6B.1 **TECHNOLOGY AND COMMUNICATION METHODS USED TO INCREASE AWARENESS AND MITIGATE IMPACTS DURING THE DEVASTATING OHIO VALLEY WINTER STORM ON JANUARY 26-28, 2009**

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1. INTRODUCTION

The Ohio Valley winter storm on January 26-28, 2009 was perhaps the most devastating weather event to strike the region in 2009. Record icing and up to an additional 4-10 inches of snow wreaked havoc over much of Kentucky, southeast Missouri, southern Illinois, and southern Indiana causing thousands of power outages which lasted for weeks. Extensive structural damage to trees, homes, and businesses totaled around $50 million in the state of Kentucky alone.

Despite the disastrous impacts of this storm, modern-day technology employed during the event helped dampen and bring awareness to its effects. A plethora of data from advanced NWP models was used before and during the storm to alert the public and NWS partners of the impending danger. In addition, several communication methods covering a wide range of customers were implemented to relay critical watch and warning information that helped save lives.

Although the Ohio Valley winter storm affected sections of four states, this study will focus on the impacts in portions of southern Indiana and central Kentucky which is under the responsibility of the Louisville National Weather Service (NWS) forecast office.

2. STORM SYNOPSIS

An east-west frontal boundary set up from northeast Louisiana to southwest Pennsylvania late on Monday, Jan 26th. A strong southerly low-level jet pumped plentiful Gulf moisture up over this boundary on Tuesday the 27th and Wednesday the 28th providing for a lengthy overrunning precipitation event (Fig. 1).

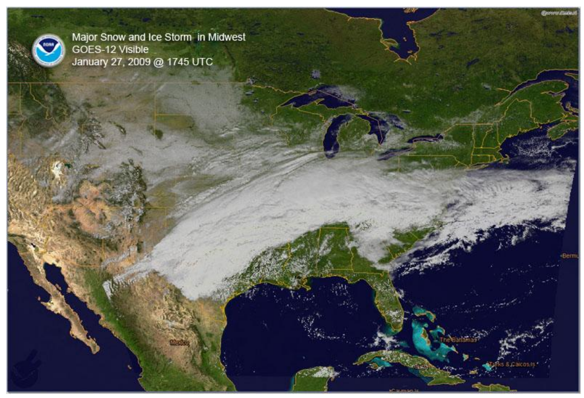

Figure 1. Visible satellite image showing extensive cloud cover across the Ohio Valley associated with a low-level jet and plentiful moisture, creating a widespread overrunning precipitation event.

A wedge of cold air in the low levels (Fig. 2) held steady throughout the event with easterly surface winds. This was topped by a warm, moist layer aloft from 850-700 mb and a moist, steady southwest flow at 500 mb (Figs. 3 and 4). This setup caused multiple precipitation type changeovers.

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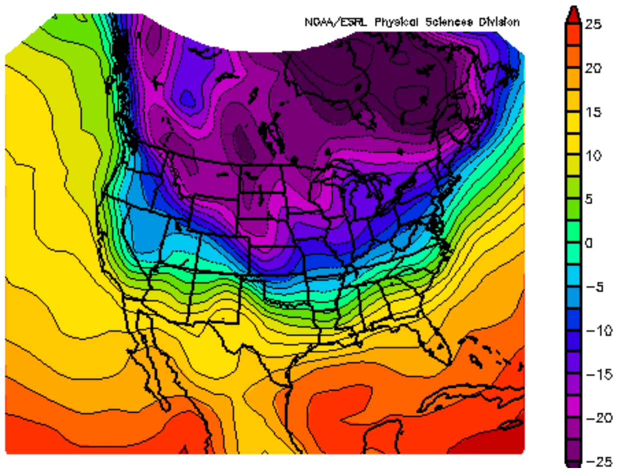

Figure 2. Reanalysis data from Jan 26th shows unusually cold surface air in place across the northern half of the country with temperatures of -10° to -5° C across much of Kentucky leading up to the ice storm. The cold air remained in place for several days adding to the severity of the event.

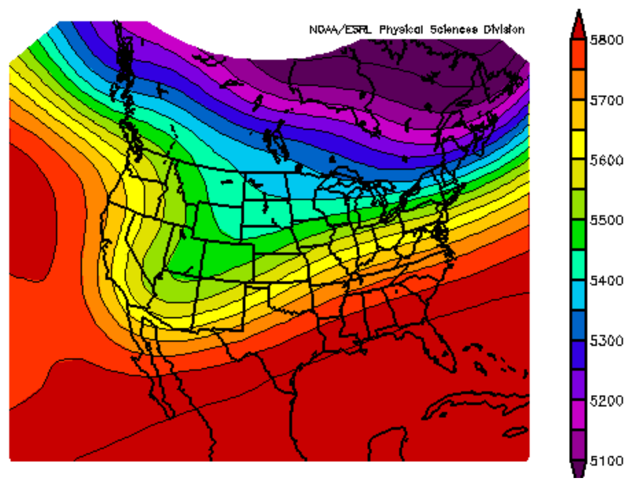

Figure 3. Reanalysis data at 500 mb from Jan 27th shows a deep trough was digging into the Four Corners region allowing a continuous stream of moist southwest flow to feed into the Ohio Valley at mid levels, increasing precipitable water values and enhancing precipitation intensity.

Precipitation came in two strong bursts caused by shortwave troughs riding along the frontal boundary. One occurred on Monday night/early Tuesday and the other on Tuesday night/early Wednesday, with steady light precipitation during the day on Tuesday between the heavier bursts. The event then ended with a moderate burst of snow Wednesday morning

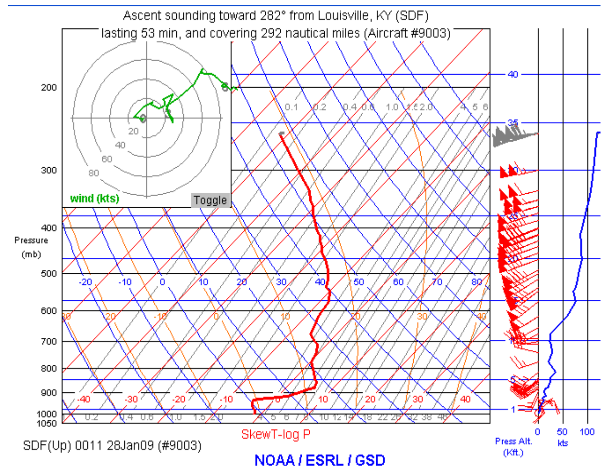

Figure 4. This aircraft sounding from Louisville International Airport (SDF) on Jan 28th shows a deep elevated warm nose of around +7° C with surface temperatures just below freezing. This is a perfect freezing rain sounding.

courtesy of a deformation zone and trowal-like structure on the back side of the system.

With a strong warm layer aloft over the southern forecast area on Monday night/early Tuesday, the first wave of heavy precipitation resulted in heavy icing over south-central Kentucky, an ice and snow mix over north-central Kentucky, and moderate snow over south-central Indiana. This wave was enhanced by frontogenetical forcing. The warm layer gained strength and moved farther north Tuesday during the day changing precipitation to steady light freezing rain with light ice accumulations over most of the NWS Louisville forecast area except extreme southern Kentucky where surface temperatures were warm enough for plain rain. The second wave of heavy precipitation occurred Tuesday night into early Wednesday in which heavy icing occurred over southern Indiana and north-central Kentucky with lighter ice amounts over southern Kentucky. Finally, a moderate burst of snow in the deformation zone of the exiting system occurred Wednesday morning over south-central Indiana and northern Kentucky with lighter snow amounts over southern Kentucky. Figures 5 and 6 show total snow and ice accumulations across the NWS Louisville forecast area, respectively.

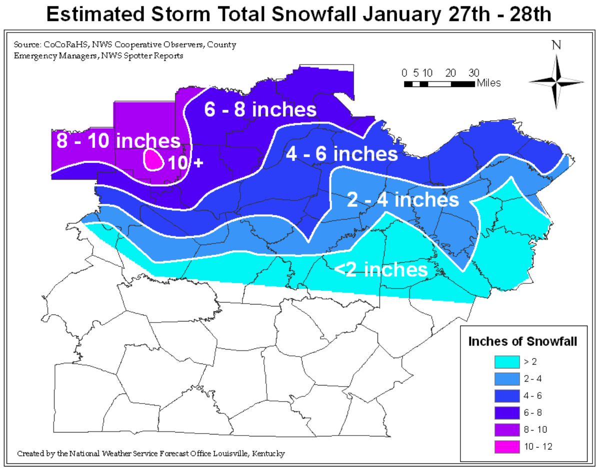

Figure 5. Storm total snow accumulations.

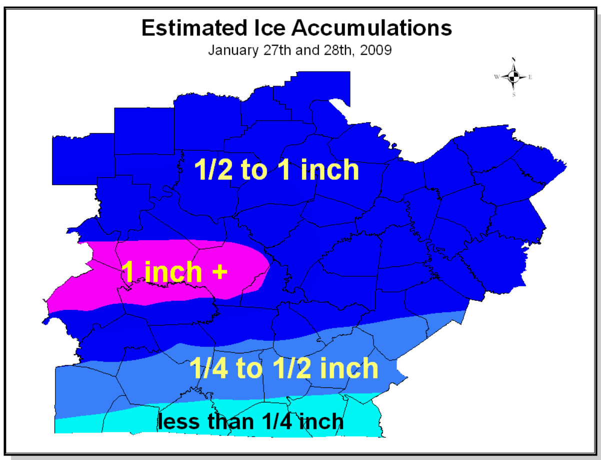

Figure 6. Storm total ice accumulations.

3. IMPACTS

Devastating damage to trees and power lines was apparent across the entire forecast area. Extensive structural damage occurred from fallen trees and ice. Power outages lasted from a few days to weeks with roughly 769,000 homes and businesses across Kentucky without power at the outage peak. Several out-of-state power crews were called in to help repair the lines. Also, the National Guard was activated to assist with clean-up, security, and distribution of food and supplies. Numerous schools were canceled for the week, and emergency shelters were set up to help storm victims. There were at least 30 known deaths across Kentucky and at least 1 known death in southern Indiana related to this storm, most due to carbon monoxide poisoning or hypothermia. The President declared Kentucky a major disaster area. The storm was estimated to cost the state of Kentucky around $50 million with the Louisville metro area alone costing approximately $2.1 million (Halladay 2009). Figures 7 and 8 show damage from the storm.

Figure 7. The ice storm snapped or bent numerous power poles causing hundreds of downed power lines.

Figure 8. Heavy icing on power lines and tree limbs caused massive destruction and left thousands without electricity for weeks.

4. NWP ENSEMBLE MODELS

Numerical Weather Prediction (NWP) ensemble models predicted the Ohio Valley winter storm quite well. The GEFS (Global Ensemble Forecast System) model showed signs of a major winter storm four to five days in advance. GEFS data for this study was obtained from the TIGGE (THORPEX Interactive

Grand Global Ensemble) database (National Center for Atmospheric Research 2008).

The GEFS model indicated a possible winter storm well in advance. Figure 9 depicts the higher precipitable water (PWAT) values in the light greens and oranges being pumped into the Ohio Valley according to the 700 mb flow contours. The contours also indicate moisture convergence over the Ohio Valley as they meet in this region. Figure 10 illustrates warm air at

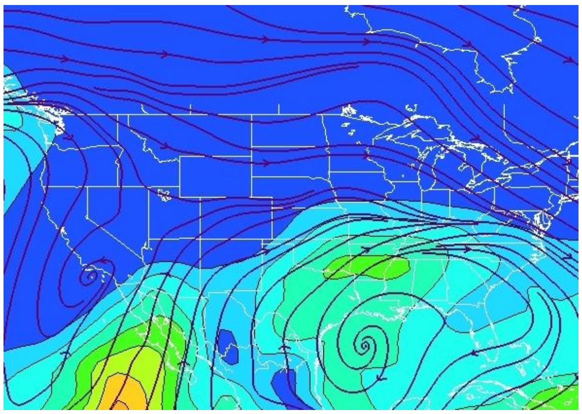

Figure 9. GEFS PWATs (image) and 700 mb flow (contours) for Tuesday morning (the 27th) from the Jan 23rd 12z model run.

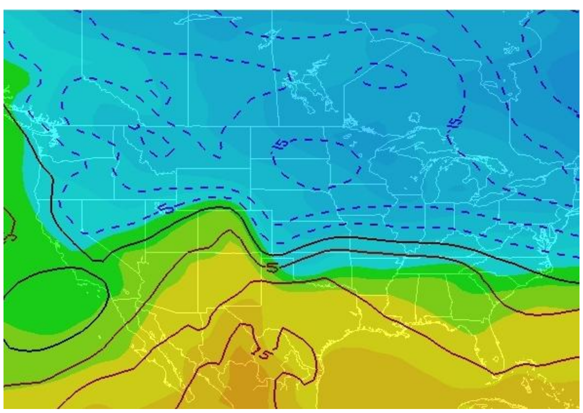

Figure 10. GEFS Surface Temperatures (image) and 850 mb Temperatures (contours) in Celsius for Tuesday morning (the 27th) from the Jan 23rd 12z model run. The blue image indicates surface temperatures below freezing while other image colors are surface temperatures above freezing. The blue contours indicate 850 mb temperatures below freezing while the red contours indicate 850 mb temperatures above freezing. The black contour is the freezing line at 850 mb.

or above freezing at 850 mb (black and red contours) overriding sub-freezing air at the surface (blue image) over the Ohio Valley. This type of temperature scheme usually results in a wintry mix and is particularly conducive for heavy icing.

Because the GEFS model showed a combination of plentiful moisture, cold air at the surface, and warm air aloft, meteorologists at NWS Louisville were able to forecast the possibility of a major winter storm four to five days in advance with above average confidence.

The SREF (Short Range Ensemble Forecast) model was quite useful two to three days ahead of time in fine tuning the details of the storm. Wandishin et al. (2005) found that the SREF exhibits fairly good skill in forecasting precipitation type, especially between snow and rain. Similar findings were discovered using the SREF for this storm.

The SREF identified the setup of this storm well (Fig.11). A surface frontal boundary is shown by the wind shift stretching from northeast Louisiana to southwest Pennsylvania. Warm, moist air being pumped over this boundary into Kentucky and Indiana is evident by the high relative humidities over these states. Figure 11 also depicts north-northeast surface winds which kept sub-freezing surface temperatures in place during the event.

As discussed in Section 2 of this paper, precipitation with this storm came in two heavy bursts. The SREF correctly identified these bursts two to three days in advance. It also performed well in predicting the vertical thermal profile of the atmosphere. For example, SREF data in Figure 12 shows cold air at the surface (temperatures below 32ºF) over southern Indiana and most of Kentucky, as denoted by the large area of dark blue. In addition, above freezing 850 mb temperatures are evident over much of Kentucky, with the 0ºC isotherm just south of the Ohio River (yellow lines). By viewing this thermal structure in vertical cross-sections and studying model forecast soundings, meteorologists were able to assess the spatial distribution of different precipitation types. As the warm layer aloft fluctuated in a north-south direction throughout the event, the SREF picked up on the varying thermal profiles over the area. This allowed NWS Louisville to accurately define areas of snow and ice in the forecast.

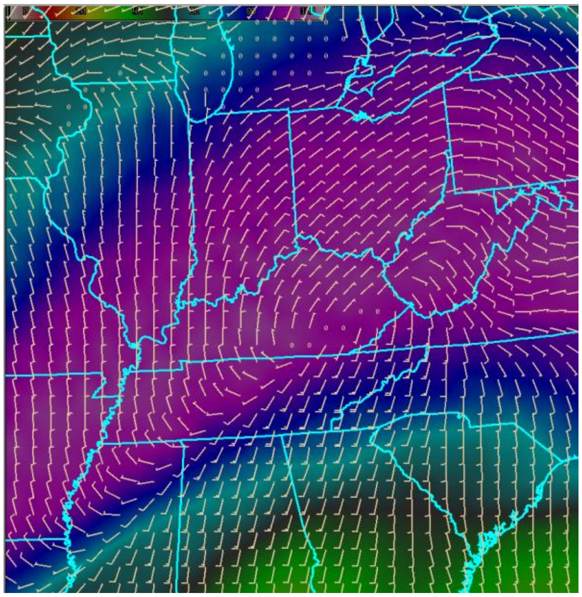

Figure 11. SREF 1000-500 mb relative humidity (image) and surface winds (kts) Tuesday night (the 27th).

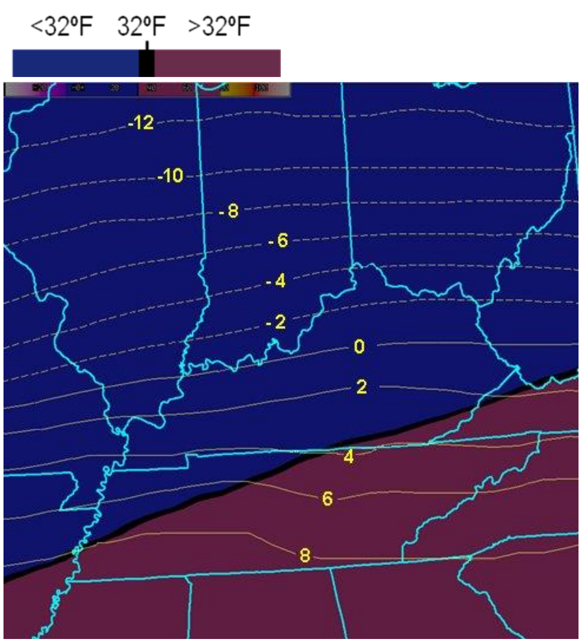

Figure 12. SREF surface temperatures (image) and 850 mb temperatures (yellow lines; values in °C) Tuesday morning (the 27th).

Overall, the SREF's performance in this case was excellent as it provided a good storm setup, accurate precipitation timing, and sound thermal structures that were close to actual observations.

5. COMMUNICATION

Because the storm was predicted to have destructive impacts, several communication methods covering a wide range of customers were implemented to relay critical watch and warning information. Interaction with the media and emergency managers was in the form of conference calls, one-on-one phone calls, web graphics, and NWS Chat. NWS products including special weather statements and mesoscale area forecast discussions were another vital avenue of communication used with this storm.

Several detailed conference calls were conducted with emergency managers, media, utility companies, and schools to greatly enhance their situational awareness, preparatory decision making, and required safety actions before and during the storm. Schools and utility companies, especially the Jefferson County Public School System (Louisville metro schools) and Louisville Gas & Electric, were particularly glad to be included on conference calls because of the impact that this winter storm had on their operations. Extra NWS staffing was utilized before and during the storm to answer one-on-one phone calls from all of our customers.

Weather graphics were posted to NWS Louisville's website for easy customer access before and during the storm. The pre-storm graphics contained information on storm timing, expected accumulations, and warning details (Figs. 13-15). These graphics also served as a supplement to the conference calls as forecasters referenced the web graphics to better explain details of the storm. During the event, the web was frequently updated to provide the most current storm information including maps of snow and ice accumulations.

Most of the weather graphics were made using FXC (FX Collaborate) in AWIPS (Advanced Weather Interactive Processing System), but some maps were prepared using GIS (Geographic Information System) software.

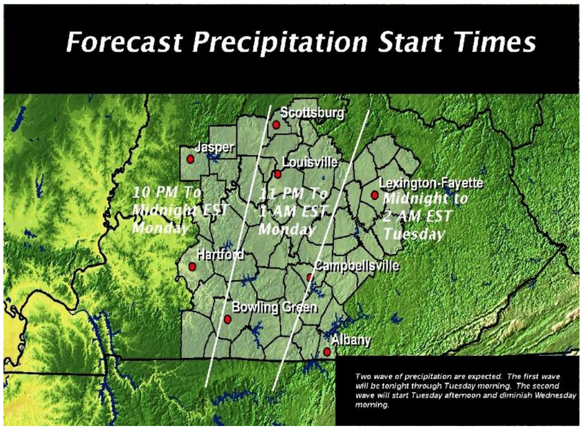

Figure 13. Storm timing graphic made in FXC.

Figure 14. Snow and ice accumulations forecast graphic made in FXC.

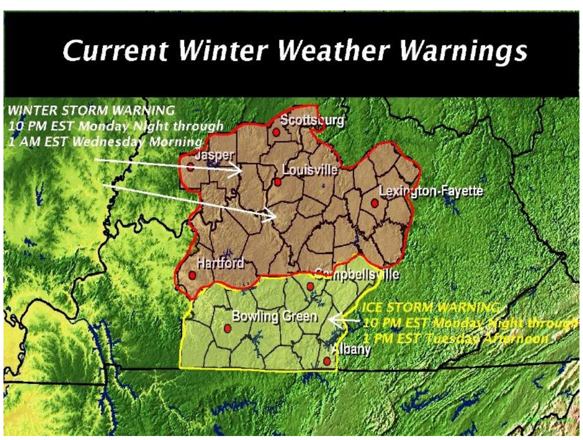

Figure 15. Warning/Advisory graphic made in FXC.

NWS Chat software was used frequently to instant message crucial information about the storm back and forth between the NWS and the media and emergency managers. Extra staffing was called in to assist in answering NWS Chat inquiries, as instant messaging was one of the most prominent forms of effective communication during the storm. Several precipitation accumulation reports and precipitation type observations were relayed through NWS Chat.

Numerous special weather statements (SPSs) and mesoscale area forecast discussions (meso AFDs) were issued by NWS Louisville to convey storm trends and the seriousness of the situation. An SPS highlighting the possibility for significant snow and ice accumulations was issued 72 hours in advance of the storm, well before the initial winter storm watch. Meso AFDs and SPSs were then issued periodically during the storm to provide the most up-to-date forecast changes and the meteorological aspects of the ongoing weather. These frequent updates were found to be very insightful to NWS customers.

6. CONCLUSIONS

Utilizing the most up-to-date technology to predict this winter storm and conveying the storm's ramifications through the most effective lines of communications were critical in dampening its effects.

NWP ensemble models gave forecasters the first warning signs of a major winter storm several days in advance. The models performed well in tracking the storm throughout the event and, therefore, forecasters were able to produce an above average confidence forecast for this storm.

More importantly, however, was the means in which the devastating impacts were communicated to the public and NWS partners. By holding conference calls and posting descriptive weather graphics and text products on the web, NWS Louisville was able to stress planning and preparation before the storm hit and continually feed vital information to customers during it. NWS Chat software was also crucial in keeping NWS partners up to speed on the storm and allowing those partners to relay storm observations back to NWS Louisville.

It is safe to say that not many people were caught off guard by the Ohio Valley winter storm of 2009. Despite its devastating impacts, Ohio Valley inhabitants were able to survive because of the preparatory actions taken ahead of time.

In conclusion, the primary focus of any forecasting agency before any inclement weather event should be to communicate to as many people and through as many avenues as possible the anticipated effects. In doing so, we facilitate a proper response to allow our customers to plan, prepare, and hopefully survive the storm.

Also, efforts should be made to improve existing communication and develop new forms of communication. In the near future, NWS Louisville will post recorded video sessions on its website for hazardous weather events. Strides are also being made nationally by the NWS and by private vendors to increase cell phone, home phone, and iPod warning services. Finally, efforts are being made between agencies to expand the web of communication through internet chat rooms.

Acknowledgements

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