Coupled HYCOM-HWRF (HyHWRF) System: Past, Present and Future

Hyun-Sook Kim, Hendrik Tolman, Carlos Lozano, Dan Iredell

the HYCOM team @ MMAB/EMC

the HWRF teams @ EMC

Hendrik L. Tolman
Chief, Marine Modeling and Analysis Branch
NOAA / NWS / NCEP / EMC

Hendrik.Tolman@NOAA.gov

Past efforts, including Lessons learned

Current efforts

- Complete the development of HyHWRF version 2 with. eddy-resolving, 1/12-degree global HYCOM (v.2.2.19).
- Implement Ocean Data Assimilation to use in-situ measurements during TC.
- Optimize configuration.

Future plan

- Employ HyHWRF for TC forecasts in different basins.
- 3-way coupling HYCOM-HWRF-WAVEWATCH III ®.

Performance of Parallel, Real-Time Forecasts of Atlantic TCs Each Season from 2008 to 2011

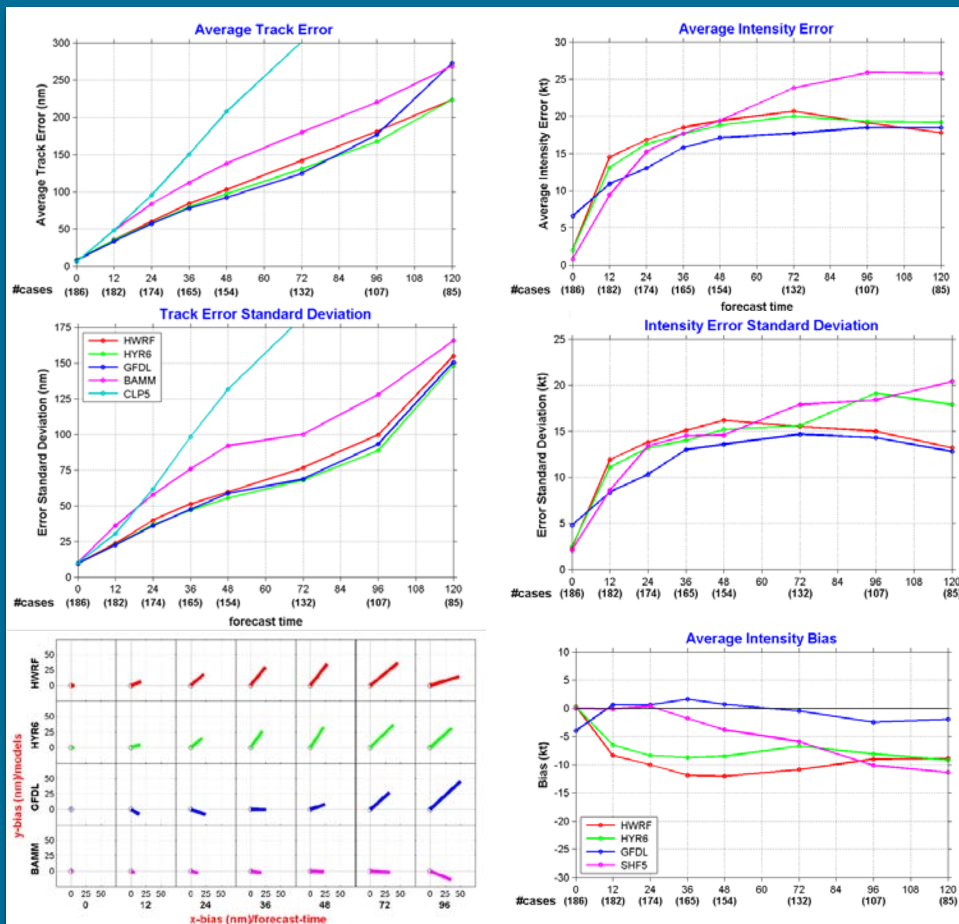
- Good comparison of SST between simulations and observations (AXBT and SST analysis).
- Good comparison of simulated SST cooling and cold wake with the observed, e.g., 6°C for Ike (09L) 2008.
- Comparable Hurricane Intensity and Track Forecast Skill (next slides for details).

Lessons learned

- Get ocean right first, then reconsider HWRF.
- Optimal ocean configuration is necessary.
- Good comparison of SST owing to DA in RTOFS-Atlantic, but improvement is required for under-estimate MLD and overestimate Z26.

Past Performance of HyHWRF Forecast: 2010 season

Alex, Danielle, Earl, Fiona, Igor, Julia and Karl (198 cases)



Track (HyHWRF – Green) Intensity

Comparison with HWRF (red)

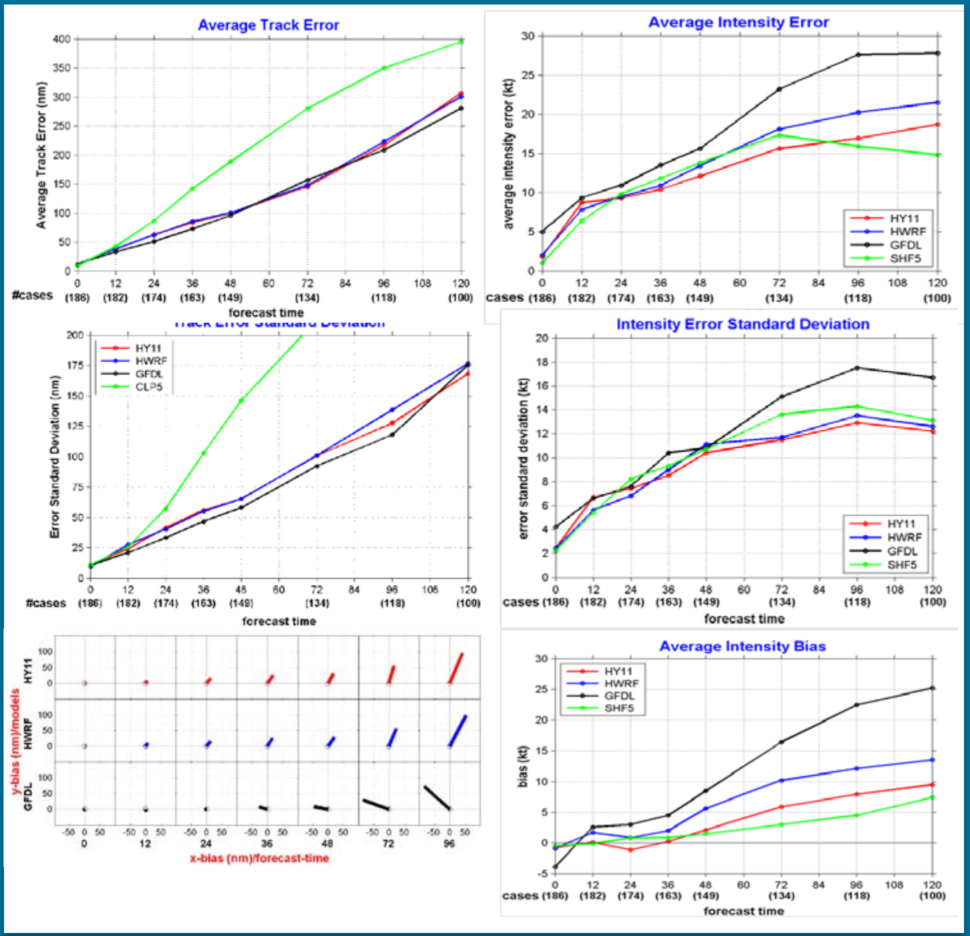
Track: Comparable forecast skill, but showing ~10 nm improvement in error, STD and bias magnitude.

Intensity: Average error improved for 0-72 h, followed by degradation due to large standard deviation; However, significant improvement in the intensity bias (by ~ 5 kt).

Past efforts

Past Performance of HyHWRF Forecast: 2011 season

Gert, Irene, Katia, Maria, Ophelia, and Philippe (186 cases)



Track (HyHWRF – Red) Intensity

Comparison with HWRF (blue)

Track: Similar average error, but showing improvement in STD for 24-120 h; Bias the same in both direction and magnitude.

• **Intensity**: Improvement in average error by ~ 4 kt for 24-120 h, but slight degradation in STD for the same period; Large improvement in bias by ~ 5 kt, including no bias for 0-36 h.

Data Assimilation (DA)

1. General Objectives

- Improve the estimate of sub-surface ocean structures based on remotely sensed observations of SSH, SST, in-situ T and S; and model estimates.
- Improve the joint assimilation of SSH, SST, T and S in a high resolution ocean forecast system.

2. Specific Objectives

- Improve initial condition of the oceanic structure, as frequently as observations allow.
- Implementation specifically designed to use in-situ observations during TC, including AXBT.

Method

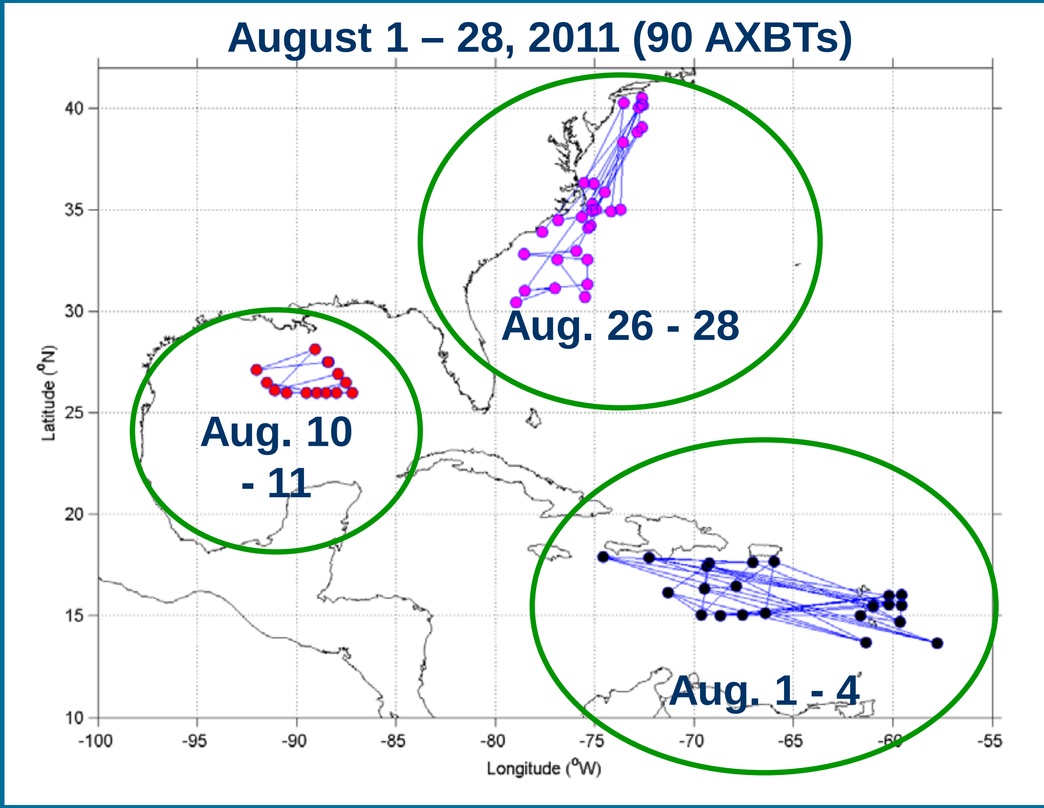
- Quality Control:
  - Observation accepted if
    - Anomaly from climatological mean is within xSTD (x=~2.3); and,
    - Anomaly from model nowcast is within xSTD, assumed no model biases.
  - where climatology sources are
    - SST: Mean and STD from PATHFINDER version 5, Casey NODC/NOAA (global)
    - SSHA: Mean and STD from AVISO (global)
    - T&S: GDEM2

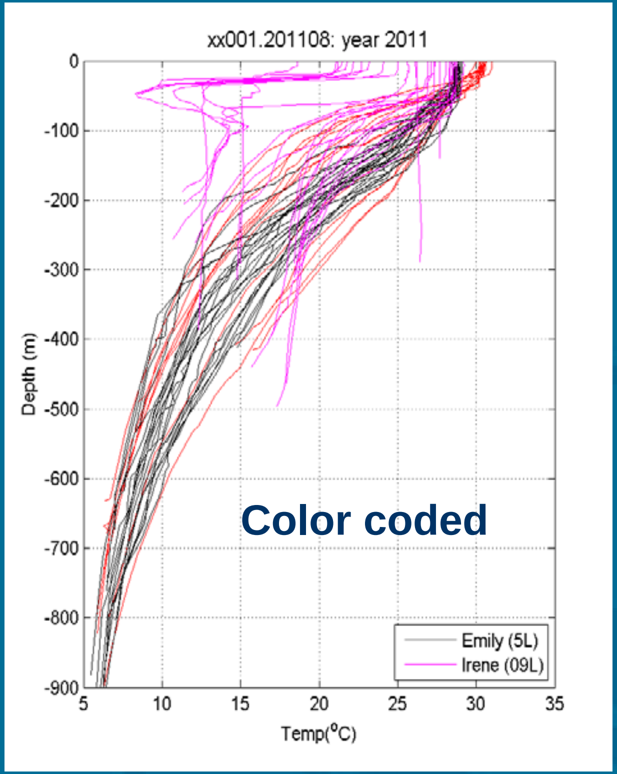
Method, continued

- Algorithm
  - 3D-VAR = 2D(along model layers)x1D(vertical).
  - 2D assumes Gaussian isotropic, inhomogeneous covariance matrix. Use Jim Purser's recursive filtering.
  - Ideally 1D vertical covariance matrix.
    - SST extended to model defined mixed layer.
    - SSH lifting/lowering main pycnocline.
    - S&T lifting/lowering above the last observed layer.

Real-Time Transimitted AXBT data for the 2011 season (by Navy, Sanabia & Black)

- ~120 AXBT transmitted in near real-time to GTS.
- Overall, good quality of data, except ...





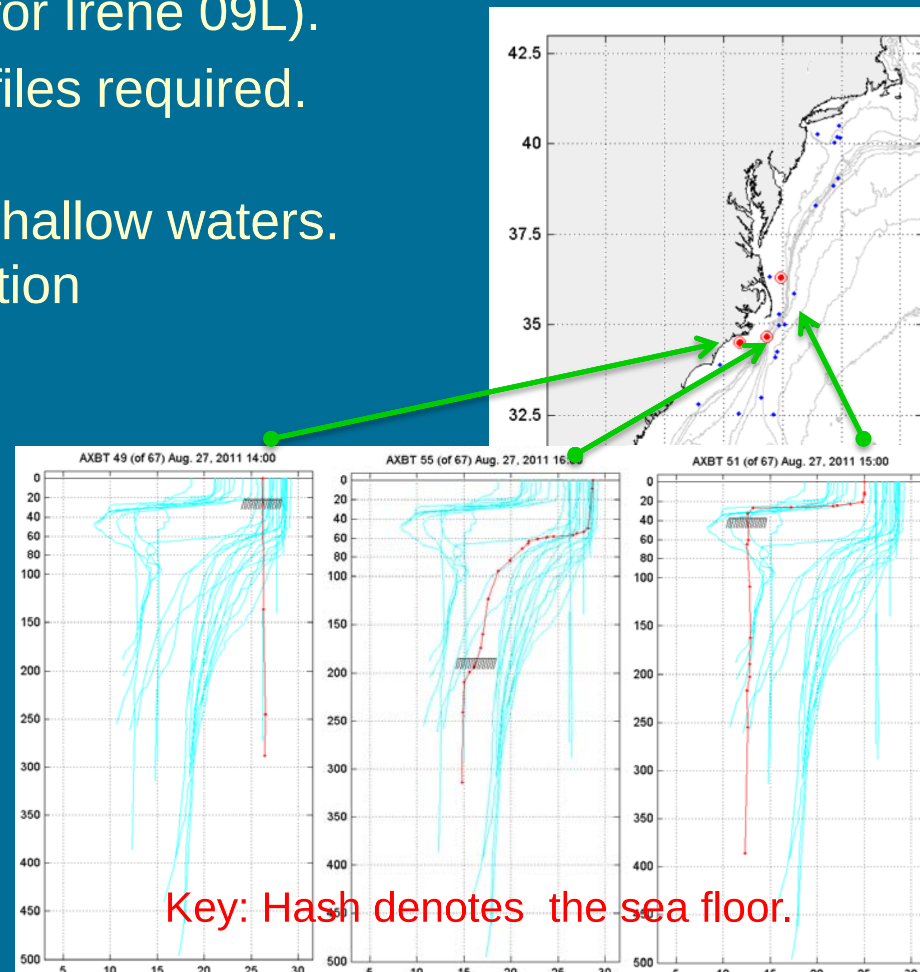
Current efforts (AXBT)

Challenges

- QC, real-time acquisitioned data, occasionally produce false data. Example see below (for Irene 09L).
- Corresponding Salinity profiles required.

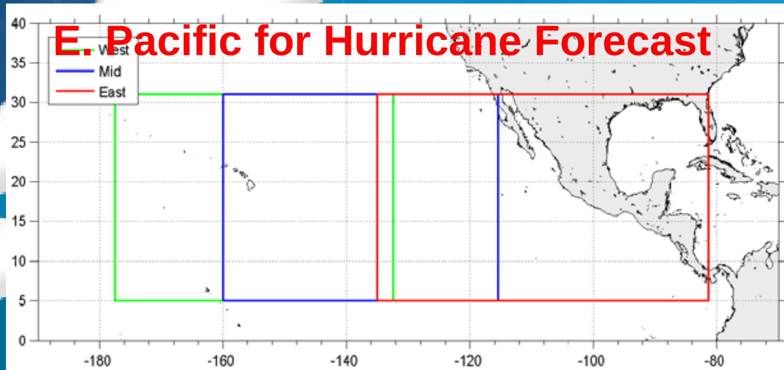
1. Problem as Measurements done in shallow waters. To rectify, we employ 1-min high-resolution topography*. in QC to filter false data.

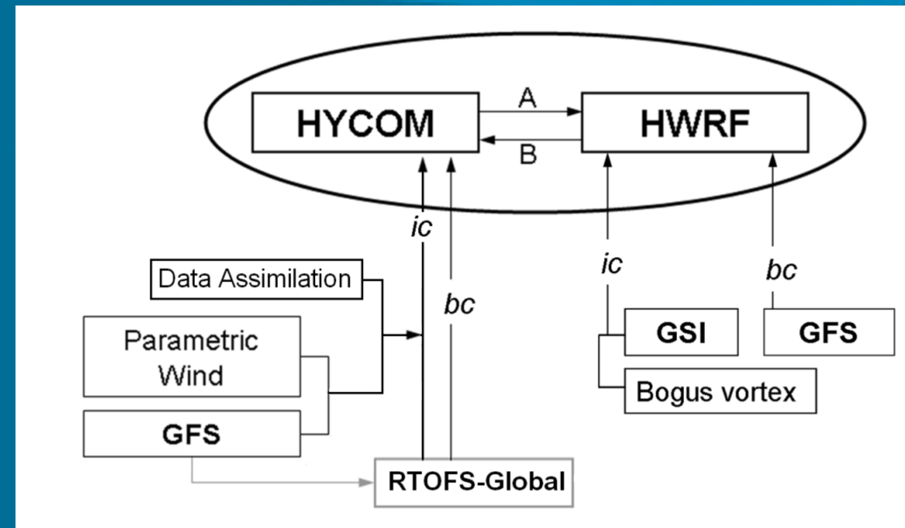
2. For Salinity, use GDEM2 (or GDEM3), and AQUARIS remote-sensed SSS for update.



* Sandwell and Smith ,2009; http://topex.ucsd.edu/cgi-bin/get_data.cgi

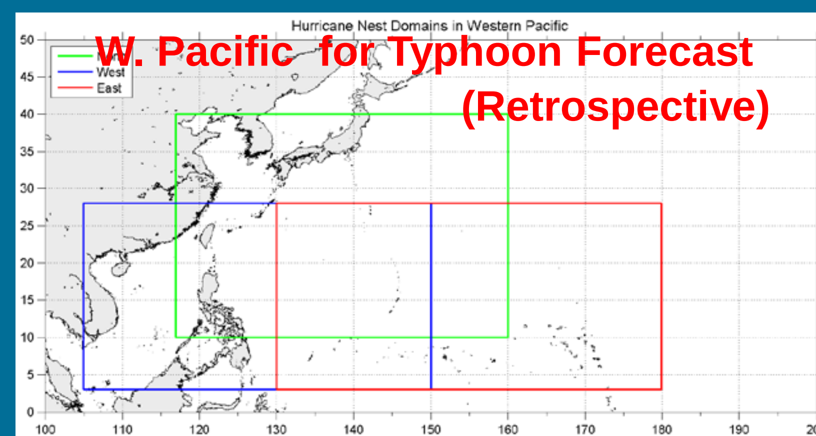
Current efforts (ocean)





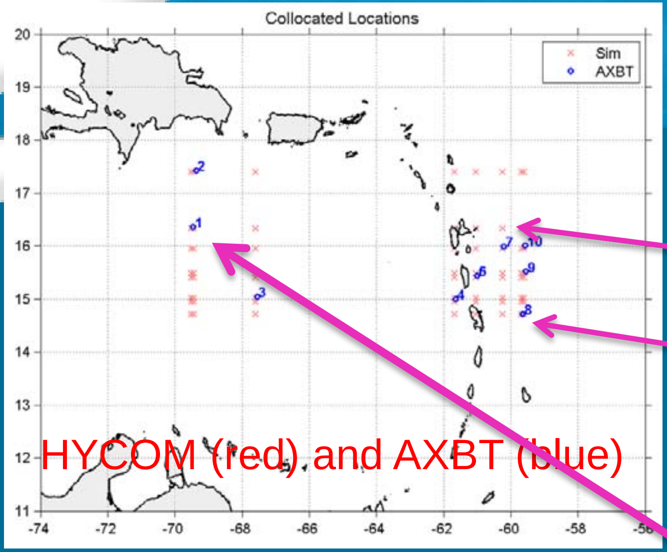
Ocean modeling HyHWRF v2 (HyHWRF2)

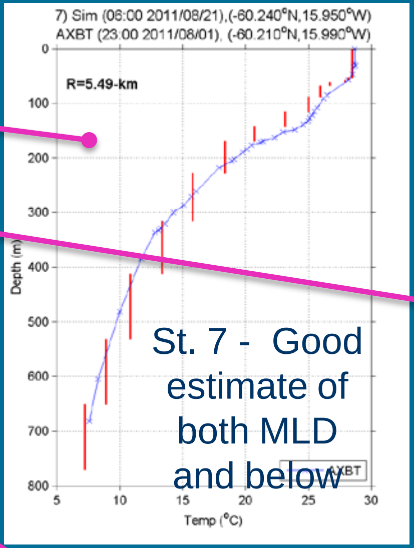
- Eddy-resolving, 1/12-degree and 32-layers (better res. in the mixed layer) HYCOM.
- IC/BC from RTOFS-Global.
- Provide uniform ocean to E. Pac. and Atlantic – easier to configure.
- Data Assimilation.
- Re-locatable, practically anywhere in the world.
- ESMF (NUOPC) compliant – advantage for 3-way coupling.



Current efforts (ocean)

OCEAN IC for Irene (08L) 2011





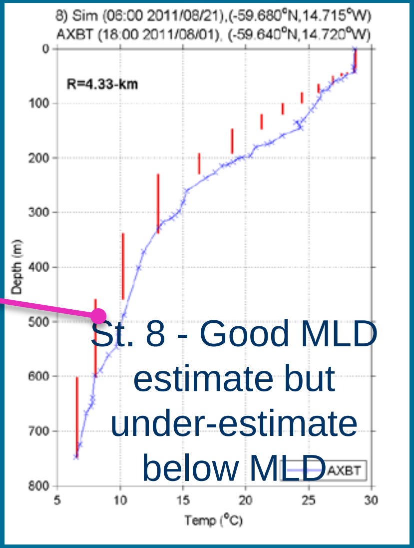
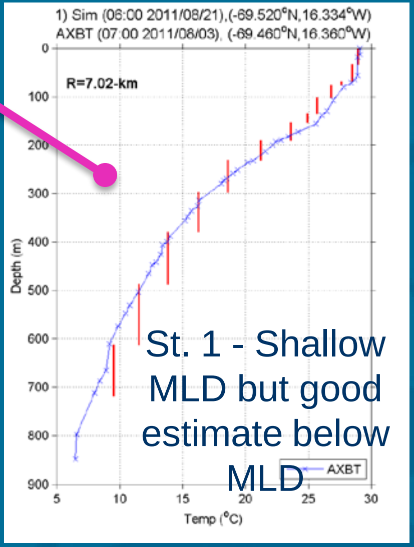


Table 1. AXBT sample locations; sea surface temperature (SST) difference (°C), mixed layer depth (m) and Z26 (m) with simulation. Mixed layer too shallow (as known).

AXBT	Lon	lat	dSST @z=x	MLD (m)		Z26 (m)	
				sim	obs	sim	obs
1	69.46	16.36	-0.5	35	60	110	140
2	69.37	17.43	-0.3	40	80	90	130
3	67.55	15.05	0.0	40	50	55	115
4	61.64	15.00	+/-0.2	30	60	75	95
5	61 .00	15.44	+0.1	45	70	75	85
6	61.00	15.44	-0.2	45	80	75	85
7	60.21	15.99	-0.2	55	60	80	100
8	59.64	14.72	+0.2	40	50	70	85
9	59.55	15.52	+/-0.1	30	50	65	95
10	59.57	16.01	+0.1	50	50	75	85



HyHWRF version 2.

- Optimal Configuration.
- Parallel Real-Time Run for the 2012 season.
- Place the system in Western Pacific to study Typhoon prediction.

Data Assimilation.

- Complete implementation.
- Sensitivity study and Optimal sampling strategy via OSSE (Halliwell et al).
- Design to use Microwave Image (MI) SSS and SST.

Three-way coupling with WAVEWATCH III®.

Thank you!