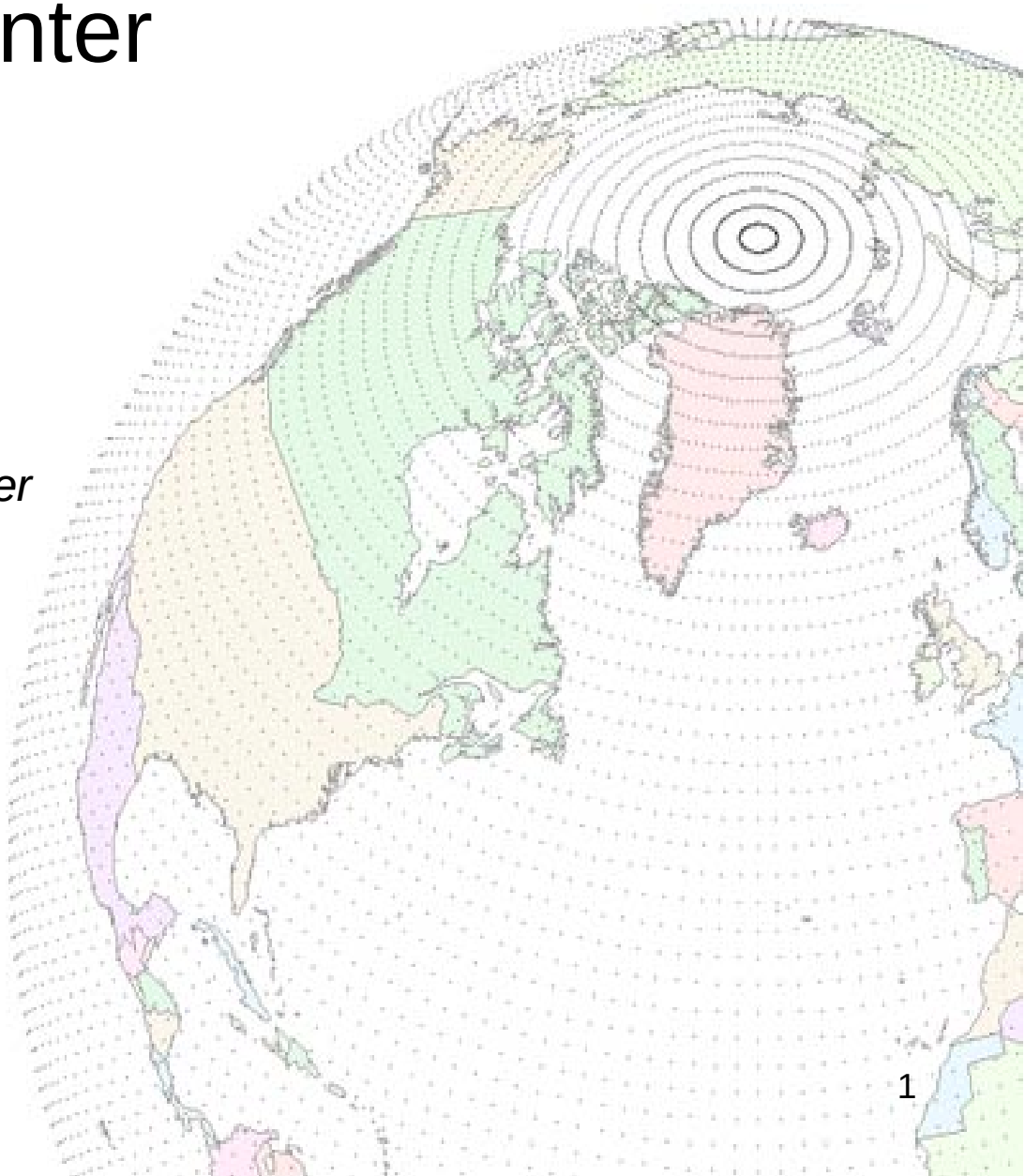
NOAA's Colorado Basin River Forecast Center

Kevin Werner

Andy Wood

NOAA/NWS

Colorado Basin River Forecast Center

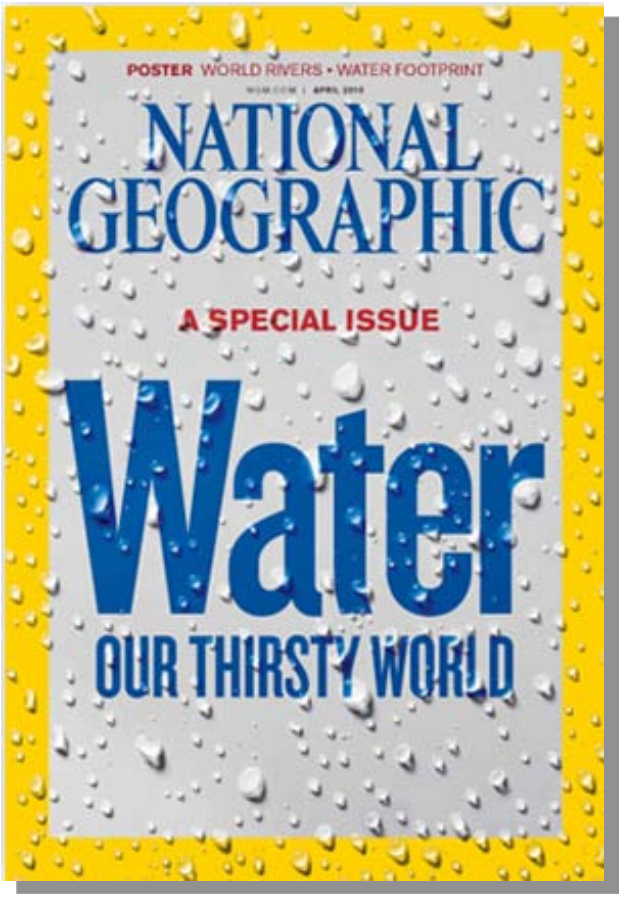


INL MWWI
***Waters of the West* Workshop**
Salt Lake City, UT
July 19, 2011

Outline

- River Forecast Center overview (Kevin)
- R&D Efforts (Andy)

The Global Water Imperative



Protect Life and Property
- **Floods and droughts cause more U.S. economic losses than any other type of natural disaster**

Support Economic Security
- **Water has always been a critical component in the success of any economic endeavor**

Protect Health and Environment
- **Water is the lifeblood of this planet**

Mitigate Escalating Risk
- **Triple Threat: Scarcity and floods, climate change, and aging infrastructure**

"Nearly half of the streams and lakes in the U.S. are not clean enough to sustain swimming and fishing and our infrastructure has been given a D grade"

Who we 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

Colorado Basin River Forecast Center

One of 13 River Forecast Centers

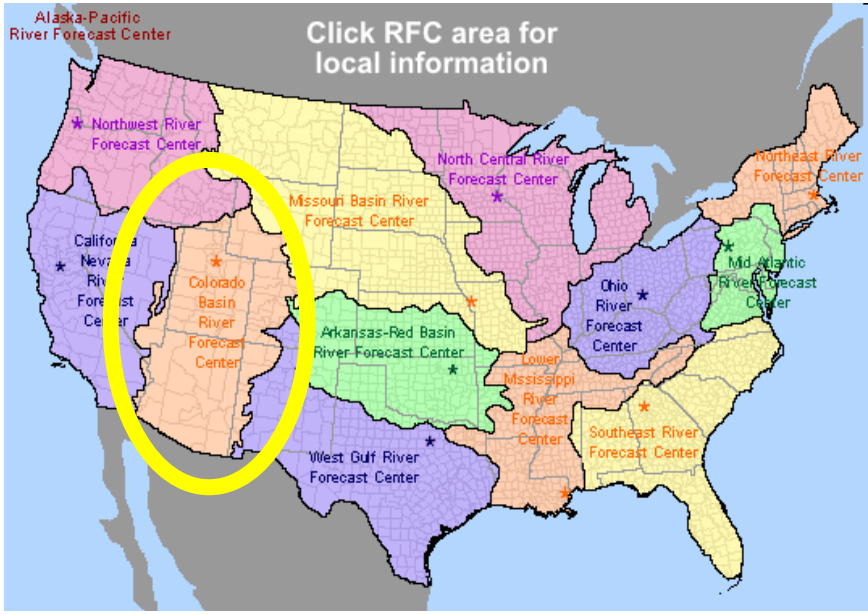
Established in the 1940s for water supply forecasting

Three primary missions:

1. Seasonal **Water supply forecasts** for water management

2. **Daily forecasts** for flood, recreation, water management

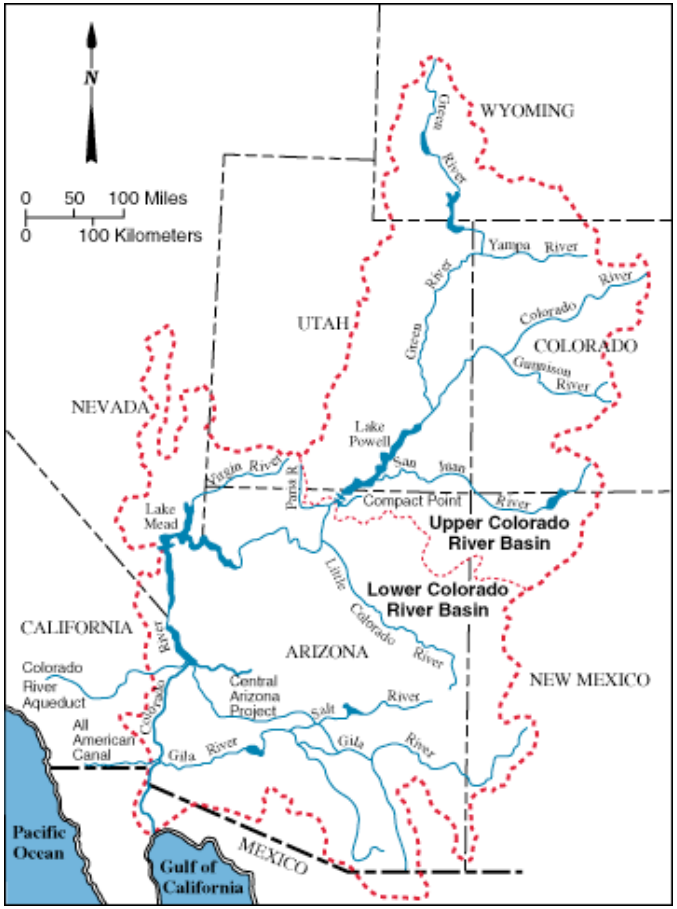
3. **Flash flood warning support**



www.cbrfc.noaa.gov

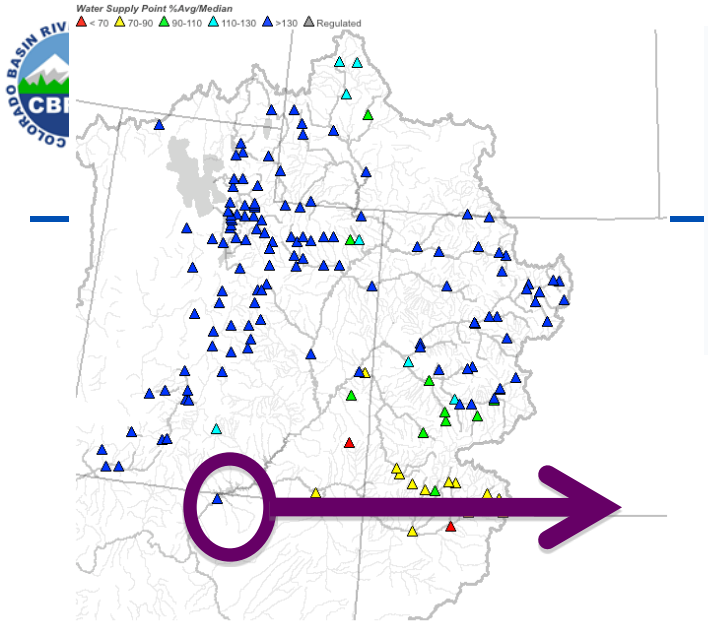
Colorado River

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



Colorado River Allocation

- Colorado Compact (1922) divided water between the upper basin and lower basin – 7.5 MAF each
- Mexican Water Treaty (1944) allocated Mexico 1.5 MAF
- Arizona v. California (1964) allocated water among lower basin states
- Interim Guidelines (2007) specify shortages and surpluses through 2026 that are tied to forecasts
- Key facts:
  - River is over-allocated: original allocation (16.5 MAF) was based on a series of wet years
  - Lower basin states (AZ, CA, NV) use full 7.5 MAF each year
  - Mexico uses its full 1.5 MAF
  - Upper basin states (CO, WY, UT, NM) are still “developing” their 7.5 MAF
  - No shortage has ever been declared on the river
  - Shortages would affect lower basin states first (and AZ first of all)



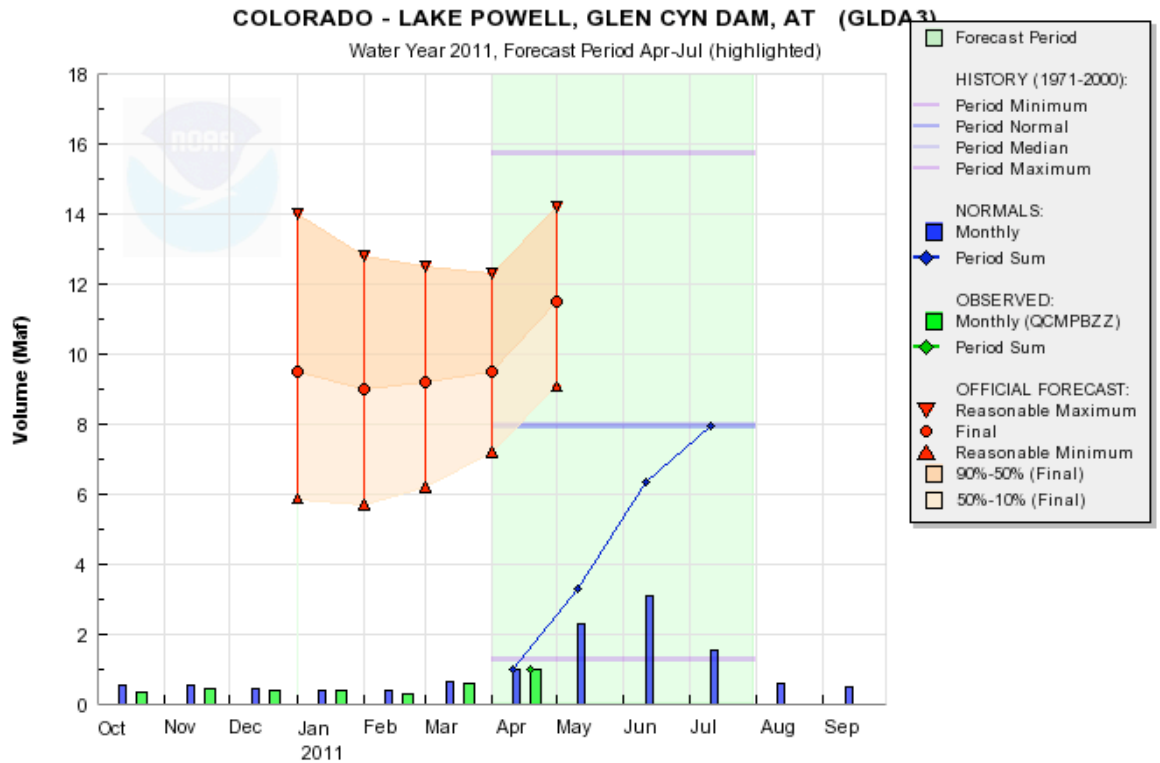
Seasonal Water Supply Forecast ⓘ

Forecast Period: Apr-Jul

11500 kaf 50% Exceedence (Official Forecast)	**149.8%** of Historical Median	**145%** of Historical Mean
9080 kaf 90% Exceedence	**14200 kaf** 10% Exceedence	**15th of 102** Official Historical Flows

Forecast Issued: May 1 2011

View Water Supply Forecast Plot



CBRFC/NWS/NOAA 05/06/11 15:22:36 UTC

Web Reference: www.cbrfc.noaa.gov/gmap/gmapm.php?wcon=checked

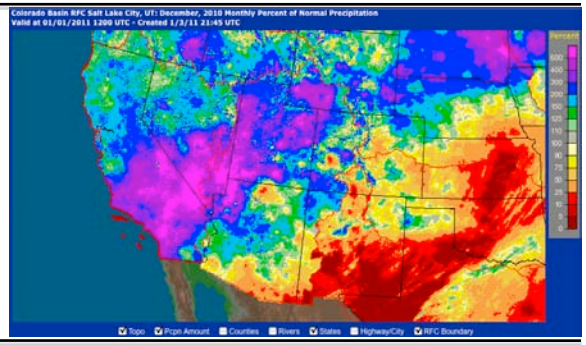
Climate Services currently offered by western River Forecast Centers

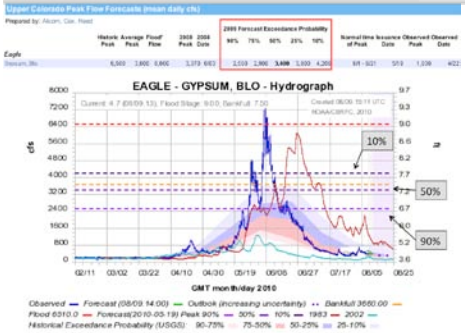
Water Supply Forecasts

- Probabilistic forecasts for amount of spring melt in western USA
- Forecasts issued at least monthly January through June
- Support water management and drought decision making

Weather and Climate Analysis

- Hourly, daily, and monthly analysis – both real time and retrospective
- In situ and remote sensing data merged through manual QC process
- Weather and climate datasets downscaled to basin scales
- Mosaic precip analysis webpage (water.weather.gov/precip) one of NWS's most popular





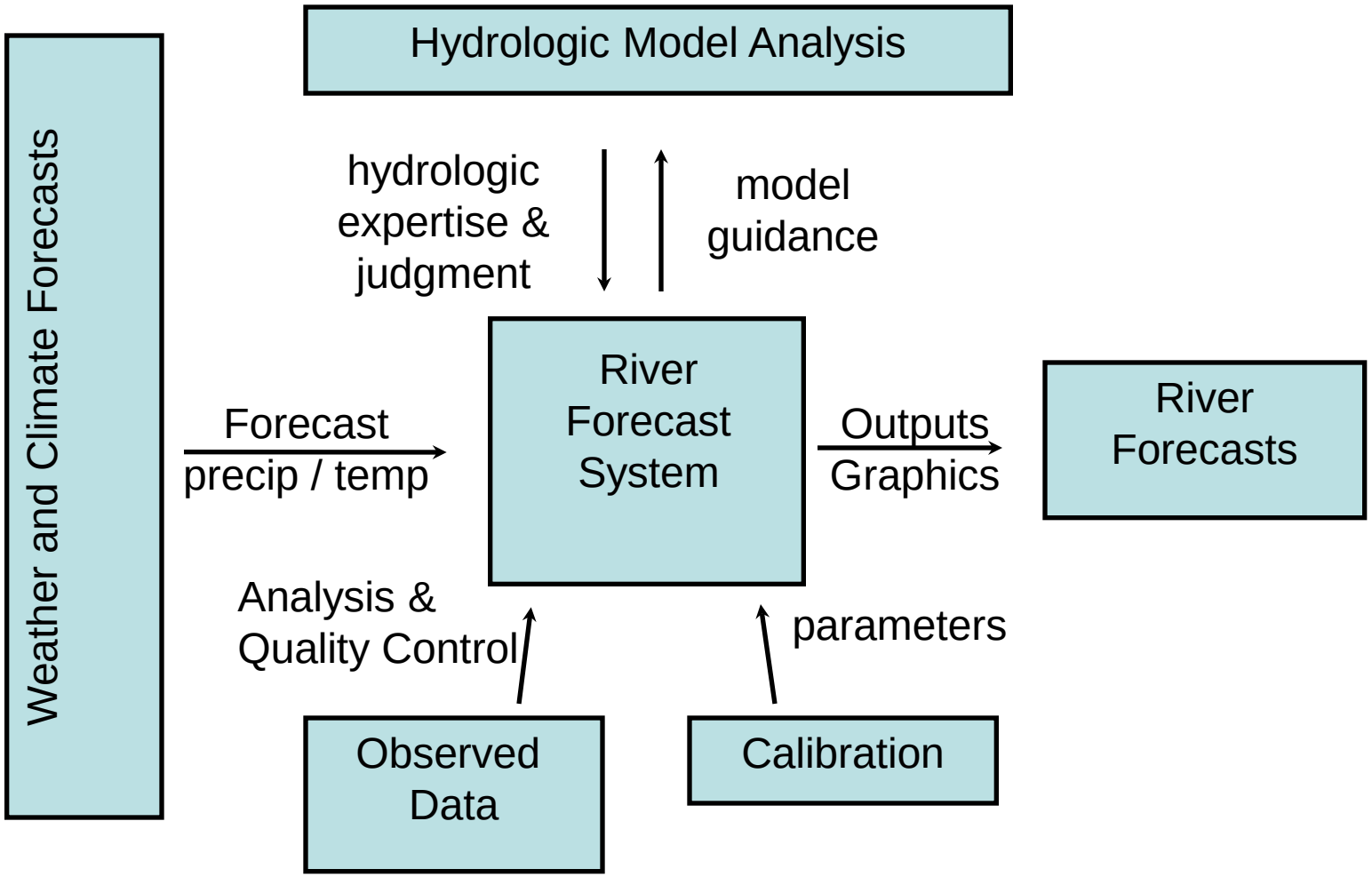
Peak Flow Forecasts

- Probabilistic forecasts snowmelt peak flow in western USA
- Forecasts issued at least monthly March until peak flow occurs
- Support water management and emergency management decision making
- www.cbrfc.noaa.gov for example

Stakeholder Decision Support

- Established working relationships with many major water agencies
- Many stakeholders receive climate services already from RFCs
- Operational center staffed 365 days per year with real time support
- Water Supply Webinars

General RFC Model-based Forecasting Approach



Outline

- River Forecast Center overview (Kevin)
- R&D Efforts (Andy)

CBRFC's Primary R&D Interactions

NOAA 'Labs'
- Office Hydrologic Development
- NCEP, CPC
- Earth Syst. Res. Lab (Boulder)
- NASA JPL
- DOE PNNL

Agency Partners
- Reclamation / USACE / USGS
- Water Districts (e.g., MWD, SNWA)
- Utilities (e.g., SLC P.U.)

CBRFC

Academic Partners
- UU, USU
- U. Colorado, CSU, *WWA*
- U. Arizona
- UCLA, Scripps
- U. Oklahoma
- UNLV, Portland State

NOAA Field
- Western Region HQ
- Weather Forecast Offices

CBRFC R&D Priorities or Projects

ET/drought-related datasets
- Dr. Mike Hobbins in-house R&D for NIDIS
- remote-sensing based ET/PET

Seasonal to Year-Two Climate / Flow Prediction
- with various academic partners
- OHD and NCEP, soon CSIRO/BOM

Ensemble Wx/Climate Prediction
- with various academic partners, OHD and NCEP

Community Hydrologic Prediction System (CHPS)
- with OHD and Deltares (NL)

Improved Land Surface Modeling
- with various academic partners

Better Precip / Temperature Operational Analyses
- mostly with agency lab partners

Hydrologic Data Assimilation
- with OHD / PNNL

Web Data Services
- mostly with agency lab partners

Climate Change Assessment
- with WWA, SLC Pub. Utilities

CBRFC's Major Funded Collaborations

Partner	Topic	Funding Source
CU (Rajagopalan)	Climate/Flow Forecasting, Model Combination	NOAA MAPP, NWS CSTAR
PSU (Moradkhani)	Climate/Flow Forecasting, Modeling, Model Combination, Data Assimilation	NWS CSTAR
NWS CPC (Mo)	ET, Drought, Flow Forecasting	NOAA TRACS / NIDIS
CU (Clark)	Snow Modeling, Drought	NOAA MAPP
UCLA (Hogue), ISU (Franz)	ET, remote sensing	(NASA WM, GOESR PG)
U. Okahoma (Yang)	Satellite Precip	NASA Precip
USU (Tarboton)	Cyber-infrastructure	NSF (we just supported)
USU (Wang), PNL (Yoon)	Climate / Flow Forecasting	NOAA MAPP (planned)

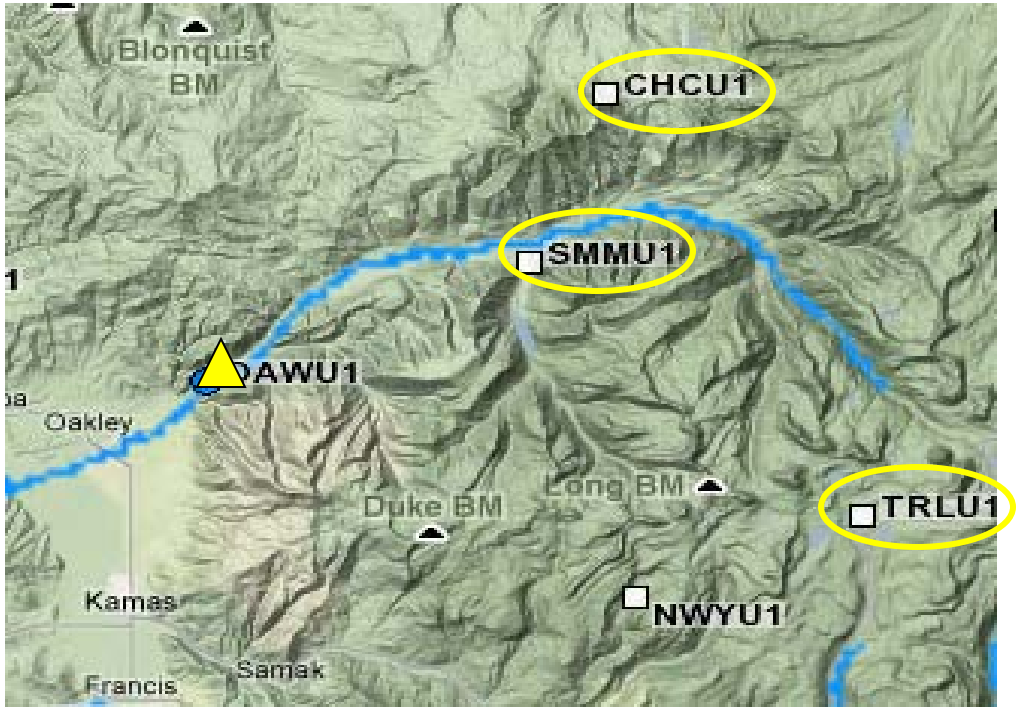
Statistical Forecast:

Trial Lake SNOTEL

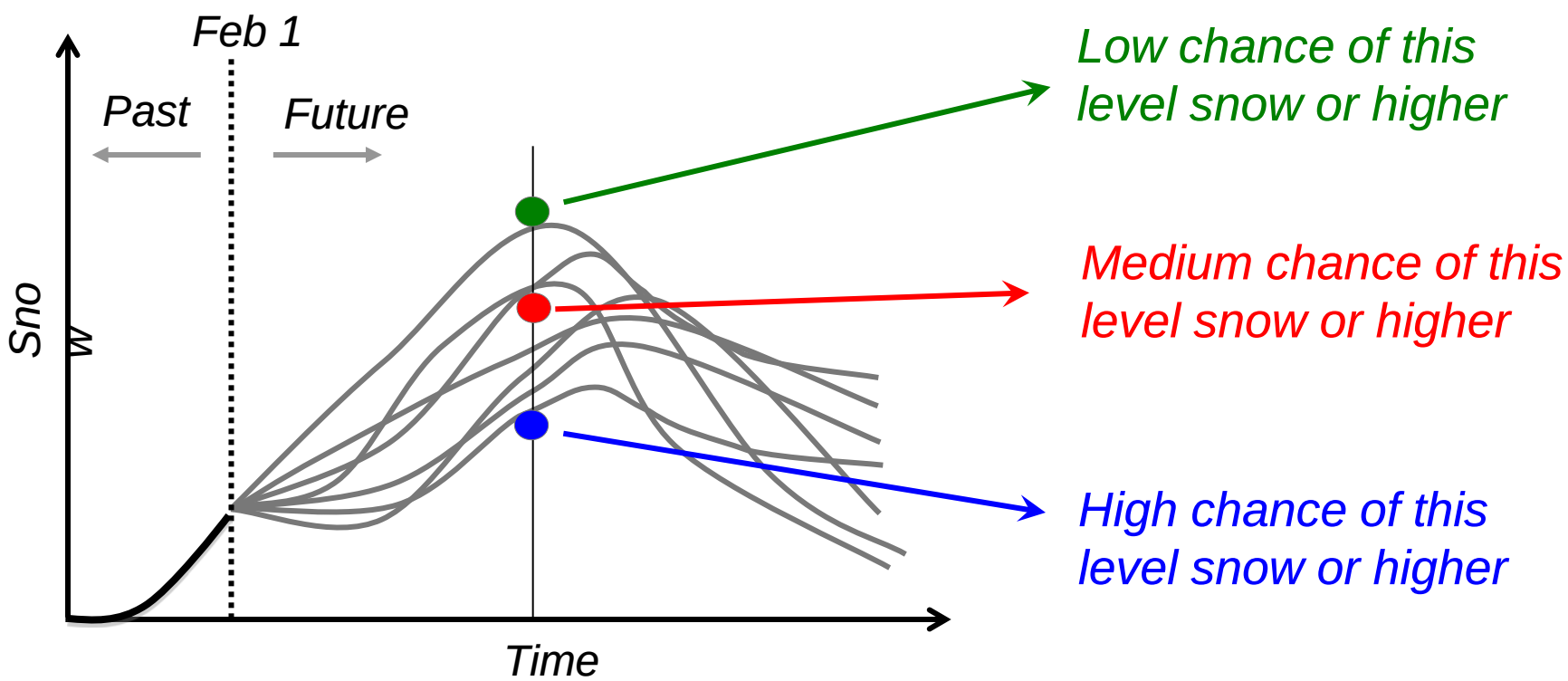
Predictor variables must make sense
Challenge when few observation sites exist within river basin
Challenge when measurement sites are relatively young
Fall & Spring precipitation is frequently used

Sample Equation for April 1:

April-July volume Weber @ Oakley =
+ 3.50 * Apr 1st Smith & Morehouse (SMMU1) Snow Water Equivalent
+ 1.66 * Apr 1st Trial Lake (TRLU1) Snow Water Equivalent
+ 2.40 * Apr 1st Chalk Creek #1 (CHCU1) Snow Water Equivalent
- 28.27



ESP (model) forecast



- ESP forecasts based on
  - (1) initial conditions (e.g. snow pack, base flow, etc)
  - (2) future meteorological scenarios

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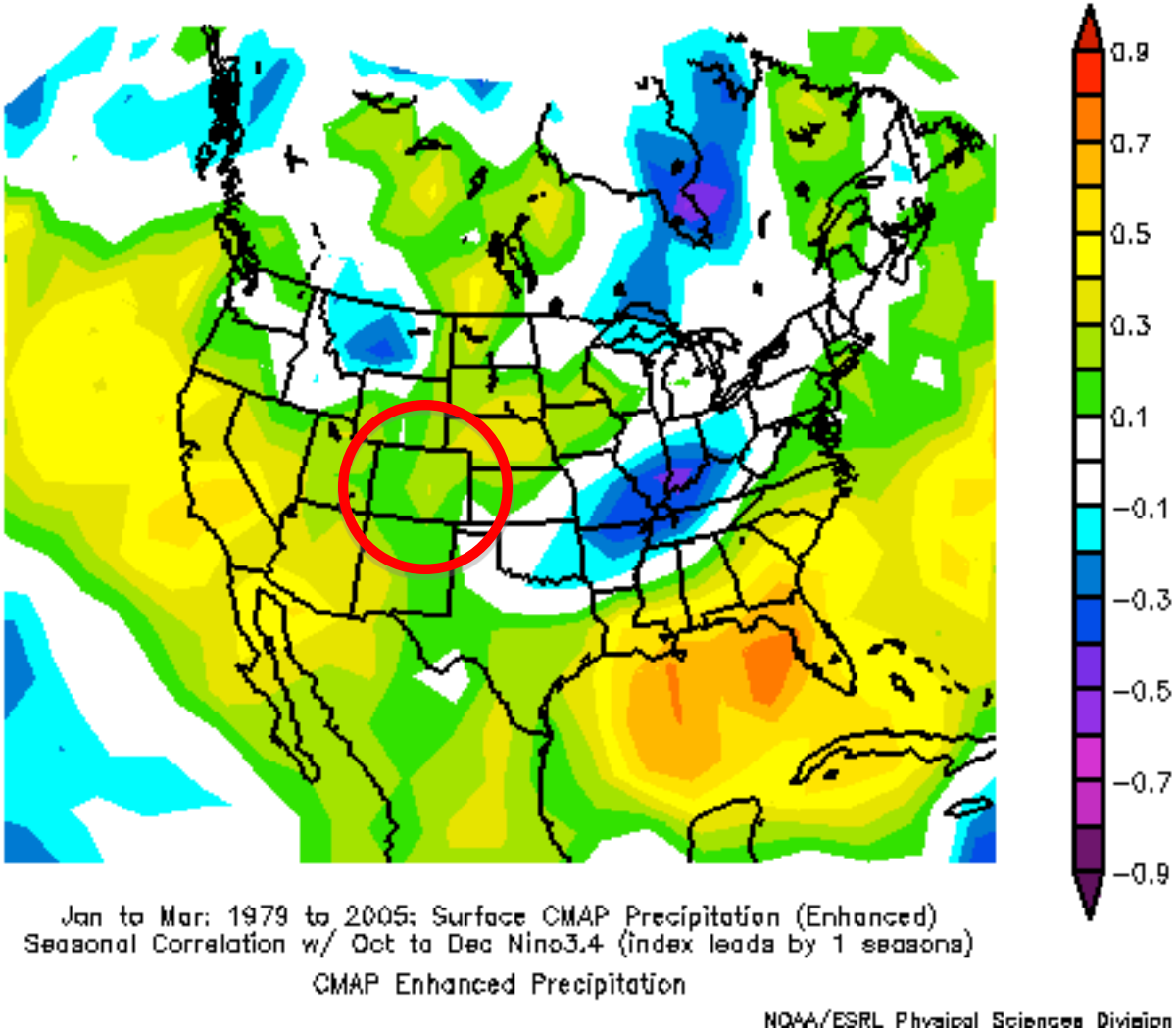
Climate-Flow Forecast Research Motivations

- ISI climate predictability is relatively ***limited*** in our region (CB)
- water management in 7 states depends on regional climate and flow forecasts



plot -- JFM Precip correlation with Nino 3.4, lag 1 season

SI/Y2 Climate and Streamflow Forecasting Workshop

NOAA/NWS Colorado Basin River Forecast Center
Salt Lake City, UT – March 21-22, 2011

Organized by
CBRFC
Reclamation

Sponsored by
Colorado Water Conservation Board
NIDIS

Academic Researchers

Gillies & Wang, USU
Troch, UA
Piechota, UNLV
Moradkani, PSU
Rajagopalan, CSU
Wolter, CU

Streamflow Forecasting Research Development Operations

CBRFC
OHD

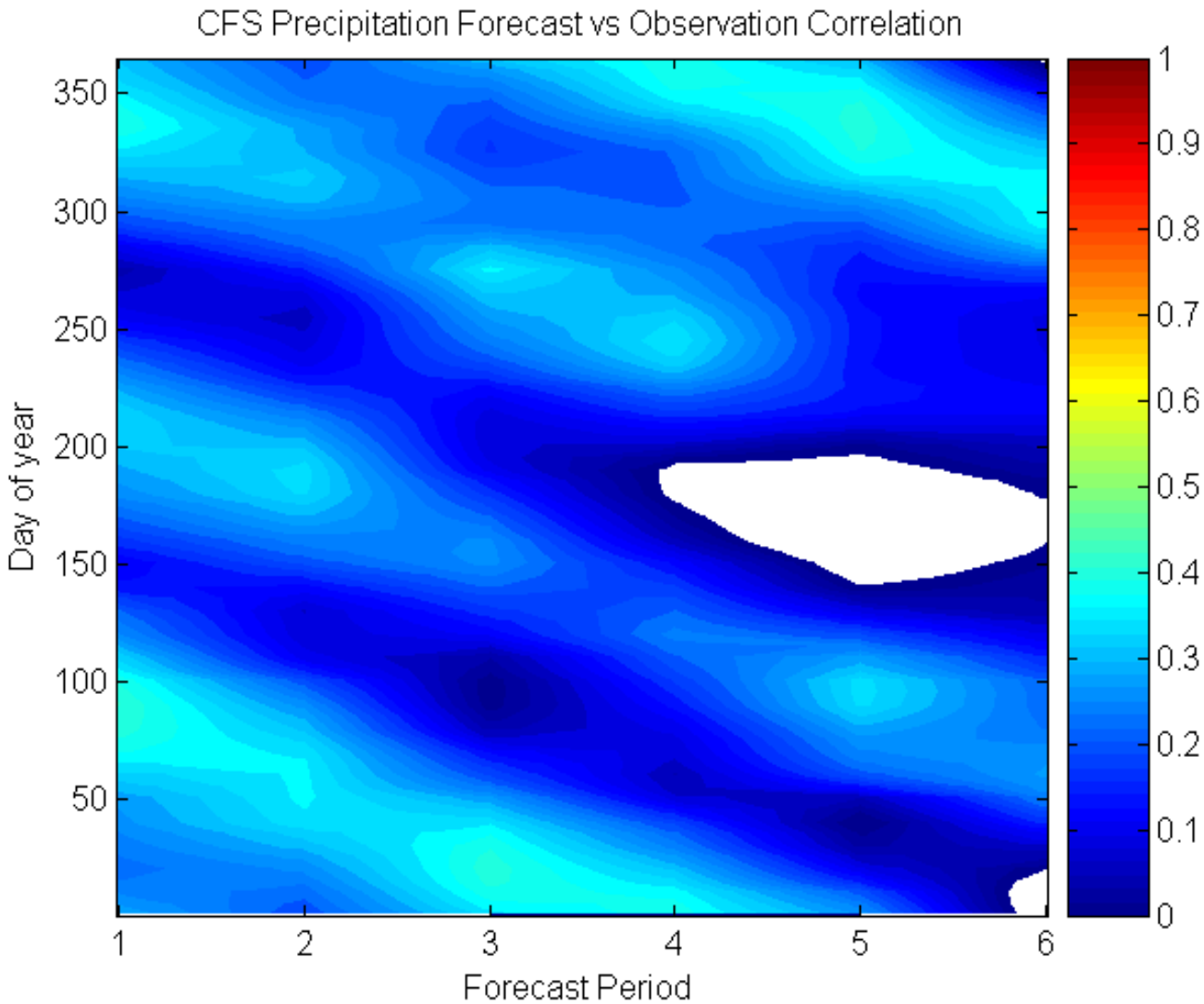
Partners in Water Management

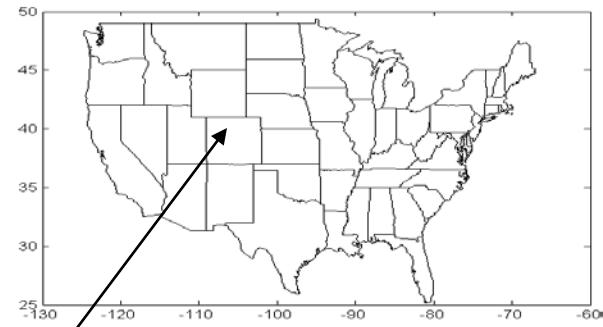
Reclamation
Colorado Basin

Others: Becky Smith (student, CSU); Sponsors (CWCB) and Consultant (RTI)

Outcomes: (1) future workshop; (2) forecasting testbed

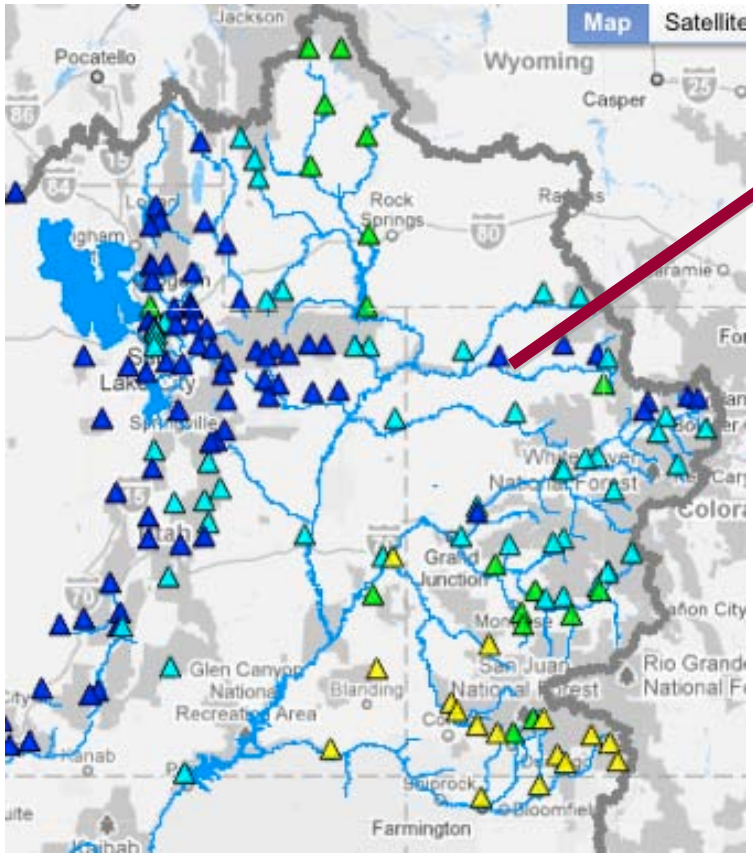
CFS Seasonal Forecast Skill - Precipitation

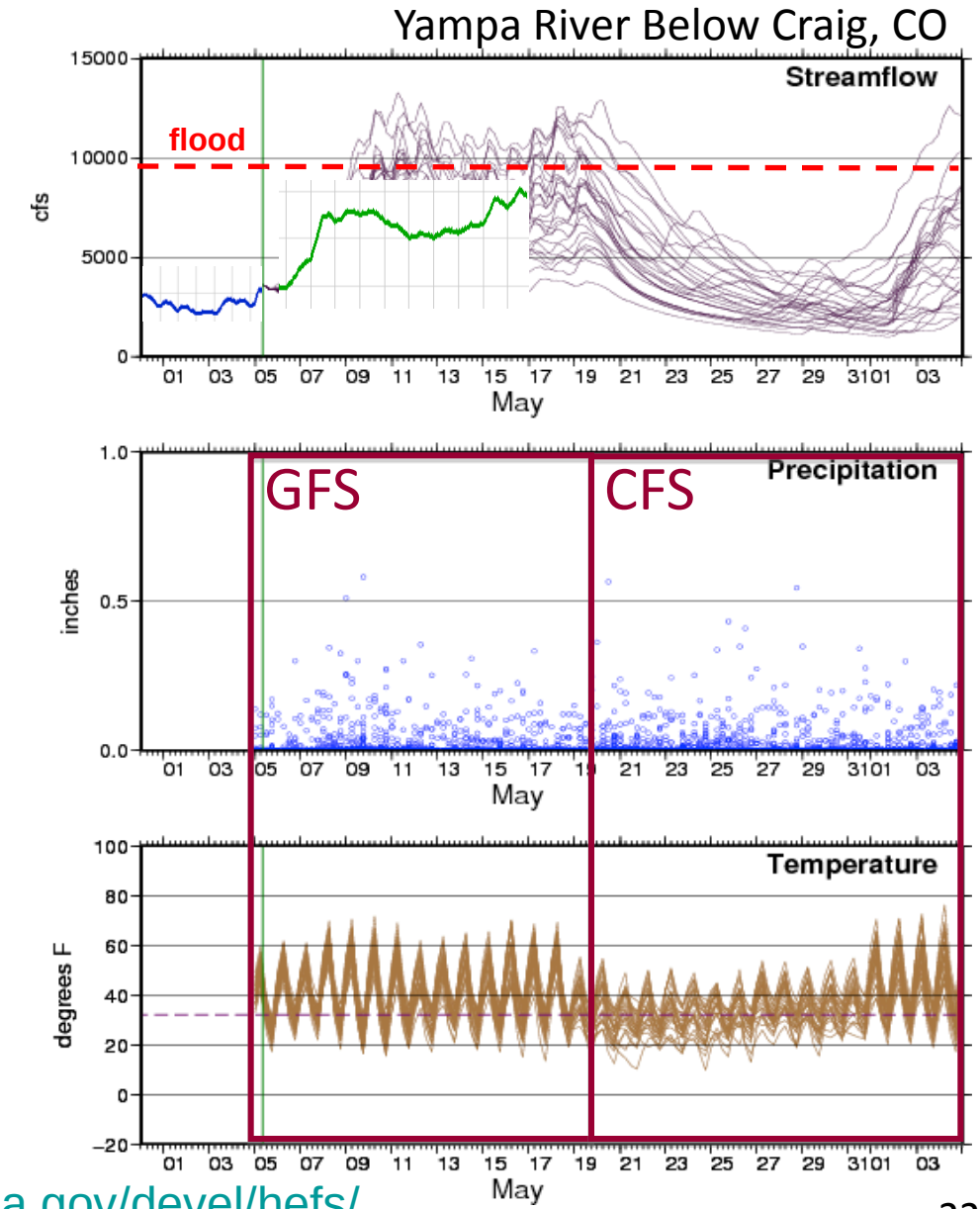




Example of Experimental Ensembles

GFS and CFS based ensembles:
experimental products updated daily at Colorado RFC (CBRFC) & California-Nevada RFC (CNRFC)

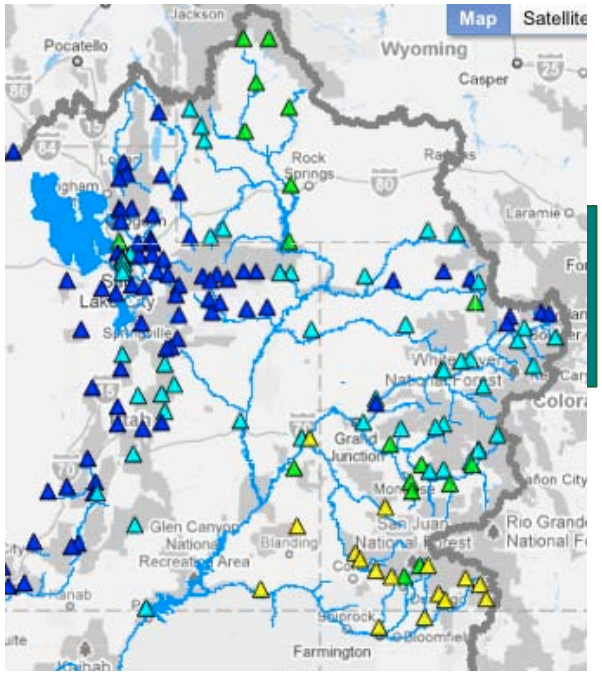


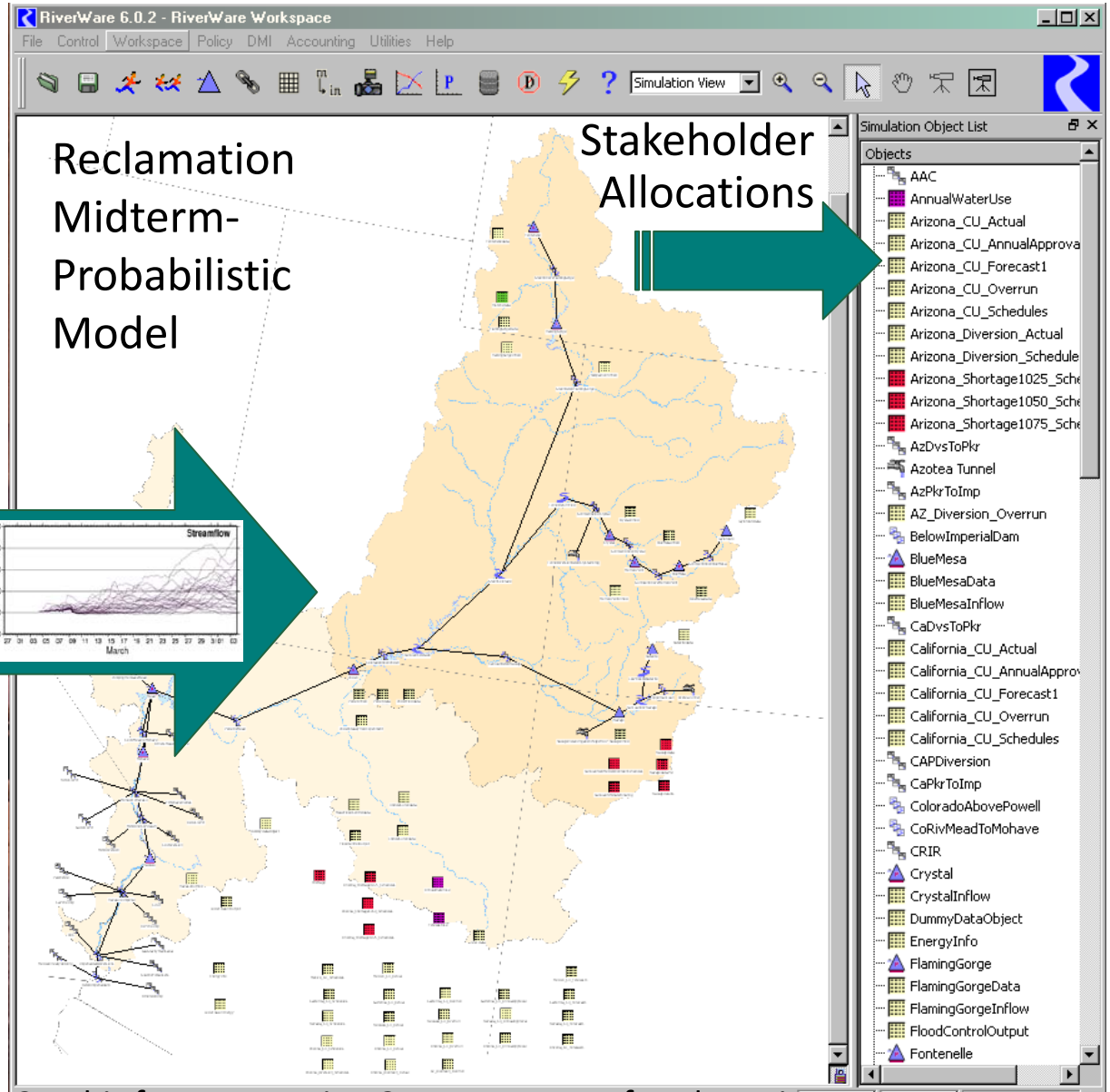


www.cbrfc.noaa.gov/devel/hefs/

Linkage to Water/Energy Management

In development…
CFS-based flow forecasts for Reclamation water management



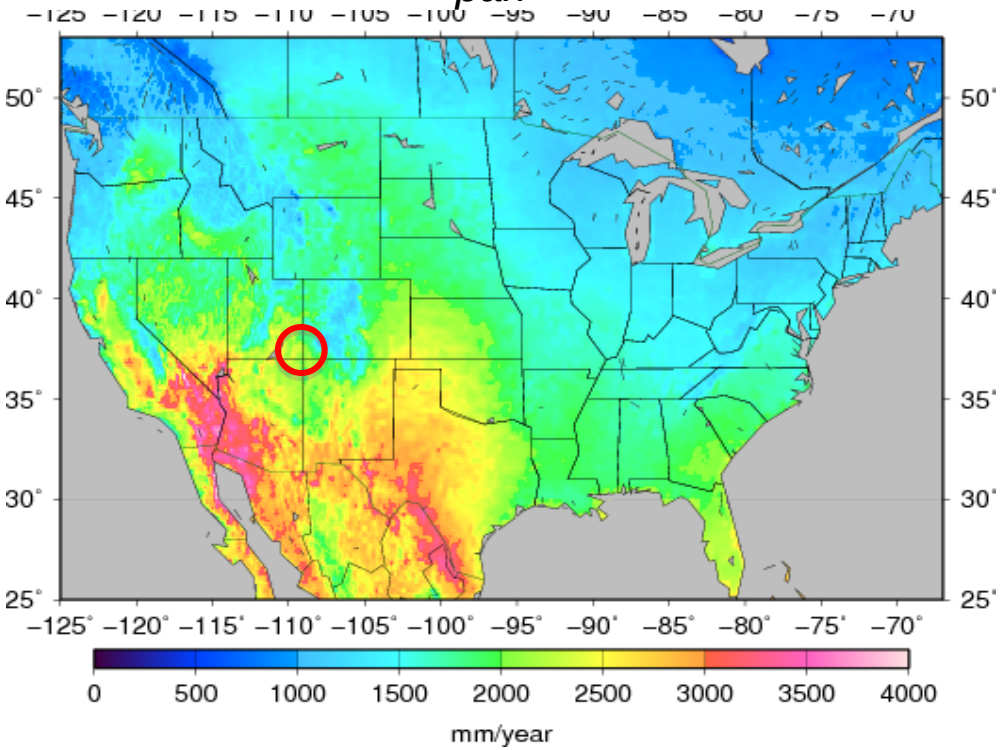


Graphic from Dr. Katrina Grantz, Bureau of Reclamation

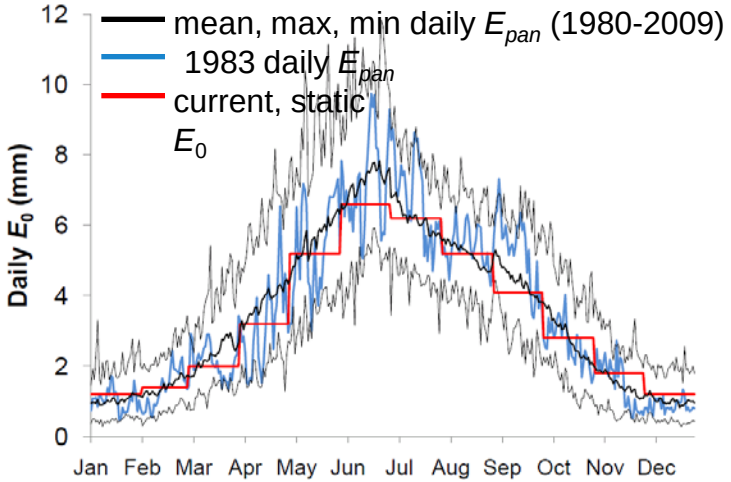
Dynamic evaporative demand across CBFC

Animas River test-basin

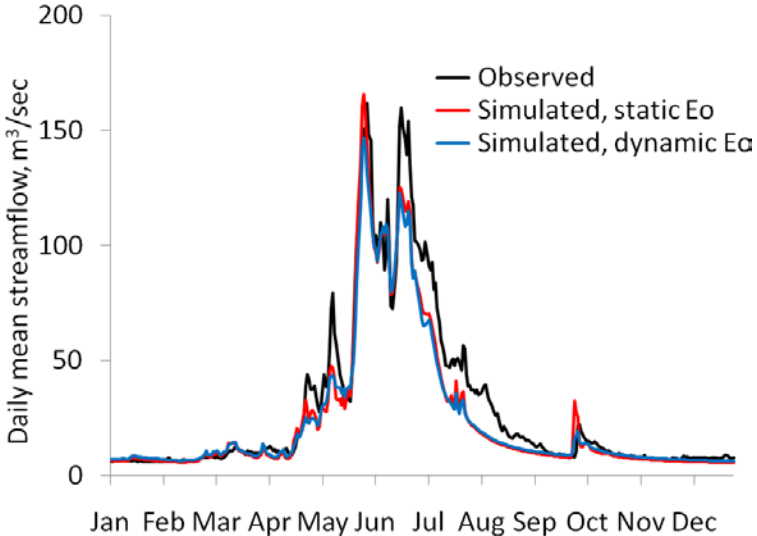
Mean annual E_{pan}, 1980 -2009



E_{pan} across Animas R, 1980 - 2009 (& 1983)



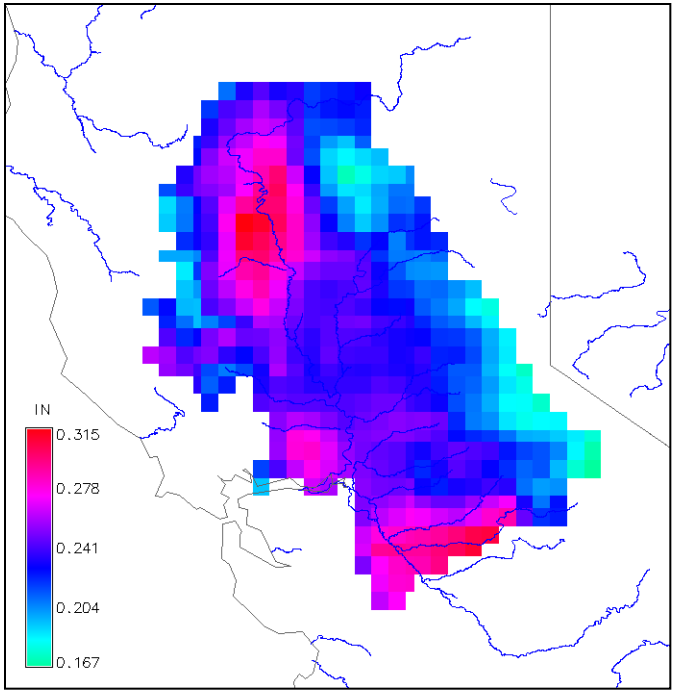
Streamflow at Animas R,1983

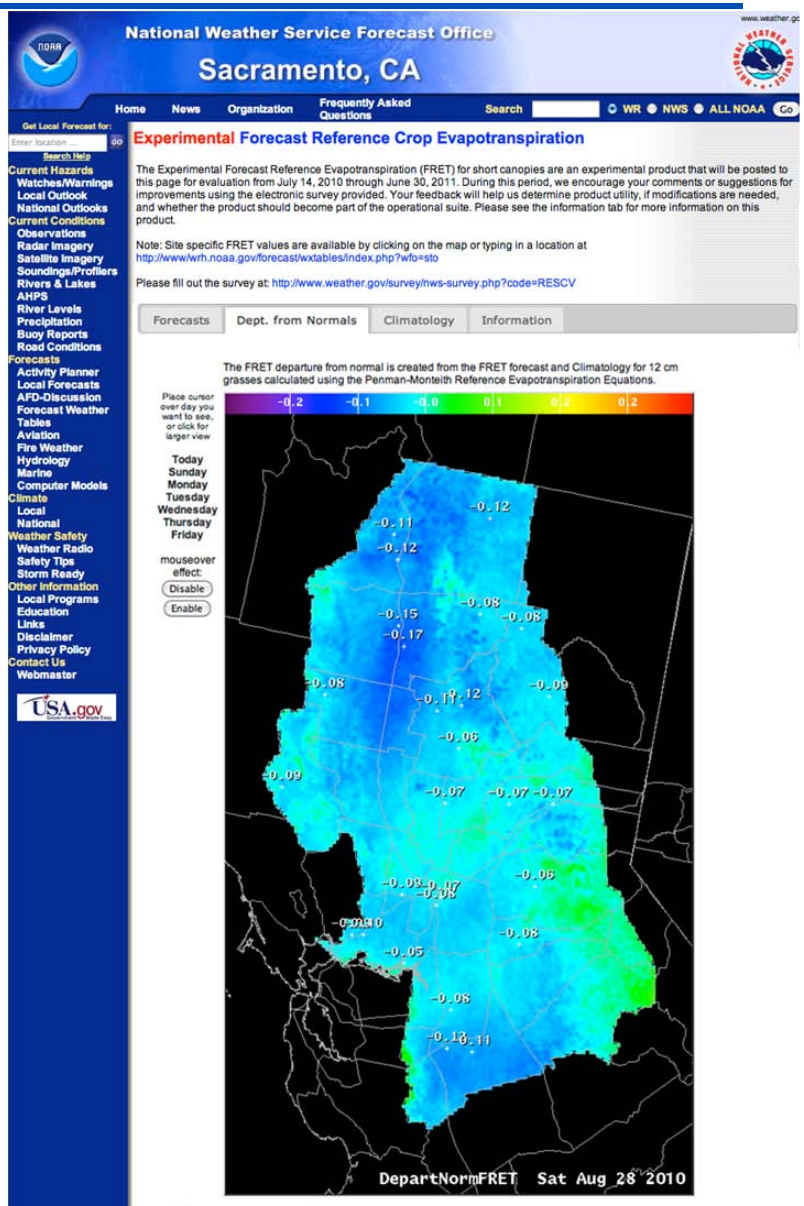


Near real time daily updates

Forecasting ET_{rc}

Climatology surface + forecasts for specific to date and tailored to WFO -> anomalies

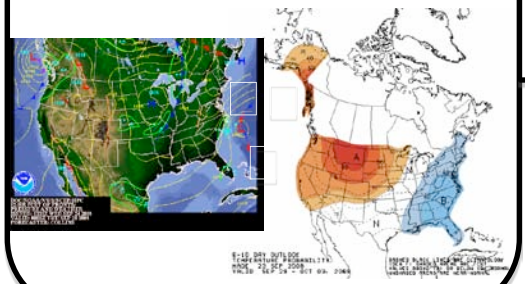




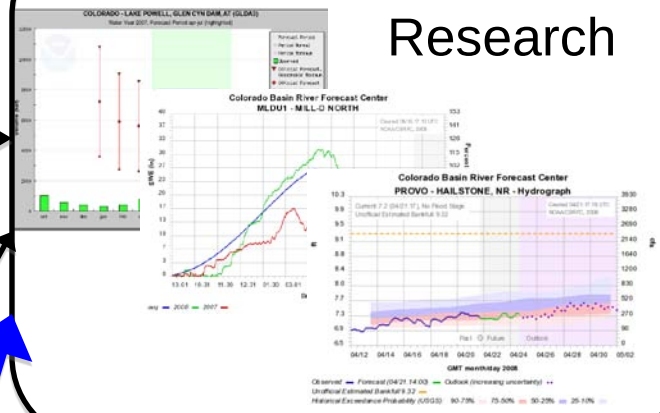
FRET website for Sacramento, CA
http://www.wrh.noaa.gov/forecast/evap/FRET/FRET.php?wfo=sto

CBRFC and NIDIS

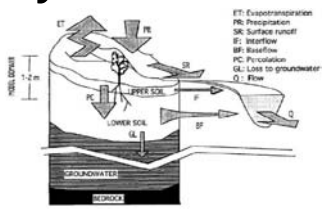
Climate and Weather Forecasts



CBRFC Forecasts & Research



Hydro Models



Research

NIDIS

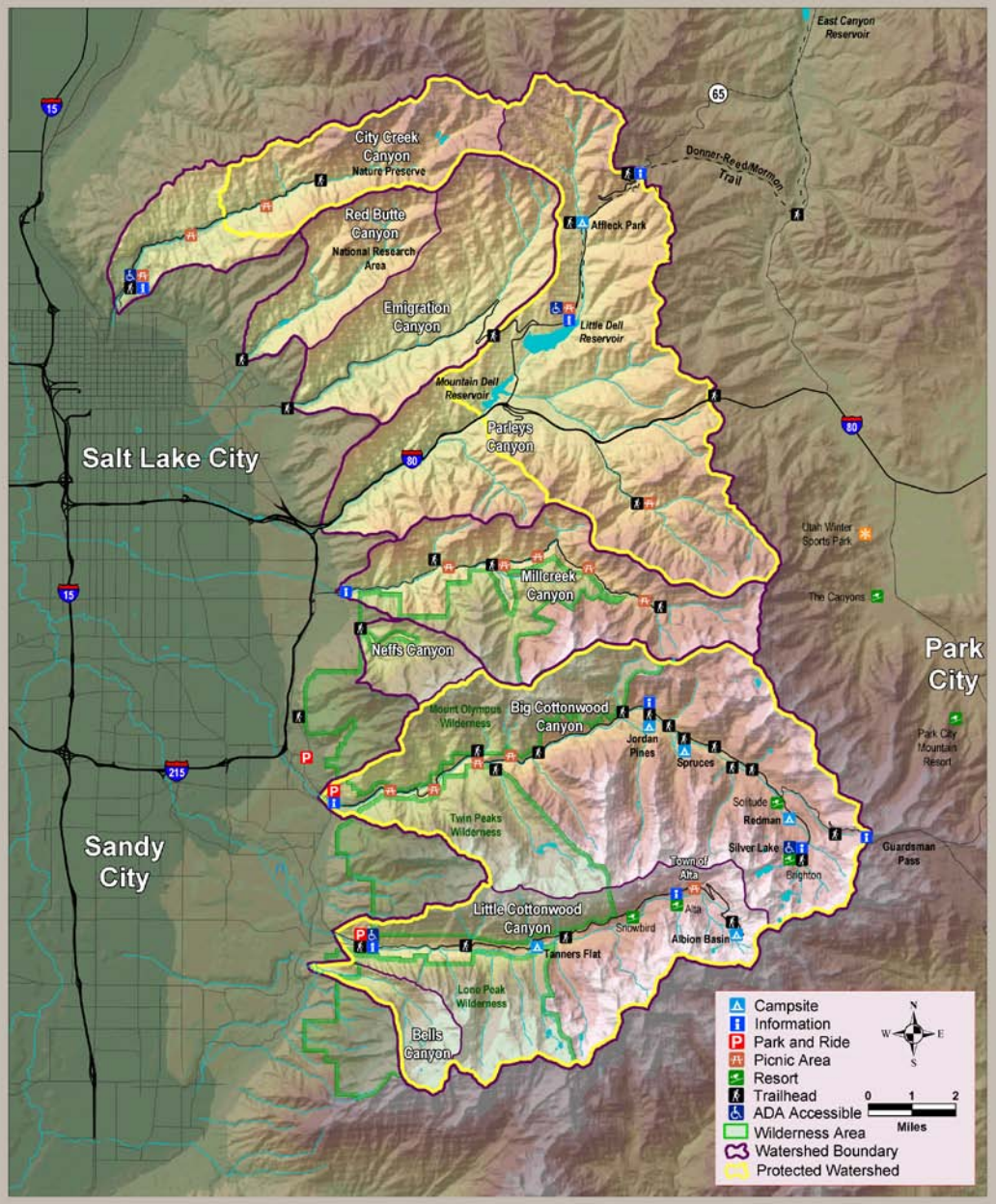
NIDIS

NIDIS

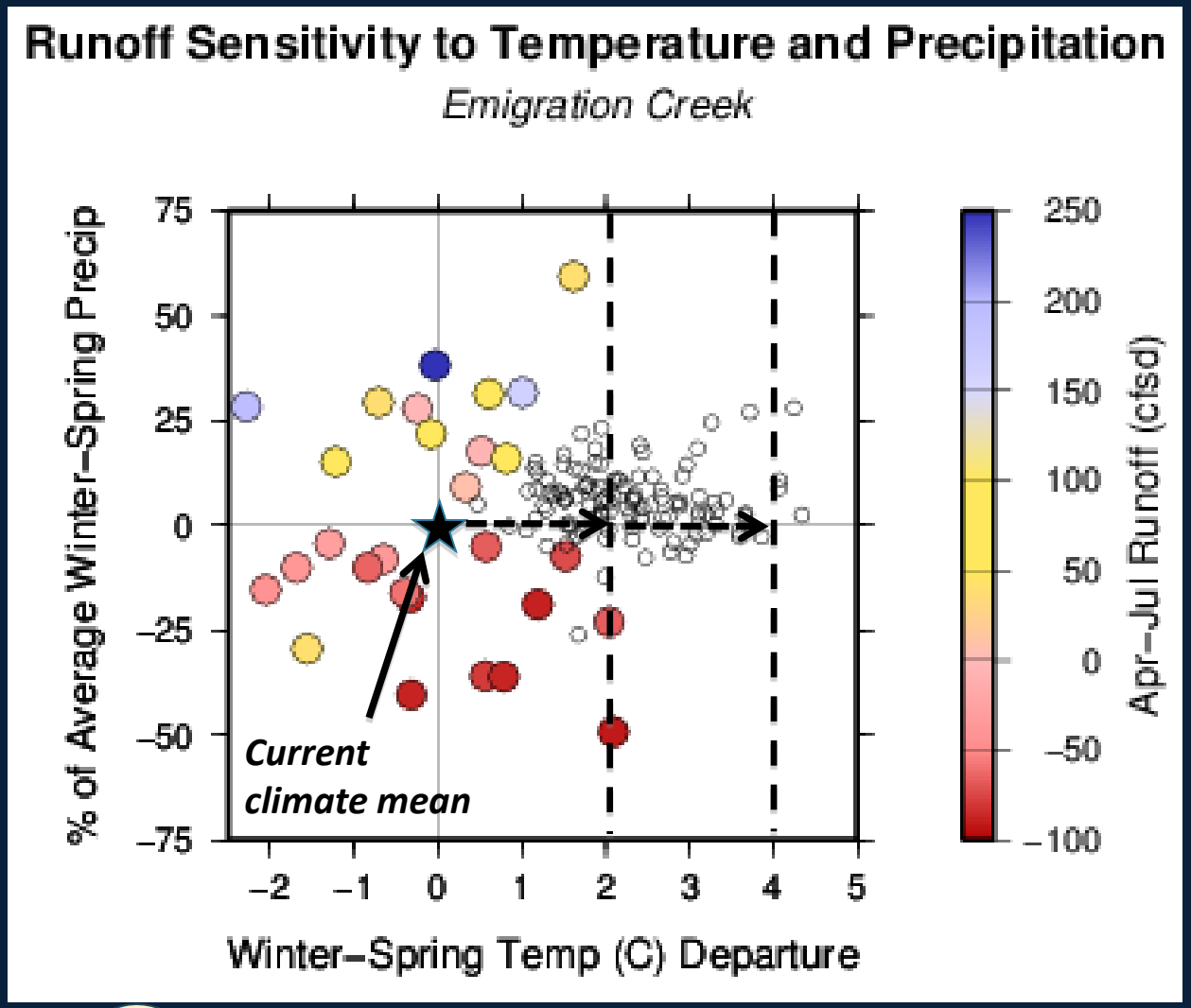
Decision

Value

Salt Lake City Watersheds



Streamflow – Future Climate Response



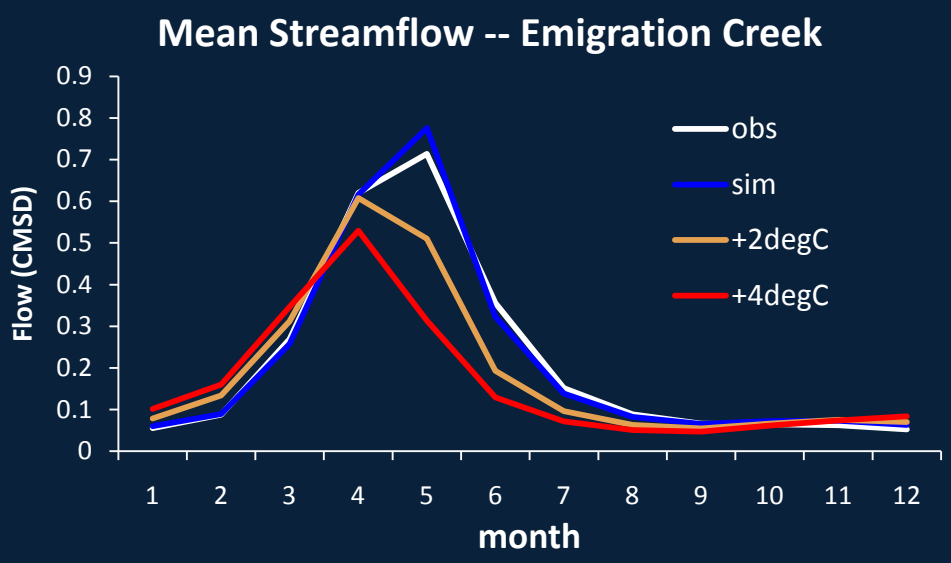
Emigration Canyon

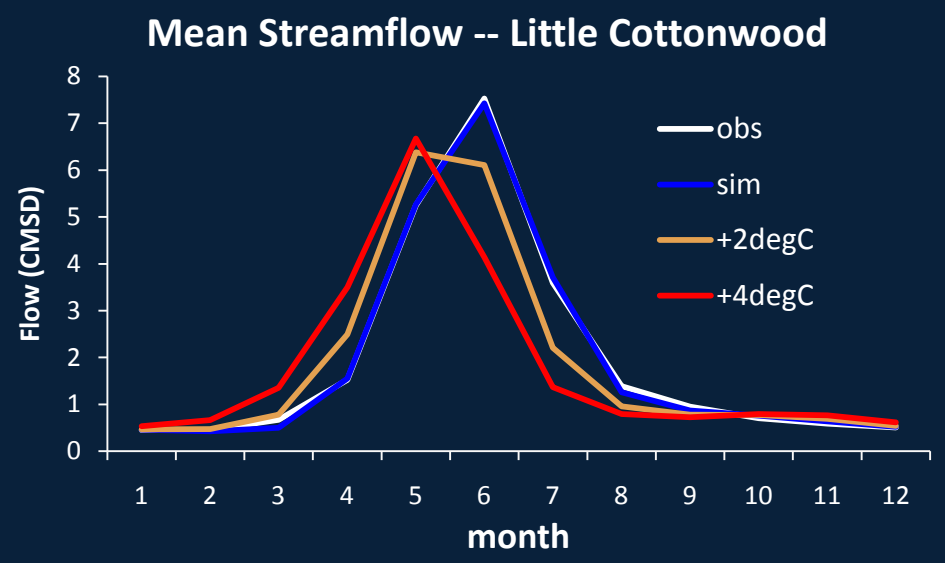
Let's take a look at two simple change scenarios

- No change in precip
- +2 deg C uniform
- + 4 deg C uniform

This is the so-called "Delta method" or "perturbation method"

Sensitivity of Flow to Projected Temp Changes

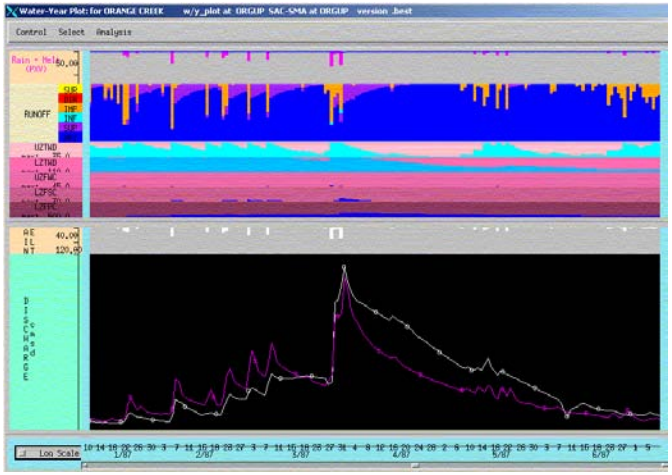


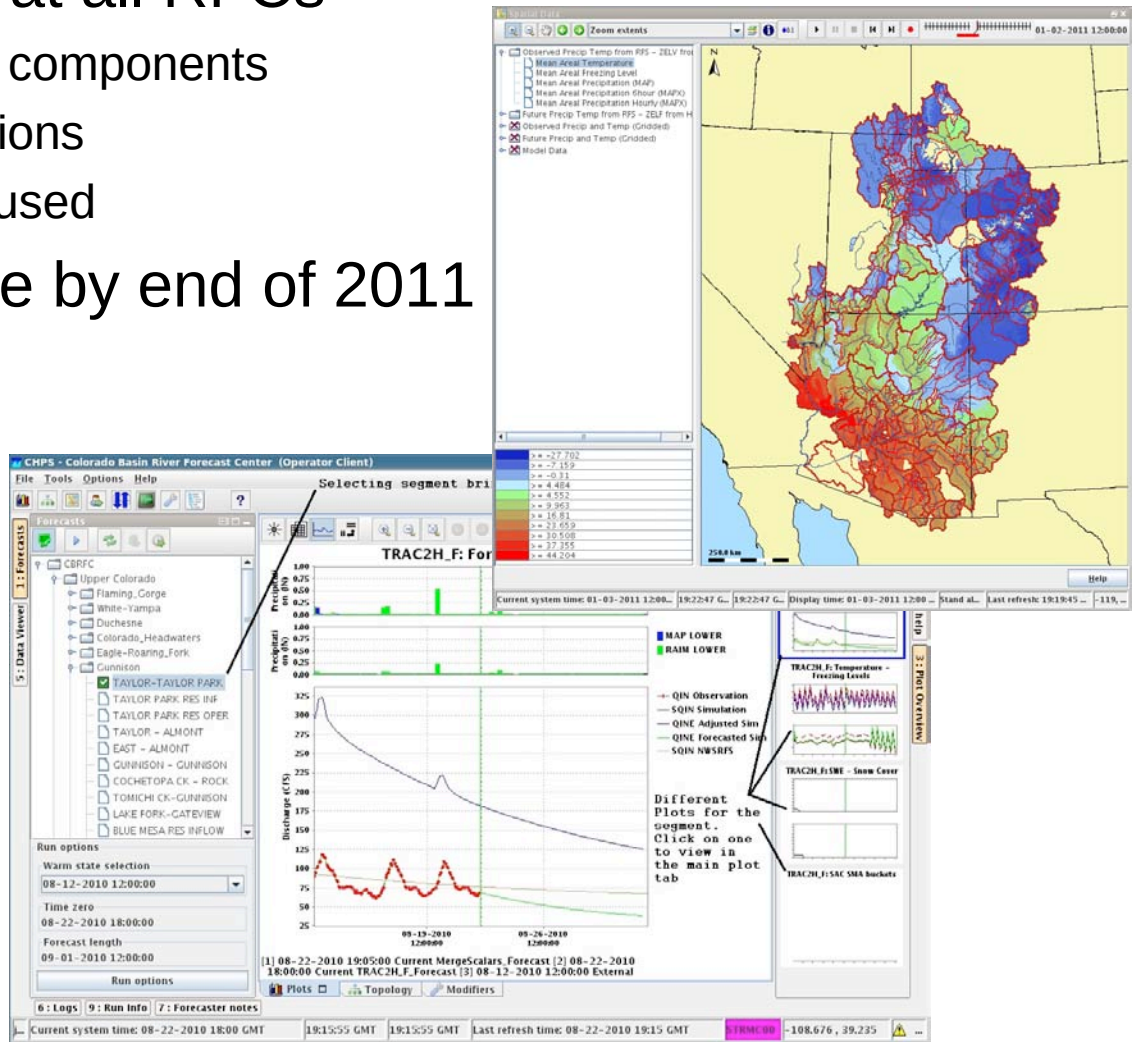


- Mean annual cycles are well calibrated
- Even at +2 degrees, annual cycle diminishes flow
- +4 degrees: annual cycle progressively more altered (time, volume)
- Emigration Creek (lower elevation) more vulnerable than Little Cottonwood Creek (higher elevation)

Community Hydrologic Prediction System CHPS

- New modeling structure at all RFCs
  - Facilitate testing new model components
  - Facilitate research to operations
  - More insight into the model used
- Implementation complete by end of 2011





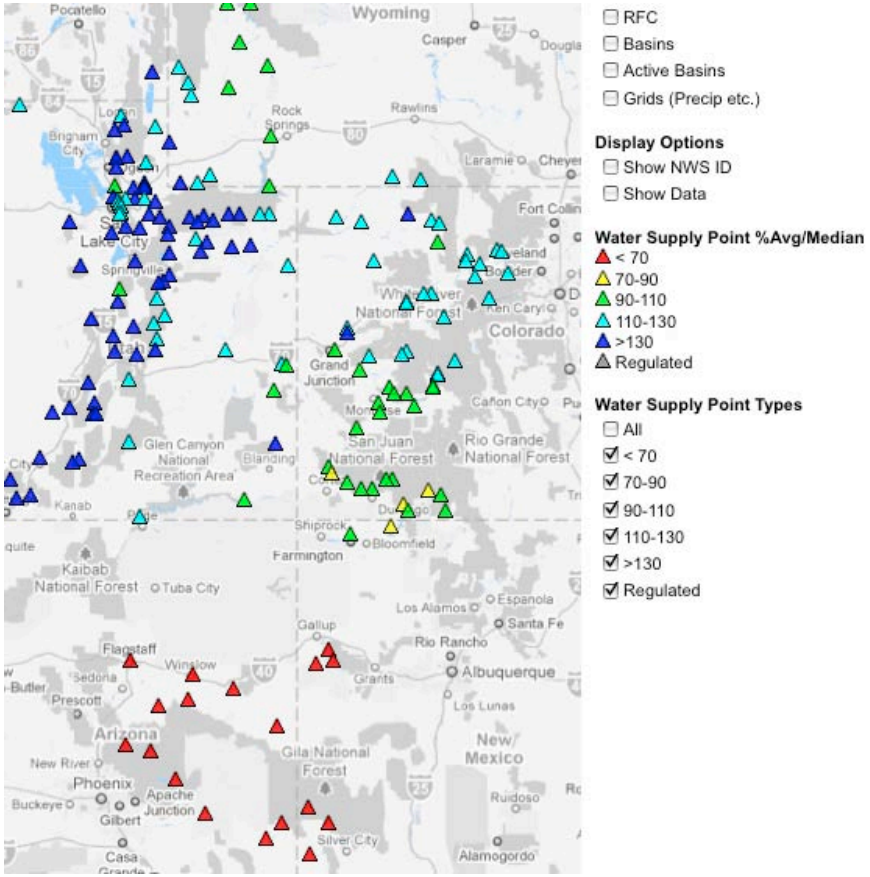
Take-aways

CBRFC is an operational office.

- Staffed and issue forecasts 365 days/year
- Support regular stakeholder decisions and maintain relationships with stakeholders

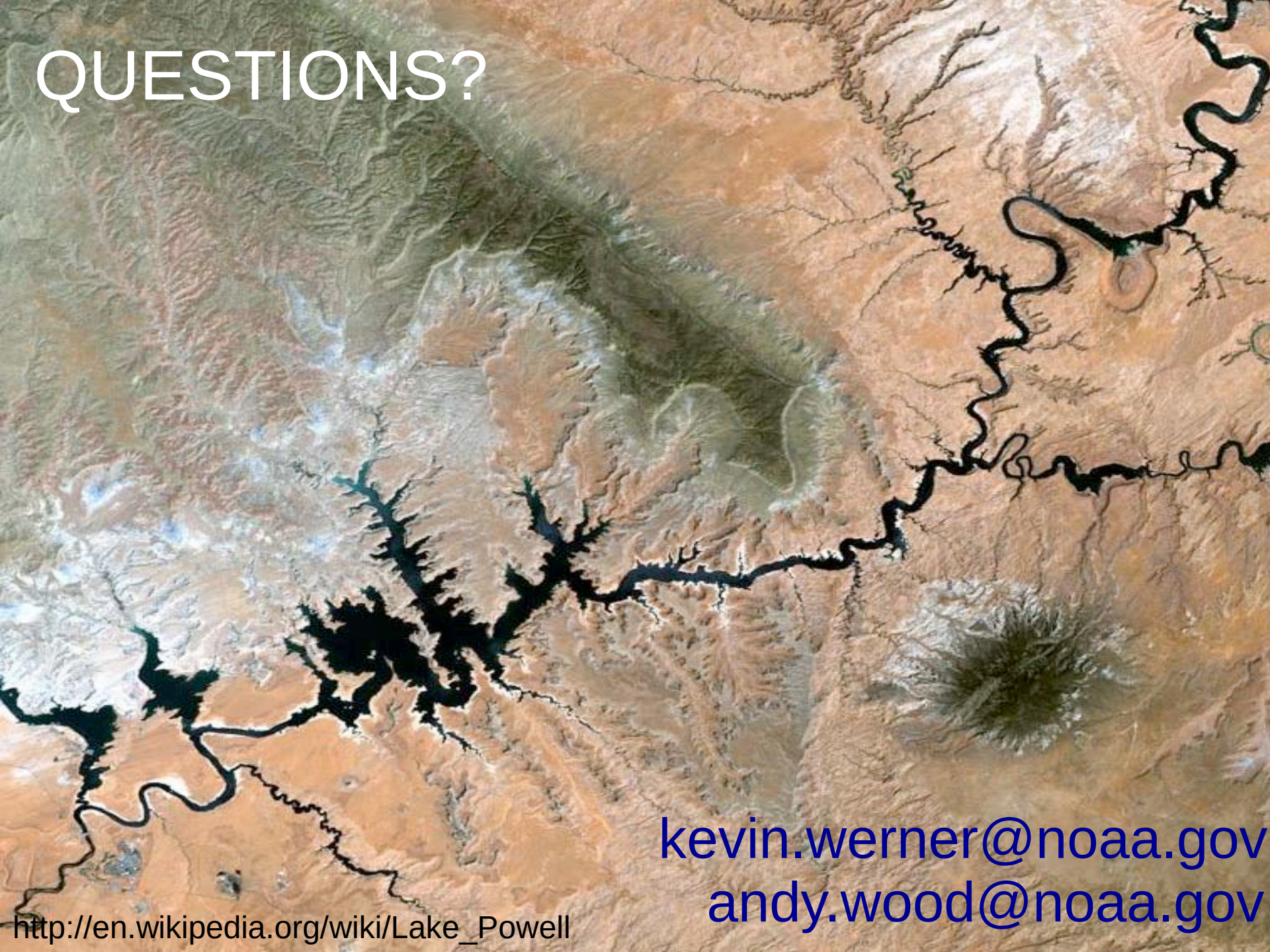
CBRFC also supports R&D to improve forecasts and datasets

- Partners in applied research at universities and agency labs
- Supports / participates in grant seeking activities
- Guides funding agendas



February Water Supply Forecast

QUESTIONS?



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http://en.wikipedia.org/wiki/Lake_Powell