WEATHER ANALYSIS AND FORECASTING ISSUES IN THE CENTRAL UNITED STATES

BY PATRICK S. MARKET, NEIL I. FOX, BRIAN PETTEGREW, AND ANTHONY R. LUPO

The Soil, Environmental, and Atmospheric Sciences Department at the University of Missouri–Columbia hosted the Second Conference on Weather Analysis and Forecasting Issues in the Central United States (WAFICUS II) in late 2003. Regional meetings such as this one, which bring together the operational, private, and research sectors to discuss common meteorological problems in order to find common interests, have been occurring more frequently during the past few years [e.g., the annual High Plains Workshop, the Northeast Regional Workshop (Auciello 2002)]. The underlying idea of addressing familiar meteorological and forecast challenges by all sectors in the Central Region remains the same as that from WAFICUS I (Lupo and Market 2003), and these types of gatherings provide a forum for the beneficial exchange of ideas.

As was the case for the first meeting, those in attendance at WAFICUS II[1] and who spoke at the meeting were from all sectors of atmospheric science, and included the Storm Prediction Center (SPC), National Weather Service Forecast Offices (NWSFOs; or simply WFOs), the private sector, and the academic community.

The May 2003 tornado outbreak garnered much of the attention by the speakers; however, this was not the only topic addressed. Heavy rain and flooding, and winter weather were also topics of presentation and discussion, with presentations using case study analyses, climatologies, and dynamics to highlight these concerns. A winter weather workshop presented the attendees with an opportunity to discuss issues surrounding forecasting a complex spring precipitation event that unexpectedly produced snow.

MAY 2003—A LOOK BACK. The keynote address was given by Daniel McCarthy (Storm Prediction Center) and examined the salient points surrounding

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WHAT: Central Region meteorologists met to discuss the challenges of predicting extreme weather in the Midwest and High Plains
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[1] The Joint Student Chapter of the University of Missouri–Columbia–American Meteorological Society (AMS) and the National Weather Association (NWA) sponsored the meeting.

the May 2003 period of severe weather. The discussion focused on 3–12 May during which an exceptional 340 tornadoes occurred, including 71 in Missouri, 23 of which were in the Pleasant Hill (EAX) County warning area (CWA). McCarthy demonstrated improvements made by the meteorological community by comparing the fatalities caused by the superoutbreak of 3–4 April 1974 (310 in 147 tornado events) to those from the 9-day period in May 2003 (38 fatalities in 340 tornado events). He stated that we have a long way to go because this was still 38 fatalities too many.

After an analysis of the synoptic and mesoscale factors leading to the outbreaks of the 3–12 May period, McCarthy pointed out that these tornadoes were likely the result of several large outbreaks that occurred in rapid succession. He also pointed out that these events were "textbook" severe weather outbreaks and are worthy of study for the students in the audience. He also reiterated that the key to convective initiation in unstable air during these events was the low-level jet (LLJ). He showed that tools and indices used by the weather forecasters (e.g., the significant tornado parameter) performed very well. He also advised the students present to learn Miller's rules for forecasting severe weather [developed by Air Force Colonel Robert C. Miller during the late 1940s through 1960s (see Galway 1992)], because these rules still work well in severe weather forecasting and analysis today.

Following McCarthy, Suzanne Fortin (EAX WFO) reviewed the impact of the 4 May 2003 tornadoes on the EAX CWA. Fortin showed that 5 of the 23 tornadoes that touched down included two F4 tornadoes, which moved through the Kansas City metropolitan area. She described the flow regime as "progressive southwesterly flow," which means that the Midwest was impacted by the regular progression of synoptic-scale cyclones that drew moisture originating over the Gulf of Mexico and naturally contributed to increased instability. She also compared the conditions of 4 May 2003 to other historical outbreaks that impacted the CWA (e.g., May 1957, May 1977) and found that synoptic-scale conditions were similar to the latest outbreak.

Andrew Kunz (University of Missouri–Columbia) moved up to the planetary scale, and showed that a persistent southwest-to-northeast jet was anchored over the North American continent. This resulted from the occurrence of two blocking events over the eastern Pacific and western Atlantic, which developed in late April and persisted into early May. They allowed for the persistence of a large-scale baroclinic zone across the southern portion of North America that triggered at least three large-scale severe weather outbreaks in rapid succession. He showed that the development of two simultaneous blocking events in the Northern Hemisphere is not an unusual event, occurring approximately 29 days annually. What was unusual in this case, however, was the occurrence of simultaneous blocking events off either coast of North America during the spring season, because this flow regime is comparatively rare (only 1% of all simultaneously occurring events). Thus, it is reasonable to assume that severe weather outbreaks such as the May 2003 events, though rare, would not be unprecedented, even if a similar event has not been documented during the last 50 yr.

SCIENCE INTO SERVICE. Michael Hudson (EAX WFO) discussed the success of the WFO and several community groups, such as storm spotters and Kansas City metropolitan area broadcast meteorologists, in issuing consistent and coherent warnings to the general public to take appropriate actions for the protection of lives and property. As a result, severe weather fatalities were surprisingly low given the scope in time and space of the outbreak(s) and the populated areas that were affected. The formula for this success started with proactive efforts to integrate the latest science on severe weather research into internal and external education outreach events. Increased efforts to bring this information to outreach events, such as workshops and storm spotter training sessions, resulted in all those involved in the warning process bringing a higher level of service to the community.

HEAVY RAIN AND FLASH FLOODING. Several speakers focused on the perennial problem of heavy rain and flooding in the Central Region by presenting case studies of memorable events. Bradley Mikelson (Saint Louis University) examined the 24-h rainfall event of 3–4 June 2002 that impacted a large area from central Iowa into northern and western Illinois with as much as 11 in. of rain. Four-inch rainfall amounts were common across the two-state region, causing significant property damage. Mikelson examined the synoptic and mesoscale aspects of the event using Weather Surveillance Radar-1988 Doppler (WSR-88D) radar and Geostationary Operational Environmental Satellite (GOES) imagery to reveal the interaction of the low- and upper-level jet with a strong quasi-stationary surface boundary. Outflow boundaries from earlier mesoscale convective systems (MCSs) were the loci of subsequent convective activity. These MCSs produced rainfall rates as heavy as 2 in. h^{-1}.

Thomas Williams (Western Illinois University) presented an examination of the large-scale events

that brought several flash flooding events to the same areas during the late spring and summer of 2002. The weather conditions leading to these flooding events were examined with several meteorological and hydrological factors implicated, and, in many cases, compounding each other. These included stationary frontal boundaries and abundant moisture, which resulted in training thunderstorm events. Heavy rainfall saturated the ground, allowing additional thunderstorms to produce excessive runoff and flash flooding.

Angela Hutti (Western Illinois University) looked back at the 1993 flooding in the Central United States by assessing the impact these events had on ecosystems across the region. While most assessments focus on the negative impacts of such heavy flooding, Hutti pointed out that there were some benefits as well, such as the replenishment of both soil nutrients across the region, and water in wetland areas, lakes, and ponds. She also focused on the unusually persistent flow regime that brought copious amounts of rain to an area that had been unusually wet for at least 6 months prior to the event itself.

Brian Pettegrew (University of Missouri–Columbia) discussed precipitation efficiency (PE), which is the ratio of moisture ingested into and precipitated out of a storm. Many previous studies have used instantaneous values of efficiency, quite often in hailstorm events over mountainous regions. This work calculated the average efficiency over the lifetime of an MCS using a climatological approach instead of calculating instantaneous PE values. These averages were then correlated to bulk environmental features, as calculated by the GOES sounder, in order to obtain a predictive equation that can be used to forecast heavy rainfall and flash floods. Current work is now underway to analyze and compare various methods of calculating PE in order to correlate these values to PEs obtained via the full moisture budget equation.

WINTER WEATHER. Two presentations focused on the issue of winter weather, and this was followed by a workshop that was designed to take forecasters through the step-by-step process of determining the time of onset and type of precipitation for a past event that provided a stiff challenge to the forecasting community. The first presentation was given by Christopher Melik (University of Missouri–Columbia), who focused on the dynamics that forced vertical motions in a rapidly developing U.S. cyclone in early November 1999. He demonstrated that, given today's technology, observational data can be gathered in real time, without the aid of model analysis, to produce realistic vertical motion fields using several techniques, and these were shown to be similar to those eventually available via the National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) reanalysis (Kalnay et al. 1996).

Charles Graves (Saint Louis University) examined several cases of banded heavy snowfall events across the Midwest with the idea of looking at the case-to-case variability of the critical processes contributing to these types of events. In particular, he demonstrated the role of midlevel frontogenesis, conditional symmetric instability (CSI), and the trough of warm air aloft (TROWAL) across the spectrum of weak-to-strong cyclogenesis events.

A winter weather workshop presented by Patrick Market (University of Missouri–Columbia) wrapped up the afternoon as attendees were asked to reexamine a particularly difficult late-season snowfall case that caught the Saint Louis Metropolitan area by surprise during the morning rush hour of 10 April 1997. Market asked workshop attendees to examine observational data and model runs in order to determine whether or not, in hindsight, the key mechanisms for such a snowfall event could have been found. In addition, participants were asked to determine whether this was an event in which the cold air needed to produce the snowfall resulted from, for example, the generation of vertical motion (and the resultant adiabatic cooling), or the cold air already in place.

CONCLUSIONS. During the past few years, regional workshops have become part of the growing trend, indicating increasing cooperation among the private, government, and academic sectors in meteorology in order to bring a greater level of service to the public. WAFICUS II continued to provide an outlet for the discussion of the pertinent issues to forecasters in the region and collaboration between the three sectors in sharing research results across the Central Region of the United States. The students who were in attendance were also able to benefit from the discussion surrounding these issues.

The meeting incorporated many of the suggestions provided by attendees of WAFICUS I. Among them was the implementation of a forecasting workshop, which those who attended found quite useful. Information about WAFICUS II can be found on the WAFICUS homepage, available through the University of Missouri–Columbia Atmospheric Science Program (online at http://weather.missouri.edu).

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