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Hydrology and Earth System Sciences Discussions

Interactive comment on "Prediction of snowmelt derived streamflow in a wetland dominated prairie basin" *by* X. Fang et al.

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Response to referee #1 and #2's comments:

Abstract The abstract has been shortened. It is more concise in terms of methods used for the study, and some numerical results have been added.

Introduction and objectives As pointed out by both referees, the objectives have been rewritten to make this paper more concise and clearer about what it intends to achieve. We also think in consideration of their comments that conducting comparisons between the calibrated and uncalibrated modelling approaches is not of the greatest interest for make a contribution to advancing hydrological science. These two modelling approaches are not very different except for two DEMs used. Thus, we decided to

change the objectives; that is, the calibrated modelling approach has been deleted, and the paper focuses on developing a physically based, modular hydrological model for a Canadian Prairie wetland dominated basin and deriving model parameters using field survey data, digital elevation model (DEM), satellite imageries, stream network and wetland inventory GIS data. This is the uncalibrated modelling approach; we want to assess the model's performance using this approach by evaluating simulated winter snow accumulation, spring soil moisture, and basin streamflow.

Modelling methods An updated flowchart of physically based hydrological modules has been created to replace the original one shown in Fig. 2. As commented by referee #1, a simple name "Wetland module" has been used instead of lengthy "Soil moisture balance calculation with. . .", and these two-way arrows have been corrected. Also, referee was wondering about if the arrow can be put leading off to routing from the wetland module shown in the original Fig. 3. In original Fig. 3, arrows of surface runoff, subsurface discharge, and groundwater discharge were shown for various wetland module systems (e.g. soil columns, groundwater, wetland pond, and depression). In the updated flowchart of physically based hydrological modules, a runoff arrow has been added to connect wetland module and Muskingum routing module.

As the paper's objectives changed, the corresponding sections on explaining methods have been altered as well. We concentrated on explaining parameter estimation based on field survey data, LiDAR DEM, satellite imageries, stream network and wetland inventory GIS data. We completely deleted sections on methods of using the topographic map based DEM. Therefore, we have reworded the descriptions of modelling methods.

As indicated by both referees, maps showing sub-basins (or RBs) and HRUs have been added as new Fig. 5. This shows locations of HRUs and sub-basins and can provide clarification to readers about what the routing among different HRUs and among sub-basins. Also, as suggested by the referee #1, the procedure for estimating surface depression was well described in the text; thus, we think there is no need to have the original Fig. 5 and decided to delete it.

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For the “fill pit” algorithm used for the surface depression storage estimation, a citation has been added regarding this algorithm. This was suggested by the referee #2. With respect to using the ArcGIS cut/fill method with LiDAR DEM, additional discussion has been given in the discussion section to explain the uncertainty of using such method in estimating the surface depression storage.

From, the referee #1’s comment, a table summarizing the initial and maximum values of surface depression storage has been added. This allows readers to know what estimated surface depression storage values are in the Prairie Pothole Region, since the surface depression storage is relatively new parameter in the model. In addition, more explanation has been given on justifying the value of the attenuation in the Muskingum routing. The routing sequence within and between RBs has been explained more, and with the addition of the map of basin RBs and HRUs, the routing sequence is more clear (as suggested by referee #2).

Results/discussion We decided to focus the paper’s objectives on the evaluation of modelling simulation using the previous “uncalibrated” approach and thus the comparisons of the previous “calibrated” and “uncalibrated” approaches have been deleted from the results. We have rewritten the results: focusing on comparisons of modelling simulations and observations. Many good comments from both referees have been incorporated into rewriting the results.

It should be noted that Figures 7 and 8 show the results of SWE for sub-basin 1, and they are merely an example to the readers what the full simulations look like (there is not space for all of them of course). This simulation was neither particularly good nor bad and was not deliberately selected. Instead, we included the RMSD for all sub-basins in the original Table 1 to inform the readers about simulation accuracy in all sub-basins. In regards to the referee #1’s comments on the model’s infiltration simulation, we used the simple prairie frozen soil infiltration model developed by Gray et al. (1985) for snowmelt infiltration, combined with the Green-Ampt infiltration model for unfrozen soils so that we could estimate both snowmelt and rainfall infiltration. A

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more physically detailed approach would be to use Gray et al.'s parametric expression (2001) in the model to estimate the snowmelt infiltration into the frozen soils, so the model could better represent the formation of ice layers in soil. However, this requires a new infiltration module that combines Gray's infiltration model (2001) with the Green-Ampt model, switching as the soil thaws. We do not have the full set of information to create such a module now, though this is our next research goal. Note that the soil moisture was observed by reflectometer-type soil probes which only measure liquid water content and cannot be used to compare to total frozen+liquid soil moisture during the frozen soil period.

In the discussion section, as indicted by the referee #1, discussion on the results of simulations of SWE and soil moisture (i.e. the reasons causing the differences between the simulations and observations) have been given; the shape of the simulated hydrographs and reasons for the difference between the simulation and observation have been discussed. Since the paper's objectives have been narrowed down to evaluating model's performance using various techniques in model parameter setup, many discussions on model's structure (e.g. HRUs setup, model's routing) and techniques used in model parameterisation (e.g. automated method using LiDAR DEM for estimating surface depression storage) have been given. These discussion points explain both the model's strength and shortcoming in modelling snow hydrology for the complex prairie wetland basin. Again, valuable and insightful comments from both referees have been considered in rewriting the discussion section and we are grateful for these.

Conclusions The objectives of this study changed to evaluating the model's performance using field survey data, digital elevation model (DEM), satellite imageries, stream network and wetland inventory GIS data, and is no longer about comparing two modelling approaches. Thus, the conclusions have been revised focusing on new results and problems arising from the model's HRUs setup and wetland storage estimation.

Response to referee #2's comments on technical corrections

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Comment 1: P1106 L14 Missing “The” before “Majority” Response 1: Yes. “The” has been added before “Majority”.

Comment 2: P1107 L16 to end of paragraph: Objectives are very broad and should be refined Response 2: Yes. The objectives have been rephrased and more specific objectives have been defined.

Comment 3: P1111 L12 The description of the two approaches is not clear as worded. Response 3: Yes. The section of modelling methods has been rewritten.

Comment 4: P1118 L12 Missing “the” between “partition” and “amount” Response 4: Yes. The missing “the” has been added.

Comment 5: P1117 L27 Typo “Length-are” Response 5: Yes. Typo “Length-are” has been replace by “Length-area”.

Comment 6: P1121 L27 What does this mean "in which errors may magnify" (vague/unclear) Response 6: The results section has been rewritten, so this is fixed. More discussions on causing the simulated hydrographs have been given.

Comment 7: P1122 L2 Missing "the" after "had" Response7: Yes. This has been rewritten.

Comment 8: P1123 L26 to end of paragraph: check grammar Response 8: Yes. The discussion section has been rewritten.

Comment 9: Figures 7-10 should be larger (hard to read as is) Response 9: The legends, text on axes in the figures have been enlarged. They are certainly readable in our manuscript now. Perhaps, the figures were smaller in the HESSD journal article template.

Comment 10: Abstract: Too long Response 10: The abstract has been shortened with more concise description about methods used in the study and addition of some numerical results.

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