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Hurricane Sandy damage, Long Beach, NY. Credit: Andrea Booher, FEMA

Improving Hurricane Forecasts

The prediction of a hurricane's track and intensity, as well as rainfall it produces, relies heavily on numerical weather prediction (NWP) models. However, great uncertainties still remain in the formulation of a few key model physics components that are critical to the development of hurricanes. Over the past decade, research has been carried out at NOAA's Earth System Research Laboratory (ESRL) to combine atmospheric observations, laboratory experiments and computer modeling studies to develop, test and improve the representations of air-sea momentum and heat fluxes together with rainfall production in NOAA's hurricane models. ESRL has developed new observing technologies to obtain the required data.

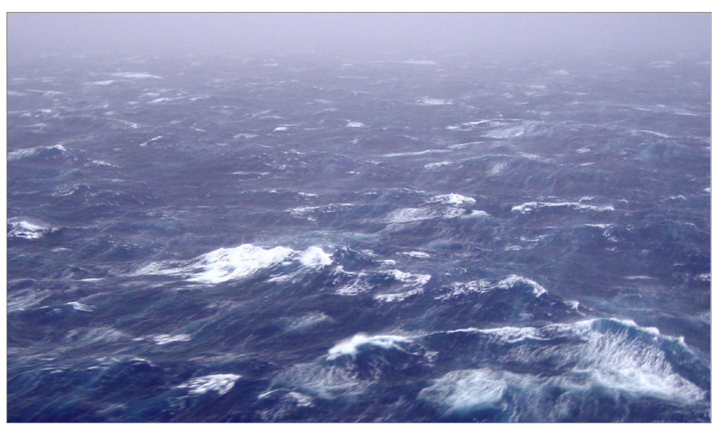
Why consider air-sea interactions in hurricane forecasting?

Hurricanes are essentially natural machines for extracting heat from the ocean and converting it into wind and rain. One uncertainty in NWP models is the formulation of the momentum and heat fluxes across the air-sea interface. All the formulations currently used in operational NWP models were developed using observations taken under winds weaker than those associated with a typical hurricane. Under hurricane conditions, the air and sea are separated by a spray-filled transition layer. Momentum and heat exchanges across such a layer should take into account the effect of sea spray, but they currently do not.

As the source of marine aerosols, sea spray droplets can affect cloud microphysical processes responsible for rainfall production in tropical cyclones. There is a need to better represent the interaction between the aerosols produced by sea spray and rain production processes in NOAA's operational hurricane models.

How is this being addressed?

Beginning with a method developed in 1994, researchers at ESRL have developed a new, refined method that incorporates air-sea heat exchanges, observations from new field experiments, and updated theoretical understanding. A unique



Ocean whitecaps during a hurricane. Credit: Chris Fairall, NOAA aspect of the new method is that it includes the sea-spray contribution to the air-sea heat fluxes for winds greater than 25 m/s. ESRL has developed new radar technologies to measure surface waves and sea spray from NOAA P-3 hurricane hunter aircraft.

Testing and evaluation of this new method are being performed in NOAA's operational hurricane model (HWRF) and the community weather research and forecast model (WRF-ARW). Through ongoing research with both the operational and research models, ESRL scientists will be able to determine the sensitivity of the sea-spray calculation to the uncertainties in wave dynamics, and the motion and heat-producing feedbacks of sea spray. They will also be able to make the method more general by including both the spray evaporation feedback and stress reduction effects.

Researchers from NOAA and universities are closely collaborating to evaluate the impact of the improved air-sea flux method on the dynamic marine boundary layer under hurricane conditions.

A recent effort has been initiated to properly account for the aerosols produced by sea spray in the cloud microphysics parameterization scheme used in the HWRF model to improve the accuracy of rainfall production of the model. This effort will increase the skill of NOAA's operational hurricane model in quantitative precipitation forecast, which is extremely important for predicting land-falling tropical cyclones.

What are the benefits?

The inclusion of the impact of sea spray on the air-sea energy exchange in weather prediction models will increase the accuracy of hurricane track and intensity. Properly accounting for the aerosols produced by sea spray in NOAA's operational hurricane model will increase the accuracy of the rainfall prediction associated with land-falling tropical cyclones, which will lead to better flood control in the coastal states. Ultimately, the societal impact of this research is significant because it will improve the nation's coastal evacuation warning system and ultimately save lives.

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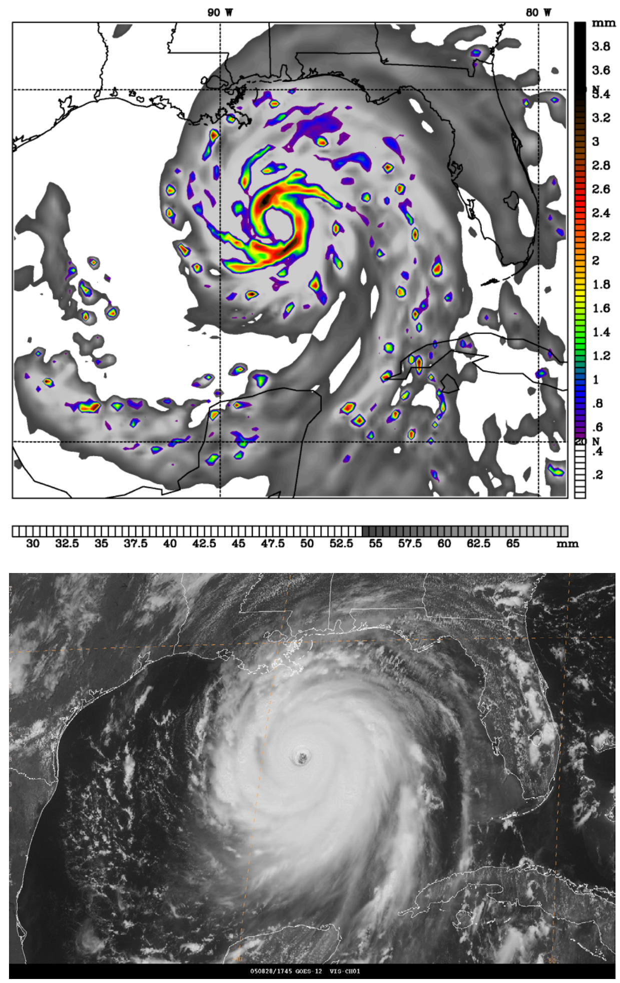
Visit us online at:
www.esrl.noaa.gov/psd/psd3/hurricane/

ESRL engineers checking out the W-band radar instrumentation during test flights on the NOAA P-3 near Tampa, FL. Credit: NOAA



Hurricane Katrina near peak intensity on August 28th, 2005. *Simulation created by the WRF-ARW model for 18:00 UTC (top). Grayscale is vertically integrated water vapor, color scale shows water vapor and clouds. GOES-12 Satellite image at 17:45 UTC (bottom).*