Lagrangian pathways and residence time of warm Circumpolar Deep Water on the Antarctic continental shelf

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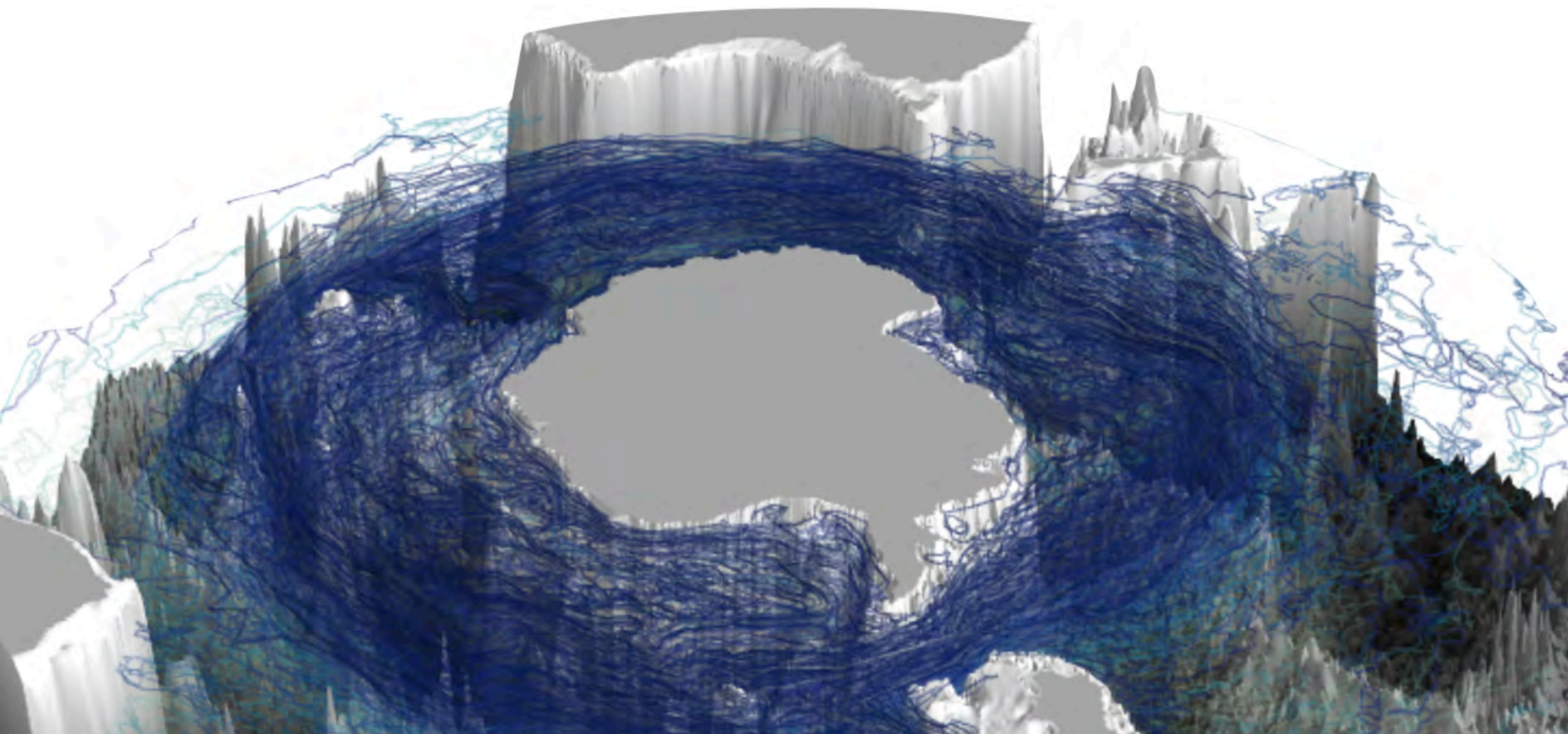
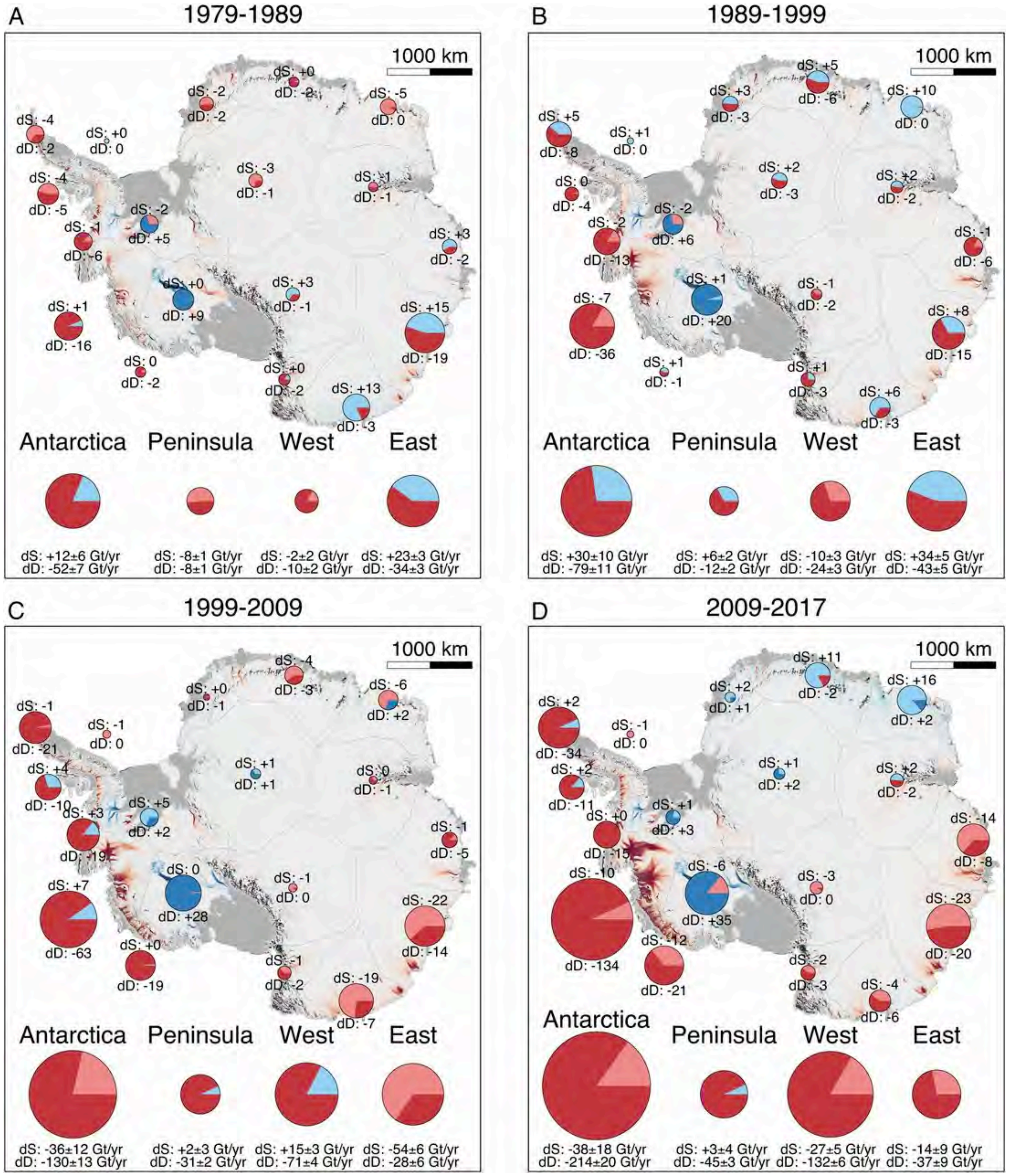
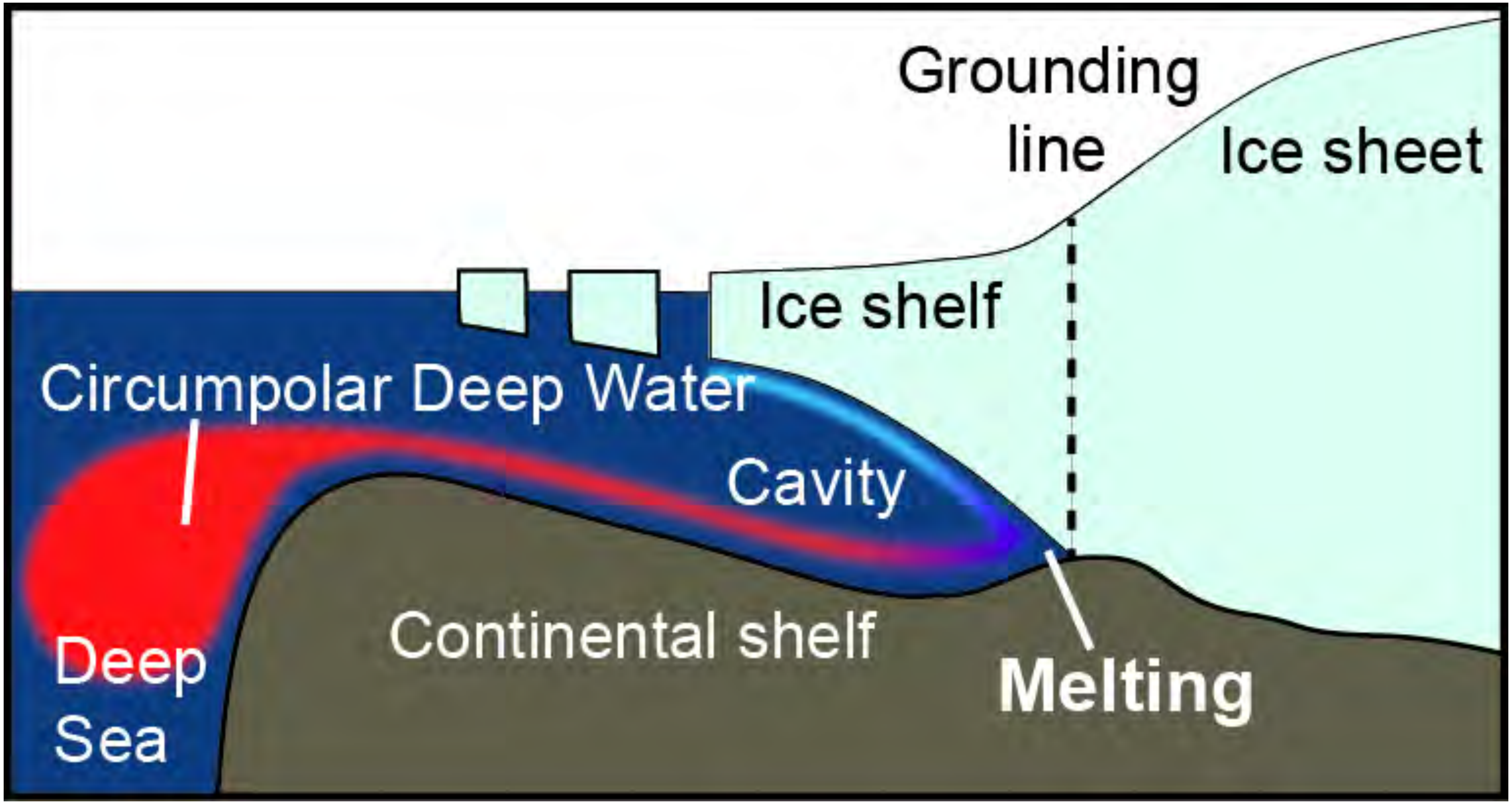


Background and Motivation



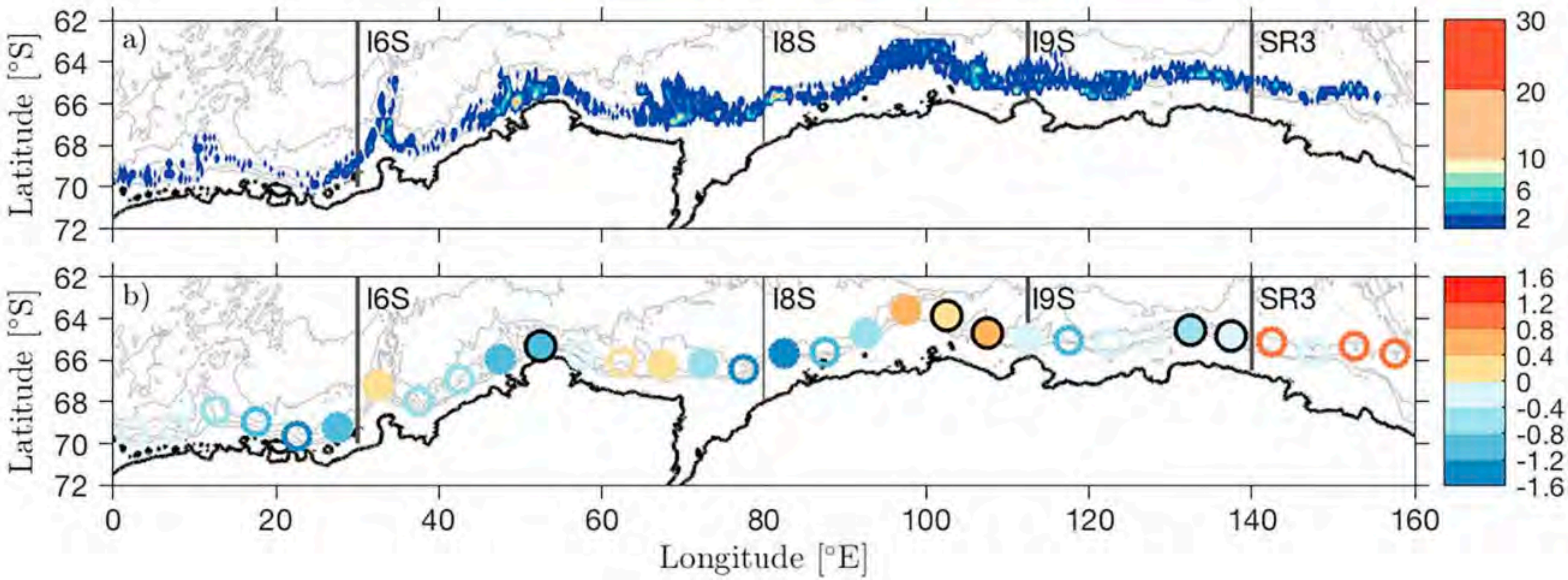
Rignot et al. 2019

Background and Motivation



Inflow of Circumpolar Deep Water (CDW) from offshore drives ice shelf basal melt

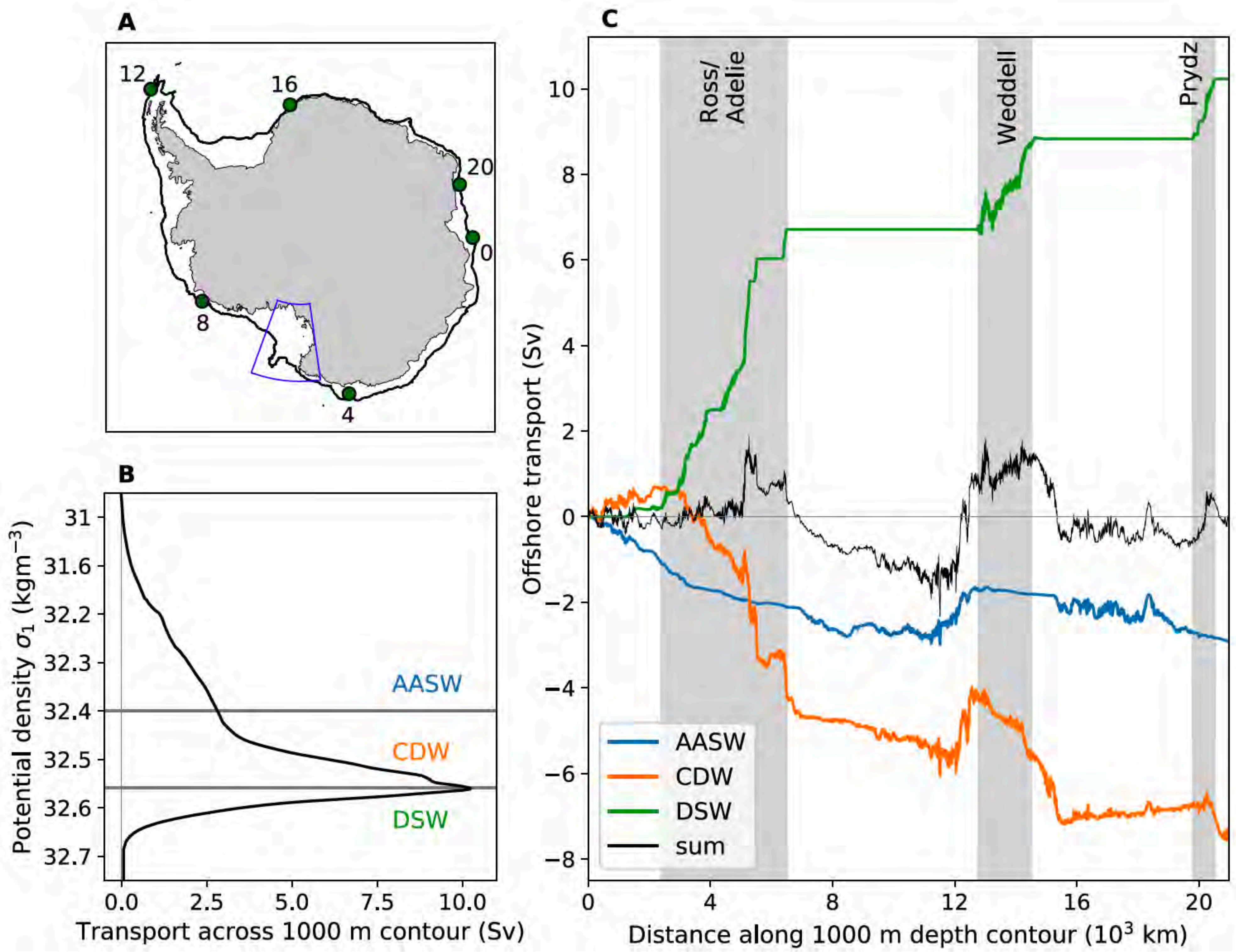
Background and Motivation



Along-slope variability in onshore CDW transport

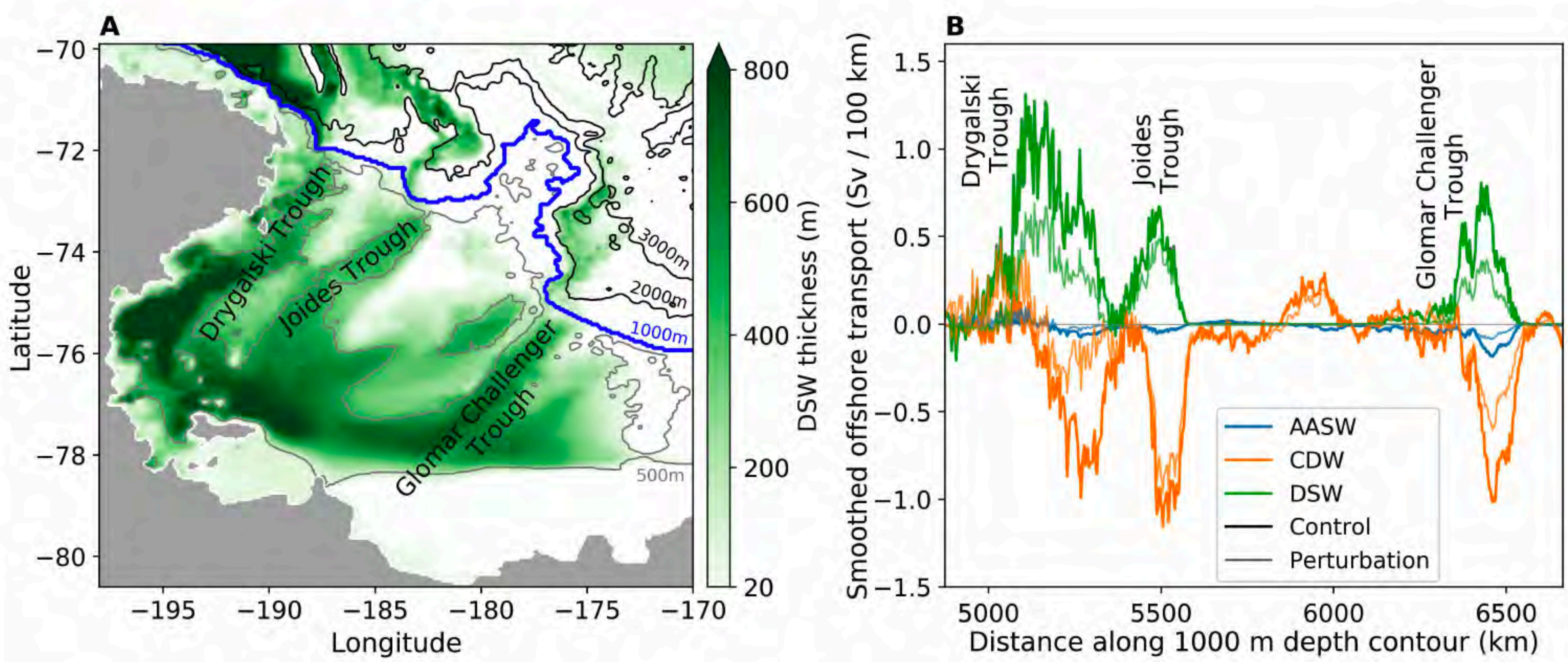
Foppert et al. 2019

Background and Motivation



Morrison et al. in revision

Background and Motivation



Implies strong CDW inflow in regions cold shelf regions, not warm regions where greatest ice shelf melt is observed

Morrison et al. in revision

Background and Motivation

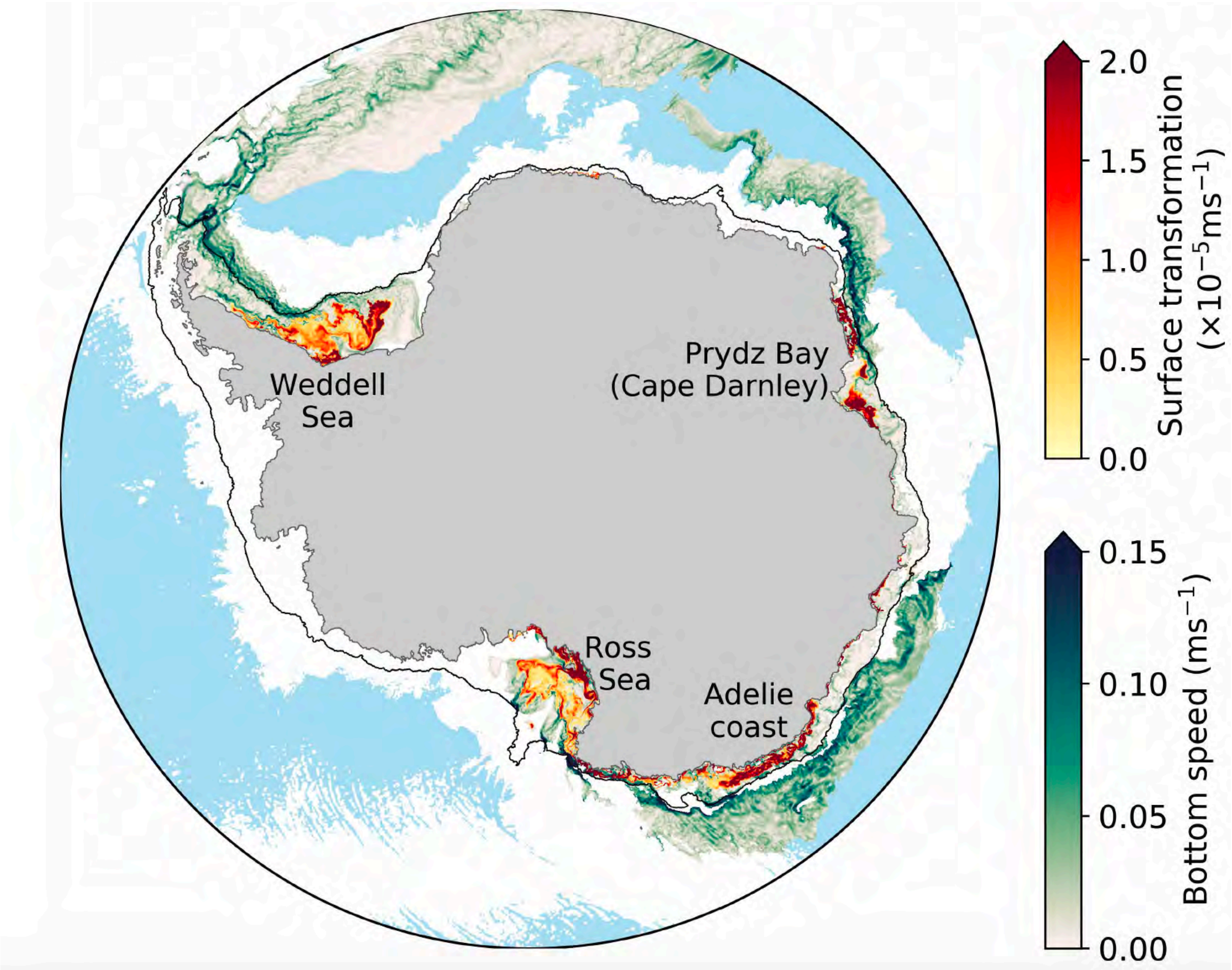
Goal: investigate circumpolar variations in the timescale and transformation of warm CDW on the Antarctic continental shelf

What is the residence time of warm CDW on the continental shelf in different regions?

How rapidly and where is onshore flowing CDW transformed on the shelf?

What is the advection timescale for CDW particles from the shelf break to ice shelf fronts in different regions?

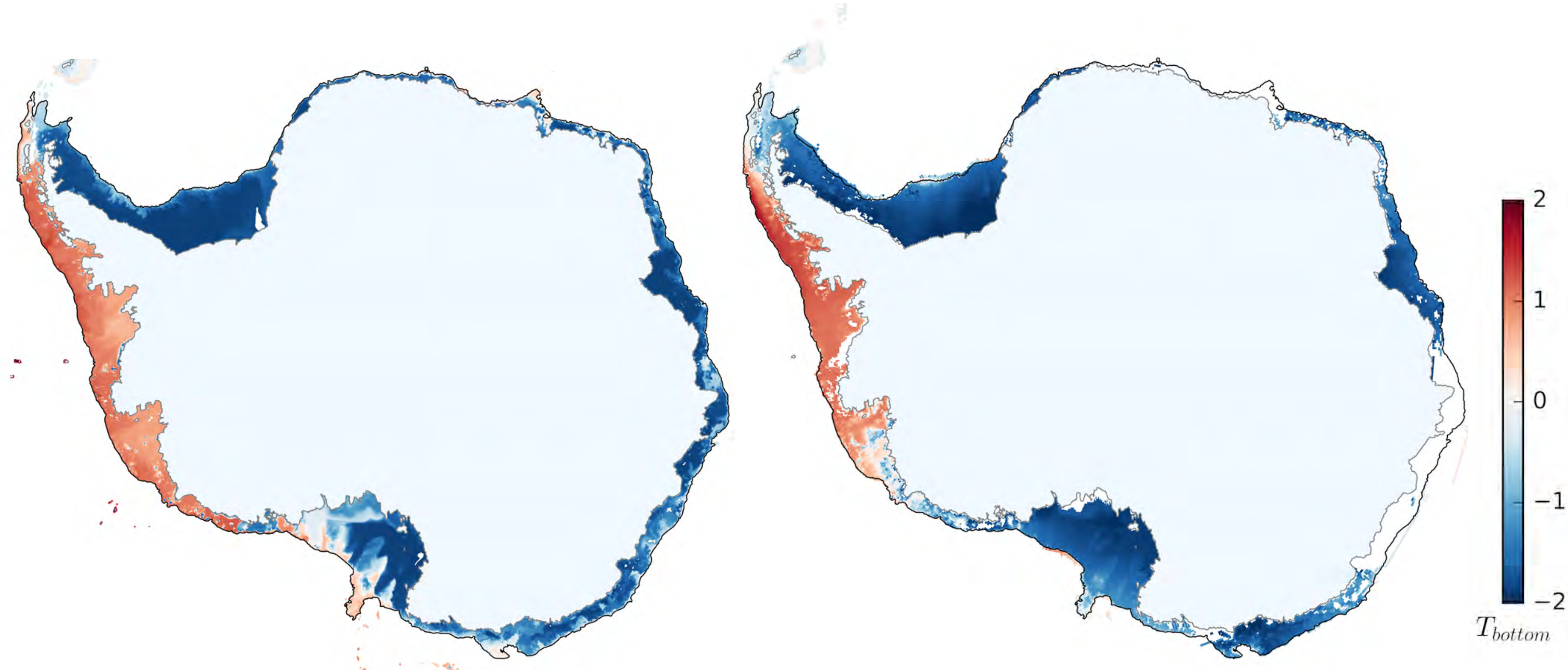
Model



- MOM01 ocean-sea ice model
- Forced with CORE Normal Year Forcing (no interannual variability)
- 0.1° horizontal resolution and 75 vertical levels (2.6-5.5 km along Antarctic continental slope)
- 10 years of daily averaged velocity output (following 80 year spin-up)

Morrison et al. in revision

Model



Shelf bottom temperature from model (left) and observations (right). Model biased warm in Ross Sea

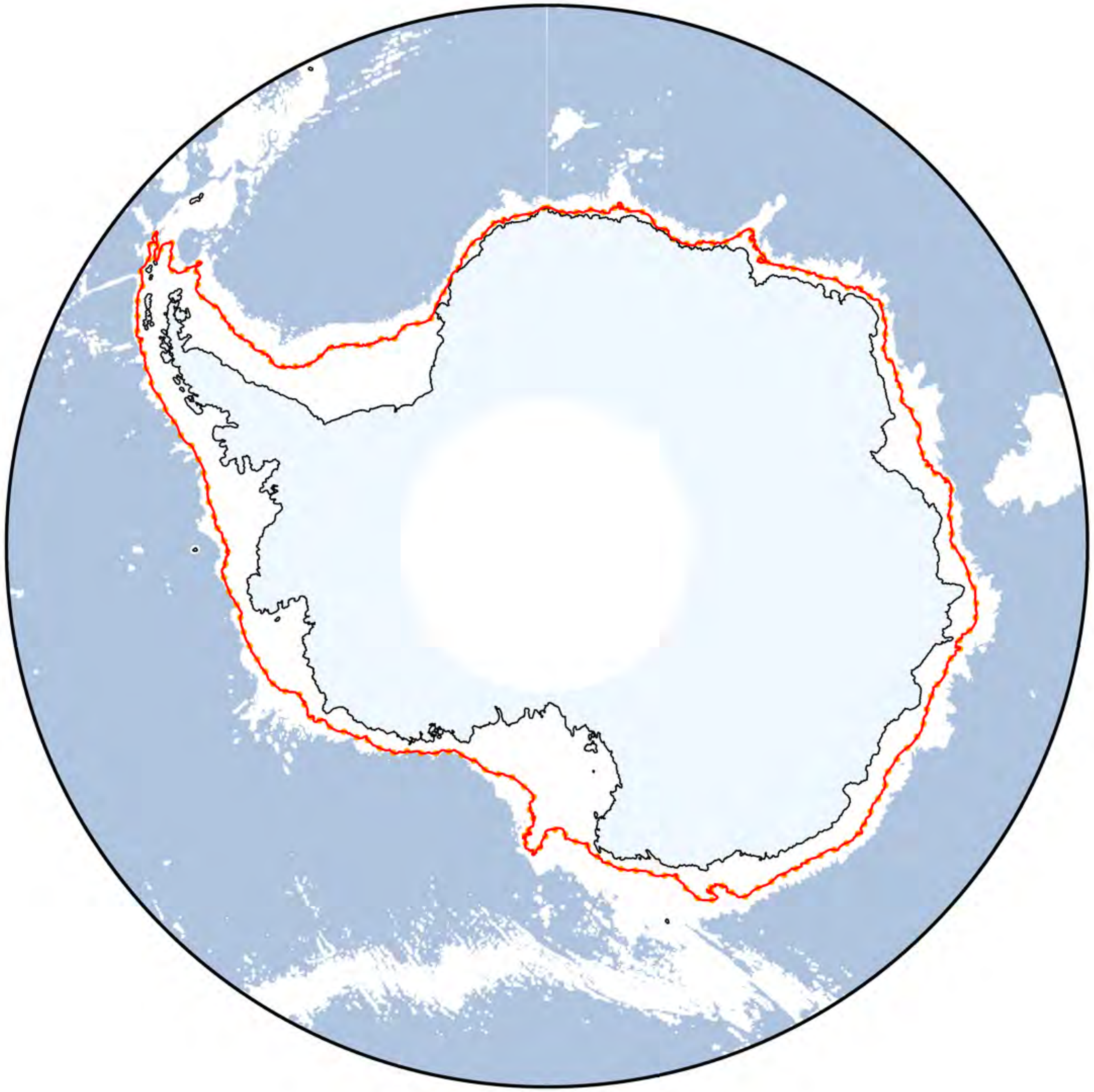
Lagrangian experiment

- Release particles spaced evenly in depth (every 20 m) from the surface to 1000 m at 100 km intervals along the 1000 m isobath on the continental slope

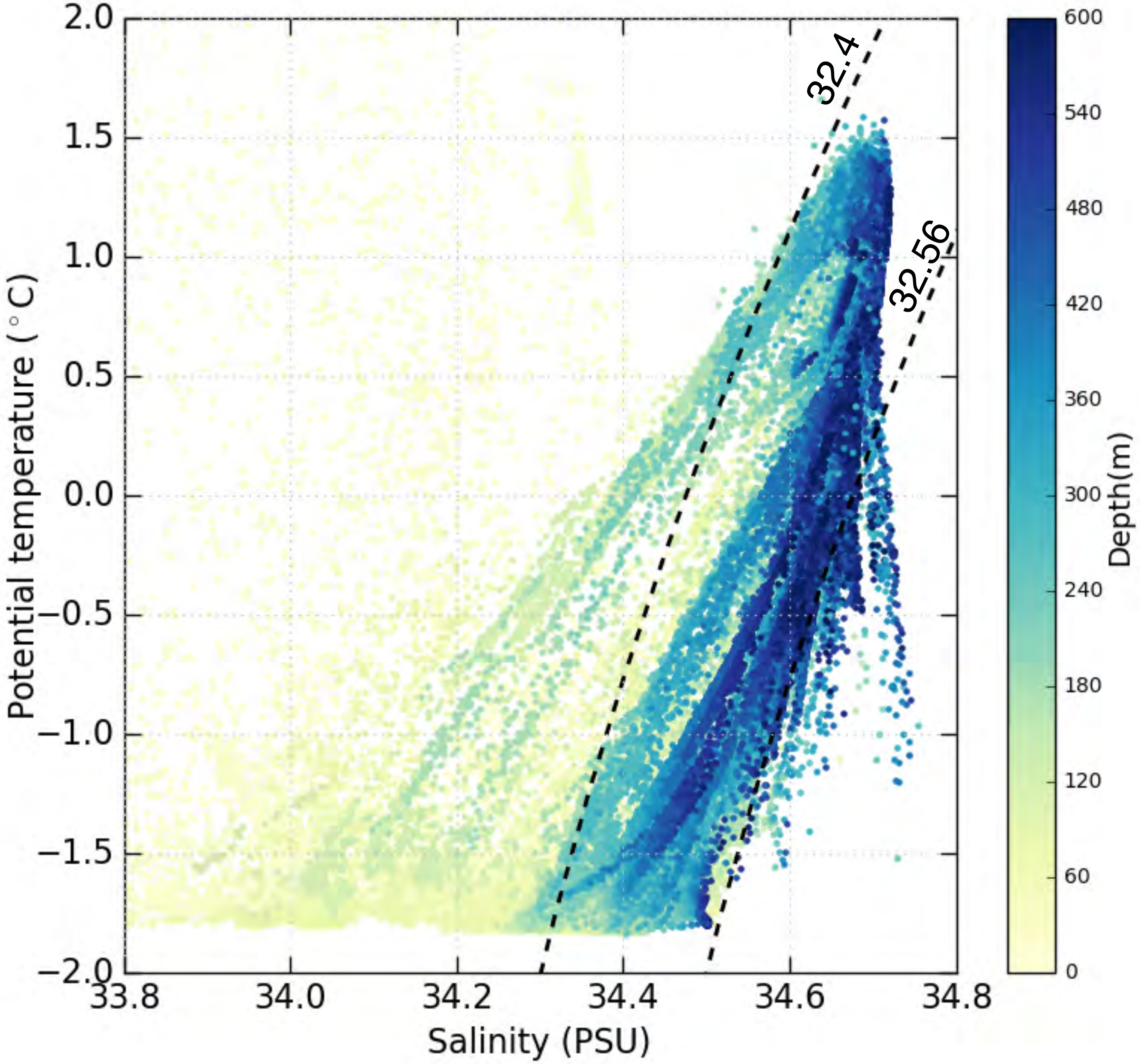
- Repeat release every 5 days for a year (total >300,000 particles), then track for 5 years

- Track particles that travel up onto continental shelf

- Save T and S along particle trajectories



Results



Initial T-S and depth distribution of particles moving onshore

CDW defined by density range $32.4<\sigma_1<32.56$

Tamsitt et al. in prep

Results

- 19% of initial released particles are CDW moving upslope
- Half of these stay on the shelf more than 10 days
- 30% of upslope CDW reaches the 500 m isobath
- 10% of upslope CDW transforms to lighter/denser water mass while on the shelf

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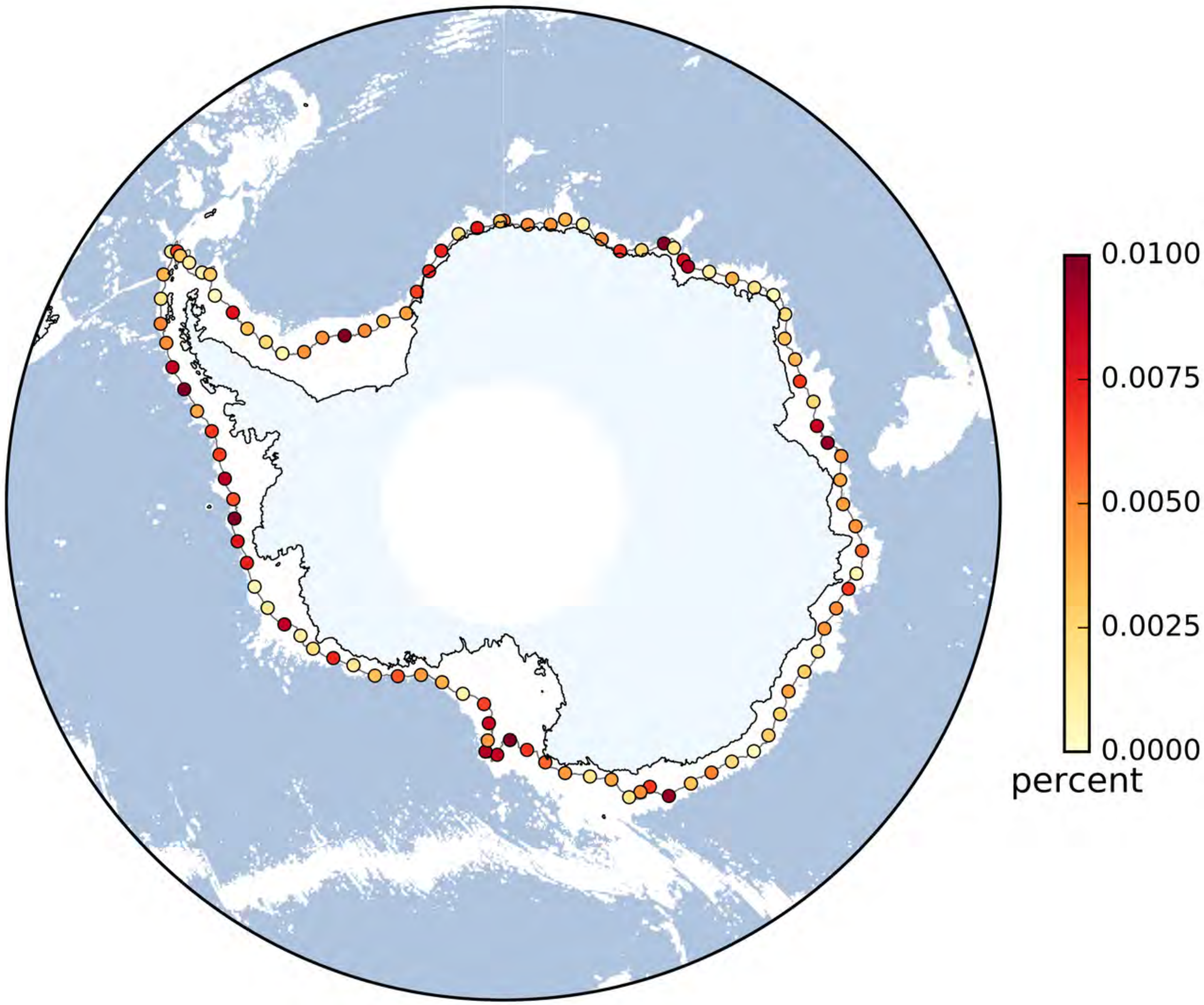


Percent of CDW particles flowing upslope toward shelf along the 1000 m isobath

Tamsitt et al. in prep

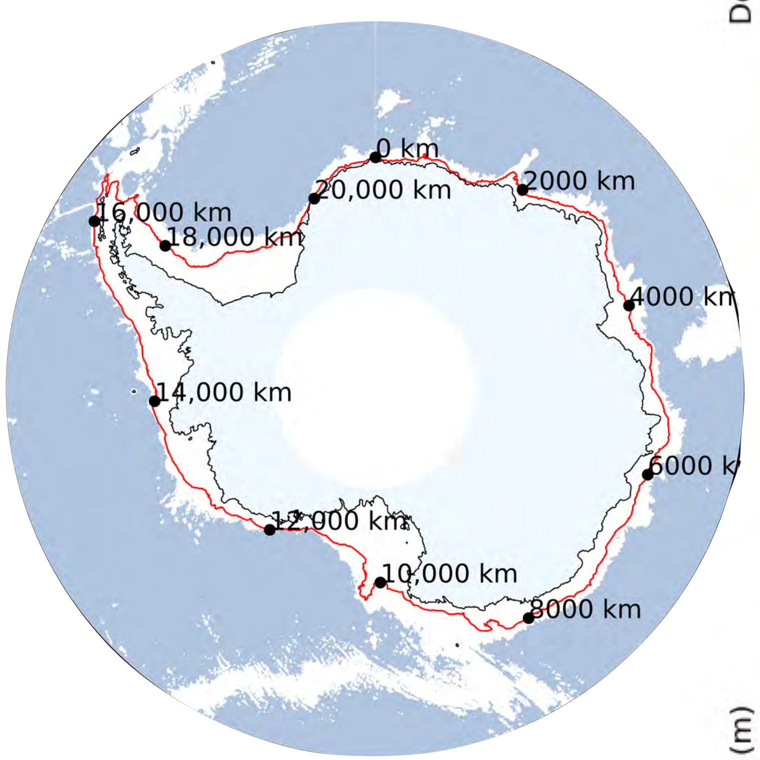
Results

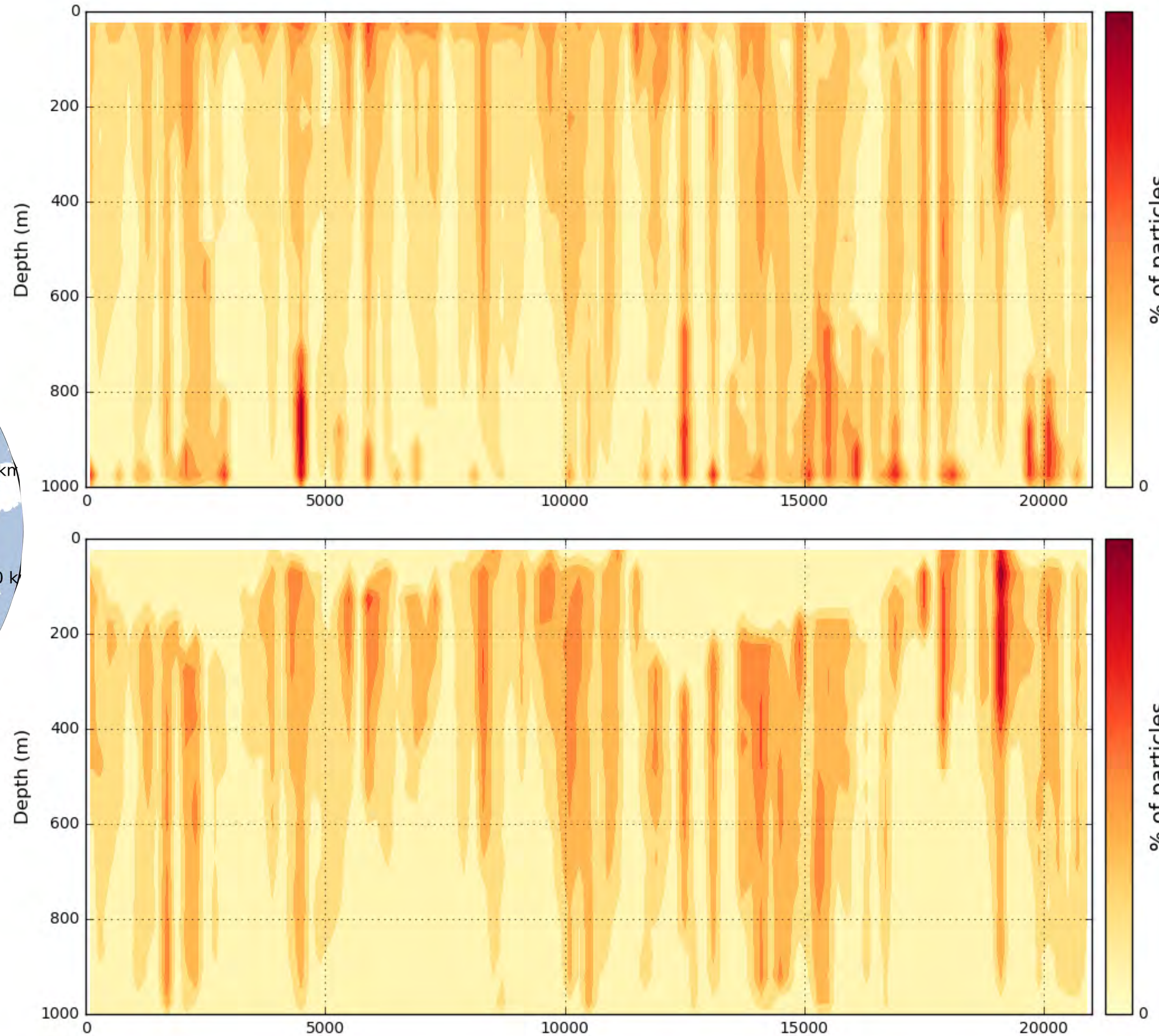
Distance contour around shelf following 1000m isobath

Tamsitt et al. in prep

Results

Depth vs distance along 1000m isobath for upslope particles (top=all, bottom=CDW)

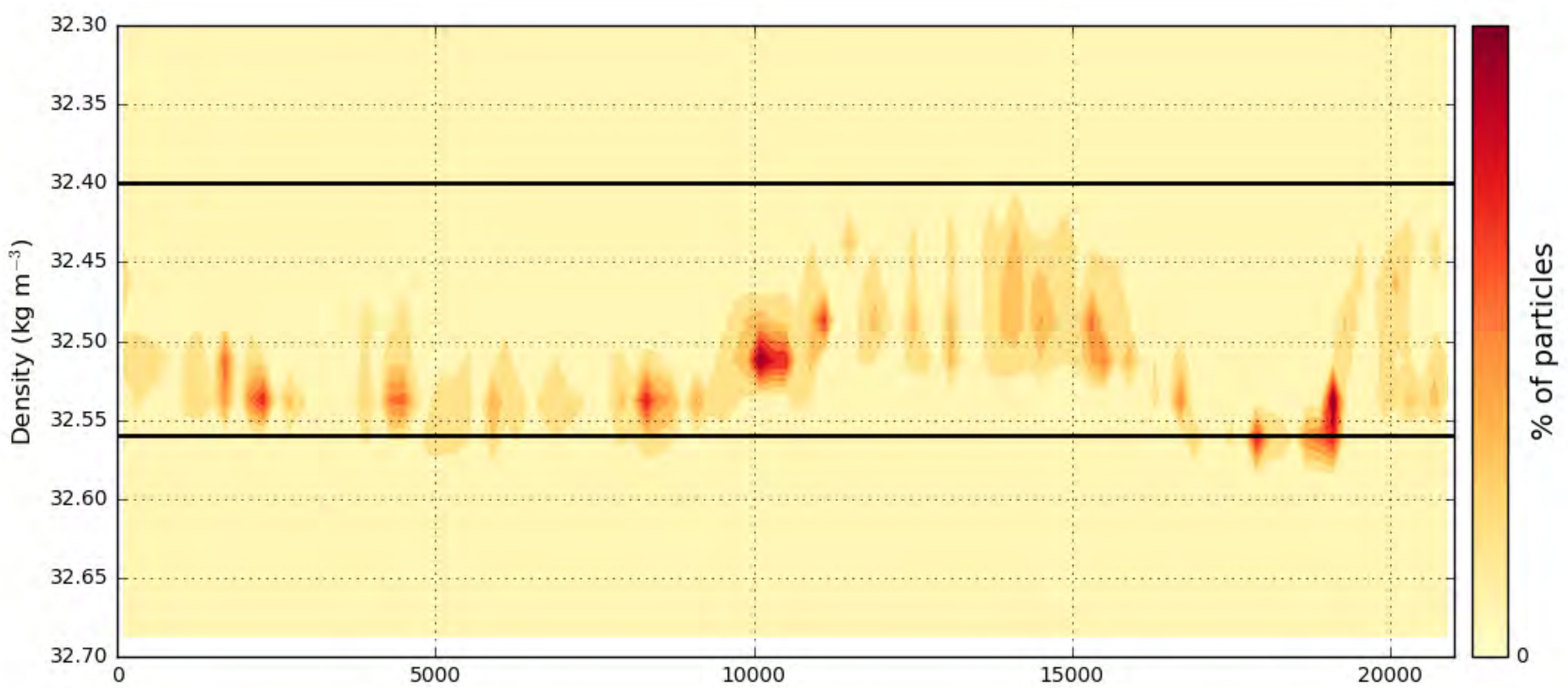




Tamsitt et al. in prep

Results

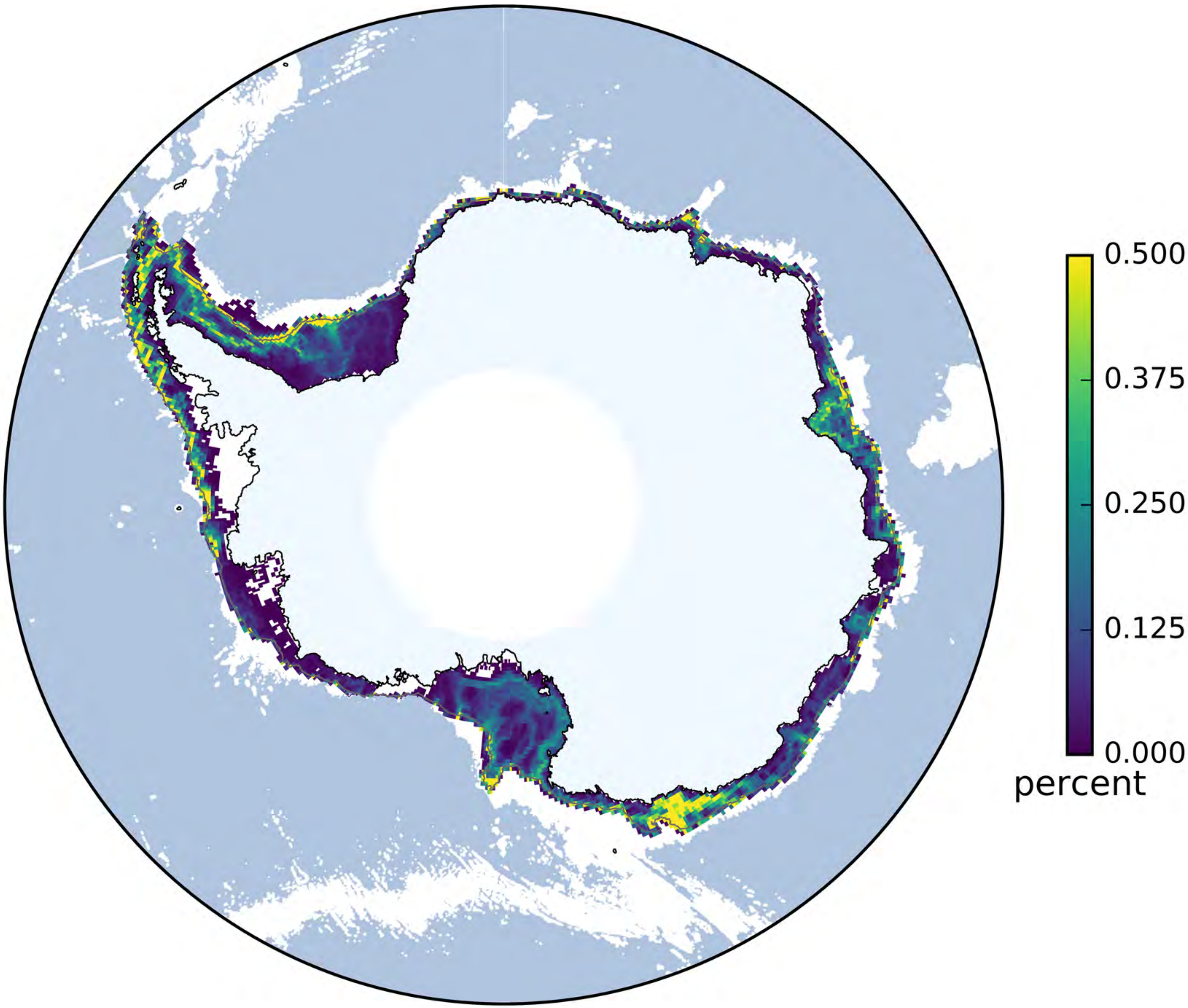
Density vs distance along 1000m isobath for upslope CDW particles



Tamsitt et al. in prep

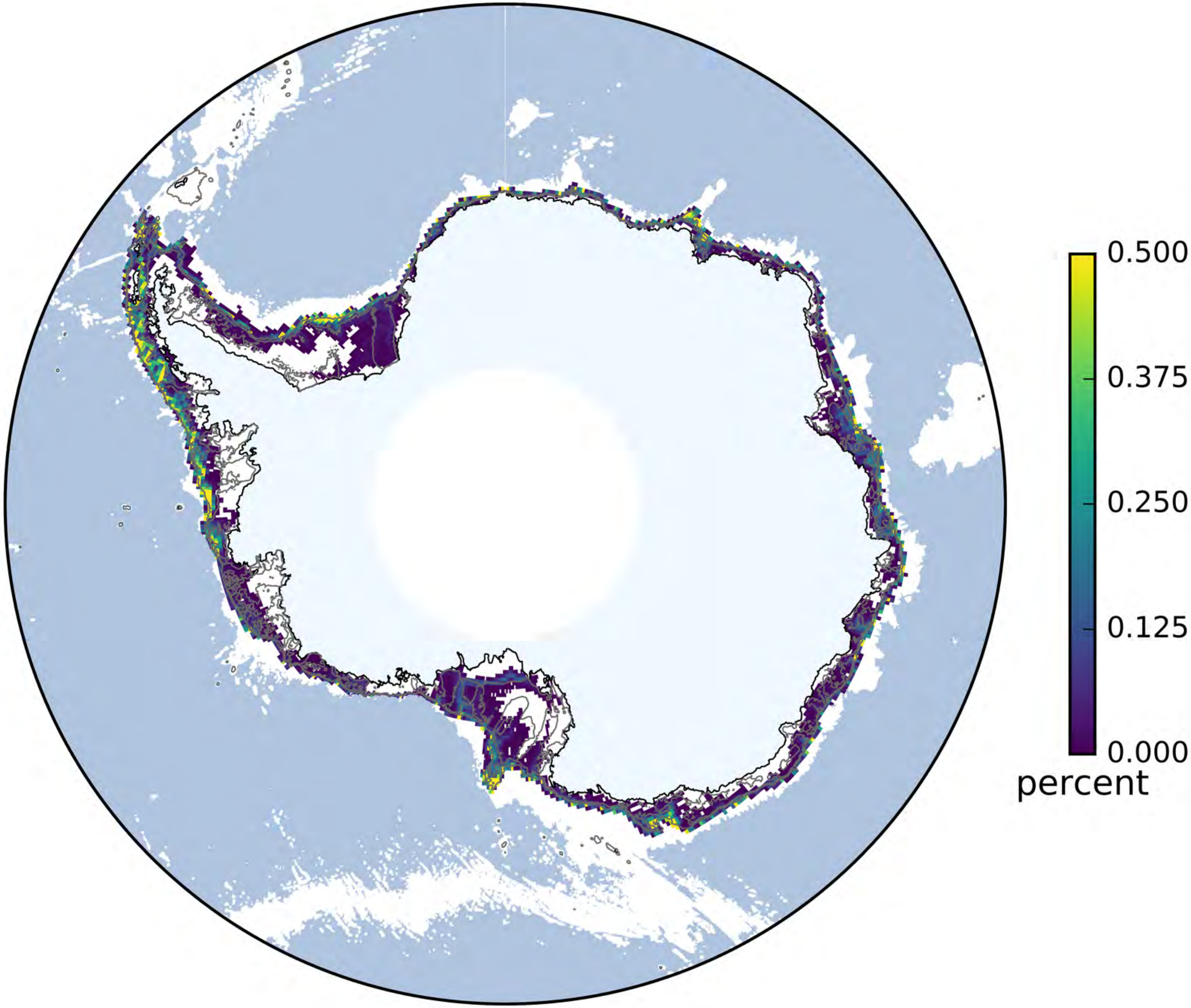
Results

Pathways of CDW on shelf, white means no particles there while on shelf



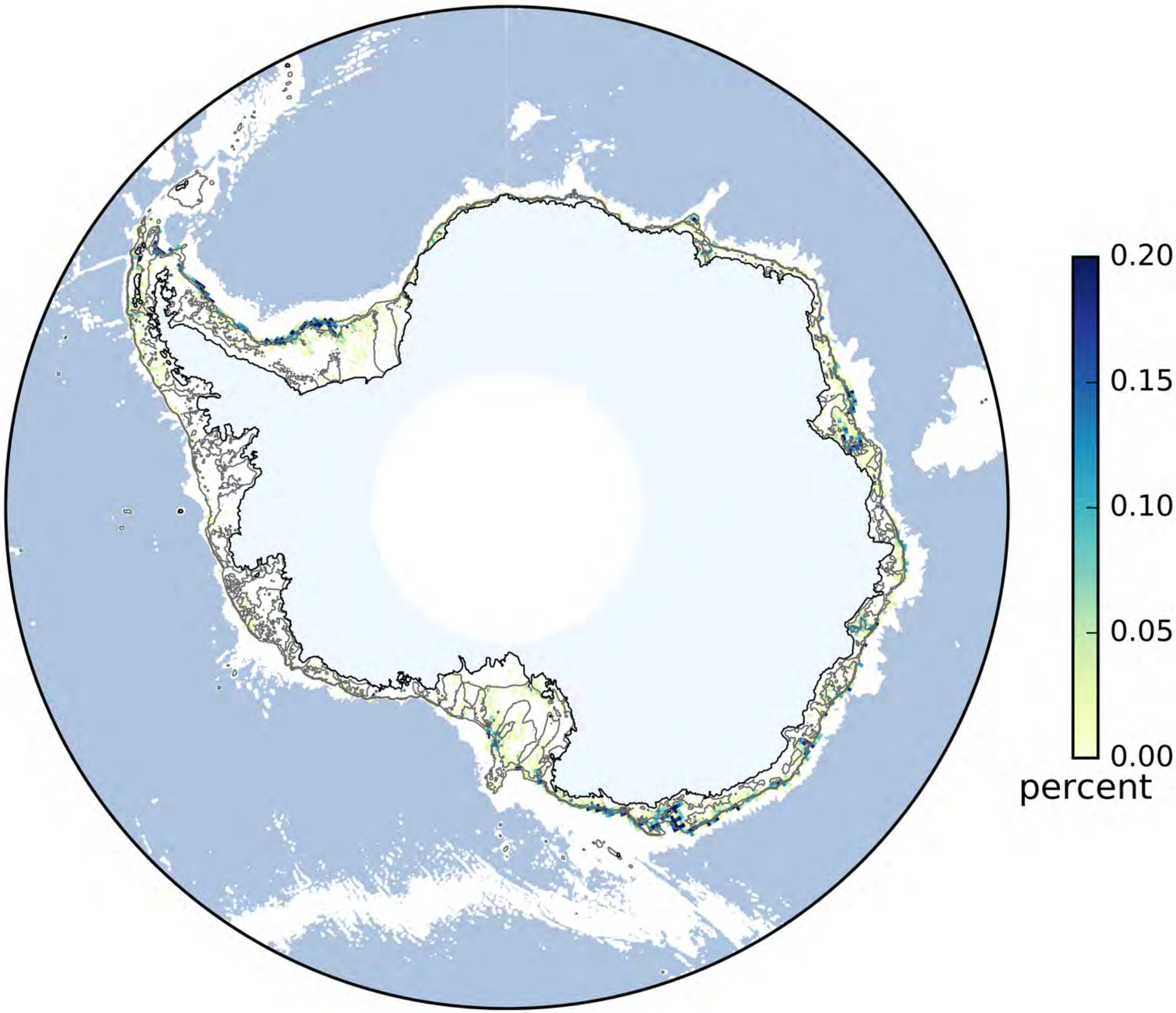
Results

Pathways of CDW on shelf, only up until transformed out of CDW density range



Results

Location of transformation for crossing density threshold (32.4<sigma1<32.56)



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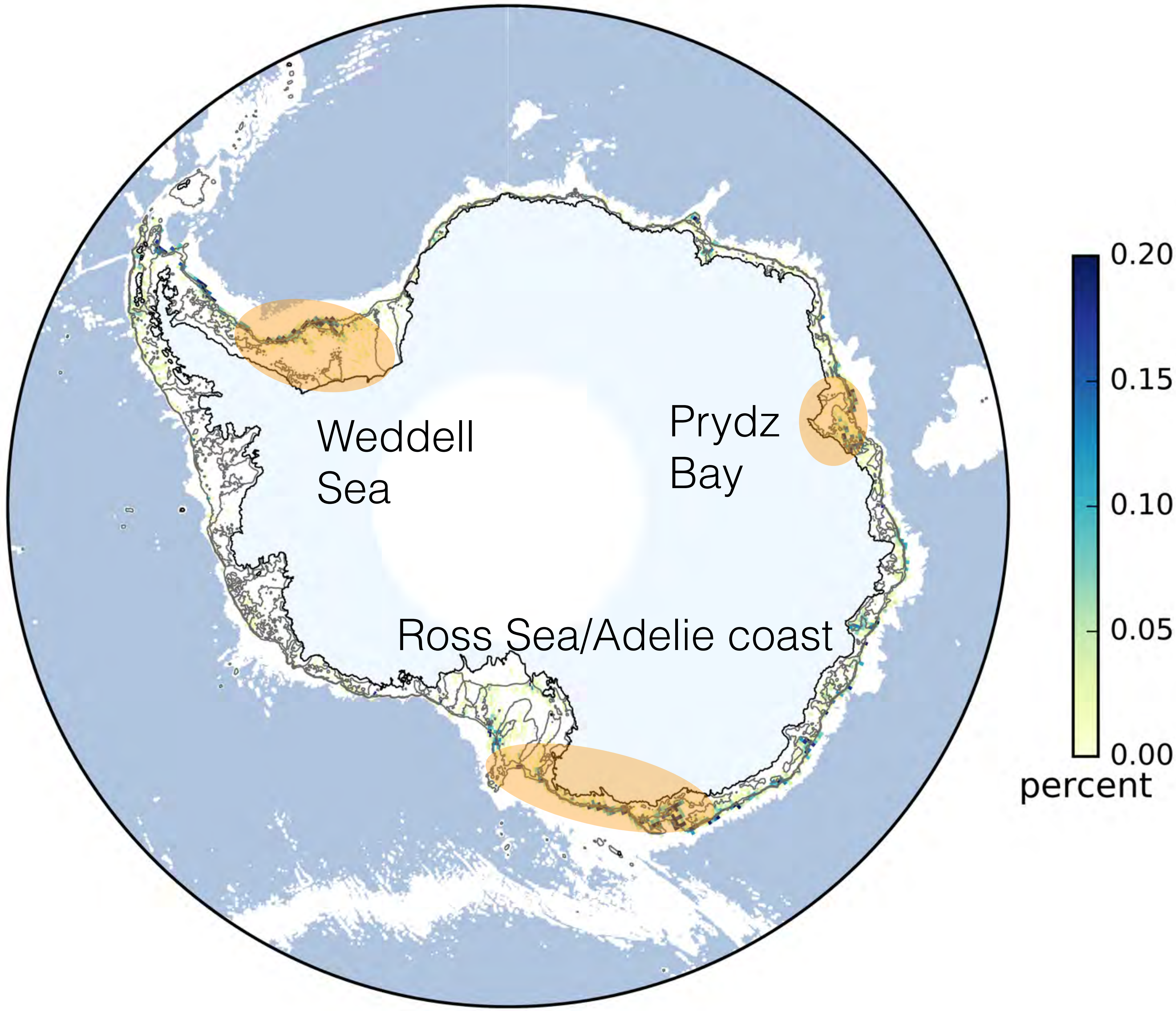
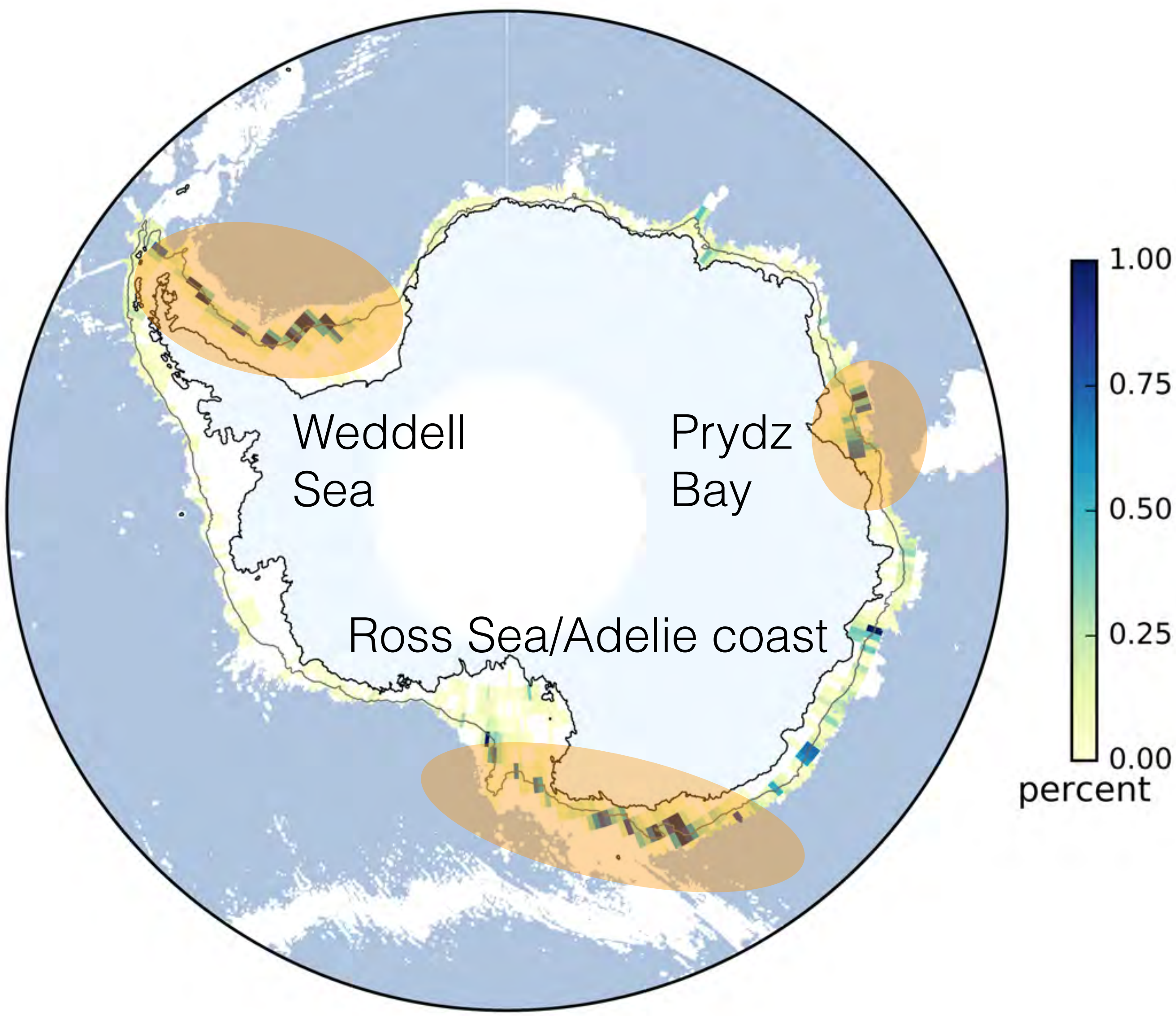
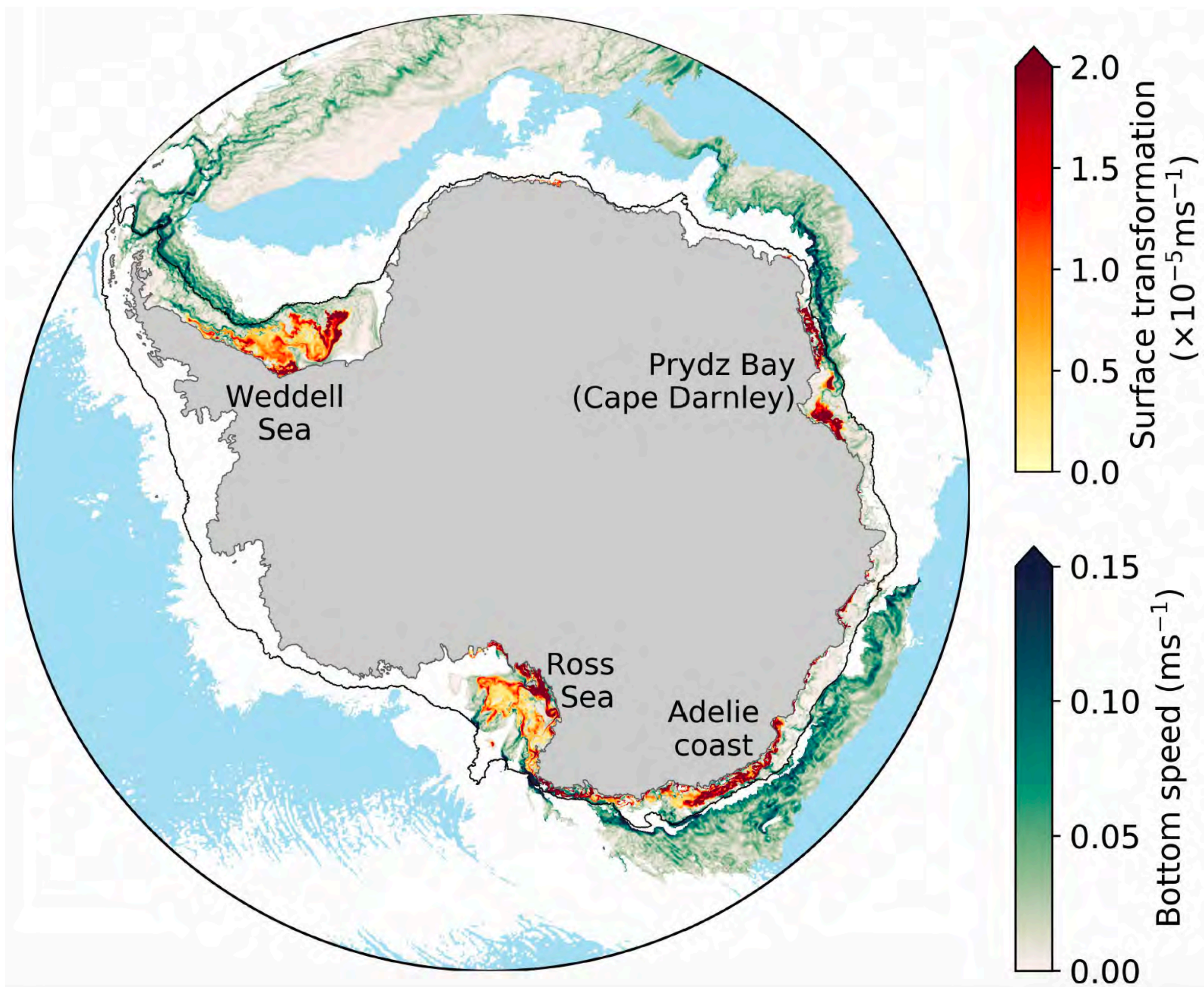


Results

Location where CDW is transformed
(leaves $32.4<\sigma_1<32.56$ density range)



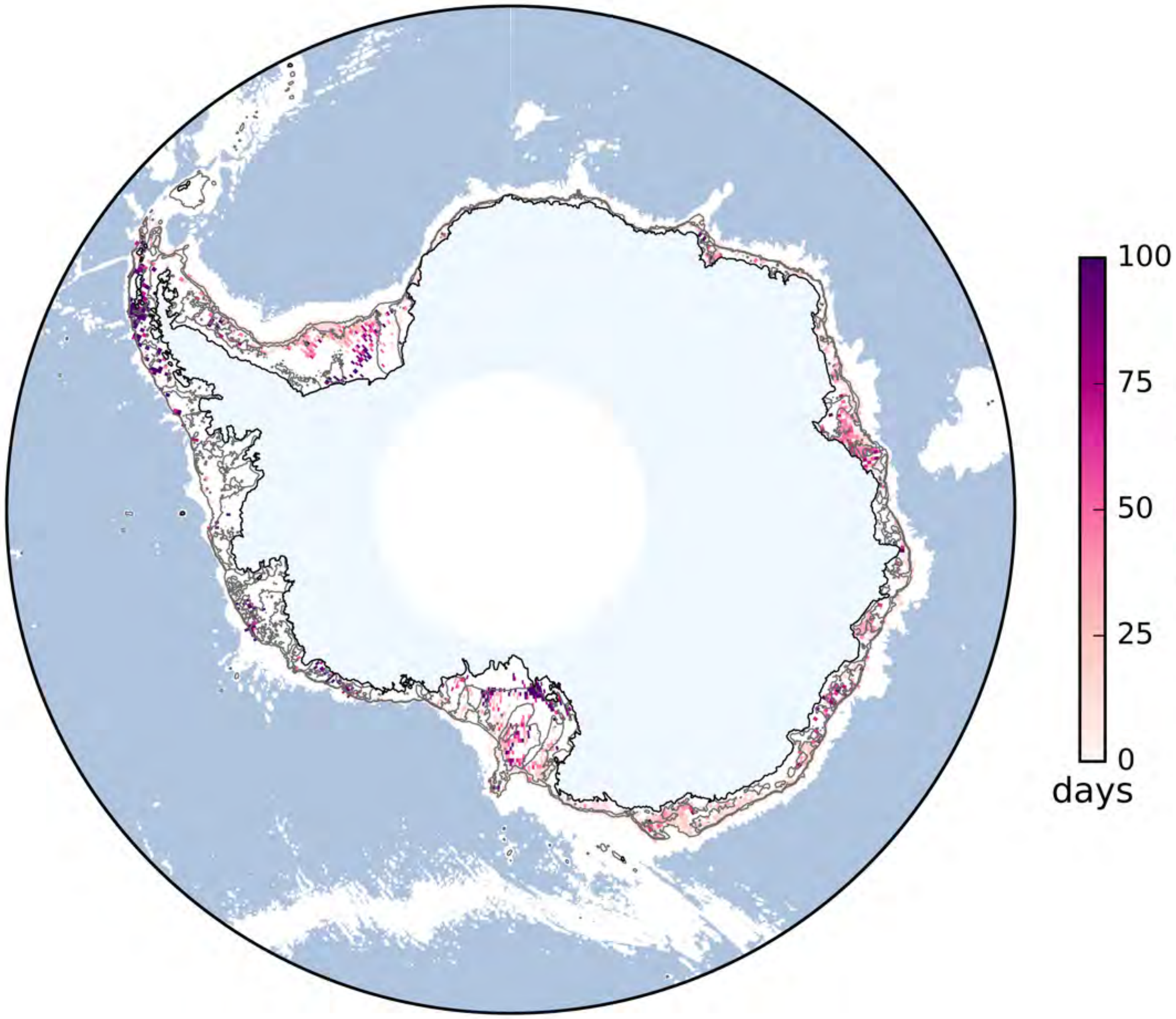


Agrees with locations of strong surface water mass transformation, but concentrated near shelf edge rather than coast

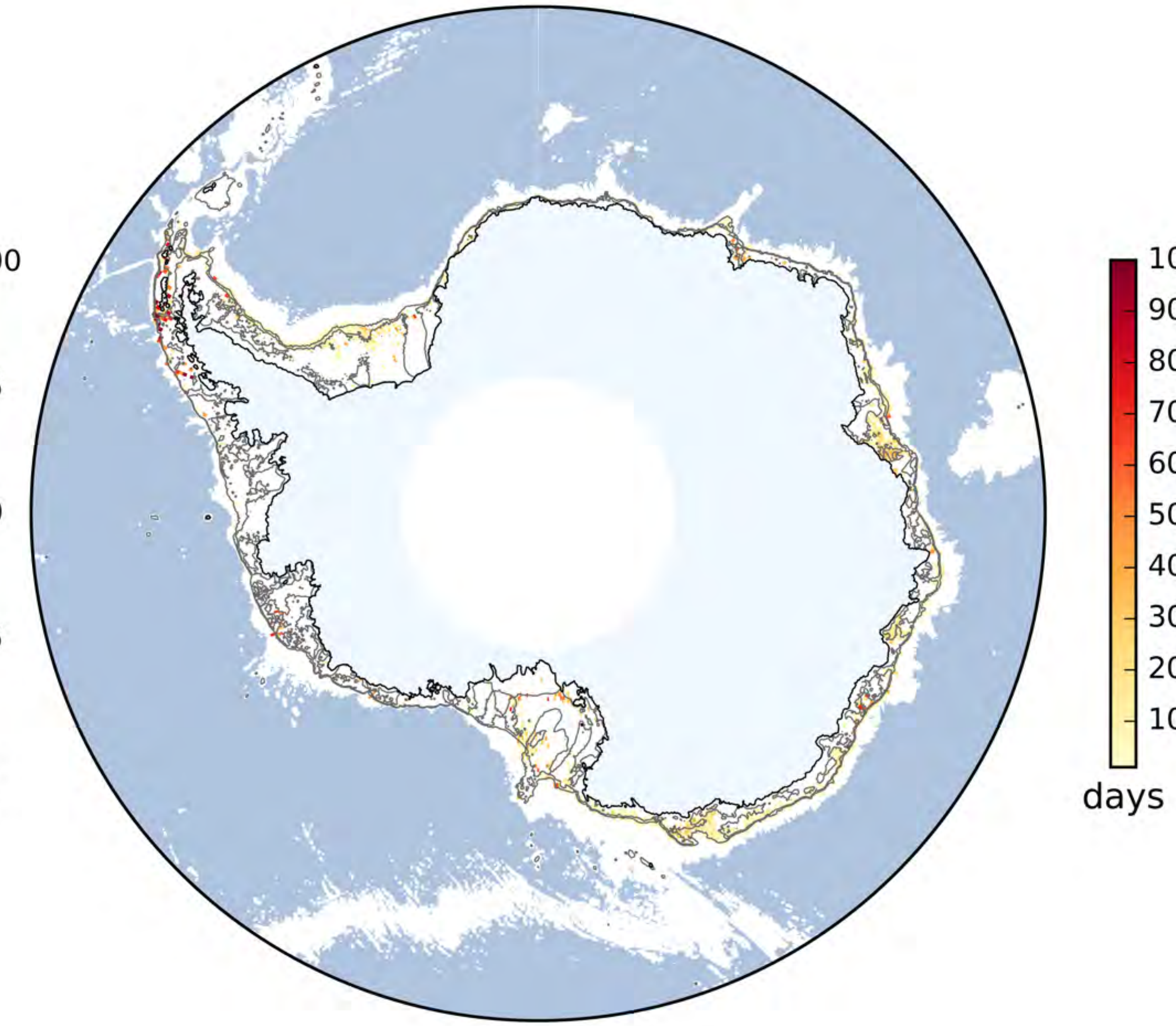
Tamsitt et al. in prep

Results

Mean age of CDW at time of transformation



Standard deviation of age of CDW at time of transformation

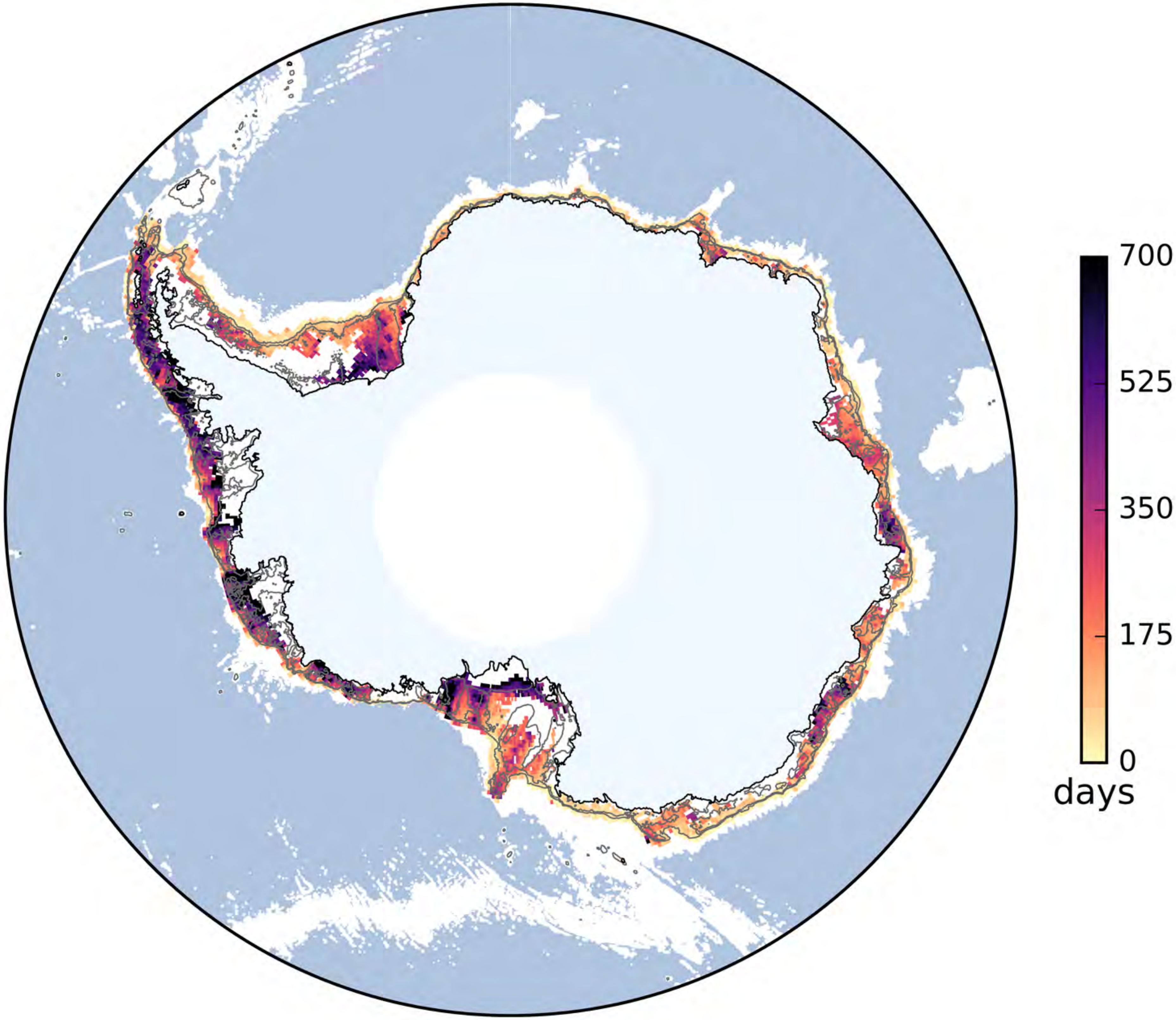


Longer time to transformation in WAP/Amundsen/Belinghausen, and far from shelf edge in Ross/Weddell

Tamsitt et al. in prep

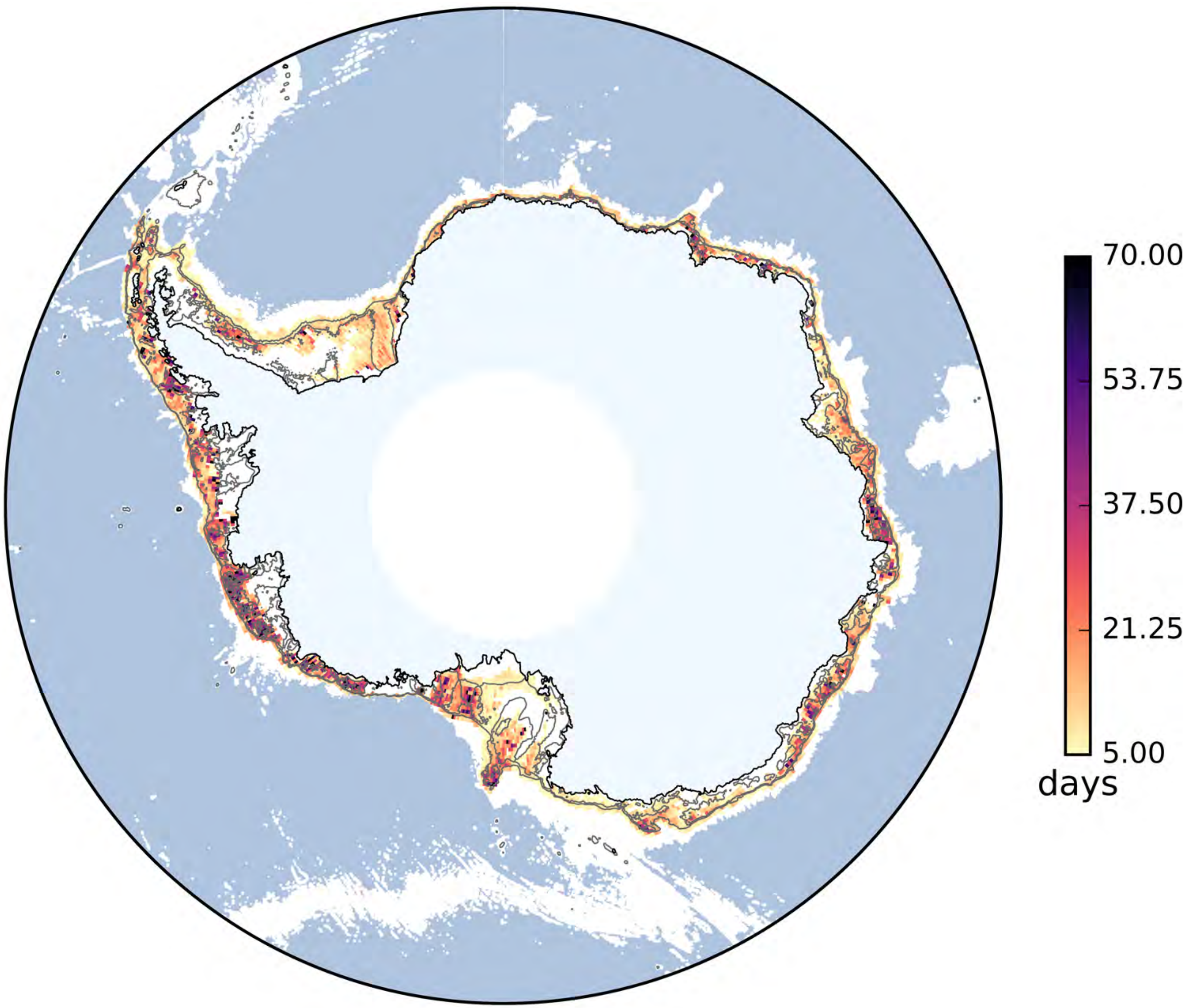
Results

Mean age of CDW
(time since release)



Results

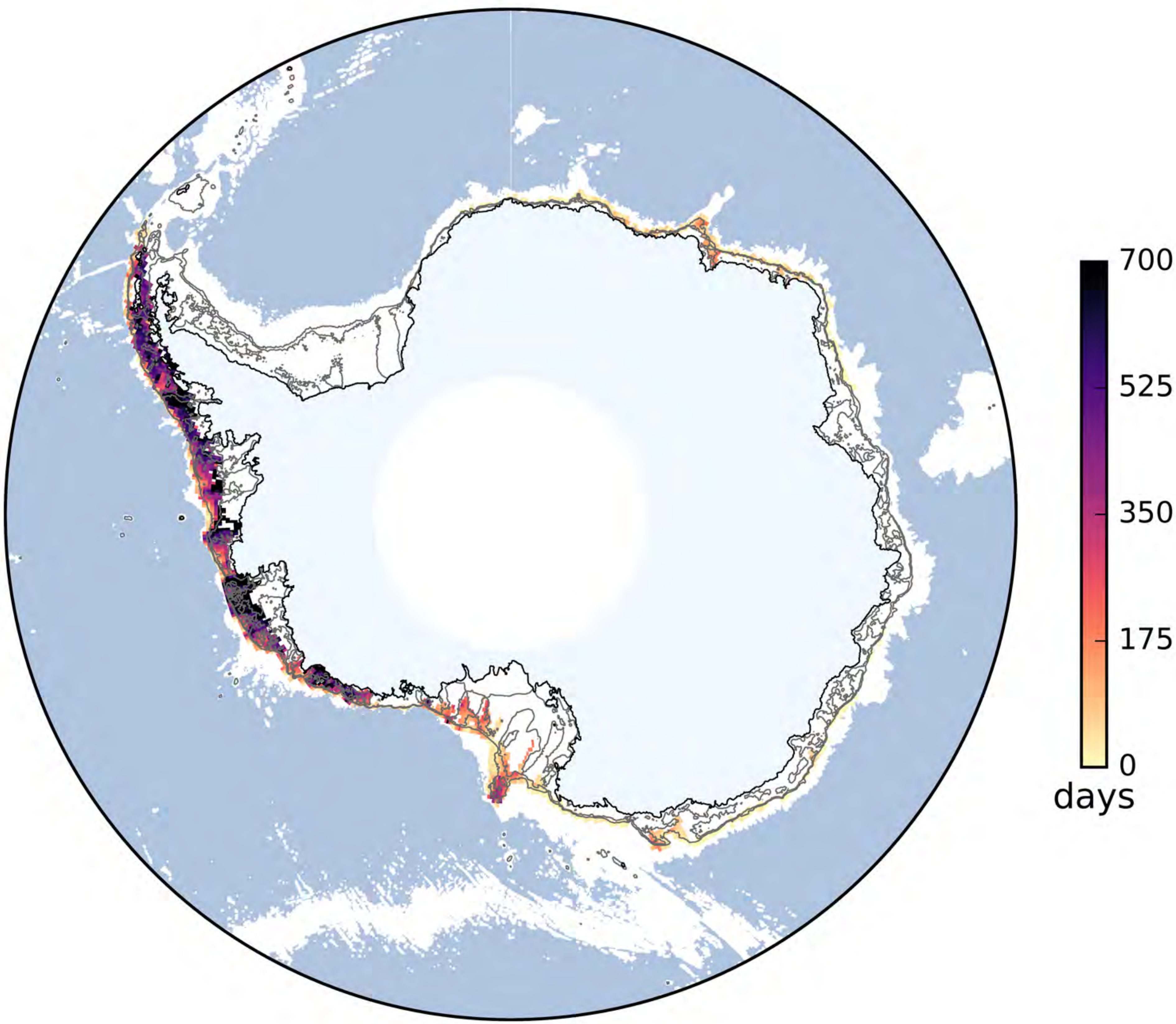
Mean CDW particle-days spent in bin



Results

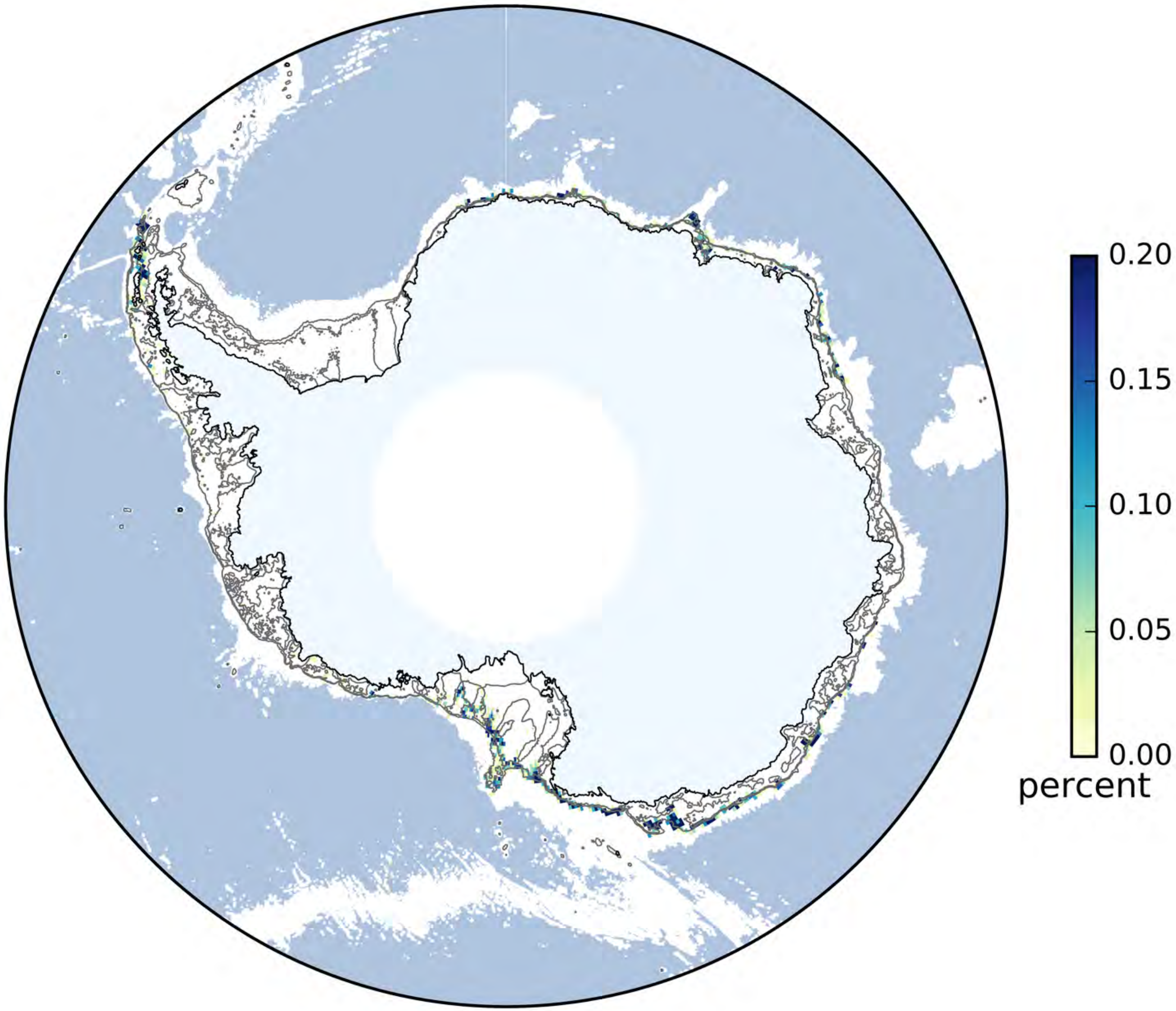
Alternate definition:

Mean age of CDW >0C



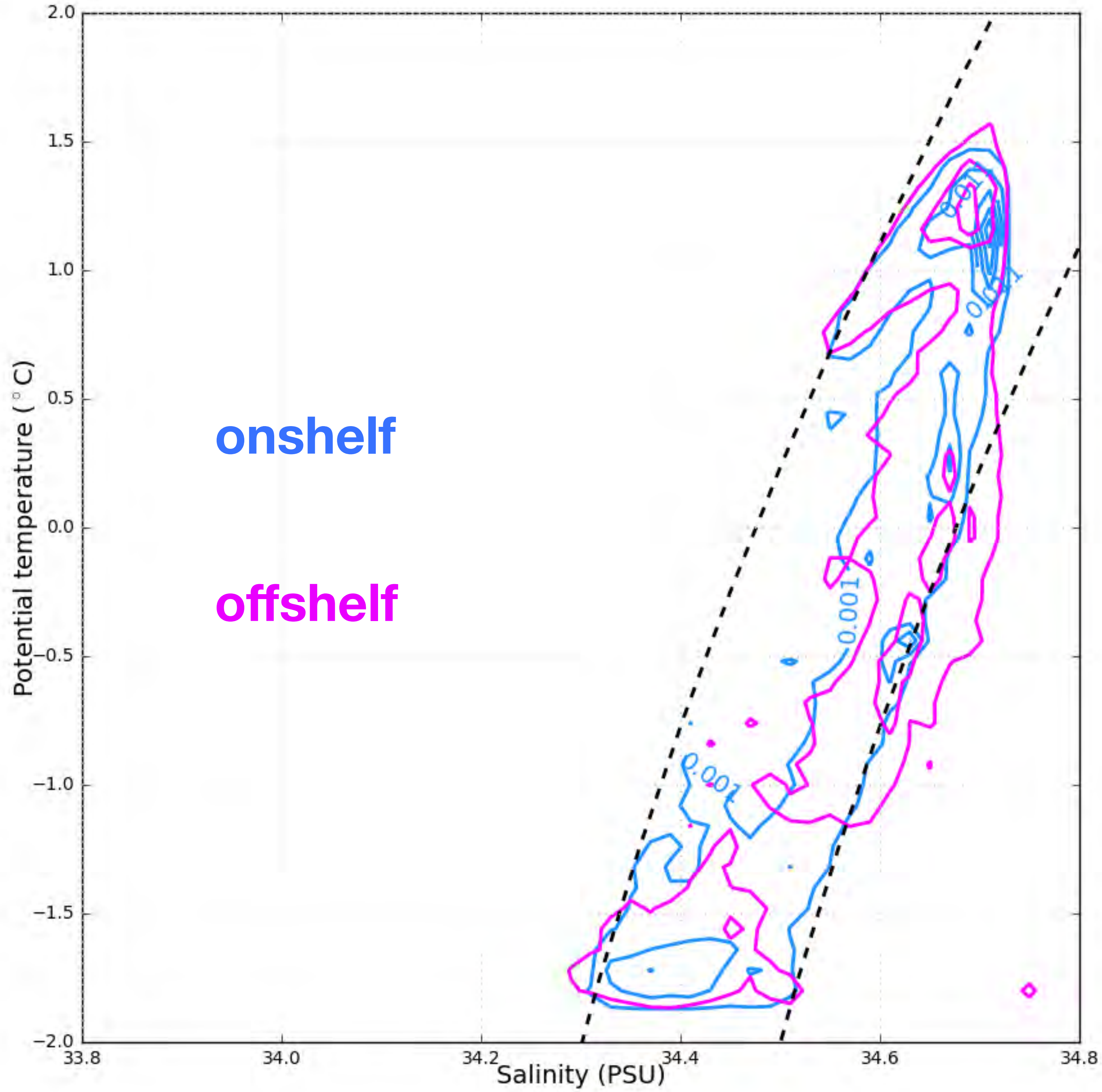
Results

Location of transformation for initially >0C CDW (crossing temperature threshold)



Results

Distribution of particles in T-S space



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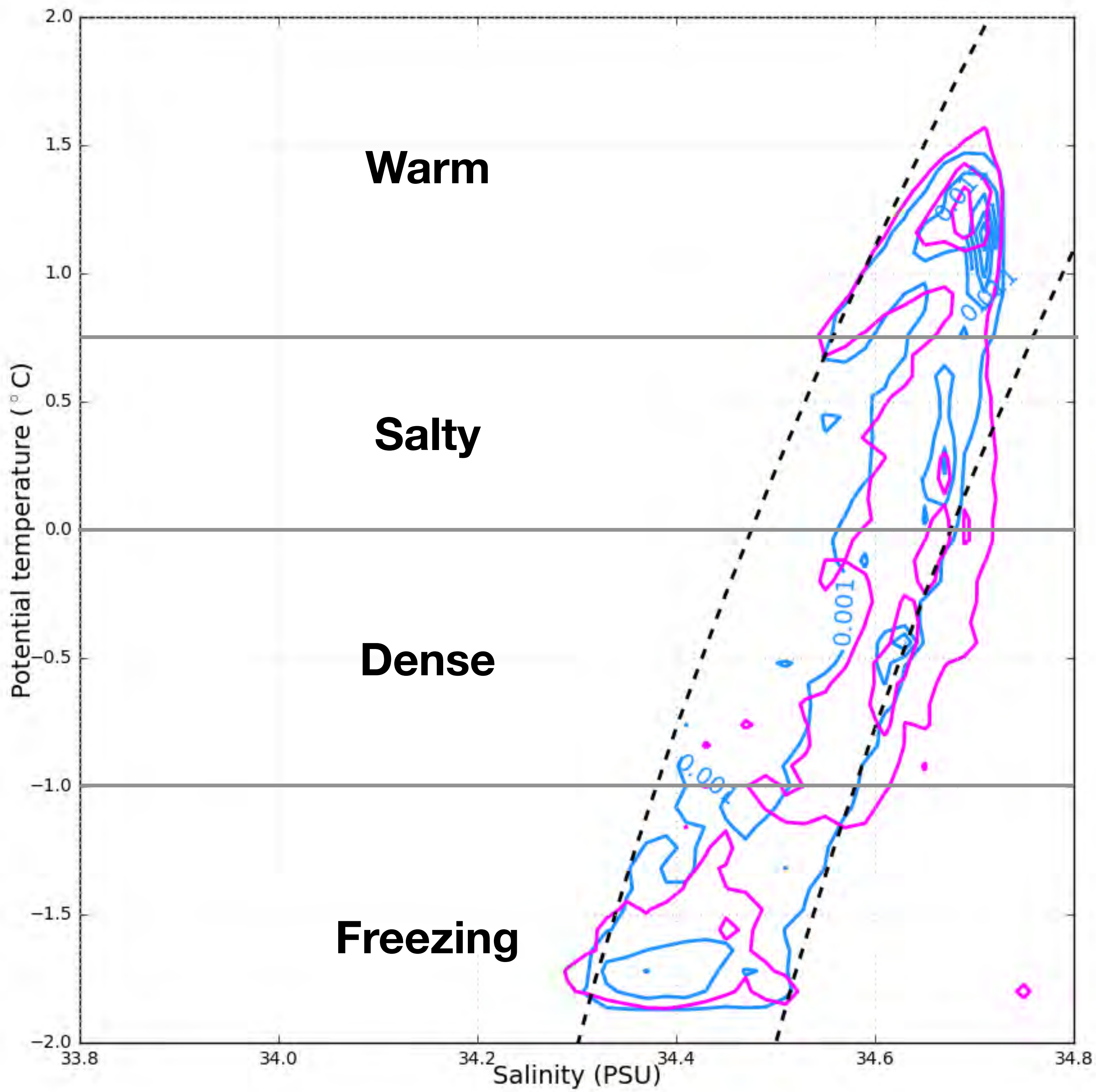
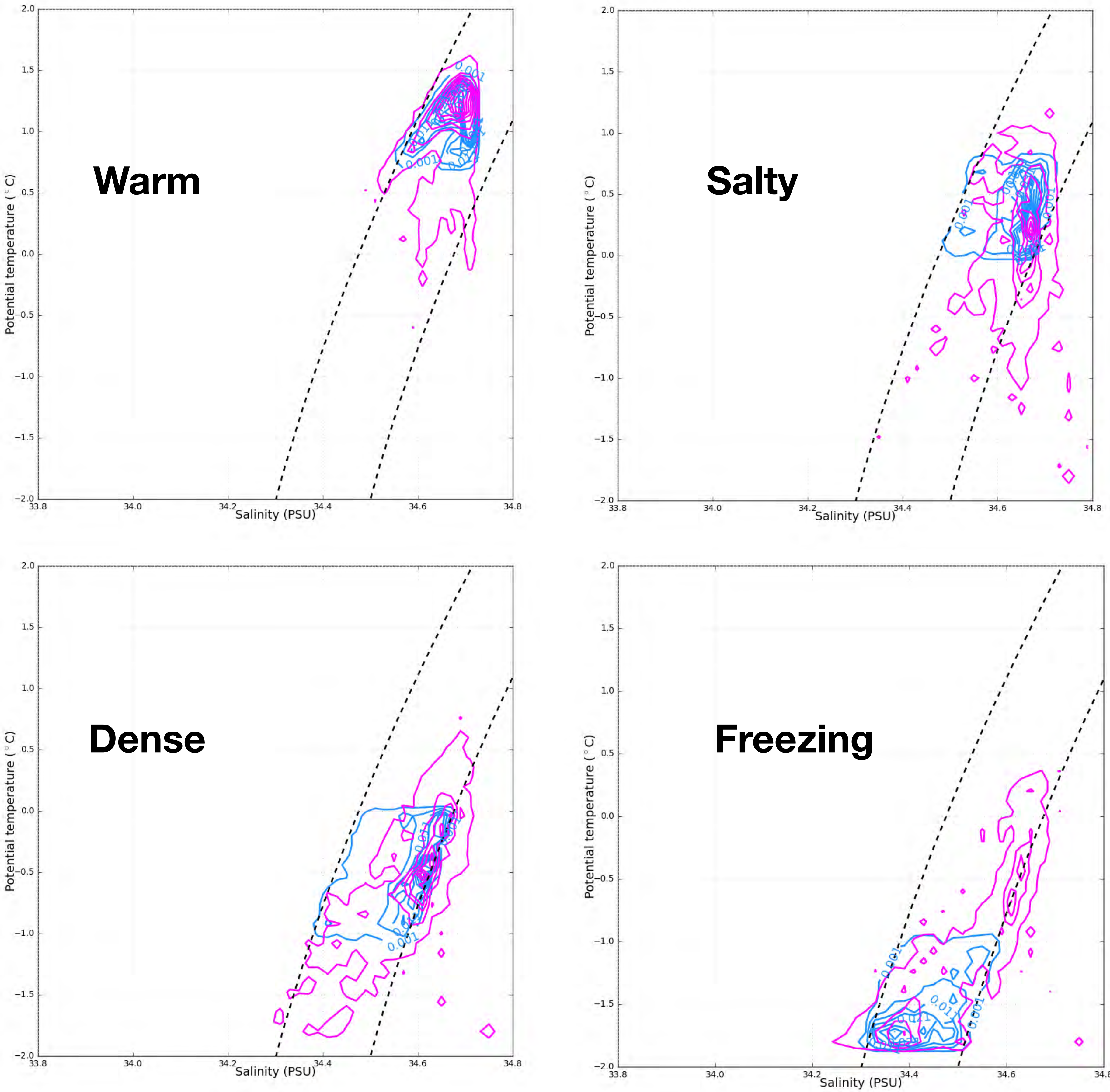
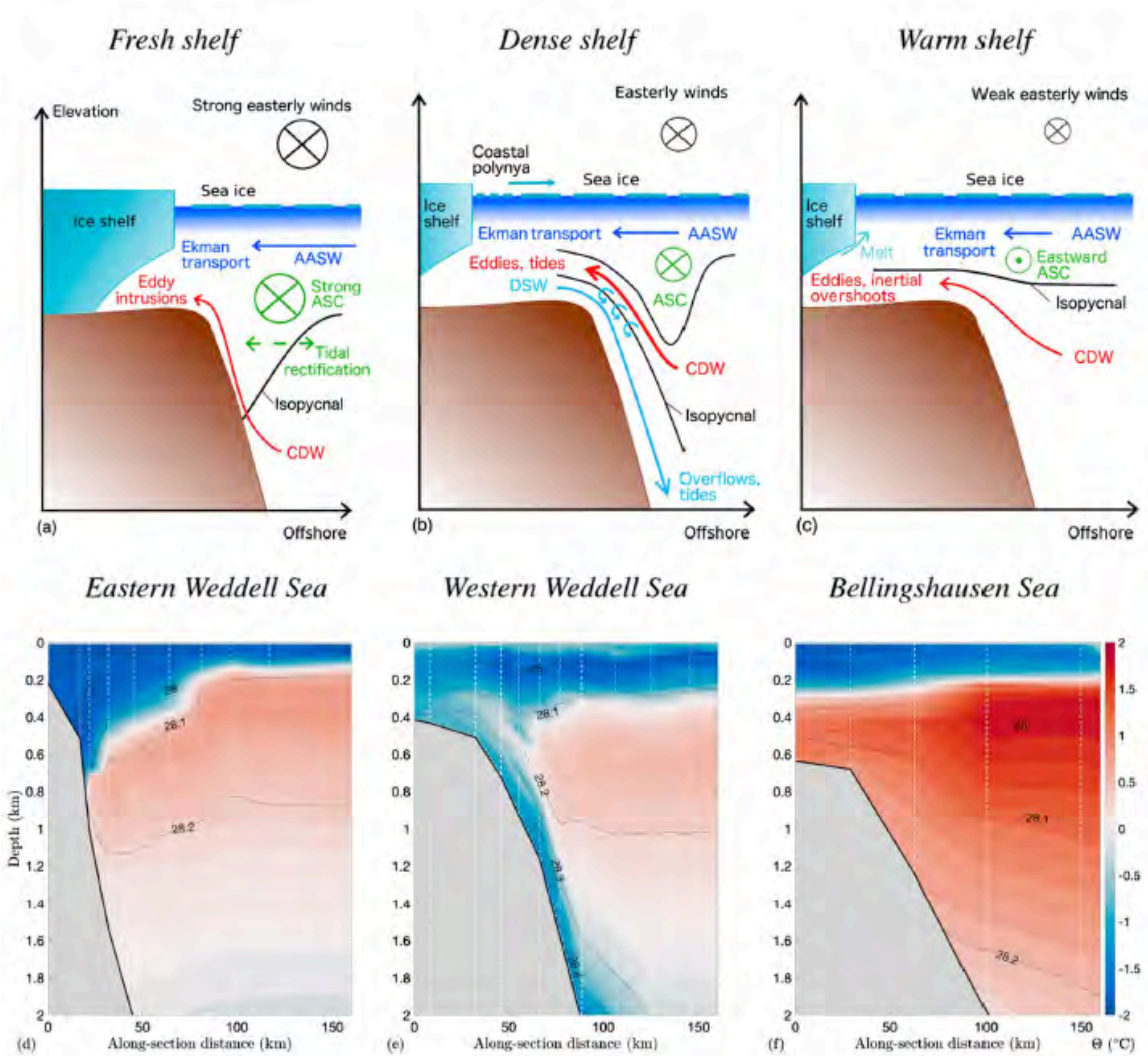


Results


Warm
Salty
Dense
Freezing
Potential temperature (° C)
Salinity (PSU)

Results

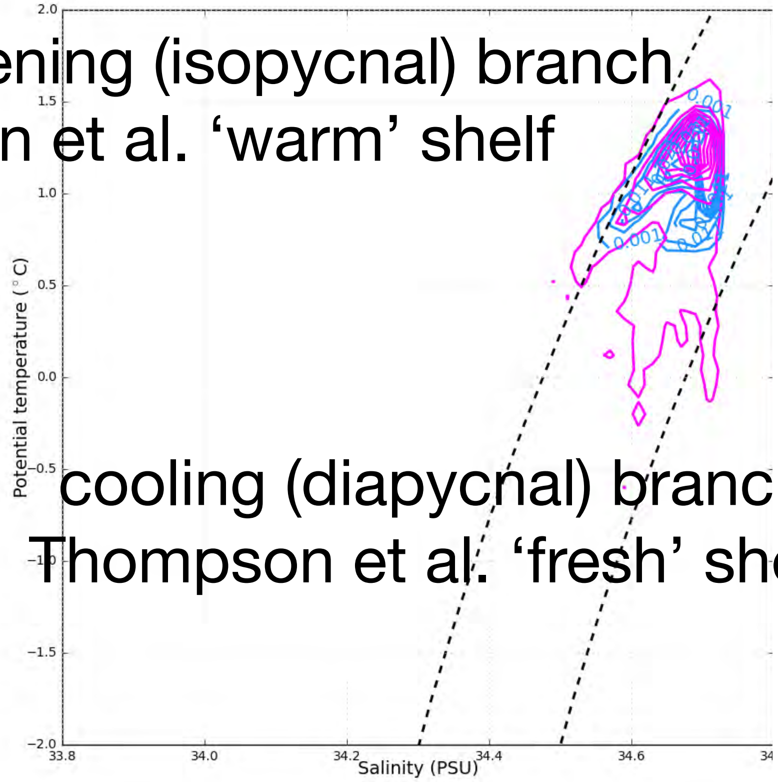


Thompson et al. 2018

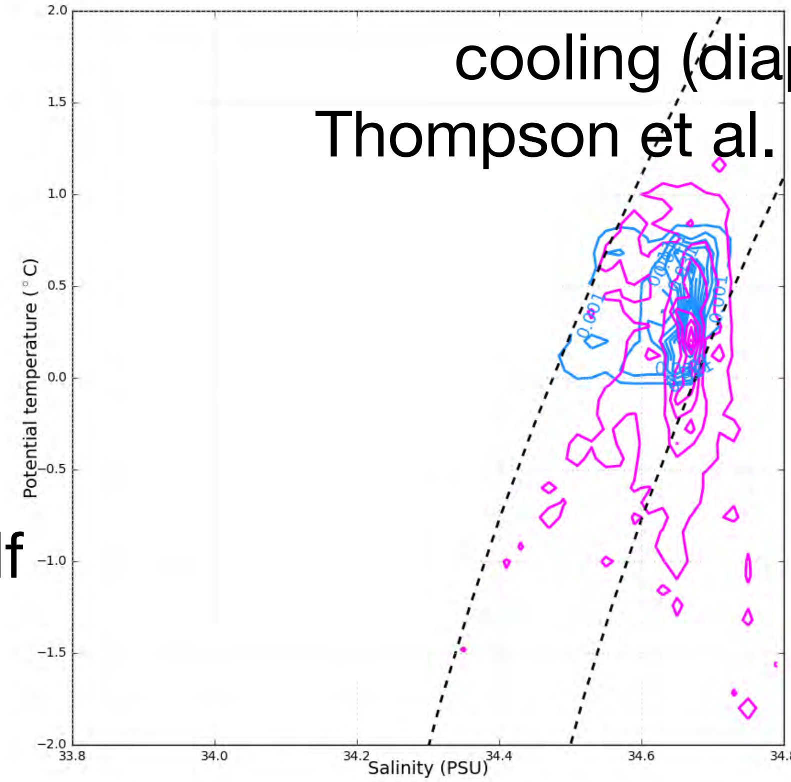
Results

cooling/freshening (isopycnal) branch
Thompson et al. ‘warm’ shelf

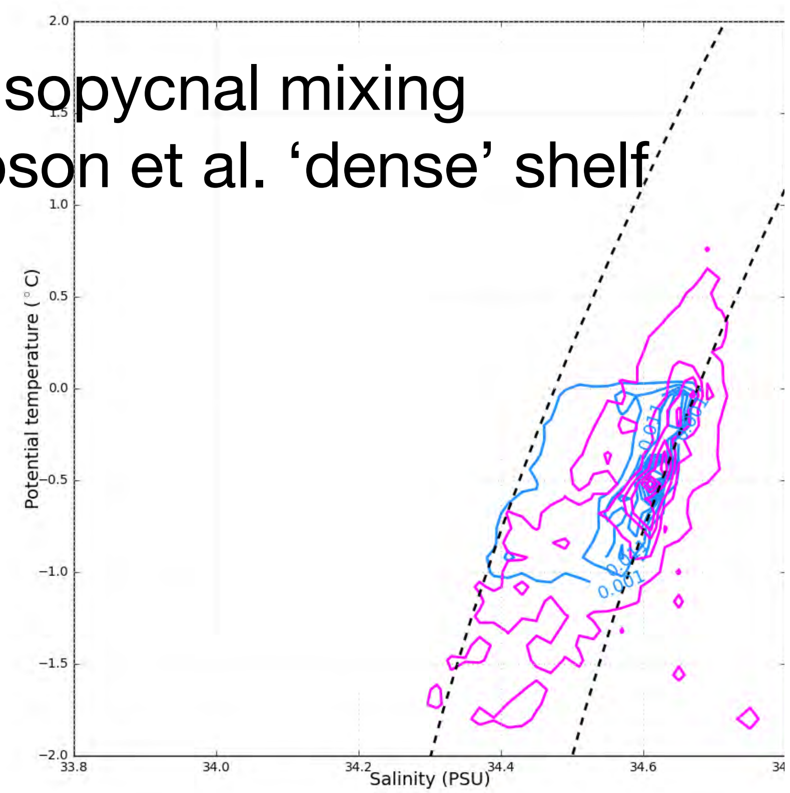
cooling (diapycnal) branch
Thompson et al. ‘fresh’ shelf



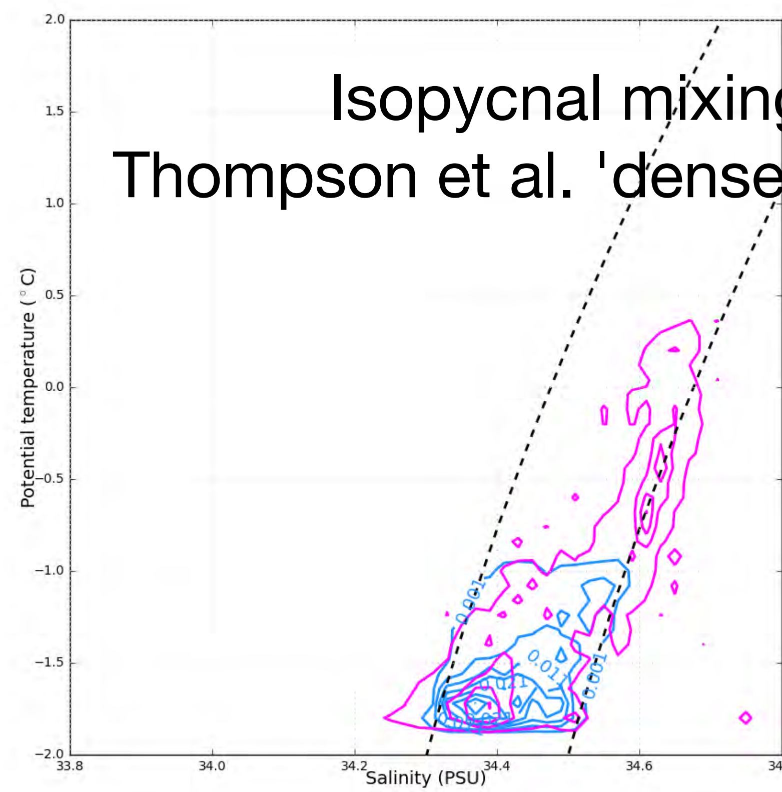
cooling (diapycnal)
Thompson et al. ‘fresh’ shelf



Isopycnal mixing
Thompson et al. ‘dense’ shelf



Isopycnal mixing
Thompson et al. 'dense’ shelf??



Summary

- Inflow of CDW particles onto shelf is localised, with varying depth and properties

- CDW is transformed more rapidly and thus has a **shorter residence time in cold shelf regions** (Prydz, Ross/Adelie, Weddell), but there is highly localised spatial patterns in residence time

- The transformation of CDW on the shelf in T-S space shows distinct regimes: **isopycnal (cooling+freshening) vs diapycnal (pure cooling)**

Challenges and future work

- Dominated by particles on shelf for short time periods, need carefully chosen additional criteria
- Zoom in on local/regional residence time
- Further analysis of different residence time and transformation in different shelf slope regimes
- ‘Tag’ particles with volume transport across 1000 m isobath
- Advection timescales to ice shelf fronts

Questions?