

NATIONAL WEATHER SERVICE
WINTER WEATHER EXPERIMENT
2003-2004

HPC PERSPECTIVE



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

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1. Introduction

Evaluation of the second Winter Weather Experiment (WWE2) 2002-2003 by the National Weather Service (NWS) Office of Climate, Water, and Weather Services (OCWWS), NWS Headquarters of Western Region (WR), Southern Region (SR), Central Region (CR), Eastern Region (ER) and the National Centers for Environmental Prediction (NCEP) Director's Office led to the decision to expand WWE2 activities across the four contiguous U.S. (CONUS) NWS regions for the winter season 2003-2004 (WWE3). The goal of WWE3 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. Initially, WWE3 was targeted to cover only the "four corners" region of the U.S. in order to focus explicitly on the challenges of collaboration and winter weather forecasting in the intermountain region. However, input from WR, SR, CR, and ER led to the decision to expand WWE3 coverage over most of the CONUS. Details of the experiment and the results are provided below.

2. Goals of WWE3

In general, the primary goal from WWE2 was retained for WWE3 – "To improve winter weather services to the public via enhanced collaboration among NWS operational offices".

Secondary goals were as follows:

- ▶ Determine the best method to make the winter weather NCEP/WFO collaboration process as efficient as possible
- ▶ Determine the best method to facilitate concise and practical collaboration among NCEP and WFOs
- ▶ Optimize content of NCEP HPC graphics used in support of WFO/HPC collaboration
- ▶ Evaluate performance of the NCEP Environmental Modeling Center's (EMC) Short Range Ensemble Forecasts (SREF) during winter events

An additional goal for WWE3 was to evaluate the workload associated with the collaborative process involving HPC and a large number of WFOs (77) spanning different time zones. (WWE2 incorporated WFOs in the eastern time zone only).

3. Strategy

3a. General concept

WWE3 attempted to meet its established goals by invoking a process consistent with previous WWEs:

- HPC provided a preliminary suite of winter weather graphics to the WFOs. The graphics served as a means to communicate and visualize HPC's assessment and adjustment of newly arrived operational model guidance
- Verbal collaboration with WFOs impacted by a significant event followed the issuance of the internal graphics

Ideally, this process would increase the potential for a coherent and consistent suite of public winter weather products issued by the NWS. It should be noted that as in WWE2, no additional FTE resources were allocated to any participating office in support of WWE3.

3b. WWE3 Sectors

Although a large number of WFOs participated in WWE3, the required support by HPC was

categorized into two sectors – an Intermountain and Non Intermountain region (IM and non IM regions, respectively). The breakdown was necessary for two primary reasons – deadline considerations (due to varying time zones) and required products of HPC. Non IM WFOs requested the same graphic suite provided by HPC in WWE2 (accumulation related graphics and low track graphics). Conversely, it was mutually agreed upon by HPC and the IM WFOs that graphics depicting HPCs forecast of mid level pattern evolution (rather than accumulation and low tracks graphics) would most benefit IM participants. A figure depicting the two sectors is found in the Appendix.

3c. Timelines

Technically the WWE3 began 12 UTC October 1, 2003 and terminated 12 UTC April 1, 2004. However, the start dates were staggered for each sector to the climatological onset of winter in each region. The IM start date was October 1, 2003 and the non IM start date was November 1, 2003. Activities were conducted on a daily basis twice per day in three phases for both WFO sectors:

- I. HPC assessment of newly arrived operational and ensemble model guidance
- II. HPC graphic preparation
- III. HPC/WFO Verbal Collaboration

Phase I and II required no action by any WWE3 WFO. Due to the differences in time zones, phase III was conducted separately for each WFO sector. The product suite was delivered to the WFOs using the same internal web site as in WWE2. All WWE WFOs were notified when phase II was completed and only the subset of those WFOs impacted by a significant winter weather event were requested by HPC to join a collaboration call. Contents of the graphics and attributes of the collaboration calls are found in the section below. A summary of WWE3 deadlines is provided in the Appendix.

4. HPC Products and Services in support of the WWE3

4a. HPC WWE Enhanced Graphic Suite

The HPC WWE forecaster relied on the operational NCEP EMC model output (GFS and Eta), the ensemble forecasts of the SREF and GFS 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 5 graphics are supplied in the Appendix):

- ▶ *500 mb Heights Graphic*
This graphic was generated explicitly for the Intermountain region WFOs. Despite diverse requests regarding the content of a graphic depicting the evolution of the mid troposphere, the most common and mutually agreed upon parameter was 500 mb heights out through lead time 72. The HPC WWE forecaster produced a graphic depicting HPCs forecast of the pattern evolution at 500 mb in 12h increments out to F72. For reference the operational GFS, Eta, and SREF mean forecast were plotted on this same graphic.
- ▶ *Storm Track Graphic (STG)*
Similar to previous WWes, 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.

4b. Assumptions

In the non IM region, topographical winter events were not explicitly covered by WWE3. This included Lake Effect Snow events and/or any local orographically enhanced events.

4c. WWE Web Page

All WWE graphics were posted to a web site designed specifically for the WWE. During the WWE3, 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 shot of the web page is provided in the Appendix.

4d. Notification Message

Based on the graphics or request from a WFO, 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.

4e. Collaboration Calls

Audio chat sessions were scheduled last no longer than 15 minutes and were conducted at times agreed upon by each NWS region prior to the WWE3 start date. Times were chosen to allow 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 as 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. For a few WFOs, calls occurred at the end of a shift as opposed at the beginning. These WFOs attempted to utilize information gleaned in the calls to help brief the incoming shift. During events that impacted more than 15 WFOs in a sector, two simultaneous calls were conducted by HPC. Typically the WFOs were split by using the arrival time of the event. For example – group “A” would consist of WFOs impacted by an event f00-f36 while group “B” would consist of WFOs impacted by an event after fhr 36. The WWE forecaster invoked the assistance of either the Day 2-3 QPF or Model Diagnostic forecaster to facilitate the second call for group “B”.

5. Required Hardware/Software

Since the web was the primary vehicle to deliver the HPC graphics and normal land-lines were used in collaboration calls, no additional hardware or software was required at a WFO to participate. However, WFOs new to WWE3 were required to configure AWIPS to receive the NFDHCMQPF message.

6. Training

Minimal mechanical training was required in order to spin up a WFO for the WWE3. 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 month 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 – for all WWE forecasters and those forecasters at HPC that potentially would be invoked to assist in collaboration calls.

7. Testing

A brief testing phase was implemented for the two weeks prior to a given sectors start date. The 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 access to the WWE Web Site

These 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.

8. Feedback and modifications to the WWE During the Season

Part of the success of previous WWEs 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 WWE3. 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.

9. 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, as in WWE2, WWE3 was just one of many factors in the decision making process at a WFO. A single metric to isolate the WWE's impact on the NWS winter weather forecast process was not obvious. Therefore, several metrics were used to obtain a fair judgment on the effectiveness of the WWE in meeting its primary goal. These metrics were derived by both objective and subjective means.

9a. 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 trend in statistics for those WFOs participating in previous WWEs. WFOs new to the WWE this season were compared to those not in the WWE in their NWS region. The results showed improvements over the previous year in ER, SR, and WR compared to WFOs not participating in WWE3. ER scores broke their own records for best scores. For the second year in a row, despite being a part of the WWE, CR WWE WFOs showed worse scores in POD, CSI, FAR, and warning lead time during WWE3 as compared to the previous WWE. See the Appendix for a table of ER and CR winter weather verification scores.

9b. 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 for combined snow/sleet accumulations. 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.

9c. Objective results - Low Track Graphic

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. Averaged over the CONUS and the duration of the WWE3, a blend of the GFS/Eta offered slightly lower error than the SREF mean (which offered slightly lower error than HPC). The error differences between these three sources of guidance are less than 15 nm. HPC’s manual forecast of low track position showed the least error at any lead time compared to unblended objective model output. The Eta verified better than the GFS in the short time ranges, with the GFS eventually offering a better starting point than the Eta after fhr 48. Consistent with findings in WWE2, a combination of the operational GFS and ETA actually outperformed the mean of all the SREF components.

9d. Subjective feedback - WFOs

Intermountain region WFOs felt despite the high expectations, most did not find the structure of WWE3 beneficial to their operations (although a few WFOs did feel WWE3 benefited their office). Intermountain WFO suggestions for improvement include:

- Scheduled interaction by phone not required – 12 Planet should suffice
- Collaboration with HPC on model diagnostics should include information on initialization and justification by HPC on solution preference
- HPC forecasters must be knowledgeable on diagnostic fields used by IM region WFOs at levels used by IM WFOs

Non Intermountain region WFOs felt that overall the WWE process benefited operations (and in some WFOs continued to benefit operations). Non-intermountain WFO suggestions for improvement include:

- Shortening duration of collaboration calls
- Use of 12 Planet for routine collaboration vs. phone call
- Increase of HPC reference concepts for heavy snow (CSI, frontogenesis, isentropic lift) in collaboration
- Improving run to run consistency in accumulation graphics
- Improving consistency between accumulation graphics and HPC QPF

9e. Subjective feedback - HPC

HPC WWE forecasts felt that accommodating both HPC's operational product suite and the experiment as it was configured spread HPC resources too thin. There is a need to consolidate operational and experimental production to continue a WWE-like process on a national scale. Further, 12Planet should be used as the main line of collaboration (phone calls should be reserved to only when event AND model differences are significant). The most optimal collaboration scenario in WWE3 was during events when than 15 WFOs within a 72 hour period.

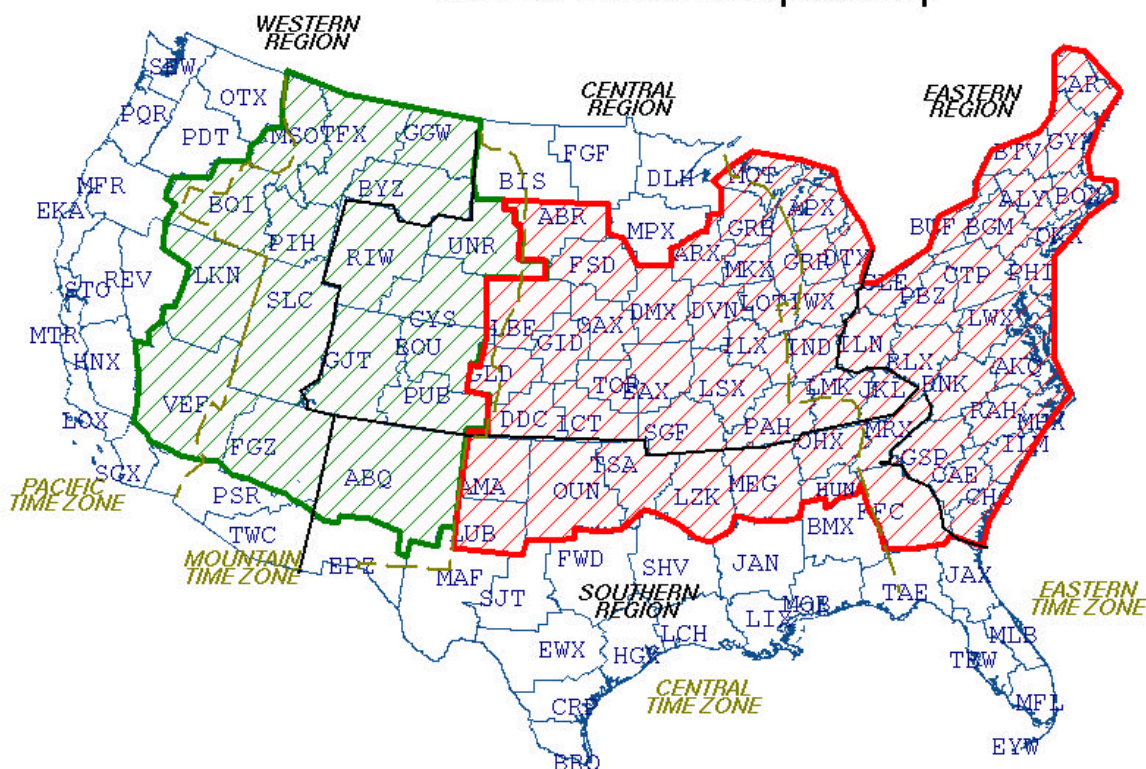
9. Conclusions and Recommendations - an HPC perspective

Overall the WWE3 met its goals. The expansion to a near CONUS scale (with 77 WFOs participating) provided the NWS critical experience required to establish a paradigm leading to successful WFO/NCEP collaboration for winter weather events. However, it became painfully clear via WWE3 that routine collaboration calls were too long at times and did not afford the required collaboration beneficial to WFOs populating grids for the National Digital Forecast Database (NDFD). Further, HPC was stretched beyond its limit during events spanning large geographical regions trying to accommodate both an experimental and operational product suite. Given the experience and feedback of WFOs and HPC gleaned over the three WWEs, HPC proposes the following paradigm be adopted for the winter season 2004-2005. It is important to realize that this proposal is heavily based on WFO feedback.

HPC proposes that WWE and operational winter weather activities be consolidated onto the Winter Weather Desk at HPC. This would be accomplished by implementing the beneficial components of WWE in place of HPC preliminary external winter weather product suite. This implies the time/resources used for the producing the HPC preliminary external product suite would be reserved for producing an internal preliminary suite of graphics for WFOs AND collaboration with WFOs. This would allow both HPC and WFOs the opportunity to collaborate prior to finalizing their own external product suite. Since the WFOs final product suite is provided in deterministic form via the NDFD, the WFO targeted HPC internal product suite would also be deterministic. However, in order to compliment and not compete with the NDFD, the HPC final product suite would remain probabilistic. This would also satisfy the NWS Vision 2005 to increase the amount probabilistic information in the NWS product suite. 12 Planet should become the primary vehicle for collaboration. HPC led collaboration calls would only be used when collaboration by 12 Planet becomes inefficient (or by request of a WFO). This strategy has already met preliminary approval by each regional WWE focal point (including NWSH). Details of this proposal will be submitted for approval by NCEP to the NWS Operations Committee in June 2004.

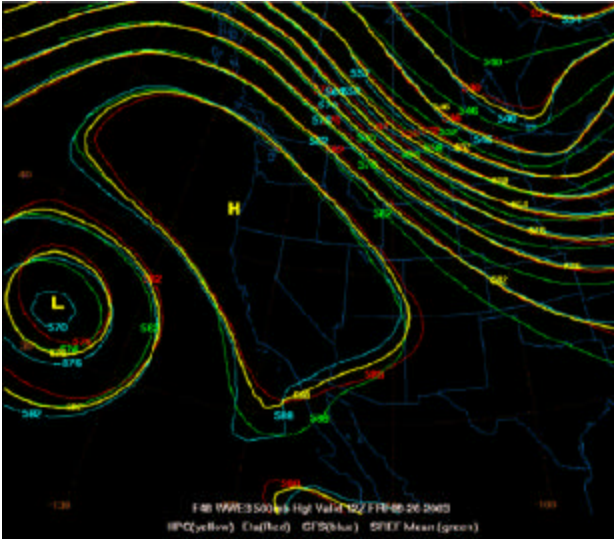
APPENDIX

WWE III WFO Participant Map

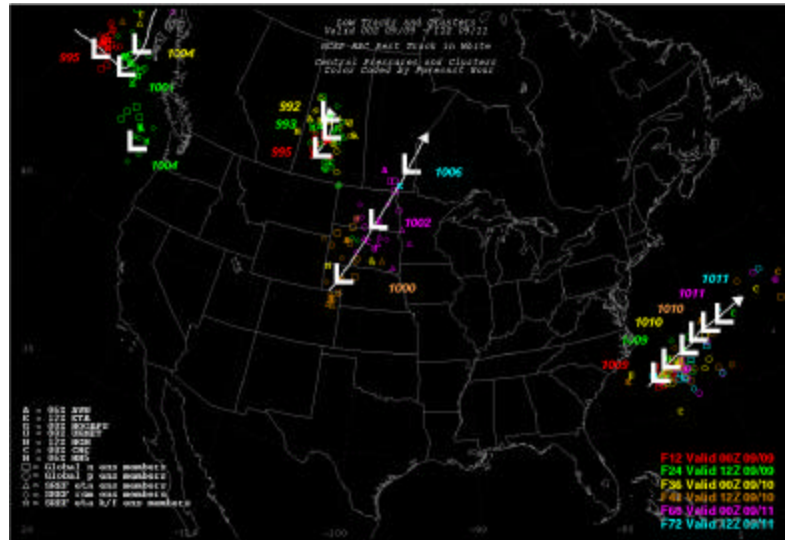


WWE3 Participating WFOs

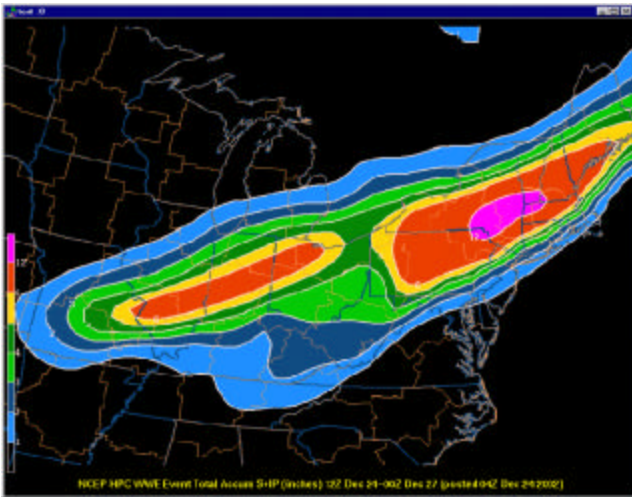
| Event Time Line During WWE Windows (all times in UTC) | |
|--|--|
| 0400/1600 | Operational and SREF guidance available, HPC begins composition of WWE graphics |
| 0525/1725 | HPC completes WWE graphics, post to WWE web site, transmits NDFDHCMQPF message to WFOs |
| 0530/1730 | WFO deadline to direct HPC to conduct collaboration call (if not originally intended to be held) |
| 0545/1745 | Collaboration call begins for non Intermountain Region WFOs |
| 0600/1800 | Collaboration call ends |
| 0630/1830 | Collaboration call begins for Intermountain Region WFOs (0730 & 1930 after time change) |
| 0645/1845 | Collaboration call ends (0745 & 1945 after time change) |



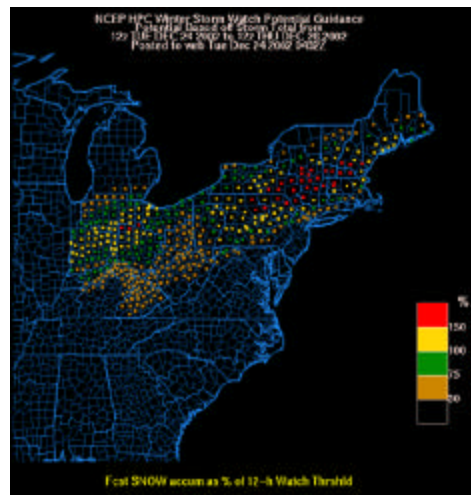
One frame from a 72h 500 mb Height Graphic Loop



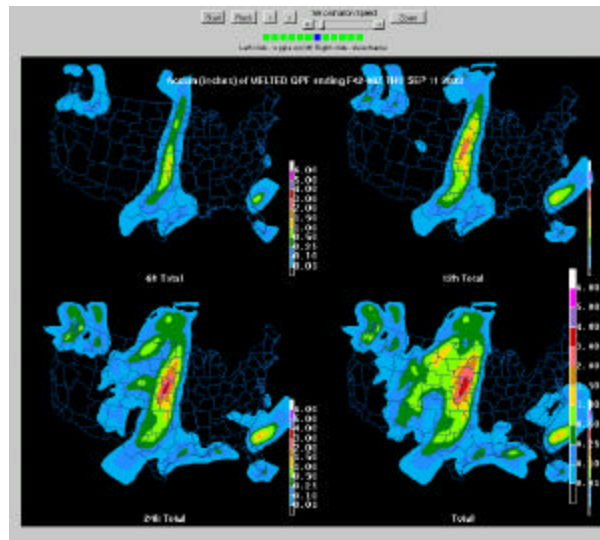
Low Tracks Graphic



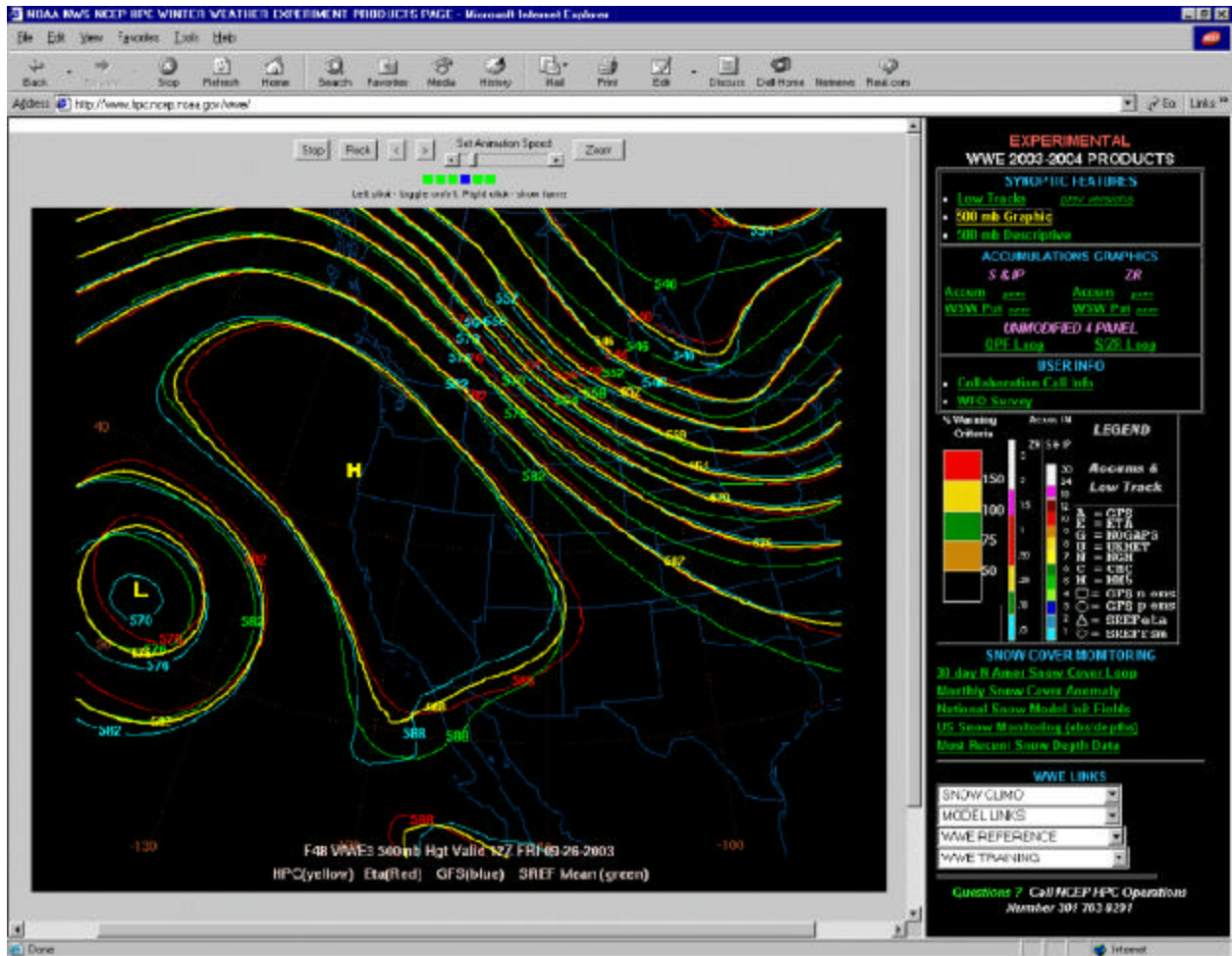
ETAG graphic



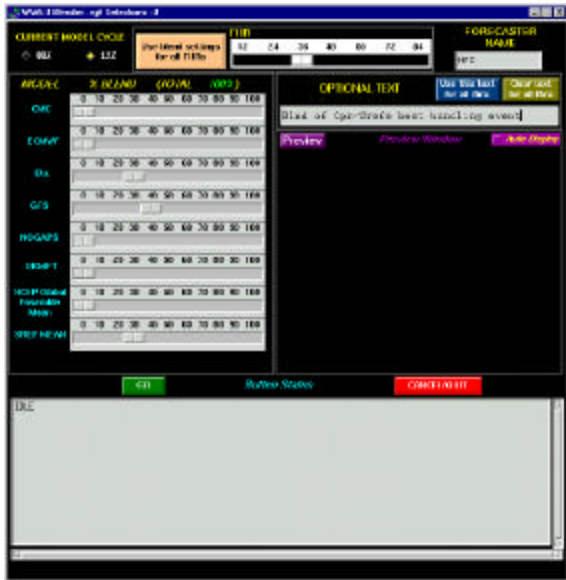
Winter Storm Watch/Warning Potential Graphic



One 6h frame of a 120h Accumulation loop



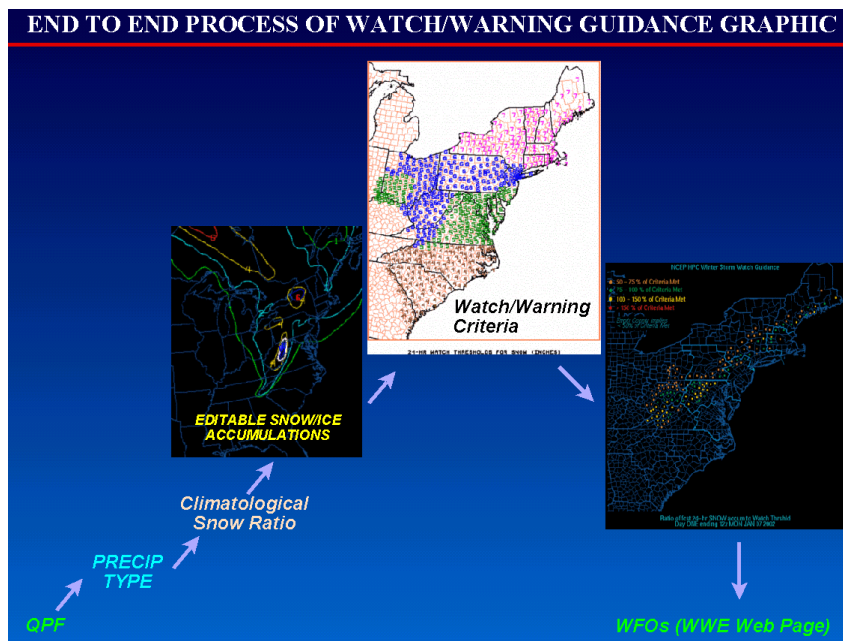
WWE Web Page Interface



Interface used at HPC to generate 500mb graphics



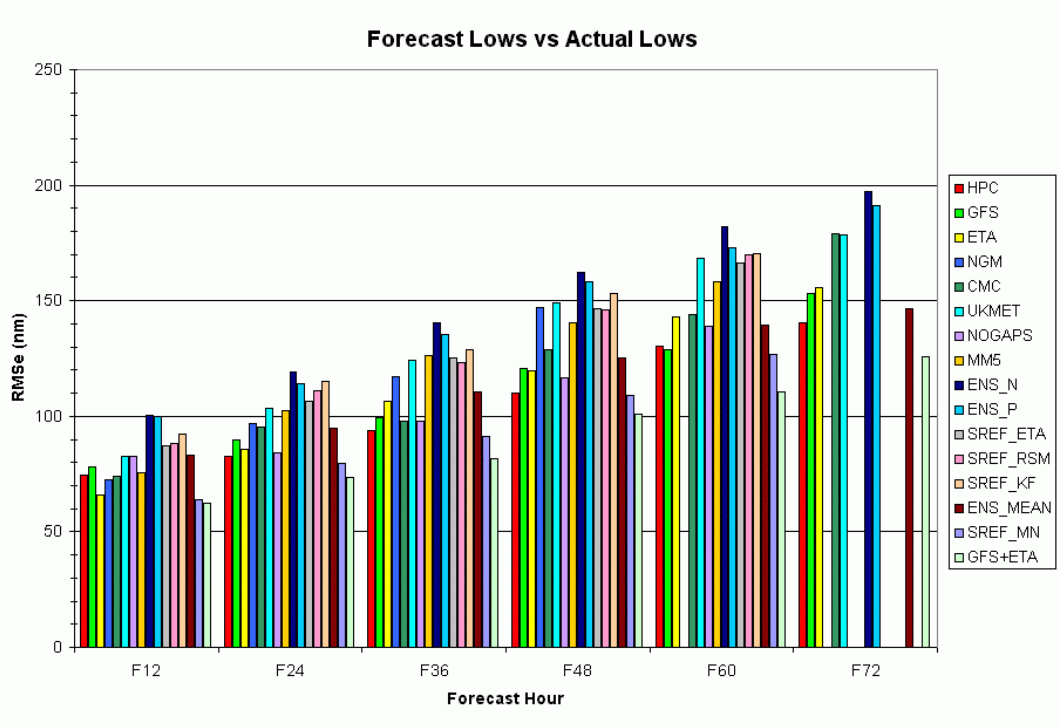
Interface used at HPC to generate starting point accumulations



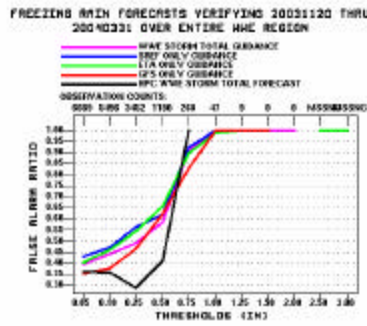
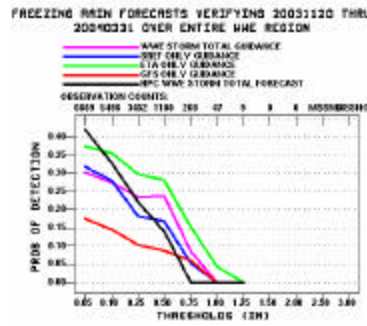
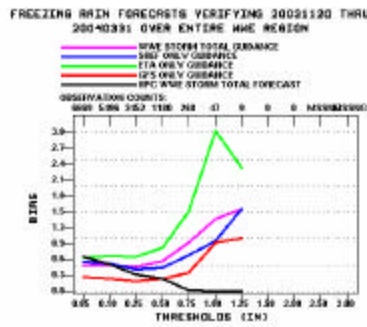
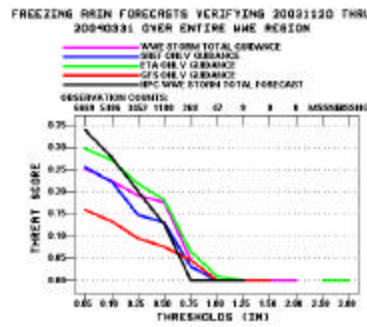
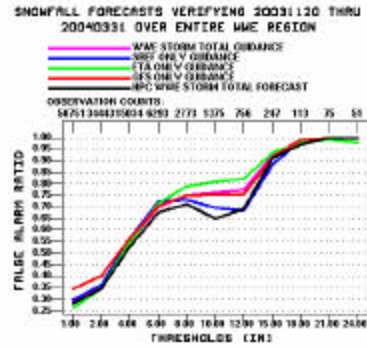
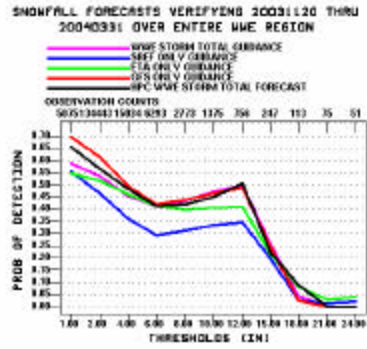
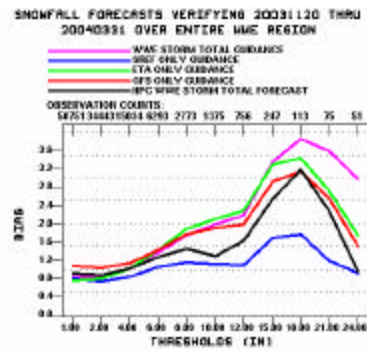
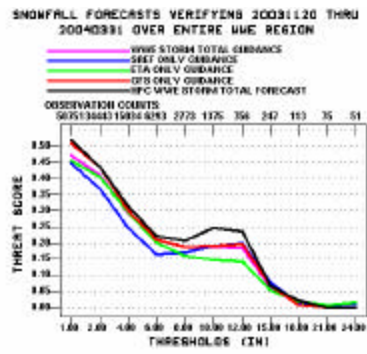
Algorithm Schematic to produce accumulation related WWE graphics



NWS regional Winter Weather Watch/Warning Statistics as a function of WWE3 participation



WWE Low Tracks Graphic Verification



WWE ETAG Verification (Combined Snow/Ice Pellets top, Freezing Rain bottom)