Evaluation and Guidance Development of HAFS Version A QPF over the Caribbean and Surrounding Regions

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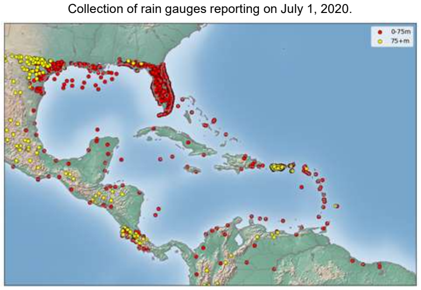
Background

- 27% of tropical cyclone (TC) deaths are caused by freshwater floods from extreme rainfall (Rappaport, 2014).
- Flood deaths occur more often than deaths resulting from any other hazard associated with TCs (Rappaport, 2014).
- Skillful TC track forecasts are associated with skillful quantitative precipitation forecasts (QPF; Lonfat et al. 2007, Marchok et al. 2007).
- Hurricane models (HWRF) have shown to provide skillful QPF forecasts in comparison to global models (GFS; Ko et al. 2020).
- **GOALS:**
  1. Analyze 2020 hurricane season for extreme precipitation over Caribbean and surrounding regions using HAFS v0.1A.
  2. Post-process high-percentile precipitation for 2021 hurricane season for the same region with special focus on elevated terrain using HAFS v0.1A.

Datasets

- 2020 Hurricane season evaluation period:
  - July 2020 – November 2020
- HAFS v0.1A QPF is model used for evaluation
- Stage IV gridded rainfall observations are used over CONUS
- Collection of rain gauges are used over Caribbean, Central and South America, and Southeast U.S. Obtained from:
  - Caribbean Institute for Meteorology and Hydrology (**CIMH**)
  - National Meteorological Institute in Costa Rica (**IMN**)
  - Climate Prediction Center (**CPC**), NWS, NOAA
  - Community Collaborative Rain, Hail, and Snow Network (**CoCoRaHS**)
- **2004** stations reporting at 12 UTC daily
  - There are some daily inconsistencies in stations reporting.

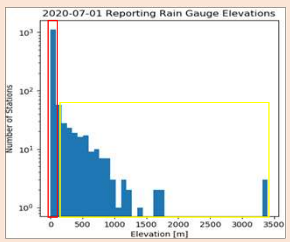
Collection of rain gauges reporting on July 1, 2020.

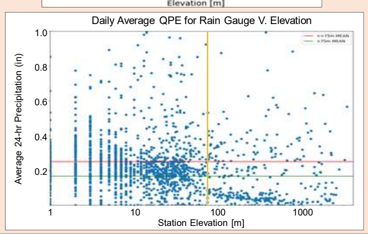


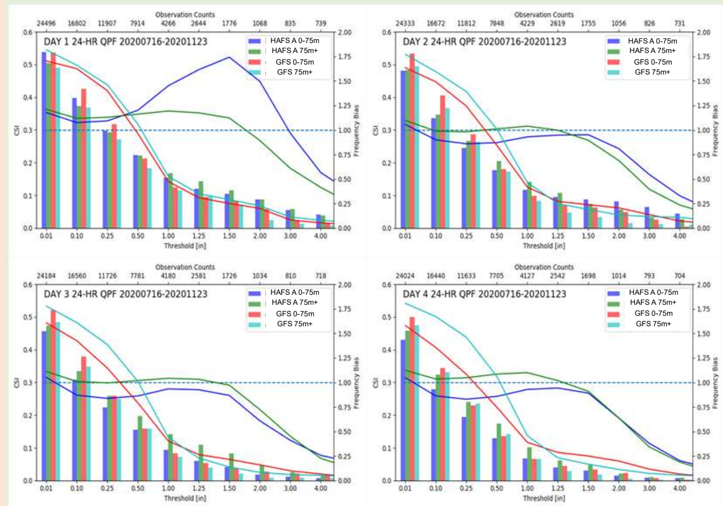
2020 Hurricane Season QPF Verification using Gauges

Rain Gauge Elevation Analysis

- Why partition data by elevation?
  - Investigate the difference between the forecasted rainfall near sea level and in higher terrain (likely further from coast).
  - Is the influence of orographic features observed within the model forecast?
  - If pattern exists, can this influence be included within bias-correction?
- 75 meters ASL splits dataset well with geographically diverse distribution.
- Rain characteristics for gauges above and below 75m also have different daily average rainfall.



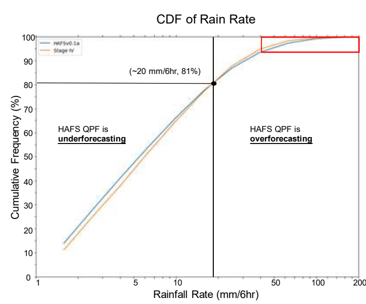


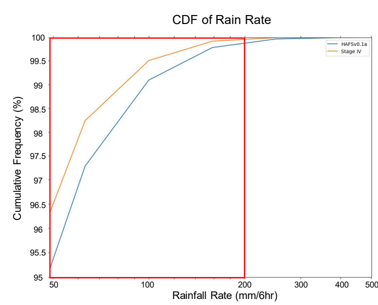


Bulk Critical Success Index (CSI) Statistics

- GFS outperforms HAFS in rainfall thresholds **UP TO** 0.25 inches.
- HAFS improves skill over GFS at higher thresholds (greater than 0.25 inches) for shorter lead times (days 1 & 2).
- HAFS f-bias is much closer to 1 in all scenarios in comparison to GFS.
- Evaluating skill by elevations:
  - Higher terrain forecasts perform better for HAFS on days 3 & 4.
  - Days 1 & 2 don't show conclusive evidence of difference in skill between station elevations.

QPF Bias analysis using Stage IV QPE





Cumulative Distribution Function (CDF) Statistics

- Completed for landfalling TCs over CONUS during 2020.
- Overall, HAFS produces rain rates close to Stage IV observations.
- HAFS initially produces higher frequency of lowest rain rates which prolongs underforecast.
- High percentile events (greater than 95% cumulative frequency) have potential for large overforecasting deviations.

Bias Correcting Model QPF

- **Goal**: Use observed QPE and model QPF along with other atmospheric parameters to reduce bias and increase the skill of the forecast QPF.
- **Testing Sample**:
  - "Fitting" dataset will be 2020 hurricane season using HAFS v0.1A
  - "Evaluation" dataset will be 2021 hurricane season using HAFS v0.2A
- **Start Simple**:
  - Preliminary testing will use linear regression to calibrate the model.
  - Uses probabilistic techniques to obtain a deterministic forecast.
- **Increase Complexity**:
  - Develop bias-correction algorithm using machine learning.
  - Build a Neural Network algorithm using similar information that is ingested into linear regression algorithm.
  - Removes linear dependence on predictors and decreases developer bias.
- **Inclusion of atmospheric parameters:**
  - To better inform the bias correction algorithm, various atmospheric parameters will be included (upslope flow, relative humidity, and precipitable water).

Future Work

- Produce bias-corrected QPF for HAFS v0.2A while considering the influence of elevation on rainfall.
- Verify skill of bias-corrected forecast using metrics already established for HAFS v0.1A.
- Expand verification to gridded analysis over the model domain to supplement gauge verification.
  - Two datasets that would work over the Caribbean are CMORPH (CPC product) and IMERG (NASA product).
  - Caveat: QPE derived from satellites carry their own bias to account for in verification process.
- End goal: Develop a well analyzed bias-correction scheme to recommend for implementation in future HAFS versions that provides enhanced information for elevated terrain QPF.

References

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