Drought in the Pacific Northwest: 1920-2013

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Study domain

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

- **Gridded station observation**
  - Interpolated to 1/16°

- **Run hydrological model**
  - VIC (Liang et al, 1994)

- **Generate outputs**
  - Data source: NOAA and Environment Canada (Prep, Tmax, Tmin)

- **Do SAD (Andreadis et al 2005) analysis**
Drought monitor for the PNW

The dataset is taken from UW drought Monitor:

http://hydro.washington.edu/forecast/monitor_west/
Approach

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

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

Cumulative Probability

![](chart.png)

Built by all results on May 1\(^{st}\) during historical time
Approach

• Severity-Area-Duration (SAD) analysis
  – Examine all these 3 factors
  – Drought can cluster and split
  – Severity: “1- average percentiles”
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  – 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
SAD results for the PNW 1920-2013
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The most severe droughts are: early 1930s, 1930s, 1977 and early 2000s
1977 Drought Example
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Water supply

The four rivers for Portland, Seattle, Tacoma and Everett
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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

http://quickstats.nass.usda.gov/#1E023F7F-3547-35F1-AD5F-91DCE97E9413
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: