

# NOAA's Colorado Basin River Forecast Center

## Developing Climate-Informed Ensemble Streamflow Forecasts over the Colorado River Basin

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# Acknowledgements

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- John Lhotak – Development and Operations Hydrologist
- Kevin Werner – NOAA Western Regional Climate Services Director
- Michelle Stokes – Hydrologist In Charge



# Overview

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- Points to Take Away
- Background
- Data and Methodology
- Provisional Results
- Next Steps



# Points to Take Away

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- The CBRFC is attempting to utilize climate information to inform long-term streamflow projections
  - Utilize projections of precipitation and temperature change from BCSD CMIP3 and CMIP5 data to inform historical inputs driving ESP products
  - Provisional results indicate earlier and decreased seasonal (April – July) runoff



# Points to Take Away

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- Further efforts will attempt to incorporate:
  - Changes to evapotranspiration
  - Use of a stochastic weather generator
  - Couple with a reservoir operations model
- Will eventually separate runs by SRES and RCP scenarios

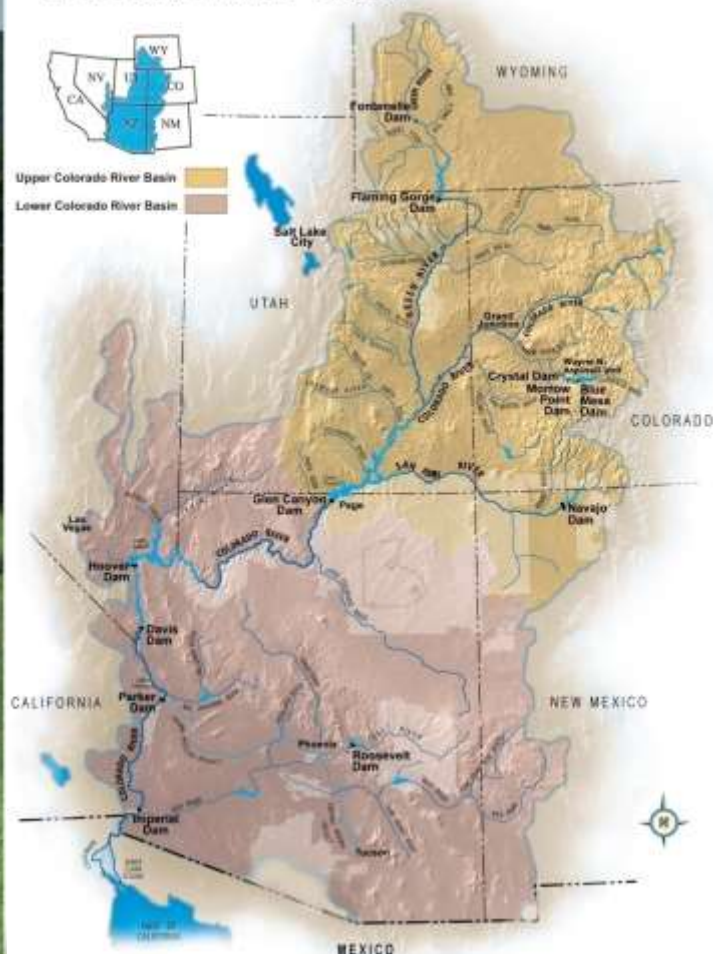




# Background

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## Colorado River Basin



- Stakeholders throughout the Colorado River Basin are developing long-term policy guidelines
  - Some decisions are based on CBRFC forecasts
  - Agencies need to take climate change information into account
- CBRFC would like to provide decision support



# Background

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- CBRFC ensemble forecasts rely on current and initial conditions and future climate (precipitation and temperature) as defined over a historical period spanning 1981 – 2010
  - Can also include 5-day QPF and 10-day QTF
  - Limited by sequencing and magnitude of climate events in the historical period



June 29, 2002



December 23, 2003

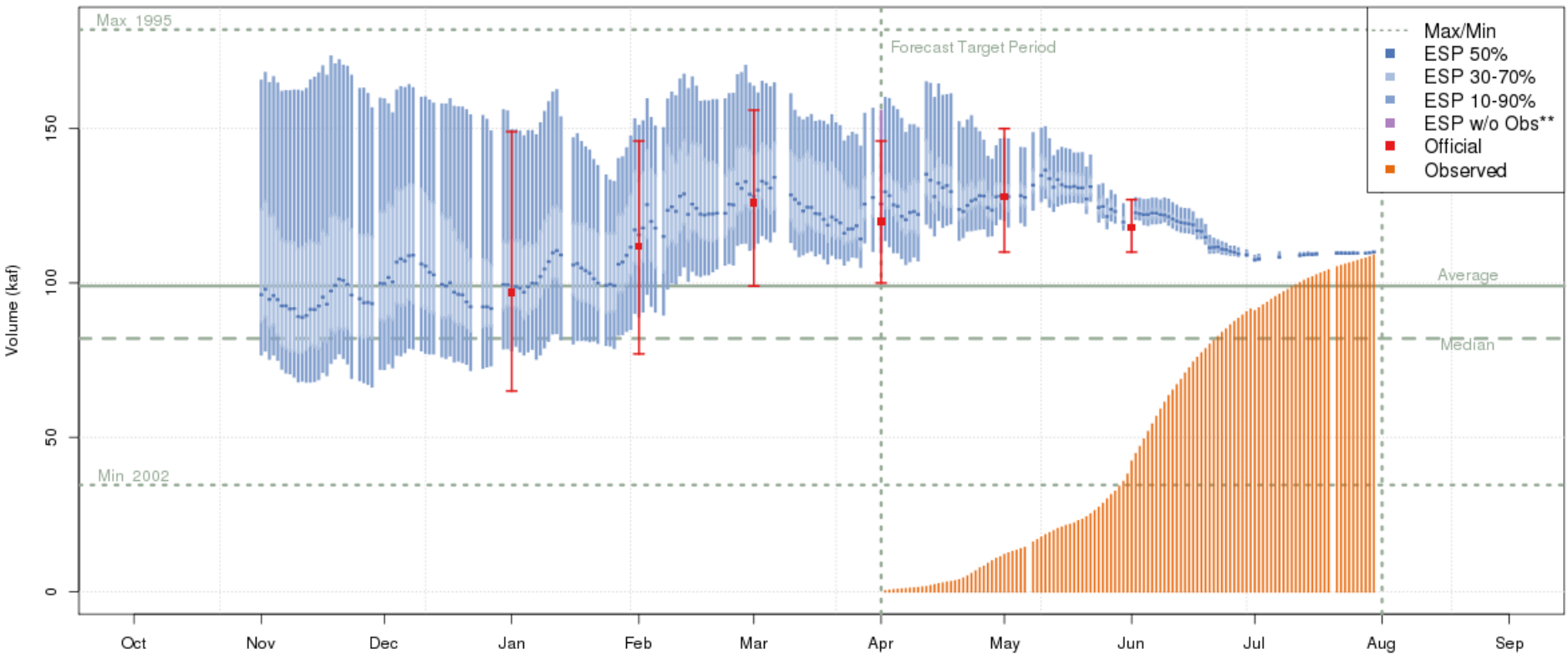
Photos by John Dohrenwend



# Ensemble Streamflow Prediction

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Taylor - Taylor Park Res (TPIC2) Apr-Jul 2014 Runoff Forecast (Includes 5 Day Precip Forecast)  
2014-06-01 Official 50% Forecast: 118 kaf (119% of average)



Plot Created 2014-08-11 12:49:46, Lastest ESP Run from 2014-07-30, NOAA / NWS / CBRFC  
The latest ( 2014-07-30 ) 50% ESP forecast ( 110 kaf) changed 0.2% from previous day and -7.4% from July 1  
\*\*These ESP forecasts do not include observed and are not total runoff.





# How can we help?

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- Providing decision support for policy makers means making projections at a policy scale
  - Information from the latest climate projections
  - Innovate ways to develop climate patterns outside of the historical record
    - Working with the University of Colorado
    - Incorporation of other climatic indicators
- Partner with stakeholders to understand needs



# Data and Methodology

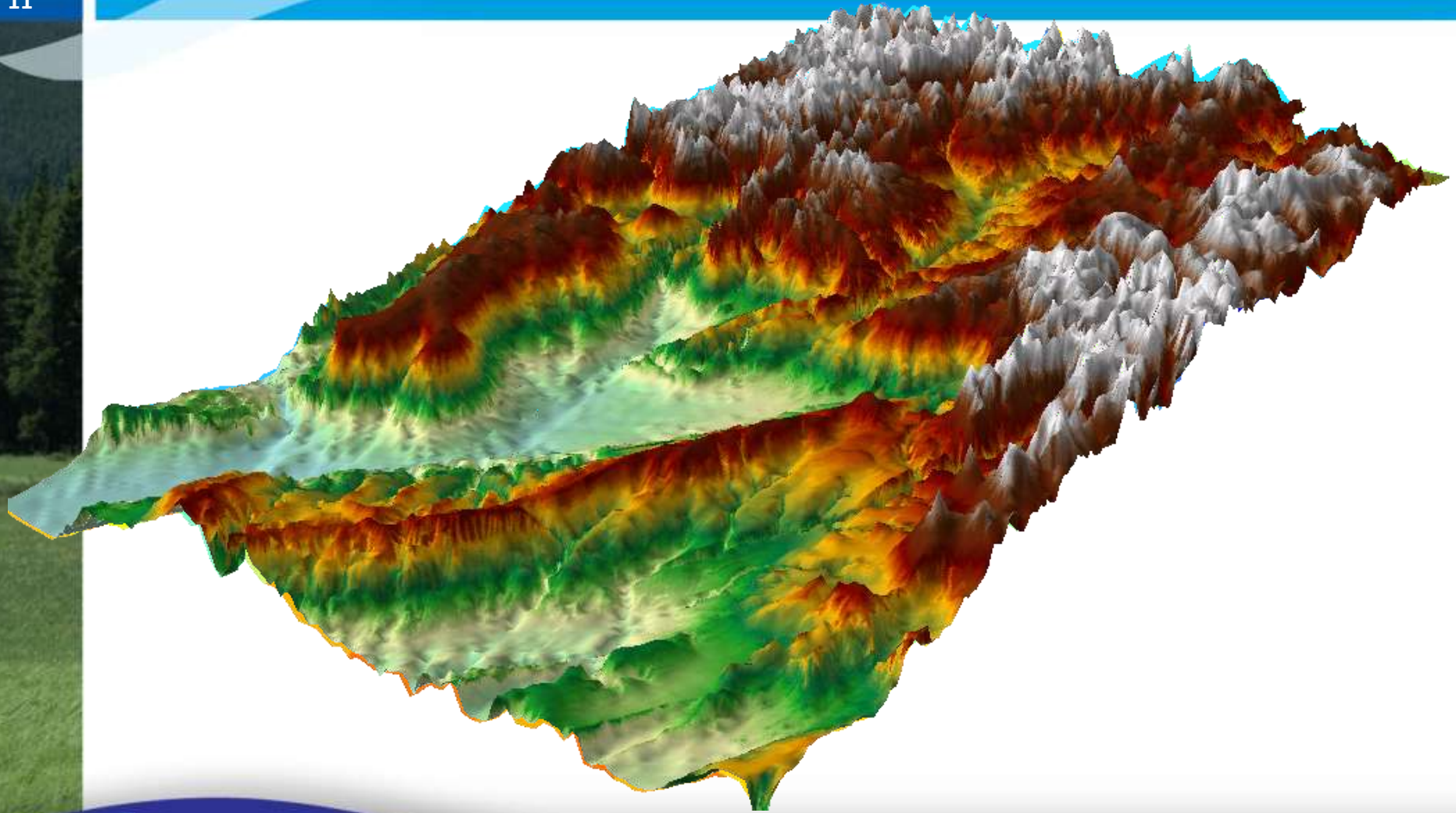
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- To “inform” our current historical input of climate data we utilized projected changes from BCSD CMIP3 and CMIP5 data
  - BCSD CMIP data is made available by Reclamation, LLNL, and others at:  
[http://gdo-dcp.ucllnl.org/downscaled\\_cmip\\_projections/dcpInterface.html](http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html)
  - Gridded projections of climate need to be averaged over spatial zones defined in the CBRFC’s lumped hydrologic model
- Currently averaged over all model runs



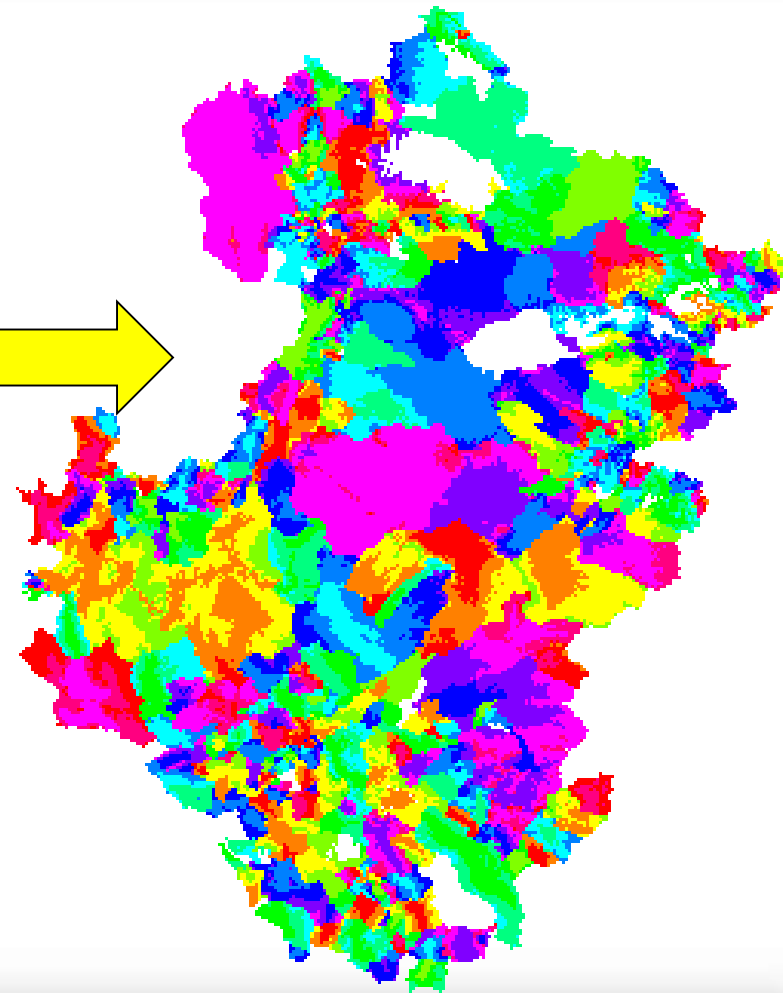
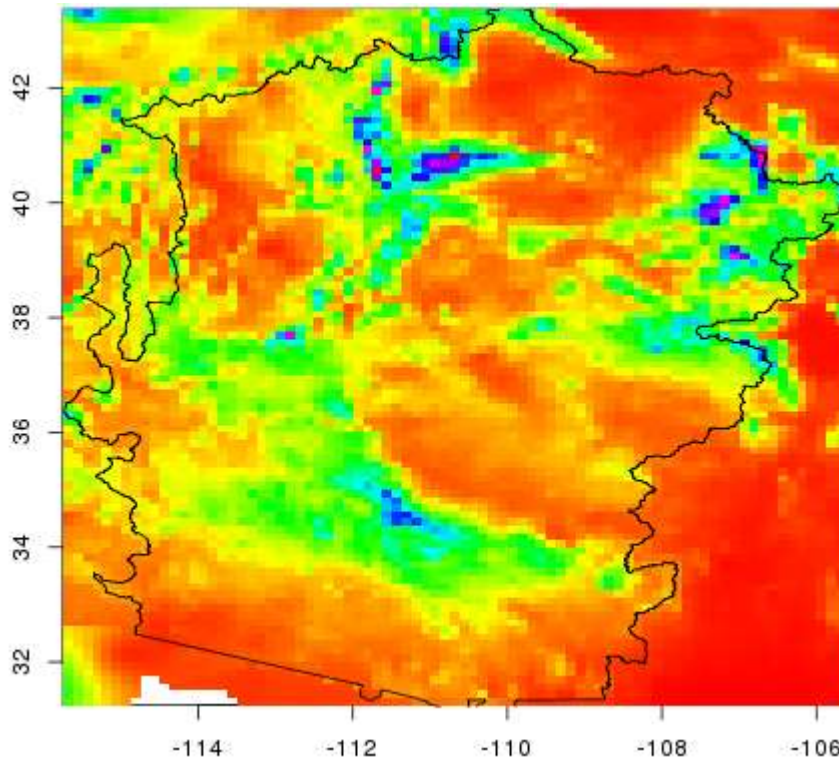
# Need for Downscaling

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# Gridded to Lumped Inputs

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# Data and Methodology

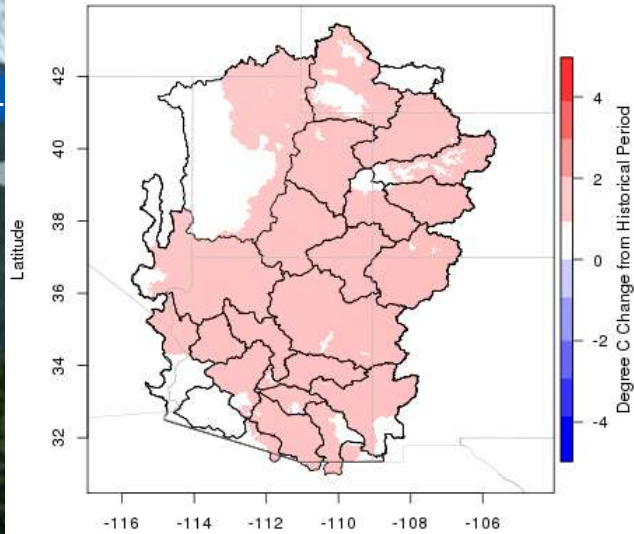
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- Average, relative modeled change from 1981-2010 to three future periods is derived
  - 2010-2039, 2040-2069, 2070-2099
  - Gridded values are averaged over each zone
  - Percent change in precipitation is considered
  - Degrees Celsius change in temperature is considered
- Historical information perturbed to develop “climate informed” input

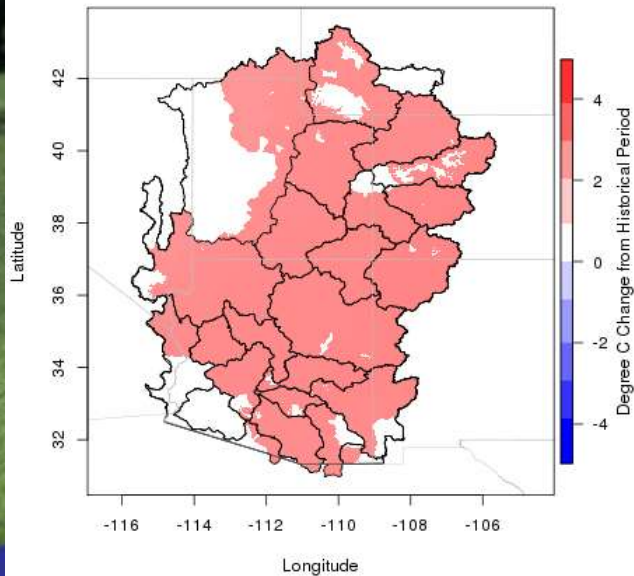


# Results - Temperature

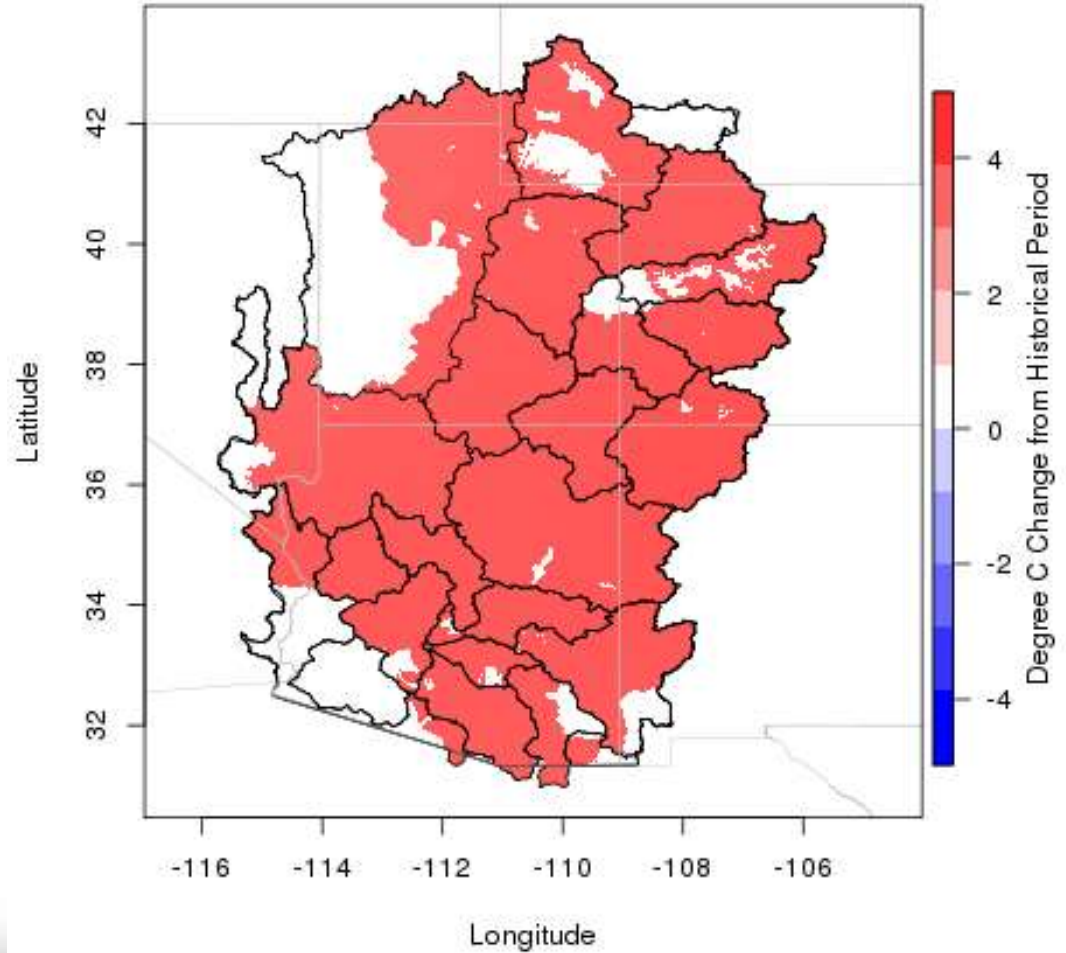
BCSD CMIP5 Ensemble Mean Temperature Change  
from 1981-2010 to 2010-2039



BCSD CMIP5 Ensemble Mean Temperature Change  
from 1981-2010 to 2040-2069

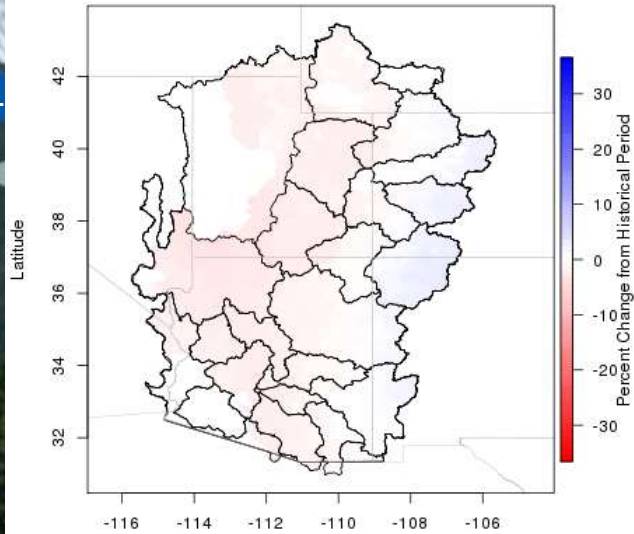


BCSD CMIP5 Ensemble Mean Temperature Change  
from 1981-2010 to 2070-2099

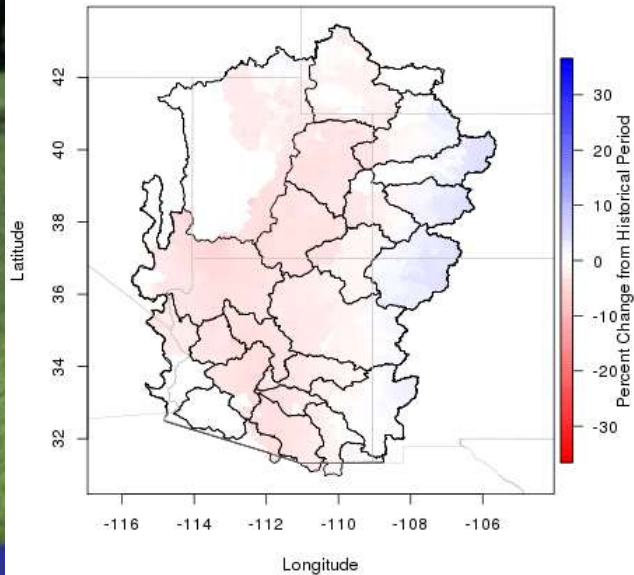


# Results - Precipitation

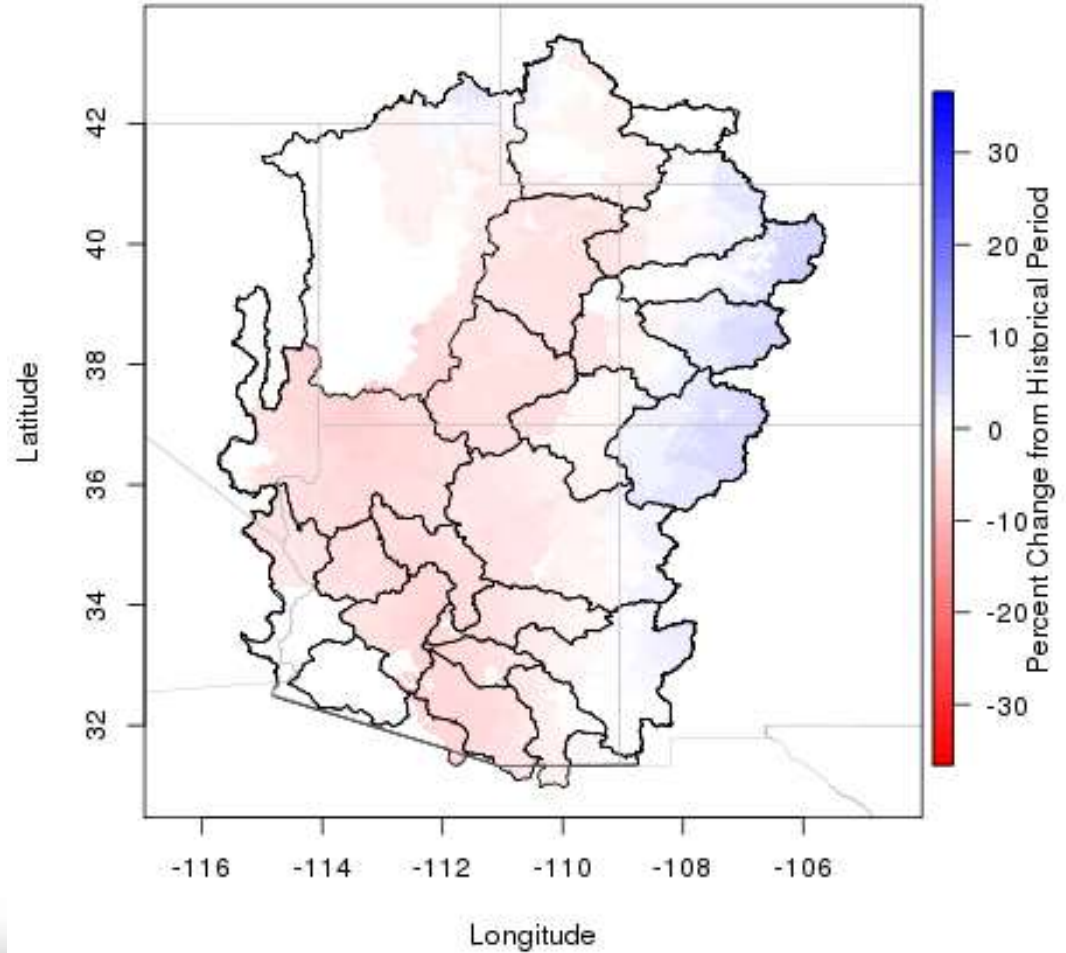
BCSD CMIP5 Ensemble Mean Precipitation Change  
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BCSD CMIP5 Ensemble Mean Precipitation Change  
from 1981-2010 to 2040-2069



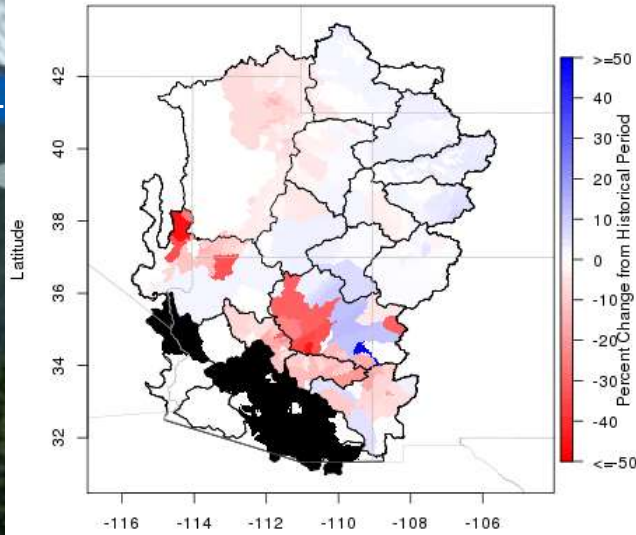
BCSD CMIP5 Ensemble Mean Precipitation Change  
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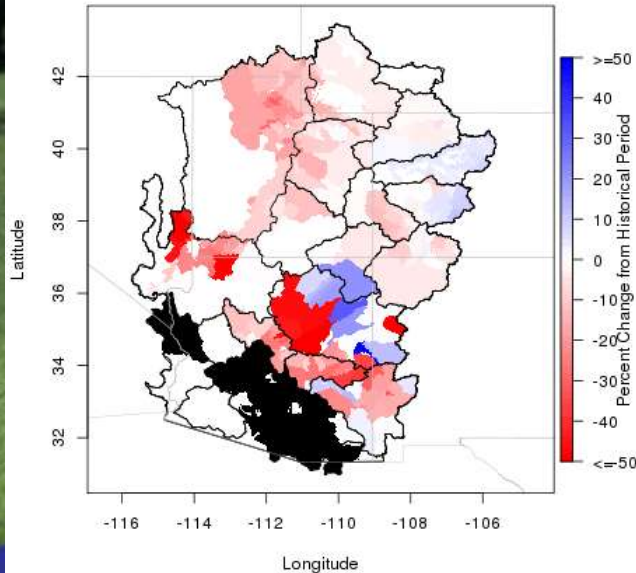


# Results - Streamflow

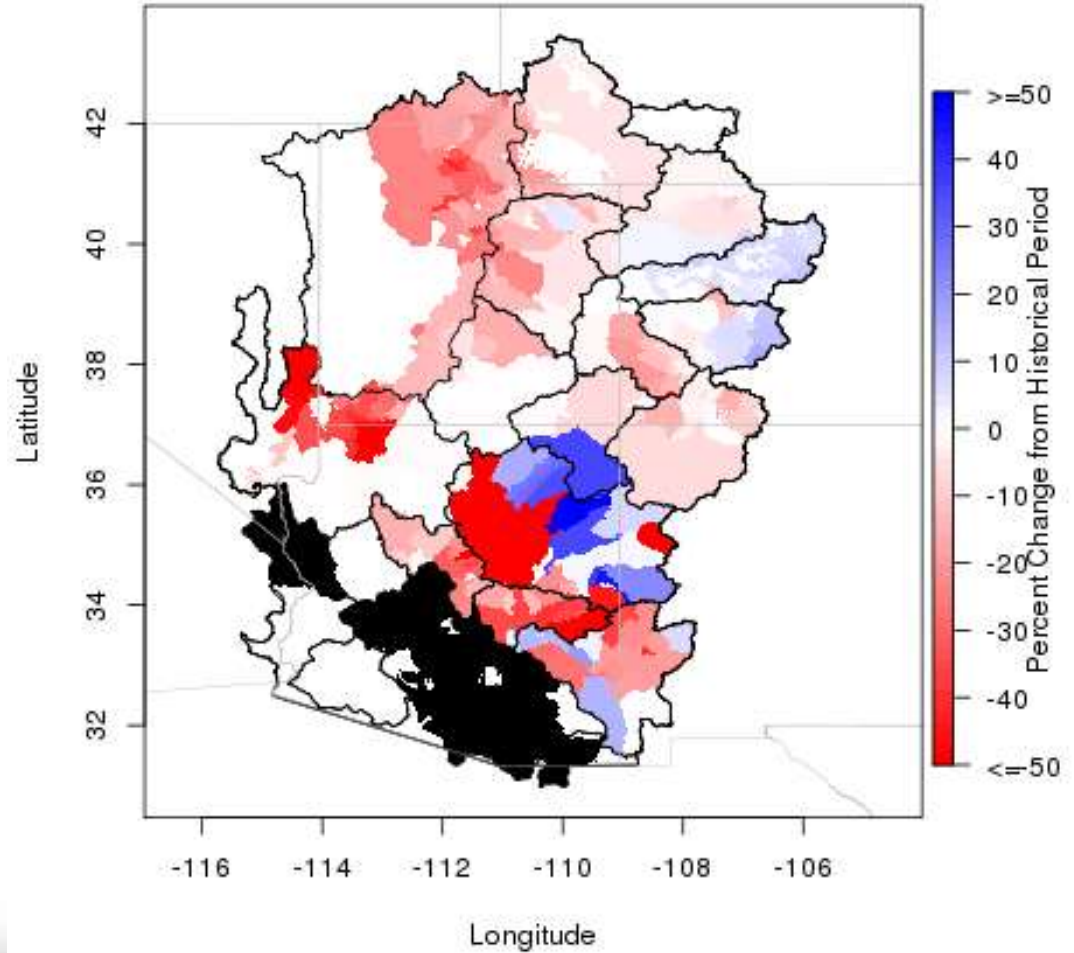
Avg Seasonal CMIP5 Change  
from 1881-2010 to 2039



Avg Seasonal CMIP5 Change  
from 1881-2010 to 2040-2069



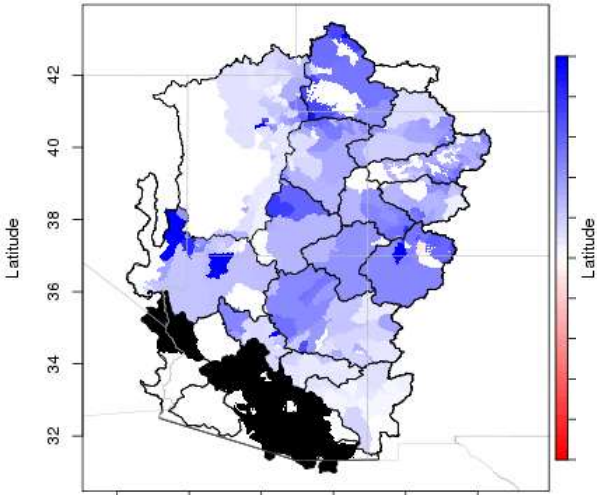
Avg Seasonal CMIP5 Change  
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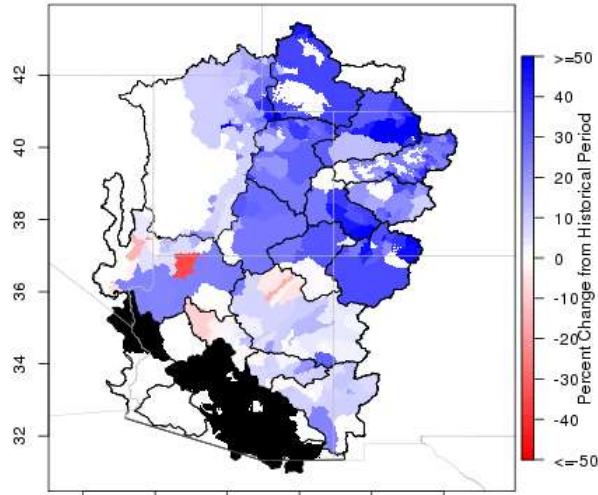


# Streamflow Impacts

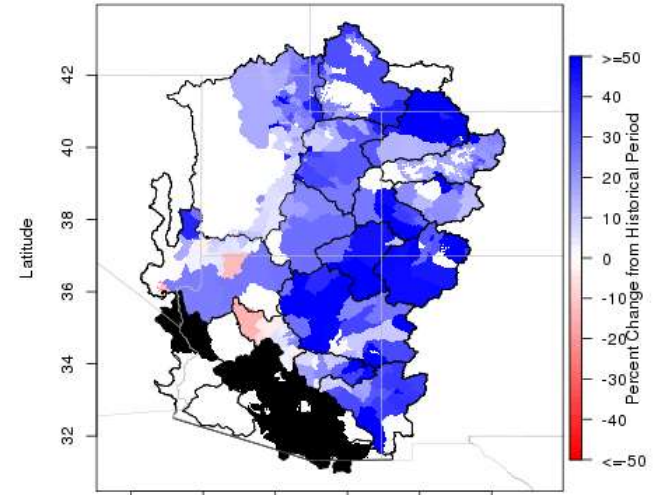
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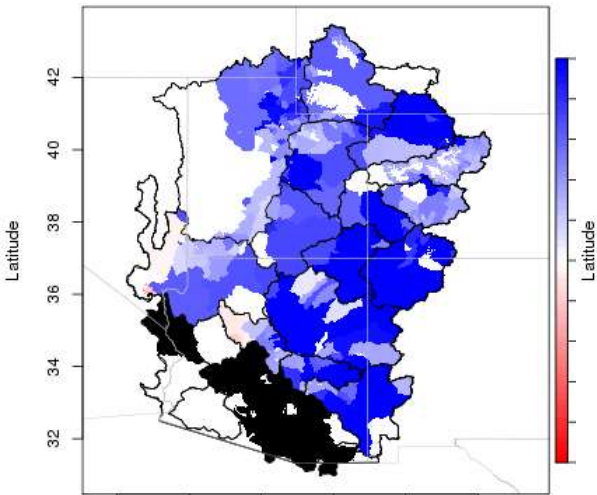
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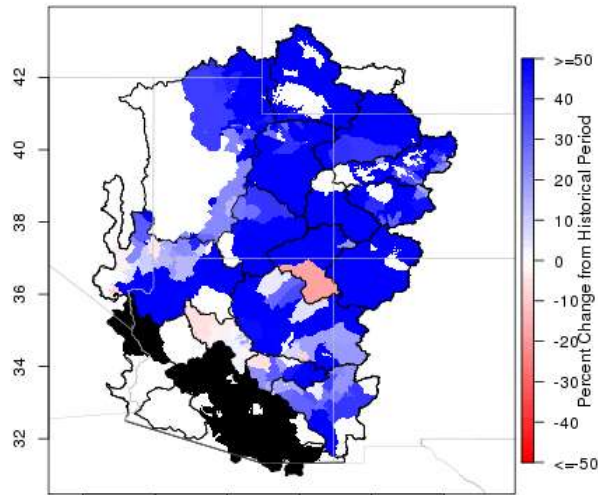
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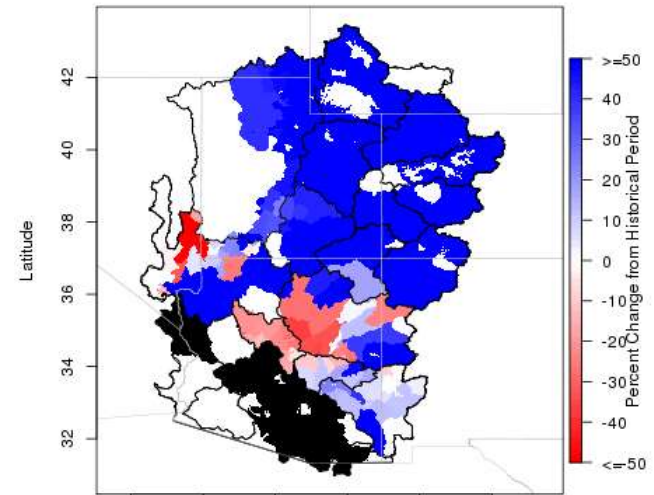
**Avg Jan CMIP5 Change  
from 1981-2010 to 2070-2099**



**Avg Feb CMIP5 Change  
from 1981-2010 to 2070-2099**



**Avg Mar CMIP5 Change  
from 1981-2010 to 2070-2099**



-116 -114 -112 -110 -108 -106

Longitude

-116 -114 -112 -110 -108 -106

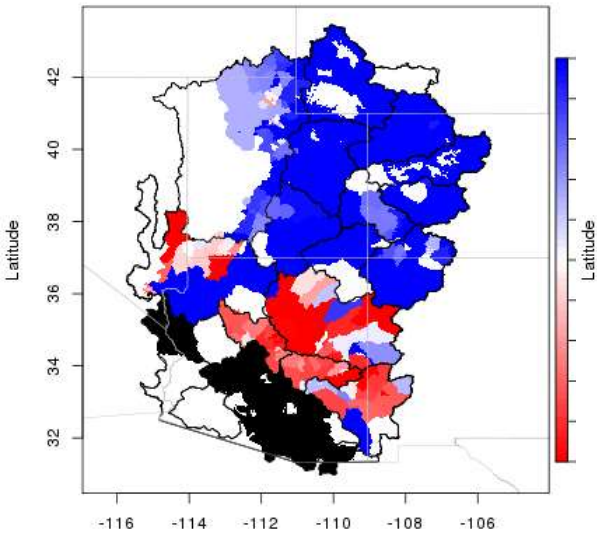
Longitude

-116 -114 -112 -110 -108 -106

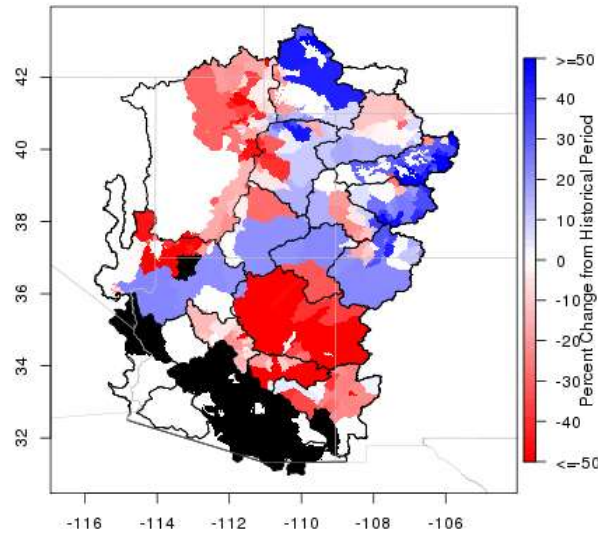
Longitude

# Streamflow Impacts

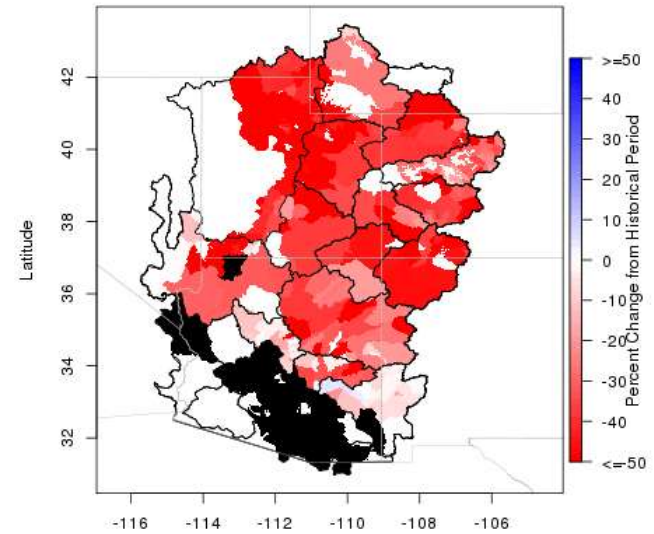
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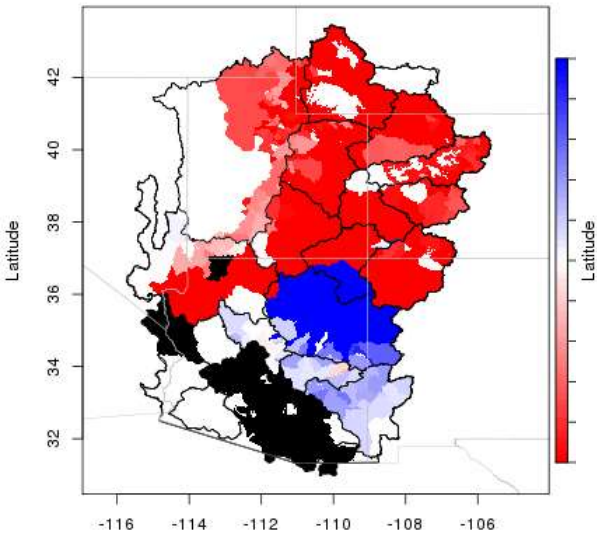
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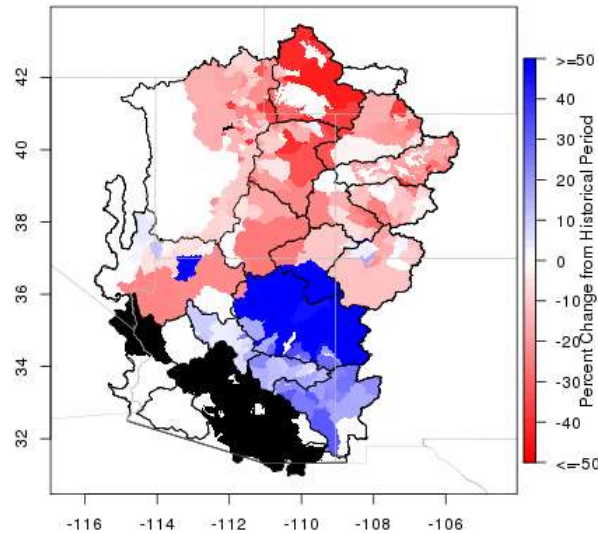
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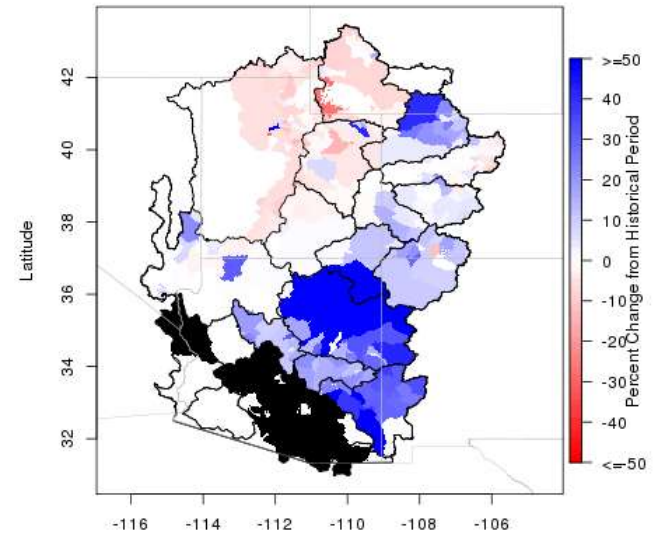
**Avg Jul CMIP5 Change  
from 1981-2010 to 2070-2099**



**Avg Aug CMIP5 Change  
from 1981-2010 to 2070-2099**



**Avg Sep CMIP5 Change  
from 1981-2010 to 2070-2099**



Longitude

Longitude

Longitude

# Limitations

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- Process is still dependent on historical sequences of precipitation and temperature
- Process does not incorporate a dynamic ET component (yet!). ET is derived using a monthly coefficient that is static through time
- Possible wet bias introduced during the BCSD process?



# Next Steps

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- Working with colleagues at the University of Colorado to utilize a stochastic weather generator
  - Capable of producing weather sequences not observed in the historical record
  - Can be weighted to incorporate other climate information (e.g., teleconnections, CPC info)
  - Latest results show increased reliability and accuracy using IRI forecast information





# Next Steps Continued

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- Build on past work done in our office to incorporate dynamic evapotranspiration
- Partner with stakeholders to make this work for them
  - Impacts to reservoir operations?
  - Inform long-term policy development
- Compare with recently released VIC streamflow projections



# Questions?

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[www.cbrfc.noaa.gov](http://www.cbrfc.noaa.gov)



# Extra Slides

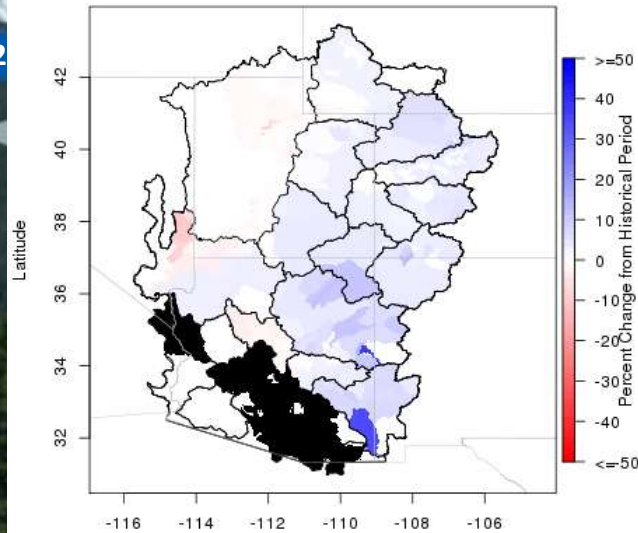
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[www.cbrfc.noaa.gov](http://www.cbrfc.noaa.gov)

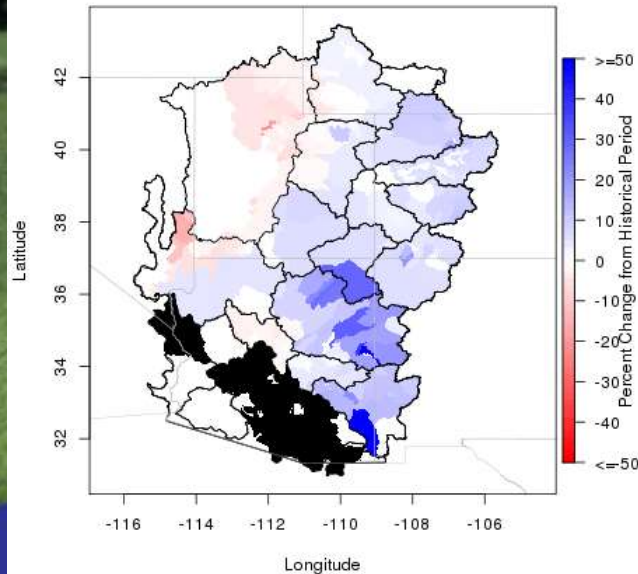


# Streamflow Impacts

Avg Annual CMIP5 Change  
from 1981-2010 to 2010-2039



Avg Annual CMIP5 Change  
from 1981-2010 to 2040-2069



Avg Annual CMIP5 Change  
from 1981-2010 to 2070-2099

