

The DOW at Western Illinois University: Education, Outreach and Research (WIUDOW)

Project final report

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The Doppler on Wheels (DOW) was deployed to Western Illinois University (WIU) from September 16 to October 4, 2013. The DOW was used as part of the PI Redina Herman's GEOG 300: Principles of Meteorological Instrumentation course, which had an enrollment of 19 undergraduate Meteorology majors, ranging from Sophomores to Seniors. There were 9 field deployments to various sites in west-central Illinois. In addition to student projects in the weather instruments course, the DOW was also involved in 7 outreach events for the community and local schools.

Educational Objectives

This was the first opportunity that the Meteorology program at WIU had to use a large piece of research equipment such as the DOW. Both current and former students were very excited to get the opportunity! The primary objective for the DOW deployment was to enhance instruction in the Meteorology program at WIU. The secondary objective was to use the DOW for outreach when it was not being used for 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 (some of whom are former Meteorology undergraduate students) had the opportunity to tour the DOW and receive training. A few of our former students, one driving 6 hours, made a trip back to WIU to see the DOW. Our department also has a discipline-specific student organization called the Severe Weather Club, with about 30 members. The Severe Weather Club toured the DOW. The following courses, taught as part of the Meteorology program, toured the DOW:

- Sept. 16, Department of Geography course tours of the DOW
 - 43 students from Tom Williams' GEOG 120 (Introduction to Weather and Climate) general education, natural sciences course
 - 8 students from Redina Herman's GEOG 329 (Dynamic Meteorology I) junior-level course required for Meteorology majors
 - 41 students from Tom Williams' GEOG 120 (Introduction to Weather and Climate) general education, natural sciences course
- Sept. 17, Department of Geography course tours of the DOW
 - 32 students from Marcus Buker's GEOG 120 (Introduction to Weather and Climate) general education, natural sciences course
 - 7 students from Marcus Buker's GEOG 333 (Meteorological Data Analysis and Visualization) junior-level course required for Meteorology majors
 - 21 students from Tom Williams' GEOG 322 (Synoptic Meteorology I) junior-level course required for Meteorology majors

The DOW was directly incorporated into the Principles of Meteorological Instrumentation 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. Since this is an instruments class, the course material focused on instrument issues rather than an in-depth look at the radar operations.

In addition to enhancing the Instruments course, the DOW campaign also provided data for future student research projects. Several students from the weather instruments course have expressed an interest in continuing their data analysis and using project results in their Senior Thesis. Two student groups are presenting their findings at our Undergraduate Research Day in April 2014. One student group is presenting results at the 2014 Central Iowa National Weather Association Severe Weather and Doppler Radar conference at the end of March 2014. The data will also be used in the GEOG 333: Meteorological Data Analysis and Visualization course.

The second objective for the DOW visit was educational outreach. Our goal was to have the DOW doing outreach when it was not being used by students in the instruments course. The DOW visited four local schools where students from junior high and high school learned about the DOW. There were also two multi-county community events (Conservation Day and Farm Safety Day) taking place during the DOW's visit to WIU. Students from WIU's Severe Weather Club accompanied the DOW technician to these events and talked to 4th and 5th grade students about the radar and weather awareness. Western Illinois University and the Department of Geography also sponsored a presentation by Karen Kosiba (Thanks Karen!) that was advertised on local television stations and newspapers and open to the community. The DOW was available after the presentation for members of the community to tour. Numerous news articles, both on air and in print, were also written about the DOW while it was at WIU.

Deployment and Class Procedures

Class procedures were designed to enhance the Instruments course. Each student in the Instruments course came up with project ideas and then students were grouped by like topic. Students completed a site analysis, carried out their project and analyzed the data as part of the DOW Project Report that was due near the end of the semester. Since this was an Instruments course and not a Radar Meteorology course, special attention was given the instrument characteristics and issues that arise during field work.

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. West-central Illinois was in a long dry period when the DOW arrived in late September, so we focused on predominately clear-air projects. This is fortunate because it only rained twice during the entire time the DOW was at WIU, once near the beginning of the DOW visit and once near the end.

Before the DOW arrived, students were asked to come up with field project ideas. Each student came up with clear-air and precipitation situation project ideas. Each student turned in a paragraph describing their project idea and how the DOW was suitable for observing the situation. Students were then put into groups of 2-3 based on their clear-air project ideas. Some of these project ideas included: modification of wind by a wind farm, detection and tracking of power plant steam/heat, detection of morning fog over a lake, anomalous propagation caused by a morning inversion, influence of the Mississippi River on radar returns, tracking harvest debris downwind of a soybean field being harvested, detection of the urban heat island effect, and the effect of a city-scape on the ambient wind pattern. These ideas were grouped into 6 main topics and a total of 8 groups (two groups each for wind farms and power plant smoke stacks.) Each student in the group focused on a particular aspect of the main topic. For example, one group of three students examined three different aspects of an early-morning visit to Spring Lake: (1) fog over the lake, (2) fog over the land surrounding the lake and (3) morning inversion effects.

Before the DOW arrived at WIU, student groups completed a site analysis (using GoogleEarth) to determine the optimal location for their deployment. (See Appendix A: DOW Field Report Writing Guide, Project Planning and Site Selection/Study Area Description sections) The site analysis document they turned in included GoogleEarth images, elevation maps and target information. Instructor feedback was given on the site analysis and students revised their analysis to include more detail and a contingency plan if the original site was not ideal.



James Cundiff and John Adams helping Paul Robinson set up the DOW.

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. When most of the students had been trained to use the DOW they met with the DOW technicians, Paul Robinson and Ab Pfeifer, 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. Paul Robinson was incredibly helpful in giving pre-project feedback and offered some great suggestions during deployments. I know CSWR does not usually send Paul on educational deployments, but having Paul's expertise made the DOW visit much more educational than it would have been otherwise!



Soybean harvest project pictures.

Each deployment was given a maximum of five hours for completion, including travel time. It turned out that five hours was often not quite enough. 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 takes time to get set up once we arrive at the deployment site. Sometimes the deployment site was not ideal so we needed to move to a better site. The equipment didn't always work correctly so the problem had to be fixed before data collection could resume. Once we got the first look at the data, the scanning strategy might need to be changed or the original project idea might need to change. These are all things I wanted my students to experience first-hand so that they recognize that flexibility in the field is essential.

While in the field students kept a journal documenting scan information, site details, etc. Students were told to write down anything that might be significant. Students were also told to document the site by taking pictures to create a 360⁰ panorama. The PI, Redina Herman, was present at almost every deployment to help students determine what they were observing and what should be documented. The following projects were carried out:

- Sept. 21 at 9:00AM-4:00PM: Powerton Generating Station smoke stack emissions in Pekin, IL
- Sept. 22 at 5:00AM-10:00AM: Fog at Spring Lake and a morning inversion layer over a corn field near Spring Lake

- Sept. 23 at 1:00PM-6:30 PM: Bishop Hill wind farm north of Galesburg
- Sept. 24 at 11:00AM-5:30PM: Bishop Hill wind farm north of Galesburg
- Sept. 26 at 1:00PM-7:00PM: Urban effects (heat island and wind deflection) caused by Galesburg
- Sept. 28 at 9:00AM-4:00PM: Powerton Generating Station smoke stack emissions again, then cloud and precipitation structures outside of Galesburg
- Oct. 1 at 3:00PM-8:30PM: Propagation of soybean harvest particulates
- Oct. 2 at 4:00PM-9:30PM: Havana Power Station smoke stack emissions in Havana, IL
- Oct. 3 at 3:00PM-6:30PM: Structure of a passing thunderstorm



Top image: Thunderstorm observations. Bottom images: Site selection and operations at the Bishop Hill Wind farm.



Students making observations near Galesburg, IL

There were two issues that were common among the student projects. The first issue is that the phenomenon being investigated was often too close to the ground. Side lobes were a real issue during clear-air observations of near-ground targets. (This problem led to one of the on-going projects being conducted by students. John Adams and James Cundiff are diagnosing side lobe characteristics using radar imagery, high resolution LIDAR elevation data, and ArcGIS line-of-site analysis tools.) Surprisingly, none of the students proposed projects having to do with clouds. The second issue is that power lines in rural Illinois were very common and incredibly hard to detect on GoogleEarth images during the site selection stage of the project. To alleviate this problem, students had one or two back-up sites picked out before the deployment. When these problems occurred, students had two choices: (1) modify the original project idea to examine something else at the deployment site or (2) make the most of it and see what could be discovered from the data collected. This led to some interesting observations and insights.

The data analysis portion of the project was completed using SOLO3. Students learned to navigate in the LINUX environment 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 the photographs they had taken at the site to connect objects in the photographs to locations on the radar image.

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. Since the DOW was used for an Instruments class, students focused on instrument issues such as site selection, operation of the DOW and any issues that arose, ground clutter diagnosis, and data characteristics.

Finally, students completed a survey documenting who did what in the project. This was designed to hold students accountable for their role in the project. It was also designed to get feedback on operating the DOW and suggestions for future use of the DOW (see Appendix C).

Overall, the DOW field projects were a huge success. Students learned how to plan and carry out a field project using the DOW. They then used SOLO3 to visualize their data and interpret it. The DOW is a large instrument with moving parts, so students also learned that an instrument does not always work like it is supposed to work. 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 and had great things to say about the DOW visit. Some of the comments are:

- “The opportunities presented in this class were outstanding. The things we did were amazing and made this the best course I have ever taken.”
- “Real-life, hands-on experience. One example being the DOW.”
- “I was able to do a lot of hands-on training with the instrumentation. The DOW project was the best project of the class.”
- “Working with the DOW was very instructional, educational and fun.”

The outreach events were also a great success, both from the number of people reached and the comments we got during and after the outreach. The following quote is from Linda Wilson, 7th grade Team Leader at Macomb Junior High School:

“Wow! What a wonderful event you put on for our students! All of our 7th and 8th grade students were able to view and learn about the Doppler on Wheels during your visit on 10/1. It was a challenge to make time for about 300 students but your presenters did an excellent job. As a teacher, I am extremely pleased to have this experience provided to our students and found it very interesting myself. Ab did a super job of fielding questions from our students and makes a great educator! The present and former WIU students also did a great job interacting with students and sharing their enthusiasm. Thank you so much for thinking about us and including Macomb Junior – Senior High School in your time here. It is greatly appreciated.”

Outreach Activities

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 was used in the following outreach events:

- Sept. 26, DOW was at the Warren-Henderson County Progressive Farm Safety Day
 - Approximately 250 students toured the DOW and learned about weather awareness. This is an annual event for all public and private school 5th grade students in the Warren and Henderson County area sponsored by the Warren Henderson County Farm Bureau.
- Sept. 27, DOW was at the McDonough County Conservation Day
 - Approximately 150 students toured the DOW. This 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.
- Sept. 30, DOW was available for Macomb Senior High School students to visit and ask questions

- Approximately 180 high school students from Geology, Sociology-Geography, and General Sciences classes visited the DOW
- Sept. 30, Dr. Karen Kosiba from the Center for Severe Weather Research gave a public presentation entitled "Running the Wrong Way: Chasing Tornadoes and Hurricanes for Science"
 - Approximately 40 community members and students attended the talk and toured the DOW after the presentation.
- Oct. 1, DOW was available for Macomb Junior High School students to visit and ask questions
 - Approximately 300 students from all of the 7th and 8th grade science classes visited the DOW.
- Oct. 2, DOW was available for Galesburg High School students to visit and ask questions
 - Approximately 90 high school students from Physical Science, Physics, Earth Systems and Environmental Sciences classes visited the DOW.
- Oct. 4, DOW was available for Bushnell-Prairie City High School students to visit and ask questions
 - Approximately 195 high school students from the Algebra I, Algebra II, Geometry, Pre-Calculus, Trigonometry, Chemistry, and Laboratory Sciences classes visited the DOW.

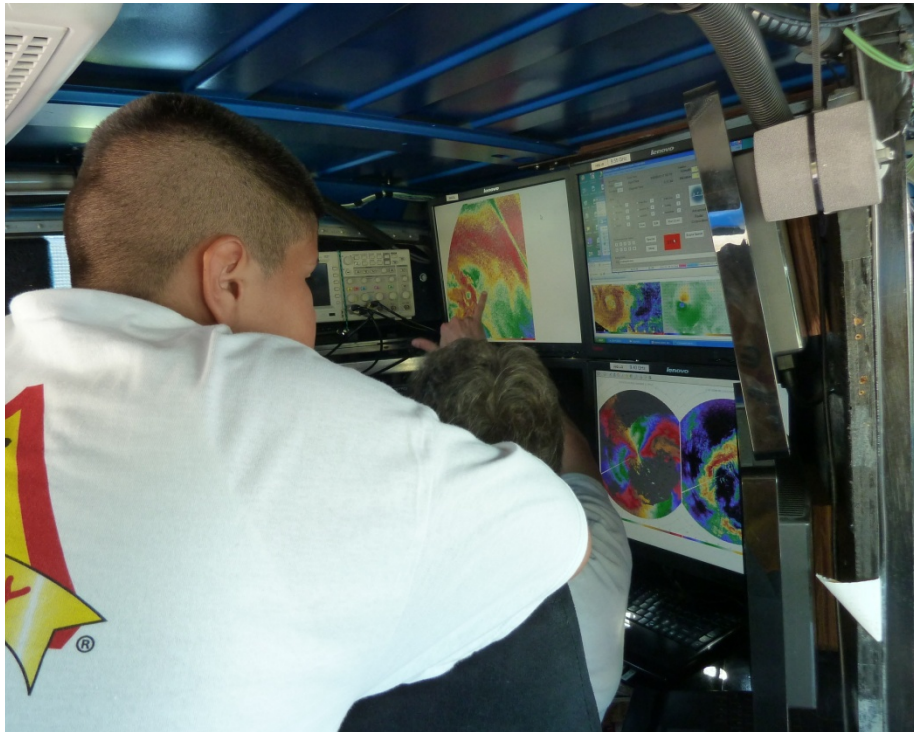
During the visit to Western Illinois University, the DOW reached nearly 1400 people, including WIU students, students from local schools and community members from the Macomb and surrounding areas!



DOW visit to the Macomb Junior-Senior High School



DOW visit to the Macomb Junior-Senior High School



DOW visit to Conservation Day in McDonough County



DOW visit to the Warren-Henderson County Progressive Farm Safety Day

In addition to the number of individuals directly reached, the DOW was also featured in several news articles, both on air and in print. The articles about the DOW are listed here.

- WIU Geograpy Department article
at http://www.wiu.edu/news/newsrelease.php?release_id=11000
- WIU Public Relations article on Sept. 17, 2013 at
http://www.wiu.edu/news/newsrelease.php?release_id=11016
- WGEM news article and interview on Sept. 18, 2013
at <http://www.wrex.com/story/23469778/2013/09/18/discovery-channels-storm-chasers-mobile-doppl>
- WKHQA interview and article posted on Sept. 17, 2013
at <http://www.youtube.com/watch?v=Bc8o4wajr3I> and <http://www.connecttristates.com/news/story.aspx?id=948324>
- McDonough County The Voice front page news article on Sept. 19, 2013 at
<http://www.mcdonoughvoice.com/article/20130918/NEWS/130919224/1001/NEWS>
- Western Courier front page news article on Sept. 27, 2013
at http://www.westerncourier.com/news/macomb-is-on-doppler-s-radar/article_cfdda42-277a-11e3-8737-0019bb30f31a.html
- Tri-States Public Radio interview and article on Sept. 17, 2013 at <http://tristatesradio.com/post/wiu-students-get-rare-chance-use-mobile-radar>

Lessons Learned

The WIUDOW project was incredibly successful. The DOW was integrated into the GEOG 300: Principles of Meteorological Instrumentation course as one of the field projects that student groups had to complete. Since this is an Instruments course, students focused primarily on instrument-related issues and using the DOW to collect data. Students spent a few weeks before the DOW arrived learning about doppler radar, proposing a field project and documenting their proposed field site. Once the DOW arrived, students received training, carried out their field project and documented their experience in the project report.

West-Central Illinois had been in a long period without rain, so most of the student projects focused on clear-air observations. This allowed students to get hands-on experience with the DOW without precipitation, but it also made data interpretation more challenging. Ground clutter was a problem because the student projects were looking at phenomena close to the ground. One student group discovered that a single train track became two train tracks in the radar image. These students have continued their data analysis using SOLO3 and ArcGIS to document characteristics of the radar beam side lobes.

Power lines were a ground clutter source that was difficult to detect during site selection using GoogleEarth. After the first deployment where power lines were determined to be a real problem when detecting power plant steam emissions, project groups were told to pick one or two back-up sites in addition to the original site. Still, the DOW team often had to choose a site “on-the-fly” because of power lines.

The DOW was a fantastic tool to use in the Instruments class, but having DOW data analyst, Paul Robinson, available to help with clear air data interpretation made the field projects so much more beneficial than they would have been otherwise. Paul was able to help interpret data in the field so that scanning strategies were adjusted to bring out interesting details. Paul is not usually available to accompany the DOW, but it would be very beneficial to have someone available who was willing to help with data interpretation during deployments, especially in clear-air situations.

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 your 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.

Appendix C:

Post-project Review

Your name: _____

Partner 1 name: _____

Partner 2 name: _____

Indicate who completed each of the following tasks by putting an X in the appropriate box(es). You may check more than one person for each task.

Task	You	Partner 1	Partner 2
Discussed ideas for a DOW project and site locations with the group			
Helped Paul or Ab navigate to the deployment site			
Collected data using the DOW			
Documented the site(s) with the camera			
Took notes about the DOW operations DURING the deployment			
Came up with a scanning strategy for the DOW deployment			
Downloaded and unzipped sweep files			
Ran or helped run SOLO3			
Interpreted DOW images, including ground clutter and interesting features			
Wrote part(s) of the report			
Inserted figures/images and provided figure/image caption information			
Determined how many DOW files were created and how big the data set was			

Answer the following questions:

1. Which parts of the report did YOU write? Be specific.

2. Which parts of the report did you provide data/input for? Be specific.

3. List any additional tasks that you completed for the DOW project.