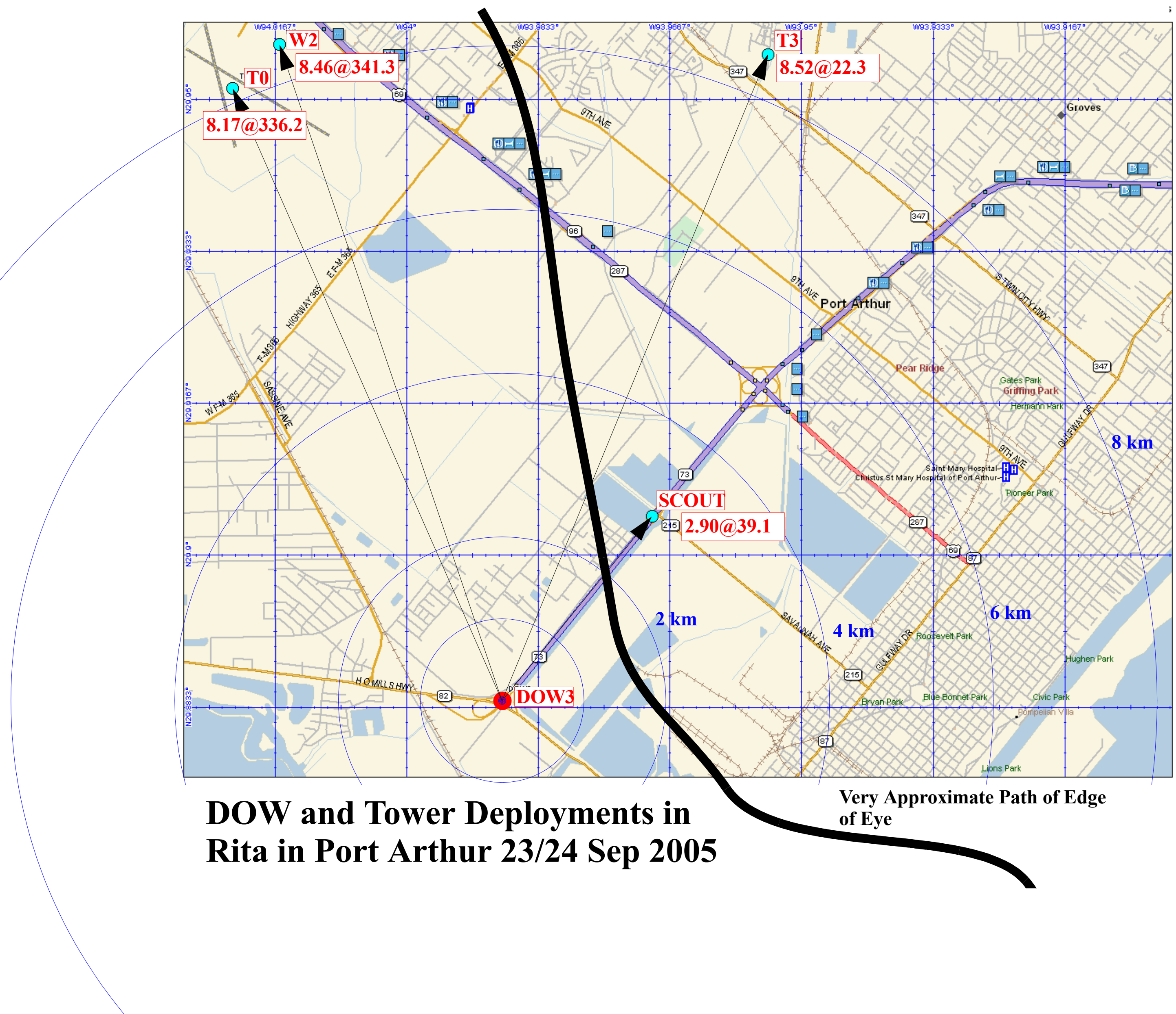
Preliminary Comparison of DOW and In Situ Wind Measurements in Hurricane Rita

Joshua Wurman, Center for Severe Weather Research, jwurman@cswr.org 720-304-9100
Curtis Alexander, University of Oklahoma
Paul Robinson, Center for Severe Weather Research
Forrest Masters, Florida International University

A Doppler On Wheels (DOW) mobile radar and an instrumented support vehicle (SCOUT) were deployed by the Center for Severe Weather Research (CSWR) to intercept the landfall of Hurricane Rita on 23-24 September 2005. The Florida Coastal Monitoring Program (FCMP) deployed several instrumented towers to the landfall region. Close coordination of the DOW and FCMP teams permitted a valuable combined data set to be collected. Boundary layer wind streak signatures were evident in both the DOW and tower data and individual specific wind gusts were resolved by both radar and tower instrumentation.

The DOW3 radar was deployed on a highway overpass on the south side of Port Arthur, Texas (Fig. 1) approximately 8 km to the SSW and SSE of two FCMP towers, T0 and T3. The DOW

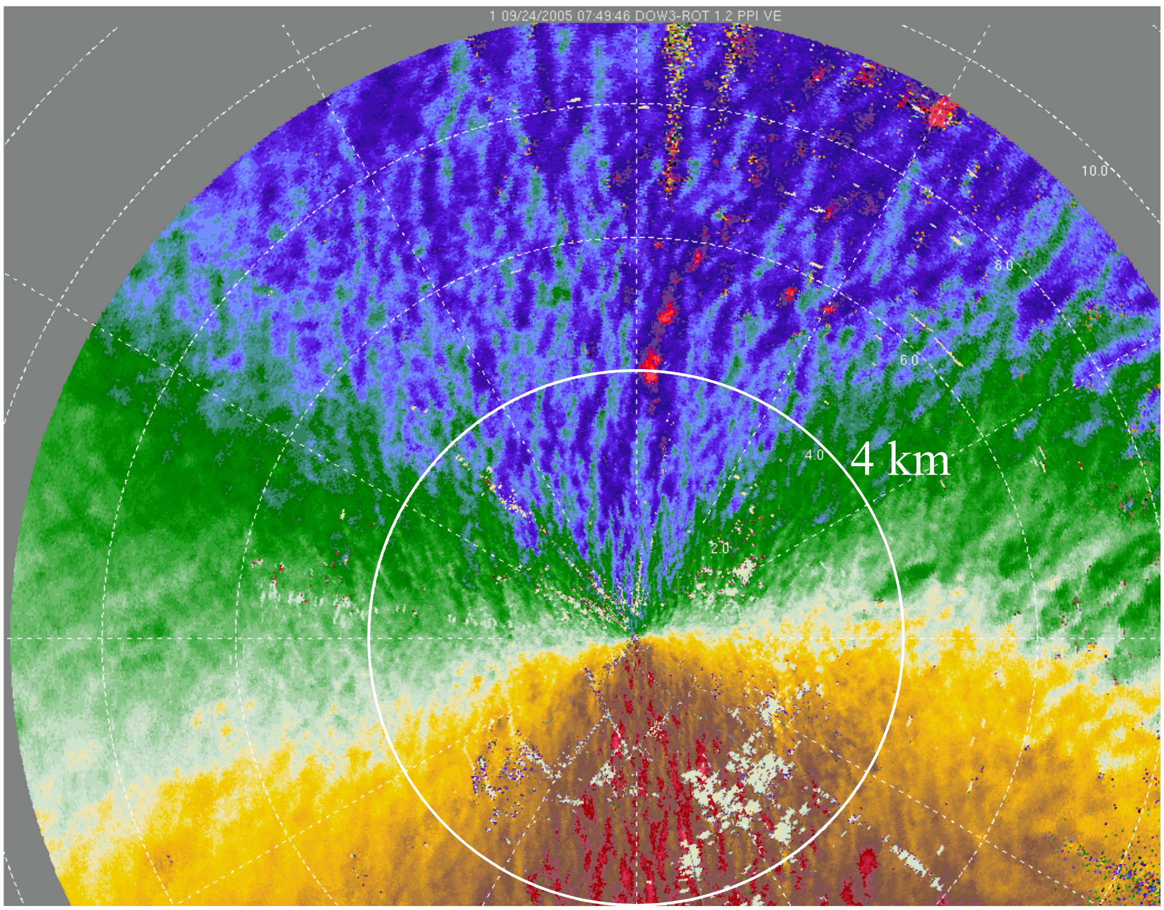


DOW and Tower Deployments in Rita in Port Arthur 23/24 Sep 2005

was deployed so that it was nearly directly downwind of one or the other towers during NE then NW winds associated with the landfall as the center of the eye of Rita crossed just to the east of Port Arthur. The western edge of the eye, as revealed by DOW reflectivity data, passed across Port Arthur.

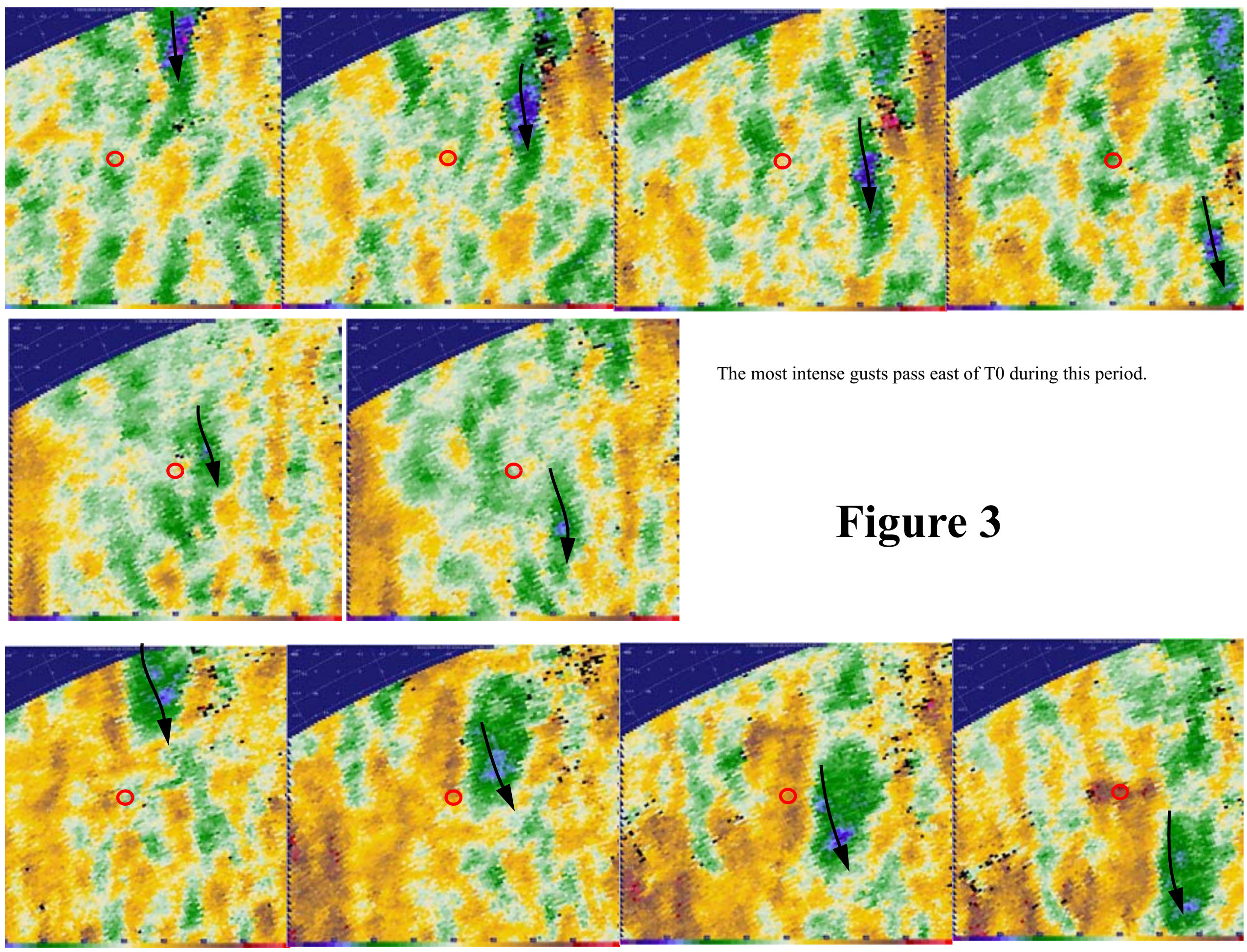
During a several hour deployment, the DOW collected data at only one elevation angle, 1.2° (with a few very short period exceptions), conducting 360° survey scans every 11-12 seconds, resulting in approximately 3000 sweeps at this single level. Radar gates were 25 m, resulting in unprecedented spatial and temporal scale, albeit only 2D, resolution of boundary layer structures and evolution.

The expected fine-scale boundary layer rolls, with wavelengths << 1 km, were revealed (Fig. 2).



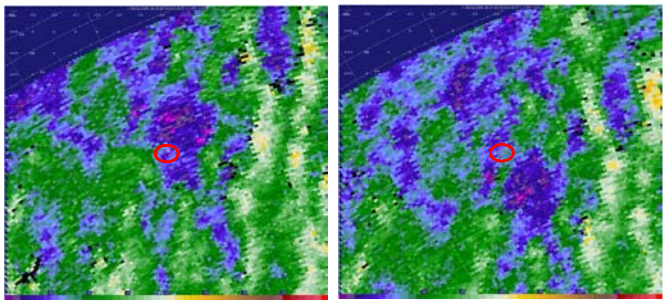
In this case, due to the 11-12 s update rates of the scans, the propagation and evolution of features within the wind streaks associated with these rolls was revealed.

Individual features in the wind streaks, moving at ~35 m/s, could be resolved as they impacted, or just missed the T0 and T3 towers. (Figs. 3,4,5) In Figure 3, three different intense wind gusts pass just to the east of tower T0, missing by < 1 km. In Figure 4, a broad region of high wind is seen to impact T0. In Figure 5 various wind field structures revealed in the DOW data impact or miss T0.



The most intense gusts pass east of T0 during this period.

Figure 3

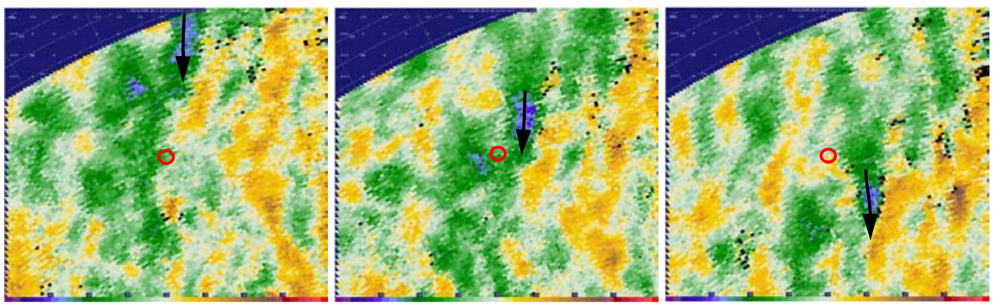


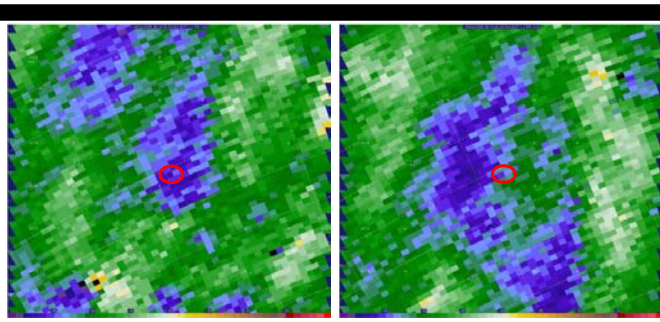
08:21 high wind period (zoomed out)

Figure 4

Velocity scale in plots below is re-centered

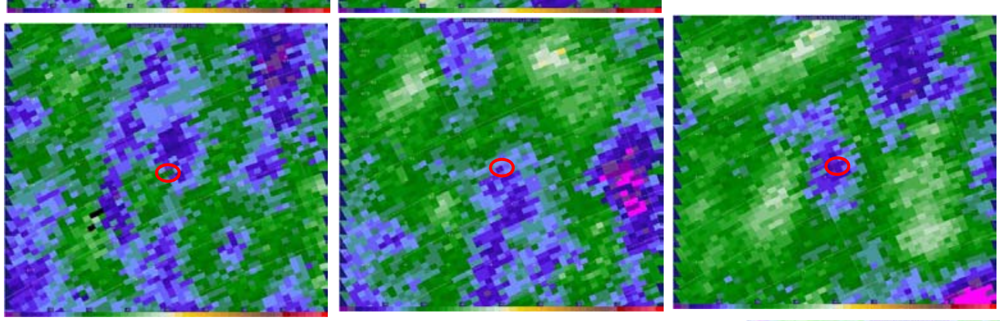
Strong gust just missing T0 to east



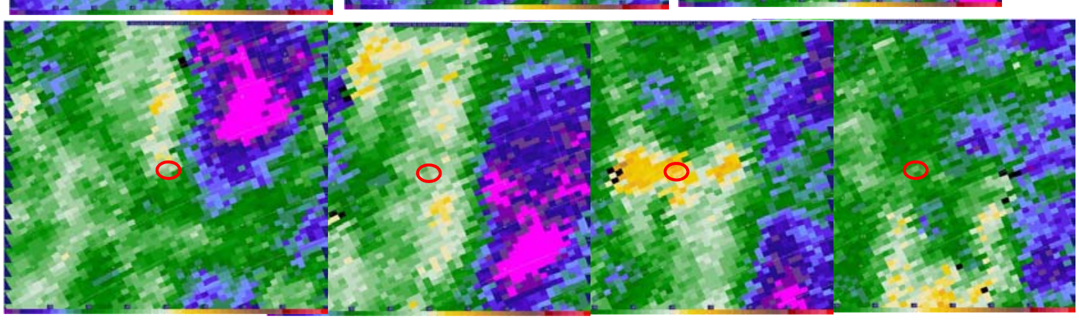


08:19:30 gust

Figure 5



08:26:30 high period

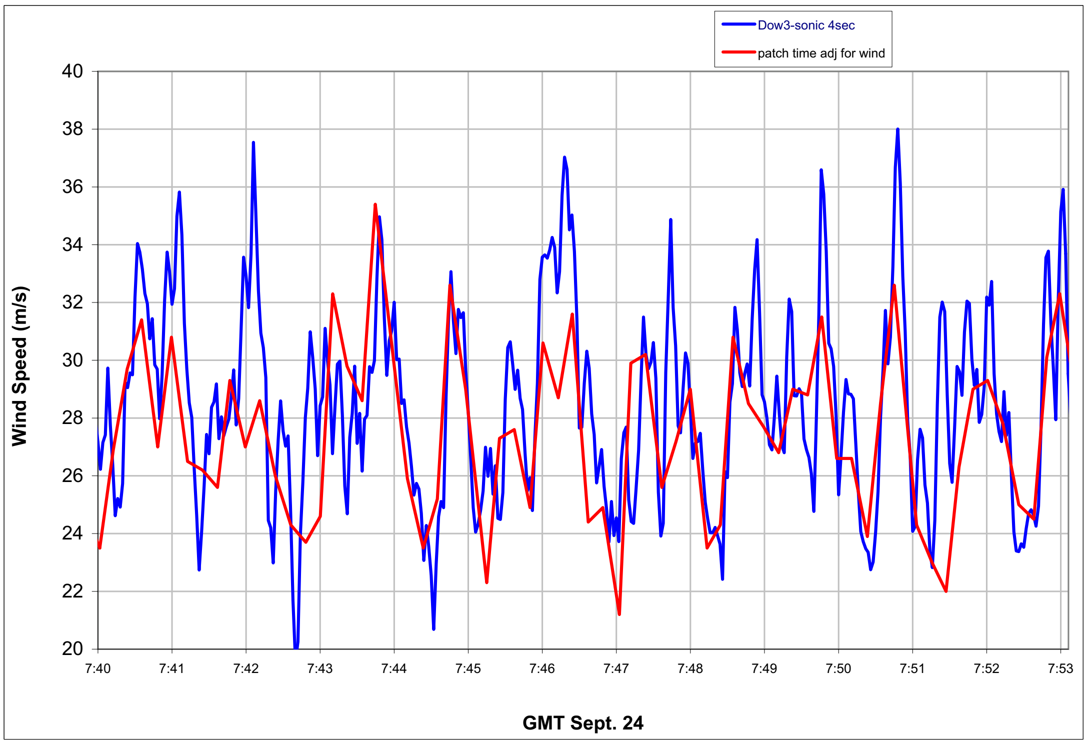


08:28
lull

gust
passes
to east

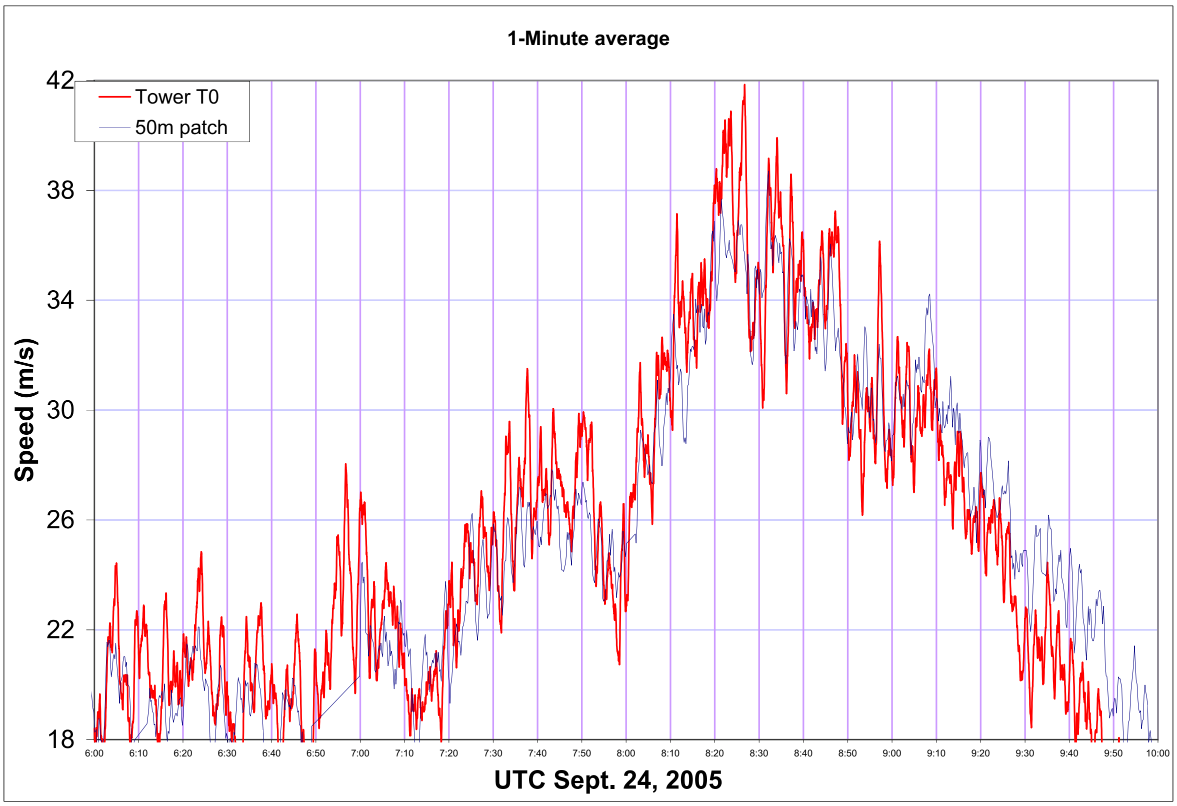
The DOW 2D wind fields, as they evolve in time, and pass over T0, T3, SCOUT, and the DOW3 10 m instrumented tower, can be compared to the time series from the in situ instruments.

Doppler data from limited ranges, typically 50 m x 50 m "swaths", are compared to anemometer data. In Figure 6, DOW Doppler data from a "swath" 200 m upstream of the DOW, at an altitude of 7 m above the DOW (about 10-15 m AGL) are compared to sonic anemometer data. To allow for propagation of the gusts, the sonic data are lagged by 8 seconds. Very close correlation is seen between the Doppler "gusts" and the anemometer gusts.



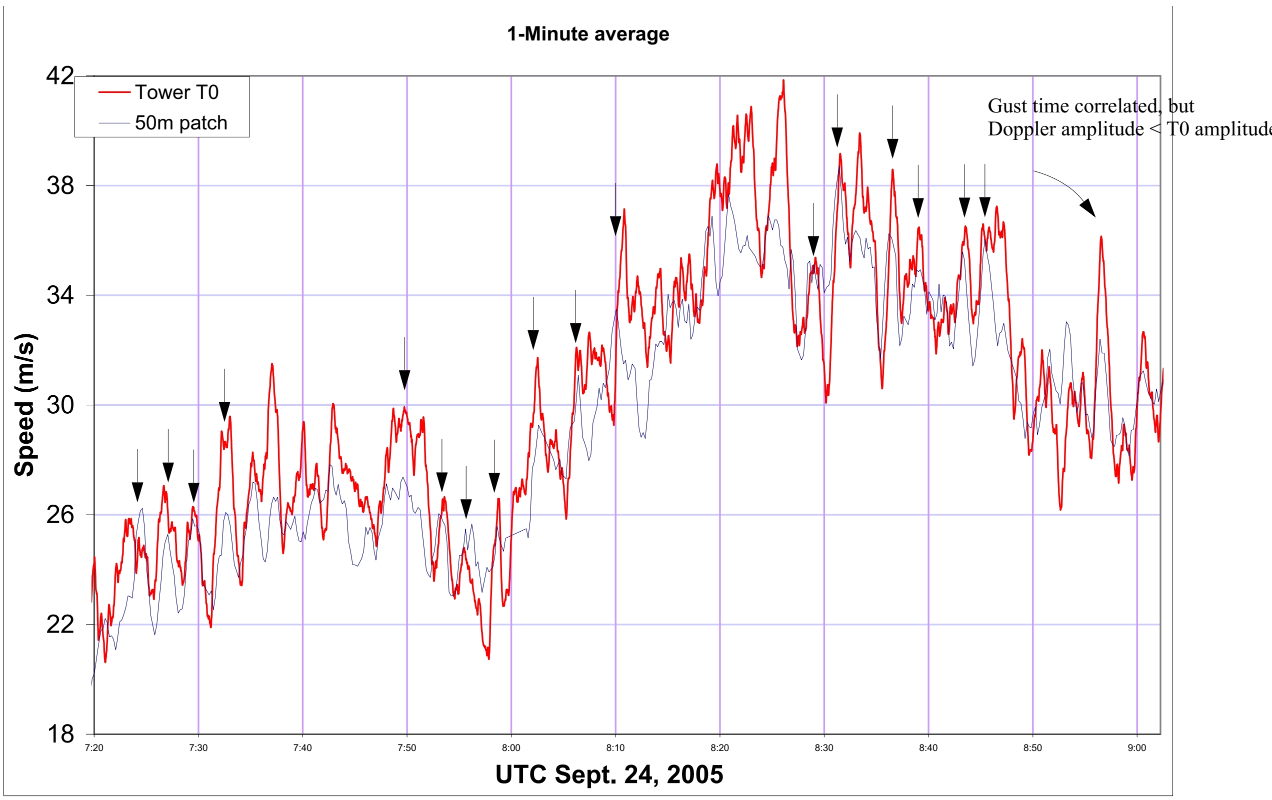
Comparison of DOW3 sonic anemometer winds, 4 s average, with upstream Doppler winds averaged over a 50 m radius circle at 200 m range. 4 s anemometer averaging chosed to correspond to 100 m trajectory @ 25 m/s. At 1.2°, 200 m range is about 7 m above DOW wheel level. An 8 s lag is applied to the Doppler data to allow for parcel propagation to the anemometer (200 m @ 25 m/s).

Using the same technique, DOW Doppler 50 m "swath" data from approximately 175 m above T0 is compared to the T0 anemometer time series. A correction factor of 0.7 results in nearly overlapping time series during the early and main portion of the landfall. Later, after the eye passage, the T0 data are < 0.7 that of the 175 m DOW data, probably due to less efficient mixing of momentum down to the 10 m AGL level in the weaker convection post-landfall.



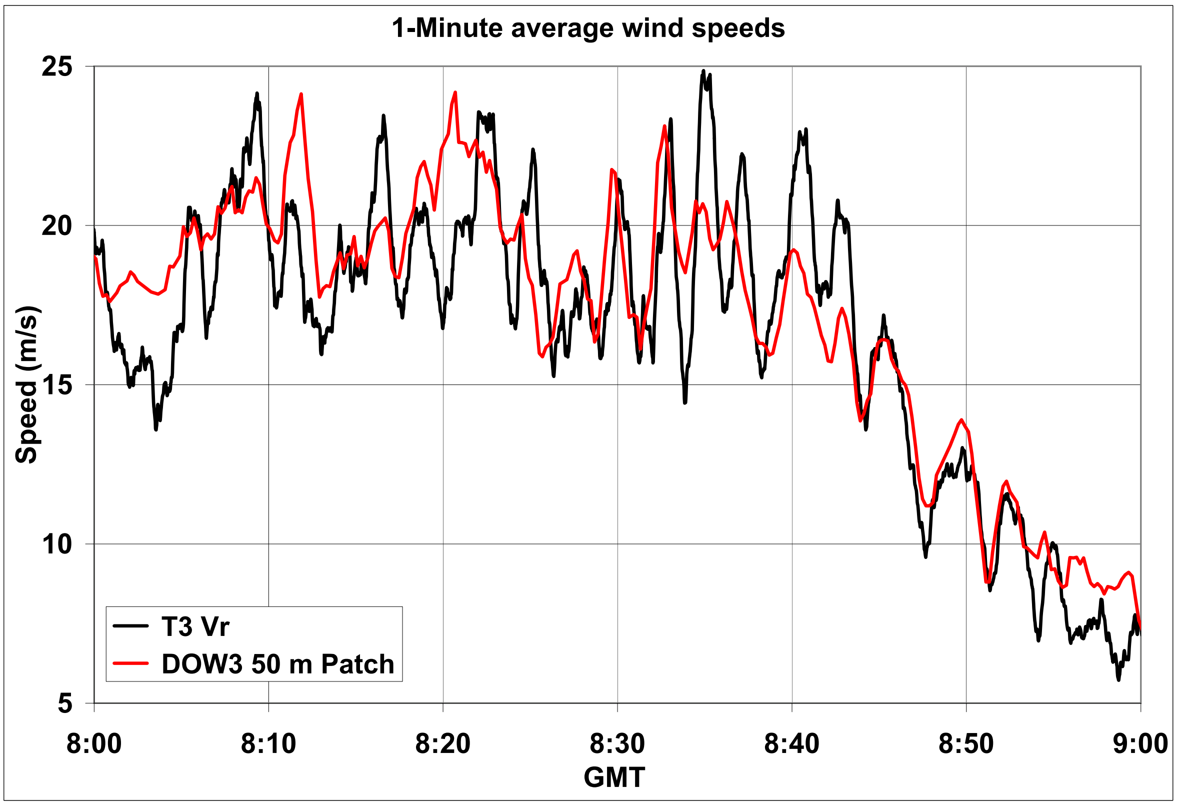
Comparison of 60 s average FMCP T0 winds with 50 m radius patch 60 s average (5x 12 sec sampling).
T0 data has been normalized by the cosine of the Doppler vs anemometer wind direction crossing angle.
Doppler data has been normalized by a 0.7 correction factor which closely aligns data prior to 09:10 UTC.
Ater 09:10, a reduction factor of less than 0.7 should be used.
DOW3 beam height (1.2° @ 8170 m range) is about 175 m above DOW wheel height (haven't surveyed DOW wheel and T0 height yet)

Not only do the long period average winds correlate excellently between the DOW and T0, but individual gusts (as visualized in DOW Figs 3,4,5) are closely correlated, at least most of the time. Individual gusts are denoted by black arrows in the figure below and most are evident in both the DOW patch and T0 anemometer data.



Comparison of Doppler and FMCP T0 winds over shorter time period to illustrate qualitative alignment of 1-min period gusts.
Amplitude of 1-min variability is higher at T0, probably due to inadequate spatial averaging method for Doppler patch. (soon to be corrected)
Same 0.7 normalization and cosign corrections applied.

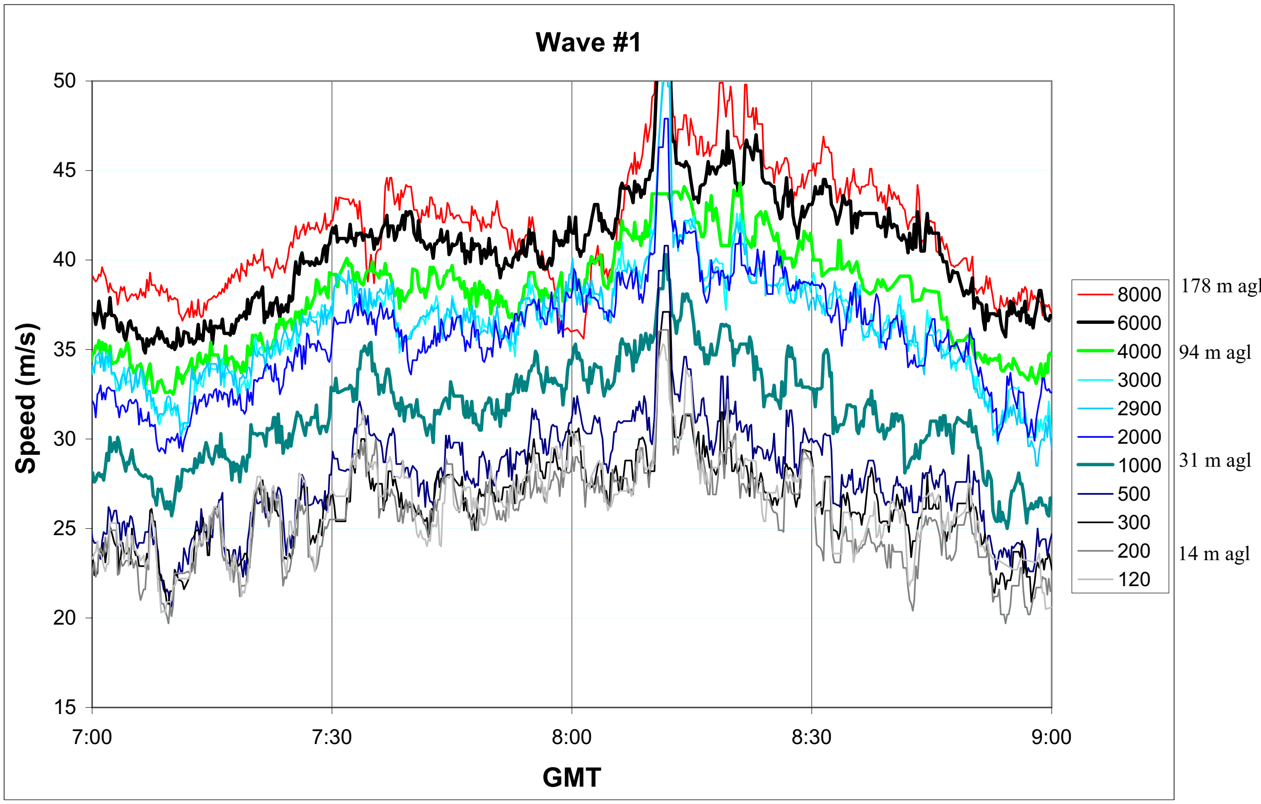
Similar calculations were performed over FCMP tower T3. While T0 was located at a very exposed airport site, T3 was more sheltered. The T3/DOW correction factor was found to be closer to 0.43.



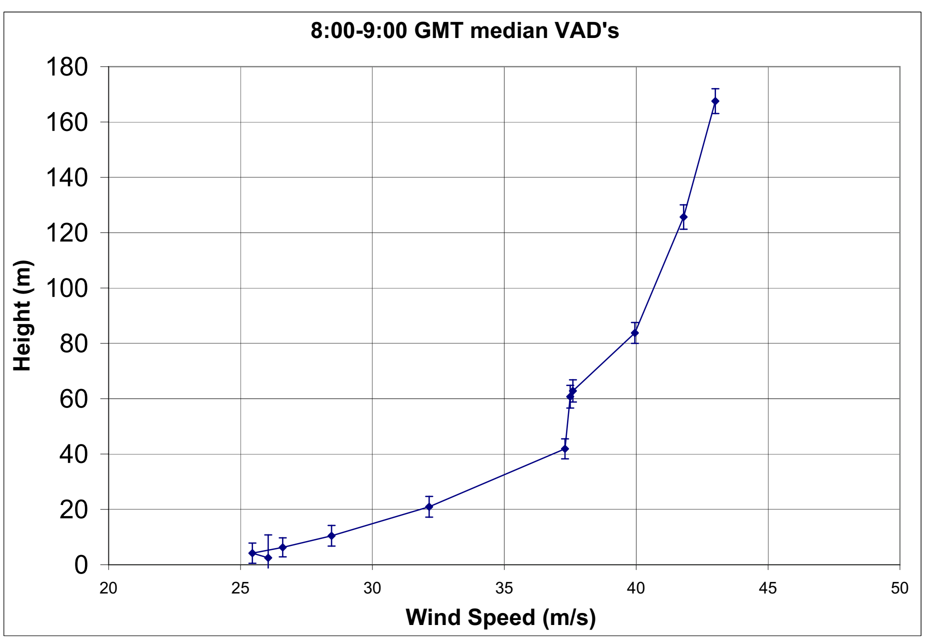
Similar DOW Doppler and FCMP T3 comparison. 0.43 normalization for apparently more sheltered location applied as well as cosine correction. 1-min gusts seem to be well correlated.

If 0.7/0.43 correction is applied to normalize the T3 data to the T0 exposure (using the DOW exposure-independent patch measurements at 100 m agl), then the corrected peak windspeeds at T3 are slightly higher than those at T0, which is what one would expect meteorologically since T3 was closer to the passage of the center of the eye of Rita.

Using VAD techniques, vertical windfield profiles were obtained every 11-12 s.



Time history of wavenumber 1 from 12 s DOW VAD's during passage of Rita.



Wavenumber 1 vs height.

Data from the SCOUT vehicle were examined to study the accuracy of sonic anemometer data. At speeds above 35 m/s, in intense rain, the sonic data appeared to saturate.

The close correlation between the DOW and FCMP tower data suggest that high resolution 2D DOW data, taken at 30-200 m AGL, can be combined with FCMP tower data (corrected for exposure using DOW time series), to produce highly detailed surface wind field maps.