Trends in Western US Snowpack

Utilizing Snow Course and SNOTEL Data

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Introduction

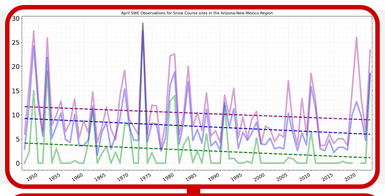
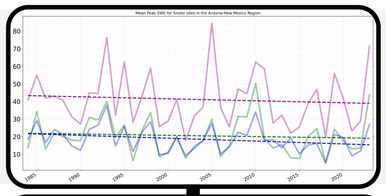
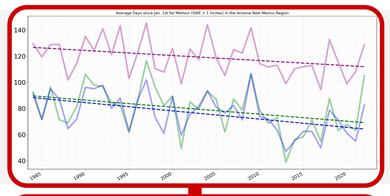
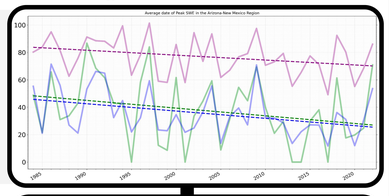
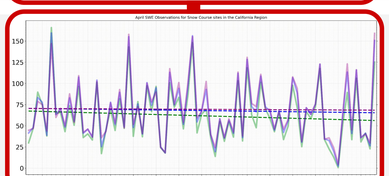
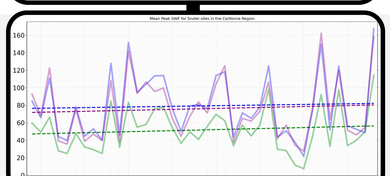
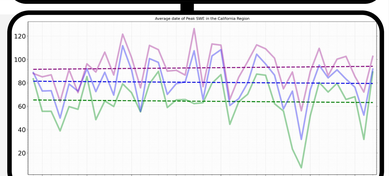
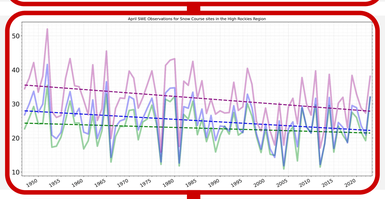
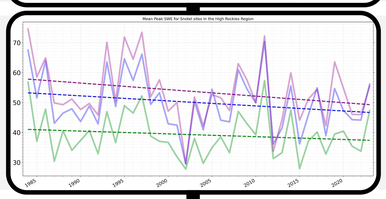
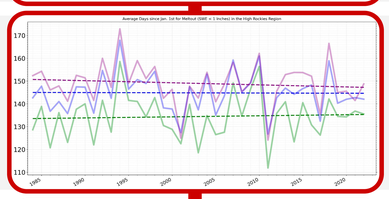
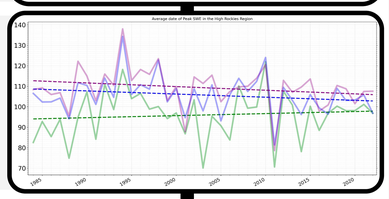
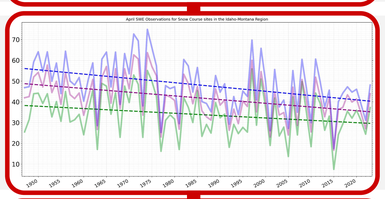
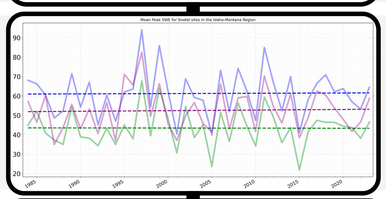
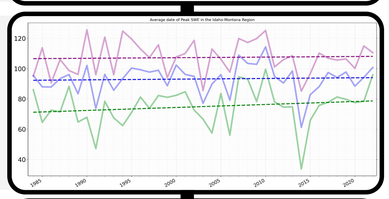
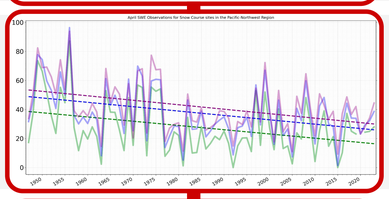
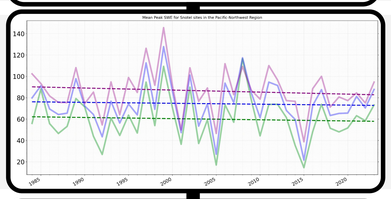
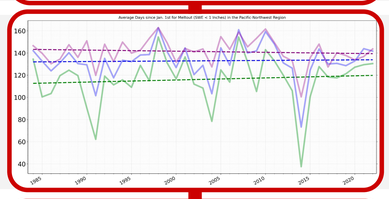
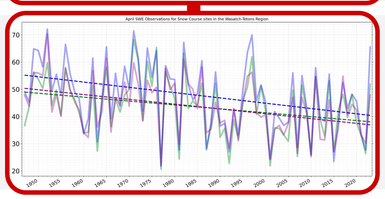
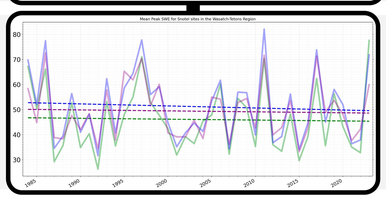
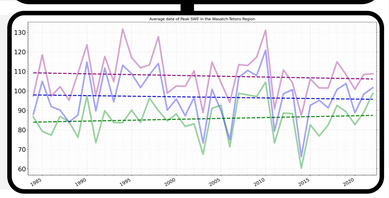
The Western US depends heavily on the seasonal snowpack stored in mountainous regions to provide water to its growing population. Even modest decreases in the long-term amount of runoff from melting snow that reaches the lowlands will have severe impacts on >70 million people, threatening drinking water availability and imperiling tens of billions of dollars in commerce. Therefore in a warming climate, it is essential to examine the state of the snowpack in the region to detect trends as they emerge.

Data

The SNOw TELemetry (SNOTEL) network is a monitoring database comprised of remote, high-elevation, automatic observation sites that monitor various climatological aspects including Snow Water Equivalent (SWE). SNOTEL sites are typically able to collect this data daily. Snow Course measurements are sites where manual data is collected regarding aspects of the snowpack, often in remote, high-elevation locations where monitoring snowpack is important. Snow Course observations are typically conducted on a monthly basis during months where snowpack is present. In general, Snow Course sites have longer periods of record than SNOTEL sites.

- 1st Elevation Tercile
- 1st Elevation Tercile Linear Trend
- 2nd Elevation Tercile
- 2nd Elevation Tercile Linear Trend
- 3rd Elevation Tercile
- 3rd Elevation Tercile Linear Trend

Results

	Snow Course April SWE Observations	SNOTEL Mean Peak SWE	SNOTEL Average Meltout Date	SNOTEL Average Peak SWE Date
Arizona & New Mexico				
California				
High Rockies				
Idaho & Montana				
Pacific Northwest				
Wasatch & Tetons				

Figs. 1A to 1F: *April SWE values for Snow Course sites in 7 different regions broken up into 3 elevation terciles.*
Y-Axis: *Centimeters* ***X-Axis***: *1947 - 2023*

Figs. 2A to 2F: *Mean peak SWE values for Snotel sites in 6 different regions broken up into 3 elevation terciles.*
Y-Axis: *Centimeters* ***X-Axis***: *1983 - 2023*

Figs. 3A to 3F: *Average days between Jan 1st. and meltout for Snotel sites in 6 different regions broken up into 3 elevation terciles.*
Y-Axis: *Days since Jan 1st* ***X-Axis***: *1983 - 2023*

Figs. 4A to 4F: *Average days between Jan 1st. and peak SWE for Snotel sites in 6 different regions broken up into 3 elevation terciles.*
Y-Axis: *Days since Jan 1st* ***X-Axis***: *1983 - 2023*

Alaska

*Long-term Alaska SNOTEL data too few for the purposes of this research.

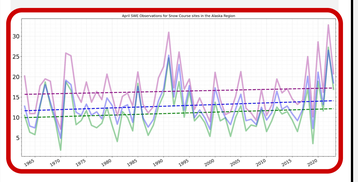


Fig. 5: *April SWE values for Snow Course sites in Alaska broken up into 3 elevation terciles.*
Y-Axis: *Centimeters* ***X-Axis***: *1963 - 2023*

Discussion

These results are foremost preliminary and future work on this research should complete a more thorough investigation of the data being used and the programs used to calculate and graph the data. As such, this work cannot be considered conclusive. These results, nonetheless, represent a variety of expected and unexpected outcomes. As expected, most trends are pointing down over time, indicating a decrease in the amount of snow received each year. Some trends point upwards however, indicating that climate change may be affecting sites in unanticipated ways. Such is the case in the Alaska trend, where there is a small but notable increase in peak SWE over time. Due to the the SNOTEL period of record being only around 40 years, these sites may be strongly affected by decadal-scale natural oscillations rather than by global warming. These results also demonstrate that SNOTEL and Snow Course data will be a potent tool to monitor climate change's impact on snowpack in the future.