Dynamical downscaling of global climate model products for water resource projection in the Southwest U.S.

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Sustainability on the Border Conference

El Paso Texas

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THE UNIVERSITY OF ARIZONA.

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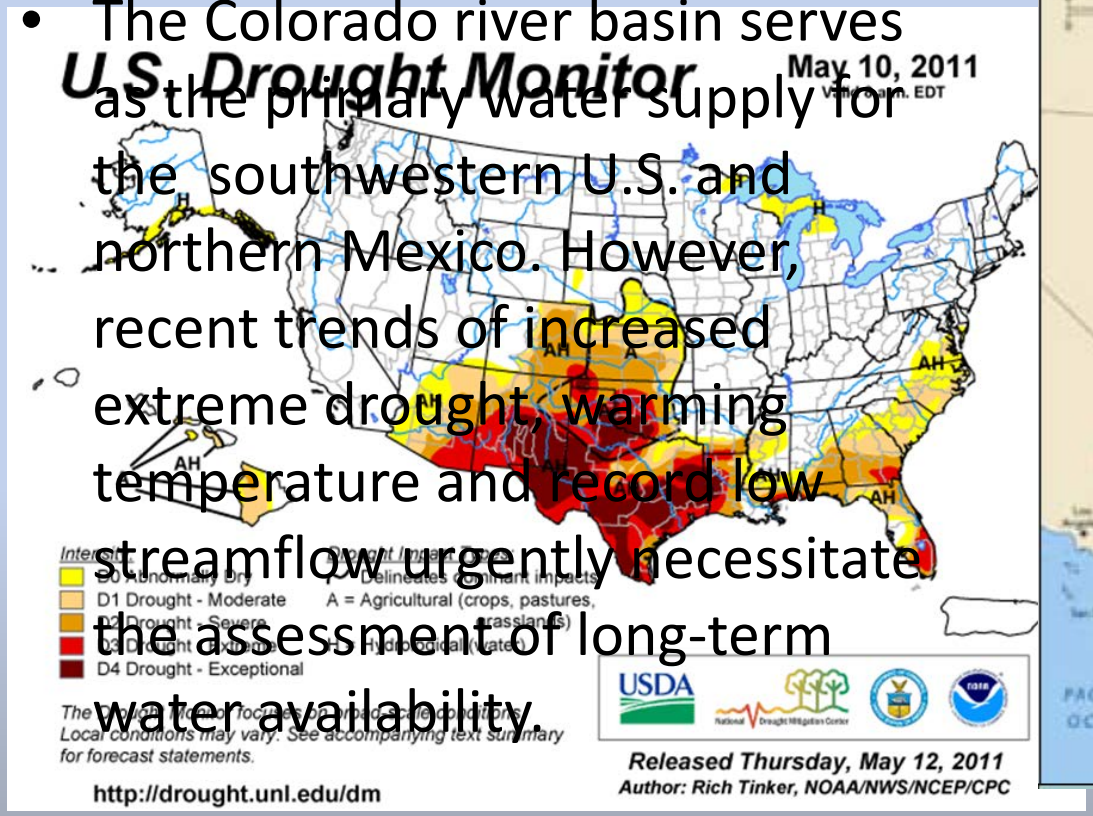
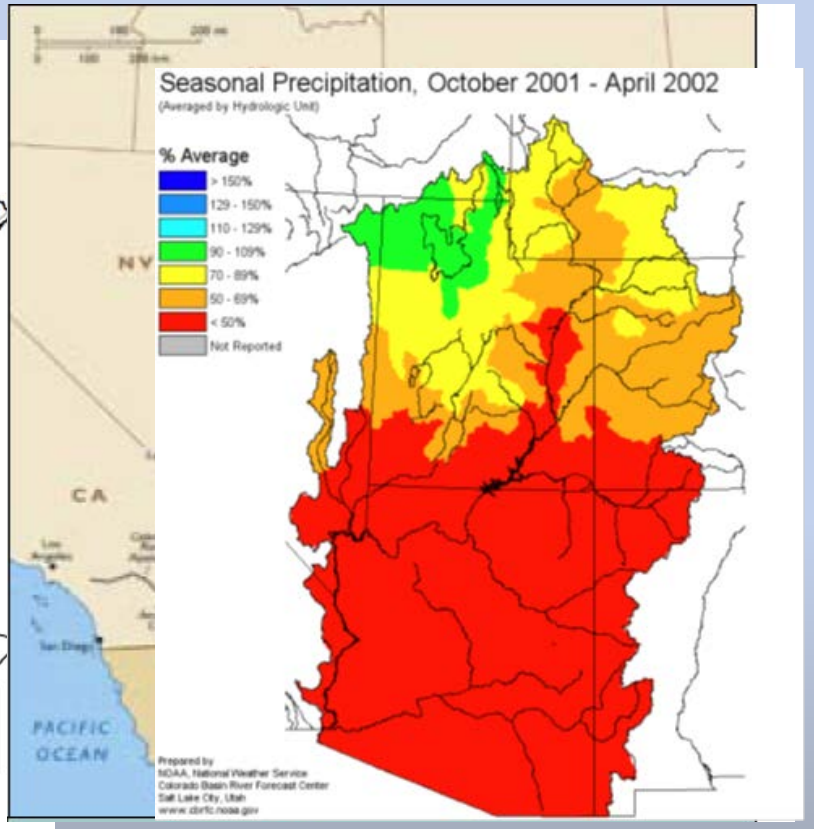
Motivation:

- The Colorado river basin serves as the primary water supply for the southwestern U.S. and northern Mexico. However, recent trends of increased extreme drought, warming temperature and record low streamflow urgently necessitate the assessment of long-term water availability.

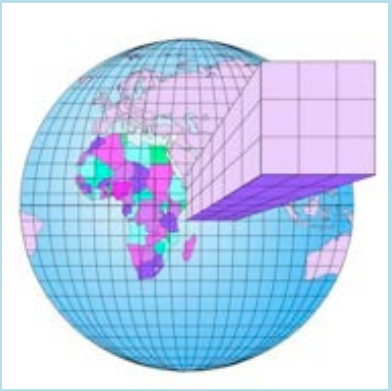




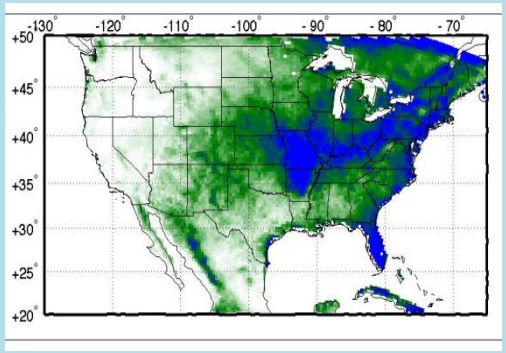
Objective: Multi-model, muti-scale numerical simulations to develop a watershed-based 20th century climatology, as a baseline to assess future climate and hydrologic variability in our region.

Multi-model schematic:

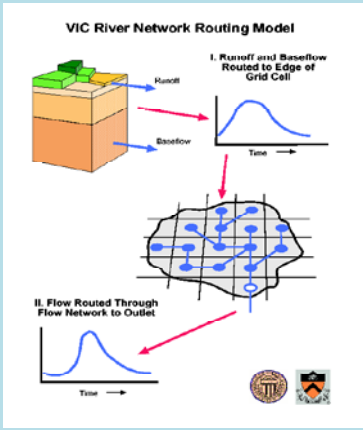
not a straight forward process!



Dynamical downscaling



Bias correction



1. Global Climate Models (GCMs) (2.5° resolution)

2. Regional climate model (RCM) simulations (35km resolution

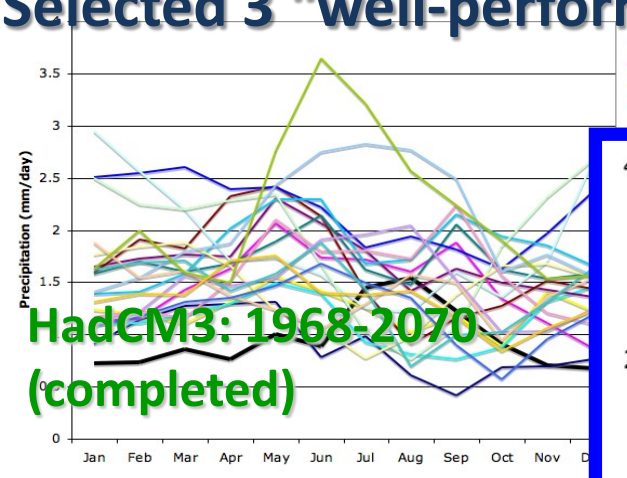
3. VIC hydrologic model watershed simulations (1/8 degree resolution)

Ultimate goal: long-term reliable future water management data for drought planning for water resource management, agriculture and natural hazards, i.e. floods, severe weather, wildfire

Introducing IPCC GCM products:

Intergovermental Panel on Climate Change (IPCC) 4th Assessment Report (released 2007)

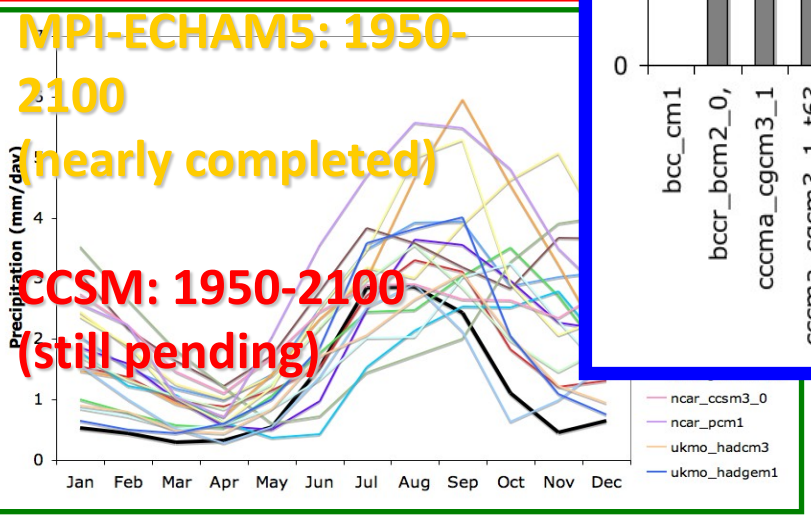
Selected 3 "well-performing" IPCC GCM products for Southwest U.S.

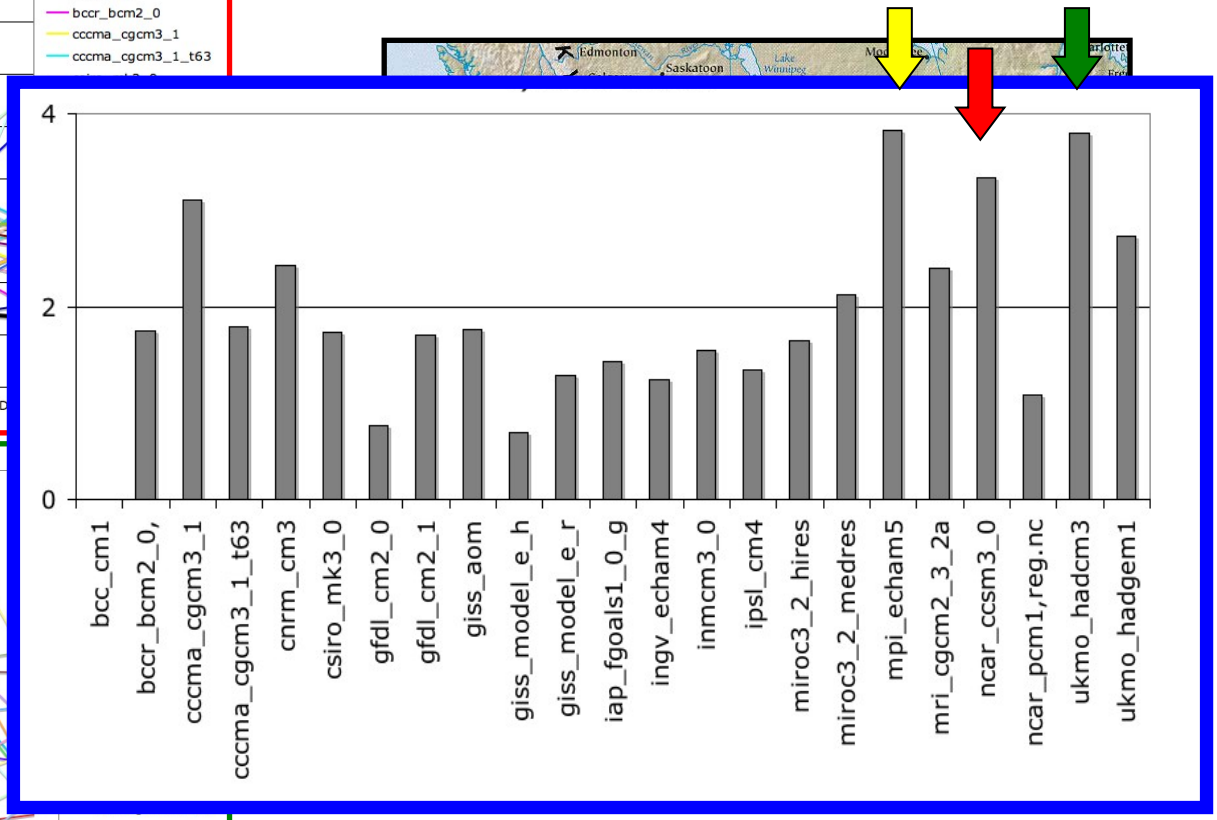


HadCM3: 1968-2070 (completed)

MPI-ECHAM5: 1950-2100 (nearly completed)

CCSM: 1950-2100 (still pending)

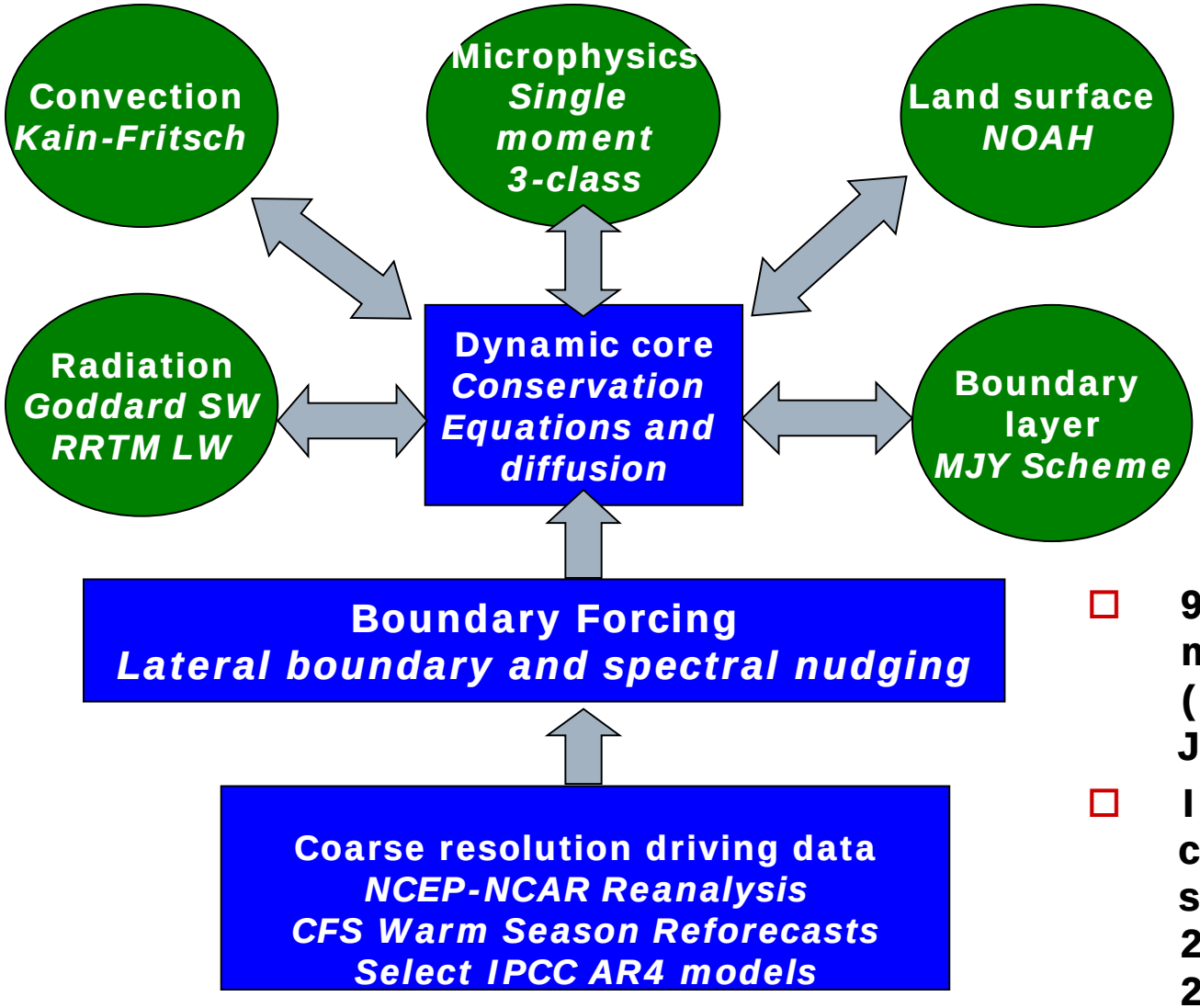




Historical GCM performance for Southwest U.S.

Dominguez et al (2009)

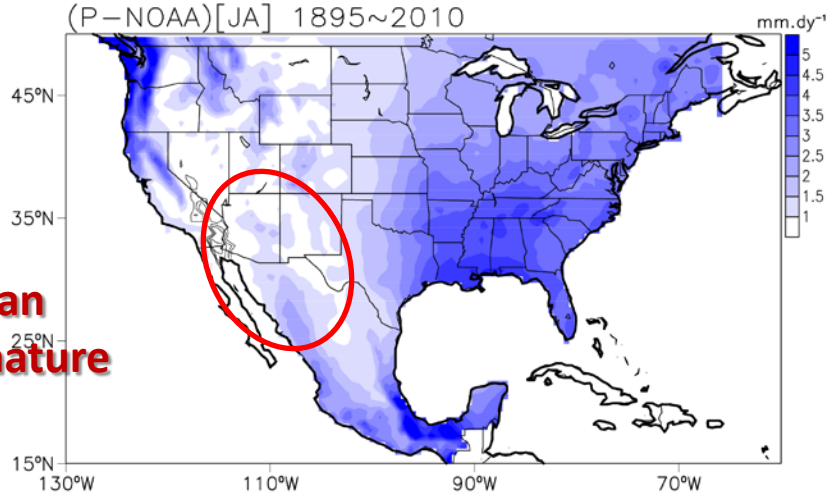
Linkage between GCM and RCM: **Dynamical downscaling** (more details see Carrillo et al. poster)



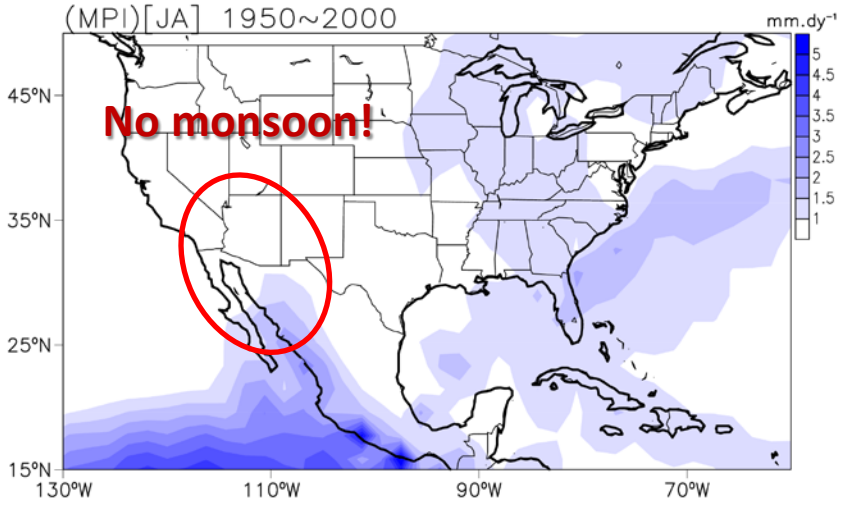
- **9 CFS ensemble members per season (1982-2000 Apr – Jun. initializations)**
- **IPCC long-term continuous simulations (mid 20th century to late 21st century)**

Does the model capture the precipitation climatology? Historical June/July precipitation (obs vs. MPI vs. WRF-MPI)

Observation

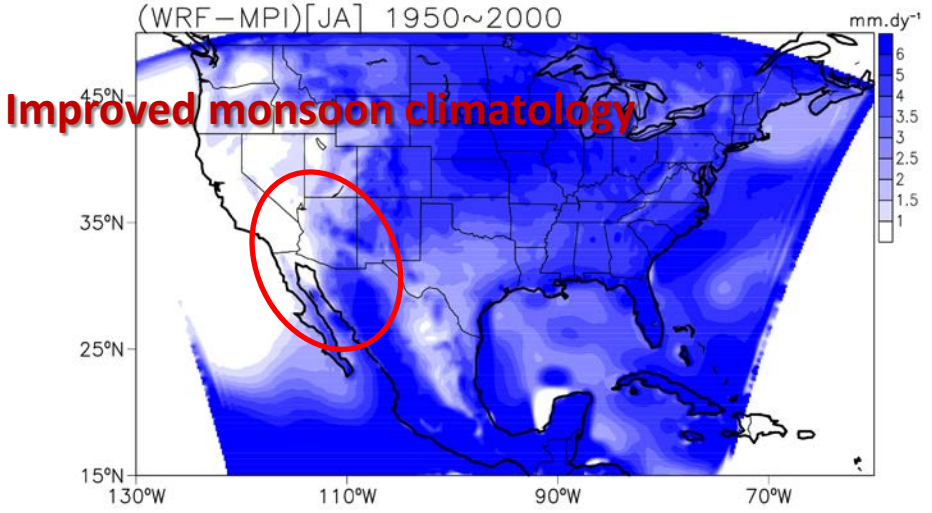


North American monsoon signature



No monsoon!

Raw GCM

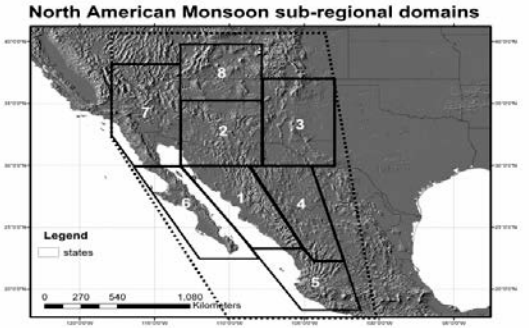


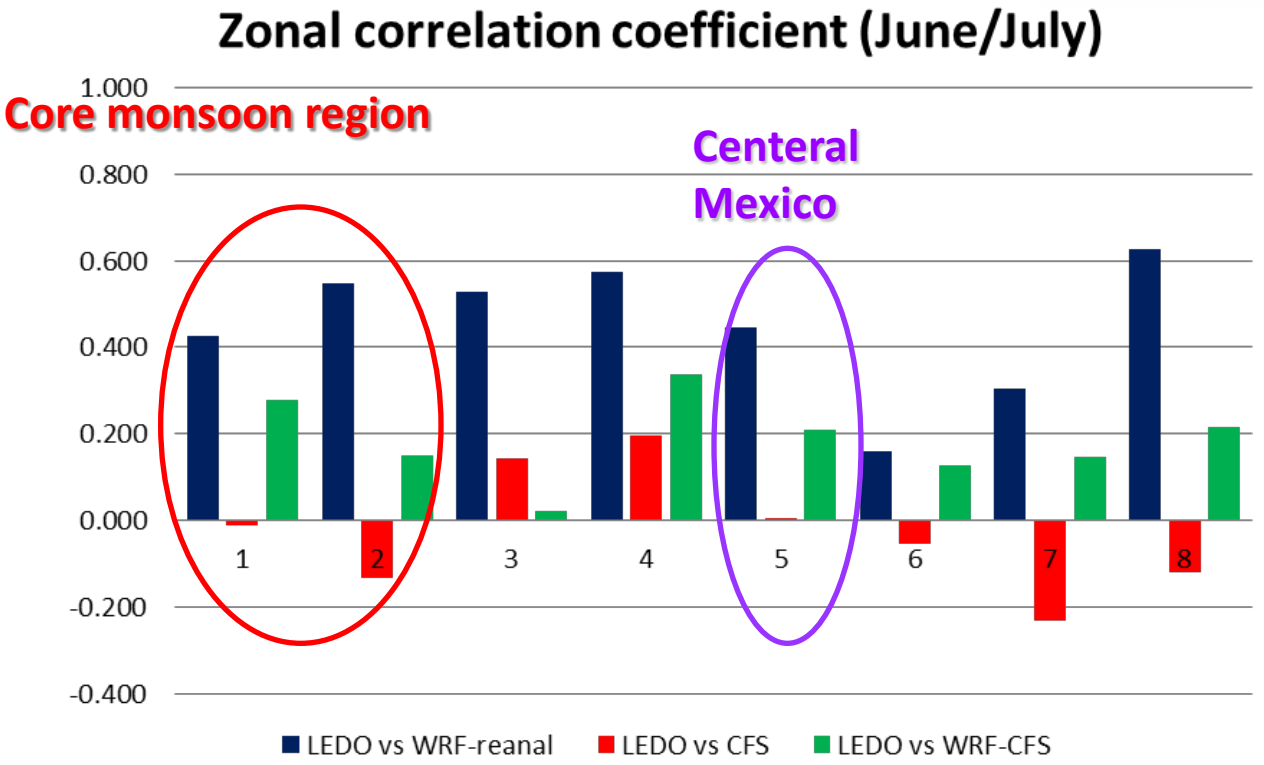
Improved monsoon climatology

RCM using downscaled GCM data

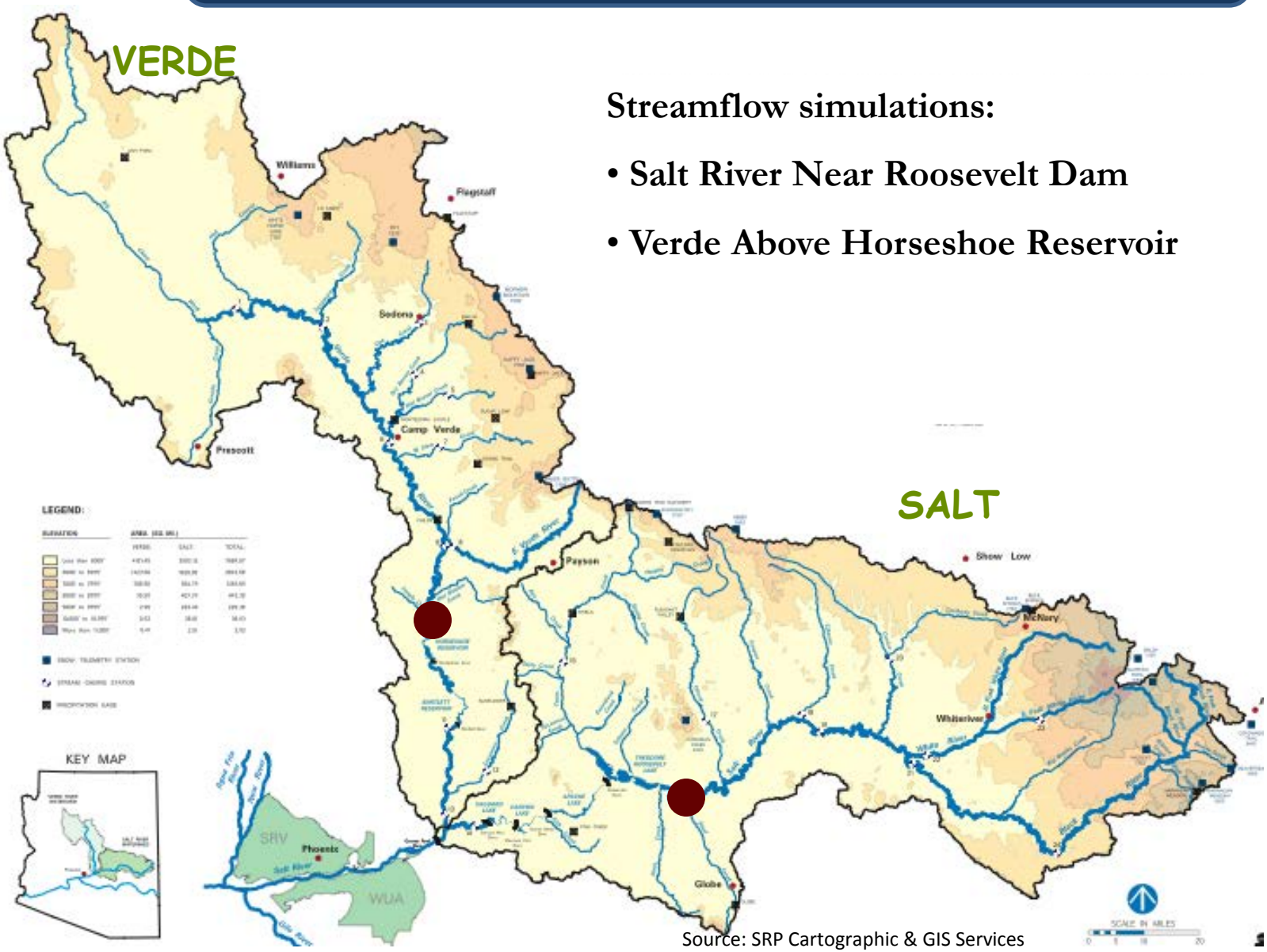
Seasonal forecast: value added with dynamical downscaling

- Overall CFS dynamical downscaling leads to improvement in early warm season seasonal forecast precipitation, especially in Mexico!





Lower Colorado River Basin- Salt and Verde

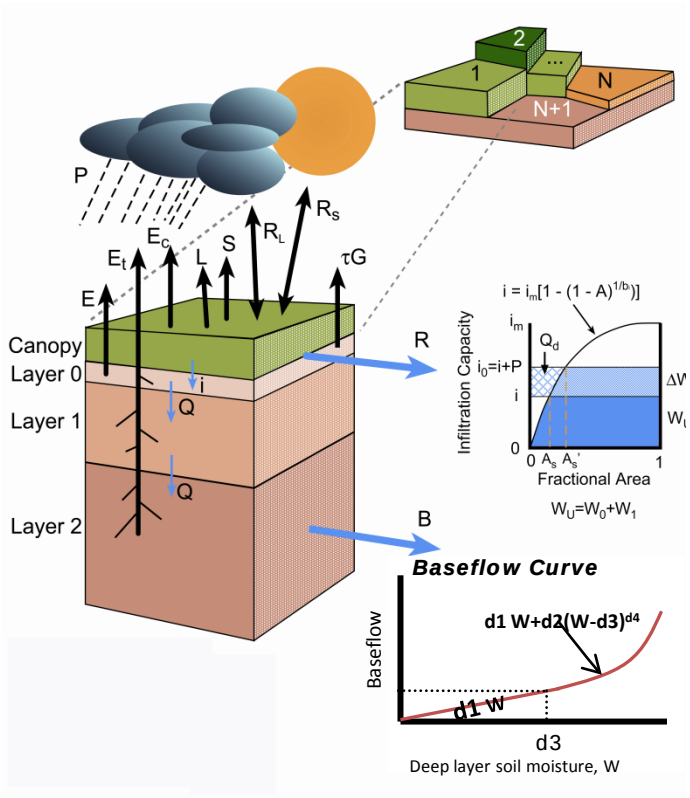


Streamflow simulations:

- **Salt River Near Roosevelt Dam**
- **Verde Above Horseshoe Reservoir**

Source: SRP Cartographic & GIS Services

Variable Infiltration Capacity (VIC) Hydrological Model



Input: Precipitation, Temperature, Pressure, Vapor Pressure, Wind, Shortwave and Longwave Radiation and Albedo

Output: e.g., Streamflow (fast and slow components), SWE, Evapotranspiration, and Soil moisture content

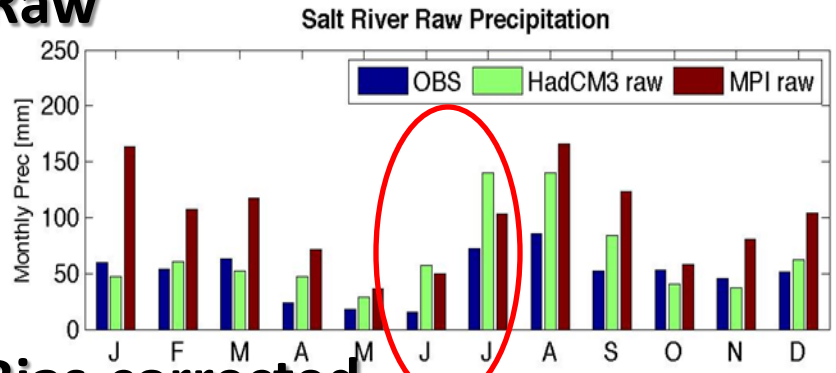
- Suitable for large basins
- Subgrid variability of: Vegetation, Soil moisture storage, Topography and Precipitation
- Energy and water balance
- Resolution 1/8 deg , 6-hourly

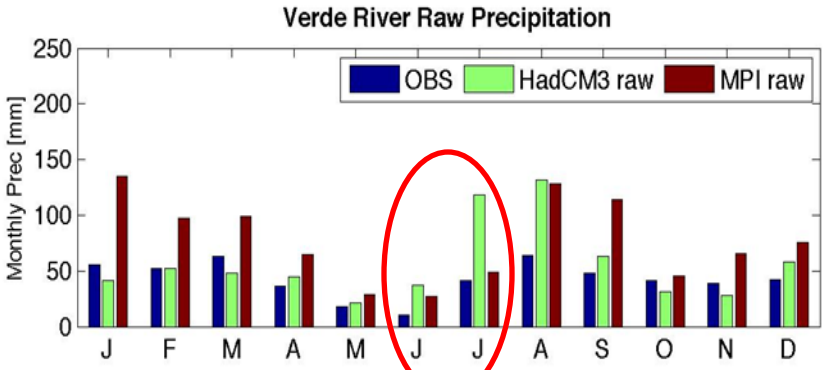
Preparing RCM data for VIC

RCM precipitation and temperatures were:

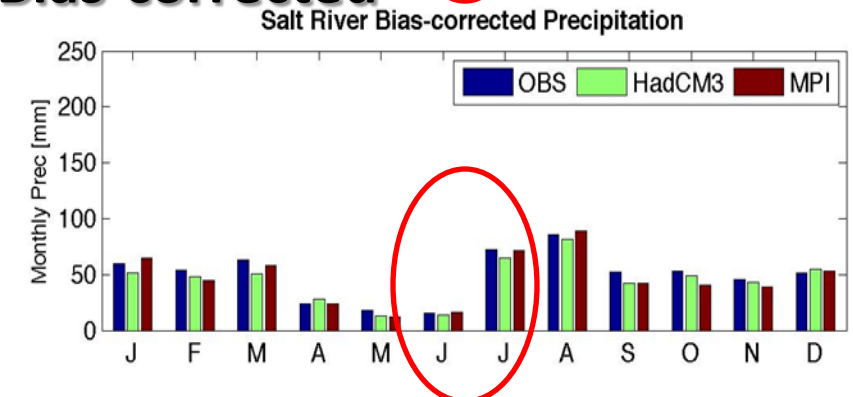
- rescaled to a 1/8 degree grid using an area weighted average
- Bias-Corrected using a Quantile method*

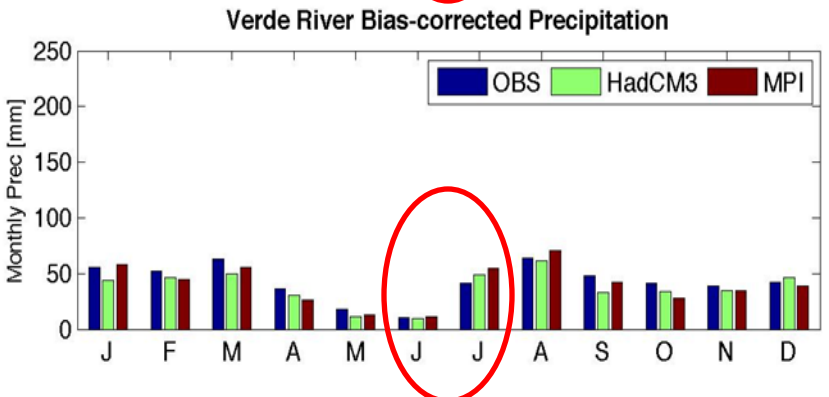
Raw





Bias-corrected

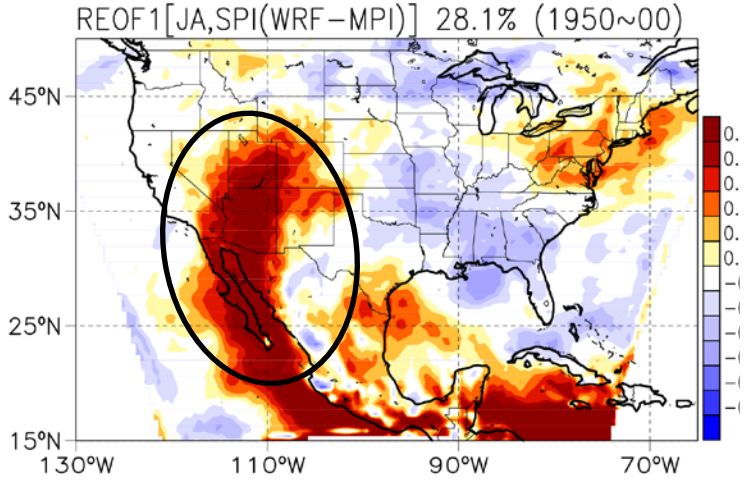




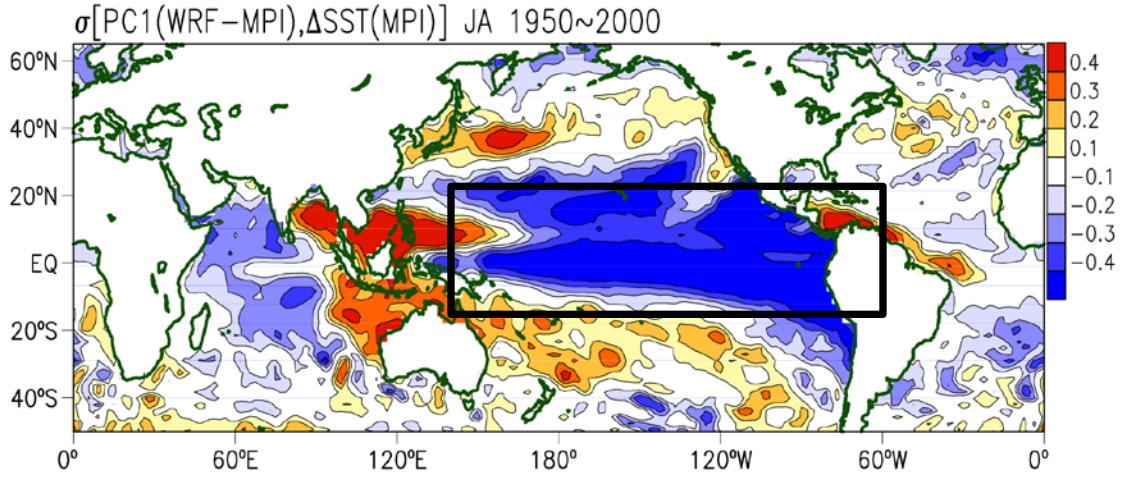
Why not bias-correct raw GCM data?

- Bias correction could be done for the raw GCM, however, results will not have any interannual variability, because of the GCM's poor performance in representing monsoon precipitation.

Downscaled products capture the interannual variability

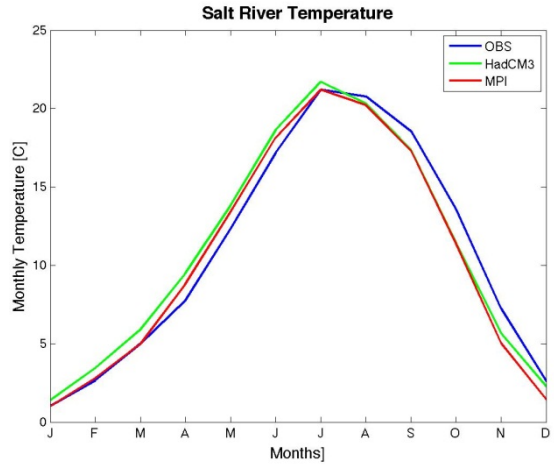


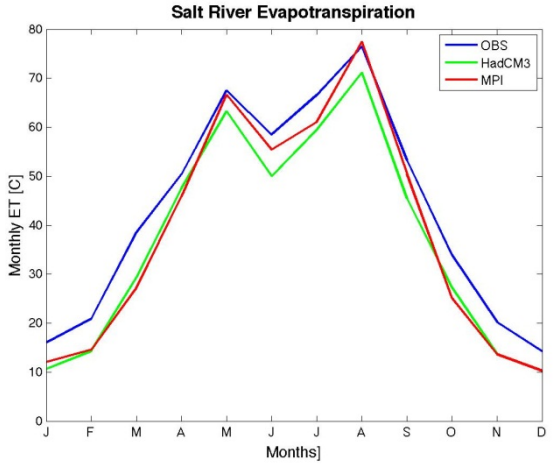
Wet summer signature

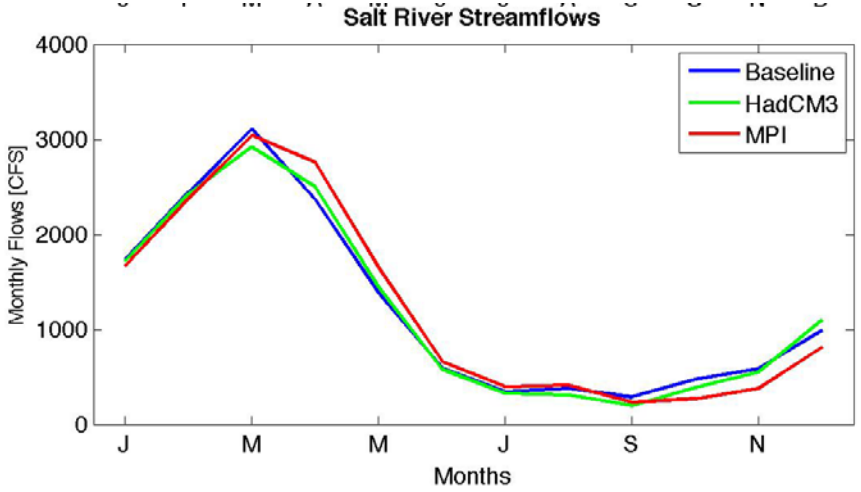


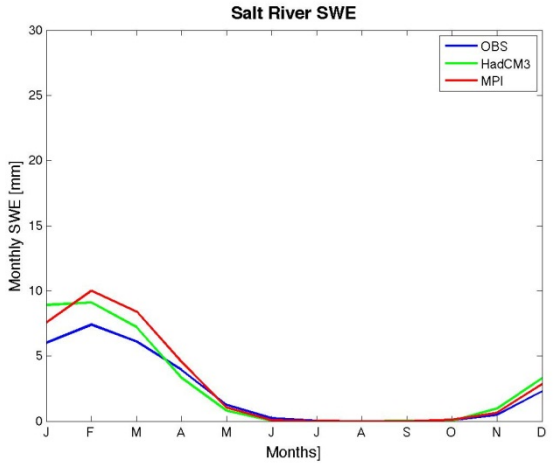
La Nina sea surface temperature pattern

Hydrology model result: Salt River Basin (50 year climatology, monthly average)







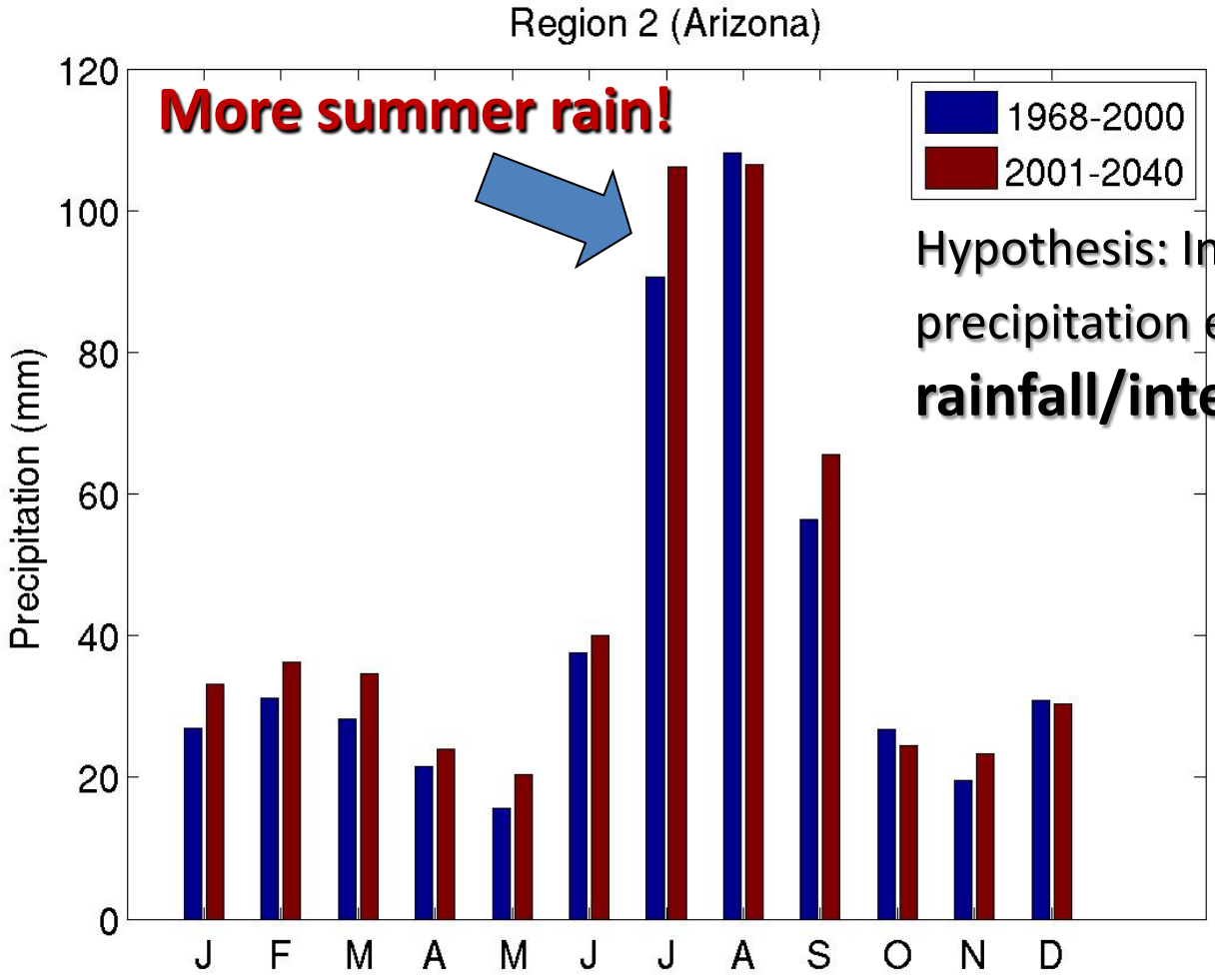


Summary

- Dynamical downscaling adds value to climatology and interannual variability. Especially better representation in the warm season.
- Hydrology model is able to produce reliable historical streamflow and evapotranspiration trends for the lower Colorado River basin
- Combination of natural variability and climate change is likely causing a more extreme climate, more intense wet/dry events, 2011 is a great example.
- Ongoing task: develop a integrated modeling system for hydrologic projections with bias correction for the future.

Ultimate goal: Utilize the unique signatures of our multi-model multi-scale product to gain a clear insight of the future water resource projection

What is the trend of future precipitation in Southwest U.S.?



Hypothesis: Increased extreme precipitation events. **Intensified rainfall/intensified drought**


Thank you
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