6B.12 The National Severe Storms Laboratory QPE verification system

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1. INTRODUCTION

There exist widely recognized and significant challenges towards producing high-resolution hydrometeorological information for a spectrum of water resources applications and for water resource decision makers. The National Mosaic and QPE (Quantitative Precipitation Estimation) (NMQ) project addresses the pressing needs for high-resolution multisensor QPE for all seasons and geographical regions in support of comprehensive hydrometeorological and hydrologic data assimilation and distributed hydrologic modeling (Seo et al. 2005). The overarching objectives of the NMQ project are 1) create a real-time system to develop and to test methodologies and techniques for physically realistic high-resolution rendering of hydrometeorological and meteorological processes, 2) create a framework for community research and development (R&D) of hydrometeorological applications for monitoring and prediction of freshwater resources in the United States across a wide range of time and space scales, 3) through a test bed, facilitate research-to-operations (RTO) of new applications, techniques and approaches to QPE and short-range QPF (Quantitative Precipitation Forecast).

The primary user interface for next generation/experimental QPE products (Q2) is the QPE Verification System (QVS). The QVS is a user interactive web portal composed of four parts:

- Data ingest;
- Product display;
- Analysis tools;
- Statistical verification methods.

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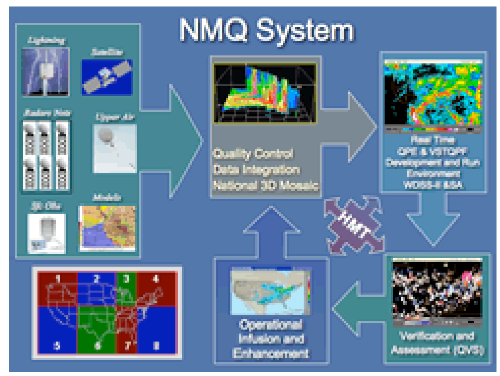

Figure 1. NMQ system schematic.

Figure 2. NMQ/QVS main page.

An emphasis is placed on the ability to compare Q2 products with operational products as well as additional experimental applications produced externally. For instance, the NWS Stage IV data are available. Another key aspect of the QVS is the availability of various ground truth gauge networks (e.g., Kim et al. 2006).

This paper provides an overview of the QVS. Access to the web site is available at www.nssl.noaa.gov/projects/newq2/tutorial/. In addition, a case example using hurricane Humberto is used to demonstrate some of the capabilities available with the QVS.

2. DATA INGEST

The NMQ system ingests data from a number of sensors and products from various sources (Fig. 1):

- 128 WSR-88D radars (5 min)
- Gauge data set that includes 5500 gauges from many different networks (hourly)
- Satellite IR images (15 min)
- Rapid Update Cycle 20 km resolution (RUC) model analysis variables (hourly)
- NWS Hydro Estimator (satellite-based) precipitation (hourly)
- NWS Stage IV precipitation (1, 6, and 24 hour)

2. PRODUCTS

NMQ creates and displays many experimental products derived from radar, satellite, numerical weather prediction (NWP) models and gauges, both individually and combined. Figure 2 shows the main QVS web page. A "blog" and a tutorial are available and provide updates to the system and descriptions of all data and products. Appendix A of the tutorial gives a brief description of the products and acronyms. Briefly the following product categories are available:

- 3-D reflectivity and derived products such as VIL and composite reflectivity (CREF; Fig. 3); (see Zhang et al. 2006)
- Experimental and operational QPE including current rates, accumulations and precipitation type.

As mentioned, NWS operational QPE products such as a 4 km gauge analysis from the Climate Prediction Center at NCEP, Stage IV from River Forecast Centers (RFCs) and the satellite Hydroestimator are also online. Experimental Q2 product names have the form "Q2product-accumulation period." For instance Q2 hybrid scan reflectivity (HSR) 1 h accumulation is denoted as Q2RAD_HSR-1H. As discussed below, the Q2RAD product is the result of application of different Z-R relations.

3. ANALYSIS TOOLS

The category "Analysis tools" refers to a set of interactive methods for exploring various aspects of the data. An "Analysis tools" tab is available on each product page.

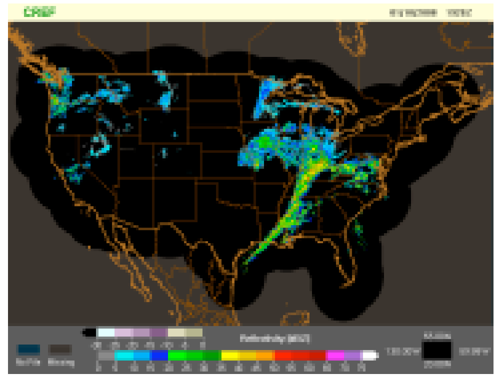

Figure 3. CONUS CREF product at 1920 UTC on 10 January 2008.

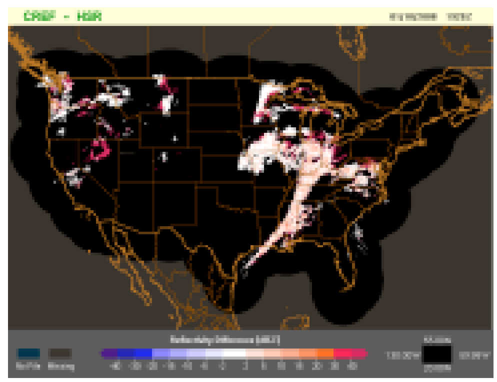

Figure 4. "2 product difference" for the CONUS subtracting hybrid scan reflectivity (HSR) from composite reflectivity (CREF).

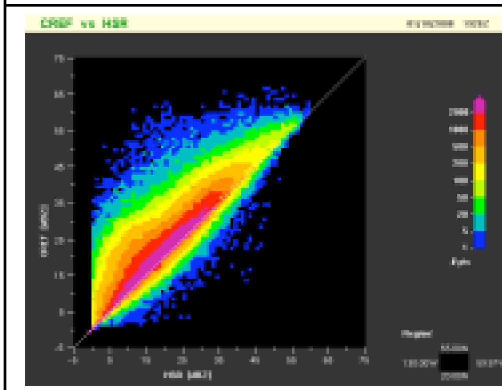

Figure 5. Scatterplot of CREF and HSR (see Fig. 4).

These tools include a 2-product difference (Fig. 4) and scatterplots (Fig. 5). Other tools such as scatterplots of gauge vs. other products function in common with the statistical scoring methods described below.

4. VERIFICATION/SCORING TOOLS

Quantitative evaluation of QPE products is at the heart of the QVS. For the foreseeable future, gauge data will be the primary validation dataset for remotely sensed QPE. There are sundry gauge networks in existence each with different levels of quality.

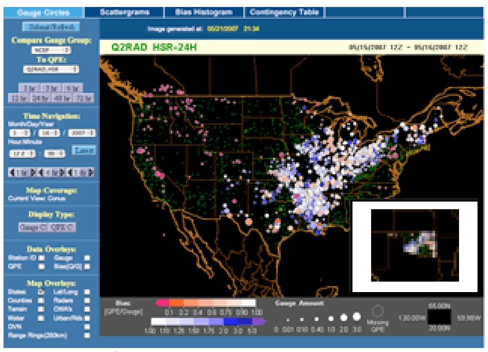

Figure 6. Gauge circle map showing 24 h rainfall across the CONUS ending 1200 UTC on 16 May 2007. Circle size is related to gauge amount. Color indicates the bias with cool colors indicating underestimation by radar and warm colors overestimation. Note the tabs at the top. Inset shows an example of the Oklahoma Mesonet data.

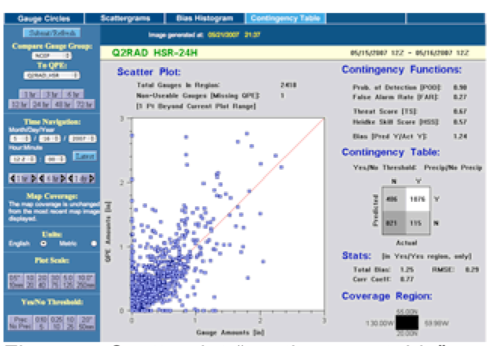

Figure 7. Scatterplot "contingency table" corresponding to data in Fig. 6. The plot and data are scalable using the buttons at the left.

Currently the QVS ingests data from the HADS network and the Oklahoma mesonet. The gauge tab on the main page provides access to the gauge data with each network having a separate tab.

Statistics are determined on a point-by-point basis and are accessed by clicking on "Analysis tools" then one of 3 scatterplot tabs at the top (Fig. 6). Each gauge circle is color coded according to product vs. gauge bias while the circle size is proportional to the gauge amount. The contingency table (Fig. 7) provides a number of scoring metrics including POD, FAR, and CSI. Additional information is in the online tutorial.

5. CASE STUDY OF HURRICANE HUMBERTO

On 13 September 2007 hurricane Humberto rapidly developed from a tropical depression along the NE Texas coast (Fig. 8). This limited case study provides an example of how the QVS can be used with focus on the following products and tools:

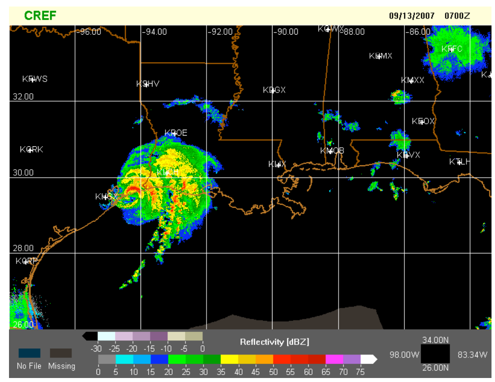

Figure 8. Composite reflectivity at 0700 UTC on 13 September 2007. Humberto was designated a Hurricane at 0515 UTC.

- 1 h and 24 h HADS gauges
- precip flags
- hybrid scan reflectivity
- time series
- and vertical profiles of reflectivity.

5.1 *CST radar-based precipitation algorithm*

The radar-based hybrid scan reflectivity QPE product is the result of using 3 different Z-R relations depending on a determination that a grid point is convective,

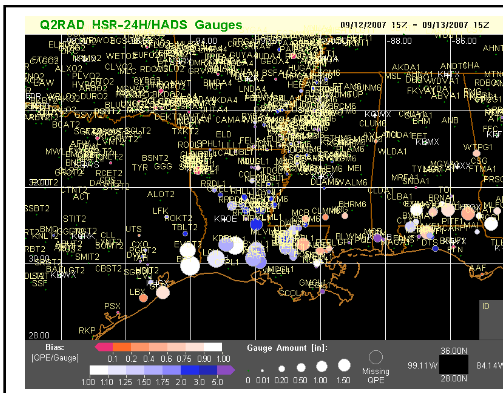

Figure 9. As in Fig. 6 except for 13 September 2007. The BPT gauge is identified for later analysis.

stratiform, or tropical/warm rain (hence CST; Xu et al. 2008). An algorithm processes a VRP every 5 min and determines if the profile represents warm rain processes and a tropical Z-R is applied. A convective rain rate is applied if the reflectivity exceeds various thresholds. Remaining valid data are assigned a stratiform rate.

5.2 *Hurricane Humberto not "tropical"*

Since the storm was fast moving, rainfall totals are modest (Fig. 9). Note that there is good agreement between the Q2RAD data and the gauges near the gulf coast.

An examination of the precipitation flags that determined which Z-R was used, HSR, and 1 h accumulations from the CST algorithm indicates that the convective and stratiform rates were most appropriate for deriving precipitation (Fig. 10). Between 0600 UTC and 1100 UTC, it is apparent that a tropical Z-R would have cause overestimation. A VPR from the Houston radar (Fig. 11) and the map of precipitation flags (Fig. 12) during the time of Hurricane development confirm the lack of a warm rain profile.

5. NMQ/QVS PLANS

The NSSL plans to continue the development of new products and verification methods. Next steps are to determine multi-sensor confidence fields that can be used to combine data from various QPE sources. Additional verification methods will include the object oriented evaluation methods in the NCAR WRF MET. Special gauge networks are being evaluated and added to QVS. Each network will have its own tab and the statistics will reflect only those data the user selects. Soon the WSR-88D network with be retrofitted for dula-polarization (DP). DP QPE products will be available for concept development and testing within QVS.

Other experimental and operational products are being added and include the

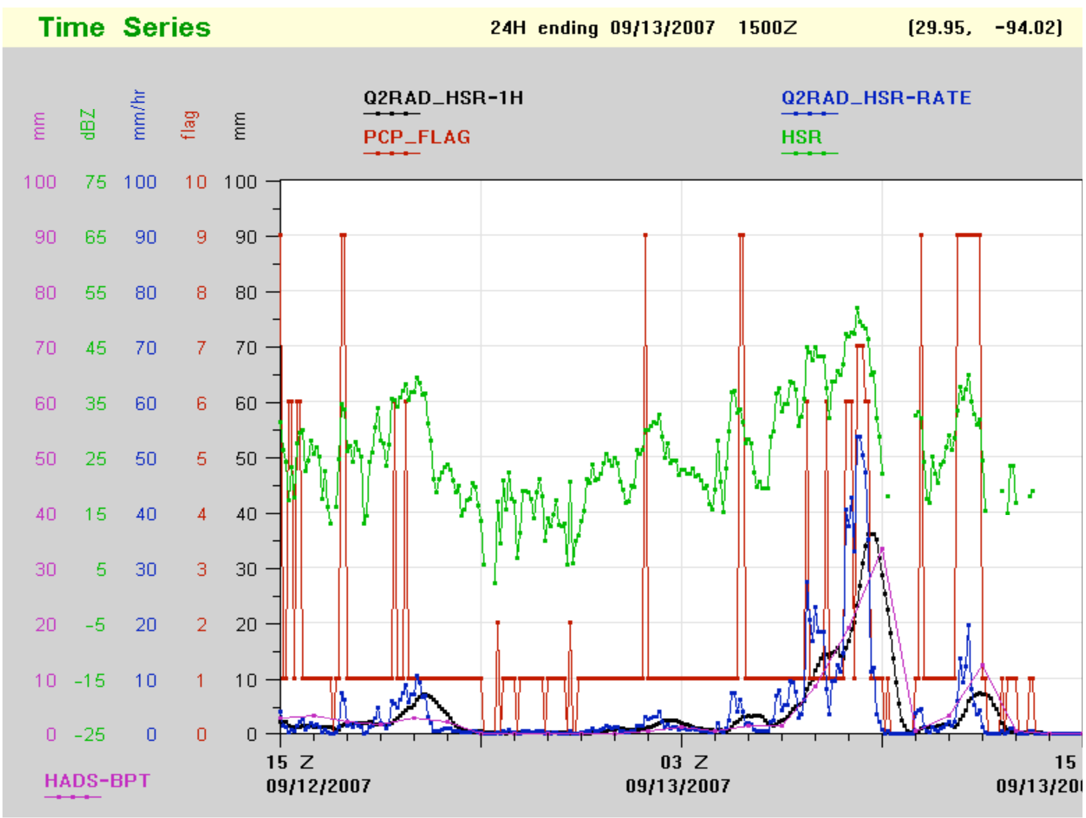

Figure 10. Time series of Q2RAD_HSR-RATE (blue), Q2RAD-HSR-1H 1-h accumulations (black), PCP_FLAG (red) HSR (green) and HADS-BPT gauge. Q2 Rates and accumulations are every 5 min. PCP_FLAG 7 is convective, 3 is stratiform and 9 is tropical. Hurricane Humberto passed over the gauge between 0600 UTC and 1100 UTC 13 September.

Mountain Mapper (MM) products produced by RFCs in the West. MM does not use radar data so comparisons between multi-sensor and MM QPE will provide a business case as to whether MM products can be improved.

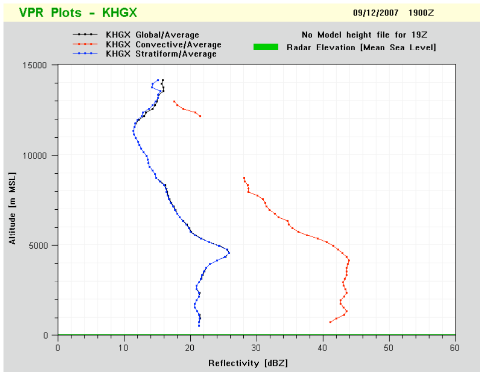

Figure 11. Vertical profiles of reflectivity from the KHGX radar near Houston at 1900 UTC 12 September. The blue/red profile is a time average for stratiform/convective data.

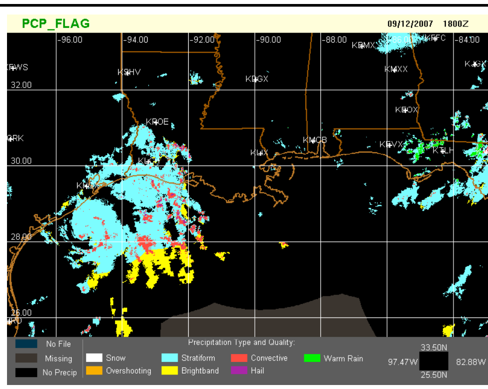

Figure 12. Snapshop of precipitation flags at 1800 UTC on 12 September. Flag color codes are shown at the bottom.

6. SUMMARY

The NMQ/QVS system was designed to provide robust techniques for evaluating experimental precipitation products. Efforts are ongoing to demonstrate the utility of new methodologies for inclusion into operational systems. Cutting edge science applications such as dual-polarization QPE and spatial evaluation methods will soon be included.

ACKNOWLEDGEMENTS

The NMQ QVS system is the results of the combined efforts of a number of people in the NSSL Hydrometeorological Research Group. Jian Zhang is the project leader for the NMQ program which is supported by the Federal Aviation Administration. Brian Kaney is the lead developer for the QVS system. Ken Howard provides direction for the team.

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