Geophysical Research Abstracts, Vol. 9, 08367, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-08367

Drag of the water surface at extremely short fetches: observations and modelling

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The specific properties of the turbulent wind stress and the related wind wave field observed in laboratory at different fetches and for various wind speeds without and with mechanical waves are described and analyzed using the Wind Over Wave Coupling (WOWC) model. Compared to typical ocean wave fields, laboratory wind wave fields observed at very short fetches are characterized by higher average significant wave steepness, but much smaller wave breaking rate. The related surface drag evolves with fetch and wind following the dominant wave steepness, increasing rapidly with fetch until it reaches a saturation value which is a function of wind speed. Taking into account the mentioned wave field peculiarities, the relative contribution to surface drag of the air flow separation stress due to wave breaking proves to be small, except at large fetch and high wind speeds, and the model predicts remarkably the measured wind stress values. This fact can also explain the striking decrease of the dimensionless surface roughness length with wind forcing observed in laboratory. The evolution of the wind stress in the presence of mechanical waves is more complex, this quantity being increased at low and high winds, and significantly diminished at moderate wind speeds and intermediate fetches compared to the surface stress for a purely wind wave field. Such a behavior is well reproduced by the model when the noticeable damping of the dominant wind wave growth observed in these conditions is taken into account. Finally, these laboratory experiments enable us to test the robustness of the WOWC model in a new parameter regime and, hence, to provide a new insight into the fundamental links between the sea state and the structure of the air surface turbulent boundary layer.