Simulations of Near-Ground Hurricane Winds Influenced by Built Structures

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Introduction
Accurate hurricane near-ground wind forecasts are important, but difficult due to uncertainties in how the wind interacts with structures onshore. This study examines winds in four separate structural environments by using the Weather Research and Forecasting (WRF) model hurricane wind forecasts as input for the Fluent computational fluid dynamics (CFD) model. Resulting velocity magnitudes are normalized to the “undisturbed” winds at all elevations to assist forecasters in issuing guidance.

Methodology
wake cases (Rita, Katrina, and Wilma) were simulated using Fluent (ANSYS) with a 40 x 40 grid spaced in US vertical steps. Subsequent boundary conditions, vertical wind profiles were developed from the median of highest predicted 10-meter winds at a single vertical level for each hurricane. Four domains, including a single story house, a two story house, a suburban array, and an urban environment, were constructed in Gambit for Fluent simulation (Fig. 1).

Results

- In our best simulations, the central minimum pressure was 10% lower than that observed (Fig. 2a and 2b), likely due to the coarseness of the model’s initialization data (Kimball and Dougherty, 2006).
- street networks, which are critical features in hurricane forecasting (WRF-3DVAR). Thus, future efforts will focus on data assimilation to improve our simulations.
- For飓风 winds, the suburban and urban environments reduced virtually the entire profile from the expected values in the lowest 20 meters (Figs. 4c and 5c).
- We determined that a profile extracted from the region of maximum predicted hurricanes would be sufficient for flow simulations in Fluent.

WRF Profile Normalization
The suburban and urban environments reduced virtually the entire profile from the expected values in the lowest 20 meters (Figs. 4c and 5c).

WRF 10-Meter Wind Normalization
Figure 6 reveals how well the WRF 10-meter forecasted winds at the single vertical level compare to the results of the Fluent simulations (Figures 4 and 5). The suburban environment decreased virtually the entire profile from the expected values in the lowest 20 meters (Figs. 6c and 6d).

WRF 10-Meter Wind Normalization

References


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Conclusions
The WRF forecasted 10-meter winds from our Hurricane Katrina simulations compare well with winds measured by instrument placed in Katrina’s path. While these results appear reasonable for subsequent Fluent simulations, our goal remains to improve our hurricane simulations by using WRF-3DVAR.

In general, the structural environments act to decrease the magnitude of the incoming profile in regions at or below the elevation of the structure(s), and act to slightly increase winds at higher elevations.

Height dependent scaled adjustments are recommended when forecasting winds for each structural environment, based on the implications of Figure 6.