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Surface waves in air-sea interactions

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The world ocean surface, 70.8% of the area of Earth surface, is permanently covered by surface waves associated with local wind conditions, and this affects all air-sea interaction processes. The controlling influence of oceans, particularly in forming weather, is turbulence in the atmospheric and oceanic boundary layers and micro interaction of water and air flow in vicinity of their interface. The goal of this presentation is an overview on the surface waves impact in the air-sea interactions.

Wind waves relate directly to interactions at the air-water interface that affect turbulent regimes in the atmospheric surface layer and the ocean's upper layer and finally result in exchange of momentum, energy, heat, and moisture. The character of this transport is regulated by the turbulence of boundary layers around the air sea interface. Part of the wind energy and momentum is transferred directly from atmosphere to drift currents, while another part goes into growing surface waves. These waves determine the small-scale configuration of the air-sea interface and that affects the turbulent transfer.

An important feature of the atmospheric boundary layer over the ocean is the expenditure of momentum and energy of the wind on the generation of waves and currents. This constitutes a fundamental difference of the atmospheric surface layer from the ordinary boundary layers above smooth or rough solid surfaces. The sea surface roughness, in difference to immovable surfaces, varies in a very wide range from 10^{-7} m to 0.1 m, and in some situations is even less than the viscous friction length scale of the dynamically smooth surface. The sea surface roughness predominantly depends on the surface wave age. The Charnock's constant is not a universal constant but a function of the wave age and varies from 10^{-3} to 1. The surface waves influence on the turbulent fluxes of momentum, heat and evaporation over the ocean surface. This influence causes the variability's of the drag coefficientC_u, the heat transfer coefficient C_T and the evaporation coefficientC_E. Their variability constitutes one and half orders of magnitude as (C_u, C_T, C_E) ≈0.5*10^{-3} $\div 10^{-2}$, depending on the wave age.

Because of the wave impact on the ocean upper layer, the near surface friction layer is composed of three dynamically different sub-layers in difference to the classical near surface layer of constant turbulent fluxes. The turbulent energy production in the ocean upper layer by the wave breaking exceeds significantly the mean shear effect in the vicinity of the ocean surface, the near surface wave-turbulent sub-layer where the turbulence is produced by wave breaking and turbulent diffusion of the wave kinetic energy. This sub-layer is followed by the diffusive turbulent sub-layer where the turbulent viscosity and diffusivity are constant over its entire thickness. And only below of these two sub-layers there is the classical turbulent layer with constant turbulent fluxes.

This discussion shows that the turbulent boundary layers around the air-sea interface and the interface itself are the unified dynamical system.