Evolution of the atmosphere during hail events over central Florida

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1. Introduction

On January 5, 2010, the hail threshold criteria for National Weather Service (NWS) Severe Thunderstorm Warnings changed from 3/4 inch (191 mm) to 1 inch (254 mm) or larger. For 2008 and 2009 approximately 30 percent of the severe hail reports met the new criteria. This study examines the evolution of the atmosphere for incremental severe hail events. The hail reports were gathered through Storm Data (2010). This study compares the evolution of the atmosphere beginning 72 h prior to the day of the event for different hail size increments from ¾ - 4+ in (19-102 mm). The period of study is a 30 year period from 1980 to 2009 for 17 counties in central Florida (Fig. 1). These counties are roughly within coverage of the NWS Ruskin, FL WSR-88D radar.

Figure 1. Area of study in central Florida.

The number of hail days per month (Fig. 2) is highest during the warm season with over 25 hail days reported during May, June, and July. Hail was not reported from any of the sample area during Nov and Dec. The maximum hail size days are skewed toward the cool season with the largest hail falling in March. Out of the 1257 reports of hail that was ¾ inch (19 mm) and larger, 59 percent were less than one inch (25 mm). Figure 2 shows the size distribution of the hail reports. Interestingly the totals between one and two inches (25-51 mm) are skewed towards golf ball size 1.75 inch (44mm) since 1.25 inch (32 mm) is less familiar half dollar size and 1.5 inch (38 mm) hail is often related to walnut or ping pong ball.

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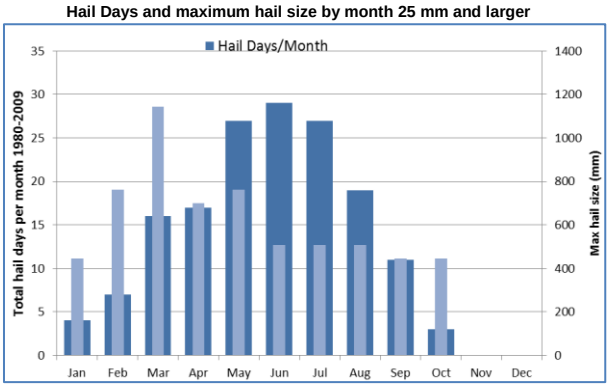


Figure 2. Hail Days and maximum hail size by month 25 mm and larger 1980-2009.

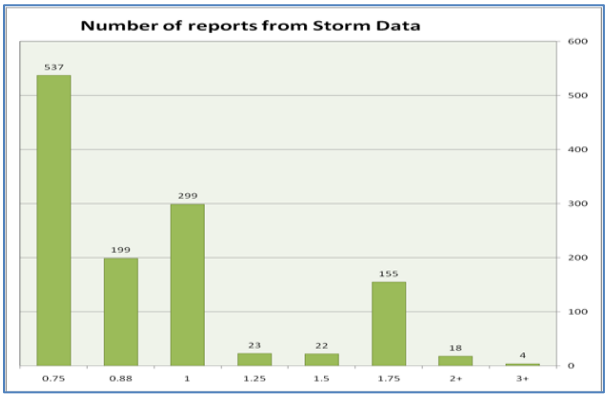
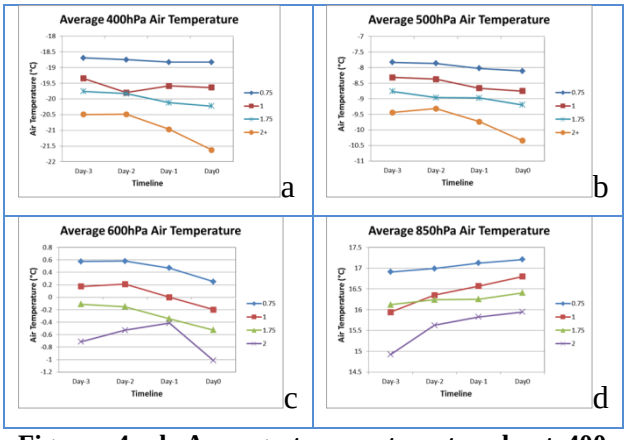


Figure 3. Distribution of reported hail sizes in inches.



Figures 4a-d. Average temperature trends at 400, 500, 600 and 850 hPa for 0.75, 1.00, 1.75 and 2+ inch and greater hail sizes from Day -3 to Day 0

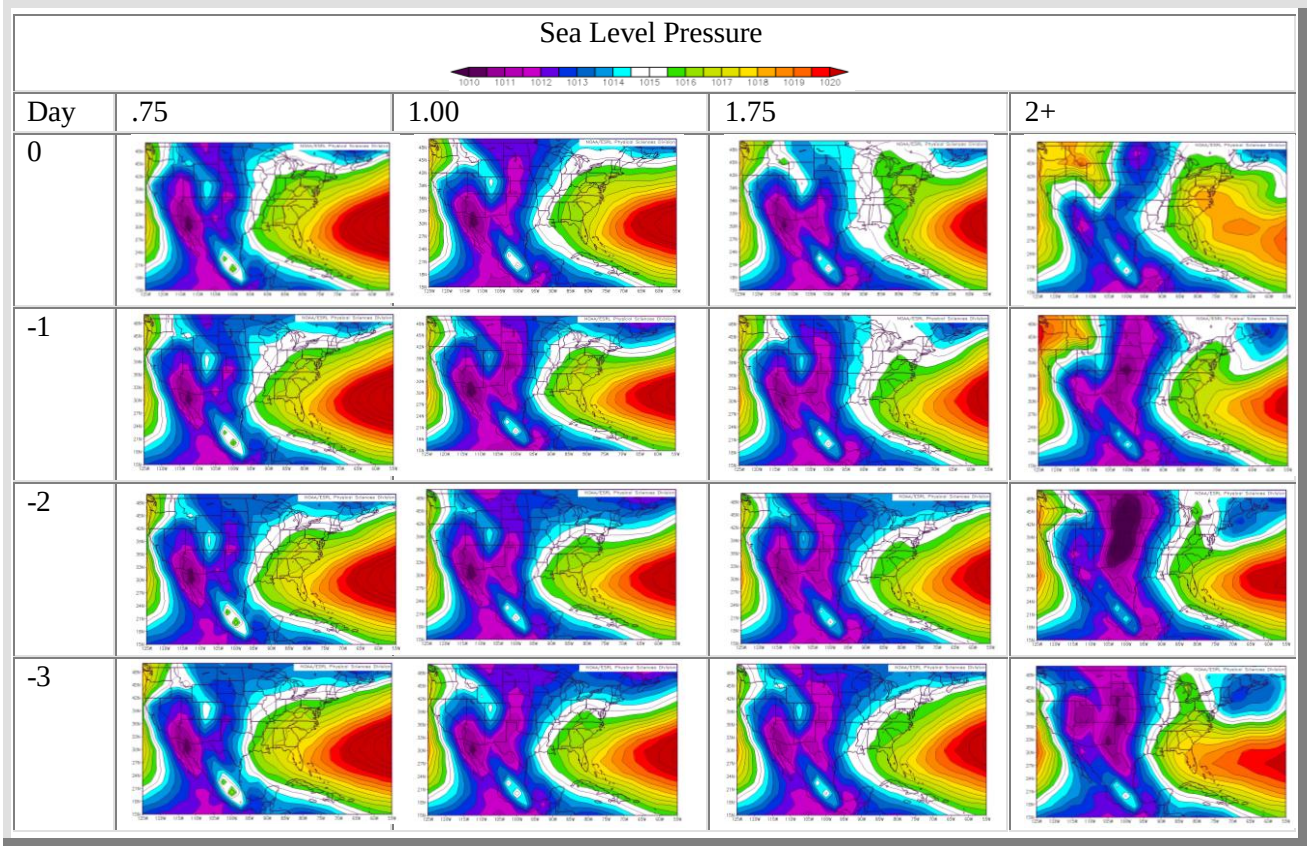


Figure 5. Sea level pressure composites for Day -3 to Day 0 for 0.75, 1.00, 1.75, and 2.00 inch and greater hail.

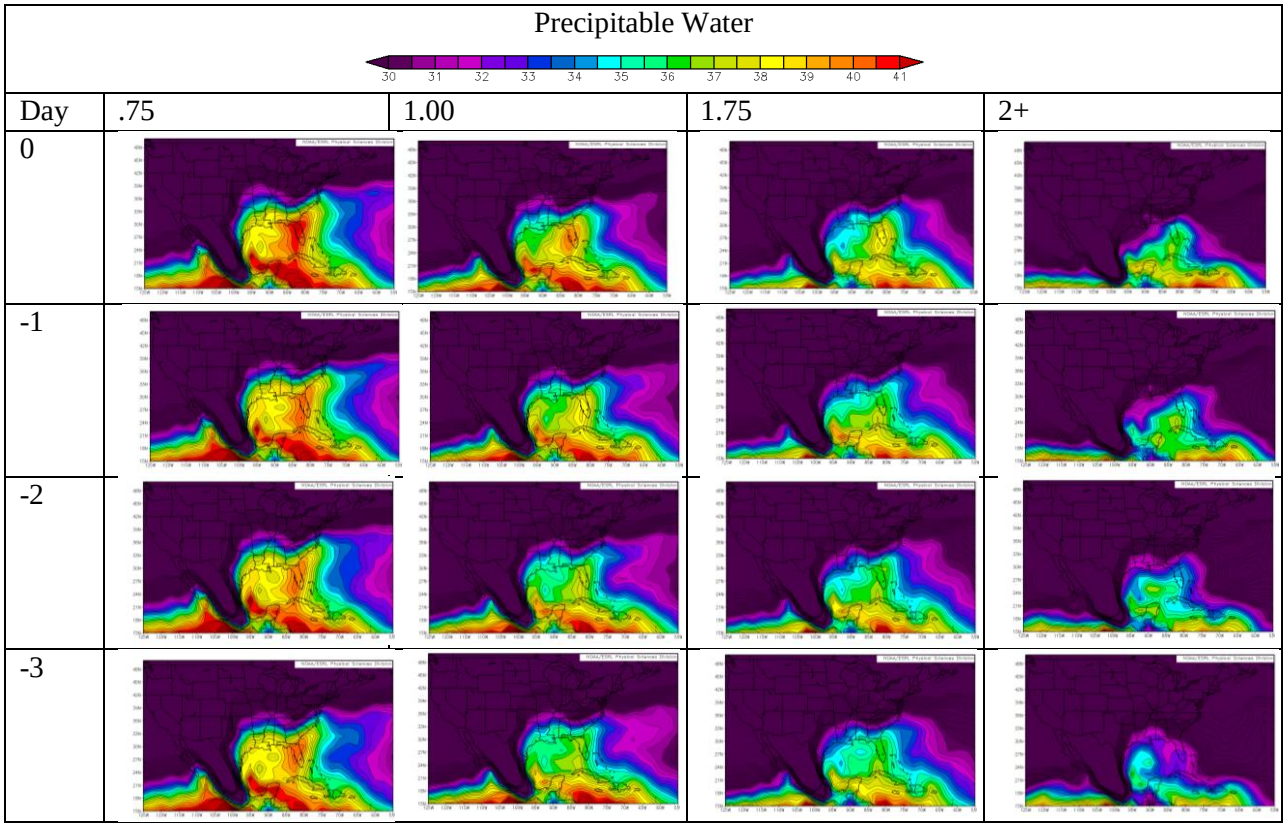


Figure 6. Precipitable water composites for Day -3 to Day 0 for 0.75, 1.00, 1.75, and 2.00 inch and greater hail.

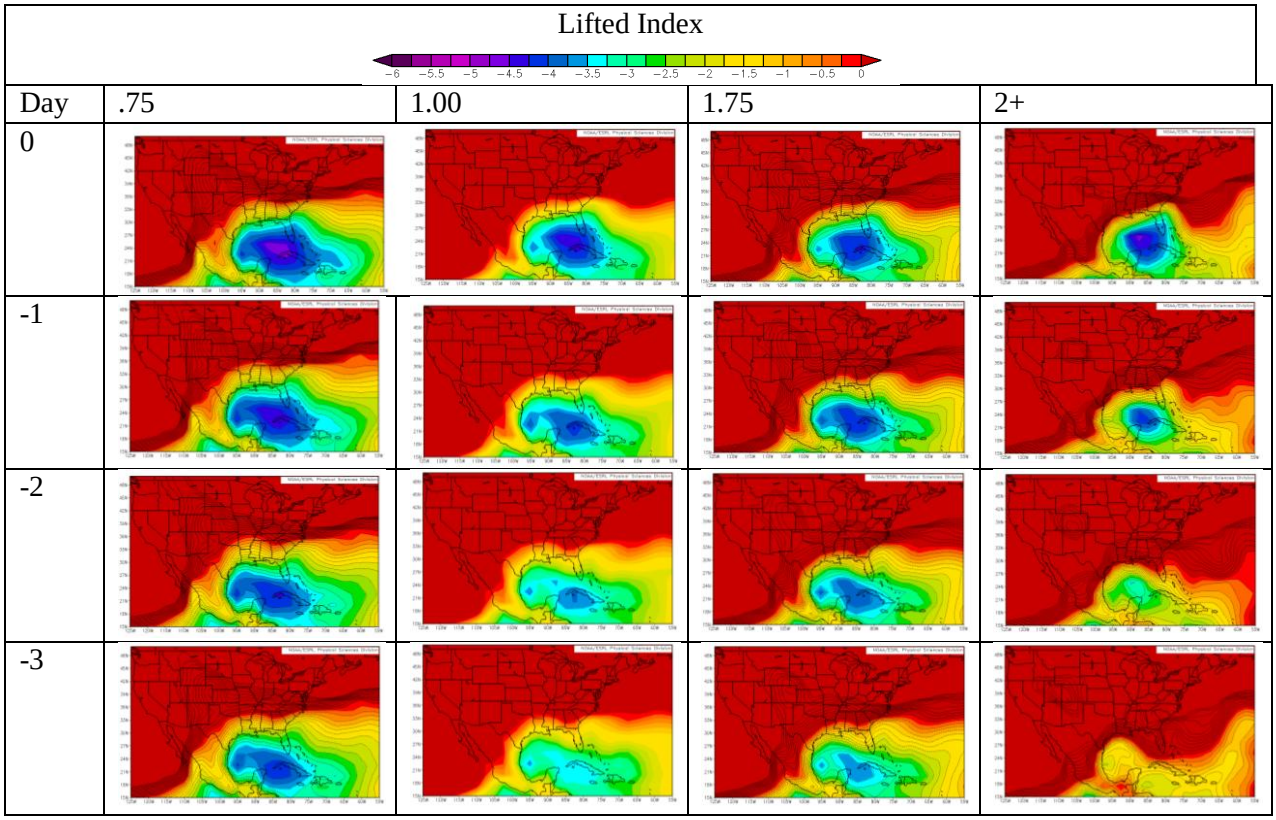


Figure 7. Lifted index composites for Day -3 to Day 0 for 0.75, 1.00, 1.75, and 2.00 inch and greater hail.

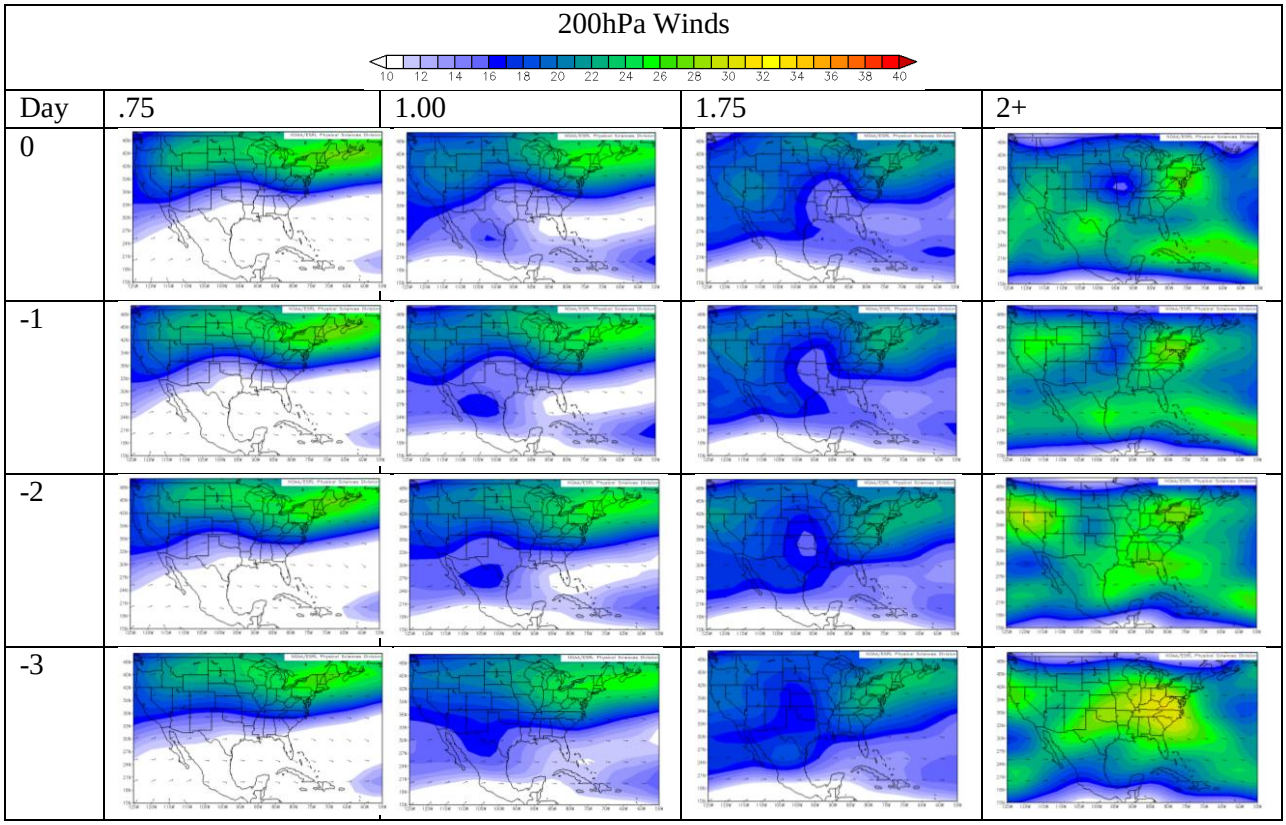


Figure 8. 200hPa wind composites for Day -3 to Day 0 for 0.75, 1.00, 1.75, and 2.00 inch and greater hail.

2. Temperature Comparisons

Figures 4a-d show the average temperature trends at 400, 500, 600, and 850 hPa for 0.75, 1.00, 1.75 and 2+ inch and greater hail sizes from Day -3 to Day 0 over the area of study. A distinct temperature difference appears between the different hail sizes. Temperatures associated with the smaller hail sizes are warmer than those for larger hail. At 850 hPa, the temperatures rise between day -3 and Day 0. At the other levels the temperatures cool between Day -3 and Day 0. The temperatures, associated with 2 inch and larger hail, are colder and a very distinct decrease occurs toward Day 0 at 600, 500, and 400 hPa.

3. Composite patterns

Figures 5-8 are composites (averages) of the mean of wind, moisture (precipitable water) and instability (lifted index) for each hail size category (0.75, 1.00, 1.75, and 2.00+ inches) from the NCEP/NCAR Reanalysis (Kalnay et. al., 1996) and were produced from the interactive web site from the NOAA/ESRL Physical Sciences Division at http://www.esrl.noaa.gov/psd/. The composites represent patterns three days prior to the event (Day -3) to the event day (Day 0)

Sea Level Pressure (Figure 5)

0.75 – The subtropical ridge extends across central Florida all four days with weak troughing indicated along the mid to upper eastern seaboard.

1.00 – The troughing is more pronounced just off the eastern seaboard and the subtropical ridge appears slightly weaker.

1.75 – The eastern seaboard trough is more pronounced and the subtropical ridge drifts to south Florida as a prong of high pressure intensifies over the northeast U.S.

2+ – The subtropical ridge axis over south Florida on day -3 weakens and shifts north over the Mid-Atlantic States by Day 0.

Precipitable Water (Figure 6)

0.75 – The general position of the moisture distribution remains the same, but increases in magnitude approaching the day of the event.

1.00 – Moisture distribution is similar to 0.75 inch but a northerly moisture surge through Day 0 becomes more pronounced.

1.75 – Higher values originating from the northwest Caribbean Sea advect northward. Moisture maximum for the state extends through southwest Florida.

2+ – Higher values initially over the southwestern Gulf of Mexico move north and east of Florida by Day -1 with maximum values over south Florida the day of the event.

Lifted Index (Figure 7)

0.75 – Lifted index ridge axis extending from the east coast of Florida through the northwest Caribbean Sea becomes amplified through the time series. Values fall from about -3 to -4 over south Florida.

1.00 – A broad area of lifted index values of about -3 over much of the Caribbean Sea and southern Gulf extend northward through the period as a maximum develops off the southwest Florida coast.

1.75 – A broad maximum of lower lifted index values will generally remain in place but increase in magnitude over the southern Gulf as the lifted increase ridge axis amplifies over eastern Florida.

2+ – An area of lower lifted index values (-2) over the western Gulf of Mexico propagates to the central Gulf and decreases in value to -5 with values of -4 extending over south Florida.

200 hPa Winds (Figure 8)

0.75 – Flow remains rather zonal over much of Florida. A weak ridge propagates eastward towards the Midwest as a wind maximum develops in the northeast US.

1.00 – Upper level flow gradually weakens over Florida but the pattern does show some amplification over the eastern U.S.

1.75 – Strong zonal flow over the state at Day -3 weakens by Day 0 as a ridge over the central US broadens eastward.

2+ – A wind maximum over the eastern U.S. splits resulting in a southern branch across Florida by day -1 and pushing south of Florida by Day 0.

4. Discussion and Conclusion

Synoptic scale weather parameters were examined for the purpose of recognizing atmospheric patterns conducive for severe hail events over central Florida Increases in moisture, instability, and to a lesser degree shear, typically lead to these extreme hail events. It is the evolution of these elements that provide support for earlier notification of the possibility of large hail in National Weather Service outlook products. Advances in forecasting and earlier warnings for these events may save lives and will most likely save property.

5. References (Available by request)