Identifying Connections Between Large-Scale Climate Variability and the Local Hydroclimate of the Upper Colorado River Basin

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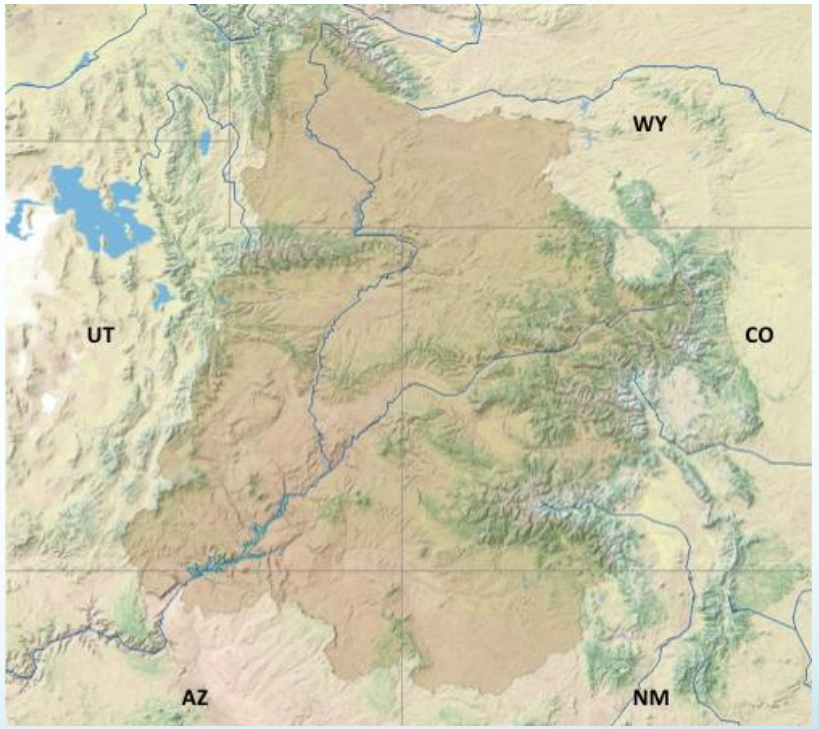
Intro and Motivation

- Hydroclimatic variability in the UCRB has a large impact on water supplies for a large region of the western U.S.
- Recreation, water availability, wildfires, wildlife, and vegetation in the UCRB are highly sensitive to inter-annual variability.
- We need to know what drives this inter-annual variability.



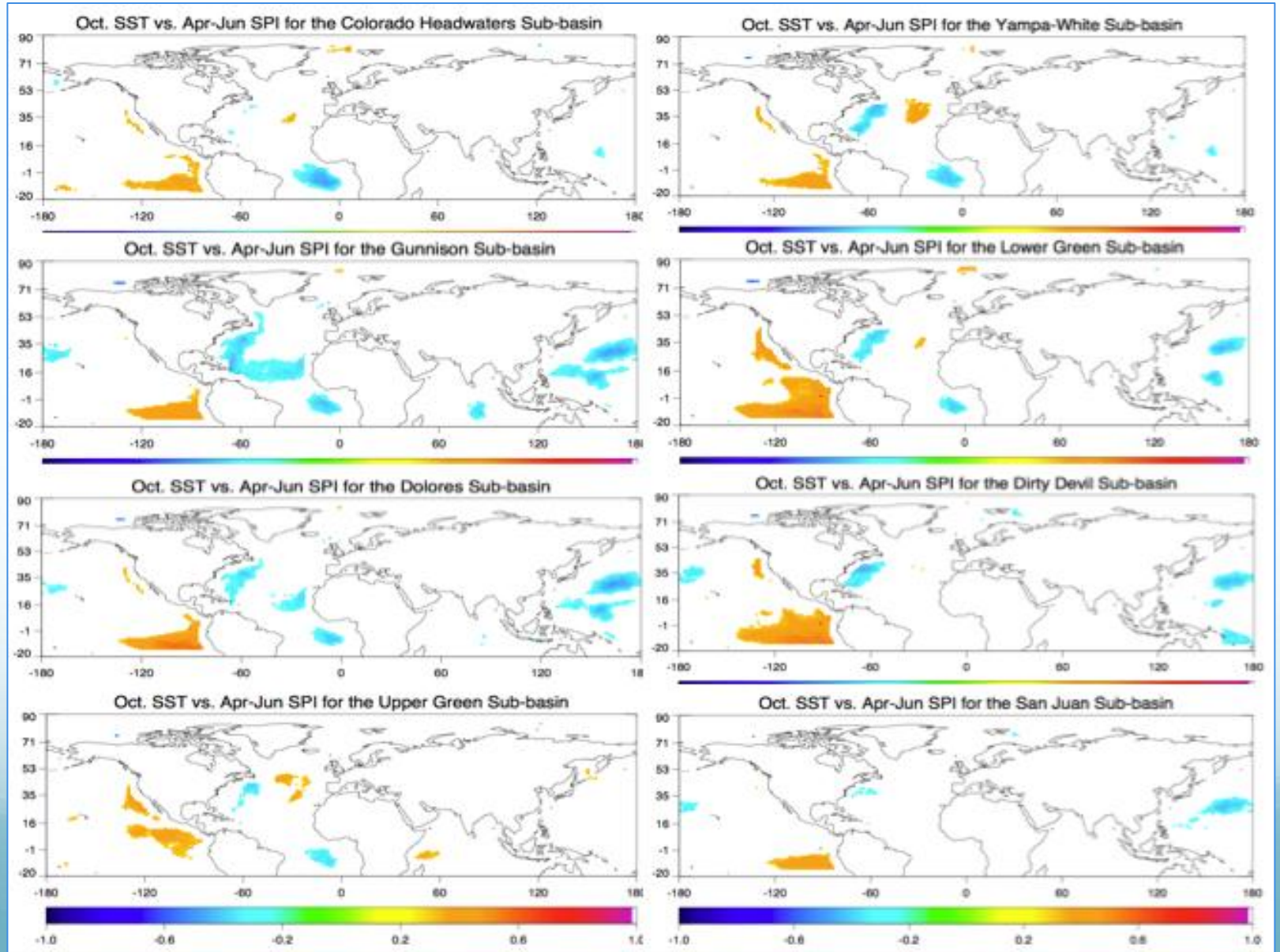
Intro and Motivation

- The Colorado Basin River Forecast Center (CBRFC) provides water supply and streamflow forecasts for critical “snowmelt” season.
- These forecasts are heavily dependent on snowpack.
- Prior to January, when snowpack is limited, water supply forecasts need reliable forecasts of future climate (Redmond and Koch 1991).
- Many studies have shown the statistical connection between the local climate and large-scale variability (e.g. Switanek et al. 2009; Aziz et al. 2010; Hurkmans et al. 2009).
- Greater need for a physical understanding of these teleconnections.

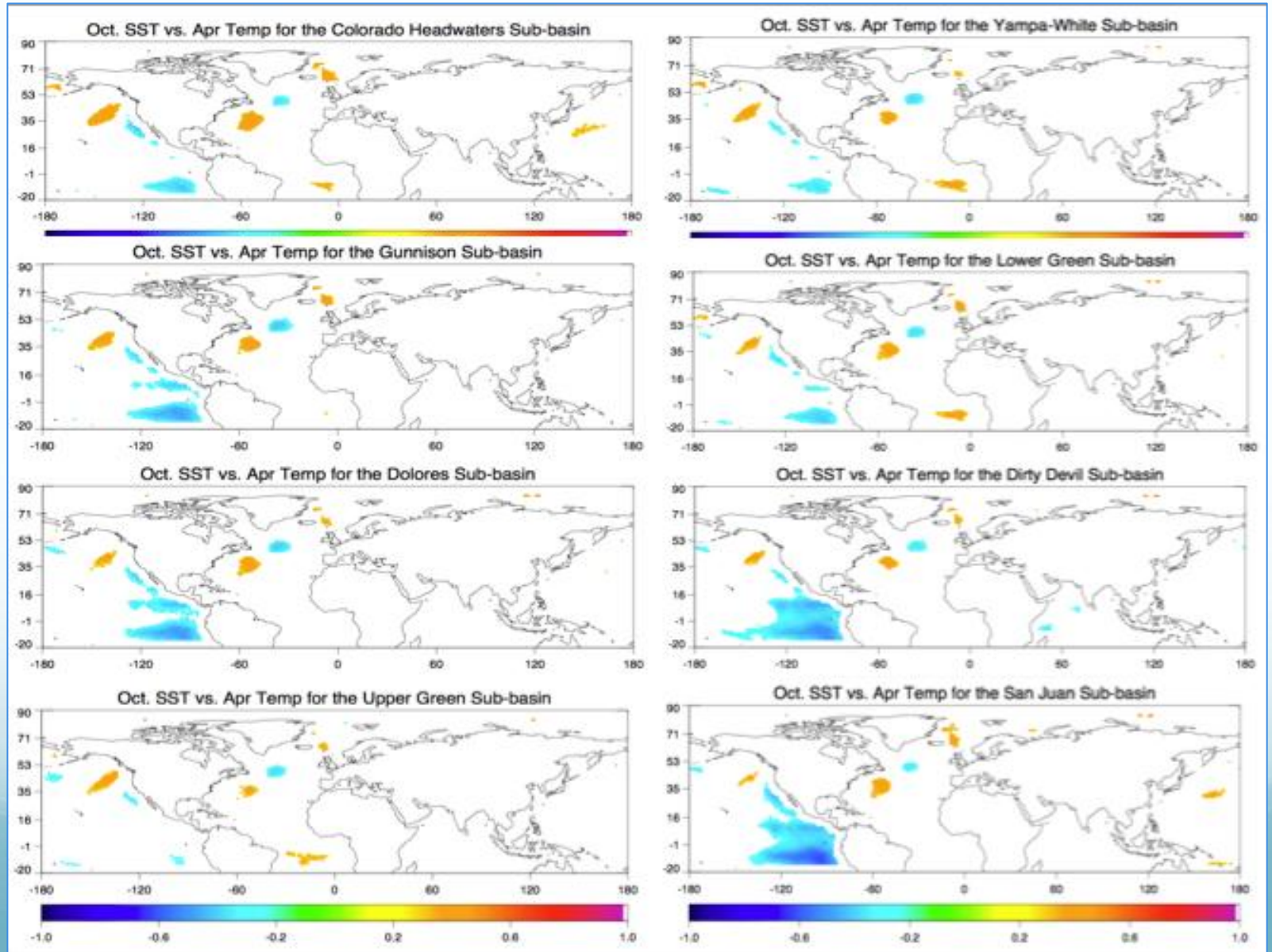
Data and Methodology

- Separate UCRB into 8 sub-basins
- Calculate monthly sub-basin averages of temperature and precipitation
- PRISM dataset
  - www.prism.oregonstate.edu
  - Monthly P, Tmax, Tmin 1981 – 2010
  - 4km resolution
- For each gridpoint, calculate a temperature Z-score and standardized precipitation index (SPI). Average all gridpoints over a sub-basin.
- Hadley Centre sea surface temperatures
  - http://www.metoffice.gov.uk/hadobs/hadisst/
  - Monthly SST 1981 – 2010
  - 1° x 1° resolution

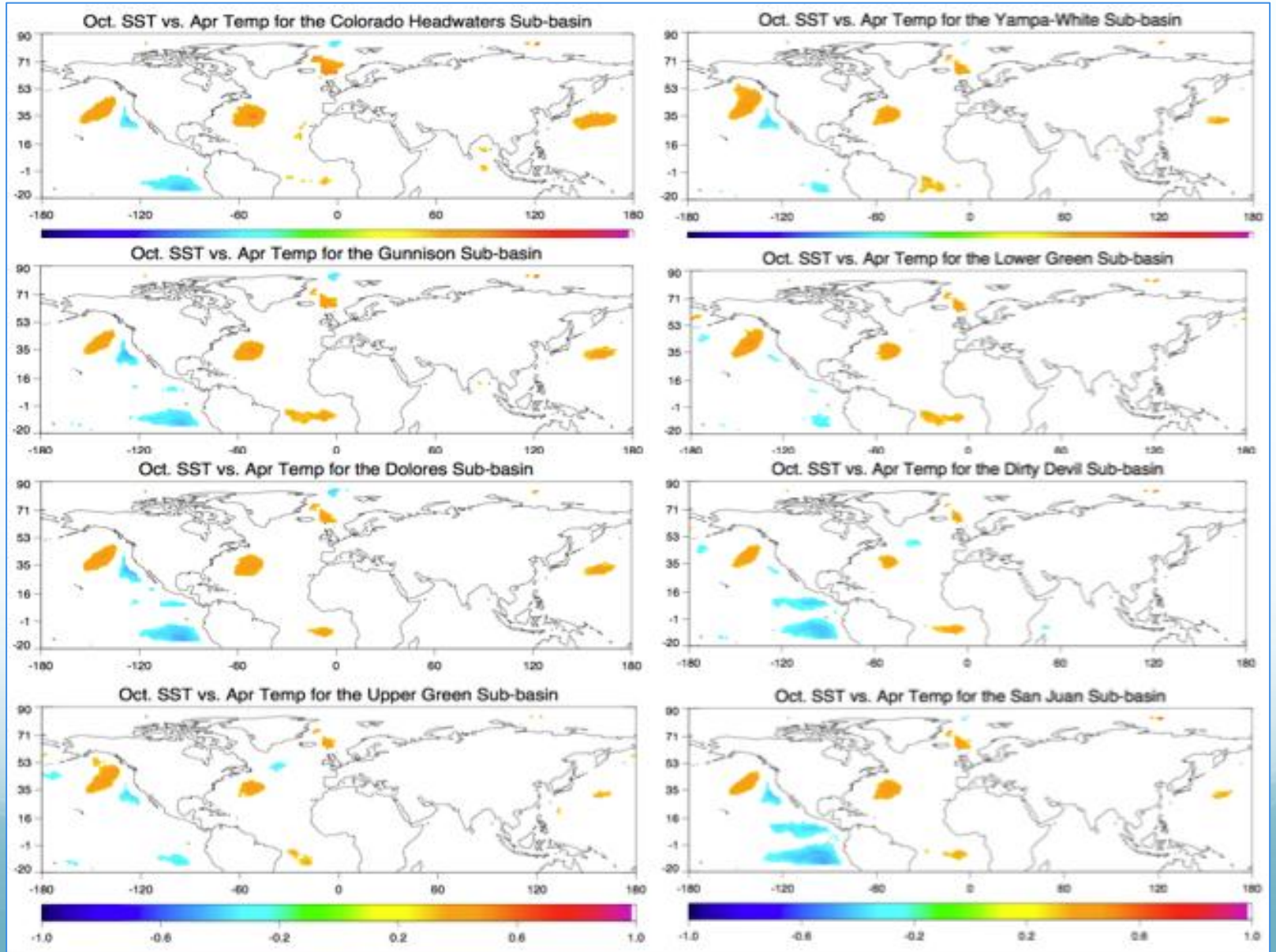
Correlations SST vs SPI



Correlations SST vs Tmax

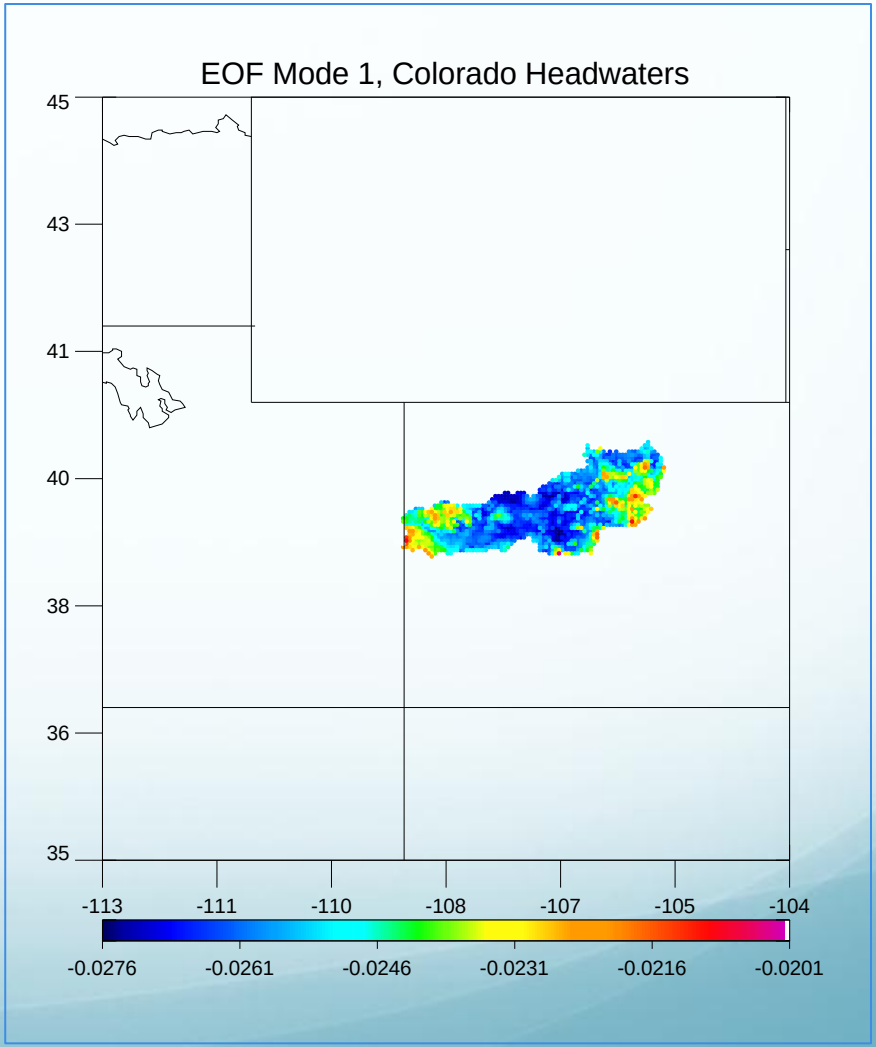


Correlations SST vs Tmin



Temporal and Spatial Variability in UCRB

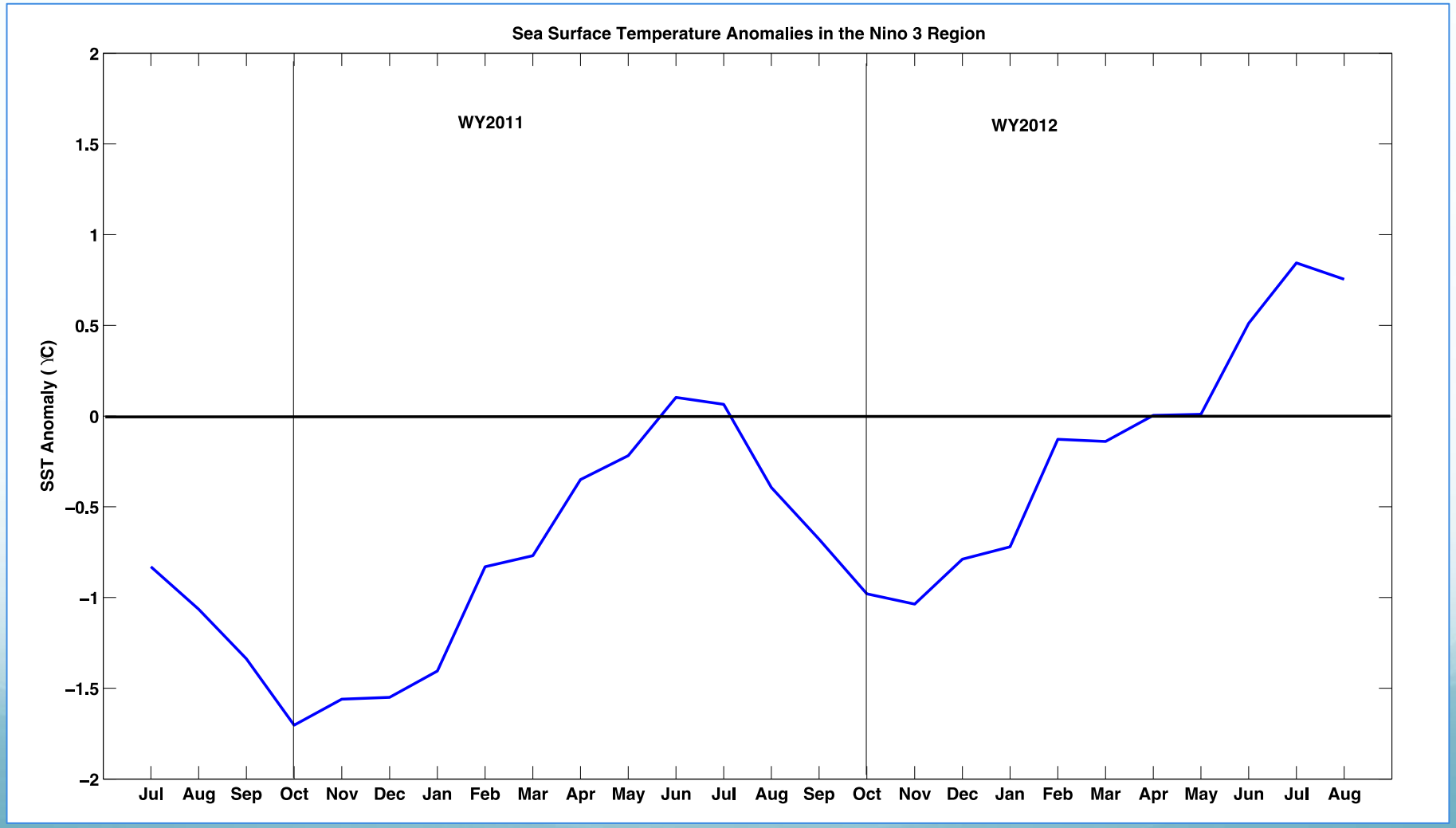
- EOF Analysis of each sub-basin's Apr – Jun SPIs and Jun Tmax and Tmin
- First mode of variability—little spatial variations
- Precipitation
  - High year-to-year variability
  - Weak fit to ENSO or other oscillations/indices
- Temperature
  - 2 – 3 year variability more likely
  - Lower modes possibly dominated by PDO



What Next?

- “Significant” correlations are not necessarily strong correlations.
- **Why** is the correlation between ENSO and the UCRB climate not greater?
- Comparison of two similar ENSO years with very different UCRB climates
  - What happened differently in the UCRB?
  - What was different about storm tracks?
  - Can these differences be predicted?

Comparison of Two Cold Phase ENSOs



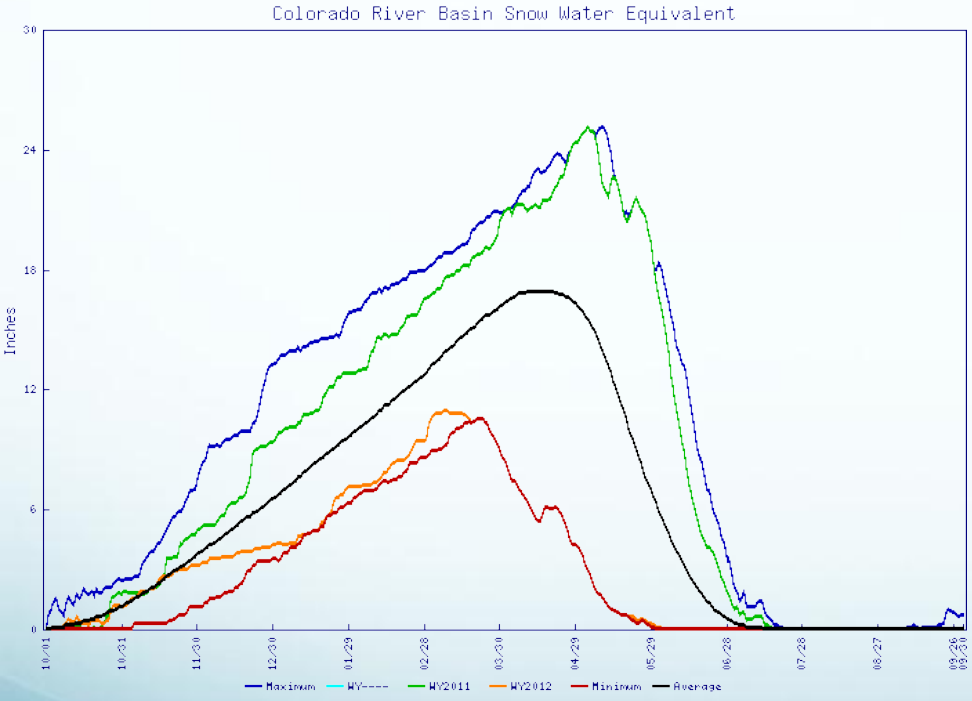
Case Studies: Water Year 2011

- Precipitation
  - Week-to-week consistent and widespread.
  - Widespread below average only during January.
  - All other months near to above average.
  - Many places in the basin experienced one of the wettest/snowiest seasons on record.
- Temperature
  - Warmer than average in the early winter (October – December).
  - Cooler than average from January – June.
  - Overall the season was cooler than average (near average to the south).

Case Studies: Water Year 2012

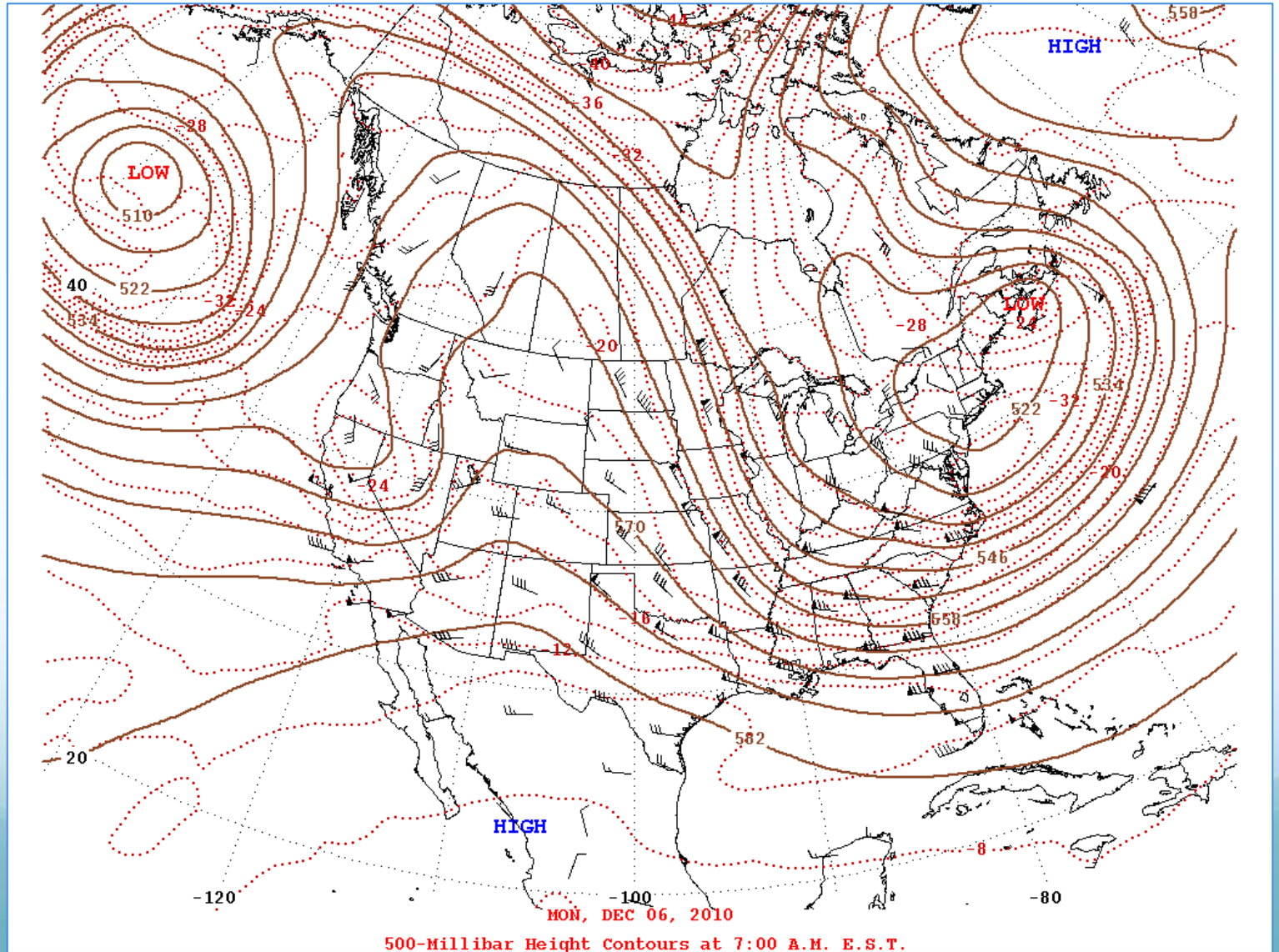
- Precipitation
  - More spotty, not as widespread.
  - Near to below average for most months out of the winter/spring.
  - Above average precipitation in October and February.
  - Many places in the basin experienced one of their driest seasons on record (below the 5th percentile).
- Temperature
  - Cooler than average in the early winter (October – December).
  - Warmer than average from January – June.
  - Overall the season was warmer than average.

Differences in Snowpack



- Tower SNOTEL
- Snowpack Time
  - 2011 – 285 days
  - 2012 – 249 days
- Frequency Distribution
  - 2011: Less than 120 days of 0 to low accumulation, over 50 days > .50 in.
  - 2012: More than 120 days of 0 to low accumulation, only 20 days > .50 in.
- December Example
  - 2011: 24 days with snow, 9 days > .50 in.
  - 2012: 16 days with snow, 0 days > .50 in.

Synoptic Situation
Ex. December 2010



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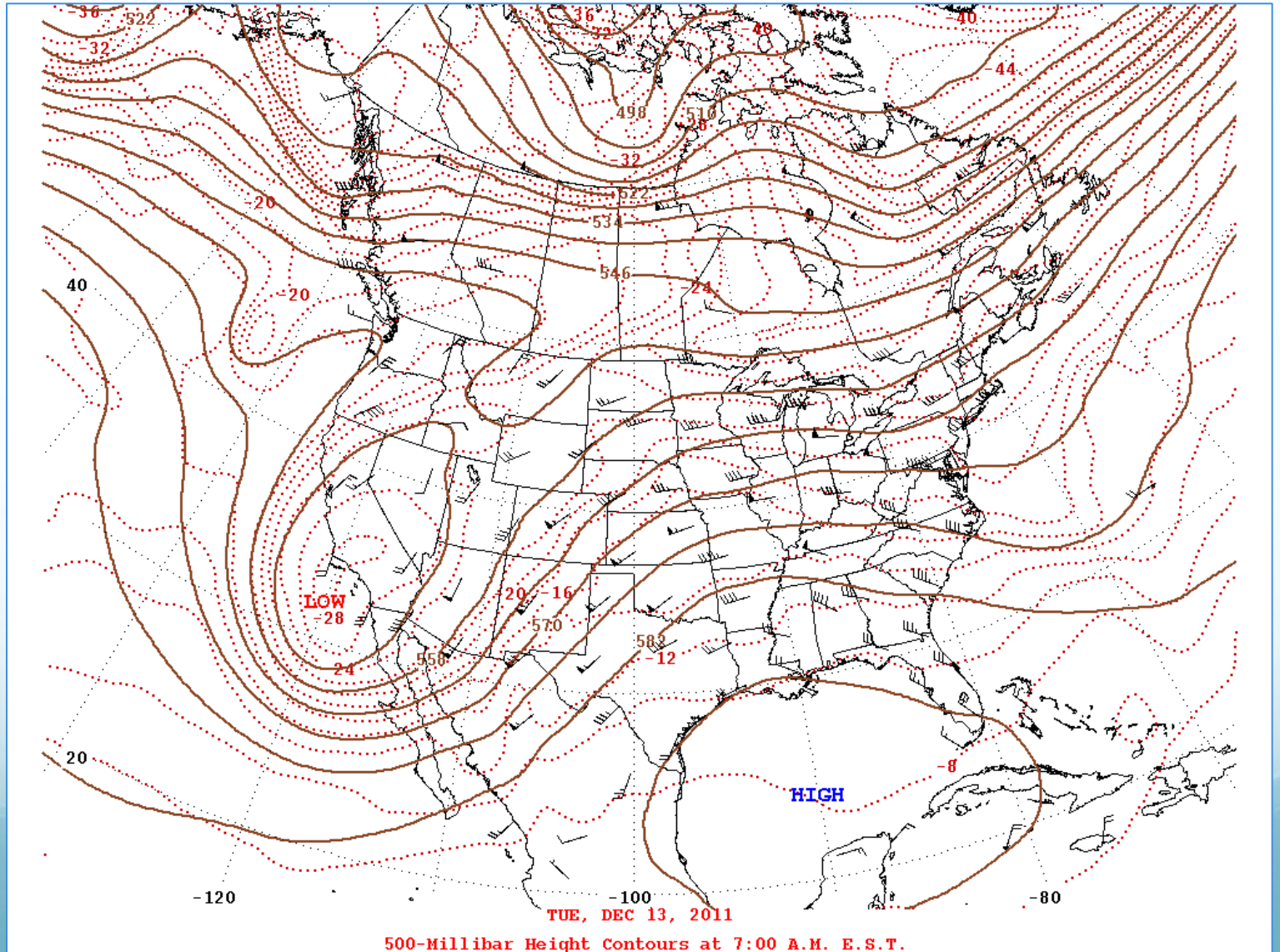

What's the Large Scale Difference?

- December 2010 was a stronger La Niña and December 2011 was a weaker La Niña.
- Description:La Niña associated with drier than normal conditions in southwest and wetter than normal in the Pacific Northwest.
- What actually happened
  - December 2010, southwest was much wetter than average ??
  - December 2011, Pacific Northwest was drier than average ??

What's the Large Scale Difference?

- Arctic Oscillation (AO)
  - Negative phase results in more active storm track pushed further south.
  - Positive phase means storms remain further north.
  - December 2010—negative phase.
  - December 2011—positive phase.
- Pacific North American (PNA)
  - Strongly correlated with ENSO.
  - Even with weak La Niña conditions in December 2011, PNA was weak positive.
  - Positive PNA is associated with ridging over the western U.S.

Final Comments

- December 2010
  - Much wetter than average.
  - Strong La Niña, negative AO, negative PNA.
- December 2011
  - Drier than average.
  - Weak La Niña, positive AO, weak positive PNA.
- In both cases, for the UCRB, the AO and PNA phases seemed to drive the weather pattern.
- What next?
  - AO and PNA, more difficult to predict in the long-term.
  - More case studies… how do these work with El Niño?

Questions?

Colorado State University