Geophysical Research Abstracts
Vol. 18, EGU2016-7642, 2016
EGU General Assembly 2016

The study of droplet-laden turbulent air-flow over waved water surface by direct numerical simulation

Oleg A. Druzhinin (1,2), Yuliya I. Troitskaya (1,2), Sergej S. Zilitinkevich (1,2,3)

(1) Institute of Applied Physics, Nizhny Novgorod, Russia (druzhinin@hydro.appl.sci-nnov.ru), (2) Nizhny Novgorod State University, Nizhny Novgorod, Russia, (3) Finnish Meteorological Institute, Helsinki, Finland

The detailed knowledge of the interaction of wind with surface water waves is necessary for correct parameterization of turbulent exchange at the air-sea interface in prognostic models. At sufficiently strong winds, sea-spray-generated droplets interfere with the wind-waves interaction. The results of field experiments and laboratory measurements (Andreas et al., JGR 2010) show that mass fraction of air-borne spume water droplets increases with the wind speed and their impact on the carrier air-flow may become significant. Phenomenological models of droplet-laden marine atmospheric boundary layer (Kudryavtsev & Makin, Bound.-Layer Met. 2011) predict that droplets significantly increase the wind velocity and suppress the turbulent air stress. The results of direct numerical simulation (DNS) of a turbulent particle-laden Couette flow over a flat surface show that inertial particles may significantly reduce the carrier flow vertical momentum flux (Richter & Sullivan, GRL 2013). The results also show that in the range of droplet sizes typically found near the air-sea interface, particle inertial effects are significant and dominate any particle-induced stratification effects. However, so far there has been no attempt to perform DNS of a droplet-laden air-flow over waved water surface.
In this report, we present results of DNS of droplet-laden, turbulent Couette air-flow over waved water surface. The carrier, turbulent Couette-flow configuration in DNS is similar to that used in previous numerical studies (Sullivan et al., JFM 2000, Shen et al., JFM 2010, Druzhinin et al., JGR 2012). Discrete droplets are considered as non-deformable solid spheres and tracked in a Lagrangian framework, and their impact on the carrier flow is modeled with the use of a point-force approximation. The droplets parameters in DNS are matched to the typical known spume-droplets parameters in laboratory and field experiments.
The DNS results show that both gravitational settling of droplets and their inertia are important and influence droplets dynamics and spatial distribution and their impact on the carrier air-flow. The results show that droplets, whose settling velocity is of the order of the air friction velocity, accumulate preferentially in the vicinity of the water surface, in the viscous sublayer and buffer regions of the boundary layer. Under the influence of droplets turbulent wind stress is reduced and mean wind velocity is increased as compared to the droplet-free case. These effects become more pronounced for larger droplet mass fractions and smaller surface-wave slopes.

This work is supported by RFBR (Nos. 14-05-00367, 14-05-91767, 15-35-20953, 16-55-52025, 16-05-00839) and by the Russian Science Foundation (Nos. 14-17-00667, 15-17-20009).