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Evaluation of the Meteorological Service of Canada Land-Cover Sensitive Snow Water Equivalent Algorithm

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ABSTRACT

Given the dynamic variability of snow cover in both space and time, and the need to understand the role of snow cover in climatological, hydrological and modelling studies, consistent and synoptic acquisition of snow cover information is required. To meet these data objectives, satellite passive microwave imagery has been utilized as a data source because of all-weather imaging capabilities, rapid scene revisit time, and the ability to derive quantitative estimates of snow water equivalent (SWE). The Meteorological Service of Canada (MSC) has developed a land-cover sensitive SWE retrieval algorithm for central Canada, based on the vertically polarized brightness temperature difference index for the 19 and 37 GHz channels of the Special Sensor Microwave/Imager (SSM/I). SWE is computed separately for open environments, deciduous, coniferous, and sparse forest cover, with the final per-pixel SWE value representing the area-weighted average based on the proportional land cover within each pixel.

In this study, 5-day averaged (pentad) passive microwave derived SWE imagery for the winter season (December, January, February) of 1994/95 is compared to a network of fourteen *in situ* measurement sites located throughout central Canada in order to assess algorithm performance (Figure 1). Daily snow depth data for these stations were converted to SWE using regionally and seasonally averaged density values. Consistently strong and positive correlation results indicate that the surface and microwave datasets capture a similar seasonal SWE evolution (Table 1). Calculation of mean bias error (MBE) for regions with varying proportional land cover within the four algorithm classes shows that retrieved SWE remains within ± 10-20 mm of surface observations, independent of fractional within-pixel land cover (Table 1). No bias towards under or over-estimation is evident except in high-density coniferous regions where the MSC algorithm consistently underestimates SWE relative to the surface measurements.

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Algorithm performance is notably improved, however, when compared to a previously developed dual channel (19V and 37V) MSC algorithm that does not consider land cover. Still focussing on the 1994/95 winter, total SWE values were calculated for the forested region outlined in Figure 2. Both algorithms produce highly correlated SWE values; however, the old algorithm consistently underestimates SWE relative to the new land-cover sensitive approach. Because the absolute difference in SWE between the two algorithms remains nearly constant even as SWE increases through the winter season, the proportional SWE underestimation decreases as the season progresses. Given that the earlier assessment showed that the new land-cover sensitive algorithm still underestimates SWE in densely forested areas, it is apparent that the new MSC scheme does represent an improvement over the previous algorithm.

A comparison of final snow ablation dates in the spring was also performed. Figure 3 illustrates the temporal precision with which the MSC algorithm identified the spring season 'snow-off' date compared to the surface data record for the stations shown in Figure 1. The MSC algorithm overextends the snow cover season, especially in forested regions, by failing to accurately identify the timing of spring ablation. For three stations (Cigar Lake, Key Lake, Island Falls) complete ablation is mistimed by more than one month. These results indicate that melt season adjustments to the algorithm are likely necessary, perhaps to account for the effects of wet soil and vegetative emission.

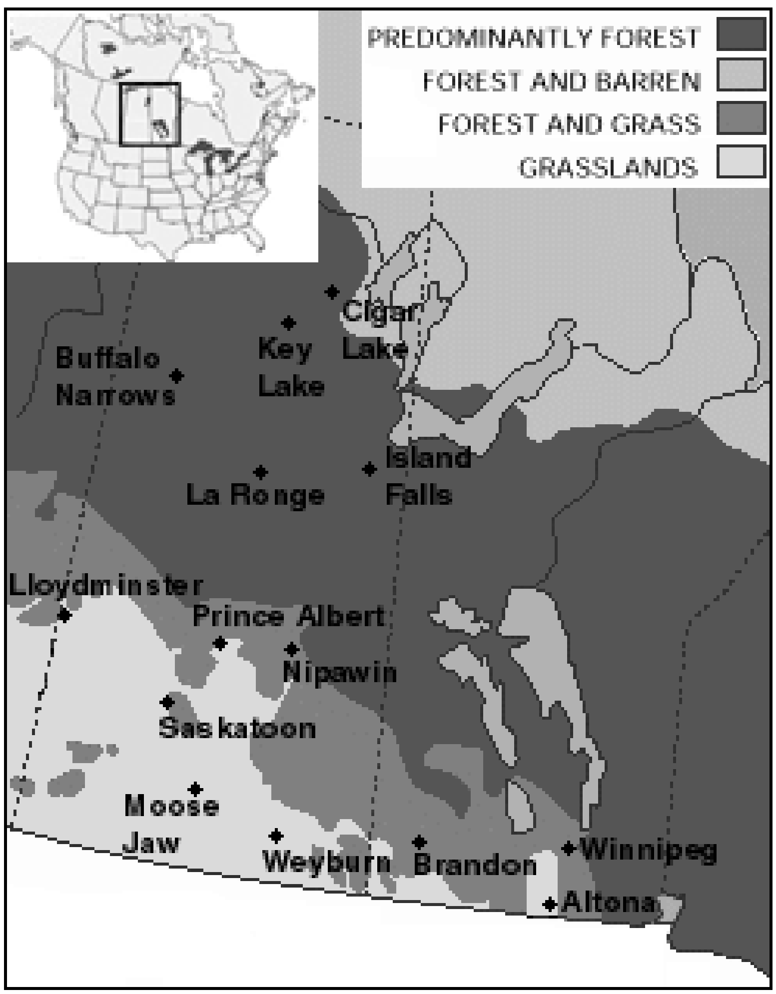

Figure 1. Stations for which *in situ* and passive
microwave derived SWE measurements were compared.

Table 1.Comparison between surface and SSM/I SWE estimates.
Coniferous (c), deciduous (D), sparse (S), open (O) land cover are in percent.

Station	C	D	S	O	r	MBE (mm)
La Ronge	96			4	0.76	14.9
Cigar Lake	93			7	0.81	10.8
Island Falls	85			15	0.94	36.2
Key Lake	85			15	0.83	20.6
Buffalo Narrows	77			23	0.96	3.1
Nipawin	35			65	0.72	11.0
Prince Albert	35			65	0.87	9.5
Weyburn		5		95	0.72	10.1
Moose Jaw			3	97	0.92	4.3
Altona				100	0.95	8.1
Brandon				100	0.75	15.7
Lloydminster				100	0.94	13.3
Saskatoon				100	0.76	20.3
Winnipeg				100	0.92	8.2
Average					0.85	12.4

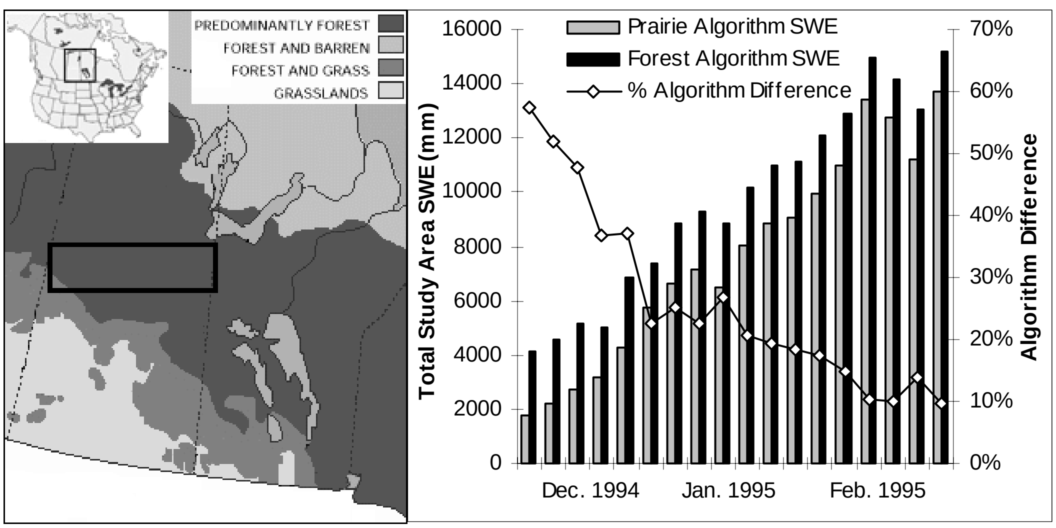

Figure 2. Comparison of current MSC land-cover sensitive algorithm and previous MSC algorithm that does not consider land cover. Graphic on left illustrates the study area for which total SWE was calculated.

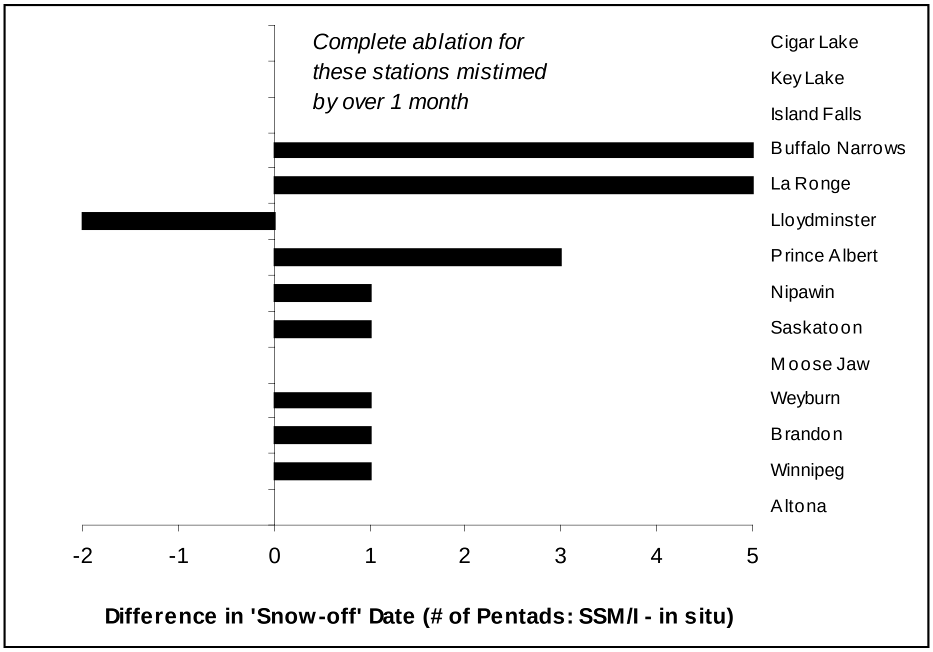

Figure 3. Comparison of snow-off timing between the passive microwave and *in situ* SWE datasets.