Atmospheric weather patterns and their contributions to the fall stratification break-down on the Southern New England shelf

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i) Why we all should care about stratification (N^2) variability at shelfbreak fronts:

- N^2 **constraints vertical motions** and the nutrient upwelling in a highly productive coastal region.
- N^2 **facilitates frontal instability** and surface layer exchange between the coastal and the open ocean.

ii) The goal: We aim to identify the pathways of wind-driven destratification close to a shelfbreak front under varying forcing and frontal state characteristics.

iii) Why this region?

- Impact: The US East Coast warms rapidly.
- Generalizability: A wide variety of forcing processes meets a 'textbook'-shelfbreak with smooth bathymetry. Opportunity: A multi-year observational dataset [1].

Clustering revealed that these two downwelling-favorable high-wind patterns destratify the shelf the most:

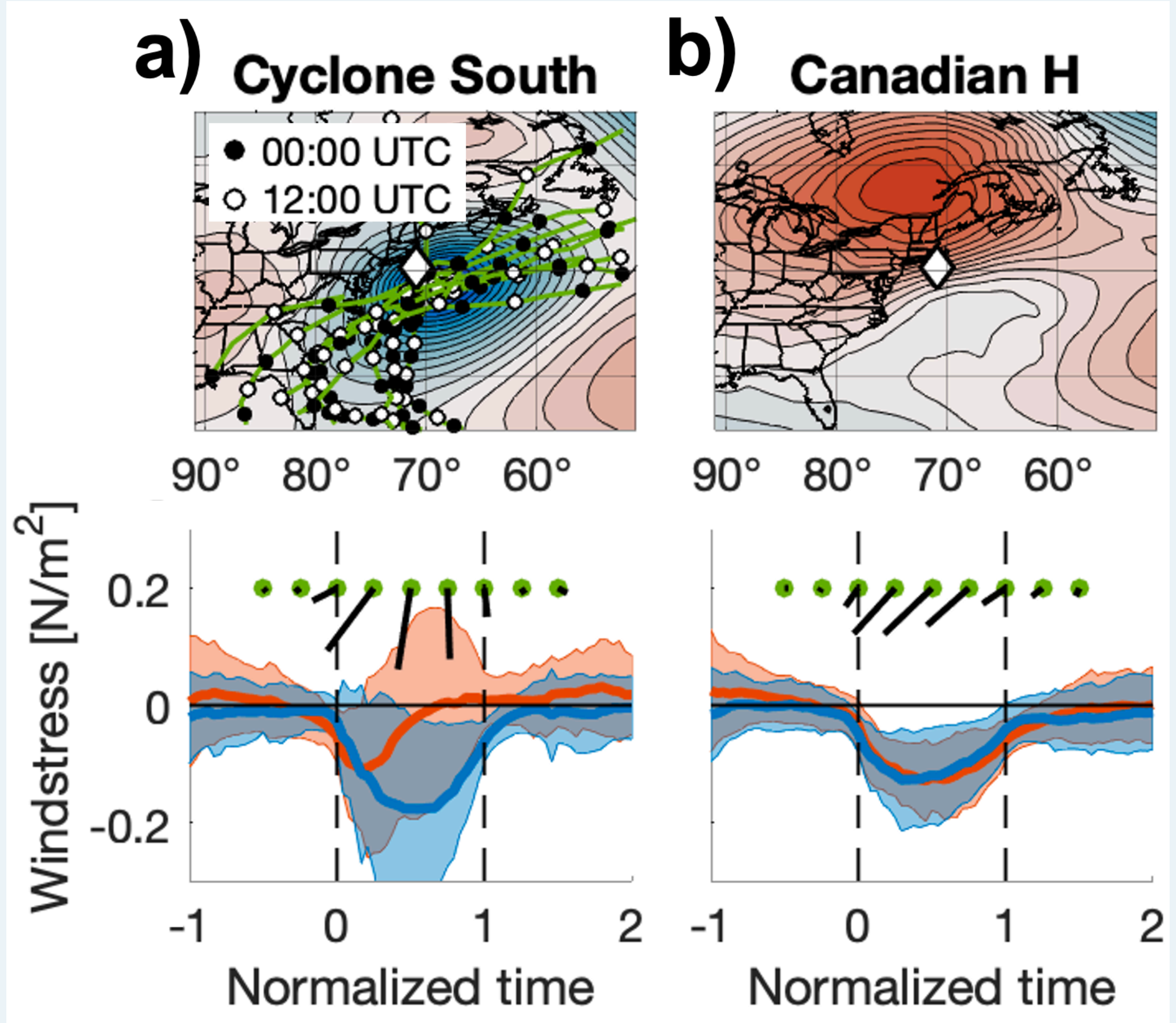

Fig. 1: Mean characteristics of impactful downwelling-favorable high-wind event patterns. Upper row: Mean sea level pressure fields. Lower row: Composite timeseries observed by mooring array (white diamond).

Check out our preprint on the categorization of high-wind events:

Lobert et al.
(in review)

The steadiness of a synoptic high-wind forcing pattern determines whether coastal destratification is caused rather locally or advectively.

This claim is backed by the following 2 observations:

i] Hydrography vs. impact

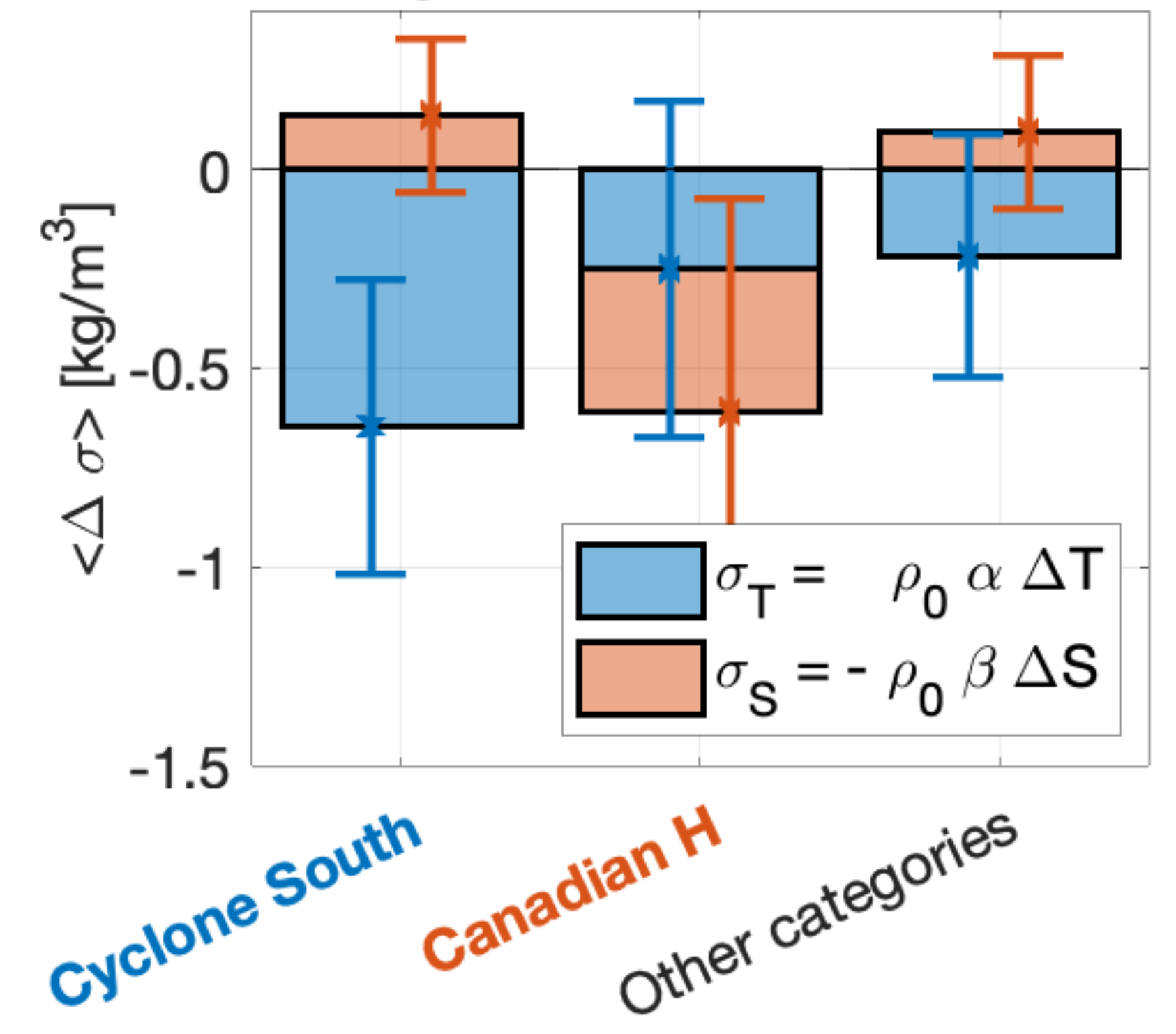

Fig. 2: Salinity (S)/ Temperature (T)-contributions to shelf destratification for individual events point to advection vs. surface cooling as 'source' of destratification.

ii] Dynamical forcing regime vs. impact

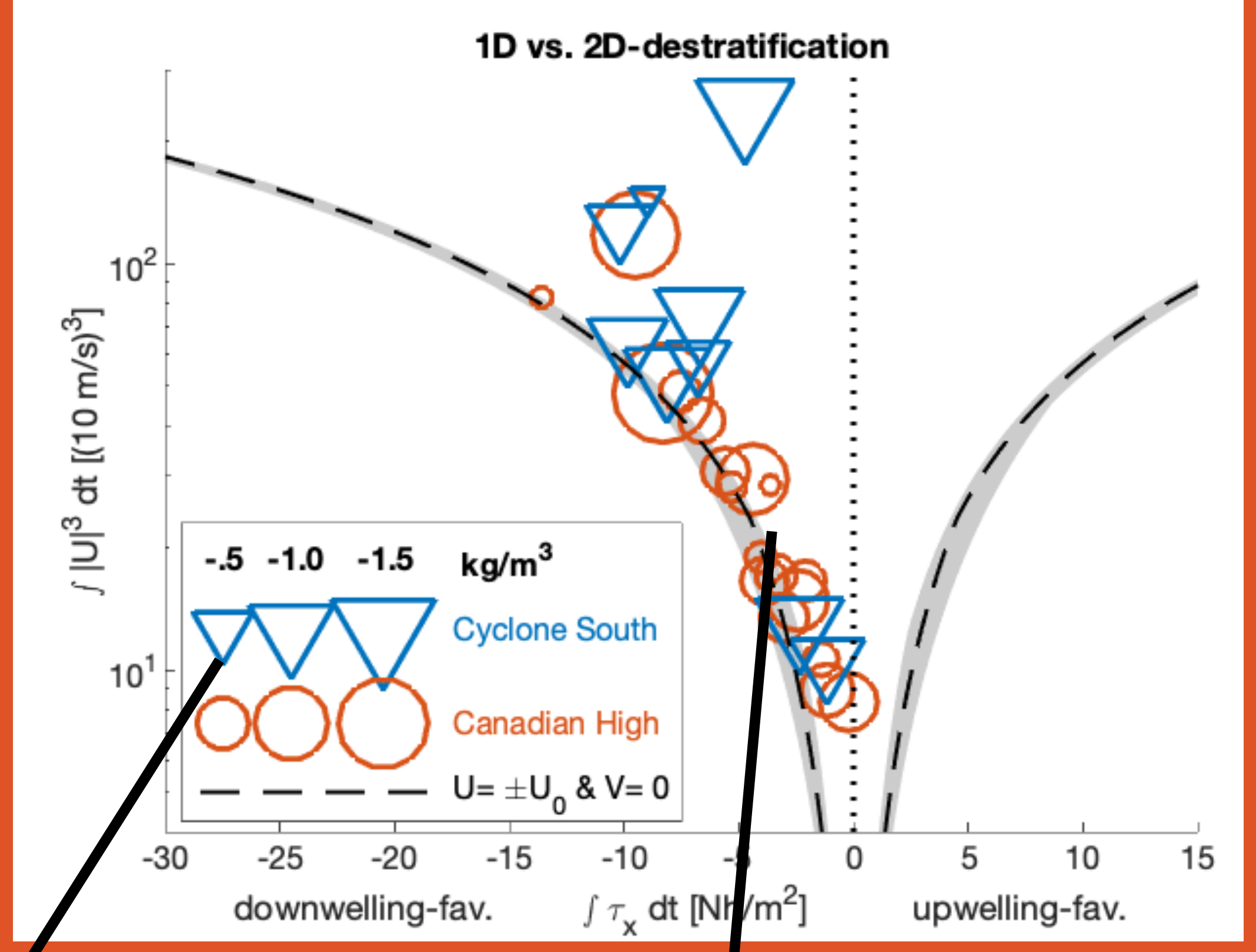

Fig.3: Scalar estimates of 1D local TKE-input $\propto \int |u|^3\, dt$ and 2D cross-shelf Ekman transport $\propto \int \tau_x\, dt$. The Ekman-cell is more effective in terms of required wind forcing strength.

The attempt of a unifying framework in 2D:

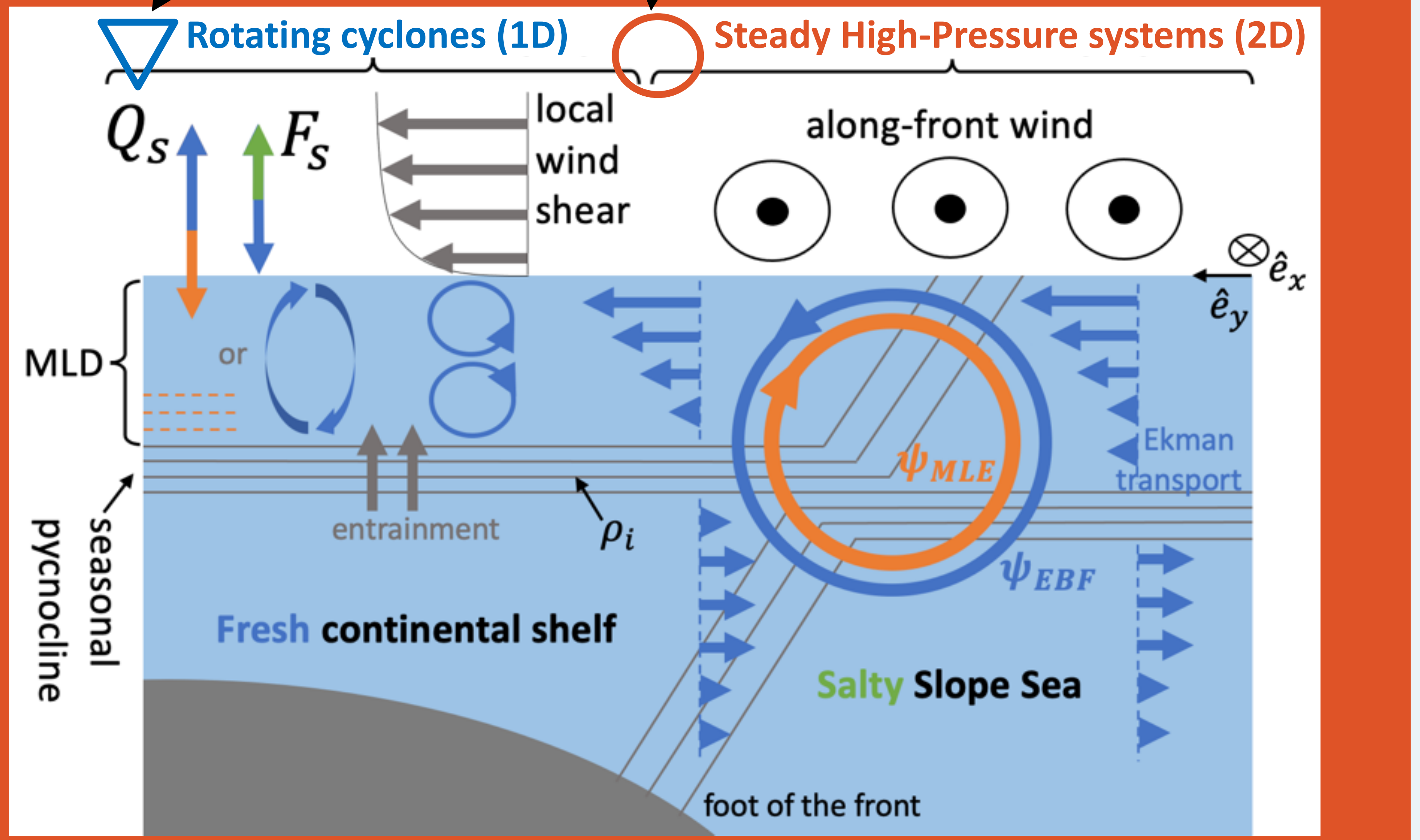

Fig. 4: Sketch of downwelling-favorable wind forcing processes affecting the shelfbreak ocean stratification in a 2D framework. Left: Forcing characteristics of rotating cyclones. Right: Forcing characteristics of steady high-pressure systems. Along-shelf gradients are neglected.

In addition: Shelfbreak frontal instability

The Southern New England Shelfbreak front is inherently unstable in both models [2] and observations [3]. In an idealized model [4] …

- … finite-amplitude frontal meander scales are set by the length scales of present barotropic (BTI) and baroclinic (BCI) instability.
- … symmetric instability (SI) can facilitate the development of other instability with larger growth rate in the vicinity of the front.

Hypothesis: The steadiness of the forcing event determines the mix of instability mechanisms favored.

Preliminary test: Check cross-shelf glider sections for dynamical conditions that allow flow instability.

BCI: Richardson-Number: $Ri = {N^2}/{|\partial \boldsymbol{u}/\partial z|^2}$

assumptions to allow computation from glider transects [5]

SI: Ertel PV: $q = \boldsymbol{\omega_a} \cdot \nabla b \approx -\frac{|\nabla_h b|^2}{f} + N^2(f+\zeta) \approx -\frac{|b_y|}{f} + N^2(f - u_y)$

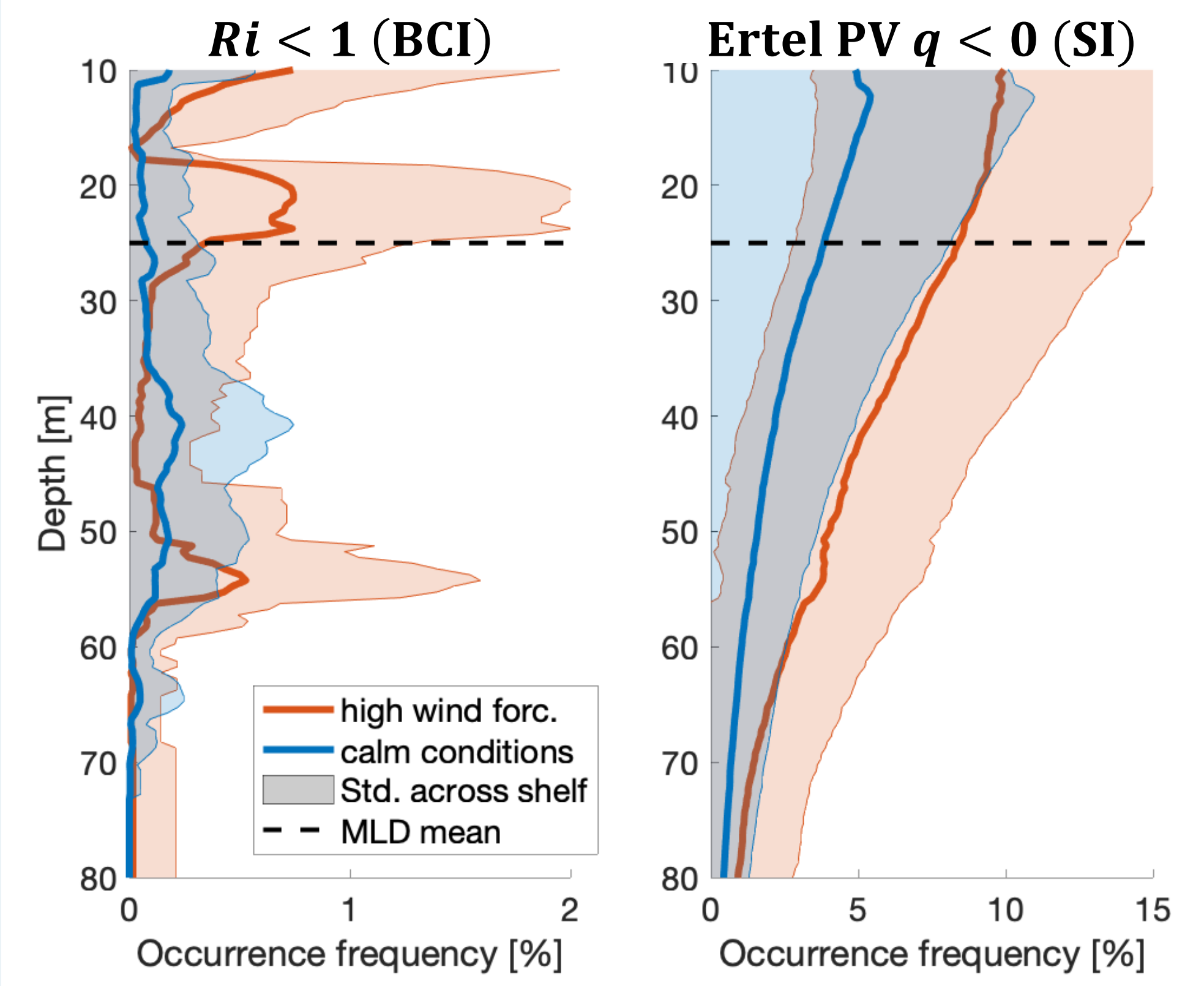

Fig. 4: Occurrence frequency necessary for instability conditions as a function of depth and averaged across the shelfbreak (from 39.85-40.35°N). a) Ri < 1 as a condition for BCI; b) Ertel Potential vorticity q < 0 as a condition for SI [6]. All data from gridded glider transects.

Some preliminary observations:

- **The obvious one:** Instabilities are more prominent when winds are strong.
- **BCI-conditions:** most typically at the surface and MLD
- **SI-conditions:** most often in ML; monotonous decrease below.

So, what's next then?

1) Explore how far data availability allows to differentiate between different forcing regimes (e.g., forcing steadiness) and ocean state (e.g., frontal state).
2) Add the missing components to the picture/framework, i.e.,
    - the Ekman Buoyancy Flux (EBF) and its sub-surface structure,
    - Barotropic Instability (BTI)
    - along-shelf variations and frontal meander scales.

References

[1] OOI Coastal Pioneer Array: ooinet.oceanobservatories.org
[2] Flagg and Beardsley (1976). *J. Geophys. Res.*, **83**(C9)
[3] Fratantoni and Pickart (2003). *J. Geophys. Res.*, **108**(C5)
[4] Zhang and Gawarkiewicz (2015). *J. Phys. Oceanog.*, **45**(10)
[5] Thompson et al. (2016). *J. Phys. Oceanog.*, **46**(4)
[6] Hoskins (1974). *Q.J.R. Meteorol. Soc.*, **100**

To the abstract:

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