Surface Fluxes under Weak Wind Conditions

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LONG-TERM GOAL

The traditional bulk flux formula with Monin-Obukhov similarity theory, used in almost all numerical models, often behaves poorly in weak wind conditions. We will develop a new bulk formula for sea-surface fluxes, which is substantially improved for weak wind conditions.

OBJECTIVES

We propose to examine each of a number of physical mechanisms thought to be important for weak wind conditions by collecting aircraft and tower data in both open-ocean and fetch-limited conditions. This investigation relies on improved eddy correlation data and fast response observations of the wave field. Our contention is that existing analyses for weak wind situations are often strongly influenced by observational errors and analyses problems, which will be given special emphasis in this study.

APPROACH

We will be implementing eddy correlation and wind and temperature profile measurements on the CBLAST WHOI offshore tower near Martha's Vineyard. We are also designing LongEZ aircraft flights to study spatial variation of surface fluxes. With proper flight design, the combination of aircraft, tower and buoy flux data provide for more robust examination of the stress and surface flux fields. The aircraft data includes a faster thermistor, improved sea surface temperature and improved laser and scatterometer interrogation of the surface wave field. The processed data will be analyzed toward the goal of improving physical understanding and parameterization of sea surface fluxes and will be provided to LES and larger-scale modeling groups.

WORK COMPLETED

We have continued with instrumentation testing including intercomparison between the Handar 2-D sonic anemometers and CSAT 3-D sonic anemometers. We have continued to make intercomparison tests with the 3-D hotfilm anemometer. Using existing LongEZ data, we have evaluated flux error terms due to platform motion in the presence of strong vertical gradients. We have been concerned that this error could be potentially large in stratified cases where vertical gradients could be large. We are presently providing justification to the NOAA SERA program via Jerry Crescenti for deployment

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14. ABSTRACT
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of the Velocity in CBLAST weakwind 03. Our observational strategy is currently in a state of change neccitated by the tragic loss of Tim Crawford.

We have begun analysis of the pilot experiment data from 2001 by concentrating on eight flights. Much of the initial analysis has concentrated on testing the various systems on the LongEZ

RESULTS

Our evaluation of the behavior of the LongEZ data indicated the following problems and suggested solutions.

1. In previous experiments, the surface radiation temperature measured by the LongEZ has been problematic but improvements have been made. We compared the LongEZ SST measurements with buoy measured SST and found that the LongEZ values are too low by about 1.5C. Similar results are indicated by comparison of the LongEZ measured heat flux with the LongEZ measured air-sea temperature difference and assuming that the air temperature is correct. We have therefore recalibrated the LongEZ SST data.

2. The moisture measurements indicated many situations with the relative humidity well above 100%. We have re-calibrated the moisture to prevent such supersaturation conditions. The resulting vertical moisture gradient agrees much better with the observed moisture flux.

3. Comparison with the laser measurements indicates that the GPS measured altitude is about 3.7 m too high.

4. Comparison with buoy winds indicates that the LongEZ winds may be too strong, as previously concluded in earlier studies. The comparison of turbulence quantities between the buoy and LongEZ shows a mixture of results.

Overall, the LongEZ data appears to be of high quality, particularly after making the adjustments noted above. Eight flights selected for scientific analysis included stable cases, neutral cases and weakly unstable with heat fluxes on the order of 10 W/m^2 or less. The preliminary analysis indicates that the usual Charnock relationship seriously over predicts the surface stress and that this over prediction is not related to semi-collapse of the turbulence in offshore advection of warm air, as in some previous studies. Our hypothesis is that this over prediction is related to wind following swell. For the pilot experiment, swell phase direction was not available from independent platforms, and analysis of the laser data from the LongEZ is not yet completed.

Based on our intercomparison tests, we are confident that the Handar anemometers can accurately measure the vertical structure of the mean velocity as well as vertical and horizontal structure (catwalk) structure of the eddy wind field. Our confidence in the ability of the hotfilm anemometer systems to measure the momentum flux in very stable conditions (where sonic anemometers underestimate the flux due to pathlength averaging) has increased but we still need to continue our investigation of the behavior of the triple hotfilm system.

Our plans for the ground based experiment for 2003 is close to the original plan for 2002 and is outlined below.

In cooperation with Jim Edson, we will deploy sonic anemometers for momentum and virtual heat flux on the offshore tower. To compute vertical temperature gradients, thermocouples will be deployed at 12 levels. These observations will be carried out primarily by Jielun Sun and Sean Burns of the National Center for Atmospheric Research. In addition, redundant thermocouples will be deployed with the Campbell sonic anemometers for direct measurement of the sensible heat flux. The redundant thermocouples allow for some breakage of the fine wires, necessary for the sparser schedule of offshore instrument maintenance. Based on previous experience, we do not anticipate a high breakage rate over the sea in weak and moderate wind speeds. A LI-COR gas analyzer will be deployed with one of the sonic anemometers. Along with the fast response thermocouple, this will allow two independent measurements of the heat and moisture fluxes. A three-dimensional hot film anemometer will be experimentally deployed close to the sea surface to better capture the turbulence in thin stratified boundary layers where the sonic anemometers suffer from flux loss due to pathlength averaging. Three or more two-dimensional Handar sonic anemometers will be placed within the lowest 10 m to measure vertical structure of the wind field in weak wind very thin boundary layers.

Our assessment of the errors due to fluctuations of platform height with buoys and aircraft are found to be generally small but not sufficiently predictable to construct criteria. Much of the platform displacement error is random and can be reduced by applying flux sampling criteria.

RELATED PROJECTS

In "Spatial Variations of the Wave, Stress and Wind Fields in the Shoaling Zone" (N000149710279), we are evaluating different simple formulations of the surface stress using a variety of coastal zone data sets.

PUBLICATIONS

Mahrt, L., D. Vickers, W. Drennan, H. Graber and T. Crawford, 2002: Fluxes measured from moving platforms. Submitted to *J. Atm. and Oc. Tech.*