NOAA's National Weather Service
California-Nevada River Forecast Center

Hazard Warning Capabilities, Improvements in Monitoring

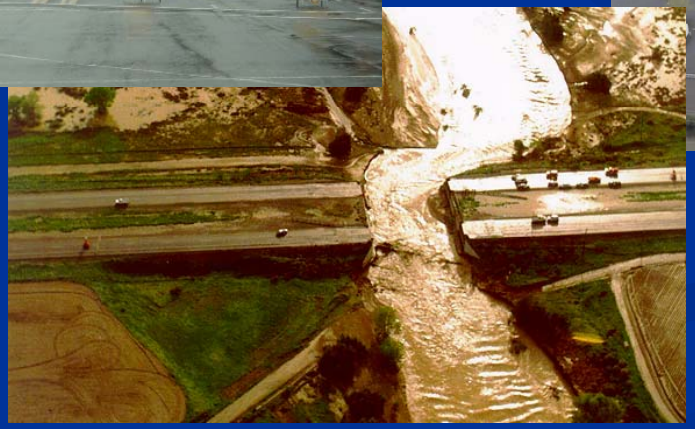
Rob Hartman
Hydrologist in Charge

Outline

- Background on CNRFC and Routine Operations
- Elements that may contribute to workshop objectives
  - HAS operations
  - Storm summaries
  - Daily river / reservoir forecasting
  - Ensemble forecasting
  - Watershed calibration data

Mission of NWS Hydrologic Services Program

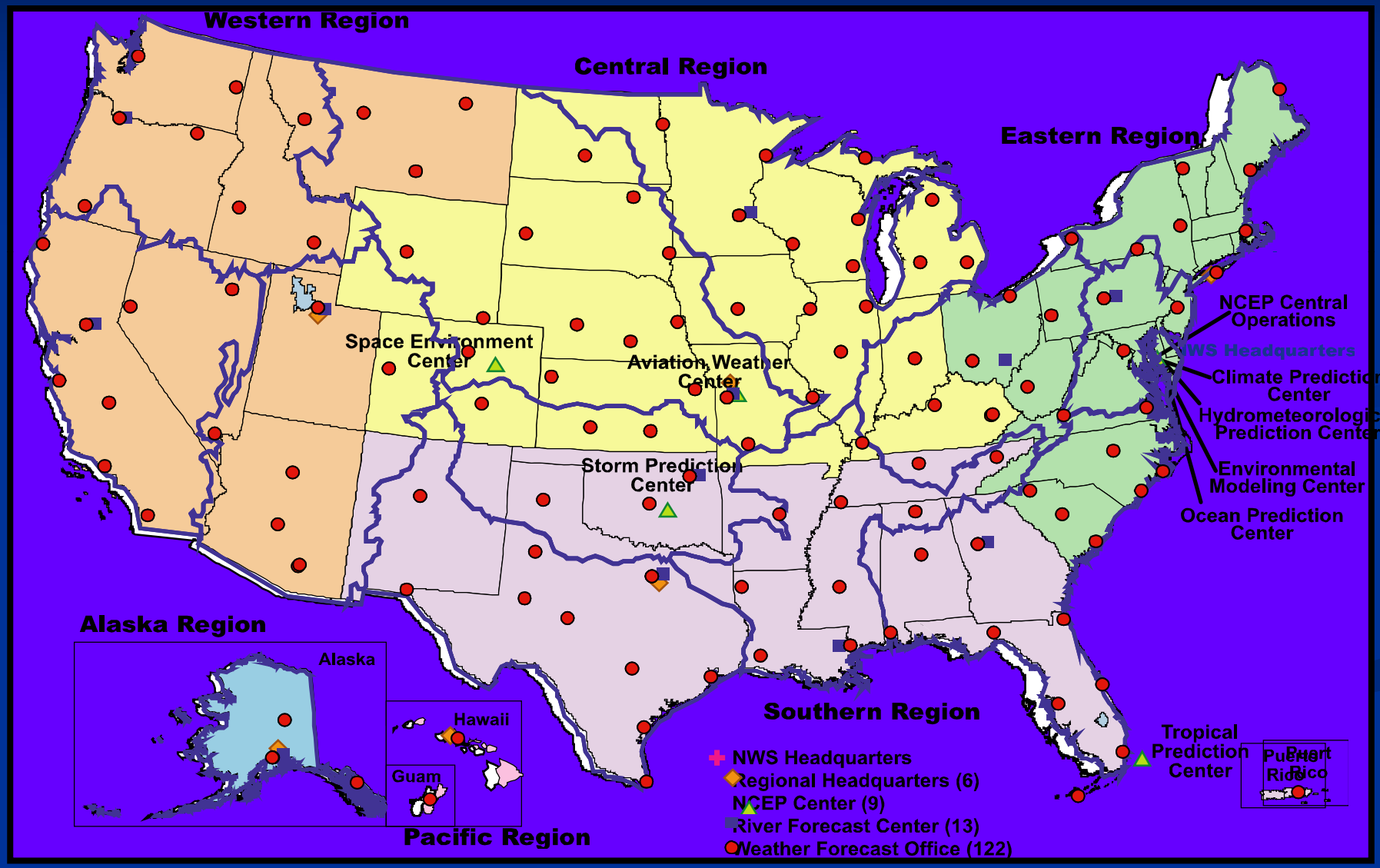
- Provide river and flood forecasts and warnings for the protection of lives and property



Mission of NWS Hydrologic Services Program

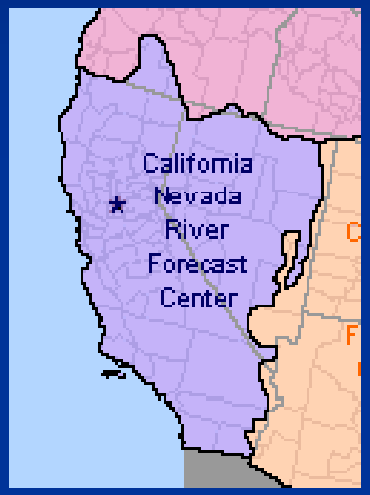
- Provide basic hydrologic forecast information for the nation's environmental and economic well being

NWS Structure: Five Regions
122 WFO's 13 River Forecast Centers (RFC's)

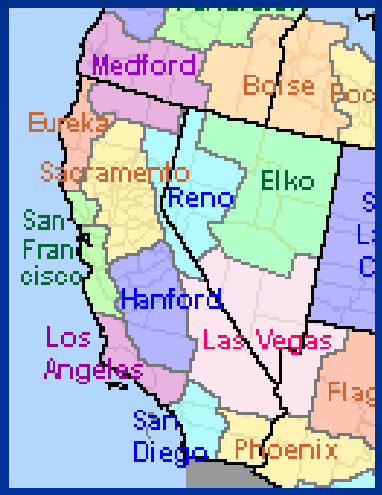


CNRFC Customers

RFC



WFOs



Public Warnings

Water and Flood Management Agencies, Utilities

CNRFC Staffing

NWS/CNRFC

- Hydrologist in Charge
- Development and Operations Hydrologist (DOH)
- Service Coordination Hydrologist (SCH)

- 3 Senior Hydrologists
- 2 Hydrologists
- 2 Senior HAS Forecasters
- 2 HAS Forecasters

- Information Tech. Officer
- Administrative Assistant

California DWR/DFM

- Hydrology Branch Chief
- 7 Engineers/Forecasters

CNRFC Program Areas

- Flash Flood Support
- Dam Break Support
- Flood Forecasting
- Snowmelt Forecasting
- Water Supply Forecasting

Available CNRFC River Forecasts

Forecast	Duration	Season	Frequency	Probabilities
Flood and Routine	5 Days	Year-round	Daily +	No
Ensemble Streamflow Prediction	10-Day 20-Day April - July	Year-round	Daily	Yes
Water Supply	April – July	January to June	Monthly +	Yes

CNRFC Hydrologic Modeling

Short Range … … … … … … Long Range

CHPS

6 hour time step
modular, deterministic

CHPS - ESP……

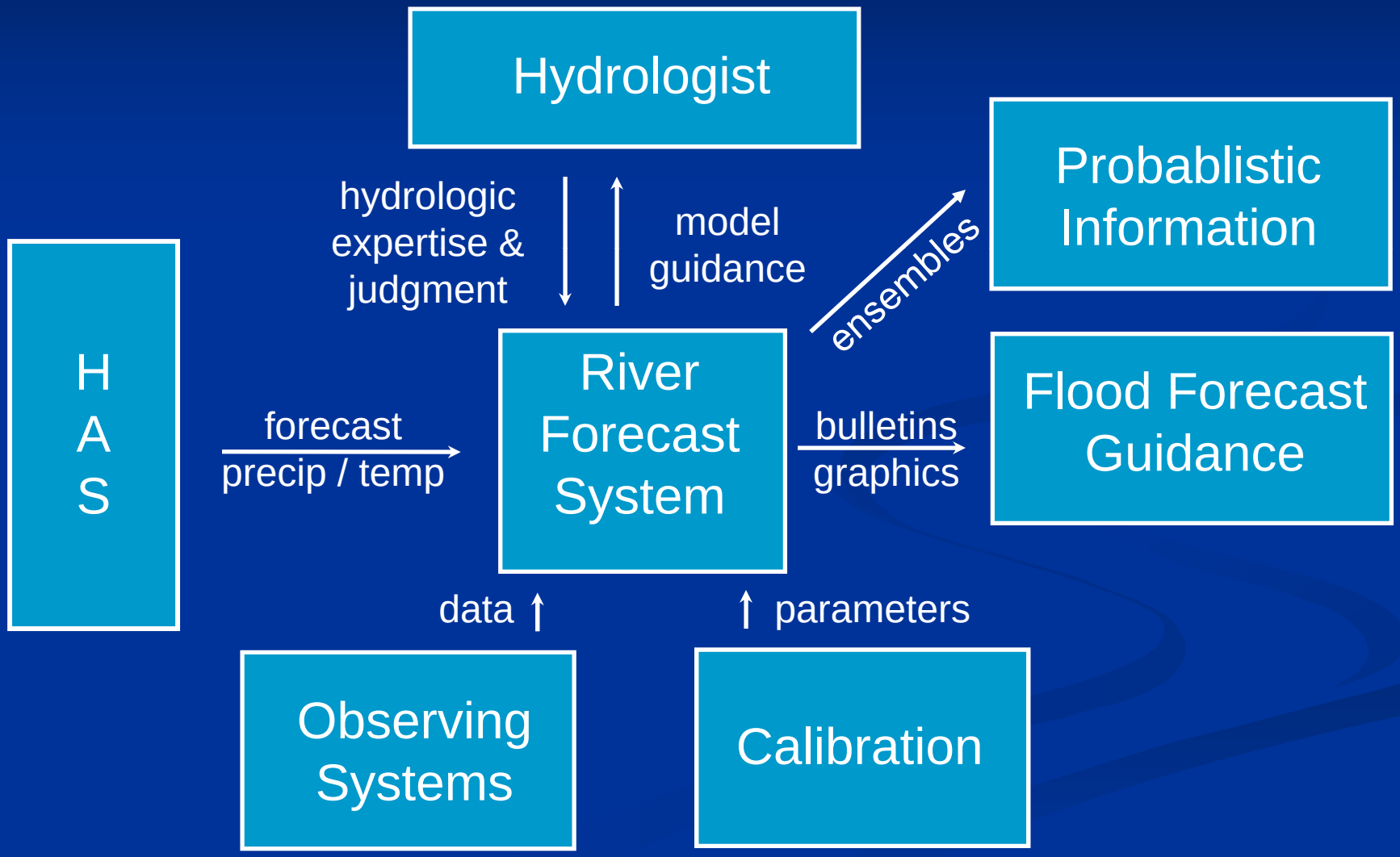
CHPS configuration
probablistic (ensemble)

Statistical

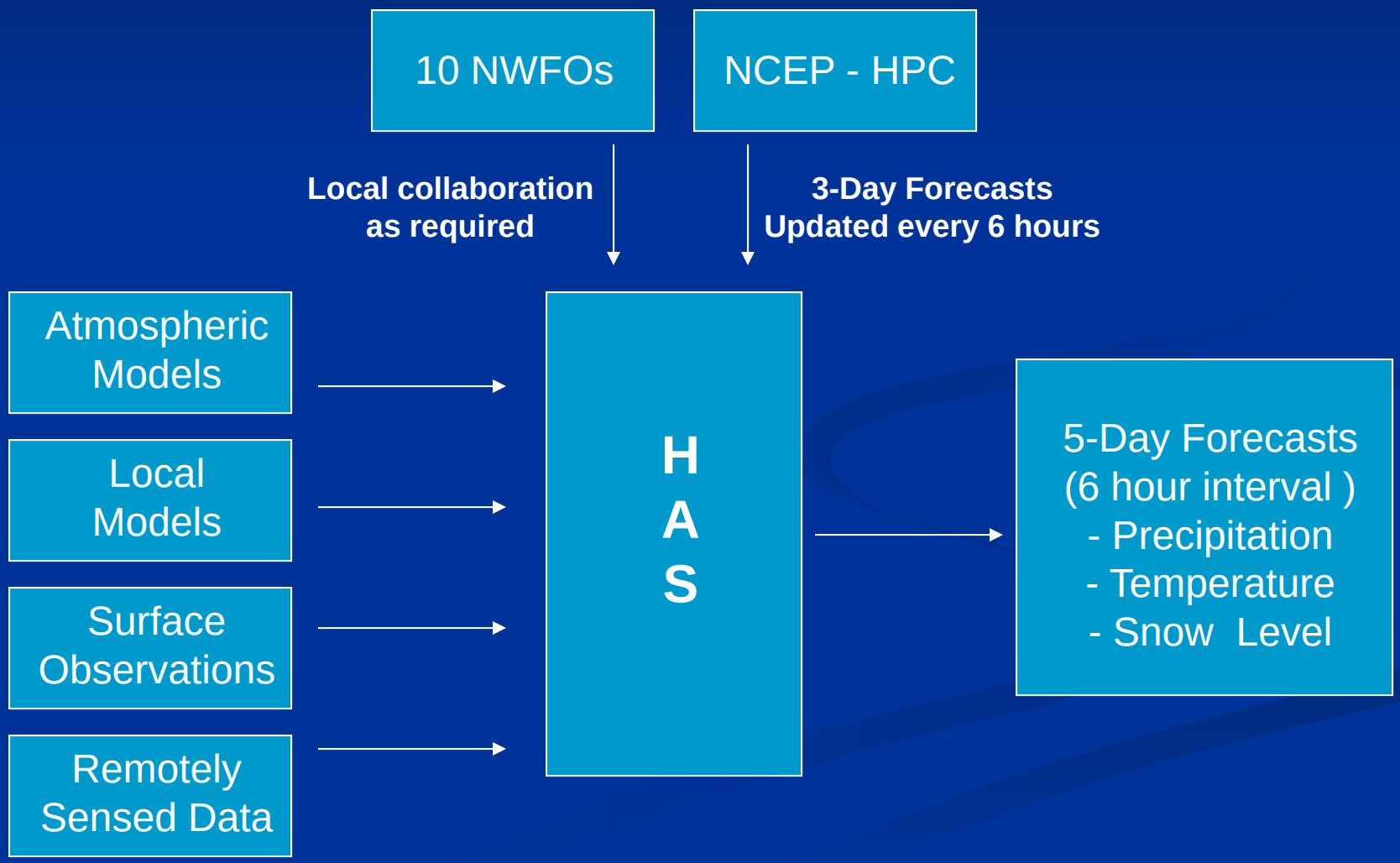
simple, efficient, inflexible

Operational River Forecasting

(Hydrology)

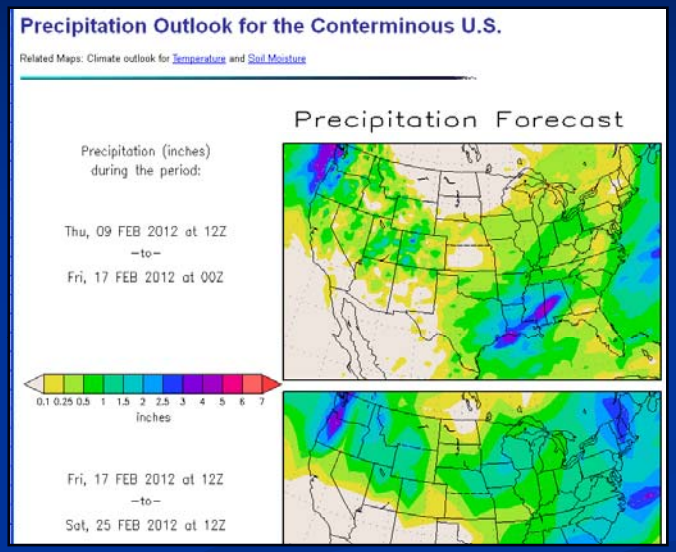


Operational HAS Function
(Meteorology)

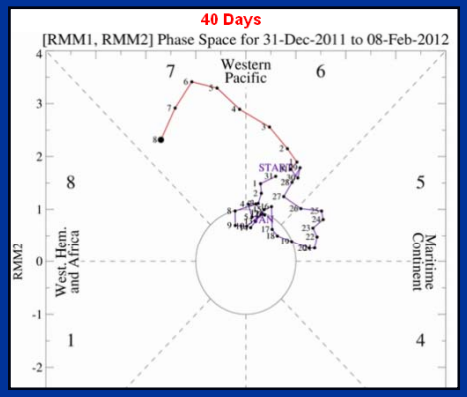


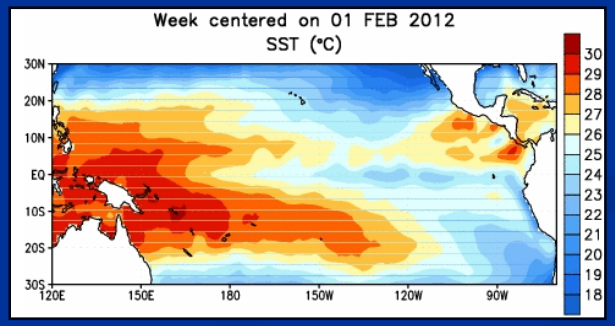
Meteorological Forecast Process

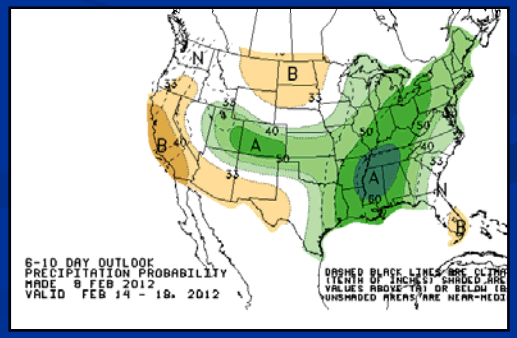
- <u>First look: Seasonal/Monthly</u>
  - Long-range Model
    Run-Accumulated Precipitation



  - Cyclical patterns
    - Madden-Julian Oscillation
    - ENSO
    - CPC Outlooks (6-10 days, 8-14 days, one month, three month)

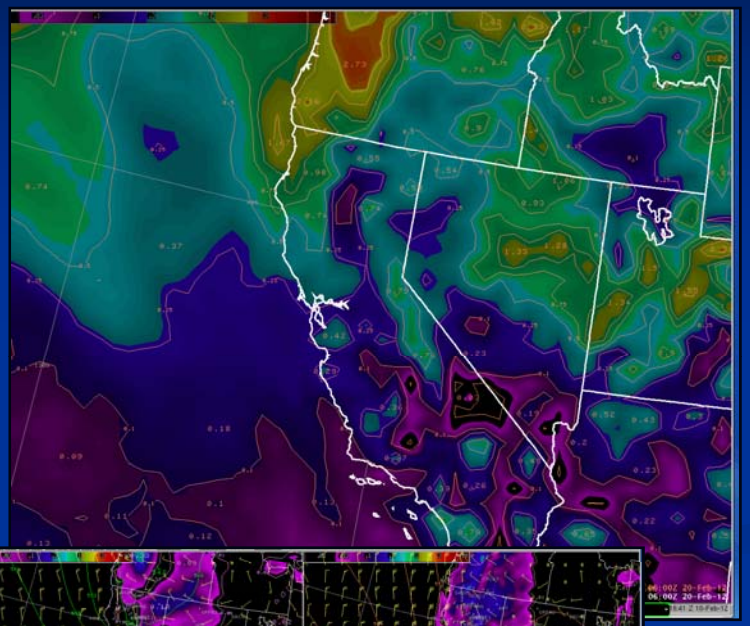


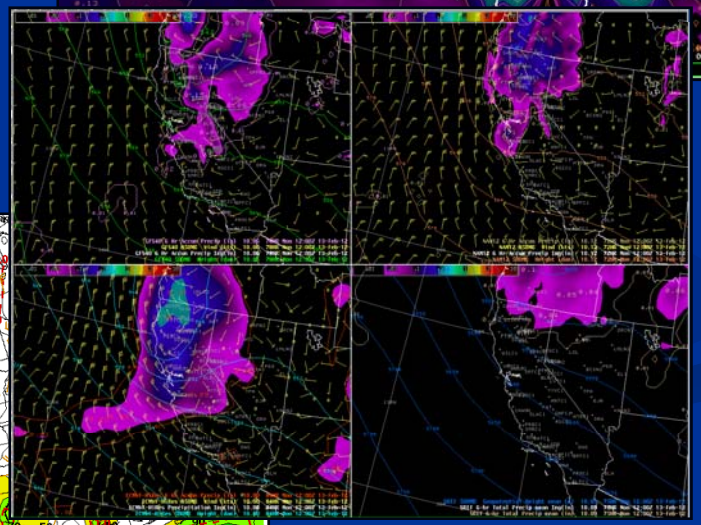


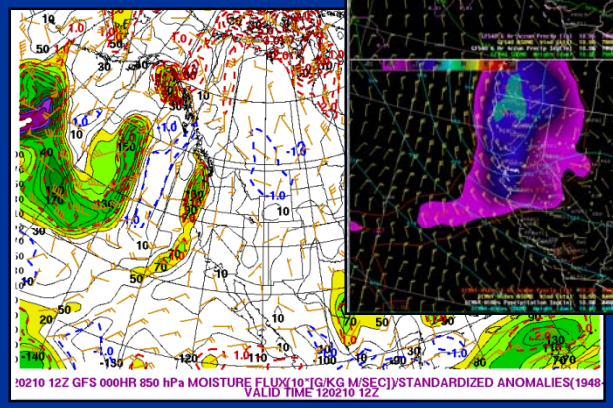


Meteorological Forecast Process

- <u>Next step: Long Range</u>
  - Time range: 7-16 days
    - Furthest operational models extend
    - Low confidence in details
    - Addressed in FOC briefings
  - Attention paid to
    - Model consistency
    - Statistical anomalies
    - Storm analogues
    - RHEA orographic model

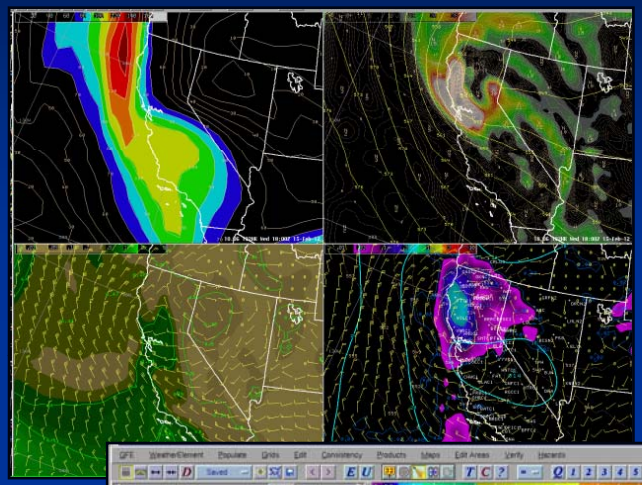


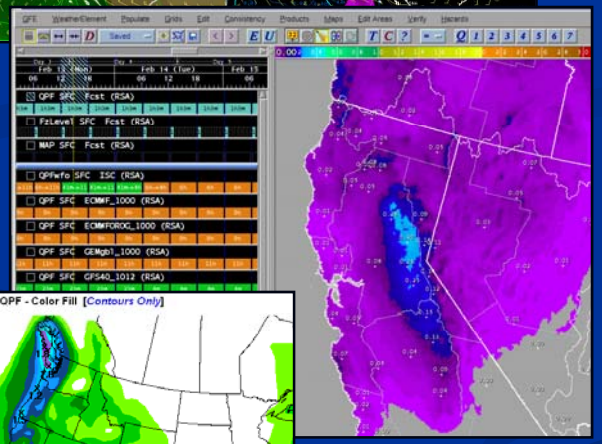


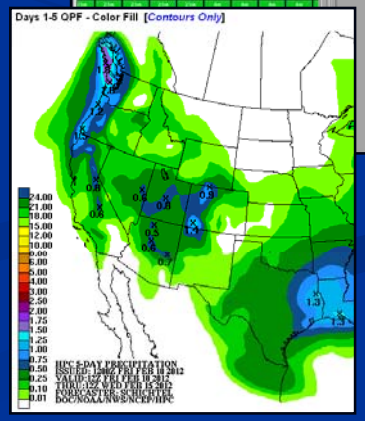


Meteorological Forecast Process

- <u>Next step: Medium Range</u>
  - Time range: 4-6 days
    - Start issuing QPF forecast in 6-hr increments
    - Higher confidence in model solutions
  - Chose a particular model to follow or a blend
    - Minor changes made once a model is chosen
  - Start collaboration with partners
    - Weather Forecast Offices
    - Hydrometeorological Prediction Center
    - State Agencies
    - Emergency Managers

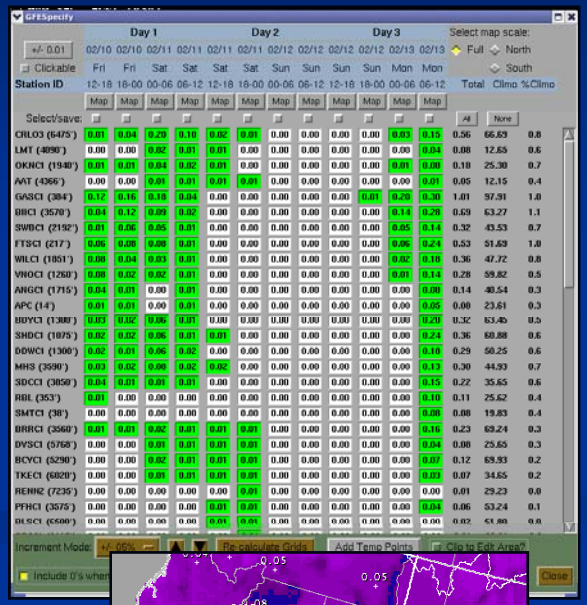


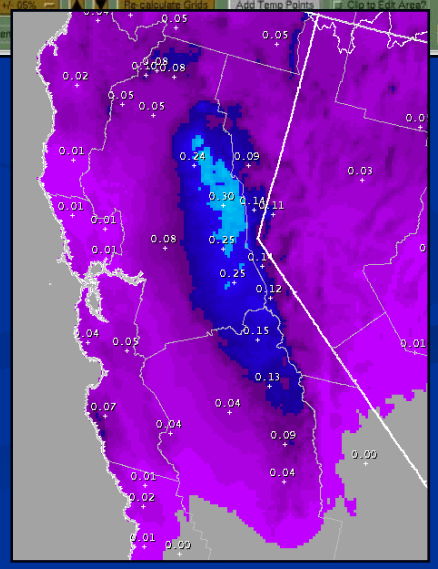




Meteorological Forecast Process

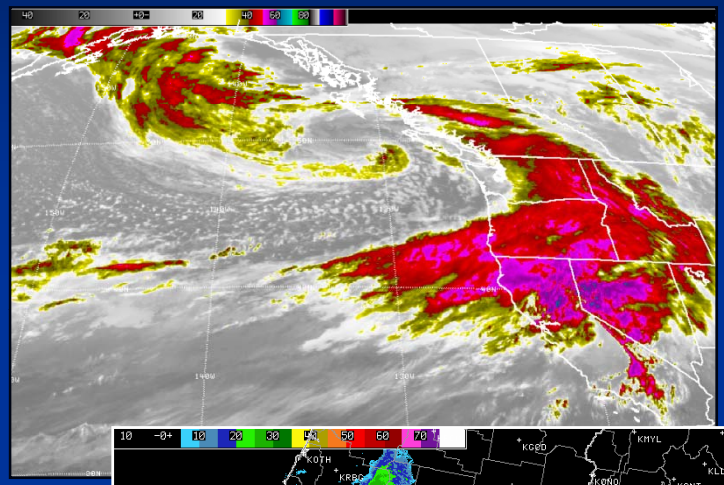
- <u>Next step: Short Term</u>
  - Time range: 1-3 days
    - Continue issuing QPF forecast in 6-hr increments
    - Updated twice a day (at a minimum)
    - Higher confidence in model solutions
    - Most time spent on this time range
  - Continue to follow a particular model solution
    - Forecaster makes significant changes based on experience
    - Add in known local effects to compensate for model biases

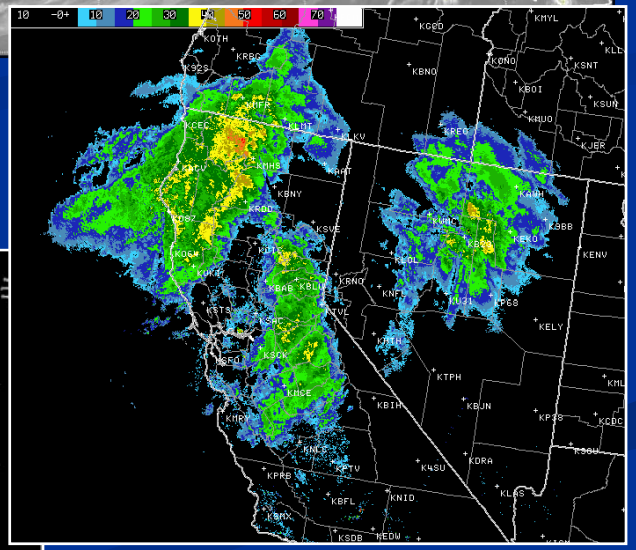


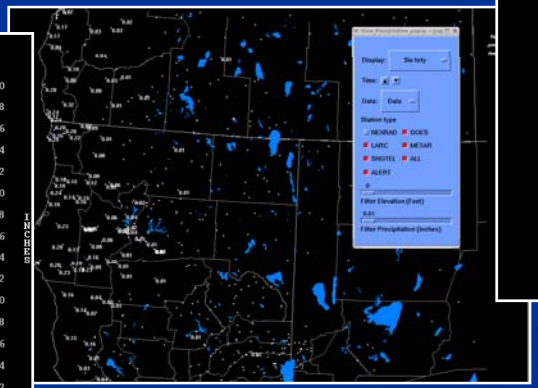


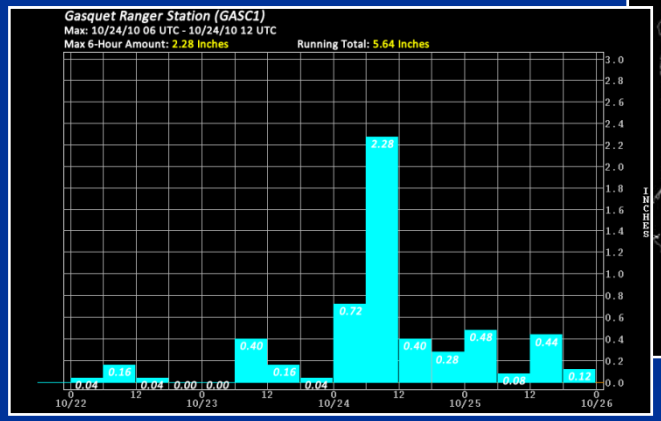
Meteorological Forecast Process

- <u>Finally: Now-casting</u>
  - Time range: Current through next 6 hours
  - Focus on
    - Radar Data
    - Satellite Imagery
    - Gauge Data
  - Key in on current trends to give a better picture of immediate concerns









Storm Summaries

October 23, 2010 - October 25, 2010 ***Location / Event:*** ***Northern/Central CA and Northern NV Early-Season Heavy Precipitation Event***
Authors: Dan Kozlowski, Kyle Lerman, and Mike Ekern

December 16, 2010 - December 23, 2010 ***Location / Event:*** ***California and Nevada***
Authors: Kyle Lerman, Mike Ekern, Dan Kozlowski, and Brett Whitin
2009 - 2010 Winter Season

October 13, 2009 - October 14, 2009 ***Location / Event:*** ***Northern/Central CA and Western NV Early-Season Heavy Precipitation Event***
Authors: Kyle Lerman, Mike Ekern, and Dan Kozlowski

December 24, 2005 - January 03, 2006 ***Location / Event:*** ***Southwest OR, Northern CA, and Western NV Significant Precipitation Event***
Authors: Dan Kozlowski and Mike Ekern

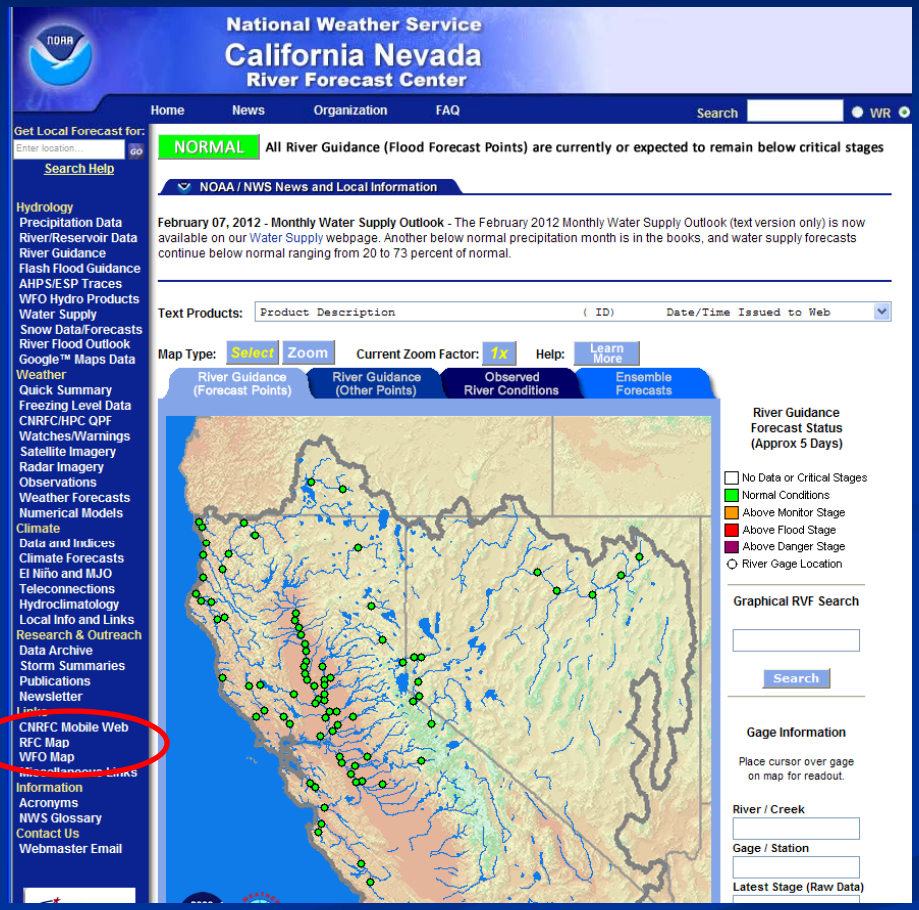
April 02, 2006 - April 06, 2006 ***Location / Event:*** ***Southern Sierra Nevada and San Joaquin Valley Significant Precipitation Event***
Authors: Dan Kozlowski and Mike Ekern

January 07, 2005 - January 11, 2005 ***Location / Event:*** ***Southern California Significant Precipitation Event***
Authors: Dan Kozlowski and Mike Ekern

February 17, 2005 - February 23, 2005 ***Location / Event:*** ***Southern California Significant Precipitation Event***
Authors: Dan Kozlowski and Mike Ekern

May 17, 2005 - May 19, 2005 ***Location / Event:*** ***Northern California Significant Precipitation Event***
Authors: Dan Kozlowski and Mike Ekern

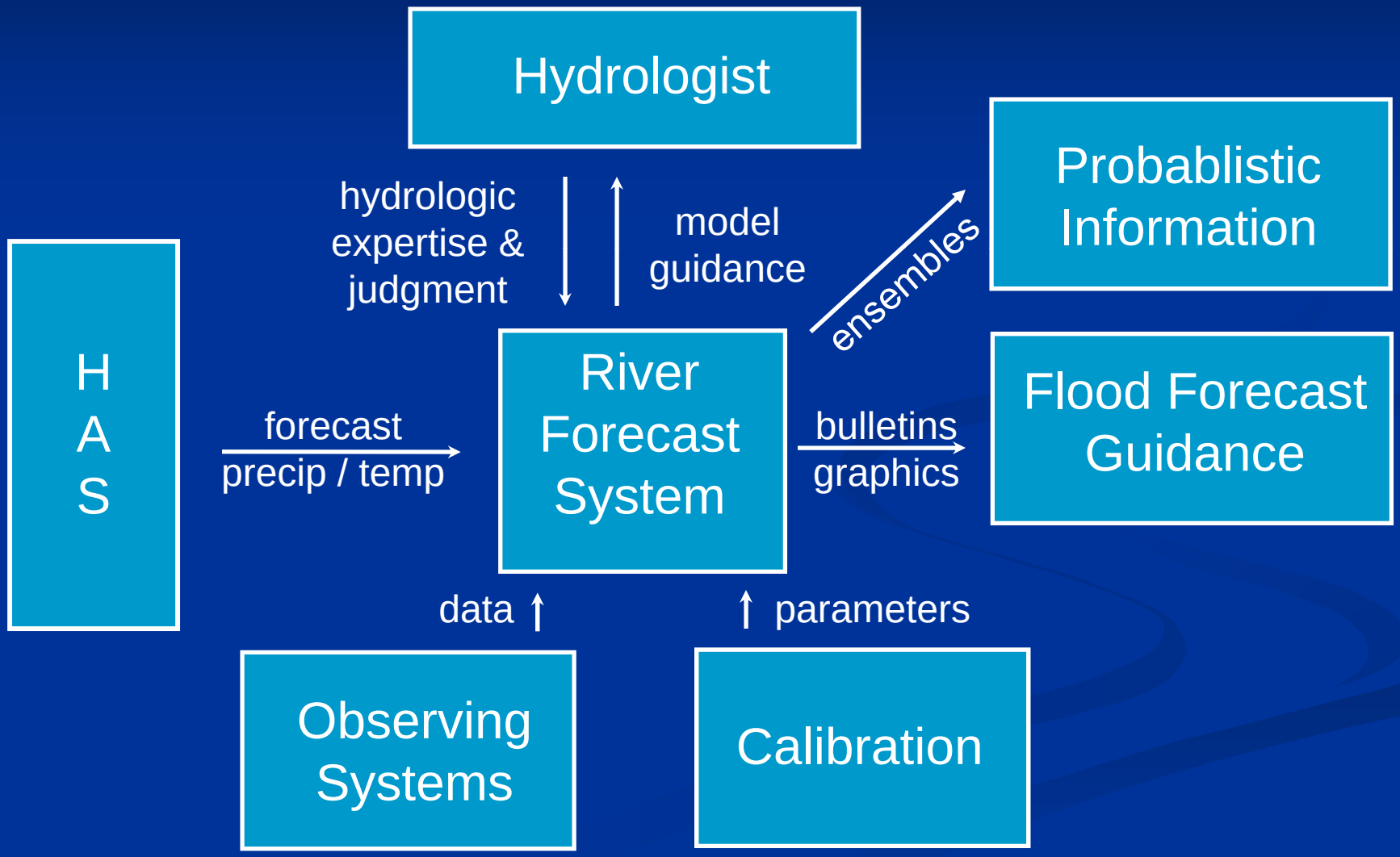
December 26, 1996 - January 03, 1997 ***Location / Event:*** ***Southwest OR, Northern CA, and Western NV Significant Precipitation Event***
Authors: Dan Kozlowski and Mike Ekern



* Currently working on February 1986

Operational River Forecasting

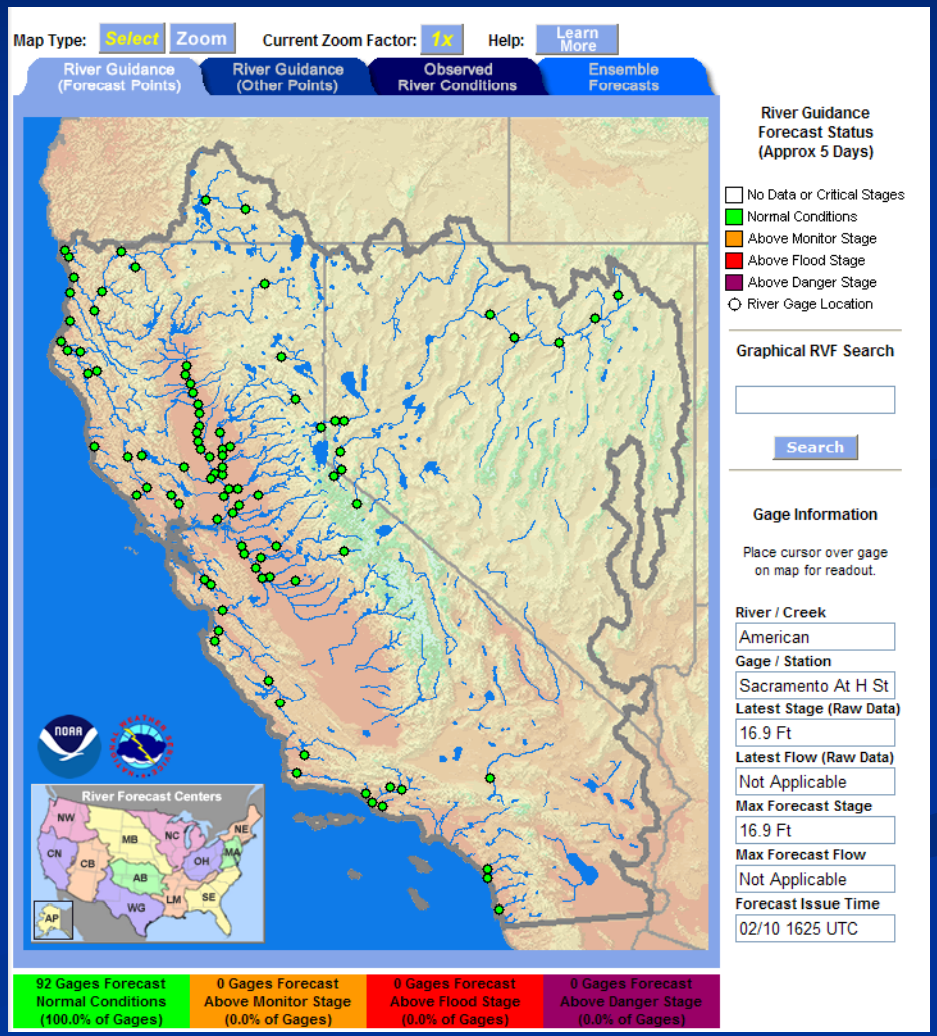
(Hydrology)



River Guidance

- ~220 flood, non-flood, and reservoir locations
- Updated w/each model run
  - 2x / day winter weekdays
  - 1x / day summer weekdays and weekends
  - 4x / day during flood events

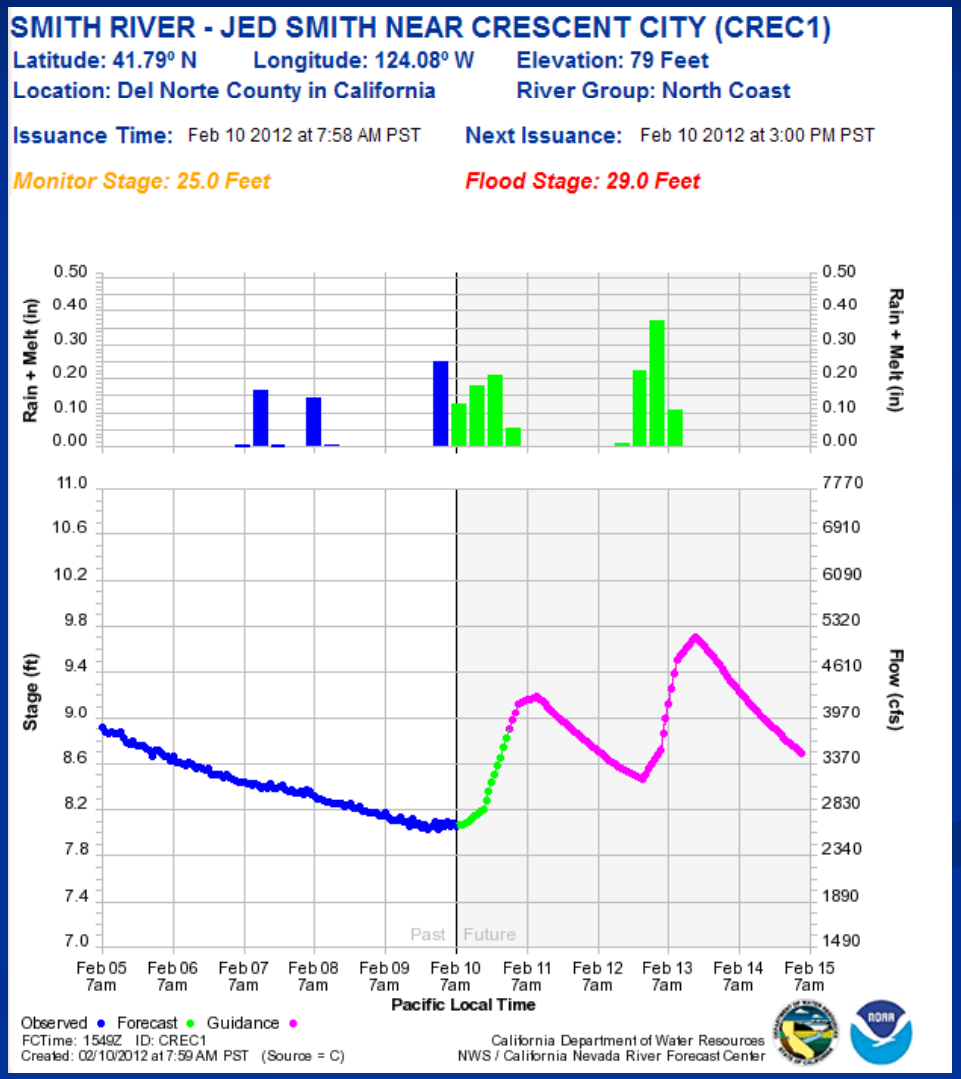
(www.cnrfc.noaa.gov)



River Guidance

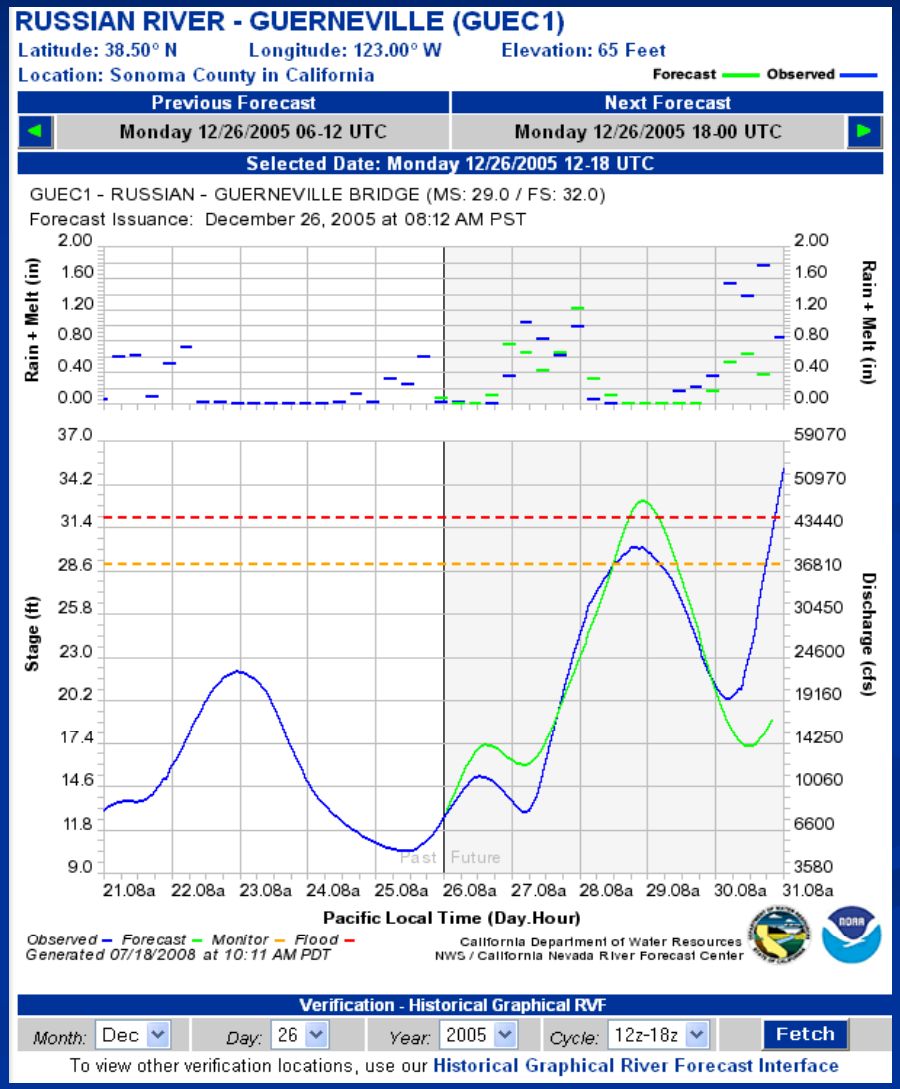
- Graphical
  - -/+ 5 days
  - Obs + Forecast + Guidance
  - Available
    - CNRFC Website
    - CDEC Website
  - Interpretation
    - Online help
    - 1 page flier

(www.cnrfc.noaa.gov)



River Guidance - Verification

- Flood locations only
- -/+ 5 days
- Observed and Forecast
  - precipitation
  - streamflow
- Select by
  - date
  - next/previous
  - looping
- Available
  - All flood forecast locations
  - CNRFC Website
- Interpretation
  - Online help
- All since Fall 2003

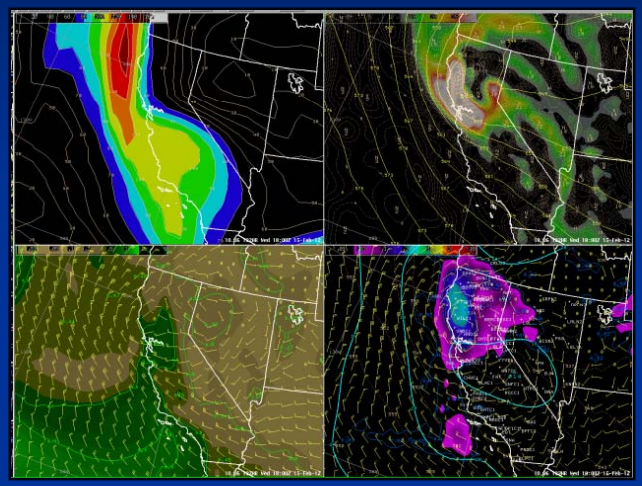


Improvements in Forecasts Over Time

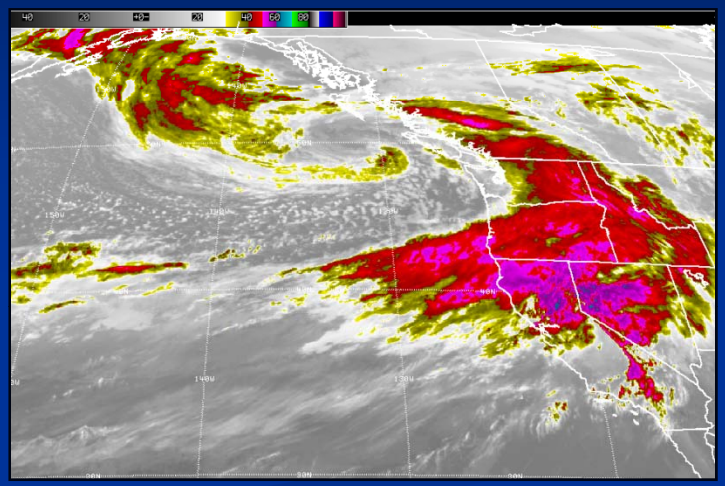
- Meteorological improvements
  - faster computers
  - better model physics
  - improved data assimilation
  - improvements in remote sensing → better model initialization

- Hydrologic improvements
  - faster computers
  - better visualization
  - improved data utilization
  - potential addition of hydraulic and hydrodynamic processes

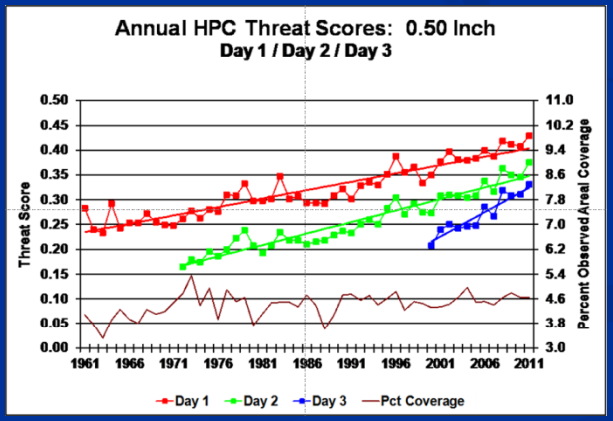
Improvements in Forecasts Over Time



faster computers, better model physics
improved data assimilation



improvements in remote sensing
→ better model initialization

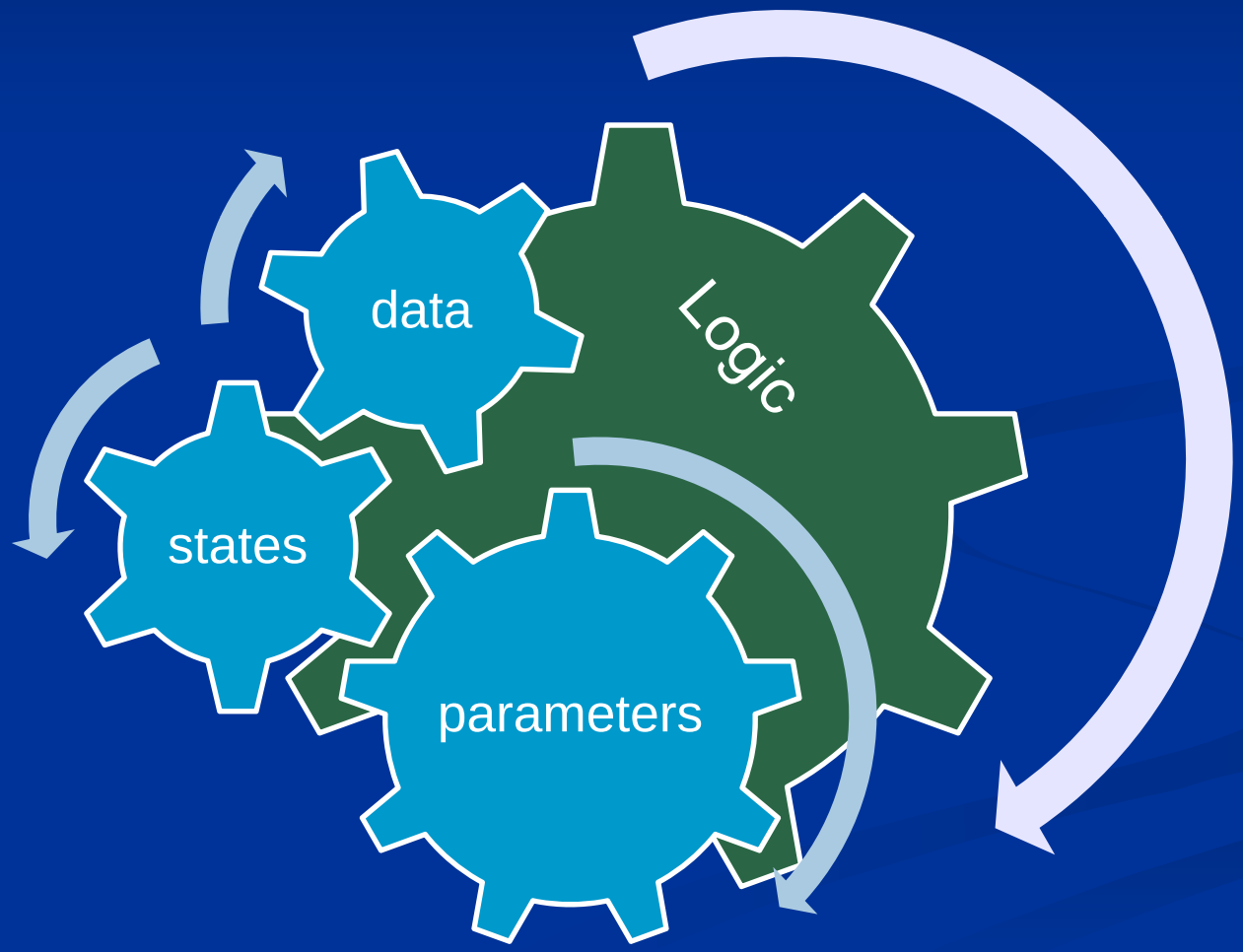


long-term changes in skill

Ensemble Forecasting

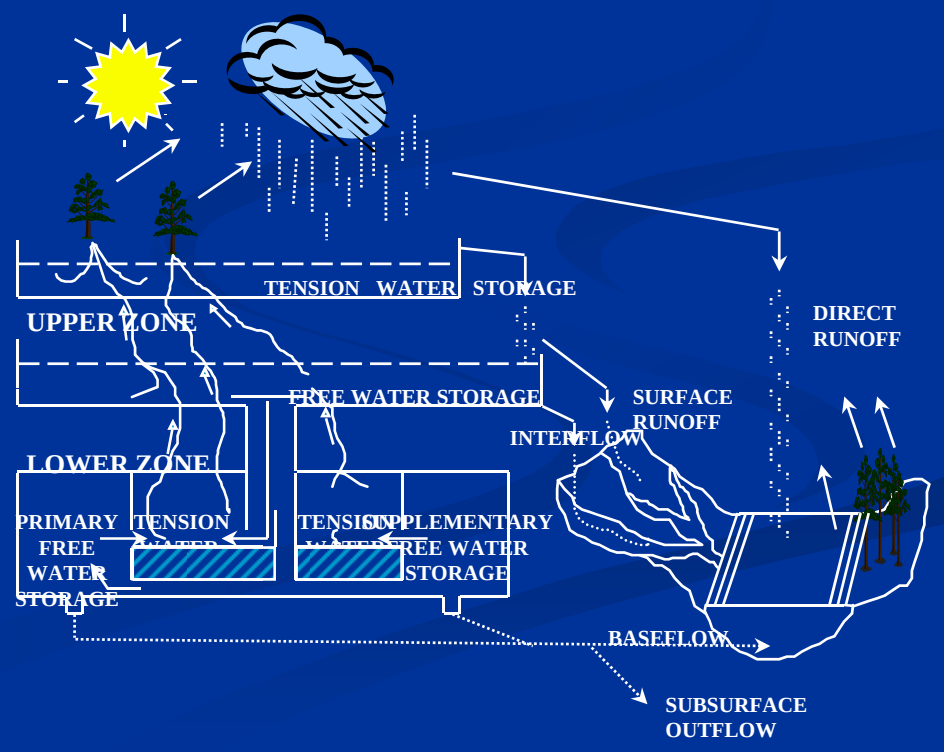
A three member “ensemble”

Model Components

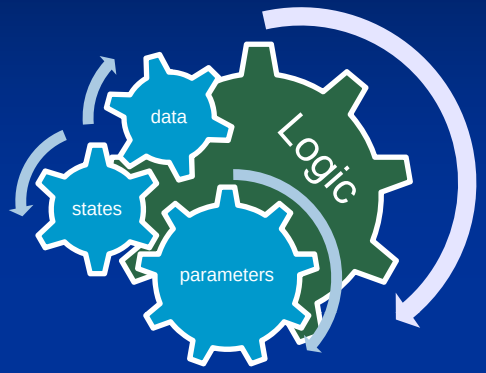


Common Hydrology Models

- Rain-Snow Elevation
- Snow Accumulation/Ablation
- Soil Moisture
- Unit Hydrograph
- Reservoir
- River Routing
- Arithmetic Transforms



Model Results



- "Result differences" come from different…
  - Model States
    - Current snow water, soil moisture, reservoir storage, etc.
  - Input Data
    - Precipitation, air temperature, freezing level, assumed reservoir regulation, etc.

Ensemble Streamflow Prediction

- Use same forecasting infrastructure as Flood/Routine forecasts (CHPS)
  - Same models (logic+parameters), observed data, model states
- Modeling system run with multiple scenarios of future precipitation and temperature
  - Scenarios are
    - Spatially and temporally coherent
    - Equally likely
    - Leverage short-term weather forecast (14 days)
- Resulting stream flow scenarios form a set that can be statistically sampled and analyzed

Ensemble Streamflow Prediction

Daily RFC Operations
- Data Ingest
- Data QC
- Model Updating

Current Conditions
- Soil Moisture
- Snowpack
- Reservoir Levels
- Streamflow

HAS Unit Forecasts

Historical Time Series

All Years of Record

Numerical Weather Model Forecasts

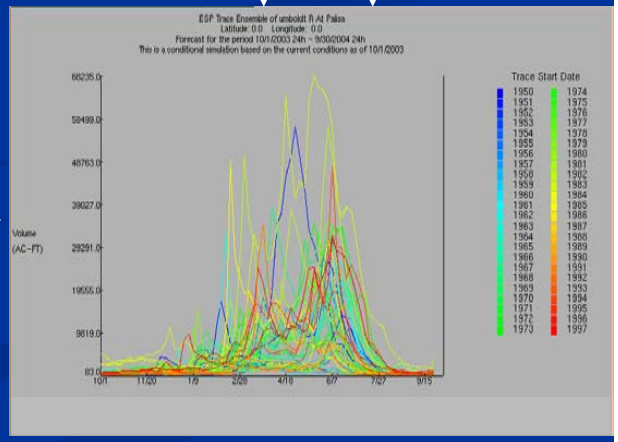
Met Ensemble Preprocessor

Mean Areal Time Series

Precipitation Temperature

CHPS Hydrologic Models

Flexible Period of Interest



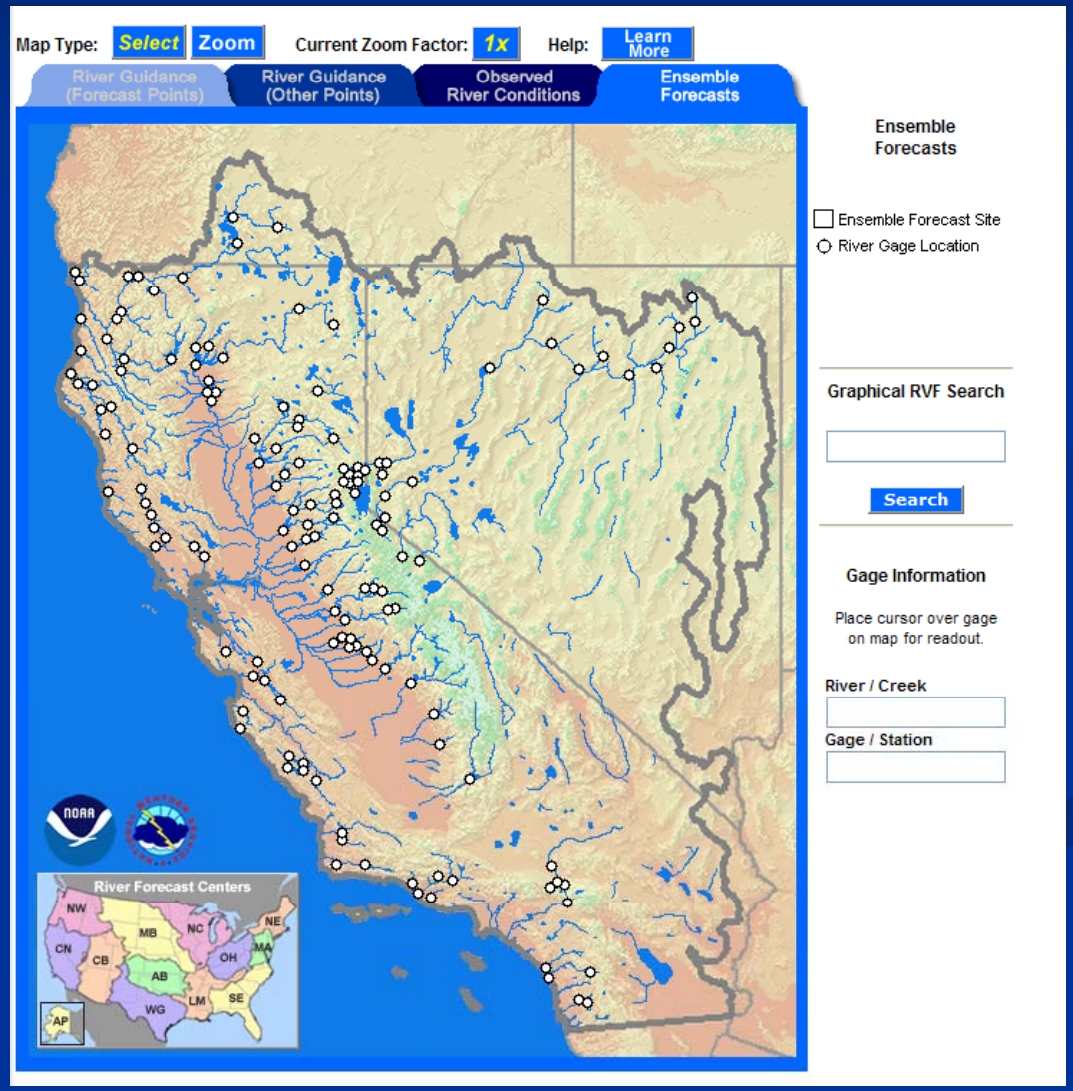
Time

ESP Product Generation

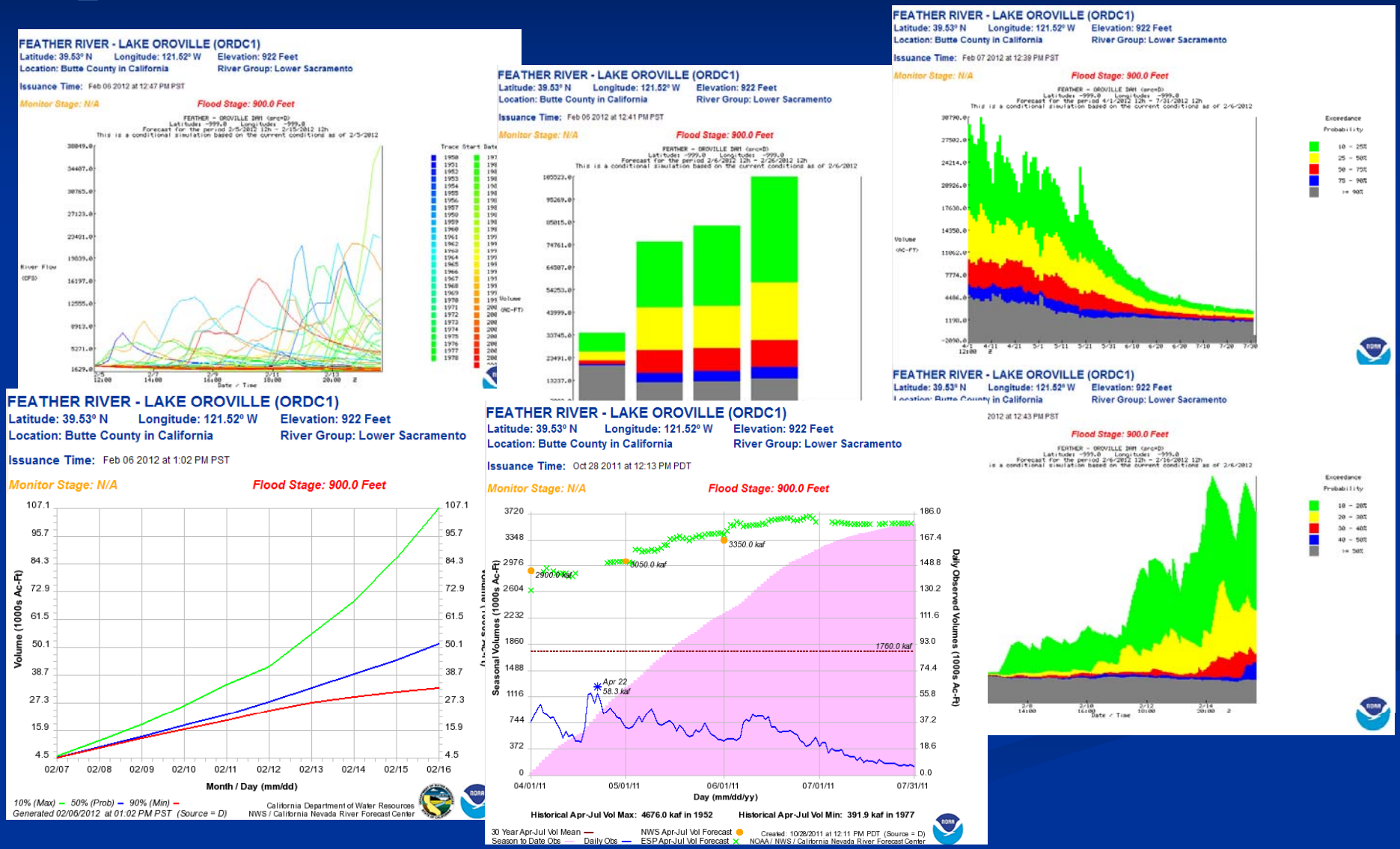
- Significant flexibility
  - User selectable time aggregation
    - 6 hrs to 1 year (or more)
  - User selectable window
    - Days, weeks, months or multiples there of
  - Probablistic information about
    - Peaks
    - Number of days to critical thresholds (e.g. Flood Stage)
    - Accumulated volume
    - Many more

Standard Ensemble Products

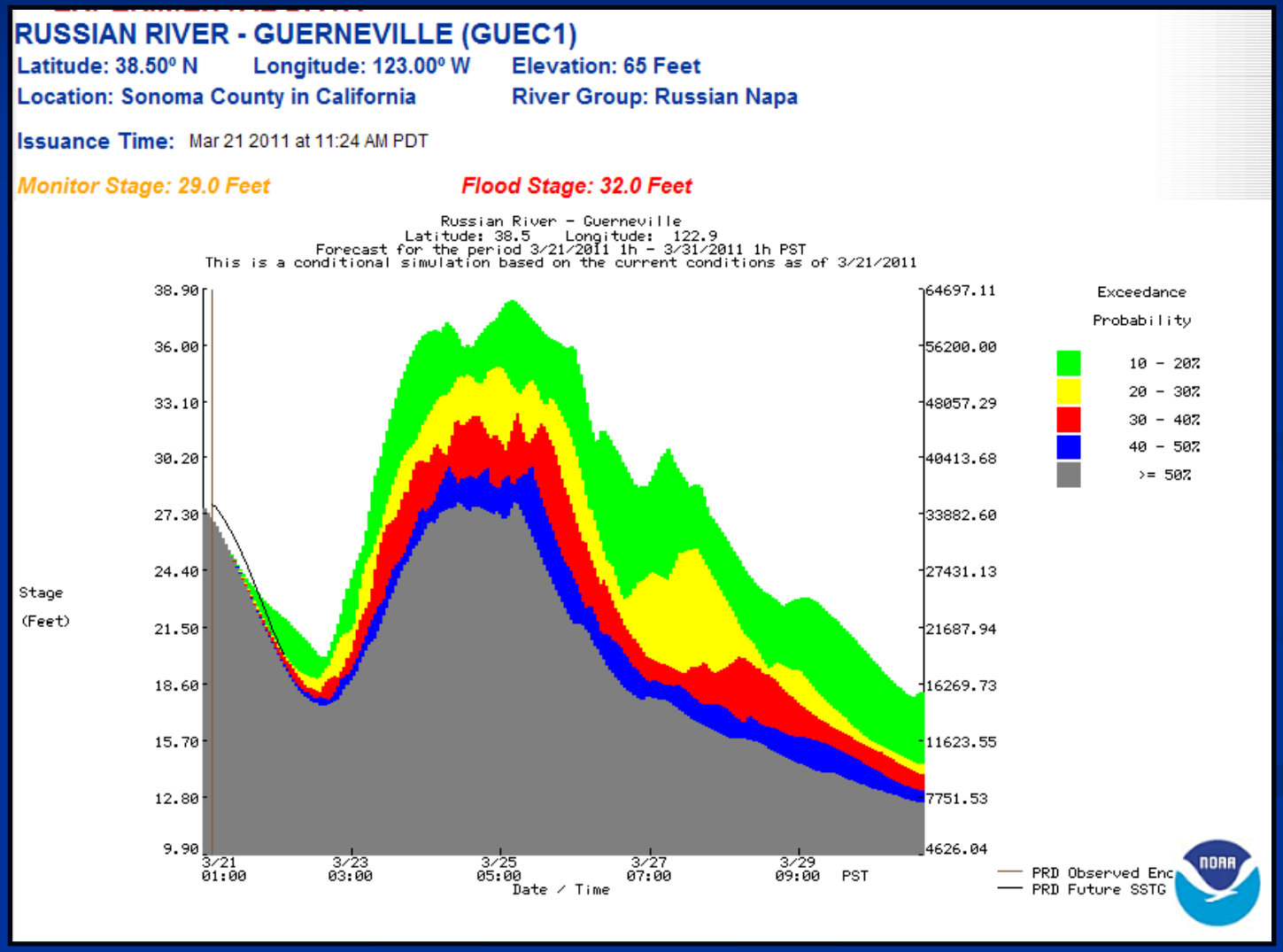
- 140+ locations
  - 10-day
    - Probabilities
    - Accumulated Volume
  - 20-day
    - Probabilities
    - Traces
    - 4x5-day Probabilities
  - Apr-Jul
    - Probabilities
    - Trend Plot
  - Build Your Own



Sample ESP Products



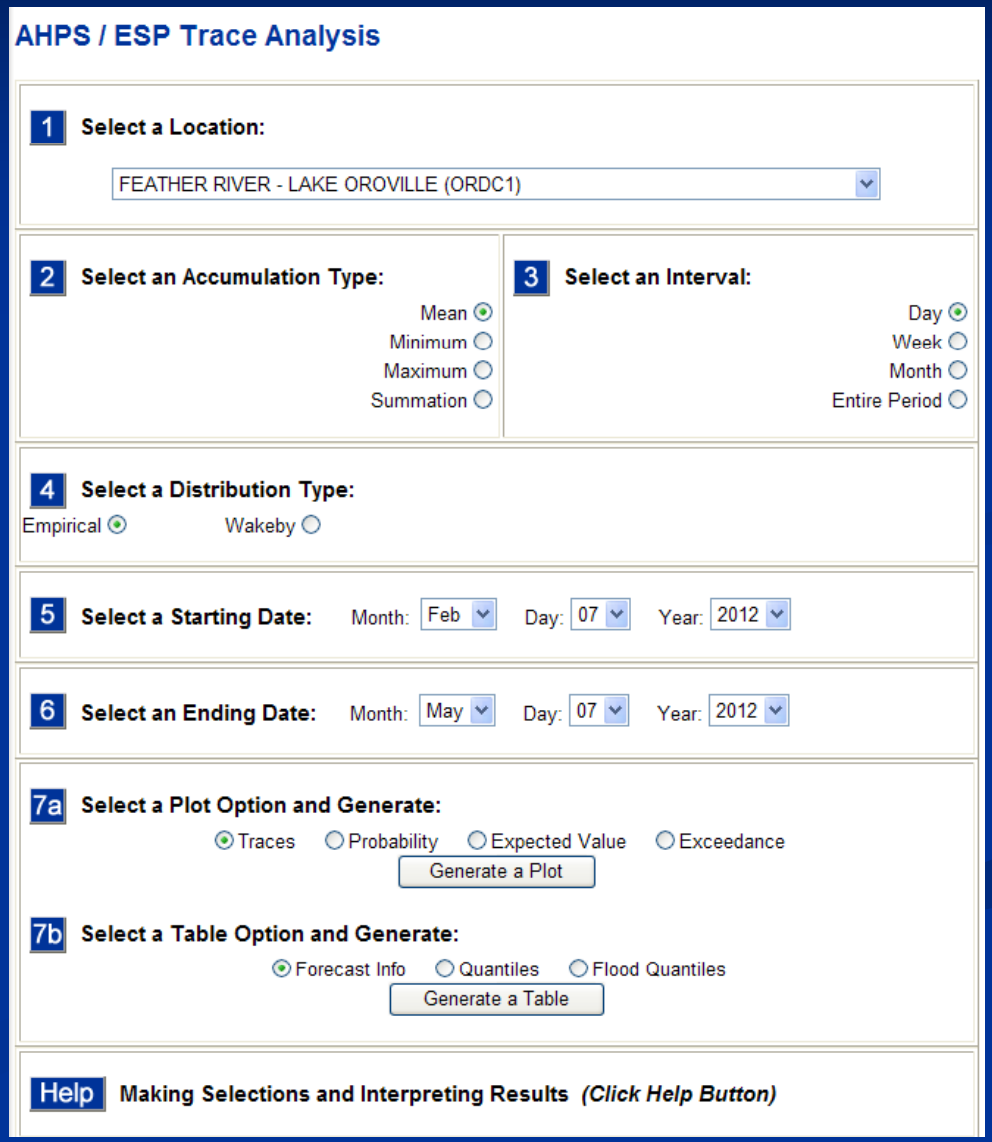
Prototype Short-Term Ensembles



CNRFC Ensemble User Interface

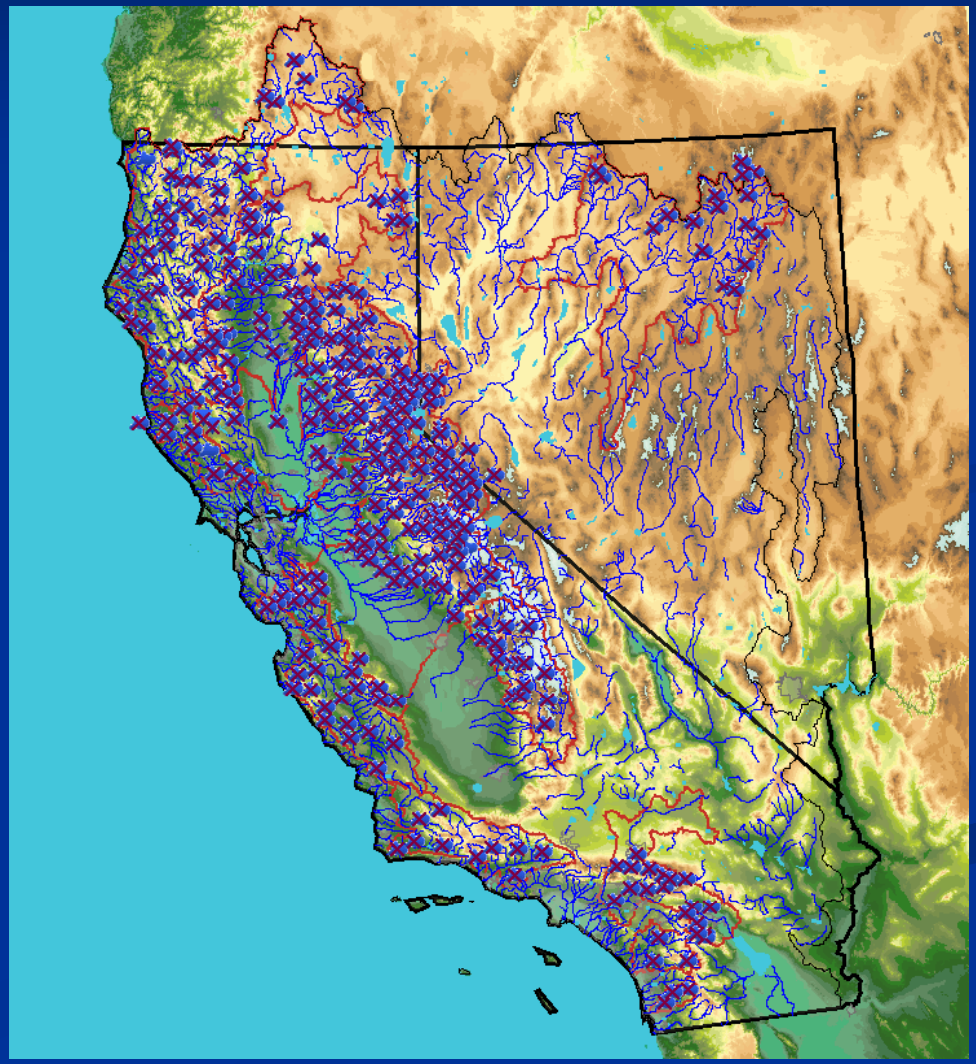
- "Create Your Own"
- Ensembles run nightly
- Assumes knowledgeable user
- Online help and interpretive tools available

(www.cnrfc.noaa.gov)

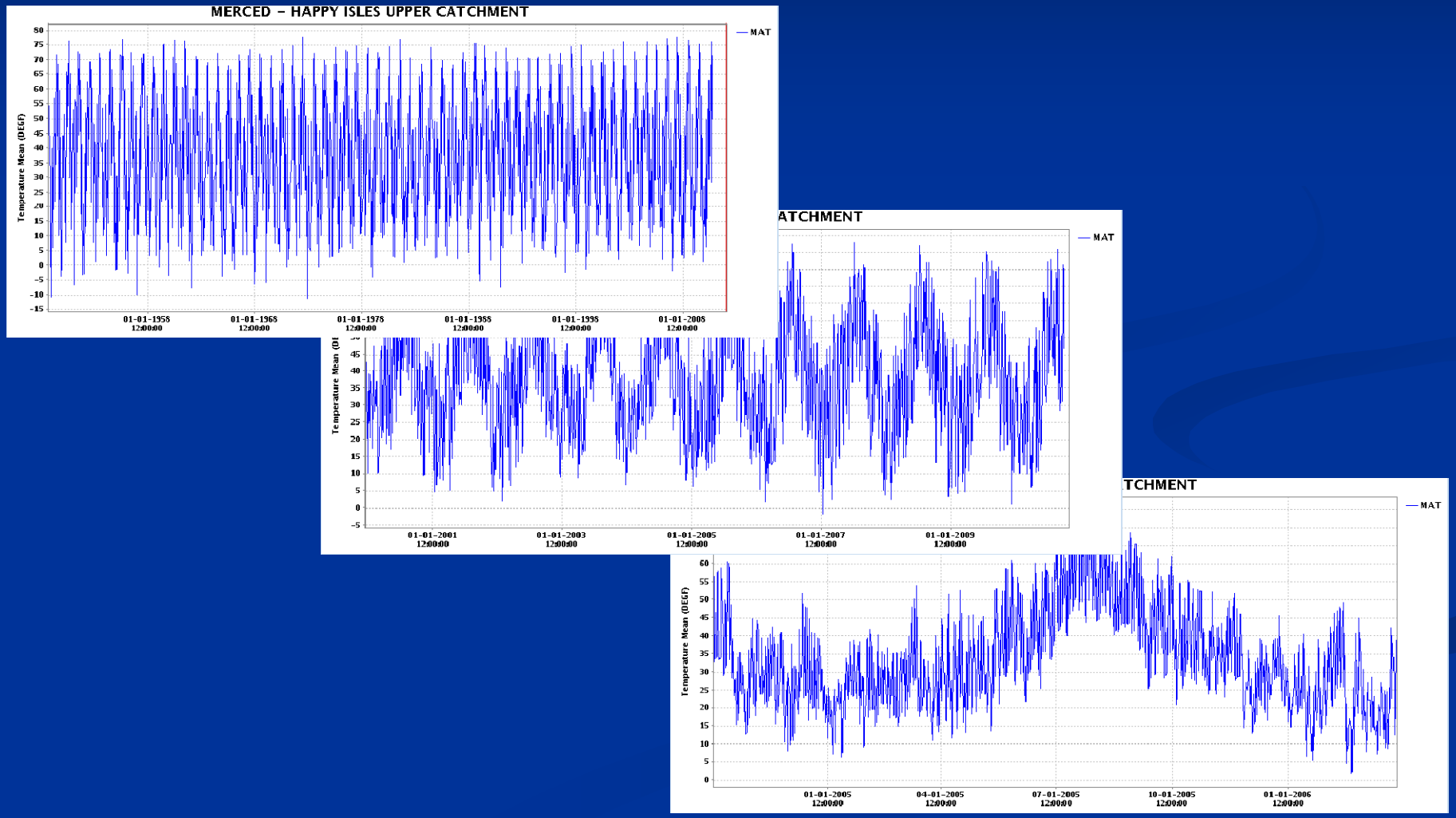


Watershed Calibration Data

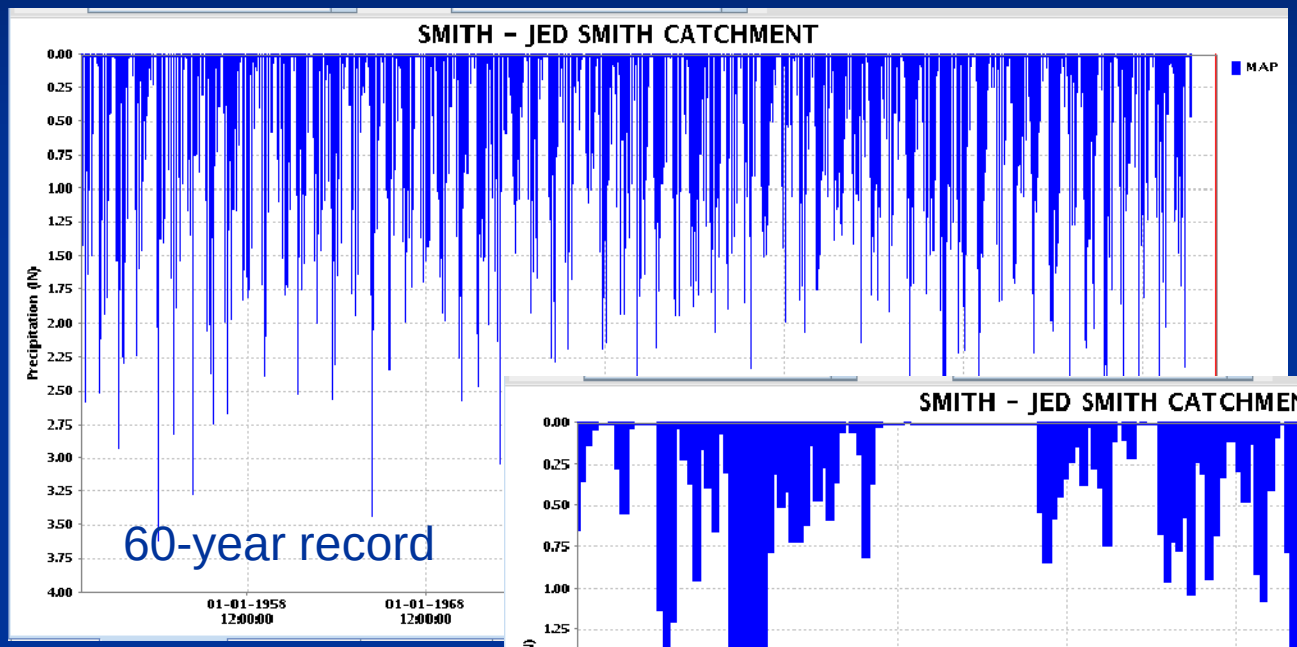
- MAPs and MATs
  - 10/1948 – 09/2010
  - 6 hr time steps
  - ~350 subareas
  - Data sources
    - COOP
    - CDEC
    - SNOTEL
  - Used for calibration
  - Using for ESP
- Are they stationary?
- Data resource for CC investigations

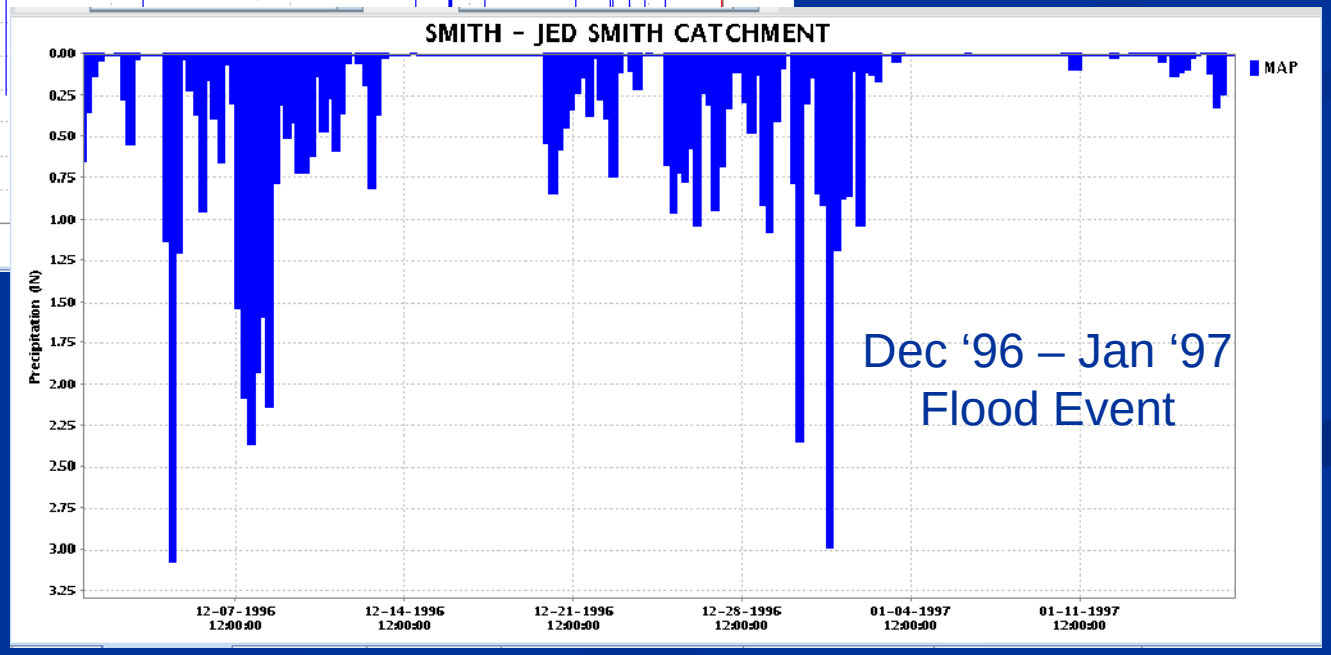


Mean 6-hr Air Temperature
Merced (Happy Isles) Above 9000’



6-hr Basin Precipitation
Smith River nr Crescent City





California-Nevada
River Forecast Center