THE APPLICATION OF POM

TO THE CAVITY

BENEATH THE AMERY ICE SHELF

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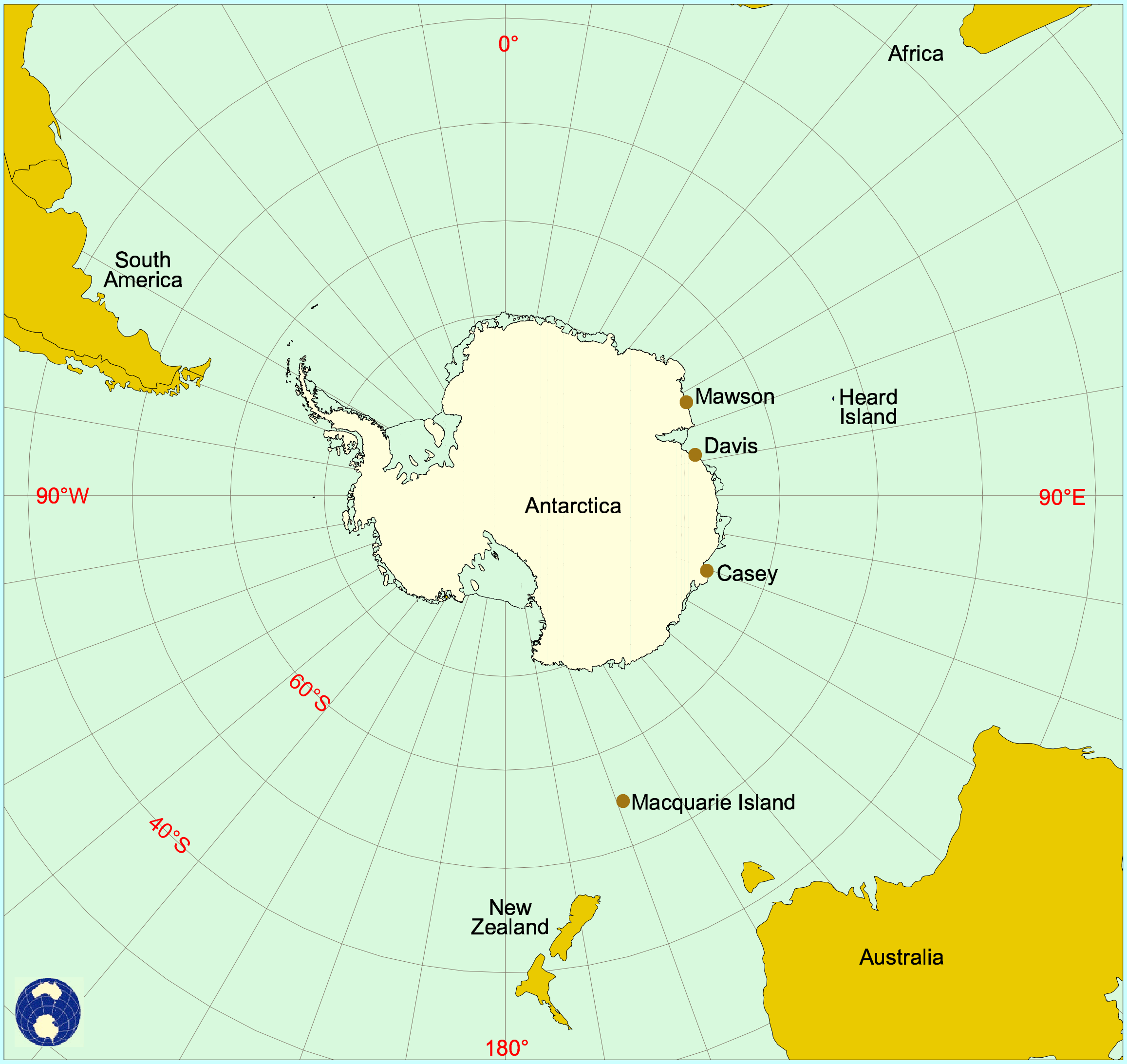
Produced by the Australian Antarctic Data Centre,
Australian Antarctic Division,
Department of the Environment and Heritage, July 2000

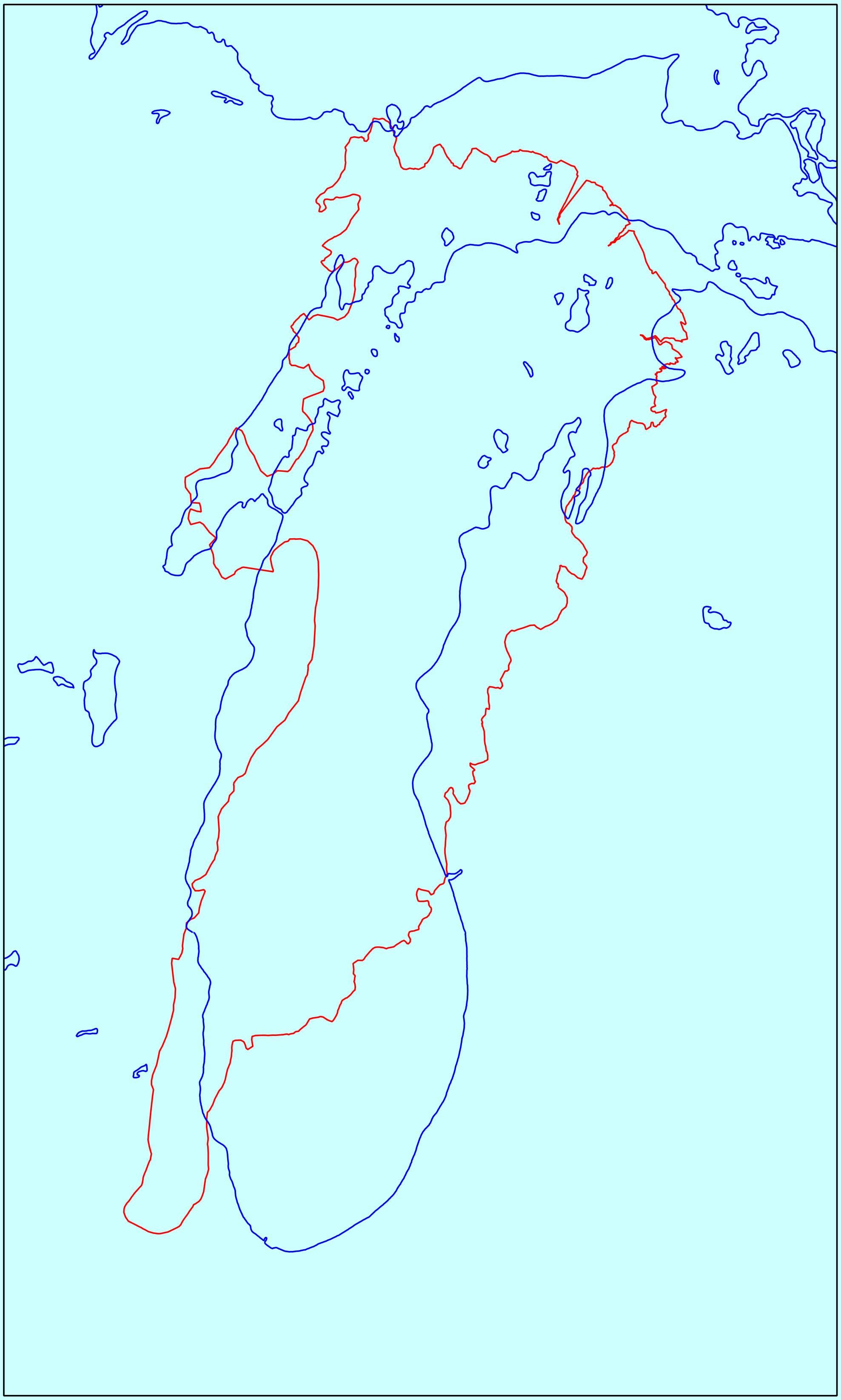


Projection: Polar Stereographic
True Scale at 71°S

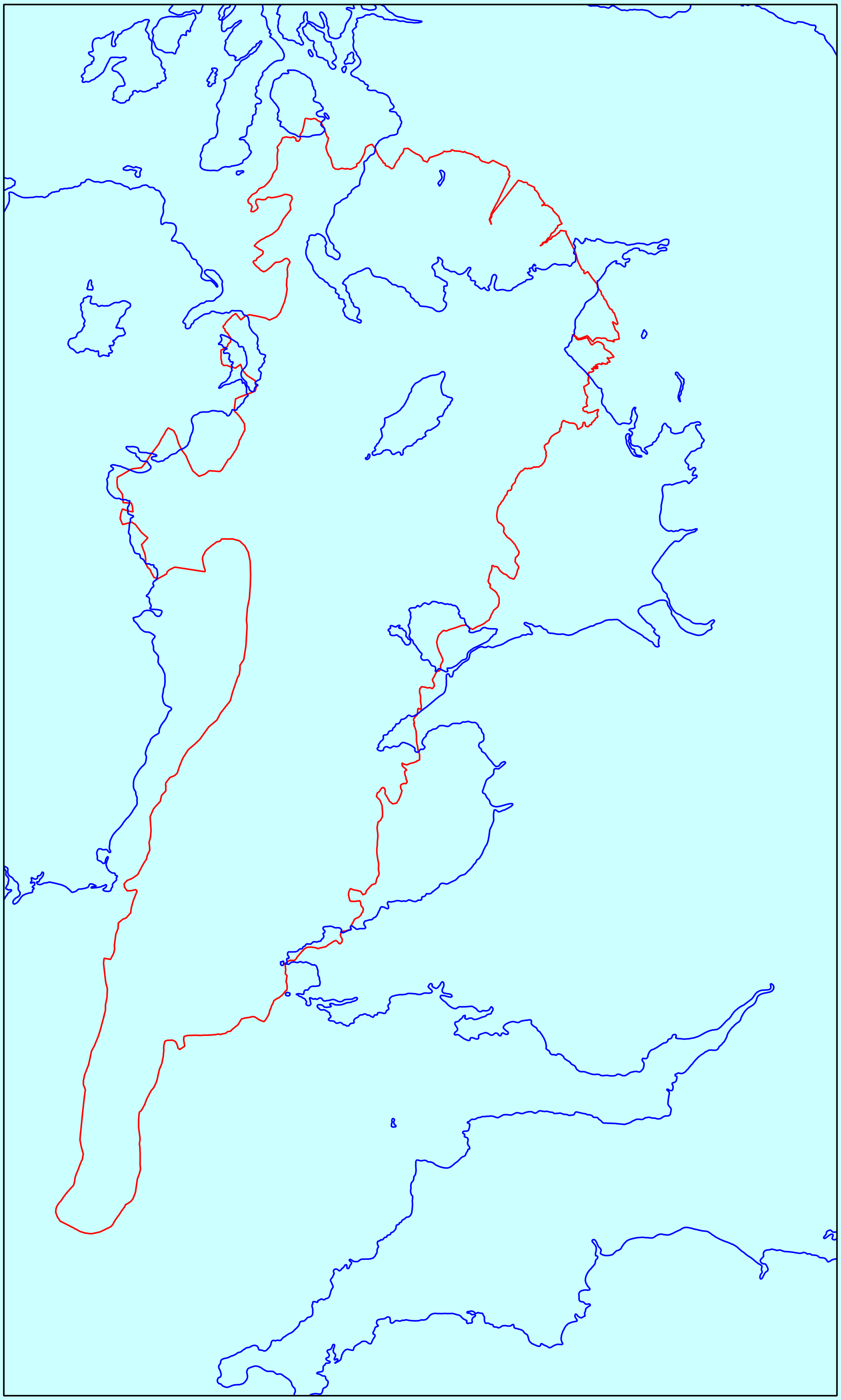
● Permanent Australian Station

Amery Ice Front

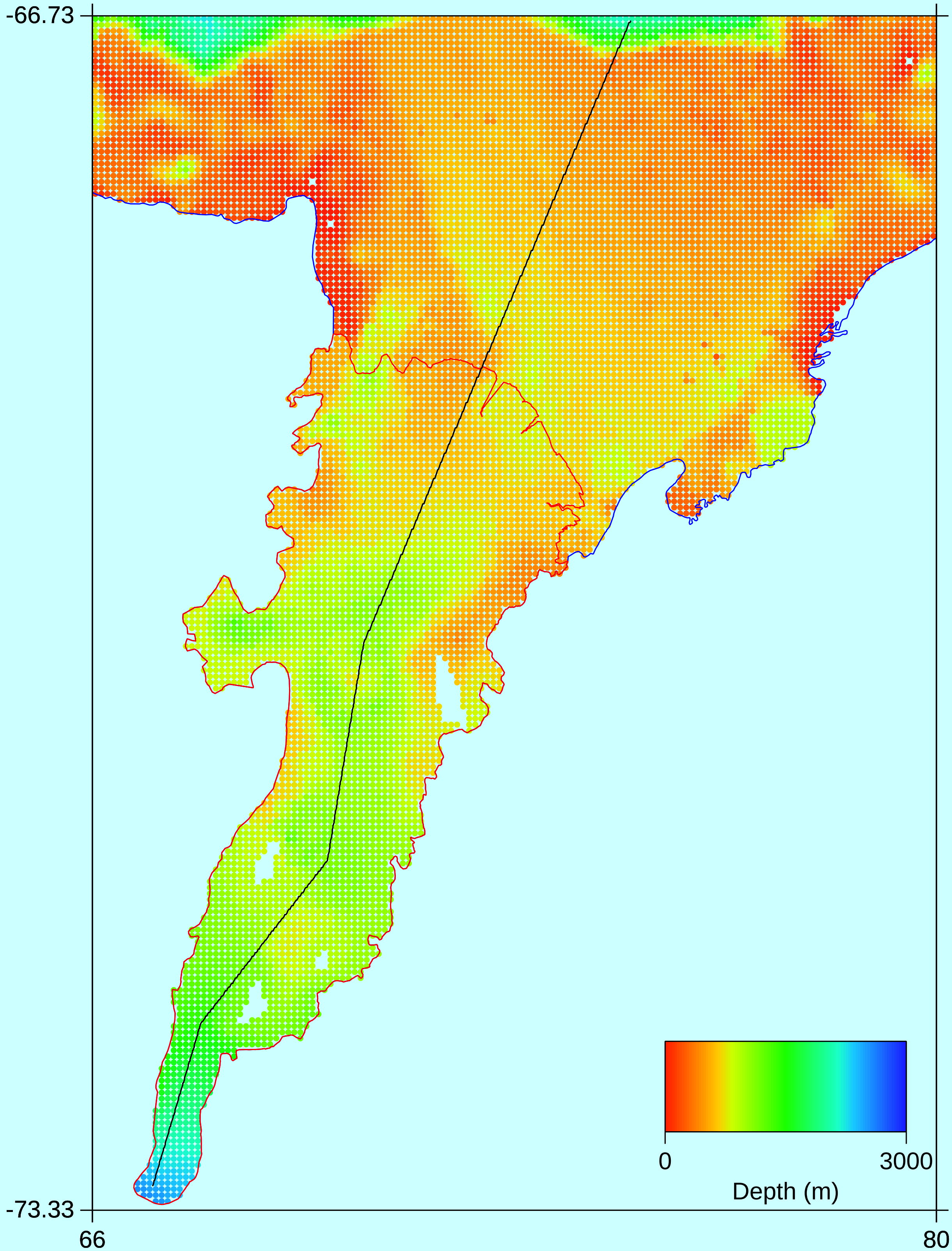
Amery vs Lake Michigan



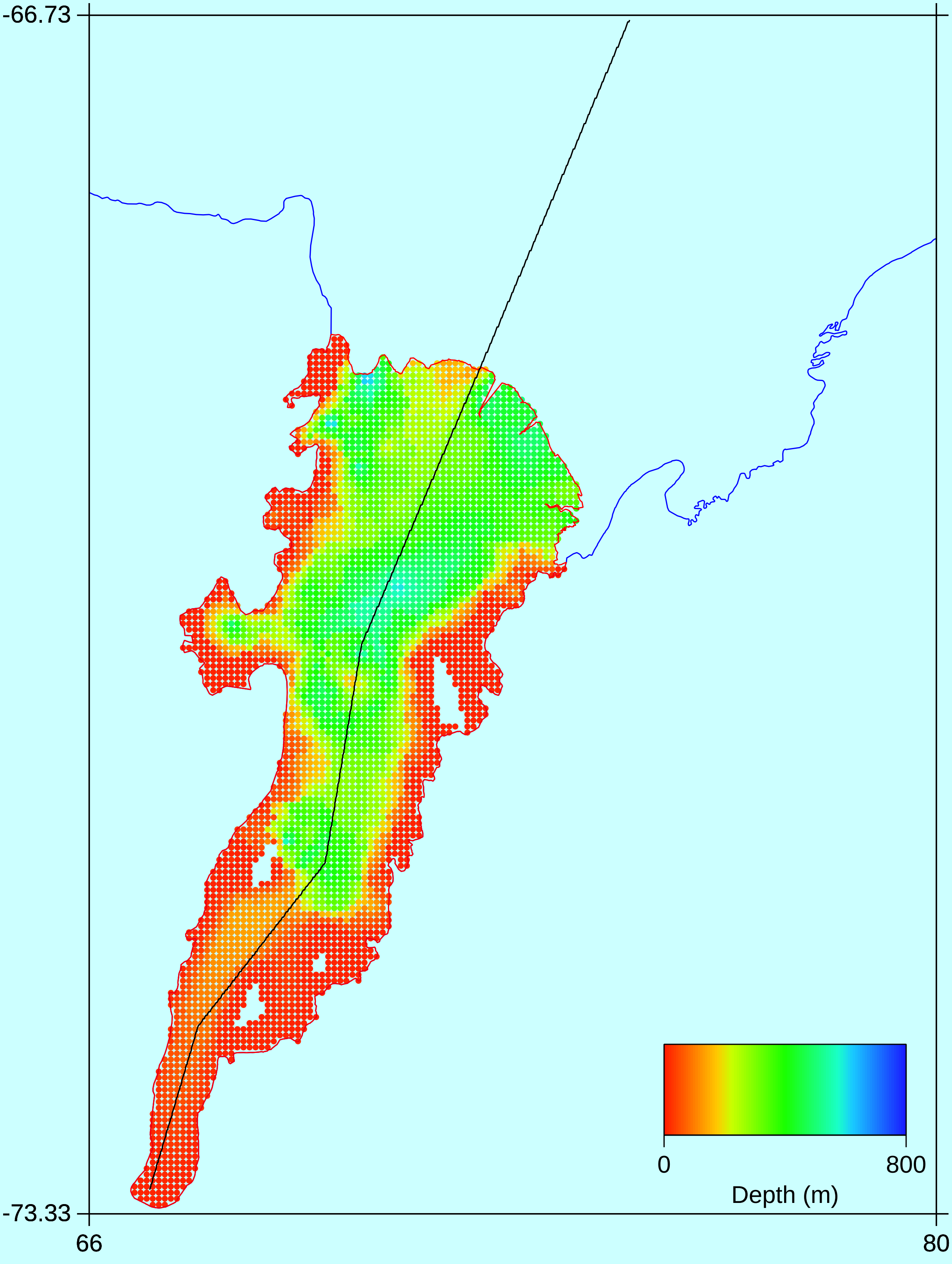
Amery vs Irish Sea



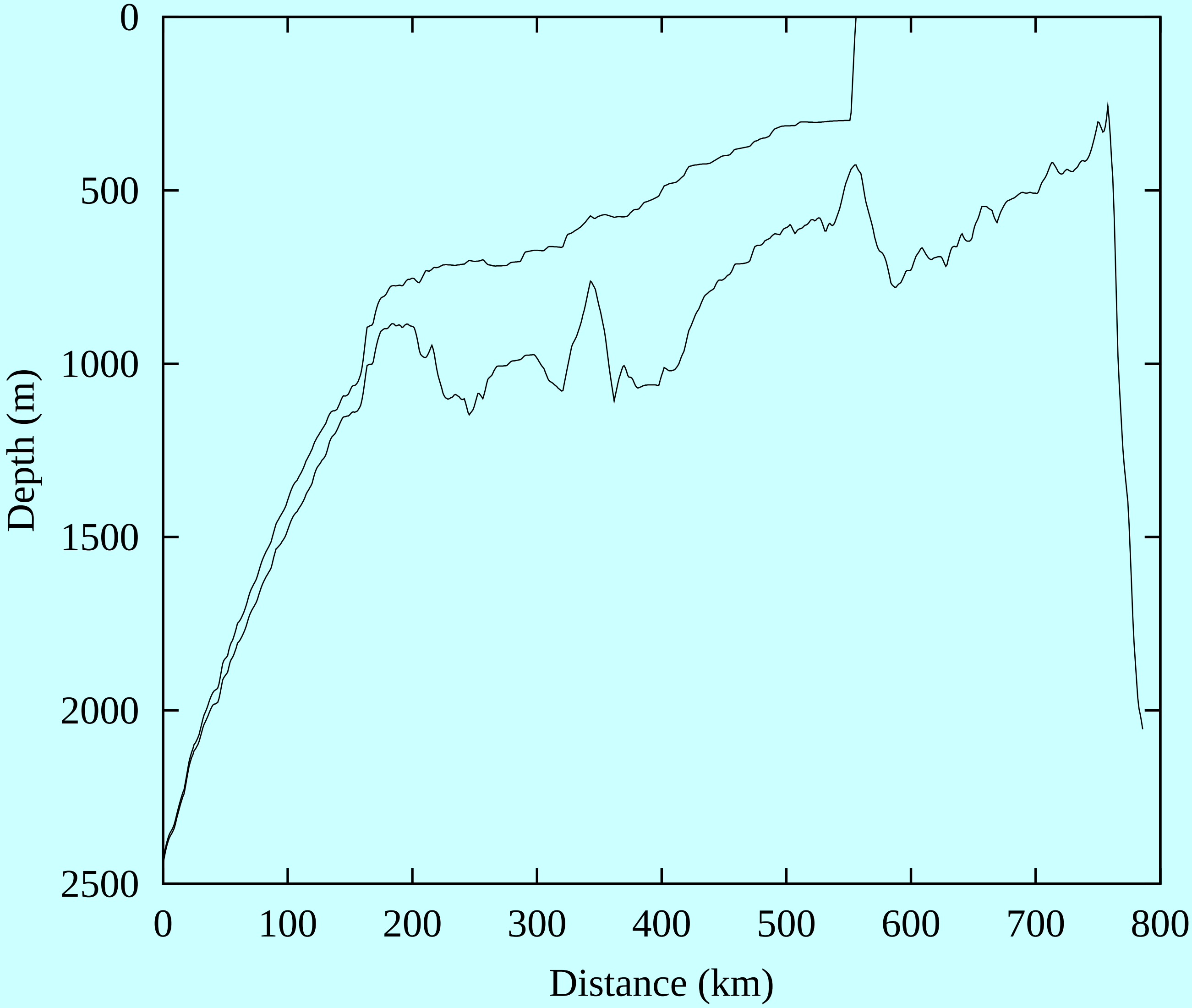
Bathymetry



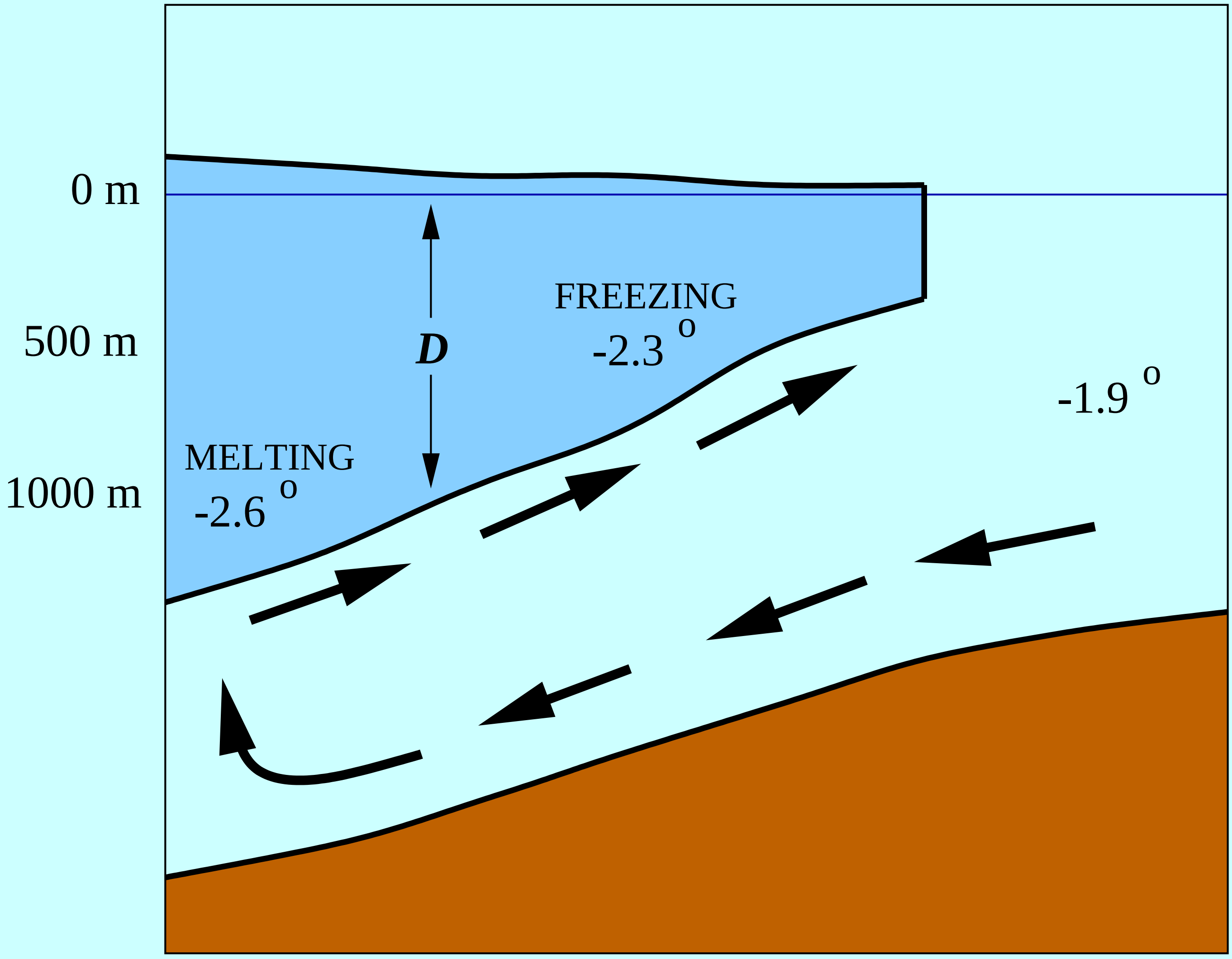
Water Column Thickness



Longitudinal Section



Melting and Freezing at the Ice/Ocean Interface



Why Are we Interested in the Cavity Under the Amery Ice Shelf?

- Part of a larger study of the mass balance of the Antarctic Ice Sheet, which includes modelling of the ice shelf itself.

- Rate of melting and refreezing under the ice shelf?

- Dependence of the above on global warming?

Model Requirements

- Currents: average $\approx$ tidal $\approx$ 0.02 ms^{-1}
- Large range of depth
- Large range of ice draft
- Large range of water column thickness
- Boundary layers associated with both bottom and ice/ocean interface
- Area: 59,000 km^2; Average water column thickness: 215 m
- Rossby radius: 5,000 m
- e-folding time of cavity $\approx$ 3 years. Hence model runs of about $\approx$ 14 years.

Hence require:

- Free-surface 3-D baroclinic model
- sigma- or isopycnic coordinates (to cope with topography and boundary layers)

Solutions

- Grosfeld (Munster): Generalised coordinate version of Cox/Bryan (Gerdes) – Larsen and Filschner-Ronne, coupled with ice model

- Beckmann/Hellmer (AWI): SPEM/SCRUM/ROMS – whole Southern Ocean

- Holland (New York): MICOM (isopycnic) – Filchner-Ronne

- Present: POM – Amery.

  Grid sizes: 4 km and 8 km.

Required Modifications to Incorporate Ice Shelf into POM

- Define new 'SEAMOUNT' for initialisation.

- Define additional horizontal U, V and E masks for ice shelf.

- Apply surface pressure to depress ocean surface by D (i.e. apply adjustment D to all heights that are multiplied by g (GRAV), *except* in baroclinic pressure and buoyancy gradients).

- Dynamics at ice/ocean interface: invert bottom friction code (yields u_*).

- Thermodynamics at ice/ocean interface (2-equation formulation of Holland and Jenkins, 1999):

  - Interface assumed to be at local freezing temperature (T_f) (*converted to potential temperature*).

  - Heat flux assumed $\propto u_*(T_{ocean} - T_f)$.

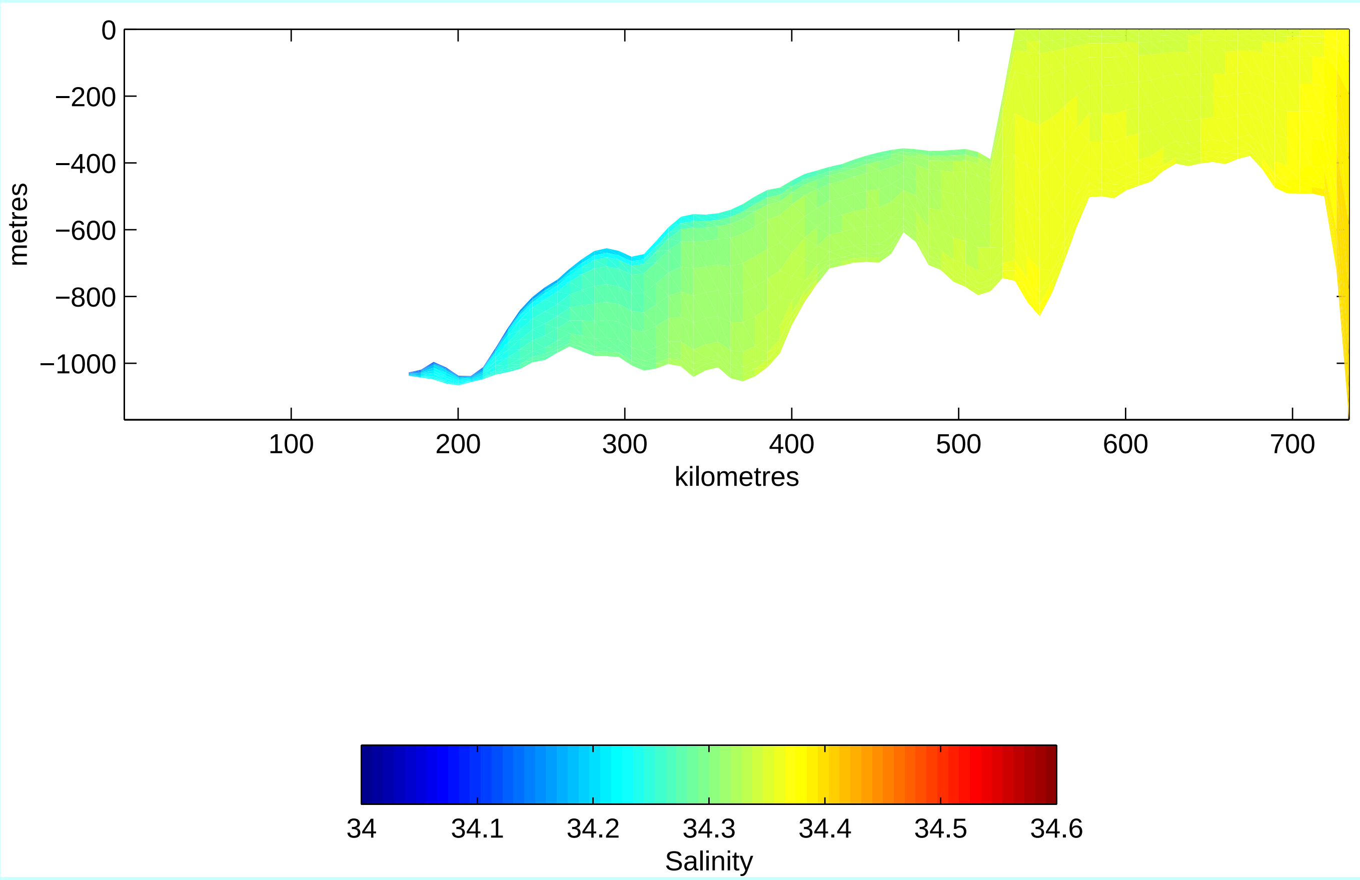
  - Heat flux yields melting or freezing rate.

  - NOTE adjustments to resultant T and S fluxes to account for TBIAS and SBIAS.

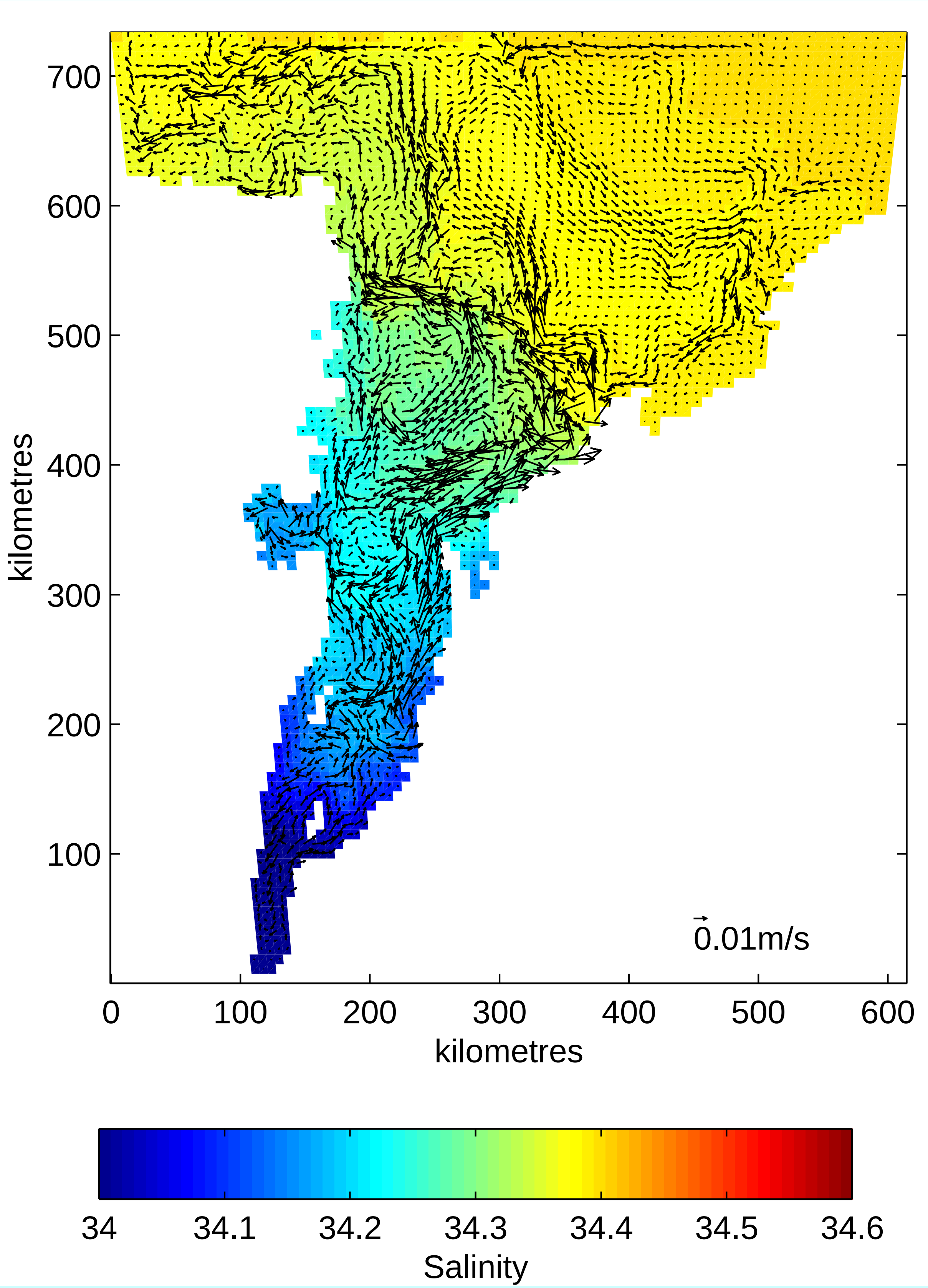
  - Add source/sink of water to volume conservation equation in external mode.

  - Set W(I,J,KB)=0, reverse order of vertical integration of W and stop at K=2 (this puts source/sink of water in top cell).

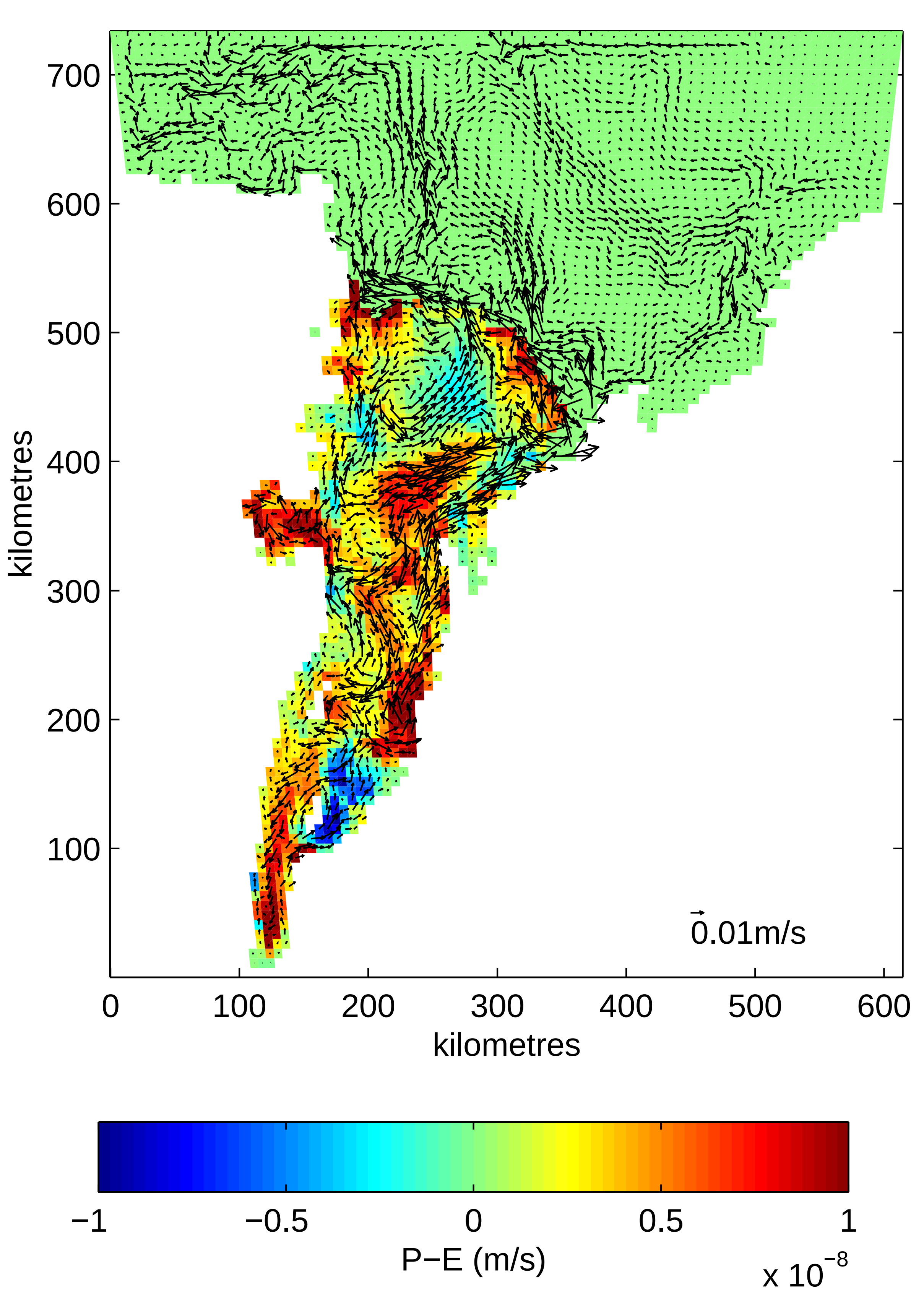
Initial Results – South-North Salinity Section



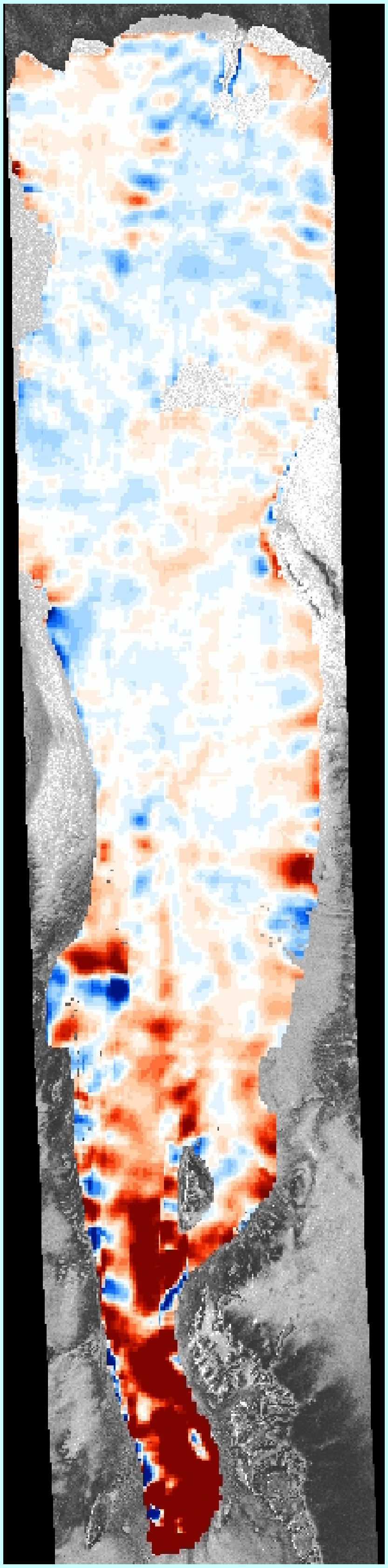
Initial Results – Salinity Map



Initial Results – Melting/Freezing (P-E) Map



'Observed' Melting/Freezing



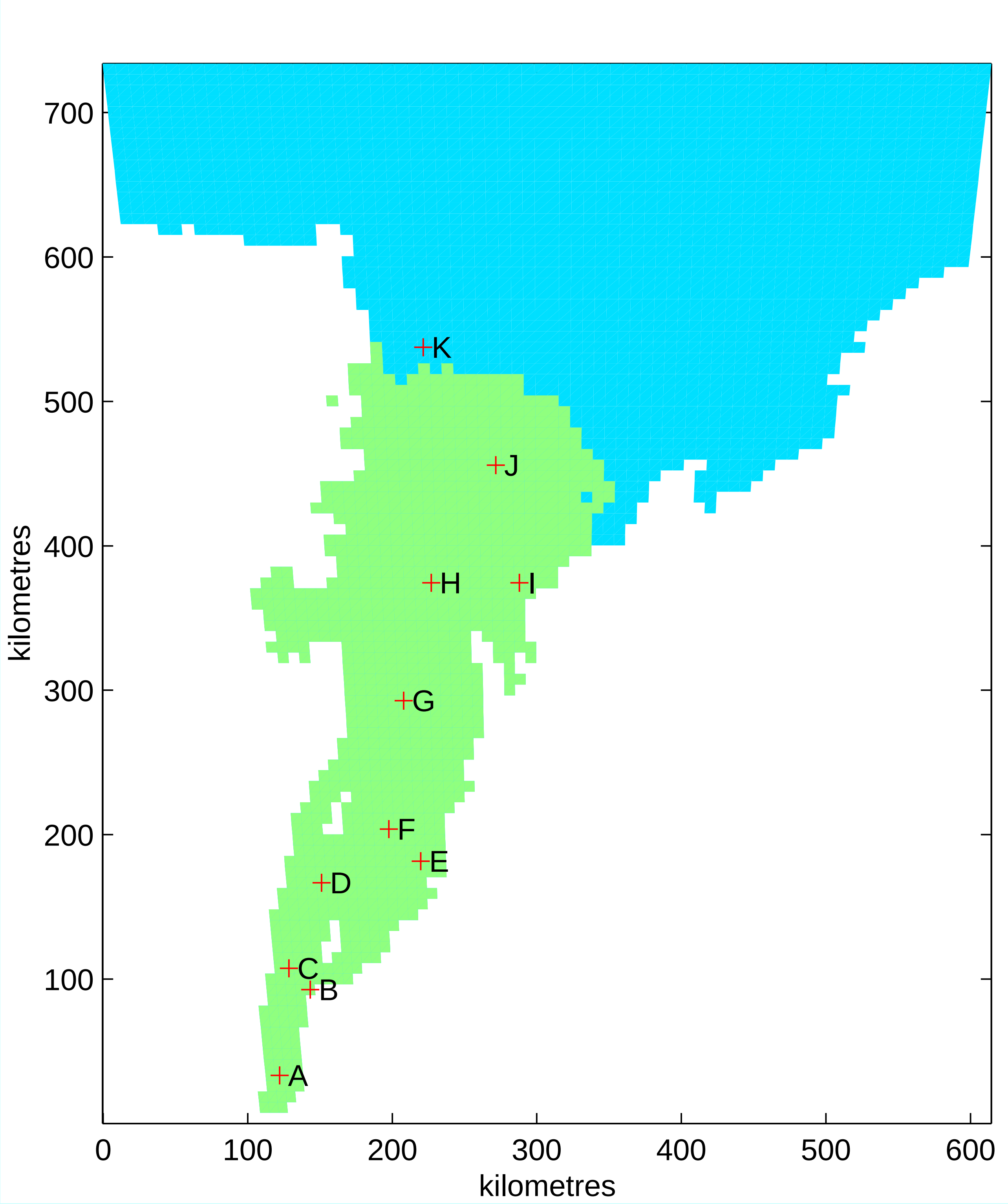
Red: 10 m/year
(3.2×10^{-7} ms^{-1})
melting

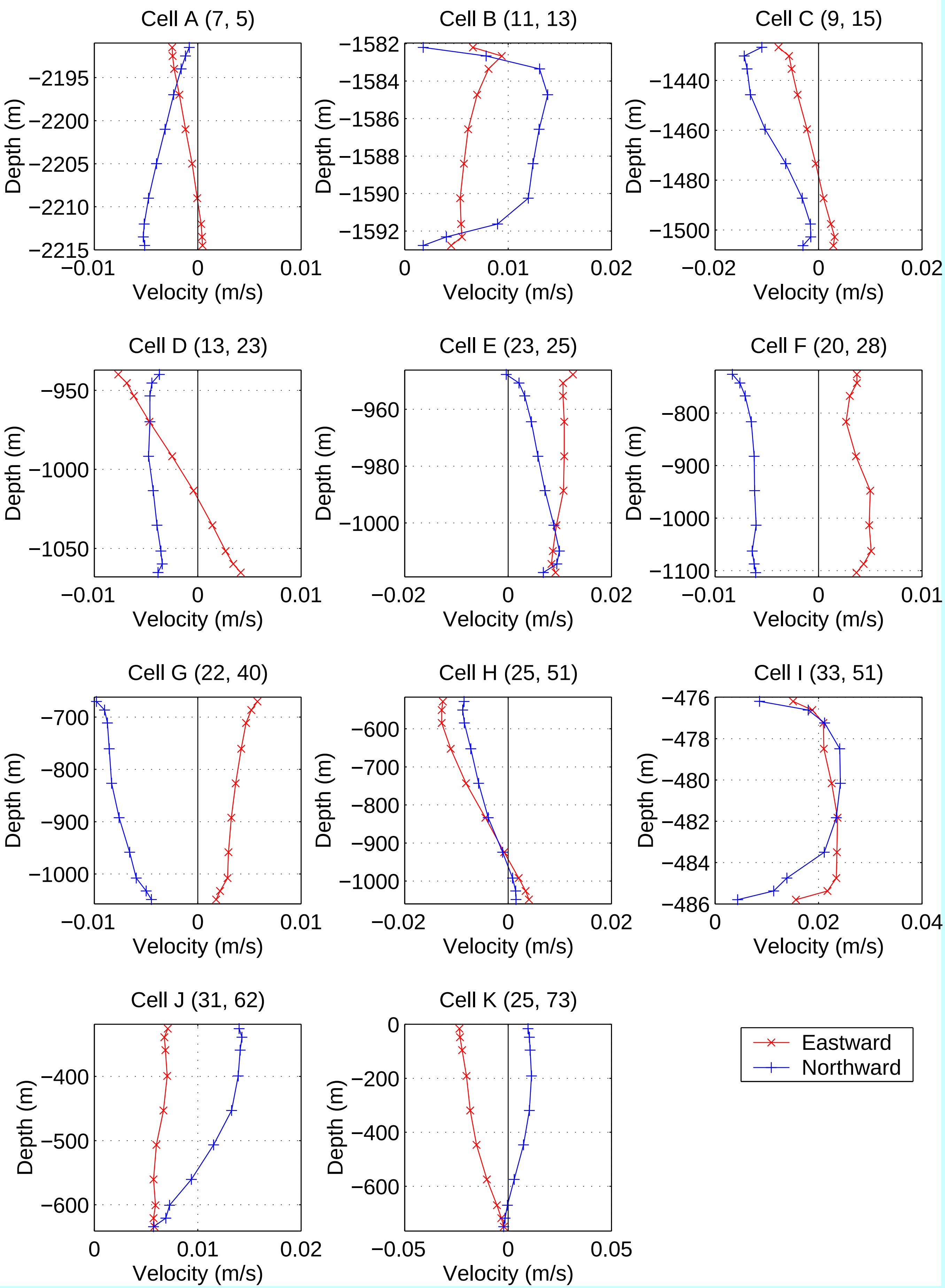
Blue: 10 m/year
(3.2×10^{-7} ms^{-1})
freezing

Kinematic estimation based on SAR, altimetry and ice density model

(Young, Hyland and Gale)

Locations of Current Profiles




Cell A (7, 5)
Cell B (11, 13)
Cell C (9, 15)
Cell D (13, 23)
Cell E (23, 25)
Cell F (20, 28)
Cell G (22, 40)
Cell H (25, 51)
Cell I (33, 51)
Cell J (31, 62)
Cell K (25, 73)
Depth (m)
Velocity (m/s)
Eastward
Northward

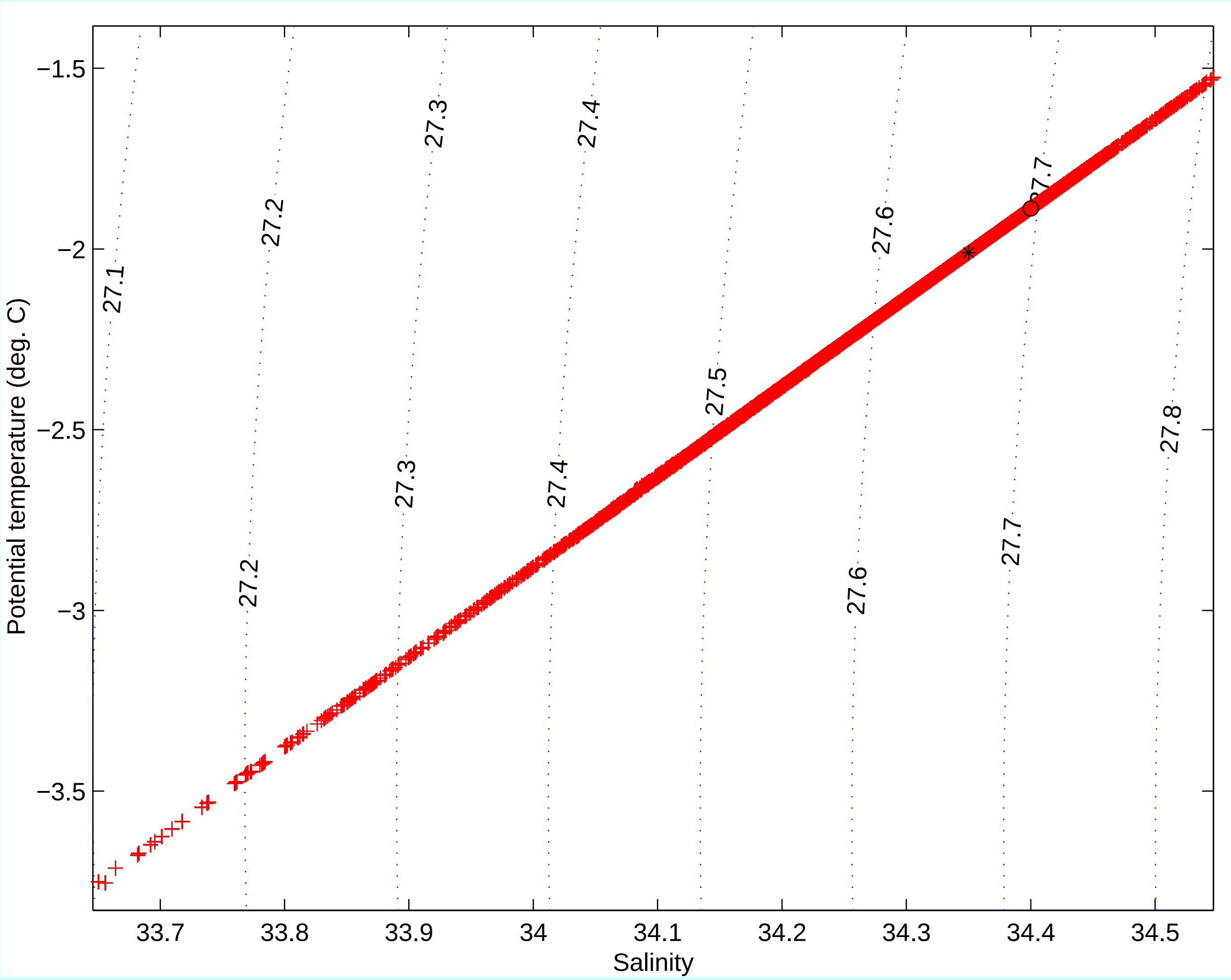
Advection Problem

- With initial conditions and ocean water at $T = -1.89^\circ$ and $S = 34.4$, there is *nothing warmer* within the model

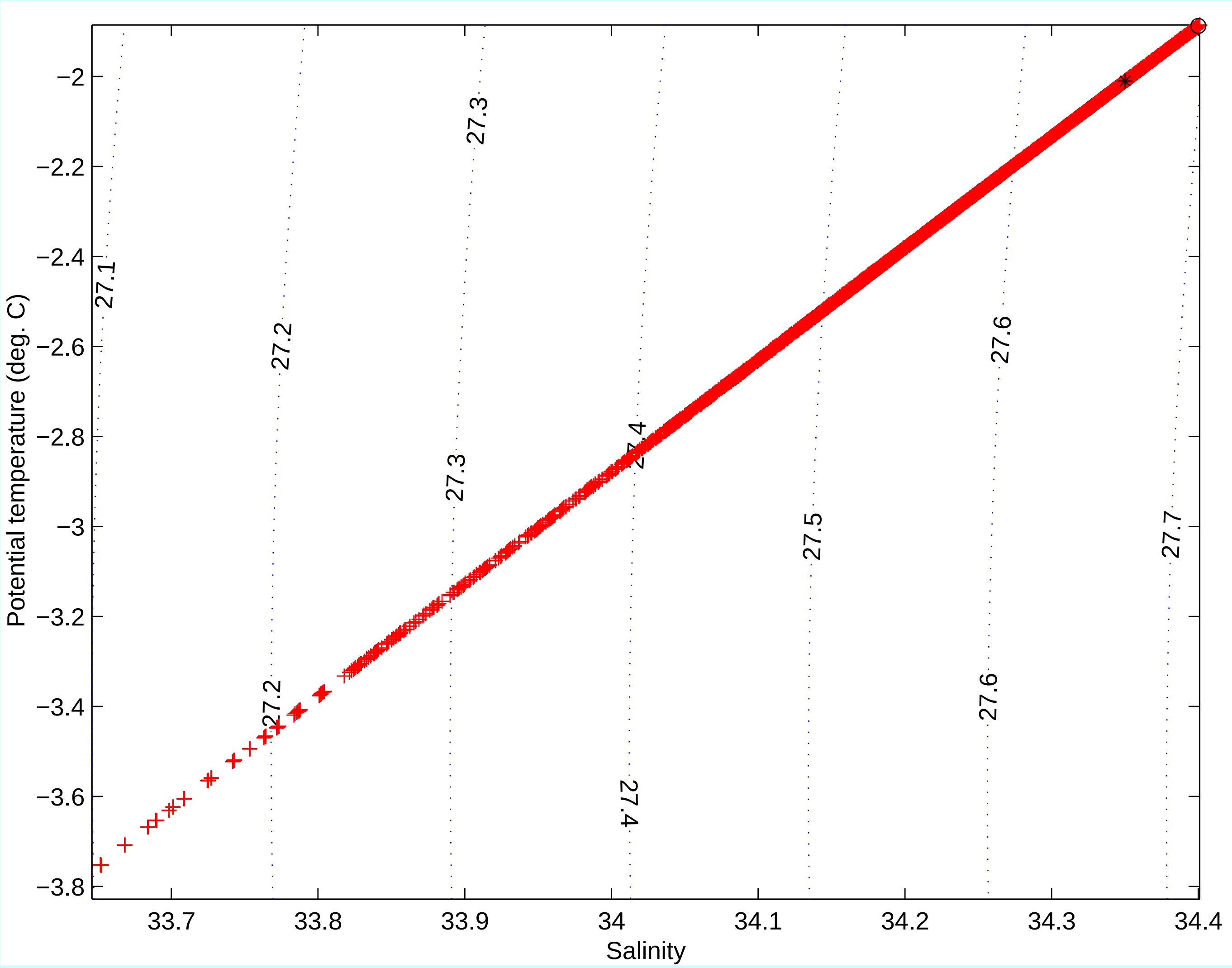
- Hence water properties can only move in direction: $T < -1.89^\circ$ and $S < 34.4$

- 'Ringing' of centred advection scheme generates water with $T > -1.89^\circ$ and $S > 34.4$

T-S Diagram; Centred Differencing, HORCON=0.5, Additional (A_M, A_H)=100



T-S Diagram; Smolarkiewicz, HORCON=0.5, Additional (A_M, A_H)=100



Future Work

- Inclusion of tides (present melting/freezing rates are too low).
- Migration to ROMS?
- Model tuning and validation.
- Investigations of present and warming scenarios.
- Coupling with an ice shelf model.