Impact of global warming on snow in ski areas: A case study using a regional climate simulation over the interior western United States

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Overview

- Skiing industry is vulnerable to climate change
- 71 ski areas in the interior western United States investigated
- 30-year WRF regional climate models (recent past; near future (RCP 8.5))
- Vertical adjustment technique for snow and temperatures
Meteorological parameters in Ski Resorts

- 5 by 5 box of grid points
- Linear Regression
- For ski resorts and SNOTEL
- SWE and temperatures

Validation and correction for SWE using SNOTEL

Apply correction to SWE in ski resorts

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How does natural snow change?

- Lower elevations see significant decrease throughout the season
- Higher elevations do not have significant changes in the mid-season
How to evaluate skiing conditions?

• Artificial snow is of great importance to ski resorts
• Combine natural snow and artificial snow
• Production potential for artificial snow depends on wet-bulb temperature $T_w$ (Olef et al. 2010)

$\rightarrow$ Determination of artificially provided SWE $SWE_{AP}$

• Snow Day: $SWE_{AP} + SWE_{WRF} > 200 \text{ mm (at one third of vertical extent)}$

$\rightarrow$ Day that has sufficient snow for skiing

• Snow indicators (Abegg et al. 2020) and key period (Nov 15 – Apr 15)
• Various Snow Indicators
• All snow indicators decrease
• Lower elevation is impacted more by larger decreases
• Median Key Period Snow Days
• Number of Snow Days decreases everywhere
• 100-day and 120-day thresholds for economical viability
• **Thanksgiving Period**: Nov 22 – Dec 1
• Percentage of years with at least 8 snow days in the period
• Large decreases except at high elevations in Colorado
• **Christmas Period:** Dec 23 – Jan 1
• High elevations are not impacted / remain unchanged
• Mostly slight decreases / Large impacts only locally
Conclusions

• Skiing conditions in 71 ski resorts in the IWUS were investigated in the recent past and the near future

• SWE and temperature values are determined using a vertical adjustment technique; validation and correction using SNOTEL

• Impacts of climate change on ski resorts throughout the domain

• Natural snow/snow indicator decreases vary between ski resorts

• Thanksgiving/Christmas skiing operations are impacted differently

• Low elevation and low latitude ski areas are more vulnerable