Relationships between Atmospheric Circulation, Mountain Snowpack and Adjacent Lowland Precipitation in the Western U.S.

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Introduction

High elevation snowpacks provide vital water sources for an increasing population in the western U.S. Some of the recent issues related to mountain snowpack include recreation and tourism, hydrology and water supply. How these is potentially impacted in monitoring of snowpack changes (Cayan 1996; Sellers et al., 1998; Clark & Stuiver, 2000; Mote et al. 2005).

This research examines variably in montane, as measured by Age I SWE (snow water equivalent) on three mountain ranges: the Northern Colorado Rockies (NCR), the Northern Sierra Nevada (NSN) and the Northern Oregon Cascades (NOC). The selected networks had similar snow cover and maximum extant SWE values. For each mountain range, we divided the sites into east and west slopes, since transverse variability along each range is much smaller than that across it. To avoid spatial scale issues, we selected sites without mountainous topography and released the mean of several stations for each site (Table 1). All these methods were used to monitor.

Indication analysis was done for:

a) Past trends in SWE and LWP, and their relationship
b) Differential Circulation controls on SWE

Conclusions regarding the relative sensitivities of snowpack in the three locations to environmental change are obtained.

Data

Age 1 SWE for 1957-2000 inclusive was obtained from U.S. Snow records at most, available from the National Resources Conservation Service (NRCS) for Colorado and Oregon, and the California Department of Water Resources for the west slopes, since transverse variability along each range is much smaller than that across it. To avoid spatial scale issues, we selected sites without mountainous topography and released the mean of several stations for each site (Table 1). All these methods were used to monitor.

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Climatic Data Center (http://www.ncdc.noaa.gov). Details of monthly and annual precipitation and temperature for each site were used. Higher sites were selected to be representative in the “typical” elevation range. Rare events that were not used.

SWE is the total cumulative October – April J SWE precipitation (mm) and labeled (mm) from National Weather Service Station through the National Climatic Data Center. Details of monthly and annual precipitation and temperature for each site were used. Higher sites were selected to be representative in the “typical” elevation range. Rare events that were not used.

Maps of Anomalous 700 mb Circulation for Three Mountain Ranges

Maps of Anomalous 700 mb Circulation for Years of High SWE (Upper Quartile) minus Years of Low SWE (Lower Quartile) in the Three Mountain Ranges

Synoptic Signatures for Unusual Years

The top left set of maps shows the anomalous circulation at 700 mb for five years of high SWE (defined as occurring in the top 25% of all years) minus five years of low SWE (defined as the lowest 25% of all years) for each mountain range. The maps illustrate how anomalous flow associated with SWE is related to particular mountain range. In NSN the anomalous flow is north-westerly over the Cascades and the Pacific Northwest, whereas in NCR and NOC it is southerly. In NOC the anomalous flow over the Cascades is southerly and over the west slopes, southerly. There are no strong circulation signatures for the NCR, suggesting that SWP is a lesser determinant in circulation in the region.

The circulation signatures for LWP are not nearly as strong as those representing SWE and NSN with north-westerly flow compensating over the western U.S. The low pressure systems in the north (high pressure systems in the south) are the most productive in building up LWP. The high pressure systems in the north are less advantageous in the building up springtime LWP.

Finally the maps to the right show the anomalous 700 mb circulation for five years of high SWE (defined as occurring in the top 25% of all years) minus five years of low SWE (defined as the lowest 25% of all years) for each mountain range. The maps illustrate how anomalous flow associated with SWE is related to particular mountain range. In NSN the anomalous flow is north-westerly over the Cascades and the Pacific Northwest, whereas in NCR and NOC it is southerly. In NOC the anomalous flow over the Cascades is southerly and over the west slopes, southerly. There are no strong circulation signatures for the NCR, suggesting that SWP is a lesser determinant in circulation in the region.

Discussion and Conclusions

We analyzed Age 1 SWE and LWP on both the east and west slopes of three mountain ranges in the western U.S.: the Northern Colorado Rockies (NCR), Northern Sierra Nevada (NSN) and Northern Oregon Cascades (NOC).

Trends in LWP and SWE were found to be discernible. Although SWE is decreasing in three locations (both slopes of NOC and the east slope of the NCR), LWP does not decrease. The relationship between SWE and LWP is examined through regression analysis. SWE and LWP are highly correlated for years with high SWE values and low LWP. However, there does not appear to be a significant relationship on the west slope for any of the slopes. In the west slope the correlation is not as strong, indicating that snowpack accumulation can take place without a corresponding increase in LWP.

The Rocky Mountain snowpack is not only sensitive to changes in summertime rainfall and temperature conditions, but also to changes in low-elevation precipitation and snowpack accumulation. Although the overall trend in LWP is decreasing, the trend is more pronounced in the west slope of the NCR. The trend in SWE is not as pronounced, indicating that snowpack accumulation can take place without a corresponding increase in LWP.