Supporting Information for Evaluation of New Snow Interception and Canopy Snow Ablation Parameterisations for Partitioning Snowfall in Needleleaf Forests

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1 Description of New Modules added to the Cold Regions Hydrological Modelling Platform (CRHM)

The following describes the new modules added to the CRHM software as part of this research. The new modules are fully implemented in the CRHM repository here and specific changes are documented in pull request #471.

1.1 Initial Snow Interception

Description:

A new module called `CanopyVectorBased` was added to CRHM to compute initial snow interception in the canopy as described in Cebulski & Pomeroy (2025a). This module differs from the existing CRHM `CanopyClearingGap` module based on Ellis et al. (2010) which calculated initial interception as a function of antecedent canopy snow load and canopy density. The new module represents an improvement by calculating initial interception as a function of snowfall and canopy density (function of canopy coverage and hydrometeor trajectory angle) based on observations presented in Cebulski & Pomeroy (2025a). The association of interception with canopy snow load is now handled only once by the canopy snow unloading routine in the canopy snow ablation module.

Module Code:

- https://github.com/acebulsk/crhmcode/blob/alex-ceb-thesis-changes/crhmcode/src/modules/ClassCRHMCanopyVectorBased.cpp
- https://github.com/acebulsk/crhmcode/blob/alex-ceb-thesis-changes/crhmcode/src/modules/ClassCRHMCanopyVectorBased.h

1.2 Canopy Snow Energy and Mass Balance

Description:

A new module called `CanopySnowBalance` simulates the physically-based energy and mass balance of snow stored in forest canopies following developments from Cebulski & Pomeroy (2025b). It is designed to be paired with the `CanopyVectorBased` module and together with `CanopySnowBalance` replaces the `CanopyClearingGap` module in CRHM. The `CanopySnowBalance` represents both dry- and melt-induced canopy snow unloading coupled with energy balance-based melt and sublimation calculations.

Module Code:

- https://github.com/acebulsk/crhmcode/blob/alex-ceb-thesis-changes/crhmcode/src/modules/ClassCanopySnowBalanceCRHM.cpp
- https://github.com/acebulsk/crhmcode/blob/alex-ceb-thesis-changes/crhmcode/src/modules/ClassCanopySnowBalanceCRHM.h
- https://github.com/acebulsk/crhmcode/blob/alex-ceb-thesis-changes/crhmcode/src/modules/ClassCanopySnowBalanceBase.cpp
- https://github.com/acebulsk/crhmcode/blob/alex-ceb-thesis-changes/crhmcode/src/modules/ClassCanopySnowBalanceBase.h

2 Canopy Snow Load Evaluation

Figure S.1 shows a subset of Figure 5 from the main manuscript to better illustrate select spring snow events with mixed snow/rain.

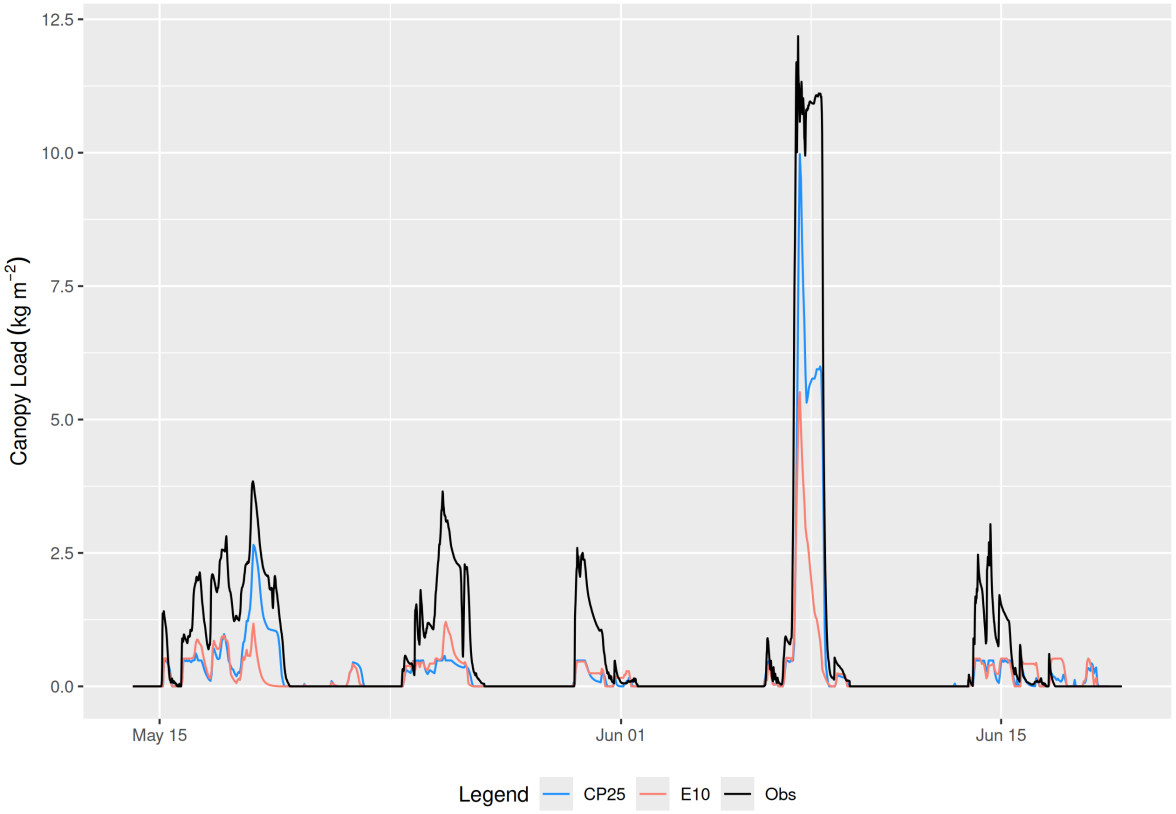

Figure S.1: Timeseries of simulated (CP25 and E10) and observed (weighed tree) canopy load at Marmot Creek for select spring snow/rain events between May and June 2019.

3 Canopy Snow Load Simulation

Figure S.2 shows a subset of Figure 11 from the main manuscript to illustrate the difference in initial accumulation of snowfall in the canopy between the two models.

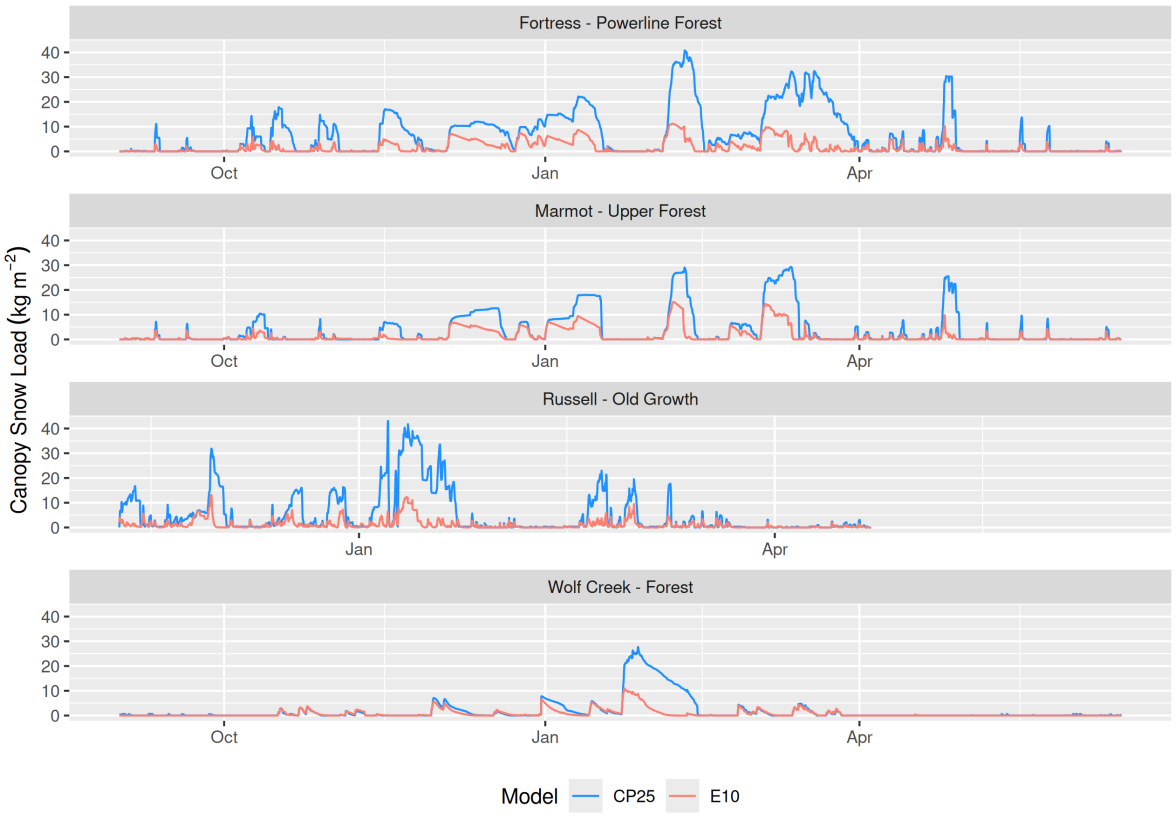

Figure S.2: Timeseries of simulated canopy load for CP25 and E10 at each station for select water years. The water year 2017 was selected for Fortress, Marmot, and Wolf Creek, while 2007 was selected for Russell.

References

Cebulski, A. C., & Pomeroy, J. W. (2025a). Snow interception relationships with meteorology and canopy density. *Hydrological Processes*, *39*(4), e70135. https://doi.org/10.1002/hyp.70135

Cebulski, A. C., & Pomeroy, J. W. (2025b). Processes governing the ablation of intercepted snow. *Water Resources Research*, *in review*.

Ellis, C. R., Pomeroy, J. W., Brown, T., & MacDonald, J. (2010). Simulation of snow accumulation and melt in needleleaf forest environments. *Hydrology and Earth System Sciences*, *14*(6), 925–940. https://doi.org/10.5194/hess-14-925-2010