

EGU21-8539

<https://doi.org/10.5194/egusphere-egu21-8539>

EGU General Assembly 2021

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## Shear instability of wind drift as the initiation mechanism for the bag-breakup fragmentation of the air-water interface at high winds.

**Yuliya Troitskaya**

Institute of Applied Physics, Nonlinear Geophysical Processes, Nizhny Novgorod, Russian Federation (yuliya@hydro.appl.sci-nnov.ru)

The "bag breakup" fragmentation is the dominant mechanism for generating spray in hurricane winds, which parameters substantially affect the exchange processes between the ocean and the atmosphere and, thereby, the dynamics of the development of sea storms. This fast process can only be studied in lab using sophisticated experimental techniques based on high-speed video filming. In such circumstances, the transfer of laboratory data to field conditions requires a kind of theoretical model that describes how the initiation of disturbances occurs, which then lead to fragmentation events, what is the threshold for fragmentation, what is the volume of liquid, which determines the size of spray droplets, that undergoes fragmentation, and how it depends on wind parameters, etc. The conclusions of the model can be first verified in the laboratory experiment and then applied to field conditions.

In the present work, such a model is proposed. First of all, a linear theory of small-scale disturbances on the water surface under the action of a strong wind has been built, which makes it possible to describe their structure, dispersion properties and determine the threshold value of the dynamic air flow velocity at which such disturbances become growing. These disturbances comprise small-scale ripples concentrated within the thin surface layer and growing fast due to shear instability of the wind drift flow in the water. The peculiarity of the structure of these disturbances enables one to consider the nonlinear stage of their evolution within the Riemann simple wave equation modified to describe the increasing disturbances. The analytical solution of the obtained equation suggests the scaling of the volume of liquid undergoing the "bag-breakup" fragmentation, to estimate the scale of the formed droplets and the speed of their injection into the atmosphere. The scaling correctly describes the dependencies of these quantities on the wind friction velocity obtained in laboratory experiments.

The obtained results are applied for the construction of the fetch-dependent spray generation function, which is applicable in the field. Within the Lagrangian stochastic model for the inertial droplets in the marine boundary layer, the momentum, heat, moisture and enthalpy exchange coefficients are calculated. One should notice substantial feedback effect on the atmosphere caused by the presence of spray in hurricane conditions.

This work was supported by RFBR grant 19-05-00249 and RSF grant 19-17-00209.

