Geophysical Research Abstracts
Vol. 13, EGU2011-1080, 2011
EGU General Assembly 2011

On Reynolds stresses over wind waves

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The interaction of wind with water waves forms a complex system in which the wind energy and momentum are transferred to waves resulting in their spatial and temporal evolution, which in turn affects the air flow over the water surface. To get better understanding of mechanisms governing this transfer, experiments in a facility that consists of a wind tunnel coupled with a wave tank, and is capable of generating winds with mean velocity exceeding 15 m/s were carried out. The test section is 5 m long, 0.4 m wide, and 0.5 m deep. Mean velocity profiles, as well as turbulent velocity fluctuations in horizontal (u) and vertical (w) directions were carried out using an X-hot film at about 50 vertical locations at a number of fetches and for a range of wind flow rates. Simultaneously with thermo-anemometry, instantaneous surface elevation and static pressure fluctuations were measured as well. For more details on the experimental facility see Liberzon and Shemer .[1,2] The vertical distributions of the normal $\overline{u'^2}$, $\overline{w'^2}$ and shear $-\overline{u'w'}$ Reynolds stresses were obtained for each fetch and wind speed. Extrapolation of $-\overline{u'w'}(z)$ to the water surface yields the shear stress at the interface and the friction velocity $u*$. Cross-spectral analysis of the measured instantaneous surface elevation, the static pressure fluctuation and the Reynolds stresses allowed to obtain the phase relations and the degree of coherence between various parameters as a function of the vertical location. The dependence of the measured phase lags on dominant wave parameters, in particular on the wave age $c/u*$ is presented. The validity of some of the existing models for water waves' excitation by wind is discussed in view of these results.

References:

[1]Liberzon D. and Shemer L., An inexpensive method for measurements of static pressure

fluctuations. *JTECH-A* 27, 4, 776-784, 2010.

[2]Liberzon, D. and Shemer, L. Experimental study of the initial stages of wind waves' spatial evolution. Submitted for publication to *J. Fluid Mech.*, 2010.