The DOW at Western Illinois University: Education, Outreach and Research (WIUDOW2)
Project final report

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The Doppler on Wheels (DOW) was deployed to Western Illinois University from September 14 to October 3, 2015. The DOW was used as part of the GEOG 300: Weather Instruments course, which had an enrollment of 9 undergraduate students, including 6 meteorology, 1 pre-business economics, 1 geology and 1 computer science major. While this was a small class, the DOW never sat idle for very long. If it wasn't out on a project, the DOW was at an outreach event. The DOW was also used in an Honors Thesis project that will be presented at the 2016 AMS Annual Meeting Student Conference and the WIU Undergraduate Research Day. In addition to student projects, the DOW was also involved in 5 outreach events for the community and local schools, 7 class tours for WIU students and the WIU Homecoming Parade.

Since this was the second time the DOW was deployed to WIU, we improved on what we accomplished two years ago. Just the fact that we worked with the DOW before made the entire experience go more smoothly. Course instruction related to the DOW and radar operation/interpretation was more targeted to issues the students were most likely to encounter in the field and project planning was more effective given what we'd learned during the first deployment. Student projects ended up much more complete this year because the PI was better able to direct the investigation. Our outreach events were also better because the schools had seen the DOW before and knew what to expect. Several high school teachers even designed class assignments to go with the DOW visit this time. We also included a trip to the WIU Quad Cities campus where students and the local community had the opportunity to visit the DOW.

Educational Objectives

The primary objective for the DOW deployment was to enhance instruction in the Meteorology program at WIU, with a specific focus on the Weather Instruments course. The secondary objective was to use the DOW for outreach when it was not being used by courses in the Meteorology program.

The DOW was used to enhance instruction in the Meteorology program in numerous ways. All of our current Meteorology undergraduate and Geography graduate students had the opportunity to tour the DOW and receive training. Thirteen training sessions were held for 29 students from Sept. 14 through Sept. 18.

Class tours also gave both meteorology majors and general education students a chance to talk to the DOW technician and get a tour of the truck. Students also saw footage from some research missions the DOW has been on. The following courses toured the DOW:

- 86 students from two sections of Marcus Buker's GEOG 120 (Introduction to Weather and

Climate) general education, natural sciences course
- 9 students from Redina Herman's GEOG 329 (Dynamic Meteorology I) junior-level course required for Meteorology majors
- 50 students from Tom Williams' GEOG 120 (Introduction to Weather and Climate) general education, natural sciences course
- 12 students from Redina Herman's GEOG 432 (Physical Meteorology) senior-level course required for Meteorology majors
- 9 students from Redina Herman's GEOG 300 (Weather Instruments) elective course required for Meteorology majors
- 10 students from Marcus Buker's GEOG 322 (Synoptic Meteorology I) junior-level course required for Meteorology majors

In order to enhance instruction, the DOW was directly incorporating into the Weather Instruments course. The use of the DOW in the Instruments course had several goals: (1) introduce students to the operation of a research radar, (2) plan and carry out a field project, including scanning strategy, site selection and flexibility while in the field, and (3) visualize radar data using SOLO3 and interpret the data to gain insight into the observed phenomena. In addition to enhancing the Instruments course, the DOW campaign also provided data for future student research projects. The visualization and analysis of this data will also be incorporated into the GEOG 333: Data Visualization and Analysis course in fall 2016.

Deployment and Class Procedures

Not all of the students in the Instruments course had taken the Radar Meteorology course, so the first step was to present students with the background they needed to understand how radar works and how to interpret the data. Most of this was covered during lecture before the DOW arrived. Students were also given reading assignments on radar data interpretation, especially clear-air returns. Based on what we learned during the first DOW visit, additional lecture time was devoted to radar issues such as ground clutter, range folding and velocity folding. Students were also shown examples of these artifacts from the first visit so they could pick them out.

Fall in Western Illinois is typically dry, so students were asked to come up with both clear-air and precipitation project ideas. Students turned in a paragraph describing their project idea and how the DOW was suitable for observing the situation. Students then formed groups based on their clear-air ideas. During the first DOW visit groups were assigned based on similarity of topics, but this year students formed their own groups. This likely helped move the projects along faster because student projects evolved more naturally. Some of these project ideas included: modification of wind by a wind farm, analysis of precipitation over a wind farm, detection and tracking of power plant smokestack emissions in Canton, analysis of the evolution of the boundary layer at dusk, analysis of wind patterns associated with the Keokuk dam on the Mississippi River, and tracking of harvest debris.

Before the DOW arrived at WIU, student groups completed a site analysis (often without actually visiting the site) to determine the optimal location for their deployment (see Appendix A: DOW Field Report

Writing Guide.) The site analysis document students turned in included GoogleEarth images and target information.

Once the DOW arrived at WIU, students were scheduled for training on operation and data collection. All of the students in the Instruments course received training. After most of the students had been trained to use the DOW then students met with the DOW technician, Alycia Gilliland, during one class period to talk about their project ideas and practical considerations. Some of the topics we discussed were scanning strategy suggestions, site selection issues students may not have considered, and any additional issues students should be aware of for each project.

During the first DOW visit each deployment was given a maximum of five hours for completion, including travel time. Mission times were more flexible during the second DOW visit. Students learned that it is not as simple as driving to a location, collecting data, and then coming home. Sometimes getting to the deployment site was an adventure due to the height of the DOW. It also takes time to get set up once we arrive at the deployment site. These are all things I wanted my students to experience first-hand so that they recognize that flexibility in the field is essential. The study sites were invariably changed as the DOW technician determined the final site locations. In the future it would be nice to try to stick more closely to the students' original project idea as long as there is no harm to the DOW or its occupants. While in the field, students were told to write down anything that might be significant. Students often have a hard time determining what was important so these became great teachable moments. Students were also told to document the site using photographs. The PI was present at every deployment to help students determine what they were observing and what they should be documenting.

The following projects were carried out:

- Sept. 18: Wind farm turbulence during precipitation
- Sept. 20: Analysis of smokestack emissions from the Canton, IL power plant
- Sept. 23: Evolution of the boundary layer as the sun sets
- Sept. 26 and 30: Harvest debris tracking
- Sept. 26: Winds near the Mississippi River dam at Keokuk
- Sept. 29: Wind farm turbulence during clear conditions

Once all of the student projects were complete, students had to write up their results following the DOW Field Report Writing Guide in Appendix A. During the first DOW visit students focused predominately on instrument issues such as site selection, operation of the DOW and any issues that arose, ground clutter diagnosis, and data characteristics. During this second DOW visit the project report goals shifted more toward data analysis. This was certainly a benefit of having had the DOW previously. The PI was far more confident in helping with the analysis and the students rose to the new level of expectation quite easily.

The data analysis portion of the project was completed using SOLO3. Students learned to navigate in the LINUX environment in order to extract their files to the appropriate location, then used SOLO3 to visualize the data (see Appendix B). Students documented ground clutter on the radar images using photographs they had taken at the site to connect objects in the photographs to locations on the radar image. They also did a more thorough analysis of the data to address their research questions.

Overall, the DOW field projects were again a huge success. Students learned how to plan and carry out a field project using the DOW. They also used SOLO3 to visualize their data and interpret it. The DOW brought aspects to the Instruments class that would have been impossible otherwise.

Project Assessment

The main project assessment was the completion of the DOW Field Report. It was clear from the reports that every student learned a lot about instrumentation, field projects and data collection from the DOW visit. Students also completed a Course Evaluation at the end of the semester but these results are not available yet.

Outreach Activities

The second objective for the DOW visit was educational outreach. The DOW visited Galesburg High School, Macomb High School and Macomb Junior High School where students visited the DOW. The DOW was also at Conservation Day for McDonough where 300 fifth-grade students visited the DOW. Students from WIU's Severe Weather Club accompanied the DOW technician, Alycia Gilliland, to these events. The DOW was also featured in numerous news articles, both on air and in print.

One of the original objectives was to make the DOW available for educational outreach events when it was not used by the Instruments class. The DOW participated in the following outreach events:

- Sept. 25, DOW was at the McDonough County Conservation Day
    - Approximately 300 students toured the DOW. Severe Weather Club students from WIU talked to students and gave them a tour of the DOW. Conservation Day is an annual event for all public and private school 5th grade students in McDonough and surrounding counties sponsored by the McDonough County Soil and Water Conservation District, University of Illinois Extension and the Western Illinois Regional Council. Several parents told me their kids came home talking about the DOW.
- Sept. 21, DOW visited Galesburg High School and was toured by AP Physics, Physics, Earth Systems, Physical Science, and Math classes
    - Severe Weather Club students from WIU talked to students and gave them a tour of the DOW. Several of the teachers designed course activities related to the DOW in preparation for the visit. This is certainly a benefit of having seen the DOW before.
- Sept. 22, DOW visited the Quad Cities campus of WIU and was toured by a physics lab group, other university personnel and community members
    - Our first visit to the Quad Cities campus was a huge success.
- Oct. 2, DOW visited Macomb Senior High School

- More of the high school classes came out to see the DOW than during our first DOW visit. Severe Weather Club students from WIU talked to students and gave them a tour of the DOW.

- Sept. 24, DOW visited Macomb Junior High School
  - More of the junior high school classes came out to see the DOW than during our first DOW visit. Severe Weather Club students from WIU talked to students and gave them a tour of the DOW.

Lessons Learned

The WIUDOW2 project was incredibly successful. The DOW was integrated into the GEOG 300: Weather Instruments course as one of the field projects that student groups had to complete. Students learned an incredible amount about field project planning and the need to be flexible.

One difficulty that we faced, especially during deployments where the event being observed is changing location quickly over time, is that it is hard to tell what exactly the radar is looking at. For example during the harvest project, it would have been helpful to have a way to determine when the radar was point in the right direction because the right direction kept changing based on where the moving harvester equipment was located. It might be useful to have a fisheye camera on top of the truck so that we could determine the position of the harvester and the direction of the radar at any given time. We had to poke our head through the hole in the top of the truck (with very limited visibility) or get out of the truck to see what was going on. By the time we figured out what we were looking at the image on the screen was long gone.

As mentioned by others, it would also be useful if we could look at recently recorded data so students can verify what they saw. This paired with the fisheye lens video would help a lot. Often we never did figure out what we'd seen because the signature on the screen was only there for a short time. If there was a video then we could perhaps figure it out.

One student's project ended up being unsuccessful, but not because we didn't get data. This student was very frustrated by the experience both in the truck and especially later because he never felt like he had enough information to determine what he was seeing. This was not the only student to become frustrated with the experience. Perhaps if we request the DOW again then I will plan to videotape the deployment (maybe recording the student/PI conversation and what is shown on the screen at the time) in the hopes that students will find it easier to make sense of their data. Not everyone is equally equipped to look at specks on a screen and connect that to a 3-D field that varies in time outside the truck. Clear-air projects are especially difficult.

There were some data management changes from the first to the second DOW visit that may have led to more student frustration. It would help if students were allowed to take project notes in their own notebook rather than the DOW technician's notebook so they could look at the notes right away instead of waiting for a scanned copy of the notes to get back to them. The PI and students should also have access to the data soon after the deployment instead of at the end of the DOW visit. During the first

DOW visit students sent a scanned copy of their notes to the DOW technician so the students always had their notes. Students also got a copy of their data within a day or so after the deployment. I believe these data management changes led to more frustration on the part of the students.

Overall, the second DOW visit ran more smoothly in many ways than the first. The PI was much more prepared and therefore more helpful to students in project planning and data interpretation. The DOW technician knew quite a lot about weather and data collection using the DOW and she made some great suggestions to get the best data. Getting the best data in a learning environment however, is not always the goal. Everyone involved should keep this in mind.

Meteorology majors at Western Illinois University would like to thank the Center for Sever Weather Research and the National Science Foundation for the opportunity to use the DOW radar. This was a once-in-a-lifetime experience for most of our students. Several of them are more interested in graduate school and instrumentation as a result of their experience with the DOW.

Appendix A:

Dow Field Report Writing Guide

For your DOW project report, you are going to document your DOW experience! Most of the report's length will probably be pictures and images rather than text. Your DOW project report should answer the following questions:

Project Planning

1. What is your overall topic area?
2. What specific attributes of the overall topic are you looking at? (Each member of the group should answer this!)
3. What was the original deployment plan for the DOW?

Site Selection/Study Area Description

1. What time did you arrive at each deployment site? What time did you leave?
    a. If you had more than one stop then you will have more than one answer for this.
2. Describe your deployment site(s).
    a. Latitude/longitude
    b. Elevation
    c. GoogleEarth images showing surrounding areas (both close and far views)
    d. Ground clutter (include pictures and label dominant ground clutter objects)
3. What were the good qualities of your deployment site?
4. What were the bad qualities of (problems with) your deployment site?
5. What were the atmospheric conditions like during your deployment?
    a. Wind direction and did it change during the deployment
    b. Wind speed and did it change during the deployment
    c. Cloud cover
    d. Stability
    e. Humidity

DOW in Action

1. How was the truck leveled? (include a picture of the bubble level)
2. Which way was the front of the DOW pointing?
3. Did your deployment go exactly as described in your original deployment plan? (The answer here has been NO for every deployment I've been on!)
4. What part(s) did not go exactly as planned?
    a. How did your deployment plan have to change?
    b. Did the instrument work correctly all the time? Did the frequency need to be adjusted? Did the truck need to be re-leveled? Was ground clutter a problem? Etc.
5. What was done to fix the problem(s)?

6. Exactly what scans were run?
    a. Describe any RHI, PPI (survey) and/or PPI (sector) scans that were done.
    b. Describe the elevation angles for PPI scans.
    c. Describe the azimuth angles for RHI and PPI (sector) scans.
7. What specific aspects of your overall topic did you look at?
8. What interesting things did you see while scanning?

Ground Clutter Diagnosis

1. Using your lowest (or near lowest) elevation scan, label the dominant ground clutter objects. These should be the same ground clutter objects seen in your Site Selection pictures.

Data Description

1. How many files were generated during your deployments?
2. What is the total size of data generated during your deployments?

Data Analysis

1. What interesting things can you see in the data? (include pictures!)
    a. RHI
    b. PPI
    c. Velocity
    d. Reflectivity
2. What were the radar beam issues that you encountered?

Appendix B:

LINUX and SOLO3 Instructions

Getting started with LINUX:

- Log in using your WIU Username and Password
- If you cannot log in then see your instructor.

Open a terminal window

- Click on Applications at the top left-hand of the screen
- Choose Accessories, then choose Terminal
- This will open a command-line window.

Explore some commands and find your files

- Type 'ls' What is displayed?
- Type 'mkdir DOW' 'mkdir' is the command to create a directory (with the name DOW, in this case)
- Type 'ls' What is displayed?
- Type 'pwd' 'pwd' is the command to tell you where you are in the directory tree
    - This is your HOME directory. Write your home directory address here:_____
    - ~ can be used in place of typing the home directory location explicitly
- Type 'cd ..' This command takes you up one directory level.
    - 'cd' means change directory
    - 'cd' with nothing after it will take you to your home directory
- Type 'ls' to display the contents of the /home directory
- There should be a directory called 'WIU-DOW-2013'
- Type 'cd WIU-DOW-2013' to enter the directory.
    - NOTE: you could also type 'cd W*' to enter directory because the * acts like a wild card to fill in the rest of the name. This only works because there is no other directory with a W as the first letter!
- Type 'ls'
- This directory contains 3 subdirectories: Goshen, Russell, and SweepFiles. Goshen and Russell are data sets for the Goshen, WY and the Russell, KS tornadoes. (Feel free to look at them when/if you have time!) SweepFiles contains the DOW files from your experiments.
- Go into the SweepFiles directory
- Type 'man ls' this is a manual page for the command 'ls'.
    - When you are done hit the 'q' key to exit. Most commands in LINUX have 'man' pages!
- Type 'man cp' What does the 'cp' command do?
- The syntax for 'cp' is 'cp <source> <destination>' where <source> is the name of the file you are copying and <destination> is the name of the directory where you are putting the copy.

Copy your files to your directory

- Type 'cp <yourfilename.tar.gz> ~/DOW' this commands copies your file to the DOW directory

that you created above. Remember, ~ is short for your HOME directory
    - NOTE: This may take a while!

Unzip your files

- Your files have been “tarred” (the .tar part) and “zipped” (the .gz part). Tarring creates one file with all of your content. Zipping creates a compressed version of the file. You will have to undo both
- Type 'tar -xvf <yourfilename.tar.gz>' to extract your files. This will take some time!
- Type 'ls' to see the directory where you files are located.
- Go to the directory with your files
- List your files in the screen to verify that they are there.
    - Sometimes the files will be in a subdirectory. If so, then go to the subdirectory.

Run Solo3

- When you are in the directory with your files, type 'solo3'
    - This starts the SOLO3 program.
- SOLO will start with 4 data windows. You can change this by going to Config and choosing a different number of windows. For most of our applications, we used velocity and reflectivity, so two windows should be sufficient.
- Right-clicking on a data window will bring up visualization options. Click on Parameters+Colors.
    - Set the Parameter for one window to DBZHC (reflectivity) and the Parameter for the other window to VEL (velocity).
    - You can also change the color table. 'carbone17' has 17 colors. For most of your applications, more colors would be better. Try 'carbone42' or higher.
    - Each time you change something you have to Replot to apply your changes.
    - There are also other things you can do with the Parameters+Colors window and the Frame1/2 options, but they are beyond the scope of this course. **For those of you who are continuing your radar research, you will need these additional tools! I will send out a guide close to the end of the semester... you have plenty to do in the mean time!**
- Most of the interesting things we saw happened pretty close to the radar, so you will need to use the Zoom to get a closer look.
- You can double-click at any location in the data field to re-center on that point.
- The right and left arrows on your keyboard will step forward and backward through the data.
    - Sometimes this gets “stuck”. To fix it, open a Parameters+Colors window by right-clicking on some data. This usually works.
- There are LOTS of cool things you can do to visualize your data, but for this course I want you to answer the questions in the Ground Clutter Analysis, Data Description, and Data Analysis sections of the DOW Field Report Guide.

To save your data images, use Alt-Print Screen to print the active screen. This will create a .png file that you can import into your DOW Field Report.