Airborne Surveys of the Loop Current Complex from NOAA WP-3D Aircraft During DWH Oil Spill

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HURRICANE FORECASTERS ARE PREDICTING A HALF-DOZEN CATEGORY TWO'S, SEVERAL CATEGORY FOUR'S, AND FOR THE FIRST TIME EVER...
NEWS
THE TIMES-PICAYUNE
A CATEGORY 10-W40.
NEWS

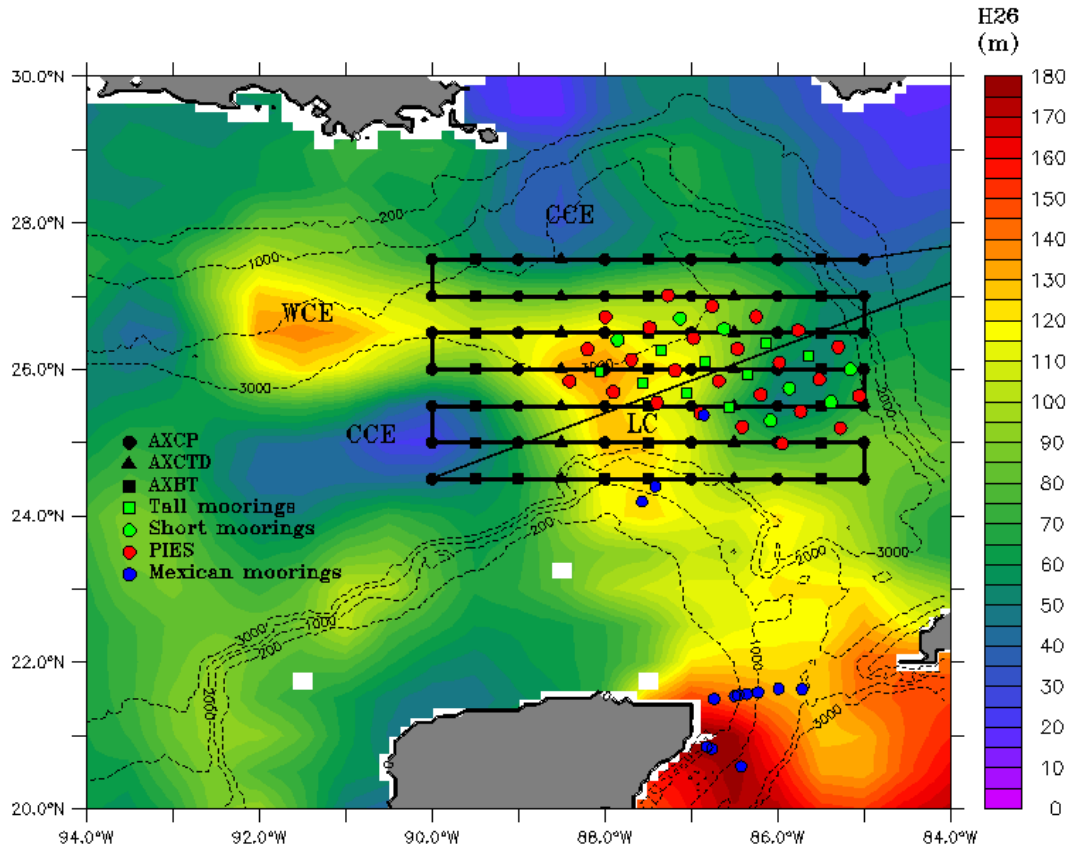
NOAA WP-3D profiling over BOEMRE Moorings (In Collaboration with AOML HRD, AOC, TPC, NCEP)

Deliverables include:

V, T, S profiles to 1,000 m @ 2-m resolution.

Surface winds (SFMR, GPS) provided by HRD.

Atmospheric profiles of V, T and RH @ 5-m resolution.



Expendables deployed from P-3 and proposed moorings relative to the LC, WCE and CCE superposed on late Sept 05 altimetry derived 26°C isotherm depth (after Rita).

Goal and Objectives

Goal: Provide synoptic snapshots of the Loop Current and surrounding eddy field's thermal, momentum and haline structure. Specific objectives are:

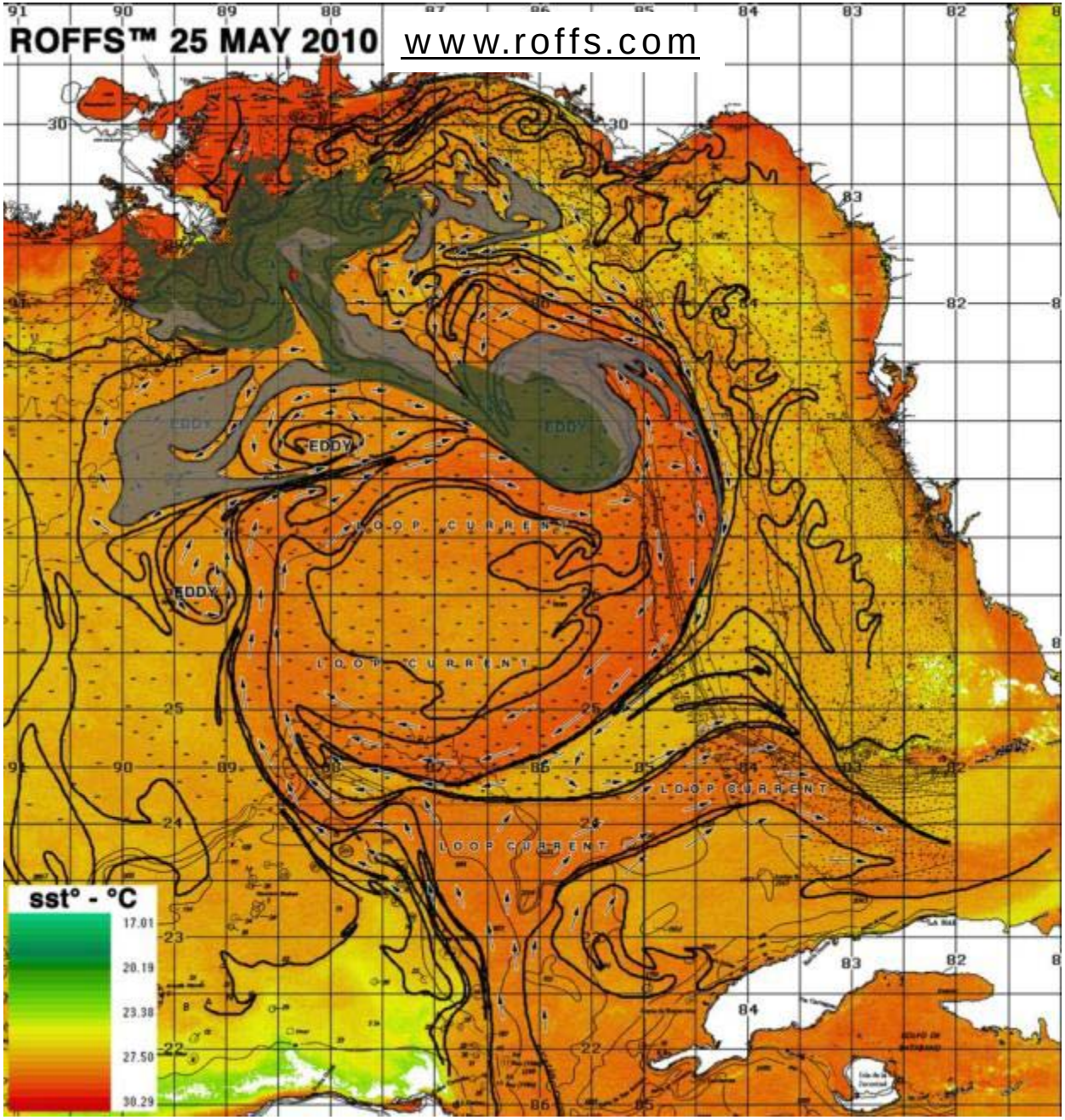
Observe temperature, current and salinity structure from NOAA P-3 at 7 to 10 day intervals including the BOEMRE moorings.

Resolve mesoscale ocean variability associated with eddy shedding.

Provide these data to the National Centers (NAVO) for assimilation into predictive models and vector ships to regimes of variability.

Examine the overlying atmospheric structure using GPS sondes relating structure to flight level winds as well as the brightness temperatures from the SFMR.

Document SST variations from downward looking IR for oceanic and atmospheric boundary layers.


ROFFS™ 25 MAY 2010
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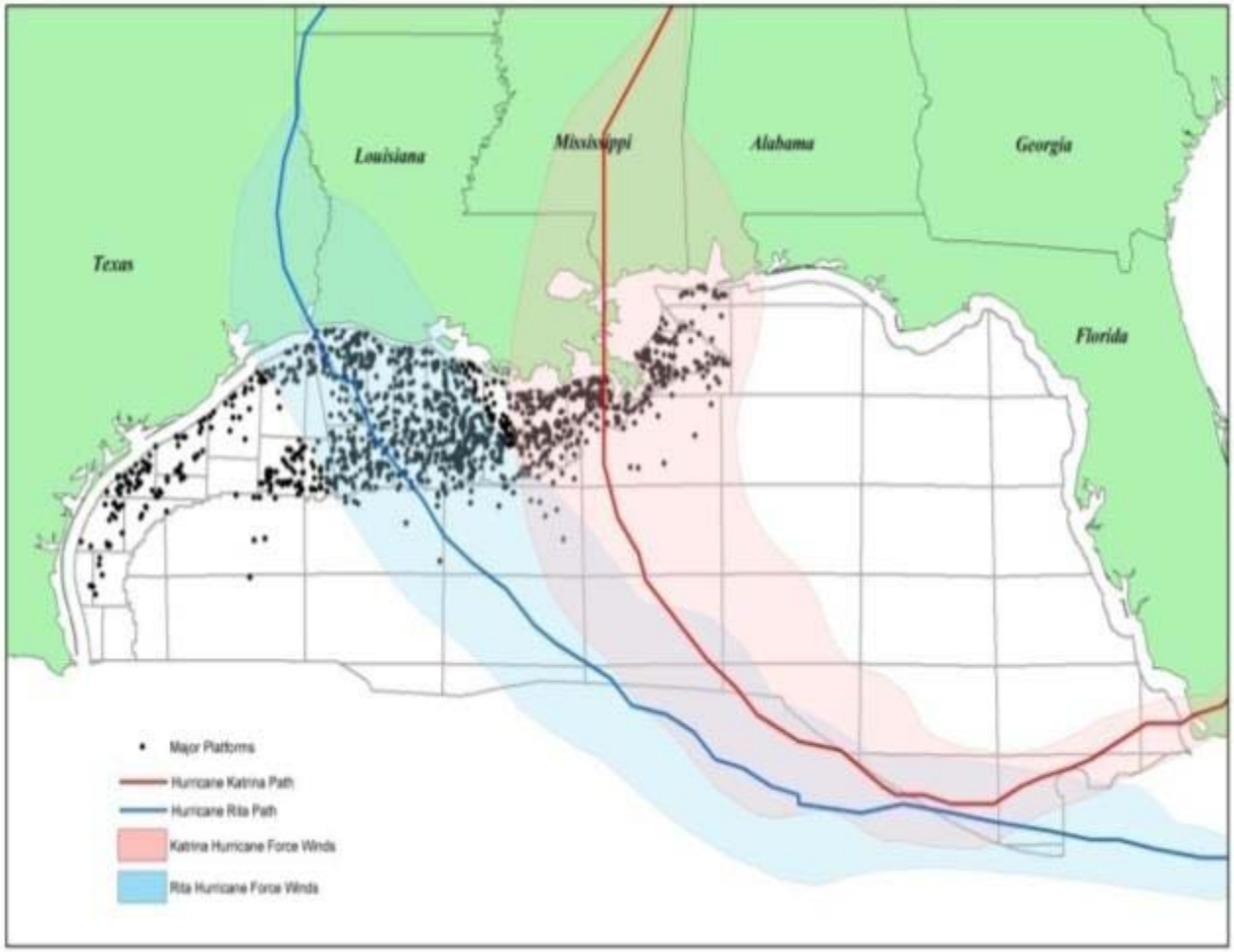
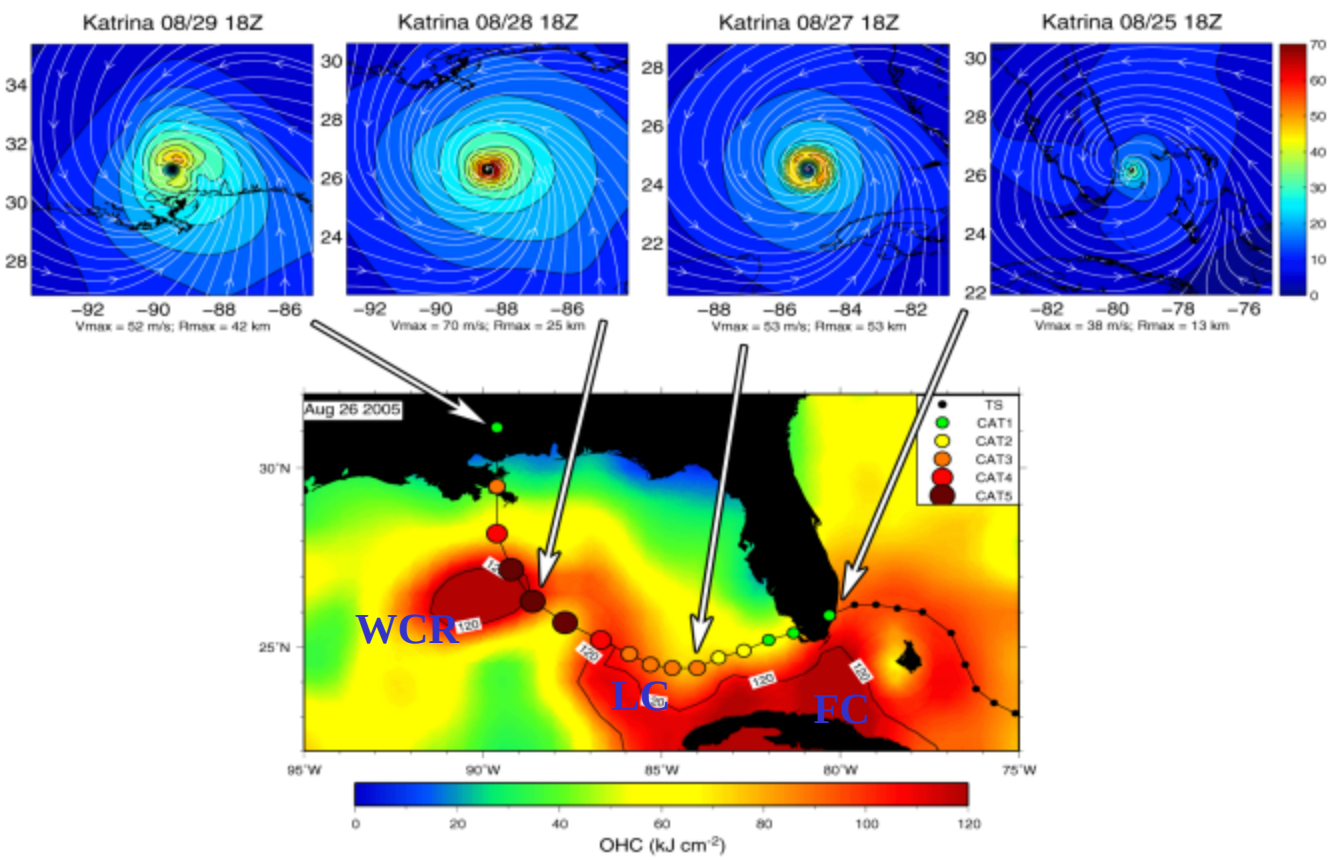
EDDY
EDDY
EDDY
LOOP CURRENT
LOOP CURRENT
LOOP CURRENT
LOOP CURRENT
sst° - °C
17.01
20.19
23.38
27.50
30.29



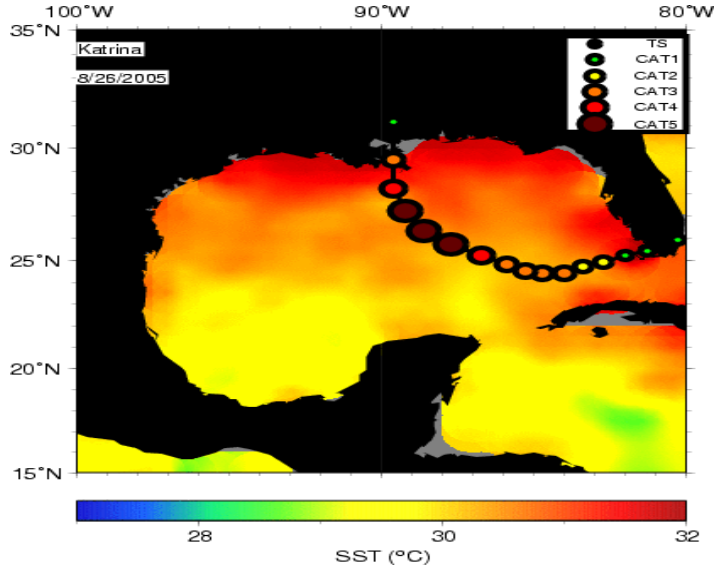
Tracks of Katrina and Rita (2005) in Northern Gulf of Mexico relative to oil rigs.

Over 35% of the rigs were damaged or destroyed in the Gulf.

Pain at the pump!



In 2005: Katrina (896 mb), Rita (892 mb), Wilma (882 mb) Trifecta



MOTIVATION: Katrina wind field with HRD wind fields (Powell et al.). relative to the the LC and WCR based on satellite data in Aug 05.

SST Image from TMI (lower panel).

Is SST Enough?

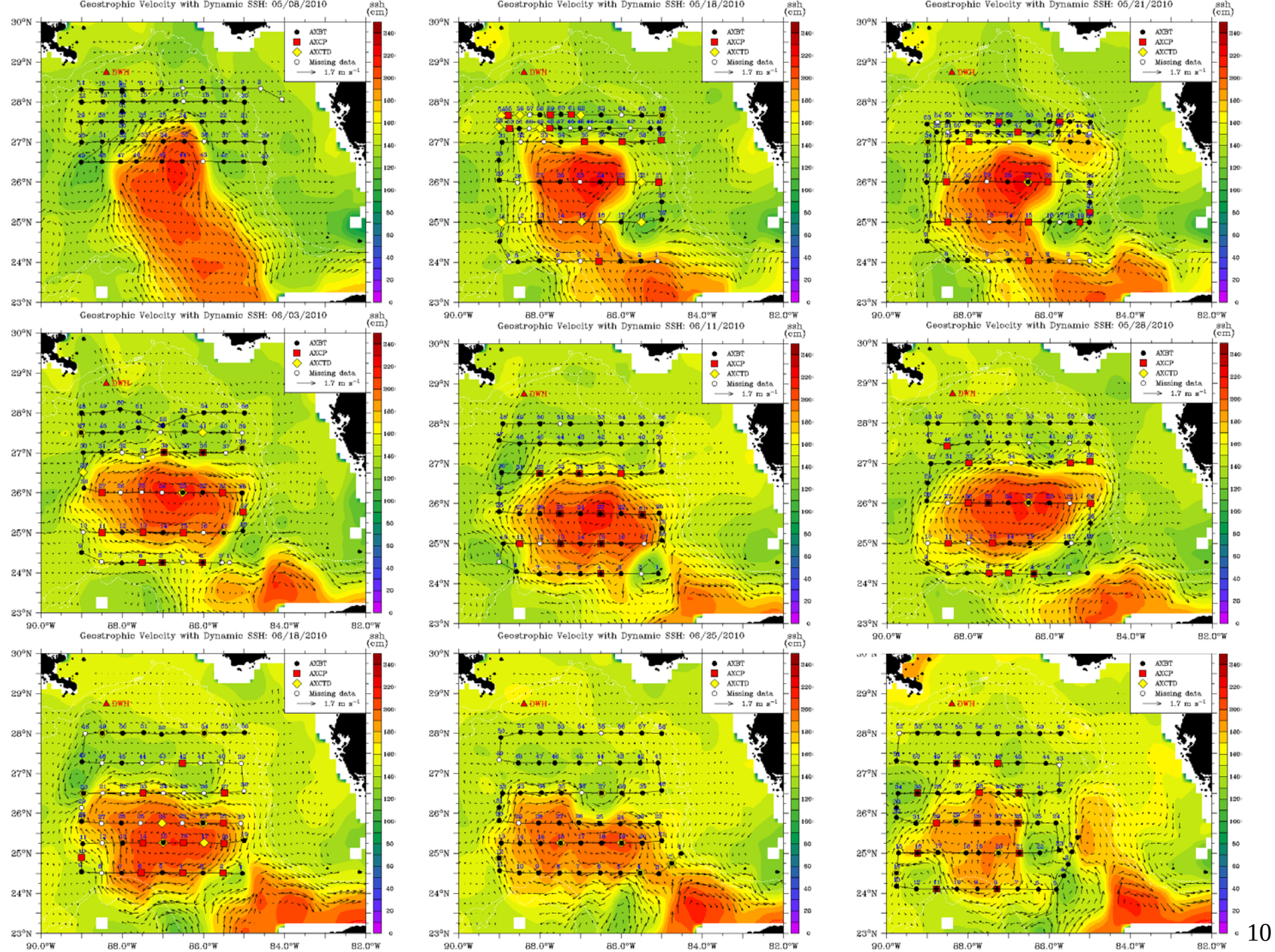
DWH Mapping Approach:

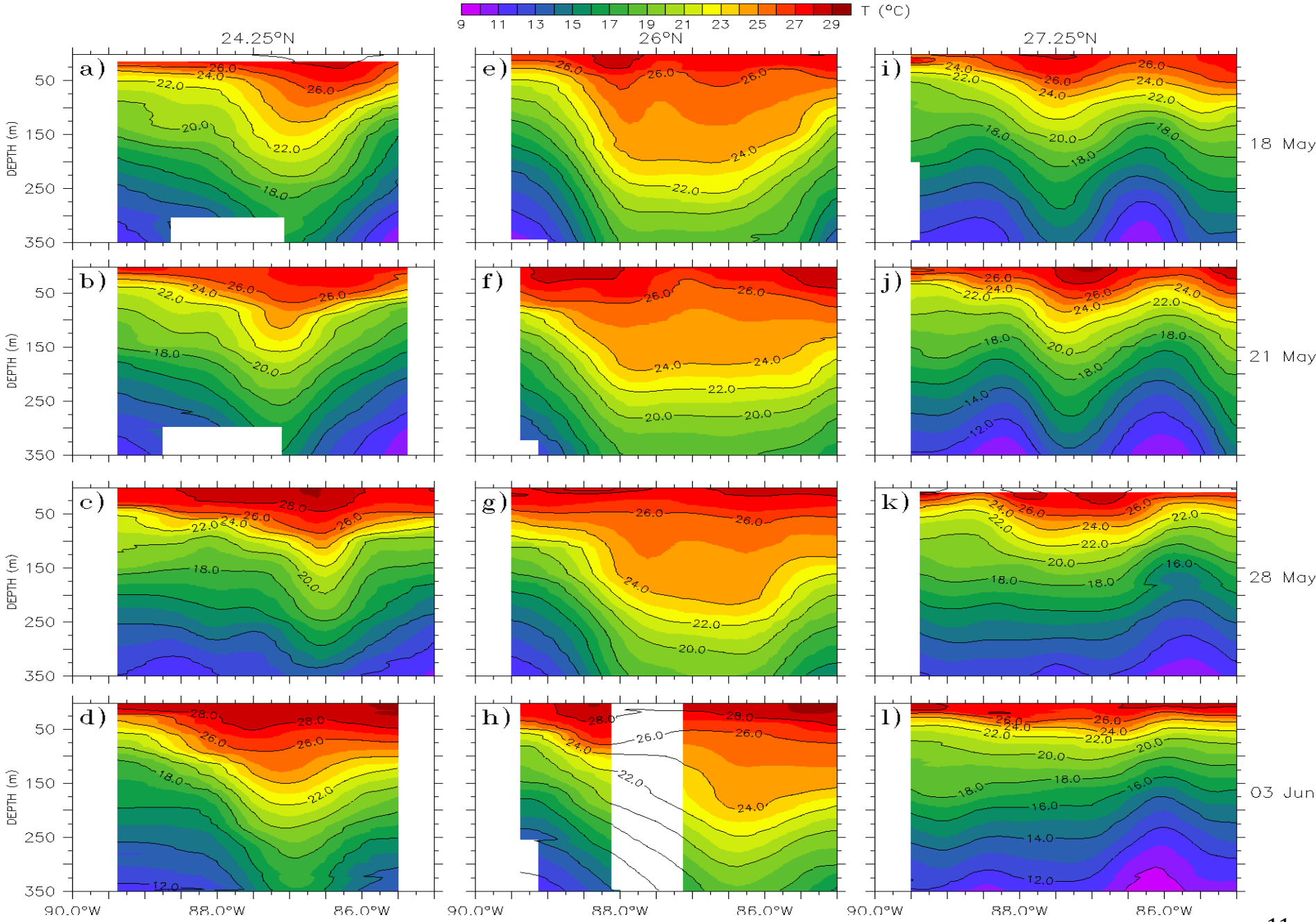
- Airborne Expendables (AXCP :1,500 m; AXBT: 350 m; AXCTD:1,000 m; GPS) deployed in lawnmower pattern across the LC/Warm and Cold eddy features.
- Flight level winds, temperatures, etc
- Brightness temperatures from the Stepped Frequency Microwave Radiometer (SFMR)
- Downward Looking IR
- Downward Looking Camera
- Nine Flights plus Bonnie Wake
- Two Ocean Heat Content Mapping Flights for Hurricane Intensity Forecasting (satellite calibration)

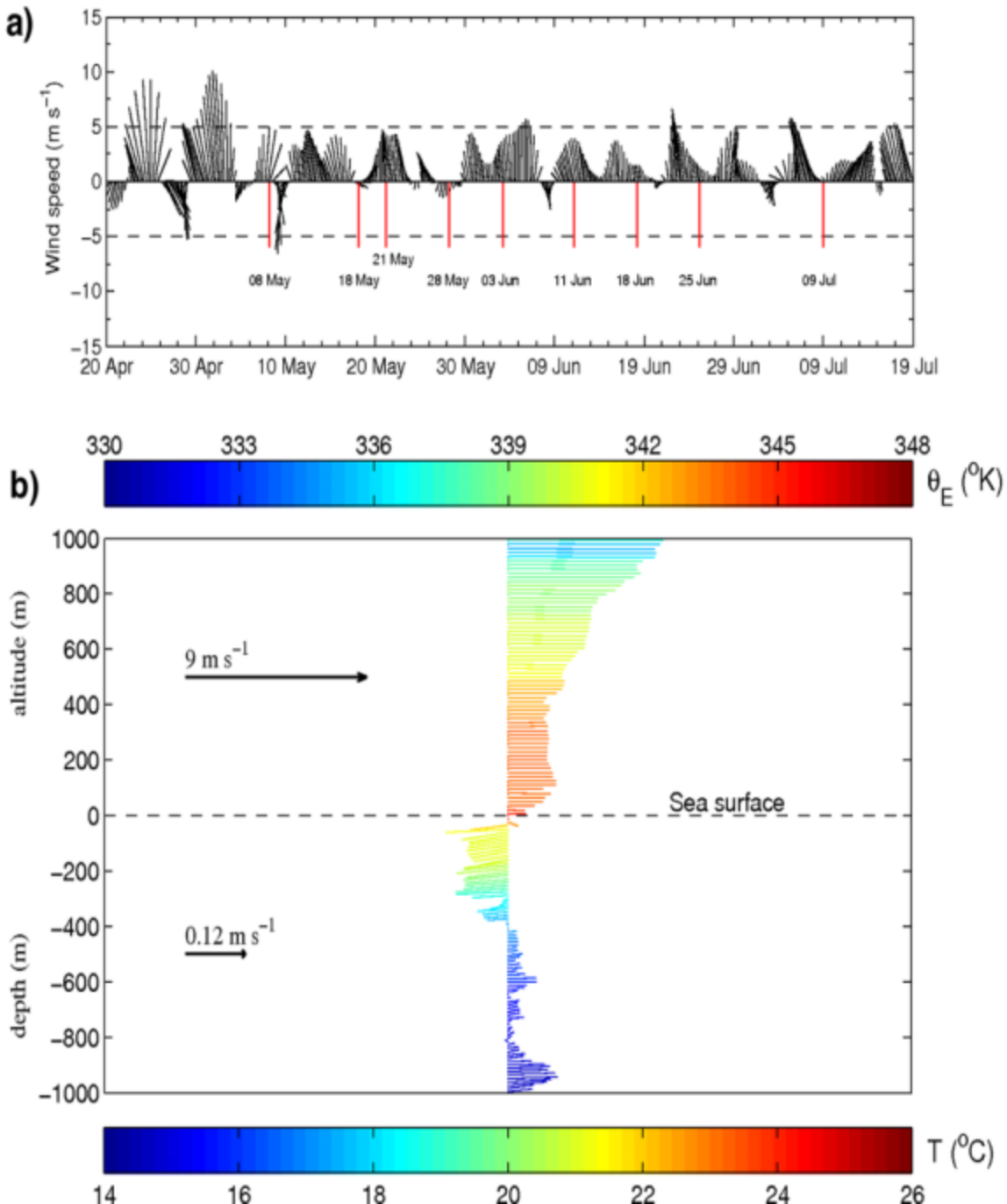
Recurrent Theme: Ocean observations critical in improving oceanic and coupled modeling under weak and strong winds.

Summary of DWH and *OHC* Flights Deployed (Successful)

Flight	AXBT	AXCP	AXCTD	TOTAL
100508H	52 (48)	0	0	52 (48)
100518H	29 (28)	26 (10)	11 (10)	66 (48)
100521H	42 (39)	22 (11)	2 (2)	66 (52)
100528H	41 (37)	22 (9)	2 (1)	63 (47)
100603H	37 (34)	23 (11)	6 (6)	66 (51)
100611H	53 (49)	15 (10)	0	68 (59)
100618H	34 (23)	22 (8)	8 (7)	63 (38)
100625H	58 (53)	0	6 (6)	64 (59)
100709H	59 (54)	12 (12)	6 (3)	77 (69)
100724H	*35(33)*	*0*	*0*	*35(33)*
100812H	*6(6)*	*6(5)*	*0*	*12(11)*
100909H	*62(58)*	*0*	*20(17)*	*82(75)*
100924H	*30(30)*	*10(5)*	*20(20)*	*60(55)*
TOTAL	538(492)	158 (88)	81 (72)	777 (645)


Geostrophic Velocity with Dynamic SSH: 05/08/2010
Geostrophic Velocity with Dynamic SSH: 05/18/2010
Geostrophic Velocity with Dynamic SSH: 05/21/2010
Geostrophic Velocity with Dynamic SSH: 06/03/2010
Geostrophic Velocity with Dynamic SSH: 06/11/2010
Geostrophic Velocity with Dynamic SSH: 05/28/2010
Geostrophic Velocity with Dynamic SSH: 06/18/2010
Geostrophic Velocity with Dynamic SSH: 06/25/2010
ssh (cm)
AXBT
AXCP
AXCTD
Missing data
1.7 m s-1
DWH
30°N
29°N
28°N
27°N
26°N
25°N
24°N
23°N
90.0°W
88.0°W
86.0°W
84.0°W
82.0°W


T (°C)
9 11 13 15 17 19 21 23 25 27 29
24.25°N
26°N
27.25°N
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
l)
DEPTH (m)
50
150
250
350
18 May
21 May
28 May
03 Jun
90.0°W
88.0°W
86.0°W

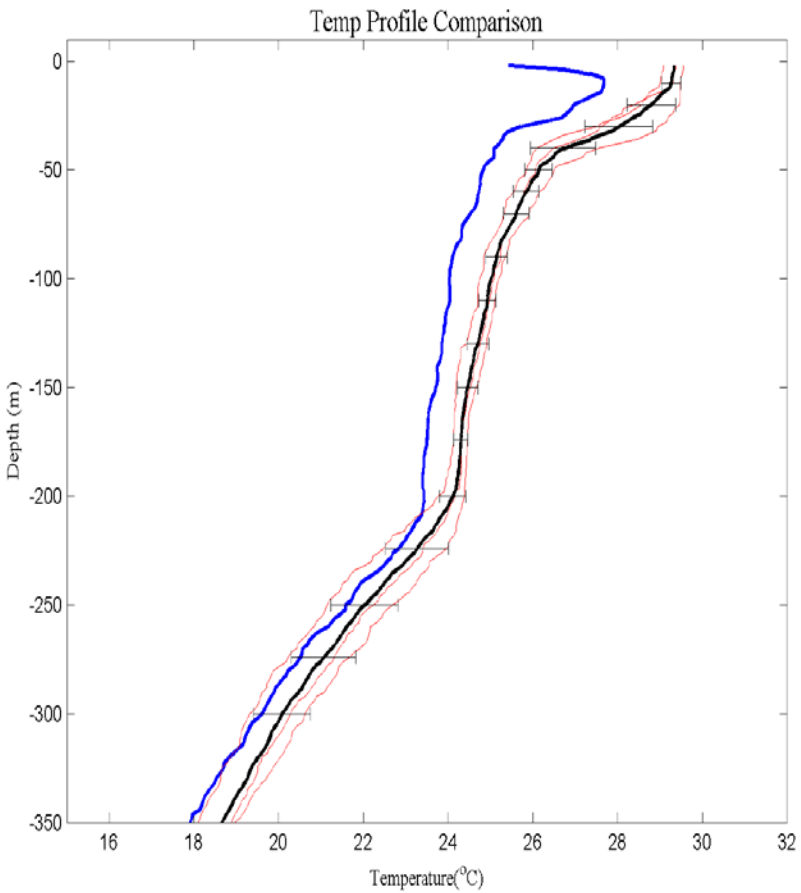


Surface winds at buoy 42040 (29.2 N, 88.2 W, or ~55 km to the NE of DWH rig). Six-hourly winds in an ocean context. Red lines indicate dates of P-3 flights.

Vertical distribution of winds (from GPS) and currents (from AXCP) at 27.7 N, 88.8 W on 18 May WP-3D flight. Color bars for θ_E (air) and T (ocean).

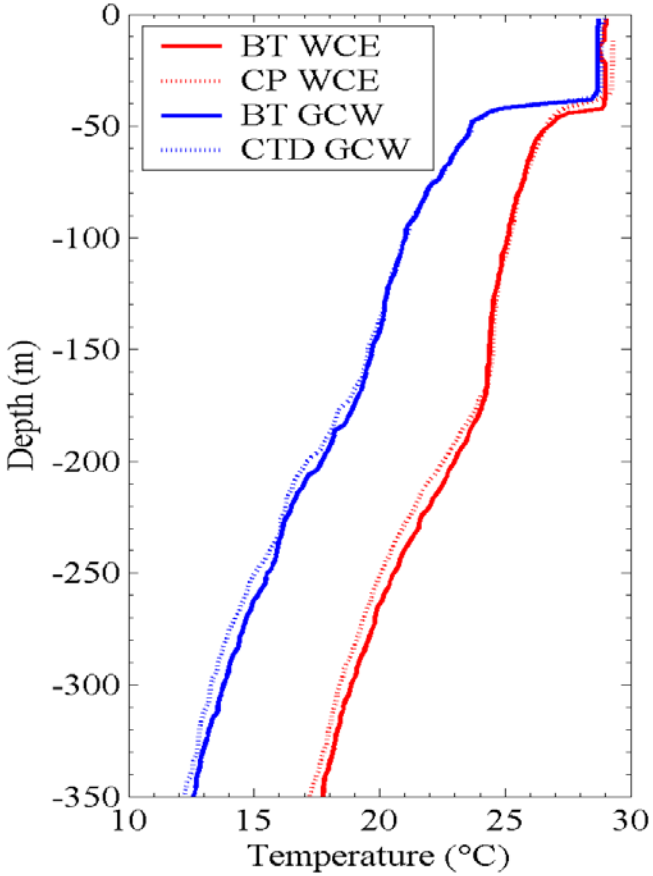
AXBT Profiles

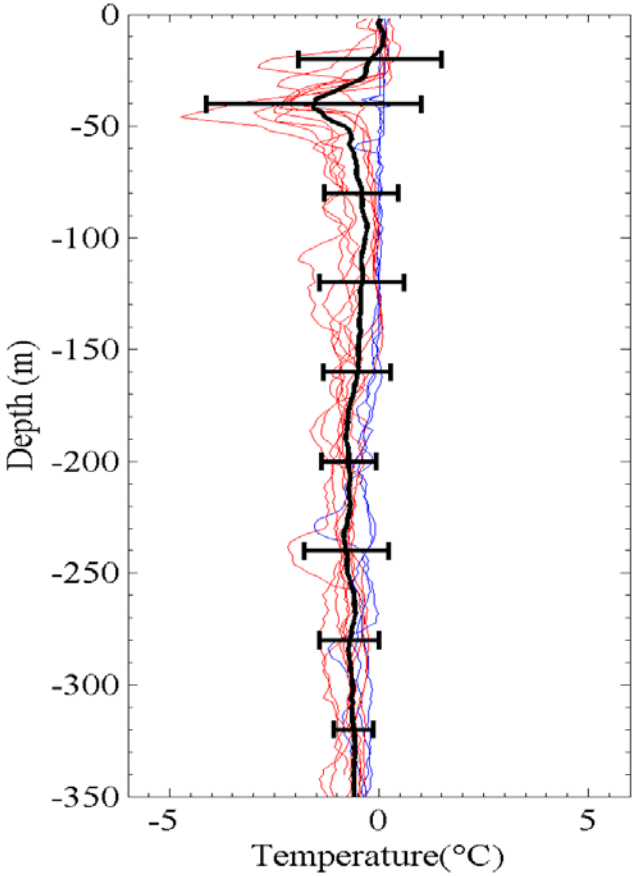
Three profiles (red) surrounding a bad profile (blue) with mean and 95% confidence. Note the 1-2C offset



Implication: assimilation scheme.

AXBT Versus AXCP and AXCTD

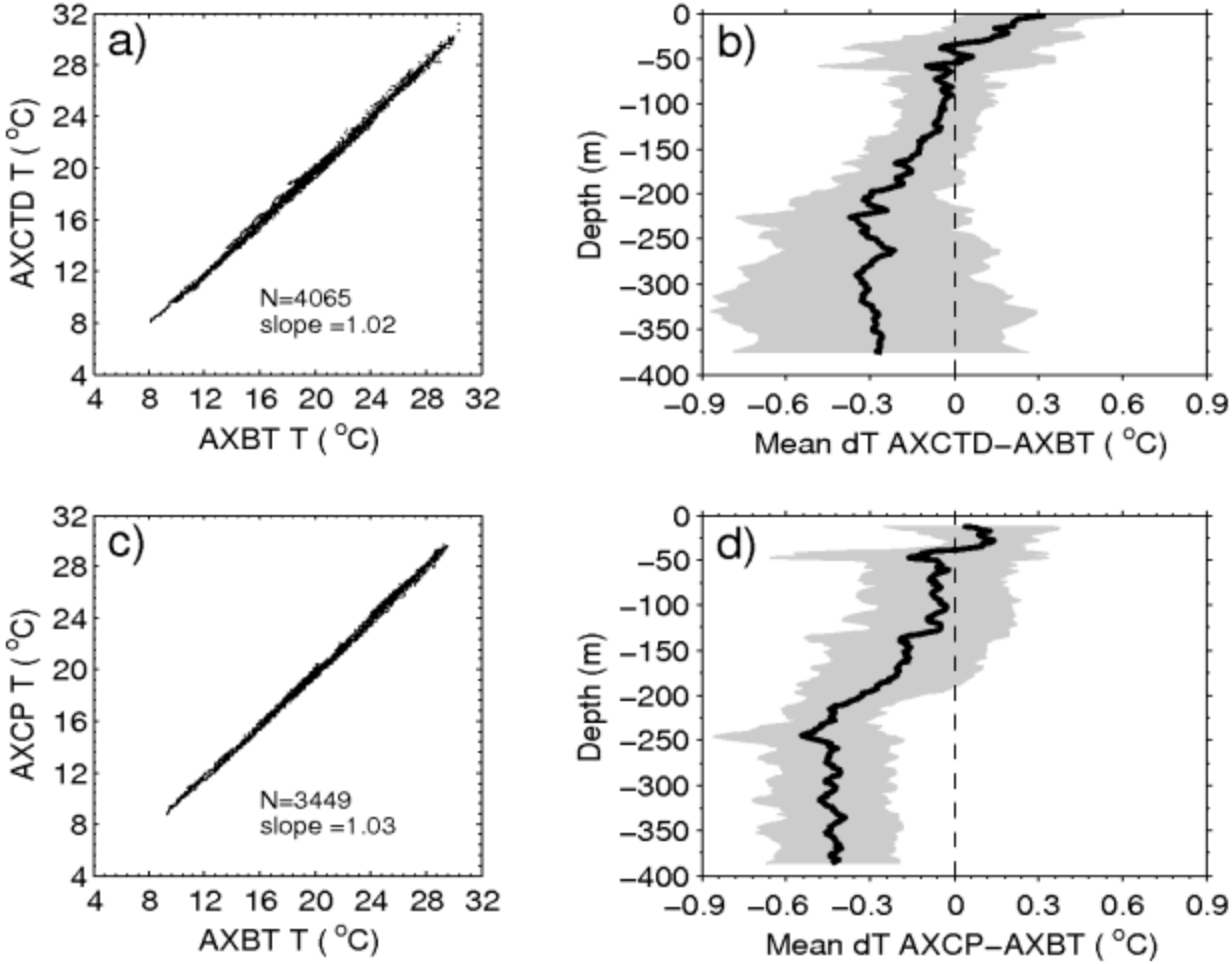




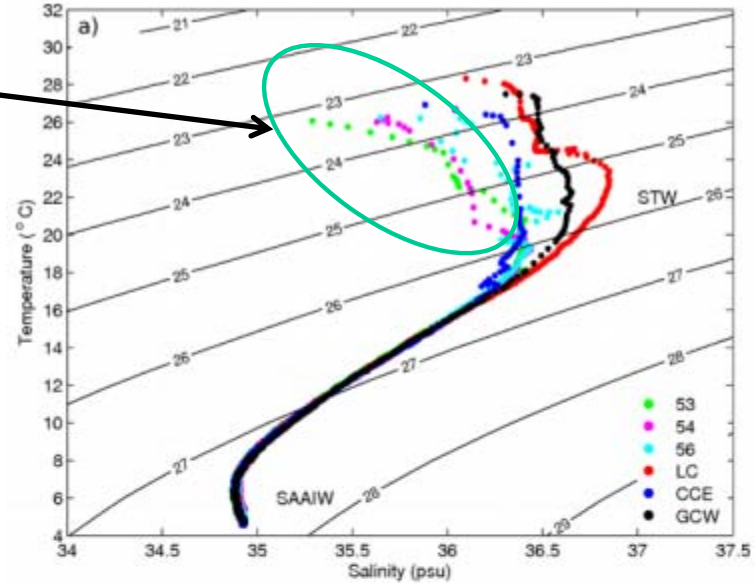
AXBT Pairs/Fall Rates:

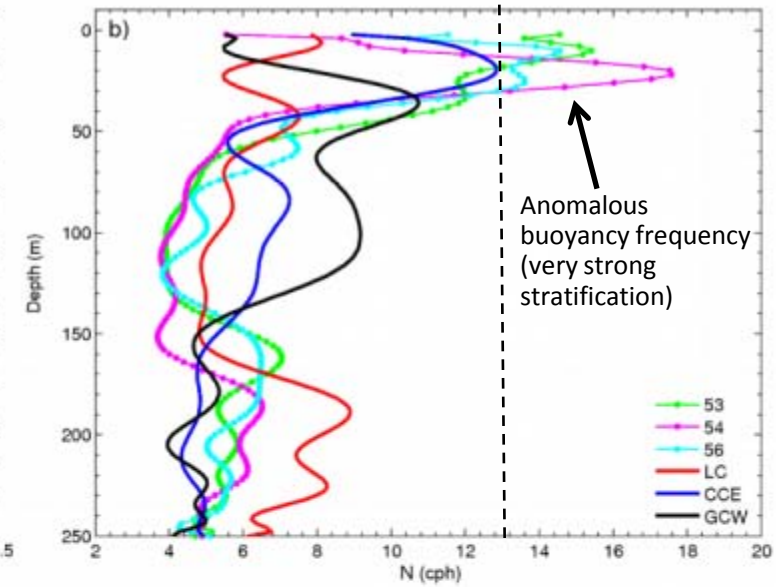
22 Pairs

20 Pairs

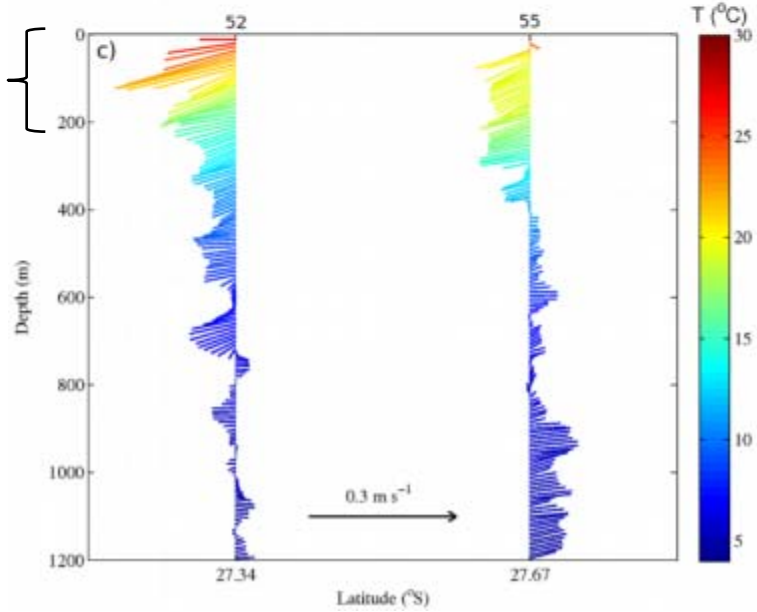


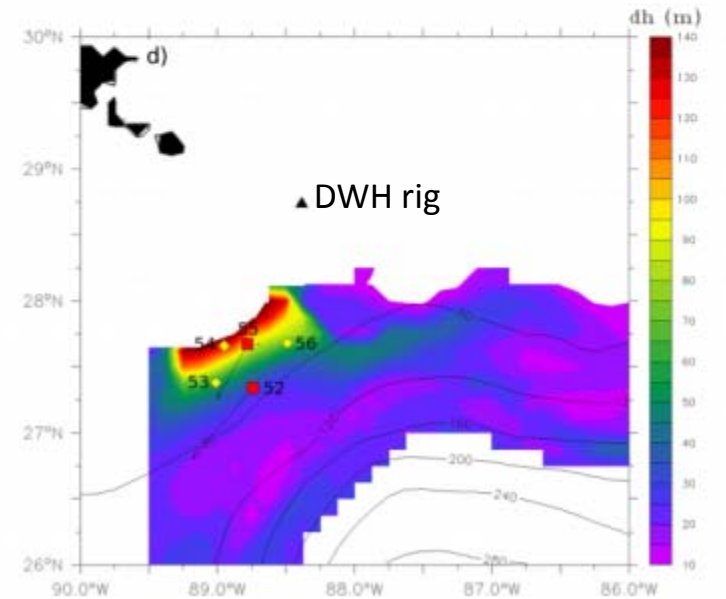
Anomalous low salinity in waters warmer than 19°C, including the thermostad.





Horizontal currents over the upper 200 m are predominantly SW (from the DWH rig).



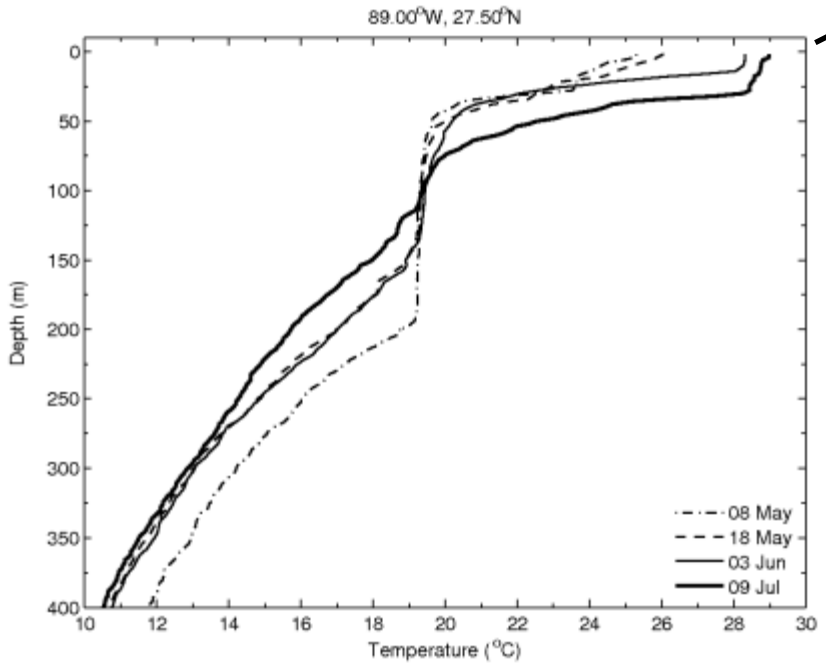


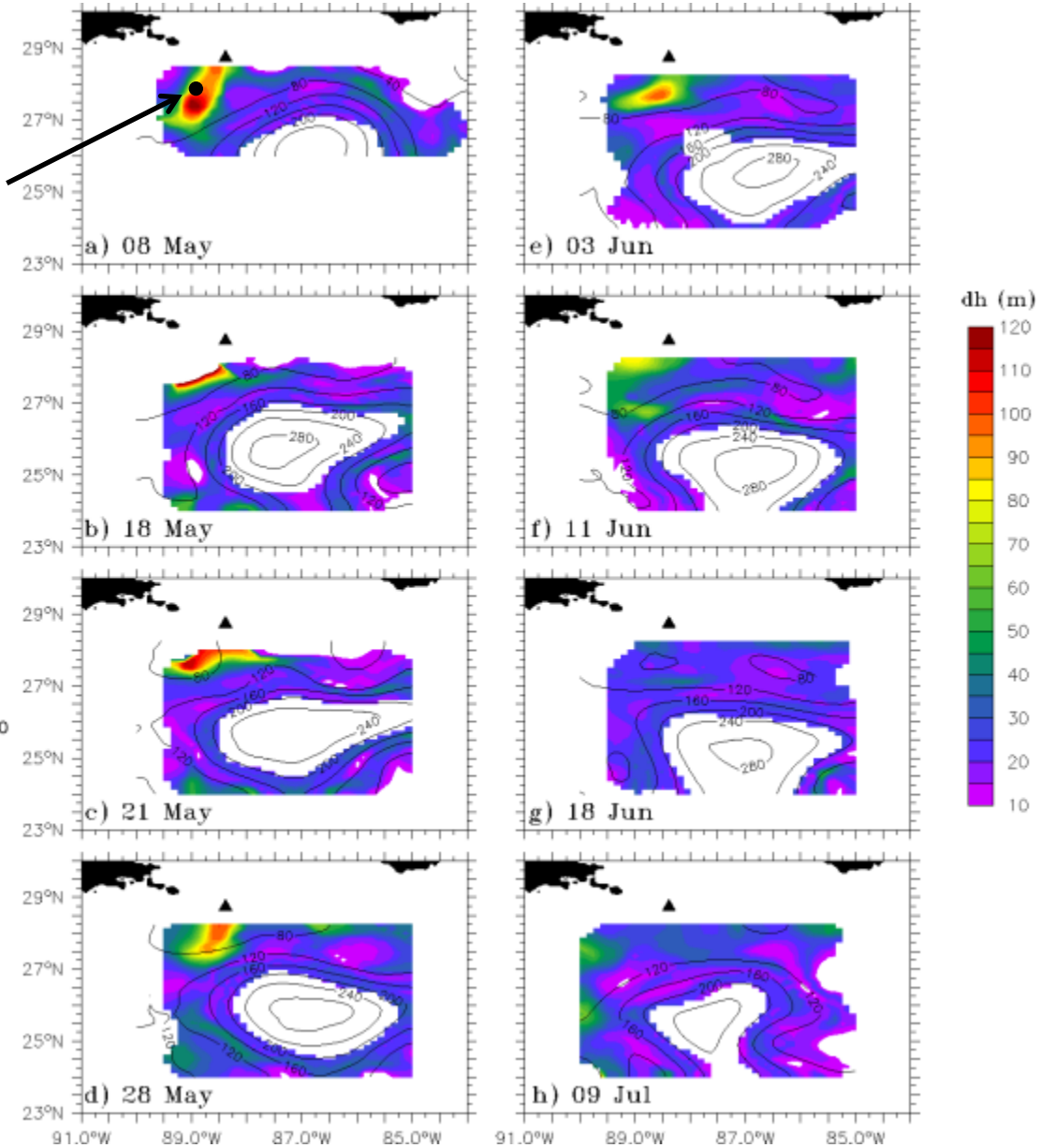
AXCP

AXCTD

WP-3D data

Subsurface thermostad (WP-3D data)



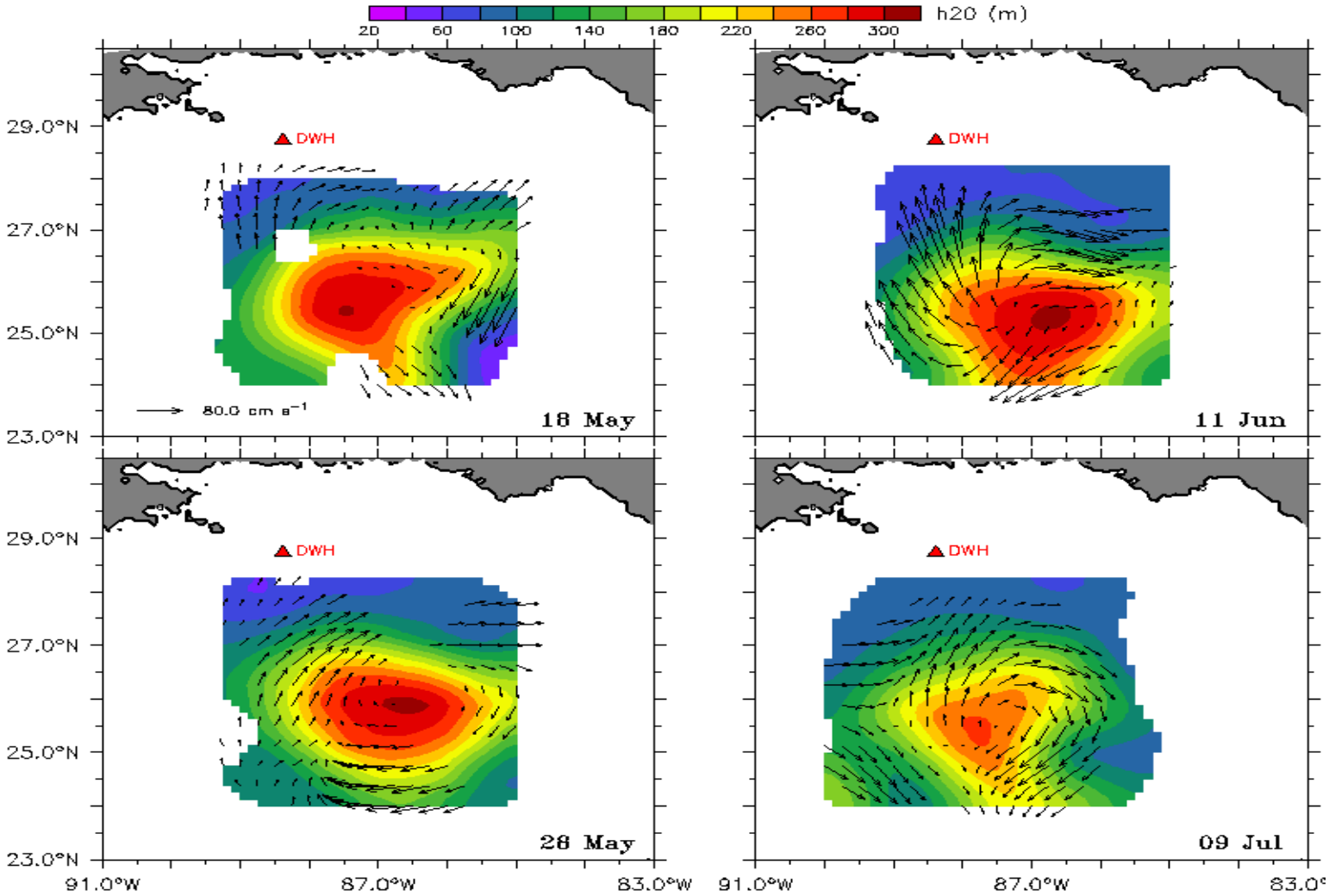


- **Remnant of a deep mixed layer caused by strong cold fronts?**
- **Strong stratification over the upper 50 m.**
- **Waters below the 100 m depth level get colder over time by effect of a developing cold core eddy.**

dh: layer thickness between the 19 and 20°C isotherms.

Contours are the depth of the 20°C isotherms.

Evolution of Eddy Franklin: *In-Situ* Data

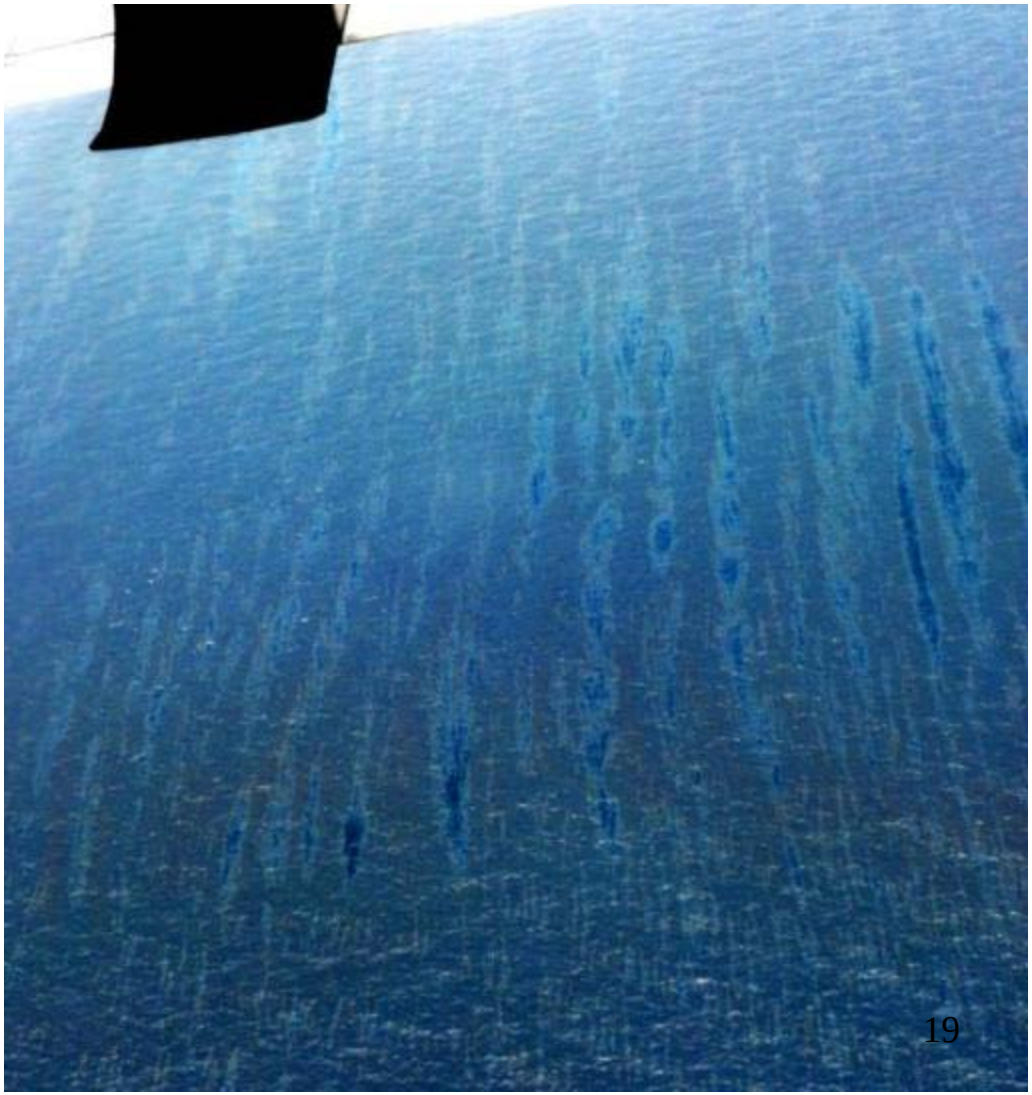


Wind Rows Aligned with Winds-Langmuir Cells?

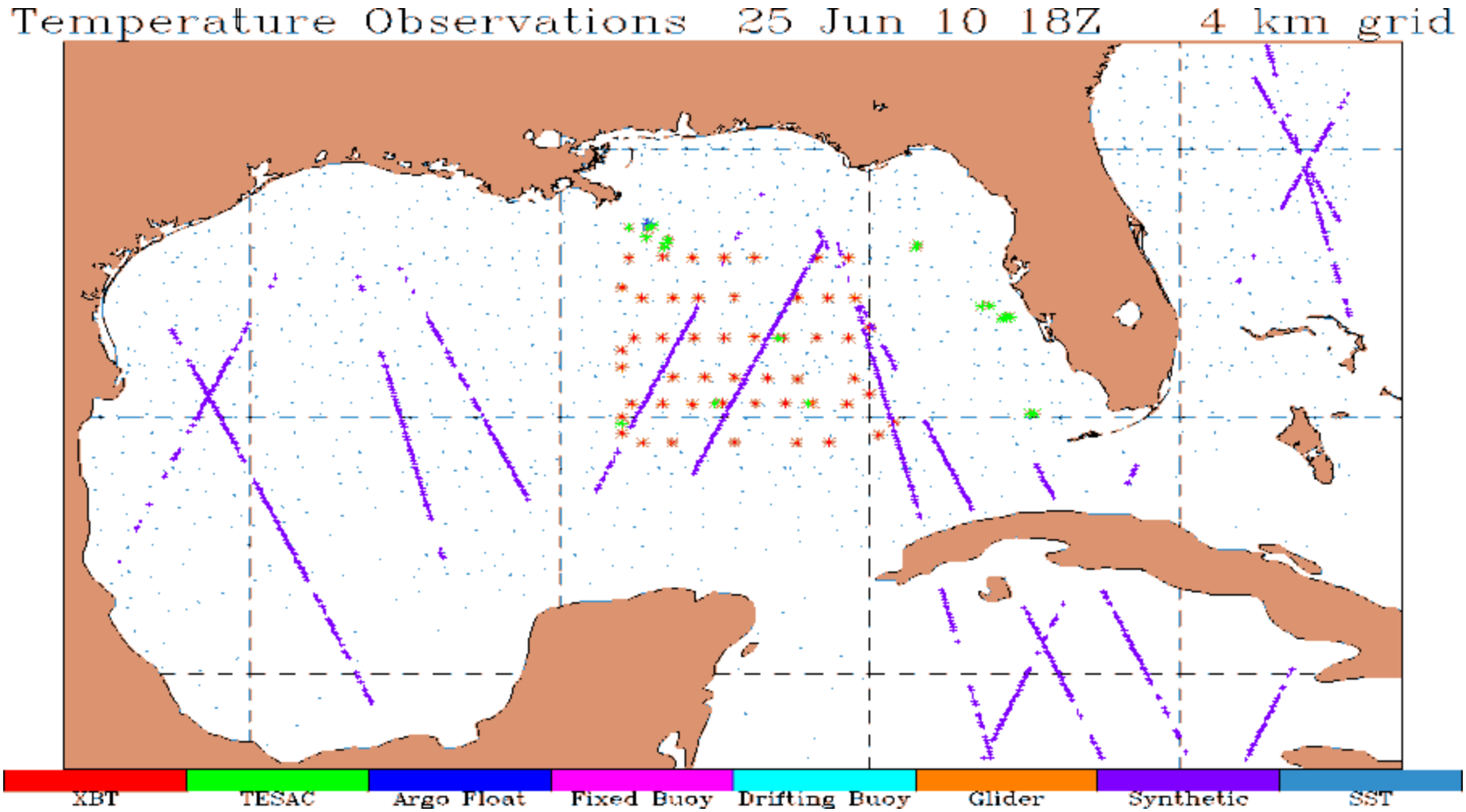
Winds were about 3 to 5 m/s.

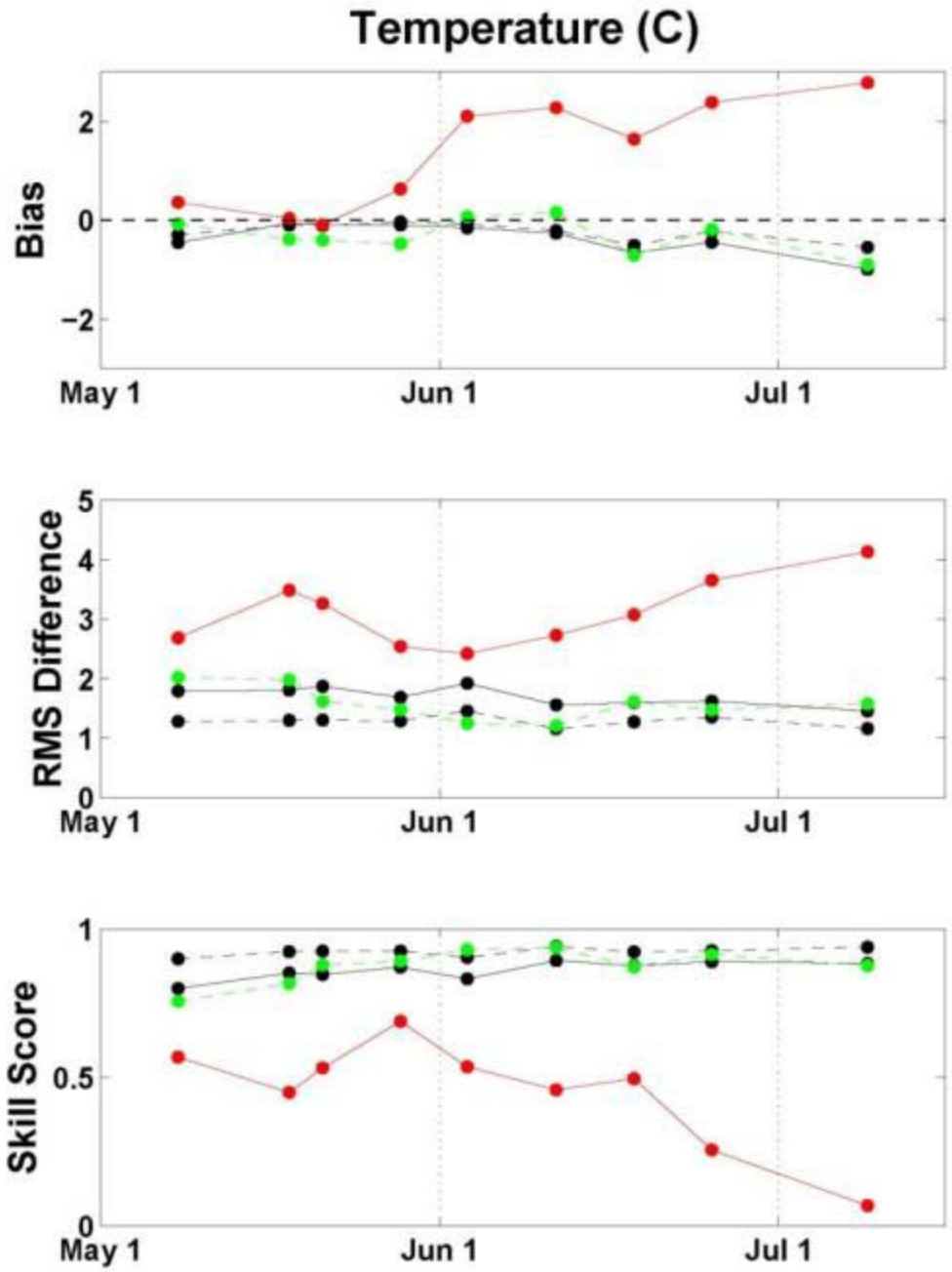
Alternating convergence and divergence cells

Implications redistribution of oil in surface layer and near-surface mixing.



T(z) Data Assimilation into Models





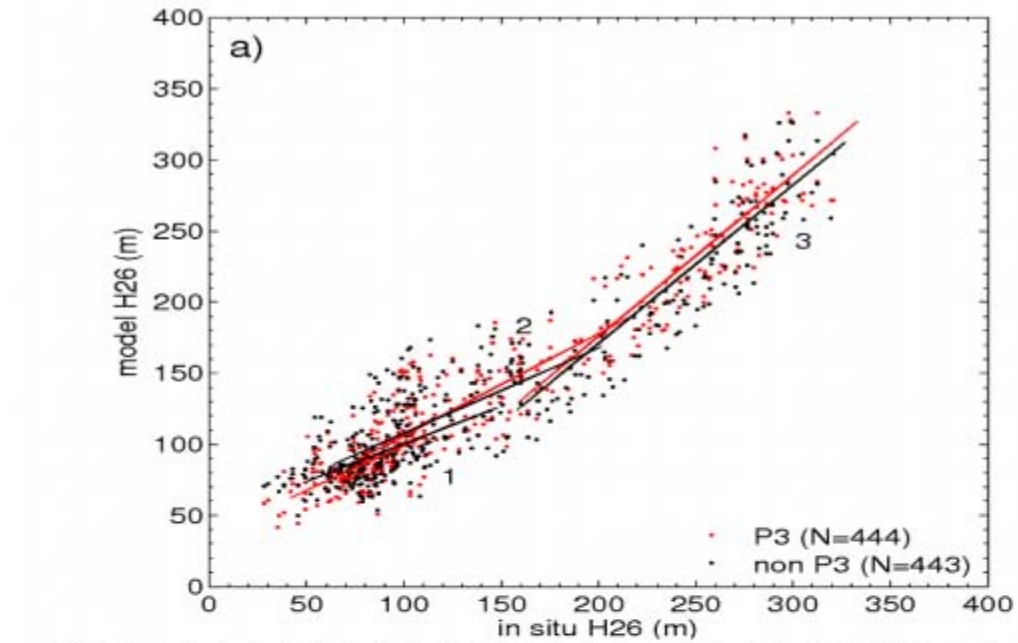
Evaluation of 4 HYCOM Nowcasts

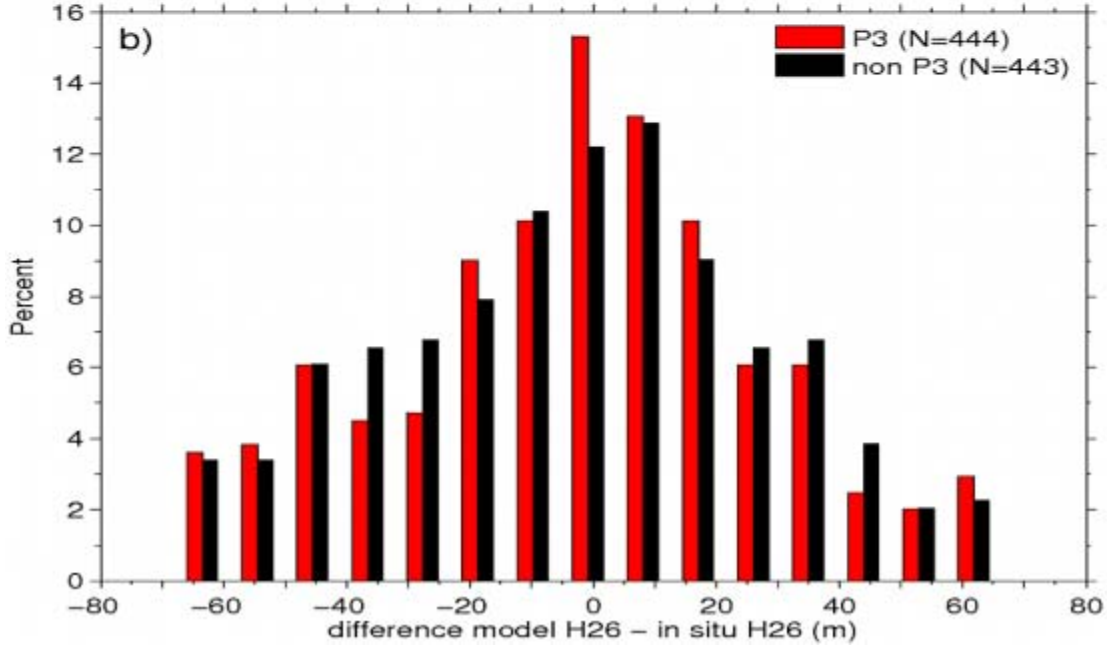
MODELS:

Navy 0.04-degree GOM HYCOM
Navy 0.08-degree global HYCOM
NCEP/EMC RTOFS

Solid lines – No P3 assimilation
Dashed lines – With P3 assimilation

This evaluation compares temperature from all AXBT profiles over the depth range from 30 to 360 m

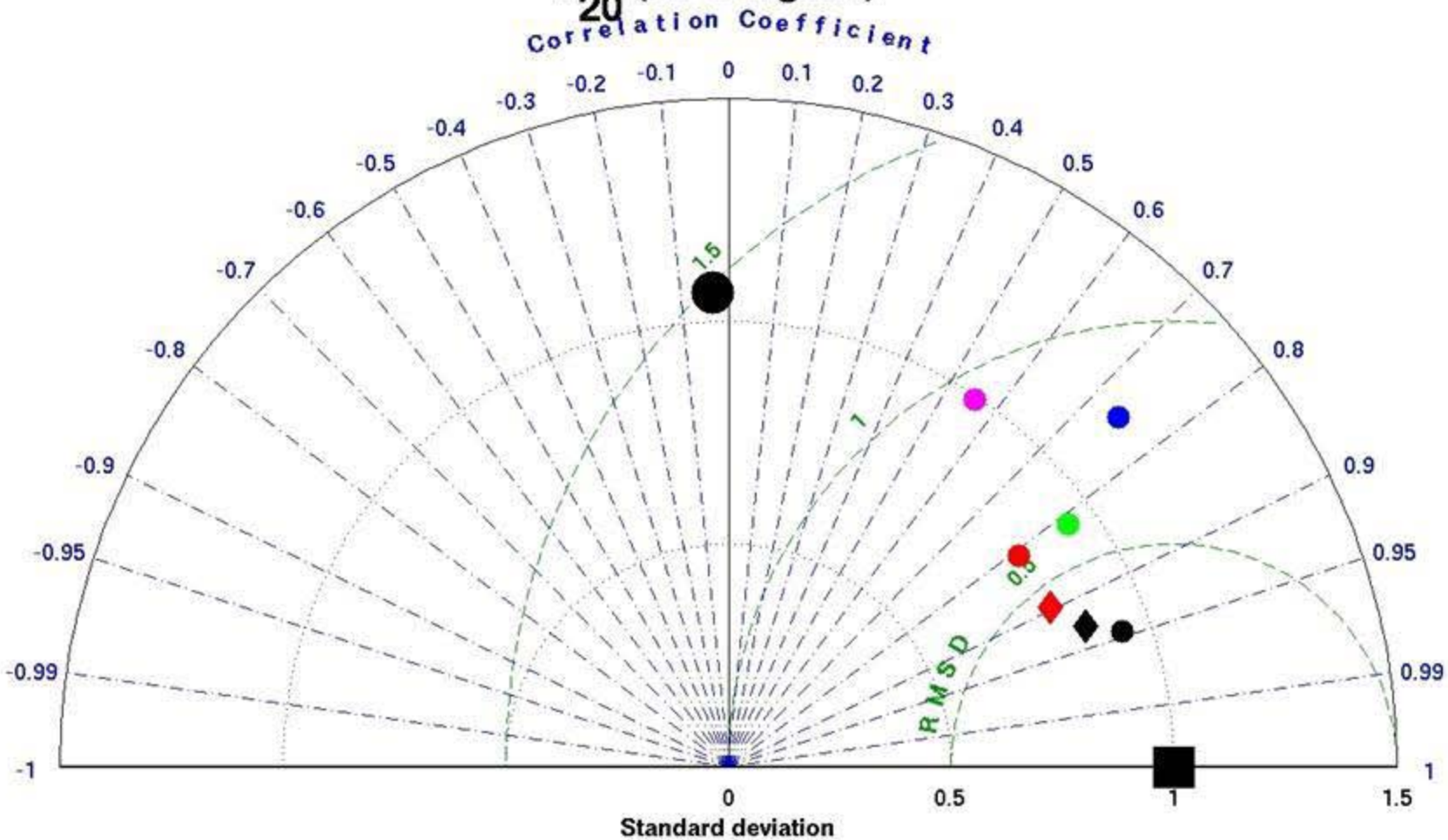




Scatter Between Model and Observed 26C Isotherm Depths with (red) and without (black) Assimilation of P3 Profiles

Histogram of 26C Isotherm Depths Differences

H_{20} (all 9 flights)



Reference Points

- Perfect comparison
- No assimilation (GoM HYCOM)

OSE Data-Assimilative Analyses

- GoM HYCOM (includes P-3)
- GoM HYCOM (denies P-3)

Other Data-Assimilative Analyses

- Navy Global HYCOM
- NRL IASNFS NCOM
- NCSU SABGOM ROMS
- NOAA/NOS NGOM POM
- NOAA/NCEP/EMC RTOFS HYCOM

Progress Summary

Need to construct a more coherent blueprint for the future in case of another oil spill or strong TC in GOM.

The LC is an important contributor to ocean circulation that affects the Florida Keys (Florida Current) and Eastern Seaboard (Gulf Stream).

Targeted obs (LC or storm-coordinate system) of temperatures, currents and salinities are needed to improve the models. We cannot solely rely on synthetic temperature structure from satellite products.

Combine the various data sets (gliders, moorings, expendables, ship-based) into a coherent mosaic of the LC complex that impact ecosystem to hurricane responses.

Determine appropriate update cycle in oceanic data assimilation schemes (1, 3, 5 days?)

How do we effectively get data into the models to better understand potential pathways of oil in real time or the ocean response to TC passage?

Reference

Powell, M.D., S. Murillo, P. Dodge, E. Uhlhorn, J. Gamache, V. Cardone, A. Cox, S. Otero, N. Carrasco, B. Annane, and R. St. Fleur. 2010. Reconstruction of Hurricane Katrina's wind fields for storm surge and wave hindcasting. Ocean Engineering 37:26–36.