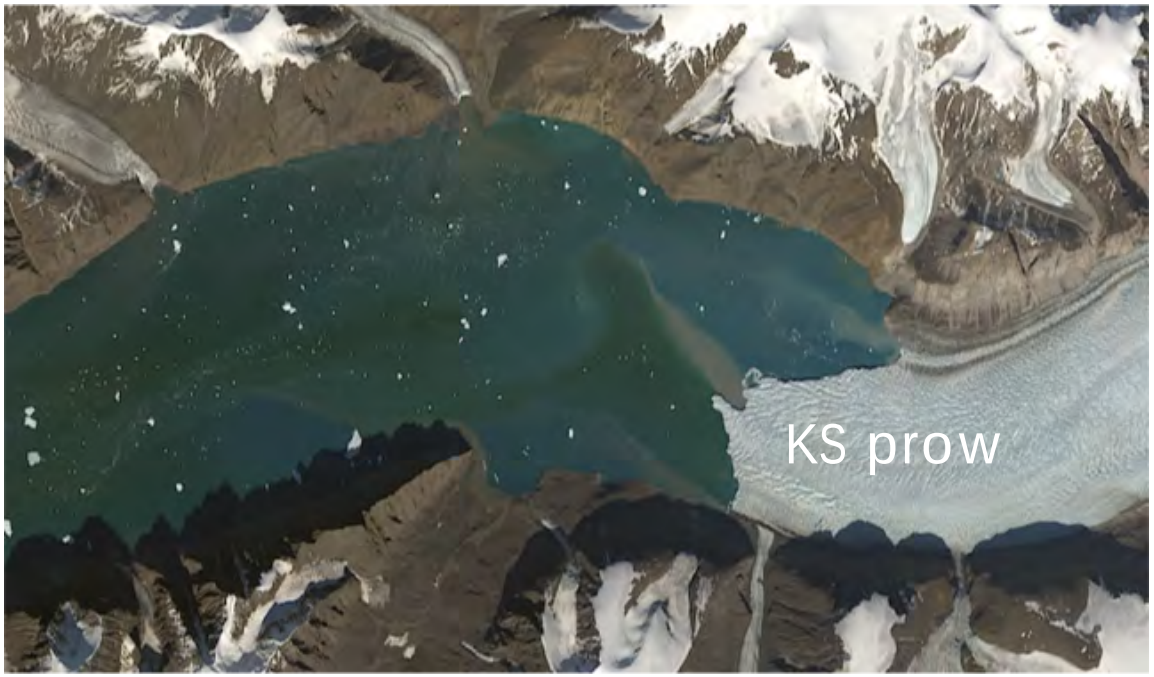


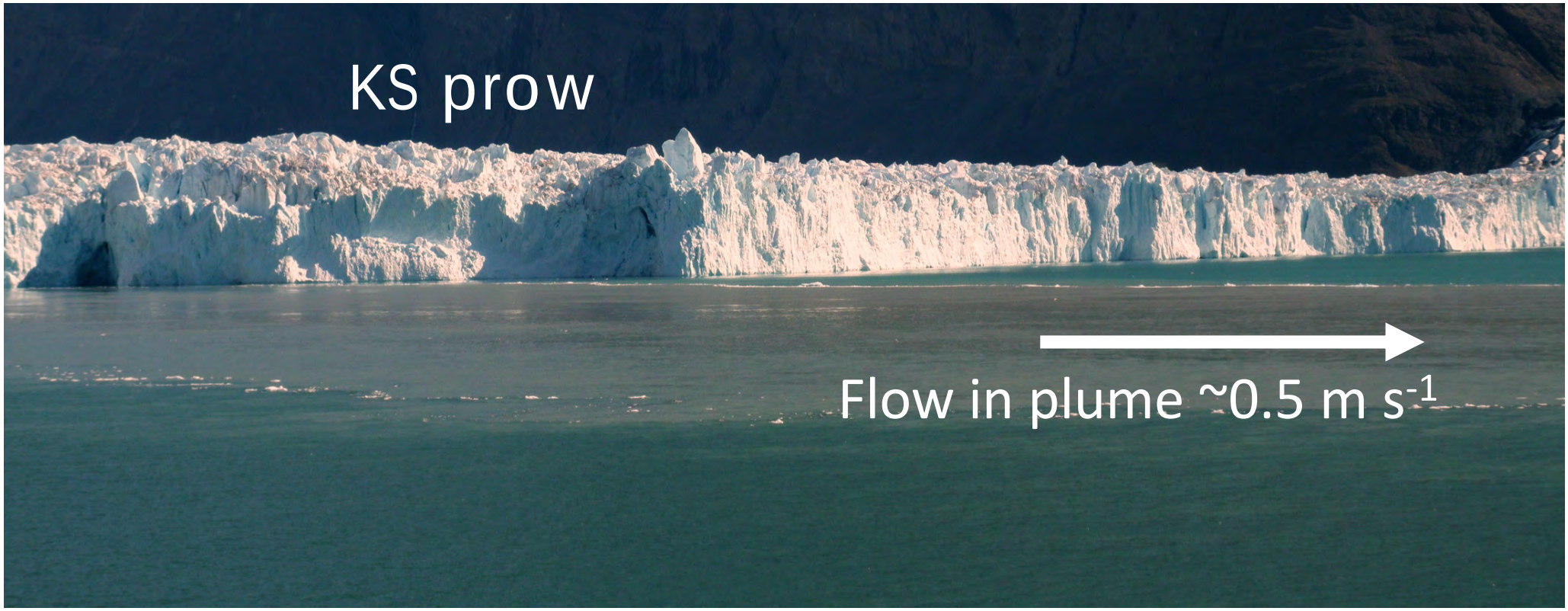
Grounding Line

Fried et al., 2015
Rignot et al., 2015

Elevated submarine melt and calving near subglacial discharge conduit

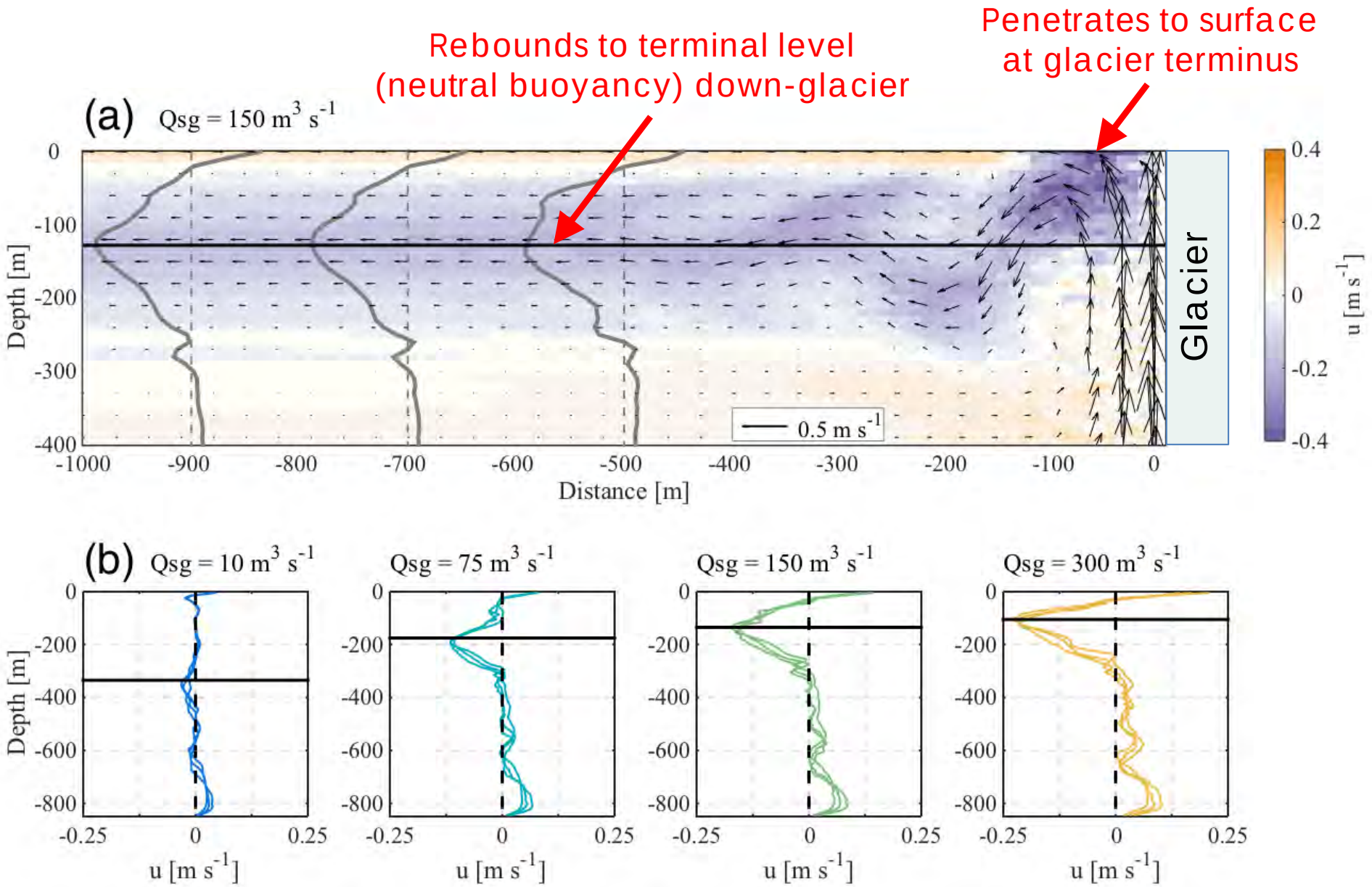
Feedbacks on fjord circulation





MITgcm
non-hydrostatic
10 m resolution

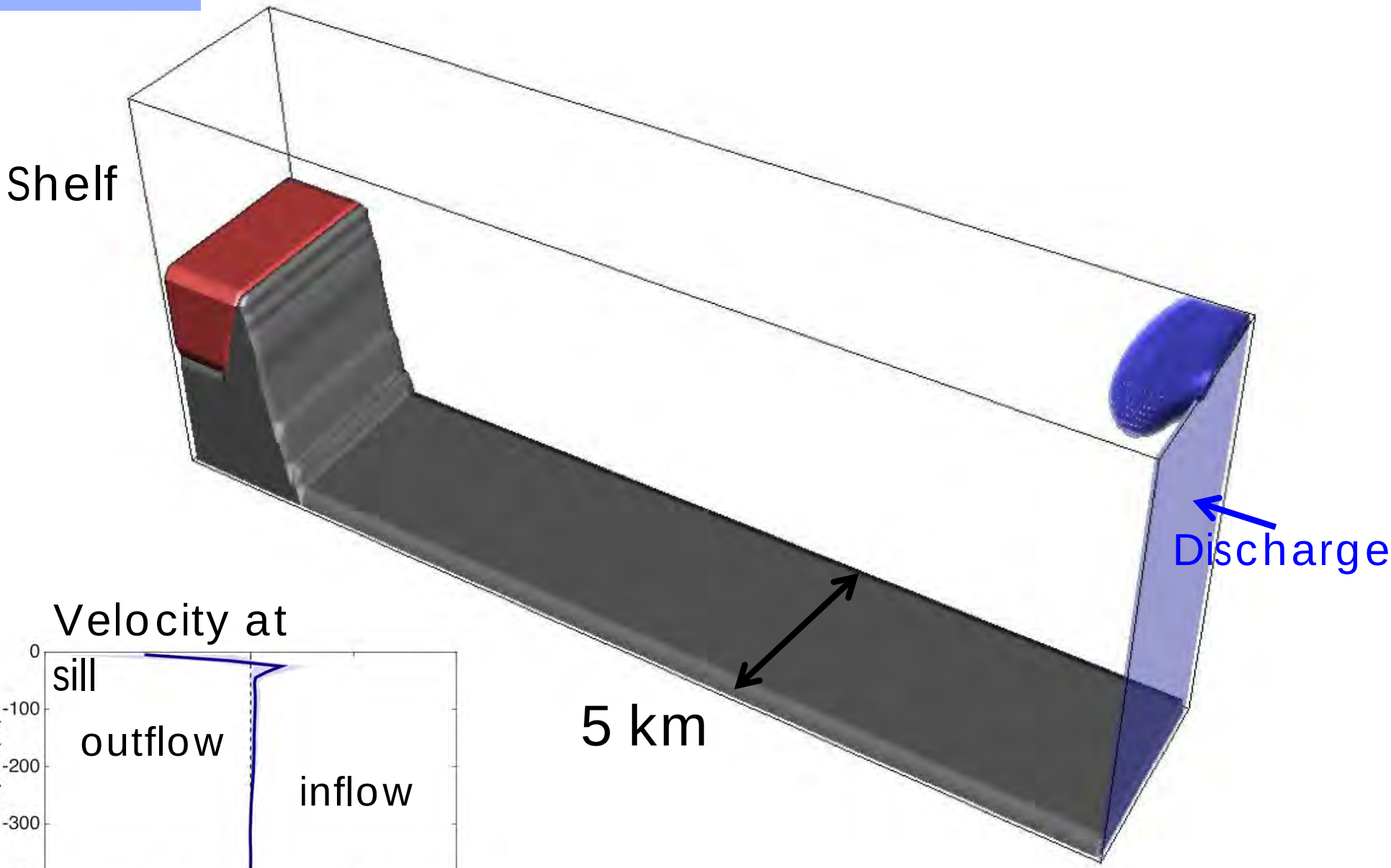
Forcing: Buoyancy



Carroll et al., 2015

Narrow
Shallow

Forcing: Buoyancy

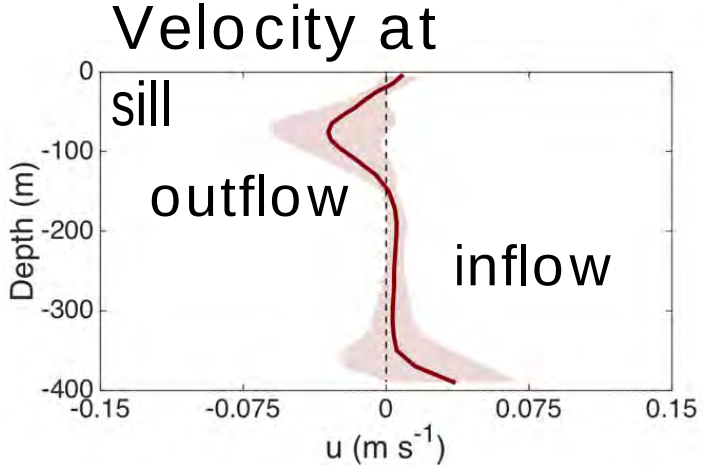


Velocity at

Wide
Deep

Forcing: Buoyancy

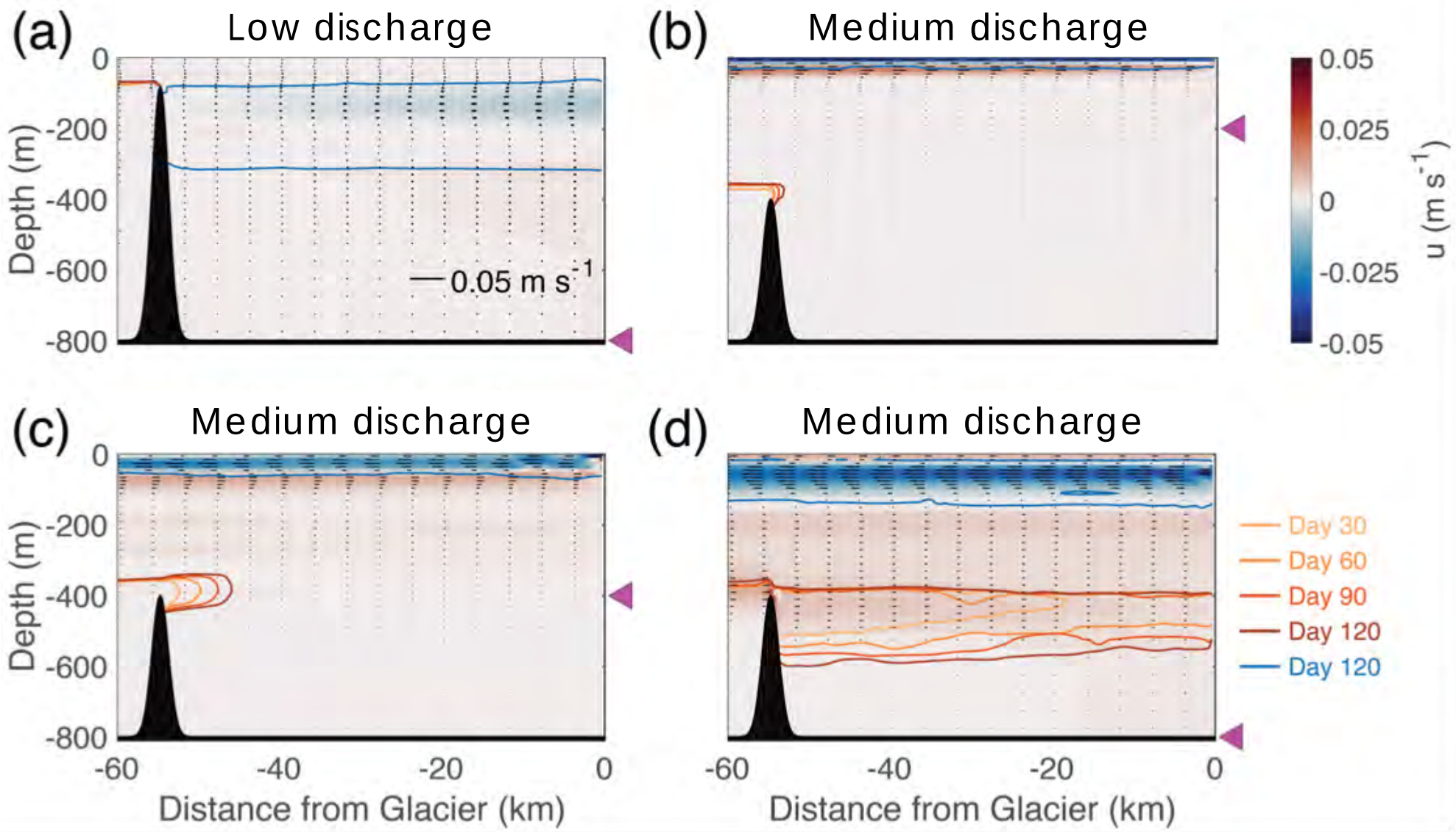
Shelf



10 km

Discharge

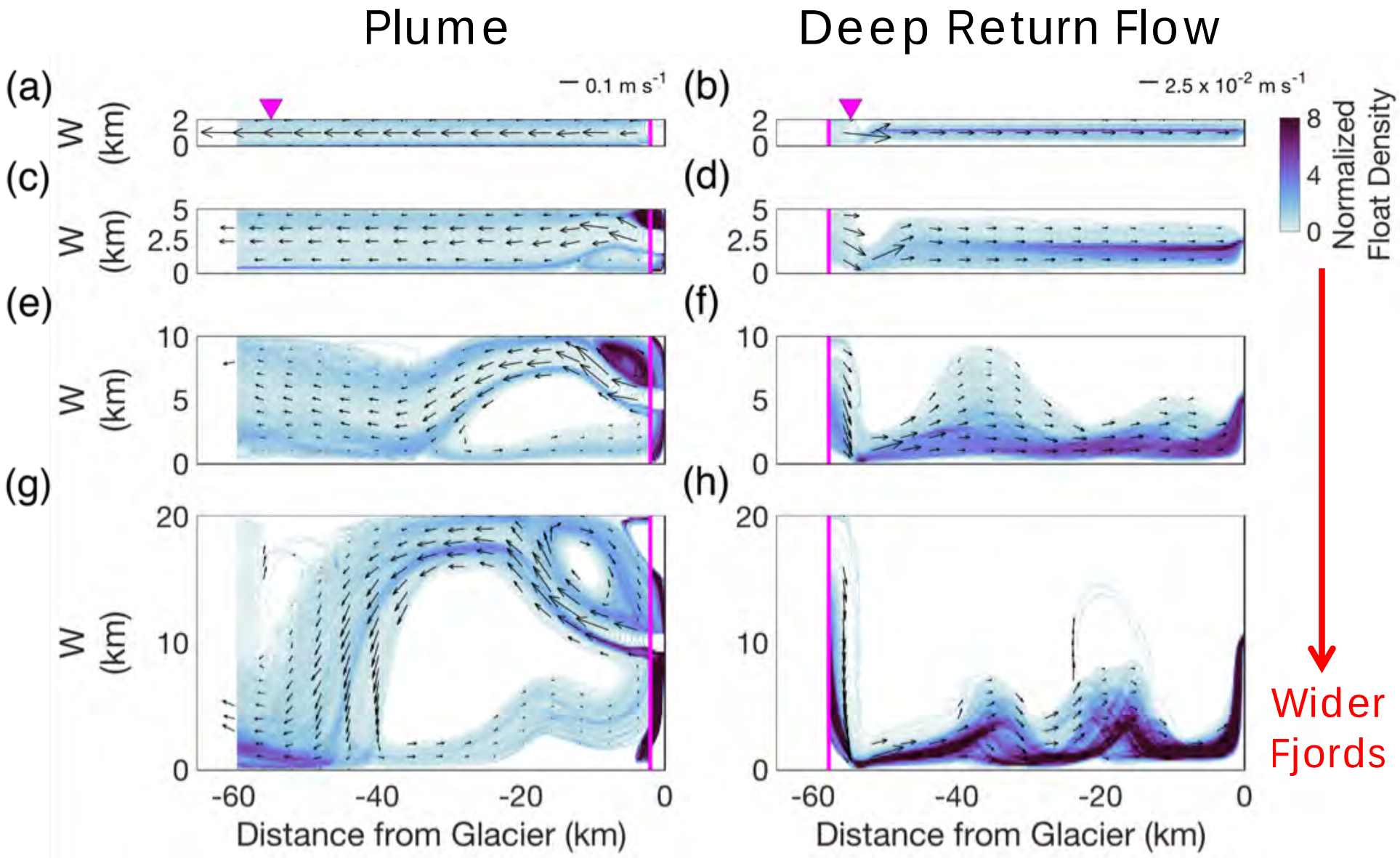
Forcing: Buoyancy



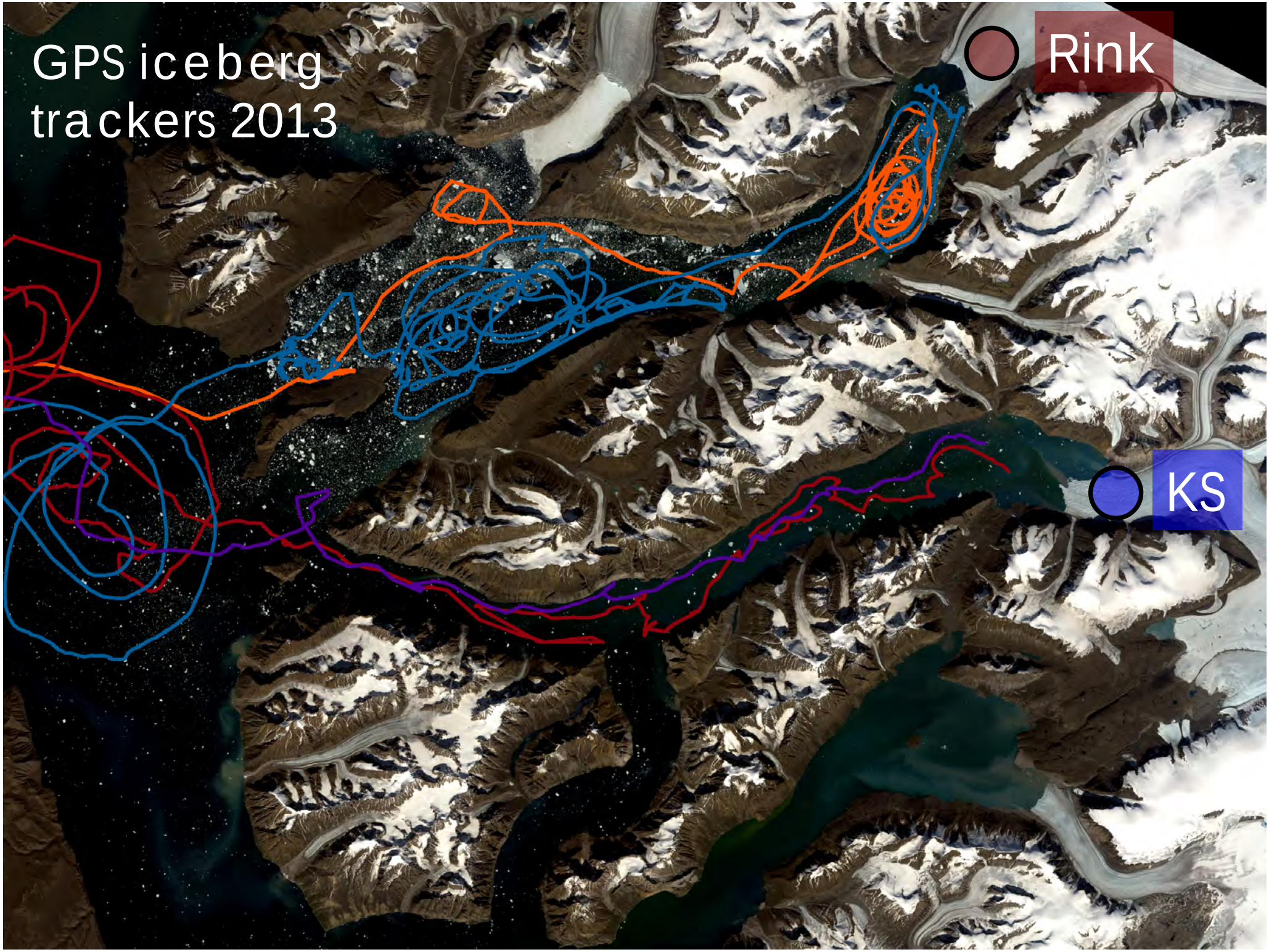
◀ = Grounding Line Depth

Carroll et al., 2017

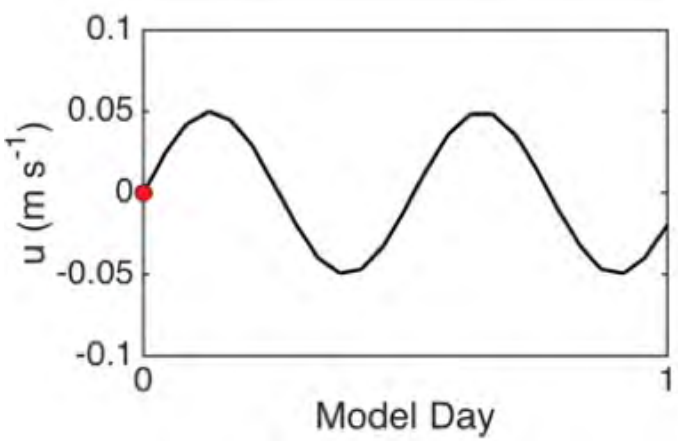
Forcing: Buoyancy

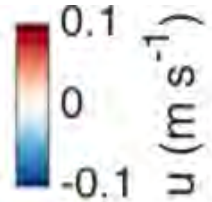


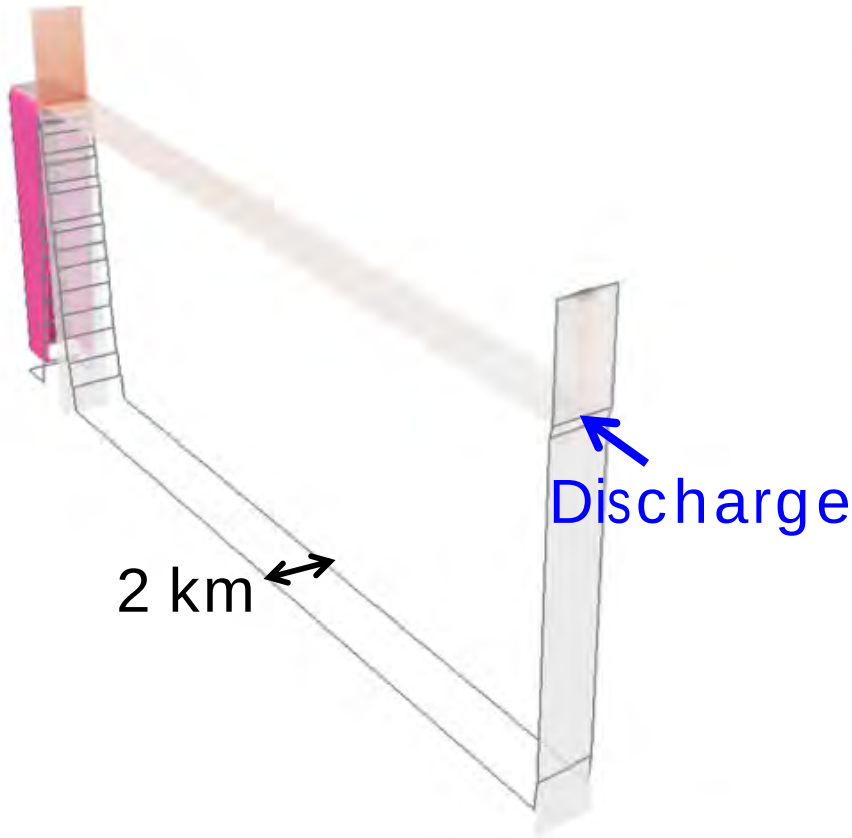
Carroll et al., 2017

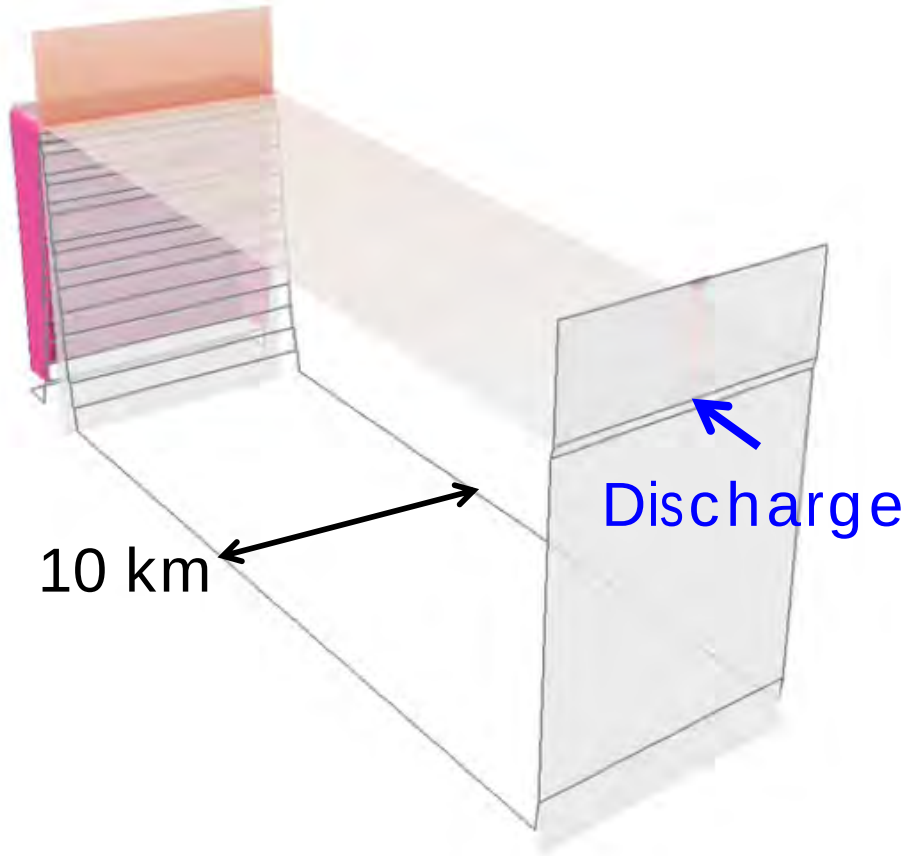

GPS iceberg trackers 2013
Rink
KS

Forcing: Tide-sill Mixing









Summary

- Need to quantify magnitude and timing of forcing mechanisms across parameter space of Greenland fjords.
- Critical to understand the complete shelf-trough-fjord-ice system
- Fjord-scale processes modulate submarine melting of Greenland outlet glaciers and freshwater transport to the North Atlantic