CBRFC Decision Support for Colorado River Water Management

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AGU Chapman Conference
Portland, OR
July 31, 2013

Why are we so bad at Research to Operations??

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Outline

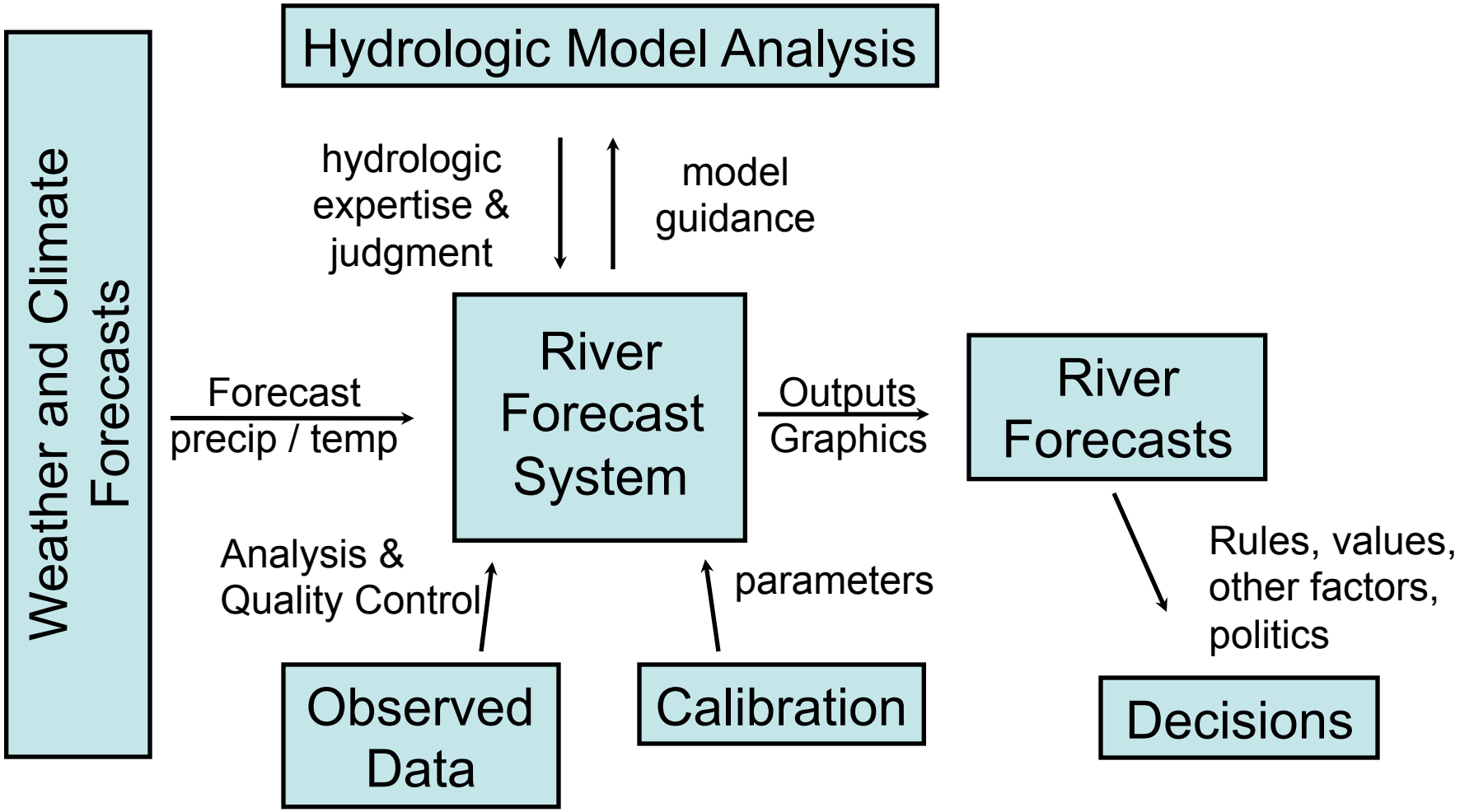
Background

Improving CBRFC and USBR mid-term modeling and forecasting

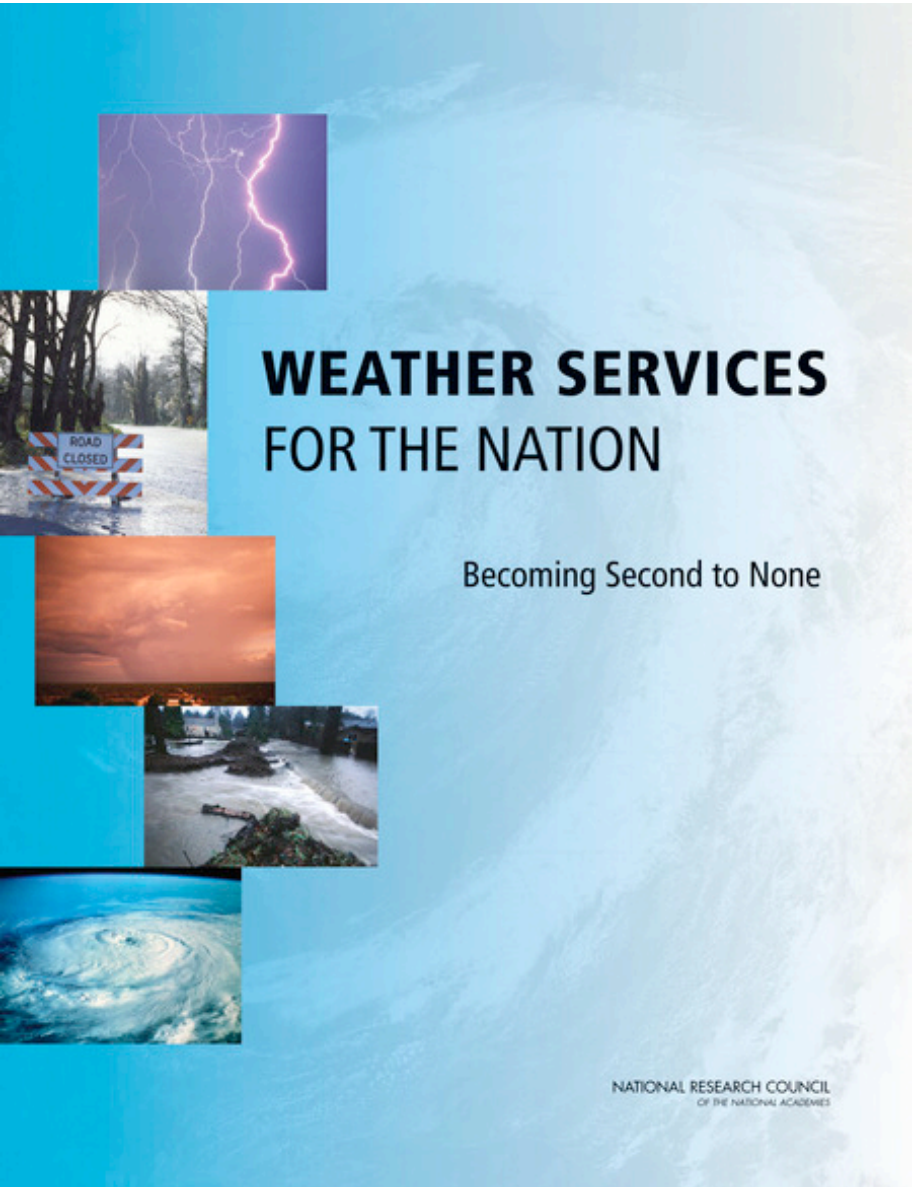
JPL/CBRFC snow data collaboration

Lessons Learned

Forecast Process

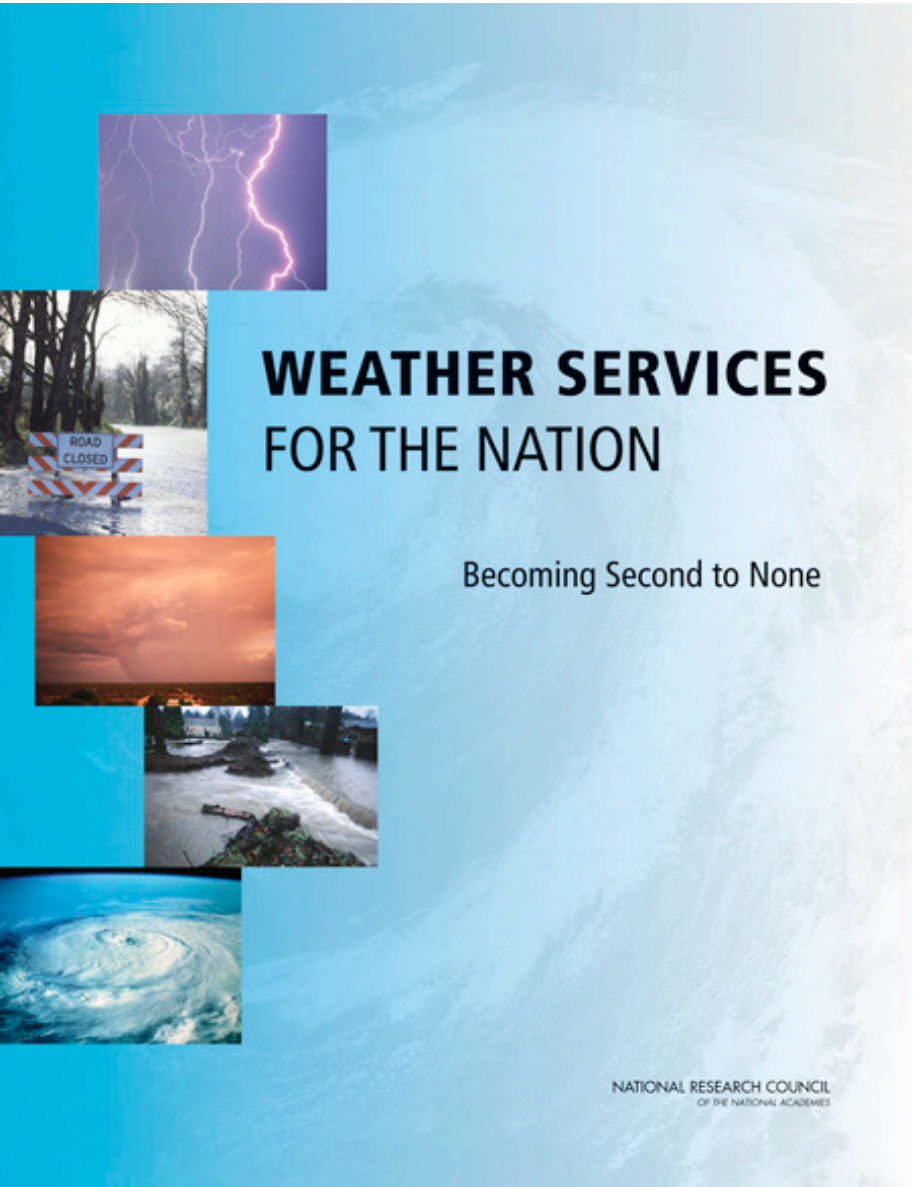


Background: 2012 NAS Report



"The level of sophistication and representativeness of real world processes, as well as characterizations of uncertainties, in non-NWS research and operational communities outpace those used in NWS-hydrology operations. **NWS hydrological prediction models are simplified, often lack real physical meaning**, and are **limited in terms of ensemble and data assimilation capabilities.**"

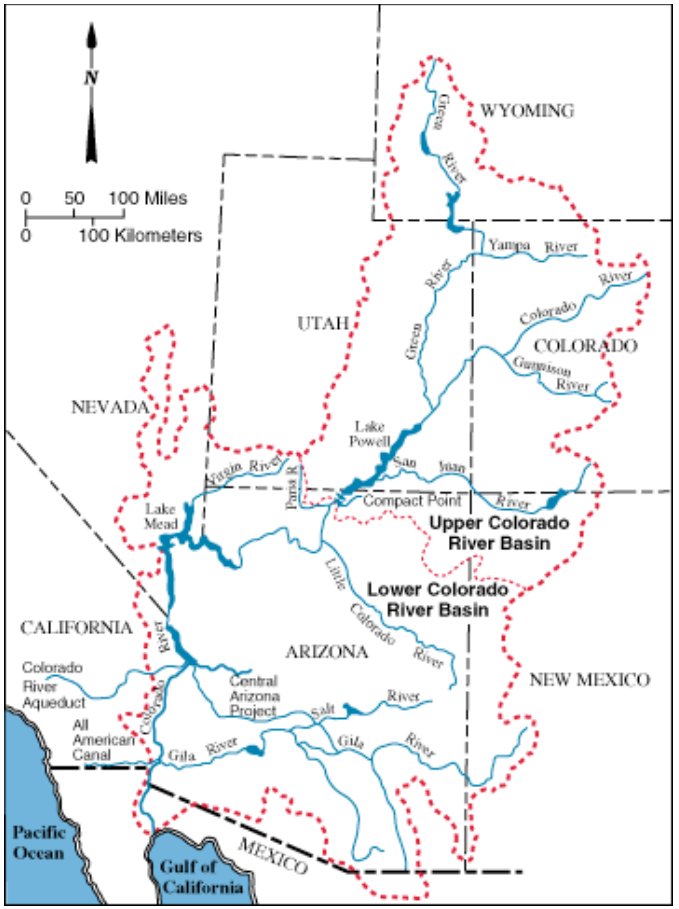
Background: 2012 NAS Report



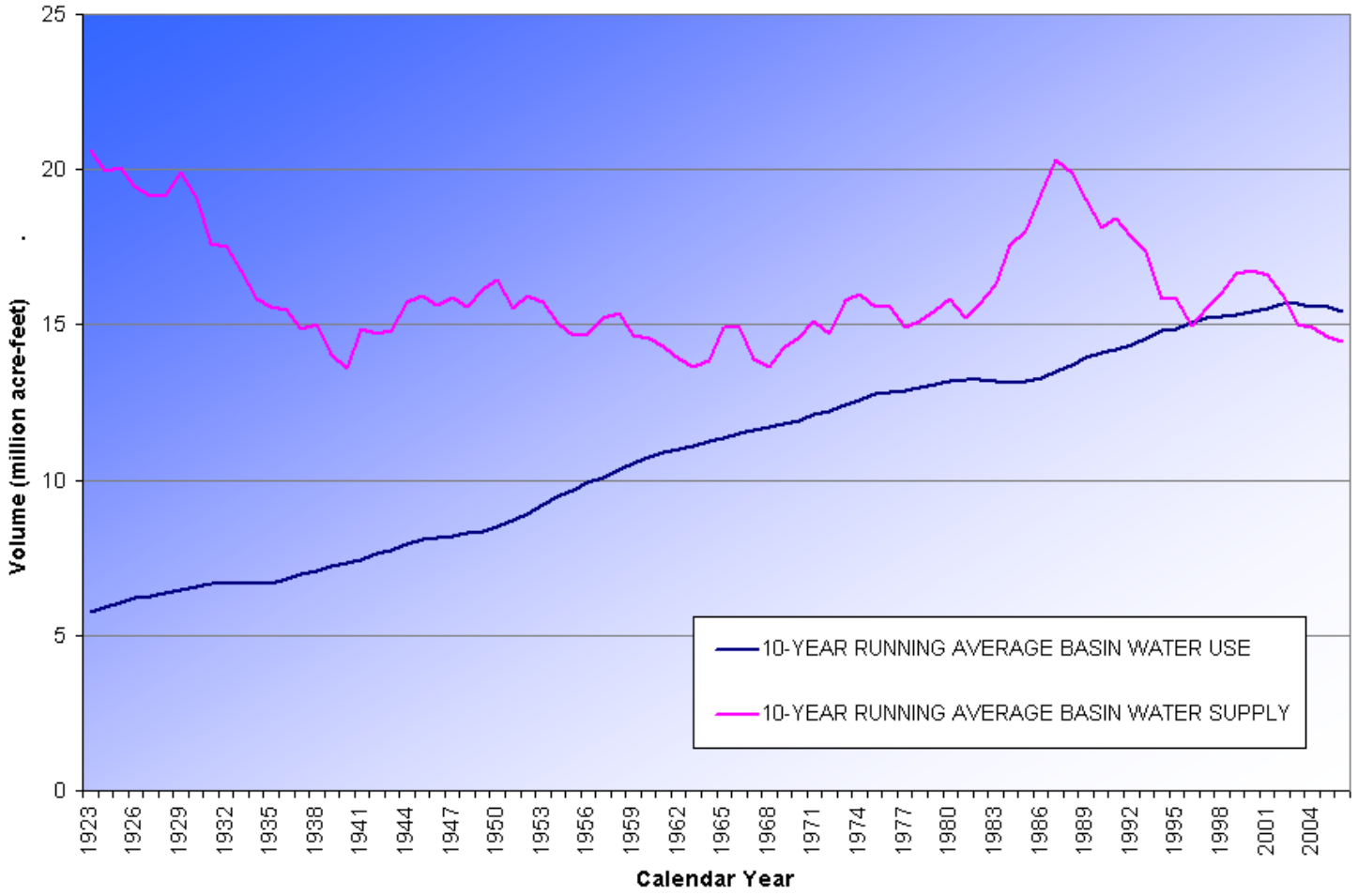
Copious manual, subjective manipulation of forecasting workflows likely results in excessive forecaster-to-forecaster forecast quality variance either within or between RFCs. Placing the hydrologic forecaster over-the-loop, as opposed to in-the-loop, would shift forecaster duties to general forecast job management, model data assimilation, uncertainty quantification, forecast interpretation, product development, and forecast communication. In essence, time saved from laborious, subjective data quality control and attribution tasks needs to be re-allocated to continual quantitative, objective system assessment, forecast production, and communication and model research and development."

Colorado River

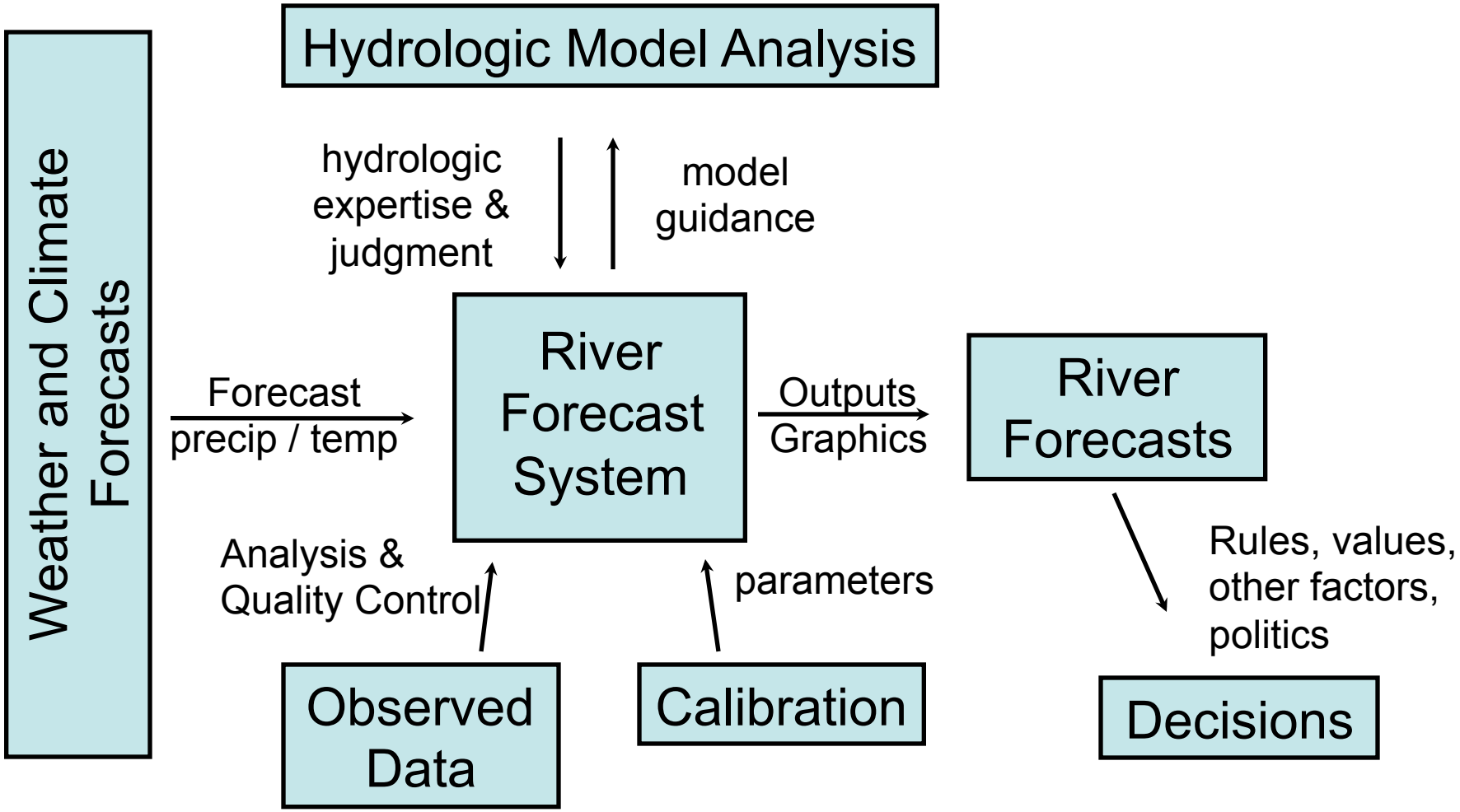
- 25 million people rely on Colorado River water
- 3.5 million acres of irrigation
- 85% of runoff comes from above 9000 feet
- Mean annual discharge is about 12.4 MAF
- Storage capacity is about 60 MAF (4 times mean annual flow)
- River is fully used and little flows to ocean



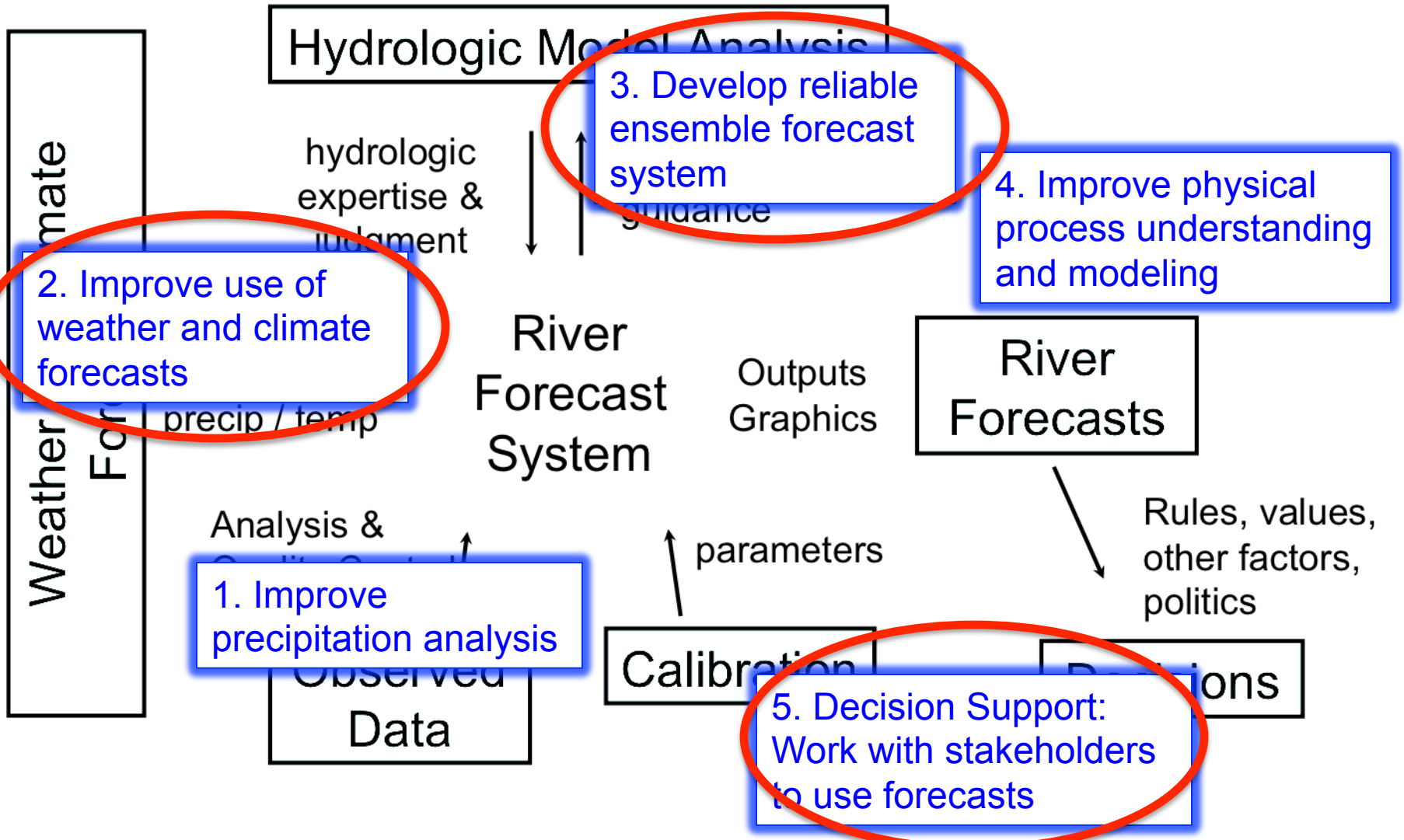
Long Term Supply / Demand



Forecast Process



CBRFC Research Needs



Water Supply Decision Support

The past

Seasonal water resources forecasting and modeling in the Colorado Basin
circa 1980 - 2010

Coordinated Forecast (single number) → 24 month study → Stakeholders

The future

Seasonal water resources forecasting and modeling in the Colorado Basin
Near future

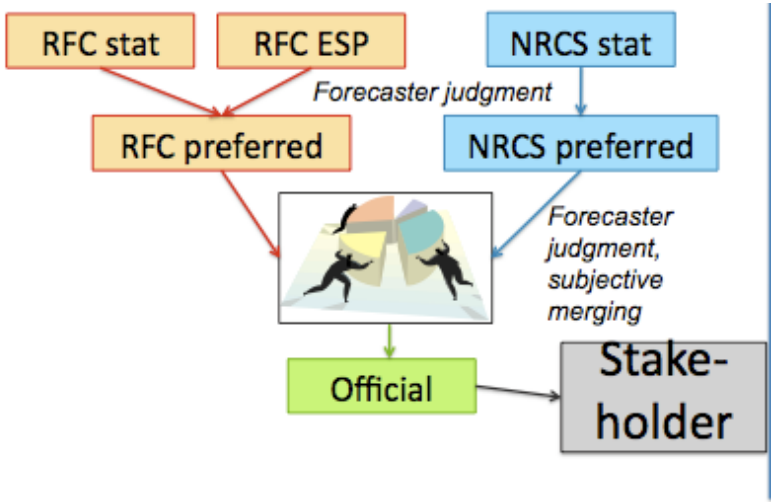
Hydrologic Ensembl Forecast System → Mid-Term Probabilistic Model → Stakeholders

Efforts in parallel --

- CBRFC working to improve probabilistic flow forecasts
- BOR working to implement probabilistic water management model

Past CBRFC Methods

- Official forecasts coordinated each month with NRCS/NWCC
- Skill primarily from accumulating snow pack
- Updated monthly or semi-monthly
- Probabilistic but not ensemble based
- Not repeatable
- Subjective
- Forecaster Role:
  - Monitor forecast process and system
  - Add judgement to forecast process



Hydrologic Ensemble Forecast System

The Science of NOAA's Operational Hydrologic Ensemble Forecast Service

Julie Demargne[1,2], Limin Wu[1,3], Satish Regonda[1,4], James Brown[5], Haksu Lee[6,3], Minxue He[1,4], Dong-Jun Seo[7], Robert Hartman[8], Henry D. Herr[1], Mark Fresch[1], John Schaake[9], and Yuejian Zhu[10]

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[5] *Hydrologic Solutions Limited, Southampton, UK*

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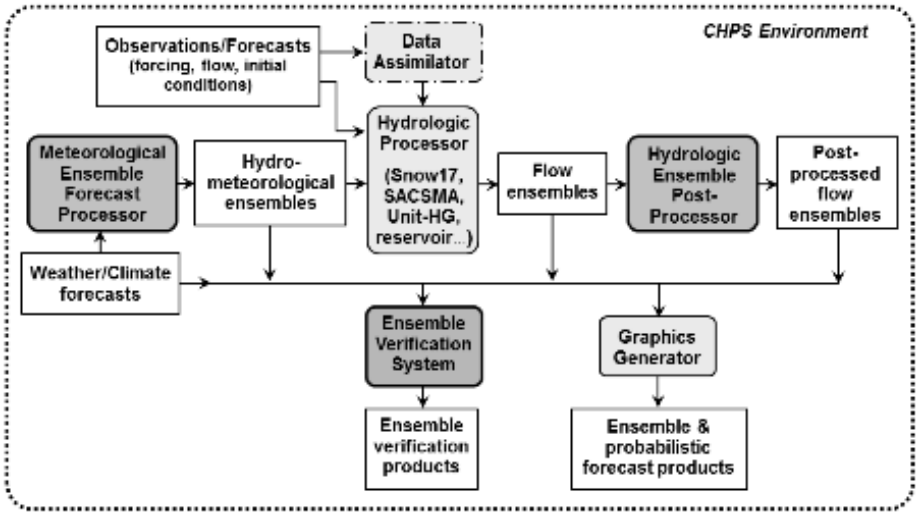
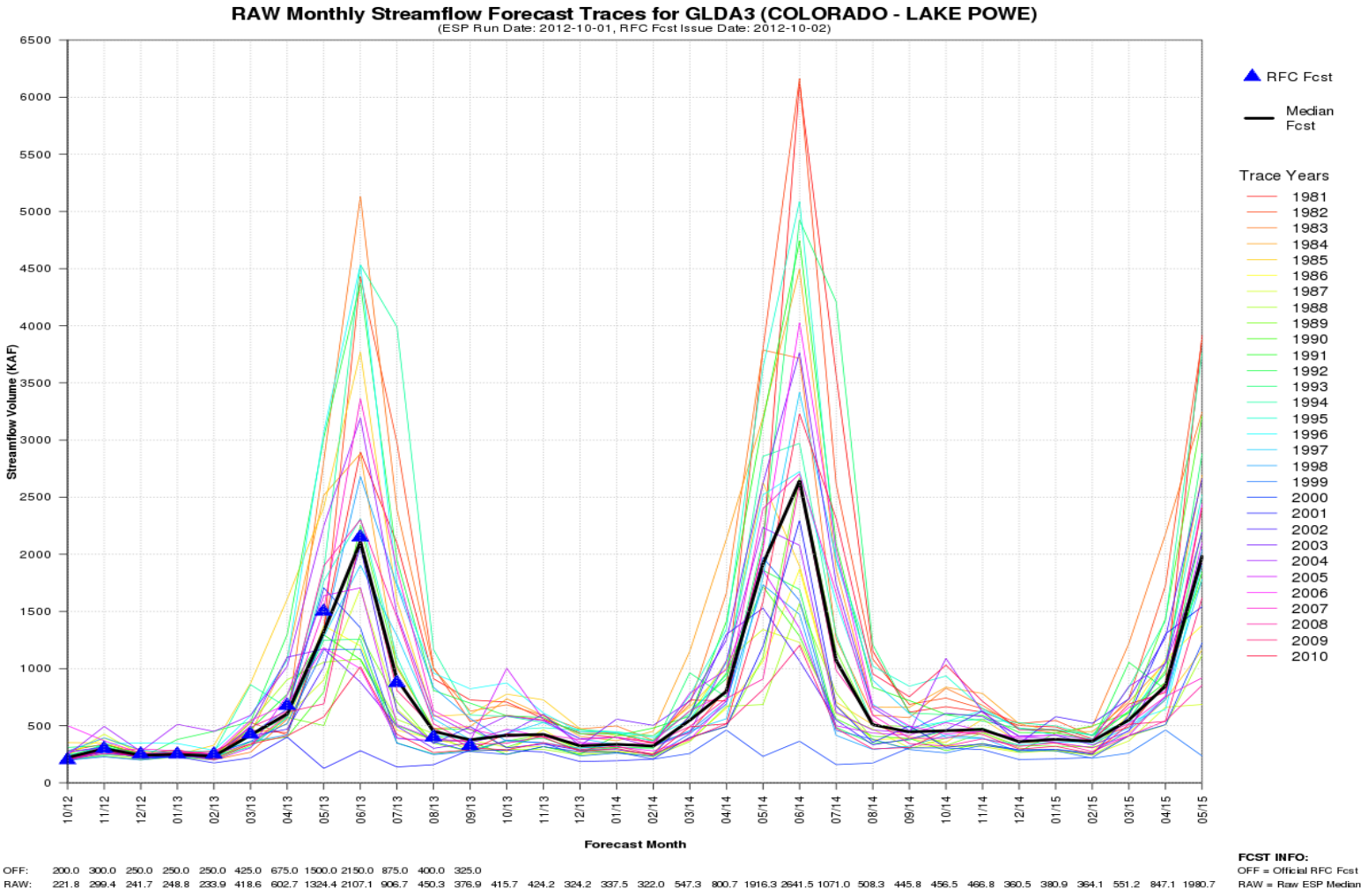


Target CBRFC ESP Paradigm

- Objective, repeatable ensemble forecasts
- Routinely integrate skill from weather and climate predications through HEFS and/or other techniques (e.g. wx generator)
- Daily updating forecasts out one year everyday.
- Forecaster role:
  - Monitor forecast process and system
  - Apply judgement (less frequently?)
  - Decision support
  - Work to improve forecast system and processes based on objective standards
  - Follow best practices identified by CPC

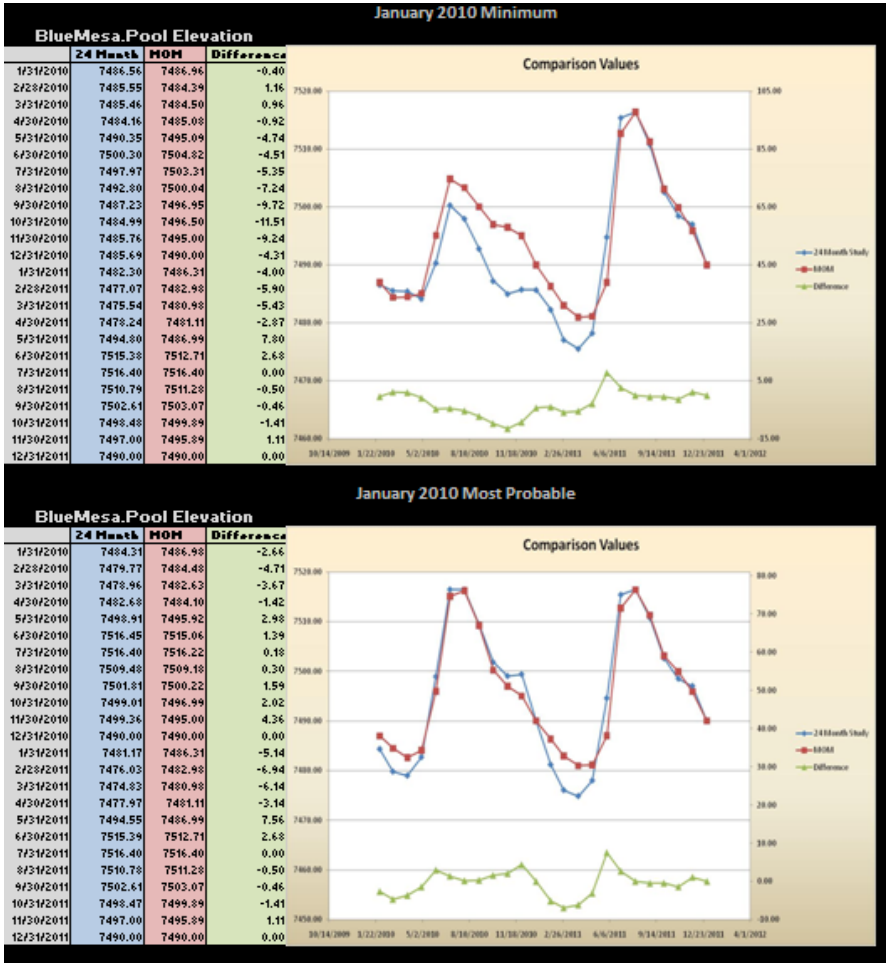
ESP for MTOM


RAW Monthly Streamflow Forecast Traces for GLDA3 (COLORADO - LAKE POWE)
(ESP Run Date: 2012-10-01, RFC Fcst Issue Date: 2012-10-02)
Streamflow Volume (KAF)
Forecast Month
RFC Fcst
Median Fcst
Trace Years
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
OFF: 200.0 300.0 250.0 250.0 250.0 425.0 675.0 1500.0 2150.0 875.0 400.0 325.0
RAW: 221.8 299.4 241.7 248.8 233.9 418.6 602.7 1324.4 2107.1 906.7 450.3 376.9 415.7 424.2 324.2 337.5 322.0 547.3 800.7 1916.3 2641.5 1071.0 508.3 445.8 456.5 466.8 360.5 380.9 364.1 551.2 847.1 1980.7
FCST INFO:
OFF = Official RFC Fcst
RAW = Raw ESP Median

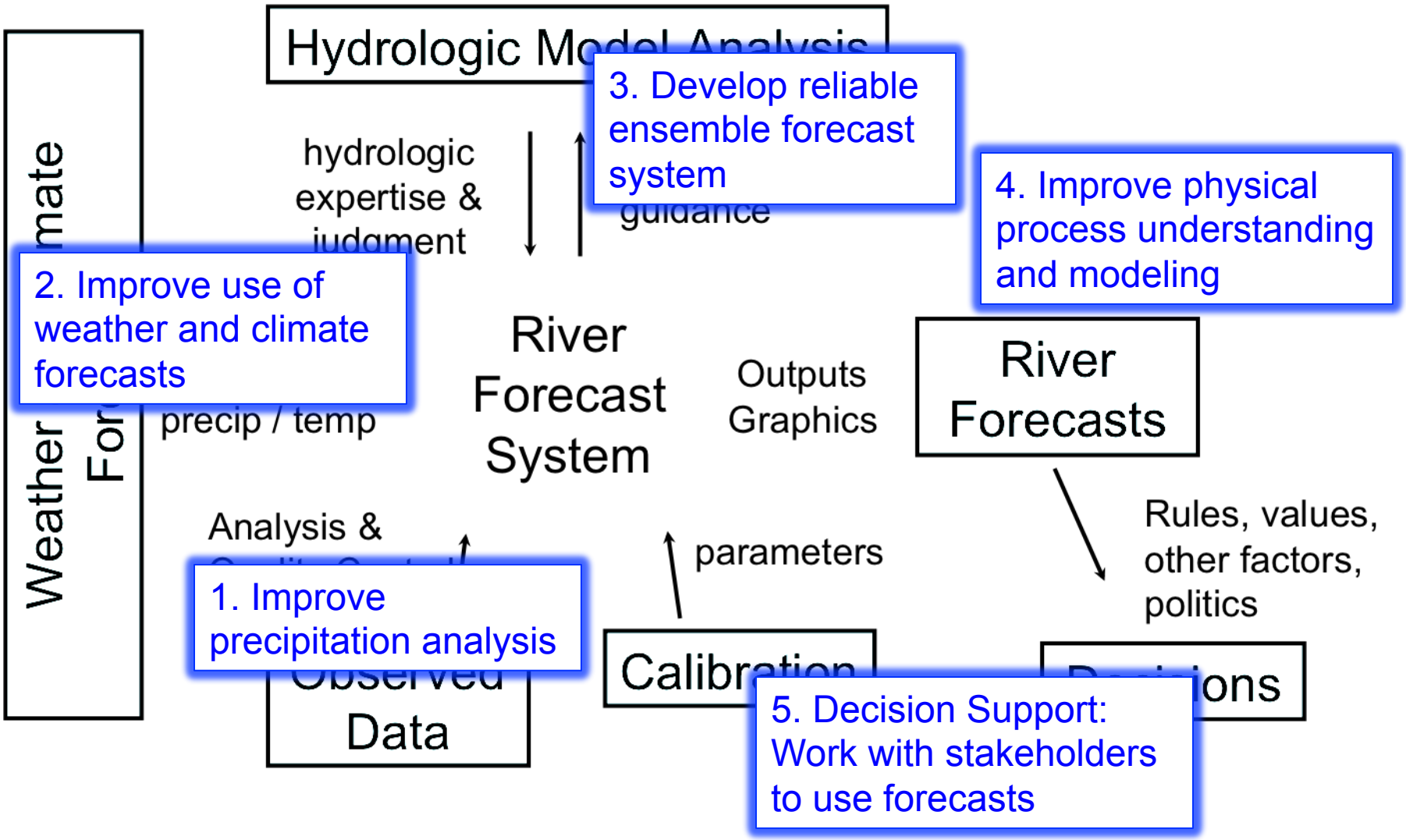
USBR Mid Term Operations Model

Mid-Term Probabilistic Model:

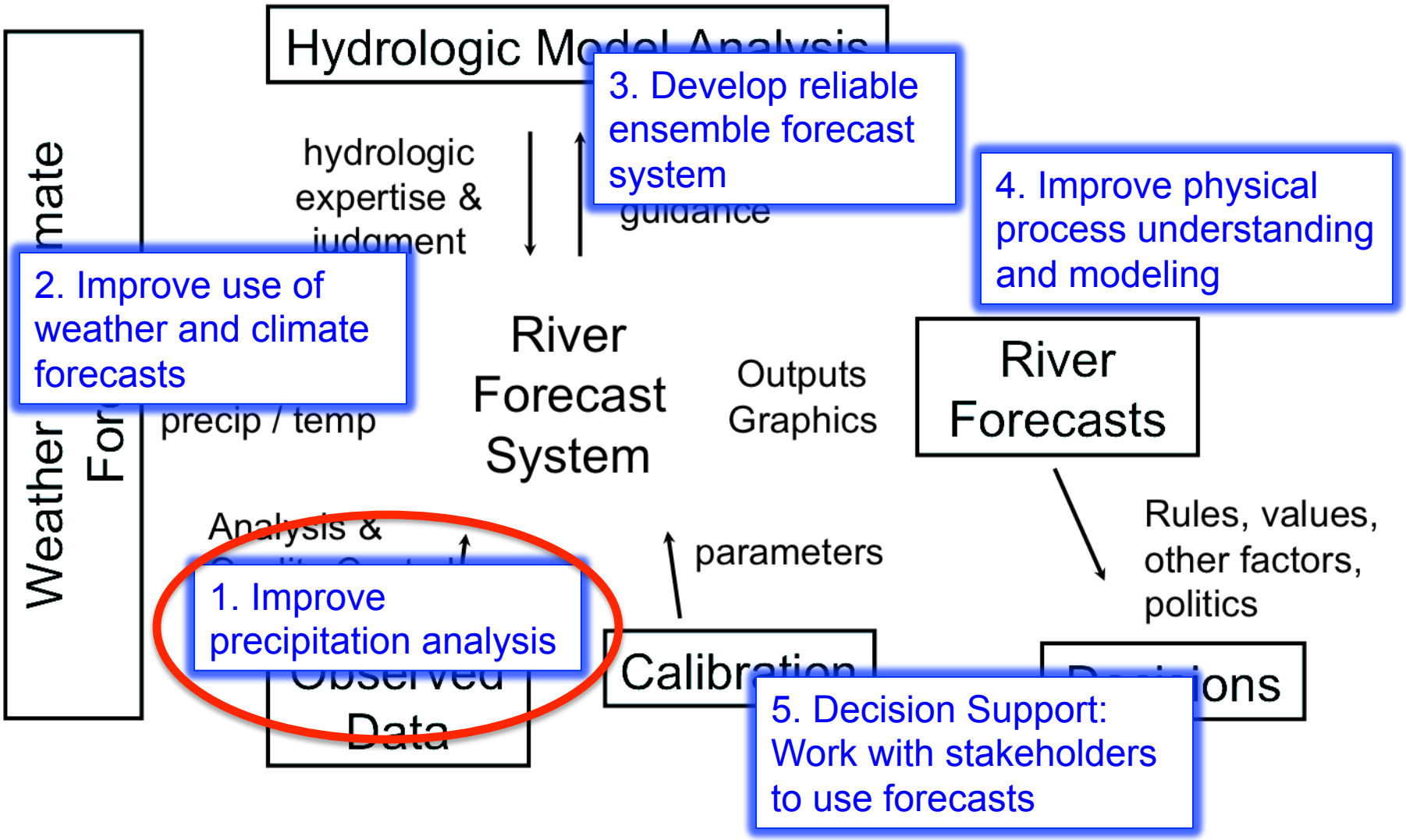
- Uses CBRFC ensemble forecasts for first two years
- Uses “rules” (prioritized logic) to determine releases
- Output will be ensemble forecast for reservoir operations
- Currently undergoing real time testing
- Expected deployment by WY2014



Why is Research to Operations So Hard???



One Recent Success Story



Adding snow data in CBRFC Operations via CBRFC-NASA Collaboration

CBRFC-NASA/JPL Collaboration
Ongoing over the past **~2 yrs**

CBRFC primarily focused on satellite-derived snow cover observations from MODIS

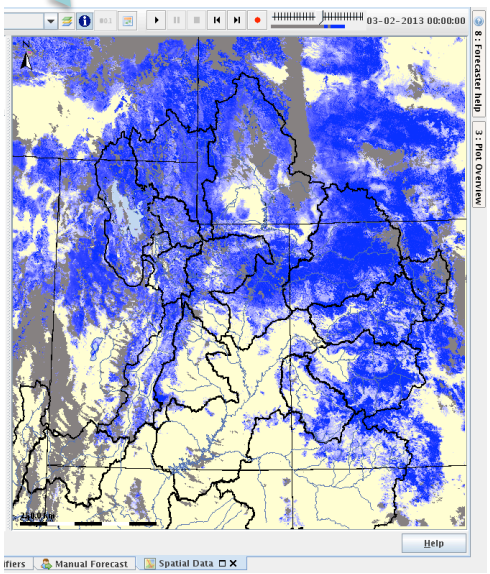
Collaborative research-to-operations effort enables research group (NASA) and operations group (CBRFC) to learn about characteristics of each type of scientific environment

Unique effort "in the trenches" with 3 week visit to CBRFC of NASA researcher

For a successful collaboration, both sides must be willing to understand the other's perspective and to adapt.

Feedback from all CBRFC forecasters has been positive regarding NASA snow cover data as an additional source of snow information and tool to use in the forecasting process.

Examples of NASA data use at CBRFC:



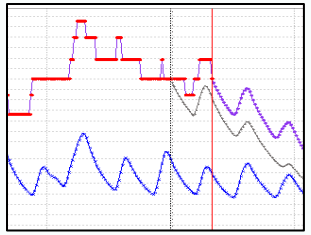
MODSCAG snow cover (in CHPS display) across the upper portions of CBRFC area

March 2, 2013 (gray = cloud)

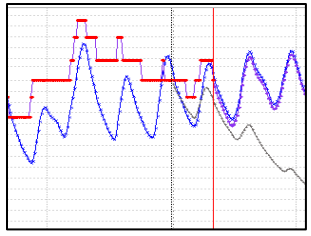
Improving forecasts using information about snowpack presence from MODSCAG of streamflow

Example: East Fork of the White River, near Fort Apache, AZ (April 29, 2013)

Before adjustment:
Model simulation lower than **recent observations**



After adjustment:
model simulation more representative of **recently observed streamflow.**
Official forecast was higher than previous and ultimately closer to observations.



CBRFC/NASA/JPL Collaboration

Collaboration → **very beneficial** to both CBRFC and NASA/JPL

CBRFC wins:	NASA/JPL wins:
Detailed knowledge of the NASA/JPL snow cover and dust-on-snow datasets: 1. Benefits that the datasets offer 2. Limitations they may have and how to overcome them (vegetation, clouds, etc.) CBRFC knows who in the NASA/JPL group to contact : 1. If there are any data outages 2. With questions about the science and algorithms behind the datasets	Detailed knowledge of the CBRFC forecast process: 1. Daily operations with deterministic flow forecasts 2. Seasonal water supply/runoff forecasts 3. The manual nature of the forecasting Awareness of how CBRFC interacts with RFC stakeholders and users Knowledge of options and limitations for data integration into CHPS and SNOW17

Why is it working?

Substantive Importance

Funding

People and Relationships

Going Forward…

Goal: Repeat favorable conditions for research to operations to it better and faster

Challenges:

- NWS and Academic incentive structures
- Communication and understanding between researchers and forecasters
- Redesign forecast process from ground up
-

Questions?

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