2nd University of Nebraska DOW Education and Outreach (UNDEO-2)

Final Report

1. Introduction

The second **U**niversity of **N**ebraska **D**OW **E**ducation and **O**utreach (UNDEO-2) project was conducted in the spring of 2011. Both UNDEO (in 2008) and UNDEO-2 were supported as "educational deployments" of the NSF Lower Atmospheric Observing Facilities. This support enabled a 14-day deployment of a Center for Severe Weather Research Doppler on Wheels (DOW) to meet the following two principal objectives:

1. *Education*: Provide undergraduate and graduate students in Dr. Adam Houston's *Radar Meteorology* course an opportunity to use a sophisticated research radar to collect data for student research projects
2. *Outreach*: Exhibit a platform in the NSF deployment pool to a broad audience of current and future scientists and members of the general public.

During UNDEO-2 students deployed DOW 6 near Kansas City, MO where data on multiple airmass boundaries along with "training" supercells were collected. The DOW was also exhibited to the nearly 1,000 visitors of the 11th annual Central Plains Severe Weather Symposium.

2. Education goals and activities

The main goal of the education component of this project was to *significantly advance student understanding of weather radar theory and applications through the operation of a cutting-edge research radar and analysis of the data collected*. UNDEO-2 achieved this goal through the following: Students in Radar Meteorology,

1. Developed research projects that used data collected by the DOW during UNDEO-2
2. Were trained by Justin Walker (radar technician for the Center for Severe Weather Research - CSWR) to operate the DOW
3. Completed a "lab" exercise that used the DOW for a guided exploration of fundamental concepts in radar theory
4. Developed an experiment design to use the DOW to collect data necessary for their proposed research projects
5. Executed the experiment in at least one of the three IOPs conducted during UNDEO-2
6. Analyzed the data collected and synthesized their results into final term papers

The schedule followed during UNDEO-2 appears in Table 1.

Table 1 Schedule for UNDEO-2

10 March	Student project abstracts due
17 March	IOP planning meeting.
27 March	DOW arrived on campus
28-29 March	DOW operation training
30 March	DOW lab exercise
2-4 April	Deployment near Kansas City, MO

4-8 April	Supplemental DOW data collection in the Lincoln area
5 April	Dr. Kosiba's departmental seminar and Q&A during *Radar Meteorology* and *Severe and Hazardous Weather*
9 April	Exhibition of DOW at 11th Central Plains Severe Weather Symposium
10 April	DOW leaves campus
27 April	Student term papers due

Individual graduate students and undergraduates in small groups were tasked with developing research projects that dealt with phenomena that could be associated with a frontal passage; a meteorological event that we felt had a high probability of occurrence during UNDEO-2. Students were given the freedom to determine the specific focus of their project but were vetted by Dr. Houston in his review of their project abstracts, submitted 2 weeks prior to the DOW's arrival on campus. Research topics were generally focused on basic concepts in radar meteorology. This simplicity was imposed in the vetting process to ensure that students were able to complete the work in ~1 month's time following the IOPs. The list of student project topics follows:

- The Impact of Spatial Resolution on the Velocity Field: A Comparison between DOW and WSR-88D Data
- Evaluating the Evolution of a Gust Front using a DOW
- Wavelength Disparities between the WSR-88D and DOW 6
- Time Series of Helicity Calculated from VAD-Derived Wind Profiles
- The Correlation Between Vertical Velocities And Reflectivity Values
- The Effects of a Gust Front on Winds Above the Boundary: A Field Study
- Comparison of a Thunderstorm Gust Front Observed by the DOW to Density Current Theory
- Modification of a Gust Front by an Urban Area

Following abstract submission and review, the students met as a group with Dr. Houston to devise a deployment and scanning strategy that would yield data that could best satisfy every project objective. This planning meeting was not only a logistical necessity but also 1) gave students a sense of the challenges involved in executing a collaborative field project and 2) reinforced the cooperative nature of the overall endeavor.

DOW 6 arrived on campus Sunday 27 March and the training for DOW operations commenced on Monday. The training was administered by Justin Walker, CSWR Technician. Every student in Radar Meteorology was trained to operate the radar. The training covered basic DOW operation including powering up the radar; scheduling, configuring, and visualizing radar scans; and powering down the radar. New to the training process for UNDEO-2 was a training manual developed by Mr. Walker. The students found this manual very helpful both during the training and during the IOPs.

As with UNDEO-2, airmass boundaries served as the focus of the IOP for the first UNDEO, which took place in November 2008[1]. However, in part as a consequence of limiting the IOP to southeast Nebraska, the primary IOP of the first UNDEO was only marginally successful. One strategy to increase the probability of a successful IOP could have been to increase the project

[1] More information on the first UNDEO, including the final report, can be found at www.eol.ucar.edu/deployment/educational-deployments/undeo.

length from 14 to, say, 21 days. However, in UNDEO-2 we adopted the strategy of broadening the region over which the IOP could be executed: the IOP was allowed anywhere within ~800 km of Lincoln that targetable meteorological phenomena were predicted for the predetermined date of the IOP. This turned out to be an effective strategy for UNDEO-2.

Three IOPs took place during UNDEO-2 (Table 2). Radar operations during the deployments were performed by the students working in shifts. The cooperative nature of such an activity had the ancillary benefit of fostering teamwork amongst the students.

Table 2. Intensive operation periods during UNDEO-2.

IOP 1	3 April	17:32-19:00Z	6 km north of Pleasant Hill, MO	Clear air Daytime PBL
IOP 2	4 April	00:56-03:04Z	7 km east of Spring Hill, KS	Cold front Gust front Training supercells
IOP 3	7 April	20:10-21:41Z	3 km southeast of Ashland, NE	Stratiform precipitation

The IOPs of 3-4 April were part of a deployment to the Kansas City, MO area (Figure 1). In IOP2, more than 2 hours of data were collected on a cold front that initiated a series of supercells and associated gust fronts that passed within range of the DOW (Figure 2). In-situ near-surface observations of temperature, moisture, pressure, and wind were also collected by a CSWR tornado pod deployed near the DOW (Figure 3) and by a mesonet station on the DOW. The radar data collected during IOP2 were used in every student project.

Figure 1. Students participating in IOP2 near Kansas City, MO.

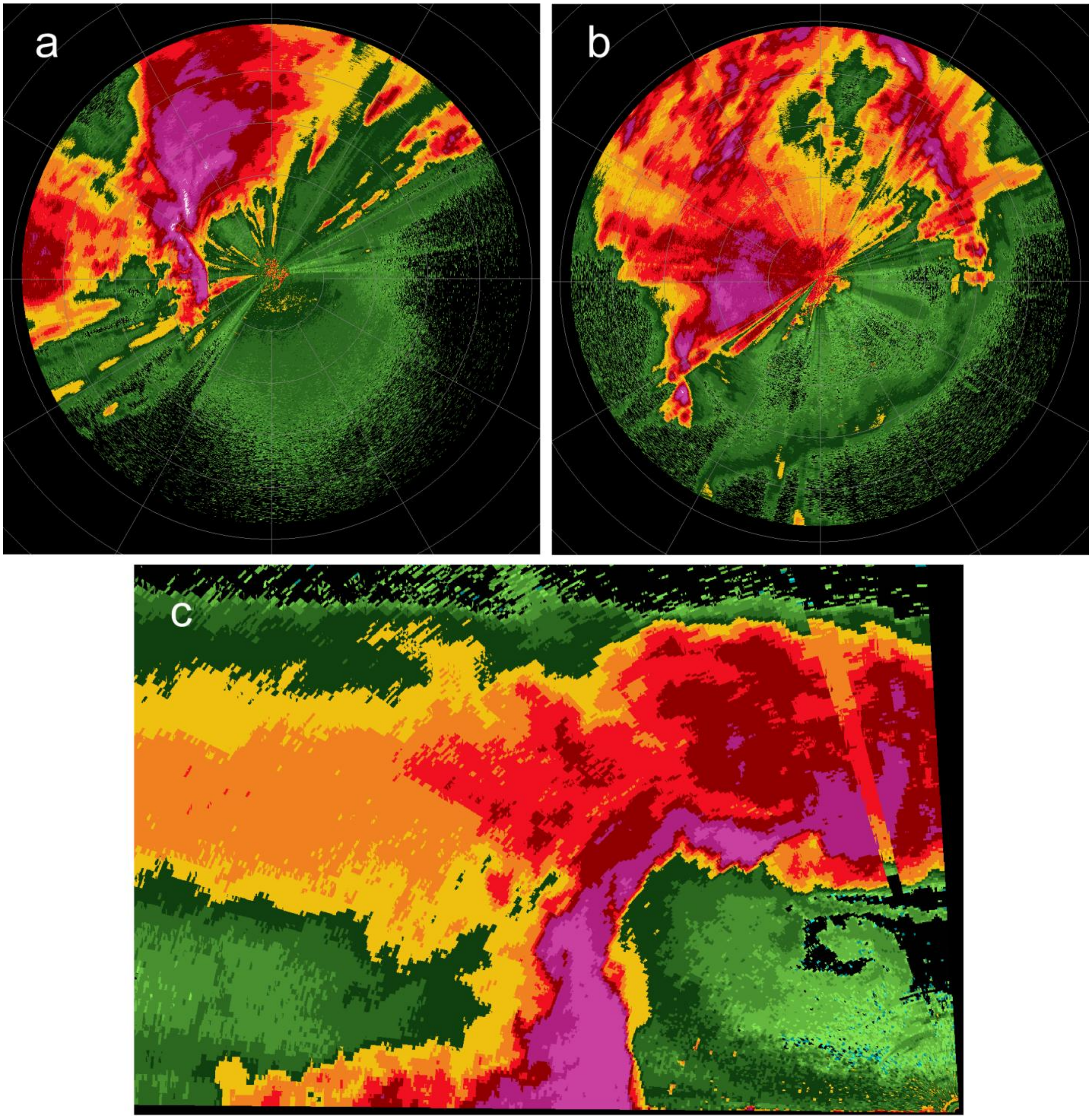

Figure 2. Examples of the DOW data collected during IOP2. a) PPI at 01:54Z of a supercell just west of the radar, b) PPI at 02:21Z of fineline south through east of the radar associated with the gust front from the supercell illustrated in panel a, and c) RHI at 01:57Z taken at west southwest through the pendant of the supercell illustrated in panel a.

UNDEO-2 also offered students in *Radar Meteorology* as well as non-major undergraduates enrolled in the William H. Thompson section of *Severe and Hazardous Weather* the opportunity to participate in a Q&A session administered by Dr. Karen Kosiba, Center for Severe Weather Research senior scientist (Figure 4). Severe *and Hazardous Weather* is a general education course with a typical enrollment of ~150 students. The William H. Thompson (WHT) section of this course is a restricted enrollment (~30 students) section that is part of the WHT Scholars

Learning Community. WHT scholars have been awarded a Susan T. Buffett Foundation scholarship, eligible to low-income students who have graduated from Nebraska high schools and exhibit strong academic potential. Dr. Kosiba also presented a brown-bag seminar to the students and faculty of the Department of Earth and Atmospheric Sciences.

3. Outreach

The principal component of the outreach objective was the exhibition of DOW 6 at the 11th annual Central Plains Severe Weather Symposium (CPSWS; Figure 4). Organized by Dr. Ken Dewey, the CPSWS targets a broad audience primarily composed of members of the greater-Lincoln community but also includes students and faculty from the Meteorology/Climatology program as well as students enrolled in general education courses taught within the program. The CPSWS also attracts employees of the nearby NWS office in Omaha/Valley and the Air Force Weather Agency at Omaha's Offutt AFB.

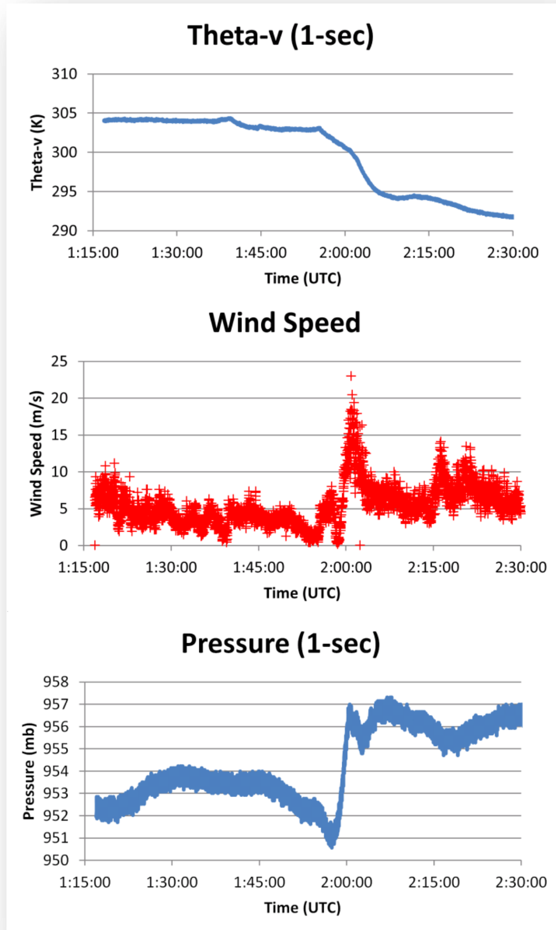

Figure 3. Tornado pod data collected during IOP2.

4. Assessment of Student Learning

The success of UNDEO-2 and identification of opportunities for improvement were assessed using the following vehicles:

- <u>Anonymous survey of the students</u>
  Students were asked to evaluate how well the learning objectives were met. The survey and average results are included in Table 3. Student comments on UNDEO-2 from end-of-semester course evaluations appear below:
  - "The DOW experience is unmatched by any other in any class. It's very beneficial to physically use the radar to better understand what we're taught in the classroom."
  - "Maybe two weekends of deployment would allow more students the opportunity to operate the DOW."
  - "Wish we had more time with the DOW."
  - "I really enjoyed and got a lot out of the DOW project."
- <u>Graded assessment in *Radar Meteorology*</u>
  Student learning was also measured through standard assessment tools ("lab" exercise, final exam, project report, etc.) The "lab" exercise used appears in Table 4.

Figure 4. (Left) Dr. Karen Kosiba holding Q&A session with the William H. Thompson scholars section of Severe and Hazardous Weather. (Right) DOW 6 at the Central Plains Weather Symposium.

Table 3. Summary of student survey. Bold values are the average scores received.

1. Karen Kosiba's Q&A	Very poor	1 2 3 4 5 **3.77**	Very good
2. Length of the on-campus deployment of the DOW	Too short	1 2 3 4 5 **2.62**	Too long
3. Helpfulness of Justin Walker	Not helpful	1 2 3 4 5 **4.92**	Very helpful
4. Effectiveness of the DOW training	Not effective	1 2 3 4 5 **4.54**	Very effective
5. Involvement of students in the strategic planning of the deployments for data collection	Too little	1 2 3 4 5 **2.92**	Too much
6. Involvement of students in the actual deployments for data collection	Too little	1 2 3 4 5 **3.0**	Too much
7. Overall benefit of the DOW visit	No benefit	1 2 3 4 5 **4.77**	Very beneficial
8. Overall enjoyment during the activities associated with the DOW visit	No enjoyment	1 2 3 4 5 **4.92**	Very enjoyable

Table 4. DOW "lab" exercise

METR 463/863 DOW Exercise

Assigned:
Due:

Your answers to the following questions will be based on 3 surveillance scans. Use an elevation angle that is low enough to get non-clutter returns. Each scan will be executed with a different configuration file. Capture images from the Hiq-Hi screen of **both** reflectivity and radial velocity for each of the following configurations:

Config File	PRF (Hz)	Pulse Duration	Hits
Single1	1,000	1 us	50
Single2	4,000	0.2 us	50
UNL10	1,000	1 us	10

Save the images from these scans and **include them in your write-up.**

1. Pulse Repetition Frequency sensitivity

   A. Calculate the maximum unambiguous ranges for the PRFs from Single1 and Single2.

   B. How does the theoretical R_{max} compare to the actual ranges of the data that are displayed?

   C. Calculate the Nyquist velocity for the PRF from Single1 and Single2.

   D. Determine the maximum (unfolded) radial velocity detected.

2. Beamwidth

   A. Note the beamwidth from the specifications of the DOW

   B. Assuming a typical antenna efficiency for a circular, parabolic reflector, calculate the theoretical beamwidth of the DOW antenna system.

   C. How would the theoretical beamwidth change if the wavelength was 10 cm instead?

   D. How much closer to a target would the DOW need to be if sampling required a beam diameter of 10 m?

3. Sensitivity to hit count

   The spatial resolution of data collected by a radar depends on factors that include beamwidth, dwell time and PRF, and pulse length. It also depends on how the data are processed at the software level. The number of pulses that are averaged to calculate a particular data point is referred to as hits.

A. Considering the time to independence, and assuming the same PRF, what impact would you expect the number of hits to have on the quality of the reflectivity and radial velocity fields?

B. Compare the scans from Single1 and UNL10 and qualitatively describe the impact the number hits on the reflectivity field.

C. Compare the scans from Single1 and UNL10 and qualitatively describe the impact the number hits on the velocity field.