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USING STORM TOP DIVERGENCE SIGNATURES AS LARGE HAIL INDICATORS IN THE BOISE CWA

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Introduction

Forecasters in Boise have been using a "rule of thumb" that 75 knots (kt) of Storm Top Divergence (STD) is a good threshold to issue a Severe Thunderstorm Warning for hail. This study compares STD values of large (1.00" diameter) hailstorms with STD values of small (0.50" diameter) hailstorms, all occurring within the Boise County Warning Area (CWA). The purpose of this study is to see how well the 75 kt STD guideline compares with large and small hail cases, in order to refine warning guidelines based on STD. This study uses all large hail cases available since 1995, when the Weather Service Radar - 1988 Doppler (WSR-88D) was installed in Boise (KCBX).

Data and Methodology

A total of 25 verified reports of 1.00" diameter hail were found using the National Climatic Data Center's (NCDC's) Storm Event Database. Of the 25 cases, WSR-88D Archive II base data was available for only 18 of them.

WSR-88D Archive II base data was analyzed using WATADS Version 10.2. Cases were thrown out if 1) radar data indicated no storm in the area, 2) excessive beam blockage existed, or 3) the storm was out of range. After quality control, a dataset of 14 large hail cases remained. A control set of nine small hail cases was also made. This included reports of 0.50" diameter hail on days where there was no severe hail reported. Although severe criteria is 0.75" (WSOM Chapter C-40), the gap between 0.50" and 1.00" reports should help to minimize errors in reporting hail size.

Most of the original storm report times were adjusted to match when the radar data indicated the storm was actually nearest to the location. In some cases, times were off by nearly one hour. This could be due to the fact that there are two time zones in the Boise CWA (Mountain and Pacific), and possible confusion between Standard and Daylight time.

Storm Top Divergence and Probability of Severe Hail (POSH) values were recorded for several volume scans surrounding the report time. Whether or not a mesocyclone was detected by the algorithm was also noted. The maximum STD and POSH values, found 30 minutes prior to and 15 minutes after the time of the modified storm reports, were used.

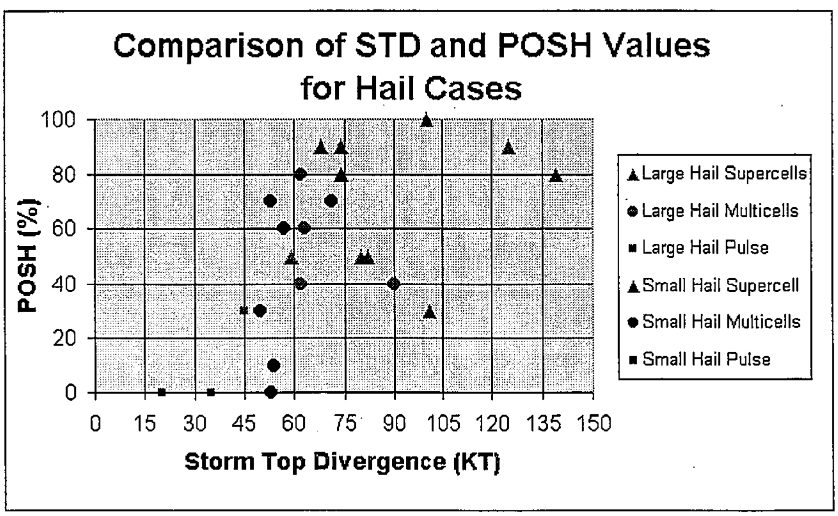
The maximum STD values were found using cursor readout values in WATADS. In most cases, both the inbound and outbound velocities were obtained from the same elevation angle. The exceptions were when storms were to close to the radar, say within 100 km. In these cases, the inbound and outbound values were taken from adjacent elevation angles, to obtain maximum STD values for a given height. To ensure quality, cross sections were taken through the STD couplets in order to verify heights, and also to rule out spurious values. Some limitations in using STD include gaps between elevation angles, and beam broadening at long ranges; therefore, the maximum values obtained, therefore, may be underestimated in some instances (Witt and Nelson, 1991).

The storms were classified as Supercell, Multicell, or Pulse. Storms were labeled Supercells if there was obvious rotation persisting over several volume scans. Multicellular storms encompass all organized convection, including squall lines and sustained unicellular storms. Pulse storms include all unorganized, short-lived convection.

Analytic Results

Thirteen of the 14 large hail cases had maximum STD values of 59 kt or greater, compared to only 7 of 14 having STD values greater than 75 kt (figure below). At the same time, there were no small hail cases with STD 75 kt. As one might expect, the majority (9 of 14) of the large cases were Supercells. Four out of the five remaining large cases were Multicells. The remaining large hail case was an outlier. Not only did it have a STD value much lower than the rest (45 kt), but it was also the only large hail Pulse storm. Conversely, only one of nine small hail cases was a Supercell.

The figure shows this relationship between storm type and STD. Notice how storm type progresses from Pulse to Multicell to Supercell with increasing STD.



Large and small hail cases plotted against STD and POSH.

The above figure shows a mixture of hail size and storm types, concentrated between 45 and 75 knots of STD. This zone of STD is critical when it comes to warning decision making.

As for POSH, none of the large hail cases had maximum POSH values less than 30%, while no small hail case had a POSH greater than 80% (Figure).

Conclusions and Recommendations

Of the 14 large hail cases, 13 of them had maximum STD values at or above 59 kt, compared to 7 of 14 having STD greater than 75 kt. Although only large hail occurred with storms exhibiting STD values 75 kt, seven large hail cases had STD < 75 kt, with a mixture of large and small cases found between 45 and 75 kt. Removing the large hail outlier at 45 kt reveals a concentration of large hail cases from about 60 to 75 kt.

POSH has been shown to be a less reliable discriminator, with five of nine small hail cases and 10 of 14 large hail cases falling within the same data range, between 30% and 80%. It may be of some use to note that all large hail cases had a POSH of at least 30%. It should be noted that the WSR-88D algorithms in WATADS 10.2 are implementations and not the exact same code (See "Implementation Differences in WSR-88D Algorithms" in Chapter six of the WATADS 10.2 documentation).

While the large hail dataset consists of all cases possible since installation of the WSR-88D radar, far more small hail cases occurred than were included in this dataset. It is believed that the nine small hail cases are sufficient for comparison, however.

Based on the data in this study, it is recommended that forecasters at Boise use ~ 60 kt of STD as a lower limit when it comes to issuing warnings for large hail, with increasing confidence as STD goes above 75 kt. Also, storm relative velocity cross sections should be taken through all STD signatures to ensure quality.

It is clear that in addition to STD signatures, knowledge of storm type and environmental conditions should be taken into account during the warning process. Take for example a December Supercell, with 50 kt of STD. Based on STD statistics alone, chances are it does not contain severe hail. However, the fact that it is a Supercell, coupled with unusually low freezing levels and a high POSH, may justify a warning.

Future studies on large hail in the Boise CWA should attempt to resolve the differences between large and small hail storms in the 45 to 75 kt of STD zone, taking into account environmental factors such as buoyancy, shear, freezing levels, wet-bulb zero heights, and lapse rates. A refined large hail warning method could be produced, based on STD and any environmental parameters that show discrimination between large and small hail cases.

It has been shown that on a national scale, there appears to be little hope in predicting hail severity using purely thermodynamic sounding predictors (Edwards and Thompson, 1998). It is therefore recommended that any hail predictors based on environmental conditions incorporate kinematic, as well as thermodynamic influences.

The obvious limiting factor to this study was the number of cases available. This was due to the fact that 1) hail 1.00" in diameter in the Boise CWA is rare, and 2) archived WSR-88D data for Boise has only been available since 1995. It is recommended that additional hail cases be added to this dataset as they become available. In the short term, it would be beneficial to add cases from adjacent CWA's in order to get a larger dataset.

References

Edwards, Roger, and R. L. Thompson, 1998: Nationwide Comparisons of Hail Size With WSR-88D Vertically Integrated Liquid Water (VIL) and Derived Thermodynamic Sounding Data. *Wea. Forecasting*, **13**, 277-285.

WATADS (WSR-88D Algorithm Testing and Display System) 2000: Reference Guide for Version 10.2 [Available from Storm Scale Applications Division, National Severe Storms Laboratory, 1313 Halley Circle, Norman, OK 73069.]

Witt, A., M. D. Eilts, G. J. Stumpf, J. T. Johnson, E. D. Mitchell, and K. W. Thomas, 1998: An enhanced hail detection algorithm for the WSR-88D. *Wea. Forecasting*, **13**, 286-303.

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