Geophysical Research Abstracts
Vol. 13, EGU2011-9313, 2011
EGU General Assembly 2011


# Air-sea interface in hurricane conditions

Alexander Soloviev (1,2), Silvia Matt (1), and Atsushi Fujimura (2)

(1) Oceanographic Center, Nova Southeastern University, Dania Beach, United States (soloviev@nova.edu; Silvia.Matt@nova.edu), (2) Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, United States (afujimura@rsmas.miami.edu)

Improving hurricane prediction models requires better understanding of complex processes taking place in the oceanic and atmospheric boundary layers at high wind speeds. The role of sea spray in this process is not yet completely understood. Estimates provided in Soloviev and Lukas (2006) suggest that, in the framework of existing sea spray generation functions (see e.g., Andreas 2004), the reduction of turbulent friction due to buoyancy effects associated with the entrainment of spray droplets in the airflow has a relatively small effect on the drag coefficient. Furthermore, the wind loses a part of its momentum to accelerate the spray, which should result in a slow increase of the drag coefficient with wind speed rather than its decrease. In this work, we further develop the hypothesis formulated in Soloviev and Lukas (2006) that the change of the air-sea interaction regime in hurricane conditions is associated with the mechanism of direct disruption of the air-sea interface by pressure fluctuations working against surface tension. This is achieved through the Kelvin-Helmholtz (KH) type instability of the air-sea interface. This instability initiates the tearing of short wavelet crests, subsequent smoothing of the sea surface, and detachment of the airflow from waves, which reduces the drag coefficient at the air-sea interface (Powell et al. 2003; Donelan et al. 2004; Black et al. 2007). A nondimensional number $K = u_{*a}/\left(g\sigma_s\rho_w/\rho_a^2\right)^{1/4}$ is the criteria for the KH instability (Soloviev and Lukas 2010). (In this formula $u_{*a}$ is the friction velocity from the air side, $g$ the acceleration due to gravity, $\sigma_t$the surface tension, $\rho_w$ and $\rho_a$ are the water and air density, respectively.) In order to investigate the mechanism of the disruption of the air-sea interface, we have conducted a series of numerical experiments using the computational fluid dynamics software *ANSYS Fluent.* The 3D experiments were initialized with either a flat interface or short wavelets and wind stress was applied, ranging from zero stress to hurricane force stress. The wind stress was applied either at the upper boundary of the air layer or through the horizontal pressure gradient. The disruption of the air-water interface resembling the KH instability is observed when wind reaches hurricane force. The numerical experiments with imposed short wavelets demonstrate the tearing of wave crests, formation of water sheets and spume ejected into the air, and smoothening of the water surface. In conclusion, a conceptual framework for merging the effects of the two-phase environment with the contribution to the drag from waves is discussed.

References:

Andreas, E.L., 1998: A new sea spray generation function for wind speeds up to 32 m s$^{-1}$. *J. Phys. Oceanogr.* 28, 2175-2184.

Black, P.G., E. A. D'Asaro, W.M. Drennan, J. R. French, P. P. Niiler, T. B. Sanford, E.J., Terrill, E. J. Walsh, and J. A. Zhang , 2007: Air-Sea Exchange in Hurricanes: Synthesis of Observations from the Coupled Boundary Layer Air-Sea Transfer Experiment. *Bulletin of the American Meteorological Society* 88(3): 357-374.

Donelan, M. A., B. K. Haus, N. Reul, W. Plant, M. Stiassnie, H. Graber, O. Brown, and E. Saltzman, 2004. On the limiting aerodynamic roughness of the ocean in very strong winds. *Geophysical Research Letters* 31, L18306.

Powell, M.D., P.J. Vickery, and T.A. Reinhold, 2003: Reduced drag coefficient for high wind speeds in tropical cyclones. *Nature* 422: 279-283.

Soloviev, A., and R. Lukas, 2006: *The Near-Surface Layer of the Ocean: Structure, Dynamics, and Applications.* Springer, 572 pp.

Soloviev, A., and R. Lukas, 2010: Effects of bubbles and spray on air-sea exchange in hurricane conditions. *Boundary-Layer Meteorology* 136, 365-376.