Wind-Driven Cross-Shelf Transport on a Shelf with Curvature

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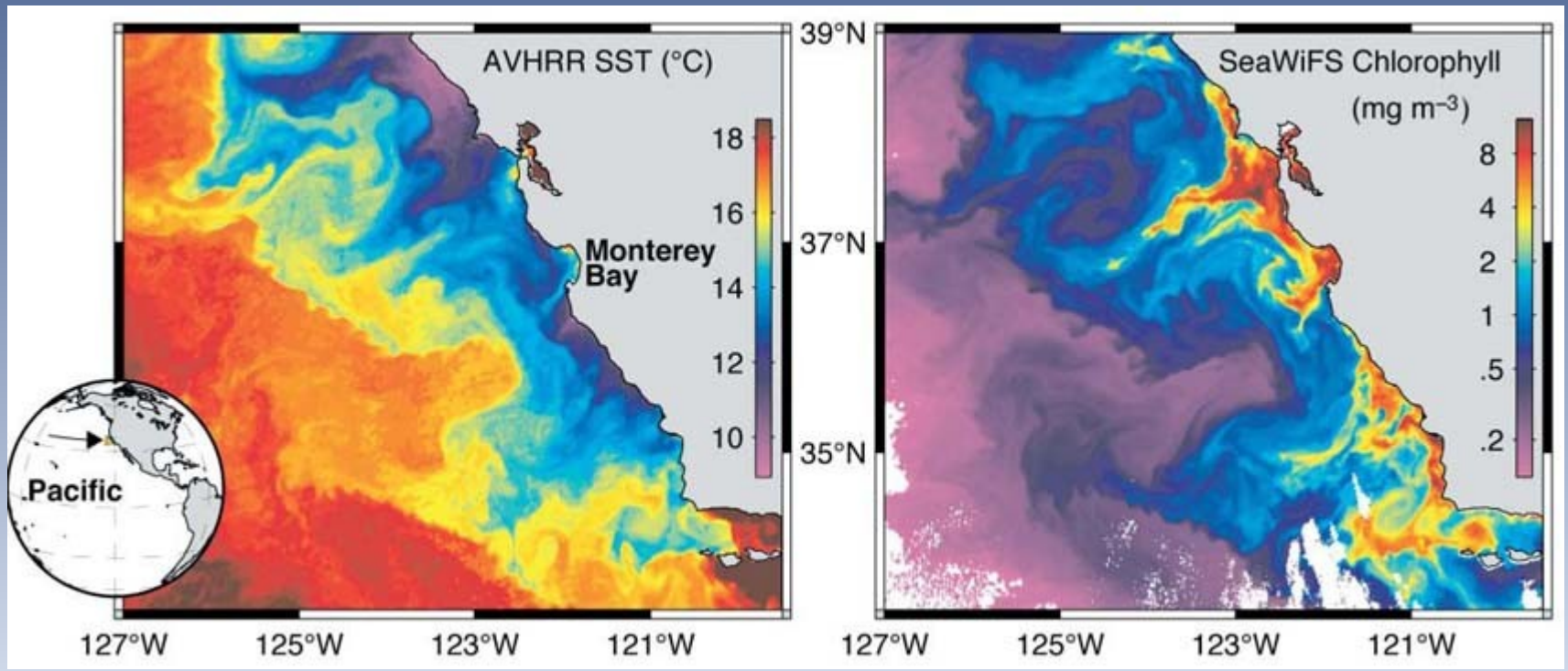
Geostrophic currents on a shelf are dominantly along-isobath (PV conservation)

Large cross-shelf gradients in physical and biochemical variables elevate the importance of the secondary cross-shelf flows.

Example:

Cross-shelf transport off of California yields cold filaments…

… and offshore export of chlorophyll-rich waters.



Gag grouper (*Mycteroperca Microlepis)* spawn along the outer shelf edge in winter through early spring.

Larvae are transported onshore to nursery habitat (sea grass) in the coastal region by some undetermined mechanism.

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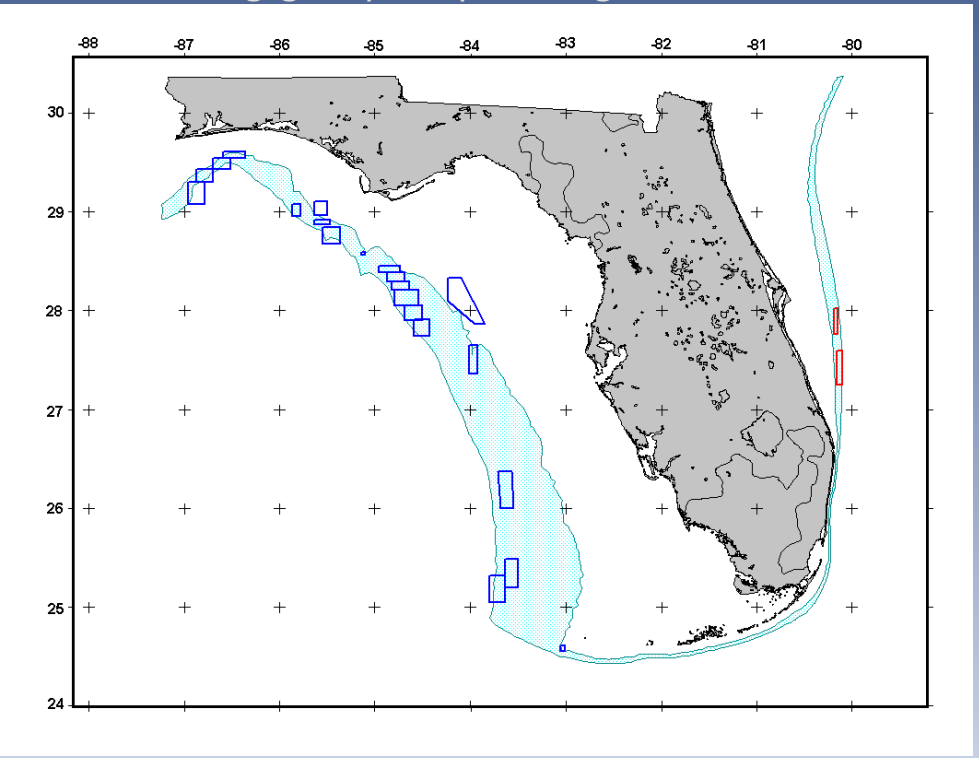
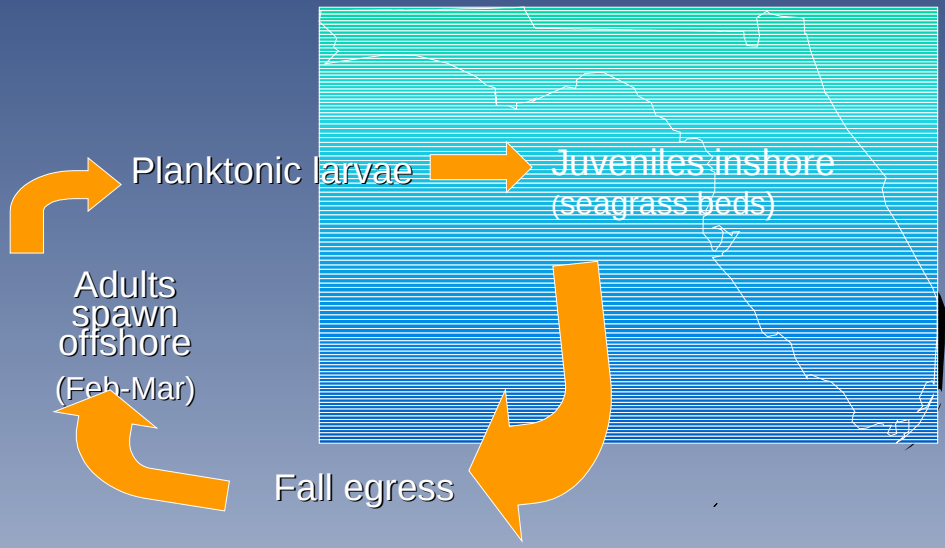
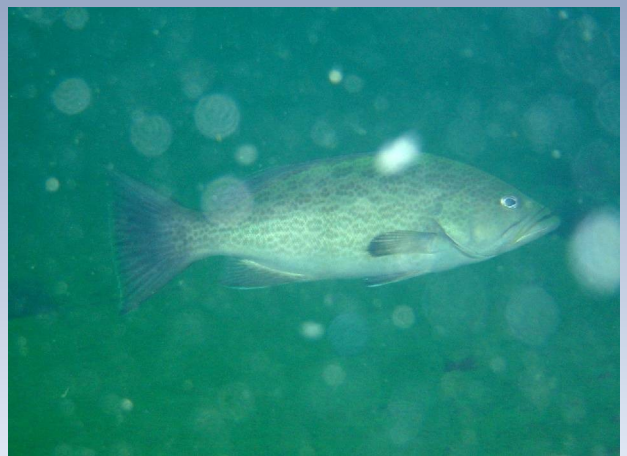
Grouper life history stages

Gag grouper spawning locations

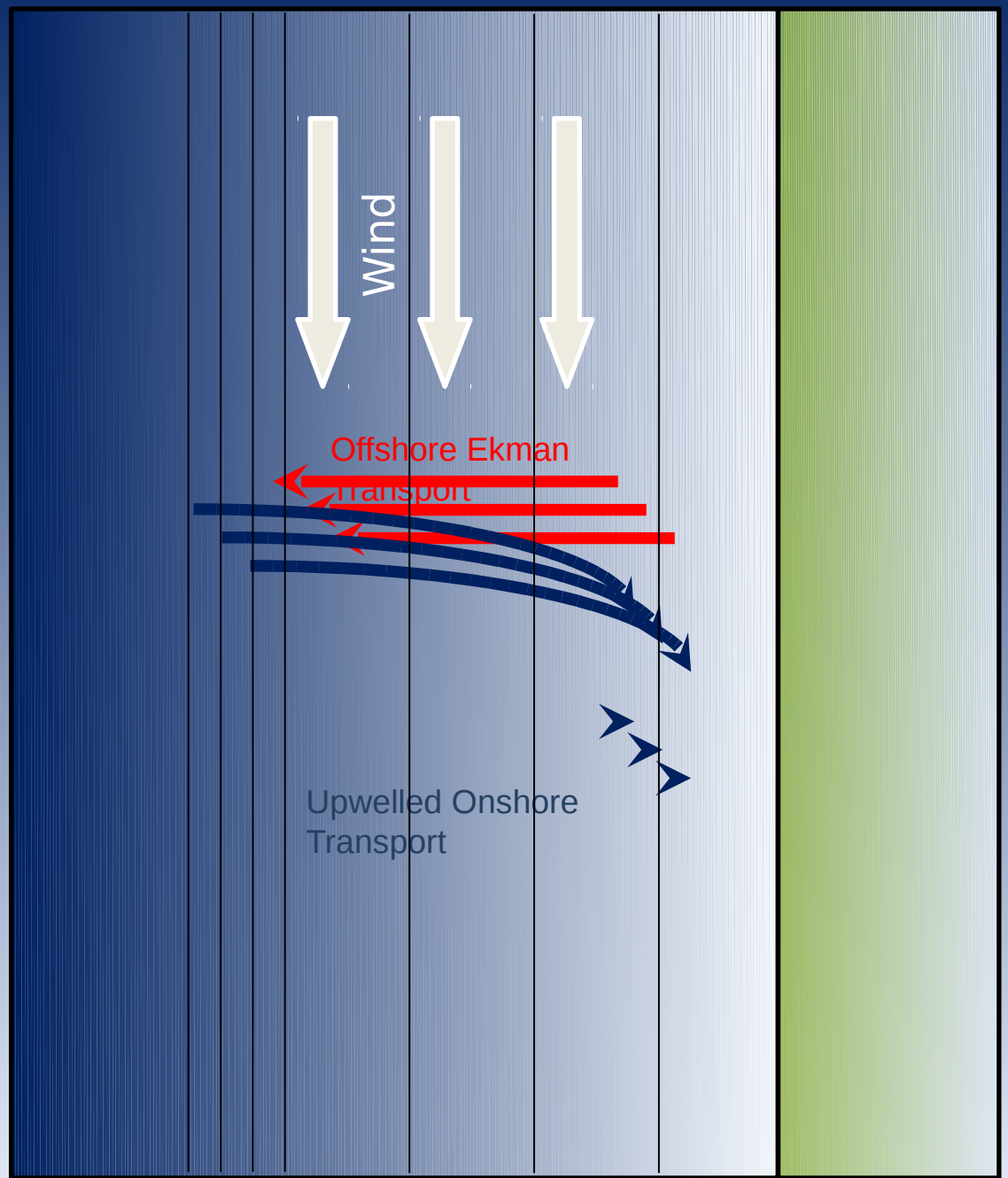


Courtesy C. Koenig, FSU

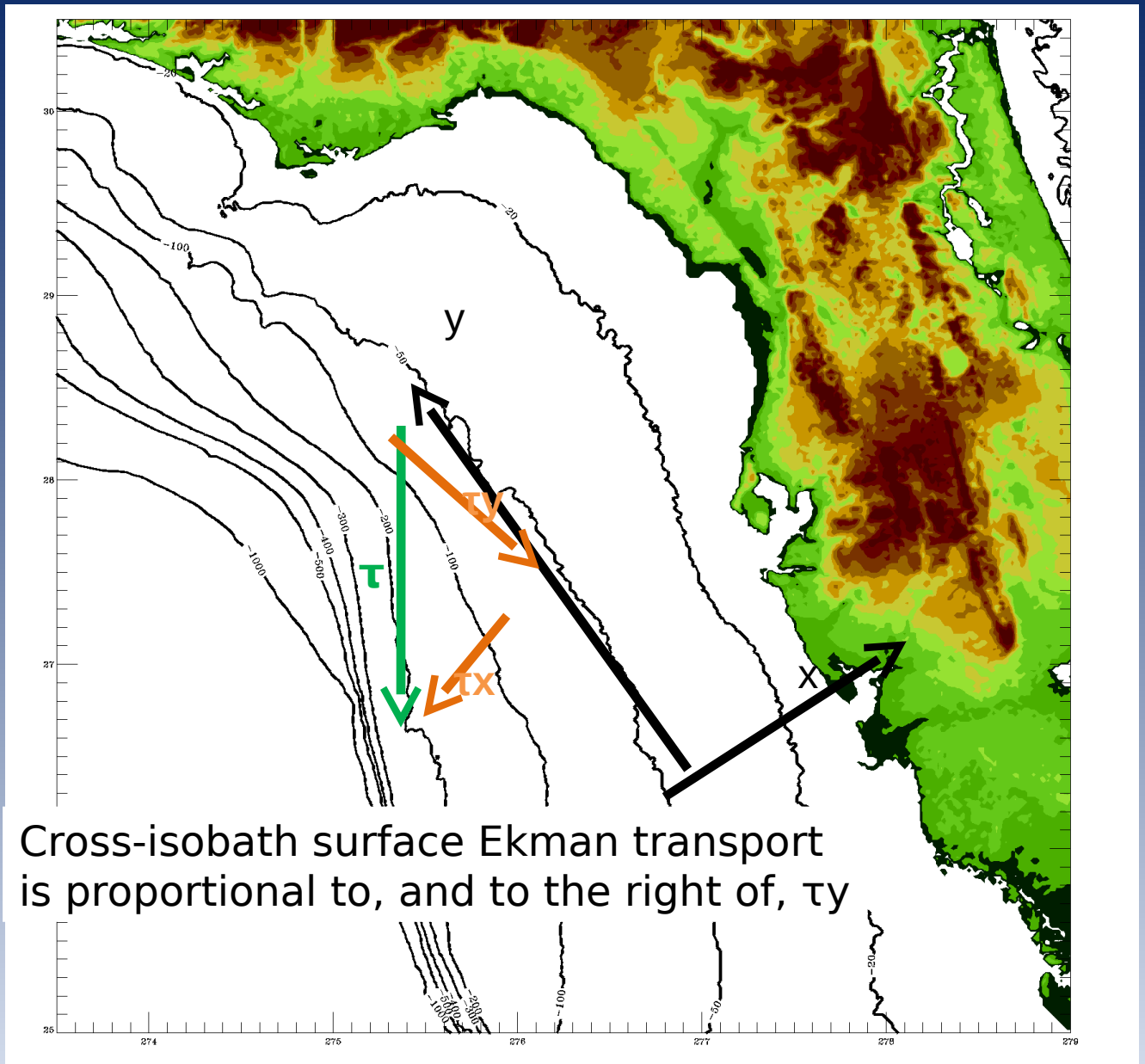




Idealized Coastal Upwelling

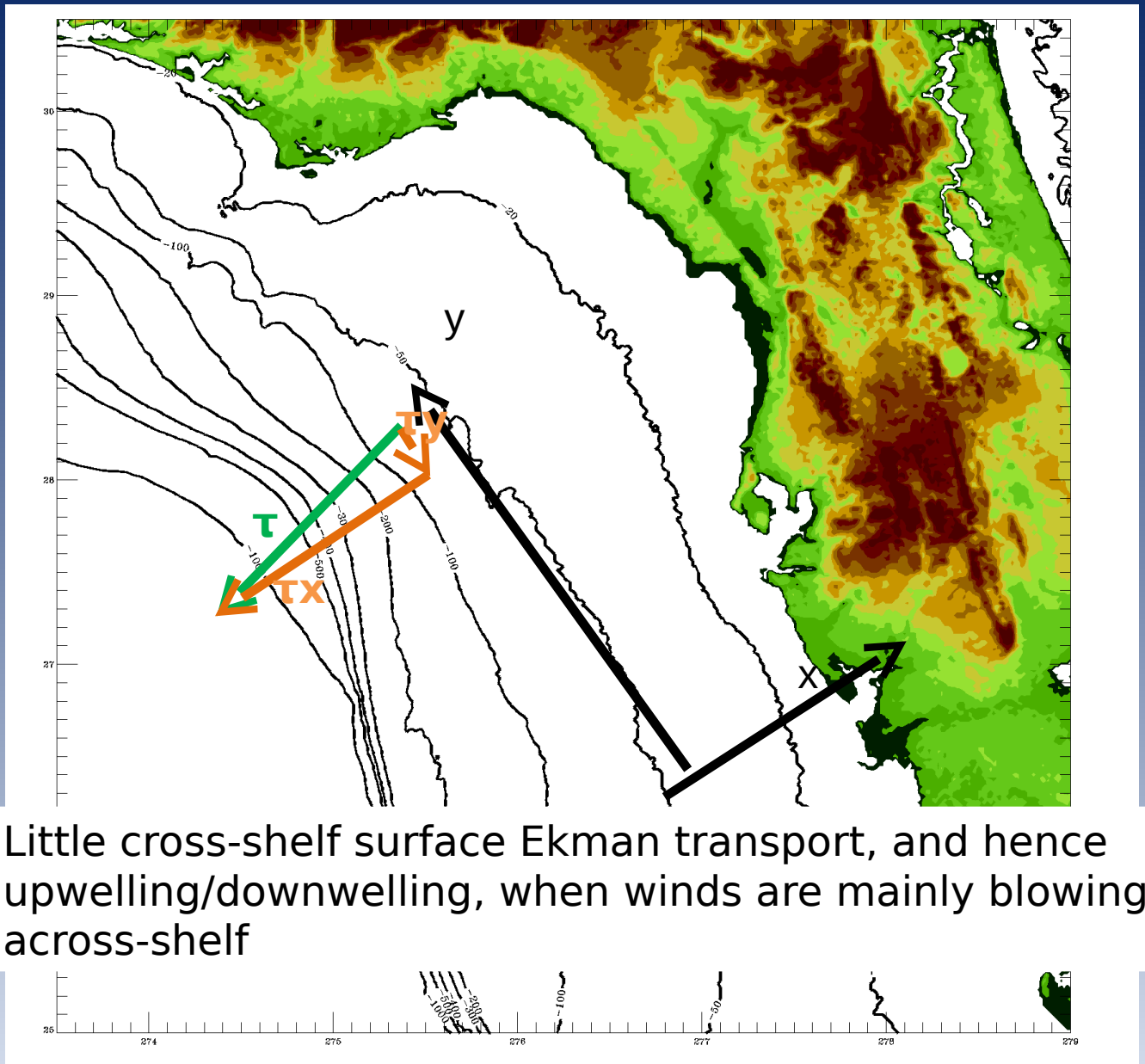


Coastal Upwelling on a Realistic Shelf



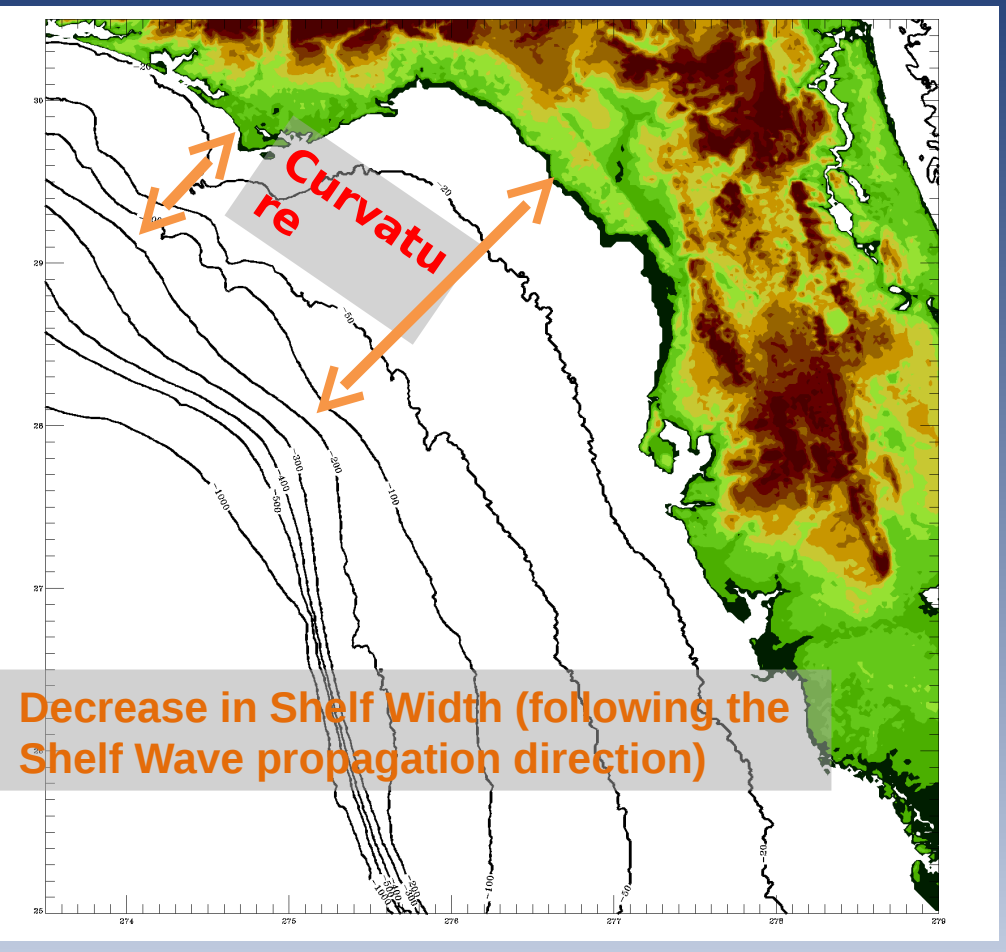
Cross-isobath surface Ekman transport is proportional to, and to the right of, τy

Coastal Upwelling on a Realistic Shelf



Little cross-shelf surface Ekman transport, and hence upwelling/downwelling, when winds are mainly blowing across-shelf

This does not look like an idealized straight shelf



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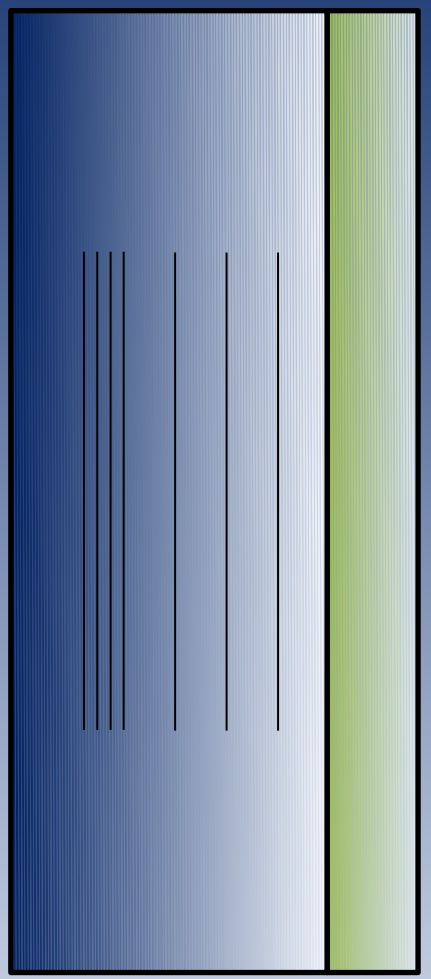
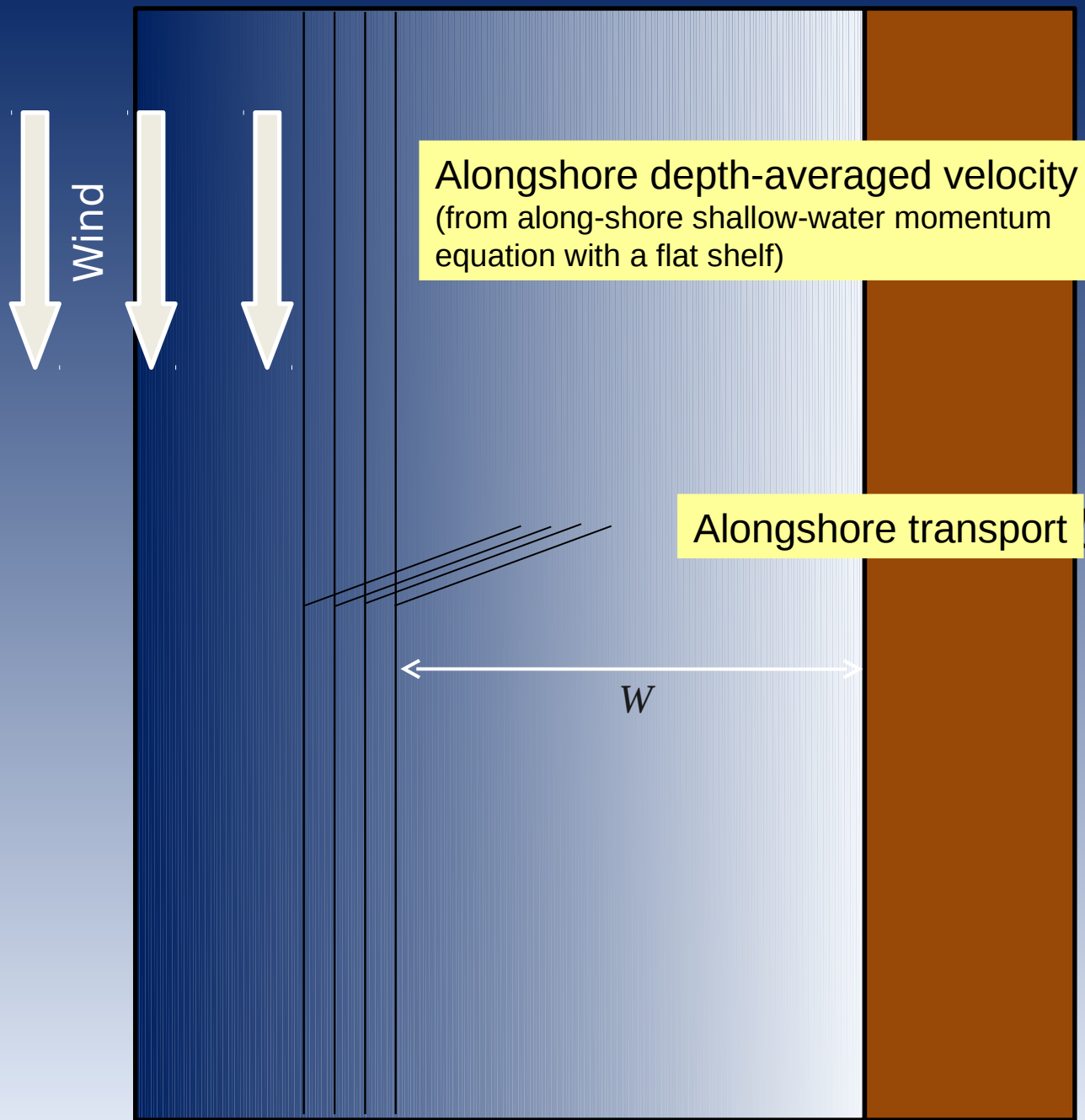


Cross-shelf Transport due to Changing Shelf Width



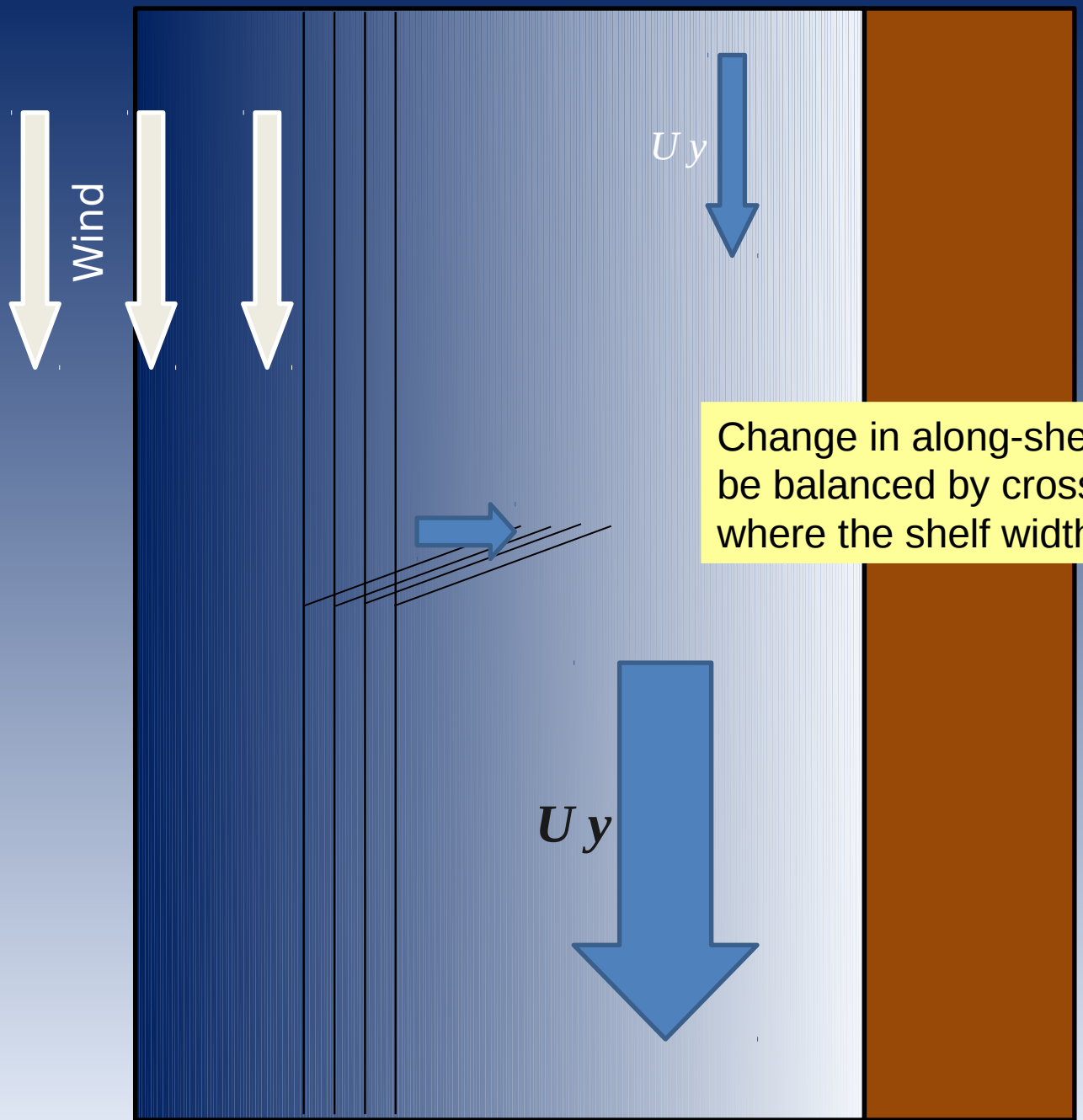
Alongshore depth-averaged velocity
(from along-shore shallow-water momentum equation with a flat shelf)

$$\bar{u}^y = \frac{\tau^y}{\rho_0 r}$$

Alongshore transport

$$U^y = W \bar{u}^y$$

Cross-shelf Transport due to Changing Shelf Width

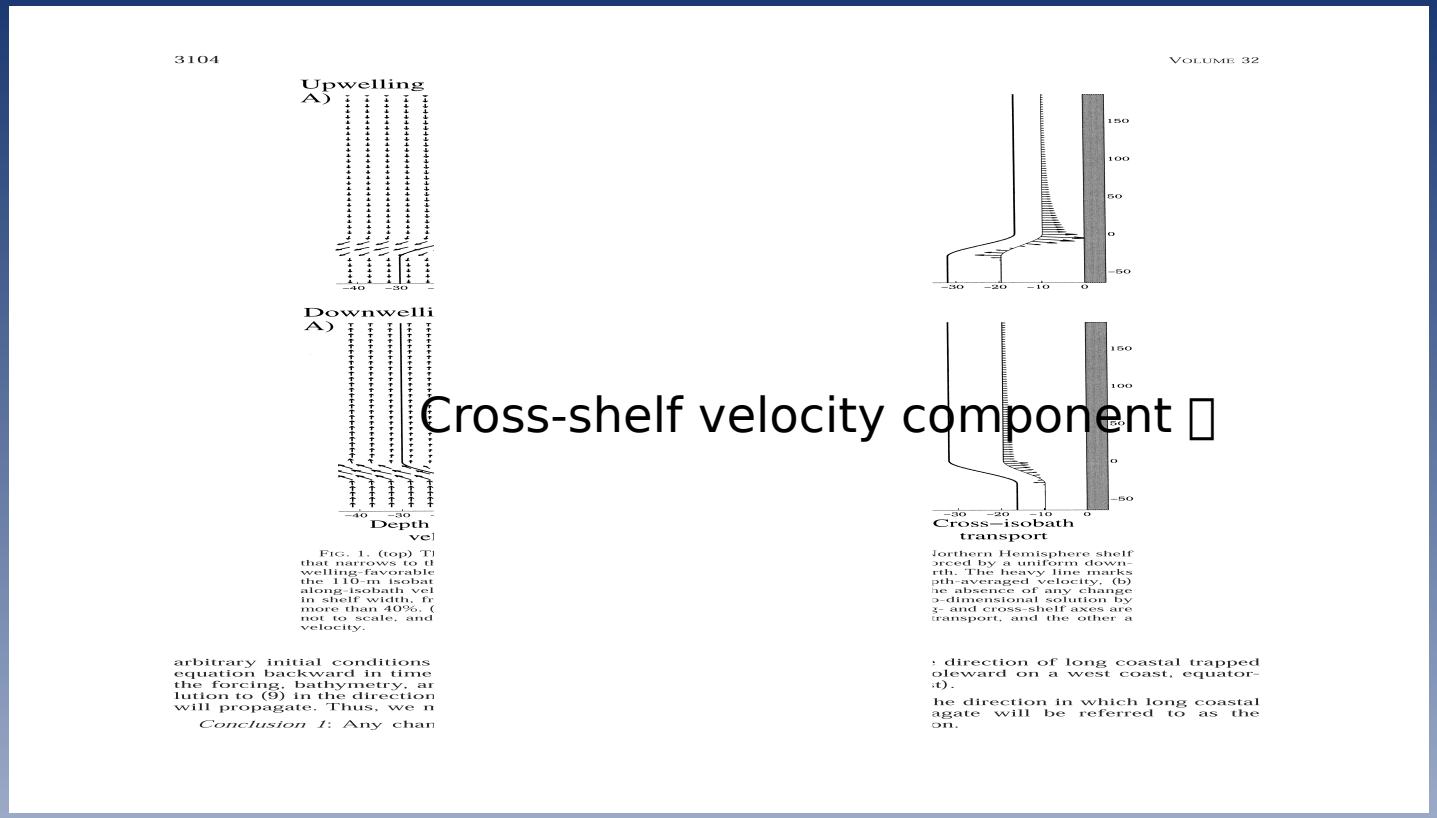


$$\bar{u}^{y} = \frac{\tau^{y}}{\rho_0 r}$$

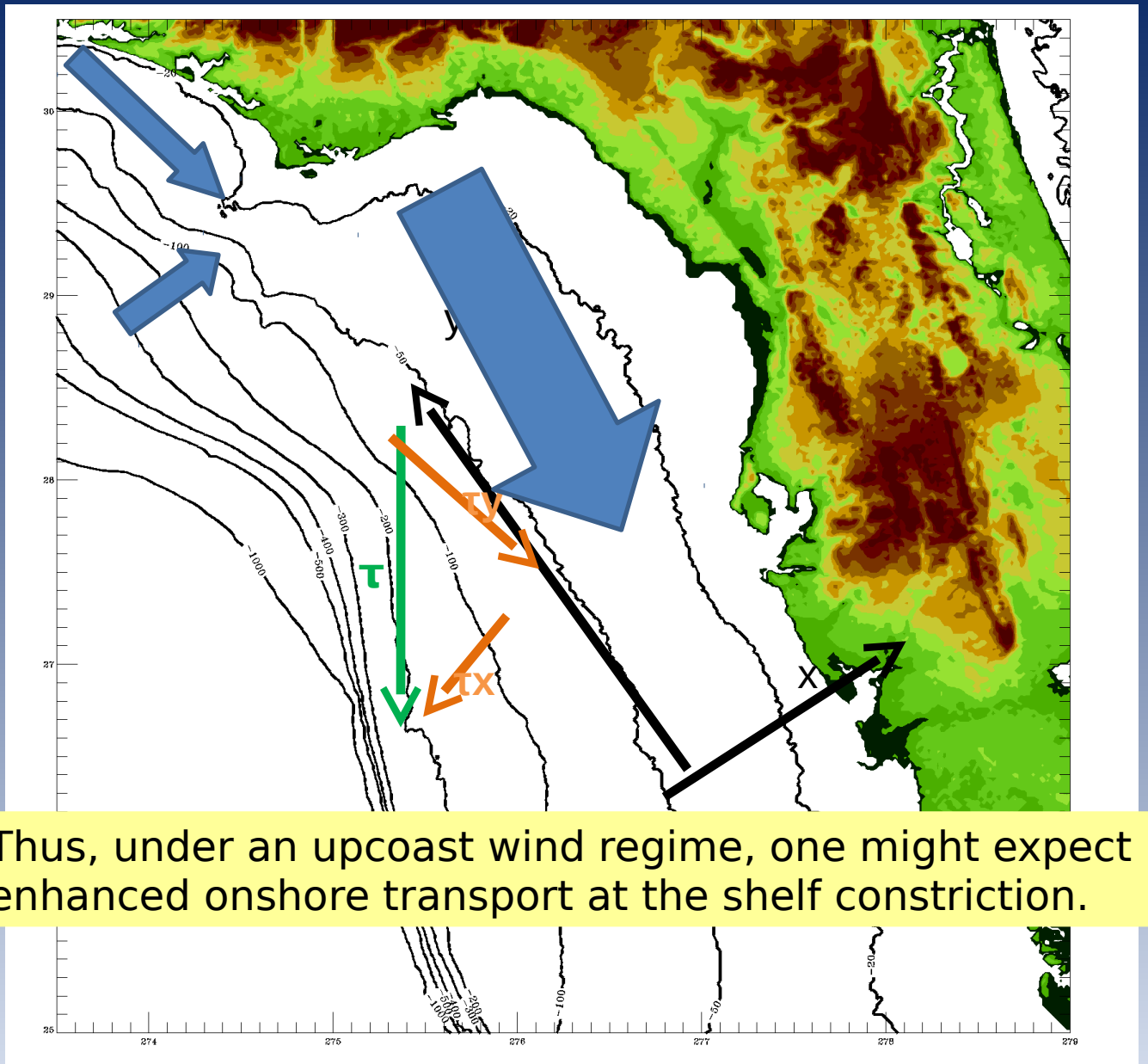
$$U^{y} = W\,\bar{u}^{y}$$

Change in along-shelf transport must be balanced by cross-shelf transport where the shelf width changes.

Solution to a linear, steady homogeneous potential vorticity equation over an idealized shelf - upwelling wind case

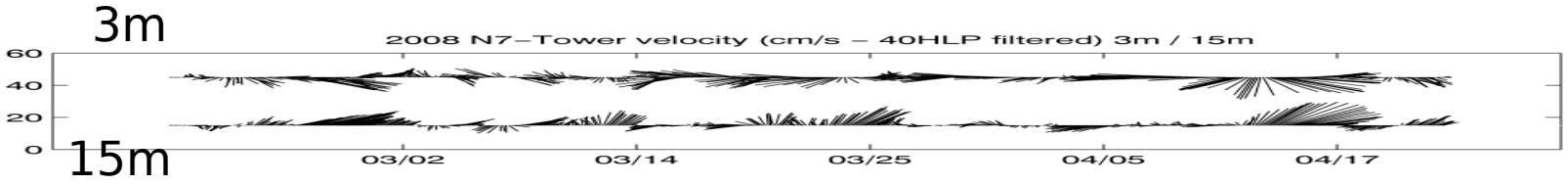


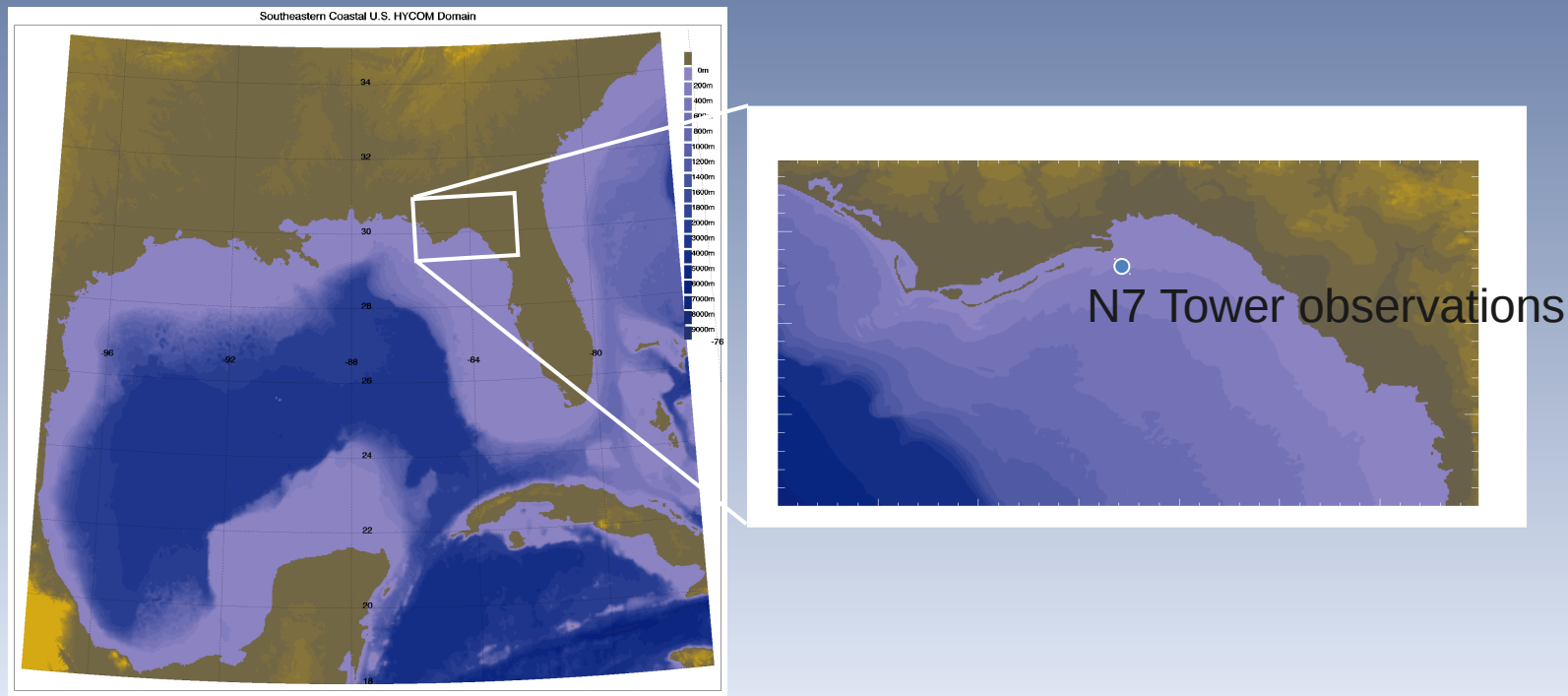
From *Pringle, JPO, 2002*



Thus, under an upcoast wind regime, one might expect enhanced onshore transport at the shelf constriction.

Upwelling on the Northern West Florida Shelf





Upwelling Index for the northern West Florida Shelf

A spatially-varying upwelling index is computed as the pseudostress projected onto the along-isobath direction

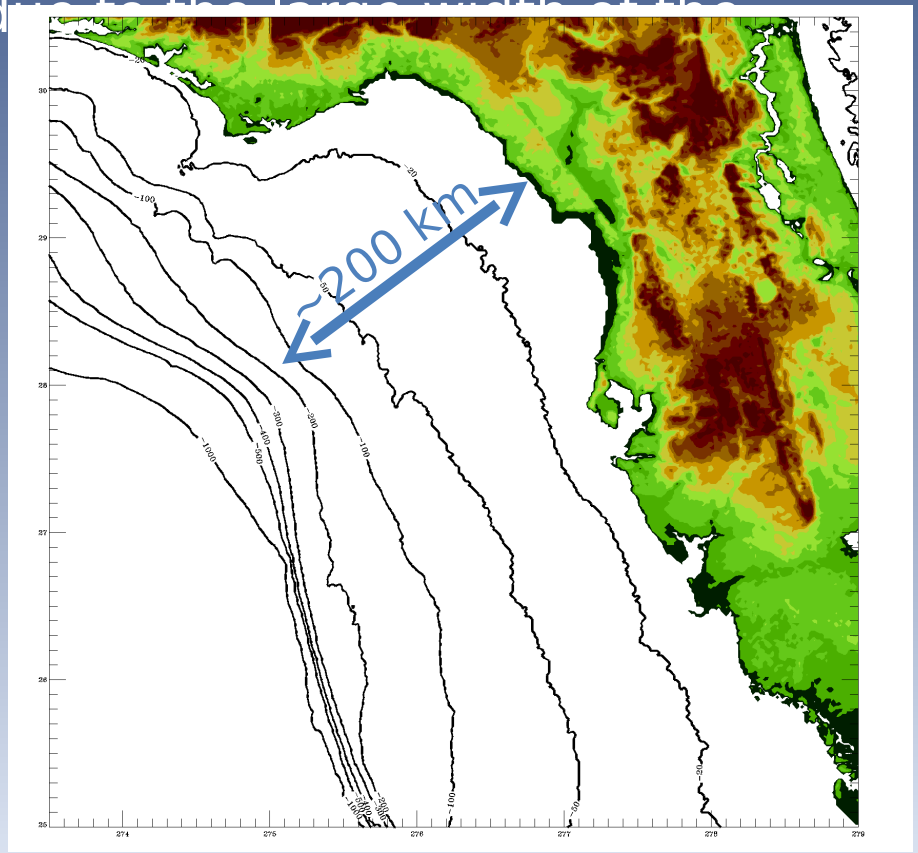
- Positive in the topographic wave propagation direction downwelling

QuikSCAT winds can be used d[illegible] to the large width of the shelf

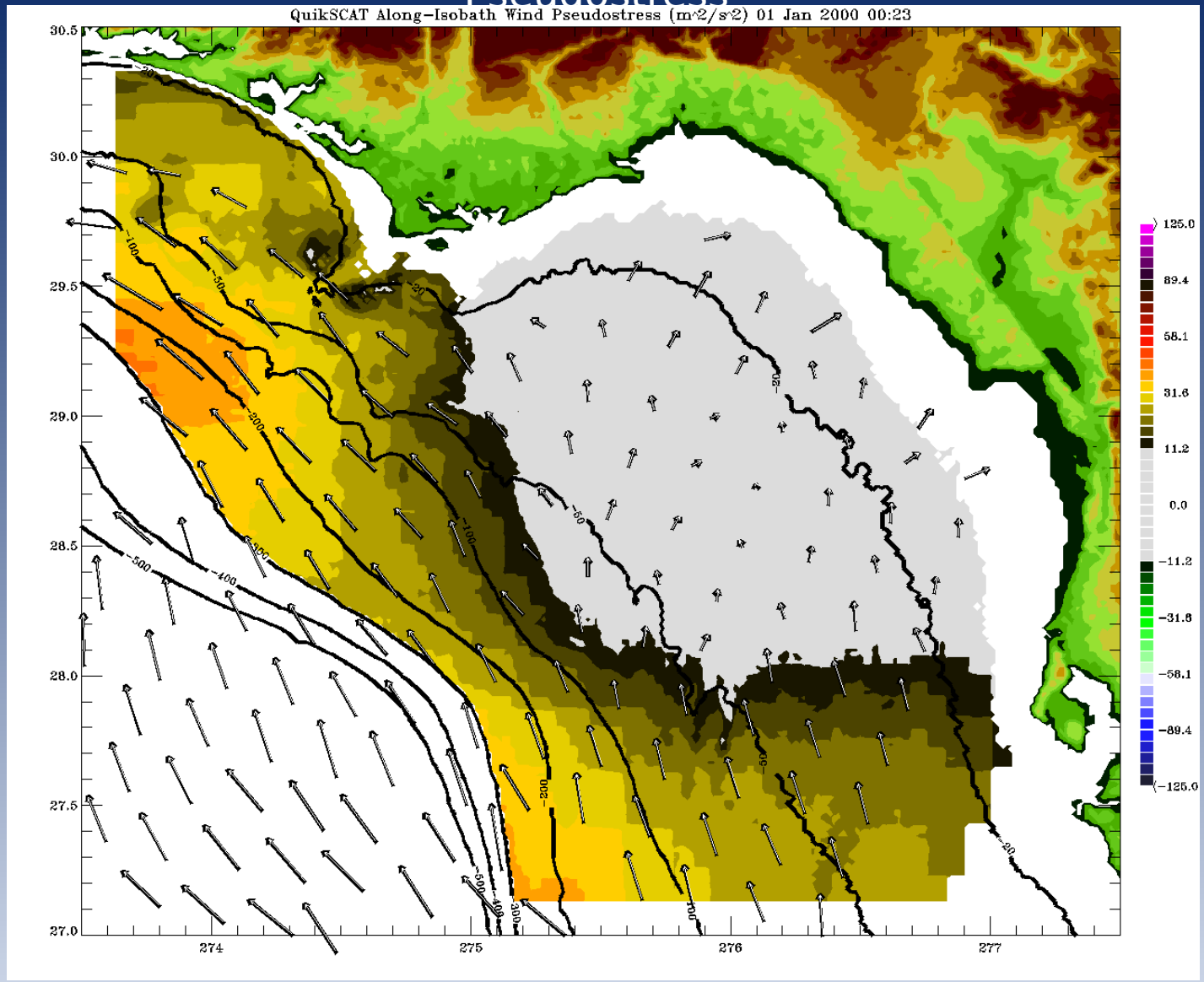
1. The topographic gradient is computed over a ~30km length scale (comparable to Rd)

2. QuikSCAT Level 2B winds are converted to pseudstress $|\mathbf{u}|\mathbf{u}$

3. Pseudostresses are bin-averaged and projected onto the local along-isobath direction

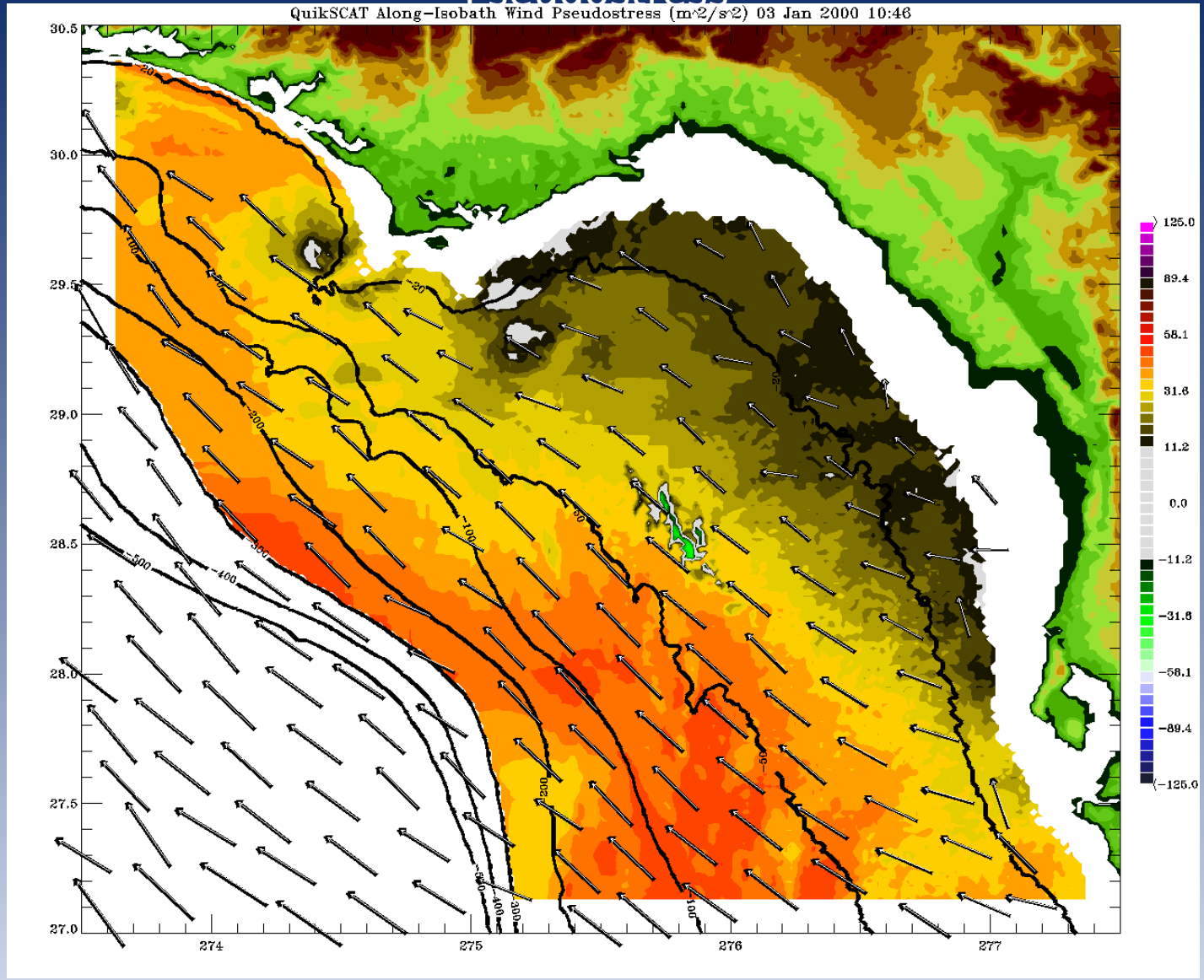


SeaWinds/QuikSCAT Along-Shore Pseudostress



01 Jan 2000 00:23 UTC

SeaWinds/QuikSCAT Along-Shore Pseudostress



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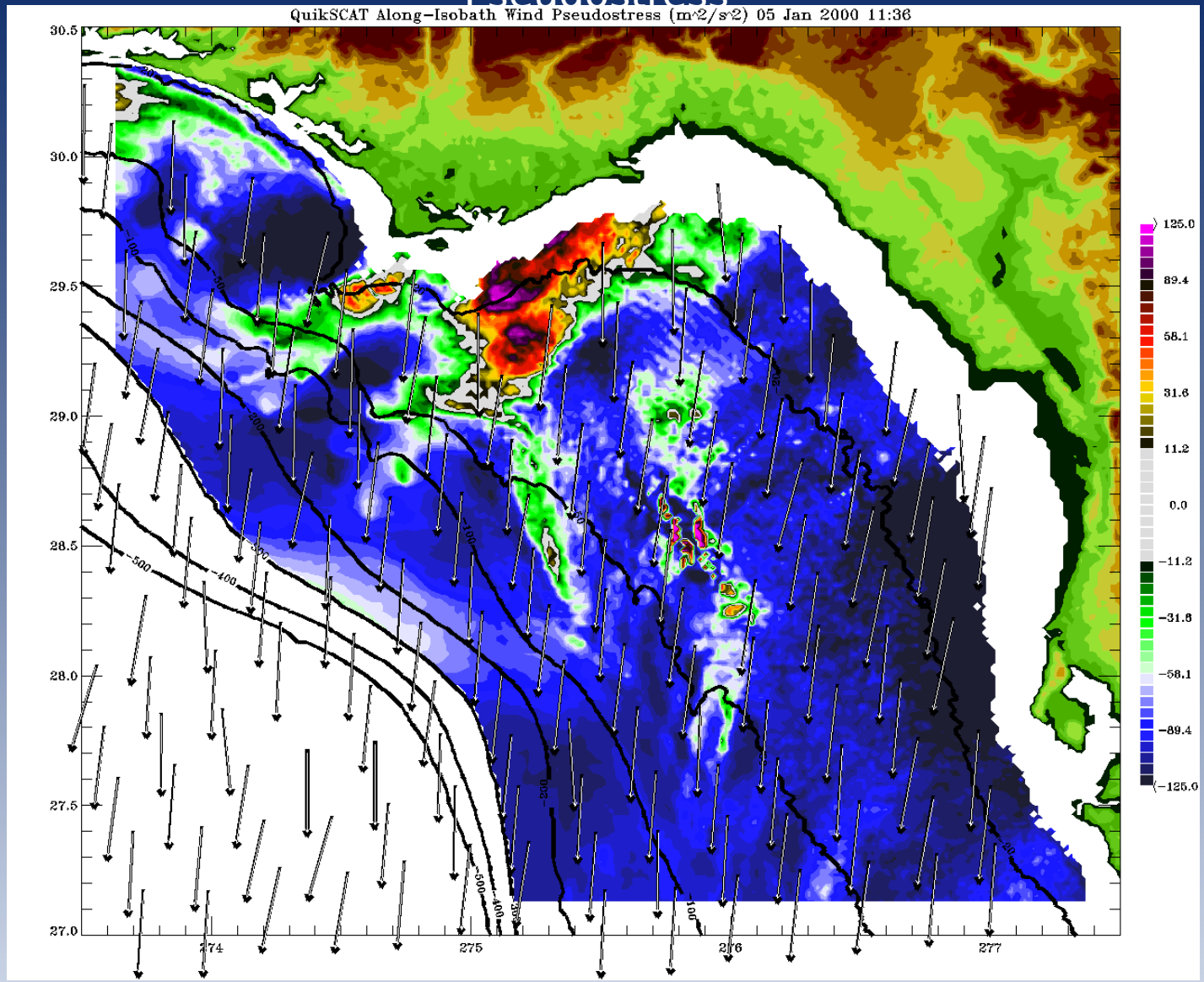

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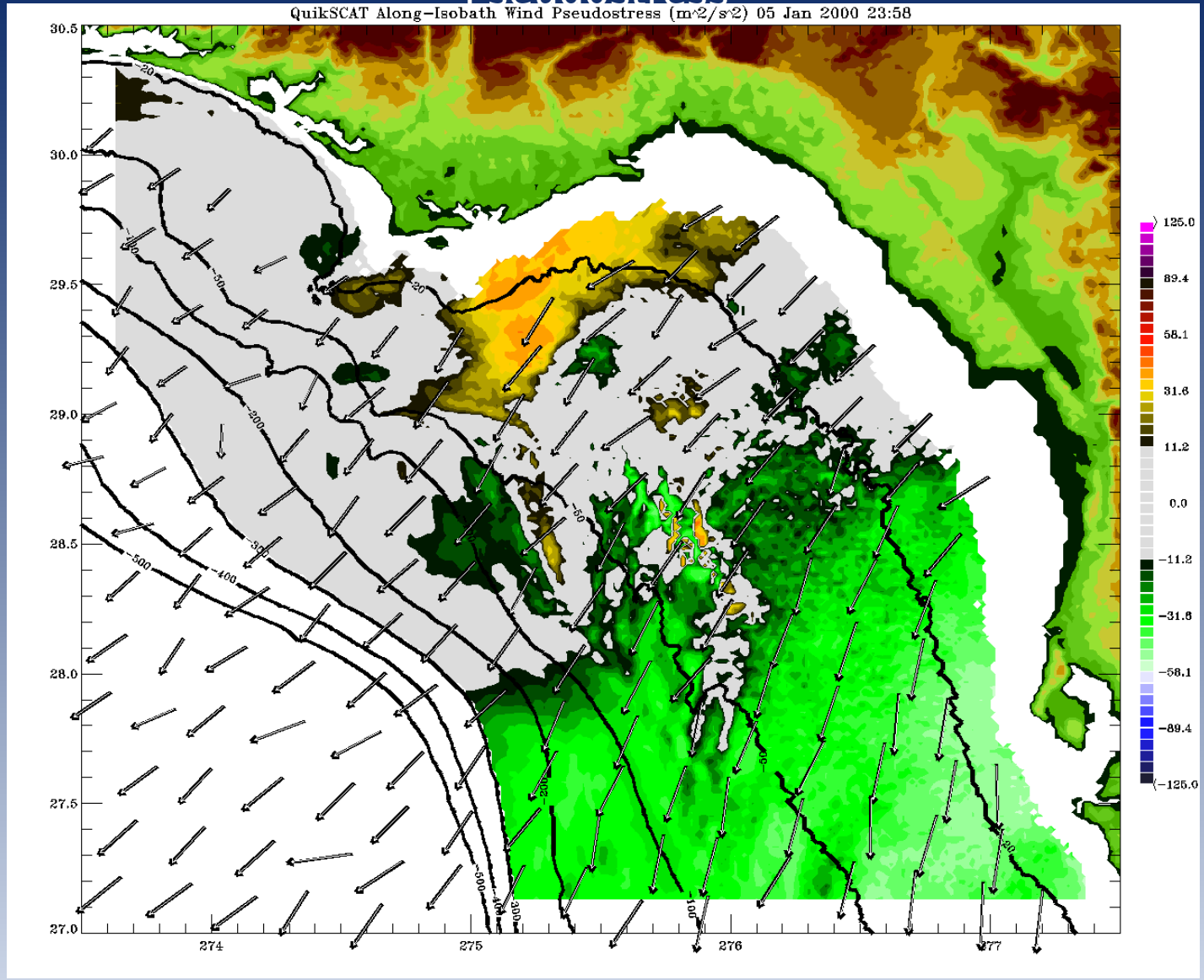
SeaWinds/QuikSCAT Along-Shore Pseudostress



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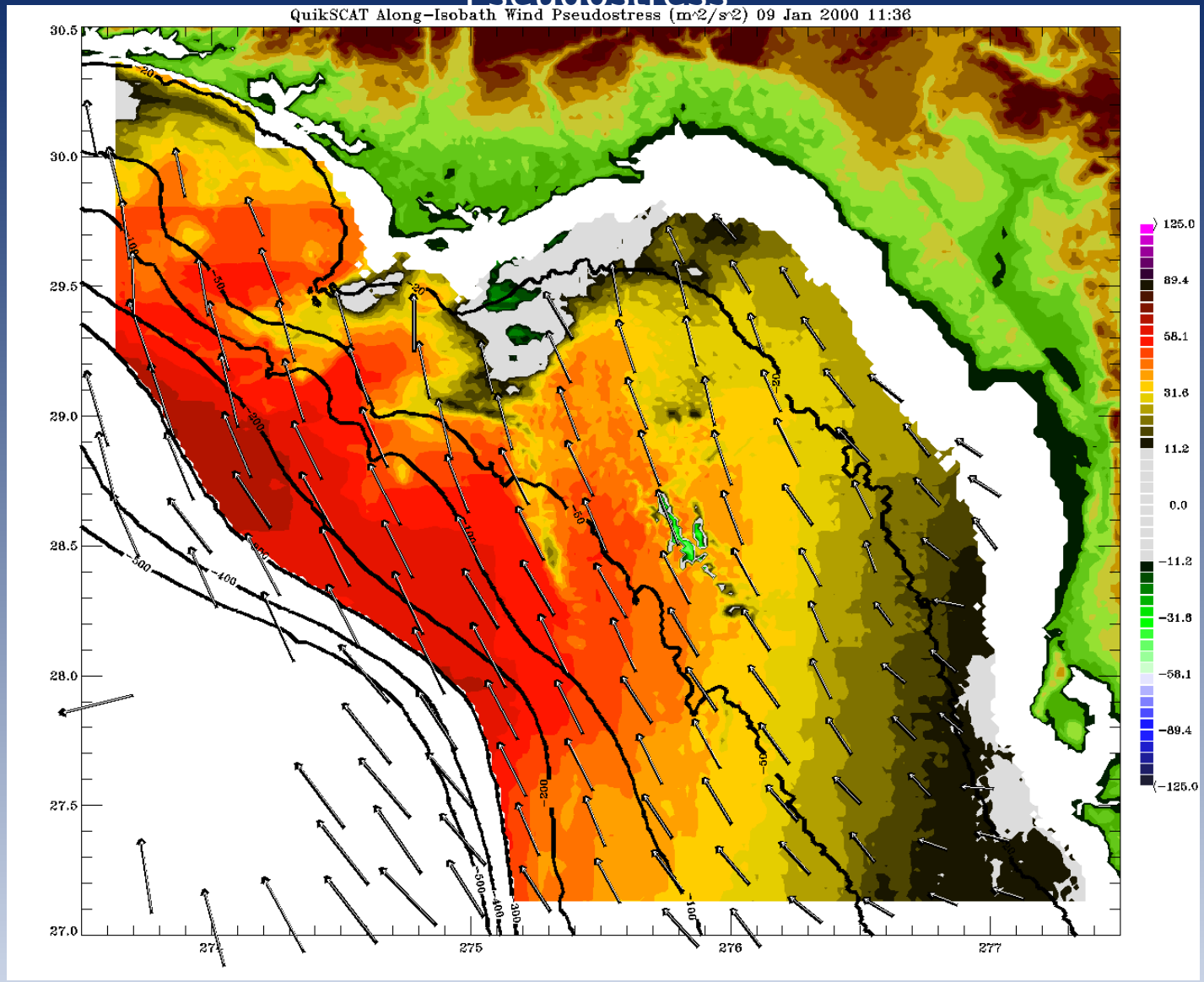
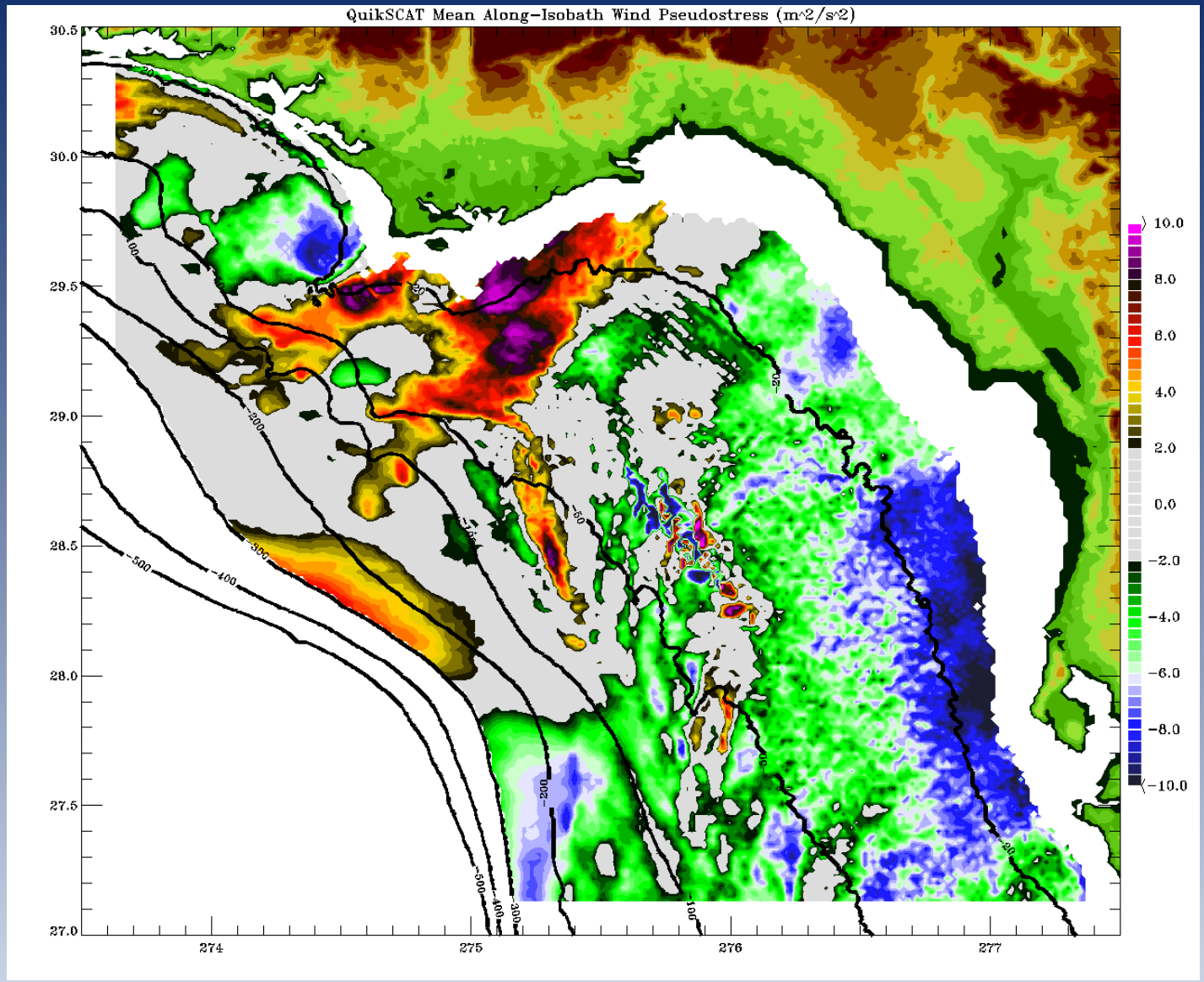
SeaWinds/QuikSCAT Along-Shore Pseudostress



09 Jan 2000 11:36 UTC

1999 – 2009 Mean



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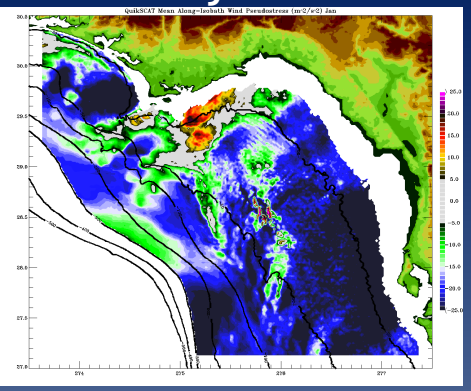

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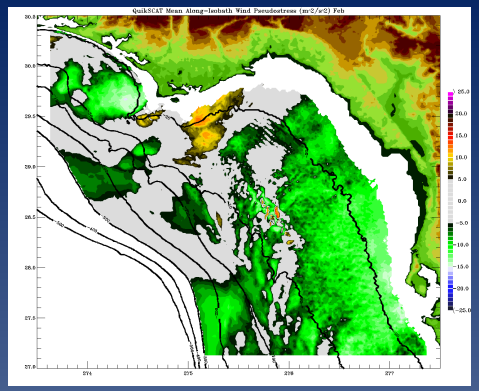

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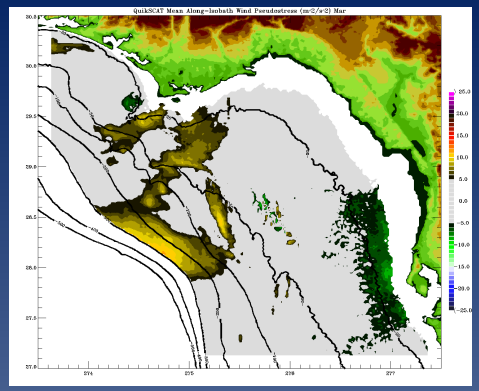

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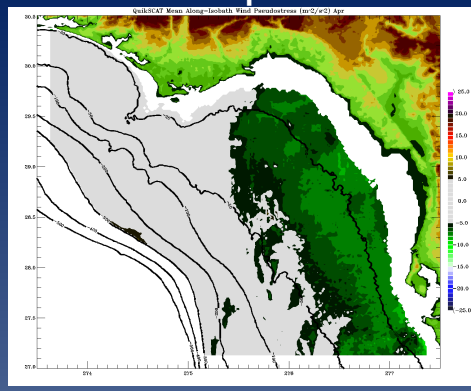

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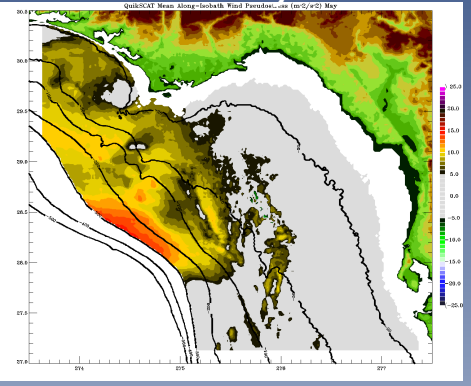

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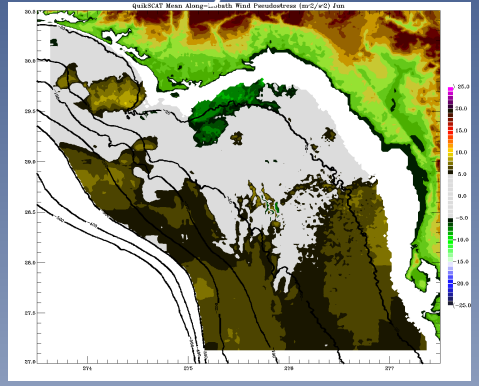

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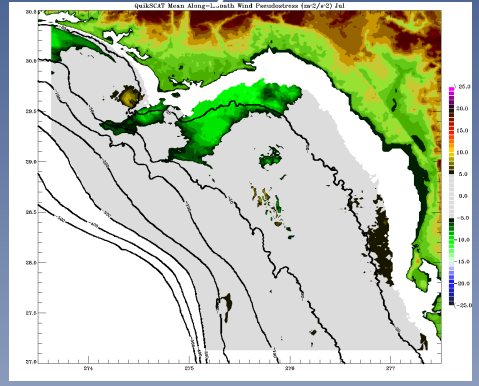

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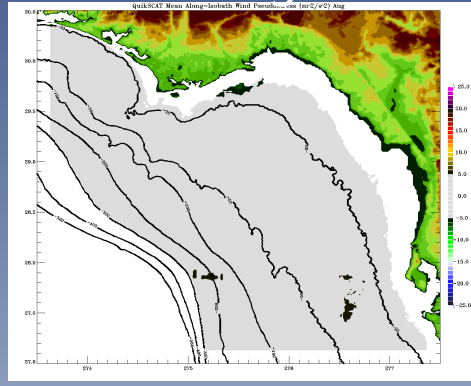

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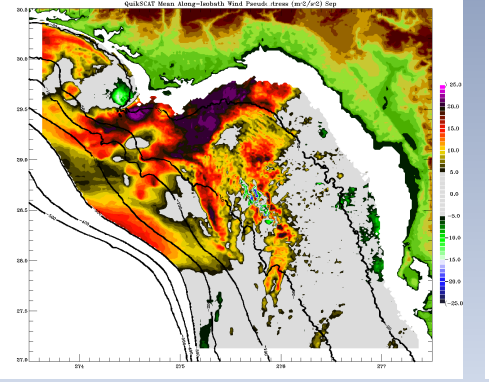

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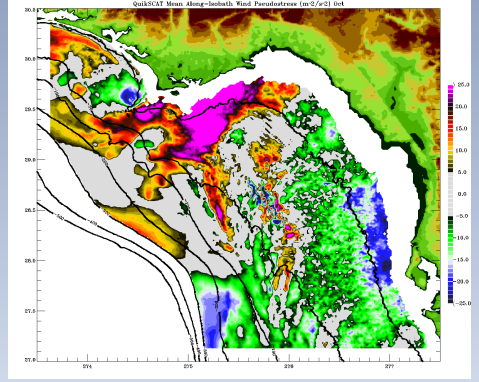

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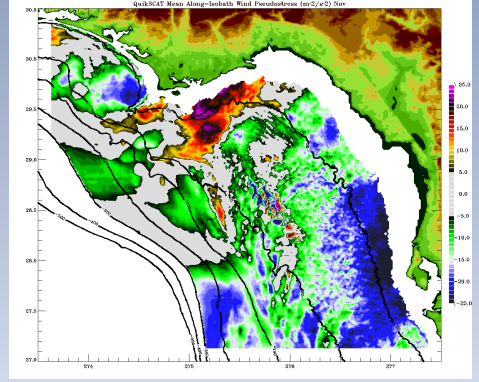

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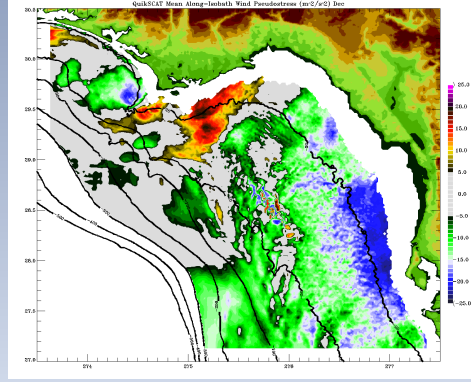
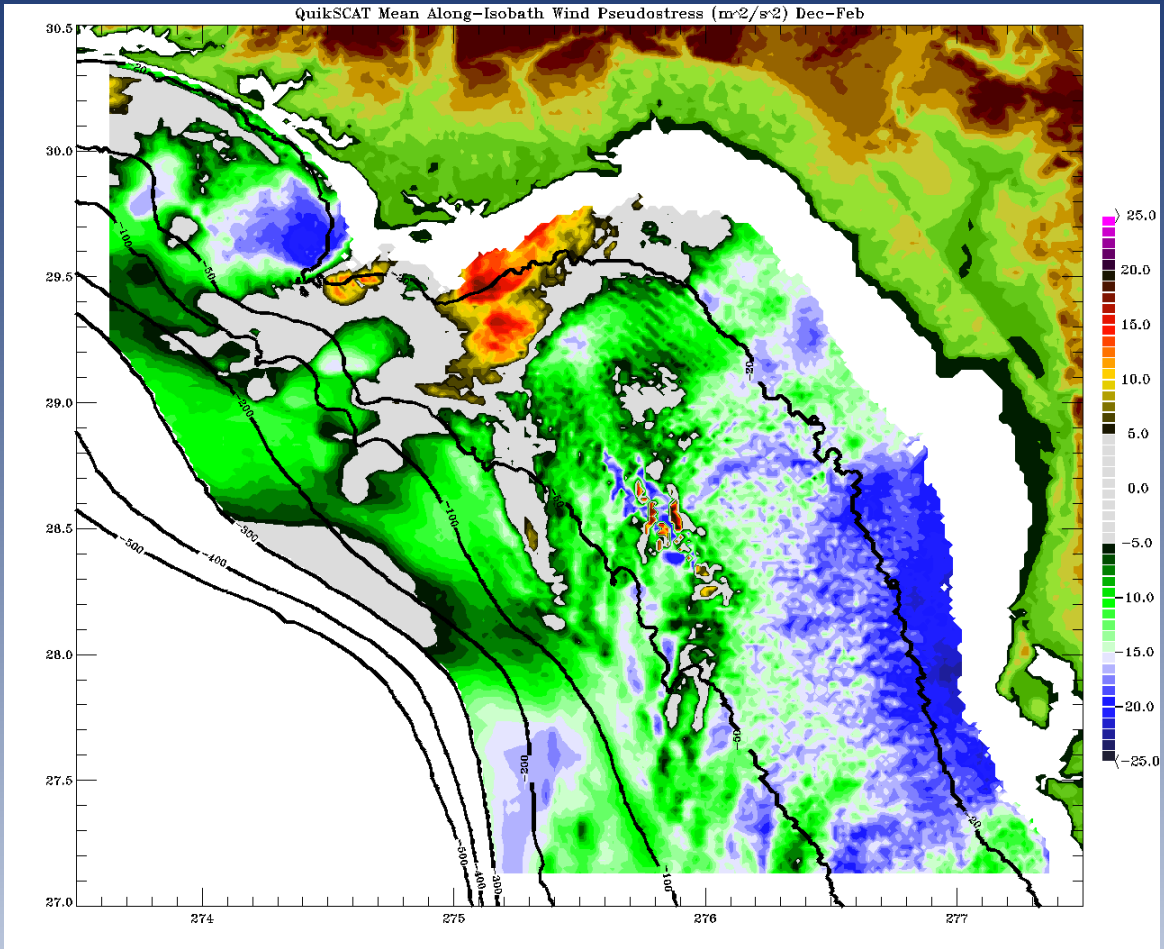


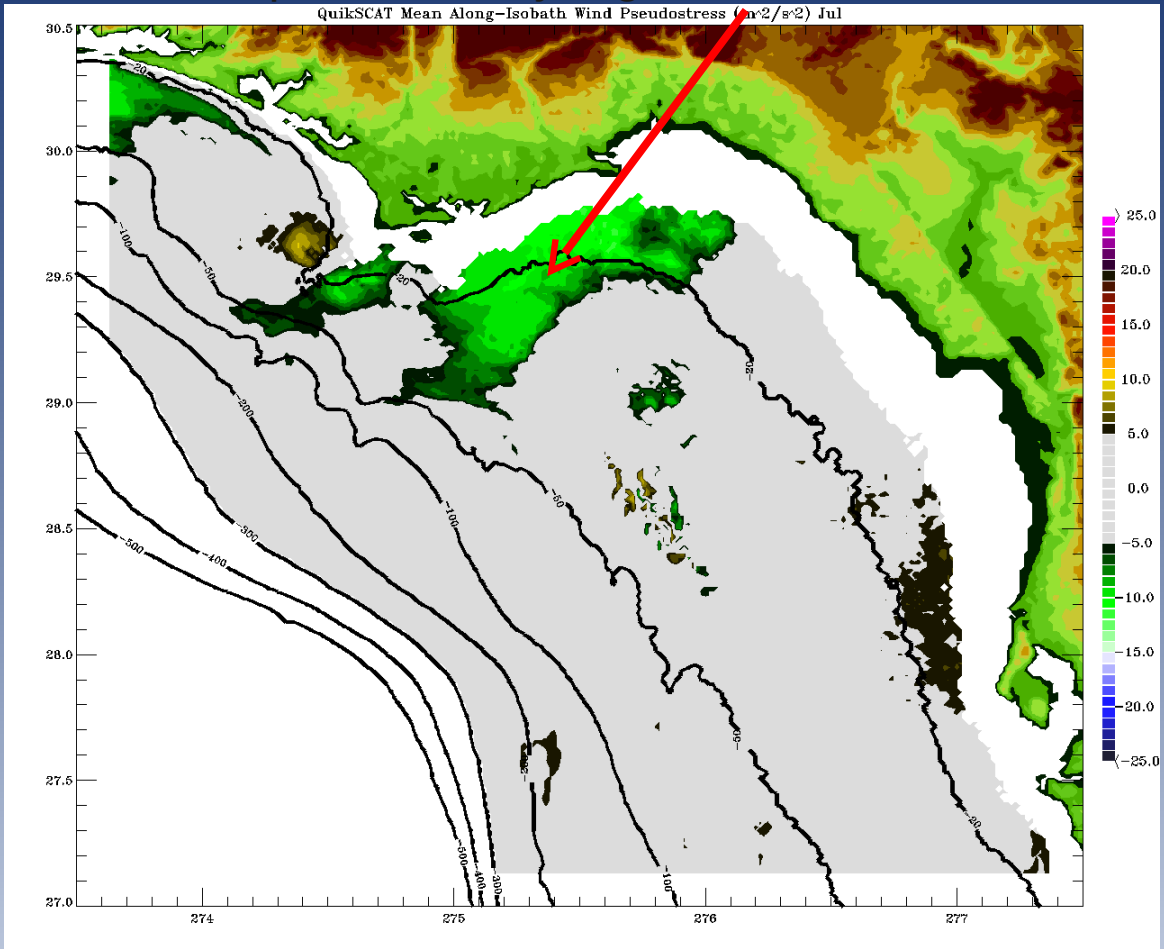
Dec-Jan-Feb Climatology
(spawning season)

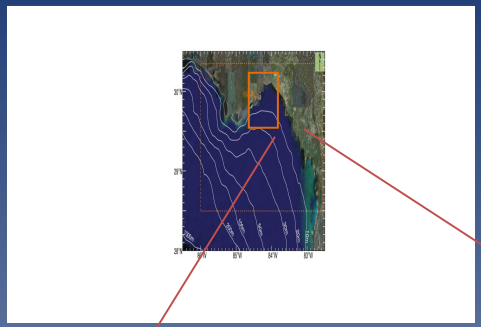


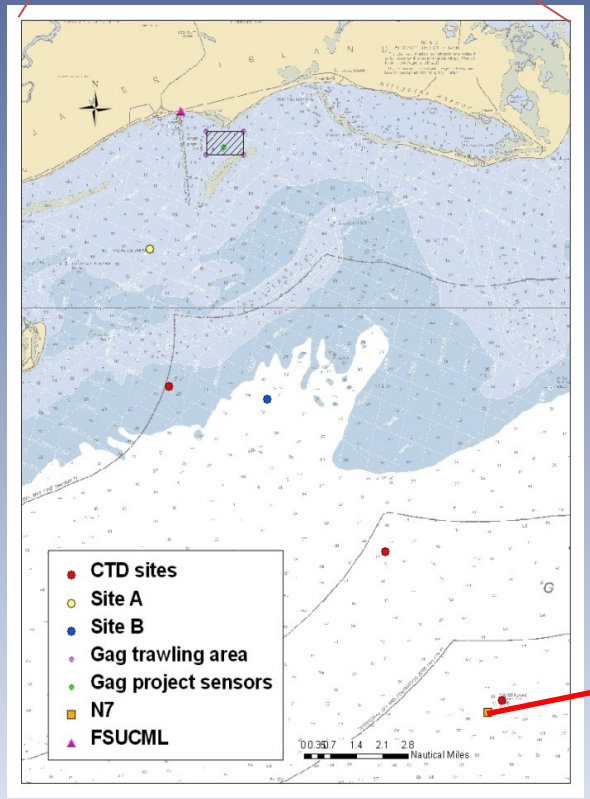
North-northeasterly winds produce a dominant upwelling pattern over the shelf with onshore surface Ekman transport in the western Apalachee Bay region

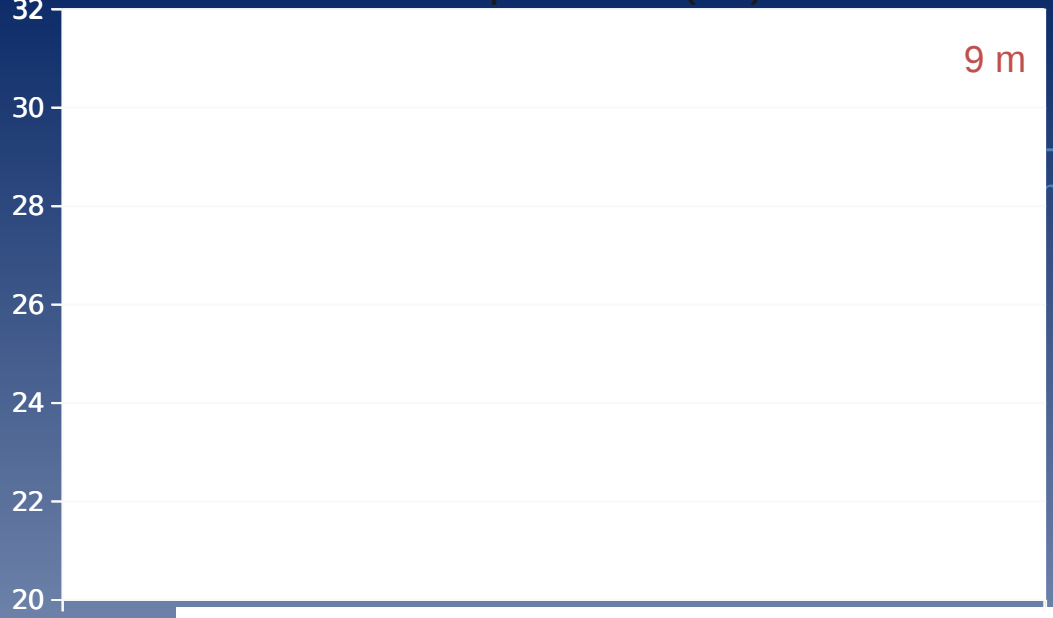
July Climatology

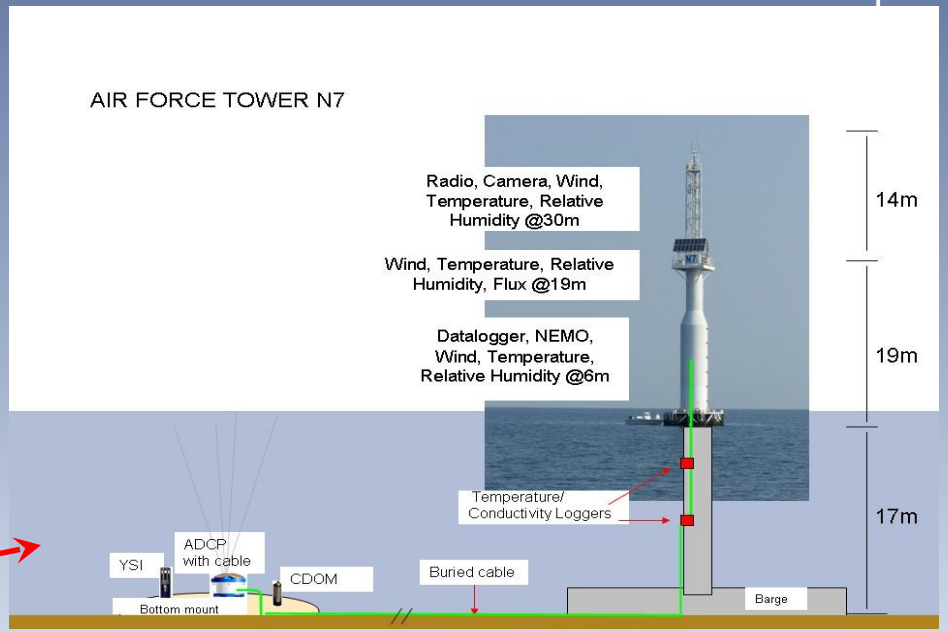
Only month with upwelling-favorable winds over the northern And western Apalachee Bay region






CTD sites
Site A
Site B
Gag trawling area
Gag project sensors
N7
FSUCML
Nautical Miles


Water Temperature (°C)
32
30
28
26
24
22
20
9 m
-bottom
n)


AIR FORCE TOWER N7
Radio, Camera, Wind, Temperature, Relative Humidity @30m
Wind, Temperature, Relative Humidity, Flux @19m
Datalogger, NEMO, Wind, Temperature, Relative Humidity @6m
14m
19m
17m
Temperature/ Conductivity Loggers
YSI
ADCP with cable
CDOM
Buried cable
Bottom mount
Barge

Summary

- QuikSCAT winds are useful for studies of the West Florida shelf due to its width.
- The curvature of the northern West Florida Shelf produces significant along-shore variability in inferred cross-shelf transport
- The narrowing of the shelf suggests regions of enhanced cross-shelf transport due to simplified dynamics
- A localized region of upwelling is suggested by the analysis, and is evident in the observations
- This work would be further supported by extending the NGI observational array westward toward the narrower portion of the shelf to provide a better characterization of the cross-shelf transport pathways.