Science, Society, and Western Water: A Journey Through a Exotic Landscape

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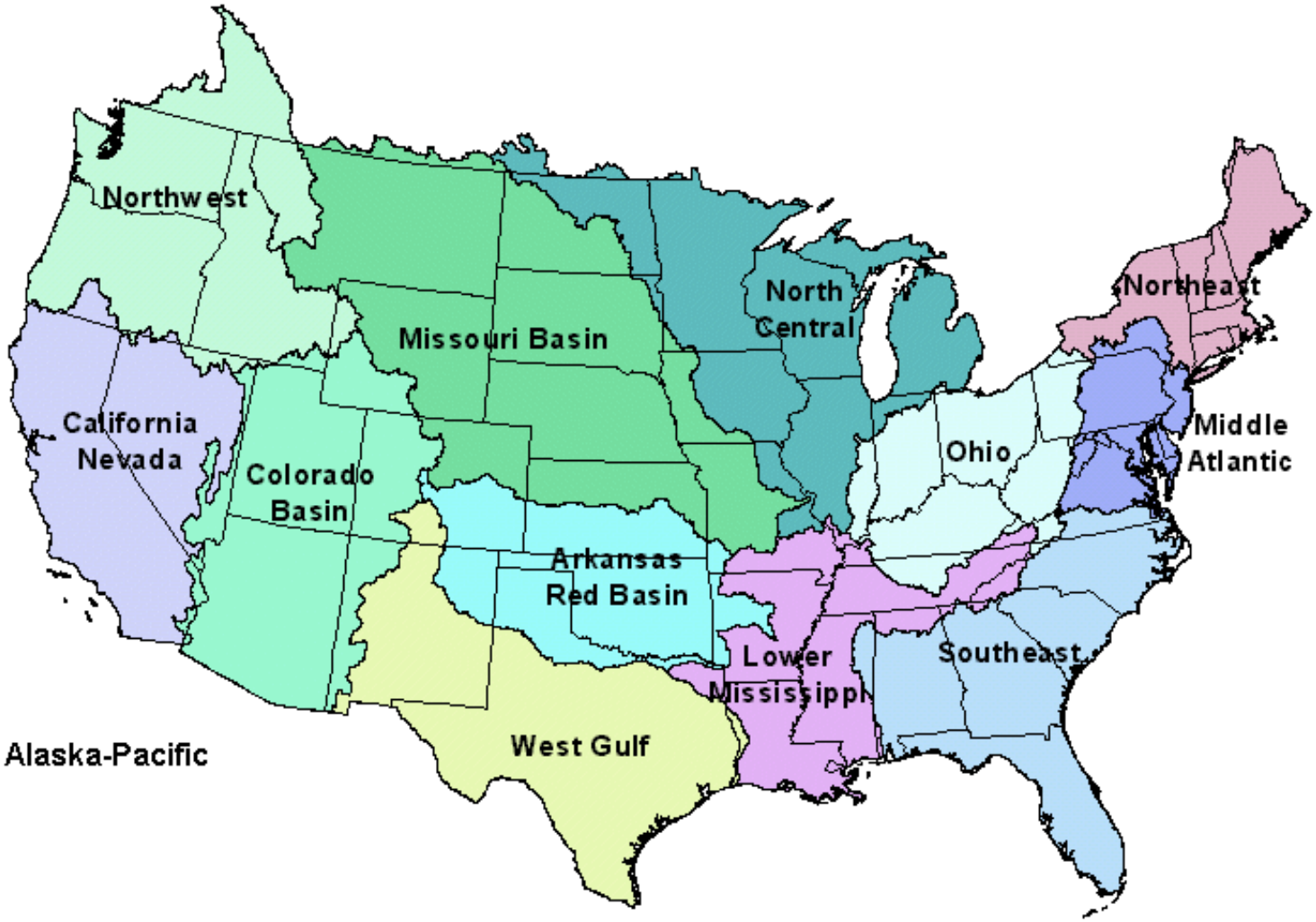
NOAA/NCDC
Asheville, NC
April 25, 2014

Outline

- Introduction
- Background: The Colorado River and NOAA's River Forecast Centers
- Six Years as a Service Coordination Hydrologist
- Six Weeks as a Regional Climate Services Director

Introduction

Background: NOAA's River Forecast Centers



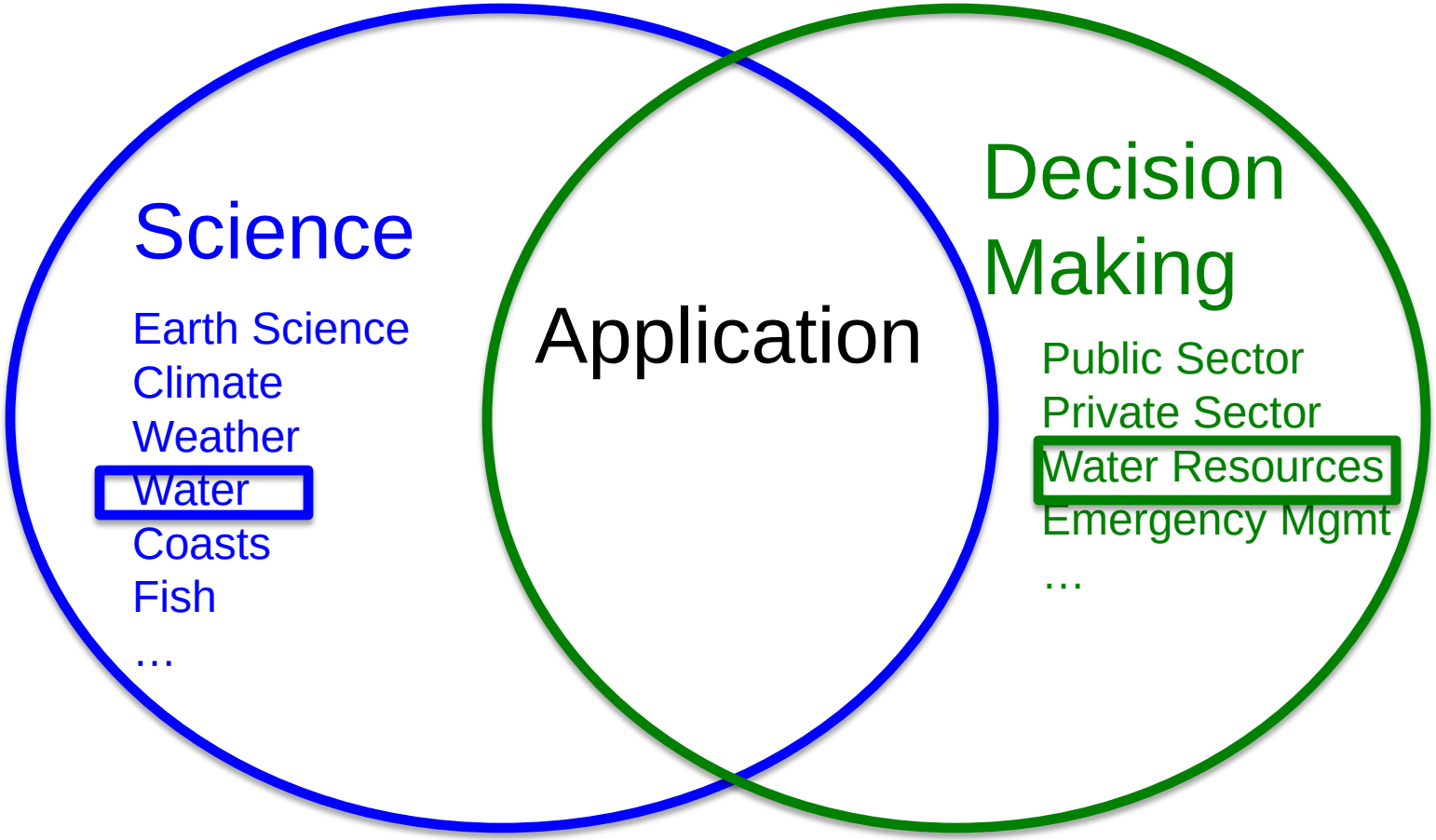
Who we (now they) are…

Mission: To understand and predict changes in the Earth's environment … to meet our Nation's economic, social, and environmental needs

Mission: The NWS provides weather, hydrologic, and climate forecasts and warnings … for the protection of life and property and the enhancement of the national economy

The Colorado Basin River Forecast Center generates streamflow forecasts and related datasets for the Colorado and eastern Great Basins

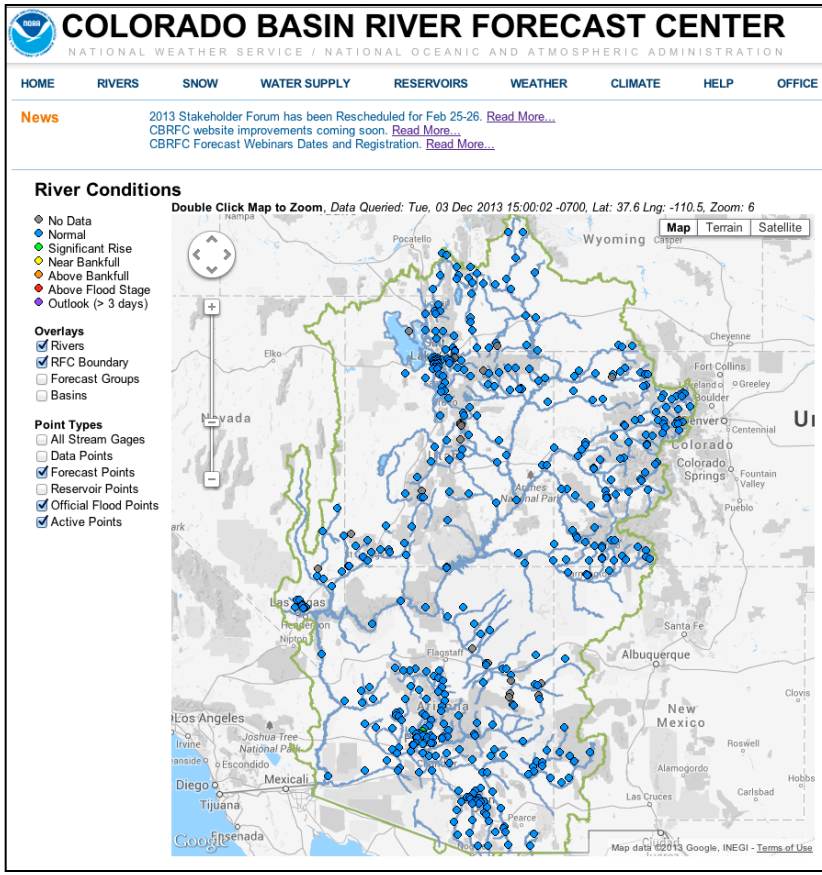
Linking Science to Society



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Colorado Basin River Forecast Center

- The Colorado Basin River Forecast Center (CBRFC) generates streamflow forecasts across the Colorado and Utah. The latest forecasts, data, and more are available online:
  - **Daily streamflow forecasts**
  - **Long lead peak flow forecasts**
  - **Water supply forecasts**
  - **Webinar briefings**
  - **Email updates**
  - **And More….**



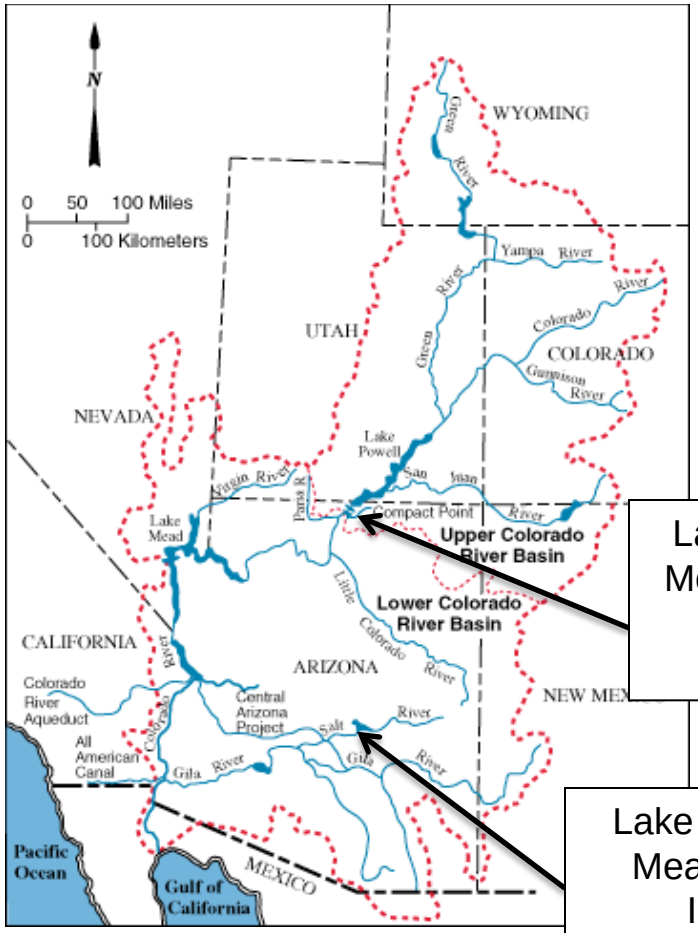
www.cbrfc.noaa.gov

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 15 MAF
- Storage capacity is about 60 MAF (4 times mean annual flow)
- River is fully used and little flows to ocean

Colorado River Basin

- Key Characteristics:
- Mostly semi-arid with average annual precipitation ranging from 3” to 75”
- Runoff dominated by snowmelt from mountains: 85% of runoff comes from elevations above 9000 feet
- Reservoir storage capacity (~60 MAF) is ~4 times mean annual flow (~15 MAF)
- Average annual water demand approximately equal to supply



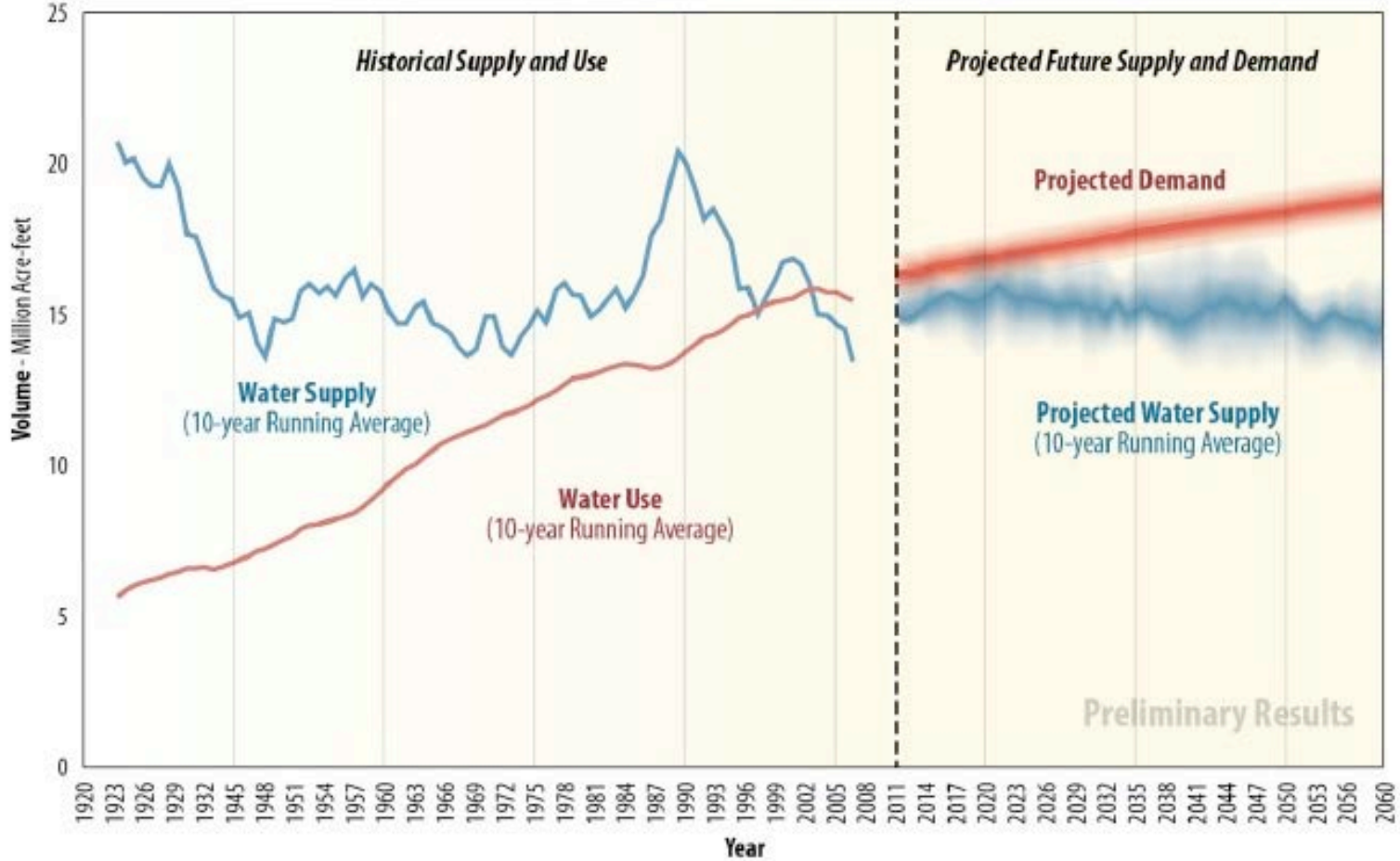
Lake Powell Mean Annual Inflow: ~12 MAF

Lake Roosevelt Mean Annual Inflow: ~0.7 MAF

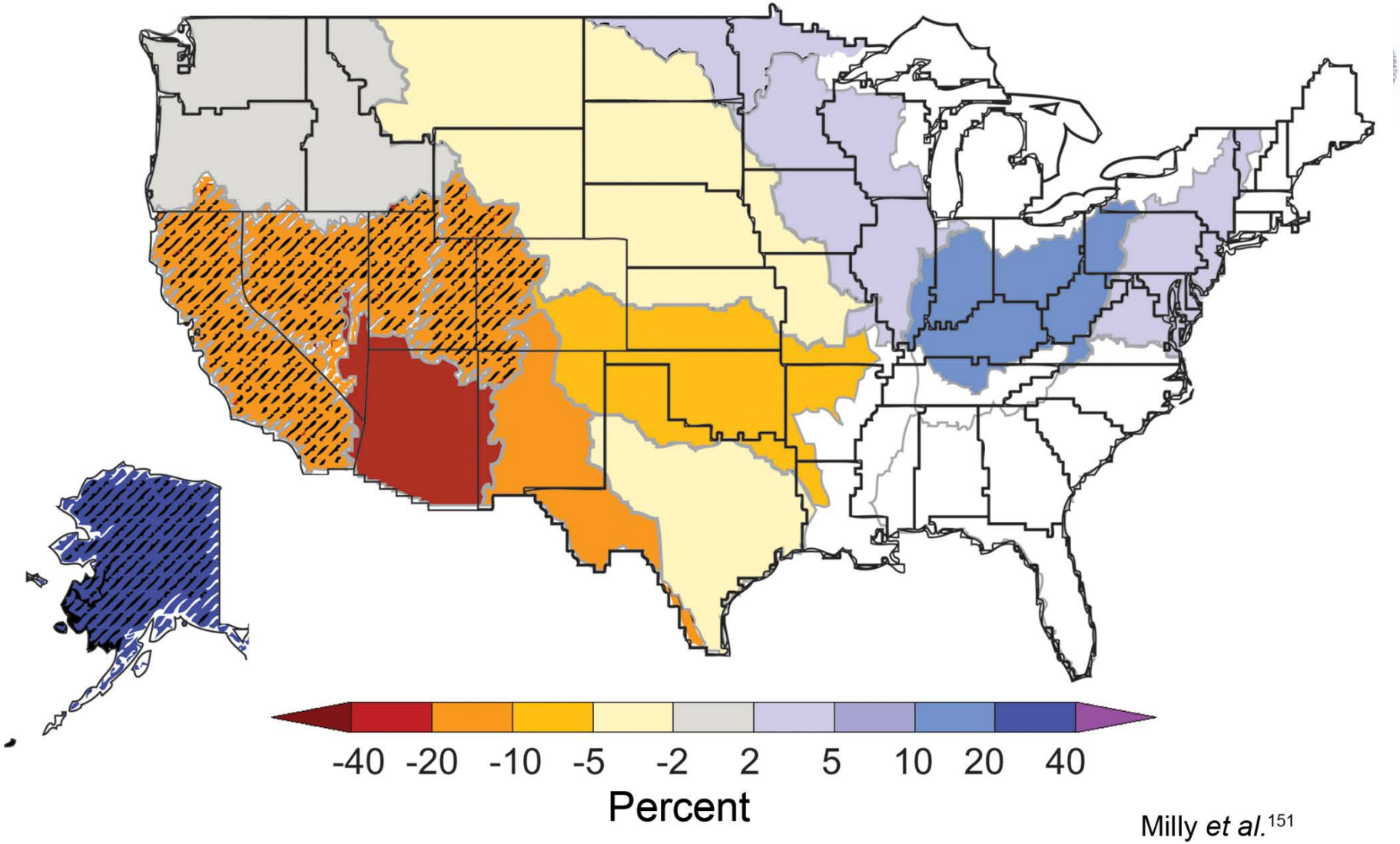
Supply and Demand

FIGURE 2

Historical Supply and Use and Projected Future Colorado River Basin Water Supply and Demand



Credit: USBR



Milly *et al.*[151]

Projected changes in median runoff for 2041-2060, relative to a 1901-1970 baseline, are mapped by water-resource region. Colors indicate percentage changes in runoff. Hatched areas indicate greater confidence due to strong agreement among model projections. White areas indicate divergence among model projections. Results are based on emissions in between the lower and higher emissions scenarios.[91]

$$ Value of Water Supply Forecasts

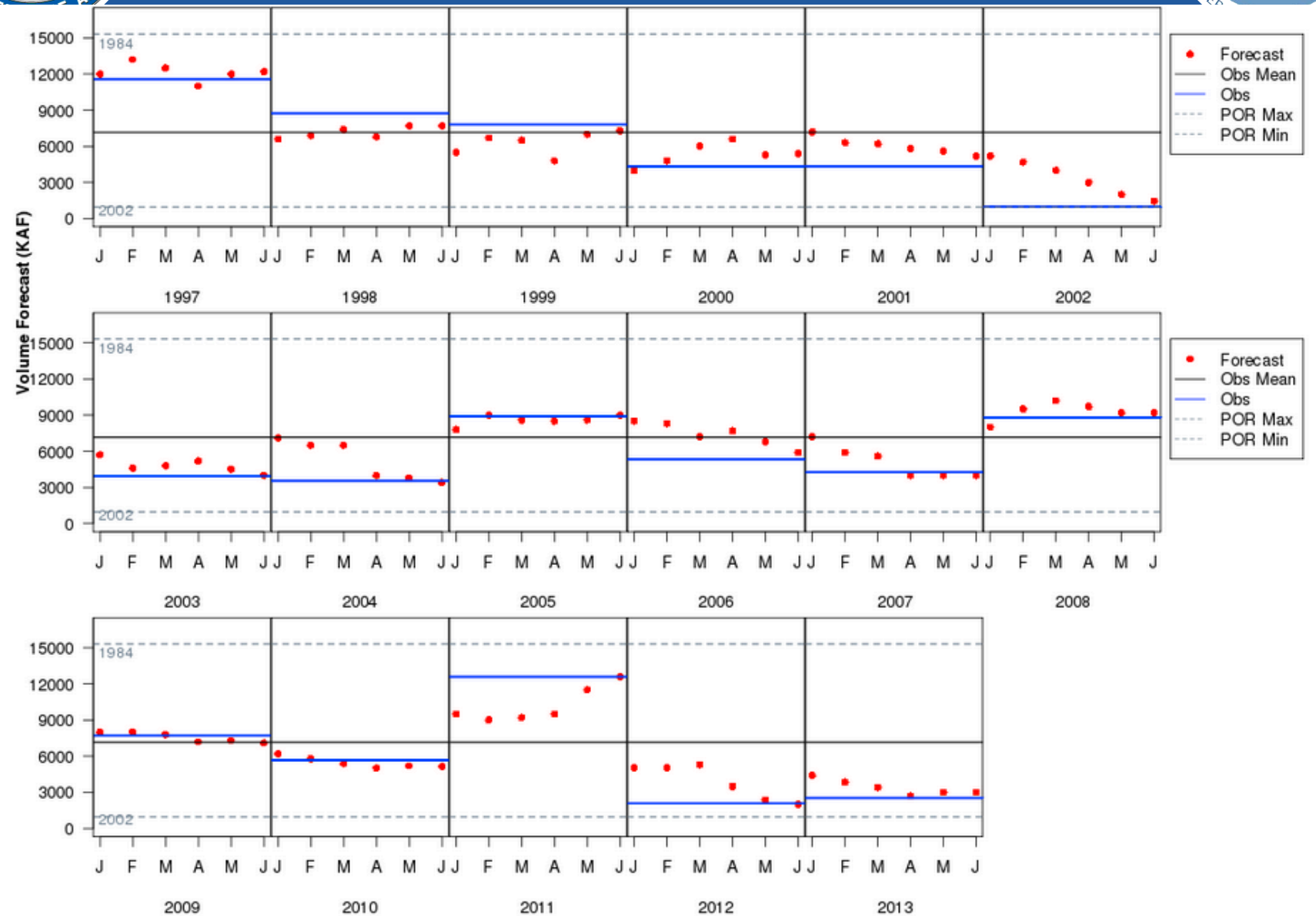
- Damage from 1/10 AZ storm: $11m[a]
- Damage from 6/10 UT flooding: $6.5m[a]
- Damage from 12/10 UT/NV storm: $11m[a]
- Damage from 2011 runoff CO/UT: $5.0m[a]

- Colorado River average annual runoff: 15 MAF
- Replacement value of $200-800/AF -> $3-12b[b]

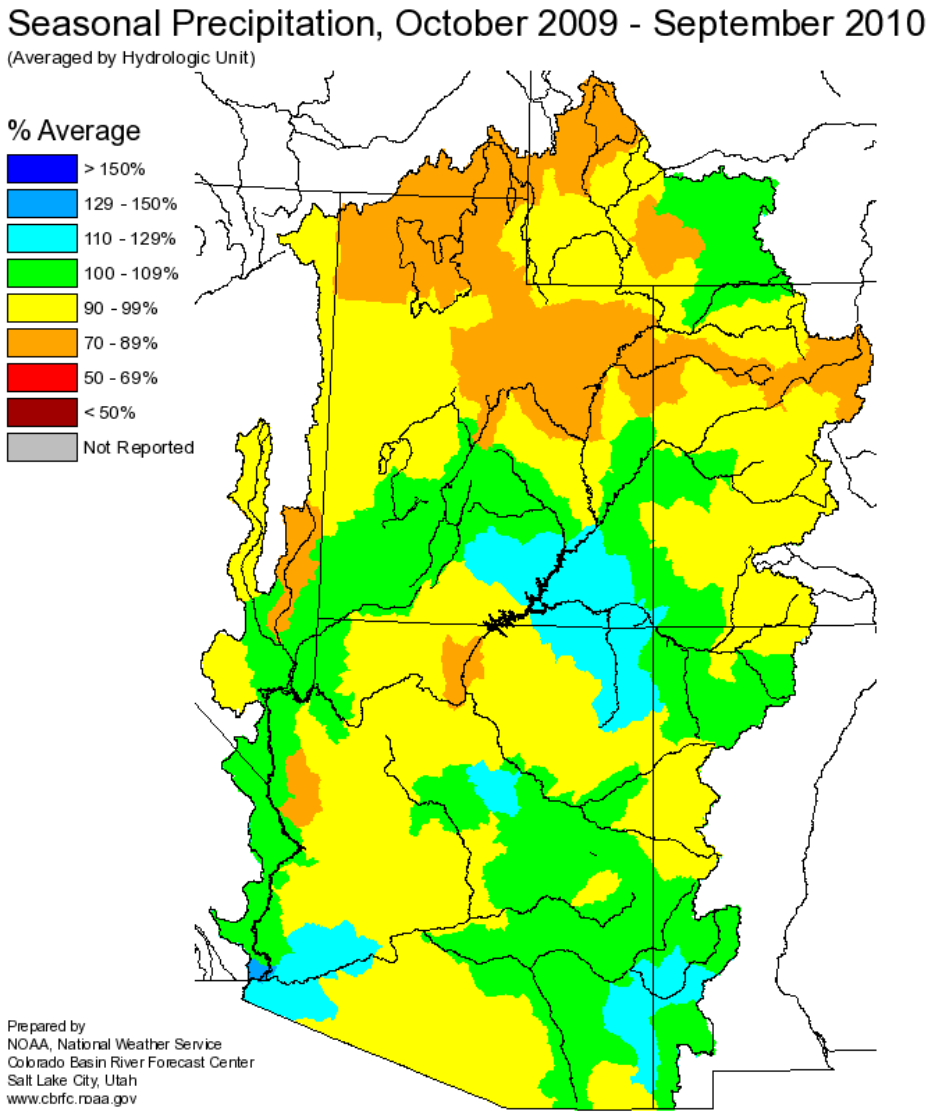
- **Economic value of water resources (every year) far greater than flooding damages

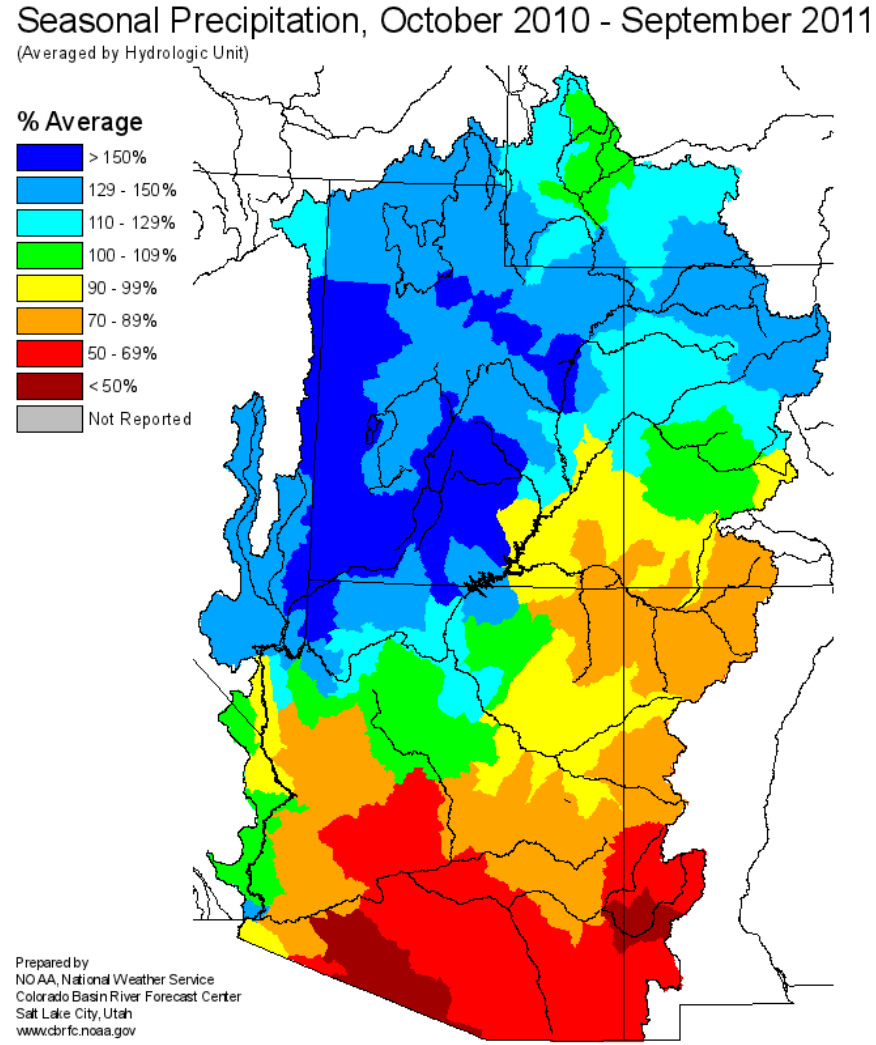
- Sources:
- a: WFO, FEMA (via stormdata); b: Communication with water managers in basin

Lake Powell Inflow



WY2010-2011


Seasonal Precipitation, October 2009 - September 2010
(Averaged by Hydrologic Unit)
% Average
> 150%
129 - 150%
110 - 129%
100 - 109%
90 - 99%
70 - 89%
50 - 69%
< 50%
Not Reported
Prepared by
NOAA, National Weather Service
Colorado Basin River Forecast Center
Salt Lake City, Utah
www.cbrfc.noaa.gov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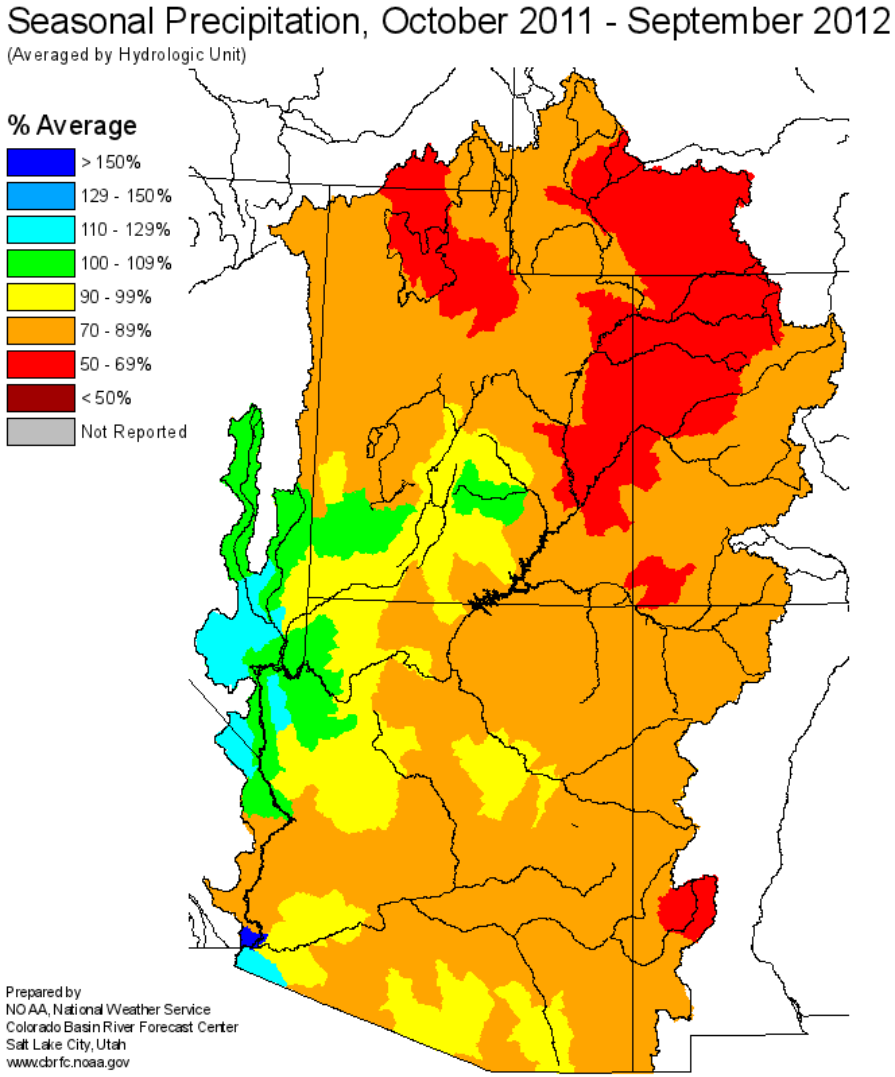
WY2012-2013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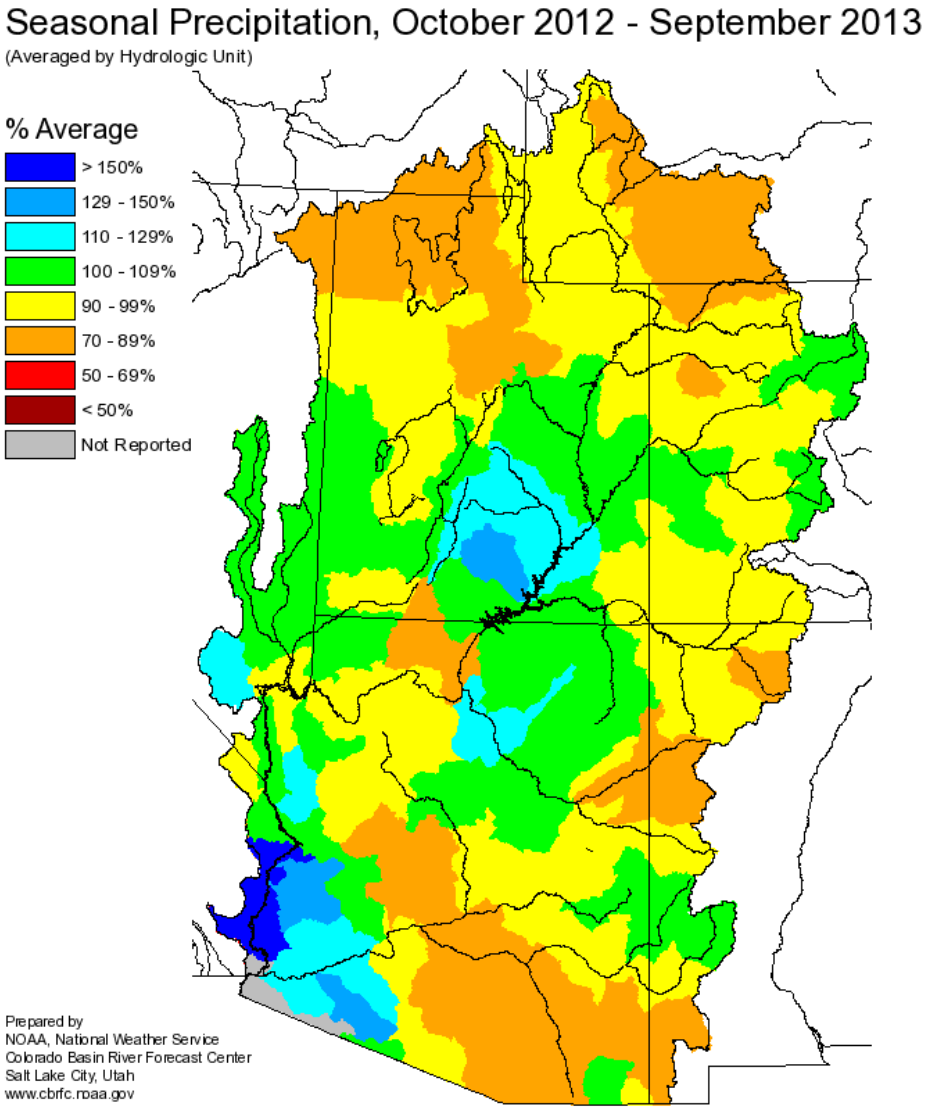
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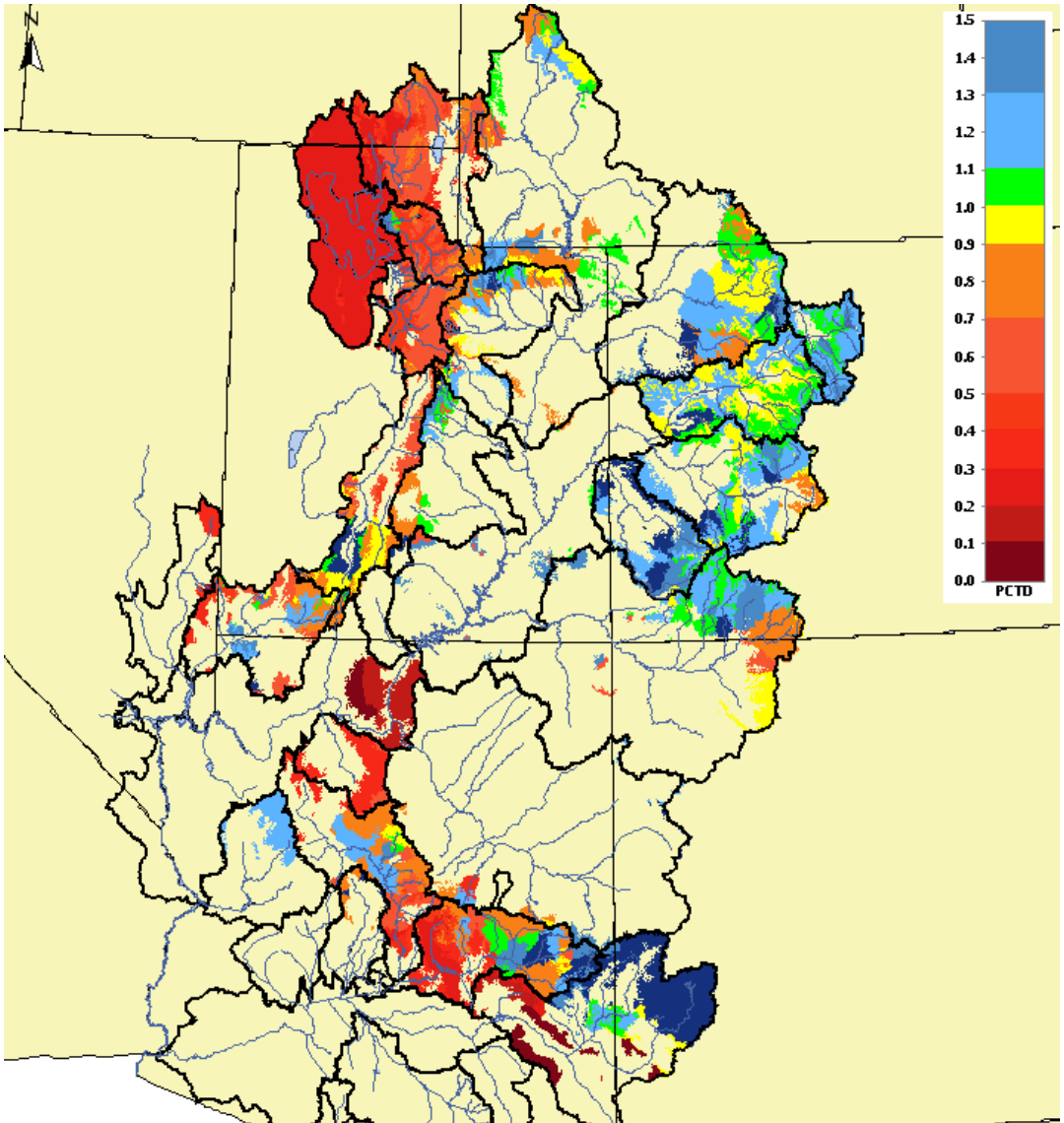
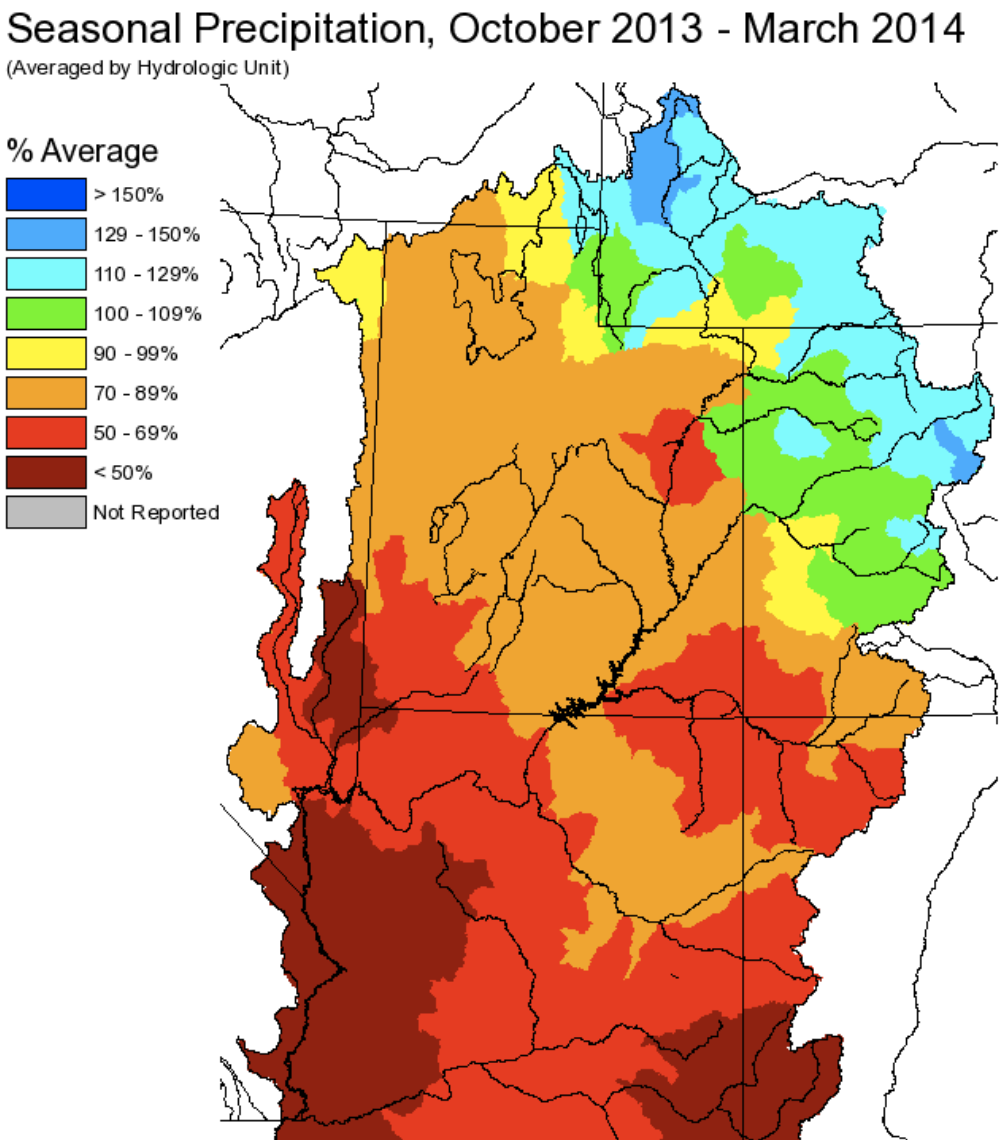
WY14 Soil Moisture



WY14 precip


Seasonal Precipitation, October 2013 - March 2014
(Averaged by Hydrologic Unit)
% Average
> 150%
129 - 150%
110 - 129%
100 - 109%
90 - 99%
70 - 89%
50 - 69%
< 50%
Not Reported

WY14 Snow

Snow Conditions

Data Queried: Thu, 24 Apr 2014 11:05:02 -0600

Help, **Double Click Map to Zoom**, *Lat: 37.6 Lng: -110.5, Zoom: 6*

Search Points

Forecast Group

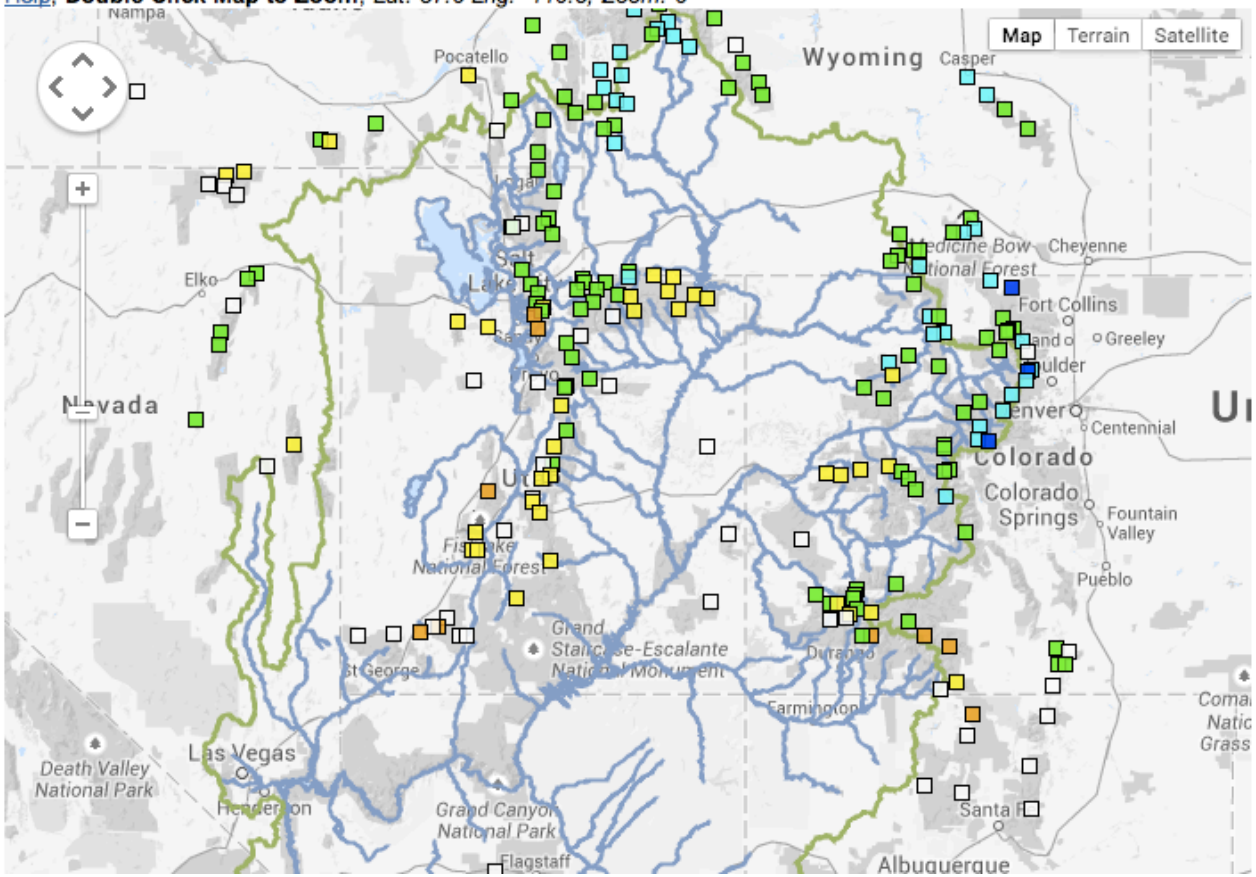
All Points

Overlays

- [x] Rivers
- [x] RFC Boundary
- [ ] Forecast Groups
- [ ] Basins

Snow Sites

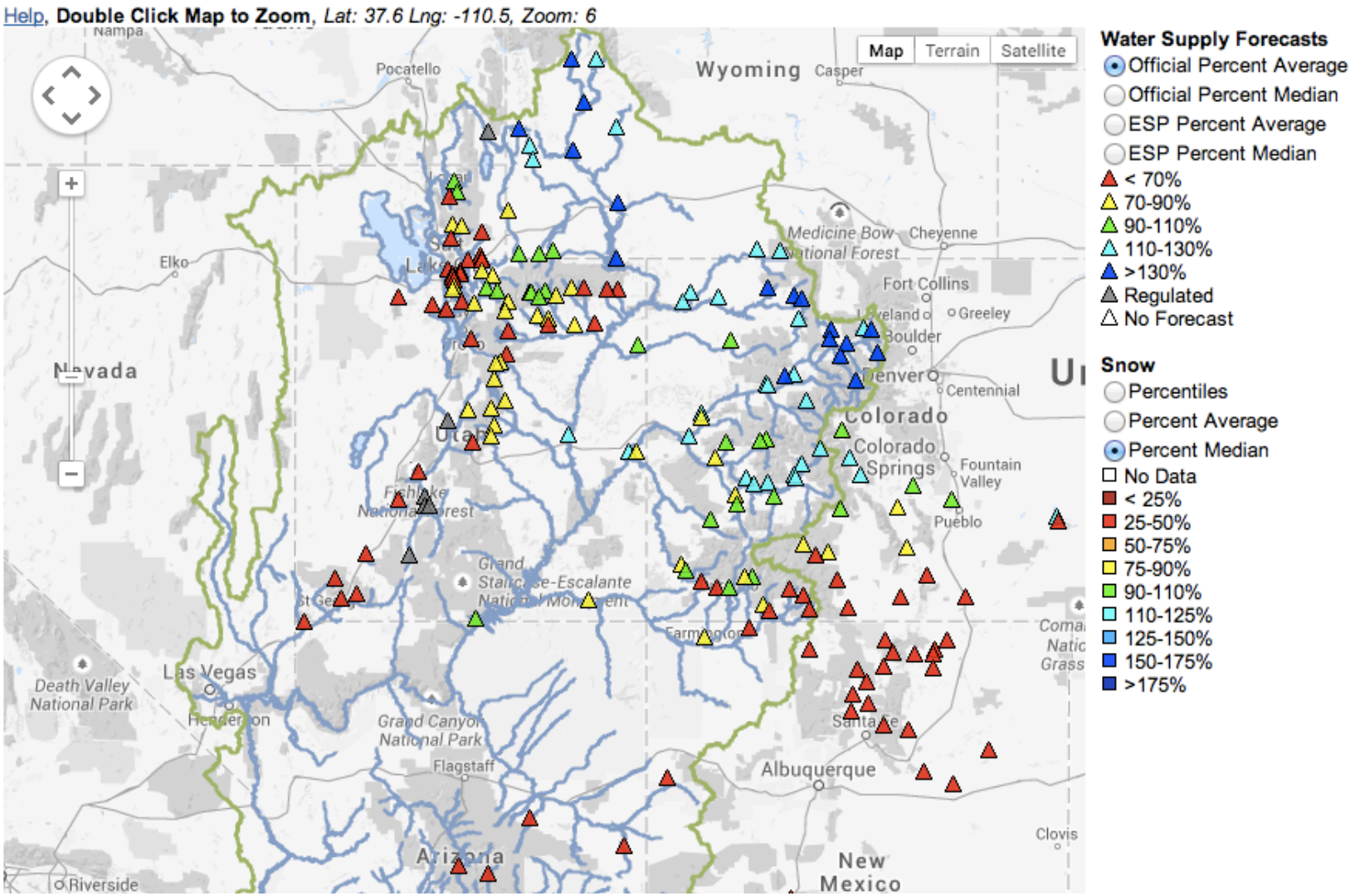
- [ ] All
- [ ] No Data
- [ ] No Average
- [x] < 7000 ft
- [x] 7000-8000 ft
- [x] 8000-9000 ft
- [x] 9000-10000 ft
- [x] > 10000 ft



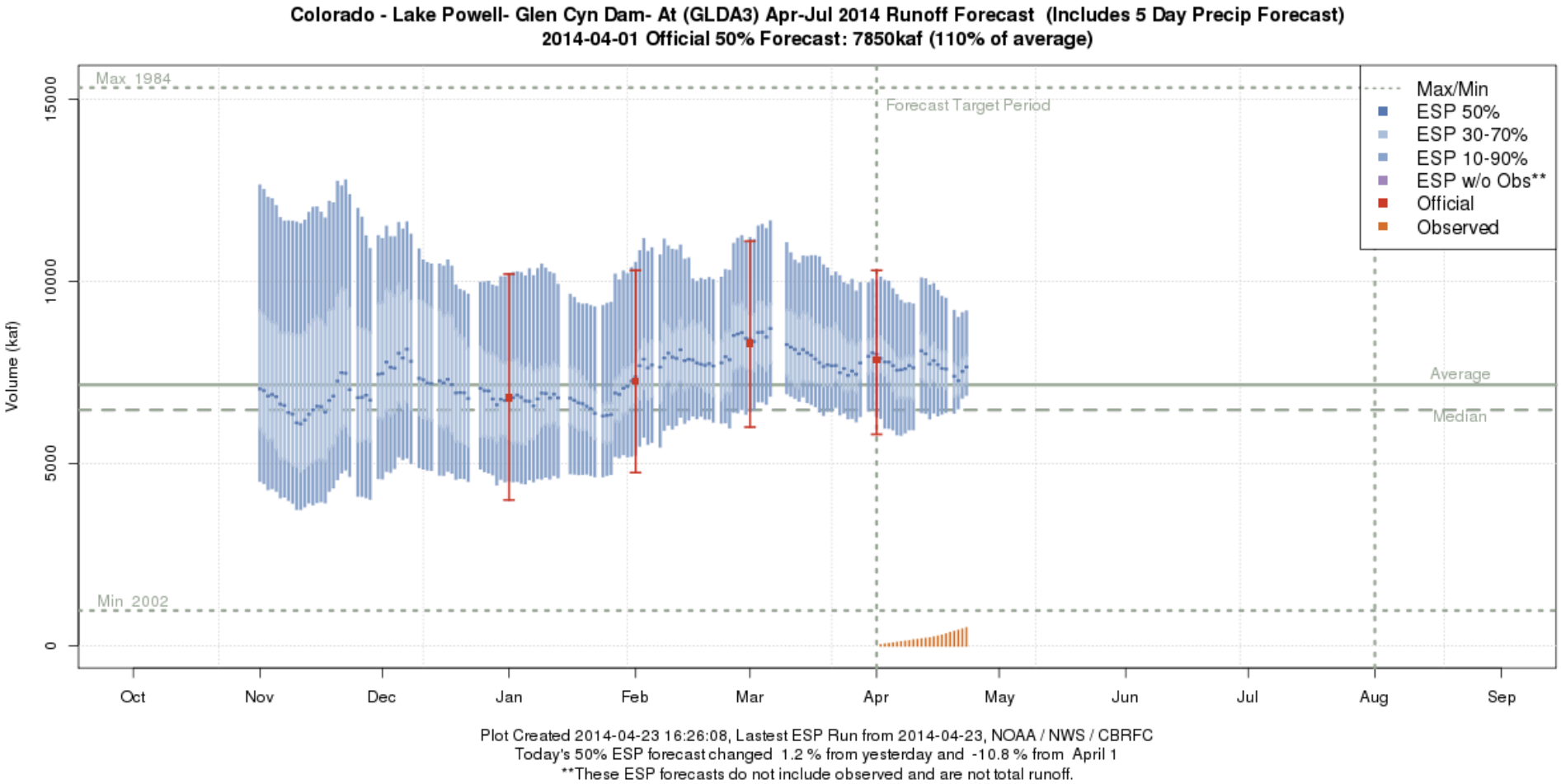
Snow

- (•) Percentiles
- ( ) Percent Average
- ( ) Percent Median
- No Data
- Low
- <10
- 10-25
- 25-75
- 75-90
- >90
- High

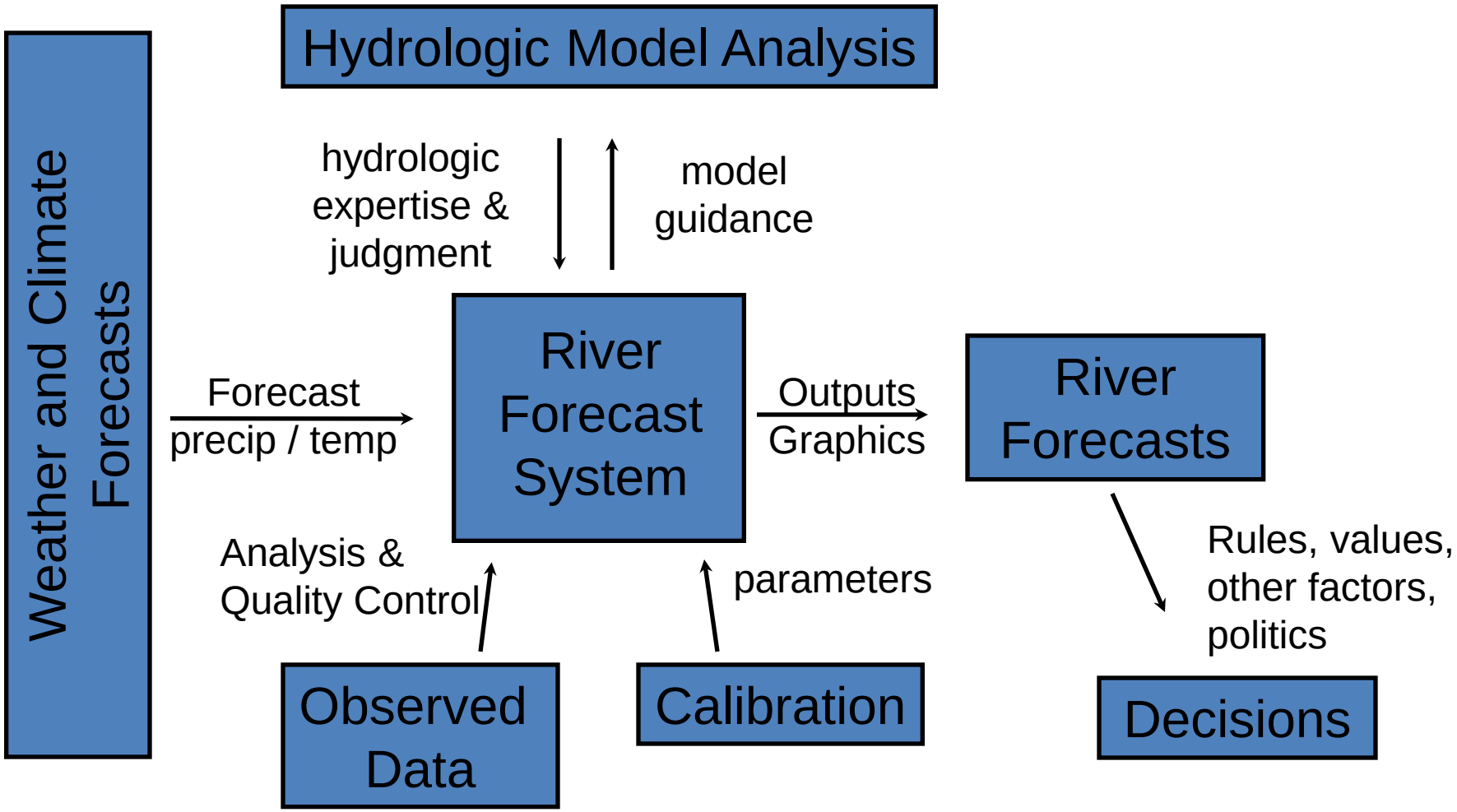
WY14 Forecasts



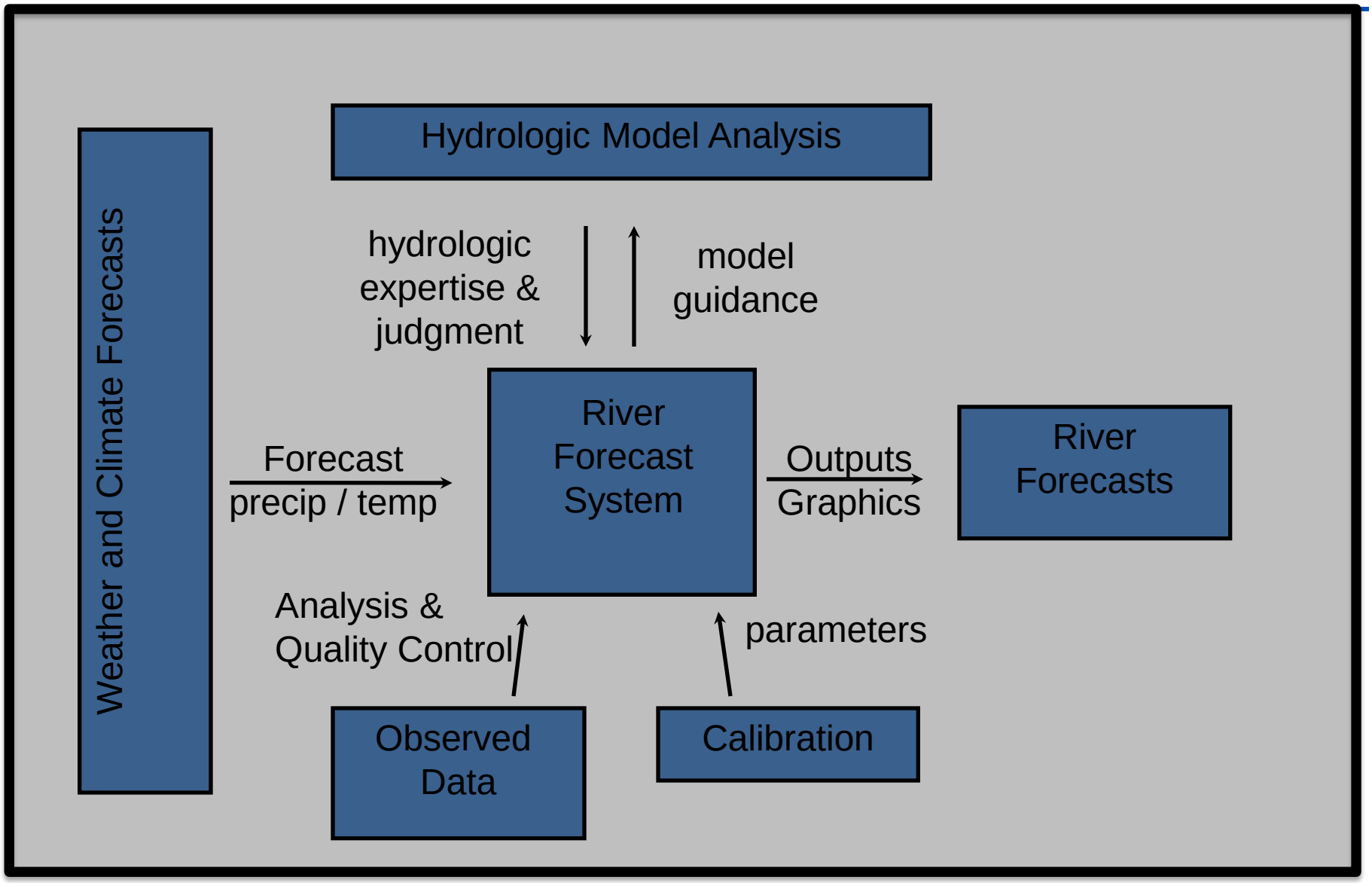
WY14 Forecasts



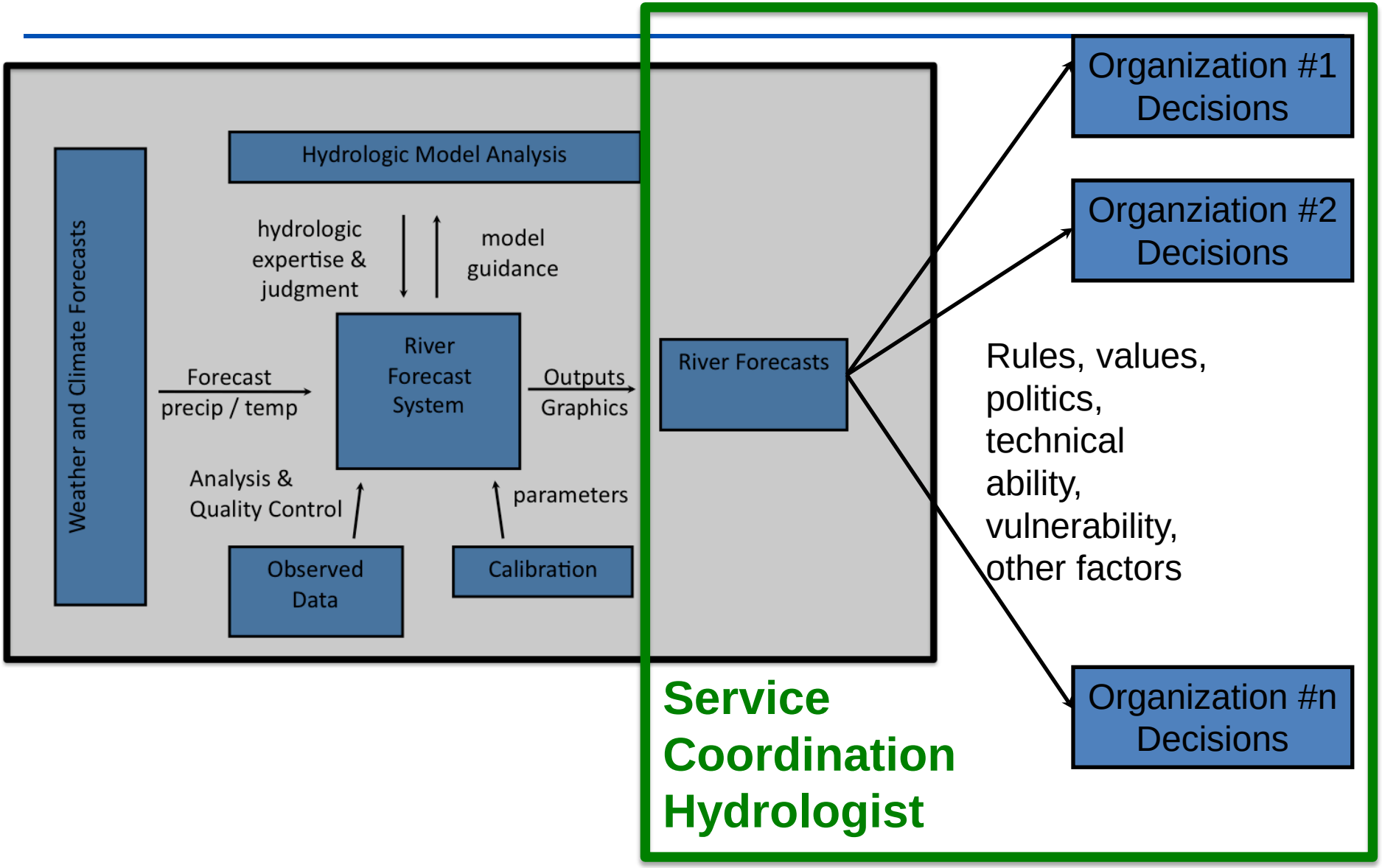
Forecast Process



BLACK BOX


Hydrologic Model Analysis
Weather and Climate Forecasts
hydrologic expertise & judgment
model guidance
Forecast
precip / temp
River Forecast System
Outputs
Graphics
River Forecasts
Analysis & Quality Control
parameters
Observed Data
Calibration

RFC Forecast Process

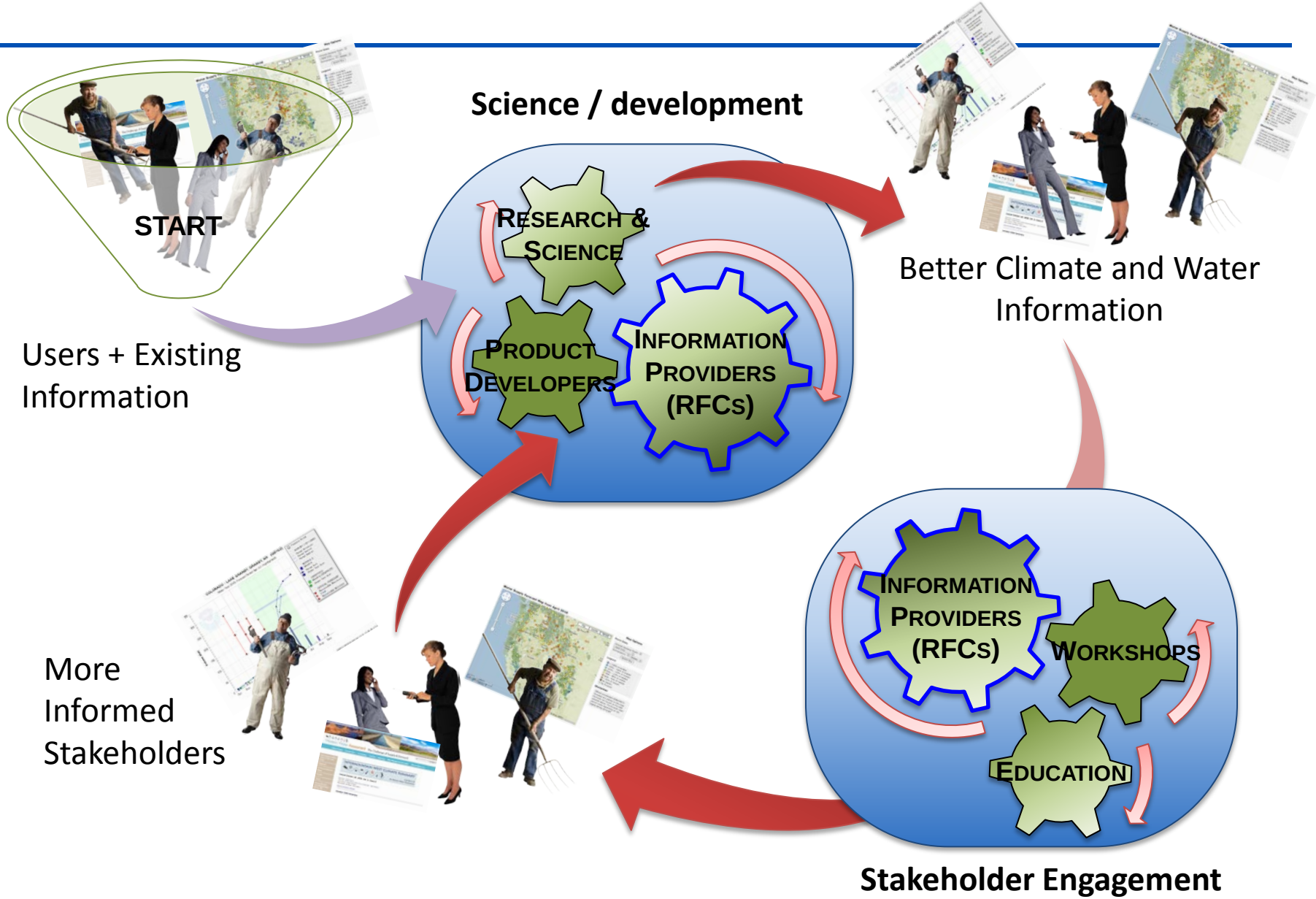


Previous Research on Water Management and Forecast Usage

- **Forecasts generally not used.** Water management agencies value reliability and quality above all else. Unless those are threatened, agencies have little incentive to use forecasts.
- **Forecast use correlates with perceived risk.** Forecast usage not dependent on agency size or on understanding of forecast skill and reliability.
- **Policy and infrastructure in USA limit use of forecasts.** Many operating decisions are tied to observed data and do not allow flexibility.
- **Hopeless?**
- **No!** Long term drought, increasing demands, and climate change projections for less water each present opportunities for increasing forecast usage.

Study	Method(s)	Geographic Area(s)
(Rayner et al., 2005)	Field Research: Semi-structured Interviews	USA: Pacific Northwest, Southern California, and Washington, DC
(O'Connor et al., 2005)	Survey	USA: South Carolina and Susquehanna River Basin of Pennsylvania
(Lemos, 2008)	Field Research: Observation of Meetings	USA and Brazil
(Dow et al., 2007)	Survey (building on earlier work (O'Connor et al., 2005))	USA: South Carolina and Susquehanna River Basin of Pennsylvania
(Callahan & Miles, 1999)	Field Research: Semi-structured interviews	USA: Pacific Northwest
(Ziervogel et al., 2010)	Case Study	South Africa
(Pulwarty & Redmond, 1997)	Field Research: Semi-structured interviews	USA: Pacific Northwest

Strategy: Integrated and Iterative



CBRFC Strategies

- **Science and Development**
  - Implement new modeling software (CHPS)
  - Enhance ensemble forecast capabilities (HEFS, CU SARP weather generator project)
  - Improve model ET (NIDIS post doc)
  - Test new snow models (RISA/WWA, USU, NASA)
  - Test new snow data (NASA)

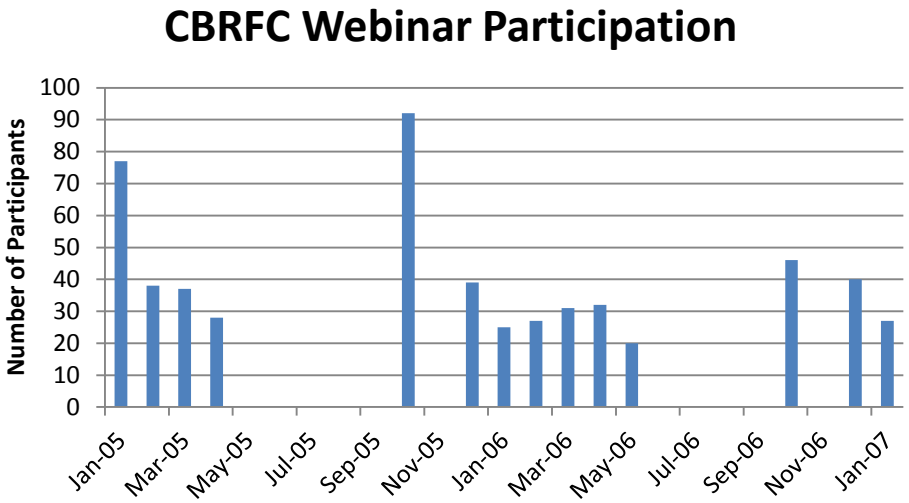
- **Stakeholder Engagement**
  - Annual stakeholder forums
  - Monthly water supply and peak flow forecast webinars
  - Stakeholder scenario workshops (RISA/WWA and CLIMAS)
  - Decision support system development (USBR, Denver water, and SARP

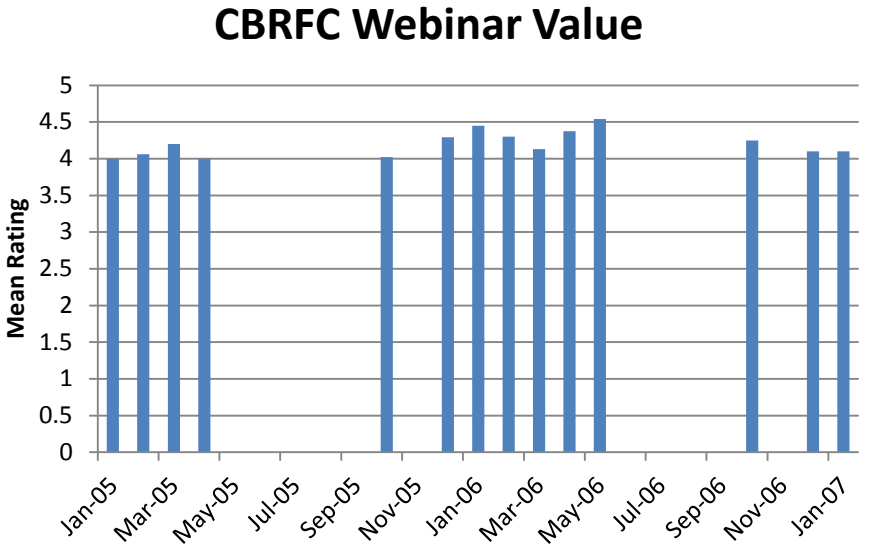
CBRFC Stakeholder Forum

- 2-3 Day Annual Meeting
- Participants from all over CO basin attended
- Main focus on science and forecast needs within basin
- Key requirements from forum:
  - Simple ways to communicate forecasts relative to important thresholds
  - Post-mortems
  - More info on the 30 year average update
  - Objective water supply forecast system
  - Greater CBRFC participation in stakeholder meetings
  - 2 year forecast for Colorado
  - Greater transparency in forecast process
- Full reports online (under papers and presentations -> reports)

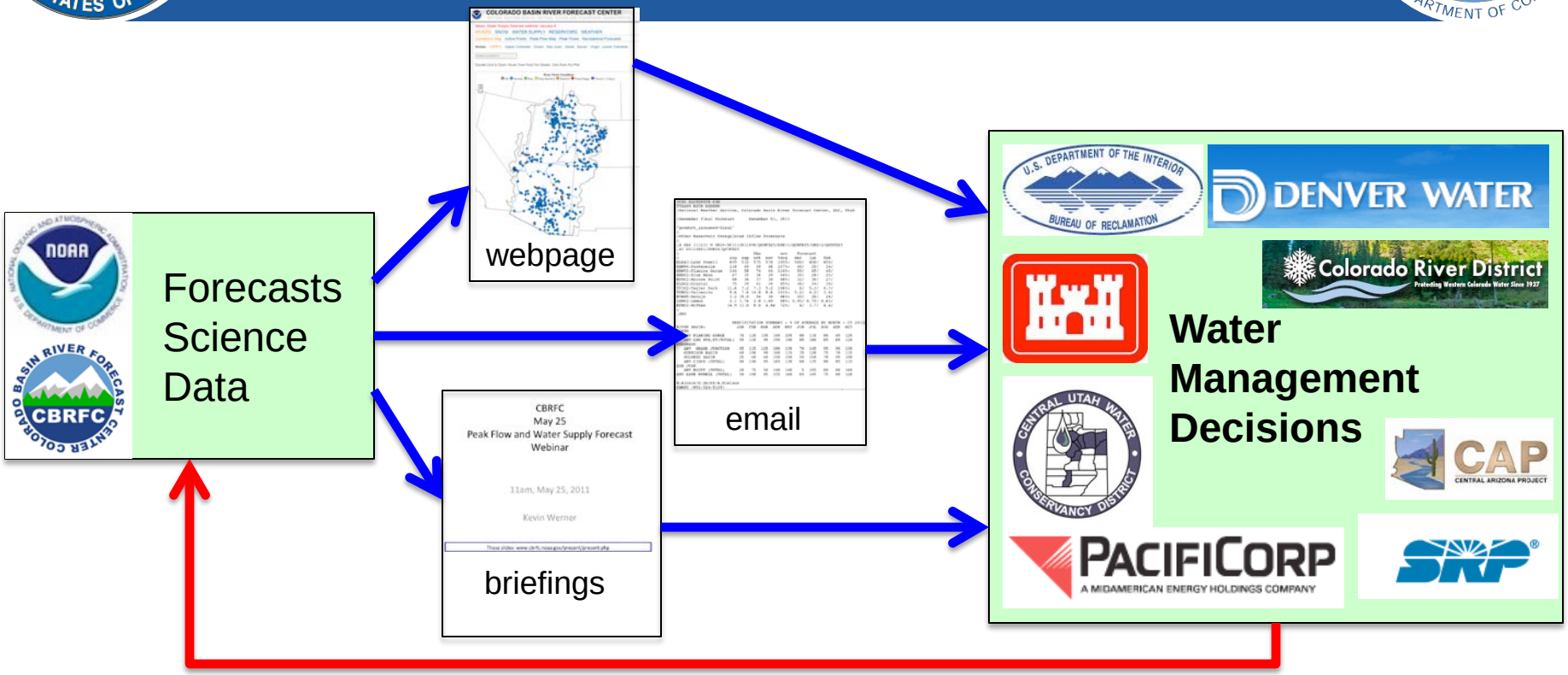
CBRFC Webinars

- Monthly webinars discuss water supply and peak flow forecasts January through June
- Annual webinar to review previous year and look ahead to next
- Started in February 2009
- Poll participants each time
- Recently started central Utah specific webinar
- Results:
  - Participation ebbs and flows with climate
  - Stakeholders value forecast verification
  - Stakeholders value climate and streamflow forecasts that are connected
  - Stakeholders value discussion time





Scenario Study: Motivation



How effective are forecasts in informing water management decisions?

- Forecast information transmission?
- Effective forecast products and tools?
- Meeting forecast information requirements?
- Feedback and iteration with decision makers?

National Weather Service

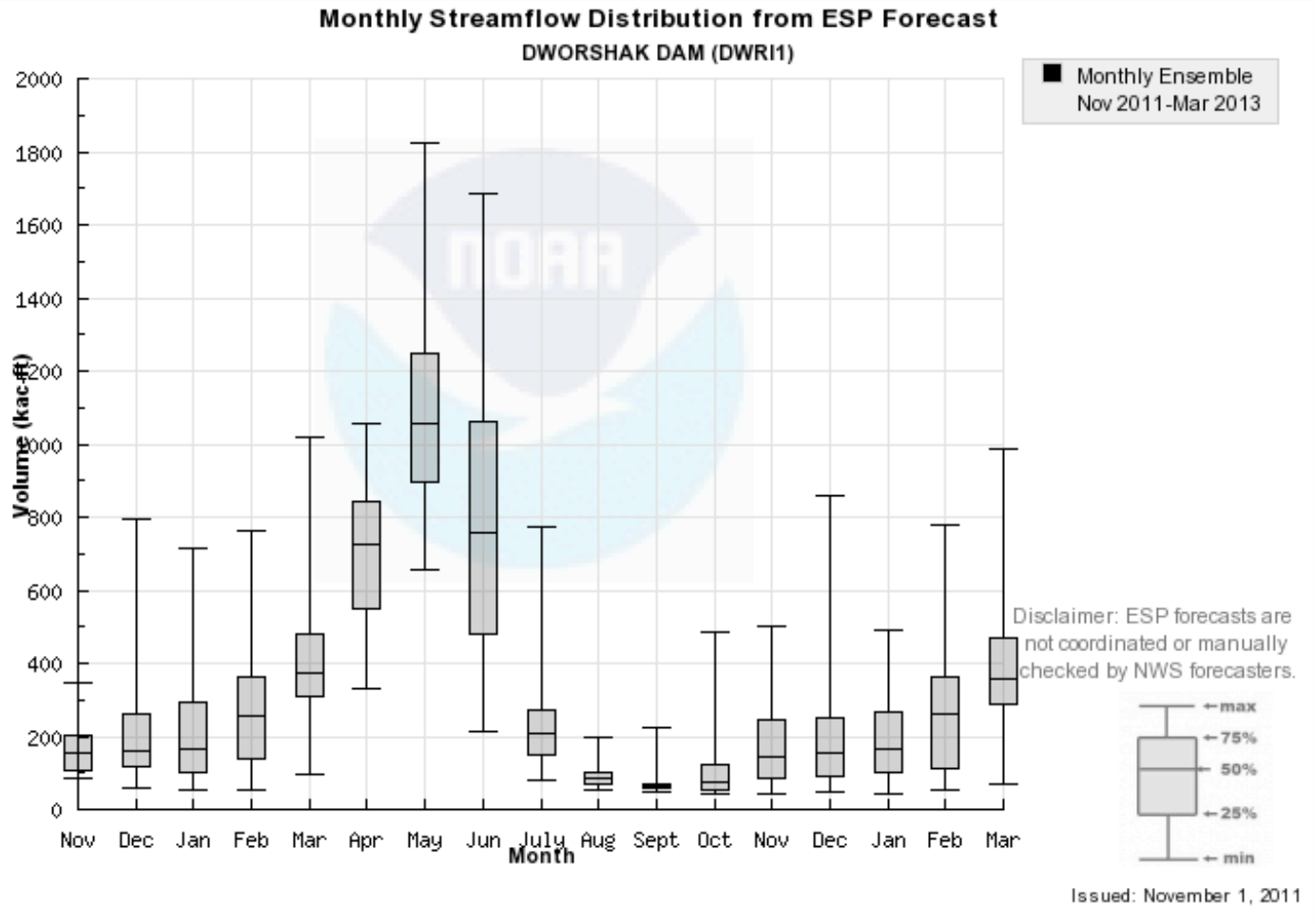
National Water Resources Outlook

Home Maps Points Help

Summary | Ensemble Plot | Forecast Evolution Plot | Forecast Ranking Table | Climate Variability | Forecast Verification | Data Checkout

Ensemble Plot

Nf Clearwater River at Dworshak Dam, Idaho (DWRI1 / NWRFC)



Need Help?

Graph Options

Forecasts

Current Forecast
November 1, 2011

- [ ] Forcing Year
- [ ] ENSO Biased Forecast

Archives

- [ ] Average Runoff
- [ ] Historical Observations

Season Options

Seasonal Constraints
Sept 12 to Mar 13

- (•) Monthly
- ( ) Accumulation

Link to this page/plot

Source: wateroutlook.nwrfc.noaa.gov

National Weather Service

National Water Resources Outlook

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Ensemble Plot

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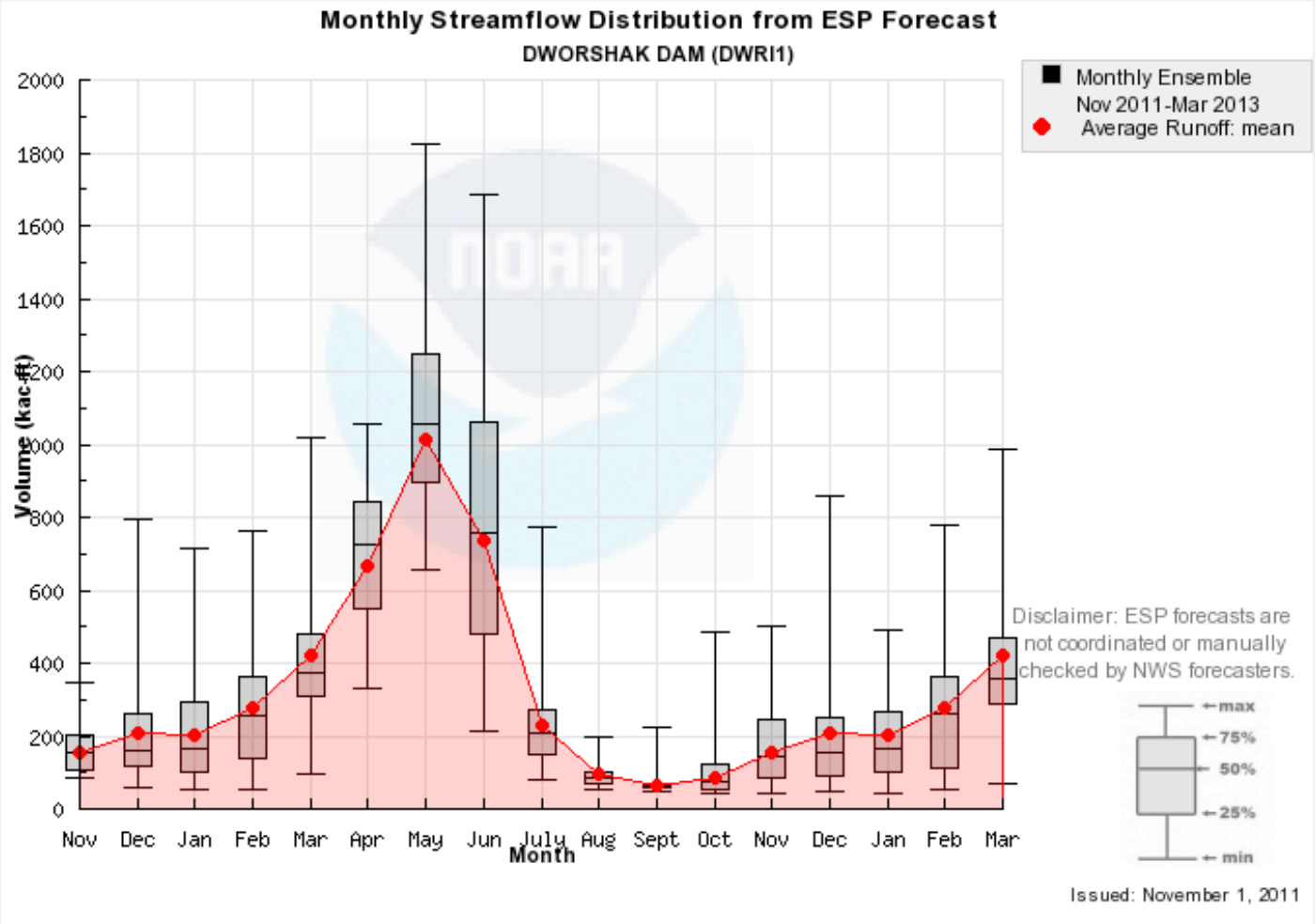


Need Help?

Graph Options

Forecasts

Current Forecast: November 1, 2011

☐ Forcing Year

☐ ENSO Biased Forecast

Archives

☑ Average Runoff: Mean

☐ Historical Observations

Season Options

Seasonal Constraints: Nov 11 to Mar 13

◉ Monthly

○ Accumulation

Link to this page/plot

National Weather Service

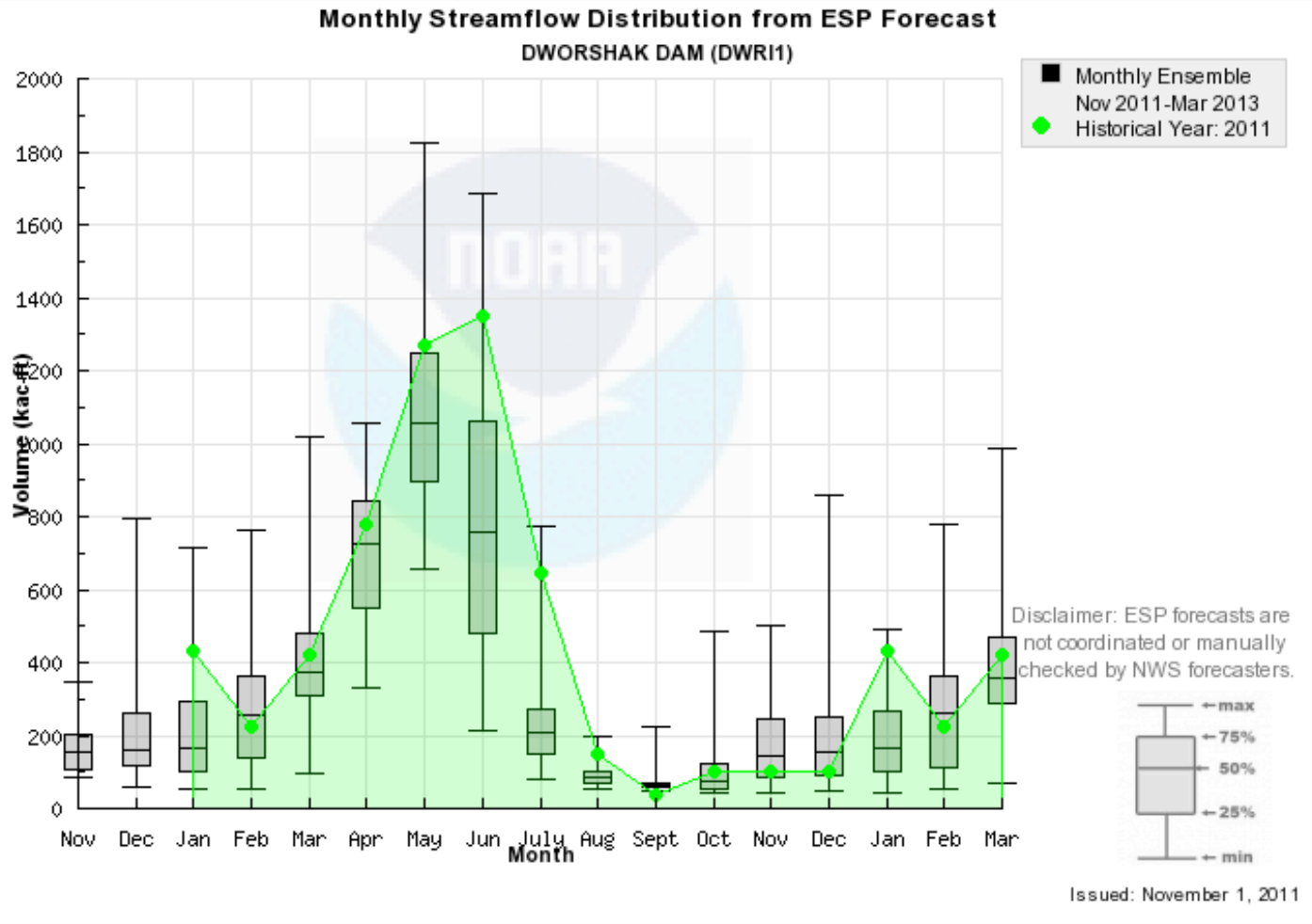
National Water Resources Outlook

Home Maps **Points** Help

Summary **Ensemble Plot** Forecast Evolution Plot Forecast Ranking Table Climate Variability Forecast Verification Data Checkout

Ensemble Plot

Nf Clearwater River at Dworshak Dam, Idaho (DWRI1 / NWRFC)



Need Help?

Graph Options

Forecasts

Current Forecast
November 1, 2011

☐ Forcing Year

☐ ENSO Biased Forecast

Archives

☐ Average Runoff

☑ Historical Observations
2011 Off

Season Options

Seasonal Constraints
Nov 11 to Mar 13

◉ Monthly

○ Accumulation

Link to this page/plot

National Weather Service

National Water Resources Outlook

Home | Maps | **Points** | Help

Summary | **Ensemble Plot** | Forecast Evolution Plot | Forecast Ranking Table | Climate Variability | Forecast Verification | Data Checkout

Ensemble Plot

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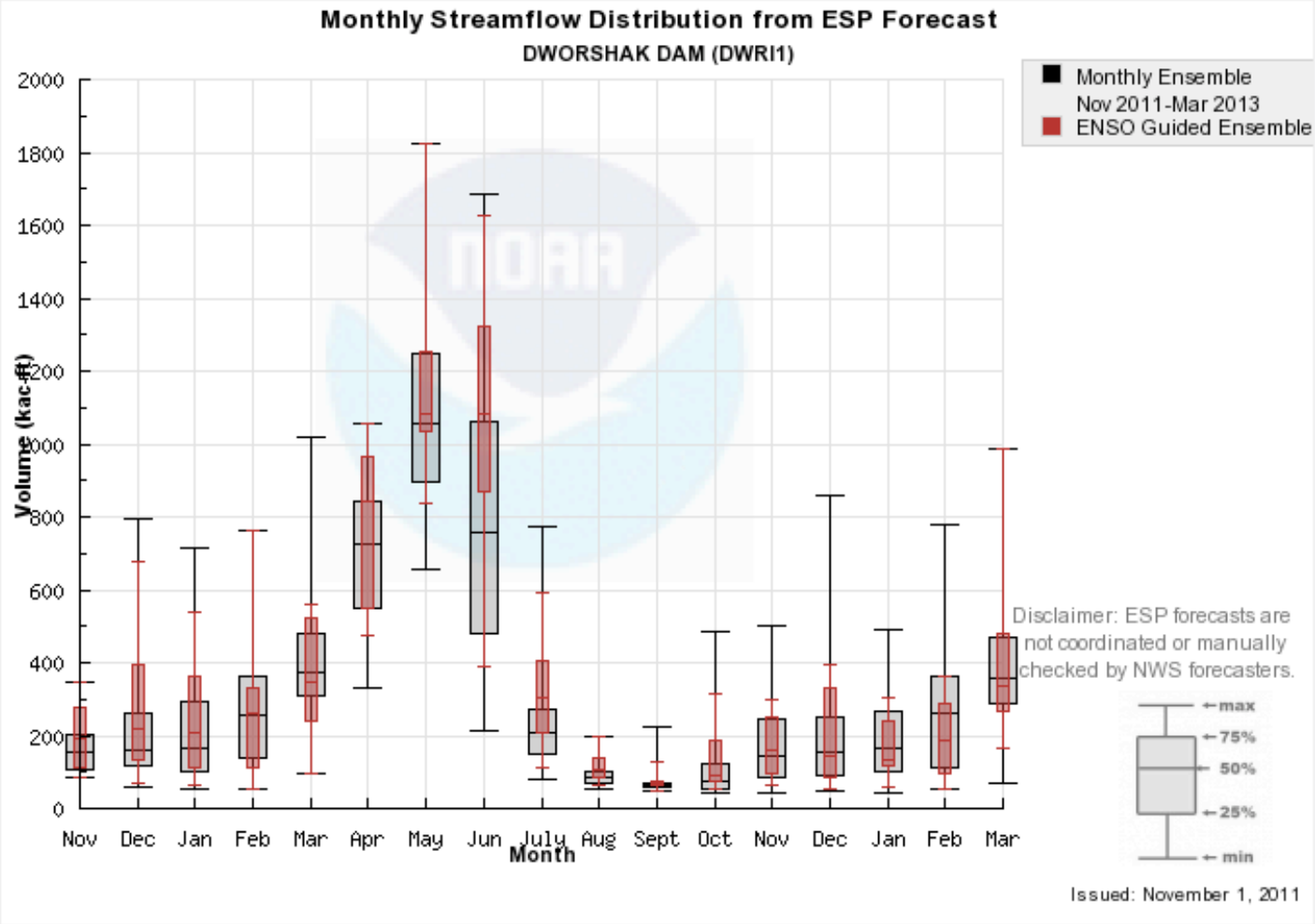


Need Help?

Graph Options

Forecasts

Current Forecast
November 1, 2011

☐ Forcing Year

☑ ENSO Biased Forecast
La Nina | All

Archives

☐ Average Runoff

☐ Historical Observations

Season Options

Seasonal Constraints
Nov 11 to Mar 13

◉ Monthly
○ Accumulation

Link to this page/plot

Forecast Application

- Previous research and personal experience show forecasts, especially ensemble forecasts, are seldom used
- When used, forecasts use is motivated more by risk perception than forecast skill or applicability

- **Question: How do decision makers incorporate forecast uncertainty?**

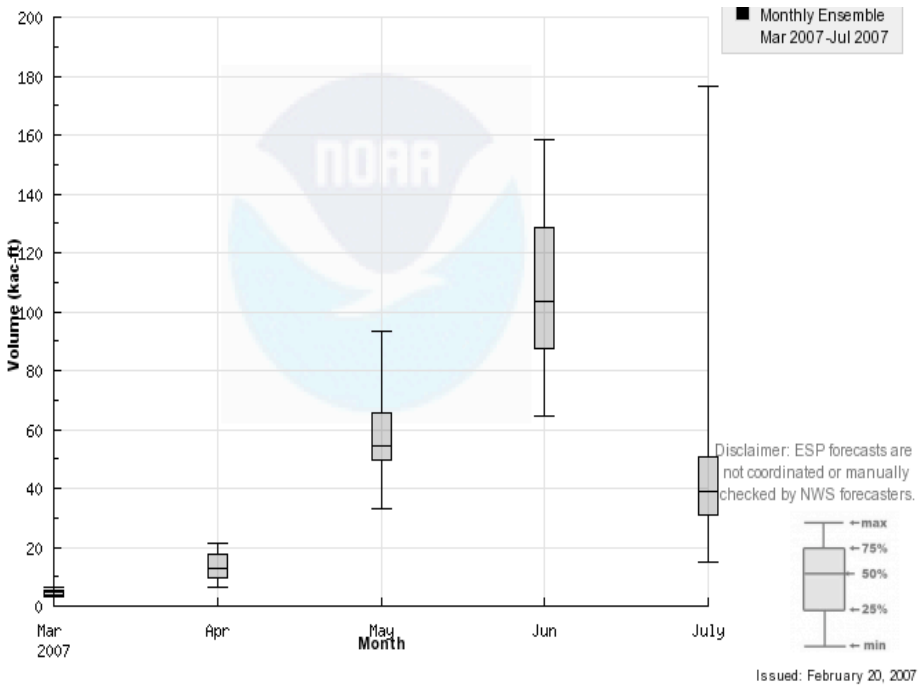
Reservoir Operation Scenario: Method

- Participants given a series of forecasted monthly reservoir inflows (i.e. on right)

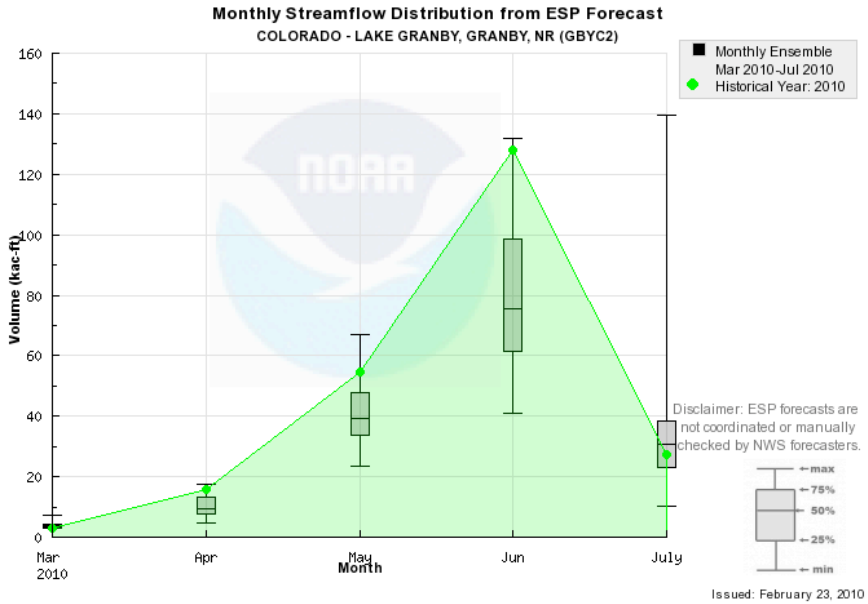
- As simulated time passes, participants given monthly observed inflow and new forecast each month

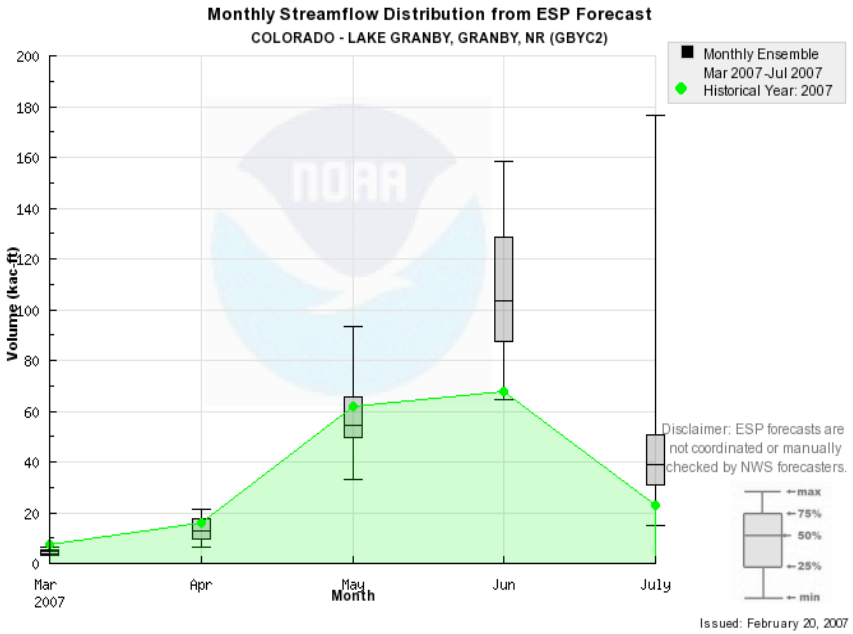
- Participants generate new release schedule each month:
  - Must release between 15 and 60 kac-ft per month
  - Reservoir must not overtop
  - "Winner" has highest ending level without overtopping

- Conducted at workshops:
  - AMS Annual Meeting Short course
  - Utah Stakeholder Meeting
  - NWS Training



Reservoir Operations Scenario

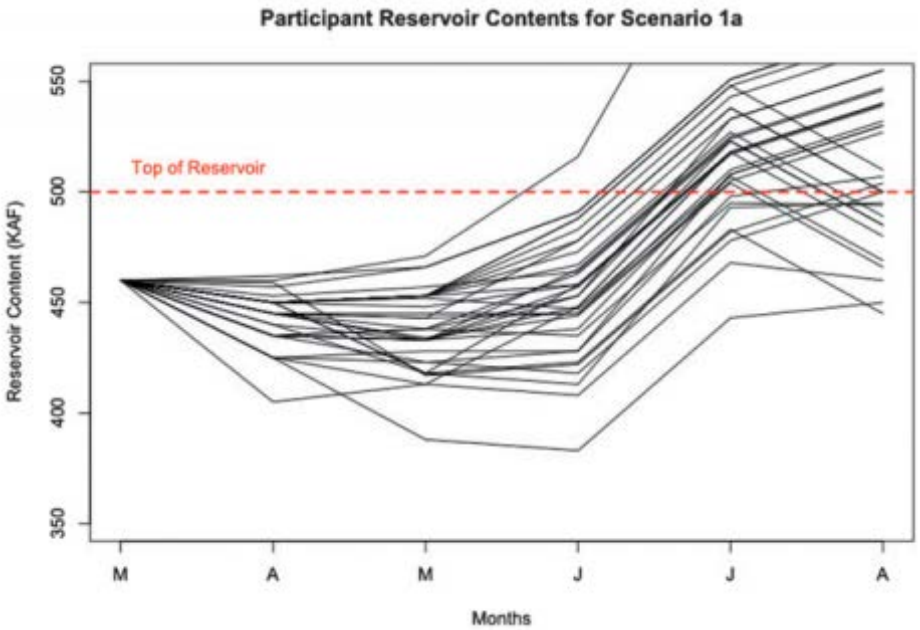


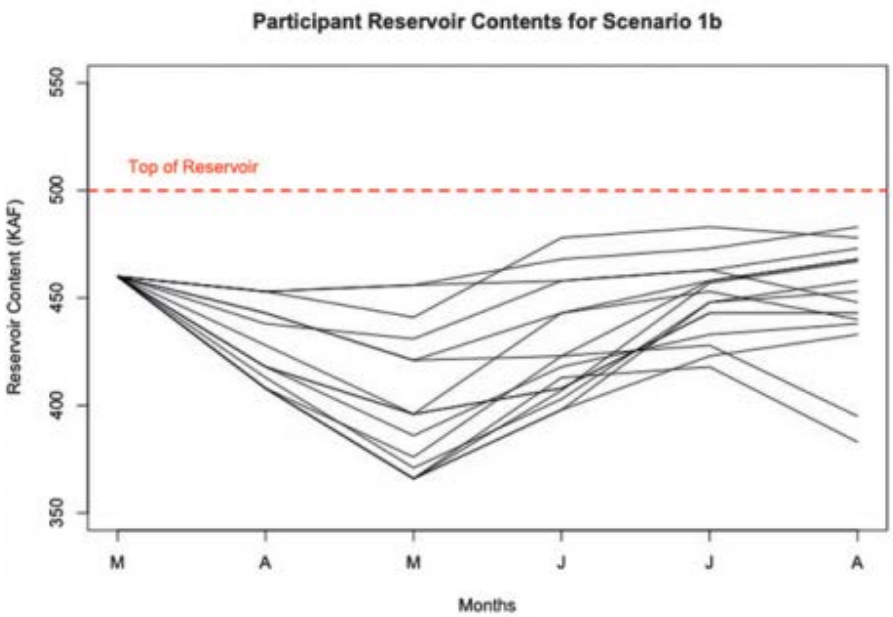


Group 1a:
Actual forecasts for Lake Granby 2010
Underforecast peak flow (June)

Group 1b:
Actual forecasts for Lake Granby 2007
Overforecast June and July volumes

Results





Underforecast scenario

26% of participants proposed sufficient releases on March 1

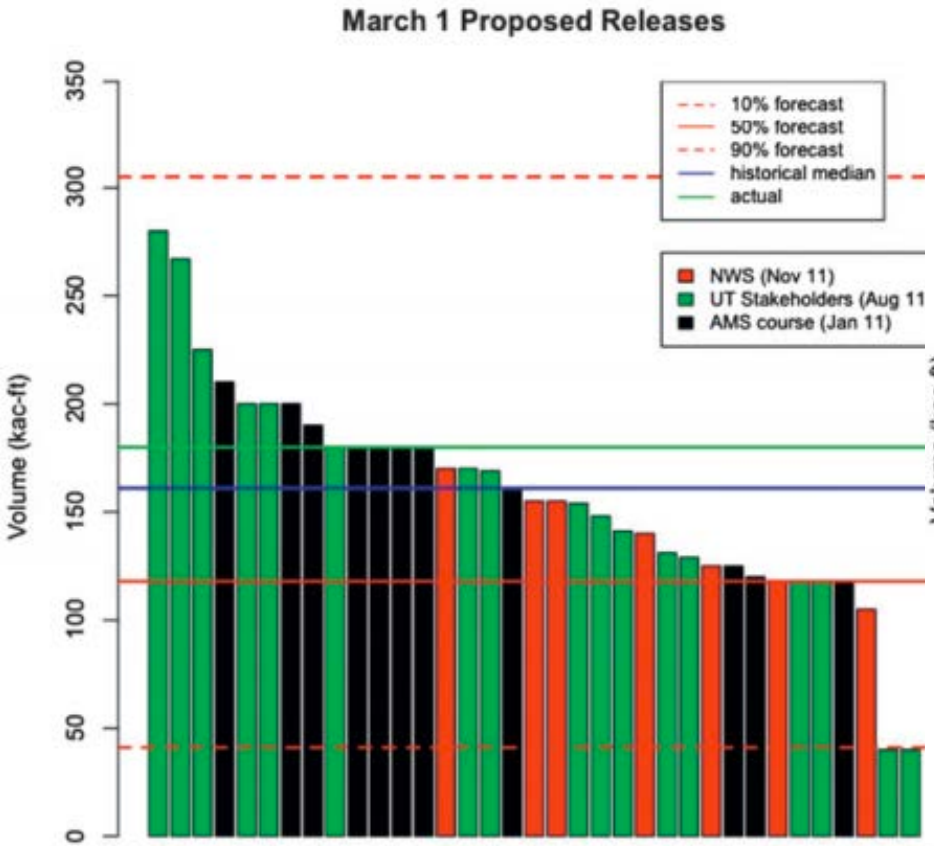
40% of participants implemented sufficient releases

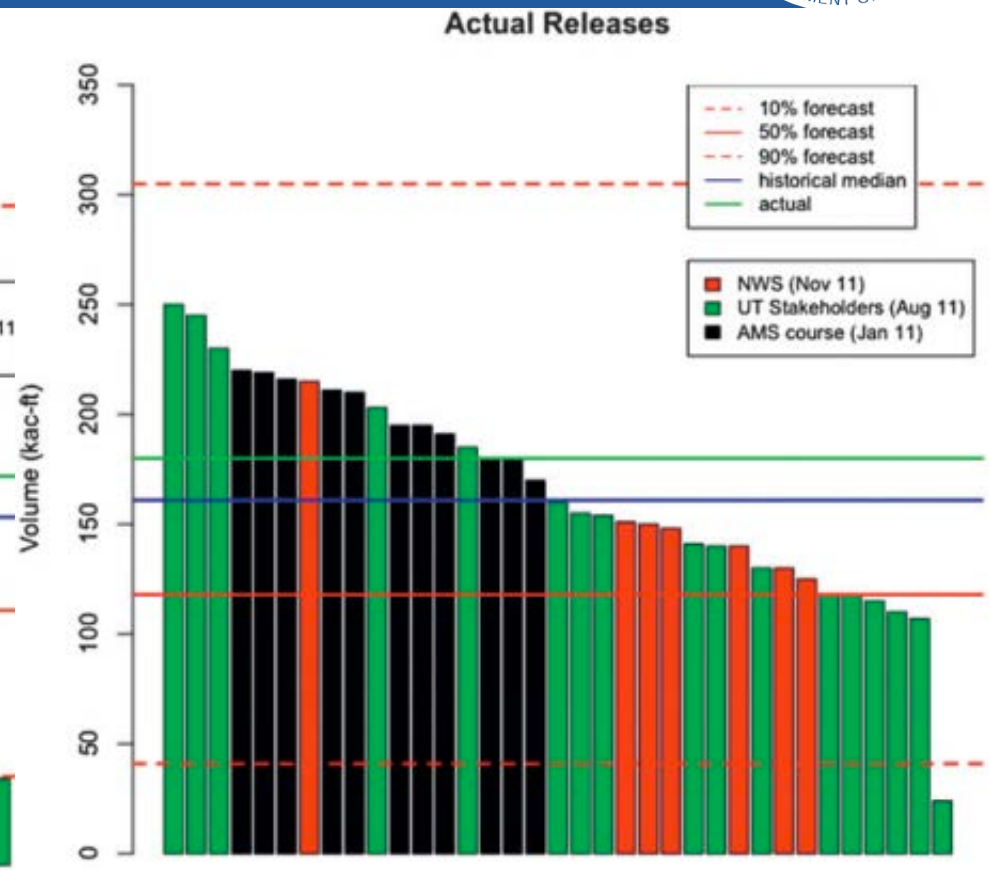
Overforecast scenario

88% of participants proposed sufficient releases on March 1

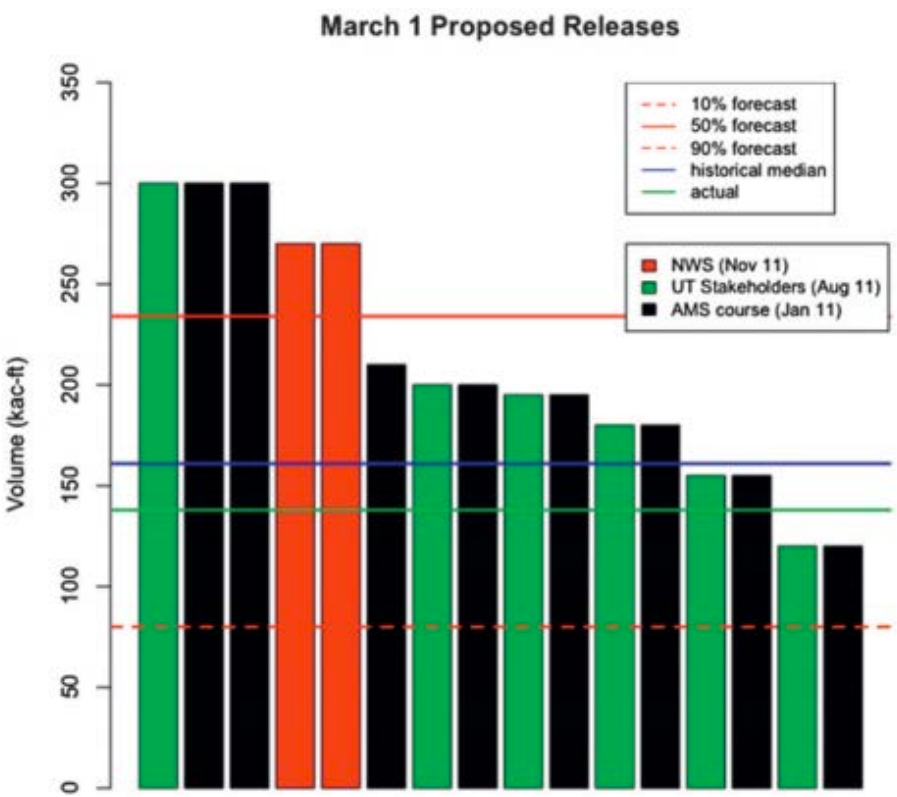
100% of participants implemented sufficient releases

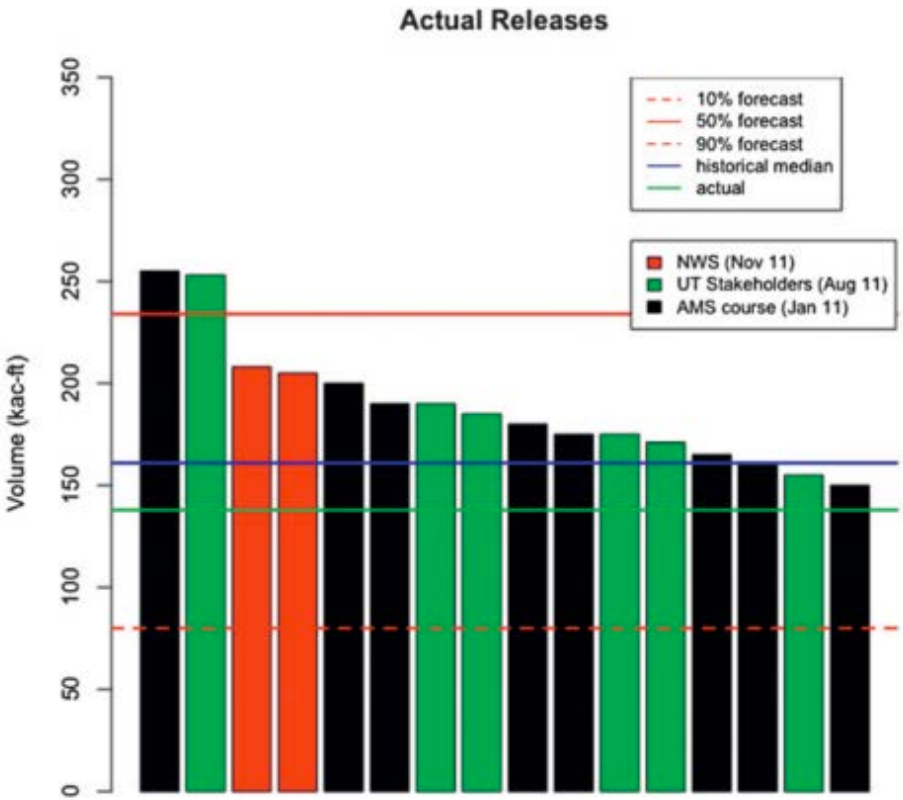
Results: Scenario 1a





Results: Scenario 1b





Results

•Scenario 1a:

- Observed inflow was near the top of the forecast distribution.
- Most participants took a “wait and see” attitude choosing not to draw reservoir down early.
- Almost no one planned for the worst cast scenario choosing instead the median forecast and/or historical median inflow to plan from.
- An objective decision support tool could significantly add value to this decision making process.

•Scenario 1b:

- Observed inflow was near the bottom of the forecast distribution.
- Most planned for something near the historical median.
- As with 1a participants, most took a “wait and see” attitude. This approach worked for 1b.

Conclusions

- Forecast agencies cannot take for granted their forecasts are applied in the manner intended.
- People do not generally consider the tails of the forecast distribution. In reality this is where extreme events are typically represented.
- Forecast agencies and water resource managers need to partner on forecast application in order to fully realize potential value of forecasts

Decision Support System

- ESP output increasingly available for stakeholders
- AHPS pages
- Wateroutlook pages
- Experimental RFC website
- "Raw" ESP output used by some water management agencies to optimize operations

RFC ESP Forecasts

Results of Dillon ESP Simulations

Date of Traces: 4/7/08

Note: When elevations correspond to a specific date, the elevation occurs at the end of that date.

Trace	Elev < 9002 Date	Elev > 9002 Date	# Days < 9002	Elev = 9011 Date	Elev = 9017 Date	Elev May 26	Elev June 30	Peak Comp Inflow cfs	Peak Comp Inflow Date	Peak Outflow cfs	Peak Outflow Date	From May 26 - September 3. Days <450 out	Days 450-699	Days 700-1199	Days 1200-1399	Days >= 1400 out
1976	n/a	n/a	0	6/2	6/8	9006.60	9017.99	2266	6/6	1747	6/13	0	71	19	7	4
1977	n/a	n/a	0	5/24	6/4	9011.70	9017.23	1990	6/6	1432	6/9	0	83	11	4	3
1978	5/10	5/23	14	6/12	6/18	9002.70	9018.20	2539	6/15	1591	6/24	0	76	16	4	5
1979	5/12	5/20	9	6/6	6/13	9004.30	9018.60	2735	6/15	2173	6/18	0	69	12	2	18
1980	n/a	n/a	0	6/9	6/16	9004.40	9017.94	2226	6/12	1321	6/22	0	79	17	5	0
1981	n/a	n/a	0	6/2	6/8	9006.80	9017.82	2857	6/9	2219	6/13	0	66	21	6	8
1982	5/14	5/28	15	6/17	6/25	9001.10	9018.73	2033	6/18	1702	7/2	0	79	13	3	6
1983	5/10	6/9	31	6/20	6/23	8999.00	9019.29	3384	6/24	2781	6/28	0	55	25	2	19
1984	5/7	5/20	14	5/31	6/8	9006.10	9018.55	2549	6/15	2311	6/17	0	55	20	4	22
1985	n/a	n/a	0	6/2	6/8	9006.30	9017.83	2877	6/9	1935	6/12	0	71	16	4	10
1986	n/a	n/a	0	6/5	6/13	9005.70	9017.90	2349	6/9	1515	6/19	0	75	17	6	3
1987	n/a	n/a	0	5/25	6/8	9011.10	9017.88	2107	6/8	1331	6/16	0	76	19	6	0
1988	5/11	5/16	6	6/8	6/15	9003.80	9018.15	2357	6/9	1875	6/21	0	76	13	3	9
1989	n/a	n/a	0	5/29	6/9	9008.80	9017.70	1912	5/30	1331	6/22	0	76	19	6	0
1990	5/13	5/23	11	6/7	6/12	9002.80	9018.17	2926	6/10	1971	6/16	0	71	15	3	12
1991	5/8	5/19	12	6/3	6/10	9005.40	9018.10	2395	6/12	1959	6/15	0	71	15	3	12
1992	n/a	n/a	0	5/18	5/27	9016.20	9017.81	1875	5/21	1391	6/14	0	60	32	9	0
1993	5/11	5/15	5	6/3	6/12	9005.10	9018.40	2789	6/18	2404	6/19	0	69	10	7	15
1994	n/a	n/a	0	6/2	6/8	9006.50	9017.62	2241	6/7	1442	6/16	0	77	14	7	3
1995	5/8	6/10	34	4/8	6/21	9000.00	9019.96	3843	7/9	3613	7/10	0	48	18	3	32
1996	n/a	n/a	0	5/24	6/3	9012.60	9017.91	2273	5/25	1840	6/11	0	68	16	5	12
1997	5/13	5/16	4	6/6	6/12	9004.30	9018.52	2535	6/19	2311	6/23	0	69	11	4	17
1998	n/a	n/a	0	6/2	6/13	9005.40	9017.89	2122	6/3	1054	6/24	0	72	29	0	0
1999	5/12	5/23	12	6/6	6/12	9003.70	9019.05	2854	6/21	2559	6/22	0	56	19	2	24
2000	n/a	n/a	0	5/22	5/28	9014.60	9017.46	2736	5/31	2334	6/2	0	72	14	3	12
2001	n/a	n/a	0	5/25	6/1	9011.40	9017.64	2292	6/3	1759	6/5	0	70	17	3	11
2002	n/a	n/a	0	5/31	6/8	9006.20	9017.24	2465	6/1	1169	6/13	0	87	14	0	0
2003	5/11	5/21	11	5/30	6/3	9005.10	9018.26	3180	5/31	2139	6/19	0	62	13	6	20
2004	n/a	n/a	0	5/27	6/6	9010.40	9017.52	1836	6/8	1311	6/11	0	85	13	3	0
2005	5/12	5/20	9	5/29	6/8	9007.80	9017.89	2074	5/24	1679	6/21	0	72	18	4	7
	n/a	n/a														
Min	5/7	5/15	0	4/8	5/27	8999.00	9017.23	1836	5/21	1054	6/2	0	48	10	0	0
Max	5/14	6/10	34	6/20	6/25	9016.20	9019.96	3843	7/9	3613	7/10	0	87	32	9	32
Avg	5/10	5/23	6	5/31	6/9	9006.53	9018.11	2487	6/9	1873	6/17	0	71	17	4	9
90% Ex	8-May	16-May	0	5/23	6/2	9002.54	9017.51	1983	5/29	1320	6/10	0	56	12	2	0
70% Ex	10-May	19-May	0	5/29	6/8	9004.37	9017.83	2236	6/5	1493	6/13	0	69	14	3	3
50% Ex	11-May	20-May	0	6/2	6/8	9005.90	9017.93	2376	6/9	1799	6/17	0	71	16	4	9
30% Ex	12-May	23-May	10	6/5	6/12	9007.10	9018.22	2736	6/12	2149	6/21	0	76	18	5	12
10% Ex	13-May	5-Jun	14	6/9	6/18	9011.79	9018.76	2951	6/19	2420	6/24	0	79	21	7	20

Assumed RT off until June 1 and April "normal" operating plan thereafter. Took HT from April "normal" plan.
Assumed Fernandez' suggestion and then held the 470 release.

Raftable flows approx 450 - 1800 cfs. Optimum for commercial approx 700 - 1400 cfs.
Good stream fishing approx 450 cfs and below. Marginal fishing 450 - 700 cfs.

Reservoir Management

Future Steps

- Test improvements to human understanding of probabilistic forecasts
- Investments in decision support important but need to (re)focus on:
  - Objective decision support systems
  - Better understanding decision making process

Challenges

- Culture change – getting NOAA staff buy in for service mentality
- Coordination with other NOAA entities
- External barriers – Political, educational, and awareness all prevent stakeholders from taking advantage of forecasts
- Partnerships – Multi-agency partnerships needed to fully address stakeholder needs

Lessons Learned

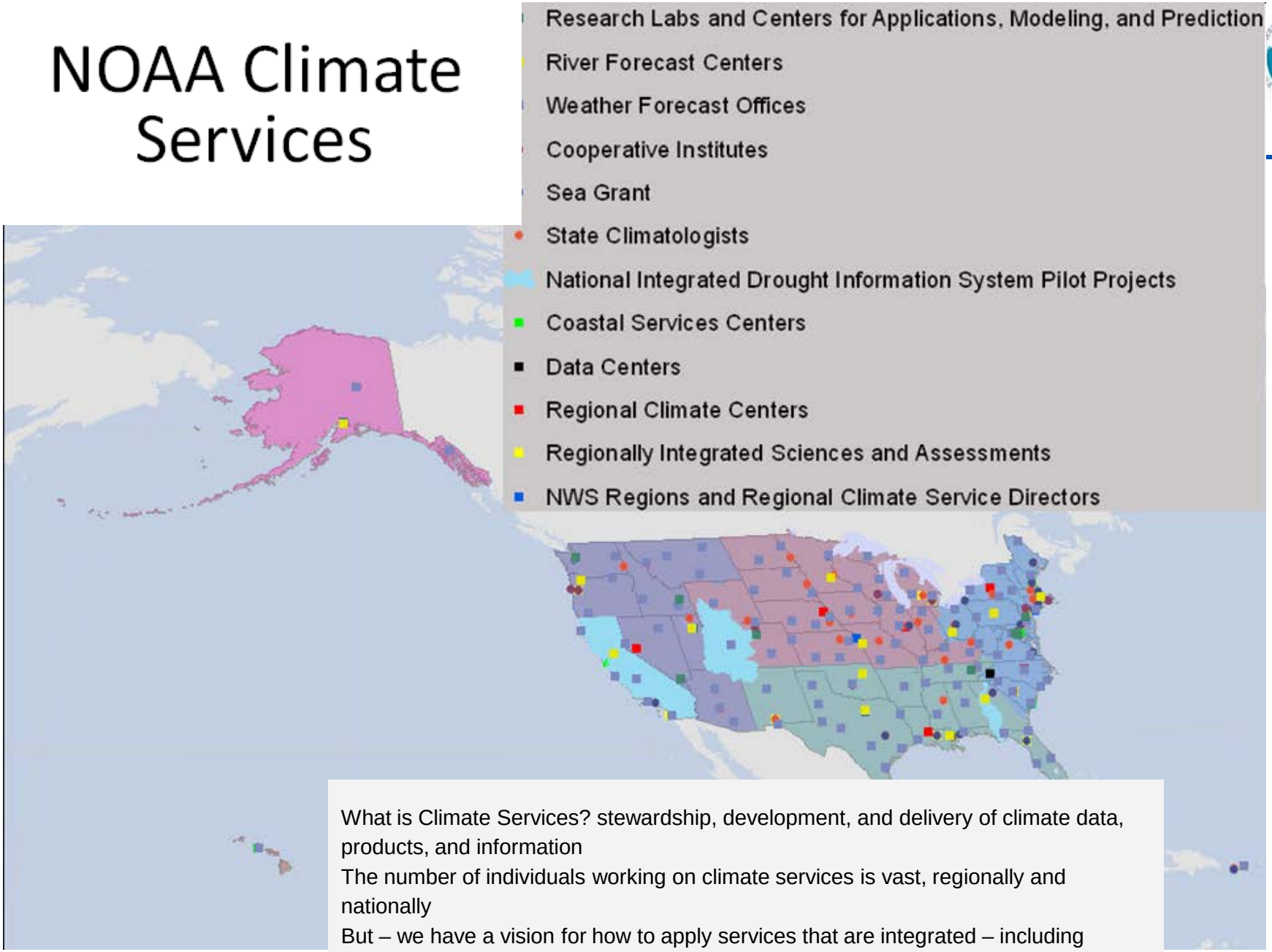
- Bringing science to decision makers is **difficult**
- **Relationships** matter – they take time and investment to build. Cannot build effectively over gotomeeting
- **Responsiveness** matters – Need robust and **transparent** requirements tracking process
- **Substance** matters
- Organizations tend to be internally focused; the **best service organizations are externally focused**

6 Weeks as an RCSD

Background

- Climate services exist throughout NOAA:
  - NWS - CPC, WFOs, RFCs, Regions, NWSH, ...
  - OAR - NIDIS, ESRL, CPO, RISA, …
  - NESDIS - NCDC, NEIO, …
  - NMFS - FSCs, RCs, …
  - NOS - CSCs, OCRM, …
- Other agencies, organizations, etc are playing too
- Little formal coordination in place

NOAA Climate Services



What is Climate Services? stewardship, development, and delivery of climate data, products, and information

The number of individuals working on climate services is vast, regionally and nationally

But – we have a vision for how to apply services that are integrated – including regionally

Background:

NCDC RCSD Strategy for FY14

NCDC strategy points:

- NCDC's needs and realities continue to change, especially with respect to budget. Some of the changes affect RCSDs.
- RCSDs' primary roles going forward will be, in priority order, to
  - Provide strategic direction to and oversight of region's RCC
  - Help customers exploit NCDC products and services in context with broader NOAA products and services
  - Coordinate information and support NOAA's outreach in response to significant regional climate event or trends
  - Capture and report customer needs and priorities to Center management
  - Help coordinate regional climate service projects or capabilities with other agencies
- Travel constraints will require new approaches to performing jobs
- RCSDs are expected to build support relationships with other NCDC employees to have reach-back expertise and increase effectiveness
- The RCS Advisory Board advises the Center Director
  - Board recommendations may or may not become RCS policy or program changes
- RCSDs will help inform and review the Center's Engagement Plan, and will instrumental in its successful execution

Western Region RCSD Vision

- Climate services for the western region will help real time decision making for a broad base of consumers by providing context to current and expected changes to their weather and water environment.
  - Decision makers in the **water resources**, **wildfire**, and **coastal resources** sectors will be a particular focus.

Near Term Strategy

- Better connect NOAA climate services and water resources
  - California drought immediate challenge and opportunity across NOAA services including NMFS
  - Colorado River longer term opportunity with 14 year drought and Interim Operating Guidelines replacement due in 2025
- Explore climate service requirements from other key sectors
  - Wildfire
  - Coasts
- Build and strengthen NCDC applications in region
- Explore and promote regional connections between application development (e.g. RISA, SARP, MAPP, NMFS/FSC,…) and operations (e.g. RCC, WFO, RFC, …)

Major Initial Projects Proposed

- NOAA California drought services assessment
- Colorado River forecast and reservoir operations uncertainty assessment
- Climate services landscape and network analysis

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

California Drought
NOAA Service Assessment

Motivation: Despite being the mostly costly natural disaster, unlike for most other weather related disaster types, NOAA has never formally reviewed its services provided to decision makers faced with drought. The California drought is particularly severe and likely to be particularly costly (Western Farm Press estimated agriculture impacts alone to be $8B)

Synopsis: NOAA would loosely follow NWS service assessment approach. A cross line office team led by WR RCSD would be assembled to evaluate NOAA services provided to California decision makers. Assessment would take place over the summer 2014 (also leverage NIDIS May 2014 drought forum). The team would report its scope and plan as well as draft report to leadership within each line office.

Key Questions:

- What are/were the key decisions on the drought impact? Who is/was making them?
- What NOAA services were useful to these decision makers? What could have been better?
- What roles did the NOAA Line Offices play? Where did those intersect? How effective were the interactions between Line Offices?
- Are NOAA entities supporting other NOAA entities' information needs and feedbacks related to drought?
- Where are there opportunities for improving predictability on weekly to seasonal timescales
- What opportunities exist for improved environmental data access to decision makers?
- What opportunities exist for coastal resource programs to support drought decision makers?

Colorado River Forecast and Operations Uncertainty

Motivation: The still ongoing 14+ year drought on the Colorado River coupled with ever increasing usage of its water resource has led to increasing scrutiny on the policies governing shortages, surpluses, the operation of the two largest reservoirs in the nation, Lakes Powell and Mead, and the NOAA forecasts that support them. At a February 2014 drought workshop, the major water districts requested NOAA and USBR to put together a proposal to **quantify their uncertainties** so that they could be understood better in real time and so that the districts could support efforts to reduce major uncertainties.

Synopsis: WR RCSD would organize team to draft proposal, interact with relevant NOAA entities, basin states, and water districts to gain support and oversee execution.

Climate services landscape and network analysis

Motivation: Western Region experienced a 2.5 year vacancy in the RCSD position. The NOAA western regional collaboration team developed a proposal to address the impacts caused by this vacancy through an expedited assessment and network analysis of the climate services landscape in the west.

Synopsis: The proposed work includes four elements:

1. **Climate services landscape assessment** - This project will identify the federal, state, tribal and local regional climate services stakeholders within the 8-state footprint of the Western Climate Services Region.
2. **Network analysis** - Utilizing social network analysis techniques, this project will map and measure relationships and flows of climate services information between people, groups, organizations within the 8-state footprint of the Western Climate Services Region.
3. Water supply forecast assessment - Supporting water management agencies that rely on snow melt from mountain basins is a unique service offered by NOAA in the west. This project will assess the economic value of the water supply forecasts made by the River Forecast Centers in the region.
4. Water supply forecast strategic communication - This project will develop recommendations for more effective communication and application of NOAA services.

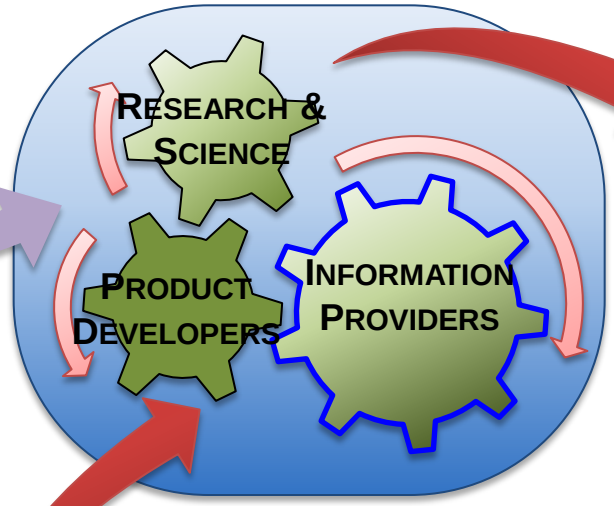
Other Engagements

- NOAA Western Collaboration Team
- NCDC Science Council
- NOAA/WSWC Congressional Briefing on water resources
- Western States Federal Agency Support Team (WestFAST)
- Climate Change and Water Working Group (CCAWWG)
- NOAA Climate Adaptation Team (NCAT)
- Salt Lake City Mayor's advisory group on climate change (informal)
- Utah State University's Spring Runoff Conference planning group
- California May 2014 drought forum planning team
- Mesa State College's Colorado River workshop planning group
- NOAA Drought and Water Resources Societal Challenge
- Coastal climate adaptation training analysis
- CSC/RCSD climate adaptation training inventory/analysis

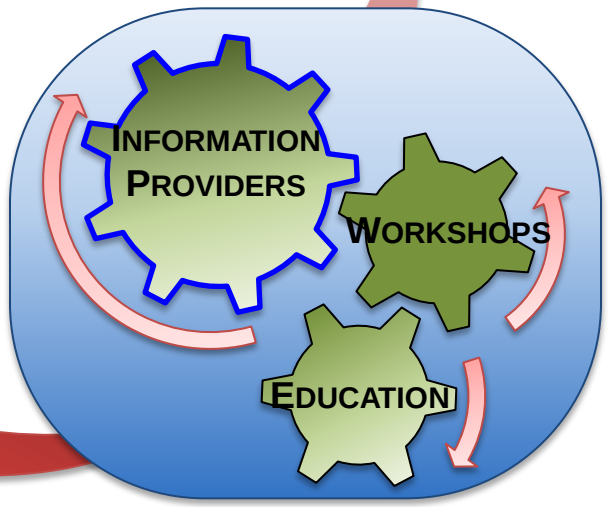
Summary

Users + Existing Information

Science / development



Better Climate and Water Information



Stakeholder Engagement

More Informed Stakeholders

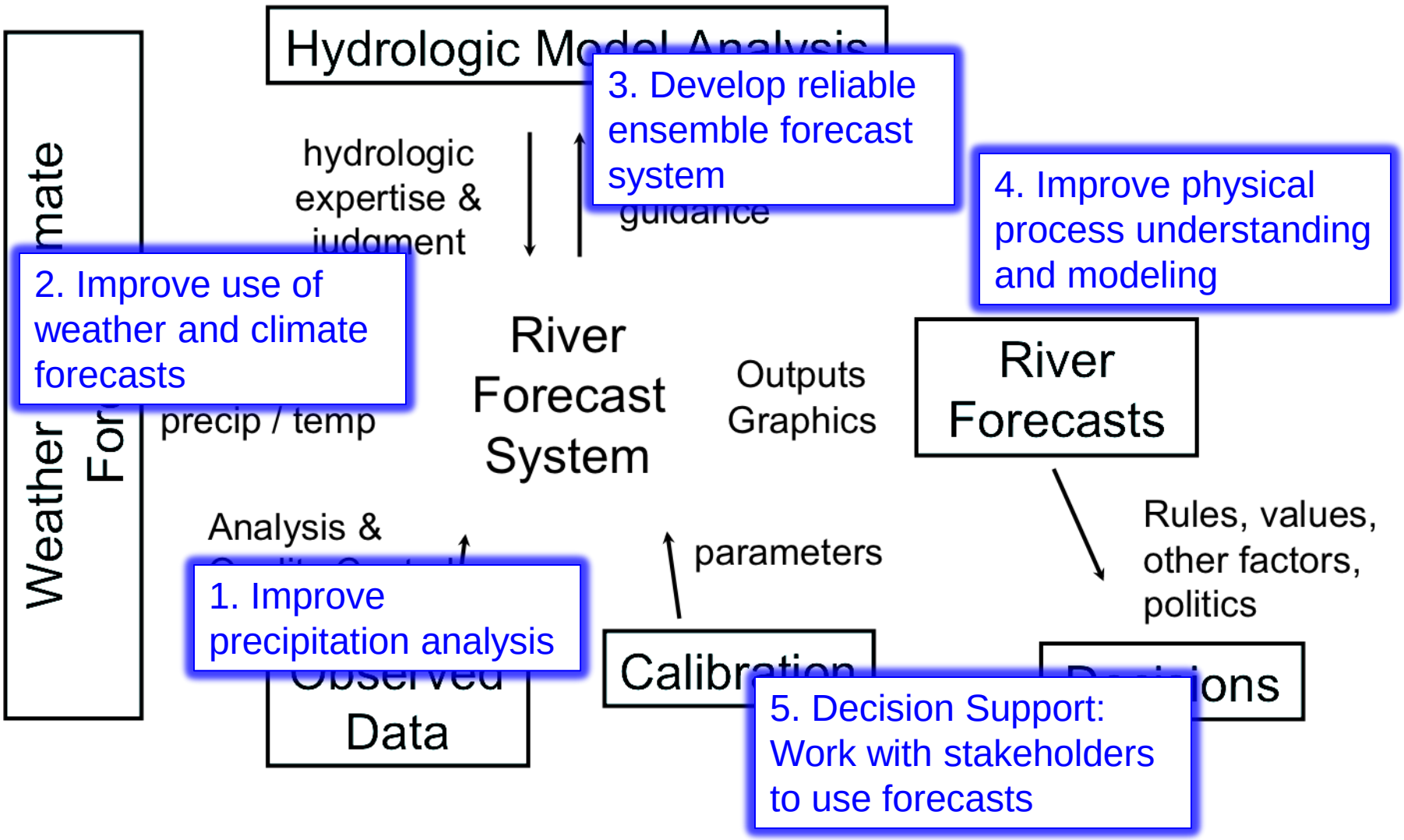
Questions?

Kevin Werner

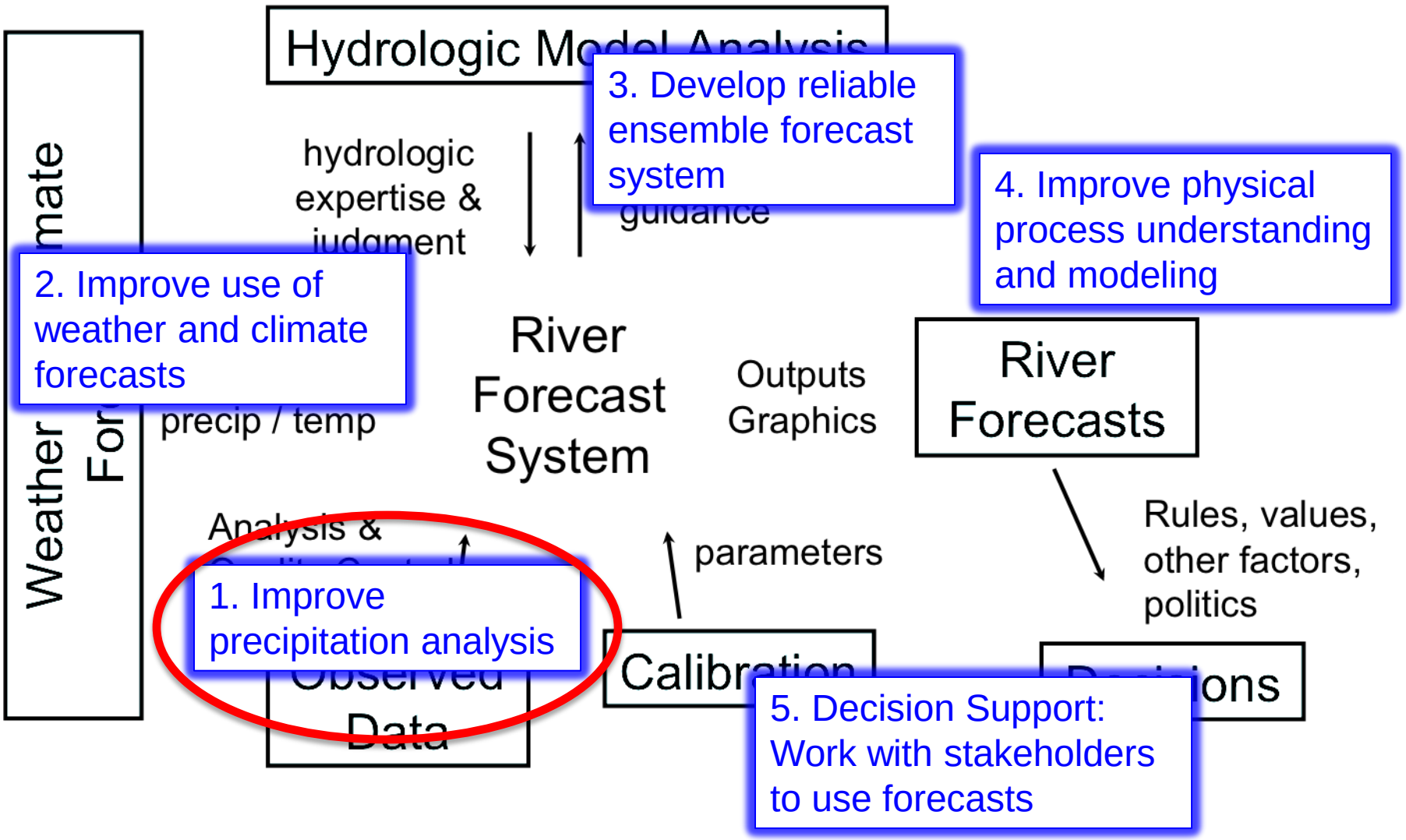
Western Region Climate Service Director
Phone: None yet
Email: kevin.werner@noaa.gov

Backup Slides

Why is Research to Operations So Hard???



One Recent Success Story



Adding snow data in CBRFC Operations via CBRFC-NASA Collaboration

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

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

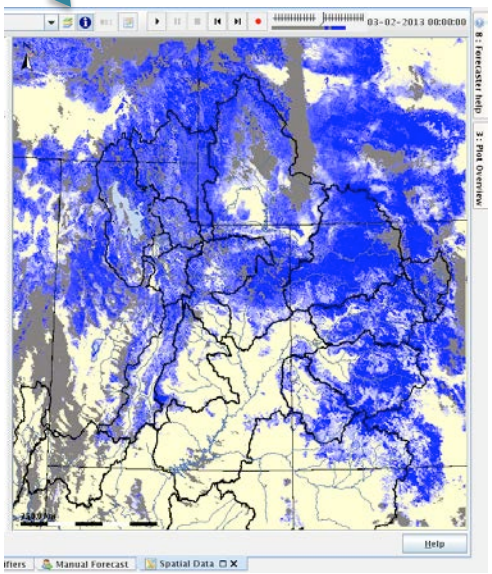
Collaborative research-to-operations effort enables research group (NASA) and operations group (CBRFC) to learn about characteristics of each type of scientific environment

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:



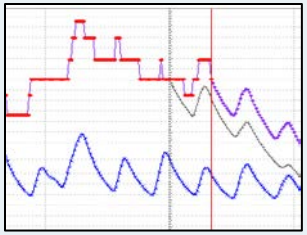
MODSCAG snow cover (in CHPS display) across the upper portions of CBRFC area

March 2, 2013 (gray = cloud)

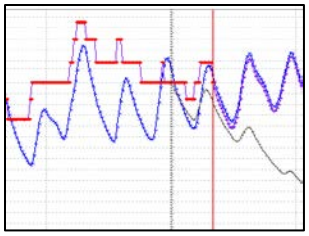
Improving forecasts using information about snowpack presence from MODSCAG of streamflow

<u>Example:</u> 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
- People and Relationships
- Funding

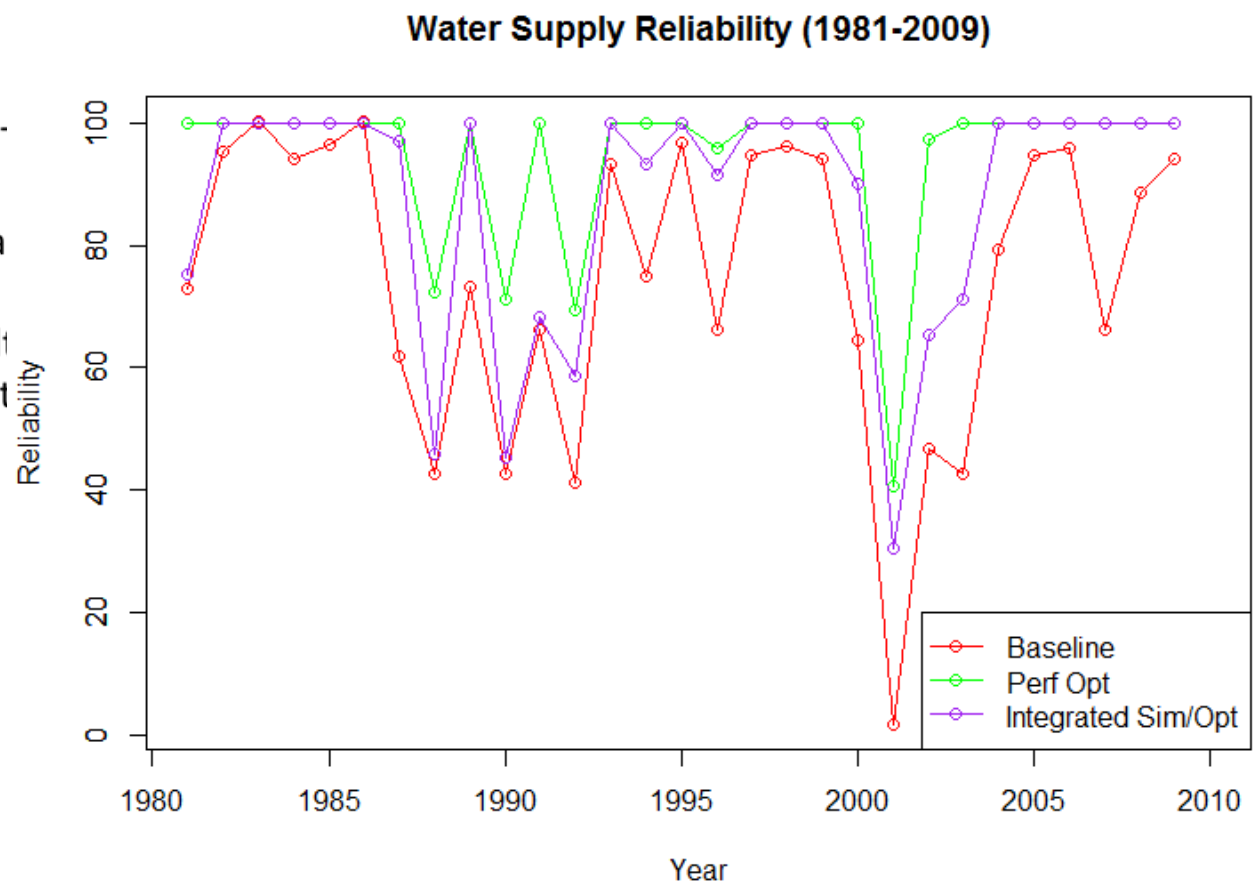
Project Goals

Demonstrate the potential usefulness of climate forecasts and create an appropriate framework for their application

- Co-generate knowledge concerning system operations between researchers and water managers
- Generate ESP streamflow using reforecasts at partner locations
- Evaluate skill of GFS and CFSv2 and corresponding streamflow in the context of decision making
- Disseminate data, case studies, and recommendations to the broader water community

Initial Results

Optimizat

Objective Function

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