



HYCOM Progress and Plans Related to SWOT

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Global HYCOM Real-Time Systems with Tides

Current operational system at the Naval Oceanographic Office is .08° Global HYCOM (9 km) with data assimilation

- does not include tides

Upgrades in Progress

.04° Global HYCOM (4.5 km)

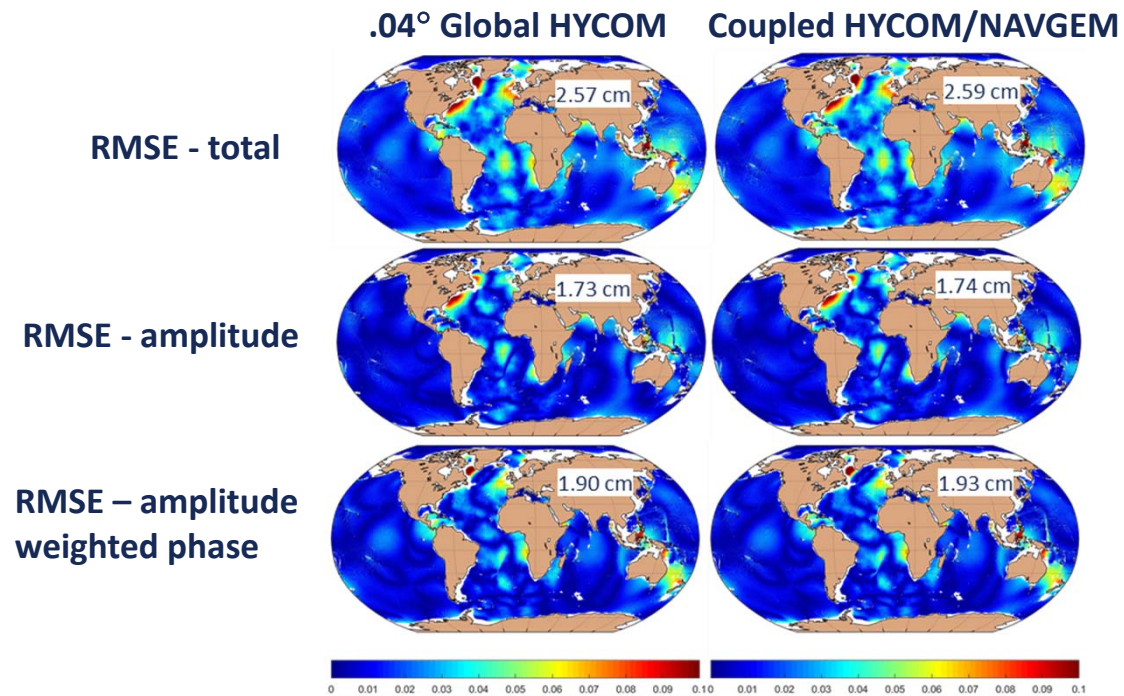
- Includes tides and 3D-VAR data assimilation
- We borrow from traditional data assimilation to make a correction to the model forcing to reduce the tidal error (ASEnKF – Ngodock et al., 2016)
- Forced by 3 hourly NAVGEM forcing
- Currently in late 2018, being spun up to real-time

ESPC Coupled HYCOM/NAVGEM

- .04° ocean, T681L60 (19 km, 60 level) atmosphere
- includes tides and ocean/atmosphere data assimilation
- 1x/hour coupling between ocean and atmosphere
- System is running daily in near real-time (currently roughly 3-4 day lag, expect to be ≤ 1 day early/mid summer)

One of these systems will be transitioned to operations, that decision process is ongoing

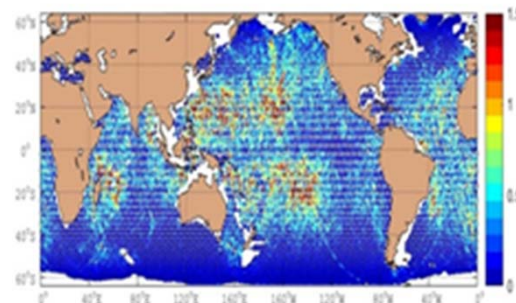
Global HYCOM Barotropic Tides vs TPXO



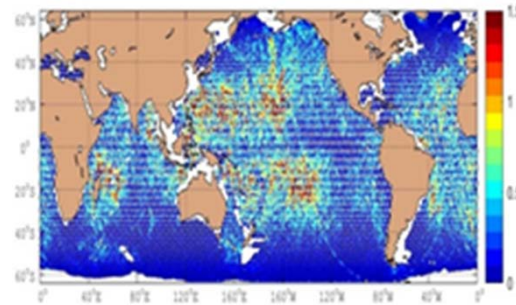
M_2 tides compared to TPXO8 for 2017
RMSE partitioned using formula (3) in Shriver et al. (2012)

Global HYCOM Baroclinic Tides vs an Altimeter-Based Analysis

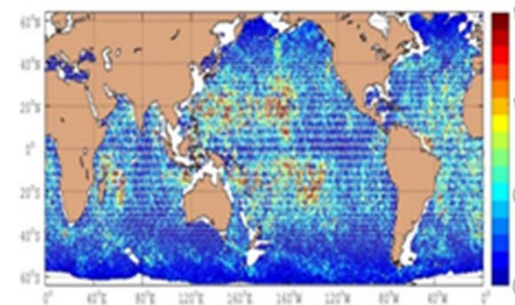
.04° Global HYCOM



Coupled HYCOM/NAVGEM



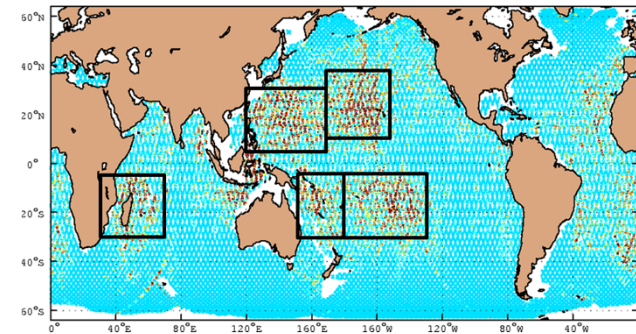
Altimeter-based analysis



M₂ baroclinic tides compared to altimeter-based analysis for 2017

Global HYCOM Baroclinic Tides vs an Altimeter-Based Analysis

Box locations	Satellite based	Coupled HYCOM/ NAVGEM	.04° Global HYCOM
NE Pacific	0.79	0.86 0.81	0.86 0.81
NW Pacific	0.79	0.99 0.93	0.99 0.93
SE Pacific	0.84	0.88 0.83	0.88 0.83
SW Pacific	0.73	0.75 0.70	0.74 0.70
Madagascar	0.71	0.81 0.76	0.81 0.76



All units in cm

Red numbers are 5 year record length values (using Fig 8 from Ansong et al. 2015)

M2 internal tide amplitude root mean square averages over the subregions used in Shriver et al. (2012)

Global HYCOM with Tides – Simulations Available for SWOT Community

.04° Global HYCOM

- Includes tides
- We borrow from traditional data assimilation to make a correction to the model forcing to reduce the tidal error (ASEnKF – Ngodock et al., 2016)
- Forced by 3 hourly NAVGEM forcing
- Netcdf files for 1 year (1x/hour snapshots of steric/total SSH) from a data assimilative run are available on a data server at the University of Michigan, write me for details.
- Netcdf files for 1 year without data assimilation, 1x/hour snapshots of steric/total SSH and upper meter/15m currents, should be available early/mid summer.

Global HYCOM – CalVal Support

We have infrastructure and experience to support research using operational systems

- Supporting ONR field program with results extracted from current operational system.
 - Results are extracted and pushed to collaborators within hours of system completion
 - Should expect similar turnaround for CalVal, depending on complexity of post-processing required

ASEnKF Tidal Improvements in HYCOM

M₂ Tides with the ASEnKF forcing correction have smaller errors than the initial and intermediate simulations

M2 Error / No ASEnKF



Simulation	Global RMS	Median Global RMS	Atlantic RMS	Median Atlantic RMS	Global excluding Atlantic RMS	Median Global excluding Atlantic RMS
Initial T0	7.0	5.3	6.8	5.6	7.0	4.8
Intermediate T1	4.4	3.2	7.3	7.1	3.5	3.5
1 cm constant observation error ASEnKF T2	2.8	1.7	5.2	5.2	2.0	1.8
Spatially varying observation error ASEnKF T3	3.2	1.6	6.3	6.2	2.0	1.5
0.5 mm constant observation error ASEnKF T4	2.8	1.9	4.6	4.6	2.3	1.9
Blended ASEnKF T5	2.6	1.7	4.4	3.8	2.1	1.5

M2 Error / ASEnKF



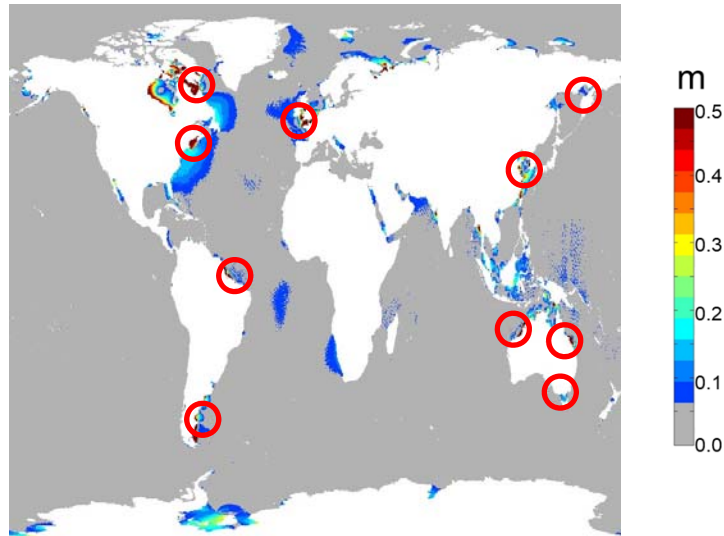
**M₂ Error
relative to
TPX08**

ASEnKF Tidal Improvements in HYCOM

- M_2 Tides with the ASEnKF forcing correction have smaller errors than the initial and intermediate simulations
 - None of the models perform well in the Atlantic or Indonesian Seas
 - Ensembles generated with large scale perturbations
 - If the ensemble doesn't contain the error structures then the ASEnKF can't make correction
- Way forward – based upon the “back effect” of large coastal tides upon open-ocean tides (Arbic et al. 2007, 2009; Arbic and Garrett, 2010)
 - New perturbations with smaller scales (*focus of this effort*)

ASEnKF Tidal Improvements in HYCOM

HYCOM M_2
Error Map
relative to
TPX08



- New ensemble set was designed (24 total members) focusing on these high error areas
- Initial results were encouraging but variance of ensemble members was too low
 - Perturbations are being adjusted to better match error amplitudes
 - This work is ongoing and we expect updated results later this summer

Summary/Conclusions

- .04° Global HYCOM with tides and DA
 - coupled system – in real time now, uncoupled – in real time later this summer
 - coupled or uncoupled to be run operationally? TBD
 - M_2 barotropic and baroclinic tidal errors are comparable between the two systems.
- Work is underway to further reduce barotropic tide error in HYCOM which should help improve the internal tide
 - improved ASENKF
 - initial results are encouraging but more work is needed
- 1 year of results from an assimilative .04° Global HYCOM simulation (ssh) are available now and results from a non-assimilative simulation will be available early/mid summer (ssh, u/v) for science team research.