

# **Streamflow responses in the Western US to the 2015 drought**

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# USGS investigation of streamflow responses to the 2015 drought

- Six state region: CA, ID, NV, OR, UT, WA
- Continuous records at ~1252 streamflow gages including 1117 sites gaged from 1981 to 2010
- Low flow measurements at ~1016 ungaged sites including 341 sites gaged from 1981 to 2010 but not in 2015
- State, tribal, and federal cooperators/collaborators
- Analysis underway
- Preliminary results for 300 gaged sites with relatively unaltered streamflow

# Predicting streamflow responses to drought

*Streamflow generally varies with precipitation, so lower streamflow is likely in years with lower precipitation...*

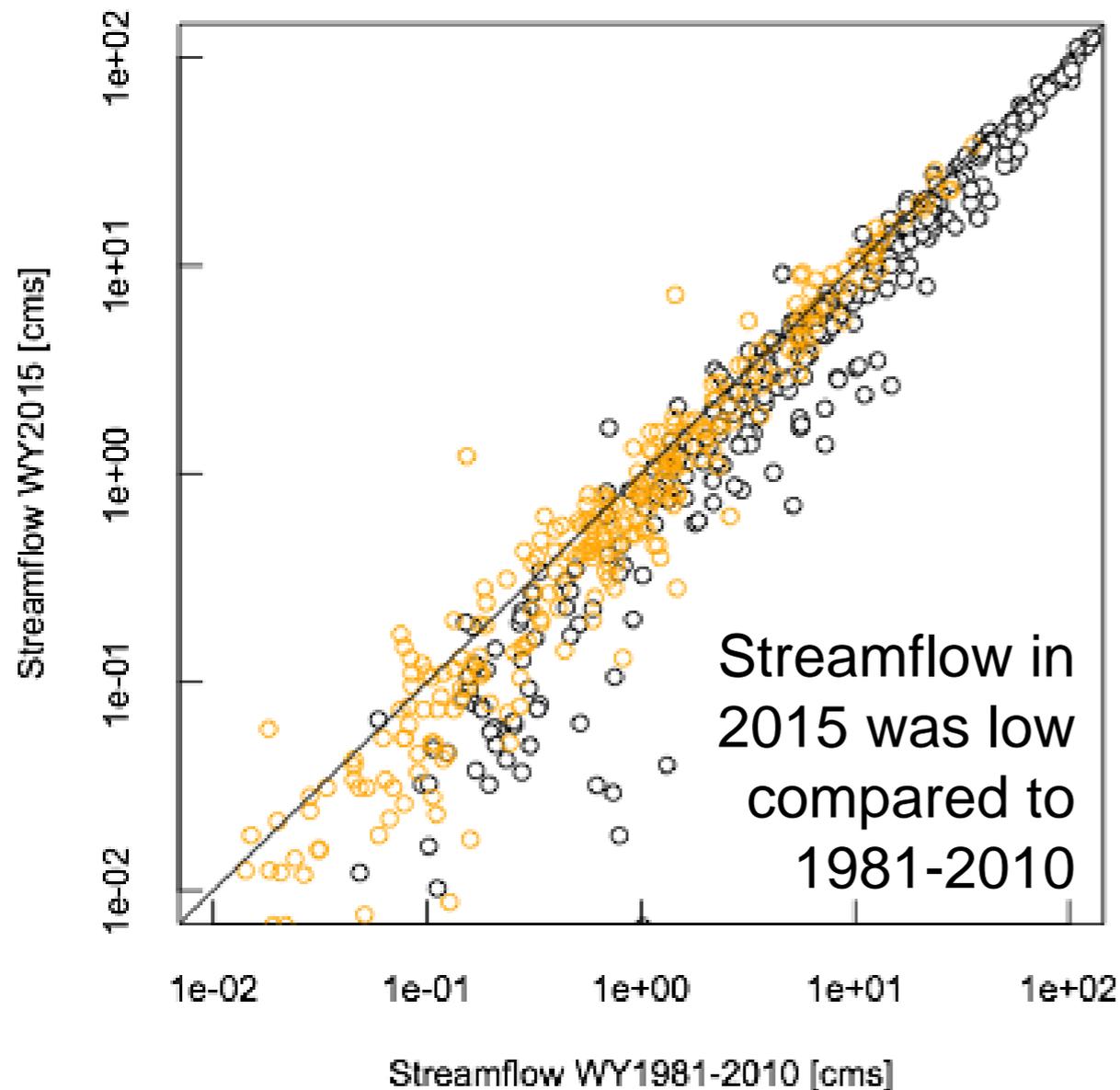
WY 2015 streamflow was in lowest quartile of annual streamflows for 1981-2010 at most sites (n = 300) with relatively unaltered flow

WY 2015 minimum daily streamflow was in the lowest quintile of annual minimum streamflows at most sites.

Unresolved issues:

- How much does streamflow vary with precipitation?
- Where is streamflow most sensitive to variability in precipitation?
- What factors other than precipitation contribute to low streamflow and could be used as early warning?

# Streamflow for 2015 compared to median WY1981-2010



Median of ratios (2015 to 1981-2010) for 300 sites with relatively unaltered flows:

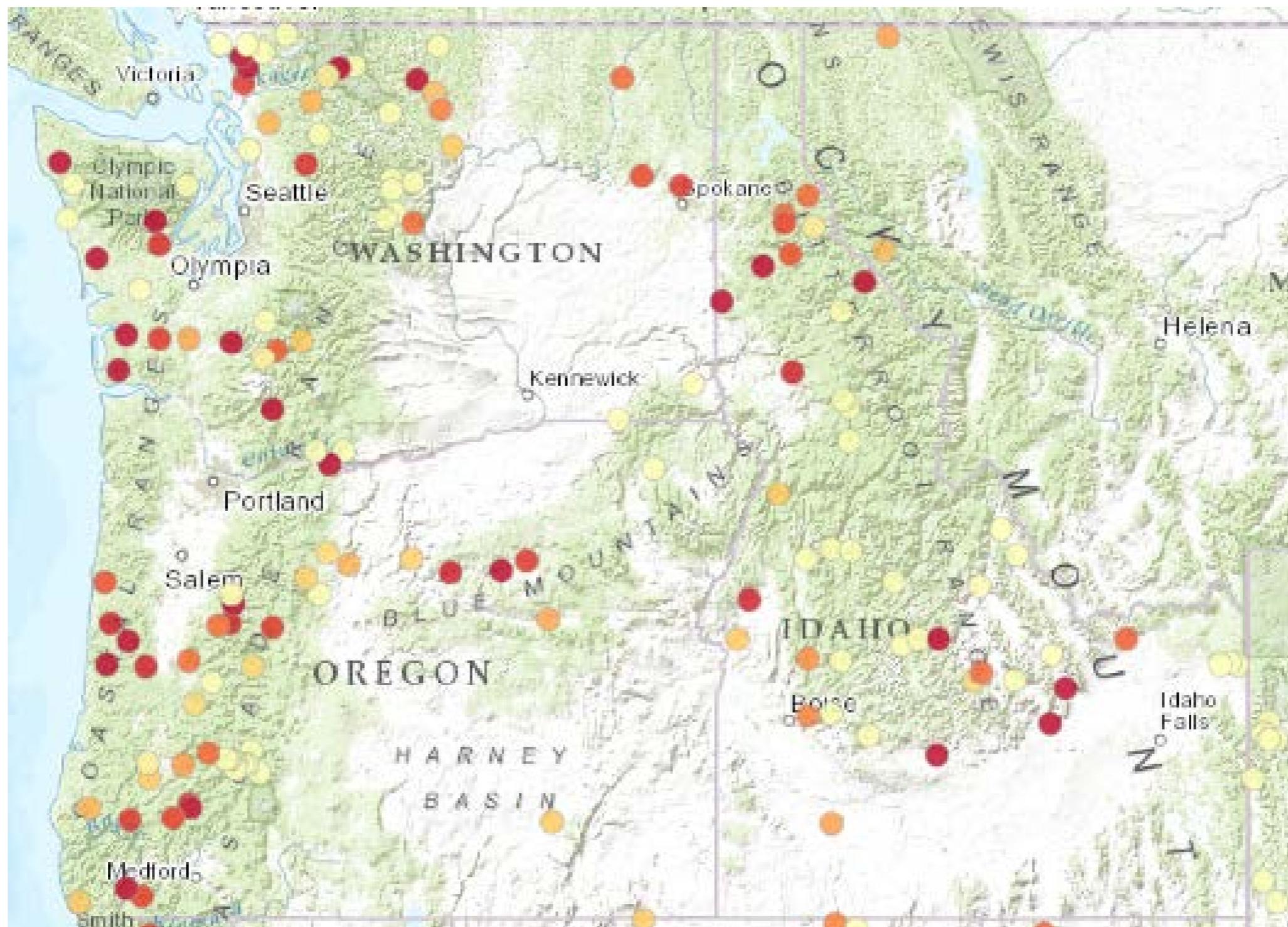
Mean streamflow 0.72

Minimum streamflow: 0.79 (less extreme)

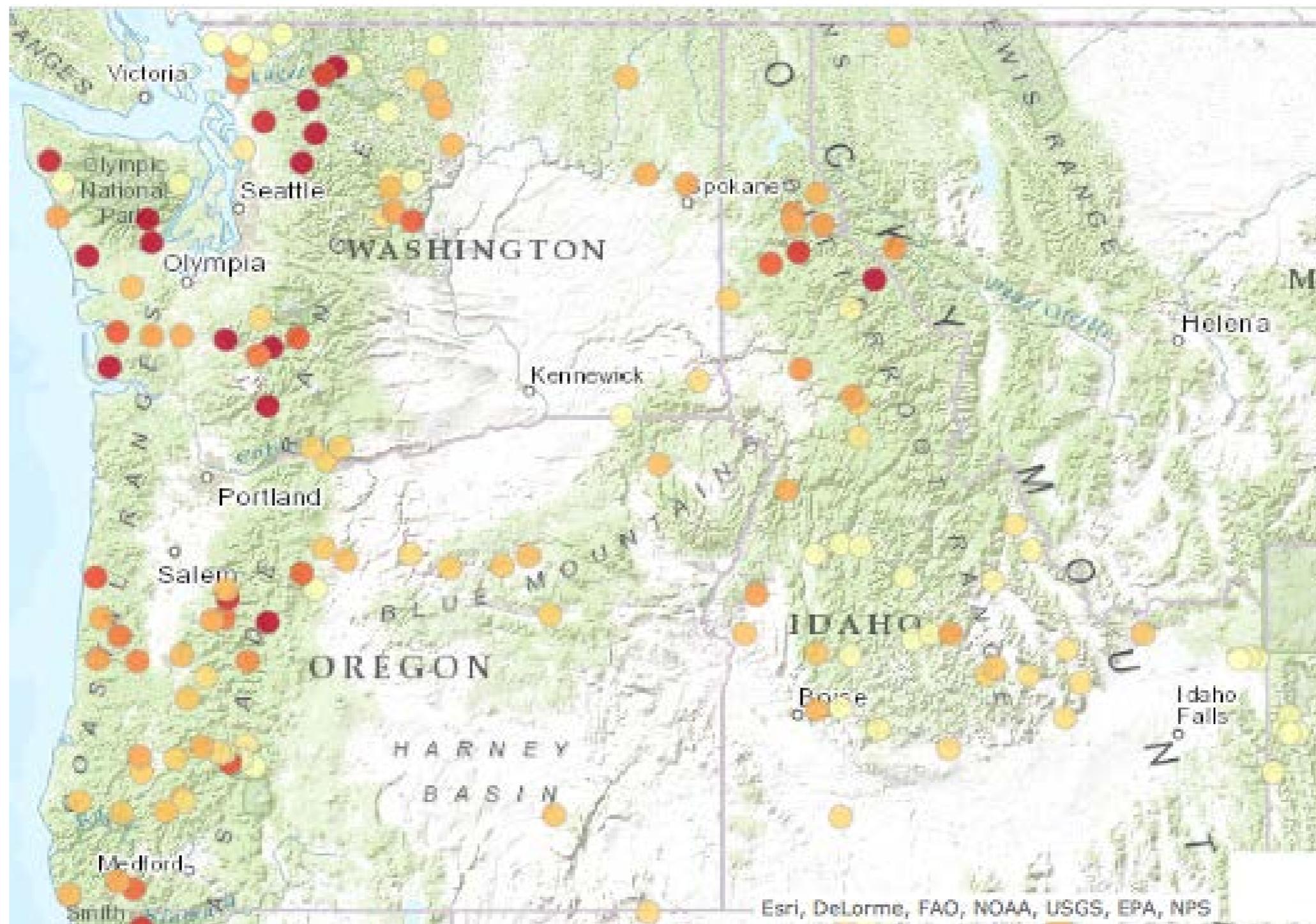
Greatest relative difference in smaller basins

Mean streamflow (black) and minimum daily streamflow (orange)

# Minimum streamflow: 2015 as percentile of 1981 to 2010: <0.1 (red), >0.3 (yellow)



# Minimum streamflow: 2015 as deviation from 1981-2010 <-0.05 cm (red), yellow >0 cm



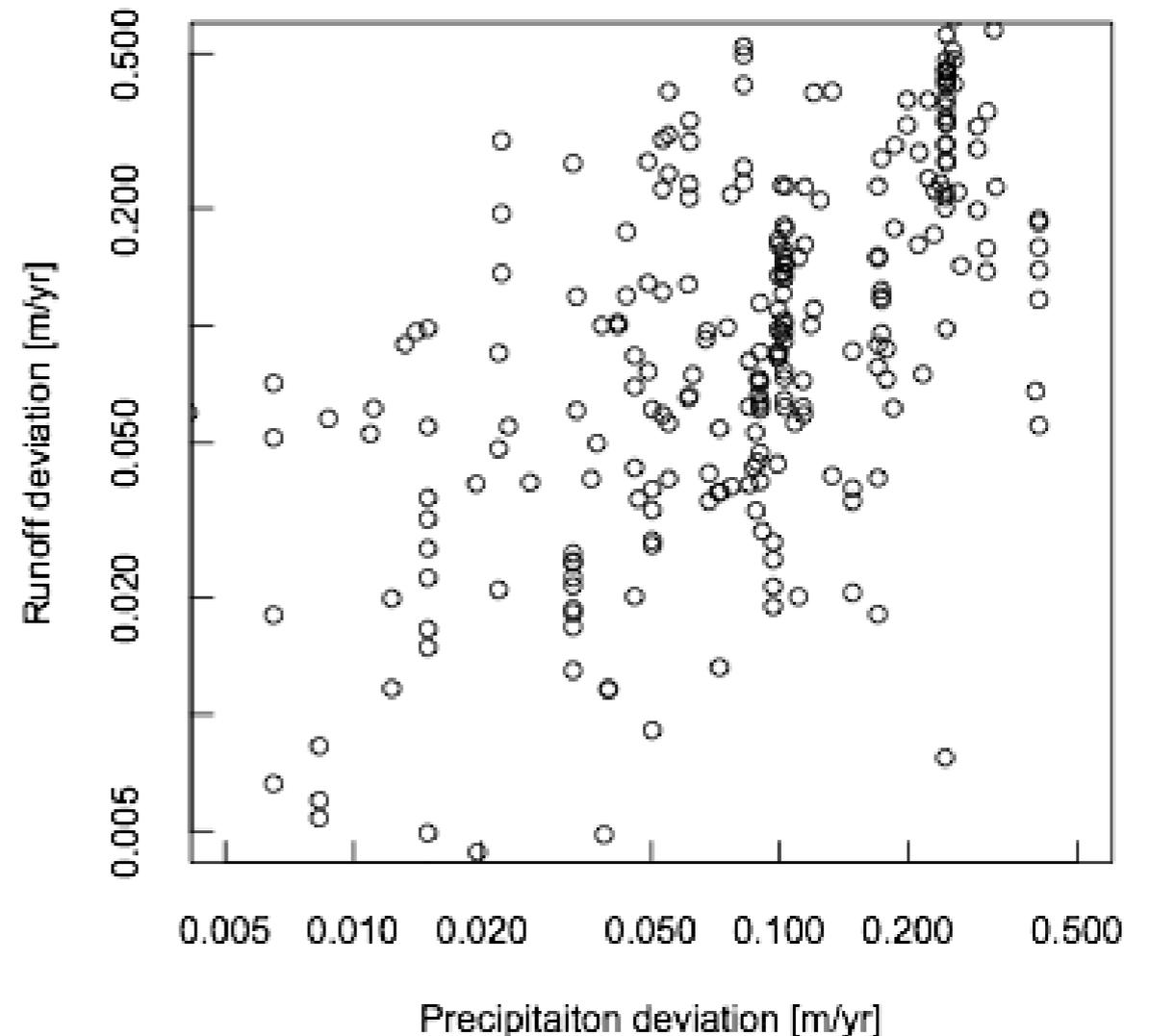
# Early warning of low runoff: precipitation

Precipitation is a reliable indicator of annual runoff at most locations.

Other streamflow characteristics (summer flow volume, minimum streamflow) require more sophisticated approach for “early warning” at most sites.

Median Pearson correlation coefficient for WY 1981 to 2010 (n = 300 sites):

- **Mean streamflow: 0.86**
- **Minimum streamflow: 0.57**



Difference between median 1981-2010 and 2015 for precipitation and runoff

# Potential early-warning factors for minimum streamflow

The annual length of seasonal dry period is highly correlated with annual low flows (median Pearson correlations coefficient = -0.73), but requires forecasting for early warning.

Some possible alternative early-warning factors and their physical basis:

- Serial correlation of annual minimum stream flow (inter-annual groundwater storage)
- Snowpack (fluvial recharge, length of time that base flow will be supported solely by groundwater)
- Basin geology (groundwater storage)
- Basin area (groundwater storage)
- Seasonal climate outlook (length of seasonal dry period)

# Early warning factor: serial correlation

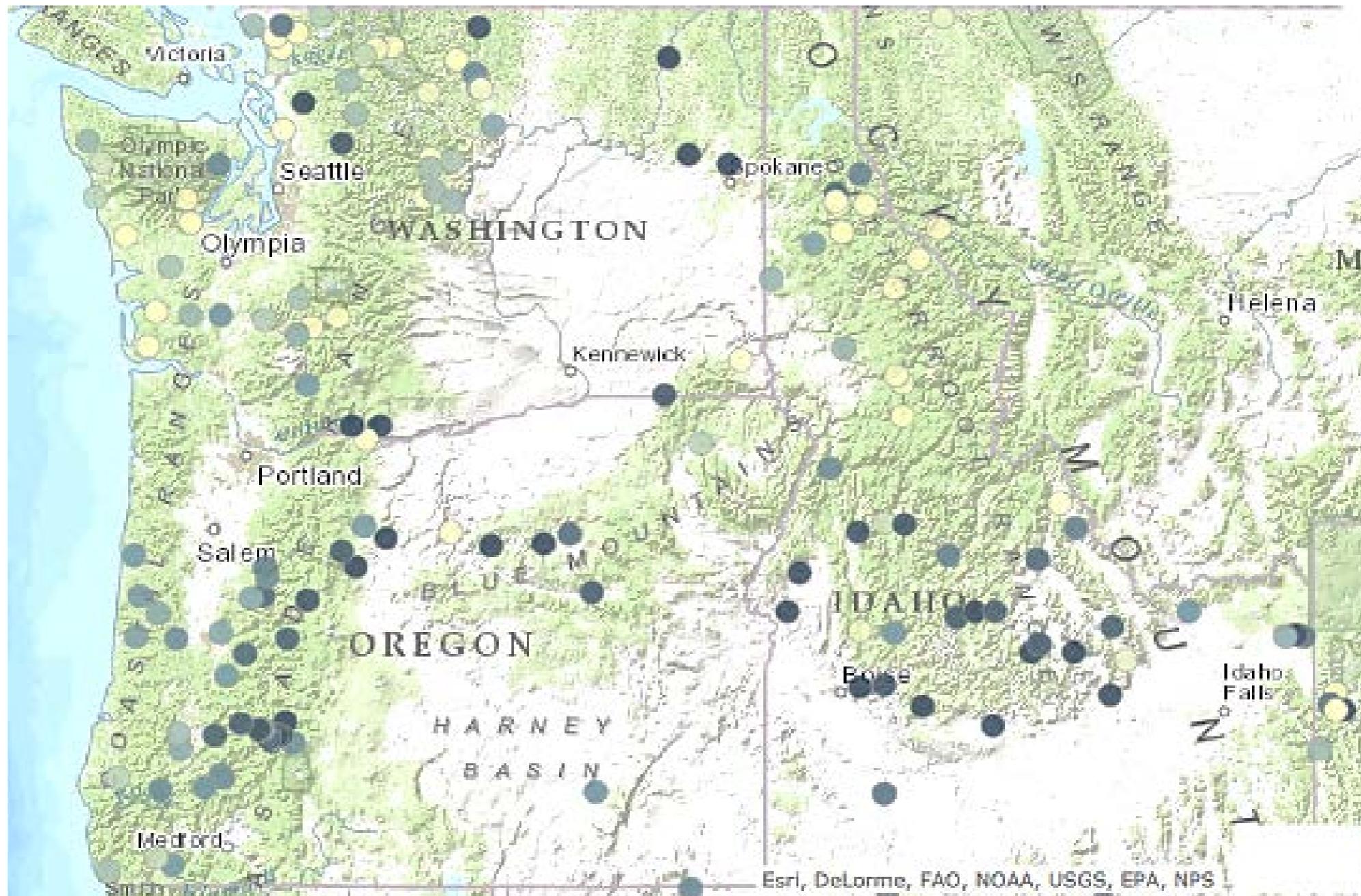
Serial (year-to-year) correlation for minimum streamflow is generally higher than for mean streamflow or precipitation

Median Pearson correlation coefficient for sequential annual values (year  $y$ , year  $y+1$ ) for WY 1981 to 2010:

- Annual precipitation: 0.18
- Annual mean streamflow: 0.23
- Annual minimum streamflow: 0.31

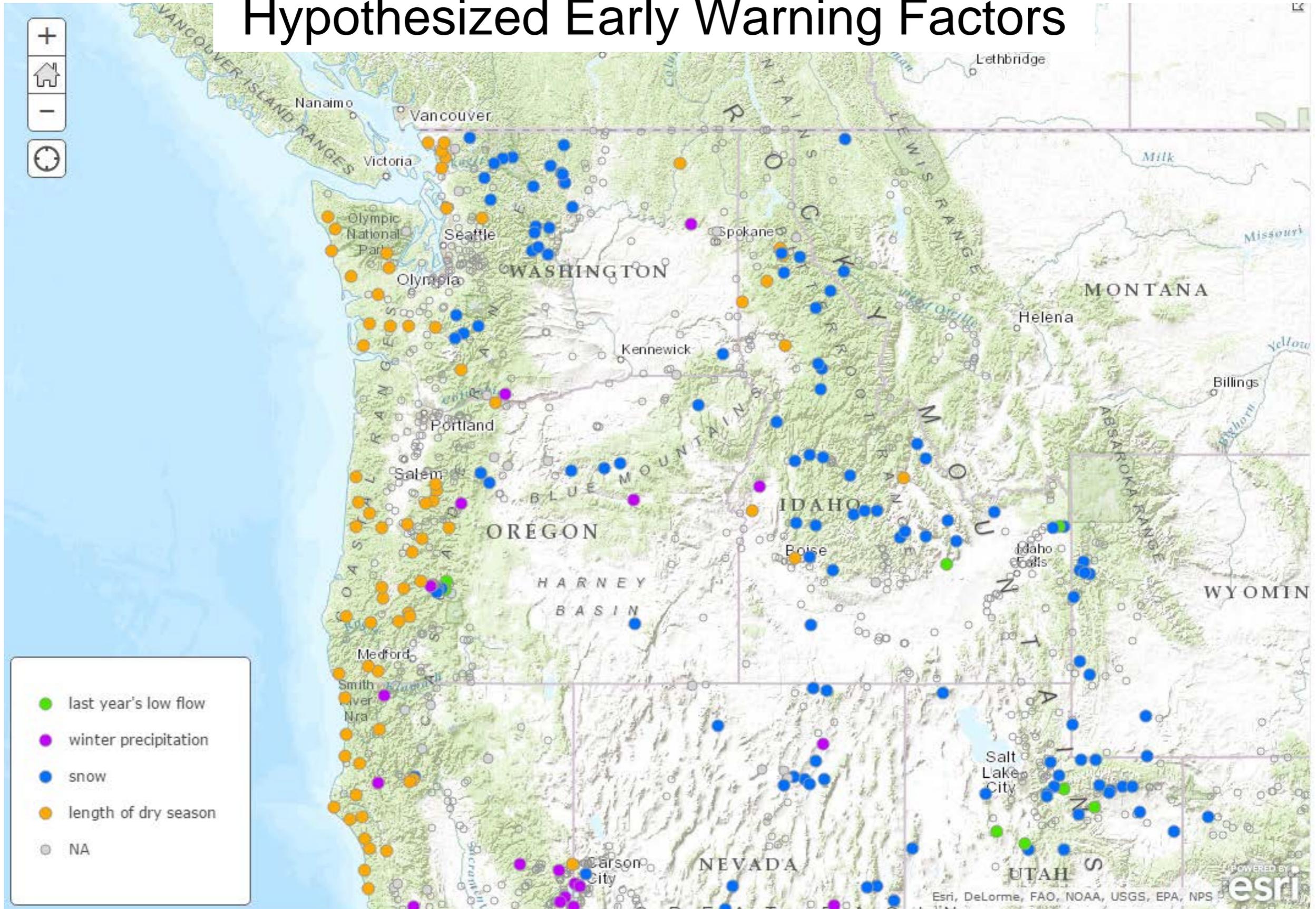
Last year's minimum streamflow may indicate the likelihood of relative low or high minimum streamflow this year at some sites (e.g., where groundwater recharge responds slowly to precipitation)

# Serial correlation of annual minimum streamflow:



Blue indicates locations where minimum streamflow is correlated (Pearson's coefficient > 0.5) with last year, yellow indicates low or no correlation (< 0.3)

# Hypothesized Early Warning Factors



# Summary

- **USGS is analyzing potential factors that could be used as early-warning of low flow streamflow based on the 2015 drought**
- **Variable responses of different streamflow characteristics**
- **Low flow response depends on site type, may be feasible to determine at gaged sites, but could be difficult to pick for ungaged sites.**
- **Low flow at many sites depends on the length of seasonal dry period, which requires forecasting**