Improving Earth System Model Predictions using Data Assimilation

Research and Applications

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National Center for Atmospheric Research
Data Assimilation Research Section (DAReS) - TDD - CISL

CISL
Computational & Information Systems Lab

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

DA Background

Data Assimilation: A brief background

- Data Assimilation (DA) is process of combining a model's prediction of a state (e.g., SST, Pressure) with observations to obtain an improved estimate of the state and its uncertainty
- Probabilistic approach through Bayes' rule:

$$p\left(x|y\right) \approx p\left(y|x\right) \cdot p\left(x\right)$$

- Ensemble Kalman Filter (EnKF)
  - Large-scale systems
  - Nonlinear regimes
  - Easy to implement
  - Relatively cheap
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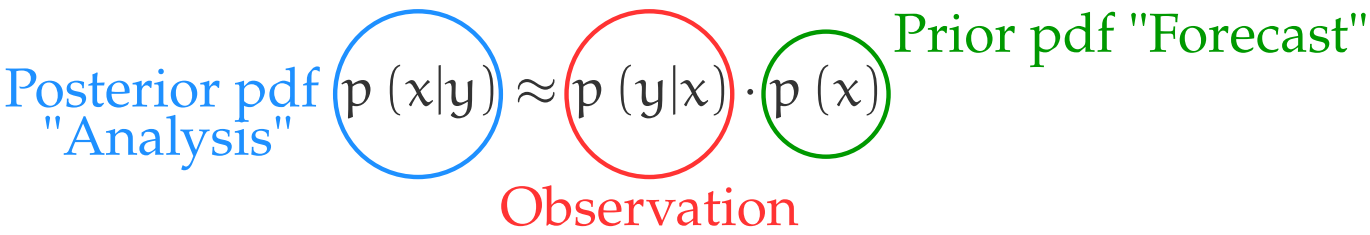

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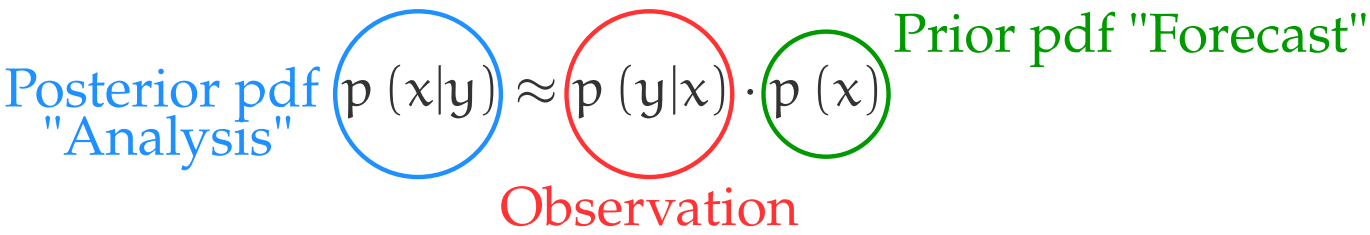

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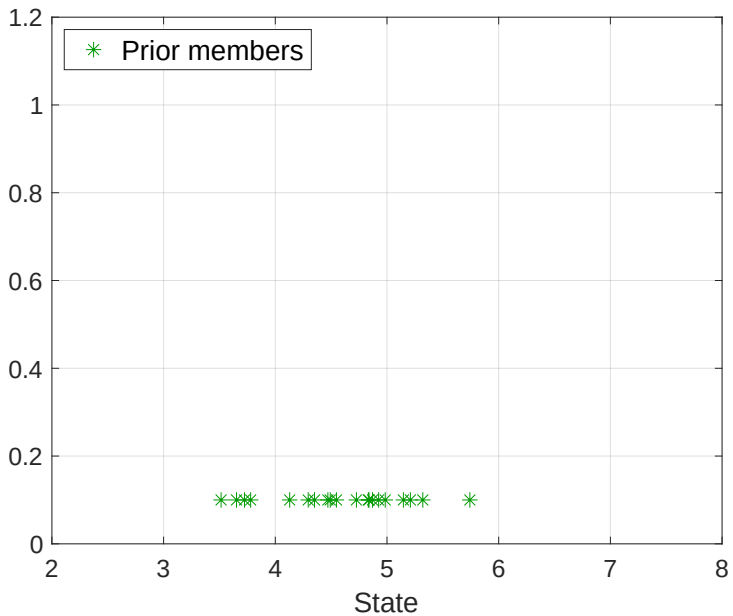

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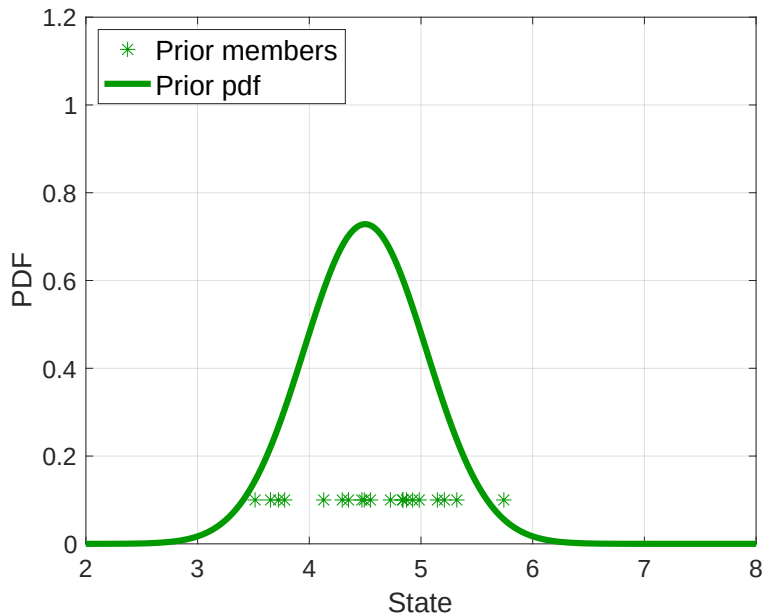

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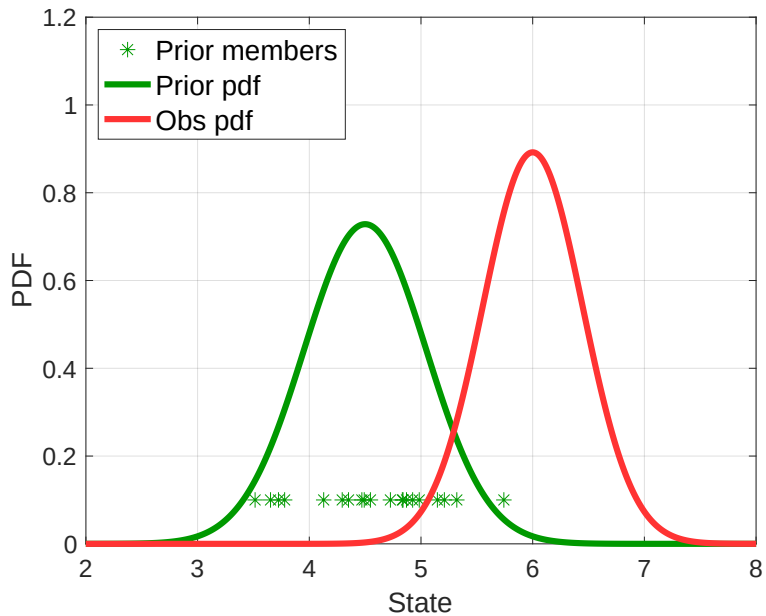

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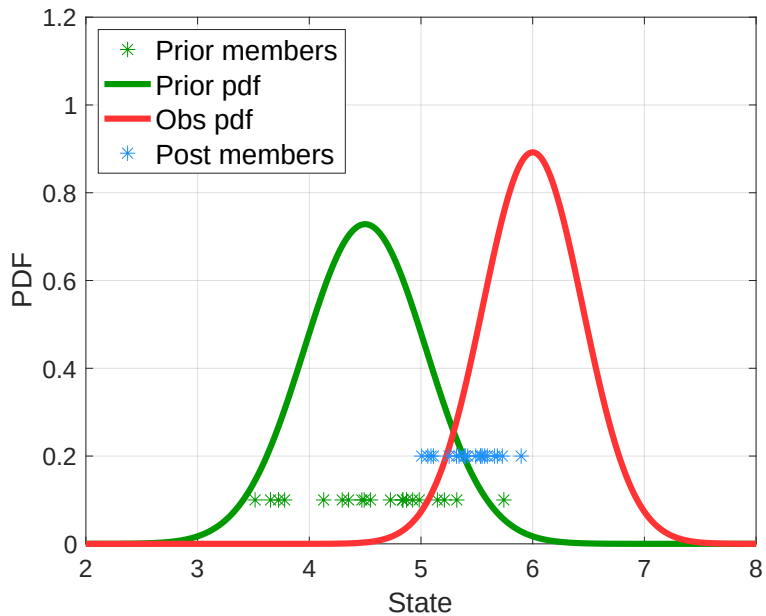

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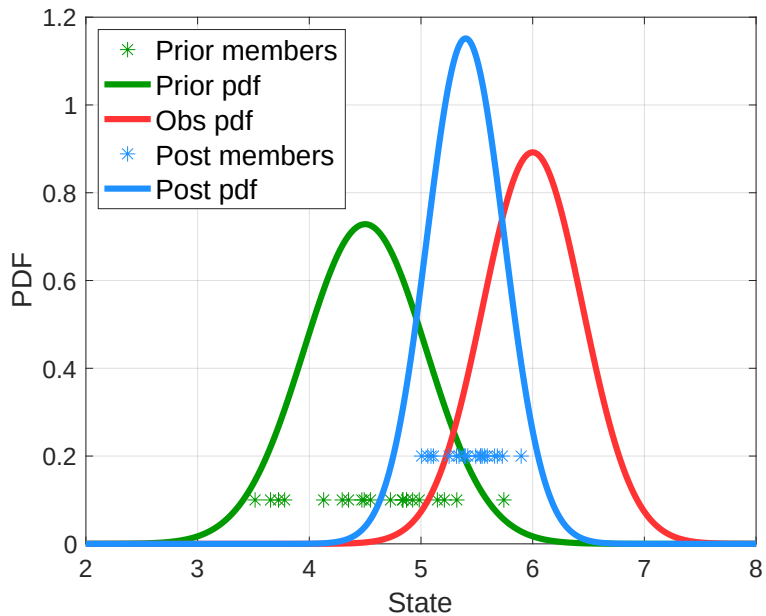

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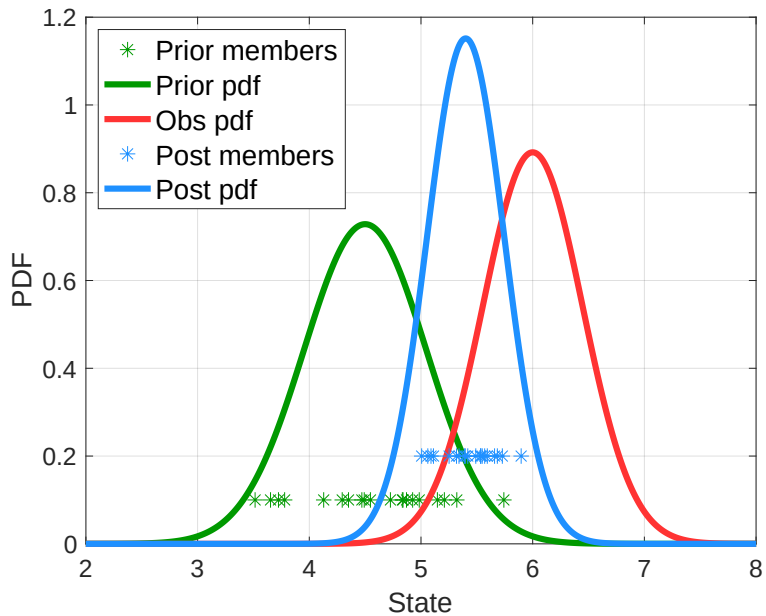

DART: Data Assimilation Research Testbed

- In-house community facility for ensemble DA; developed and maintained by my team (DAReS) in CISL
  - Framework
    - Flexible, portable, well-tested, extensible, free!
    - Source code distributed on Github: NCAR/DART
    - Models: Toy to HUGE, including CESM
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    - Theory based, widely applicable techniques
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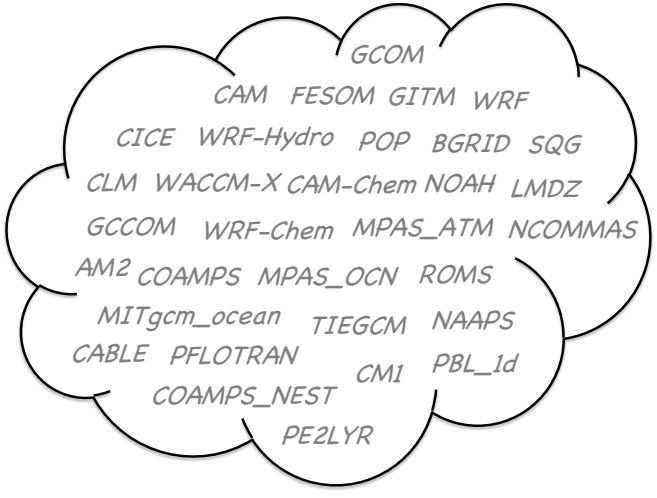

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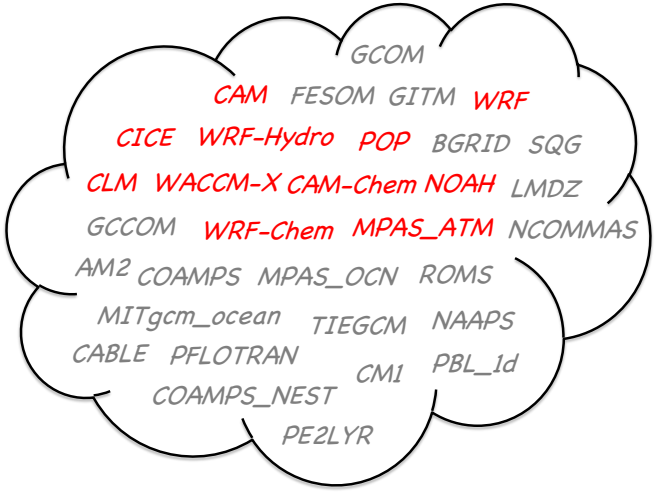

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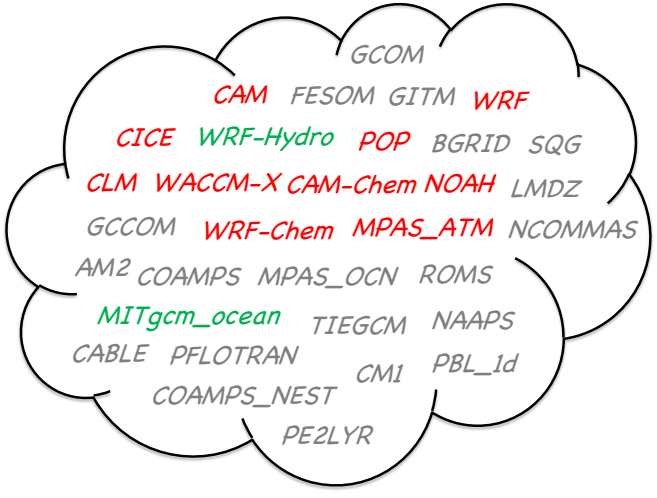

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Research Supporting High-Impact Applications

Predicting Floods using National Water Model

- Collaborative effort between RAL and CISL
- Interface DART and WRF-Hydro to enhance flood prediction in the Carloinas during Hurricane Florence, 2018

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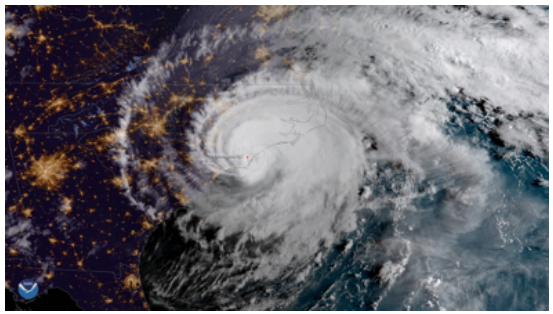

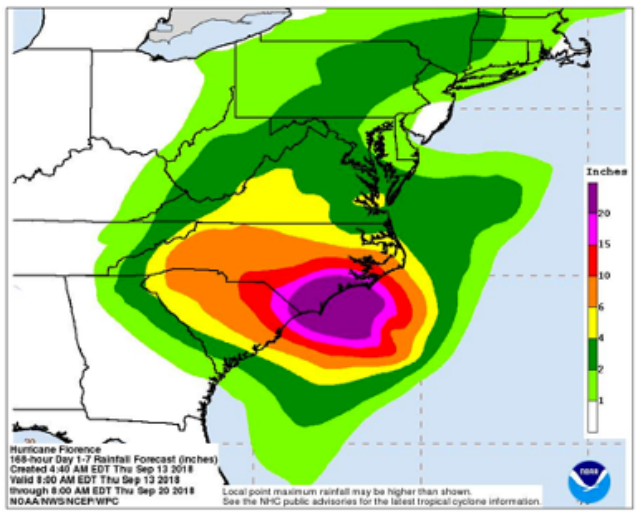

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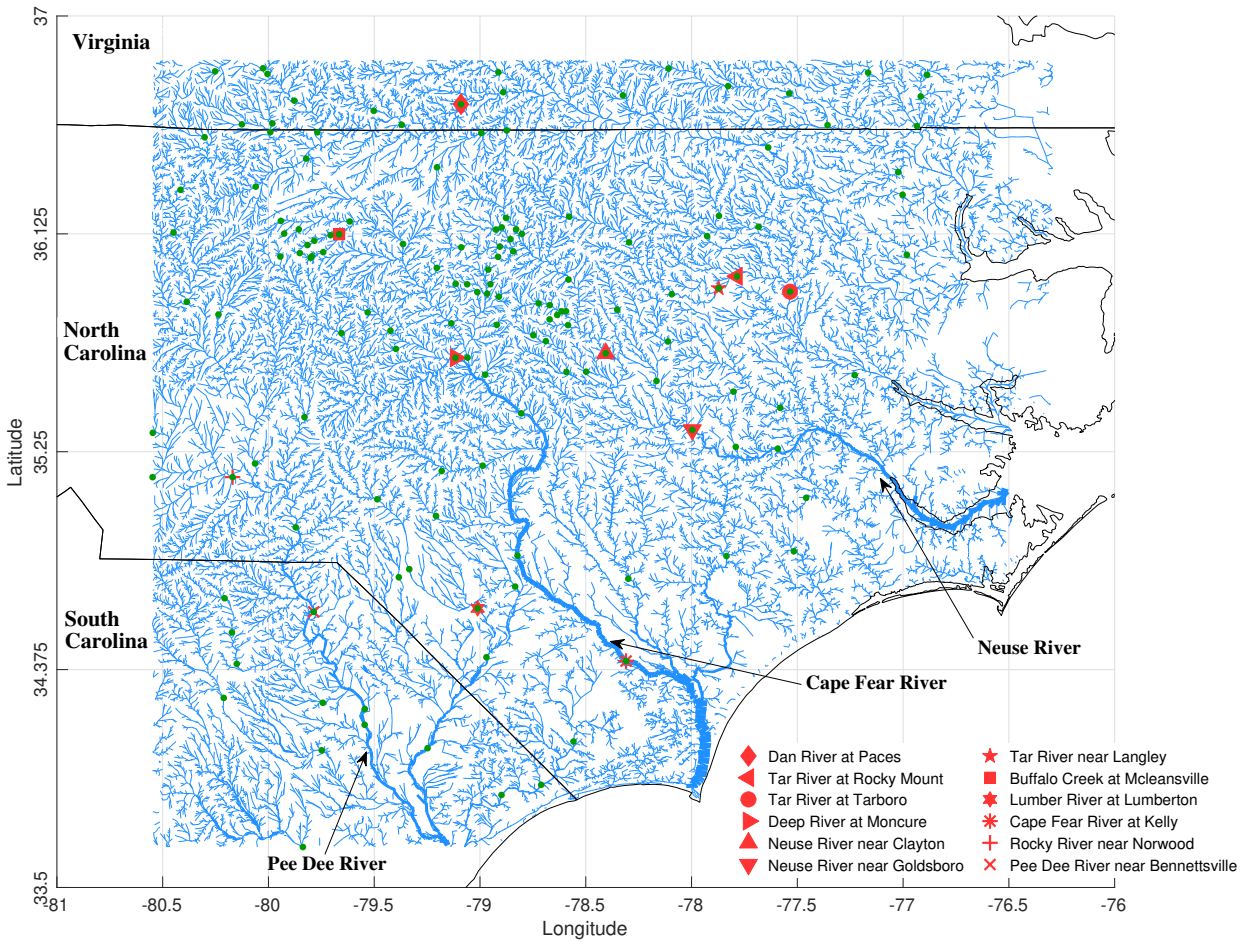

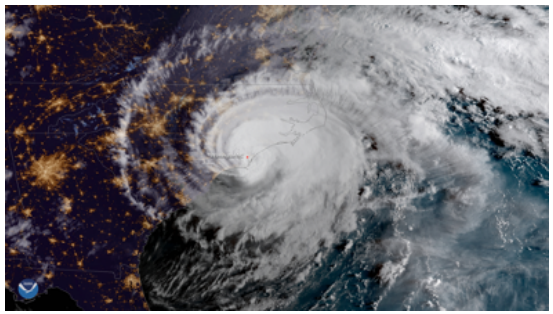

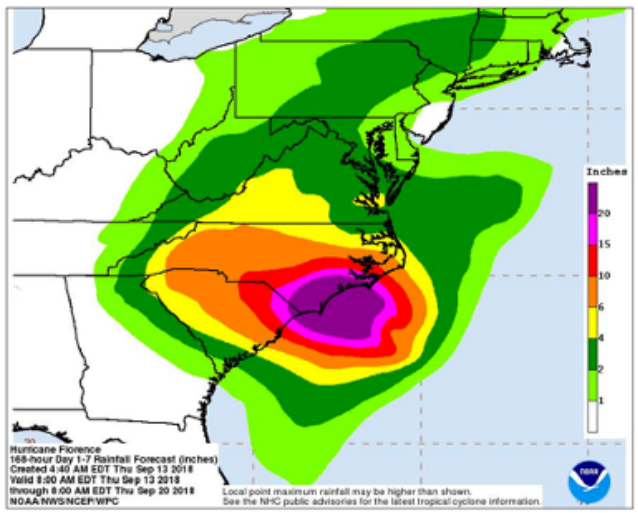

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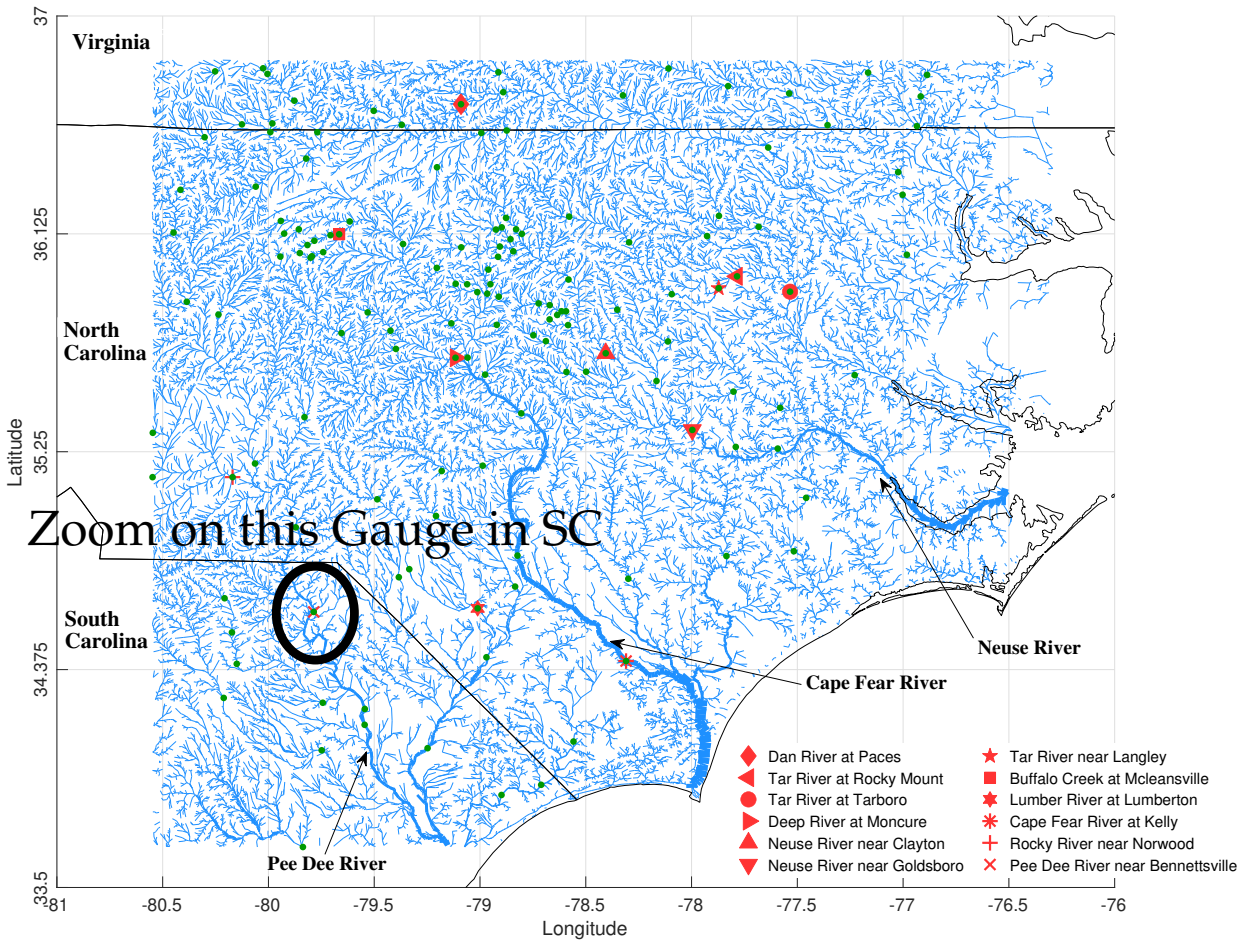

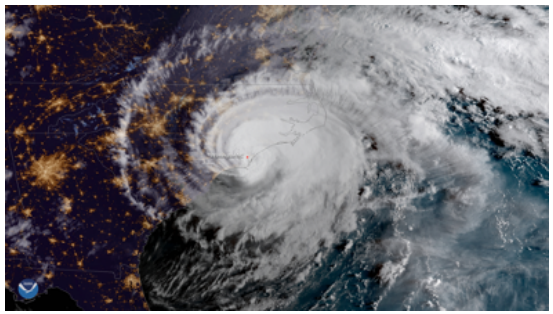

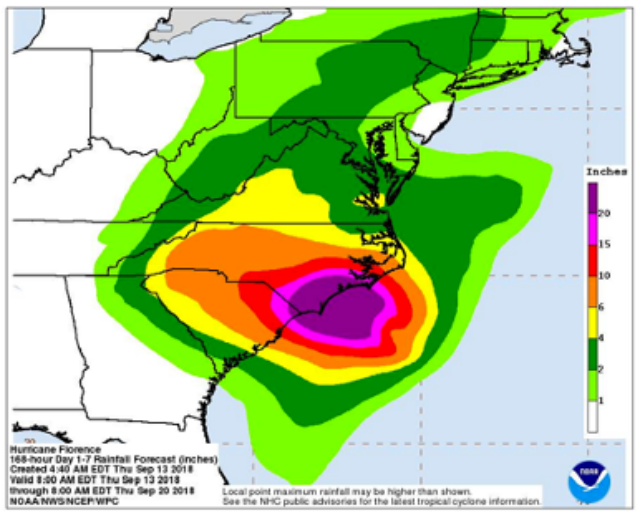

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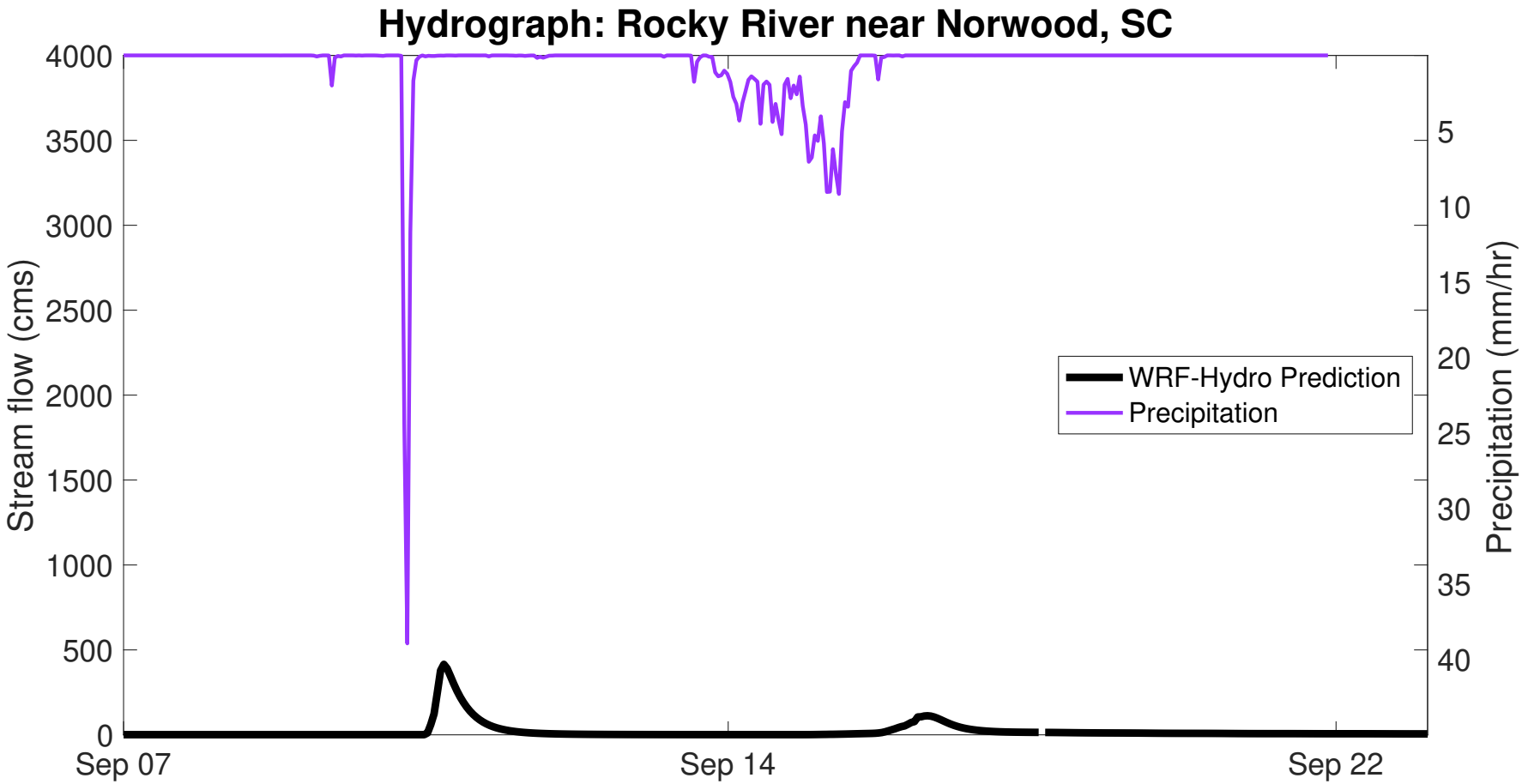

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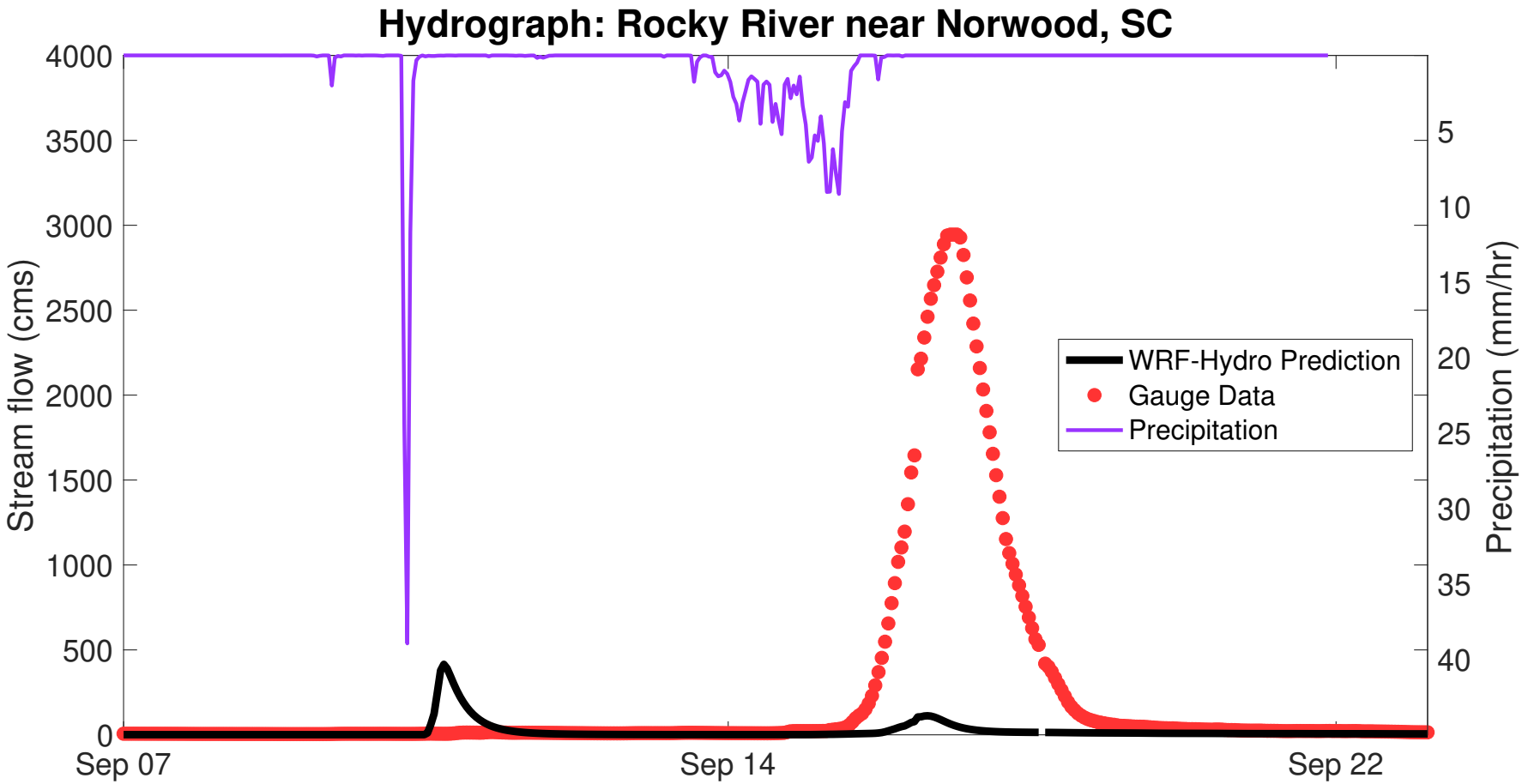

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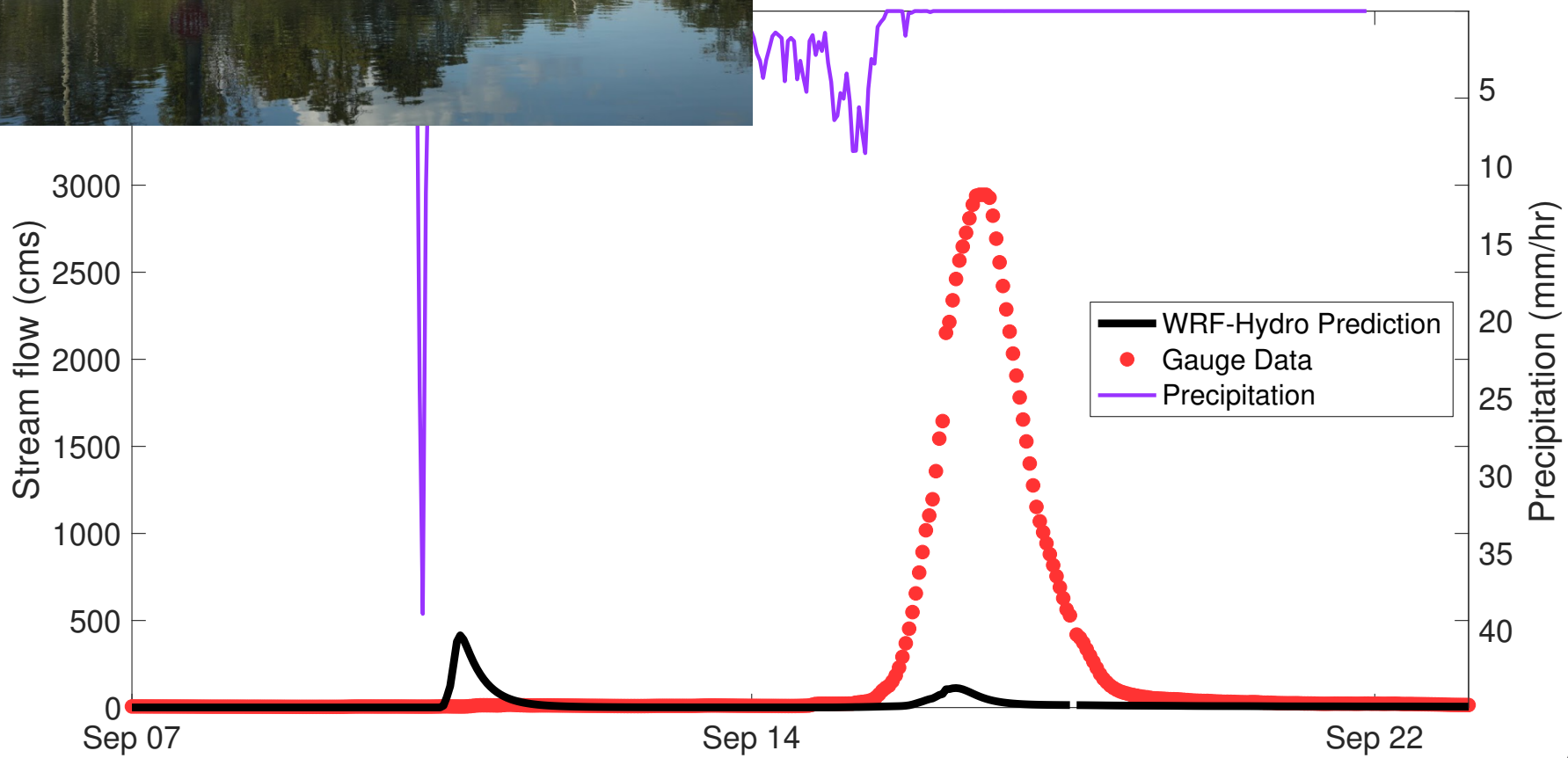

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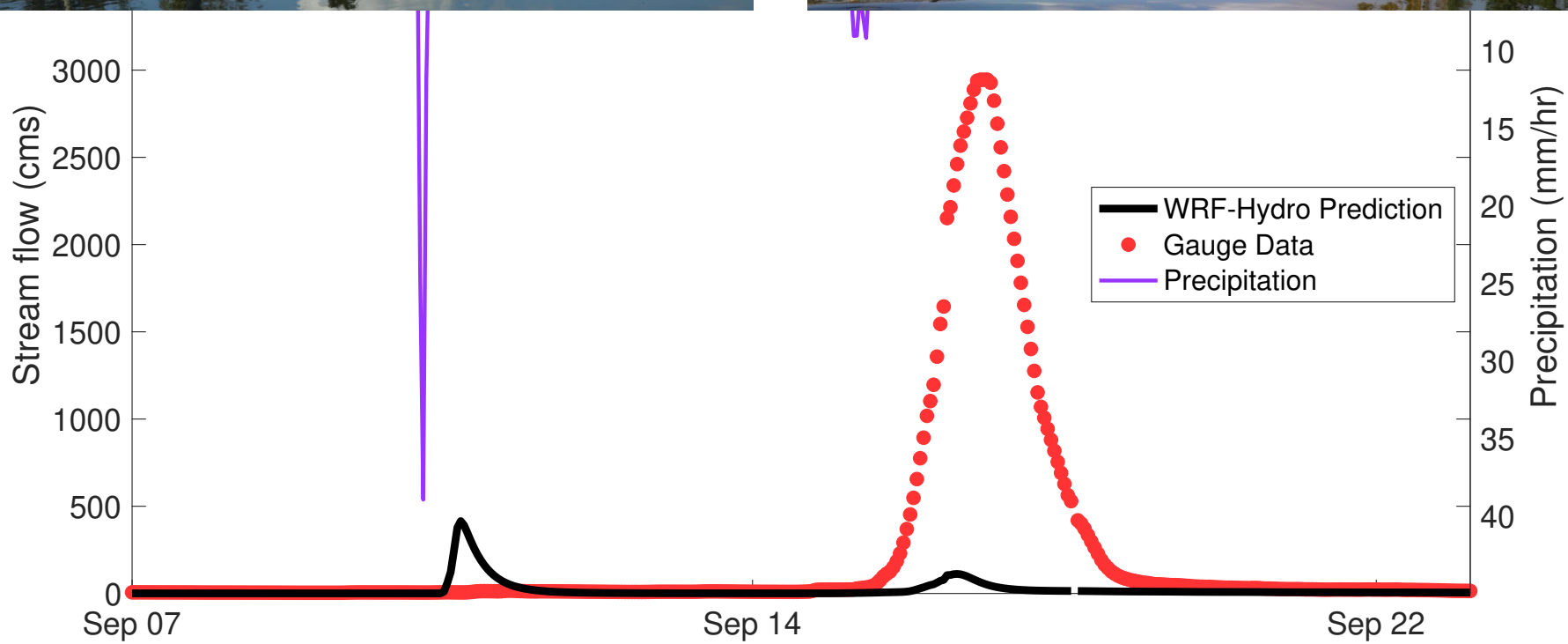

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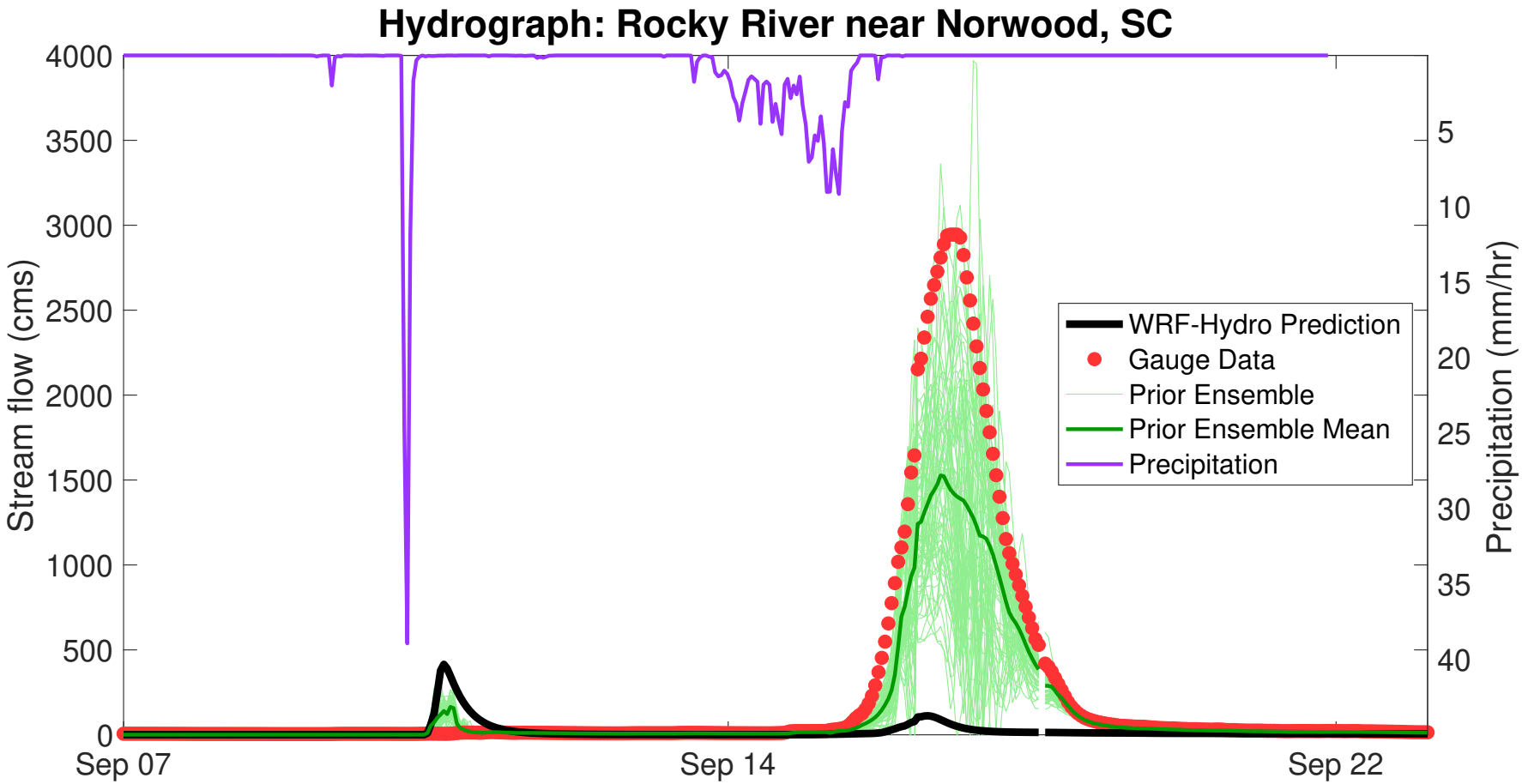

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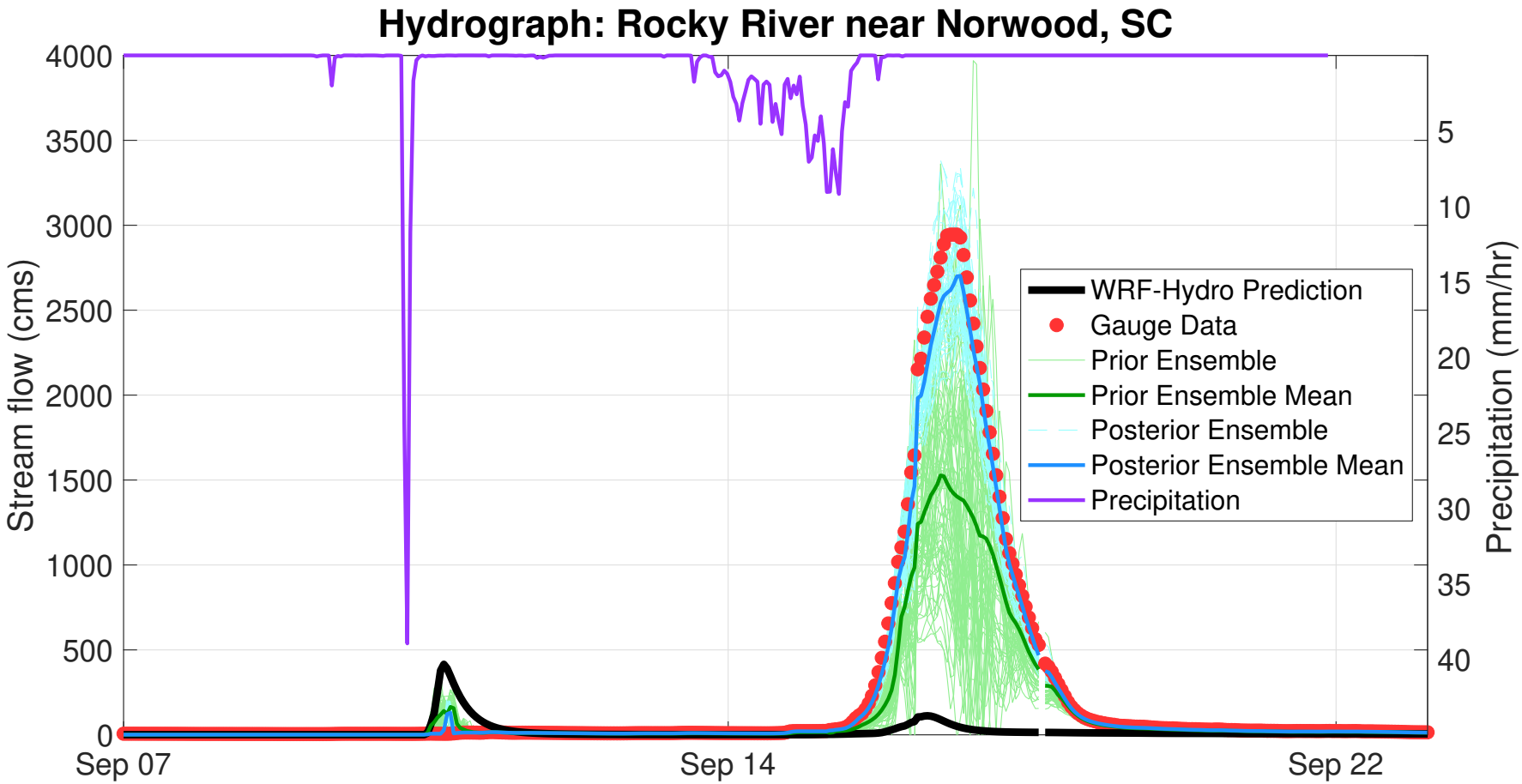

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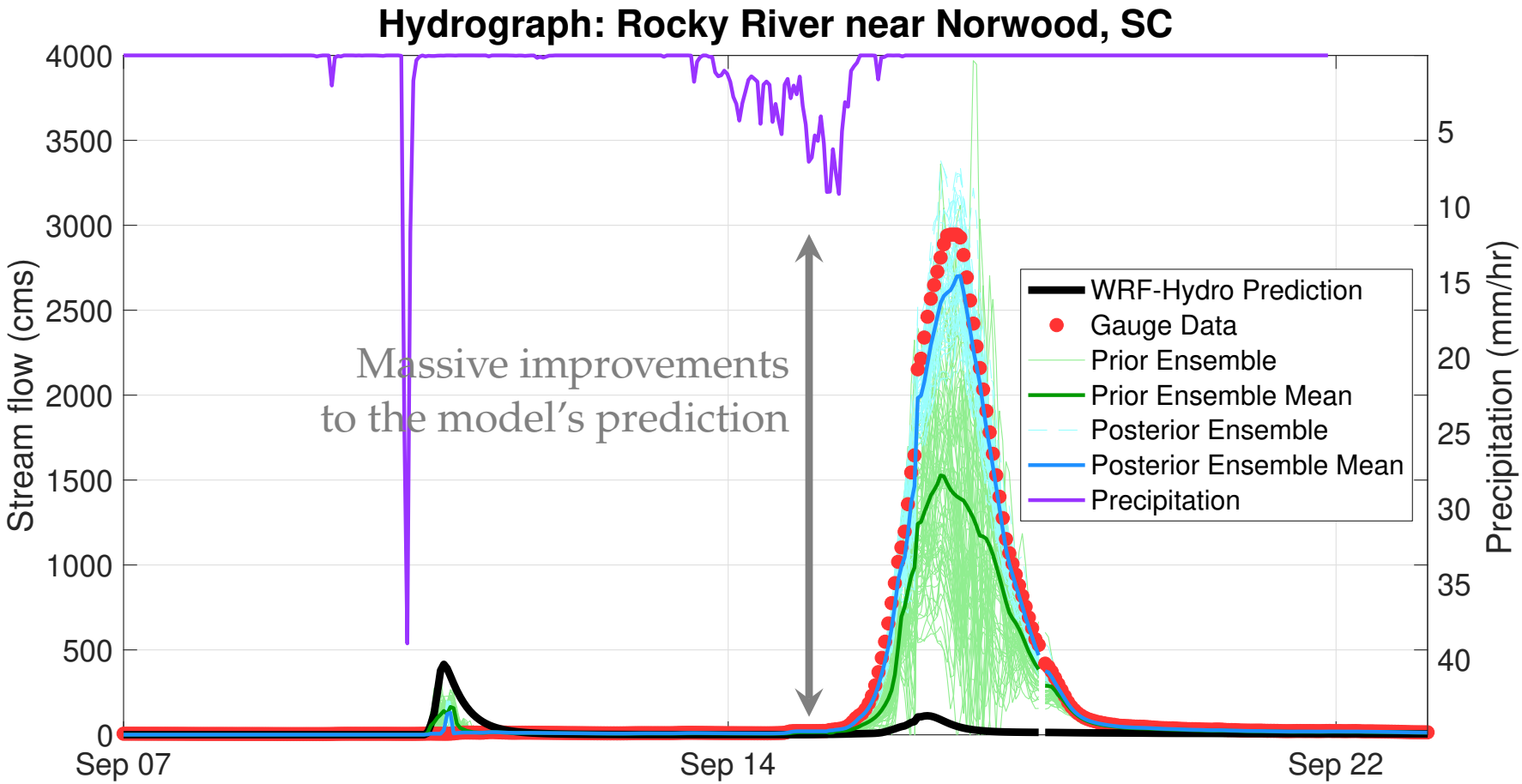

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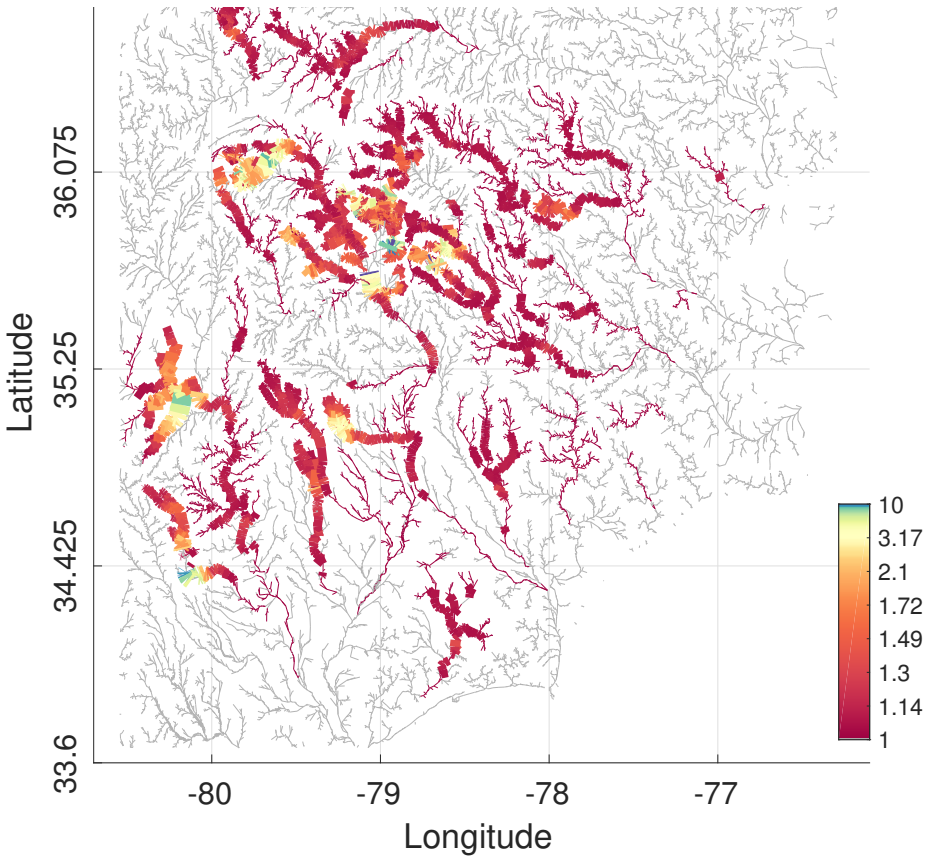

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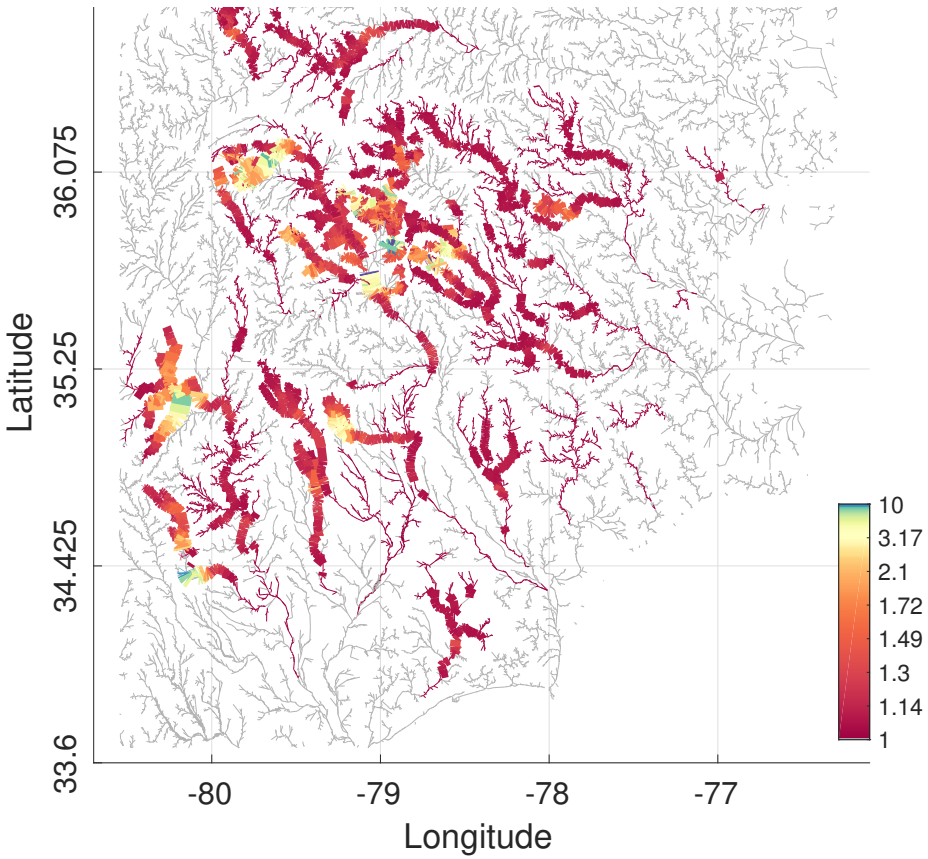
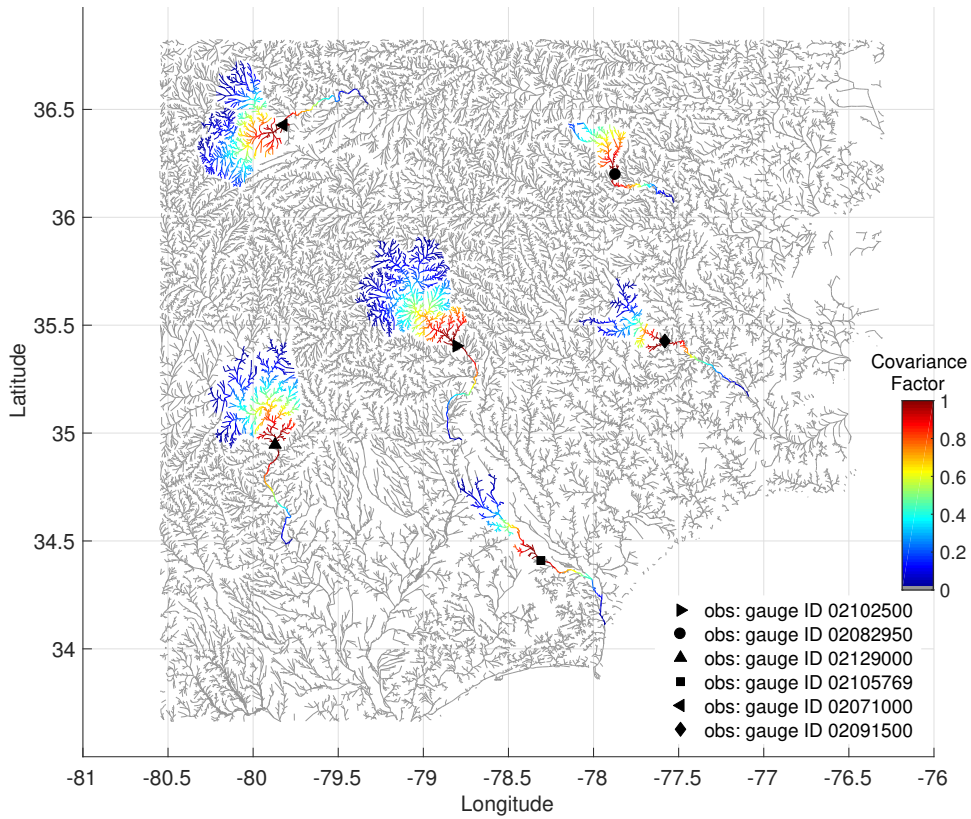


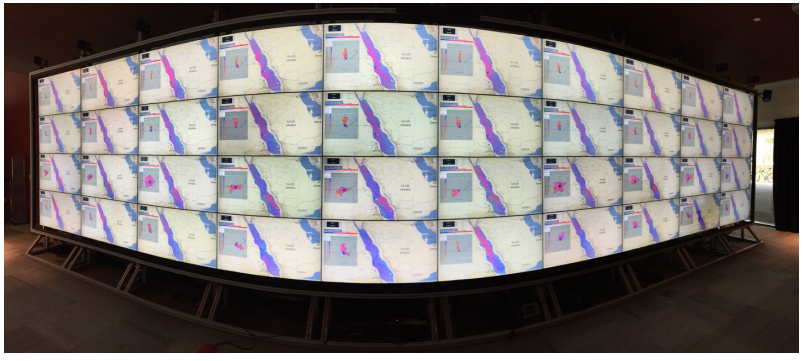


The Red Sea Initiative: Framework

- An exciting project with external collaborators (KAUST, SIO)
- Advance coupled DA science and apply knowledge to NCAR community models

The Red Sea Initiative: Computing

Cray XC40: 7.2 Pflop/s
6.5K dual-socket compute nodes
200K processor cores



The Red Sea Initiative: Uncertainty Assessment

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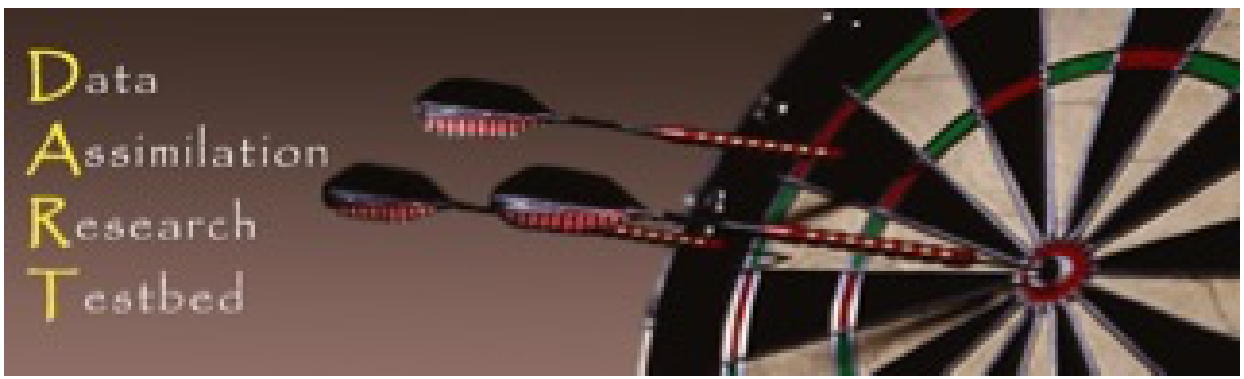

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