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Editorial: Advances in observations and modeling of snow, forest-snow processes and snow hydrology

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Editorial on the Research Topic
Advances in observations and modeling of snow, forest-snow processes and snow hydrology

Snowpacks are integral to both regional and global water cycles, playing a pivotal role in land-atmosphere feedbacks that dynamically link with extreme events, such as floods, droughts, and wildfires. Their significance is magnified in mountainous regions, where precipitation mainly falls as snow in the winter and is limited in summer months when water demand peaks and alternative sources may fall short. In forested regions with seasonal snowpack, the forest canopy cover plays a crucial role in regulating snow accumulation and melt dynamics, and consequently, water availability. Yet, despite its importance, it's a field still requiring extensive research, particularly due to significant data gaps in regions such as snow-rain transition zones and semi-arid regions in the Western U.S. Advances in remote sensing, particularly through high-resolution satellite imagery and LiDAR technology, have provided invaluable insights into the patterns and dynamics of forest-snow interactions. Meanwhile, field observations remain necessary for identifying and understanding forest-snow processes that might be overlooked or inadequately represented in current snow and hydrology models. Such oversights could result in gaps in our understanding and predictive capabilities in snowpack dynamics and their implications for water resources and extreme events in mountainous regions. This special topic provides a collection of manuscripts that address some of these important research gaps.

Kraft et al. paper, "*Forest impacts on snow accumulation and melt in a semi-arid mountain environment*", delves deep into the driving factors of snow accumulation and melt processes across varying forest structures in southern Idaho, USA. The team gathered extensive field data over multiple years, capturing metrics like snow depth, snow density, and various components of the snowpack's energy balance, including radiation and snow/soil temperatures. These observations were collected at two sites—one characterized by marginal snowpack and the other by seasonal snowpack—both encompassing a range of forest structures, from densely forested areas to open terrains and forest edges. A key insight from the data analysis is the balancing act between the canopy's shading, which decelerates snowmelt, and canopy interception, which diminishes snow depth. This dynamic results in comparable snowmelt timings in both open and forested regions. The study also investigates the influence of spring storms on snow disappearance timing between the open and forest. Overall, the study highlights that changes in forest structure, especially those caused by events like wildfire or bark beetle infestations, can shift the dominant drivers of snow processes and profoundly affect the availability of snow water.

Dickerson-Lange et al., "*Forest gap effects on snow storage in the eastern cascade range, Washington, United States*" bridges a critical data gap critical for understanding the relationship between forest density and snowpack in the Eastern Cascades region of the United States. Analysis of multi-year snow observations focuses on the impact of forest management practices, specifically thinning and prescribed burning, on the magnitude and duration of snow storage. The findings indicate that strategies to reduce forest density may enhance snow storage and thus water availability by decreasing losses from the intercepted snow through sublimation and melt. Yet, it's unlikely that these practices would counteract the climate-driven reduction in snow storage duration, with the potential exception of creating gaps in north-facing forests.

Yang et al. harness the high-resolution remote sensing in mountainous regions to provide detailed evaluations of snow-covered area patterns in mountain meadows and forested environments across the Sierra Nevada, as presented in the manuscript titled "*High-resolution mapping of snow cover in montane meadows and forests using Planet imagery and machine learning*". They use PlanetScope imagery from Planet at ∼3-m resolution and a machine learning technique, random forest, to derive snow-covered area maps across 7,741 mountain meadows in the Sierra Nevada. The performance of the snow mapping model is quantified across the meadows, forest gaps, and in the vicinity of trees. The model has F scores of 0.83 and higher in meadows and large forest gaps and can identify snow in areas close (>10 m) to forest edges. The model and code are made publicly available for others to use.

Lastly, motivated by the increased fire activity and its widening impact in recent years, Koshkin et al. provides a comprehensive review titled "*Wildfire impacts on western United States snowpacks*". This review synthesizes the most recent research on the effects of fire activity on forests and snowpacks. They highlight that snow disappearance day can advance by 4–23 days following a fire, with melt rates increasing by up to 57%. This is likely due to the changes in snow albedo, allowing for more radiation to be absorbed by the snowpack, and the loss of canopy cover permitting a larger amount of solar radiation to reach the snow surface. These changes in the snow dynamics in burned areas have effects on water resources, as the fire-affected areas increase in size and elevation, overlapping with critical snow zones. To deepen our understanding of these fire-induced changes on snow and forests, there's a pressing need for further studies leveraging remote sensing tools, ground observations, and advanced modeling techniques.

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