A NOTEWORTHY YEAR FOR SUPERCELLS AND TORNADOES IN THE WESTERN UNITED STATES IN 2018

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1. INTRODUCTION

While overall tornado counts have been very low across the United States in 2018, above-normal tornado activity has occurred with supercells in areas near the Rockies Front Range (particularly eastern Wyoming) into the Intermountain West and several of these events are highlighted herein. Preliminary storm reports for Wyoming and Idaho are shown in Fig. 1. During the afternoon of 27 May, a cyclic tornadic supercell produced EF2-rated damage northwest of Cheyenne, Wyoming. An EF3 tornado occurred near Gillette, Wyoming, on 1 June. On 6 June, multiple strong tornadoes, which included a 45-minute-duration tornado with EF3 damage as well as a satellite EF2 tornado, occurred north of Laramie, Wyoming. In addition to the Wyoming tornado events, a long-lived supercell that produced a tornado in eastern Idaho on 31 May is also highlighted.

2. CASE EXAMPLES

Four cases of regionally significant severe weather and tornadoes are preliminarily reviewed from 2018.

a. 27 May 2018 – Southeast Wyoming

On 27 May 2018 severe thunderstorms were active from portions of Wyoming and southern Idaho to the central High Plains including a sub-regional favorable area for tornadoes across southeast Wyoming. This included a cyclic tornadic supercell that produced EF2-rated damage northwest of Cheyenne, Wyoming (Fig. 2). A closed mid/upper-level low that was centered over the Great Basin moved slowly eastward from Nevada and Utah with weak mid-level height falls and cooling aloft occurring as far east as the central High Plains by the evening of 27 May. Aided by steady surface cyclogenesis across eastern Colorado, a strengthening pressure gradient and low-level east/southeasterly winds contributed to a relatively moist boundary layer from far northeast Colorado into eastern Wyoming by mid/late afternoon. Multiple cyclic supercells developed across southeast Wyoming and produced tornadoes near Interstate 25 just north of Cheyenne. Based on the SPC Objective Analysis (SPC Mesoanalysis; Bothwell et al. 2002), Fig. 3 features the estimated environment around the timing (~20 UTC) and location of these tornadic supercells. Estimated MLCAPE was 2163 J/kg, effective bulk shear of 51 kt, along with 0-1 km and 0-2 km SRH of 103 m^2/s^2 and 229 m^2/s^2, respectively. The estimated STP value was 2.3. The Storm Prediction Center (SPC) featured a 2% tornado risk across much of this corridor where the tornadoes occurred and a Severe Thunderstorm Watch mentioned the possibility of a tornado or two across the region.

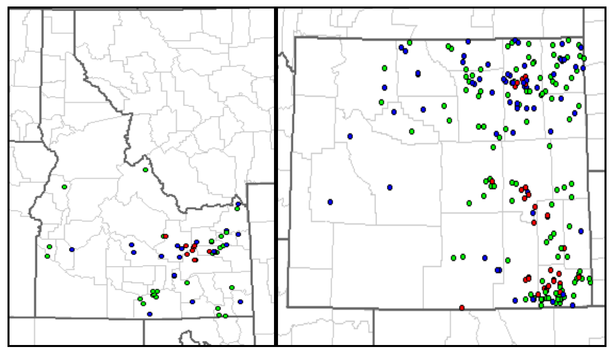

Figure 1. Preliminary 2018 storm reports for Idaho (left) and Wyoming (right), including tornadoes (red), severe and/or damaging thunderstorm winds (blue dots), and severe hail (green dots).

Figure 2. KCYS 0.5° Base Reflectivity and tornado warnings (red polygons) at 2229 UTC 27 May 2018.

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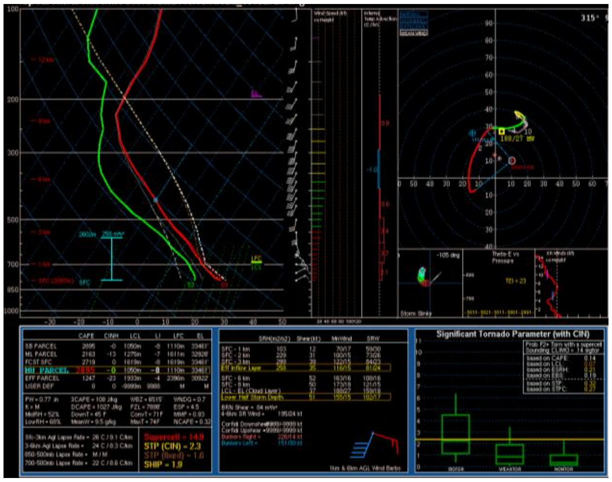

Figure 3. SPC Mesoanalysis sounding from 20 UTC 27 May 2018 in proximity to EF2 tornado north of Cheyenne, WY.

b. 31 May 2018 – Southeast Idaho

A relatively long-tracked multi-hour supercell produced two tornadoes across southeast Idaho on the afternoon of 31 May (Fig. 4). This included a 12-mile-track tornado that began around 22 UTC and crossed portions of the Idaho National Laboratory (INL) to west of Idaho Falls. This tornado moved through a sparsely populated area and was assigned an EF1 damage rating (Fig. 5). In their damage assessment, the NWS Pocatello office noted “large sections of two snow fences were heavily damaged. Multiple steel beams were bent and twisted to varying degrees, with portions of those beams that were below the surface moved approximately one inch.” (StormData).

Regarding the meteorological setup, upper-air data featured an eastward-shifting and amplifying shortwave trough over the Pacific Northwest. A relatively moist air mass was in place in advance of this shortwave trough. The 31 May 1200 UTC observed sounding from Boise, ID (BOI) featured a Precipitable Water (PW) value of 0.68 inches, while Elko, NV (LKN) and Salt Lake City, UT (SLC) measured 0.75 and 0.73 inch PW, respectively. These PW values were in the upper 10-15% daily climatological values based on a long-term database (Rogers et al. 2014). An SPC mesoanalysis-derived proximity sounding estimated around 400 J/kg MLCAPE with SBCAPE/MUCAPE slightly over 1000 J/kg (Fig. 6). Relatively straight long hodographs contributed to 50+ kt effective bulk shear, which was likely maximized across eastern Idaho (Fig. 7). Likely aided by a frontal wave and orographic effects/terrain channeling, surface winds increased and generally become east-southeasterly during the afternoon across the eastern Snake River Plain, which likely enhanced low-level hodograph curvature on a meso-beta scale. The tornadoes occurred in the absence of tornado probabilities (less than 2%) in SPC Day 1 Convective Outlooks. A Severe Thunderstorm Watch was in effect for the region during the afternoon and early evening.

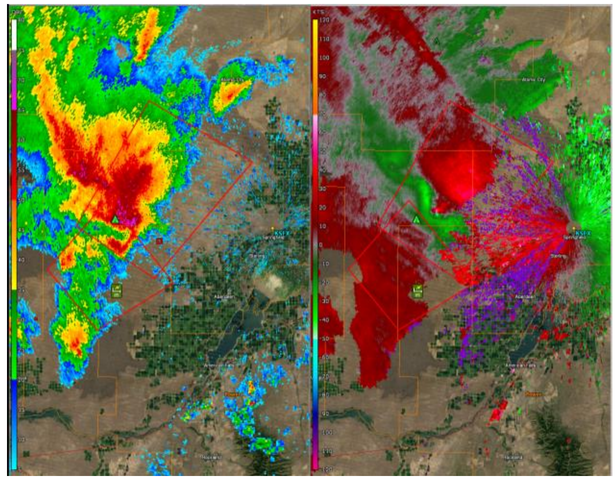

Figure 4. KSFX 0.8 Base Reflectivity (left) and 0.8 Storm Relative Velocity (right) 2133 UTC 31 May 2018.

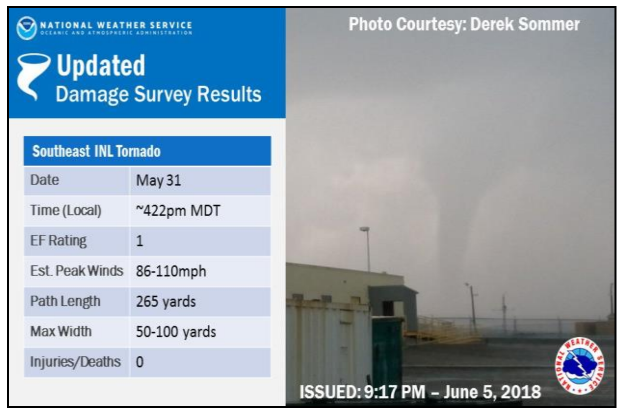

Figure 5. 31 May 2018 tornado information courtesy NWS Pacatello, ID.

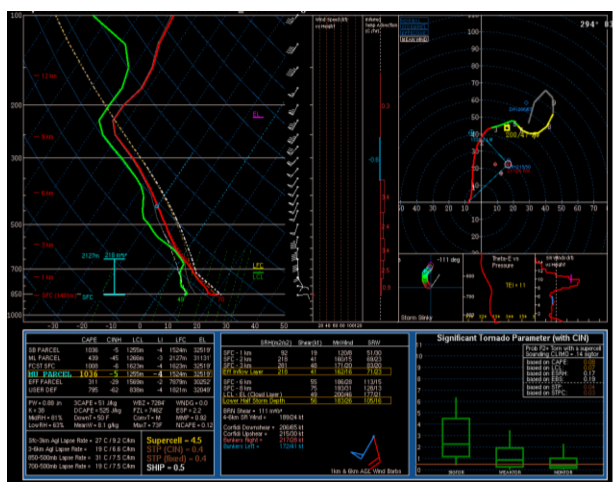

Figure 6. SPC Mesoanalysis sounding from 2200 UTC 31 May 2018 for the tornado near the Idaho National Laboratory.

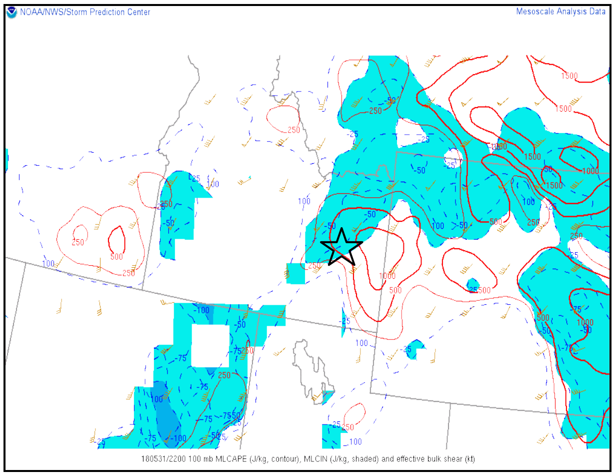

Figure 7. 31 May 2018 22 UTC SPC Objective Analysis 100 mb MLCAPE, MLCIN, effective bulk shear and tornado locations (star).

c. 1 June 2018 – Northeast Wyoming

Four tornadoes occurred on 1 June in northeast Wyoming including an EF3 tornado that struck the Oriva Hills Subdivision north of Gillette, WY (Fig. 8). The tornadoes generally occurred to the north of a west/east-oriented surface front that was advancing south-southeastward across the region, while a shortwave trough was spreading northeastward over the Northern Rockies toward the northern High Plains. Within the post-frontal environment, a proximity sounding based on SPC mesoanalysis data supports environmentally favorable conditions for supercells with estimates of 1380 J/kg MLCAPE in conjunction with effective bulk shear of 45 kt (Fig. 9). Low-level shear appears to have been lacking based on available observational/model data, but a vorticity-rich environment near and north of the surface boundary and ample low-level moisture and buoyancy (0-3 km MLCAPE; Fig. 10) are speculated to be compensatory factors for tornado development (Caruso and Davies 2005). The tornadoes occurred in the absence of tornado probabilities (less than 2%) in SPC Day 1 Convective Outlooks. A Severe Thunderstorm Watch was in effect for the region during the afternoon and early evening.


Figure 8. 1 June 2018 EF3 damage in Oriva Hills Subdivision north of Gillette, WY courtesy NWS Rapid City, SD.


Figure 9. SPC Mesoanalysis sounding from 19 UTC 1 June 2018 in proximity to EF3 tornado near Gillette, WY.

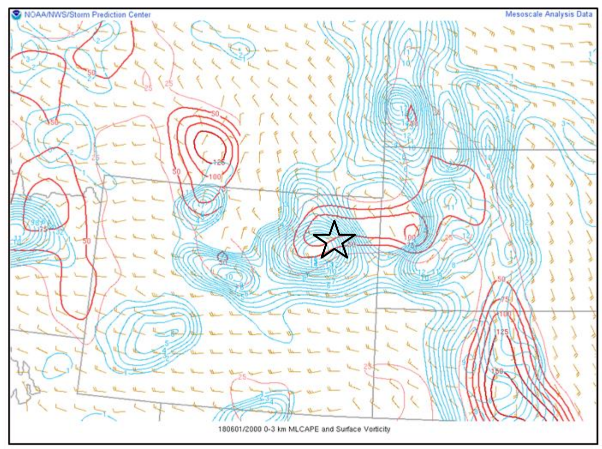

Figure 10. 1 June 2018 20 UTC SPC Mesoanalysis 100 mb MLCAPE, MLCIN, effective bulk shear and tornado locations (star).

d. 6 June 2018 – Southeast Wyoming

On 6 June, multiple strong tornadoes, which included a 45-minute-duration tornado with EF3 damage as well as a satellite EF2 tornado, occurred north of Laramie, Wyoming, shortly before 00 UTC (Fig. 11). According to NWS Cheyenne (2018) survey details, numerous wooden power poles were snapped along with several galvanized steel utility poles which were bent 90 degrees at the base consistent with an EF3 tornado. A satellite tornado developed 2 miles to the south of the original tornado. This tornado damaged treetops and caused EF2-rated structural damage to a well-built attached garage, which collapsed as it was lifted off the foundation and shifted to the east.

Per upper-air analysis, an upper-level ridge initially existed over the region but a subtle shortwave trough advanced northeastward from the Great Basin toward Wyoming and northern Colorado late in the day. Very steep lapse rates existed across the region along with a relatively moist low-level environment within a post-frontal regime. As low-level southeasterly winds strengthened during the mid/late afternoon, the surface dewpoint at Laramie (2,184 m/7,165 ft elevation) increased from 21°F at 21 UTC to 47°F at 22 UTC and 51°F at 23 UTC. Based on SPC mesoanalysis proximity sounding data (Fig. 12), MLCAPE was estimated to be 2600 J/kg around the time of supercell development in central Albany County (about 8 miles north of Laramie). Deep-layer/low-level winds were only modestly strong (25 kt or less through the lower half of the troposphere) but ample veering with height (east-southeasterly near-surface winds) contributed to an estimated effective bulk shear around 37 kt. SPC Day 1 Convective Outlooks had a 2% tornado risk near where the tornadoes occurred. A Severe Thunderstorm Watch was in effect for the region (including Albany County) during the afternoon and early evening.

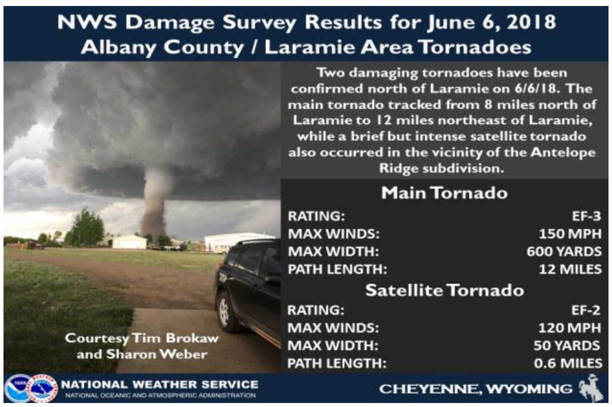

Figure 11. 6 June 2018 tornado information courtesy NWS Cheyenne, WY.


Figure 12. SPC Mesoanalysis sounding from 23 UTC 6 June 2018 in proximity to tornadoes near Laramie, WY.

3. CONVECTION-ALLOWING MODELS/ENSEMBLES

With horizontal model grid spacing around 3 km, convection-allowing models (CAMs) provide explicit convective storm forecasts. Researchers and operational forecasters have found that ensemble HMFs from CAMs can provide considerable forecast utility (Jirak et al. 2010). This includes HMFs related to 1-km AGL simulated reflectivity for diagnosing convective mode and intensity, updraft helicity (UH; Kain et al. 2008) for representing a rotating updraft in a simulated storm, updraft speed as a measure of convective overturning, and 10-m AGL wind speed for identifying convectively generated wind gusts. Clark et al. (2012) and Clark et al. (2013) examined the relationship of strong UH values to tornadoes and tornado path length.

For each of the previously highlighted tornado events of 2018, plots of 24-hr ensemble maximum 2-5 km AGL UH and smoothed neighborhood probabilities (exceeding 75 m^2/s^2) from the HREF are shown in conjunction with tornado reports (red dots) (Figs. 13-16). In each case, strong UH values generally coincided with the respective regional corridor of supercell and tornado occurrence.

While cursory examinations of CAMs and CAM ensembles, such as the HREF, generally showed supercell- (and potentially tornado-) related forecast utility in for these events, it is worth noting that forecasters commonly observe relatively higher UH values in the higher elevation and near-mountainous areas in and around the Rockies in the absence of tornadoes, especially in post-frontal scenarios.

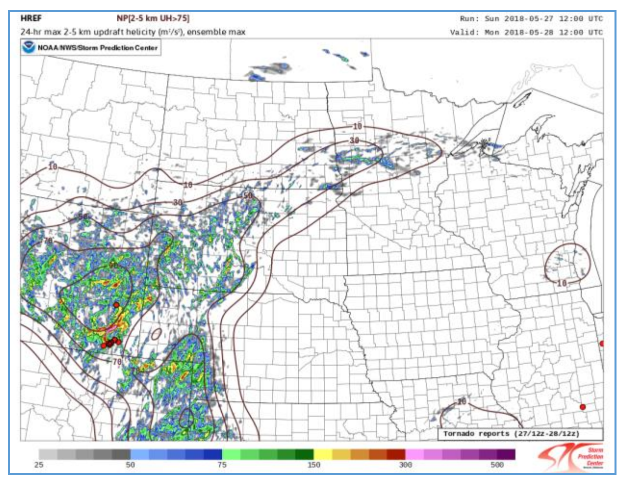

Figure 13. 12 UTC 27 May 2018 HREF 24-hr ensemble maximum of UH (m^2/s^2) and smoothed neighborhood probabilities (exceeding 75 m^2 s^{-2}) with tornado reports (red dots).

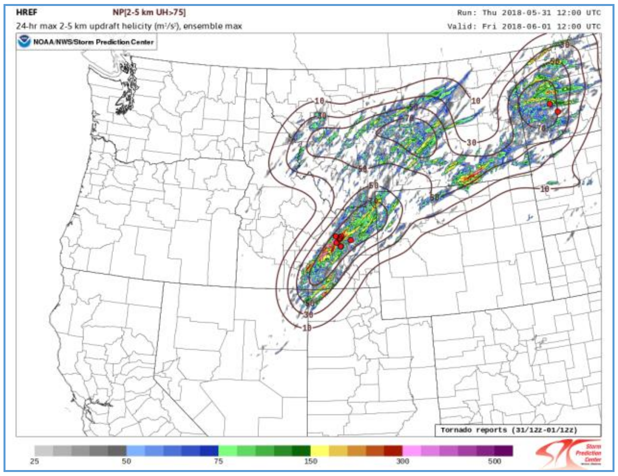

Figure 14. Same as Fig. 13, except for 12 UTC 31 May 2018.

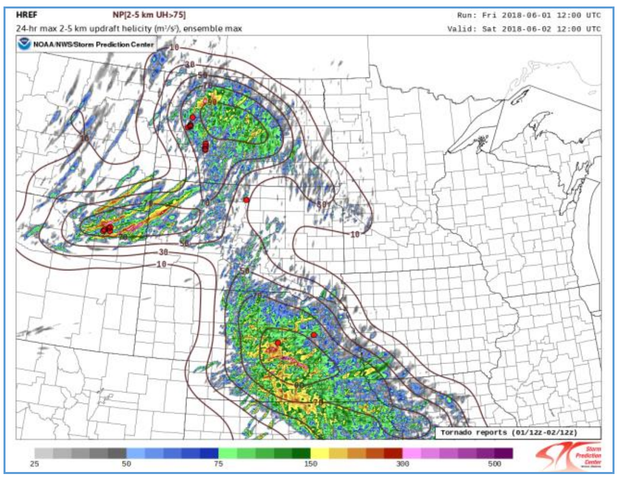

Figure 15. Same as Fig. 13, except for 12 UTC 1 June 2018.

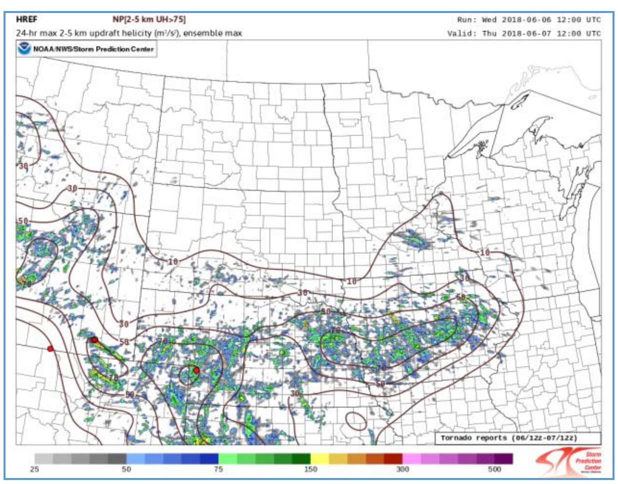

Figure 16. Same as Fig. 13, except for 12 UTC 6 June 2018.

4. TORNADO CLIMATALOGY

The state of Wyoming, in particular, experienced a well-above-average number of tornadoes and a relatively rare number of significant (EF2+) tornadoes in 2018. This is in contrast to the well-below-normal yearly tornado numbers for much of the Great Plains states. For example (as of mid-November 2018), Wyoming had more preliminary tornado reports (31) for the year than Oklahoma, which had a preliminary number of 26 tornadoes, less than half of Oklahoma's long-term average (1950-2017) of around 56 tornadoes. Wyoming's long-term average is around 10 tornadoes per year, and the state averages just one (E)F2+ tornado in a given year (64 total between 1950-2017). In 2018, Wyoming had at least six EF2+ tornadoes in 2018. Wyoming's three EF3+ tornadoes in 2018 is the first year Wyoming has experienced multiple intense tornadoes in a calendar year since 1955 (two F3 tornadoes).

5. SUMMARY

While 2018 has been well-below average for nationwide tornado counts, it was a relatively active year for severe thunderstorms and tornadoes in areas of the western U.S., such as Wyoming. Each of the highlighted cases herein featured moisture content that was at or above normal values. Illustrating this heightened moisture content, averaged PW values during May and June 2018 at the Riverton, WY (RIW) sounding location were about 7% above normal as compared to historical soundings (Rogers et al. 2014). Salt Lake City (SLC) observed soundings were found to be 2% above normal for these same months.

Most of the discussed events featured synoptically evident characteristics for the possibility of severe thunderstorms including supercells; however, various mesoscale/storm-scale factors (as not uncommon) were readily apparent factors in several of these tornado events. It is also worth noting that all of these cases occurred when the potential for tornadoes (especially strong tornadoes) was expected to be relatively low (e.g., 2% or less tornado probabilities in SPC Convective Outlooks, low STP values in SPC mesoanalysis, etc.).

6. REFERENCES

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