DOW Radar Observations of Wind Farms

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The DOW

•The DOW (Doppler on Wheels) is a mobile 3-cm wavelength radar designed to sample spatially and/or temporally small weather phenomena.

•Since the debut of DOW 1 during the 1995 tornado season, DOWs 1-8 have collected data in various field campaigns internationally.

•Due to its mobility and ease of use, the radar is ideal for student operation under educational deployments.

•DOW 7 (pictured below) was requested by the Department of Earth and Atmospheric Sciences at Purdue University in 2009.

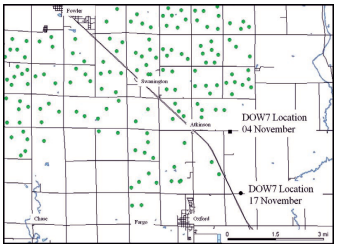
•The DOW radars are NSF Lower Atmospheric Observing Facilities and can be requested from the NSF through an expedited process for educational purposes (see www.eol.ucar.edu/deployment /educational-deployments).[1]

DROPS

DROPS: **D**OW **R**adar **O**bservations at **P**urdue **S**tudy

•Student-led field experiment in the Fall of 2009 deploying the DOW around northwestern Indiana.

•Class consisted of senior undergraduate and graduate students.



•Teams determined deployment and scanning strategies, then operated the DOW themselves.

Table 1. Roof observations on the four-story civil engineering building at Purdue University during both deployments.

	4 Nov 2009	17 Nov 2009
Time of observation (UTC)	1750–1810	1500–1600
Max temperature	12.6°C	6.1°C
Min wind speed (kts)	16	17
Prevailing wind direction	210°	60°

Wind Farm Deployments

•Two teams deployed the DOW at a wind farm in Benton County, Indiana on separate days.

•One day of clear air sampling (4 Nov 2009) and one day of scanning in heavy rain and winds (17 Nov 2009; see Table 1).

•Both PPI and RHI scans were conducted (see Table 2).

Table 2. Scanning strategies for 4 Nov 2009 at 40.562°N, 87.224°W.

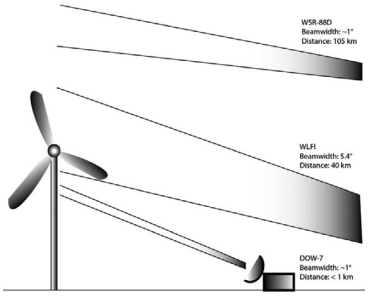
Scan type	Elevation range	Azimuth range	Azimuth/elevation rate
PPI	0.5°–15.5°	45°–135°	5° s^{-1}
RHI	0.5°–15.5°	60°–90°	5° s^{-1}
RHI	0.5°–15.5°	90°–120°	5° s^{-1}
PPI	0.5°–15.5°	10°–180°	5° s^{-1}

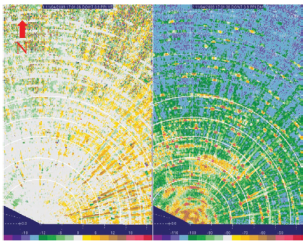
Results

•Results from the DOW were qualitatively compared to two other local Doppler radars: KIND and WLFI.

•The large beamwidth of the WLFI TV radar results in nearly constant wind farm sampling.

•Due to the WSR-88D's distance from the wind farm, the turbines are only sampled in certain weather conditions.





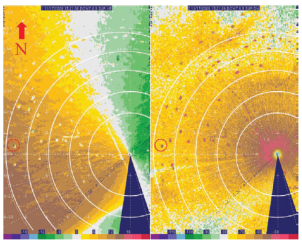
•The clear air deployment resulted in patterns consistent with beam blockage and multipath scattering.

•Azimuthal velocity differences between adjacent radial beams were as high as 30 ms^{-1}.

•Differences across the wind farm field may be due to variations in the angle of attack of the radar beam relative to the turbine blade.

•The deployment in heavy precipitation did not result in multipath scattering, but did produce isolated velocity couplets.

•The figure to the right denotes a region of high shear and reflectivity returns, corresponding to a velocity difference of ~30 ms^{-1}.



Conclusions[1]

•The deployment of the DOW near the Benton County Wind Farm in November 2009 resulted in the observation of features that have been found in previous studies on the impact of wind farms on WSR-88D operations, including multipath scattering and velocity couplets that appear as isolated tornadic vortices.
•The clear-air day [4 November] exhibited mostly multipath scattering, whereas the main observations on the precipitating day were of isolated velocity couplets.
•Velocity couplets on the precipitating day (17 November) were only present in the lowest elevation scans, which may result in the identification of a low-level couplet by the WSR-88D detection algorithms.
•In the DOW data, the features are exaggerated, because of the close proximity of the DOW relative to the wind farms.
•The authors…hope that this work serves to illustrate the importance of enabling students at various educational levels in the atmospheric sciences to have the opportunity to participate in field work and to engage in the investigation of current problems in their area of study. Such programs can not only prove to be an excellent learning experience but may also create a foundation upon which further research can be based.

Reference

[1]Toth, M., E. Jones, D. Pittman, D. Solomon 2011: DOW radar observations of wind farms, Bull. Amer. Meteor. Soc., 92, 987–995.