AQPI: Systems Requirements for Hydrological Functions

Lynn E. Johnson, Greg Pratt, Rob Cifelli, Jungho Kim
CIRA/Colorado State Univ. and NOAA ESRL, Boulder, CO

AGU 100 FALL MEETING

Introduction

San Francisco Bay is a highly urbanized estuary and the surrounding communities are susceptible to flooding in inland rivers and creeks that drain to the Bay, and along the Bay shoreline. The Advanced Quantitative Precipitation Information (AQPI) system is being developed that involves high resolution radar storm tracking and flood prediction models (Fig. 1).

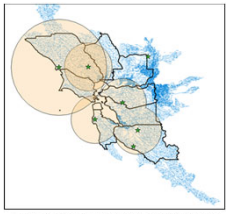

Figure 1 AQPI radar network is intended to provide flood guidance for ~11,000 stream reaches in SF Bay region.

To help assure that AQPI system products are appropriate and usable we are asking flood agency leaders to describe how they currently conduct their flood awareness, warning and response activities; how these activities could be supported by the AQPI products; and to recommend how these products could be formulated to support their jobs. A spiral approach for prototyping and testing is used (Fig. 2). Results of these reviews are presented to reflect how users' assessments are informing design of the real-time AQPI system.

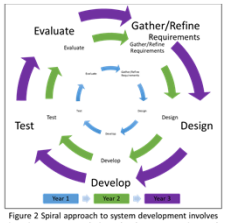

Figure 2 Spiral approach to system development involves iterative prototype design, development, testing and evaluation.

National Water Model

The NWM is a distributed hydrologic model (DHM) that simulates observed and forecast streamflow over the entire continental United States (CONUS). The NWM computes the hydrologic balance on a 250 m grid, aggregates excess precipitation to a 1 km) grid, and routes these flood flows using the NHD-PlusV2 stream network (Figure 4). In the AQPI region, there are ~11,000 stream segments where flow forecasts are generated.

Figure 3 The NWM flow forecasts can be accessed via a web page to zoom in and select any stream segment. The forecast hydrograph is then displayed for the selected forecast time frames.

The NWM system has four forecast time frames: 1) Analysis - Updates to adjust to USGS gaged flows (-3 to 0 hrs; 1-hr update), 2) Short-term forecast (0 to 18 hrs; 1-hr update), 3) Medium-range forecast (0 to 10 days; 6-hr update), and 4) Long-range forecast (0 to 30 days; 1-day update).

The NWM can provide a variety of flood forecast products, including hydrographs at any location (Fig.3 - peak flow, time-to-peak, duration of high flow), and grid displays of streamflow, soil moisture (Fig. 4), streamflow anomaly, snowpack, and ponded water depth.

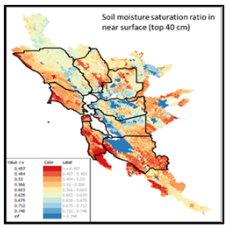

Figure 4 Soil moisture levels are accounted and updated; this provides a basis for initial conditions important to determining surface runoff.

AQPI Hydrologic Products

A variety of watershed hydrologic information products are anticipated for the AQPI system, some from the NWM and others customized per guidance from flood agencies.

Another anticipated product includes portrayal of flood recurrence (RI) levels for all stream reaches (Fig. 5). Over-plotting the flow RI levels onto the forecast hydrograph provides an indication of criticality of peak flows (e.g 100-year level) and is generally understood by flood managers and the public.

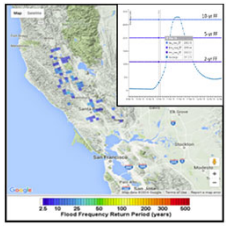

Figure 5 For AQPI, the forecast flows will be portrayed as their pre-computed threshold frequency (TF) level.(e.g. 100-year return frequency). The TF levels will be over-plotted onto the forecast hydrograph.

Linking the RI levels to locations of at-risk bridge crossings (Fig. 6) and other flood impact features (e.g. schools and hospitals). This guidance provides location cues for flood response agencies in deployment of mitigation resources. This type of display is an example of impact-based decision support system functionality envisioned by the NWS Weather Ready Nation.

Figure 6 Impact features, such as bridge crossings, will be included so that the locations of at-risk facilities can be automatically identified.

The NWM has limited capability to map floodplain inundation for tributaries, except where local agencies apply their own hydrologic-hydraulic (H&H) models (see Support for Local Models below). For the AQPI project the tributary flows feed into the USGS Costal Storm Modeling System (CoSMoS) which simulates the coupled hydraulics of the intertidal zone, and maps inundation (Fig. 7).

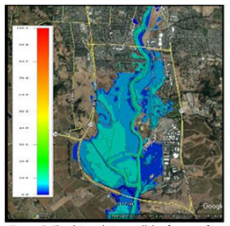

Figure 7 Flood inundation will be forecast for the coastal and inter-tidal areas using the CoSMoS hydrodynamic model.

Support for Local Models

Various flood agency procedures have been identified through the requirements gathering process which the AQPI system intends to support.

An example is the Contra Costa QPF spreadsheet tool that gathers data from NWS forecast web pages into excel worksheets keyed to the 7-5-3-2 protocols. (Fig. 8 and 9). Marin County uses a similar method.

Information for the "Thresholds" plot	Year to Date+ (inches)	Avg 30 Days+ (inches)	Avg 7 Days+ (inches)	Avg or Max 24-hr Rainfall Forecast++ (inches)	6-hour Flash Flood Trigger
Thresholds	7.00	5.00	3.00	2.00	3.00
Current Max/Future Average Conditions	0.24	0.19	0.02	0.00	0.00

Figure 8 Local methods for flood threat assessment, such as the Contra Costa County 7-5-3-2 application, will be supported by generating rainfall amounts for the accounting periods, threshold levels, and zones. (https://www.contracosta.ca.gov/4923/Flood-Forecast-Tool)

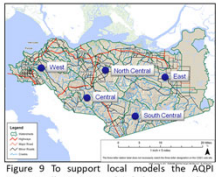

Figure 9 To support local models the AQPI system will retrieve and tabulate antecedent and forecast rainfall amounts for specific locations and/or zones as required. (https://www.contracosta.ca.gov/4923/Flood-Forecast-Tool)

Support for Local Models (cont)

Several SF Bay region flood agencies have developed sophisticated H&H models which may be used to simulate forecast flood flows and inundation areas. The AQPI project can provide forecast rainfall amounts for sub-basins of these models (Fig. 10).

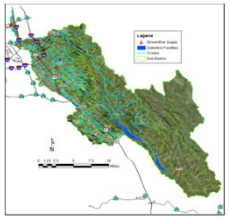

Figure 10 The AQPI project can parse rainfall amounts for sub-basins of local H&H models. Example for Santa Clara county shown.

Local H&H models may also be applied to map forecast flood inundation areas (Fig. 11).

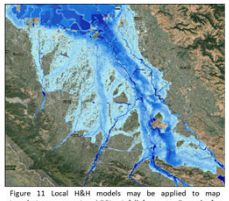

Figure 11 Local H&H models may be applied to map inundation areas using AQPI rainfall forecasts. Example for Santa Clara county shown. (Courtesy CSU Center of Excellence for Risk-Based Community Resilience Planning)

There is need to obtain forecast inflows into various reservoirs in the AQPI region. The NWM forecast flows for reservoir tributaries can tabulated and provided to support local agency water accounting procedures (Fig. 12). A demonstration of integrating NWM flows into a ResSim operations model was done (Fig. 13).

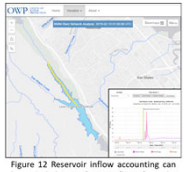

Figure 12 Reservoir inflow accounting can be provided using forecast flows from the NWM. Example for SFPUC's Crystal Reservoir shown.

Figure 13 ResSim model for upper Russian River was reconfigured using NHDplus stream reaches to accept NWM inflows.

Assessment of Hydrologic Products

Requirements for the content and format of the hydrologic products were identified with local flood response agency staff. Summaries follow:

- Users want AQPI rainfall parsed to their sites and basins as input to their local flood warning procedures and models.
- DHM approach rated of great interest as it provides hydrologic forecasts for all grid locations, including ungaged locations.
- Normalizing the flow levels to their flood frequency equivalent was strongly endorsed. Need to overlay flood impact levels onto the flow hydrograph, including TF and historic floods, and gage readings where available.
- The NWM was rated Sometimes to Frequently accurate enough for flash flood magnitude, location, timing, and impacts. Water management can be represented in local models for flood impacts and reservoir operations.
- Having all flood information in single place is very helpful; saves time and effort. A tool can be built that will help all areas, notwithstanding local staffing limitations.

Acknowledgements

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