

# 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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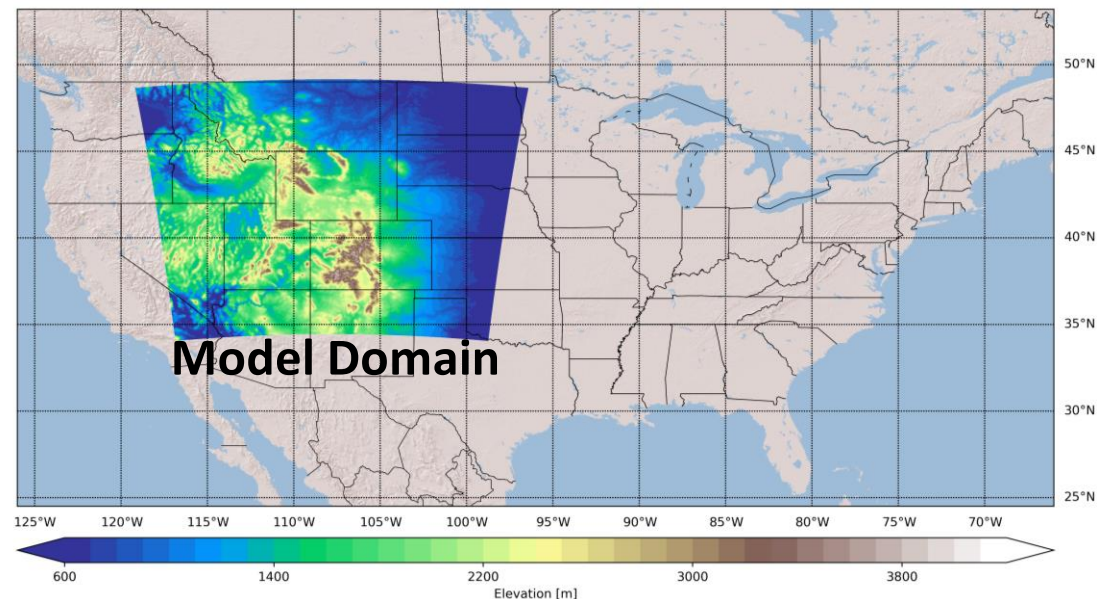
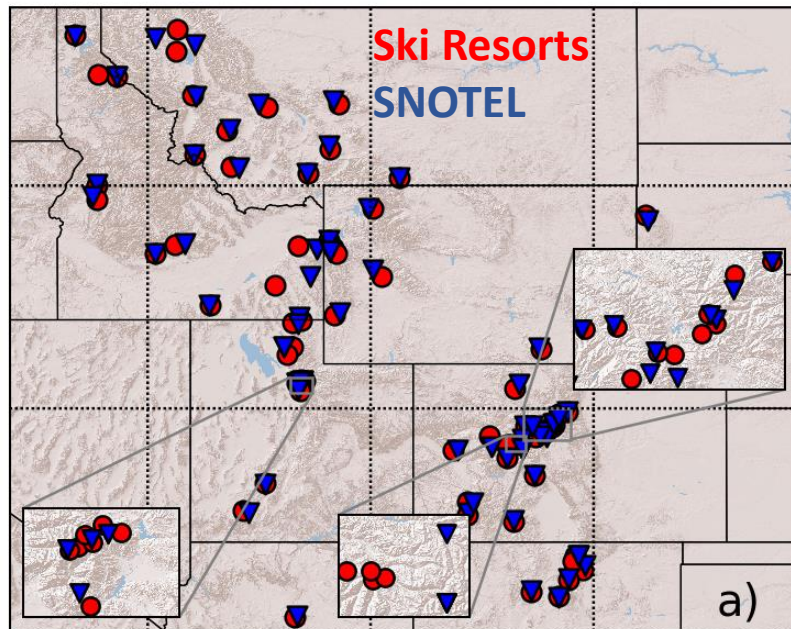
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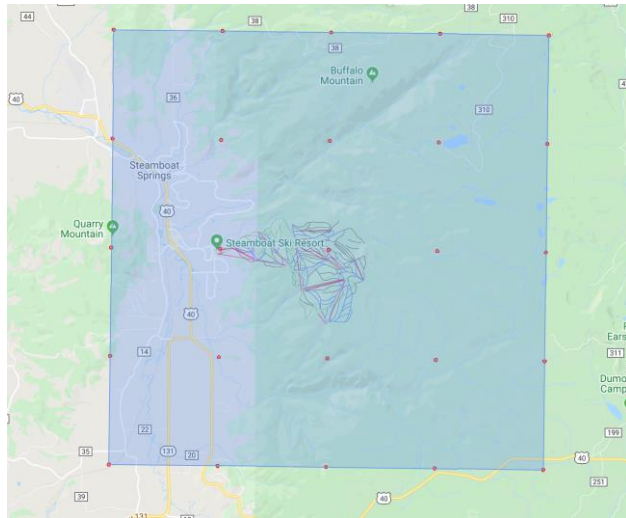


# Overview

- 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

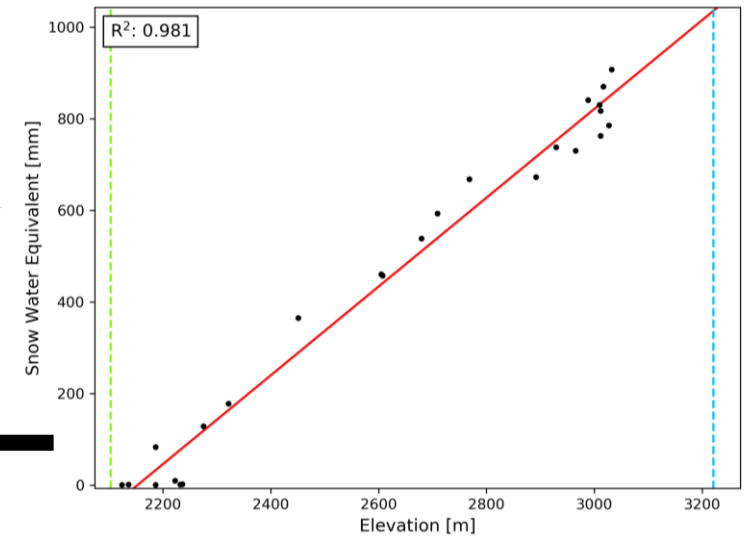


# Meteorological parameters in Ski Resorts

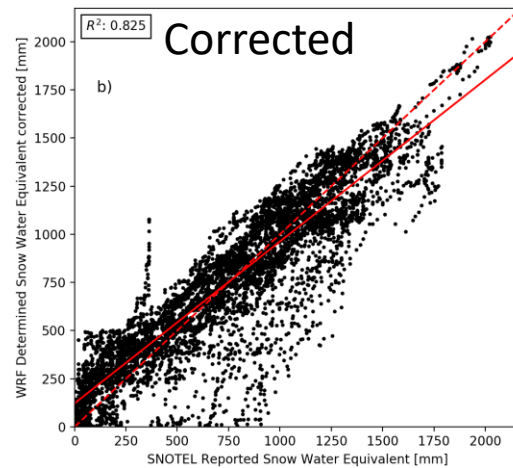
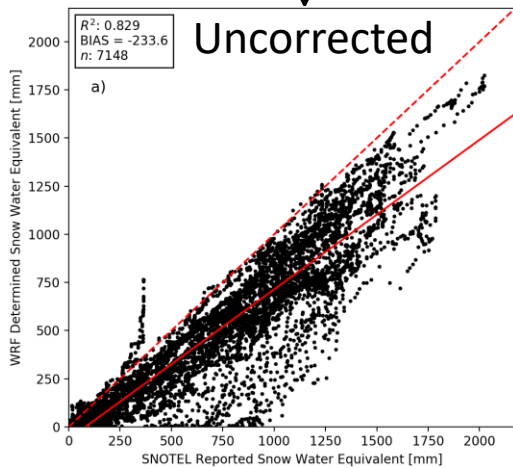


- 5 by 5 box of grid points
- Linear Regression

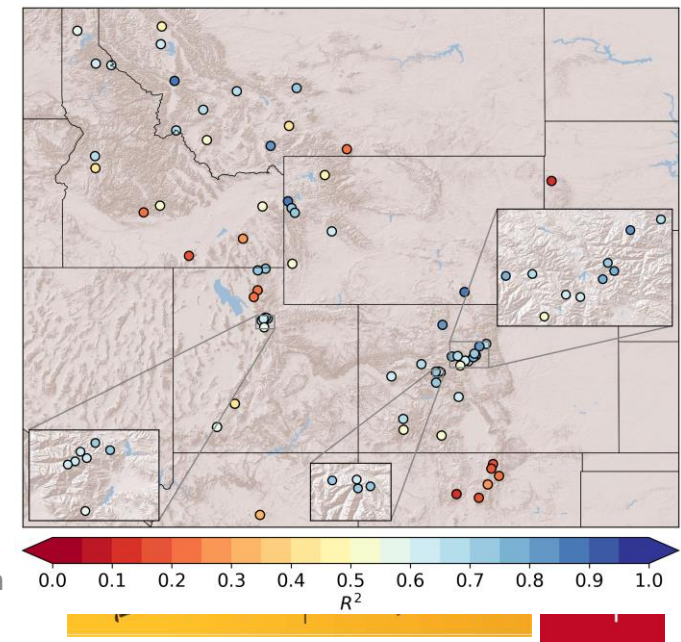
- For ski resorts and SNOTEL
- SWE and temperatures



Validation and correction for SWE using SNOTEL



Apply correction to SWE in ski resorts

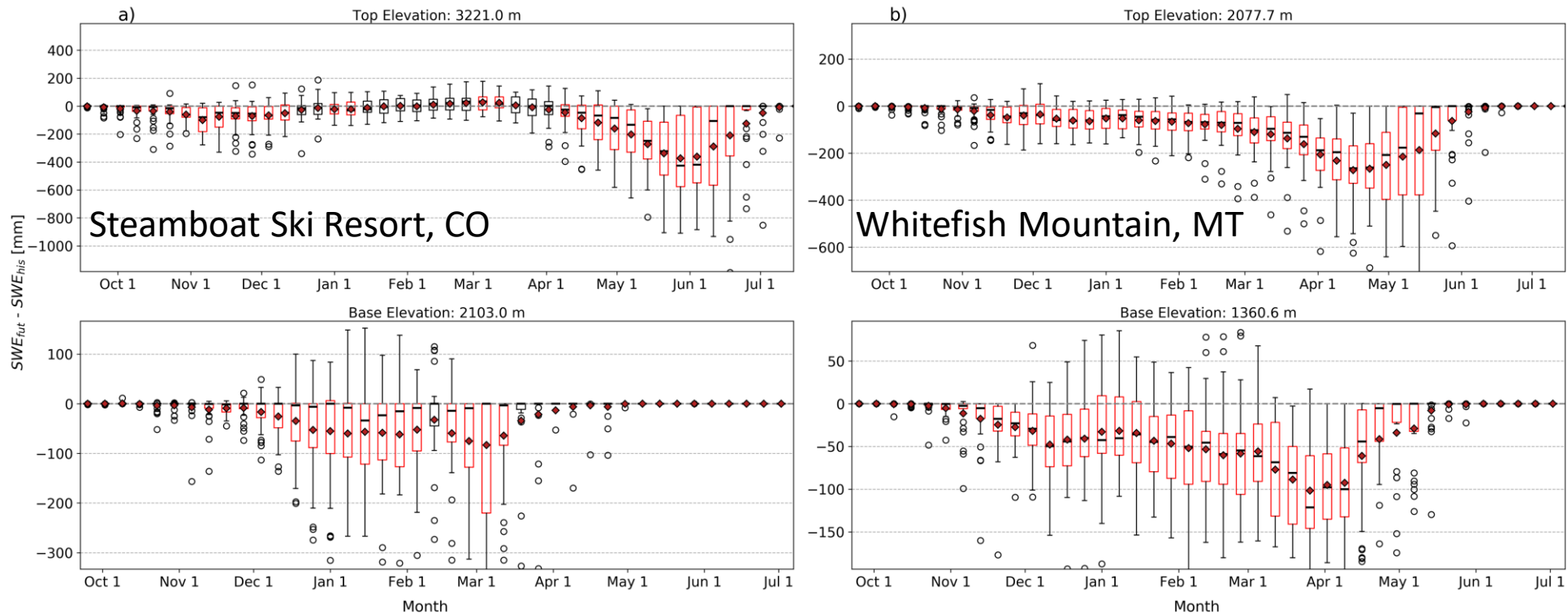


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# How does natural snow change?

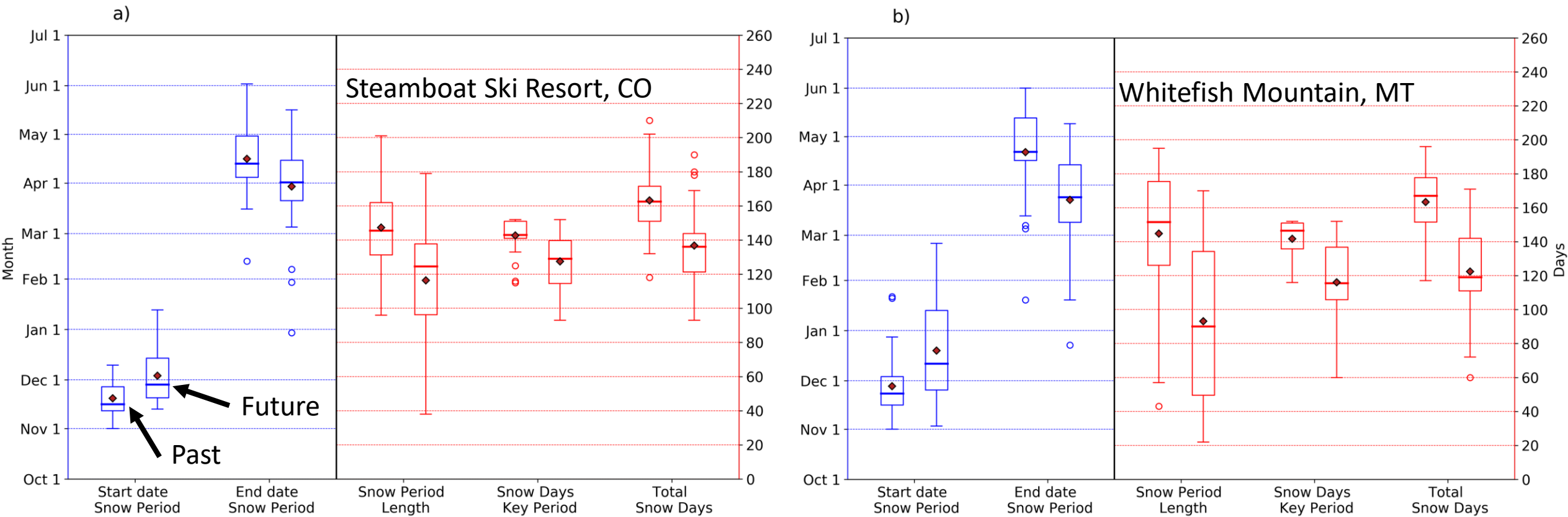
- Lower elevations see significant decrease throughout the season
- Higher elevations do not have significant changes in the mid-season



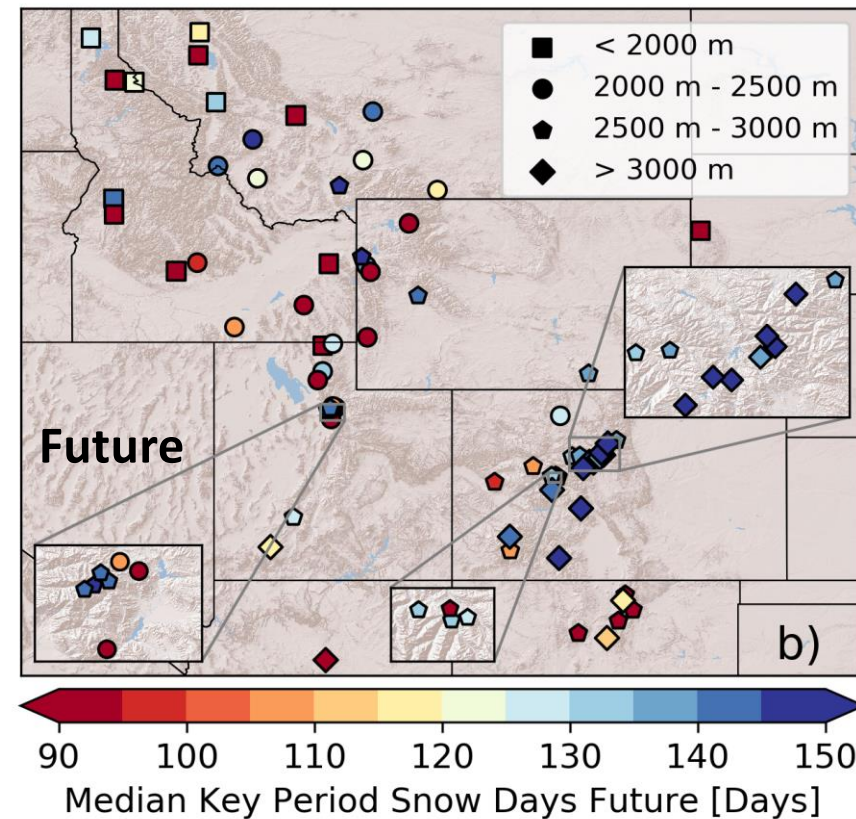
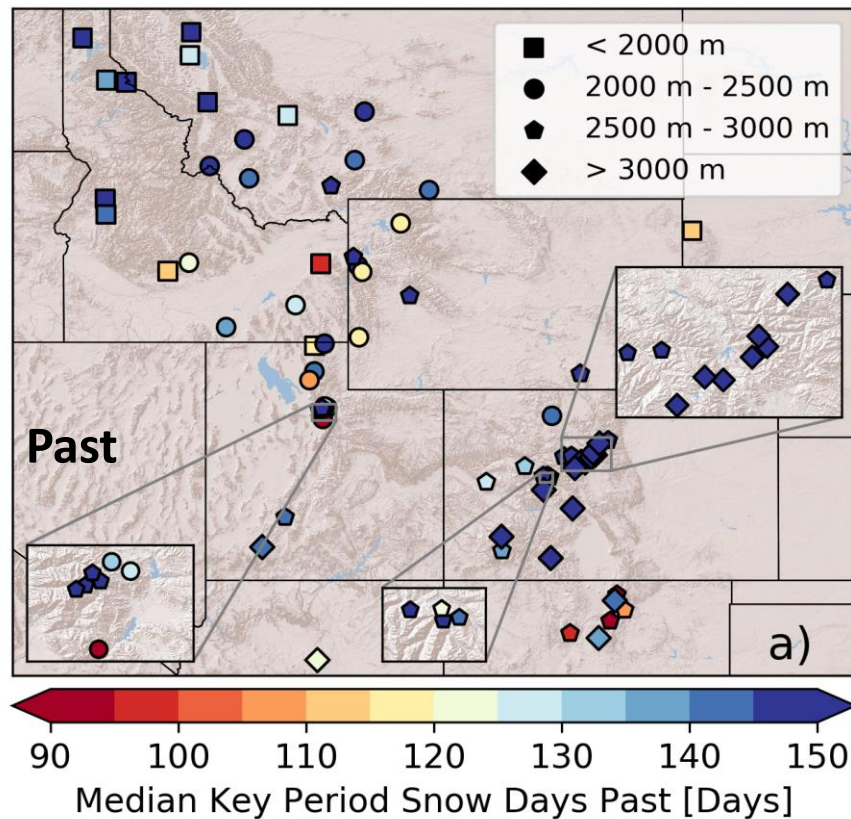
# How to evaluate skiing conditions?

- 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  $T_w$  (Olefs et al. 2010)
  - Determination of artificially provided SWE  $SWE_{AP}$
- Snow Day:  $SWE_{AP} + SWE_{WRF} > 200$  mm (at one third of vertical extent)
  - Day that has sufficient snow for skiing
- Snow indicators (Abegg et al. 2020) and key period (Nov 15 – Apr 15)

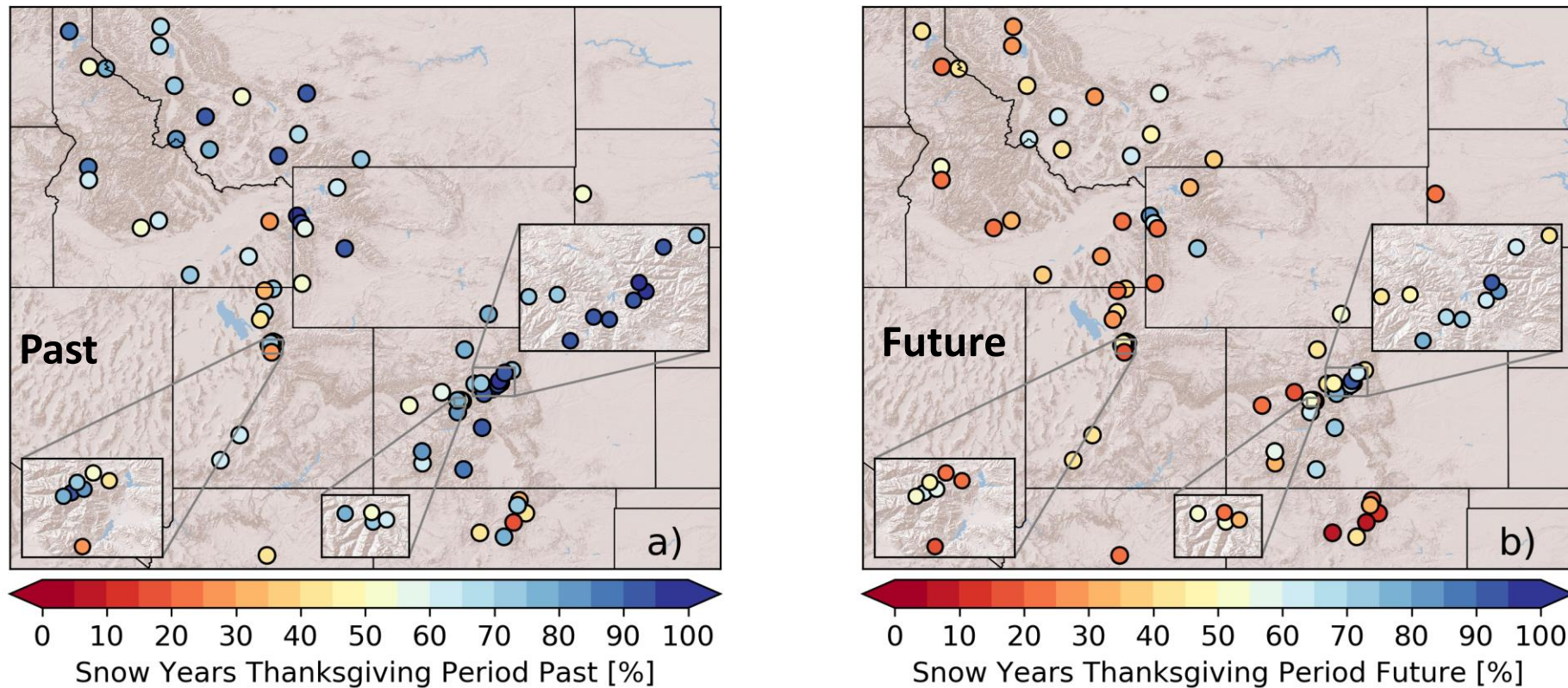
- **Various Snow Indicators**
- All snow indicators decrease
- Lower elevation is impacted more by larger decreases



- Median Key Period Snow Days
- Number of Snow Days decreases everywhere
- 100-day and 120-day thresholds for economical viability

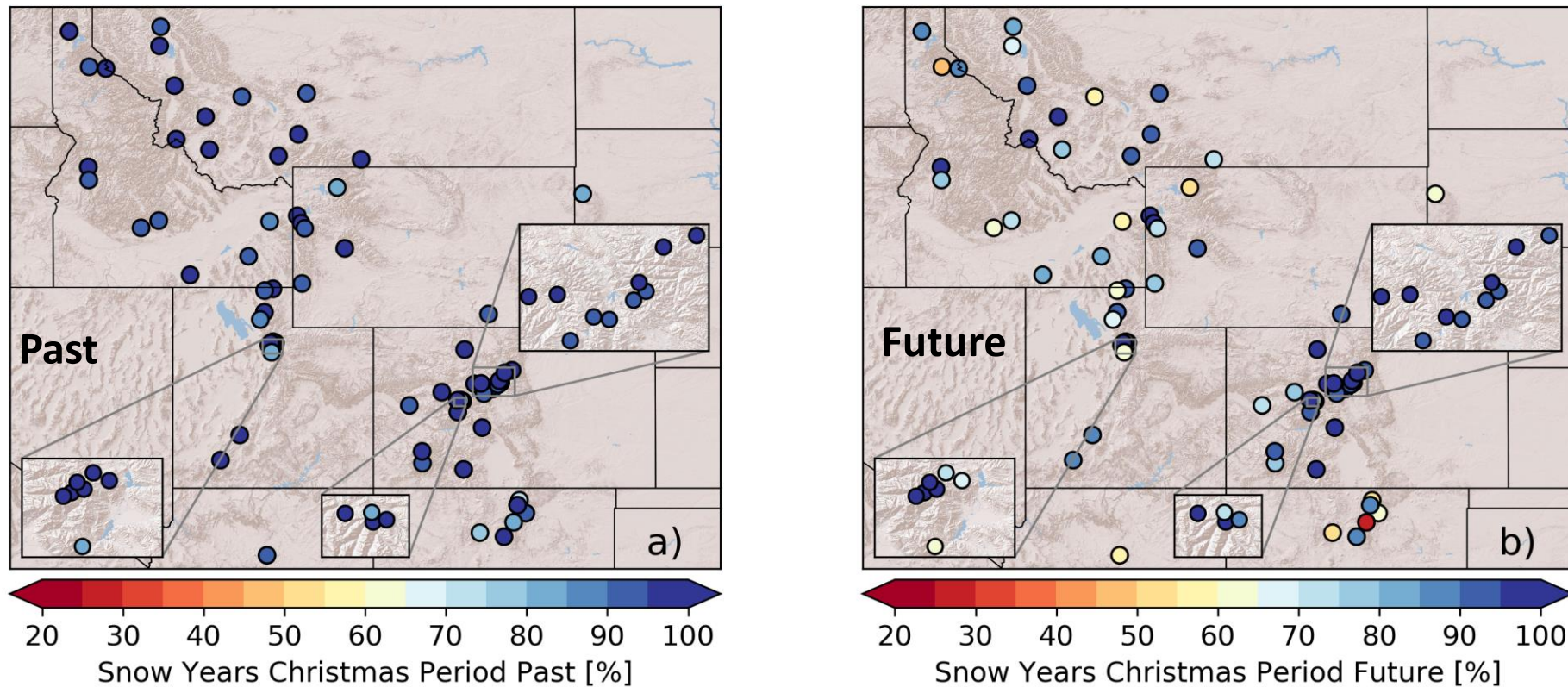


- **Thanksgiving Period: Nov 22 – Dec 1**
- Percentage of years with at least 8 snow days in the period
- Large decreases except at high elevations in Colorado





- **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