Is the State of the Air-sea Interface a Factor in Rapid Intensification and Rapid Decline of Tropical Cyclones?

*Alexander Soloviev[1,3], Roger Lukas[2], Mark A Donelan[3], Brian K Haus[3], Isaac Ginis[4]

1. Nova Southeastern University, 2. University of Hawaii, 3. University of Miami, 4. University of Rhode Island

Some of tropical storms undergo spectacular rapid intensification and rapid decline. These processes have not yet been completely understood and still are a serious challenge in the tropical storm intensity prediction. Important physics of atmospheric, oceanic, and interfacial components are not yet well understood and implemented in tropical cyclone forecast models. Specific ambient environmental conditions including the ocean thermal and salinity structure and internal vortex dynamics (e.g., eyewall replacement cycle) have been considered by hurricane researchers among the factors favorable for rapid storm intensification. Here, we pursue the hypothesis that the state of the sea surface is another factor in rapid storm intensification and the rapid storm decline. In a laboratory experiment and coordinated numerical simulation, we have found that the air-water interface under hurricane force wind may develop Kelvin-Helmholtz shear instability. The resulting two-phase environment suppresses short waves and alters the aerodynamic properties of the sea surface (Soloviev et al. 2014). The unified wave-form and two-phase drag parameterization model shows the well-known increase of the drag coefficient (C_d) with wind speed, up to ~30 m/s. The negative slope of the Cd wind-speed dependence from approximately 40 m/s to 60 m/s favors rapid storm intensification.Around 60 m/s, one version of the new parameterization shows a local minimum (“sweet spot”) of C_d. However, the positive slope of the C_d wind-speed dependence above approximately 60 m/s favors rapid storm decline. The storms that go above category 3 may have tendency to rapidly decline, when they enter areas of lower ocean heat content or less favorable atmospheric conditions.

Soloviev, A., R. Lukas, M. Donelan, B. Haus, and I. Ginis. The air-sea interface and surface stress under tropical cyclones. *Nature Scientific Reports* 4, 5306 (2014).

Keywords: Air-sea Interface, Tropical Cyclone, Rapid Intensification, Rapid Decline

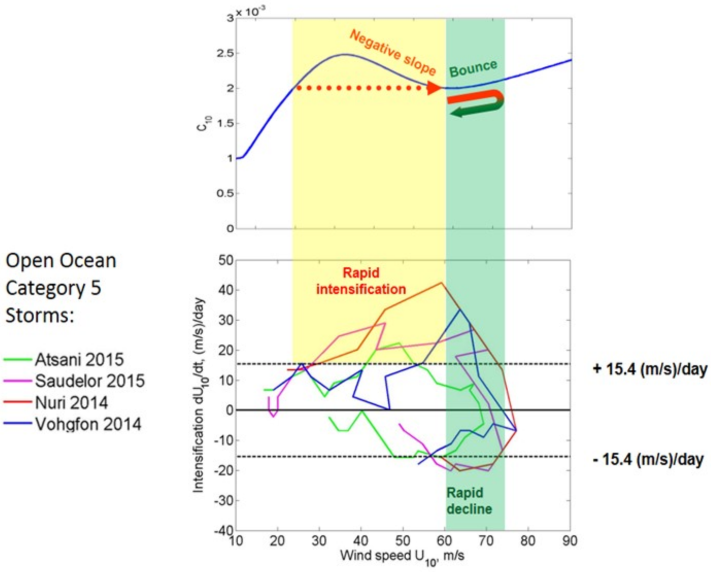

Figure. Rapid intensification and rapid decline of some 2014-2015 Category 5 Tropical Cyclones. Top: The air-sea drag coefficient as a function of wind speed; (bottom) the rate of wind speed change DU_{10}/Dt in (m/s)/day as a function of wind speed U_{10} in m/s. Rapid intensification is defined as a tropical cyclone intensity increase of at least 15.4 m/s in 24 hours; this level is shown by a dashed line U_{10} = 15.4 m/s. Rapid decay is defined as a tropical cyclone intensity decrease of at least 15.4 m/s in 24 hours; this level is shown by a dashed line U_{10} = -15.4 m/s.