P1.12 SEVERE WEATHER THREAT DISCRIMINATION IN SOUTHEAST OREGON AND SOUTHWEST IDAHO USING PRE-STORM ENVIRONMENTAL DATA

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I. Abstract

Fifty years of sounding data, 500 hPa and surface pressure charts from days that produced severe weather in the Boise CWA were examined to find parameter thresholds and specific patterns that would be conducive to severe weather. Only events that occurred within four hours of the sounding and within 100 nm of the Boise, ID upper air site were used. Soundings that were deemed unrepresentative or contaminated were rejected from the study. From the remaining soundings, four categories were formed: Hail, Tornado, Wind, and Multiple Event. In addition, a null data set was formed by examining ten years of data at the Boise airport. Days that reported lightning but no severe weather were used to form this set, and again soundings that were deemed unrepresentative or contaminated were rejected from the study. It was assumed that none of the null cases had unreported severe weather, and local terrain effects on the immediate storm environment were not taken into consideration.

All of the cases were then split into Warm Season, which spans roughly May to August, and Cool Season, which is split from September to April. Among the findings of the research, it was found that supercellular parameters were not very useful for the Boise CWA, however, useful differences were found among the following parameters: CAPE, DCAPE, Lifted Index, 0-6km Bulk Shear, 700-500 mb lapse rates, and WINDEX. These findings will be discussed further in the paper. Differences were also discovered between the synoptic pattern and the type of severe weather that it produced, which will also be discussed further. Although the sample size is relatively small, it is hoped that the findings in this study can be used for further studies in the West.

II. Introduction

Severe weather is not especially common in Southwest Idaho and Southeast Oregon, but each year there are reports of large hail, severe straight-line winds, and tornadoes. There have been several studies of Idaho and/or Pacific Northwest severe weather (e.g. Andretta, et. al. 2004, and Evenson and Johns, 1995). No research to date has focused on our area of interest; Southwest Idaho and Southeast Oregon (our County Warning Area (CWA)) (see Fig 1). In an effort to better-understand the conditions that precede severe weather events for this particular area, proximity soundings and synoptic patterns associated with these events were collected and analyzed. Specifically, observed upper air soundings that occurred within 4 hours and 100 nm of the Boise, ID sounding site, and 500 hPa and surface pressure charts were examined.

An attempt was made to find sounding parameters that differentiated between days with hail, wind, tornadoes, multiple types of severe weather, or “null events”. An attempt was also made to use the synoptic patterns to differentiate between types of severe weather. This paper will be organized into the following sections: Methodology; Results; and Discussion and Future Research.

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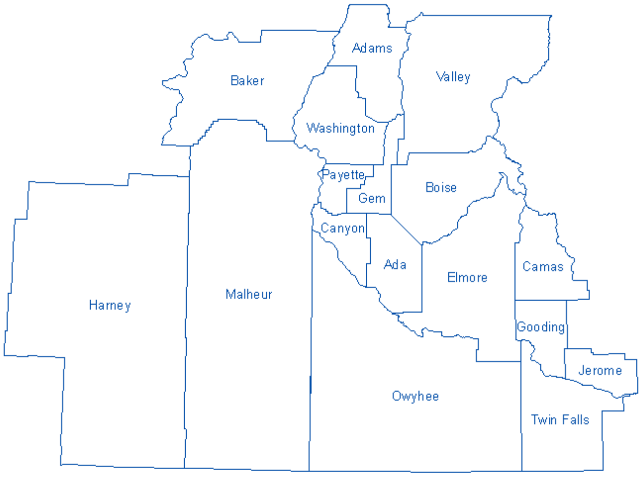

Fig 1. Area of interest. Harney, Malheur, and Baker Counties are in Oregon. Remainder are in Idaho.

III. Methodology

The period of examination was 1955 to 2005. Storm Data (NCDC) was used to determine the types, times, and locations of severe weather events in the Boise County Warning Area (approximately Southwest Idaho and Southeast Oregon – see Fig 1). A list of events was compiled and separated into four types of events: hail only; wind only; tornado only; and multiple event. Upper air soundings were then gathered for each event. These soundings were quality-controlled objectively with two criteria: within four hours of an event; and within 100 nm (185.2 km) of an event (similar to Ramsay and Doswell, 2005, except they used within 3 hours of an event as a criterion). In addition, a "null set" of data was gathered. This set was composed of soundings from days between 1991 and 2000 that KBOI reported thunder, but there were no severe weather reports anywhere in the area of study. Our goal was to have a null set as large as our largest severe weather type set. It was also assumed that "null" days had no unreported severe weather.

All of these soundings were then subjectively analyzed, with both authors examining them for representativeness. Those that were deemed unrepresentative were rejected. Others were edited to better fit observed surface temperature and dewpoint close to the severe weather event(s). Local terrain effects on the immediate storm environment were not taken into consideration. Finally, some were deemed usable in their original form. At the end of this process, there were 16 tornadic events, 61 hail events, 67 wind events, 31 multiple-type events, and 70 null events.

The following parameters were computed from each sounding: surface-based CAPE (SBCAPE); precipitable water (PW); lifted index (LI); downward CAPE (DCAPE); lifted condensation level (LCL); freezing level (FZLVL); bulk Richardson number (BRN); WINDEX, energy-helicity index (EHI); bulk shear (shear); surface dewpoint depression (Tdd sfc); 700-500 hPa lapse rate (75LR); and the product of SBCAPE and shear (CAPE*shear). Each of these was computed in the standard fashion, except where otherwise specified. The data sets were further broken down into "warm season" and "cold season" sets, split roughly from May to August, and from September to April, respectively. Averages for each severe weather type, by season, were calculated. Furthermore, histograms were constructed. These averages and histograms were examined to see if there were any significant differences between severe weather types and/or null set. Findings will be discussed in the next section, Results.

Once these sets of data were assembled, Daily Weather Maps (NCDC) were used to gather 500 hPa and surface pressure charts for each severe weather and null day. The charts were grouped by severe weather type (or null), and then categorized into one of the following patterns: positive tilt trough (PTT); negative tilt trough (NTT); PTT with ridge breakdown (PTTRB); NTT with ridge breakdown (NTTRB); trough overhead (TO); High over Low Block (HOLB); zonal flow with embedded shortwave (ZFES); ridge centered on the CWA (RIDGE); upper low to southwest with a ridge over the Gulf of Alaska (LSWRGA); and northwest flow (NWF); Each of these is defined simply as they read, with the following clarifications: ridge breakdown occurs when a ridge, which has been in place for several days, is slowly displaced by the incoming trough; an HOLB is associated with easterly flow aloft over the CWA; and LSWRGA is similar to HOLB, but far enough west that no easterly flow is observed over the CWA. Charts with frequencies will be presented in the next section.

IV. Results

Cool Season

As we analyzed the sounding parameter data set, we did not find any differences which would pass the student-T test at the 95% confidence level. Although the sample is a relatively small data set, there were some trends that cannot be proved at this time but are still worth reporting (see Table 1). It should also be noted that only 2 cases with multiple events occurred in our sample set, and therefore will not be included in the cool season section.

For each table listed below, weather type is shown in the first column. The second column, N, represents the number of cases in each weather type. The number listed in each box is the percent of cases out of N that met the criteria listed at the top of each column. Highlighted entries simply point out the more significant percentages for a weather type and parameter.

For cool season, hail events appear to be associated with higher CAPE. Additionally, hail and tornado events seem to occur with higher DCAPE, and lower LIs. Although all cases but one had 0-6 km bulk shear values greater than 30 kts, examining cases with shear values greater than 60 kts revealed that hail and wind tend to be higher shear events.

Warm Season

Examining CAPE in warm season reveals that days with multiple events or tornadoes are typically higher CAPE and lower LI days. DCAPE appears to be higher for tornado and wind events. One possible explanation for this is that many tornadoes in the West tend to be influenced by outflow boundaries and local terrain rather than tornadoes which are formed in supercellular thunderstorms. Concerning moisture, multiple events showed higher precipitable water (PW) values, while interestingly tornado cases appeared to be associated with lower PW values than wind or hail cases (see table 2).

Considering 0-6 km bulk shear, the null, wind, hail, and tornado data sets were nearly identical in the percentage of cases with shear greater than 30 kts. Still, 68% of days with multiple events occurred with shear greater than 30 kts, indicating shear is an important factor to consider when evaluating whether there are multiple threats. It should also be noted as a comparison between cool and warm seasons, that in 38% of all cool season cases 0-6 km bulk shear was greater than 60 kts, where in warm season cases only 6% of events had shear greater than 60 kts.

WINDEX values appear to be a good indicator of wind and tornado threats. Although a high percentage of hail cases had a WINDEX greater than 70, there is a rapid decrease in the number of cases that report WINDEX values higher than 80. Lapse rates also seem to be steeper for wind and tornado cases. For CAPE*Shear, a slightly higher percentage of tornado cases had values greater than 20,000 m3/s3, while just under half of the days with multiple events met this criteria (see table 3).

One difference to note between seasons is the surface dew point depression for wind cases. In the cool season, 86% of the cases had surface dew point depressions less than 10 Celsius degrees, while in the warm season less than 2% of the cases had a dew point depression less than 10. A possible explanation for this is that cool season wind cases tend to be frontal, especially given that 71% of the cases had 0-6 km bulk shear greater than 60 kts. Warm season wind cases in the West are often in situations where the sounding would have an “inverted V” profile, indicating dry lower levels (which would be indicated by a higher surface temperature and dew point spread) and moisture in mid to high levels.

Owing in large part to the small sample size, we were unable to find any statistically significant differences between upper-air patterns (see Table 4). However, there are some interesting observations worth noting. Tornadoes seem to be favored by TO pattern. Also, there were no tornadoes reported under the LSWHGA or NWF patterns. In addition, tornadoes in the warm season seemed to have a disproportionally large percentage of HOLB and ZONAL pattern occurrences. There were no wind cases reported with the TO pattern. There were no multiple event days in the RIDGE pattern. Null cool season events seem to be dominated by NTT patterns. These are often thought of as producing instability and shear, so this is not a surprising finding. However, why this pattern is not also the most common for other severe weather types and seasons is not understood.

V. Discussion and Future Research

Although cool season severe weather events are rare and the relatively small number of cases makes it difficult to make solid conclusions, there were some apparent differences that were worth noting. Wind events do not appear to be driven by thermal instability, but require a great deal of shear. They are clearly not driven by large surface dewpoint depressions and mid to high based moisture, as with most warm season wind events. Hail events appear to require the highest CAPE, while hail and tornado events appear to require the highest DCAPE values. LIs were the lowest for hail and tornado events while bulk shear was the highest for hail and wind events.

Warm season also revealed differences worth reporting. Higher CAPE and lower LI days seem more conducive to producing multiple events or tornadoes. Higher moisture and shear also seem to be more favorable for multiple events to occur. Steeper lapse rates and higher DCAPE and WINDEX appear to be favorable for wind and tornado events. Tornado parameters aligning with wind parameters may indicate that many of these tornadoes are influenced by outflow boundaries and interactions with terrain, rather than forming from supercells.

Concerning patterns, it does appear that the TO (trough overhead) pattern is associated with tornadoes, although due to the small number of cases, this will need to be investigated further. Our best hypothesis is that the pre-existing vertical vorticity associated with troughs overhead may help lead to tornadogenesis. Further research will be needed to test this hypothesis. Wind events did not occur under the TO pattern. We found this odd because we expected that the cold temperatures aloft associated with the trough would lead to strong updrafts and potential downbursts. Finally, there were no multiple event days under a RIDGE pattern. We feel this is because this pattern rarely combines sufficient shear and thermal instability to create an environment favorable for more than one type of severe weather to occur at a time.

In the future, we would like to gather more events in real time and be able to track which tornado events are mesocyclone-related and which are formed from outflow and/or local terrain influences. We would also like to be able to obtain a sufficient number of reports in each severe weather type and season to have statistically significant numbers so that we could draw meaningful conclusions from our data.

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Weather Type	N	CAPE < 600 J/kg	DCAPE > 200 J/kg	DCAPE > 600 J/kg	LI < -2.0	LI < -4.0	Bulk Shear > 60 kts
Null	5	100%	20%	0%	40%	0%	0%
Wind	7	86%	29%	0%	14%	0%	71%
Hail	7	29%	71%	29%	86%	43%	57%
Tornado	5	80%	80%	20%	60%	20%	0%

Table 1. Cool season distributions of selected parameters.

Weather Type	N	CAPE 0-999 J/kg	CAPE ≥ 1000 J/kg	DCAPE ≥ 1000 J/kg	LI < -4.0	PW ≥ .7 in	Bulk Shear > 30 kts
Null	71	70%	30%	30%	34%	51%	57%
Wind	60	73%	27%	62%	38%	68%	53%
Hail	53	68%	32%	38%	36%	62%	54%
Tornado	11	45%	55%	55%	45%	55%	55%
Multiple Events	31	48%	52%	37%	58%	81%	68%

Table 2. Warm Season distribution of selected parameters

Weather Type	N	WINDEX ≥ 70 mph	WINDEX ≥ 80 mph	WINDEX ≥ 90 mph	700-500 mb LR ≤ -8 ºC/km	CAPE*Shear ≥ 20k m3/s3
Null	71	48%	17%	3%	21%	19%
Wind	60	85%	53%	22%	59%	20%
Hail	53	72%	25%	0%	28%	20%
Tornado	11	64%	45%	18%	55%	27%
Multiple Events	31	58%	10%	3%	32%	44%

Table 3: Warm Season distribution of selected parameters

Pattern	Tornado Cool Season	Tornado Warm Season	Hail Cool Season	Hail Warm Season	Frontal Winds (Cool)	NonFrontal Winds (Warm)	Multiple Cool Season	Multiple Warm Season	Null Cool Season	Null Warm Season
PTT	1	1	1	7	1	13	1		3	17
NTT	2		1	13	2	13		3	7	13
PTTRB		1		3		2		2		
NTTRB		1		10		16		6		5
TO	2	1		3				1		6
HOLB		3		3		3		6	1	3
ZONAL		4		6	1	9		3		9
RIDGE		1		5	1	6				1
LSWRGA				3		1		1	2	2
NWF			1	1		2				1
Totals	5	12	3	54	5	65	1	28	13	57
PTT	20.00%	8.33%	33.33%	12.96%	20.00%	20.00%	100.00%	21.43%	23.08%	29.82%
NTT	40.00%		33.33%	24.07%	40.00%	20.00%		10.71%	53.85%	22.81%
PTTRB		8.33%		5.56%		3.08%		7.14%		
NTTRB		8.33%		18.52%		24.62%		21.43%		8.77%
TO	40.00%	8.33%		5.56%				3.57%		10.53%
HOLB		25.00%		5.56%		4.62%		21.43%	7.69%	5.26%
ZONAL		33.33%		11.11%	20.00%	13.85%		10.71%		15.79%
RIDGE		8.33%		9.26%	20.00%	9.23%				1.75%
LSWRGA				5.56%		1.54%		3.57%	15.38%	3.51%
NWF			33.33%	1.85%		3.08%				1.75%

Table 4. Number and percent of synoptic patterns by weather type and season.

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