

Interactive comment on “Assimilation of passive microwave AMSR-2 satellite observations in a snowpack evolution model over North-Eastern Canada” by Fanny Larue et al.

Anonymous Referee #2

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This paper evaluates the assimilation of AMSR-2 brightness temperature observations at 11 GHz, 19GHz and 37GHz into the Crocus/DMRT-ML models to analyse snow water equivalent. Results are evaluated against in situ data obtained from 12 sites representing different land cover types in Québec, Eastern Canada. This study is very relevant for the scientific community as assimilating radiances to analyse snow conditions in physical snowpack models is of high interest for hydrology and numerical weather prediction applications. The paper shows promising results for moderate vegetation cover and the method opens larger scale applications possibilities. The text has a number of language issues and grammar mistakes, some of which are listed below. The manuscript should be checked by a native English speaking colleague. However

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the paper is very well organised, results are presented with appropriate figures and tables, and very interesting discussion and conclusion sections are provided. I suggest this paper to be accepted for publication in HESS after the comments below are accounted for.

Page 9 lines 11-12: " To generate a three hourly-continuous meteorological forcing database for running Crocus, successive GEM forecasts were taken from the +09 forecast hour to the +18 forecast hour provided at the 00 and 12 UTC analysis time of each day." It is not clear to me what it means. Did the authors take forecasts at 00 UTC steps covering 09UTC to 12UTC and at 12UTC steps covering 18UTC to 21 UTC? Does it match the AMSR2 pass at 1pm local time? The authors should clarify in the text and also it would be clearer to use UTC everywhere, also when describing the AMSR data both UTC and local time could be provided (page 5 section 2.2 and page 7 section 3.1.1).

Page 10 lines 18-20: " Hence, as soon as a snowfall is detected with GEM precipitation data, the IL firstly added on the top of the surface was positioned 4 cm from the surface in the simulated snow profile. The maximum number of detected IL was fixed at two. In this case, the first detected IL was 20 positioned at 8 cm from the surface and the second at 4 cm after a snowfall was detected." please clarify/reformulate this part. From the first sentence the reader understands that the first IL is at 4cm depth, but from the second and third sentences it is indicated that the first one is at 8cm depth and the second at 4cm.

In section 3.4.2 it would be very useful to include a table with the list of experiments with a short name for each and indicating in the caption the experiment period and sites. So that the reader would have centralised in the table the experiment set-up information. For example experiment names like "DA1_TB19-37", "DA2_TB19-37,TB11-19", "DA3_TB_11,19,37". Using these short names in Section 4 when presenting the results would be much clearer. Also the first sentence of the section 3.4.2 starts with "In a first step,...", it should be followed by "In a second step," probably page 15, line

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17 when introducing the experiment on all sites. It is not a problem to reveal the fact that the best configuration will be DA of TB11,19,37 at this stage, it will only make the paper clearer. Page 18: section 4.2.1, first paragraph: there is no need to repeat in the results section the experiments that were conducted: please remove the first sentence of section 4.2.1. Finally, even the last experiment, with free snow stickiness and forest parameter, presented in Section 5, should be described in Section 3.4.2 and included in the experiment list table. It is surprising for the reader to be informed in Section 5 that another experiment was conducted. In other words, the paper should not necessarily follow the chronology of the research developments. It should present the experiments and the results/discussion without holding new experiment description for the results and discussion sections.

Page 20 line 6 and Figure 6: The way it is formulated page 20 and in the caption, it is not straightforward to understand the meaning of "SWE ensemble obtained with the DA of the three frequencies (referred to as 'SWEDA')". The reader may wonder why this one is called SWEDA whereas the DA of TB 11, 19 37 GHZ had no specific name. Please use experiment names and provide a table in section 3 (see comment above).

Minor comments:

table 1 Caption: replace: "Characteristics of the nivometric stations: SWE (in kg m⁻²) data, Latitude (Lat.),..." by "Characteristics of the nivometric SWE stations: Site number, Latitude (Lat.),"

Table1 caption: GEM is used here but only defined later in section 2.2. So, define it on its first occurrence in Table 1's caption.

Page 5, line 11: remove "further"

Page 5 line 13: replace "1pm" by "1pm local time"

Page 5 last paragraph: make sure tenses are consistent: line 12: "Crocus computes" and line 13-14: "The DMRT-ML ... was used to "

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Page 6 line 13: ".." -> "."

Page 8, table 2, caption: clarify if the winter period January to March as indicated in the caption, or if it is 1 January to 1 March as indicated in the text page 7 line 18.

Page 8 line 17 "formulations in" -> "formulations of"

Page 10 line 24: reformulate by something like: "The PMW brightness temperature (TB) emitted at the scale of the AMSR-2 product can be written as (2) for each grid cell as"

Page 11 line 15: "the expression of TB TOA in boreal areas was described by the Eq. (2)" for consistency please update Eq 2 (page 10) by replacing "TB=" by "TB TOA="

Page 12 line 3: remove "throughout the year"

Page 12 line 7: "In the Eq.7"-> "In Eq. 7"

Page 12 lines 17-20: update the text to ensure tenses consistency. For example lines 17-18: "Forest parameters (ω , $\gamma\nu$) depend on the forest characteristics, such as the biomass and the structure of the canopy for each site. To take into account the temporal variations of these characteristics, the forest parameters were linked to the LAI." can be replaced by: "Forest parameters (ω , $\gamma\nu$) depend on the forest characteristics, such as the biomass and the structure of the canopy for each site. They also depend on LAI which allows to account for the seasonal cycle in the forest emission". Also check the rest of the paragraph.

Page 12 line 31: replace "value couple" by "set of values", replace "(considered constant in frequency)" by ", defined at each frequency (11 GHz, 19 GHz and 37 GHz)", and replace "for each frequency (at 11, 19 and 37 GHz) in V-pol" by "at V-pol".

Page 12 line 32 / page 13 line 1: This sentence is not clear, it should be reformulated. Do you mean that the parameters were optimised also at H-pol or that the V-pol set of parameters were tested at H-pol?

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Page 13 lines 9-12: the 3 sentences on observation errors and ensemble inflation technics should be removed because they are not well formulated and the description given on the next page (page 14) is very clear.

Page 14, lines 19-21: This sentence repeats lines 12-13: " Hence, to avoid a 20 degeneracy problem, the weight of the 25-th selected particle (wekeep) must always be larger or equal to the inverse of the ensemble size (N=150)." Please update the text to avoid repeating sentences.

Page 15, first paragraph, last sentence: this statement should be placed earlier in the paragraph, before the three experiments are described.

Page 14 line 30 and page 15 line 8: The information on the DA experiments length and period should not be spread in the text. It should be clearly stated once.

Page 16 line 5: remove "(constant in frequency, Sect. 3.3.3)"

Page 16, section 4.1: update the text to use consistent tenses.

Page 18 line 19: replace "according to the studied period" by "for the studied period"

Page 27 lines 14-15: replace "explain" by "explains" and "up to" by "larger than".

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