# Hydrologic Changes in the Western U.S. from 1916-2003

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## Changes in Simulated April 1 Snowpack for the Cascade Range in Washington and Oregon

<table>
<thead>
<tr>
<th></th>
<th>Current Climate</th>
<th>“2020s” (+1.7 C)</th>
<th>“2040s” (+2.5 C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 1 SWE (mm)</td>
<td></td>
<td>-44%</td>
<td>-58%</td>
</tr>
</tbody>
</table>

![Map showing changes in April 1 snowpack for the Cascade Range in Washington and Oregon](attachment:image)
Effects to the Cedar River (Seattle Water Supply) for “Middle-of-the-Road” Scenarios

Obs. Summer Water Availability is Declining

Figures courtesy of Matt Wiley and Richard Palmer at CEE, UW
Observed Climate Change and Hydrologic Impacts for the West

Physical Characteristics of the Mountain West

Elevation (m)  DJF Temp (C)  NDJFM PCP (mm)
Schematic of VIC Hydrologic Model and Energy Balance Snow Model

Source: Mote et al. (2005)

Trends in April 1 SWE 1950-1997

Source: Mote et al. (2005)
Relative Trend in April 1 SWE (% per year)

1916-1997

Effects of Temp

Relative Trend in April 1 SWE (% per year)
Effects of Precip

Decadal Climate Variability Doesn’t Explain the Loss of SWE Due to Warming

1916-97
1947-97
1925-46 with 1977-95

Relative SWE Trends Due to Temperature Effects Alone (% per year)
Seasonal Water Balance
Naches River

Current Climate

More runoff in winter and early spring, less in summer

2040s Scenario (+ 2.5 C)
As the West warms, winter flows rise and summer flows drop


Figure courtesy of Iris Stewart, Scripps Inst. of Oceanog. (UC San Diego)
Effects of temperature and precipitation

-19% per decade

Effects of temperature alone

-25% per decade

Trends in April 1 SWE for the WA and OR Cascades

y = -0.5851x + 295.29

y = -0.7553x + 301.86
**Conclusions**

- Large-scale changes in the seasonal dynamics of snow accumulation and melt have occurred in the West as a result of increasing regional temperatures.

- The most sensitive areas are coastal mountain ranges with relatively warm winter temperatures (e.g. the Cascades)

- Hydrologic changes include earlier and reduced peak snowpack, more runoff in March, less runoff in June, and corresponding increases in simulated spring soil moisture and decreases in late summer and fall soil moisture.

- Because these effects are shown to be predominantly due to temperature changes, we expect that they will both continue and increase in intensity as global warming progresses in the 21st century.