Toward better simulations of hurricane winds in urban canopies

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INTRODUCTION

Goal of project: Use NCAR's Cloud Model 1 (CM1) at the large-eddy scale and the Weather Research and Forecasting (WRF) Model at the mesoscale to better understand and forecast how buildings affect hurricane winds in the urban canopies of coastal cities.

Goal of poster: Summarize the achievements of the team in the first year of the project, then describe plans for years two and three.

CM1: VALIDATON OF FLOW AROUND BUILDINGS

Buildings in CM1 (Figs. 1-2) are represented by an immersed boundary method (IBM). Buildings of different sizes and shapes will be grouped to represent idealized and real cities.

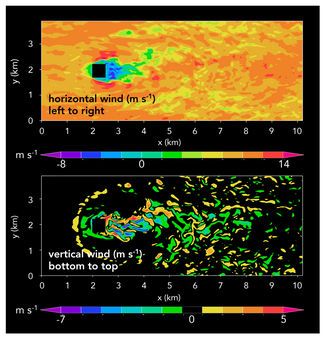
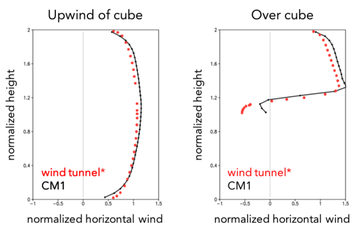


Figure 1. CM1 simulation of flow around a cube (black). Horizontal (top) and vertical (bottom) wind speeds (ms^{-1}) are shaded according to the color bar.



* wind tunnel data are from Martinuzzi and Tropea (1993)

Figure 2. Validation of CM1 simulations (black) vs. wind-tunnel observations (red) upwind (left) and over (right) the cube. Height is normalized by the dimensions of the cube. Velocity is nondimensional.

WRF: SENSITIVITY STUDIES WITH REAL CASES

We reviewed landfalls in the last 20 years, selecting cyclones based on intensity, impact on urban environments, and the likelihood of successful simulations (Fig. 3).

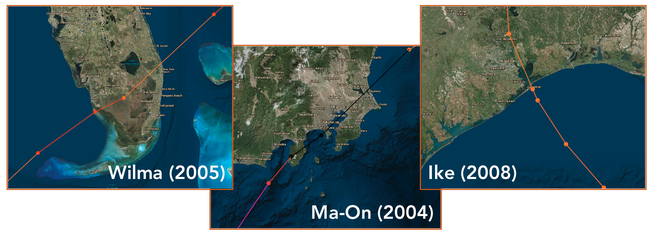


Figure 3. Three tropical cyclones that made landfall over metropolitan areas within the last 20 years: Wilma (2005), which struck Florida, Ike (2008), which struck Texas, and Ma-On (2004), which struck Japan (tracks in colored lines).

To assess the baseline performance of the unmodified Building Effect Parameterization (BEP) when wind speeds in urban canopies reach hurricane strength, we are conducting sensitivity experiments with the WRF Model (Fig. 4) focused on Irma (2017) (not shown) and Frances (2004).

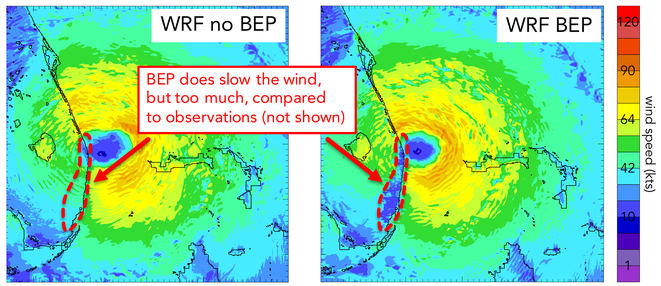


Figure 4. WRF Model simulations of 10-m wind speed (shaded in kts) in Frances (2004) without BEP (left) and with the current out-of-the box BEP (right). BEP does decelerate the wind over Miami and surrounding areas (region within dashed lines) as expected, but observations show the deceleration is too great.

PLANS FOR YEARS TWO AND THREE

1. Validate CM1 against Doppler radar observations (Fig. 5).

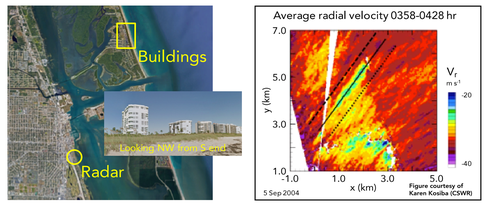


Figure 5. In Frances (2004) the Center for Severe Weather Research's Doppler on Wheels ("radar" on left) scanned wind (shaded on right) around buildings on a barrier island.

2. Execute idealized CM1 simulations over parts of cities.
3. Continue WRF Model simulations to compare with CM1 simulations as basis for improving BEP.
4. Simulate range of idealized hurricanes over range of idealized cities, creating an ensemble of results.

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