1. Introduction

Recent studies strongly suggest that the increase in anthropogenic greenhouse gases will induce significant global climate changes in this century. Future changes in regional hydroclimate in response to the global climate change is an important concern for California. California relies heavily on the cold season precipitation and snow accumulation for the water supply during dry warm seasons. Significant changes in the precipitation and snow accumulation in California are of particular concern because a large fraction of the annual water supply in the state depends on snow accumulation in the Sierra Nevada. Since it is quite difficult to simulate changes in regional precipitation and snow accumulation from the global climate models, considerable part of the uncertainty lies in the fact that the global models are not able to accurately simulate precipitation and snow accumulation in the Sierra Nevada. The large-scale salient forcing including SST has been updated at 6-hour intervals.

2. Experimental Design

- **The dynamical downscaling is performed using the RESM based on WRF 2.2.1** (http://wrf-model.org). The physics options selected in this experiment include the NOAH land-surface scheme, the RTM longwave radiation scheme, Dudhia shortwave radiation, and the WSM 3-class with simple ice cloud microphysics scheme.
- **Overall decreases in the cold season precipitation are projected for California** (Fig. 3.3a).
- **The projected decrease in the surface albedo is more pronounced in winter than in fall.**
- **The large warming in the high elevation region is accompanied by a large decrease in the surface albedo.**
- **The spatial pattern of the seasonal precipitation changes are associated closely with the rainfall changes.**
- **One exception is in the northern Sierra Nevada region where rainfall increases in both seasons.**
- **The increase in rainfall in the region is one of the most important consequences of the projected snowfall increase in cold climate into rainfall in warmer climates.**

3. Results

- **Increases in the low-level temperature by 1-2.5K are projected** (Fig. 3a).
- **Seasonally, the low-level warming is larger in winter** (Fig. 3a) than in fall (Fig. 3b).
- **Geographically, the warming signals increase towards the north, away from the coastline, and in higher elevations.**
- **The largest warming occurs in the high elevation Sierra Nevada region during winter (JFM).**
- **The cold season rainfall decreases in California.**
- **Snowfall also decreases everywhere in California.**
- **The decreases range between 25% and 50% of the control data.**
- **The projected snowfall decrease is larger in winter than in fall.**
- **The projected snowfall increases in high elevation regions will be an important concern for the water supply in California as the warm season water supply in the region heavily relies on snowfall driven runoff in high elevation regions.**

In response to the precipitation and temperature changes, the seasonal mean SWE and runoff in high elevation regions decrease substantially, most notably in winter. The decrease in winter SWE will exert an adverse impact on the warm season water supply in the region.

**Table 1.** A summary of the climate change signals in key surface hydrological variables. The numbers in the parenthesis are the climate change signals in terms of the percent of the control climate.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Signal</th>
<th>Change</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold season rainfall</td>
<td>Decrease</td>
<td>10-20%</td>
<td>20-30%</td>
</tr>
<tr>
<td>Snowfall</td>
<td>Decrease</td>
<td>25-50%</td>
<td>50-60%</td>
</tr>
<tr>
<td>Runoff</td>
<td>Decrease</td>
<td>15-25%</td>
<td>25-35%</td>
</tr>
</tbody>
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**Figures:**
- Figure 1.1: Map of the changes in U.S. annual mean surface air temperature and precipitation for impact assessment for the U.S. due to climate change. The map is from the IPCC Fourth Assessment Report on the basis of the SRES-A1B emission profile.
- Figure 1.2: The snow-water equivalence (SWE) in (JIFRESSE) [Global Climate Data Preprocessing and Post processing](http://www.jifresse.ucla.edu) and 30-year mean precipitation and temperature from the Global Land Data Assimilation System (GLDAS) for the boundary condition for the model.

**References:**