Final Report

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

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Summary: The Doppler on Wheels (DOW) deployed to Hobart and William Smith Colleges (HWS) from 13 to 28 February 2013*[1]. 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 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 lake-effect snow, mixed-phase precipitation, and mesoscale cold frontal passage during the two-week project period. Students not only gained valuable experience in the field collection of data, but also honed their real-time forecasting, communication, and presentation skills.

During the spring 2013 semester, many of the students who participated in the GEO-WIND-HWS project were enrolled in GEO 265 *Weather Measurements* at HWS. This class spent several weeks learning about many aspects of weather radars. Thus, the DOW radar and its dual-polarization capabilities allowed these students hands-on opportunities that greatly complemented the classroom taught materials. Additionally, the students in *Weather Measurements* were tasked with creating large vinyl posters (6’ x 3’) describing a variety of different aspects associated with radar meteorology and severe weather systems. The thirteen posters created by GEO 265 students and Professor Laird were made with an eye towards the variety of outreach events that were scheduled during the GEO–WIND–HWS project. The final posters are shown in the appendix of this report. Professor Laird and GEO 265 students worked closely with the Office of Communications at HWS in the final design and production of the posters. The Office of Communications provided funds to print and purchase stands for displaying the indoor/outdoor vinyl posters. 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://www.hws.edu/dailyupdate/NewsDetails.aspx?aid=16246)

Furthermore, students in GEO 260 *Weather Analysis* and GEO 355 *Mesoscale and Severe Weather* played a significant role in the GEO–WIND–HWS project. GEO 260 is an intermediate-

[1] The DOW rapid scan radar was deployed to HWS during the first week of the project because of a mechanical problem with the dual-polarization DOW 6 radar. After being repaired the DOW 6 was then brought to HWS to replace the DOW rapid scan for the second week of the project.

level course taken by students during a semester following their completion of our introductory meteorology course. GEO 355 is an advanced course taken by students further along in atmospheric science curriculum. Both of these classes contain a component that focuses on forecasting. Thus during the GEO-WIND-HWS project, students in each of classes took turns in providing daily DOW deployment forecasts for the next day. On each day, the assigned students created a three paragraph forecast. The first paragraph described anything interesting that was forecast to occur over the eastern half of the United States (synoptic forecast). The second paragraph discussed the meteorological impacts and conditions forecast within the DOW deployment area (mesoscale forecast; Fig. 1). Finally, the third paragraph included a deployment recommendation for the DOW that was considered when deciding upon potential operations for the following day. These forecasts were disseminated to all meteorology students at HWS. Thus, students were exposed to the challenges and time constraints of real-time forecasting.

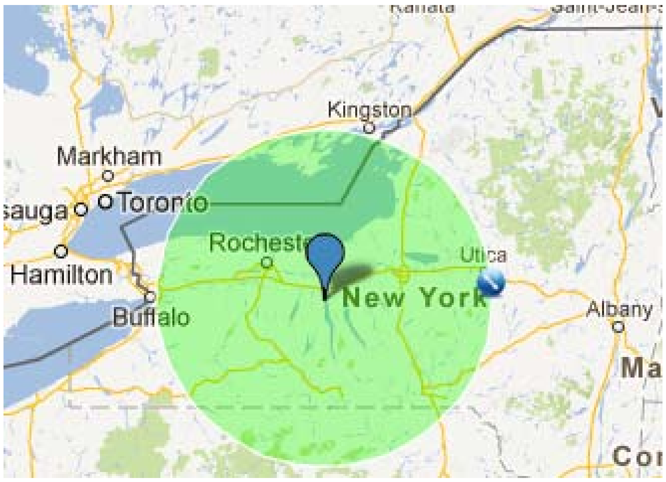


Figure 1: Region for potential DOW deployment during the GEO–WIND–HWS project. The blue marker indicates the location of HWS.

In addition, students in GEO 182 *Intro to Meteorology* and GEO 186 *Intro to Hydrogeology* utilized DOW radar data in classroom exercises. Each class of 20-40 students completed a lab exercise that focused on the DOW and weather radar data after taking a complete tour of the mobile weather radar. 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 three upper level classes (GEO 260, GEO 265, and GEO 355). Additionally, students from the two introductory classes who completed the in-class lab and were interested in participating in the deployments also completed the DOW training. In total, the pool of participating students in the deployments numbered around 40. Each of these students signed up to participate in multiple periods during the GEO–WIND–HWS project should a deployment occur. An additional 40-45 students gained experience with the DOW radar through the introductory classroom lab activities.

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 on either 14 February or 15 February. These students met with DOW technician, Ab Pfeiffer, in small groups of 1–3 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
16 February	Operations	8	n/a
17 February	Operations	7	n/a
19 February	Operations	8	n/a
20 February	Outreach	5	30
21 February	Outreach	3	60
22 February	Outreach	5	150
23 February	Outreach	10	400
24 February	Operations	1	n/a
27 February	Outreach	3	120
27 February	Operations	6	n/a

1. **16 February 2013:** The first DOW deployment occurred along the south shore of Lake Ontario near the town of Sodus Point. During this deployment a lake-effect band of light-to-moderate intensity set up along the south shore of Lake Ontario. From time to time, this band shifted onshore allowing for intermittent bursts of snow. In addition to collecting radar measurements, a number of onlookers noticed the DOW and stopped by, allowing the students to describe their activities to interested community members.

2. **17 February 2013:** This DOW deployment occurred just to the northwest of Geneva. On this day, northerly low-level flow set up light-to moderate snow along the length of Seneca Lake. Additionally, intermittent snow from upstream Lake Ontario also was occasionally observed visually and by the DOW.

3. **19 February 2013:** The DOW was positioned to the west of Geneva as prefrontal precipitation and eventually a cold front passed across central NY. For much of the day, precipitation was light in nature. However, as the cold front passed, both wind and precipitation increased. The observed wind shift and change in precipitation type from rain to snow coincided nearly perfectly with frontal passage as indicated by the radial velocity field on the DOW.

4. **20 February 2013:** This day featured the first outreach activity as the DOW traveled to the Boys and Girls Club of Geneva. Approximately 30 teenagers interacted with HWS faculty and students and received a tour of the DOW. This activity marked the first use of the DOW outreach posters.

5. **21 February 2013:** The DOW was parked near the center quad of the HWS campus on this day as students from GEO 182 and GEO 186 both completed their lab activities and toured the radar. In addition, a number of HWS students and staff stopped by the DOW and were given impromptu tours by DOW radar technician Ab Pfeiffer and upper-level GEO students.

6. **22 February 2013:** Professors Laird and Metz gave a “Friday Faculty Lunch” talk about weather radars and the DOW radar to ~75 faculty colleagues at HWS. Afterwards, faculty and students were invited out to the DOW. Approximately 150 people visited the DOW

throughout the day. Additionally, WHAM ABC Channel 13 out of Rochester came to campus to film footage of the DOW and interview GEO-WIND-HWS participants. A short ~1 minute segment on the DOW and associated activities at HWS ran on subsequent newscasts during 22 February and 23 February. The WHAM Channel 13 interview is available on-line at http://www.13wham.com/news/local/story/Doppler-On-Wheels-Now-At-Hobart-DOW/KmB6NpisVUCd59cl5gr1-A.cspx?autoplay=1

Additionally, the Finger Lakes Radio Group conducted an interview during this event and posted a story and photos on-line at http://www.fingerlakesdailynews.com/news/details.cfm?clientid=16&id=66811#.USq8d-gVg7A

Some of the people that visited the DOW during this event were kids from the Discovery Playground program at HWS that provides children with interdisciplinary academic enrichment opportunities that enable them to experience discovery and creativity in ways that enhance their inquisitiveness, curiosity and confidence (see photo of group below).

7. **23 February 2013:** The largest outreach event of the entire GEO–WIND–HWS project occurred on this day as the DOW visited the Rochester Museum and Science Center from 10 AM – 5 PM. Approximately 400 people visited the DOW radar and viewed the outreach banners. Additionally WROC CBS Channel 8 out of Rochester visited and interviewed Professors Laird and several students. The station ran a ~2 minute segment on newscasts during 23 February and 24 February. Additionally, the DOW was a featured story on a 30-minute severe weather special later in the spring. The WROC Channel 8 interview is available on-line at http://rochesterhomepage.net/fulltext/?nxd_id=373422&fb_action_ids=10151774697014899&fb_action_types=og.likes&fb_source=aggregation&fb_aggregation_id=288381481237582

   Additional media footage and interviews collected by WROC Channel 8 were collected and will be incorporated into a Spring Severe Weather special program to air during May 2013.

Photos below show some of the HWS students that participated in the DOW radar outreach event on 23 February at Rochester Museum and Science Center and Professor Laird being interviewed by WROC Channel 8.

8. **24 February 2013:** The DOW was deployed to the south shore of Lake Ontario near Sodus Point to collect data. Again, the radar sampled a lake-effect snow band along the southern shore of Lake Ontario and noted interesting mesovorticies in the radar data.

9. **27 February 2013:** The final outreach event occurred at 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.

10. **27 February 2013:** The final data collection deployment of the GEO-WIND–HWS project occurred to the west of Geneva as the dual-polarization radar sampled an area of mixed-phase precipitation associated with a slow-moving extratropical cyclone. Data was collected during intermittent periods of snow, sleet, and rain with pronounced mesoscale bands in the precipitation with observation of low-level convergence.

Student Research: All DOW radar data during the GEO-WIND-HWS project has been archived. 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. Thus, in subsequent semesters a student (or students) will likely utilize this data as a component of an independent study research project. The DOW radar data collected on several project dates would make for interesting research case studies. While subsequent research will be part of the student experience, the primary foci of the GEO-WIND-HWS project were the real-time student experience of operating the DOW radar during the 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.

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.

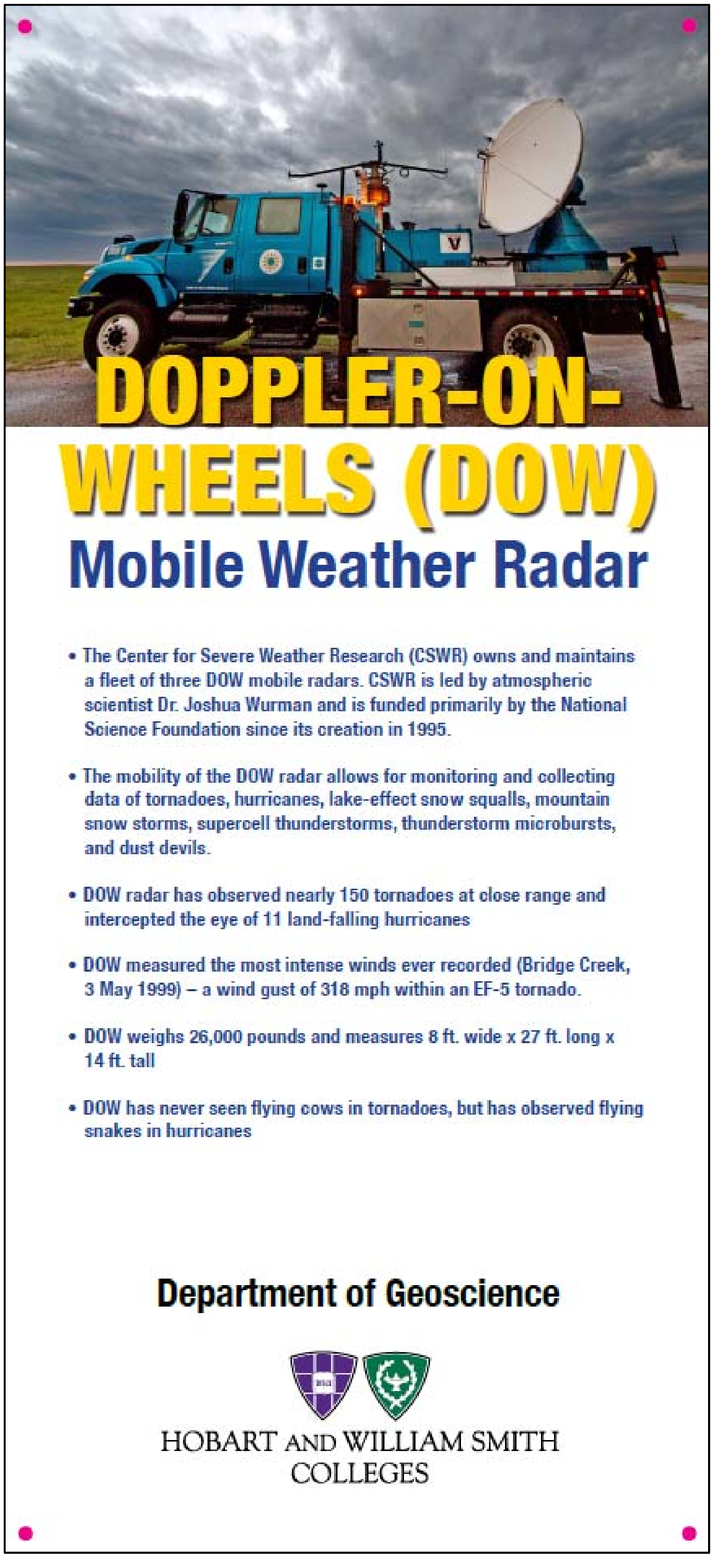
The outreach events and tours of the DOW radar were very successful in large part from the participation of HWS students. They played a large role in interacting with the people of all ages visiting the DOW radar. The student discussed a variety of weather-related topics with visitors, as well as discussing 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 created by GEO 265 students were a successful resource for providing information to DOW radar visitors on several aspects of weather radars and weather systems.

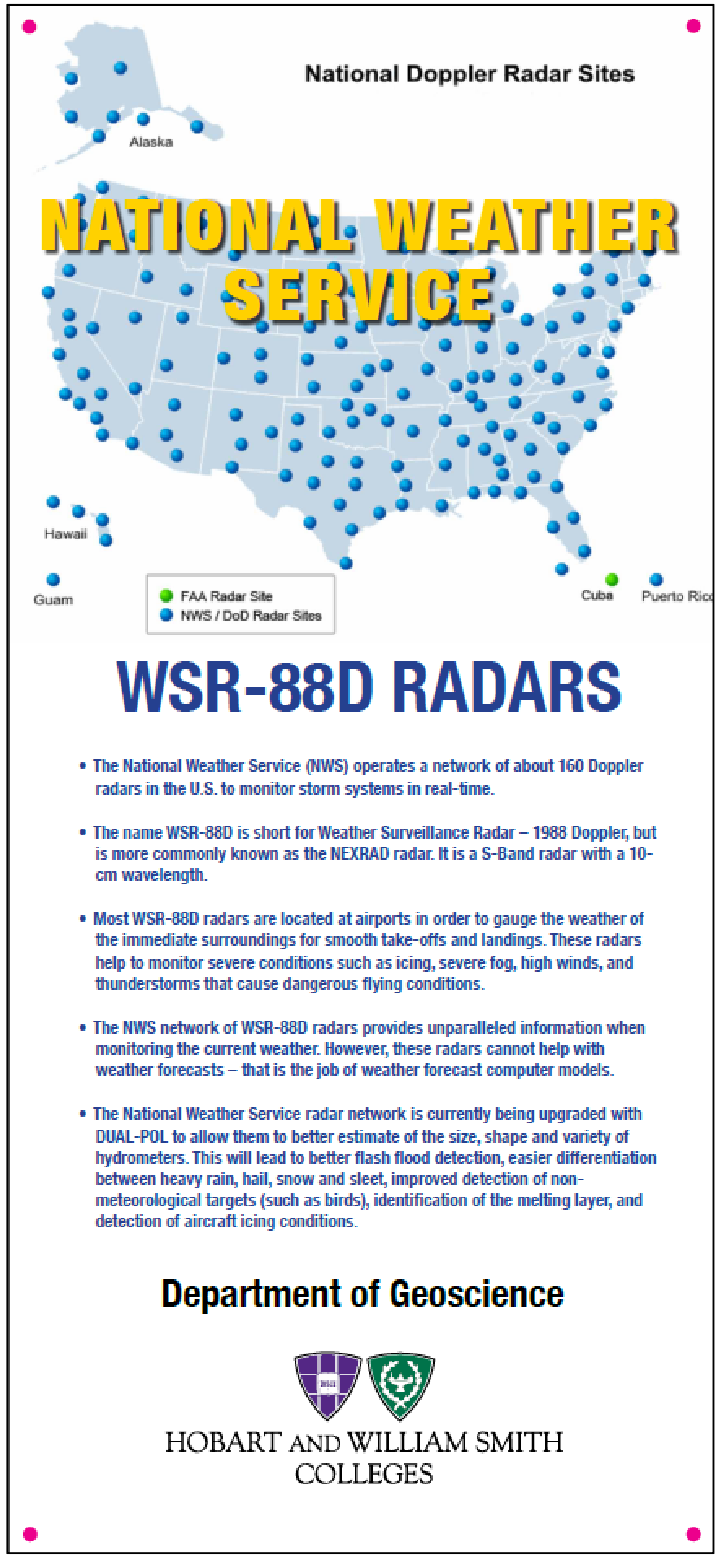
During the winter of 2013–2014 Professors Laird and Metz will be participating in the OWLeS lake-effect field project in the Lake Ontario and Finger Lakes region. A number of students from HWS will participate and the GEO-WIND–HWS project allowed these future participants to have already been trained in the operation of DOW radars.

Finally, from a forecasting perspective, students learned a tremendous amount from their daily DOW deployment forecasts. While learning how to forecast through artificial in-class activities is a vital part of a meteorological education, students seemed much more invested in their forecasts when they knew that they would play a role in whether or not the DOW radar would be deployed. Each student had the opportunity to create two forecasts across the timeframe of the GEO–WIND–HWS project and they almost universally improved as they gained forecasting experience and had the opportunity to read other student forecasts.

We hope we will be able to have the DOW radar visit for another education and outreach project during the spring 2015.

Appendix: GEO 265 Weather Measurements Informational Posters used for outreach events during the GEO-WIND-HWS project. The dimensions of each poster are 6 ft. x 3 ft. Posters were displayed at locations surrounding the DOW radar during outreach events to promote discussion with visitors while waiting to tour inside of DOW radar.





WEATHER RADAR

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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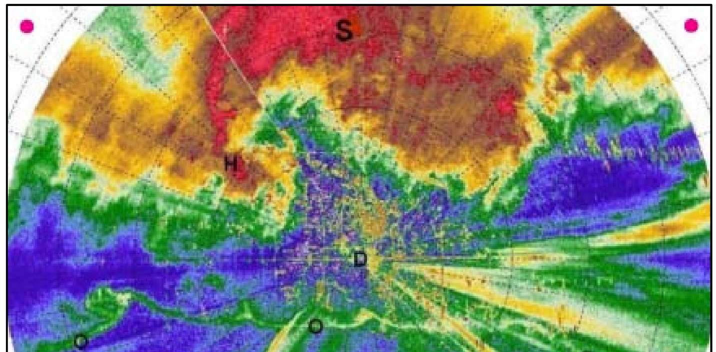

WEATHER RADAR

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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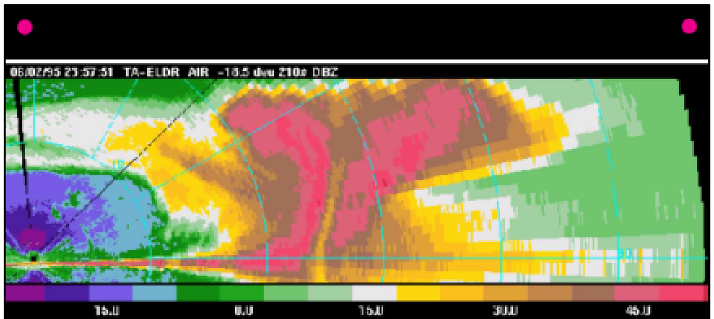

AIRBORNE
WEATHER RADARS

- Yes, "Kermit the Frog," "Gonzo," and "Miss Piggy" are connected to weather radars. They are nicknames for three weather research planes called HURRICANE HUNTERS that use airborne Doppler weather radars when flying through hurricanes.
- The idea of airborne Doppler weather radars is less than 45 years old. They are now routinely used by the National Hurricane Center to fly missions through developing tropical cyclones and hurricanes before these storms make land-fall.

- Airborne weather radars collect measurements as the plane flies around or through the severe weather. They have been used to collect weather information on supercell thunderstorms, tornadoes, blizzards, lake-effect snow storms, and hurricanes.
- Some airplanes even have two Doppler radars on board so they can collect DUAL-DOPPLER information to better determine speed and direction of winds.

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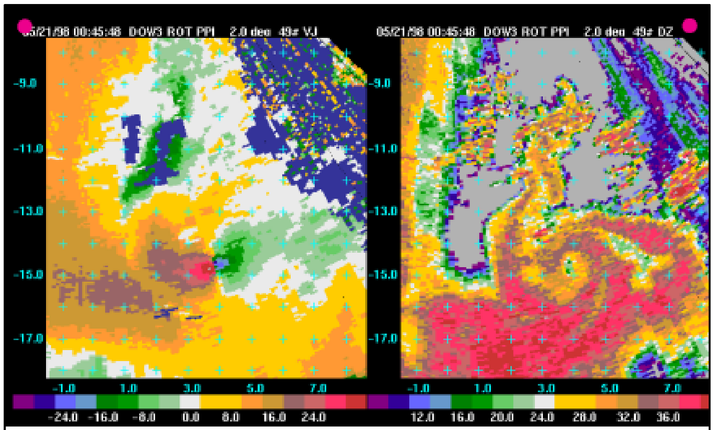

DOPPLER
WEATHER RADARS

- Doppler radars were first used to collect weather information about storm motion in the 1950s.
- Doppler radar differs from conventional radar because Doppler can measure the partial motion of targets toward or away from the radar.
  - Negative values indicate movement towards the radar
  - Positive values indicate movement away from the radar
- Doppler radars have allowed meteorologists to better determine wind speeds, storm motions, and possible locations of severe weather.
- Doppler radar is crucial for monitoring and NOWCASTING severe weather, such as lake-effect snow bands, downbursts, supercell thunderstorms, and tornadoes.
- Using its Doppler capability the Doppler-On-Wheels (DOW) mobile radar has measured winds of greater than 300 miles per hour in an EF-5 tornado and observed small vortices inside lake-effect snow bands over Lake Ontario.

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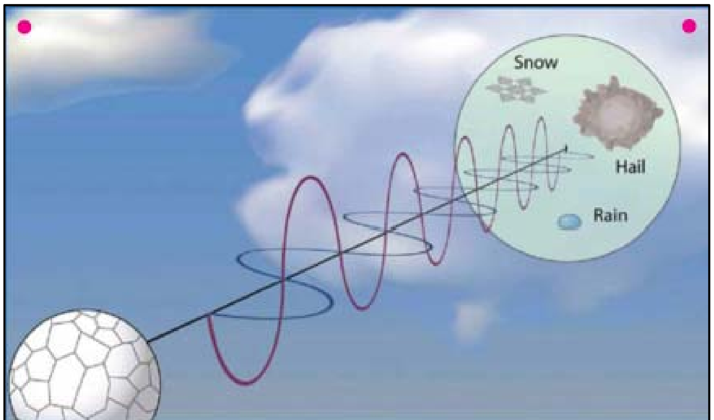

DUAL-POLARIZATION WEATHER RADARS

- Conventional radars only send out one pulse of energy, which is polarized horizontally and can only "see" one axis of non-circular precipitation particles (called HYDROMETERS) in a storm.
- Dual polarizing technology uses two perpendicularly polarized radar beams to measure vertical and horizontal reflectivity to provide more information about weather systems and their precipitation.
- Dual-Polarization (DUAL-POL) radars can determine the type of precipitation (rain, snow, hail), the size of hydrometers, and where they are located in a storm.
- Since not all raindrops are spherical and no two snowflakes have the same shape, DUAL-POL gives meteorologists a new advantage in monitoring storms. It helps improve flood NOWCASTING with better rainfall estimates and improve NOWCASTING of snowfall amounts.
- All National Weather Service radars (WSR-88Ds) in the U.S. will be completely upgraded with DUAL-POL capabilities before May 2013.

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CAREERS in Meterology & Atmospheric Science

- METEOROLOGY is the science of the atmosphere. ATMOSPHERIC SCIENCE is the broader term often used to describe the combination of meteorology with other branches of physical science involved in studying the atmosphere.
- METEOROLOGISTS use scientific principles to explain, understand, observe, or forecast the earth's atmospheric phenomena and/or how the atmosphere affects society.
- Meteorologists can have many different JOBS including daily weather forecasting, atmospheric research, teaching, working for private companies, and broadcasting via several media outlets (e.g. TV, internet, radio).
- Private weather companies serve a variety of climate-sensitive clients, such as farmers, commodity investors, insurance companies, utilities, and transportation and construction firms.
- WOULD METEOROLOGY BE A GOOD CHOICE FOR YOU? Answer these four questions and talk to a meteorologist
    1. Are you curious about the world and why it is the way it is?
    2. Would you like to work in a field of science that has many important applications in human affairs such as warning others of hazardous weather or investigating the atmospheric forces that shape our weather and climate?
    3. Are you intrigued by the idea of using mathematics as a language to describe things that happen in the world around you?
    4. Do you enjoy science and math?

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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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ICE STORMS & Freezing Precipitation

- Supercooled rain occurs during ice storms, where raindrops have a temperature below freezing but are not frozen. When the supercooled rain hits the ground, it immediately freezes.
- Supercooled raindrops typically occur from melted ice crystals and can remain unfrozen in the air until the temperature drops to - 41 °F (- 41 °C).
- New York State typically experiences more ice storms than any other state in the U.S.
- 20% of all weather related injuries are caused by ice storms and freezing precipitation.
- During the last major ice storm in the Northeast U.S. (January 4th – 10th, 1998) there were a total of 17 deaths, 500,000 customers without electricity, a total accumulation of 3 inches of ice in some areas, and close to $1 billion in damages.

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LAKE-EFFECT SNOWSTORMS

- Some of the biggest snowfalls in North America are associated with lake-effect snowstorms.
- These storms form as cool air moves across warmer water. It is all about heat and moisture moving from the water into the air.
- Other key ingredients for these storms are strong winds, a long fetch (distance wind blows across water), surface friction, and how air temperature changes with height.
- In addition to the North American Great Lakes, these storms occur over northern Canadian lakes, the Great Salt Lake in Utah, the Finger Lakes in New York, Lake Baikal in Russia, the English Channel, and even the Sea of Japan.
- These storms are best monitored by weather radars and satellites; however, that doesn't keep them from causing significant impacts, especially to transportation.

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