

NATIONAL WEATHER SERVICE
WINTER WEATHER EXPERIMENT
2002-2003

HPC PERSPECTIVE

Final Report
by the
National Centers For Environmental Prediction (NCEP)
Hydrometeorological Prediction Center (HPC)

June 30, 2003

Peter C. Manousos
HPC Science and Operations Officer
and HPC WWE Focal Point

1. Introduction

A Winter Weather Experiment (WWE) coordinated by the National Weather Service (NWS) Office of Climate, Water, and Weather Services (OCWWS), NWS Eastern Region (ER) Headquarters, and the National Centers for Environmental Prediction (NCEP) Director's Office was conducted last winter season (2001-2002). The goal of the experiment was to improve winter weather services to the public via a suite of enhanced products from NCEP's Hydrometeorological Prediction Center (HPC) for use by NWS Weather Forecast Offices (WFOs) in support of their winter weather watch and warning program. Analysis of the WWE by the participants led to the decision to continue the experiment for a second winter season (2002-2003) with expansion to 31 WFOs from both ER and Central Region (CR). Details of the experiment and the results are provided below. See the Appendix for a list of participants.

2. Framework for WWE 2002-2003

2a. Goals

The primary goal from last season's (2001-2002) WWE (WWE1) remained valid for 2002-2003 (WWE2)- specifically:

- ▶ To improve winter weather products and services to the public via a suite of enhanced products and services from NCEP HPC for use by participating WFOs in support of their winter weather watch and warning program.

Secondary goals from WWE1 were also retained as follows:

- ▶ To evaluate the role of HPC in facilitating a collaborative set of guidance products among WFOs and HPC as a prototype for the National Digital Forecast Database (NDFD) era of the NWS.
- ▶ To evaluate the performance of the NCEP Environmental Modeling Center's (EMC) Short Range Ensemble Forecasts (SREF) during winter events. (The lack of winter events during the 2001-2002 winter season prevented a full evaluation of this aspect during the WWE1).

Additional goals for WWE2 were:

- ▶ To evaluate the workload associated with the collaborative process involving HPC and a large number of WFOs. (WWE1 initially incorporated only four WFOs and expanded to eight by the end of the season. In contrast WWE2 incorporated 23 ER WFOs and 8 CR WFOs).
- ▶ Establish if or not a verification metric could be derived that established the effectiveness or impact of the WWE on either issuance of winter weather watches/warnings or the decision making process of forecasters with regards to winter weather watches/warnings.

2b. Assumptions

No additional FTE resources were allocated to any participating office in support of WWE2. Because both the HPC and WFO product suites were primarily schedule driven, the established times for collaboration set by the ER participants in WWE1 were used as a target for this experiment. Topographical winter events were not explicitly covered by WWE2. This included Lake Effect Snow events and/or any local orographically enhanced events.

2c. Enhancements Over WWE1

Suggestions on enhancing the WWE were provided by ER and HPC at a WWE 2001-2002 post

analysis meeting held at ER Headquarters in June 2002. Several of these suggestions were incorporated in the experiment and are listed below. See the Appendix for a comparison table between WWE1 and WWE2.

- ▶ WWE2 called for HPC to facilitate collaboration among all participating WFOs.
- ▶ The enhanced product suite from HPC included a storm tracks graphic similar to that produced in support of WWE1, but also depicted an indication of the clustering of low pressure centers.
- ▶ The enhanced product suite from HPC included an event total graphic (for snow and ice) to help facilitate collaboration.
- ▶ Chat sessions between HPC and the WFOs included text collaboration supplemented by an audio chat session if necessary for the weather situation at hand. The audio chat session was targeted to last no longer than 15 minutes. Only the audio chat sessions required interested parties to be participating at the same time.
- ▶ In order to streamline the transition of the WWE participants' respective operations toward the NDFD era, the WWE attempted to be structured in a fashion consistent with the NDFD paradigm.

3. Products and Services

3a. Timelines

Given the goals and framework outlined above, WWE2 was conducted from November 1, 2002 through April 1, 2003. WWE2 activities were conducted on a daily basis twice per day in 2-hour windows between 15-17 UTC and 03-05 UTC. These windows coincided with the arrival of new model guidance at HPC and were also prior to when WFOs produced schedule-driven public forecasts. The first hour of the 2-hour collaborative window was used primarily by the HPC WWE forecaster to compose graphical products. There was no task requirement of an WFO during this time. By the end of the first hour the HPC forecaster posted the graphics to a web site and then notified the WWE WFOs if or not a collaboration call was requested by HPC. If a collaboration call was requested by HPC, participating WFOs would join HPC in a conference call. A table illustrating the event time line during the 2-h windows is supplied in the Appendix.

3b. HPC WWE Enhanced Graphic Suite

The HPC WWE forecaster relied on both the operational NCEP model output (GFS and Eta) and the ensemble forecasts of the SREF and Global Forecast System (GFS) developed by Environmental Modeling Center (EMC) and routinely produced by NCEP Central Operations (NCO) to support the WWE.

The HPC WWE forecaster prepared four graphical products to support the WFO's forecast process (examples of these 4 graphics are supplied in the Appendix):

- ▶ *Storm Track Graphic (STG)*
Similar to the previous WWE STG, the STG in this experiment depicted the track and central pressure of the low(s) affecting the WWE area through 72 hours. It was derived from the HPC WWE forecaster experience based on the suite of model output

(operational and ensemble) available to the HPC WWE forecaster, including SREF and GFS ensemble output. (See the Appendix for list of model guidance available to HPC.)

- ▶ *Event Total Accumulation Graphic (ETAG)*
Because precipitation associated with winter storms had different start/end times over individual WFOs within the WWE area, the ETAG depicted the amount of winter precipitation (snow/ice) accumulating from the initial time of the forecast through the end of the event, but not exceeding 120 hours lead time. The ETAG depicted future storm total accumulations only and did not incorporate amounts where precipitation had already begun to accumulate. Two ETAG graphics were produced, one depicting accumulation of freezing rain in inches, and the other the combined accumulation of snow and sleet in inches.

- ▶ *Winter Storm Watch/Warning Potential Graphic*
HPC compared the ETAGs to winter storm watch/warning criteria in each zone of participating ER and CR WFOs. A graphic was generated depicting by how much the ETAGs exceeded watch/warning criteria for both 12 and 24 hour thresholds. The assumption was made that most winter weather events occurred within at least a 24 hour period and more typically within a 6-12 hour period.

- ▶ *Combined Snow/Sleet Accumulation Loop*
Because start/stop times of accumulations were not discernable in the ETAGs, a supplemental loop of accumulations was generated in 6 hour increments out to 120 hours. This allowed the forecasters to better discern start and end times of the event in their county warning areas (CWAs) as well as the time frame when the majority of accumulations were expected to occur.

3c. WWE Web Page

All WWE graphics were posted to a web site designed specifically for the WWE. During the WWE2, AWIPS was unable to accommodate modifications to graphics (addition of new products) on a time scale necessary to successfully support the experiment. The web page was password protected since the graphics were experimental in nature and meant for internal use only. The web page remained outside of the AWIPS firewall as a number of links on the web page pointed to data sources residing outside of the AWIPS firewall (such as EMC model output, NESDIS Snow monitoring tools, NCDC snow climatology information, etc.) A screen capture of the web page interface is Appendix.

3d. Notification Message

Based on the graphics and any input from the WFOs via text chat (see below) or phone call, the HPC determined if an audio chat session was necessary. The HPC forecaster notified the WWE participants *if or not* an audio chat session was proposed by transmitting a Hydrometeorological Coordination Message (NFDHCMQPF) on AWIPS to all WFOs in the WWE. If an audio chat session was proposed, the message included appropriate dial-in pass codes required for participants to join the call. The messages did not always literally indicate which WFOs were requested to join, rather a geographical reference was utilized instead. Otherwise the message stated no audio chat session was going to be initiated by HPC. In situations where HPC did not propose an audio call but, a participating WFO felt one should be conducted, they would contact the HPC forecaster, who then re-transmitted the message indicating that an audio chat session would indeed be conducted at the request of the WFO. An example of a notification message is found in the Appendix.

3e. Collaboration Calls

Audio chat sessions were scheduled to last no longer than 15 minutes and were conducted during the last 15 minutes of the 2-h window. This allowed WFOs sufficient time, at their discretion, to view the graphics and supply comments or ask questions to HPC prior to the start of the audio chat session. The collaboration calls were structured so that they were led and facilitated by HPC. Typically HPC would lead off the call with a few statements on model performance and how that pertained to the meteorology of the event. HPC would then solicit input from the participating WFOs one by one asking the WFOs to share their major concerns about the event. The calls were used a method to get all WFOs impacted by a winter weather event and HPC on the same page early in the forecast process. The calls were not intended to be the arena where final watch/warning decisions were made, nor where HPC would dictate or suggest to a WFO where watch or a warning should be posted.

3f. Text Chat

The collaborative tool utilized to support text chat was AOL Instant Messenger (AIM) running on a PC in manner consistent with what was being conducted to support the prototype NDFD WFOs. The text chat did not require all participating offices to be on line at the same time, but enabled forecasters to exchange information at their convenience. The text chat was used primarily as a means to allow HPC and WFOs to comment on the graphics posted to the web site. WFO input was used to identify issues to raise in the audio chat session. No text chat occurred during audio collaboration calls. However, in the situation where no audio chat session was required, HPC remained available to field any questions or comments from the WFOs via the text chat during the remainder of the 2-h window.

4. Required Hardware/Software

The only additional software required by the WFOs to participate in the WWE was the text chat collaborative tool. The text chat tool used was AIM which was required to be installed and activated on at least one PC.

NCEP HPC was required to also install AIM. Additionally, HPC needed to develop the following software to aid in generating the WWE enhanced graphical product suite:

- ▶ Script to semi-automate low tracks
- ▶ Script to produce the event total graphic
- ▶ Script to produce winter storm watch potential graphic
- ▶ Script to produce the combined snow/sleet accumulation loop
- ▶ Macro to transmit NFDHCMQPF message from HPC to WWE WFOs
- ▶ Archive procedures for all HPC WWE generated products

HPC also needed to develop the following in order to gather feedback from both the WFO and HPC forecasters:

- ▶ External on-line survey for WFO WWE forecasters
- ▶ Internal on-line survey for HPC WWE forecasters

NCEP NCO Computing Development Branch needed to develop a NMAP functionality to display counties under winter weather watches and warnings so that HPC could more effectively collaborate with the WFOs.

Finally, both WFOs and HPC needed to configure their AWIPS to receive, alarm or alert the NFDHCMQPF message. An example of a script interface is found in the Appendix.

5. Training

Minimal mechanical training was required in order to spin up a WFO for the WWE2. However procedural and conceptual training on the WWE was provided by HPC in a 60 minute training session via the VISIT teletraining paradigm. This training session was provided to all WWE focal points prior to the start of the experiment. The training session was offered multiple times over a 2 week period to accommodate WFO WWE focal point shift schedules. The content of the training included an overview of the WWE, list of deadlines, review of both procedural and conceptual issues, mechanical training, and a list of action items required of the WFO WWE focal point to complete prior to the start of the experiment. A review of ensembles pertaining to the SREF attributes was also provided. At HPC, training covered the above plus technical training on producing the graphics to support the WWE. HPC WWE forecasters were also sent to the Warning Decision Training Branch Winter Weather Workshop at COMET in Boulder, CO.

6. Testing

Prior to the start of the experiment on November 1, 2002 a testing phase was implemented from October 1 - 31, 2002. This test phase was used for WFOs to successfully demonstrate their mechanical capability to participate in the WWE. A WFO was deemed mechanically ready to participate in the experiment if they participated in the HPC WWE VISIT teletraining session and accomplished the following tasks:

- ▶ Verified receipt of a test NFDHCMQPF message transmitted from HPC
- ▶ Demonstrated ability to dial into a collaboration call
- ▶ Verified successful install activation of AIM (via transmission of text messages to HPC)
- ▶ Verified access to the WWE Web Site

These four tasks were typically conducted in conjunction with HPC and took no more than 5 minutes to complete per WFO. Like the training sessions, tests were scheduled and conducted at times by determined by the WFOs.

7. Feedback and modifications to the WWE During the Season

Part of the success of WWE1 was the ability to modify the experiment in mid-course to take advantage of lessons learned and to try out new ideas. That principle was adhered to in WWE2. Suggestions on how to modify the WWE were gathered from both WFOs and HPC. WFO feedback was gathered by many methods including periodic reviews of the WWE with the WFO WWE focal point. These reviews were HPC facilitated conference calls occurring at least once monthly where the participants verbalized issues and concerns with the experiment. The reviews supplemented unscheduled WFO feedback to HPC via online surveys. WFO feedback was also gleaned from text chat, audio collaboration calls, and phone calls to HPC from WFOs. HPC feedback was provided via on line internal surveys and ad hoc emails. All feedback was reviewed and requested modifications were implemented if feasible.

8. Results

In order to validate the WWE and measure the degree to which it met its primary goal, a performance measure needed to be established. However, the WWE2 was just one of many factors in the decision making process at a WFO. Therefore a single metric to isolate the WWE's impact on the NWS winter

weather forecast process was not obvious. In of itself, this was a significant finding of the WWE. In lieu of a single metric, several metrics were used to obtain a fair judgement on the effectiveness of the WWE in meeting its primary goal. These metrics were derived by both objective and subjective means.

8a. Objective results - WFO watch/warning statistics

An attempt to establish the impact of WWE on winter weather watch/warning statistics was made by noting the changes in statistics for the WWE WFOs from last season. Despite being a part of the WWE, CR WWE WFOs showed worse scores in POD, CSI, FAR, and warning lead time during WWE2 as compared to the previous WWE despite experiencing nearly the same number of events. Conversely, ER WWE WFOs scores improved and experienced twice the number of events as they did the previous season. Grouped together the WWE2 WFOs showed a slight improvement in verification scores compared to the previous season. See the Appendix for a table of ER and CR winter weather verification scores.

8b. Objective results - Verification of HPC graphics

The Event Total Accumulation Graphic of freezing rain and combined snow and sleet was also verified. This graphic was produced by HPC by performing manual edits on a semi-automatically generated “starting point” grid of accumulations (see the Appendix for a schematic on how QPF grids were converted to snow or ice grids). These grids were derived using a grid of QPF from either HPC, Eta, or GFS and converting the QPF to accumulations using precipitation type output from a combination of the Eta, GFS, and SREF model output. Details of the verification procedures of these graphics can be found at http://www.hpc.ncep.noaa.gov/wwe_verify. The results indicate that modifications made by the HPC WWE forecasters to the “starting point” grid were improvements, despite a low bias in mid accumulation ranges (7-11") and a high bias in the lower accumulation ranges (2-6"). For freezing rain, HPC made less dramatic improvements compared to combined snow/sleet grids. Little improvement was made for freezing rain thresholds above .25". Verification results are available in the Appendix.

Verification of the surface Low Tracks Graphic was conducted in similar fashion to how NCEP Tropical Prediction Center produced track error verification for named tropical system. The forecast position of surface low position by HPC and the full suite of models available to HPC was compared to the HPC manual surface analysis each forecast hour out to 72h lead time. RMS error in nautical miles was calculated with the results displayed in the appendix. HPC’s manual forecast of low track position showed the least error at any lead time compared to the objective model output. Therefore, it is concluded that HPC added value to model low track forecasts and offered a better starting point than raw model output.

8c. Objective results - SREF verification on Low Track

Further scrutiny of the Low Tracks Graphic verification results reveal interesting findings. The GFS verified better than the Eta, but the SREF mean verified better than either the Eta or GFS. Further, the mean of the like members of the SREF verified worse than the mean of the entire SREF suite. However, a combination of the operational GFS and ETA actually outperformed the mean of all the SREF components. This validated subjective impressions of HPC forecasters that a blend of the operational guidance outperforms the SREF mean for surface low track. This also suggested that the SREF system competed with operational output despite being run off an earlier initialization and run at lower resolution as compared to the operational models.

8d. Subjective feedback - WFOs

Feedback gathered from the WFOs indicated that the WWE aided in the collaborative process. Most wanted the process to continue next season with at a minimum the ETAG serving as a basis for collaboration. The WFOs want continue involvement of HPC in their forecast process, but to varying degrees. The WFOs felt that the collaboration calls should be targeted or sectorized to specific areas. The WFOs also felt that the content calls should be long enough to allow both discussion of the meteorological aspects of the event as well and model performance as it pertains to the event. Text chatting was strongly not preferred as the WFOs felt that it did not significantly add to the collaboration process of the WWE.

8e. Subjective feedback - HPC

Feedback gathered from HPC via the on line surveys, emails, and an electronic final evaluation indicated that the WWE enhanced the normal winter weather forecast process at HPC. Perceived utility of the SREF output varied. While use of the precipitation type output was a preferred choice on a daily basis at HPC, SREF mass field output was not quite as useful as the operational guidance. Mechanically, HPC forecasters favored the audio call over the text chat. Also the HPC forecasters felt the need for more time to donate to the WWE, especially if the WWE is to expand geographically. In addition, it was felt that consolidating operational and experimental duties would be a prerequisite to accommodate any expansion of the WWE.

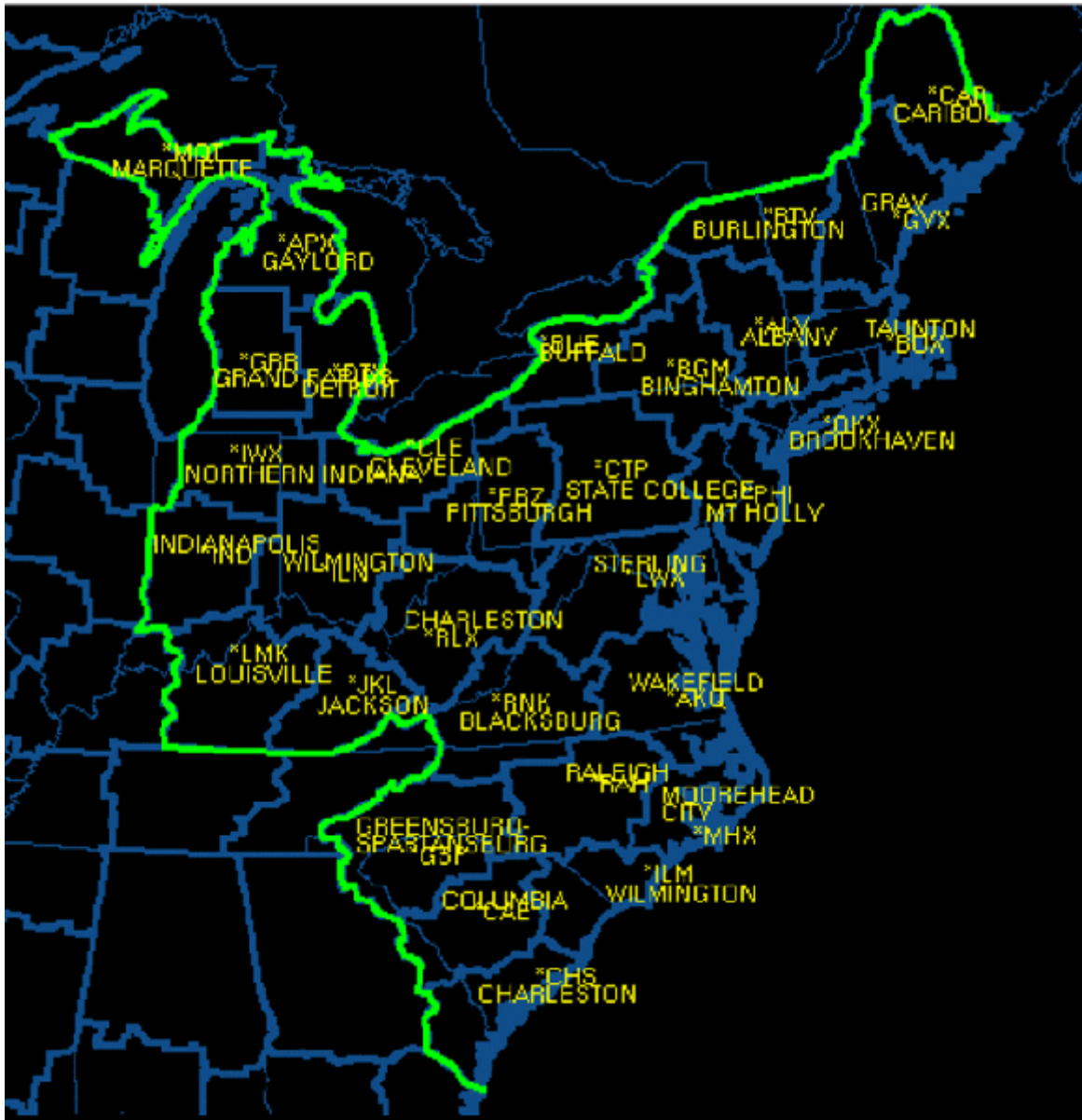
8f. Results Summary

Overall the WWE II met its goals. The subjective perception by the majority of participating WFOs was the WWE met its goals by fostering collaboration which led to a coherent set of watches/warnings issued across adjacent WFO county warning areas (CWA). HPC provided value added guidance in support of the WWE and lead a concise audio collaboration session. Text chatting was not preferred and at most should supplement audio calls but not replace it. The WFOs favored the ETAG as the graphic to center the collaboration call to help launch the winter weather forecast process. The call influenced both HPC and WFO operational forecasts. SREF output in conjunction with operational output would be required to accommodate any future WWEs. However the precipitation type output of the SREF would be used more heavily than the mass field output. Finally, the ability to implement frequent mid-course corrections on short notice benefits the experiment process.

9. Recommendations - an HPC perspective

The previous two WWEs have iterated on a process that has become beneficial for both NCEP and most WWE2 WFOs. However, many questions remain and must be addressed before transitioning WWE procedures into operations in the NWS. It is therefore recommended that another experiment be conducted next winter season focusing on at a minimum the intermountain region of the U.S. This will help address the question of if or not this process can serve WFOs with complex terrain in their CWAs. It is also recommended to expand the WWE across multiple time zones to address how to best conduct collaboration with WFO in these areas. It is further recommended to add a sufficient number of WFOs to the WWE to assess workload issues at NCEP and how an NCEP operational center can facilitate collaboration with a large number of WFOs. Efforts should focus on transitioning the WWE data flow into the AWIPS architecture (specifically IFPS GFE). At a minimum these questions need to be answered before the WWE can be declared operational. Ultimately, the goal is to iterate on a process that benefits both NCEP and all WFOs experiencing winter weather as it will then likely benefit the public. Assuming success of the next WWE, the next step would be to go operational nationally at least on an experimental basis.

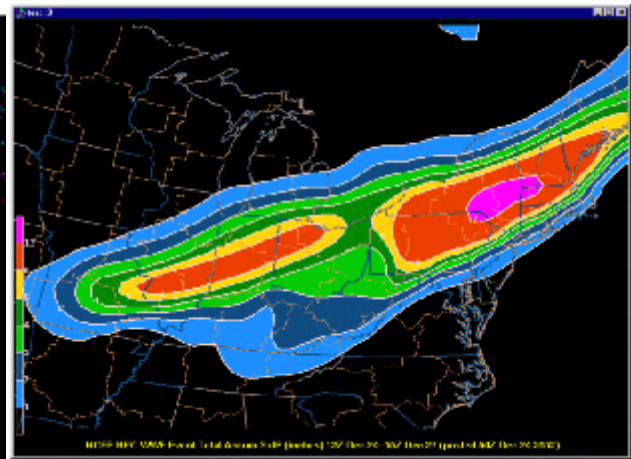
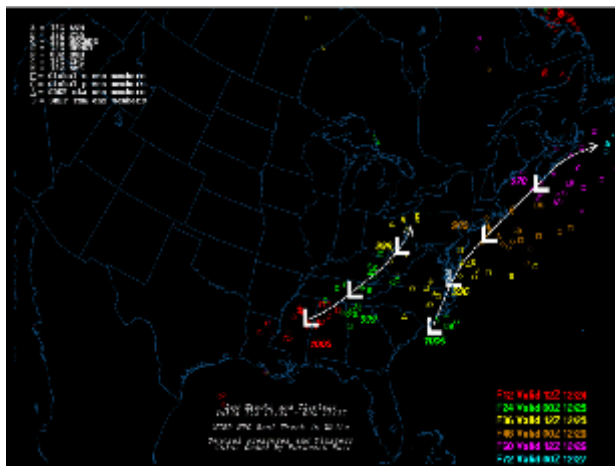
APPENDIX



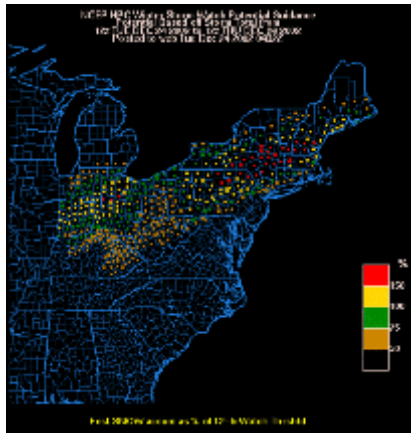
WWE2 Participating WFOs

WWE 2002-2003 Comparison to WWE 2001-2002	
<i>Additions</i>	<i>Eliminations</i>
<p>Enhanced Storm Track Graphic Depicting Clustering of Low Pressure Centers</p> <p>Event Total Graphic For Snow and Ice Accumulations</p> <p>Enhanced Graphic Depicting Exceedance Thresholds of Winter Storm Watch/Warning Criteria by Zone</p> <p>Use of an audio chat session via Meet Me Call as the collaboration tool when all interested parties are participating at the same time</p>	<p>3-7 day text discussion</p> <p>Web-based Chat Tool Web-4m as collaboration tool</p> <p>Use of a text chat session as the collaboration tool when all interested parties are participating at the same time</p>

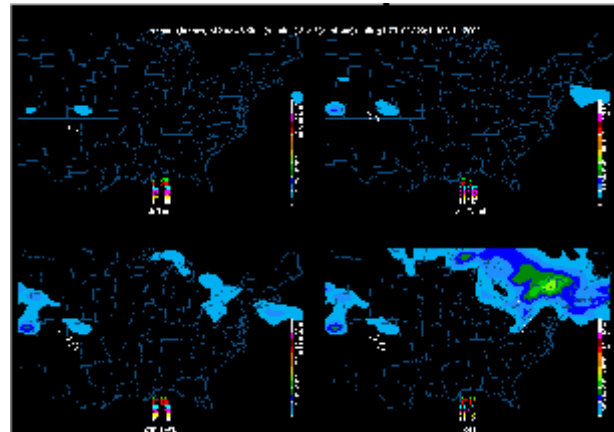
Event Time Line During WWE Two-Hour Windows (all times in UTC)
0300/1500 HPC begins composition of WWE graphics; HPC unavailable via text chat
0400/1600 HPC deadline to post WWE graphics, HPC available via text chat*
0405/1605 HPC deadline to issue HCM
0415/1615 WFO deadline to notify HPC to hold an audio chat session (if originally not required by HPC)
0420/1620 HPC deadline to issue HCM (if audio chat session not originally required but requested by WFO)
0445/1645 Audio chat session initiated (if required)
0500/1700 Deadline for audio chat session to end (if required)
<p><i>* HPC remained available via text chat through 0500/1700 if an audio chat session was not held, and 0445/1645 if it was held.</i></p>



Low
Graphi
graphic



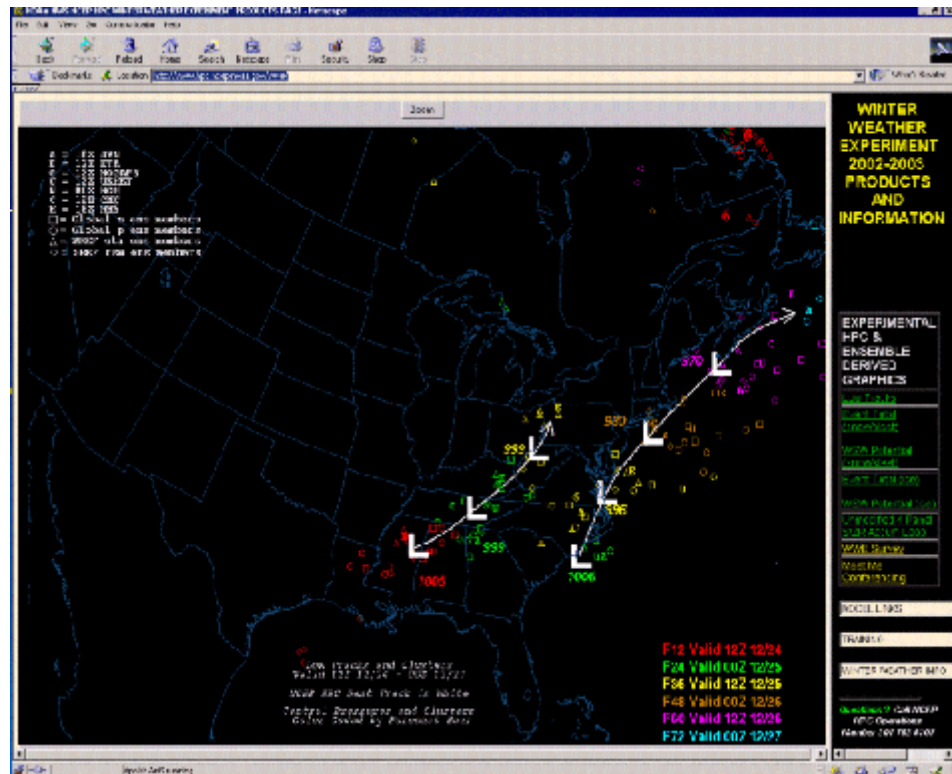
Tracks
c
ETAG



Winter Storm Watch/Warning Potential Graphic

One 6h frame of a 120h Accumulation loop

Model Output Available at HPC					
NCEP			Non-NCEP		
Mesoscale	Global	Ensemble Prediction Systems	Mesoscale	Global	Ensemble Prediction Systems
Eta	GFS	Global	RUC	ECMWF	CMC
NGM		SREF	MM5 (AFWA)	NOGAPS	ECMWF
Eta-Y(Eta using GDAS)			CMC	UKMET	



WWE Web Page

HYDROMETEOROLOGICAL COORDINATION MESSAGE
 NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION
 HYDROMETEOROLOGICAL PREDICTION CENTER...NWS...CAMP SPRINGS MD
 1135 PM EST MON DEC 23 2002

Interface

FROM HPC WINTER WEATHER EXPERIMENT FORECASTER

AN AUDIO CHAT SESSION WILL BE HELD FROM 0545-0600Z
 AT PHONE NUMBER 877 952 3910 (PASSCODE 412439).

UPDATED GRAPHICS HAVE BEEN POSTED TO THE WWE WEB SITE AND THE CHAT
 ROOM WILL REMAIN OPEN THROUGH 0540Z.

SYSTEM WE'VE BEEN WATCHING FOR SEVERAL DAYS NOW LIKELY WILL AFFECT
 A LARGE PORTION OF THE WWE AREA OVER THE NEXT 48 HRS.

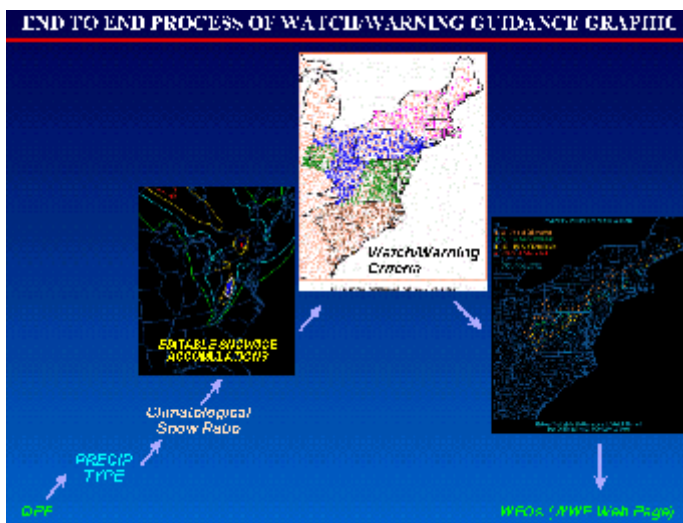
WWE OFFICES THAT WILL BE DIRECTLY IMPACTED BY THE EVENT INCLUDE
 THOSE ACROSS THE OH VALLEY AND FROM THE NORTHERN MID ATLIC NEWD
 THROUGH NEW ENGLAND.

ALTHOUGH THE OFFICES DIRECTLY IMPACTED BY THE EVENT ARE REQUESTED
 TO PARTICIPATE IN THE AUDIO CHAT SESSION, ALL WWE SITES ARE WELCOME
 TO JOIN.

SULLIVAN/HPC FORECAST OPERATIONS BRANCH

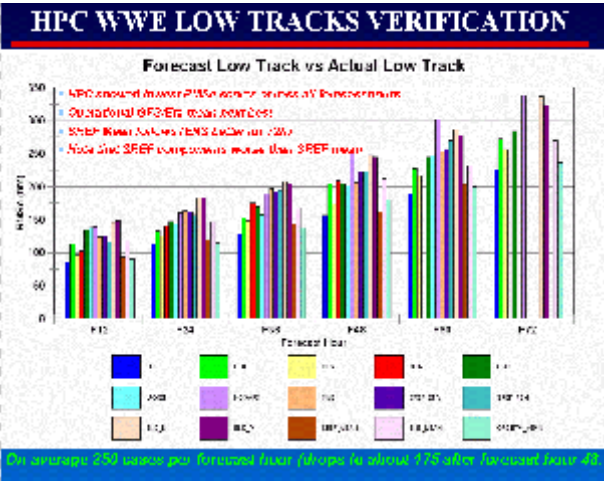


WWE Interface to generate accumulation grids

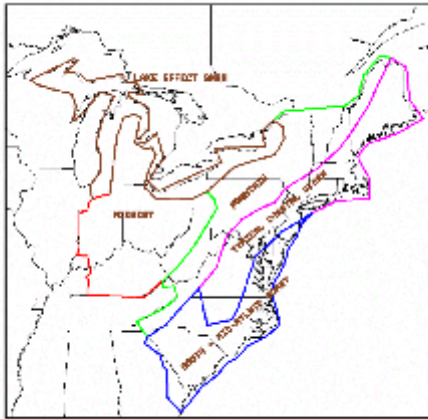


	R4				R6			
	Obs	01-05	08-13	Obs	Obs	01-05	01-05	DefT_4
E OF MTCO A. WFOE	000	00	00	1,000	000	00	00	100%
Advised: Winter Advisory on contingent to 1st year rather than winter storm watch (R4 only)	000	00	00	1,000	000	00	00	100%
A.M. station nearby the expected. Spans 07 WFOE	000	00	00	1,000	000	00	00	100%
Brooks their own statistical analysis for a position advised	000	00	00	1,000	000	00	00	100%
Improvement in warning state for ER WFOs	000	00	00	1,000	000	00	00	100%
participating in DOT, units and last year's field clearer than improvement rate of only 85%	000	00	00	1,000	000	00	00	100%
WFOE - 4 watch-warnings	000	00	00	1,000	000	00	00	100%
40 days in 4 of 10 WFOE in last year (2017)	000	00	00	1,000	000	00	00	100%
40 WFOE advised into last year's WWL and 100000	000	00	00	1,000	000	00	00	100%

Algorithm Schematic to produce accumulation related WWE graphics

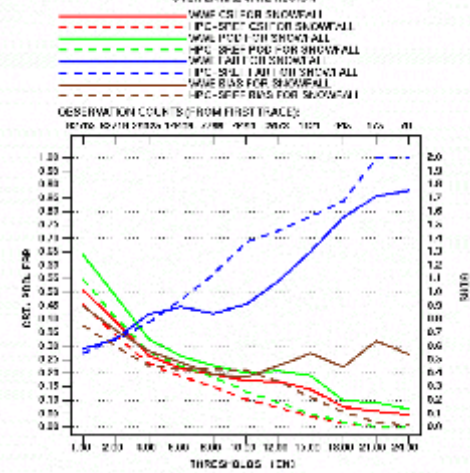


R and ER Winter Weather Watch/Warning Statistics

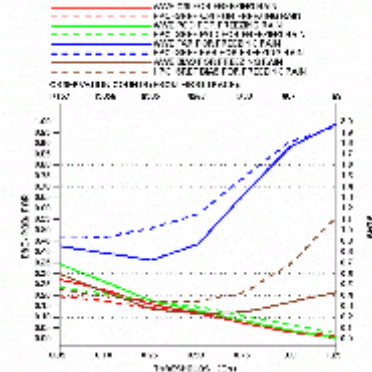


WWE Low Tracks Graphic Verification

Records for all events with forecasts were used for the 1996-2012 period.



Records for all events with forecasts were used for the 1996-2012 period.



WWE ETAG Verification areas WWE ETAG Verification (Combined Snow/Ice Pellets left, Freezing Rain right)