Global Coastal Upwelling/Downwelling Estimates from SeaWinds

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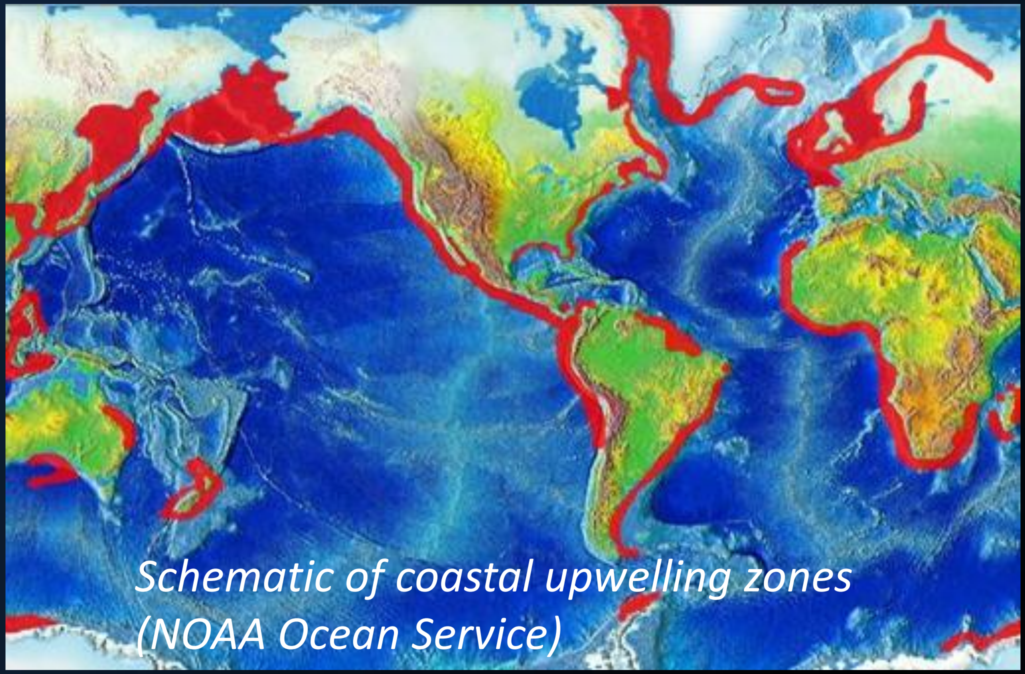
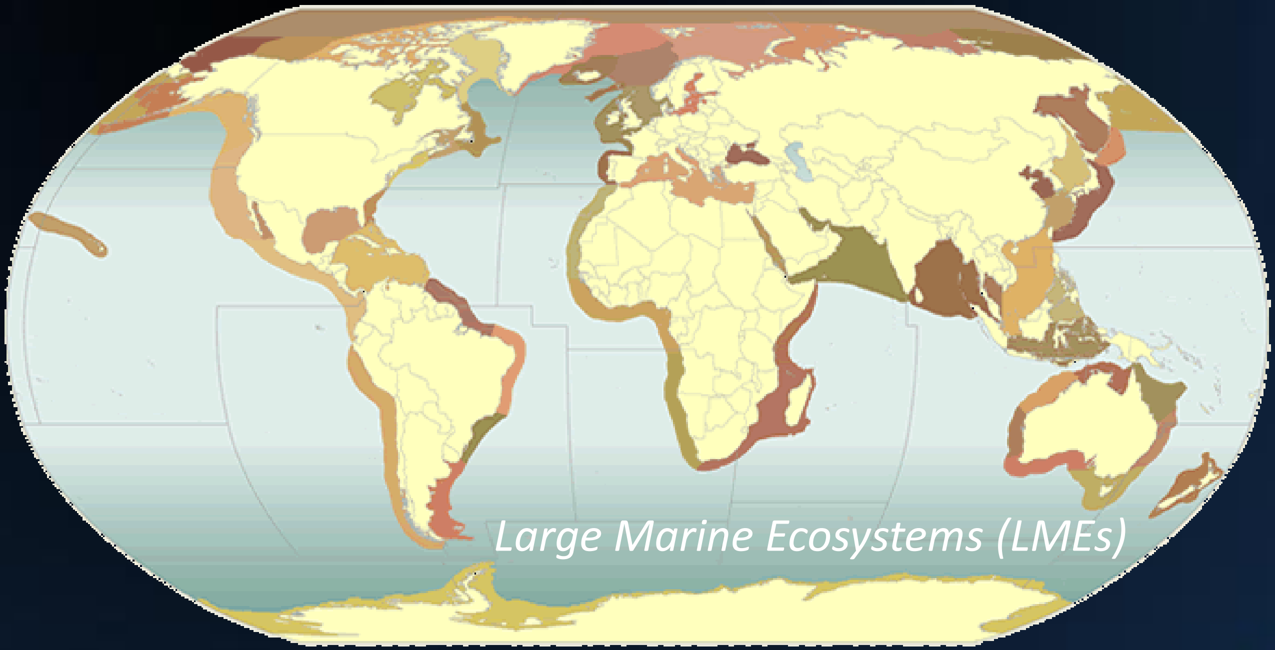


Schematic of coastal upwelling zones (NOAA Ocean Service)

Objectives:

Develop estimates of coastal upwelling/downwelling globally from satellite scatterometer winds.

Use this global product to describe spatio-temporal variability of upwelling-favorable winds at multiple scales.



Large Marine Ecosystems (LMEs)

Variability in coastal upwelling has important implications for:

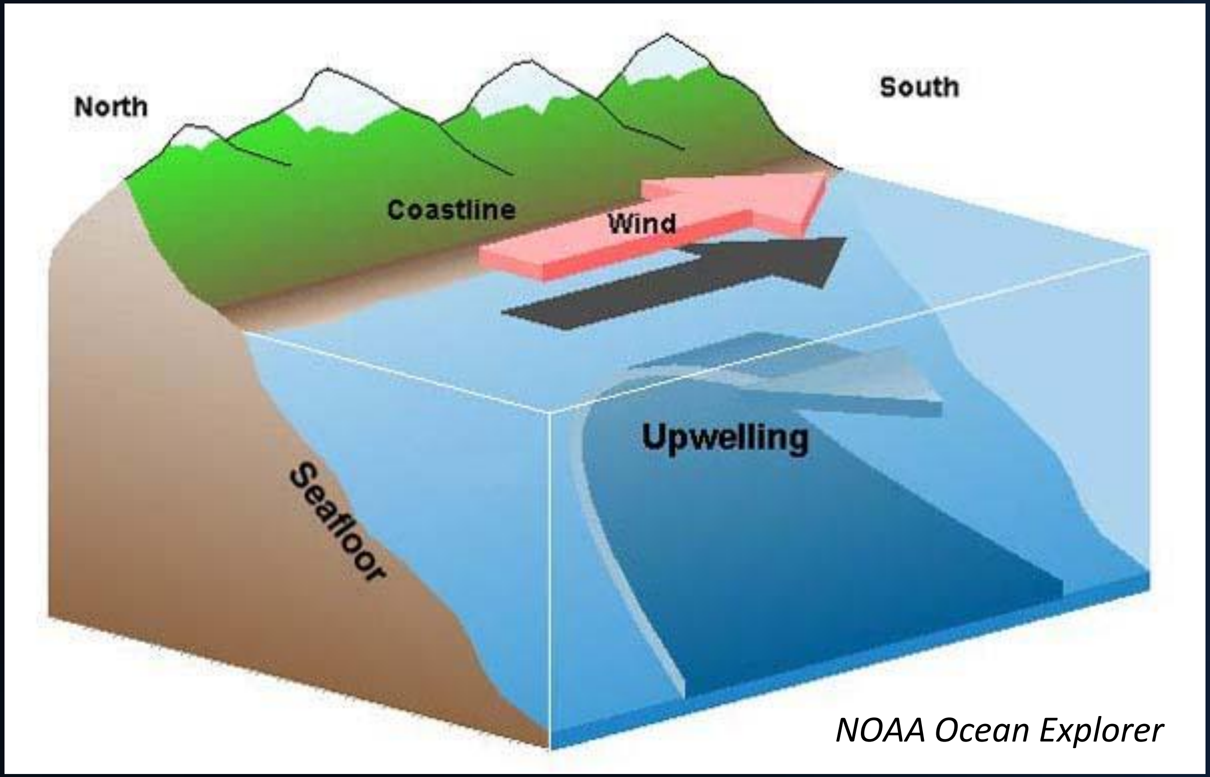
Nutrient supply to large and small marine ecosystems

Carbon sequestration

Regional climate

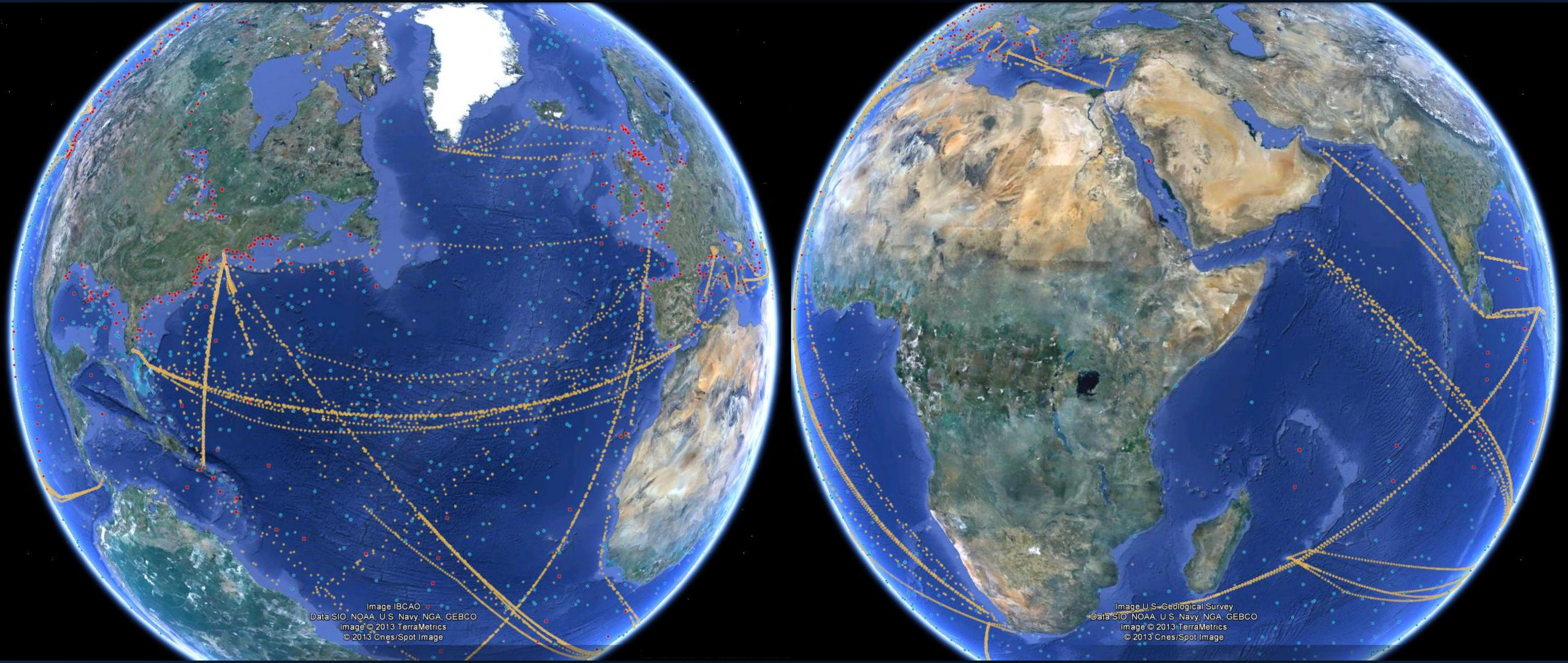
Cross-shelf transport of biota

Fate of coastal pollutants



Global maps of daily cross-shelf Ekman transport are computed from the 10-year record of SeaWinds scatterometer observations.

This provides a tool for exploring the spatio-temporal variability of potential upwelling zones over all coastal regions, which is particularly important in regions with sparse *in situ* observations.



JCOMMOPS *in situ* wind observations – April 2013

Methodology

- QuikSCAT/SeaWinds (25 km L2B product) swath 10m wind vectors (u_w , v_w) are converted to stresses as

$$\left(\tau_x, \tau_y\right) = \rho_a\, C_d\, \left\|\mathbf{u}_w\right\| \left(u_w, v_w\right)$$

C_d is calculating using the Large and Pond (1982) quadratic formulation.

- (S_x , S_y) are bin-averaged over 50 km overlapping bins (centered every 0.1°) for each day

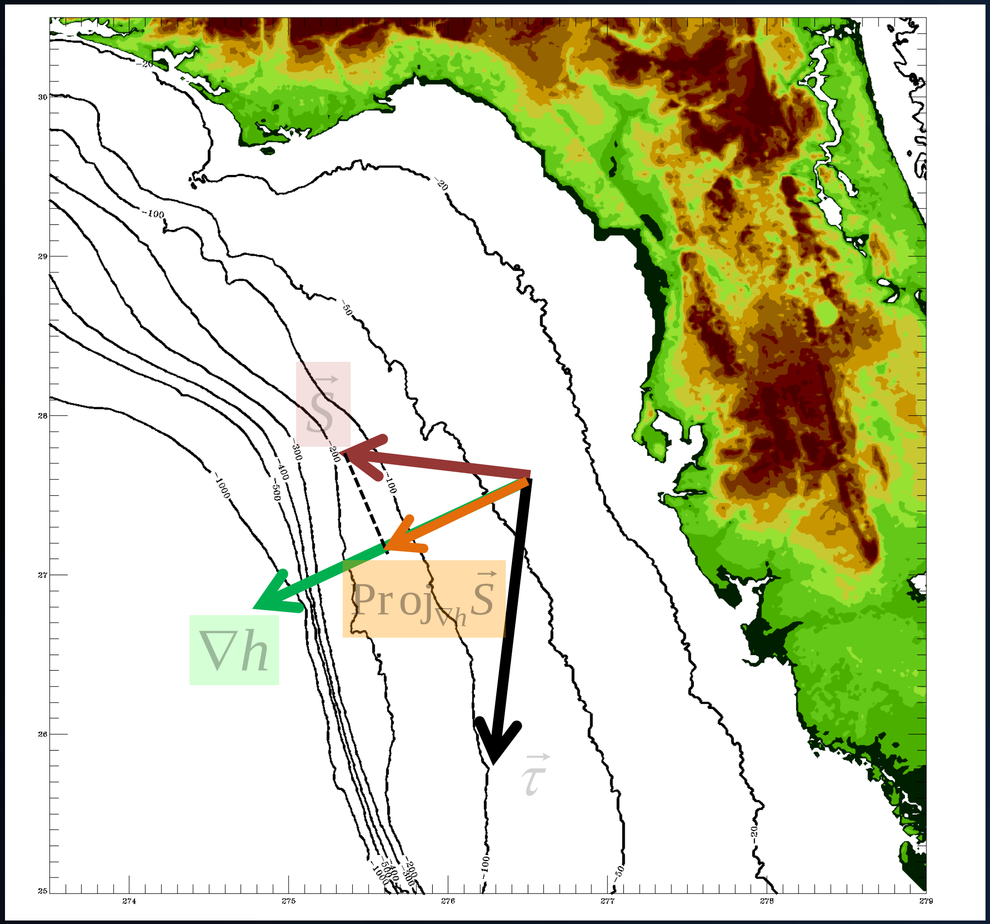
- Transport in the ocean surface Ekman layer is calculated as:

$$\left(S_x, S_y\right) = \frac{1}{\rho_0\, f} \left(\tau_y, -\tau_x\right)$$

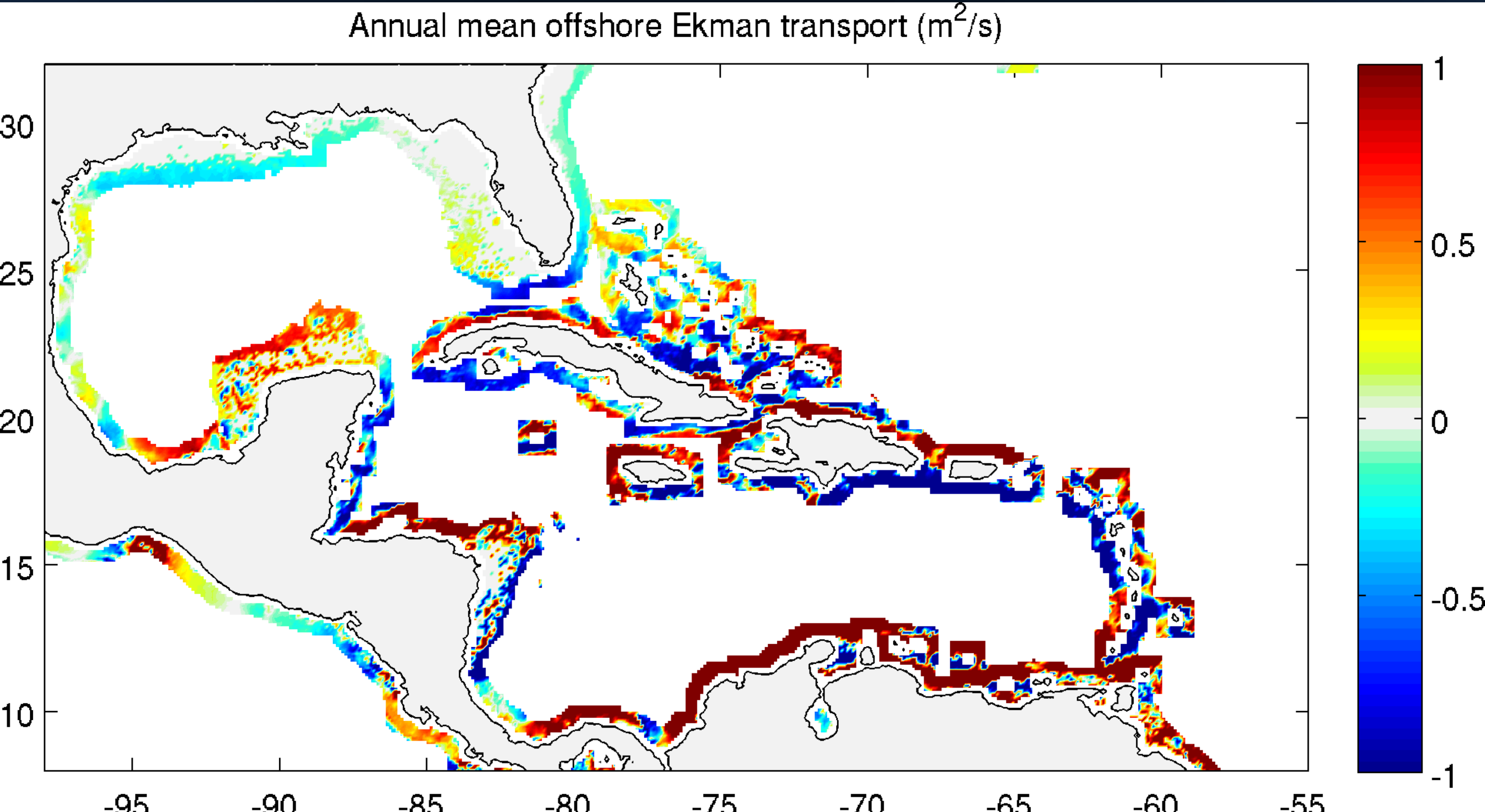
The air density ρ_a and the ocean density ρ_0 are derived from ICOADS monthly climatology data.

Methodology

- The Ekman transport vector is projected onto the (positive offshore) bathymetric gradient
  - Bathymetric gradient computed from the ETOP02 global bathymetry data set for all locations (subsampled to 0.1° resolution) from 15km from the coast out to 70 km or the 200m isobath, whichever is furthest.
  - Gradient averaged over 60 km length scales (30 km near the coast).

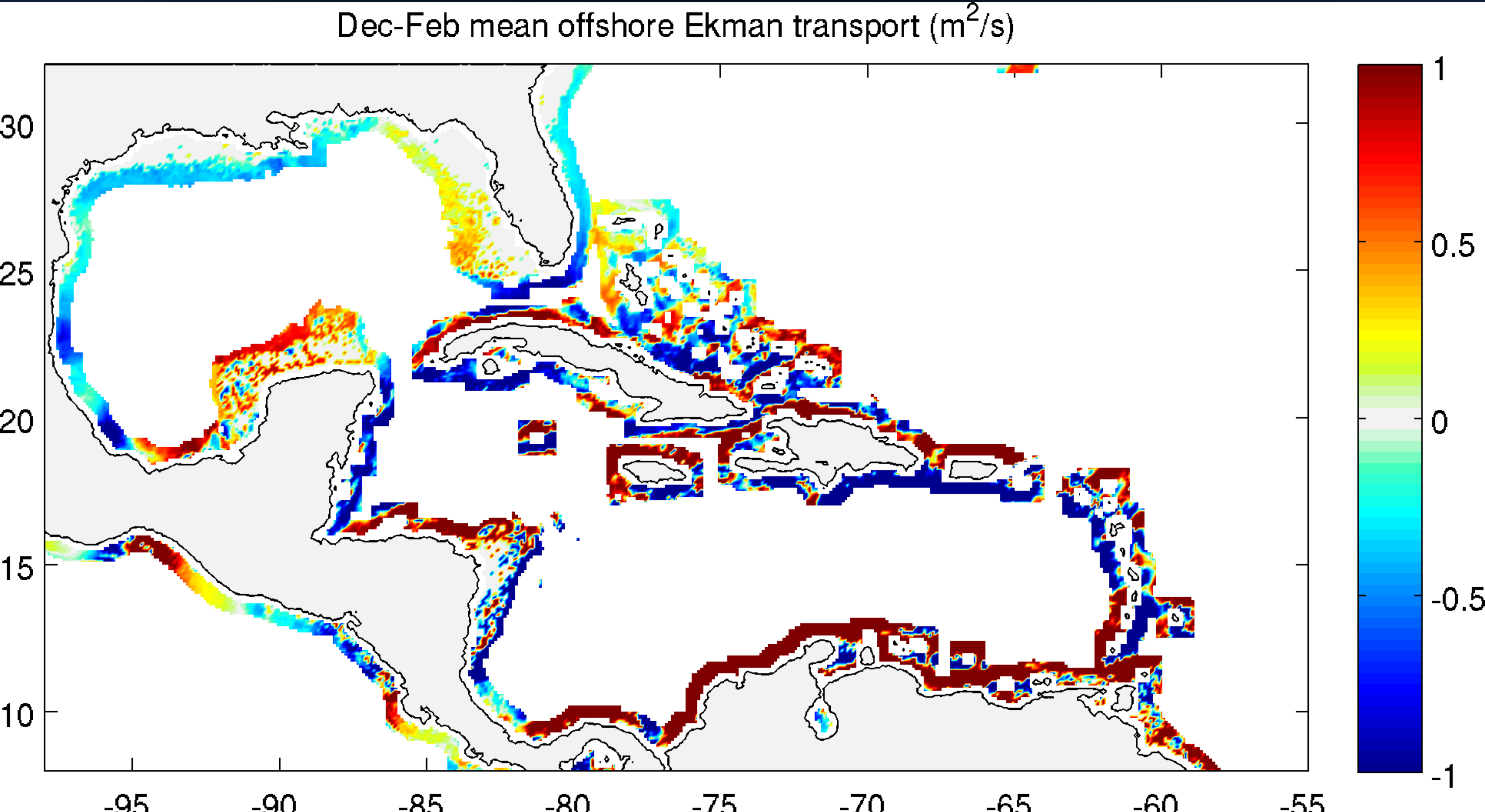


10-year Annual Mean Cross-Isobath Ekman Transport from SeaWinds

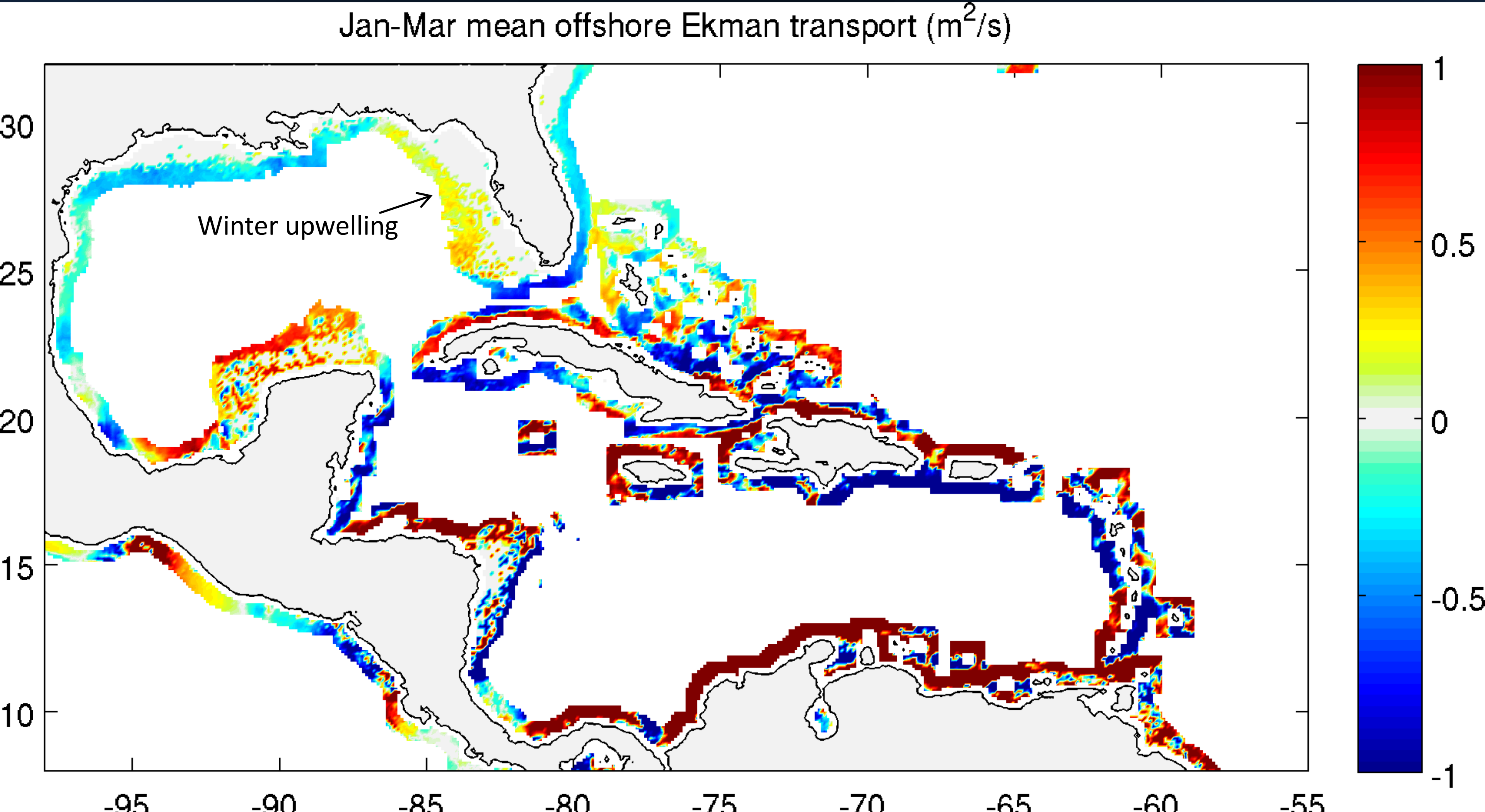


Very flat regions (bathymetric slope < .001) are masked.

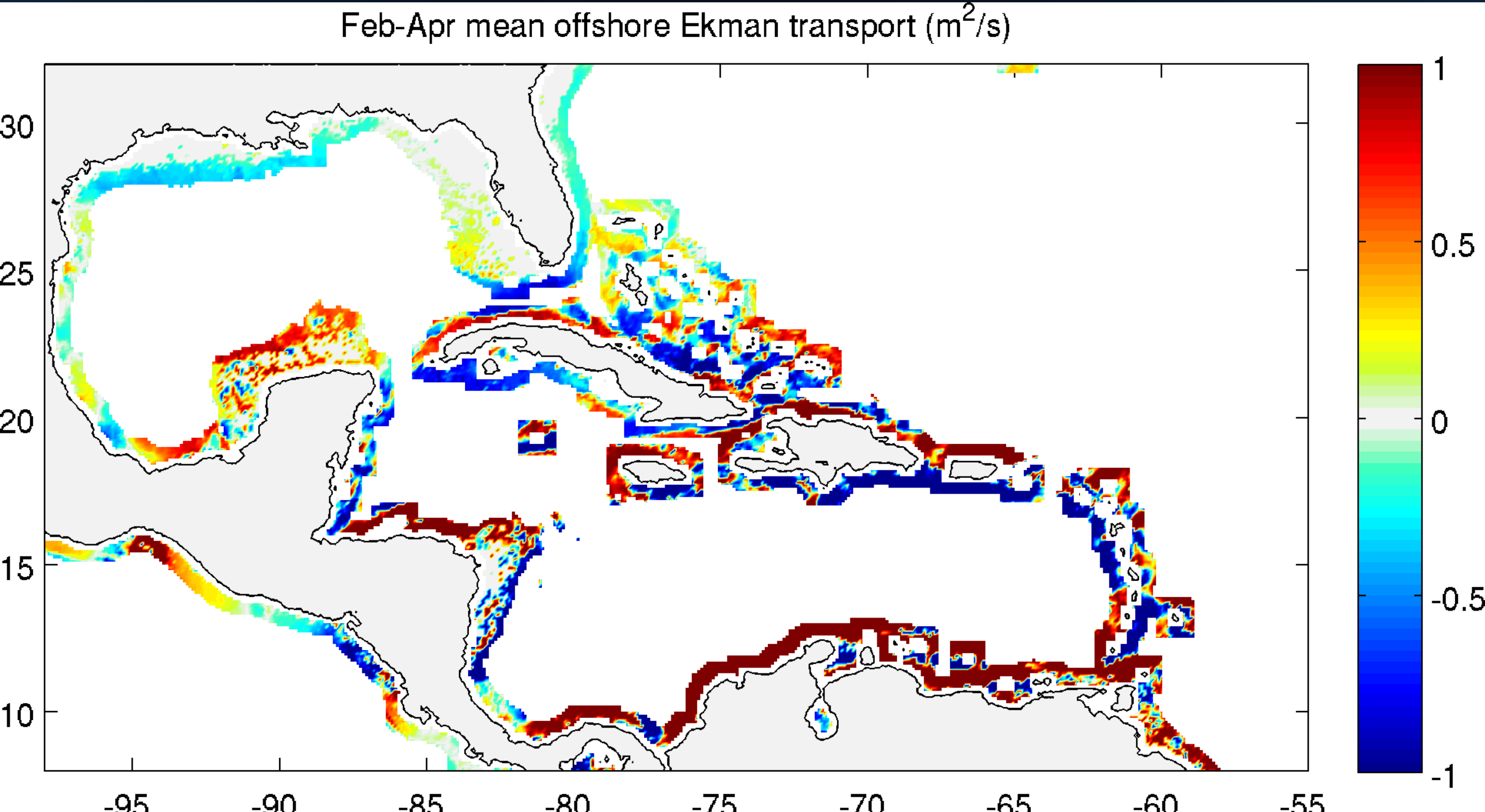
Annual Cycle



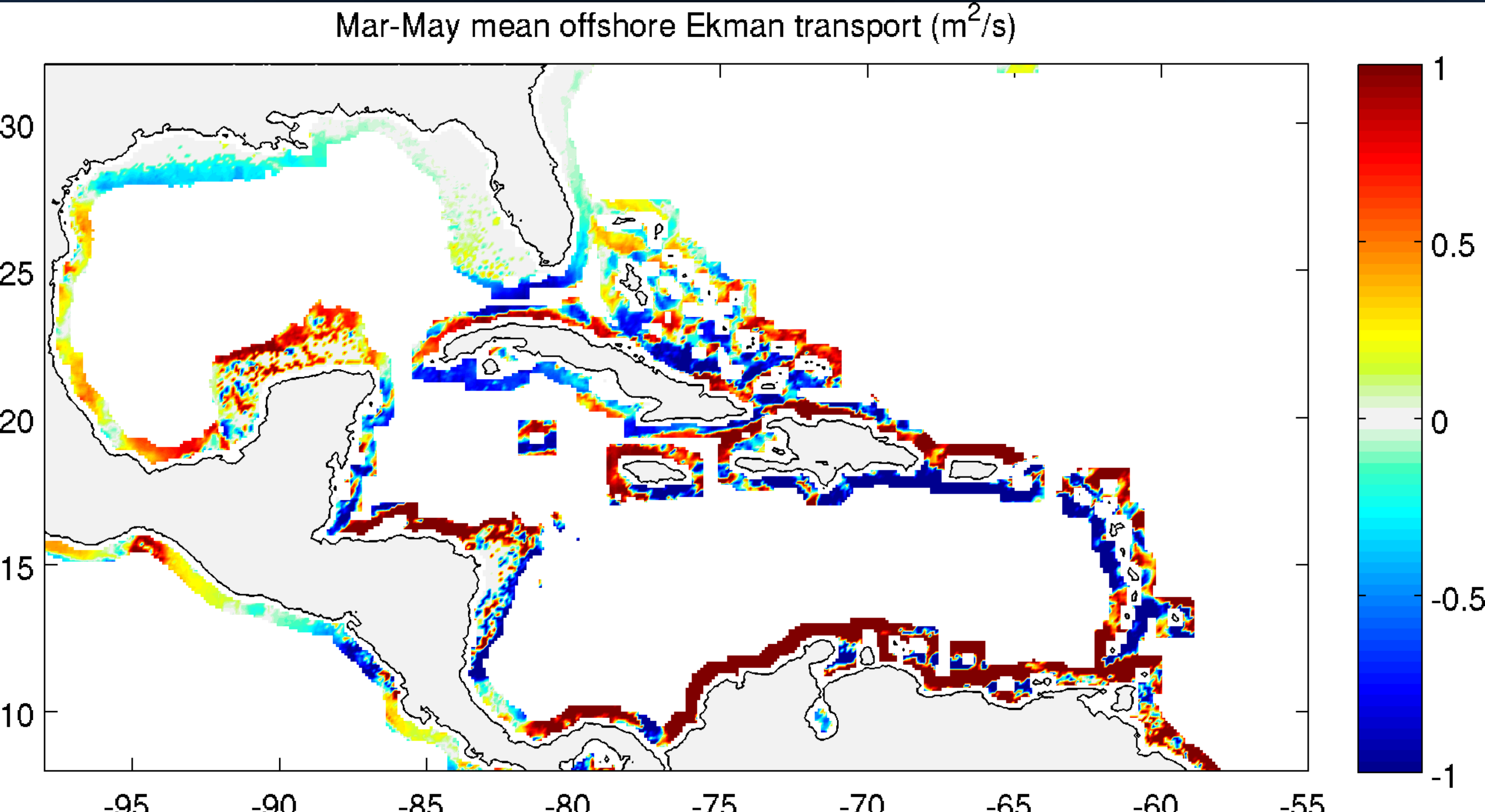
Annual Cycle



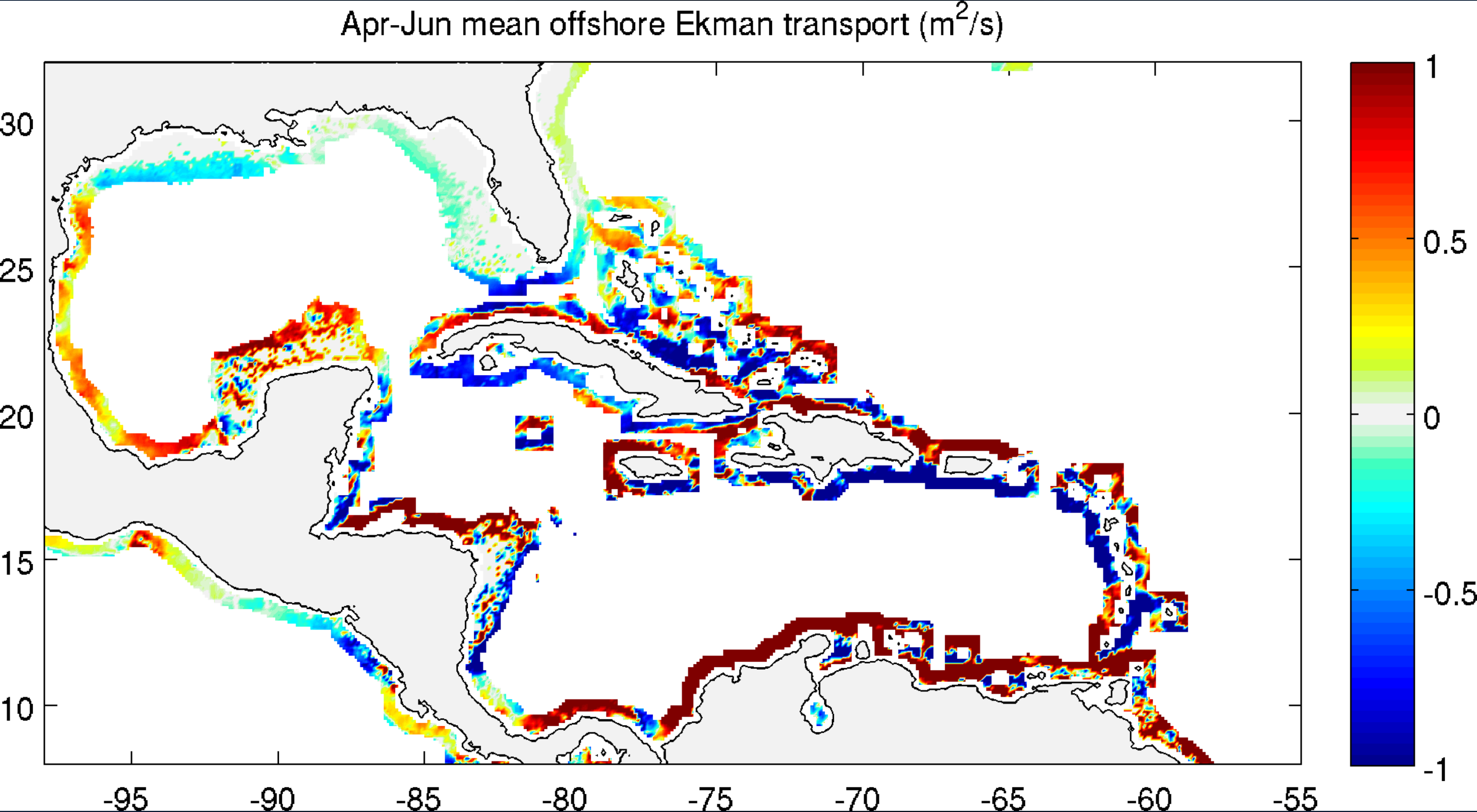
Annual Cycle



Annual Cycle

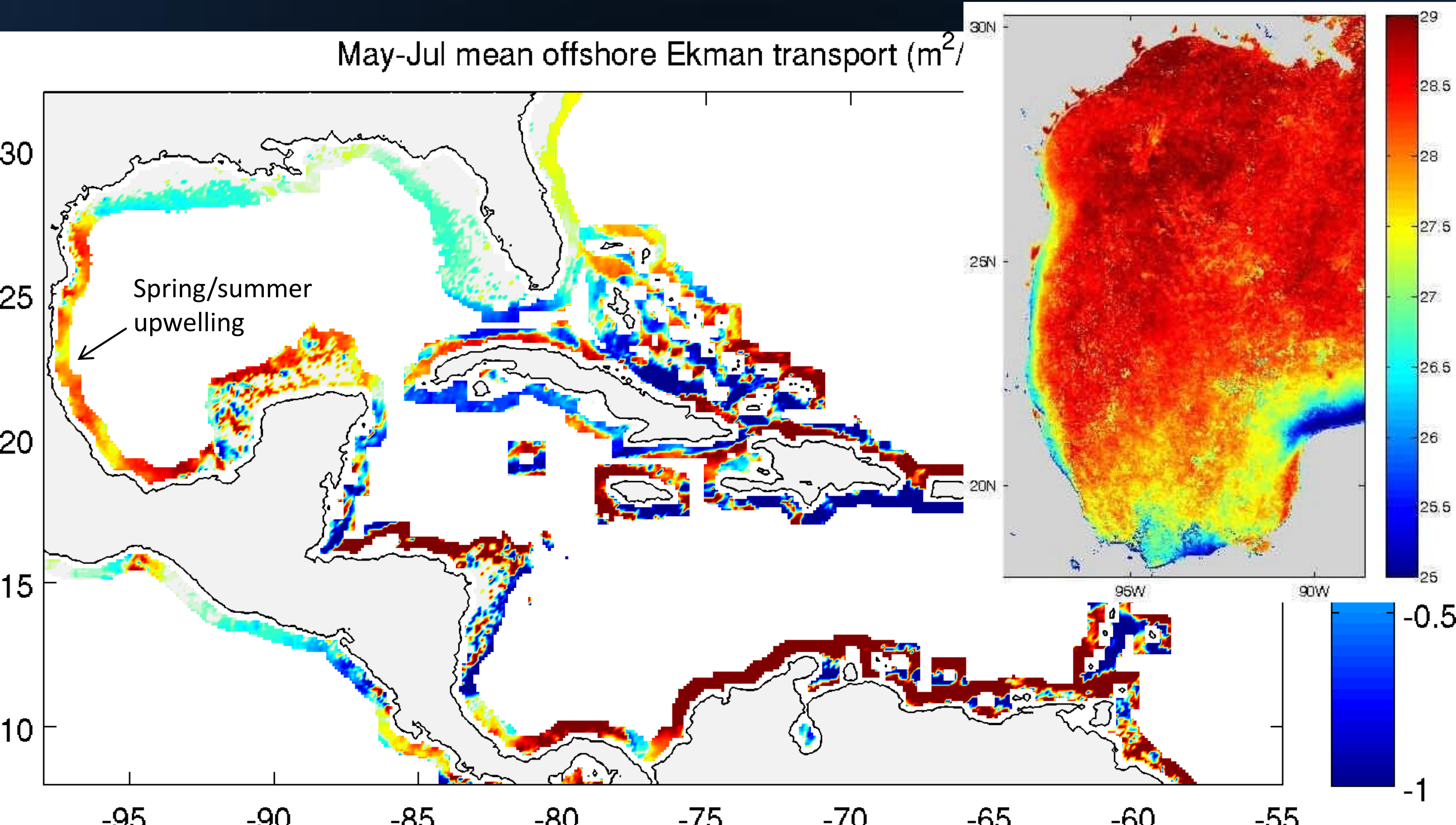


Annual Cycle



Annual Cycle

Zavala-Hidalgo et al., Ocn Dyn., 2006



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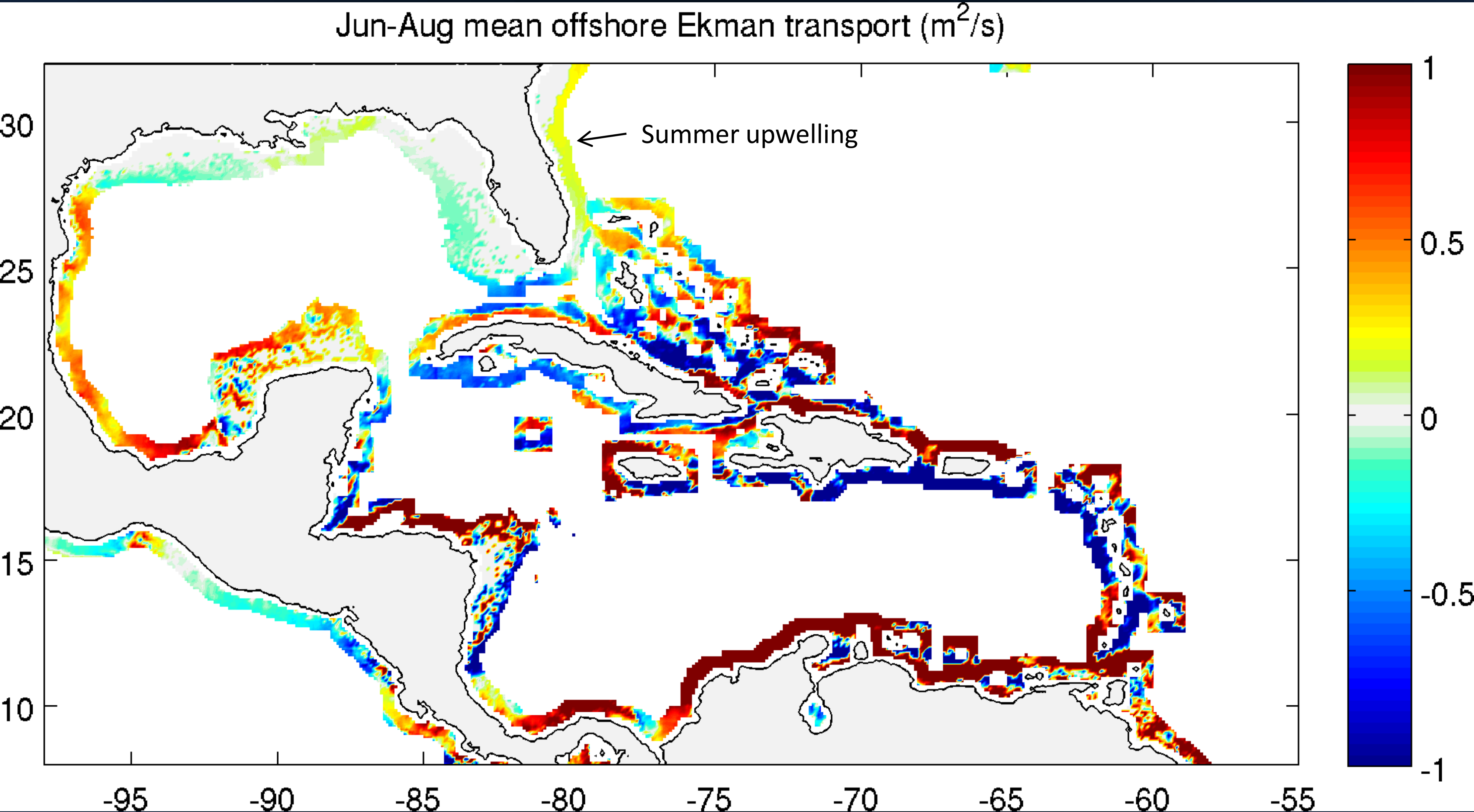

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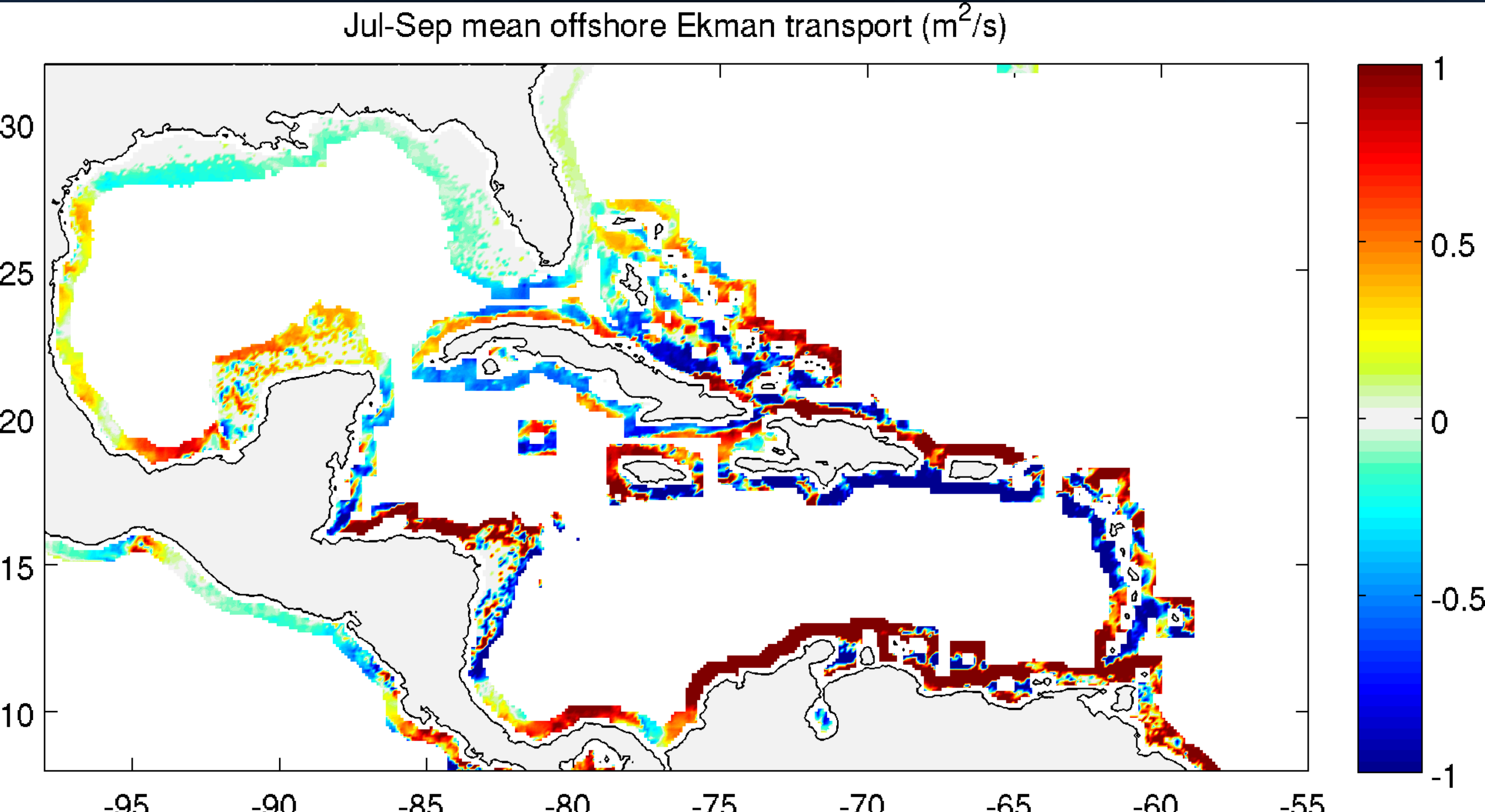
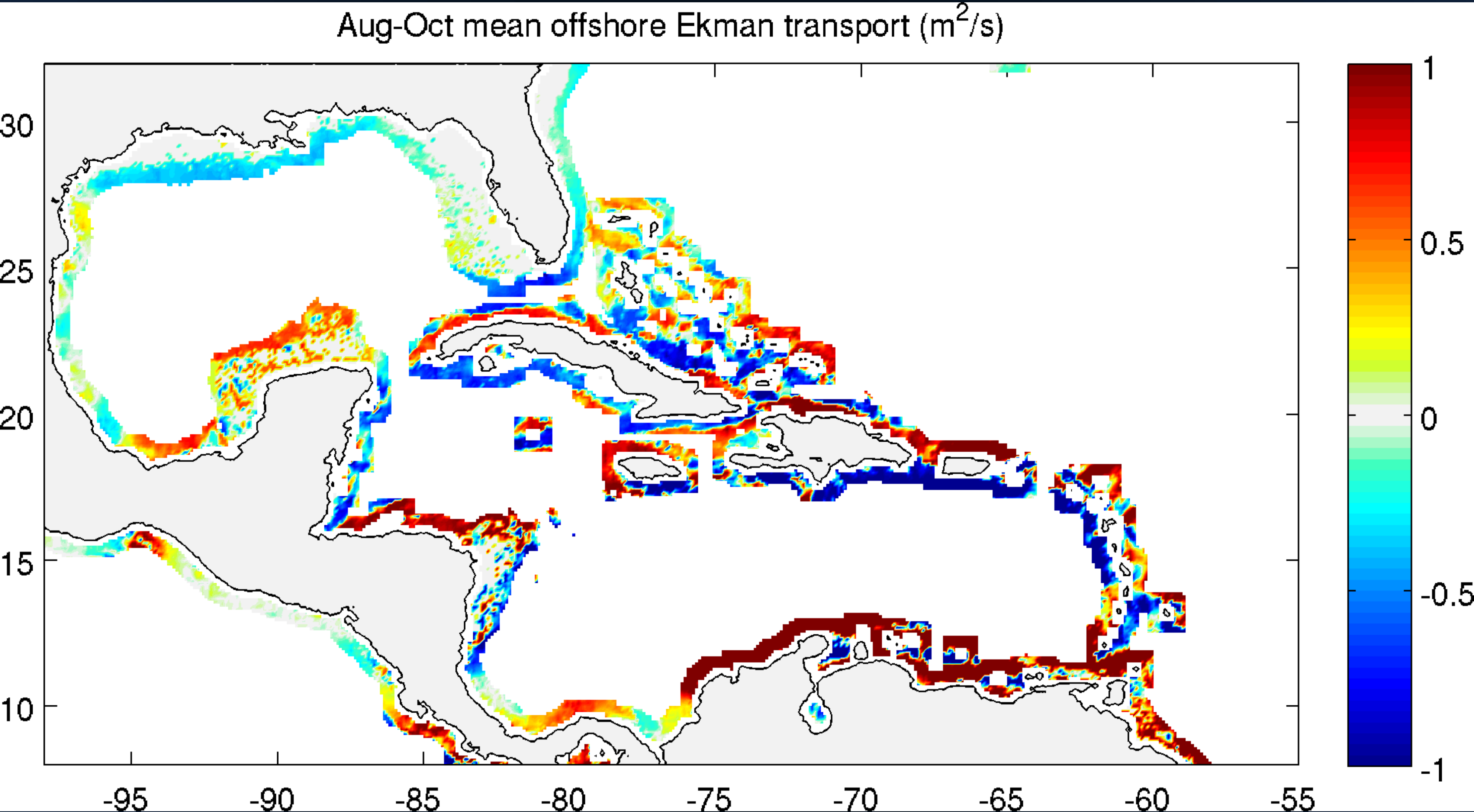
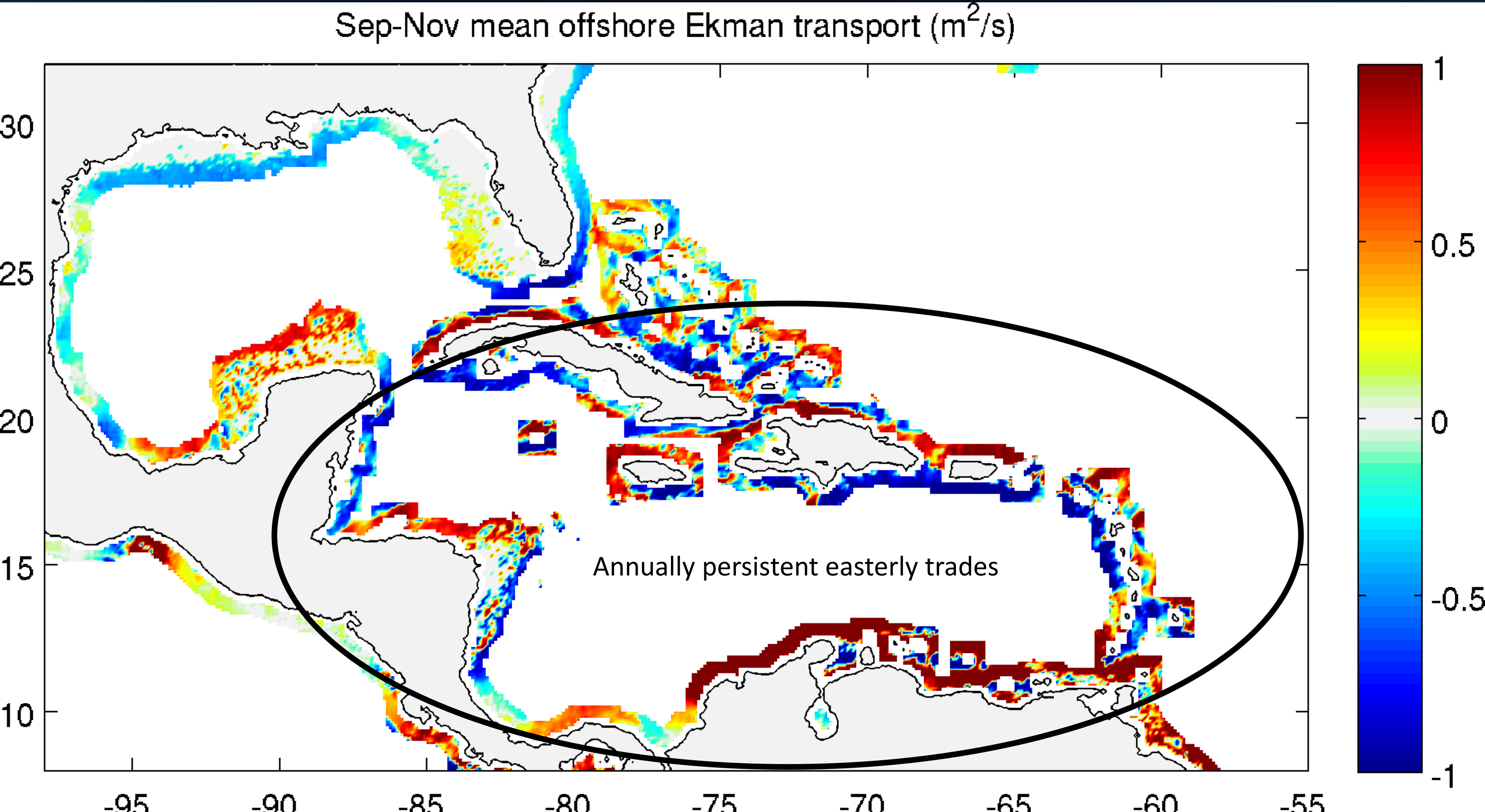


Annual Cycle



Annual Cycle



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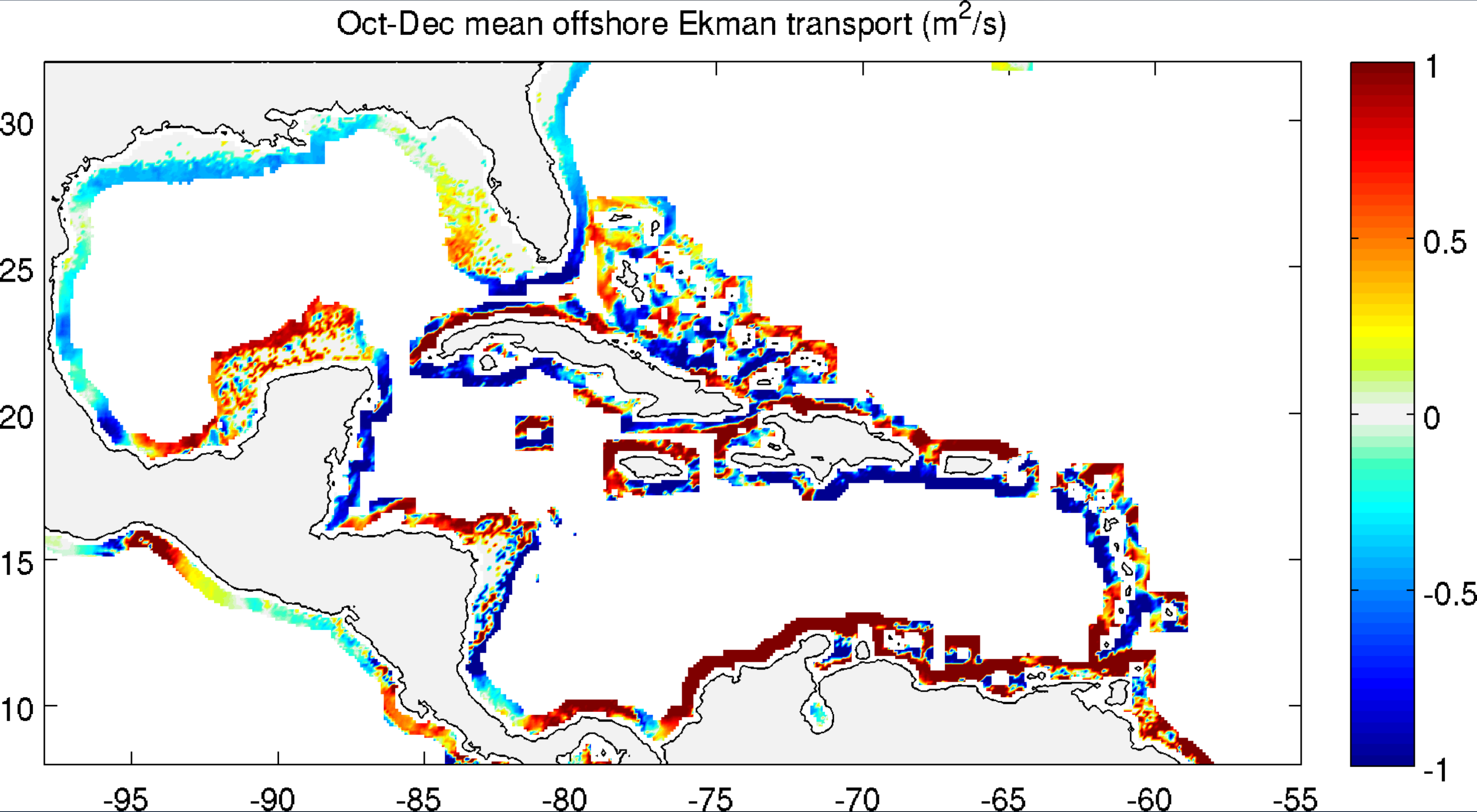

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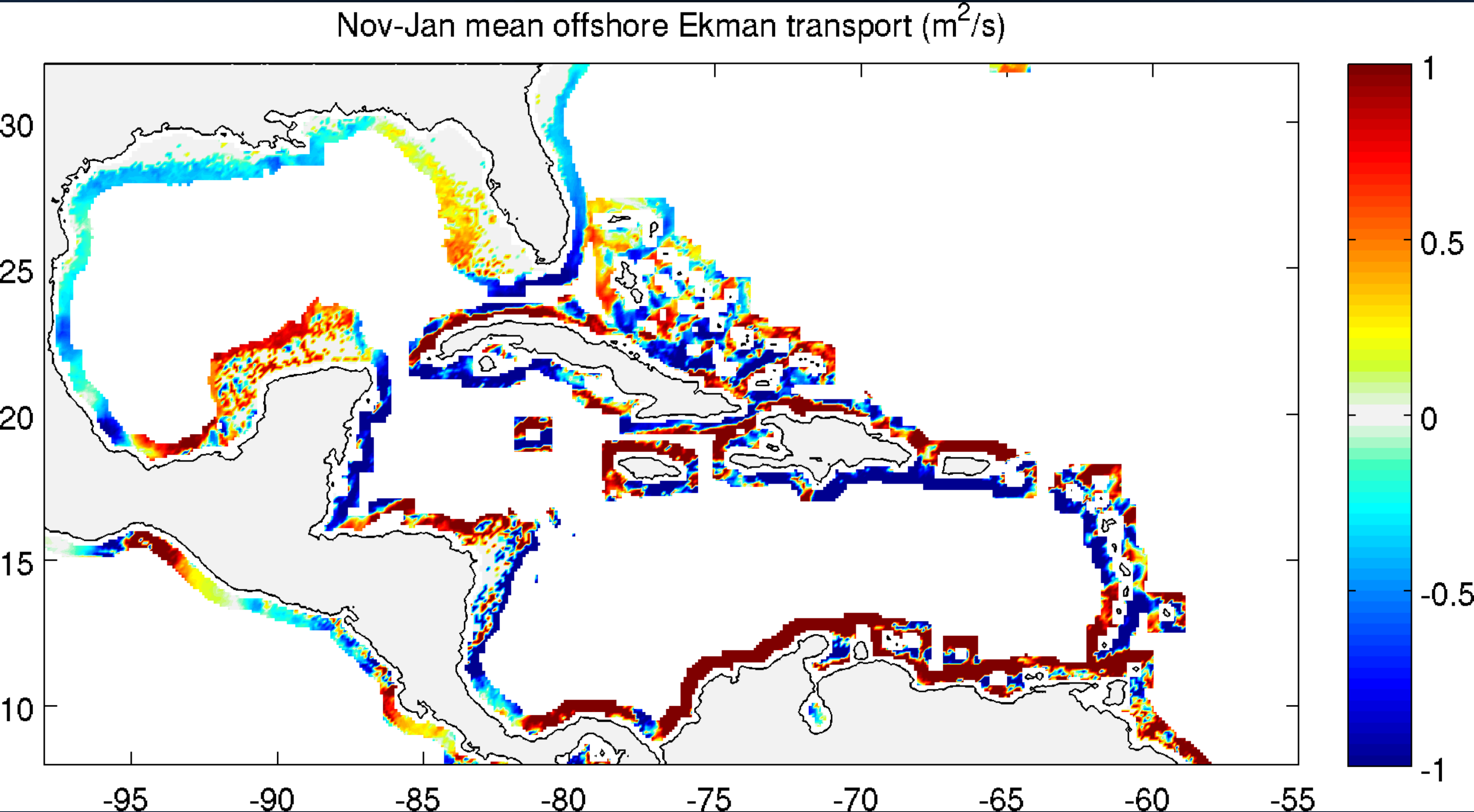
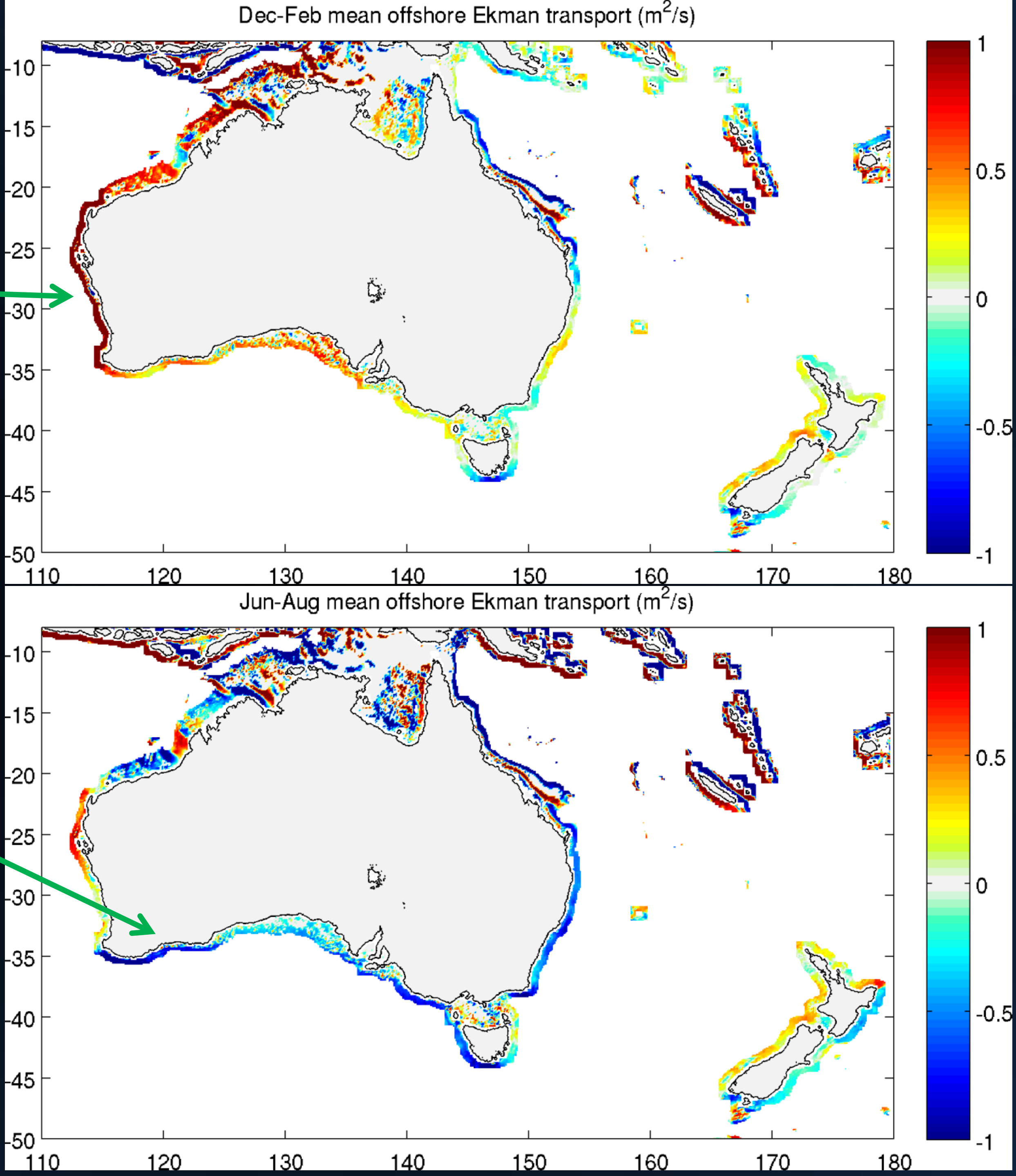
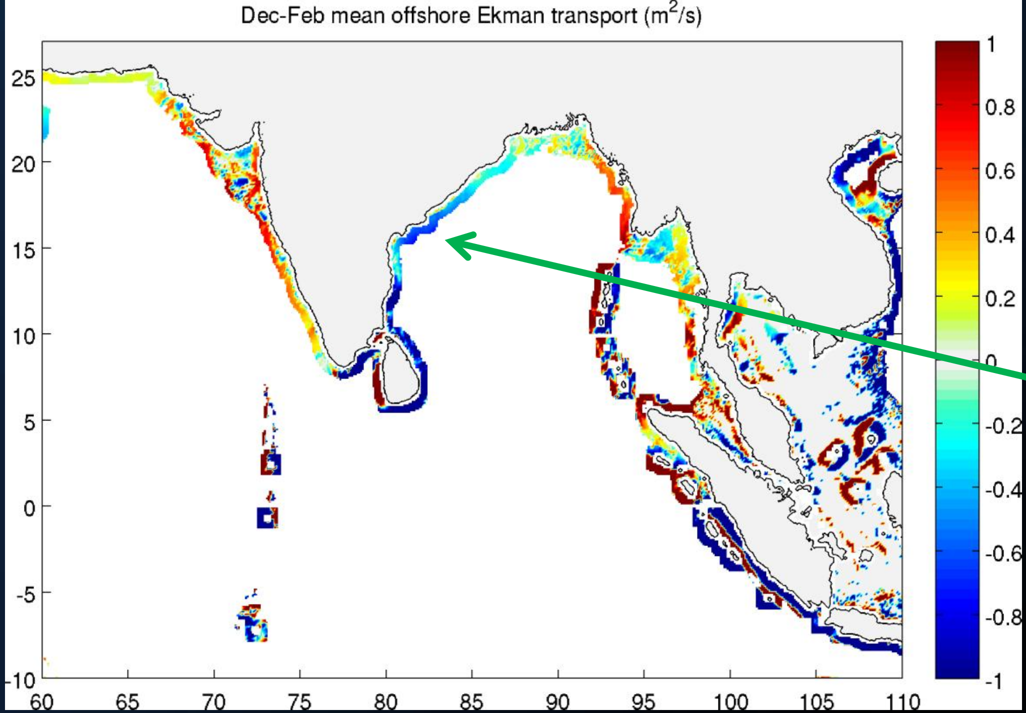


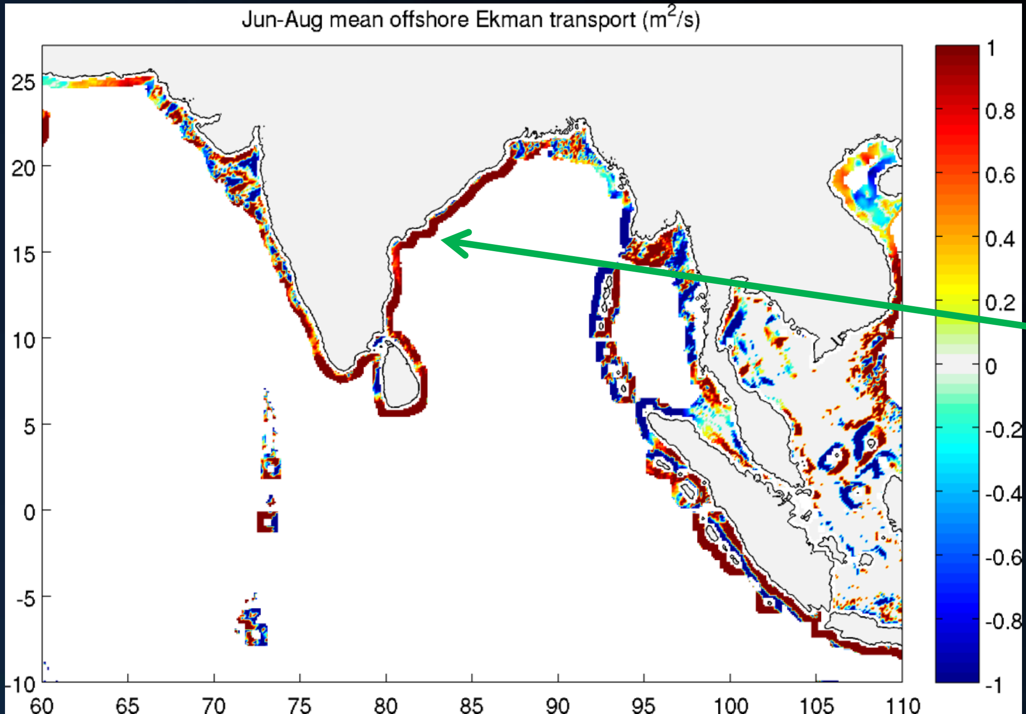
Identification of Coastal Zones with Upwelling-Favorable Winds

Austral summer upwelling

Austral winter downwelling

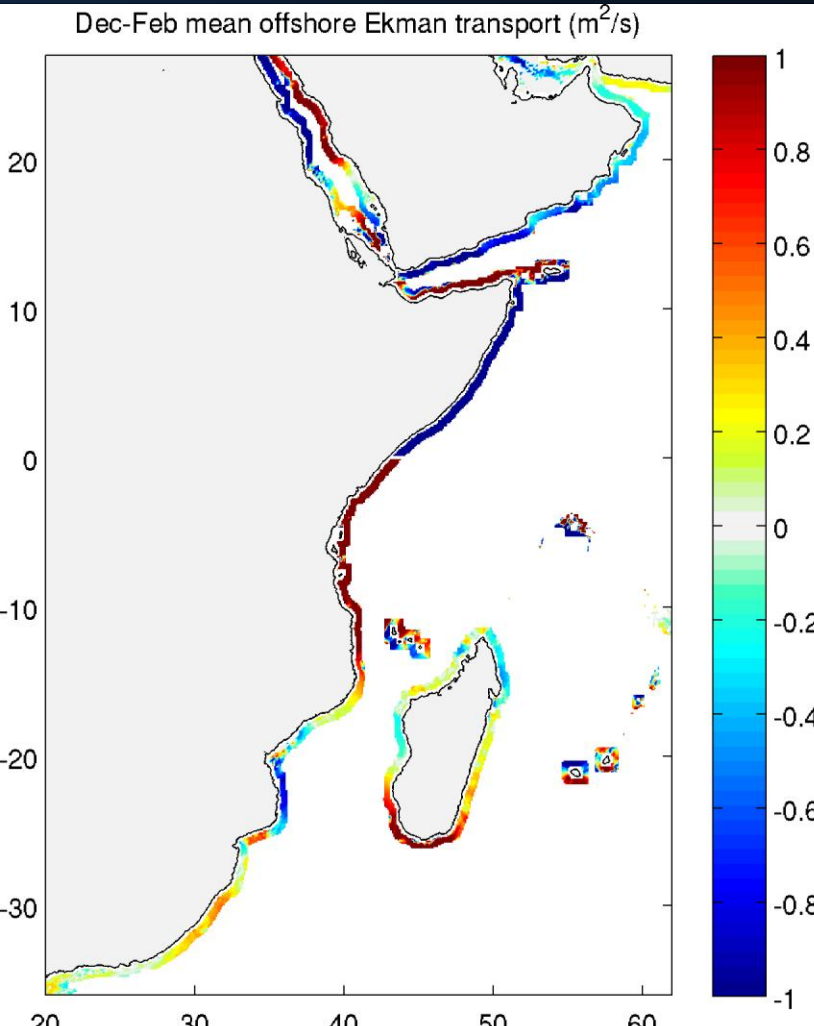




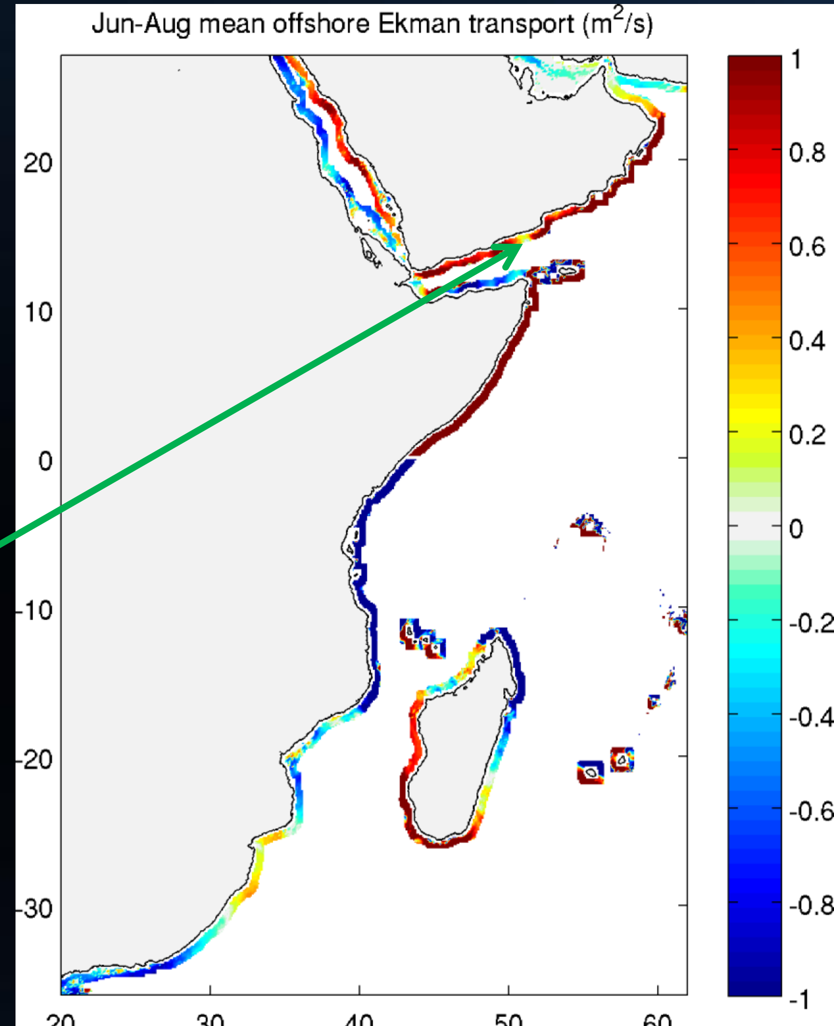


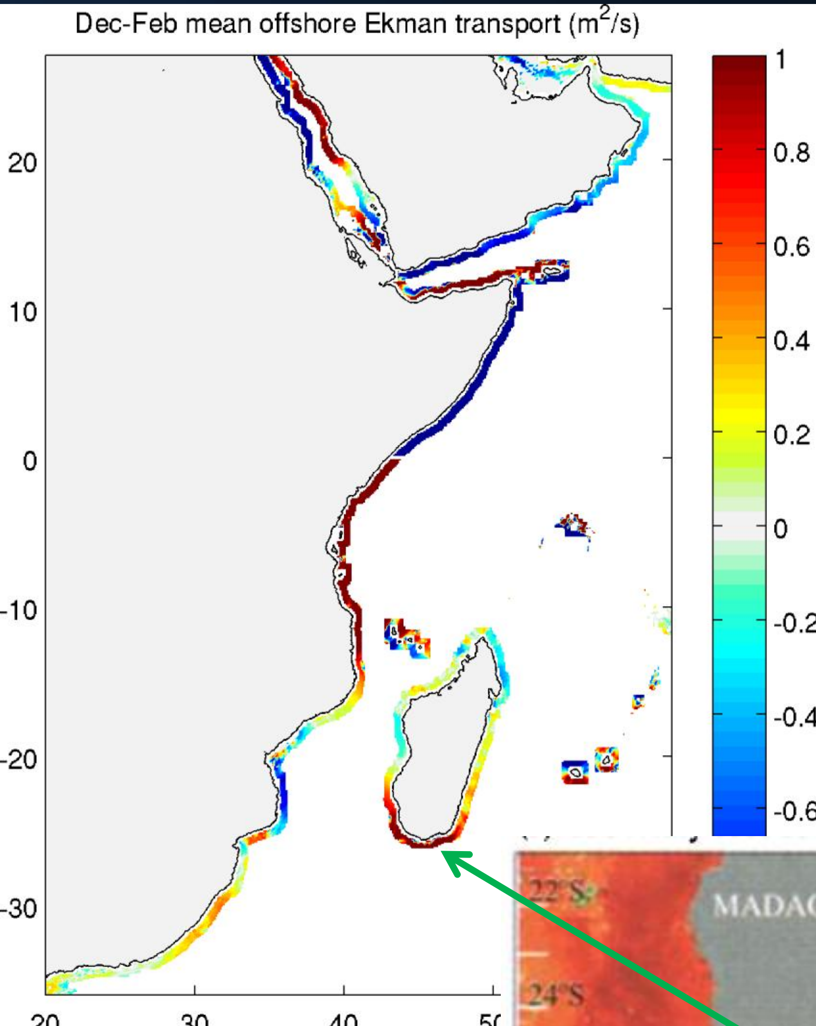
Western Bay of Bengal
Downwelling during
NE Monsoon

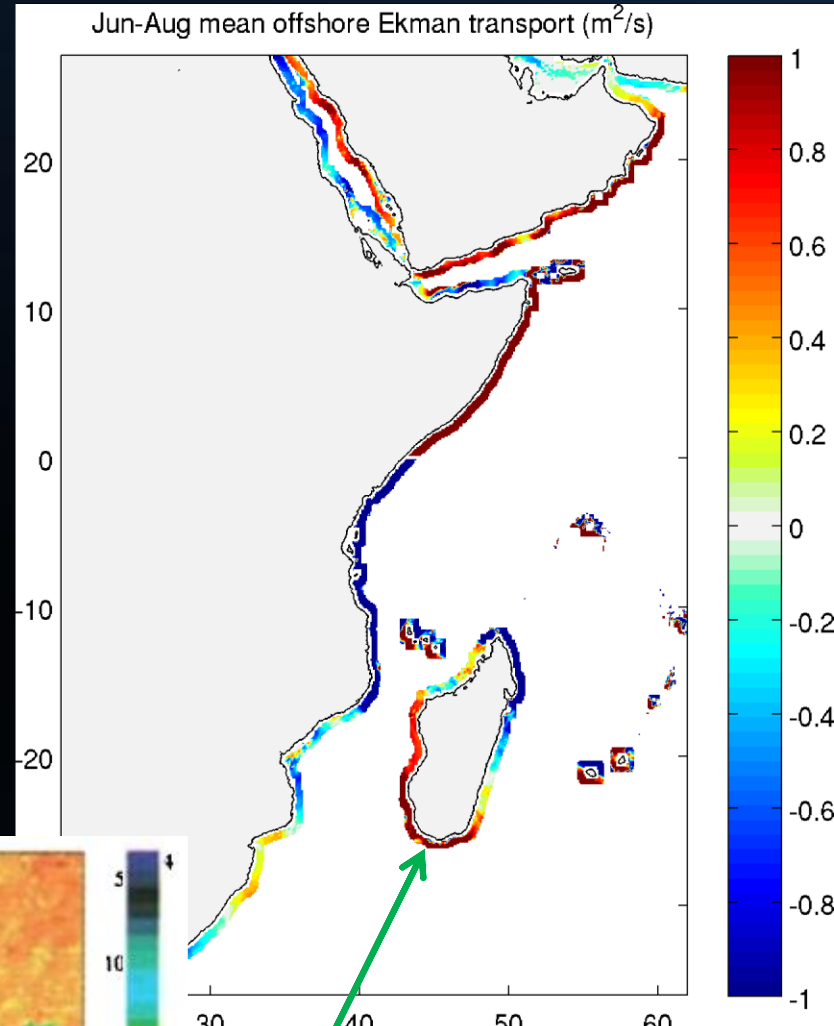
Western Bay of Bengal
Upwelling during
SW Monsoon

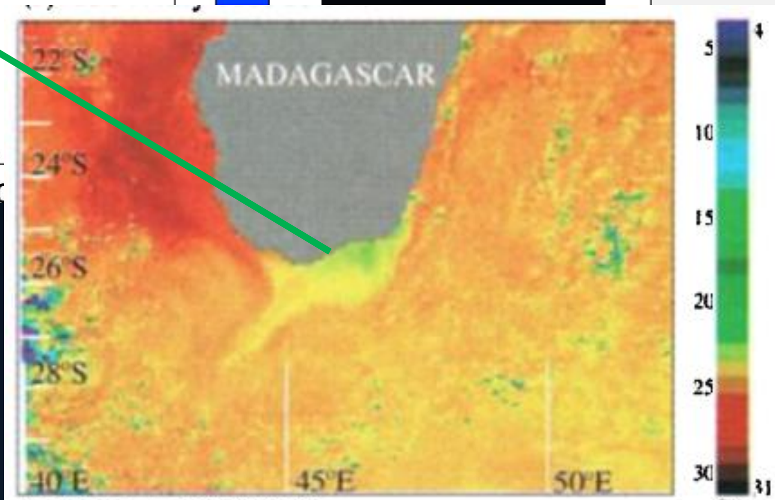


Summertime upwelling
Under SW Monsoon winds





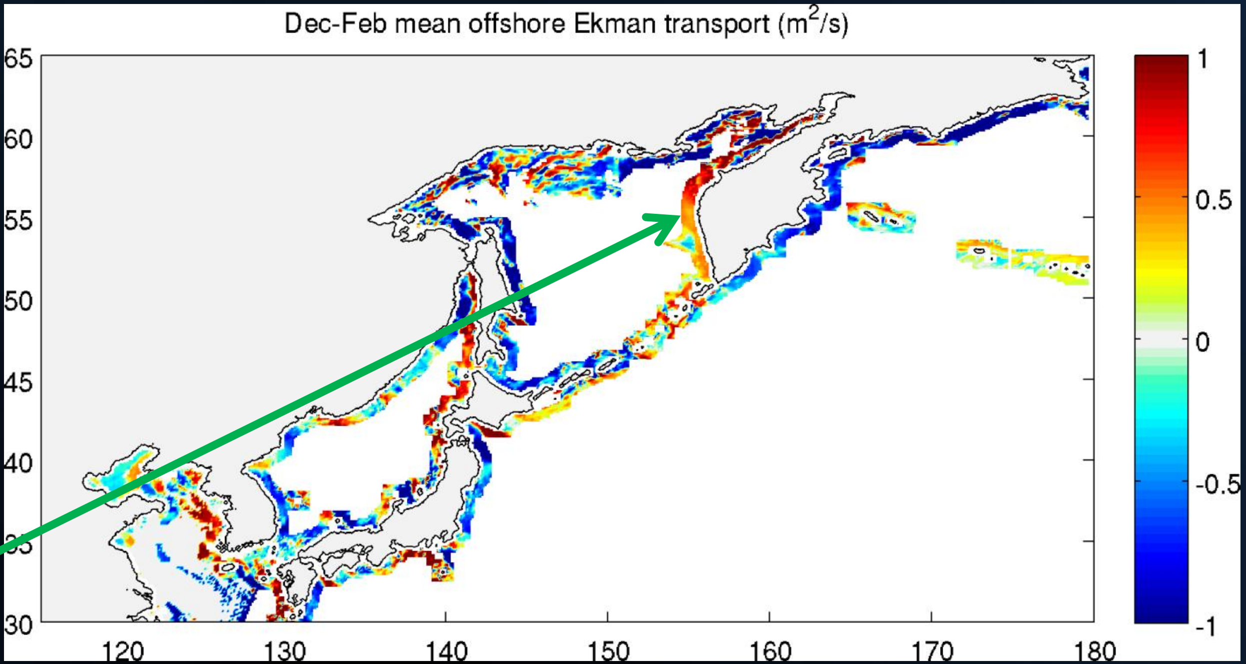


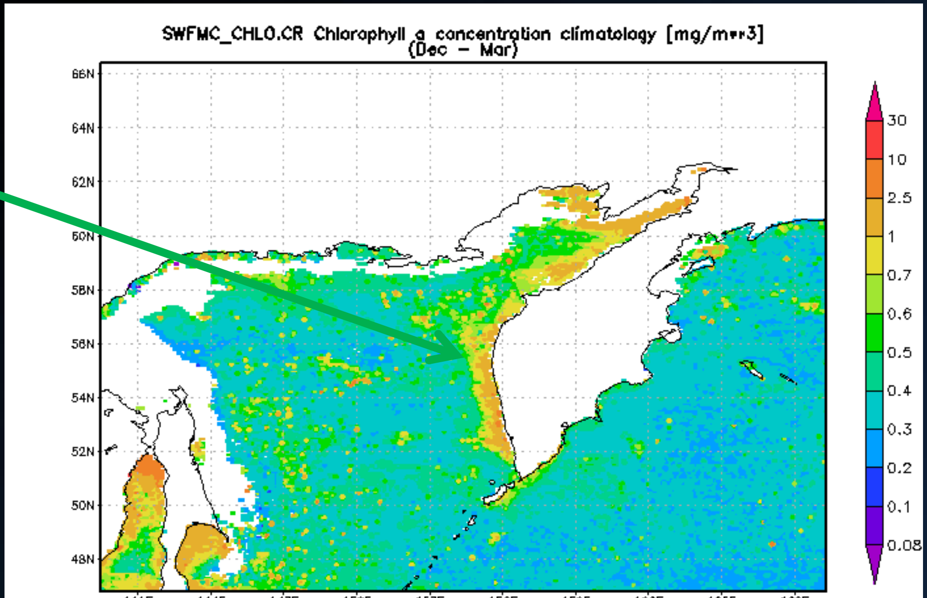


(c) 9 March 2000 13:21z

South Madagascar Upwelling
(*DiMarco et al., GRL 2000*)

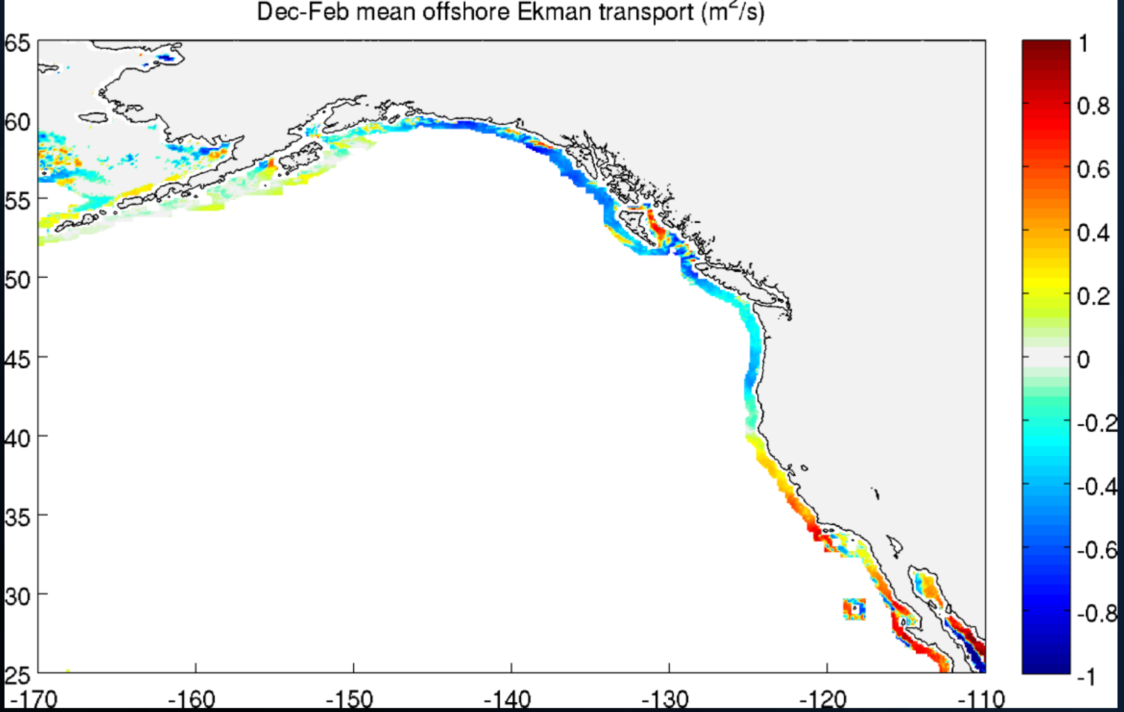
Wintertime
Sea of Okhotsk
Upwelling

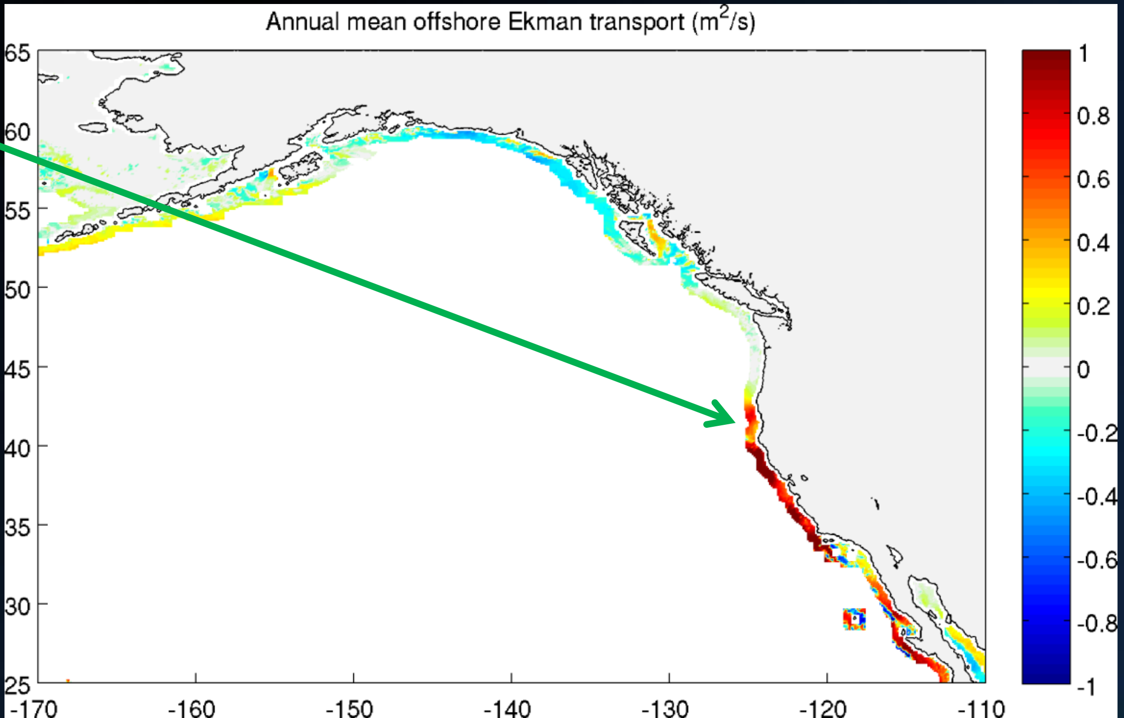




http://disc.sci.gsfc.nasa.gov/giovanni

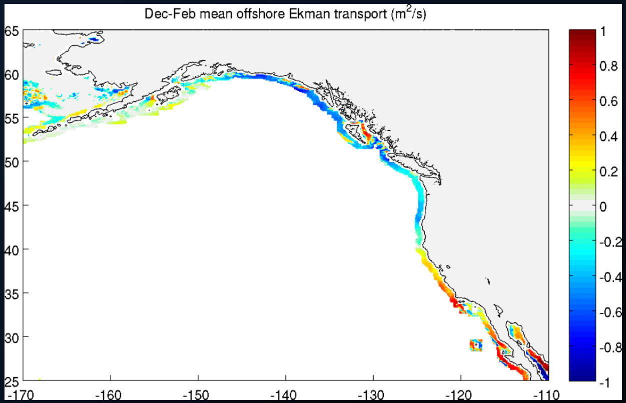
Western US coast summer upwelling

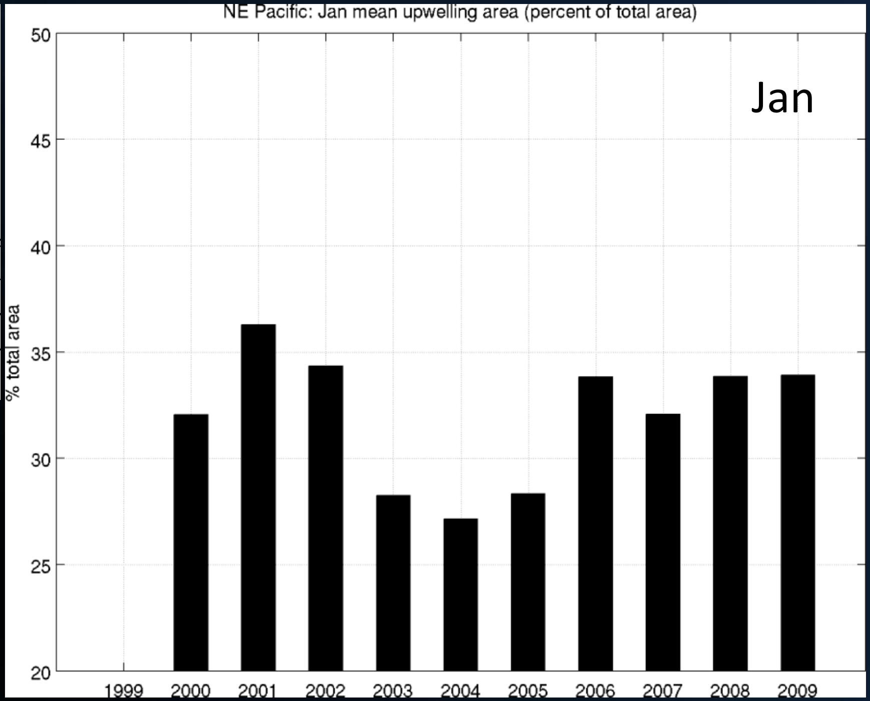


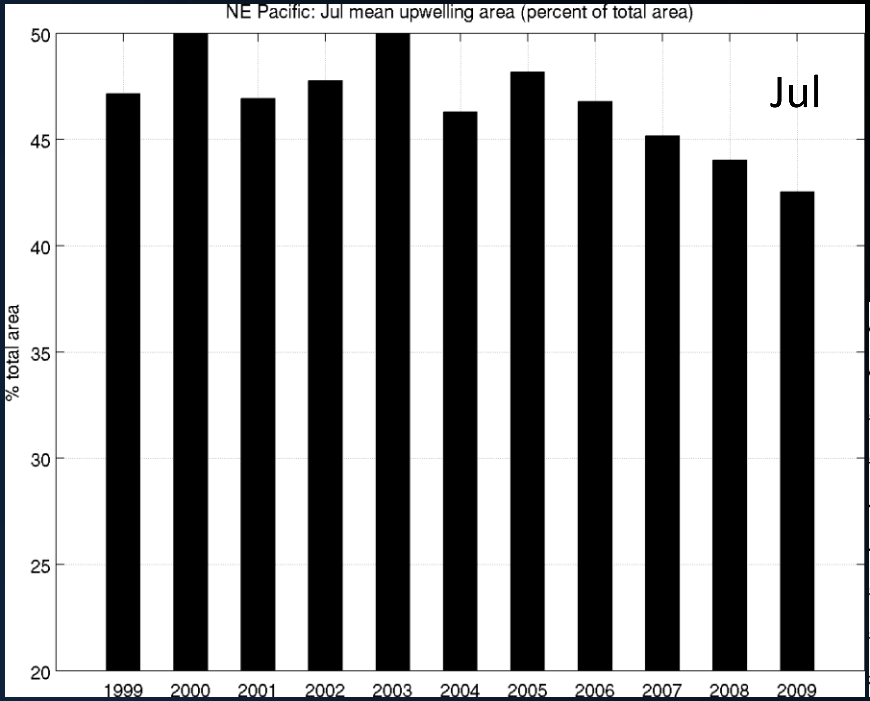


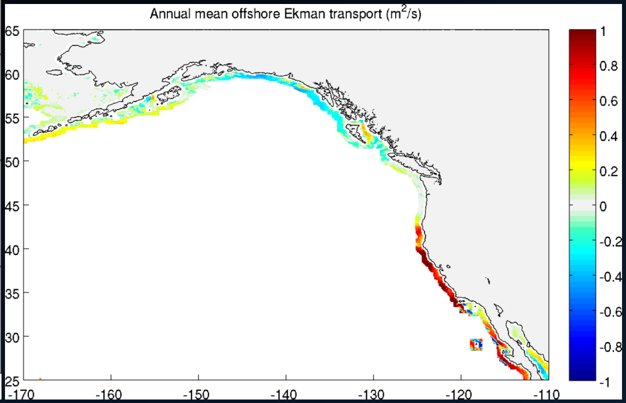
Temporal Variability

Interannual Variability: Area of upwelling-favorable winds

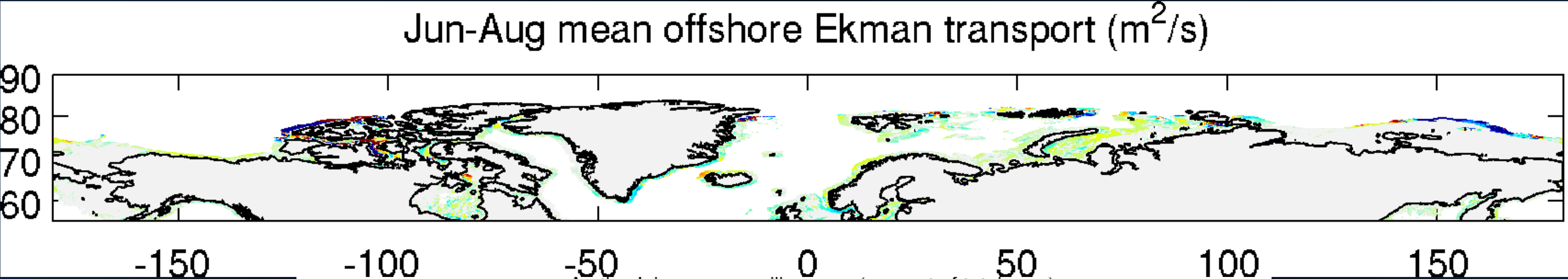


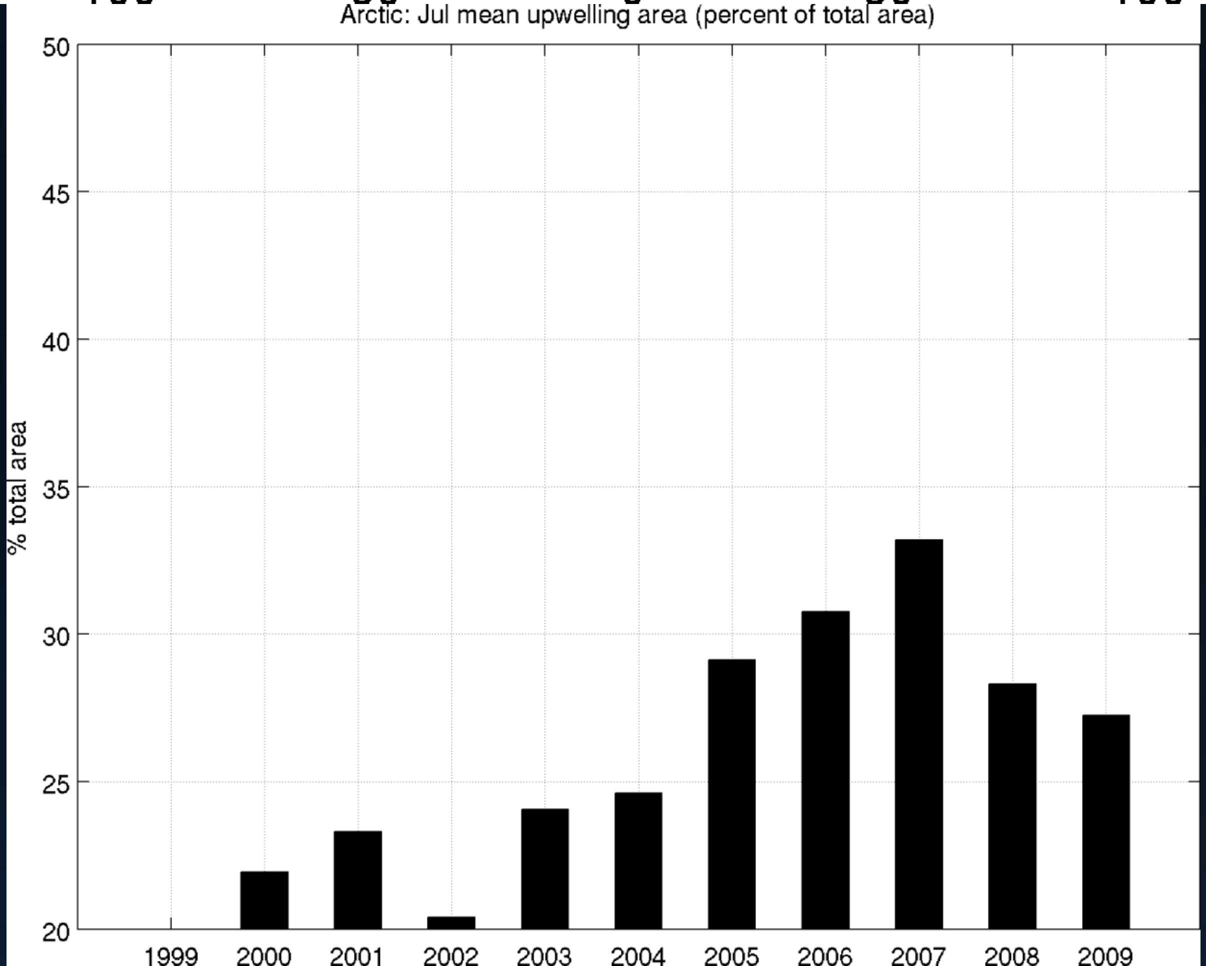




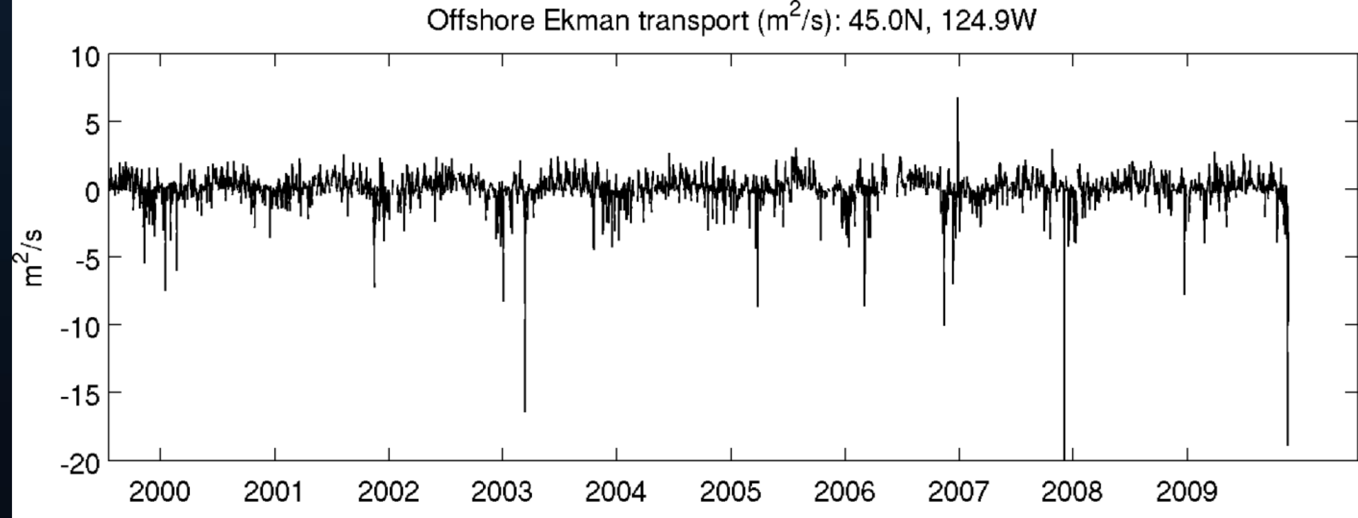


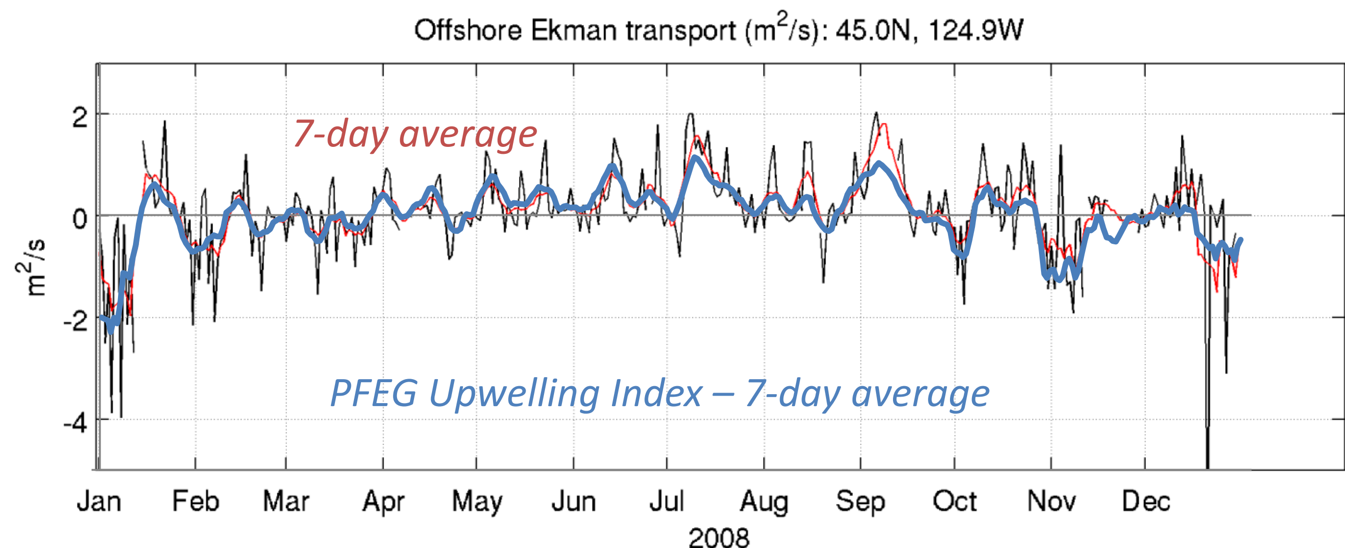
Interannual Variability: Area of upwelling-favorable winds

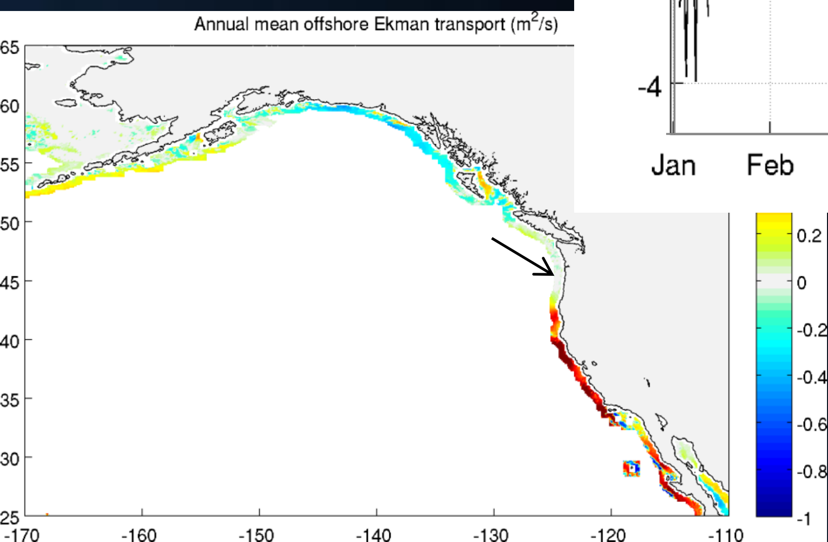




Upwelling Indices







Conclusions and Next Steps

- Daily estimates of cross-shelf Ekman transport (upwelling/downwelling) have been computed from the ~10-year QuikSCAT/SeaWinds data set

- This product allows inspection of multi-scale spatio-temporal resolution of upwelling/downwelling-favorable winds

- The product has applications to marine ecosystem studies
    - Daily variability
    - Seasonal variability
    - Interannual variability

- Next Steps:
    - A web-based front-end will allow quick generation of map and time series derived products (e.g. upwelling indices).
    - Inclusion of data from multiple sensors
    - Extension to near-real-time