Spatial Variability of Upwelling on a Shelf with Complex Geometry inferred from Scatterometry

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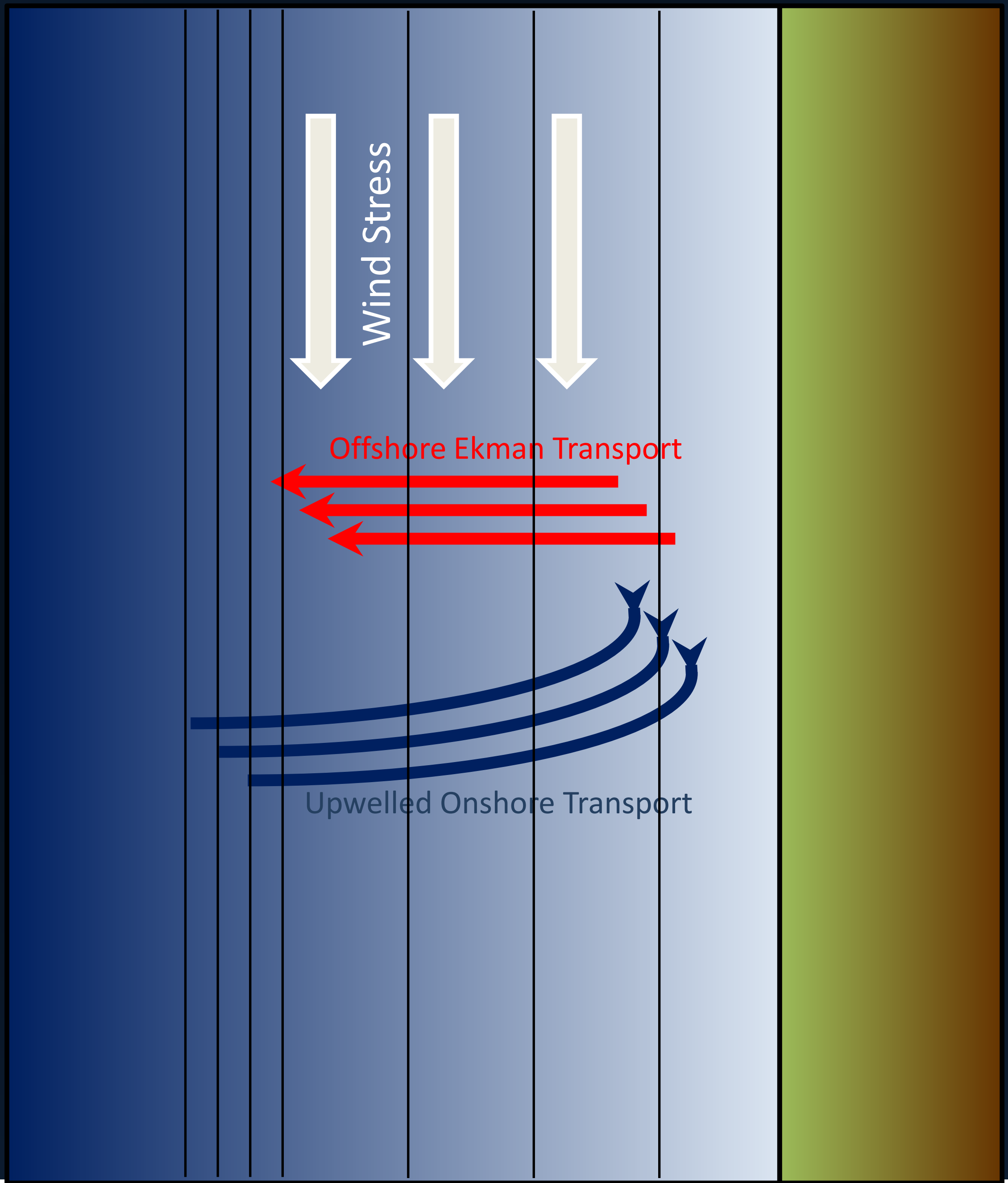
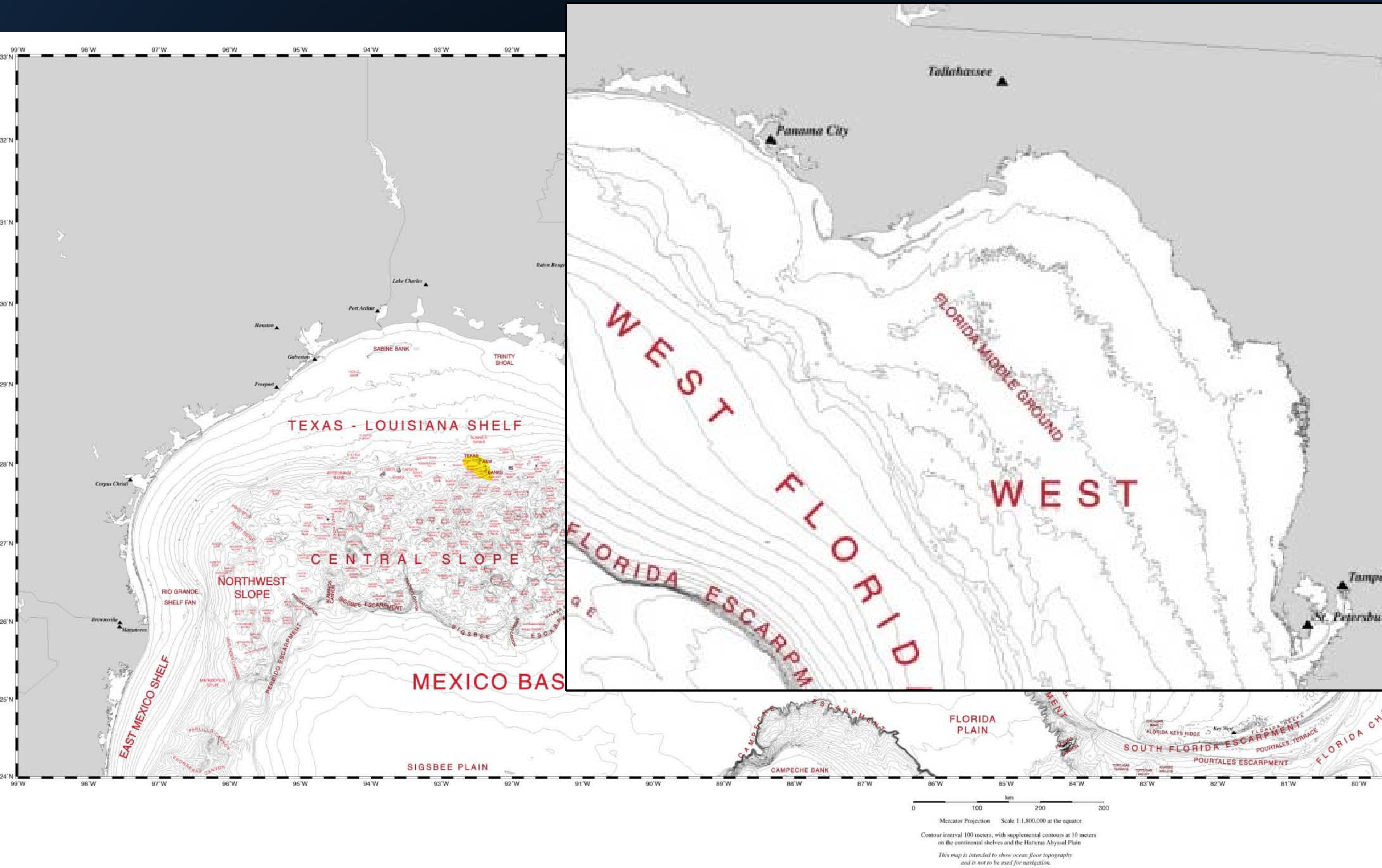
Idealized Coastal Upwelling





Tallahassee
Panama City
FLORIDA MIDDLE GROUND
WEST FLORID
WEST
FLORIDA ESCARPM
Tampa
St. Petersburg
Lake Charles
Baton Rouge
Port Arthur
Houston
Galveston
Freeport
Corpus Christi
Brownsville
Matamoros
SABINE BANK
TRINITY SHOAL
TEXAS - LOUISIANA SHELF
CENTRAL SLOPE
NORTHWEST SLOPE
RIO GRANDE SHELF FAN
SIGSBEE ESCARPMENT
PERDIDO ESCARPMENT
EAST MEXICO SHELF
MEXICO BAS
SIGSBEE PLAIN
CAMPECHE BANK
FLORIDA PLAIN
Key West
FLORIDA KEYS RIDGE
SOUTH FLORIDA ESCARPMENT
POURTALES TERRACE
POURTALES ESCARPMENT
km
0 100 200 300
Mercator Projection Scale 1:1,800,000 at the equator
Contour interval 100 meters, with supplemental contours at 10 meters on the continental shelves and the Hatteras Abyssal Plain
This map is intended to show ocean floor topography and is not to be used for navigation.

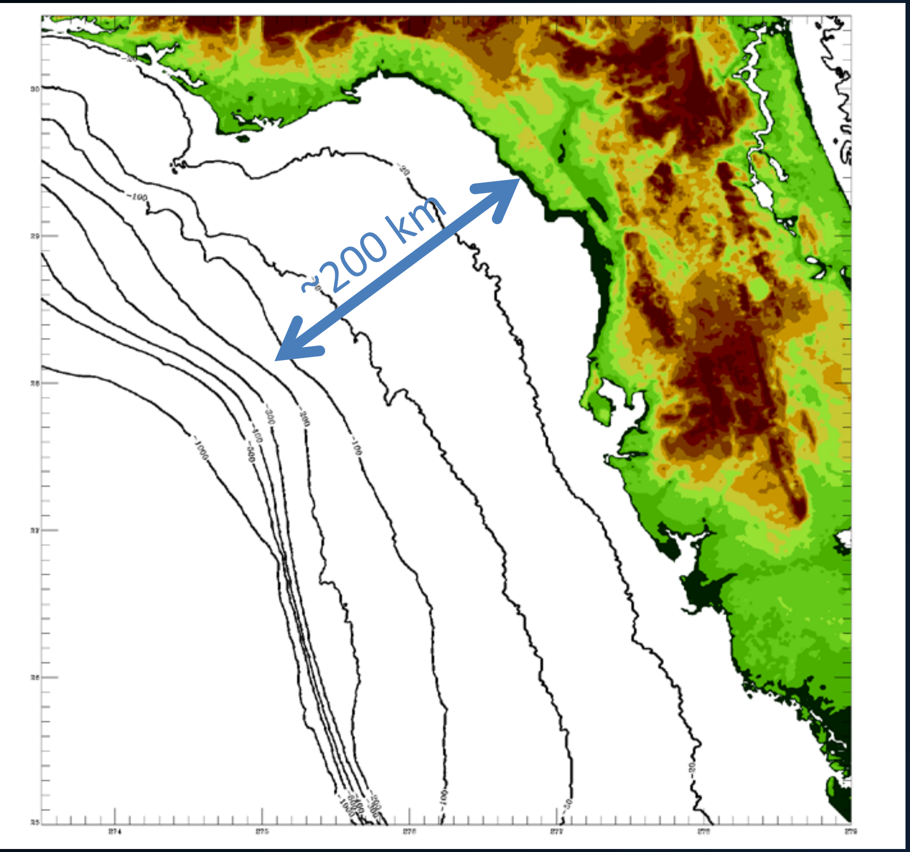
Upwelling on the northern West Florida Shelf

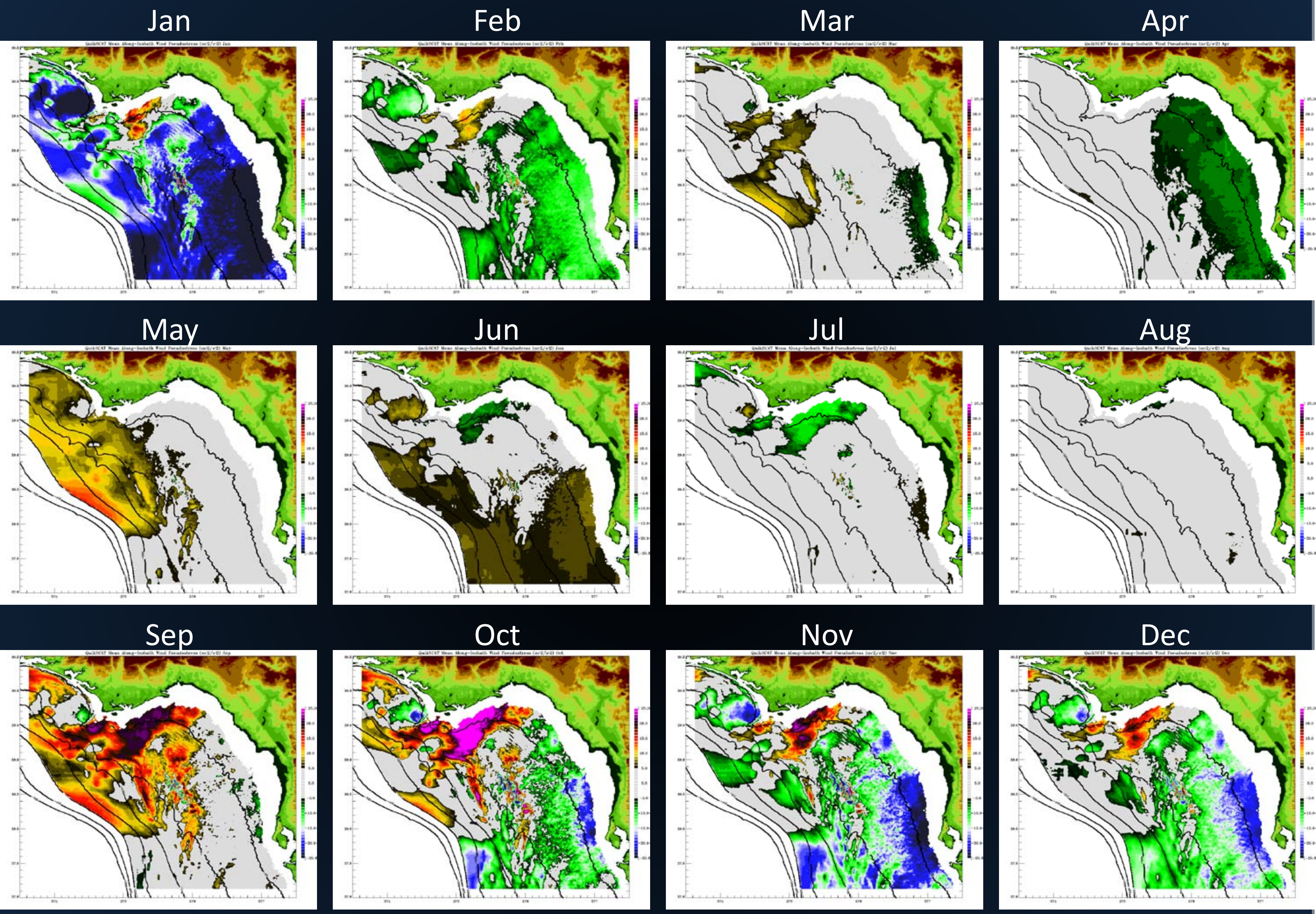
QuikSCAT wind pseudostress is projected onto the along-isobath direction

- Positive in the topographic wave propagation direction → downwelling

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

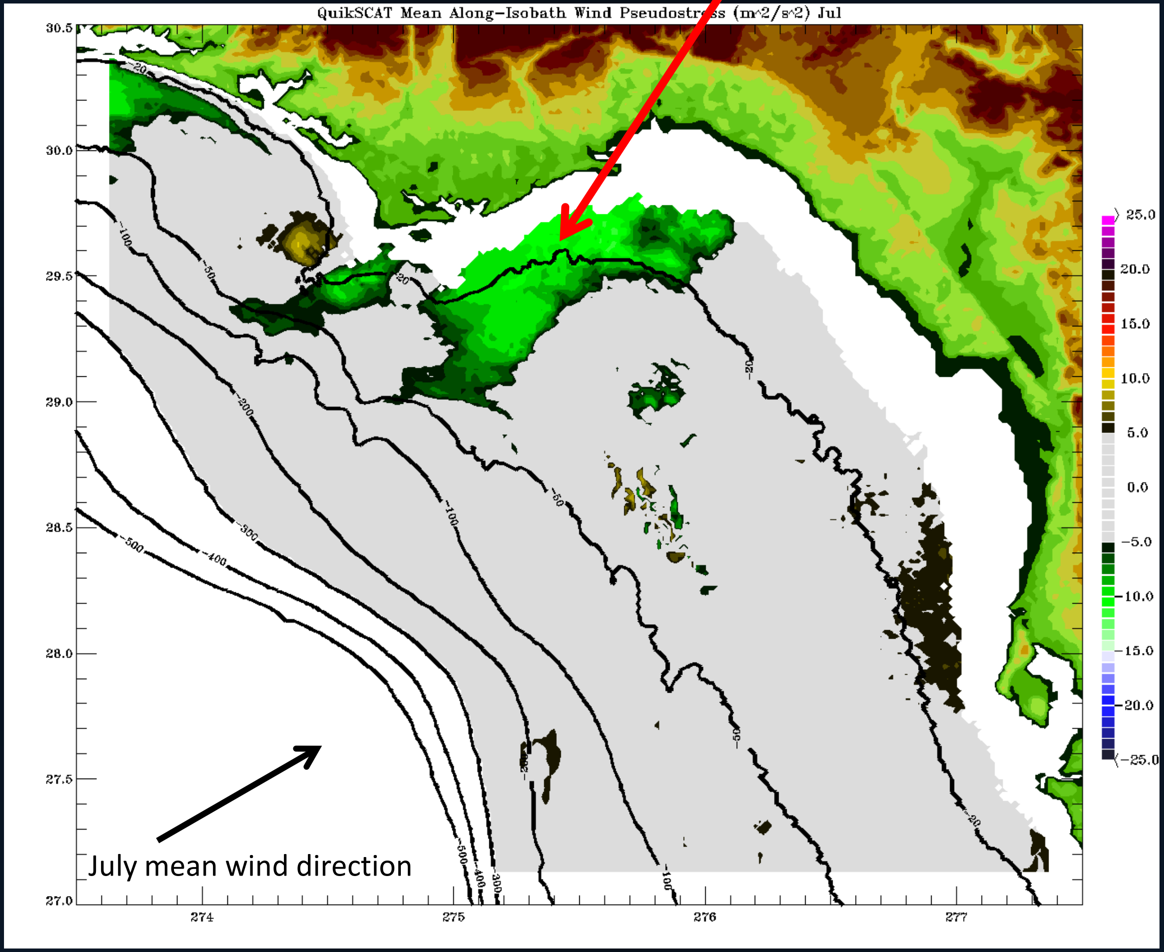
   (Computed between 10m and 300m isobaths)




Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

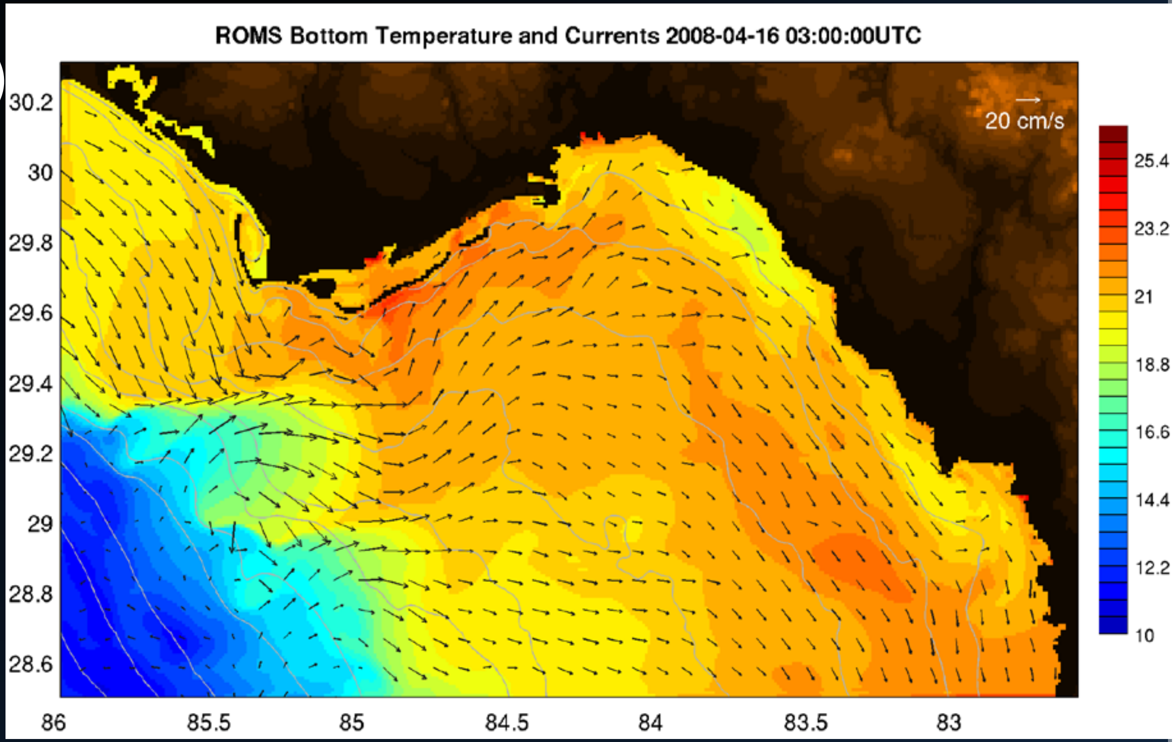
July Climatology

Upwelling-favorable winds only over the northern and western Apalachee Bay region



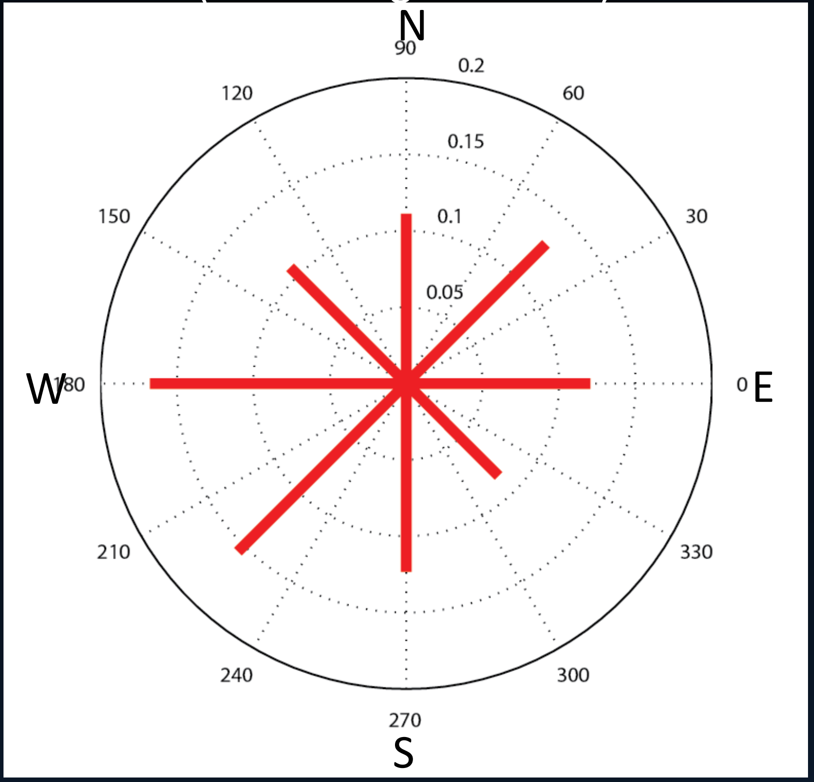
Numerical Simulation

- ROMS configured for northeastern Gulf of Mexico
  - 30 arcsec (~800 m) horizontal resolution
  - 30 vertical stretched terrain-following layers
- Nested within 1/25° HYCOM Gulf of Mexico Hindcast
- Surface forcing – COARE 3.0 fluxes with CFSR atmospheric variables
- 5-year simulation (2005-2009)
- 3-hourly hourly output

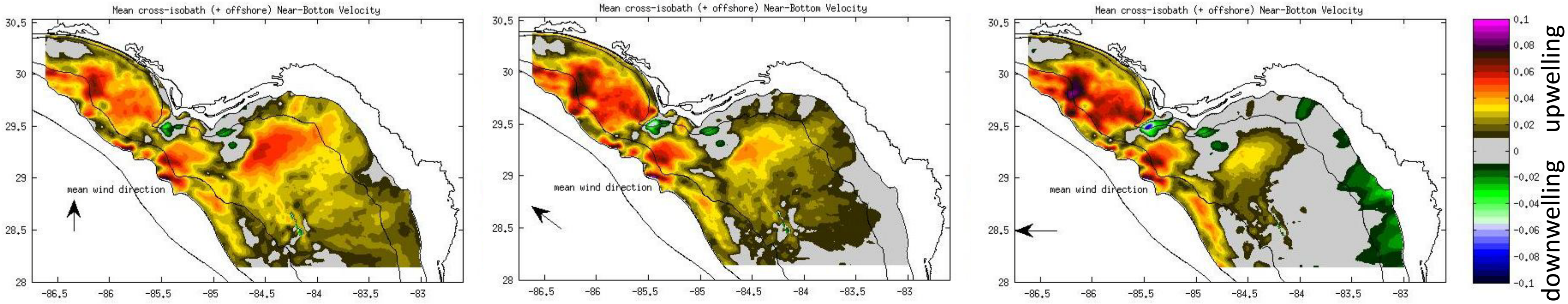


- Near-bottom currents are subset in time based on the spatially-averaged wind direction (in 45° bins)
- Near-bottom velocity and wind fields are temporally averaged for each directional bin
- Near-bottom velocity is projected onto the topographic gradient
- Winds are projected along isobaths

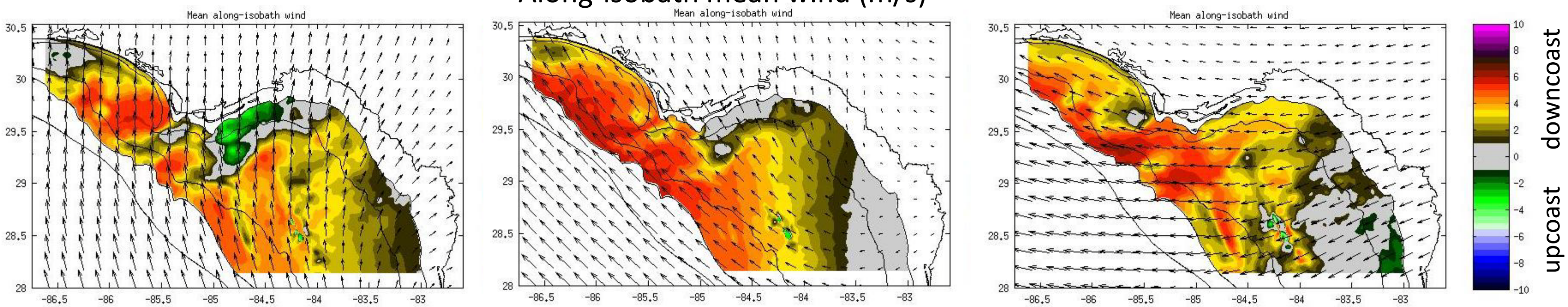
Wind Directional Histogram
(metorological sense)



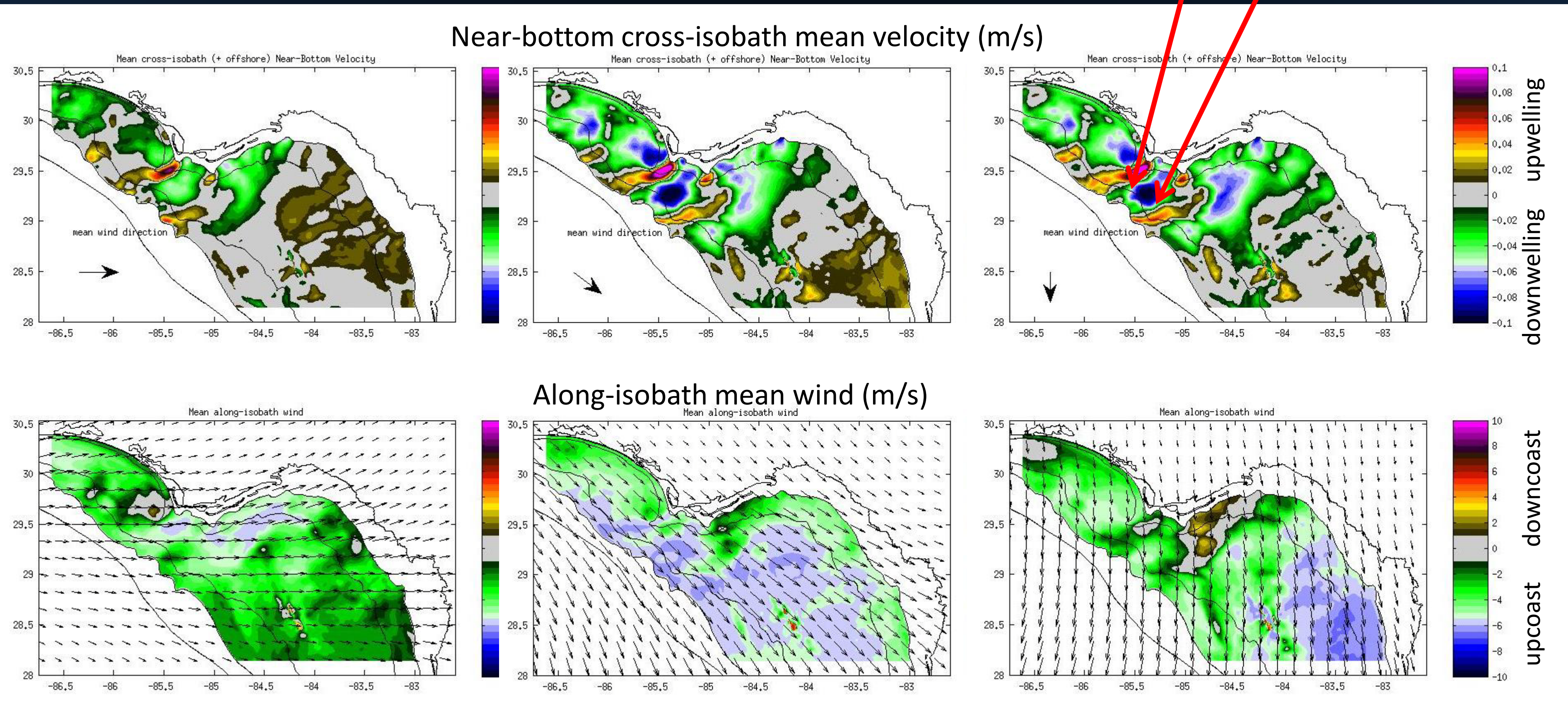
Near-bottom cross-isobath mean velocity (m/s)



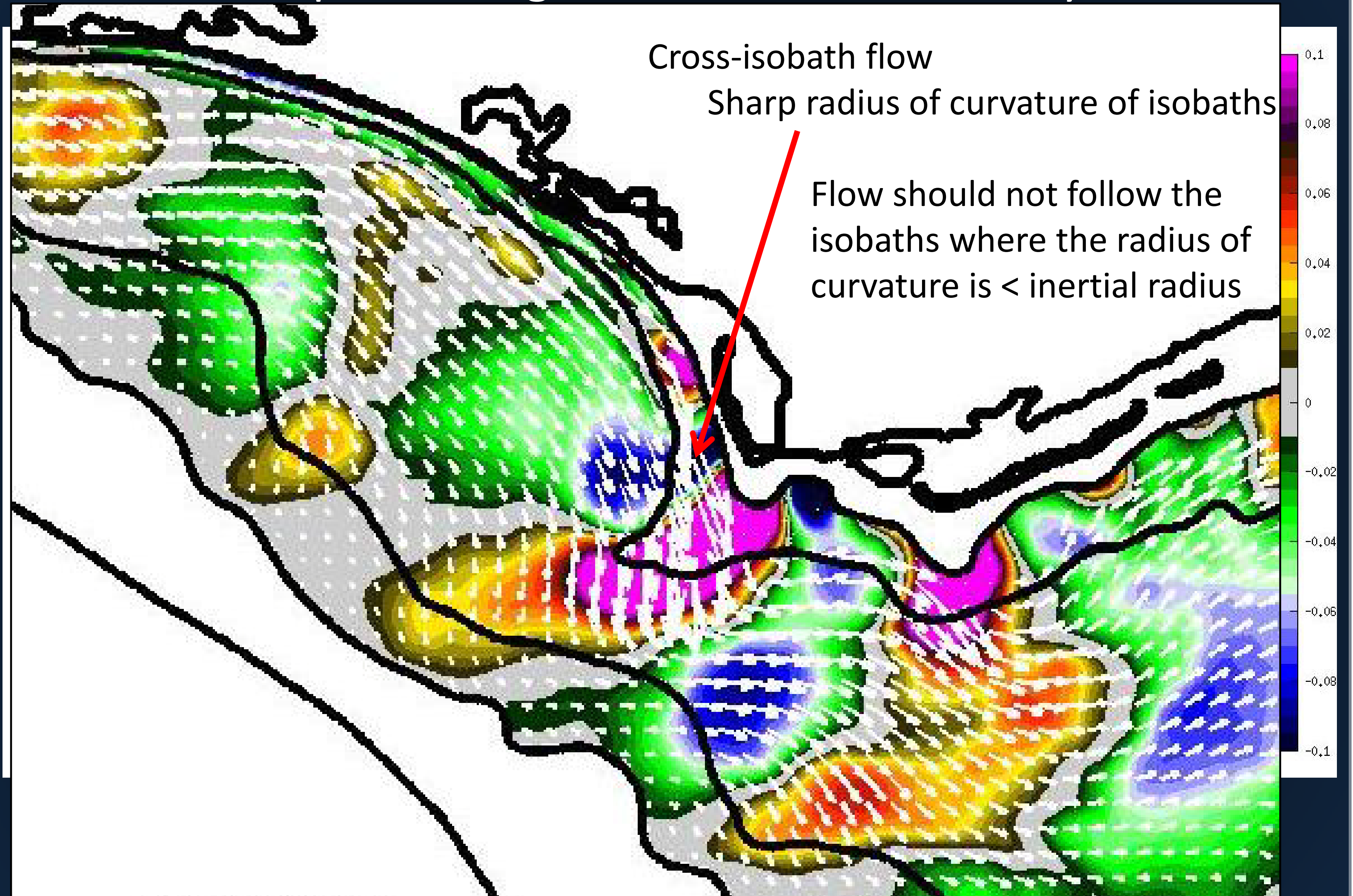
Along-isobath mean wind (m/s)

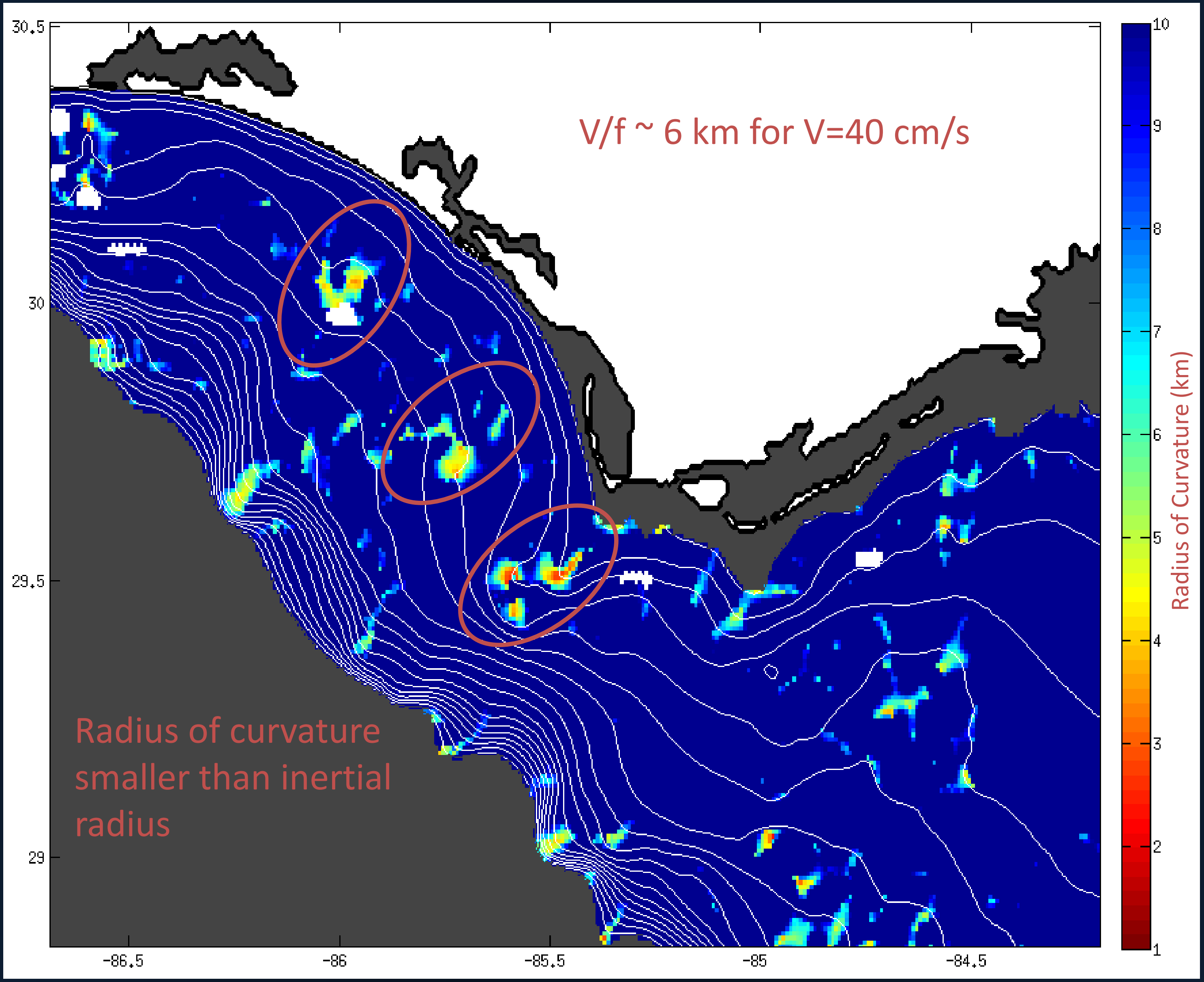


Regions of alternating up-isobath and down-isobath transport

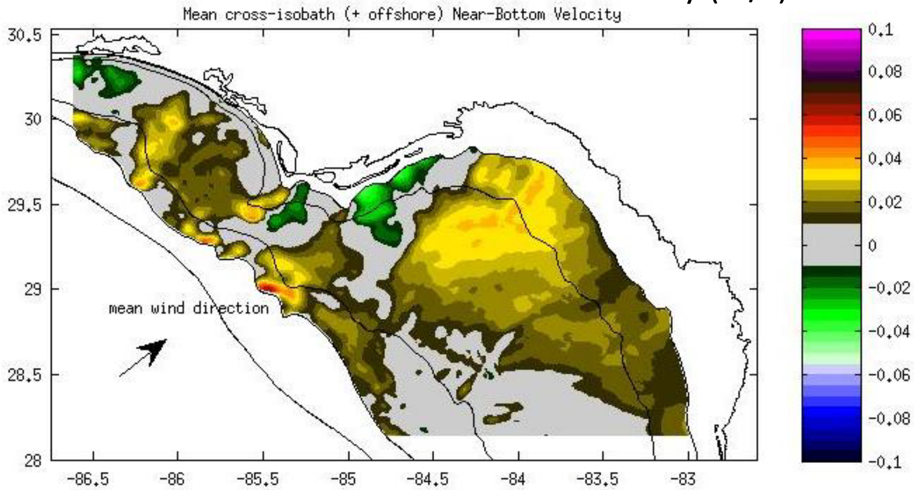


Depth-Averaged Near-Bottom Velocity



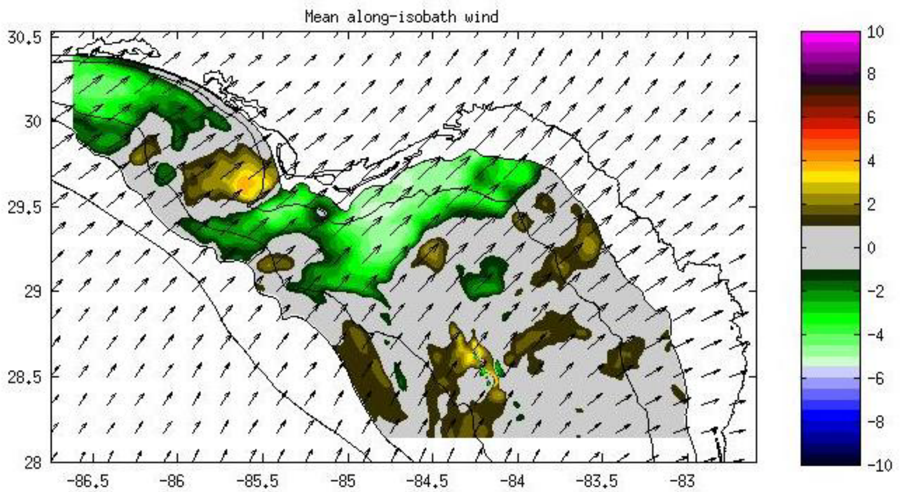

V/f ~ 6 km for V=40 cm/s
Radius of curvature smaller than inertial radius
Radius of Curvature (km)
10
9
8
7
6
5
4
3
2
1
30.5
30
29.5
29
-86.5
-86
-85.5
-85
-84.5

Near-bottom cross-isobath mean velocity (m/s)

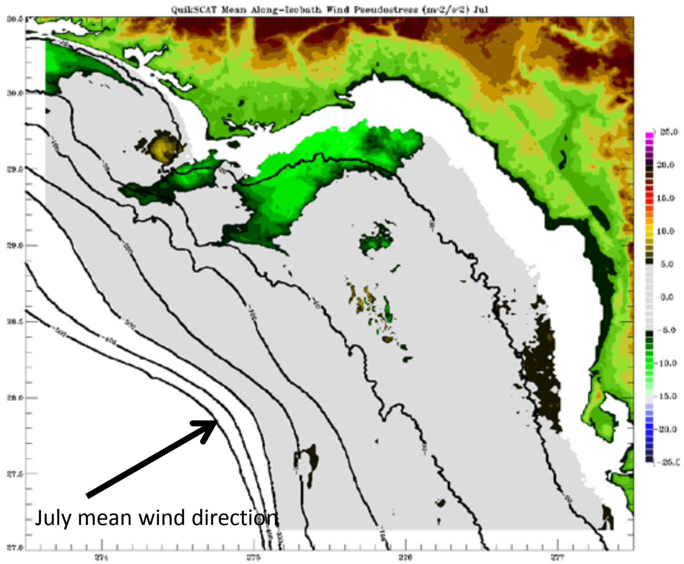


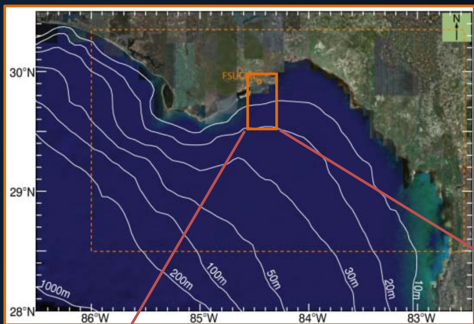
The model simulates the localized upwelling patch inferred by the scatterometer winds.

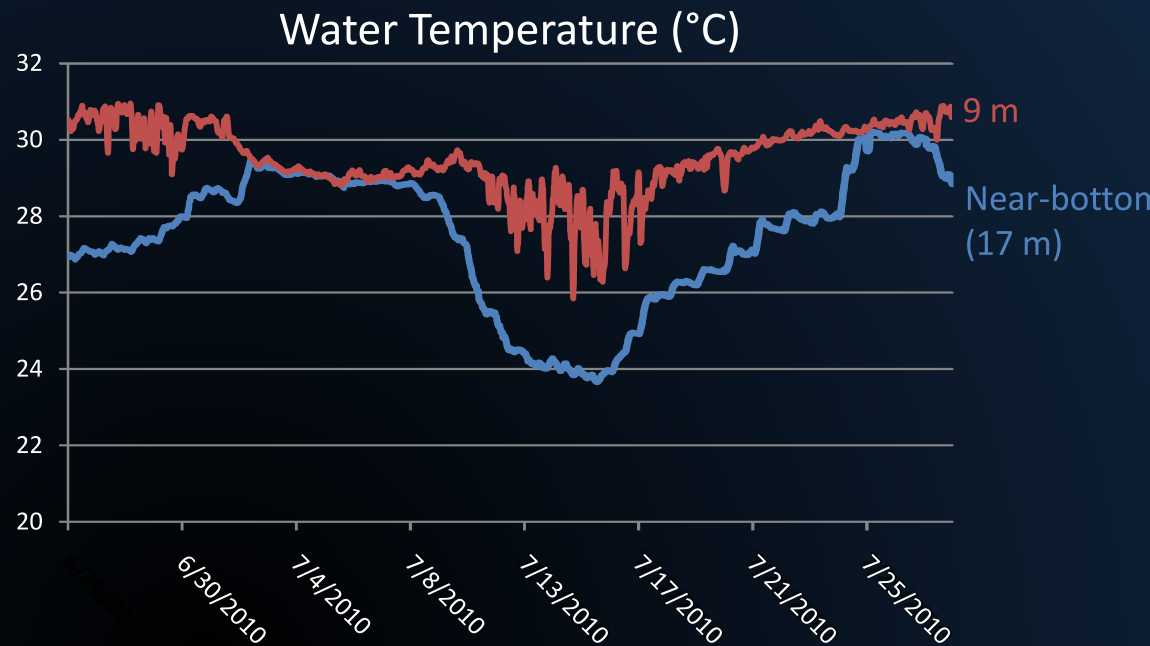
Along-isobath mean wind (m/s)

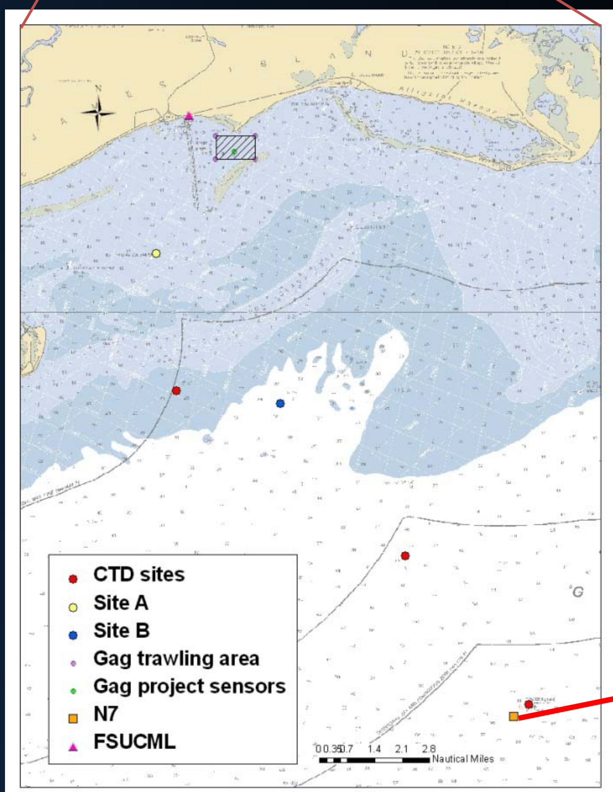


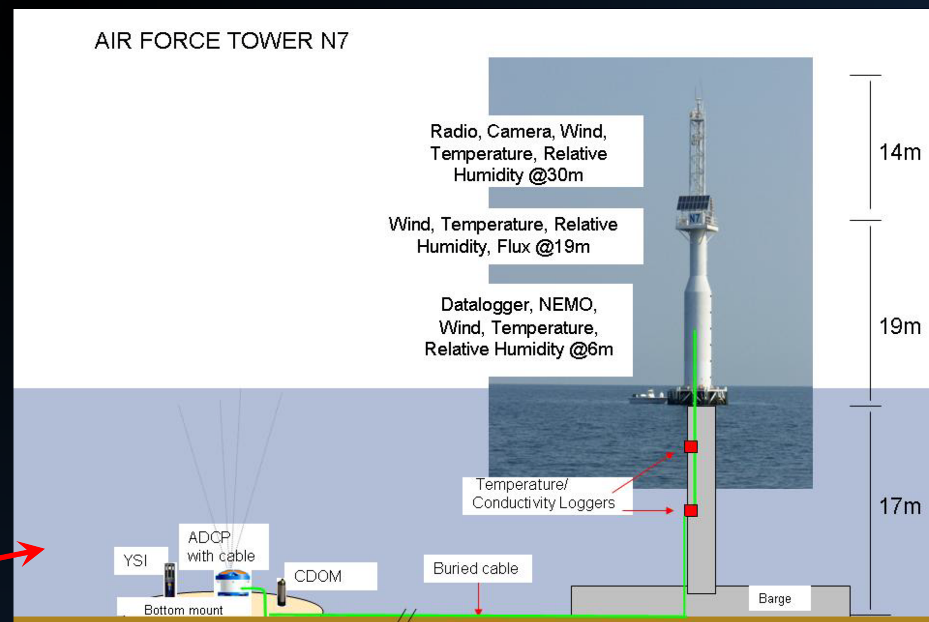
July Climatology
QuikSCAT pseudostress




30°N
29°N
28°N
86°W
85°W
84°W
83°W
1000m
200m
100m
50m
30m
20m
10m
N


Water Temperature (°C)
32
30
28
26
24
22
20
9 m
Near-bottom
(17 m)
6/30/2010
7/4/2010
7/8/2010
7/13/2010
7/17/2010
7/21/2010
7/25/2010


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


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

Conclusions

- A numerical model shows that spatial inhomogenieties in near-bottom cross-isobath transport can occur due to complex shelf geometries

- Drastic curves (90°) in bathymetry contours can support localized upwelling regions where the radius of curvature is sufficiently large

- Surface winds can be reasonably used to infer the existence of localized upwelling patches given knowledge of the bathymetry.

- Current knowledge of coastal upwelling zones around the globe may be enhanced by analyzing the scatterometer-derived wind fields together with bathymetric data sets.