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Estimating snowcover along elevation gradients in the Sierra Nevada of California from MODIS and blended ground data

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Accurate, frequent satellite-derived snow covered area (SCA) products provide the opportunity to explore the spatial patterns of snow, as well as the impact of snow accumulation and ablation on snow distribution along elevation gradients. Blending a MODIS fractional snow cover product with interpolated point snow water equivalent (SWE) measurements and energy balance calculations yields composite maps of the spatial distribution of SWE. Results from the 2004-2006 water years show the utility of the MODIS fractional SCA product to estimate snow accumulation and melt along 300-meter elevation gradients in the Upper Merced and Tuolumne River basins of the Sierra Nevada of California. The analysis considers the elevation bands from 1,500 to 3,900 m with 40% of the elevation between 2,100-2,700 m, while the 1,500 m elevation band is considered the transitional rain/snow zone. Spatial maps of SWE highlight elevational bands that contribute significantly to snowmelt across the basin, as well as those elevational bands that are susceptible to warming and thus rapid depletion of the snowcover. All three years highlight the severe limitations of using the very limited ground-based, operational network of snow measurements to estimate snow water equivalent across a basin. Using a season-long energy-balance approach it becomes apparent that higher elevations, above the highest snow measurement site (about 2,700 m) contribute a disproportional share of the basin snowmelt relative to elevations from 2,700 m down to the snowline. The results of the 2004 ablation season demonstrate the implications along the elevation gradients of an above normal mid-season snowcover of 120% impacted by an unseasonable warm and dry air mass that rapidly depleted the snowcover across all elevation gradients, leading to a below average snowpack of 84% by April 1.