P3.12 A FORECASTER CHALLENGE: CONVECTIVELY ENHANCED WINDS IN A STRONGLY FORCED SYNOPTIC ENVIRONMENT IN COMPLEX TERRAIN

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1. INTRODUCTION

Two similar storms impacted the Grand Junction National Weather Service (GJT) County Warning Area (CWA) during the late spring cool season of 2006. Even though the physical forcing mechanisms for these storms were somewhat similar, the GJT staff, in coordination with the Storm Prediction Center (SPC) handled these events quite differently from a forecasting standpoint. This study will first detail the historical precedence for convectively-enhanced wind events in synoptically-forced environments. Next, an overview of the environmental conditions observed in these two events including the problematic forecasting issues for this complex topographic region will be discussed. Finally, some “best practices” for these cool-season convective wind events will be presented.

2. BACKGROUND

In order to put the product selection decision making process undertaken by GJT into perspective, we introduce the rationale and a brief methodology behind the choice of watch/warning products available to the office for these two cases.

The NWS issues a variety of phenomenologically based watch and warning products to warn the public of an imminent threat to life and property. Regarding the specific threats from high wind events, NWS warning products are categorized by whether or not the event is precipitation-based.

Severe thunderstorm watches fall under precipitation-based products. A watch is issued after collaboration between the Storm Prediction Center (SPC) and the local Weather Forecast Offices (WFOs) affected by a potential watch. Issued for a valid time of several hours, the goal of a watch is to provide at least one hour lead time to convectively-induced winds of 50 knots or greater and at least 1.9 cm diameter hail. Forecasters at SPC apply an ingredients-based method to determine the areal and temporal bounds where they expect a significant number of severe thunderstorms (Johns and Doswell, 1992). A forecast of convective coverage is a function of the presence of forcing mechanism(s), instability and adequate moisture for thunderstorms (Moller, 2001). Watches are usually issued for those potential events where significant deep layer shear and instability will produce organized convection in the form of supercells or long-lived multicells. The most widespread convectively-induced severe wind environments favoring long-lived multicell systems or derechos often contain high values of deep layer vertical wind shear and widespread convective initiation (Johns and Hirt, 1990). The range of candidate environments may include large values (>2000 J kg^{-1}) of convective available potential energy (CAPE) and weak synoptic forcing to those exhibiting low CAPE (<1000 J kg^{-1}) and strong synoptic forcing (Evans and Doswell, 2001). Some of these environments exhibit low enough CAPE to challenge the applicability of severe thunderstorm watches (Corfidi et al. 2006).

Local WFOs issue a severe thunderstorm warning if severe winds (50 knots or above) are expected to occur over the lifetime of the warning product which are usually valid for up to 1 hour. It is an example of a warning covering a small temporal and spatial phenomenon for a precipitating event with little or no predictability beyond one hour. Usually NWS forecasters issue a severe thunderstorm warning for deep, moist convective events. Although, there is no specific criterion for lightning to be present

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(NWSI 10-511, 2006), it is a concern by some WFOs that the public may be confused if the target storm for a warning does not contain lightning (Kruzdlo and Cope, 2005). A subset of radar-based severe storm signatures include substantially high reflectivity aloft, an elevated intense echo overhang, a bounded weak echo region (BWER), severe radial winds, or indications of a mesocyclone (Burgess and Lemon, 1990; Moller, 2001). Sometimes warnings are issued with weaker storm scale radar-based signatures if other conditions such as the environment or spotter reports provide enough evidence to issue a warning. But severe thunderstorm warnings are then intended for short-lived and small scale events.

Severe non-precipitation type wind watches and warnings are issued solely by the local WFO (NWSI 10-515, 2006). The watch and warning versions of a non precipitation-based high wind product tend to be longer-fused than their convective counterparts. Synoptic scale wind events are well anticipated by forecasters given an accurate synoptic-scale diagnosis extrapolated forward and assisted by forecast models. These are the largest synoptic wind events temporally and spatially. However, a downslope wind event is a candidate for these products and exhibits a similar spatial dimension to that of a severe thunderstorm but it is typically longer lasting. Other non-convective phenomena produce spatially large but temporally small high wind events (e.g., cold fronts).

Table 1 is a summary of various phenomena (in underlined italics), applicable wind-related warning products, whether the phenomenon is precipitation-based, and the spatial/temporal scale of the phenomenon. Note that a short-duration (t < 1hr), small scale (< 5000 km^2) non-precipitating severe wind event, there is no applicable public sector type of warning. Only special marine warnings or airport warnings can be issued for such a phenomenon.

There are other occasions when the atmosphere offers up a combination of convectively- and non convectively-based phenomenon in the same area that can cause confusion amongst forecasters with regards to what watch/warning is most appropriate. One example includes strong gradient winds with weak convection superimposed (Krudzlo and Cope, 2005). A second example occurs with a gust-front well separated from its convective source. This situation prompted a dust storm warning for winds to 50 knots and then a severe storm warning is also needed for the initiating cell (Green, 2004 personal communication).

3. STORM OVERVIEW

In this section a brief synoptic overview is presented for both events. The various highlights are also discussed.

	Precipitation-based	Nonprecipitation-based
Small t<1hr	**SVR**, SMW, Airport warning	SMW, Airport Warning, “?” no public product.
	Small multicell or individual cells	*Gust front*
Small t>1hr	2 or more **SVR**	High Wind Warning
	Eyewall, Organized convection	*Downslope wind*
Large t<1hr	2 or more adjacent **SVR**,	“?” no public product
	MCS	*Dry Cold front,*
Large t>1hr	Reissue 2 or more SVRs, SMWs	High Wind Warning
	Rare MCS	*Gradient winds*

Table 1. Product types and phenomena categorized by small and large temporal and spatial scales, as well as, the presence of lack of precipitation. SVR indicates Severe Thunderstorm Warning, SMW refers to Special Marine Warning. The question marks refer to phenomena that do not have a warning product for which it is specifically suited.

a. 5 April 2006 Case study

On 5 April 2006, a strong cold front moved through the eastern Great Basin region and subsequently, through western Colorado. The front was associated with a deep positively-tilted trough indicated at 500 hPa (Figure 1a). Ahead of the surface front, analyzed 700 hPa winds were 20 to 25 $m\ s^{-1}$ across northeastern Arizona (Figure 1b), while observed wind speeds at several mountain locations across eastern Utah and western Colorado exceeded 30 m s^{-1} (250-hPa wind speeds of 60 to 65 m s^{-1} across northern Arizona). At approximately 1700 UTC, a line of deep moist convection (DMC) developed over the Utah Wasatch Front. Given that the favorable near storm environment existed for severe winds and/or hail, SPC and GJT decided to issue a Severe Thunderstorm Watch at 1730 UTC. The line moved east at 12 m s^{-1}, with individual cell

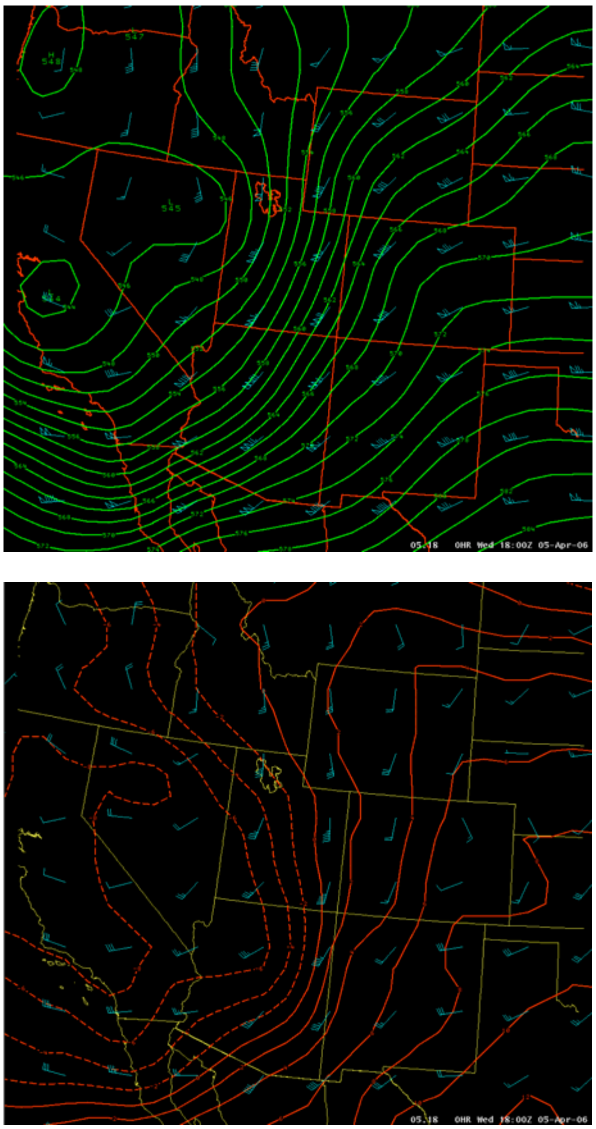

Figure 1. a. GFS80 initial 500-hPa height and 250-hPa wind at 1800 UTC on April 5, 2006. b. GFS80 initial 700-hPa temperatures and wind at 1800 UTC on April 5, 2006.

movement at 25 to 30 m s^{-1}. This line of DMC eventually moved into the GJT forecast area.

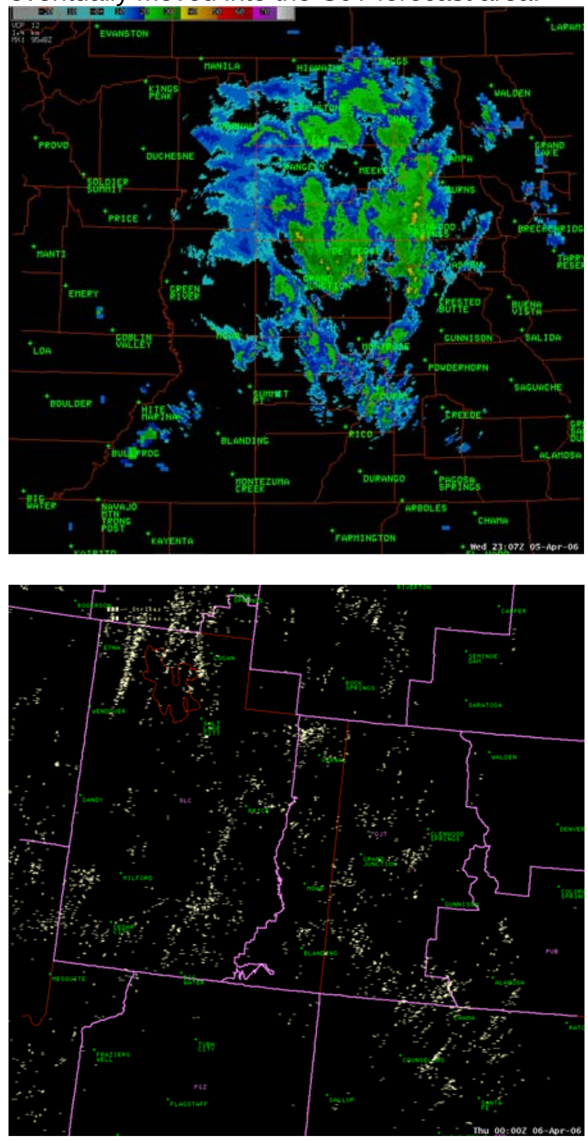

Figure 2. a. KGJX radar composite reflectivity near the time of peak convection on April 5, 2006, at 2307UTC. b. Composite lightning strikes for the 24-hour period ending April 6, 2006 at 0000 UTC.

However, the thunderstorms weakened considerably shortly thereafter. Though convective cells covered most of the GJT area, a relatively small percentage of them produced lightning (Fig 2b). The GJT office issued 5 Severe Thunderstorm Warnings and verified 2 severe wind events with one missed event (CSI

33%). Figure 2a shows composite reflectivity during a more intense period of the storm (2307 UTC). One High Wind Warning and eight Wind Advisories were issued during the afternoon hours of 5 April.

The High Wind Warning was verified with three of the wind advisories being verified. Six Winter Storm Warnings and two snow and blowing snow advisories were also issued to address wind and precipitation concerns. To complicate the forecast process during this event, a Flood Warning, and Red Flag Warning were also issued.

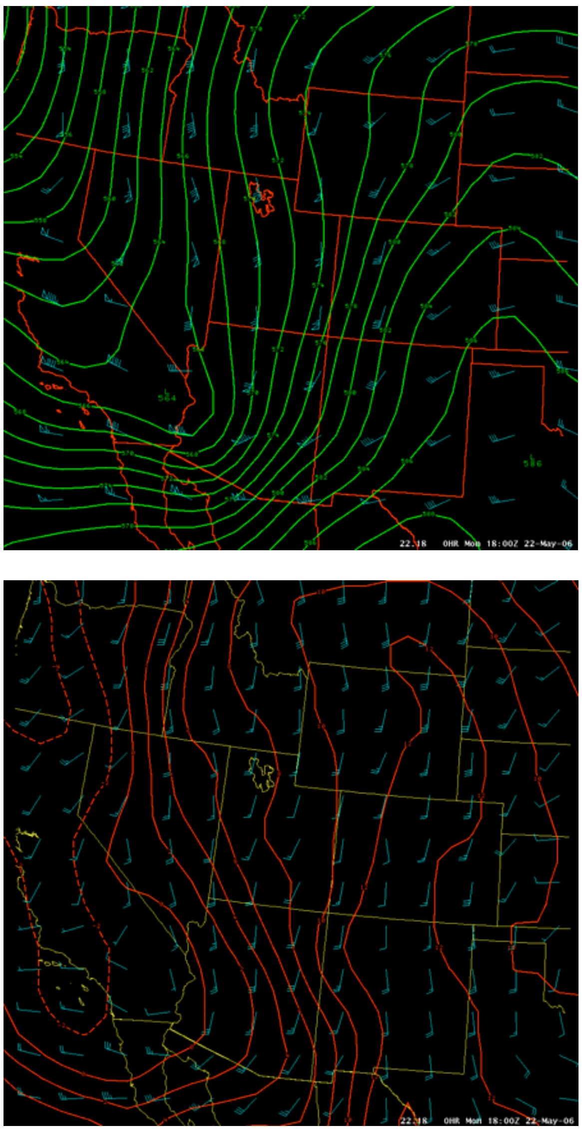

Figure 3. a. GFS80 initialized 500-hPa height and 250-hPa wind at 1800 UTC on May 22, 2006. b. GFS80 initial 700-hPa temperatures and wind at 1800 UTC on May 22, 2006.

b. 22 May 2006 Case study

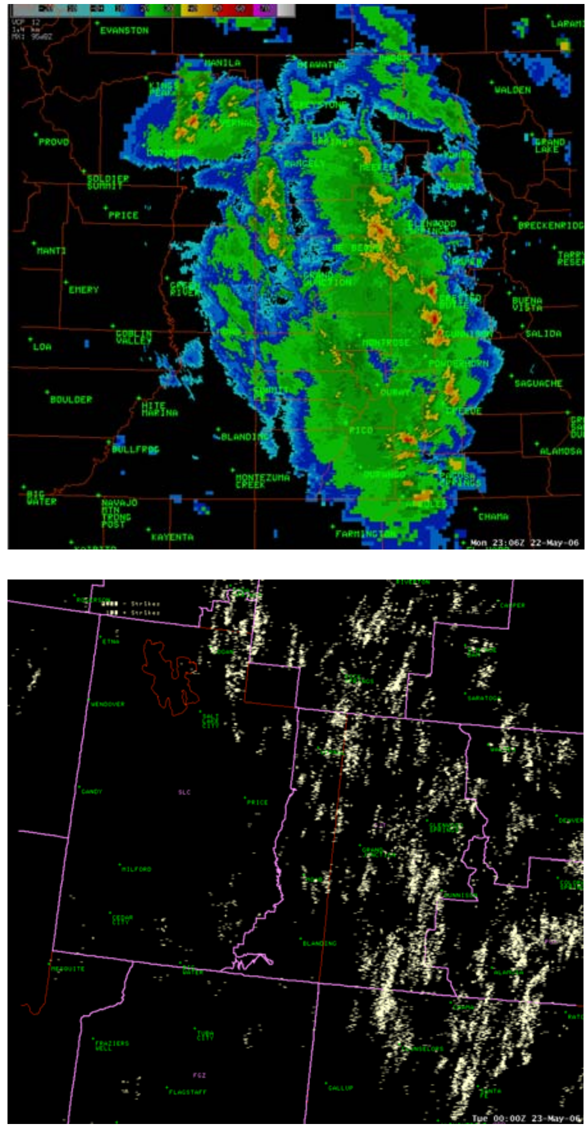

Figure 4. KGJX radar composite reflectivity near the time of peak convection on May 22, 2006, at 2306 UTC. b. Composite lightning strikes for the 24 hour period ending May 23, 2006 at 0000 UTC.

On May 22, 2006, a negatively tilted shortwave trough aloft moved north into the Great Basin and central Rockies (Figure 3a). Analyzed winds were much weaker than the 5 April 2006 case with 250-hPa winds of to 35 m s^{-1} and 700-hPa analyzed winds of 10 to 15 m s^{-1} (Figure 3). Temperatures (Figure 3b) were significantly higher than on 5 April (Figure 1b), with surface temperatures 5 to 10°C warmer, and 700-hPa temperatures 10 to 20°C warmer across eastern Utah and western Colorado. Widespread convection (Figure 4a shows a more intense period of this event at 2306 UTC) developed along and ahead of the upper trough in eastern Utah and western Colorado, with much more lightning (Figure 4b) generated than the 5 April event. Rather than issue a Severe Thunderstorm Watch, GJT decided to issue a broad scale Wind Advisory for this event. With low relative humidities and dry surface fuels, GJT also issued a Red Flag Warning.

Observed wind speeds generally reached 15 to 25 m s^{-1} throughout eastern Utah and western Colorado due to the large scale pressure gradient. Anemometers at a dozen locations measured speeds that reached severe thunderstorm criteria. The contribution from thunderstorm outflow only needed to be 5 to 10 m s^{-1} to meet severe thunderstorm wind criteria. Although a Wind Advisory was already in place, a dozen severe thunderstorm warnings were issued by GJT to address severe criteria winds. Most of the warnings were issued for the strongest thunderstorm cells which moved over sparsely populated areas with no weather monitoring stations. Consequently, the verification statistics for the May 22, 2006, severe thunderstorm warnings were low (CSI = 8%). However, thirteen wind advisories zones verified in eastern Utah and western Colorado (CSI =46%) with nearly all of the false alarms coming within 5 m s^{-1} of reaching the criteria.

4. SUMMARY AND LESSONS LEARNED

Even though these two events were similar, they were handled differently from a forecast perspective. The 5 April case exhibited stronger winds, better forcing and it occurred in a much colder environment. The May event, however, displayed a more widespread convective signal. The main impetus for the Severe Thunderstorm Watch for the April event was the strong line of storms which developed over Utah during the late morning. This line weakened after the Watch was issued. In both cases, a combination of long fused non-precipitating and/or precipitating-based warnings and advisories were issued for much of the GJT CWA. Finally, the forecast process was complicated by fire weather and hydrological highlights Nonetheless, the situational awareness was not compromised in either event.

The primary lesson learned from this study is that within these convectively-enhanced wind events in synoptically-forced environments, it is best to address these severe type winds with a broader long-fused warning or advisory such as a High Wind Warning or Winter Storm Warning (based on precipitation expectations). This long-fused highlight would prepare the public for the expected hazards. One of the forecast challenges found in these two events was that the highest winds were not found in regions of the strongest convective signature. Based on the pre-storm environmental winds, the contribution from convective enhancement of the winds only needed to be 5 to 10 m s^{-1} to meet severe thunderstorm wind criteria. This criterion was often reached with weak or decaying convective cells. To address these marginal severe winds with a short-fused Severe Thunderstorm Warning is difficult, especially over sparsely populated regions with complex terrain in the Intermountain West, as indicated by our CSI for both events. It is suggested that Severe Thunderstorm Watches and Severe Thunderstorm Warnings in this environment (where a long-fused highlight is in effect) be limited to the extreme severe events where excessive severe winds and/or severe hail is expected with strong organized convection.

5. ACKNOWLEDGEMENTS

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