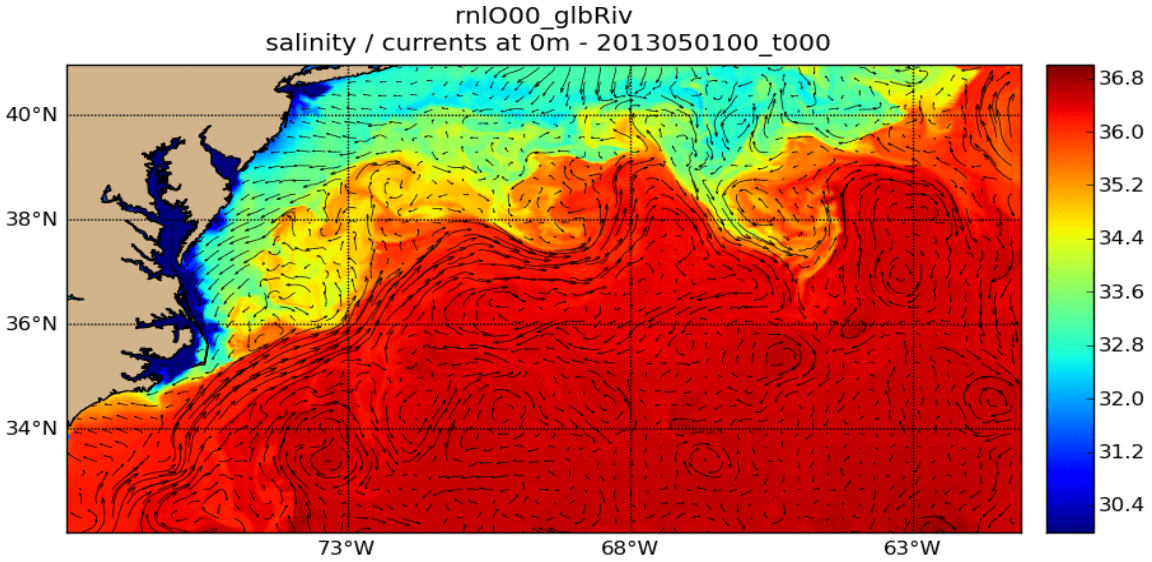
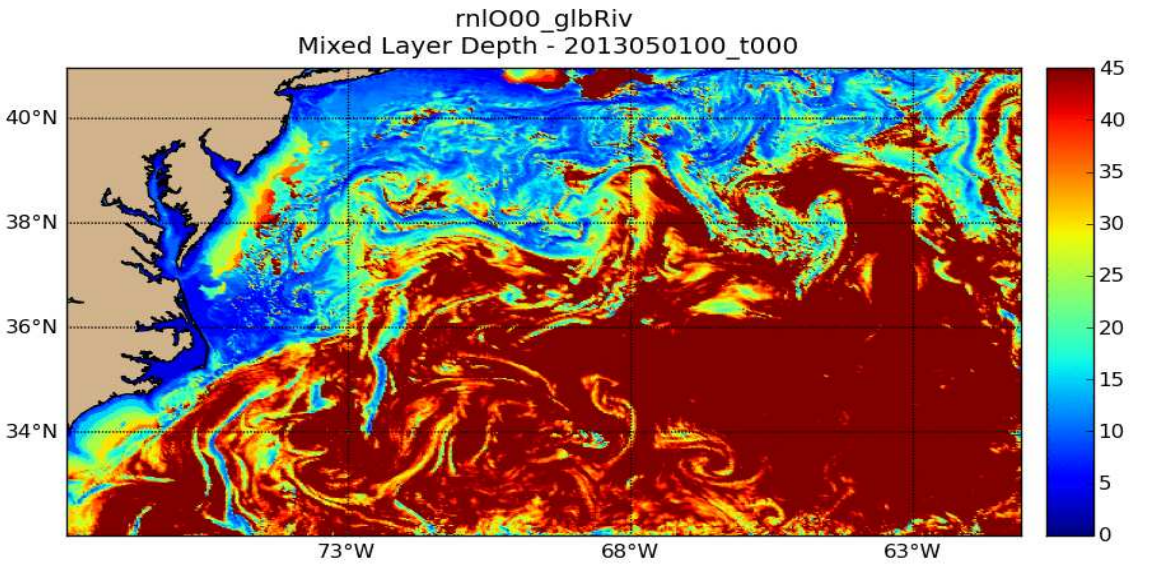
Frontogenesis Predictability in the Gulf Stream

Gregg Jacobs, Jim Richman, Naval Research Laboratory





Internal tides affect mixed layer depth across shelf

Ocean mesoscale modulates mixed layer depth

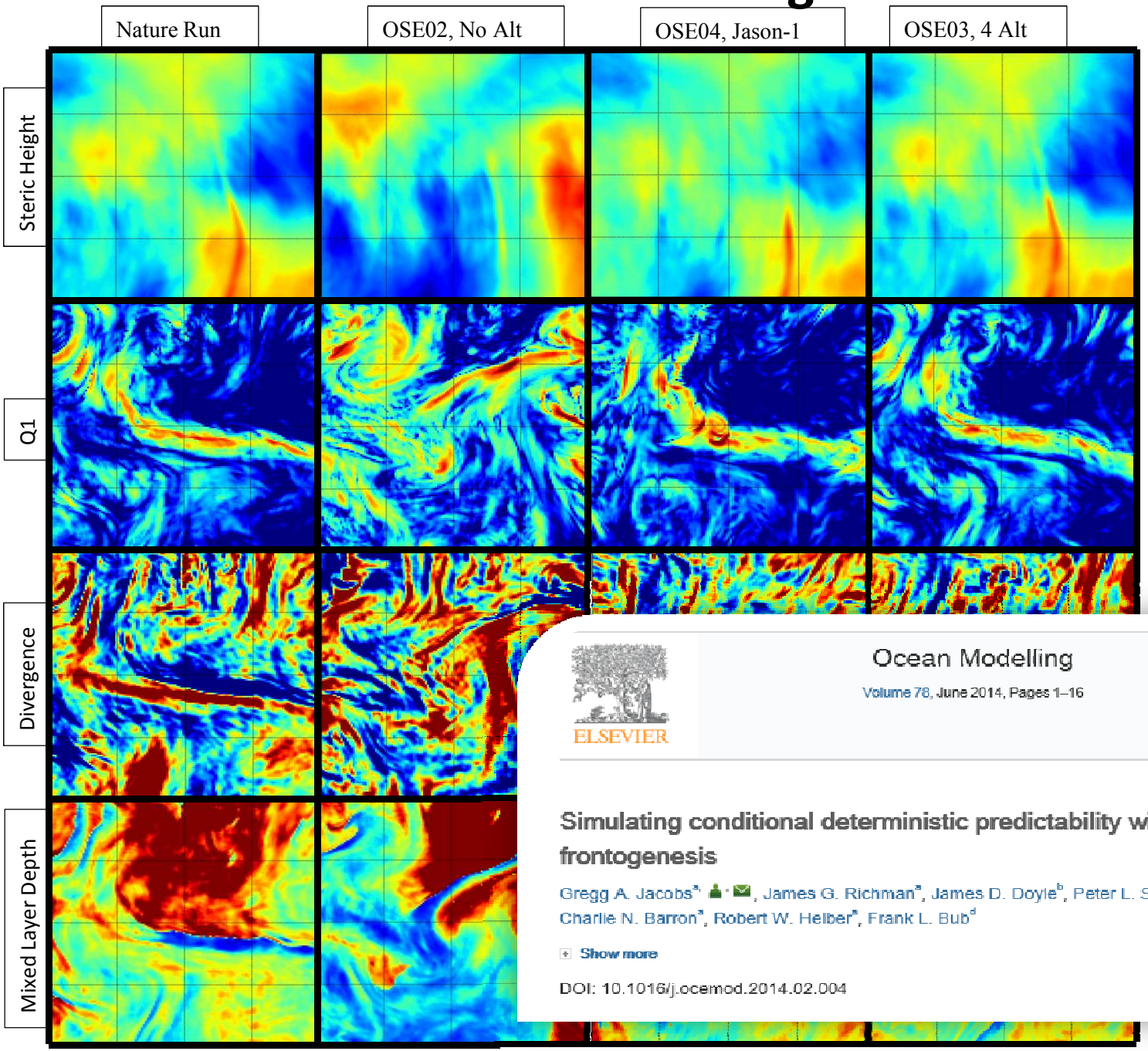
The mesoscale field is nondeterministic but predictable to an extent given altimeter observations

Filaments of thinned mixed layer depth wrap around mesoscale features

These features are driven by frontogenesis and associated ageostrophic motion

Are the filaments driven by frontogenesis predictable?

From 2011 OSTST: Predicting unobserved filaments



February 13, 2005

- steric height relative to 1000m (top row, color bar range 1.92 to 2.58 m)
- frontogenesis Q_1 (second row, log color bar range -13 to -12)
- surface divergence (third row, color bar range -12X10^{-6} to

n)
row,
e 0 to
all
o 24°N
L27°E)

Ocean Modelling

Volume 78, June 2014, Pages 1–16

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Simulating conditional deterministic predictability within ocean frontogenesis

Gregg A. Jacobs[a], James G. Richman[a], James D. Doyle[b], Peter L. Spence[c], Brent P. Bartels[c], Charlie N. Barron[a], Robert W. Helber[a], Frank L. Bub[d]

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DOI: 10.1016/j.ocemod.2014.02.004

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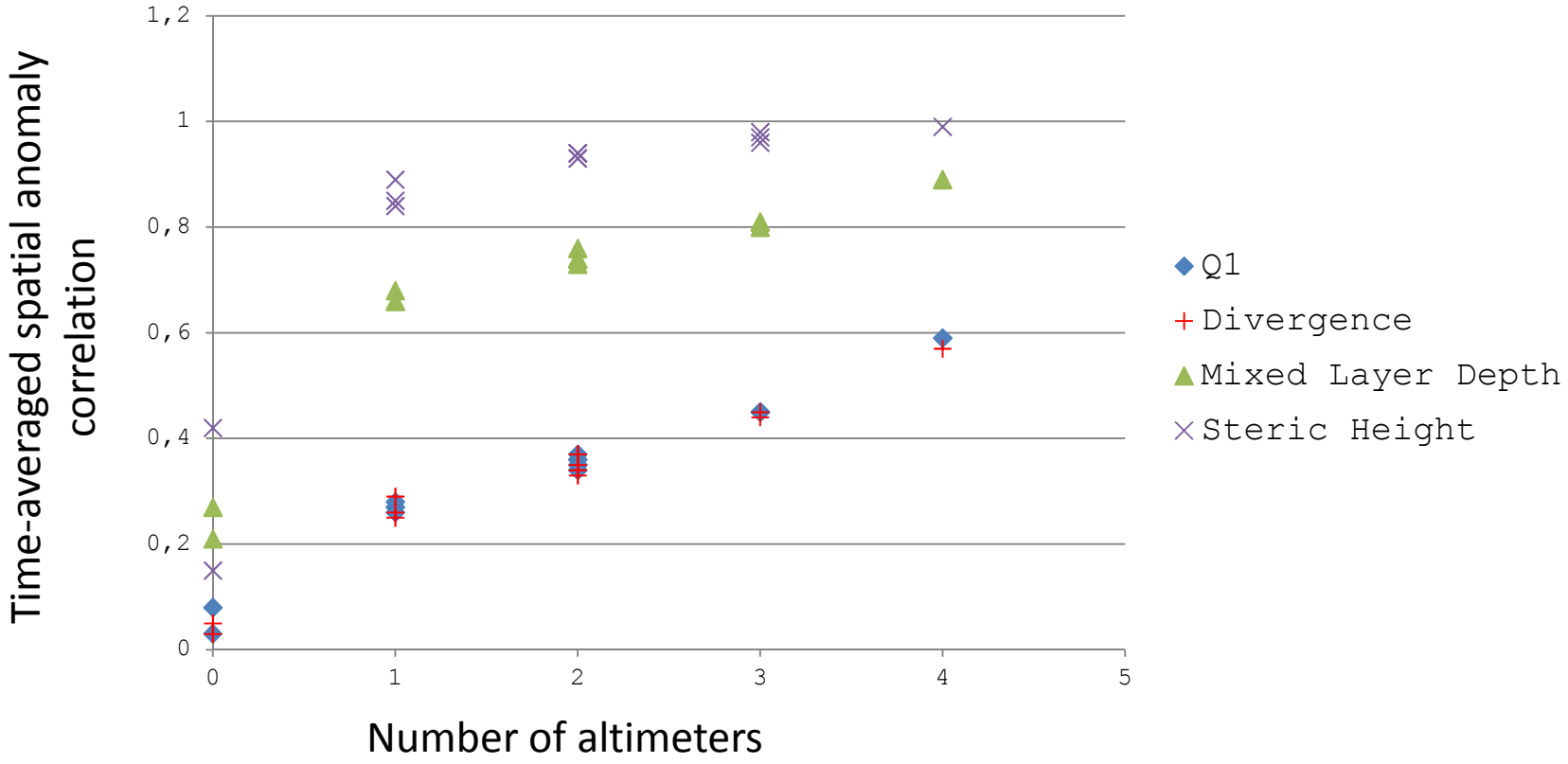
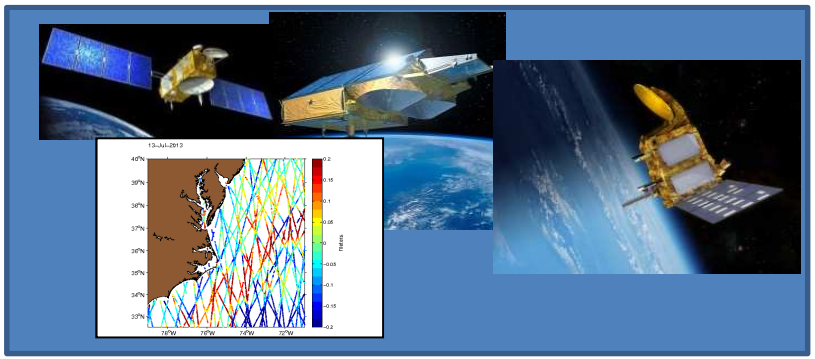
Simulating conditional deterministic predictability within ocean frontogenesis

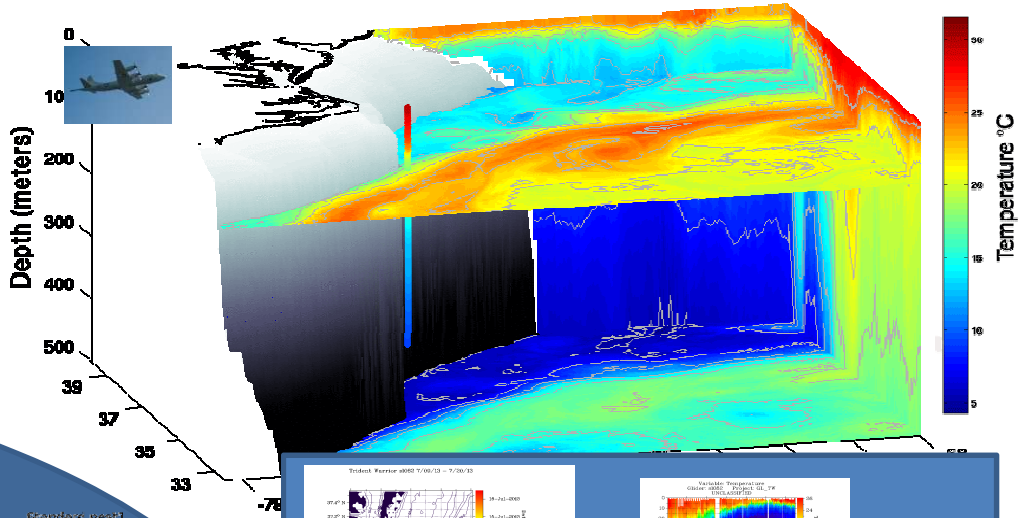


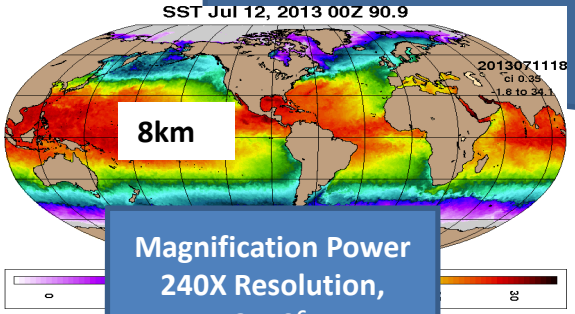
Demonstration of submesoscale frontogenesis prediction in a *simulated* environment

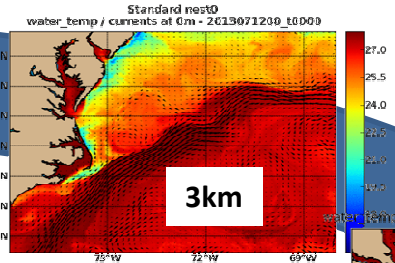
An experiment of opportunity, July 2013

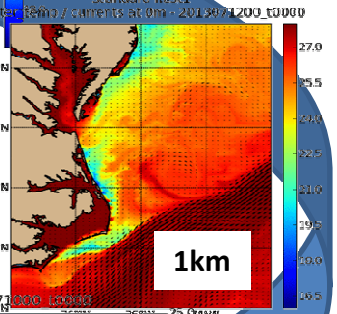


Gulf Stream experiment, 2013 — 11 July

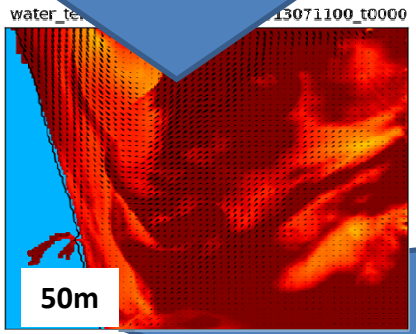


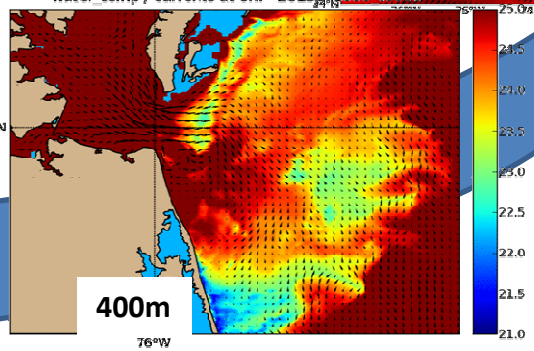


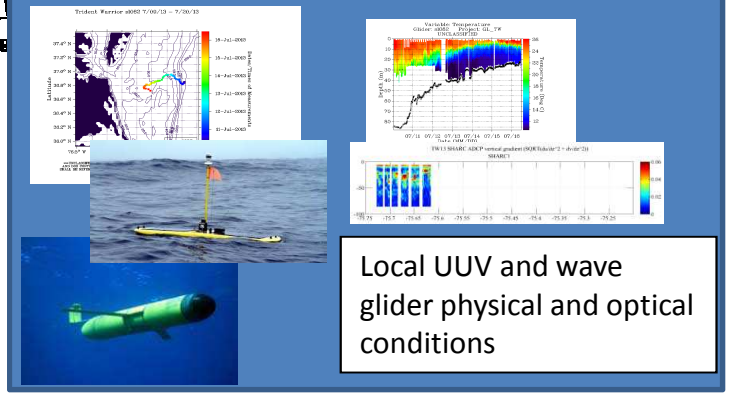




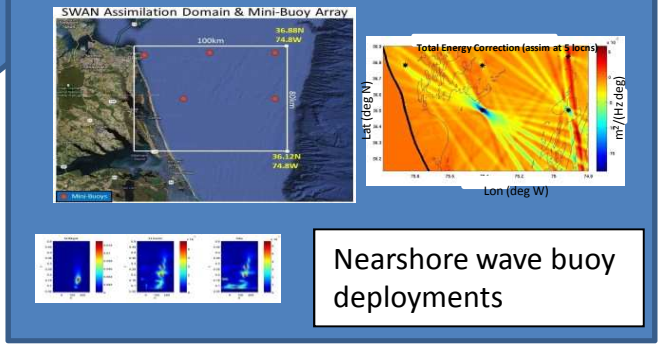
Magnification Power
240X Resolution,
13×10^6 X
Computational





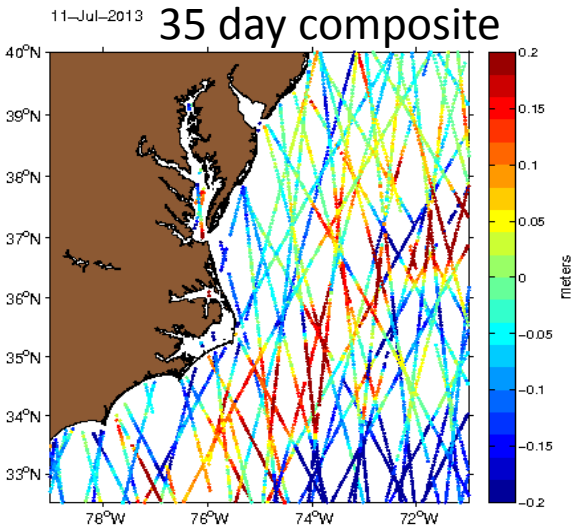


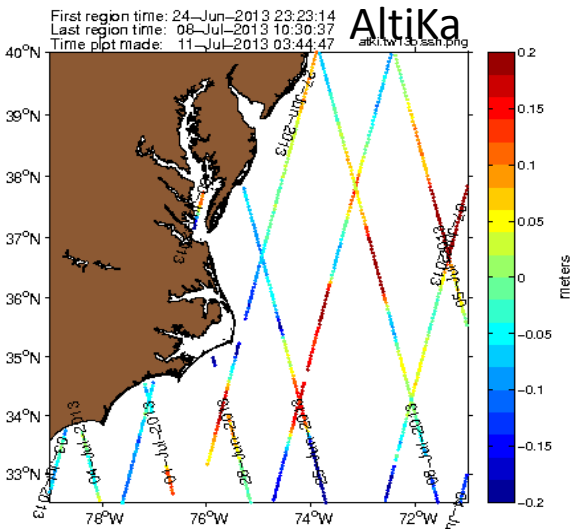
Local UUV and wave glider physical and optical conditions

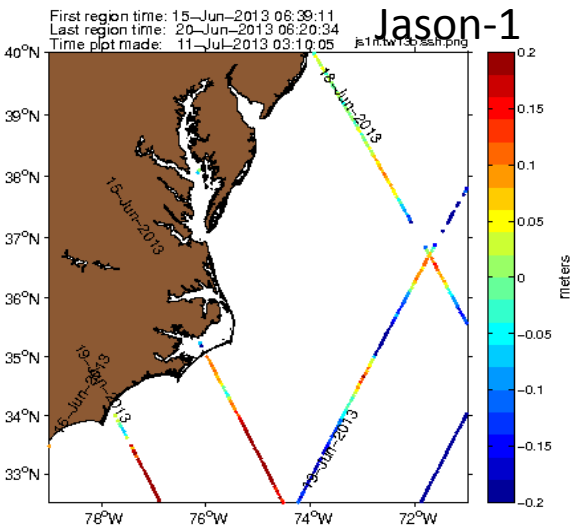


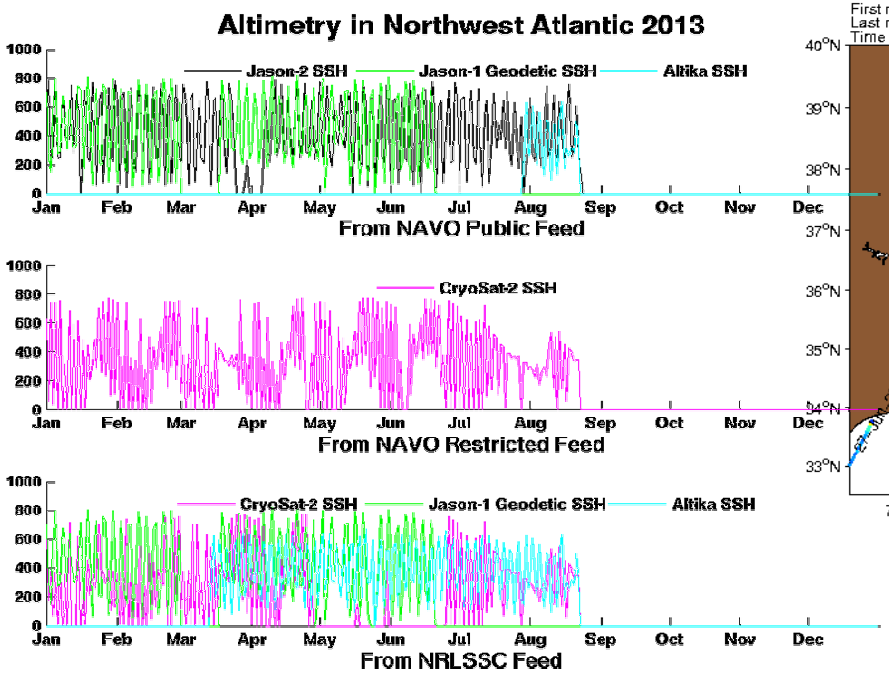
Nearshore wave buoy deployments

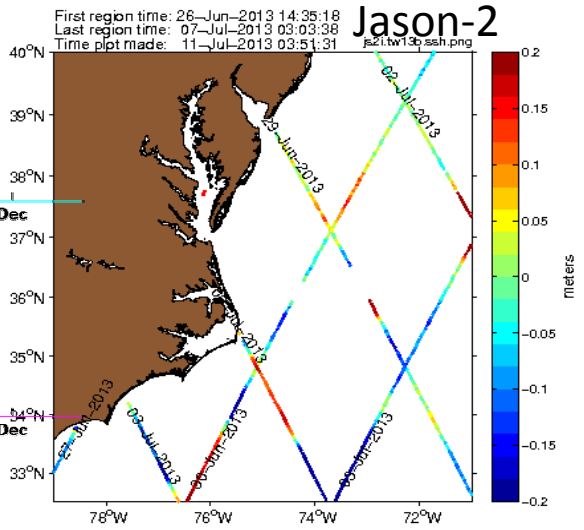
Altimeter coverage
AltiKa, Jason-2, Jason-1 Geodetic, CryoSat-2

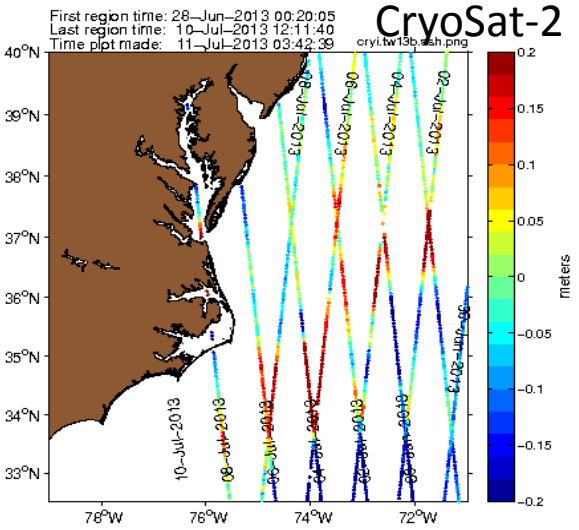








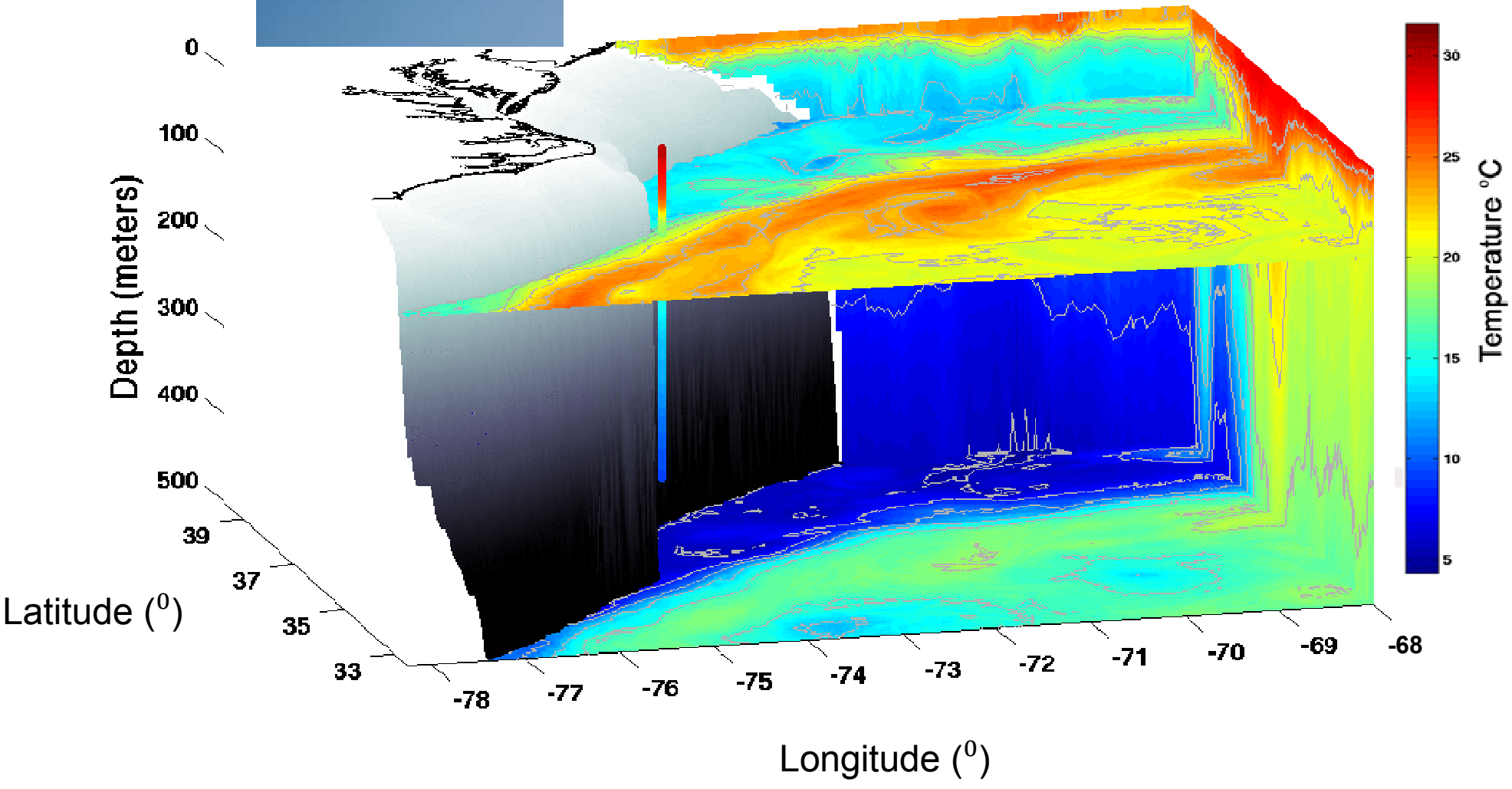




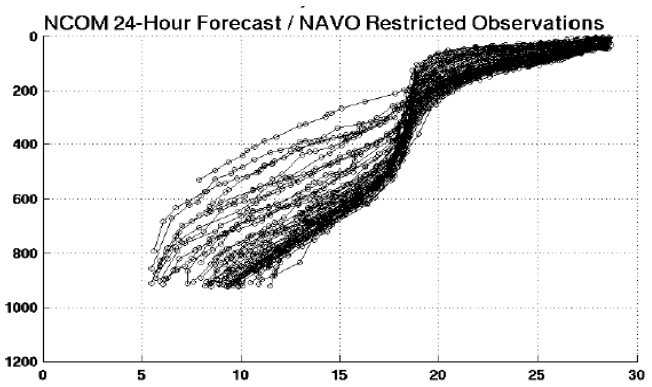
Demonstration in real environment

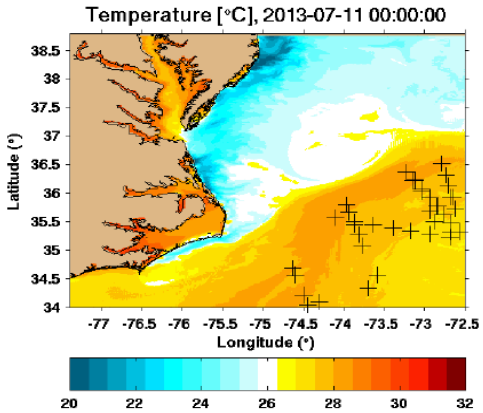
4 P-3 flights (July 11, 15, 17, 18, 2013)

285 AXBTs

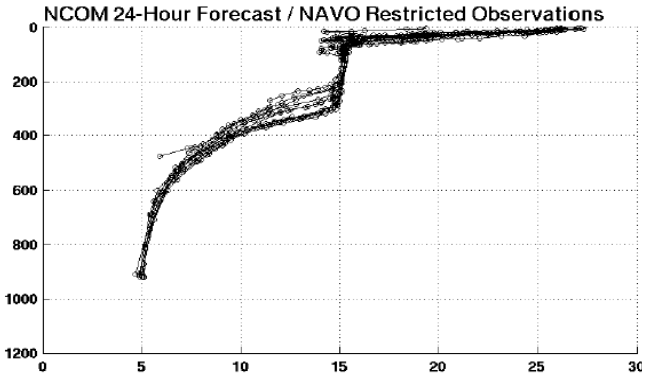


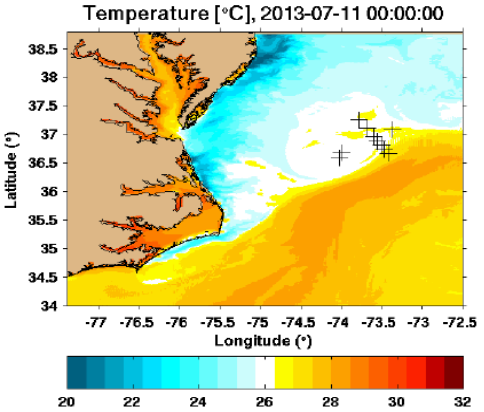
AXBT Observations



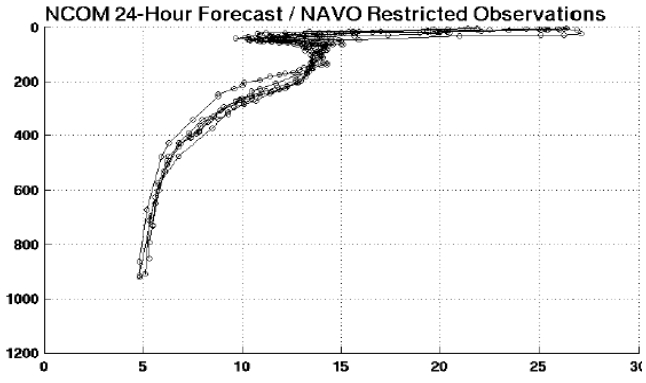


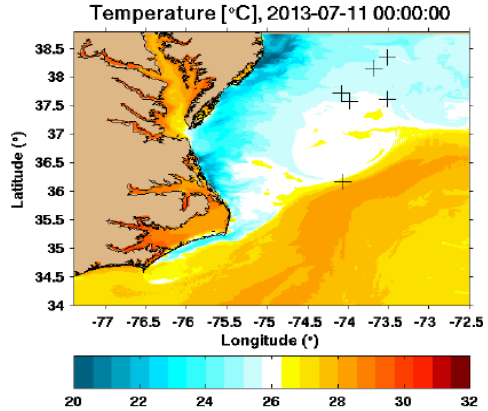
Warm deep thermocline at 600-800 m in waters south of the Gulf Stream in the recirculation gyres





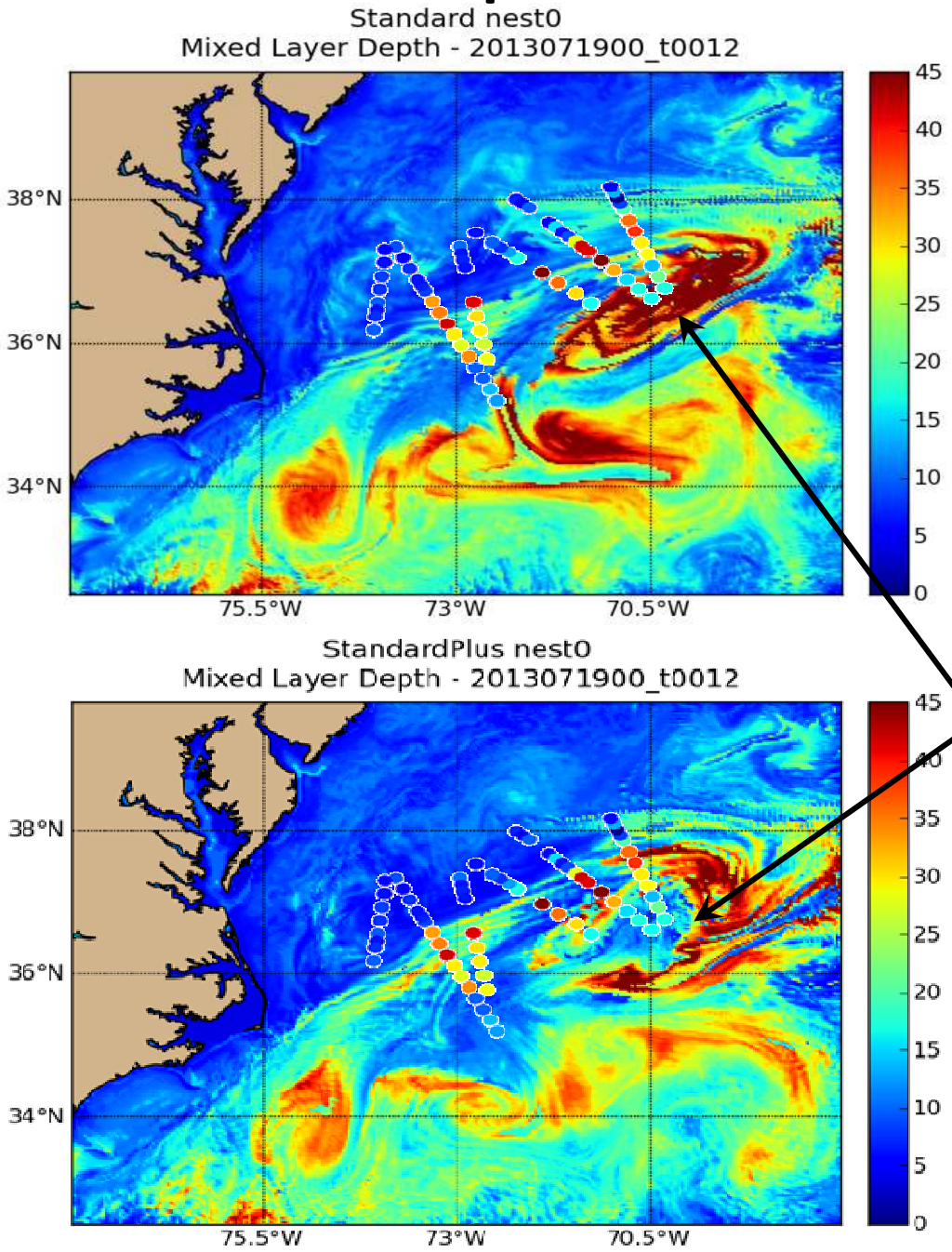
Anticyclone on the northern side of the Gulf Stream with base at ~300m





Temperature inversions in the northern Laborador Sea waters (also in climatology)

Impact of AXBT Observations



Several experiments were run in real time

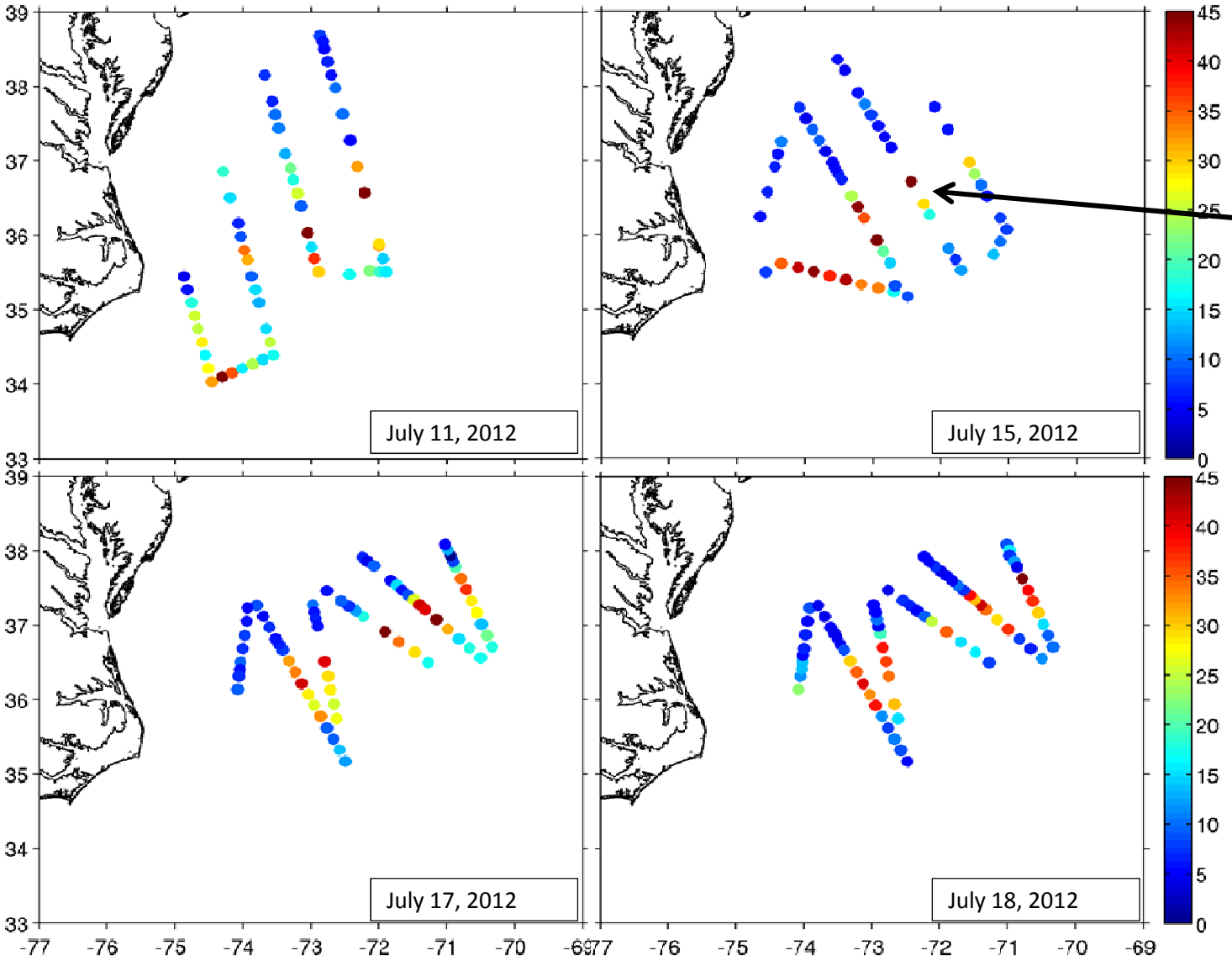
Standard experiment did not assimilate AXBT data

Standard Plus experiment did assimilate AXBT data

Anticyclonic recirculation gyre south of Gulf Stream shows significant change with AXBT data

MLD associated with recirculation gyre is also impacted

Observed mixed layer depth



MLD is strongly modulated by mesoscale structure

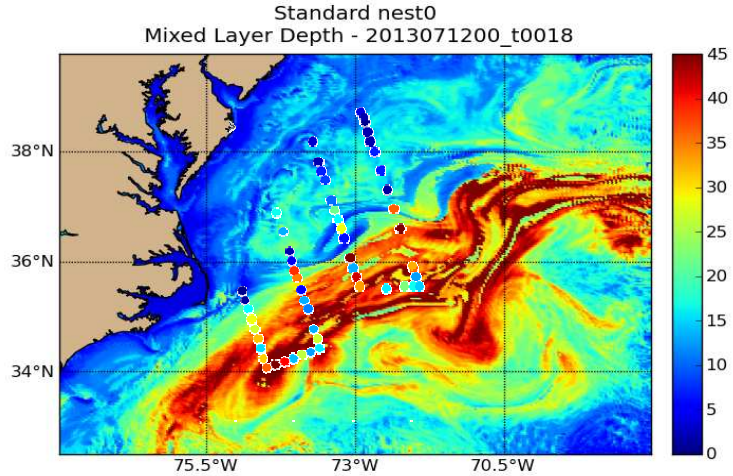
Deeper mixed layer occurs across recirculation gyres

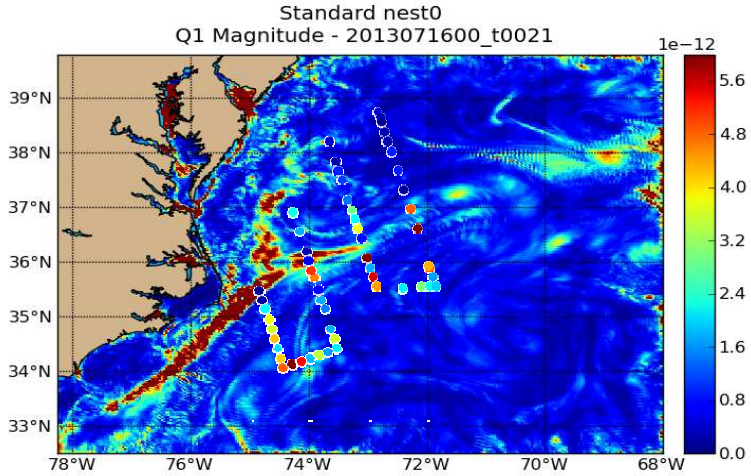
Quantifying by MLD is challenging

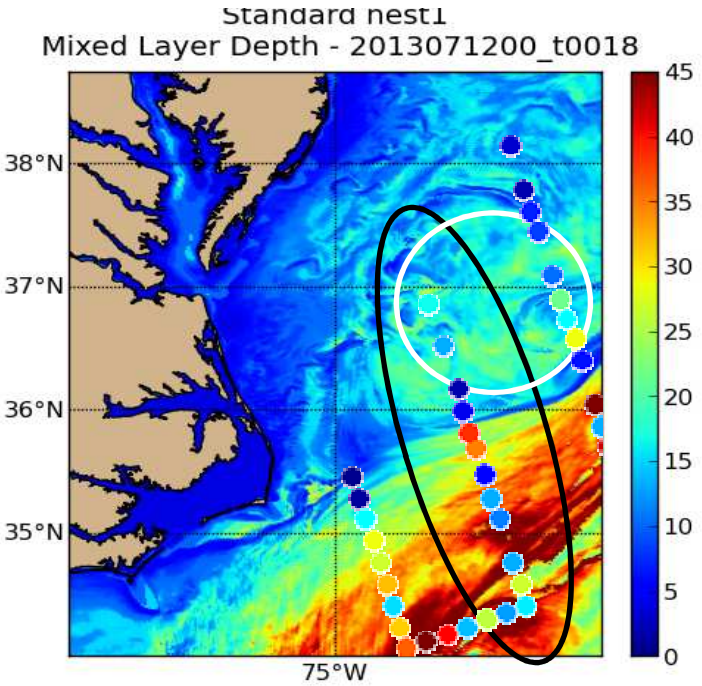
Winter presents very deep mixed layers where frontogenesis is not sufficient to have impact

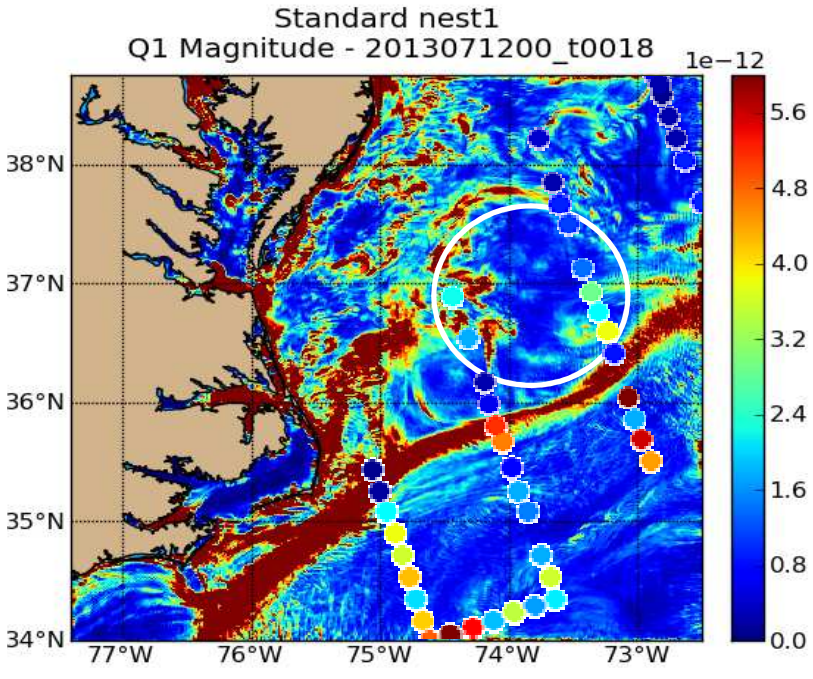
Summer presents very shallow mixed layers in which frontogenesis may have little opportunity for impact

Observed MLD related to Q1 in Standard

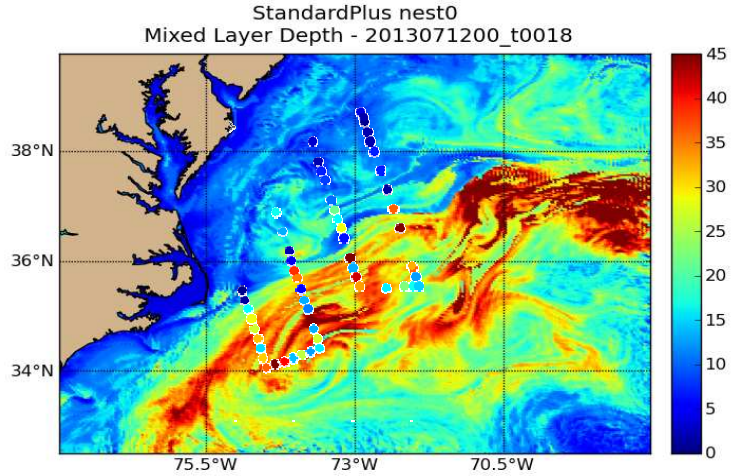


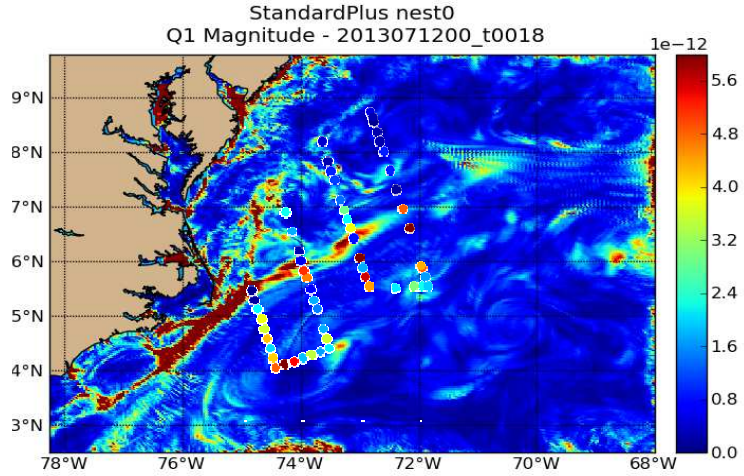


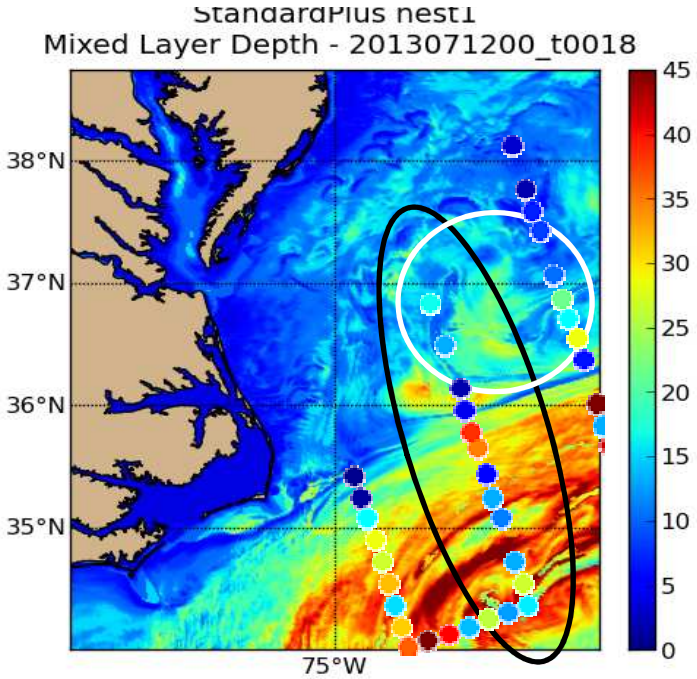


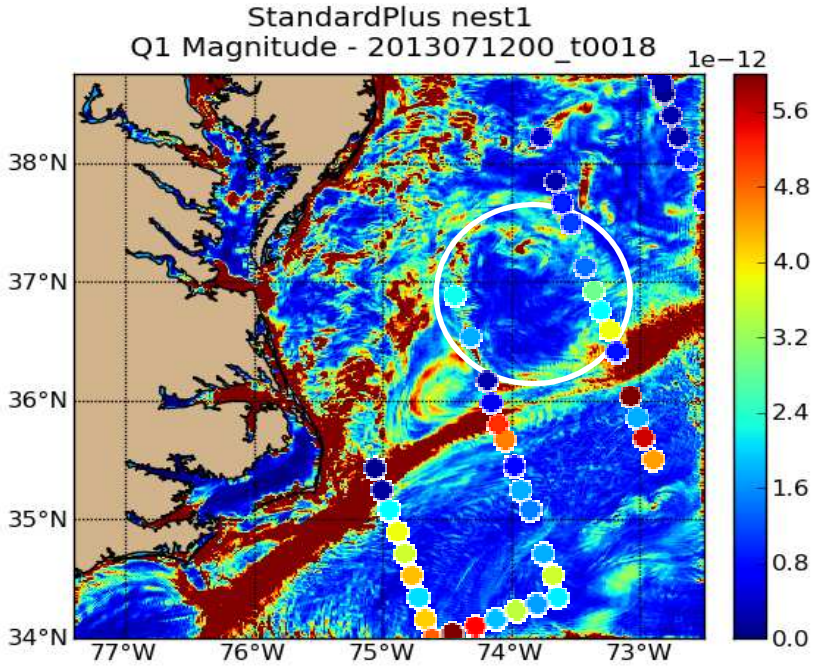


Observed MLD related to Q1 in Standard Plus







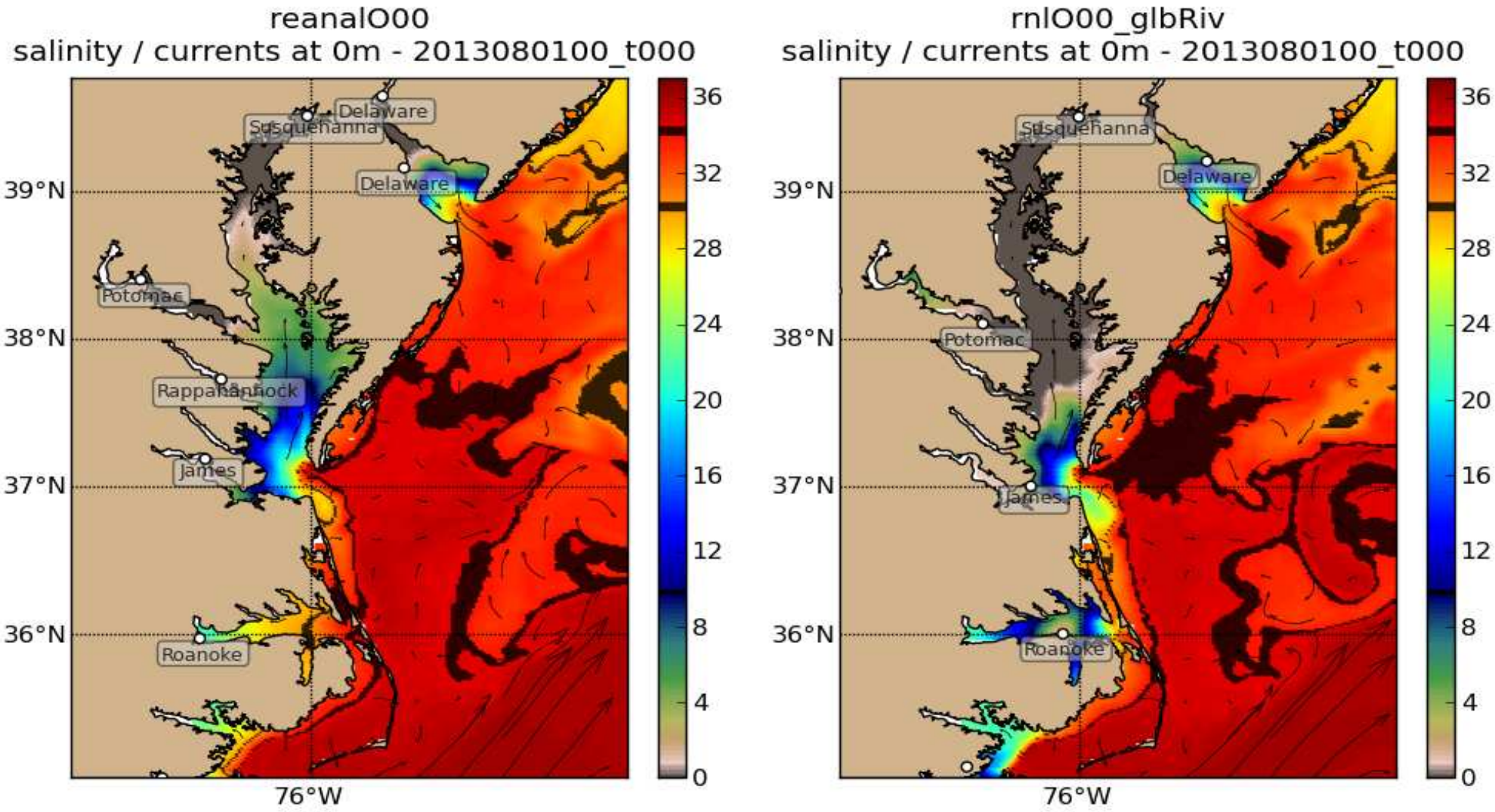


Conclusions

- **AXBT observations are consistent with predicted areas of thinning mixed layer**
- **The challenge of submesoscale frontogenesis prediction is the precise positioning of mesoscale structure**
- **SWOT should be expected to advance frontogenesis predictability greatly and open far more extensive opportunity to understand the processes**

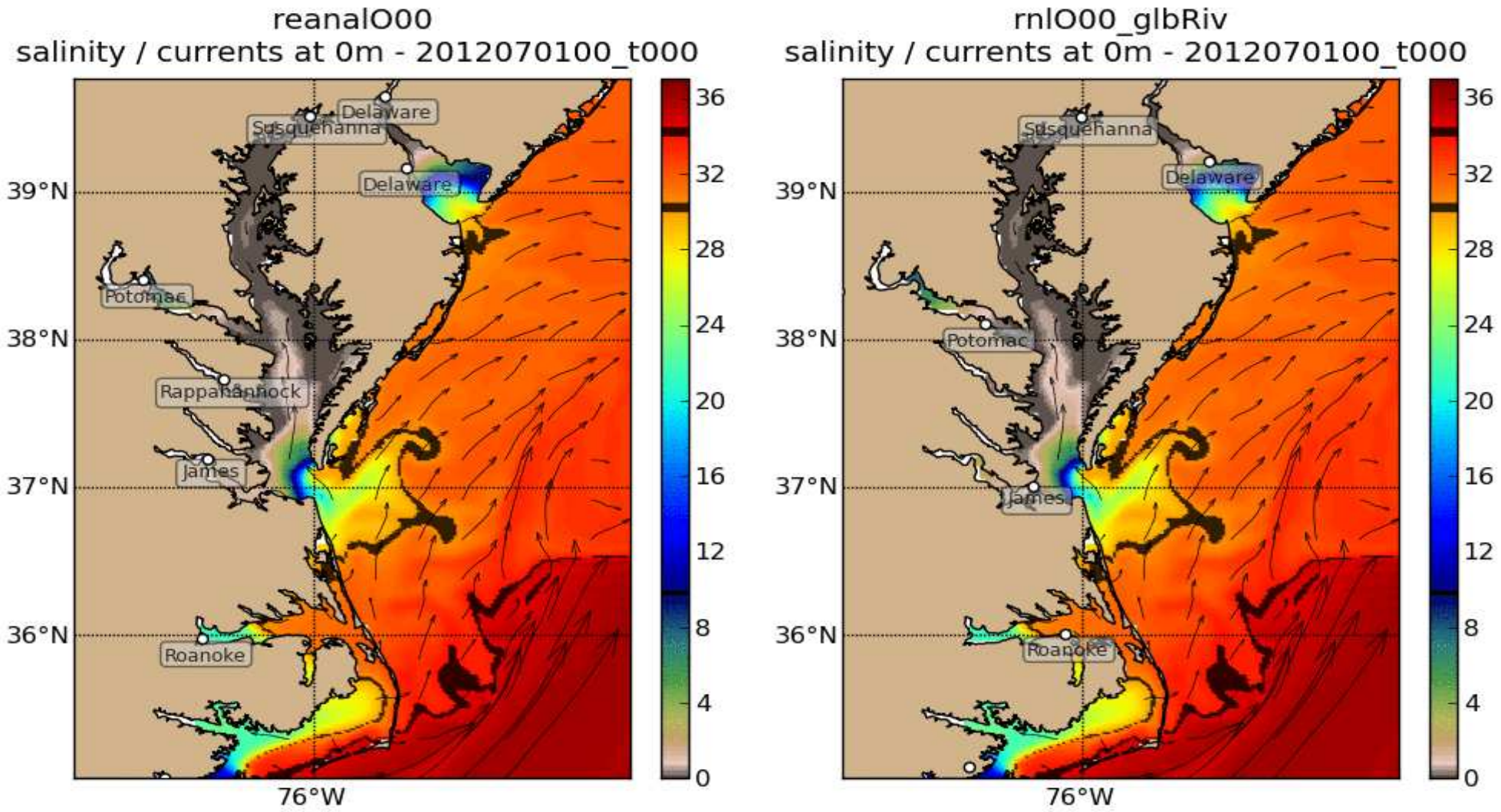
- **SWOT will also advance the coastal circulation by providing fresh water runoff**

Effects of observed river flows on coastal circulation



Questions?

Effects of observed river flows on coastal circulation



From 2011 OSTST: Predicting unobserved ocean filaments from altimeters

10 days every 3 hours

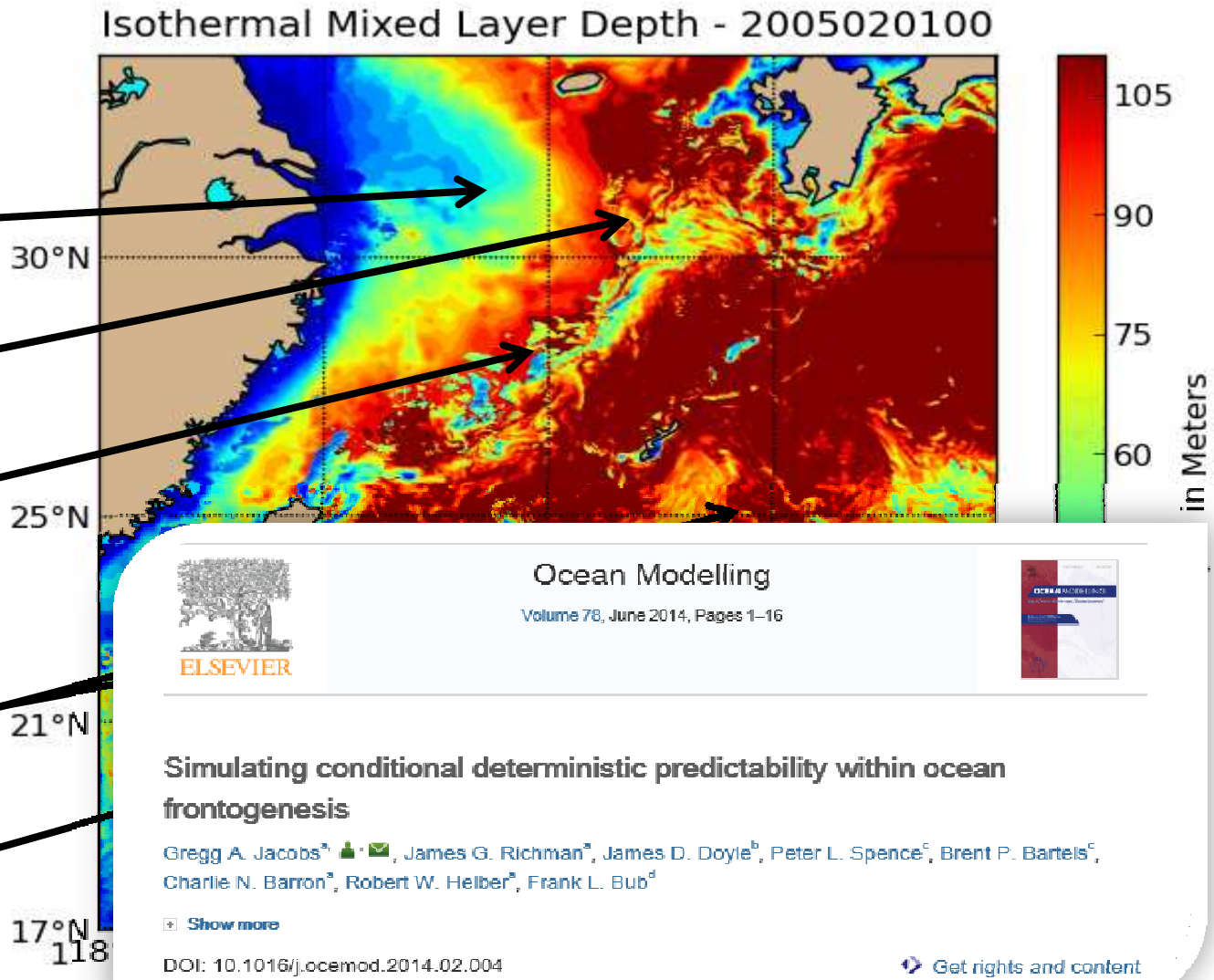
Tidal effects:

- Isothermal layer to the bottom on shelf
- Internal waves propagating onto the shelf
- Kuroshio sloshing

Minor diurnal heating effects

Deeper mixed layer in anticyclones

Most importantly, frontogenesis filaments



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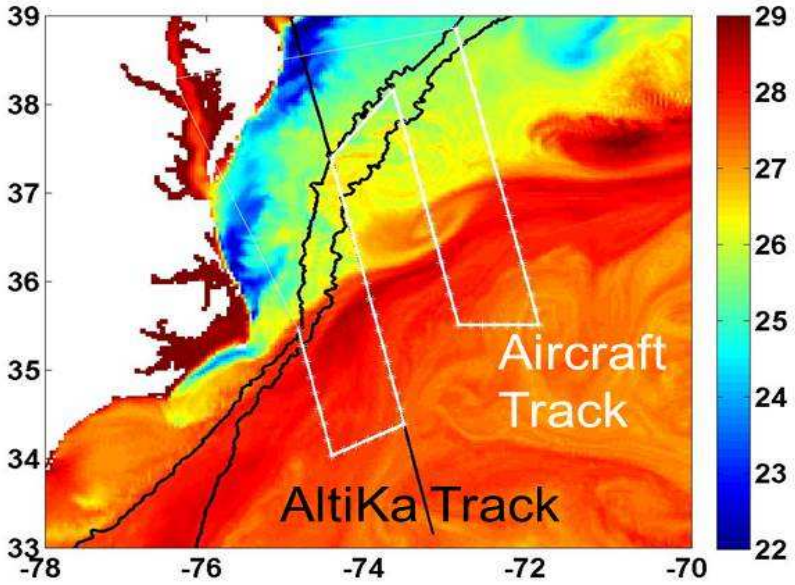
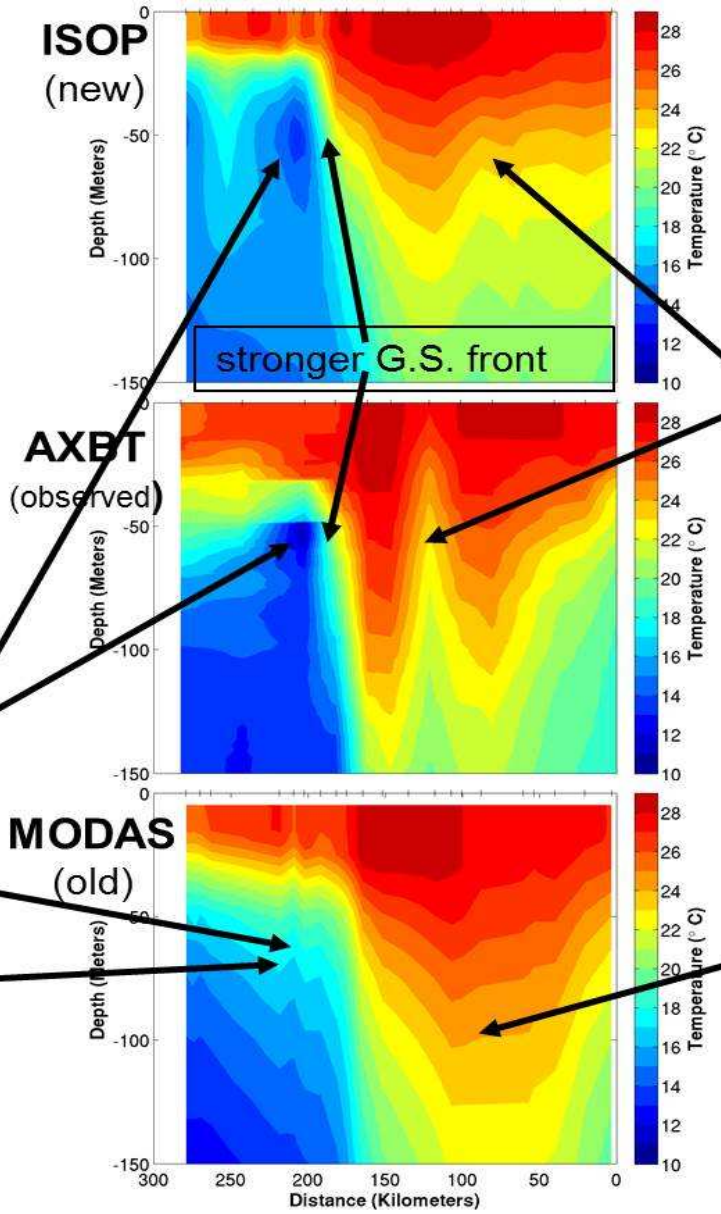
One aircraft flight along AltiKa track to verify vertical covariance structures in assimilation process





stronger G.S. front

ageostrophic thinning

intermediate temperature minimum, temperature inversion below

weaker Gulf Stream front

no intermediate temperature minimum, no temperature inversion

no ageostrophic thinning

NCOM (using NCODA with ISOP or MODAS) and AXBT sections are on 11 July below an AltiKa underflight during Trident Warrior '13