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Storm surge and wave simulations in the Gulf of Mexico using a consistent drag relation for atmospheric and storm surge models

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To simulate wind fields and water levels, numerical weather prediction (NWP) and storm surge models generally use the traditional bulk relation for wind stress, which is characterized by a drag coefficient. These models are tuned independently from each other in order to obtain appropriate results. A commonly used drag coefficient in those models is based on the Charnock relation, whereby the magnitude of the drag coefficient increases monotonically with increasing surface wind speed.

Recent observations, however, have indicated that the magnitude of the drag coefficient levels off from a wind speed of about 30 m/s and then decreases with further increase of the wind speed. Above approximately 30 m/s the stress above the air-sea interface starts to saturate due to sea spray. The observed decrease in the drag coefficient is contrary to the current drag formulations that are used in NWP and storm surge models.

In this study, a drag parameterization based on the relation proposed by Makin (2005) is tested. The parameterization, which is based on Charnock's relation, gives the observed reduction in the drag coefficient for extreme wind speeds. This improved parameterization has been implemented consistently in the NWP model HIRLAM (High Resolution Limited Area Model) and the storm surge model Delft3D using identical drag coefficients. The effect of waves (i.e. wave induced surge) has been accounted for in the simulations by directly coupling Delft3D with the SWAN wave model in an online mode. Numerical experiments using coarse (10 km.) and intermediate (2 km.) resolution grids were carried out for the tropical storms Katrina (2005) and Ivan (2004) in the Gulf of Mexico. The computed wind fields, water levels and wave fields show good agreement with observational data.