



Operational Hydrologic Ensemble Forecasting

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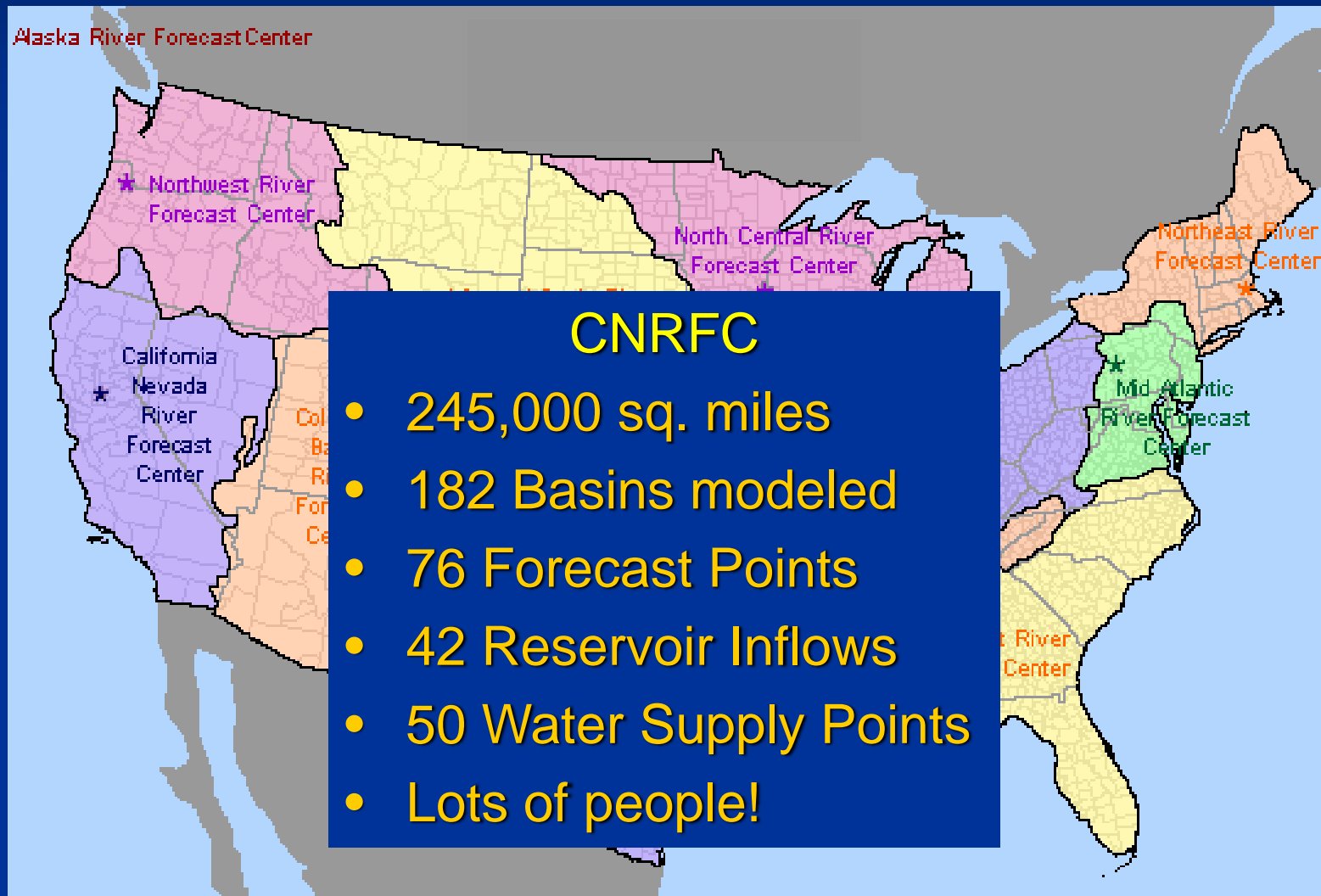
Mission of NWS Hydrologic Services Program



- Provide river and flood forecasts and warnings for the protection of lives and property.
- Provide basic hydrologic forecast information for the nation's environmental and economic well being.



NWS River Forecast Centers





CNRFC Hydrologic Products and Services



Short Range Long Range

Local Flood Warning Systems Support

Flash Flood Guidance

Headwater Guidance

Flood Forecast Guidance

Reservoir Inflow Forecasts

Spring Snow Melt Forecasts

Water Supply Volume



CNRFC Hydrologic Modeling



Short Range Long Range

(Site Specific)

NWSRFS – OFS

6 hour time step
modular, deterministic

ESP.....

NWSRFS configuration
probablistic (ensemble)

Statistical

simple, efficient,
inflexible



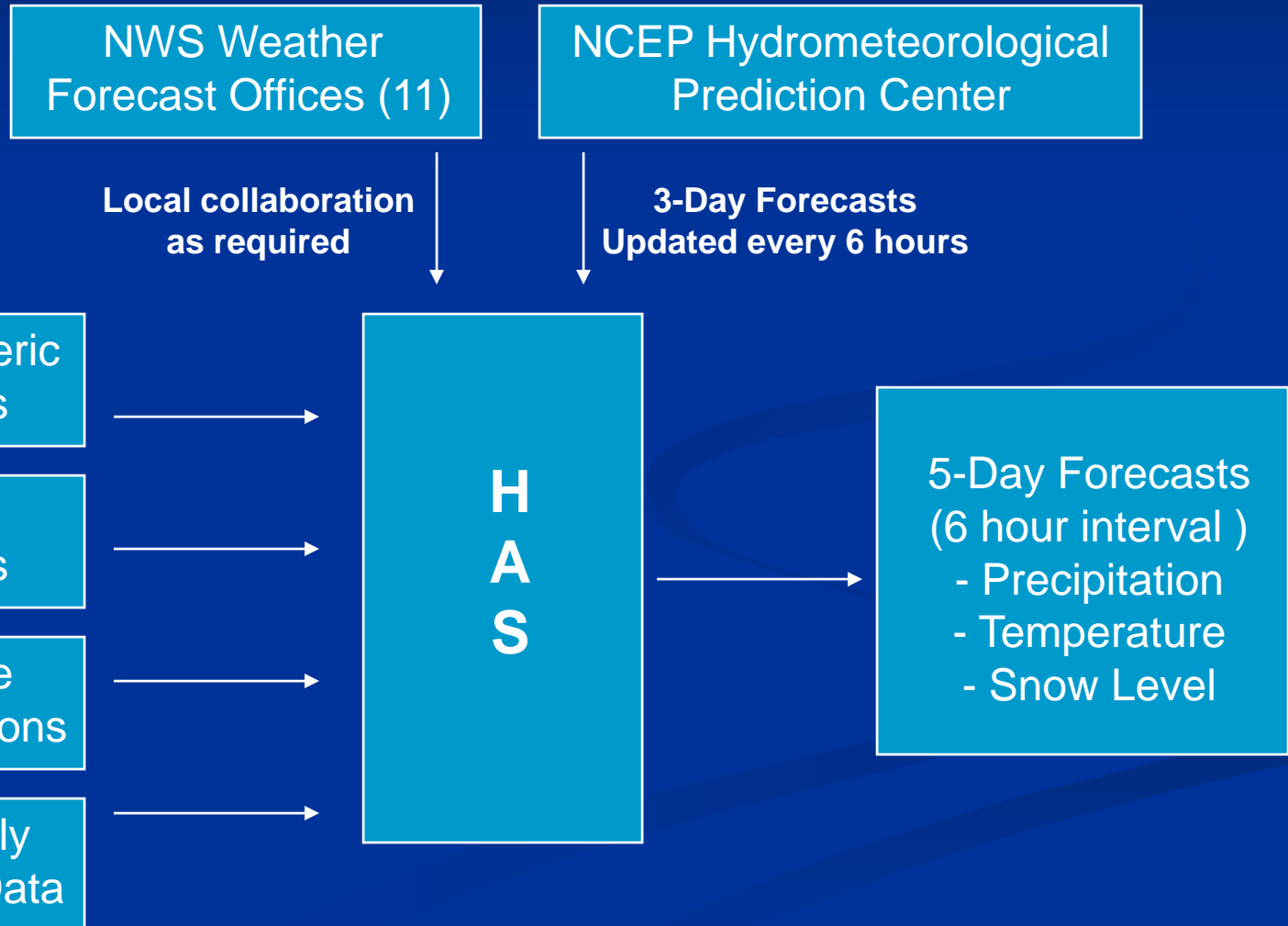
HAS Operations

Hydrometeorological Analysis and Support





Operational HAS Function

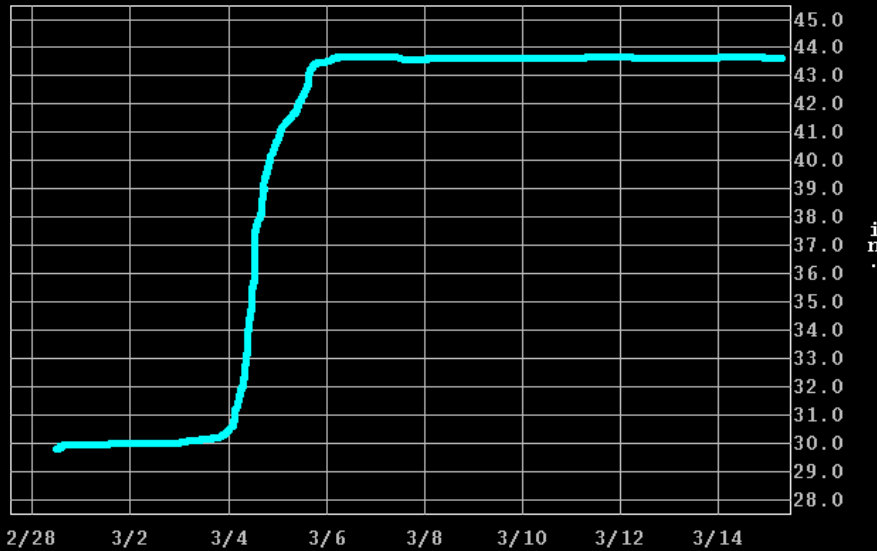




Forecaster Experience



San Marcos Pass
50078 SMCC1 PCIRZZ Precip. (ALERT)
Elevation 2300
Max= 43.7 at 03/15/101 23:30Z
Min= 29.6 at 03/01/101 00:37Z
Last= 43.7 at 03/15/101 23:30Z



Pattern recognition - historical case studies

Gain familiarity with topography and gage network

Develop knowledge base on:
...NCEP model performance
...locally run models and tools



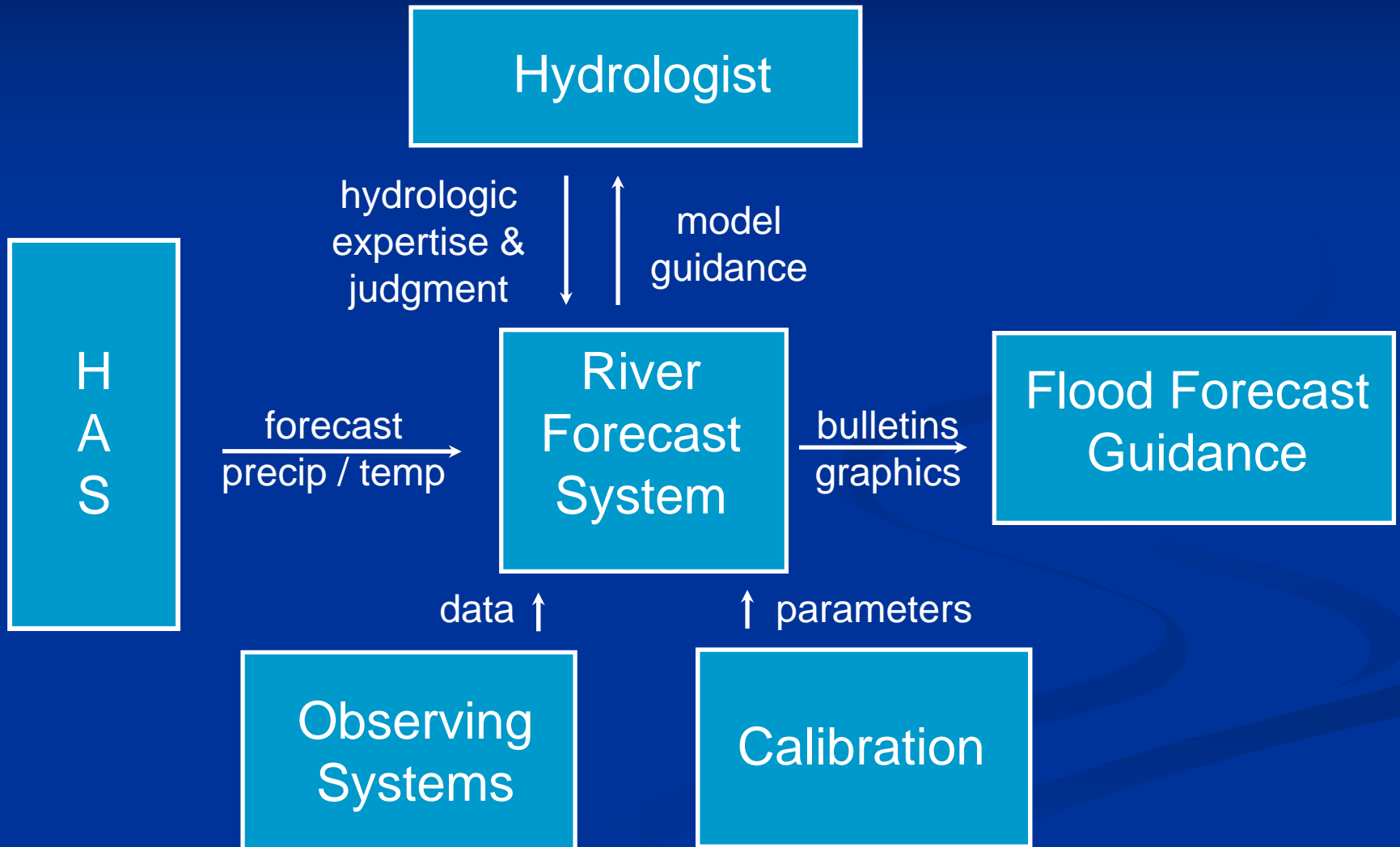


Hydrologic Operations





Operational Flood Forecasting

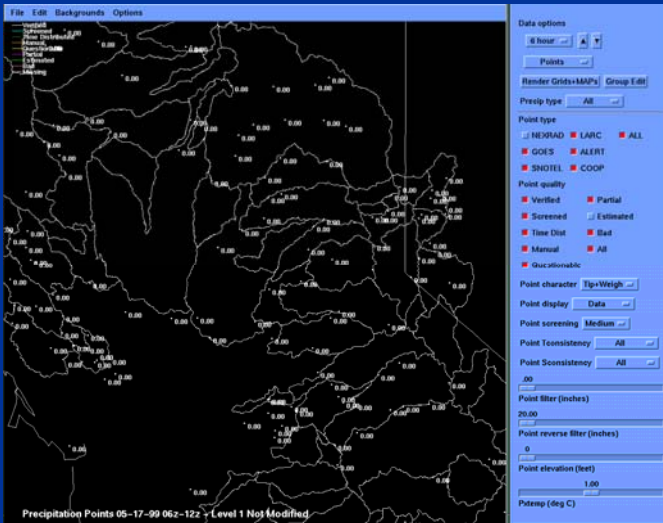
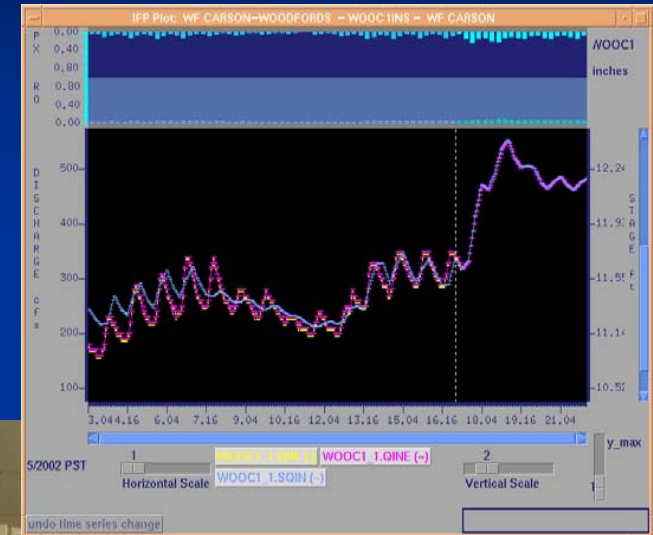




Forecaster Experience



- Watershed characteristics
- Model idiosyncrasies
- Data and gage issues
- Customer and partner needs

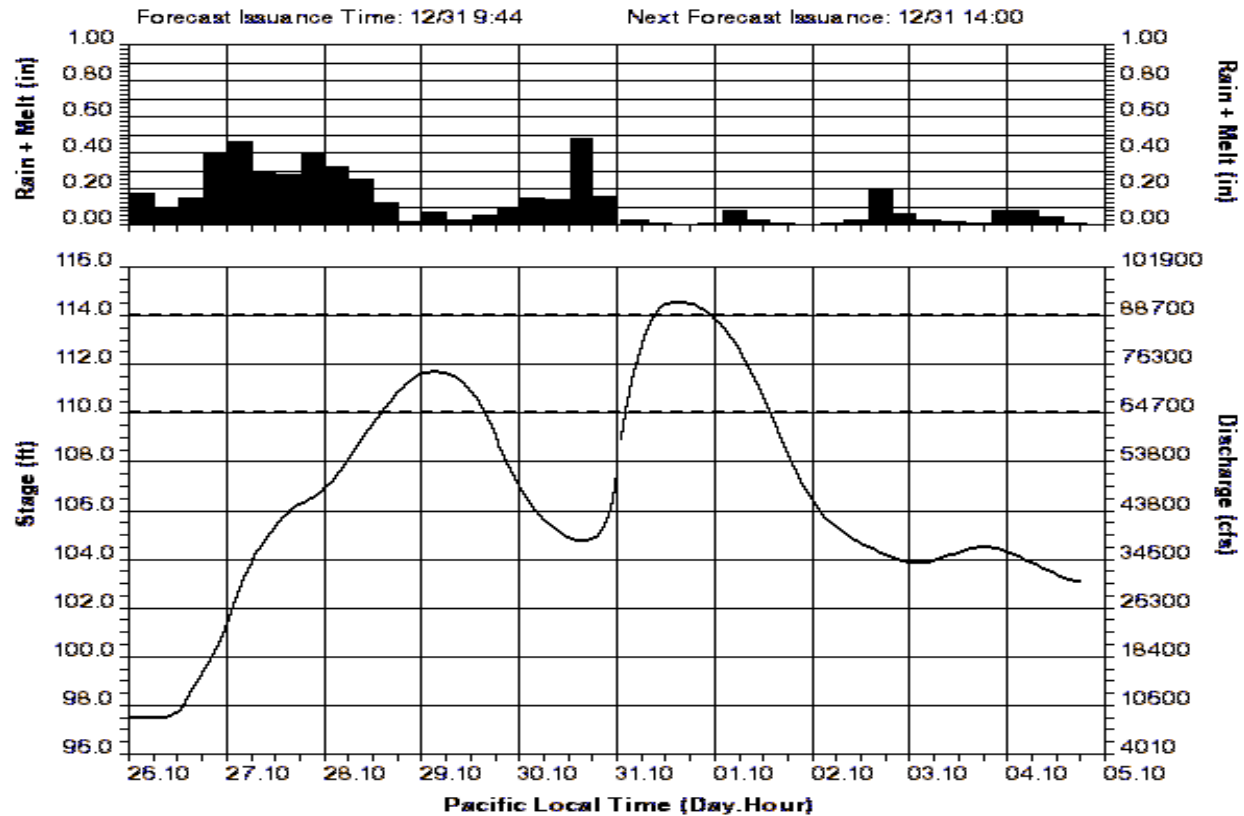




Flood Forecast Guidance



ORFC1 - SACRAMENTO RIVER - Ord Ferry



Observed - Forecast - Guidance - Monitor 110.0 - Flood 114.0 - California Department of Water Resources
California Nevada River Forecast Center (CNRFC), NWS/NOAA

Monitor Stage: 110 feet
Flood Stage: 114 feet



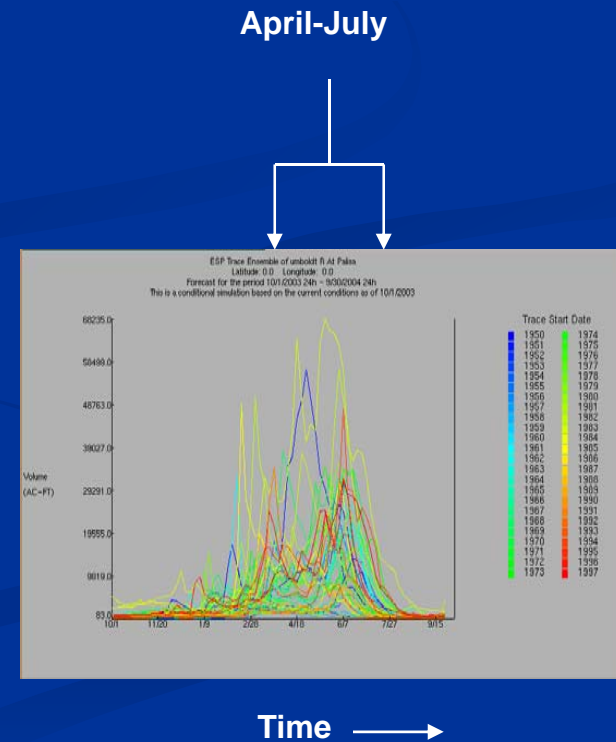
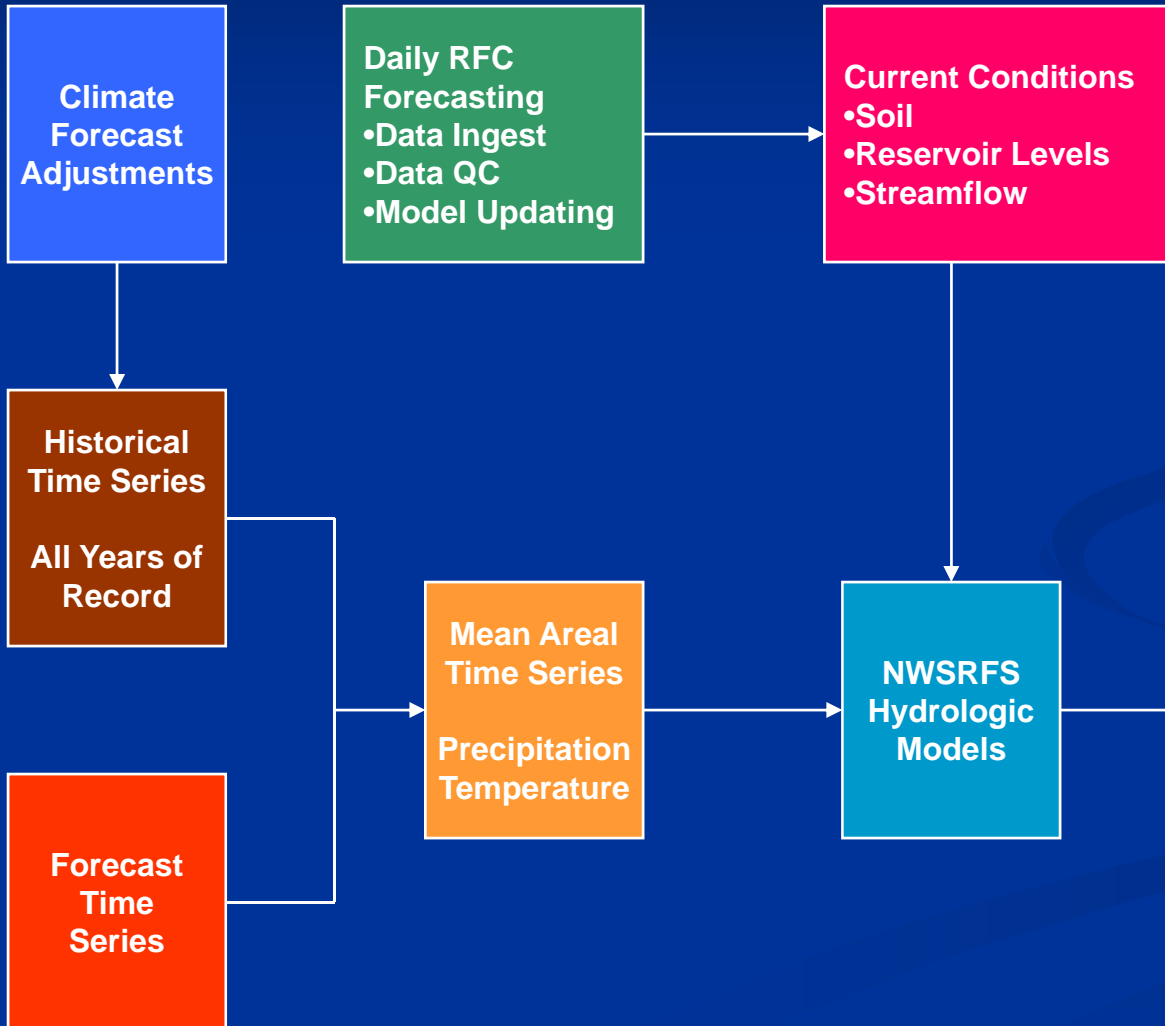
Hydrologic Ensemble Forecasting



- Initial NWS use as an alternative procedure for generating seasonal water supply volumes.
 - Regression-based techniques are still dominant, but ESP use is increasing rapidly.
- Initially considered viable in the time domain where weather/climate uncertainly fully dominates.
 - Used to be ~30 days and beyond.
 - Commonly 15 or less today.



Ensemble Streamflow Prediction





April-July Volumes

~50 locations

Monthly Updates

Water Supply Outlook



**CALIFORNIA
AND
NORTHERN NEVADA**

**March
2003**



California Nevada River Forecast Center
NOAA National Weather Service
Sacramento, California

www.wrh.noaa.gov/cnrfc/water_supply.html



Forecast of Runoff Volumes for the Snowmelt Season

Issued Wednesday, June 5, 2002

Produced by the NWS California Nevada River Forecast Center and the California Dept. of Water Resources

Remarks: The 5-day period begins with temperatures well above normal. Into the weekend, a weak trough will move into the intermountain west and lower temperatures closer to normal. High pressure will rebuild early next week and once again warm temperatures to above normal. No precipitation is expected.

Please note: Snowmelt peak flows have occurred or are occurring at all forecast points. This will be the final snowmelt forecast for this season. Any agency requiring additional snowmelt forecast guidance is requested to contact the CNRFC.

Forecasts reflect predicted short-term precipitation and temperature as well as the predicted shift from normal climatology provided by NOAA's Climate Prediction Center.

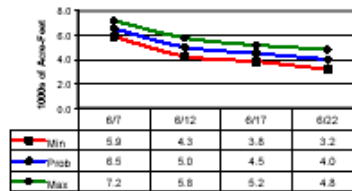
Min: Reasonable minimum (90 percent chance of being exceeded)
 Prob: Most probable volume (50 percent chance of being exceeded)
 Max: Reasonable maximum (10 percent chance of being exceeded)
 Pk Vol/Date: Most probable peak 1-day volume of runoff (in thousands of acre-feet) and the date of occurrence

Indicated values are unimpaired flow volumes in thousands of acre-feet in 5-day intervals for the next 20 days. The date indicated above each column is the mid-point of the 5-day interval.

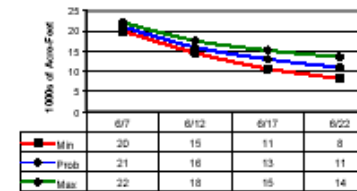
Spring Snowmelt Forecasts

covers
next 20 days

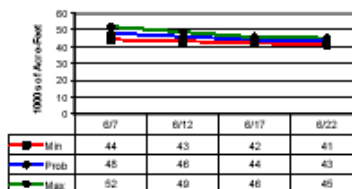
Willamson River at Chiloquin



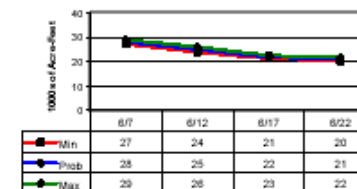
Trinity River at Lewiston



Shasta Reservoir Inflow



Feather River at Oroville



www.wrh.noaa.gov/cnrfc/snowmelt.pdf



Current Benefits of ESP



- Flexibility
 - Time periods (hours to seasons)
 - Flow attributes (peaks, lows, volumes, times)
- Ability to objectively integrate weather and climate forecasts
 - Pre-adjustment techniques
 - Post-processing techniques



Potential Benefits ESP



- Accurate short and medium range probabilistic forecasts.
- Objective integration of forecaster and model information and skill.
- Accurate forecast reliability information.
 - For forecasters!
 - For customers.



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



CNRFC



Ensemble Implementation (AHPS)

- Phase I - Medium and long-range ESP
 - Headwaters and unregulated points. (FY03-07)
- Phase II - Medium and long-range ESP
 - Regulated points (FY06-10)
- Phase III - Short-term ESP
 - All flood forecast points and reservoirs (FY08-12)



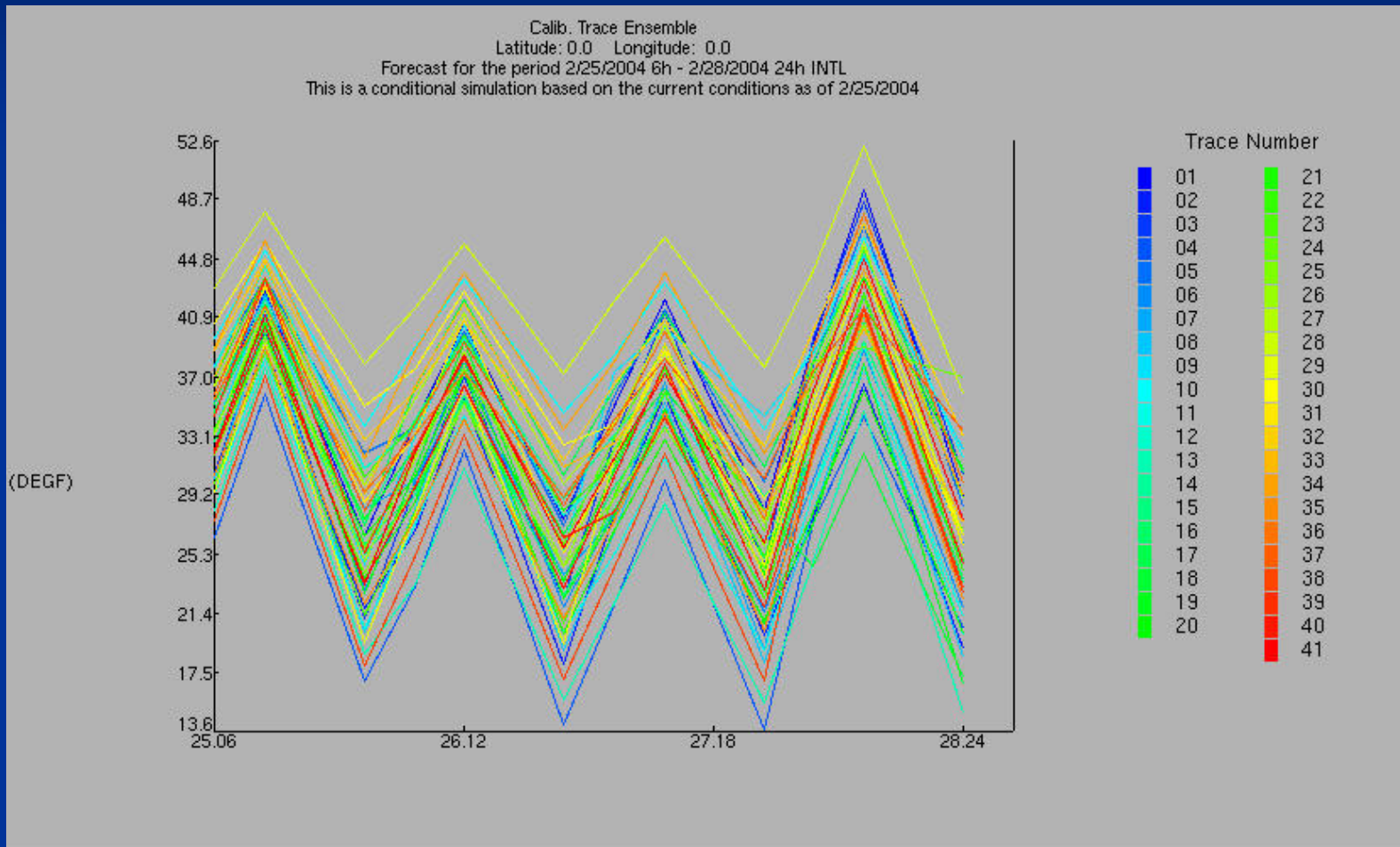
Short-term Ensemble Prototype



- 5 day Precipitation and temperature ensembles
- Based on operational deterministic precipitation and temperature forecasts
- Uses forecast (skill) and watershed climatology
- Reliability is unknown
 - Need to develop retrospective analysis.



5 day temperature ensembles

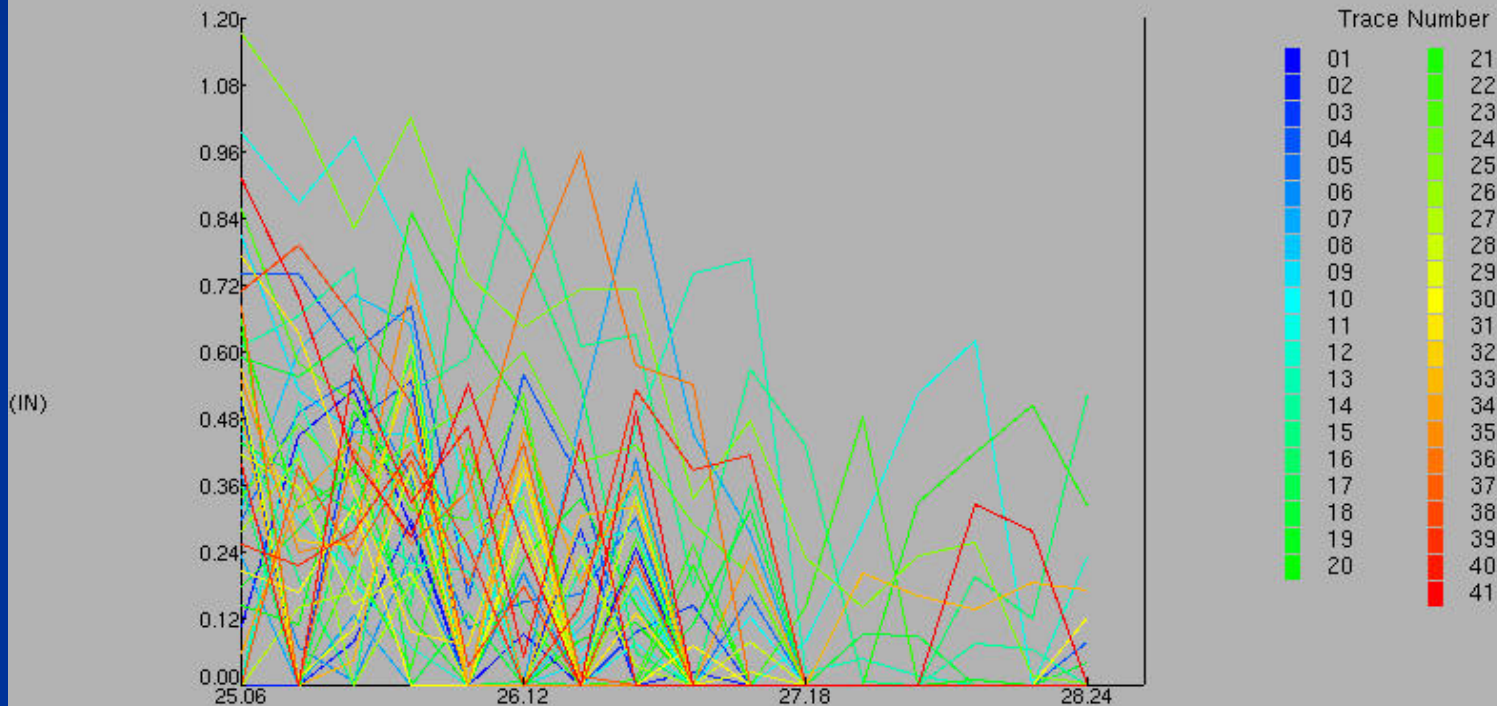




5 day precipitation ensembles



Calib. Trace Ensemble
Latitude: 0.0 Longitude: 0.0
Forecast for the period 2/25/2004 6h - 2/26/2004 24h INTL
This is a conditional simulation based on the current conditions as of 2/25/2004

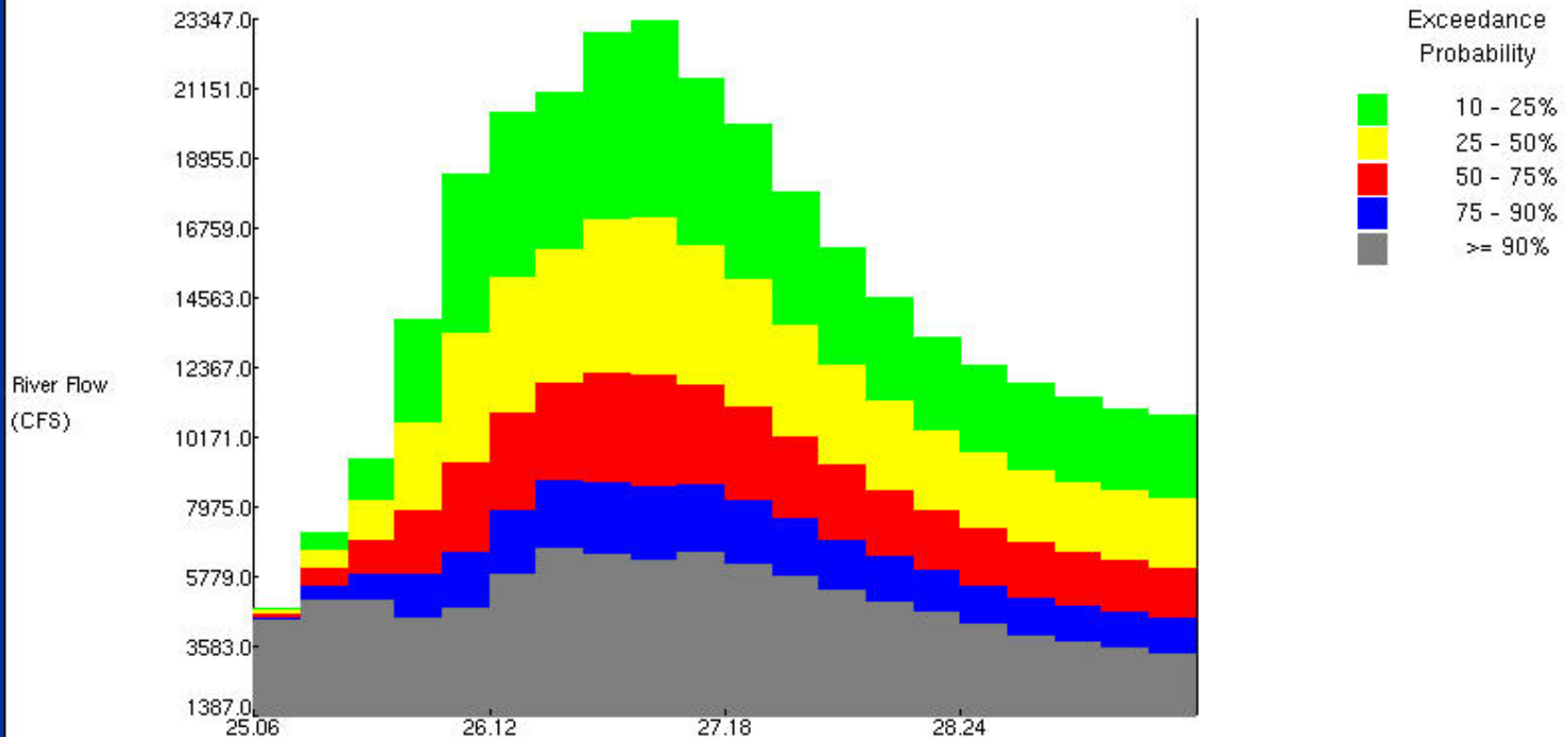




American River – 5 day ESP



6 Hour Chances of Exceeding River Levels on the AMERICAN-FOLSOM FNF
Latitude: 38.7 Longitude: 121.2
Forecast for the period 2/25/2004 6h - 2/29/2004 24h INTL
This is a conditional simulation based on the current conditions as of 2/25/2004





Ensemble Challenges

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

OBSERVATIONS

precipitation
air temperature
streamflow

MODEL STATES

snow
soil moisture
basin routing

MODELLING SYSTEM

simplifications
temporal issues
scale issues

?

MODEL PARMS

snow
soil moisture
basin routing

HUMAN INPUT

education
training
experience
mental state

FORECASTS

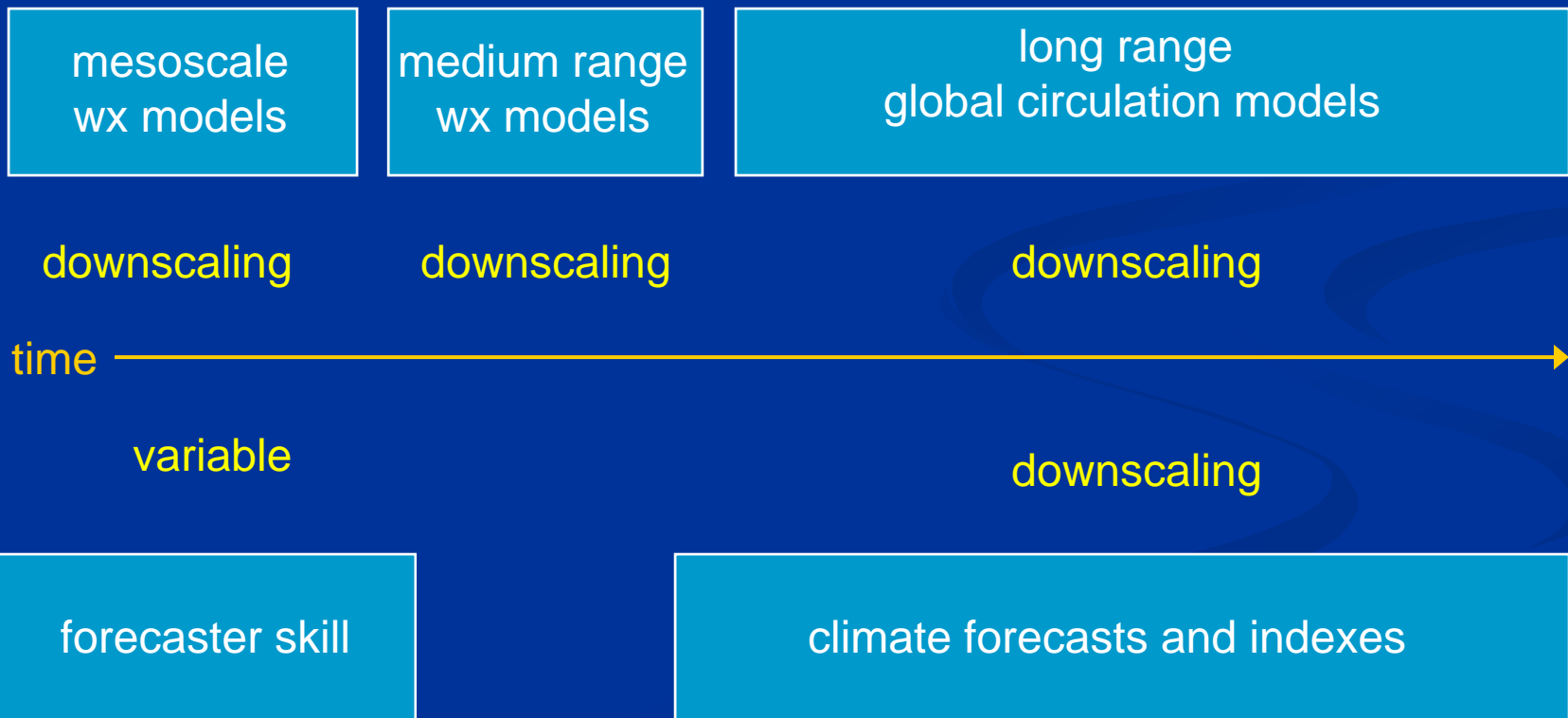
precipitation
air temperature
regulation



Ensemble Challenges



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

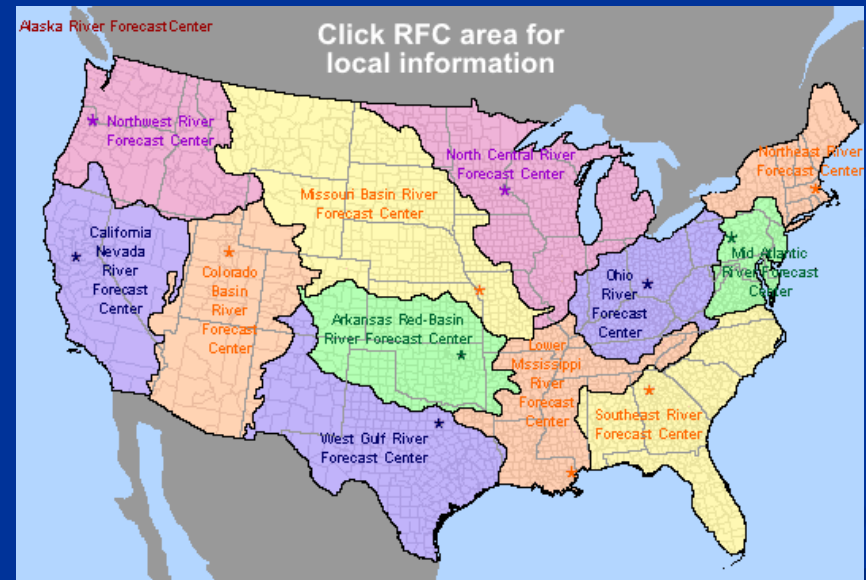
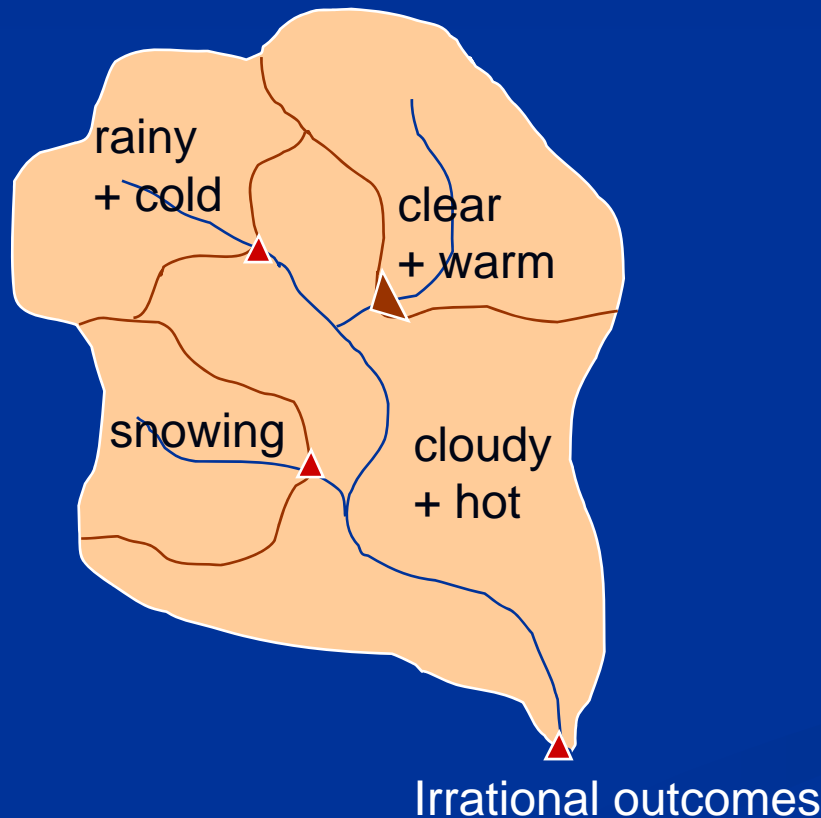




Ensemble Challenges



- Maintain spatial and temporal relationships across very large areas.





Ensemble Challenges



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



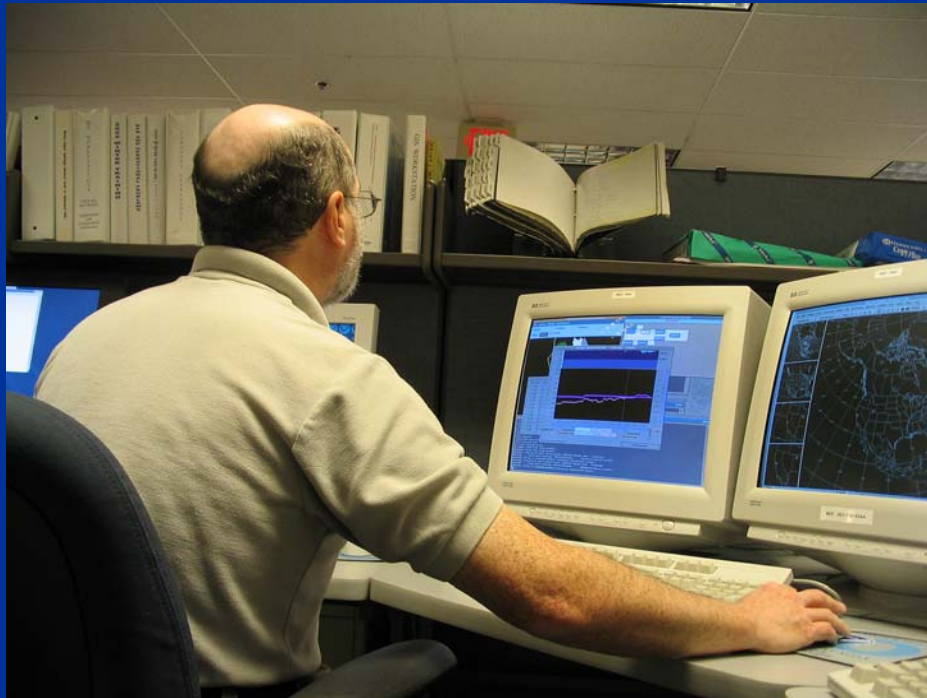
- Forecasters add value to short-term QPF.
 - HPC adds value to models
 - RFC adds value to HPC



Ensemble Challenges



- Include forecaster guidance of hydrologic model operation



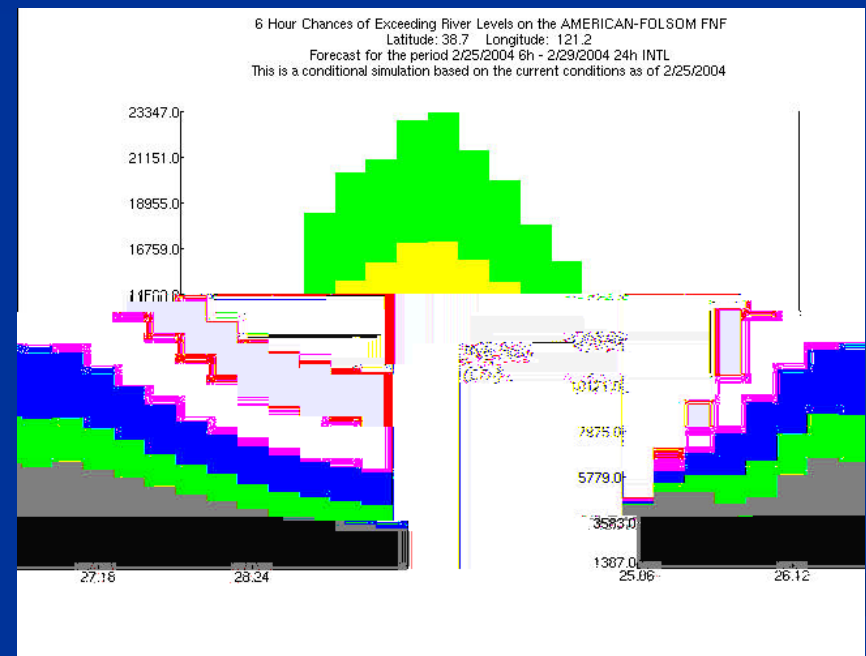
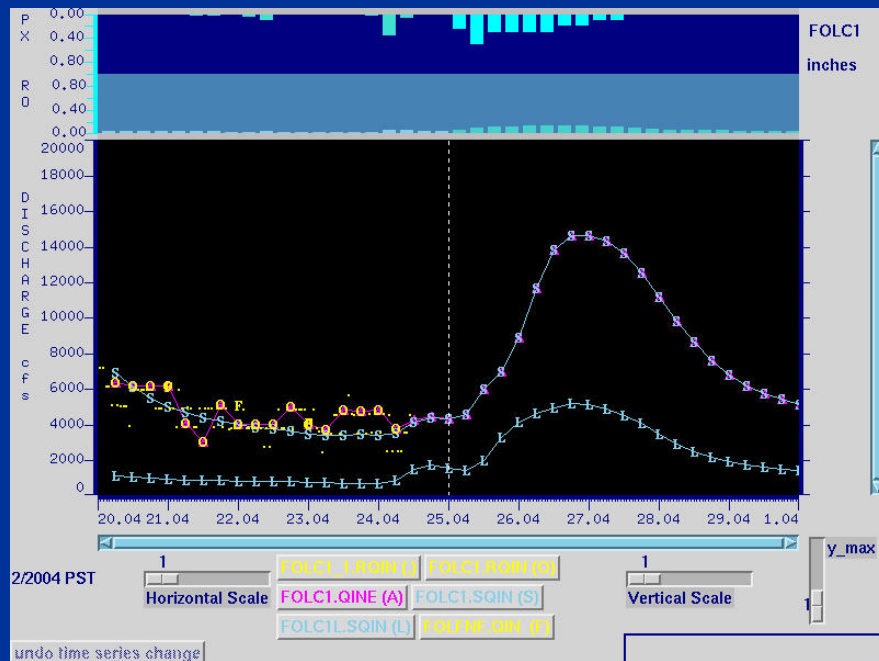
- Hydrologic models require on-going tuning.
- Forecasters commonly adjust or influence raw model output.



Ensemble Challenges



- Maintain coherence between deterministic and ensemble forecasts





Where Are We Headed?



- Shorter time step modeling (1 hr vs. 6 hr).
 - Significant benefits for smaller fast responding watersheds.
- **Production of uncertainly information.**
 - **Essential to forecasters.**
 - **Increasingly useful for many customers.**
- Broader support for unengaged and smaller watersheds.
 - Distributed modeling?
- Visualization of impacts.
 - Flood inundation mapping (static, near real time).
- Broader application of hydrologic forecasts and information.
 - Low flow information and drought information.



What Do We Need?



- Better precipitation and temperature forecasts (QPF and QTF).
- Reasonable operational assessment of hourly gridded hydrologic model inputs.
 - Precipitation, Temperature, Freezing Level.
- **Operationally functional ensemble techniques for all time domains.**
- Better assessment of diversions, accretions throughout the year.
- **Meaningful reliability statistics for customers.**
- Feedback from customers.
 - Are we providing the right information?



Thank You