1.8 QIWI - A WEB-BASED FLASH FLOOD MONITORING TOOL

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1. INTRODUCTION

The Areal Mean Basin Estimated Rainfall (AMBER) algorithm (Davis and Jendrowski, 1996) uses United States NEXRAD (NWS's NEXt generation RADar, the NEXRAD or WSR-88D) reflectivity data to estimate average rainfall accumulations in small watersheds. Its utility has been demonstrated in the Honolulu, HI, Pittsburgh, PA, Tulsa, OK, and Sterling, VA National Weather Service Forecast Offices (NWSFOs). AMBER alerts forecasters when basins are receiving heavy amounts of rainfall relative to Flash Flood Guidance (FFG) values. The value of AMBER as a flash flood monitoring tool is limited by uncertainty in WSR-88D rainfall estimates and the applicability of county-wide or region-wide FFG values to small basins.

In response to these potential shortcomings, a real-time system has been recently developed to ingest improved estimates of rainfall from the Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPE SUMS) algorithm (Gourley et al. 2001). These accumulations are averaged in small basins (i.e., typical areas are 15 mi^2) and fed into a *web-based* AMBER display system called QIWI (QPE SUMS Interactive Web Interface). The QIWI interface displays average basin rainfall relative to configurable thresholds. Terrestrial parameters for each basin are listed so that the thresholds may be set appropriately. A detailed map background showing cities, topography, highways, railroads, rivers, dams, and recreational sites is also supplied. This paper demonstrates the utility of QIWI for a flash flood that occurred on July 15, 1999 in Sabino Canyon near Tucson, AZ, USA.

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2. QIWI DESCRIPTION

QIWI is essentially a web-based version of the AMBER algorithm with several modifications. Arthur and Howard (2001) evaluated the performance of AMBER during tests at 2 NWSFOs. They recognize that the accuracy of AMBER output is limited by the accuracy of radar-derived precipitation estimates and FFG values.

QIWI ingests gridded rainfall data from the QPE SUMS precipitation algorithm. QPE SUMS algorithm offers more accuracy due to its use of multiple sensors such as a mosaic of rain rates from several NEXRAD radars. Secondly, QIWI provides more hydrologic information about each basin indicating the potential basin response to input rainfall. These parameters may be used to fine-tune FFG values for each basin of concern. Note that current FFG values used in NWS operations are primarily determined on a county-wide basis from antecedent soil moisture conditions. This is but one parameter related to basin runoff. All hydrologic parameters listed in QIWI are the same ones used in a distributed-parameter hydrologic model (e.g., Vieux and Gaur 1994).

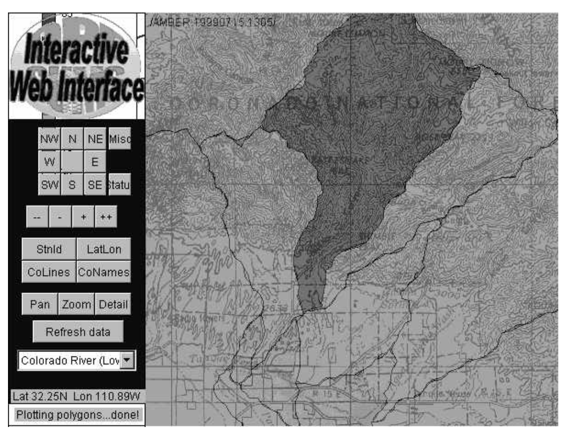

Figure 1. Illustration of QIWI web-based display.

Lastly, feedback from NWS forecasters has led to the inclusion of a detailed map background for georeferencing capabilities. This map consists of tiles of United States Geological Survey (USGS) Digital Raster Graphics (DRGs). These are scanned-in, colorized images of standard series topographic maps. They include all relevant geopolitical and terrestrial features in the QIWI domain. Basin boundaries and basin-averaged rainfall relative to FFG are overlain on this map background.

3. BASIN HYDROLOGIC ATTRIBUTES

QIWI shows the spatial distribution of basin-averaged rainfall as illustrated in Fig. 1. Additionally, users may click on any basin and view a time series of basin-averaged rain rate and 6 hour accumulation. The QIWI time series for the Sabino Canyon flash flood on July 15, 1999 is presented in Figure 2.

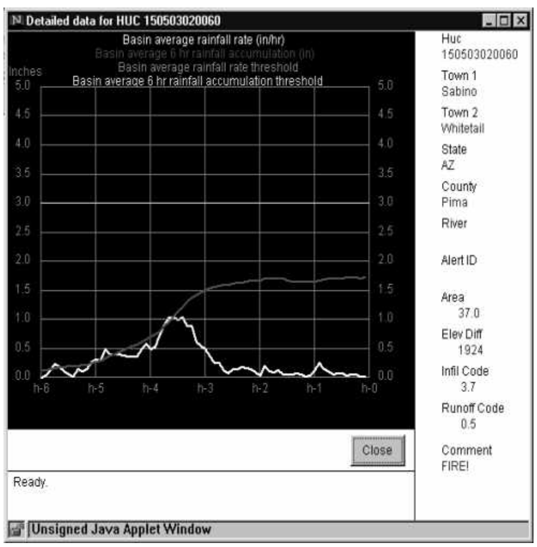

Figure 2. QIWI trend window valid at 1640 UTC on July 15, 1999 for Sabino Canyon, AZ.

Trend windows also show threshold values corresponding to FFG and several basin hydrologic attributes. Basin attributes such as basin area, slope, potential infiltration rate, and potential runoff rate may be used to fine-tune existing FFG values. They indicate the potential basin response to rainfall. Each attribute is described below.

<u>BASIN ID</u> - 12-digit hydrologic unit code (HUC) basin identifier

<u>LAT</u> - latitude of basin outlet point

UNITS: decimal degrees

<u>LON</u> - longitude of basin outlet point

UNITS: decimal degrees

<u>AREA</u> - area of basin

UNITS: square miles

<u>TOWN1/TOWN2</u> - towns located in basin.

<u>MAJOR RIVER</u> - major river that flows in basin

<u>COUNTY</u> - US county that basin resides in

<u>STATE</u> - US state that basin falls within

<u>ALERT ID</u> - ALERT precipitation sensor ID that lies within basin.

<u>ELEV DIFF</u> - elevation difference (in meters) from the highest to lowest point in basin. Higher numbers coincide with steeper basins. Flood flows may occur quickly and dangerously in these basins.

UNITS: meters

<u>INFIL CODE</u> - potential infiltration rate. Low numbers correspond to well-drained soils and gravel. High numbers represent soils that are clayey, have a high water table, or are shallow to an impervious layer. This attribute is derived from hydrologic soil groups (HSG) from the STATSGO database.

UNITS: none

RANGE:0-5

<u>RUNOFF CODE</u> - potential surface runoff rate. Low numbers suggest surface roughness values are high such as in forested lands. Smoother surfaces in urban and sandy areas have higher runoff codes. This parameter is derived from a land use/land cover (LULC) database.

UNITS: none

RANGE:1-5

<u>COMMENTS</u> - user notes about basin. Remarks about flooding or wildfire history may be recorded in this column.

4. CASE STUDY: SABINO CANYON FLASH FLOOD

Sabino Canyon is a heavily recreated region in the Santa Catalina Mountains near Tucson, AZ, USA. In a given summer day, hundreds of people hike, swim, and picnic around Sabino River. On July 15, several inches of precipitation fell in the headwaters of Sabino Canyon. Fortunately, the heaviest rain fell well before sunrise. At the basin outlet, several residents were airlifted from tops of structures. There was no loss of life because the event occurred before most tourists arrived.

Archive Level II radar data from Arizona WSR-88D radars were obtained and input to QPE SUMS precipitation algorithm. QIWI data were also generated for this case study. The USGS in Arizona provided discharge data recorded at the basin outlet point. Figure 3 shows the basin-averaged rainfall rate and basin discharge. Notice that the time of maximum rainfall rate occurs *1 hour and 10 minutes* prior to the peak discharge. If QIWI were running in real-time at the Tucson forecast office, it could have alerted forecasters to the danger of an impending flash flood.

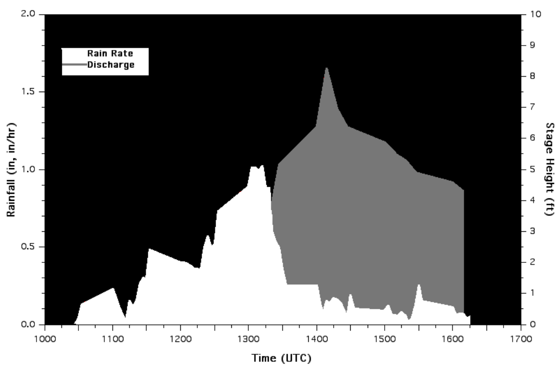

Figure 3. Basin-averged rainfall rate (white) and basin discharge (gray) for Sabino Canyon flash flood.

5. RECOMMENDATIONS

An AMBER or QIWI application can be beneficial to the flash flood forecast process if the following is true.

- The input radar rainfall estimates are accurate
- The flash flood guidance values apply appropriately to each basin
- Forecasters are aware of features such as roads, towns, residential area, bridges, and recreational sites that may be affected by a flash flood
- Forecasters are cognizant of areas that drain into basin

QIWI ingests gridded QPE SUMS rainfall estimates as opposed to rainfall data from the operational Precipitation Processing System (PPS). When using rainfall from the PPS, caution must be exercised when using radar data at far range, where beam blockages are significant, a distinct melting layer is present, or the Z-R equation being employed doesn't apply. The QPE SUMS precipitation algorithm addresses these constraints and employs additional sensors where needed.

Flash flood guidance values must be basin-specific as opposed to being county-wide or region-wide. Factors contributing to a basin's response include basin area, basin geometry, slope, infiltration characteristics, runoff velocity, and antecedent soil moisture conditions. All of these factors must be taken into consideration. QIWI supplies many of the aforementioned parameters for each basin so users may adjust FFG values more accurately.

A flash flood monitoring tool must consider upstream effects. In the western US, rain can fall several kilometers upstream in a different basin. In time, the water can flow into basins downstream. If there are several contributing tributaries, a flash flood can result well downstream from the area that received the rainfall. Improvements are being made to QIWI so that it can aggregate data upstream and thus be aware of precipitation falling in all contributing basins.

QIWI offers forecasters the ability to determine the likelihood of flash flooding during a rainfall event. In the future, stream flow predictions will be available with the use of a distributed parameter rainfall-runoff model. This approach is under investigation.

5. REFERENCES

References are available from the author upon request.