Climatological Context of Extreme Events: The South Dakota Blizzard of October 2013

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Introduction

- Strong low pressure system produced an intense winter storm over eastern Wyoming and western South Dakota on 4-5 October 2013.
- **Featured**:
  - Record largest 2-day snowfall total for early autumn at 60% of long-term stations (Figure 1).
  - Wind speeds over 70mph, visibility < 100 ft.
  - Total column precipitable water (PW) was above the 90th percentile in Rapid City, SD and 50-100% above normal in the surrounding region (Figure 2).
  - Rain preceding the strong cold front transitioned to snow.

Impacts

- The blizzard of October 2013 devastated local and regional communities in western South Dakota, killing an estimated 43,000 livestock animals, including nearly 20% of the state's cattle.
- Temperatures in the mid-to-upper 80s on 30 September; no cool season acclimation.

Historical Context

- Blizzard was anomalous, but not unprecedented for annual time scales. Largest snowfall events typically occur during the shoulder months of winter.
- Observational data from the Rapid City, SD sounding show a statistically significant ($p<0.1$) increase in PW for early October (1966-2013).
- No significant trend in extreme PW.

Research Question

- The rarity and associated impacts of this event raise the question as to the potential role of anthropogenic climate change.

Climatological Data and Methods

- Daily Tmax, Tmin, P and PW are acquired from 8 CMIP5 models for pre-industrial (PI), and modern day (MD) experiments (2000-2029). Snowfall liquid equivalent derived using Dai (2008) empirical transform.
- ERA-INTERIM reanalysis data were used to calibrate intramodel biases and provide a 'recent climate' context spanning 1979-2013.

Blizzard by the Numbers

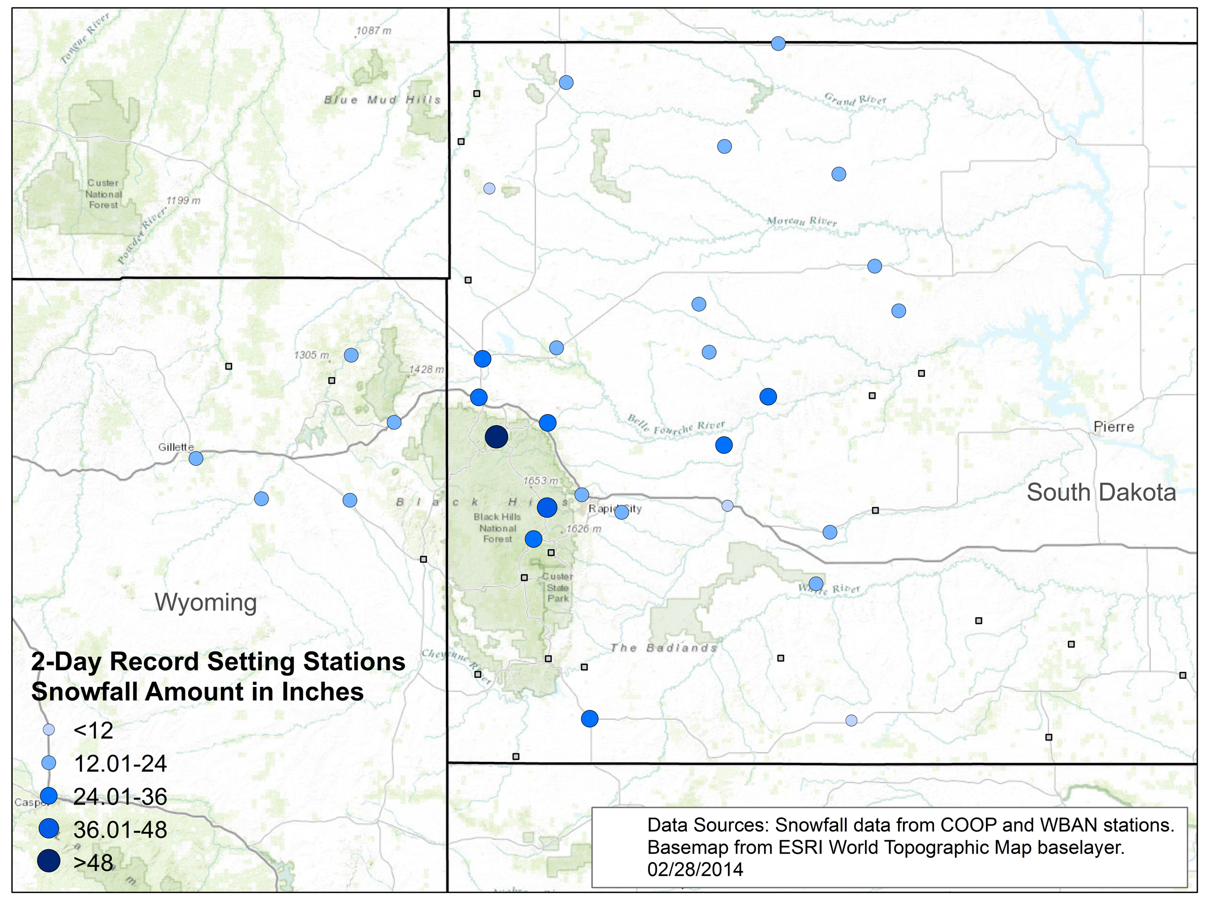

Figure 1. The October 2013 blizzard set early autumn (Sep-Oct) snowfall records at nearly 60% of the reporting, long term (>30 yrs) Coop and Wban sites across eastern Wyoming and western South Dakota. Records were set for both 1- and 2-day maximums, with snowfall totals ranging from 8" to 55".

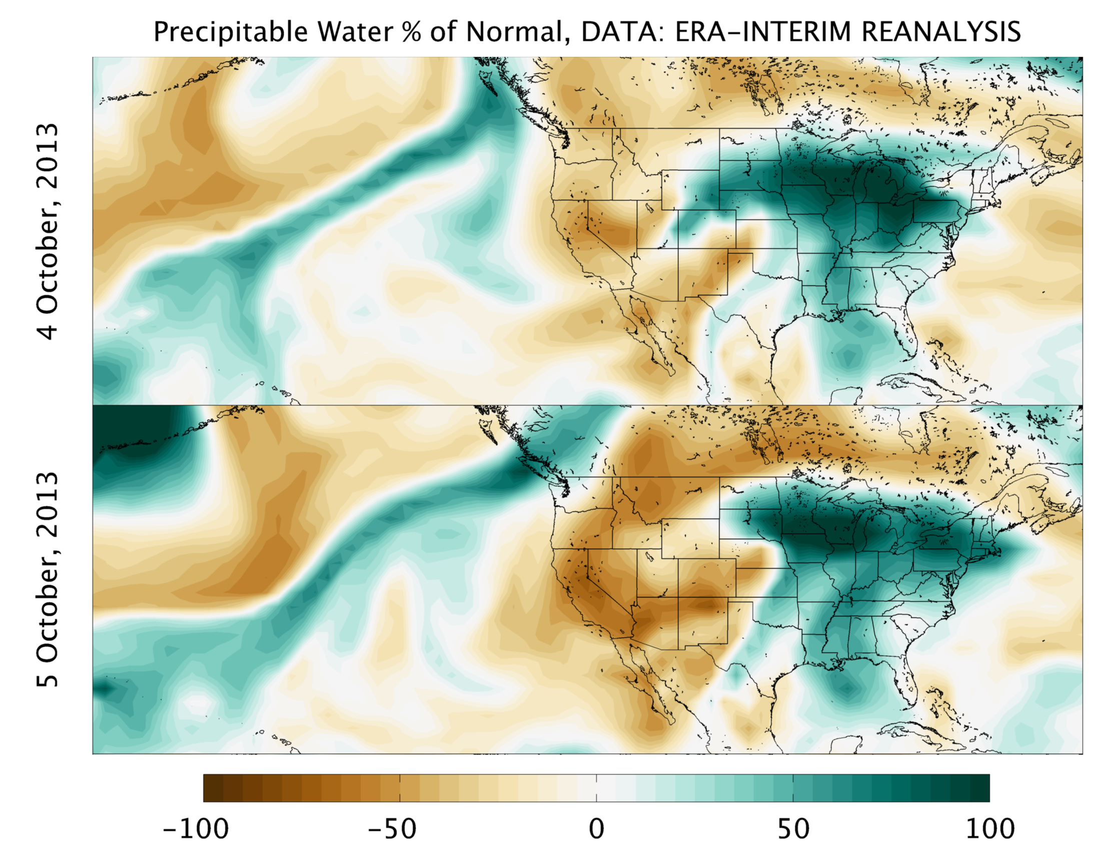

Figure 2. Atmospheric water vapor associated with the October 2013 storm is shown here as percent of normal. Low-level moisture transport was conducive to bringing much of the anomalously high water vapor to western South Dakota.

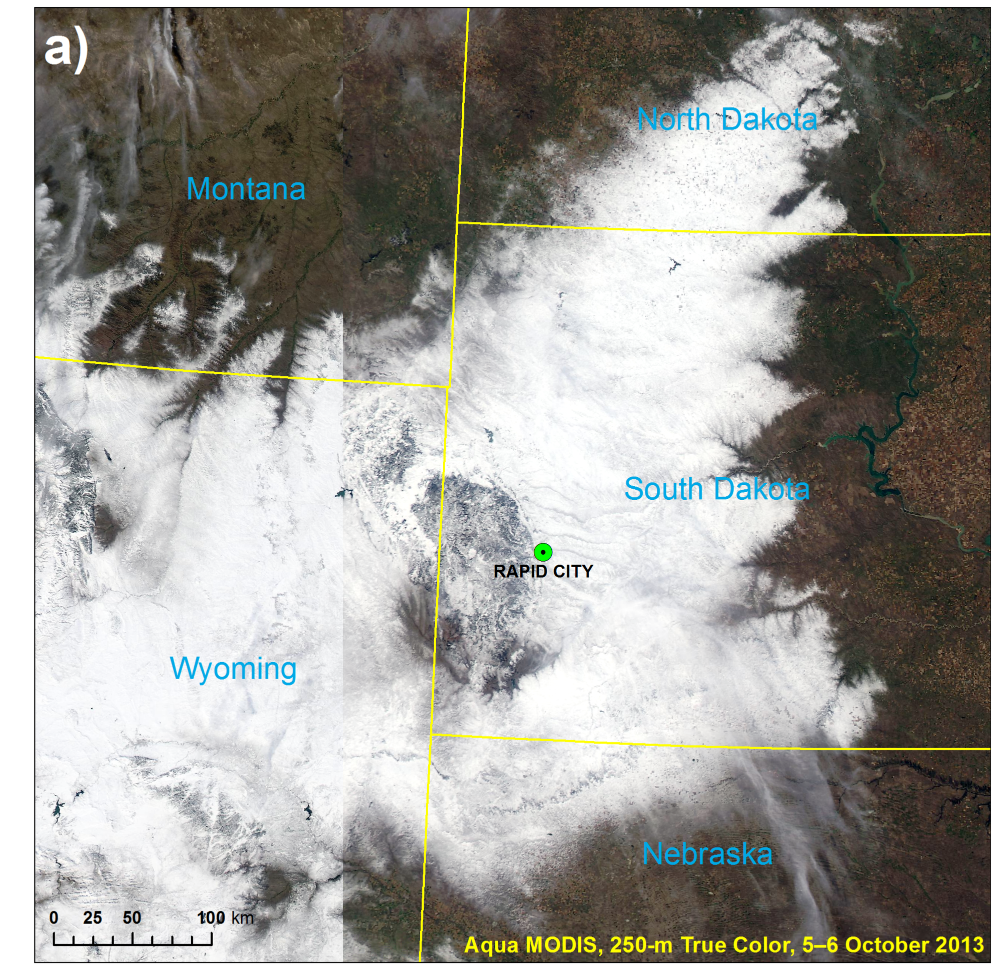

Figure 3. NASA's Terra satellite captured this image of the unseasonal snowcover resulting from the October blizzard. The Black Hills appear darker despite heavier snowfall due to dense vegetation.

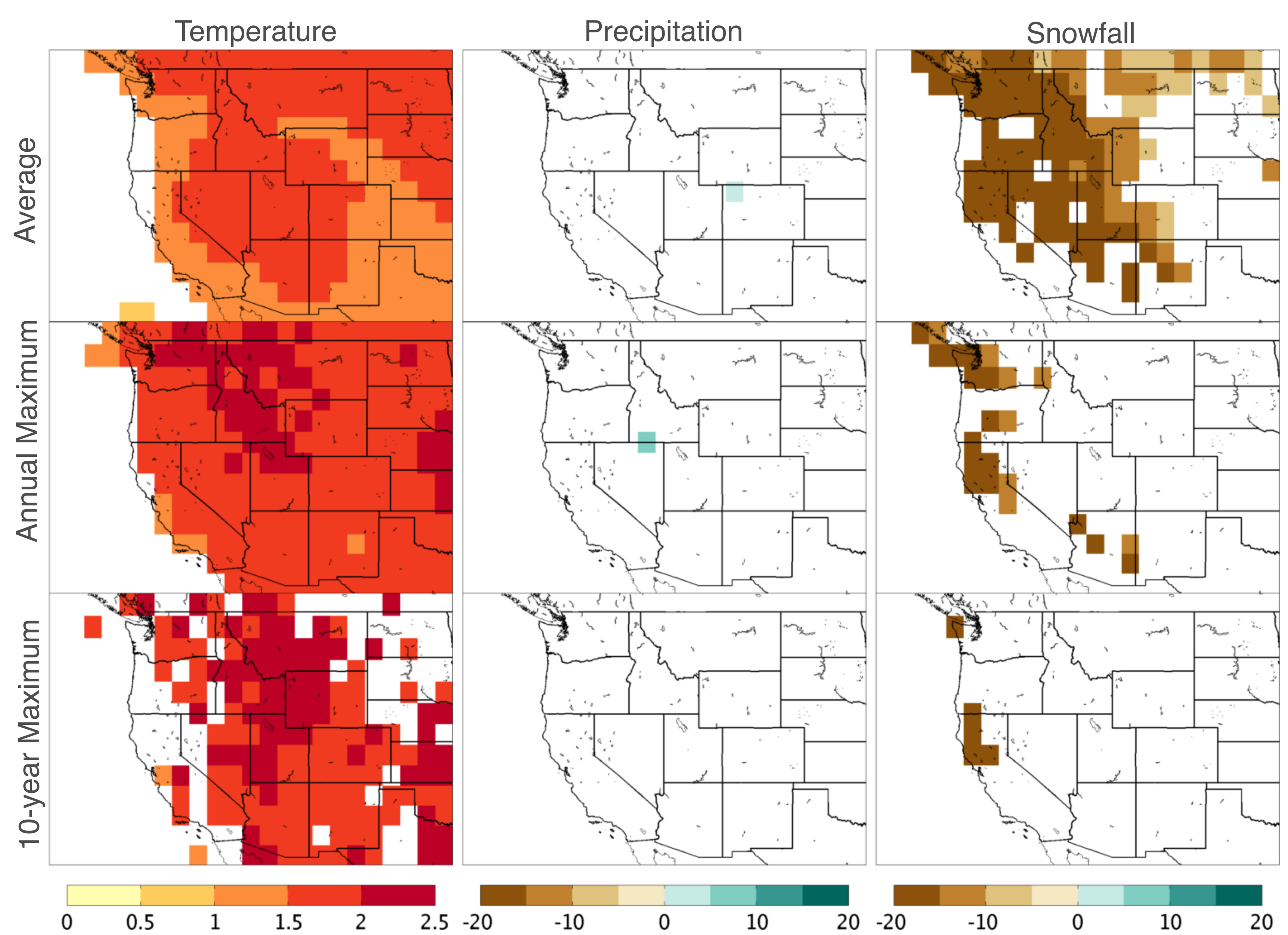

Figure 4. The average change in temperature (°C, left), precipitation (%, center) and snowfall (%, right) between the MD and PI runs for 8 models shown for three time steps: the mean annual change (top), the annual maxima (center), and the 1-in-10 year maxima (bottom). White regions represent those areas where fewer than 4 of the 8 models showed a statistically significant difference between MD and PI.

Attribution to Climate Change

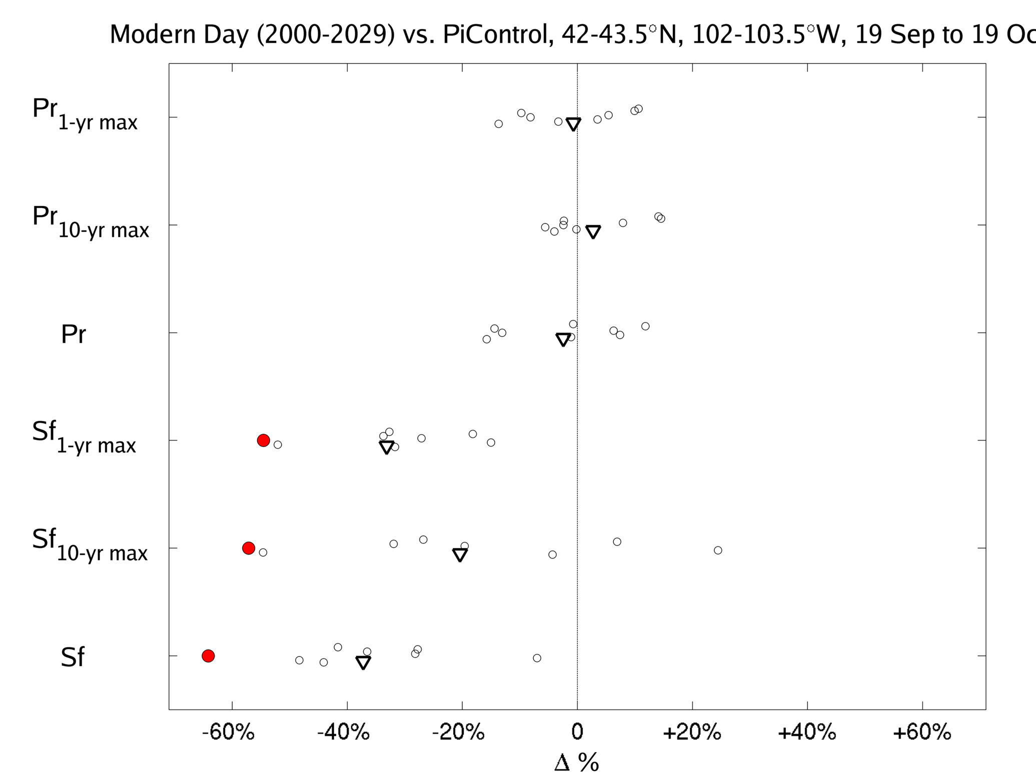

Figure 5. Intramodel differences in the percent change in precipitation (Pr) and snowfall (Sf) between MD and PI in western South Dakota over a 30-day period centered on October 4. Differences shown are annual extreme (*1-yr max*), 1-in-10 year annual extreme (*10-yr max*) and overall means. Statistically significant differences are denoted by red circles, triangles denote the 8-model average.

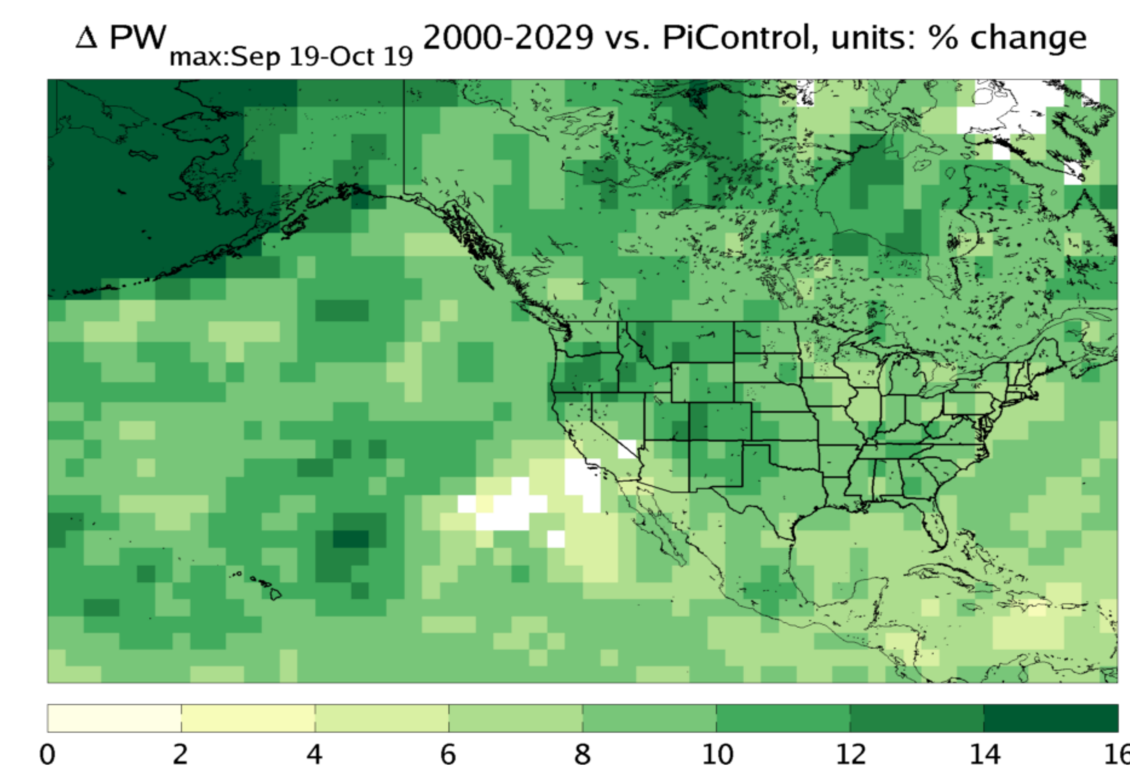

Figure 6. The percent change in maximum PW for the 30-day period centered on October 4 between the PI and MD runs, averaged over 4 models. White regions represent areas where fewer than half of the models showed a statistically significant difference between MD and PI.

Conclusions

- Increased early autumn precipitable water of ~ 5-10% consistent with observations and general Clausius-Clapeyron relationship.
- No attributable link between anthropogenic climate change and heavier precipitation/snowfall in early autumn for western South Dakota
- More broadly, increased temperature and hot extremes across the continent and decreased snowfall (but not extremes) in the western US does appear partially attributable to anthropogenic forcing.