Connection between internal wave activity and outer shelf and slope circulation during winter 2012 off Long Bay (SE US)

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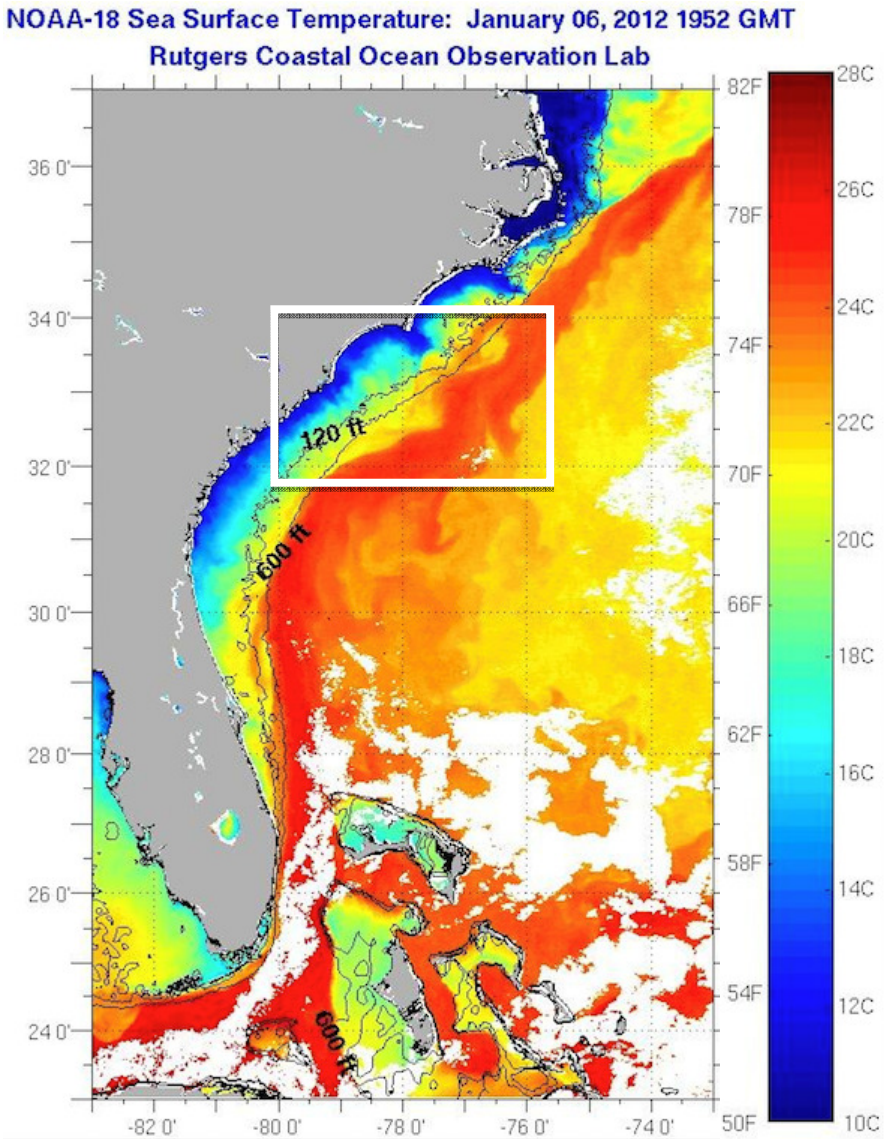
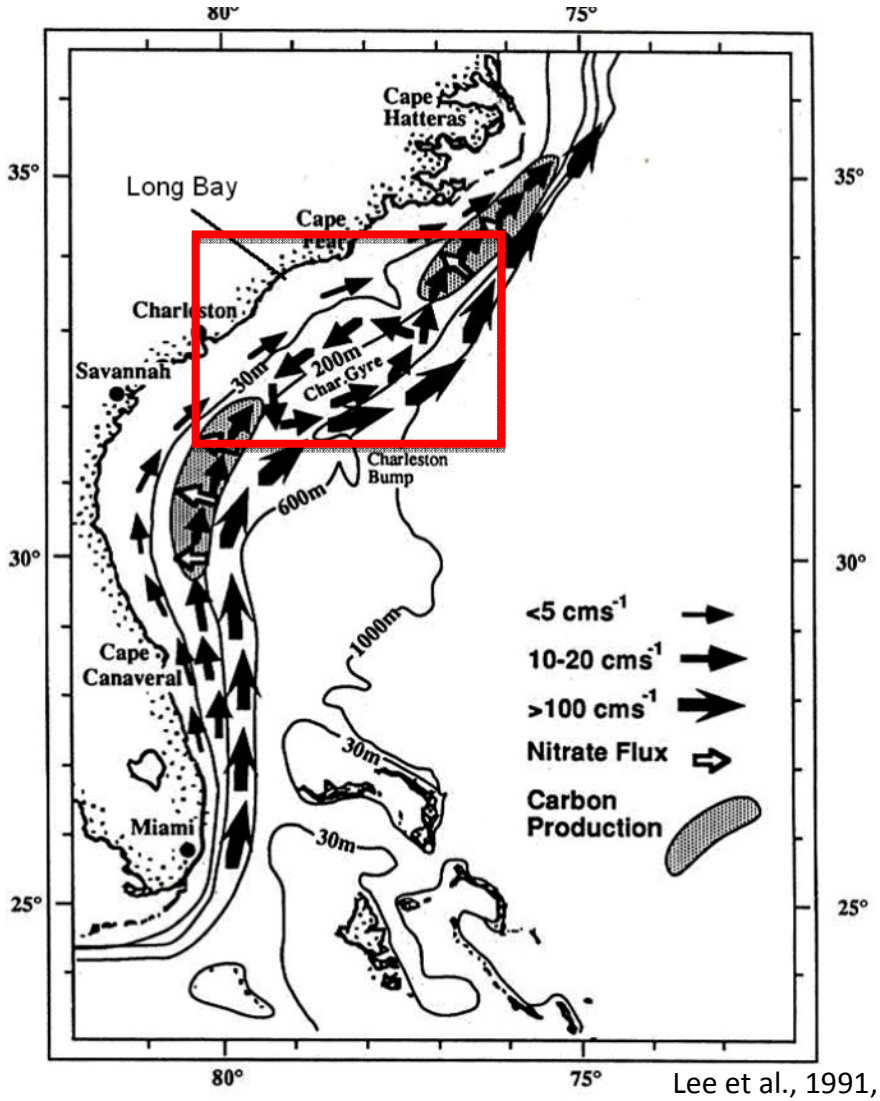
Oceanographic setting: NW Atlantic where the Gulf Stream runs along the SE coast of the US. Study area is *Long Bay*

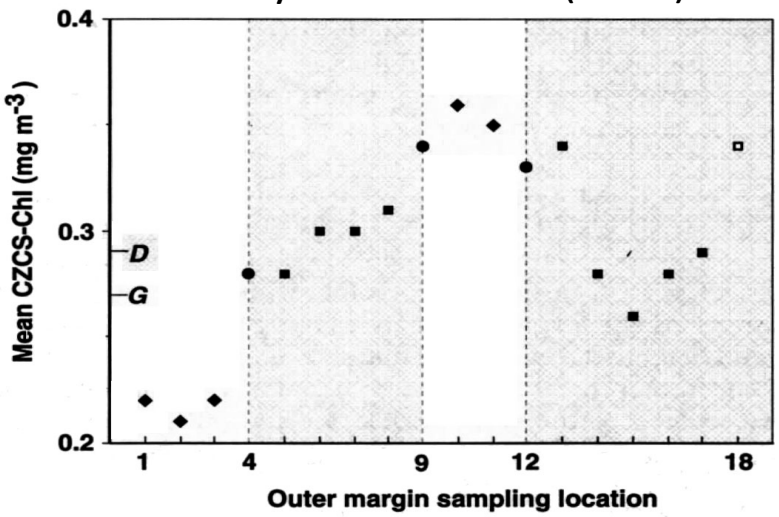




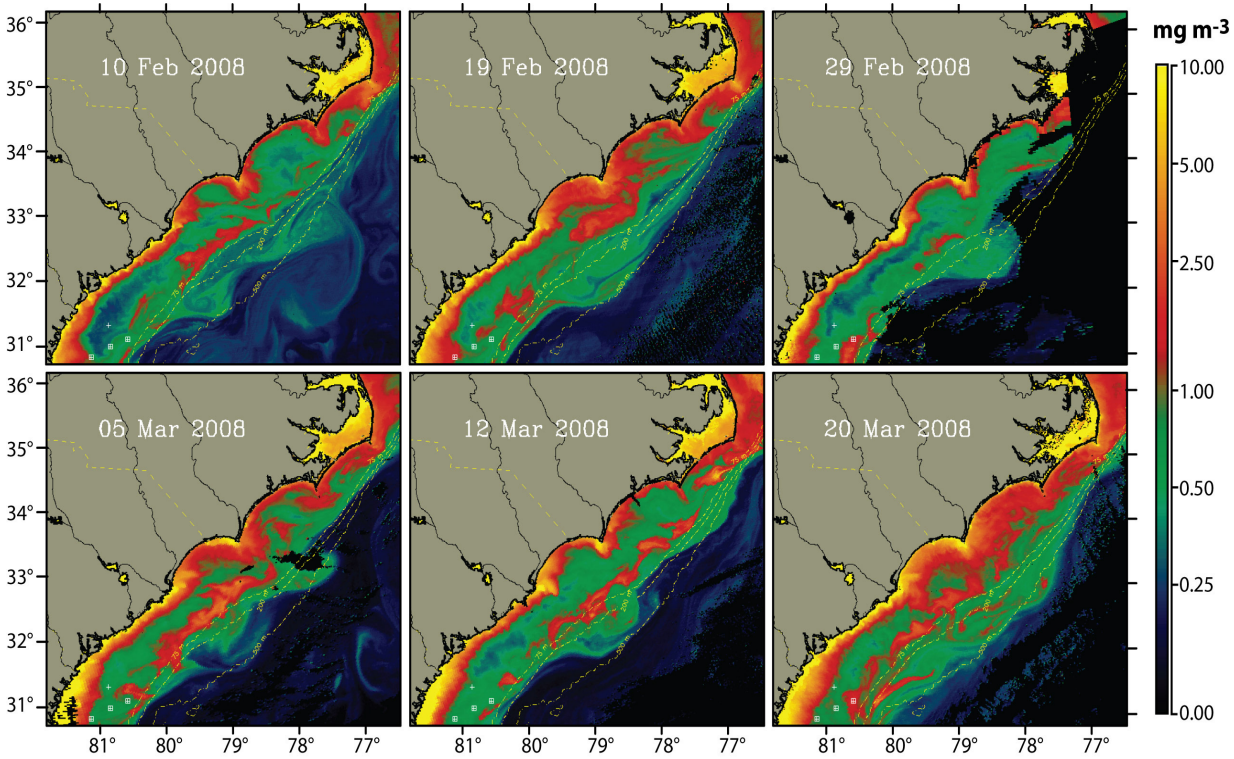
Lee et al., 1991, JGR

Ryan and Yoder (1996) found maximum wintertime Chl off Long Bay, outside frontal eddy decay regions. What supports the productivity in this area?

Ryan and Yoder (1996)



MODIS imagery (from J. Nelson, 2010)



Nutrient Input

- Possible mechanisms:
  - Gyre/Warm Filaments – strong circulation over upper slope - onshore component?
  - Wind-driven exchange – Ekman layer deepening and transport? (but how is this unique to Long Bay)
  - Slumping-driven exchange – dense water formation on the shelf (also, how unique?)
  - ***Internal tide-driven mixing – does the absence of Gulf Stream on upper slope enhance this process?***

Field program – (January – March 2012)

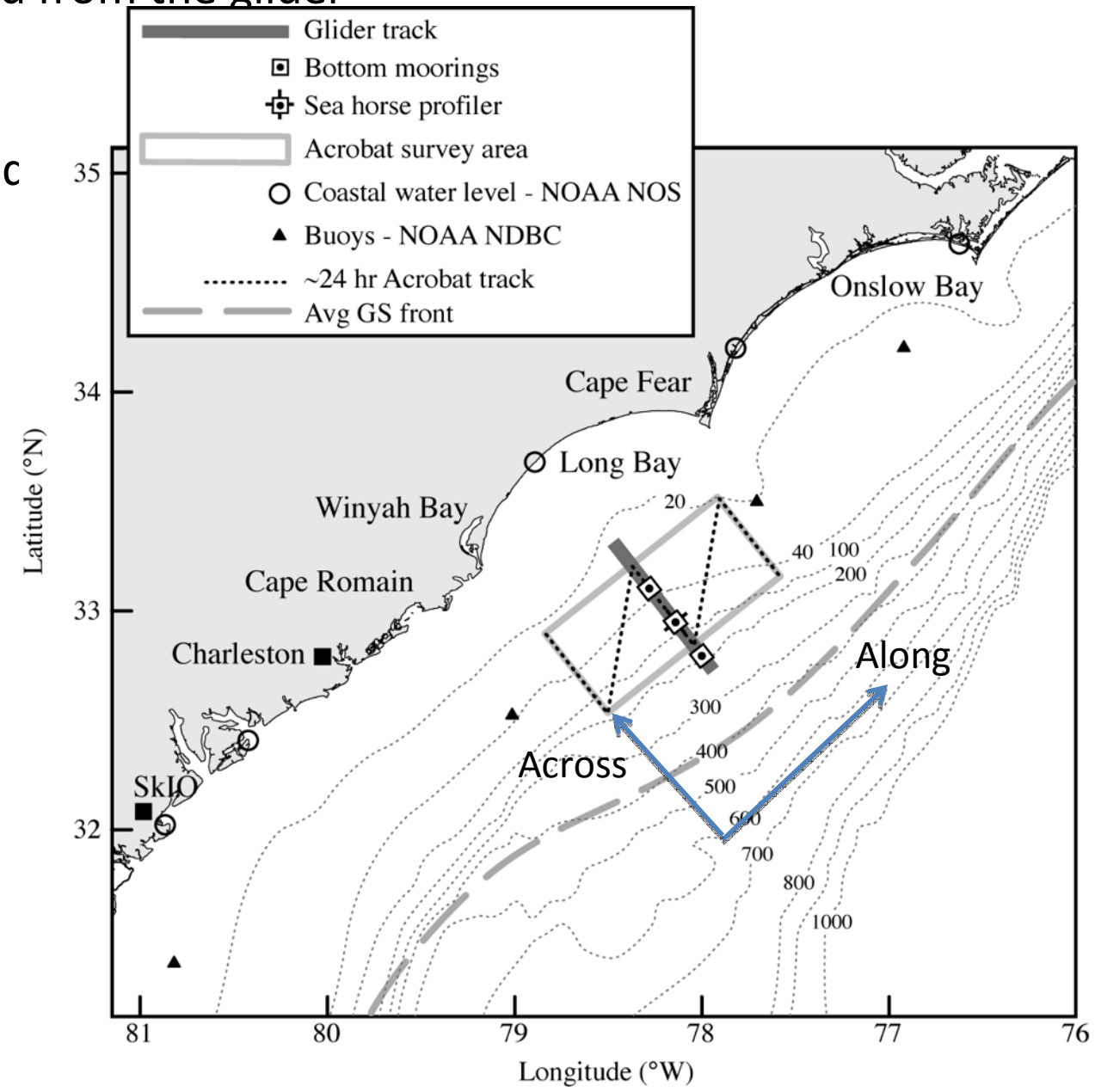
- mooring, glider and shipboard sampling
- will examine density field from the glider and moored observations (depth-averaged current removed to better represent internal waves)

Cross-shelf array:

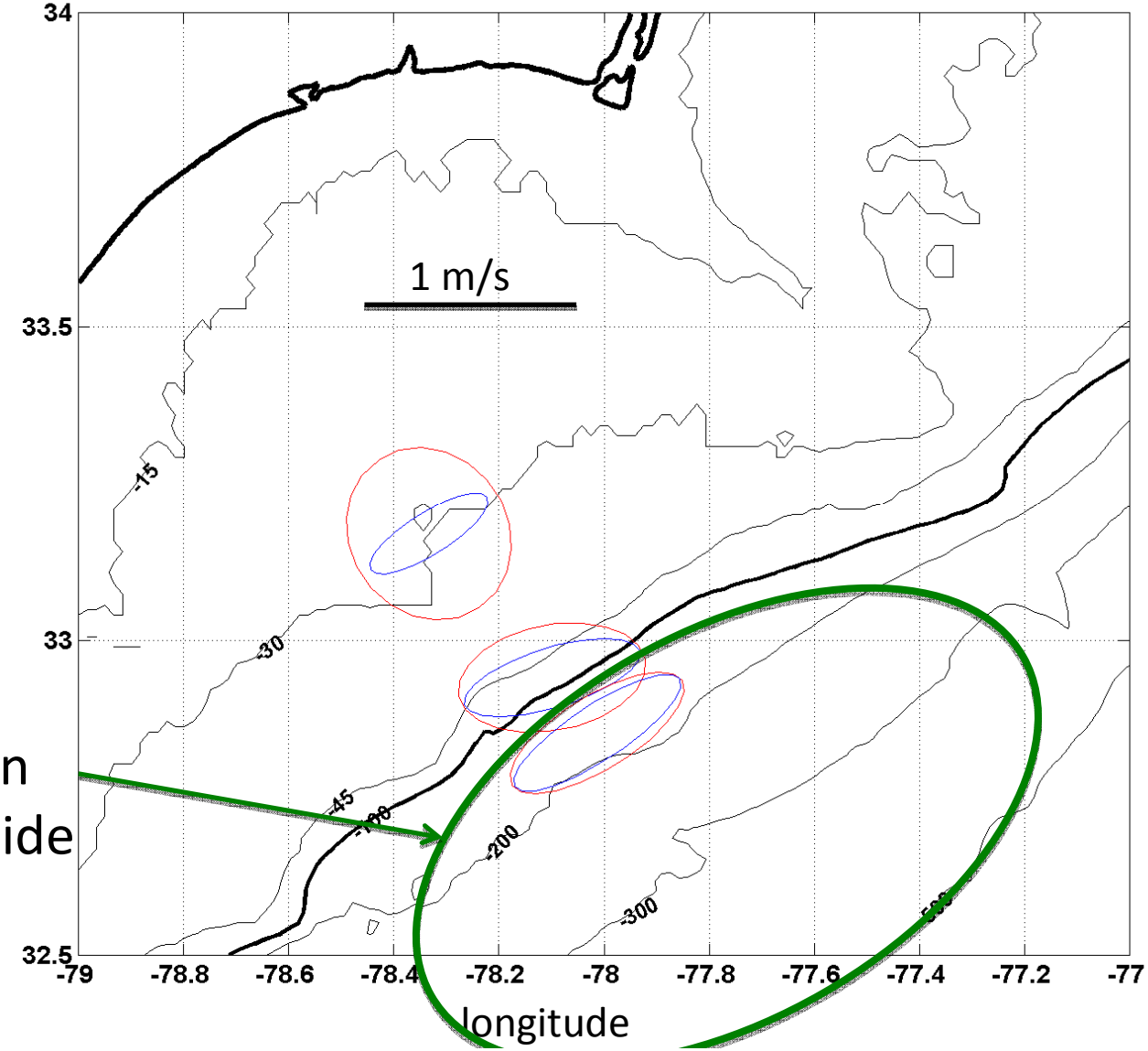
LB1 – 30 m

LB2 – 75 m

LB3 – 175 m

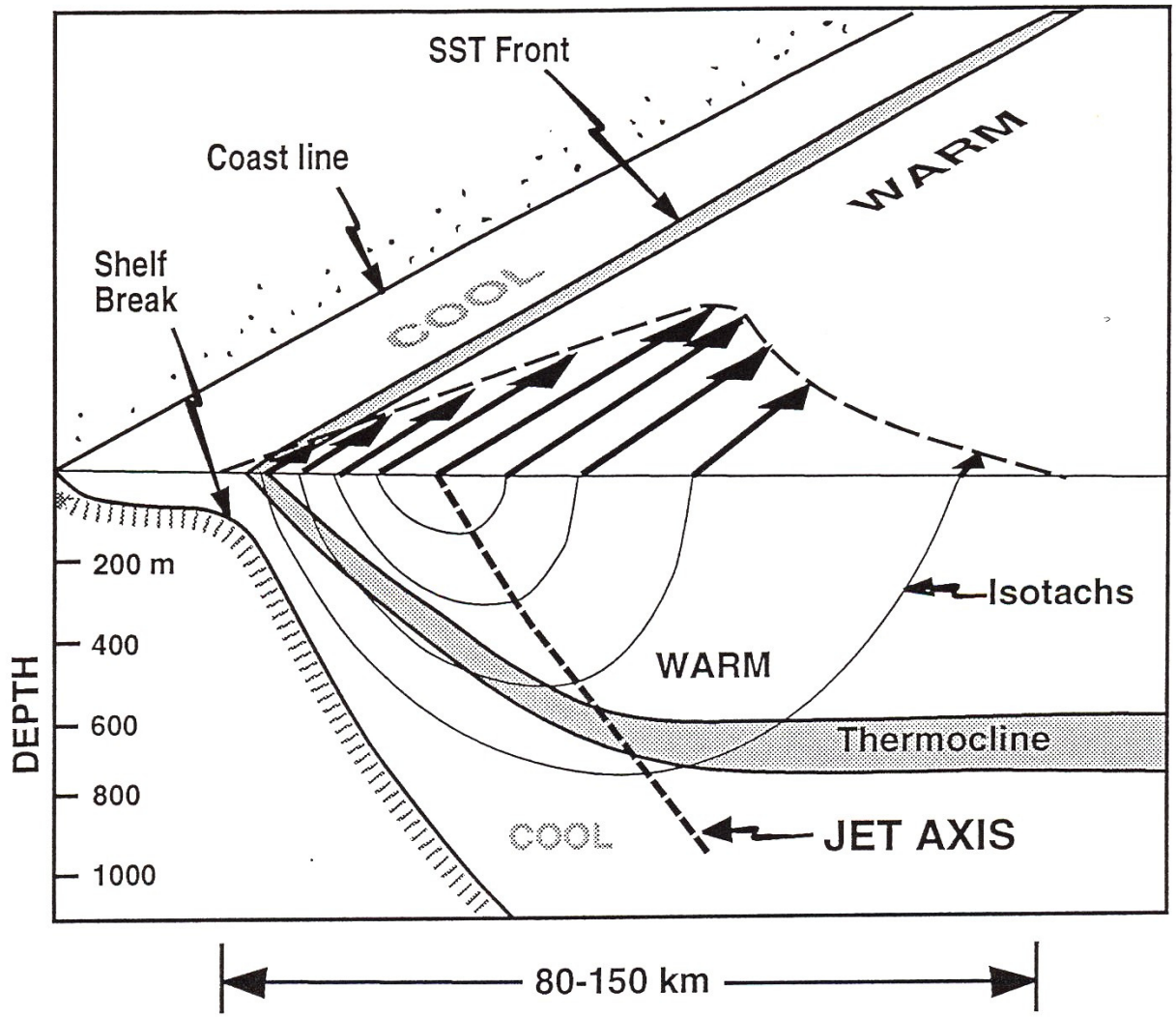


Variance ellipses – full and detided - relatively strong cross-shore semi-diurnal tidal currents at shelf (0.35 m/s), weaken offshore (0.1 m/s), good potential to generate internal tide over the slope between 500 and 100 m depths.

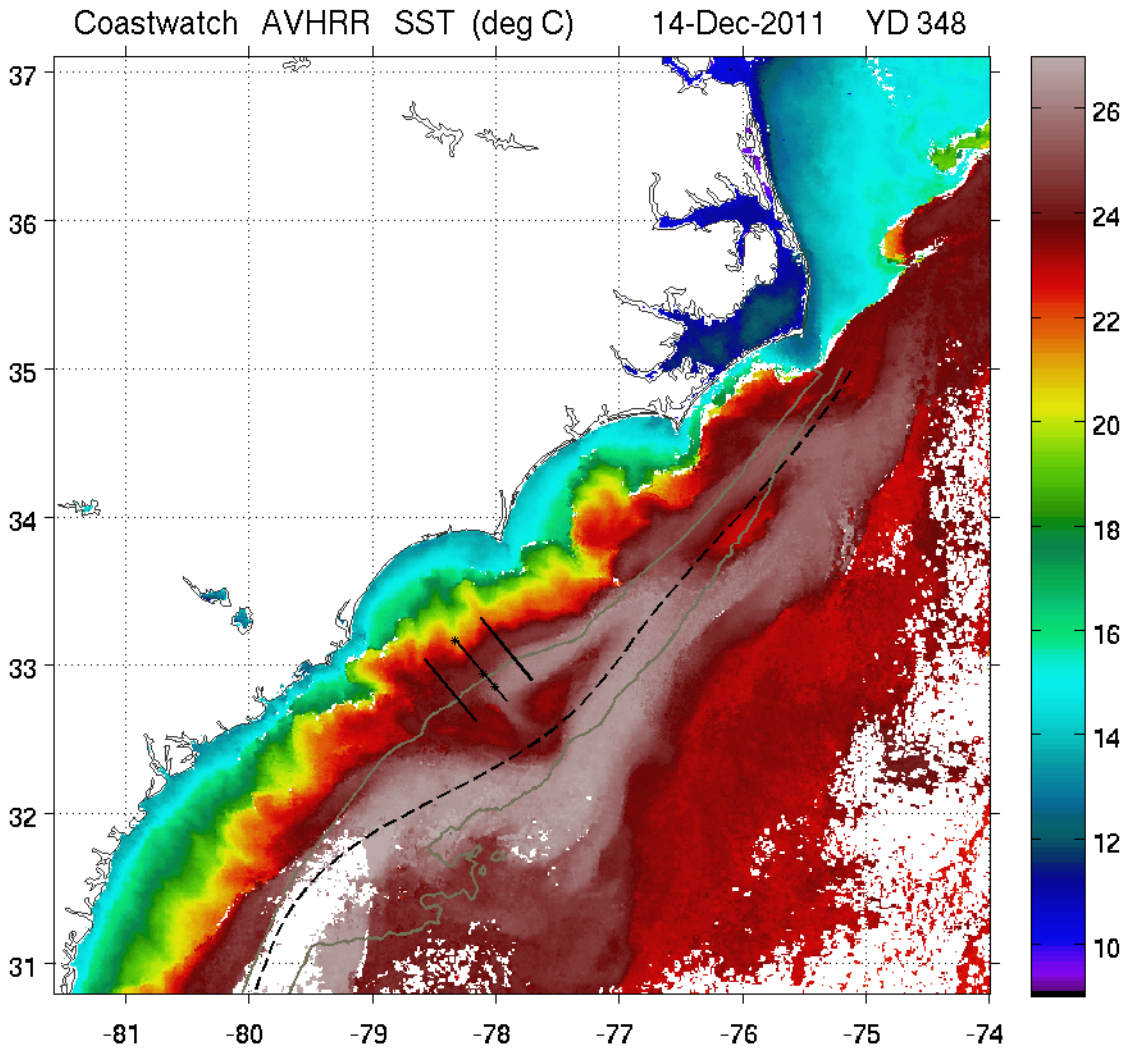


Likely generation site of internal tide

Canonical Gulf Stream structure – strongly shoaling thermocline, surface-trapped baroclinic jet. This mass field does not favor onshore propagation of an internal tide



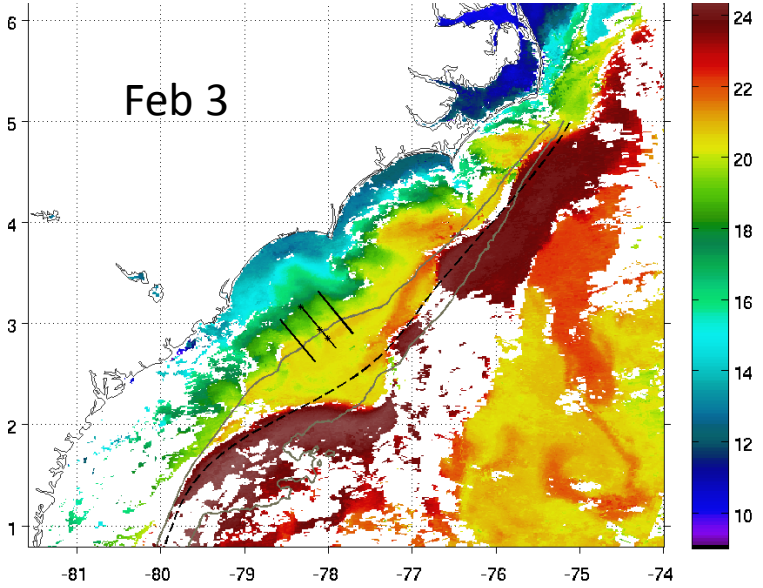
Further complication - warm filaments – onshore component of frontal eddies.

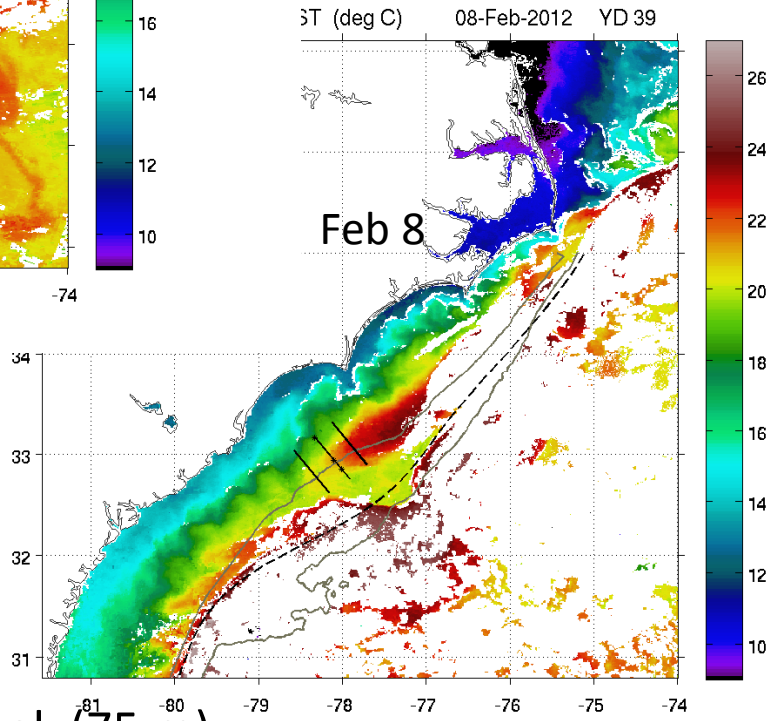


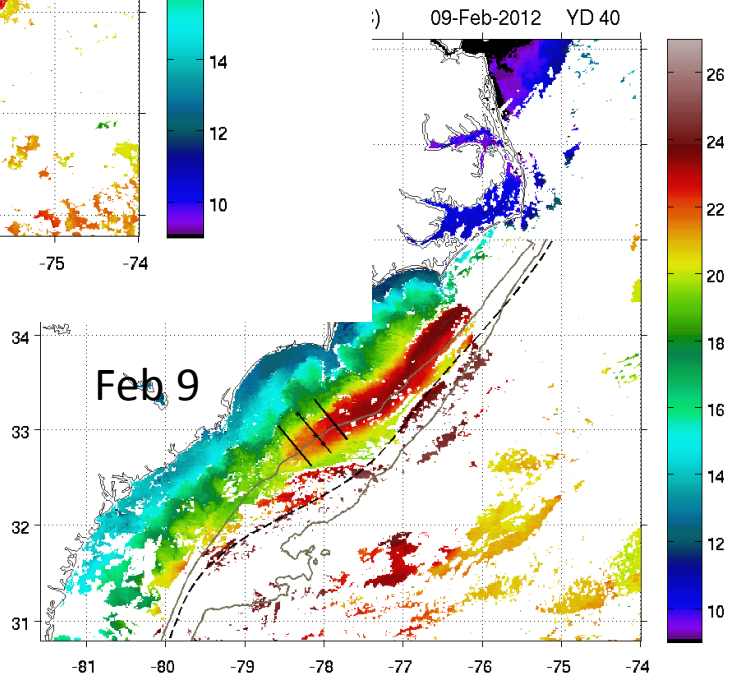
Grey lines: 100 m and 600 m

Dashed black: mean Gulf Stream shoreward front position (Miller, 1993)

Filament example



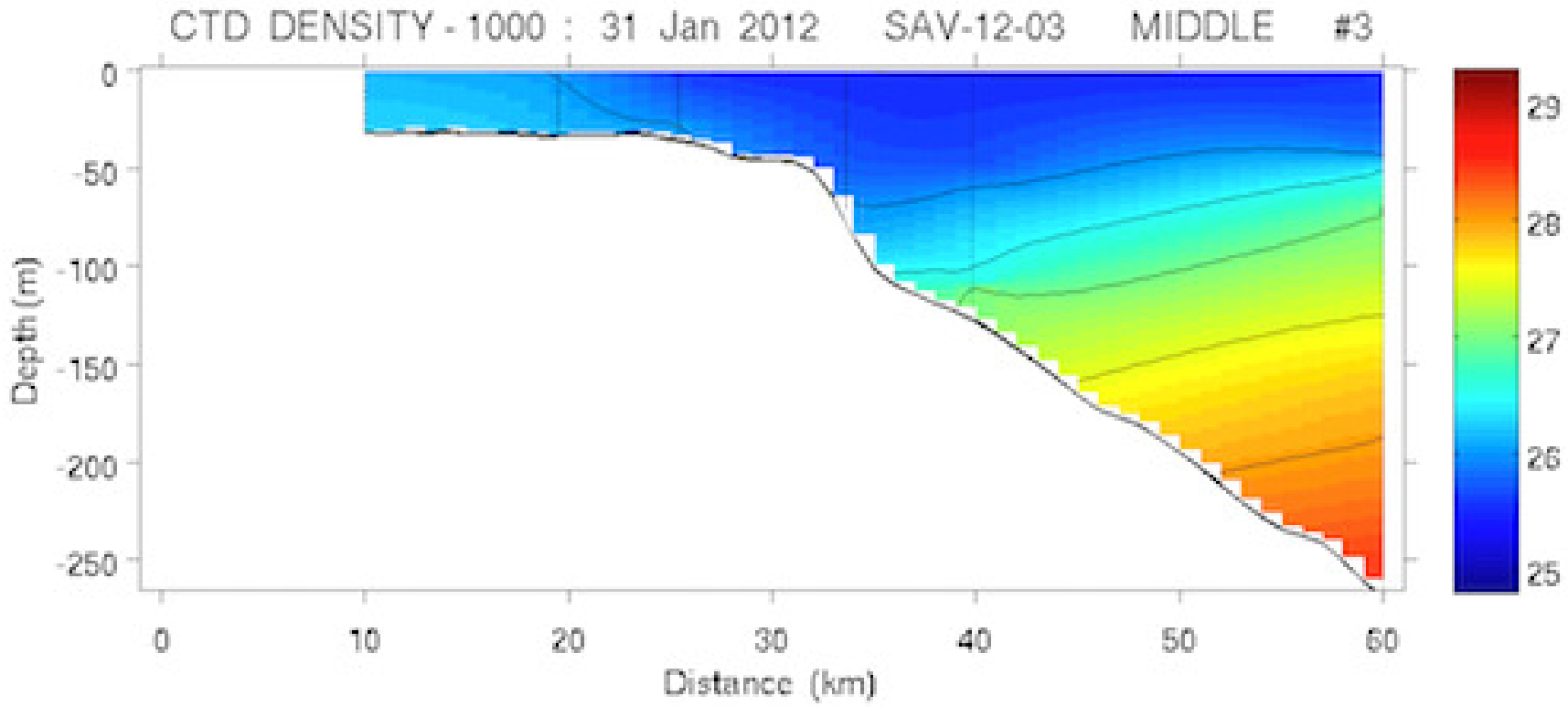




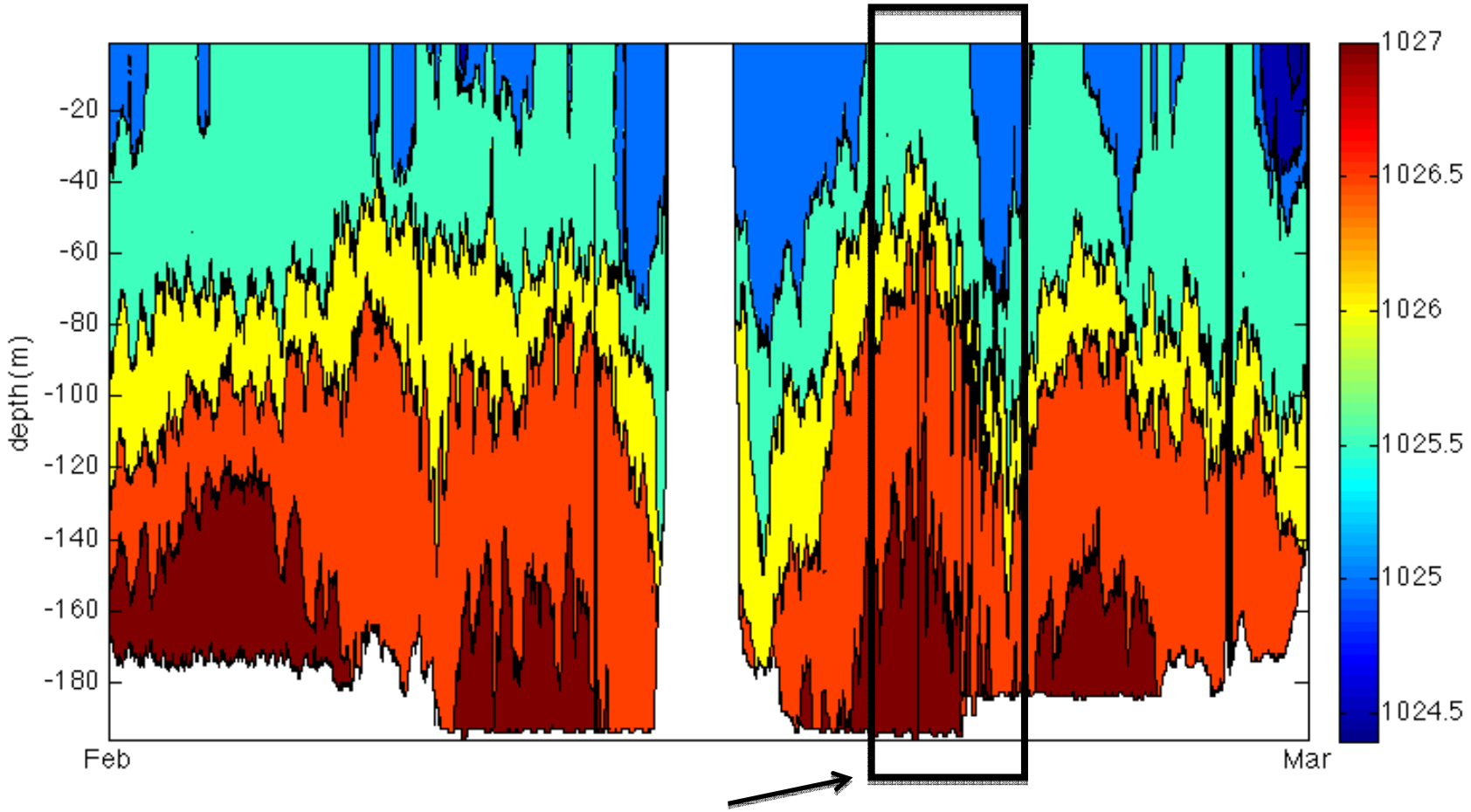
Seen along the shelfbreak (75 m)

Saw rapid SW progression
of some detached filaments

Cross-shelf density section collected when a warm filament occupied the shelfbreak and upper slope (flow is equatorward out of the screen). Note cross-shelf density gradient over the upper slope is ***reversed*** from Gulf Stream case. This mass field may favor onshore propagation of an internal tide.

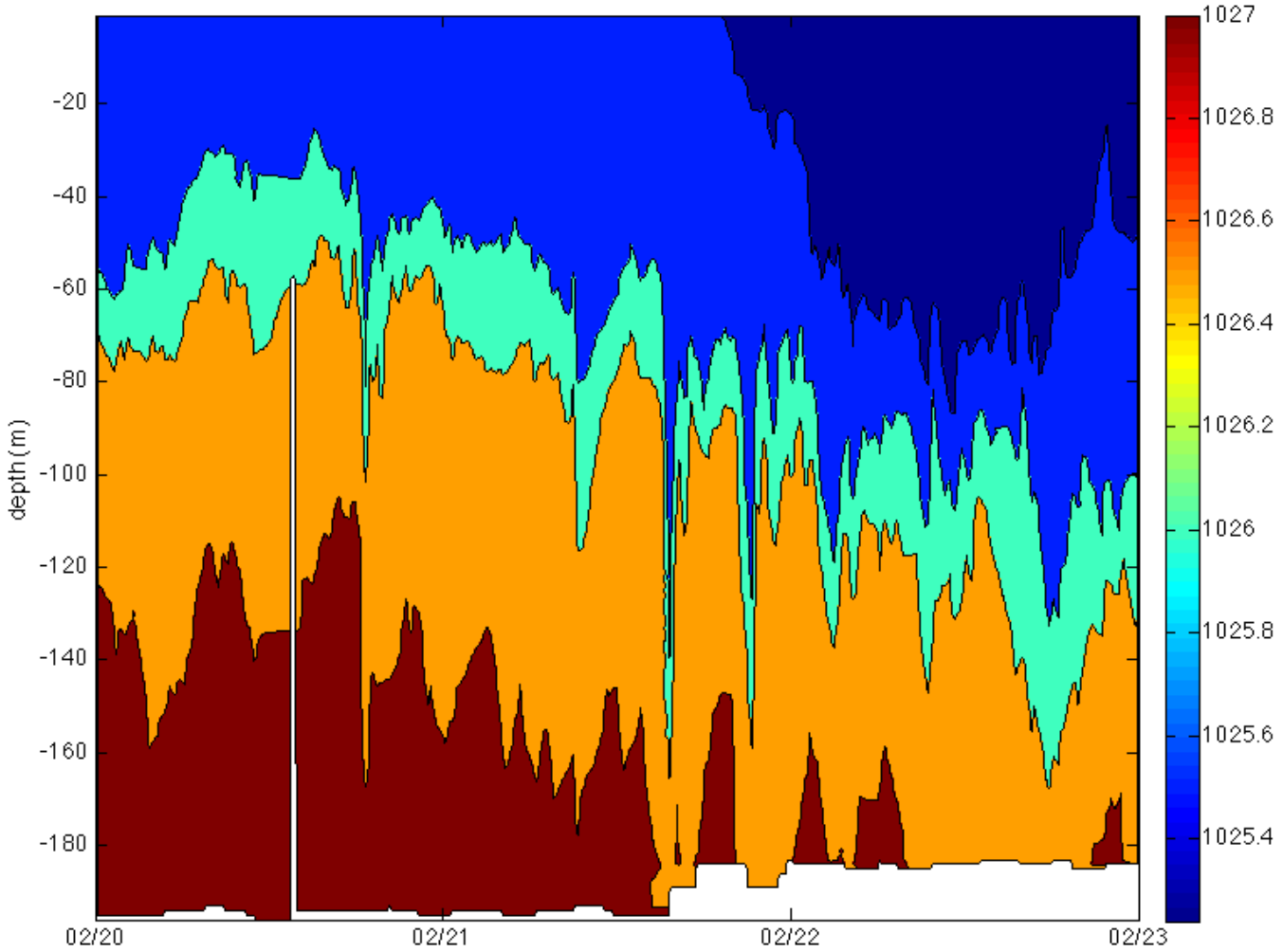


Density field along the glider track over the slope in Feb. 2012 exhibiting regular tidal oscillations and large lower frequency variations in isopycnal depths.



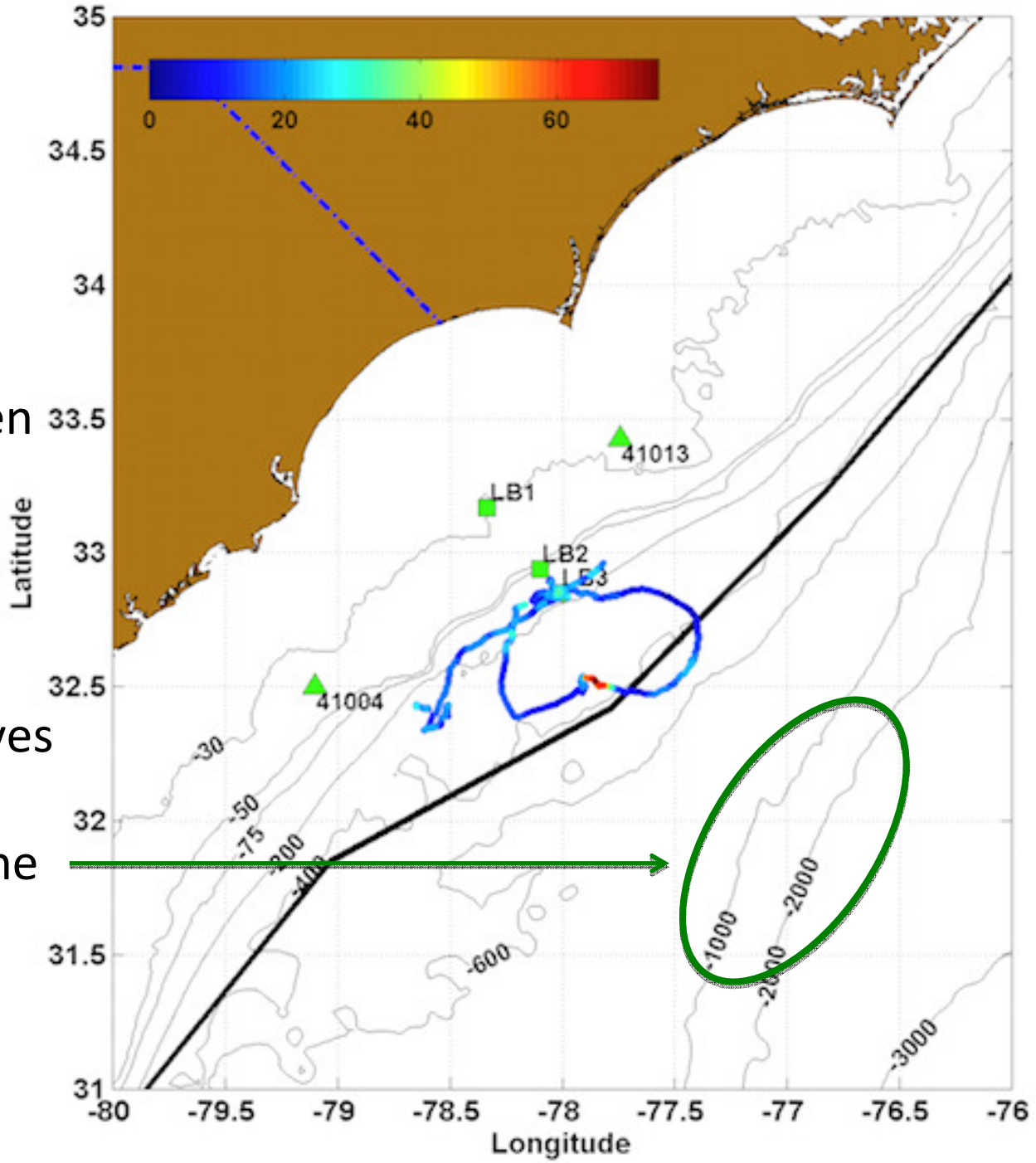
Zoom in shown on next slide

Isopycnals over 3 days in mid-Feb. displayed large amplitude (> 50m in 400m total water depth) displacements, the only time waves of this scale were observed.



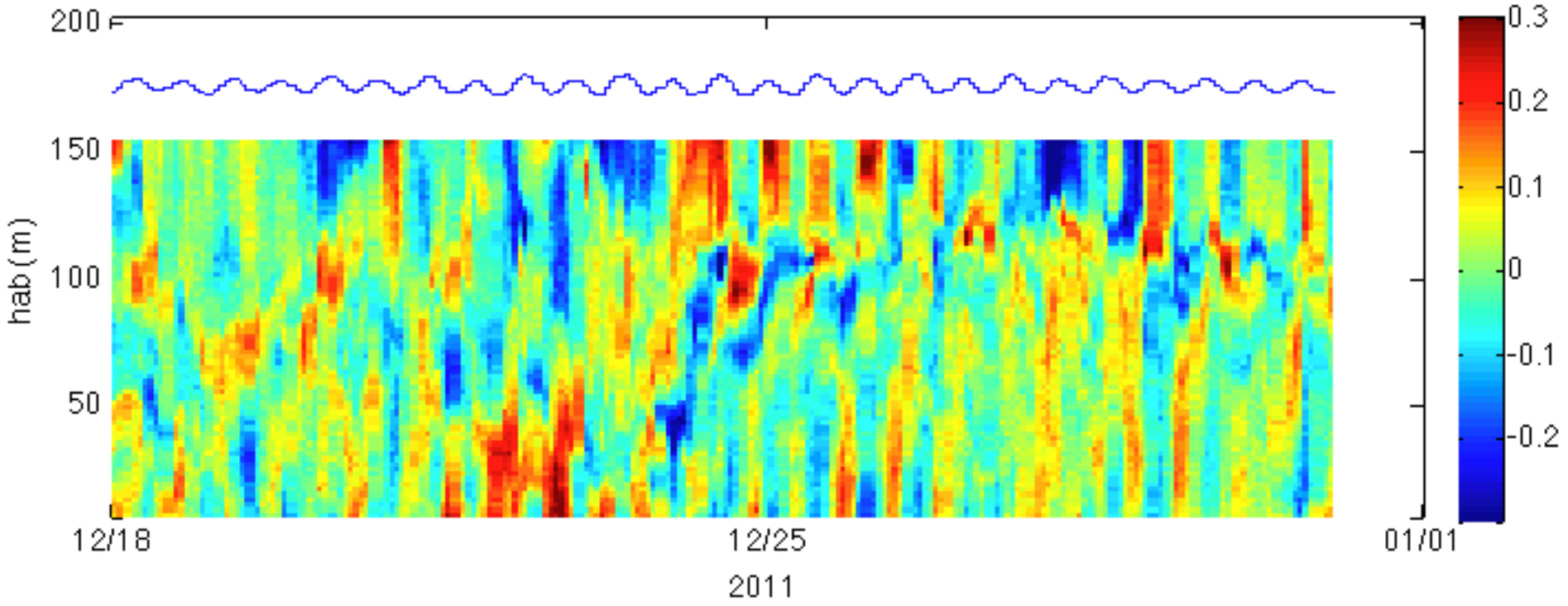
Glider track during Feb. 2012. Color indicates amplitude of isopycnal displacements at semi-diurnal frequencies. Largest waves were seen only briefly while glider was seaward of upper slope.

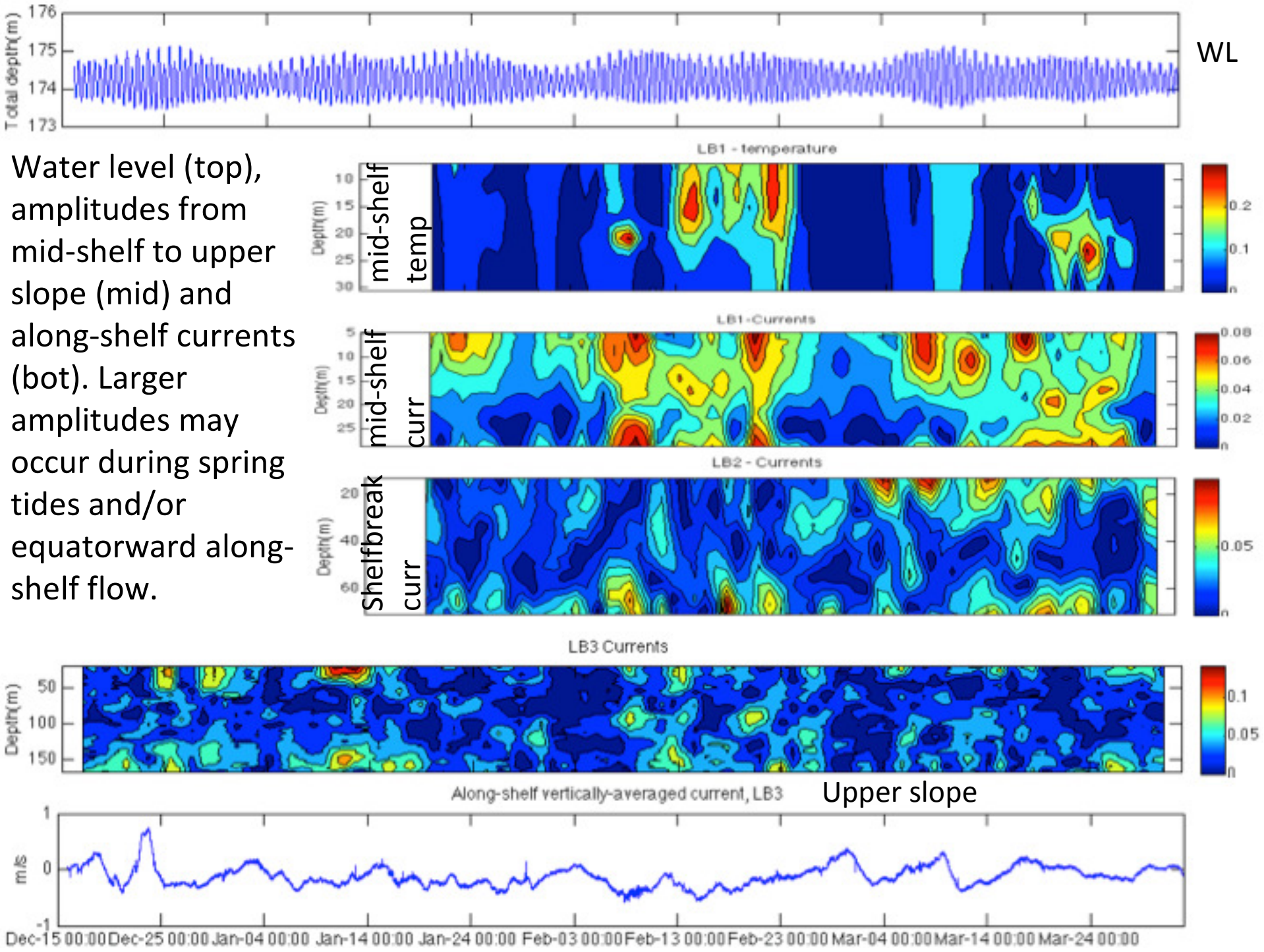
Do large amplitude waves suggest a second generation sight over the lower slope region farther offshore?



Two week time series of cross-shelf velocity profiles over the upper slope indicating regular but poorly organized internal tide.

Use complex demodulation as a first approach to quantifying the time-varying magnitude of the internal tide in the mooring data.





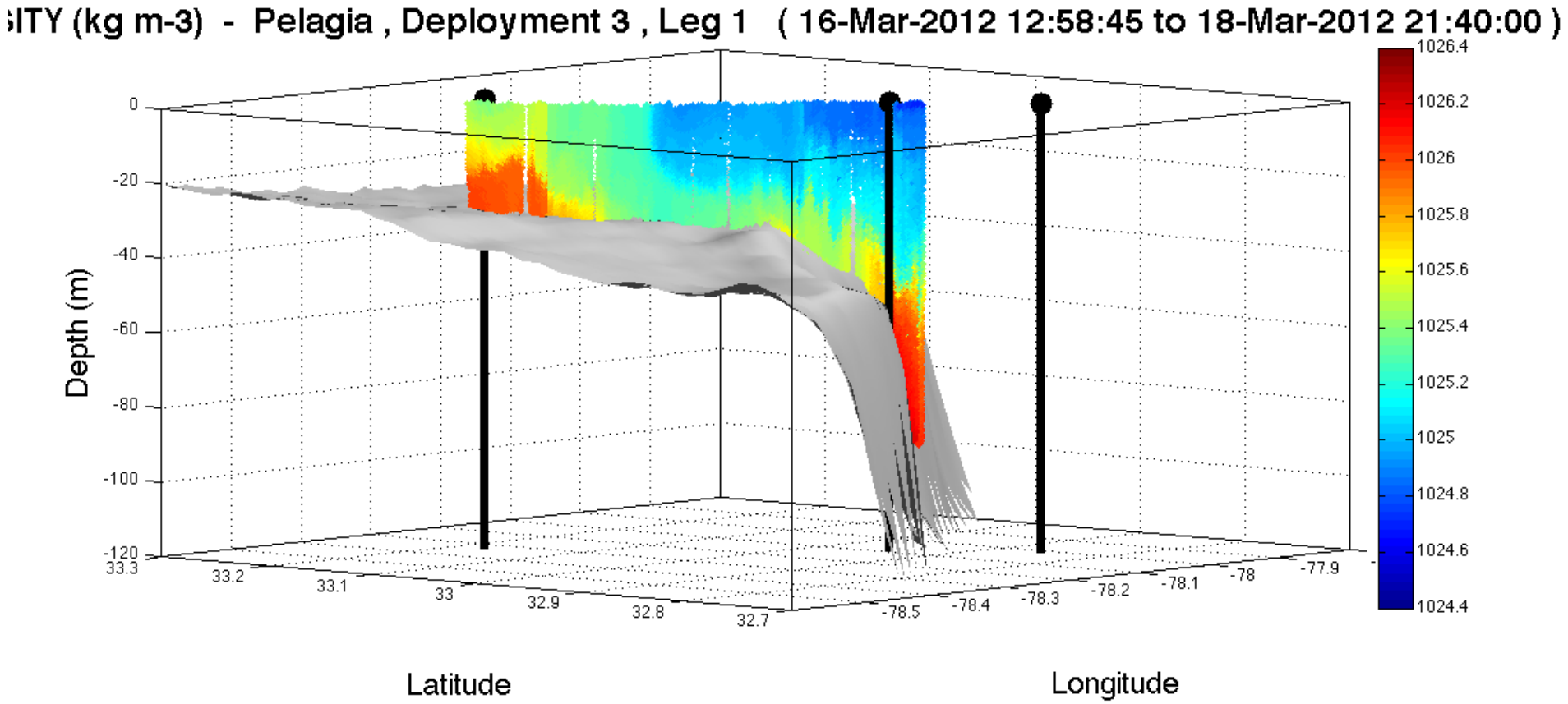
Water level (top), amplitudes from mid-shelf to upper slope (mid) and along-shelf currents (bot). Larger amplitudes may occur during spring tides and/or equatorward along-shelf flow.

Summary

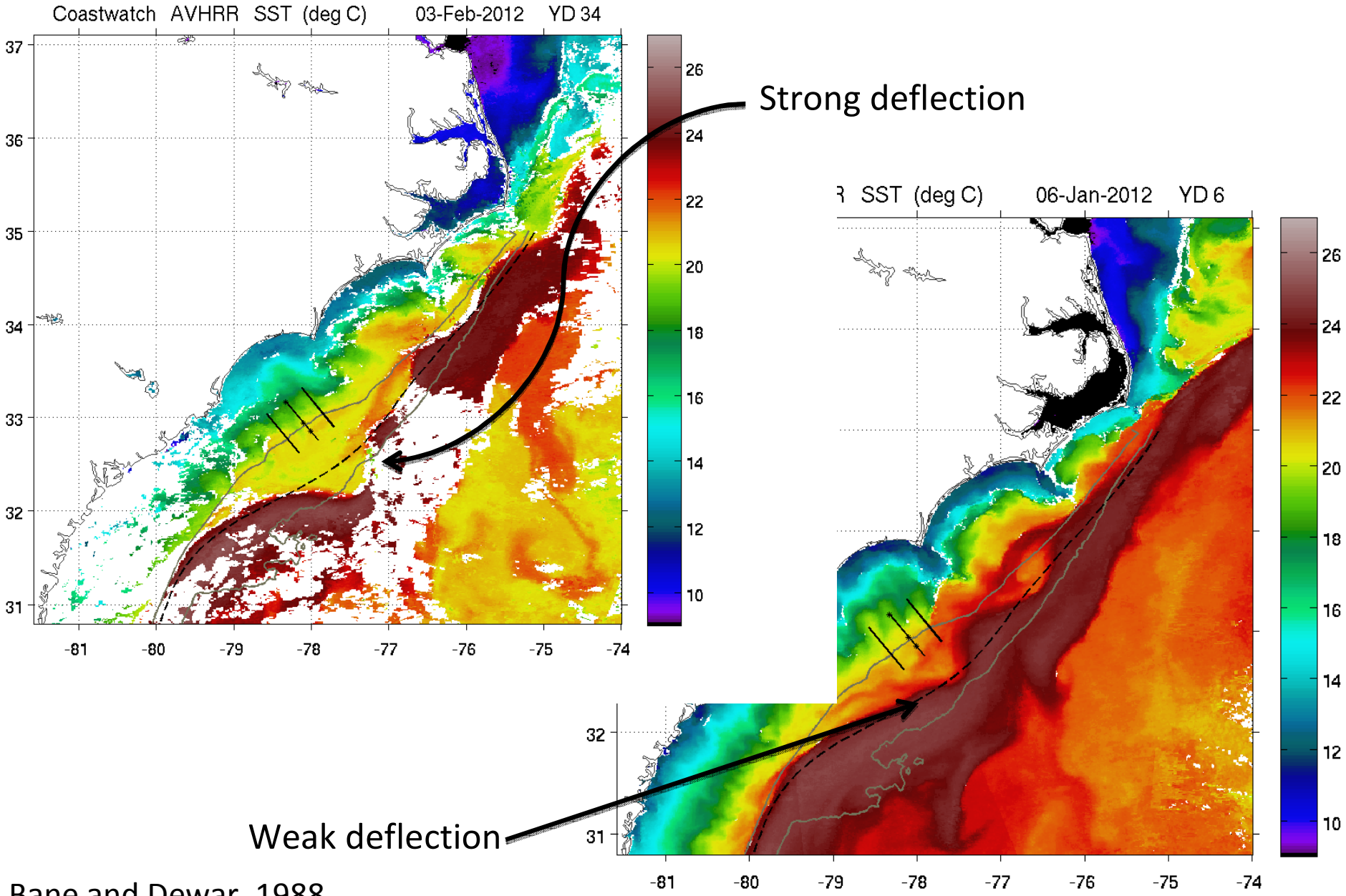
- Cross-shelf oriented tides have the potential to generate an internal tide
- Strong alongshelf flow associated with Gulf Stream processes reverse the cross-shelf density gradient over the upper slope
- Glider and mooring observations document a moderate amplitude internal tide
- Temporal variations of the internal tide may correlate with external tide range and/or alongshelf flow but lack persistence.
- Large amplitude internal waves observed seaward of upper slope may indicate a second source region

Thanks to crew of the R/V Savannah for field effort, Sara Haines, Julie Amft, Trent Moore, Chris Calloway for initial processing and analysis and Dongsik Chang and Klimka Szwaykowska for help piloting the gliders

Glider density section – typical of conditions observed over winter -
dense water on inner shelf, decreases moving horizontally offshore
- consistent with mean vertical shear of alongshore current (thermal wind shear of 0.002 1/s)
- may explain pronounced offshore bottom flow at shelfbreak



Gulf Stream deflection – based on position relative to 600 m isobath



Bane and Dewar, 1988

2012 field season