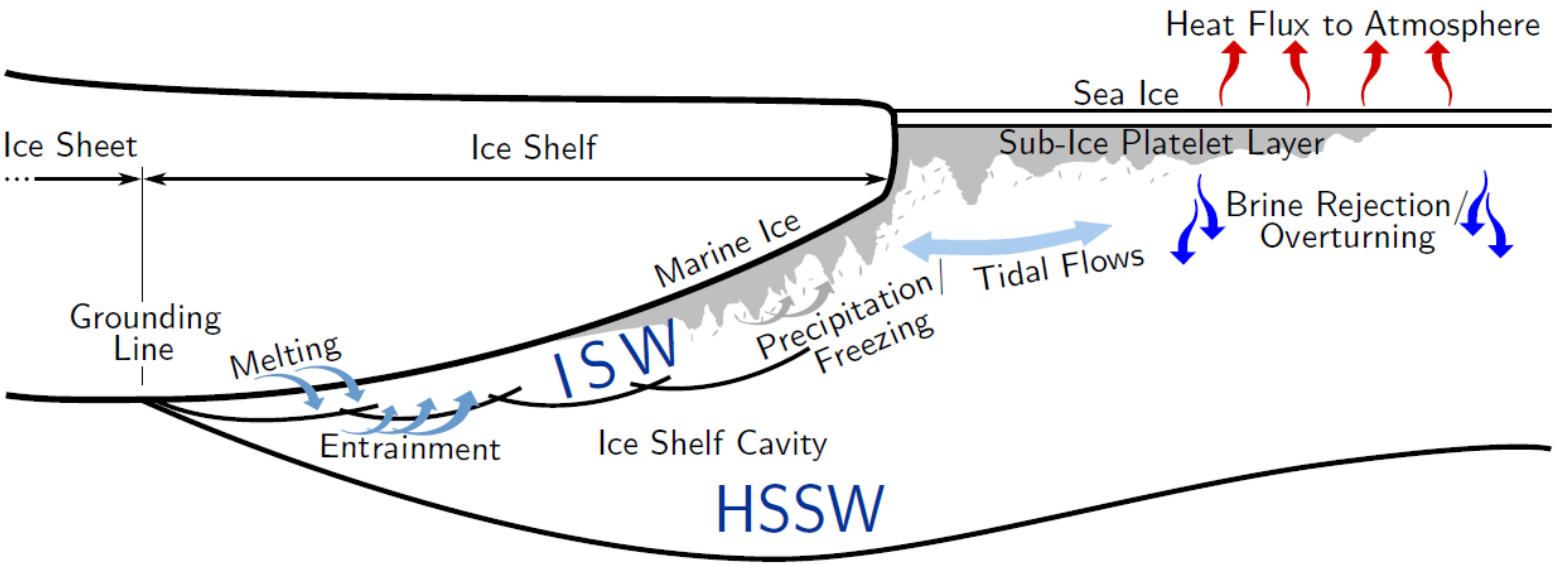
Extension of an Ice Shelf Water Plume Model

Ken Hughes

Pat Langhorne, Greg Leonard, Craig Stevens

Physical Processes



Ice Shelf Water (ISW): A water mass with a temperature below the surface freezing point

Location

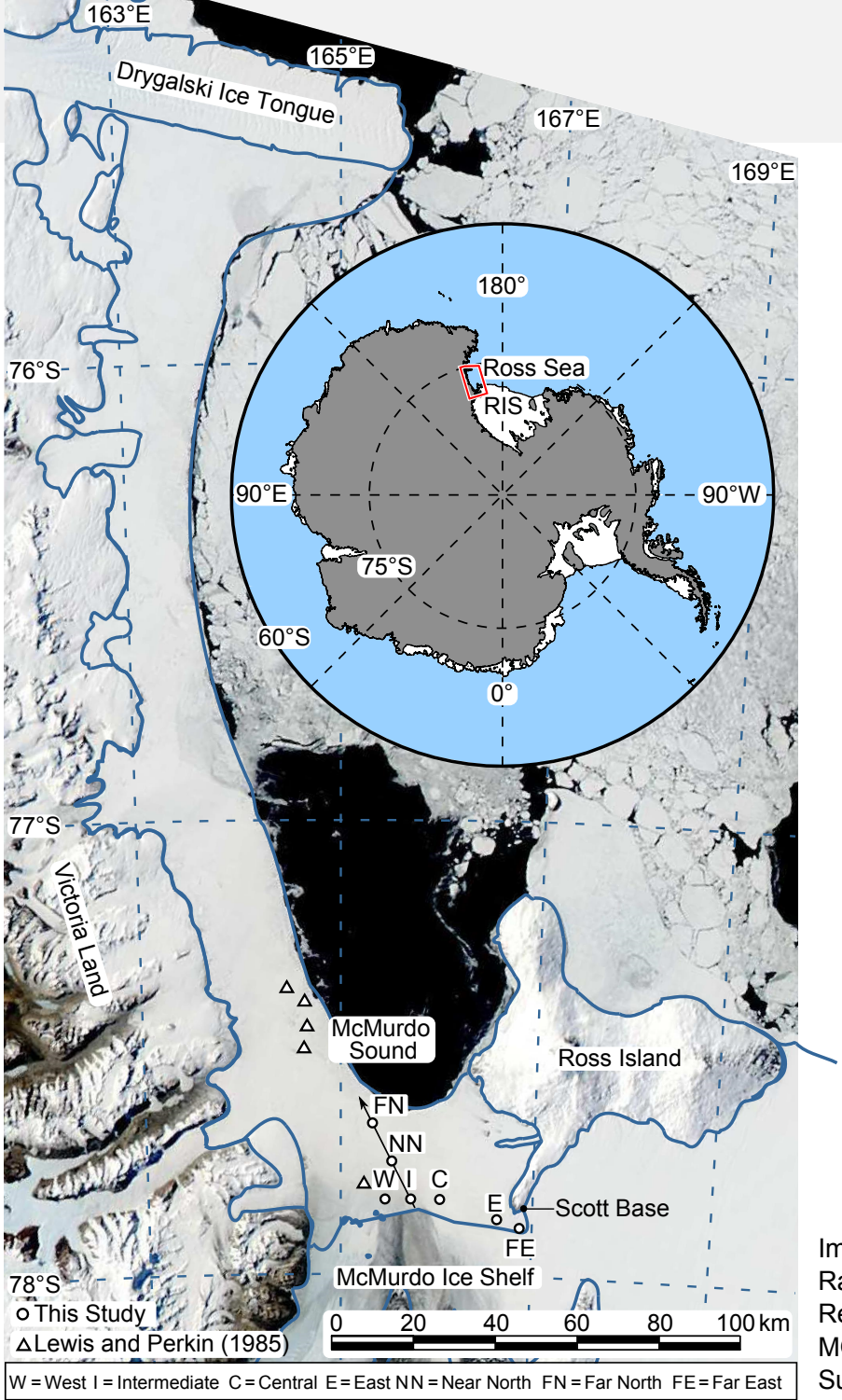
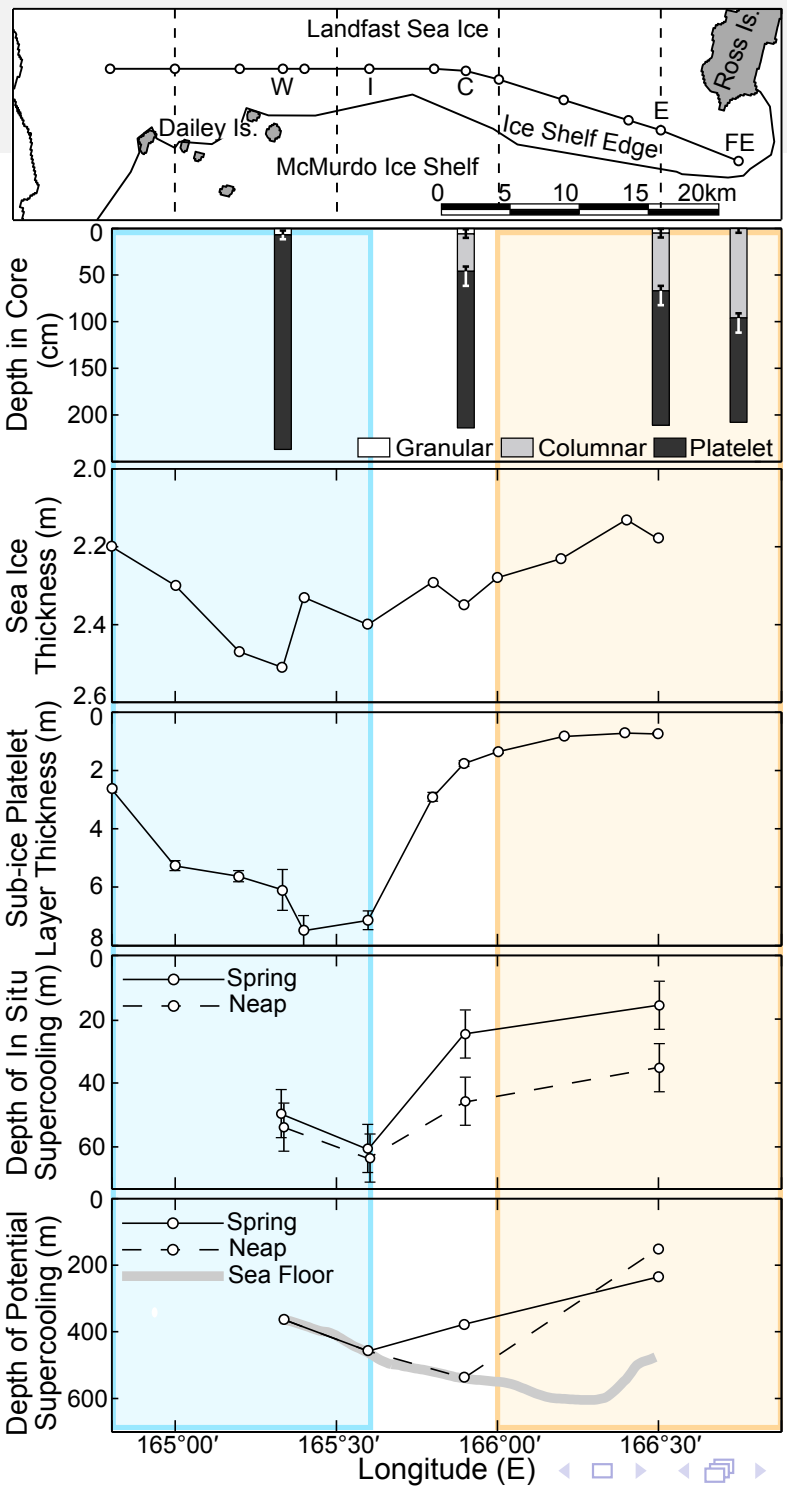
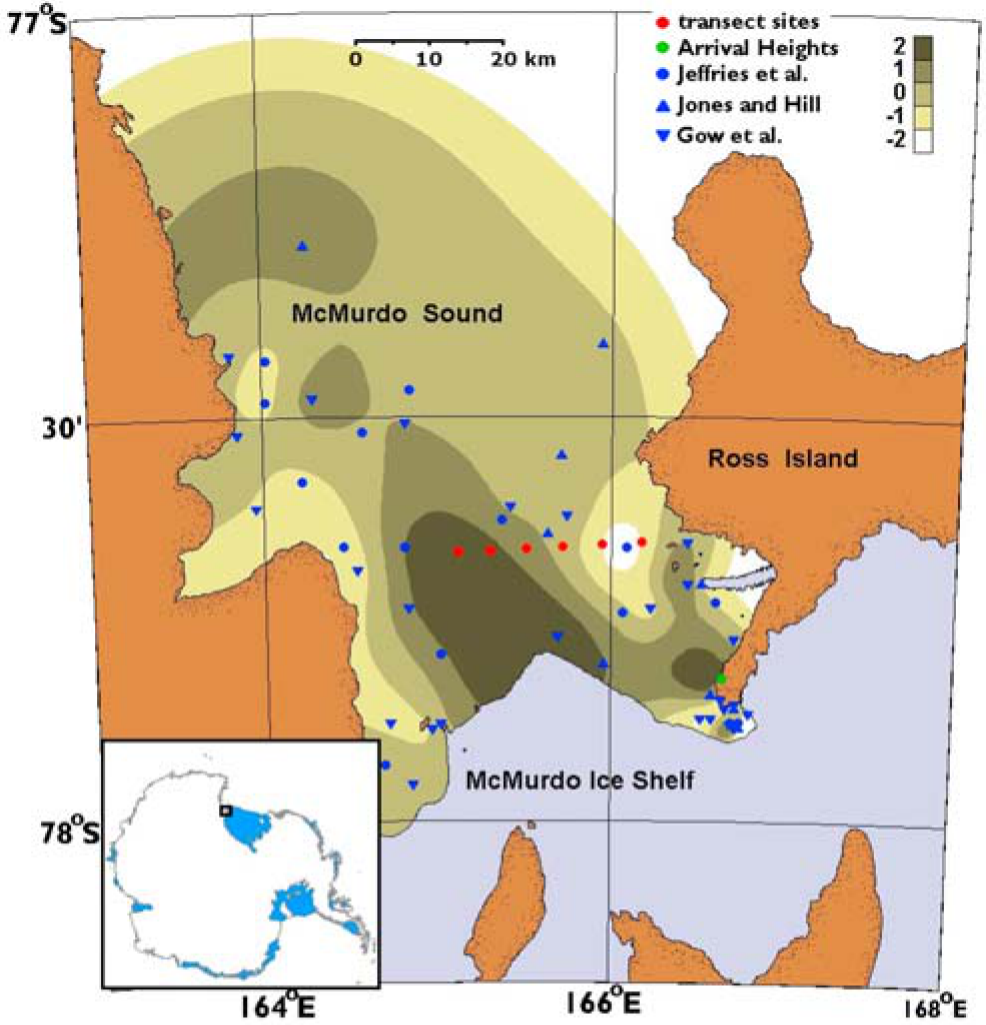


Image:NASA Rapid Response MODIS Subsets

Observations



What this means

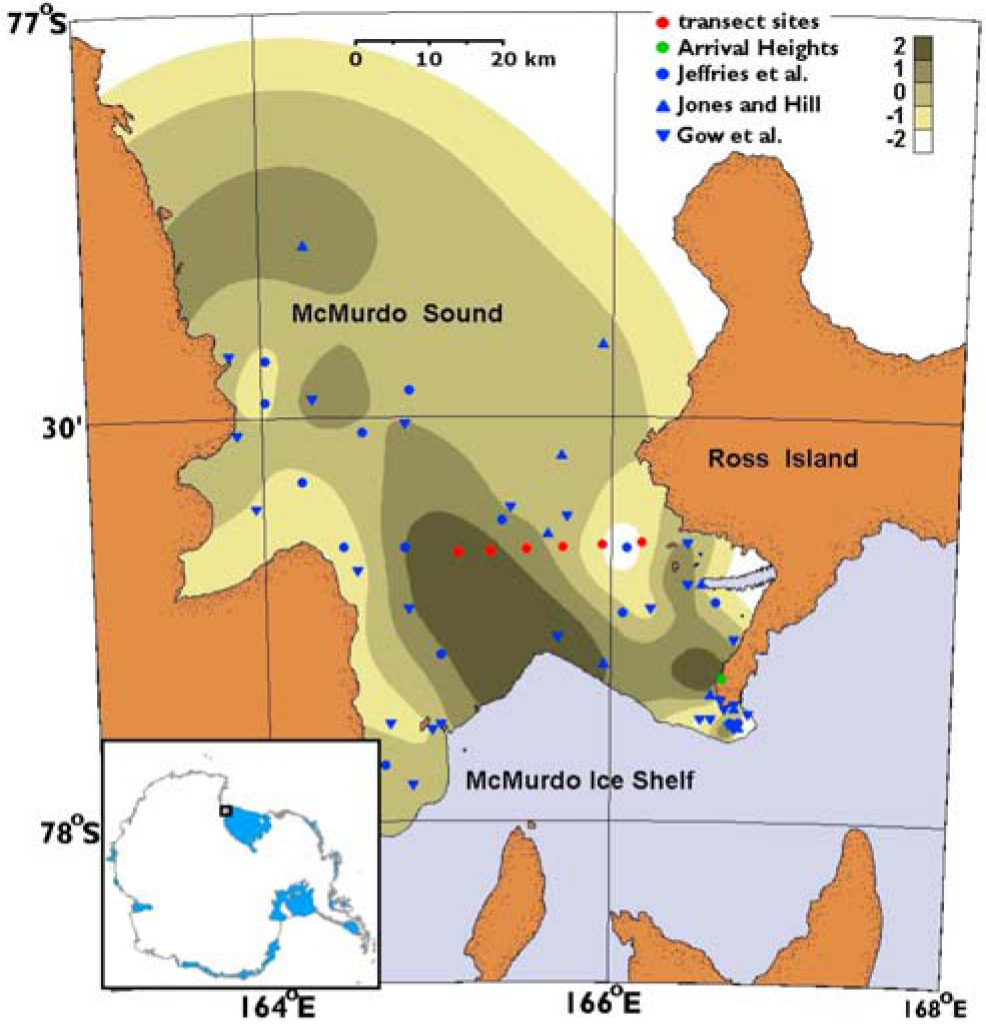


Dempsey et al. (2010), JGR, 115

- Our observations are consistent with the understood outflow of supercooled water
- High platelet percentages since we were very close to the ice shelf
- Platelet ice formation driven by oceanic processes

We want to model the supercooled water in McMurdo Sound

What this means



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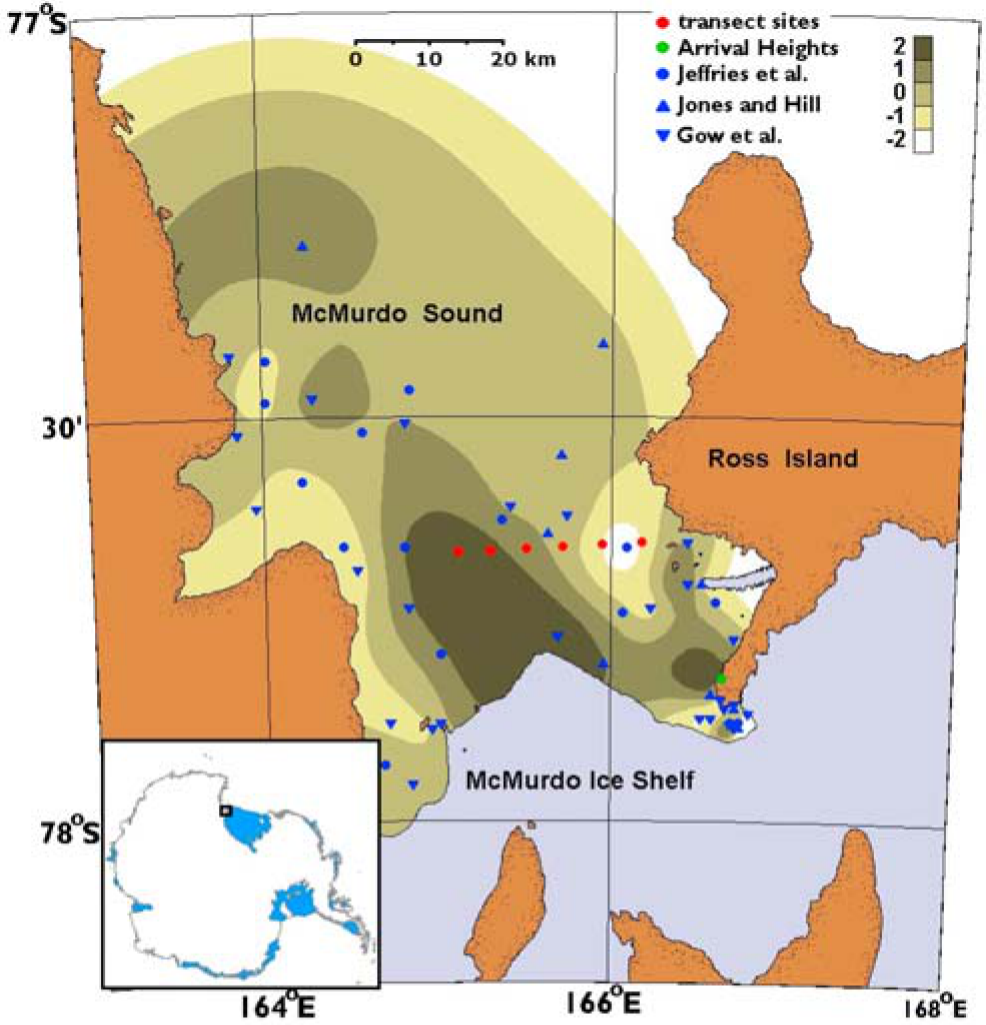

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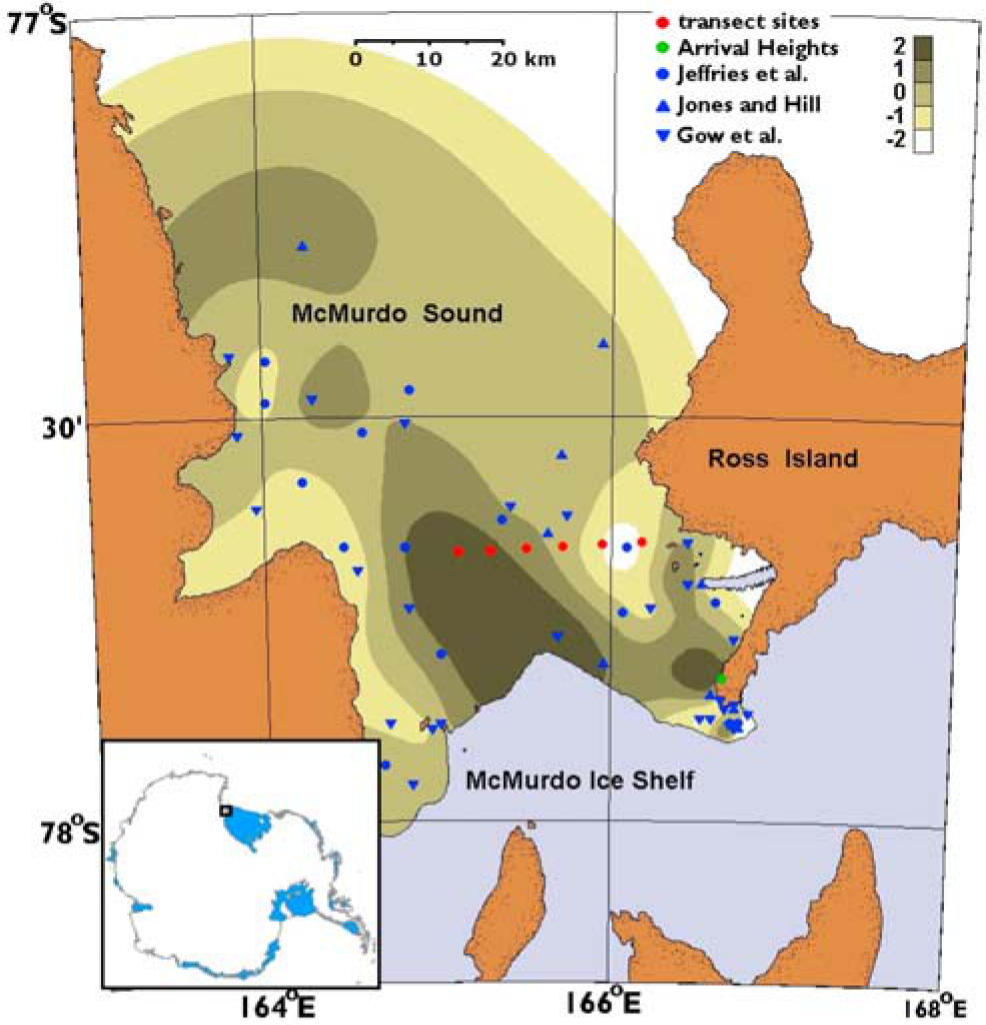

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Numerical Plume Model

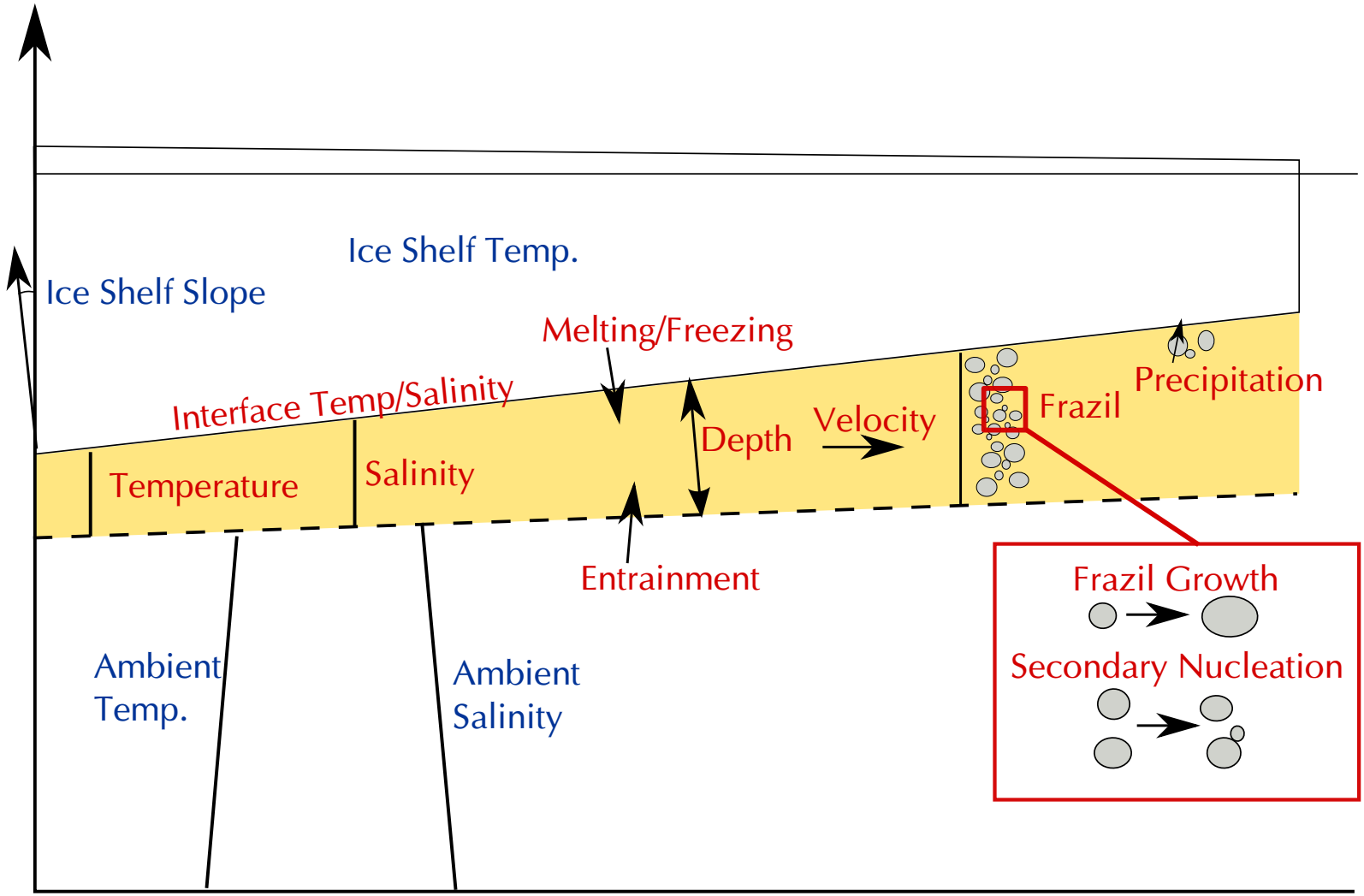
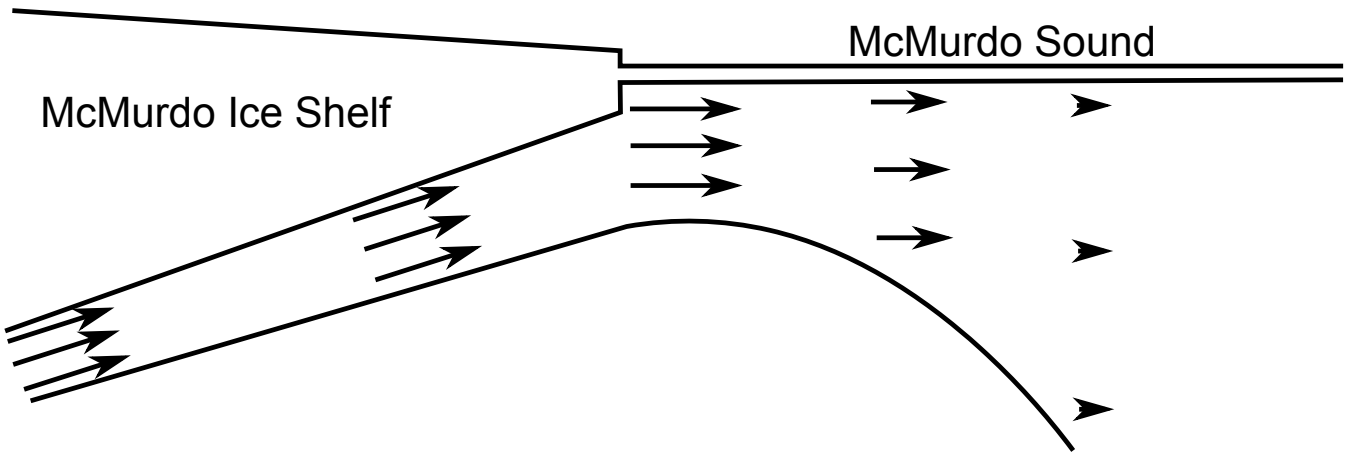


Image adapted from Smedsrud and Jenkins (2004), JGR, 109

Extension to Sea Ice



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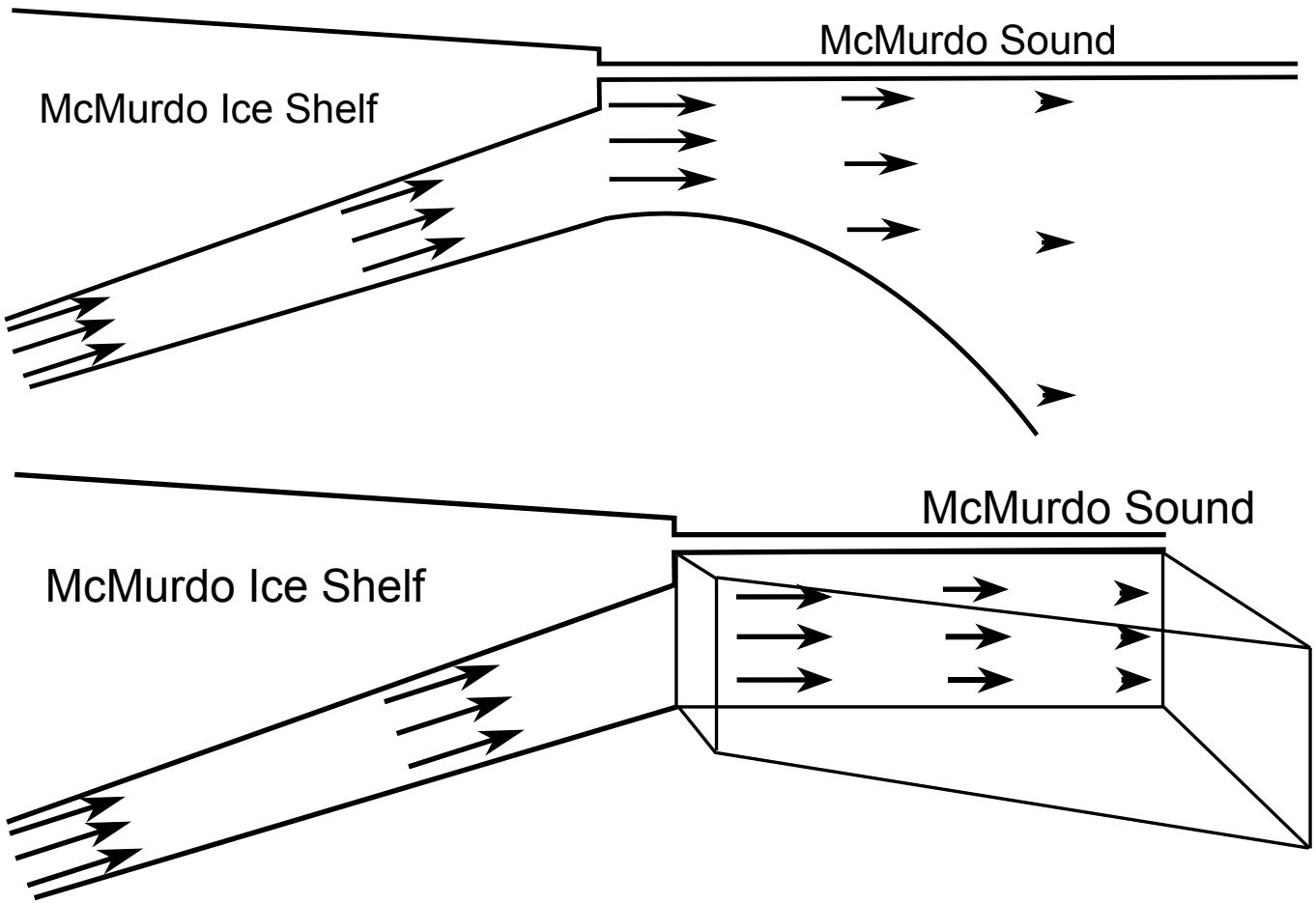
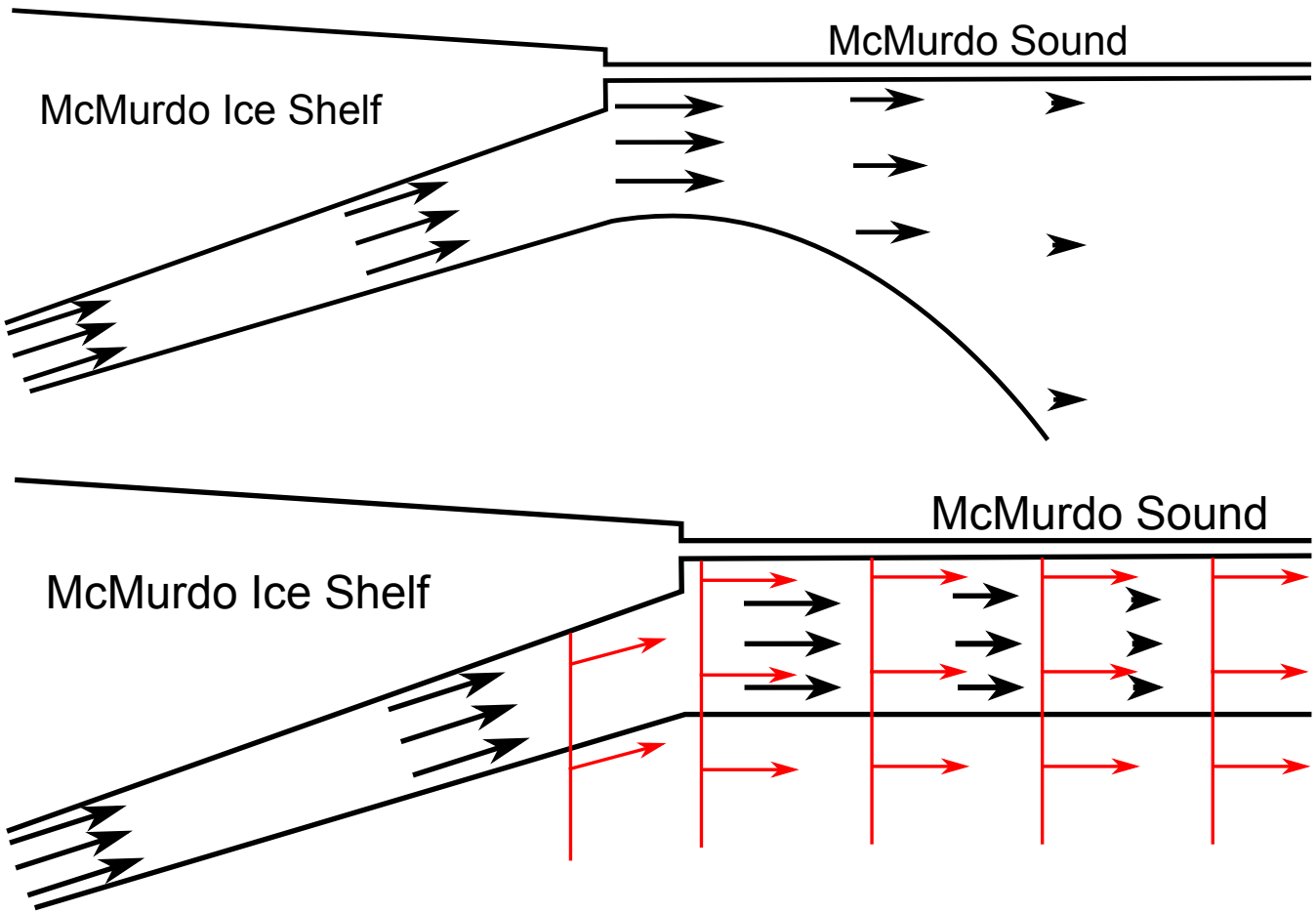


Extension to Sea Ice



Background ocean circulation
(wind-driven circulation, geostrophic currents, tidal rectification, topographic effects)

Sea Ice Processes

- Significant heat flux to atmosphere
- Freezing (not melting) regime

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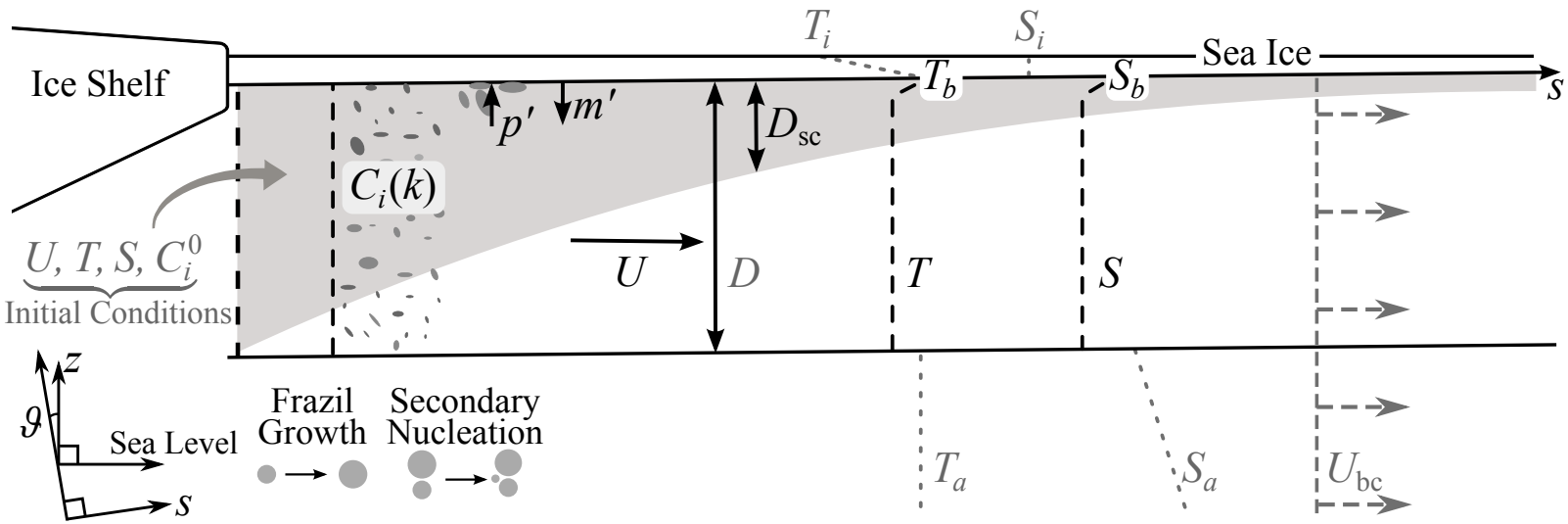
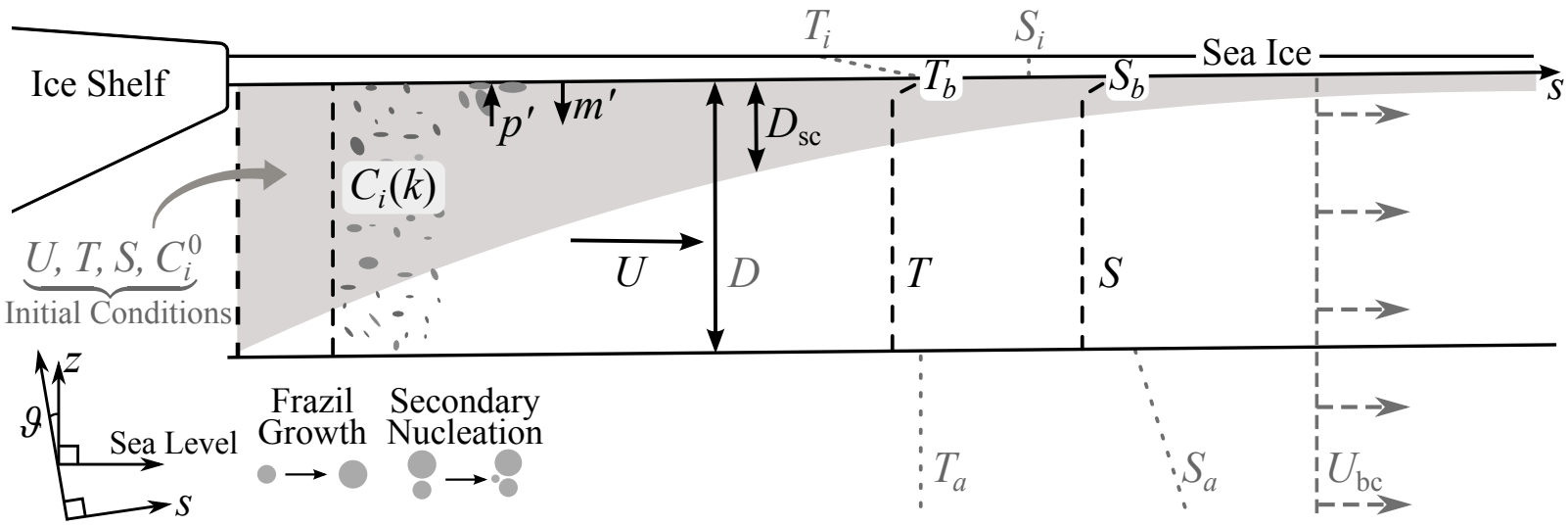
Model Schematic

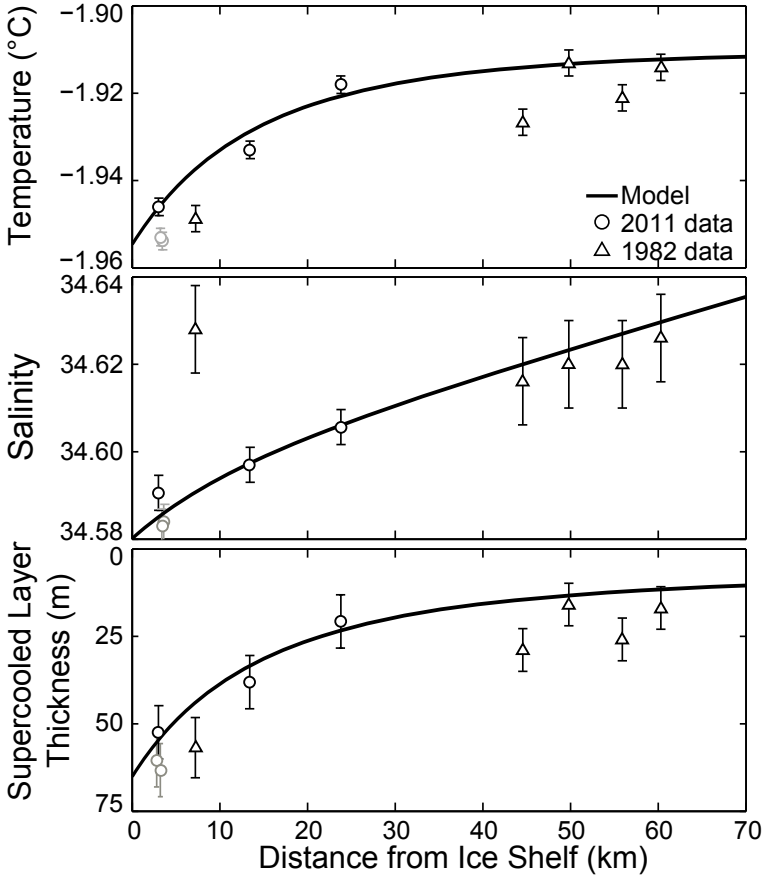


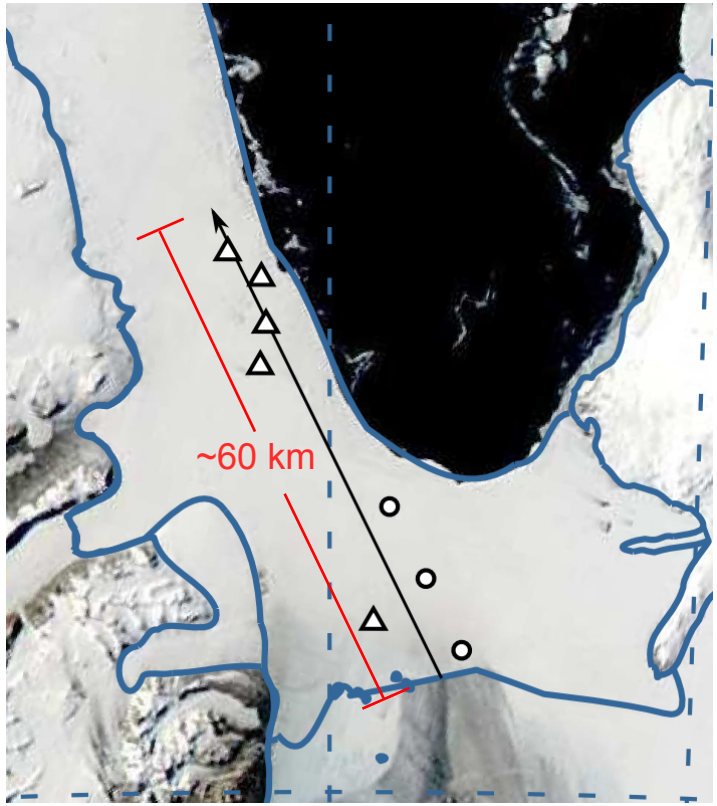
Model Schematic



Model output is comparable with measurements below sea ice

Results

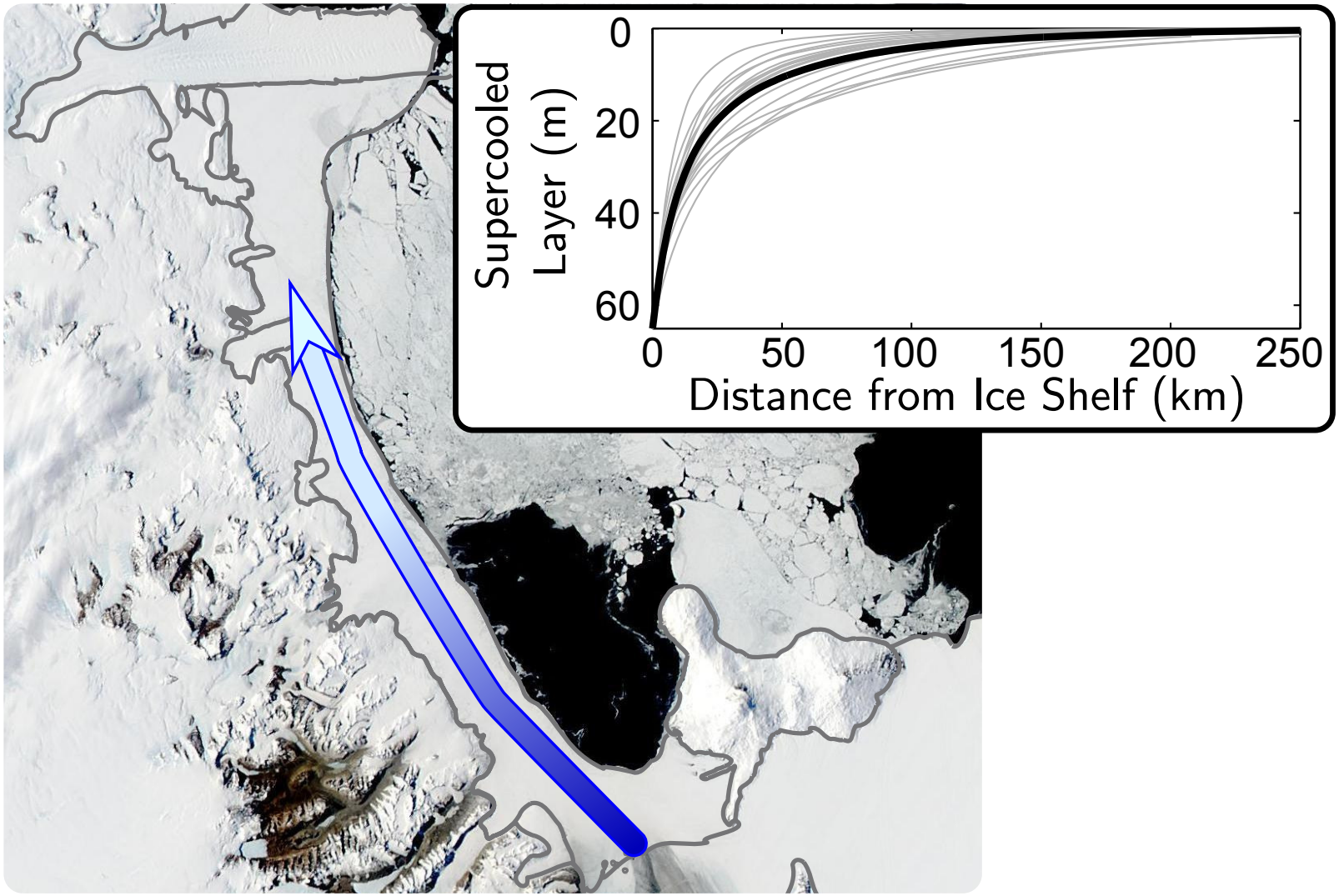




Results

How far can the supercooled water go?

Predictions



Predictions

- Importance of background ocean circulation
- Supercooling growth enhancement
- Frazil ice crystal size distribution

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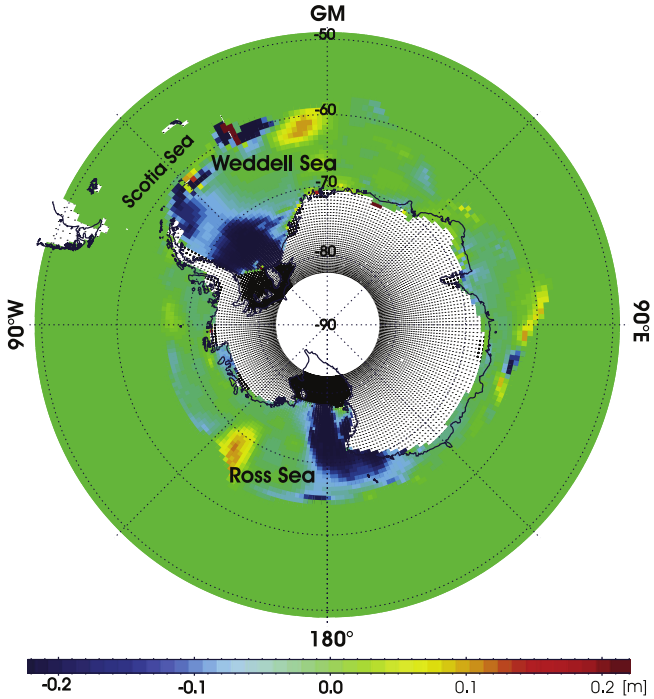
Supercooling Length Scales

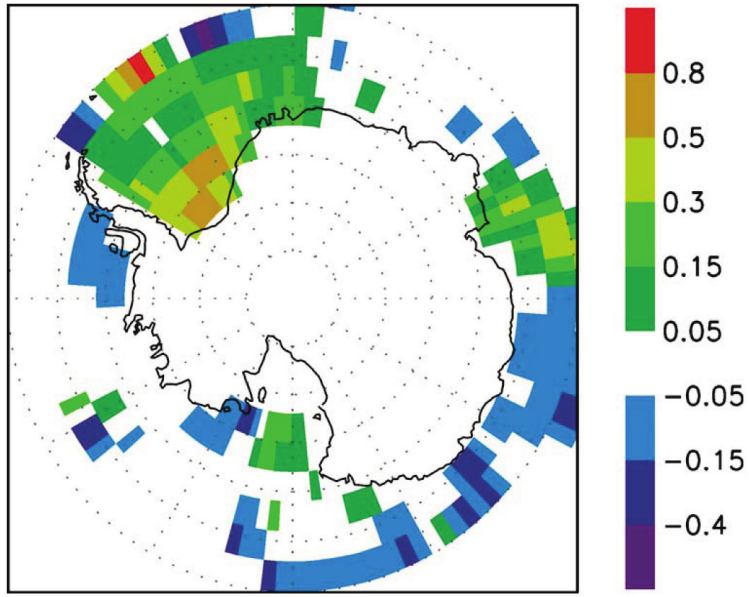
- Supercooling and enhanced sea ice growth decays over 50–100 km length scale
- Stevens et al. (2009) – Supercooled water can persist 250 km from edge of McMurdo Ice Shelf

Stevens et al. (2009), Ocean Sci., 5

Supercooling Length Scales

- Large-scale models suggest sea ice growth affected up to 1000 km from ice shelf.





Hellmer (2004), GRL, 31 Beckmann and Goosse (2003), Ocean Modell., 5

Acknowledgements

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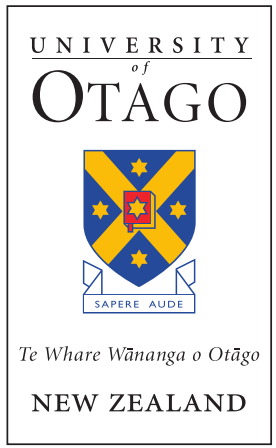
All McMurdo Sound images from NASA Rapid Response MODIS Subsets



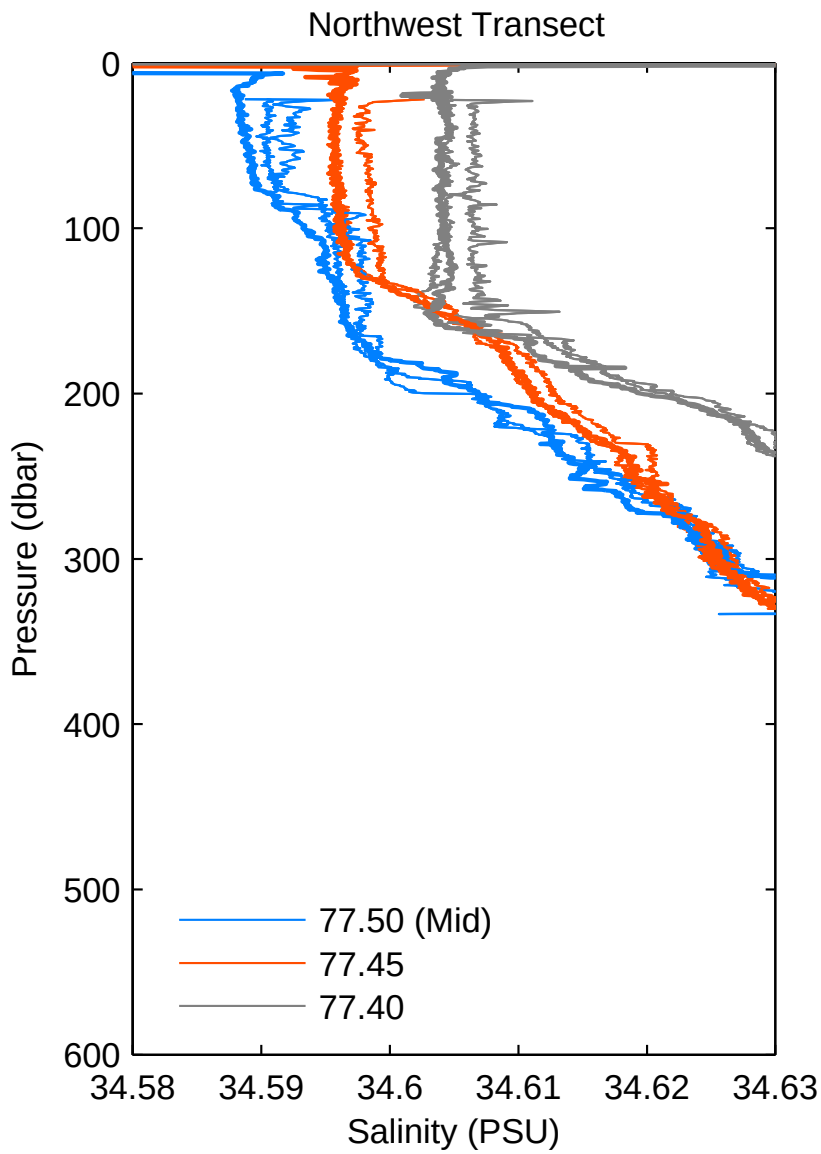
References

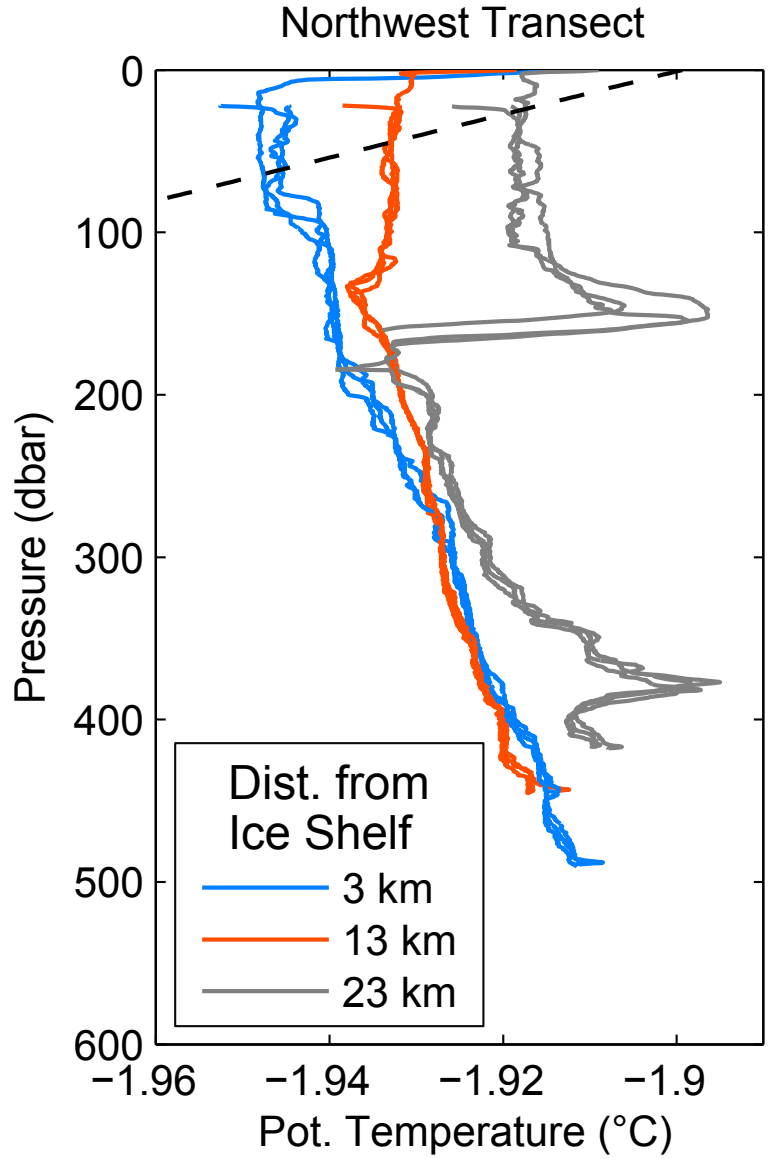
Stevens, C. L., N. J. Robinson, M. J. M. Williams and T. G. Haskell (2009), Observations of turbulence beneath sea ice in southern McMurdo Sound, Antarctica, *Ocean Sci.*,5, 1407–1436.

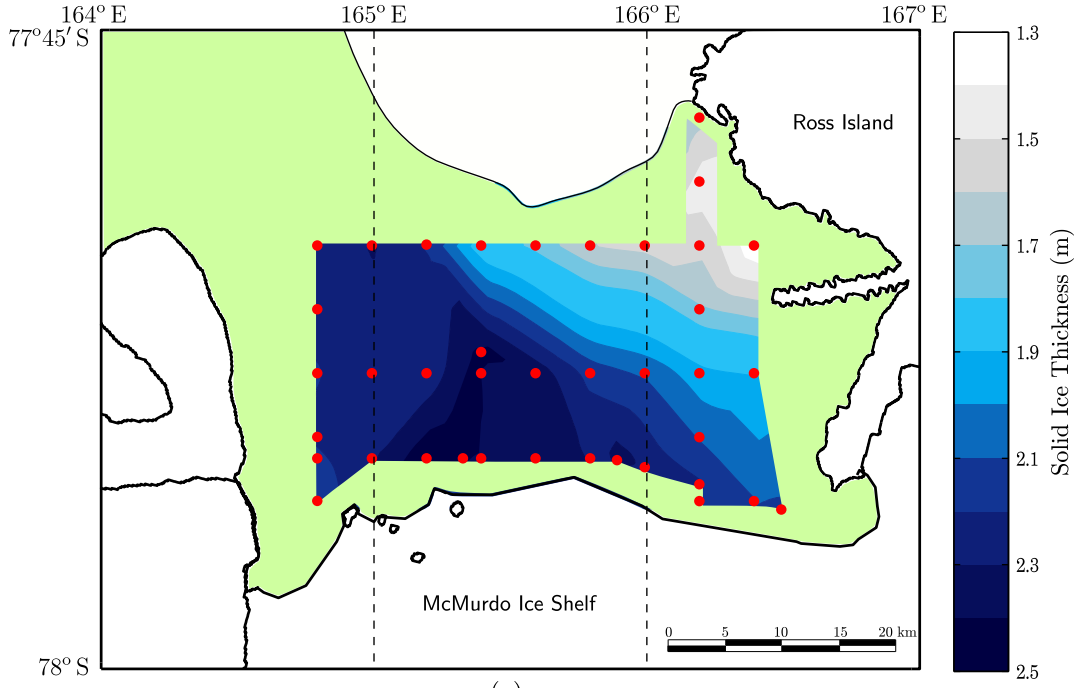
Smedsrud, L. H. and A. Jenkins (2004), Frazil ice formation in an ice shelf water plume, *J. Geophys. Res.*, 109, C03025, doi:10.1029/2003JC001851.

Hellmer, H. H. (2004), Impact of Antarctic ice shelf basal melting on sea ice and deep ocean properties, *Geophys. Res. Lett.*, 31, L10307, doi:10.1029/2004GL019506.

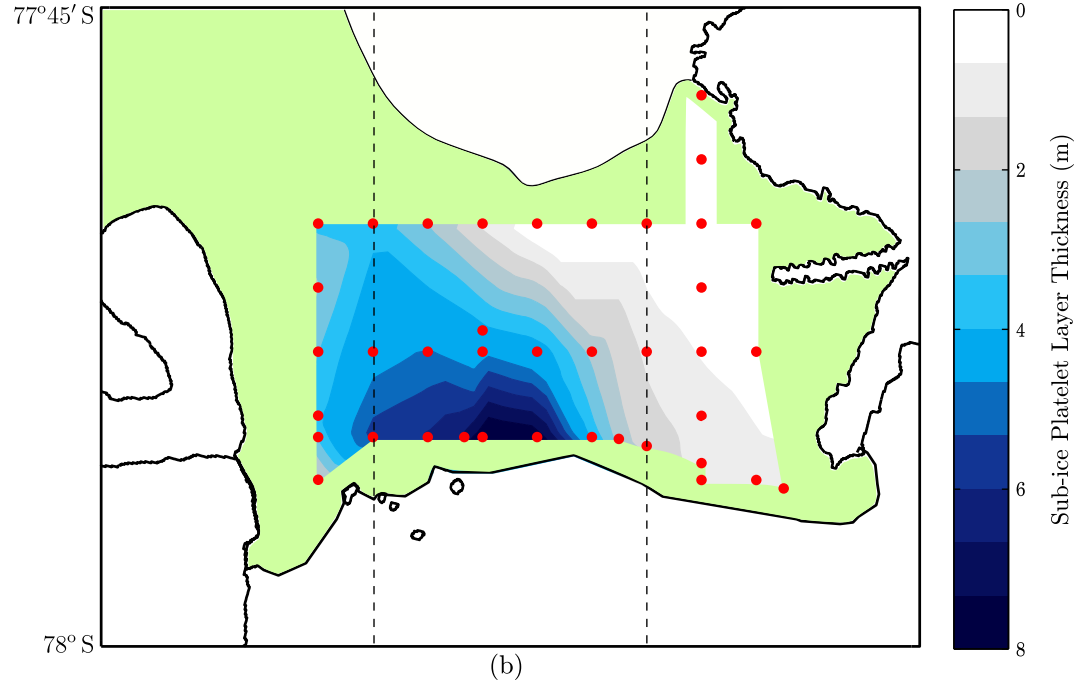
Dempsey, D. E., P. J. Langhorne, N. J. Robinson, M. J. M. Williams, T. G. Haskell and R. D. Frew (2010), Observation and modeling of platelet ice fabric in McMurdo Sound, Antarctica, *J. Geophys. Res.*, 115, C01007, doi:10.1029/2008JC005264.



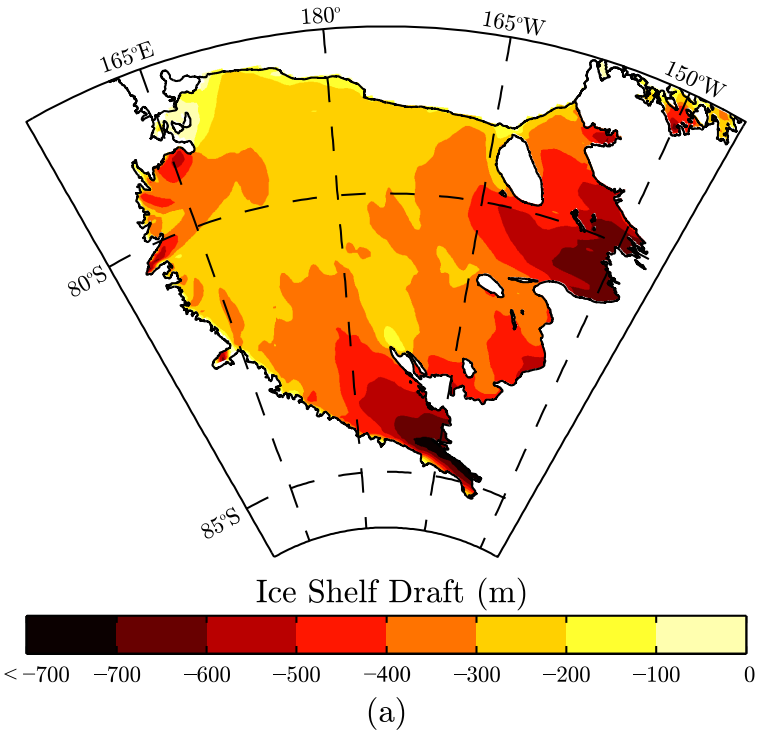



164° E
165° E
166° E
167° E
77°45′ S
78° S
Ross Island
McMurdo Ice Shelf
0 5 10 15 20 km
1.3
1.5
1.7
1.9
2.1
2.3
2.5
Solid Ice Thickness (m)

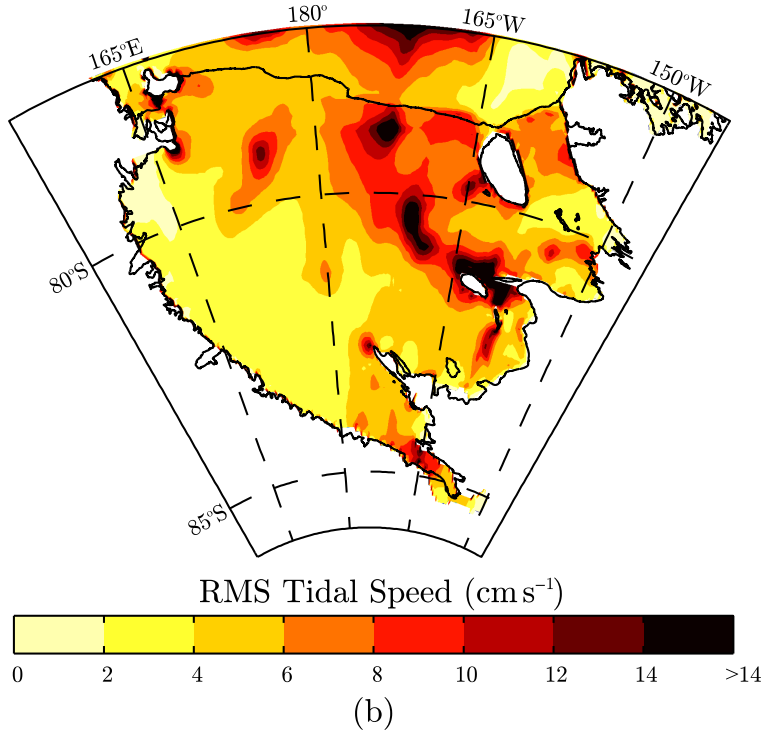
(a)


77°45′ S
78° S
0
2
4
6
8
Sub-ice Platelet Layer Thickness (m)

(b)



(a)



(b)