Relationships between climate and winter wheat yields in the Columbia Basin

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Introduction

- **Yields of winter wheat have increased in the Columbia basin and globally over the past 30-years primarily due to advances of agricultural techniques.**
- **Interannual variability in yield are spatially coherent suggestive of large-scale climate drivers for dryland farming.**
- **A gradient of energy and moisture across the study area presents an opportunity to explore relationships between climate and yield to devise improved yield forecasts using seasonal climate forecasts.**

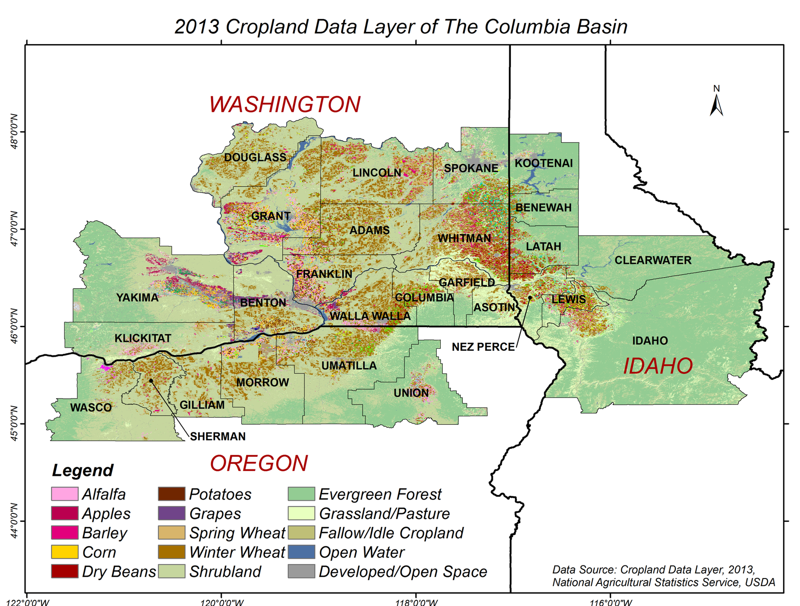

Figure 1: *The 27 counties in the Columbia basin with winter wheat yields. Brown shading denotes winter wheat cropland in 2013.*

Data and Methods

- Winter wheat yield records (unit: bu/acre) for 27 counties in Idaho, Oregon and Washington were acquired for all years 1972-2013 from the National Agricultural Statistics Service.
- County averaged daily maximum and minimum temperature, accumulated precipitation, specific humidity, wind speed and solar radiation from 1979-2013 were aggregated from the surface meteorological dataset of Abatzoglou (2013).
- Four metrics were considered:
  1. Oct-Jun precipitation total
  2. Oct-Jun growing degree-days (GDD, 0ºC)
  3. Mar-Jul Potential evapotranspiration (PET) calculated with Thornthwaite (Th) method and Penman-Monteith (PM, Allen et al., 1998) method respectively
  4. Palmer Drought Severity Index (PDSI)

Trends and Spatial Autocorrelation

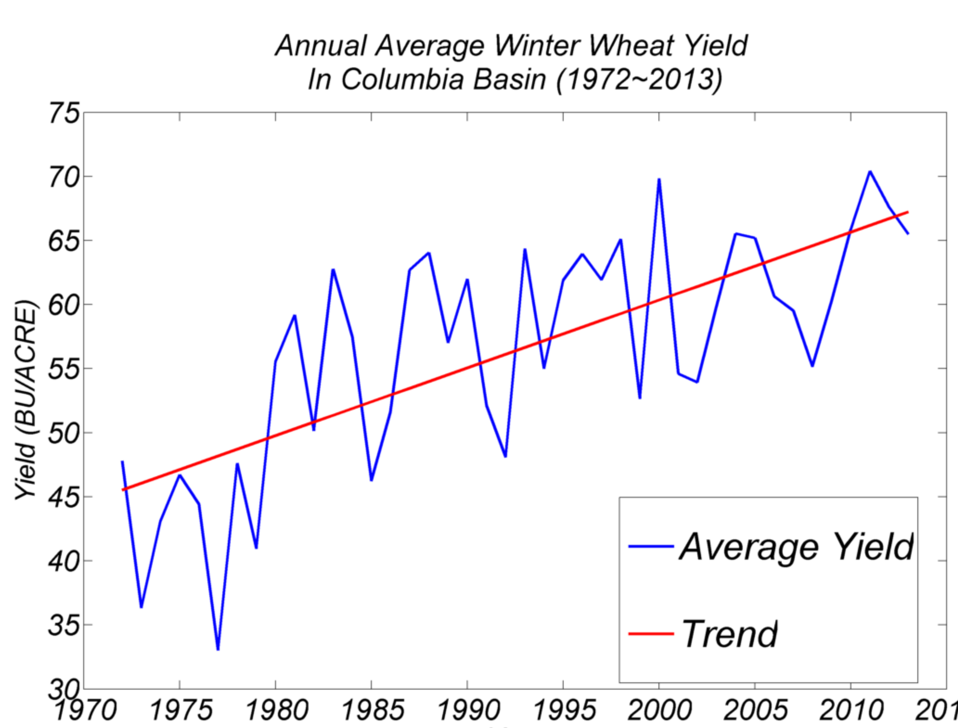

Figure 2: *Annual winter wheat yield averaged over the 27-counties in the Columbia Basin from 1972 to 2013. The black line is the best fit line for the average winter wheat yield of just less than 1%/yr. Detrended yield was subsequently used to remove technological advances.*

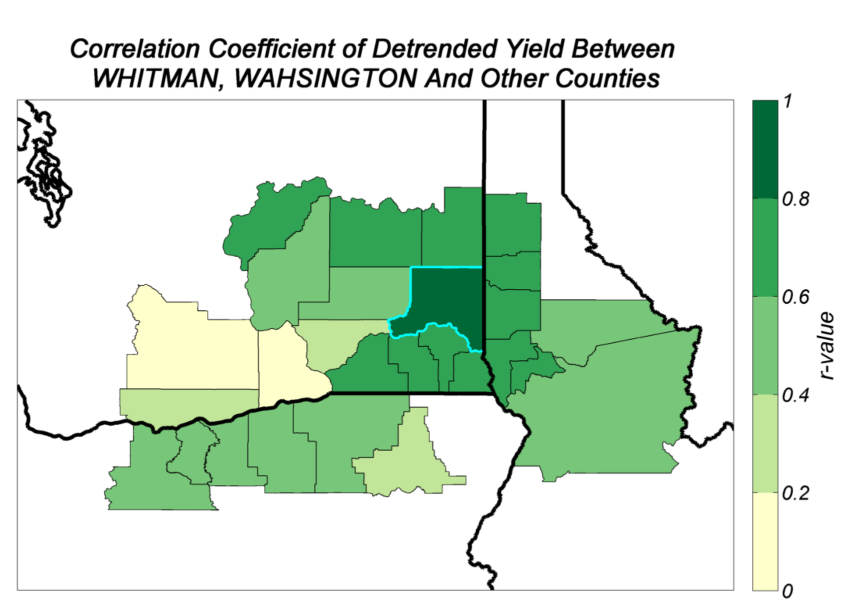

Figure 3*: Spatial correlation of detrended yield between Whitman County and other counties in Columbia basin. Strong spatial autocorrelation of interannual wheat yields suggests a climatic driven process.*

Results

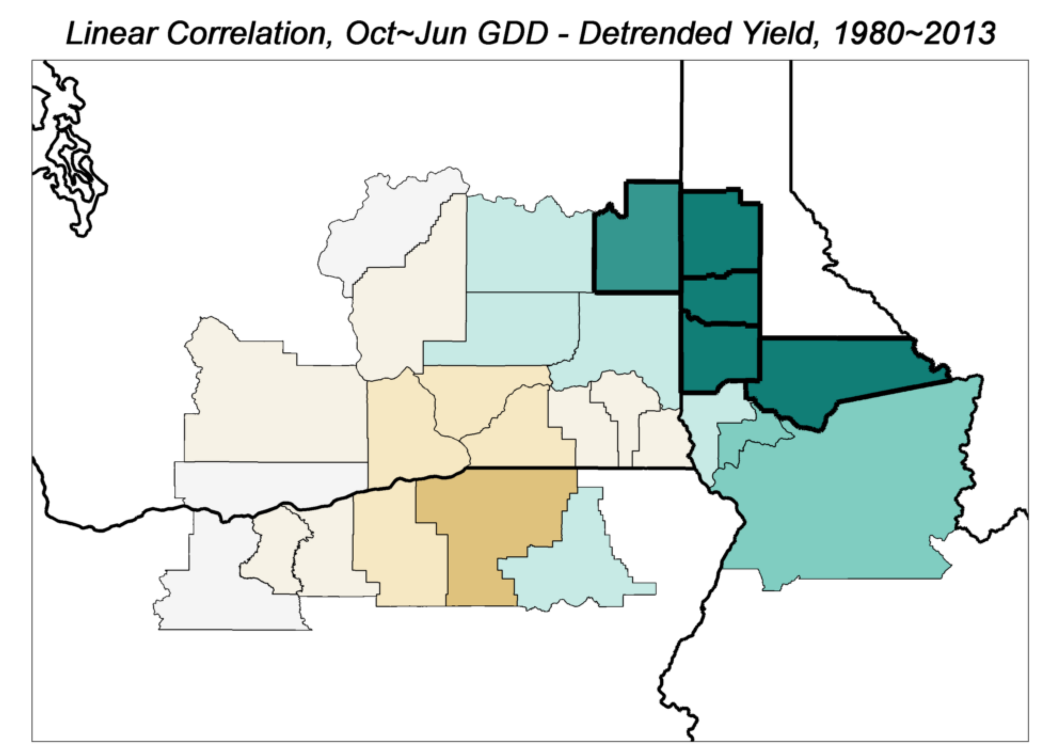

Figure 4: *Linear Correlation between Oct-Jung GDD and detrended yield. Statistically significant relationships are delineated by thick county boundaries.*

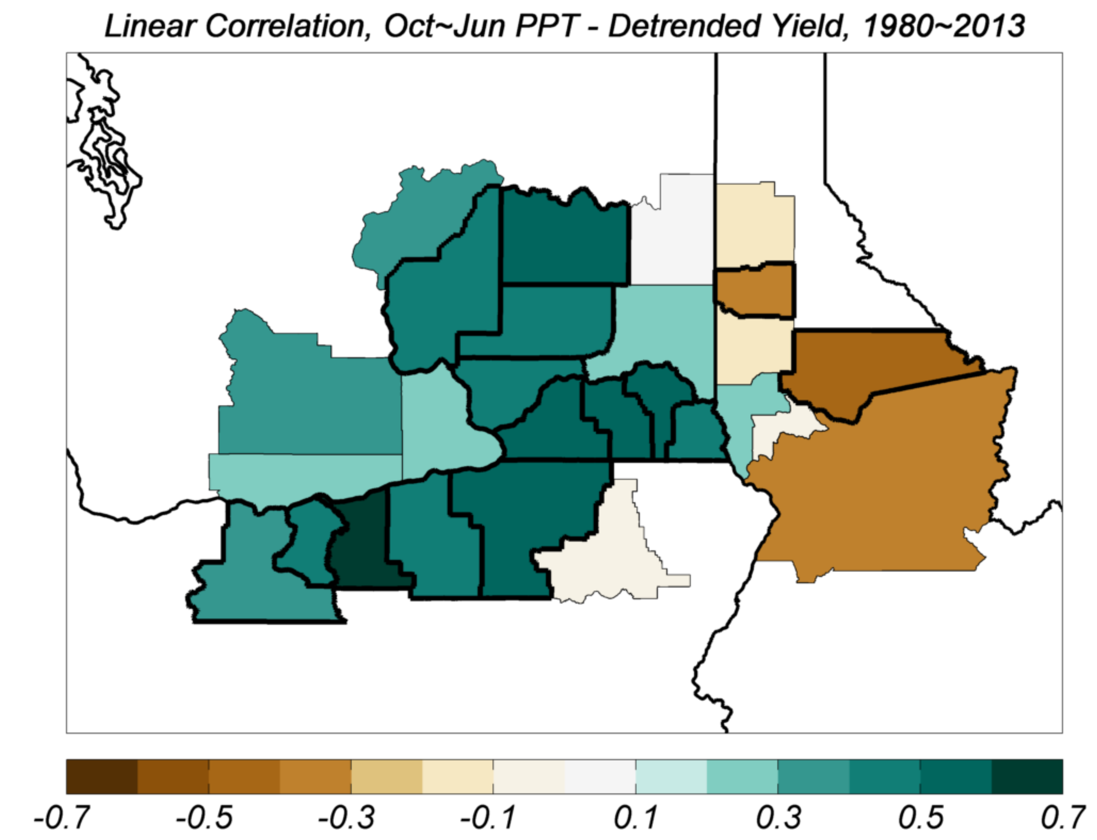

Figure 5*: Linear correlation between Oct-Jun precipitation and detrended wheat yield.*

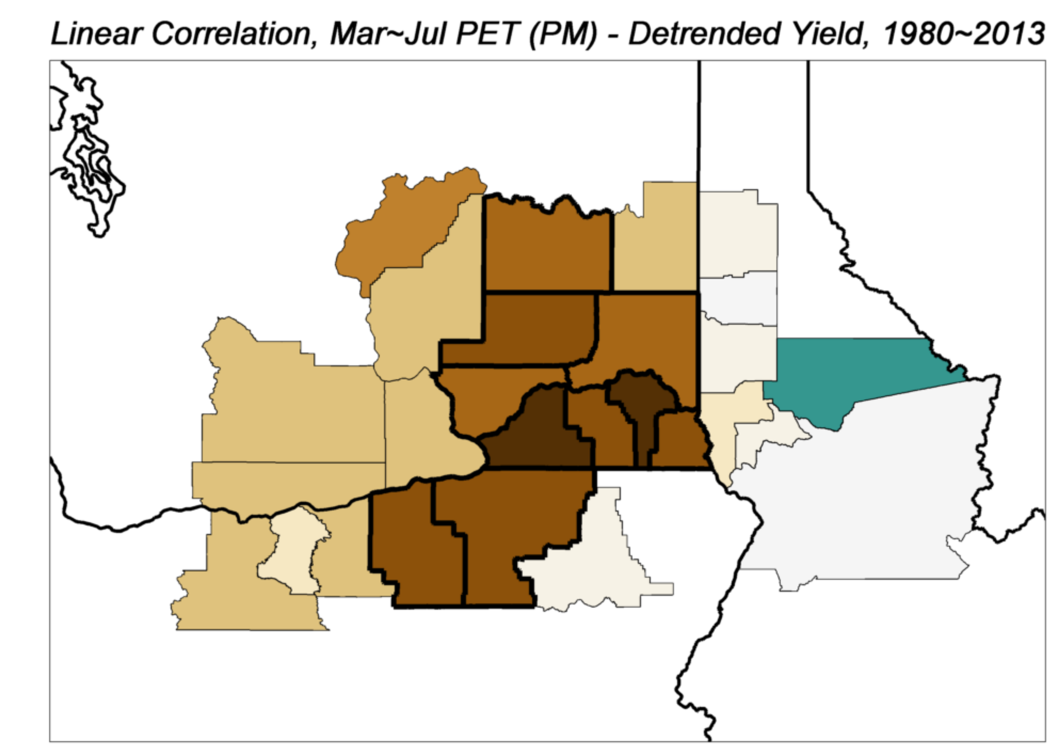

Figure 7: *Linear correlation between Mar-Jul PET (calculated by Penman-Montieth method) and detrended wheat yield.*

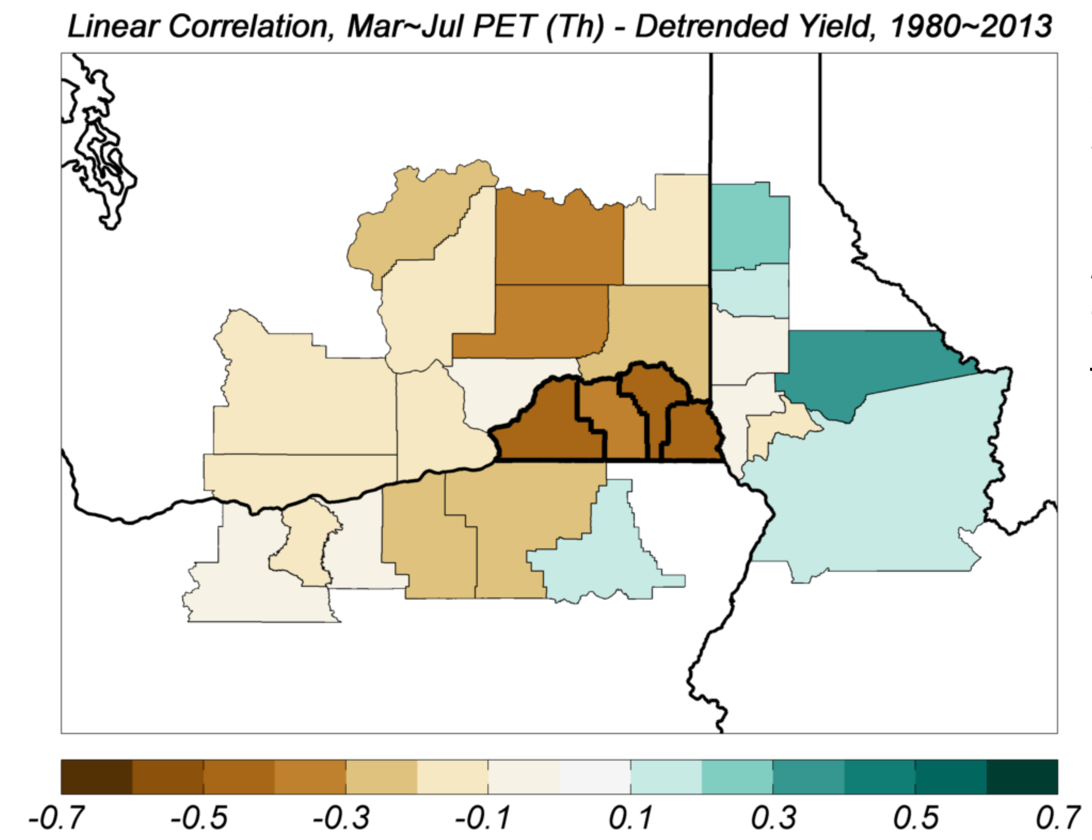

Figure 8: *Linear correlation between Mar-Jul PET (calculated by Thornthwaite method) and detrended wheat yield.*

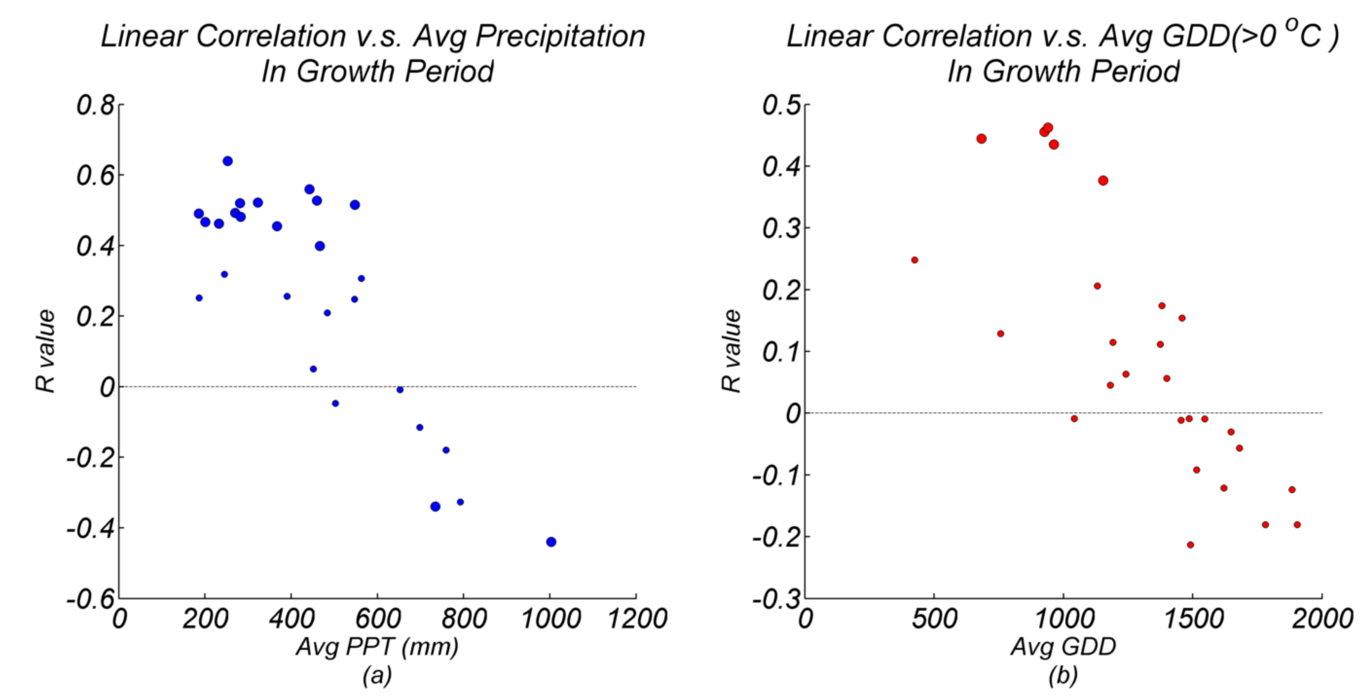

Figure 6 (left): *Scatterplot of Oct-Jun. climatological precipitation vs. PPT-yield correlation.*
(right): *Scatterplot of Oct-Jun. climatological GDD vs. GDD-yield correlation. Statistically significant relationships indicated by large symbols*

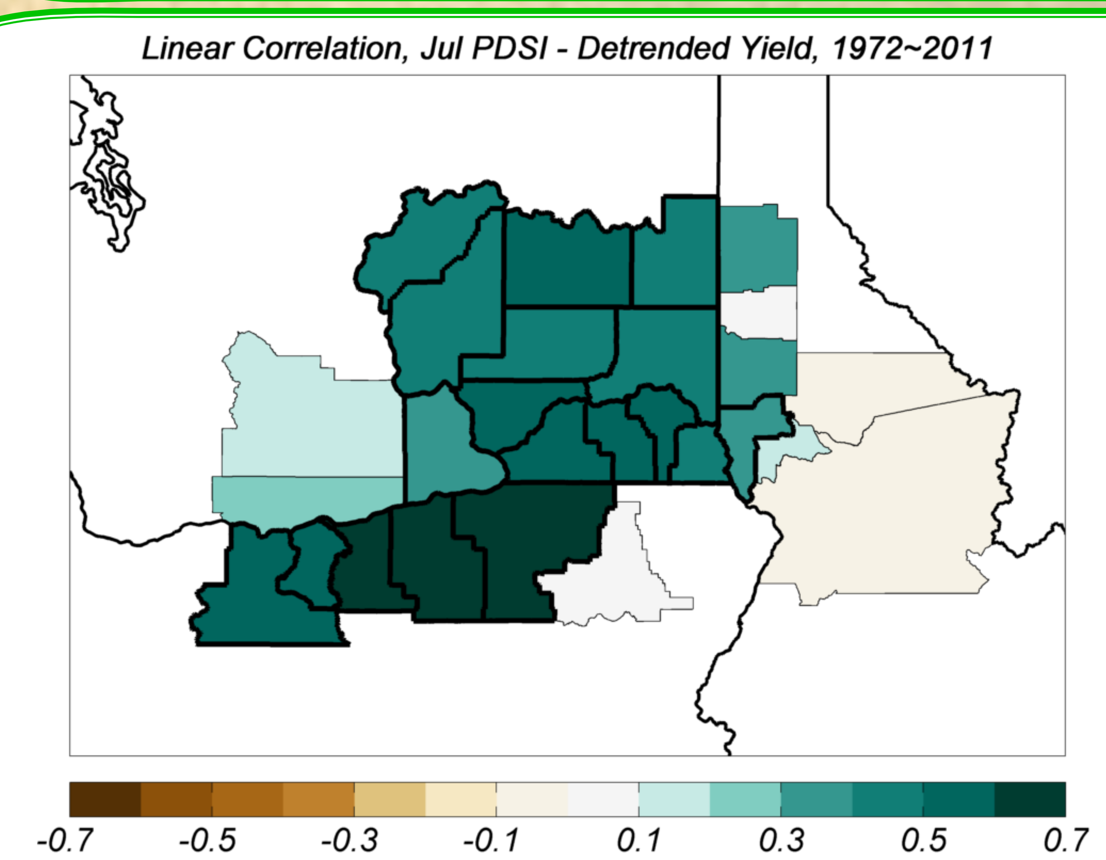

Figure 9: *Linear correlation between July PDSI and detrended wheat yield.*

Findings

- **Oct-Jun precipitation positively correlates with the winter wheat yield in the drier portions of dryland farming in the Columbia basin that are water-limited. However, the negative correlations were found in the wetter counties suggesting detrimental affects of wet winters on yield.**
- **Oct-Jun GDD showed positive correlation to wheat yield in the Idaho Palouse and Spokane county, regions that might be energy-limited.**
- **Spring to mid-summer PET had a significant negative impact on wheat yield in the middle of Columbia basin. Counties located further west and east, were less affected due to potential irrigation and more abundant moisture, respectively.**
- **Drought viewed through PDSI had significant impacts on winter wheat yield in most counties in the Columbia basin except those counties that exhibit sufficient water supply and a developed irrigation system. Additional drought indices might provide stronger links to yield.**
- **Relationships between climate and wheat yield varied substantially across the study region. This statistical approach may supplement processed based models to provide forecasts of wheat yield due to climate variability (e.g., ENSO) as well as climate change.**

References

Abatzoglou, J.T., 2013, Development of gridded surface meteorological data for ecological applications and modeling, International Journal of Climatology, doi: 10.1002/joc.3413
Allen RG, Pereira LS, Raes D, Smith M, (1998) Crop evapotranspiration, guidelines for computing crop water requirements. FAO Irrig. and Drain. Paper 56, Food and Agric. Orgn. of the United Nations, Rome, Italy. 300 pp