Application of a Hurricane Boundary Layer Model for Improved Surface Wind Forecast

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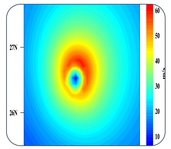
Homeland Security Challenge

Damaging wind due to landfalling hurricanes occur within the first few hours of landfall due to abrupt change in surface roughness from ocean towards the land. This study investigates the impact of land-roughness on the hurricane's near-surface wind structure using a physics-based Hurricane Boundary Layer (HBL) model. An application of this model for Hurricane Florence (2018) is presented here. This research will help improve our understanding and prediction of hurricane wind speed and structure during landfall.

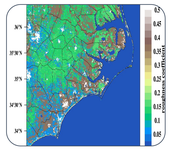
Methodology

Vortex Generation



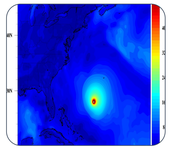
- Construct a 3-Dimensional vortex consistent with the observations.
- NHC track data are used for generating gradient wind at the top of the boundary layer from which HBL calculates wind at 10m height.

Surface Roughness and Coastline Specification



- 0.5 km resolution MODIS based land cover climatology.
- 0.25 km resolution GMTED based topographic data.

HBL-ERA5 Blended Wind



- To improve representation of wind at the outer radii of the HBL simulated vortex.
- To provide background environmental wind in the HBL Simulated wind field.

Results

Wind Cross-section validation with airborne SFMR-based observations

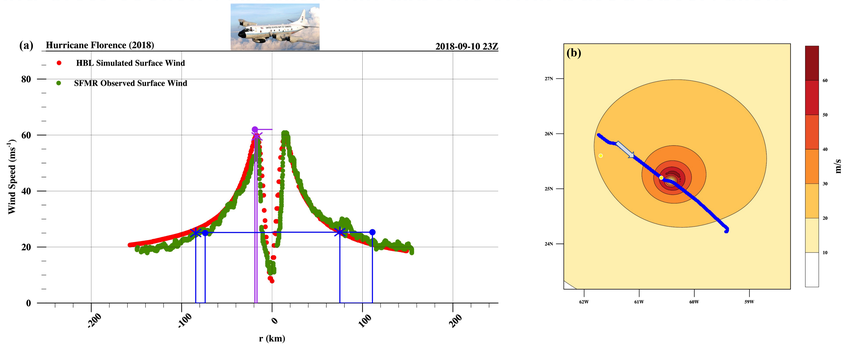


Fig 1. Surface wind comparisons with the airborne Stepped Frequency Microwave Radiometer (SFMR) based observations for Florence collected during September 10, 23:00 UTC. (a) is showing the wind cross-section as a function of storm radius. Green colored line is the observed wind and red colored line is the HBL Simulated wind. The flight track is shown blue colored line in (b) with the background wind contour from the HBL Simulated 10m wind.

Wind Speed Comparisons with Buoys over Water

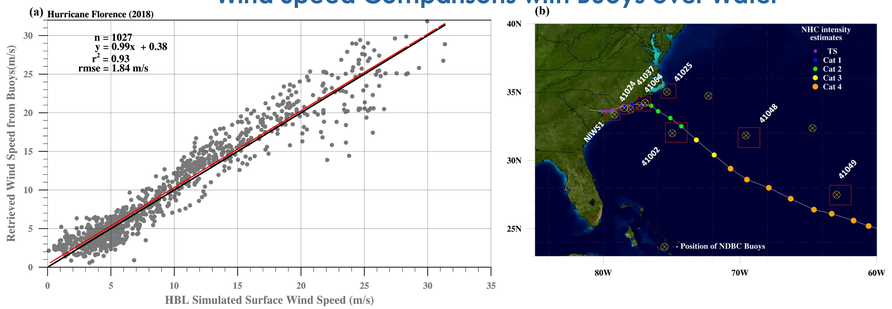


Fig 2. (a) Scatter plot showing the HBL-ERA5 blended wind comparisons with buoy observations. The modeled wind was compared with 8 buoy observations. The modeled regression line is shown in red color and best fit line is shown in black color. (b) Map showing the location of buoys as well as the track of Hurricane Florence. The filled colored circle is showing the category of the hurricane based on Saffir-Simpson scale.

Results (Continued)

Wind Speed and direction Comparisons with Land-based Stations

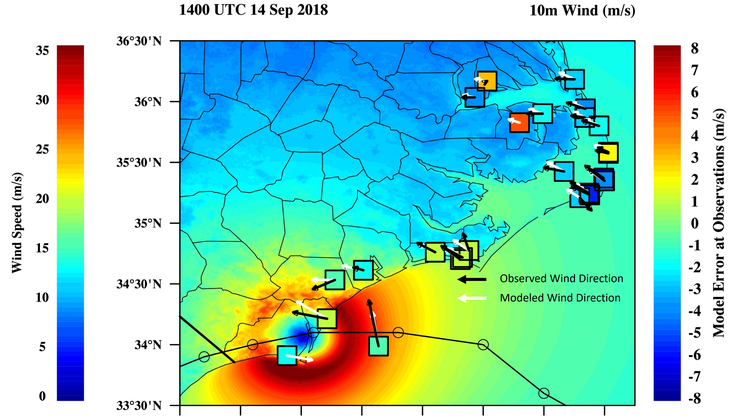


Fig 3. Wind speed and direction comparisons with observations during the landfall of Hurricane Florence. Markers representing the magnitude of error at the location of observations, The black and white colored arrows representing the observed and modeled wind direction, respectively.

Conclusions

- Vortex structure simulated by the HBL model for Hurricane Florence is consistent with observations.
- HBL simulated wind speed and direction agree reasonably well with observations; specifically, HBL can simulate peak wind speed reasonably well, which is an important factor for storm surge prediction.
- Further improvements in the HBL model are possible with updated higher resolution land roughness and increased spatial resolution.

Acknowledgements

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