Proceedings of ERAD 2006

The Hydromet Decision Support System: operational applications in hydrometeorology and flash flood prediction

J. William Conway[1], Dr. Gabriele Formentini[2], Dr. Luciano Lago[2], Dr. Andrea Rossa[2]

[1] Weather Decision Technologies, Norman, Oklahoma, USA

[2] Regional Agency for Environmental Protection and Prevention of Veneto, Meteorological Centre of Teolo, Italy

1. Introduction

Weather Decision Technologies (WDT) in collaboration with the National Severe Storms Laboratory (NSSL) in the USA, and the Regional Agency for Environmental Protection and Prevention of Veneto (ARPAV) in Italy have developed a severe weather monitoring and hydro-meteorological package termed the Hydromet Decision Support System (HDSS). This system integrates data from radars, rain gauges, satellite and numerical models to provide high resolution Quantitative Precipitation Estimates (QPE) and Quantitative Precipitation Forecasts (QPF). The focus of this paper is to briefly describe the hydrometeorological components of the system that include:

- radar quality control including clutter removal, bright-band identification, hybrid scans, and scan filling
- mosaicking of radars in the Veneto region
- processing of the data using a suite of applications called Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPE-SUMS) for the derivation of QPE fields
- forecasts of radar reflectivity fields using the McGill Algorithm for Nowcasting Precipitation Using Semi-Lagrangian Extrapolation (MAPLE)
- derivation of QPF fields using the results of MAPLE
- a Flash Flood Prediction Algorithm (FFPA) which combines QPE and QPF values to forecast flash flood areas based on basin Flash Flood Guidance (FFG) values
- automated alerting of basins that have exceeded,, or are forecast to, approach or exceed FFG values

Data and product outputs are available via customized web pages and a three-dimensional graphical workstation.

Correspondence to: Bill Conway

bconway@wdtinc.com

2. HDSS System Components

2.1 3D Mosaic Algorithm

The 3-D Mosaic algorithm used as part of the HDSS was developed by the NSSL (Zhang et al., 2005). The 3D Mosaic algorithm collects data from two radars in the Veneto region (Teolo and Loncon), removes artifacts from the data, and re-samples the data to a 3D Cartesian grid. Initially, data from each radar are interpolated from polar coordinates to the grid using a vertical adaptive Barnes interpolation scheme and gap filling to account for beam spreading with height and power density distributions. An occultation correction is applied to the data based on the local terrain and the scanning strategy. Figure 1 shows an example of the occultation correction for the Teolo and Loncon radars. The figure shows for a particular scanning strategy which elevation angle is being used from which radar for processing to mitigate as much beam blockage as possible.

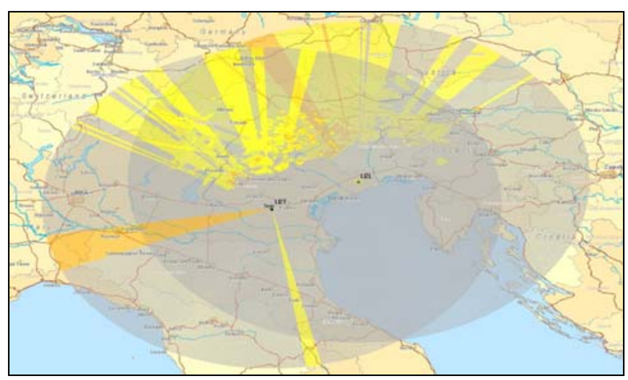

Figure 1. Example of scans being used for a particular scanning strategy over Veneto. The grey/yellow/orange colors represent data to be used from the 1st/2nd/3rd tilts respectively. The Teolo radar (LIZT) is to the southwest, Loncon (LIZL) is to the northeast.

In addition, a maximum value approach is implemented at close range to alleviate under-sampling. The HDSS then mosaics the individual radars onto a 1x1 km grid in the horizontal with 21 levels in the vertical. Figure 2 shows a mosaic example from the Teolo and Loncon radars. It can be seen from Figure 2 that except for the blocked region to the southwest of the Teolo radar, the remainder of the blockage is mitigated.

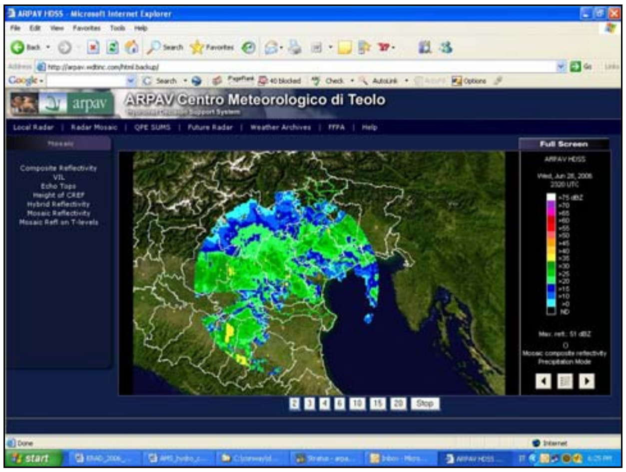

Figure 2. Example of 3D Mosaic over Veneto region shown in the ARPAV Web page.

2.2 Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPE-SUMS)

QPE-SUMS (Gourley et al., 2001, 2004) provides accumulated precipitation estimates for any period of time using algorithms that automatically remove radar artifacts, employ differential Z-R relationships, and integrate data from multiple sensors. Precipitation estimates are provided on a 1 km x 1 km grid and are updated every 5 minutes.

QPE-SUMS has several sub-processes that are used to provide the most optimal QPE. These sub-processes include bright band identification, segregation of convective versus stratiform areas, delineation of precipitation phase, Vertical Profile of Reflectivity determination, satellite integration and precipitation estimation, and rain gauge bias corrections.

An example of the corrections applied within QPE-SUMS is the adjusted radar QPE on an hourly basis using both a spatially non-uniform bias adjustment technique called local gauge adjustment (LGC), and a mean field (domain) adjustment (GC). These adjustments are intended to remove non-uniform biases that may be due to improper use of Z-R relationships, range-dependency in QPEs from reflectivity profiles that decrease with height, and contamination from hail, birds, ground clutter, chaff, and other echoes from non-weather targets. For the LGC, the difference between the gauges and the radar estimates is computed at each gauge location (e.g., G-R). These differences are then analyzed to the 1x1 km QPE-SUMS common grid using the same Barnes objective analysis scheme that is utilized to determine the gauge-only precipitation estimate. In essence, this creates a grid of local biases. Finally, the local bias field is added to the radar hourly products to yield the radar-local bias adjusted QPE products. These bias corrections are also utilized to provide 5 minute updated locally bias adjusted fields. For the GC scheme a mean (1/N.R/G) is calculated on an hourly basis using all grids within the domain. The domain-wide bias is then applied to each grid point. Additionally, the grid of biases are available for display in real-time and are also accumulated over long periods of time to allow analysis of the differences in biases in different locations. Figure 3 shows an example of the objective analysis of the range gauges covering the Veneto region.

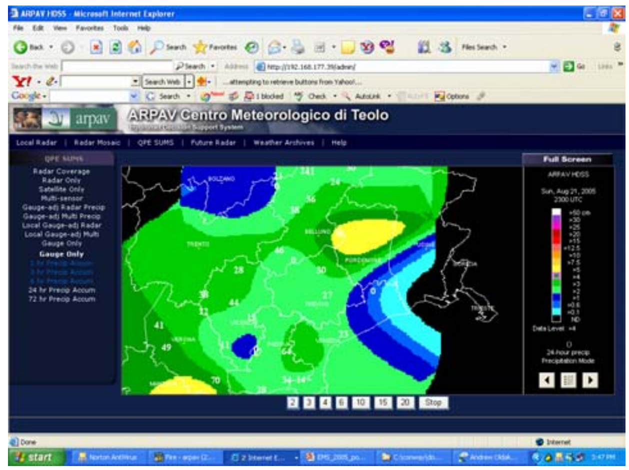

Figure 3. Example of objective analysis of rain gauges over Veneto region.

Figure 4 shows an example of QPE-SUMS accumulation over a 1 hr time period.

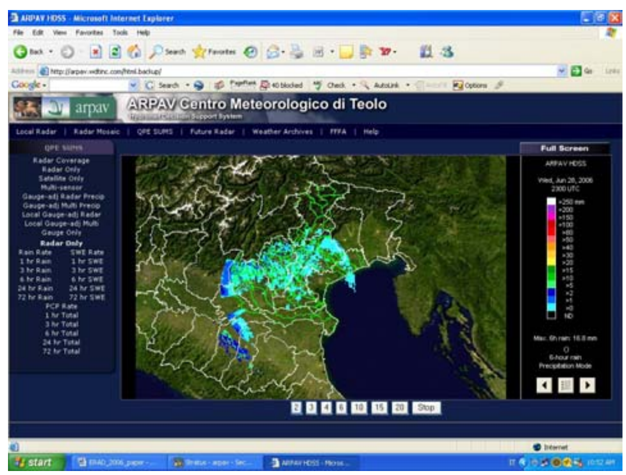

Figure 4. Example of QPE-SUMS rainfall accumulation over a 1 hr time period.

2.3. MAPLE Quantitative Precipitation Forecasts

HDSS includes a software system called the McGill Algorithm for Precipitation Nowcasting Using Semi-

Lagrangian Extrapolation (MAPLE – Germann and Zawadzki, 2002 and Turner, et al., 2004) that predicts the evolution and movement of reflectivity fields out to six hours in advance. Output from MAPLE is used not only to monitor future reflectivity positions but also to produce QPF estimates of total precipitation by applying Z-R and Z-S relationships to the MAPLE forecasts. Figure 5 shows an example of total forecast rainfall accumulation from MAPLE over a 3 hr period.

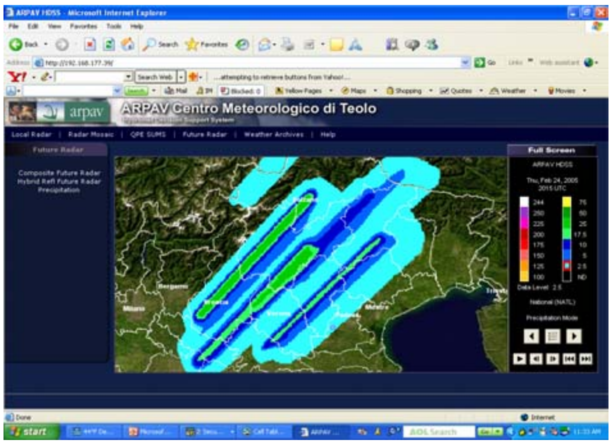

Figure 5. Example of MAPLE forecast total rainfall accumulation over a 3 hr period.

2.4. Flash Flood Prediction Algorithm

A Flash Flood Prediction Algorithm (FFPA) that utilizes delineated basins covering a region as a basis for flash flood monitoring is also included in the ARPAV HDSS. FFPA combines output from QPE-SUMS and forecast rainfall amounts from MAPLE to provide as accurate as possible total forecast rainfall accumulations for each basin. The FFPA compares the forecast basin accumulations against Flash Flood Guidance (FFG) values for each basin. Warnings are automatically generated for basins whose total accumulations are approaching or exceeding FFG values.

A flash flood case has yet to be collected over the Veneto region with the Loncon and Teolo radars, thus to demonstrate FFPA we have used radar data from a US hurricane case (Francis - 2004) and translated the data over the Veneto region. Data from the WSR-88D locations of Melbourne, and Tampa Bay, Florida was set to playback as if they were located at the Loncon and Teolo locations respectively. Although not exact, these two WSR-88D radars are similar enough to the Teolo-Loncon configuration for testing purposes.

Figure 6 shows an example of QPE-SUMS output for a total accumulation period. Figure 7 shows an example of the MAPLE forecast total accumulations for the following 1 hr period shown in Figure 6.

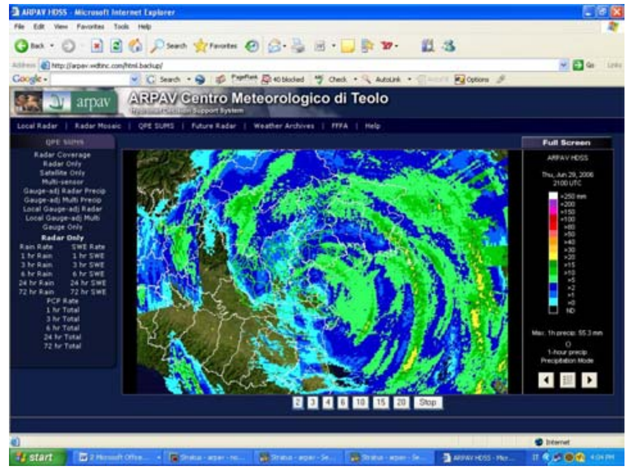

Figure 6. QPE-SUMS total rainfall accumulation over a 1 hr period.

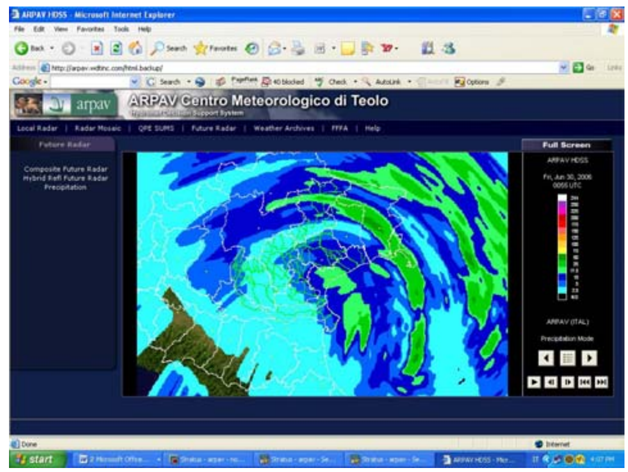

Figure 7. MAPLE 1 hr total accumulation forecast. In this figure the green lines near the center of the image represent delineated basins.

FFPA records the total past accumulations given by QPESUMS and the forecast total accumulations given by MAPLE. These total accumulations are kept for each basin and compared to FFG values.

Figure 8 shows an example of basins that are approaching or exceeding FFG values. The figure shows a table of color coded basins and a basin map depicting basins that are approaching (yellow) or exceeding (red) FFG values. FFG values are set by the user through a Web interface and are immediately updated when changes are made.

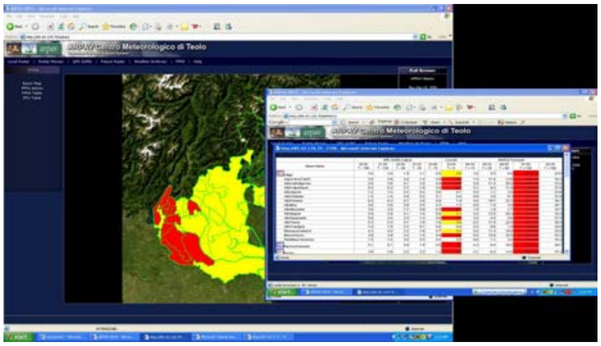

Figure 8. Example of basin map and table for the Veneto region. Table shows all delineated basins and their total accumulations over various periods of time. Yellow (red) represents basins that have surpassed 80% (=100%) of their FFG values.

3. Summary

This paper has described an operational tool to be utilized for severe weather and hydrometeorological applications – the Hydromet Decision Support System (HDSS) that has been established in the Veneto region. The purpose of HDSS is to provide the latest state-of-the-science system available to give operational users the ability to provide timely, accurate warnings of hazardous weather situations. The ARPAV HDSS will continue to be expanded to include more radars, lightning data, new algorithms and functionality.

4. References

Germann, U. and I. Zawadzki, 2002: Scale-dependence of the predictability of precipitation from continental radar images. Part I: Description of methodology, *Mon. Wea. Rev.,* **130**, 2859-2873.

Gourley, J.J., R.A. Maddox, and B.M. Clarke, 2004: A multisensor approach to partitioning convective from stratiform echoes. *Preprints, 3rd European Conf. Radar Met*., Visby, Sweden, 305-309.

Gourley, J.J., and C. Calvert, 2003: Automated detection of the bright band using WSR-88D data. *Wea. Forecasting*, **18**, 585-599.

Gourley, J.J., J. Zhang, R. A. Maddox, C.M. Calvert, and K. Howard 2001: A real-time precipitation monitoring algorithm - Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPE-SUMS). *Preprints, Symp. On Precipitation Extremes: Predictions, Impacts, and Responses.* AMS, Albuquerque, NM, 57-60.

Turner, B.J., I. Zawadzki, U. Germann, 2003: Scale-dependence of the Predictability of Precipitation from Continental Radar Images. Part III: Operational Nowcasting Implementation (MAPLE), Submitted to *Mon. Wea. Rev*

Zhang, J., K. Howard, and J.J. Gourley, 2005: Constructing three-dimensional multiple-radar reflectivity mosaics: Examples of convective storms and stratiform rain echoes. *J. Atmos. and Oceanic Tech.*, **22**, 30-43.

Zhang, J., S. Wang, and B. Clarke, 2004: WSR-88D reflectivity quality control using horizontal and vertical reflectivity structure. *Preprints, 11th Conf. Aviation, Range, and Areospace Met*., Hyannais, MA. AMS.About radar and meteorology. *J. Hydrometeor*. **6**, 532-549.