P20.8 ROTATIONAL SHEAR NOMOGRAM FOR TORNADOES

Kenneth Falk*
William Parker
National Weather Service, Shreveport, Louisiana

1. INTRODUCTION

Operational meteorologists commonly use a mesocyclone recognition nomogram (Fig. 1) developed by Andra (1997), which relates rotational velocity and range from the WSR-88D, to mesocyclone strength, for issuing tornado and severe thunderstorm warnings.

This mesocyclone recognition nomogram has had good success, but it also has a major limitation. Unfortunately, it does not take into account the diameter of a mesocyclone, which may be an important factor in determining mesocyclone intensity (NSSL, 1997). An example of this limitation is the mini supercell, which is noted to have a mesocyclone diameter of about 2 nm (Burgess et al, 1995). The original nomogram was not applicable for this type of thunderstorm. In order to aid forecasters with this type of storm, a second nomogram was needed.

Since mesocyclone diameter may be an important part of mesocyclone intensity, we developed a rotational shear nomogram to help improve tornado warning decision making. We used rotational shear because it takes into account both the rotational velocity and the diameter of a mesocyclone, and it is readily available to the operational forecaster using the WSR-88D. To make the tornado warning decision process easier for forecasters, areas on the nomogram were labeled as minimal mesocyclone, tornado possible, tornado probable, and tornado likely.

Forecasters in Shreveport, LA have been using this rotational shear nomogram and have shown improved tornado warning verification results.

2. DATABASE

Data was gathered on 50 mesocyclones, most occurring in the NWSO Shreveport county warning area (CWA), but a few outside the Shreveport CWA. These mesocyclones were detected in the lower levels of the storms. All mesocyclones in this study occurred over the south central and southeast United States. The data covered a 5 year time period from 1994 through 1998, although the data in the first 2 years of the study was sparse due to the lack of available WSR-88D radars. Of the 50 mesocyclones in the database, 32 produced verified tornadoes and 18 did not produce a tornado.

*Corresponding author address: Kenneth Falk, National Weather Service Office, 5655 Hollywood Ave., Shreveport, LA 71109; e:mail: Ken.Falk@noaa.gov

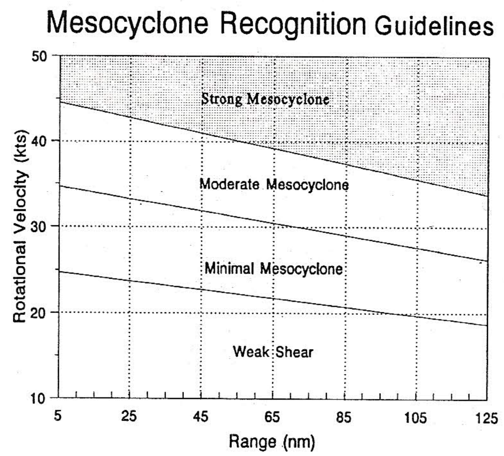

Figure 1. Mesocyclone recognition nomogram (Andra, 1997).

For those events in the Shreveport CWA, we made a concentrated effort to verify whether or not a tornado occurred by sending staff members to the area where a mesocyclone occurred to do a storm survey. Several times in heavily wooded rural areas, where a tornado was not previously reported to the office, we found a tornado track as a result of a storm survey.

In order to calculate rotational shear, we must first determine rotational velocity. The equation for rotational velocity (Vr) is:

$$Vr = \frac{|Vi| + |Vo|}{2} \quad (1)$$

where Vi and Vo are the maximum inbound and outbound winds in a mesocyclone as determined by the WSR-88D (Andra, 1997).

The VR shear function on the WSR-88D display was used to calculate rotational shear (Sr) on each mesocyclone in the database. Rotational shear is a relationship between rotational velocity and diameter of a mesocyclone, and is calculated by:

$$Sr = \frac{2\,Vr}{D} \quad (2)$$

where Sr is rotational shear in s^{-1}, Vr is rotational velocity in m/s, and D is mesocyclone diameter in m (NSSL, 1997).

Figure 2 shows the data plotted on a graph of rotational shear (Sr) vs range from the radar of each mesocyclone.

Verified tornado events were plotted with a triangle, and non-tornadic mesocyclones plotted with a circle. There were two tornado cases not plotted on this figure because their rotational shear values were significantly above 36 s^{-1}, the highest reading on the figure.

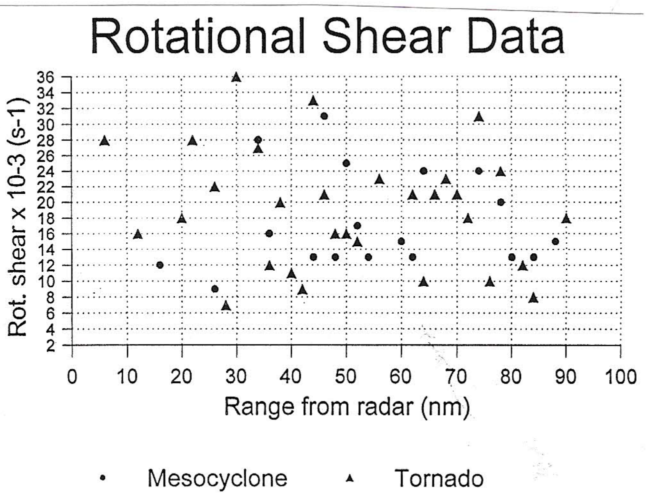

Figure 2. A plot of 48 tornadic and non-tornadic mesocyclones vs radar range. Two tornadic mesocyclone cases were not plotted on the figure because their rotational shear values were >36 s^{-1}.

It should be noted that less data was gathered on mesocyclones that had low rotational shear values simply because most of these events were not considered significant enough by the staff to report them to the authors.

3. ROTATIONAL SHEAR NOMOGRAM

Based on the 50 mesocyclone events gathered over 5 years, we developed a mesocyclone rotational shear nomogram of rotational shear (s^{-1}) vs radar range (nm). Instead of dividing the nomogram into areas describing mesocyclone strength, we opted to display the categories on the nomogram in a way that would encourage proper decision making on issuing tornado warnings (Fig. 3). We labeled the nomogram categories as minimal mesocyclone, tornado possible, tornado probable, and tornado likely.

The tornado possible category gives the forecaster the option of issuing a tornado warning, a severe thunderstorm warning, or no warning, while at the same time heightening the concern that a tornado could occur. Indeed, in about 50% of the mesocyclones in this category, a tornado did occur! However, it is noted that not all non-tornadic mesocyclones that occurred in this category were recorded in the database, thus it is somewhat less than a 50% tornadic mesocyclone rate.

The more strongly worded categories of tornado probable and tornado likely, lead the forecaster toward issuing a tornado warning unless there is a good reason not to, such as convection being elevated over cool surface air, or suspected errors in WSR-88D velocity data.

During the study an attempt was made to differentiate between mesocyclones that occurred in tornadic environments from those that occurred in non-tornadic environments. Unfortunately, only a few mesocyclones occurred in environments that were considered to be truly non-tornadic, and thus we were not able to properly differentiate between tornadic and non-tornadic mesocyclone environments. Although we had hoped to create a rotational shear nomogram for non-tornadic environments, we were not able to do so.

Since storm relative winds can create shear sufficient to change the environment on the storm scale to be favorable for tornadoes, the only environment we determined to be non-tornadic was when convection was elevated above a deep layer of cool surface air. In an environment favorable for elevated convection, the rotational shear nomogram would not be applicable.

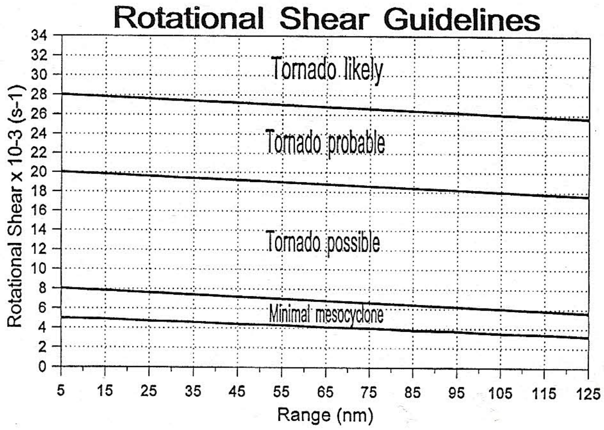

Figure 3. A rotational shear nomogram divided into categories of minimal mesocyclone, tornado possible, tornado probable, and tornado likely based on 50 mesocyclone events over the south central and southeast United States.

The rotational shear nomogram should be used as another tool in the warning decision making process. We use this nomogram in addition to other tools we have available to make a tornado warning decision. Some of the other tools we use include storm structure, the mesocyclone recognition guidelines nomogram, the maximum inbound and/or outbound wind magnitude in a mesocyclone, and spotter reports.

4. CONCLUSION

The Shreveport area experiences two severe weather seasons each year, one during the late winter through early spring, and the other during the late fall through early winter. After some tornado events for which we did not issue a tornado warning, we decided to develop another tool that could help us in the warning decision making process for tornadoes. Upon review of rotational shear data of specific cases involving tornadoes, we felt this parameter could aid us in issuing earlier tornado warnings. From this, the rotational shear nomogram was developed.

The rotational shear nomogram is another tool that can be used in the tornado warning decision making process. It is a helpful guideline that can significantly impact verification numbers, when used with other guidelines. This nomogram enhanced the Shreveport NWSO office's tornado warning program, and possibly could benefit other offices around the country.

5. ACKNOWLEGEMENTS

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6. REFERENCES

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