# Wind speed suppression by large buildings in hurricanes

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Near surface (< 100 m above sea level (ASL)) ultra-fine-scale DOW[1] radar velocity data reveal a systematic decrease in wind speeds in the hurricane boundary layer in the wake of tall structures. This wake persists for a couple to a few kilometers. Analyses of DOW data showing these effects obtained during the landfall of Hurricanes Frances (2004) are presented. Radar sweeps obtained at 0.5 and 1.1 degree elevations are analyzed on both sides, upstream and in the wake, of large buildings, such as shore-front condominiums. Differences in the decrease of wind speeds as parcels proceed across barrier islands with and without structures are compared.

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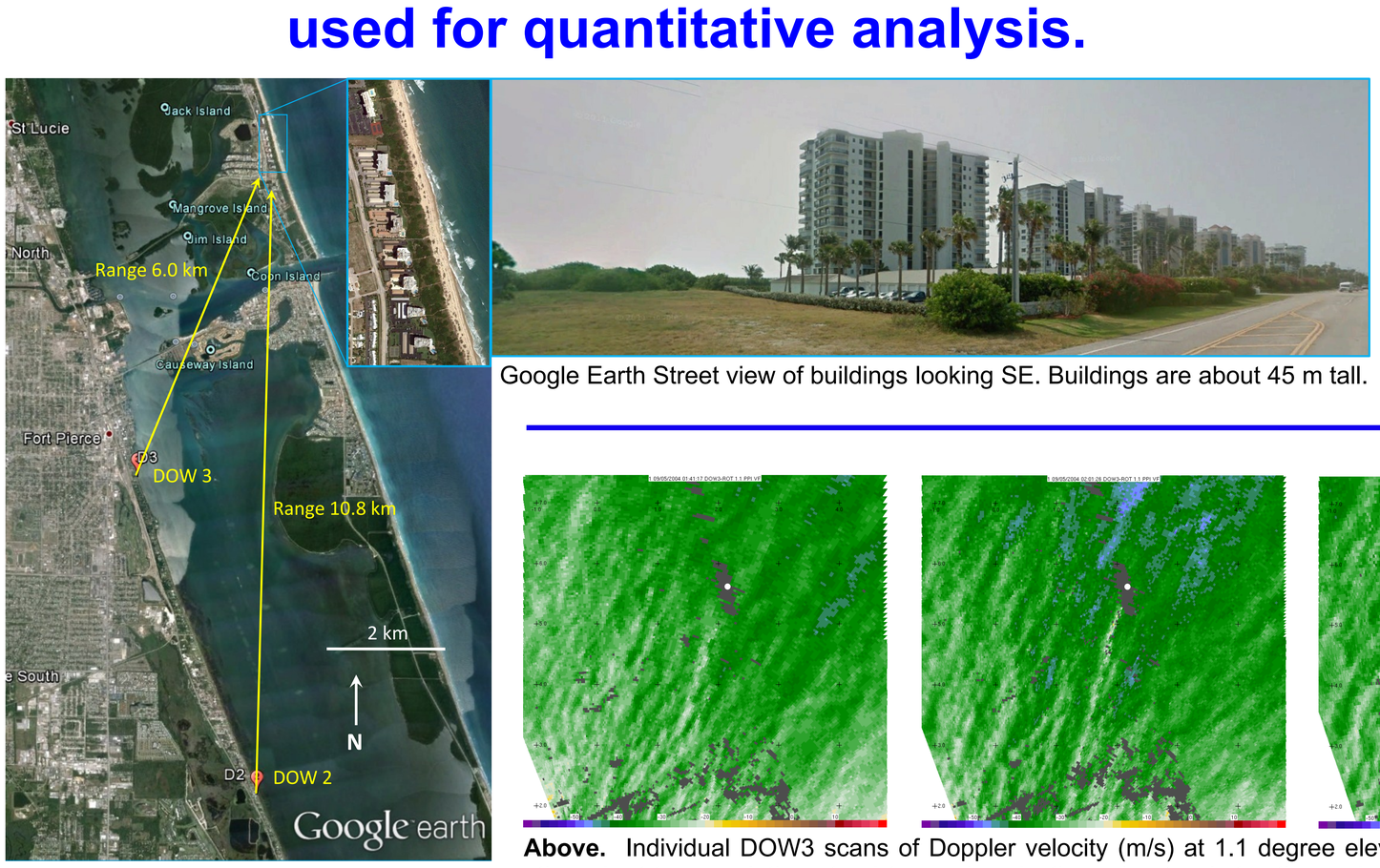
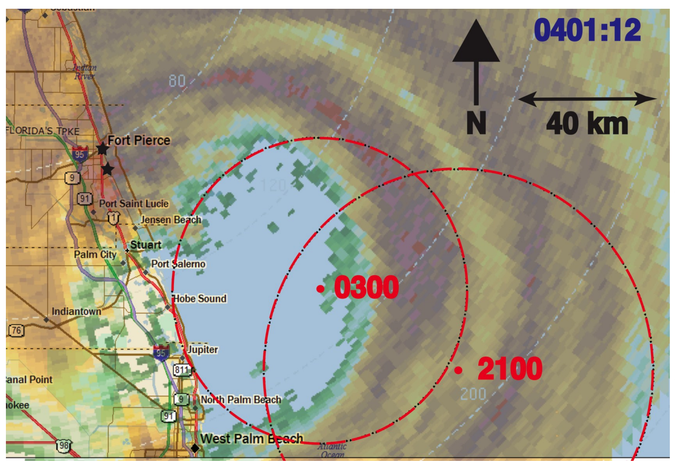
## DOW deployment sites and building group used for quantitative analysis.




**Above.** Two DOW radars recorded wind flow across the buildings (blue box, inset and close-up photograph), each from a different range and Doppler angle.



Google Earth Street view of buildings looking SE. Buildings are about 45 m tall.

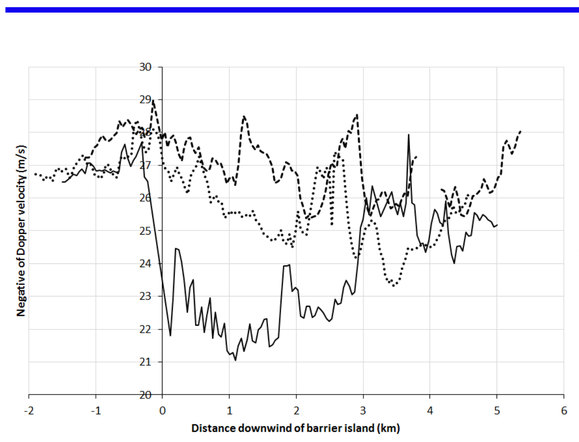


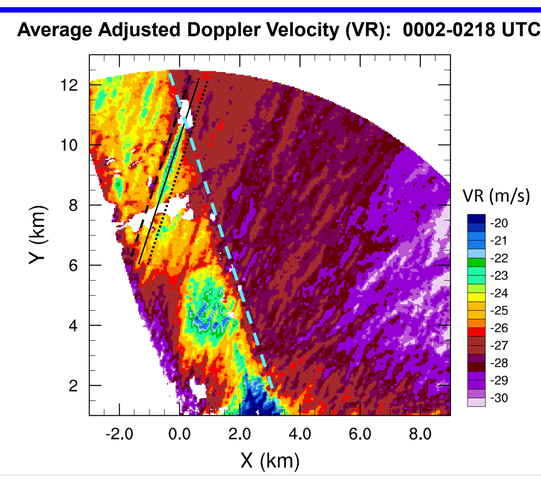

**Left.** Location of the DOW radars on the Florida coast (black stars), during the landfall of Hurricane Frances on 05 September 2004. Radar reflectivity measured by the Melbourne, FL WSR-88D is shown at 0401:12, near the time of landfall. Location of the approximate eye centers are shown as red circles at 2100 and 0300 UTC.

## Methodology



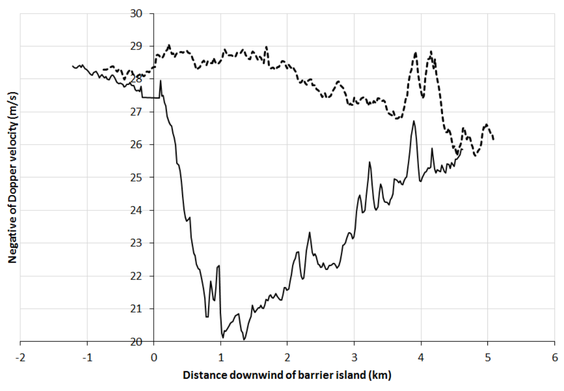
**Above.** Individual DOW3 scans of Doppler velocity (m/s) at 1.1 degree elevation illustrate how wind streaks (example circled in white) and other short-term variations tend to mask reductions due to obstructions. In order to determine the average reduction of wind speed, many sweeps are objectively analyzed[2] to a Cartesian grid and the point-by-point average speeds calculated. In order to remove speed variations due to DOW viewing angle and height, a cosine correction is applied and speed is adjusted to a height of 10 m ASL assuming a log profile and a roughness length of 0.03 m. The white dot indicates the position of the building group. Tick marks are distance (km) north and east of DOW3. Color table is centered at Doppler velocity = -20 m/s. Slowly varying wind direction allows for long averaging times.

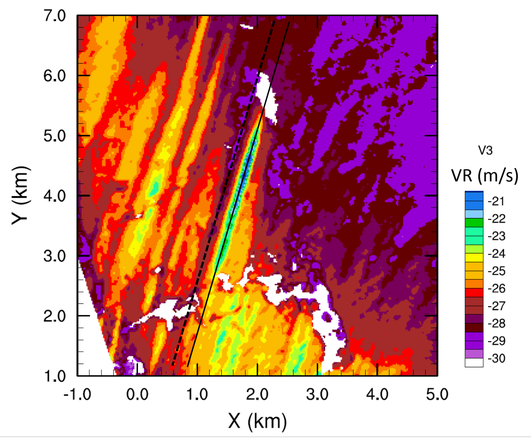



### Experiment 1: DOW2

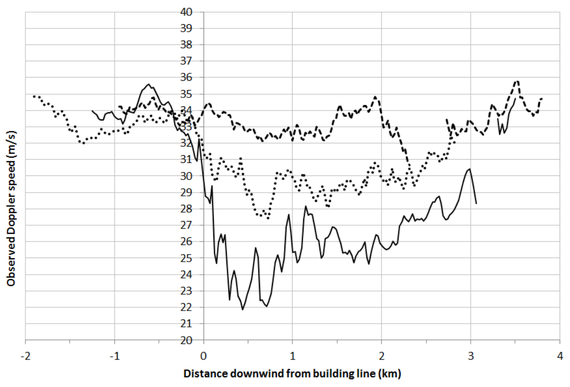
- Average of 27 0.5-degree elevation (75m AGL at Target) scans.
- Target line speeds reduced by 4-5 m $s^{-1}$ (17%) 1 km downwind.
- Speed reduction in lee of barrier island (blue dashed line) is evident.

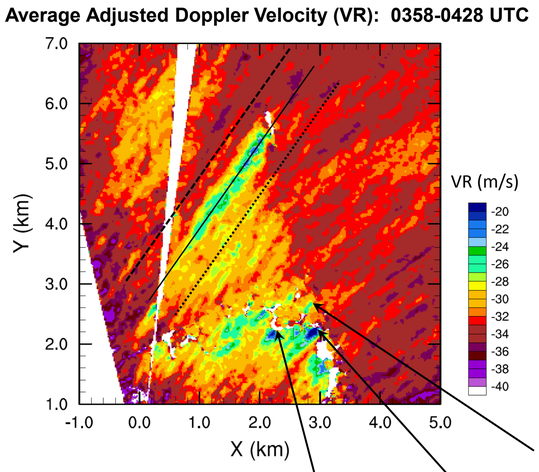



### Experiment 2: DOW3

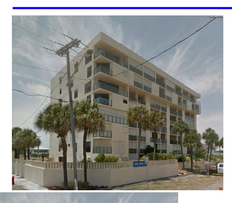
- Average of 77 1.1-degree elevation (100 m AGL at Target) scans.
- Target line speeds reduced by 7-8 m $s^{-1}$ (28%) 1 km downwind.

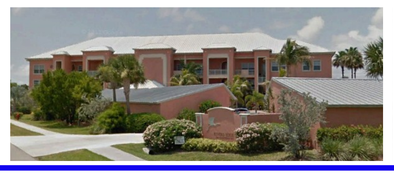


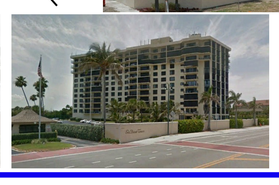




### Experiment 3: DOW3

- Average of 14 0.5-degree elevation (55m AGL at Target) scans.
- Speeds reduced by 9-10 m $s^{-1}$ 0.5 km (29%) downwind.
- Wind shadows remain despite turning and strengthening of wind during eye wall approach.







Examples of identifiable buildings creating wind shadows in DOW data. Each was surrounded by smaller buildings such as residential housing. Photographs by Google Earth Street view.

## Results

Graphs (far left column) display the reduction of wind speed in the wake of the buildings (solid black) as a function of distance downwind of the barrier island, and in the wake of no large obstructions (dotted/dashed lines) for comparison. Same lines are plotted on maps of average VR in right column.

Results of three experiments depicted here show the following:

1. Averaging of many scans reduces the magnitude of wind streaks allowing wind shadows to be seen. Especially apparent in Experiment 2 using 77 scans.
2. General reduction of wind strength lee of barrier island. Especially apparent in Experiment 1 with wider domain.
3. Reduction of wind strength by 20-30% in wake of 45-m tall “Target” line of buildings.
4. Individual above-average height buildings identifiable as reductions in wind field strength. Apparent from photographs in Experiment 3.
5. Results robust to:
   a) Radar being used (Experiment 1 vs. others)
   b) Wind direction (Experiment 3 vs. others)
   c) Wind strength (Experiment 3 vs. others)
   d) Elevation of scan (Experiment 2 vs. others)
   e) Distance to target (Experiment 1 vs. others)
   f) Obstruction size (Photographs in Experiment 3)

[1] DOW radars sample every 0.4 deg in azimuth and 37 m (DOW2) , 62 m (DOW3) in range completing each scan every 9–120 seconds depending on scan strategy.

[2] The objective analysis is a two-pass Barnes scheme using kappa = 0.002 $m^2$ and gamma = 0.3. Dx = Dy = 20 m. One sweep was used for each analysis time.

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