



Assessment of Snowpack-Influencing climate Change in the Colorado Rockies and Oregon Cascades using a Simple Winter Precipitation Index

Has recent climate change benefited mountain snowpack?

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Introduction

This study looks for signs of change in snowpack conductive factors (SCF), which are climatically related, and independent of changes in absolute precipitation. Changes in the SCF in the Rocky Mountains of Colorado, and the Cascades of Oregon, in the western United States, are sought using a simple index: the ratio of the percent of average snow water equivalent (SWE) divided by the percent of average precipitation, (%SWE/%PPT).



Snowpack Index

The %SWE/%PPT index is computationally simple, but its physical interpretation requires some explanation. This index is a ratio between the percent of the average

amount of SWE and the percent of the average total winter precipitation, for the same place and time. Thus, it is insensitive to changes in absolute precipitation, but does indicate whether the snowpack is what it should be, given the amount of precipitation that has fallen, relative to the past mean. The basis for the past %SWE and %PPT is the period 1961-90.

HOW TO INTERPRET THE INDEX

A ratio of one indicates that factors impacting snowpack conditions are unchanging, even if the snowpack is lower or higher than average. A ratio of less than one indicates the SCF are changing toward less of the winter precipitation being held in the form of snow (some may simply say it is warmer, but this would be an over-simplification). Conversely a ratio of greater than one indicates SCF are changing toward more of the winter precipitation being sequestered in the snowpack. These ratios are relative to the period 1961-1990.

EXAMPLE

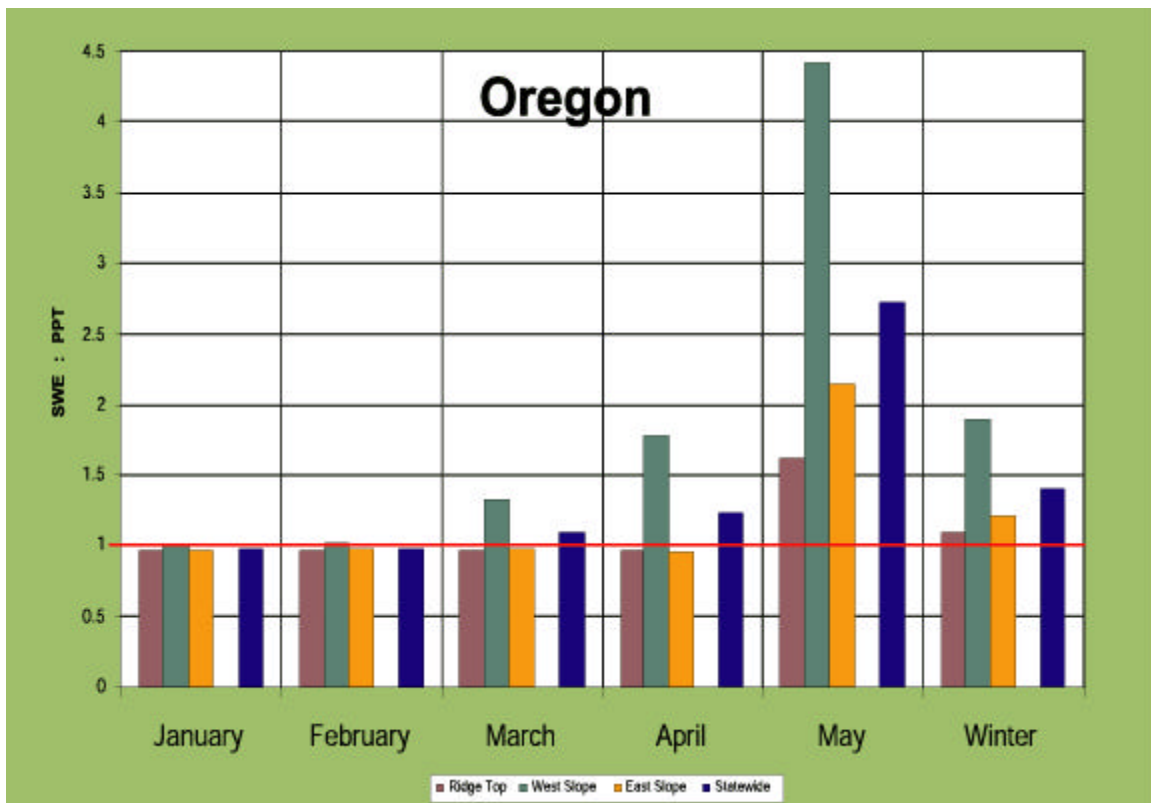
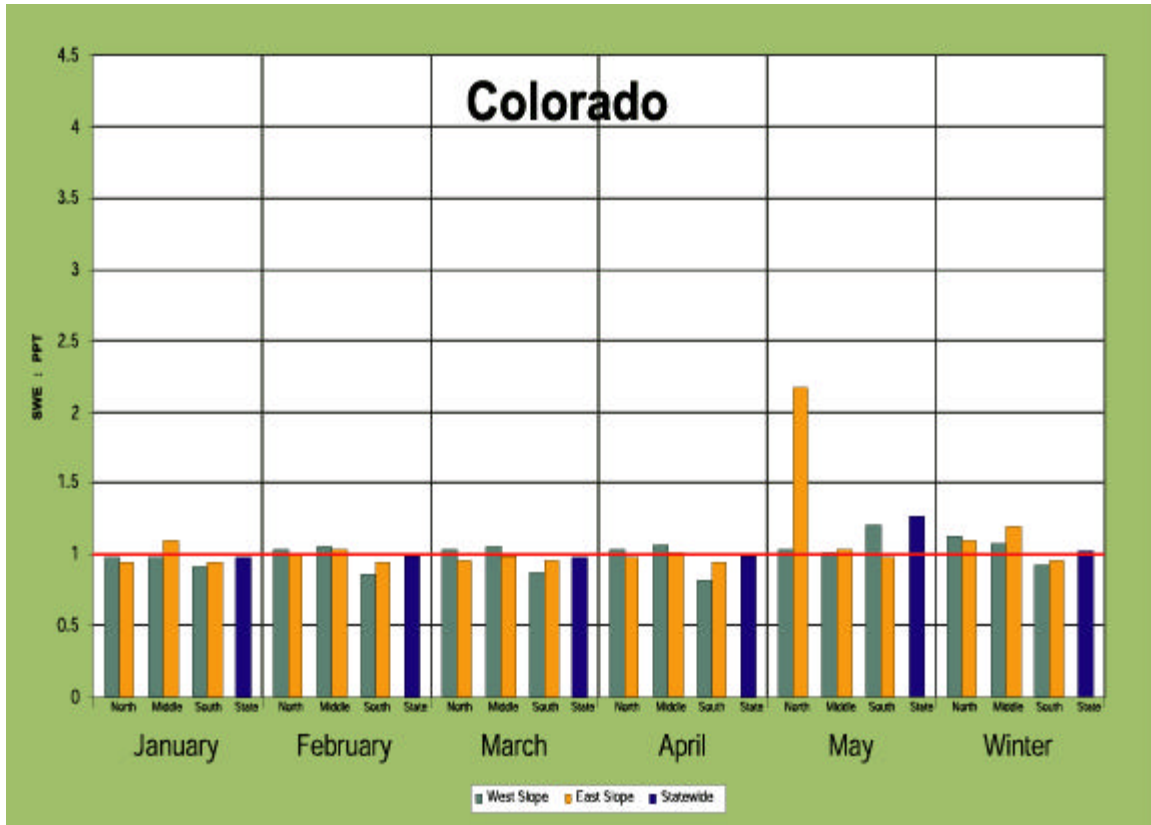
If the snowpack SWE (snow water equivalent) on April 1 is 73% of average at this particular site, and the total winter precipitation there is 73% of average, then the ratio of one indicates no change in SCF. However, if the snowpack SWE is 108% and the total precipitation to date is 115%, the ratio is less than one, indicating that there would be more snowpack if conditions were not changing, and thus factors that negatively effect snowpack formation are increasing. Conversely, if the SWE is 73% of average, and the total precipitation is 65%, the ratio of greater than one indicates that SCF are increasing relative to the past mean.

Trends in the ratio are very conservative, because of the base period used for determination of “average”. Since the SWE and precipitation data analysed are for 1981-2000, and the base period is 1961-1990, any trends will be very conservative.

INDEX CHARACTERISTICS

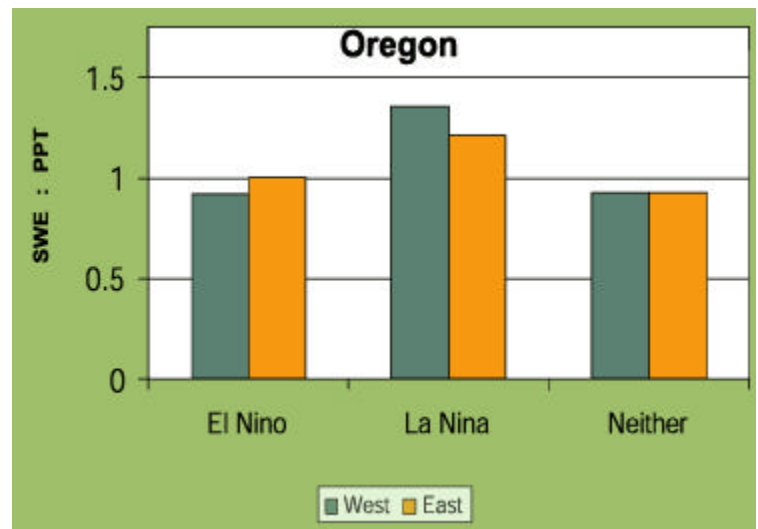
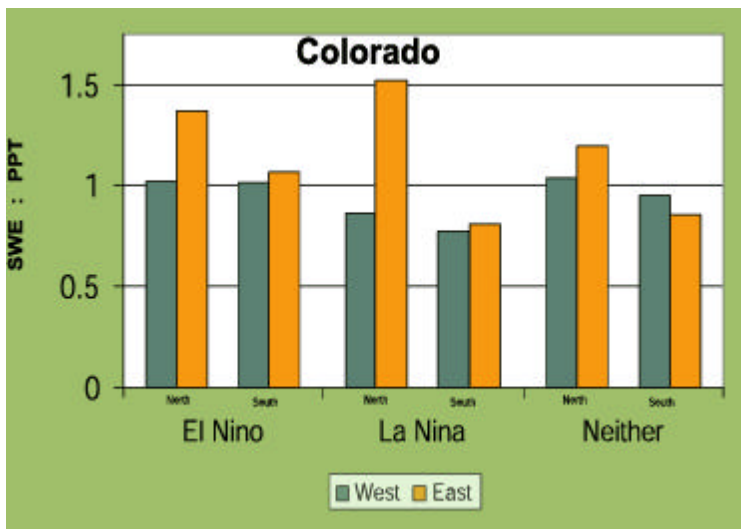
At both sites, the ratios tend to be lower (less precipitation is sequestered in the snowpack) in the early months of the season (J, F, M), and increase (more precipitation is sequestered in the snowpack) later, in April. The increase in late season is so large that it dominates the season average. Within this pattern, in Oregon, the ratios are above one on

the west slope, and below one on the east. In Colorado, they tend to be above one in the northwest, and below one in the southeast.



ENSO

There are clear ENSO phase related differences in the SCF in Oregon, but not in Colorado. In Oregon, the ratios are enhanced (more precipitation in the snowpack) during La Nina, depressed during El Nino (except on the east side), and intermediate during the “neither” phase. Also, these patterns do not appear to be month-sensitive through the course of the winter, which is in contrast to the overall record. In Colorado, although there are no strong tendencies, the ratios are higher in the SE during El Nino, and lower in the NW during La Nina. They also tend to be higher in the NE late in the season during El Nino (an increase in upslope snowstorms is a possible result of increasing meridional flows associated with El Nino), and during the “neither” phase.



SUMMARY

Factors that control whether winter precipitation is sequestered in snowpack, or not, are evaluated for change, in the mountains of Colorado and Oregon. The conditions that determine if winter precipitation is held in the snowpack, not the absolute increase or decrease of snowpack, is the quantity assessed in this study. The results show that these factors are changing with respect to the 1961-1990 period.

SPATIAL CHANGE

In Colorado, factors conducive to precipitation being sequestered in the snowpack (SCF), are generally declining in the south and east, and increasing in the north and west, but this has a strong season component. In Oregon, the SCF are generally increasing in the west, and decreasing in the east, with a strong seasonal component here, also.

TEMPORAL CHANGE

In both Colorado and Oregon, the full winter averages for the whole state, shows snowpack conductive factors (SCF) increasing. However, this is not true for most of the winter months, individually. January, February, and March generally show declines in the SCF, and May shows a great increase. The May increase is large enough to swamp the declining signal of the other months, resulting in a seasonal and statewide average ratio of greater than one, indicating more of the winter precipitation is sequestered in the snowpack. The only regions of the two state area that show a seasonal decline are the southeast and southwest Colorado.

ENSO

The phase of the El Nino- Southern Oscillation appears to have a significant influence on the SCF in Oregon, but not in Colorado. In Oregon, the ratios are higher (more winter precipitation is sequestered in the snowpack) during La Nina, lower during El Nino (except on the east slope), and intermediate during the “neither” phase. In Colorado, the ratios tend to be lower in the SE and NW during La Nina’s, and higher in the SE during El Nino’s. They are also higher in the NE during the “neither” phase, and late in the winter during El Nino’s.