

# “Joint Analyses of Drifter and Float Data in Atlantic Hurricanes”

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Award Number: N00014-02-1-0401

## LONG TERM GOAL

The long-term goals of this research are to deploy and use autonomous ocean borne instruments to document the ocean response and the structure and strength of air-sea interaction to hurricane strength winds. These data are used for both real-time monitoring of hurricanes as well as for the improvement of the performance of ocean and atmosphere coupled models.

## OBJECTIVES

In late August of 2003 and 2004 during the CBLAST Hurricane Study, a total of 50 drifters were successfully air-deployed in front of class 4 hurricanes *Fabian* and *Frances*. In July 2004, NAVAIR had placed wind-drifters in the 'hurricane alley' north of the Antilles, which significantly enhanced the data set from a class 1 hurricane, *Jeanne* during the third week of September 2004. The objectives of this research are to perform: a) analysis of the ocean near surface circulation forced by these hurricanes and b) joint analysis of drifter and profiling float data sets in the response of the water column at depth. A principal anticipated result of these analyses would be an estimation of the stress on the ocean surface as a function of hurricane strength wind speed. We wish to answer the question: What is the wind dependence of the drag coefficient for winds over 30m/sec?

## APPROACH

The approach for analysis of the ocean circulation response to a hurricane is to use both the GPS and Argos fixes to compute the drifter observed currents at drifter locations. These calculations were to be used to determine the momentum content change of the upper layers that occurred during the storm and relate these to the momentum flux into the ocean during the passage of a hurricane. The SST and subsurface temperature changes were to be related to the entrainment and surface heat fluxes. The entrainment fluxes are expected to be a function of initial stratification and the mechanical energy fluxes from the hurricane. MIT OGCM was initialized with realistic initial stratification before *Frances* and the SST and subsurface response from the model was to be used for selecting the ‘best’ model for stress. The key cooperating personnel are Yan Morzel and Ralph Milliff at CORA and Sarah Zedler at SIO.

## Report Documentation Page

*Form Approved*  
*OMB No. 0704-0188*

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1. REPORT DATE <b>30 SEP 2006</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2006 to 00-00-2006</b>	
4. TITLE AND SUBTITLE <b>Joint Analyses of Drifter and Float Data in Atlantic Hurricanes</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>University of California, San Diego, Scripps Institution of Oceanography, 9500 Gilman Drive, La Jolla, CA, 92093</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

## WORK COMPLETED

The following tasks have been completed:

- 1) The velocity along each of the drifter tracks has been computed and these data are now available for analysis.
- 2) The wind data from *Frances* has been corrected for biases relative to QSCAT observations.
- 3) The SST data processing is complete. There are a total of 55 sensors from which SST was observed before and after the passage of *Frances*.
- 4) MIT OGCM was used to generate the response of *Frances* in a realistic ocean environment. These model data will be used in the second year of analysis to select drag coefficients for hurricane strength winds.

## RESULTS

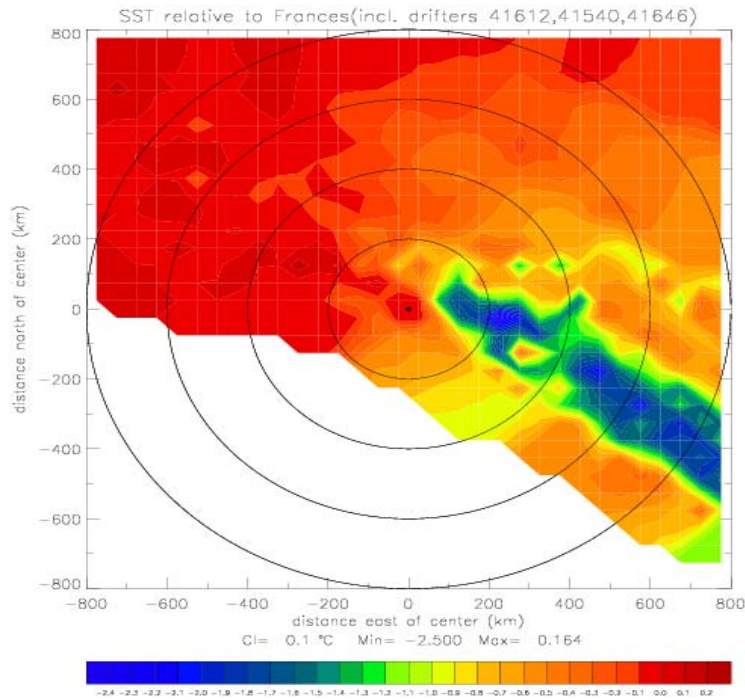
Besides the completion of the data processing (<http://www.cora.nwra.com/~morzel/drifters.frances.html>) the analysis has produced the following dynamical results:

1. A quantitative two-dimensional map of the SST change that was caused by the passage of *Frances* (Figure 1). This is based on 20 drifter data that were on GTS and is being upgraded with the additional 35 drifter and float sensor data. These will be compared to numerical model results.
2. Polar and radial speed distributions as a function of radius were computed from drifter wind and pressure observations in *Frances* (Figure 2) using the radial momentum equation:

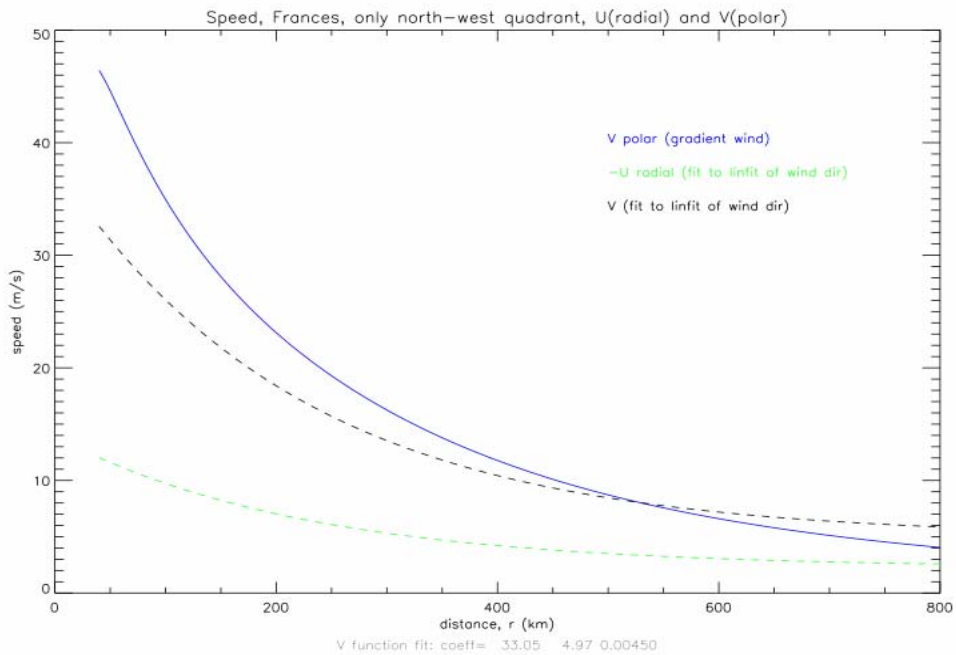
$$(V^2 / r) + fV \cong dP / \rho dr$$

3. The turbulence stress scale height,  $h$  (Figure 3), was computed from the polar momentum equation:

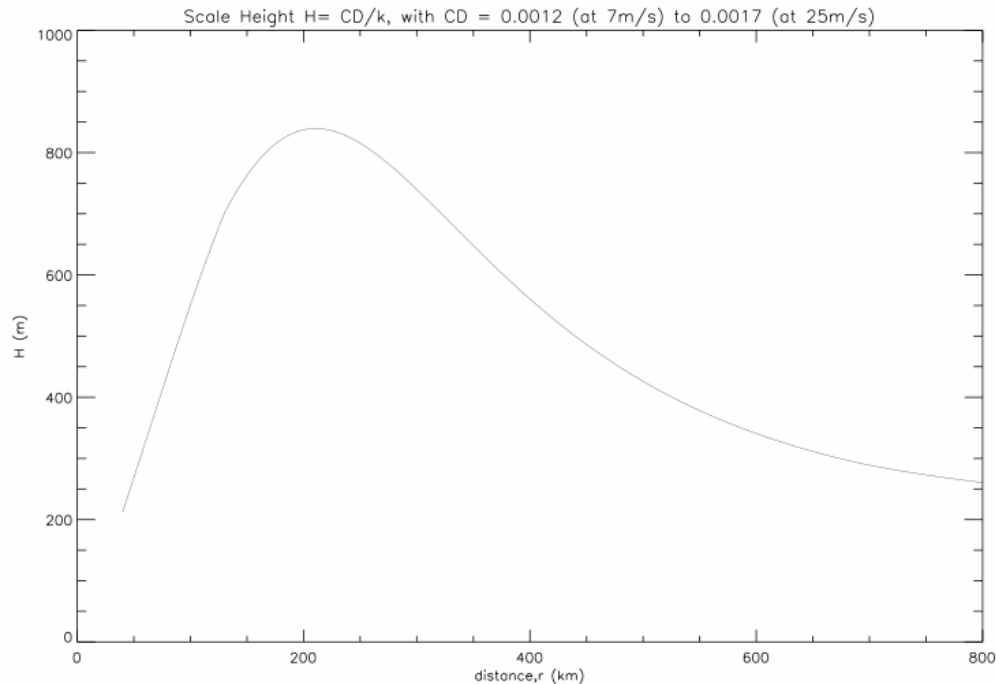
$$U[(dV / dr) + (V / r) + f] \cong -C_D (V^2 + U^2)^{1/2} V / h(\text{scaleheight})$$



**Figure 1. Drifter observed change of SST during passage of Frances graphed in the coordinate moving coordinate system relative the its center.**



**Figure 2. Polar (black) and radial (green) wind components derived from drifter speed and direction observations. The blue line is the polar cyclostrophic polar wind speed derived from radial momentum equation.**



**Figure 3. The turbulent stress scale height,  $h$ , as a function of radius relative to Frances center in its northwest quadrant derived from the polar momentum balance using CBLAST drag coefficient.**

## IMPACT/APPLICATIONS

The CBLAST drifting buoys with subsurface data chains (ADOS) and wind sensors (MINIMET) did not function correctly in 2004 during the passage of *Frances*. In September 2005 the 8 ADOS and 12 MINIMET drifters, based on CBLAST designs but with corrected software, were deployed into Hurricane *Rita* in the Gulf of Mexico. All 20 drifters produced surface and subsurface data through the passage of *Rita*. This success had a large impact on the Hurricane research community in the US in that for 2006, NOAA acquired 30 ADOS drifters (and 12 MINIMETS) that are awaiting deployment at Keesler AFB. No hurricane has appeared in 2006 season as of October 4 in which to utilize this equipment. For 2007 NOAA has acquired 20 additional Hurricane drifters. In 2007, a potential deployment of 62 drifters will be possible that should form a significant new data set for Hurricane monitoring and model validation.

## TRANSITIONS

CBLAST has passed on the methodology of deploying drifters from C-130-J aircraft from University researchers directly to the AF operational Hurricane Hunter 53rd Squadron. Complete operational data processing is now in place at Service Argos. Both NAVY and NOAA make use of the operational data sets from these (and other) drifters. SIO continues to assist the training of the 53<sup>rd</sup> Squadron crews in the deployment of drifter containers from the C-130-J aircraft by providing 20 training packages in 2006. The transition of the method of construction of the CBLAST drifters from SIO to private industry was completed.

## **RELATED PROJECTS**

The NOAA funded “Global Drifter Program” and the National Hurricane Center continue to work closely with this ONR/CBLAST project in both analyses and methodologies of observations. Sarah Zedler, with support from NSF, is using our CBLAST data to compare with MIT OGCM model solutions.

## **PUBLICATIONS**

Black, P.G., E. A. D’Asaro, W.M. Drennan, J.R. French, P. P. Niiler, T.G. Sanford, E.J. Terrill, E.J. Walsh and J.A Zhang: “Air-Sea exchange in hurricanes: Synthesis of observations from the Coupled Boundary Layer Air-Sea Transfer Experiment (CBLAST)” (Accepted for publication in the *Bulletin of AMS*, June, 2006).