DOW IMPACT ON HURRICANE SCIENCE

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The DOW Network Pioneered the Study of Land-Falling Hurricanes Using Mobile Radars

1995: Hurricane Fran: 1st Mobile Radar Hurricane Intercept

DOW1 radar collects 1st in situ data by mobile radar

Discovers Hurricane Boundary Layer Rolls (HBLRs) (Wurman and Winslow 1998)

1998: Hurricane Bonnie: 1st Mobile Radar Hurricane Dual-Doppler

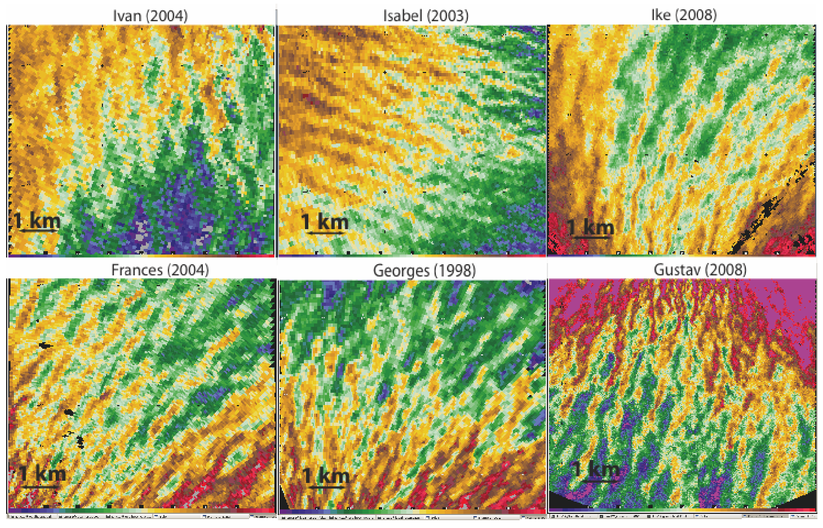
Multiple-Doppler intercepts in Bonnie Isabel, Frances, Georges, Ivan, Isaac with baselines < 10 km

BL fluxes associated with HBLRs can be calculated

2005: Hurricane Rita: 1st Mobile Radar + In situ wind mapping

DOW collects 1st integrated radar + in situ data for surface wind mapping and damage comparisons

- DOWs deploy in *very* forward locations to collect nearly pristine marine exposure data
  - Fast scanning (7–12 s updates) to resolve rapidly evolving BL evolution
  - DOWs have intercepted 12 hurricane eyewalls at the point of landfall



Examples of Hurricane Boundary Layer Streaks observed by the DOWs

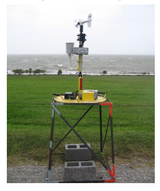
Plaquemines Parish, LA (Isaac, 2012) (on levee)

Galveston Island, TX (Ike, 2008) (on overpass)

Waterproof, LA (Gustav, 2008) (sugarcane field)

Example DOW Deployments

On seawall (Ike, 2008)



On levee (Isaac, 2012)

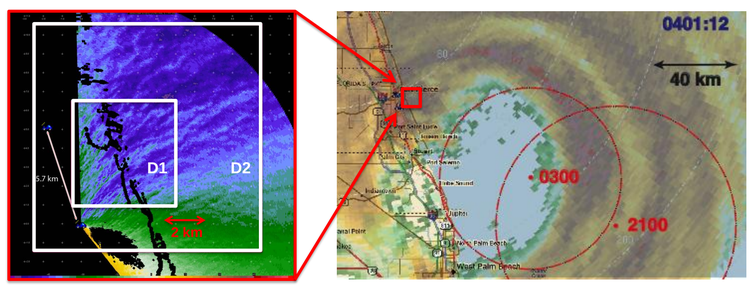
Example In Situ Deployments

Hurricanes Intercepted by DOW Radars 1996-2012

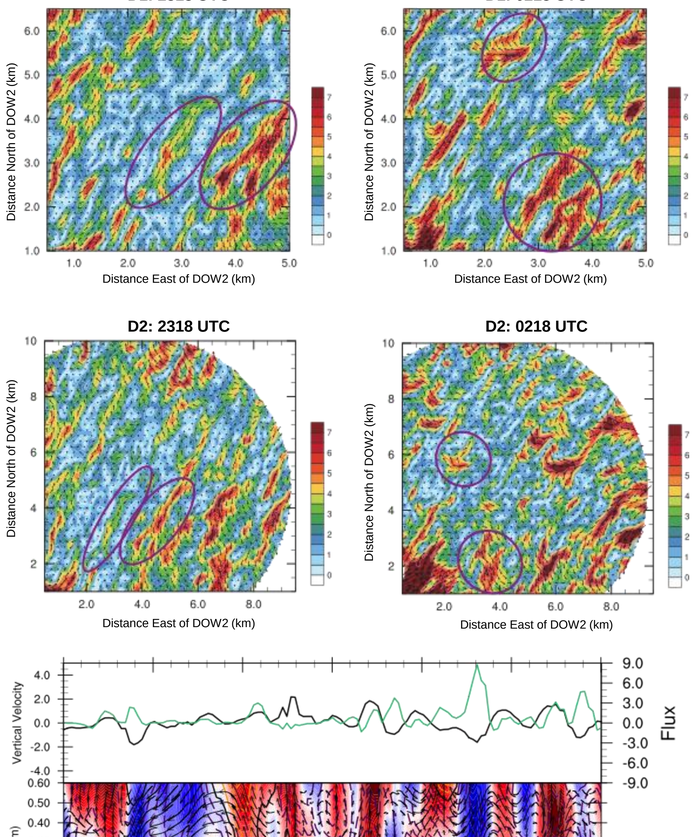
HURRICANE FRANCES (2004): Fine-Scale 3-D Dual-Doppler and Quantification of Momentum Fluxes Due to HBLRs

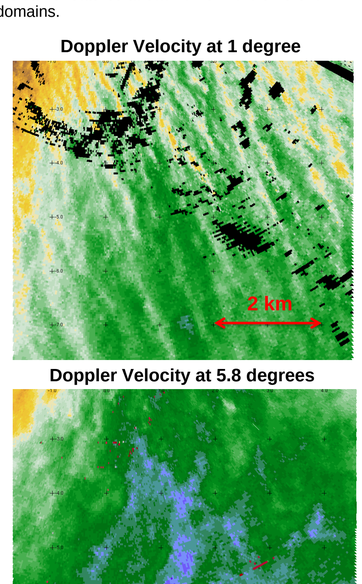
RIGHT: Positions of DOW2, DOW3, the dual-Doppler domains (white boxes) and example Doppler velocity data from DOW2 . Two domains of different size and grid spacing were used in this analysis: one that resolved very small scale features (D1) and another that allowed for the study of boundary layer features through a larger vertical extent (D2). The baseline between the DOWs was **5.7 m**, allowing for features < 200m to be resolved in the dual-Doppler analyses.

FAR RIGHT: Red box indicates the approximate location of the dual-Doppler domains relative to the hurricane eyewall, as Frances makes landfall near 0401:12 UTC.



LEFT: Dual Doppler analysis of Hurricane Frances at 100 m AGL for the D1 (top) and D2 (bottom) domains at 2318 (left) and 0218 (right). Horizontal perturbation winds are depicted with colored contours (magnitude) and vectors. Perturbation winds (including the vertical component) increase in intensity with time. Both domains capture the sub-kilometer scale HBLRs, but D1 resolves features 100–200 m in size. Purple ovals show examples of the same features at each time in the different domains.



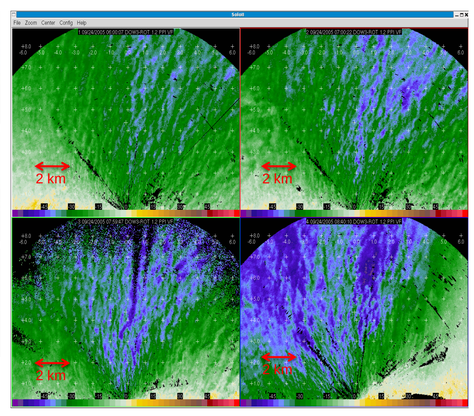


ABOVE: DOW observations of the variation in the velocity structure with height.

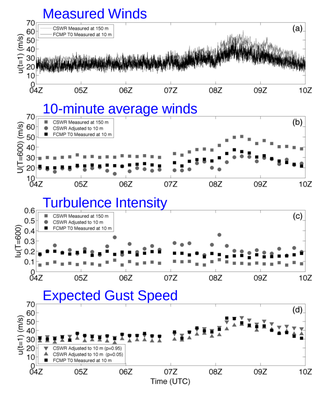
LEFT: Vertical cross-section through the HBLRs at 0218 UTC. Top line plot shows the vertical velocity (green) and 1-D momentum flux (black) at z = 100m due to the HBLRs.

HURRICANE RITA (2005): Combining Rapid-Update DOW and In Situ Tower Observations to Create 2-D Maps of Near-Surface Winds

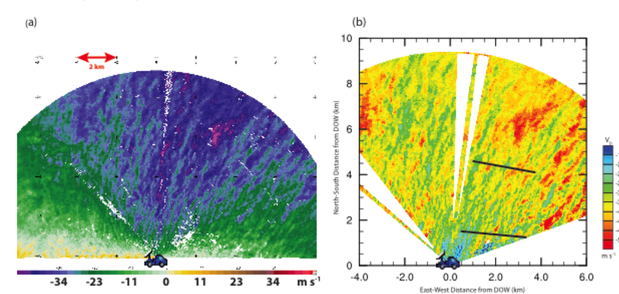
ABOVE: Overview of the deployment of the DOW and the FCMP weather stations (T0 and T3) during Hurricane Rita. The weather stations were located within the 10 km of the DOW. Left depicts a fine-scale view of the deployment using Google Earth imagery. The pictures on the right show the deployment locations (from top to bottom) of T0, T3 and the DOW, respectively.

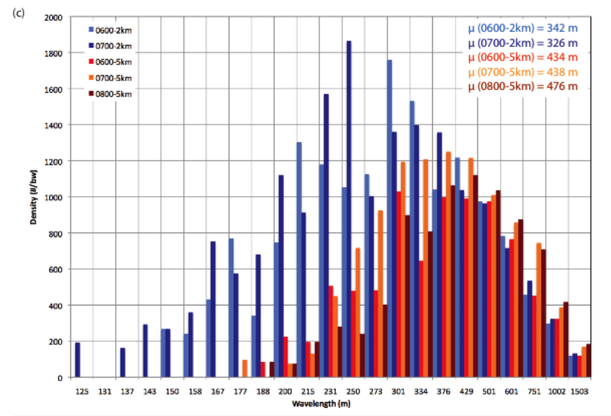


ABOVE: Doppler velocities observed by DOW3 in hurricane Rita as a function of time. Boundary layer streaks increase in intensity as the eyewall approaches land.



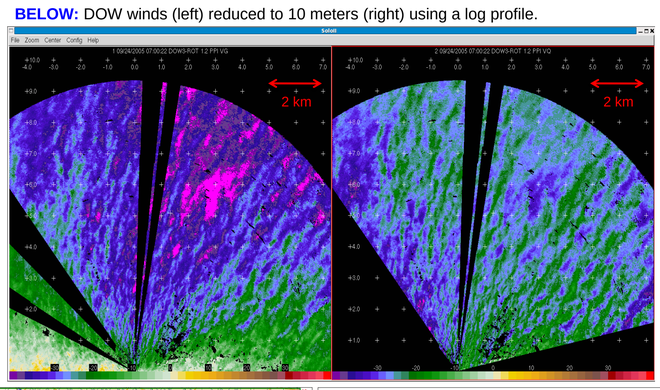
ABOVE: Intercomparison between DOW and 10 m tower winds. DOW winds are corrected for observation angle, exposure of towers (which varies depending on wind direction), and altitude of radar observations. Comparison with T0 tower (at left on map above) shown.

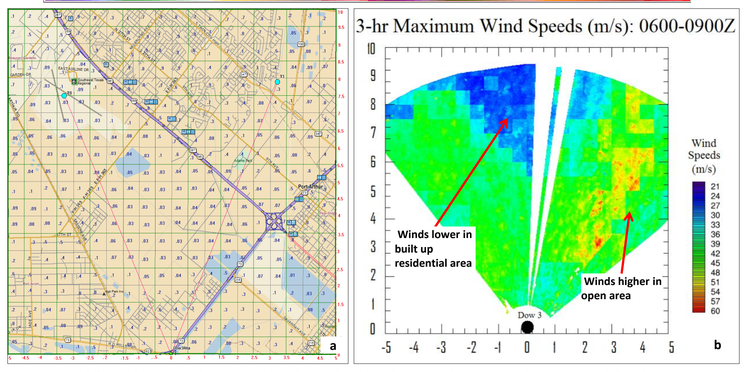




ABOVE: (a) Raw DOW Doppler velocity and (b) objectively analyzed cosine-corrected Doppler velocity at 0710:10 UTC. The objective analysis captures much of the sub-kilometer-scale variability, particularly close the radar. Cross-section locations used in the FFT analysis are shown as black line segments in (b). (c) FFT analysis at 2 km and 5 km range from the DOW during three one hour periods starting at the indicated times. The value of mean wavelengths for each time and location are given in the top right corner of the plot.

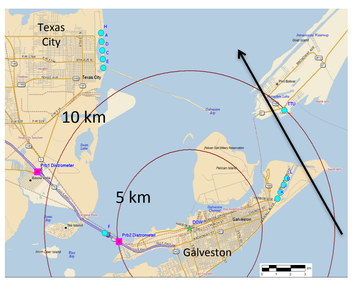
BELOW: DOW winds (left) reduced to 10 meters (right) using a log profile.



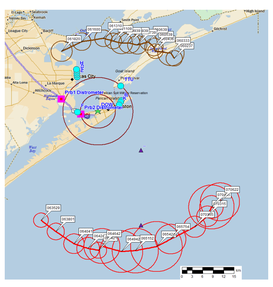


ABOVE: **(a)** Surface roughness values based on land usage for Port Arthur, TX and **(b)** the corresponding 3 hour maximum wind speed at 10 m AGL based on the DOW wind measurements. Axes are in kilometers.

HURRICANE IKE (2008): Analysis of Eyewall Mesovortices and Surface Wind Field With Rapid–Update DOW and 1, 2, and 3.5 m AGL In Situ Observations

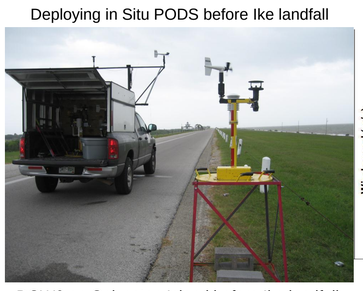


ABOVE: Deployment of DOW6 (green star), two mobile mesonets (pink squares) and ten PODs (aqua circles) during the landfall of Hurricane Ike. Mesonets obtain 3.5 m AGL wind measurements and PODS obtain 1 and 2 meter AGL wind observations. Arrow denotes path of center of eye.



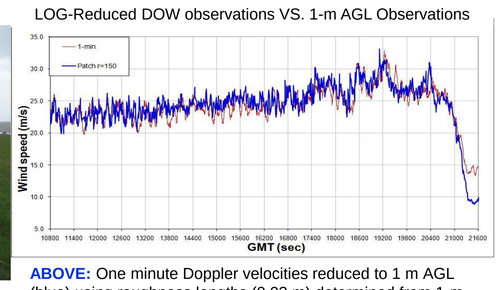
ABOVE: Positions of DOW6 and PODs relative to the observed propagation of two distinct mesovortices occurring 0602:37-0618:02 UTC (brown circles, north of DOW 6) and 0635:29-0706:22 UTC (red circles) embedded within the eyewall of Hurricane Ike.

Deploying in Situ PODS before Ike landfall

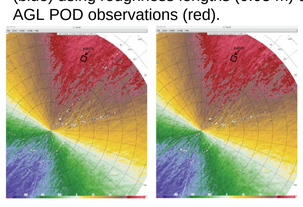


DOW6 on Galveston Island before Ike landfall

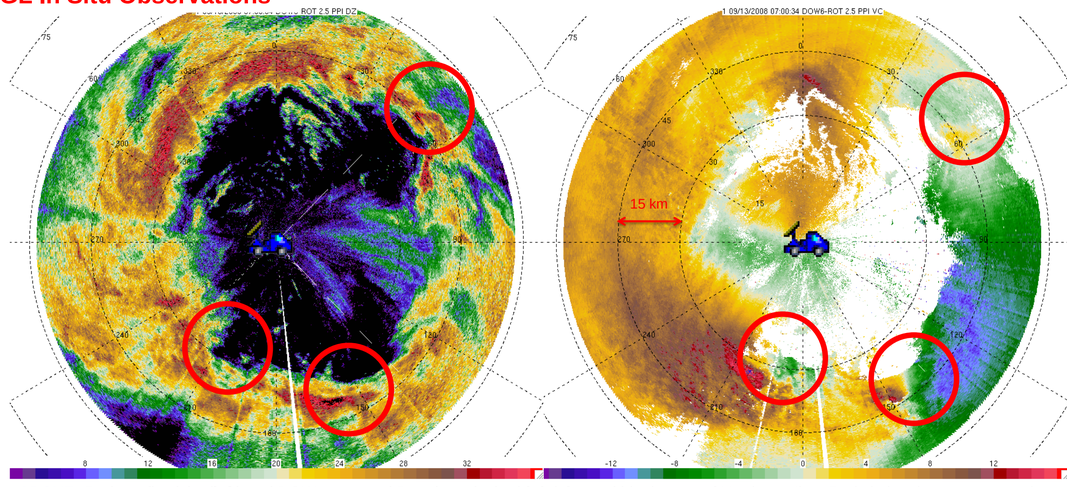
LOG-Reduced DOW observations VS. 1-m AGL Observations



ABOVE: One minute Doppler velocities reduced to 1 m AGL (blue) using roughness lengths (0.03 m) determined from 1-m AGL POD observations (red).

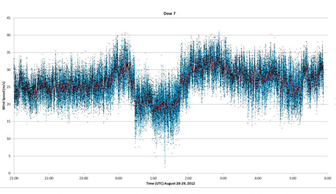


LEFT: Example of the patch applied to the DOW data in order to retrieve the winds at the location of the pod.

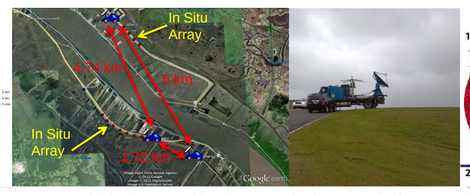


ABOVE: Radar reflectivity (**left**) and DOW-measured Doppler velocity (**right**) from within the eye of Hurricane Ike. Red circles denote mesovortices.

HURRICANE ISAAC (2012): Finest-Scale Multiple Doppler and Multi-level Surface Observations

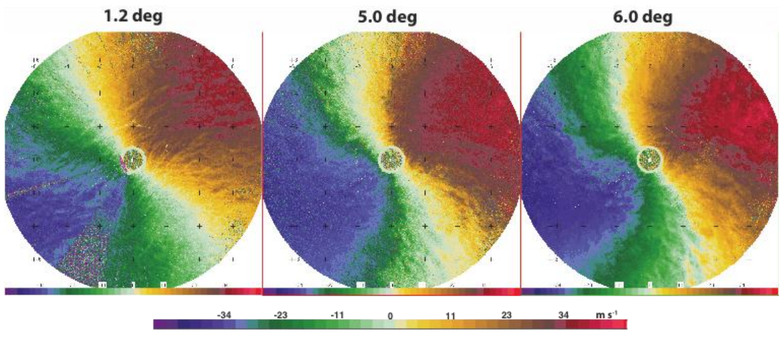


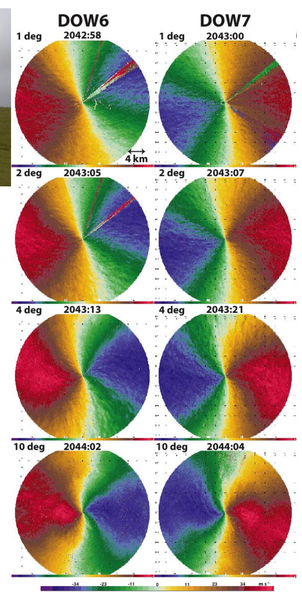
TOP: One second winds observed by the DOW7 anemometer. Anemometer observations are also available from 1 to 10 m AGL



TOP: Multiple DOW and in situ array deployment (left) and DOW7 deployed on a levee (right). Dual-Doppler baselines range from 1.72 to 6 km; the smallest multiple Doppler network in a hurricane, to date.

RAPID-SCAN DOW
2003:56 UTC

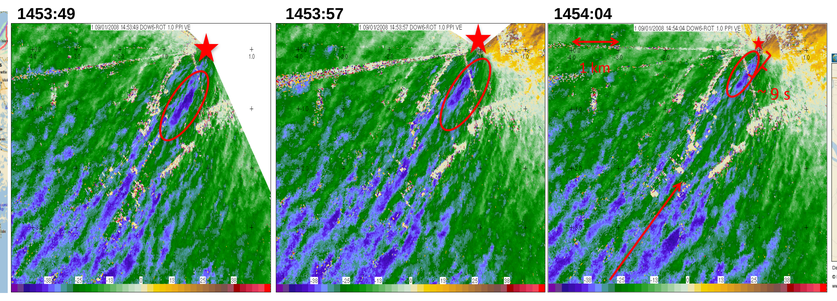




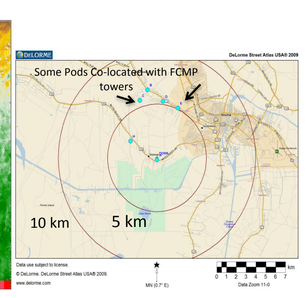
TOP: Example of DOW7 and DOW6 Doppler velocity observations.

HURRICANE GUSTAV (2008): Correlation of Structural Damage with Individual Wind Streaks

ABOVE: Deployment locations of DOW6 and five PODs (aqua circles) relative to path of Gustav's eye.



ABOVE: DOW scans every 8 seconds through an individual wind gust as it destroys a building. DOW data indicate the leading edge of the most intense portion of the wind-streak / gust impacts DOW and building at 1454:04 + :09 = 1454:13.



ABOVE: Details of DOW, Tower, Pod deployment. Brown circles depict range from the DOW.

ABOVE: Screen captures of video taken of roof collapse ~5 m from DOW. Collapse begins at about 1454:13 UTC.