Flux and Wave Measurements during the Adverse Weather Experiment

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LONG-TERM GOALS

The long-term goal is to investigate the impact of an adverse weather front on mixing, air-sea interaction, and sediment transport in the shallow water column over the continental shelf.

OBJECTIVES

The objectives of the Adverse Weather Experiment (AWE) are: i) to parameterize the vertical fluxes of heat and momentum and the turbulent kinetic energy (TKE) dissipation rate in the upper oceanic mixed layer, and ii) to parameterize the buoyancy and momentum fluxes in the marine atmospheric boundary layer (MABL) during the passage of an adverse weather front over the warm continental shelf, off the east coast of Florida. A related objective is to employ the new parameterizations to improve present, laboratory based, sub-grid closure schemes used in turbulence models of the oceanic boundary layer. This project is part of a multi-institution effort. The objectives of this component of the project are:

A) To measure fluxes (momentum and heat) in the MABL, along with supporting wave (directional spectra) and meteorological parameters at a site adjacent to the AWE-AUV survey area;

B) To use the above measurements, along with those of OSCR and an ADCP to parameterize measured TKE dissipation rates by wind stress, current shear, buoyancy and wave parameters.

APPROACH

The key variables thought to influence TKE dissipation rates in the upper ocean mixed layer are the wind stress, buoyancy flux (Anis and Moum, 1995), horizontal shear, and surface wave field (Terray et al, 1996). Hence measurement of these parameters is a very important part of an effort to parameterize TKE dissipation rates. During the Adverse Weather Experiment measurements were carried out as follows:

- Mobile autonomous underwater vehicles (AUVs) were utilized to make measurements of current profiles, conductivity, temperature and small scale turbulence, including TKE dissipation rates (Dhanak and Holappa, FAU).

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14. ABSTRACT
The long-term goal is to investigate the impact of an adverse weather front on mixing, air-sea interaction, and sediment transport in the shallow water column over the continental shelf.

15. SUBJECT TERMS

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- An air-sea interaction spar (ASIS) buoy was deployed adjacent to the AUV survey area to measure eddy-correlation momentum and buoyancy fluxes in the MABL, along with surface wave spectra and supporting mean meteorological and sea surface parameters (Drennan, RSMAS).

- An ocean surface current radar (OSCR) and a moored Acoustic Doppler Current Profiler (ADCP) were deployed continuously during AWE to measure the horizontal and vertical surface current structures, respectively, over the period of the experiment (Shay, RSMAS).

Using the data collected over the continental shelf during several adverse weather events, the idea is to parameterize the TKE dissipation rate in terms of the key forcing parameters.

WORK COMPLETED

On 7 April 2000, an ASIS buoy was moored at 26º 3.75' N 80º 5.42' W, at 20 m depth, off Dania, FL, at the northern end of the AUV survey area. The buoy remained on site for 5 weeks, and was recovered on 11 May 2000. During the deployment, the buoy was instrumented for flux and wave measurements as follows: 3D wind vector (Solent 1012R3A sonic anemometer), air temperature (2 fast response thermistors, and Rotronic), humidity (Rotronic), surface elevation (8-gauge capacitance wave wire array), surface currents+SST+salinity (SensorTek UCM-60DL) and buoy motion (3 accelerometers, 3 rate gyros, 1 compass). During AWE the data return rate for most sensors was near 100% throughout the deployment period. The data have been processed to yield shear and buoyancy forcing, along with wave, surface current and mean meteorological information (Figure 1). Work is ongoing, in collaboration with other AWE participants, to address how these forcing parameters relate to larger scale features and oceanic turbulence.

RESULTS

A summary of the ASIS data is shown in Figures 1 and 2. In Fig. 1, the wind speed, air temperature and sea surface temperature are shown, along with momentum and buoyancy forcing parameters (friction velocity, u_*, and Obukhov length, L) derived from the measured turbulent fluxes. The Obukhov length, related to the ratio of buoyant to shear forcing, has been calculated following two approaches: one using a bulk buoyancy flux derived from measured mean temperatures and humidity, and the other using a buoyancy flux calculated directly from the sonic temperature flux (obtained via eddy correlation), with corrections following Dupuis et al. (1997). Both are plotted in Figure 1, and the agreement is very good, although there is evidently a systematic underestimate of bulk L compared with sonic-derived L in the unstable regime. This underestimate of roughly 20% is consistent with a reduction of the measured bulk SST by 0.7˚C. During AWE, the bulk SST was measured at a depth of roughly 5m, and hence may not be representative of the near-surface layer during much of the day (e.g. Price et al. 1986; Fairall et al 1996).

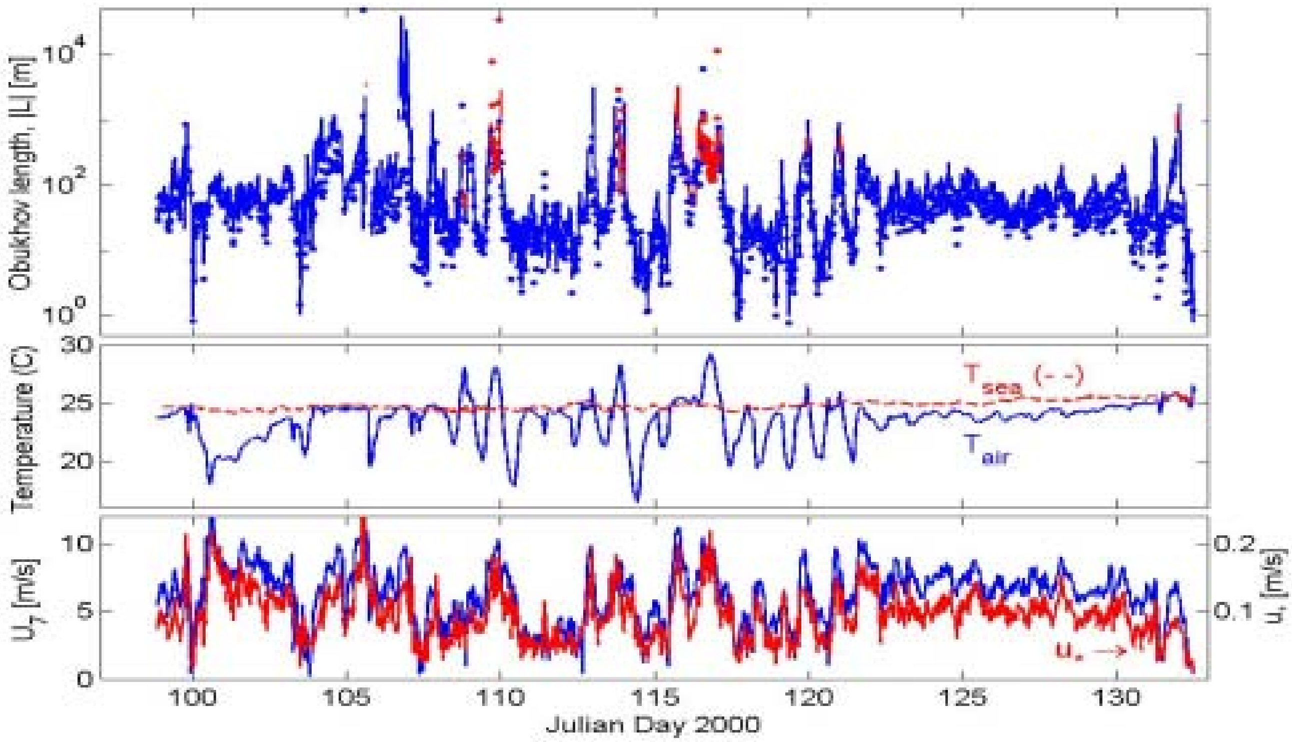

Figure 1: Conditions during AWE experiment. The panels show:
(top) Obukhov length |L|: L<0 –Blue; L>0 –Red; L_{sonic} (solid); L_{bulk} (•);
(middle) Air temperature –Blue, and sea surface temperature -Red;
(bottom) Wind speed at 7m - Blue, and friction velocity - Red
[Primary features of figure are described in main text]

Of special interest for the scientific objectives are the two periods JD 99-100 and 109-110 when cold fronts passed through the domain – note the wind shifts and changes in air temperature in Fig. 1. Note also the rapid increase in wave energy during the first period as the wind shifts onshore (Fig. 2). These periods coincide with AUV missions (Dhanak, FAU) during which TKE dissipation rates were measured, and hence are of primary interest in achieving the experimental goals. OSCR surface current data (Shay, RSMAS) are available throughout the ASIS deployment period. Another event of interest is JD 114, when cool continental air was advected over the warmer coastal waters, resulting in high buoyancy forcing.

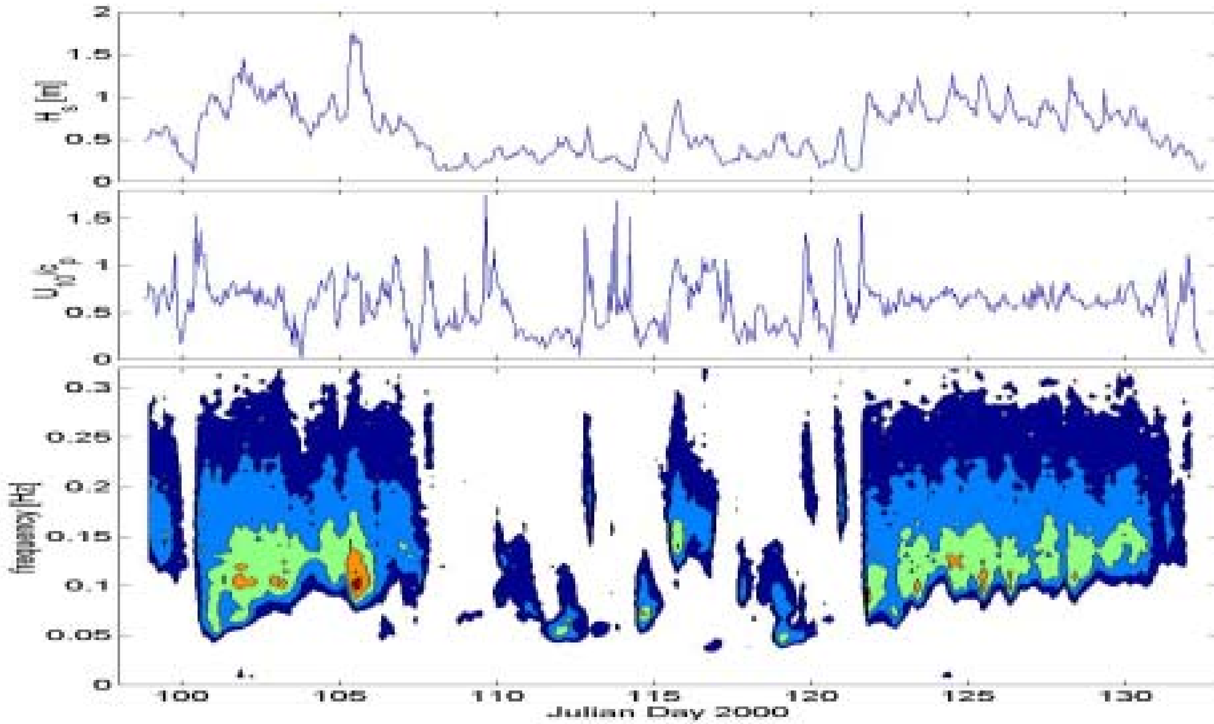

Figure 2: Wave conditions during AWE experiment. The panels show: top) Significant wave height; middle) Inverse wave age; bottom) Evolution of 1D surface elevation spectrum. The contours showing spectral energy are spaced logarithmically.
[Primary features of figure are described in main text]

IMPACT/APPLICATIONS

These are the first simultaneous measurements of TKE dissipation rates along with all the principal forcing terms (wind shear, buoyancy flux, surface waves and horizontal shear). These measurements, taken in a variety of meteorological and wave conditions, with varying surface current shear, will allow us to parameterize the TKE dissipation rate in terms of the important physical forcing variables. This in turn will allow for improvements to the sub-grid closure schemes used in turbulence models of the upper ocean mixed layer.

TRANSITIONS

The ASIS data are presently being used by other participants in the AWE experiment. Transitions to the wider community are expected upon completion of the joint analysis. Several manuscripts are in preparation.

RELATED PROJECTS

The Adverse Weather Experiment is a multi-institution effort involving three ONR-funded projects. The other two projects are Dhanak and Holappa (FAU) and Shay (RSMAS). Lueck (U Victoria) is also a participant in AWE.

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