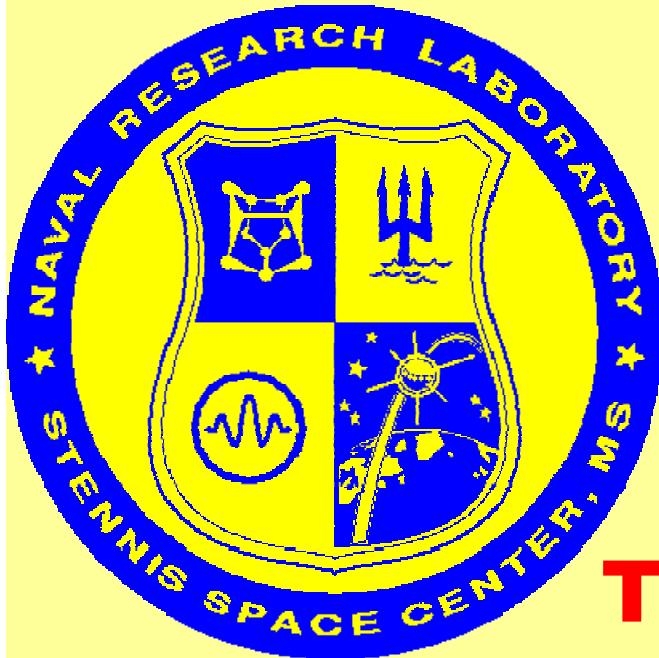


**20 Oct 2010**



# **FORECAST SYSTEM AND ADAPTIVE SAMPLING IN SUPPORT OF REP\_10**

## **The NRLSSC Team:**

**Germana Peggion, E. Coelho, C. Rowley,  
L. Smedstad, K. Heaney, P. Spence, and D. Sitton.**

**The wind team: M. Phelps, P. Posey**

**The computer team: B. Maloy, D. Goolsby**



**[gpeggion@uno.edu](mailto:gpeggion@uno.edu)**

**This presentation would not have  
been possible without the generous  
contribution of the NURC team.**

**A very special thank to our friend  
*Alberto Alvarez***



For the *first* time in our collaboration with NURC:

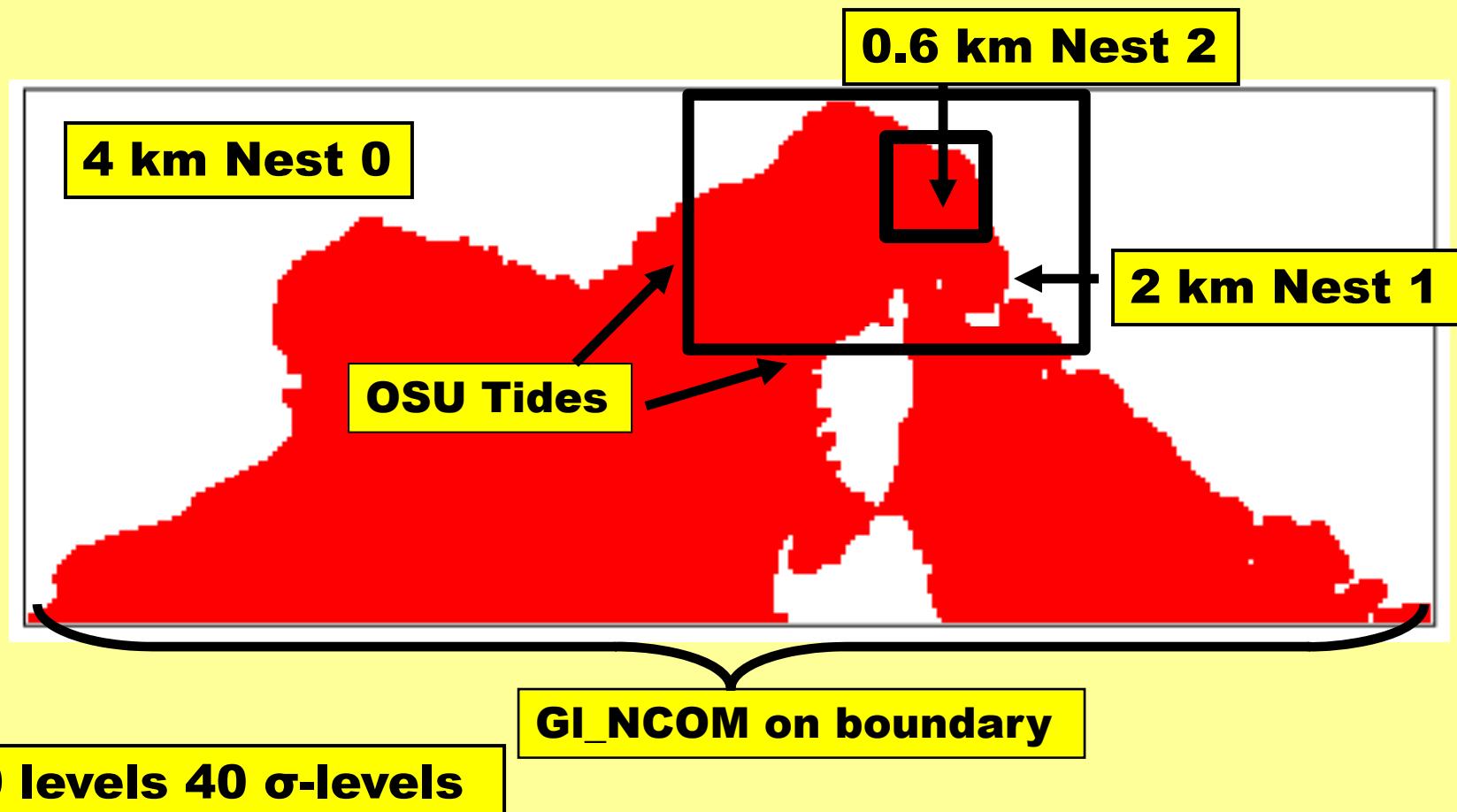
1. Assimilated realtime data
  - NCODA (J. Cummings)  
**No more free run !!!**
2. Provided 72hr forecast (60 hr real forecast)
3. Identified areas of model uncertainties and ocean variability (32 ensemble)
4. Estimated Cost Function (ETKF)



5. Ran a Genetic Algorithm
6. Gave guidance to glider Laura
7. Retrieved and processed Laura data
8. Back to Start
9. Done a preliminary '*realtime*' evaluation from the other gliders and CTDs data
10. No acoustic component

**Simulations started at 10:00 (GMT+1),  
glider path delivered at 17:00**

# The 3 nested Domains



# Domain Configuration

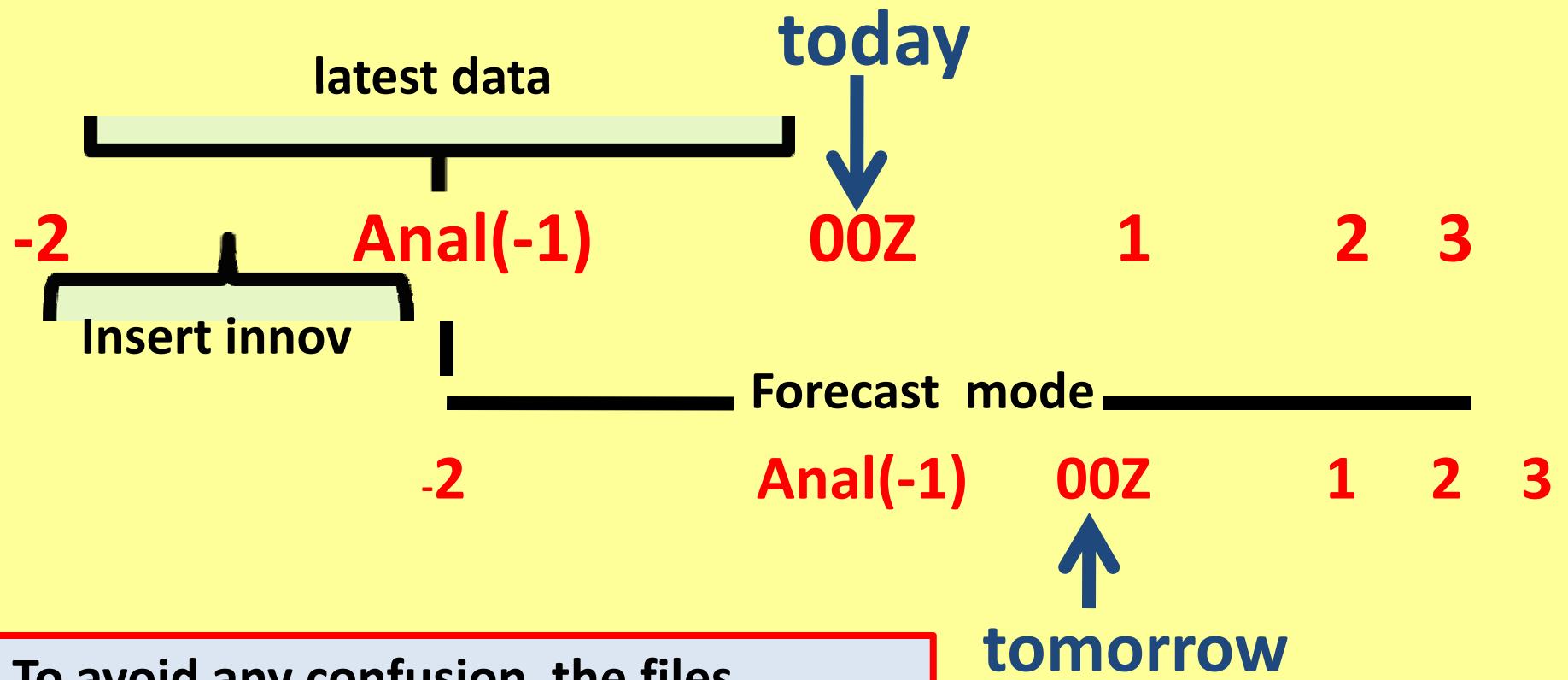
## Anywhere Anytime System

- Data Assimilation for **Nest0** and **Nest1**
  - Data from operational server
  - Laura (up to 18Z of previous day)
- **Nest2 is a free run**
  - forced by the OBC from Nest1
- **32 ensemble for Nest1**

# Domain Configuration

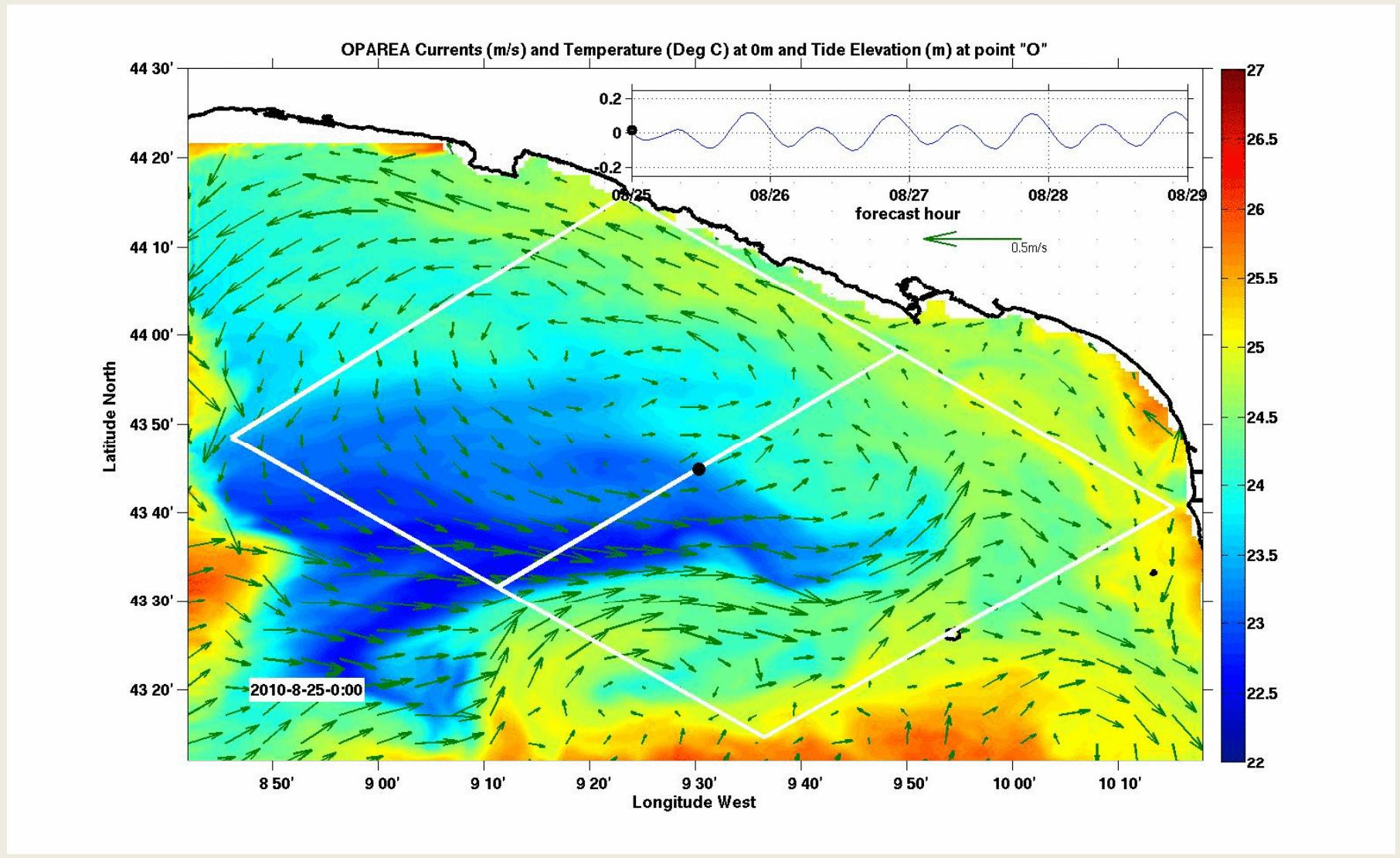
- **Coamps europe3** winds from 20070519
- **NCOM\_gl** from yesterday forecast
- Simulations done on the **house cluster**
  - 4-8 cpus per domain
  - 64 total cpus for ensemble

# The Forecast Cycle



To avoid any confusion the files posted on the ftp have the time stamp relative to today and not analysis time

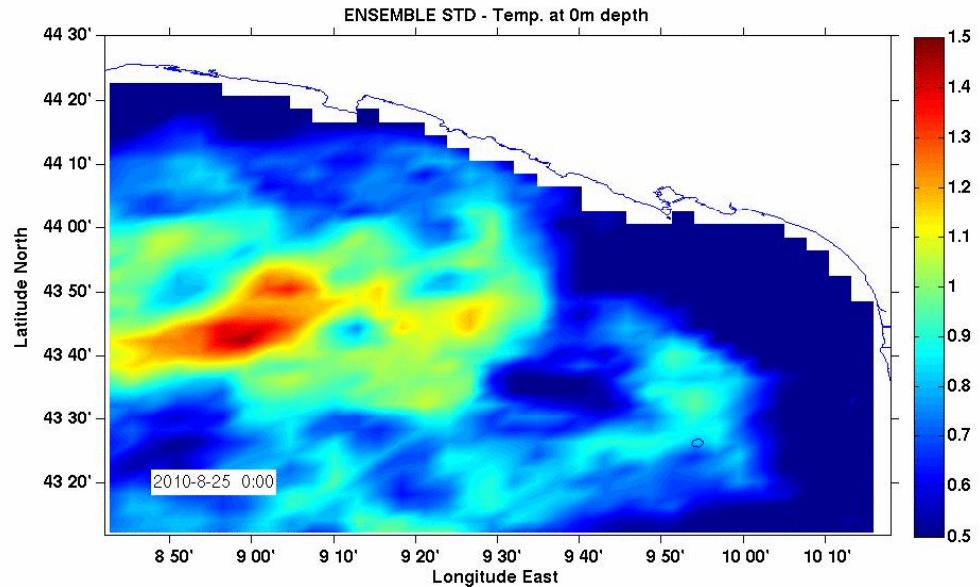
# Nest1 Temperature & Currents at 0m



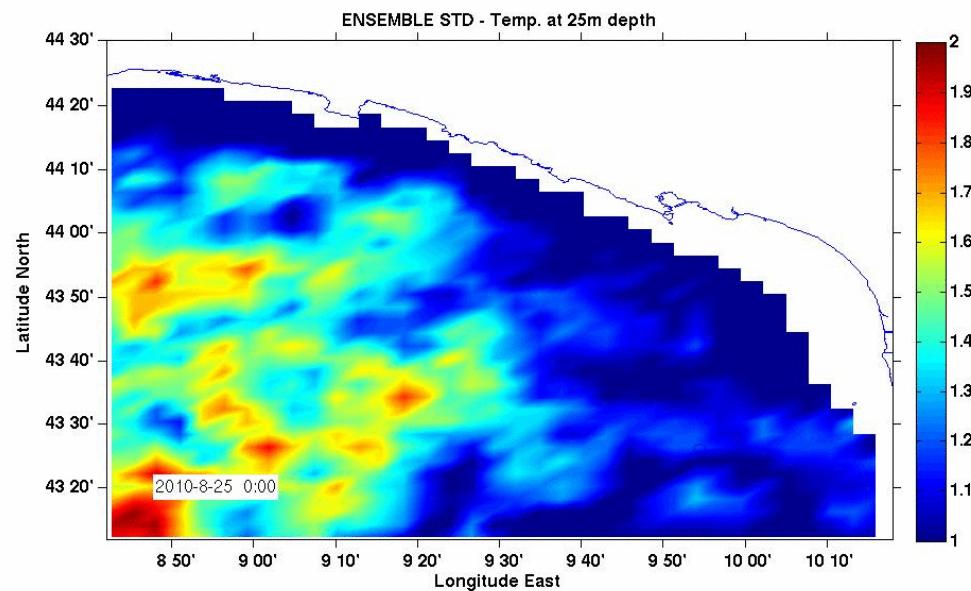
# Ensembles

- They represent the **forecast uncertainty**
  - Initial conditions:  
Ensemble Transform, *Bishop and Toth, 1999*
  - Surface forcing:  
Space-time deformation of wind (COAMPS) fields
- Adaptive sampling guidance using the
  - Ensemble Transform Kalman Filter (ETKF; Bishop, *et al.*, 2001)  
applied to the ocean model output
- Covariance fields
  - to be feed back to the data assimilation  
(not implemented yet)

# ENSEMBLE STD: Temperature



50m



# RISK MANAGEMENT EXAMPLE

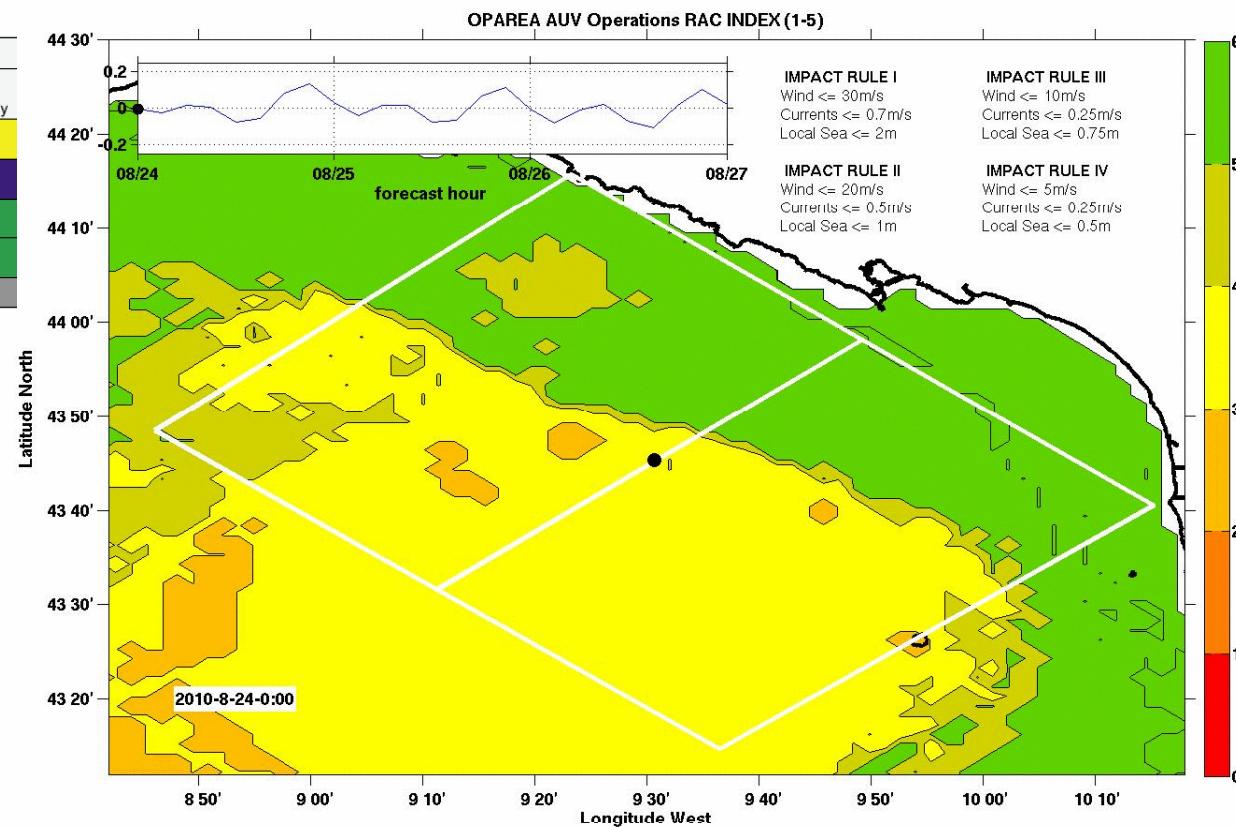
## AUV/GLIDER OPS DURING MREA10

Risk Management Matrix		PROBABILITY			
SEVERITY	Likely	A	B	C	D
		Probable	May	Unlikely	
I Death, Loss of Asset	1	1	2	3	
II Severe Injury, Damage	1	2	3	4	
III Minor Injury, Damage	2	3	4	5	
IV Minimal Threat	3	4	5	5	

1-Critical 2-Serious 3-Moderate 4-Minor 5-Negligible

### PROB. RULES

**A > 0.75**  
**0.75 > B > 0.5**  
**0.5 > C > 0.25**  
**0.25 > D > 0.1**



# Cost Function Morphologies

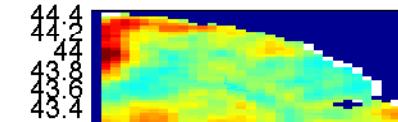
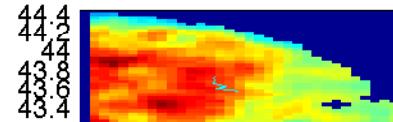
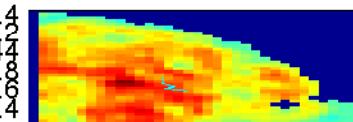
**Central Forecast**

**0m**

**25m**

**100m**

**Ens\_Spread\_T**

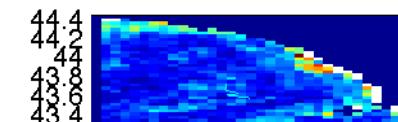
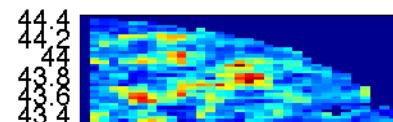
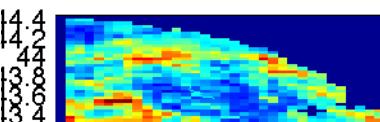


Ensemble Mean Temp 0m

Ensemble Mean Temp 25m

Ensemble Mean Temp 100m

**Ens\_Mean\_T**

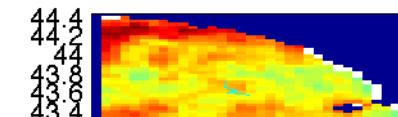
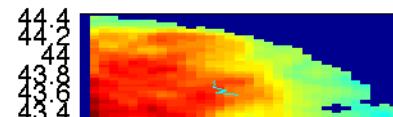
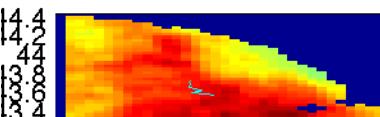


Mean Spread Temp over time 0m

Mean Spread Temp over time 25m

Mean Spread Temp over time 100m

**Mean\_Spread\_T\_over\_time**



CF Temp

CF BLG

CF ILG

CF SLD

CF SLD

CF SLD

**TOFU**

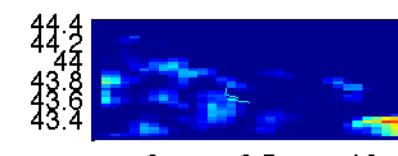
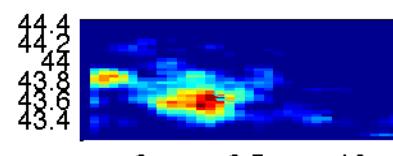
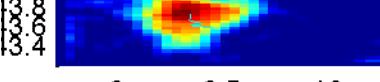
**CF Temp**

**CF BLG**

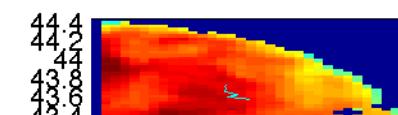
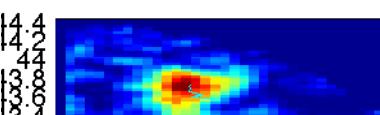
**CF ILG**

**CF SLD**

**Combined**



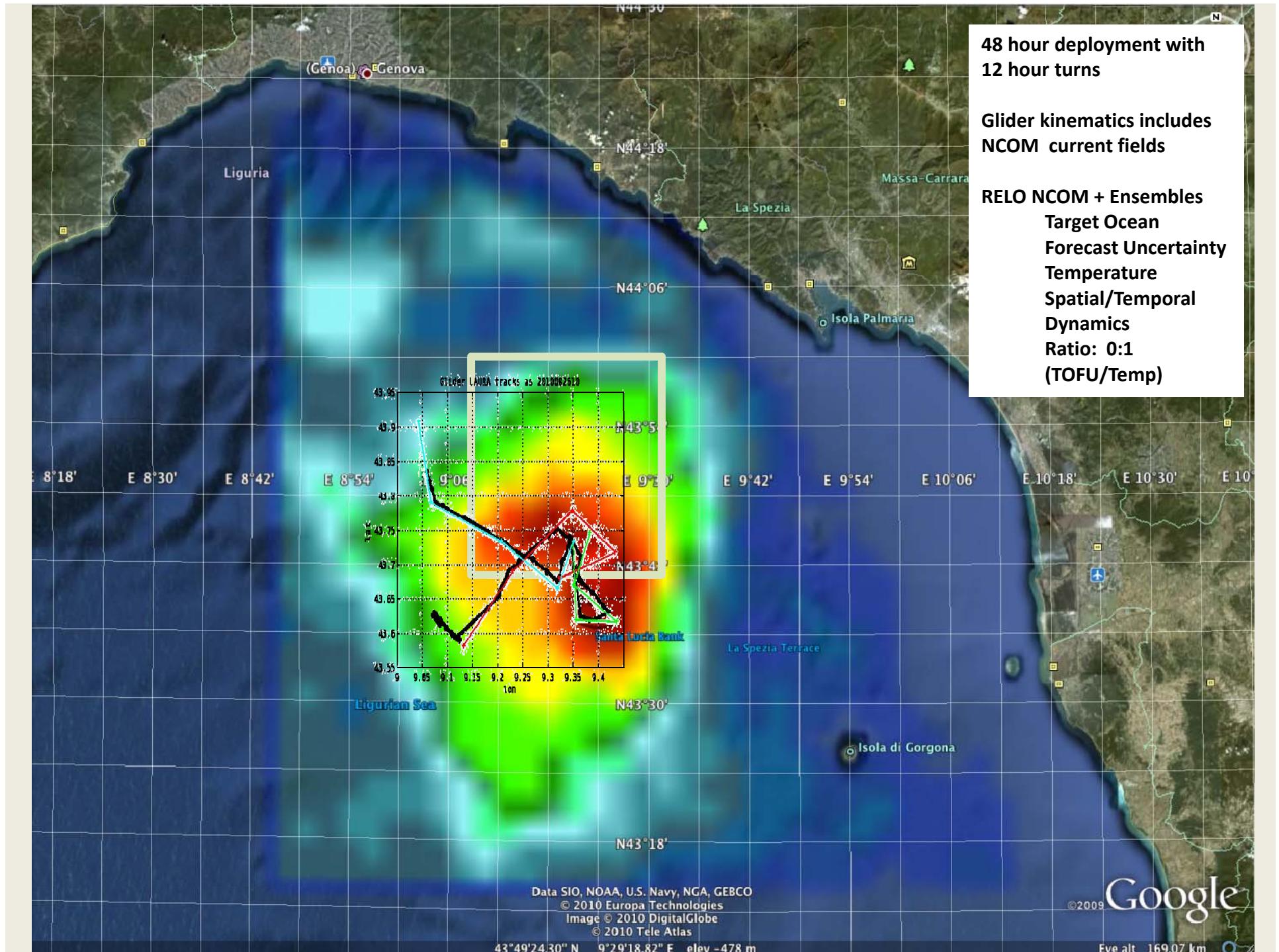
CF SLD



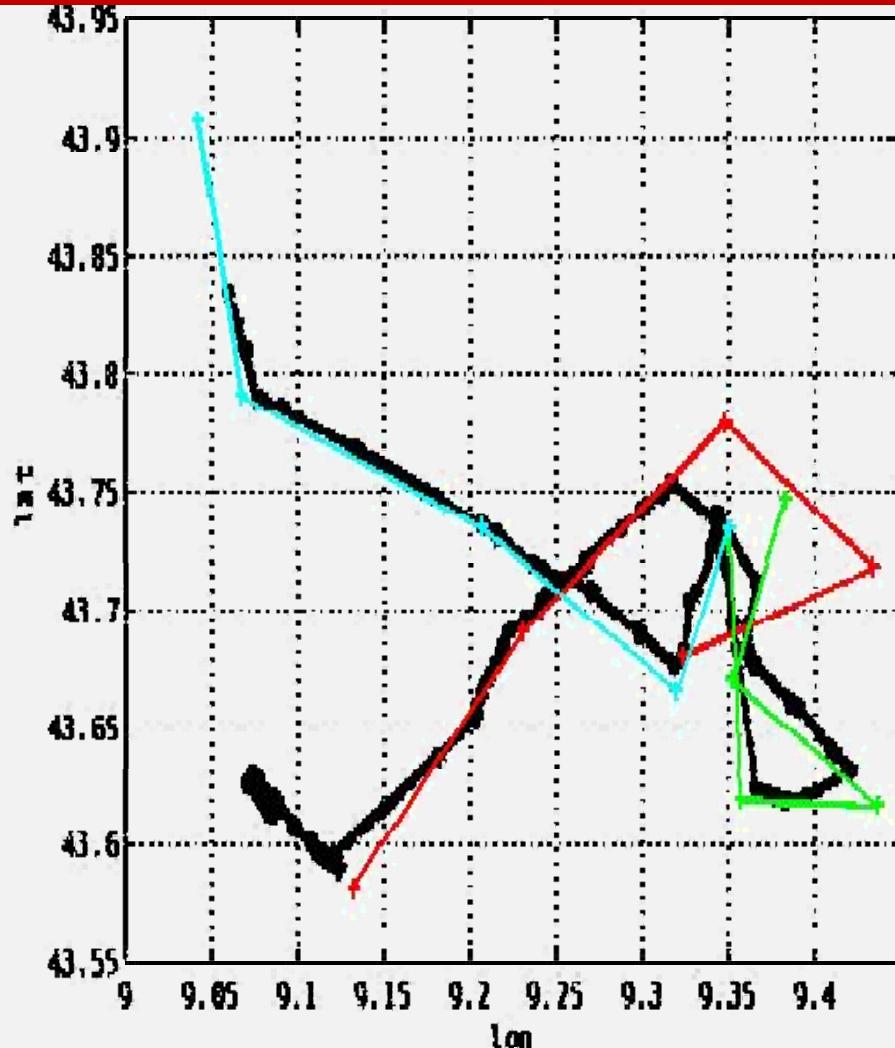
CF SLD

# **Optimal Glider Adaptive Sampling**

- **Goal**
  - Reduce model forecast uncertainty by determining the optimal sampling strategy of multiple heterogeneous sensors for collection of in-situ data
- **K. Heaney (Keynote Friday 14:00)**



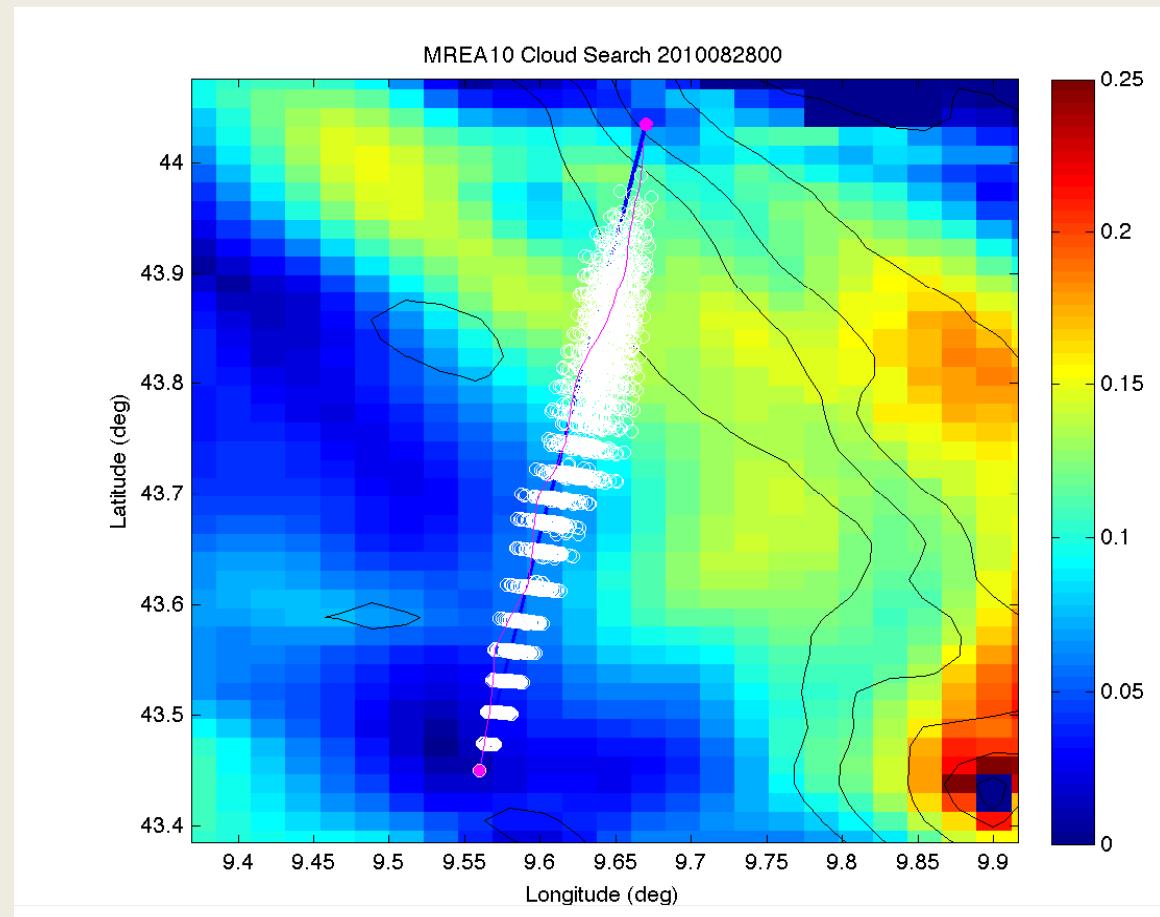
# Glider Laura Tracks



**Black – actual track  
Colors –delivered paths**

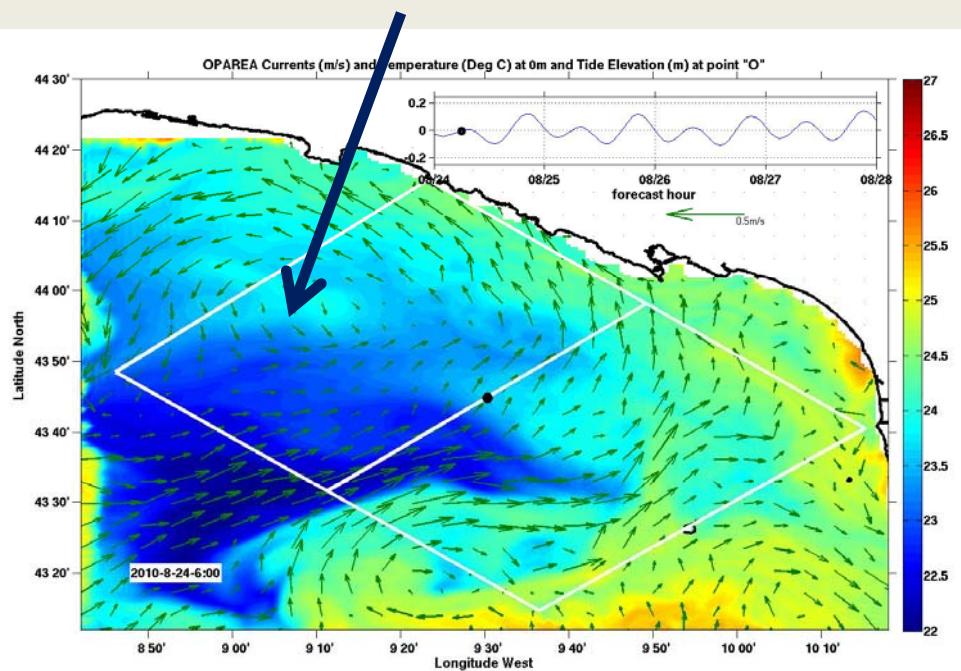
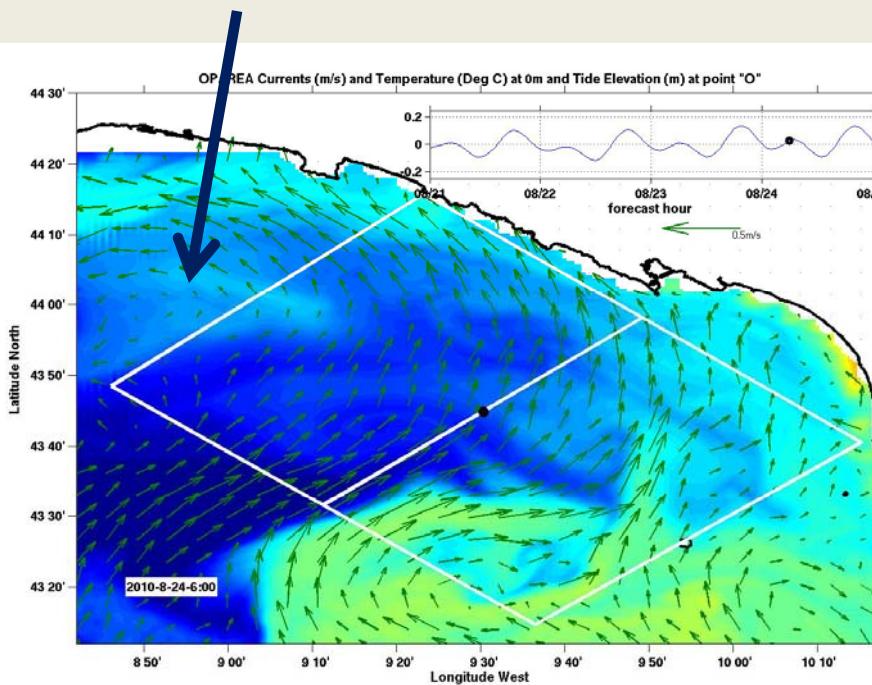
# Glider Race Optimal Search

- **Track search**
  - **48 hour run**
  - **Random turns at 8 hours**
  - **Minimize distance from finish line at 48 hours.**
- **GA could be used for multiple parameter search**
  - **Min/max surface depths**
  - **Turns**



# Preliminary evaluation

# Effects of Data Assimilation

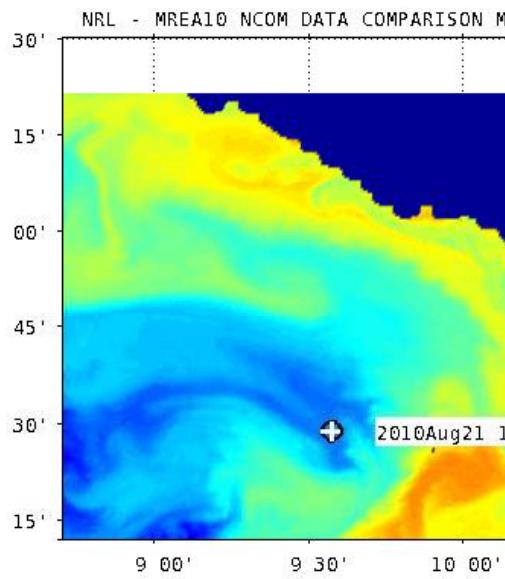


**78hr forecast from 2010082100**

**6hr forecast from 2010082400**

Eddy on the NW corner has moved inside the target area

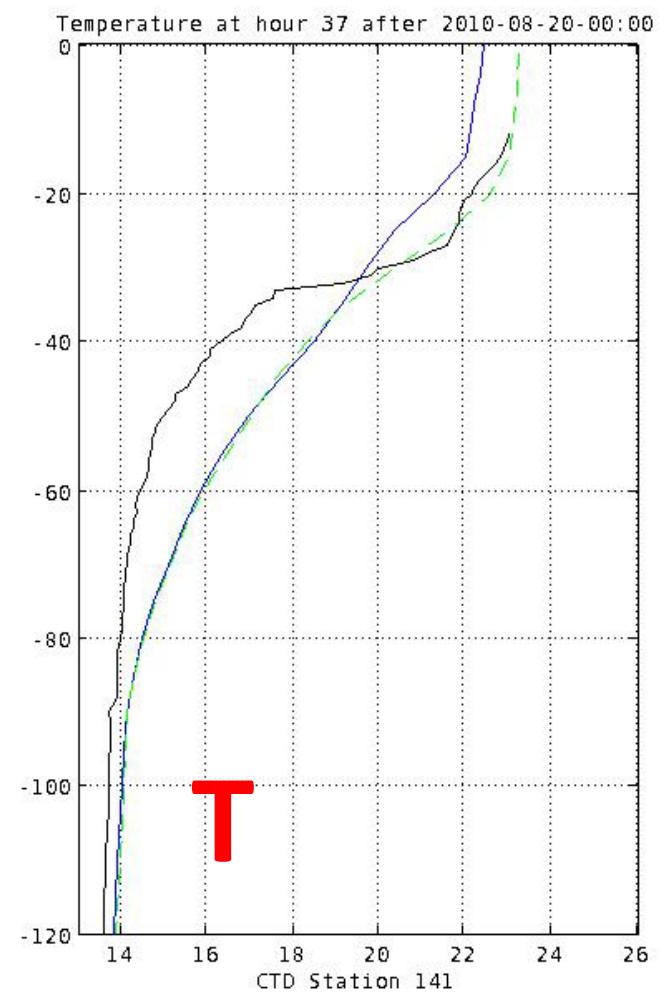
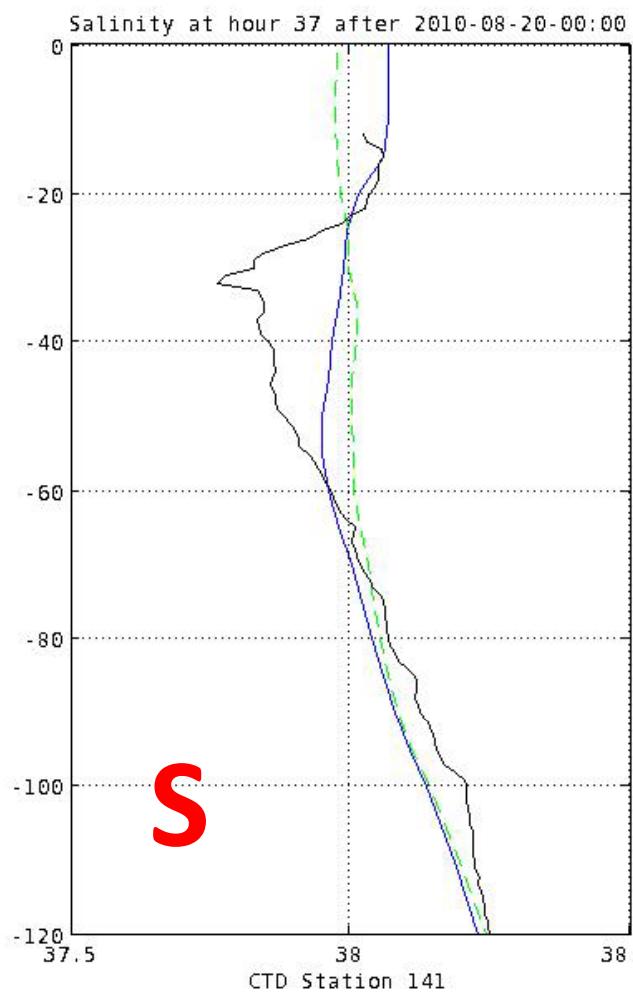
# Before Laura Data (20071020)



CTD

Nest1

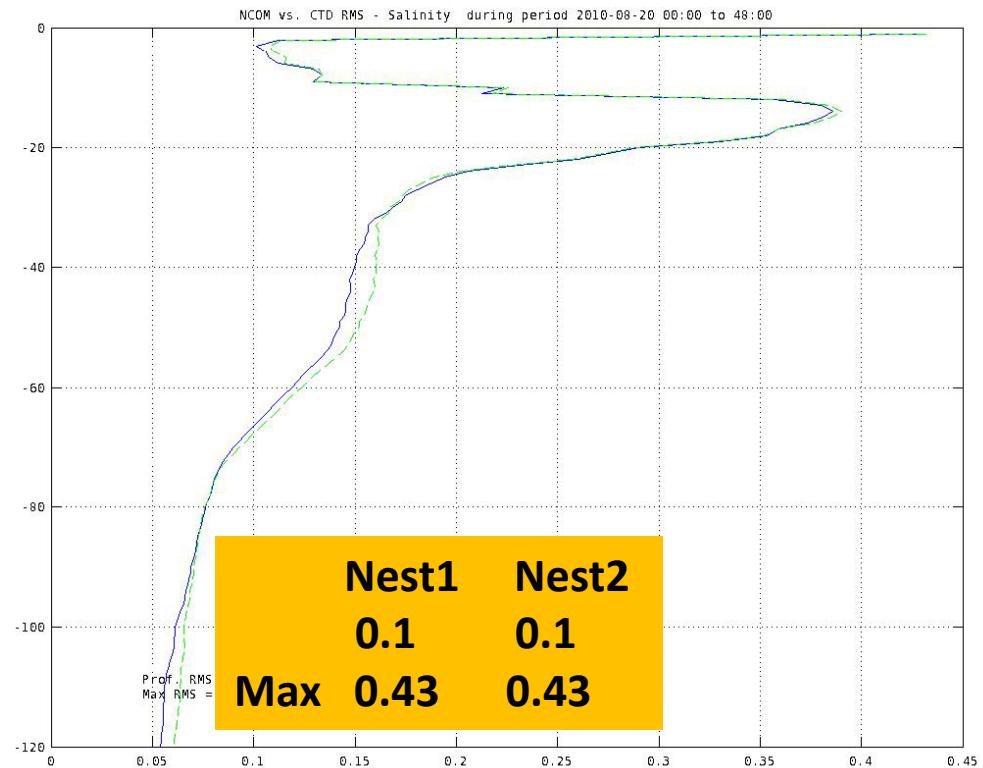
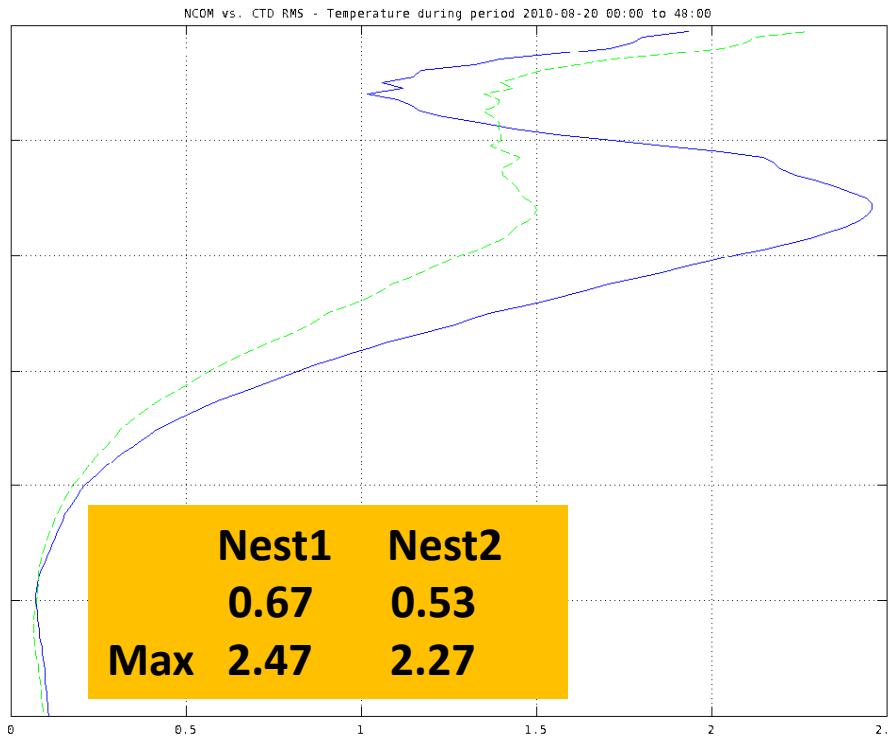
Nest2



CTD Station 141

# Before Laura Data (20071020)

## RMS Target area

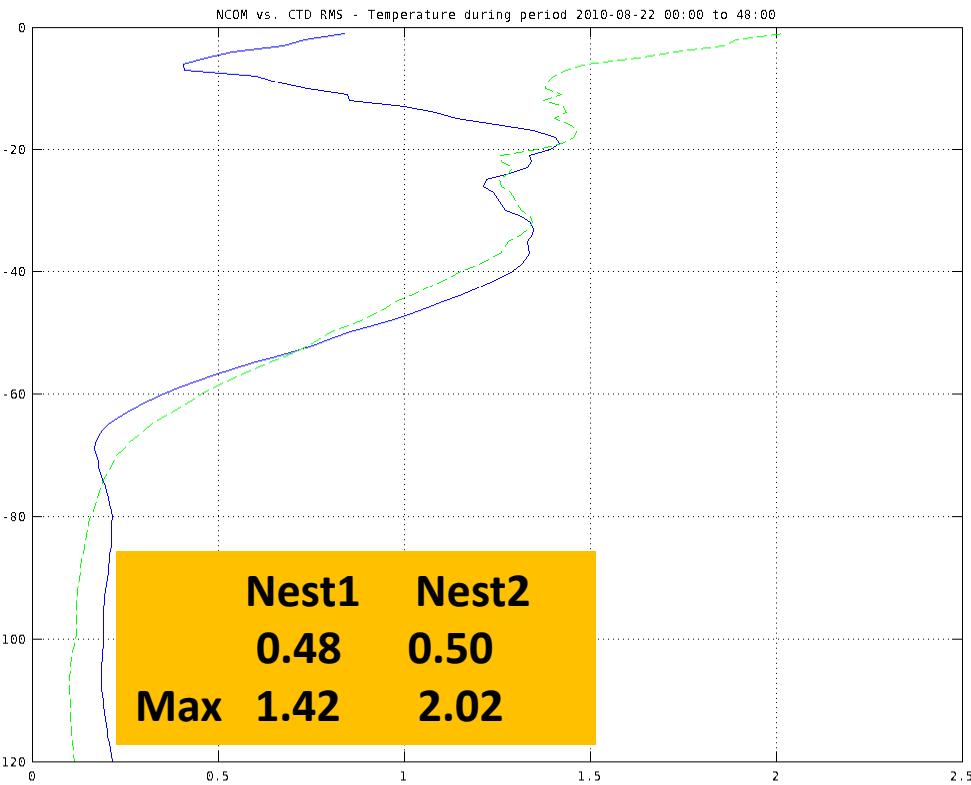


# Temperature

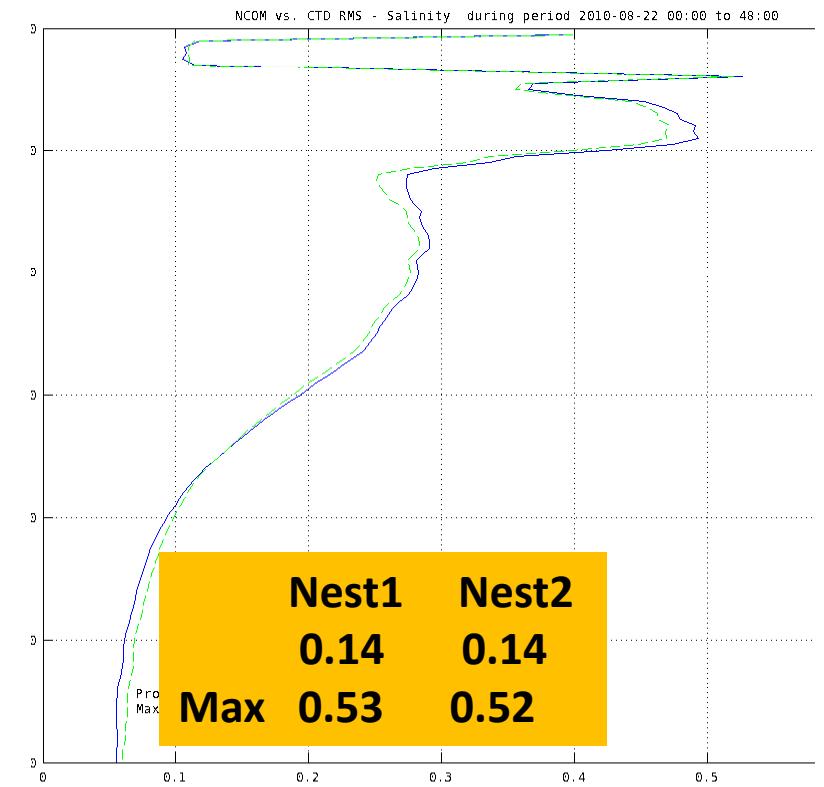
# Salinity

# After Laura Data (20071022)

## RMS Target area

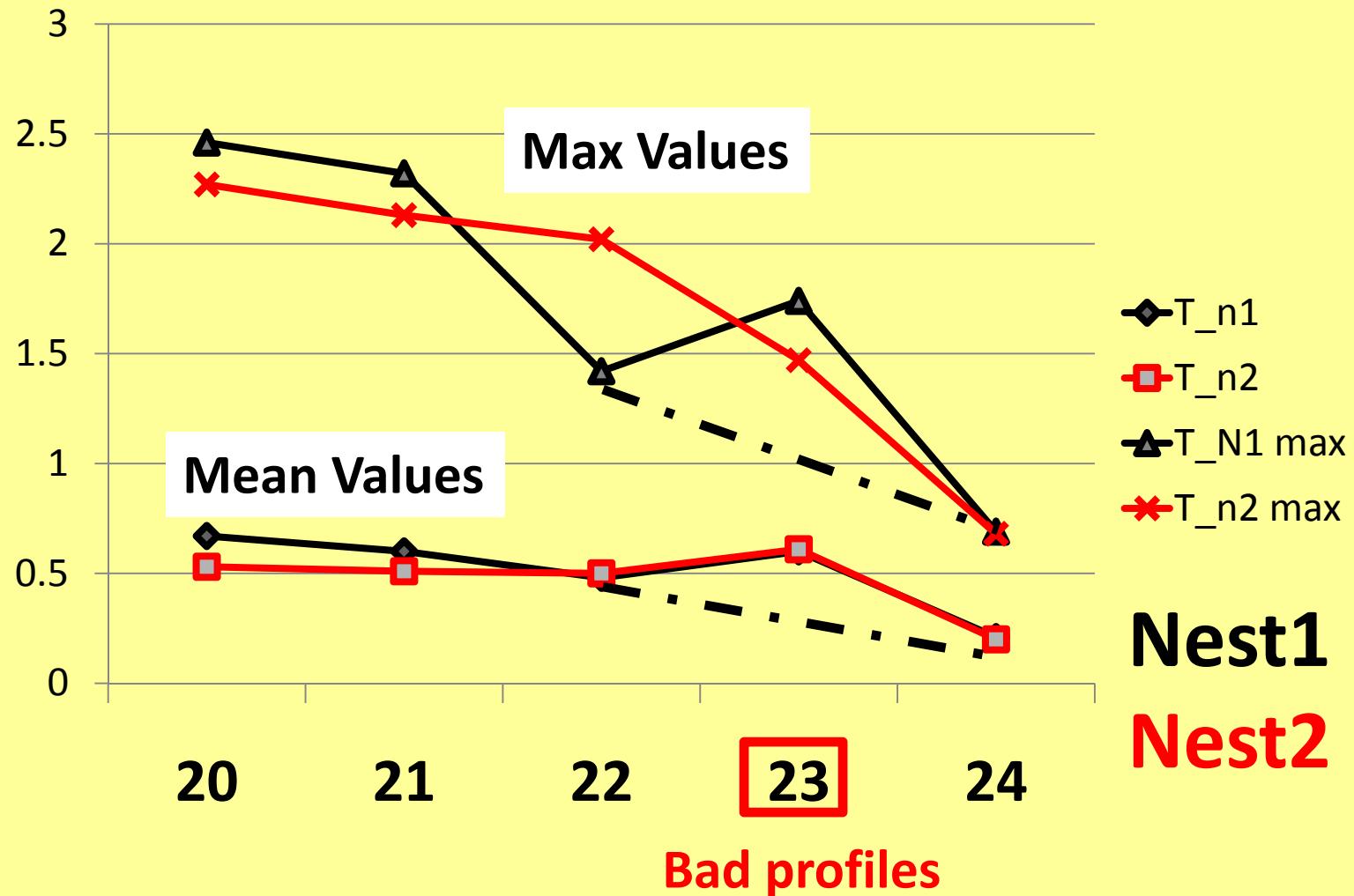


Temperature



Salinity

# Temperature RMS for target area



# Conclusions

During the Mrea10 The NRL team has:

- Provided 72 hr forecast
- Identified areas of forecast uncertainty
- Determined optimal sampling strategy
- Guided Laura
- Effectively improved forecast and reduced model uncertainties

# **Coupled Ocean-Atmosphere for Mrea10**

**output available @ NRL web**

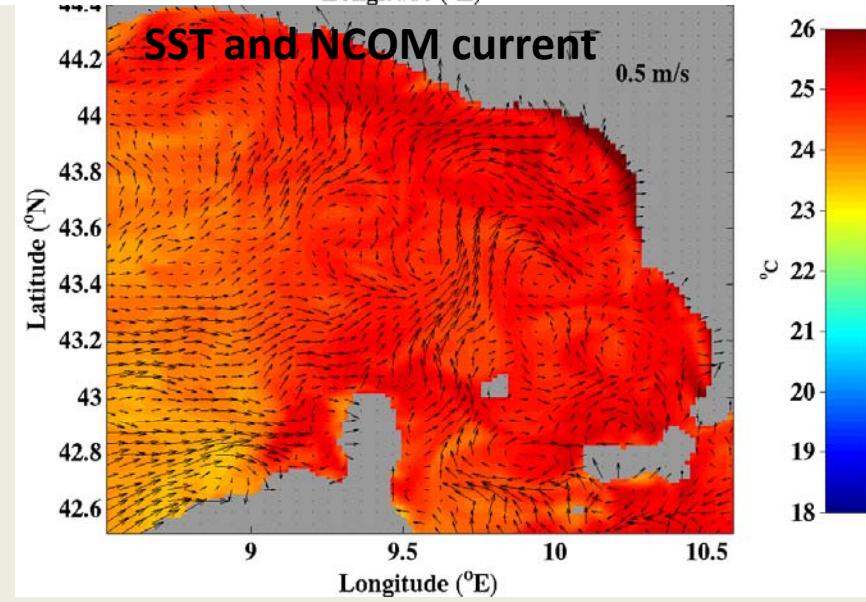
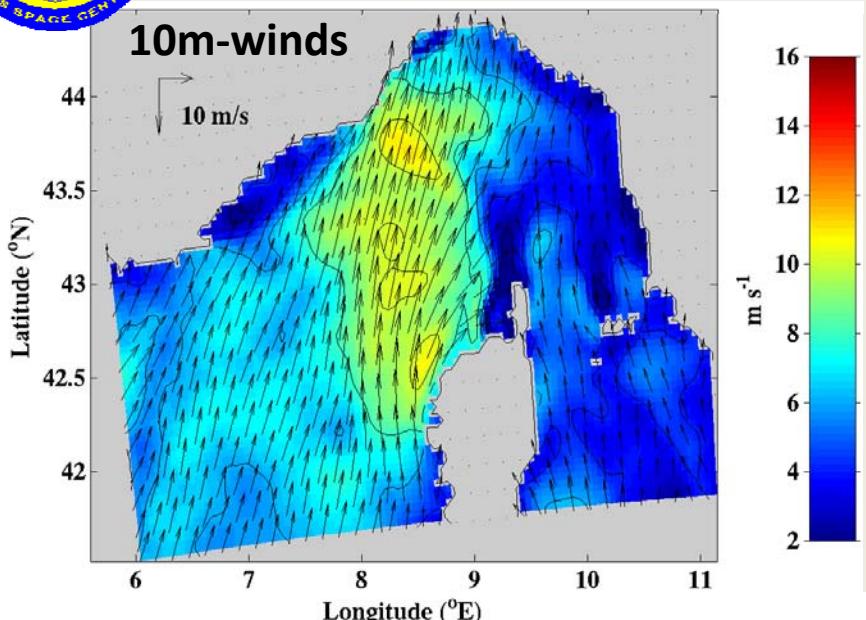
**Tommy Jensen**

**Travis Smith**

**[tommy.jensen@nrlssc.navy.mil](mailto:tommy.jensen@nrlssc.navy.mil)**



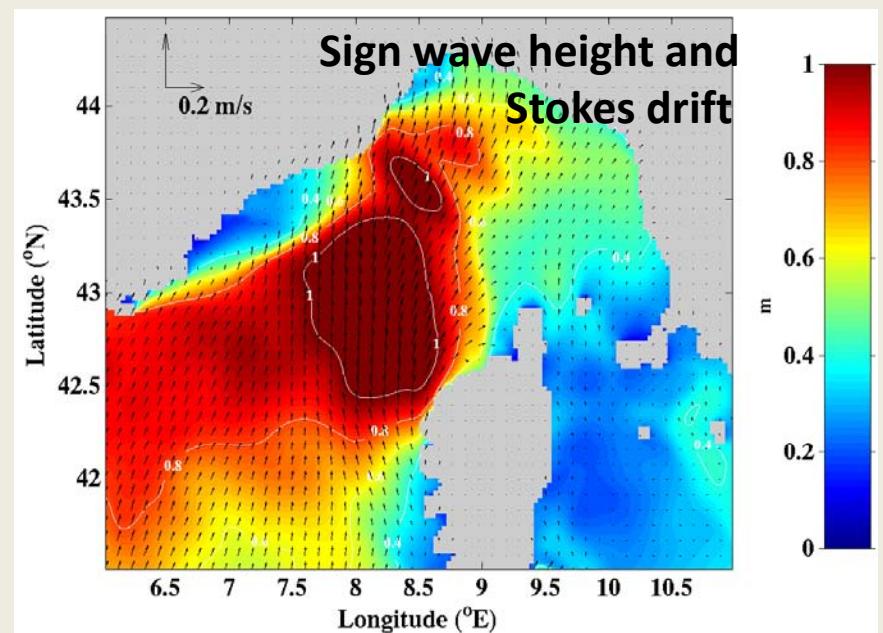
# COAMPS coupled 24 and 48 hour forecasts



Hourly forecasts plots of 10-m winds and wind speed, SST and surface currents, significant wave height and Stokes drift. Currents were provided from August 24 to August 31. A 24 hour or 48 hour forecast was provided each day starting 00 UTC. NetCDF files with the ocean state are available.

Plots:

**12 hr forecast from August 27**







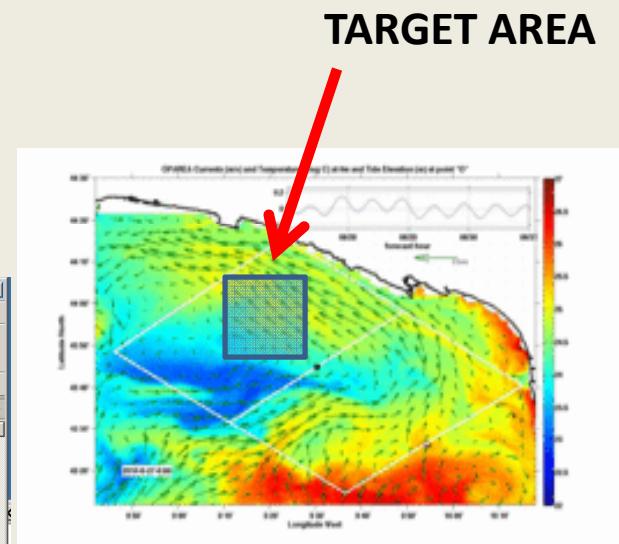
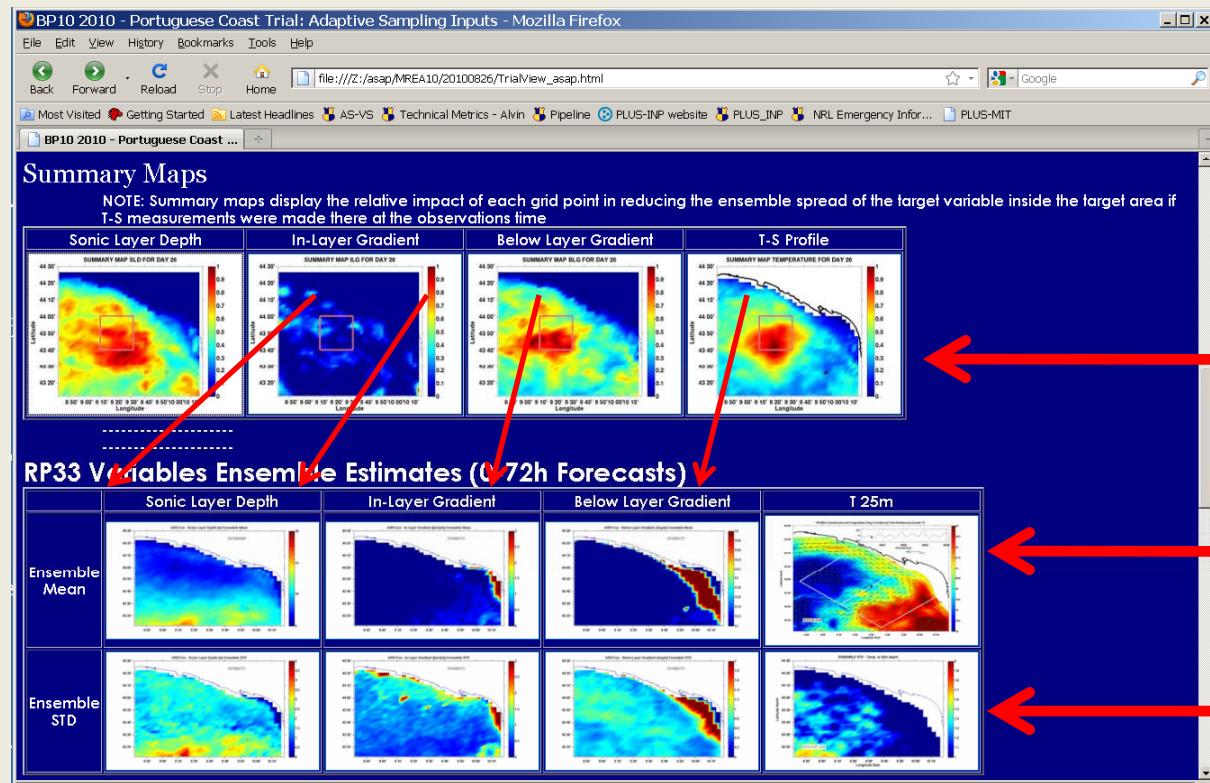




# Sampling Strategies

## MREA10 Test Case

### TOFU PROCESSING ENSEMBLE AND COST FUNCTIONS FOR KEY VARIABLES SLD – ILD – BLG – Temp/Sal Prof

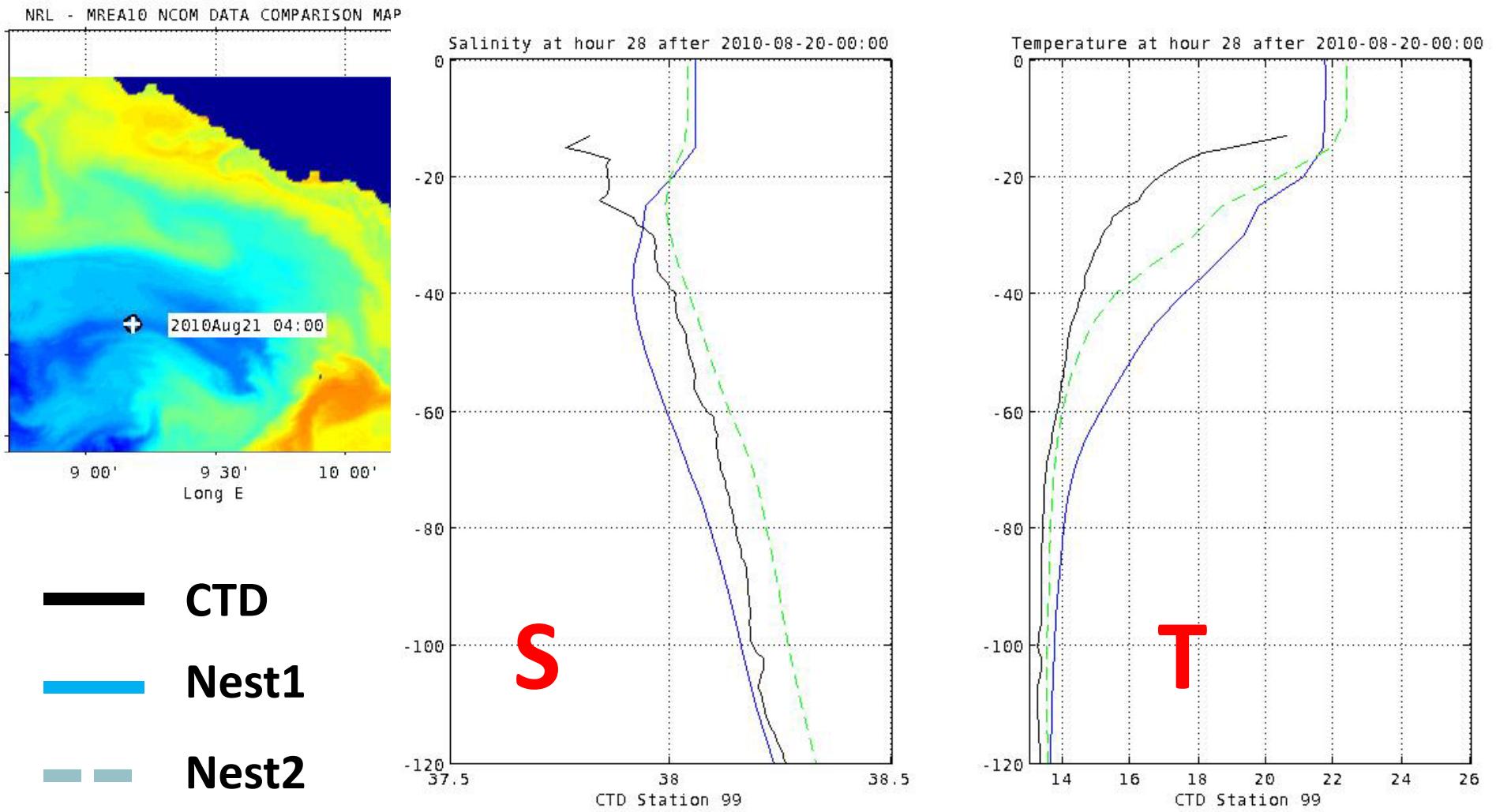


Sensitivity (summary) Maps  
for target area

Space-Time Variability

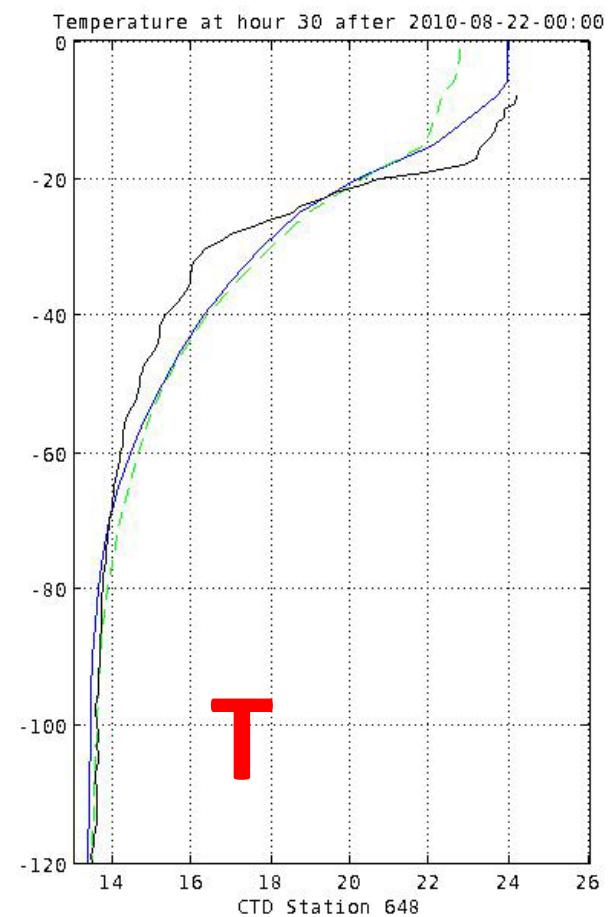
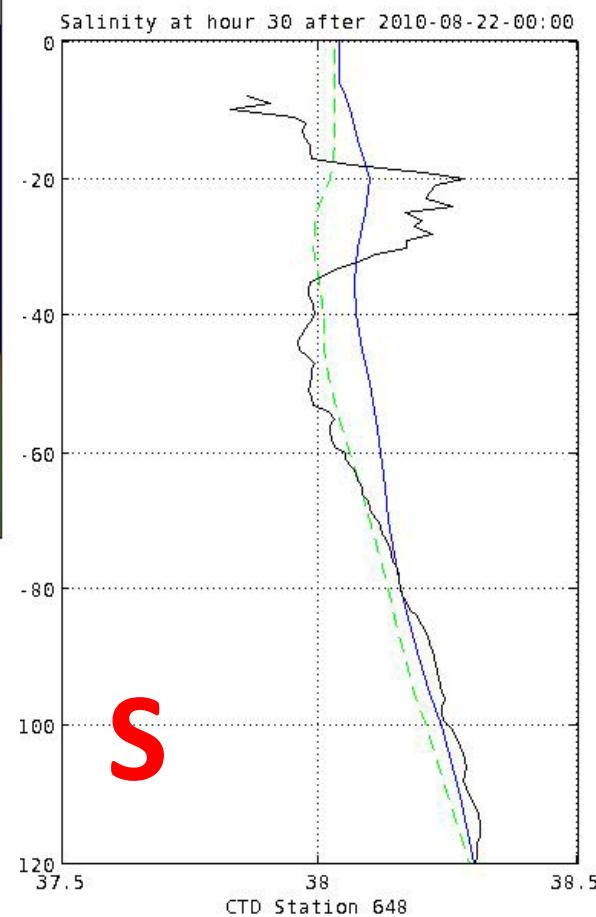
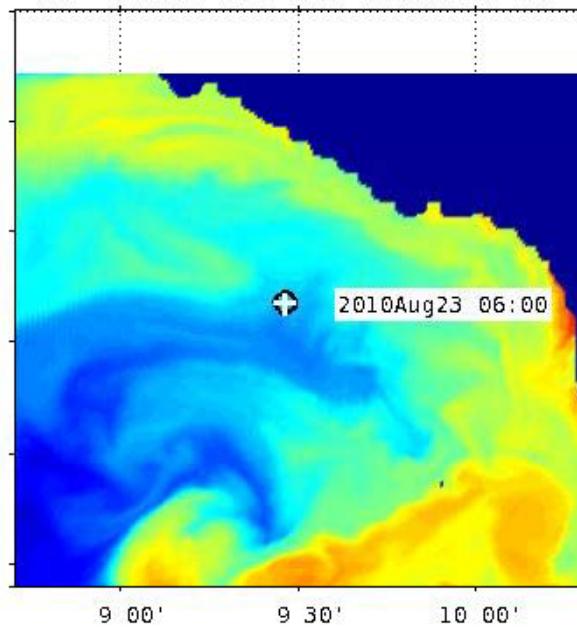
Ensemble Spread  
(uncertainty)

# Before Laura Data (20071020)



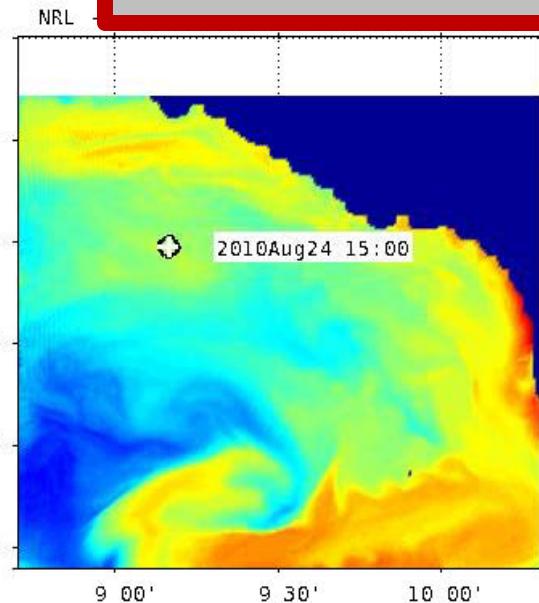
CTD Station 99

# After Laura Data (20071022)

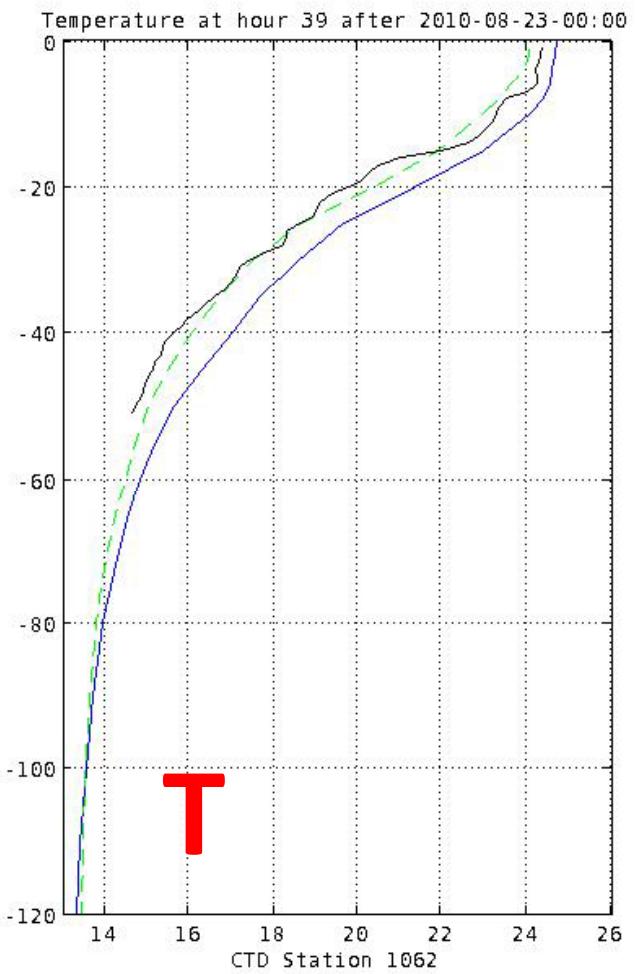
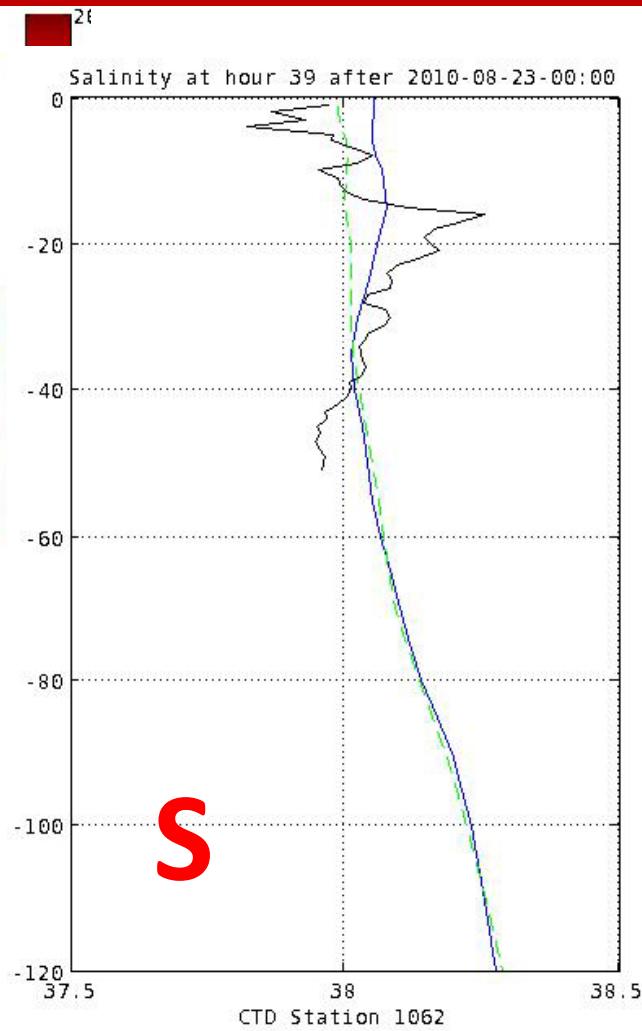


**CTD Station 648**

# After Laura Data (20071023)



- CTD
- Nest1
- Nest2



**CTD Station1062**

# Coupled COAMPS grids

