What will happen to snow around Jackson Hole in the 21st century?

Climate Information Sheet

September 2024

- **IN THE WINTERS, SNOW WILL BE REPLACED BY RAIN**
- **SNOWPACK WILL DECLINE MORE IN LOWER ELEVATIONS**

Temperature is expected to rise in future decades, at a rate of as much as 1°F per decade later in the century. For more details on this, please find our climate information sheet on Jackson Hole temperature changes using the QR code on the reverse.

This prediction is based on the CMIP6 climate simulations, and this climate information sheet uses the same WUSD3 dataset to examine predicted changes in precipitation and snowpack. The WUSD3 dataset consists of 15 CMIP6 climate models, bias-corrected with historical data and dynamically downscaled to a grid resolution of 9 km (5.6 miles)

Any changes in precipitation patterns in this warming climate?

The annual total precipitation is not expected to change much during the 21st century in the Greater Yellowstone Area. The year-to-year variability in precipitation is very large, a climate characteristic of all of the interior western USA. This large variability will remain.

On average, winters are predicted to become wetter (Fig. 1a). That does not mean more snow. In fact, the most impactful change is that more precipitation will fall as rain instead of snow in the cold season, esp. at lower elevations (Fig. 1b). The summer precipitation shows no trend, but with the earlier snowmelt and higher temperatures, the soils will tend to be drier in the warm season, which has implications for wildfires.

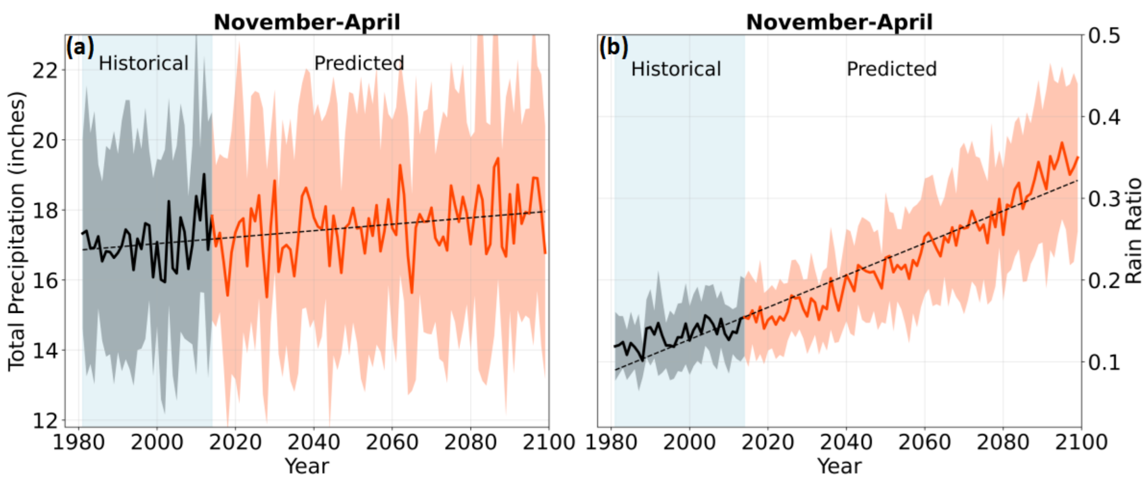

Figure 1:

(a) total precipitation

(b) the fraction of precipitation that falls as rain, during the cold season (defined here as 1 Nov – 30 April).

Trend lines are added (Source: WUSD3 data)

What about the mountain snowpack?

The snowpack is measured in terms of snow water equivalent (SWE), that is the depth of water after melting the snow. Water managers are especially interested in the SWE on 1 April, as the seasonal snowpack generally peaks around that time and provides guidance for streamflow during the following warm season. April 1st SWE data are used to guide reservoir operations under interstate agreements.

Historically, SWE in the Greater Yellowstone Area (GYA) has not changed much, the year-to-year variability has been much larger than any trend (Fig. 2a). But a substantial decline in the seasonal snowpack is anticipated, especially for the second half of the 21st century. This is due to a combination of more rain, especially in the shoulder seasons, and warmer air temperatures, resulting in earlier melt.

The predicted trend in SWE depends on elevation.

Below 7000 ft in the GYA (Fig. 2b), i.e. in the valleys including Jackson Hole and the northern and western parts of the GYA, the decline in seasonal SWE has started already. By the end of the century, peak SWE will be about one third of the historical peak SWE, on average. By that time, uncertainties related to human choices and to model physics result in larger uncertainty in the prediction. The shading in figure 2 represents the standard deviations from the mean: it captures not only year-to-year variability, but also model spread.

In the high elevations, above 9000 ft (Fig. 2d), such as the Wind River Range, the Absorakas, the Teton Range and the Beartooth Range, the snowpack is far more substantial, the predicted SWE decline is much smaller, and it only becomes significant by the second half of the 21st century.

Peak SWE will move earlier by about one month towards the end of the century. The reduction in peak SWE, and its shift towards earlier in spring, has profound implications for water management in the GYA.

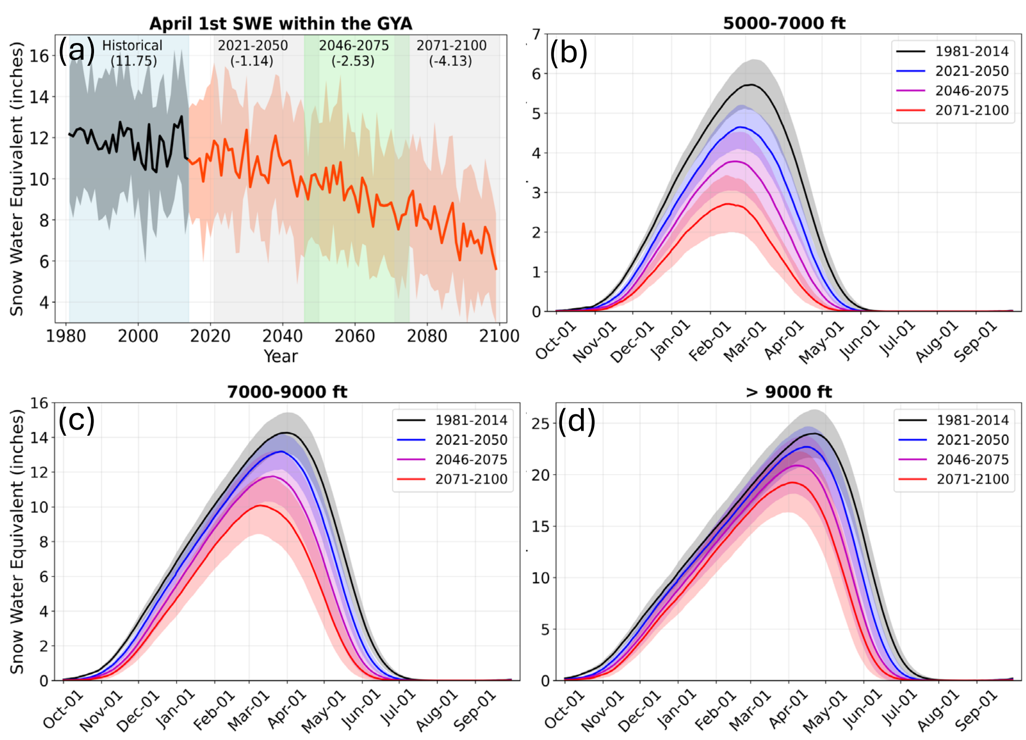

Figure 2: Snowpack is expected to decline, mainly at lower elevations.

(a) April 1st SWE trend within the GYA. The values in parenthesis represent the mean historical SWE and the change in SWE relative to the historical value for four future 20-year periods.

Panels (b-d) show the predicted average seasonal SWE cycle (and its variability in shading) in three different elevation belts:

(b) between 5000 and 7000 ft

(c) between 7000 and 9000 ft

(d) above 9000 ft.

Rahimi, S., and co-authors, 2024: An Overview of the Western United States Dynamically Downscaled Dataset (WUS-D3). *Geoscientific Model Development* 17, no. 6 (March 20, 2024): 2265–86. https://doi.org/10.5194/gmd-17-2265-2024 The WUSD3 daily post-processed dataset (Tier 3) can be downloaded from an open-data bucket on Amazon S3: s3://wrf-cmip6-noversioning/ at https://registry.opendata.aws/wrf-cmip6/.

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