The University of Nebraska DOW Education and Outreach (UNDEO) Project

1. Introduction

The University of Nebraska[1] is requesting a 14-day on-campus deployment of a Doppler on Wheels (DOW) for classroom-instruction and hands-on experience with a cutting-edge radar system. The **U**niversity of **N**ebraska **D**OW **E**ducation and **O**utreach (UNDEO) project has two principal objectives:

1. Education: To provide undergraduate and graduate students in *Radar Meteorology* an opportunity to use a sophisticated research radar to collect invaluable data
2. Outreach: To exhibit a new and valuable platform in the NSF deployment pool to a broad audience of current and future scientists and members of the general public.

The most direct benefactors of the educational component of this project will be the 15 students enrolled in *Radar Meteorology,* a course for upper-level undergraduate majors (10) and graduate students (5) in the University of Nebraska – Lincoln (UNL) Meteorology/Climatology program. These students will be trained to operate the radar, will collect data during at least one intensive operations period (IOP), and will use the data collected to produce small group research projects. Other majors in the Meteorology/Climatology program, particularly those with previous exposure to weather radar theory (~3-5 additional students), will also be invited to receive training in DOW operations.

The outreach component of this project will target a broader audience. The Meteorology/Climatology program consists of ~100 undergraduate majors and 18 graduate students. The program also teaches several general education courses with a total enrollment of ~250. These pools of students would comprise a sizable fraction of the audience that would benefit from the outreach component of this project. Outreach activities would also be opened to the larger university and greater-Lincoln community populations. The placement of Lincoln in tornado alley ensures that there will likely be considerable interest within the university and greater-Lincoln communities. The PIs also intend to advertise outreach activities through the NWS in Omaha/Valley, the Air Force Weather Agency (AFWA) at Offutt AFB, and the AMS local chapters in Omaha and at UNL.

2. Educational Goals and Activities

The goal of the educational component of this project is 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. The proposed project aims to achieve this goal through the following.

1. Students will be trained by a staff member of the Center for Severe Weather Research (CSWR) to operate the DOW
2. Students will complete a "lab" exercise that uses the DOW for a guided exploration of fundamental concepts in radar theory
3. Students will develop an experiment design to use the DOW to collect data necessary to answer a small collection of basic scientific questions
4. Students will execute the experiment in at least one IOP
5. Students will use the data collected to craft individual and small group research projects

[1] The University of Nebraska – Lincoln has been a UCAR member since 1979.

6. Josh Wurman, director of CSWR, will give a lecture on current research underway at CSWR and elsewhere in the storm research community.

In the week prior to the proposed deployment, students in *Radar Meteorology* will develop a general experiment design aimed at collecting data of a frontal passage during the 14-day deployment. Climatologically, at least one frontal passage is to be expected during a 14-day period in early-mid November. The students will plan for three scenarios: 1) frontal passage without precipitation, 2) frontal passage with non-convective precipitation, and 3) frontal passage with convective precipitation. The experiment design will focus on basic strategies for capturing phenomena/processes that will serve as the foci for the individual and small group research projects and will require only a cursory familiarity with the DOW. (In the unlikely event that there is no frontal passage, alternate meteorological phenomena will be targeted. It is quite unlikely that no suitable phenomena will occur during a 14 day period in November.)

The student projects will likely draw from the following list of topics:

- Evolution of meso-γ scale waves along a front
- Dual-Doppler wind analysis using the Omaha/Valley WSR-88D
- Bright band identification and interrogation
- Ground-clutter changes due to anomalous propagation
- Clear air detection as a function of radar parameters
- Kinematic vertical structure of a front
- Downbursts and vortices as manifested in Doppler radar data

Most of the topics are focused on basic concepts in radar meteorology. This simplicity is imposed deliberately to insure that both undergraduate and graduate students are able to complete the work in ~1 month's time following the IOP. It should also be noted that while the focus of the anticipated data collection is on frontal phenomena, the student projects will be flexible enough that the IOP can be focused on any targets of opportunity.

Approximately two-days of training are anticipated for the 15 students in *Radar Meteorology* and 3-5 additional students in the Meteorology/Climatology program. Immediately following the training, 1 day will be reserved for the students in *Radar Meteorology* to complete an exercise developed to further acquaint them with the operation of the DOW and to enable exploration of fundamental concepts in radar theory. Example questions are as follows:

- Execute two sector scans with two different PRF values. Calculate the maximum unambiguous range for each PRF. Qualitatively describe the change in the character of the reflectivity and velocity fields.
- Assuming a typical antenna efficiency for a circular, parabolic reflector, calculate the theoretical beamwidth of the DOW antenna system. How does this compare to the stated beamwidth? How would the theoretical beamwidth change if the wavelength was 10 cm instead? How much closer to a target would you need to be if sampling required a beam diameter of 50 m?
- Using the latest OMA sounding, use the raytrace program to calculate the beam path for the 0.5º beam. Is this superrefraction or subrefraction? How much smaller or larger would the ground clutter footprint be if standard refraction was assumed?
- Use the DOW to identify either a meteorological or non-meteorological target. What is the value of effective radar reflectivity factor of this target? What is the distance? Using the specifications of the DOW, calculate the amount of power associated with this return.

The IOP will be chosen by the students, PIs, and CSWR staff. Radar operations will be performed by the students working in shifts. The cooperative nature of such an activity has the ancillary benefit of fostering teamwork amongst the students. The IOP will also engender a sense of ownership of the data; a perception that will invariably add value to both the data sets and the projects that are crafted from them.

Student projects will be conducted in small groups and will culminate in both a paper and in-class presentation. It is hoped that the better student projects could also be submitted for presentation at regional and perhaps national conferences.

3. Outreach Goals and Activities

The proposed outreach component will serve to educate a general audience by exhibiting current and future NSF-supported storm-scale research. The principal mechanism for satisfying this objective will be a talk/open-house led by Josh Wurman. Prior to and immediately following the talk, the DOW will be available for viewing near the lecture hall.

4. Ancillary Student Benefits

It is anticipated that the students will benefit from this work in at least two additional ways. First, it is likely that several students from UNL will participate in the upcoming second phase of the Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX-2). The training and education of students provided by this project promises to increase the value of their contribution to VORTEX-2. Second, the data collected during this project can be made available to undergraduate students participating in the UNL UCARE research. UCARE (Undergraduate Creative Activities and Research Experiences) is a UNL program funded by the Pepsi Endowment and Program of Excellence funds aimed at creating "intellectual partnerships between UNL faculty and undergraduates by providing funds for research". UCARE funding can be solicited once each year to pursue research projects led by an undergraduate student who is guided by a faculty mentor.

5. Assessment of Student Learning

The success of this program and identification of opportunities for improvement will be assessed using the following vehicles:

- Anonymous survey of the students
  Students will be asked to evaluate how well the learning objectives were met and will also be asked to make recommendations for improvement.
- Graded assessment in *Radar Meteorology*
  Student learning will also be measured through standard assessment tools (final exam, project report, project presentation)

Request Form

Part I: General Information

Requestor Name	Adam Houston
Institution and Address	University of Nebraska, Department of Geosciences 214 Bessey Hall Lincoln, NE 68588
Phone and Email	(402)472-2416, ahouston2@unl.edu

Part II: Project Description

Project Title	The University of Nebraska DOW Education and Outreach (UNDEO) Project
Project Location	Lincoln, Nebraska
Start and End Dates	November 10-21
NSF Facilities Requested	1 - Doppler on Wheels
Number of Expendables Requested	None

Part III: Educational Activities Description

Number of Students Involved	Education: 12 Undergraduates, 8 Graduates Outreach: ~250 Undergraduates, ~15 Graduates
Desired Training Activities Conducted by Facility Staff	2 days of training to operate the DOW. One technician will also remain in Lincoln during the entire deployment.

Part IV: Operational Requirements

Data Needs	Archived radar data in DORADE format
Data Analysis Needs	Processing with Solo software and dual-Doppler analysis may require limited assistance following the project
Communication Needs	No special communication needs

University of Nebraska DOW Education and Outreach (UNDEO)

Final Report

February 2, 2009

1. Introduction

The University of Nebraska DOW Education and Outreach (UNDEO) project was conducted in November of 2008. UNDEO was an NSF-funded collaboration between the Department of Geosciences at the University of Nebraska – Lincoln (UNL) and the Center for Severe Weather Research (CSWR) that allowed for a 15-day on-campus deployment of a Doppler on Wheels (DOW) for classroom-instruction and hands-on experience. UNDEO had two principal objectives:

1. Education: To provide undergraduate and graduate students in *Radar Meteorology* an opportunity to use a sophisticated research radar to collect invaluable data
2. Outreach: To exhibit a new and valuable platform in the NSF deployment pool to a broad audience of current and future scientists and members of the general public.

The most direct benefactors of the educational component of this project were the 14 students enrolled in *Radar Meteorology,* a course for upper-level undergraduate majors (8) and graduate students (6) in the UNL Meteorology/Climatology program. These students were trained to operate the DOW, crafted research proposals for using the DOW, collected data during three intensive operations periods (IOP), and used the data collected in a class assignment. The outreach component of this project targeted a broader audience. The principal mechanisms for satisfying this objective were three presentations given by Dr. Josh Wurman, director of CSWR. The audiences for these talks (totaling ~160 people) were non-major undergraduates, Meteorology/Climatology undergraduates, and the general public. Additionally, Justin Walker (CSWR technician and DOW operator during UNDEO) exhibited the DOW to ~175 students at a local public elementary school.

2. Training for DOW operations

DOW-6 (Figure 1) arrived on campus Sunday November 9 and the training for DOW operations commenced on November 10. The training was administered by Justin Walker, CSWR Technician. All 14 students in Radar Meteorology, the PI of UNDEO (A. Houston), and 3 graduate students with prior radar meteorology coursework were trained. The training covered basic DOW operation including powering up the radar; scheduling, configuring, and visualizing radar scans; and powering down the radar. All training was administered in the first three days of UNDEO.

Figure 1. DOW-6.

3. Outreach presentations

Three outreach presentations were given by Dr. Wurman during his visit November 13-14. The first of these presentations was given to ~60 students in Dr. Deborah Bathke's survey-level *Severe and Hazardous Weather* class (Figure 2). The second presentation was to a general audience composed of ~75 people from the UNL and greater-Lincoln communities. The third outreach presentation was to ~30 UNL Meteorology/Climatology majors.

Figure 2. Josh Wurman talks with students in Severe and Hazardous Weather.

Additionally, during UNDEO Justin Walker and Alex Gibbs (UNL M.S. candidate and participant in a university K-12 outreach program) exhibited the DOW at Huntington Elementary School in the Lincoln Public School system. Approximately 175 students attended this exhibition.

As part of the educational component of UNDEO, Dr. Wurman also gave a fourth presentation to the *Radar Meteorology* class. This lecture was also attended by several recent graduates and several faculty (total attendance was ~20).

4. Student projects

Individual graduate students and undergraduates in small groups were tasked with developing radar 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. The students were given the freedom to determine the focus of their project. Several suggestions were made:

- Evolution of meso-γ scale waves along a front
- Bright band identification and interrogation
- Ground-clutter changes due to anomalous propagation
- Clear air detection as a function of radar parameters
- Kinematic vertical structure of a front
- Downbursts and vortices as manifested in Doppler radar data

Abstracts were submitted and graded with suggestions for improvements, particularly related to the hypotheses and methodology. Those students who chose to focus on a phenomenon that required precipitation were asked to design a backup plan. The following is a list of the projects proposed:

- "Comparison of radar measured clear air velocities with observed velocities"
- "Estimating the freezing level by detection of the bright band"
- "Changes in airmass boundary orientation/movement as it transitions from rural to urban regions"

- "Kinematic vertical structure of a cold front"
- "Comparing environmental variables using Doppler radar and idealized modeling"
- "Frontal passage and depth: A comparison of the DOW and 88D Doppler radars"
- "Manifestation of turbulence within a cold front"
- "Kinematics of frontal motion and structure"
- "Vertical structure of a cold front"

After the projects were formulated, the students met with the PI, Dr. Wurman, and Justin Walker to devise a deployment and scanning strategy that would yield data that could best satisfy every project objective.

5. DOW deployments

Three IOPs took place during UNDEO (Table 1) and while cold fronts were sampled on two of the deployments, data retrieved was incapable of satisfying many of the student project objectives. In IOP2 (Figure 3a), clear air scatterers were more than sufficient to represent the location of the cold front but the shallow layer of biological scatterers yielded a poor vertical presentation of the front. In IOP3 (Figure 3b), the density gradient and associated convergence across the cold front were insufficient to yield an adequate presentation of the cold front on radar. Because of insufficient data and limited time available for the students to revise projects, the PI decided not to require student projects. Instead, the data collected were used in an end-of-semester assignment that required students to interrogate the data and compare the fronts observed in IOP2 and IOP3.

Table 1. Intensive operation periods during UNDEO.

IOP 1	Nov. 16	17:27-18:26Z	1 mi SW of Davey, NE (12 mi north of Lincoln)	Clear air Daytime PBL
IOP 2	Nov. 22	17:25-21:00Z	1 mi SW of Davey, NE	Clear air. Back-door front
IOP 3	Nov. 24	00:49-02:39Z	4 mi ESE Falls City, NE (82 mi southeast of Lincoln)	Clear air. Cold front

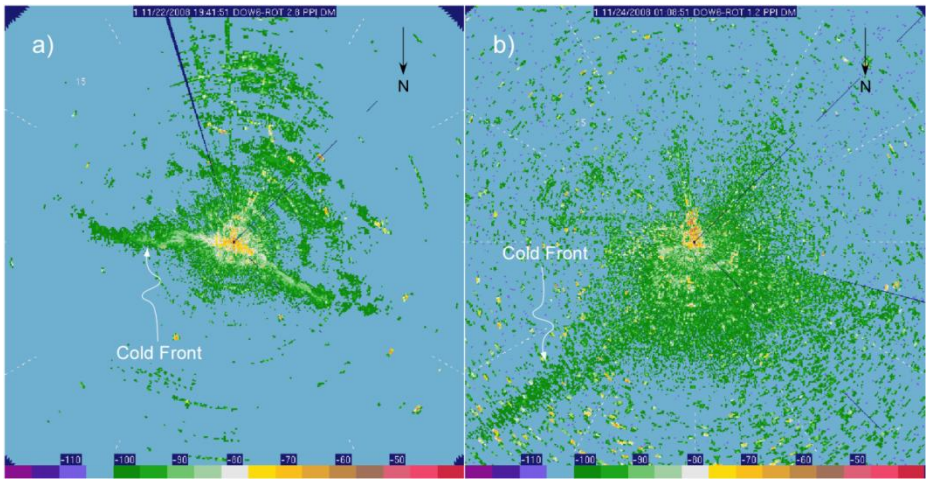

Figure 3. Cold fronts sampled in a) IOP2 (November 22) and b) IOP3 (November 24).

6. Evaluation of UNDEO

At the end of the semester, the students were surveyed in an effort to gauge the effectiveness of UNDEO and solicit suggestions for improvement. The survey and survey results are summarized in Table 2. A synthesis of the student comments and the PI's own observations appears below. Also included in this assessment are recommendations for avoiding problems encountered.

- The planning of student projects and execution of DOW field deployment was rushed. The PI submitted the UNDEO proposal in October for on-campus deployment the following month. This did not allow for enough time for the students to prepare their projects and feel involved in the strategic planning. The proposal to OFAP should be submitted no less than 6 months prior to the start of the semester in which the DOW is to be used.
- While the students generally felt that the length of the on-campus deployment of the DOW was long enough, they uniformly lamented about the lack of good cold fronts during the deployment. As stated above, the limited biological scatterers were partly to blame for the poor data. Thus, better data for this project would have been retrieved earlier in the semester. This experience also demonstrated that the training of students, strategic discussions, scouting for deployment locations, and talks by Dr. Wurman should all occur before field deployments. This significantly compresses the actual time available for field deployments. Therefore, 21 days seems to be a more appropriate time frame for on-campus deployment. Not only will this allow for more possible days for deployment and a better chance of retrieving good data, but will also insure that more students can participate in the deployments. The extra days of downtime associated with a longer deployment can be used for additional community outreach (e.g., DOW visits to local K-12 schools).
- Dr. Wurman's talks were well received but could have been better if more time was allotted for them. Several students suggested two lectures to the *Radar Meteorology* class and two presentations to the Meteorology/Climatology majors. Furthermore, it is very likely that the turnout for Josh's general audience talk would have been considerably higher if it had been on a Saturday instead of a Thursday. Thus, a 3-4-day visit by Dr. Wurman, with at least one day on the weekend, instead of a 2-day, Thursday-Friday visit would be better.
- Justin Walker was a great asset to the project. This speaks to Josh's abilities to interact with the students and his affable nature but also speaks to the need to have a CSWR staff member in residence during the entire on-campus deployment.
- It is important that all data collected during the deployments be uploaded to a local server prior to the completion of the on-campus deployment. During UNDEO, pod data were collected the last day before the DOW returned to Colorado. Unfortunately, the pod was left on during the return trip and the cyclic logger overwrote the data collected during the last deployment. Moreover, because the data needed to be transferred from Colorado back UNL and because Thanksgiving was immediately following the execution of UNDEO, there was about a week-long delay before the data were available to the students.

Table 2. Summary of student survey.

1. Josh Wurman's talk to the Meteorology/Climatology majors	Very poor 1 2 3 4 5 Very good 3.6	
• "There was way too much information in one short lecture. Maybe there should be two parts. If it is here for two weeks, there could a lecture each week."		
2. Josh Wurman's lecture to *Radar Meteorology*	Very poor 1 2 3 4 5 Very good 3.9	
• "Very interesting and beneficial." • "Obviously we didn't have enough time to cover everything. He should have tailored it more for 1.25 hr lecture." • "Needed more time to finish – it was good, wanted to see more examples." • "He went over a lot of storms he had been in. I wanted to know the ins and outs of the DOW." • "I would have really liked more info on the DOW. But all in all, it was very informative. It's great to learn about how tech. is used in a field type of setting." • "There was a lot of good information, but I feel like he was rushed. I found his strategy very interesting for collecting radar. I would like it if he taught two lectures, because it is very applicable to the class."		
3. Length of the on-campus deployment of the DOW	Too short 1 2 3 4 5 Too long 2.8	
• "Length of time was about right. Timing was just bad." • "Too short…we didn't get any good data!" • "Would usually be the perfect amount of time, but we had NO good fronts come through." • "I think it was the perfect amount of time; it was just unfortunate that the weather was not cooperating. I think you would get better data if it came one month earlier."		
4. Helpfulness of Justin Walker	Not helpful 1 2 3 4 5 Very helpful 4.8	
• "The guy was a real trooper. He was definitely a priceless asset to our experience with the DOW." • "Justin was very helpful. If the DOW comes back, send him with it."		
5. Involvement of students in the strategic planning of the deployments for data collection	Too little 1 2 3 4 5 Too much 2.3	
• "With some many projects it was hard to feel involved. Some had projects that were more active than others." • The planning of the deployment was very hands off. If we had more time to plan, I think it		

would be nice for the students to choose where we go or how to collect our data."

6. Involvement of students in the actual deployments for data collection

Too little 1 2 3 4 5 Too much

3

- "Uncontrollable times of deployment did not allow me to go out on a deployment."

7. Overall benefit of the DOW visit

No benefit 1 2 3 4 5 Very beneficial

4

- "I think this gives us an invaluable experience and an advantage when moving on in our careers"
- "In the future, if a good weather event comes through and students are able to complete their projects, I would recommend allowing time for them to present their findings to the class."
- "Good project for the class, just the timing wasn't right. Maybe mid-October would have worked better."
- "For future classes and attempts I think it will be better and be a great first-hand experience as it was still good experience this time to show difficulties in DOW deployment."
- "Excellent to use, easy to use, and an overall great experience to operate and learn from."
- "I hope they will be around more."
- "We didn't have enough time to get a good project together. Could be a good project with more time in the future."
- "I really enjoyed the experiment. I just wish we could have had more time to plan."

8. Overall enjoyment during the activities associated with the DOW visit

No enjoyment 1 2 3 4 5 Very enjoyable

4.2

- "I've been waiting a long time for some serious field experience. I think it's awesome to introduce this into the department."
- "I would've enjoyed it more if there were exciting events, which isn't anybody's fault! Overall it was fun."
- "The deployment was fun. It's neat to say that I have that experience under my belt. Very few people can say that they have operated a DOW."

7. Appendices

a. Press release for Josh's talk

Hurricane and tornado intercepts by the Doppler on Wheels Nov. 13

Released on 11/11/2008, at 2:00 AM

Office of University Communications
University of Nebraska–Lincoln

WHEN: Thursday, Nov. 13

WHERE: Wick Alumni Center, 1520 R Street

Lincoln, Neb., November 11th, 2008 —

The Doppler on Wheels, a mobile Doppler radar that has been used to retrieve unparalleled data near some of nature's most severe atmospheric phenomena, will be the subject of a Nov. 13 lecture at the University of Nebraska-Lincoln.

Josh Wurman, director of the Center for Severe Weather Research in Boulder, Colo., will speak at 5 p.m. in the Wick Alumni Center, 1520 R St. His talk will highlight the intercepts of hurricanes and tornadoes by the Doppler on Wheels.

Wurman and the DOW are featured on the reality series "Storm Chasers," airing on the Discovery Channel. The talk is free and open to the public and is sponsored by the National Science Foundation and the UNL Department of Geosciences. The DOW will be on display outside the Wick Center starting at 4:30 p.m.

Before serving as the director of the Center for Severe Weather Research, Wurman was an associate professor of meteorology at the University of Oklahoma. He earned his bachelor's, master's and doctoral degrees at the Massachusetts Institute of Technology.

The Center for Severe Weather Research is a nonprofit research organization funded primarily by the National Science Foundation, with close collaborations with the National Center for Atmospheric Research and Pennsylvania State University.

Contacts:

- Adam Houston, Assistant Professor, Geosciences, phone: (402)472-2416

b. Articles on visit on local television and papers

KOLN/KGIN (Lincoln/Grand Island)

http://www.kolnkgin.com/home/headlines/34973189.html

The DOW, or doppler on wheels, is a weather radar mounted on a truck. With it, scientists can see the small scale details of tornadoes, hurricanes and even wildfires. Dr. Joshua Wurman, with the center for severe weather research visited the capital city to show and tell what the DOW can do, and help out meteorology students.

"They're getting hands on experience with state of the art insturmentation that will help them be better scientists, better forecasters and really understand the technology in a way that is much better than just classroom learning" said Wurman.

The DOW is equipped with other weather instruments as well as computer and navigation systems. This is just one of three DOWs used by Dr. Wurman to gather inside information on the atmosphere.

"There are a lot of things in the atmosphere, a lot of small things, a lot of violent things, a lot of things which change quickly which we don't understand very well because we haven't been able to get data in them before" Wurman said.

Since 1995, 141 tornadoes have been intercepted from all over the plains including Nebraska. The Cornhusker State has been a part of the severe weather research according to Dr. Wurman.

"We've seen some amazing storms in Nebraska over the years. One of our first two DOW data sets which was very important for us scientifically was out in western Nebraska in Scottsbluff....Nebraska is a very fruitful area for us to do science."

Science Dr. Wurman says can make you safer.

"We could make warnings better. We could make warnings further ahead of time so people would have more time to take action and we think we can save people's lives and maybe even save some property."

That is ultimately what it is all about when it comes to learning about these deadly storms.

Scarlet: The news source for faculty and staff at the University of Nebraska-Lincoln

A visit from the Doppler on Wheels

Nov 20th, 2008 | By admin | Category: Campus News, November 20, 2008

TORNADO DRIVING - Students in Deborah Bathke's Meteorology 101 class listen as Josh Wurman, director of the Center for Severe Weather Research in Boulder, Colo., discusses how not to drive while storm chasing. Wurman and the Doppler on Wheels, a mobile Doppler radar, visited campus on Nov. 13. Wurman also spoke at the Wick Alumni Center. Wurman and the DOW are featured on the Discovery Channel reality series "Storm Chasers." Photos by Troy Fedderson/University Communications