

**Millersville University Educational DOW (MEDOW)**

**Final Report**

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Project Title: Millersville University Educational DOW (MEDOW)

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## 1. Summary

The Doppler on Wheels 6 (DOW 6) visited Millersville University's campus for the Millersville University Educational DOW (MEDOW) project from March 30<sup>th</sup> to April 7<sup>th</sup>. The project was made possible by an Educational Deployment grant sponsored by the National Science Foundation. The project provided opportunities for undergraduate students in the Radar Meteorology course (ESCI 449), Meso- and Storm Scale Meteorology (ESCI 444) and Physical Meteorology course (ESCI 340) for training, participation in observation periods, development of a case study and conference presentation and incorporating the DOW into a number of large and high-impact outreach activities. Additionally, one observation period supported the research idea as stated in the proposal that hazardous weather warnings could be improved and refined if weather radar were operated in the relatively radar-sparse area of the Piedmont section of southeastern PA.

## 2. Educational Objectives and Training

The main objective of MEDOW was to advance student understanding of the weather radar as an instrument and its applications in the study of specific meteorological phenomena by allowing the students to have a direct hands-on experience. The project was primarily designed for students enrolled in the *Radar Meteorology* (ESCI 449: 29 students), but students in two other courses: *Meso- and Storm-Scale Meteorology* (ESCI 444: 19 students) and *Physical Meteorology* (ESCI 344: 22 students) also participated in training and observation periods. Radar Meteorology is a 400-level undergraduate course which serves as an elective for meteorology majors, but as the enrollment suggests, it is a popular elective. Students in this course learned the fundamentals of radar, operations, and products prior to the DOW's arrival. In addition, the students were provided with background information on the DOW, its capabilities and applications as discussed in a number of papers based on field projects that utilized the DOW system. Students in *Meso- and Storm-Scale Meteorology* and *Physical Meteorology* also learned about the DOW and its applications as applied to topics covered in these courses such as the storm structure and radiative transfer.



Fig 1: Photograph of students on March 30 at the arrival of DOW on campus. From left to right: Brandon Molyneaux, Anthony Rossi, Ashley Orehek, Daniel Harp, and Elizabeth Morehead.

For the duration of the DOW 6 visit, 35 students completed the extended training sessions (40 minutes) conducted by CSWR technician Alycia Gilliland. The

training sessions began on March 30<sup>th</sup> and continued through April 5<sup>th</sup>. In addition to the training seminars, Dr. Josh Wurman from CSWR traveled to Millersville University and presented a seminar on March 30<sup>th</sup> as part of the seminar series for the Millersville University Student Chapter of the American Meteorological Society. On March 31<sup>st</sup>, he also provided a technical lecture for the combined sections of the Radar Meteorology and Meso- and Storm-Scale Meteorology courses. Furthermore, Dr. Pamela Heinselman from the National Severe Storms Laboratory provided a talk on the Phased Array Radar for the students in the Radar Meteorology course on April 4<sup>th</sup> while the DOW 6 was on campus. Her talk included case studies and comparisons with DOW data and applications and provided the students with an additional opportunity to learn about the DOW system in a larger context.



Fig 2: Dr. Wurman presented a seminar as part of the Student Chapter of the American Meteorological Society's speaker series for the undergraduate meteorology students.

### 3. Deployments

There were three intensive observation periods (IOPs) during MEDOW: April 2, 2014; April 4, 2014; and April 7, 2014. Students from the Radar Meteorology, Meso- and Storm-Scale Meteorology and Physical Meteorology courses participated in the three IOPs. Additionally, two students worked with Dr. Brian Billings on a case study resulting from one of the IOPs. The results of this study will be presented at the 2016 AMS Conference on Mountain Meteorology in June in Burlington, VT.

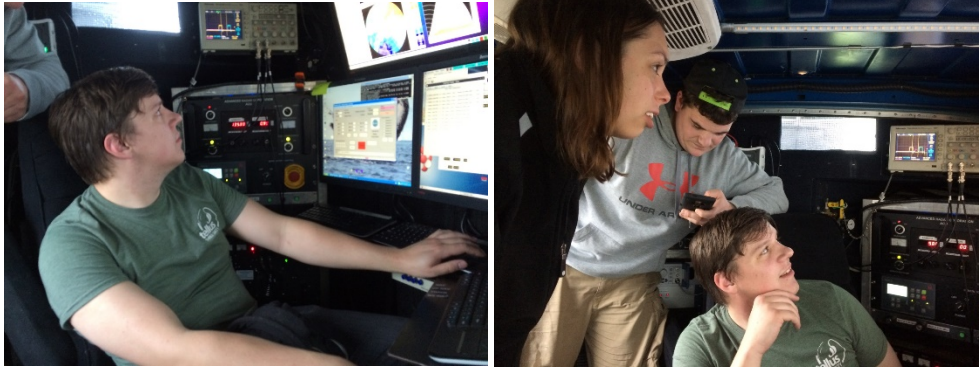


Fig 3: Students actively participated in the IOPs. Left Image: James Perkins. Right Image: from left: Amanda Sleinkofer, Corey Tober, and James Perkins.



Fig 4: DOW 6 during IOP 1 on April 3, 2016. The Millersville water tower is visible in the background.

### 3a. Intensive Observing Period 1

The top deck of a two-story parking garage on the north end of the campus of Millersville University provides a clear view of several ground targets with known dimensions (Fig. 4). Therefore, on Sunday, April 3<sup>rd</sup> the DOW 6 was deployed to this site as the lot is typically unused on the weekend. The objective was to use radar-measured reflectivities and different target geometries to estimate the gain of the DOW's antennae using the radar equation, which had been introduced in the Physical Meteorology and Radar Meteorology courses.

Since the weather on this day was mostly clear, the ground targets stood out clearly on the scans. Students would visit the site during the two hours of observations to see the data being collected and attempt to locate certain landmarks. One example was a large water tower located to the west of the parking garage that can be seen near the same location on the 1° elevation scans (Fig. 5).

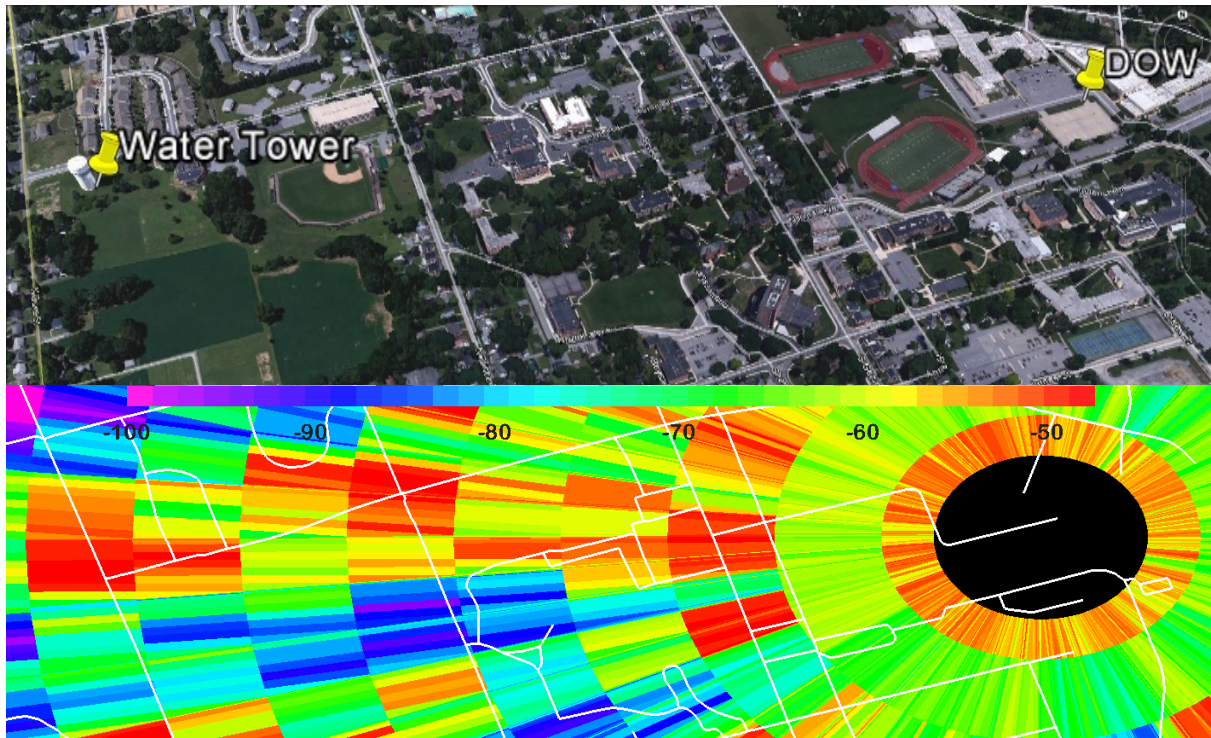


Fig 5: Location of the water tower in relationship to the DOW (top) and corresponding image of received power over the same street grid (bottom)

### 3b. Intensive Observing Period 2

The first precipitation event after the training and major outreach event had been completed occurred during the afternoon of Monday, April 4<sup>th</sup>. The DOW 6 was deployed along a road west of Millersville University (about three miles west of the campus) that offered relatively high ground and few low-level obstructions. Students from the Radar Meteorology course who had already received training accompanied the radar and operated it for approximately two hours as the precipitation passed over the area.

This case was of particular importance since it illustrated the potential value of a lower power radar in the Millersville area as was stated in the proposal. The WSR-88D at State College overshot and as a result did not capture most of the precipitation, while only the northern and southern halves of the line were sampled by radars at Philadelphia and Sterling, respectively (Fig. 6). Interestingly, when the DOW data is overlaid on the NEXRAD coverage the primary result is for the reflectivities to decrease (Fig. 6), demonstrating that the other radars are sampling the storm at too high of an elevation where a significant amount of evaporation has not yet occurred.

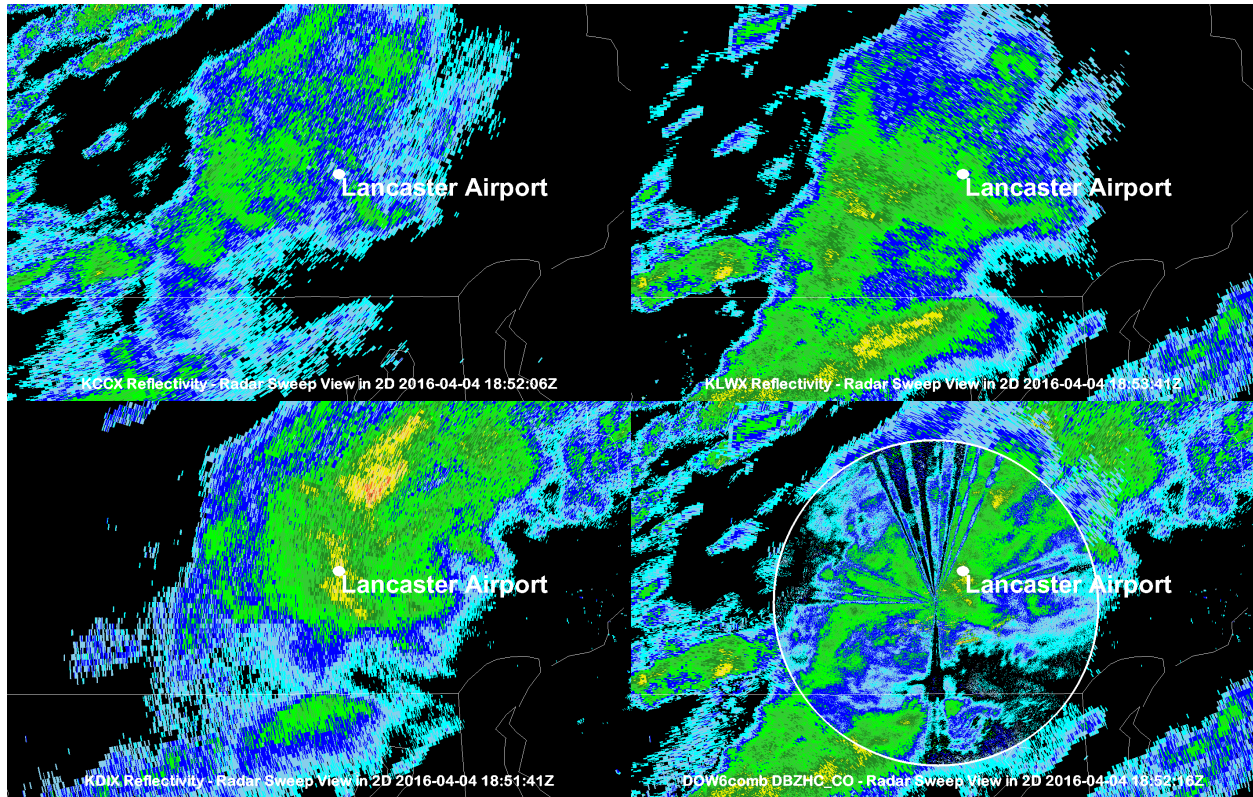


Fig 6: Reflectivity measured by the WSR-88Ds at State College (upper left), Philadelphia (upper right), and Sterling (lower left) and by DOW 6 (inside circle in lower right) during IOP 1.

The scans after most of the rainfall had passed also proved valuable as a case of topography affecting the weather of the Piedmont region. Figure 7 shows a sharply defined boundary in the velocity data separating good return from pure noise. This line moves in a southerly direction and is oriented with the section of the Appalachians running WSW-ENE across northern Pennsylvania. The lack of returns and corresponding clearing in visible satellite imagery suggest that this feature represents dry downslope air after the frontal passage. Two students, with help from faculty advisors, will pursue additional analysis of this aspect of the event and present the results as a poster at this summer's AMS Conference on Mountain Meteorology in Burlington, VT.

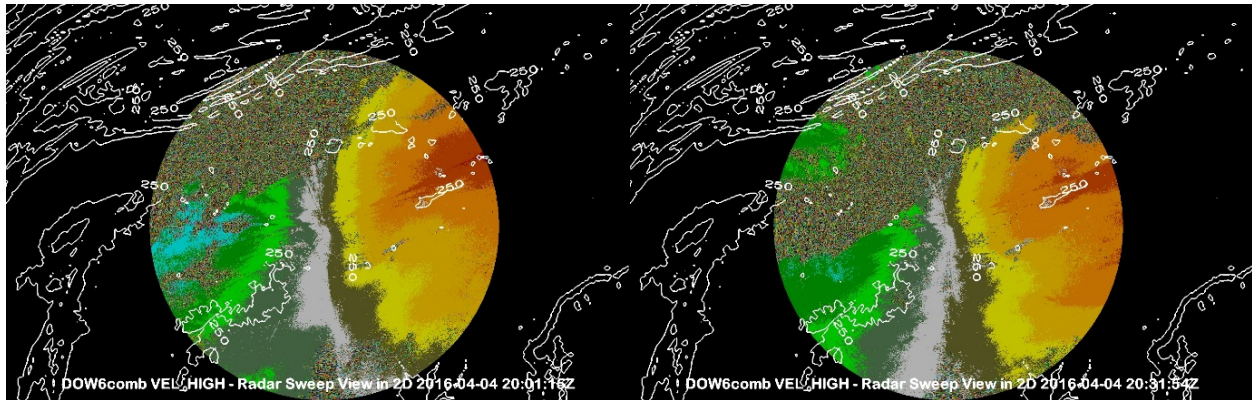


Fig 7: Radial velocity at 2001 (left) and 2031 (right) UTC during IOP 2. The terrain elevation is contoured every 250 m.

### 3c. Intensive Observing Period 3

While 0.09 inches of rain were observed at Millersville during the IOP 2 event, a much stronger convective event was forecast to occur on the last day of the project on April 7<sup>th</sup>. Therefore, a final deployment was scheduled for that morning at the same site west of Millersville used in the second IOP. Data collection started at 1243 UTC and continued for the next three hours. Radar meteorology students participated in the IOP for this event.

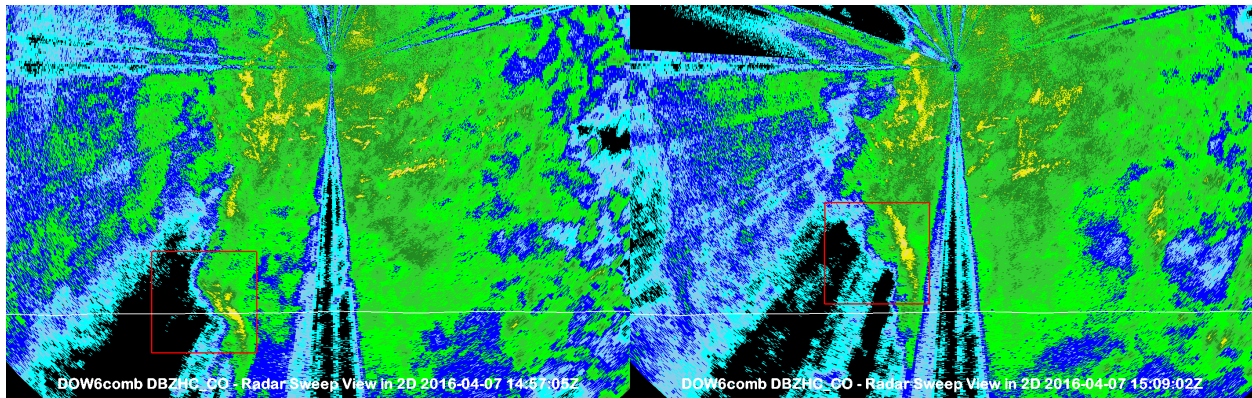


Fig 8: Reflectivity at 1457 (left) and 1509 (right) UTC during IOP 3. The red box shows the bowing portion of the line and associated attenuation.

Light rain which had commenced just prior to the start of operations would increase and decrease in intensity throughout the period in advance of a thin line of strong convection. The most obvious sign of the trailing edges strength was the bowing of one segment moving northeast from Maryland to the DOW's location (Fig. 8). This portion of the line also caused considerable attenuation, resulting in a lack of returns behind the bow that remained in place as it moved over time.

When this convective line reached the radar site, it produced heavy rain driven by strong winds with a highest measured gust from the DOW's surface station of  $12 \text{ ms}^{-1}$  (27 mph). There was

also small hail mixed in with this precipitation. Figure 9 shows an RHI scan through the line as it approached the radar. While two columns of larger positive values precede it, the final passage is characterized by values of differential reflectivity closer to zero. Slightly to the east on the Millersville campus, 0.96 inches of rain occurred with this event.

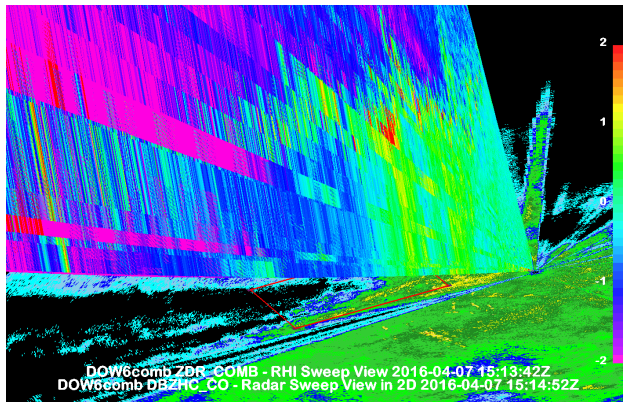


Fig 9: RHI of differential reflectivity at 1513 UTC and PPI of reflectivity at 1514 UTC during IOP 3.

#### 4. Additional Research and Classroom Use

The timing of the MEDOW project created a logistical issue in terms of using the data in the current semester's courses since it was three weeks before the end of the semester. As a result plans are in place to incorporate the data for future assignments and projects in future offerings of Radar Meteorology and Physical Meteorology. Three students along with Brian Billings are further working on the data from IOP 2 and will present the results at the AMS Mountain Meteorology Conference in June 2016 in Burlington, VT.

Furthermore, the data collected during IOP 2 provided direct evidence to support the need for a radar in the local area to address the current radar data void. There are ongoing discussions and a focused effort on the development of a proposal over the summer.

#### 5. Outreach

The MEDOW project had a significant outreach component that included two major education and outreach events with large attendance. Over 700 individuals experienced the DOW. This included the demonstration of the DOW at the **Public Weather Awareness Day (PWAD)** event which took place on 2 April 2016. PWAD was sponsored by the Millersville University Student Chapter of the AMS and is an event open and free to the community. Over 400 members of the community, including many school children, gather to experience a sundry of hand-on activities and a variety of games all designed to increase awareness on all topics related to weather and climate. Furthermore, the event includes representatives from NOAA, AccuWeather, Weather



Trends International, the Pennsylvania Emergency Management Agency, and many others. The DOW was parked outside along with fire trucks from the community Blue Rock Fire Company and was undoubtedly the center of attraction and had a constant stream of visitors inside the cab.



Fig 10: Public Weather Awareness Day, April 2.

Fig 11: Balloon Launch at Public

Weather Awareness Day.

Inside the DOW 6 cab, Ms. Gilliland showed examples of data and past events and explained how the radar is used to look at different types of precipitation events and storm systems. Visitors were able to see the controls and computer screens and particularly enjoyed videos of past tornado events sampled by DOW 6.

In addition, on April 5<sup>th</sup> Millersville University hosted the *29<sup>th</sup> Annual Women in Mathematics and Science Conference*. The Conference brought in over 350 students from the surrounding schools and was designed to introduce and encourage female students in middle and high school to pursue education and careers in Mathematics and Science. This year's Conference keynote speaker was Dr. Pamela Heinselman from the National Severe Storms Laboratory who spoke about her career path with a special focus on the Phased Array Radar and her research. The Conference included a demonstration period and the DOW was on display in front of the Student Memorial Center, where the Conference took place (see footage on the DOW on April 5<sup>th</sup>).

In addition to the students in the Radar Meteorology, Meso- and Storm-Scale Meteorology, and Physical Meteorology that participated in formal training and the three IOPs, a number of other meteorology students participated in informal training with the DOW. Millersville Meteorology has 120 meteorology majors and most were introduced or received information training while the DOW was on campus. It is also important to note that during training and off-times the DOW was parked in a centrally located parking space and was continuously surrounded by students and other visitors.

## **6. Media Coverage**

Blue Ridge News 11

Regional TV broadcast station Blue Ridge News 11 interviewed several students and developed a news story that was broadcast as part of evening news segments on April 1 and was also added to the news station's YouTube channel.

<http://www.cable11.com/>

MUTV99

Communication students interviewed Sepideh Yalda and Ashley Orehek and created a feature story on the DOW 6 visit to Millersville University. The feature story also included footage of

the DOW and the connection to the Women in Mathematics and Science Conference. This feature was shared in specific courses on campus which included students that were not meteorology majors. The feature can be accessed through the following link:

<https://drive.google.com/file/d/0B6y2uwlZfVZ6X09BRV9EcW1TcDA/view?invite=CPv39f0N&ts=57338733&pref=2&pli=1>

## Weather Information Center

Eric Horst, Director of the Millersville University Weather Information Center utilized Twitter to relay messages regarding the DOW's arrival and usage on the campus of Millersville University.

<http://www.atmos.millersville.edu/~wic/>

## 7. Project Success

### *Instructor Perspective*

Despite the shortened period of deployment due to the delayed arrival of DOW 6 due to the truck's mechanical problems, Sepideh Yalda and Brian Billings were pleased with the outcomes of MEDOW from an educational, outreach, and data collection perspective. The opportunity provided especially for the students in the Radar Meteorology course to have direct hands-on experience with the radar was invaluable. In addition other students had an opportunity to learn more about the radar that was enhanced by related course materials and lectures provided by Dr. Wurman. The two large outreach activities were highly successful reaching a broad and diverse audience. Furthermore, the data collected during IOP 2 provided direct evidence to support the need for a radar in the local area to address the data void. There are ongoing discussions and a focused effort on the development of a proposal to address this issue.

Students were extremely enthusiastic about having the opportunity to obtain hands-on training and be able to participate in observing periods. Additionally, the PWAD event is sponsored and managed by the meteorology students and they were very pleased to be able to have the DOW available for this event that attracts large numbers from the community.

CSWR technician Alycia Gilliland played a critical role in the success of the MEDOW project. She tirelessly trained a large number of students that were interested in the more detailed training and was directly involved in the IOPs and the outreach activities.

### *Student Perspective (Ashley Orehek)*

As a new officer for our chapter of AMS, I wanted to make the school year different. I wanted to do something no one has done before, but what? I thought back to the previous summer (2015), when I participated in the Plains Elevated Convection at Night (PECAN)

campaign. I worked with Karen Kosiba and the Center for Severe Weather Center (CSWR) for half of the campaign, operating mesonets and a DOW. I thought back to the 2015 Northeastern Storms Conference hosted by Lyndon State College (LSC); they had a DOW on display in conjunction with a deployment at LSC.

First goal: Let's bring a DOW to Millersville! Let's bring it for our spring Radar Meteorology class, for Public Weather Awareness Day, for community outreach, for student research. Second goal: While it is here, either Josh Wurman or Karen Kosiba would speak to the AMS chapter about their research field, enlightening chapter members and encouraging a different meteorology field. I sought out my advisor, Dr. Yalda, with my idea. She liked it and agreed to help me. She enlisted another professor with the project, too. Together, we researched and worked on a proposal and stayed in contact with the CSWR. We succeeded in bringing a DOW to campus for the first time.

I encouraged all students to "play" with the DOW while it was here. Many students had positive feedback. Junior Elizabeth Morehead said, "I think the DOW as a whole was a great experience. It was a chance for hands on learning and learning about research and getting to help with it." Community members, too, were intrigued by the impressive instrument. Junior Amanda Sleinkofer wishes it was around longer. "I thought it was really nice having the DOW and we should have [a radar] all the time for research purposes." We do wish we had a radar all of the time. Who knows, the next generation of Millersville Meteorology could have one. The information we collected with the DOW may help our case in getting a radar for south-central Pennsylvania.

Josh Wurman mesmerized over 50 students with his presentation on the DOW's history and what it has seen. He relived tales of "too close for comfort" encounters with tornadoes and navigating waterlogged streets in hurricane-impacted areas and wowed them with impressive radar graphics and videos. Students kept him well after his presentation with questions.

All around, we had a successful deployment. First, I'm glad everyone took advantage of the opportunity, got their hands on something different, and learned about a field they could delve into. Second, I'm glad that I could share something I found very intriguing with Millersville Meteorology. Third, I'm very thankful for Dr. Yalda. She really helped me get the project off the ground and make the school year different for Millersville Meteorology. She helped me fulfil my two goals for the school year.

## **8. Lessons learned and closing remarks**

Overall, the MEDOW project provided an invaluable experience for the students in multiple courses, as well as students in the meteorology program and other students at Millersville University. We are also pleased that this was a student/faculty collaborative proposal and the student proposer (Ashley Orehek) was engaged through all stages of this educational proposal and deployment. In addition, we were fortunate to be able to have three IOPs considering the short period of the deployment along with conducting two large outreach events. We have

learned a great deal during our first experience with this type of project and look forward to utilizing the data collected for future course case studies and assignments and will work on resolving some of the data conversion issues. It is important to note that as a direct result of observations obtained during IOP 2 a number of faculty are planning to work on a proposal for a potential operational radar for the local area to address the gap in observations by the surrounding WSR-88Ds.

We are thankful to NSF for providing this educational deployment opportunity especially considering the timing of our request.