

Merging multiple datasets to support SWE estimation from a range of sensors

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INTRODUCTION

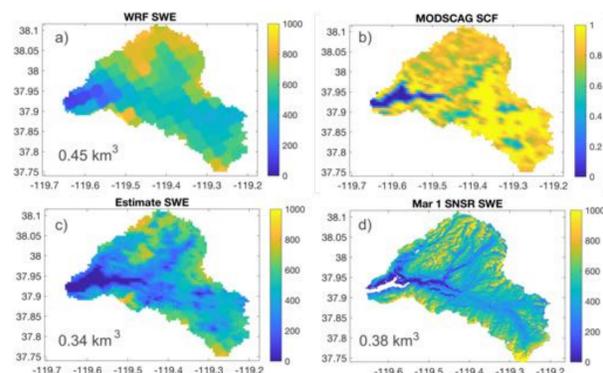
- SnowEx need strategies to merge multiple types of observations
- Mountain regional climate model (RCM) **accuracy:** snowfall > energy balance

METHODS

1. The Blender algorithm estimates daily precipitation, SWE, snow cover fraction (SCF) and melt at 500 m resolution.
2. Blender 1.0 uses WRF, MODIS SCF, CERES Syn as input to a constrained optimization problem to estimate mass and energy states and fluxes
3. Test: Tuolumne, Sierra Nevada (775 km²).

RESULTS

- In situ snow pillows and courses: RMSE WRF 99 mm. Blender: 48 mm
- Diff. from SNSR: WRF 18%. **Blender: 10%.**



DISCUSSION

- ~4 km RCMs constrained by energy balance could be deployed globally
- This would produce a new estimate of global mountain SWE at 500 m resolution
- Blender 2.0 has been adapted to treat forest effects, ignored in v1, and to add in MODIS LSTs
- Blender 2.0 will be used to pull in L-band InSAR phase at SnowEx 2017 Grand Mesa

Combining regional climate models and satellite measurements improves SWE accuracy and spatial resolution

PROBLEM FORMULATION

We used the HPC language Julia to solve the following mass-and-energy constrained optimization problem:

$$\min_x \sum \left(\frac{x_i - \bar{x}_i}{\sigma_i} \right)^2$$

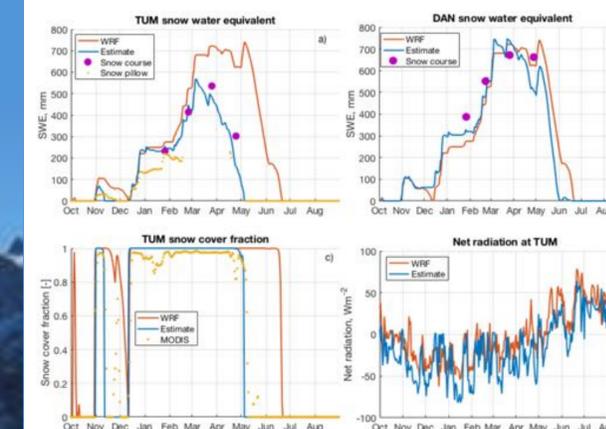


$$\text{subject to: } \frac{dSWE}{dt} = P - M$$

$$M = [R_s^\downarrow(1 - \alpha) + R_l^\downarrow - R_l^\uparrow - H - LE]SCF$$

where R_s^\downarrow , R_l^\downarrow , and R_l^\uparrow are the (surface) downwelling shortwave, upwelling longwave and downwelling longwave respectively, α is albedo, ρ is water density, L is latent heat of vaporization, LE is latent heat flux, H is sensible heat flux, P is precipitation, and Q is runoff; the vector x represents the Blender estimate of SWE, SCF, R_l^\uparrow , H , and E , σ represents uncertainty, and the overline denotes either WRF or observed estimate, respectively. CERES R_s^\downarrow and R_l^\downarrow and WRF α are taken as given. Forest impacts will be considered in future versions.

IN SITU COMPARISON



DATASETS USED

- WRFv4 with Noah-MP model simulations: 3 km resolution, forced by NARR at boundary conditions
- SCF: MODIS Snow Covered Area and Grain Size (MODSCAG)
- R_s^\downarrow and R_l^\downarrow : CERES Synoptic: hourly, 1° resolution
- In situ data: the CA DWR snow surveys and snow pillows, after QA/QC by UW
- 90 m SWE estimates from UCLA Margulis group Sierra Nevada Snow Reanalysis (SNSR)

Details, references and links via the QR code at left



Take a picture to see flow chart and more

Photo taken looking down at Tuolumne Meadows on December 23, 2014 (with Unicorn Peak in the background) by Laura and Rob Pilewski (the Tuolumne Winter Rangers).