HYCOM Progress and Plans Related to SWOT

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Global HYCOM Simulations with Tides

Current operational system at the Naval Oceanographic Office is .08° Global HYCOM with data assimilation
- does not include tides

Plans in Progress

.04° Global HYCOM

- Upgrade to existing .08° HYCOM system
- 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

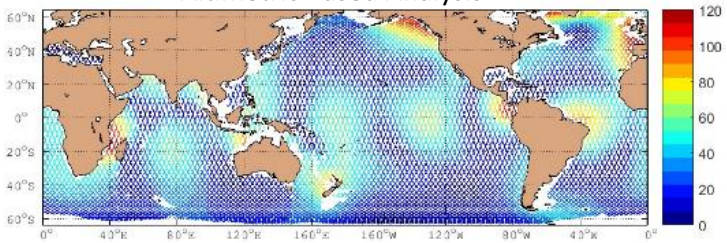
ESPC Coupled HYCOM/NAVGEM

- .04° ocean, T681L60 (19 km, 60 level) atmosphere
- includes tides and ocean/atmosphere data assimilation
- 1x/hour coupling between ocean and atmosphere

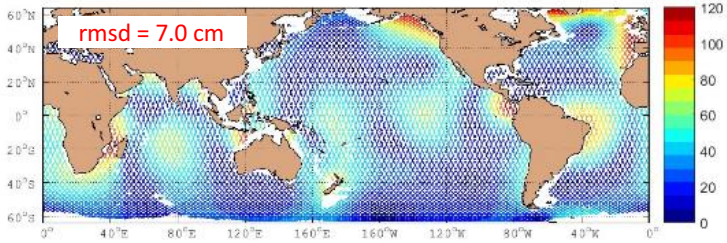
We expect to have both running daily and in real time by the end of 2018

HYCOM M_2 Barotropic Tidal Amplitude vs. Alimetric Based Analysis

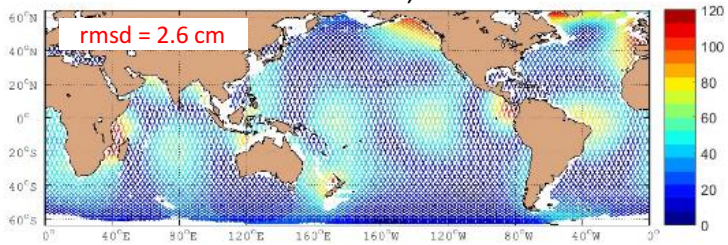
Altimetric Based Analysis



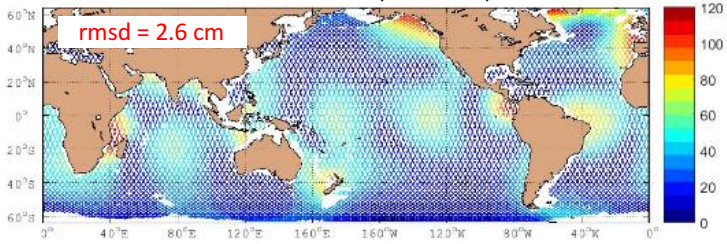
0.08° Global HYCOM



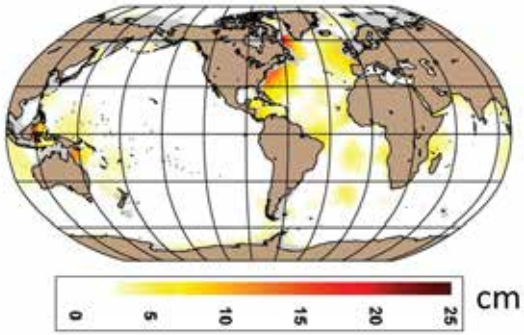
0.08° Global HYCOM, ASEnKF



0.04° Global HYCOM, ASEnKF, DA



M2 RMS Error vs TPXO8

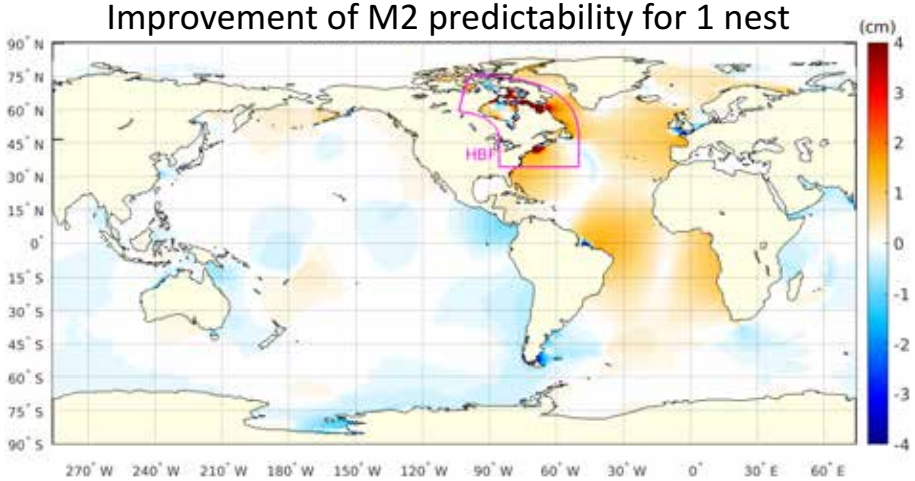


White areas are regions with RMS error less than 2 cm

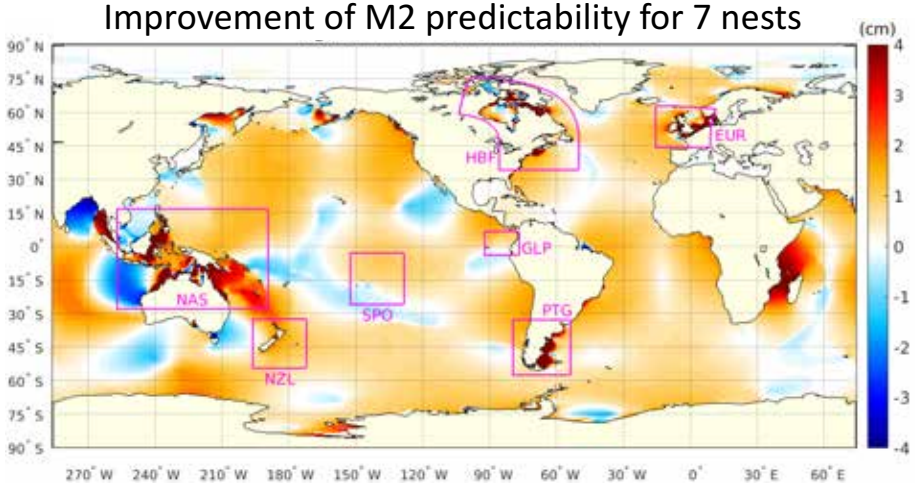
rmsd is with respect to T

Surface Tide Predictability – Two Way Nesting

Improvement of M2 predictability for 1 nest



Improvement of M2 predictability for 7 nests



- In global ocean models the coastal tides are not well resolved
- These “bad” coastal tides affect the predictability of the open-ocean tides due to the back-effect
- We can improve the global ocean tides by two-way nesting 1/75° child domains in a 1/25° parent domain. Our initial development is in a barotropic version of HYCOM
- Improvement = $RMS_{no\ nest} - RMS_{nest}$
- The global SSH RMSE is reduced from 4.12 to 3.41 cm (17%)

SSH RMSE with TPXO8-Atlas (cm)

	No Nest	1	2	3	4	5	6	7
GLB	4.12	4.04	4.02	3.98	3.52	3.47	3.44	3.41

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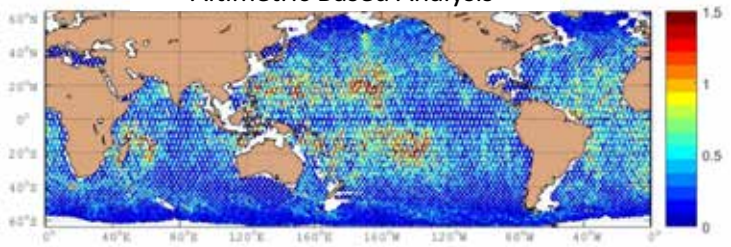
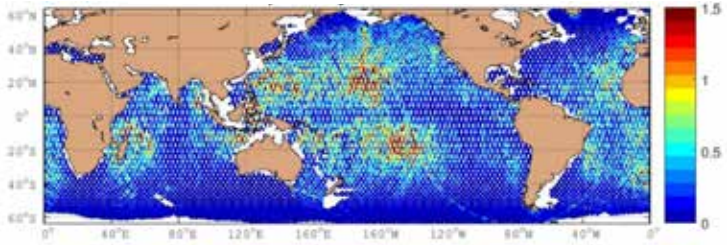
HYCOM M_2 Internal Tidal Amplitude vs. Alimetric Based Analysis

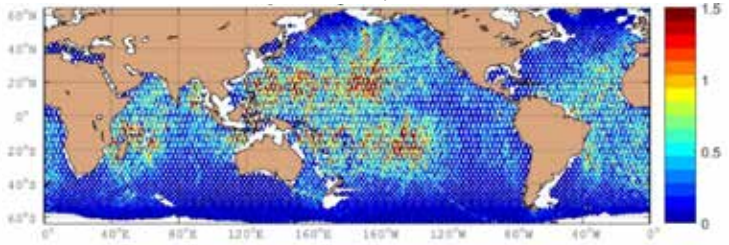
Altimetric Based Analysis



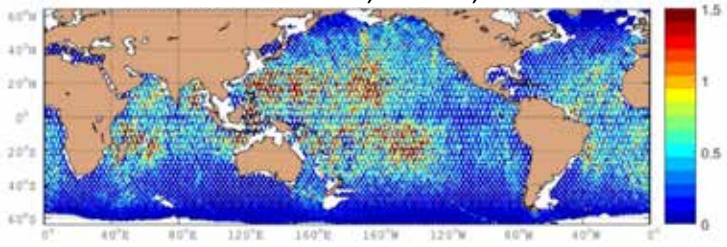
0.08° Global HYCOM



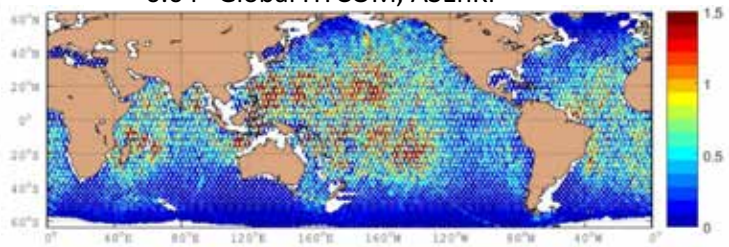
0.08° Global HYCOM, ASEnKF



0.04° Global HYCOM, ASEnKF, DA



0.04° Global HYCOM, ASEnKF



results obtained via filtering a total SSH tidal analysis along track as was done in Shriver et al. (2012)

HYCOM M_2 Internal Tidal Amplitude vs. Alimetric Based Analysis

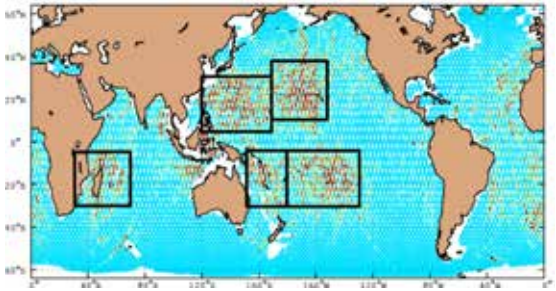
	Ray – altimeter based analysis	18.5 (1 yr, .08°, no DA)	06.1 (1 yr, ASENKF, .08°, no DA)	21.4 (3 mo., ASENKF, .04°, DA)	22.1 (3 mo., ASENKF, .04°, no DA)
Hawaii	0.79	0.87 (0.83)	0.99 (0.94)	0.95 (0.83)	1.06 (0.92)
NW Pac	0.79	0.76 (0.73)	0.98 (0.94)	1.11 (0.97)	1.19 (1.04)
Fr. Polynesia	0.84	0.80 (0.76)	0.89 (0.85)	0.96 (0.84)	1.03 (0.90)
SW Pac	0.73	0.59 (0.56)	0.78 (0.74)	0.84 (0.73)	0.92 (0.80)
Madagascar	0.71	0.66 (0.63)	0.86 (0.81)	0.90 (0.78)	0.96 (0.83)
World ocean	0.45	0.40 (0.38)	0.48 (0.45)	0.52 (0.45)	0.58 (0.51)

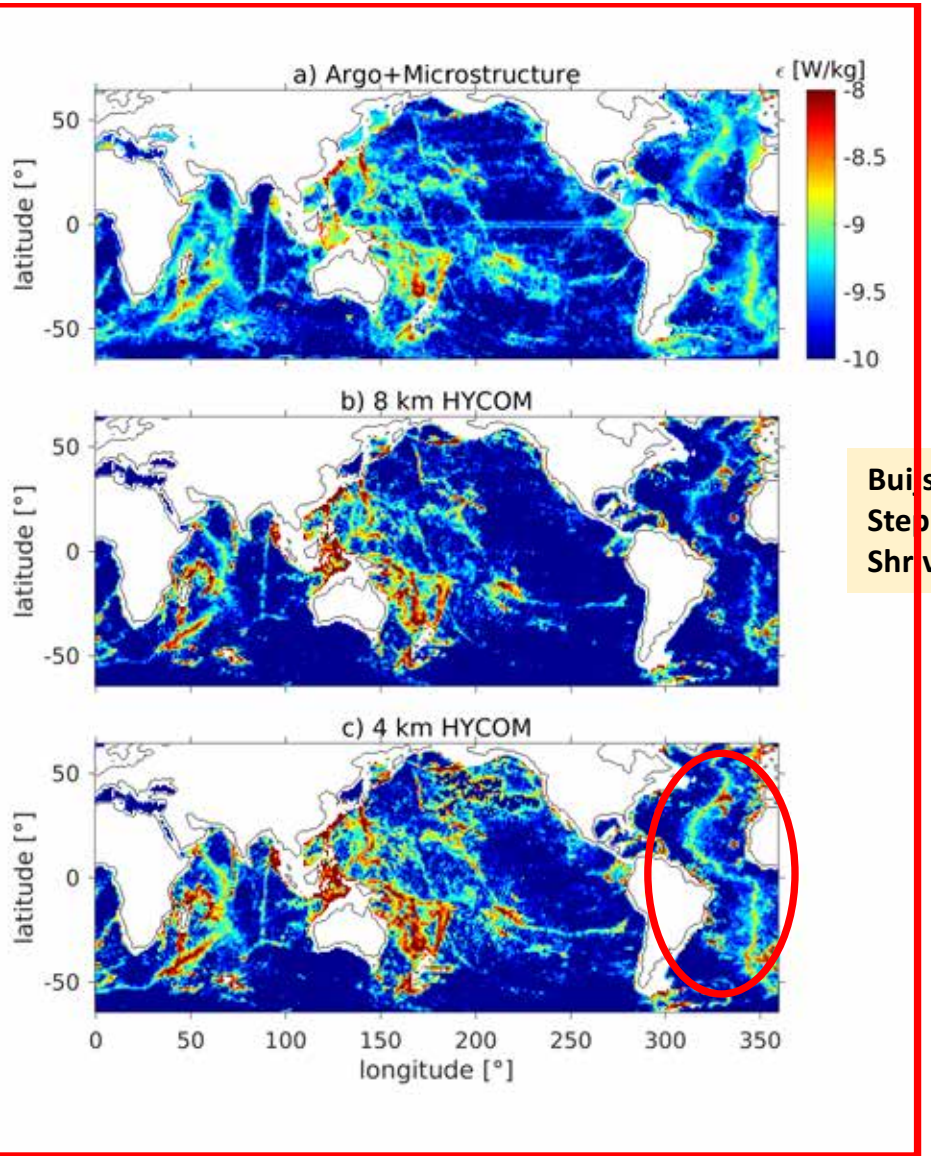
All units in cm

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

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

- 18.5 under predicts M2 int. tides
- 06.1 is OK in South Pac; North Pac and Madagascar are too energetic
- 22.1 is too energetic overall
- *21.4 with DA is closest to altimetry*, but it is still too energetic in NW Pac

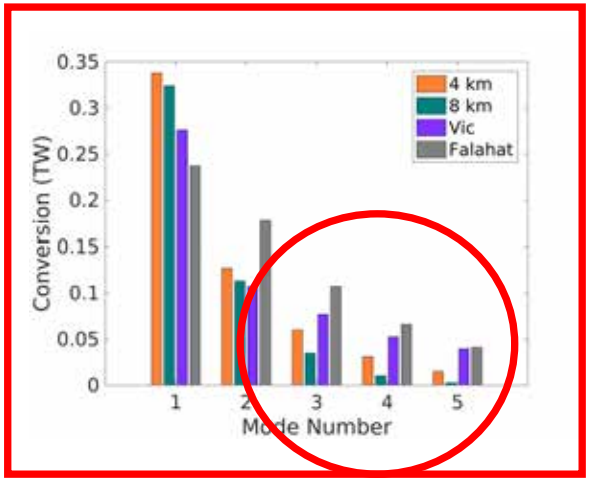




Buijsman, Stephenson Shriver

Internal Tide Predictability

- We are computing internal tide energetics in 8 km and 4 km 3D HYCOM simulations
- In 4-km HYCOM more higher modes are generated (and dissipated) => see MAR
- Barotropic to baroclinic conversion rates compare well with analytical models by Vic and Falahat
- Good agreement with Argo dissipation rates (Whalen)



Tide Improvements in Progress

We have identified areas with significant barotropic tide errors that the Ngodock et al. (2016) ASEnKF fails to correct. These areas include the Hudson Strait, Amazon Delta and the English Channel.

Besides 2 way nesting, we are developing another approach to reduce the barotropic tide error

- Improve the ASEnKF used in HYCOM.

  - Our theory is that the perturbations used to develop the ASEnKF don't contain the proper error structure, so they can't make the needed corrections. We have tested smaller scale perturbations in these high error areas and they corroborate the preceding conjecture.

  - We are presently designing a new set of perturbations focusing on these high error areas. We are continuing development and expect to be testing an improved set of perturbations and their ability to help further reduce the barotropic tidal error later this year.

Summary/Conclusions

- .04° Global HYCOM with tides and DA running daily should be available later this year

- Our DA doesn't degrade the accuracy of the internal tides
  - Simulations with DA feature internal tides that are closer to the altimetry observations

- Work is underway to further reduce barotropic tide error in HYCOM which should help improve the internal tide
  - improved ASENKF
  - two way nesting

- Internal tide energetics
  - In 4-km HYCOM more higher modes are generated (and dissipated)
  - Barotropic to baroclinic conversion rates compare well with analytical models
  - Good agreement with Argo dissipation rates