Embry-Riddle Aeronautical University
Convective-Boundary Research Engaging Educational Experiences
ERAU C-BREESE
Doppler-on-Wheels Final Report

Shawn Milrad (milrads@erau.edu)
and Chris Herbster (herbstec@erau.edu)
Meteorology Program
Applied Aviation Sciences Department
Embry-Riddle Aeronautical University
Daytona Beach, FL

1. Summary and Educational Objectives

Embry-Riddle Aeronautical University Convective-Boundary Research Engaging Educational Experiences (ERAU-CBREESE) was an 18-day Doppler-on-Wheels (DOW) deployment from the Center for Severe Weather Research (CSWR), funded by the National Science Foundation (NSF). ERAU-CBREESE ran from 4 – 21 May 2015 in central Florida; the project was organized and operated at ERAU by Principal Investigator (PI) Dr. Shawn Milrad, Dr. Chris Herbster (Associate Professor, Meteorology), and Robert Haley (Weather Systems Administrator, Meteorology). ERAU-CBREESE was offered as a "Summer A" (first summer term) 3-credit course aimed at ERAU Meteorology undergraduates. Eight ERAU students registered for the course (6 meteorology majors, 2 meteorology minors), with an additional 4-6 students auditing the course.

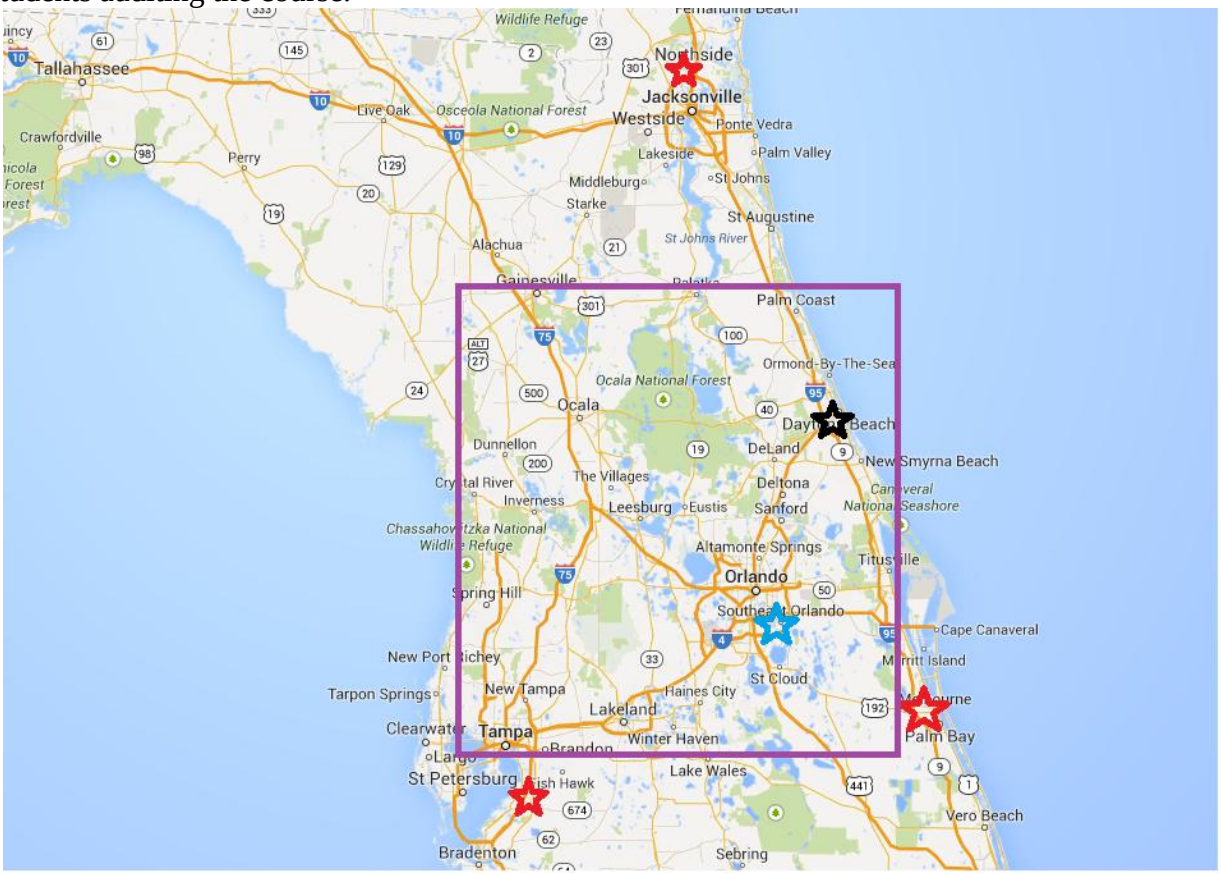

***Figure 1*:** Google map of Central Florida with the pre-determined ERAU C-BREESE domain outlined by the purple box. Locations marked are: ERAU Daytona Beach campus (black star), Melbourne (MLB), Jacksonville (JAX), and Tampa Bay (TBW) WSR-88D NEXRAD radars (red stars), and the Orlando (MCO) Terminal Doppler Weather Radar (TDWR, blue star).

The leading objectives of ERAU-CBREESE were to:

- Further the education of ERAU Meteorology undergraduates by incorporating the DOW into a summer course that provided hands-on experience with the latest radar technology and field equipment.
- Expose ERAU Meteorology undergraduates to a real-time forecasting and real-world research environment.

- Utilize collected DOW data to undertake a detailed modern scientific analysis of sea-breeze processes and convection in central Florida.
- Expose local K-12 students and the general public to Doppler radar technology, ERAU Meteorology, and atmospheric science research.

Figure 1 shows the planned ERAU C-BREESE domain across central Florida. One of our primary goals was to sample sea-breeze fronts, convergence, and convection in several locations representative of the warm-season climatology in the Florida peninsula. ERAU C-BREESE sufficiently accomplished this, with five IOPs near the Atlantic coast, two near the Gulf coast, and one in the center of the peninsula.

The remainder of the report is organized as follows: Section 2 recaps the training and local outreach efforts, specific IOPs are discussed in Section 3, Section 4 details a small sample of student post-deployment research, and Section 5 presents lessons learned, student retrospectives and future plans.

2. Training and Outreach Activities

a. Training

DOW-6 arrived at ERAU on the morning of Monday, 4 May 2015. DOW-6 remained in the ERAU parking lot (Fig. 2) for approximately three hours. Students were trained in groups of three by CSWR technician Alycia Gilliland (Fig. 2). They learned the differences between high and low frequency pulses, elevation angles, and about range-height indicator (RHI) scans. They also learned how to operate the DOW computer, properly take notes, and were introduced to the sample outreach displays. In total, 13 students (including those auditing) and three faculty/staff members were trained. The training day also provided campus-wide exposure and publicity for ERAU C-BREESE, as we had numerous curious staff and students stop to ask about the DOW.

Following the training session, ERAU C-BREESE students and faculty met to discuss the upcoming week's weather. The discussion included a review of sea-breeze processes and convection, and a look at the suite of numerical model forecasts. A sea-breeze centric forecasting links page was established: http://wx.erau.edu/faculty/milrads/ForecastingLinks.html.

Figure 2: (left) DOW-6 at the ERAU campus just after it arrived on Monday, 4 May 2015, and (right) DOW course students being trained how to use and manipulate the radar and use the accompanying software.

b. Local School Outreach

Date and Time	Outreach Location	Numbers and Notes
Tuesday, 5 May 2015 8 am – 11 am	Mainland High School Volusia County Schools Daytona Beach, FL	98 people reached, including several incoming ERAU Meteorology majors
Tuesday, 5 May 2015 2 pm – 4 pm	Galaxy Middle School Volusia County Schools Deltona, FL	174 people reached
Date and Time	**Outreach Location**	**Numbers and Notes**
Wednesday, 6 May 2015 8 am – 11 am	Belle Terre Elementary School Flagler County Schools Palm Coast, FL	337 people reached; future science outreach relationship with ERAU established
Wednesday, 6 May 2015 11:30 am – 1:30 pm	Palm Coast High School Flagler County Schools Palm Coast, FL	41 people reached
Wednesday, 6 May 2015 3 pm – 4:30 pm	Rymfire Elementary School Flagler Boys and Girls Club Palm Coast, FL	80 people reached
Date and Time	**Outreach Location**	**Numbers and Notes**
Monday, 18 May 2015 8 am – 11 am	Pathways Elementary School Volusia County Schools Ormond Beach, FL	317 people reached; most popular vehicle at "Vehicle Day"

Table 1: Details of ERAU C-BREESE local school outreach visits including (left) date and time, (middle) location, and (right) number of people reached and notes about each visit.

One of the primary missions of ERAU C-BREESE was to perform outreach to the local community, particularly K-12 students. This served several purposes: 1) Increase awareness of Doppler radar capabilities, technology, and CSWR/NSF educational deployments, 2) expose local high, middle, and elementary school students to field research and instrumentation, and 3) increase the visibility of the ERAU Meteorology Program throughout central Florida.

Figure 3: (left) DOW-6 at Mainland High School in Daytona Beach, on Tuesday, 5 May 2015, and (right) at Belle Telle Elementary School in Palm Coast, on Wednesday, 6 May 2015 (Table 1).

Table 1 details each local school outreach stop. Most of the outreach was completed in the first two post-training days (5 – 6 May 2015), with five total school visits in that time. Over 700 people (students and staff) across two counties were reached during those five diverse visits, including 337 alone at Belle Terre Elementary School in Flagler County. The staff at Belle Terre was so impressed with ERAU Meteorology students during our visit that they invited us to participate and present at their annual Science Day event during the 2015 – 2016 school year.

At each outreach stop, one DOW course student remained inside DOW-6 at all times, explaining the imagery on the screens to visitors. The imagery included DOW reflectivity and radial velocity from the Goshen, WY 2009 tornado during VORTEX-2, DOW reflectivity and velocity scans from Hurricanes Isaac (2012) and Ike (2008) along the Gulf Coast, and video taken during the landfall of Isaac. One or two additional DOW course students would staff the tornado pod, which was typically placed on the sidewalk outside DOW-6. Alycia Gilliland, Shawn Milrad, and Chris Herbster supervised and helped with crowd control at each outreach location, but almost all of the scientific material was explained by DOW course students.

Figure 3 shows pictures from Mainland High School in Daytona Beach and Belle Terre Elementary School in Palm Coast. In the left-hand picture, DOW course student Josh Young is explaining the mesonet tower and other aspects of DOW-6 to high school students. In the right-hand picture, ERAU Meteorology major Jenny Brown can be seen in the foreground explaining the tornado pod to a group of third-graders.

Our final school outreach visit took place on 18 May 2015, near the end of the deployment. We were invited to participate in Pathways Elementary School's (Ormond Beach) Vehicle Day, which included other vehicles such as firetrucks, police cars, municipal repair vehicles, and public buses. DOW-6 was by far the most visited vehicle at the event, and we reached more than 300 people (Table 1)

Overall, we found the school outreach visits to be extremely rewarding. A large number of local K-12 students were exposed to meteorological instrumentation and research, ERAU students gained experience in public scientific outreach while becoming more comfortable operating the DOW equipment, and each event generated substantial local exposure for the ERAU Meteorology Program. Through ERAU C-BREESE, ERAU Meteorology was also able to establish future working relationships and contacts with local community schools.

c. NOAA Hurricane Awareness Tour

Through a partnership with the National Weather Service in Jacksonville, FL (NWS JAX), ERAU C-BREESE was invited to participate in the NOAA Hurricane Awareness Tour stop at Northeast Regional Florida Airport in Saint Augustine, FL. This was an all-day (8 am – 5 pm) public event on Thursday, 7 May 2015. DOW-6 was located on the grassy area of the tarmac near local emergency management and media exhibit booths (Fig. 4). Two NOAA hurricane hunter aircraft (G-IV and P-3, Fig. 4) were available for school and media tours in the morning and general public tours in the afternoon. These aircraft greatly increased the attendance at the event, during which 550 people toured DOW-6. In addition, ERAU Meteorology students were able to tour the NOAA aircraft, meet with the hurricane hunters, and establish relationships that may lead to future internship and employment opportunities.

During the event, Dr. Shawn Milrad did a full interview about ERAU C-BREESE, DOW technology, and ERAU Meteorology with Action News (CBS) Jacksonville chief meteorologist Mike Buresh, which was later aired during their half-hour hurricane special. Through this interview, we were also able to secure Action News' participation in an ERAU C-BREESE IOP (see Section 2d). Finally, this event helped establish a better working relationship with NWS JAX, and exposed a large public audience to ERAU C-BREESE, CSWR, and ERAU Meteorology. We consider this event one of the major and lasting successes of the deployment.

Figure 4: (left) NOAA Hurricane Hunter (P-3 and G-IV) aircraft at the Hurricane Awareness Tour at the Northeast Florida Regional Airport in Saint Augustine on Thursday, 7 May 2015 , and (right) DOW-6 at the same location, with Dr. Shawn Milrad being interviewed by Action News (CBS) Jacksonville chief meteorologist Mike Buresh.

d. *Campus and Community Outreach*

We had two additional outreach events not discussed above: 1) Open House on the ERAU campus on Friday, 8 May 2015, and 2) an appearance at the Museum of Arts and Sciences in Daytona Beach on Sunday, 17 May 2015. These two events reached a total of more than 100 people combined, including a large group of homeschooled children on 8 May. Moreover, these outreach opportunities provided ERAU C-BREESE and DOW-6 additional community exposure, as both events were heavily advertised in local print media and university web publications. As with the school outreach events, DOW course students took the lead in explaining the DOW-6 equipment and displays to visitors.

We had two comprehensive television media interviews during the deployment: 1) Action News (CBS) Jacksonville, during the Hurricane Awareness Tour and IOP7, and 2) News13 (Orlando) during IOP8. ERAU students and Dr. Shawn Milrad were interviewed by each news crew and segments about ERAU C-BREESE and DOW technology aired on each station in mid-late May. Figure 5 shows DOW course student and ERAU Meteorology major Katie Lenninger being interviewed by Action News Meteorologist Garrett Bedenbaugh during IOP7. The interview included a live shot on the 5 pm local newscast of the thunderstorms DOW-6 was scanning at the time. Overall the media coverage allowed ERAU students to get experience with public speaking and exposure, and was very beneficial to the notoriety of the ERAU Meteorology Program, CSWR educational deployments, and NSF support.

Figure 5: ERAU DOW course student Katie Lenninger being interviewed by Action News (CBS) Jacksonville meteorologist Garrett Bedenbaugh on Tuesday, 19 May 2015, near Hastings, FL.

3. Deployment Procedures and IOPs

a. Planning IOPs

Each morning of a particular IOP, ERAU C-BREESE faculty, staff, and students would meet in the ERAU Meteorology Lab to examine weather data and agree on a plan for the IOP. The weather discussions were led by Dr. Shawn Milrad, but were generally informal and collaborative, with student participation very encouraged. Weather discussions would start with observational tools such as satellite imagery, surface plots, and 1200 UTC soundings. Subsequently, we usually examined high-resolution model output such as NCEP High-Resolution Rapid Refresh (HRRR) and NWS Melbourne's 2 km WRF model. When viewing forecast model output, we primarily focused on mass fields and forcing mechanisms (sea-breeze onset, wind shifts, convergence, instability, vertical wind shear, etc.), and not model forecast radar reflectivity. We ended the forecast discussion with a look at the general weather patterns for potential upcoming IOPs (mostly using global numerical weather prediction models), so that students were prepared for the days to come.

The final step of each morning meeting was to determine a deployment location for that day's IOP. This was not an easy task, as much of central Florida is lined with tall trees, lakes, and rivers. Generally scanning toward the coast (e.g., Atlantic Ocean, Tampa Bay) was not a problem, but choosing acceptable locations for scans in other directions was often challenging. Before departing ERAU, faculty and students scoured Google Maps street and terrain view for possible scanning locations. Some of this work had been done prior to the arrival of DOW-6 and

some was weather-dependent. In general, the locations we selected ended up being suitable for 360° scans at all elevation angles.

During each IOP, students had to take comprehensive notes about what they were scanning, how they were scanning it, and how each meteorological phenomenon was evolving over time. For these purposes we created student activity worksheets that asked the following questions:

- How often is the DOW taking a horizontal scan? Explain the decision-making process.
- Describe the phenomena you are scanning. Include approximate location (direction and distance) and time information.
- What are the spatial dimensions (i.e., width) of the phenomena you are scanning?
- What is the maximum intensity of the reflectivity?
- What is the radial velocity?
  - Do you see any radial velocity couplets? If so, describe their intensity and location.
  - Do you see a microburst or downburst signature? If so, describe their intensity and location.
- How has the phenomena you are scanning changed over time? Be as descriptive as possible.
- How do the radar scans compare to what you are seeing visually. Be as descriptive as possible.

These worksheets were collected at the end of each IOP and used by both Alicia Gilliland and ERAU faculty to assess student performance and add to the IOP logs. They were extremely useful in the post-deployment research portion of the DOW course (Section 4) when students started to analyze DOW data.

b. Specific IOPs

Table 2 describes each of the eight IOPs, including locations, times, and observed phenomena. The IOP locations are shown on a map of central Florida in Fig. 6. In general, there were 2-4 DOW course students inside of DOW-6 during each IOP. Not all DOW course students participated in each IOP, and the students were inside DOW-6 on a rotating basis. Overall, each DOW course student participated in at least half of the IOPs, with four students participating in at least 75% of the deployments. When there were more students on an IOP than could fit in the DOW at one time, students who were not in the DOW would keep an eye on surface observations, NEXRAD radar and satellite imagery, primarily using smartphones. Dr. Shawn Milrad was present for all eight IOPs, while either Dr. Chris Herbster or Robert Haley were always present to assist.

For IOP1 (Table 1), in an effort to ease students into taking DOW observations, we chose a day where convection was unlikely, but a sea-breeze front was expected. We chose to deploy at the Titusville, FL marina on the Indian River (Fig. 6), which presented good views for scanning. Students were able to identify and record the sea-breeze front moving inland throughout the afternoon. This experience allowed students to get comfortable with operating DOW-6 and properly take the required amount of notes, which made subsequent convective IOPs (IOP2 – IOP8) run much more smoothly.

IOP	Date, Time and Location	Observed Phenomena
IOP1	Saturday, 9 May 2015 11:00 am – 3:00 pm Titusville, FL (marina)	Sea-breeze front
IOP2	Sunday, 10 May 2015 11:00 am – 4:00 pm Rockledge, FL	Sea-breeze front; distant air-mass thunderstorms
IOP3	Monday, 11 May 2015 noon – 3:00 pm Grand Island, FL	Sea-breeze front and convergence; air-mass thunderstorms
IOP4	Tuesday, 12 May 2015 noon – 5:00 pm Hastings, FL	Sea-breeze front and convergence; strong thunderstorms; weak rotation
IOP5	Friday, 15 May 2015 11:00 am – 6:00 pm Pasco County, FL	Strong air-mass thunderstorms; Gulf coast sea-breeze front and convergence
IOP6	Saturday, 16 May 2015 noon – 7:00 pm Clearwater, FL (Tampa Bay)	Gulf Coast sea-breeze front; distant thunderstorms
IOP7	Tuesday, 19 May 2015 noon – 6:00 pm Hastings, FL	Sea-breeze front; weak but numerous air-mass thunderstorms
IOP8	Wednesday, 20 May 2015 noon – 3:00 pm Rockledge, FL	Sea-breeze front
IOP8	Wednesday, 20 May 2015 4 pm – 7 pm Daytona Beach, FL	Line of strong thunderstorms; shelf clouds, mammatus, gust fronts

Table 2: Overview of the eight IOPs (left) during ERAU C-BREESE, including dates, times, and deployment locations (middle), and observed phenomena (right). The colors match locations marked in Fig. 6.

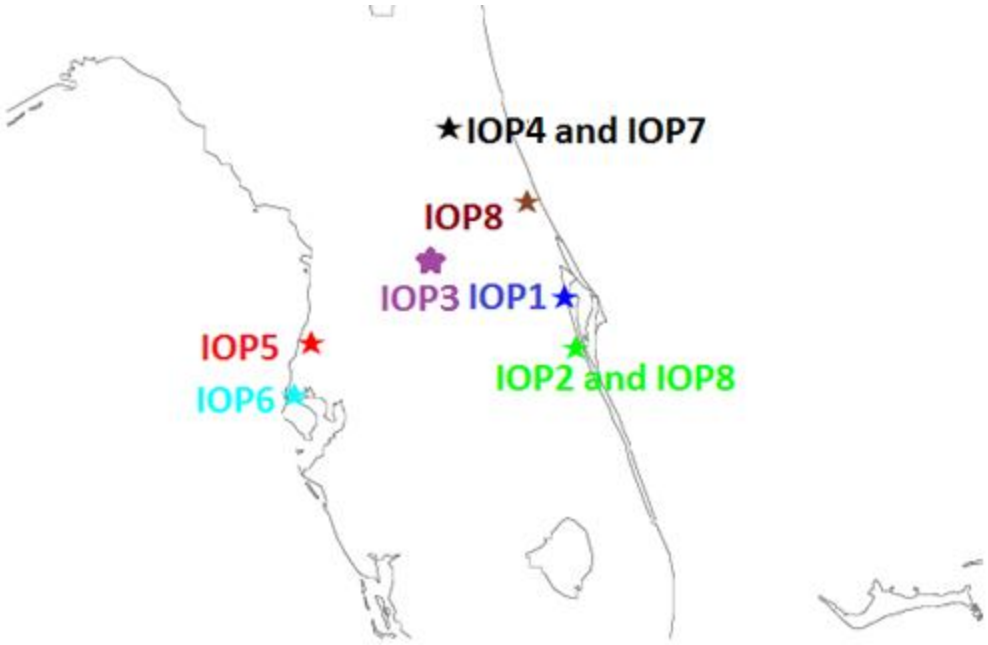

Figure 6: Map of IOP locations during ERAU C-BREESE, as detailed in Table 1.

The following subsections detail three IOPs during which some of the most interesting phenomena were observed.

i. **Hastings, FL: 12 May 2015 (IOP4)**

On Tuesday, 12 May 2015, we left ERAU just before noon, with a target area for IOP4 in western St. John's County (Fig. 6). The predominant large-scale flow was westerly, and an easterly Atlantic sea breeze was expected to develop by early afternoon, suggestive of sea-breeze convergence near the Atlantic coast, just west of Interstate 95. Our forecasts proved very accurate, and we observed the Atlantic sea-breeze front move over Interstate 95 around 1 pm. Around 1:30 pm, we reached our target deployment location near Hastings, FL (west of Interstate 95). Sea-breeze convergence was already taking place and air mass thunderstorms were developing all around us.

Figure 7: (left) DOW-6 underneath a strong thunderstorm that produced weak mid-level rotation and (right) other air-mass thunderstorms in the distance on during IOP4 (12 May).

Figure 7 shows DOW-6 scanning during IOP4 with thunderstorms located within 10 km of the deployment location. One of these thunderstorms later developed ~20 knots of gate-to-gate shear (mid-level rotation). Dr. Milrad and two students who were not inside the DOW drove about 5 km from the deployment site to look for visual cues and saw a weakly rotating wall cloud (not shown).

IOP4 was a particularly rewarding experience for DOW course students, because they were able to associate DOW reflectivity with updrafts and other visual cues, since the thunderstorms were in such close proximity without being directly overhead. Updrafts continued to pulse throughout the afternoon (Fig. 7), and we recorded more than three hours of data. Participating students found IOP4 to be a particularly rewarding and interesting experience, based on verbal post-IOP feedback. Not only did we observe interesting sea-breeze convection, but our forecasts were very accurate, which helped to bolster student confidence for subsequent IOPs.

ii. **Pasco County, FL: 15 May 2015 (IOP5)**

Friday, 15 May 2015 featured strong large-scale easterlies with the Bermuda High located off the Atlantic coast. As such, our forecasts called for the Gulf coast sea-breeze to initiate mid-afternoon and result in surface convergence just north of Tampa Bay. IOP5 took place in Pasco County, approximately 20 km north of Tampa. We had an excellent view of cumulonimbus formation to the south (Fig. 8) for the majority of the IOP. Figure 8 shows a pileus (cap) cloud during cumulonimbus development, as well as a possible gravity wave signature located just downshear. As in IOP5, the students gained valuable experience associating radar structures with visual cues. The IOP5 thunderstorms were some of the strongest and highest that we observed during ERAU C-BREESE, and provided an interesting comparative case study to the following day (IOP6, Section 4).

Figure 8: (left) Looking south towards Tampa Bay at a developing thunderstorm with a pileus (cap) cloud and possible gravity wave on Friday, 15 May 2015, and (right) later in the afternoon, when the same thunderstorm was at peak intensity.

iii. **Daytona Beach, FL: 20 May 2015 (IOP8)**

IOP8 (our final IOP) took place on Wednesday, 20 May 2015. The large-scale flow featured dominant westerlies, with Atlantic sea-breeze onset expected to occur by mid-afternoon. Forecast models and NWS forecasts suggested that the strongest convergence would occur south of Daytona Beach. As such, we deployed to Rockledge, FL (Fig. 6) shortly after noon. News13 (Orlando) followed us to our deployment site, acquiring footage and doing some additional interviews for their news segment (Fig. 9). Although we did observe the sea-breeze front moving over us visually and on DOW reflectivity/velocity, it was apparent around 3 pm that there was a lack of convergence and updrafts in the area. Using a smartphone app, we observed substantial thunderstorm development north of Daytona Beach. As a group, we decided to undeploy from Rockledge and relocate to an open field near the ERAU campus in Daytona Beach (Figs. 6, 10).

Figure 9: DOW-6 awaiting thunderstorm initiation and sea-breeze convergence in Rockledge, FL, during the early afternoon of Wednesday, 20 May 2015. In the background is the News13 (Orlando) van.

Figure 10: (left) Shelf cloud just ahead of an intense line of thunderstorms in the Daytona Beach area during the early evening of Wednesday, 20 May 2015 (IOP8) and (right) DOW-6 scanning the same thunderstorms underneath mammatus clouds near the ERAU campus.

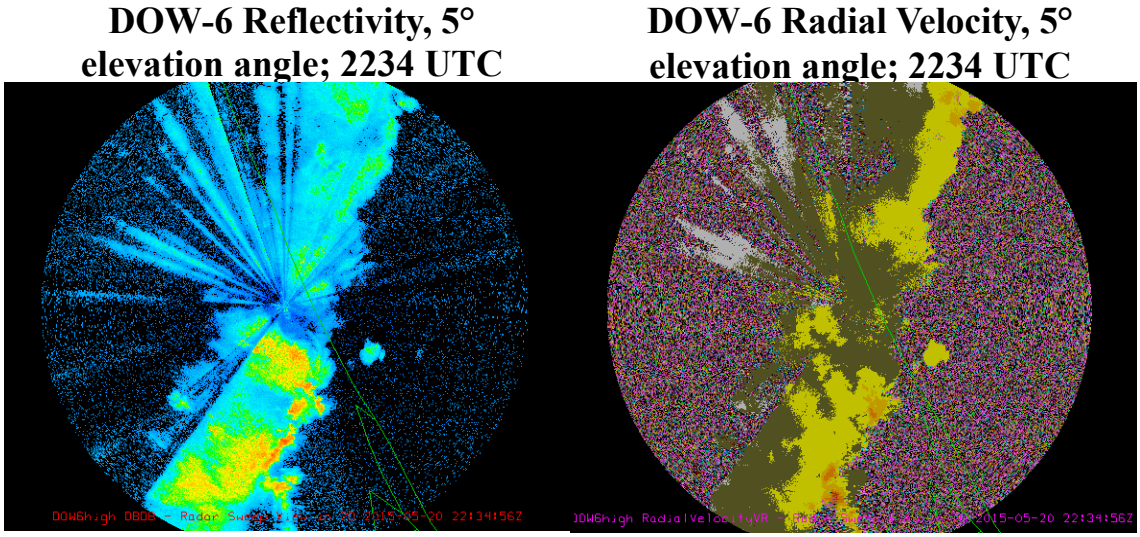

Figure 11: DOW-6 reflectivity (left) and radial velocity (right), at 5° elevation, centered on Daytona Beach at 2234 UTC 20 May 2015 (IOP8). The data were plotted with IDV.

The relocation to Daytona Beach was complete by just after 5 pm, as an intense line of thunderstorms approached the area from the northwest (Figs. 10-11). Three students and Alycia Gilliland remained inside DOW-6 and scanned these storms for approximately two hours. At the same time, Dr. Shawn Milrad and three other students drove approximately 10 km south to Port Orange, FL, where they observed the shelf cloud shown in Fig. 10.

Figure 11 shows 5° elevation angle scans of reflectivity and radial velocity at 2234 UTC, at the same time of the shelf cloud in Fig. 10. The reflectivity showed a 50 – 60 dBz line of thunderstorms that produced strong gust fronts observed in the radial velocity field (Fig. 11).

IOP8 was broadly considered our most successful IOP. Not only did it feature the most intense storms of any IOP, but the visual structures were also by far the most impressive of any during ERAU C-BREESE. The severity of the storms (which prompted NWS severe thunderstorm warnings) allowed us to collect a very interesting dataset that several of the

DOW course students chose to focus on for their post-deployment research projects. It is also of note that IOP8 featured the strongest vertical wind shear (20-25 kt, not shown) of any IOP. This likely contributed to the severity of the storms along the Interstate 95 corridor.

4. Post-IOP Research

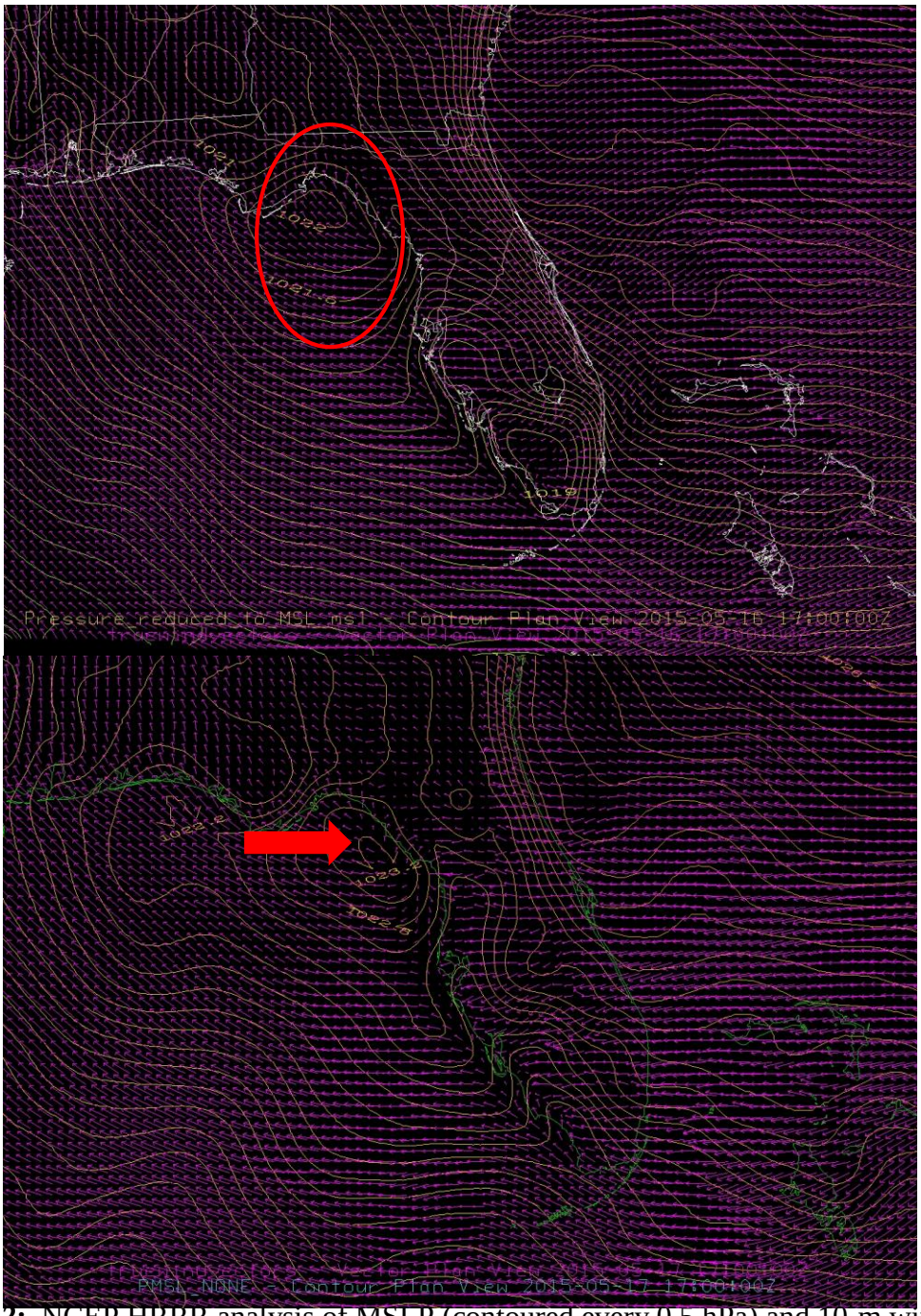

Figure 12: NCEP HRRR analysis of MSLP (contoured every 0.5 hPa) and 10-m wind (vectors) for (top) 2200 UTC 16 May 2015 and (bottom) 2200 UTC 17 May 2015. The red circle (top) and arrow (bottom) point to the mesoscale MSLP anticyclone in the northeastern Gulf of Mexico. The data were plotted with IDV.

Following the departure of DOW-6 on 21 May 2015, the DOW course transitioned into data analysis and research. Students worked in pairs on the research project of their choice; the only requirements were that the project had to involve DOW data and at least one IOP. Each project counted for 50% of a students' course grade, and required a 15-20 minute oral presentation at the end of the Summer A term. Students chose the following research project topics:

- A comparison of the active Tampa Bay convection on 15 May (IOP5) and 17 May, with the "bust" of 16 May (IOP6).
- A comparison of environmental conditions and convective ingredients on 20 May (IOP8) with the 26 April 2015 North Texas supercell outbreak.
- 20 May 2015 (IOP8): DOW vs. NEXRAD radar imagery
- 10 May 2015 (IOP2): Why was convection more intense in southwest Florida than east central Florida?

In order to begin analyzing data, students needed to be able to easily visualize the DOW dorade files. To do this, we trained them on the Unidata Integrated Data Viewer (IDV). Within a few days, they were able to regularly make IDV plots such as those shown in Fig. 11. We now summarize some of the research results of the first project listed above, completed by DOW course students Katie Lenninger and Tyler Green.

Figure 8 showed some of the strong convection observed during IOP5 (15 May 2015), from Pasco Country north of Tampa Bay. The following day (16 May), we (and the NWS) forecasted a widespread convective event in the Tampa Bay area for IOP6. In reality, thunderstorms on 16 May formed 30-50 km south of our deployment location. Meanwhile, 17 May ended up with very similar convective activity (intensity and location) to 15 May. Essentially, 16 May was the only day of the three days not to feature convection in the Tampa metropolitan area.

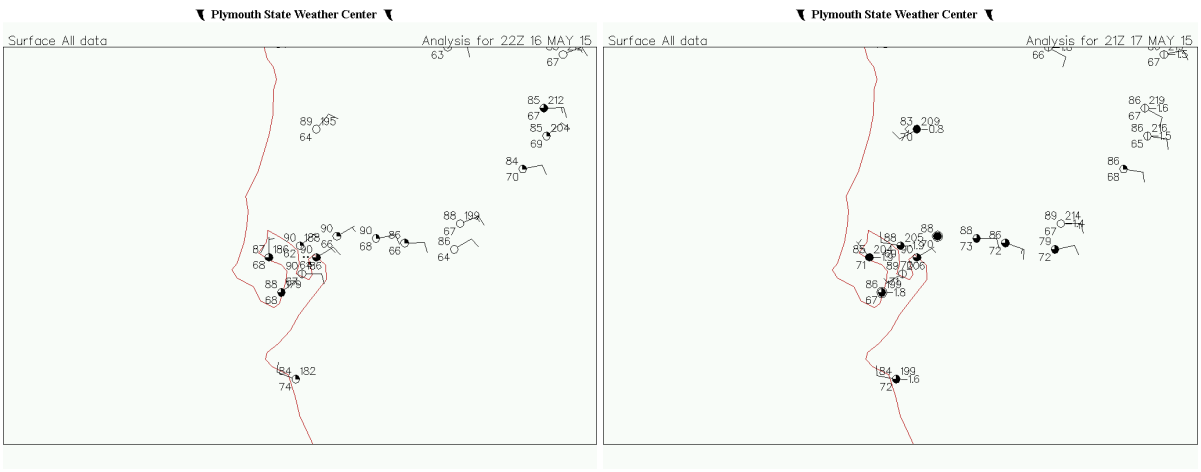

Figure 13: Surface analyses centered on Tampa Bay for (left) 2200 UTC 16 May 2015 and (right) 2100 UTC 17 May 2015. The images were retrieved from Plymouth State University's online archive, available at: http://vortex.plymouth.edu

Katie Lenninger and Tyler Green's analysis found that despite the presence of large-scale easterlies on all three days, the mesoscale and thermodynamic conditions were slightly less conducive to convection near Tampa Bay on 16 May. Figure 12 shows a meso-high present in the northeastern Gulf of Mexico during the late afternoons of 16 and 17 May, respectively. This

feature is climatologically favored in this region in the warm season (not shown), but varies in intensity and exact position. However, despite similar central MSLP values on the two days, the northwest-southeast pressure gradient was considerably stronger on 16 May (Fig. 12). The meso-high and stronger pressure gradient helped to initiate and sustain northerly surface winds (from high-to-low MSLP) into Tampa Bay during the afternoon of 16 May. As a result, the surface dewpoints were 7-10° lower (mid 60s) across Tampa Bay on 16 May than on 17 May (Fig. 13). Furthermore, the northerly surface winds on 16 May limited surface convergence (winds were converging at roughly a 90° angle, Fig. 13). Further south on 16 May and across Tampa Bay on 17 May, dewpoints were higher (low 70s), and 180° surface wind convergence was observed (Fig. 13). Both the high dewpoints and more intense surface convergence were co-located with the strongest and most widespread convective activity.

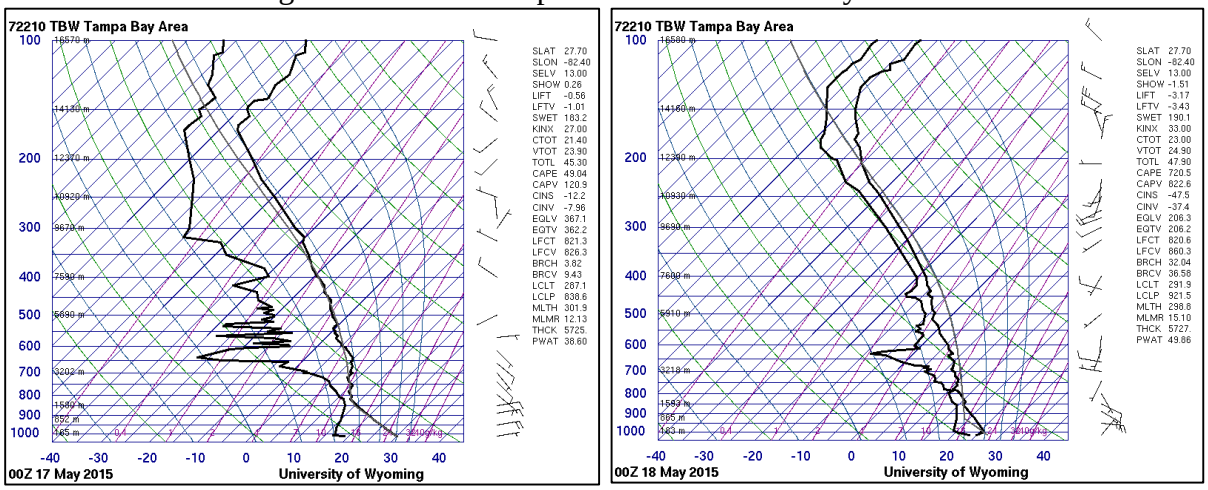

Figure 14: Observed soundings from KTBW (Tampa Bay) for (left) 0000 UTC 17 May and (right) 0000 UTC 18 May. The images were retrieved from the University of Wyoming's online sounding archive, available at: http://weather.uwyo.edu/upperair/sounding.html

Katie Lenninger and Tyler Green's analysis also revealed a distinct lack of mid-level moisture on 16 May compared to 17 May (Fig. 14). Exactly how much of this mid-level dry air was related to the meso-high in the northeastern Gulf of Mexico requires further investigation, but its presence almost certainly resulted in weaker updrafts over Tampa Bay during IOP6 (16 May).

Overall, the post-deployment research projects allowed the students to gain invaluable insight into the meteorological processes and conditions necessary for sea-breeze convection in central Florida. They also learned how to properly conduct atmospheric research and data analysis, skills that will serve them well in future classes and career endeavors. Finally, having and analyzing high-resolution DOW data has allowed us to gain deeper insight into sea-breeze and convective structures, formation, and maintenance. We anticipate that as we delve further into ERAU C-BREESE data over the coming months and years, multiple student-driven research projects, presentations, and peer-reviewed publications will result. These opportunities would not have been possible without CSWR and NSF support for ERAU C-BREESE.

5. Summary and Future Work

a. Lessons Learned

Overall, the 18-day ERAU C-BREESE deployment was an immense success for ERAU Meteorology, its students, and the broader ERAU and central Florida communities. Scientifically, a DOW was used for the first time (to our knowledge), to closely examine sea-breeze processes and convection in central Florida. This dataset will be used by ERAU Meteorology faculty and students for countless research projects, presentations, and publications in the months and years to come. Across the local community, over 1000 K-12 students and staff toured DOW-6 and learned about Doppler radar technology and meteorological field research, and a few new relationships between ERAU Meteorology and local school districts were established. Two news segments on ERAU C-BREESE aired in two regional media markets, giving increased notoriety to the educational deployment, ERAU Meteorology, CSWR, and NSF educational support. The News13 (Orlando) news segment on ERAU C-BREESE can be viewed here: https://www.youtube.com/watch?v=eIj_gdGRIF4

Most importantly, the ERAU students involved in ERAU C-BREESE enjoyed a once-in-an-undergrad-career opportunity to actively participate in a real-time field campaign. The meteorological, forecast, data analysis, and outreach skills they gained through these experiences is invaluable and will serve them very well in future career endeavors.

During ERAU C-BREESE, we learned a few important lessons:

- Students work best and most collaboratively when everyone has a task to do. Although "storm chasing" involves more waiting than people often realize, as long as students are given observational tasks and feel involved in the decision-making process, they remain engaged throughout.
- The student activity worksheets (Section 3a) were an enormous help. They provided students with general guidelines and things to look for while taking observations. In addition, they allowed us and CSWR to keep very detailed logs, which were an enormous help when performing post-deployment data analysis.
- Hands-on experiential learning results in considerably more engaged and motivated students. Although field campaigns are relatively sparse and expensive, the experience can result in a large positive change in how an individual student feels about their field of study.
- Forecasting sea-breeze air mass convection in central Florida is challenging. Although convection-allowing numerical models have improved overall model skill, they still struggle with these small-scale features.
- Observing thunderstorms with a DOW is quite different from traditional "storm chasing"; not only do you need to find the closest location to the meteorological features that you are interested in scanning, but that location needs to have unobstructed views, which at times was a challenge in a region dominated by large trees, lakes, and rivers. This results in additional planning time and less ability to adjust on-the-fly, something we quickly had to adapt to after IOP1.

b. Student Retrospectives

On the whole, comments from DOW course students were extremely positive and complimentary of the ERAU C-BREESE campaign. Some anonymous samples of post-deployment student comments are as follows:

- "Thanks for making the effort to make this course happen. Regardless of the grade I really did learn a lot and it was cool to get hands on experience out in the field."
- "The best part was the fact that we went out in the field to learn instead of sitting in a classroom."
- "Being able to use the DOW really helped me to understand the meteorological material."

c. Future Work

Our immediate plans at ERAU Meteorology involve working with CSWR to submit an article to the *Bulletin of the American Meteorological Society (BAMS)* about the ERAU C-BREESE experience by the end of 2015. The article will mostly focus on the educational component of the deployment, but will briefly detail some of our early IOP research results. To that end, the DOW dataset we collected during the 8 IOPs will prove invaluable to us in the months and years to come. We hope to establish a regularly offered independent study course in which upper-level undergraduate students can freely design a research project involving DOW data and work closely with an ERAU Meteorology faculty member to see the project to fruition. There are multiple avenues and topics of possible research that each student would have to choose from.

The success of ERAU C-BREESE has resulted in increased student interest and ERAU university administration commitment in offering a severe convection field forecasting class in the Great Plains during summer 2016. Finally, we hope to apply for another educational DOW deployment from CSWR within the next 2-4 years. While the meteorological focus may be different (e.g., cool-season severe weather, tropical cyclones), we anticipate the experiences for the next generation of ERAU Meteorology students will have the same lasting impact as ERAU C-BREESE.