



Moving Toward Operational Hydrologic Ensemble Forecasts

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Outline

- Quick review of ensemble uses and current NWS operational process
- Review of ensemble challenges
- Experiences with an ensemble pre-processor to support short-term hydrologic ensemble generation
- Overview of new NOAA/NWS effort to develop a true “operational” system

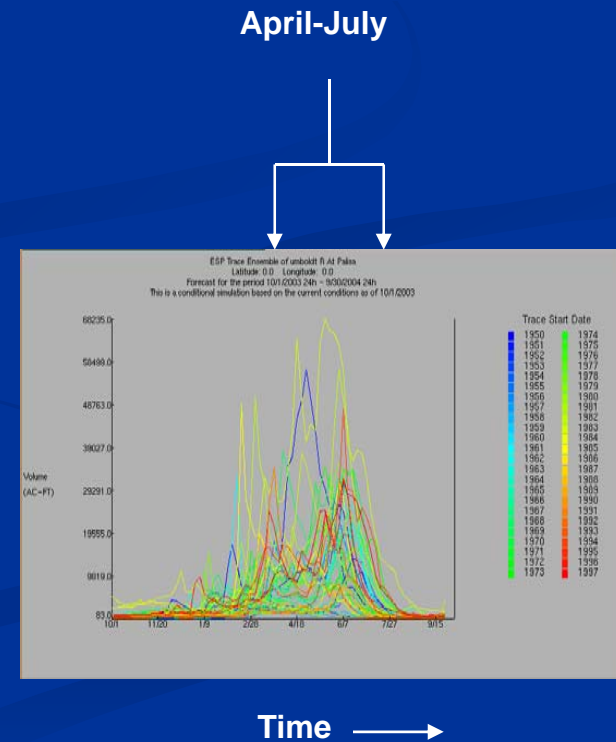
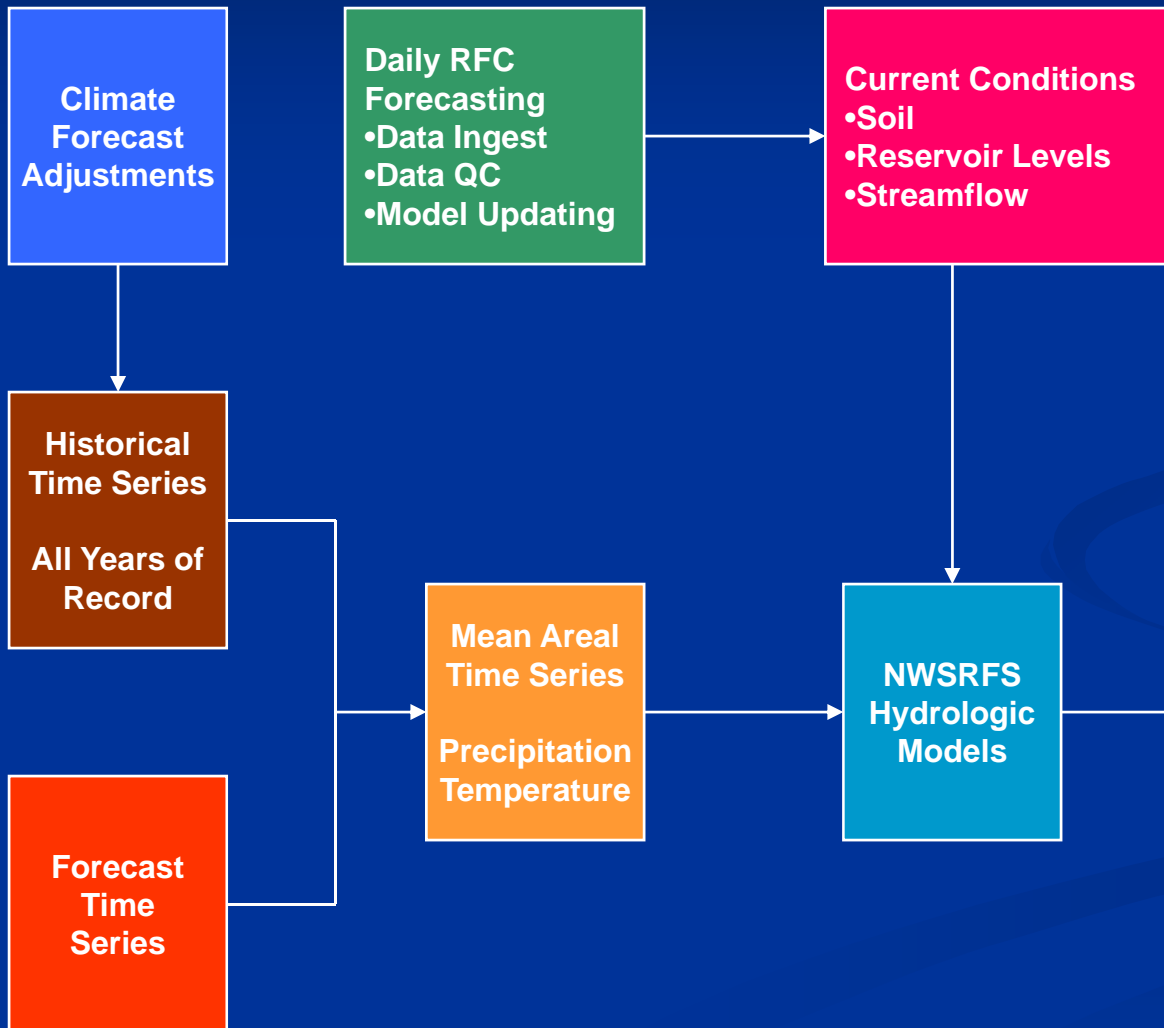


Hydrologic Ensemble Uses

- **Short-range** (hours to days)
 - Watch and warning program
 - Local emergency management activities
 - Reservoir and flood control system management
- **Medium-range** (days to weeks)
 - Reservoir management
 - Local emergency management preparedness
 - Snowmelt runoff management
- **Long-range** (weeks to months)
 - Water supply planning
 - Reservoir management



Ensemble Streamflow Prediction





Ensemble Challenge #1

- Appropriately integrate the uncertainty introduced from model, data, and human sources.

OBSERVATIONS

precipitation
air temperature
streamflow

MODEL STATES

snow
soil moisture
basin routing

MODELING SYSTEM

simplifications
temporal issues
scale issues

?

MODEL PARMS

snow
soil moisture
basin routing

HUMAN INPUT

education
training
experience
mental state

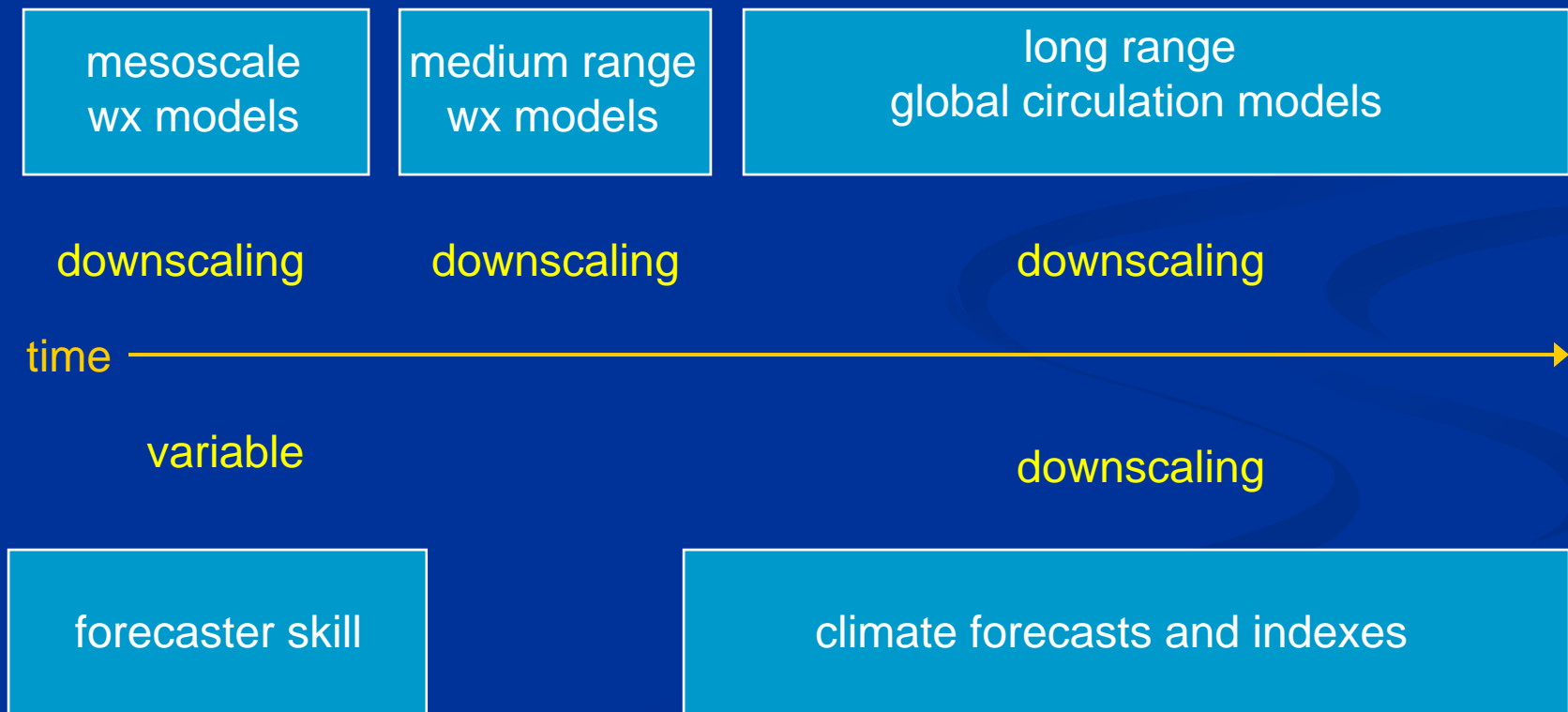
FORECASTS

precipitation
air temperature
regulation



Ensemble Challenge #2

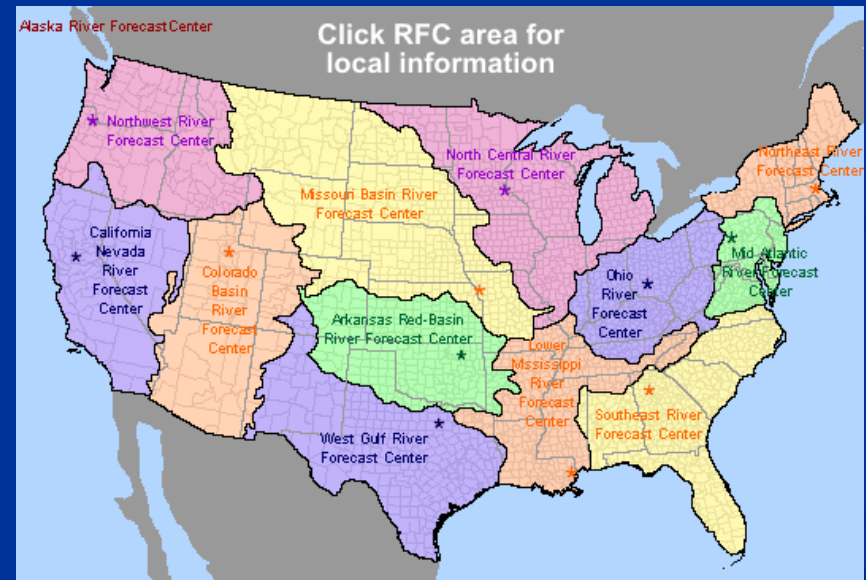
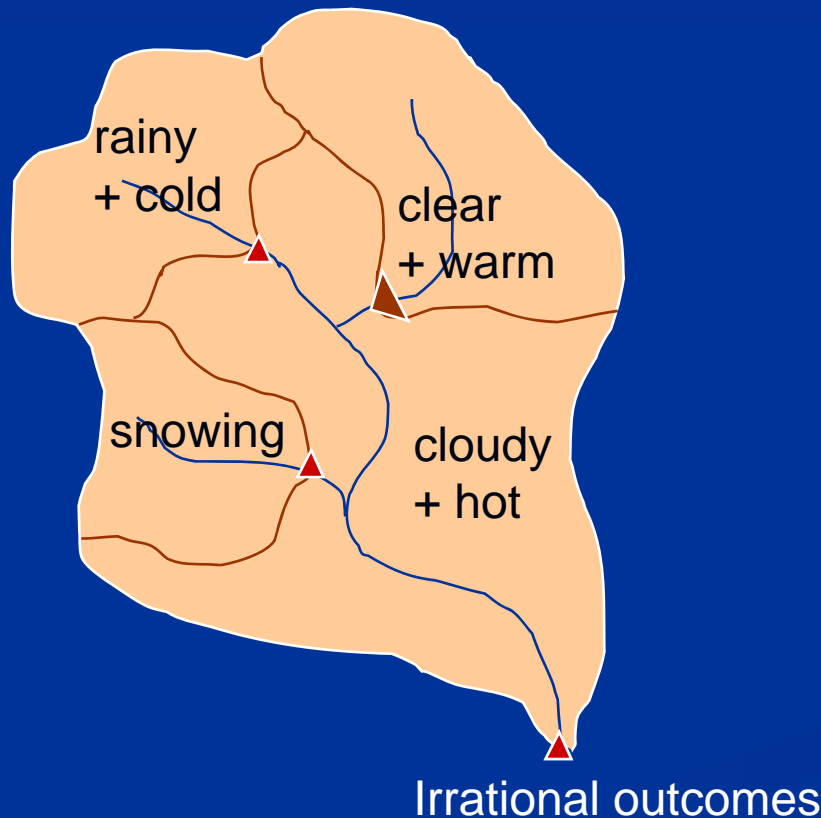
- Mesh ensemble forcing from short, medium, and long range techniques.





Ensemble Challenge #3

- Maintain spatial and temporal relationships across very large areas.





Ensemble Challenge #4

- Include forecaster skill in short-term inputs (QPF, temperature, etc.)

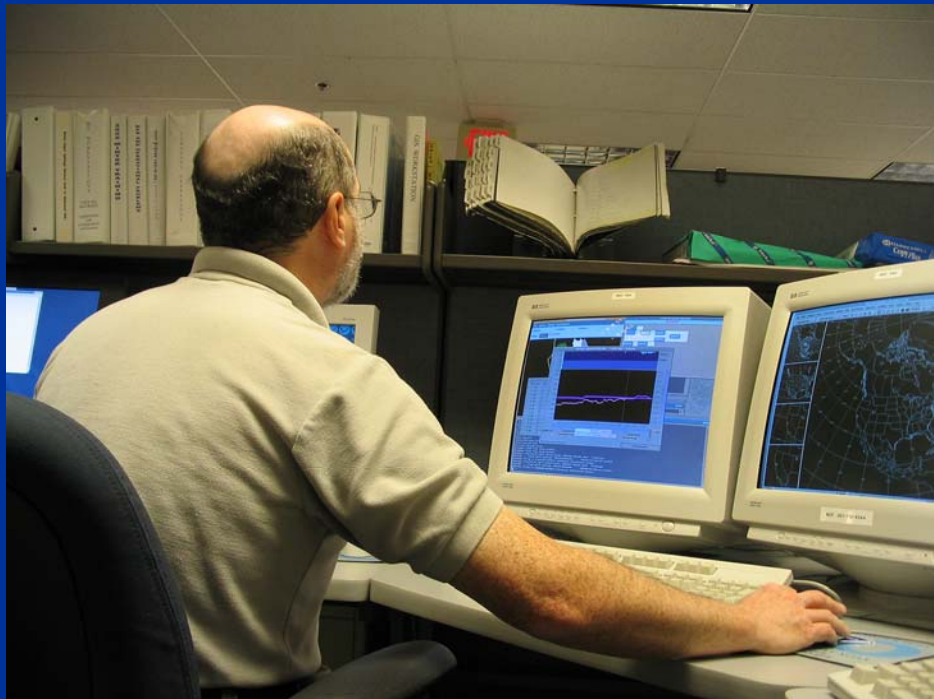


- Verification shows that local forecasters add value to
 - numerical models
 - larger scale forecasters



Ensemble Challenge #5

- Include forecaster guidance of hydrologic model operation

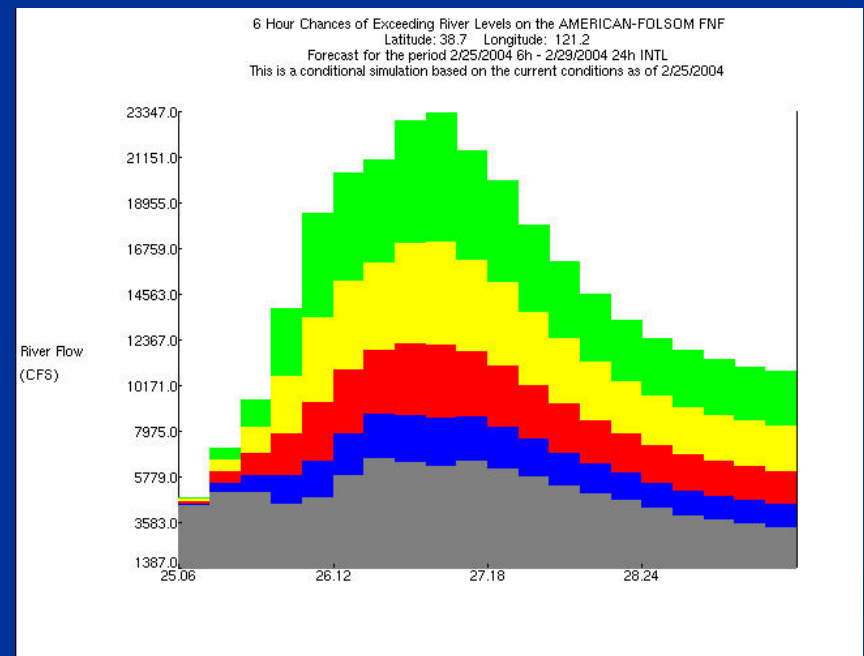
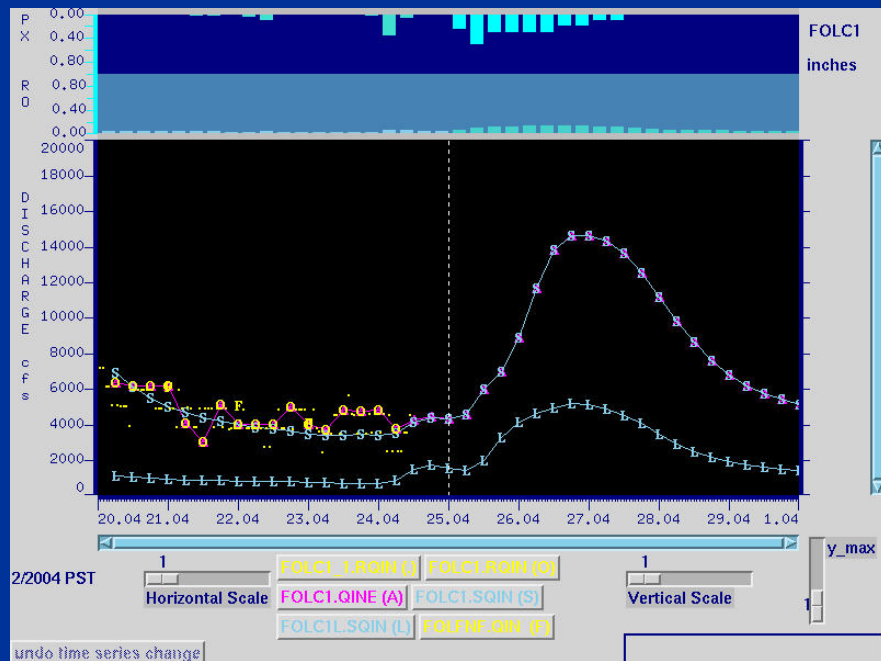


- Hydrologic models require on-going tuning.
- Forecasters commonly adjust or influence raw model output.



Ensemble Challenge #6

- Maintain coherence between deterministic and ensemble forecasts





Ensemble Challenge #7

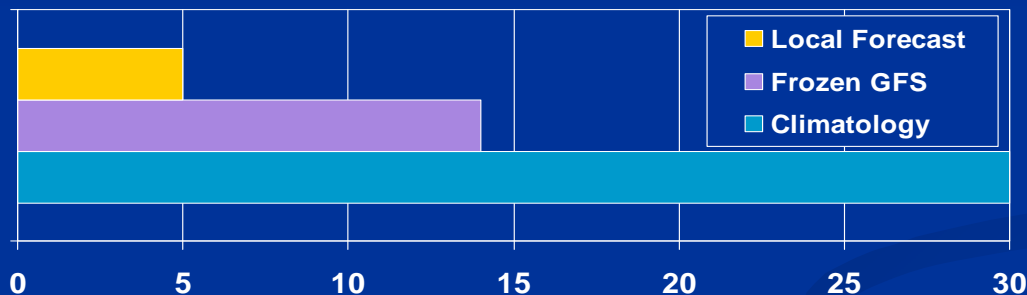
- Providing uncertainty information in a form and context that is useful to our customers
 - Education and training
 - Context and validation and verification
 - Compatibility with decision support tools
 - we will need some new ones!

“Some of our customers are eager to misuse the information we provide, others don’t want anything to do with risk/uncertainty/probability”



Short-term Ensemble Prototype

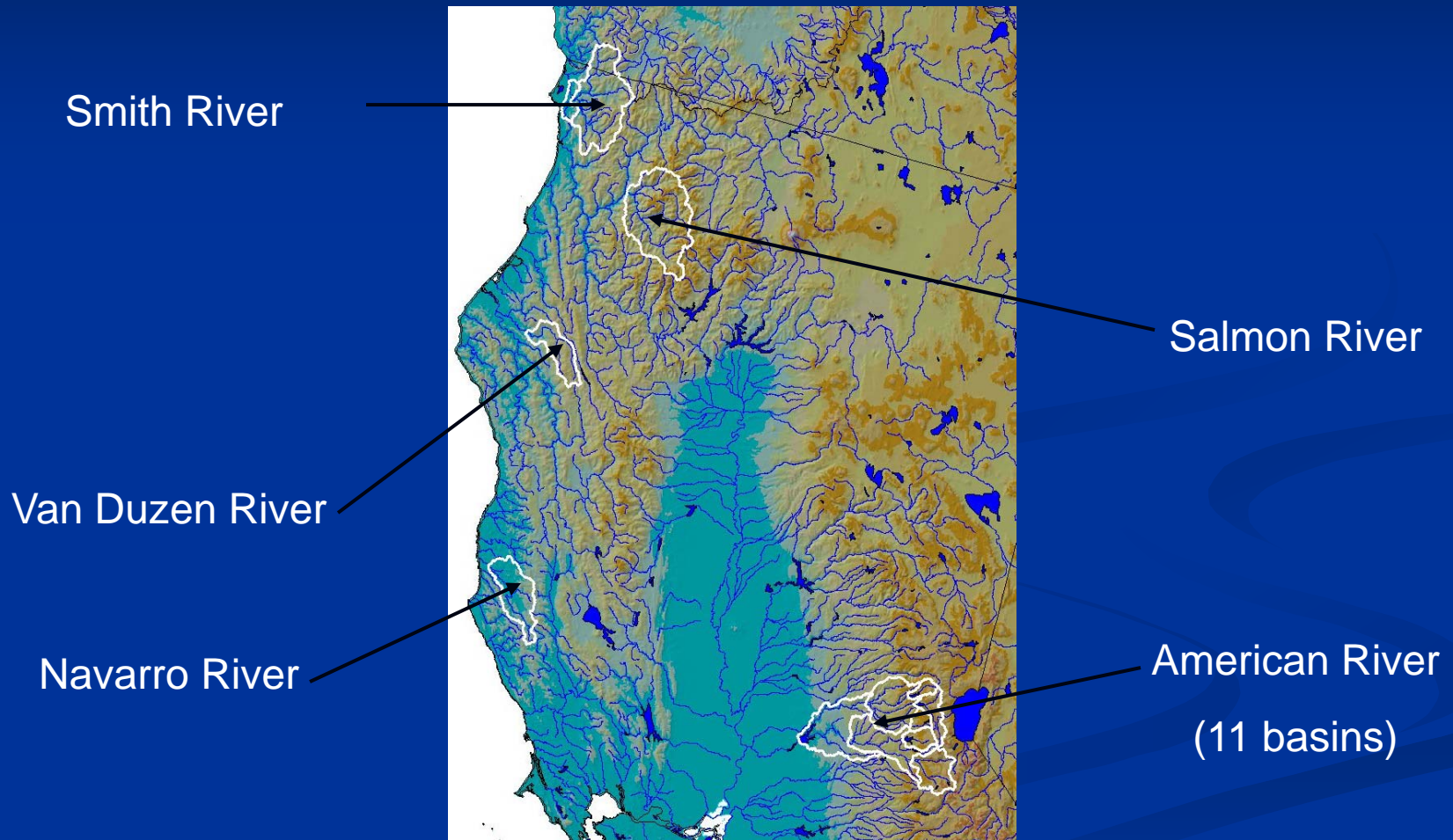
- Running in selected basin at 4 of 13 US River Forecast Centers
- Ensemble Preprocessor
 - Up to 30 days of forcing ensembles (begins to address challenge #2)



- Uses forecast (skill) and watershed climatology (challenge #4)
- Accounts for temporal and spatial coherency (challenge #3)
- Captures skill exhibited over durations $>$ model time step
- Analysis of hindcast ensembles
 - **unbiased**
 - **reasonable spread**



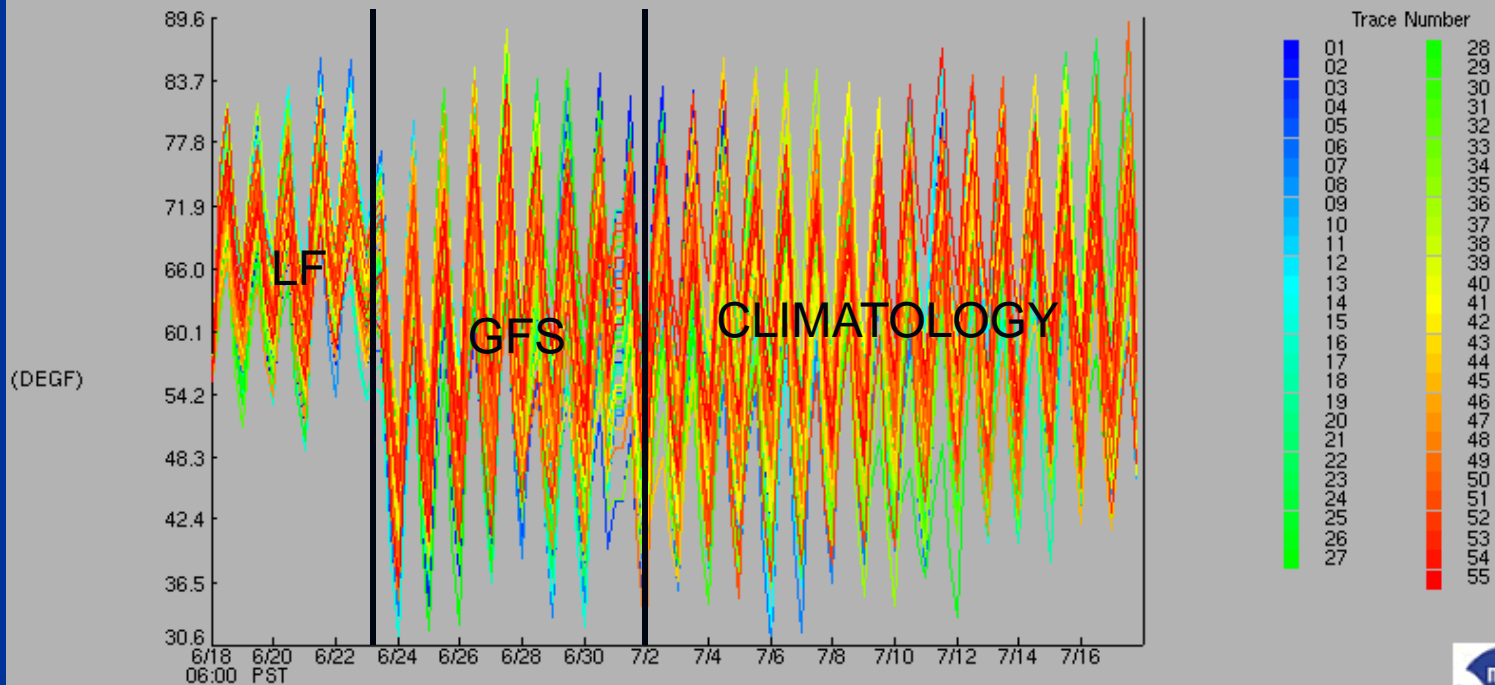
Short-term Ensemble Prototype at the CNRFC





30-day Temperature Ensembles

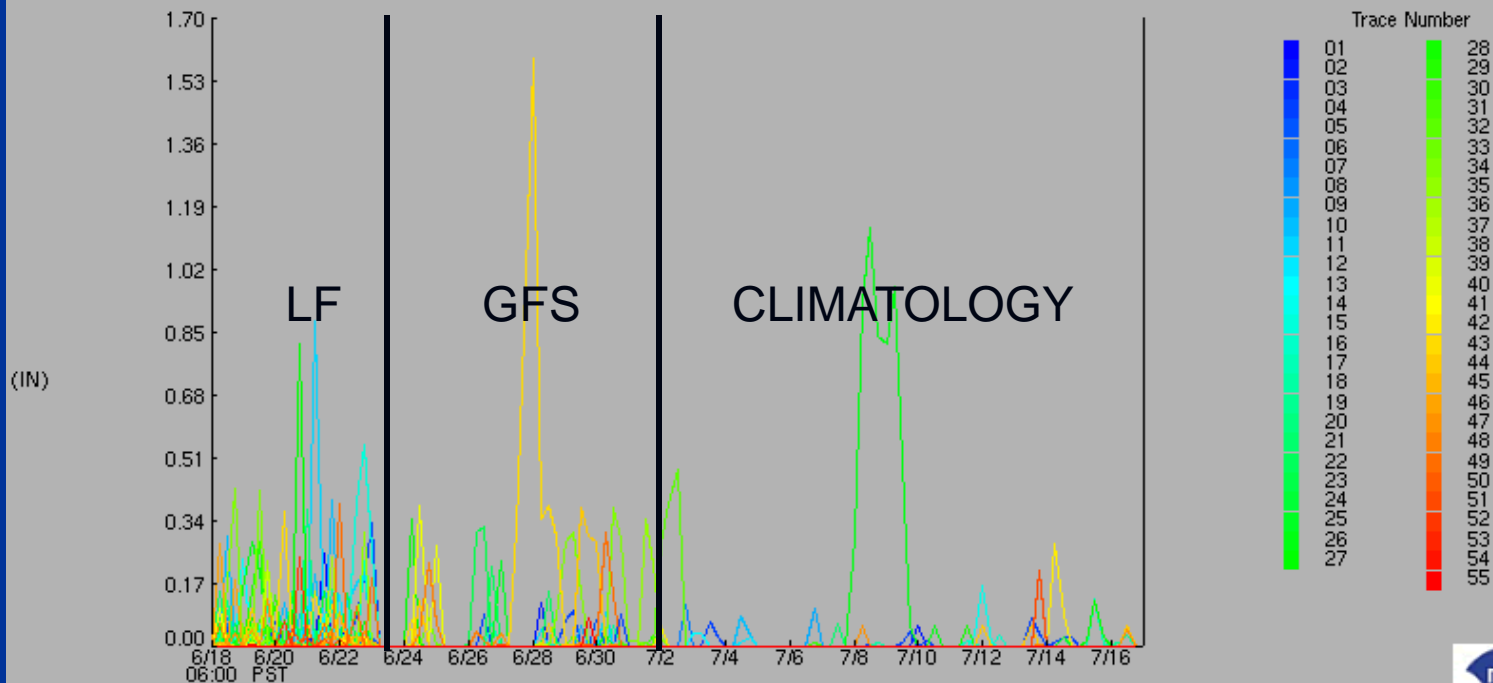
Calib. Trace Ensemble
Latitude: 0.0 Longitude: 0.0
Forecast for the period 6/18/2007 6h - 7/17/2007 24h PST
This is a conditional simulation based on the current conditions as of 6/1/2007





30 day Precipitation Ensembles

Calib. Trace Ensemble
Latitude: 0.0 Longitude: 0.0
Forecast for the period 6/18/2007 6h - 7/16/2007 24h PST
This is a conditional simulation based on the current conditions as of 6/1/2007





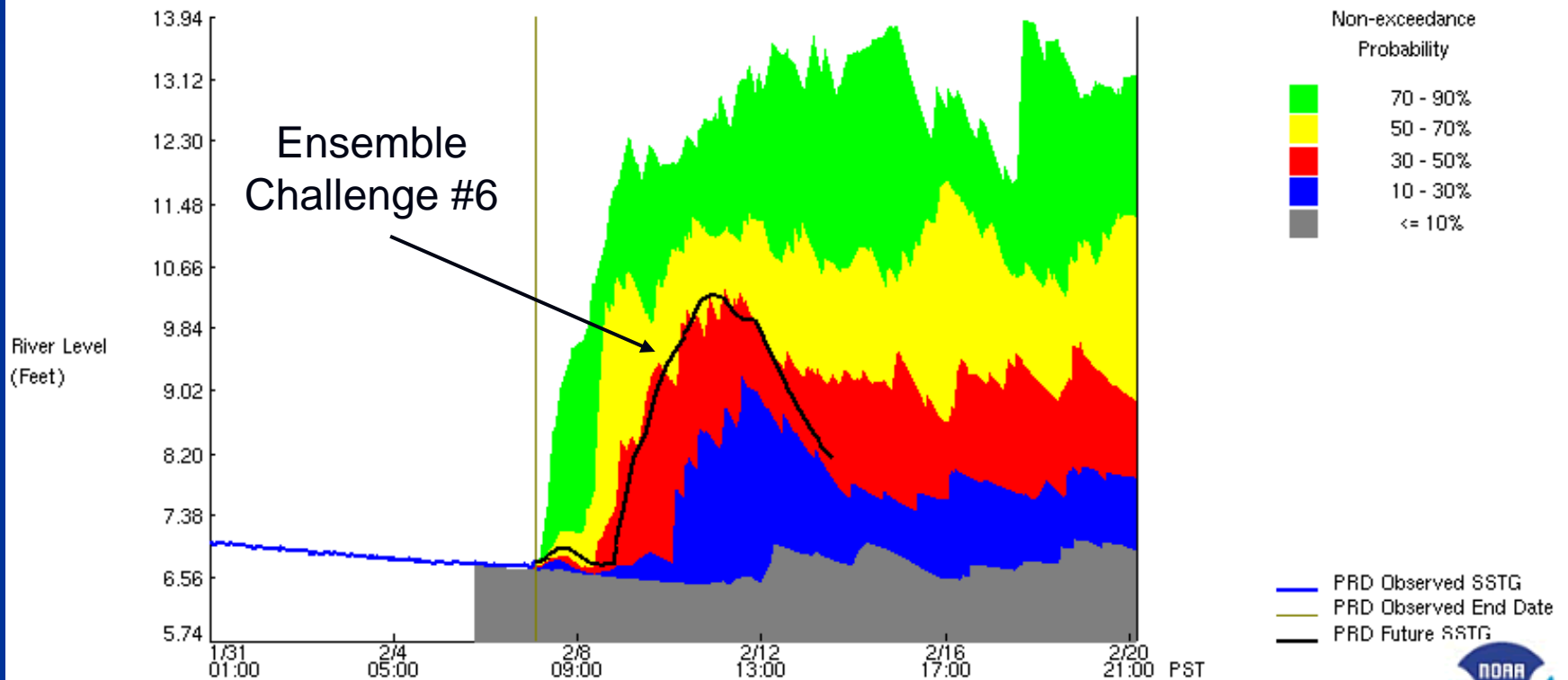
Smith River – February 7, 2007

1 Hour Chances of Not Exceeding River Levels on the SMITH at SMITH-JED SMITH SP

Latitude: 41.8 Longitude: 124.1

Forecast for the period 2/6/2007 1h - 2/20/2007 24h PST

This is a conditional simulation based on the current conditions as of 2/6/2007





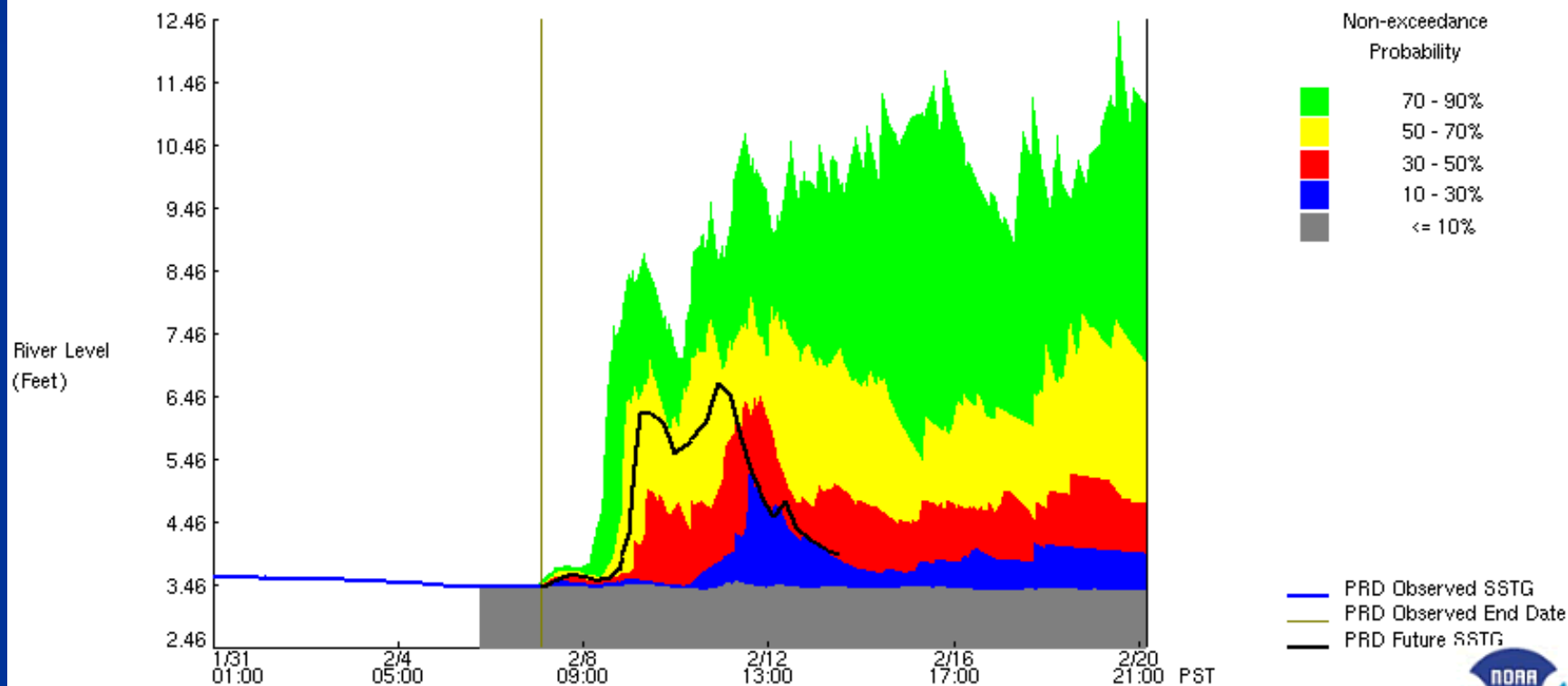
Navarro River – Feb 7, 2007

1 Hour Chances of Not Exceeding River Levels on the NAVARRO at NAVARRO-NAVARRO

Latitude: 39.0 Longitude: 123.4

Forecast for the period 2/6/2007 1h - 2/20/2007 24h PST

This is a conditional simulation based on the current conditions as of 2/6/2007





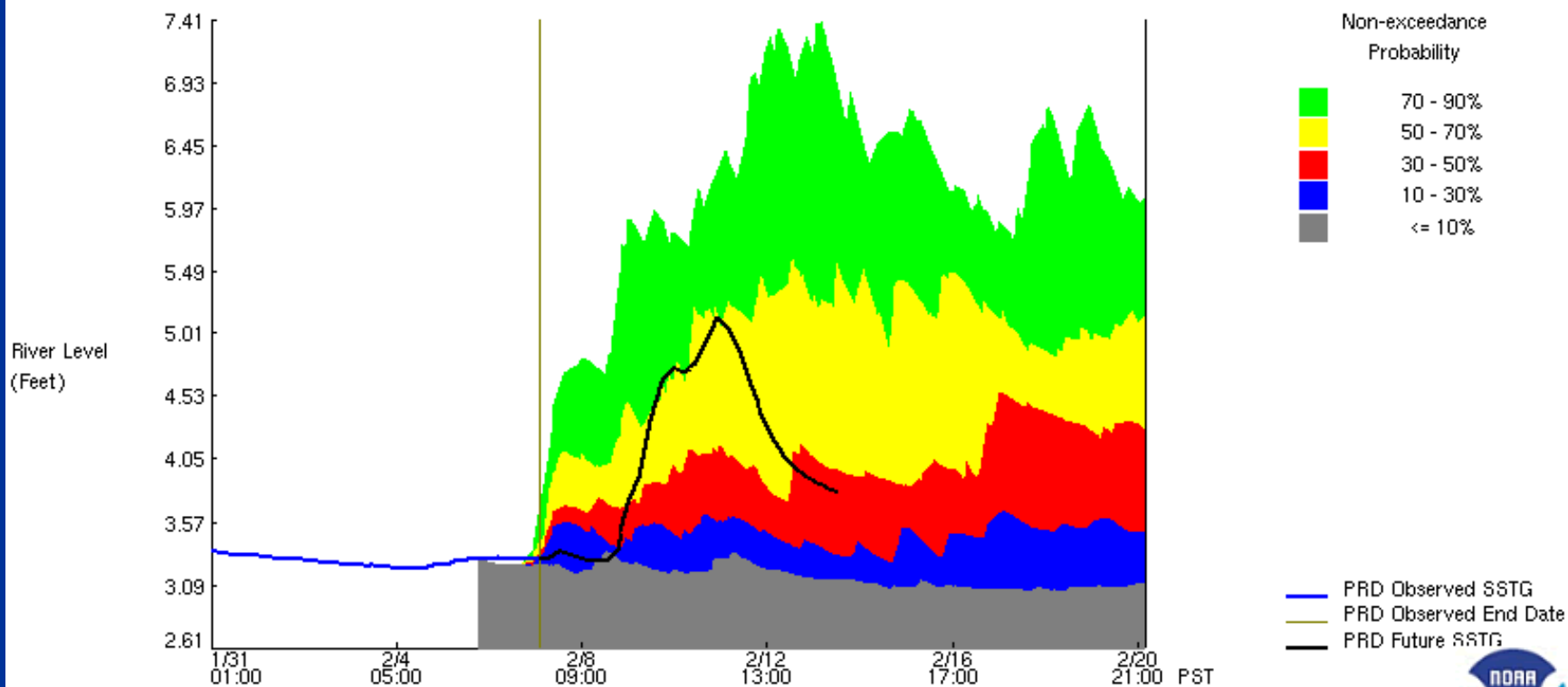
Salmon River – February 7, 2007

1 Hour Chances of Not Exceeding River Levels on the SALMON at SALMON - SOMES BAR

Latitude: 41.4 Longitude: 123.5

Forecast for the period 2/6/2007 1h - 2/20/2007 24h PST

This is a conditional simulation based on the current conditions as of 2/6/2007





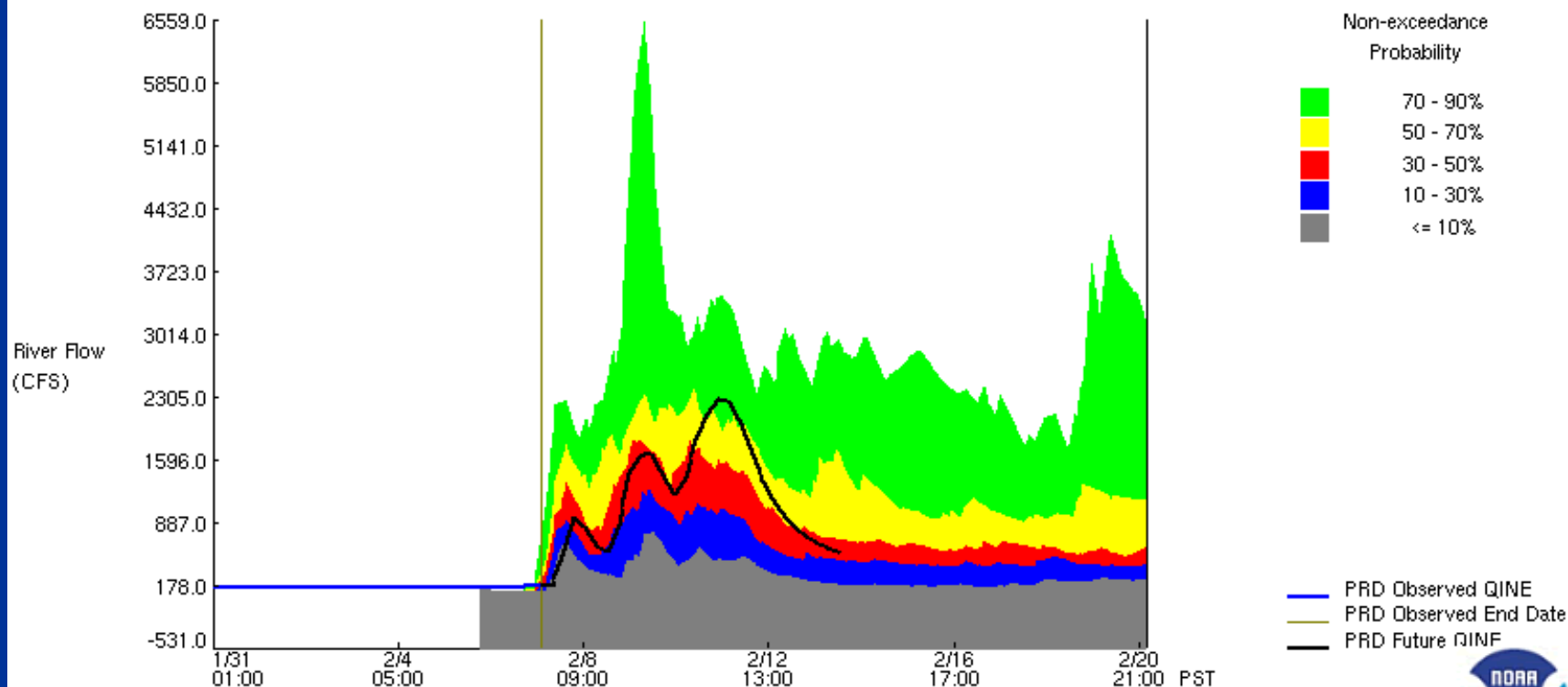
NF American – February 7, 2007

1 Hour Chances of Not Exceeding River Levels on the NF AMERICAN - NF DAM

Latitude: 39.2 Longitude: 120.6

Forecast for the period 2/6/2007 1h - 2/20/2007 24h PST

This is a conditional simulation based on the current conditions as of 2/6/2007





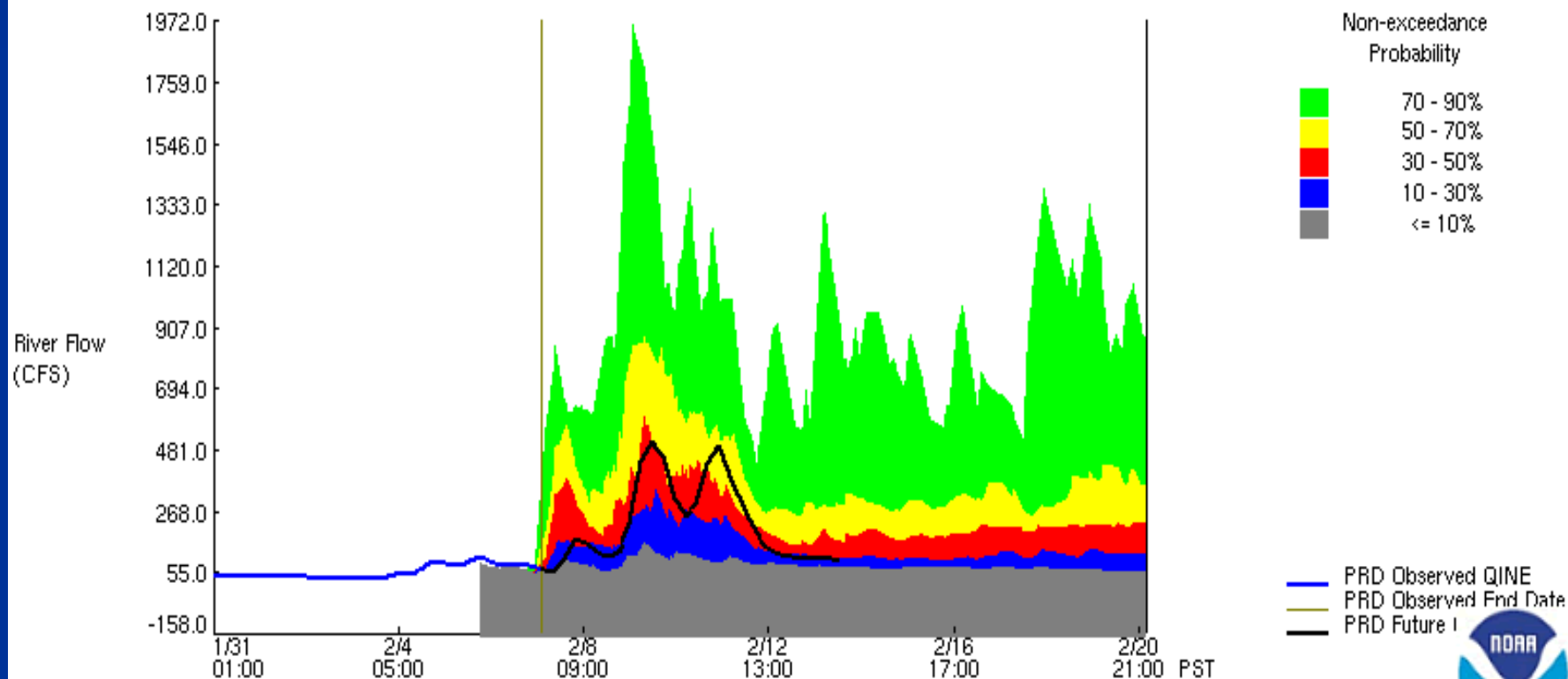
SF American – February 7, 2007

1 Hour Chances of Not Exceeding River Levels on the SF AMERICAN - KYBURZ

Latitude: 38.8 Longitude: 120.2

Forecast for the period 2/6/2007 1h - 2/20/2007 24h PST

This is a conditional simulation based on the current conditions as of 2/6/2007





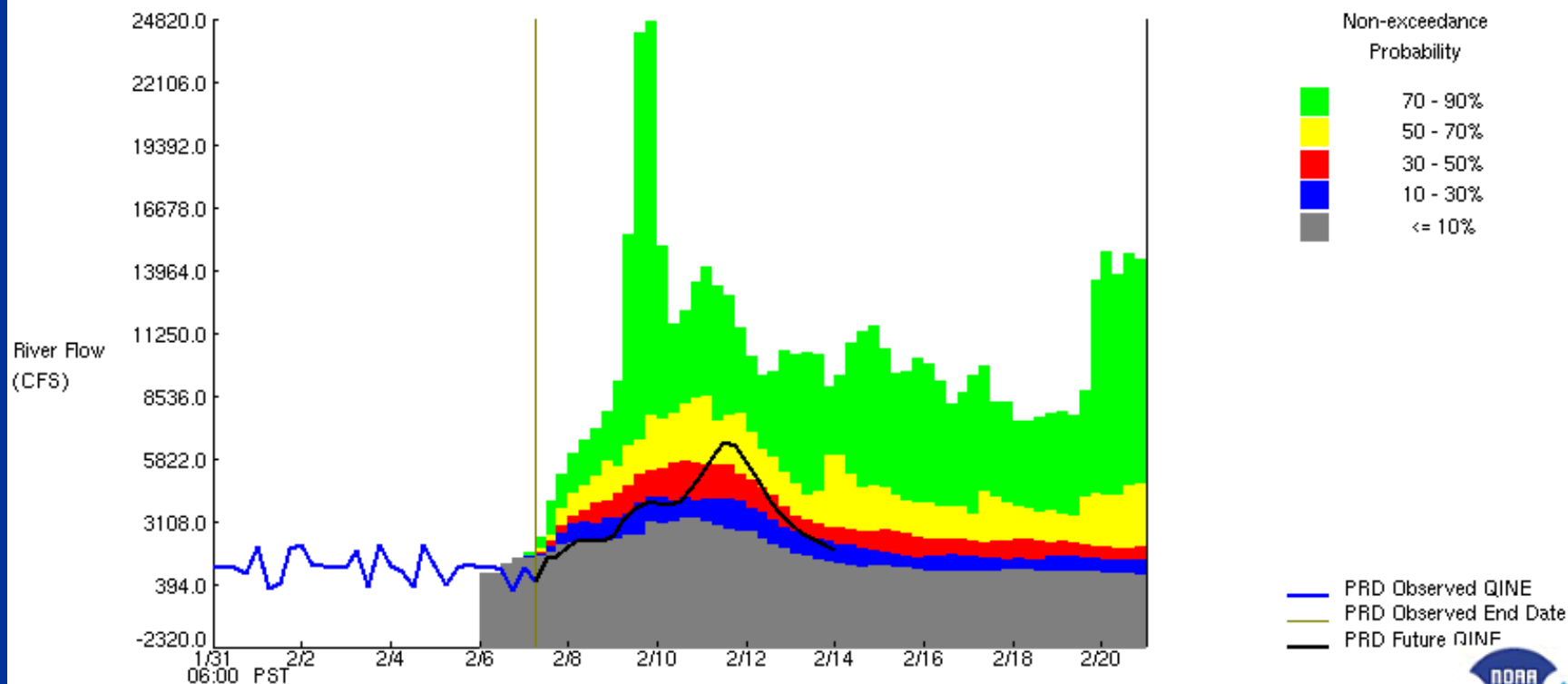
American (Folsom Reservoir Inflow) February 7, 2007

6 Hour Chances of Not Exceeding River Levels on the AMERICAN-FOLSOM RES

Latitude: 38.8 Longitude: 121.0

Forecast for the period 2/6/2007 6h - 2/20/2007 24h PST

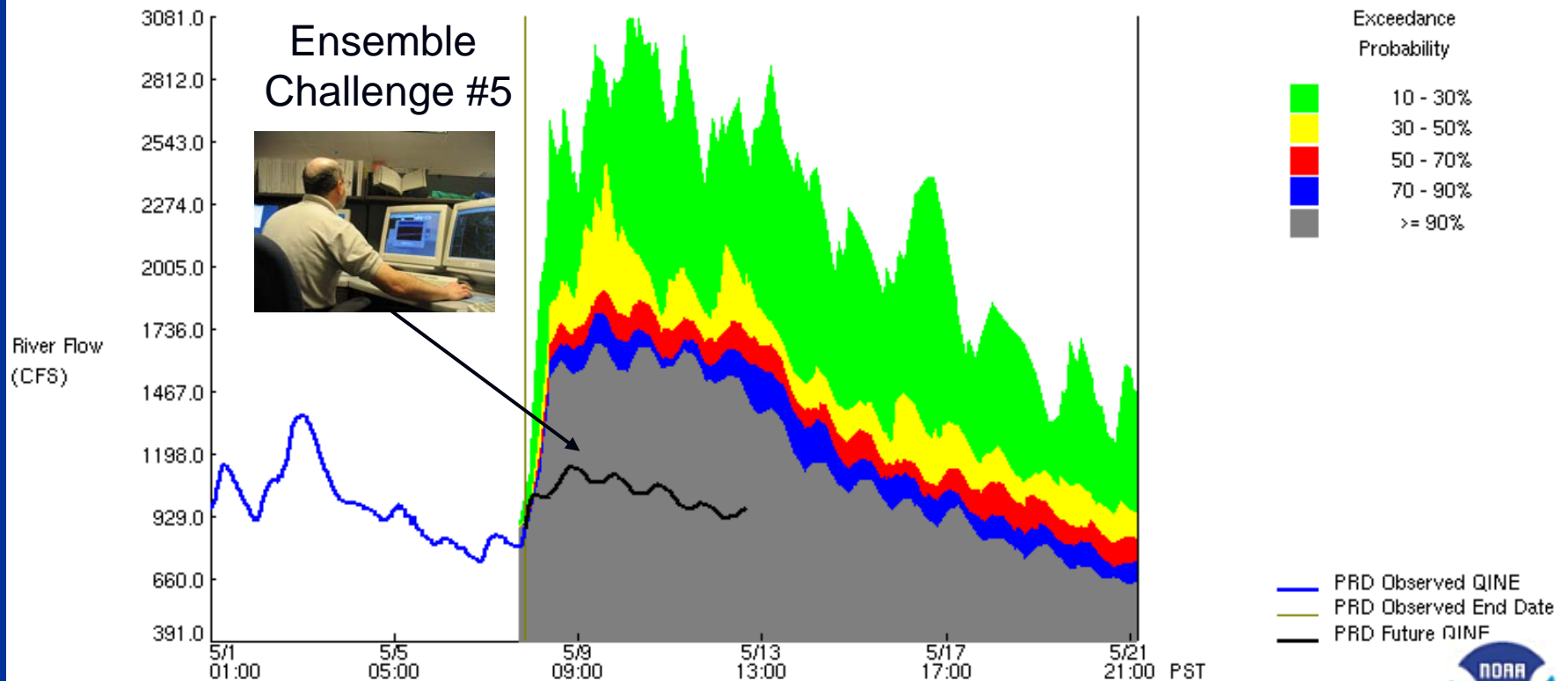
This is a conditional simulation based on the current conditions as of 2/6/2007





NF American – May 8, 2007

1 Hour Chances of Exceeding River Levels on the NF AMERICAN - NF DAM
Latitude: 39.2 Longitude: 120.6
Forecast for the period 5/8/2007 1h - 5/21/2007 24h PST
This is a conditional simulation based on the current conditions as of 5/8/2007



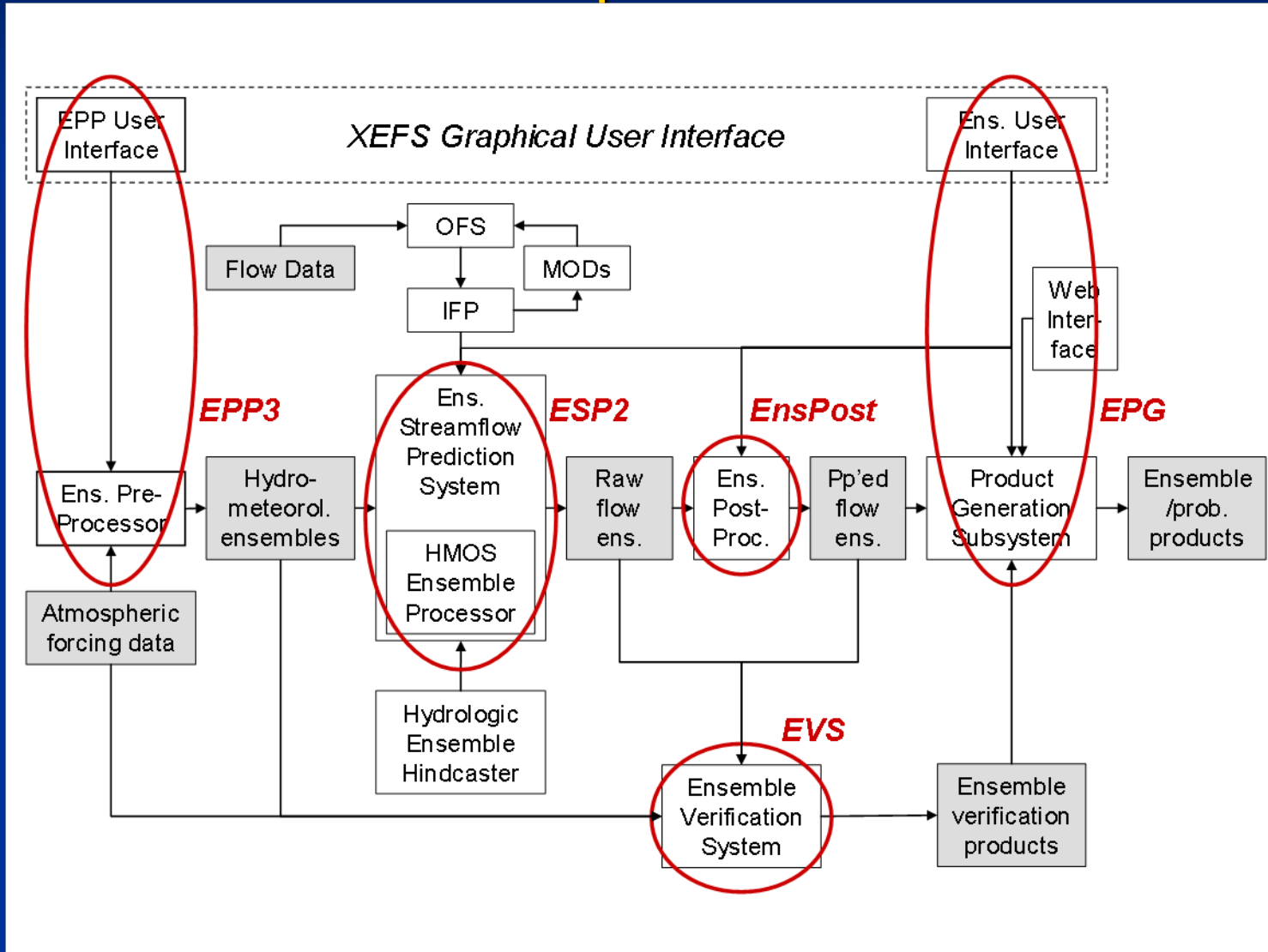


Experimental Ensemble Forecasting System (XEFS)

- NWS collaborative activity initiated in November 2006
 - Headquarters and field office effort
- Deliver a system capable of producing “operational” short, medium, and long range hydrologic ensemble products within 2 to 3 years
- Design and GAP analysis completed in May 2007.
- Planning for development and implementation is underway
 - Infrastructure plan due in late Summer 2007
 - Strong ties to Community Hydrologic Prediction System (CHPS)
 - High priority for NOAA’s Hydrology Program



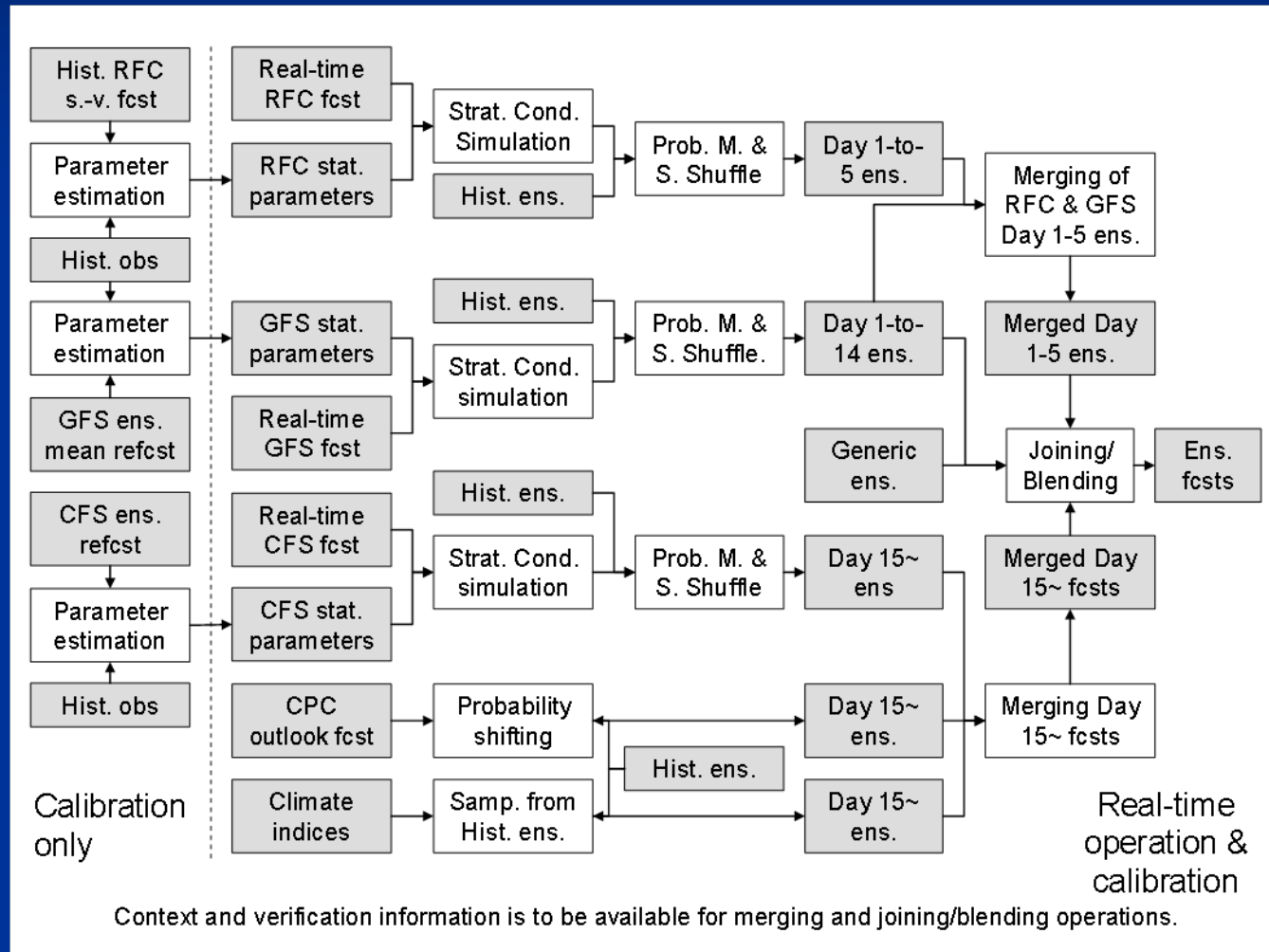
XEFS Components





XEFS

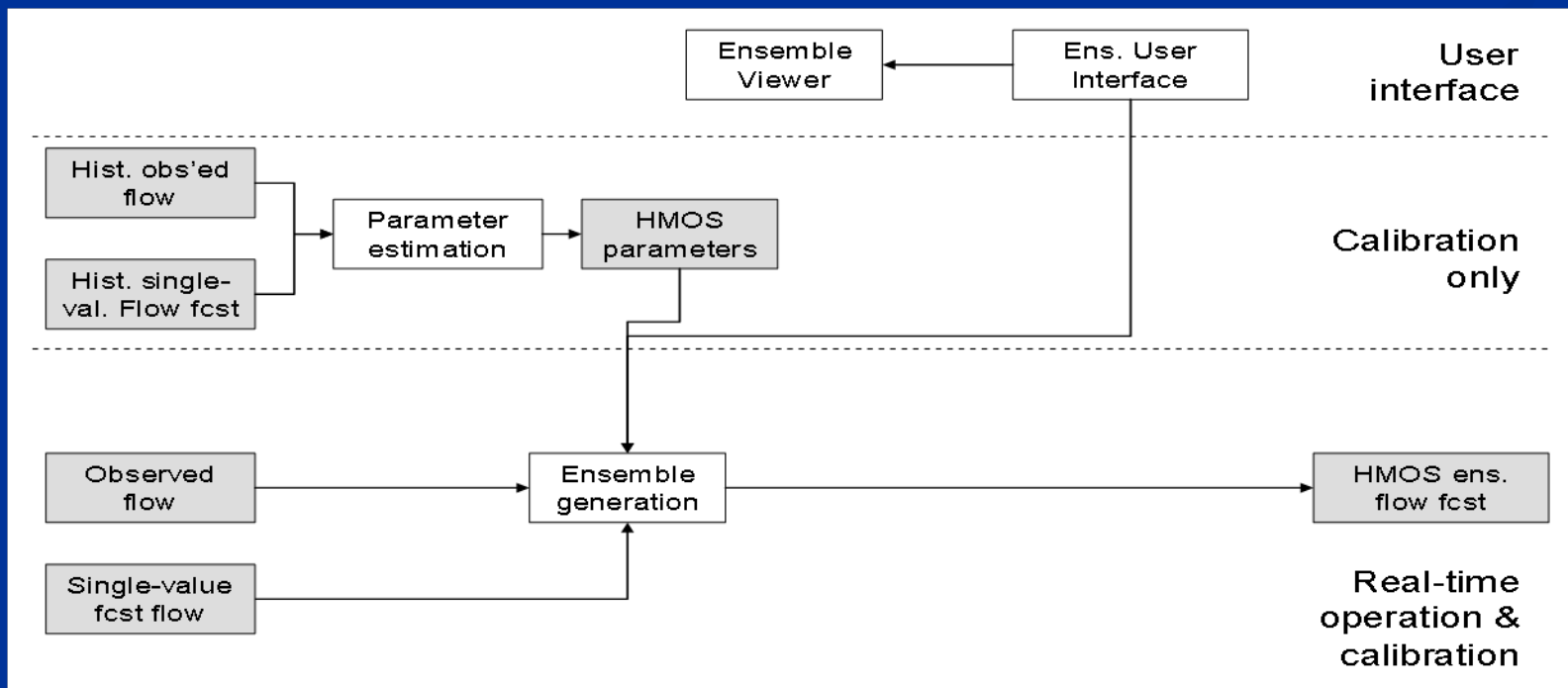
Merging/Joining/Blending Inputs (challenge #2)





XEFS - HMOS

- Based on joint probability distribution of forecast and observed streamflow
 - marginal period of record (6-8 years)
 - limited lead time (1 to 5 days)
- Explicitly includes all sources of uncertainty (challenge #1)





Summary

- Ensemble streamflow predictions meet increasing customer requirements for risk and uncertainty information
- Solid progress has been made “prototyping” an ensemble preprocessor that allows ESP to move into the short and medium time domain
- A clear and well supported pathway has been established to deliver an operational hydrologic ensemble forecasting system (XEFS) for NWS River Forecast Centers in the USA



Thank You