Assessing the MESH Model's Ability to Simulate Mountain Snowpacks

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Background

- Mountain snowpacks (Fig. 1) are vital to global water resources.
- Closing the hydrological budget in cold regions mountain basins is determined by how accurately models solve for: (1) blowing snow redistribution by wind, (2) snow interception, (3) sublimation, (4) radiation exchange and turbulent fluxes, (5) snowmelt, (6) infiltration into frozen soils, (7) evapotranspiration, and (8) snowmelt-runoff.

Research Question

How accurately are we simulating mountain snow processes using coupled hydrological land surface schemes?

Objectives

- Simulate snow accumulation and ablation in complex mountain environments using a physically based hydrological land-surface model.
- Examine model performance at different spatial scales using different meteorological forcing datasets.

Methodology

- MESH [CLASS v3.6] simulations with sub-routine for blowing snow (PBSM, Pomeroy & Li, 2000) and improvements recommended by Pomeroy et al. (1998) as implemented by Pietroniro et al. (2007).
- Model parametrization is based on the understanding of the hydrological system, with no calibration.
- Single column mode (1D) [current focus], in different mountain environments (e.g., grassland, forest, and alpine land covers) (Fig. 2.).
- Meteorological and snow observations part of the Canadian Rockies Hydrological Observatory (Fig. 3): ground-based [current focus], bias-corrected, and high-resolution meteorological forcing datasets.

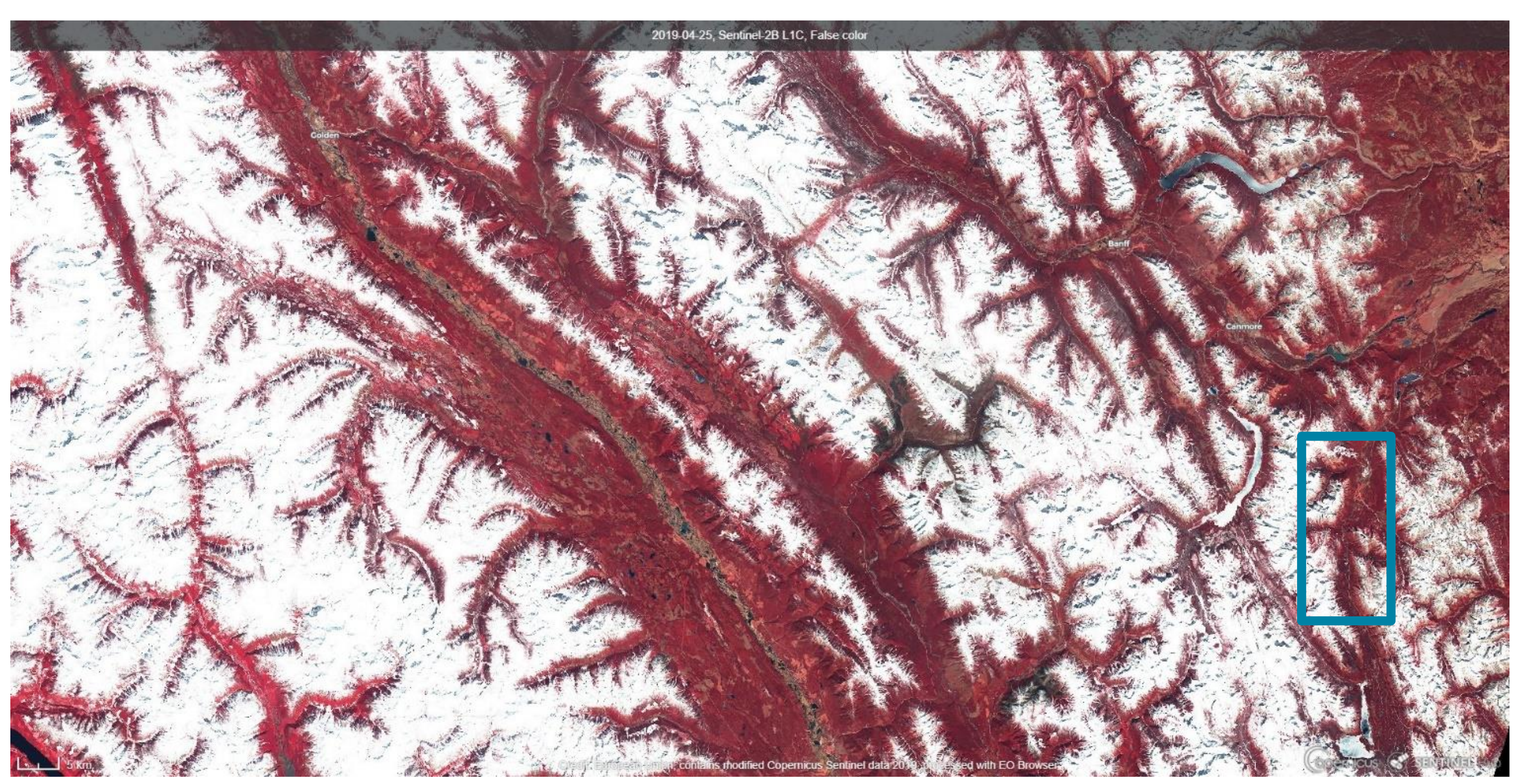

Fig. 1. Late spring snow cover in the Canadian Rockies, shown here for 25 April 2019. Locations of the Marmot Creek Research Basin and the Fortress Mountain Snow Laboratory are highlighted (blue box). Color Infrared Sentinel-2 Image.

MESH [CLASS] Single Column (1D) Example Run in Marmot Creek Research Basin

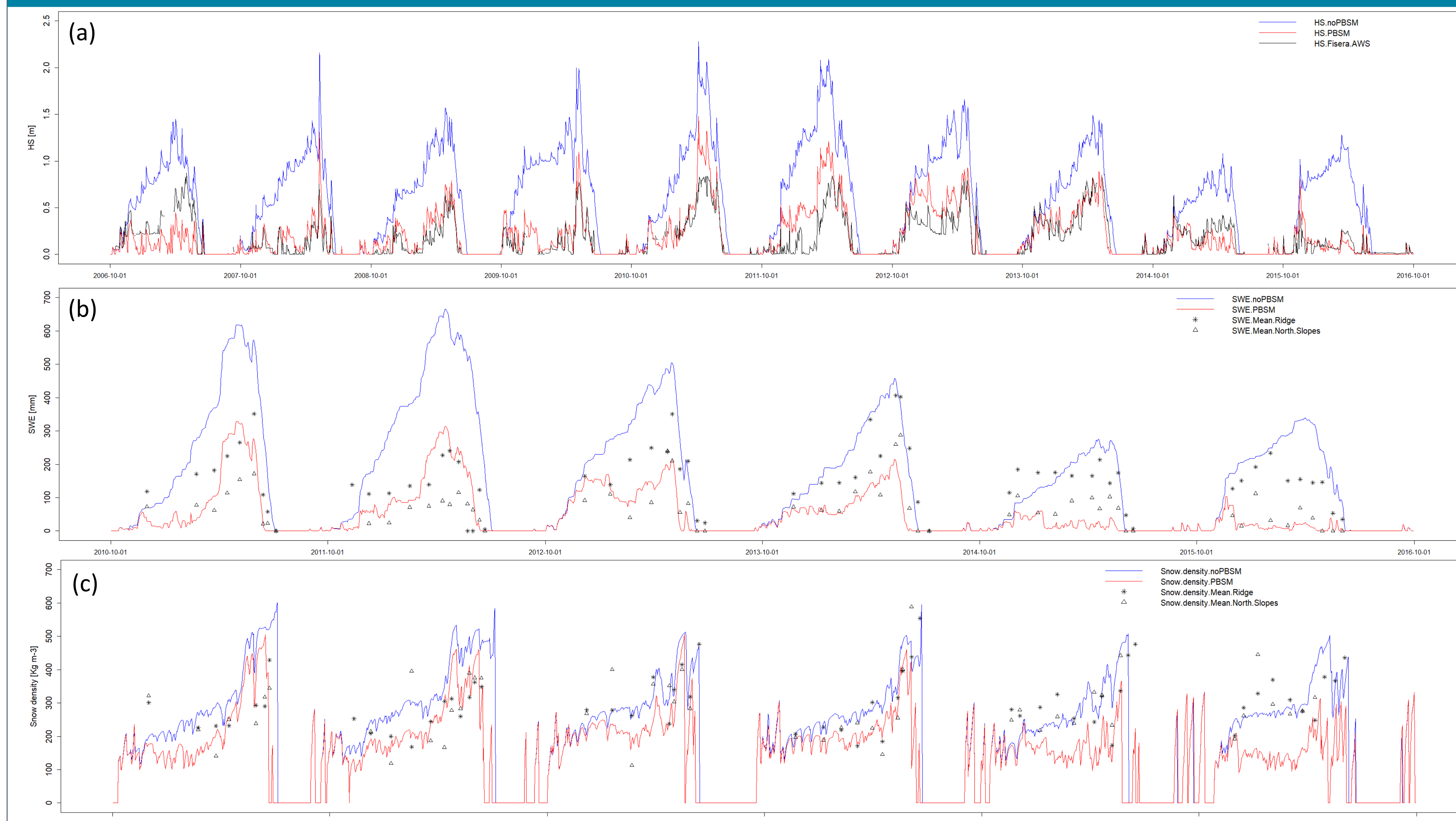

Fig. 4. (a) observed and simulated snow depth [cm] at the top of the Fisera Ridge (2006-2016), (b) observed and simulated SWE [mm], and (c) observed and simulated snow density [kg m-3] (2010-2016).

Energy and Mass Control Volumes for Snowpack in Mountains

Fig. 2. (a) GRU scale control volume for snowmelt calculation in mountains. Arrows indication the direction of fluxes (adopted after Pomeroy et al., 2007), and (b) Fisera AWS

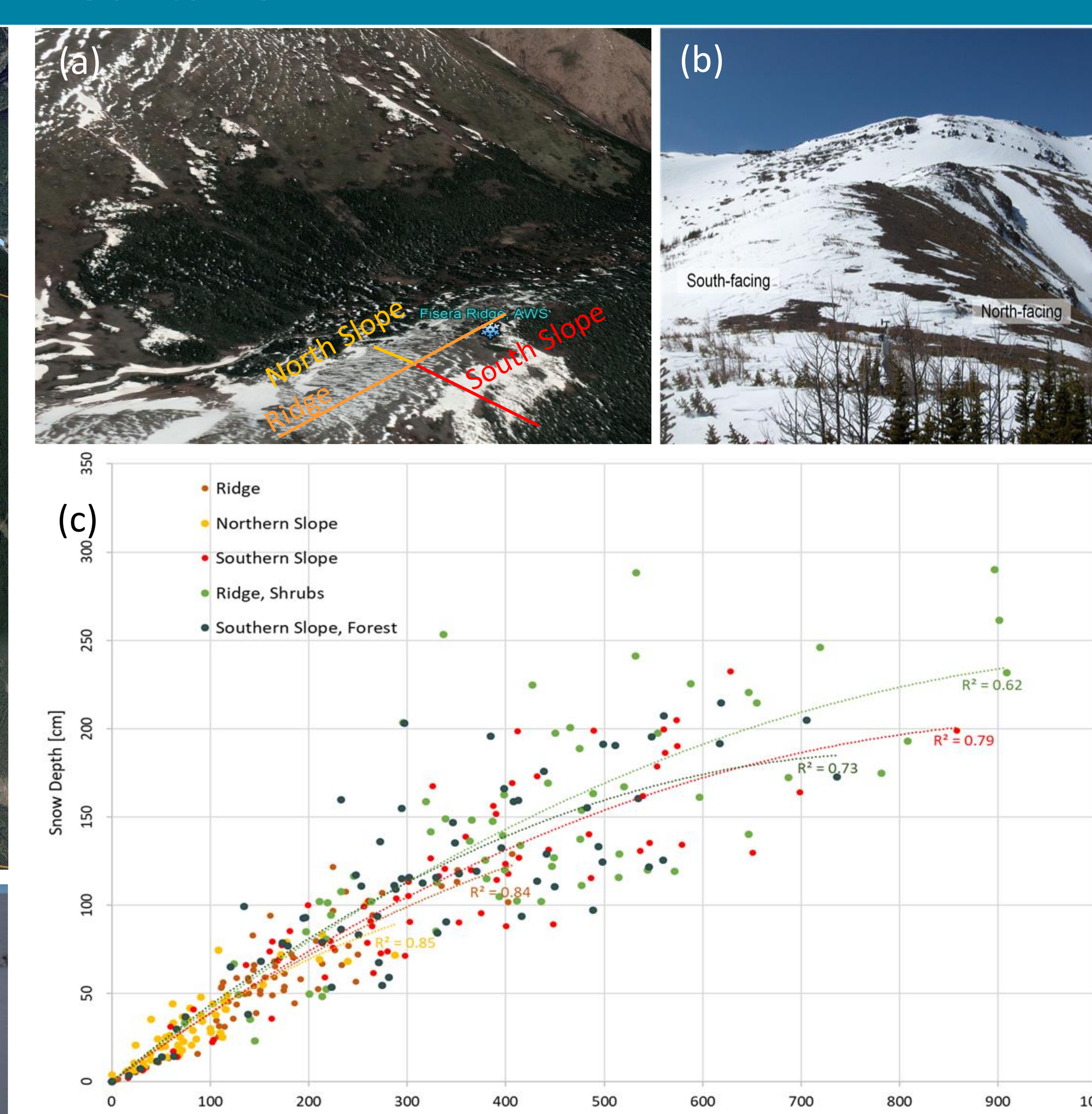

Fig. 3. (a) Fisera Ridge (2325 m) [digital globe 11 Jun 2017], (b) Ridge showing the north and south slopes, and (c) observed SWE [mm] vs. snow depth [cm] values (2010-2016).

Key points

Initial results indicate good model performance in capturing snow water equivalent (SWE), snowmelt onset, and ablation rates in complex environments when MESH uses PBSM, but poor performance when blowing snow processes are neglected by not using the PBSM option in MESH (Fig. 4).

Outcomes and Research Implications

- Meteorological and evaluation datasets have been created for snow modelling in complex mountain environments using the Canadian Rockies Hydrological Observatory and other data sources.
- These datasets will be used for testing the distributed configuration of MESH.
- Concerns related to the MESH [CLASS] single snow layer and the limited blowing snow transport over multiple grids may have implications on improving the model performance.
- Better prediction of snow accumulation and snow ablation in mountains will improve GWF's ability to forecast snowmelt-runoff contribution to rives, lakes, and reservoirs.

References

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