

2017 Heavy Rainfall Guidance Tool: Upgrades and Operations

for the Urban Drainage and Flood Control District

INTRODUCTION

The Urban Drainage & Flood Control District (hereafter, District) Heavy Rainfall and Guidance Tool (hereafter, Tool) began operations in 2015. The Tool provides a quick, but comprehensive snapshot of the daily heavy rainfall risk across six Forecast Zones placed within and surrounding the District. The 2015 version of the Tool used raw Quantitative Precipitation Forecast (QPF) data from 12 high resolution weather models and showed encouraging results. The Tool was upgraded in 2016 to provide post-processing of raw data that was shown to increase the reliability of all forecasts. A preliminary investigation into 2016 performance showed fewer false alarms and an enhanced ability to distinguish between heavy rainfall threats in the high terrain, foothills and lower elevation locations of the District.

WORK PLAN

Task 1 – Scientific and Engineering Upgrades

Sub-Task 1 – Update post-processing algorithms

Using methods provided in the 2016 Technical Memo, Dewberry will update the post-processing equations to account for 2016 data. Additionally, we will investigate the possibility of more detailed post-processing such as the incorporation of seasonality. Note that this was omitted from 2015 data because that season was, from a climatological standpoint, very atypical with many heavy rainfall days during May and early June but limited days during the latter part of the season. The 2016 season was more typical and thus should allow for the incorporation of seasonality.

Benefits

- Leverages already developed methods from 2015
- Expected to further improve Tool reliability and accuracy, especially for probabilistic forecasts

Sub-Task 2 – Incorporation of High Resolution Rapid Refresh (HRRR) atmospheric model

Currently, the Tool is updated twice a day, roughly at 8:30AM and 1PM local time. The morning update includes 13 models, while the noon update adds another four. In situations where there are rapidly evolving atmospheric features in the afternoon hours, which happens on at least several days especially later in the season, the Tool tends to underperform. One solution is to incorporate guidance that updates more frequently. A prime candidate for this is the HRRR model, operated by the National Centers for Environmental Prediction. The latest version of HRRR updates hourly and is run to a lead time of 18 hours.

We propose adding the hourly HRRR guidance into the Tool. This will allow for (i) more information during the noon update and (ii) more frequent updates. Regarding (ii), we propose adding a mid-afternoon (3PM) and early evening (7PM) update cycle that will provide better awareness of rapidly evolving conditions as well as better capture the night-time heavy rainfall threat. An example of the benefit of adding the HRRR can be seen from the July 7, 2016 heavy rainfall event over the Palmer Ridge and Southeast Colorado as shown in Figure 1. This event occurred in the evening and overnight hours. However, note that the HRRR did not predict significant precipitation in Colorado until the 20Z (or 3PM local time) run. Such information would have been conveyed by the Tool in the Late Afternoon or Early Evening update, providing several hours of lead time to end-users.

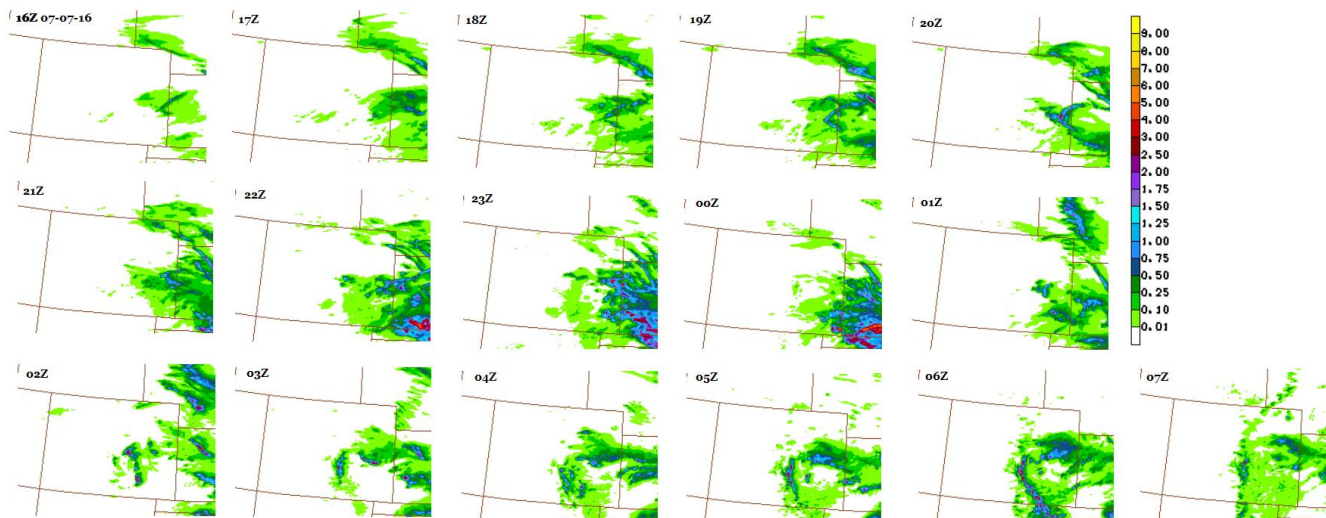


Figure 1: HRRR 15-hour precipitation forecasts, in inches, starting with 11AM (16Z) through 2AM (07Z) of July 7, 2016.

Benefits

- Additional forecast information for the noon update that will likely improve probability forecasts
- Two additional update times (mid-afternoon and early evening) will likely provide better awareness of rapidly evolving conditions as well as better capture the night-time heavy rainfall threat.

Task 2 – Outreach

While the Tool has undergone significant enhancements since the inaugural 2015 season, all of the upgrades have been geared towards improving its methods and performance. Of equal importance is for the Tool to be considered valuable by its intended end-users, comprising of Flash Flood Prediction Program (F2P2) meteorologists as well as area Emergency Managers and other decision makers. To aid in this effort, we will perform training sessions to educate users on the Tool’s methods and features, and solicit feedback on how the Tool can be improved to enhance its usability. Three trainings events are proposed:

1. Pre-season training and discussion with F2P2 meteorologists and the Boulder/Denver National Weather Service – to be held in March/April of 2017. This will help to educate technical users and how the Tool can help improve forecasts, as well as stimulate discussion and user feedback of what other features may be helpful to add or modify.
2. Pre-season training with end-users during April/May of 2017. This will provide a basic overview of the Tool functionality to non-technical end users. Feedback will be encouraged.
3. Mid-season or Post-season follow-up meeting with non-technical end-users to stimulate discussion on how the Tool has performed and areas for improvement.

Benefits

- Encourage Tool use through outreach to both technical and non-technical users.
- Determine direction of Tool’s future.
- Determine future enhancements to the Tool to better convey potential flood threats.

Task 3 – 2017 Operations

As for the previous two seasons, Dewberry recommends human-based QC when the forecasted rainfall poses a potential risk to the District. We recommend an “event-based” QC that will be conducted by a qualified Dewberry meteorologist, but only in situations where the Tool suggests threshold-exceeding rainfall (e.g. 1.0 inch/hour). The meteorologist will either provide a

stamp of approval, or a caution flag explaining why there may be an issue with that particular output of the Tool. This feature is described in the Tool's online User Manual. We estimate this process will be required on approximately 40% of the days during the F2P2 season, based on the historical record of Message Days.

In addition, the continuous automated QC routine that was developed in 2015 will continue to look for model ingestion and processing errors. Such issues will be quickly flagged, and users will be promptly notified about the potential impact on the day's guidance.

Hosting and Computing Platform

Dewberry will host the tool on our Amazon Web Services (AWS) platform, which ensures maximum uptime. All model data will also be stored on AWS and backed up weekly for subsequent validation purposes. The collective cost for hosting and computing will be \$200/month for the May-September period of the Tool's operations.

Deliverable:

1. There is no deliverable for this task. All QC logs and manual messages have been, and will continue to be, archived.

Task 4 – Validation Report

The importance of properly validating the Tool's performance is critical in evaluating the Tool's overall value. For example, 2015's validation highlighted scientific issues that were later explored in 2016 and resulted in an increase in the Tool's reliability and accuracy. Dewberry recommends an end-of-season validation for 2017 using the UDFCD's ALERT data, as well as gridded Gauge-Adjusted Radar Rainfall (GARR) estimates either through the District and/or through NOAA Stage IV. This proposal assumes that the GARR product will be provided to Dewberry by UDFCD through one of its vendors. Key aspects of the validation will investigate the Tool's performance in the following metrics:

- Was a flood threat realized (both across the full model domain and in each zone)?
- Was the timing reasonably forecasted?
- Was the forecasted QPFMAX consistent with observations?
- Was the probability forecast reliable? For example, if an event was forecasted 20% of the time, did it occur 20% of the time?

It is likely that the validation results will also provide insight on how and to what extent Tool performance can be further optimized.

Deliverable:

1. A final validation report that will include data and analysis for the 2017 operational season.

DAILY LOGISTICS

For 2017 Tool operations, we recommend adding two additional updates to the Tool, resulting in 4 updates per day. Note that the Table below includes HRRR output. The proposed update times are:

Update	Tool updated no later than:	# of models
Morning	8:30AM	Up to 17
Early afternoon	1PM	Up to 8
Mid afternoon	4PM	Up to 4
Early evening	7PM	Up to 4

Since 2015, the operational season has been from May 1 to September 30 and we do not recommend any changes for 2017.

SCHEDULE

The following schedule assumes a notice to proceed date of February 27, 2017. Earlier or later dates will allow us to adjust the schedule accordingly.

Task	Completion Date
1. Tool Upgrades	April 7, 2017
2. Outreach	To be determined
3. 2017 Operations	May 1 - September 30, 2017
4. Validation Report	November 1, 2017

STAFF

Staff	Proposed Role
Sam Crampton, P.E. <i>Principle-in-charge</i>	Principal-in-charge and will provide final quality assurance.
Dima Smirnov, Ph.D. <i>Project Meteorologist I</i>	Serve as the project manager and chief scientist, in charge of ensuring the Tool's scientific integrity and efficient operational performance.
Jason Giovanettonne, Ph.D. <i>Project Meteorologist II</i>	Provide Quality Control of the Tool's upgrades.
Brad Workman <i>Staff Meteorologist</i>	Serve as the primary day-to-day quality control meteorologist, responsible for monitoring the performance of the Tool.