1A.1 AN OVERVIEW OF CBLAST FLIGHTS INTO HURRICANES FABIAN AND ISABEL (2003)

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1. INTRODUCTION[1]

A Coupled Boundary Layer Air-Sea Transfer (CBLAST) and Ocean Winds experiment was conducted in Hurricanes Fabian and Isabel during the 2003 hurricane season. The purpose of CBLAST is to improve the understanding and parameterization of high-wind, air-sea fluxes and subsequently improve hurricane intensity forecasting. The purpose of the Ocean Winds experiment was to refine algorithms for retrieving surface winds from satellite scatterometer measurements in high-wind and rain environments. The experiment was sponsored by the Office of Naval Research, the NOAA Hurricane Research Division, NOAA Office of Atmospheric Research, United States Weather Research Program and the Ocean Winds program of the NOAA/NESDIS Office of Research and Applications. The experiment utilized two NOAA/Aircraft Operations Center WP-3D Orion aircraft flying in tandem in Fabian on Sept 2,3 and 4 and in Isabel on Sept 12,13 and 14. In each flight, two modules were flown: 1) a stair-step flight pattern was flown for the purpose of obtaining in-situ measurements of air-sea fluxes in gale force winds. and 2) a multiple GPS dropsonde deployment was performed from the two WP-3D in the hurricane eyewall to obtain estimates via budget calculations of air-sea fluxes and exchange coefficients in extreme hurricane force winds. This latter goal was achieved with the deployment of 8-12 GPS dropsondes in each eyewall penetration on the 6 flight days into these CAT 4 and 5 storms. A total of 346 GPS dropsondes were deployed during CBLAST/Ocean Winds, 308 in the hurricanes' eyewall, with 80% of the sondes reaching levels below 50 m, an unqualified success for sondes deployed in high winds.

A sample of the eyewall boundary layer structure from a single penetration in CAT 5 conditions in Isabel is described in Black, et al (2004). The twelve successful flight level mean profiles obtained by the low-level stepping WP-3D aircraft (43RF) and concurrent GPS dropsonde profiles obtained during over flights by the higher level WP-3D (42RF) are reported by Uhlhorn and Black (2004).

In addition to the in-storm WP-3D flights, a pre-Fabian deployment of 16 drifting buoys and 6 subsurface oceanographic floats was conducted into the path of Fabian on Sept 3, during the second WP-3D in-storm flight, by an Air Force Reserve WC-130J aircraft, as shown in Fig. 1. It's purpose was to obtain surface current, ocean mixed layer and surface wave observations as well as surface meteorological observations concurrent with a subsequent research flights on Sept 4. Fabian passed directly over the center of the array, despite a last minute jog to the east, thanks to direct communication with the aircraft. Of the 16 buoys deployed at 8 locations (Fig. 2), 7 survived the storm, one at each location except the furthest west point. Two of six floats survived and returned excellent data. As it turned out, the surviving buoys and floats also obtained data in the periphery of Isabel as it passed just to the south of the array during 12-14 Sept. Preliminary results are discussed in Terrill, et al., 2004.

Figure 1. Box containing two Minimet drifting buoys is deployed from an AFRC 53rd Weather Squadron WC-130J.

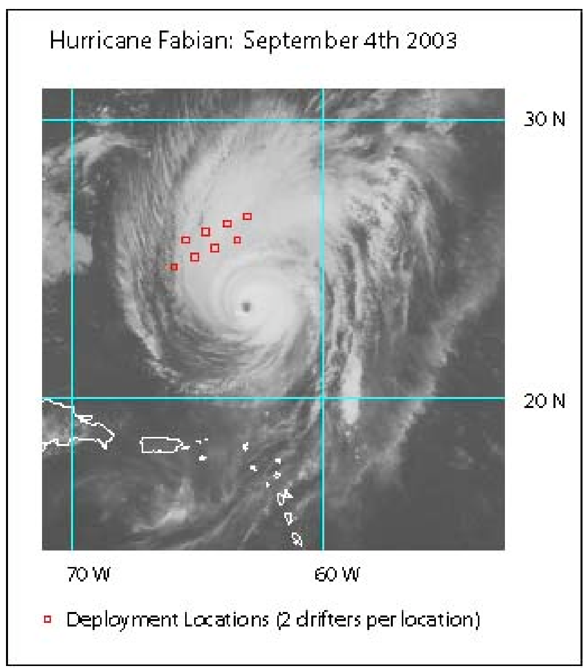

Figure 2. Deployment location of drifting buoy and float array ahead of Fabian on Sept 3, 2003.

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These flights and buoy/float deployments generated an unprecedented air-sea interaction data set for diagnosing surface fluxes at gale and hurricane force wind speeds and as input and ground truth for coupled air-sea numerical model predictions of hurricane intensity change.

2. TURBULENCE MEASUREMENTS

Unprecedented heat and momentum turbulent flux spectra were obtained from the NOAA/FRD BAT probe during 8 of the stepped descents flown in hurricane Isabel (heat flux shown in Fig. 3), after water injest problems encountered in Fabian were solved (French and Black, 2004).

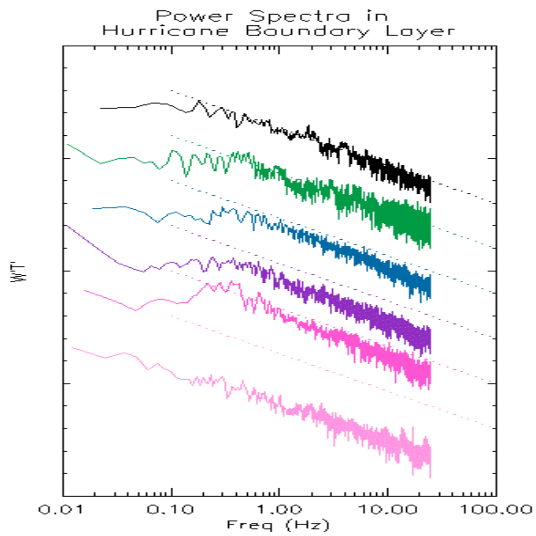

Figure 3. Heat flux (w'T') spectra for stepped descent flight legs from 2,500 ft (bottom) to 200 ft (top) in Isabel.

In addition, excellent moisture flux data were obtained from the new LICOR fast-response humidiometer probe, while a companion IRGA sensor developed problems presently under study. Sea spray spectra were obtained from the new CIP probe for at least two stepped descents which will help calibrate surface spray spectra computed in the laboratory (Fairall, et al., 2004). This may significantly alter existing estimates of total moisture flux.

3. BULK SENSOR MEASUREMENTS

Excellent observation of mean variables also were obtained in Fabian and Isabel. Excellent 2-D wave spectra were obtained with the SRA in Fabian which showed a pattern of swell consistent with CAMEX 3 and 4 observations in Hurricanes Humberto and Bonnie (Walsh, et al., 2004). This pattern reveals steep, developing waves in the rear quadrant, highest swell waves moving slightly right of the wind in the right-front wuadrant, and swell moving normal to the wind in the left semicircle, creating at least 3 distinctly different roughness regimes, which will presumably lead to different surface fluxes at the similar wind speeds. No wave data were obtained in Isabel due to a failure of the instrument.

Complementary photo observations of the sea surface at 60 Hz frequency from the Scripps MASS camera system is allowing measurements of surface momentum dissipation due to wave breaking as the velocity of the leading edge of individual breakers is computed (Kleiss, et al., 2004).

Other wave images (Fig. 4) show evidence for secondary circulations in both the ocean mixed layer and atmospheric boundary layer, which will indoubtedly modulate the fluxes.: Langmuir cells producing foam streaks with 50-100 m spacing, and roll vortex cells producing light and dark bands with 1-2 km spacing in capillary waves and spray streaks.

Figure 4. Foam streaks at 35 m/s in Fabian.

For the first time in a hurricane, continuous boundary layer wind profiles were obtained with the UMASS IWRAP system in both storms to complement the tail Doppler observations above the boundary layer (Esteban-Fernandez, et al., 2004), and the extensive dropsonde observations.

4. REFERENCES

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