Final Report

Geoscience Education and Outreach of Weather in New York using the DOW at Hobart & William Smith Colleges (GEO-WIND-HWS-III) Project

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Summary: The Doppler on Wheels (DOW) deployed to Hobart and William Smith Colleges (HWS) from 5 April to 16 April 2018. The objectives of the visit were to (1) allow students to gain experience in field collection of weather radar data, (2) enhance student knowledge and understanding of conventional and dual-polarization weather radars, (3) introduce real-time forecasting activities as part of determining DOW radar project deployment timing and location, and (4) conduct several outreach events to provide the college community (i.e., students, staff, and faculty) and the general public across central New York opportunities to tour the DOW facility and learn about weather research.

Project: The GEO-WIND-HWS-III project focused on observing high-impact weather systems in the central New York/Finger Lakes region. In particular, the DOW radar collected data during weather events, such as mixed-phase precipitation, and frontal passage. Students not only gained valuable experience in the field collection of data, but also honed their real-time forecasting, communication, and presentation skills.

Students in GEO 260 Weather Analysis and GEO 265 Weather Measurements and Computing played a significant role in the GEO-WIND-HWS-III project. GEO 260 is an intermediate-level course taken by students during a semester following their completion of our introductory meteorology course. GEO 265 is an advanced course taken by students further along in atmospheric science curriculum. GEO 260 contains a component that focuses on forecasting, while GEO 265 spends multiple weeks discussing radar meteorology. Thus in preparation for the GEO-WIND-HWS-III project, students in GEO 260 conducted weather briefings to help build skills that could be used during the project. Students in GEO 265 were well versed in radar meteorology by the time the DOW arrived. Thus, the GEO 265 students often were able to take the lead in devising scanning strategies while the DOW was in the field. When possible, a student from GEO 265 was deployed with the DOW in order to help mentor other students who were not as versed in specifics of radar meteorology.

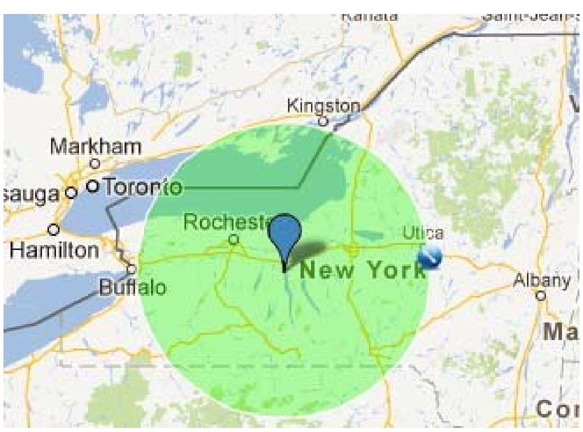


Figure 1: Region for potential DOW deployment during the GEO–WIND– HWS project. The blue marker indicates the location of HWS.

Students in both classes were asked to participate in the various outreach activities held during GEO-WIND-HWS-III. As a part of these activities, students utilized large 6’ x 3’ vinyl posters that were created during GEO-WIND-HWS-I. These thirteen posters described different aspects associated with radar meteorology and severe weather. A sampling of these posters is shown in the appendix of this report. At each outreach event, a number of the posters were set up and in conjunction with the DOW itself and served as a springboard for discussion on radar meteorology and severe weather systems. The Office of Communication at HWS also posted an article about the visit of the DOW radar to HWS for the education and outreach project. (http://www2.hws.edu/hws-welcomes-back-doppler-on-wheels/).

In addition, students in GEO 182 Intro to Meteorology utilized DOW radar data in classroom exercises. This class of 36 students also took a complete tour of the mobile weather radar and were invited to participate in deployments if space was available. Several students in GEO 182 also were individually trained in the operational procedures of the DOW radar.

Students who participated in both meteorological and outreach deployments predominately came from the two upper level classes (GEO 260 and GEO 265). In total, the pool of students who were trained for deployment numbered between 20 and 25. Each of these students were given the opportunity to sign up to participate in both operational and outreach deployments. An additional 36 students gained experience with the DOW radar through the introductory classroom work and tour in GEO 182. In order to add to the data collecting experience, students collected hand measurements of meteorological data in at least one deployment.

Deployments: All students from the upper-level classes and those who were interested in deploying with the DOW from the introductory classes participated in a one-hour training session between 5 April and 6 April. These students met with DOW technician Maiana Hanshaw in small groups of 1–2 students. These training sessions introduced students to the basic procedure to operate the DOW radar and prepared each student for participation in DOW deployments.

Table 1: DOW deployment dates.

Date	Deployment Type	# of Student Participants	# of Attendees for Outreach Event
7 April	Outreach	3	60
10 April	Outreach	4	120
11 April	Operations	8	n/a
12 April	Outreach	5	75
14 April	Outreach	5	250
15 April	Operations	3	n/a
16 April	Operations	7	n/a

1. 7 April 2018: This day featured the first DOW outreach activity. The DOW was parked in a central location on the HWS campus during an admission visit day. Perspective students and families along with current HWS students were able to visit the DOW over the course of the multiple-hour event.

2. 10 April 2018: During this outreach event, the DOW visited Midlakes (Phelps–Clifton Springs) High School. Five separate science classes (~120 students) toured the DOW radar and had opportunity to view the outreach posters to discuss severe weather and weather radars. In addition, HWS faculty and student participants provided a brief question and answer session with the Midlakes students lasting about 15–20 minutes per class.

3. 11 April 2018: This was the first operational deployment for the DOW. On this day a relatively weak system brought light rain to the Geneva, NY region. The DOW was deployed just to the south of Geneva and sampled the precipitation for nearly 6 hours. Students experimented with various sampling strategies as part of this first operational deployment.

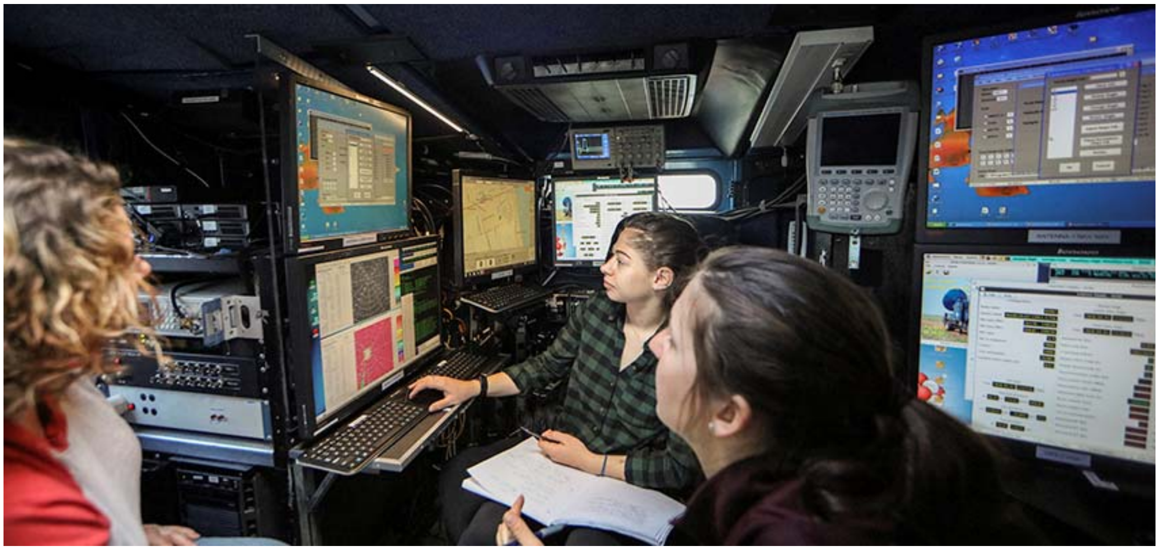
4. 12 April 2018: The DOW was parked near the center quad of the HWS campus on this day as students from Professor Laird's GEO 182 toured the radar. In addition, a number of HWS students and staff stopped by the DOW and were given impromptu tours by the DOW radar technician, Prof. Metz, and upper-level GEO students. A photo from this event is shown below.[1]

5. 14 April 2018: The largest outreach event occurred at the FLX Maker Fest at the Phelps, NY public library. This activity featured multiple exhibits dedicated the robotics, programming, engineering, science, and more. In addition to having visitors tour the DOW, HWS faculty and students set up an exhibit inside the library where they discussed meteorological instrumentation and weather in general with the many attendees[2].

[1] Photo is courtesy of HWS Office of Communications
[2] Photo is courtesy of N. Laird

6. 15 April 2018: The second data collection deployment of the GEO-WIND–HWS-III project occurred to immediately to the south of Geneva as the dual-polarization radar sampled an area of mixed-phase precipitation associated with the warm front of a slow-moving extratropical cyclone. Data was collected during a ~4 hour period when freezing rain fell throughout the region. This precipitation was particularly notable because freezing rain is extremely rare in this area during the middle of April[3].

[3] Photo is courtesy of HWS Office of Communications



7.   16 April 2018: The final operational deployment of the project also occurred just to the south of Geneva as the trailing cold front associated with the same system that brought the freezing rain into the region on the previous day passed through. This deployment was broken up into two different portions, with students deployed in the morning hours focusing on precipitation in the prefrontal environment and students in the afternoon focusing on precipitation associated with the cold frontal passage itself.

Student Research: HWS places significant focus on undergraduate research by developing opportunities in class during the academic year, as well as offering student opportunities to conduct more comprehensive research projects during the long-running Summer Research Program on the HWS campus. The real-time collection of data and the dissemination of information during outreach events about weather research and the opportunities to study atmospheric science as part of the Geoscience curriculum at HWS were of benefit to the students. These opportunities piqued many students interest and four of the students who participated in GEO-WIND-HWS-II applied to work in the 2018 HWS Summer Research Program and were accepted.

Instructor Perspectives: This project was very successful in introducing students at HWS to the field collection of weather radar data. While a number of students who participated in the project were already majoring in Geoscience with a concentration in atmospheric science, a number were still undeclared first-year/sophomore students. Out of this undeclared pool of students, a number subsequently declared a major, with some expressing interest in conducting field research. Professor Laird had multiple students from his GEO 182 class train on the DOW.

The outreach events and tours of the DOW radar were very successful in large part from the participation of HWS students. They played a large role in interacting with the people of all ages visiting the DOW radar. The student discussed a variety of weather-related topics with visitors, as well as discussing the workings of the DOW radar when visitors had a chance to climb inside the DOW radar. Not only did our students gain hands-on experience with a weather radar and enhance their understanding of radar operations and data, they also gained experience in discussing and presenting scientific information with the general public. The informational posters were a successful resource for providing information to DOW radar visitors on several aspects of weather radars and weather systems.

We hope we will be able to have the DOW radar visit for another education and outreach project sometime in the future.

Appendix A: A sampling of outreach posters used during GEO-WIND-HWS-II outreach events are included below. Posters were displayed at locations surrounding the DOW radar during outreach events to promote discussion with visitors while waiting to tour the inside of the DOW radar.

DOPPLER-ON-WHEELS (DOW)

Mobile Weather Radar

- The Center for Severe Weather Research (CSWR) owns and maintains a fleet of three DOW mobile radars. CSWR is led by atmospheric scientist Dr. Joshua Wurman and is funded primarily by the National Science Foundation since its creation in 1995.
- The mobility of the DOW radar allows for monitoring and collecting data of tornadoes, hurricanes, lake-effect snow squalls, mountain snow storms, supercell thunderstorms, thunderstorm microbursts, and dust devils.
- DOW radar has observed nearly 150 tornadoes at close range and intercepted the eye of 11 land-falling hurricanes
- DOW measured the most intense winds ever recorded (Bridge Creek, 3 May 1999) – a wind gust of 318 mph within an EF-5 tornado.
- DOW weighs 26,000 pounds and measures 8 ft. wide x 27 ft. long x 14 ft. tall
- DOW has never seen flying cows in tornadoes, but has observed flying snakes in hurricanes

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NATIONAL WEATHER SERVICE

WSR-88D RADARS

- The National Weather Service (NWS) operates a network of about 160 Doppler radars in the U.S. to monitor storm systems in real-time.
- The name WSR-88D is short for Weather Surveillance Radar – 1988 Doppler, but is more commonly known as the NEXRAD radar. It is a S-Band radar with a 10-cm wavelength.
- Most WSR-88D radars are located at airports in order to gauge the weather of the immediate surroundings for smooth take-offs and landings. These radars help to monitor severe conditions such as icing, severe fog, high winds, and thunderstorms that cause dangerous flying conditions.
- The NWS network of WSR-88D radars provides unparalleled information when monitoring the current weather. However, these radars cannot help with weather forecasts – that is the job of weather forecast computer models.
- The National Weather Service radar network is currently being upgraded with DUAL-POL to allow them to better estimate of the size, shape and variety of hydrometers. This will lead to better flash flood detection, easier differentiation between heavy rain, hail, snow and sleet, improved detection of non-meteorological targets (such as birds), identification of the melting layer, and detection of aircraft icing conditions.

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Basics – PART 1

- Radars were first used to monitor weather systems shortly after World War II. Before then, radars were primarily used to identify the location of airplanes by the Army, Navy, Air Force, and civilian air traffic controllers.

- Radars emit pulses of energy as radio waves into the atmosphere. Once these pulses hit a target, some of the energy then returns to the radar and provide information about precipitation type, size, and concentration (number in a volume of air), as well as location.

- Radars emit radio waves in a conical beam. The "radar beam" often rotates 360 horizontally around the radars position to survey the atmosphere. With each rotation, the radar increases its elevation angle to look higher in the atmosphere.

- As the pulse of energy moves outward along the radar beam axis, it is spread over a larger volume of the atmosphere. Think of a cone – with the point being the radar location.

- Most weather radars can "see" storms out to about 100 – 250 miles from their location.

- Although radars do emit directed radiation to observe storms, the average power from radars is 100 times less than the limit for maximum permissible exposure for human beings.

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Basics – PART 2

- The strength of the energy that returns to the radar from a distant target is called the REFLECTIVITY. The reflectivity is characterized by different colors that indicate the intensity of rainfall, snowfall, or hail in storms.

- The PPI (Plan Position Indicator) scan used by radars offers a 360 degree survey of the atmosphere surrounding the radar location. Continuous surveillance scanning by weather radars is used to monitor changes in position and strength of storms every few minutes.

- Weather radars are used to monitor changes that storms undergo. Radars do not help predict weather conditions beyond 1-2 hours. This short-term forecast of 1-2 hours is called NOWCASTING.

- Weather radars also can often "see" insects, birds, and bats flying in the atmosphere. Scientists have begun using information from the U.S. weather radar network to watch bird migration patterns.

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TORNADOES

- A TORNADO WATCH is issued when the atmosphere has conditions favorable for tornadoes to form.
- A TORNADO WARNING is issued when a tornado has been observed by a person or the National Weather Service radars have observed significant rotation within the severe thunderstorm.
- Tornadoes occur most often in TORNADO ALLEY – area spread across the central U.S. including the 10 states of Texas, Kansas, Oklahoma, Florida, Nebraska, Iowa, Illinois, Missouri, Mississippi, and Alabama (presented in order of greatest number of tornadoes).
- The strength of a tornado is determined by the damage it causes not by measuring its wind speeds directly. The amount of damage is related to wind speed by the Enhanced Fujita Scale (EF-Scale). The EF-Scale ranges from EF-0 (weakest) through EF-5 (strongest).
- The DOW mobile radar has measured winds of greater than 300 miles per hour in an EF-5 tornado.
- Ingredients needed for tornadoes to form:
  1. Vertical wind shear; winds change speed and/or direction with increasing height
  2. Warm moist air lifted within severe thunderstorm updraft
  3. Air temperature cooling rapidly with height above ground
  4. Circular rotation within severe thunderstorm updraft

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HURRICANES

- The word hurricane comes from the Taino Native American word, hurucane, meaning evil spirit of the wind.
- Hurricanes are one form of TROPICAL CYCLONES. Tropical cyclones are also called TYPHOONS (in western north Pacific Ocean), CYCLONES (in Indian and western south Pacific Oceans), and HURRICANES (in eastern north Pacific and north Atlantic Oceans)
- Before a storm becomes a hurricane, it first starts as a TROPICAL DISTURBANCE, then strengthens to a TROPICAL DEPRESSION, and then can intensify to a TROPICAL STORM. A tropical storm is classified as a hurricane once wind speeds increase to 74 miles per hour or higher.
- The most violent winds and heaviest rains take place in the EYE WALL, the ring of clouds and thunderstorms closely surrounding the eye.
- Every second, a large hurricane releases the energy of 10 atomic bombs as water vapor (gas) is converted to cloud and raindrops (liquid) during condensation. This energy is called LATENT HEAT RELEASE.
- Hurricanes can also produce tornadoes. They are not as strong as regular tornadoes and often last only a few minutes.
- Most people who die in hurricanes are killed by the towering walls of sea water that come inland called STORM SURGE.
- Hurricane season is from June to November when the oceans are at their warmest and the tropical atmosphere is warm and moist.

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