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TRANSITION FROM RESEARCH TO OPERATIONS: ASSESSING VALUE OF EXPERIMENTAL FORECAST PRODUCTS WITHIN THE NWSFO ENVIRONMENT

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1. Introduction

One of the goals of the NASA Short-term Prediction Research and Transition (SPoRT) Center Assessment Program is to develop metrics and conduct studies with National Weather Service (NWS) forecasters to evaluate the impacts and benefits of NASA Earth Science Enterprise (ESE) experimental products on forecast skill. At a glance the task seems relatively straightforward. However, performing assessment of experimental products in an operational environment is demanding. Given the tremendous time constraints placed on NWS forecasters, it is imperative that forecaster input be obtained in a concise unobtrusive manor. Great care must also be taken to ensure that forecasters understand their participation will eventually benefit them and Weather Forecast Office (WFO) operations in general. Two requirements of the assessment plan developed under the SPoRT activity are that it:

- Can be implemented within the WFO environment on an operational basis
- Provide tangible results for BOTH the research and operational communities.

The methodology developed in this study is similar in nature to that developed by Kain et al. (2003) to subjectively assess numerical weather prediction model performance during a special program conducted at the NOAA/National Severe Storms Laboratory (NSSL) and NWS/Storm Prediction Center (SPC). The program involved participation from a number of institutions including the SPC, Norman, Oklahoma WFO, NSSL, National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC), Forecast Systems Laboratory (FSL), and Iowa State University. Given the limited resources available in the majority of the WFO's located around the country, it is important to note that the assessment procedure described herein was implemented within the WFO on a daily basis and required no additional forecaster staffing. SPoRT Center personnel in the form of a NASA/NWS Liaison conducted independent assessments and validation of experimental products and was responsible for analyzing results.

The paper is structured as follows. Section 2 contains a description of the assessment methodology followed by details of the pilot assessment period in Section 3. Preliminary results are presented in Section 4 and the summary and conclusions are provided in Section 5.

2. Methodology

Supplemental numerical quantitative precipitation forecasts (SQPF) were chosen as the first experimental SPoRT product to be evaluated during a Pilot Assessment Program. The decision was based on the Huntsville WFO Implementation Plan developed for SPoRT (Darden et al., 2002) that identified the improvement of quantitative precipitation forecasts as a top priority for the office. The SQPF data were provided by the Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model Version 5 (Grell et al., 1994) as implemented at the SPoRT Center. The MM5 was "cold-started" twice daily (00 and 12 UTC) with the NCEP 40 km Early Eta analyses. The Kain-Fritsch convective parameterization (Kain-Fritsch, 1993) was used along with simple ice microphyscis (Dudhia 1993). An important aspect of the assessment process identified by forecasters is that the experimental data MUST be provided in the Advanced Weather Interactive Processing System (AWIPS) in order to make routine and effective use of them. Therefore, SQPF on the native 12 km MM5 grid were available for display in AWIPS on an operational basis. Model forecasts out to 24-h were evaluated in this study.

The procedure used to assess the SQPF is best described as a three-tier approach involving both forecasters and research scientists. Tier-one is a Web-based survey completed by duty forecasters on the aviation (AVN) and public (HUN) desks. The survey compiles information on how the experimental product was used in the forecast decision-making process. Up to 6 responses per twenty-four hours

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can be compiled during a precipitation event. Tier-two consists of an event post mortem and experimental product assessment performed daily by the NASA/NWS liaison meteorologist. Tier-three is a detailed breakdown/analysis of specific events targeted by the NWSFO Science and Operations Officer (SOO) and SPoRT team members. The task is performed by both NWS and NASA research scientists and may be conducted once every couple of months. Specific tasks for each tier of the assessment plan are briefly described below.

2.2 Tier 1—Forecaster Survey

The forecaster survey in its entirety is displayed in Figure 1. A forecaster is first queried if he or she looked at the SQPF. If not, a reason is selected and the survey is complete. A text box is provided at this point if the forecaster wishes to provide specific comments as to why the data were not used in the forecast process. If the SQPF was examined, the forecaster is asked to provide a subjective measure of how he or she perceives the products utility relative to operational QPF products. Feedback is requested in regards to timing, aerial coverage, amounts, and convective mode. Numerical ranking ranges from minus five to plus to five. A value of zero denotes the supplemental and operational products provide similar information, while negative (positive) values indicate the experimental products were perceived to provide erroneous (valuable) information. A text box is provided if a forecasters wishes to provide additional comments related to the SQPF. Data entered via the Web is automatically logged and stored for future analysis. The survey generally takes less than 5 minutes to complete.

2.3 Tier 2—Subjective Assessment

Tier 2 consists of a daily assessment of the experimental product. A member of the SPoRT team is designated as a liaison meteorologist between the NASA and NWS scientists. His or her task is to collect raw data and provide an initial assessment of the value of the experimental product in the forecast environment. Part of this assessment consists of comparing and contrasting the experimental QPF products with those traditionally available to the forecaster. The liaison also fills out the forecaster survey as part of the post mortem analysis and verification. This form, along with the actual forecast, forecast discussion and products available to the duty forecaster are collected. Together, they provide insight into the thought process involved with preparing that particular forecast and how the SQPF data were used in that preparation thereof. Results from tier-two will be documented, combined with information collected from the tier-one survey, and reported back to NWS forecasters.

2.4 Tier 3—In Depth Case Analysis

Tier-three consists of a detailed quantitative case breakdown/analysis. It will be executed on an as-needed basis and will directly compliment the two tiers described above. Events deemed worthy of analysis beyond that provided by the Liaison through tier-two will be identified by the NWS SOO and SPoRT Team members. Results from this analysis may include diagnostic analysis of model data on the research side. The Warning and Event Simulator (WES) available at every WFO may also be used for post analysis.

3. Assessment Period

The Pilot Program was conducted during May 2003. The month turned out to be the wettest May on record at the Huntsville International Airport where a total of 10.43 inches was reported. Figure 2 displays the monthly accumulated precipitation over the Lower Mississippi River Basin. Extraordinary rainfall totals in excess of 20 inches were estimated for portions of East-central Alabama with amounts in excess of 15 inches common across the northern part of the state.

There were three distinctly different synoptic regimes that affected the Tennessee Valley region during the month. The first ten days were characterized by a strong southwesterly subtropical jet stretching across the Southwestern US with an associated frontal boundary extending northeastward from Texas into the Great Lakes. Figure 3a shows the forecast region was clearly embedded within the jet exit region. The associated upper-level divergence combined with southerly moist inflow from the Gulf of Mexico resulted in numerous heavy rainfall and severe convective events in and around the HUN County Warning Area. One event in particular occurred on May 6 where 1.7 inches fell in a 20-minute period in Huntsville that caused extensive flooding. The synoptic regime shifted during the middle of the month when a deep cutoff trough moved eastward out of the Southern Rockies (Fig. 3b). Deep southerly flow developed ahead of the wave but the majority of deep convection occurred northwest of the Tennessee Valley region where upper-level diffluence was maximized. Precipitation events in and around the HUN CWA were not nearly as strong or frequent during this period as the trough was slow moving and convection approaching the area often decayed. Another regime shift occurred during the last ten days of May when a large-scale trough developed over the Great Lakes region placing the forecast area under predominately northwesterly flow (Fig. 3c). Precipitation events during this period were associated with cold frontal boundaries and weak upper-level disturbances swinging around the periphery of the large-scale trough.

4. Preliminary Results

In this section we report the preliminary findings of the assessment program. Please keep in mind that analysis is ongoing and that these interpretations are preliminary and subject to change. Only tier one and two were executed during this pilot program.

4.1 Survey Responses

As discussed above, the survey is the primary conduit of information between forecasters in the field and the SPoRT research scientists. It was carefully designed to capture pertinent information about the experimental products while demanding only a few moments of the forecasters time. Forecaster participation and response to the Web-based survey during the program was above 95%. Nearly 80% of completed surveys contained detailed comments about the use of the SQPF in the decision making process. Discussions after the assessment program revealed that the forecasters considered the survey to be straightforward and simple to complete while on shift. Feedback from forecasters and the quality of information collected indicates that the survey can be successfully implemented in an operational WFO environment.

4.2 SQPF Assessment

Two basic types of SQPF assessment were conducted. The first was a qualitative comparison of the SQPF with that available from the operational Eta conducted by the NASA/NWS Liaison. Images of 6-h predicted and observed NCEP Stage IV precipitation were compared through 0 to 24 hours. The Liaison would then complete the forecaster survey ranking the perceived performance of the SQPF compared to that available operationally by the Eta. Two assessments were conducted each day and are documented within PowerPoint files available to forecasters on-line at: http://wwwghcc.msfc.nasa.gov/sport/qpfassess. The quantitative assessment conducted by SPoRT research scientists consisted of bias and equitable threat scores of 0 to 6h SQPF for each 24-h numerical forecast.

4.3 Analysis

Table 1 displays the averaged results from the forecaster surveys and the qualitative assessment performed by the Liaison (ASSESS). Only those survey results for distinct precipitation events were analyzed providing a total of 62 responses for analysis. Positive (negative) values for the AVN and HUN desks indicate that the forecasters perceived the SQPF was value added (not value added) to the QPF available from the operational models. Responses averaged over the entire month are positive ranging from 0.07 to 0.74. The one exception occurs for SQPF amount as perceived from the Public Forecast Desk (HUN=-0.07).

As discussed in Sec. 2, the Southeast was under three basic large-scale forcing regimes during the month. As a result, the precipitation during those periods varied considerably. Figure 4 shows the accumulated precipitation for three ten-day periods during the study. Precipitation between 1 May and 10 May was heaviest in northern AL and south-central TN where values generally exceeded 9 inches (Fig. 4a). Figure 4b shows the heaviest precipitation during the middle of the month shifted farther west in response to the slow moving upper low located over the Southwest. A dramatic reduction in precipitation was observed during the last 10 days of May with values generally less than 1 inch observed over the study region (Fig. 4c.)

Results were broken down into the three ten-day periods during the month were the large-scale forcing over the study and the associated precipitation patterns varied dramatically. Examination of Table 1 shows a more positive response (0.00 to 1.40) during the first third of the month (compared to the monthly averages) when precipitation in the study area was greatest. Results during the latter two thirds of May became slightly negative when the upper-level forcing and precipitation events became weaker. These results suggest that the forecasters perceived that the SQPF was valuable during heavier precipitation events and not valuable when precipitation was lighter. This analysis is consistent with forecaster comments logged during the study indicating SQPF lacked value for relatively light precipitation amounts (< .25 in). Comparison of the assessment conducted by the NASA/NWS Liaison and survey results in Table 1 indicates a general positive correlation between forecasters perception of value added and that determined by the post assessment. This result is similar to that found by Kain et al. (2003).

Results from the survey and qualitative assessment were compared with quantitative QPF statistics (bias and equitable threat scores computed for both the SQPF and operational Eta (40 km AWIP 212 grid). Figure 5 displays the bias and equitable threat scores for 6-h periods for the 0-24h forecasts for the boxed region displayed in Fig. 4a. The bias for precipitation amounts exceeding 0.75 inches were near zero for the Eta indicating the model produced few events of that magnitude. The equitable threat scores (Fig. 6) indicate that the Eta QPF verified better than the SQPF for thresholds below 0.5 inches while the SQPF verified better for thresholds above. These quantitative results support forecaster perception that SQPF was beneficial to the forecast process for heavy precipitation events and not so for light precipitation events.

5. Summary and Plans

A methodology to assess if experimental forecast products provide additional information to currently available operational products has been designed and tested within a WFO environment. The procedure is best described as a three-tier approach involving both forecasters and research scientists. Tier 1 is a short and concise Web-based survey filled out by Duty Forecasters. Tier 2 involves an independent assessment of the product performance compared to operational products. Tier 3 involves an in-depth analysis of select events to improve understanding of product performance.

The first experimental product to be assessed during a Pilot Program in May 2003 was numerical supplemental quantitative precipitation forecasts (SQPF). Preliminary results indicate that the short and concise Web-based survey collected useful information from the forecasters on shift and was not perceived as a hindrance. Analysis of the results indicates that forecasters perceived the SQPF to be value added during heavy precipitation events. Forecaster perceptions were consistent with both the subjective and quantitative verification. Analysis and interpretation of the results will continue and include feedback from the forecasters that participated in the project.

Additional NASA experimental products such as visible and infrared MODIS imagery and total lightning data from the Northern Alabama Lightning Mapping Array (LMA) have been made available to NWS forecasters in the Huntsville, Birmingham AL, and Nashville, TN Offices. It is anticipated that each product will be assessed in a similar manner as that developed for the SQPF.

6. Acknowledgements
This work is funded by Dr. James Dodge at NASA Headquarters. A special thanks is given to all the forecasters in the Huntsville AL WFO.

7. References

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	TIMING			COVERAGE			AMOUNT			CONVECTIVE MODE		
Averaging Period	AVN	HUN	ASSESS	AVN	HUN	ASSESS	AVN	HUN	ASSESS	AVN	HUN	ASSESS
1 May to 10 May	0.60	0.67	0.93	0.60	0.40	0.93	0.60	0.60	1.20	0.67	0.00	1.40
11 May-20 May	-0.13	-0.50	-0.25	0.06	-0.06	0.56	-0.13	-0.56	0.00	0.25	0.13	0.75
21 may-31 May	-0.07	0.20	-0.53	-0.13	-0.13	-0.33	-0.33	-0.20	-0.27	-0.20	-0.13	0.07
Entire Month	0.13	0.11	0.04	0.17	0.07	0.39	0.04	-0.07	0.30	0.24	0.00	0.74

Table 1. Averaged forecaster survey and assessment results for the perceived value of the supplemental numerical QPF above that available on an operational basis. AVN and HUN represent the aviation and public forecaster desks respectively. ASSESS represents the post-event assessment conducted by the NASA/NWS Liaison.

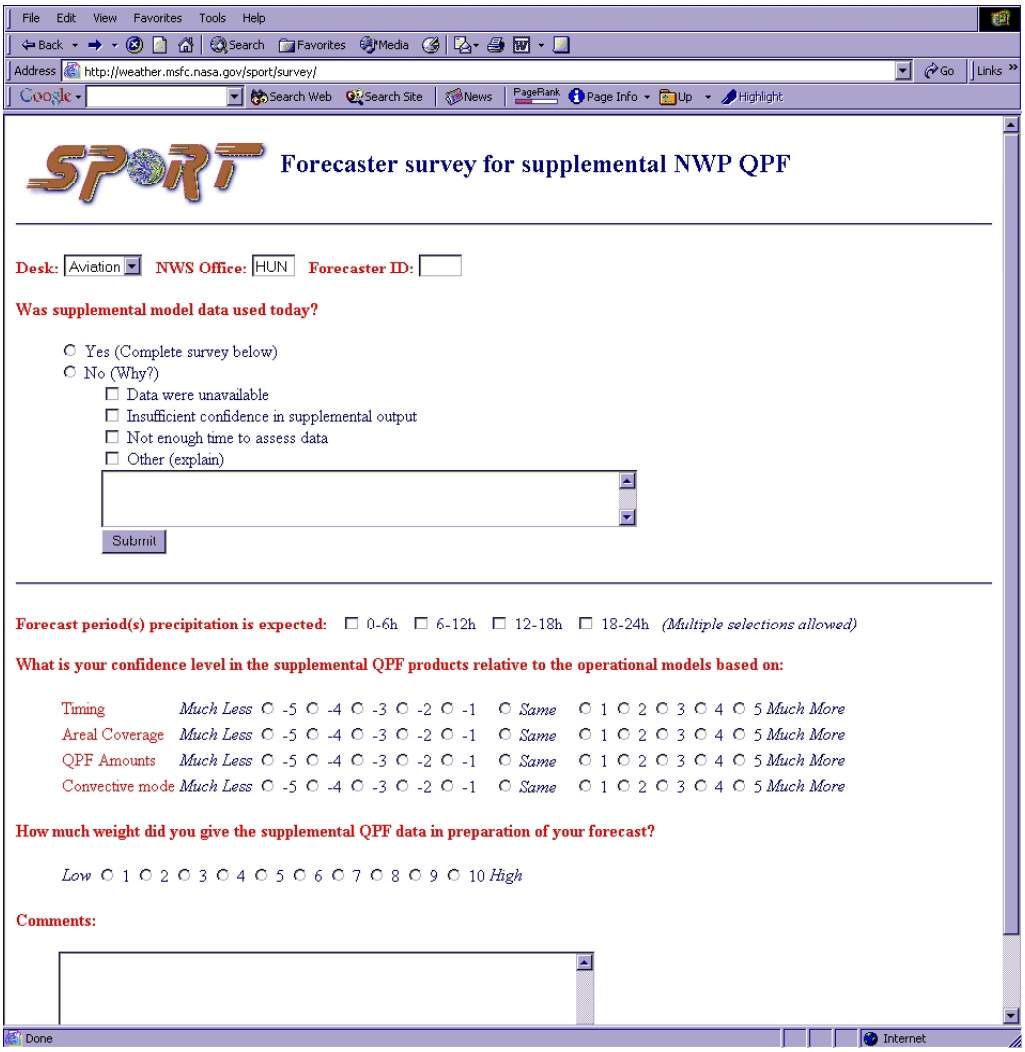

Figure 1. Survey completed by NWS Duty Forecasters to evaluate "value added" of supplemental numerical QPF products

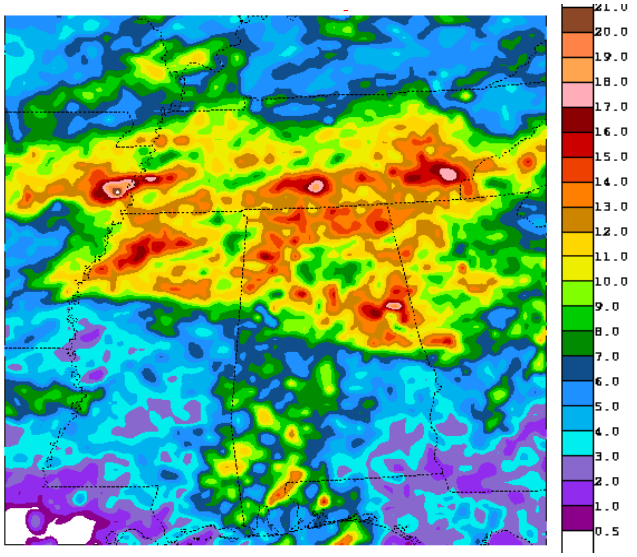

Figure 2. Observed accumulated precipitation (in.) for May 2003. Data source: NCEP Stage IV.

a) May 5 b) May 17 c) May 26

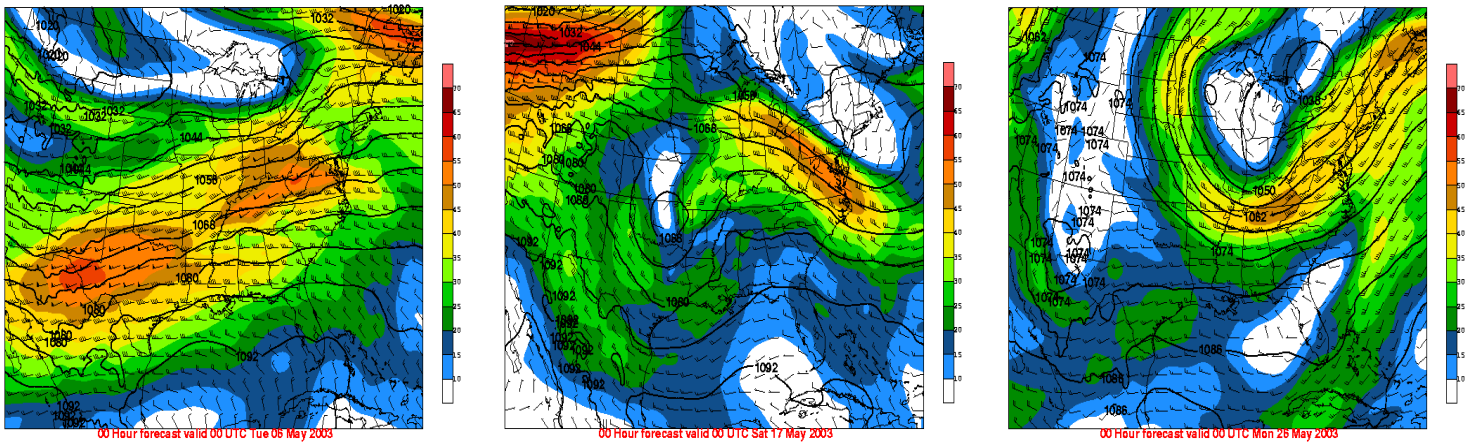

Figure 3. Upper-level analyses of 250 mb height (dm, contours) and vector wind (m/s, shaded) valid at 00 UTC a) May 5, b) May 17, and c) May 26

a) May 01 to May 10 b) May 11 to May 20 c) May 21 to May 31

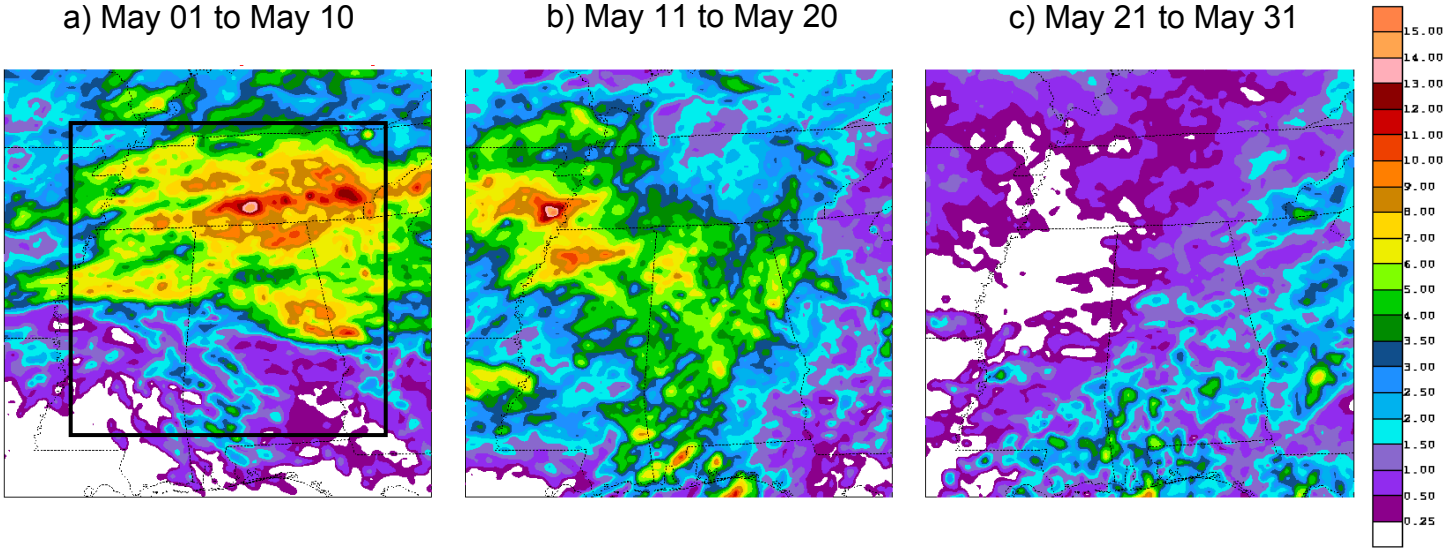

Figure 4. Observed accumulated precipitation (in.) for the period: a) May 1-10, 2003, b) May 11-20, 2003, and c) May 21-31, 2003. Data source: NCEP Stager IV. Box in panel (a) represents area used to calculate QPF statistics.

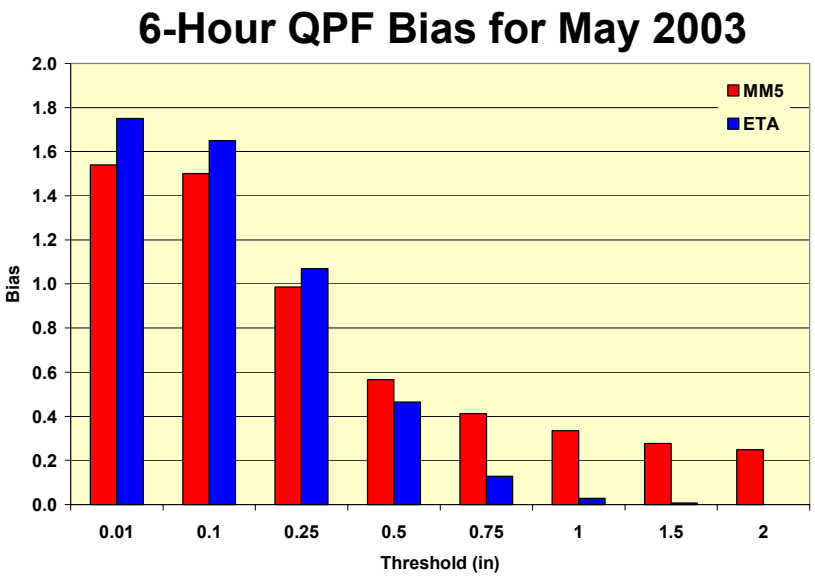

Figure 5. 6-hour model QPF bias computed from 0 to 24 hour forecasts for May 2003. Models initialized at 00 and 12 UTC daily. Statistics computed over the boxed region displayed in Fig. 4a.

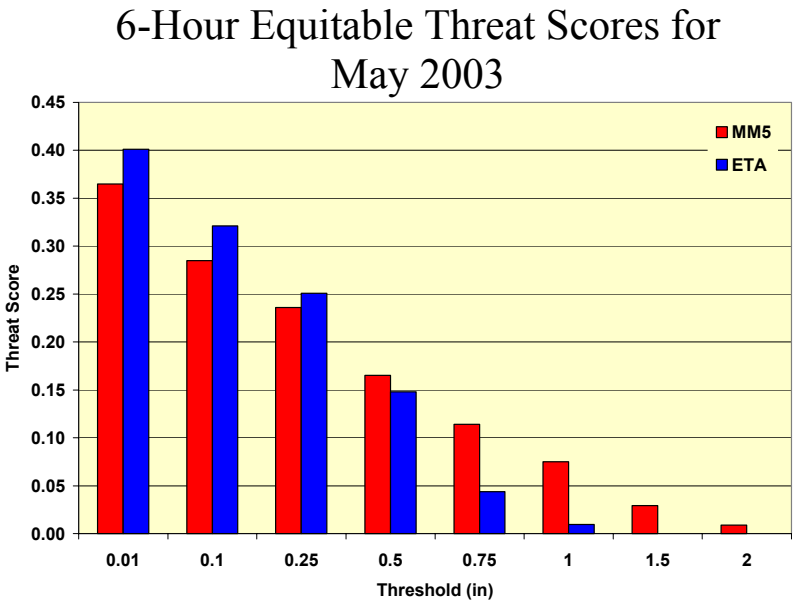

Figure 6. 6-hour equitable threat score computed from 0 to 24 hour forecasts for May 2003. Models initialized at 00 and 12 UTC daily. Statistics computed over the boxed region displayed in Fig. 4a.