P1.32 THE NATIONAL PRECIPITATION VERIFICATION UNIT (NPVU): OPERATIONAL IMPLEMENTATION

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1. INTRODUCTION

The United States Weather Research Program (USWRP) and the National Weather Service (NWS) have identified quantitative precipitation estimates (QPEs) and forecasts (QPFs) as a priority for improvement in the research and operational communities (Fritsch et al. 1998; Office of Meteorology 1999). Objective assessment and quantification of the skill of QPFs in the NWS end-to-end (ETE) forecast process are necessary to: (1) identify the value added at each step of the ETE forecast process; (2) assist in improving the forecasts by providing near real-time feedback to QPF forecasters; and (3) insure that the ETE forecast process represents the most efficient use of resources to produce quality QPF information for hydrologic services.

As a result, the NWS Office of Climate, Water, and Weather Services (OCWWS; formerly the Office of Meteorology - OM) outlined a uniform national QPF verification program and planned to establish the National Precipitation Verification Unit (NPVU) to fulfill these requirements. Verification statistics from the NPVU would serve to support NWS programmatic decisions and numerical weather predication (NWP) model changes, provide feedback to individual forecasters and forecast offices, and ultimately improve QPFs and associated products for outside users. The success of the program is dependent upon the timely availability of all QPEs and QPFs.

The basic components of the NWS national QPF verification program are described in Office of Meteorology (1999), with adjustments being made according to recommendations from the NWS QPF Process Assessment Team (NWS 1999).

This research was supported in part by an appointment to the COMET Postdoctoral Fellowship Program and UCAR Visiting Scientist Program sponsored by the National Weather Service and administered by the University Corporation for Atmospheric Research pursuant to the National Oceanic and Atmospheric Administration Award No. NA97WD0082.

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Since August 1998, a prototype NPVU has been established at the NOAA Science Center in Camp Springs, MD, where it is administered by the NWS OCWWS and co-managed by the National Centers for Environmental Prediction (NCEP) Hydrometeorlogical Prediction Center (HPC). The prototype NPVU has been integral in providing objective QPF verification for the NWS QPF Process Assessment Team in 1999 and 2000. Additionally, the prototype NPVU has supported HPC QPF verification and participated in the QPF Implementation Working Group (QPFIWG) (see http://www.nws.noaa.gov/om/qpi/qpf/iwginfo.htm for more information).

On 01 October 2000, the NWS NPVU was operationally implemented. QPF verification statistics are now available at **http://www.hpc.ncep.noaa.gov/npvu/**.

The purpose of this paper is to provide a conceptual outline of the NPVU, outline the data ingest procedures that have been established to support the verification system of the NPVU, describe the QPF verification procedures at the NPVU, summarize prior NPVU QPF verification activities, and highlight future plans and expectations.

2. CONCEPTUAL OUTLINE

The premise of a QPF verification program is dependent on the availability of both observed and forecast precipitation data. If the data are in the same format, comparisons can be made with informative performance measures. If not, then care must be taken to manipulate the data so that the observed and forecast products have similar formats. Even still, some products are incompatible for verification. For example, much debate exists over the treatment and comparison of gauge precipitation observations with areally-averaged gridded model output (Gaudet and Cotton 1998).

Ideally, QPF verification would be performed with a perfect gridded multi-sensor analysis which incorporates gauge, radar, and satellite data. Quality control of the observed data is necessary since limitations still exist in the observation and transmission of precipitation data. However, the best “ground truth” currently available for most of the country is the RFC Stage III analysis (Breidenbach et al. 1998). Precipitation

in the western U.S. is best represented by point gauge data or grids rendered via Mountain Mapper (MM, Henkel and Peterson 1996). Thus, the NPVU will utilize the aforementioned analyses as the observed data while constantly assessing, along with other appropriate NWS personnel, the quality and coverage of the observed data. Most observed precipitation data utilized by the NPVU will be gathered and sent by the NWS River Forecast Centers (RFCs).

Initially, the proposal was made to verify all precipitation forecasts from the Environmental Modeling Center (EMC), Techniques Development Laboratory (TDL), HPC, Weather Forecast Offices (WFOs), and RFCs. The NWS QPF Process Assessment Team recently recommended that QPFs from the WFOs east of the continental divide do not need to be generated for input into the NWS River Forecast System (NWSRFS). However, all WFOs may, if they have a local requirement, produce QPFs for internal and external local use. Although QPFs may vary in type, format, resolution, etc., appropriate methods will be taken to translate the QPFs to common formats for fair and accurate comparisons.

The use of climatological precipitation data in QPF verification is necessary to provide a baseline of skill with which to compare the QPFs. Appropriate precipitation climatologies, such as those developed via PRISM (Daly et al. 1994) and TDL (Charba et al. 1998), will be utilized.

Verification statistics will be computed from NWP and forecaster-generated QPFs for all possible combinations of the following *as appropriate*: (1) forecast increments of 3-, 6-, 12-, 24-h, etc. for all possible forecast projections; (2) spatial domains - nation, NWS region, geographical and climatological region, RFC domain, WFO area, river forecast group, and MAP area; (3) temporal domains ranging from individual forecast periods, cycles, and model runs to a day, week, month, season, year, etc.; and (4) spatial resolutions beginning with ~32km and including multiples thereof (4, 8, 16, 64, 128, 256 km). Measures of performance will include: threat and equitable threat score; bias score; errors (mean, mean absolute, root-mean-squared); bias; Bayesian informativeness score; correlation coefficient; Nash-Sutcliffe sufficiency score; Brier score; ranked probability score; etc. These statistics can be derived for specified precipitation thresholds and discrete intervals or for the full range depending upon the verification measure being computed.

Integral to the QPF verification program is the display and feedback method employed to relate verification information to the forecasters, model developers, researchers, and management. Statistics will be computed for offices as a whole as well as for individual forecasters, where privacy will be maintained. The World Wide Web will be the primary means of distributing QPF verification statistics and graphics, although AWIPS may be utilized at some future time.

Software developed for the QPF verification system will be located and run at the NPVU. The NPVU will perform QPF verification for the entire nation as well as for the smaller domains. Archival of all data pertaining to QPF verification at the NPVU is essential to the program. The NPVU can thus be a source of data for local verification activities.

Further details concerning the national QPF verification program are given in Section 11.3 of Office of Meteorology (1999).

3. QPE & QPF DATA INGEST

As stated earlier, the success of the QPF verification program is dependent upon the timely availability and receipt of all necessary QPE and QPF data. Thus, a flow structure of QPE and QPF data to the NPVU has been established and implemented by the QPFIWG in summer 2000. The essential data needed for the NVPU QPF verification program are 6h aggregate quality-controlled QPEs and 6h QPFs. RFC QPE data are produced at the RFCs using a variety of programs such as Stage III, RFC-wide, P1, and Mountain Mapper. RFC QPF data are produced using NCEP's NAWIPS NMAP software and Mountain Mapper.

The gridded data are first formatted in GRIB, a WMO standard, for easier transmission, distribution, and decoding. The RFCs utilize the AWIPS program 'distributeProduct' to push the data to the WAN in order to get to the NCF. From the NCF, the data can be distributed to other locations via the SBN as well as pushed to the OSO. At present, only QPF data are distributed to other NWS offices. QPE data will not be distributed until AWIPS build 5.0 or later. The OSO then pushes the data to NCEP's supercomputer, IBM SP, where the NPVU has access. All NWP QPF data are also access directly from the IBM SP. The GRIB data are retrieved from the IBM SP, archived locally, and decoded into GEMPAK gridded files.

4. QPF VERIFICATION SYSTEM

At present, QPF verification is performed via a gridded method. The grid of choice is the 32-km AWIPS grid. A horizontal resolution of 32 km is used based upon the perceived resolution of QPF skill by NWS QPF forecasters. A comparable resolution of 30 km has been used for three decades by the HPC (Olsen et al. 1995). This resolution appears to be a fairly good balance between NWP QPFs, HPC & RFC QPFs, and observed QPE. However, verification will also be performed at other resolutions, depending upon the verification measure and the desired scale of skill.

All verification data are remapped to the verification grid. Several methods are utilized. For QPE data on the 4-km HRAP grid, a simple grid-averaging technique yields 32-km areal averages of observed precipitation. For data in which the ratio of the resolution of the output grid to that of the input grid is near to one, such as the RFC QPF data on a 10-km AWIPS grid, an

area preservation technique (Mesinger 1996) is utilized. The volume of precipitation is well preserved as compared to other techniques such as bilinear interpolation.

Manual (HPC, RFC, & WFO) QPFs are compared with those NWP QPFs that are available at the time the manual QPFs are prepared. For example, when HPC forecasters prepare the 1200 UTC QPF package, they typically utilize the 0000 UTC NGM, Eta, and AVN QPFs. A multitude of verification methods and measures exist to relate the correlation between the forecast and that observed as well as relating the skill of the forecast to that of another. Thus, due to information overload difficulties, only a handful of specific informative verification statistics are computed and presented in both textual and graphical form. More specific details of the verification system are available on the NPVU Web site.

At the time of this writing, preliminary verification results were not yet available. The reader is thus directed to the NPVU QPF verification site at http://www.hpc.ncep.noa.gov/npvu/qpfv/.

5. PROTOTYPE ACTIVITIES

Because the NPVU is co-located with the HPC, the NPVU has had the opportunity of being instrumental in furthering the long-established HPC QPF verification system. The HPC verification system is composed of verification components for 6-, 24-, and 120-hr QPFs. The 24- and 120-hr systems are gridded, but use only pure gauge observations. The 24-hr analyses are hand-drawn manual analyses. The 6-hr system is a point system in which HPC forecasters quality control 600+ station observations. Further details of the HPC QPF verification program can be found in Olsen et al. (1995), McDonald et al. (2000), McDonald and Graziano (2000), and by visiting the HPC Web site (http://www.hpc.ncep.noaa.gov).

The prototype NPVU was asked to provide objective QPF verification for the QPF Process Assessment Team. QPF verification methods and results are found in the team report (NWS 1999) and in McDonald et al. (2000). Much of the development of that verification system has since been carried over to the current verification system. Figure 1 shows the mean absolute errors for 24-hr QPFS over the combined areas of the ABRFC and the OHRFC. The considerable decrease in skill by the WFOs at higher precipitation intervals compared to HPC is noted.

As a result of the recommendations made by the QPF Process Assessment Team, a QPFIWG was organized and tasked with implementing the approved recommendations. Many of the tasks of the group related directly with the NPVU in terms of data availability and QPF verification. The NPVU underwent an Operation Test and Evaluation (OT&E) from 15 June to 15 August 2000. to test and evaluate the data flow procedures that had been established. Because QPF verification relies upon the necessary data, test and evaluation of the verification methods was deferred until just prior to implementation.

One of the recommendations of the QPF Process Assessment Team was to continue the assessment over Western Region for the 1999-2000 cool season. The prototype NPVU adjusted the previous verification system and again provided objective QPF verification to the team. Figure 2 shows gridded MAEs for the CNRFC area. Figure 3 shows point MAEs for the NWRFC area. Results were presented to the team and are available in McDonald and Graziano (2000). The recommendation was made similarly in Western Region as for the rest of the CONUS. Thus, a Western Region implementation is underway and should be complete by the end of the 2000-2001 cool season.

6. FUTURE PLANS

The availability of QPF verification statistics in the beginning will be fairly basic. More diversified and specific verification results will be added in the coming

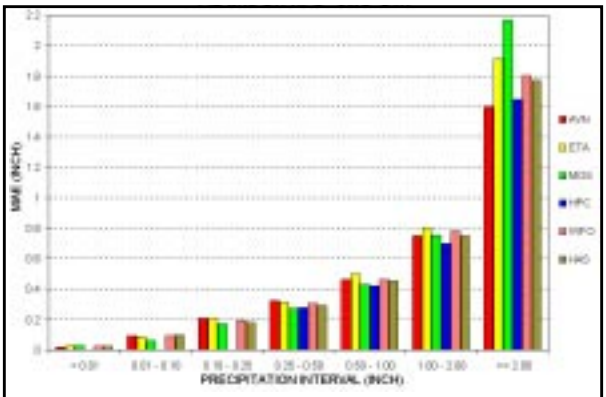

Figure 1. Mean absolute errors for 24-hr QPFs over both the ABRFC and OHRFC for the 6-mo period Oct. 1998 - Mar. 1999.

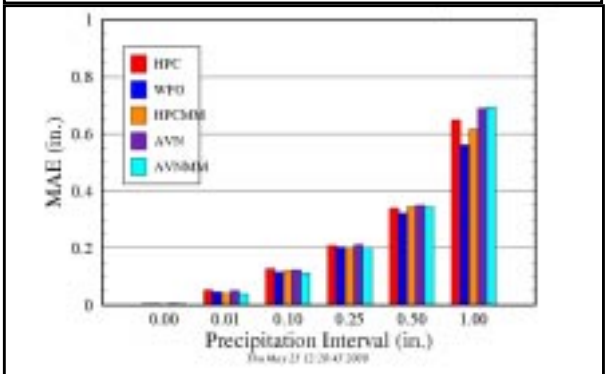

Figure 2. Mean absolute errors over the CNRFC domain for day 1 (f000-f024) 06-hr QPFs from Nov. 1999 - Mar. 2000. A gridded verification method is employed. MM designations indicate the original QPF being interpolated to points, and then remapped to a grid using Mountain Mapper.

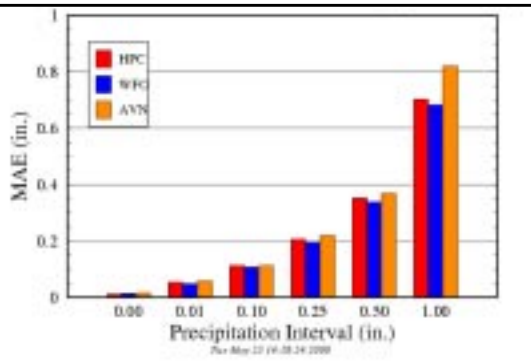

Figure 3. Mean absolute errors over the NWRFC domain for day 1 (f000-f024) 06-hr QPFs from Nov.1999 - Mar. 2000. A point verification method is used here.

year, including QPF verification for individual QPF forecasters.

The NPVU has recently agreed to become a 'one-stop shopping' location for QPE and QPF data via the Internet. The specific URL is http://www.hpc.ncep.noaa.gov/npvu/data/. Much of the data are already available in individual RFC sites, the HPC site, and others. However, the need and request of a central location for the data has logically fallen to the NPVU since much of the data already in utilized by the verification system.

7. ACKNOWLEDGMENTS

This paper would not be complete without expressing proper gratitude to those who have made the implementation of the NPVU possible., Dr. Tom Graziano first envisioned such a place as the NPVU to fill a critical hole within the NWS and has labored hard to bring it to pass. Thanks to NWS director Jack Kelly, Dr. Gary Carter, Dr. Jess Charba and the rest of the QPF Process Assessment Team; to Bill Lawrence, other River Forecast Center representatives, and the QPFIWG; to Dave Reynolds, Ed Danaher, and the forecasters and developers of HPC; to the computer support groups of NCEP; and to the verification experts of EMC.

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