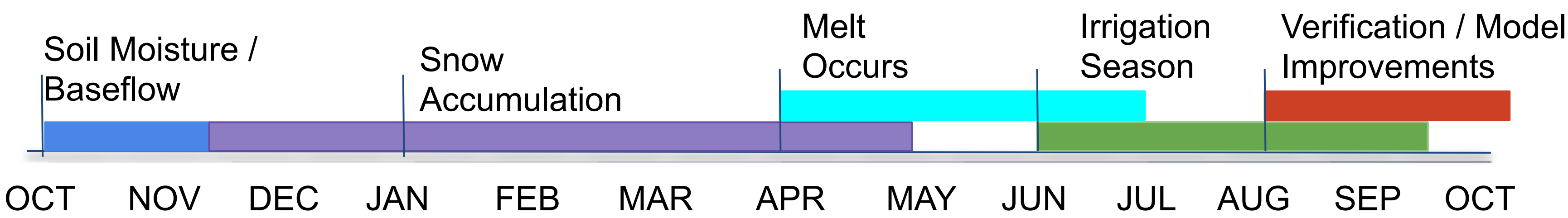
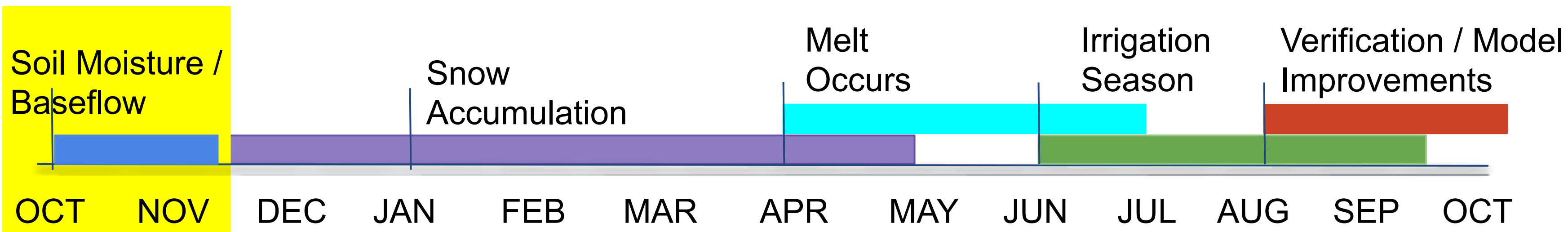
The Water Year in 45 Minutes



Operational Timeline



October 1 - Soil Moisture

- First day of the Water Year (e.g., Oct. 1, 2020 is the first day of WY 2021)
- Soil moisture is the most important model state affecting the long term forecast *at this time*.
  - Model soil moisture can affect early season water supply forecast volumes +/- 10 percent
- As the water year proceeds, the soil moisture becomes less important in snowmelt basins.
  - Snow starts to dominate
  - Very little melt at the soil/snow interface during winter
- There are two components in the CBRFC soil moisture model:
  - Baseflow
  - Tension water

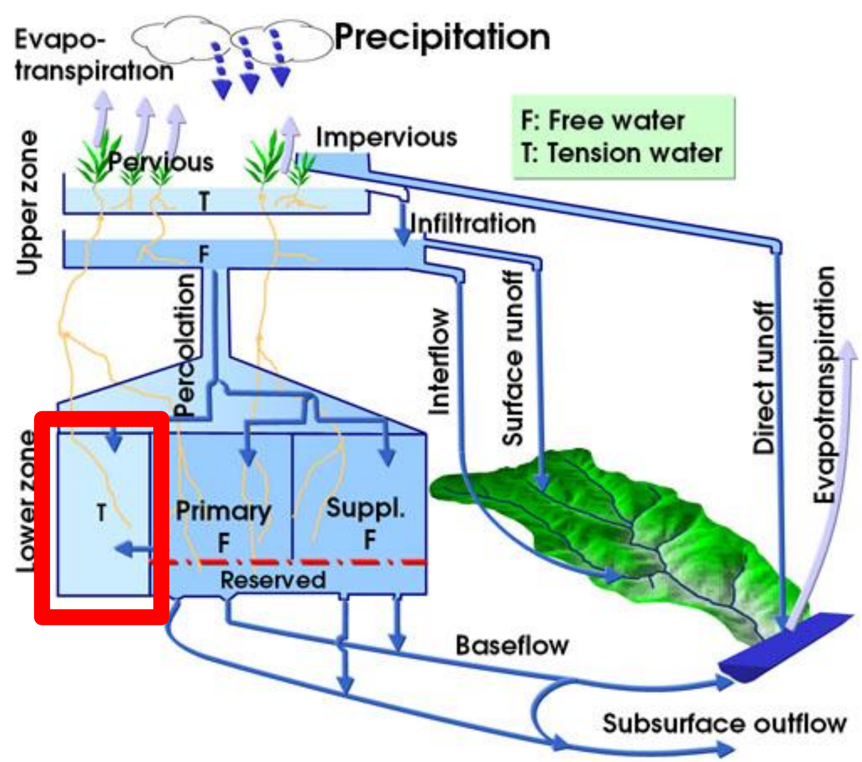
Baseflow

- We adjust model baseflow to streamflow observations after irrigation ends
  - Observations are critical for correct initial soil moisture conditions prior to runoff
- Baseflow is typically driven by:
  - Spring snowmelt (recharge)
  - Fall rain events (smaller)
  - Large recharge can affect baseflow for several years

Colorado River near Moab, Utah near baseflow conditions (USGS)

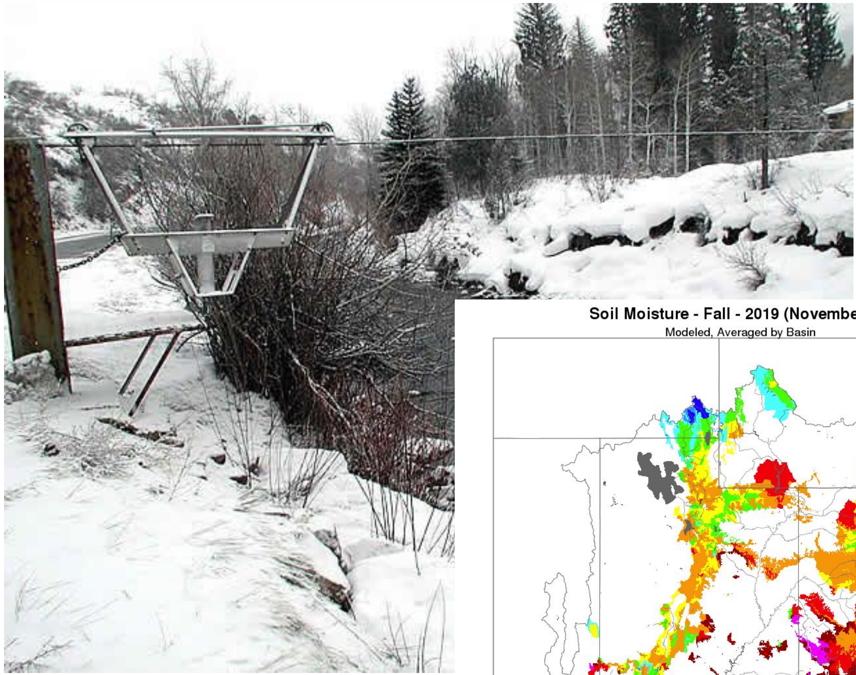
Tension Water

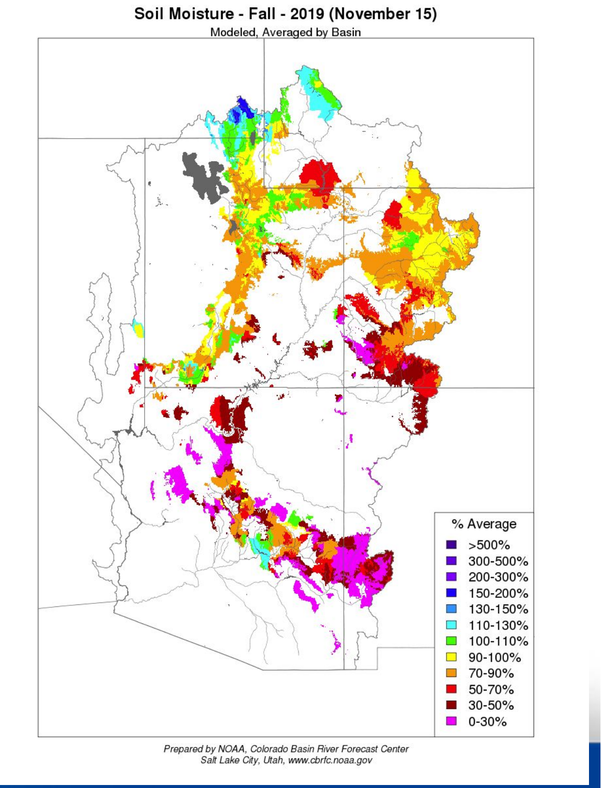
- Tension water is typically recharged every Spring
  - Mostly depleted due to Spring/Summer ET
- Fall rainfall events can recharge tension water heading into winter
  - Extensive QC process for fall precipitation to keep track of these events
- Not measured directly
  - NRCS soil moisture sensors not deep enough



Post Baseflow Analysis

- Gages begin to freeze, we lose observed flow information
- Publish map summary of fall model soil moisture conditions
  - A reflection of impacts of recently completed water year
  - Provides some insight into what future runoff efficiency could be





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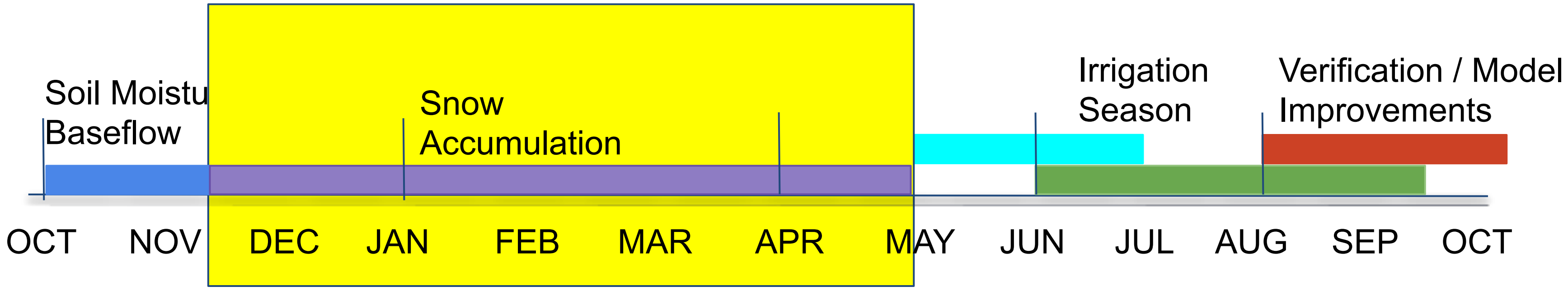
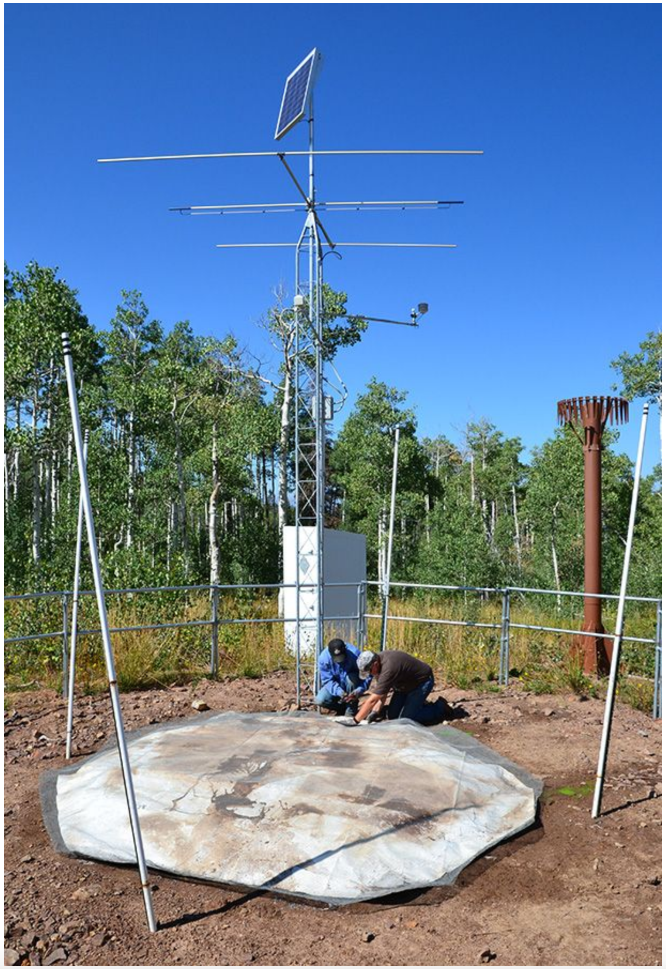


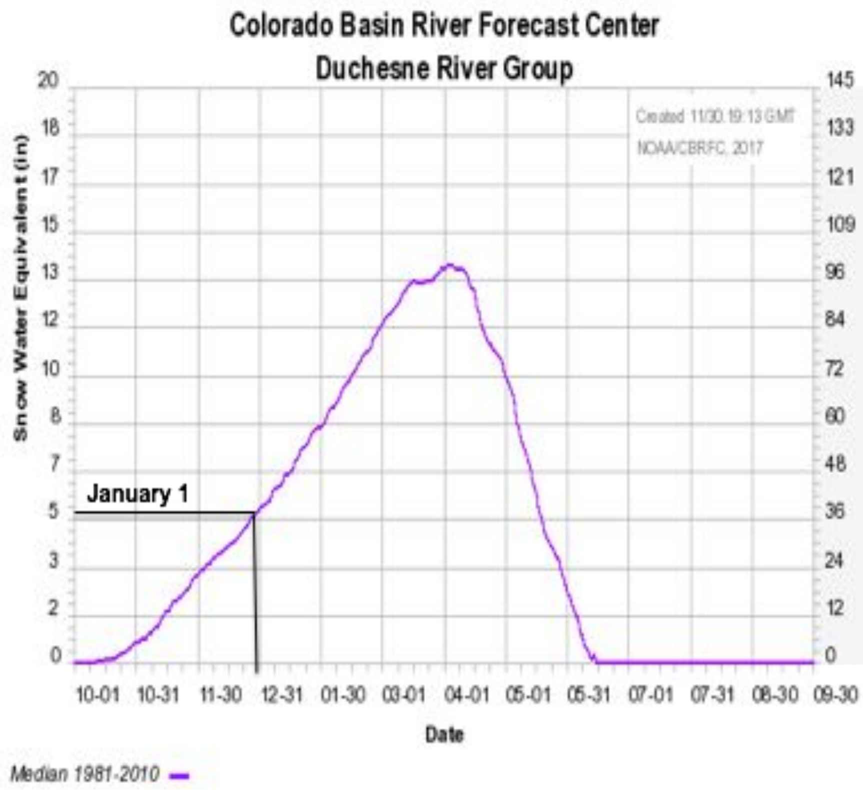
January 1 - First Water Supply Forecasts Issued

- Snow accumulation underway
- SWE begins to dominate Water Supply Forecasts
  - Use SNOTEL *precip* sensor (not SWE)
  - **QC observed precipitation daily**
  - Update model SWE biweekly using the long term precipitation total to account for short-term inaccuracies
- Compare SNOTEL snow pillow percent of normal to model
  - Rough error check
  - SNOTELs only give information where they are located



January 1 Forecasts

- What we know:
  - About 40% of snowpack accumulation
- What we don't know:
  - Future Weather
  - About 60% of snowpack accumulation

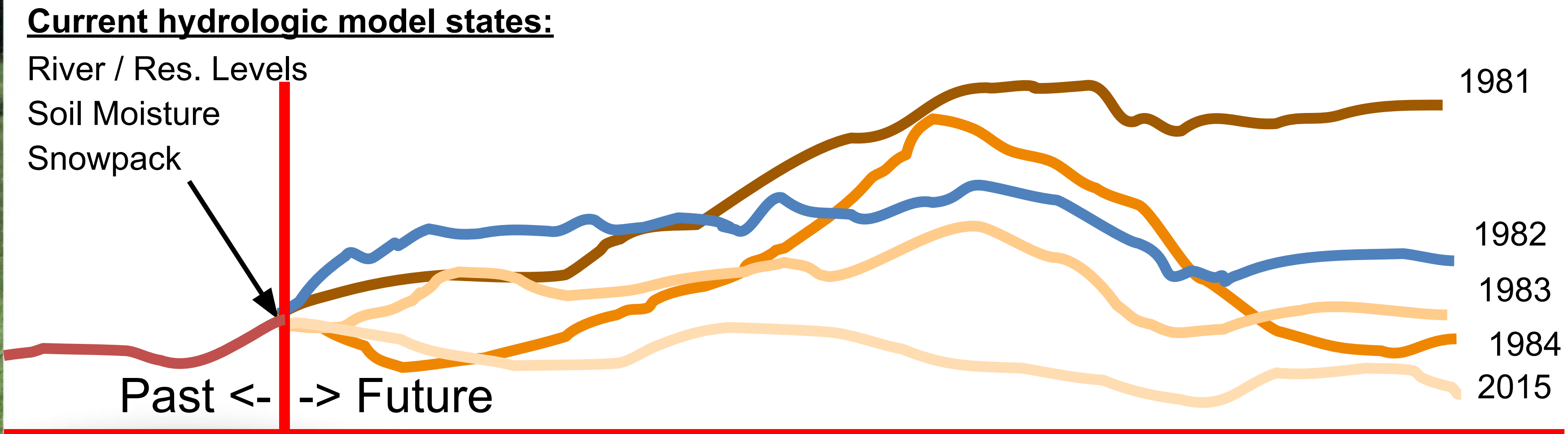


Normal snow accumulation / ablation plot for the Duchesne River Basin (NE Utah)

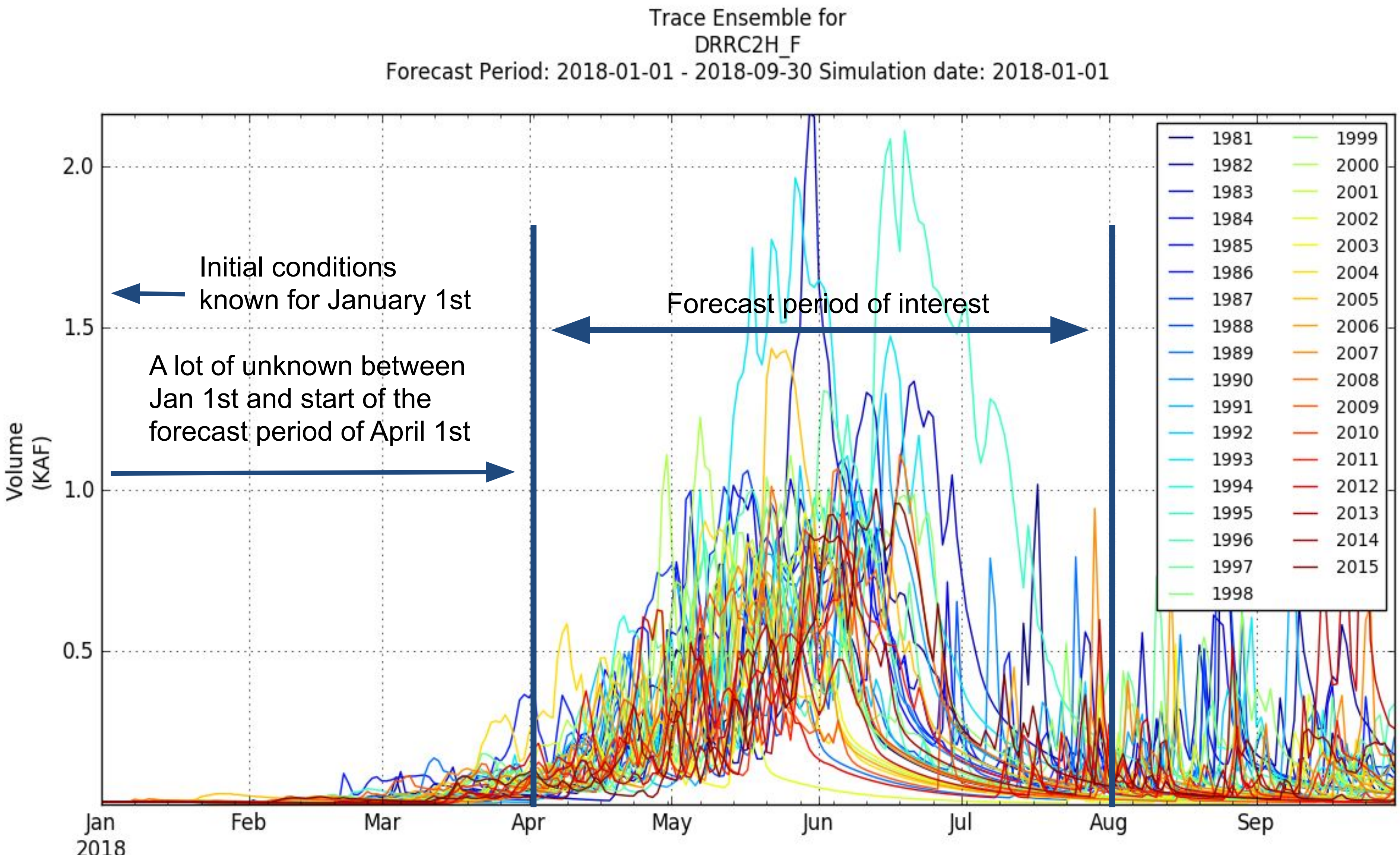
CBRFC Water Supply Forecasting

Ensemble Streamflow Prediction (ESP) Overview

- Start with current conditions of streamflow, soil moisture, snowpack
- Apply precipitation and temperature from each historical year used in model calibration (1981-2015)
  - NOQPF run only uses this climatology into the future
  - QPF run uses 7 days of forecast precipitation and temperature, then blends to climatology
- A forecast hydrograph is generated for each of those years
  - This creates an ensemble of 35 possible future streamflow patterns
  - Each year is given an equal (1/35) chance of occurring
    - Lower Colorado basin can use objective trace weighting based on type of year

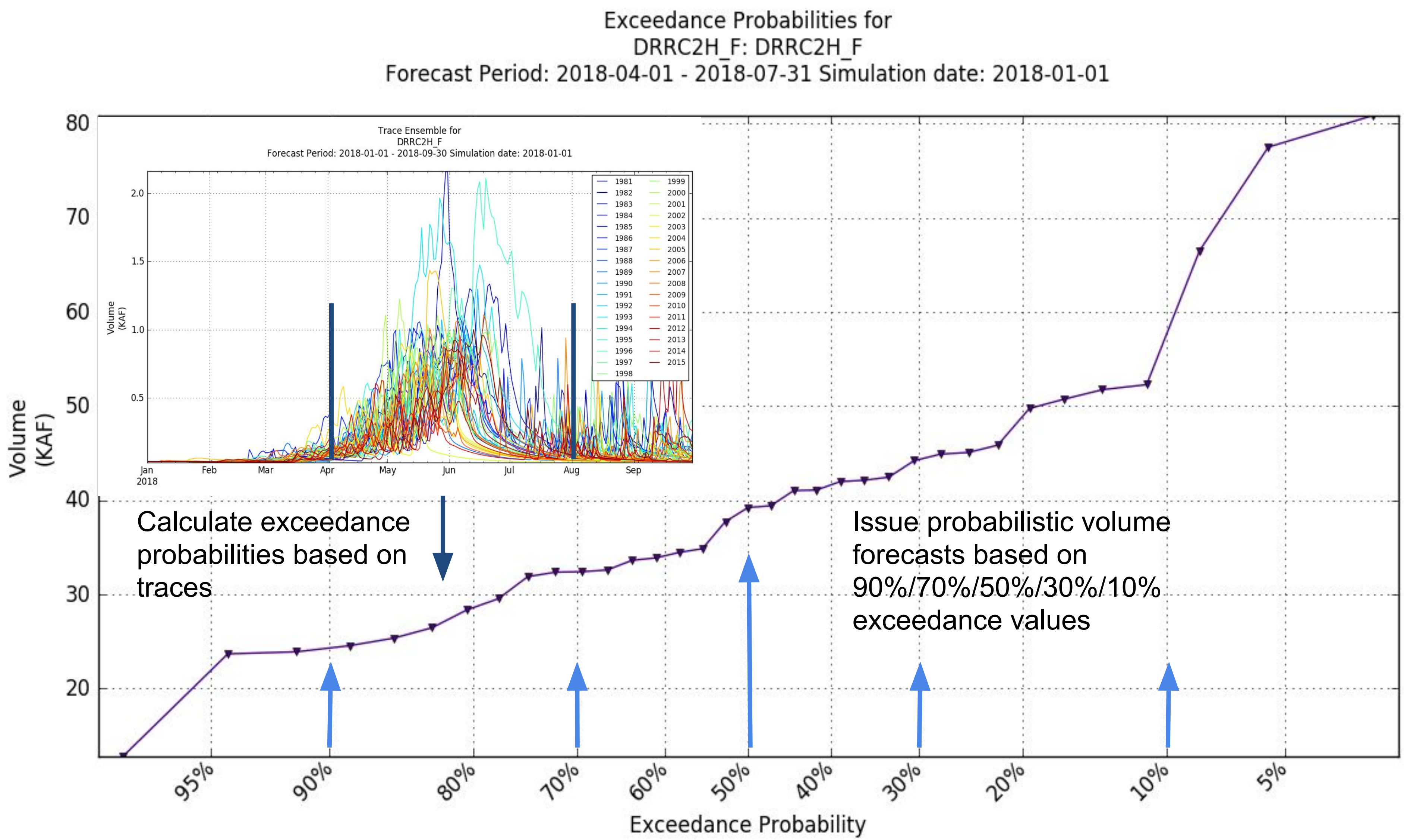


ESP Range of Possibilities

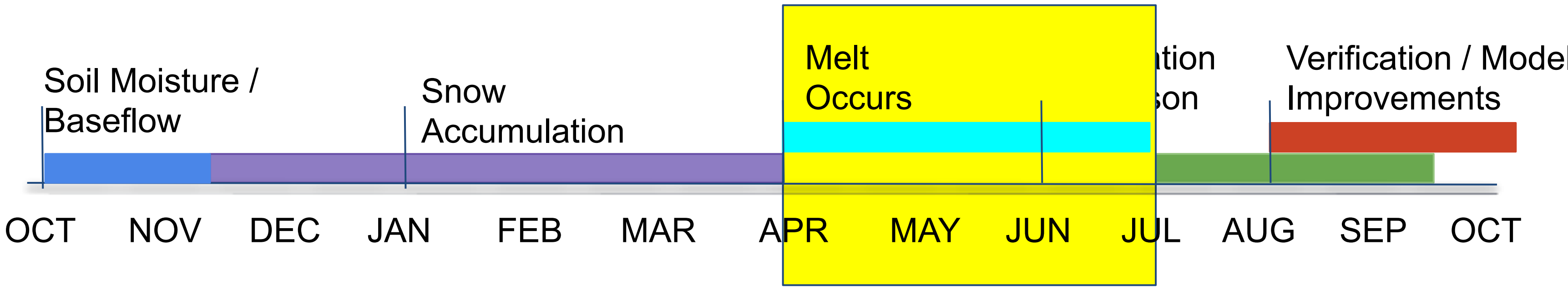


CBRFC Water Supply Forecasting

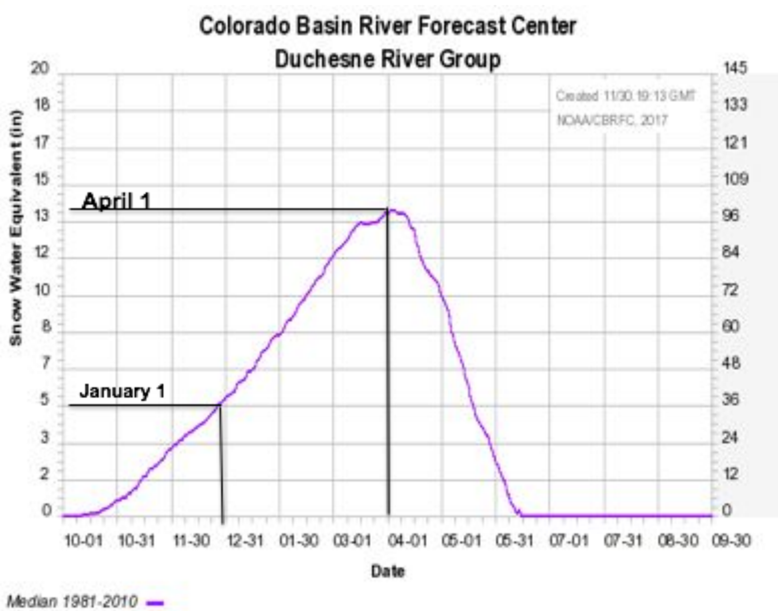
ESP Overview



Operational Timeline

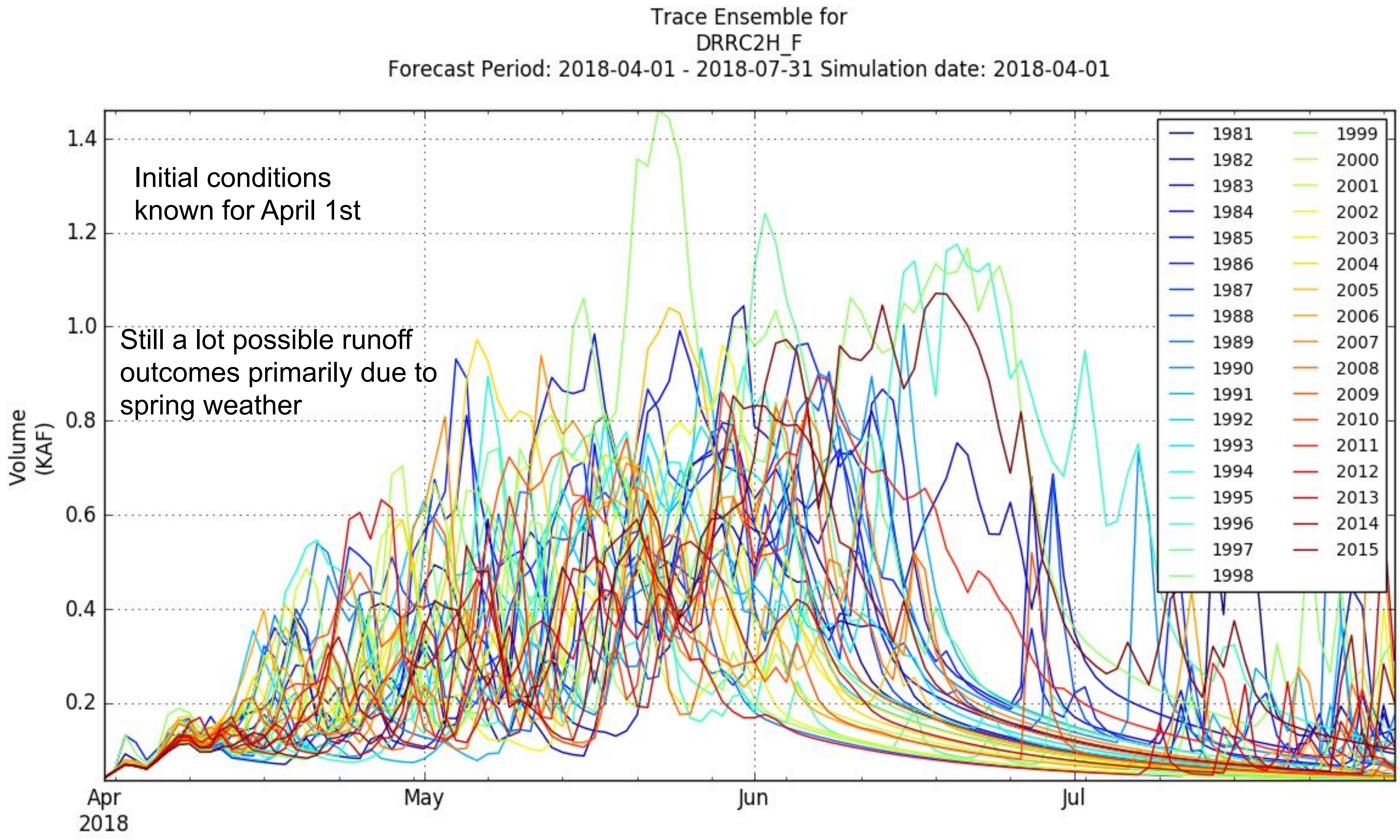


April 1 - Melt Begins



- What we know:
  - Around 90% of snowpack accumulation
  - December through March weather
- What we don't know:
  - Future precipitation (Apr-May)
  - Snowmelt pattern (temperature)
- April 1st Water Supply Forecast
  - Usually the last forecast before snowmelt begins
  - Snowpack typically near peak
- Extensive effort put into making sure that modeled SWE is as correct as it can be
  - Consistent with calibrations
  - Initial conditions are important to developing a reliable forecast

ESP Range of Possibilities

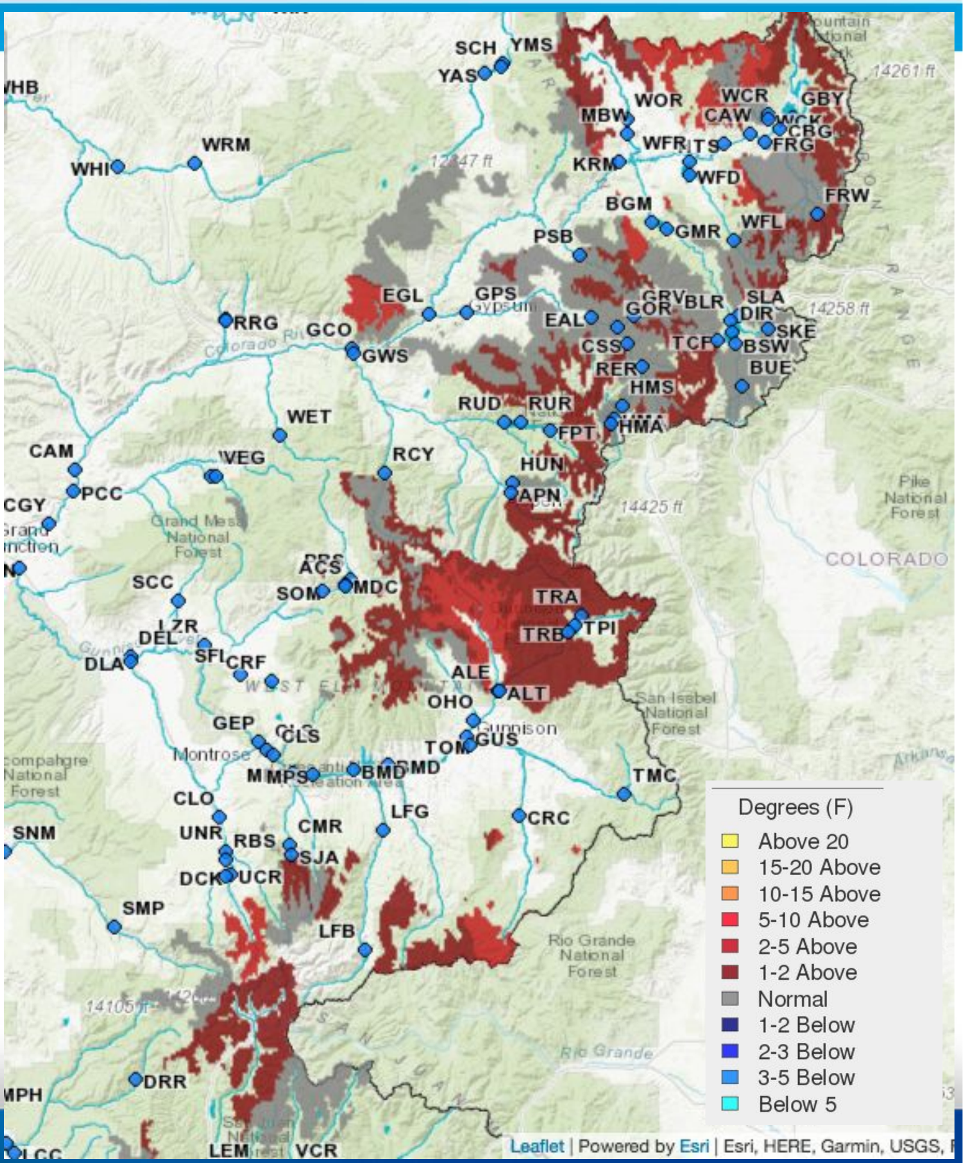


April to June - Melt Occurs

- The cycles of warming/melting and cooling/precipitation make it difficult to know the snow and soil states with absolute certainty
- Streamflow
  - As the gages come out of ice, accurate early spring flow measurements are crucial
- Precipitation
  - Rain events begin to dominate; QC of the data is very important
- Snow melt
  - We adjust the model melt rates to match the observed flows
    - We also have some techniques to change melt objectively based on dust
  - Precise location/elevation of melt difficult to determine
- Model SWE
  - SNOTEL pillows become less useful as melting occurs; SNOTEL SWE and model SWE typically diverge
    - We can no longer use our snow adjustment technique once rain events and/or melt begin
  - Start using satellite snow information to help with aerial extent
- Anecdotal evidence can be misleading

JPL Remotely Sensed Data

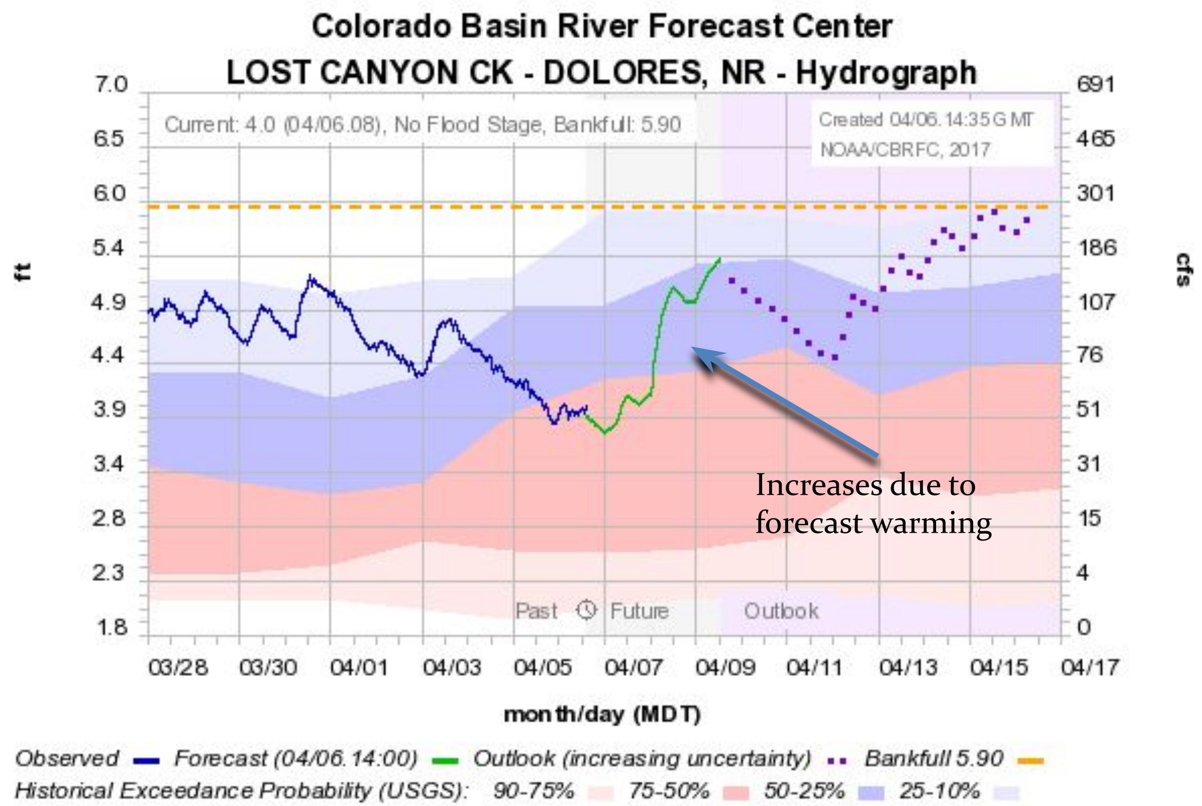
- *MODSCAG (Dust)
  - We calculated the departure from average contamination from 2000-2015
  - We calculate a temperature increase or decrease based on this
    - this can be applied in the model
  - Has shown to improve runoff simulations in the San Juan Basin
  - Does not significantly impact volumes but improves timing of melt
- Snow Cover Grids
  - Using qualitatively (binary)
  - Limited when cloudy



*MODIS Snow Covered-Area and Grain size retrieval algorithm

April to June - Melt Occurs

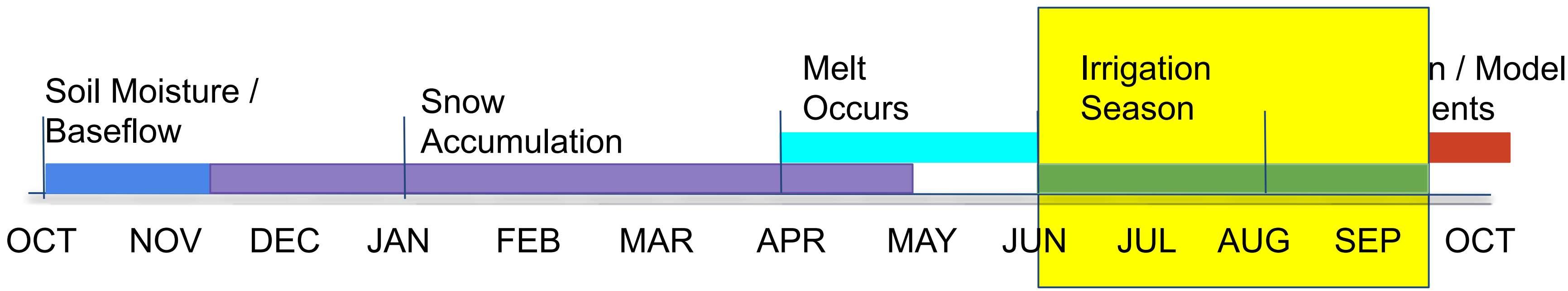
- We use 7 days of forecast precipitation and 10 days of forecast temperature in our daily streamflow forecasts



QC of these forcings becomes critical and can be challenging if meteorological models are flip flopping in their solutions.

New methodologies being used at CBRFC in the last few years have helped reduce some of the extreme fluctuations in the input forcings.

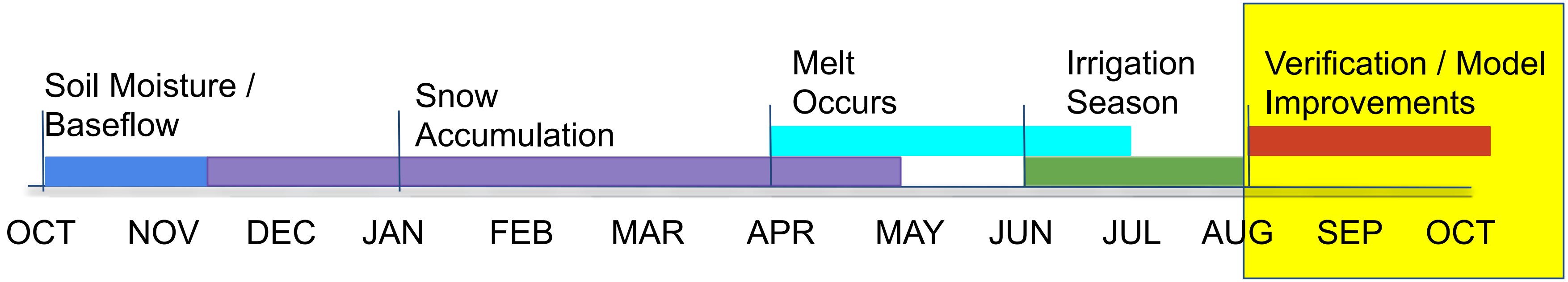
Operational Timeline



June to September - Irrigation

- Irrigation increases and is often the largest uncertainty in the daily streamflow forecast
  - Use real time diversion information where available
    - however no return flow data available and is variable
  - Otherwise we estimate depletions using a model
    - Function of temperature and acreage
    - Some areas have diversion records which are used in the calibration process, but lack real time information for day to day forecasts
- Obtaining real time information on water use and diversions is always helpful

Operational Timeline



Going Forward

- How does our operations timeline align with the timing of your decision making process?
- What are the gaps you face when making decisions? How can we help fill those gaps?
- Where do you look for information when making a decision?