

Land Surface  
Hydrology  
Research  
Group

UCLA



# Drought in the Pacific Northwest: 1920-2013

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# Study domain

- The Pacific Northwest (PNW): Columbia River Basin, and coastal drainages



# Study domain

- The Pacific Northwest (PNW): Columbia River Basin, and coastal drainages
  - Usually abundant water
  - Several severe droughts occurred (e.g. 1977 & 2001)
  - 2000-01 and 2004-05 drought in WA caused a more than 900 million combined loss (Shukla et al 2011)



Stuart Tomlinson, *“Oregon weather watch: Widespread drought could ease with wet spring”*, The Oregonian, Jan 31 2014

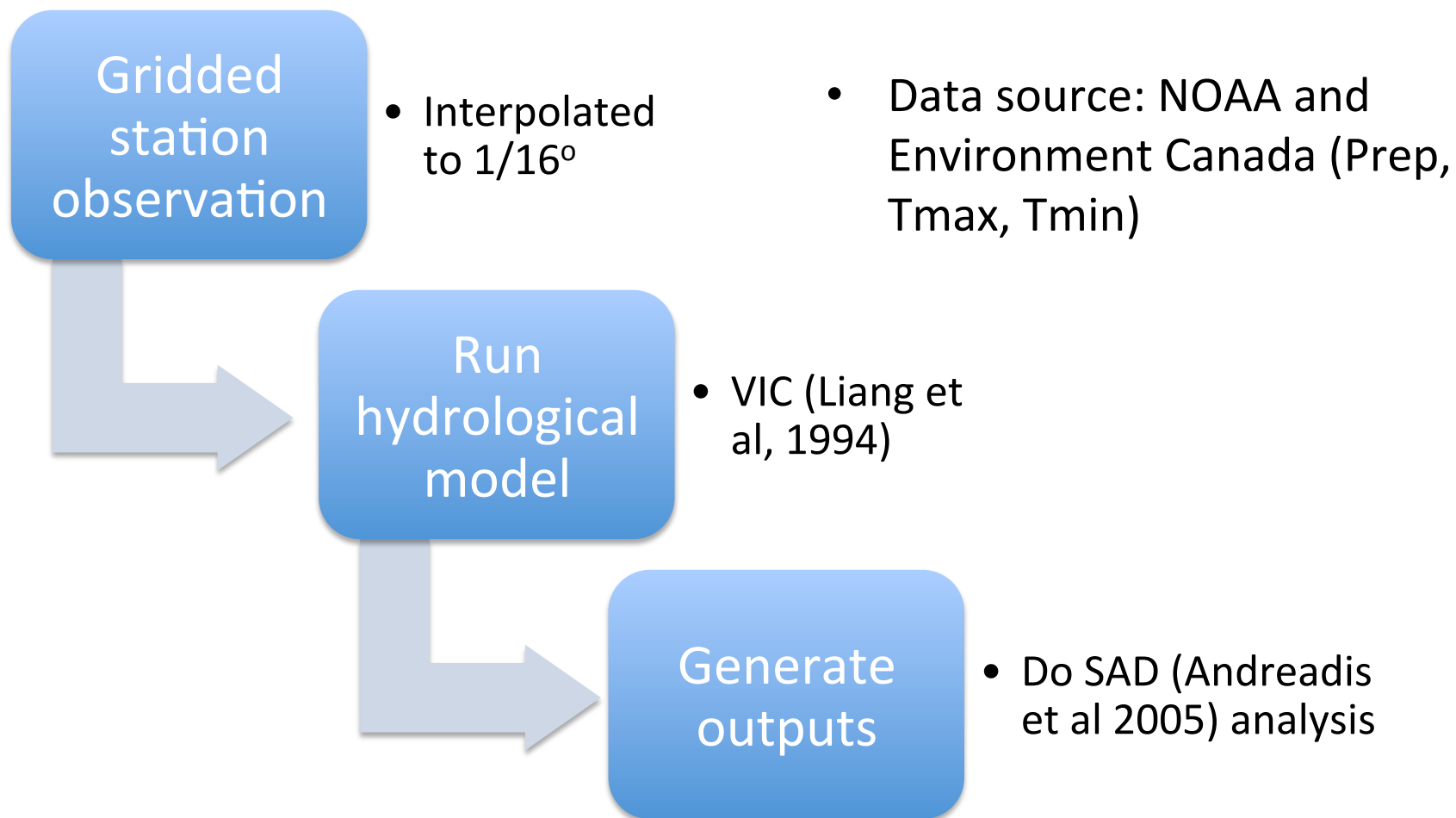
# Research questions

- What are the most severe (soil moisture) droughts inside the study domain during last nine decades?
- How do these droughts influence the region's agriculture, hydropower, water supply and recreation?

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# Approach






# Drought monitor for the PNW

The dataset is taken from UW drought Monitor:

[http://hydro.washington.edu/forecast/monitor\\_west/](http://hydro.washington.edu/forecast/monitor_west/)



## UW Drought Monitoring System for the Pacific Northwest


**Home**  
Current Conditions  
Recent Change  
Snow Observations  
Monthly Variable  
Sub-basin Time Series  
Streamflow Forecast  
Archive (1920-2010)

**Info**

**Links**  
West Coast US Monitoring

**Contacts**

**Disclaimer**



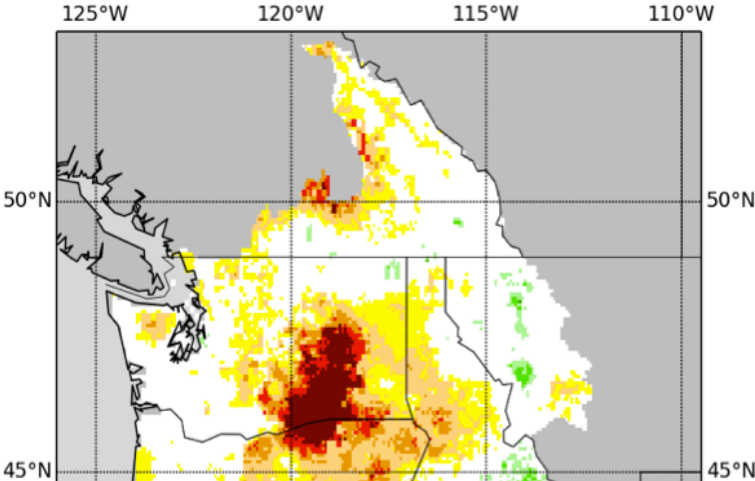
Powered by ACIS  
NOAA Regional Climate Centers

### Pacific Northwest (PNW) Current Conditions

Current percentiles for soil moisture, snow water equivalent and total moisture storage with respect to the climatological period from 1920 - 2010. These update daily by 3 pm PST, and have a lag of 1 day.  
[Click here to see a detailed description of hydrologic conditions.](#)

### Total Moisture Percentile

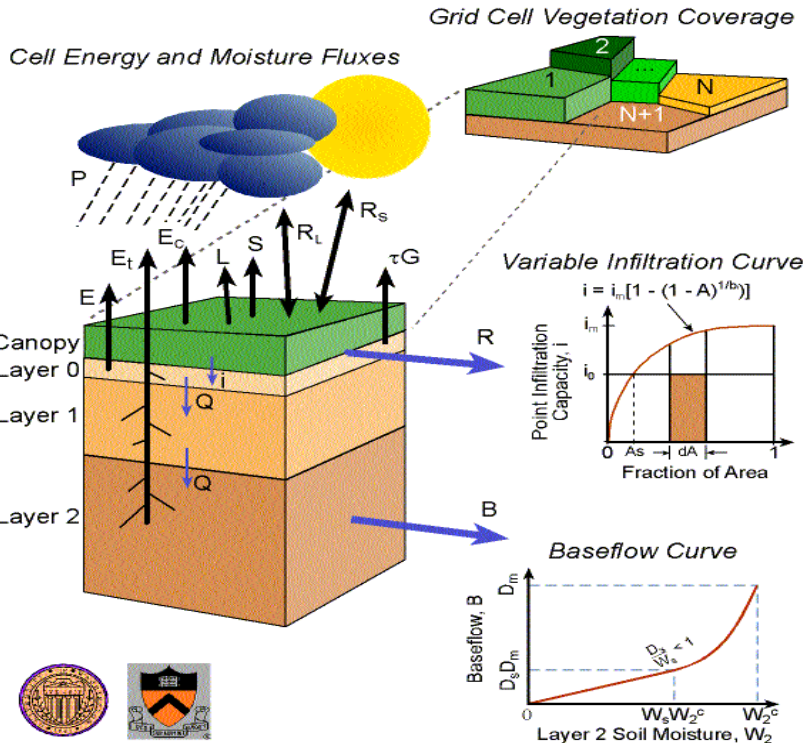
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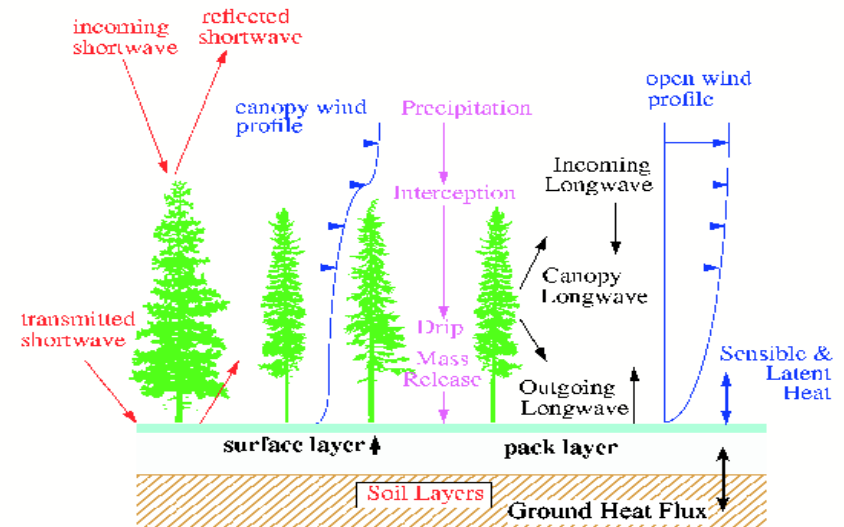
# Approach

- Run VIC at a **daily** time step with the grid-based forcing data for **1920-2013**

## Variable Infiltration Capacity - n Layer (VIC-nL) Macroscale Hydrologic Model



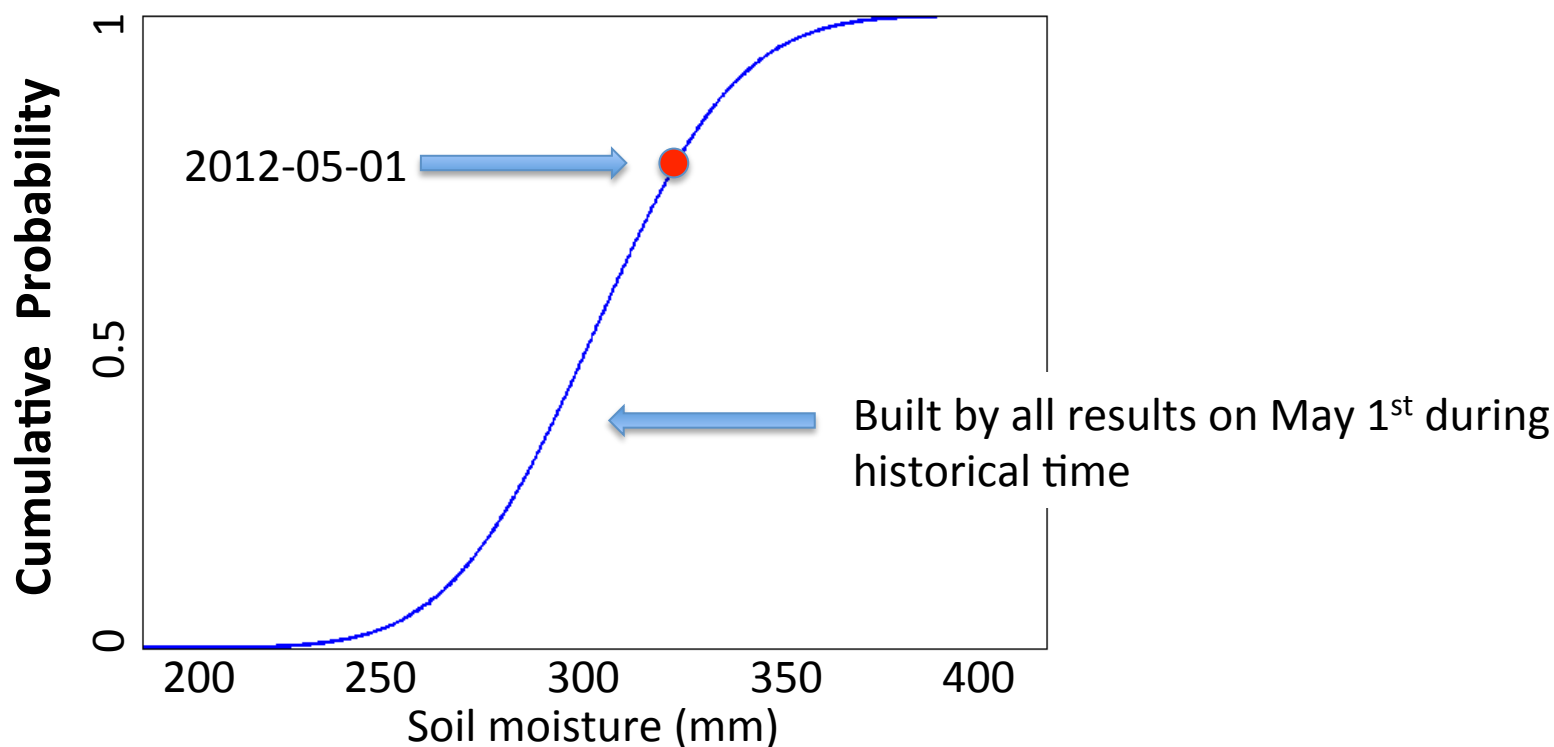
## VIC Snow Algorithm





# Approach

- Report the soil moisture as **percentiles** relative to historical simulation
  - Reduce the model bias
  - Generate uniformly distributed field



# Approach

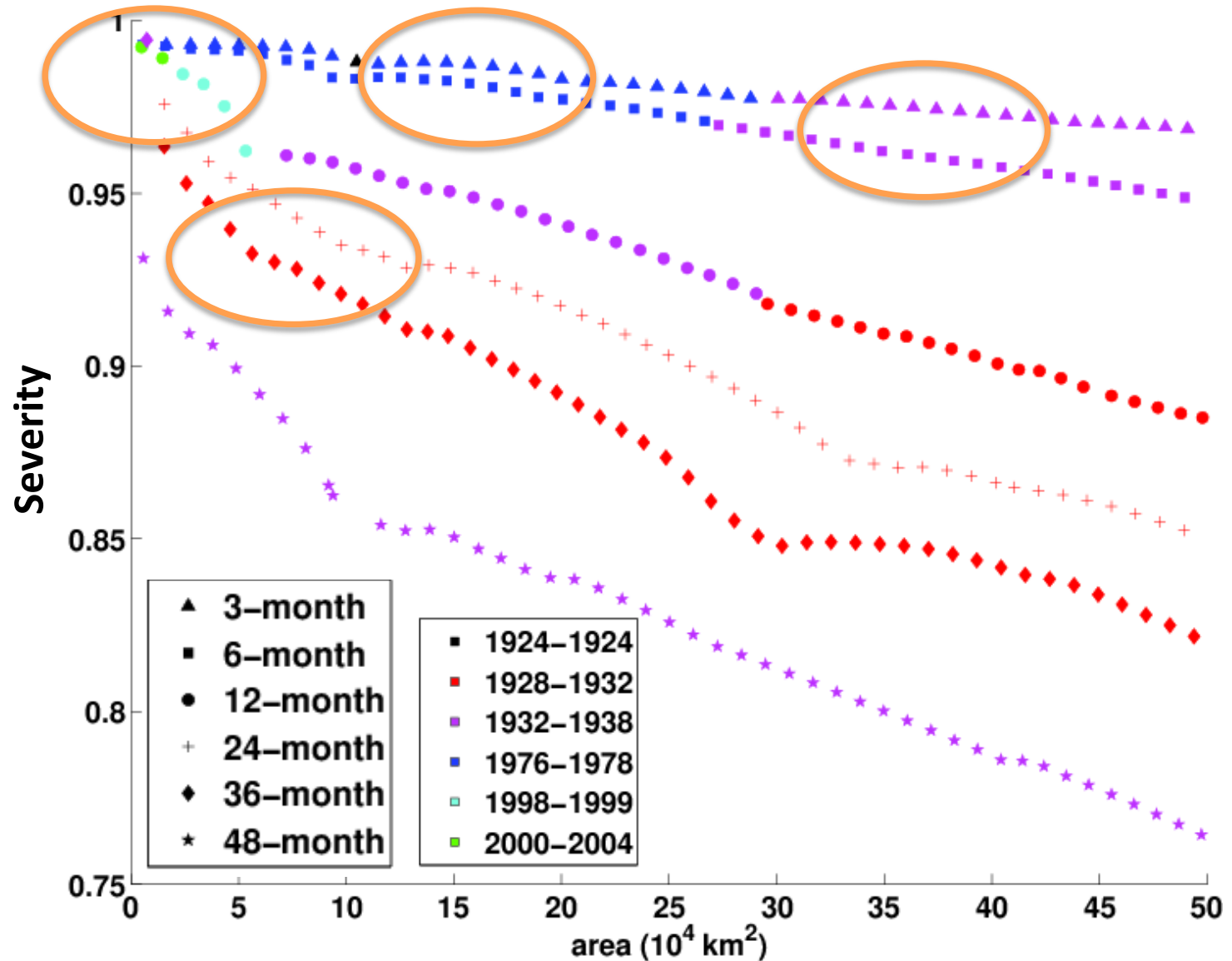
- Severity-Area-Duration (SAD) analysis
  - Examine all these 3 factors
  - Drought can cluster and split
  - Severity: “1- average percentiles”

# Approach

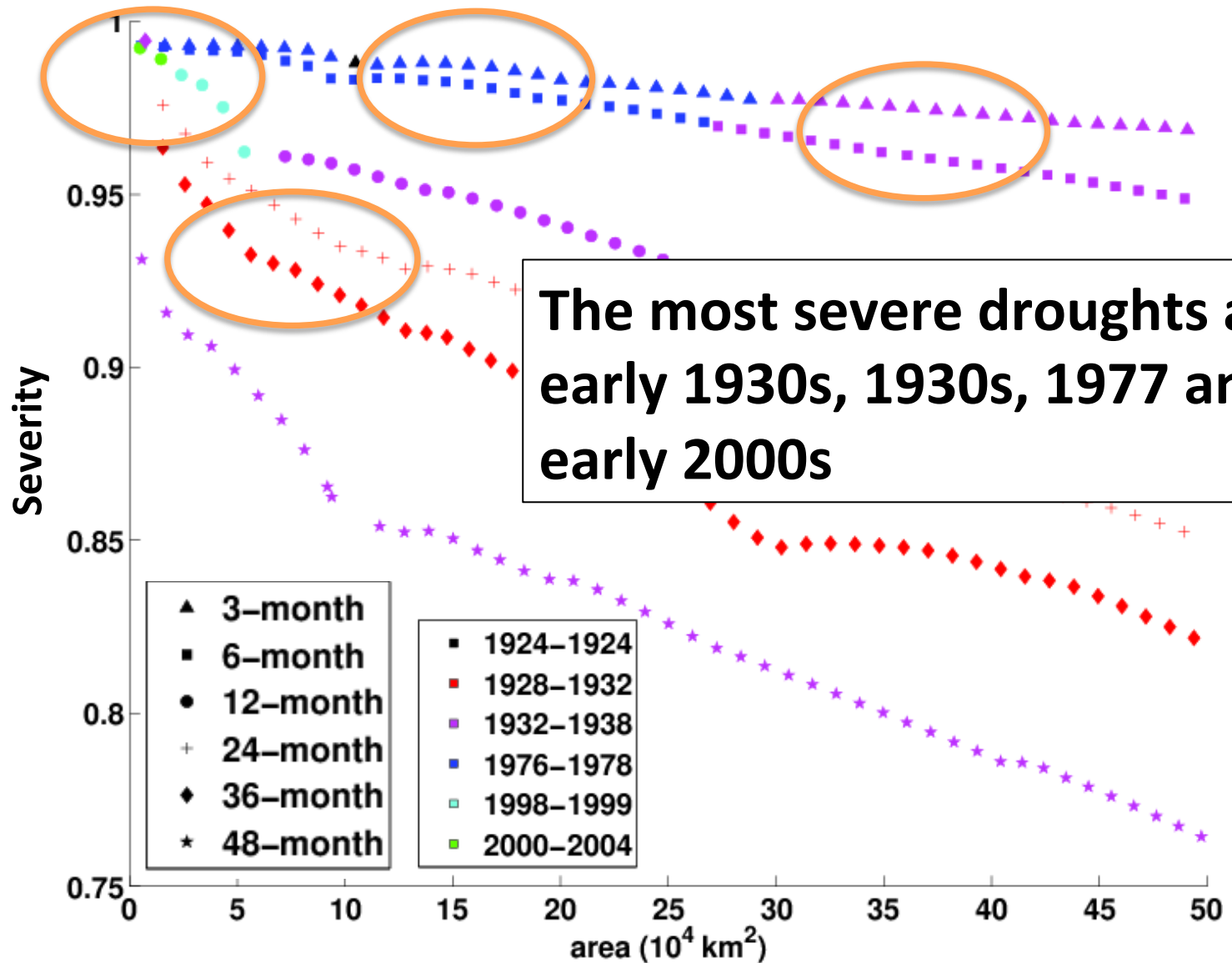
- Severity-Area-Duration (SAD) analysis
  - Examine all these 3 factors
  - Drought can cluster and split
  - Severity: “1- average percentiles”
  - Monthly soil moisture percentile below a threshold (0.2)
  - Duration is a moving-window specified (3, 6, 12, 24, 36 and 48-month)
  - Area is larger than threshold (640 grid cells)



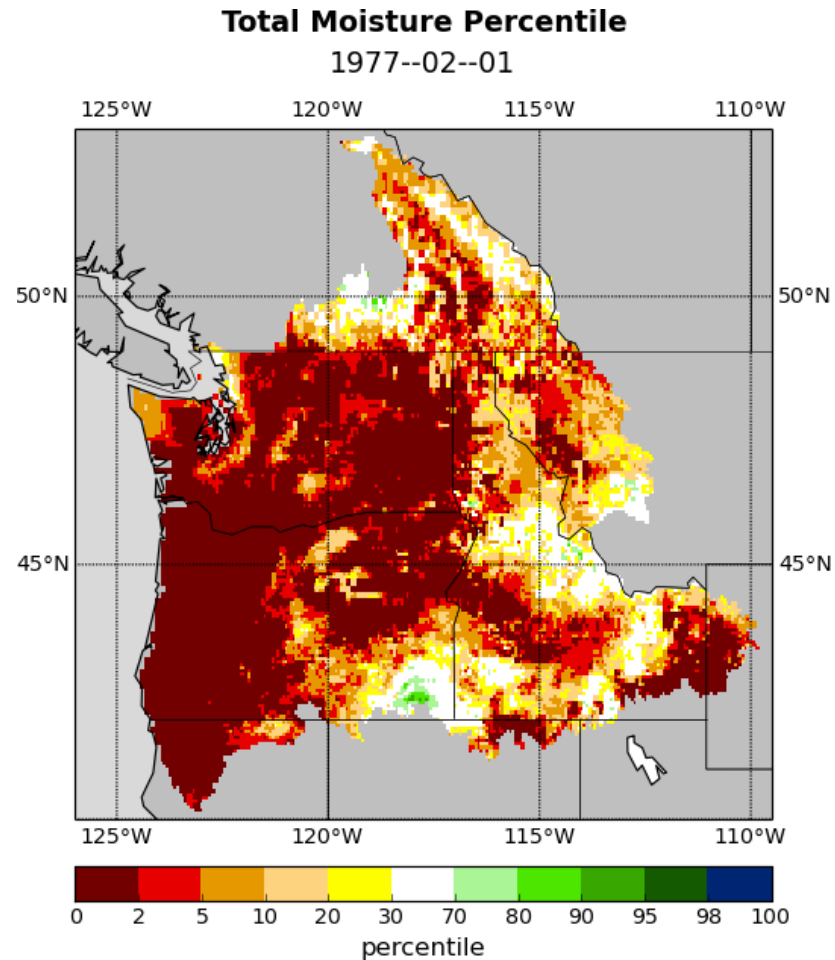
# SAD results for the PNW 1920-2013



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# 1977 Drought Example



**1977-02-01**

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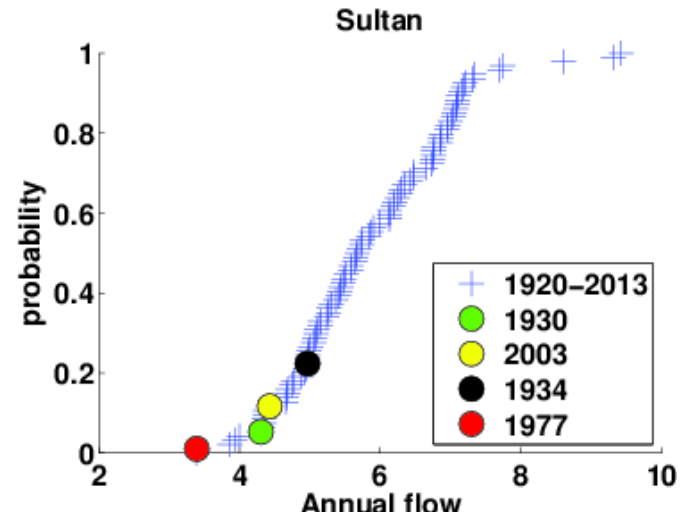
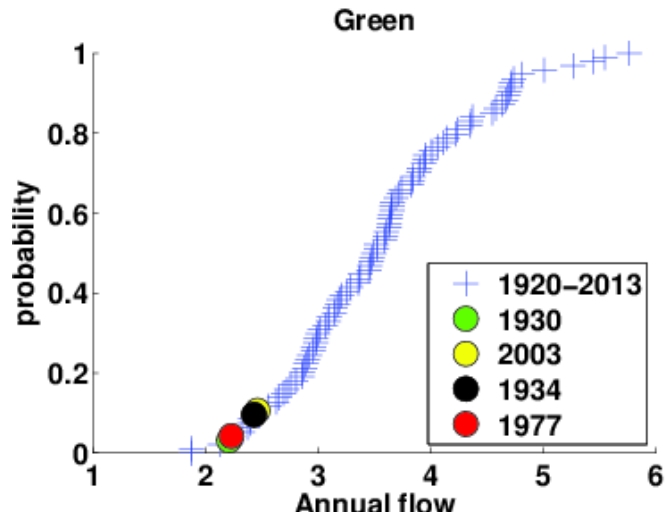
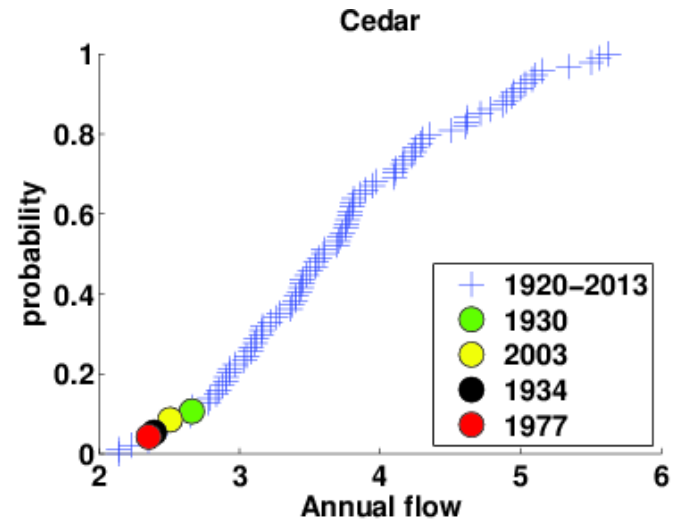
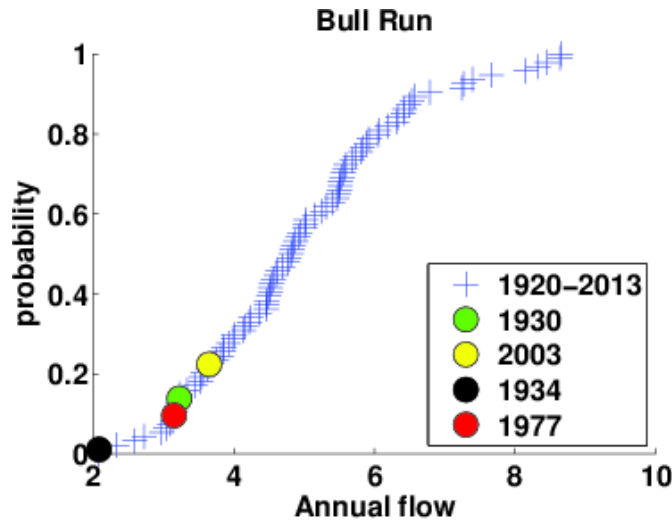
# Water supply

The four rivers for Portland, Seattle, Tacoma and Everett



# Water supply

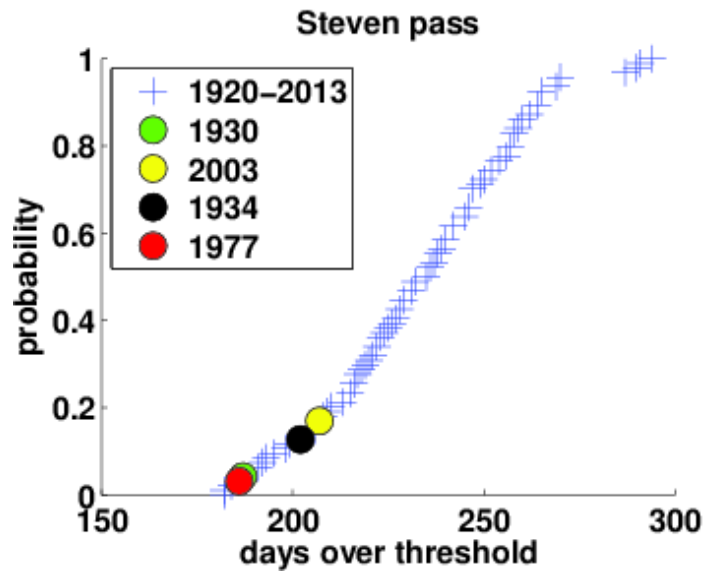
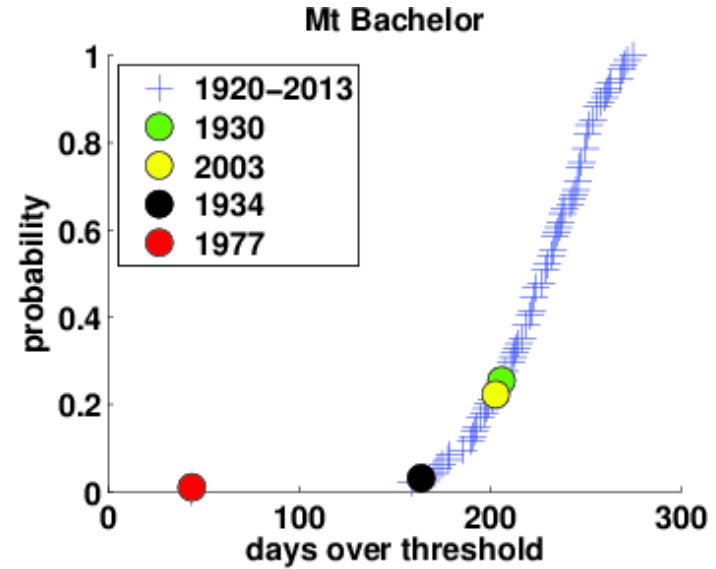
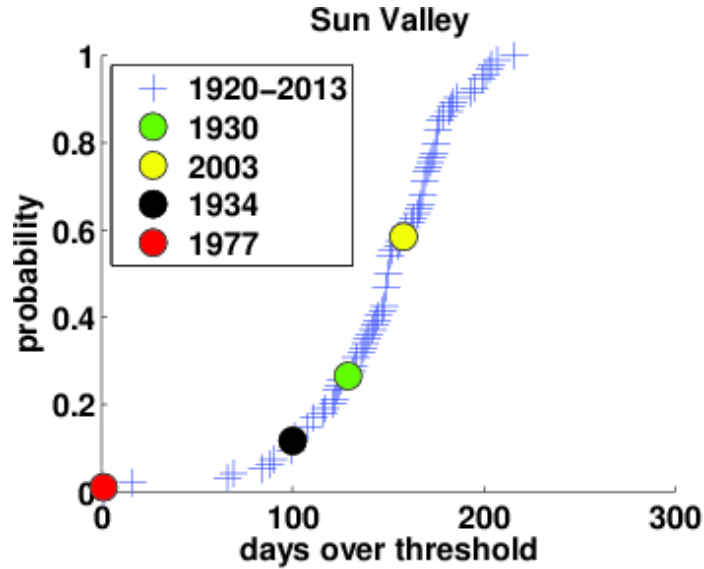
The four rivers for Portland, Seattle, Tacoma and Everett



# Recreation (skiing)

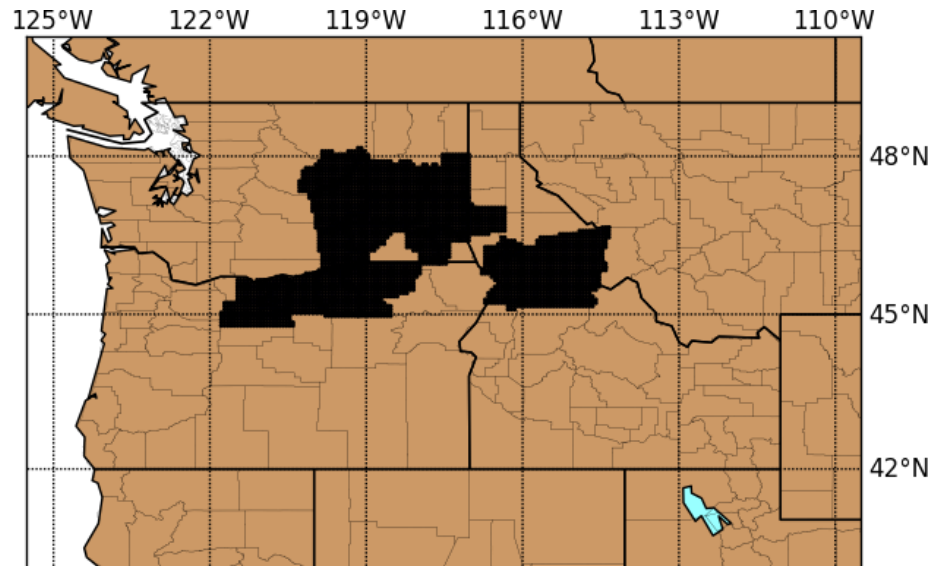
- Snow depth is most important index
  - Common minimum: **30 cm** (Scott et al 2007;Steiger 2013)
- Snow depth for Stevens pass (WA), Mt Bachelor (OR) and Sun Valley (ID)
  - Count **the number of days** that below that threshold in each water year

# Recreation (skiing)



# Dryland Agriculture (wheat)

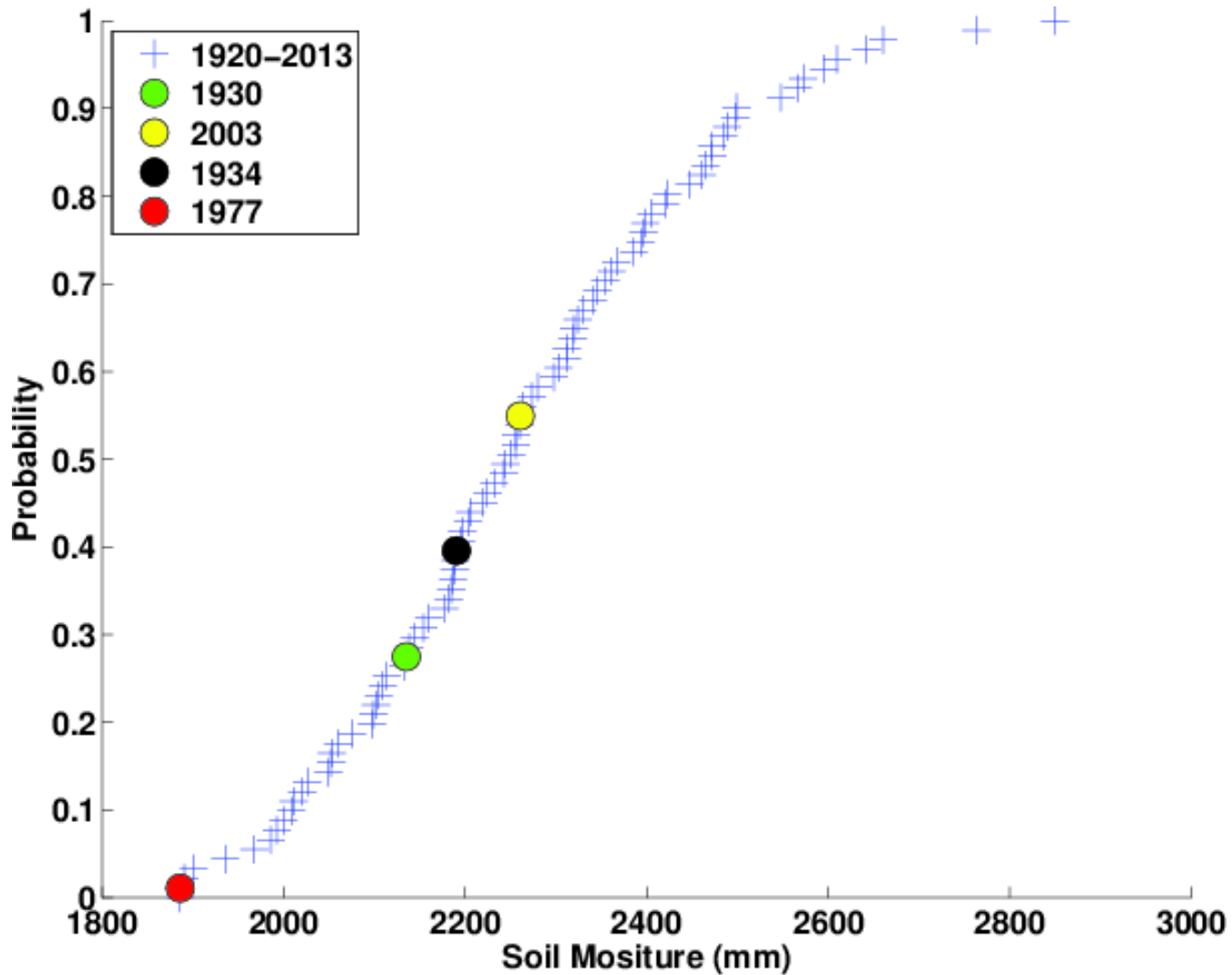
- The main counties of wheat-product (data source: USDA nation agricultural statistics service)
  - WHEAT production long-term annual average greater than 3 million BU



# Dryland Agriculture (wheat)

- The main counties of wheat-product (data source: USDA nation agricultural statistics service)
- Use Mar-Aug average soil moisture as index
  - This is the time period for wheat growing (*Usual Planting and Harvesting Dates; <http://swat.tamu.edu/media/90113/crops-typicalplanting-harvestingdates-by-states.pdf>*)

# Dryland Agriculture (wheat)



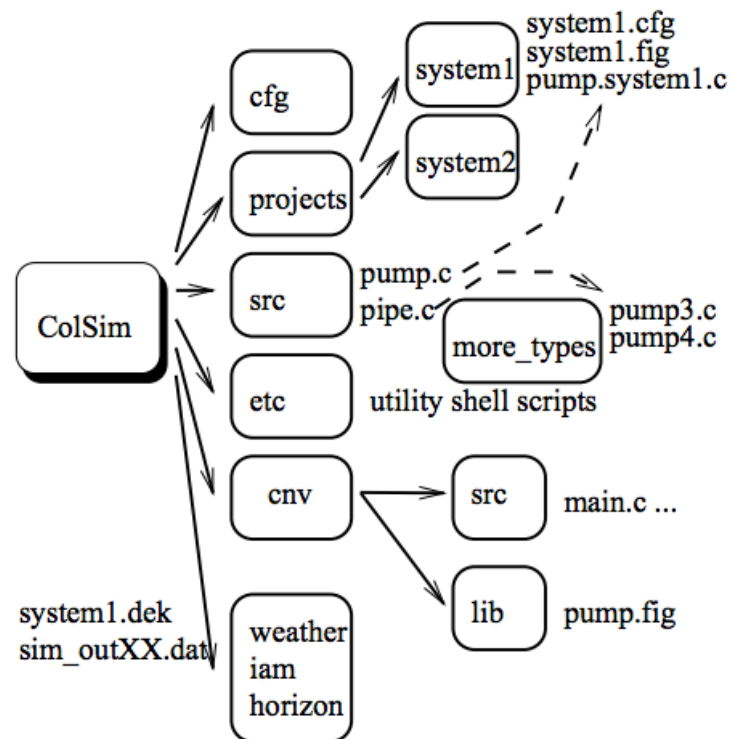
# Conclusions

- The most severe drought disasters is 1930, middle 1930s, 1977 and early 2000s of last nine decades according to SAD analysis
- The 1977 one has the worst effect on the sections we look at (water supply, agriculture and etc)
- Most of the time, these droughts has obvious influence on the region (those index are small when there is a drought)



# Next step

- Implement Columbia Simulation Reservoir *Model (ColSim)* (Hamlet et al. 1999)
  - Hydropower generation and irrigated agriculture



# Questions?

## References:

Andreadis, K., and E. Clark, 2005: Twentieth-century drought in the conterminous United States. *J. ...*, 985–1001.

Liang, X., and D. Lettenmaier, 1994: a simple hydrologically based model of land surface water and energy fluxes for general circulation models. *J. Geophys. ...*, **99**.

Dracup, J. a., K. S. Lee, and E. G. Paulson, 1980: On the definition of droughts. *Water Resour. Res.*, **16**, 297–302, doi:10.1029/WR016i002p00297.

Shukla S., A. C. Steinemann, and D. P. Lettenmaier, 2011: Drought Monitoring for Washington State: Indicators and Applications. *J. Hydrometeorol.*, **12**, 66–83, doi:10.1175/2010JHM1307.1.