Simulation Modeling Activities of the NWCC

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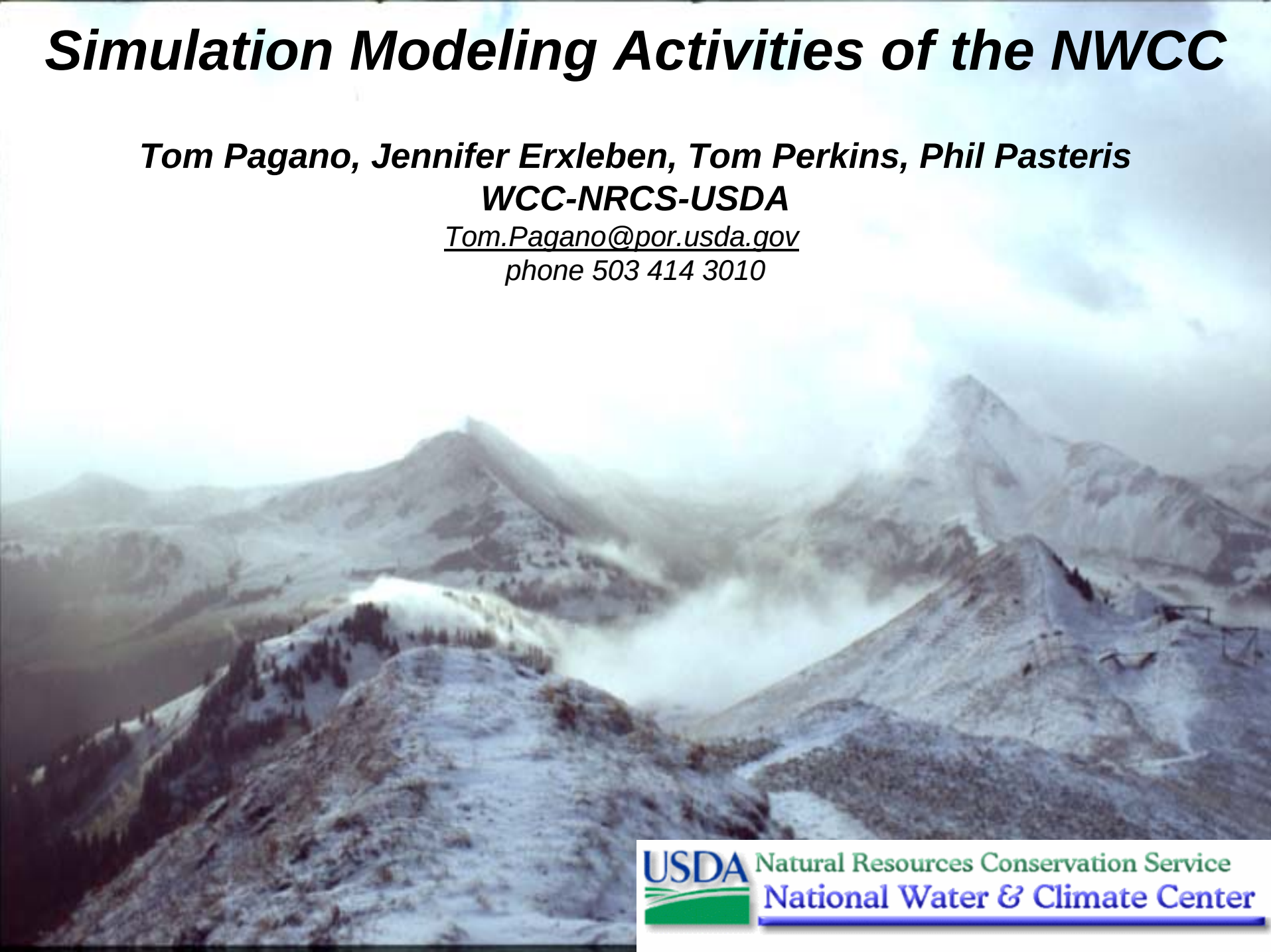


USDA Natural Resources Conservation Service
National Water & Climate Center

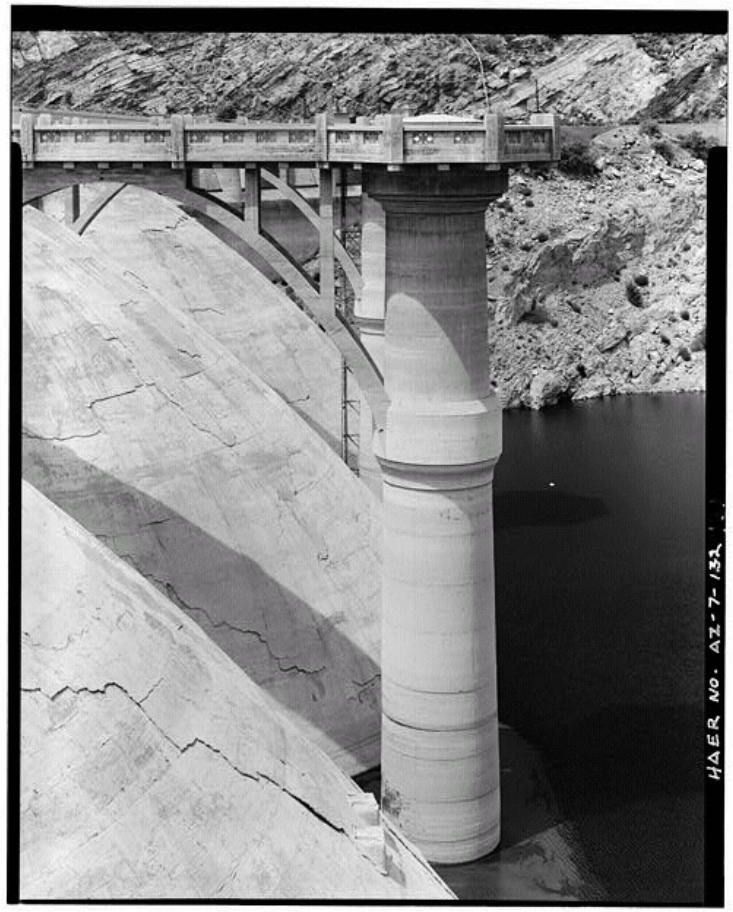
Overview

Who we are

What modeling gets us

What we are doing

Where we are headed



NRCS Water and Climate Services 2005

Tom Perkins, Dave Garen, Jim Marron, Phil Pasteris, Jennifer Erxleben, Jolyne Lea, Tom Pagano

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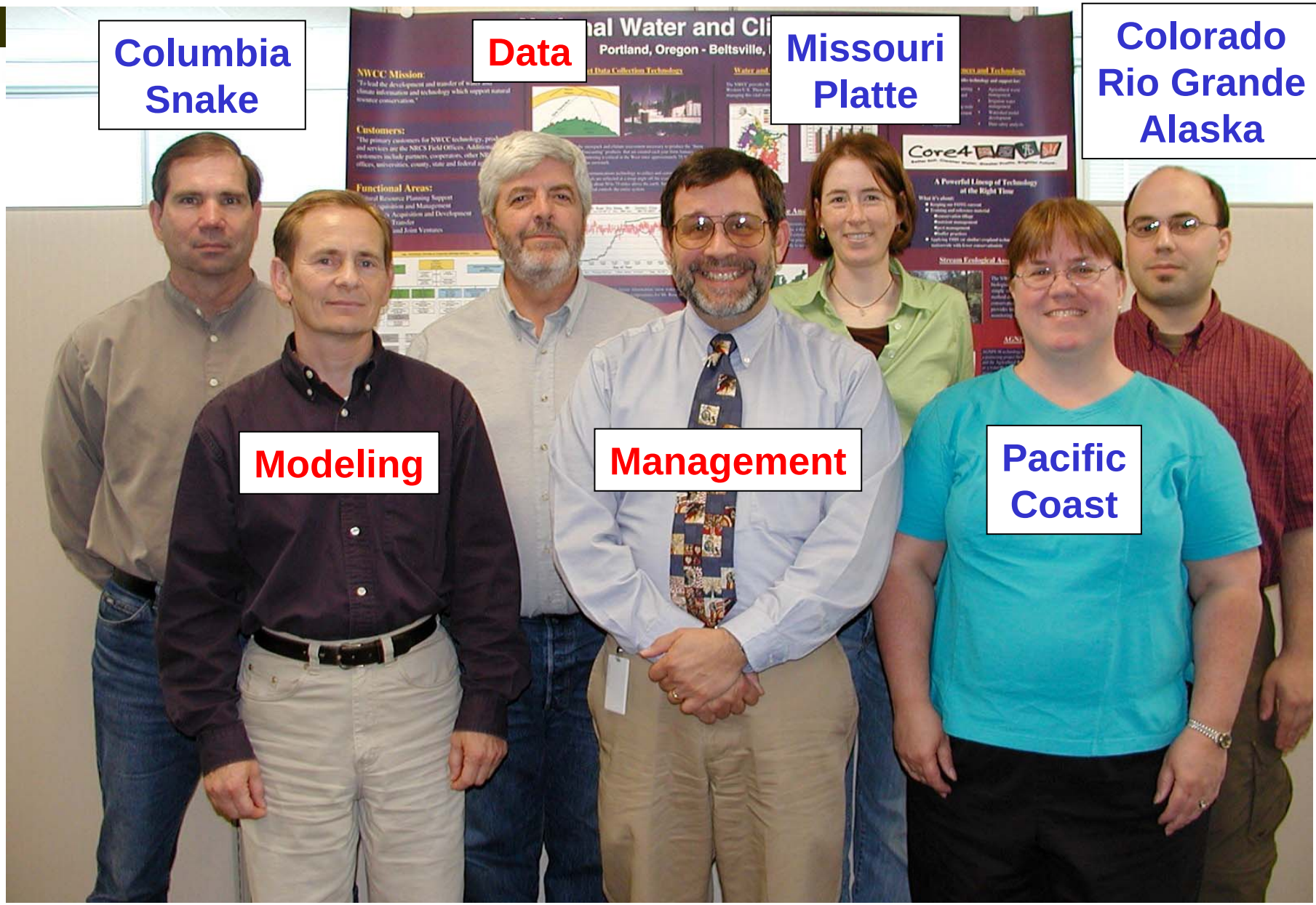

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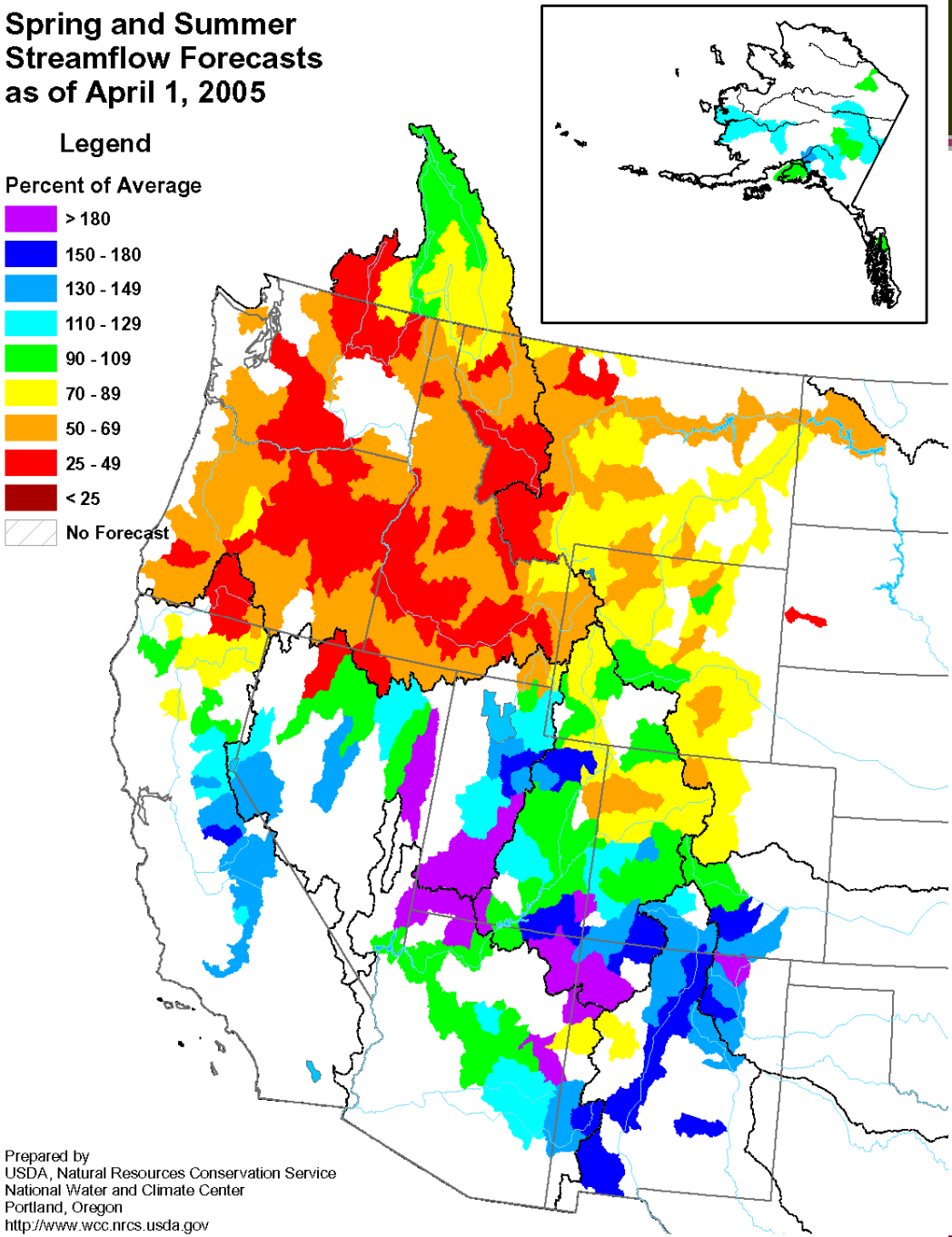

Seasonal water volume forecasts

Issued monthly/bi-monthly January-June

Primary driver: snowpack, antecedent precipitation

Probabilistic but most products deterministic

Four NRCS forecast hydrologists

Potential benefits of simulation models

Improved water resource information for agricultural customers

Explicit, quantitative estimates
of the effects of soil moisture on runoff

More realistic shapes to our error bounds
(reasonable max/min, etc) especially in arid regions

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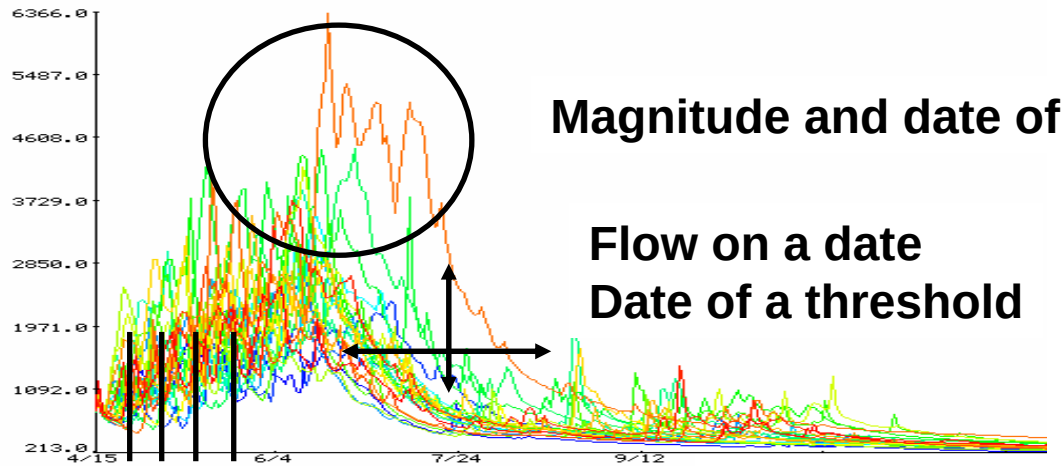
Forecasts of any parameter you can derive from a hydrograph:



Magnitude and date of peak

Flow on a date
Date of a threshold

Monthly, weekly volumes

Daily scenarios for use in a reservoir optimization program

An experimental setup (2005)

Data: Daily Tmax/Tmin, Precip from ACIS/Snotel
Martyn Clark's quality control

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Data: Daily Tmax/Tmin, Precip from ACIS/Snotel
M. Clark's quality control

Model: PRMS/MMS

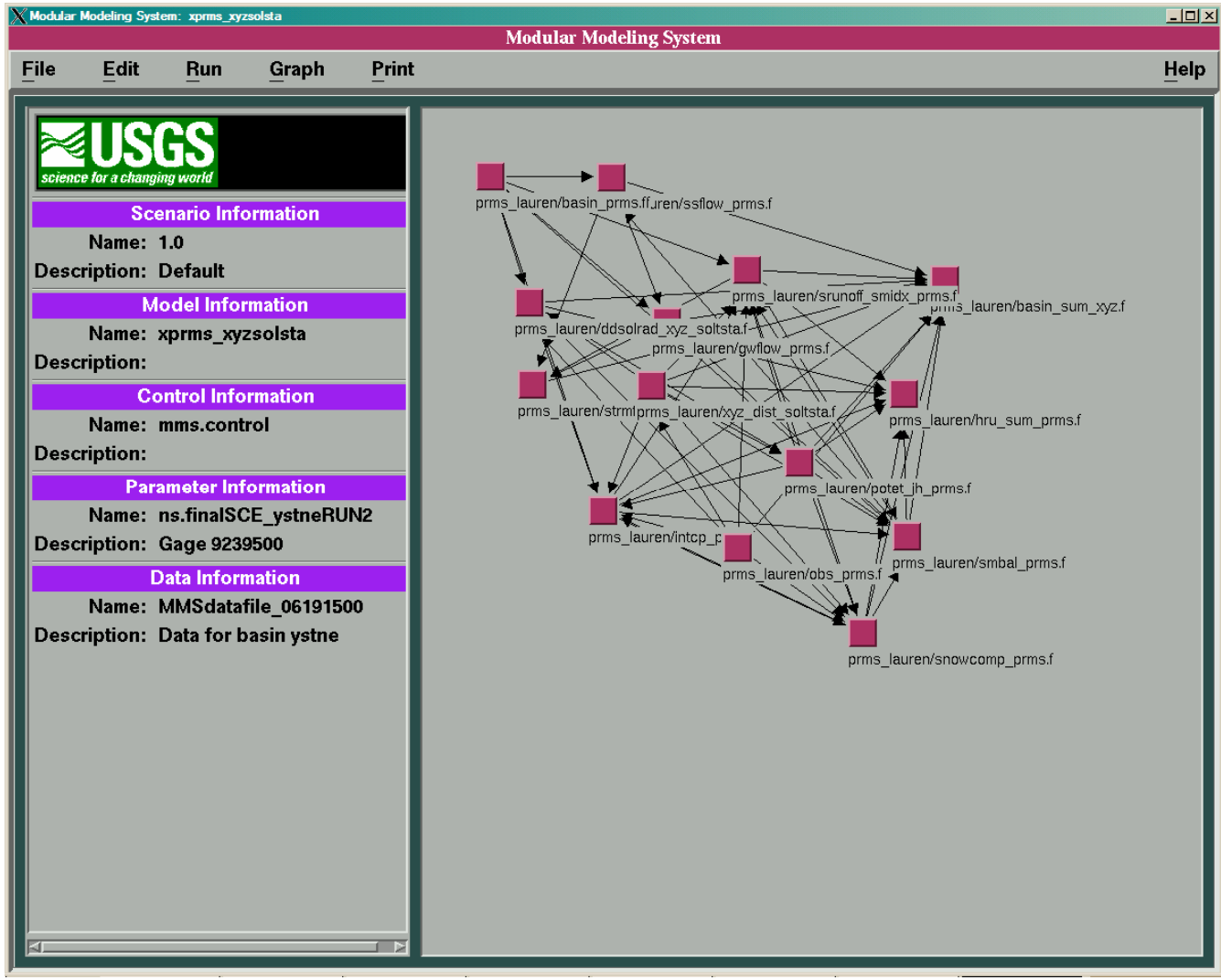
Spatial parameter estimation: GIS Weasel

Non-spatial parameter calibration:
L. Hay iterative multi-objective
internal-state calibration routine

Forecast uncertainty: vanilla ESP

USGS Modular Modeling System

Currently using "off the shelf" PRMS package

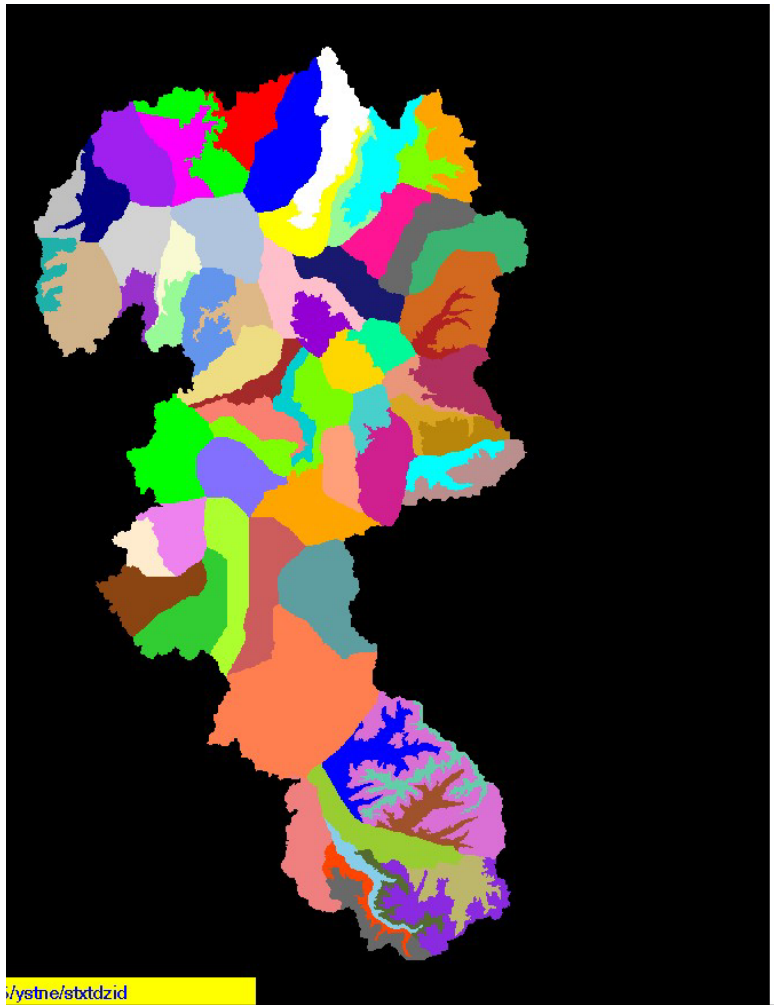


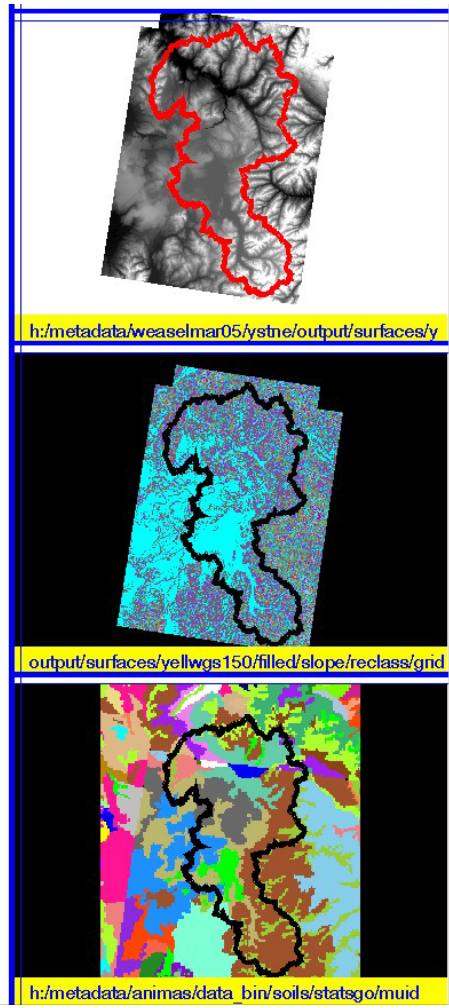
Calibration of PRMS Spatial Parameters

The GIS “Weasel”

Uses slope, aspect, elev, soils, veg type, veg density to define “Hydrologic Response Units” and associated model parameters

“1-button” Weasel recently developed and is being tested





Estimating non-spatial parameters

Traditional Approach

Manually tweak parameters to minimize bias, visually fit hydrograph to observed flow.
Not without its problems

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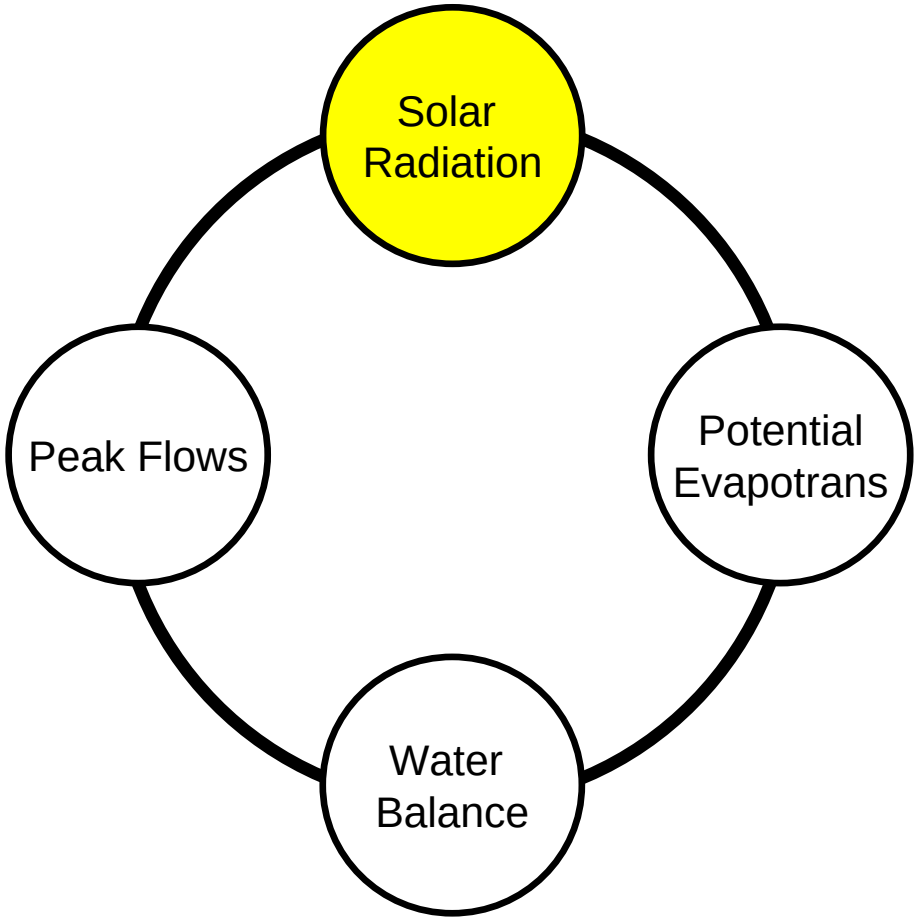
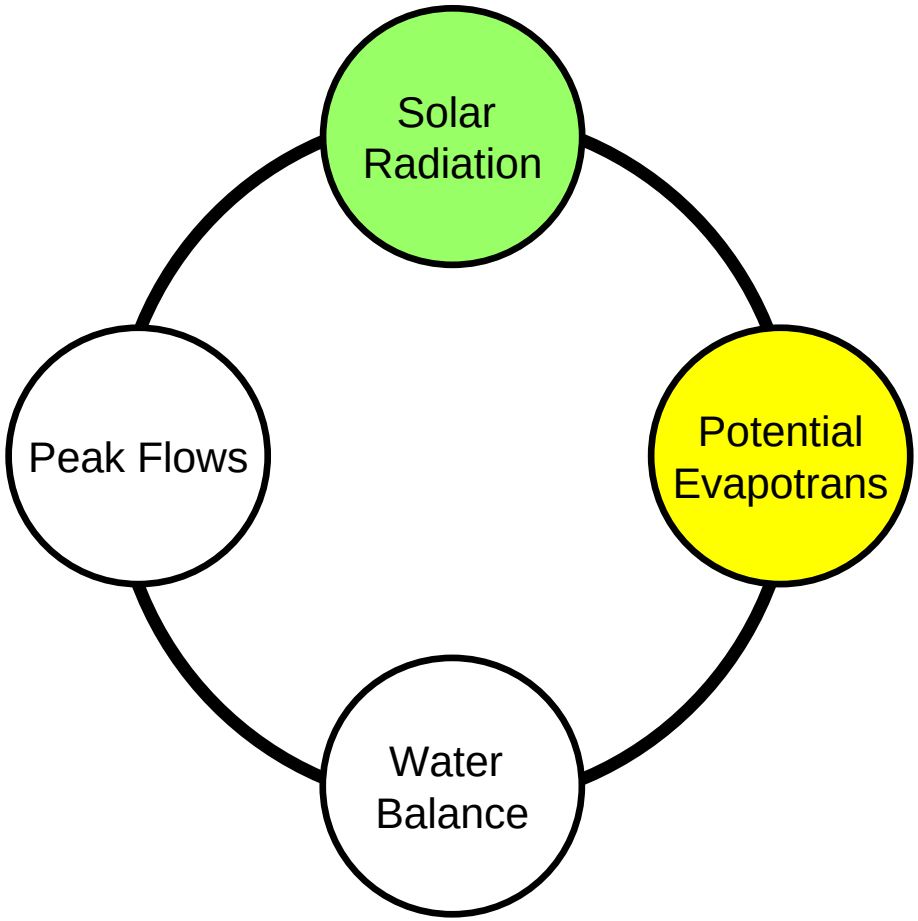
Multi-step Automatic Calibration Scheme (Hay/USGS)

Iteratively and automatically calibrate model internal states.
Not without its problems



Adjust radiation-related parameters.

Check if model seasonal cycle matches “observed” radiation data.



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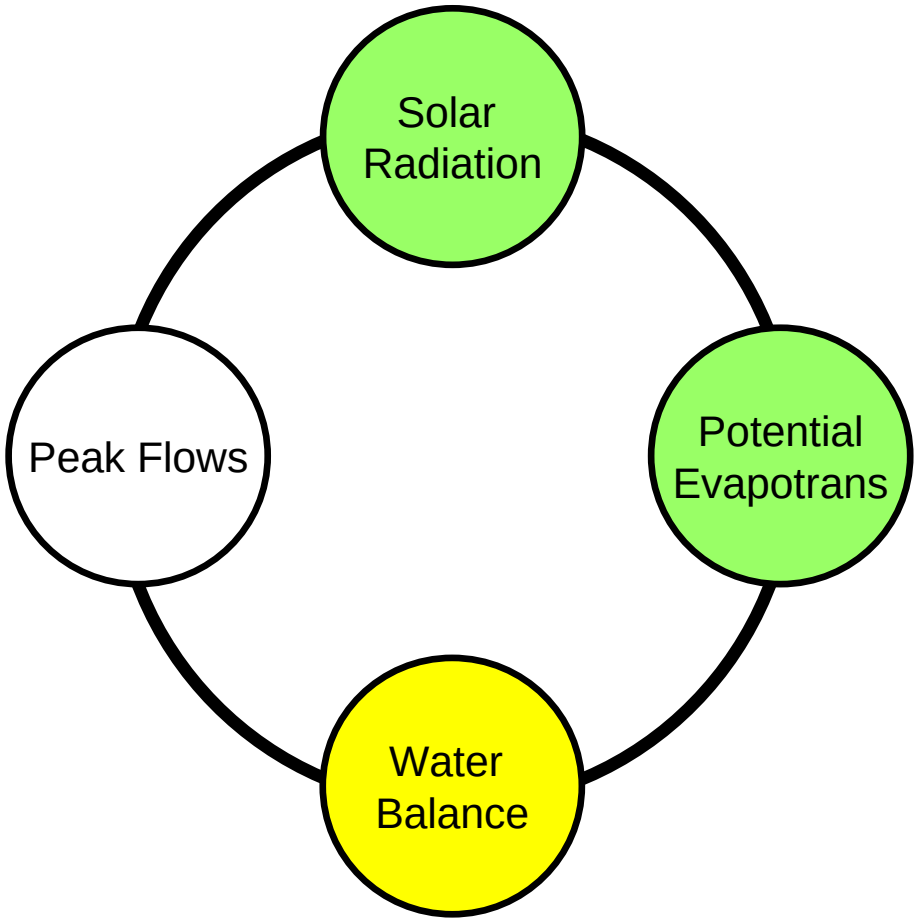
Adjust evaporation parameters.
Check seasonal cycle against “observed” potential ET data.



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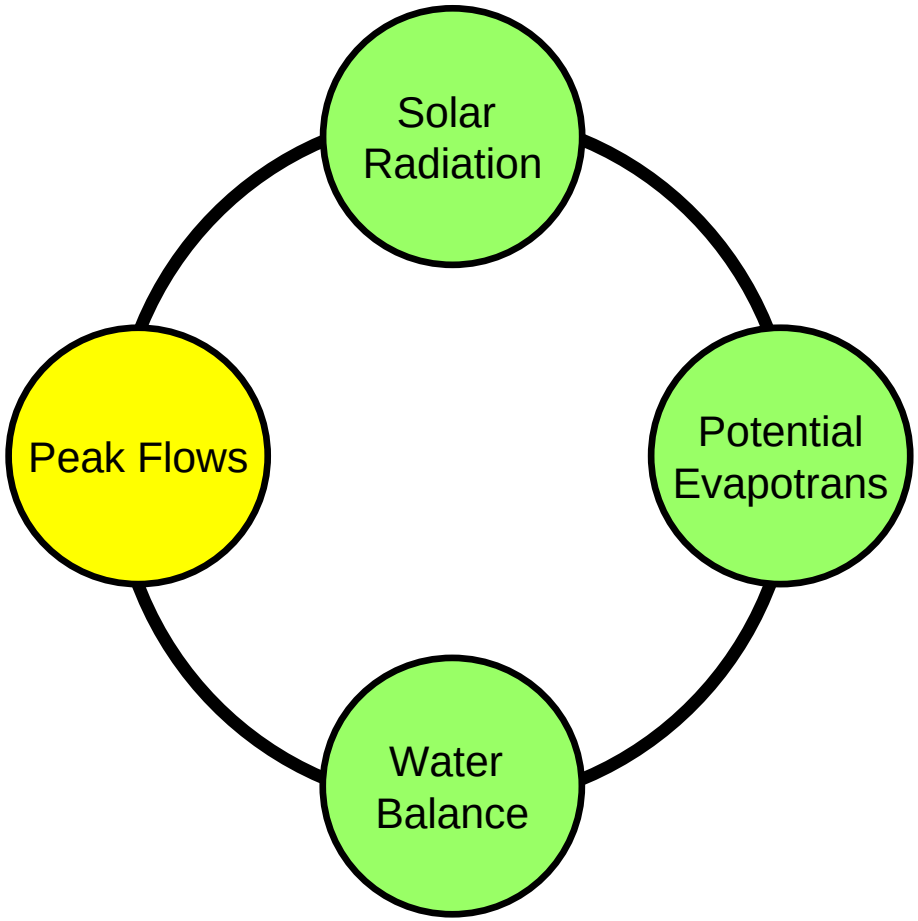
Check annual flow volume vs obs.



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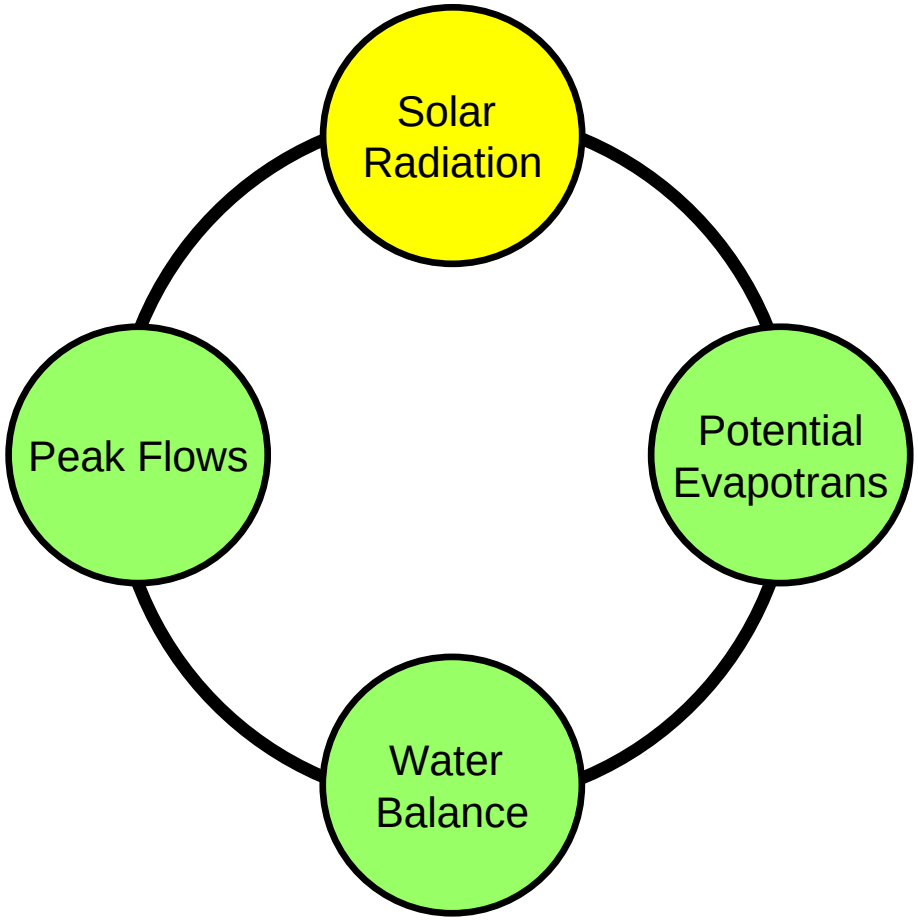
Adjust flow timing parameters.
Evaluate flow on peak flow days.



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Rinse and repeat 4-8 times.

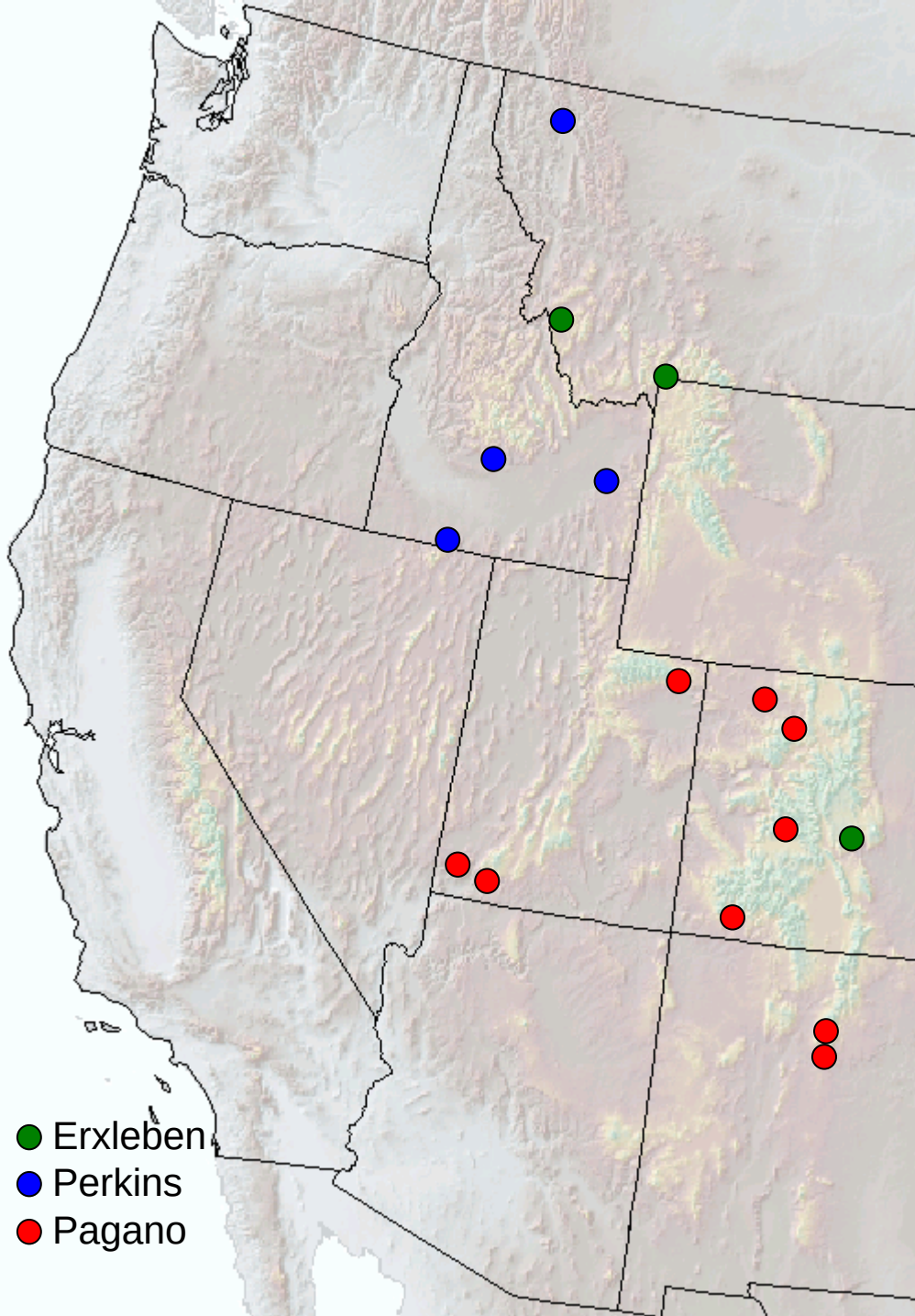
PRMS-MMS
Calibration and Operations

16 headwater basins in diverse climates

NWCC personnel calibrated
spatial parameters (Oct 2004)

USGS has automatic procedure to
calibrate remaining parameters (Nov 2004)

USGS/USBR also running PRMS model in Gunnison, San Juan, Rio Grande, Carson, Yakima, so additional basins could be a collaborative effort for 50 forecast points?



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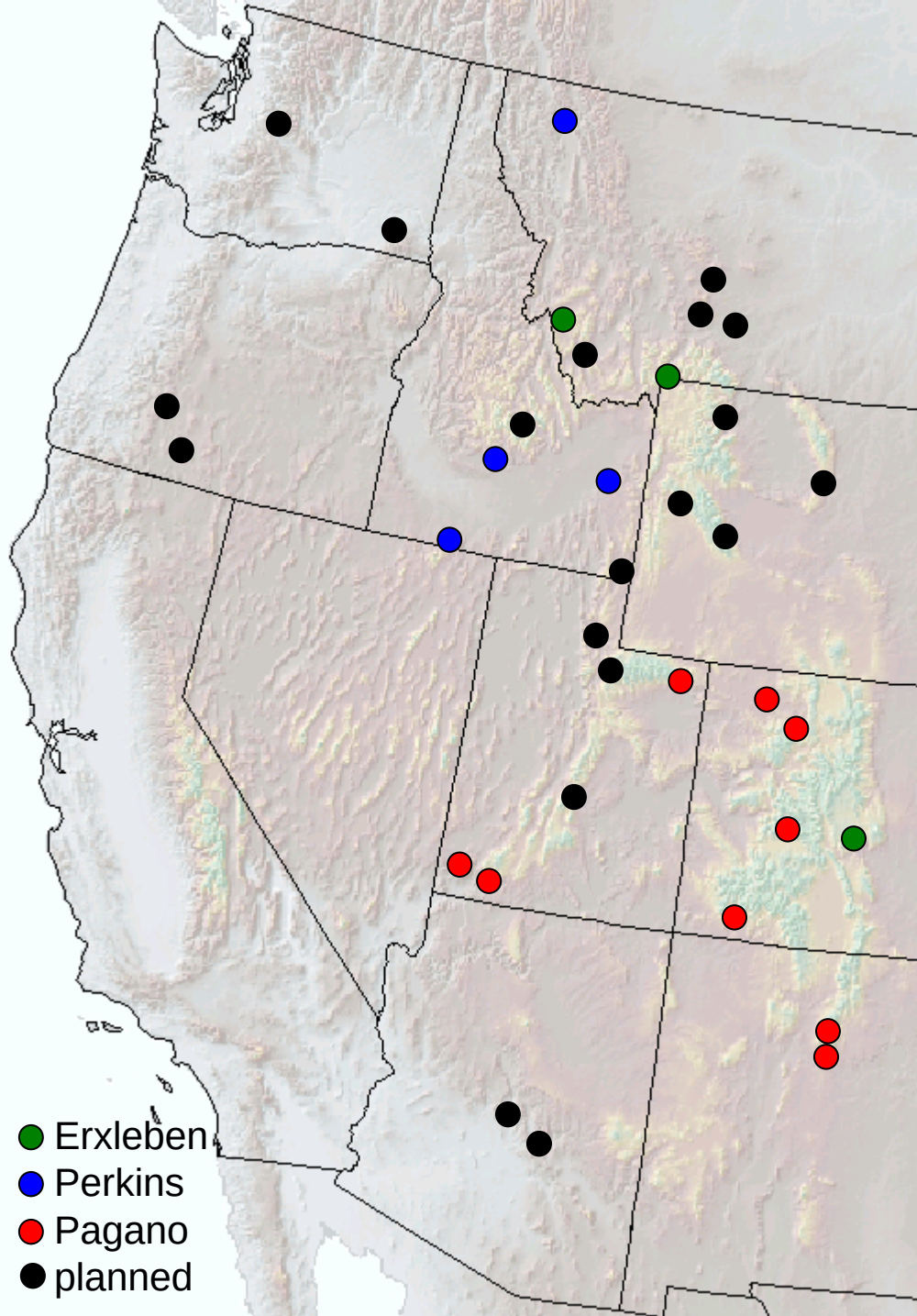
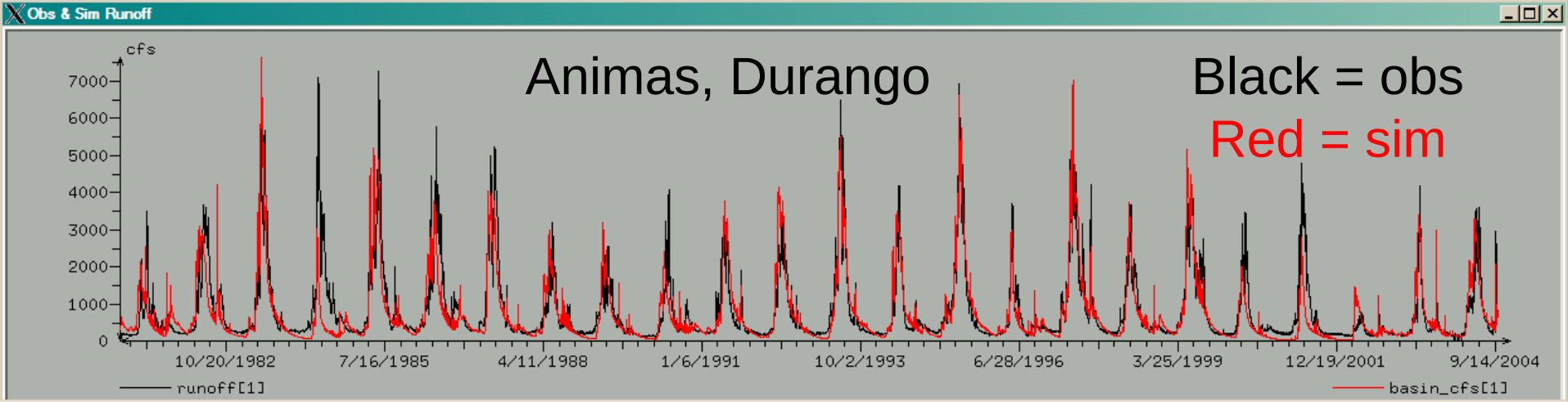
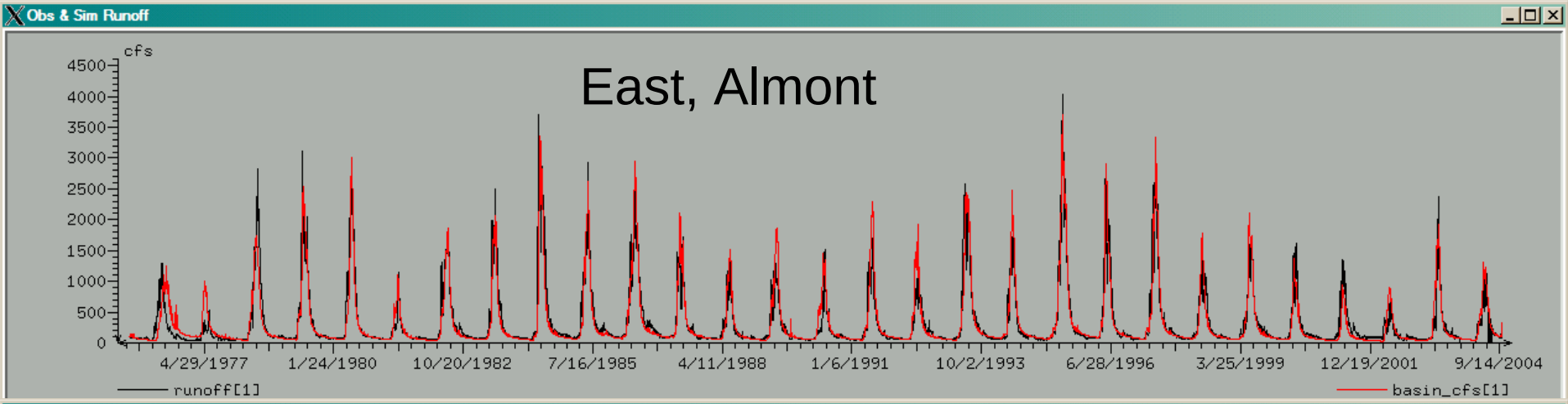
Specific plans to increase roster
to ~35 based on user needs




Obs & Sim Runoff
Animas, Durango
Black = obs
Red = sim
cfs
7000
6000
5000
4000
3000
2000
1000
0
10/20/1982
7/16/1985
4/11/1988
1/6/1991
10/2/1993
6/28/1996
3/25/1999
12/19/2001
9/14/2004
runoff[1]
basin_cfs[1]


Obs & Sim Runoff
East, Almont
cfs
4500
4000
3500
3000
2500
2000
1500
1000
500
0
4/29/1977
1/24/1980
10/20/1982
7/16/1985
4/11/1988
1/6/1991
10/2/1993
6/28/1996
3/25/1999
12/19/2001
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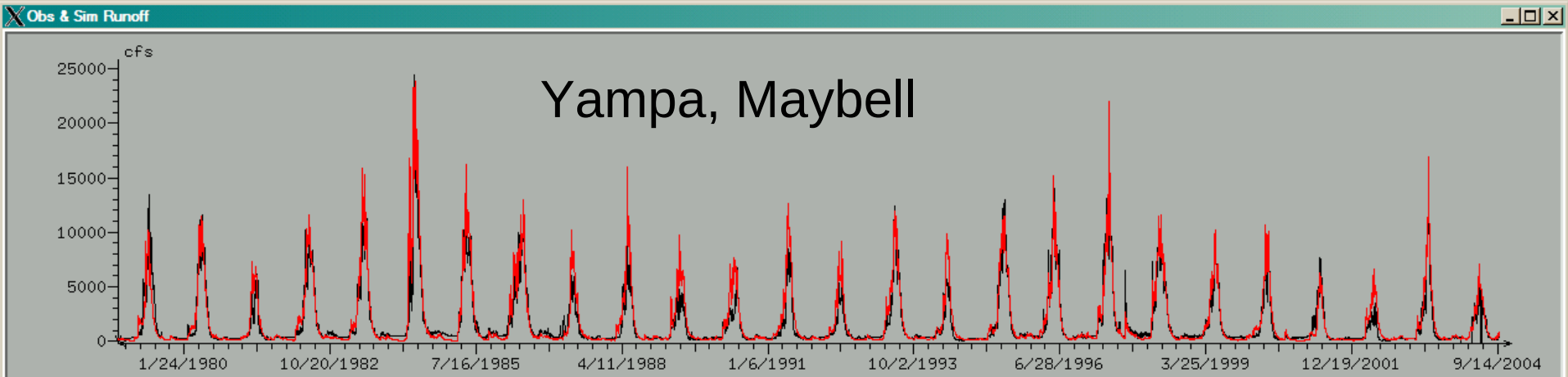
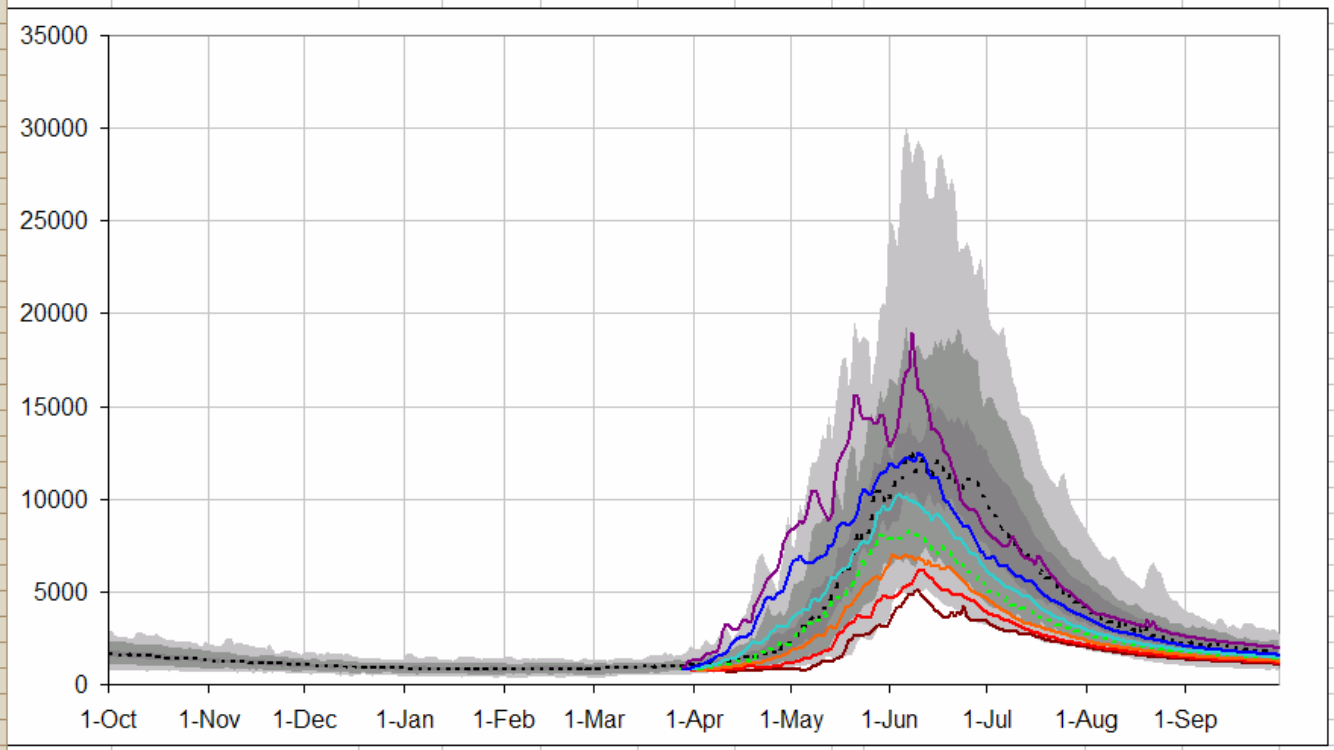

Obs & Sim Runoff
Yampa, Maybell
cfs
25000
20000
15000
10000
5000
0
1/24/1980
10/20/1982
7/16/1985
4/11/1988
1/6/1991
10/2/1993
6/28/1996
3/25/1999
12/19/2001
9/14/2004

Interim NRCS Spreadsheet-based output interface

ID	parameter set	variable	Startyr	Sitename
06191500	3	13	1959	Yellowstone River at Corwin Springs MT

Load Data Files | Change Variable | Clean Up



1	conditional streamflow (sim climatology)
2	groundwater storage (bottom)
3	precipitation
4	accumulated precipitation
5	snow water equivalent
6	snow covered area
7	soil moisture (top)
8	subsurface storage (middle)
9	total basin storage (top+mid+bot+snow)
10	tmax
11	tmin
12	cond accum flow (sim climatology)
13	**cond streamflow (obs climatology)**
14	cond accum flow (obs climatology)
15	sim streamflow (obs climatology)
16	sim accum flow (obs climatology)
17	non-snow basin storage
18	tavg

Show:	
max/min	☑
10 and 90	☑
30 and 70	☑
median	☑
Last Year	☐
Current Year	☑

	Sum	Peak
ESP	1132.8	10097.6
Hist	1688.1	17500.0
ESP%Hist	67%	58%

Analysis	Edit me	Don't Edit me
Start Search	1-Mar	37316
End Search	31-Jul	37468
Threshold	0	
Threshold as % peak?	FALSE	Analyze
Convert to k-acre-feet?	TRUE	

Benchmarks

Standard desktop computer (2.8 Ghz) doing all 16 basins x 2 parameter sets:

Gathering water year data (8 minutes) and running ESP (55 traces, 8 minutes).

Currently run on a scheduler 4x daily.

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Practical with limited personnel and hardware i.e. quick, automated.

Accurate, free of systematic biases, *honestly articulates all sources of uncertainty*, defensible.

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Transparent to forecaster, user and researcher. Accessible, understandable and portable.

Modern, flexible, dynamic, and up-gradable.

Collaborative opportunities:

Database design
Data quality
Data assimilation
Automatic calibration
Uncertainty estimation
Bias adjustment
Trace weighting
Super-ensembles
Forecast combination
Products
Delivery
Communication

A recipe for simulation modeling success:

Good timely data
“Intelligent Automation”
Friends willing to help

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A hydrologist’s perspective:

Operational hydrology is where meteorology was about 30 years ago. Operational climatologists routinely consider 10 statistical and 12 simulation model outputs, many run at universities. Why should operational hydrology be different???

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A goal: guidance from 5 defensible techniques. Many models, many parameter sets, many partners.

Thanks!