

2020 Heavy Rainfall Threat Analysis: Upgrades and Operations

for the Mile High Flood District

INTRODUCTION

The Mile High Flood District (hereafter, District) Heavy Rainfall Threat Analysis (hereafter, Tool) began operations in 2015. The Tool provides a quick, but comprehensive snapshot of the daily heavy rainfall risk across five 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. From 2017 to 2019, there were more refinements that included the addition of new high-resolution atmospheric models, two additional Tool updates during the day and yearly updates to the post-processing algorithms. In 2019, a social media component was implemented through the Twitter platform. This strategy not only helped raise awareness for the Tool, but it also provided early flood detection to a new set of end-users on high threat days. The current proposal outlines the Tool upgrades and operational support in preparation for the 2020 heavy rainfall season.

WORK PLAN

Task 1 – Tool Upgrades

Task 1.1 – Incorporation of New High Resolution Atmospheric Model

After the 2017 forecast season, the NCAR and NSSL members were discontinued, which were a significant contribution to the Tool's ensemble. So prior to the 2018 season, the HRRR ensemble (HRRRE; 9 members) was added to the Tool, which helped increase the ensemble size for the probabilistic forecasts and provided more data for the early and mid-afternoon update. Theoretically, increasing the number of models in an ensemble helps generate several different forecast solutions, while improving statistics. It is proposed that the Colorado State University 4-km Weather Research and Forecasting Model (CSU-WRF) be added to the ensemble for the 2020 season. This convective allowing model has 4-km horizontal grid spacing and is initialized at 00Z each day out to 48-hours. Dewberry will work with Russ Schumacher, the state climatologist, to set up this data pull and retrieve training data for a bias correction before being ingesting the QPF into the Tool.

After a hindcast was completed for the 2019 season, it was determined (in a preliminary analysis) that the Tool's metrics improved when the Texas Tech University WRF members (TTU-WRFens) were removed. Reminder, that while the model has 52 members run with either perturbed physics or initial conditions; Dewberry was ingesting the 9 members that had perturbed physics with one of those members thrown out (unrealistic QPF along the Continental Divide). Past QPF for training was not available for the TTU-WRFens prior to the start of the season, so biases were likely introduced using the raw QPF. Dewberry will complete a more comprehensive analysis of each TTU-WRFens member to find if there is utility gained by keeping any of the model's eight remaining members. TTU-WRFens QPF prior to 2019 remains unavailable, so Dewberry proposes an add alternative for the MHFD below.

Similar to years past, in the case that there are days that have four or less contributing models to the Tool, Dewberry will automatically issue a "use with caution" message at the top of the Tool. While it has not been an issue previously, it is possible that the numerical models may produce no files for a run, or the entire day, due to errors outside of Dewberry's control. Further, a Dewberry meteorologist will provide daily quality control of the Tool to makes sure the automated caution message suffices or needs to be manually updated.

Benefits:

- An additional, trained new numerical model and likely removal of the TTU-WRFens for 2020 will improve the probability forecasts and continue to incorporate the latest technology.

Add Alternative

The TTU-WRFens was created to compete with other NOAA/NWS operational convective-allowing models, which if trained, will likely help continue to advance and support the best available objective flood warning system to the District. For the 2020 season, Dewberry can continue collect the TTU-WRFens data. While it is unknown how many years of data are needed to train the raw QPF, two years may be enough data for an effective bias correction for the model's ensemble members. This would possibly allow the TTU-WRFens to become operational in the Tool again by 2021. Dewberry is currently working with Group NIRE to negotiate a lower price for this data.

Task 1.2 – Update Post-Processing Algorithms and Bias Corrections

To continue to refine the Tool's reliability and accuracy, Dewberry will update the post-processing equations and bias corrections to account for the 2019 data. Specifically, Dewberry will explore:

- Explore improvements to the post-processing techniques from (1) QPF based predictors, (2) non-QPF, atmospheric-based predictors and (3) possible other predictors such as seasonality and location (e.g. higher versus lower elevation zones). Using an area average value of non-QPF, atmospheric based predictors will also be tested as this may better represent the surrounding environment,
- Review change made in 2019 to the probability of exceedance thresholds, in particular, for days with high and moderate threats. Dewberry will also utilize past season data to pick the appropriate low threshold to avoid "misses",
- Examine the IDF data provided to F2P2 to make sure the QPF-Max value is capped at an appropriate value. Currently, this value is capped at 2.8 inches (Dewberry, 2019),
- Add a bias correction for the HRRRE now two years of QPF have been collected.

Sub-Task 2 – An additional evening Tool update

Currently, the Tool is updates three times a day, roughly at 8AM, 1PM and 4:30PM local time. An evening update is proposed to provide better awareness of the overnight heavy rainfall threat and offer ample lead time for end-users. This will be particularly useful during late night frontal passes, which can sometimes trigger post-frontal upslope flow heavy rainfall events. Additionally, if rainfall has ended for the day, the evening update will reflect this downtick in probability of heavy precipitation. The "cooling off" of the Tool's heavy rainfall threat will look less alarming to the end-users should they navigate to the page after hours.

Benefits:

- Evening update will give better situational awareness to end-users about the overnight heavy rainfall threat,
- Continues to leverage and develop new methods to improve Tool reliability and accuracy,
- Tool will continue to be adjusted to maximize the Hit Rate, while minimizing the Miss Rate.

Deliverables:

- An updated post-processing method to be used by the Tool during the 2020 season. All changes will continue to be archived by Dewberry and are available upon request,
- An added folder to the online archive for the evening forecasts.

Task 2 – 2020 Operations

Task 2.1 – Daily Quality Assurance and Maintenance of Operations

Although the Tool is to a large extent automated, there are two aspects that still require manual quality control. First, in situations where very few atmospheric models successfully download, Dewberry will provide a warning message cautioning users that accuracy may be temporarily degraded if 4 or less models are available. In practice, we foresee this only being an issue for the morning (i.e. first) update around 8AM MDT since more models are continuously added throughout the subsequent updates. Second, a Dewberry meteorologist will provide daily quality assurance that Tool output makes physical sense and is properly visualized on the website. If there is a high threat day, Dewberry will reach out to the MHFD project manager to provide situational awareness and be prepared to create a social media post for the District.

Hosting and Computing Platform

Dewberry will host the Tool on our Amazon Web Services (AWS) platform, which ensures maximum uptime. The Tool's daily updates will be archived and available through the Tool's website ("Archives" page). All data will be backed up monthly. Dewberry will provide a domain name and SSL certificate for the client to ensure a proper working website. The collective cost for hosting and computing will be \$204/month for the May-September period of the Tool's operations.

Deliverable:

1. All QC logs and manual messages have been, and will continue to be, archived and made available upon request.

Task 2.2 – Outreach/Education Contingency

A key purpose of the Tool is to effectively communicate the daily flood potential within the District's service area, which include the Flash Flood Prediction Program (F2P2) meteorologists, area Emergency Managers and other decisions makers. Training during 2017 educated users on the Tool's methods and features. In 2019, Dewberry completed a Tool survey to see how end-users were using it for their individual professions. Additional training interest was generated around this survey, so to continue this effort, Dewberry will complete another educational session that will be performed in coordination with the MHFD project manager as agreeable by both parties prior to the start of the 2020 season. Furthermore, Dewberry will incorporate feedback from the survey into the outreach. Dewberry will obtain a notice to proceed for Task 2.2.

Benefits:

- Communicating the features of the Tool to key end-users,
- Use feedback from the outreach for further refinement of the Tool.

Deliverable:

1. Dewberry meteorologists and/or hydrologists will develop and tailor presentations for the outreach,
2. Minutes of all outreach/education events will be available upon request.

Task 2.3 – Social Media Component

Social media, in particular the Twitter platform, has been proven adept for quickly and simply delivering important messages to end-users. In 2019, to further increase usage of the Tool, MHFD requested the development of tweets for their ALERT Flood Detection Twitter account to supplement the Tool's daily output on higher threat days. Initial results of this analysis show a successful 2019 Twitter campaign (Dewberry, 2019). Prior to the start of the 2020 season, Dewberry will further analyze and review the success of the tweets produced for the Tool. Moreover, Dewberry will improve the protocol and image templates with feedback received by end-users and the MHFD project manager. Prior to the 2020 monsoon season, there will be a

collaborative meeting between Dewberry and the MHFD project manager prior to finalizing changes made to the social media campaign.

Benefits:

- Communicating the features of the Tool to key end-users through the MHFD Twitter account,
- Use feedback for further refinement of the Tool or graphics,
- Continue to expand the pool of end-users.

Deliverable:

1. In-house database of relevant, static images that can be attached to the Tweet for visual display of the threat,
2. Technical write-up of the changes made to the social media campaign in the monthly report given to the MHFD project manager.

Task 3 – 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 by providing post-processing of the QPF-Max. Dewberry recommends an end-of-season validation for 2020 similar to 2019 that includes usage of the MHFD’s ALERT data, gridded NOAA Stage IV estimates and CoCoRaHS data for quality control. Additionally, use of other QPE data will be considered prior to beginning the validation with the project manager. 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 QPF-Max 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 2020 operational season and, as warranted, recommendations for future enhancements.

DAILY LOGISTICS

For 2020 Tool operations, Dewberry recommends 4 updates per day. The proposed update times are:

Update	Tool roughly updates at:
Morning	8:15AM
Early afternoon	1:15PM
Mid afternoon	4:30PM
Evening	7:00PM

Since 2015, the operational season has been from May 1 to September 30 and we do not recommend any changes for 2020.

SCHEDULE

The following schedule assumes a notice to proceed date of April 1, 2020. Earlier or later dates will allow us to adjust the schedule accordingly.

Task	Completion Date
1. Tool Upgrades	May 1, 2020
2. 2020 Operations	May 1 - September 30, 2020
3. Validation Report	November 30, 2020

STAFF

Staff	Proposed Role
Danny Eisner <i>Project Manager</i>	Danny will provide final quality assurance and be the administrative point of contact for the client.
Dana McGlone <i>Meteorologist I</i>	Dana will serve as the technical point of contact for the client. She will be in charge of day to day quality control of Tool output. Dana will also work closely with Jason on Tool improvements before 2020 operations begin.
Jason Giovannettone, Ph.D. <i>Meteorologist II</i>	Jason will help implement and provide quality control of the Tool's upgrades.
Ravi T. Pavuluri <i>Developer</i>	Ravi will provide application development for the Tool operations and help build the social media platform.

REFERENCES

Dewberry, 2019: 2019 MHFD Heavy Rainfall Threat Analysis Tool. Report submitted to Mile High Flood District. 43 p.