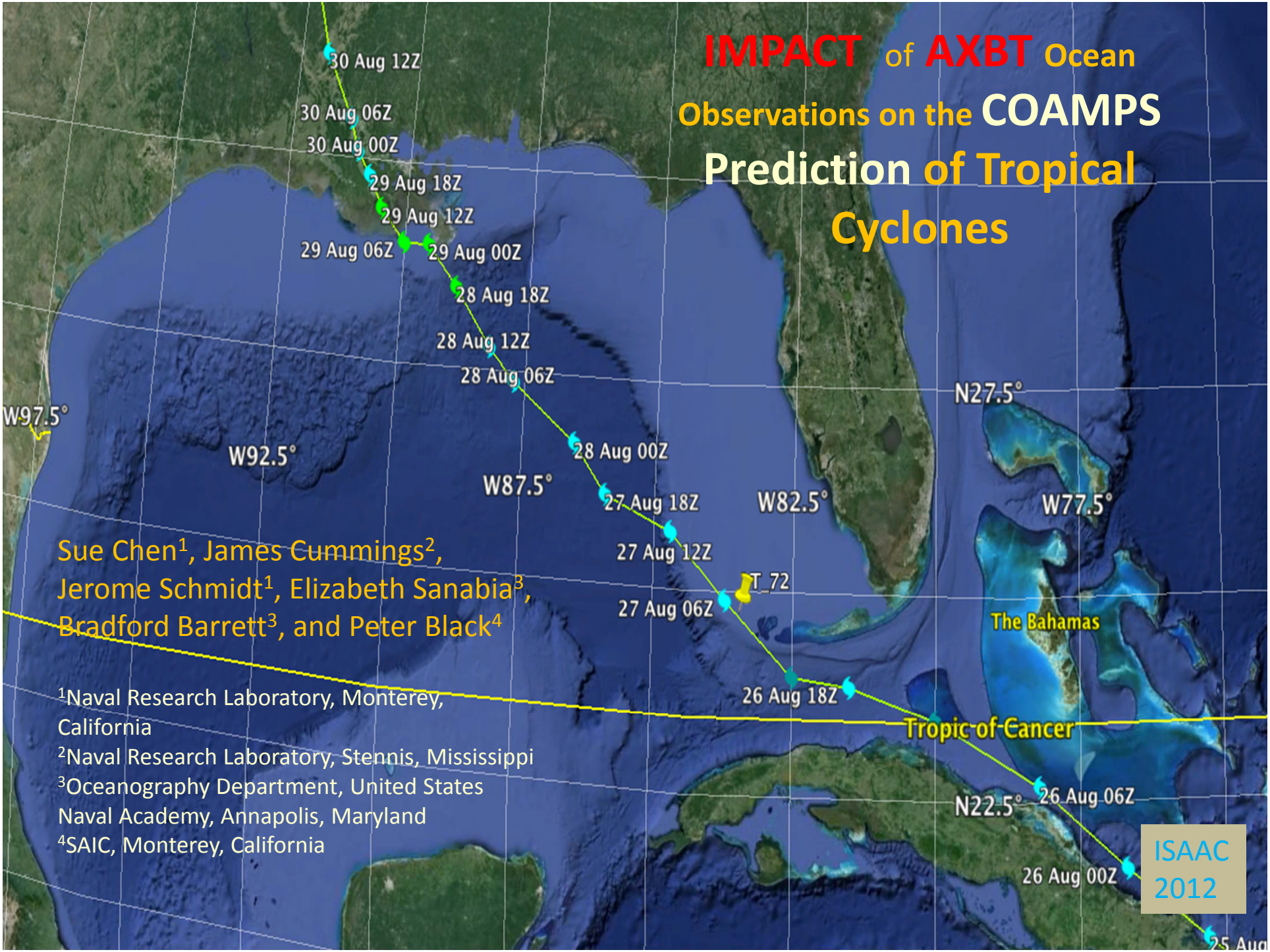

IMPACT of AXBT Ocean Observations on the COAMPS Prediction of Tropical Cyclones

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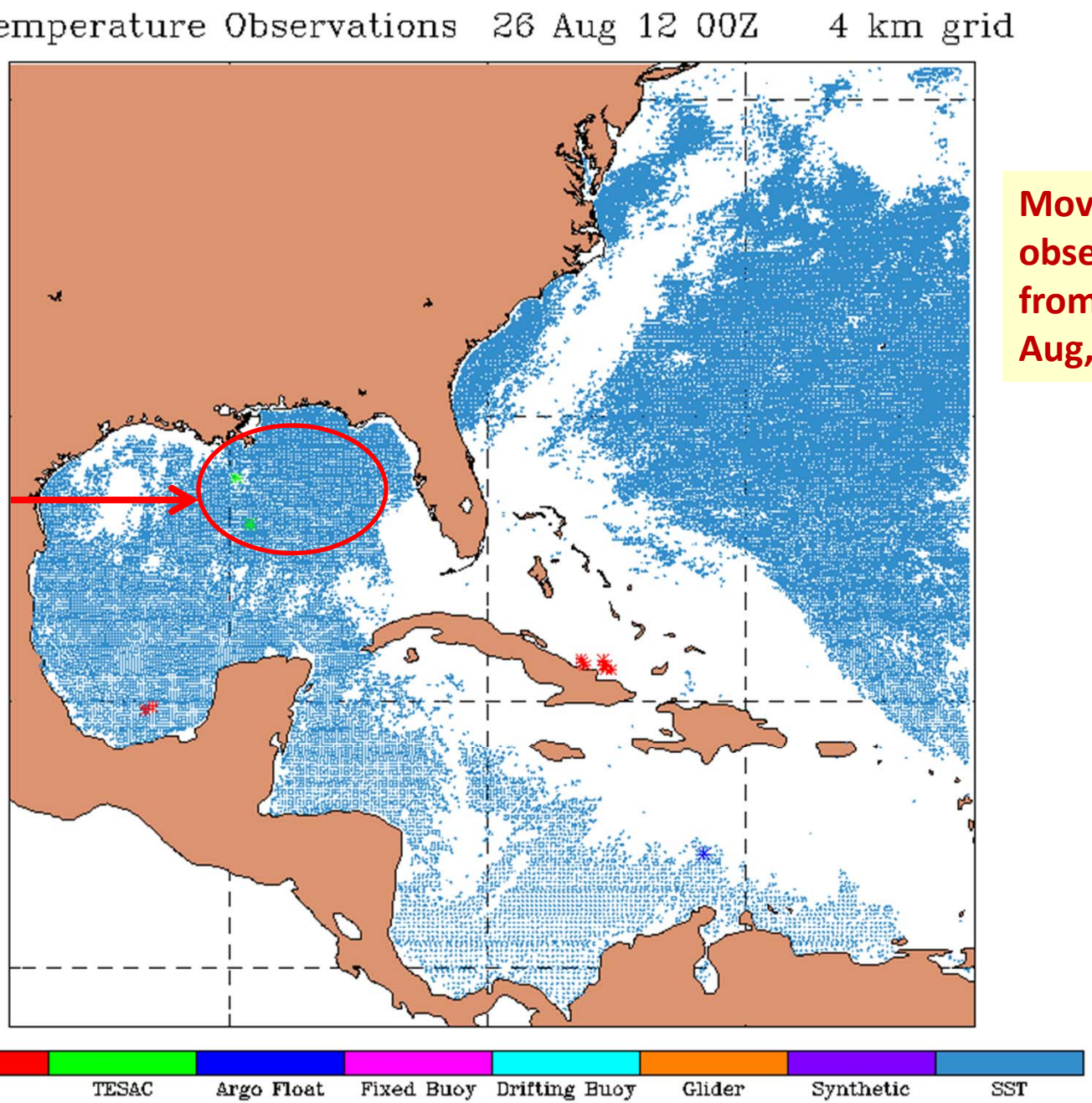
[4]SAIC, Monterey, California

Motivation

- In-situ sea temperature observations fill data void regions not covered by remotely sensed satellite observations
- Critical to improve coupled model TC forecasts *(Sanabia et al. 2013)*



Movie of SST observations from 26-29 Aug, 2012

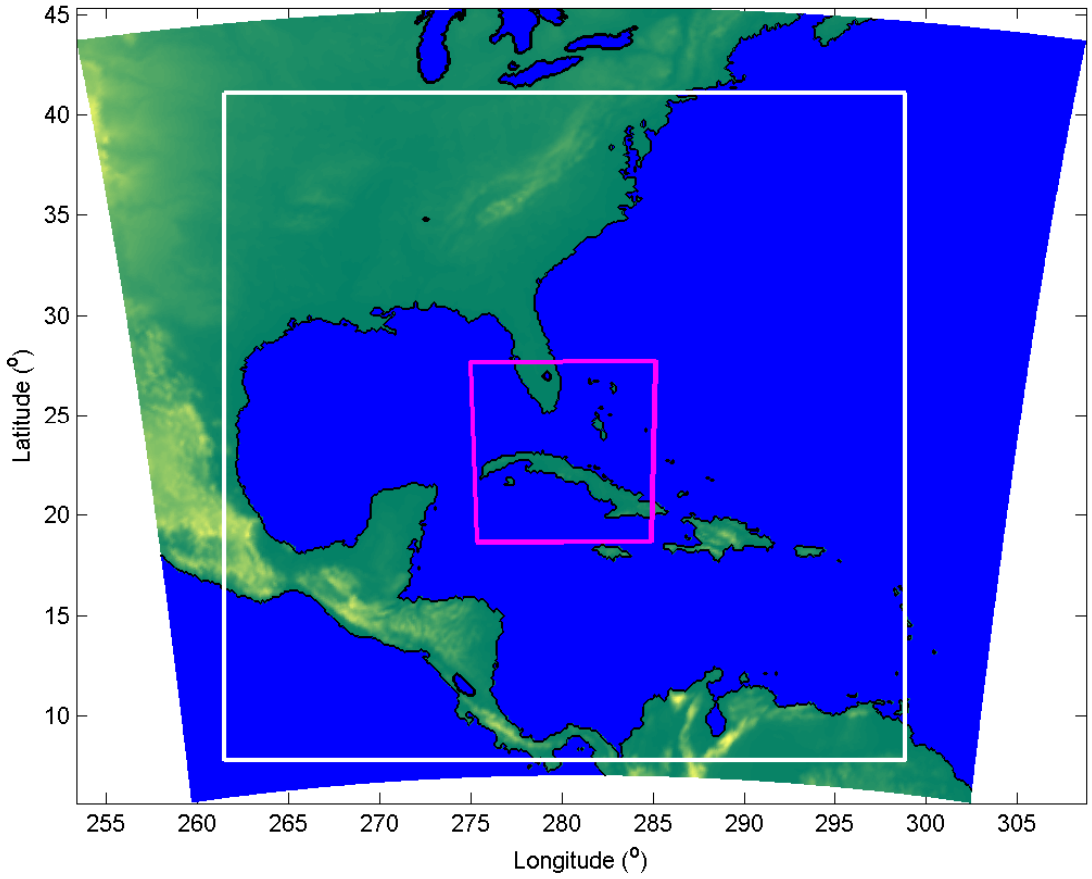
Objective: Access the AXBT observing system data Impact on coupled COAMPS-TC forecast

Approach

1. Data denial in an observing system experiment (OSE) method
    - Ok to use to access the impact of a few instruments
    - Can be computationally expensive
    - Difficult to determine data impact due to analysis differences at each update cycle time and effect of air-sea coupling

2. Adjoint sensitivity method (Langland and Baker 2004; Cummings and Smedstad 2014)
    - Computationally inexpensive
    - Ideal for routine observational monitoring
    - Adjoint sensitivity cost function: the difference between COAMPS 12 and 24h or 24h and 36h forecasts (forecast error gradients) valid at the same analysis time

COAMPS Model Configuration



Atmospheric
12 km: 400x360x60
4 km moving nest:
250x250x60

Ocean
4 km: 900x900x50
20 Z-levels in the upper ocean

Coupling interval: 6 min

With AXBT and AXBT denial experiments

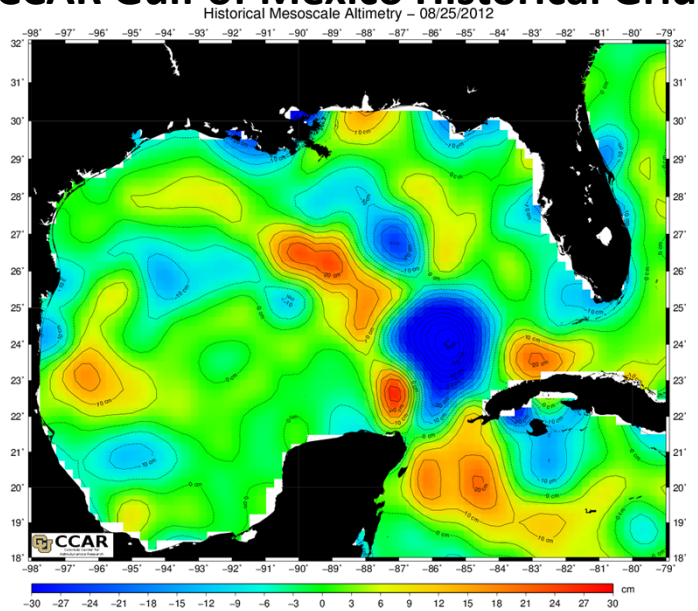
Data assimilation: 12h

Model cold start from
0000UTC 25 Aug, 2012

Nine 120h forecasts

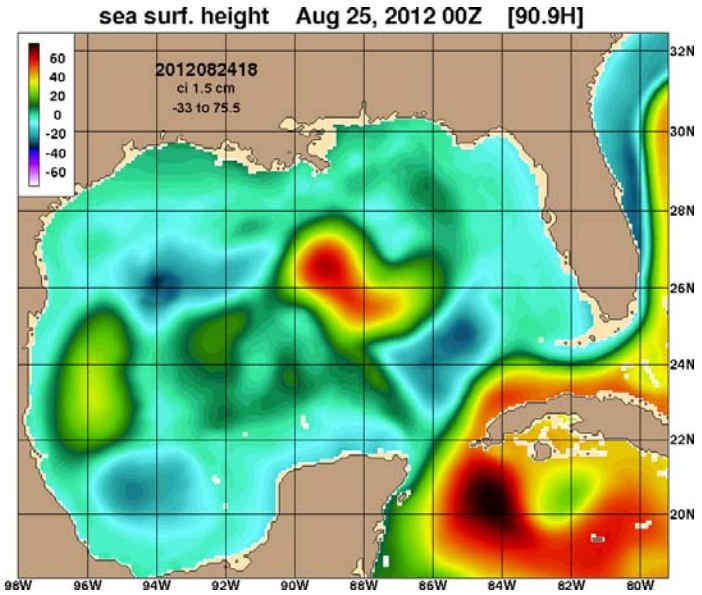
GOM Conditions: Pre-Isaac

CCAR Gulf of Mexico Historical Gridded SSHA



http://eddy.colorado.edu/ccar/ssh/hist_gom_grid_viewer

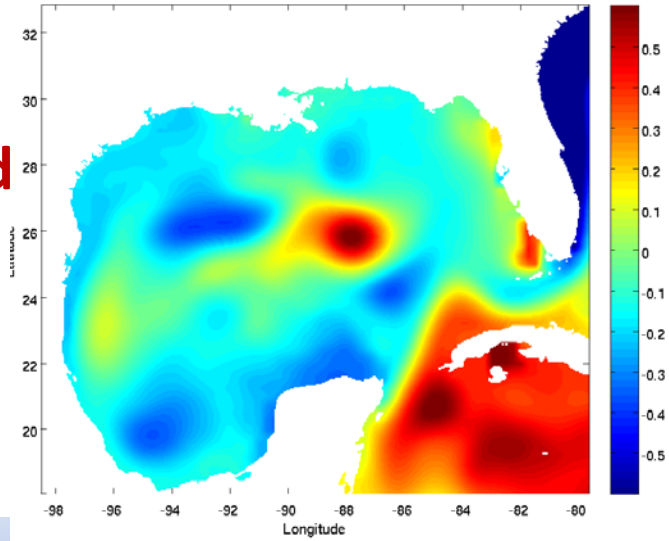
HYCOM SSH



http://www7320.nrlssc.navy.mil/GLBhycom1-12/navo/arc_list_glfmexssh.html

Discrepancies between the COAMPS initial GOM eddies with the CCAR and HYCOM analysis results from:

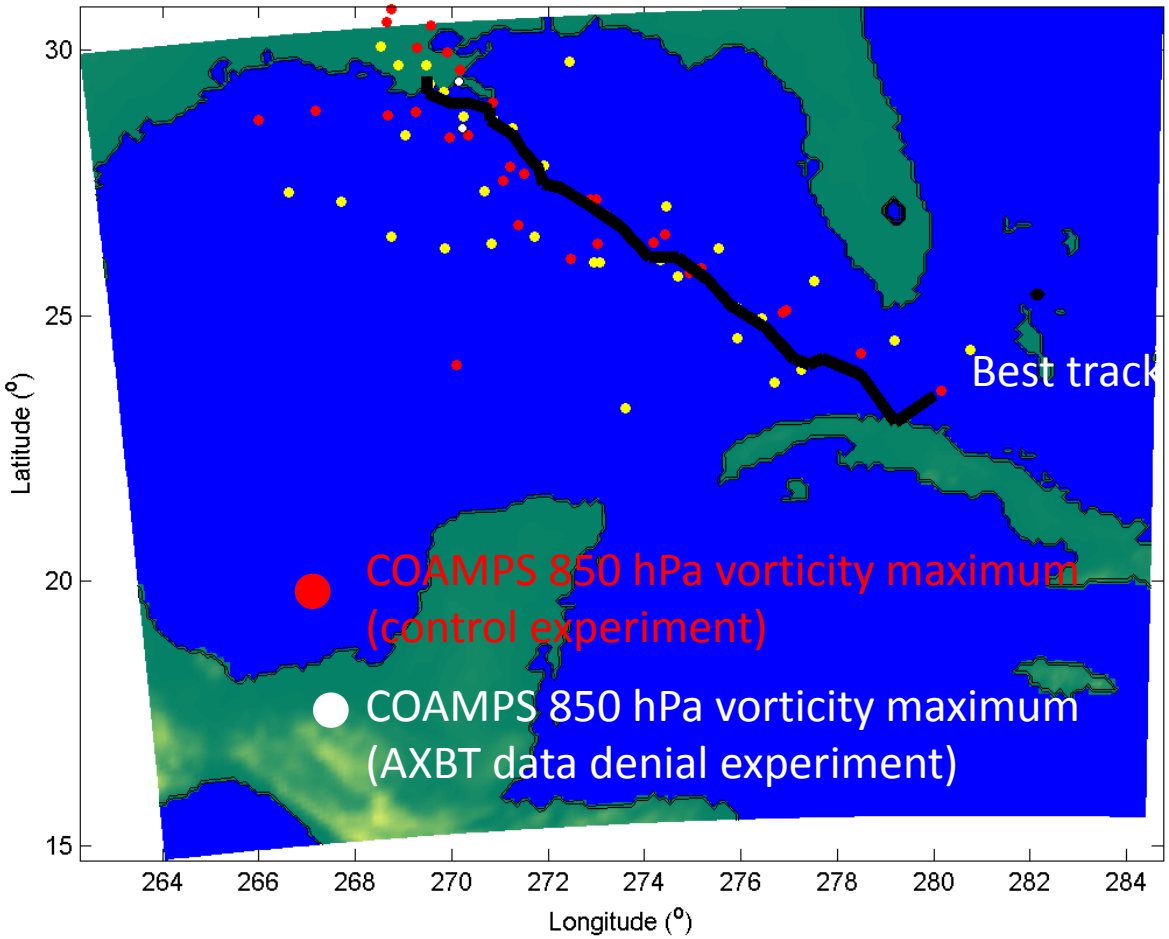
1. **Global model initial condition**
2. **Fewer observations in real-time**



gNCOM SSH – COAMPS initial condition

COAMPS Forecasts

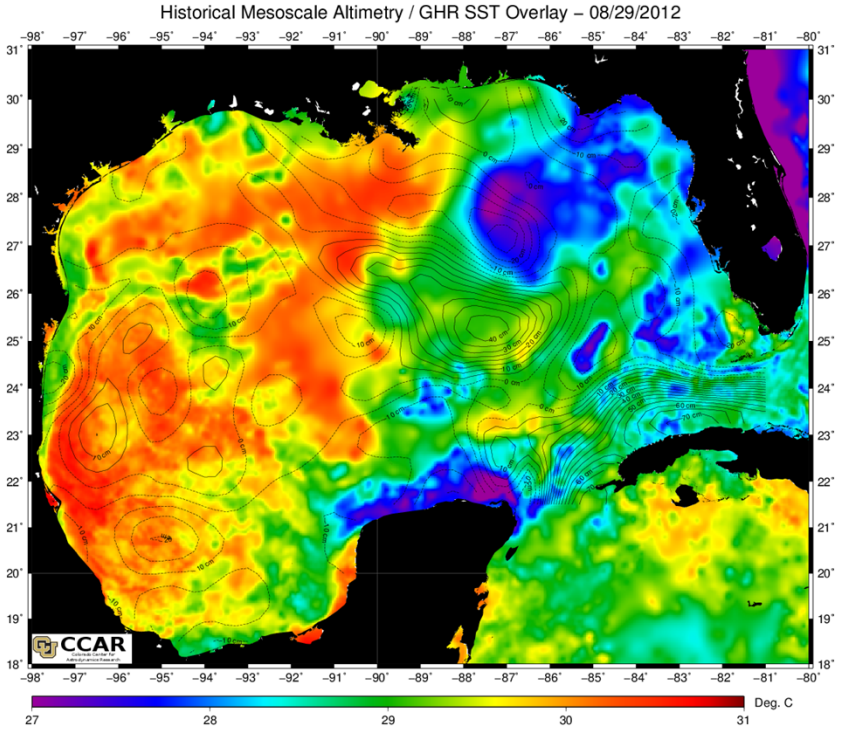
2012082612-202082900



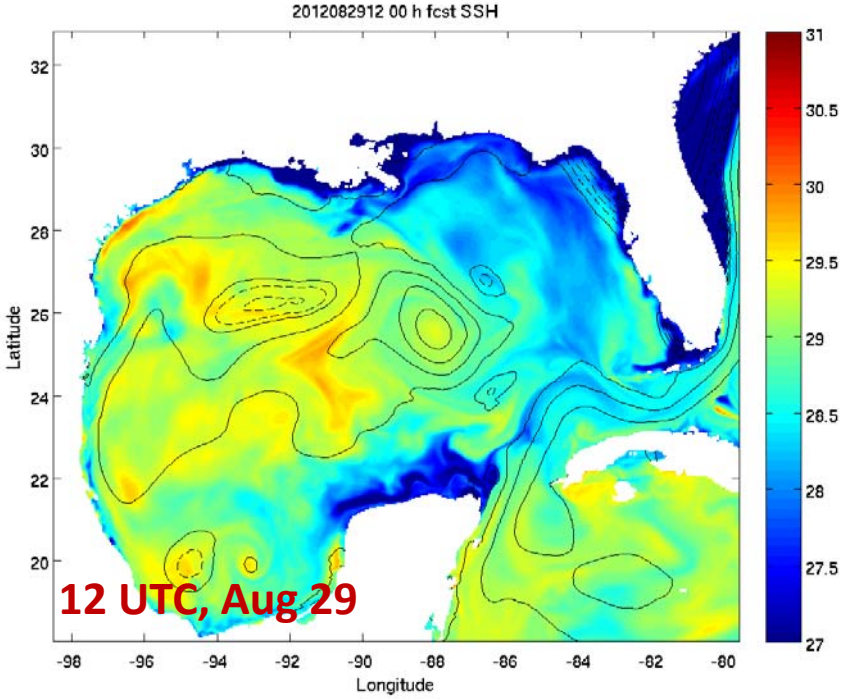
- COAMPS forecast intensities didn't reach CAT one strength
- Both the COAMPS internal and GFDL trackers failed for these weak storms
- A slightly better track with the AXBT assimilation

GOM Conditions: Post-Isaac

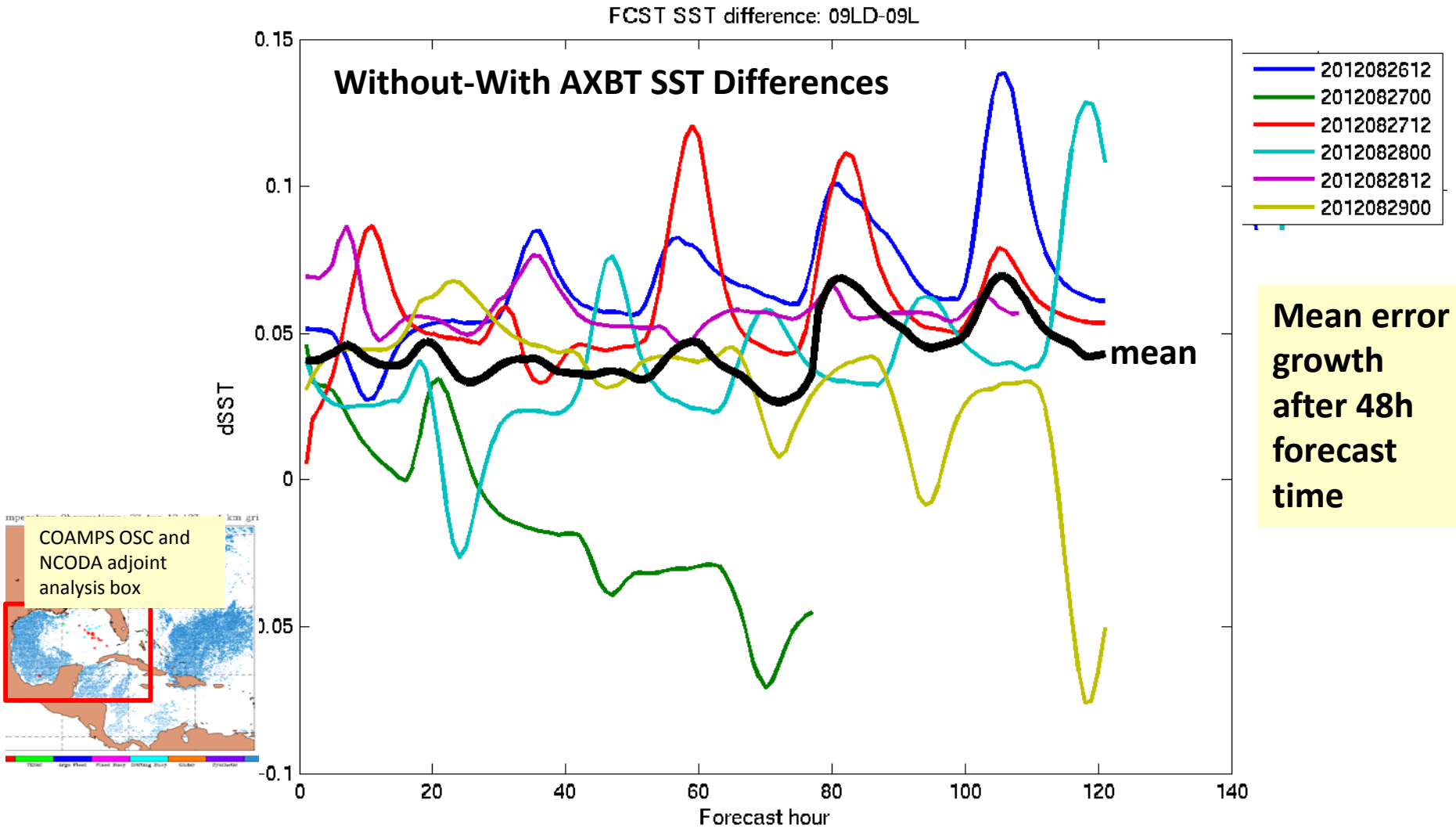
CCAR Gulf of Mexico Historical Gridded SST and SSHA



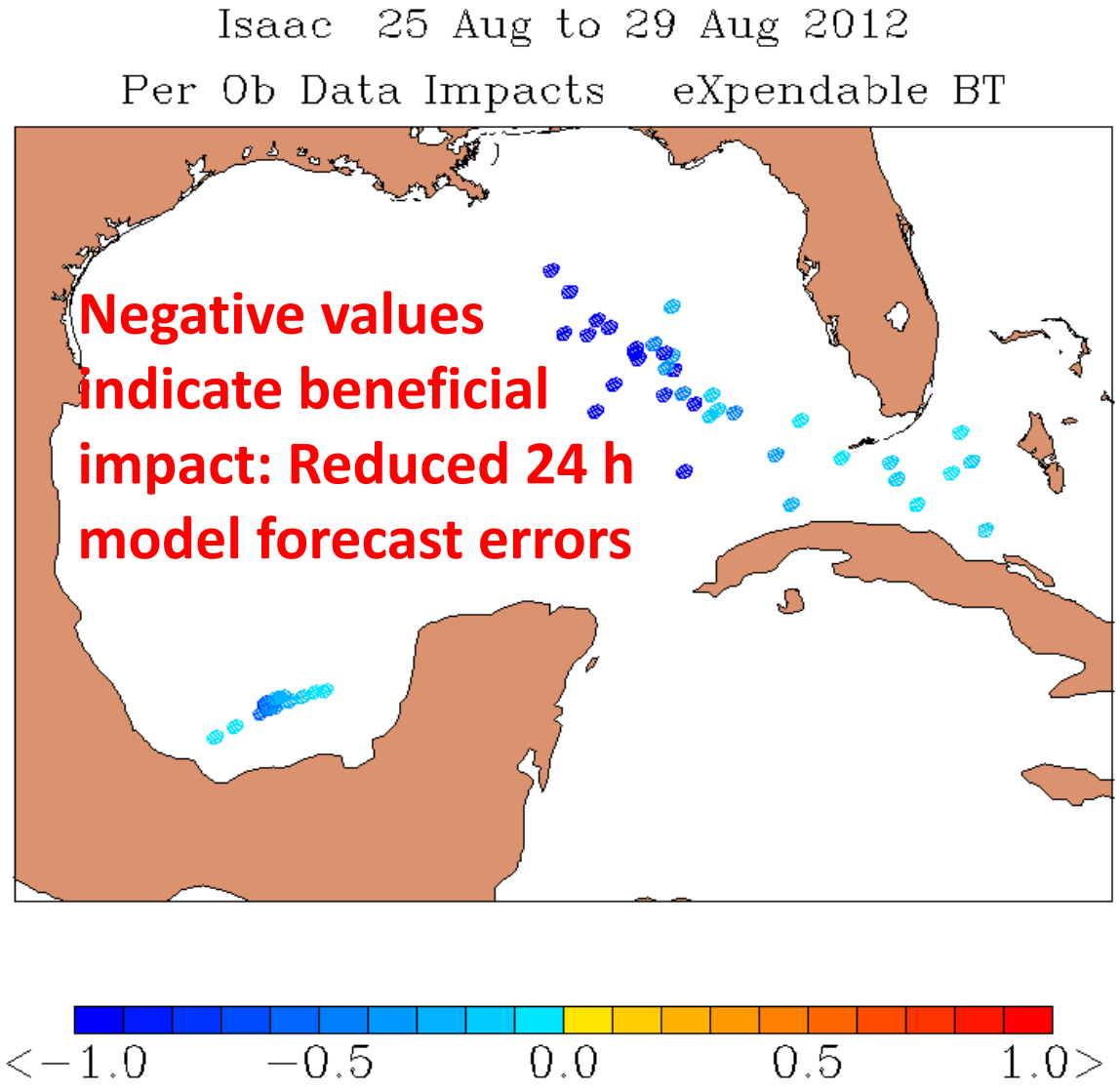
COAMPS SST and SSH



OSC Experiment



Mean error growth after 48h forecast time



$$e_{24} = \langle (x_{24} - x_a)(x_{24} - x_a) \rangle$$
$$e_{36} = \langle (x_{36} - x_a)(x_{36} - x_a) \rangle$$
$$\frac{\partial J}{\partial x_f} = e_{24} - e_{36}$$

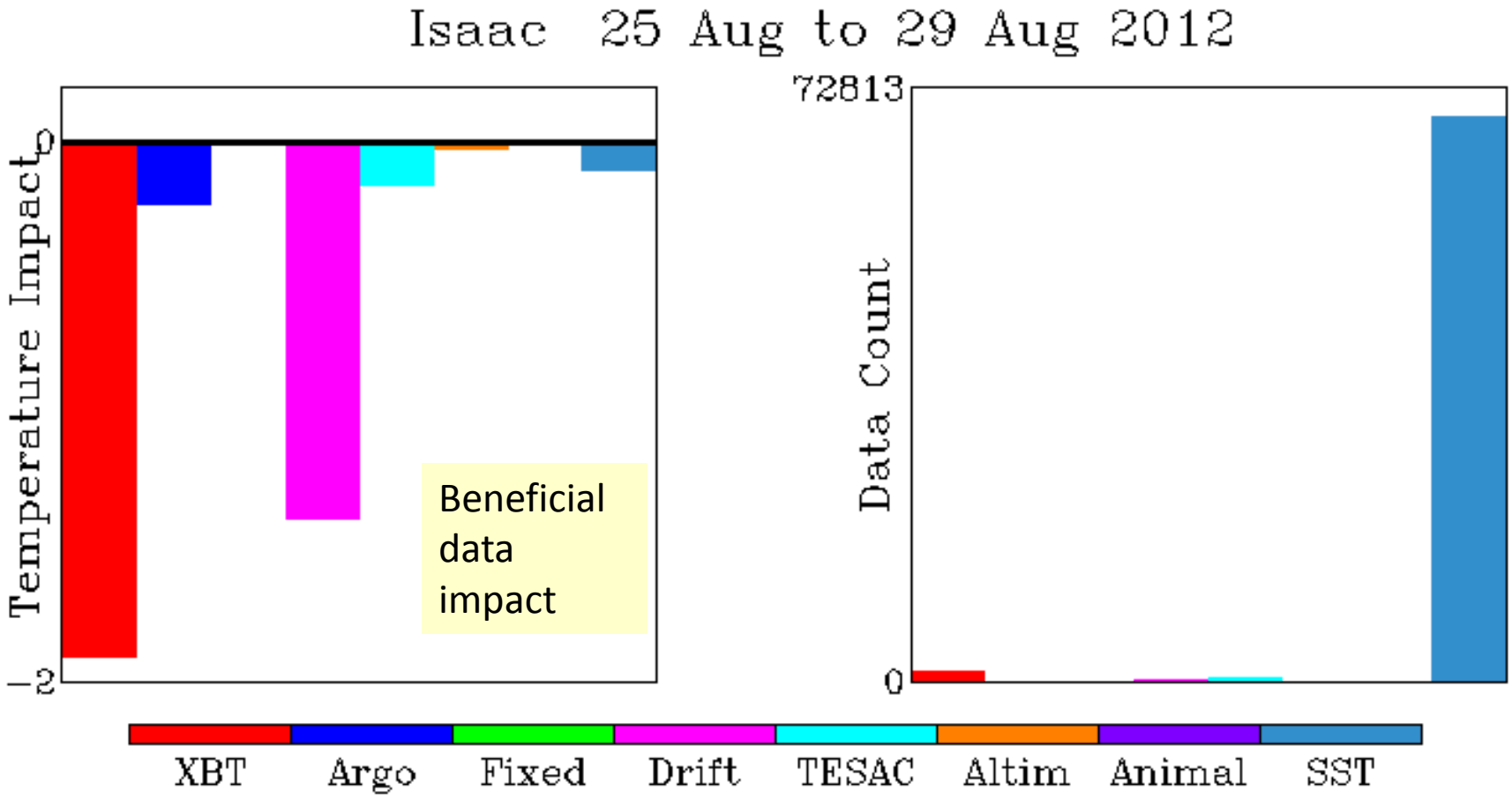
Where x_{24} x_{36} are forecast states and x_a is the verifying analysis

Assuming $\frac{\partial J}{\partial x_a} = \frac{\partial J}{\partial x_f}$

Cost function *J* is the differences between two forecast of different lengths valid at the same time (Langland and Baker 2004)

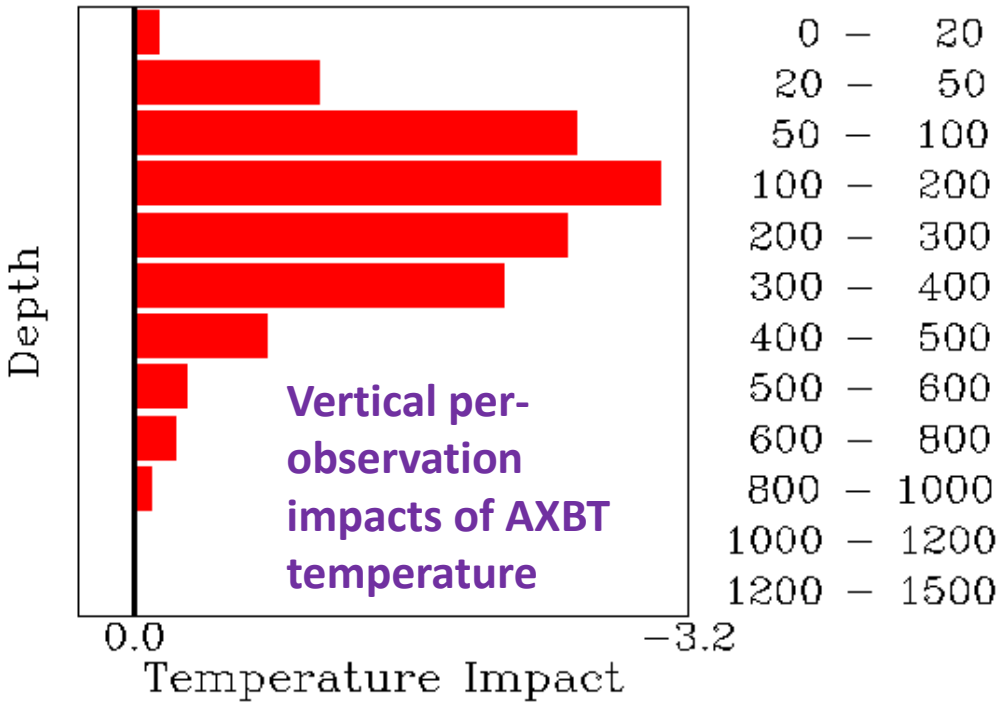
Limit on shorter forecast error estimate

Per-Observation Data Impact

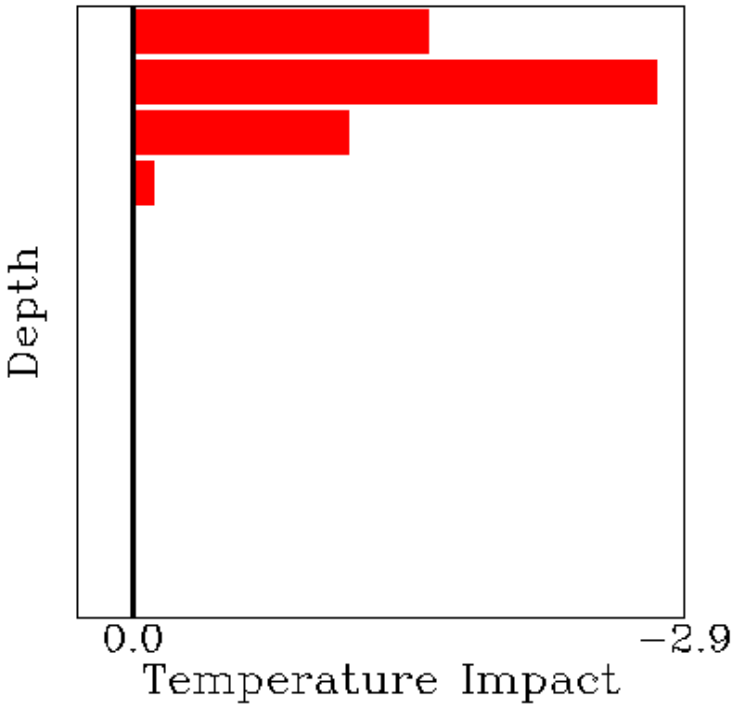


Per-Observation Data Impact

XBTs

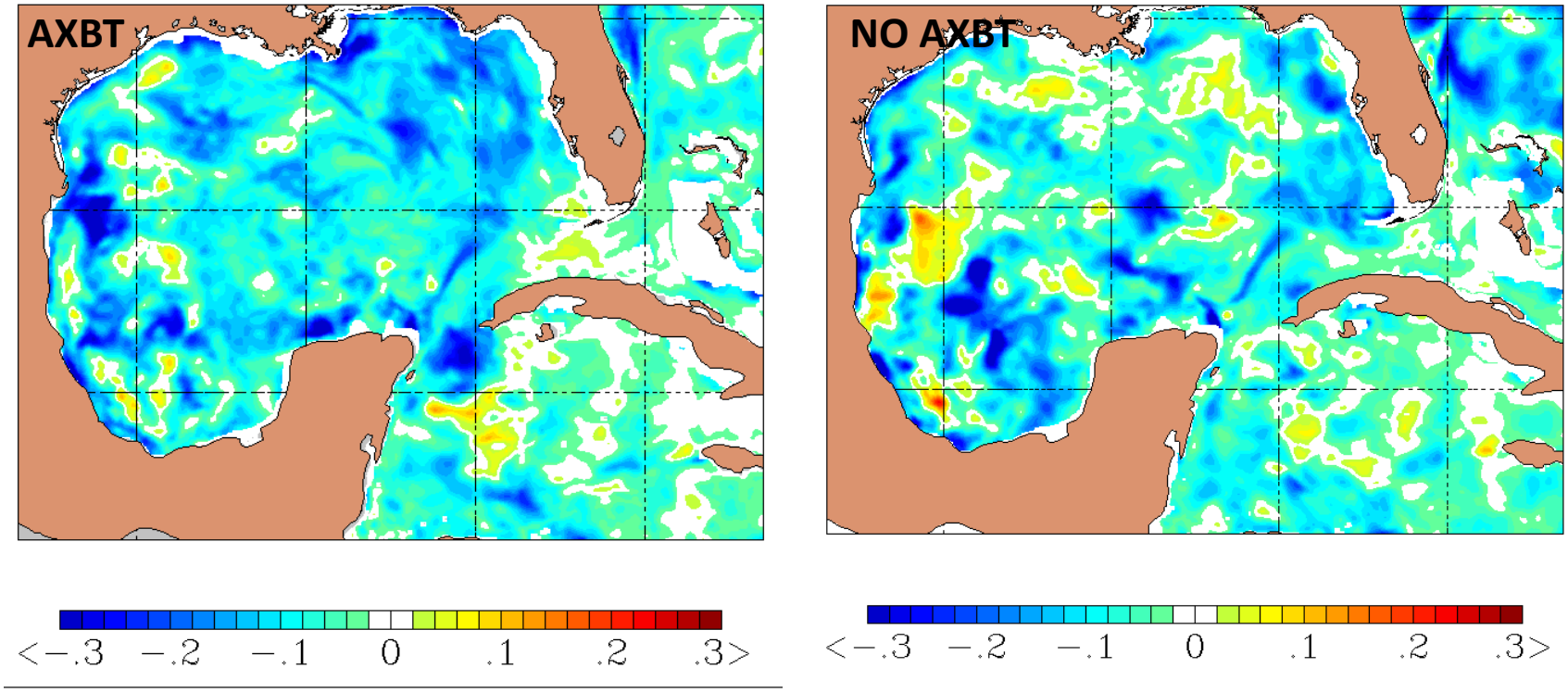


Drifting Buoys



Mean sea temperature forecast errors are reduced from the assimilation

SST



Negative values indicate beneficial impact:
Reduced 24 h model forecast errors

Summary

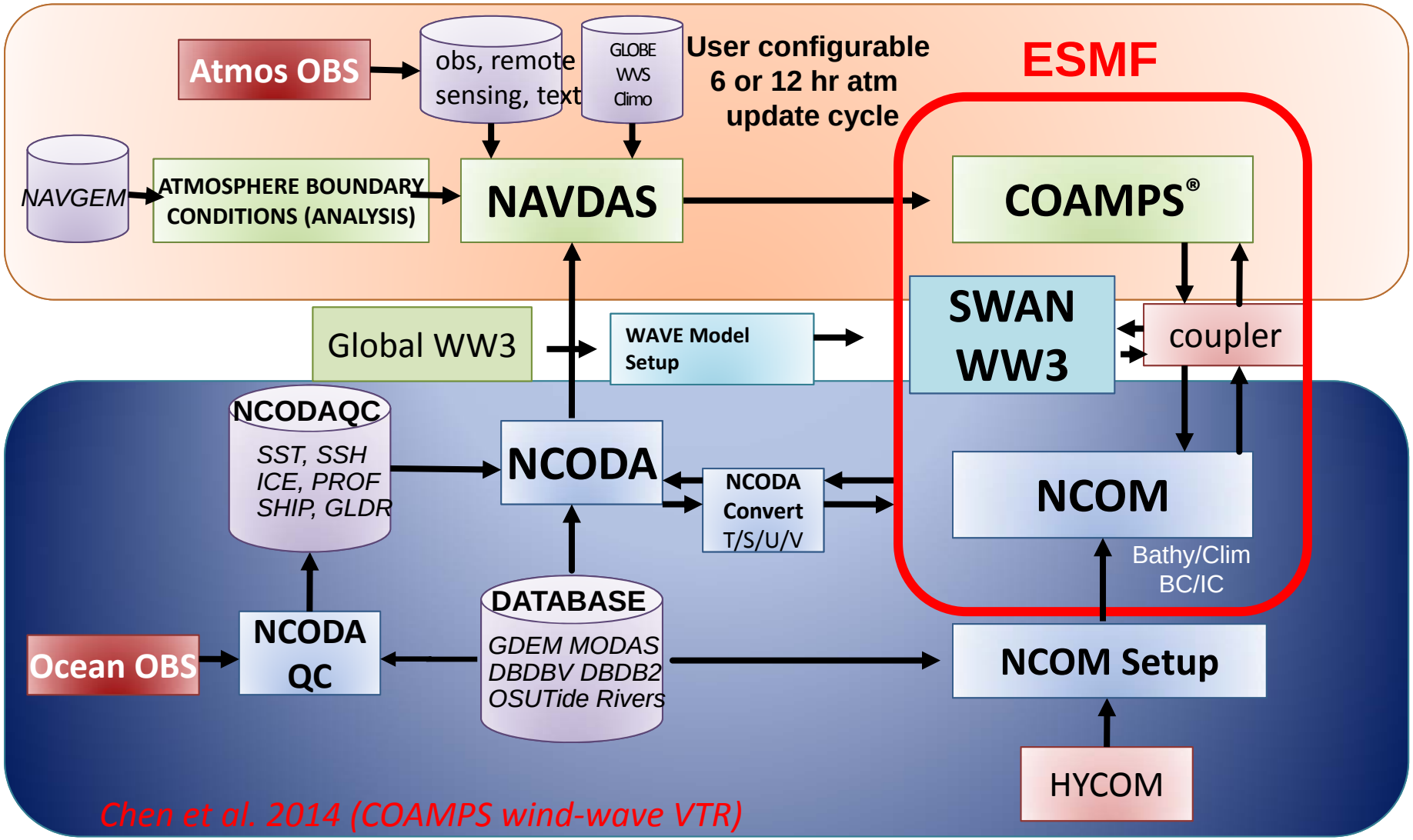
- The AXBT data impact is examined in the data denial and adjoint sensitivity experiments
- The inclusion of the AXBT data assimilation yields a maximum 1°C reduction in the 24h model SST forecast errors
- The mean domain averaged SST difference in runs using or excluding the AXBT revealed the mean error growth is small prior to the 48h forecast time
- The adjoint sensitivity analysis suggests that assimilation of AXBT has a "beneficial impact" on reducing the ocean model 24h temperature forecast errors for the upper ocean
- Exclusion of the AXBT led to the westward displacement in the modeled position of the Gulf warm core eddy when compared to observations
- A maximum of ~0.3°C reduction in the 24h model forecast sub surface sea temperature error was seen in a large area right of the hurricane Isaac best track and north of WCE when AXBT is assimilated

Future Work

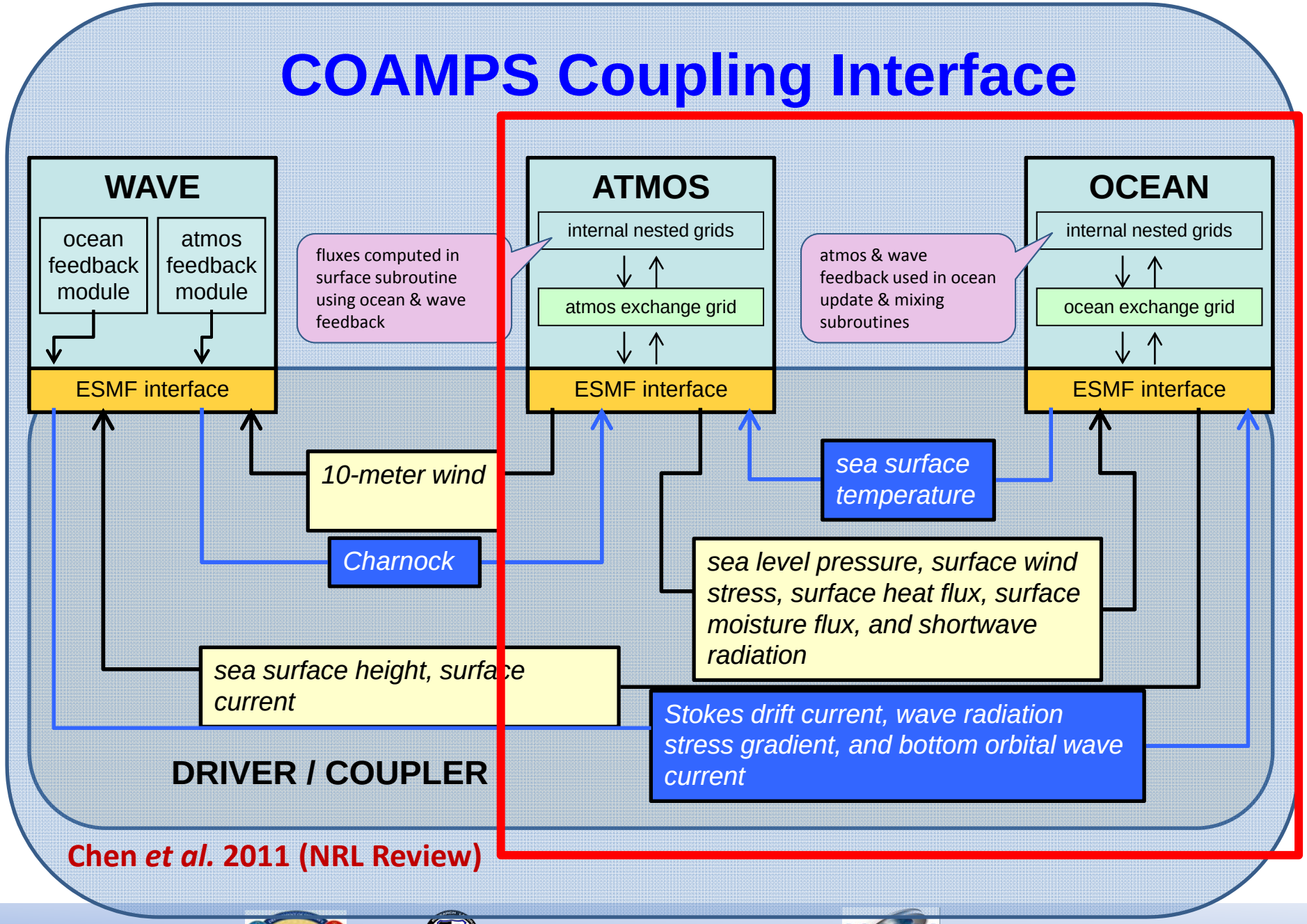
- Forecast sensitivities arising from the use of one meter vertical resolution AXBT
- Forecast sensitivities arising from higher model horizontal and vertical resolution
- Optimal AXBT sampling strategy

Supplement slides

Air-Ocean-Wave Coupled COAMPS Forecast and Data Assimilation System

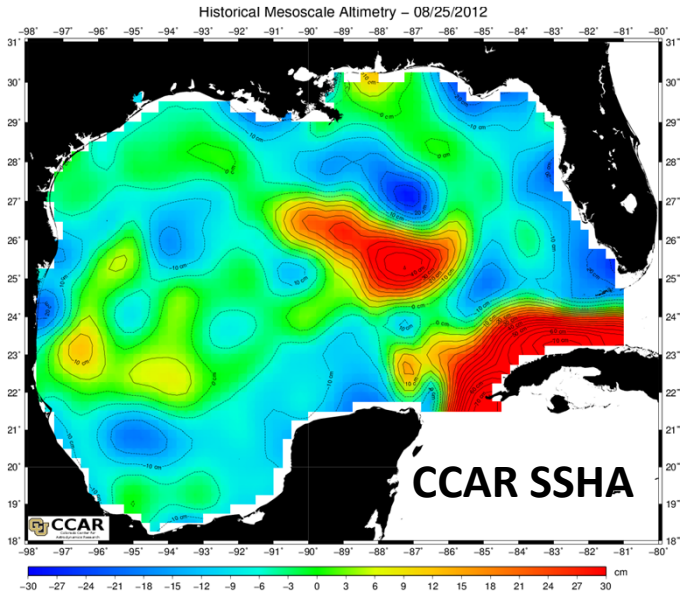


COAMPS Coupling Interface



Chen *et al.* 2011 (NRL Review)

GOM Conditions: Pre-Isaac



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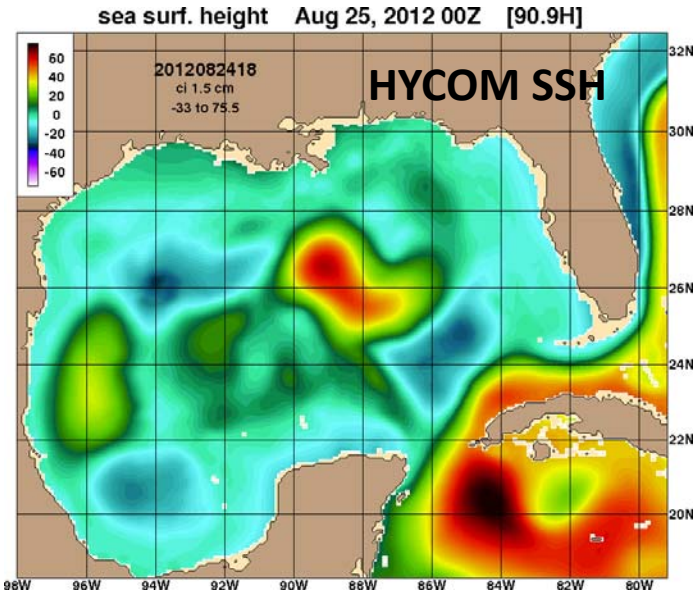
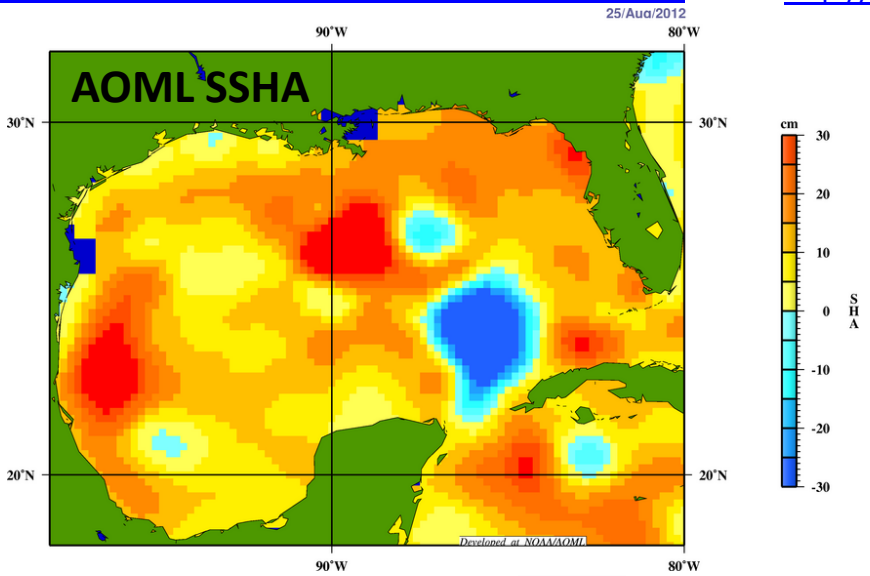
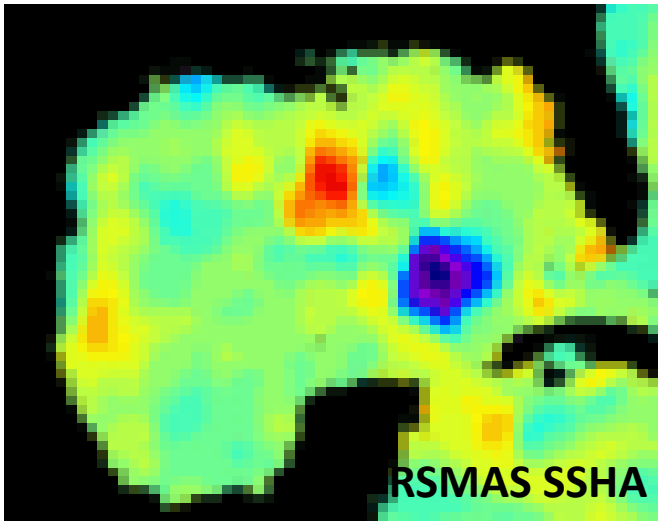


http://www7320.nrlssc.navy.mil/GLBhycom1-12/navo/arc_list_glfmexssh.html

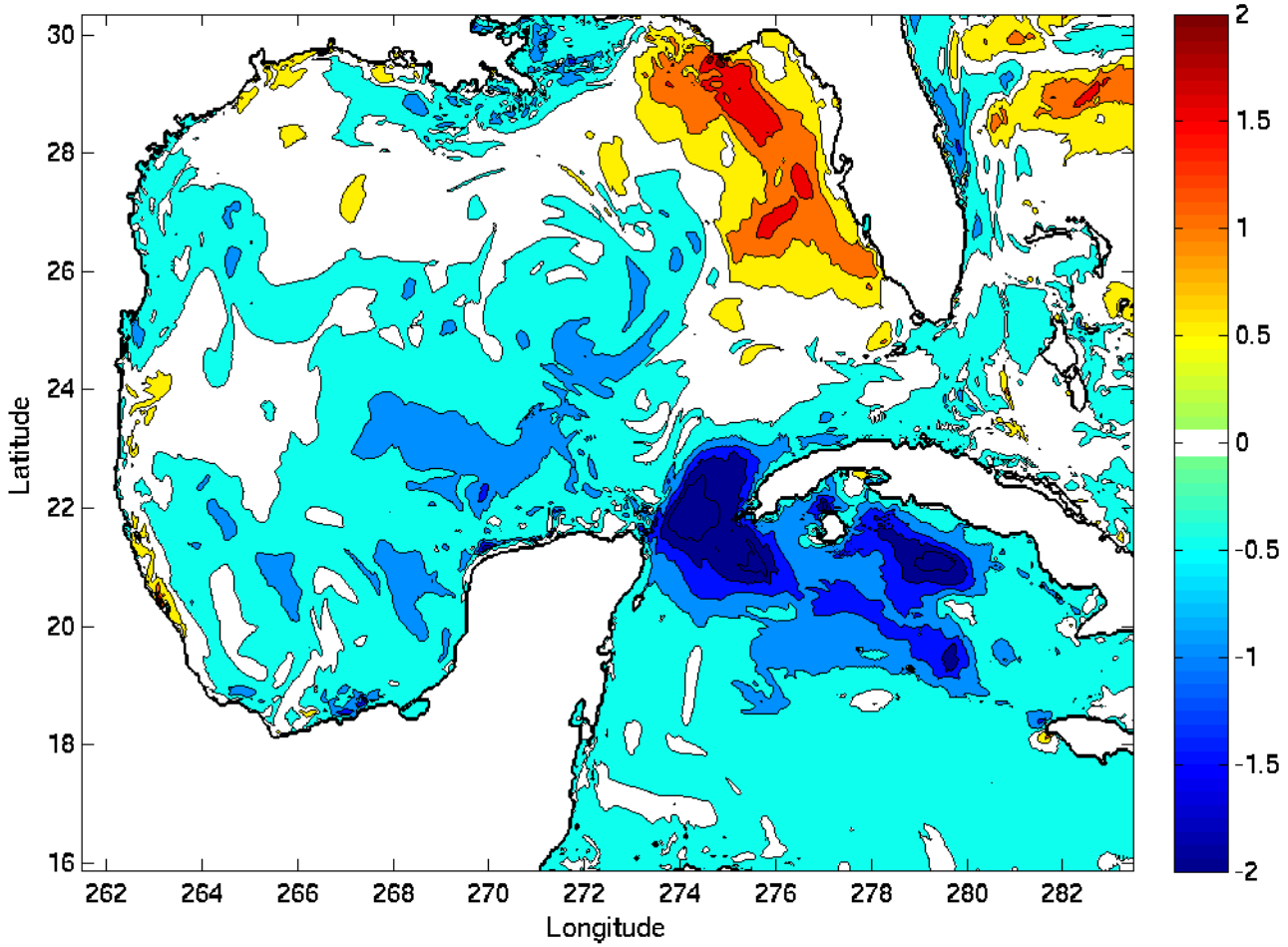


http://www.aoml.noaa.gov/phod/dataphod1/world/PHP/NEW/2012238gosha.png

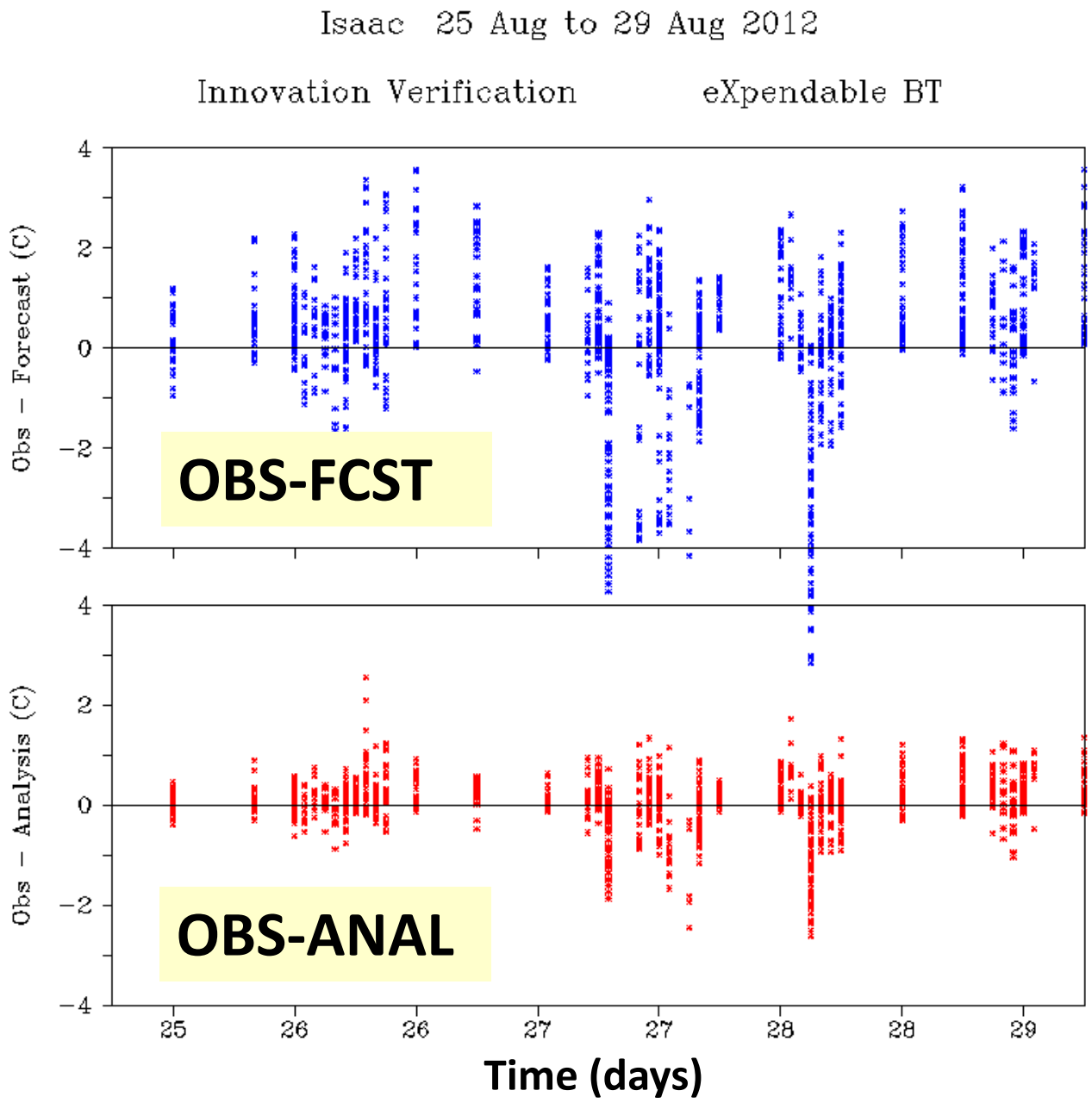


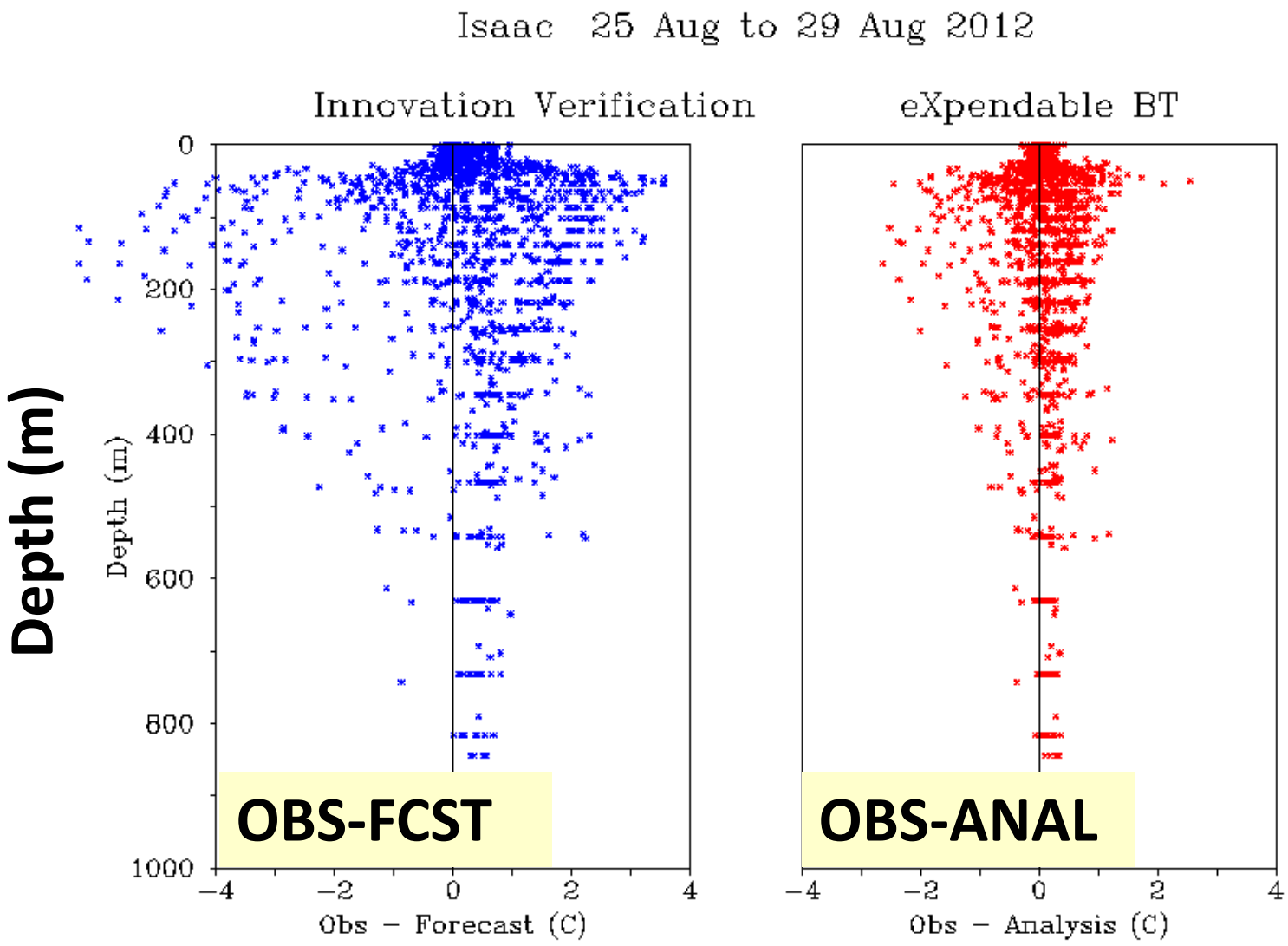
http://isotherm.rsmas.miami.edu/heat/weba/atlantic.php/

2012082912 SST difference (without-with AXBT assimilations)



A ~2°C maximum absolute SST difference in the OSC experiments


Isaac 25 Aug to 29 Aug 2012
Innovation Verification eXpendable BT
Obs − Forecast (C)
OBS-FCST
Obs − Analysis (C)
OBS-ANAL
Time (days)


Isaac 25 Aug to 29 Aug 2012
Innovation Verification
eXpendable BT
Depth (m)
0
200
400
600
800
1000
Depth (m)
−4
−2
0
2
4
Obs − Forecast (C)
Obs − Analysis (C)
OBS-FCST
OBS-ANAL

Per-Observation Data Impact

Sea Gliders