

California Extreme Precipitation Symposium  
*Paleoclimate Insights for Natural Resources Planning in California,*  
Davis CA July 9, 2018

# Tree Radial Growth Dependence on the Spatial Variability of Snowpack and Soil Moisture

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Study funded by the National Sciences Foundation (NSF) Award #1445889

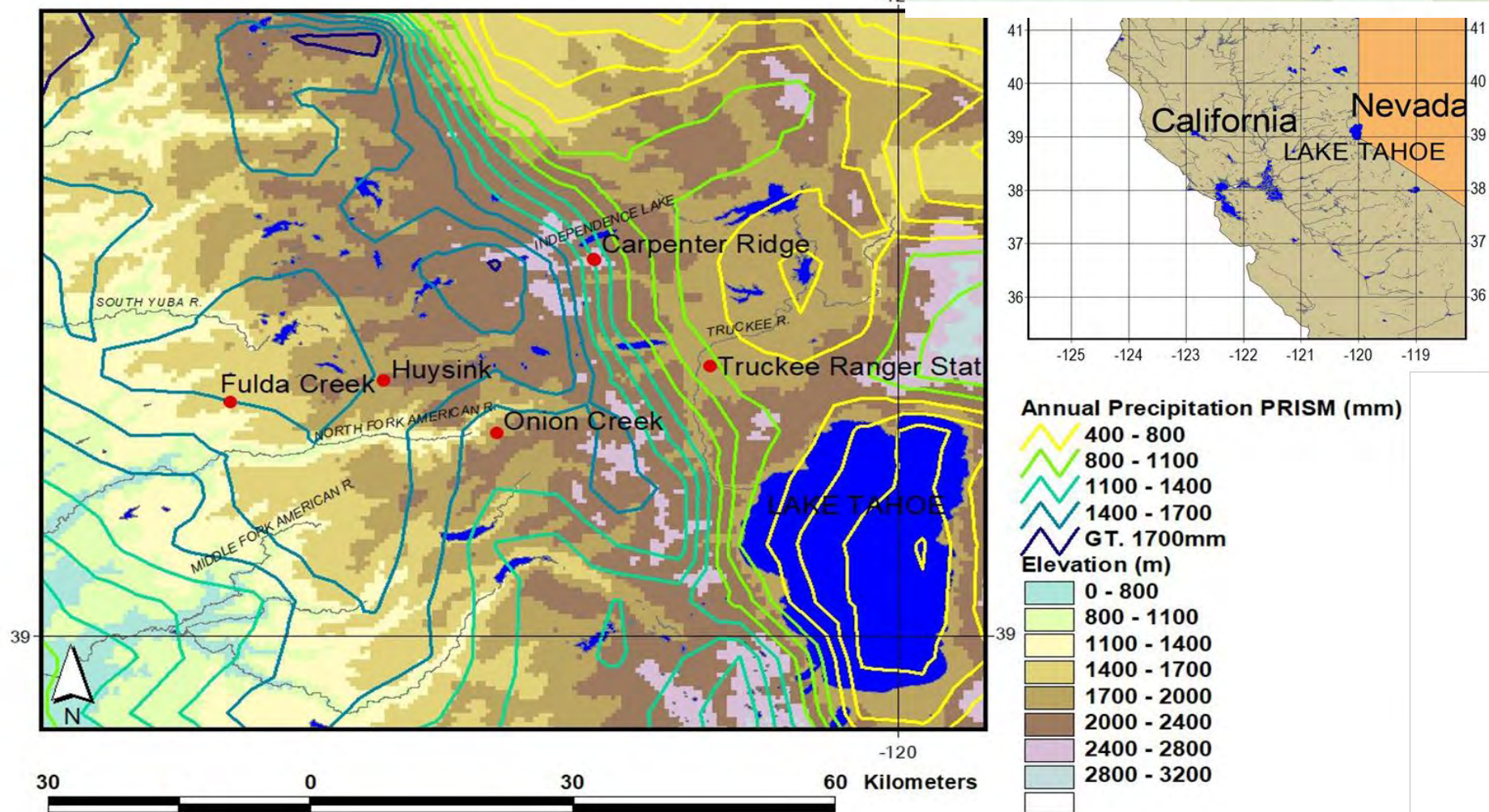


# The Study Objective

To assess whether we can use trees to detect regional spatial and temporal distribution of Soil Water Content [SWC], Snow Water Equivalent [SWE].

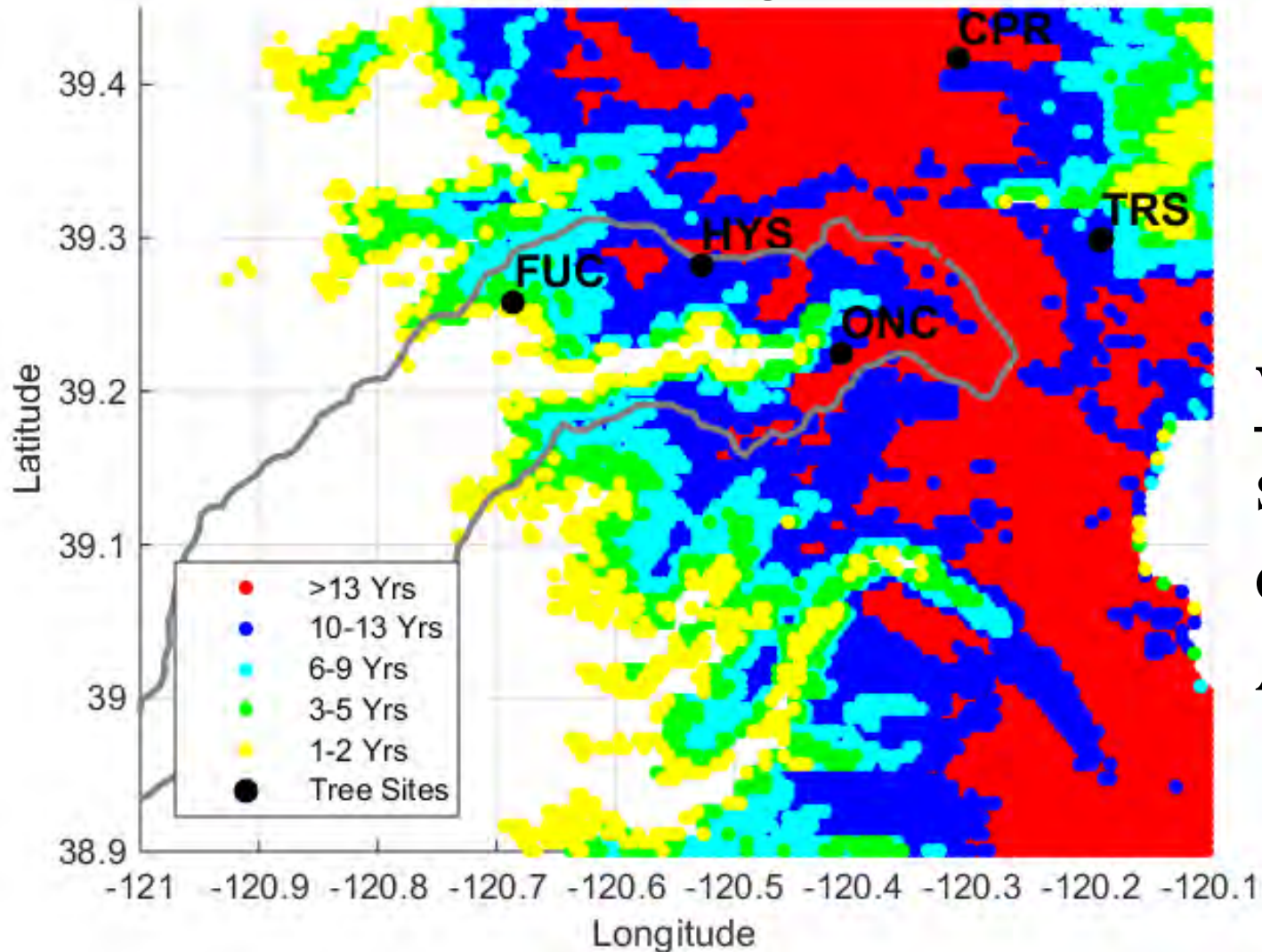
# Study Area

| Site Name                    | Elevation (m) | Latitude | Longitude | Aspect | Species                     | Common Name        |
|------------------------------|---------------|----------|-----------|--------|-----------------------------|--------------------|
| Carpenter Ridge (CPR)        | 2490-2525     | 39.4172  | -120.3121 | NE     | <i>Abies magnifica</i>      | California red fir |
| Carpenter Ridge (CPR)        | 2490-2516     | 39.4167  | -120.3110 | NE     | <i>Tsuga mertensiana</i>    | Mountain hemlock   |
| Truckee Ranger Station (TRS) | 1970-1985     | 39.2988  | -120.1915 | NW     | <i>Abies Concolor</i>       | White Fir          |
| Truckee Ranger Station (TRS) | 1970-1980     | 39.2981  | -120.1917 | NW     | <i>Pinus ponderosa</i>      | Ponderosa Pine     |
| Huysink (HYS)                | 2035-2055     | 39.2822  | -120.5278 | NW     | <i>Abies magnifica</i>      | California red fir |
| Onion Creek (ONC)            | 1890-1910     | 39.2246  | -120.4109 | SE->E  | <i>Calocedrus decurrens</i> | Incense cedar      |
| Fulda Creek (FUC)            | 1500-1540     | 39.2583  | -120.6857 | SW     | <i>Pinus ponderosa</i>      | Ponderosa Pine     |



# Snow Cover

**Number of years with winter snowpack  
MODIS (500m) during 2000-2015**



## **Winter snowpack:**

snow cover more than ~90%  
of the days during January-  
April.

# Carpenter Ridge



California Red Fir  
(*Abies magnifica*)  
CPRA



Mountain Hemlock  
(*Tsuga Mertensiana*)  
CPRT

# Truckee



Ponderosa Pine  
(*Pinus Ponderosa*)  
TRSP

White Fir  
(*Abies concolor*)  
TRSA

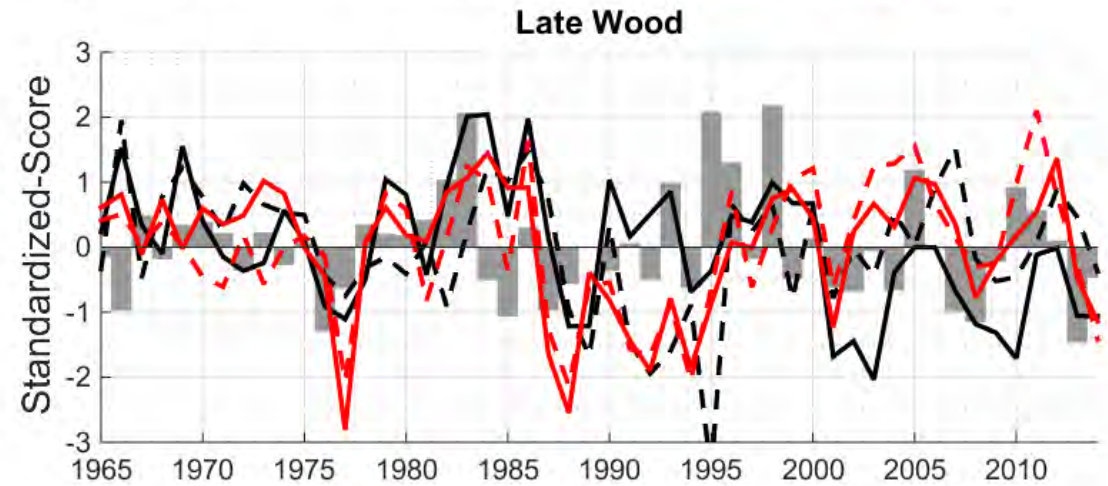
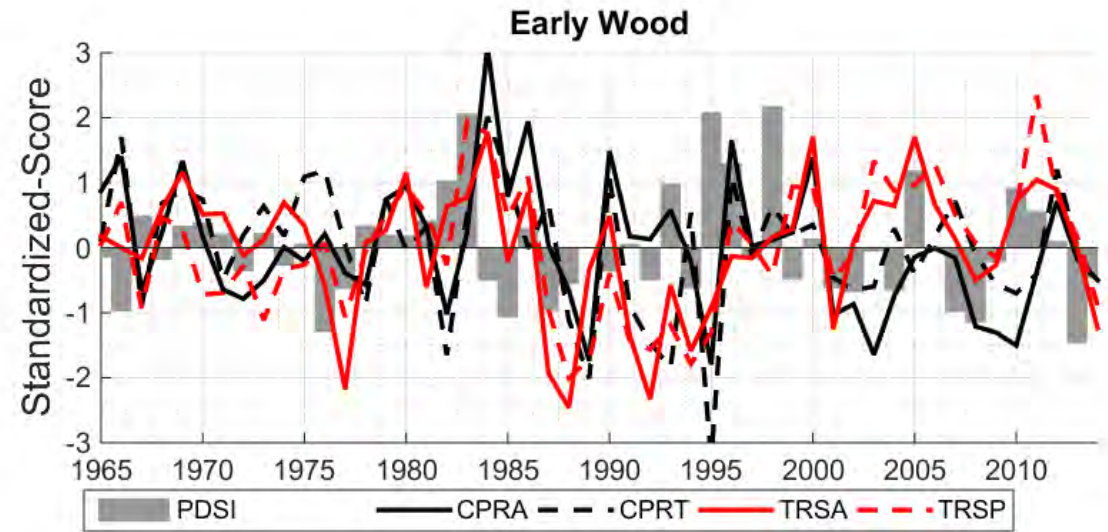


# Annual Ring

## Early and Late Wood

| Early Wood<br>Spring      | Late Wood<br>Summer      |
|---------------------------|--------------------------|
| wider cells thinner walls | narrow cells thick walls |

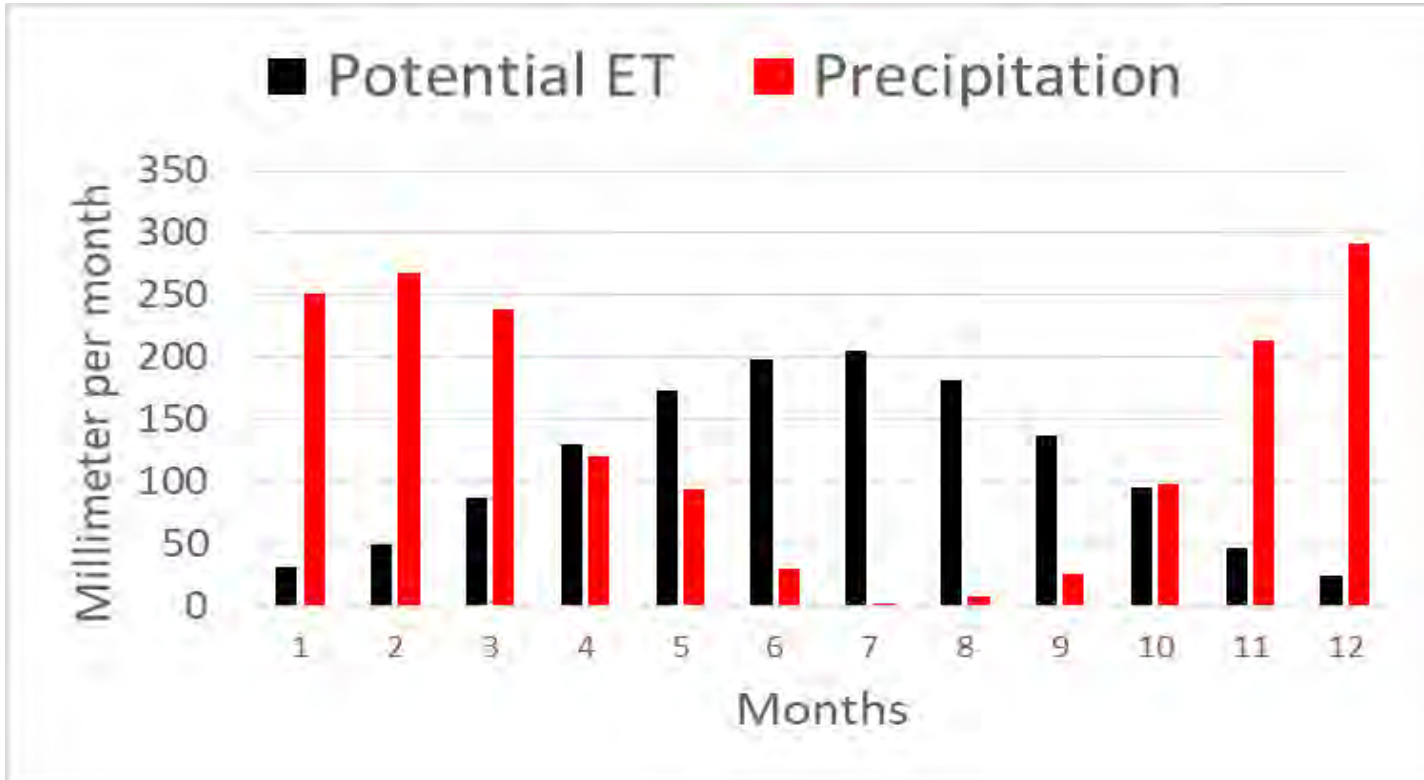
Transition is commonly caused by environmental stress



Annual 1965-2014 standard score of Early Wood & Late Wood Ring Width

gray bars: annual Palmer Drought Severity Index (PDSI) for California climate division #2 (NCEI/NOAA)

# Tree Growth Limiting Factors



## Forest ecosystem growth can be classified to:

- limited energy availability.  $PET < P$
- limited water availability.  $PET > P$

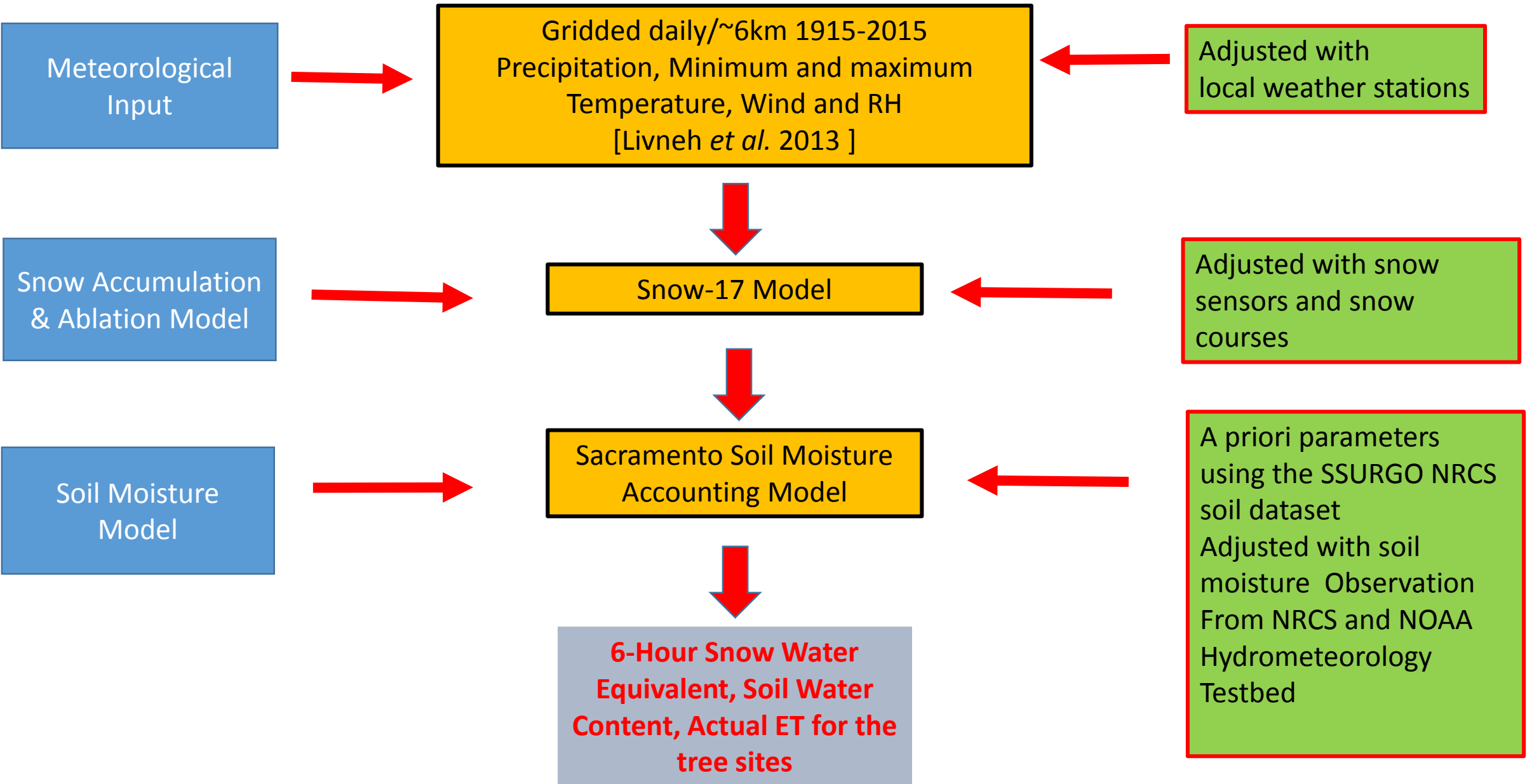
In our study area:

- $PET > P$  in lower elevations
- $PET/P$  ratio in higher elevations is dependent on the climate inter-annual variability.

Black bars: mean monthly potential evapotranspiration, northern Sierra Nevada (CIMIS)

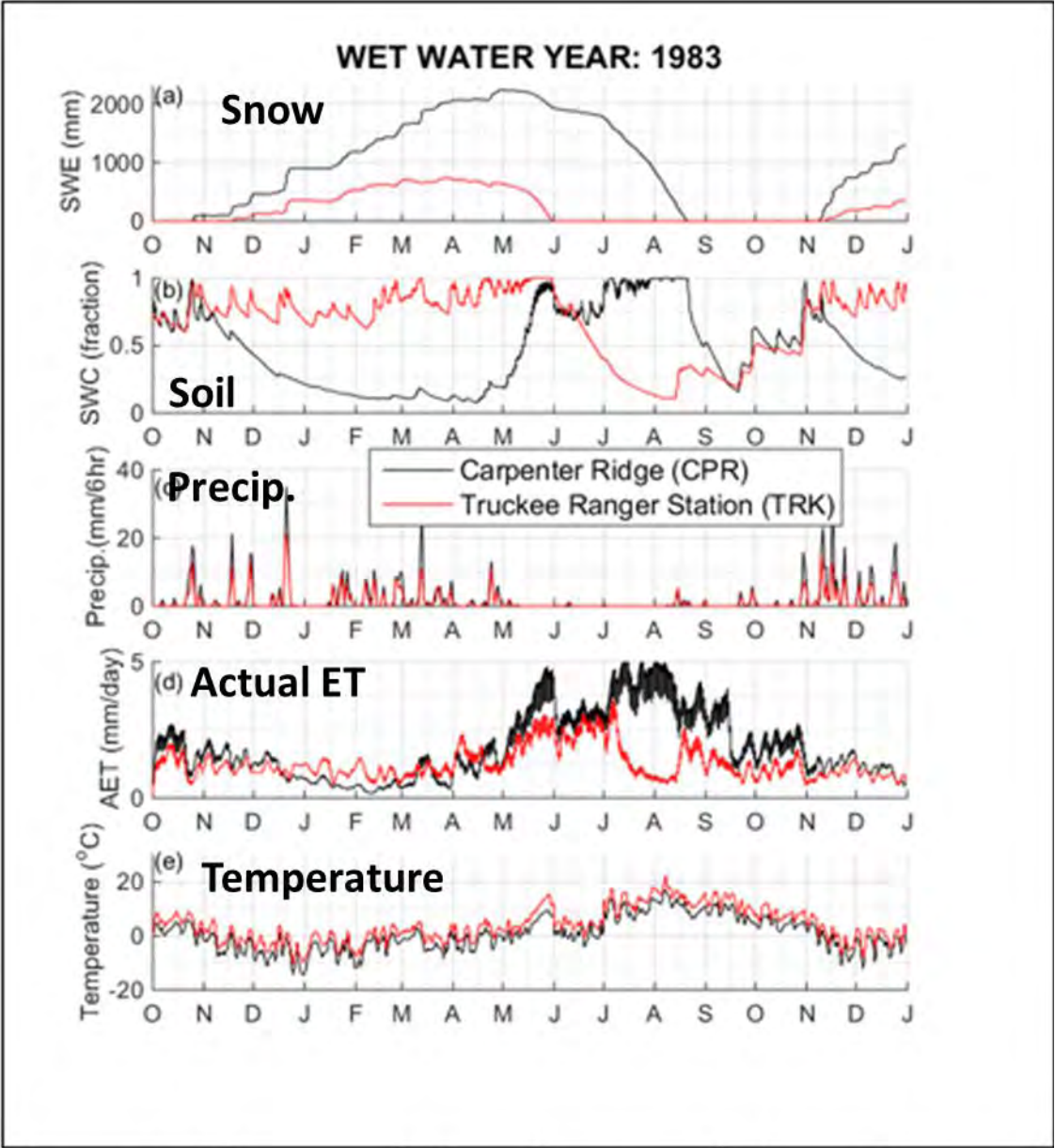
Red Bars: mean monthly precipitation at Blue Canyon

# Hydrologic model configuration for tree sites

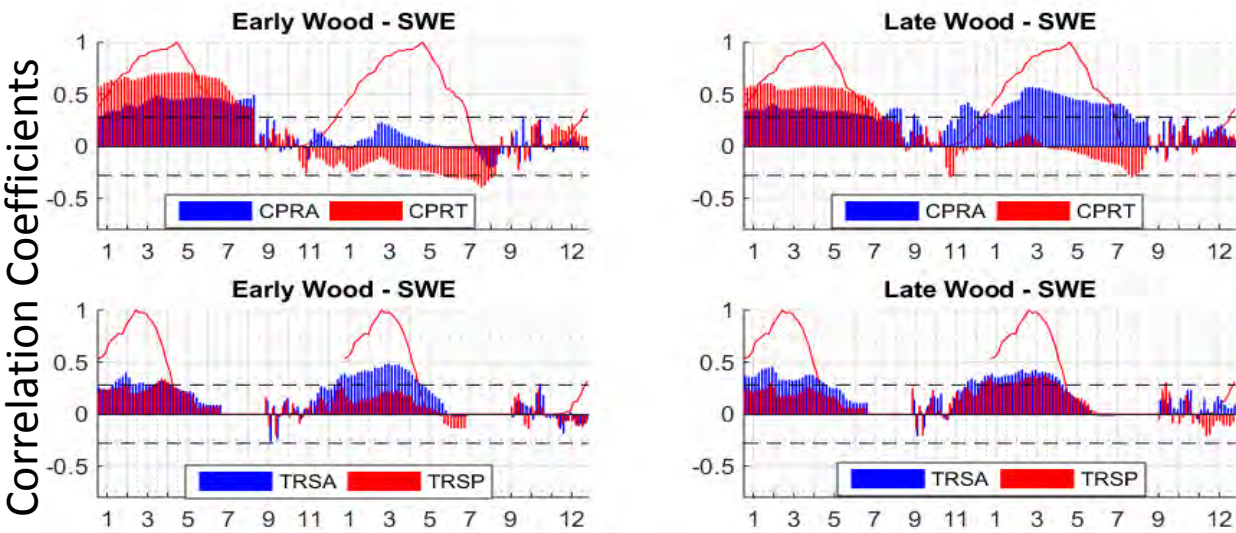




# Examples for the time series available for analysis



# Correlation between sand surface variable and Early and Late wood



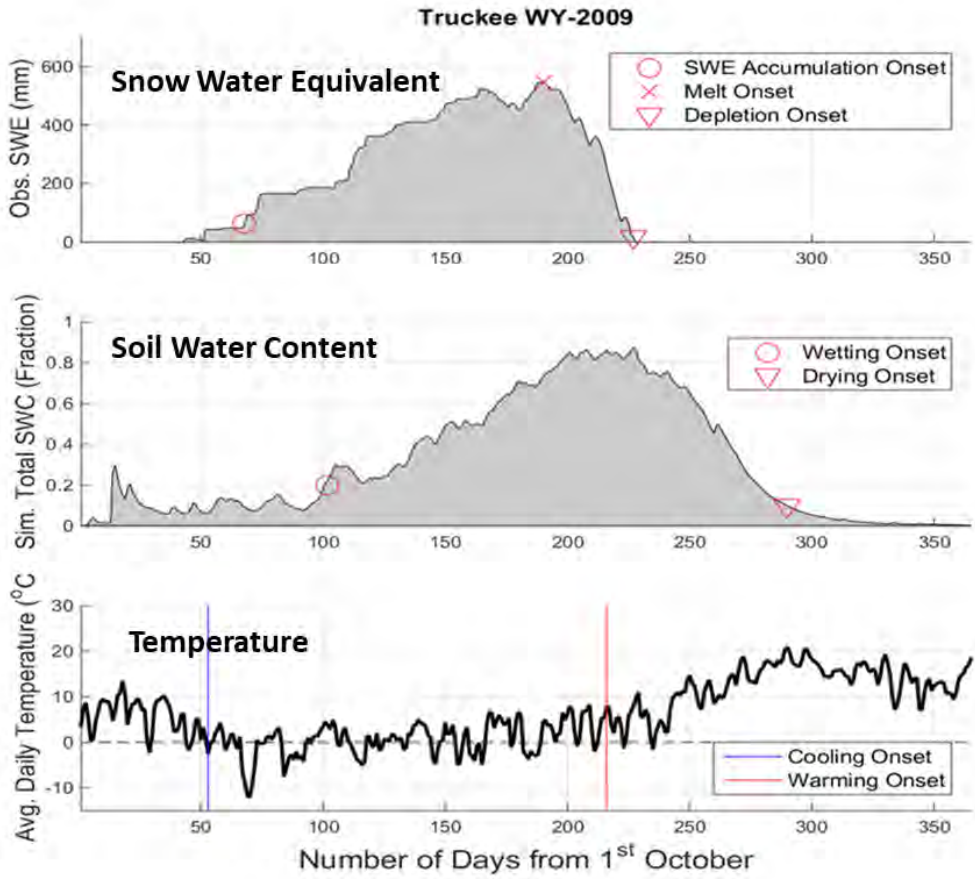
**CPRA – Carpenter Ridge Red Fir**

**CPRT – Carpenter Ridge Mountain Hemlock**

**TRSA – Truckee White Fir**

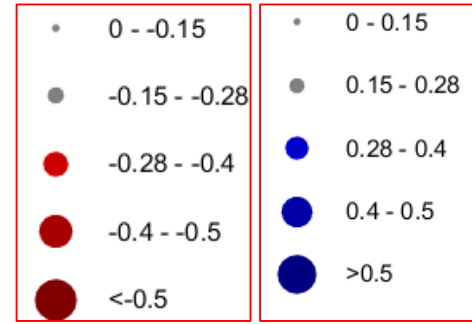
**TRSP – Truckee Ponderosa Pine**

# Climatological Indices

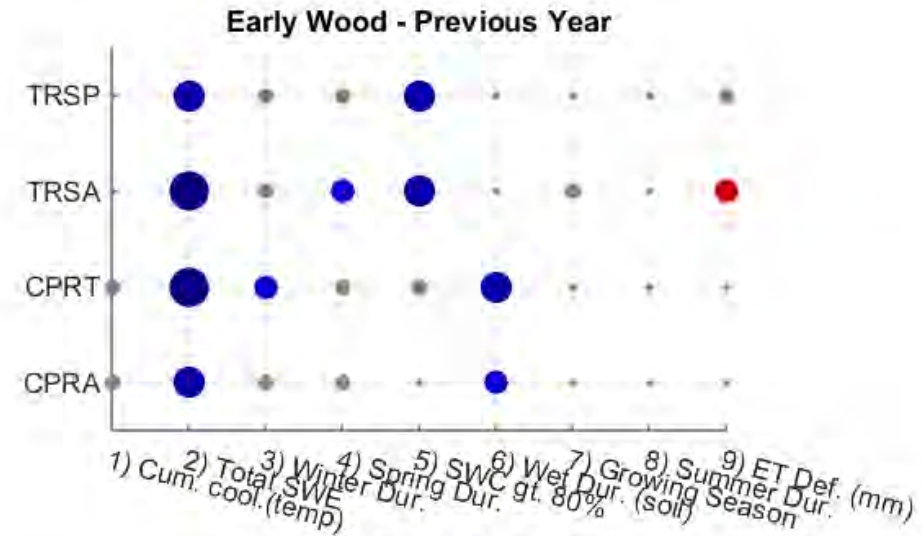
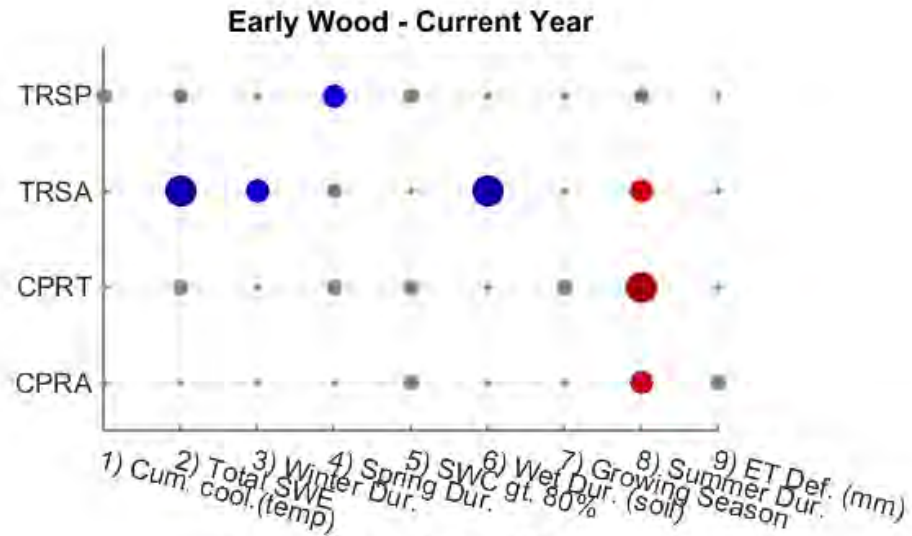


| ID    | Definition                               | Units | Notes   |
|-------|--|-------|---|
| Ind-1 | Cooling accumulation                     | °C    | Cumulative negative temperature during the Dormancy Duration      |
| Ind-2 | Total SWE                                | mm    | The total WY accumulated melt                                     |
| Ind-3 | Snowpack duration                        | Days  | SWE depletion onset – SWE accumulation onset                      |
| Ind-4 | Melt duration                            | Days  | SWE depletion onset – SWE melt onset                              |
| Ind-5 | Growing season with SWC greater than 80% | Days  | SWC during growing season   |
| Ind-6 | Wet duration                             | Days  | SWC drying onset – SWC wetting onset                              |
| Ind-7 | Duration of growing season               | Days  | SWC drying onset – SWE melt onset                                 |
| Ind-8 | Dry Duration                             | Days  | SWC wetting onset of the next year – drying onset                 |
| Ind-9 | Growing season ET deficit                | mm    | Cumulative ET deficit (PET-AET) during the growing season (Ind-7) |

## Correlation Coefficients:



## Early Wood



CPRA – Carpenter Ridge Red Fir

CPRT – Carpenter Ridge Mountain Hemlock

TRSA – Truckee White Fir

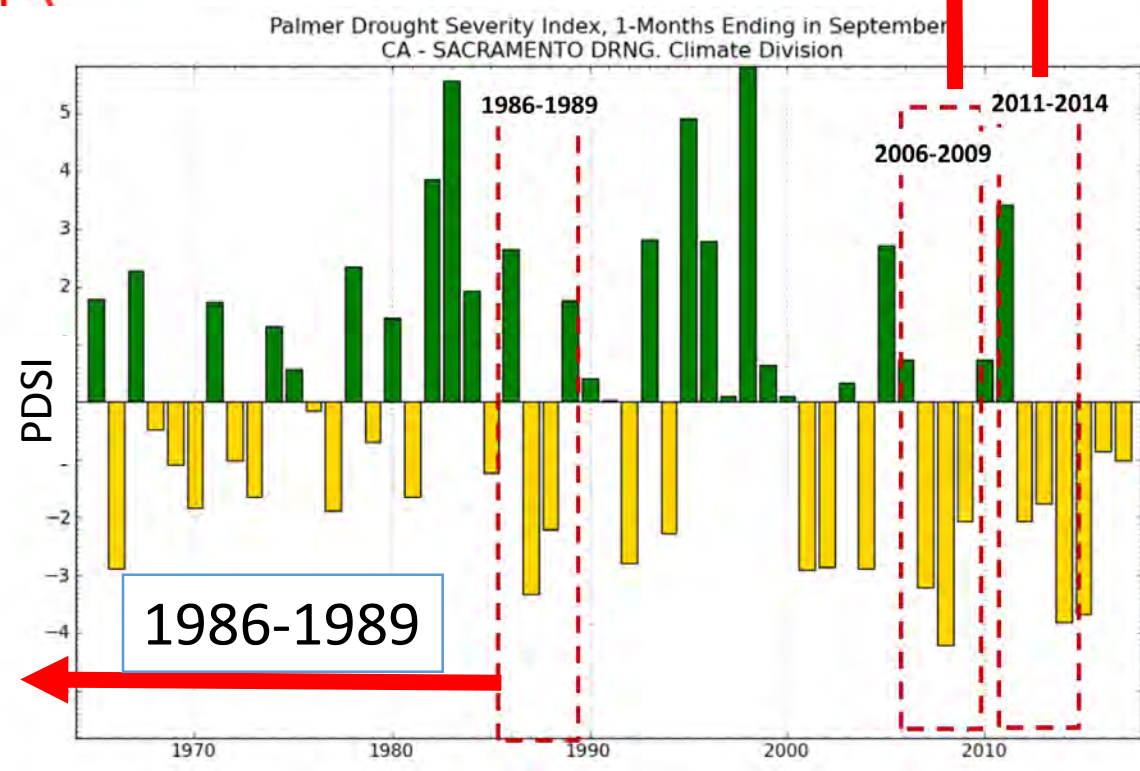
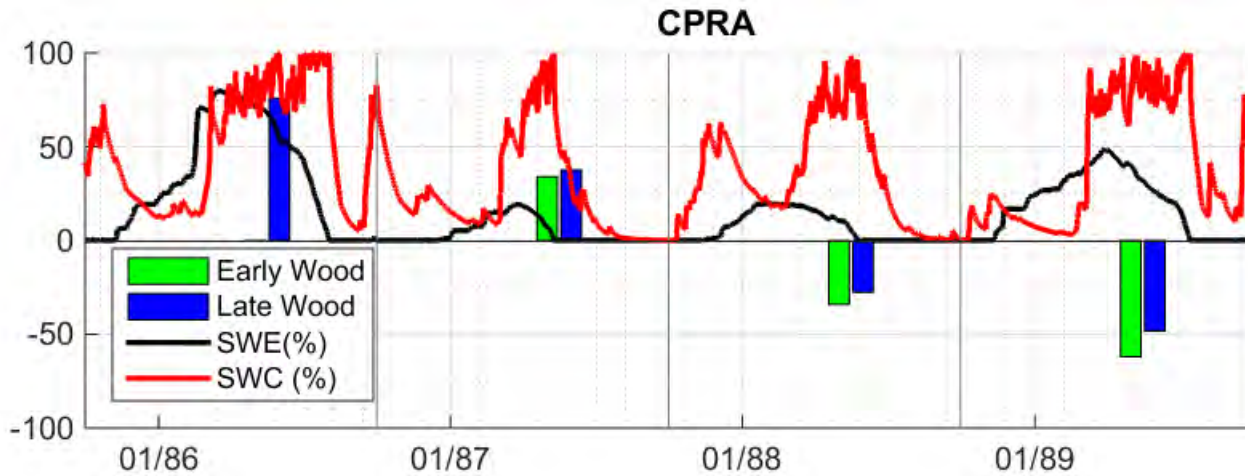
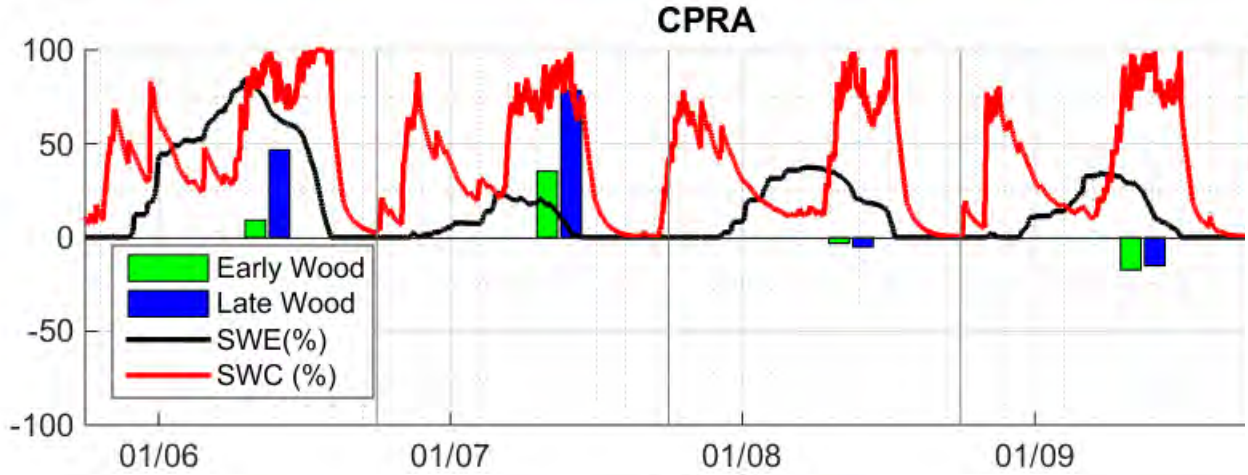
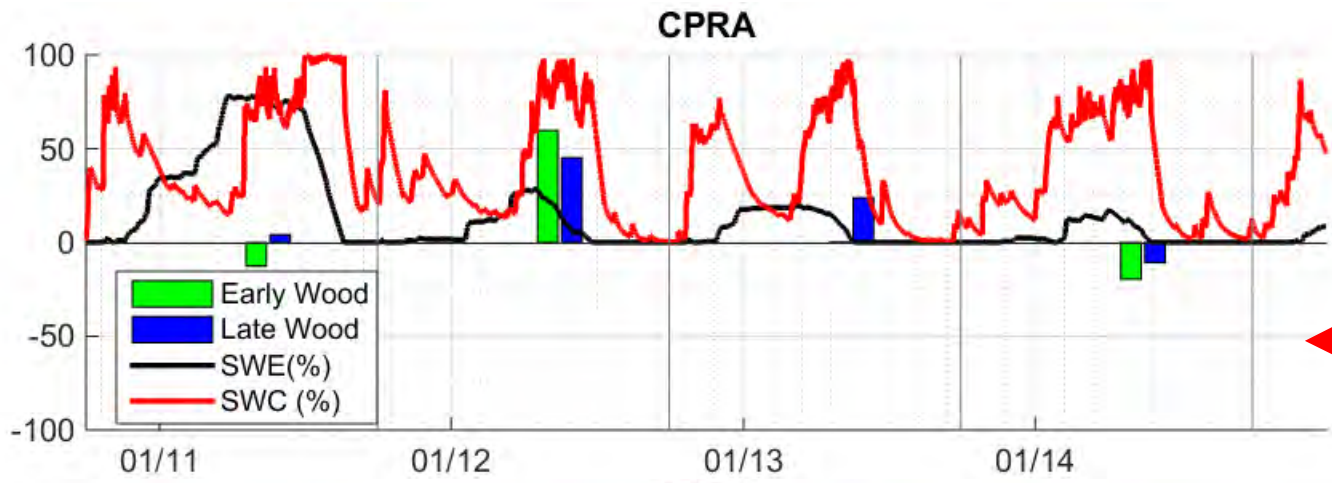
TRSP – Truckee Ponderosa Pine

# Carpenter Ridge Red Fir

2011-2014

2006-2009

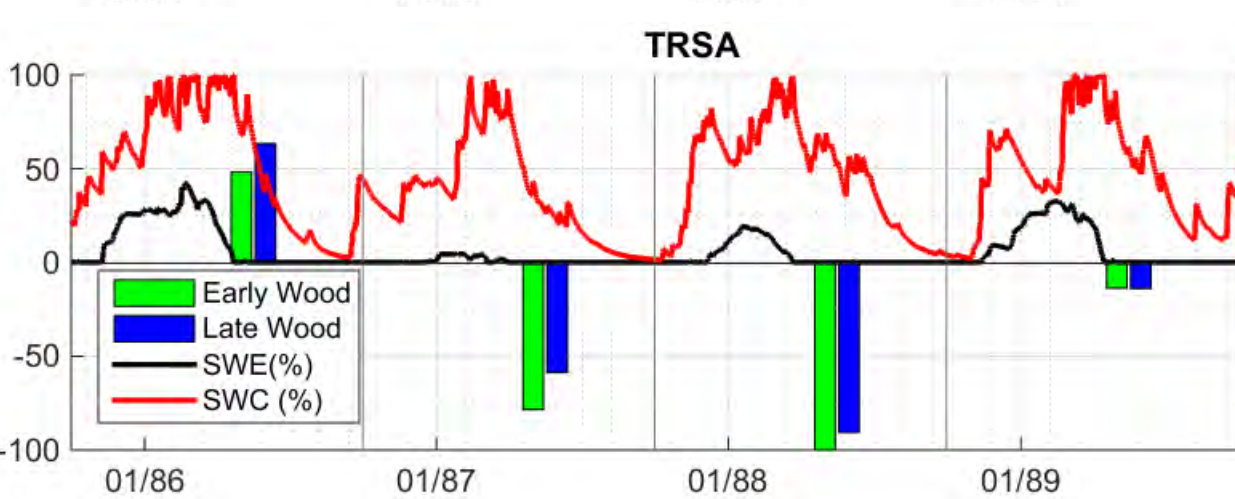
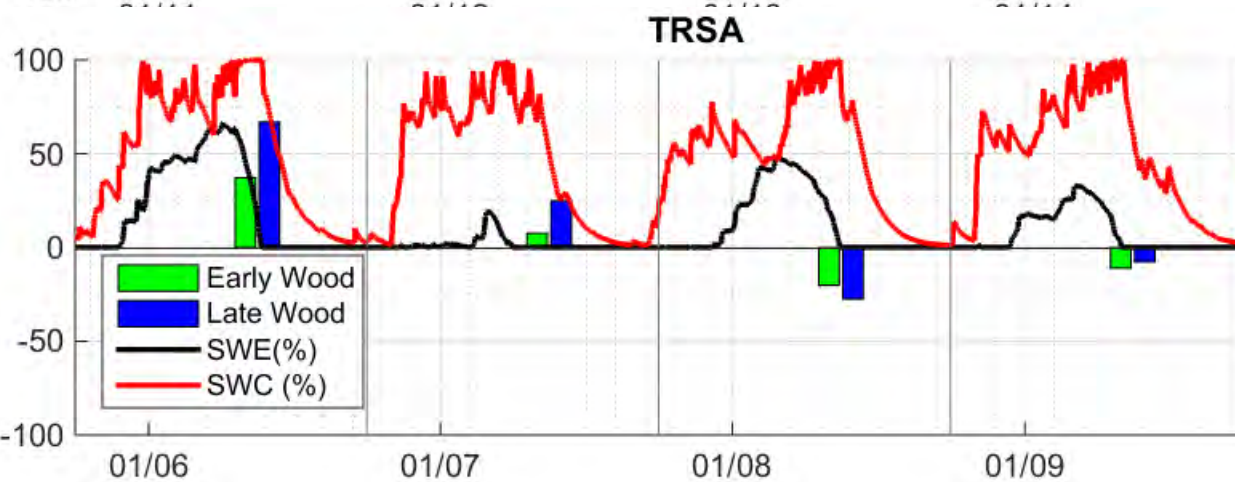
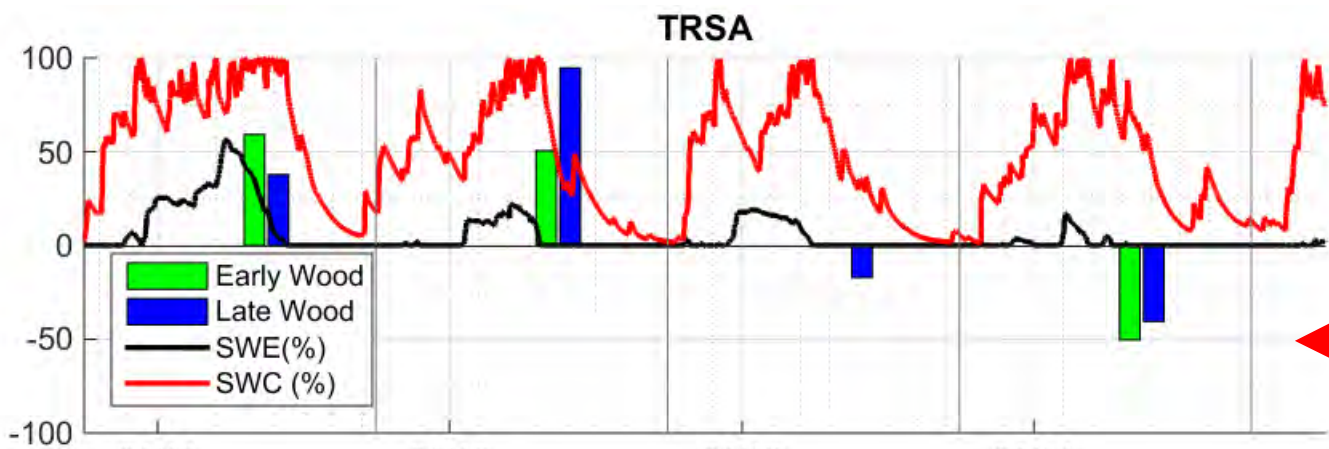
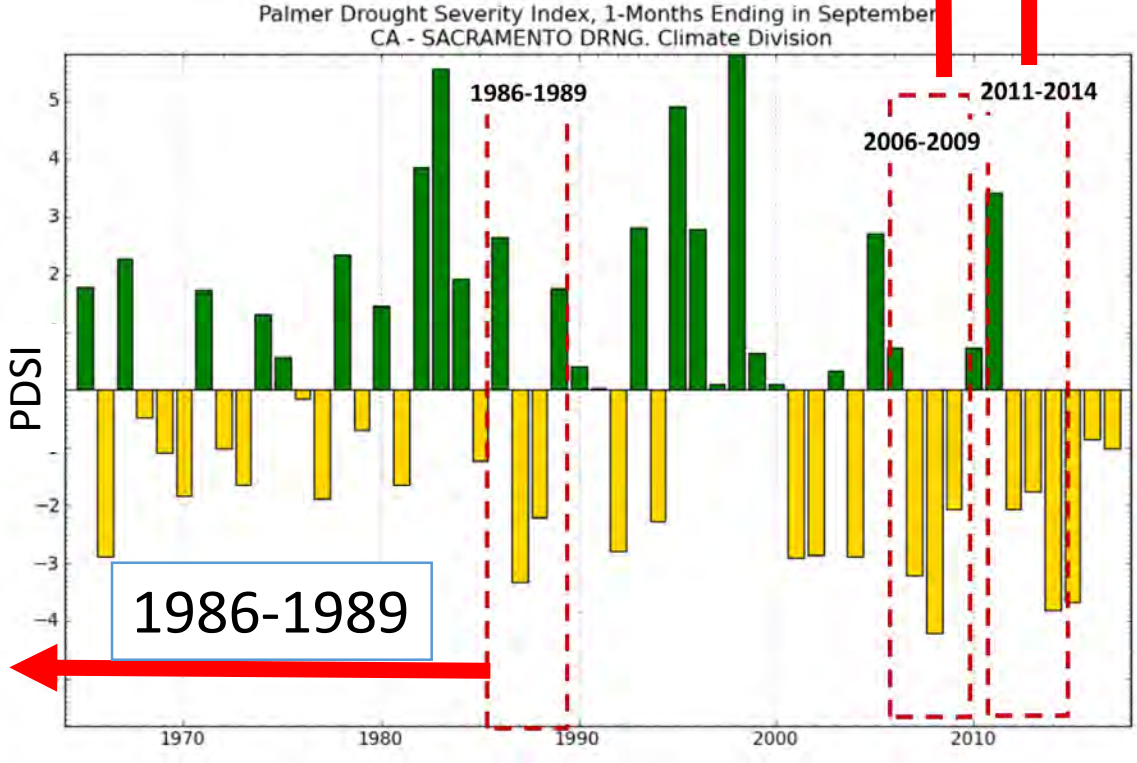
1986-1989



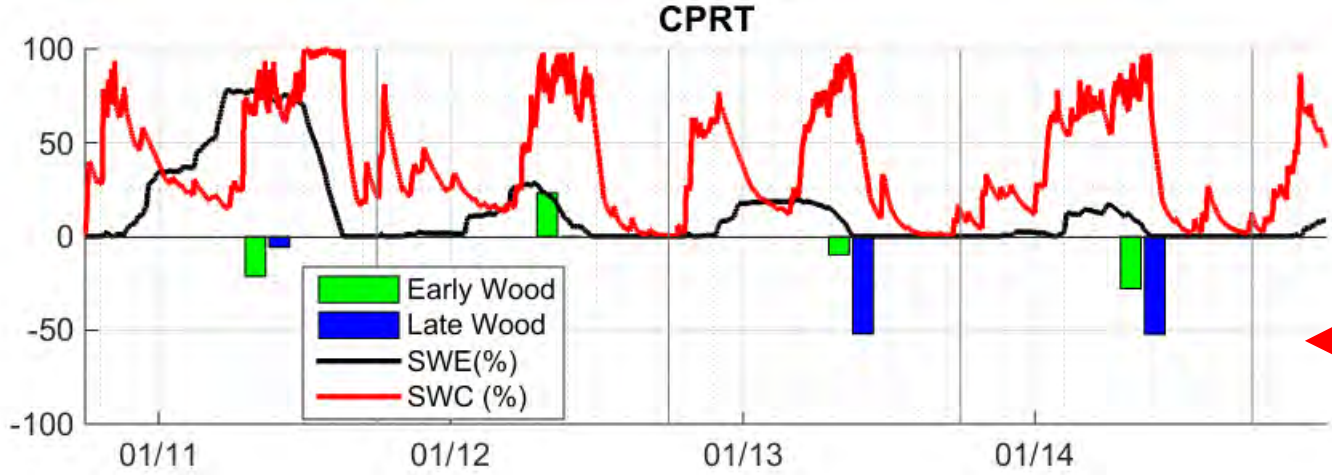
# Truckee Ranger Sta. White Fir

2011-2014

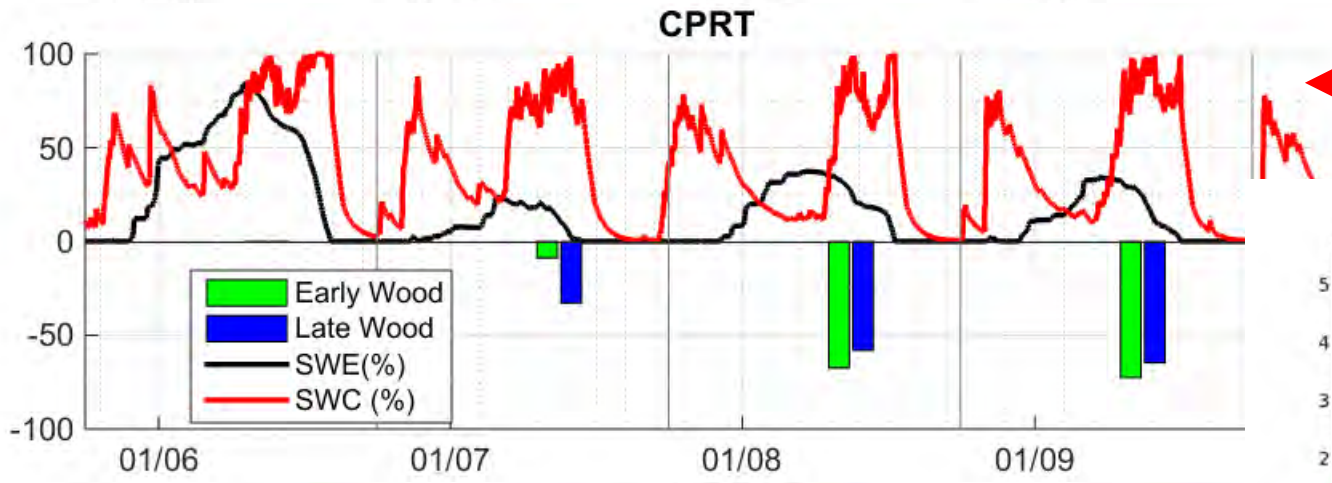
2006-2009



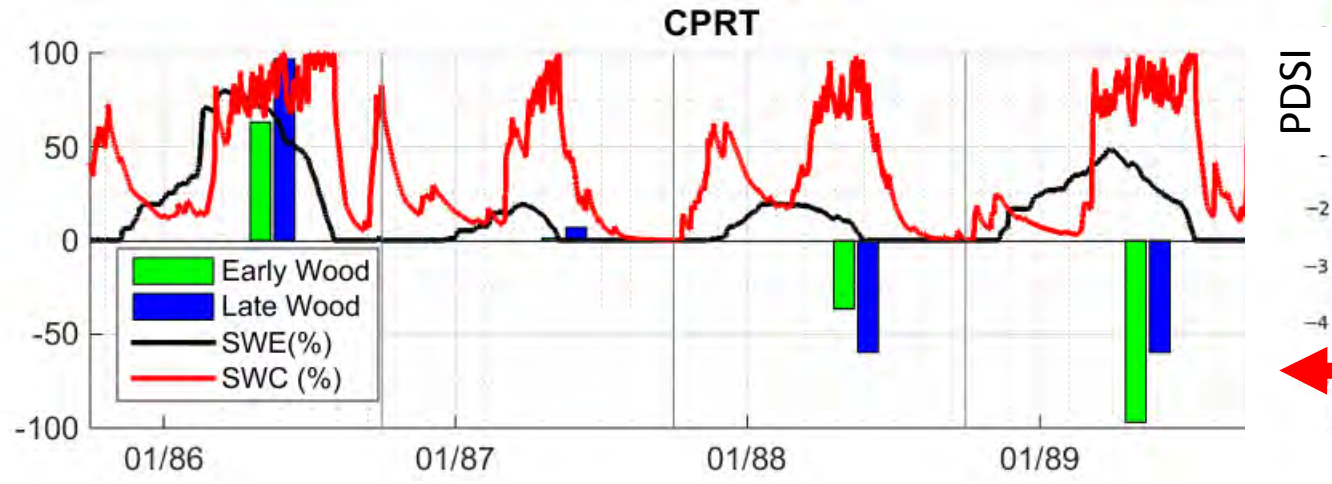
# Carpenter Ridge Mountain Hemlock



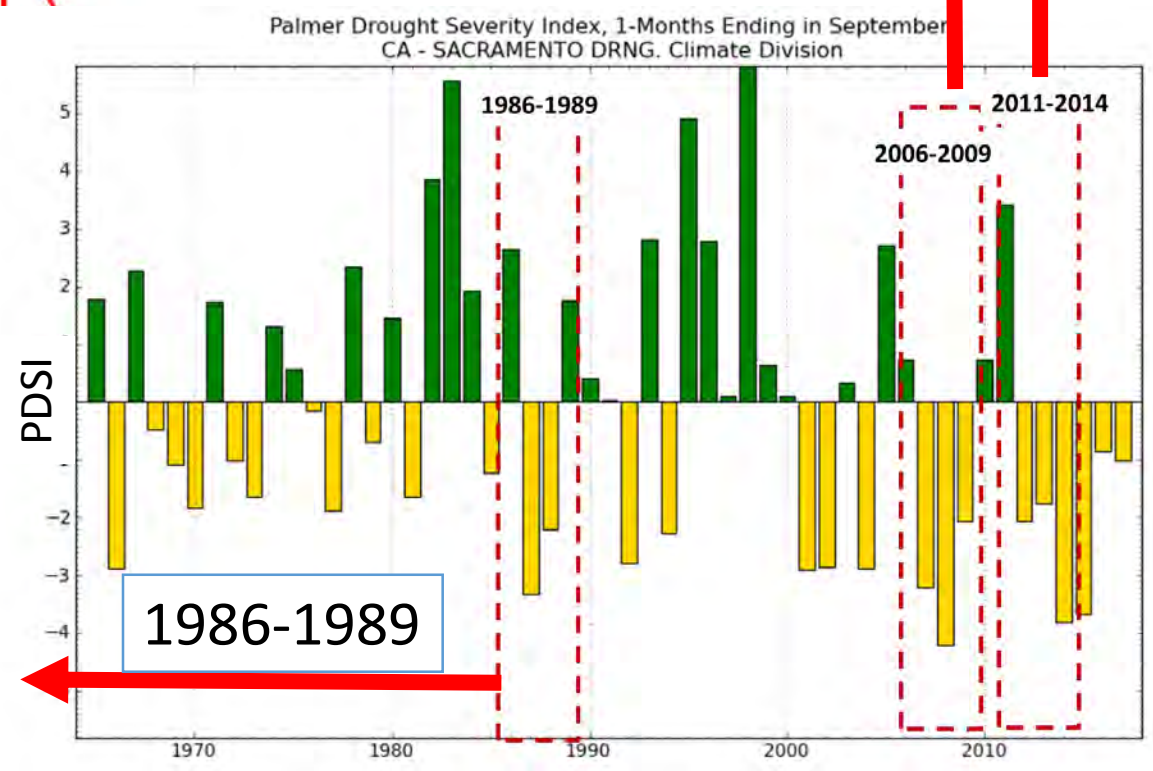
2011-2014



2006-2009



1986-1989



1986-1989

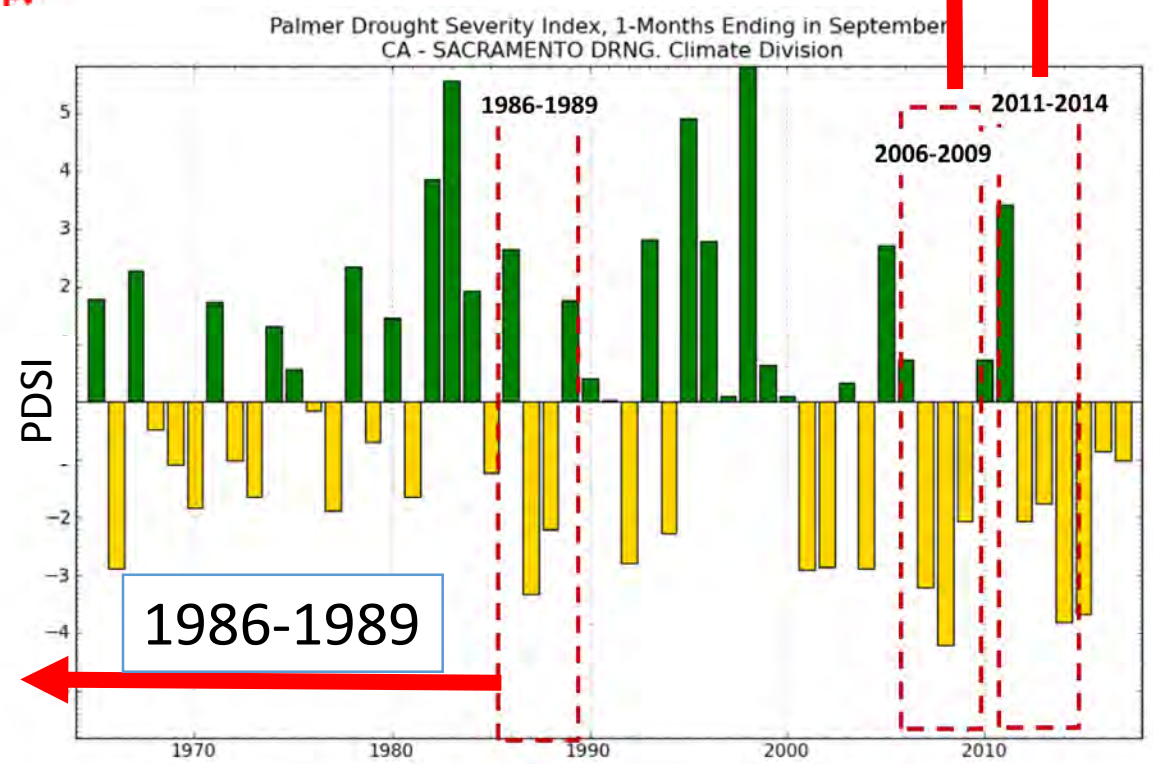
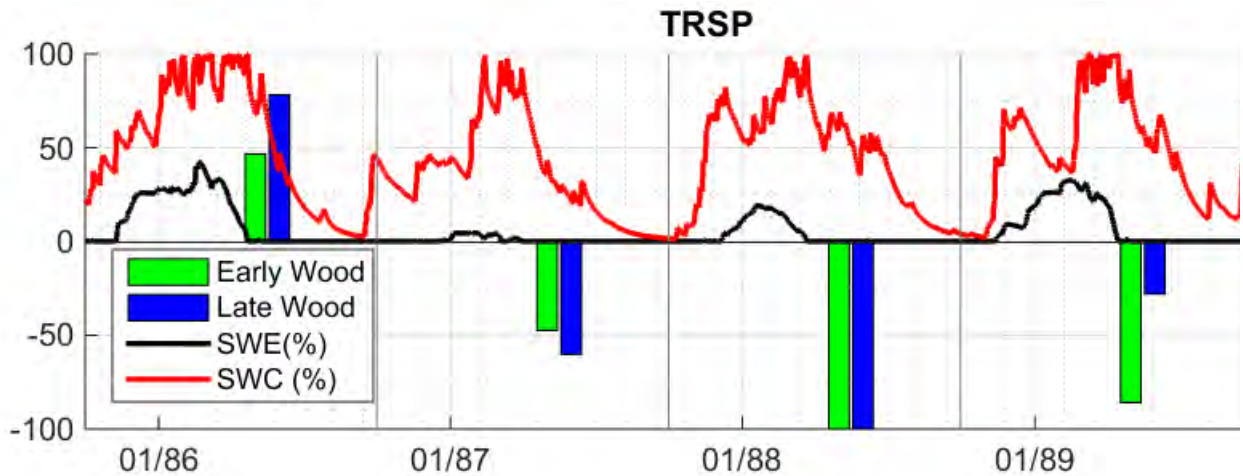
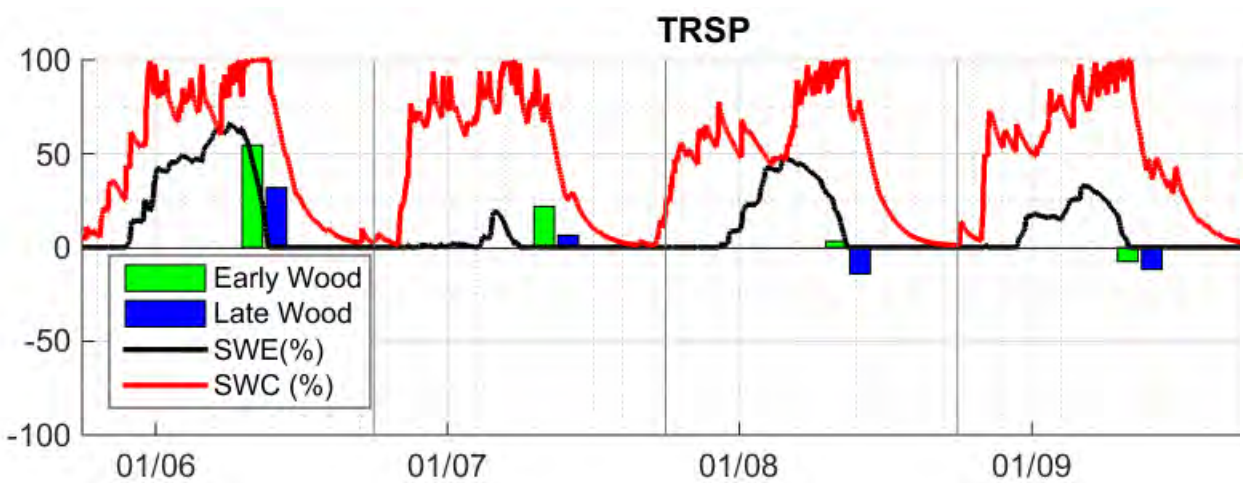
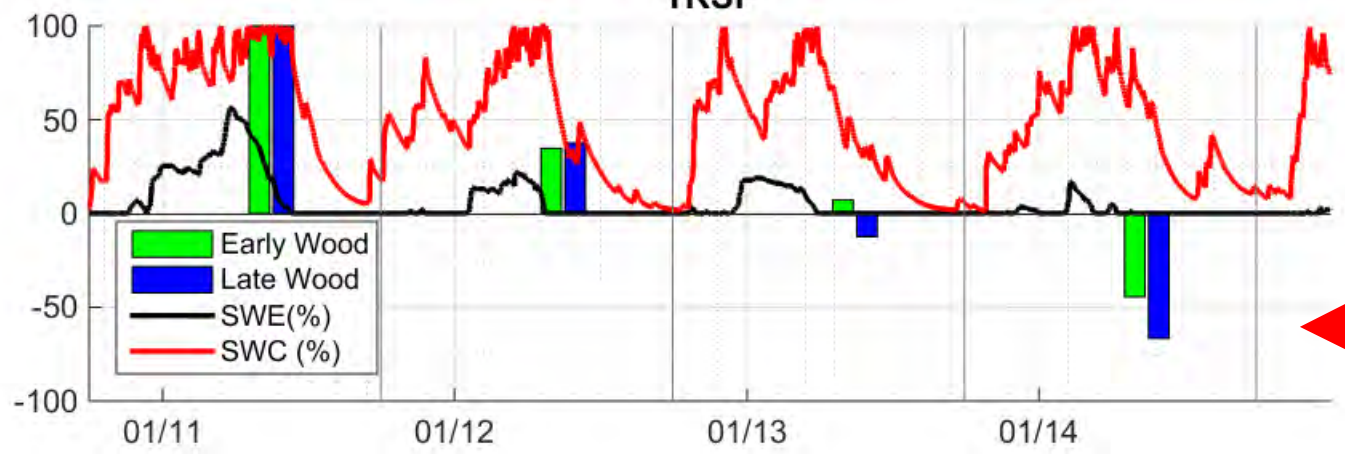


# Truckee Ranger Sta. Ponderosa Pine

2011-2014

2006-2009

1986-1989





# Key Findings

- High resolution hydrologic model is demonstrated as a valuable tool for dendrochronology studies
- Timing and strength of growth response to climate in the Sierra Nevada vary greatly among tree species and sites
- Soil water content and snowpack of the years prior to the year the rings were formed strongly impacts radial growth of conifers
- Temperature is a minor tree-growth limiting factor in this region

# Collaborators

## **Hydrologic Research Center, San Diego, California**

- Rochelle Graham
- Konstantine P. Georgakakos
- Rebecca, N. Kaliff (a summer Intern from UC Berkeley)

## **Laboratory of Tree Ring Research, The University of Arizona, Tucson Arizona**

- Dave Meko
- Ramzi Touchan
- Kai S. Lepley

**Funded by the U.S. National Science Foundation (NSF) Award #1445889**