What is up (and down) with King County river flows?

WLRD Science Seminar

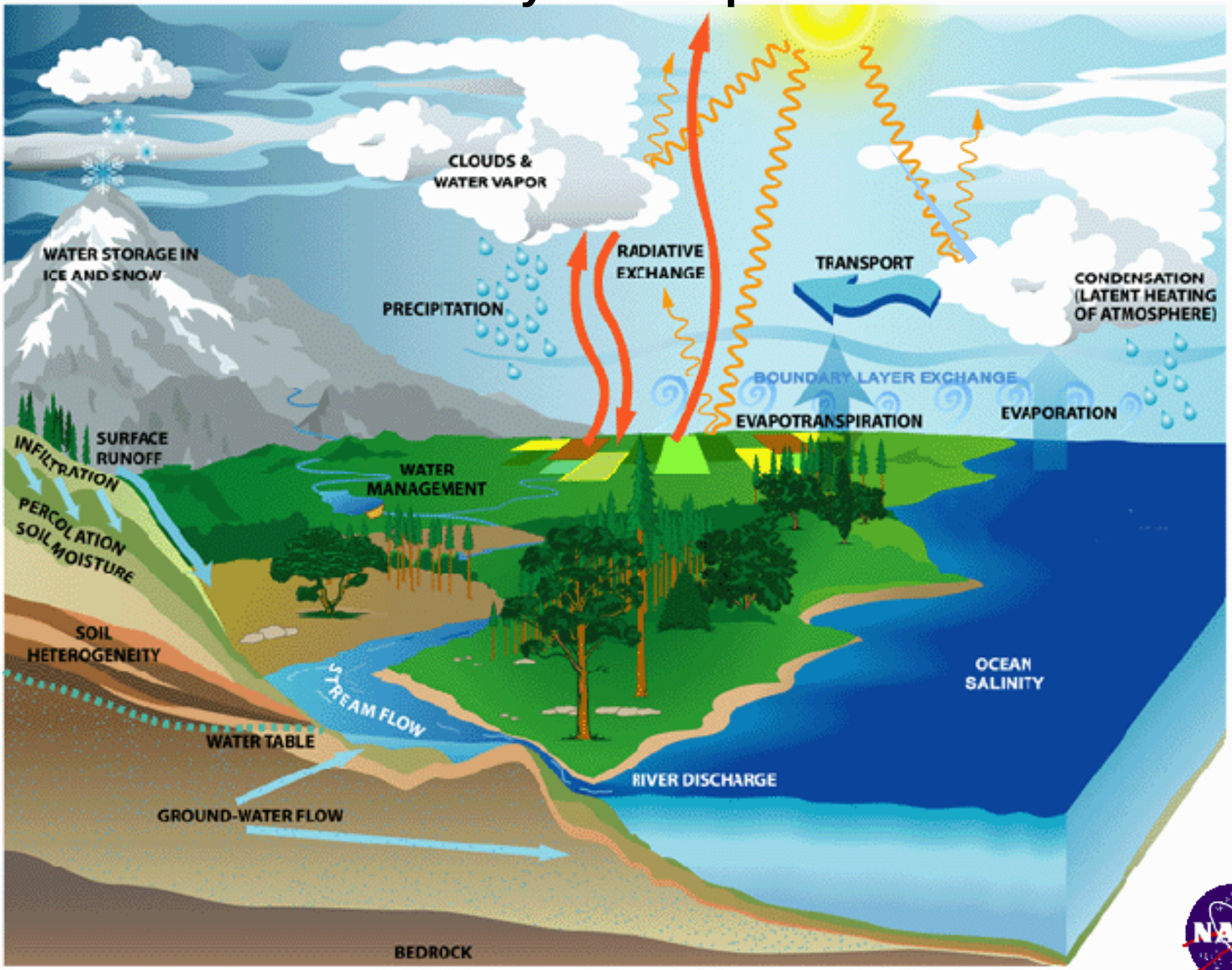
Curtis DeGasperi
King County Water and Land Resources Division

May 5, 2009

Why care about river flows?

- Aquatic and riparian ecosystems are adapted to the magnitude, frequency, timing, and duration of flow
- Humans depend on riverine ecosystem functions and can be affected by the magnitude, frequency, timing, and duration of flow.

Water Cycle Components

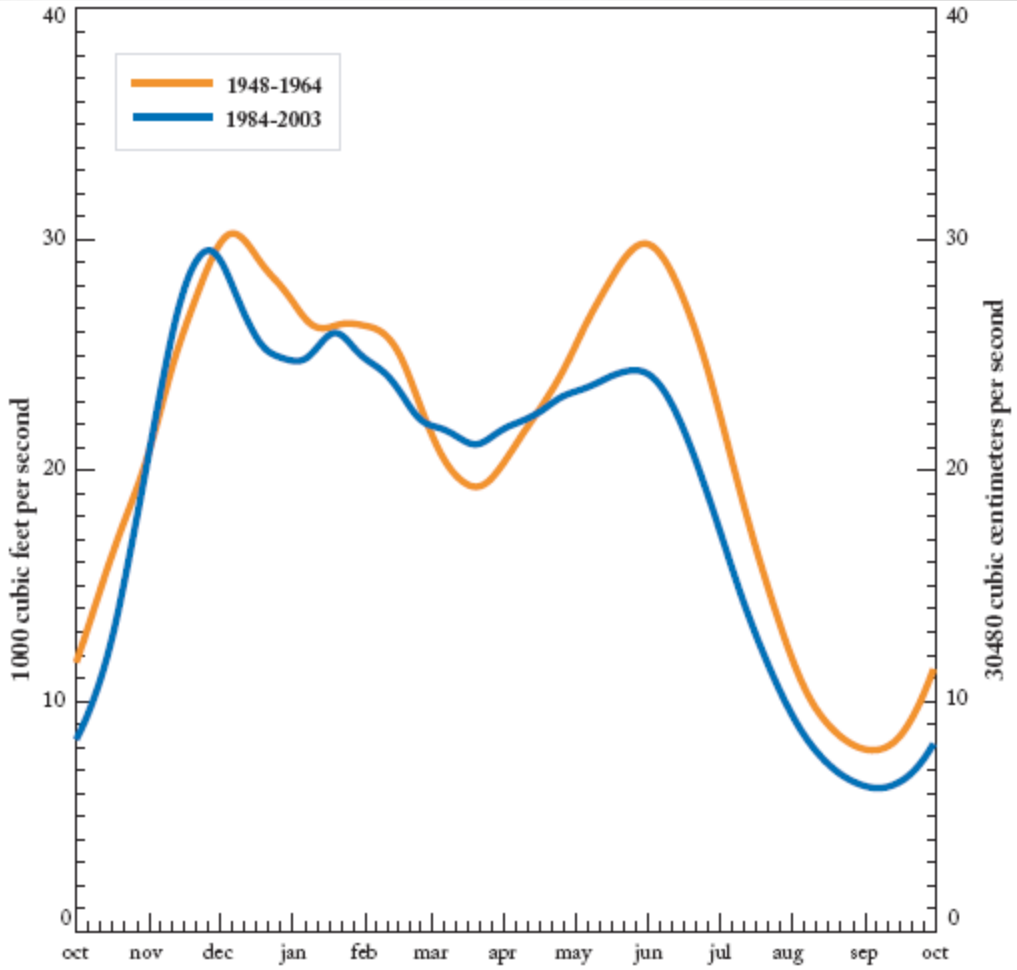


Human Impacts on Water Cycle

- Land cover change
  - Forest management
  - Urbanization
  - Channelization
- Water management
  - Reservoirs (flood control-hydropower)
  - Irrigation
  - Water supply
- Climate Change

Median April 1st Snow Pack for Snohomish Basin

HadCm3 yr 2050



Average Daily Freshwater Flow into Puget Sound

Figure 4: Average daily freshwater flow into Puget Sound (found by adding the flow of nine of the largest rivers) for 1948-1964 (orange) and 1984-2003 (blue). Note the decline in May-October and increase in March-April.

http://www.psparchives.com/publications/our_work/climate/climate_report/psat_climate2005_report_lowres.pdf

Forest Harvest, Fires, Losses

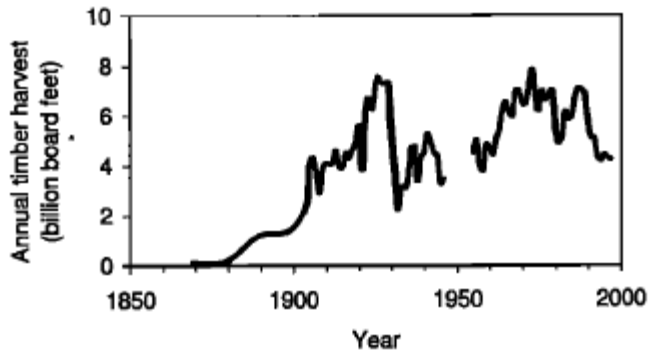
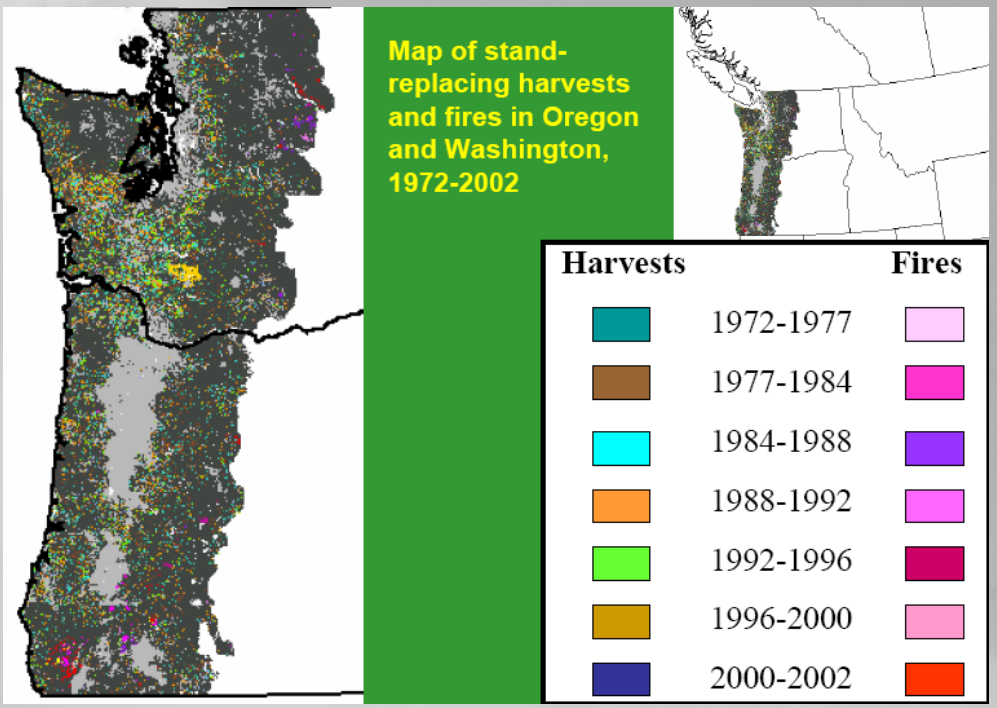


Figure 4. Annual timber harvest (lumber production) in Washington State (1869–1997). Sources are as follows: *Austin* [1970], *Hamilton* [1965], *Ruderman* [1980], *Steer* [1948], and *Warren* [1990, 1998].

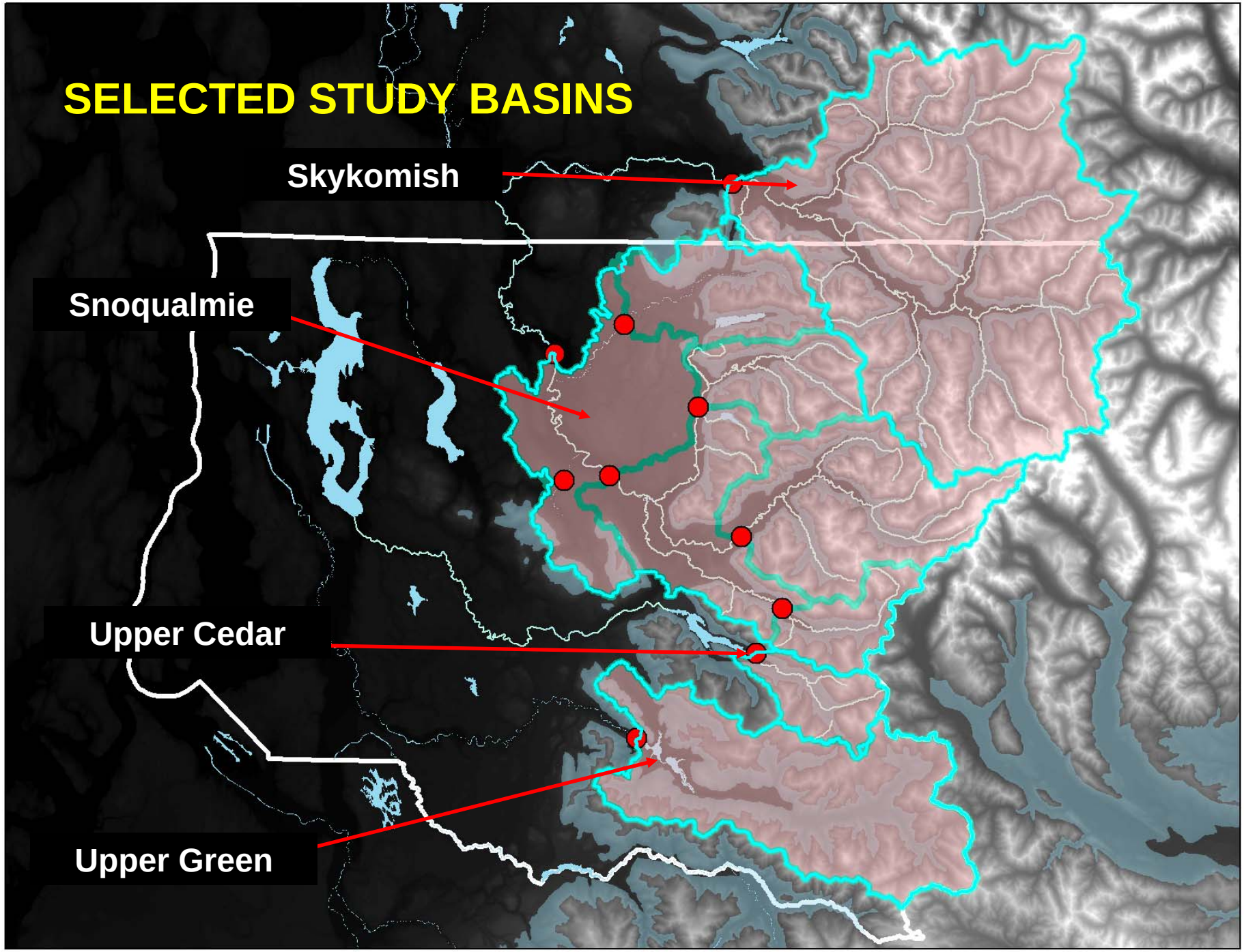


Bowling et al. (2000)

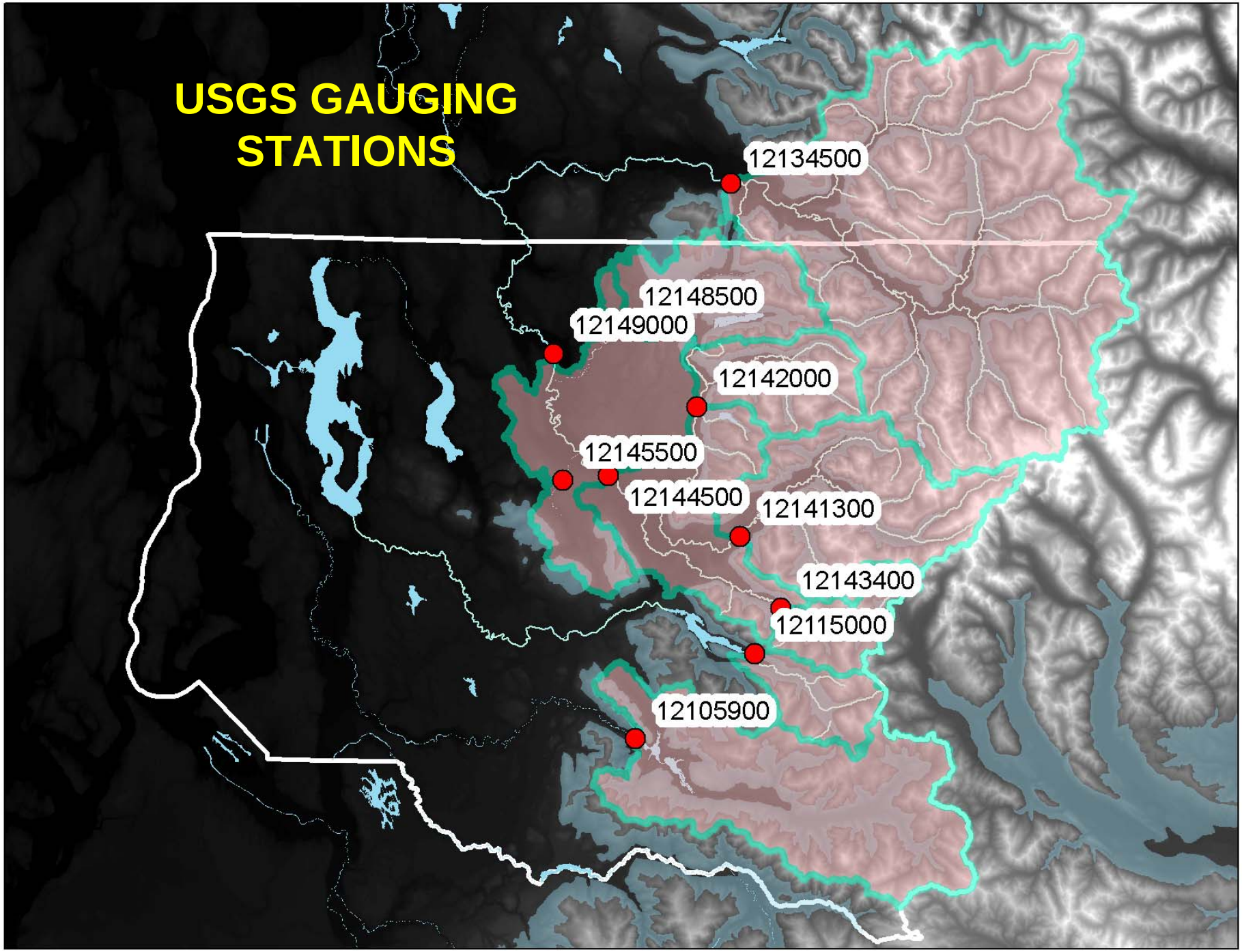
Selected Data

- Daily total precipitation for 9 stations
- Daily average discharge from 10 relatively unregulated USGS gauging stations

SELECTED STUDY BASINS

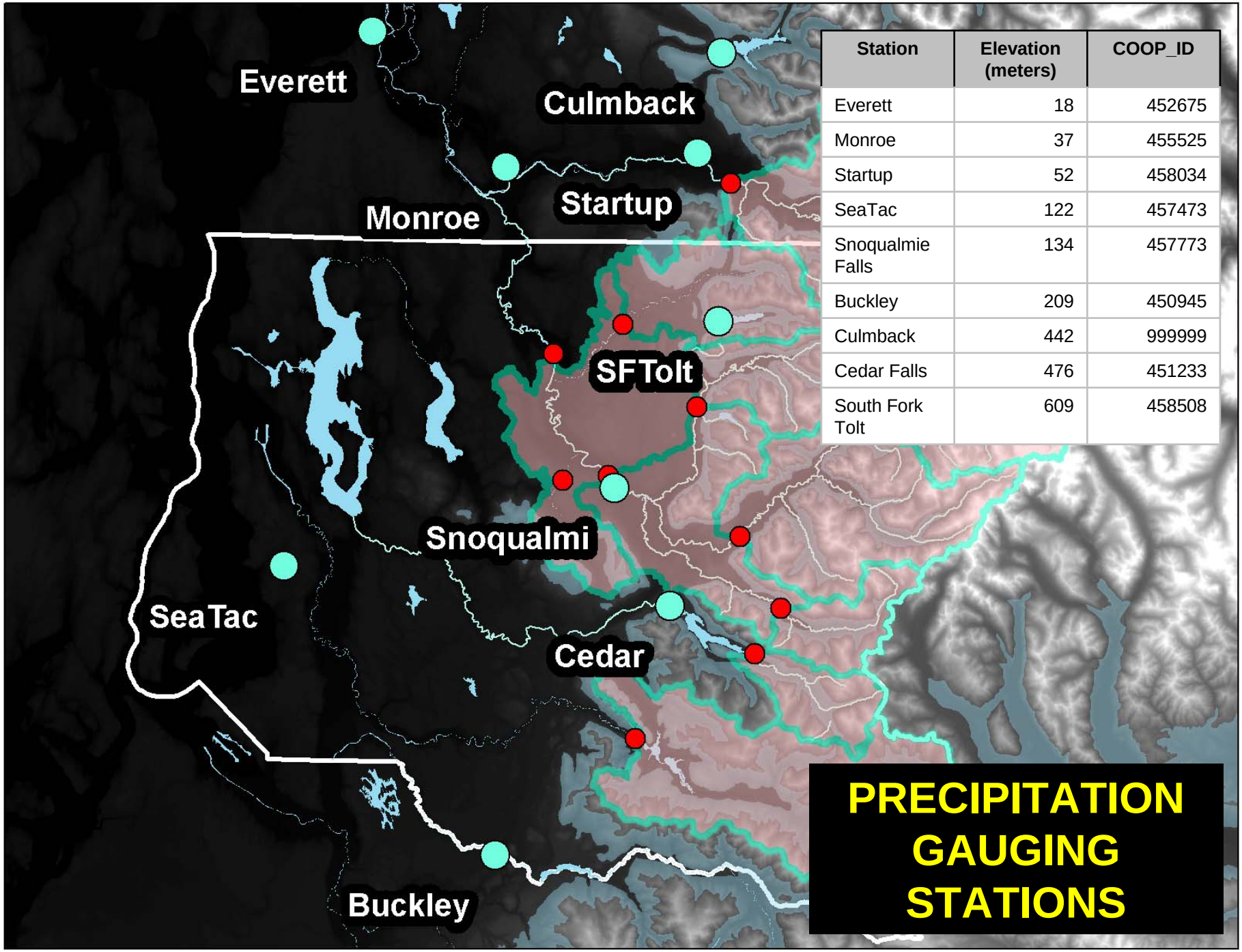


USGS GAUGING STATIONS



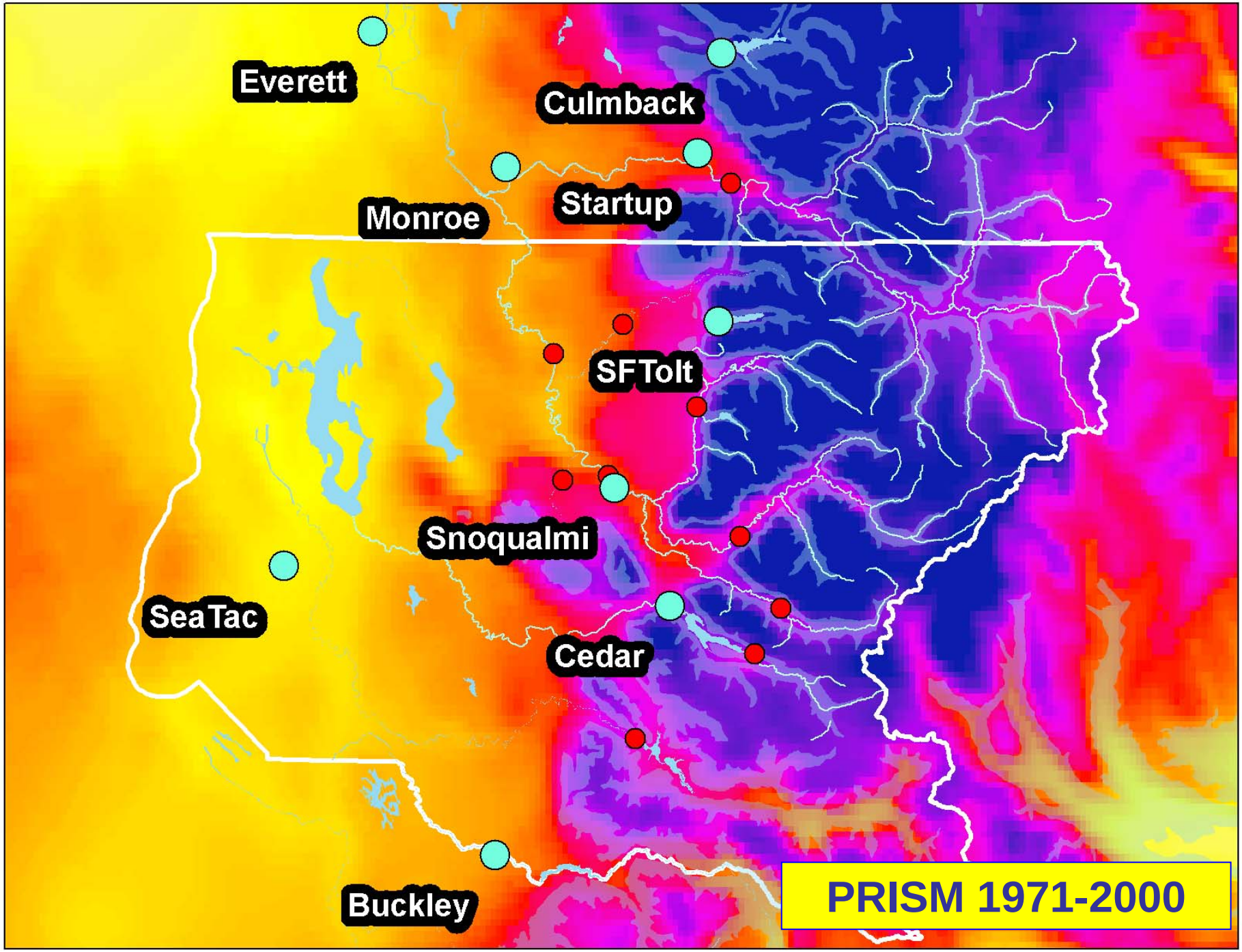
Selected USGS Stations

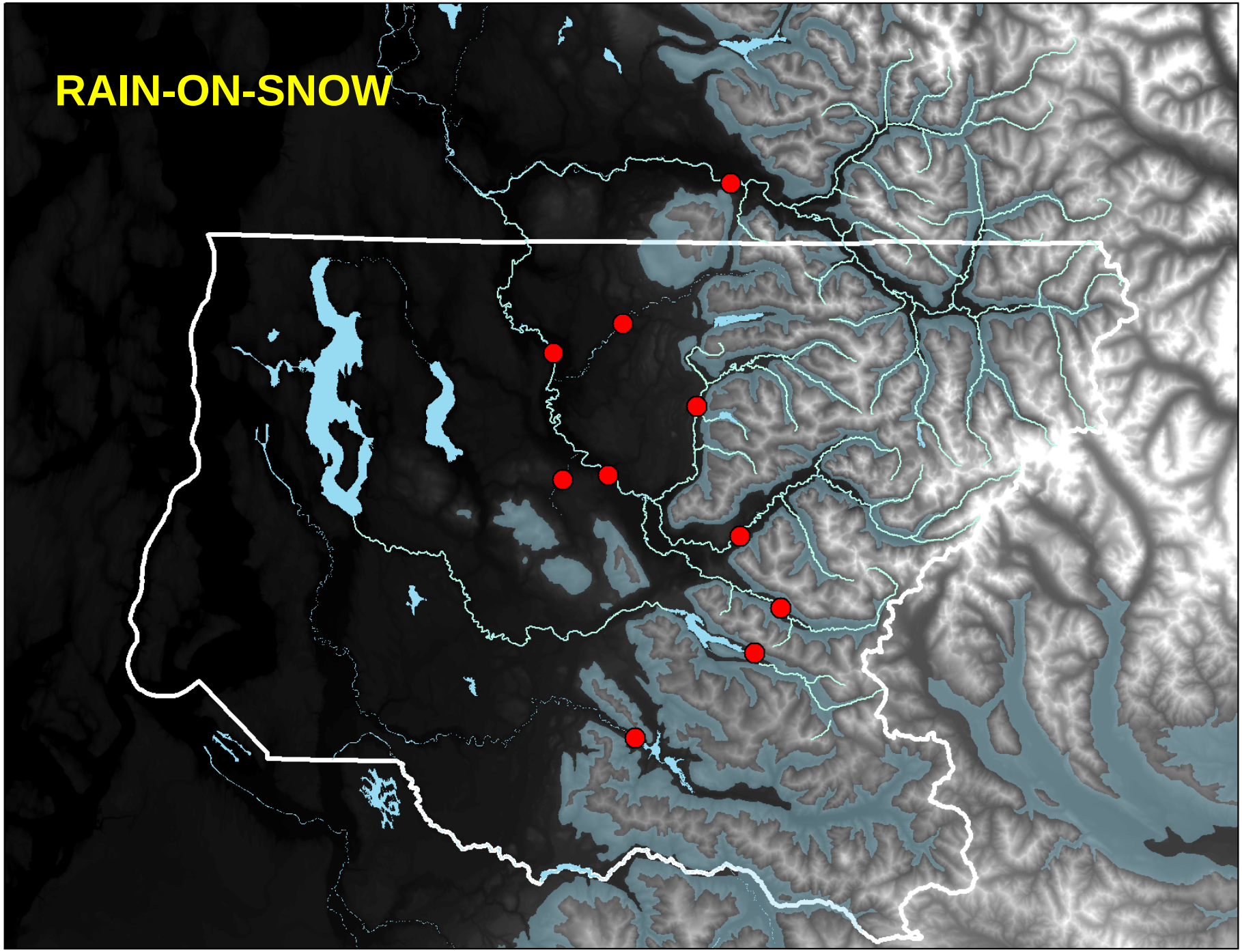
Description	Station	Area km^2 (mi^2)	Mean Elev. meters (feet)	Period of Continuous Daily Records
Skykomish River near Goldbar	12134500	1,386 (535)	1050 (3,450)	10/1/1928 to present
Tolt River near Carnation	12148500	210 (80)	720 (2,360)	9/1/1937 to present
North Fork Snoqualmie River near Snoqualmie Falls	12142000	166 (64)	930 (3060)	10/1/1929 to 9/30/1949 10/1/1961 to present
Middle Fork Snoqualmie River near Tanner	12141300	399 (154)	1040 (3400)	10/1/1961 to present
South Fork Snoqualmie River above Alice Creek	12143400	108 (41.6)	1040 (3410)	10/1/1960 to present
Snoqualmie River near Snoqualmie	12144500	971 (375)	870 (2,860)	10/1/1959 to present
Snoqualmie River near Carnation	12149000	1,530 (590)	710 (2,340)	10/1/1929 to present
Raging River near Fall City	12145500	83 (32)	710 (2,340)	9/1/1964 to present
Cedar River near Cedar Falls	12115000	105 (40.7)	1000 (3280)	10/1/1945 to present
Green River at Howard Hanson Dam	12105900	575 (220)	930 (1140)	10/1/1931 to present



Station	Elevation (meters)	COOP_ID
Everett	18	452675
Monroe	37	455525
Startup	52	458034
SeaTac	122	457473
Snoqualmie Falls	134	457773
Buckley	209	450945
Culmback	442	999999
Cedar Falls	476	451233
South Fork Tolt	609	458508

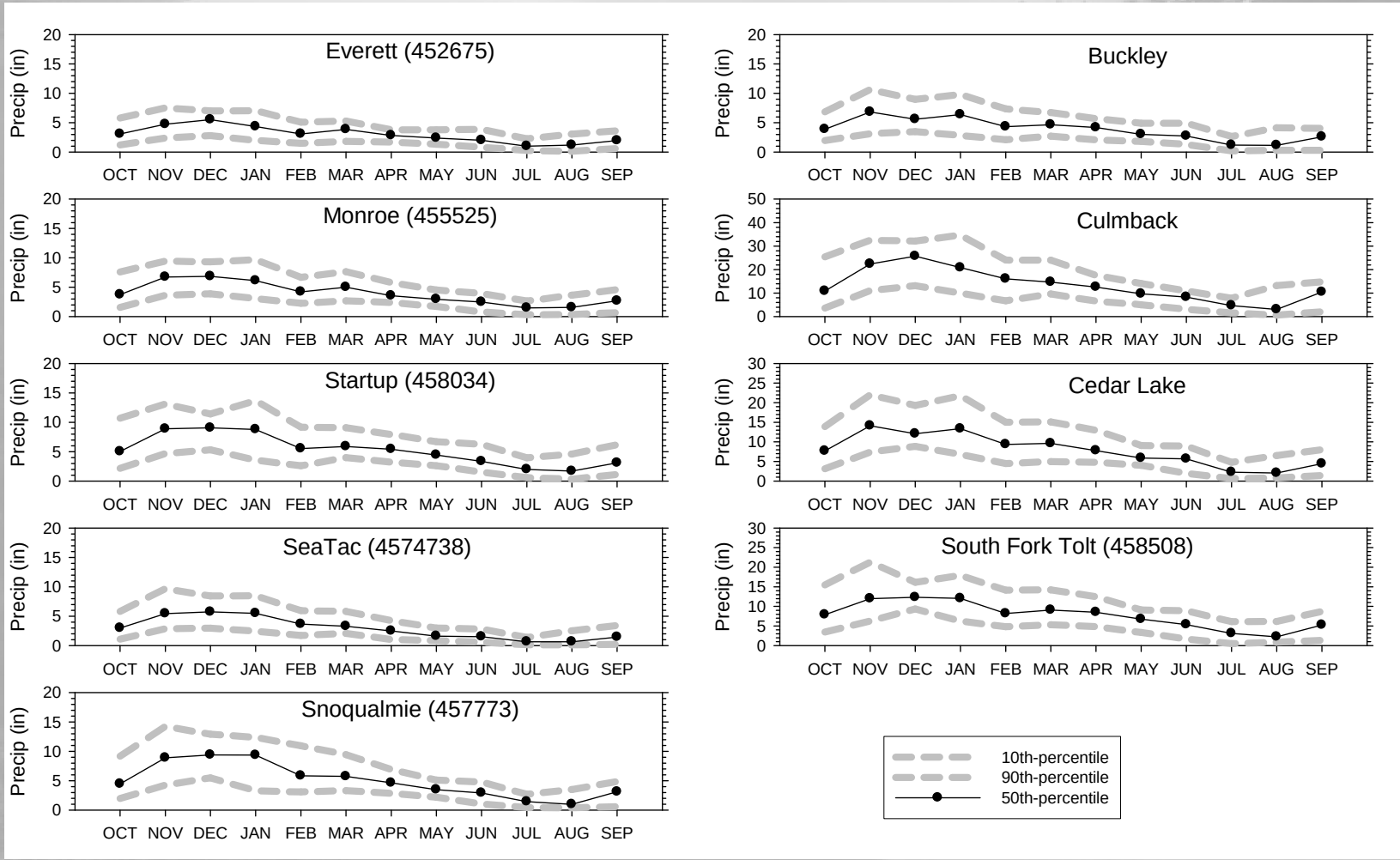
PRECIPITATION GAUGING STATIONS


Everett
Culmback
Monroe
Startup
SFTolt
Snoqualmi
SeaTac
Cedar
Buckley
PRISM 1971-2000


RAIN-ON-SNOW

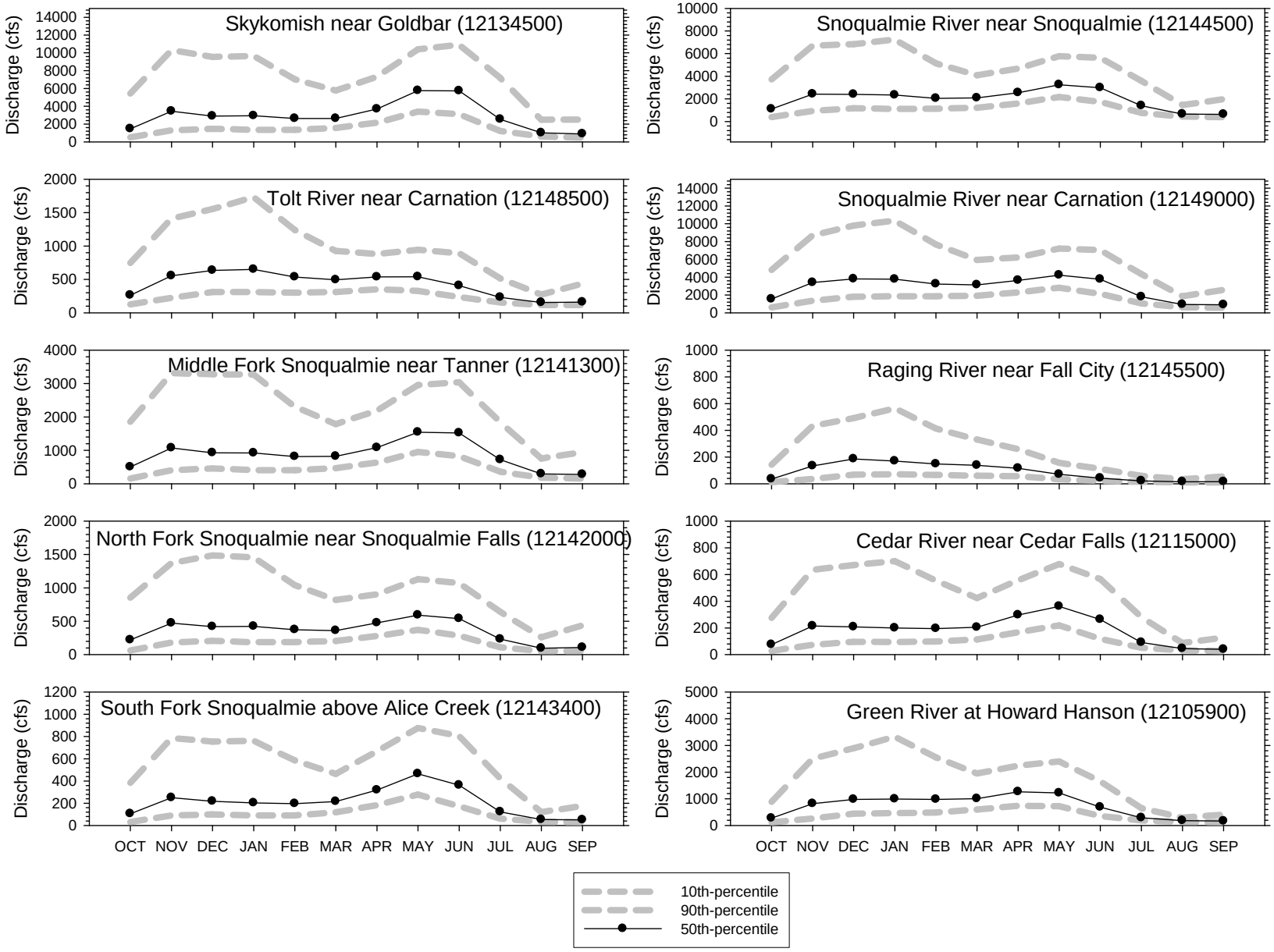
Time series plots of monthly precipitation percentiles (10th-, 50th-, and 90th-percentiles) based on water year 1962-2008 daily total precipitation records

Precipitation



USGS Discharge

Time series plots of monthly discharge percentiles (10th-, 50th-, and 90th-percentiles) based on water year 1962-2008 daily USGS discharge records



Trend Analysis Approach

- Non-parametric “distribution free” method
  - Mann-Kendall Trend test

Trend Analysis Approach

		Does a trend exist?	
		Yes	No
Has a trend been detected?	Yes	+	Type I Error: false trend detected when none exists
	No	Type II Error: failure to detect an existing trend due to weakness of the trend, of the methodology, or the shortness of the record	+

Trend Analysis Approach

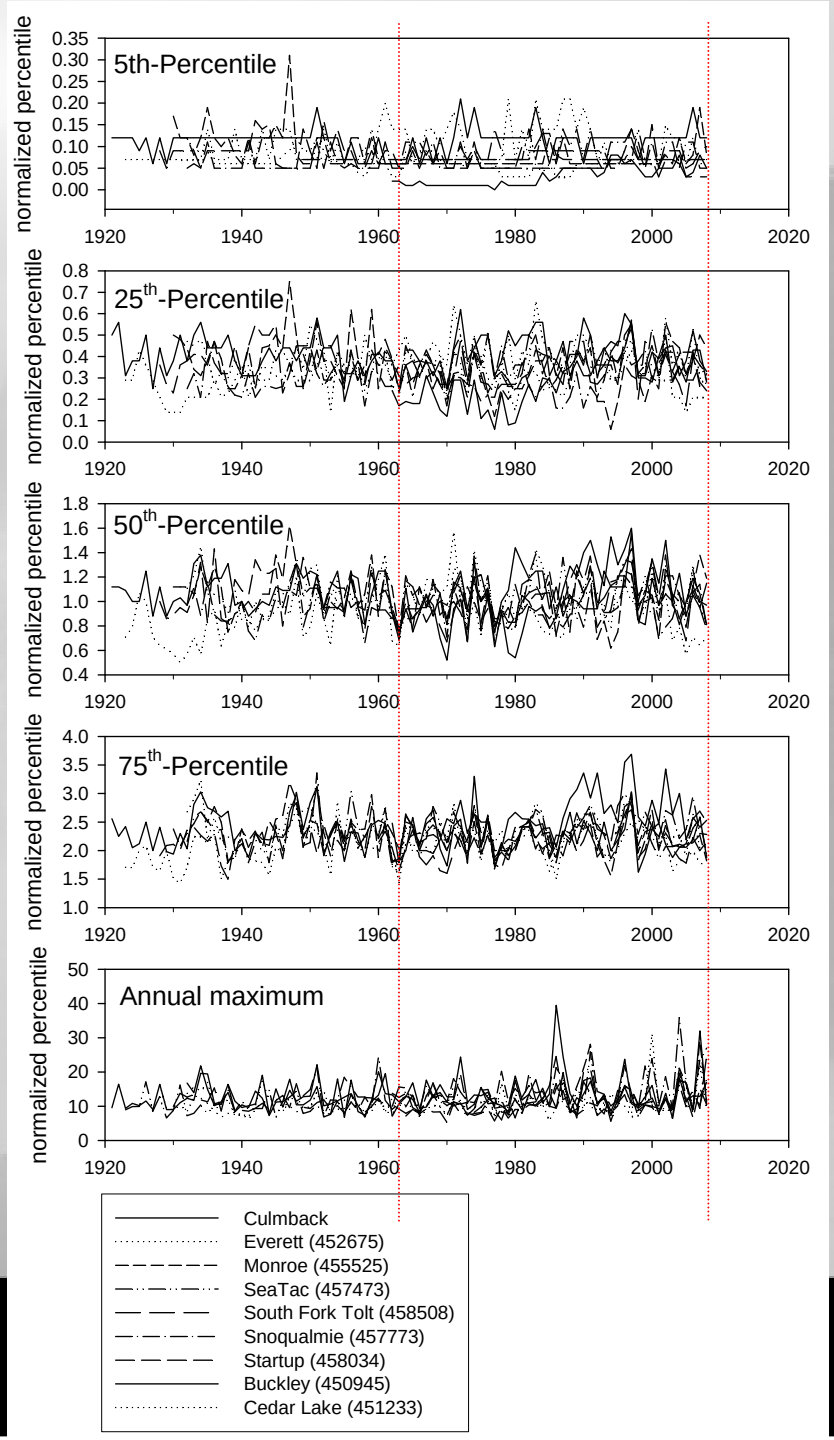
- *p between 1.0 and 0.1 (weakest evidence)*
- *p between 0.1 and 0.05 (weak evidence)*
- *p between 0.05 and 0.01 (strong evidence)*
- *p <0.01 (strongest evidence)*

“Nothing is certain, but I think some things are more nearly certain than others”

- Bertrand Russell (paraphrased)

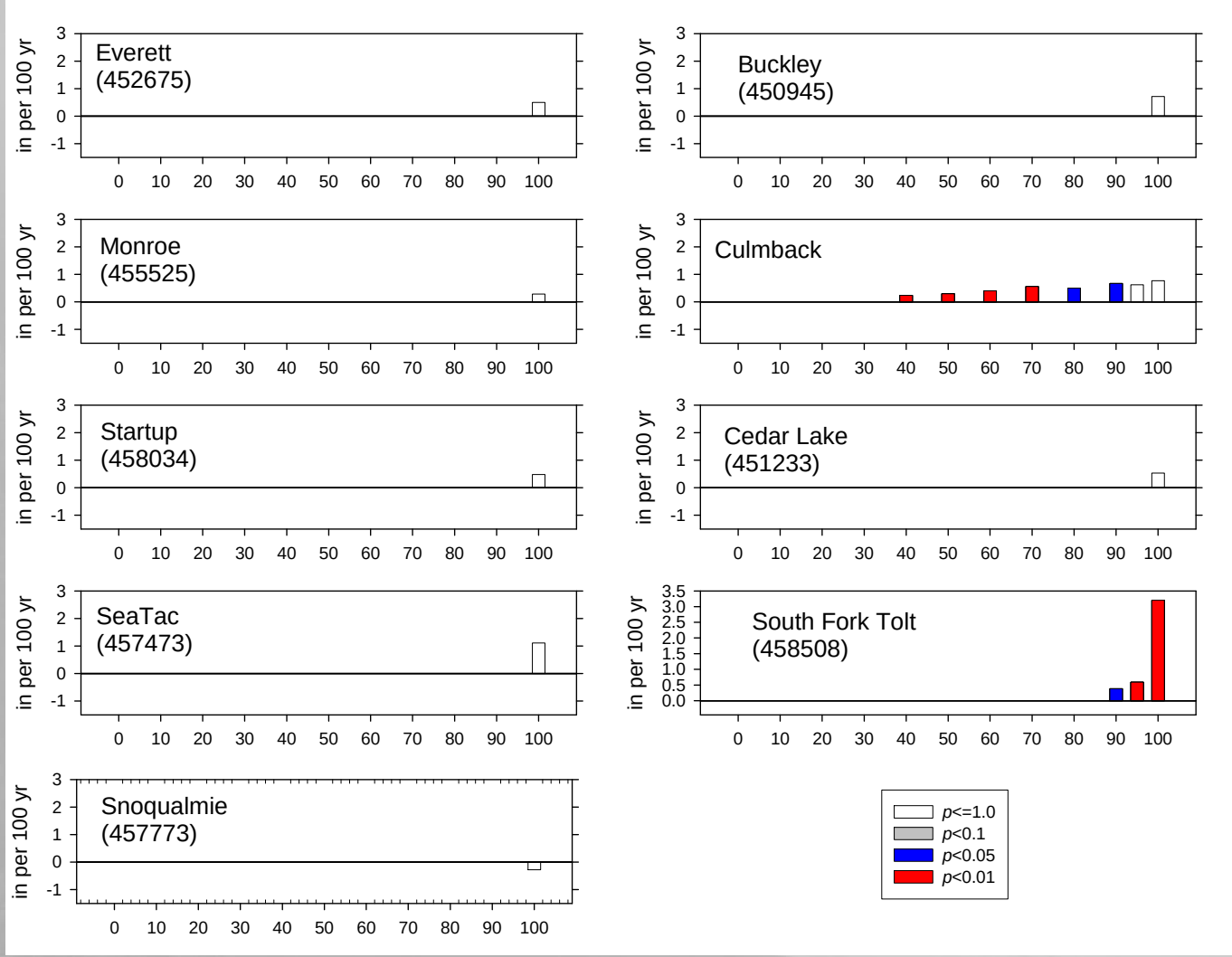
Time series plots of normalized annual precipitation percentiles (5th-, 25th-, 50th, 75th, and annual maximum divided by record median precipitation) based on water year 1929-2008 daily total precipitation records

Precipitation



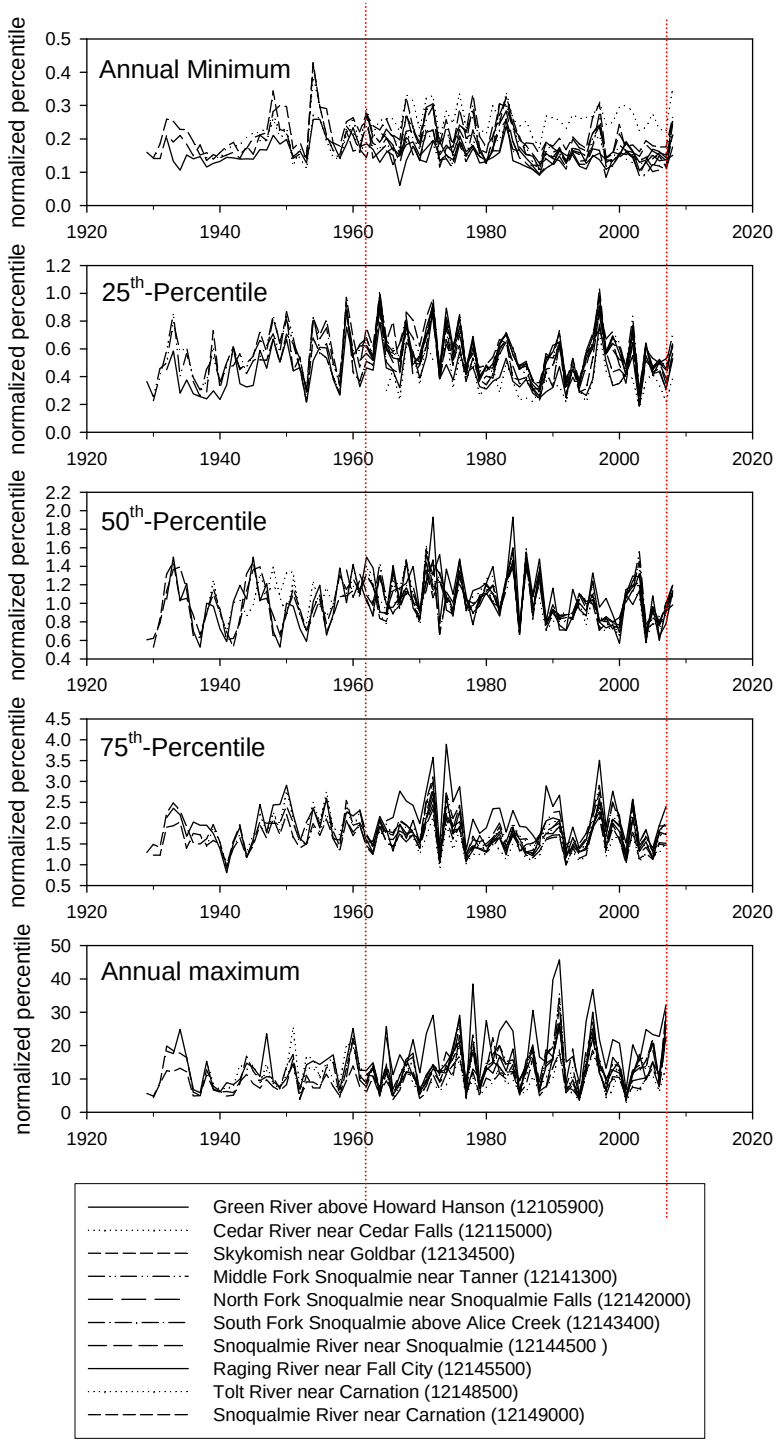
Trend plots of annual precipitation percentiles (every 10th-percentile) based on water year 1962-2008 daily total precipitation records*

Precipitation



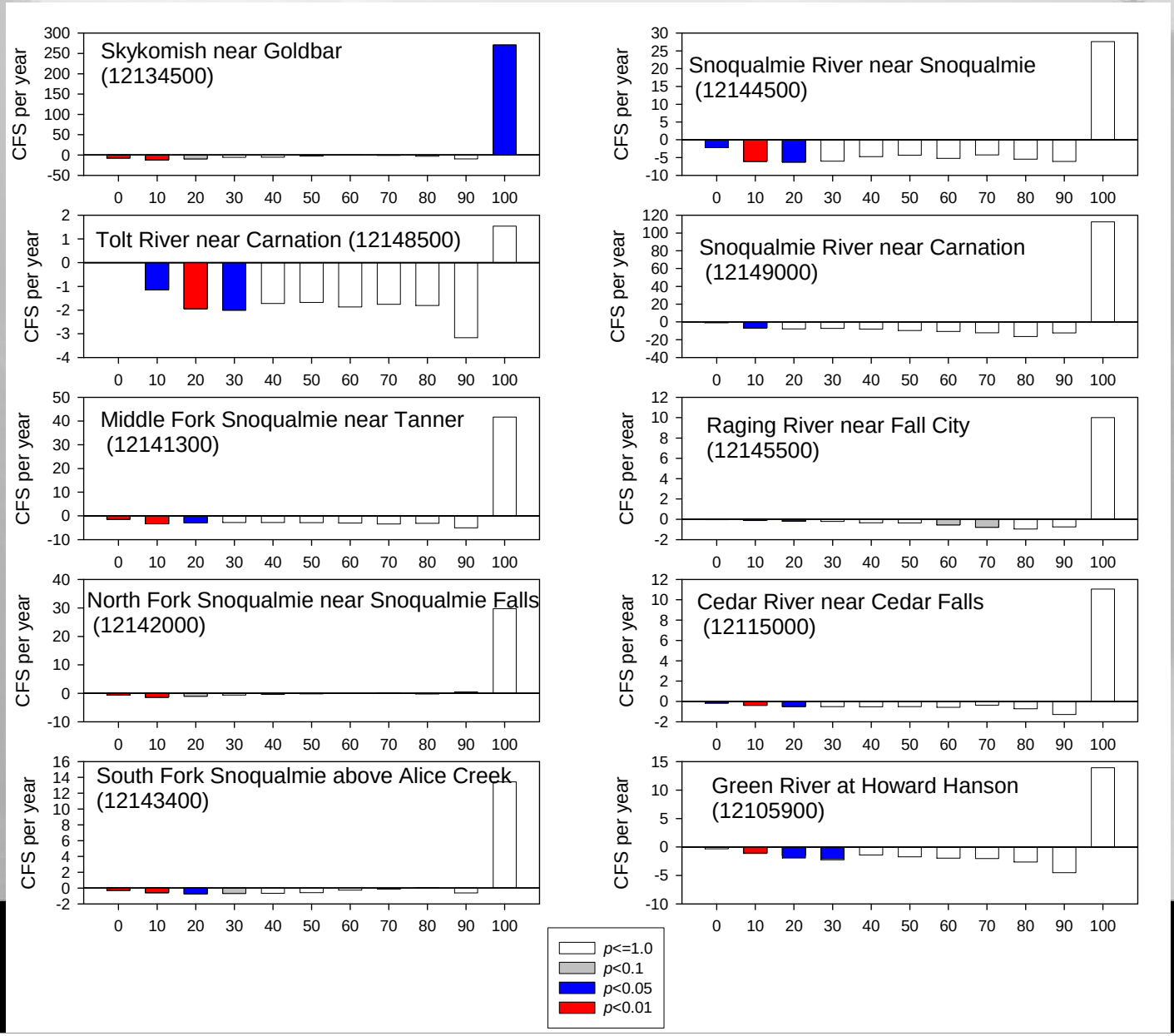
Time series plots of normalized annual discharge percentiles (annual minimum, 25th-, 50th, 75th, and annual maximum divided by record median discharge) based on all available complete water year daily USGS discharge records

USGS Discharge

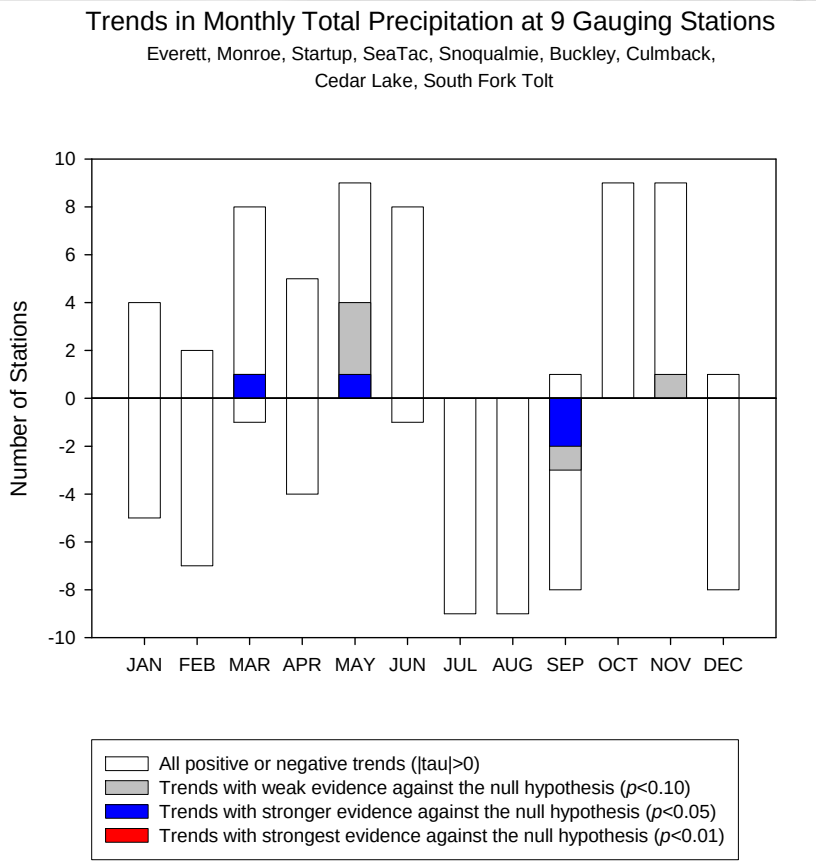


Trend plots of annual discharge percentiles (every 10th-percentile) based on water year 1962-2008 daily USGS discharge records

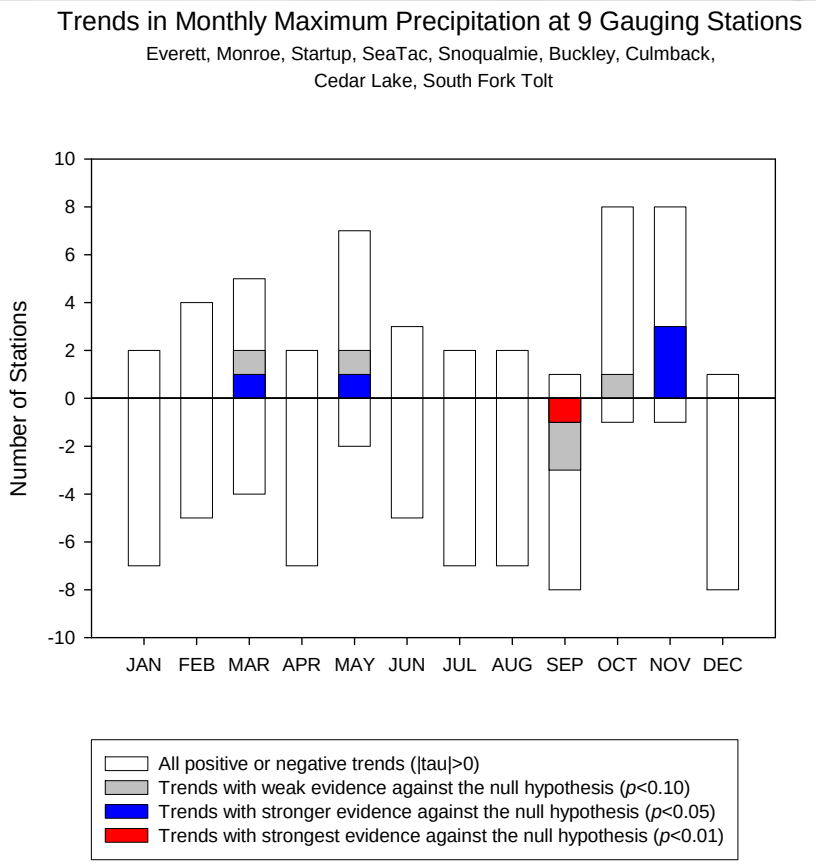
USGS Discharge



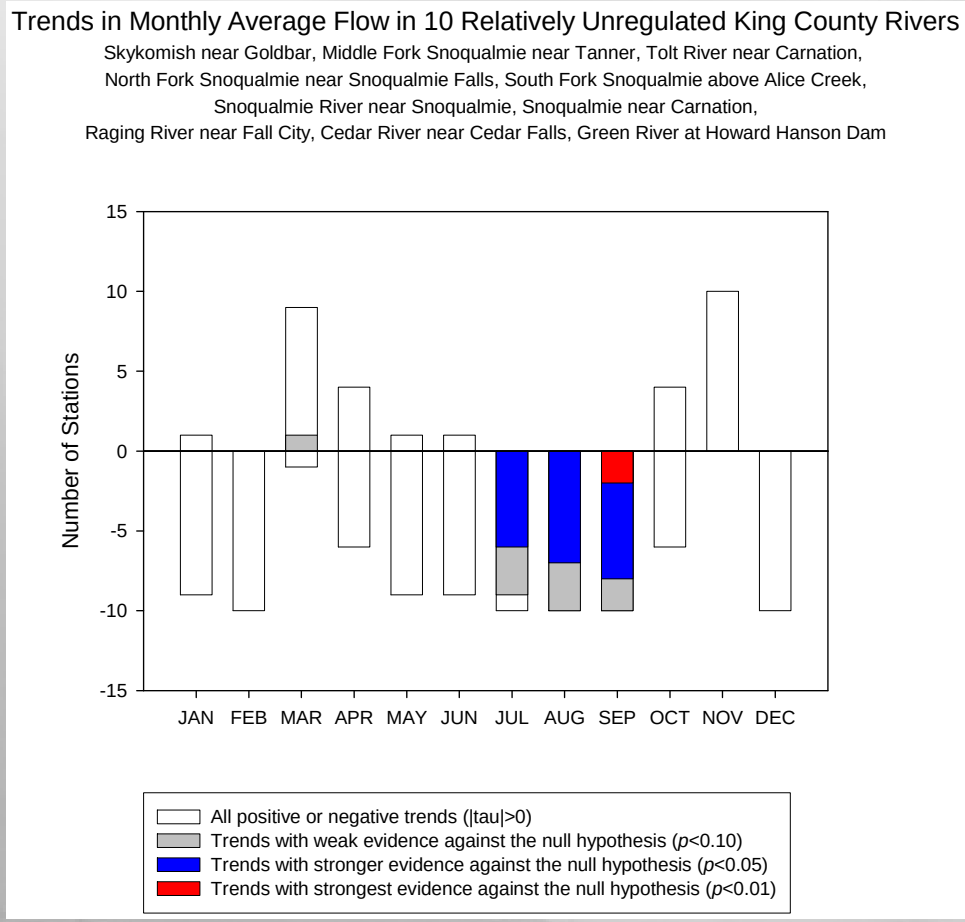
Water Years 1962 – 2008



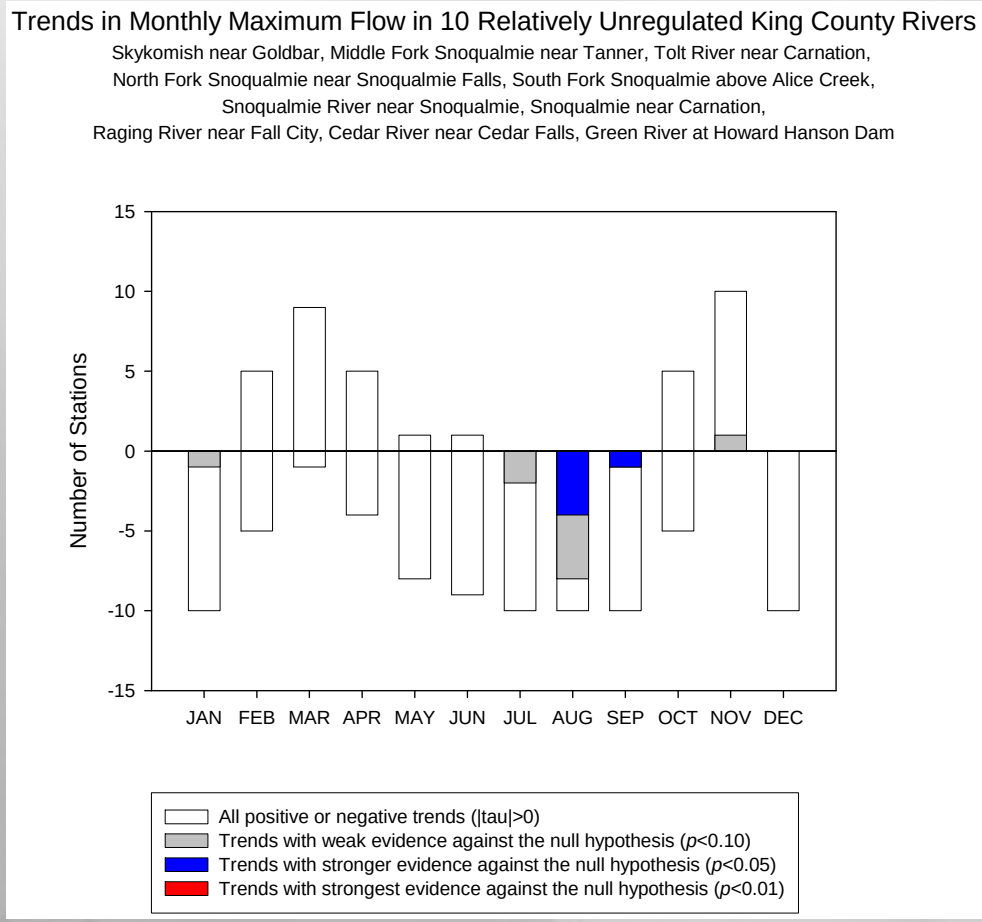
Water Years 1962 – 2008



Water Years 1962 – 2008



Water Years 1962 – 2008



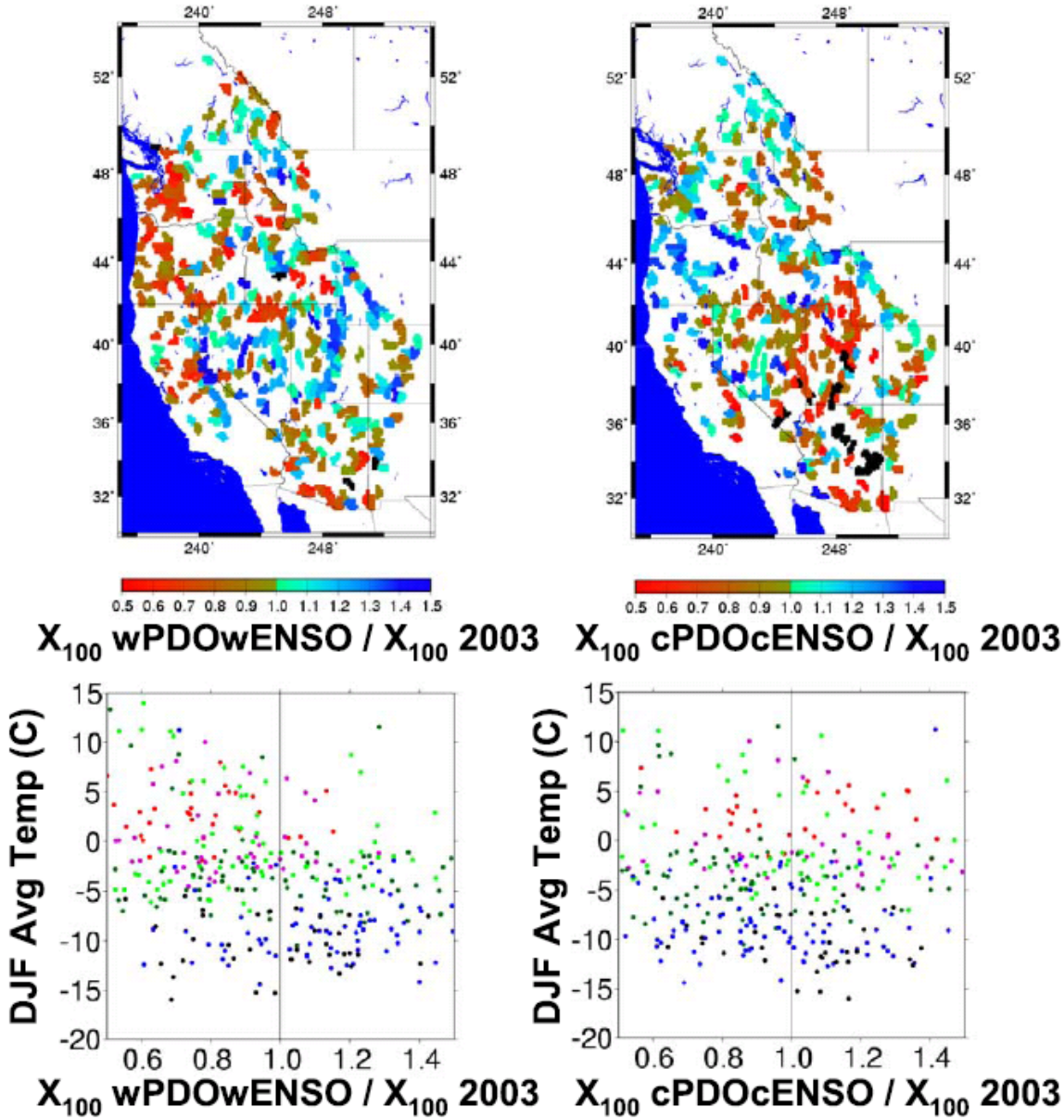


Figure 9. Same as Figure 7 except showing only warmPDOwarmENSO (left column) and coolPDOcoolENSO (right column) composites (black areas in the spatial plots are off scale on the low side).

Storm Tracks and Precipitation

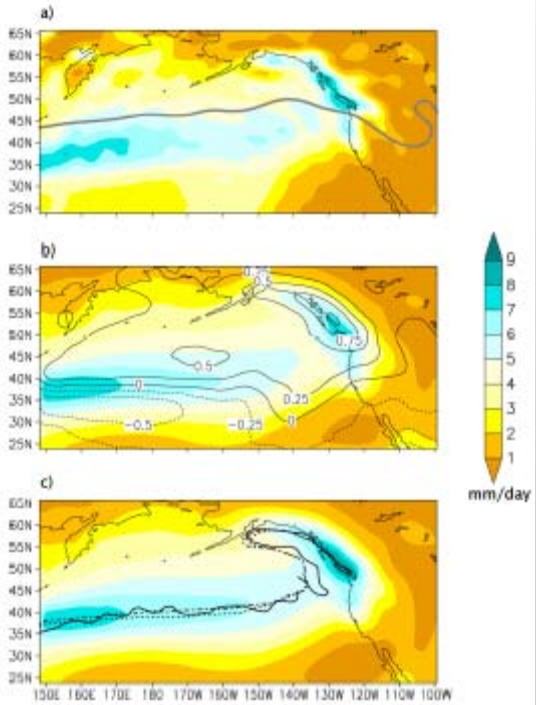


Figure 1. Precipitation tracks for (a) the NCEP-NCAR reanalysis, (b) model composite for 1950–2000, and (c) model composite for 2050–2100. Thick line in Figure 1a indicates the storm track in 500-hPa heights. In Figure 1b, contour lines indicate difference between 1950–2000 and 2050–2100 patterns. Lines in Figure 1c indicate the peaks of the NCEP-NCAR (solid), 1950–2000 (dash), and 2050–2100 (dash-dot) precipitation tracks.

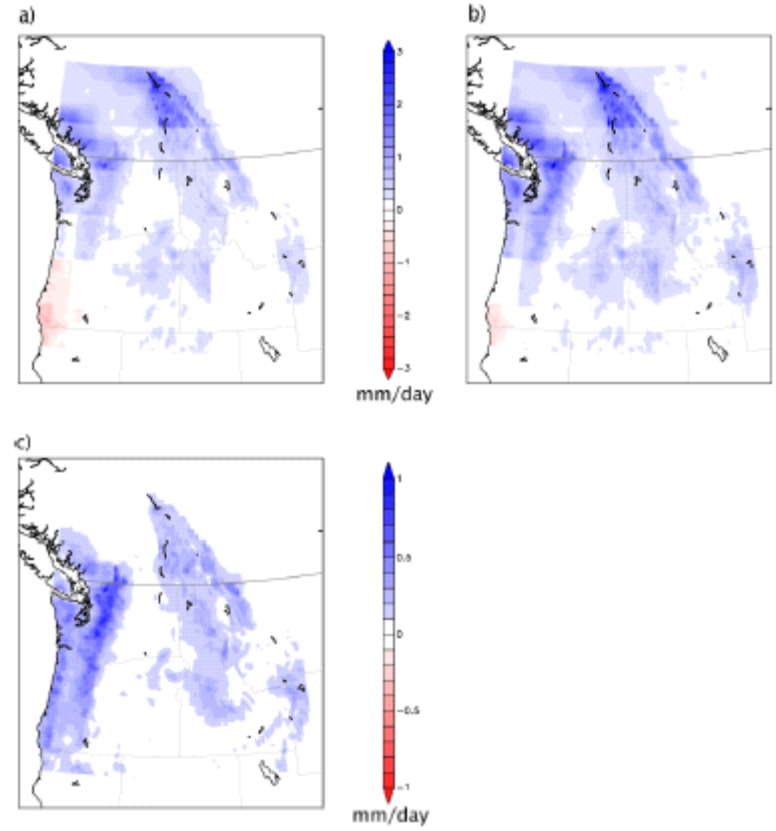
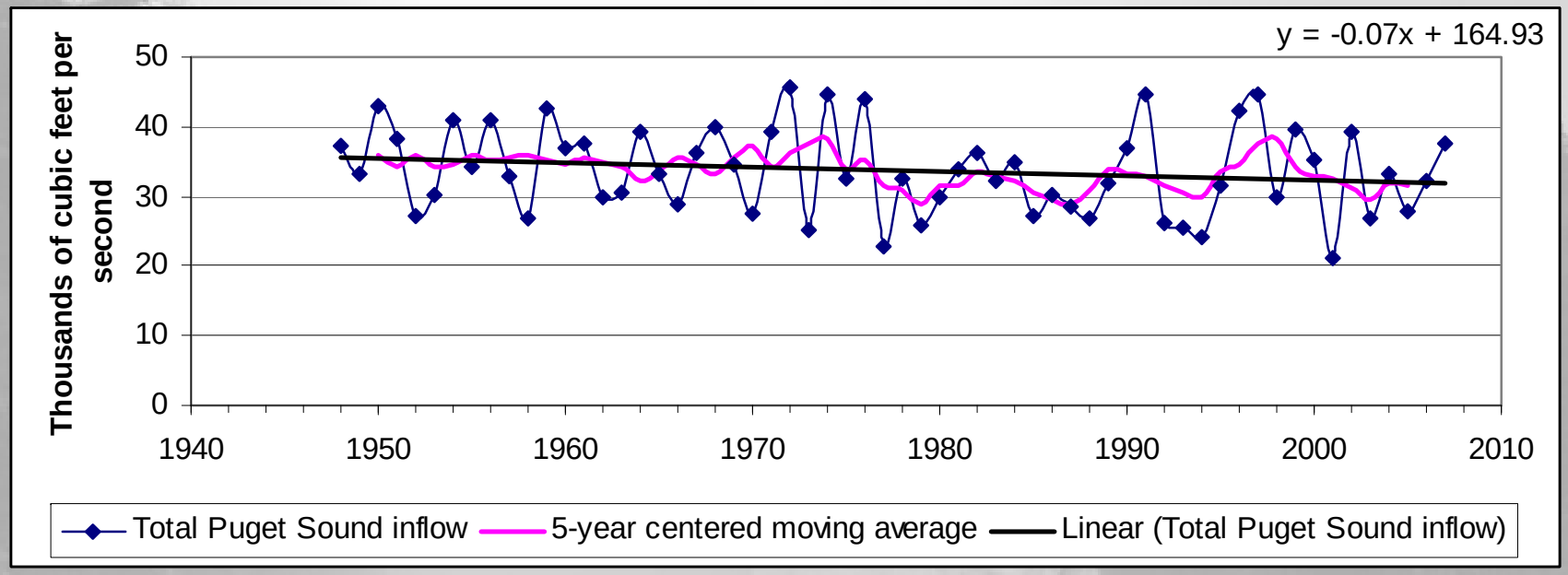


Figure 3. Difference in downscaled precipitation from 1950–2000 to 2050–2100 using (a) precipitation only as predictor and (b) precipitation and sea-level pressure as predictors. (c) Difference between Figures 3a and 3b; note different scale.



site_no	description
12200500	SKAGIT RIVER NEAR MOUNT VERNON, WA
12134500	SKYKOMISH RIVER NEAR GOLD BAR, WA
12149000	SNOQUALMIE RIVER NEAR CARNATION, WA
12101500	PUYALLUP RIVER AT PUYALLUP, WA
12167000	NF STILLAGUAMISH RIVER NEAR ARLINGTON, WA
12113000	GREEN RIVER NEAR AUBURN, WA
12061500	SKOKOMISH RIVER NEAR POTLATCH, WA
12119000	CEDAR RIVER AT RENTON, WA
12054000	DUCKABUSH RIVER NEAR BRINNON, WA

Stationarity

A random process where its statistical properties do not vary with time

Stationarity is dead

- Adaptation to climate change in the absence of a General Unified Theory
- Trade false certainty for uncertainty
- Continuity of long-term monitoring is critical
- “Modeling should be used to synthesize observations; it can never replace them.”
- Greater emphasis on soft (non-structural) management (engineering) solutions

Milley et al. 2008. Stationarity is dead: Whither water management. Science Vol. 319. no. 5863, pp. 573 - 574
DOI: 10.1126/science.1151915

Adaptation, Resilience, Overcoming Old Dichotomies

- Adapt to an uncertain non-stationary environment
- Adaptation as an integrating principle in water management – water law, policy, and management
- More and better data, information, and modeling
- Ecosystem, watershed, integrated water or watershed management

“No amount of sophistication is going to allay the fact that all your knowledge is about the past and all your decisions are about the future”

- Ian E. Wilson (former chairman of GE)