

Improving NOAA's water tools through physically motivated, data-driven, and hybrid modeling techniques

Mimi Hughes

Coauthors: Nachiketa Acharya, Diana Stovern, Kelly Mahoney, Ryan Currier, and Rob Cifelli



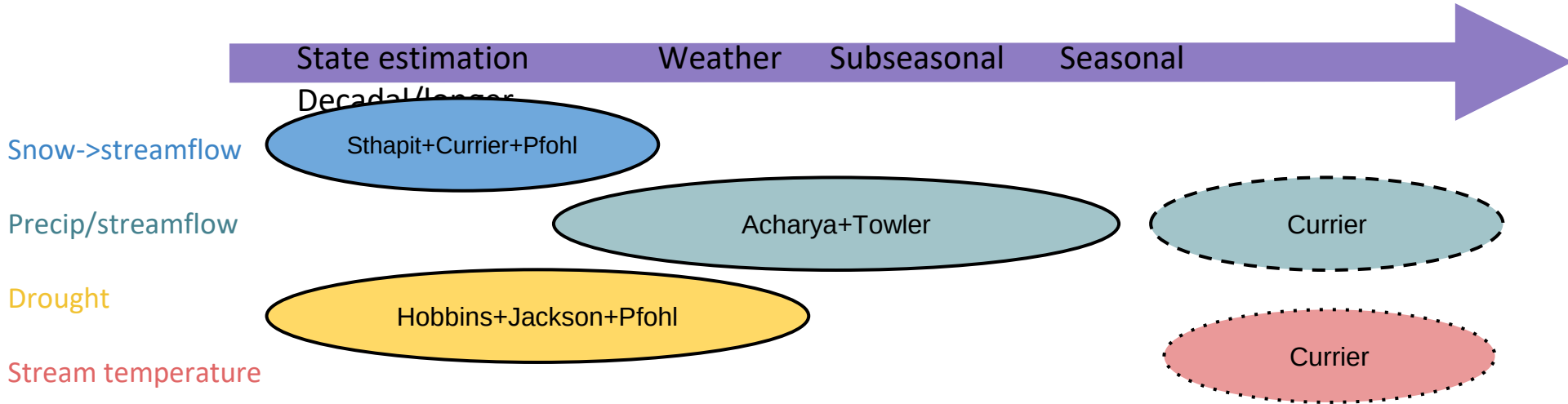
BIL NextGen: Improvements to NOAA's water forecasts

Overarching goal: To support and contribute to transformations in NOAA's water prediction tools through research to accelerate future developments and improvements for NOAA water modeling systems that are existing and/or under development.

- Explore, test, and validate innovative approaches to improve estimates and forecasts from these hydrological modeling tools through a combination of *machine learning* and *physical process-based* land surface and hydrologic modeling techniques, and through *hybrid* methods that incorporate aspects of both types of models.

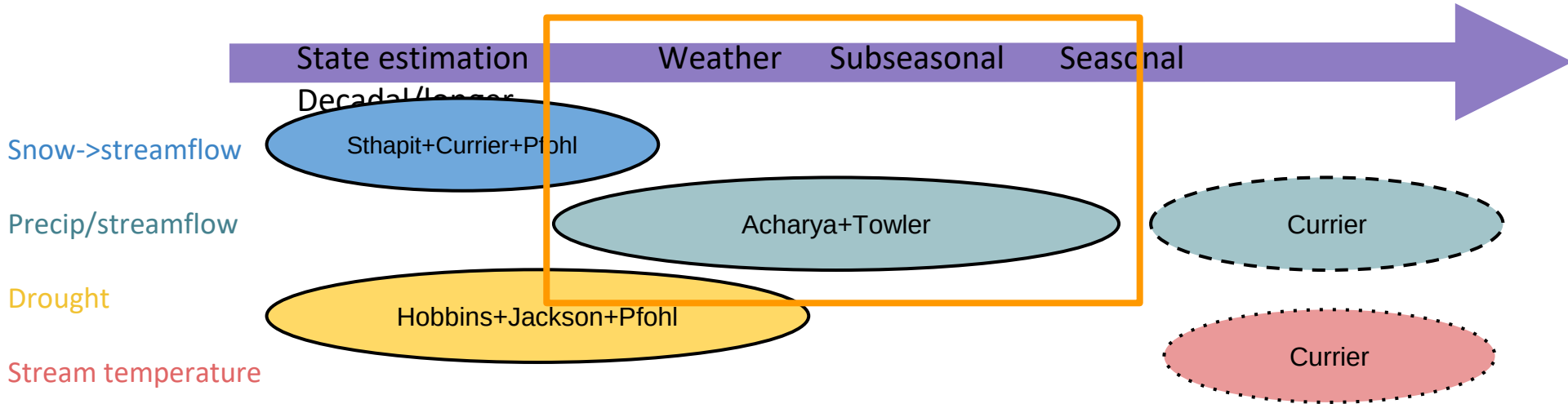
BIL == Bipartisan Infrastructure Law aka IIJA

BIL NextGen: Improvements to NOAA's water forecasts



- Data driven estimation of snow and spatial resolution impact on streamflow with NOAA Office of Water Prediction
- Ensemble forecasts of precipitation, temperature, and streamflow with NOAA Office of Water Prediction
- Dynamically downscaled hydroclimate projections with US Bureau of Reclamation
- Improved drought characterization, early warning, and forecasts with NOAA Climate Prediction Center
- Mid to end of century predictions of stream temperature with NOAA Fisheries

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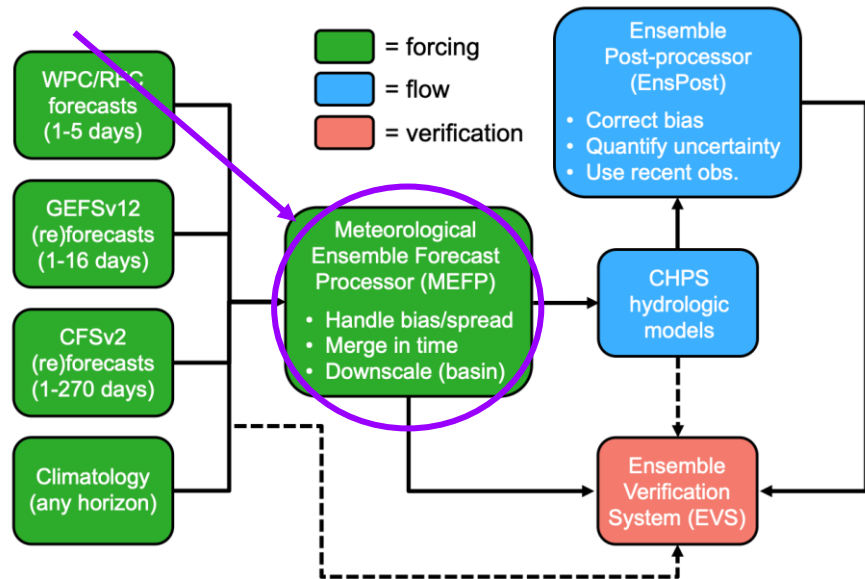
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Ensemble streamflow predictions

Improvement of the meteorological forcings for the Hydrologic Ensemble Forecast Service (HEFS).

Nachiketa Acharya is applying machine learning techniques to improve predictions (on scales of hours to seasonal) of atmospheric forcings, and Erin Towler will test those improvements in an ensemble streamflow prediction system.

HEFS workflow

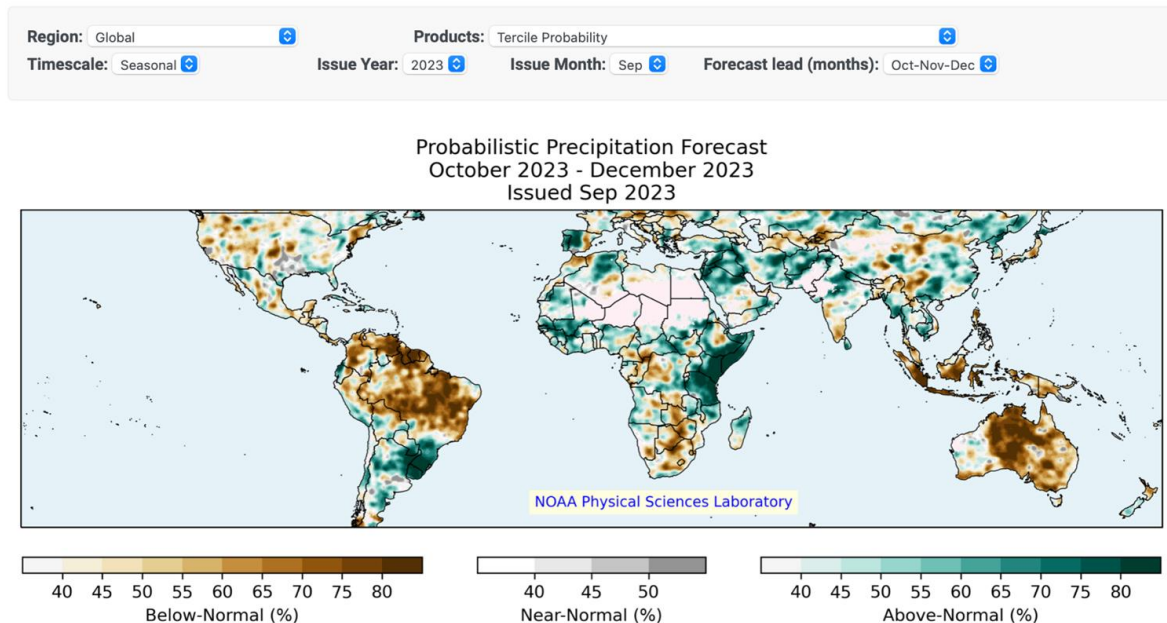


Calibrating precipitation forecasts: Example of ML based experimental monthly and seasonal forecast at NOAA-PSL (funded by FEWS-Net)

Experimental Probabilistic Monthly and Seasonal Precipitation Outlook by a Hybrid Prediction (Dynamical and Machine Learning Models) System

- Uses Extreme Learning Machine to calibrate dynamical model outputs
- Higher resolution (i.e., 0.25 degree) than other seasonal forecast products
- Extends upon standard 'tercile probability' to include probability of lowest/highest 20%
- Website includes skill assessment from hindcast period as well as on-the-fly moving forward

https://www.psl.noaa.gov/forecasts/s2s_fewsnet/

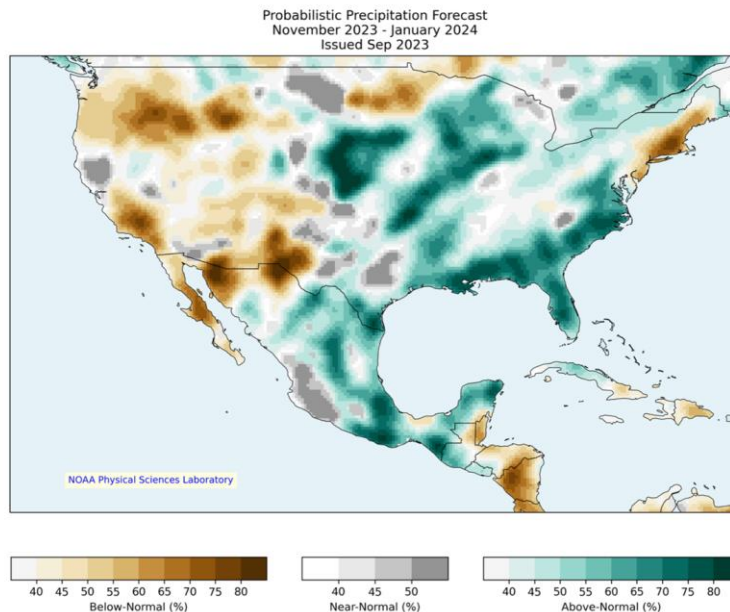


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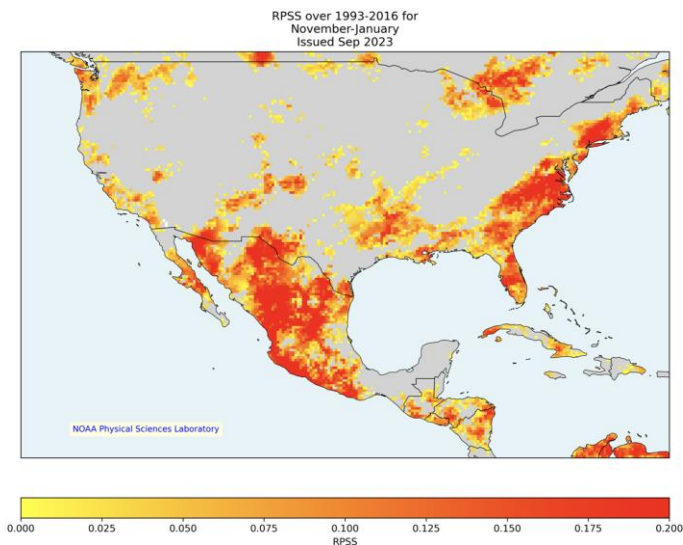
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Timescale: Seasonal Issue Year: 2023 Issue Month: Sep Forecast lead (months): Nov-Dec-Jan



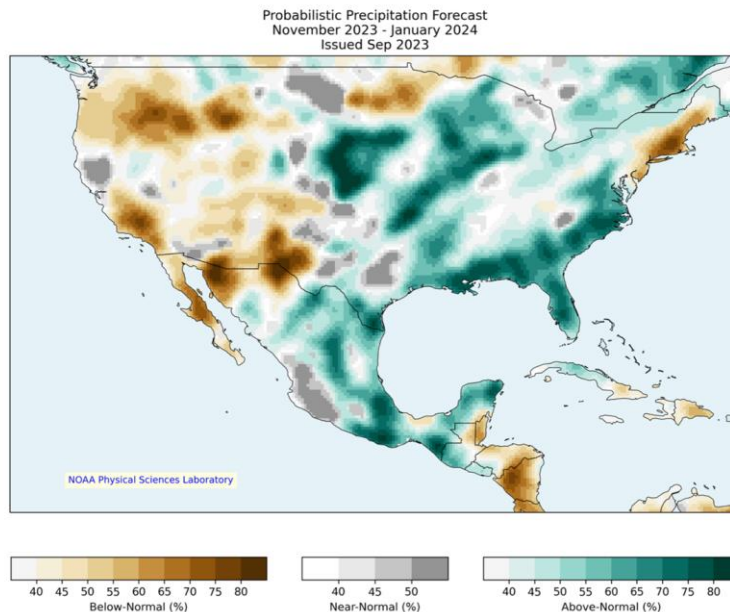
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Calibrating precipitation forecasts

JUNE 2023

HAMILL ET AL.

Improving National Blend of Models Probabilistic Precipitation Forecasts Using Long Time Series of Reforecasts and Precipitation Reanalyses. Part I: Methods

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(Manuscript received 8 November 2022, in final form 27 February 2023, accepted 1 March 2023)

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STOVERN ET AL.

Improving National Blend of Models Probabilistic Precipitation Forecasts Using Long Time Series of Reforecasts and Precipitation Reanalyses. Part II: Results

DIANA R. STOVERN^{a,b}, THOMAS M. HAMILL^{b,c} AND LESLEY L. SMITH^{a,b}

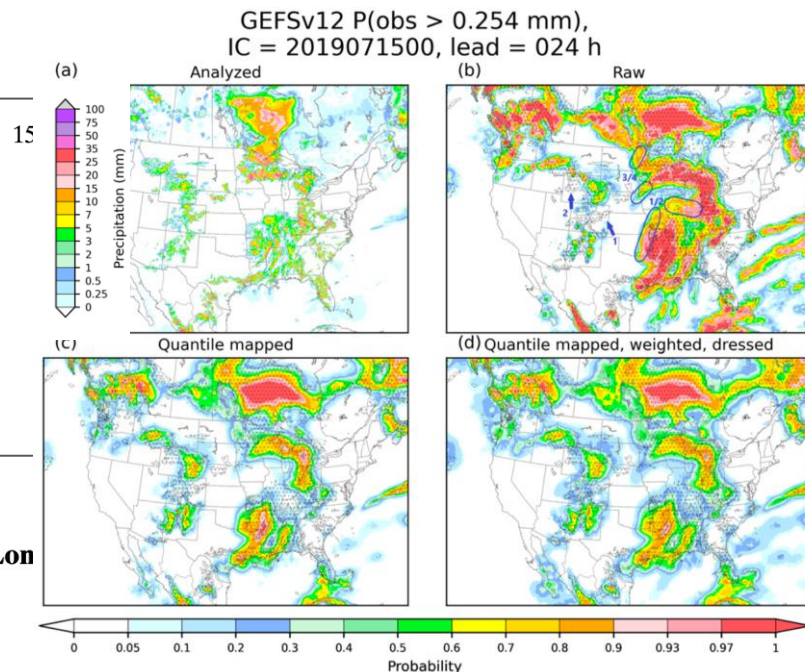
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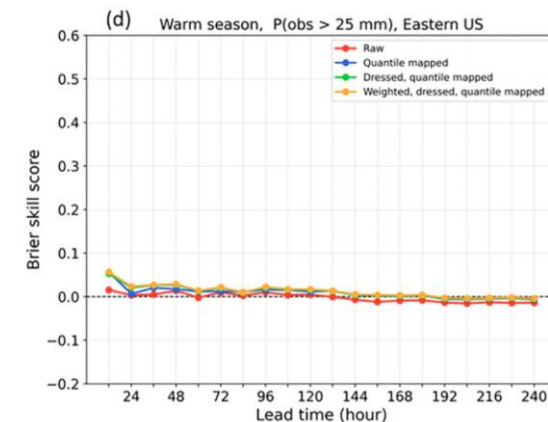
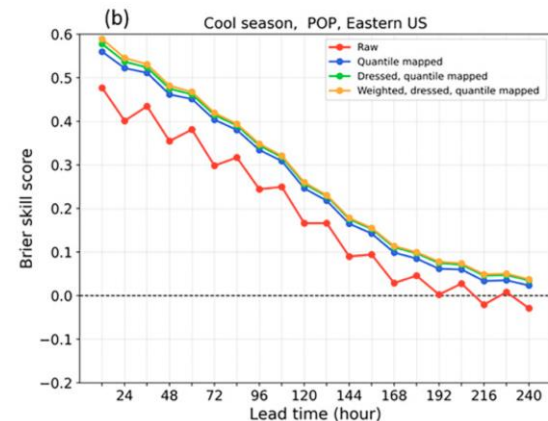
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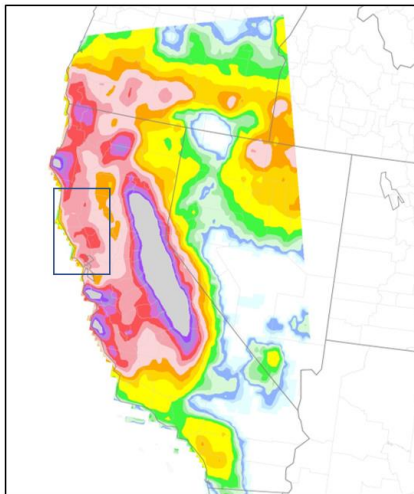
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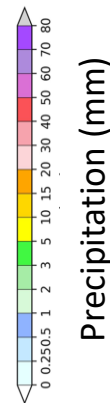
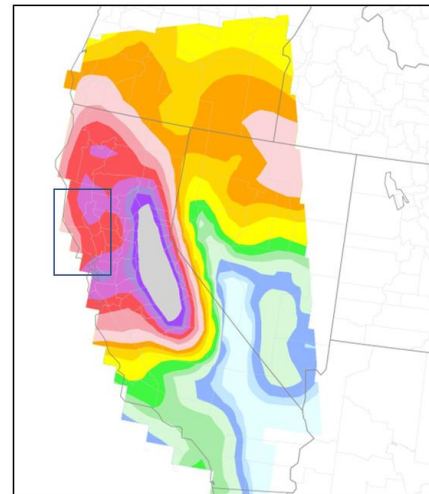
Ensemble streamflow predictions

Hydrological impact of statistical post-processing (PP): Diana Stovern and Nachiketa Acharya are testing the hydrologic impact of ensemble post-processing and variable coherency methods when applied to ensemble forcing systems.

PP GEFS 24-hr QPF – m00
Init = 20170207, lead = 24 hr

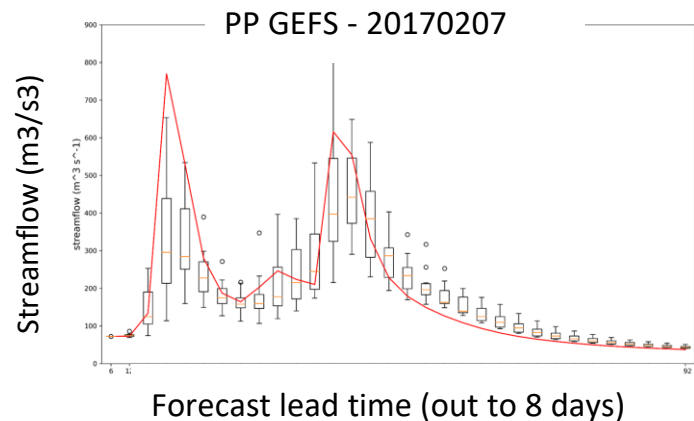
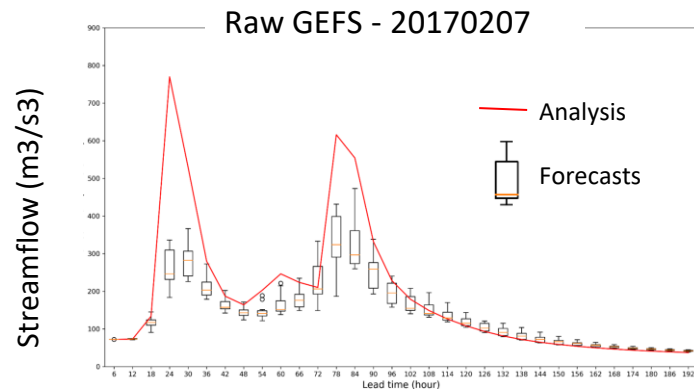
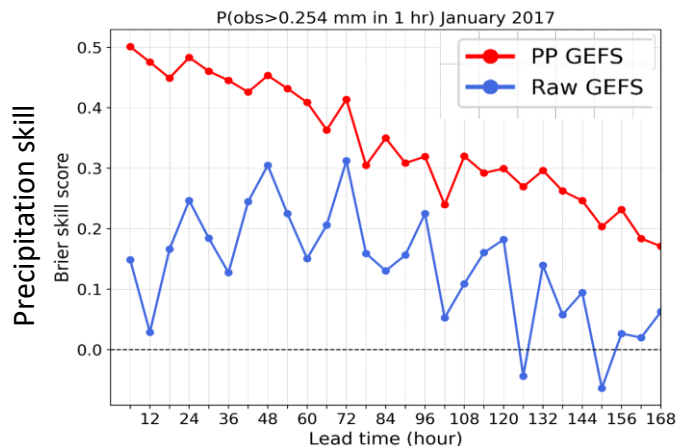


Raw GEFS 24-hr QPF – m00
Init = 20170207, lead = 24 hr



Ensemble streamflow predictions

Post-processed GEFS precipitation skill is improved for all lead times; ensemble streamflow forecast has a larger spread.

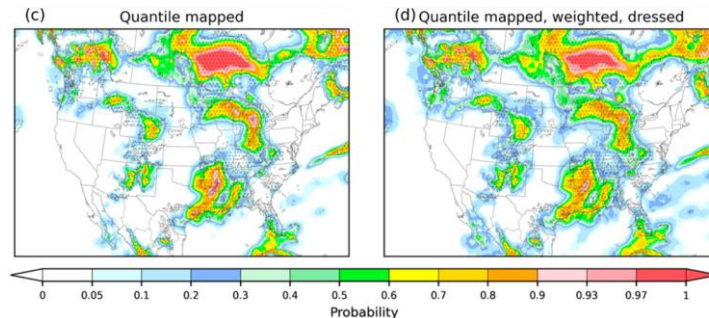


Planned activities and relevance to FIRO

- Development of evaluation methods and metrics geared towards improvements in meteorological forcings that will most likely improve upon HEFS streamflow output
 - Benchmark with existing post-processing methods ('vanilla' Quantile-Quantile mapping, bivariate meta-Gaussian in HEFS) at GEFS timescales (0-10 days)
 - Evaluate over HEFS testbed locations – can include locations relevant for Texas FIRO (partner with UTA)
 - Some focus will be on improvement in extremes
- Development of new post-processing methods and adoption of variable coherency methods, including innovative ways of stitching forecasts on longer lead time horizons (e.g., seamless from hours to seasonal)
 - Will incorporate machine learning techniques (e.g., extreme learning machine used in FewsNET precipitation predictions)

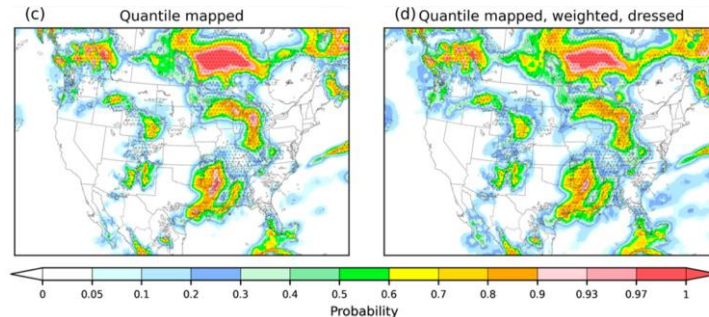
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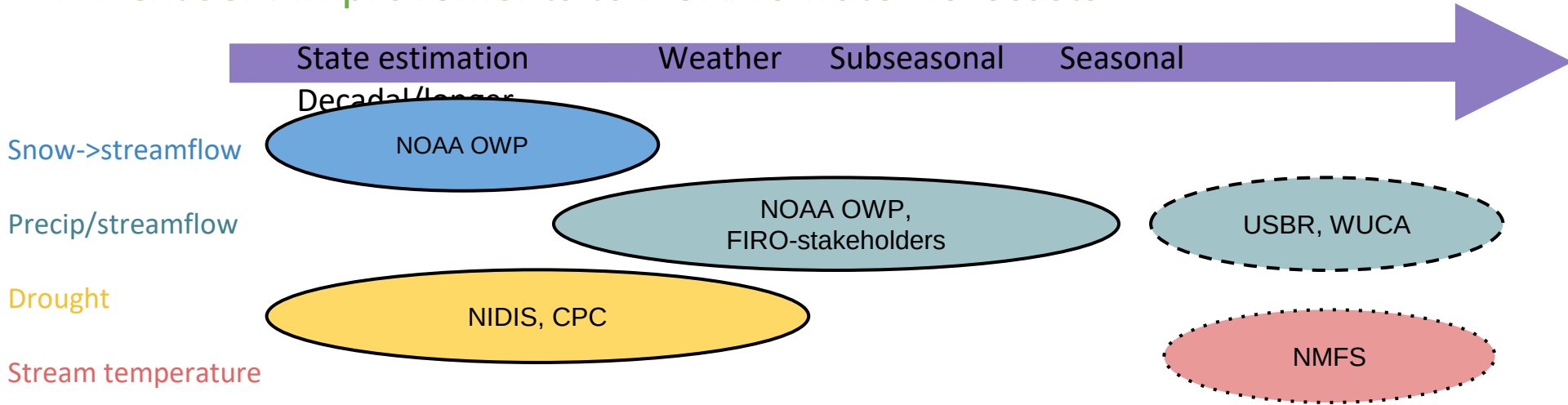


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End goal: these efforts are aiming to improve risk based decision making for stakeholders inside and outside NOAA, and as such, discussions with our applications partners will continue to evolve our foci.