

2019 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 Guidance Tool (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. In 2017, the two main refinements were (i) to add the HRRR weather model to the model ensemble and (ii) to provide three daily updates, compared to 2016's two updates. Prior to the start of the 2018 season, the Tool was (i) reduced from six forecast zones to five to create more reliable and accurate forecast across the District and (ii) incorporate new high resolution atmospheric models to improve probability forecasts and help alleviate the effects of discontinued ensemble data. This proposal outlines the scope of Tool upgrades and operations for preparation of the 2019 heavy rainfall season.

WORK PLAN

Task 1 – Tool Upgrades

Task 1.1 – Website Updates

Since Dewberry began the Tool's operation in 2015, archives of the daily data and logs have been available to the public. In order to better organize the data, and provide multiple updates throughout the day, Dewberry will work on the structural presentation of the data on the "Archives" page of the website. In addition, updates to the "Help" page will include looking into adding a glossary of relevant flood terms, and on the main page, simplifying QPF language. In order to efficiently and accurately make changes, a test group of Tool users will be sent a short list of questions that will help clarify website usage and applications. This will help drive specific website updates and changes to the Tool's presentation. Lastly, a domain name and SSL will be obtained to bring the website up to industry standards.

Benefits:

- Better organization of archived logs and forecasts will make easier searches for historical data, while other updates will help improve the presentation and application of the Tool for end-users.

Task 1.2 – Incorporation of New High Resolution Atmospheric Models

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. Increasing the number of models in an ensemble helps generate several different forecast solutions, while improving statistics, which is why Dewberry proposes adding the Texas Tech University WRF ensemble (TTU-WRF-Ens) for the 2019 season.

The TTU-WRF-Ens was created to compete with other NOAA/NWS operational convective-allowing models, which will help continue to advance and support the best available objective flood warning system to the District. While the model has 52 members run with either perturbed physics or initial conditions, Dewberry recommends starting with the 9 members that have perturbed physics. The model is initialized two times daily (00Z and 12Z) out to 48 hours with 4km output, which means an

additional 9 runs will be added to the morning update with 18 runs added to the noon and afternoon updates. In order to continue and maintain stable funding for the TTU-WRF suite of products, TTU sells their data through a third party. Dewberry proposes working with this 3rd party (Group NIRE) to negotiate the best price for this data.

In addition, the HRRR (initialized hourly) now produces data out to 36-hours for the 00Z, 06Z 12Z and 18Z runs (all other hours produce 18-hour forecasts). Therefore, it is also proposed to extend the HRRR's QPF forecast out to 24 hours with the 00Z, 06Z and 12Z runs. Dewberry will continue to monitor the research and development of high resolution numerical models for additional ensemble model members in future forecast seasons.

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 make sure the automated caution message suffices or needs to be manually updated.

Benefits:

- Additional new numerical models and more hourly QPF forecasts will improve probability forecasts, incorporate new technologies and continue to help alleviate the effects of the discontinued ensemble data from 2017.

Task 1.3 – Update Post-Processing Algorithms

To continue to refine the Tool's reliability and accuracy, Dewberry will update the post-processing equations to account for the 2018 data. Specifically, we will 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).
- Review changes made in 2017/2018 to the probability of exceedance thresholds, in particular, for days with high and moderate threats. Dewberry will also utilize past season data to pick a lower threshold for low threat days to avoid miss events.

Benefits:

- 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 2019 season. All changes will continue to be archived by Dewberry and are available upon request.

Task 2 – 2019 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.

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 also upgrade the domain name and obtain a SSL certificate for the client. 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 over the District to end-users, 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. To continue this effort, Dewberry will work with SkyView Weather to put in a contingency for general outreach and education sessions that will be performed in coordination with the UDFCD project manager as agreeable by both parties prior to obtaining a notice to proceed for Task 2.2.

Benefits:

- Communicating the features of the Tool to key end-users,
- Potentially use feedback for further refinement of the Tool.

Deliverable:

1. Dewberry meteorologists and/or hydrologists will develop and tailor presentations for each event,
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. To further increase usage of the Tool, UDFCD has requested the development of a social media component to supplement the Tool's daily output on higher threat days. After discussion with the UDFCD project manager, we believe there is an optimal frequency of tweets that balances providing important notices while not over-sharing, which can desensitize users and make Tool output less effective. Dewberry proposes creating 5 message templates and a database of relevant images for Tweets that can be easily assembled for use by the UDFCD project manager at their discretion. One template will include an alert message in case the Tool's output has substantially changed at the N2 (1PM) update. For example, this message could be used to indicate either increases or decreases in the threat level and/or spatial extent.

Development of the templates will include a collaborative meeting between Dewberry and the UDFCD project manager prior to the start of the flood season, which includes an analysis of the optimal time to send the early warning Tweet out. Dewberry also proposes alerting the UDFCD project manager on any high threat days or days the heavy rainfall threat significantly changes from the N1 to N2 update.

Benefits:

- Communicating the features of the Tool to key end-users through the UDFCD Twitter account,
- Potentially use feedback for further refinement of the Tool or graphics.

Deliverable:

1. Dewberry meteorologists and the UDFCD project manager will develop 5 message templates for use with the UDFCD Twitter account,
2. Database of relevant, static images that can be attached to the Tweet for visual display of the threat.

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 QPFMAX. Dewberry recommends an end-of-season validation for 2019 similar to 2018 that includes usage of the UDFCD’s ALERT data, gridded NOAA Stage IV estimates and CoCoRaHS data for quality control. 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 2019 operational season and, as warranted, recommendations for future enhancements.

DAILY LOGISTICS

For 2019 Tool operations, Dewberry recommends 3 updates per day. The proposed update times are:

Update	Tool updated no later than:
Morning	8:30AM
Early afternoon	1PM
Mid afternoon	4PM

Since 2015, the operational season has been from May 1 to September 30 and we do not recommend any changes for 2019.

SCHEDULE

The following schedule assumes a notice to proceed date of April 15, 2019. Earlier or later dates will allow us to adjust the schedule accordingly.

Task	Completion Date
1. Tool Upgrades	May 1, 2019
2. 2019 Operations	May 1 - September 30, 2019
3. Validation Report	November 30, 2019

STAFF

Staff	Proposed Role
Danny Elsner, PE, CFM <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 improvement before 2019 operations begin.
Jason Giovannettone, Ph.D. <i>Meteorologist II</i>	Jason will help implement and provide quality control of the Tool upgrades before the 2019 operations with Dana. He will also help monitor performance of the Tool throughout the season.
Ravi T. Pavuluri <i>Developer</i>	Ravi will provide application development for the Tool operations and help build the social media platform.

COST

We propose an hourly not to exceed cost of \$52,398 to complete the project.

Labor	Project Manager		Meteorologist I		Meteorologist II		Developer		Total	
	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost
	\$	140.00	\$	110.00	\$	132.00	\$	110.00		
1 Heavy Rainfall Guidance Tool Upgrades	3	\$420.00	127	\$13,970.00	30	\$3,960.00	6	\$660.00	166	\$19,010.00
Website Updates	1	\$140.00	12	\$1,320.00	0	\$-	6	\$660.00	19	\$2,120.00
Incorporation of New High Resolution Atmospheric Models	1	\$140.00	75	\$8,250.00	0	\$-	0	\$-	76	\$8,390.00
Update Post-Processing Algorithms	1	\$140.00	40	\$4,400.00	30	\$3,960.00	0	\$-	71	\$8,500.00
2 2018 Operations	3	\$420.00	208	\$22,880.00	2	\$264.00	20	\$2,200.00	233	\$25,764.00
Daily Quality Assurance and Maintenance of Operations	1	\$140.00	153	\$16,830.00		\$-	20	\$2,200.00	174	\$19,170.00
Outreach/Education Contingency	1	\$140.00	30	\$3,300.00	1	\$132.00	0	\$-	32	\$3,572.00
Social Media Component	1	\$140.00	25	\$2,750.00	1	\$132.00	0	\$-	27	\$3,022.00
3 Validation Report	1	\$140.00	50	\$5,500.00	2	\$264.00	0	\$-	53	\$5,904.00
Labor Subtotal	7	\$980.00	385	\$42,350.00	34	\$4,488.00	26	\$2,860.00	418	\$50,678.00
Other Direct Costs										
	Qty	Unit Cost	Total Cost							
Cloud Computing (per month)	5	\$200.00	\$1,000.00							
Hosting/SSL (per month)	5	\$4.00	\$20.00							
Texas Tech Ensemble (per month)	5	\$140.00	\$700.00							
		ODC Subtotal	\$1,720.00							
Total Estimated Cost										\$52,398.00
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