A WFS ROMS model nested into the North Atlantic HYCOM

A. Barth[1], A. Alvera-Azcárate[1], R. He[2], R. H. Weisberg[1]

[1]University of South Florida,
[2]Woods Hole Oceanographic Institution

abarth@marine.usf.edu

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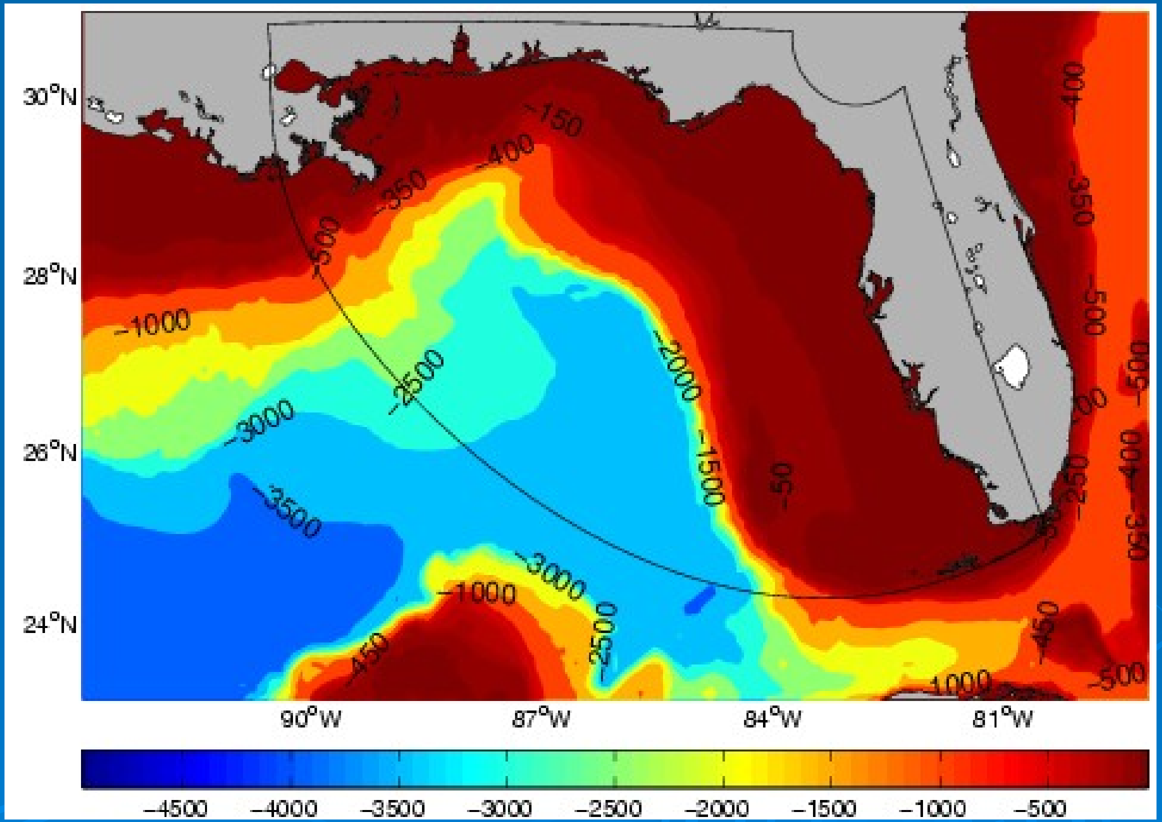
HYCOM
HYbrid Coordinate Ocean Model

West Florida Shelf domain

- Black lines show the boundary of the model domain
- Domain is composed by:
  - Broad shelf
  - Deep ocean part
- Both parts are separated by a steep shelf break



WFS ROMS model

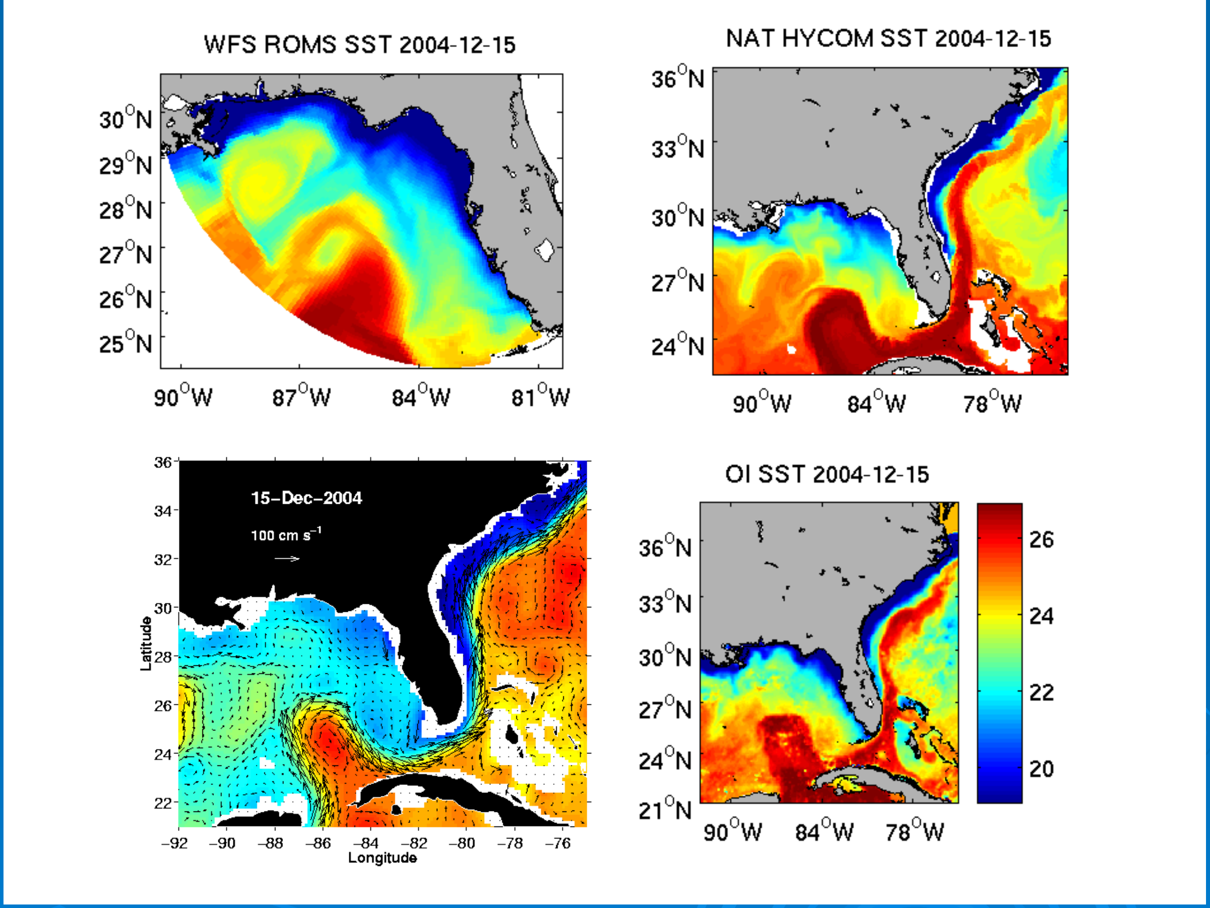
Physics	Hydrostatic 3D primitive equations, free surface
Model	ROMS 2.0 (Shchepetkin and McWilliams, 2005)
Topography	Modified ETOPO5 merged with HYCOM
horizontal grid	curvilinear grid with 4 km resolution near the coast and 10 km resolution at the open boundary
vertical grid	32 s-coordinates
Atmospheric forcings	• NCEP EDAS wind merged with *in situ* wind buoys • NOGAPS thermodynamic forcing (air temperature, relative humidity, cloud fraction and short wave radiation) • Heat flux correction by optimal interpolated SST (AVHRR, GOES, MODIS and TMI).
Open boundary conditions	Temperature, salinity and velocity from 1/12 degree North Atlantic HYCOM
Initialization	From HYCOM
River	Climatological river runoff (Mississippi River, Mobile River, Apalachicola River, Suwannee River, Hillsborough River, Caloosahatchee River , Shark River)

Nesting procedure

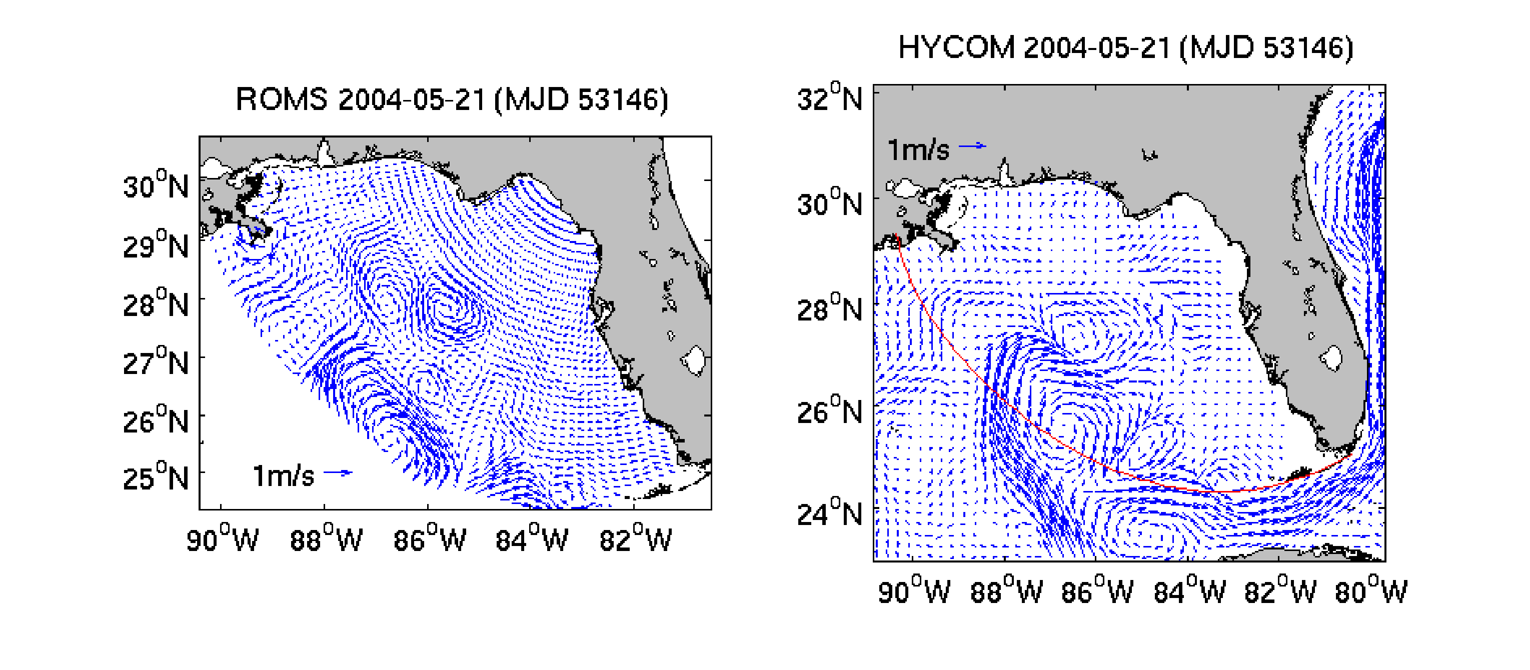
- Issues:
  - HYCOM can handle abrupt topographic variations while ROMS needs a smoother bathymetry (pressure gradient error)
  - NAT HYCOM has minimum depth of 30m, WFS ROMS minimum depth is 2m
  - But both models have to be as consistent as possible at the boundary
- Procedure:
  - NAT HYCOM fields linearly interpolated onto WFS ROMS grid
  - At some places the HYCOM needs to be extrapolated (different procedure for velocity and tracers).
  - HYCOM boundary forcing is included using a flow relaxation scheme.
  - The barotropic flow/wave at the boundary are prescribed using Chapman and Flather BC (requiring elevation and transport).

Hindcast experiment

- Starting from January 1st, 2004, a 12-month model run has been performed.
- An anticyclonic eddy can be seen in the SST of the WFS model while it is absent in the NAT HYCOM and OI SST (used for relaxation). The SSH and derived geostrophic currents confirm the presence of this eddy.



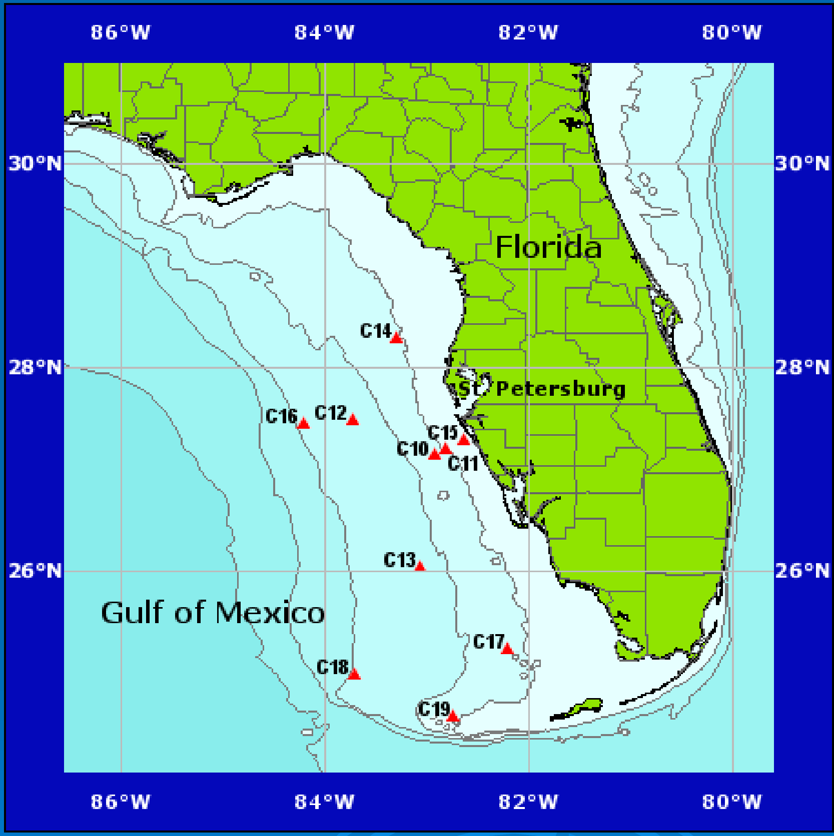
Surface velocity



- Surface currents of the WFS ROMS and NAT HYCOM model.
- The Loop Current is correctly applied as a boundary condition to the nested WFS model. While the large scale features (mainly the Loop Current) are the same, the eddy field is different.

Temperature profiles

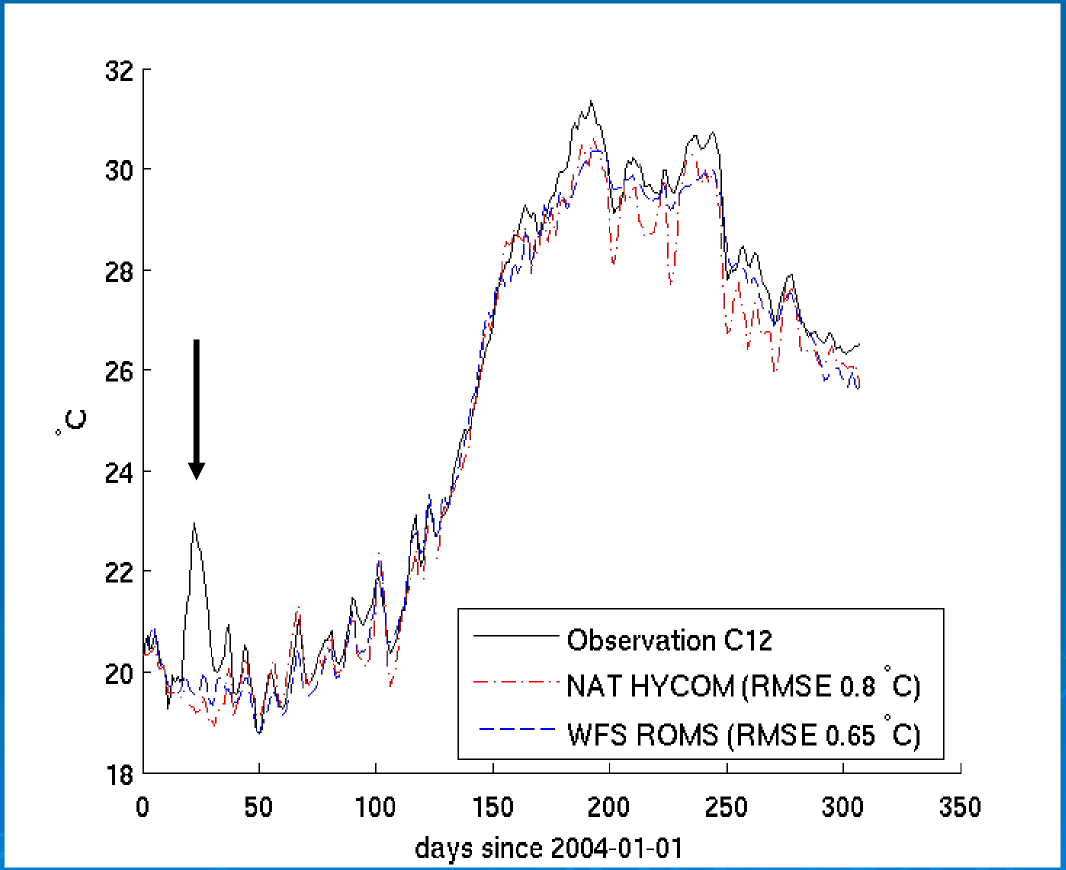
		NAT HYCOM		WFS ROMS	
Station	depth (m)	Bias	RMS	Bias	RMS
C11	19	-0.62	1.34	0.38	0.74
C12	1	-0.50	0.80	-0.36	0.65
C12	10	-1.05	1.56	-0.38	0.65
C13	10	-1.24	1.45	-0.67	0.75
C14	1	0.18	0.72	0.04	0.44
C14	5	0.07	0.78	0.02	0.44
C14	10	-1.02	2.28	0.09	0.45
C14	15	-1.82	3.27	0.34	0.60
C16	1	-0.67	1.15	-0.99	1.21



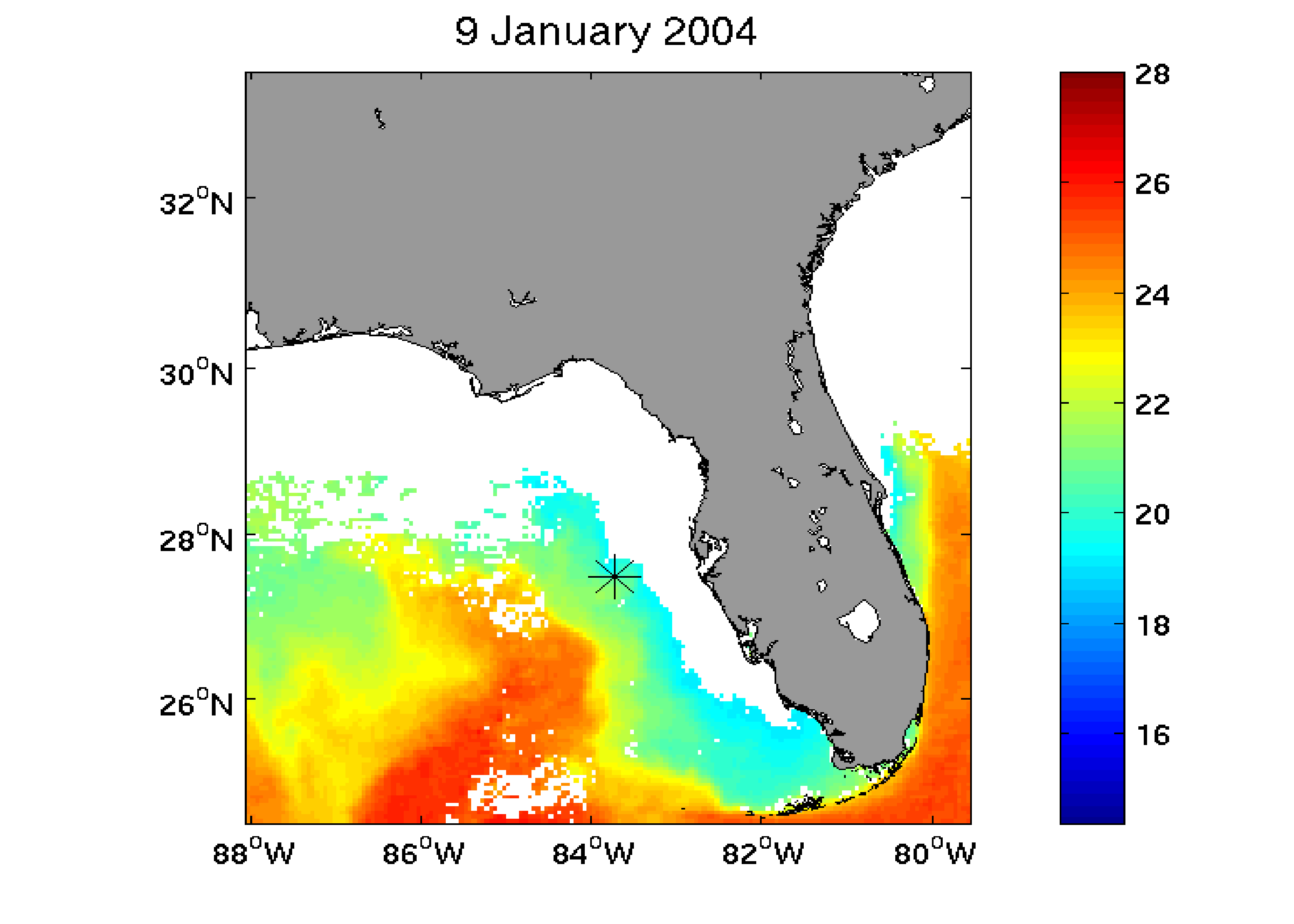
Bias and RMS errors (in deg. C) between the models and the observations at various stations on the West Florida Shelf.

Comparison of WFS ROMS temperature with *in situ* profiles

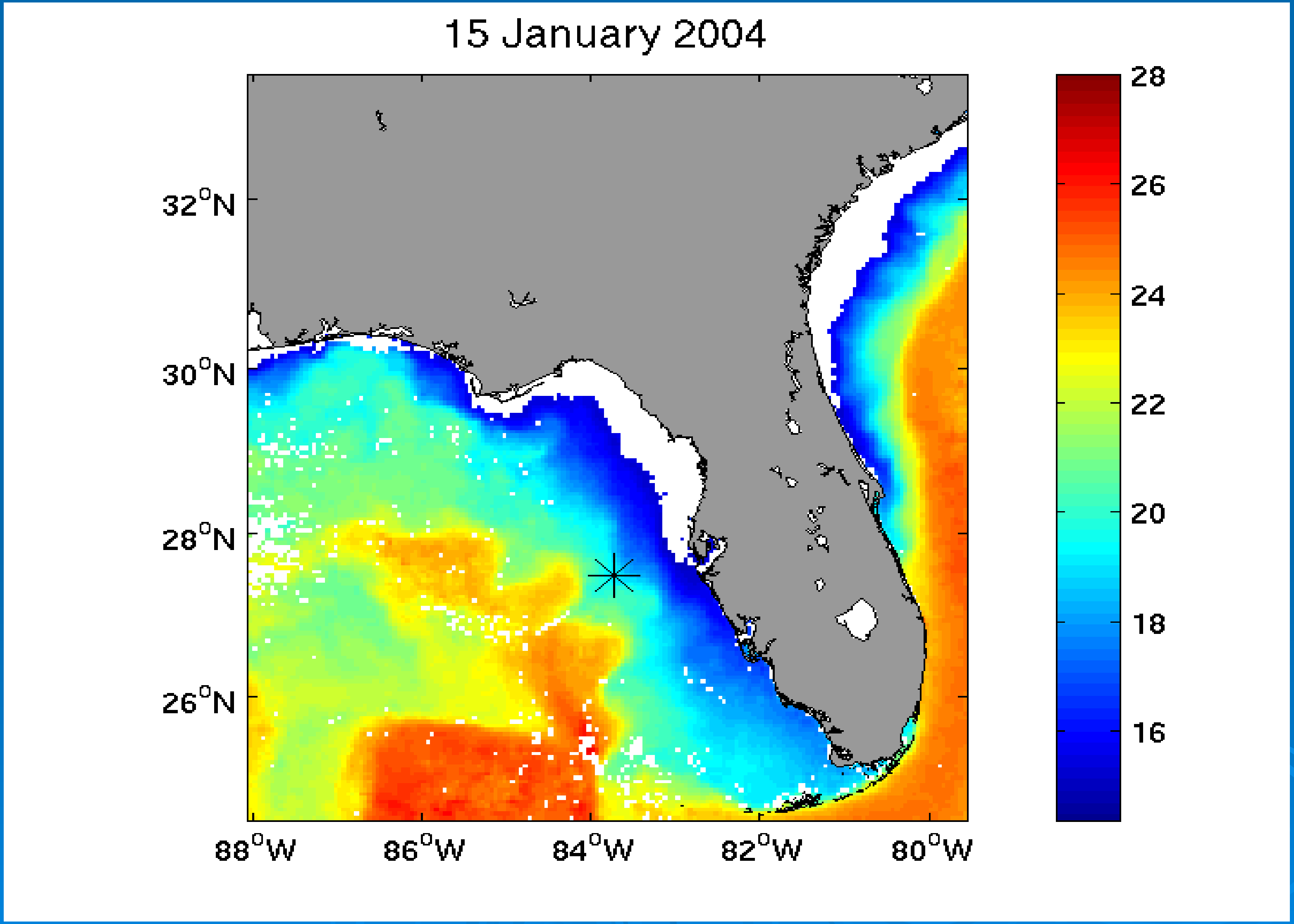
- At the surface WFS ROMS and NAT HYCOM are in remarkably good agreement with the observations except for a warm Loop Current water intrusion in mid January 2004 (day 20).



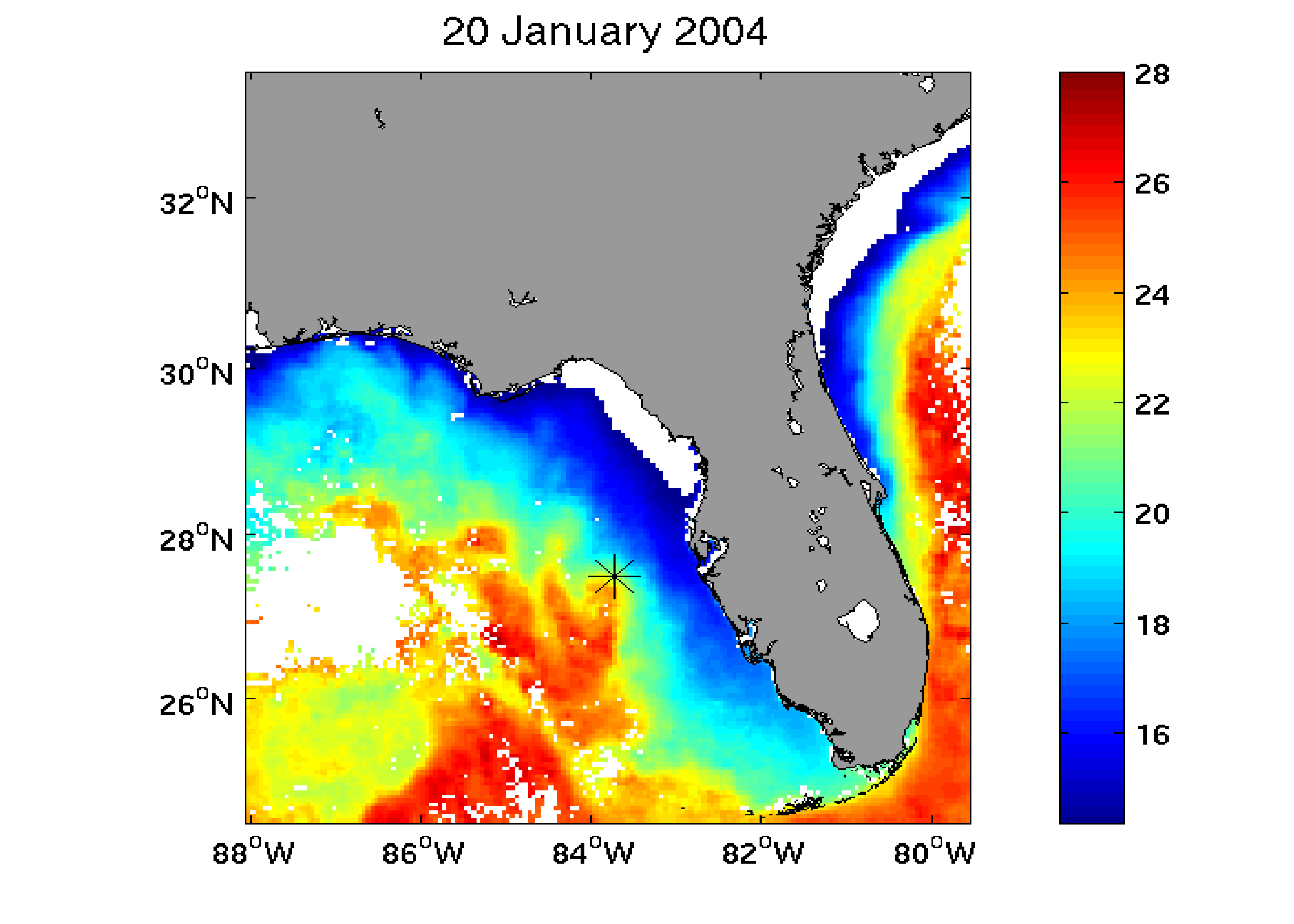
SST and station C12



SST and station C12

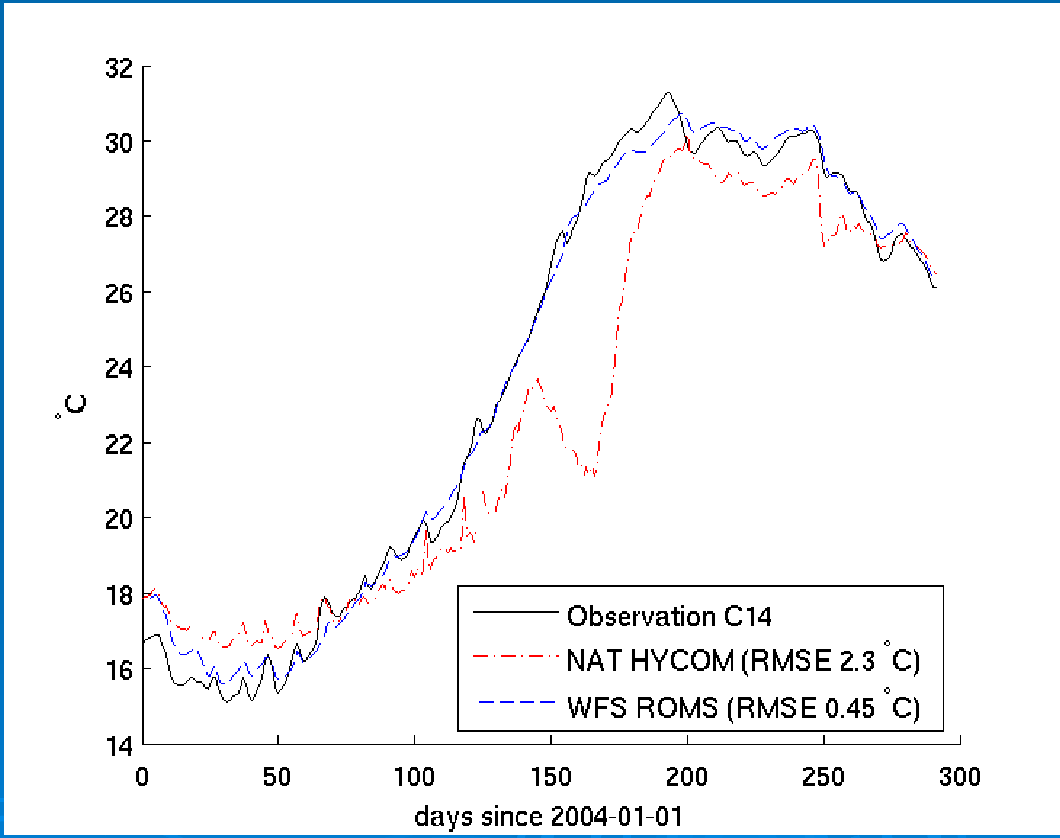


SST and station C12



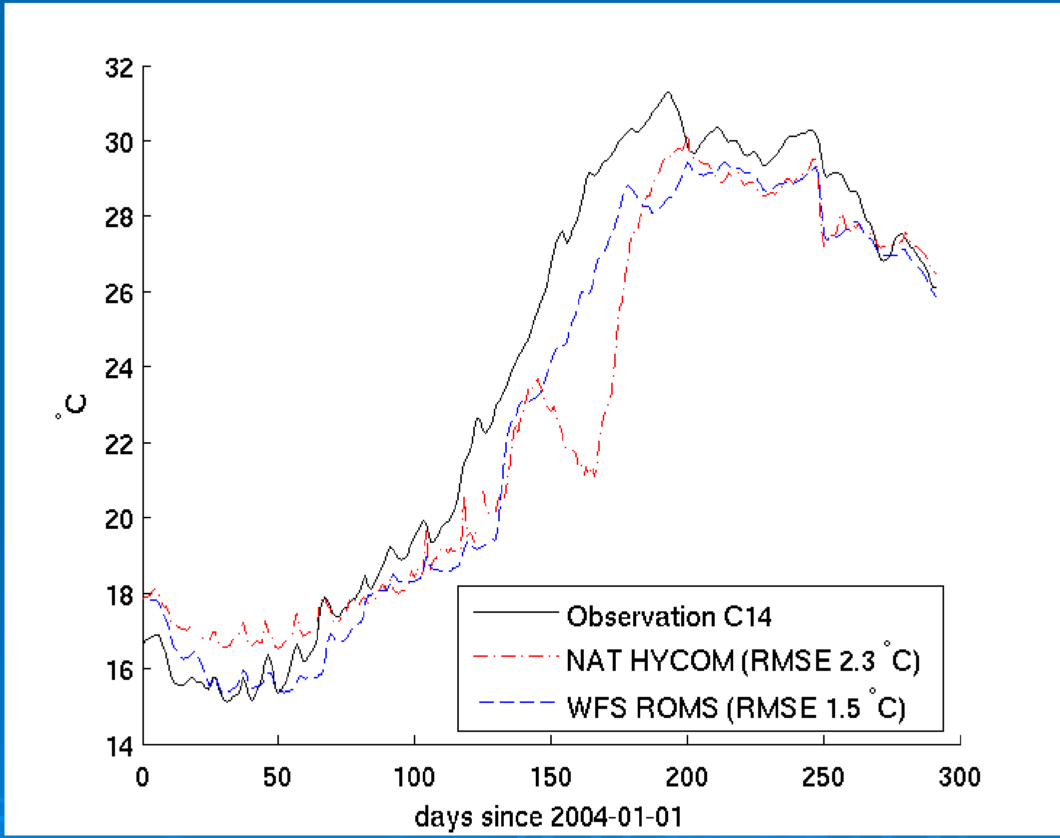
In situ temperature profiles

- At intermediate depth (15 m) the WFS ROMS model reproduces accurately the temperature trend on the WFS. During summer the NAT HYCOM model under-predicts the temperature by several degrees. At the surface and at the intermediate depth, the wind-induced stratification and de-stratification cycles are well reproduced.

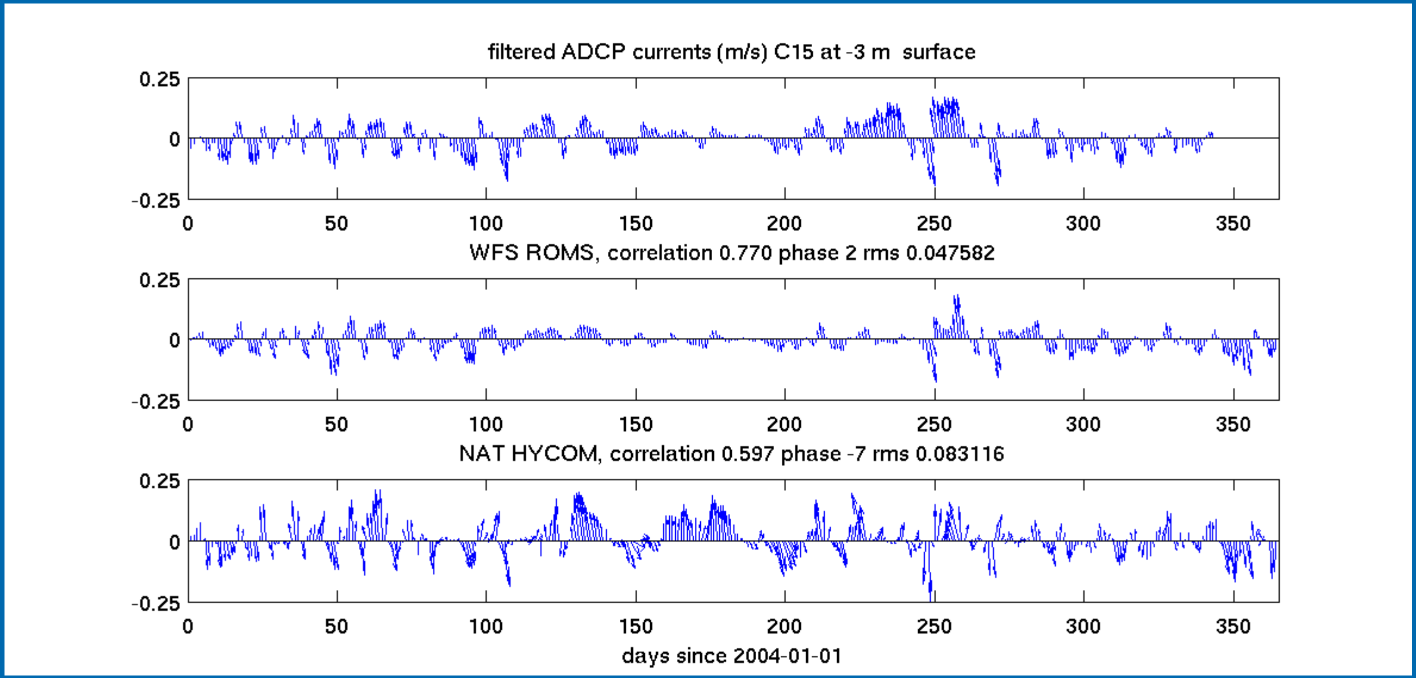


In situ temperature profiles

- Solar heat flux as a surface flux

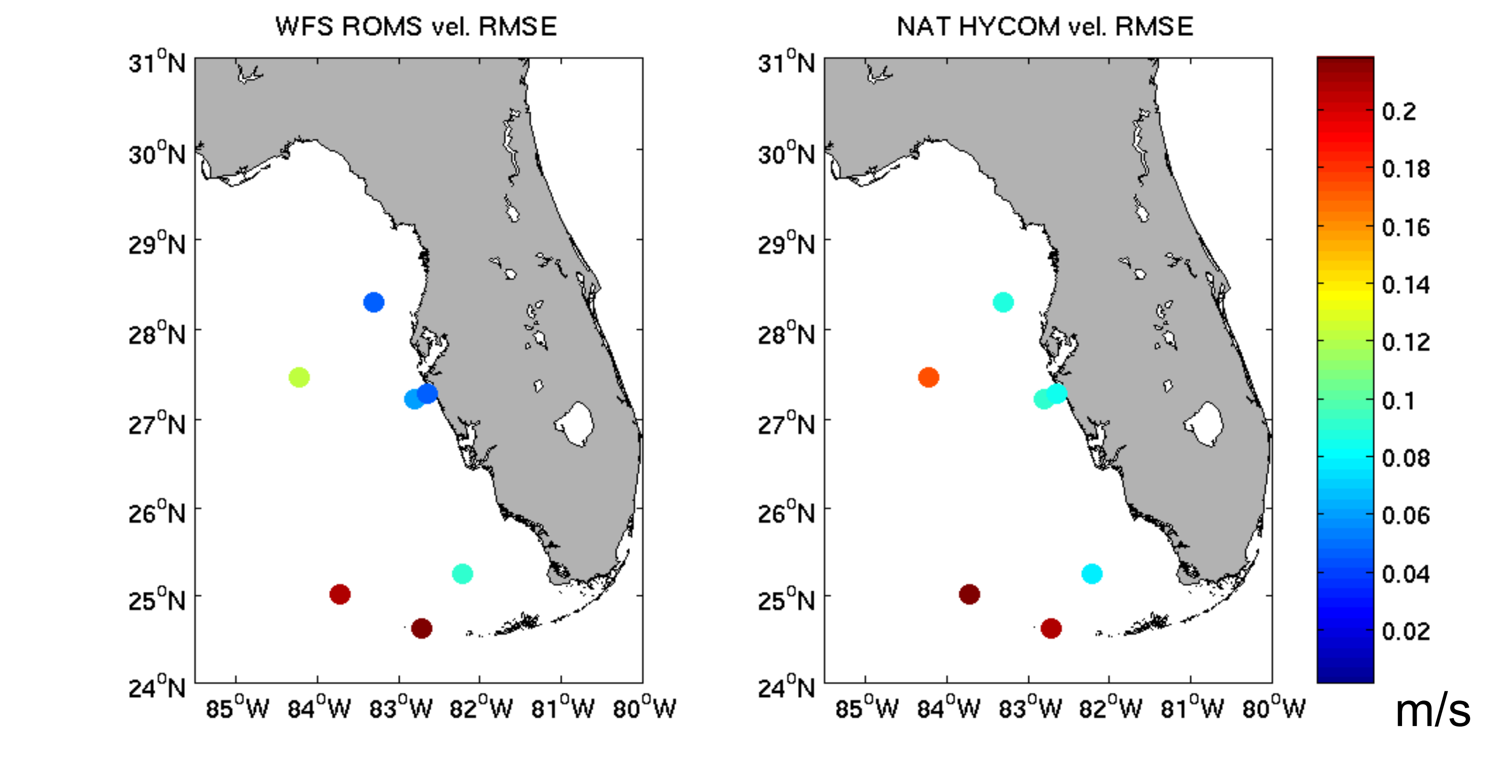


Comparison with *in situ* velocity



- Velocity at station C15 (10m isobath).
- Due to a better representation of the coast geometry, the WFS ROMS model provides better results than the NAT HYCOM. The OI winds also improve the model accuracy.
- Chapman and Flather Boundary condition improves velocity field compared to prescribed transport at the open boundary.

Spatial distribution of the velocity error

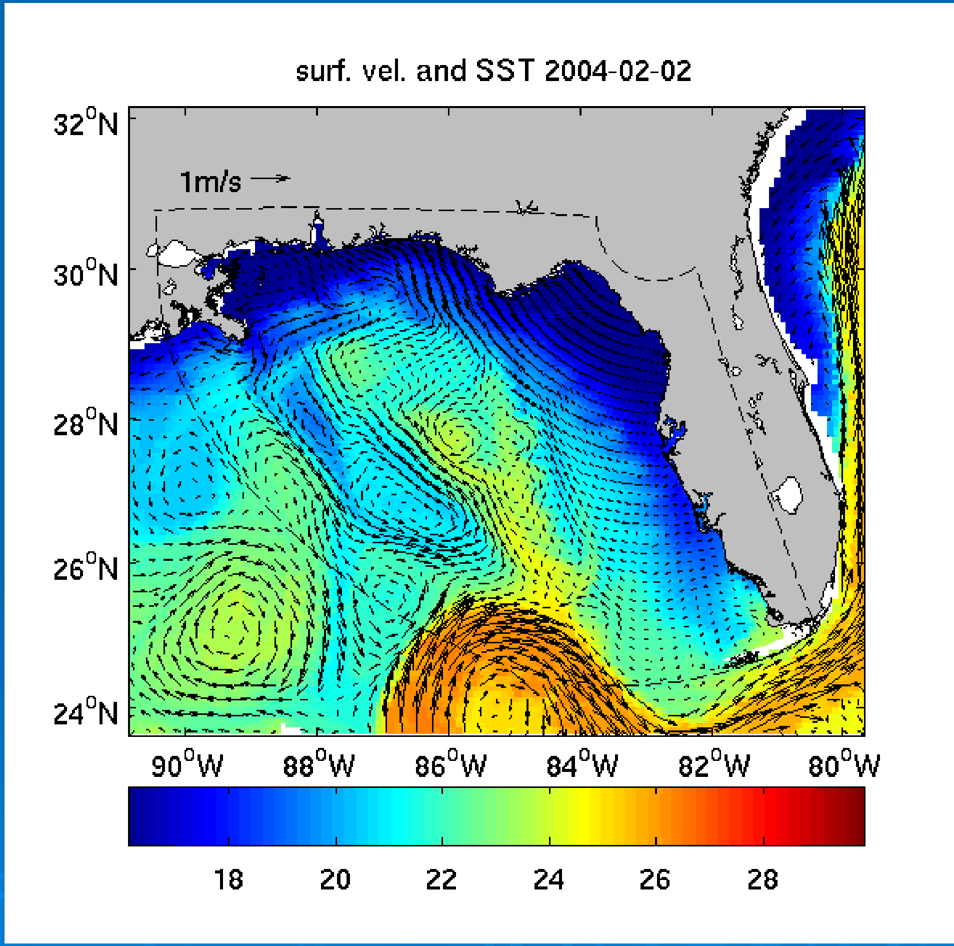


- The Keys and shelf break are problematic for WFS ROMS and NAT HYCOM.
- Overall improvement of WFS ROMS over NAT HYCOM

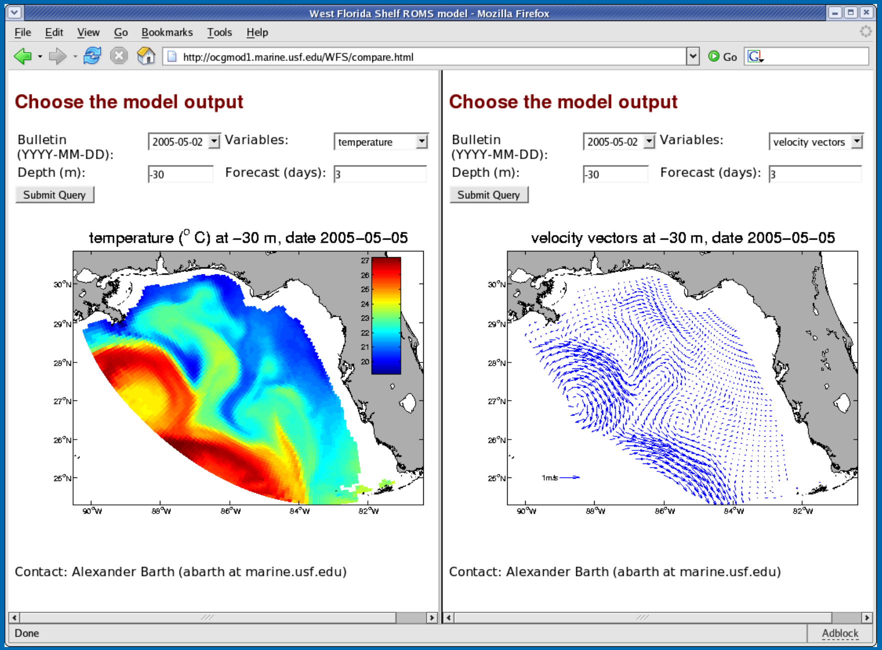
Consistency NAT Hycom and WFS ROMS

WFS ROMS SST and surface velocity is shown inside the dashed line and outside of this area is the NAT HYCOM model.

Warm water is detached from the Loop Current and transported northward as mesoscale eddies and filaments.



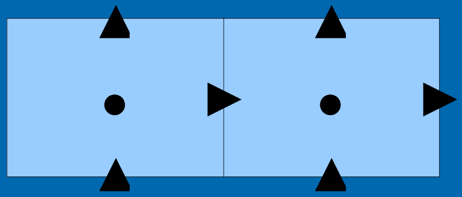
On-going development



- We are working to run this model on a daily basis and performing a one day hindcast followed by a 3.5 days forecast. Model results can be interactively plotted at http://ocgmod1.marine.usf.edu
- Missing forecasts are carried out retrospectively.

Including tides in baroclinic WFS ROMS model

- Differences between ROMS and POM in the treatment of tides (position of the open boundary)



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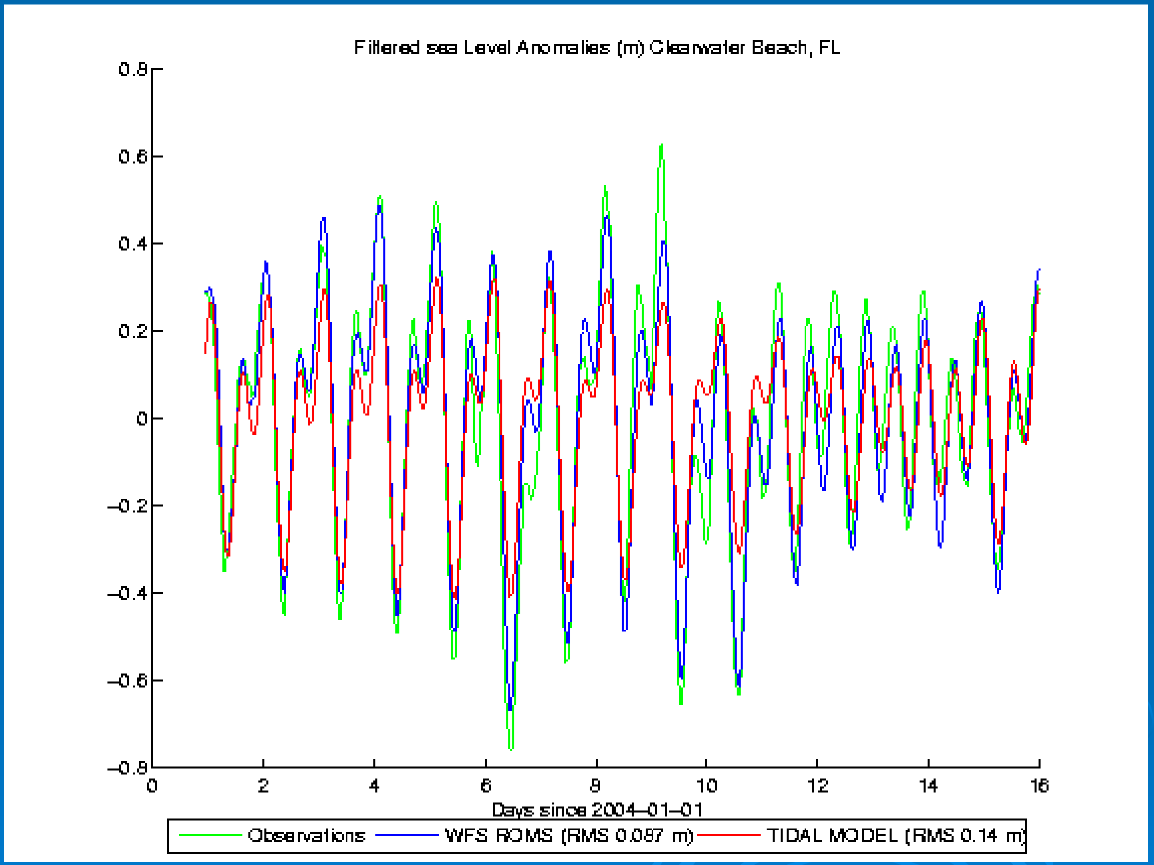
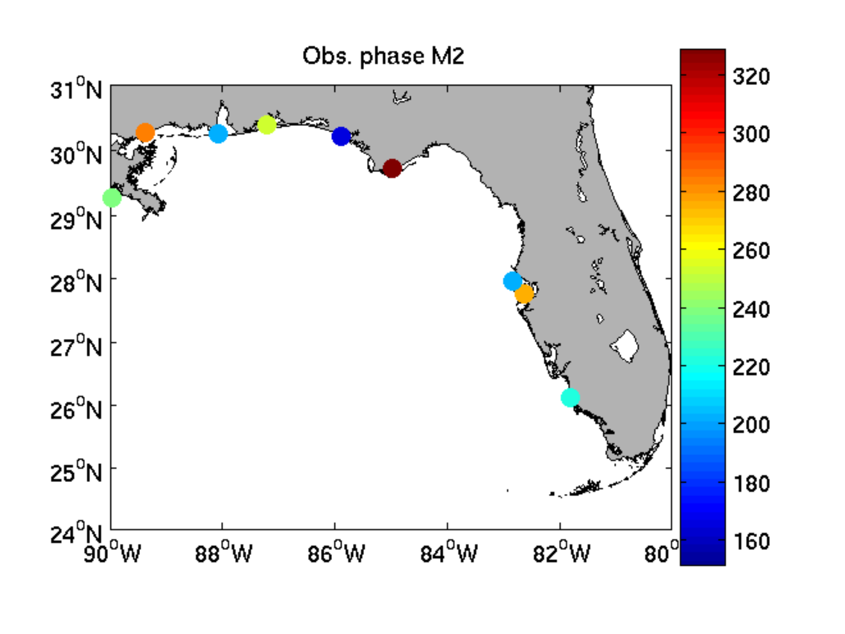
- Sea level elevation and currents from OSU TOPEX/Poseidon Global Inverse Solution imposed as Chapman and Flather BC.
- 8 primary constituents: M2, S2, N2, K2, K1, O1, P1, Q1

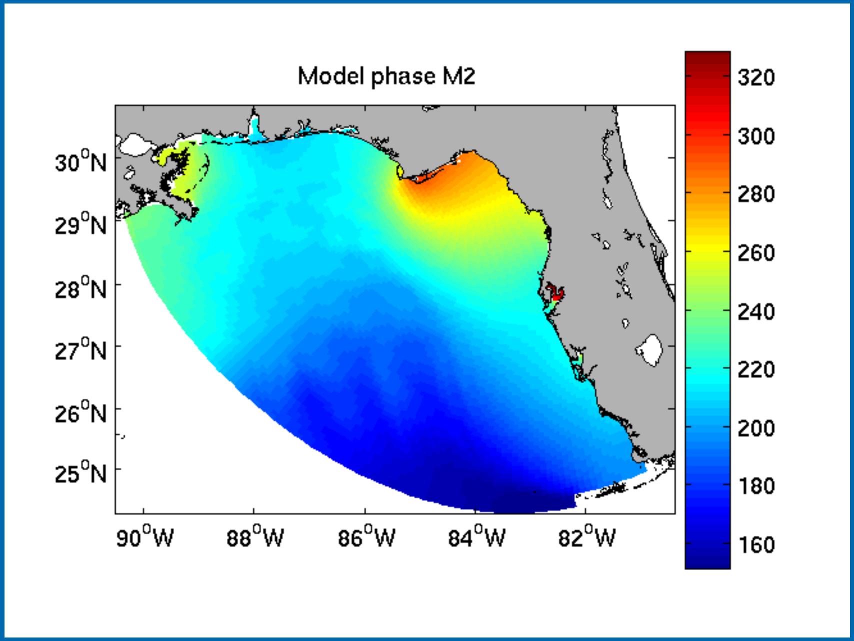
Sea level comparison

- Simulation for 15 days of WFS ROMS with tides
- Inverse Barometric effect removed from observed sea level.
- The model performance for sea level forecast need to be improved but it is already better than the Global tidal solution.



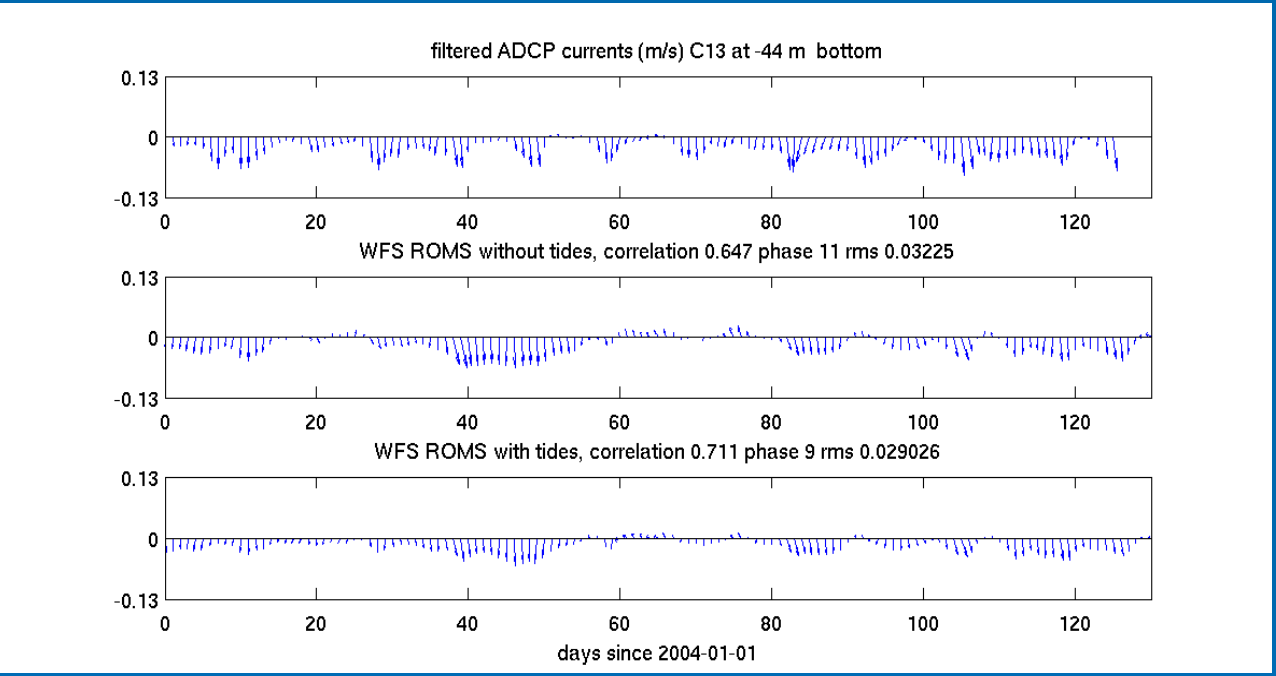
M2 Phase





- Overall a good agreement of the structure of the M2 phase

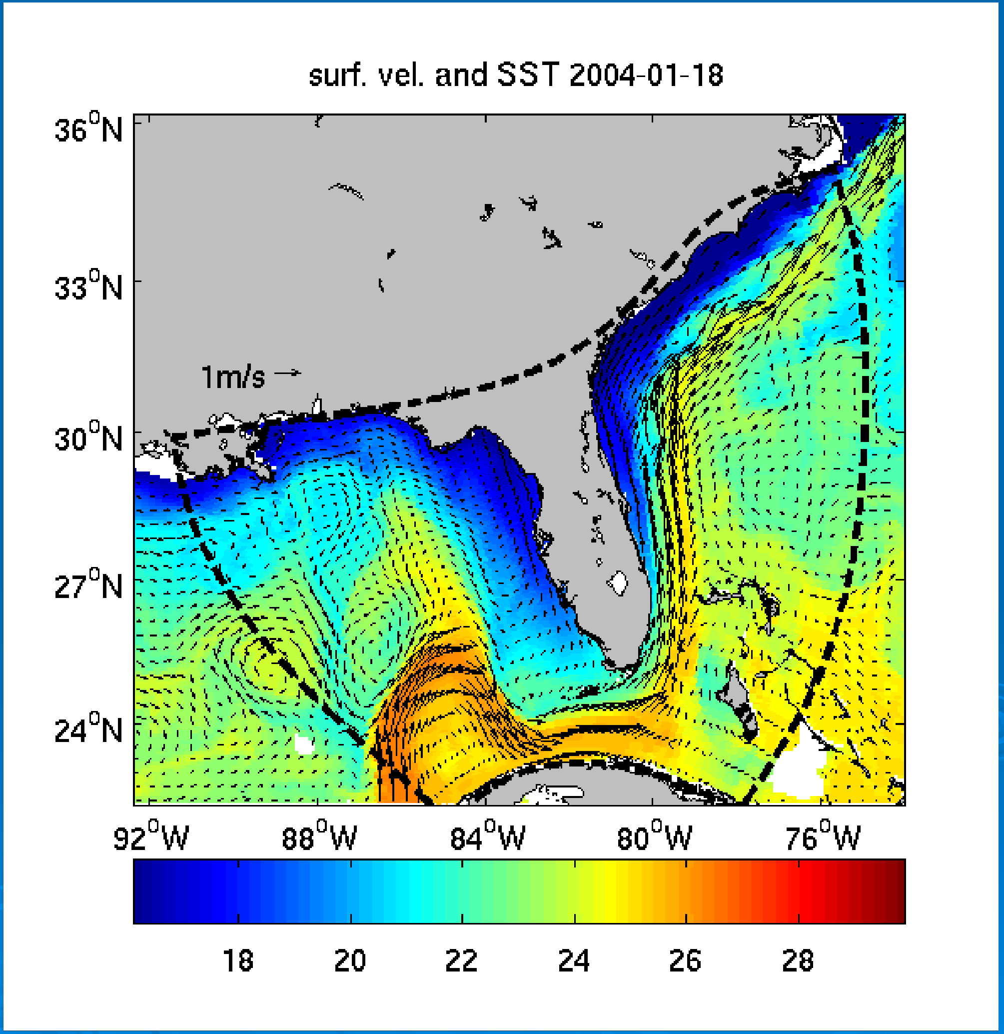
Effect of Tides on the subtidal current



- During winter months, the velocity is constantly directed to the south at bottom station C13
- In the model without tides current occasionally inverse.
- With tides these inversions are much weaker (possibly due to an increased friction)
- Better RMS error and correlation at most stations.

Work in progress: Larger Domain

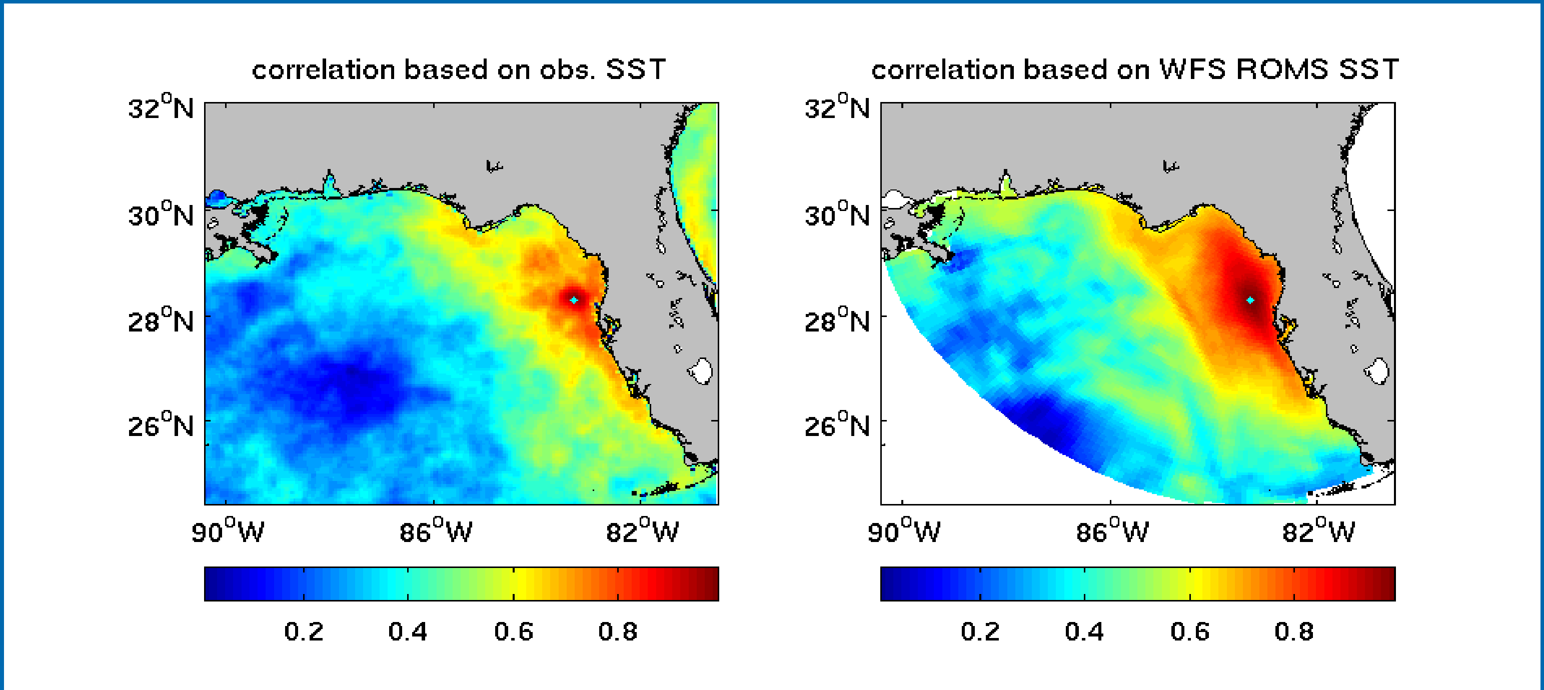
- SEACOOS domain model nested in NAT HYCOM
- Main focus will be the WFS but extended domain will presumably reduce the effect of open boundary near steep topography.
- Preliminary result of the SEACOOS domain model



Conclusions

- Both models, WFS ROMS and NAT HYCOM reproduce accurately the stratification and de-stratification cycles during winter resulting in a remarkably agreement of the variability at a frequency of 10 days.
- Overall, the WFS ROMS model reproduces more accurately (in terms of RMS) the moored temperature measurements than the NAT HYCOM.
- On the shelf, the velocity estimation of the WFS model are more accurate than the NAT HYCOM results.
- Start to add tidal information at the open boundary in addition to NAT HYCOM
- The inclusion of the tide improve at most stations the subtidal velocity
- Continue to run the WFS ROMS nested in HYCOM on a daily basis
- Presently we are also applying the methods on a larger SEACOOS domain

Future Work: Data Assimilation



- correlation of SST (obs. and model) at station C14 (cyan dot) with surrounding grid points.
- The correlation is computed with anomalies representing the variability of a time period shorter than 15 days.
- The correlation pattern will be used as structure function for data assimilation.