Impact of upper ocean warm layer thickness on hurricane intensity change in a regional coupled model

Hyodae Seo[1,2] (hseo@whoi.edu) and Shang-Ping Xie[2]
[1]Woods Hole Oceanographic Institution, [2]International Pacific Research Center, University of Hawaii, Manoa

1. Summary

The Scripps Coupled Ocean-Atmosphere Regional (SCOAR) model is used to study the relative importance between the oceanic surface and subsurface thermal parameters on the intensity of hurricane Katrina (2005). Relevant oceanic parameters to the storm intensity considered: SST, D26, UOHC, and T100

Experiments: Total 105 sensitivity tests initialized from the altered initial D26 (no change in SST) in SODA (1993-2008) and HYCOM (2004-2008) for hurricane Katrina with the same initial intensity.

Results:
1) D26 causes a greater sensitivity in the minimum SLP than SST alone: 30 hPa due to D26 vs 3-12 hPa due to SST

2) UOHC resembles the relation of D26 to SLP, confirming that D26 is a more important factor in determining UOHC and hence the storm intensity.

3) Both the depth averaged (T100) and depth integrated (UOHC) temperatures provide essentially the same forecast guidance of Katrina's intensity

2. Motivation

Studies show that Katrina intensified over the area of anomalously deep thermal structures such as the Loop Current and a warm core ring, while the SST field was uniformly high, indicating a positive correlation between depth of the subsurface warm layer and the intensity of Katrina. However, it has not been systematically investigated as to the relative impact on the intensity of Katrina using the regional coupled model.

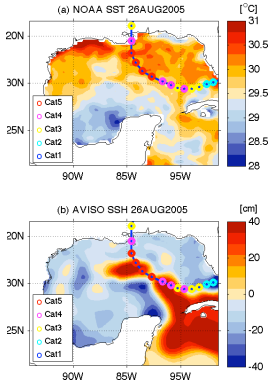
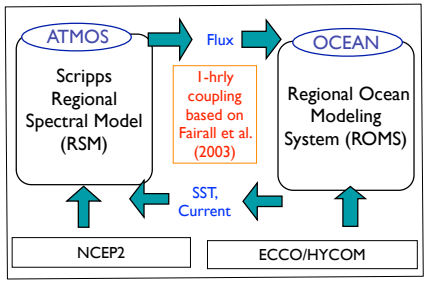


Figure 1. Observed (a) SST and (b) SSH on 26AUG2005.

3. Model: Scripps Coupled Ocean-Atmosphere Regional Model

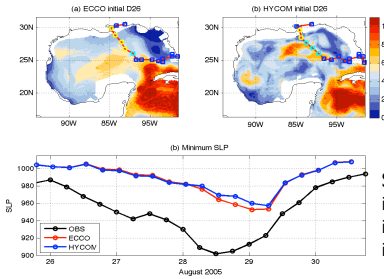


The horizontal resolutions of RSM and ROMS are identically 0.13° with the matching land-sea mask and coastline.

120 hr integration from 26AUG 2005 to 31 AUG 2005.

Ocean ICs: ECCO (1993-2008), HYCOM (2004-2008)

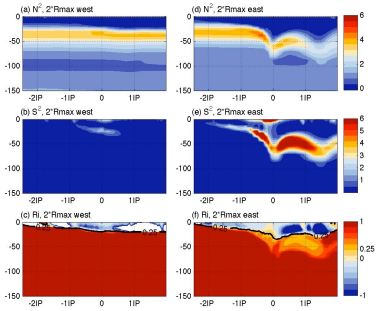
3. Initial conditions and storm intensity



ECCO and HYCOM reasonably capture the observed LC bulge over the Katrina passage.

Simulated storm intensity is weak due to inaccuracy in initialization.

4. Shear-induced mixing and right-ward bias



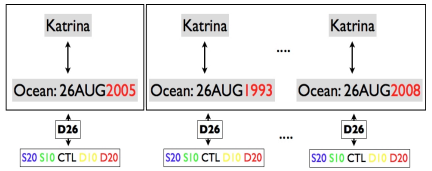
1) ECCO appears to be too strongly stratified (high N^2) in upper 30 meters in contrast to the observations (e.g, in Jaimes and Shay (2009, 2010)).

2) Shear instability (S^2) increases

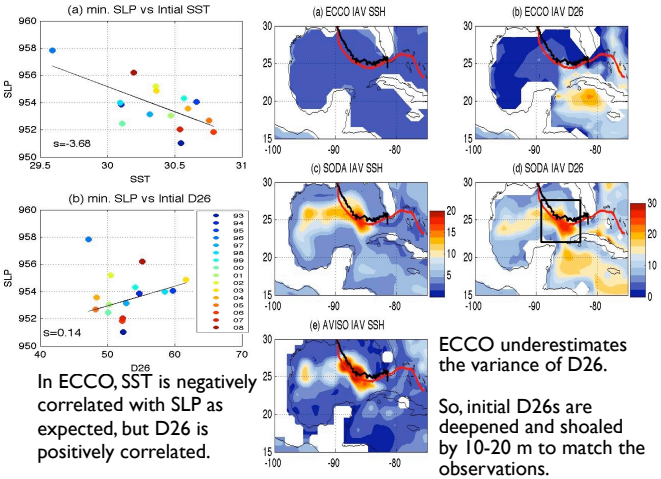
3)Ri is not lowered below criticality below 30 m.

4) A pronounced rightward bias with near-inertial process

5. Sensitivity tests with altered ocean ICs



Initial conditions in ECCO (HYCOM) are altered for different ocean phases of LC and WCR.

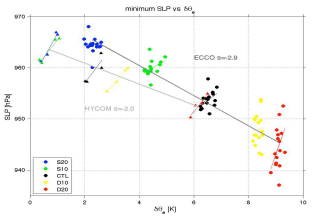


In ECCO, SST is negatively correlated with SLP as expected, but D26 is positively correlated.

ECCO underestimates the variance of D26.

So, initial D26s are deepened and shoaled by 10-20 m to match the observations.

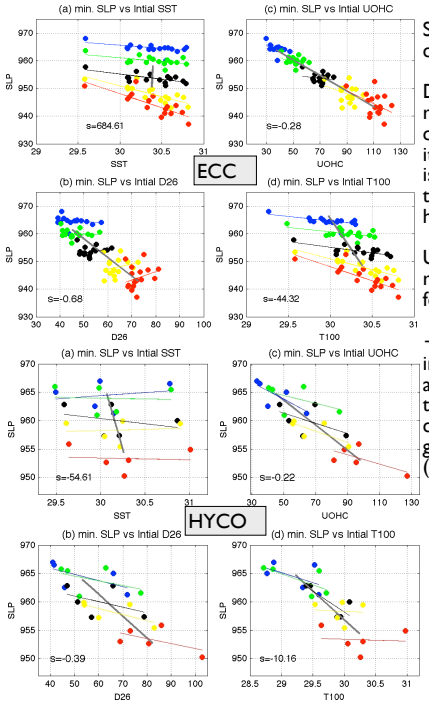
6. Why is the storm stronger with the altered D26?



It is a pick-up of θ_e by the storm via OML dynamics that determine SST through the hurricane-ocean (D26) interactions.

Increase in storm intensity is generally negatively correlated to the increase in situ θ_e owing to the different initial D26.

7. How sensitive is SLP of Katrina to different ocean states?



SST-SLP is negatively correlated: ~5-15 hPa.

D26 variation has a robust negative correlation with SLP *if* its variability in ECCO is increased to match the observations: ~50 hPa.

UOHC and T100 reflects these two features;

→The depth-integrated and depth-averaged ocean temperatures provide comparable forecast guidance in GOM (Price 2009).

HYCOM D26 variability is larger than ECCO, leading to a correct, negative correlation even in individual clusters.

8. Discussion and Future Plan

1. Hurricane-ocean interaction and the intensity of hurricane is sensitive to how well the oceanic pre-storm subsurface condition is represented.
   → Underestimation of D26 features in ECCO versus HYCOM

2. The assimilated models do not have proper resolutions to present small-scale structures (LC-bulge and WCR) on horizontal scales of ~10 km (e.g., Shay et al. 2008).

3. The results lend a strong support to the notion that subsurface temperature structure is a far more important predictor than SST-alone with greater sensitivity of the Katrina's intensity (30hPa vs 3-12 hPa)

4. The impact of ocean (slope) will likely be higher if the model produce stronger hurricanes. → A subject of future study using a accurate initialization technique.

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