Tracking Snow from Space

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Measuring the water content of snow is challenging and data are geographically sparse. That makes it hard for water suppliers and planners to know with certainty how much water they will have for the upcoming year. In addition, our snowpack can vary dramatically from year to year. In 2018, Colorado experienced an extremely low snowpack and water supplies suffered. The next year an extremely high snowpack followed. This research project used satellite data of snow cover, which is readily available and covers the entire state, to explore what influences how long snow lasts or persists in the mountains and test how well we can predict snow melt runoff from space.

This project was funded through a student research grant at the Ruth Hutchins Powell Water Center at Colorado Mesa University. In it, we examined four snow years (2016-2019) of satellite, USGS stream gage, and NRCS SNOTEL snow water equivalent data over the Grand Mesa, which supplies drinking and irrigation water to the Grand Valley and other nearby communities.

First, we analyzed how topography (slope, aspect, elevation) influenced snow persistence from year to year. Snow persistence is the percentage of time the ground was covered with snow, as observed in the satellite data called MODIS, between January 1 and July 3 of a given year (Hammond et al., 2018, Figure 1). It is calculated using the snow cover index, SCI, which ranges from 0 (no snow cover) to 100% (snow cover over the entire season). We found that elevation is the biggest factor determining snow persistence within the Grand Mesa watershed, followed by aspect, then slope. Snow persistence increases with elevation, however, there is a relatively small area on the Grand Mesa at higher elevations with greater snow persistence (Figure 2). The question becomes how sensitive this narrow range of elevation (3,000 m to 3,250 m or 9,800 ft to 10,700 ft) is to warming temperatures.

We compared SCI values from year to year with snow water equivalent data (the amount of water contained in snowpack) as well as stream runoff data. We found that the SCI correlates well with snow water equivalent and runoff in good to average snowpack years but appears to over-predict snowpack in low snow years. Further research will continue to evaluate the utility of SCI and satellite-based snow cover data in predicting snow water.

Water supply on the Grand Mesa may be at risk of diminishing in the future due to warming temperatures because the high elevation range at which snow persists is a relatively small area. Finding connections between topographic features and snow persistence are used to better understand the patterns of snow persistence on the Grand Mesa. Additionally, this study contributes to the research on the use of remotely sensed data to predict water yield and evaluate its sensitivity to climate. It contributes to the effectiveness of using spatial data (available everywhere) rather than on-the-ground data, which is geographically limited.

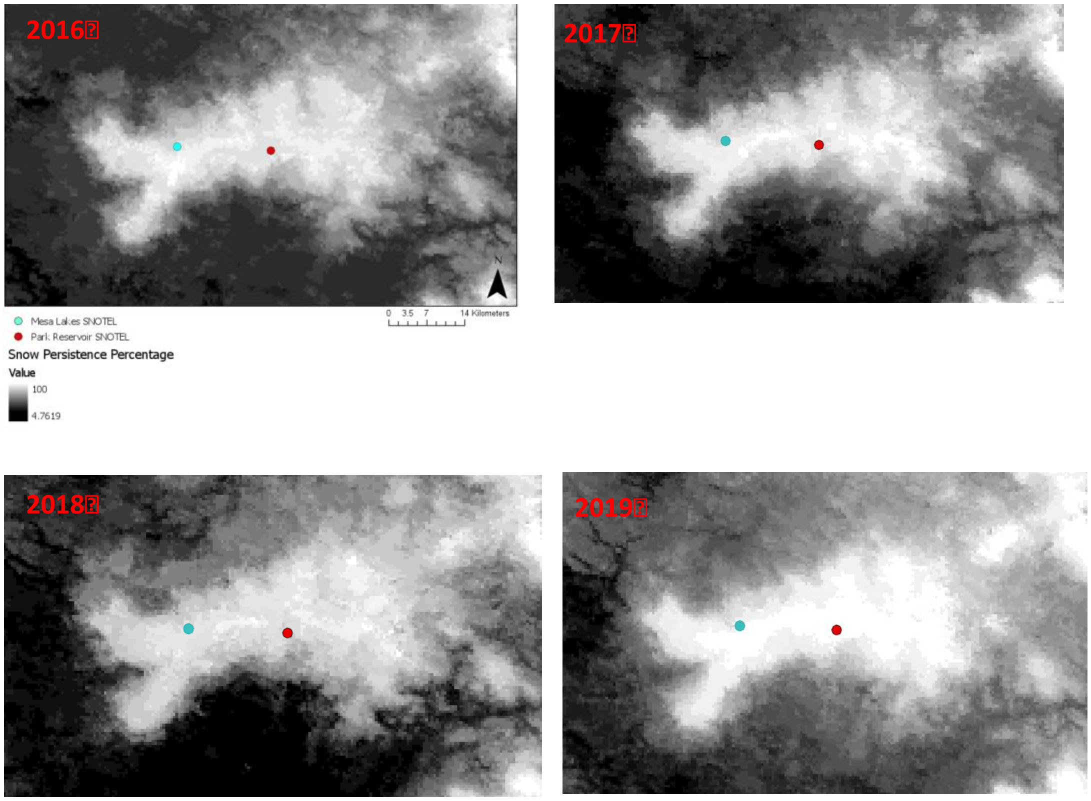

Figure 1. Snow Persistence (SCI) over the Grand Mesa from 2016 to 2019 calculated using MODIS satellite imagery.

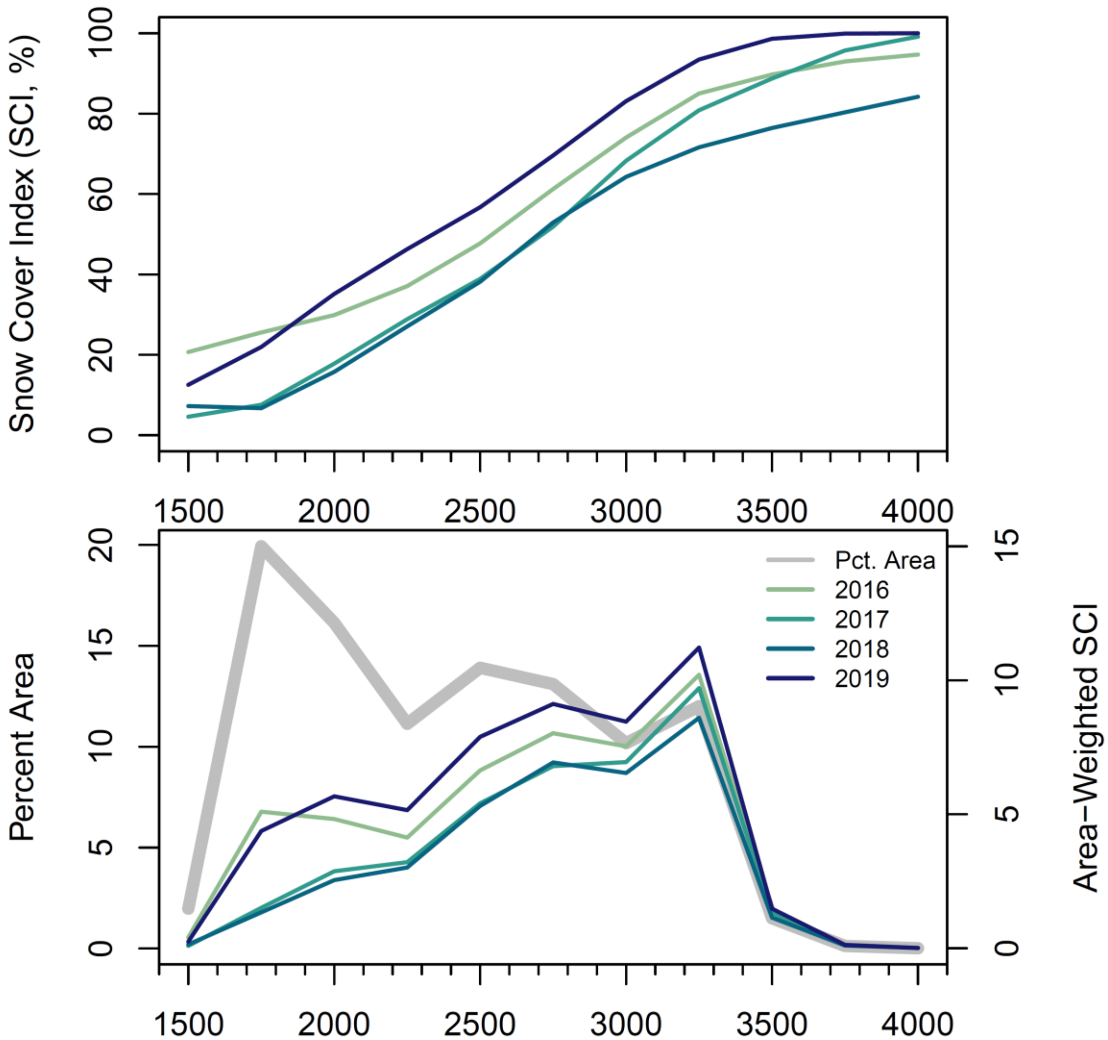

Figure 2. Snow persistence (SCI) increases with elevation. When it is weighted by area, the area-weighed SCI peaks between 3,000 m and 3,250 m (9,800 ft to 10,700 ft).

References

Hammond, J.C., Saavedra, F.A. and Kampf, S.K., 2018. How does snow persistence relate to annual streamflow in mountain watersheds of the Western US with wet maritime and dry continental climates?. Water Resources Research, 54(4), pp.2605-2623.