Slides 1 - 20 from [2018 AMS WAF/NWP]() conference

Understanding the Role of Forecast Forcings in National Water Model Errors

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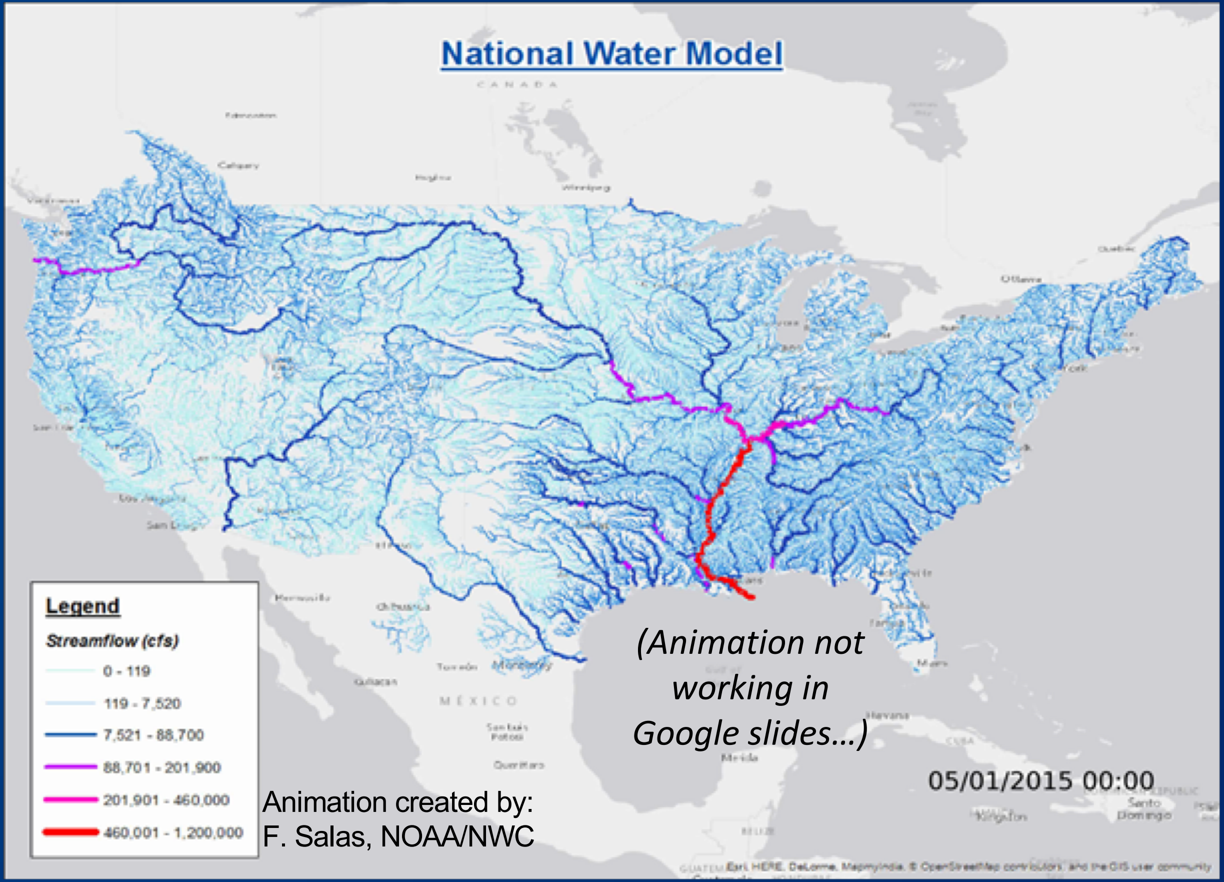
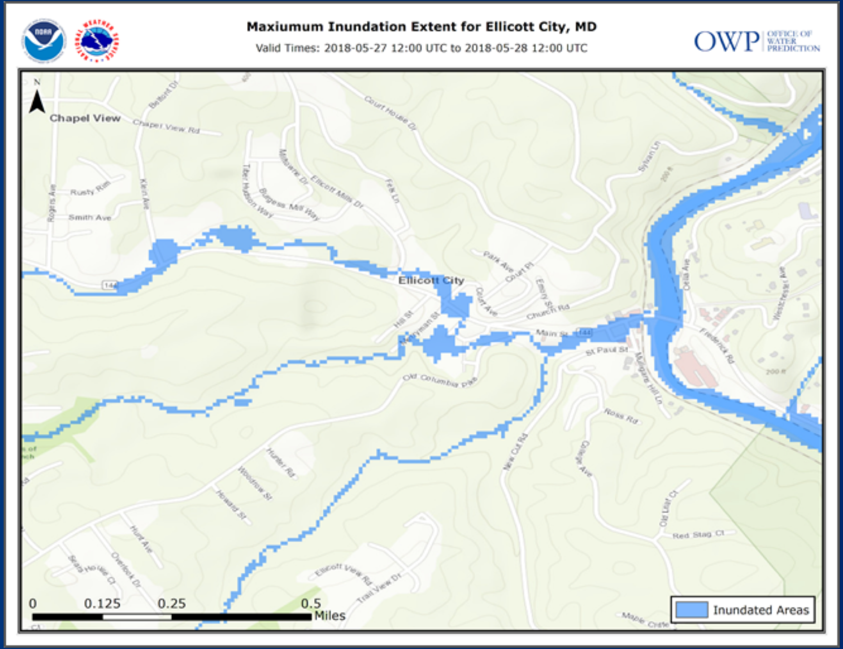
The National Water Model produces state-of-the-art, high-resolution hydrologic forecast guidance…



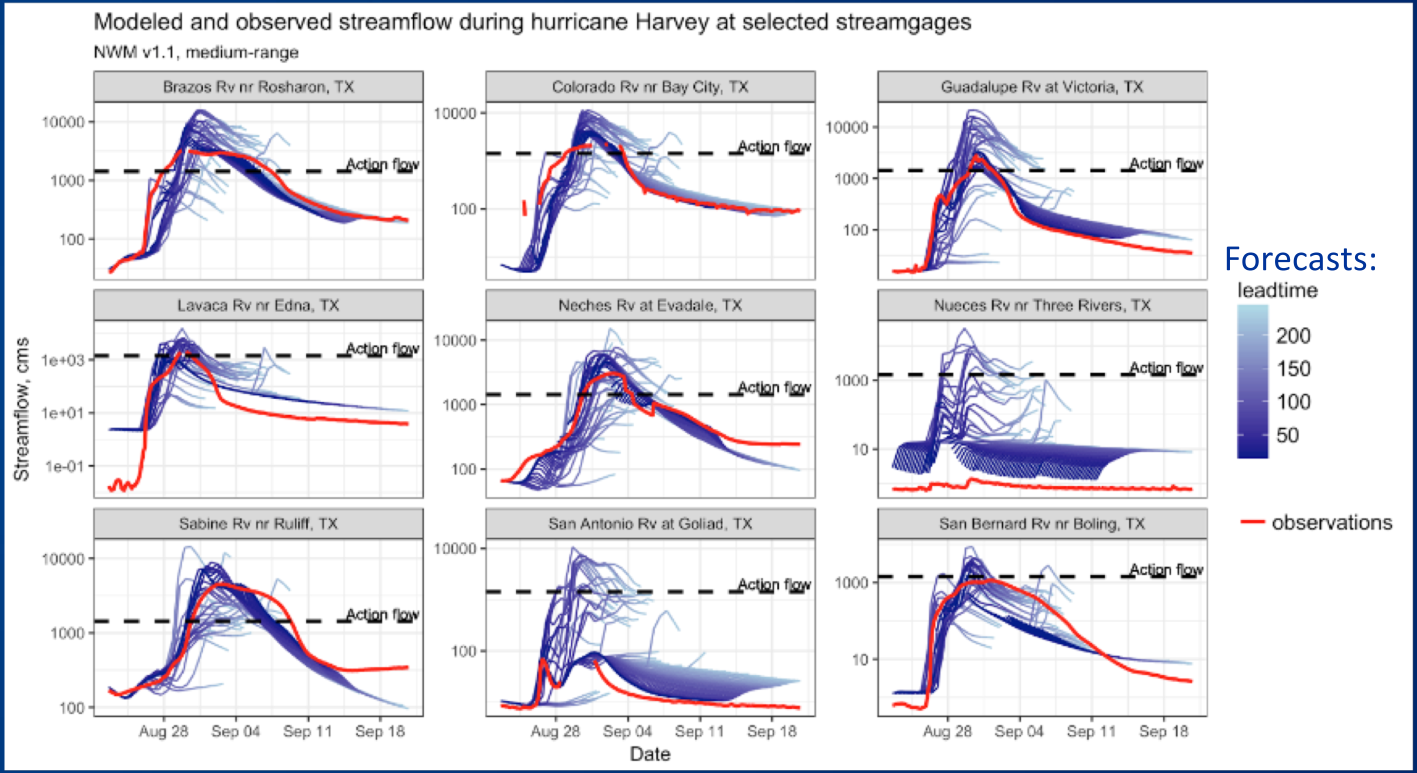
The National Water Model produces state-of-the-art, high-resolution hydrologic forecast guidance…

Images courtesy
Brian Cosgrove NOAA/OWP



NWM analysis cycle's inundation extent during recent Ellicott City, MD flash flood

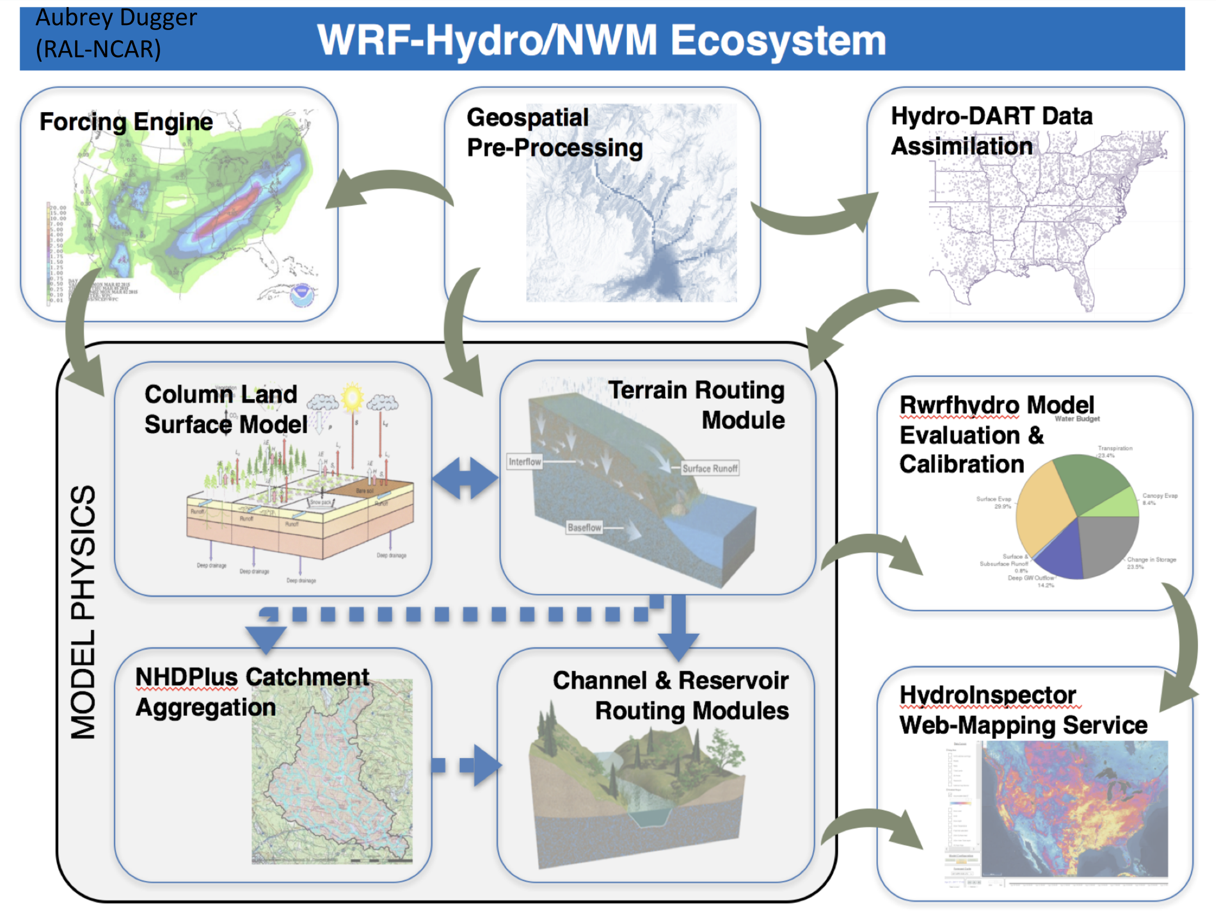
…but sometimes, it is wrong.



Example of NWM streamflow verification at various sites during Hurricane Harvey

The National Water Model

(NCAR, NOAA Office of Water Prediction, National Water Center)



NWM OPERATIONAL Cycles (V1.0 V1.1 V1.2)

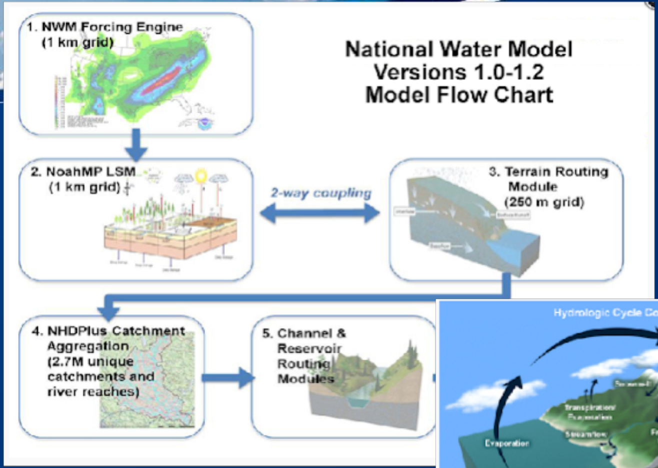
	Cycle	Forecast	Meteo Forcing
Analysis	Hourly	-3-0 hours	MRMS QPE
Short-Range	Hourly	1-18 hours	Downscaled HRRR/RAP blend
Medium-Range	4 x daily	to 10 days	Downscaled GFS
Long- Range	Daily 16 x ensembles	to 30 days	Downscaled & NLDAS2 Bias Corr. CFS

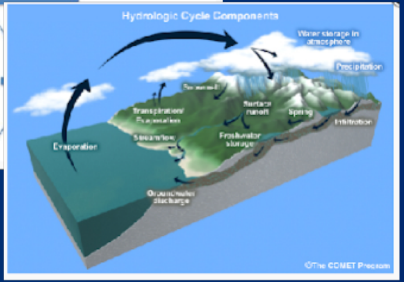
Francesca Viterbo, NOAA PSD/CIRES

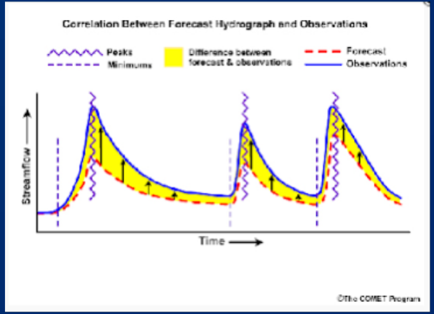
What can cause NWM forecast error?

- Atmospheric inputs (“forcings”)
  - ➢ Precipitation rate, wind, temperature, moisture, radiation, surface pressure
  - ➢ “Garbage in, garbage out”
- Hydrologic model error
- Model physics
- Physical process challenges
- Data assimilation shortcomings

Challenges exist in simply defining errors: observational shortcomings, precip-hydro response lag, water management, …







Improving NWM forecasts requires understanding errors in forcings

Why?

- Calibration: Hydro forecasts generally calibrated; should avoid compensating for systematic errors in forcing (variable by region, phenomena, model version)
- NWM development: benefit of understanding forcing error vs. NWM model error as functions of region, precipitation type, and forecast lead time

How?

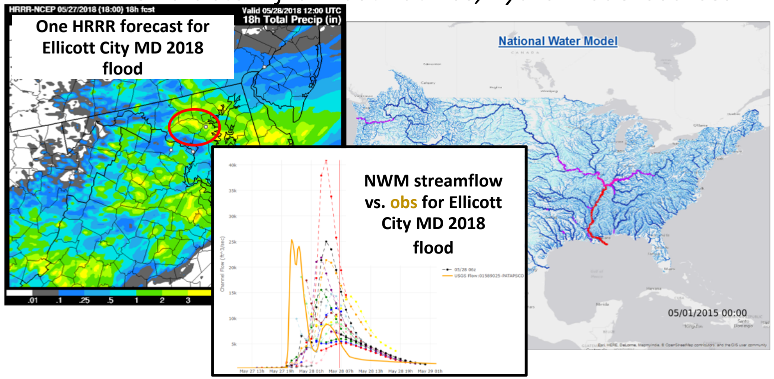
1. Separate errors: hydrologic model error, forcings errors, other
2. Diagnose, quantify, and characterize errors

OWP Evaluate Forecast Forcings Project (FY2018)

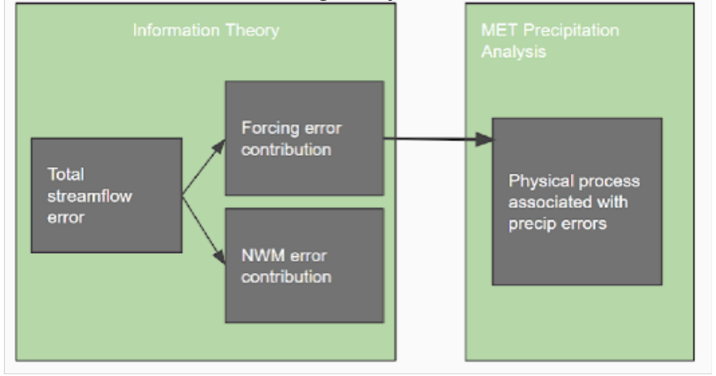
➢ *Charge: Begin exploring how to disentangle NWM error from forcing errors*

- Explore methods that are ideally:
  - Flexible; work across regions, time scales
  - Understandable by researchers, forecasters, model developers
- Initial approaches:
  - Statistical error separation methods ("Information theory")
  - Traditional meteorological verification methods correlated with traditional hydrologic verification methods

NWM errors stem from both atmos, hydro model sources



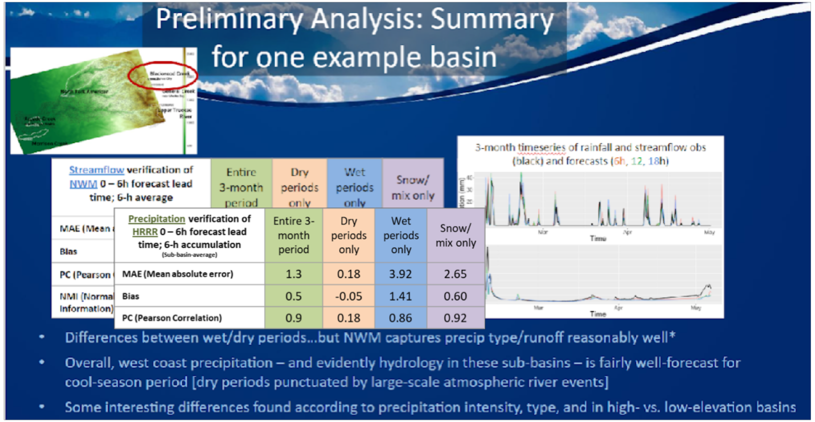
Evaluate Forecast Forcings Project initial method sketch



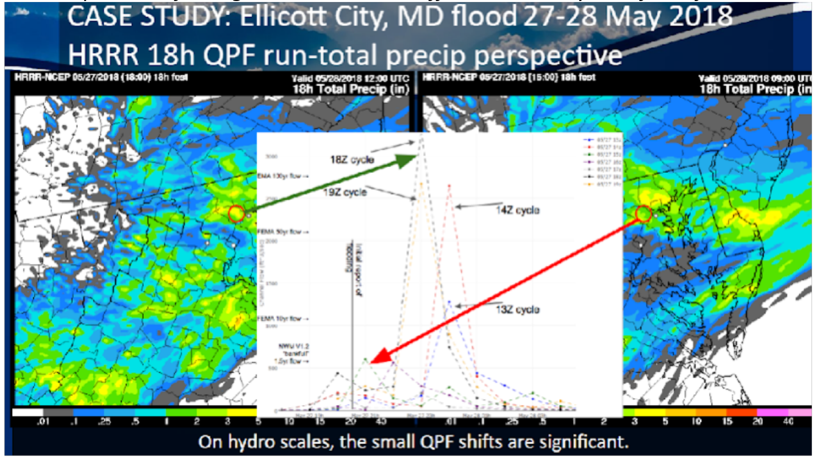
OWP Evaluate Forecast Forcings Project (FY2018)

- Work to date:
  - Regional, single-season prototype combining diagnostic verification of both precipitation (forcing skill, uncertainty) to streamflow forecast uncertainty
  - Ellicott City, MD 2018 flood case study
- Preliminary results:
  - California cold season prototype: short-term forcing forecasts quite skillful; suggests NWM forecast error more from NWM itself. NWM error from rain-snow/melt processes appears relatively small.
  - Ellicott City 2018 flood case study: basin-to-basin and cycle-to-cycle variability in relative magnitude of HRRR QPF error source and NWM error source (e.g., small but hydrologically-significant HRRR QPF spatial errors at key times; consistent streamflow timing errors even with very good forcing forecasts)
  - “Traditional” met verification (using MET software) critical to physical process, error understanding
  - Information theory: potentially promising but steep learning curve; requires longer data records, meteorological context
  - Suggests region-specific, weather-specific hydrologic verification – while complex – is likely to be of greatest benefit to NWM error understanding

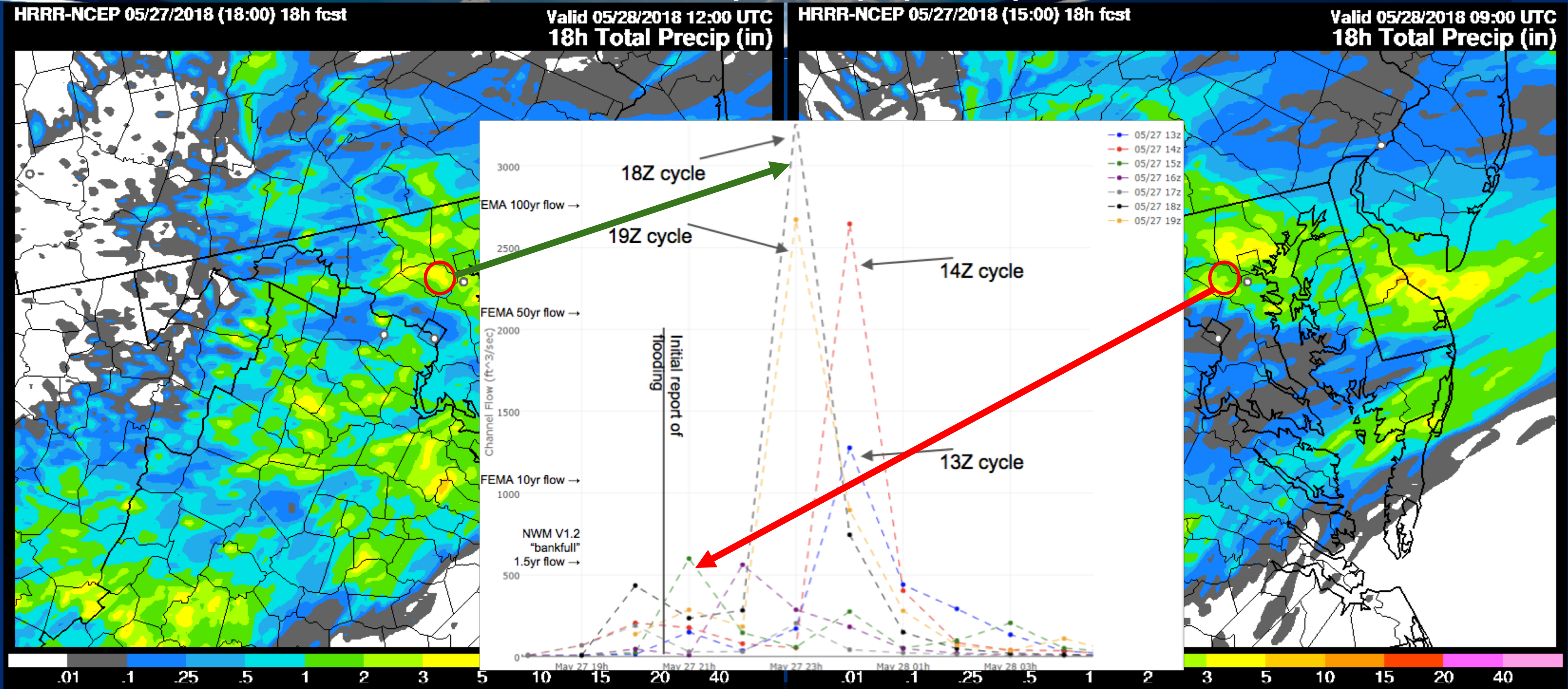
Summary of California 3-month prototype assessment



Example: Both forcing and NWM errors affect Ellicott City, MD flood forecasts



CASE STUDY: Ellicott City, MD flood 27-28 May 2018
HRRR 18h QPF run-total precip perspective



On hydro scales, the small QPF shifts are significant.

Ellicott City 2018 Flood Case Study: Summary

- Key differences in meteorological vs. hydrological verification, interpretation (relative importance of scale of displacements in space and time)
- Value of combo of object-based, grid-based, and hydro point-based verification
- Run-total QPF skillful for several HRRR cycles
- Mesoscale and finer details critical to equally skillful NWM forecasts
- Next steps:
  - More clearly connect QPF errors to NWM errors; can we isolate NWM model-specific challenges
  - Provided good QPF, consider challenges associated with hydro processes, e.g., transfer of surface water to streams?
  - Flood inundation mapping - verification??
  - Forecast process, challenges, opportunities; social science: community response and perception
  - **Suggestions?**