Assessing Dew Point Depression as an Indicator of Wintertime QLCSs in NC

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Introduction

Quasi-Linear convective systems (QLCSs) cause numerous damaging weather threats, including strong straight-line wind gusts, flooding, and short-lived tornadoes. QLCSs are a common type of storm to develop in North Carolina. The presence of moist air inflow can be a key role in the development of QLCSs.

Dew point depression (DPD), the difference between air temperature and dew point temperature, is a measure of moisture content. Small DPD values correlate to a higher moisture content. The goal of this research is to assess the feasibility of using DPD as an indicator of QLCS occurrences across North Carolina during the winter months (December through February), and to notice trends in DPD values in the days leading up to storm onset. Are wintertime QLCSs associated with unseasonably high moisture content?

Credit: NBC News

Credit: NCEI Radar Data

Hypotheses

Storm events have DPD values less than their corresponding climatological averages. DPD metrics can be used as an indicator of QLCS occurrences in the winter months.

Methodology

8 winter month QLCS events were used for this study. DPD values were calculated using hourly air temperature and dew point values from stations from the North Carolina Environment and Climate Observing Network (ECONet), a statewide network of research grade weather stations. Hourly DPD climatology was calculated using 20 years of hourly data. Using this hourly climatology, differences in storm DPD and climatological DPD values were calculated from 72 hours prior to the storm until storm onset. A T-test was then used to determine the statistical significance of these differences.

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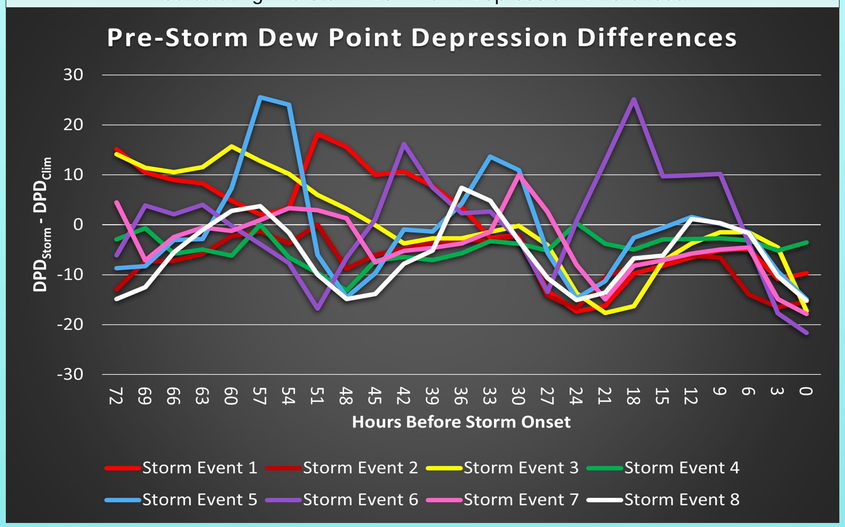
For further questions, feel free to reach out to anbenz@ncsu.edu

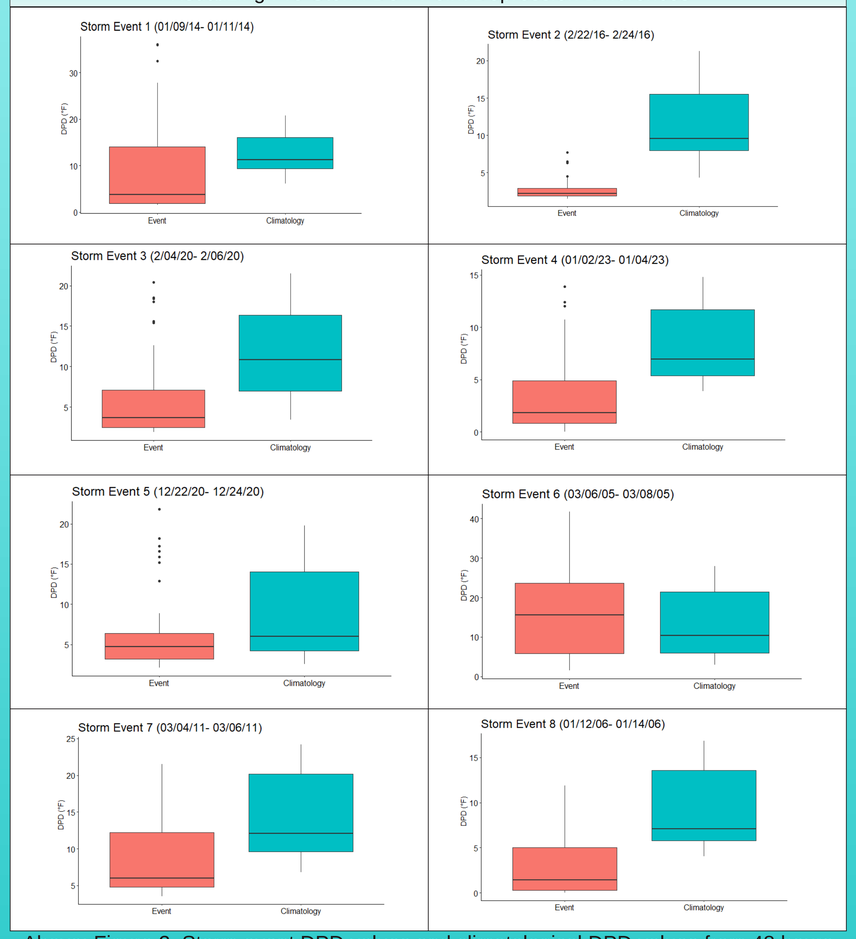
Results

Calculating Pre-storm Dew Point Depression Differences



Above: Figure 1. The difference between storm event DPD values and climatological DPD values ($DPD_{Storm} - DPD_{Clim}$) from 72 hours out until storm onset (0 hours).

Visualizing Pre-Storm Dew Point Depression Differences



Above: Figure 2. Storm event DPD values and climatological DPD values from 48 hours out until storm onset are plotted next to each other.

Determining Statistical Significance

To determine the statistical significance of the differences between DPDs, we used a T test for a comparison of means between two groups at a significance level of .05. We selected corresponding hours for storm event and climatological DPDs from 48 hours out until storm onset.

μ_1 = Storm event DPD values μ_2 = Climatological DPD Values

H_o: $\mu_1 = \mu_2$ H_a: $\mu_1 < \mu_2$

Storm Event	P-Value	Storm Event	P-Value
1	1.96e-3	5	5.326e-3
2	8.05e-12	6	8.179e-1
3	9.56e-08	7	5.683e-05
4	3.87-08	8	1.226e-06

Discussion

- Over 72 hours, there is a noticeable decrease in $DPD_{Storm} - DPD_{Clim}$ (Figure 1), and all but one storm event show DPD values less than their corresponding climatological DPDs beginning at 24 hours prior to storm onset.
- Storm event 2 showed the most defined difference between storm event DPDs and climatological DPDs.
- Statistically significant differences were seen between storm event DPDs and climatological DPDs for all but storm event 6. This was likely caused by $DPD_{Storm} - DPD_{Clim}$ being greater than 0 less than 24 hours out.

Conclusions

- These results suggest the usefulness of DPD metrics as good indicators of QLCSs 24 hours prior to the event.
- Abnormally high days of moisture content in the winter months can be indicative of QLCS occurrences. This could help weather forecasters in predicting severe storm events during the winter months across NC.
- Future research could incorporate more QLCS events, assess greater timeframes before storm onset, and analyze the steep 24-hour pre-storm onset DPD drop that was noted for three of the four storm events. Is diurnal dew point variation the only cause of the drop since storm events were analyzed at different starting hours?

References

NOAA's National Weather Service. *Squall Line/Bow Echo/QLCS*. Retrieved from Squall Line/Bow Echo/QLCS (weather.gov)
NOAA's National Weather Service Storm Prediction Center. *SPC Severe Weather Events Archive*. Retrieved from Storm Prediction Center Severe Weather Summaries (noaa.gov)
National Centers for Environmental Information. *Radar Data.* Retrieved from Radar Data (noaa.gov)
WCNC-TV. *What is a 'QLCS'? The common cause for most of the tornadoes in the Carolinas.* Retrieved from What is a QLCS and How they affect North and South Carolina | wcnc.com
NBC News. *Two dead in severe storms in Carolinas as tens of thousands lose power.* Retrieved from Two dead in severe storms in Carolinas as tens of thousands lose power (nbcnews.com)