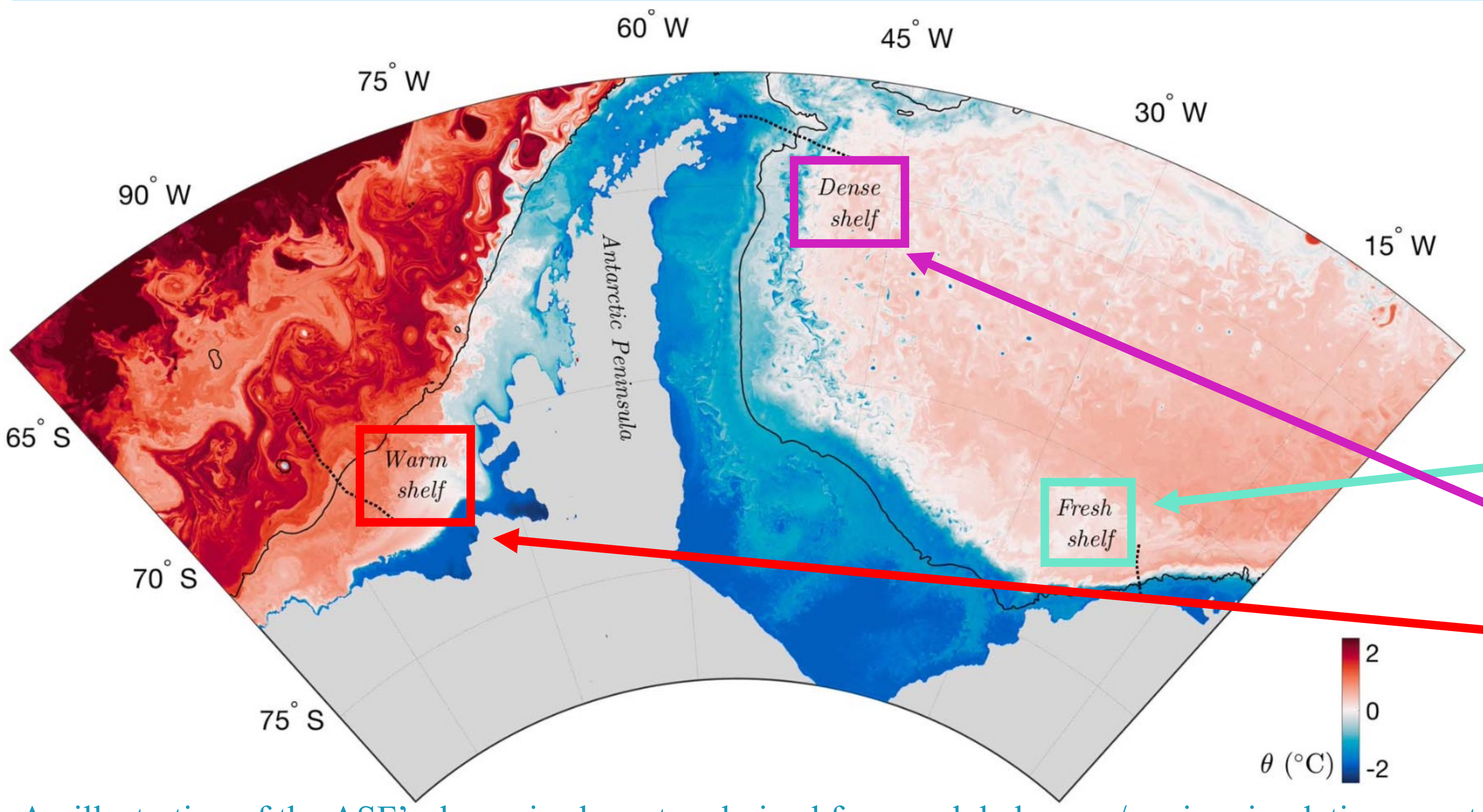
Antarctic Slope Current: system, classification and annual variability models

ABSTRACT

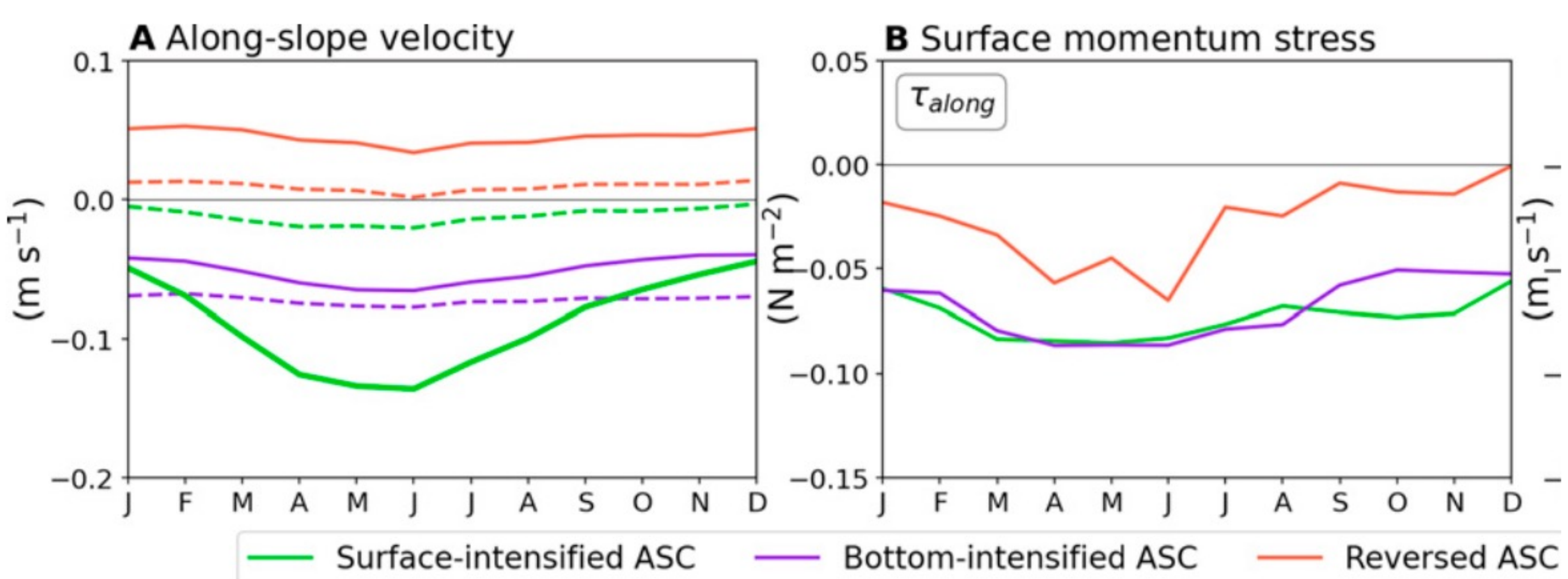
The Antarctic Slope Current (ASC) circumnavigates the Antarctic continent following the continental slope, separating the waters on the continental shelf from the deeper offshore Southern Ocean and regulates the flow of water toward the Antarctic coastline.

We can classify the current's frontal structure in 3 ranges: warm shelf, fresh shelf and dense shelf. It is difficult to reveal its spatial and sub-annual variability, as direct velocity measurements are sparse. Spatial variability of the ASC has also been characterized as three flow regimes: the surface-intensified ASC, the bottom-intensified ASC, and the reversed ASC. The surface-intensified ASC regime is stronger in the winter months. Seasonality of the winds may be the relevant driver for the seasonality along stretches of the coastline with a surface-intensified ASC. The reversed ASC has an inverted seasonality, meaning it is weaker in the winter months. The surface-intensified ASC occurs at sections of the continental slope with a fresh shelf, the bottom-intensified ASC occurs at dense shelves, and the reversed ASC occurs at warm shelves. Seasonality of the ASC is influenced not only by the mechanical forcing provided by the winds and sea ice at the ocean surface, but also by a geostrophic adjustment to changes in the cross-slope density gradient via freshwater input from basal melting and via surface water mass transformation.



An illustration of the ASF's dynamic character, derived from a global ocean/sea ice simulation run at 1/48° horizontal resolution. Colors indicate the potential temperature at a depth of 230 m, or at the ocean bed in regions shallower than 230 m, (simulation date: 9 October 2012). From Thompson et al., 2018.

- West => Warm temperature, comes close to continental slope because of the ACC front and stratification
- Est => In the Weddell Sea, all water that comes close to the slope is coming through the Weddell Sea Gyre. Over time, water in gyre has time to cool.
- Strong ACC push water through the Drake passage



Seasonal cycle of monthly along-slope velocity (a) and (b) surface momentum stress, averaged over each of the three ASC regimes. All data were transformed into an along- and cross-slope coordinate system and averaged in the cross-slope direction. All seasonal cycles are filtered with a 3-month running mean. From Huneke et al., 2022.

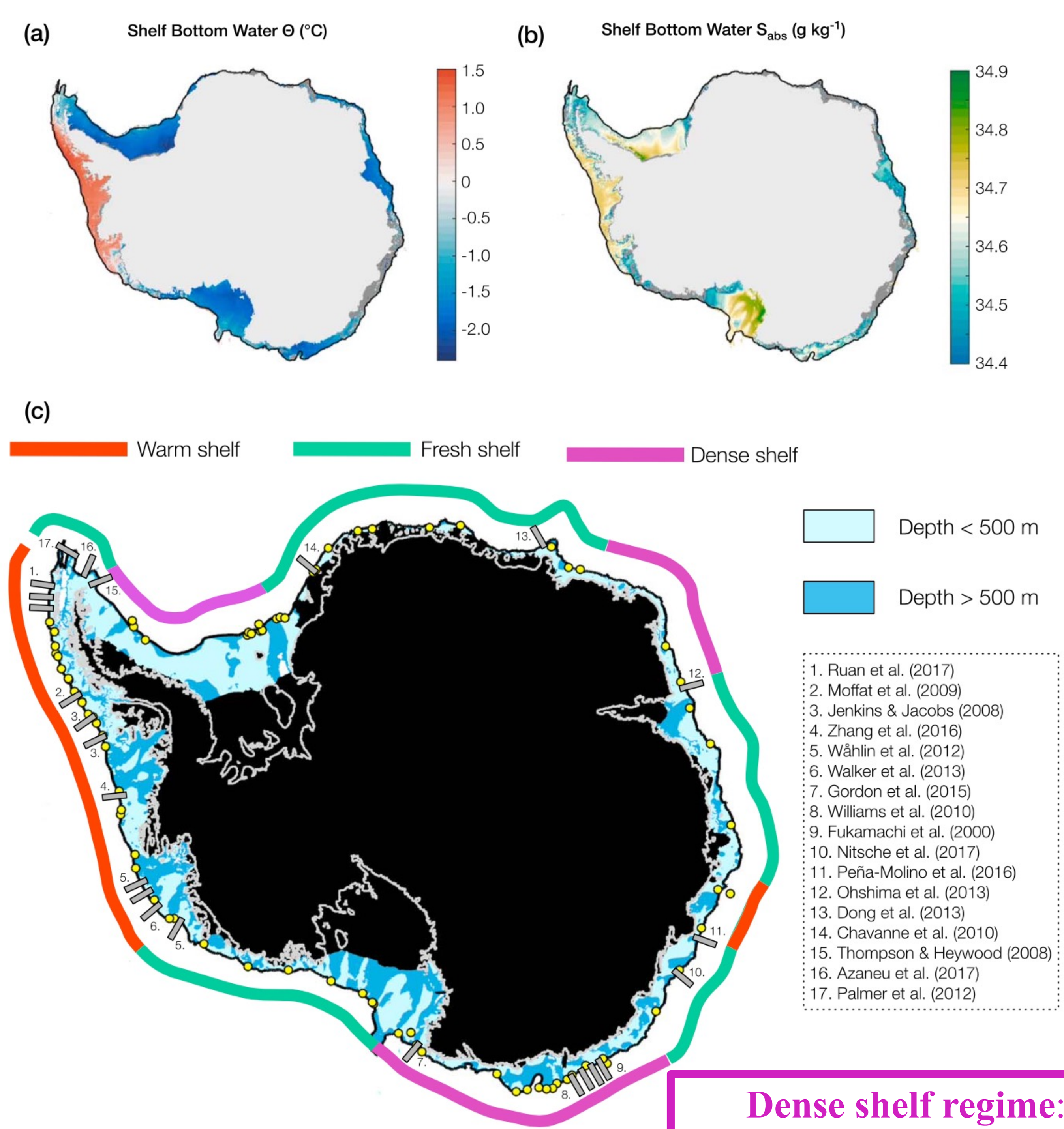
- Only the surface-intensified ASC has a pronounced seasonal signal in the surface component
- The reversed ASC has an inverted seasonality, meaning it is weaker in the winter months probably because the strengthening of the along-slope surface momentum stress component, which opposes the current, the stronger easterly winds in winter in this region will slow the current down.

References :

Huneke, Wilma G. C., et al. « Spatial and Subannual Variability of the Antarctic Slope Current in an Eddying Ocean–Sea Ice Model ». *Journal of Physical Oceanography*, vol. 52, nº 3, mars 2022, p. 347-61. *journals.ametsoc.org*, https://doi.org/10.1175/JPO-D-21-0143.1.

Thompson, Andrew F., et al. « The Antarctic Slope Current in a Changing Climate ». *Reviews of Geophysics*, vol. 56, nº 4, décembre 2018, p. 741-70. *DOI.org*,(Crossref). https://doi.org/10.1029/2018RG000624.

Rosalina RIBEIRO
University of Bergen
Rosalina.Ribeiro@etu.univ-grenoble-alpes.fr



Classification of the ASC system around Antarctica. (a) Conservative temperature and (b) absolute salinity of Antarctic Shelf Bottom Water (ASBW). (c) The colored bar shows the spatial distribution of the three ASC classifications depicted in. Figure in down: Warm shelf, Fresh shelf, and Dense shelf. From Thompson et al., 2018.

Fresh shelf regime:

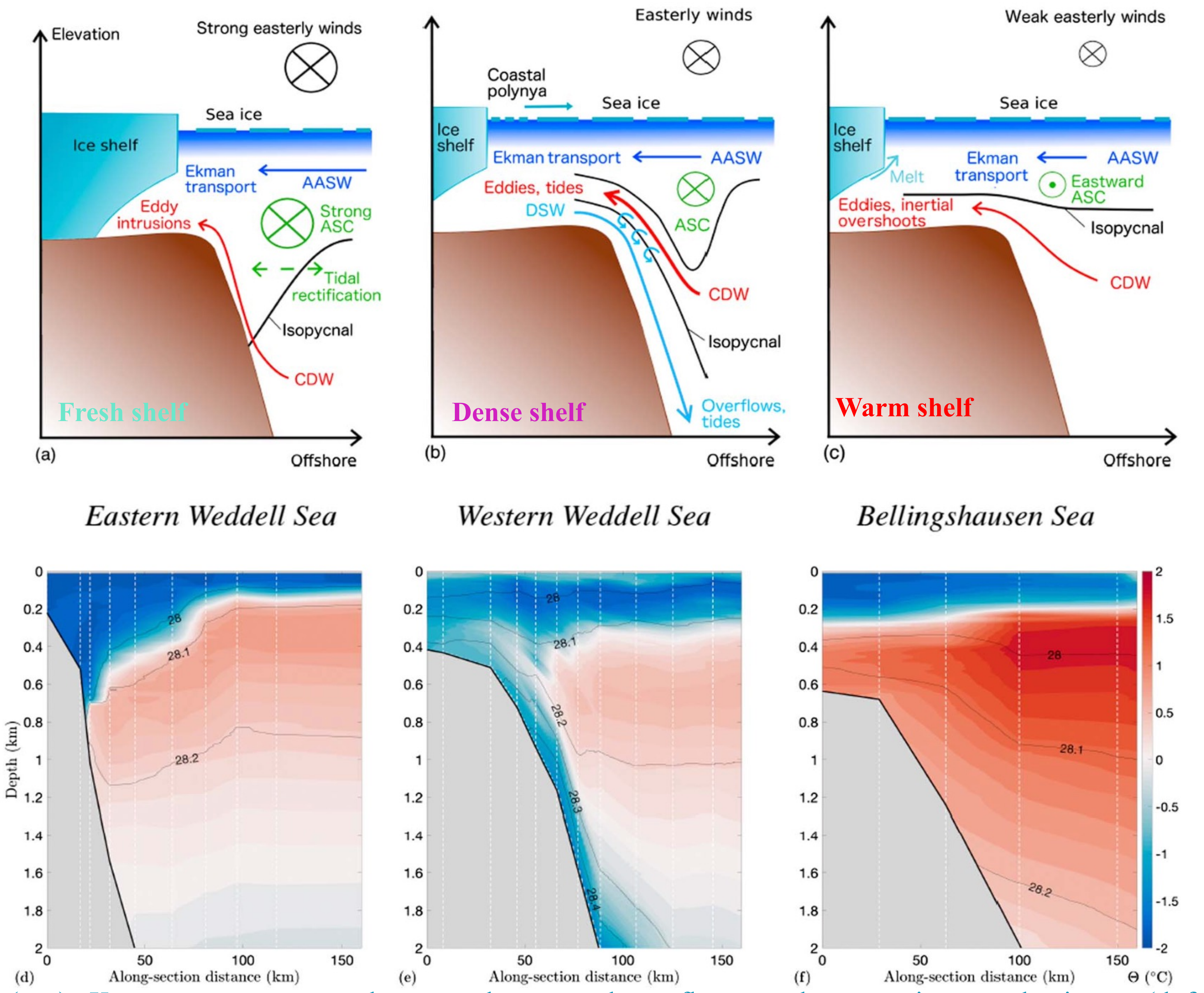
- persistent and strong easterly winds are located over the continental shelf
- westward flowing ASC,
- Strong frontal structure,, ASC,
- less saline
- bigger Ekman transport
- strong winds => big Ekman transport => downwelling of CDW => shelf break => CDW stuck in down

Dense shelf regime:

- water forms in localized sites around the Antarctic margins (western Ross Sea, Weddell Sea, Adélie coast, Cape Darnley),
- characterized by a V-shape frontal structure,
- near the seafloor, the export of dense water enhances the vertical stratification between exported DSW and overlying Deep Water,
- sea-ice formation,
- slow currents,
- wind not so strong,
- CDW has access to the shelf

Warm shelf regime:

- located in West of Antarctica
- region largely resides outside of the major gyres, where density surfaces tilt down toward the coast.
- shelves are thinning rapidly
- warm CDW has nearly uninhibited access to the shelf,
- less wind,
- temperature direct access into ice –shelf,
- CDW go on the shelf
- ice melting capacity



(a–c) Key water masses, along- and across-slope flows and supporting mechanisms; (d–f) Measurements of conservative temperature and neutral density across the ASC. From Thompson et al., 2018

Further outlook

It is very difficult to study this current and show if it has a seasonality. There are still many unanswered questions on this subject. An improved dynamical understanding of the ASC is still needed to accurately model and predict future Antarctic sea-ice extent, the stability of the Antarctic ice sheets, and the Southern Ocean's contribution to the global carbon cycle.