NOAA U.S. Weather Research Program (USWRP)

Hydrometeorology Testbed (HMT)
Multi-Radar Multi-Sensor (MRMS) Hydro Experiment

In Coordination with the HMT Flash Flood and Intense Rainfall (FFaIR) Experiment

-- 2019 HMT-Hydro Experiment Executive Summary --

The fifth edition of the Multi-Radar Multi-Sensor (MRMS) Hydro Experiment (hereinafter denoted as "HMT-Hydro Experiment") focused on the issuance of experimental flash flood warnings for the hydrologic extreme of flash flooding during a select period of the warm season. The 2019 HMT-Hydro Experiment contained a blend of experiments with real-time data and archived case playback using prototype products and techniques. The experiment was conducted in close coordination with the seventh annual Flash Flood and Intense Rainfall (FFaIR) Experiment at the NOAA/NWS Weather Prediction Center (WPC) located in College Park, MD.

The 2019 HMT-Hydro Experiment ran for three weeks during a period from 24 June to 19 July 2019 with a one-week break during the Fourth of July holiday. Forecasters from the NWS Weather Forecast Offices (WFOs) and River Forecast Centers (RFCs) along with participation from other NWS entities and research institutions assessed emerging hydrometeorological technologies and products to improve the prediction, detection, and warning of flash flooding.

There were three primary topics of interest with the 2019 HMT-Hydro Experiment: 1) the use of probabilistic information to convey uncertainty of the flash flood threat, 2) the use of Warn-on-Forecast System (WoFS) quantitative precipitation forecasts (QPFs) for short-term prediction of potential flash flooding, and 3) the initial evaluation of probabilistic quantitative precipitation estimation (PQPE) products. Various objectives of the experiment were primarily conducted through real-time experimental warning operations and archived case studies. Each week finished up with a group discussion focusing on the probabilistic products and use of WoFS QPFs in the warning decision making process.

Real-time experimental warning operations focused on the use of four probabilistic gridded flash flood products forced by the Multi-Radar Multi-Sensor (MRMS) experimental dual-pol synthetic radar QPE with evaporation correction (e.g., Figure 1):

- Probability of Receiving a Flash Flood LSR
- Probability of Minor Flash Flooding
- Probability of Moderate Flash Flooding
- Probability of Major Flash Flooding

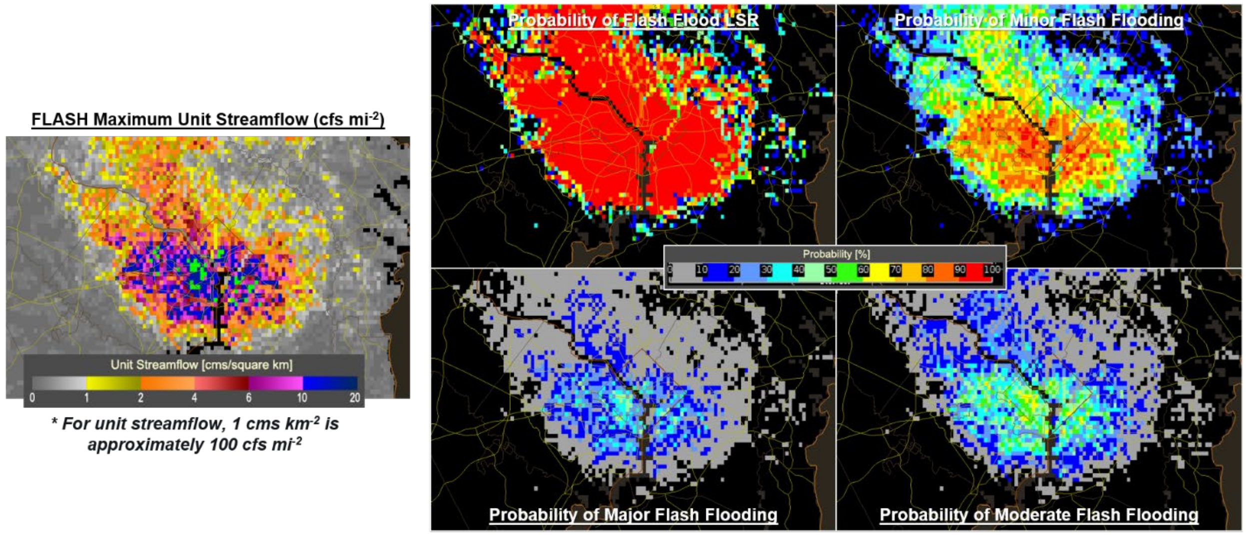

Figure 1. The Washington D.C. flash flood event as seen from the deterministic (left) and probabilistic (right) data at 1400 UTC 8 July 2019.

Participants utilized the various probabilistic data to issue experimental flash flood warnings (FFWs) using a modified WarnGen application. Each FFW issued had user-assigned probabilities for minor and major flash flood potential, while participants filled out survey questions on how the products influenced their warning decision. Subjective evaluations and feedback from the participants still showed perceived biases in the different probabilistic fields but were improved from the 2018 experiment. Evaluated experimental warnings with user-assigned minor and major probabilities were favorably rated with respect to timing, warning area, and assigned probabilities. Reliability diagrams for all experimental warnings still showed a tendency for overestimation of the assigned probabilities, yet the overestimation bias was improved upon from the 2018 experiment.

Changes in warning lead time and warning area were also assessed with the verified experimental FFWs. Twelve of the experimental FFWs had an increase in warning lead time compared to the operational FFWs. Three warnings had an increase of lead time > 30 minutes, with the OKX warning issued on 11 July having an 87-minute increase in lead time. Eight isolated flash flood events had smaller warned areas from the experimental FFWs. Five of the warning areas were over 50% smaller than the operational warning area. In all events except one, the reduction in the warned area was hundreds of square kilometers. The possibility is there to reduce false alarm area in FFWs, and the topic should consider future research.

The combination of forecasters assigning minor/major flash flood probabilities with the multiple gridded probabilistic products developed within the FLASH system provided a platform to not only give the uncertainty of a potential hazard existing but the uncertainty of the severity of the potential hazard. This approach should continue to be explored with flash flooding and other storm-scale hazards and within the concepts of the FACETs paradigm.

Archived case studies focused on the evaluation of the potential impacts of ingesting the WoFS QPFs into the flash flood prediction process. Forecasters were presented with three cases of varying degrees of flash flood potential and severity:

- Ellicott City, MD Event (1900 UTC 27 May 2018 to 2110 UTC 27 May 2018)
- Central Iowa Event (2200 UTC 30 June 2018 to 0140 UTC 1 July 2018)
- Sioux Falls CWA Event (2130 UTC 12 July 2018 to 0140 UTC 13 July 2018)

The cases focused on the coupling of the probabilistic FLASH data with the WoFS QPFs in a displaced real-time environment. Participants were given a new 0-3 h forecast every 30 minutes with a survey every half-hour regarding the uncertainty and confidence of the evolving flash flood threat. Participants were able to issue FFWs using the experimental probabilistic data that included the WoFS QPFs as a forcing.

Seven of the eight events had a positive increase in warning lead time (Table 4) for warnings that were issued prior to the first flash flood LSR. Four of the events saw an increase in average warning lead time by over 30 minutes using the experimental probabilistic FLASH data coupled with the WoFS QPFs, including the historic Ellicott City, MD flash flood of 2018 (Figure 2). The collocated flash flooding in Baltimore, MD had the average warning lead time increased by over an hour to an average lead time of 71.6 minutes using the experimental data (Figure 3). There were also multiple instances of the participants issuing flash flood statements (FFSs) to update their assigned minor and major probabilities based on the probabilistic FLASH data with WoFS QPFs.

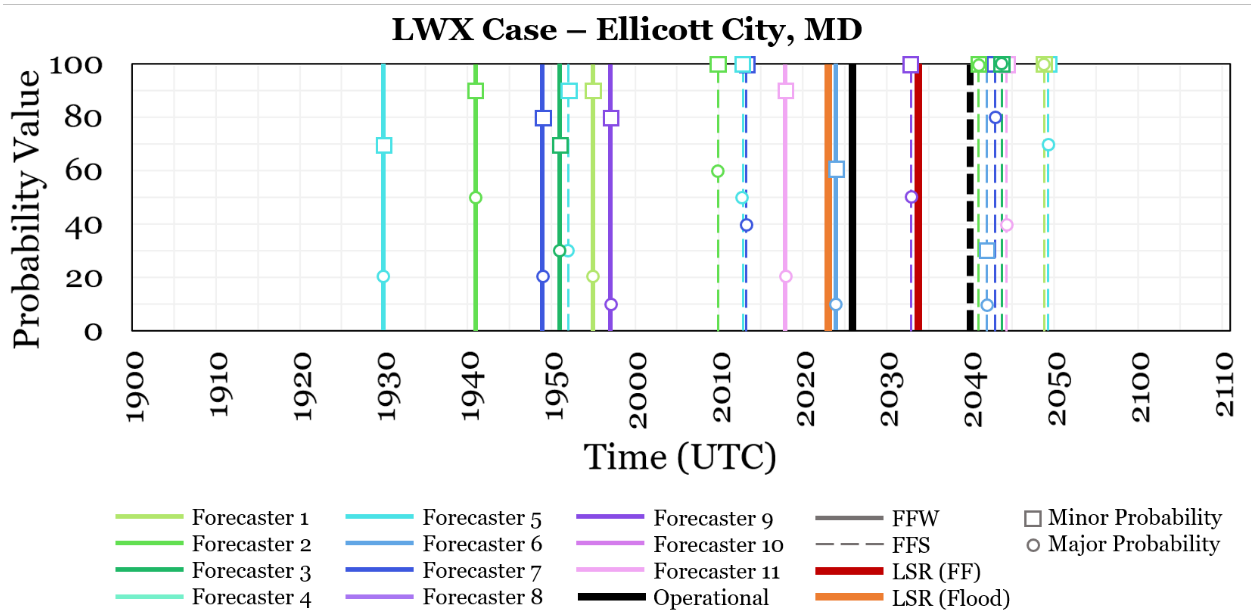

Figure 2. Timeline of all of the products issued along with LSRs for the Ellicott City, MD event in the LWX case. Forecaster experimental FFW (FFS) issuance are denoted by solid (dashed) lines in cool colors. The assigned minor (major) probabilities for each experimental FFW and FFS are denoted by a square (circle) at each time. The operational FFW (FFS) are denoted by a thick black solid (dashed) line. Flood LSRs are denoted by a thick orange line. Flash Flood LSRs are denoted by a thick red line.

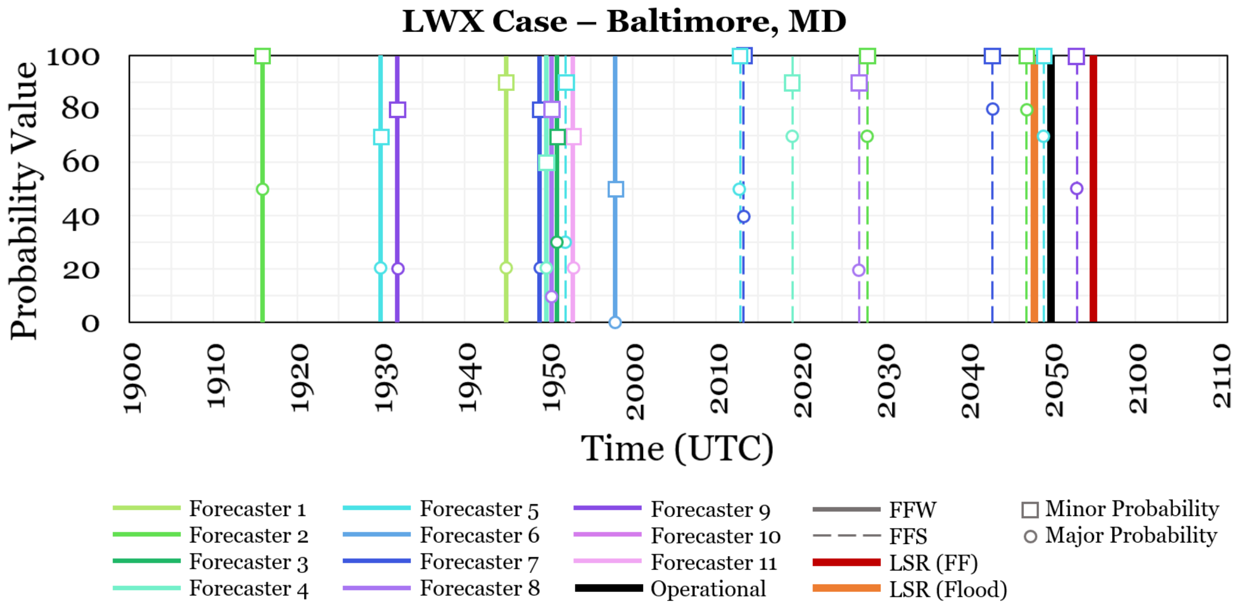

Figure 3. Same as Figure 3 except for Baltimore, MD in the LWX case.

The 2019 HMT-Hydro Experiment was the first time that participants were introduced to the PQPE product suite. A one-month data set for June 2017 was provided in a web-based format with six specific cases identified for initial analysis. Forecasters evaluated a variety of products related to the uncertainty information portrayed within the QPE data and the probabilities of exceeding various rainfall rate values. Analysis of instantaneous exceedance probabilities of rainfall rates of 25 mm h^{-1} and 50 mm h^{-1} along with temporal periods of 1 and 3 hours were found to be most relevant in understanding the magnitude of the rainfall event and the likelihood of flash flooding. Certain products were shown as being more favorable; moreover, feedback was given on how best to display the PQPE product suite. The initial set of results for PQPE will be used to refine the overall PQPE product suite.

The information and feedback gained during the 2019 HMT-Hydro Experiment will further the advancement of the science and application of probabilistic products and WoFS QPFs for flash flood prediction and warning issuance. Moreover, the lessons learned from the HMT-Hydro Experiment will help in the development of the Forecasting a Continuum of Environmental Threats (FACETs; https://nssl.noaa.gov/projects/facets/) framework for a next-generation severe weather watch/warning framework.

More information about the 2019 HMT-Hydro Experiment, including the full final report, can be viewed at https://blog.nssl.noaa.gov/flash/hwt-hydro/. For any questions regarding the 2019 HMT-Hydro Experiment, please contact the principal investigators:

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