Surface Fluxes and Wind-Wave Interactions in Weak Wind Conditions

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LONG-TERM GOALS

We will investigate a number of factors on air-sea transfer of momentum, heat, and moisture under weak wind conditions. We will focus on important impacts of swell amplitude and propagation direction and influences of large atmospheric eddies on turbulence transfer. Improved understanding of the various influences on surface fluxes under weak wind conditions will be used to modify the existing bulk aerodynamic formula.

OBJECTIVES

Our objectives for the last fiscal year are to analyze the LongEZ aircraft data collected from the 2001 CBLAST-Low pilot experiment by focusing on derivation of directional wave spectra from the three laser altimeters on board the LongEZ aircraft and participate in the planned main field campaign in 2002 by working with the LongEZ aircraft group. In the end, the main field campaign was moved to 2003 and the LongEZ aircraft was destroyed due to Tim Crawford's fatal accident. Nonetheless, we mainly focused on the wave analysis method for derivation of the directional wave spectra. Once the wave analysis is optimized for the aircraft laser altimeters, in-situ air-sea interactions will be investigated over various waves under different weather conditions.

APPROACH

After we discussed our field experiment strategy with the colleagues involved in CBLAST-Low before the 2002 pilot experiment, we decided to save our grant in 2002 and carry some over to 2003 for our participation in the main field campaign, which was delayed a year. We therefore focused on sensitivity tests of the directional wave spectra analysis. Using laser altimeters on board an aircraft to measure directional wave spectra is a new technology and was first tested during the Shoaling Wave Experiment (SHOWEX). The wave analysis method used to retrieve directional wave spectra was only applied to buoy wave measurements in the past. We have been working on retrieving directional wave spectra from the laser altimeter measurements since SHOWEX. Because of the new technology, the wave analysis method used for buoy data has to be modified and tested to investigate limitations of the wave measurements by laser altimeters and sensitivity of the retrieval method to aircraft maneuvers. In order to understand whether the wave analysis method is sensitive to various flight tracks and wave propagation properties, we constructed idealized monochromatic waves and waves consist of monochromatic waves. We simulated data collections by the LongEZ aircraft with realistic rolling motions and pitch maneuvers. The sensitivity test was performed to investigate whether the directional wave spectra analysis method works properly under various aircraft operation conditions.

WORK COMPLETED

The directional wave spectra analysis was tested for its sensitivity to a) the relative directional difference between the aircraft flight direction and wave propagation direction, b) variable aircraft travel speed relative to stationary waves, c) non-straight aircraft flight track. We are still working on the following tests: variable aircraft speed and variable aircraft roll and pitch maneuvers with a set of directional waves.

RESULTS

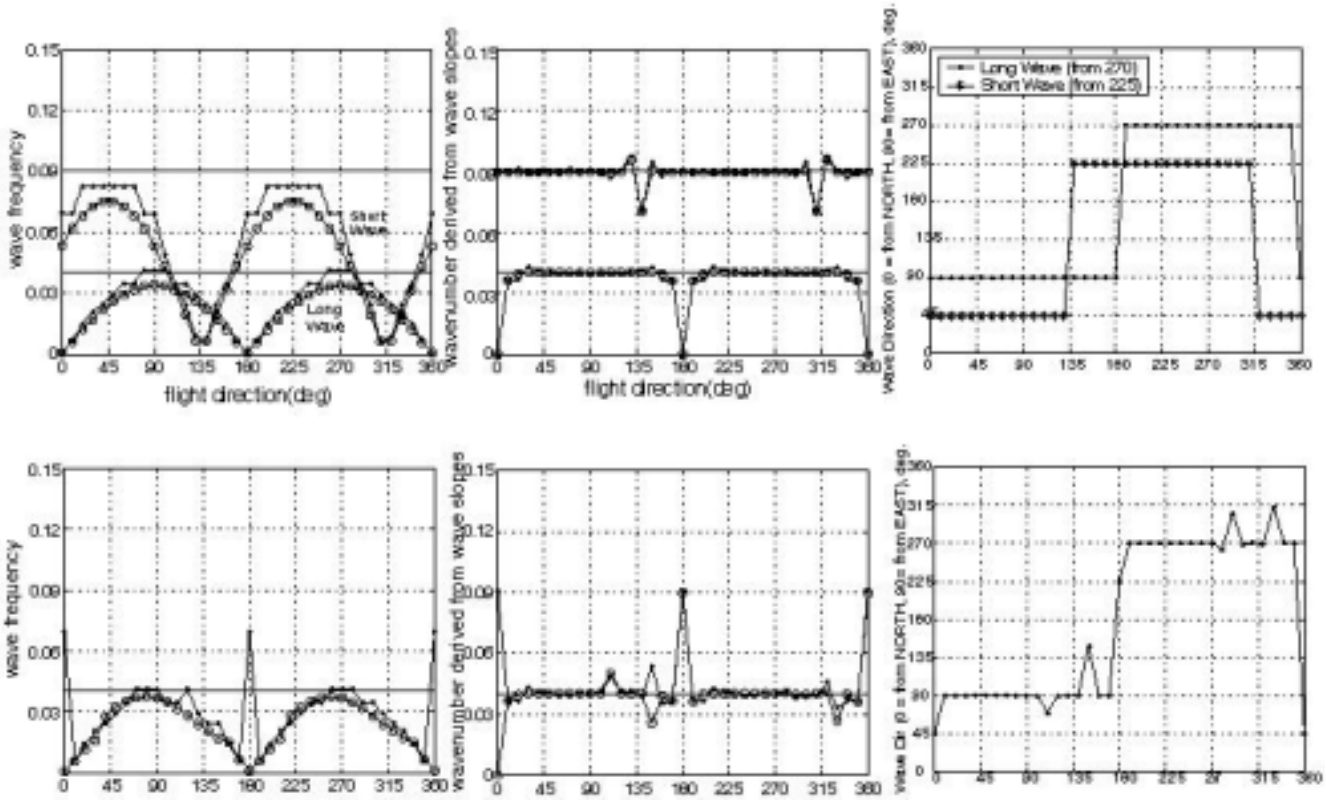

Figure 1. Directional wave spectra as functions of aircraft flight direction for two monochromatic waves (top) and a wave field consists of the two monochomatic waves (bottom). The wavenumber derived from wave slopes is independent of the flight direction (center), and the wave propagation direction (the right panels) can be retrieved.

We found that the wavelet analysis method is able to retrieve wavenumbers based on wave slopes simultaneously measured by the three laser altimeters. Therefore, the wavenumber is independent of where the wave slope is collected, whether the wave slope is collected along a straight line under the aircraft track or whether the aircraft flies at an angle from the wave propagation direction, or the aircraft flies at variable speed (Figure 1). However when the wave slope is too small to be measured by the three laser altimeters, or the random noise of the measured wave slope is large, the wave analysis method may fail to retrieve the wave propagation direction. This result implies that the size of the triangle where the three laser altimeters were located can affect retrievable wavelengths.

IMPACT/APPLICATIONS

Using laser altimeters to remotely measure directional wave spectra is a new technique. With the laser altimeters on board an aircraft, the atmospheric turbulence and directional wave spectra can be measured simultaneously along flight tracks. Success of this technique will allow us to investigate air-sea interactions over heterogeneous surfaces more efficiently and economically (Sun et al. 2001).

TRANSITIONS

RELATED PROJECTS

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

Sun, J., S. P. Burns, D. Vandemark, M.A. Donelan, L. Mahrt, T. L. Crawford, G.H. Crescenti, J.R. Frech, T. Herbers, 2002: Using laser altimeters to retrieve directional wave spectra. *To be submitted to J. Atmos. Oceanic Technol.*

PATENTS