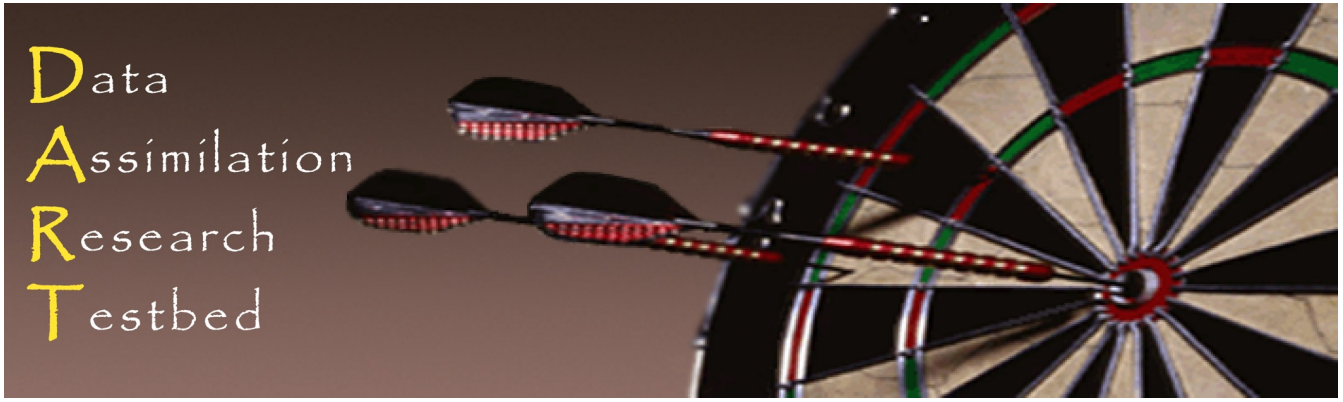
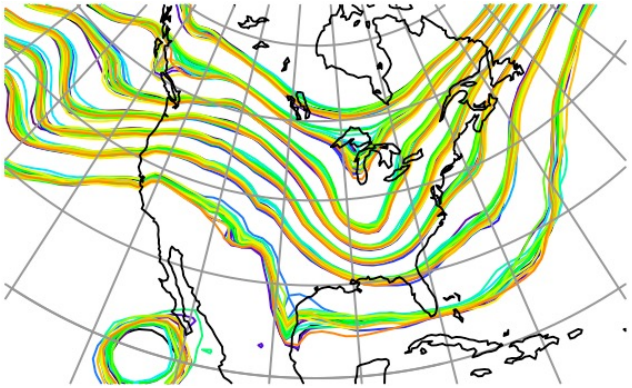


Data Assimilation using WRF-Hydro: the US National Water Model. Application to Hurricane Florence



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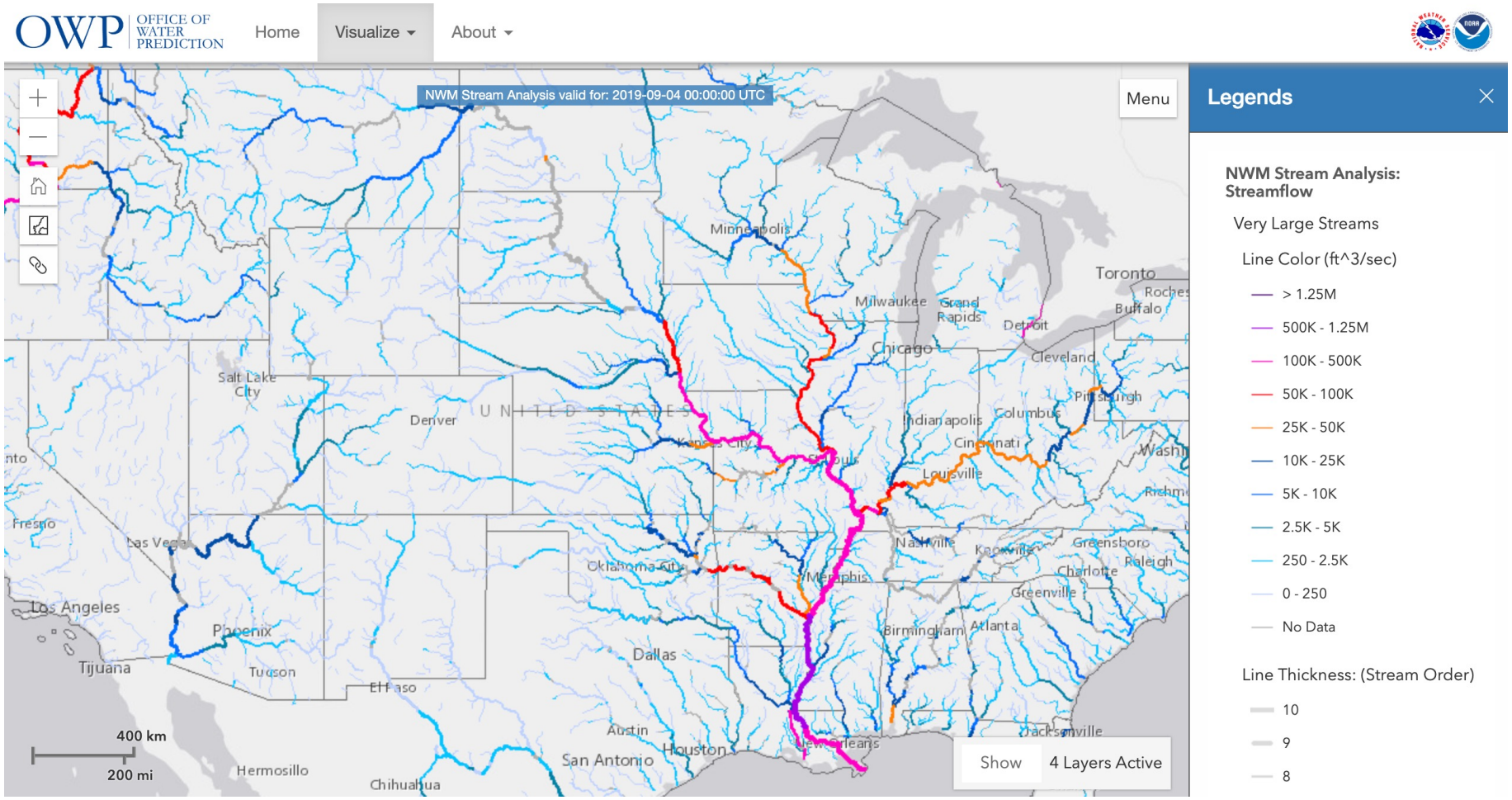
NCAR | National Center for
UCAR | Atmospheric Research

Outline

1. WRF-Hydro (The National Water Model)
2. A brief overview of ensemble assimilation
3. Hurricane Florence
4. DA results from an 80 member experiment
    - Localization
    - Model bias
    - Ensemble spread and Inflation
    - Gaussian Anamorphosis
5. Conclusion

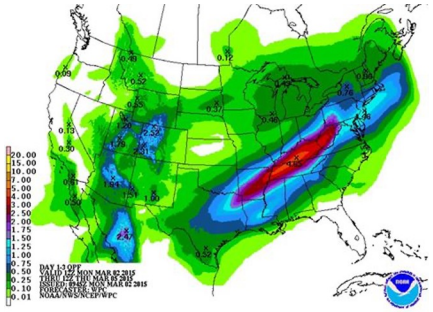
NATIONAL WATER MODEL (NWM)



https://water.noaa.gov/about/nwm

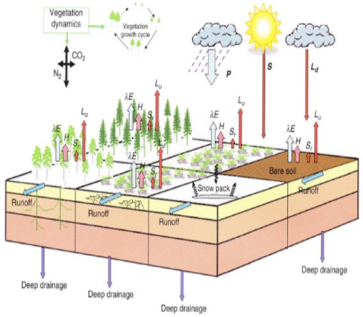
Weather Research & Forecasting Hydrologic Model

Weather Forcing Engine



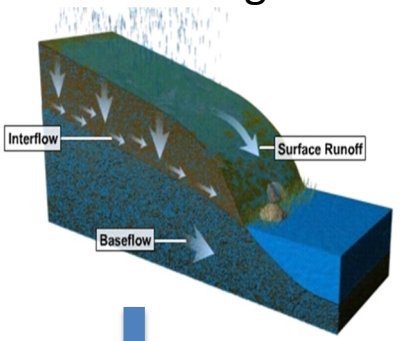
WRF-Hydro: https://www.ral.ucar.edu/projects/wrf_hydro

NoahMP
Land Surface Model

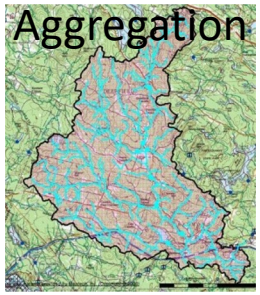


2-way coupling

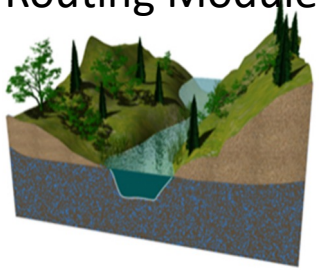
Terrain Routing Module

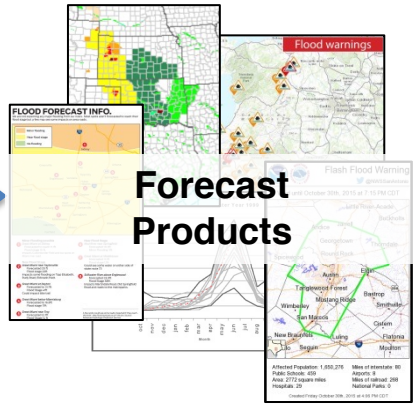


NHDPlus Catchment
Aggregation

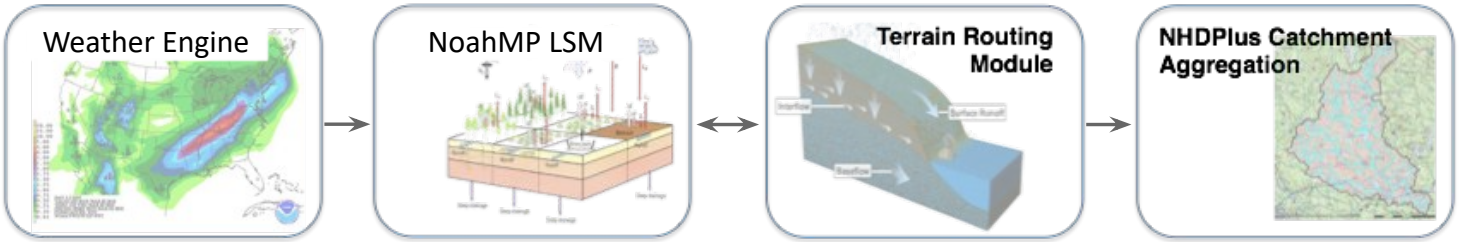


Channel & Reservoir
Routing Module

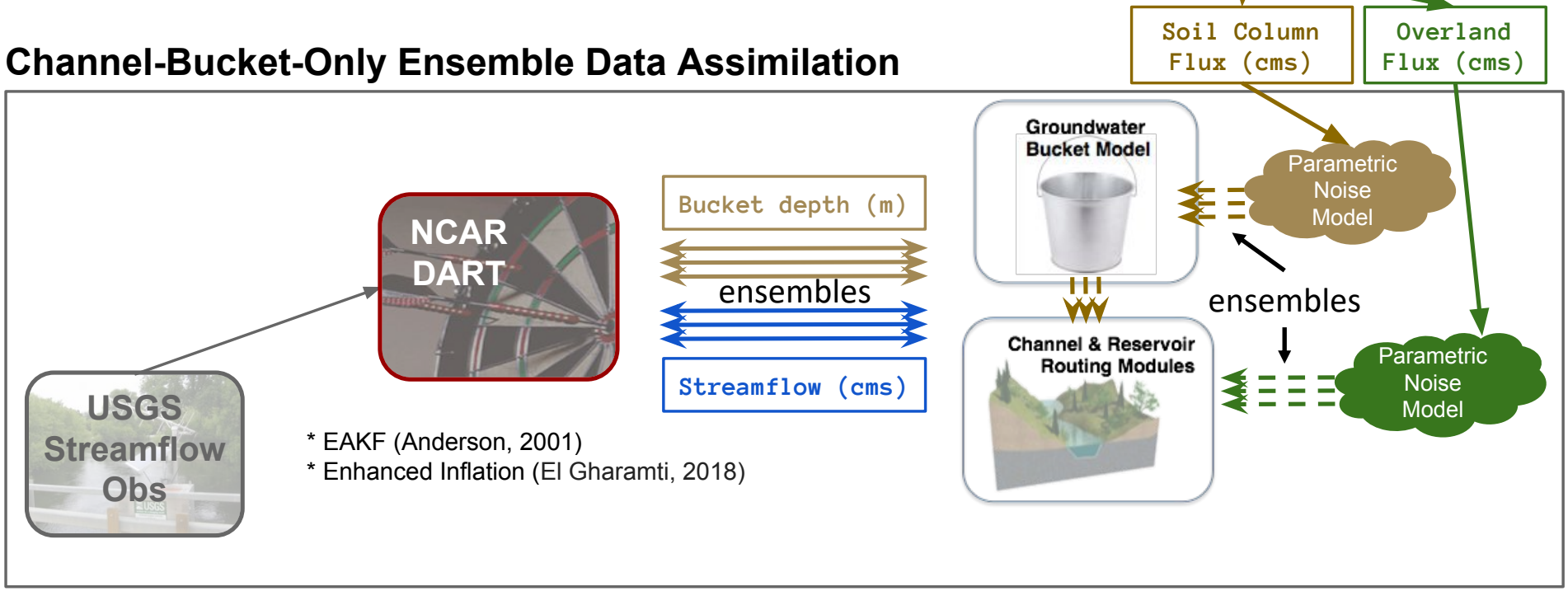




WRF-Hydro & DART …. HydroDART



Channel-Bucket-Only Ensemble Data Assimilation

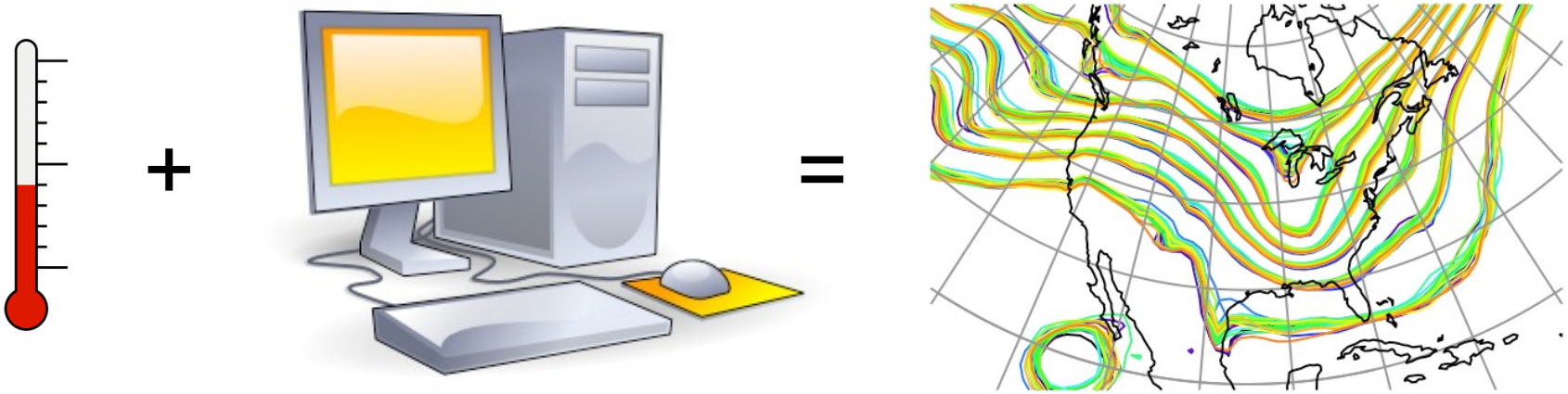


Python environment

github.com/NCAR/wrf_hydro_py.git

What is Data Assimilation?

Observations combined with a Model forecast…



… to produce an analysis.

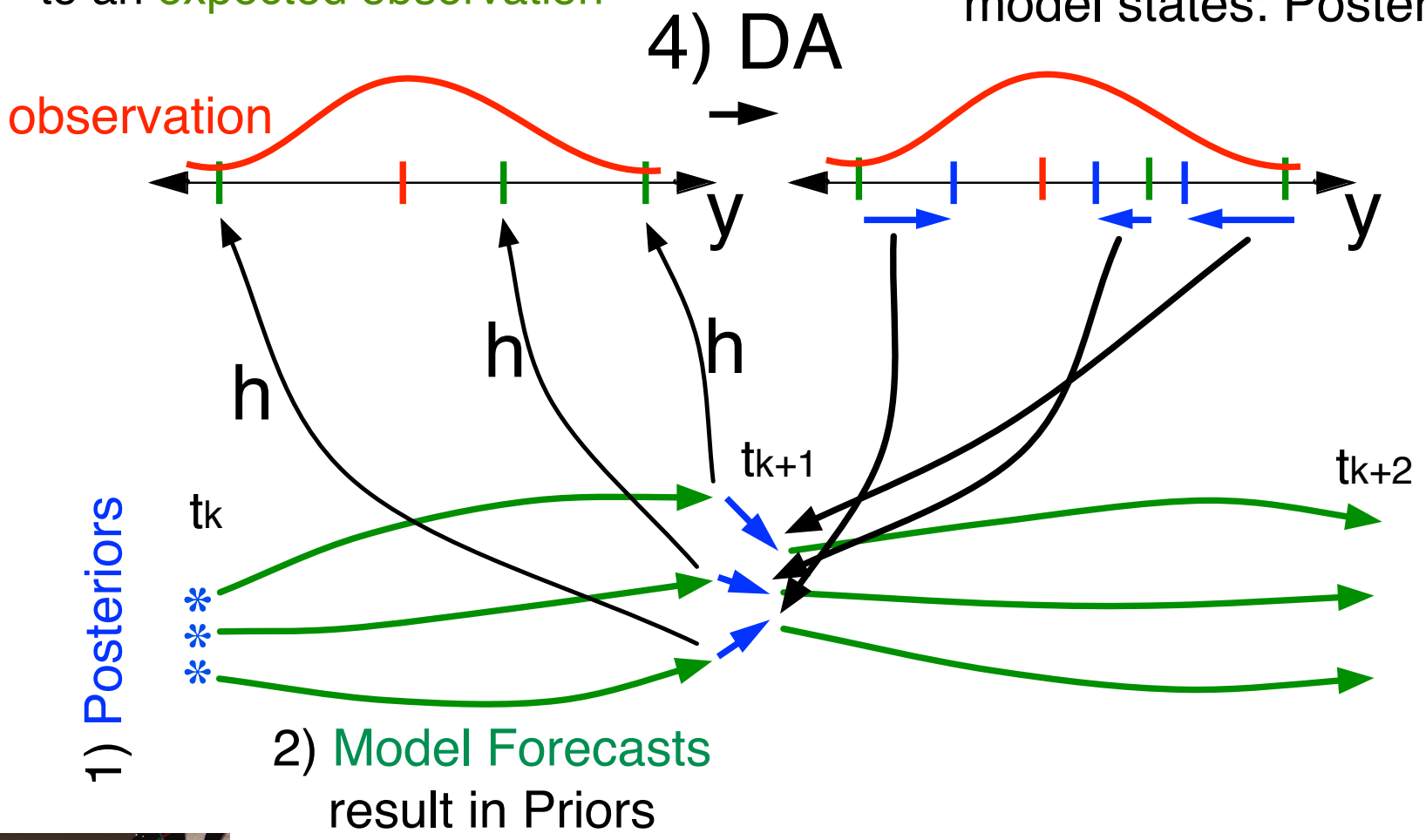
Overview article of the Data Assimilation Research Testbed (DART):

Anderson, Jeffrey, T. Hoar, K. Raeder, H. Liu, N. Collins, R. Torn, A. Arellano, 2009: The Data Assimilation Research Testbed: A Community Facility. *Bull. Amer. Meteor. Soc.*, **90**, 1283–1296. doi:10.1175/2009BAMS2618.1

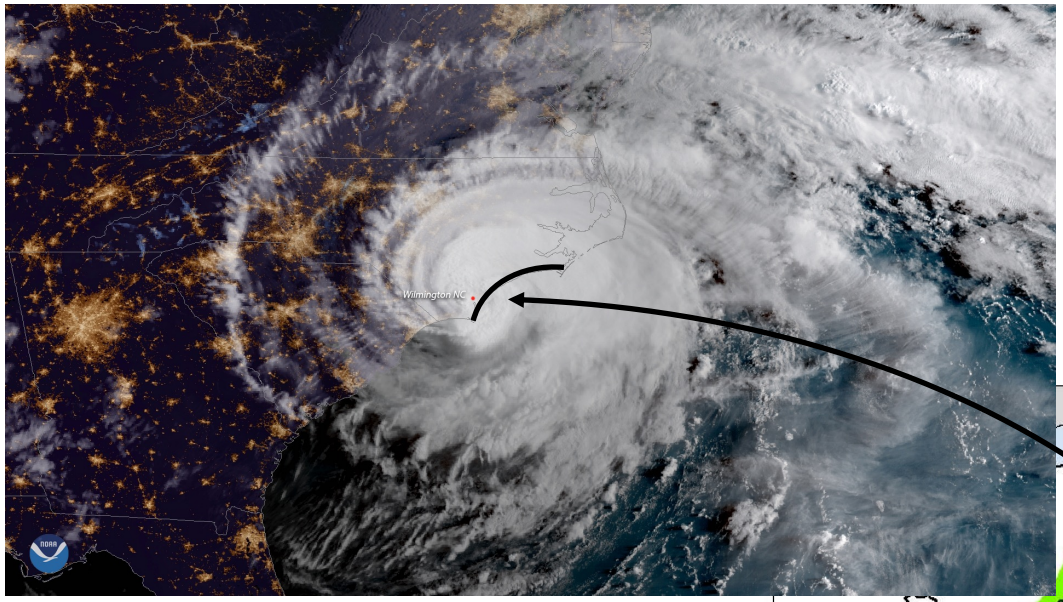
Ensemble DA in DART

3) A forward operator (h) maps each model state to an expected observation

5) observation increments and regression create new model states: Posteriors

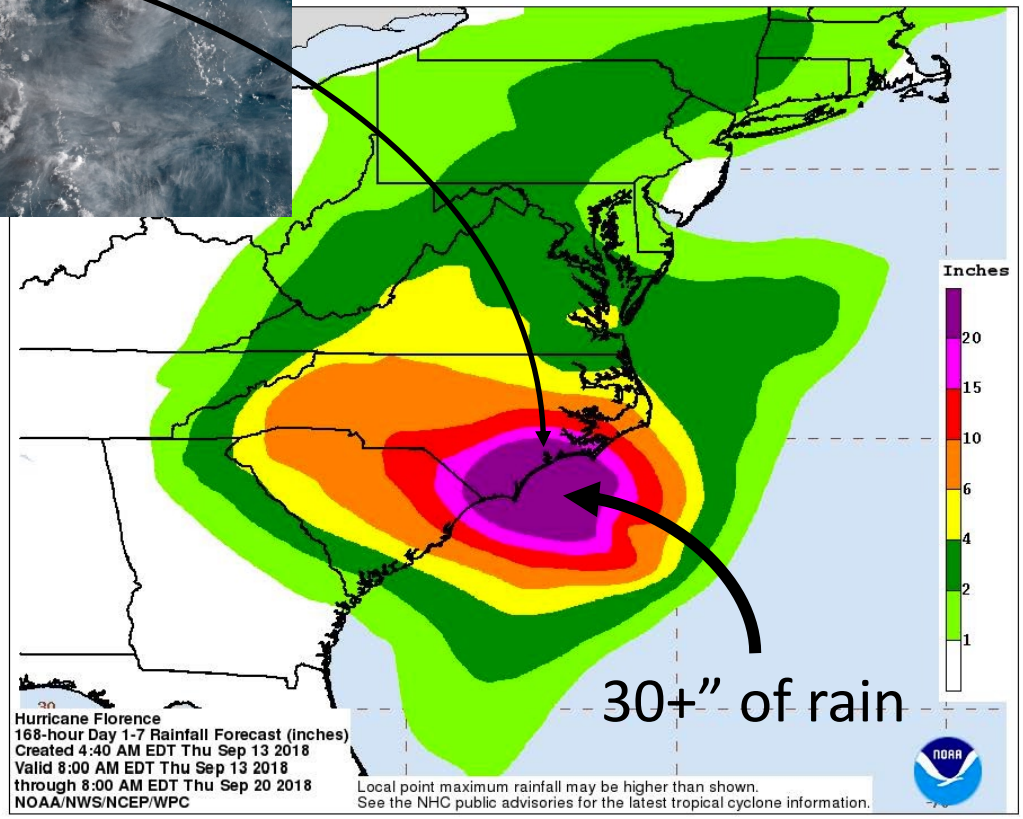


Hurricane Florence (2018)



Hurricane Florence made landfall near Wrightsville Beach, North Carolina at **7:15 a.m. ET September 14**. The GOES East satellite captured this geocolor image at 7:45 a.m. ET

Winds up to 150 mph (240 km/hr)
Damage: $24.23 billion
NOAA/NWS/NCEP/WPC



Data Assimilation Research Testbed

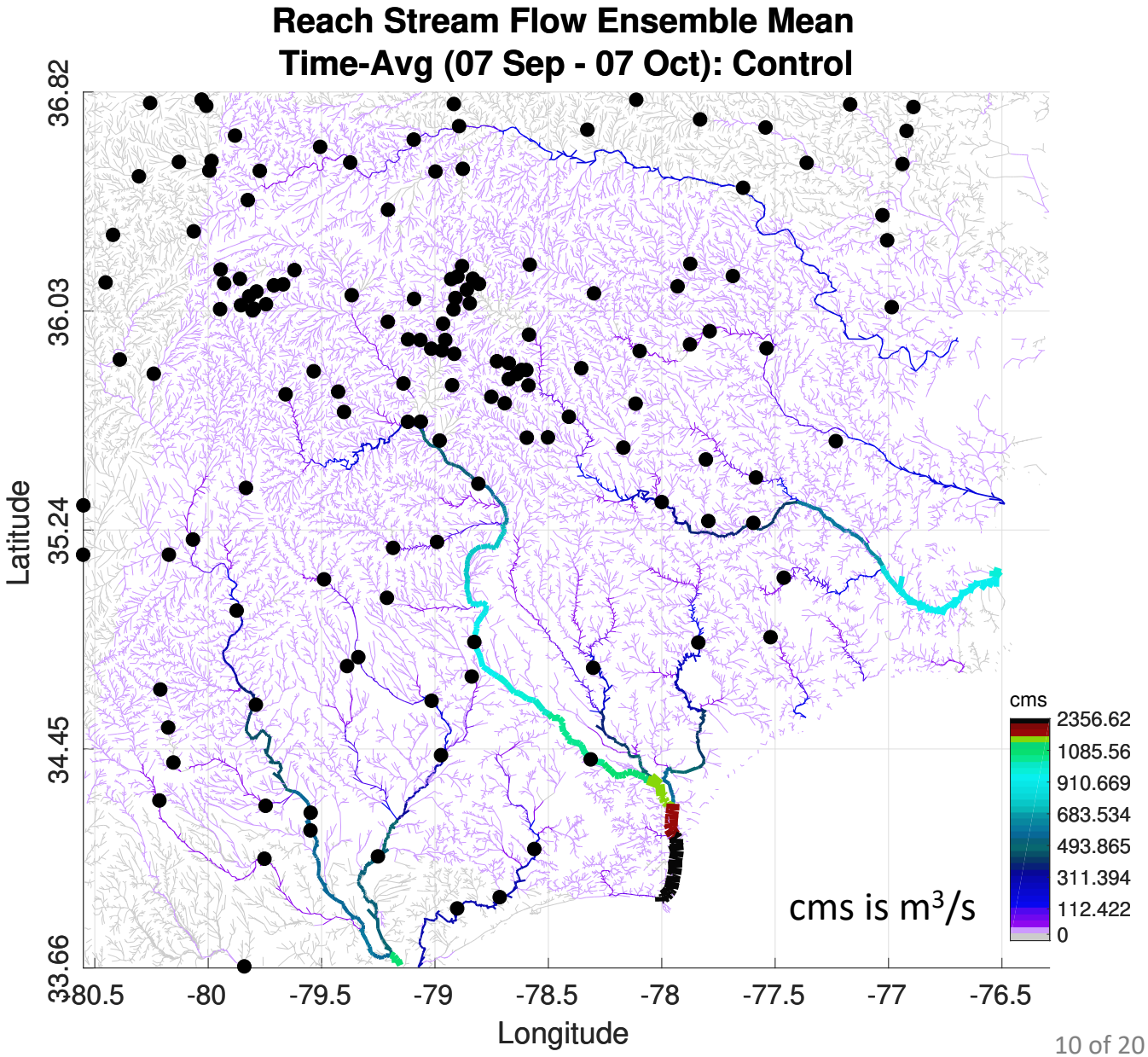
‘scale’ of Florence Domain

Control: No Streamflow DA

Monthly mean of the model. The streamflow is driven by the precipitation.

More than 100 gauges, reporting every 15 mins.

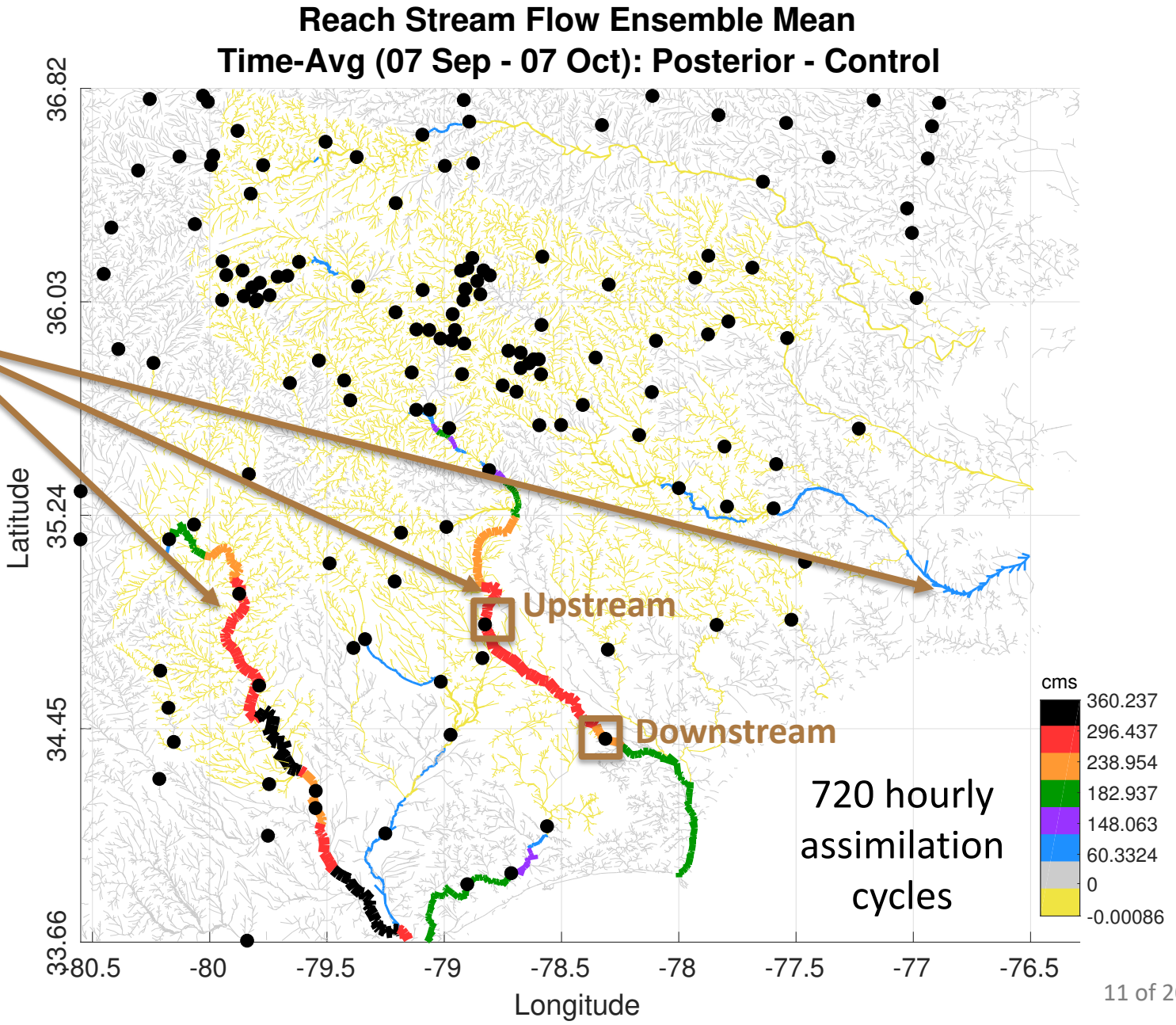
Now, what happens when streamflow gauge data is incorporated through DA?



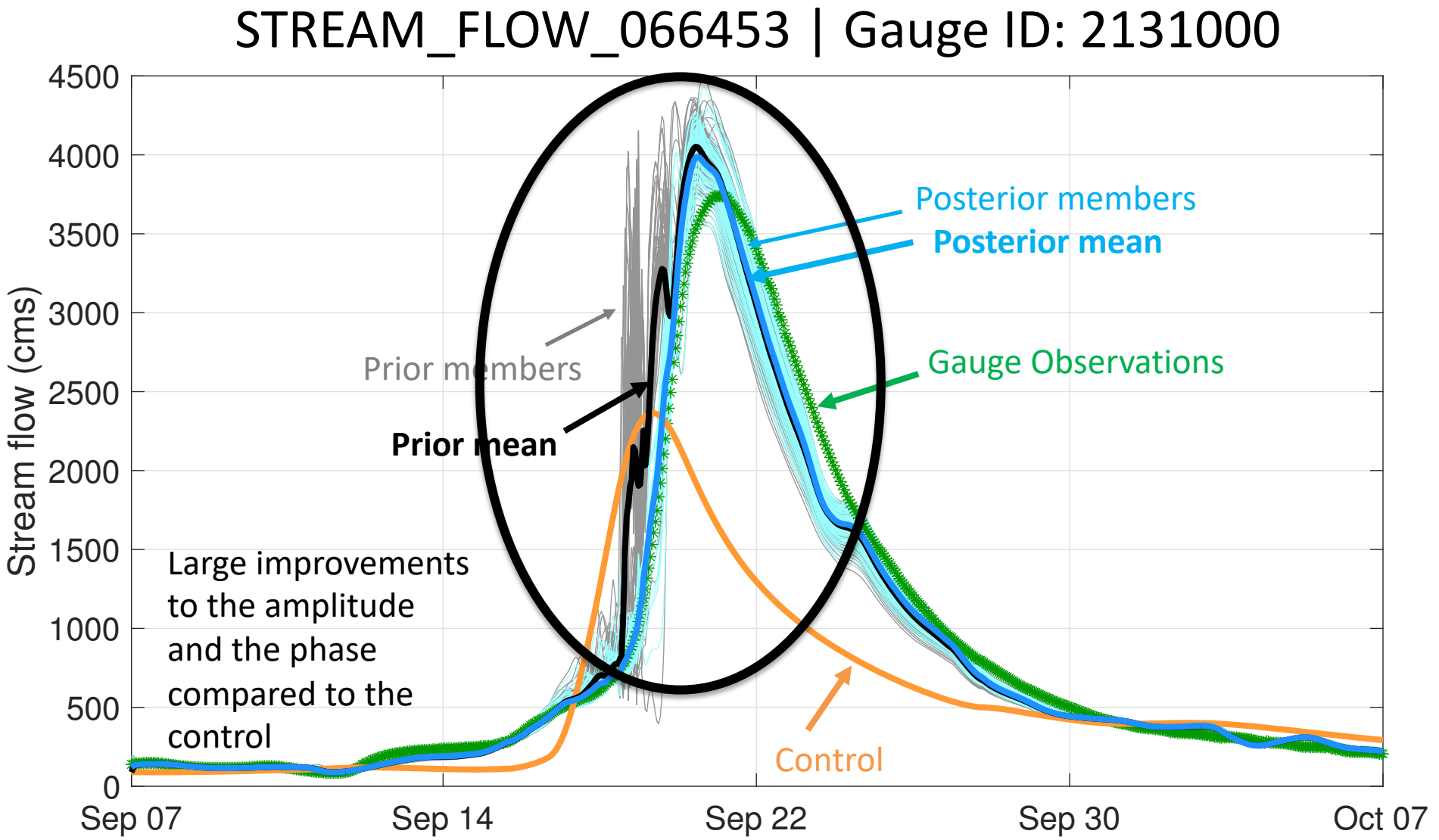
DA impact

Assimilation happens every hour

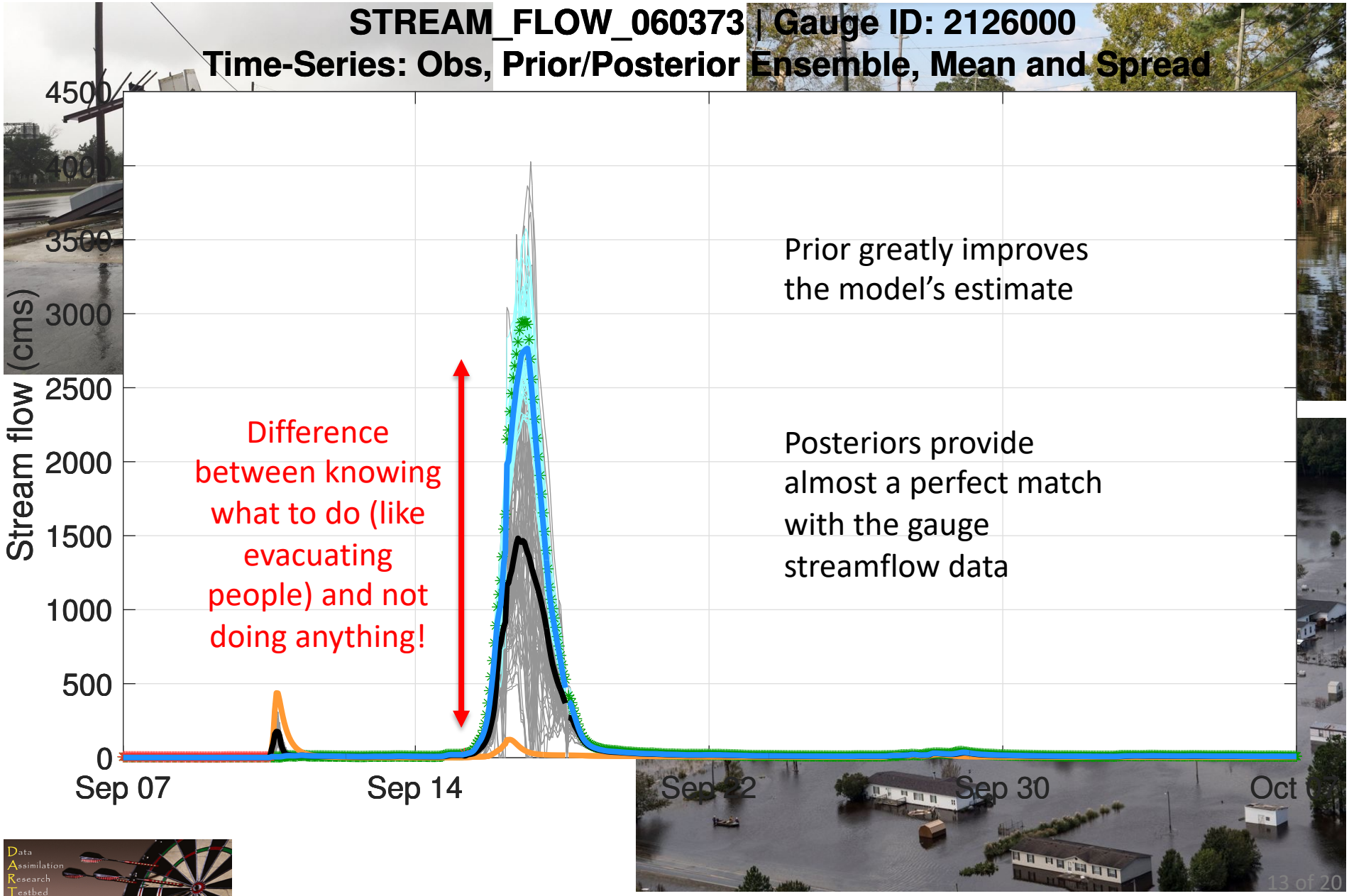
Correction along major reaches. DA is adding water to the stream channels.



Upstream Gauge

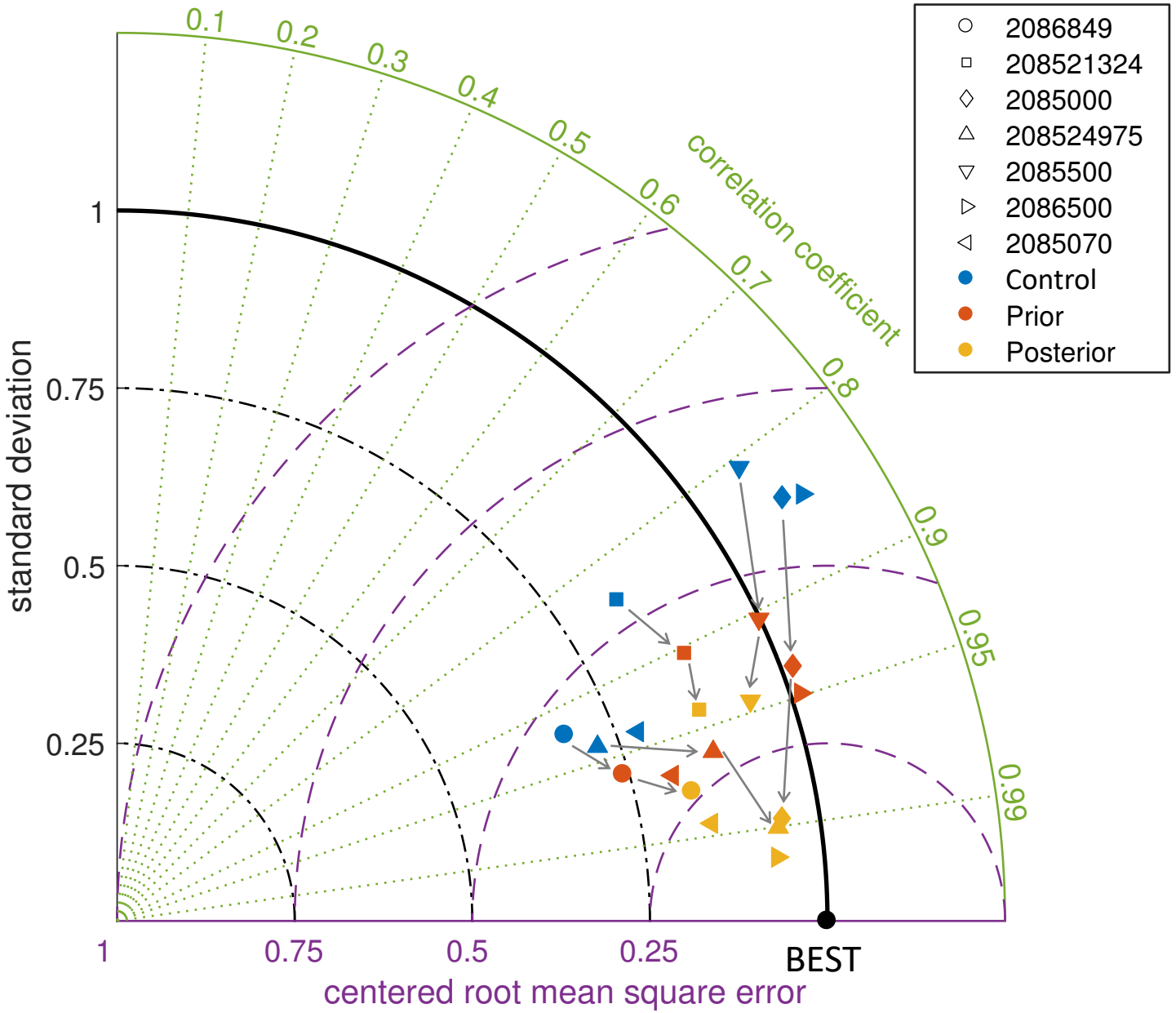


Downstream Gauge



General Improvements

Taylor Diagram



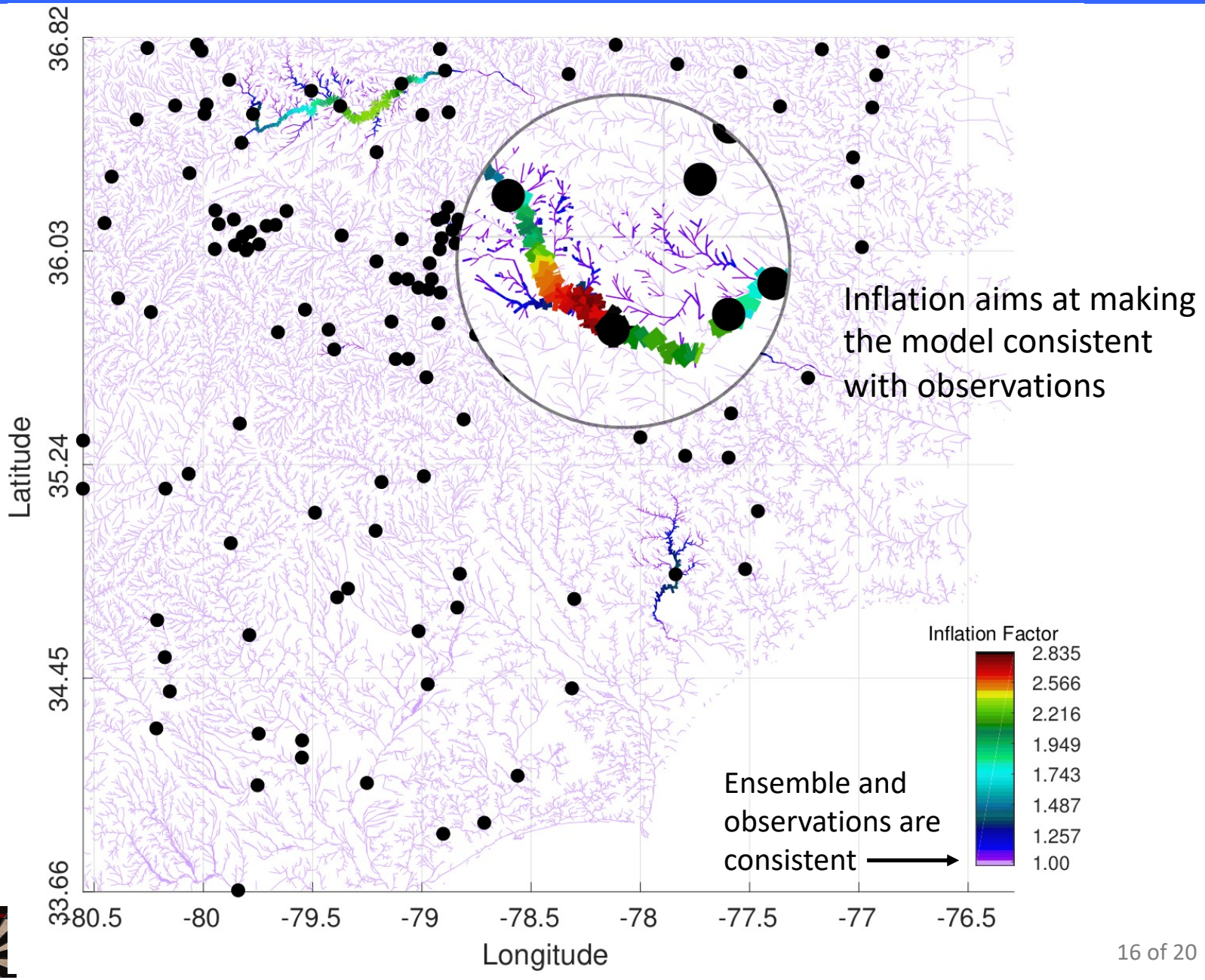
Significant Technical Enhancements

1. **Inflation:** As a way to increase ensemble uncertainty, adaptive both in space and time

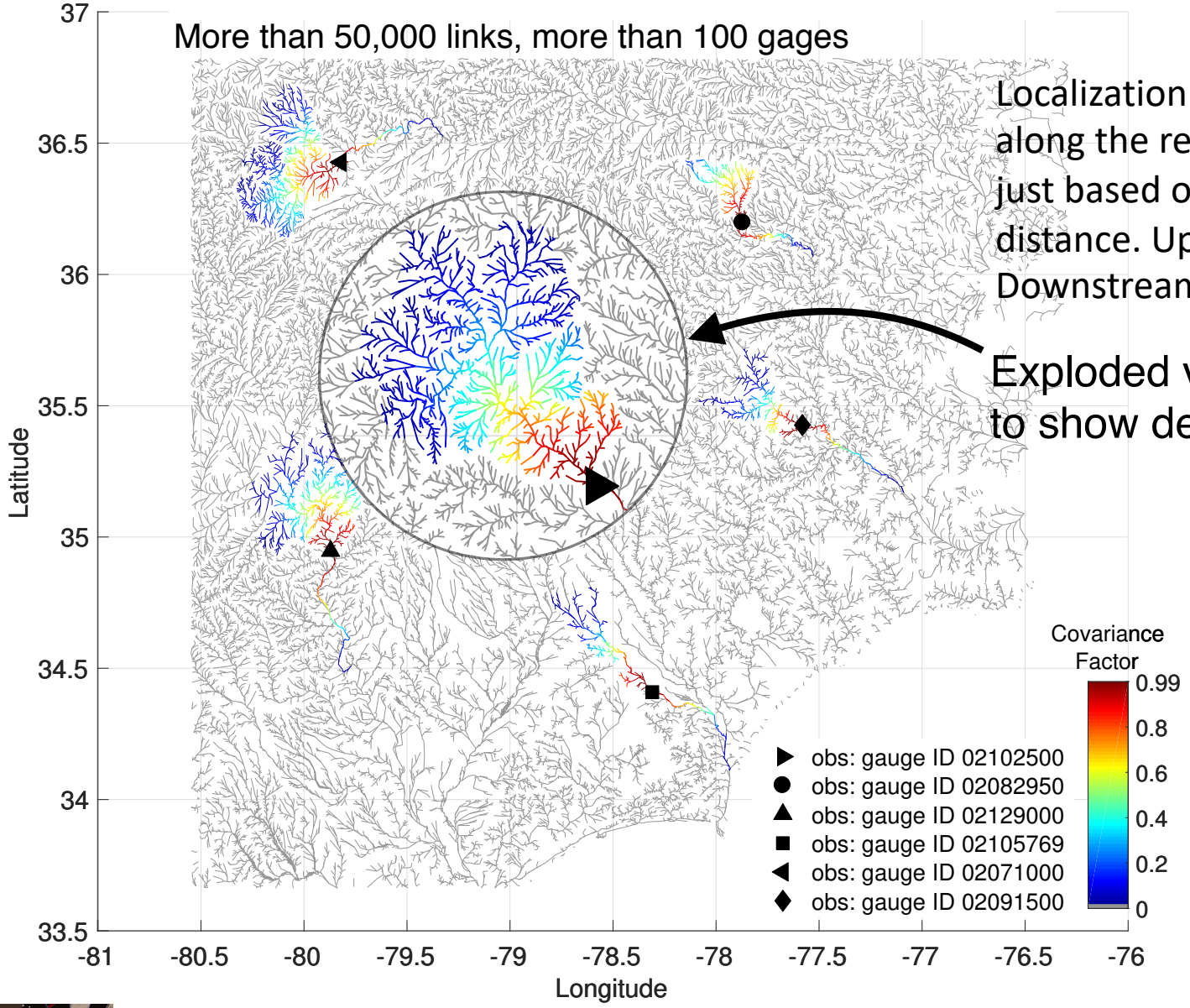
2. **Pattern-based (Along-the-stream) localization:** To minimize sampling errors

3. **Gaussian Anamorphosis:** Variable transform to accommodate positive variables (with non-Gaussian distributions)

Adaptive Inflation



Florence Domain : localization



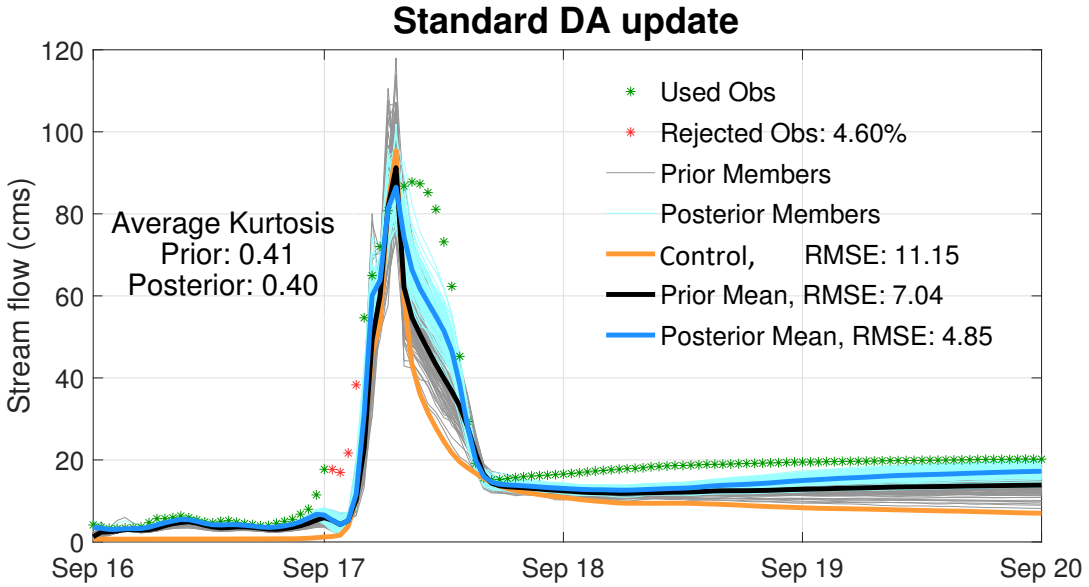
100 km localization distance is used

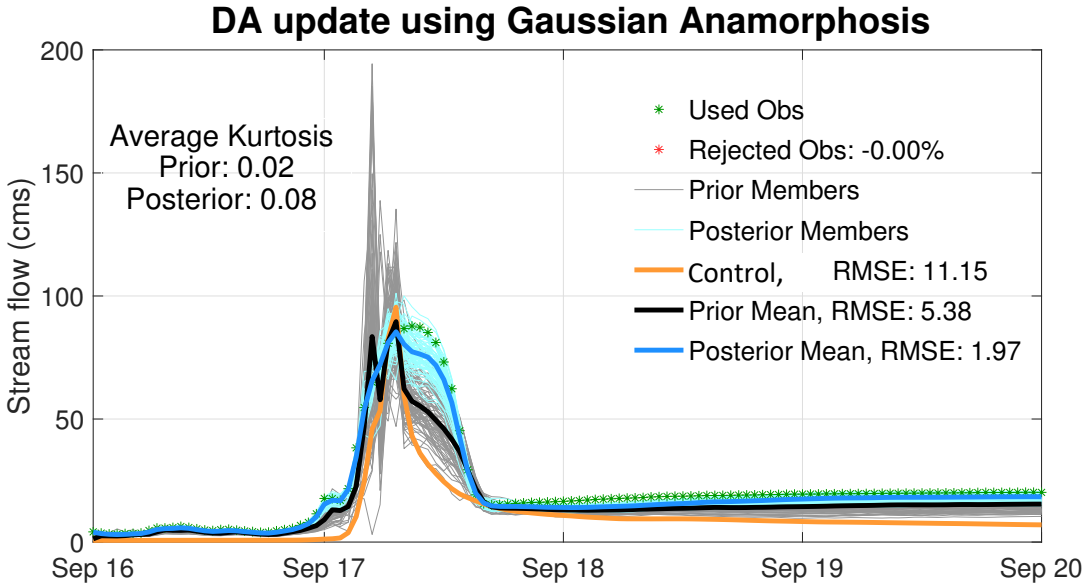
Gaussian Anamorphosis Capability

Observation rejection is improved with GA.

Better fit to the observations on Sep. 17th.

Higher order moments are almost completely eliminated using GA.





Conclusion

We use DART to perform streamflow and flood prediction with WRF-Hydro (NWM) during Hurricane Florence.

DART greatly improved the streamflow estimates

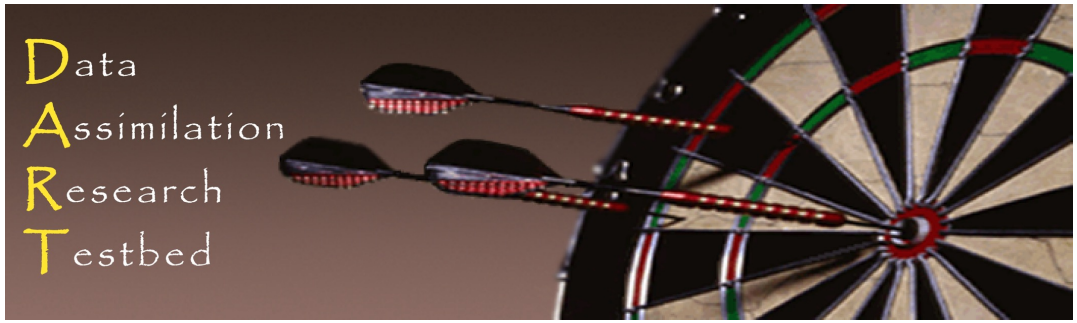
Novel enhancements to the DA algorithm were required:

- Using pattern-based localization
- Spatially and temporally varying inflation
- Gaussian anamorphosis

Next Steps: Update soil moisture, groundwater and ice; force the coupled system with an ensemble of atmospheric forcing, …

For more information:

CAM GCOM CAM-Chem FESOM ROMS WRF GITM CABLE WRF-Hydro WACCM CLM POP AM2 BGRID SQG COAMPS NOAH NCOMMAS PE2LYR MITgcm_ocean WRF-Chem COAMPS_nest NAAPS TIEGCM MPAS_ATM MPAS_OCN WACCM-X PBL_1d NOAH-MP



www.image.ucar.edu/DAReS/DART

dart@ucar.edu

CISL Computational & Information Systems Lab

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