

**THE PLYMOUTH STATE METEOROLOGY DOW PROJECT
(PSUMET-Dow)**

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The CWSU Doppler on Wheels (DOW) visited Plymouth State University, in Plymouth, New Hampshire, for the three-week period from February 7 to 28, 2014. The DOW was used for *classroom instruction* in PSU's graduate *Radar Meteorology* and *Mesoscale Meteorology* courses as well several undergraduate courses; *outreach* to the broader PSU campus, area schools, and several communities; and *research*, completing deployments across New Hampshire. DOW data will prove useful in our program-wide project to study cold-air damming and mixed-phase precipitation in central New Hampshire.

Educational and research efforts conducted with the DOW. The Plymouth State Meteorology DOW Project efforts were focused on enhancing instruction in graduate courses MT5340 *Radar Meteorology* and MT5480 *Mesoscale Meteorology*; undergraduate courses MT4510 *Senior Research*, MT4500 *Undergraduate Research*, MT4480 *Mesoscale Meteorology*, MT4330 *Current Weather Seminar*, MT3280 *Synoptic Meteorology II*, MT3230 *Atmospheric Thermodynamics*, and ESP2110 *Introduction to Environmental Science and Policy II*.

Radar Meteorology (MT5340) was the primary course to use the DOW. This course provides a broad overview of the hardware and theory behind the application of meteorological radar data. The course begins with a short history of radar meteorology, followed by a brief summary of the radar hardware and theory applicable to meteorological use and interpretation – beam spreading, ducting, anomalous propagation, etc. The differences between reflectivity, Doppler, and polarimetric measurements are discussed. Much of the remainder of the course is used to cover the different levels of WSR-88D data, the available products for each level, algorithms used to automatically analyze these data, and applying these data to real world problems, such as quantitative precipitation estimates and severe local storms detection. One element this course has lacked in the past is direct, hands-on experience with Doppler radar hardware and operations. Bringing the DOW to our campus, during the semester when MT5340 is taught, greatly enhanced the educational experience of graduate students studying weather radar. They were able to see the radar in action, learn how to operate it themselves, and participate in the design and execution of five deployments to collect data for their own semester-length research projects using the data developed by the radar.

Bringing the DOW to Plymouth also enhanced the educational experience of our undergraduate meteorology majors enrolled in *Current Weather Seminar* (MT4330), which is our course in weather forecasting practicum. The PSU meteorology faculty (including the course instructor) made a decision to “take over” this course for the three-week duration of the DOW's stay in Plymouth. We used the twice-weekly, 45-minute duration of that course's meetings to have comprehensive discussions of current and forecast weather (in the near- and middle-term), so that we could plan ahead for DOW deployments. Our primary concern in these discussions was to identify the best locations for positioning the DOW to collect data on developing winter storms. These discussions involved four to five faculty members, five to ten graduate students, and 15 to 20 undergraduates. Mr. Traeger Meyer from CWSU, the DOW's driver and radar operator, also participated in most of these discussions.

Senior Research (MT4510), *Undergraduate Research* (MT4500), *Mesoscale Meteorology* (MT4480), *Synoptic Meteorology II* (MT3280), *Atmospheric Thermodynamics* (MT3230), and *Introduction to Environmental*

Science and Policy II (ESP2110) were also involved in DOW-related educational efforts. The combined enrollment in these courses is about 70.

Plymouth State Meteorology has embarked on a student-oriented multi-course collaborative project to measure cold-air damming (CAD) events in New England. These CAD events often result in wintertime mixed-precipitation events in the region's complex terrain. Small differences in elevation in the alternating valleys and ridges may result in differing precipitation phases (such as snow, ice pellets, and freezing rain) over relatively short horizontal distances. We deployed the DOW at Plymouth Municipal Airport (K1P1) for about 15 hours during one such event, and obtained scan data showing the passage of *both* a warm front *and* a cold front *over the top* of an intense cold pool. Passage of both fronts occurred without ever inducing a change in wind direction or temperature at the airport, but the DOW scans clearly showed complex, organized precipitation patterns associated with the fronts passing overhead. This was particularly evident in the vertical (RHI) scans, using some of the dual-polarization products. The deployment involved four faculty members, as well as six undergraduates and five graduate students enrolled in several different courses. We also deployed the DOW, twice, to the Mount Washington Valley (near the base of the Mount Washington Auto Road) and collected scan data on synoptically-driven snowfall. The second of these involved scans of the Arctic Front as it passed through the valley. These efforts involved one faculty member and one undergraduate enrolled in *Current Weather Seminar*. Two other deployments were made to scan major winter weather events associated with coastal storms (Nor'easters) that also produced mesoscale snowbands. These efforts involved several more faculty members and students. The dates of the deployments are shown in the table in the next section.

Outreach. We used the DOW to introduce PSU students majoring in other fields, as well as students in area elementary, middle and high schools, and members of the general public, to science and technology.

We sent the DOW (driven by Mr. Meyer), along with several members of the faculty and staff of PSU, and ten graduate and 17 undergraduate students, to several outreach events. These are detailed in the table shown below. The outreach events included visits to five elementary, middle and high schools, the Mount Washington Observatory's Weather Discovery Center (in North Conway, New Hampshire), Plymouth State University's HUB Student Union building, two all-day deployments to the McAuliffe-Shepard Discovery Center (in Concord, NH), and the Glen House at the base of the Mount Washington Auto Road (in Gorham, NH). In all, about 945 people of all ages were shown the DOW and given short, guided tours by Mr. Traeger and PSU faculty and students. A University press release was disseminated to the White Mountains and Lakes Region communities advertising the DOW and inviting all residents and businesses to participate. The New Hampshire television station WMUR sent a crew to the Bedford event, and broadcast a short piece on the DOW's visit to the State.

Date [Feb]	Day	Faculty Member(s)	Meteorology Students	What, where and when	Estimate of people "reached" (students, members of the public, etc.)
7	Fri	Hoffman	All	Afternoon: Orientation(s) for PSU faculty and staff – Plymouth Airport	
8	Sat				
9	Sun				
10	Mon	Kelsey Miller	Schmidt Kawzenuk Henneberg Rinehart Godfrey	9:00 – 10:30 AM: Blue Heron School, Squam Lake Science Center 11:00 AM – 1:00 PM: Holderness Central School	125
11	Tues	Miller	Hammond Rinehart Godfrey	8:30 AM – 4:00 PM: Plymouth high school and elementary school	200
12	Weds	Hoffman	Schmidt	9:30 AM to 3:00 PM: Bedford High	100

			Kane Henneberg Godfrey Daigneault	School	
13	Thurs	Earick Hoffman Cordeira	Hammond Kawzenuk Rinehart Godfrey	9 – 11:30 AM: Rumney Elementary School Afternoon/evening: DEPLOYMENT TO ROCHESTER AIRPORT	100
14	Fri	Cordeira	Hammond Kawzenuk Lupo Haddad Handler Al-Momar Godfrey	Noon – 3:00 PM: Open house on Plymouth Town Square	30
15	Sat				
16	Sun				
17	Mon	Miller	Hammond Kawzenuk Lupo Haddad Handler Rinehart Al-Momar	Park in front of HUB – Radar course familiarization	50
18	Tues	Miller	Daigneault Delhay Godfrey	DEPLOYMENT TO MEREDITH DOCKS	10
19	Weds	Kelsey	Sodeur	Morning: Base of Auto Road - SCANS Afternoon/evening: North Conway – Weather Discovery Center	55
20	Thurs	Kelsey/Bush	Kane Goidfrey Delhay	Park in front of HUB	75
21	Fri	Hoffman Kelsey Miller Cordeira	Schmidt Kawzenuk Urango Lupo Kane Haddad Handler Henneberg Rinehart Godfrey Daigneault	DEPLOYMENT TO PLYMOUTH MUNICIPAL AIRPORT	
22	Sat	Hoffman	Hammond Sodeur Schmidt Kawzenuk Sass Urango Lupo Kane Haddad Henneberg Godfrey Al-Momar	All day: McAuliffe-Shepard Discovery Center/Concord	75
23	Sun	Miller	Hammond Sodeur Schmidt Kawzenuk	All day: McAuliffe-Shepard Discovery Center/Concord	90

			Kane Handler Henneberg Rinehart Godfrey Urango		
24	Mon				
25	Tues				
26	Weds	Kelsey		SCANS: Base of Mount Washington Auto Road	25
27	Thurs		Miller	Outreach – PSU Ice Rink	10
28	Fri			Depart	

Lessons learned. This was a very complex effort on our part. There were many different entities involved, including all members of the PSU meteorology faculty and staff; several graduate and undergraduate students; members of the faculty of other PSU departments; PSU administrators and PR staff; administration and teaching faculty of several public schools in the area; Town of Plymouth administration; Mount Washington Observatory staff; and McAuliffe-Shepard Discover Center staff. Organizing (including coordination) of all these separate events was the responsibility of one person (initially with some help from two others), and itself constituted a full-time job. This individual was also responsible for resolving conflicts that arose when scheduled school visits had to be cancelled to accommodate deployments. From this we have distilled the following lessons learned:

- Research should take first priority, given the scarcity of this resource, followed by education for university students, followed by public outreach. Everyone involved in the effort should understand this list of priorities.
- The specific meteorological conditions to be scanned should be determined in advance, along with a rough description of how each will be accomplished. For example, we were interested in studying cold-air damming conditions in the central New Hampshire region, and we had already worked out roughly how we would do it. That said, the team should also be flexible – able to adapt to the specifics of a meteorological event as it evolves – *and* be ready to scan “targets of opportunity” (unexpected meteorological events within the region of the deployment).
- To enhance the university education aspect of the DOW visit, students should be given four to six weeks of education in weather radar before the DOW arrives on site. Some of this time should be spent designing hypothetical field campaigns.
- We found that our use of the *Current Weather Seminar* course as a planning and outlook forum was very effective. It was also a great opportunity to involve as many students as possible in the use of the DOW. Given the improved preparatory education noted above, the students involved in planning should also be intimately involved in the planning and execution of specific field deployments.
- The public relations effort should begin about a week before the beginning of a DOW visit to a given university, and continue with regular updates to the media (preferably coordinated with the university public relations office) during the visit.
- There should be one person empowered to make the final decisions about when and where the DOW will be deployed. This person should be a member of the university’s meteorology faculty. The decisions made by this person can be made with the advice and assistance of others, but

because of conflicting demands, the decisions made by the person charged with this authority should be considered final.

- There should be on-going communication between the person charged with coordination of the DOW and all the interested parties. Should it become necessary to cancel a public outreach or educational event to take advantage of a research opportunity, this information should be communicated to the affected parties as soon as possible. But those parties should also understand, in advance, that cancellation of their events may occur with very little notice.
- During outreach events, outreach personnel should bring (1) age-appropriate handouts of some kind, which should include information about internet sites to visit to learn more about the DOW, CWSU, and the university involved; and (2) some kind of large signage that can be used to attract passersby. We noticed a difference between our first and second outreach events in front of PSU's HUB Student Union building. The first time we put the truck there without a large sandwich sign, and were able to attract the interest of about 50 people. The second time we added a large sign, and increased the number of visitors to 75.
- Research personnel should be ready to engage with members of the public during scanning deployments. During our visit to the Meredith Docks during a major winter storm, we still had about ten members of the public drop by to learn more about the DOW.