HYCOM Performance in the Gulf of Mexico During the DWH Oil Spill

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DWH Observations in Eastern Gulf of Mexico

- Unprecedented dataset, including targeted observations collected by NOAA for DWH oil spill
 - P-3 airborne synoptic surveys (NOAA/UM)
 - AXBT, AXCTD, AXCP profiles
 - In-situ observations
 - Targeted cruises
 - Surface drifters, gliders
 - Satellite-derived SST
 - Satellite ocean color
 - Altimetry-derived SSH and surface current maps
 - Heat content analyses derived from altimetry, SST, and climatology
 - Ocean surface drifters
 - Moored observations from Minerals Management Service
- Use this dataset for comprehensive ocean model evaluation and improvement effort
 - Benefits include oil forecasting, ocean model initialization for coupled hurricane forecasting

P-3 Observations (N. Shay)



Summary of Flights

Flight	AXBT	AXCP	AXCTD	TOTAL
100508H	52 (46)	0	0	52 (46)
100518H	29 (29)	26 (11)	11 (10)	66 (50)
100521H	42 (41)	22 (11)	2 (2)	66 (54)
100528H	41 (37)	22 (12)	2 (1)	65 (50)
100603H	37 (33)	23 (11)	6 (6)	66 (50)
100611H	53 (49)	15 (10)	0	68 (59)
100618H	34 (23)	22 (11)	8 (7)	64 (41)
100625H	58 (53)	0	6 (6)	64 (59)
100709H	59 (55)	12 (12)	6 (3)	77 (70)
TOTAL	405 (366)	142 (78)	41 (35)	588 (479)

9 Sept 2010 also available Overall success rate: 81.5% GPS Dropsondes deployed: 78







From Nancy Foster Cruise Report (NOAA/AOML/PhOD)



Evaluation of HYCOM Performance

- Demonstrate impact of changing vertical projection method to MODAS synthetics
- Evaluate three HYCOM-based Gulf of Mexico analyses
 - Navy 0.08° global HYCOM
 - Navy 0.04° GoM HYCOM (with and without data assimilation)
 - NOAA/NCEP/EMC RTOFS
- Evaluate these HYCOM analyses against:
 - P-3 and Nancy Foster profiles
 - Other ocean analyses generated by different model types
 - Synthetic ocean T profiles
- Perform an Observing System Experiment using GoM HYCOM to quantify impact of assimilating NOAA P-3 airborne profiles

Evaluation Metrics

- Mean bias
- RMS difference (mean bias removed)
- Murphy skill score
 - (1.0 => perfect)
 - (<0.0 => insignificant)
- Calculated vs. P-3 obs. for each of the 9 flight dates

Variables Subjected to Error Analysis

- Depth of 20°C isotherm (maps Loop Current and eddy structure)
- Upper ocean T between 30 and 360m



0.04° GoM HYCOM changed from Cooper-Haines to MODAS synthetics during the DWH oil spill



0.04° GoM HYCOM (T profiles, 30 – 360 m)

VERTICAL PROJECTION:

Cooper-Haines MODAS Synthetics

Large reduction in negative T bias and RMS errors when vertical projection changed from Cooper-Haines to MODAS synthetics. 2. Comparative evaluation of data-assimilative ocean models that did not assimilate P-3 profiles

Evaluate 5 data-assimilative analyses that did not assimilate P-3 profiles, along with one free model run, against P-3 obs.



Six Ocean Analyses vs. P3 Observations

NON-ASSIMILATIVE ANALYSIS:

Navy 0.04-degree GOM HYCOM (thick black line)

DATA ASSIMILATIVE ANALYSES:

Navy 0.04-degree GOM HYCOM NOAA/NCEP/EMC RTOFS HYCOM NCSU SABGOM ROMS Navy IASNFS NCOM NOAA/NOS NGOM POM

Large reduction in RMS errors due to assimilation

Three best performers: GOM HYCOM, SABGOM ROMS, IASNFS NCOM



Six Ocean Analyses vs. P-3 Observations

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Large reduction in RMS errors due to assimilation

Three best performers: GOM HYCOM, SABGOM ROMS, IASNFS NCOM 3. Observing System Experiment (OSE) to assess the impact of P-3 observations on data-assimilative ocean analyses

Impact of P-3 Observations on Ocean Analyses

- Collaboration between AOML and NRL-Stennis
 - NRL ran two experiments with the 0.04° GoM HYCOM using NCODA data assimilation
 - 1. Assimilate all observations
 - 2. Deny only the P3 observations
- Critical issues affecting this evaluation:
 - Results depend on choices of model and DA scheme
 - Impact of update cycle
 - Impact of relative weighting of synthetic T,S profiles derived from altimetry vs. *in-situ* T,S profiles

OSE Setup

- Run twin nowcast experiments with and without P-3 assimilation
 - 28 April through 17 July
 - Quantify error reduction due to P-3 assimilation
- Run twin ocean forecasts initialized by the two nowcast experiments
 - 3 June through 17 July
 - Quantify reduction in error growth rate due to P-3 assimilation





From Nancy Foster Cruise Report (NOAA/AOML/PhOD)



Error Analysis, Nancy Foster T Profiles, 9 July

Temperature, 30 – 360 m

Experiment	Bias (°C)	RMS Diff. (°C)	Skill Score
P-3 Profiles Assimilated	-1.11	1.41	0.88
P-3 Profiles Denied	-1.18	1.79	0.84
No Data Assimilation	-0.40	4.5	0.31

20°C isotherm depth

Experiment	Bias (°C)	RMS Diff. (m)	Skill Score
P-3 Profiles Assimilated	-21.1	35.8	0.09
P-3 Profiles Denied	-24.3	44.3	< 0
No Data Assimilation	19.3	89.5	< 0

4. Performance of the Navy 0.08[•] global HYCOM

5. Synthetic T profiles derived from satellite altimetry



Summary

- Large error reduction due to change in vertical projection method
- DA produces large error reduction
 - GoM HYCOM produces smallest error among models that did not assimilate P-3 profiles
 - Synthetic T had similar errors to GoM HYCOM, 7 out of 9 flight dates
- P-3 assimilation produces modest additional error reduction
 - Results depend on choices of model and DA scheme
 - Impact of update cycle
 - Impact of relative weighting of synthetic T,S profiles derived from altimetry vs. *in-situ* T,S profiles
- Short forecast time scales
 - P-3 advantage lost within ~1 week
 - Impact of DA lost within ~1 month
- Global HYCOM (with P-3 assim.) produced smallest errors