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SUPERCELLS OF THE SERRANIAS DEL BURRO

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1. INTRODUCTION

The Serranías del Burro (SdB) of Coahuila, Mexico has been identified as a region ideal for supercell development. The SdB are located in a region of northeast Mexico that has strong topographic relief, ranging from nearly 3 km in the highest elevations to around 150 m in the Rio Grande Valley (Fig. 1). The nearby Gulf of Mexico provides ample boundary layer moisture, and the subtropical jet enhances vertical tropospheric wind shear (Edwards, 2006, hereafter E06). There is also strong solar insolation which creates a strongly buoyant atmosphere. All of these features are necessary for supercell growth, and convection is common over the SdB.

These supercells are not just a Mexican problem however, as the storms move and/or propagate across the Rio Grande into South Texas. Since the KDFX WSR-88D NWS radar was commissioned in 1996 near Del Rio, TX, detailed observations of these storms have been available. It has been noted that these storms sometimes present radar characteristics common to supercells such as hook echoes and strong gate-to-gate shear (E06). Many of these supercells produce damaging winds, large hail, heavy rain and resultant flash flooding, and occasionally, tornadoes. The primary impact is on the National Weather Service (NWS) Austin/San Antonio (EWX) County Warning Area (CWA) (NCDC, 1950-2007). However, SdB supercells can also impact NWS Corpus Christi and Midland CWAs.

From 2004 – 2006 E06, using KDFX data, identified 13 supercells that formed over the SdB. Using the same specific radar and persistence criteria as defined by Thompson et al. (2003), E06 discovered that these supercells were frequent and long-lived. However, E06 was not a comprehensive climatology, and the EWX staff stated that the occurrence of SdB storms was more common than found in E06.

Fig 1. SdB Located in region bounded by Texas/Mexico Border and red lines. Base map ©Expedia.

Following E06 as a guide, a serially complete radar climatology of these storms was created. The goal for this work was to form a better understanding of the frequency, duration, and diurnal occurrence of these supercells.

Using Bunkers et al. (2006), for long-lived supercell comparison and Burgess et al. (1982), for average supercell lifetime criteria, the hypothesis of E06 that these storms are frequent and long lived was tested. This new understanding has provided some initial operational forecast guidelines for the National Weather Service offices serving this area of Texas.

2. DATA

To create a serially complete radar climatology, every day from the commissioning of the KDFX radar (1/26/1996) was researched. This included not only a record of days with SdB supercells, but all days with convection, and also days without convection. The NCAR Image Archive (UCAR 2008) was used to check each day through 5/31/2007.

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The NCAR Image Archive had a significant portion of missing data, so other methods for accounting for each day were used. This included checking the NCDC NEXRAD Data Inventory (NCDC, 2008a) to check for clear-air and precipitation mode radar returns (Crum et al., 1993). Although this archive does not permit actual viewing of the radar data, it enabled completion of the dataset where storms may be present. There were still days where no radar data was available from KDFX, however, including 5/27/01 to 7/11/01 after a downburst knocked out the radar. The KDFX radar is considered the primary source of data for SdB supercells, and the combination of data sources allows for a serially complete dataset, with days categorized as: 1) SdB Supercells present, 2) Convection, but not supercells, 3) No convection, and 4) missing.

After all days were accounted for, examination of the convective days was completed using the NCDC HAS Archive (NCDC, 2008b) and GR2Analyst software. Only the ninety-two (92) days that appeared to have the most obvious SdB supercells have been studied so far. For days that did not have Level II data available, NCDC Level III archived data was used as a check for the presence of supercells. This was a limiting factor to the research because the Level III data did not provide the same in-depth analysis of the echo allowed by the GR2Analyst software. In later work, GRLevel3 software will be used to account for the discrepancy.

One difference between E06 and this work is that when looking for supercell criteria, an echo that presented a radar signature common to supercells such as a hook echo, bounded weak echo region, or inflow notch, could be qualified as a supercell without storm-relative velocity data.
This is important because some storms that may not present strong enough storm-relative velocities to meet Thompson et al. (2003) criteria, could still qualify as a supercell. The velocity data were primarily used for cases where the reflectivity signature was not clear enough to identify a supercell (Bunkers, 2001).

Upon completion of the dataset, Microsoft Excel® spreadsheets were used to organize the data and determine results. ArcGIS© software was then used for mapping the storm trajectories to determine general path direction.

3. RESULTS

3.1 FREQUENCY

E06 proposed that SdB Supercells occur frequently. Of the 92 days studied with potential SdB supercells, further analysis found 76 of these storms. This translates to a frequency of about 8 per year. At this time no comparison can be made between the frequency of SdB supercells and those that form in the Great Plains, but SdB supercells appear to be at least as frequent as storms in that region (E06).

The SdB supercell distribution by month shows a significant percentage of these storms occur in the spring (Fig. 2). Although the majority of the supercells occur in April and May, a second minor peak occurs in October. This is due to the availability of sufficient shear and buoyancy that takes place in the atmosphere during those months. During the summer the atmosphere becomes tremendously buoyant (CAPE exceeding 2000 Jkg^{-1}, but this is usually accompanied by a significant mid-level cap and generally insufficient shear (0-6 km bulk shear < 15 ms^{-1}) to produce supercells, and in many cases even deep convection. In the winter, there is a strong subtropical jet and high values of vertical shear (0-6 km bulk shear > 25 ms^{-1}), but little buoyancy. The spring and fall have the best concurrence of sufficient buoyancy and vertical shear to produce supercells.

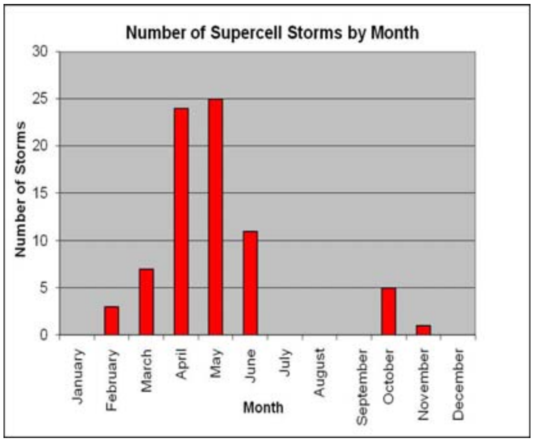

Fig 2. Distribution of SdB supercells by Month

Not all of these supercells cross into the United States, and another important characteristic is the frequency distribution of those that affect Texas (Fig. 3). Of the 76 total supercells, 28%, or 21 storms, crossed the Rio Grande as a supercell. Many more crossed into Texas without supercellular characteristics, so although the crossing supercells are of most concern, these other cells are important as well from forecast and warning perspectives.

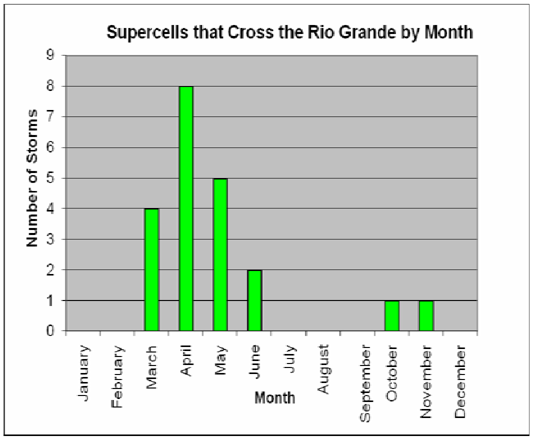

Fig 3. Distribution of SdB supercells that cross the Rio Grande into Texas by month

The number of storms that cross is mostly proportional to the total number of storms in each month. Note that because November has only one SdB supercell, it will be removed from graphs in subsequent sections as an anomalous case.

Although not visible in Fig. 3, of the 21 storms that crossed into Texas, 15 affected EWX, 5 CRP, and 1 MAF County Warning Areas (CWAs). It is obvious from these numbers that the EWX CWA has the most concern from these supercells. Creating some new guidelines from this data appears to have significant potential benefit for these forecasters.

3.2 LIFETIME

E06 suggested that SdB supercells are long lived. Fig. 4 shows the duration distribution for SdB supercells by month.

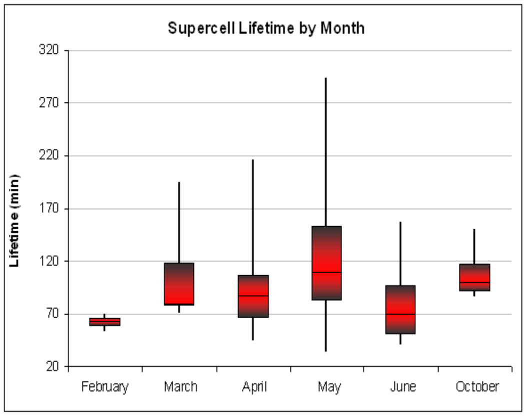

Fig 4. Box and Whisker for SdB lifetime by Month

The average lifetime for all the supercells was 105 minutes. However, some individual very long-lived supercells skew the results. For this reason, the overall median time, 94 min, is used as a more accurate representation of typical SdB lifetime. This is only 3 minutes longer than what Burgess et al. (1982) found for the average supercell lifetime, and less than half of Bunkers et al. (2006) lifetime for long-lived supercells. It appears with many more cases than used by E06, that SdB supercells are only average in duration.

Further examination of Fig. 4 reveals some other noteworthy results. The longest storms coincide with the peak occurrence in April and May. This makes sense from what is known about shear, buoyancy, and supercell sustainability. Some of these storms go beyond the criteria for a long-lived supercell stated by Bunkers et al. (2006). October has a long median lifetime, but only four storms in 10 years. Last, March has a short median lifetime and this is important to keep in mind for the next section on SdB displacement.

3.3 DISPLACEMENT

Figure 5 shows SdB displacement by month. November is left out of the diagram because it is an anomalous case. The term supercell displacement is used because this does not represent total path length. Instead, it is simply the horizontal distance between the supercell onset point and demise point. Total path length is left for future work.

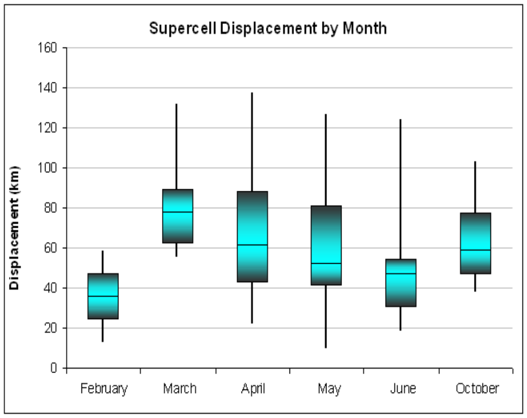

Fig.5 Box and Whisker for SdB displacement by Month

April and May have long median displacements which correspond well to their median lifetimes. October has a very long displacement although with a limited number of storms, and March has the longest median displacement of any month. While March storms had a very short median lifetime, median displacement is greatest during this month. This has a very important implication. The SdB supercells that form in March must travel significantly faster than those that form in other months. March SdB supercells form in an environment that has very strong mean wind, which moves these storms along rapidly. This implies that forecast lead times will be significantly reduced.

Using ArcGIS as described previously, the SdB trajectories were mapped by month over Coahuila and into Texas. Fig. 6 is an example for March. Although all SdB supercells are plotted on the map, the ones in red represent the March storms. Visual inspection confirms that March storm trajectories are significantly longer than the average SdB trajectory as indicated in Fig. 5.. Figure 7 is the same as Fig. 6, but the May storms are shown in red. This map is included to show a comparison for number of storms in the peak month. Fig, 8 shows the June trajectories. In Fig. 8, note the two northern storms. While most trajectories are oriented west-to-east or northwest-to-southeast, these storms show significant motion from the southwest. These trajectories are possibly due to the onset of the southwest monsoon flow, but future work is necessary to determine if this is the case.

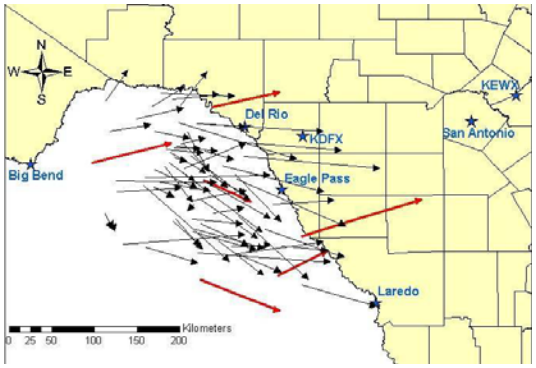

Fig. 6 SdB trajectories, March storms in red.

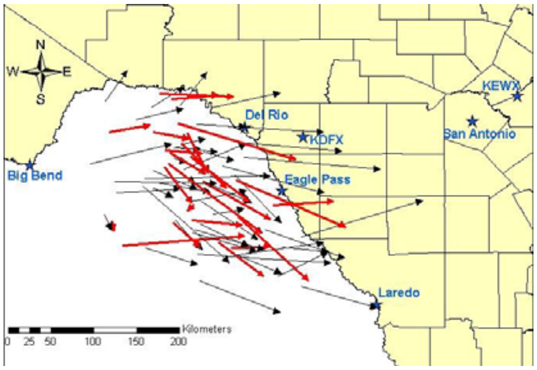

Fig. 7 Same as in 6, but for May.

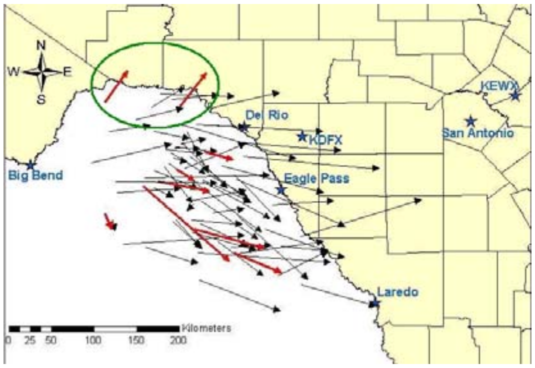

Fig. 8 Same as 6, but for June. Northeast moving supercells are circled.

3.4 ONSET

SdB supercell onset time is important for creating operational techniques. Onset time is defined as the time when the radar criteria for a supercell are first met. At EWX, the shift changes occur at 21-22 UTC and 05-06 UTC, so staffing for severe events can be altered depending on when these storms form. It was found that the median onset time was 2308 UTC,with 41% forming by 21 UTC, and 92% by 05 UTC. If no SdB supercells have formed by 05 UTC, it is unlikely that one will occur and extra staffing is not necessary. Less can be said about the 21-22 UTC shift change, but since 50% of these storms form between 21 UTC and 05 UTC, if non-supercellular thunderstorms are present at 21 UTC, it is still possible for supercells to form in the region during that day.

4. CONCLUSION AND DISCUSSION

These results significantly improve understanding of the frequency of the Serranías del Burro supercells. Future work is necessary to further explore the life cycle, severe weather threat, and forecast ability of SdB supercells, but substantial information has been gathered that can be used for operational forecasting guidelines. Contrary to what was found by E06, SdB supercells appear to have only average lifetimes, but seem to occur as frequently as in any other part of the country. The peak occurrence is in the spring, with a minor secondary peak in the fall. Storms in March travel much faster than any other month. SdB supercells form almost exclusively before 05 UTC, which is important to operational staffing decisions, and approximately 25 percent of SdB supercells cross into the United States.

5. ACKNOWLEDGEMENTS

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