National Aeronautics and Space Administration

Using NASA Airborne Snow Observatory to assess the performance of snowfall accumulations from GPM IMERG and other gridded precipitation products

Ali Behrangi and Kat J. Bormann

Jet Propulsion Laboratory , California Institute of Technology,

E-mail: Ali.Behrangi@jpl.nasa.gov

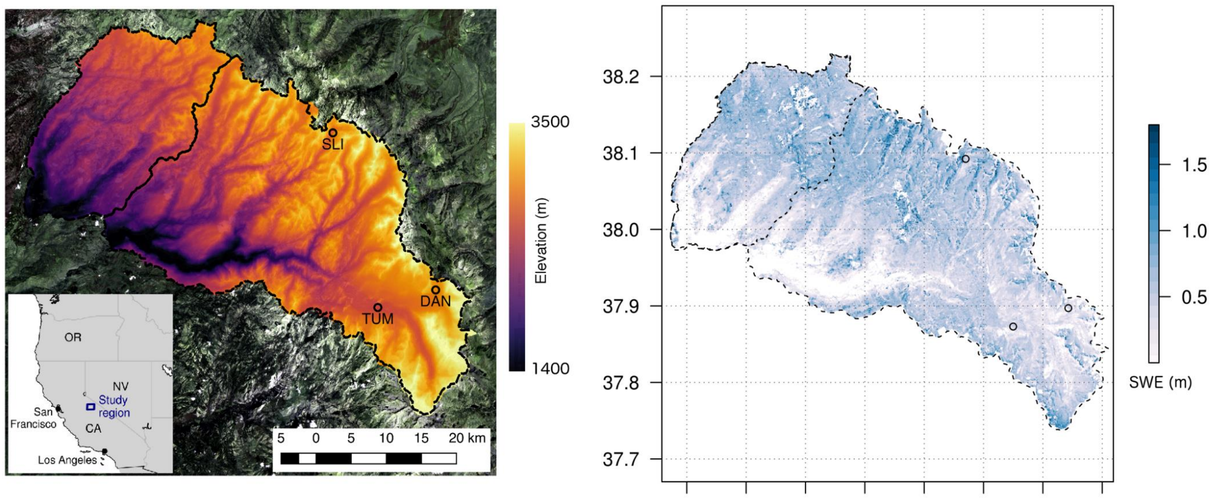
Introduction/Motivation

Given the challenges in accurate estimation of precipitation rate over cold mountainous basins (using both remote sensing and in-situ data), it is important to identify alternative ways to assess the performance of existing products. During the large snow season of 2017 in California, the Airborne Snow Observatory (ASO) (Painter et al. 2016) performed two acquisitions over the mountainous Tuolumne and the adjacent Cherry/Eleanor basins. These acquisitions provided an excellent opportunity for estimating monthly-areal snowfall rate over these basins. The new estimates are then compared with several existing products (e.g., from gauge, ground radar, and satellite) for further analyses.

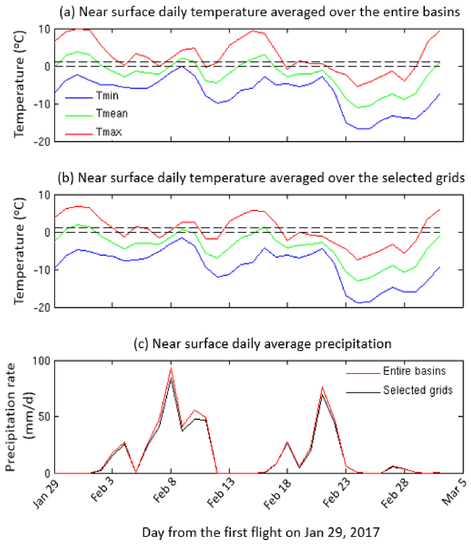
ASO uses the dual scanning lidar to accurately map the elevation surface of the snow prone portions of the mountains both without snow, to use as a baseline, and then again routinely during winter and spring when snow is present. The two elevation surfaces are geolocated onto the same raster grid and in general the snow depth retrieval is the subtraction of the baseline surface elevations from the snow-on surface elevations. The collocated spectrometer data is fused into the data stream to spatially constrain the surface subtraction to snow covered areas only and a spatially constant bias adjustment is used to vertically snap the two surface elevations prior to the subtraction.

The surface subtraction for snow depth is conducted at 3m spatial resolution and then aggregated to 50m resolution using the 3m pixel mean. The conversion from snow depth to SWE is then conducted at the 50m resolution using snow densities obtained from a physically-based snow model (iSnobal) that are further nudged with available observations. For more details on the ASO processing algorithms refer to Painter et al. (2016).

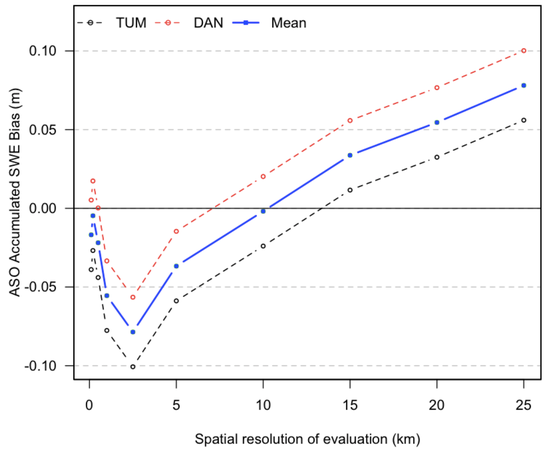
(1) Study Region



Daily near surface air temperature and precipitation time series: (a) Daily Tmin, Tmean, and Tmax averaged over the entire basins, (b) Daily Tmin, Tmean, and Tmax averaged over the selected grids, and (c) Daily mean precipitation averaged over the entire basins and selected grids. Both temperature and precipitation data are obtained from PRISM.



Assessing the relationship between spatial resolution bias using ASO high resolution data (100m)



(2) Results

Spatial distribution of snowfall accumulation from ASO and several other gridded products over the Tuolumne and adjacent Cherry/Eleanor basins for the period of Jan 29th to March 3rd 2017. The selected grids are shown by "+".

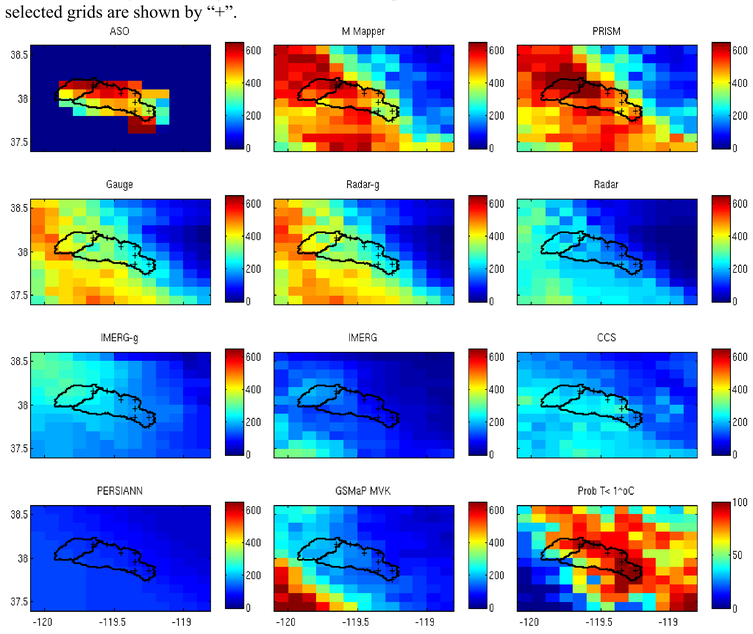
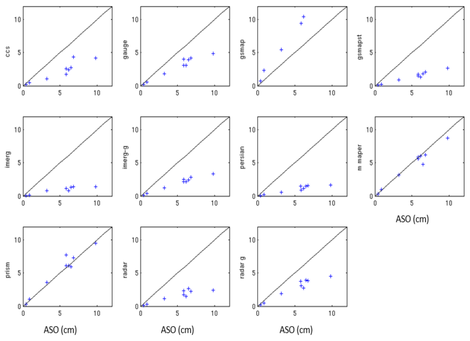
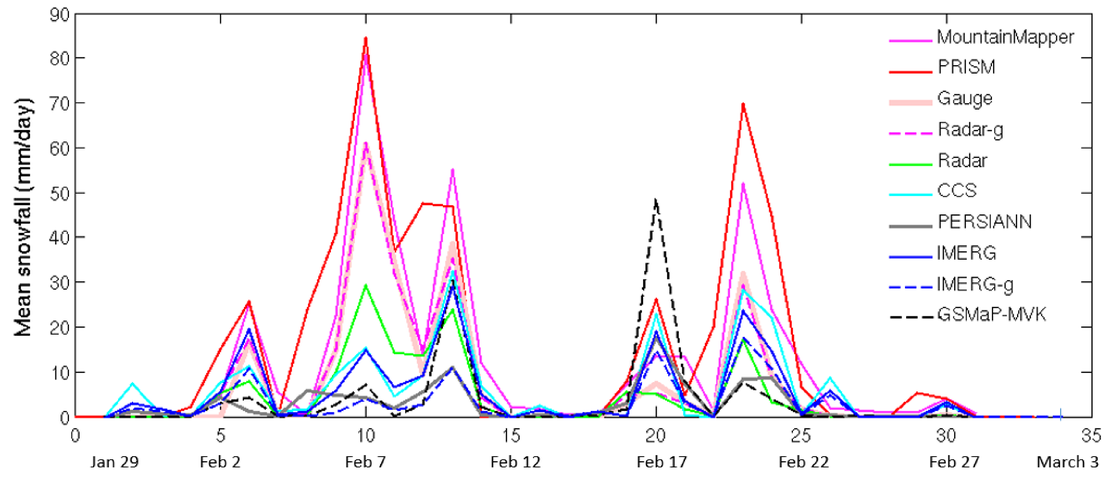


Table 1. Comparison of mean snowfall accumulation from ASO and several other products over the selected grids for the period of Jan 29th to March 3rd 2017.

Product	Cummulative snowfall (cm)
ASO	48.9 + (1.5cm)
PRISM	51.9
Mountain mapper	44.0
IMERG V4 - late	8.9
IMERG V4 -final	19. 1
PERSIANN	9.7
PERSAINN CCS	20.9
GSMaP MVK V6	13.2
Radar (MRMS)	15.5
Gauge	27.4
Radar + Gauge	26.1



Time series of daily snowfall averaged over the selected grids for the period of Jan 29th to March 3rd 2017.



Summary:

The results show that most satellite products and radar show large underestimation of snowfall accumulation compared to the ASO estimate (e.g., about half or less). Gauge correction of satellite and radar estimates reduces this difference. During this period and for the selected grids, mean snow accumulation from PRISM (51.9 cm) and mountain mapper (44.0 cm) show the best match with ASO snow accumulation (48.9 cm). Based on previous studies, monthly sublimation was estimated to be between 1 and 2.2 cm, and thus by accounting for that ASO estimate (49.9 – 51.1) is well consistent with PRISM. Despite their underestimation, satellite and radar products show high correlation (greater than 0.9) with ASO snow accumulation at the selected grids, suggesting that satellite and radar products have good skill in capturing the spatial distribution of snowfall. Furthermore, comparison of daily snowfall time series from PRIM with other precipitation products show that satellite and radar products generally capture the precipitation pattern fairly well, but large differences exist in capturing daily accumulations.

Finally, the fact that ASO provides high resolution areal estimate (versus point measurements at stations) and is suitable over mountainous terrains (e.g., versus radar that may suffer from beam blockage), makes it a unique tool to assess the performance of satellite precipitation products for snowfall retrieval in cold mountainous regions. This work shows that besides the typical ASO surveys, that often start in April and continues throughout summer months, acquisitions in cold months can be extremely valuable. Therefore, we recommend extending the timing of ASO acquisitions to late fall or early winter months. Clearly, coordination with the GPM validation team might enhance the efficiency of the efforts.

Reference:

Painter, T., and Coauthors, 2016: *The Airborne Snow Observatory: Fusion of scanning lidar, imaging spectrometer, and physically-based modeling for mapping snow water equivalent and snow albedo.* Vol. 184.

Behrangi, A. and K. Bormann, Using the Airborne Snow Observatory to assess remotely sensed snowfall accumulations over Tuolumne basin (in preparation)

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
www.nasa.gov

Acknowledgments

The research described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. ©2011 California Institute of Technology. Government sponsorship acknowledged.