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Operational Physics-Based Modeling and the Airborne Snow Observatory: Lessons Learned over Five Years in California's Sierra Nevada

Andrew Hedrick (1,2), Danny Marks (1), Jeff Deems (3), Kat Bormann (4), and Thomas Painter (4)

(1) USDA-ARS Northwest Watershed Research Center, Boise, Idaho, United States (andrew.hedrick@ars.usda.gov), (2) Boise State University, Center for Geophysical Investigation of the Shallow Subsurface, Department of Geosciences, Boise, United States (hedrick.ars@gmail.com), (3) National Snow and Ice Data Center, University of Colorado, Boulder, Colorado, United States , (4) NASA-CalTech Jet Propulsion Laboratory, Pasadena, California, United States

Over the last five winters a wide dynamic range in snowpack conditions have been observed in California's Sierra Nevada Mountains. A historic drought persisted from 2013 – 2015, followed by a slightly below average 2016 snowpack, and culminating with a very wet and cold 2017 winter season. These climatic conditions have proven to be a unique test-bed for a novel synthesis of remote sensing and physics-based modelling. Since 2013, the Airborne Snow Observatory (ASO) has flown near-weekly spring lidar surveys of the 1,200 km2 Tuolumne River Basin, which provides 80% of the water supply to the city of San Francisco, with the intent of delivering high-resolution estimates of snow water equivalent (SWE) storage to water management agencies downstream. In order to obtain SWE from these lidar-derived snow depth measurements, snowpack density must be estimated at a comparably high spatial resolution. Since the onset of the ASO campaign, iSnobal, a physically-based energy and mass balance snowmelt model, has been used to calculate density along with 17 other snowpack state variables at a daily time scale using hourly meteorological measurements from ground-based stations. In addition to providing density estimates, iSnobal can be stopped, updated, and restarted using the information from the ASO lidar surveys to guide model results to a more accurate representation of the basin SWE distribution. This work details the findings and improvements made to the ASO modelling suite over five winter seasons and five substantially different snowpacks.