

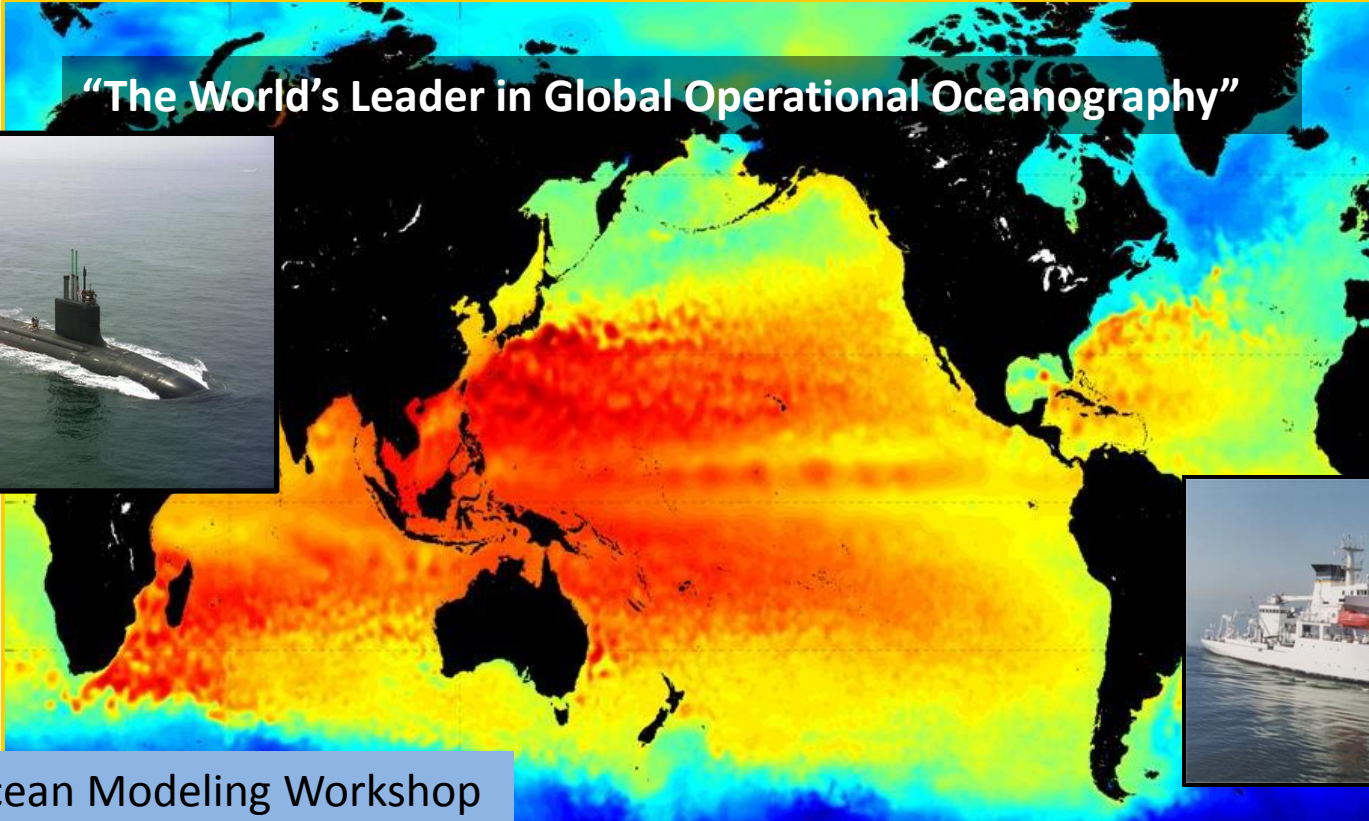


Global Ocean Forecasting

Naval Oceanographic Office



“The World’s Leader in Global Operational Oceanography”



Layered Ocean Modeling Workshop

2 - 4 June 2015

Danish Meteorological Institute

Copenhagen, Denmark

David Rosenfield

Ocean Forecaster / Model Operator

Oceanographic Department

Naval Oceanographic Office

Stennis Space Center, Mississippi, U.S.A

Observations → Global → Regional → Local → Port

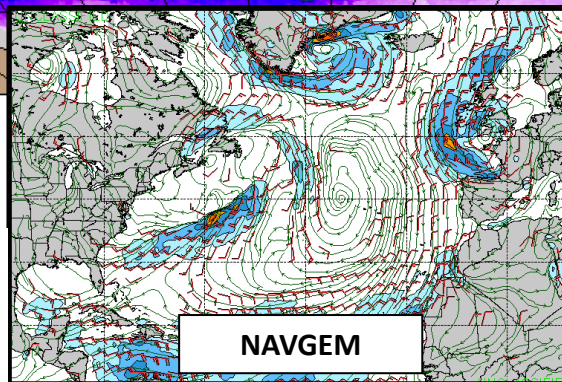
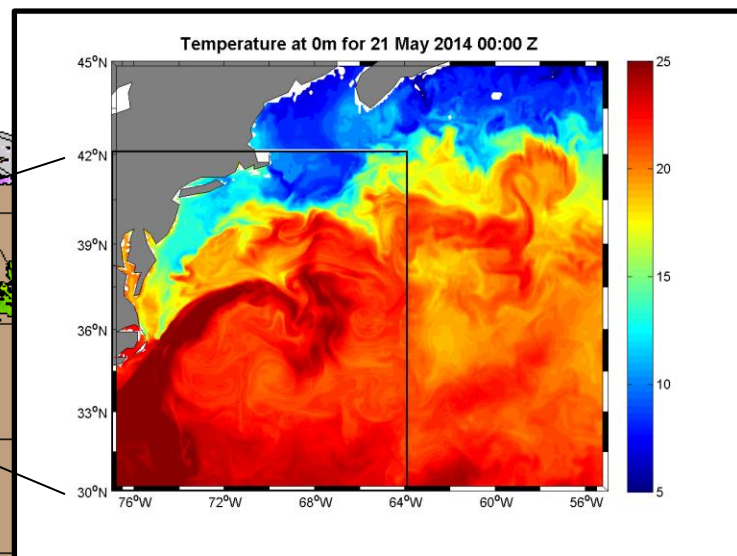
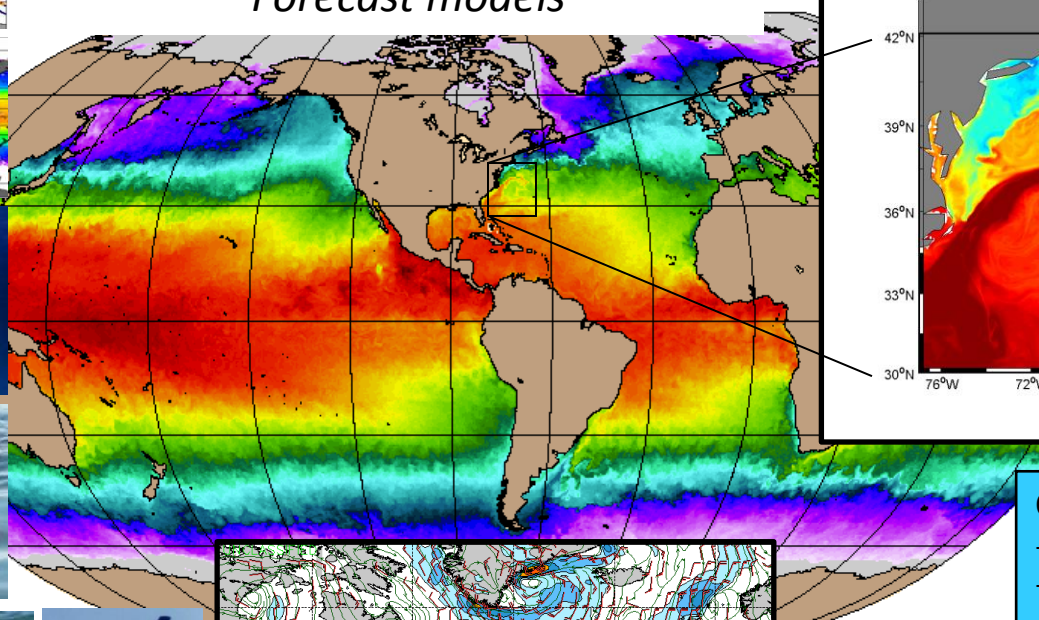
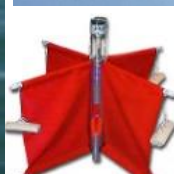
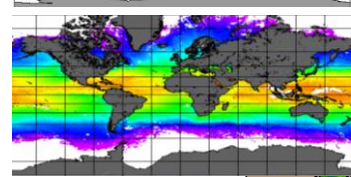
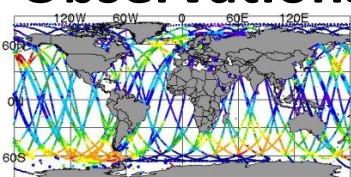
9 km

3 km

300 m

10 m

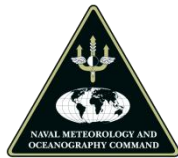
*3D full physics, Data assimilating,
Forecast models*



Oceanographers

- Configure models
- Interpret forecasts & observations
- Evaluate uncertainty
- Tailor analysis to Navy mission

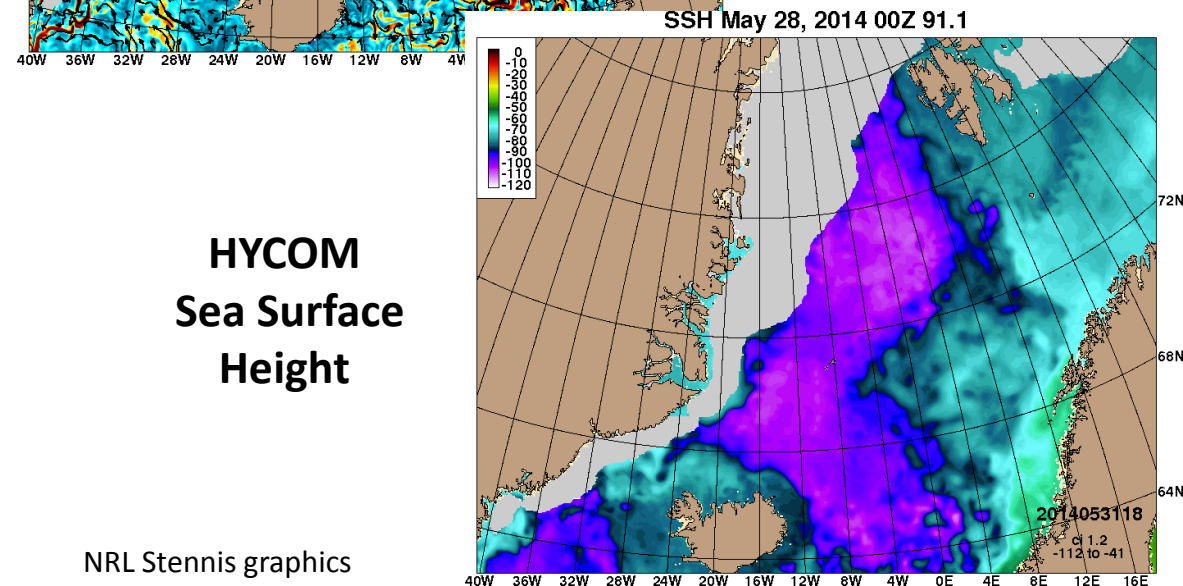
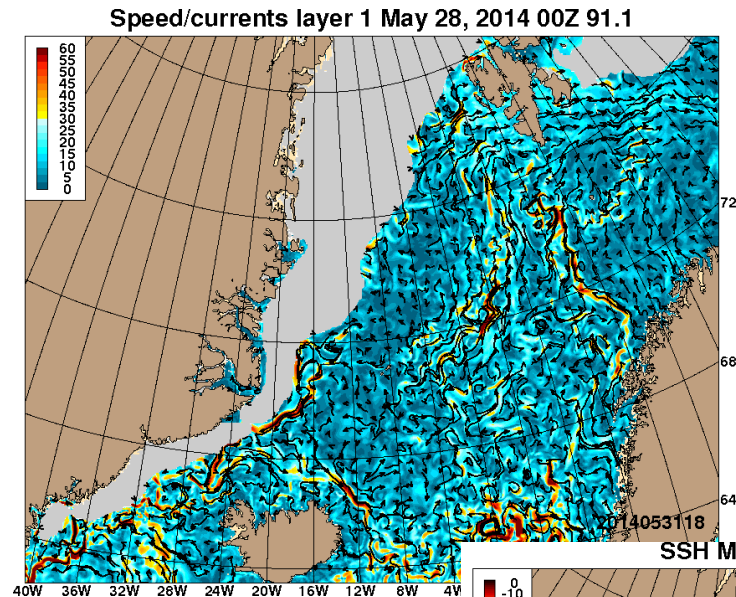
- Currents/Temp/Salinity
- Sea Surface Elevation
- Sound Speed
- Front/Feature Prediction



Global - Hybrid Coordinate Ocean Model (G-HYCOM)

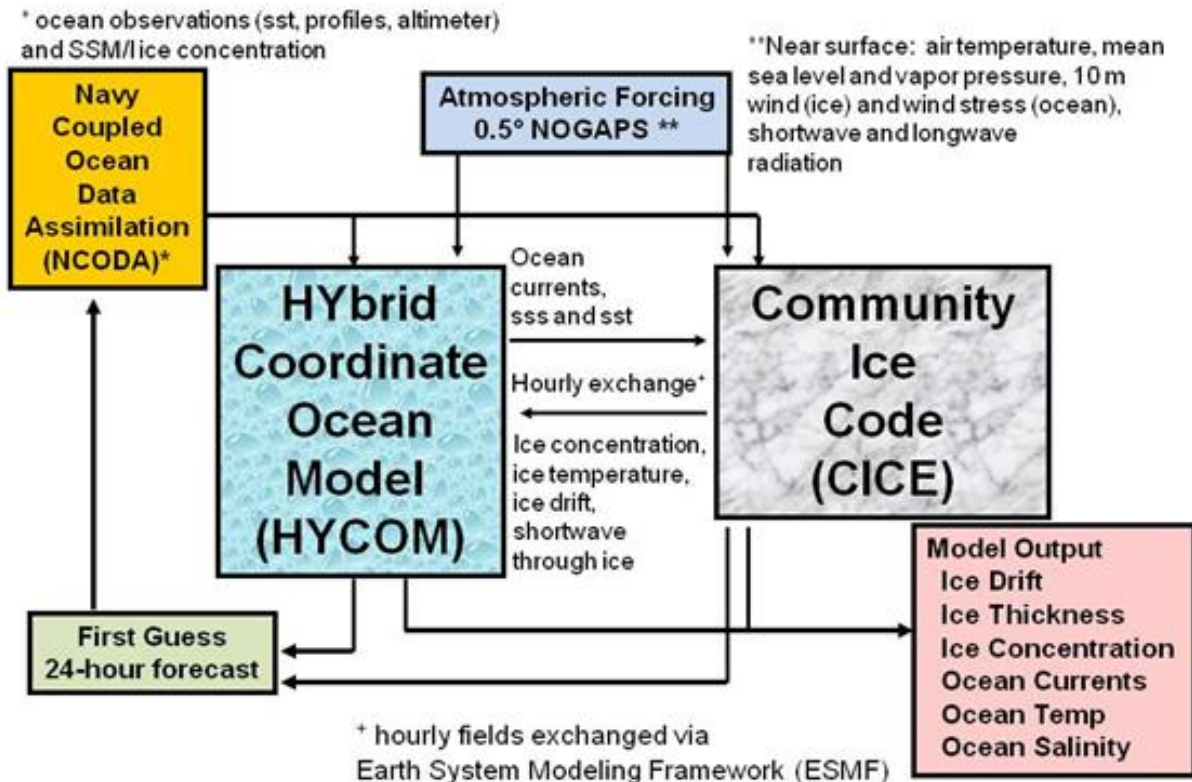


- Forecasts 3D Temperature, Salinity, Currents, Elevation
 - Out to 168 hours (7 days) every 3 hours
- Present global resolution 1/12 deg (9km / 5nm)
 - Future resolution 1/25 deg (2016) (3.8km / 1.8nm)
 - 40+ vertical layers
 - Pressure, depth, sigma coordinates as needed
- FNMOC NAVGEM atmospheric forcing
- Assimilates SST / SSH / surface obs / profile data – using the Navy Coupled Ocean Data Assimilation (NCODA) system
- Global service to NOAA, others daily
 - HYCOM fields to NOAA
 - Navy/National Ice Center Ice Forecasts



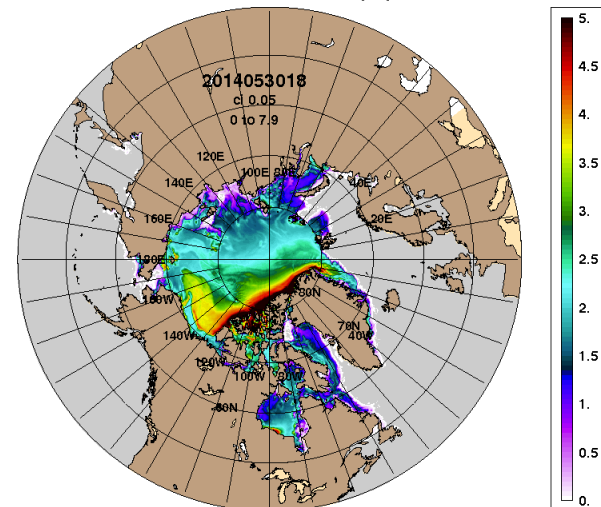
Arctic Cap Nowcast / Forecast System (ACNFS 3.0)

HYCOM/NCODA/CICE

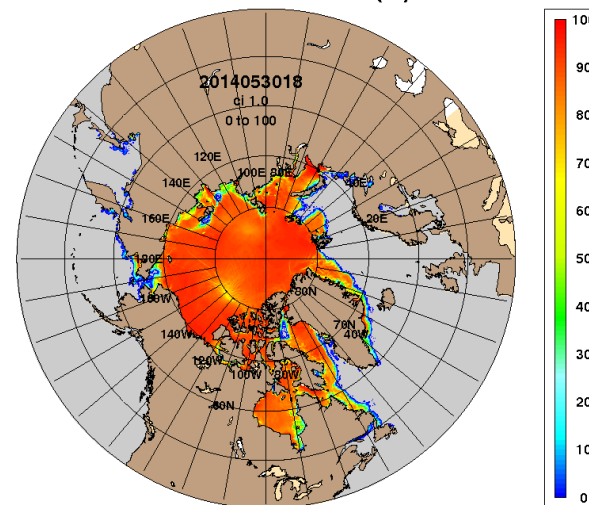


- CICE on a ~3.5 km Arctic grid
- HYCOM at 1/12°
- NCODA 3DVar data assimilation

ARCc0.08-03.9 Ice Thickness (m): 20140528



ARCc0.08-03.9 Ice Concentration (%): 20140528



NRL Stennis graphics



Regional Navy Coastal Ocean Model (NCOM)

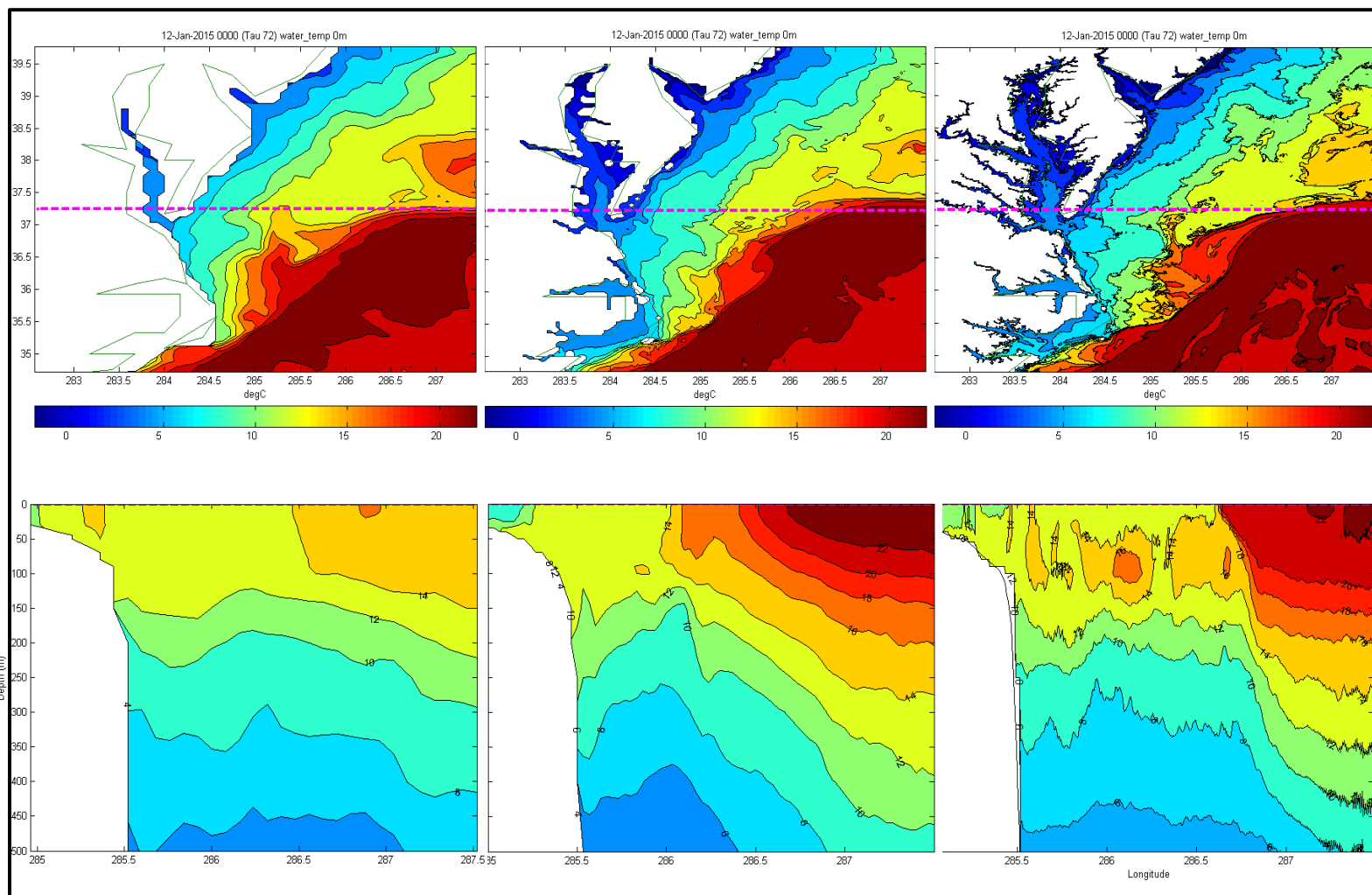


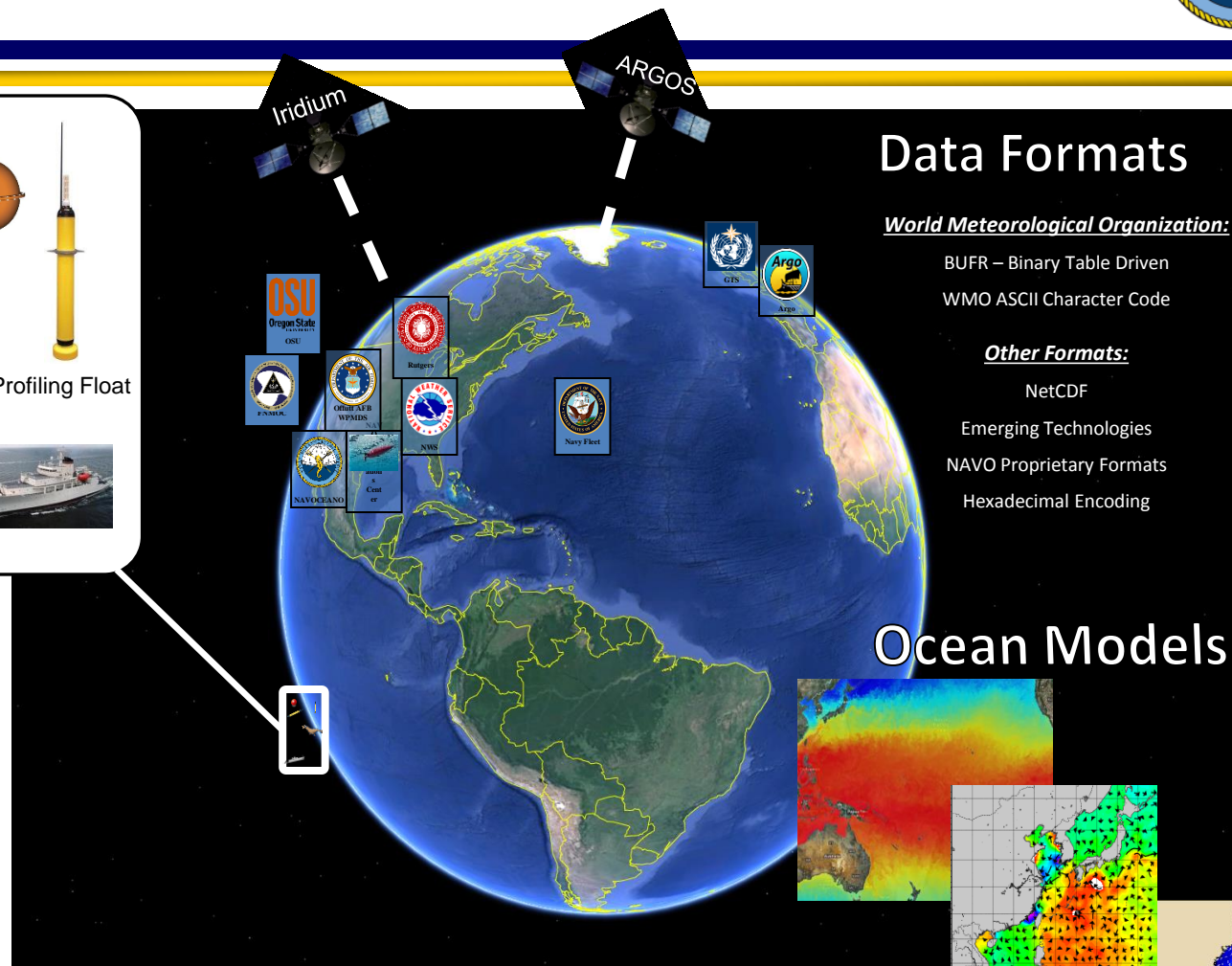
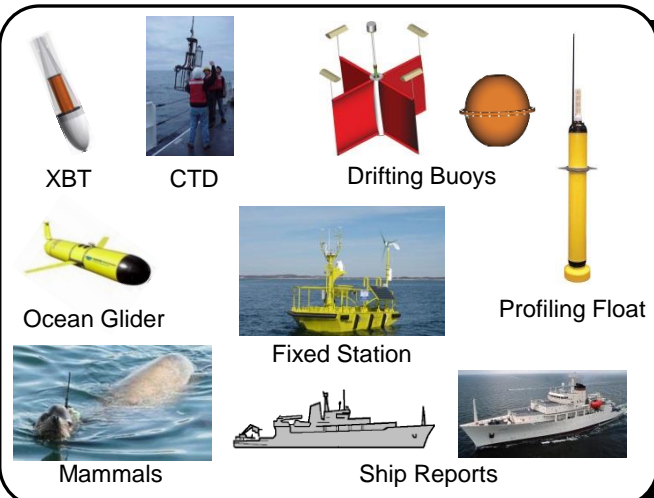
Sea Surface Temperature along 37.25°N
Global HYCOM (1/12°) → USEAST-NCOM (1/30°) → Chesapeake NCOM (1/216°)

HYCOM provides boundary conditions to Regional NCOMs with grid resolutions from 3.7 to 0.3 km

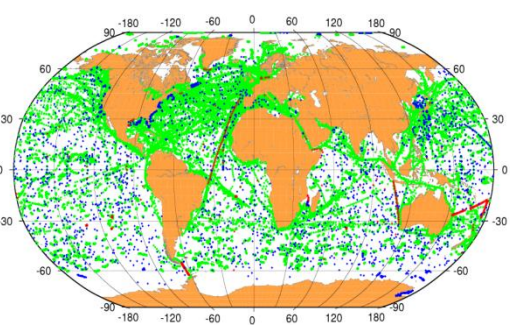
Setup and evaluation of regional scale NCOMs generally takes about 6 months whereas 0.5-0.3 km nests takes about 1-3 months.

High resolution bathymetry is crucial





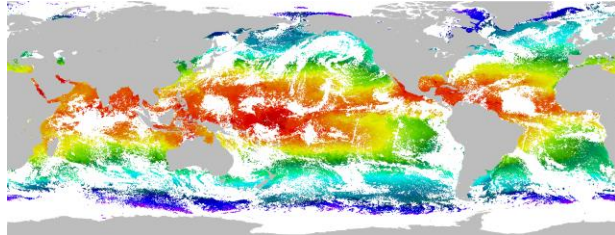
Worldwide Coverage



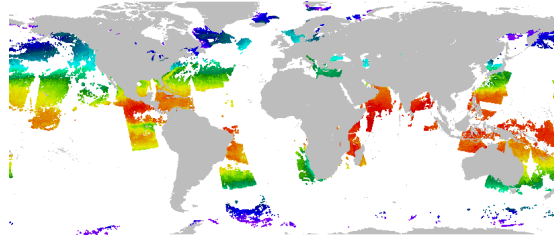
24/7 Data Input 70,000+ Unique Observations a Day

NAVO Processed

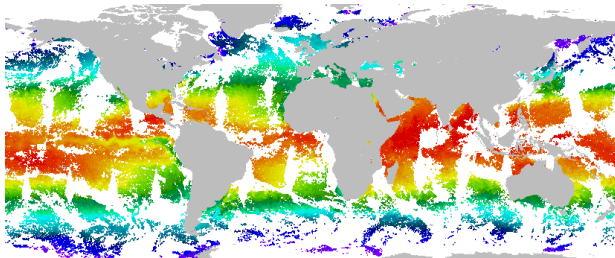
N-18/19 AVHRR GAC



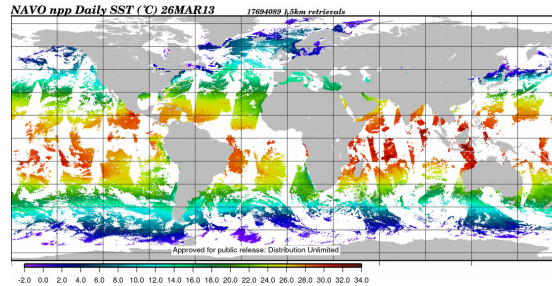
N-19 AVHRR LAC



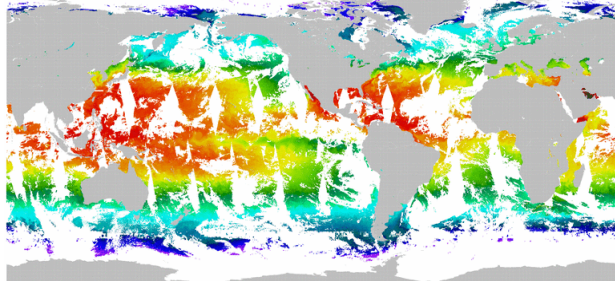
METOP - A/B AVHRR GAC



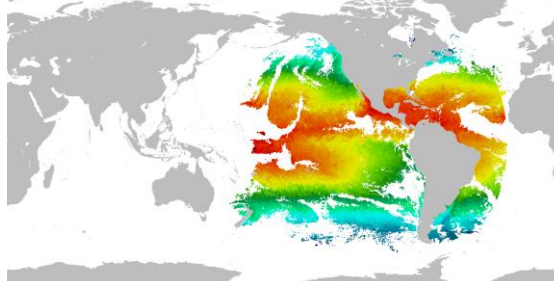
NPP VIIRS



METOP - A/B AVHRR FRAC

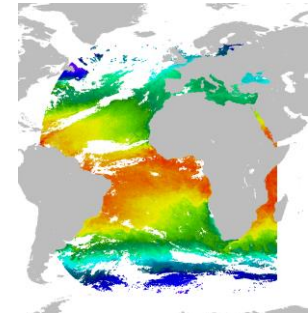


GOES-E/W

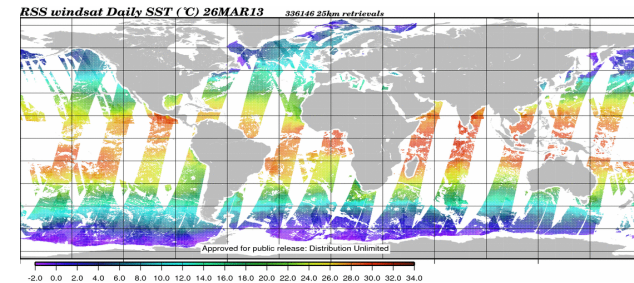


Group for High-Resolution Sea Surface Temperature (GHRSSST) Processed

MSG



Windsat



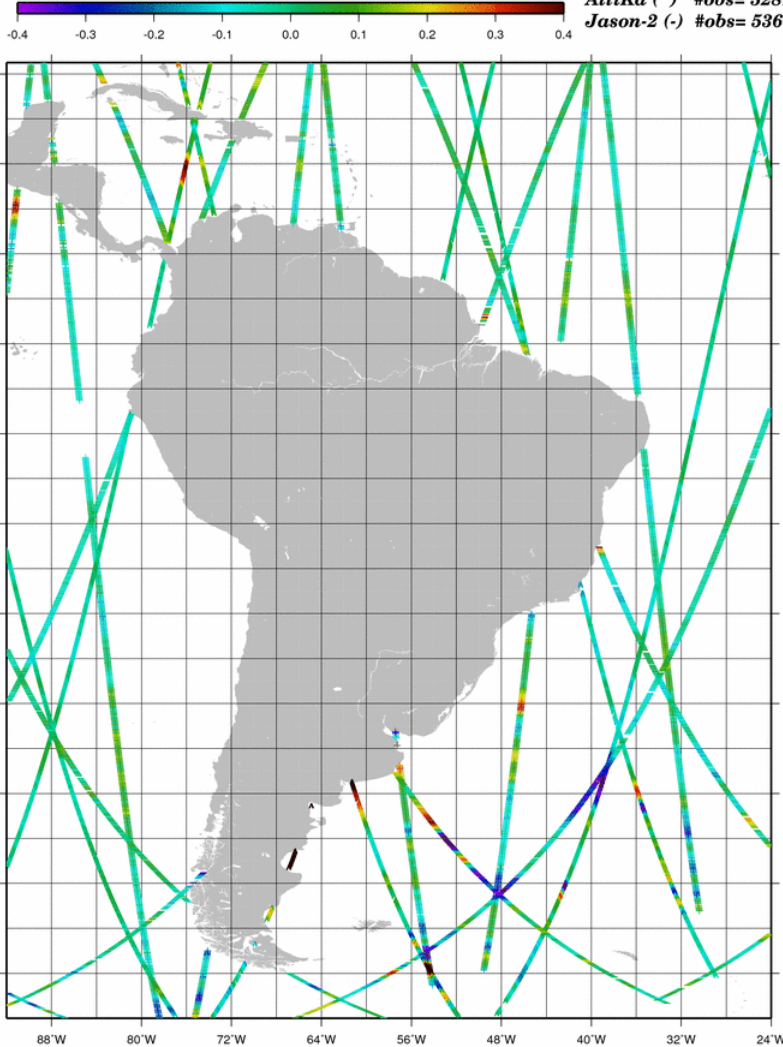


Satellite Sea Surface Altimetry Sources

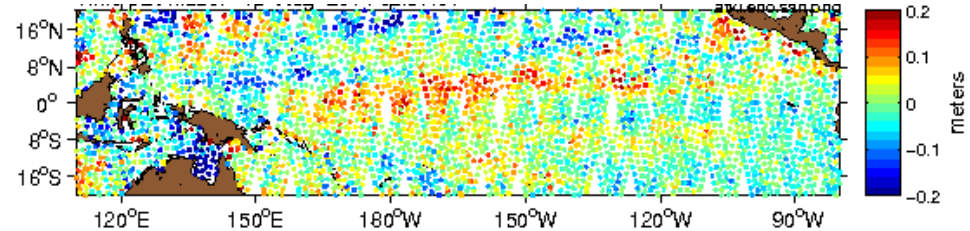


NAVOCEANO Satellite SSHa (m)
24 hours of data for 12AUG14 JD:224

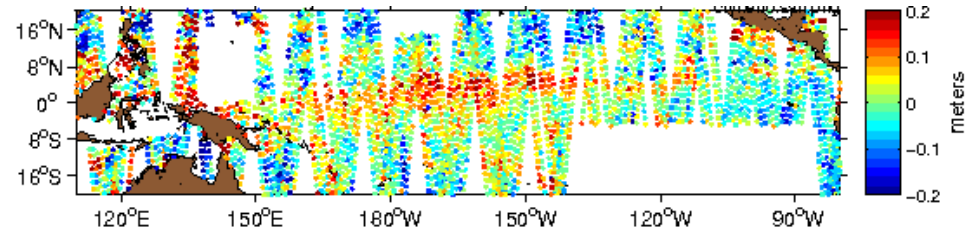
Cryosat (+) #obs= 4606
AltiKa (^) #obs= 5281
Jason-2 (-) #obs= 5367



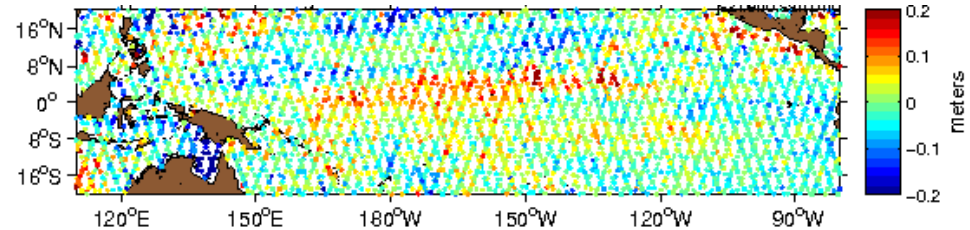
ALTIKA



CRYOSAT



JASON2





Navy – Department of Defense Supercomputing Resource Center (DSRC)



Projected Naval Oceanography and Meteorology 15% Allocation of Navy DSRC High Performance Computing (HPC) System ★

Procurement	FY15 TFLOPS/CORES	FY16 TFLOPS/CORES	FY17 TFLOPS
IBM iDataPlex *	325/15,600	325/11,728	
CRAY XC40		598/20,096	1,371
Technical Insertion - 17**			359
Total	325/15,600	923/31,824	1,730

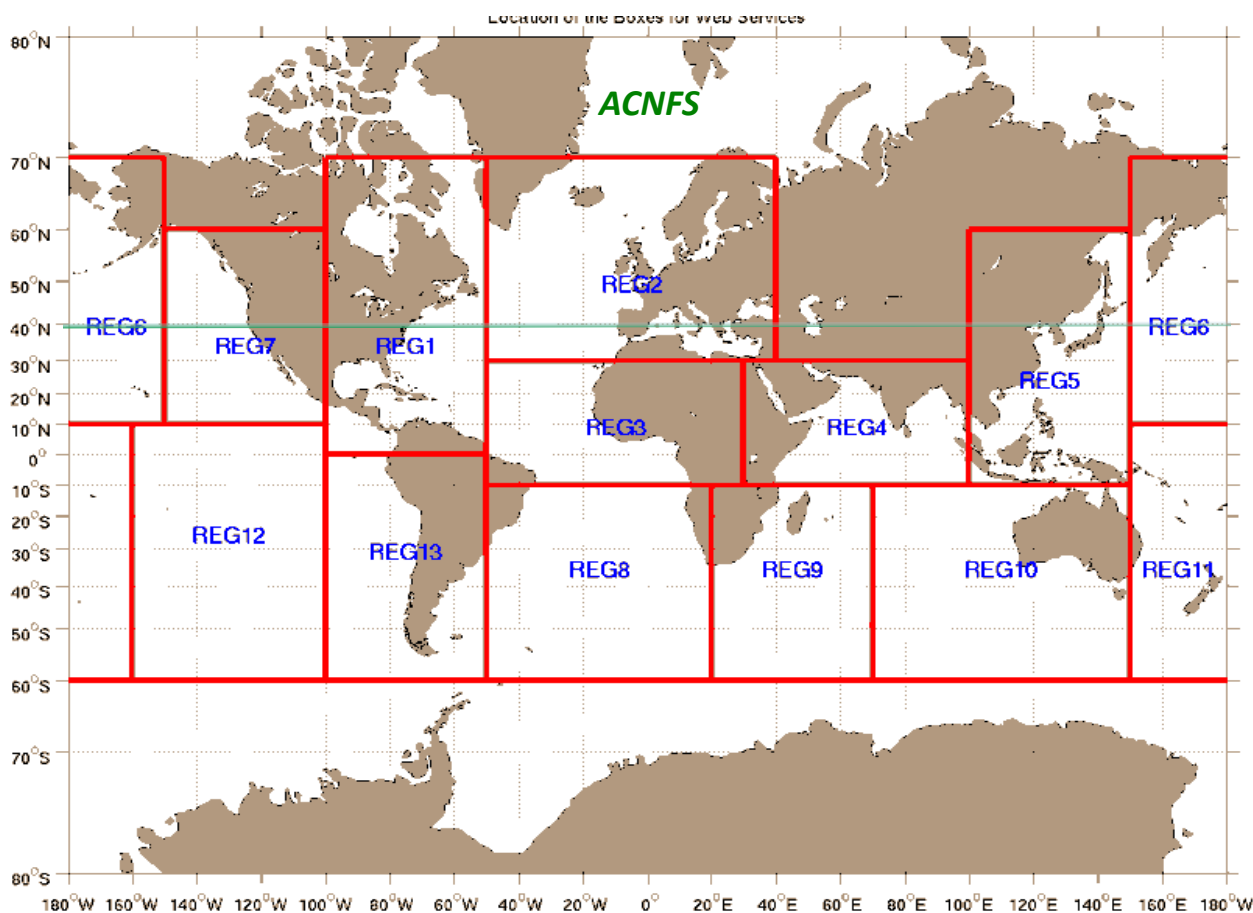
*Removed from service 12/31/2016

**Assumes Moore's Law increase and Q4 availability

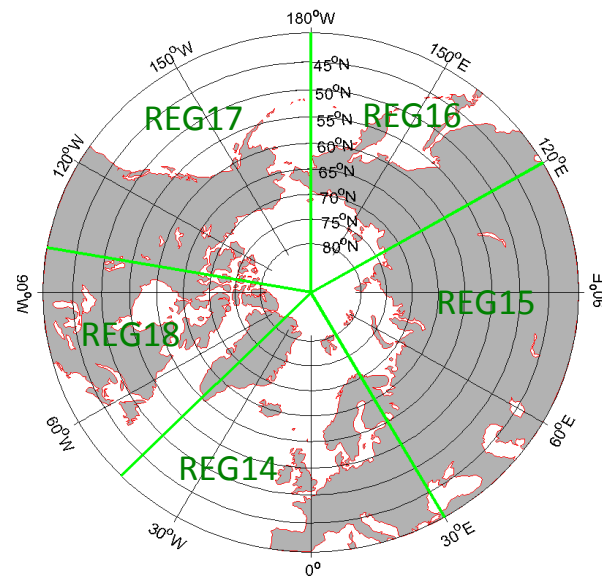


Global HYCOM Output File Sub-Regions

- G-HYCOM has too large an output to manage as one region
- Divided into 18 regions at 3 hourly intervals
- Each file has temperature, salinity, currents, and elevation



*Arctic Cap
Nowcast / Forecast System
(ACNFS)*





Global Ocean Forecasting Future Plans



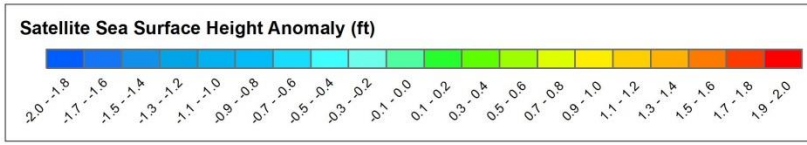
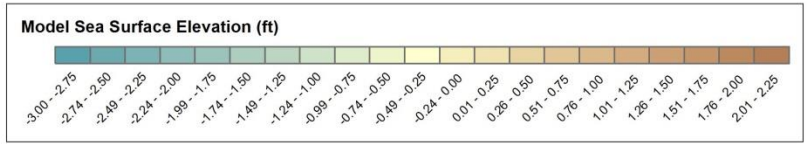
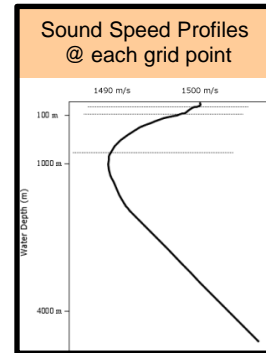
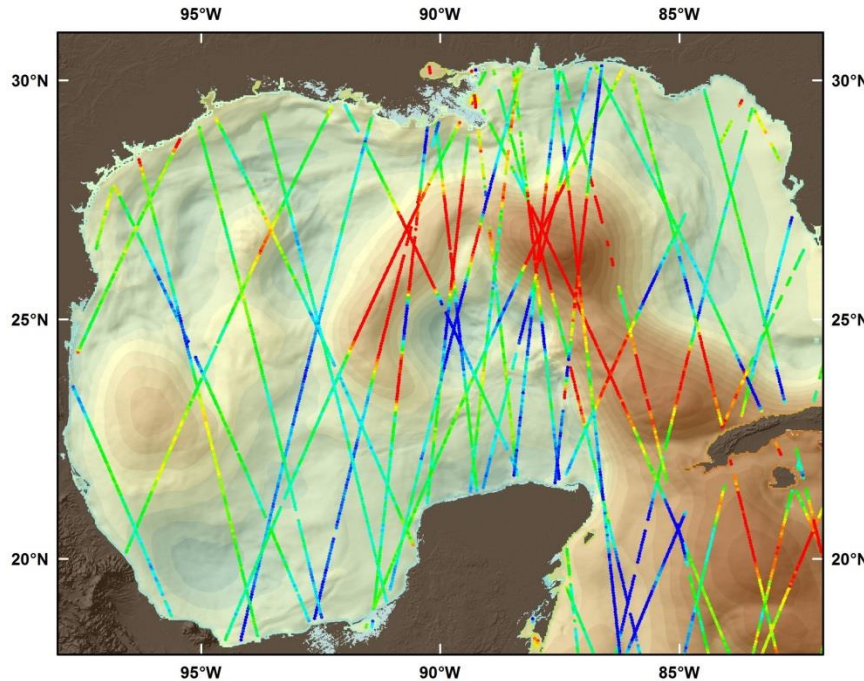
- **Next version of HYCOM is undergoing testing for transition at NAVO**
 - Merges Global HYCOM and ACNFS
 - Will provide ice forecasts in the Arctic and the Antarctic
 - Increases the number of layers from 32 to 41, horizontal resolution unchanged
 - Improved altimetry assimilation
 - Ice model will include assimilation of more satellite data and assimilation of the analyzed ice edge
- **Next major HYCOM update scheduled to be operational in 2017**
 - Horizontal resolution increased to 1/25 degree and includes tides in the model

Year	HYCOM	Assimilation	Ice	Tides	Waves
2013	1/12 deg, 32 layers	3DVAR	Energy loan	OSU	--
2015	1/12 deg, 41 layers	3DVAR	CICE	OSU	--
2017	1/25 deg, 41 layers	3DVAR	CICE	UT (Baroclinic)	--
2017	1/25 deg, 41 layers	4DVAR	CICE	UT (Baroclinic)	WW3
2018	Coupled HYCOM – NAVGEM – CICE – WW3				

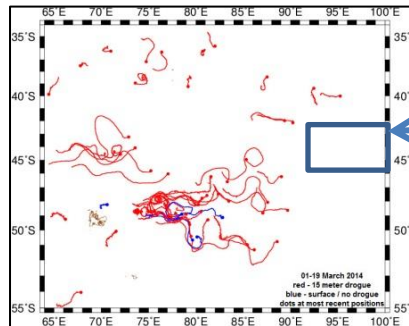


Oceanographic Feature Analysis

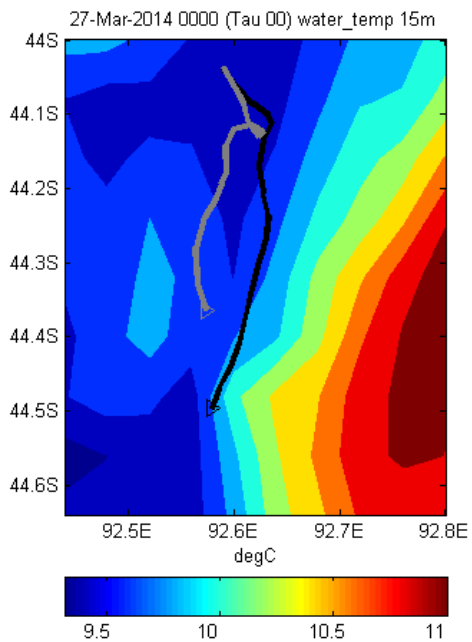
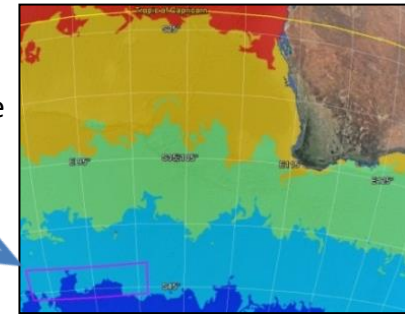
- Ocean Forecasters use model data and observations to locate features of interest to the Fleet
- Satellite Sea Surface Height Anomaly passes overlaid on HYCOM Sea Surface Elevation



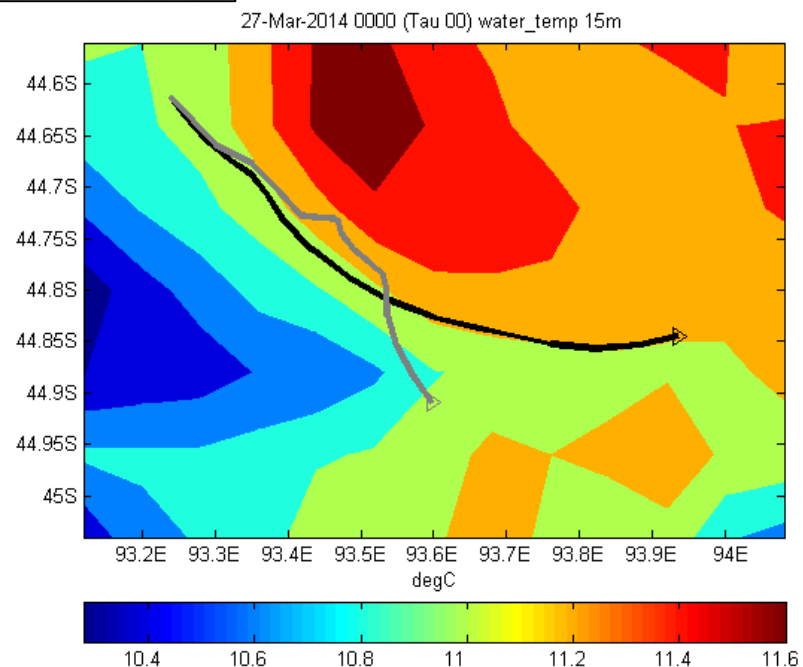
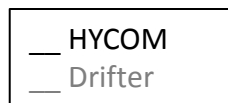
- Comparison of Australian drifter observations to HYCOM
- HYCOM produces reasonable forecasts along these frontal boundaries



No drifters in this search area before Australian deployment

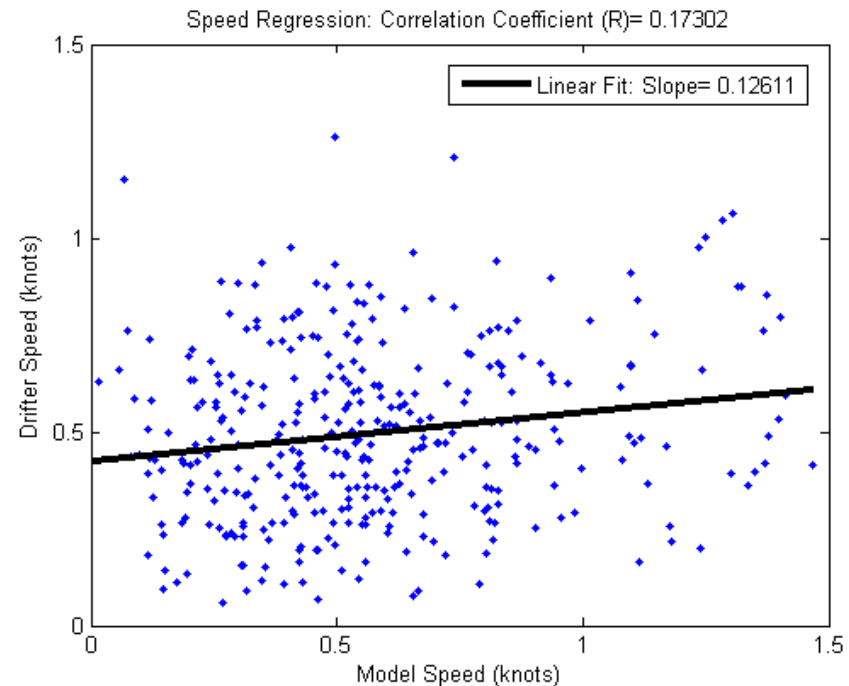
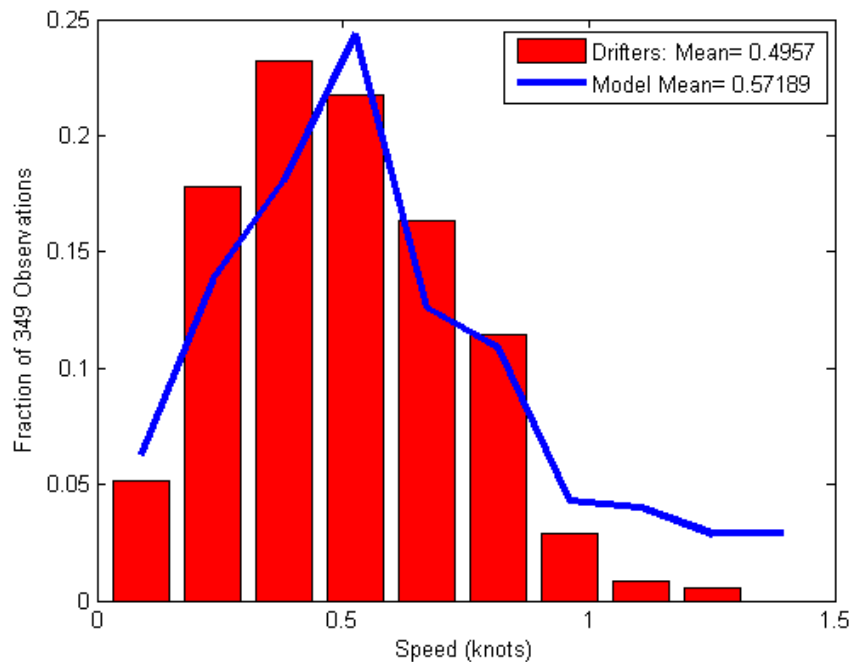


Forecast Segment Examples (48 hour)



- Inertial oscillations are difficult to reproduce because of wind event timing
- Background is mean water temperature from HYCOM model for this period

Drifter Speeds and HYCOM Drift Speeds (at Drifter Locations)



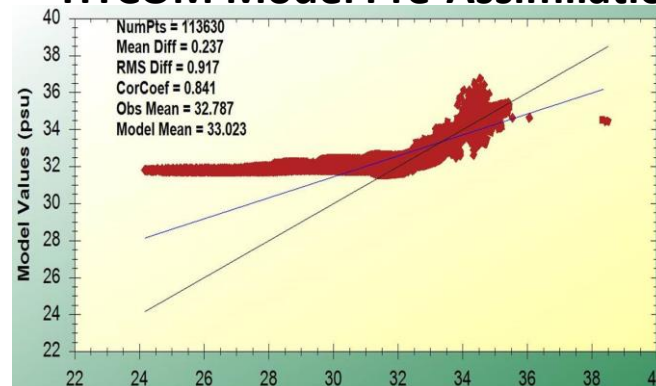
- HYCOM captures the distribution of speeds indicated by the drifter data
- This indicates HYCOM is producing an accurate representation of the flow type in the region

- However, the speeds are uncorrelated
- This indicates that the timing and location of flow features are not accurate

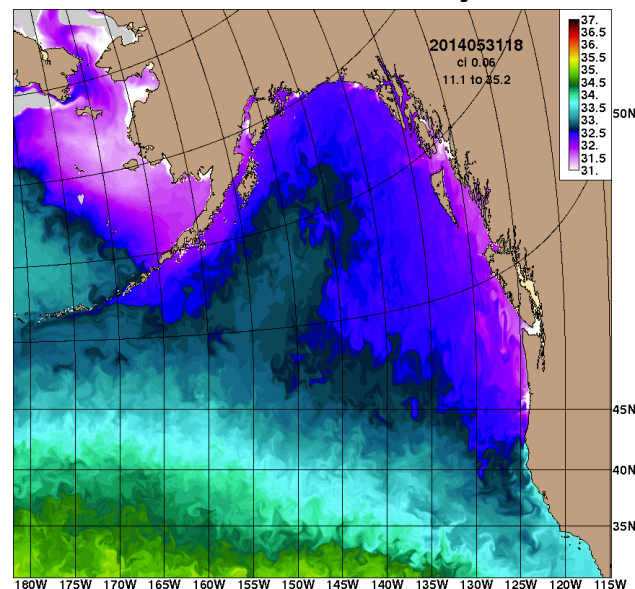
Global HYCOM Model / Data Comparisons

- HYCOM generally has good correlation between model and observations in deep water
- Data dependent
 - Satellite altimetry quality degrades near coasts
 - Gaps in profiling floats
- Tidally dominated regions have issues
- Uses databases that need tuning
 - Rivers – too much freshening of Gulf of Alaska
- NAVOCEANO has setup higher resolution regional models with tides where required

May 2014 Observations vs HYCOM Model Pre-Assimilation



Surface Salinity





Questions?

