Memorandum

To: URGWOM Technical Team Members
Date: March 12, 2021
Subject: Notes of the March 9, 2021 URGWOM Technical Team Meeting

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These notes summarize the items discussed during the March 9, 2021 Upper Rio Grande Water Operations Model (URGWOM) Technical Team meeting. The meeting began at 9:00 am and was conducted as an on-line collaboration hosted by the Corps of Engineers using the Corps' WebEx account. All those participating in the meeting introduced themselves and their names and affiliation are listed on the last page of these meeting notes.

This month's meeting agenda topics include an update on the Five-year Plan, NCAR (National Center for Atmospheric Research) hydrologic modeling and snowmelt runoff forecasts and general updates on ongoing URGWOM related activities from the Corps of Engineers, the Bureau of Reclamation, the Interstate Stream Commission and the U.S. Geological Survey.

Lucas reported to the Team on discrepancies in simulated Caballo Reservoir flood control operations and in the Elephant Butte Dam hydroelectric turbine efficiency method, which is incorrectly prioritizing power generation in conflict with operations for irrigation demand and storage. Lucas has been working on correcting these issues.

Cindy reported that the NMISC is working with Hydros in applying a blended hydrograph for use in the model runs for optimization of Elephant Butte Reservoir storage. The blending hydrograph is not meshing with the Reservoir optimization rules and solutions are being explored.

Miller reported to the Team on the updates to the URGWOM Five Year Plan. The Plan consists of three components; the narrative description of tasks, a Gantt chart schedule of tasks and a spreadsheet budget of estimated task costs. Miller presented a series of PowerPoint slides showing the Gantt chart of tasks and schedule and solicited comments from the Team on the Task items and proposed schedule.

The URGWOM tasks are divided into three categories; ongoing regular activities, model enhancement and development and planning applications. Miller highlighted aspects of certain tasks including:

- Maintaining an URGWOM database meta data file that describes the source of data and any pre-processing of data necessary for preparing the data, and
- The role that the regular rules updates tracking spreadsheet prepared by Marc plays in the model documentation.

Miller also reported that in the past, the URGWOM Technical Team had conducted formal technical reviews of the model development and documentation. The last review was in 2010. In lieu of a technical review presentation, a new task is maintaining a record of the peer review of documentation prepared by members of the Technical Team. This would consist of posting Technical Team review of Technical documents, and the author's responses, on the URGWOM myUSGS web page.

Under the model enhancement and development section of the Plan, Miller pointed out three tasks identified for investigation that are included in the Plan that were identified by Hydros during the model calibration. These include reviewing the simulation of Riverside drains to address the apparent circular routing logic, reviewing the fixed MRGCD canal seepage rates to consider changing to variable seepage rates, if adequate data are available to support a change and an investigation of the simulation of drain returns in the Albuquerque to Isleta reach. The nature of these issues may be further clarified by Intera during their review of the model calibration.

Reclamation's Rio Grande Basin study is also included in the Plan, which will begin later this year. This task involves the use of URGWOM with input from informed stakeholders in a comprehensive and interactive planning effort for the upper Rio Grande basin in NM.

Nabil reported that Intera will be providing peer review of the calibration work prepared by Hydros and that review report will be available. Cindy reported that the NMISC report on recent aerial surveys of the middle Rio Grande irrigated land will be ready in about one year. Reclamation reported that the Basin Study stakeholder training schedule will be ready soon. The Report on review of the implementation of the aquifer objects will be ready in May, 2021.

There were no representatives from the USGS attending the meeting and no report from the USGS was submitted.

Phil introduced Andy Wood and Josh Sturtevant from NCAR who have been working with Reclamation in the research of streamflow forecast techniques.

Andy presented a background on water supply forecasting and distinguishing features of statistical regressions and the Ensemble Streamflow Prediction (ESP), which has been prepared for the Rio Grande basin since 2018. NCAR has been cooperating with Reclamation and the Corps to improve modeling and forecasting capabilities by improving weather and climate inputs, application of "hindcasting" to detect systematic errors and remove biases from modeling or forecasting errors. He further described the hydrologic model being used to assess whether the characteristics of the forecast hydrograph shape is being lost due to warming. This model is used to assess new strategies for input of hydrograph shapes.

Josh presented information on the development of ESP, its parameter estimation and model calibration. He presented the results of an April 1st ESP hindcast for the upper Rio

Grande based on a 49-year (1970-2019) period, at twenty locations, and described the methods applied in the ESP post-processing bias correction process. He compared the raw ESP forecast flow data with the bias corrected data and presented a series of hydrographs of bias corrected ESP data with the URGWOM AOP run results and the observed data for gages in the upper Rio Grande for various years (2012-2019). The comparative analysis of results shows that the ESP method is more skillful than the URGWOM forecasts and produces smoother, more realistic April 1 forecasts. This is because the ESP is not based on a single analog year and takes into account climate trends that may invalidate the reliability of historic hydrograph shapes.

The Team thanked Josh and Andy for their presentation. The Team then discussed the use of ESP for forecasting the time and magnitude of the runoff peak (or double peak). This is a limitation that ESP shares with the analog (URGWOM) forecast method. Nabil reported that the preferred method of snowmelt forecasting would be based on snowpack physics and temperatures to forecast peak flow magnitude and timing. Lucas reported that Reclamation has obtained NWS forecast traces and has placed them in the HDB database and computed the forecast probabilities. The new RiverWare extension allows for the direct download use of HDB data in URGWOM.

The next regular meeting of the Technical Team is scheduled for April 13, 2021 at 9:00 am, which will also be an on-line collaboration.

The meeting adjourned at approximately 10:30 am.

ATTENDANCE LIST
URGWOM TECHNICAL TEAM MEETING
March 9, 2021

NAME	REPRESENTING
Nabil Shafike	USACE
Marc Sidlow	USACE
Phillip Carrillo	USACE
William Miller	Southwest Water Design/USACE Contractor
Mike Brown	Tetra Tech/USACE Contractor
Carolyn Donnelly	Bureau of Reclamation
Lucas Barrett	Bureau of Reclamation
Michele Estrada Lopez	Bureau of Reclamation
Dagmar Lewellyn	Bureau of Reclamation
Andrew Gelderloos	Bureau of Reclamation
Jerry Melendez	Bureau of Reclamation
Cindy Stokes	NM Interstate Stream Commission
Shalamu Abudu	NM Interstate Stream Commission
David Neumann	CADSWES
Nick Mander	Hydros Consulting

Guillermo Martinez	Intera
David Jordan	Intera
Viola Sanchez	BIA - Designated Engineer
Andy Wood	NCAR
Josh Sturtevant	NCAR
Brian Westfall	Keller Bliesner / BIA Contractor
Delbert Humberson	International Boundary and Water Commission

URGWOM TECHNICAL TEAM
March 9, 2021

Report on Update of
URGWOM Five-Year Plan
By: William J. Miller PE

URGWOM Five-Year Plan:

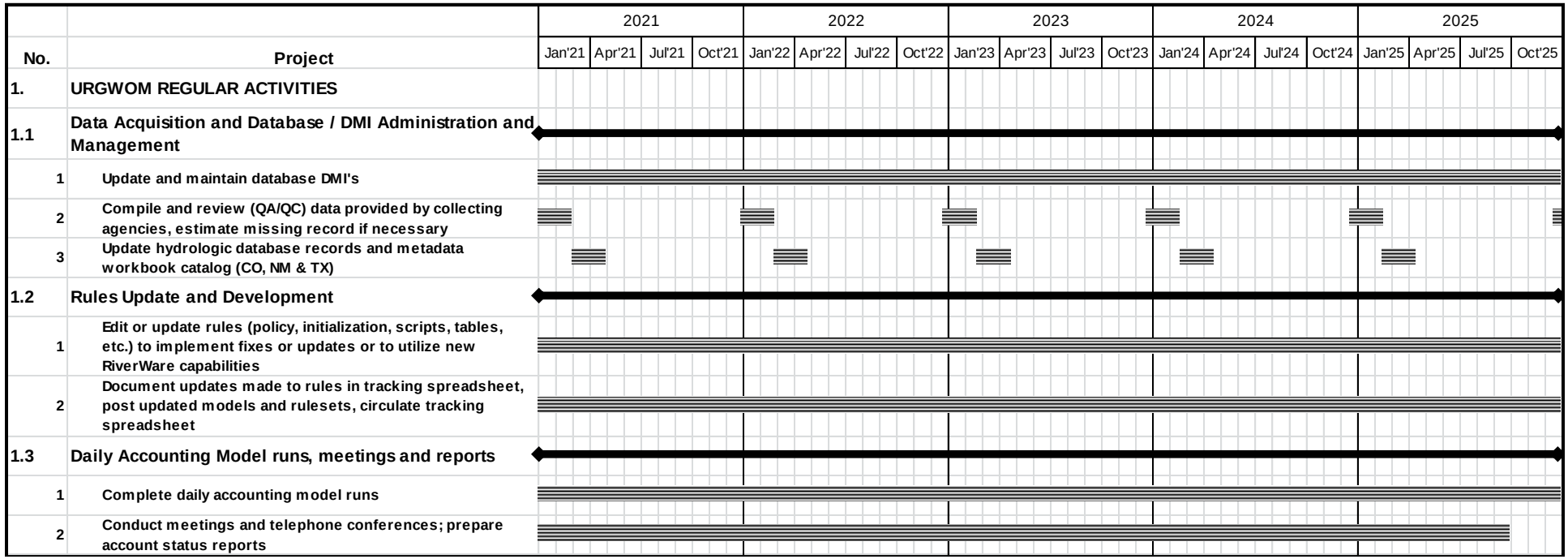
Purposes:

1. Serves as guidance for prioritizing and budgeting for agencies
2. Demonstrates the need to continue funding for development and maintenance of the model
3. Assist the Technical Team by directing their focus to specific work tasks that are underway or required in the future to improve model efficiency and reliability

Sections / Topics of Plan:

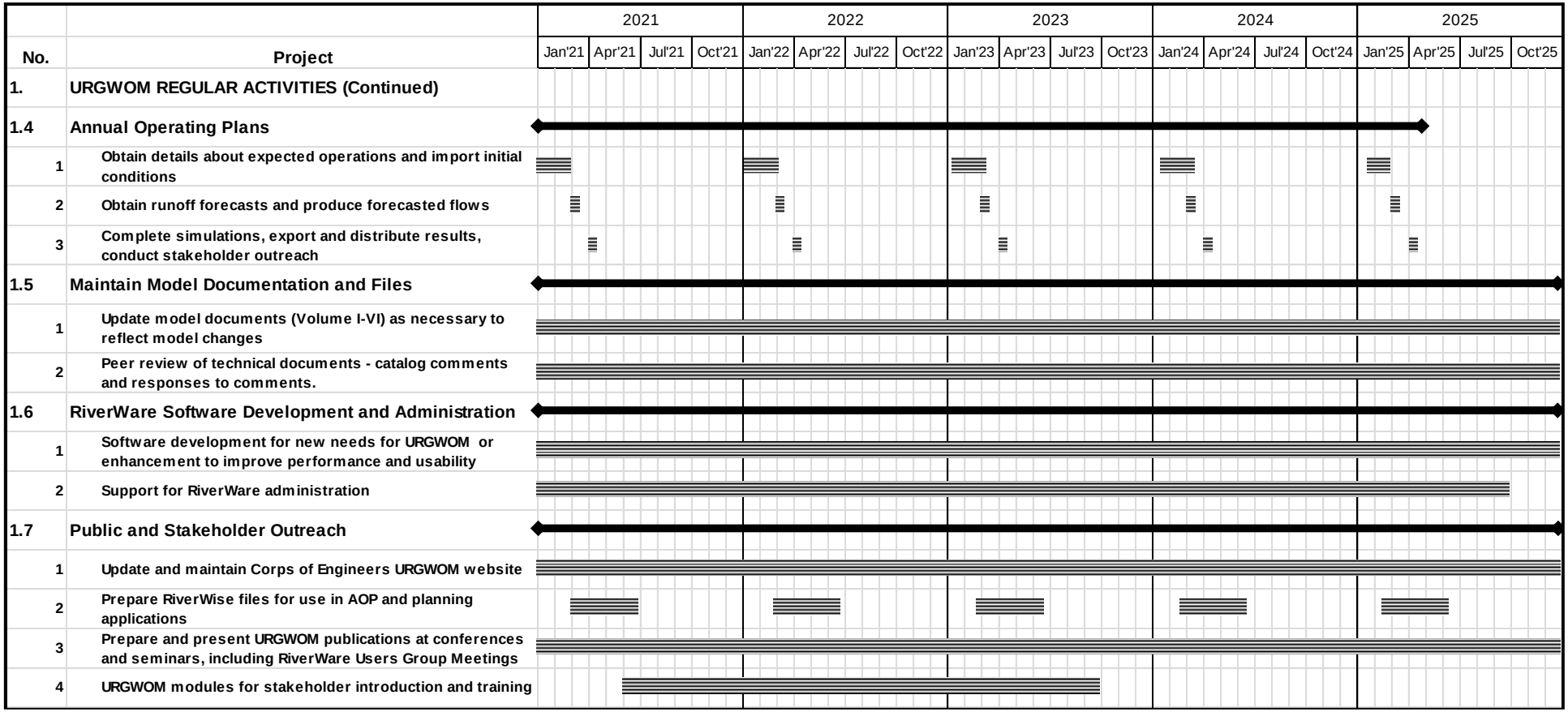
1. On-going and regular activities
2. Model development and enhancements
3. URGWOM for planning support

URGWOM Five-Year Plan (2021-2025)
URGWOM Regular Activities



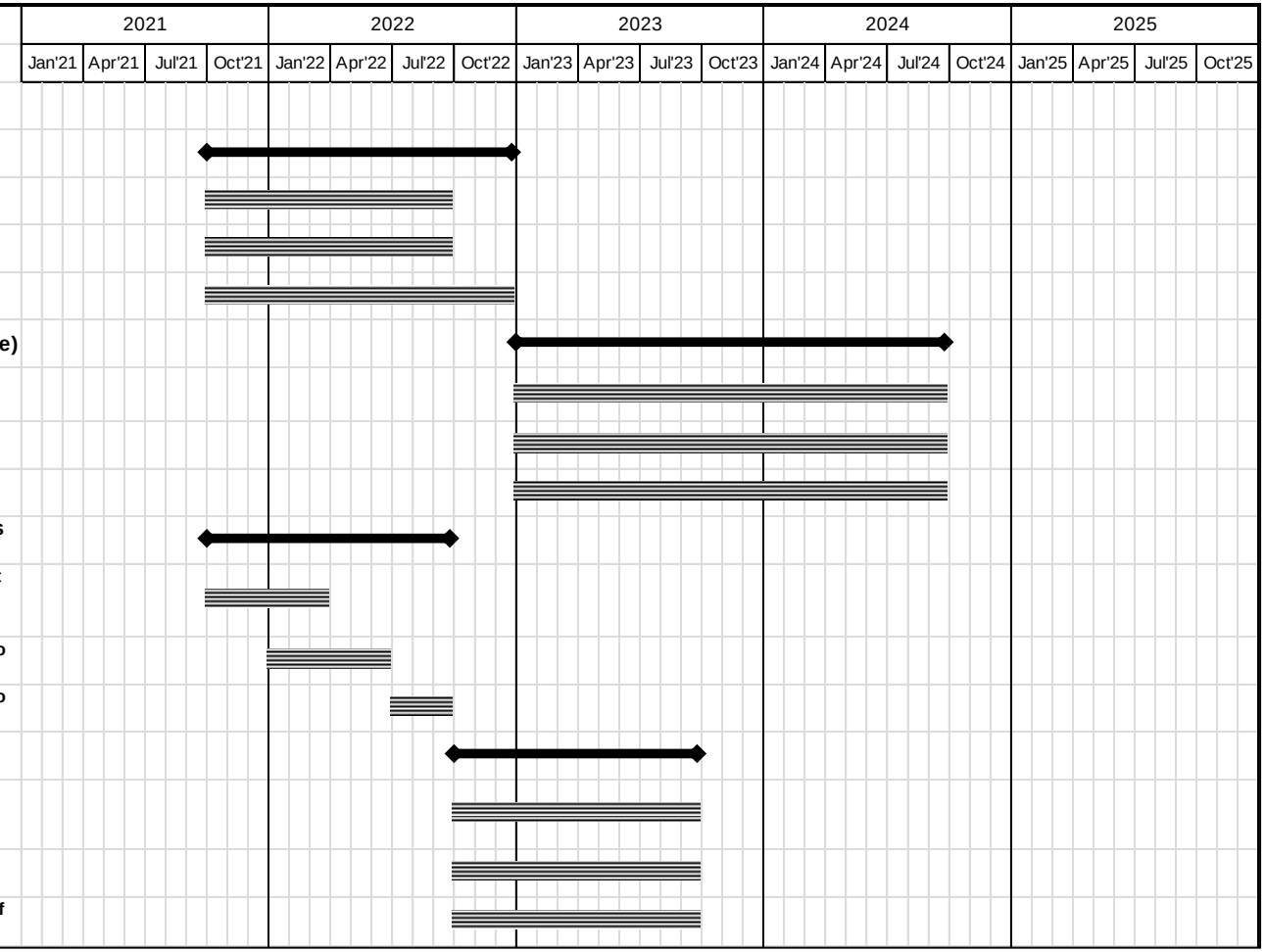
No.	Project
1.	URGWOM REGULAR ACTIVITIES
1.1	Data Acquisition and Database / DMI Administration and Management
1	Update and maintain database DMI's
2	Compile and review (QA/QC) data provided by collecting agencies, estimate missing record if necessary
3	Update hydrologic database records and metadata workbook catalog (CO, NM & TX)
1.2	Rules Update and Development
1	Edit or update rules (policy, initialization, scripts, tables, etc.) to implement fixes or updates or to utilize new RiverWare capabilities
2	Document updates made to rules in tracking spreadsheet, post updated models and rulesets, circulate tracking spreadsheet
1.3	Daily Accounting Model runs, meetings and reports
1	Complete daily accounting model runs
2	Conduct meetings and telephone conferences; prepare account status reports

URGWOM Five-Year Plan (2021-2025)
URGWOM Regular Activities (Continued)

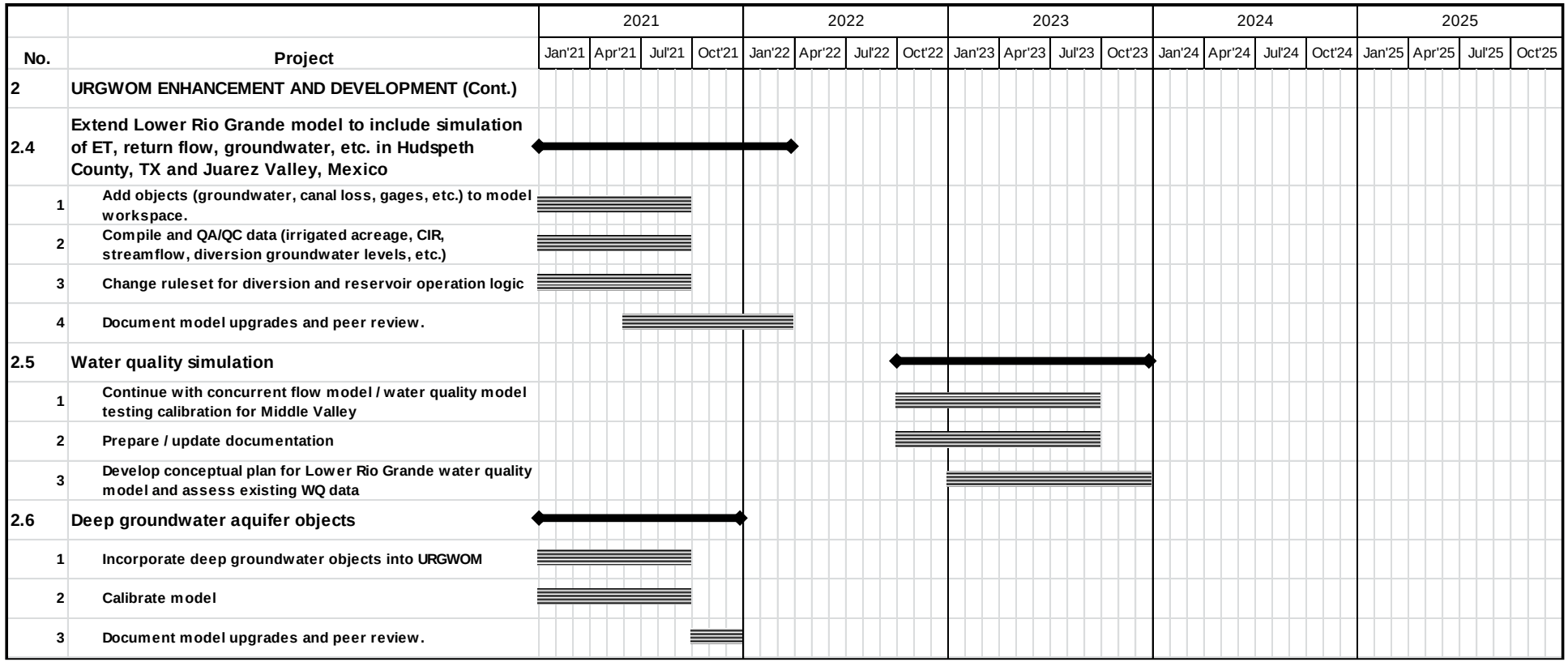


URGWOM Five-Year Plan (2021-2025)
URGWOM Enhancement an Development
(Continued)

No.	Project
2	**URGWOM ENHANCEMENT AND DEVELOPMENT**
2.1	**Enhancements to Middle Rio Grande Configuration**
1	Review MRG Riverside drain model configuration for apparent circular routing logic
2	Review canal seepage with an eye toward changing from fixed rate to variable rate
3	Investigate simulation of drain return to Rio Grande between Albuquerque and Isleta
2.2	**Real-Time Water Operations Model (middle Rio Grande)**
1	Develop DMIs to import ET & forecast data and set up URGWOM to function as a 7-10 day forecast model
2	Develop models (PRMS or HEC-HMS) for use in estimating unmeasured local inflows
3	Implement URGWOM into CWMS
2.3	**Develop Consumptive Irrigation Requirement for crops in the Espanola and Velarde areas.**
1	Compile and tabulate data on crop type and areas; conduct independent inventory of acreage and crop type if necessary.
2	Apply reference ET and computed effective precipitation to compute crop CIR
3	Adjust loss rates and computed local inflow in the Embudo to Otowi reach
2.3	**ET Toolbox enhancements**
1	Develop ET computations based on Landsat imagery of temperature and irrigated areas. Test and compare with URGWOM ET method
2	Implement CN method for forecasting daily effective precipitation based on the NRCS TR-21 method
3	Develop method to link evapotranspiration data and runoff forecasts from ET Toolbox to URGWOM real-time model

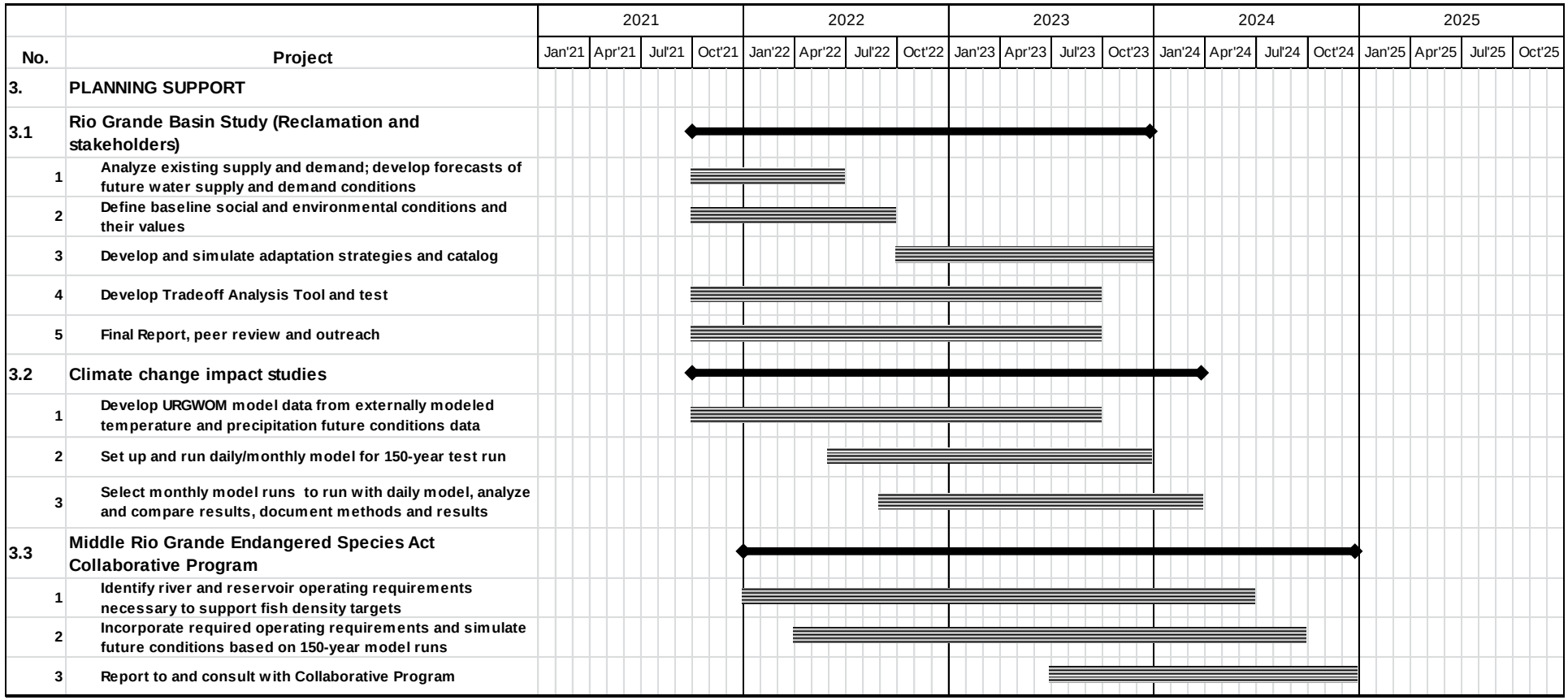


URGWOM Five-Year Plan (2021-2025)
URGWOM Enhancement an Development
(Continued)



No.	Project
2	URGWOM ENHANCEMENT AND DEVELOPMENT (Cont.)
2.4	Extend Lower Rio Grande model to include simulation of ET, return flow, groundwater, etc. in Hudspeth County, TX and Juarez Valley, Mexico
1	Add objects (groundwater, canal loss, gages, etc.) to model workspace.
2	Compile and QA/QC data (irrigated acreage, CIR, streamflow, diversion groundwater levels, etc.)
3	Change ruleset for diversion and reservoir operation logic
4	Document model upgrades and peer review.
2.5	Water quality simulation
1	Continue with concurrent flow model / water quality model testing calibration for Middle Valley
2	Prepare / update documentation
3	Develop conceptual plan for Lower Rio Grande water quality model and assess existing WQ data
2.6	Deep groundwater aquifer objects
1	Incorporate deep groundwater objects into URGWOM
2	Calibrate model
3	Document model upgrades and peer review.

URGWOM Five-Year Plan (2021-2025)
URGWOM Planning Support



No.	Project
3.	**PLANNING SUPPORT**
3.1	**Rio Grande Basin Study (Reclamation and stakeholders)**
1	Analyze existing supply and demand; develop forecasts of future water supply and demand conditions
2	Define baseline social and environmental conditions and their values
3	Develop and simulate adaptation strategies and catalog
4	Develop Tradeoff Analysis Tool and test
5	Final Report, peer review and outreach
3.2	**Climate change impact studies**
1	Develop URGWOM model data from externally modeled temperature and precipitation future conditions data
2	Set up and run daily/monthly model for 150-year test run
3	Select monthly model runs to run with daily model, analyze and compare results, document methods and results
3.3	**Middle Rio Grande Endangered Species Act Collaborative Program**
1	Identify river and reservoir operating requirements necessary to support fish density targets
2	Incorporate required operating requirements and simulate future conditions based on 150-year model runs
3	Report to and consult with Collaborative Program

URGWOM Technical Group Meeting
March 9 th, 2021

Streamflow Prediction Research supporting Annual Operations Planning in the Upper Rio Grande

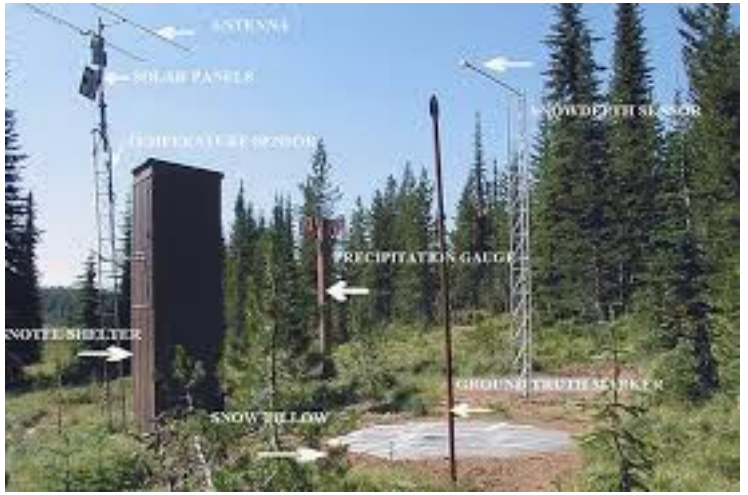
NCAR: Andy Wood, Josh Sturtevant, Flavio Lehner
Reclamation: Dagmar Lewellyn, Lucas Barrett

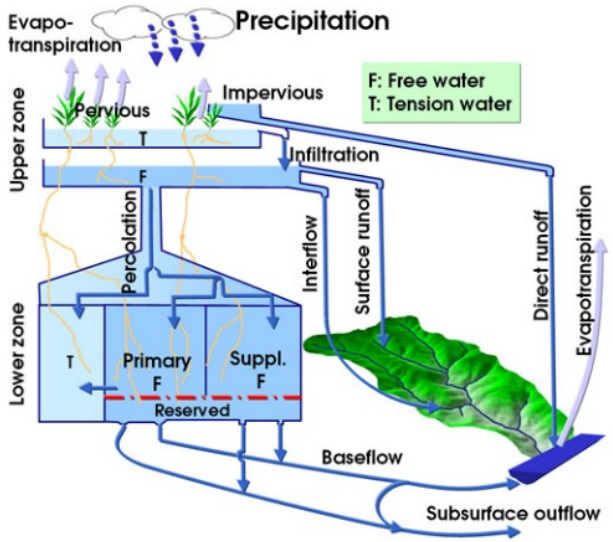
Water Supply Forecasting (WSF) Background

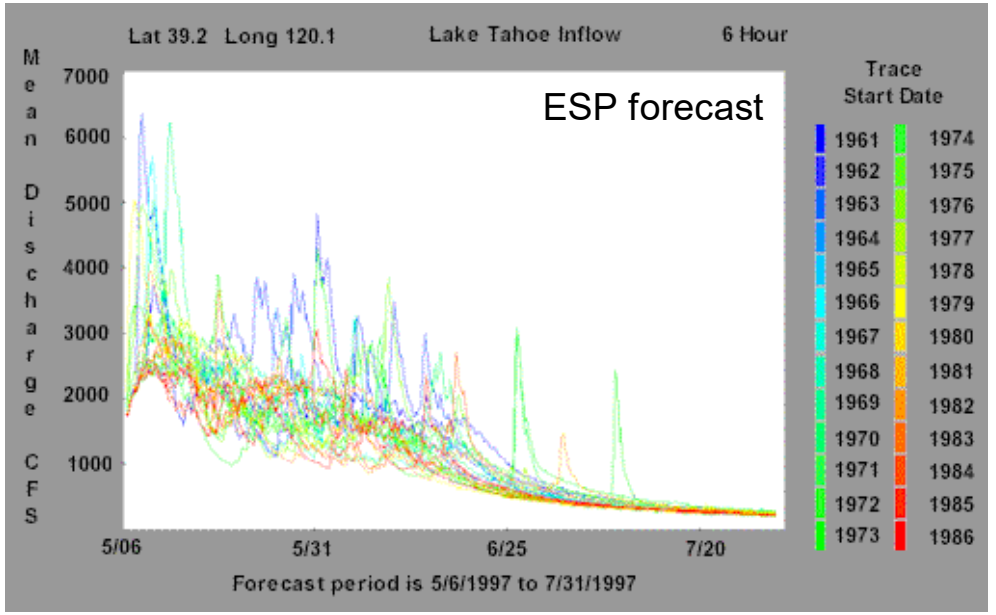
- WSF: spring runoff volume forecasts – e.g., April-July, Jan.-June, April-September
- Since the **1930s** -- US agencies (such as SCS/NRCS) used statistical regression of point snow measurements to predict runoff volumes
- Since the **1970s** -- WSFs have also been made by the NWS and other agencies using Ensemble Streamflow Prediction (ESP), a model-based technique
- NWS ESPs are just now starting to be produced for the Rio Grande Basin (by West Gulf RFC)

Snow Survey

Automated Snow Pillow (SNOTEL)



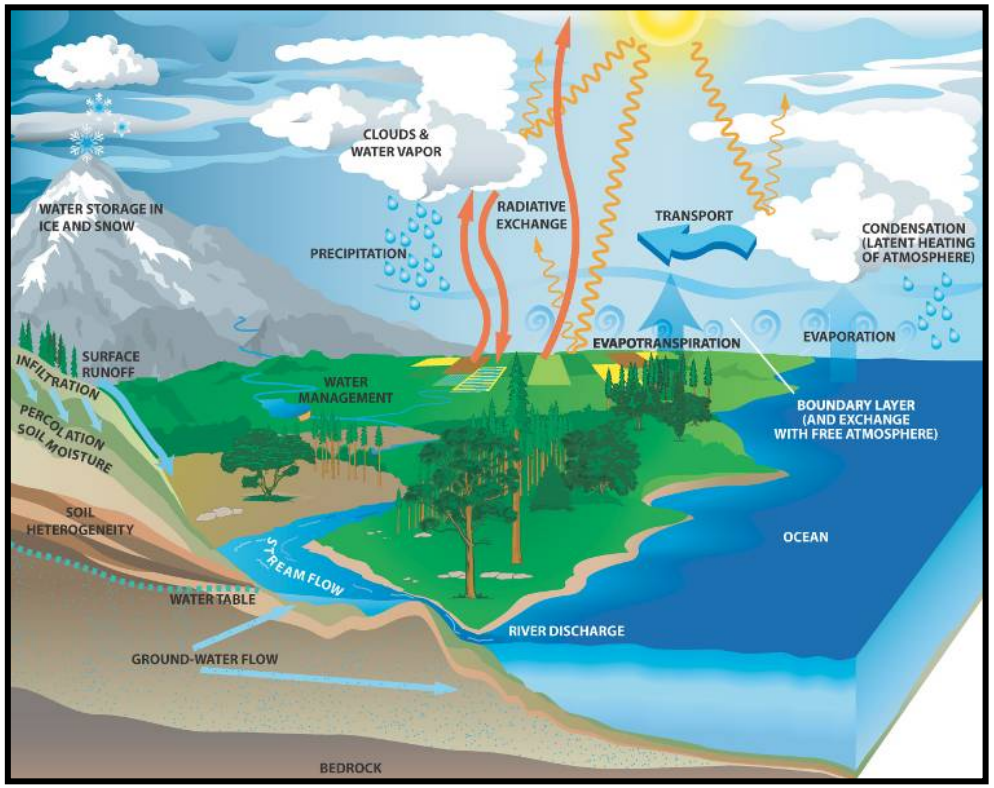




Water Supply Forecasting (WSF) Background

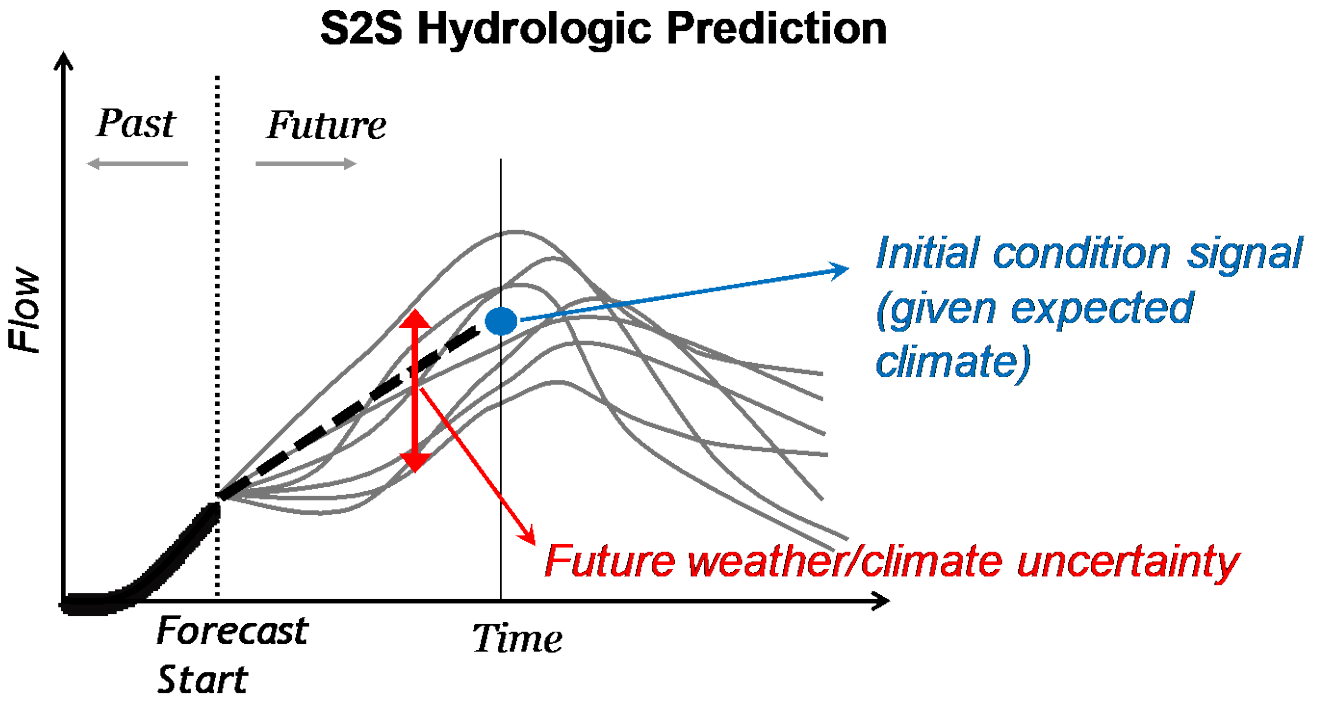
Hydrologic forecast predictability derives from two major sources

- initial watershed moisture conditions
- future weather and climate



Traditional operational long-range forecasts have harnessed watershed predictability only

- Statistical forecasts use initial snow, flow and antecedent conditions
- ESP uses initial model moisture states + historical climate sequences + weather forecasts (to 10 days)



Major strategies for improving WSFs

Since 2013, Reclamation and USACE have collaborated with NCAR to improve streamflow modeling and forecasting capabilities through a number of projects

Improving initial watershed moisture estimates

- better watershed modeling
- better meteorological forcings to the model (historical and spin-up)
- using objective data assimilation (e.g., correcting model states for SWE, SM)

Improving future weather and climate inputs

- embedding weather forecasts into ESP
- incorporating future climate information (either indices or climate model forecasts)

Systematic hindcasting and retrospective experiments

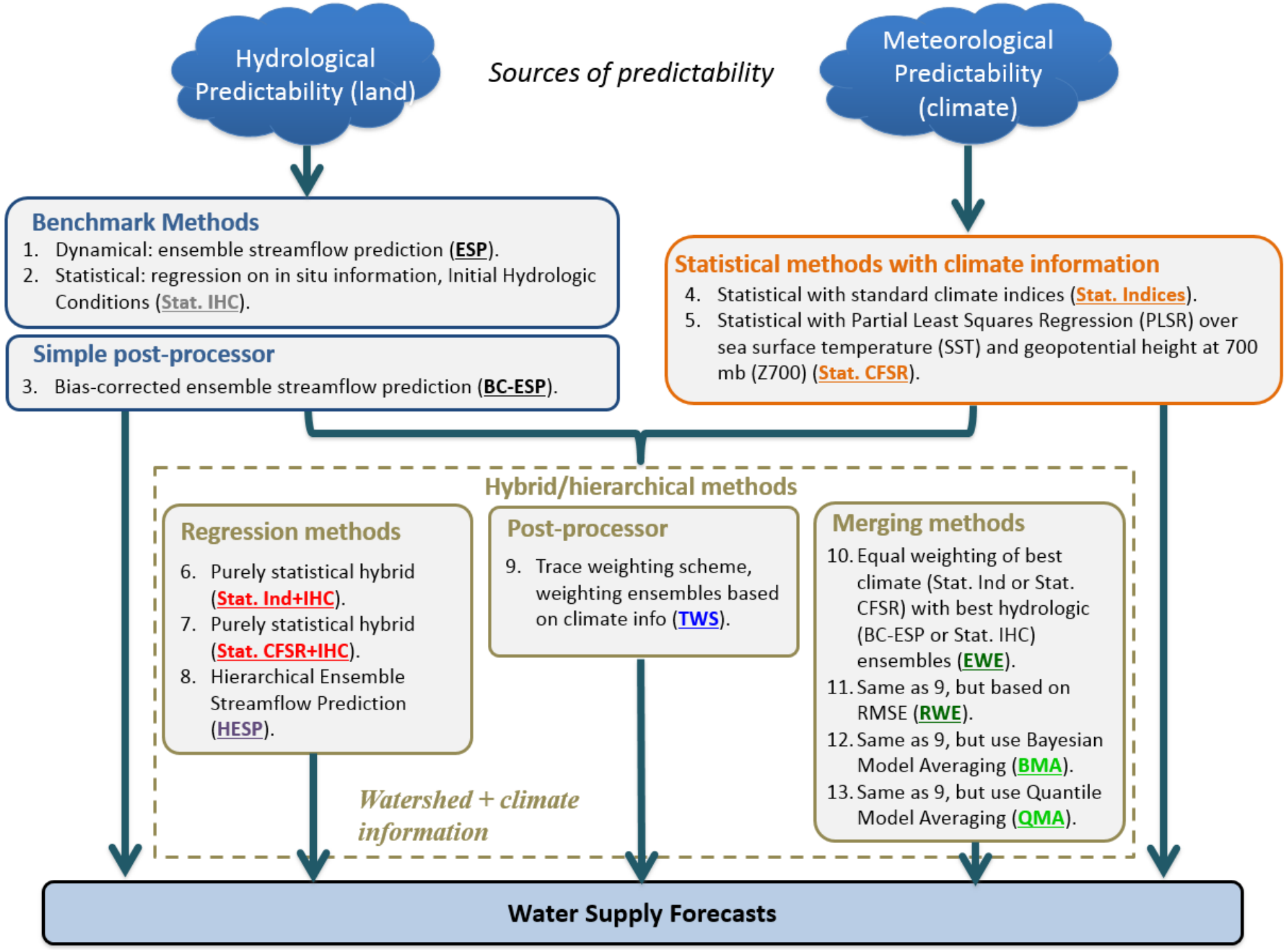
- The ability to test the WSF system over many years allows benchmarking new refinements
- It also enables verification, the detection of systematic errors in mean and spread

Forecast post-processing

- Removing systematic modeling or forecasting errors

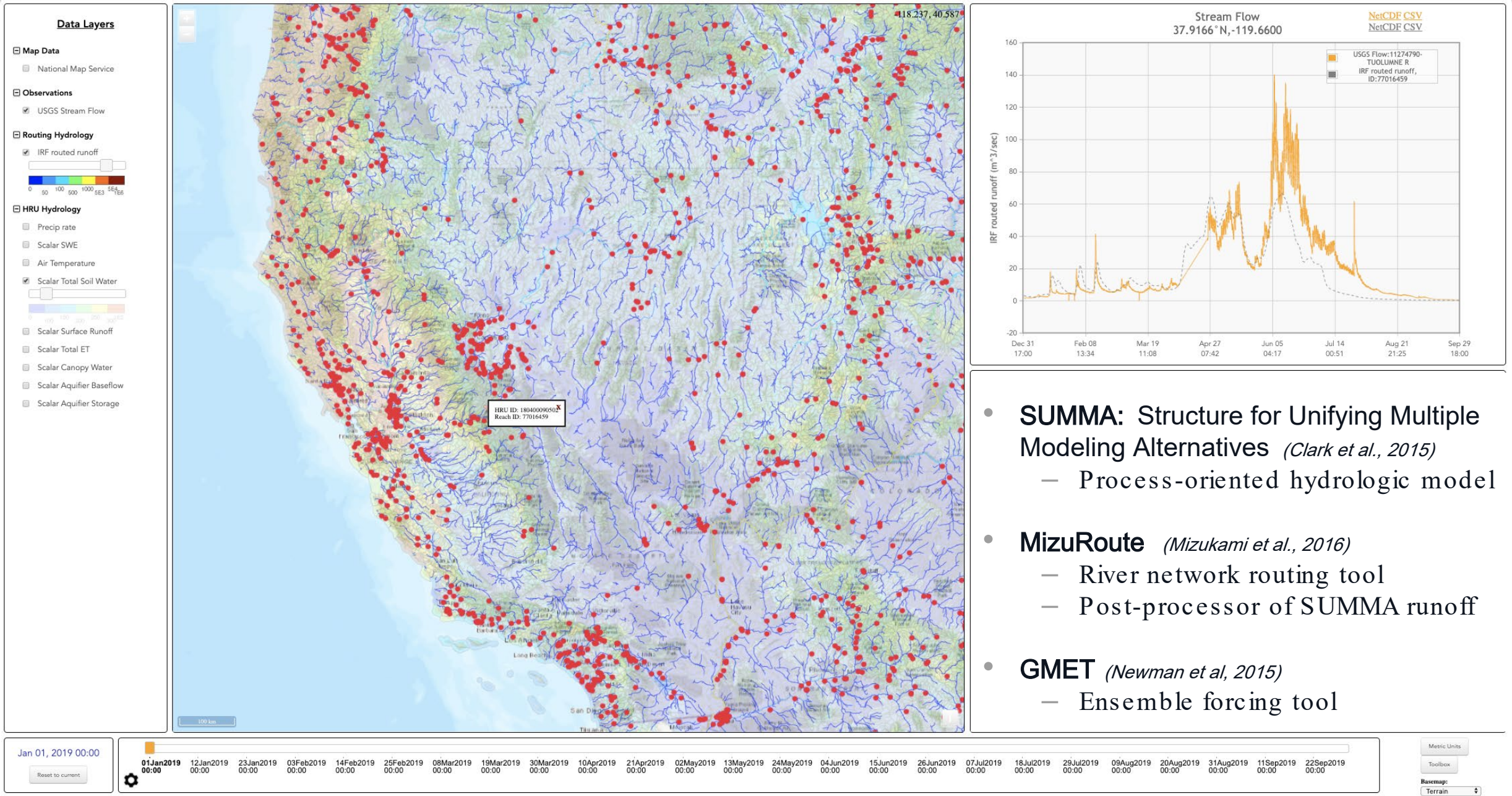
Example project:

We used ensemble hindcasts to evaluate methods of incorporating climate information into WSFs



Mendoza et al, 2017

New hydrologic modeling for west -wide research and applications



- **SUMMA:** Structure for Unifying Multiple Modeling Alternatives *(Clark et al., 2015)*
  - Process-oriented hydrologic model
- **MizuRoute** *(Mizukami et al., 2016)*
  - River network routing tool
  - Post-processor of SUMMA runoff
- **GMET** *(Newman et al, 2015)*
  - Ensemble forcing tool

Major goals of the Reclamation/NCAR Rio Grande project(s)

Evaluating ways of improving seasonal flow prediction through incorporation of climate information

- An earlier project added climate forecasts to statistical WSFs (with Flavio Lehner)
- The project will condition ESP forecasts on sub-seasonal climate forecasts

Using a long hindcast dataset to test other ways of using or enhancing ESP forecasts

- Adding a systematic bias-correction to ESP forecasts
- Testing ESP inflow sequences to RiverWare as an alternative to analog trace selection

Using new modeling (SUMMA) to assess whether predictability is being lost due to warming

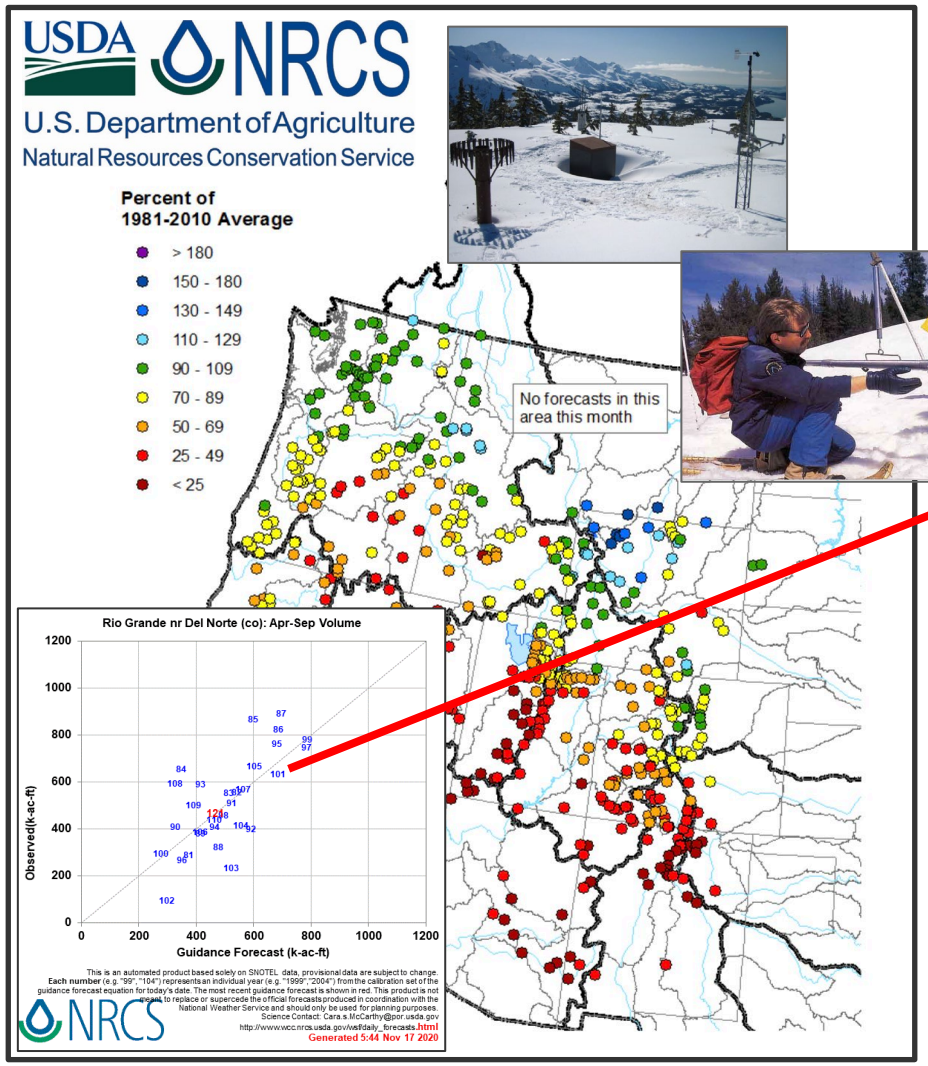
- Less snow due to temperature trends may mean less predictable spring runoff

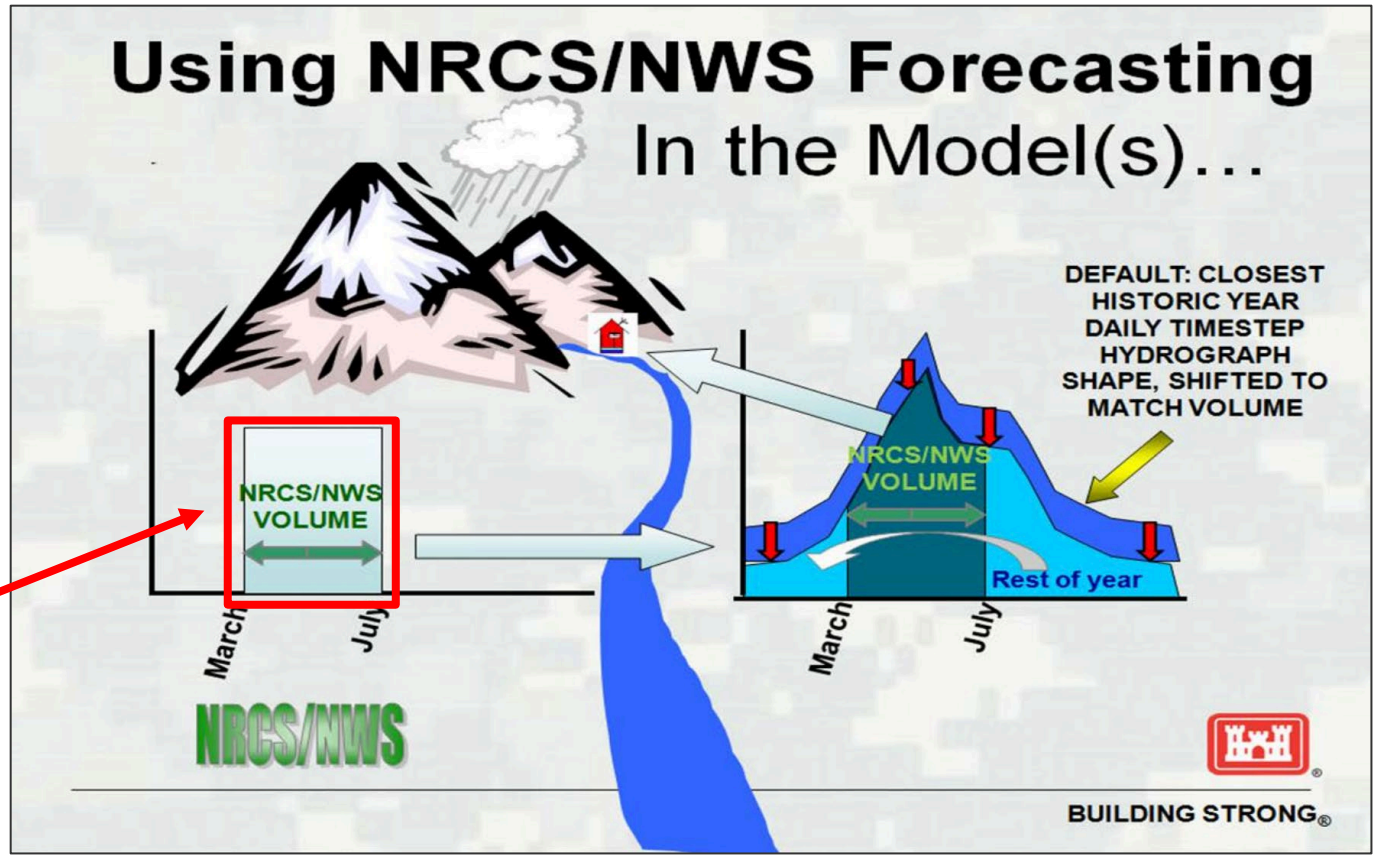
NCAR is not an operational center – but is working with Reclamation to assess strategies to use or develop further in their operations

Bureau of Reclamation: April 1st Runoff Forecasts

April 1st Forecast Process

- Flow volume forecasts from NRCS

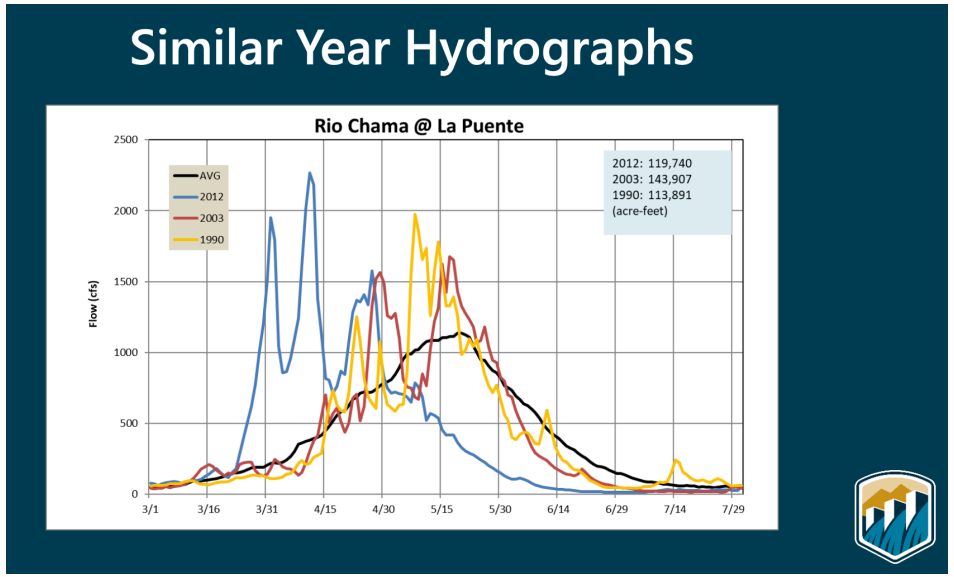


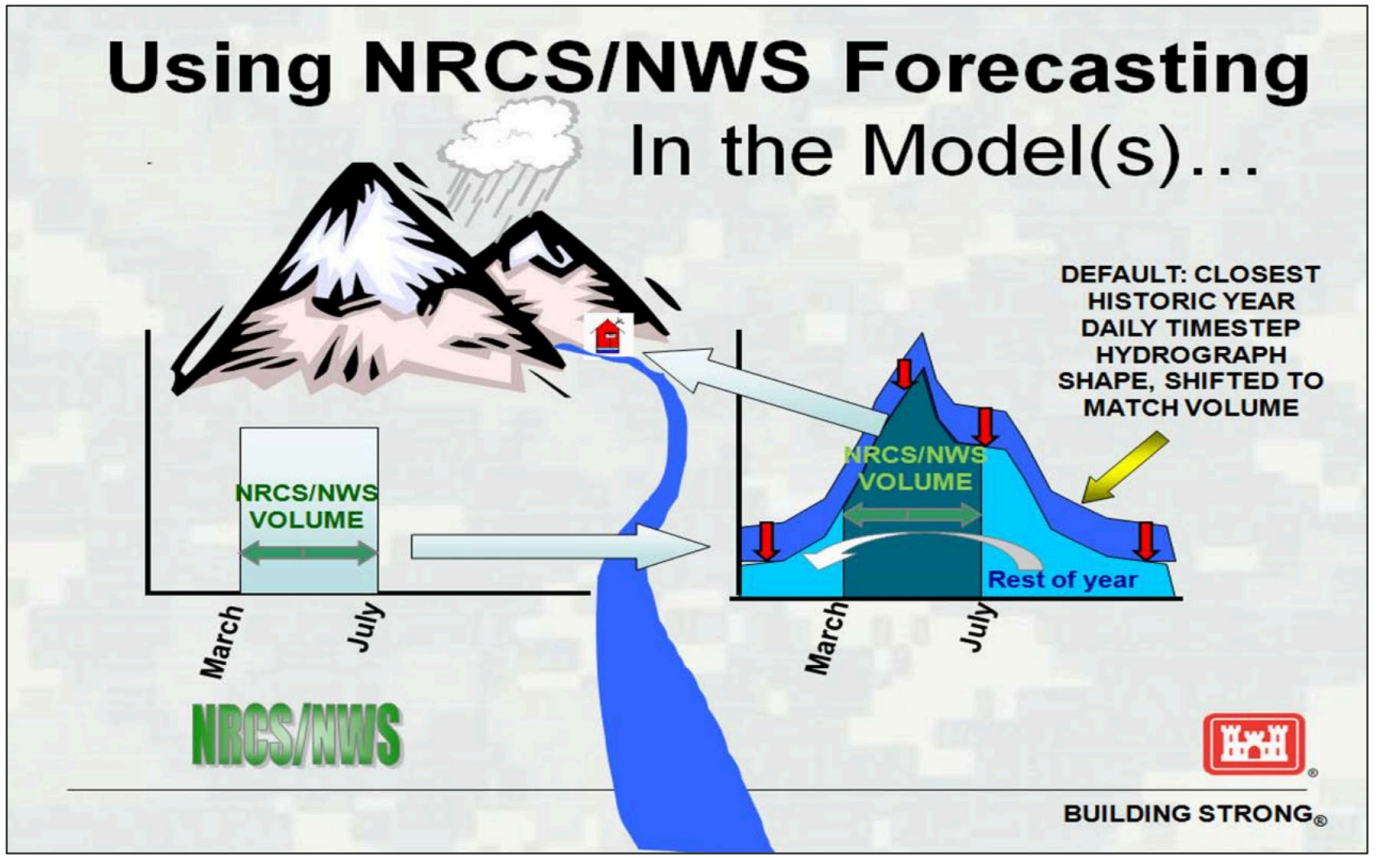


Bureau of Reclamation: April 1st Runoff Forecasts

April 1st Forecast Process

- Flow volume forecasts from NRCS
- Identify similar past years for **daily hydrograph shape**
- Analogue year is scaled to match NRCS forecasted volume



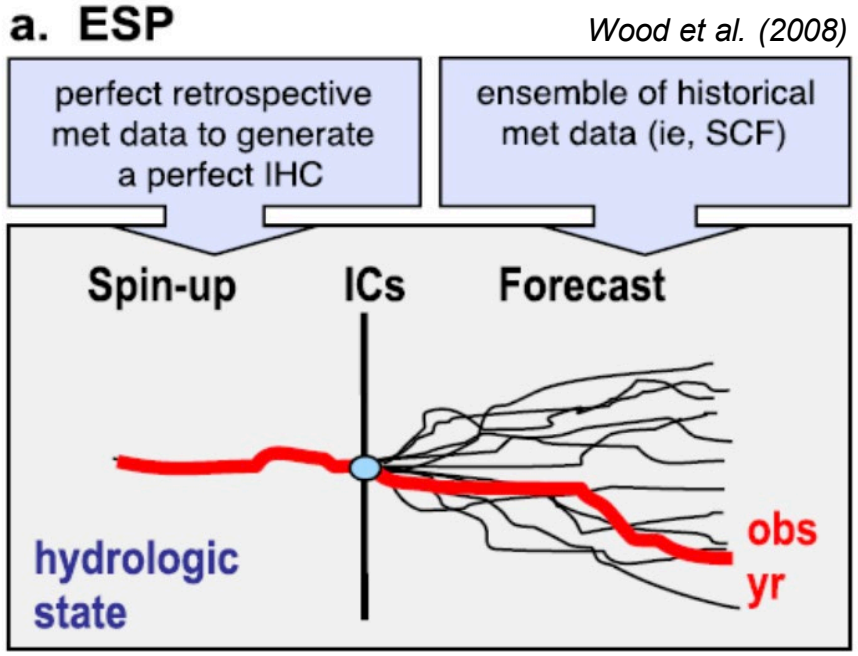


- Since 2018, WGRFC has issued new ensemble forecasts in the URG
- ***This project will help inform the use of the new NWS forecasts in Rio Grande operations***

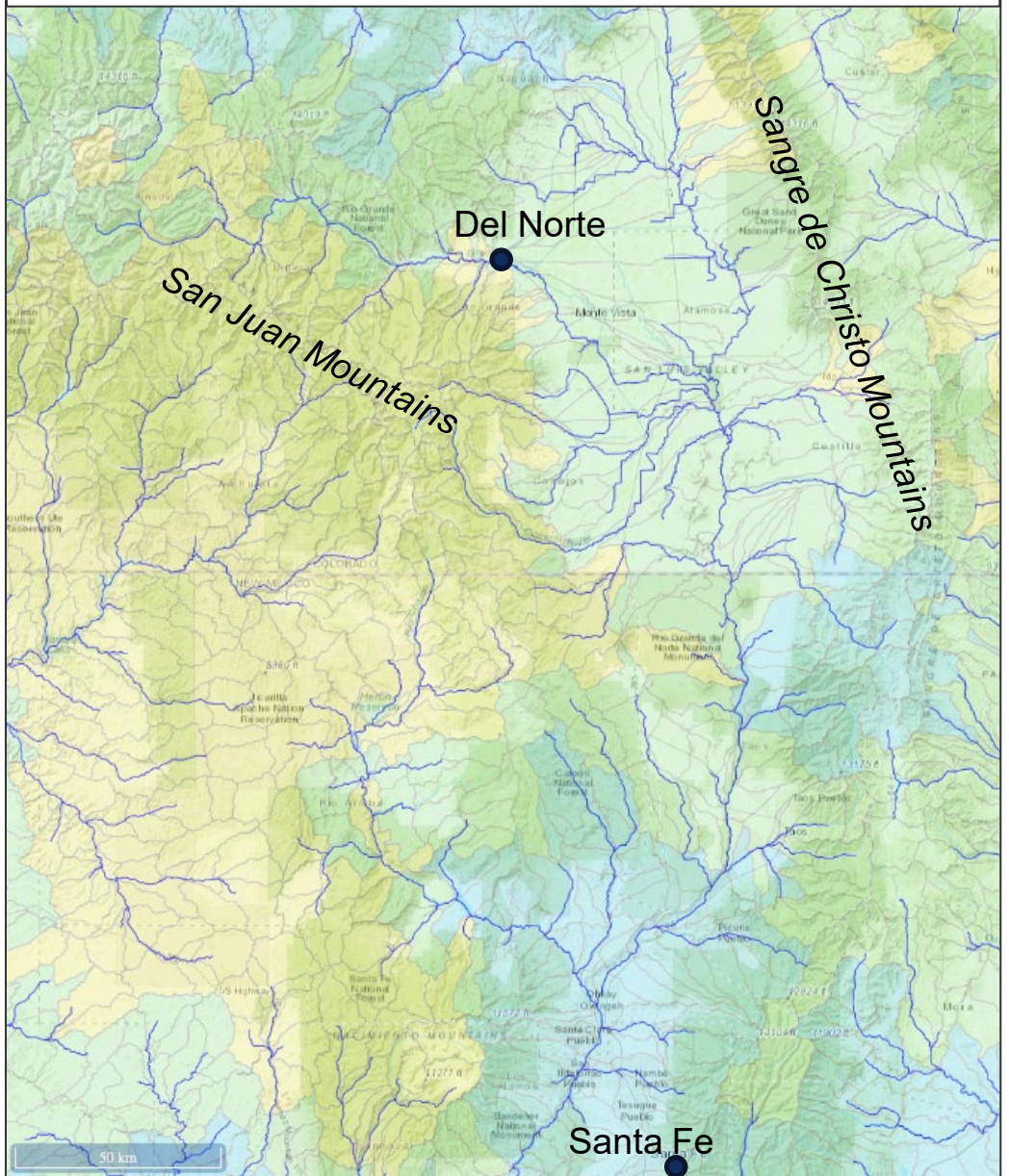
SUMMA for Distributed Watershed -based Modeling

- **SUMMA:** Structure for Unifying Multiple Modeling Alternatives *(Clark et al., 2015)*
  - Process-oriented hydrologic model
- **MizuRoute** *(Mizukami et al., 2016)*
  - Stand-alone river network routing tool
  - Post-processor of SUMMA runoff

➢ **Modeling tool to assess new strategies for input shape estimation**



HUC-12 Basins, MERIT-Hydro Network

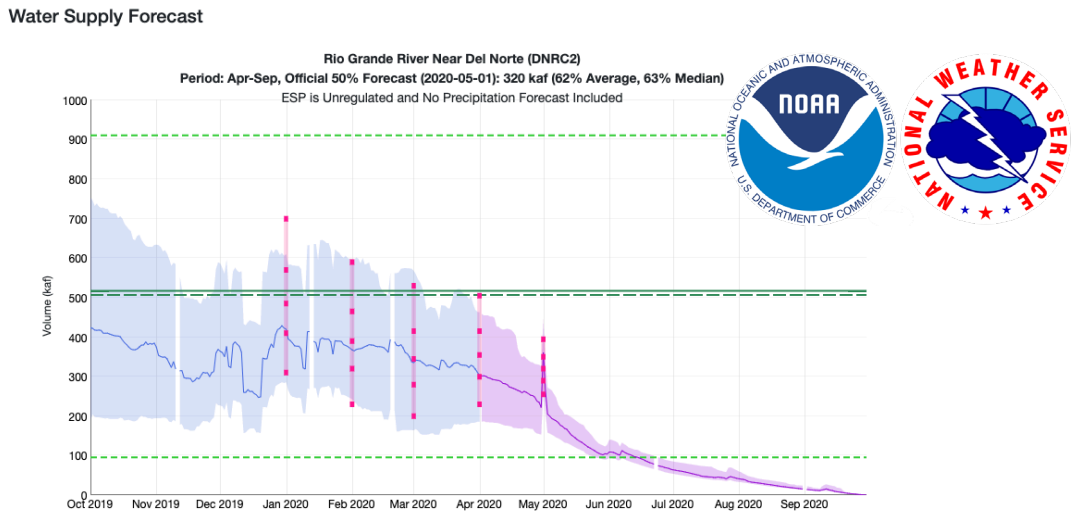


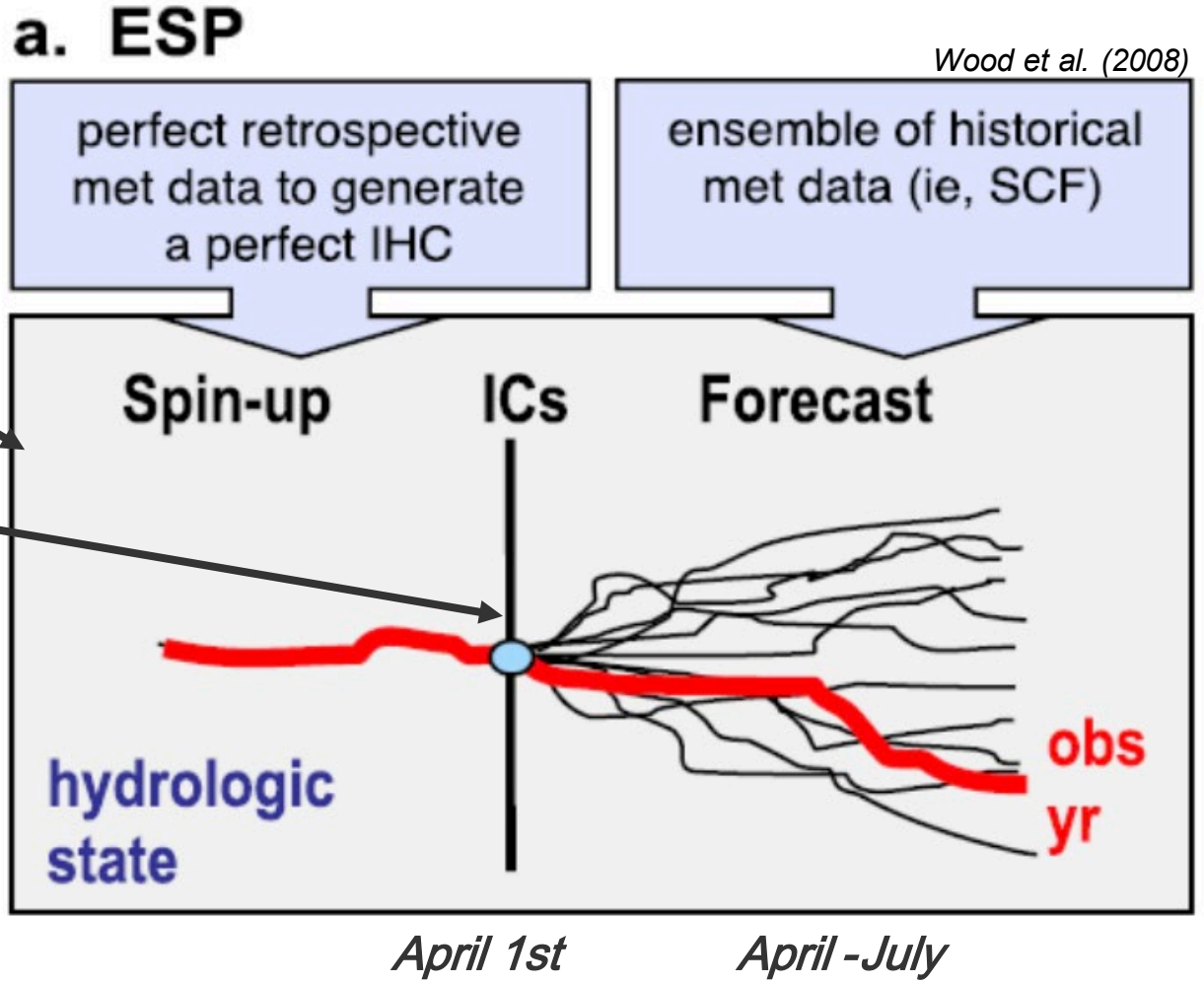
Ensemble Streamflow Prediction (ESP)

- Ensemble Streamflow Prediction- *developed by NWS & CADWR in the 1970s*
- Useful in the absence of skillful predictions of meteorology and climate

1. **Initial hydrologic conditions:**
   - Snowpack
   - Soil moisture

2. **Seasonal climate forecast:**
   - Historical meteorology

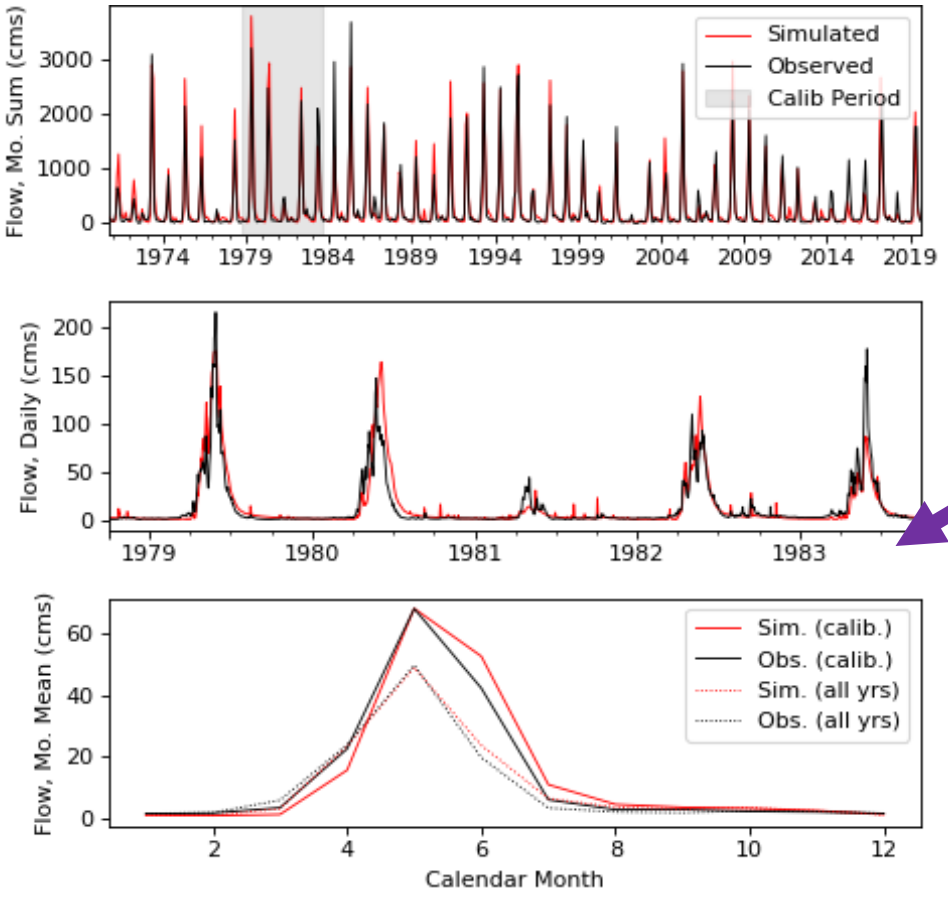




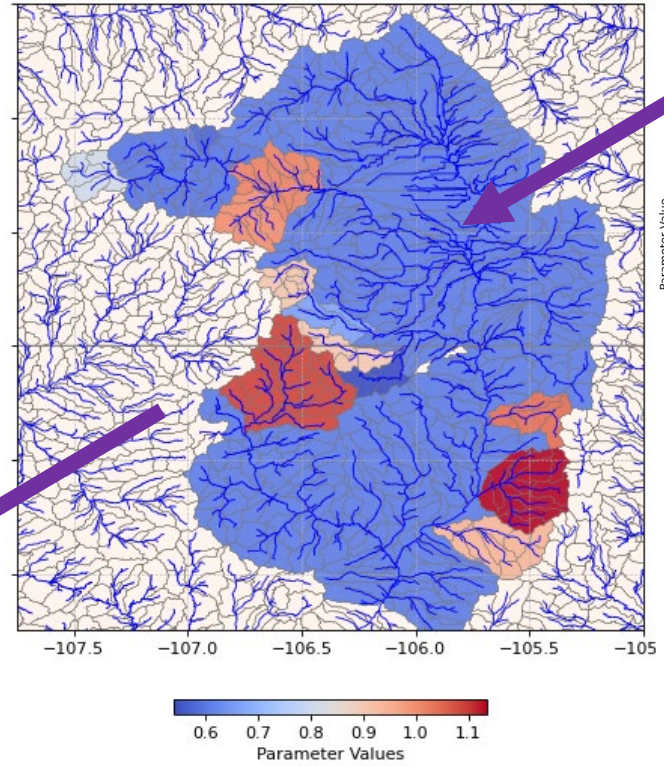
SUMMA Parameter Estimation & Model Calibration

April 1 st ESP Hindcast Process:

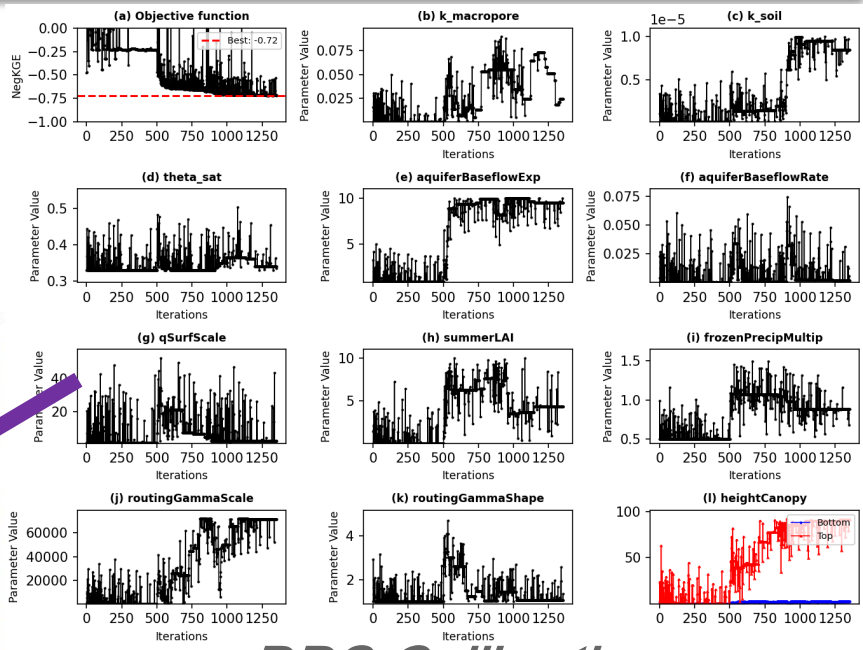
- Calibrate gauged headwater basins
  - **Gridded Meteorological Ensemble Tool** (GMET) ensemble forcing data
  - Newman et al. (2015); Mendoza et al. (2017)



Run Simulations



Embed Parameters

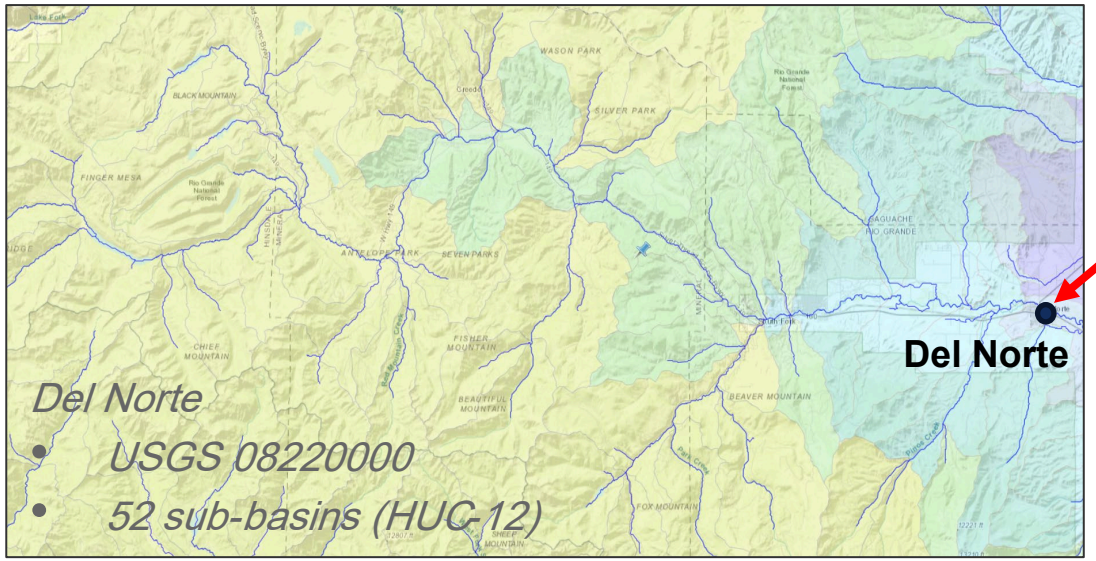


DDS Calibration

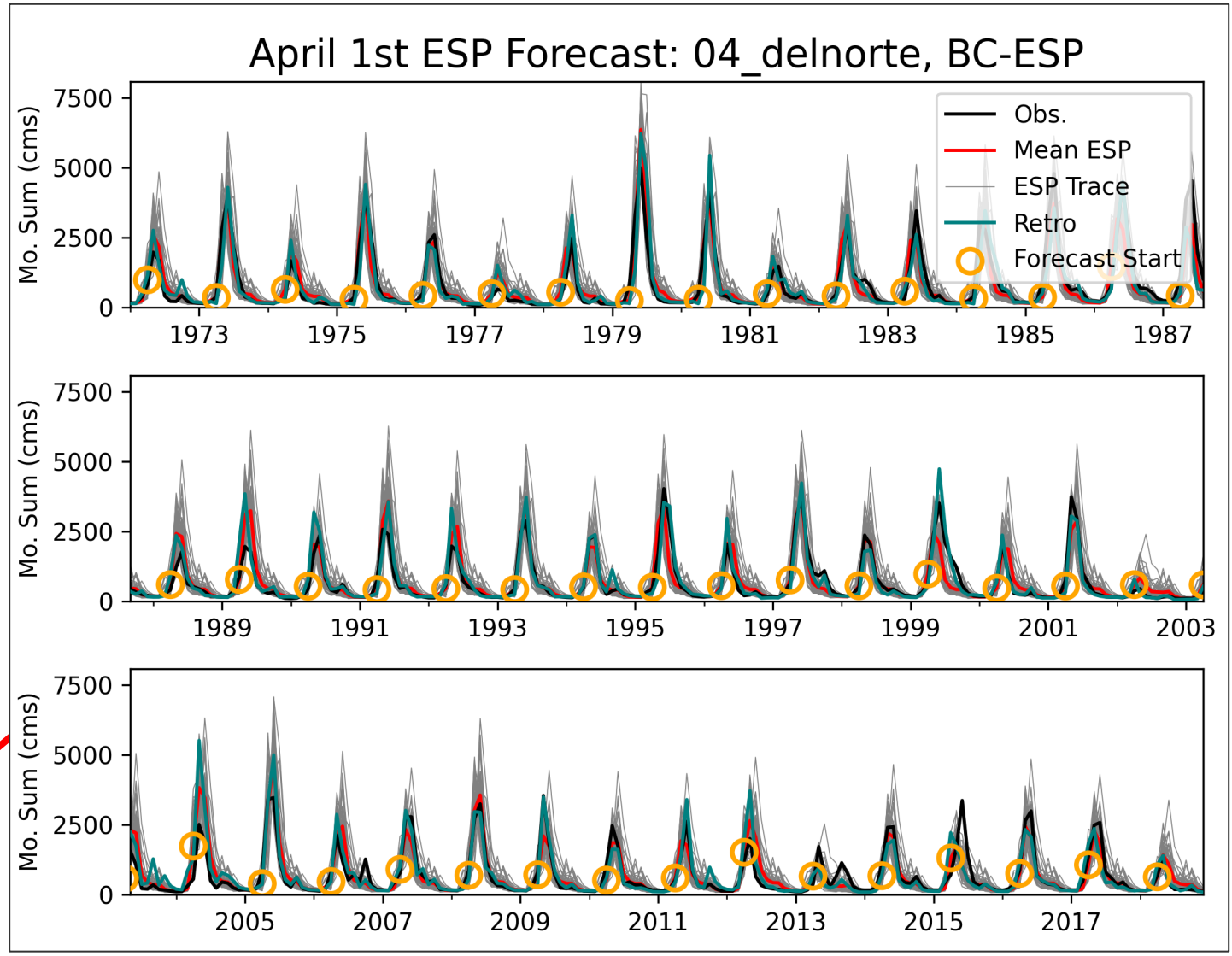
SUMMA Ensemble Streamflow Prediction (ESP) Hindcasts

April 1st ESP Hindcast Process:

- Model calibration & validation
- ESP hindcasts
- 49-year 49-member ensemble



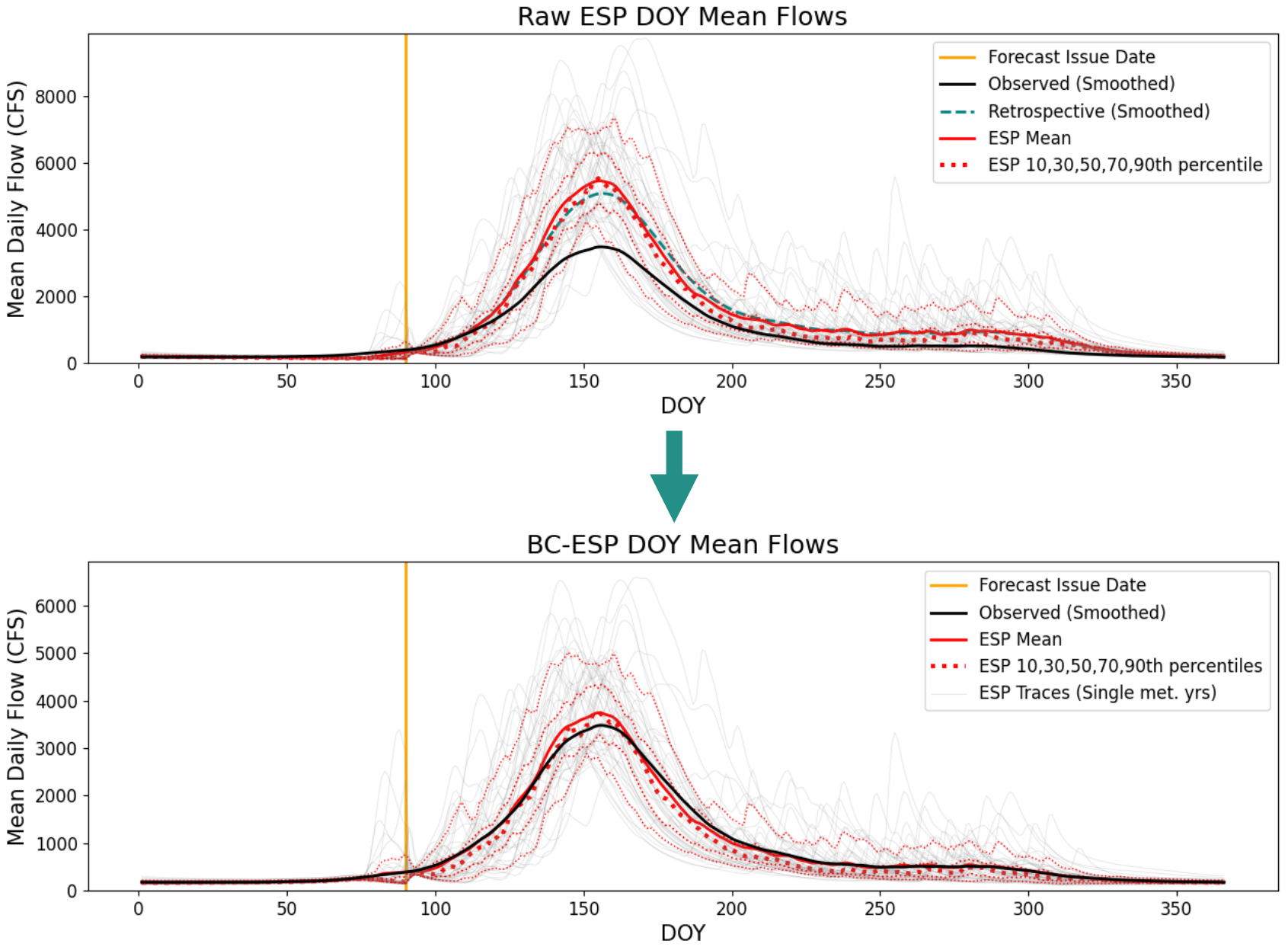
HUC12 basins colored by March 1, 2019 snowpack



ESP Post-Processing: Bias Correction

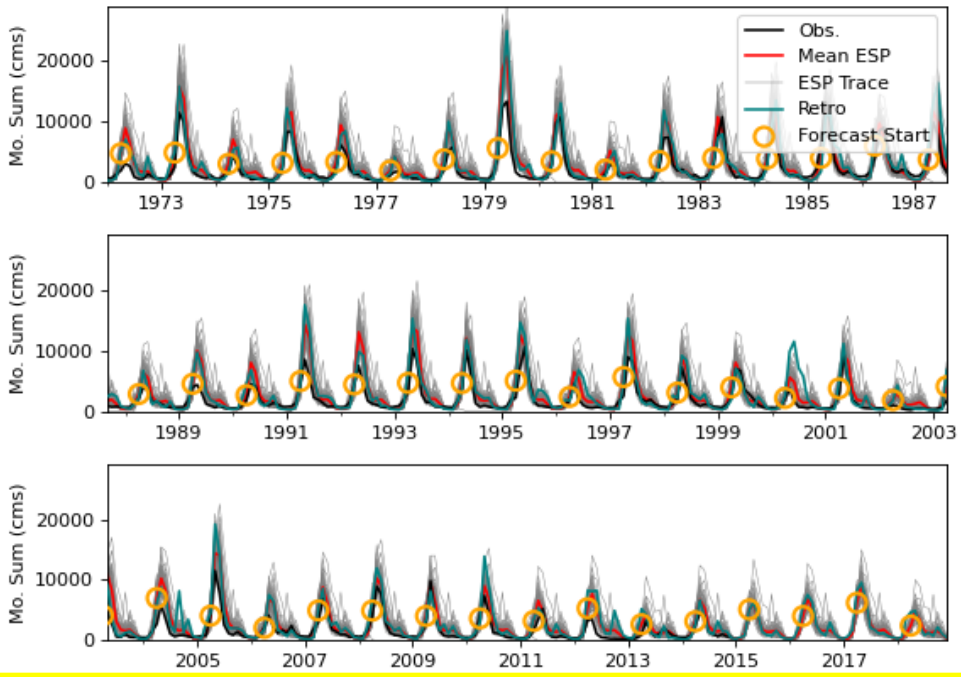
Bias corrections

- Mean DOY flows
- DOY correction
- Address systematic bias
- Preserve ensemble spread

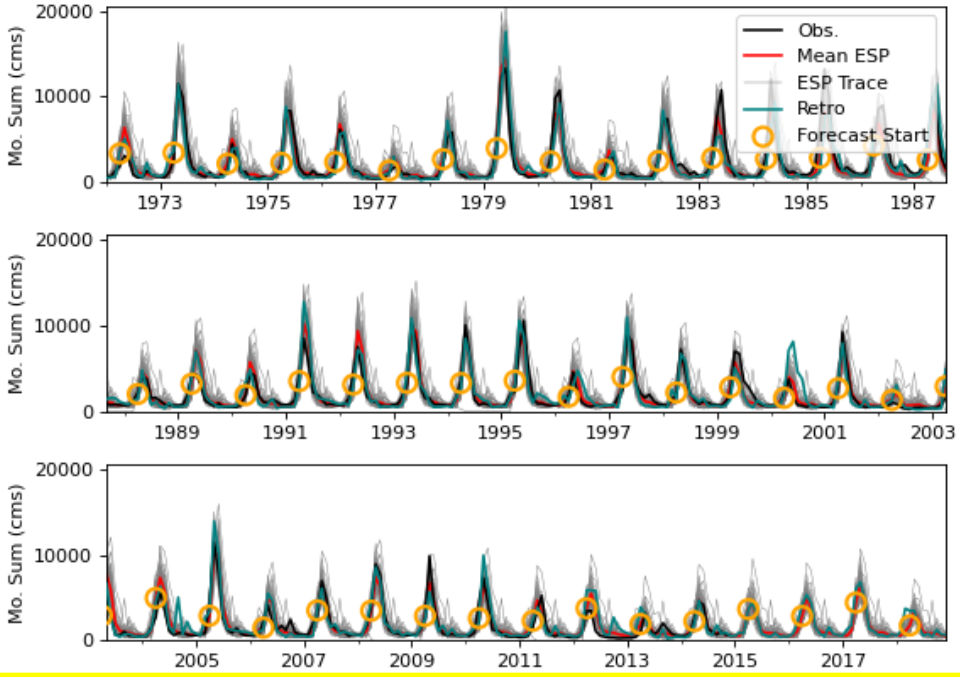


ESP Post-Processing: Bias Correction

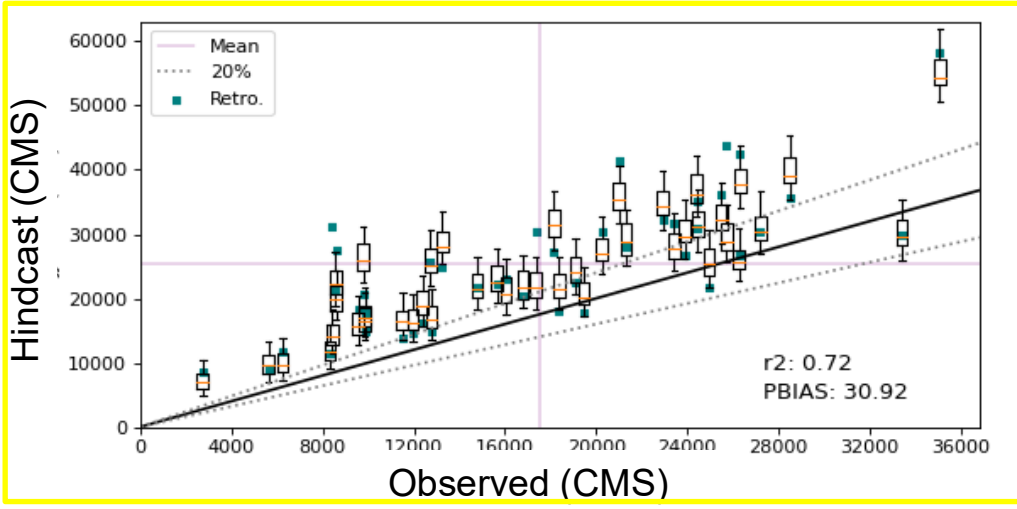
Raw ESP

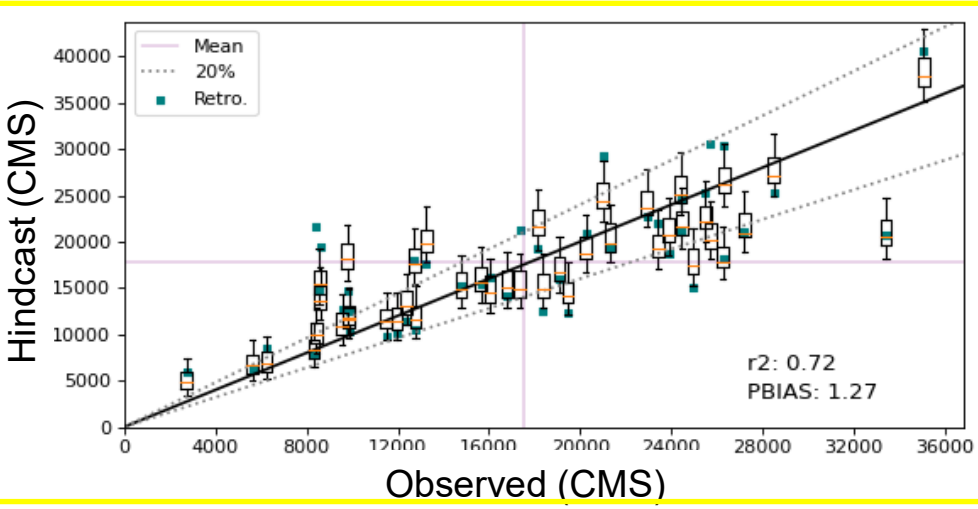


Bias Corrected ESP

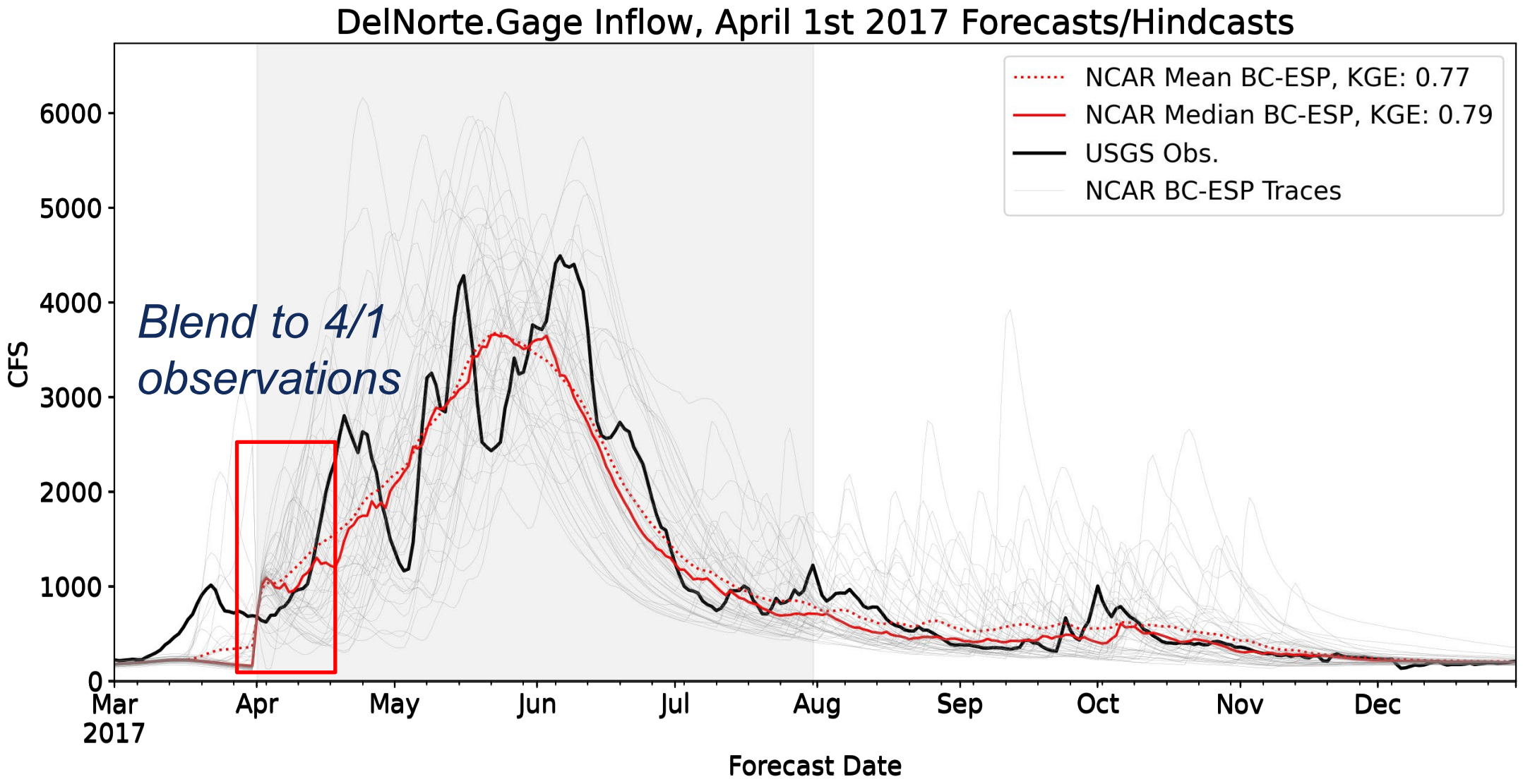


April-July Volumes





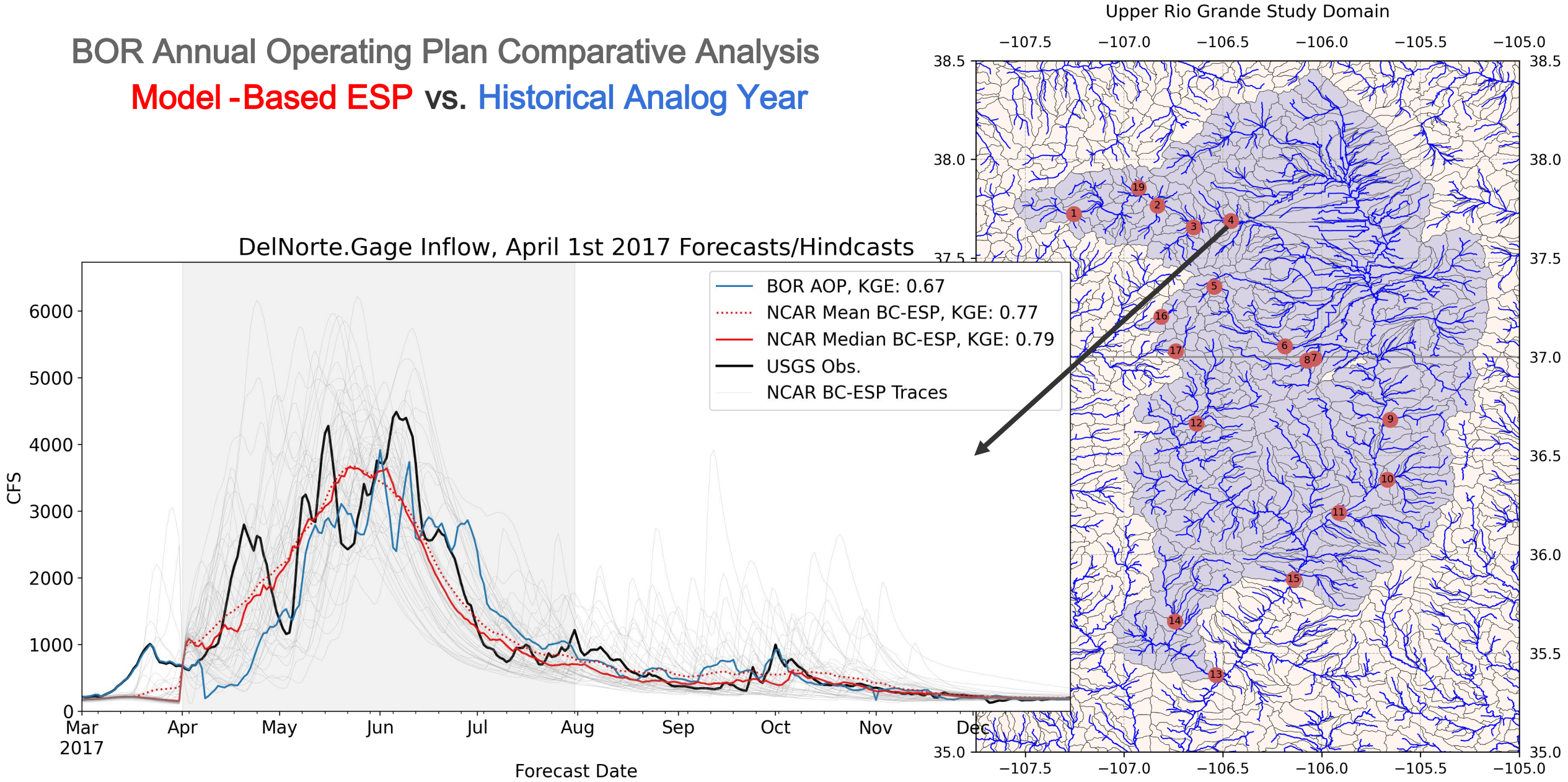
ESP Post-Processing: NRCS Volume Scaling & Obs. Blending



Examples: ESP Hindcasts vs. Historical Analog Years

BOR Annual Operating Plan Comparative Analysis

Model -Based ESP vs. **Historical Analog Year**



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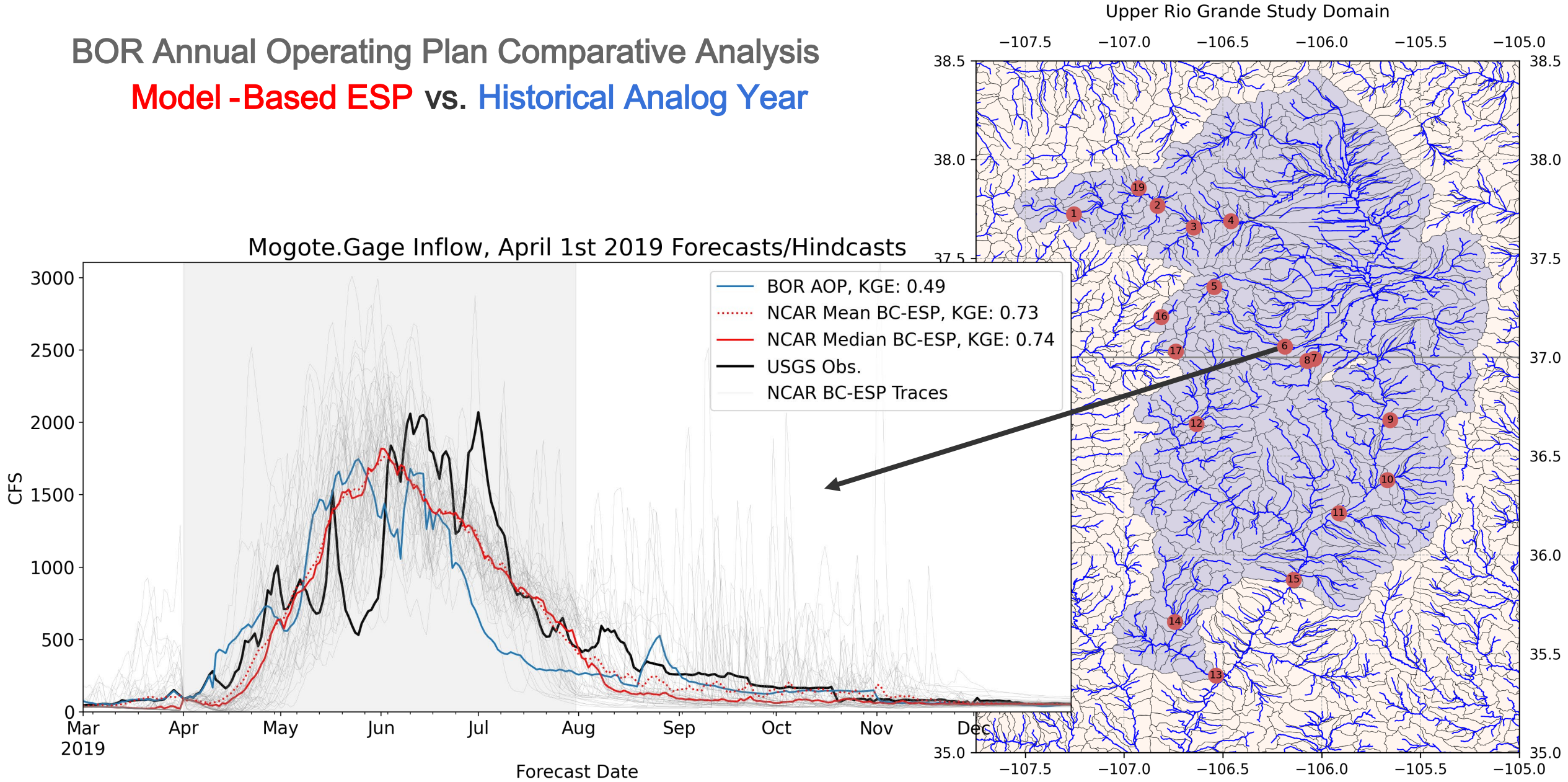

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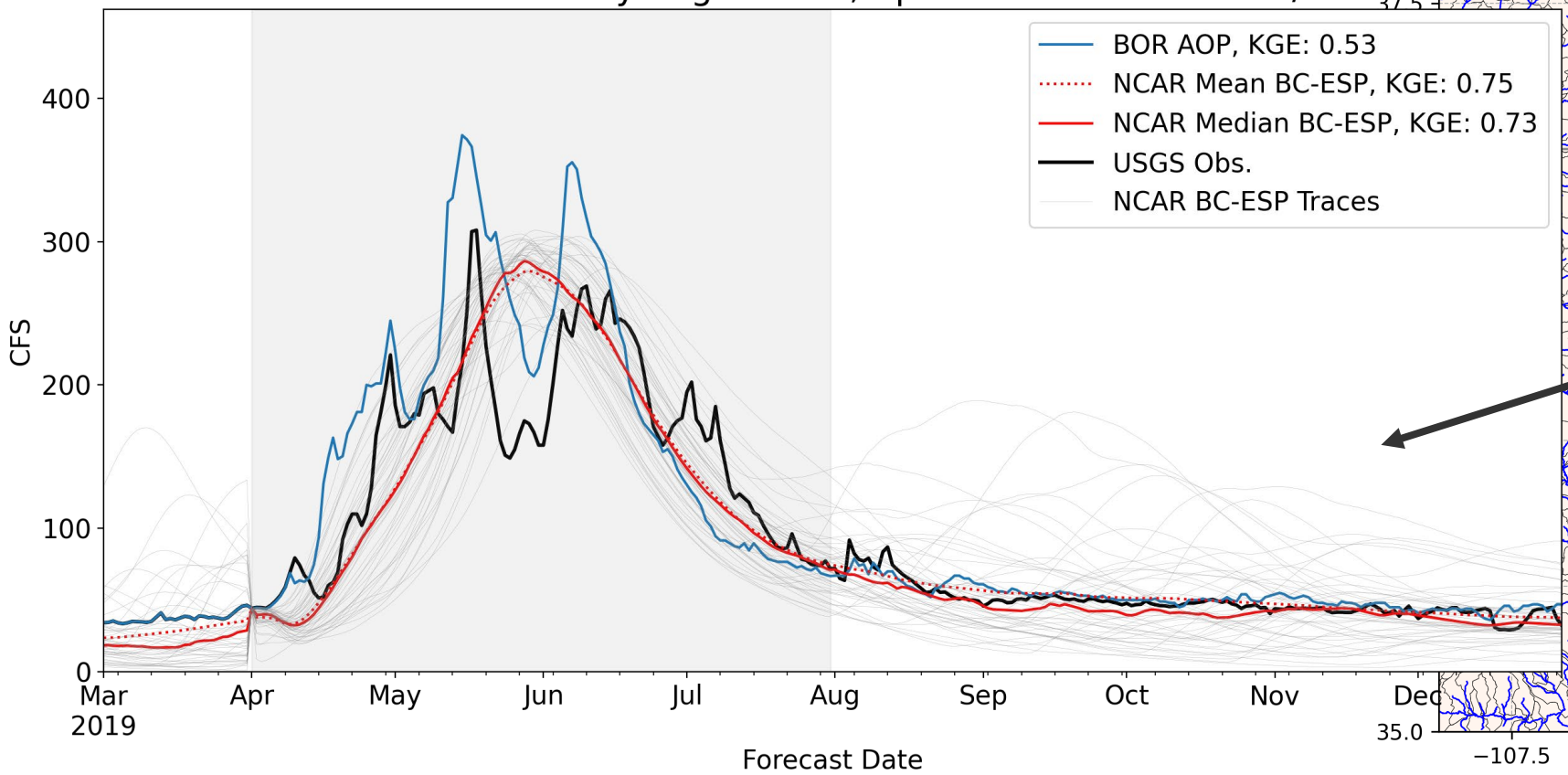

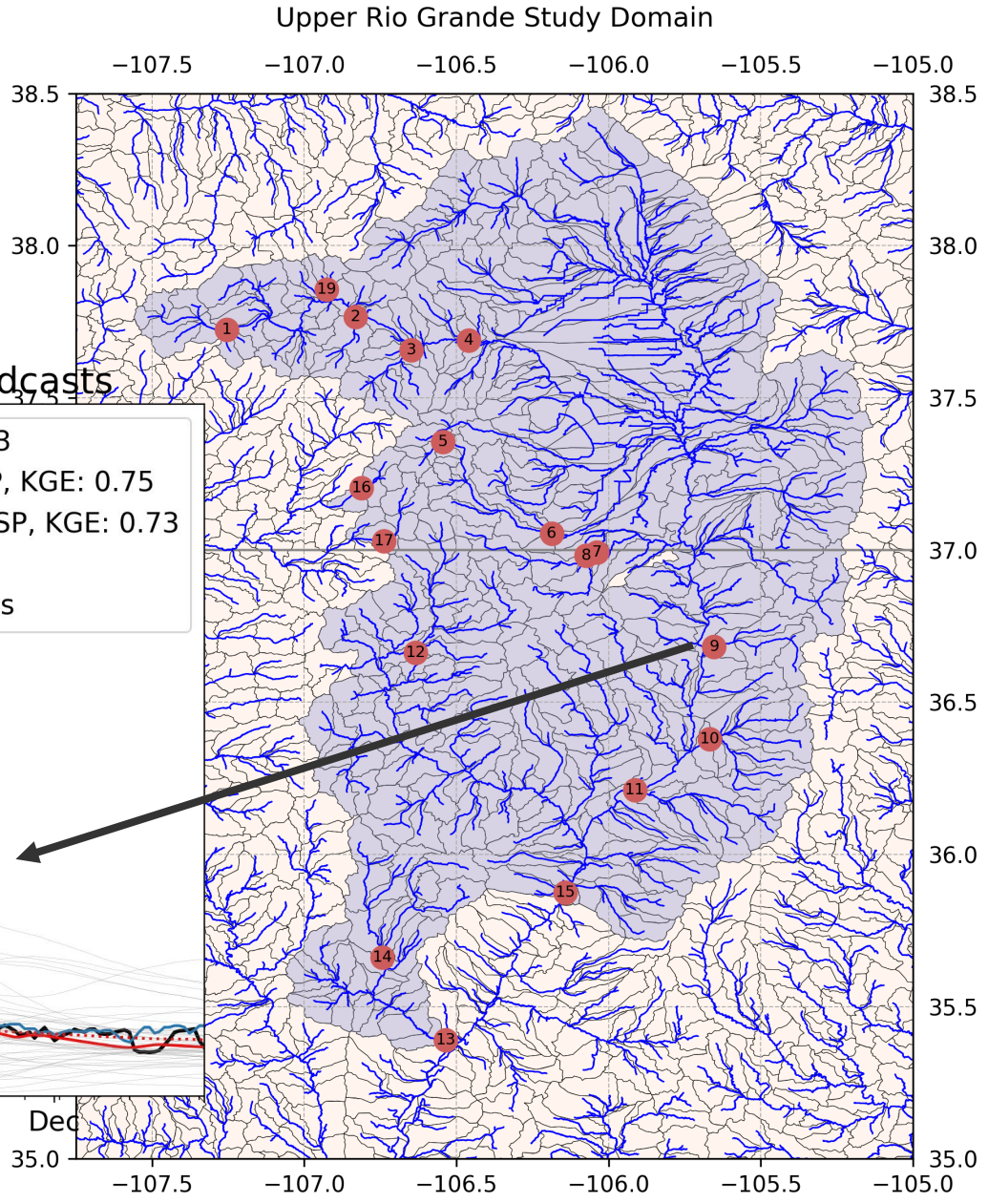

Examples: ESP Hindcasts vs. Historical Analog Years

BOR Annual Operating Plan Comparative Analysis

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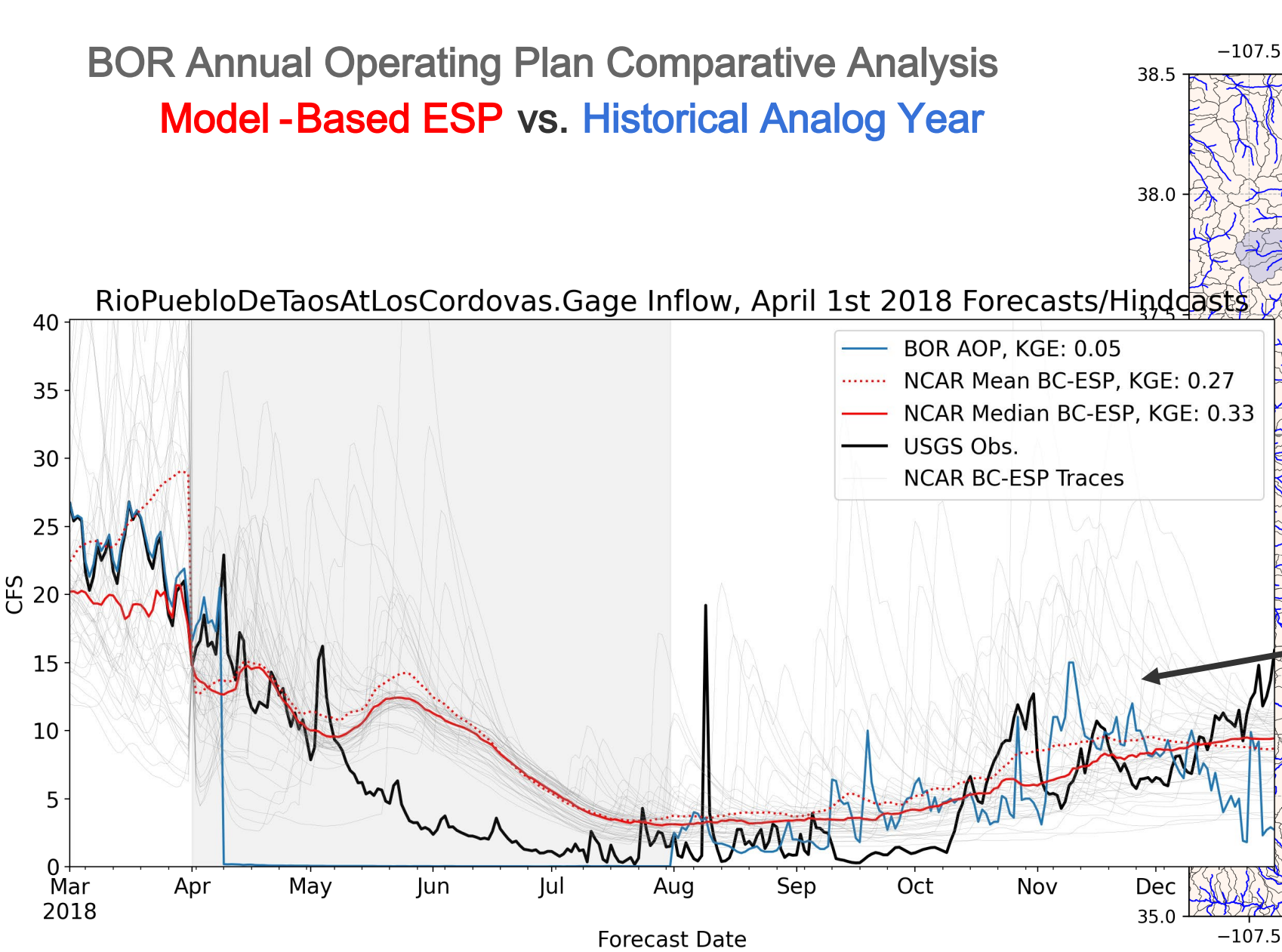
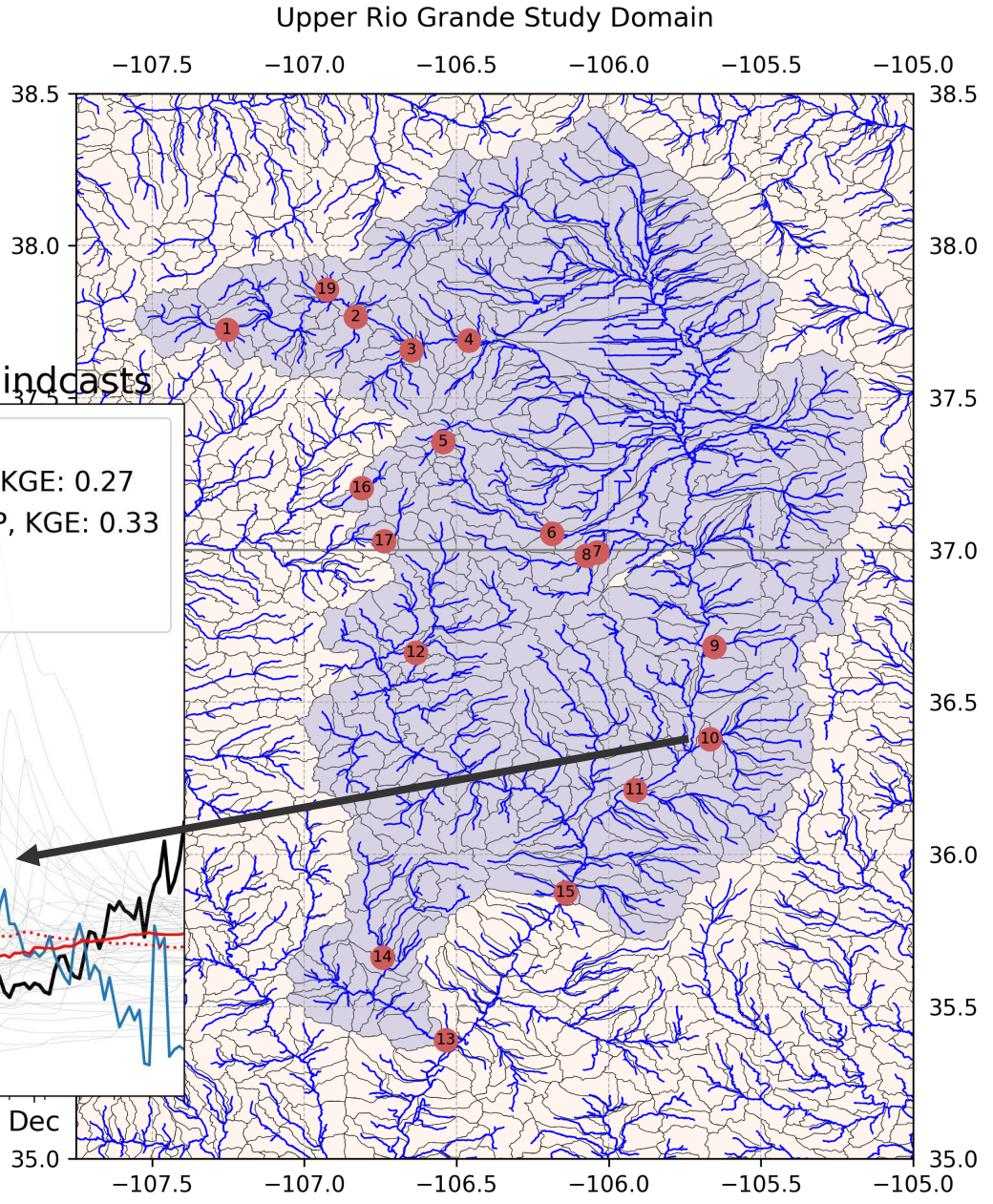
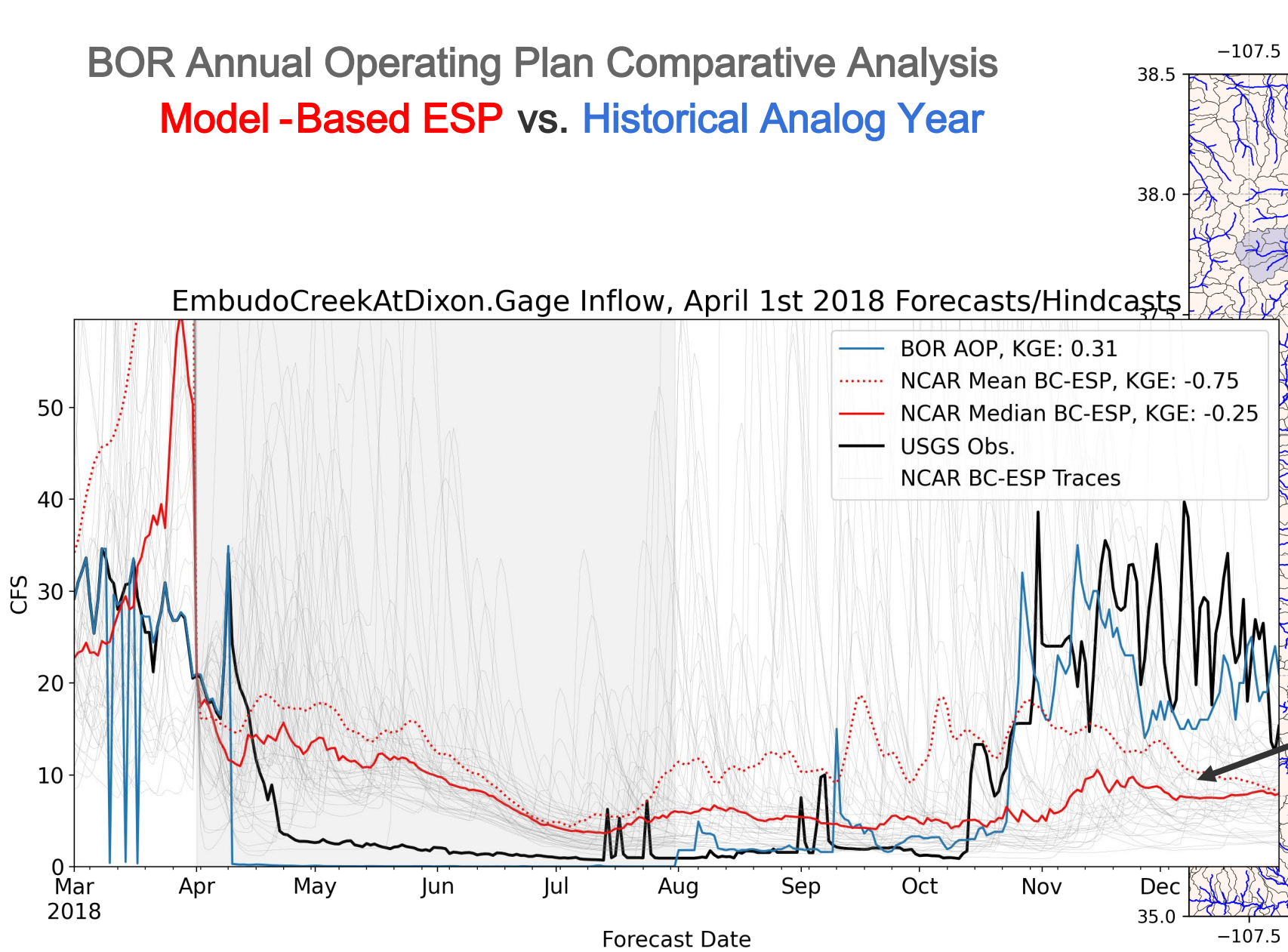


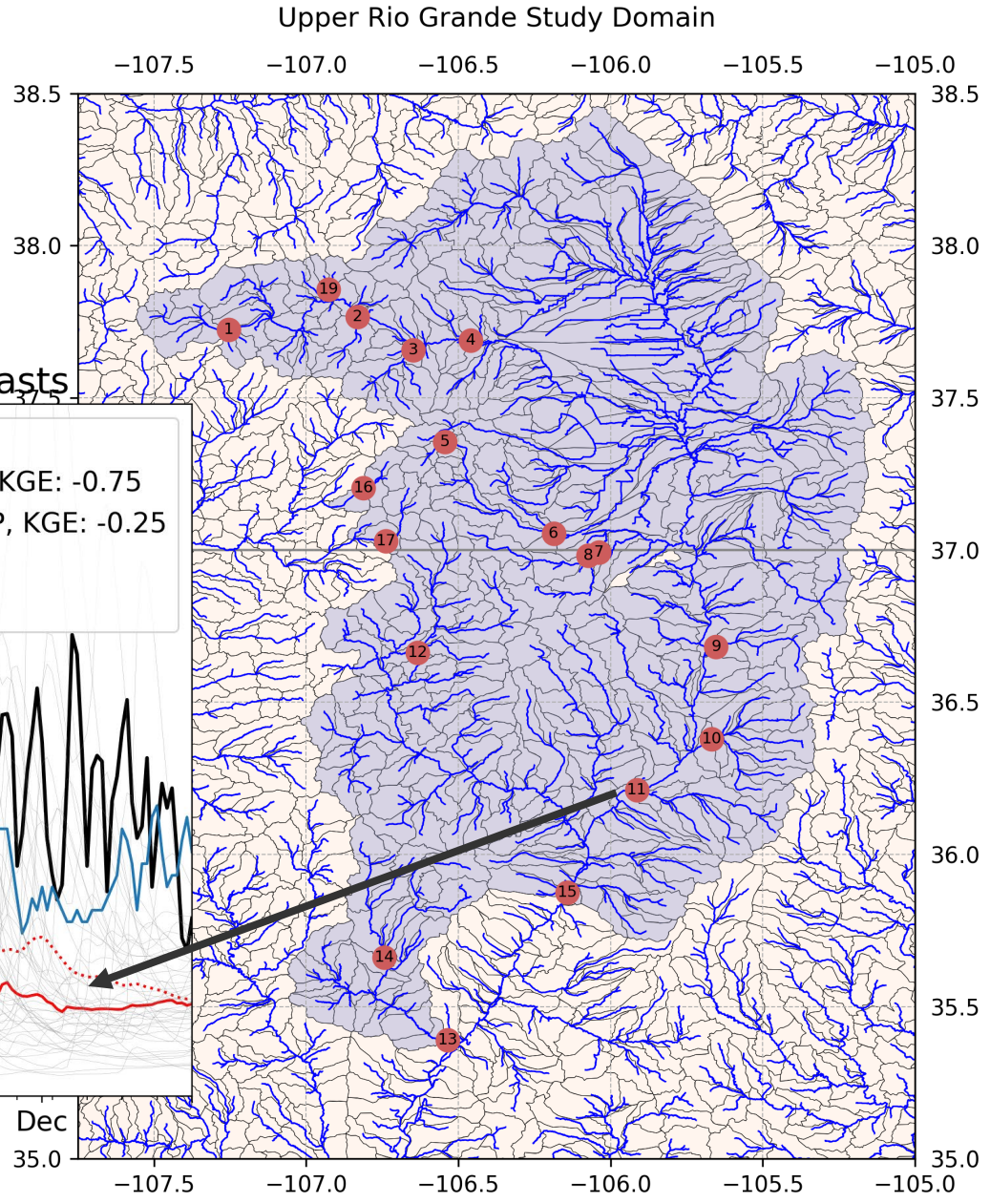


Examples: ESP Hindcasts vs. Historical Analog Years

BOR Annual Operating Plan Comparative Analysis

Model -Based ESP vs. **Historical Analog Year**

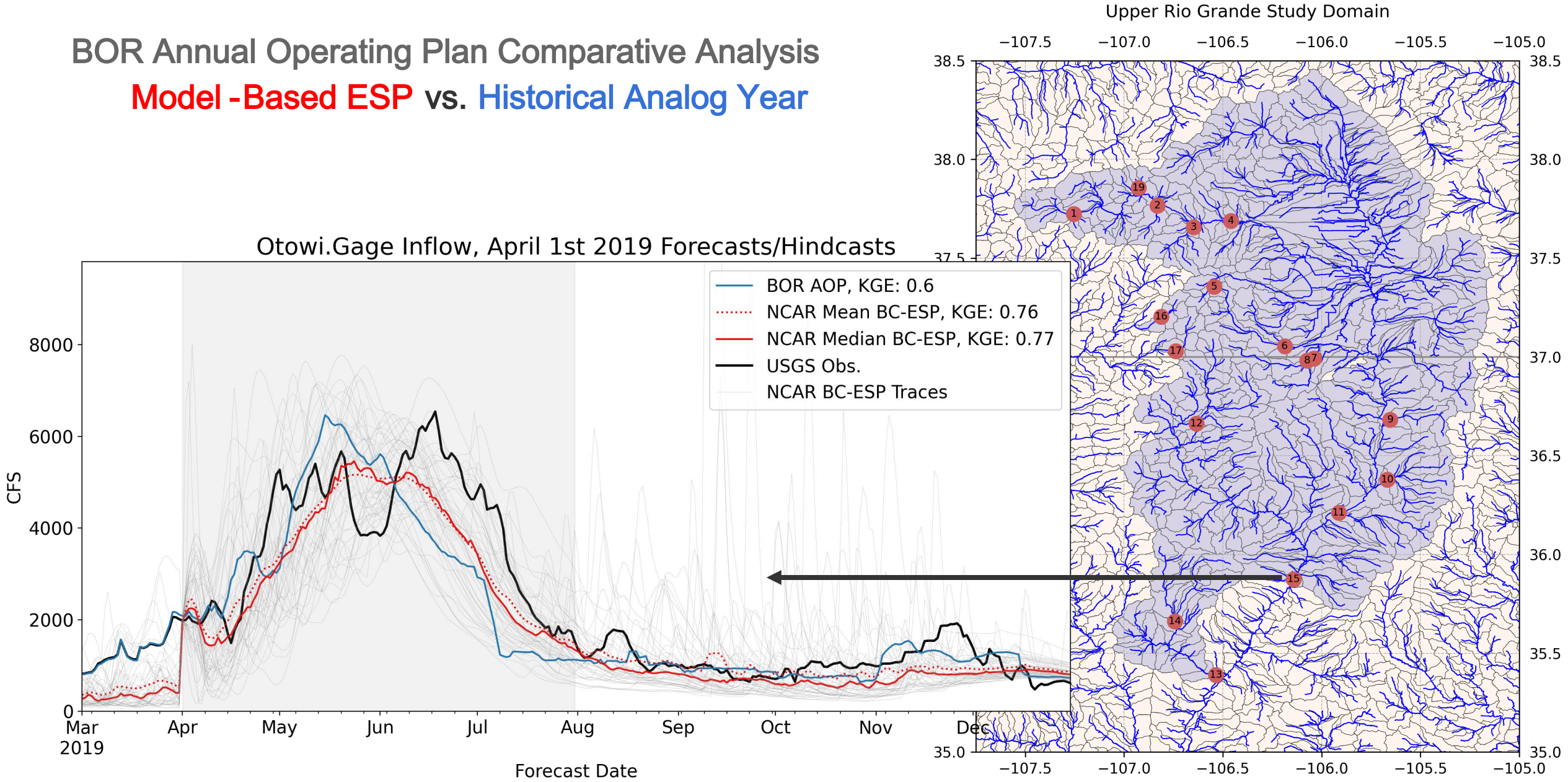




Examples: ESP Hindcasts vs. Historical Analog Years

BOR Annual Operating Plan Comparative Analysis

Model -Based ESP vs. **Historical Analog Year**

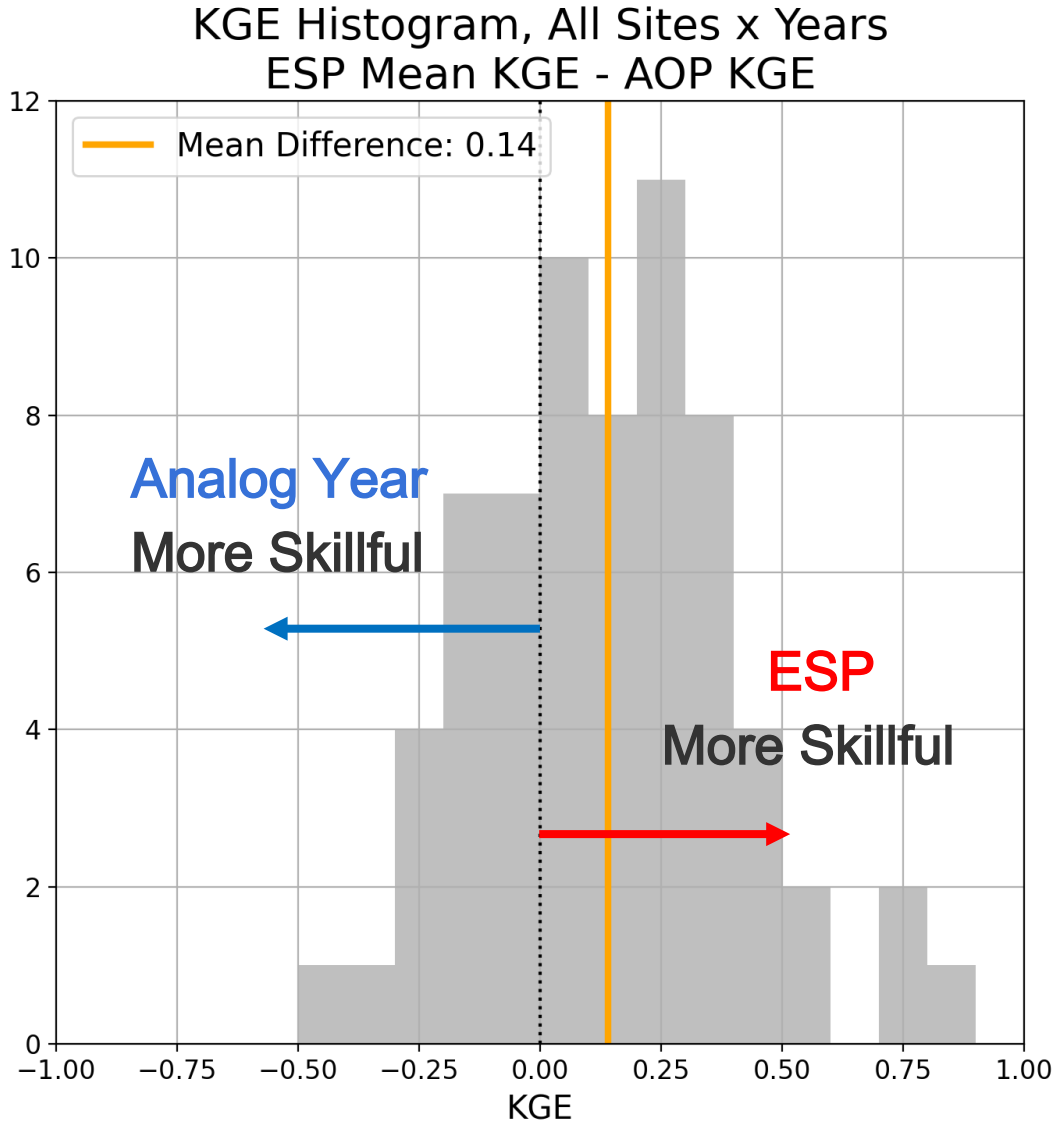


ESP Hindcasts vs. Historical Analog Years

BOR Annual Operating Plan Comparative Analysis

Model -Based ESP vs. **Historical Analog Year**

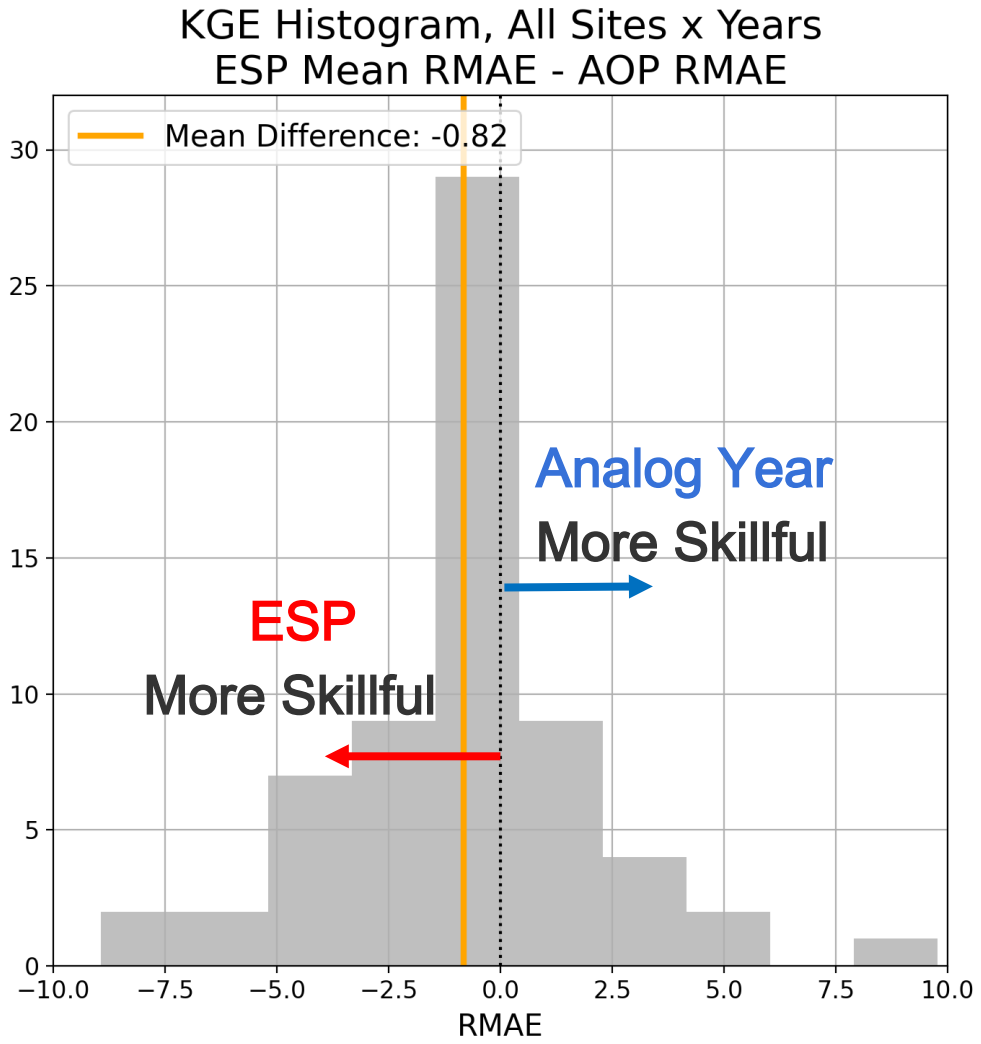
- **Compare all sites across all years**
  - 9-17 sites x 2012-2019
  - N=65
- **Evaluate with KGE (Kling -Gupta Efficiency)**
  - Larger score is better
  - Difference between scores:
    - ***Positive*** *= ESP is more skillful*
    - ***Negative*** *= Analog year is more skillful*

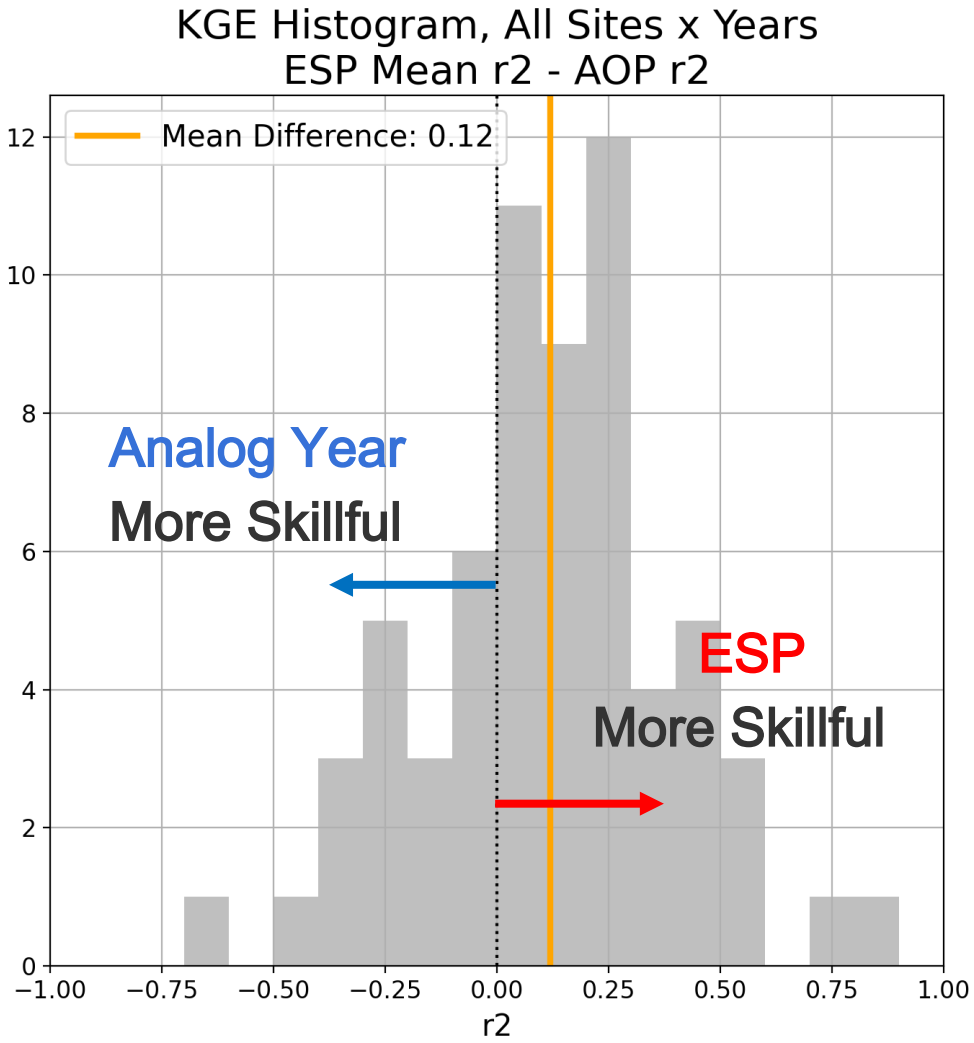


ESP Hindcasts vs. Historical Analog Years

BOR Annual Operating Plan Comparative Analysis

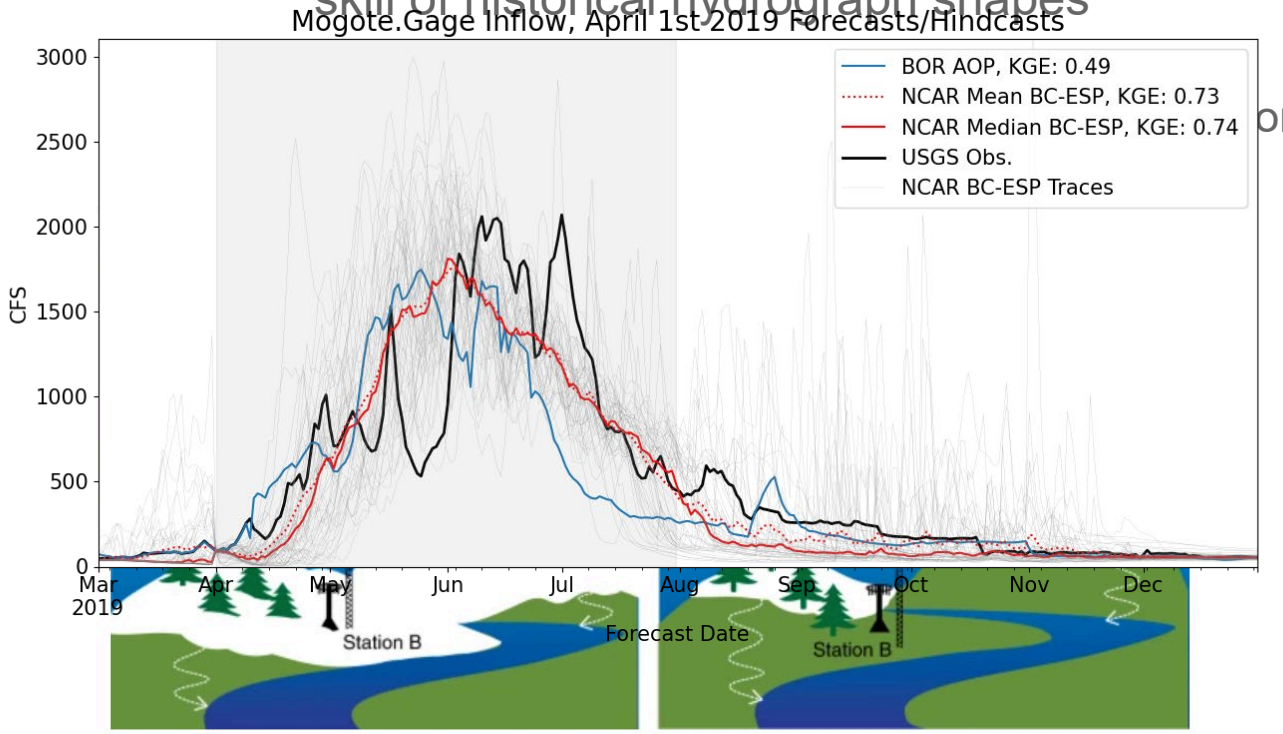
Model -Based ESP vs. Historical Analog Year

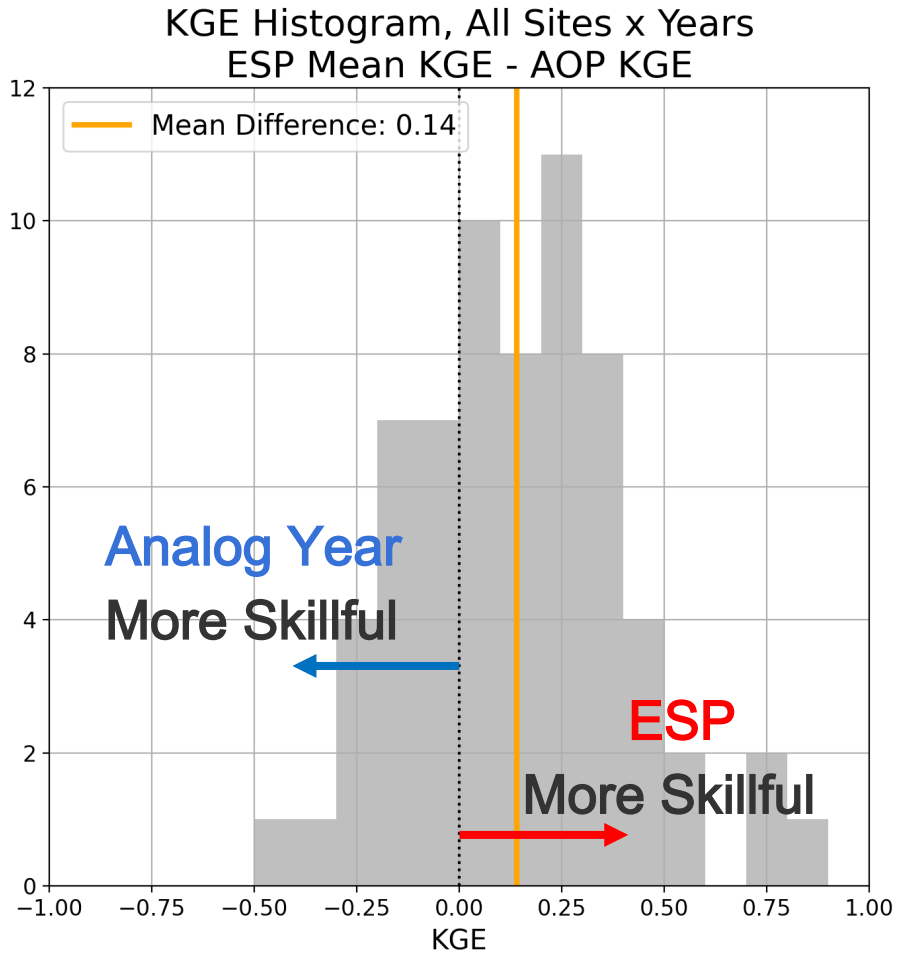




ESP Hindcasts vs. Historical Analog Years

- ESP Hindcasts vs. current practice
  - Smoother, more realistic April 1st forecasts
    - Not based on one-off analogue year
    - Conveys forecast overconfidence
  - Not dependent on hydrologic stationarity
    - Climate trends may invalidate or at least weaken the skill of historical hydrograph shapes

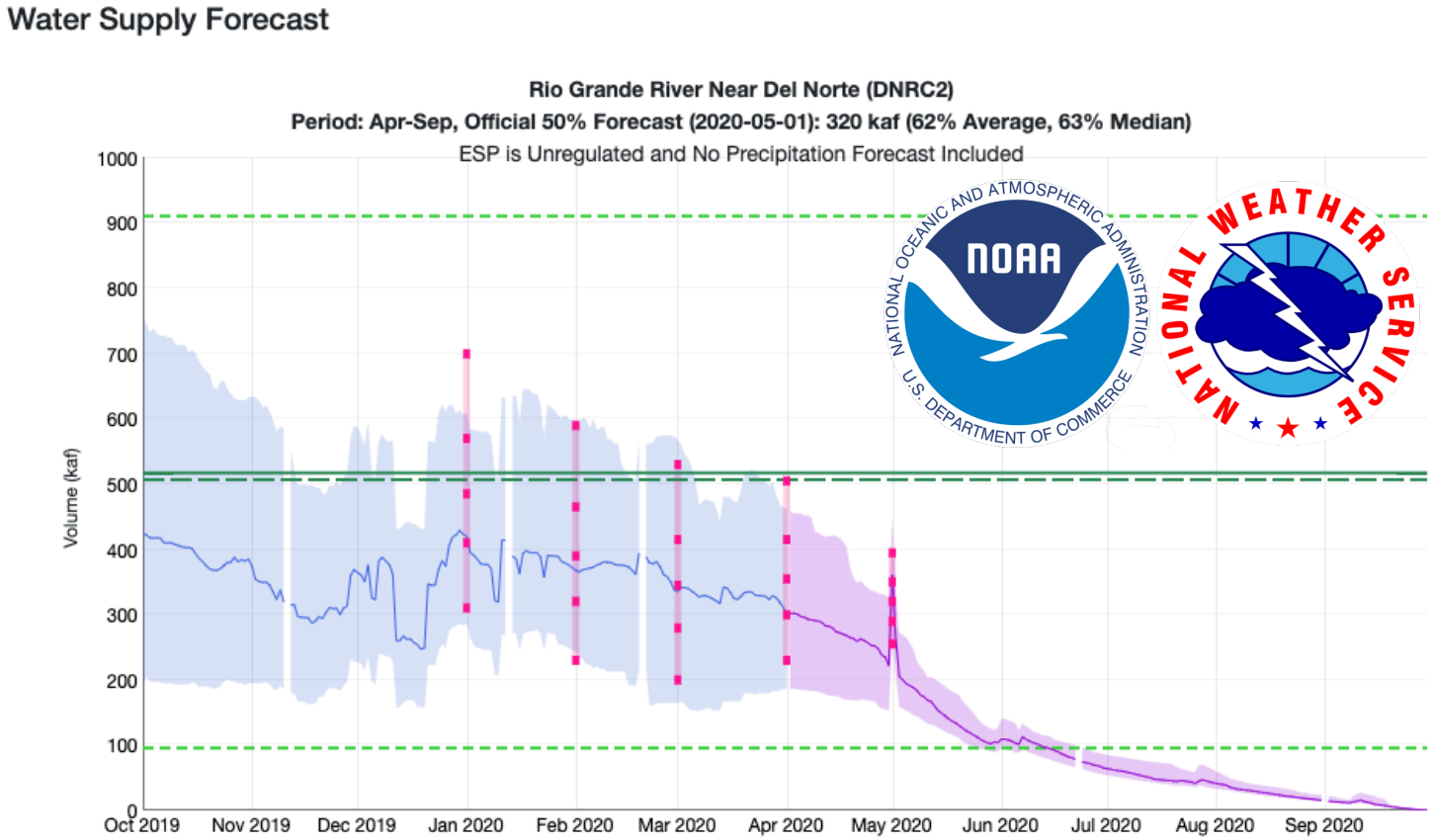


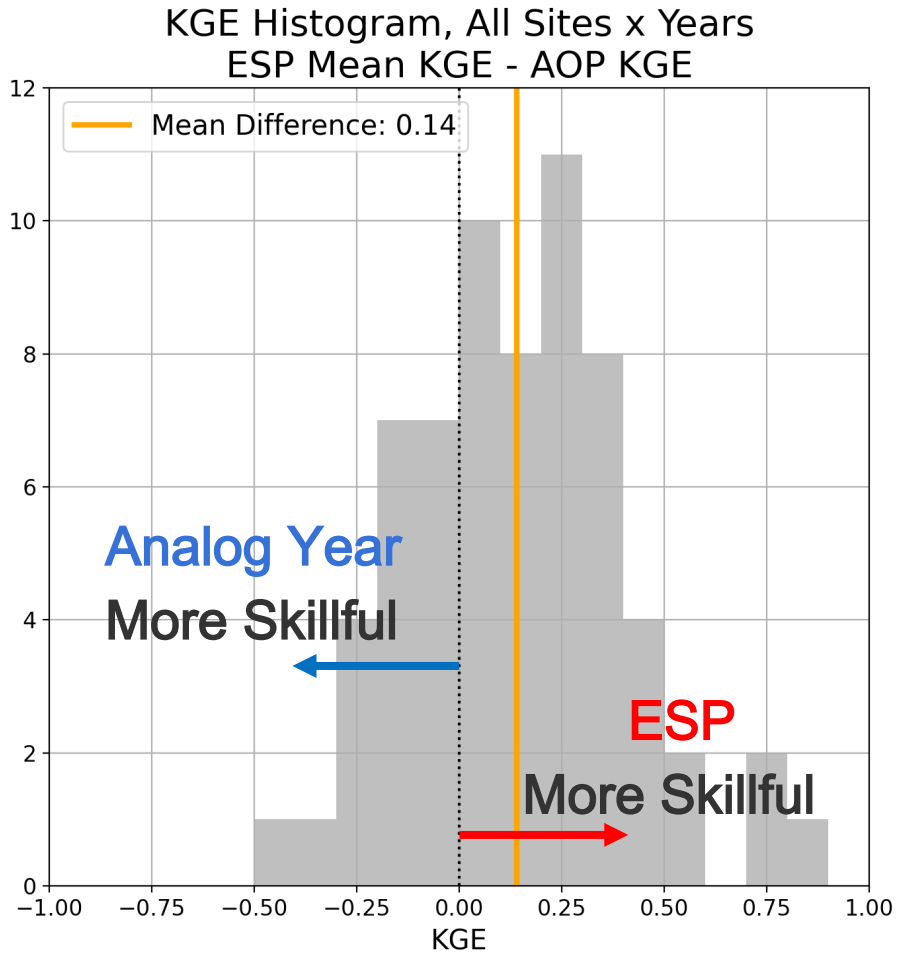


Livneh and Badger (2020)

ESP Hindcasts vs. Historical Analog Years

- Model -based ESP also allow for:
  - Uncertainty analysis
    - Do ensembles agree?
  - Using techniques such as a trace weight scheme
    - Next step: Including climate prediction information (e.g. seasonal temperature forecasts) for ensemble member selection





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