Snowmelt runoff in Southwestern Rivers
Seasonal prediction affected by climate change

NOAA’s 42nd Climate Diagnostics and Prediction Workshop

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Why didn't Elephant Butte Reservoir fill up after last winter's heavy snow?

How is the ongoing warming trend affecting snowmelt runoff, and seasonal water supply outlooks?
Accumulation and Ablation of Snowpack

Upper San Juan River headwaters

Peak snowpack occurs ~ 1 April
SWE anomalies tend to persist through accumulation season

Jones (2007)
UNM WRP
Observed Climate Variability in the Upper Rio Grande Basin

Chavarria (2016) from NOAA data

3°F increase in recent decades

Temp (Annual, °F)

Precipitation (Annual, in)

Chavarria (2016) from NOAA data
Snowpack in the Rio Grande Headwaters

~25% decrease 1958-2015

Chavarria & Gutzler (2017)
A Schematic Look at the Water Cycle

snow → snowpack
→ predictable runoff
runoff ratio $Q/SWE$ or $Q/P$

large-scale rain (winter, spring)
→ a source of uncertainty now
→ some seasonal predictability

convective rain (summer)
→ ~zero seasonal predictability

NRCS uses regression equations, derived from historical runoff and snowpack data, for its outlooks

How predictable is the flow (water supply) here?

8/11
Runoff ratios at the Del Norte gage

In later epoch: Better linear fit (Q depends more directly on SWE or P)
Shallower regression slope (reduced sensitivity of Q to SWE or P)
.... due to warmer temperatures, less snow, and more variable post-snow precip

Based on 1 Apr SWE

1958-1986

Based on winter precipitation

1958-1986

1987-2015

Apr-Jul Discharge [Mm^3]
Snowmelt Runoff in the Rio Grande: Long-term and Seasonal Outlooks

1. Climate is changing in ways that should affect surface water resources over the long term
   - Temperature ↑, Snowpack ↓
   - No significant long-term trends in observed precipitation
     Only slight downward trend in total streamflow volume

2. Climate variability & change are affecting seasonal water supply outlooks
   - Warmer temperatures diminish SWE .... decreases prediction skill
     Precip other than snowpack varies a lot .... decreases predictability
   - Runoff ratio needs care (Q/SWE or Q/P vs dQ/dSWE or dQ/dP) (ongoing research focused here)
   - We need to distinguish snowpack trends from springtime rainfall variability
Snowmelt Runoff in the Rio Grande: Long-term and Seasonal Outlooks

1. Climate is changing in ways that affect SWNA surface water resources over the long term
   .... Temperature ↑, Snowpack ↓
   .... No significant long-term trends (yet) in Precipitation or Streamflow
     Only slight downward trend in total streamflow volume

2. Climate variability & change are affecting seasonal water supply outlooks
   .... Warmer temperatures diminish SWE .... decreases prediction skill
     Precip other than snowpack varies a lot .... decreases predictability
   .... Runoff ratio needs care (Q/SWE or Q/P vs dQ/dSWE or dQ/dP)
     (ongoing research focused here)
   .... We need to distinguish snowpack trends from spring-summer rainfall variability
US Seasonal Climate Outlooks
(issued 19 Jan 2017)

Temperature

Precipitation

Not used for operational seasonal streamflow forecasts

2.5 month outlooks, for Apr-Jun 2017

http://www.cpc.ncep.noaa.gov/products/forecasts/
Model-projected Future Streamflow Change

Projected Streamflow Change
mid 21st Century

(Milly et al. 2005)

Climate Model Projections:
diminished and earlier snowmelt runoff

snowmelt dominated
rainfall dominated

Rio Grande, central NM:
3 different projections (A1B)

Hurd and Coonrod (2012)

Climate Model Projections: diminished and earlier snowmelt runoff

snowmelt dominated
rainfall dominated
Two independent seasonal forecasts
El Niño failed to produce high streamflow this year.

Early-season forecasts (Jan, Feb) were severe overestimates.
Daily Snowpack Estimate: 17 Jan 2017 (WRCC)

SWE: % median

http://www.wrcc.dri.edu/snotelanom/basinswe.html
1 Mar water supply outlook for WY 2017 [preliminary]

Baseline Snow Water Content

Percent of Average
- > 209
- 175 to 209
- 150 to 175
- 125 to 159
- 118 to 125
- 90 to 118
- 75 to 90
- 50 to 75
- 25 to 50
- < 25

Report Date:
MARCH 6, 2017

Provisional Data
Based on mountain data from NRCS SNOTEL sites

Data provided by:
Western Regional Climate Center
Desert Research Institute
Reno, Nevada

Portland, Oregon
US Seasonal Climate Outlooks
(issued 15 Dec 2016)

0.5 month outlooks, for Jan-Mar 2017

http://www.cpc.ncep.noaa.gov/products/forecasts/
Basin SWE (SNOTEL) anomalies  April 2, 2017

Numerical percentages on April 1:

Upper RG (CO) 113
Upper SJ (CO) 118
Chama 141
Red 93
("Sangre de Cristo basins")
Pecos 51
Gila nil
US Seasonal Climate Outlooks (issued 15 Dec 2016)

3.5 month outlooks, for Apr-Jun 2017

http://www.cpc.ncep.noaa.gov/products/forecasts/
US Seasonal Climate Outlooks
(issued 19 Jan 2017)

Temperature

Precipitation

0.5 month outlooks, for Feb-Apr 2017

http://www.cpc.ncep.noaa.gov/products/forecasts/
The current outlook for WY 2017
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Why didn't Elephant Butte Reservoir fill up after last winter's heavy snow?

How is the ongoing warming trend affecting snowmelt runoff, and seasonal water supply outlooks?

Steps toward improvement of seasonal WSOs, and integration of climate and hydrologic forecasts

Elephant Butte Reservoir
(Rio Grande, southern NM)
Snowpack in the Rio Grande Headwaters

Chavarria & Gutzler (2017)
Observed changes in discharge: Del Norte gage

1958-1986

Small increase in Spring (Mar-May)
Large decrease in Summer (June, July)
Flattened hydrograph; increased variability most months

1958-1986

1987-2015

No significant long term trend in annual discharge

Chavarria & Gutzler (2017)