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A theoretical model of the influence of spray on the exchange of momentum, with storm and hurricane winds

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A stochastic model of the "life cycle" of a droplet, the torn off the crest of a steep surface wave and then falling down to the water is constructed. The model includes the following constituents: i) a model of motion of a heavy particle in the forcing air flow (equation of motion), ii) a model of the wind flow (wind velocity, wave-induced disturbances, turbulent fluctuations), iii) a model of spray injection, iiii) the droplet statistics (size distribution, wind-speed dependence)

The interaction of water droplets in the atmospheric boundary layer with turbulent fluctuations is described in terms of the Markovian chain. The mean wind field in the marine atmospheric boundary layer is determined by the momentum exchange associated with the turbulent and wave momentum transfer and by sprays. The wave and turbulent momentum exchange is parameterized by the Charnok expression for the roughness parameter. Wave disturbances induced in the air flow by waves at the surface, were calculated within the model of the marine atmospheric boundary suggested in [1].

The greatest uncertainty in this model is the mechanism of droplets injection. We consider two models for the injection of droplets in the air flow. In the first model the droplets formed by the development of the Kelvin-Helmholtz instability, are entered in the flow with the orbital velocity of the wave (Koga's model [2]), The second mechanism, investigated in many papers, considers droplets from the breakdown of a jet which rises at high speeds from the bottom of the collapsing air bubble cavity [3]. To determine the number of drops injected to the atmospheric boundary layer from the sea surface, the Spray generation function proposed in [4] was in use.

Within the model the momentum acquired by every droplet in the interaction with the air flow was calculated. Depending on the particular field of air velocity, wave parameters and the radius of the droplet, it can both get and deliver momentum give impetus to the air flow during the life cycle from taking them off the water to fall into the water. Contribution of droplets to the momentum balance of air flow is determined by the total momentum balance of sea sprays. The calculations in the model showed that the momentum exchange with the spray can lead to either a weak (less than 10%) increase of the aerodynamic surface drag or to a weak reduction (within Koga's model [2]). Recommendations for the experiment on investigation of the "life cycle" of spray in the air flow are suggested.

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