

Identifying Southern Ocean fronts using unsupervised classification and edge detection

**AGU FALL
MEETING**

Online Everywhere | 1–17 December 2020

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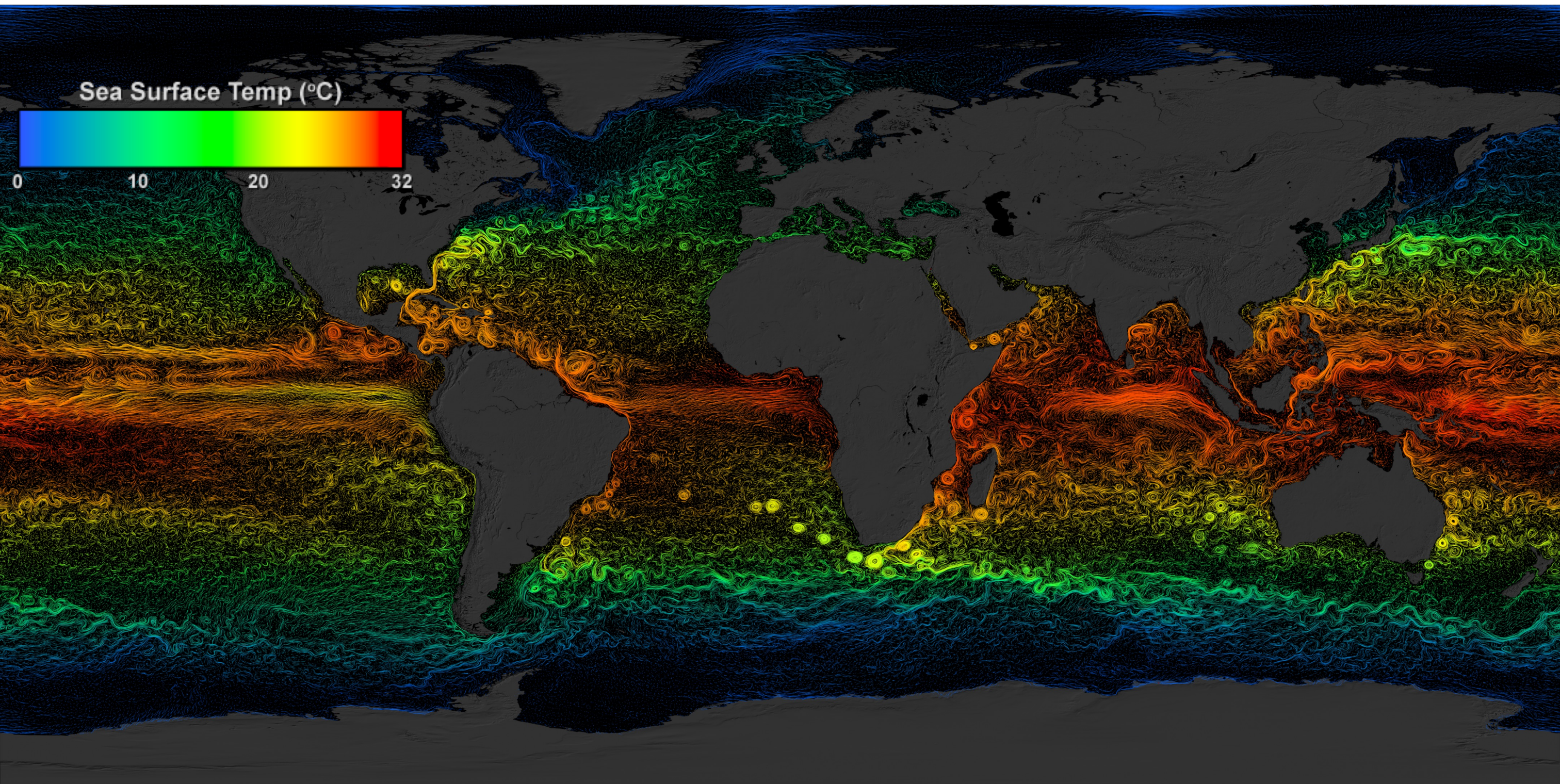
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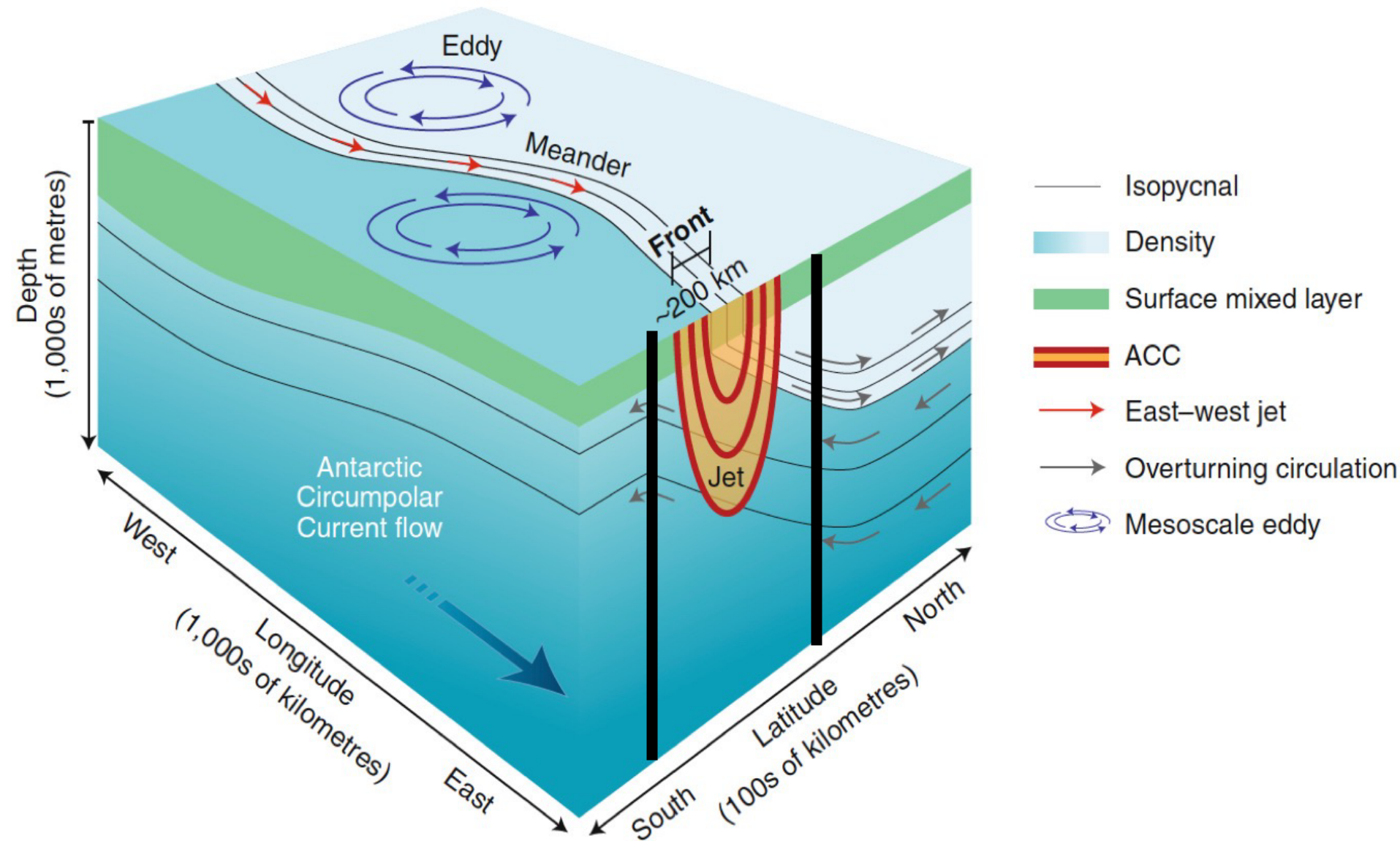


Global sea surface temperatures and currents

Credit: NASA

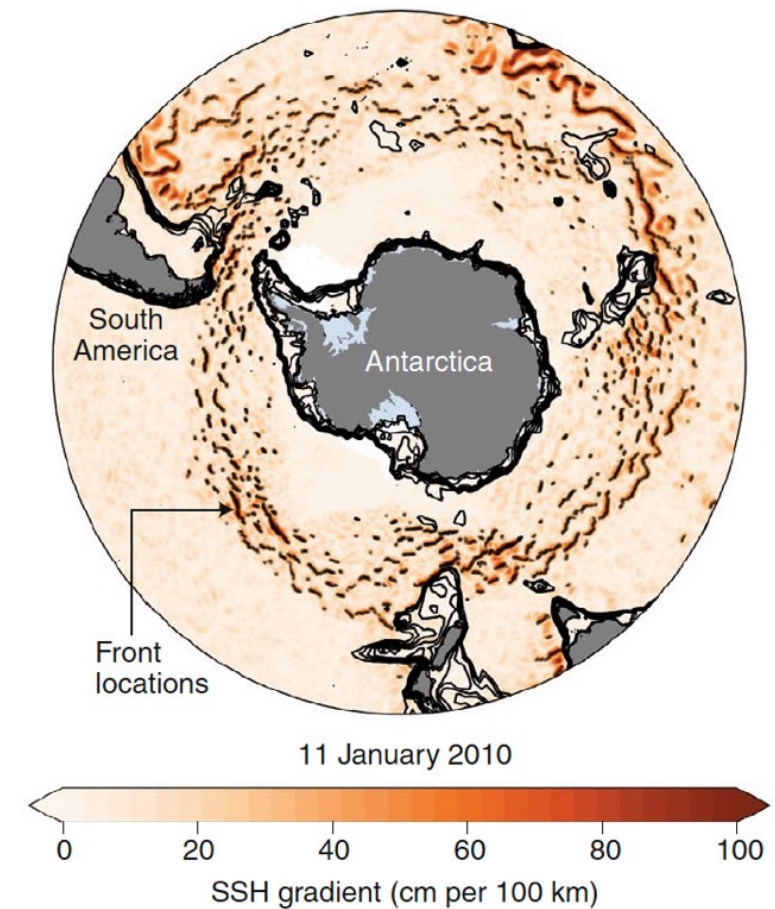
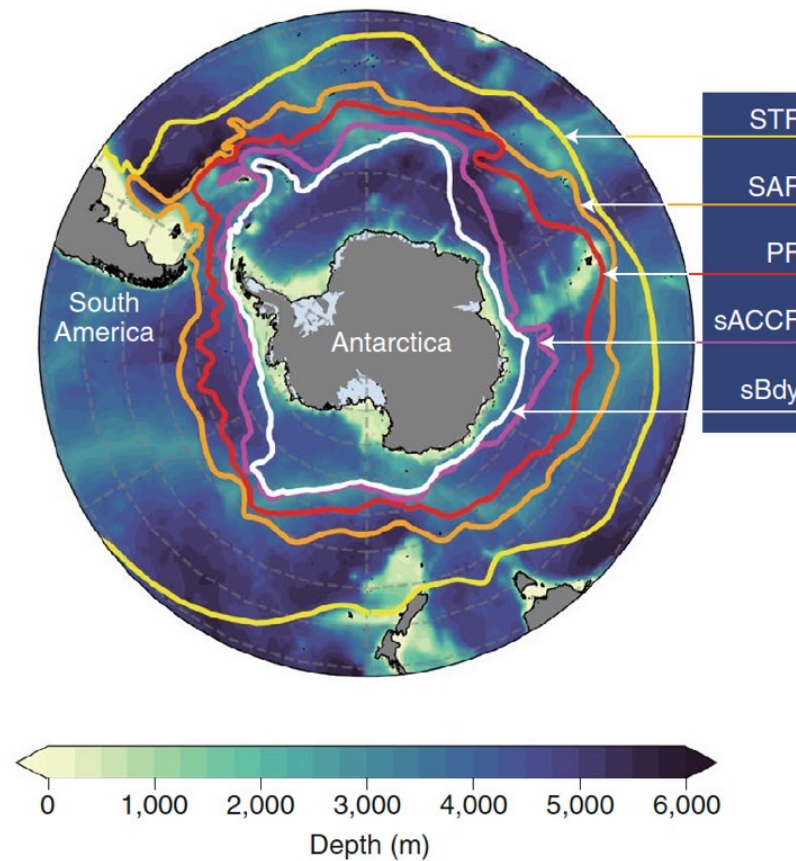


- ▶ Chapman *et al.* 2020 challenged traditional views of fronts.



- ▶ The deep reaching jets of the Antarctic Circumpolar Current are expected to correspond to sharp gradients of temperature and salinity.

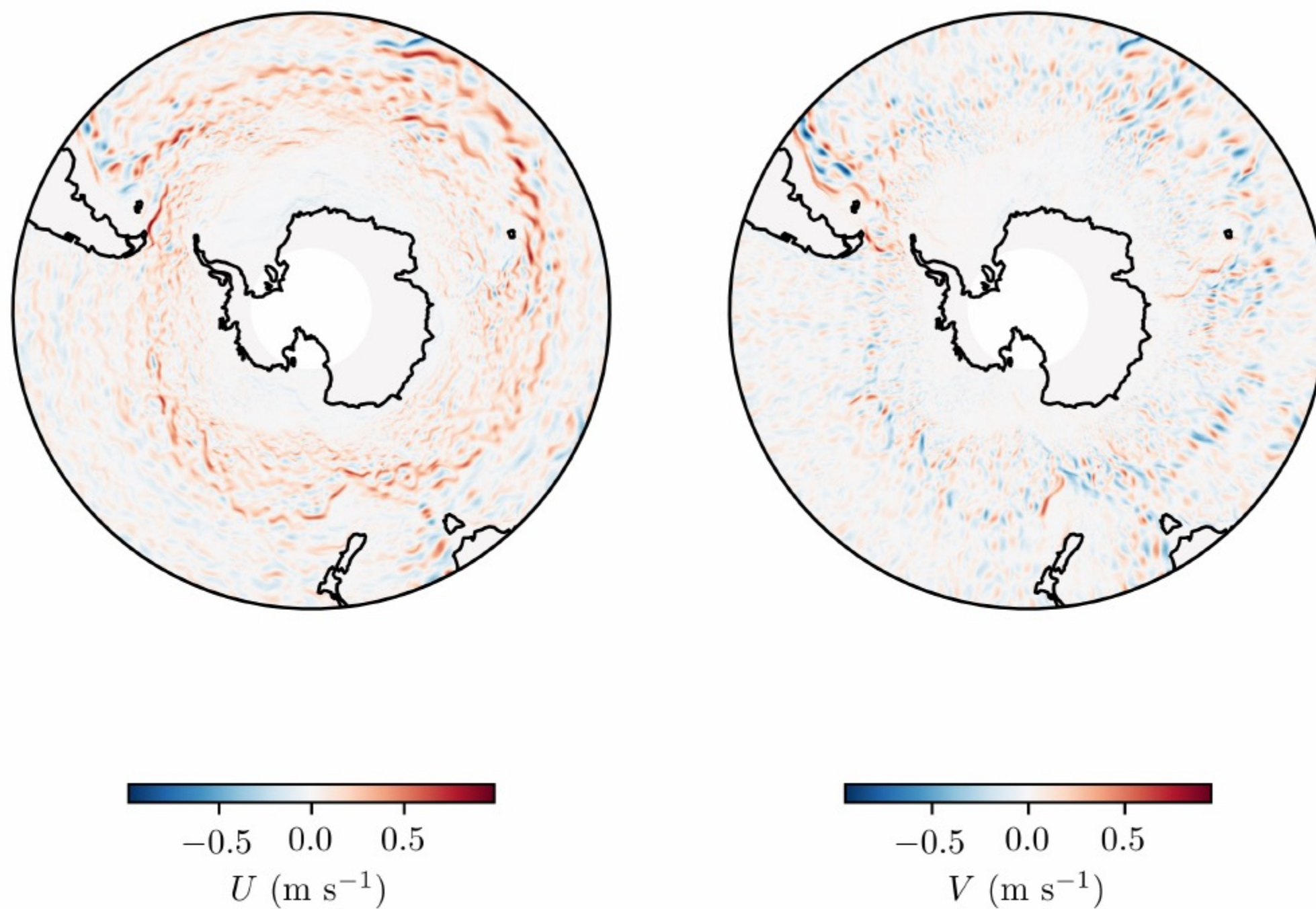




	Global	Local
Methods	Contours, Water mass criteria, GMM	Gradient thresholding, Sobel Edge, Skewness
Pro	Interpretable	Easy to define
Con	Hard to define	Hard to interpret

Table: A summary of Table 1 in Chapman *et al.* 2020.



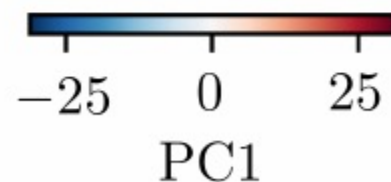
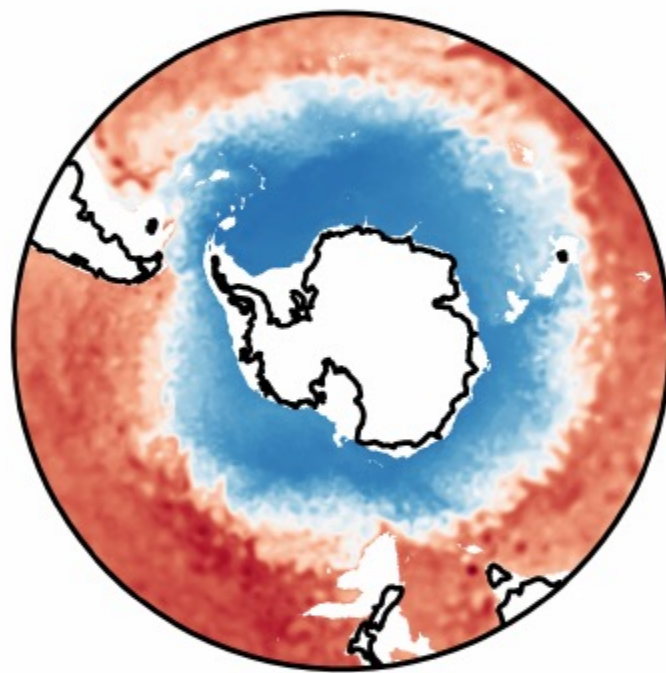


- ▶ BSOSE-i106 state estimate (Verdy & Mazloff 2017).
- ▶ Monthly mean T and S profiles between 300m–2000m (Rosso *et al.* 2020).

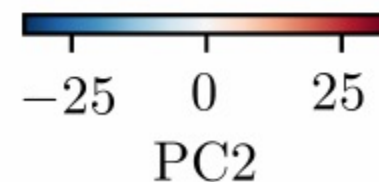
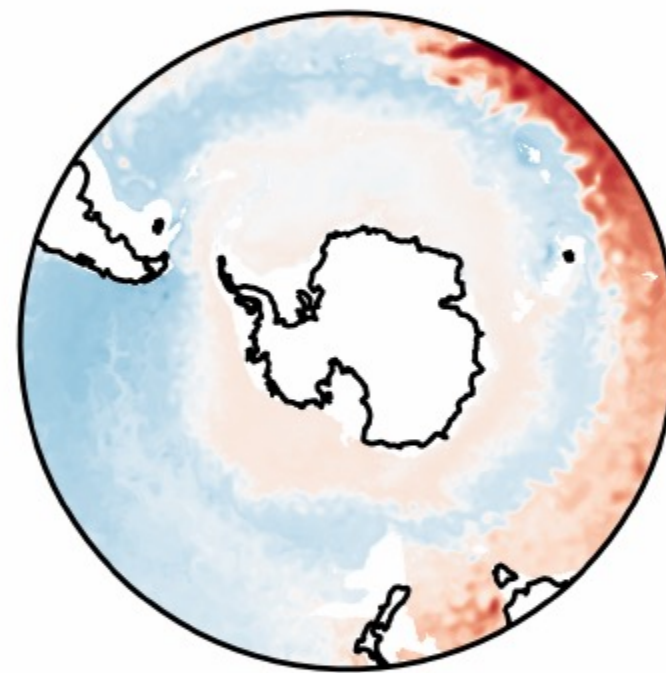


- Take coefficients from 3 principal components (North *et al.* 1982; Pauthenet *et al.* 2017).

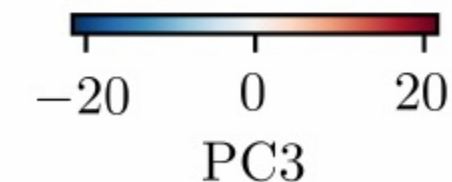
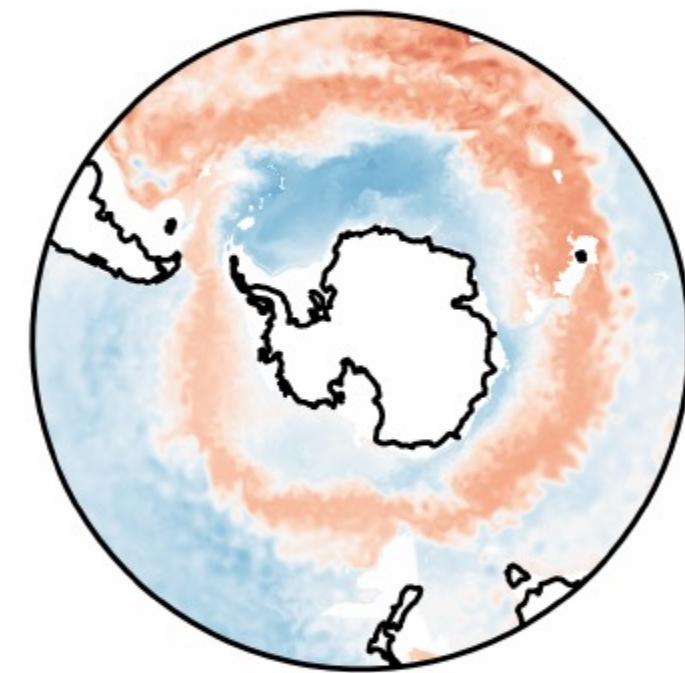
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75%



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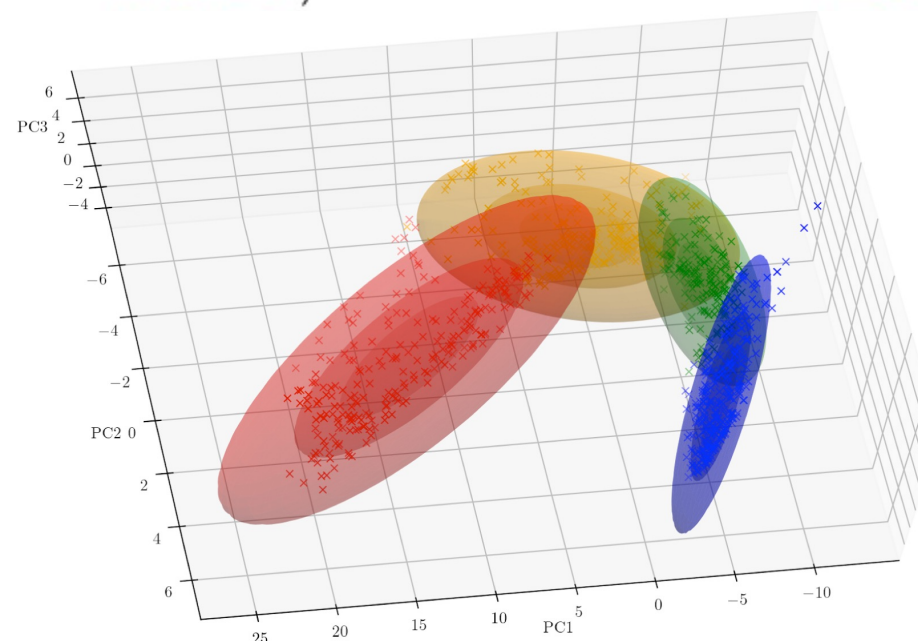
Explained
Variance:



- Using GMM (Maze *et al.* 2017; Jones *et al.* 2019).

- K clusters.

- Posterior probabilities:



$$\mathbb{P}(c_n = c_k) = \frac{\lambda_k \mathcal{N}(\vec{x}_n; \vec{\mu}_k, \Sigma_k)}{\sum_{k=1}^K \lambda_k \mathcal{N}(\vec{x}_n; \vec{\mu}_k, \Sigma_k)} \quad (1)$$

- We define (thanks to A.F.):

$$\mathcal{I}(\vec{x}_n) = 1 - \left(\mathbb{P}(c = c_k)_{\max} - \mathbb{P}(c = c_l)_{\text{runner-up}} \right), \quad (2)$$

where \vec{x}_n is the n^{th} profile's principal component values.



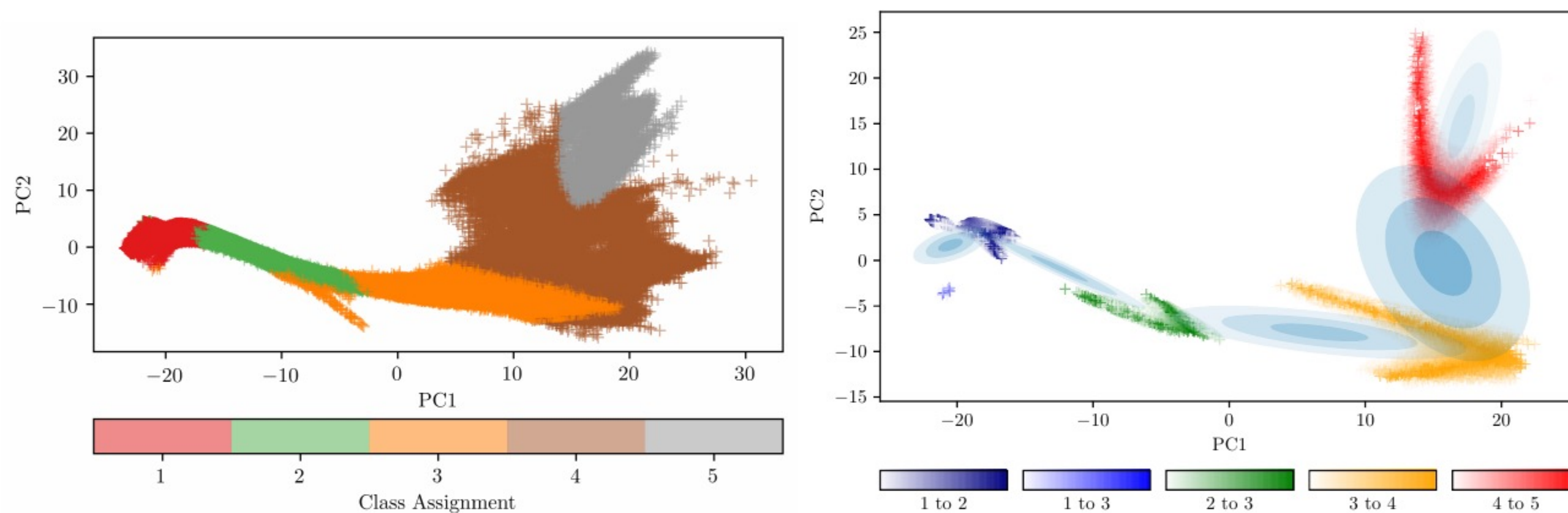


Figure: GMM and \mathcal{I} -metric with $K = 5$ in 2PC space.



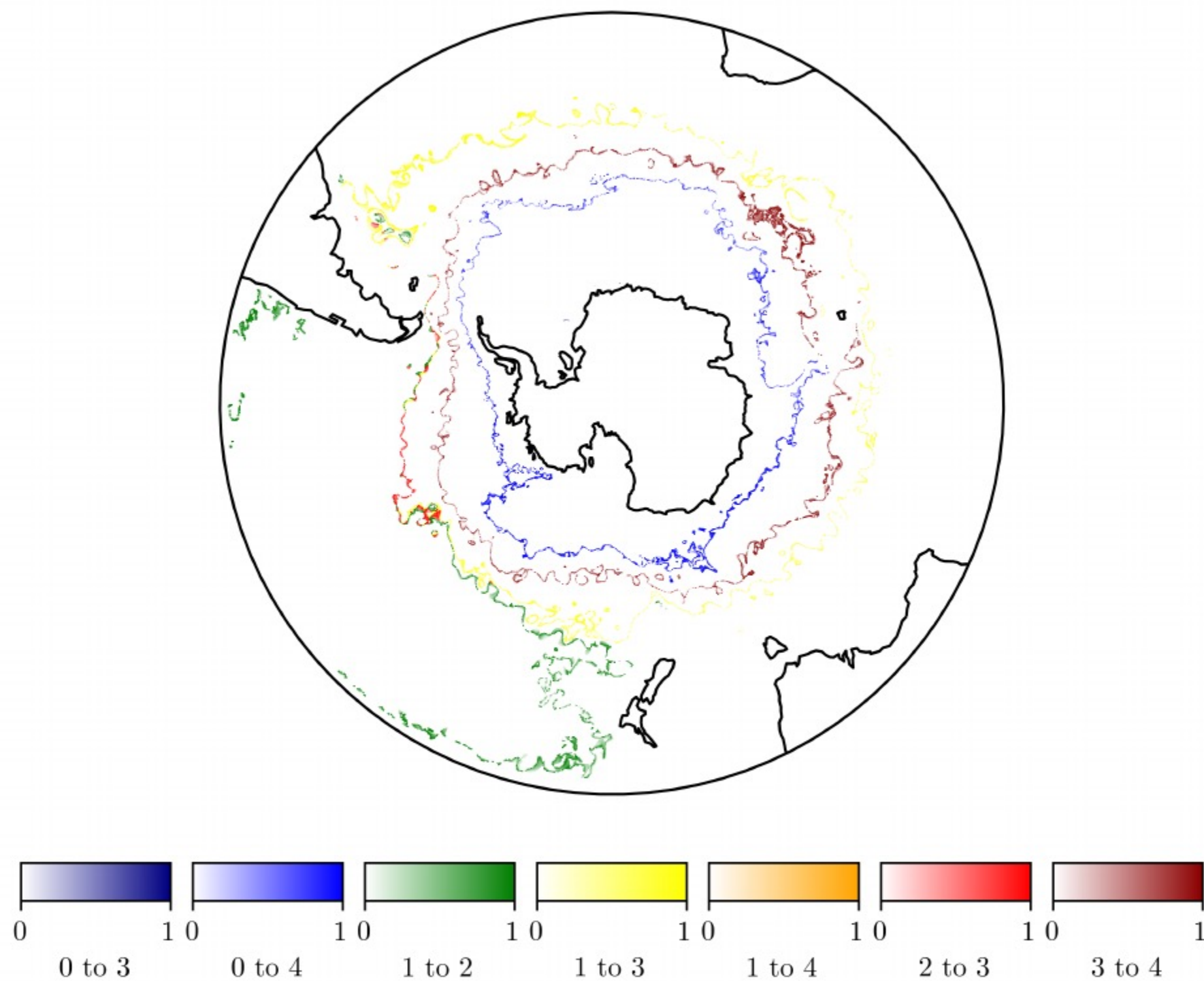


Figure: \mathcal{I} of GMM with $K = 5$.



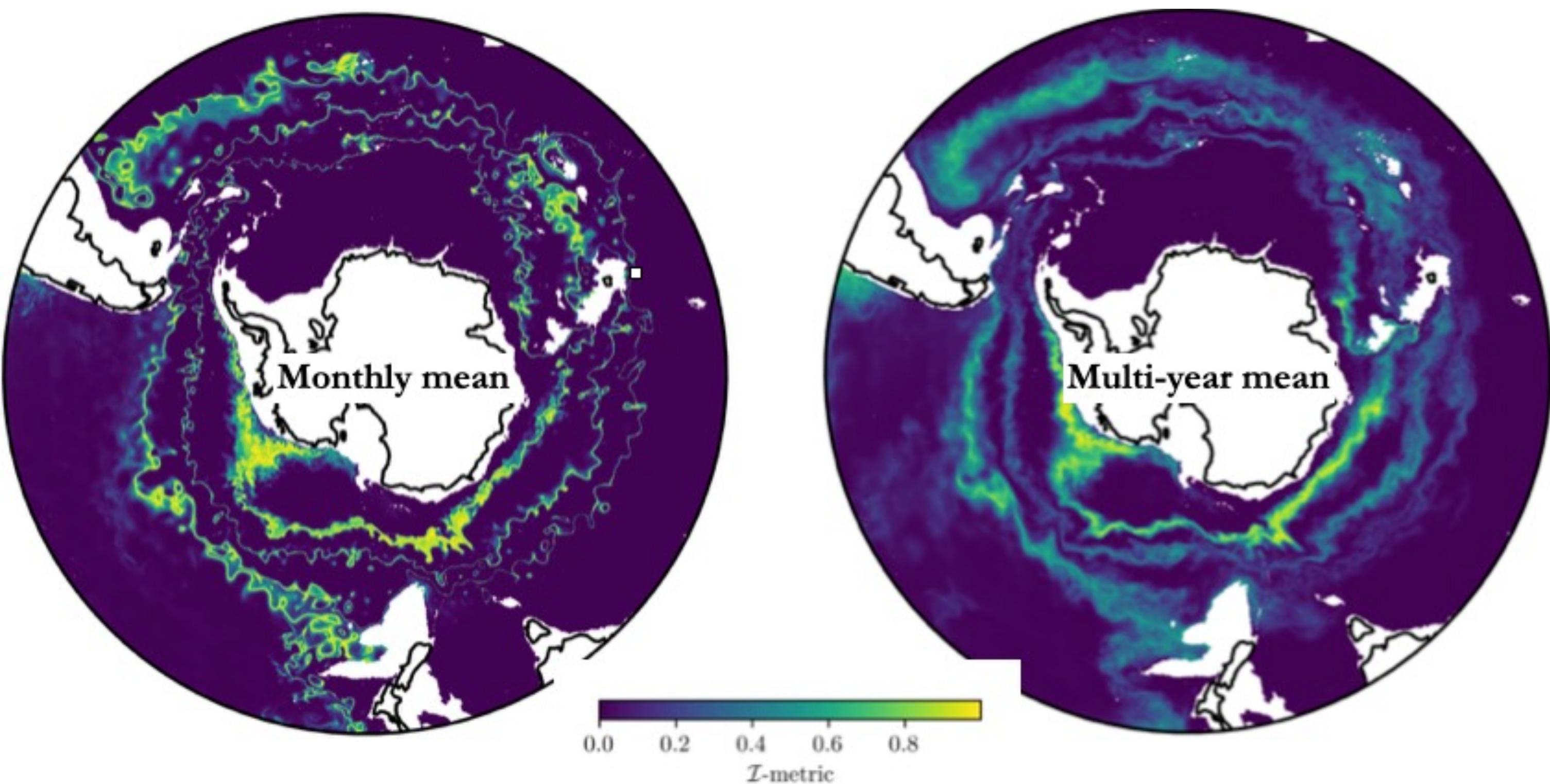


Figure: \mathcal{I} of GMM with $K = 5$.



- ▶ We build on a Sobel edge detection method (Hjelmervik & Hjelmervik 2019) on the 3 PC-fields.
- ▶ Approximately the smoothed PC 2D gradient.

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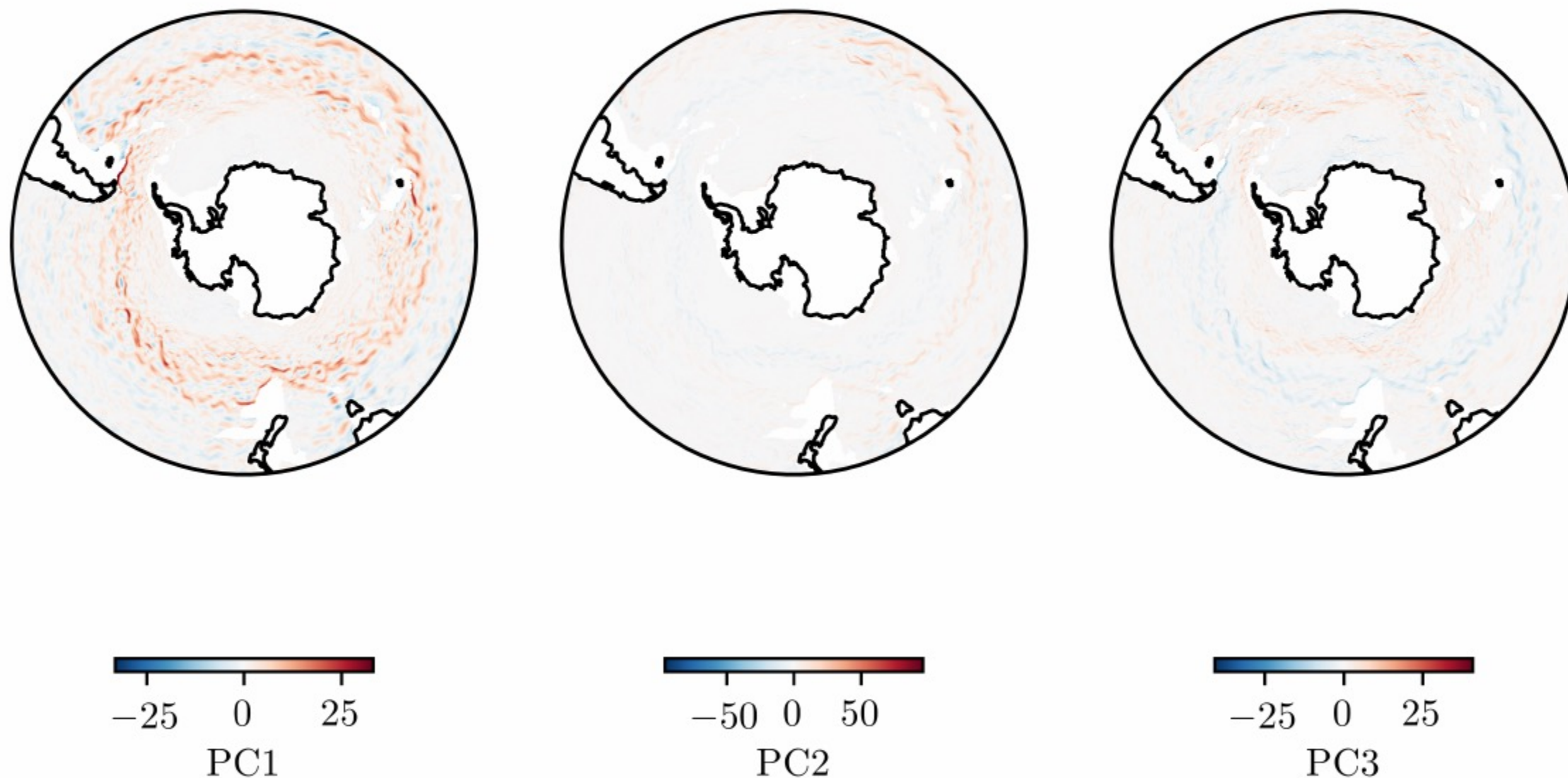
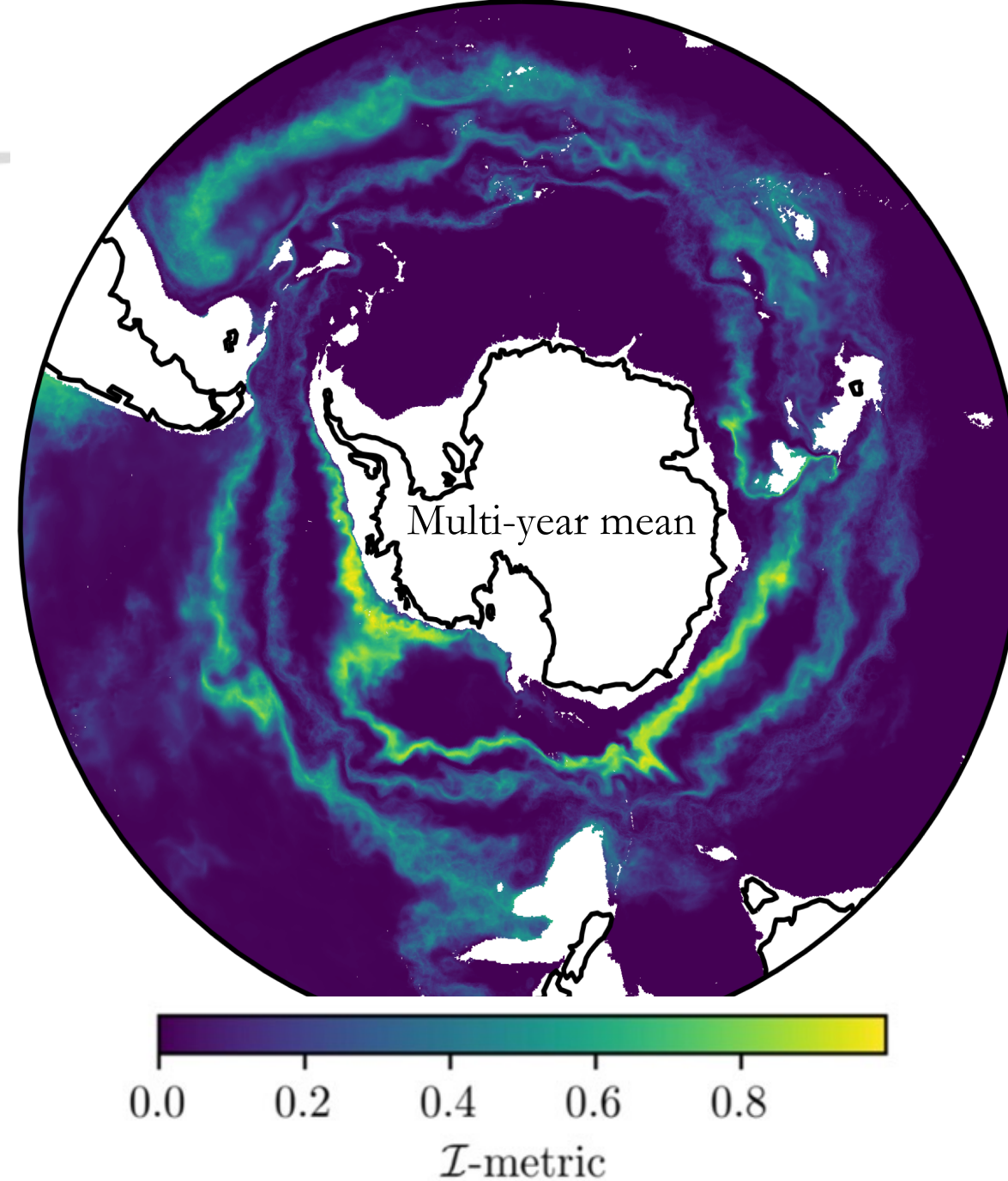


Figure: Sobel edge fronts in latitude direction.





- ▶ We propose a probabilistic metric for defining water mass boundaries. Use a depth range, not surface information.
- ▶ This expands on the classical, time-averaged view of fronts and water mass boundaries, following Chapman *et al.* 2020.
- ▶ Paper and a GitHub repository in prep.



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