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The Cryosphere Discussions

Interactive comment on "Multi-scale spatialization of snow water equivalent (SWE) according to their spatial structures in eastern Canada" *by* Noumonvi Yawu Sena et al.

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Dear reviewer, I would like to thank you for the good reviews you made for this article. I have answered each of your questions and contributed relevant and essential answers for the understanding of the article. Question 1 The contribution of this work is to spatialize the average maximum SWE in eastern Canada at both (10km and 300m) scales according to spatial variability structure, which Sena et al. delineated in their previous study (Sena et al. 2015). This work is maybe useful, but the data description/validation is unclear and may be problematic. Also, the line numbering is not fully available in the manuscript, so it was difficult to leave comments. My comments focus

on clarifying the methodology. – Snow data: Where is the location of the measurement sites (map)? How many samples for each site? What's the possible uncertainties and error of these measurements? Also, there is no description of the measurement site. It's better to provide the maps of elevation, vegetation, of the study area for a better understanding of these sites. - Another thing that I am concerned with is the only use of the snow survey station data for both estimation and validation. Since the main trust of this paper is on SWE estimation and its validation, one would expect to see a more comprehensive probabilistic assessment of SWE estimation using a suite of measures to have a convincing analysis and conclusion. In addition, including regions of A and C is problematic because there are almost no observations there. - Analysis of regional/local physiographic factors is not fully or well explained. Is it possible to explain which factor is the dominant cause for each zone? Maybe an additional table including this information is helpful. - Section 3.2: It would be difficult to read this section for those who are not familiar with this region. The authors used a bunch of different names for stations, landscape, mountains ... without any locational information in the text. Quantified comparison results between estimated SWE maps and CRCM, GEM-CLIM, Strum et al. (1995), and Langlois et al.(2014) are needed rather than just say "resemble" or "consistent". –

ANSWERS Several questions are included in this paragraph. Each has been taken separately to provide clarification. âIJŞ This work is maybe useful, but the data description/validation is unclear and may be problematic. Also, the line numbering is not fully available in the manuscript, so it was difficult to leave comments. Answer The description of the data used is presented in 2.2. The error of the models in each of the areas delineated at each observation scale is presented in all figures. The line numbering is corrected in the manuscript.

âIJŞ Snow data: Where is the location of the measurement sites (map)? How many samples for each site? What's the possible uncertainties and error of these measurements? Answer The distribution of snow survey stations is added to Figure 1. As noted

in Section 2.2, only stations with more than 10 years of observations are included. A critical review of the stations was carried out in Sena et al.2019. Errors in models developed in explicitly delineated areas are shown in each of the figures at both the regional and local scales.

âIJŞ Also, there is no description of the measurement site. It's better to provide the maps of elevation, vegetation,. of the study area for a better understanding of these sites. Answer This manuscript focuses on the spatialization of the snow water equivalent according to the limits of the different spatial structures delimited at the regional and local scale. The description of the snow survey stations and the different physiographic variables that condition the spatial variability of snow cover are further discussed in previous work by SENA et al, 2015 and 2019.

âIJŞ Another thing that I am concerned with is the only use of the snow survey station data for both estimation and validation. Since the main trust of this paper is on SWE estimation and its validation, one would expect to see a more comprehensive probabilistic assessment of SWE estimation using a suite of measures to have a convincing analysis and conclusion. Answer The method adopted takes into account the size of the data available in each of the zones with homogeneous spatial structures in terms of snow water equivalent (Séna et al.2015). The estimation of the SWE is a function of the physiographic meta-variables at the regional scale and of all the station data followed by variographic analysis of the clean residuals for each zone except Zone C (Fig.2 regional scale). At the local scale, it is the local residuals that are inputs to the models and that are combined with the estimates obtained at the regional scale. In this approach and in relation to the reduced data size, the goal is to spatialize the SWE as a function of the degree of variability conditioned by the different physiographic variables at each scale of observation. The probabilistic approach was not used in this study.

âIJŞ In addition, including regions of A and C is problematic because there are almost no observations there. Answer The few stations survey available for the water equivalent of snow in Zone C (3 stations) was - limited in the application of the selected

method. However, the method of resampling the regional snow water equivalent values made it possible to suggest a local estimate. In Zone A, the number of stations (14) available made it possible to apply the methodology adopted.

âIJŞ Analysis of regional/local physiographic factors is not fully or well explained. Is it possible to explain which factor is the dominant cause for each zone? Maybe an additional table including this information is helpful. Answer The approach adopted in this manuscript takes into account the physiographic metavariables U1, U2 ,U3 ,U4 obtained at the regional scale and others at the local scale U1LZ, U2LZ, U3LZ, U4LZ, U5LZ, U6LZ. The analysis of physiographic metavariables is carried out in the previous work of Sena et al.2015.

âIJŞ Section 3.2: It would be difficult to read this section for those who are not familiar with this region. The authors used a bunch of different names for stations, landscape, mountains ... without any locational information in the text. Answer Mountain and landscape names have been added to the maps.

âIJŞ Quantified comparison results between estimated SWE maps and CRCM, GEM-CLIM, Strum et al. (1995), and Langlois et al.(2014) are needed rather than just say "resemble" or "consistent". – Answer5 Corrections have been made.(line28-32, page 21)

Question 2 Fig 8: three sub-figures are identical. Specific comments: Answer2 Fig. 8 is corrected.

Question 3 What are the criteria for choosing both scales (10km vs 300m)? Answer3 The scale of observation of the phenomenon must be chosen taking into account previous studies and sufficiently large to cover the entire spatial variability of the phenomenon (Gustafson, 1998). In this study, the spatial variability of the SWE can only be measured at the scale that gives the spatial dimension of the data.At the local scale, the spatial variability of the physical parameters of the snow is measured on a 300m line of snow (MDDEFP 2008). At this observation scale, local variability is under the in-

fluence of specific local underlying processes. The regional observation scale selected is between 10 and 100 km and corresponds to the regional scale where the processes of the major atmospheric circulation agents are observed (Marsh 1999, McKay and Gray 1981). (For information, see Sena et al. 2015).

Question 4 Page 2, Line 11: remove "The spatial variability of the snow cover is explained by physiographic factors, which generate spatial structures at different scales." Answer4 The sentence is corrected.

Question 5 Page 4, line 4: (MDDELCC, 2001) -> What means of 'MDDELCC'? I also had a hard time finding this citation in the reference. Answer5 The reference is added in the bibliographic reference. The correction is made

Question 6 4. Section 2.3: Which resampling method is used for SWE estimates at a local scale? I stop here because the line numbering is not available after page 4. Answer6 Only the resampling of the estimated snow water equivalent value was carried out in Zone C. The resampling tool of the PCI Geomatica software was applied to the snow water equivalent values from the regional scale (10km x 10km) to the local scale (300m x 300m).

Reference Gustafson EJ (1998) Quantifying Landscape Spatial Pattern: What Is the State of the Art? Ecosystems (1):143-156. Marsh P (1999) Snowcover formation and melt: recent advances and future prospects. Hydrological Processes 13(14-15):2117-2134. McKay GA & Gray DM (1981) Distribution of snow cover in Handbook of Snow. 153-190 p MDDELCC (2008) Manuel d'instructions à l'usage des observateurs en nivométrie, Québec (Ministère du Développement Durable, de l'Environnement de la Lutte contre les Changements Climatiques, Québec), p32.

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