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Overview of the Storm Prediction Center

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Abstract

The Storm Prediction Center (SPC) is an office of the U.S. National Weather Service in Norman, OK. The SPC specializes in forecasts of tornadoes, other severe convective storms, and fire-weather potential across the conterminous U.S. From a small start as a tornado-prediction unit in the 1950s, the SPC has evovled to a staff of 22 full-time forecasters, a research and science-support unit, and several managers. In addition to the severe-weather forecast role, SPC is a prolific producer of operationally useful scientific research, offers various online forecasting tools to the meteorological community at large, and provides informative public outreach via its website and social media.

1. Introduction

The Storm Prediction Center (SPC), a national forecasting center and unit of NOAA's National Weather Service located in Norman, OK, predicts conditions favorable for severe and nonsevere thunderstorms, as well as for wildfires, across the continental United States (U.S.). The SPC is one of nine national centers comprising the National Centers for Environmental Prediction (NCEP) distributed around the U.S., the others being the Aviation Weather Center (AWC), Climate Prediction Center, Environmental Modeling Center, Weather Prediction Center (WPC), NCEP Central Operations, National Hurricane Center, Ocean Prediction Center, and Space Weather Prediction Center. As with most of the other NCEP centers, SPC offers specialized guidance to a diverse audience that includes the general public, media, emergency managers, military, civilian governments at federal, state and local levels, and NWS local forecast offices (Fig. 1). A brief history of the development of SPC appears in section 2.

The SPC has a primary misson of forecasting severe local storms, which represent a substantial hazard to the United States (U.S.) populace and a negative economic impact. Th U.S. has ~1000 ornadoes y^{-1}; and recent years have seen several violent, deadly tornadoes that produced over $1 billion in damage (e.g., Doswell et al. 2012). Climatologically, the NWS classifies convection as severe, as documented in the SPC database (Schaefer and Edwards 1999), if it produces a tornado, hail ≥1 in (2.5 cm) diameter, or measured or estimated gusts ≥50 kt (25 m s^{-1}). Significant severe weather is classified as a tornado rated EF2 on the Enhanced Fujita scale (Edwards et al. 2013), hail ≥2 in (5 cm) diameter, or convective gusts ≥65 kt (33 m s^{-1}). The SPC severe-weather database also includes wind-damage reports, regardless of the responsible windspeed (if known). The SPC issues severe-weather outlooks as early as eight days in advance, along with mesoscale discussions and public watches for near-term severe-storm potential. Details on these forecasts appear in section 3. Other forecast functions of the SPC include fire-weather outlooks, general-thunderstorm forecasts, probabilistic thunder outlooks, and mesoscale discussions for hazardous winter weather. Details on other SPC forecasts are provided in section 4. Section 5 summarizes data, maps and publications that are not part of the official forecast suite, but that SPC offers online for the benfit of meteorological audiences.

2. History and structure

Unless otherwise cited, all pre-1999 information here is distilled from Corfidi (1999), who gave a detailed history of the SPC and its predecessors in the twentieth century.

The need for a national forecasting agency devoted to tornadoes (and other severe storms) began in the 1870s, when J. P. Finley of the U.S. Signal Corps developed the first documentation of numerous U.S. tornadoes, recruiting over 2000 volunteers to provide tornado-event information that often included accompanying weather conditions (Galway 1992). From that foundational understanding, Finley attempted to produce "tornado alerts". However, his superiors prohibited those forecasts from being made public, fearing that using the word "tornado" would cause panic. The ban on explicit tornado forecasts was kept until 1938, though inertial avoidance of the word continued in forecasts by the U.S. Weather Bureau (predecessor to NWS) until the 1950s. Meanwhile, understanding of synoptic-scale weather patterns and conditions favorable for tornado-producing thunderstorms increased, both empirically and in the literature (e.g., Showalter and Fulks 1943).

In March 1948, tornadoes struck Tinker Air Force Base, OK, five days apart. Two U.S. Air Force forecasters, E. J. Fawbush and R. C. Miller, investigated the conditions preceding the first tornado, then correctly forecasted the potential for another tornado based on occurrence of a similar pattern. That success led to their development of an Air Force Severe Weather Warning Center (SWWC) at the same base. Public dissemination of SWCC forecasts created demand, which was strengthened by a later military ban on their public release. This demand ultimately led to a civilian severe-storms forecasting unit of the Weather Bureau in Washington, DC. By March 1952, that unit used temporary forecasters to issue teletype "bulletins" loosely analogous to today's watches. Though success was mixed at first, the Washington unit's "bulletins" verified well enough for a few major springtime tornado events to justify a formal, official Severe Weather Unit (SWU) in May 1952. By September 1952, the SWU was staffed by five full-time forecasters working rotating shifts, including nights, weekends and holidays, from March through June. Those were the predecessors to today's SPC lead forecasters, who still bear most of the responsibility for severe-weather watches (section 3). In January 1953, the SWU began issuing daily discussions of severe-storm potential nationwide—the predecessors to today's SPC day-1 outlooks (section 3).

After a series of extraordinarily destructive and deadly tornadoes in 1953, the division was renamed the Severe Local Storms (SELS) unit. SELS added researchers and chartists, then moved to Kansas City, MO, in 1954. Kansas City was a more strategically advantageous location for SELS, being both a major teletype switching node and located in a more tornado-prone part of the U.S. The SELS unit grew through the 1960s, 1970s and 1980s, becoming part of a larger office known as the National Severe Storms Forecast Center (NSSFC) that also included an aviation forecasting unit. In addition to researchers employed by NSSFC's Techniques Development Unit (TDU), operational forecasters became involved in applied research, including formal publications. This tradition of active forecaster participation in storm research continues today, with numerous formal and informal publications produced at least in part by the forecast staff. The TDU, forerunner of today's SPC Scientific Support Branch (SSB), also provided expertise and maintenance for the growing prevalence of computers in the analysis and forecasting process. Still, hand analysis of surface and upper-air charts remained an important foundational part of the forecasting process (e.g., Sanders and Doswell 1995), and continues today (e.g., Fig. 2), as a means to diagnose subtleties of features crucial to severe-weather potential that still escape automated analyses.

By the early 1990s, scientific understanding of conditions favorable for severe storms had advanced enough for SPC forecasts to include detailed insight on storm environments and behavior (e.g., Johns and Doswell 1992). This included the fundamental principle of ingredients-based forecasting (e.g., Doswell 1987; Johns and Doswell 1992; Moller 2001)—the necessary ingredients for organized severe weather being moisture, instability, (mechanisms for) lift, and vertical wind shear. Juxtapositions and magnitudes of these ingredients, in space and time, still form the basis for SPC forecasts of severe-storm risk.

In 1995, SELS was renamed SPC in anticipation of its 1996 move to Norman, OK, to share a facility with a NOAA research group (National Severe Storms Laboratory, NSSL) that had left Kansas City in the 1960s. The national aviation-forecasting unit remained in Kansas City as the AWC. By that time, SPC was issuing multiple day-1 outlooks, day-2 outlooks, watches, and mesoscale discussions. That forecast suite grew in Norman to encompass the full set of products described in the sections 3 and 4. In 2006, SPC and NSSL moved into a new edifice on the University of Oklahoma

(OU) campus, the National Weather Center, which also contains the OU School of Meteorology, Norman NWS Forecast Office, NWS Warning Decision Training Branch (WDTB), Oklahoma Climatological Survey (including Oklahoma Mesonet), and several cooperative research institutes.

The SPC (staff listing) includes two divisions: the Operations Branch (forecasters) and the SSB, overseen by a small management staff. Within the Operations Branch, SPC employs 22 full-time forecasters. Five lead forecasters supervise shifts, monitor the hazardous weather situation nationally, issue most watches and some outlooks, and proofread all products. A longstanding SELS philosophy of "two pairs of eyes on every product" helps to ensure high quality and mimimal errors in each forecast. The 10 mesoscale/outlook forecasters issue most outlooks and mesoscale discussions (section 3). Seven mesoscale assistant/fire-weather forecasters perform most general-thunderstorm forecasting, all fire-weather outlooks and many mesoscale discussions. The SSB employs hardware and software experts who maintain computer systems and programs that enable forecast operations to function, as well as meteorologists who work with forecasters, NOAA Hazardous Weather Testbed (HWT) participants and other scientists to infuse the latest techniques into the forecast process.

While SPC is a self-contained office within the National Weather Center building, its strong ties and common interests with the other proximal weather organizations led to the HWT in the late 1990s. In the HWT, researchers from NSSL, OU, and other universities join with WDTB trainers, and with forecasters from SPC, other national and international centers, NWS offices and the private sector, for yearly forecast experiments. HWT participants evaluate new numerical models, conduct applied-forecasting trials, and assess new warning techniques before they become operational. Weiss et al. (2007) and Clark et al. (2012) described HWT activities.

3. Convective forecasts

In describing SPC severe-weather products, we follow the same conceptual model used in the forecasting process—Snellman's (1982) "forecast funnel". The SPC diagnoses and predicts an event beginning at hemispheric to synoptic scales with extended outlooks, and works down to the mesoscale with discussions and watches (Fig. 3). SPC does not issue tornado and severe thunderstorm warnings; those are the responsibility of the local NWS offices (Fig. 1). The accompanying PowerPoint presentation contains graphic and text examples of the forecast products summarized here.

a. Convective outlooks

SPC issues scheduled convective outlooks for severe storms, valid 2–8 days prior, then specific hail, wind and tornado breakdowns for the current day. With temporal proximity to an event, outlooks necessarily incorporate less syoptic-scale numerical model guidance, and more input from both diagnostic data and short-fused, high-resolution models. Examples of the latter appear in section 5.

The convective day is defined from 1200–1159 UTC. The discontinuity conveniently falls near the local morning minimum in climatological severe-weather potential over most of the U.S. Probabilities (Fig. 4) are valid within a 25-mi (40-km) radius from a point, for a grid spacing of 80 km, and were derived from historical severe-storm reports and associated SELS and SPC categorical outlooks. Probabilities objectively define outlooks for the meteorological audience, and make them straightforward to verify against actual severe-weather reports. Individual NWS offices infuse SPC outlook guidance into their own gridded forecasts. Meanwhile, the legacy slight, moderate and high categorical risks remain as a relative indicator of threat for use by public, media and emergency-management audiences. Table 1 summarizes specifications for convective outlooks and links to current examples.

Day-4–8 outlooks feature a short text discussion and a single graphic that contains a categorical severe-weather outlook line for any day(s) where an area of ≥30% risk can be forecast for severe weather. Uncertainties involved in lower-end severe events and mesoscale processes preclude forecasts for ≤30% probabilities, though tests are planned at lower thresholds for future implementation. Day-3 outlooks likewise are driven by probabilities, but contain both categorical and probabilistic maps, along with a general-thunderstorm area that outlines a ≥10% grid-based potential for cloud-to-ground (CG) lightning strikes, and a somewhat longer text discussion. Because of uncertainties inherent to severe-storm forecasting that far in advance, day-3 outlooks cannot be issued with probabilities supporting a high risk (Fig. 4); however, the otherwise similar day-2 outlooks can.

By day-1, sufficiently large probabilities of either damaging wind or tornadoes can support a high risk (Fig. 4). Though the most complex SPC product, the day-1 outlook also is consistently the most popular, in terms of SPC website hits. This is because it contains the most information: both categorical and probabilistic maps of specific severe-storm hazards (hail, wind, tornado), with a technical discussion. The discussions tend to be detailed and lengthy for major events, offering a great deal of insight into synoptic- to mesoscale processes causing the threats. The Day-1 outlooks also include a general-thunderstorm forecast thresholded to ≥10% gridded cloud-to-ground lightning probabilities. As accessories to the day-1 outlooks, enhanced thunderstorm forecasts give temporal breakdowns of probabilistic CG lightning potential within the day-1 period, including 40% and 70% areas within the 10% lines as necessary.

b. Mesoscale discussions

As a severe-weather event draws closer, uncertainty usually diminishes in time and space, and the juxtaposition of favorable ingredients becomes more apparent. Boundaries that act as foci for severe thunderstorm development and maintenance also become more evident, through both subjective and objective mesoanlyses in combination with short-term numerical guidance. High-resolution, convection-allowing models, such as those developed and refined via the HWT, are a recent operational tool that allows forecasters to gauge the potential for both convective initiation and specific mode (e.g., supercell, quasi-linear, clustered, etc., after Smith et al. 2012).

Once confidence in a scenario is sufficient enough that watch issuance can be estimated probabilistically, SPC issues a mesoscale discussion (MD). The MD, an unscheduled forecast issued as necessary, has both textual and graphical components, the latter outlining an area and offering a visual summary of the threat. Accompanying text states the probability of a watch, headlines the area affected, and gives detailed meteorological reasoning. Probabilities are related to categorical watch potential as follows: unlikely (5% or 20%), possible (40% or 60%), or likely (80% or 95%). Once a watch has been issued, MDs provide updated information on the changing scenario every 2–3 h in the watch area, and offer insight into the potential for additional watches. The SPC typically issues around 2000 MDs y^{-1}.

c. Watches and status reports

The severe-weather watch is the most urgent forecast product of the SPC, a notice that severe storm could develop or move into an area in the next few hours. Watches serve as the preparatory step to local NWS warnings. The SPC usually issues 700-1000 watches y^{-1}. Watches typically cover an area of ~25 000 mi^2 (64 750 km^2) but can vary greatly from that average, depending on the size of land area threatened, the duration of the risk and the speed of translation of the parent weather system. The watch comes in components that serve public, aviation and meteorological audiences, and typically is valid for 6–9 h after issuance. Watches for unusually steady-state or slowly translating severe-weather situations, such as slow-moving tropical cyclones, can last up to 12 h.

Before issuance, watches are collaborated with local NWS offices. When the lead forecaster (or designee) decides a watch is necessary, a list of affected counties is drawn via computer and sent via internal bulletin to the affected NWS offices, along with a reminder of the telephone number. SPC then uses a conference call to finalize whether a watch will be issued, and if so, the watch dimensions in space and time, as well as its type (tornado or severe thunderstorm). The watch is transmitted once collaboration is done. A legacy polygon (known in SELS days as a “watch box”) still is sent to approximate the watch for aviation purposes only.

Watch configuration is both an art and a science—the science part using situational meteorology and the art being known colloquially as “boxology”, or strategically placing watches for best effect and minimal clutter. For example, it usually is desirable to have either one watch in a local NWS jurisdiction (Fig. 1), or if two are needed, to have them expire simultaneously. However, purely meteorological considerations (e.g., a longer-lasting threat in one corner of a local NWS area that would require later watch expiration) should override expediency when necessary.

Watch type ultimately is tied to the probability of a tornado anywhere in the watch. Probabilities sufficient to drive the tornado watch category are assigned when the SPC expects at least one strong (≥EF2[1]) tornado or >2 tornadoes of any rating. During "high risk" and some "moderate risk" outlook scenarios, SPC may issue a "particularly dangerous situation" (PDS) watch. Usually, PDS watches are for threats of multiple strong to violent tornadoes (EF2–EF5); though PDS severe thunderstorm watches can be issued for extreme derecho environments (Johns and Hirt 1987; Evans and Doswell 2001). Although local NWS offices are responsible for clearing counties from watches, or cancelling them completely, SPC provides hourly status updates during original watch valid times as guidance, suggesting areas of remaining threat. Local NWS offices (usually in coordination with SPC) also can extend watches in space and/or ≤2 h of time.

4. Other SPC forecasts

a. Fire-weather outlooks

In response to a void in nationwide forecasting for conditions suitable for the spread of wildfires, and a lack of a national center devoted to fire weather, SPC began issuing experimental fire-weather outlooks in 1998. The mesoscale assistant forecasters prepare these outlooks. Operational day-1 through day-3 fire-weather outlooks began in 2001; the suite (Table 2) now includes day-3–8 forecasts analogous to the day-4–8 convective outlooks. As with the convective outlooks, fire-weather outlooks include graphical and text components, and become more specific and more diagnostically driven with temporal proximity to the forecast period.

Fire-weather outlooks are focused on outlining probabilistically driven categorical "critical" areas, where forecast meteorological conditions indicate rapid growth of wildfires is possible. The day-3–8 fire-weather outlooks can contain critical areas for: 1) Dry thunderstorms (producing little or no rain), with ≥40% probability of dry thunderstorms where dry fuels exist within 12 mi (19 km) of a point during the 24- h period of the indicated day; and/or 2) ≥70% probability of strong winds, low RH, and warm temperatures concurrent for at least 3 h, where dry fuels exist. Dry thunderstorms only can be forecast in the day-3 portion of the period. Antecedent drought conditions are considered when contempating the inclusion of a marginal situation in an outlook area.

Day-2 and day-1 fire-weather outlooks may include all the critical areas of the day-3 portion of the extended outlook. In addition, day-2 and day-1 fire-weather outlooks can include an extremely critical area, the highest threat level of wildfire starts and spreads in SPC products. Sub-critical areas are tagged with an "elevated" risk category, when conditions are somewhat favorable, but probabilities are too low or conditional to draw a categorical risk area.

b. Winter-weather MDs

Although most winter-weather forecasting is the responsibility of the WPC, mesoscale discussions for hazardous winter-storm conditions began in SELS-Kansas City and continue in the SPC forecast suite. These discussions cover the mesoscale aspects (parts of states and out to ≈6h) of heavy snow, blizzards, freezing rain, and mixed precipitation. Winter-weather MDs are when the forecaster expects any of the following: 1) ≥2 h of snow rates ≥1 in h^{-1} (2.5 cm h^{-1}) at elevations 4000 ft (1219

[1] This describes the rating of tornado damage by the Enhanced Fujita (EF) scale, which indicates but cannot definitively prove tornado intensity. See Edwards et al. (2013) for a history and description of the EF scale.

m) MSL, or of rates ≥2 in h^{-1} (5 cm h^{-1}) between 4000–8000 ft (1219–2438 m) MSL; 2) freezing rain rates 0.05 in 3 h^{-1} (0.04 cm h^{-1}); 3) Blizzard conditions—defined as snow reducing visibility to <0.25 mi (0.4 km) within 35 mph (15.6 m s^{-1}) windspeeds. Climatologically or geographically rare events may justify an MD below those criteria.

5. Non-operational products and services

Digital archives of several SPC forecast products are available online from 2004 onward. In addition to scheduled and as-needed forecasts, the SPC offers storm reports in multiple formats and time periods. Daily severe-weather report listings and maps are updated throughout the convective day, from local storm reports sent by NWS offices. These initial reports consist of raw data, often containing errors or duplications. As such, daily SPC report logs should be considered preliminary only. Preliminary storm reports that are later confirmed and quality controled are submitted by local NWS offices into the final NWS *Storm Data* dataset. As detailed in Schaefer and Edwards (1999), *Storm Data* tornado reports are segmented by county, since they are used to verify warnings and watches. However, SPC connects the segmented tornado tracks into single-tornado listings, as part of the 1950–2012 SPC severe weather database. The same data also are available as GIS shapefiles. Even the final data should be used with great caution; historical severe-weather data are known to be fraught with inconsistencies, inaccuracies and secular artifacts (e.g., Verbout et al. 2006). Many severe-weather events from January 2000 onward also have been archived at SPC with summary meteorological information. The SPC warning-coordination meteorologist also offers a website with numerous types of severe-weather occurence information, charts and maps.

Both research- and forecasting-related resources for the rest of the meteorological community can be found on the SPC website. Throughout its history, SPC and its SELS predecessor have been very active in contributing operationally meaningful research to the science of severe local storms. Sixty formal papers and 116 conference articles are available on the SPC publications page as of October 2013, with more projects underway. All of these papers, and the other web content that follows, are in the public domain, free for use worldwide. Several other forms of educational information appear on the SPC website, including frequently asked questions answered regarding the SPC itself, as well as tornadoes and derechoes. Tornado safety information and the EF scale also are covered.

Diagostic forecasting tools for the conterminous U.S., developed wholly or in part at the SPC, are available online, including: daily U.S. upper-air charts, skew T–log$p$ representations and parameters of observed soundings, automated mesoanalyses (Bothwell et al. 2002) in eight overlapping sectors, toggled composite charts, an interactive tornado-environment map, and a set of composite-analysis sectors for fire-weather forecasters.

Numerical model guidance offered by SPC includes a version of the Short-range Ensemble Forecast (SREF) system (Du et al. 2009). The SPC uses ensemble model output from SREF and other systems routinely in forecast operations, and SPC scientists have been leaders in developing and adapting SREF guidance for this purpose (e.g., Guyer and Bright 2008). The results of those efforts are online at SPC, in the form of graphical SREF forecasts tailored to severe-storms, winter-weather and fire-weather concerns. Several high-resolution, explicit convection-allowing models can be assembled into an ad-hoc ensemble for operational use as well; the resulting Storm-scale Ensemble of Opportunity (SSEO) is used often by SPC forecasters to aid in timing convective initiation, as well as judging probable storm mode. The SPC provides SSEO products online.

6. Summary and future

The SPC provides a wide variety of forecasts, diagnostic and educational information, mainly regarding severe local storms and fire weather. The SPC and its predecessors have been pioneers and innovators in severe-weather forecasting for over 60 y, and plan to remain so in the future. Collocated with a diverse group of meteorological organziations in the National Weather Center, SPC meteorologists and other scientists collaborate often to improve prediction of hazardous weather, including via the HWT. High-resolution numerical guidance tested in the HWT will continue to assume a greater influence in the forecasting process. Meanwhile, NWS-wide efforts to infuse social-science concepts into forecast services, as well as to link efforts more intensively with emergency managers and other non meteorological disciplines (Lindell and Brooks 2013), will be applied to SPC specialities. The result, in the form of survey-driven input and direct research collaboration, should help SPC to define its audiences better and refine its forecasts to target their needs.

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REFERENCES

Bothwell, P. D., J. A. Hart, and R. L. Thompson, 2002: An integrated three-dimensional objective analysis scheme in use at the Storm Prediction Center. Preprints, *21st Conf. on Severe Local Storms*, San Antonio, TX, Amer. Meteor. Soc., JP3.1.

Clark, A. J., and Coauthors, 2012: An overview of the 2010 Hazardous Weather Testbed Experimental Forecast Program Spring Experiment. *Bull. Amer. Meteor. Soc.*, **93**, 55–74.

Corfidi, S. F., 1999: The birth and early years of the Storm Prediction Center. *Wea. Forecasting*, **14**, 507–525.

Doswell, C. A. III, 1987: The distinction between large-scale and mesoscale contribution to severe convection: A case study example. *Wea. Forecasting*, **2**, 3–16.

——, G. W. Carbin, and H. E. Brooks, 2012: The tornadoes of spring 2011 in the USA: an historical perspective. *Weather,* **67**, 88–94.

Du, J., and Coauthors, 2009: NCEP Short-Range Ensemble Forecast (SREF) system upgrade in 2009. Preprints, *19th Conf. on Numerical Weather Prediction/23rd Conf. on Weather Analysis and Forecasting*, Omaha, NE, Amer. Meteor. Soc., 4A.4.

Edwards, R., J. G. LaDue, J. T. Ferree, K. Scharfenberg, C. Maier, and W. L. Coulbourne, 2013: Tornado intensity estimation: Past, present, and future. *Bull. Amer. Meteor. Soc.*, **94**, 641–653.

Evans, J. S., and C. A. Doswell III, 2001: Examination of derecho environments using proximity soundings. *Wea. Forecasting*, **16**, 329–342.

Galway, J. G., 1992: Early severe thunderstorm forecasting and research by the United States Weather Bureau. *Wea. Forecasting*, **7**, 564–587.

Guyer, J. L., and D. R. Bright, 2008: Utility of Short-range Ensemble Forecast (SREF) guidance for forecasting the development of severe convection. Preprints, 24th Conf. Severe Local Storms, Savannah, GA, 13A.1.

Jirak, I.L., S. J. Weiss, and C. J. Melick, 2012: The SPC Storm-scale Ensemble of Opportunity: Overview and results from the 2012 Hazardous Weather Testbed spring forecasting experiment. Preprints, 26th Conf. Severe Local Storms, Nashville, TN, P9.137.

Johns, R. H., and W. D. Hirt, 1987: Derechoes: Widespread convectively induced windstorms. *Wea. Forecasting*, **2**, 32–49.

——, and C. A. Doswell III (1992): Severe local storms forecasting. *Wea. Forecasting*, **7**, 588–612.

Lindell, M. K., and H. E. Brooks, 2013: Workshop on Weather Ready Nation: Science imperatives for severe thunderstorm research. *Bull. Amer. Meteor. Soc*., in print.

Moller, A. R., 2001: Severe local storms forecasting. *Severe Convective Storms, Meteor. Monogr.*, No. 50, Amer. Meteor. Soc, 433–480, doi: 10.1175/0065-9401-28.50.433.

Sanders, F., and C. A. Doswell III, 1995: A case for detailed surface analysis. *Bull. Amer. Meteor. Soc.*, **76**, 505–521.

Schaefer, J. T., and R. Edwards, 1999: The SPC tornado/severe thunderstorm database. Preprints, *11th Conf. on Applied Climatology,* Amer. Meteor. Soc., Dallas, TX, 603–606.

Showalter, A. K., and J. R. Fulks, 1943: Preliminary report on tornadoes. U.S. Weather Bureau, Washington, DC, 162 pp.

Smith, B. T., R. L. Thompson, J. S. Grams, C. Broyles, and H. E. Brooks, 2012: Convective modes for significant severe thunderstorms in the contiguous United States. Part I: Storm classification and climatology. *Wea. Forecasting*, **27**, 1114–1135.

Snellman, L. W., 1982: Impact of AFOS on operational forecasting. Preprints, *Ninth Conf. on Weather Forecasting and Analysis*, Seattle, WA, Amer. Meteor. Soc., 13–16.

Verbout, S. M., H. E. Brooks, L. M. Leslie, and D. M. Schultz, 2006: Evolution of the U.S. tornado database: 1954–2003. *Wea. Forecasting*, **21**, 86–93.

Weiss, S. J., and Coauthors, 2007: The NOAA Hazardous Weather Testbed: Collaborative testing of ensemble and convection-allowing WRF models and subsequent transfer to operations at the Storm Prediction Center. Preprints, 22nd Conf. on Weather Analysis and Forecasting/18th Conf. on Numerical Weather Prediction, Salt Lake City, UT, Amer. Meteor. Soc., 6B.4.

FIGURES

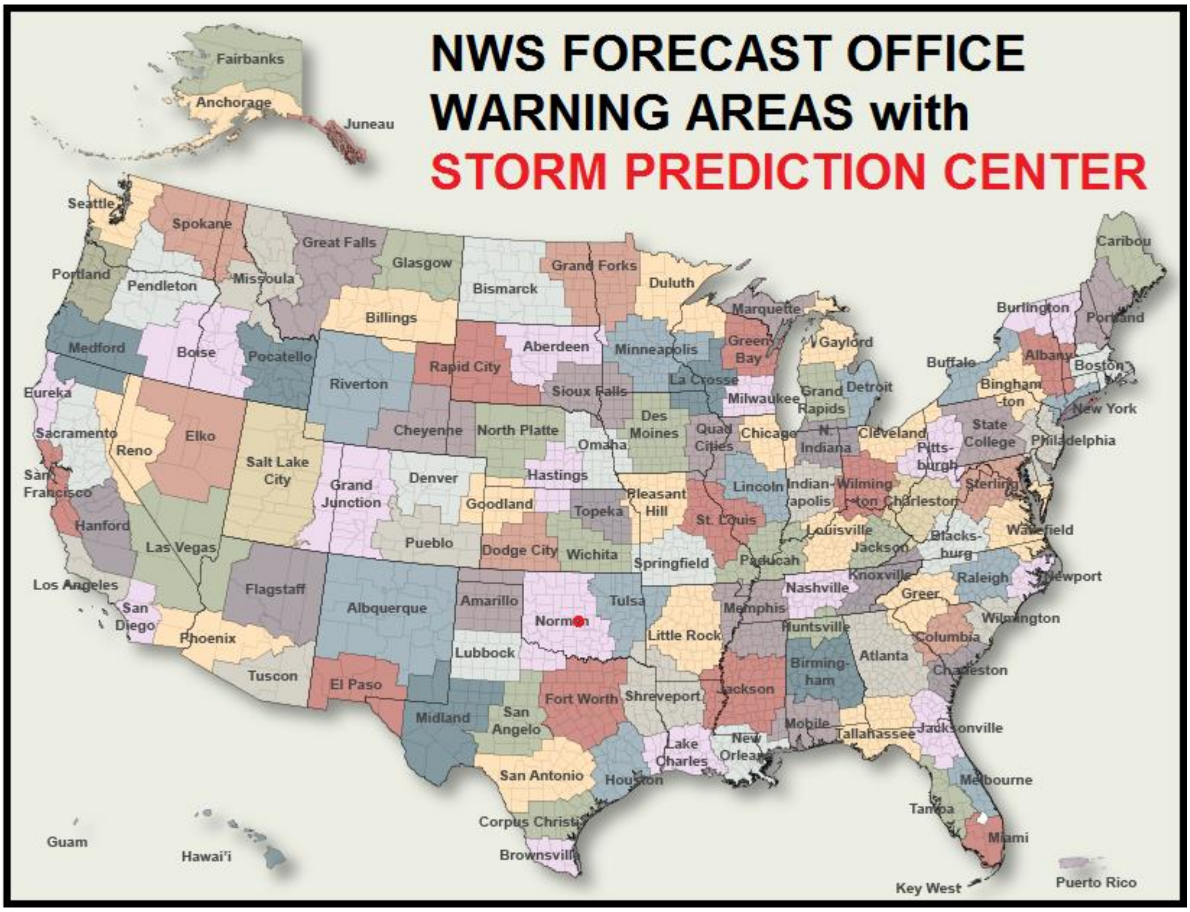

Figure 1: Map of local U.S. National Weather Service forecast office warning domains (shaded and labelled). State outlines are in black, county lines gray. SPC location (Norman, OK) is a red dot. SPC forecasts only for the conterminous U.S.—not Alaska, Hawaii, Puerto Rico or Guam. *(Map courtesy of NWS.)*

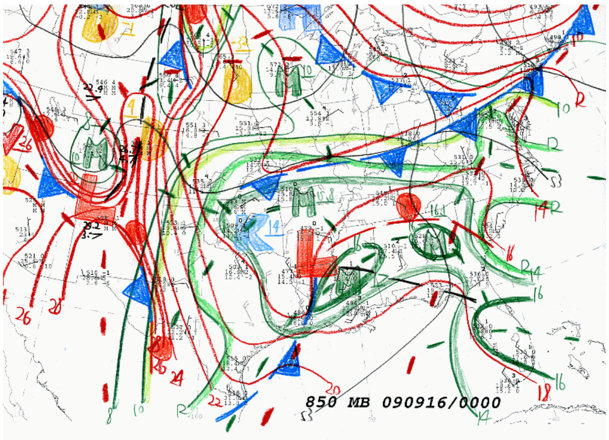

Figure 1: Example of an operational, subjective SPC hand analysis: the central and eastern U.S. portion of an 850-hPa chart from 16 September 2009. Frontal symbols, highs and lows are drawn conventionally, with isotherms in red. Isodrosotherms (green) are shaded progressively darker with greater moisture. Moist (green) and thermal (red) axes are represented by thick, loosely dashed lines. M symbols represent moisture maxima. D symbols represent moisture minima (dryness). SPC forecasters hand-analyze numerous surface and upper-air charts daily for depth of situational awareness and diagnostic understanding.

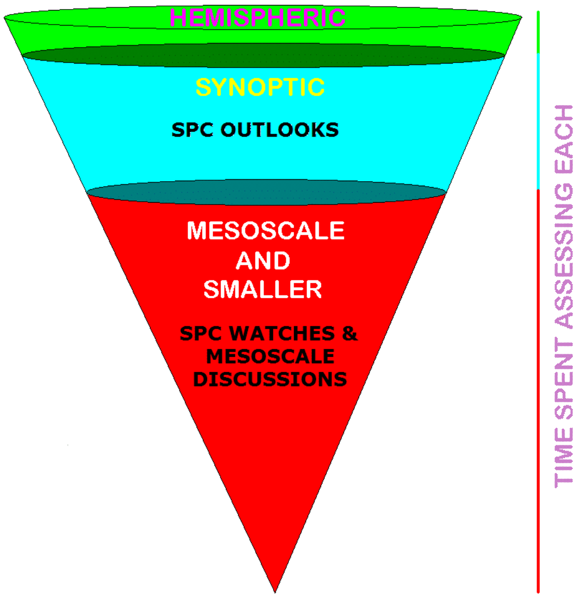

Figure 3: How the "forecast funnel " (Snellman 1982) concept applies to SPC products. There is some overlap; for example, outlooks often discuss mesoscale features on day 1, and watches and mesoscale discussions depend on input from the synoptic scale. Examples of specific SPC forecasts appear in the PowerPoint presentation.

Day 3 Probability to Categorical Outlook Conversion

(SIGNIFICANT SEVERE area needed where denoted by hatching - otherwise default to next lower category)

Outlook Probability	Combined TORN, WIND, and HAIL
5%	SEE TEXT
15%	SLGT
30%	SLGT
45%	MDT

Day 2 Probability to Categorical Outlook Conversion

(SIGNIFICANT SEVERE area needed where denoted by hatching - otherwise default to next lower category)

Outlook Probability	Combined TORN, WIND, and HAIL
5%	SEE TEXT
15%	SLGT
30%	SLGT
45%	MDT
60%	HIGH

Day 1 Probability to Categorical Outlook Conversion

(SIGNIFICANT SEVERE area needed where denoted by hatching - otherwise default to next lower category)

Outlook Probability	TORN	WIND	HAIL
2%	SEE TEXT	NOT USED	NOT USED
5%	SLGT	SEE TEXT	SEE TEXT
10%	SLGT	NOT USED	NOT USED
15%	MDT	SLGT	SLGT
30%	HIGH	SLGT	SLGT
45%	HIGH	MDT	MDT
60%	HIGH	HIGH	MDT

Figure 4: Conversion tables for SPC outlooks as labeled. Hatched shading is conditional on the presence of a 10% significant-severe area for that hazard. SEE TEXT areas are labeled but not outlined on the categorical map. SLGT snads for slight risk, MDT for moderate risk. Probabilities are explained in the text of this article.

Table 1. SPC severe-weather forecast products, as of 2013. Hyperlinks go to either the dedicated page for that forecast type on the SPC website (except for status reports, which are overwritten). All times UTC. A convective day is defined as 24 h long, beginning at 1200 UTC. Changes in UTC product deadlines between Daylight Savings Time (DT) and Standard Time (ST) are specified. TC stands for tropical cyclone.

SPC PRODUCTS	**VALID PERIOD**	**TIME(S) ISSUED**	**EVENT COVERAGE**
Day-4–8 Severe Outlook	Fourth through eighth future convective day	0900 for DT, 0830 for ST	Categorical line representing 30% probability of any severe weather; meteorological discussion. No general thunder line.
Day-3 Severe Outlook	Third future convective day	0730 for DT, 0830 for ST	Categorical and probability lines for all severe weather collectively according to Fig. 4, with technical discussion. Categorical slight risk invoked at 5% total-severe probabilistic threshold *only if valid entirely for TC tornadoes*. No high risk.
Day-2 Convective Outlooks	Second future convective day	0600 for DT, 0700 for ST; 1730	As with day-3, except high risks are permitted (but rare).
Day-1 Convective Outlooks	Upcoming (for 0600 issuance) or ongoing convective day	0600, 1300, 1630, 2000, 0100	Categorical for all severe weather collectively, triggered by event-specific probabilities for tornado, wind and hail (Fig. 4). Accompanied by detailed, sectional discussion with synopsis.
Mesoscale Discussion	30 min to 3 h	As needed, before and during watches	Text discussion of mesoscale threat and either ongoign watch(es) or probability for new watch issuance. Graphic areal outline.
Severe Thunderstorm or Tornado Watch	Up to 12 h	As needed	Aviation and public watch products, affected county listing, tornado probability for the entire watch area dictates its type.
Watch Status Report	Up to 1 h	20-40 min past each hour during watches	Lists counties remaining in threat area covered by associated watch, defines remaining severe-weather threat to the right of a line.

Table 2. SPC fire-weather forecast products, as of 2013. Hyperlinks go to the dedicated page for that forecast type on the SPC website. All times UTC. A fire-weather day is defined as 24 hours long, beginning at 1200 UTC. Changes in UTC product deadlines between Daylight Savings Time (DT) and Standard Time (ST) are specified.

SPC PRODUCTS	**VALID PERIOD**	**TIME(S) ISSUED**	**EVENT COVERAGE**
Day-3–8 Fire Weather Outlook	Third through eighth future fire-weather day	2200	Categorical and probability lines for dry thunderstorms and strong winds/low RH/warm temperatures where dry fuels exist. Categorical critical designation invoked at 40% threshold for dry thunderstorms and 70% for strong winds/low RH/warm temperatures.
Day-2 Fire Weather Outlook	Second future fire-weather day	1000; 2000	Categorical lines for dry thunderstorms (isolated and scattered) and strong winds/low RH/warm temperatures (elevated, critical, and extremely critical) where dry fuels exist.
Day-1 Fire Weather Outlooks	Upcoming (for 0900 issuance) or ongoing fire-weather day	0900 for DT, 1000 for ST and 1700	Same as day-2.