Visual and Radar Observations of Storms

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Introduction

- This work is motivated by observations taken during the SUNY Oswego Storm Forecasting and Observation Program, which has lead teams of undergraduate meteorology students to the USA Plains to forecast for and observe thunderstorms since 2007.
- Visual observations of weather can be some of the most important yet least focused-upon data in our field.
- Real-time comparisons between radar and visual observations aid in research and understanding of storm behavior.
- In higher education, diagrams and pictures are important in supporting learning of complex ideas (Bligh et al. 2010).
- Many university courses now involve simulations, images, and other techniques to open new areas of learning (Bligh et al. 2010).
- Specifically in meteorology, it is important to engage students in critical thinking particularly early in their major curriculum (Barrett and Woods 2012).
  - Large-lecture introductory meteorology courses usually teach by lecturing content that does not accomplish the goal of "application learning."
- Students who are active learners have the potential to increase their interest in scientific research (Barrett and Woods 2012).
- Studies show that students understand scientific principles through field experiences and performed better in the classroom because of insights gained in the field (Barrett and Woods 2012, Etherton et al. 2011).
- More detailed and dense field observations, such as during the VORTEX projects, contribute to a better understanding of severe weather processes (Edwards and Hodanish 2006).
- Storm observation in the field is a valuable tool in the assessment and verification of severe weather events (Edwards and Hodanish 2006).
- Observational data from spotters and storm chasers have been shown to benefit real-time warning operations (Edwards and Hodanish 2006).
- Several research projects (Wakimoto et al. 2011, Atkins et al. 2012, and Atkins et al. 2014) during VORTEX II used comparisons of visual observations and radar data to understand processes such as the visual relationship between the tornado and the low-level mesocyclone and the evolution of wall clouds and tornadoes.
  - These projects used a process called photogrammetry which overlays radar data onto a photograph.
  - Atkins et al. (2012) found that it may not be possible to infer tornado intensity based on the strength and evolution of the mesocyclone.

Data and Methods

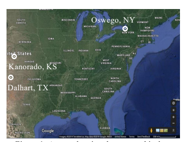

Figure 1: A map showing the geographical locations of where the three storms took place

- Selected photographs of storms observed during the 2019 Oswego program that showed interesting structural features
  - Storm 1: Dalhart, TX on 1 June 2019: Supercell
  - Storm 2: Kanorado, KS on 8 June 2019: Non-Supercell (landspouts)
  - Storm 3: Oswego, NY on 8 August 2019: Waterspout
- Gathered photo. information (i.e., time, focal length, looking direction, latitude and longitude)
- Obtained NEXRAD Level II radar data from the nearest radar site to the photo. location
- Plotted radar data in GR2Analyst as a four-panel of Base Reflectivity, Radial Velocity, Differential Reflectivity (Z_{DR}) and Correlation Coefficient (CC)
- Plotted our location (Lat/Lon) as a cross symbol on the radar data
- Plotted the approximate field of view of the photo. on the radar image
- Compared the placement of features from the photos. to the radar images (e.g., updraft edge, hail core, wall cloud, tornado).

<u>Equipment:</u>

Camera:
- Nikon D3200 DSLR
- 1.5X focal length crop sensor
- Two lenses:
  - Most common was wide angle 18-55mm focal length
  - Other was telephoto 55-200mm focal length
- All photos were taken in manual mode and with autofocus

Radar:
- Used nearby WSD-88 S-band radars at 0.5˚ tilt.

Figure 2: A photo of the camera that was used.

Results

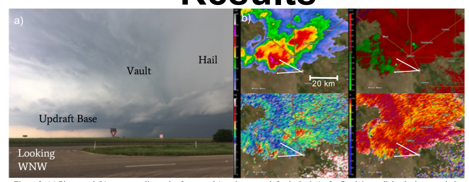

Figure 3: (a) Photo. and (b) corresponding radar four-panel (starting upper left, clockwise) of reflectivity, radial velocity, correlation coefficient, and differential reflectivity for a supercell near Dalhart, TX on 1 June 2019 at 2151Z. The cross-symbol marks our current location and the arrows show the photo.'s approximate field of view. Our location is about 20.4 km from reflectivity core.

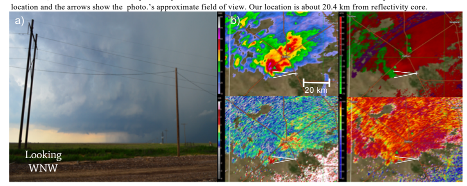

Figure 4: Same as Figure 3, but at 2207Z.

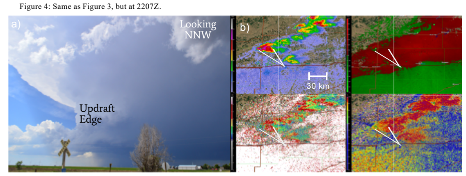

Figure 5: Same as Figure 3, but for a thunderstorm in Kanorado, KS on 8 June 2019 at 2123Z. Our location is about 33.3 km from reflectivity core.

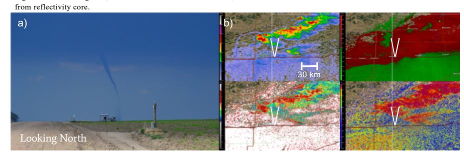

Figure 6: Same as Figure 5, but at 2150Z. Our location is about 31.5 km from reflectivity core.

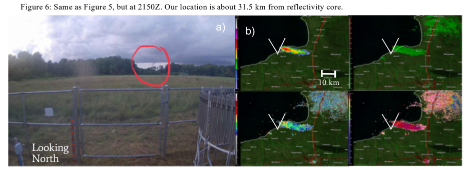

Figure 7: Same as Figure 3, but for a thunderstorm in Oswego, NY on 9 August 2019 at 0024Z that produced a waterspout. The cross-symbol marks the New York State Mesonet's location and the arrows show the photo.'s approximate field of view. Photo. from Oswego Mesonet station about 7 km from reflectivity core.

Results

- Dalhart, TX:
  - Hail core is analyzed based on the radar data as the region with reflectivity values greater than 60 dBZ and Z_{DR} values ~ 0 dB (Fig. 3b). This corresponds visually to the lighter grey region in the photo. (Fig. 3a).
  - The wall cloud corresponds to the development of the hook echo and exists near the updraft region (Fig. 4).
- Kanorado, KS:
  - The time of landspout formation corresponds to the development of a region of convergence on the radial velocity data (Fig. 6).
  - The time of landspout formation also corresponds to the weaker part of the thunderstorm complex (Figs. 5 and 6; weaker max. reflectivity and "softer"/not as distinct updraft cloud edges visual structure).
- Oswego, NY:
  - Showed the importance of visual observations in detecting features not detected by radar (e.g., no rotation in the radial velocity).

Discussion

- Reviewing our examples, we see that features observed visually correlate well to features on the radar imagery, especially for the Dalhart case.
- In the cases of Kanorado and Oswego, there was little-to-no evidence of rotation on the radial velocity data when the landspouts/waterspout occurred.
- In the Kanorado case, spotter reports of the landspouts caused the tornado warning to be issued. This case shows the importance of spotters and visual observations in assisting the National Weather Service in issuing warnings during severe weather.
- The Oswego case highlights the point that the use of webcams can be an important tool for real-time visual weather observations that can detect hazarduous weather.

Conclusions

- The use of visual observations to study storms is a useful way of understanding storm processes and study the evolution of storms.
- The greater availability of visual observations allows us to see features that are not well detected by the radar imagery.
  - Can help to issue severe warnings
- Visual observations can help supplement the concepts learned in the classroom and help students apply the information they learn.

Future Work

- Preform photogrammetric analysis comparing the correct radar tilts to the corresponding location of the feature in the photograph
- Maybe compare satellite data for anvil features of some storms (different perspective)
- Look into more storms as well as cold season events (lake-effect snow)
- Obtain more data during the SUNY Oswego Storm Observation and Forecasting Program in Spring 2020
- Possibly get DOW (Doppler on Wheels) radars to obtain higher resolution radar data and be better able to have the photos. and the radar data on the same plane while observing a storm
- Create an atlas of radar and visual observations of storms for use in education

Thank You to the participants of the 2019 SUNY Oswego Storm Forecasting and Observation Program.

References Available Upon Request