# Assimilation of snow interception information into a Cold Regions Hydrological Model

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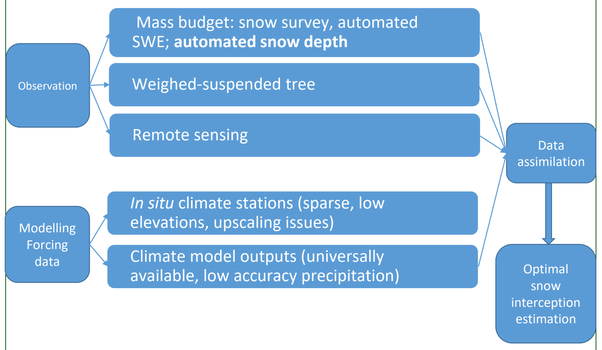
## Motivation




## Objectives

The objectives of this research are:

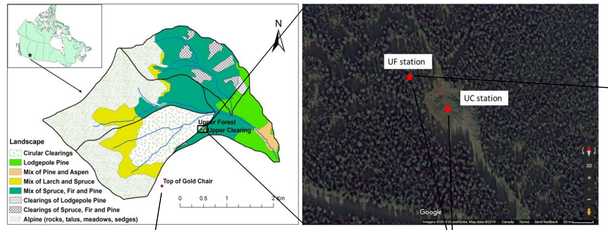
to determine effective ways to use automatically measured snow depth under forest canopies and in clearings to quantify snow interception losses in the forest.

to examine the influence of assimilating surface measured and remotely sensed snow interception information to snow interception simulations

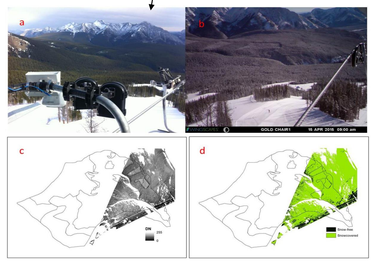
## Methodology

- Mass balance interception estimation
  - $\mathrm{Int} = \Delta\mathrm{SWE}_{\mathrm{UC}} - \Delta\mathrm{SWE}_{\mathrm{UF}}$
- Fresh snow density estimation
  - Hedstrom and Pomeroy (1998)
  - Jordan et al. (1999)
  - Snowpack model simulation (Snobal in CRHM)
- Model: Cold Region Hydrological Modelling platform (CRHM)
  - Snowpack module: Snobal (Marks et al., 1998)
  - Interception module: Hedstrom and Pomeroy (1998); Parviainen and Pomeroy (2000); Ellis et al., (2010)
- Snow interception assimilation
  - CRHM forced by ECCC's GEM NWP
  - Ensemble Kalman Filter (EnKF)
    - Tree measured interception (DA_Tree)
    - SR50-derived interception (DA_SR50)
  - Rule based insertion
    - Time-lapse photos interception (DA_TLC)
    - Model SWE<1 mm & Observed canopy snow = YES : Model SWE = 3 mm
    - Model SWE>1 mm & Observed canopy snow = NO : Model SWE = 0 mm
    - Others : No DA
  - No DA controls: CRHM forcing by GEM (GEM) & local observed climate data (ObsMet)

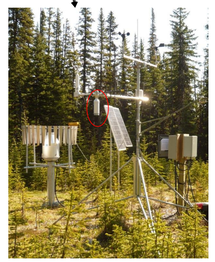
## Study area and Materials




Marmot Creek Research Basin



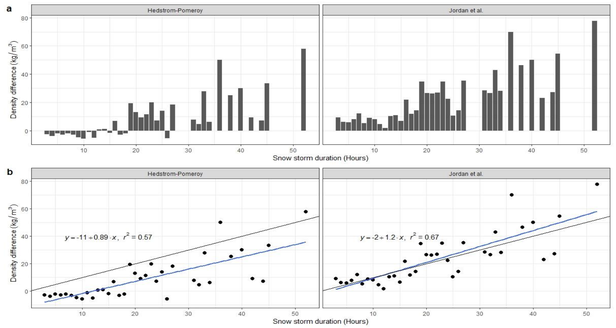

Time-lapse photos (Lv and Pomeroy, 2019)



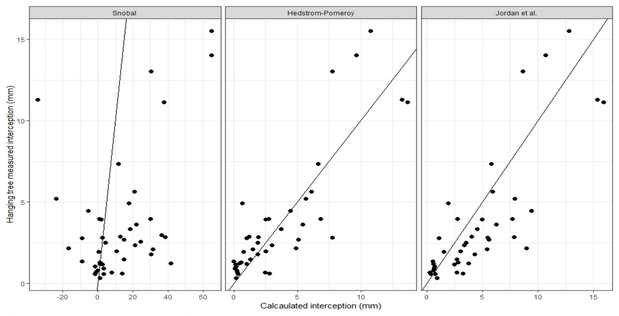
Met-stations

weighed, hanging-tree lysimeter

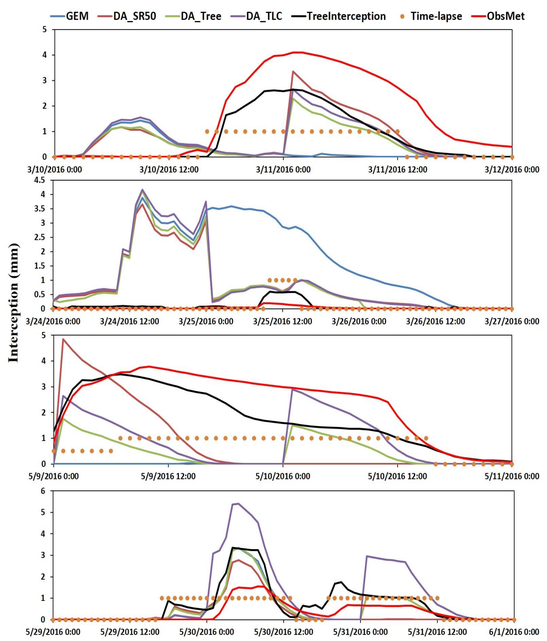
## Results




Comparison of snow storm duration (hours) to the difference between measured and calculated fresh snow density using two methods at the Upper Clearing.

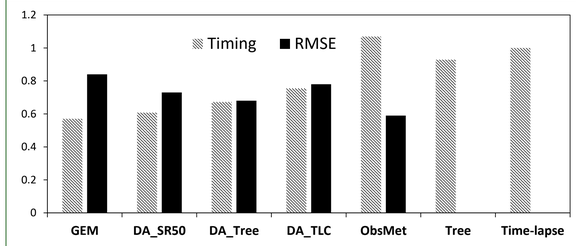



Comparisons between snow interception estimated by mass balance from snow depth observations and three methods to estimate fresh snow density against weighed tree observations at the forest site



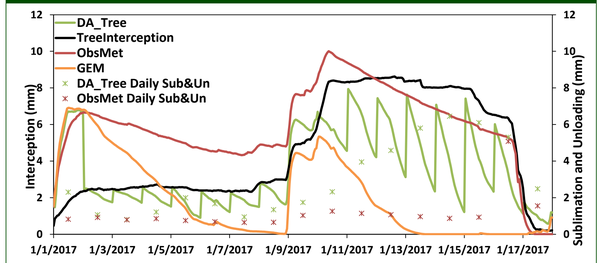

Comparison of simulated snow interception from DA with CRHM driven by GEM data (DA_SR50, DA_Tree, DA_TLC) and control open loop simulations (GEM, ObsMet) to suspended tree measurement and time-lapse camera derived canopy snowcover timing (0, 1, and 0.5 denote canopy snow free, canopy snow covered, and unknown, respectively)

## Results (Continued)




Snow interception timing of DA experiments driven by GEM data (DA_SR50, DA_Tree, DA_TLC), open loop controls (GEM, ObsMet), and tree (Tree) and time-lapse camera (Time-lapse) measurements (timing from others has been normalized to Time-lapse, shaded bars, unit: 1), and RMSE of snow interception from DA experiments and controls when compared to hanging tree measurement (dark bars, unit: mm)

## Limitations of DA




Comparison of open loop ObsMet (observation driven) & GEM (GEM driven), and DA_Tree (GEM driven) simulated canopy interception to weighed tree measured snow interception (unit: mm). Stars show the accumulated daily unloading and canopy snow sublimation from DA_Tree and ObsMet simulation (unit: mm)

## Conclusions

- In sheltered environments during snowstorms, fresh snow density can be effectively estimated using **air temperature** from the Hedstrom-Pomeroy (1998) relationship with a small **post-snowfall densification rate**.
- Although the GEM-driven simulations after DA were not as accurate as models driven by locally observed meteorology, DA **improved** the simulation accuracy of snow interception **amount** and **timing**.
- Snow interception data assimilation is greatly **influenced** by the **assimilation frequency** and **quality of forcing data**. There are limits to improvements of simulations when forcing data are poor.

## References

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