

Surface Fluxes and Wind-Wave Interactions in Weak Wind Conditions

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LONG-TERM GOALS

We will isolate a number of influences on air-sea transfer of momentum, heat, and moisture for weak wind conditions. We will focus on the important impact of swell amplitude and propagation direction and the explicit influence of large atmospheric eddies on the stability functions for the transfer coefficients for surface fluxes. Improved understanding of the various influences on sea surface fluxes for weak wind speeds will be used to construct a new bulk aerodynamic formula.

OBJECTIVES

Our objectives for the last fiscal year were to participate in the CBLAST-Low pilot experiment conducted in July-August, 2001 at Martha's Vineyard, conduct preliminary data analysis of the LongEZ aircraft data, identify characteristics of spatial and temporal variations of atmospheric and oceanic states at Martha's Vineyard for the upcoming main field campaign next year.

APPROACH

To participate in the CBLAST-Low pilot experiment by analyzing the LongEZ aircraft data during the experiment to identify instrument problems and quality-control the aircraft data. To conduct preliminary data analysis, especially surface waves, to understand spatial variations of air-sea interactions under weak wind conditions as soon as we receive the calibrated data from the NOAA LongEZ aircraft group.

WORK COMPLETED

We participated in the CBLAST-Low field experimental planning meeting at WHOI in May 2001. We helped develop flight plans for the pilot experiment. Sean Burns at NCAR participated in the CBLAST-Low pilot experiment by using data obtained from the LongEZ aircraft to identify instrument problems and spatial and temporal variability in the region of Martha's Vineyard. A CBLAST-Low web page (see the web address above) was created at NCAR to document our research and the information involving the LongEZ aircraft missions. Flight summary plots are posted on our web site, which include flight tracks, flight altitudes, flight date and time, and weather information for each flight during the pilot experiment.

RESULTS

We found that the on-site data analysis was crucial to identify instrument problems as well as to understand spatial and temporal variations of air-sea interactions for on-site modifications of designed flight patterns. Figure 1 demonstrates one of our data quality-control plots for checking consistency of spatial patterns of measured surface skin temperature (SST), air-temperature, and wind speed from a flight mission over the ASIMET buoy. The plot shows that the spatial pattern of SST and air temperature is consistent with each other, i.e. warmer air was over warmer water. In addition, both SST and air-temperature measurements from each flight track were steady with no obvious instrument drifts between flight tracks. In contrast, the wind speed measurement is flight-direction-dependent, and post-correction of the wind speed is needed. The wind speed problem is known to be associated with all the aircraft measurements. The post-correction can be easily achieved.

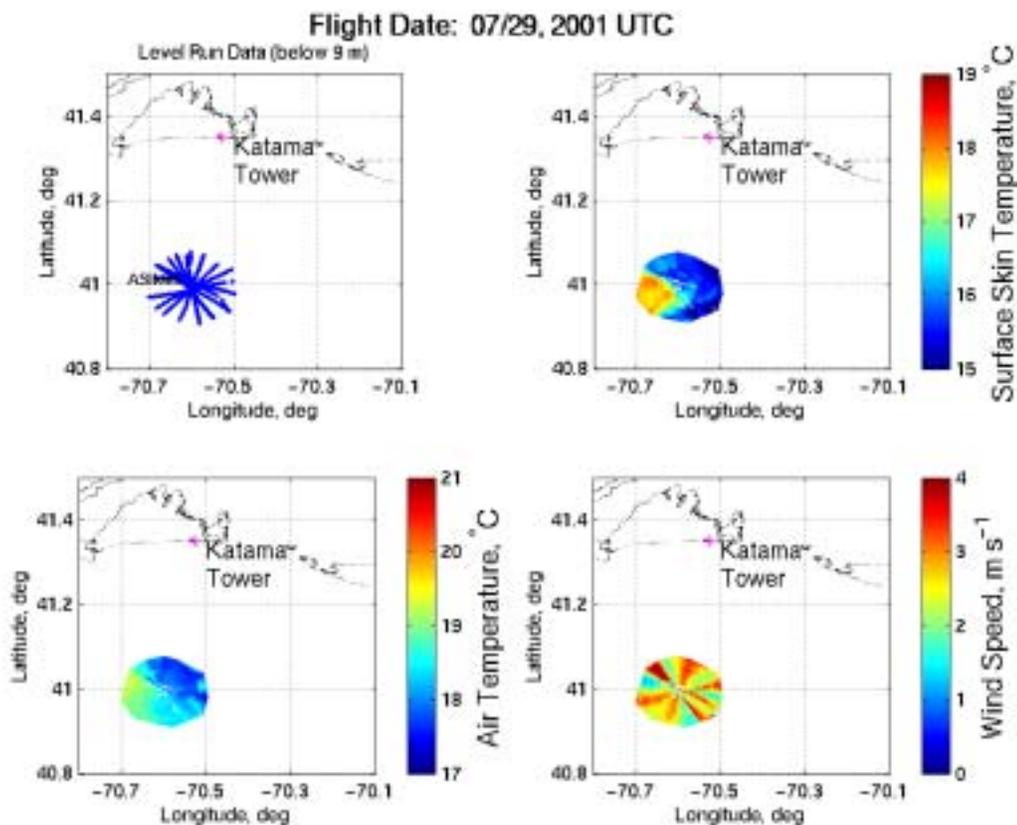


Figure 1: Low-level flight tracks (upper left), surface skin temperature (upper right), air temperature (lower left), and wind speed (lower right) for the flight over the ASIMET buoy south of Martha's Vineyard, MA conducted on 29 July 2001.

During the pilot experiment, the LongEZ aircraft flew over the ASIMET buoy 12 times, from which proper buoy-aircraft intercomparison can be made. Preliminary data analysis for the intercomparison was conducted during the pilot experiment. Our results indicate that downward solar radiations and

wind directions from the aircraft and buoy compare well. Specific humidity compares well after mix-up of CO₂/H₂O data outputs on the LongEZ aircraft was fixed. On average, the air temperature and wind speed tend to be higher from the aircraft than from the buoy probably due to vertical variations of the wind and air temperature since the aircraft was above the buoy measurement levels. In addition, we found that the pressure measured by the aircraft tends to be higher than that measured by the buoy. We will investigate this discrepancy once the calibrated aircraft and buoy data are available. Preliminary data analysis also indicates that the data drop-out from laser altimeter measurements as described in Sun et al. (2001) still exists. The range of the laser dropout rate is between 1 and 20%. The dropout rate increases with decreasing wind speed.

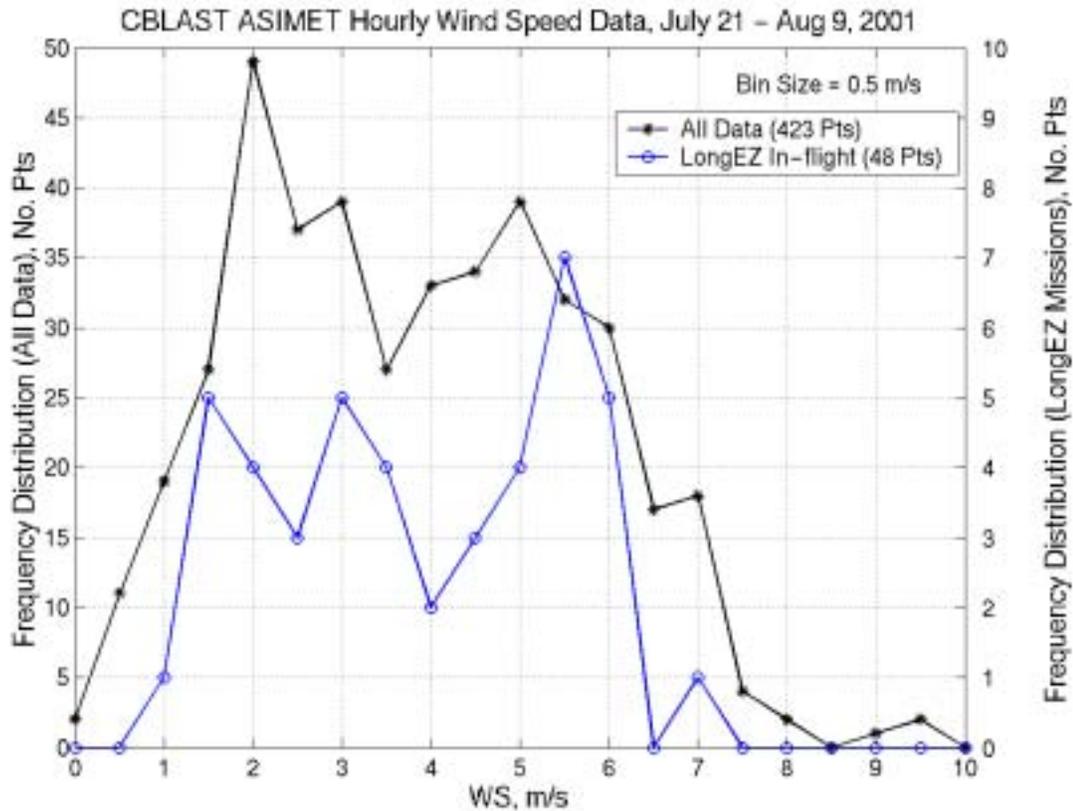


Figure 2: Frequency distributions of wind speed measured by the ASIMET buoy (black, left axis) and frequency distributions of the ASIMET wind speed when the LongEZ was airborne (blue, right axis) between July 21- August 9, 2001. The number of points in the vertical axes represents the number of hours. Each point is bin-averaged hourly wind speed.

Due to the spatial coverage of the LongEZ aircraft observations, we also found that the surface skin temperature was not uniform even within the experiment region. This spatial variation of the water temperature can play an important role in air-sea interactions under weak wind conditions.

The wind speed during the pilot experiment was about 2 m/s for almost 50 hours, and about 5 m/s for almost 40 hours out of 423 hours, including day and night data (Figure 2). The LongEZ flights

experienced wind speed less than 4 m/s for 60% of the total flight time, considering the LongEZ only flew in the daytime, and some weather conditions limited the LongEZ flight missions.

IMPACT/APPLICATIONS

It is crucial to conduct on-site data analysis to detect instrument problems and modify flight patterns to capture important features to accomplish our long-term goals.

TRANSITIONS

Due to our on-site efforts to quality-control the aircraft data, some instrument problems were found and corrected quickly. In addition, our preliminary data analysis is useful for post-data calibration to ensure high-quality data. More aircraft data analysis will be conducted once the LongEZ aircraft data processing is completed by the NOAA LongEZ group.

RELATED PROJECTS

We are also sponsored by ONR to investigate air-sea interactions in the coastal zone by analyzing data collected from SHOWEX. Our experience on data-quality controls and choosing flight patterns to satisfy flux-sampling criteria helped the success of the CBLAST-Low pilot experiment. The program for processing surface wave spectra, which we developed during SHOWEX, will be used to analyze air-sea interactions under weak wind conditions once the LongEZ aircraft data are available.

REFERENCES

Sun, J., D. Vandemark, L. Mahrt, D. Vickers, T. Crawford, and C. Vogel, 2001: Momentum transfer over the coastal zone. *Journal of Geophysical Research*, **106**, 12,437-12,448.

PUBLICATIONS

PATENTS