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Climate Change Impact on Drought Risk and Uncertainty in the Willamette River Basin

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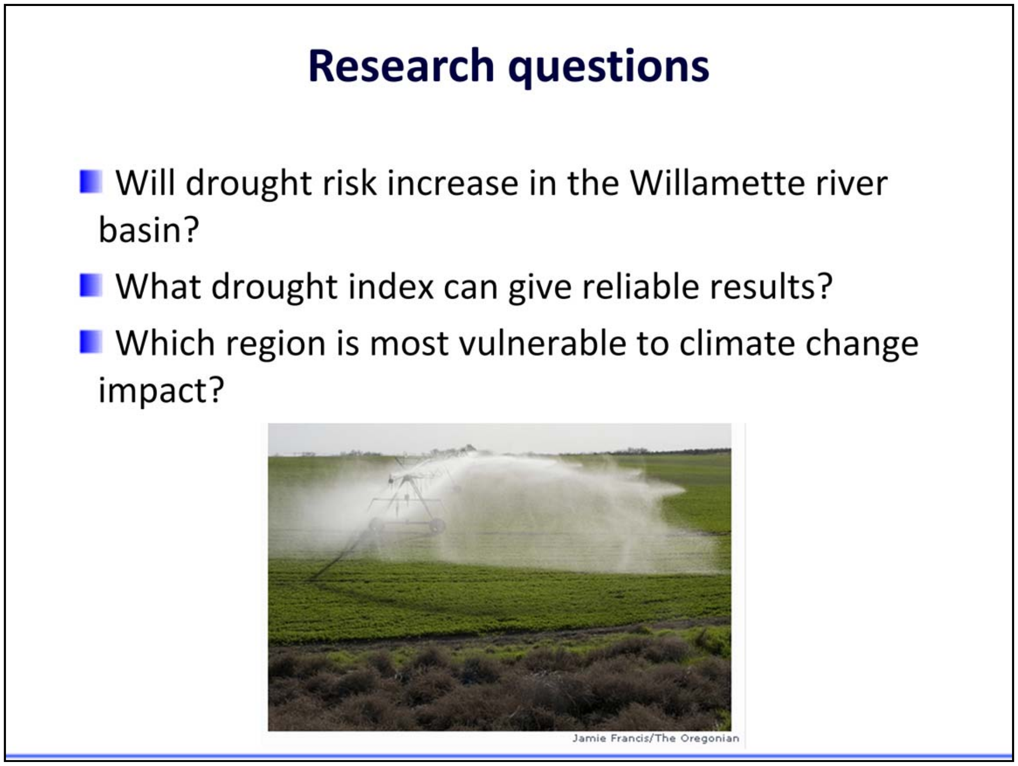
Thank you. Chairman.

I'm Il-Won Jung, a Post doctoral scholar at PSU.

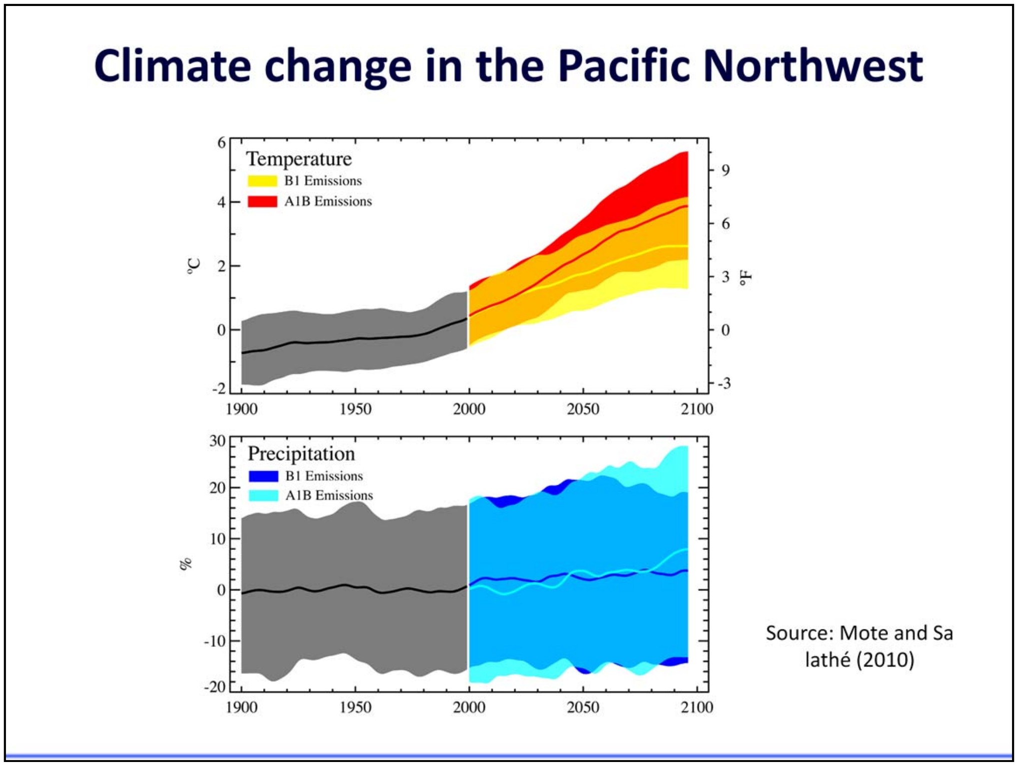
I'm going to talk about "How can climate change affect change in drought frequency and risk in the Willamette River Basin?"



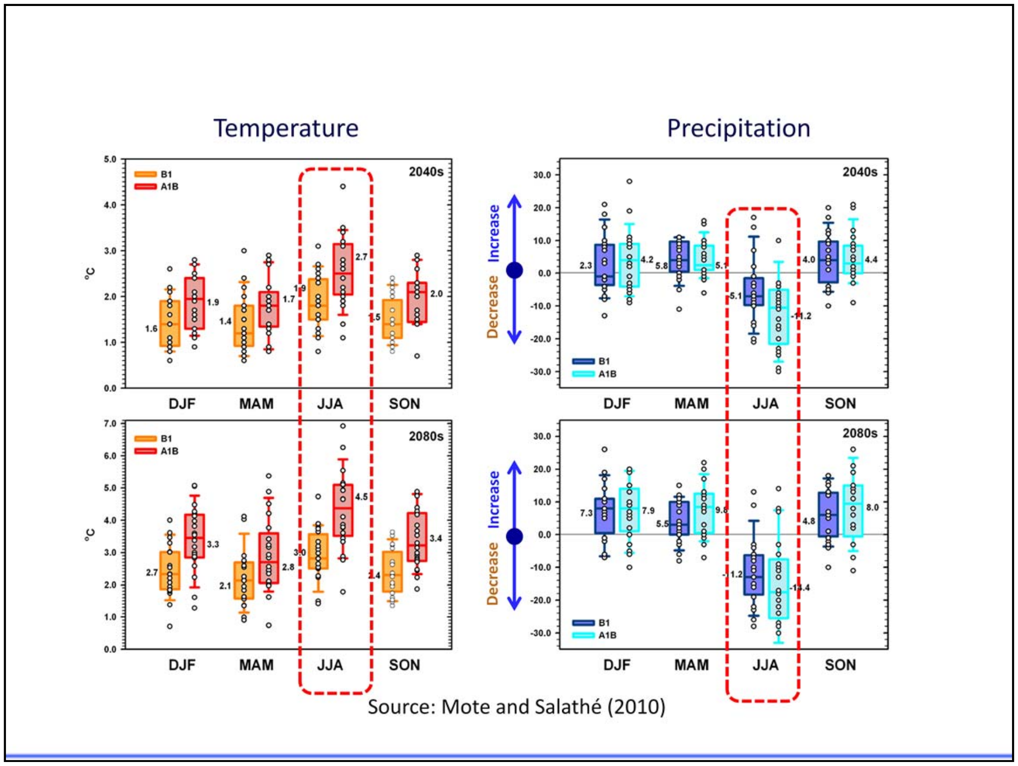
We have three major research questions. Will drought risk increase or decrease in the Willamette river basin?

To do this, what is the best way that the drought index can give more reliable r esults?

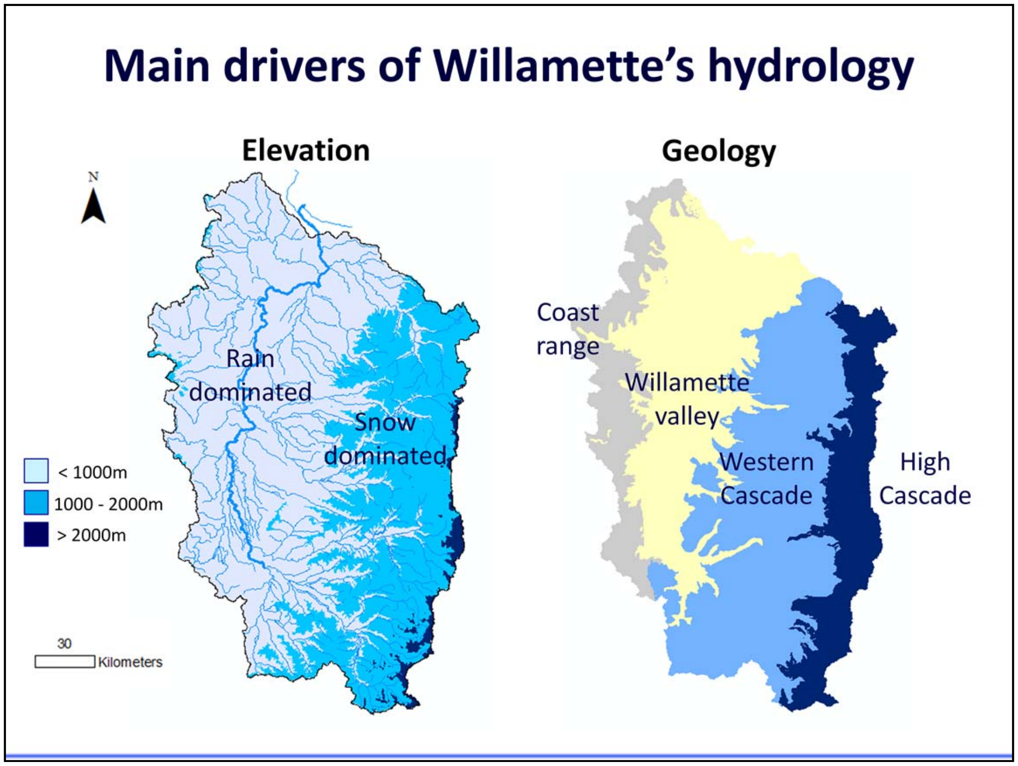
Finally, which region is most vulnerable to climate impact?



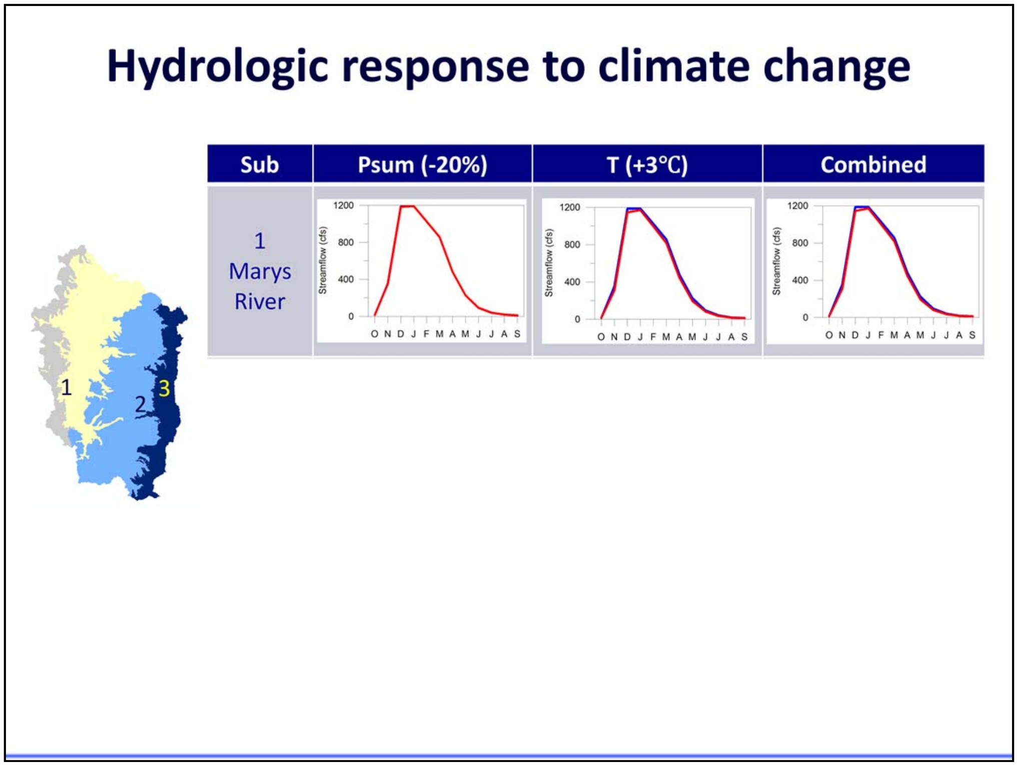
Global climate models show a consistent increase in temperature in the Pacific Northwest. The temperature increase probably induces change in hydrology conditions. However, annual precipitation change is not clear in the future, some models show increases but others show decrease.



However, there are important things in seasonal change that we have to consider. Summer in the PNW generally shows dry and warm weather. Most global climate models project drier and warmer summer, which could increase drought risk. Therefore, what are important drivers which can examine reliable projection of future drought risk in the Willamette River Basin.



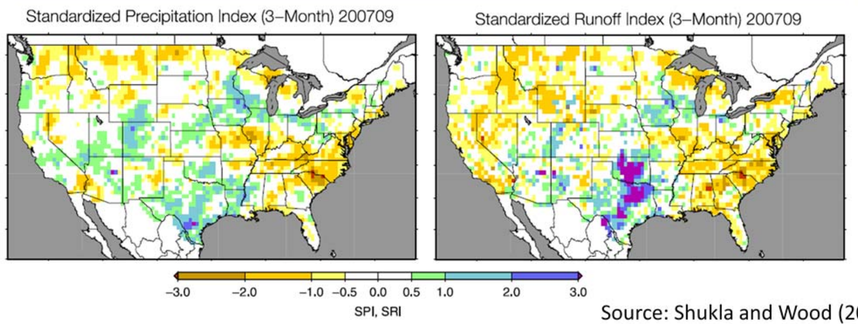
The Willamette River basin has different elevation ranges. In the low elevation region most precipitation falls as rain but in the high elevation region snowfall is dominant in the winter season. The snowpack and snowmelt in high elevation regions contribute different hydrologic regimes from low elevation regions. The other important driver is geology. Especially, High cascade region has most distinct a deep groundwater system which stores precipitation in the groundwater and it runs off slowly.



This shows the different responses of three river watersheds to climate change. Marys river located in the Willamette valley at a low elevation. A 20% decrease in summer precipitation will not change the runoff very much because amount of summer precipitation is less than the other season. Blue line shows reference results and red line shows changed results. Lookout creek at the high elevation show significant runoff response to temperature change and combined change. Runoff of Clear lake in the high cascade is sensitive to temperature change. These results indicates that elevation and geology are key drivers to estimate reliable future runoff change in these regions and associated with drought change.

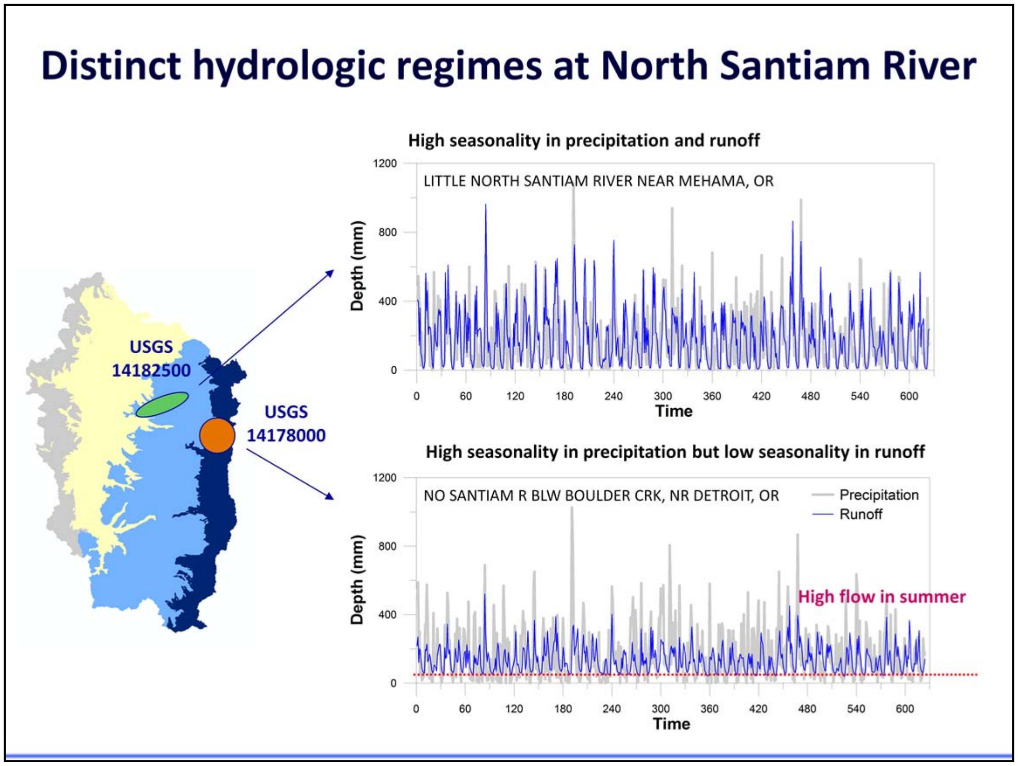
SPI vs. SRI

Standardized Precipitation index (SPI)	Standardized Runoff index (SRI)
Thomas McKee at Colorado State Univ. (1993)	Shukla and Wood at Univ. of Washington (2008)
A statistical method for assessing Rainfall	A statistical method for assessing runoff
Climatological drought index	Hydrological drought index

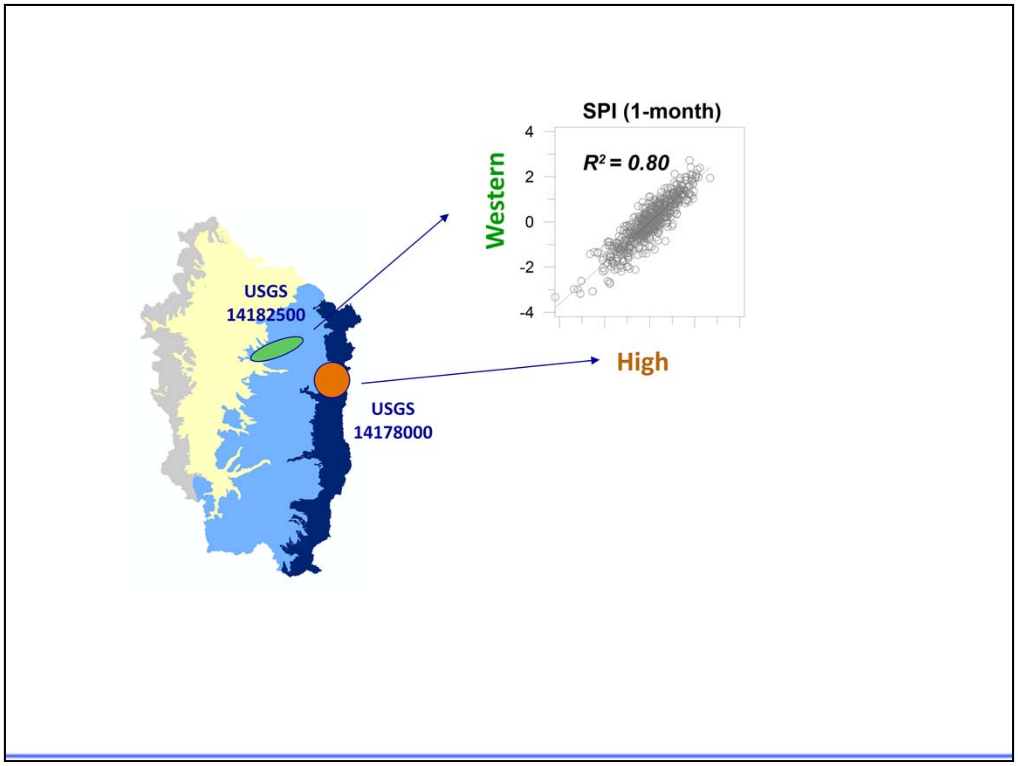


Source: Shukla and Wood (2008)

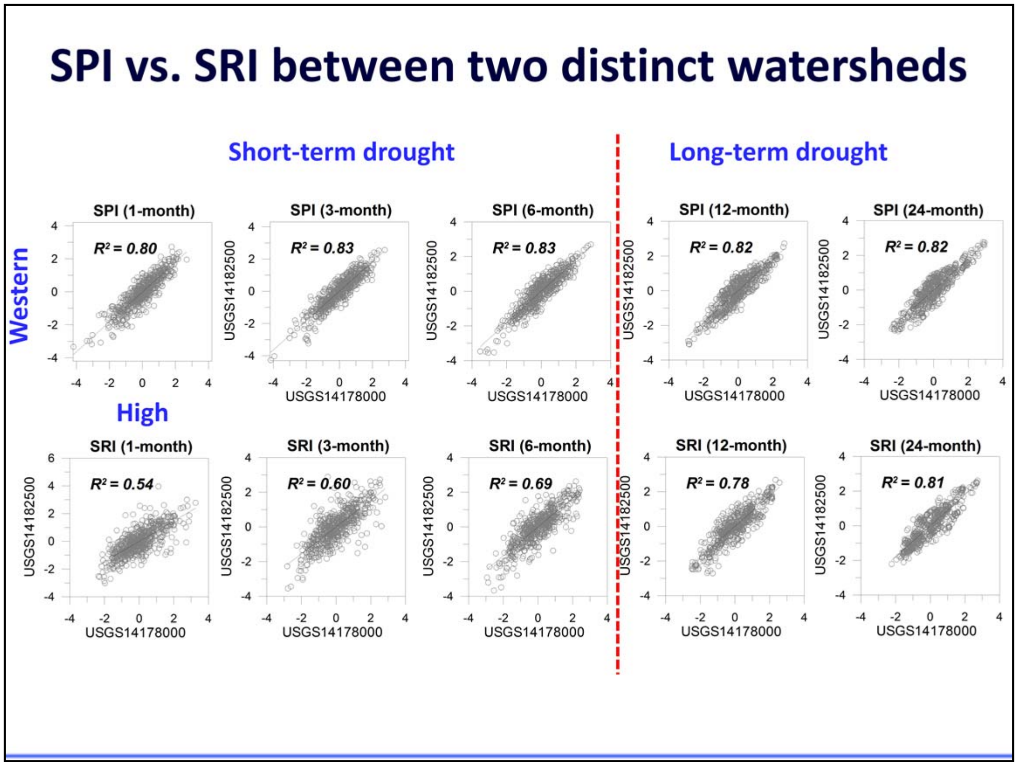
We employed two different drought indices, SPI and SRI.



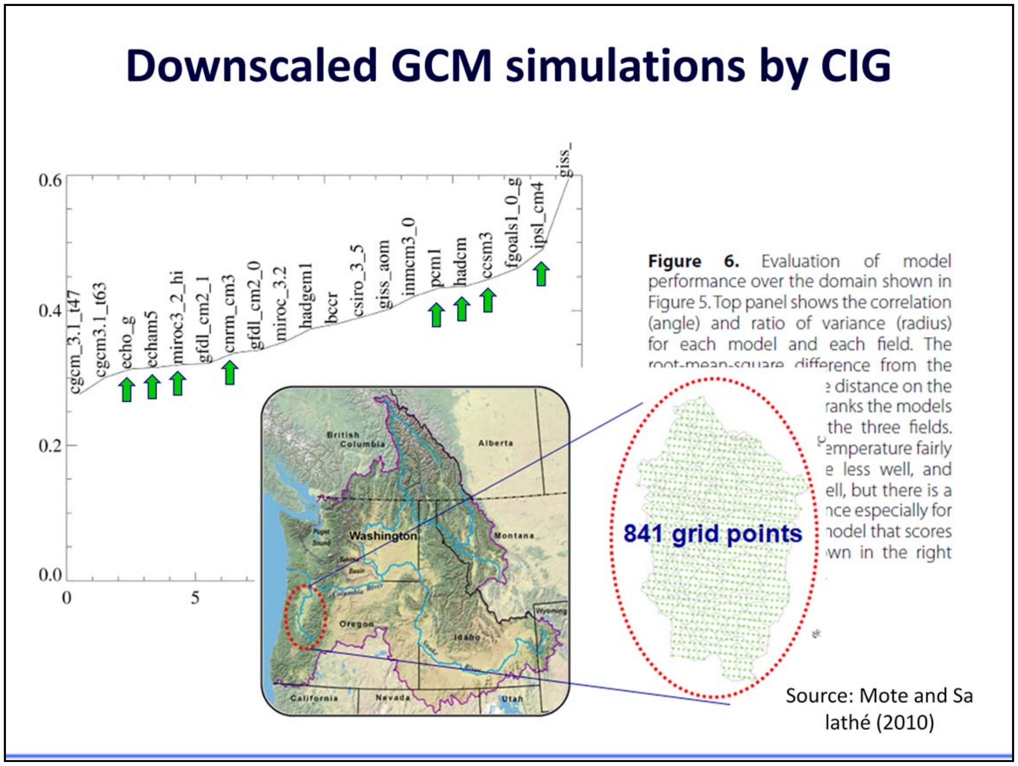
We compared streamflow data of two watershed in the North Santiam River. Yo u can see here, their precipitation patterns are similar but runoff are different. We calculated SPI and SRI indices and compared them.



This show SPI index using 1 monthly precipitation data. Both results show high correlation. This indicates that SPI can not consider geology effect. SRI shows difference between two watersheds because of different hydrologic regimes.



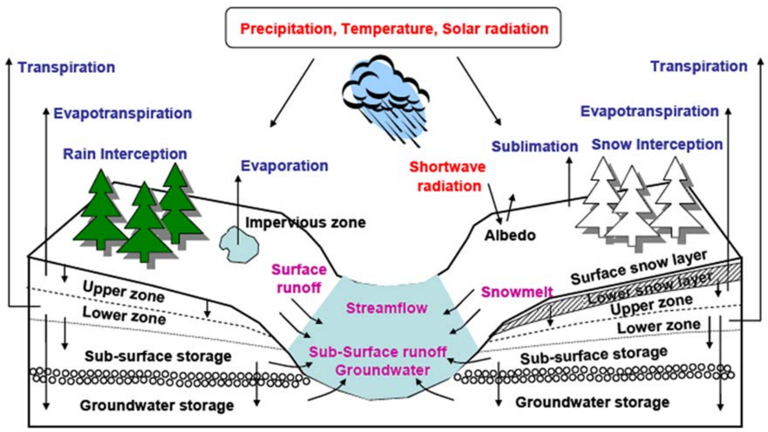
This figure show the relation SPI and SRI according to drought persistence periods. SPI is similar between two watershed regardless of persistence periods but SRI is quite different in short-term drought. But in long-term drought SRI also show similar results. This result attributed from removing seasonality of streamflow. And long-term runoff change is dominated by climate change than geographical characteristics.



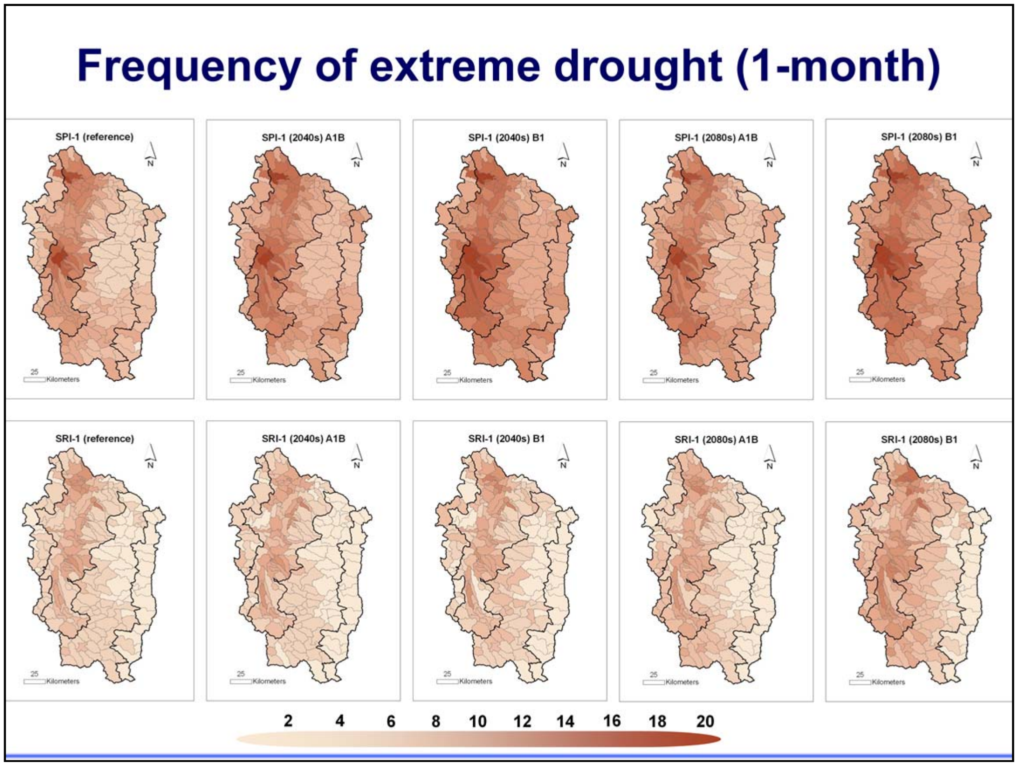
In order to examine future drought change, we used statistically downscaled GCM simulations by Climate impacts group in Washington university. CIG ranked 20 global climate model based on performance of historical climate simulation. We used 8 GCM simulations with A1B and B1 GHG emission scenarios.

Precipitation Runoff Modeling System

- PRMS model is physically based, semi-distributed hydrologic model
- Developed by USGS (Leavesley et al., 1983)

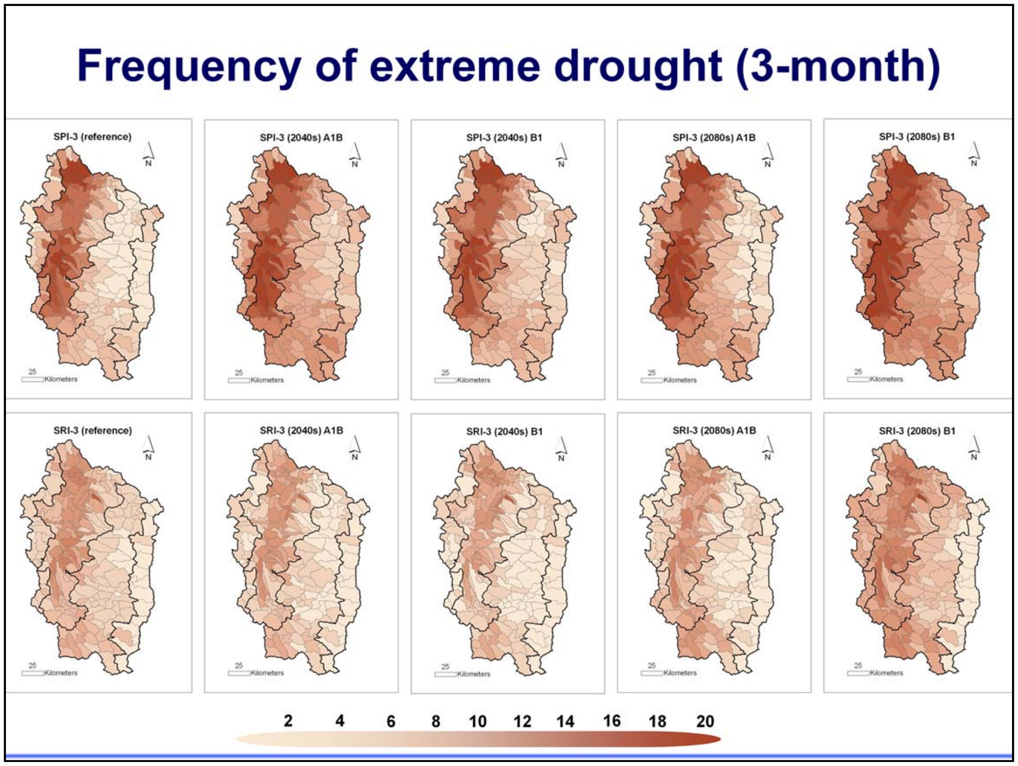


PRMS model is physically based semi-distributed hydrologic model, developed by USGS. This model simulate water balance and energy balance regarding snow accumulation and snowmelt.

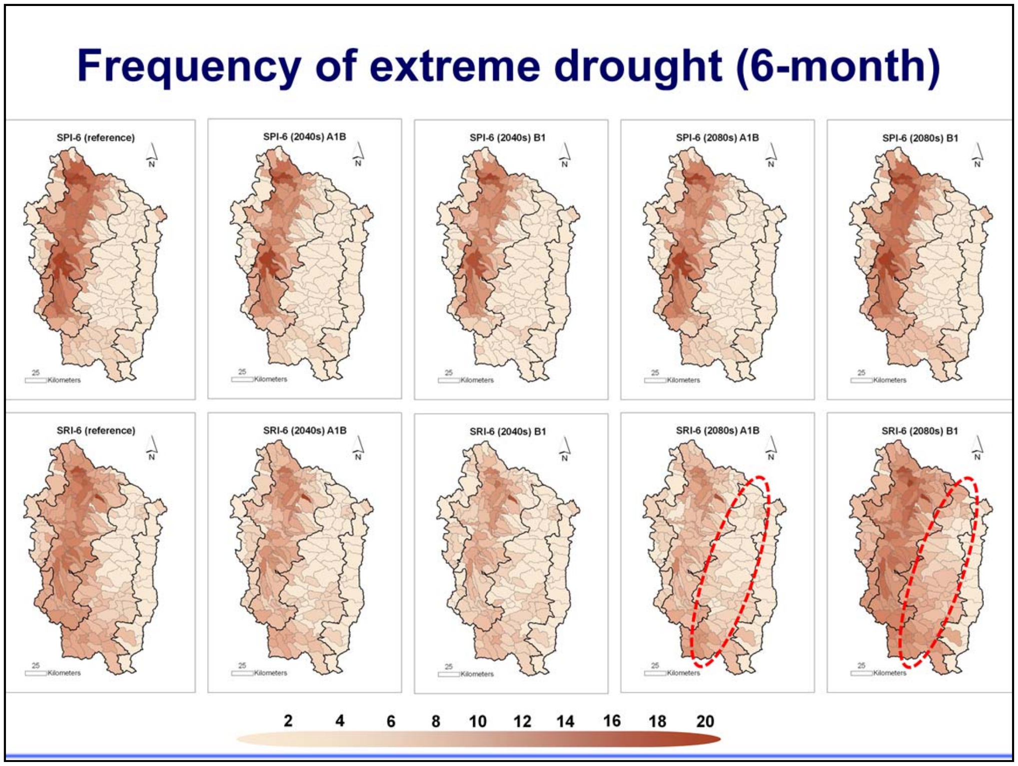


This is multi-model ensemble results. This figures show relative frequency of 1 month drought in reference, two future period under 2 emission scenarios.

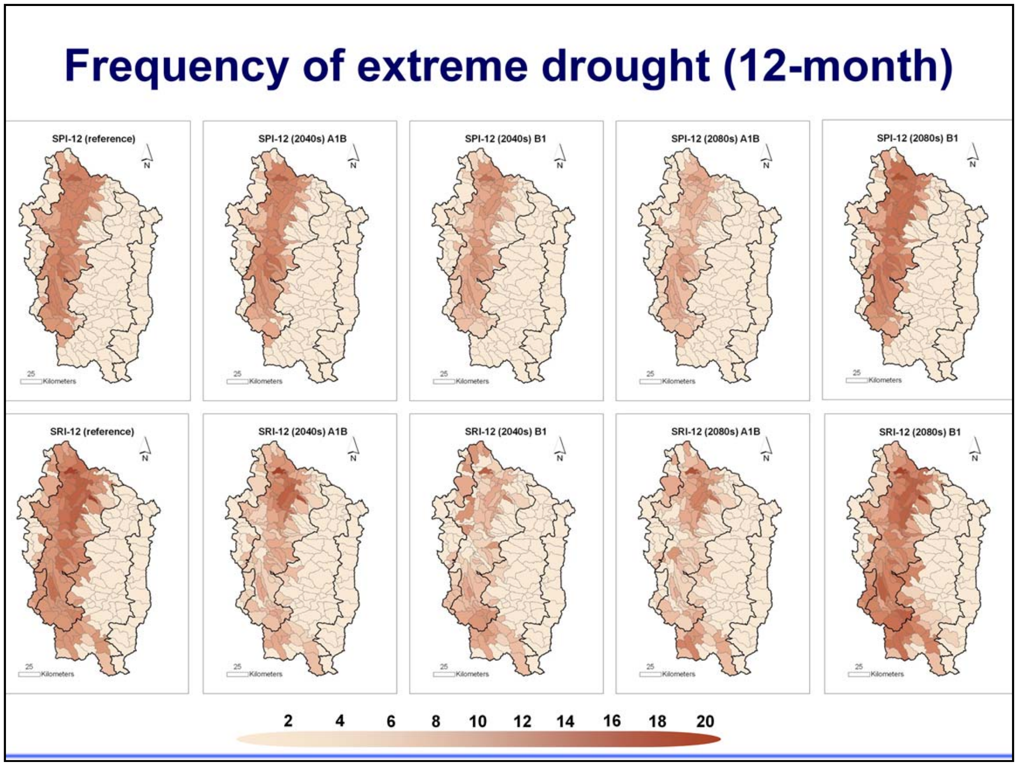
As you can see here, Willamette Valley is more vulnerable to drought risk under SPI and SRI. SPI show increasing drought frequency over whole Willamette river basin cause summer precipitation decrease. However, SRI in high cascade show no change because they have deep ground water system.



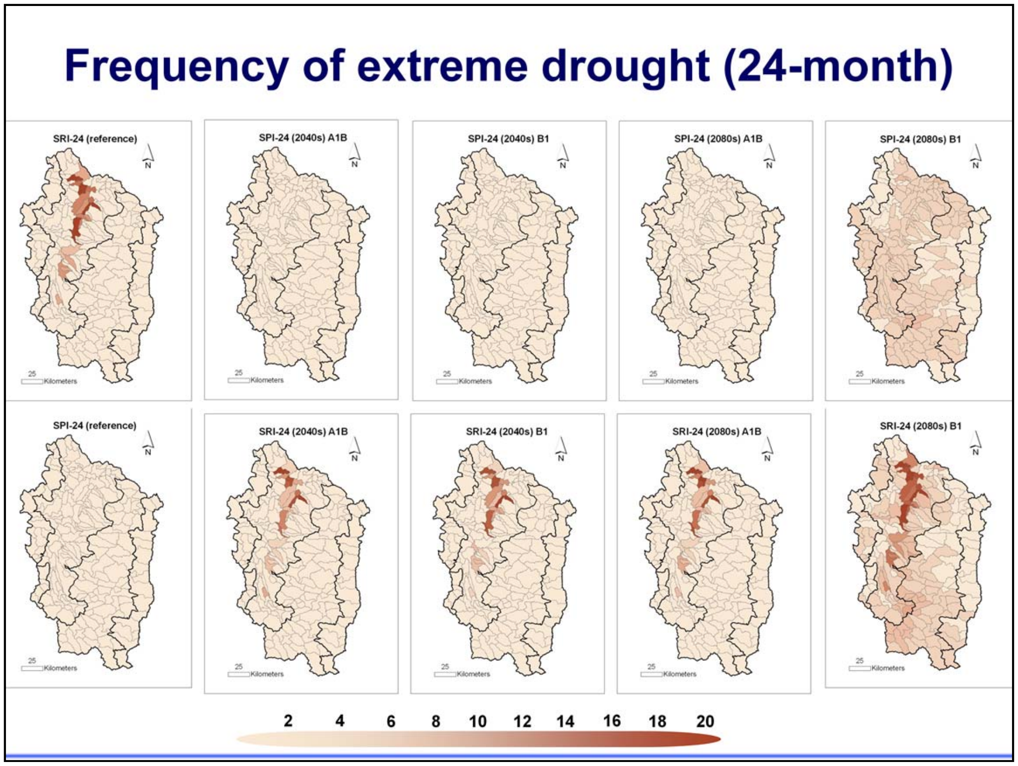
This is frequency of 3-month drought. It showed similar results with 1-month drought change.



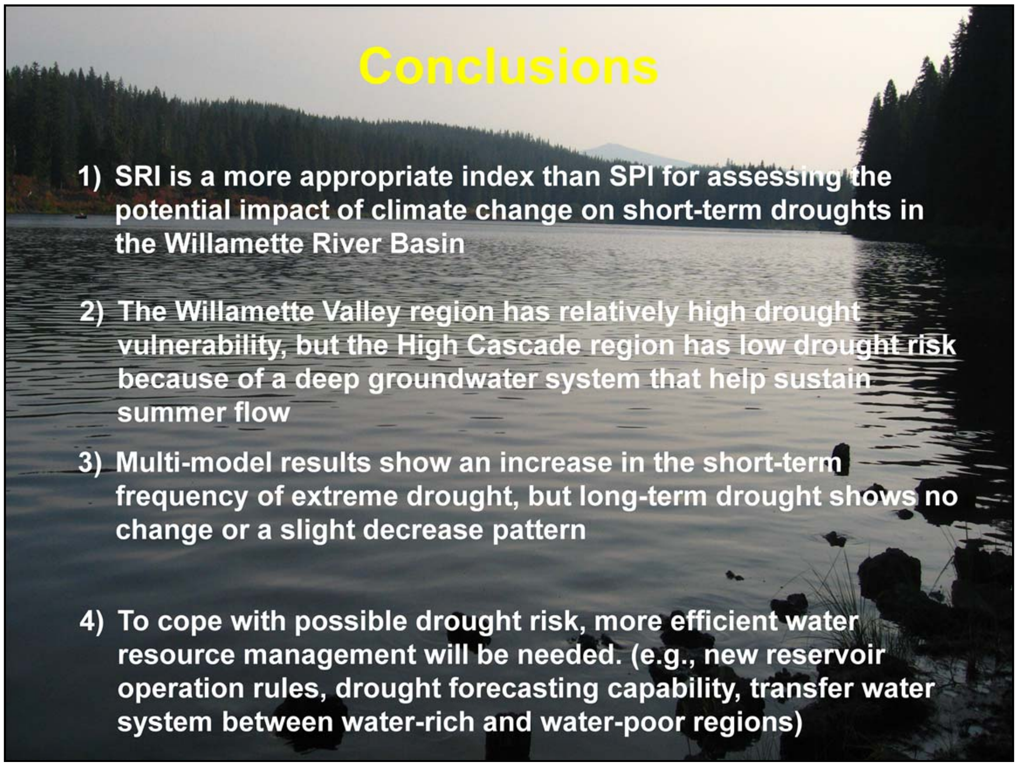
6-month SPI did not significant change. However, SRI show slightly increase frequency of drought in snow-dominated region. It could be attributed from snowmelt decrease in these regions.



The frequency of 12-month drought show slight decrease because annual precipitation is increase.



This is result of 24-month drought. It is similar to 12-month drought change.



These are important results obtained from this study.

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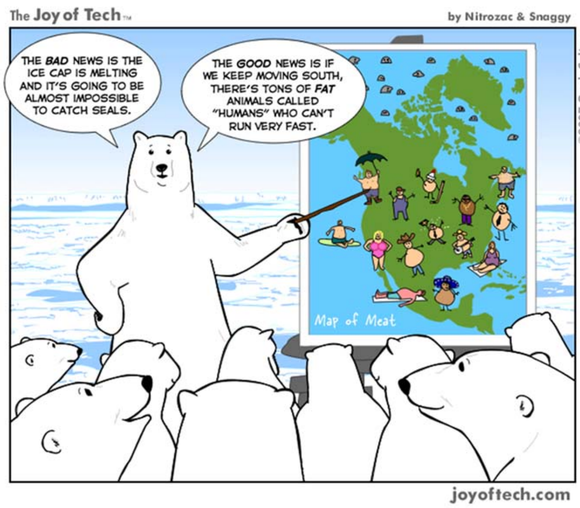

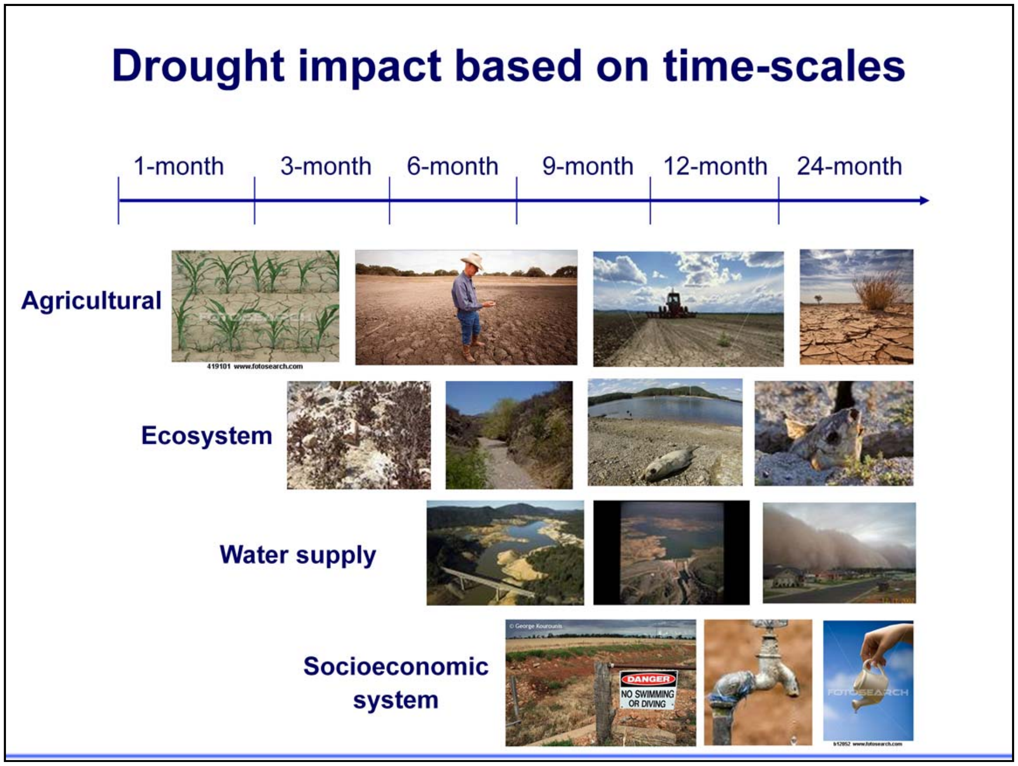

This figure show drought impact based on different time-scales. Short-term drought causes agricultural damage, mid-term drought affects the ecosystem, and long-term drought relates to water supply and hydropower generation. How can we estimate this phenomenon?