Analyzed Surface Fields in Support of COOS: Geostrophic Currents based on Altimetry, Surface Winds and Cloud-Free Sea Surface Temperature

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1. Introduction

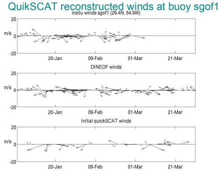
An increasing demand exists for regional coastal ocean observations and models. Accurate surface forcing functions are necessary for both the circulation models and their multidisciplinary applications. Here we present several data sets covering the contiguous eastern Gulf of Mexico and southeast Atlantic: fields of winds, cloud-free Sea Surface Temperature (SST), and geostrophic surface drifter trajectories. These fields are used for analyzing the circulation characteristics of the domain.

These data sets, originally created for the West Florida Shelf, were expanded for the Southeast Atlantic Coastal Ocean Observing System (SEACOOS) and for broader environmental applications.

2. Multivariate reconstructions using DINEOF

DINEOF (Data INterpolating Empirical Orthogonal Functions, Alvera-Azcárate et al (2005)) is an EOF-based technique used in a multivariate approach to reconstruct missing data. Here we explore the benefit of co-analyzing Sea Surface Temperature (SST), chlorophyll-a concentration, and QuikSCAT winds. In particular, we studied the utility of combining SST + chlorophyll, SST + 1 day lagged SST + chlorophyll, and SST + 1 day lagged winds to construct cloud-free SST (and other) fields. To assess the quality of the reconstructions, we compared reconstructed fields to *in situ* data. We found that the combinations of SST + chlorophyll and SST + lagged SST + chlorophyll significantly improved the results obtained by reconstructions of SST alone. All the experiments correctly represent the SST, and as an example we discuss a downwelling event observed on the West Florida Shelf.

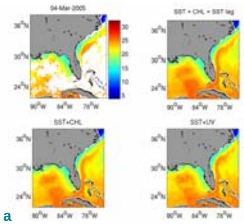
QuikSCAT reconstructed winds at buoy sgof1



Examples of the reconstruction of the cloudy SST on 4 March (**a**) and 10 March 2005 (**b**) using different combinations of variables.

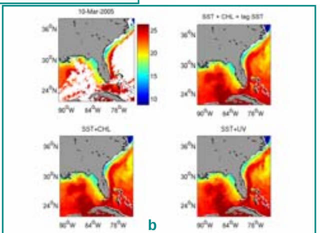
- SST plus 1-day lagged SST
- SST plus chlorophyll
- SST plus 1-day lagged QuikSCAT winds

The three combinations are very similar qualitatively, and are able to represent the major features of the Gulf of Mexico SST, as well as some meso-scale features.



Buoys used for the validation

* are SST buoys and ○ are wind buoys



Error of reconstructions compared to *in situ* data

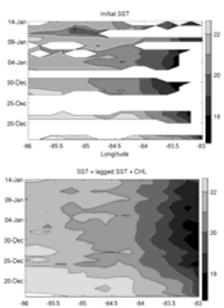
	RMS (°C)	bias (°C)	correlation	Std. Dev. (°C)*
SST	0.76	-0.09	0.59	1.04
SST + 1 day lag wind	0.75	0.01	0.6	1.00
SST + CHL	0.62	0.05	0.71	0.93
SST + 1 day lag SST + CHL	0.6	-0.01	0.69	0.89

* *in situ* data 0.97°C

The best reconstruction in terms of RMS error is the combination of SST + 1 day lag SST + chlorophyll (see Table). However, all three multivariate reconstructions improve the monovariate (only SST) reconstruction. The standard deviation of the SST + 1 day lag SST + chlorophyll data set is smaller than the observations, and the reconstruction is smoother than with the other tests.

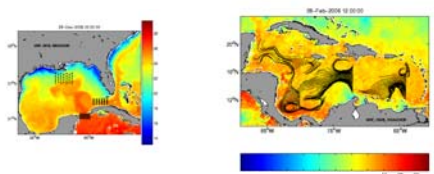
Transect studied for the downwelling event

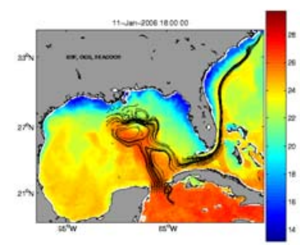
As an application example consider a series of downwelling and upwelling sequences observed on the West Florida Shelf (WFS). We use satellite SST along a transect situated at 28°N (see picture at right). Temperature variations are seen over the entire transect with large cloud gaps. The reconstructed SST shows the variations more clearly, and inspection of the winds (not shown) accounts for the waxing and waning of the SST field. Such upwelling and downwelling occurrences are of great ecological importance. DINEOF is capable of accurately reproducing these in the presence of cloud contaminations.



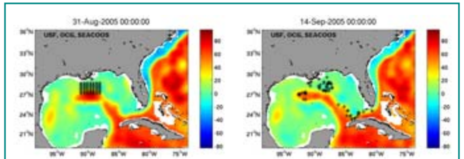
3. Surface Geostrophic Drifters

We simulate Lagrangian surface drifter trajectories by analyses of surface geostrophic currents. Sea level anomaly fields from the CLS Space Oceanography Division (Collecte Localisation Satellites, http://www.cls.fr) are added to a mean Sea Surface Height (SSH) field calculated from the HYCOM model to obtain absolute SSH, the gradient of which is used to calculate geostrophic currents. Simulated trajectories then follow from a Runge-Kutta second order integration, with a time step of 6 hours. In the following images for the Caribbean Sea and Gulf of Mexico the drifter trajectories are superimposed on our cloud-free OI-SST product. These trajectories are updated weekly.





Our first application of this product was to track the path of Mississippi River waters after **Hurricane Katrina**. Due to the northern penetration of the Loop Current, waters of Mississippi River origin were rapidly transported towards the Florida Keys.



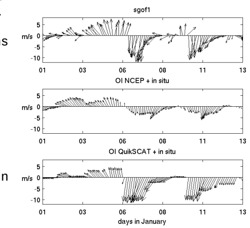
Surface drifters' initial position and result of the advection 15 days later, on 14 September 2005

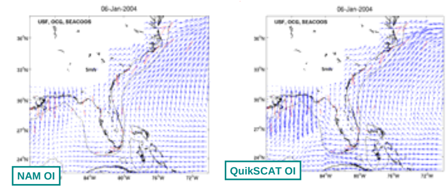
4. OI surface Wind Fields

We presently produce a 3-hourly wind field analysis by merging NCEP NAM winds with *in situ* data using Optimal Interpolation (OI). Since the NAM winds are coarse we combine the NAM analyses offshore of the 200m isobath with in situ winds inshore of the 200m isobath. The resulting OI wind fields were shown to improve upon the accuracy of coastal ocean circulation model simulations (He et al, 2004) and these winds are used as forcing functions for our present WFS circulation models (e.g., Barth el al., 2006).

Here we present a similar analysis using QuikSCAT winds in place of NAM winds, and we study the potential for using this satellite data source as part of the OI analysis. One disadvantage of QuikSCAT winds is their temporal resolution (two satellite passes daily compared to 3-hourly time step for NAM). An advantage, however, is that QuikSCAT data can be used near the coast.

Two OI analyses (QuikSCAT + *in situ* data and NAM + *in situ* data) are shown to the right in comparison with in situ buoy winds omitted from the analysis (buoy sgof1). The NAM OI analysis is too weak compared to the buoy data. The QuikSCAT OI winds are stronger and able to better represent the observations.





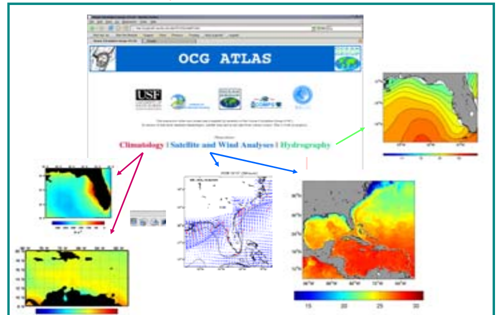
The two figures to the left show examples of OI analysis fields, with the in situ buoy data in red. Again, we can see that QuikSCAT winds are stronger at some locations. Our future tests will consist of an OI wind product that merges all three data sources (NAM, QuikSCAT and *in situ* winds). This will combine the high temporal resolution of NAM and the accuracy of QuikSCAT winds near the coast.

5. OCG ATLAS

As part of our COMPS and SEACOOS Coastal ocean observing systems activities all of the products mentioned in this poster, as well as atmospheric and T/S climatologies, are available at the Ocean Circulation Group Atlas, at

http://ocgmod2.marine.usf.edu/ATLAS/initialP.html

For a complete list of available variables, please take one of the handouts at the bottom of this poster.



6. Conclusions

Multivariate DINEOF:
The use of multiple variables in the analysis of cloudy SST helps improve the accuracy of the reconstruction. The combinations SST plus chlorophyll, SST plus lagged SST plus chlorophyll and SST plus winds all improved the results obtained using only SST.

Surface geostrophic drifters:
Developed to track waters of Mississippi River origin after Hurricane Katrina, we now have a Lagrangian surface drifter simulation tool for the Gulf of Mexico and the Caribbean based on analyses of surface geostrophic currents.

OI sea surface winds:
New tests using QuikSCAT suggest that satellite winds when merged with in situ data by OI lead to a better representation of the coastal ocean winds than the NCEP NAM + in situ winds. The next step is to combine the attributes of both the NAM and QuikSCAT winds. Other model winds when available (e.g., COAMPS) may also be combined.

References

Alvera-Azcárate, A., A. Barth, M. Rixen and J.-M. Beckers. 2005. Reconstruction of incomplete oceanographic data sets using Empirical Orthogonal Functions. Application to the Adriatic Sea. Ocean Modelling, 9, pp 325 - 346.

Alvera-Azcárate, A., A. Barth, J.-M., Beckers and R.H. Weisberg. 2006. Multivariate reconstruction of missing data in SST, chlorophyll and wind satellite fields. In preparation.

Barth, A., A. Alvera-Azcárate, R.H. Weisberg, and R. He. Hindcast Experiment Nesting a Baroclinic West Florida Shelf Model in a 1/12° North Atlantic HYCOM Model. Submitted to Journal of Atmospheric and Oceanic Technology, 2005.

He, R., Y. Liu and R. H. Weisberg. 2004. Coastal ocean wind fields gauged against the performance of an ocean circulation model. Geophysical Research Letters, 31, L14303 (doi:10.1029/2003GL019261)

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