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Interactive comment on "A surface model for water and energy balance in cold regions accounting for vapor diffusion" *by* Enkhbayar Dandar et al.

Anonymous Referee #2

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This manuscript describes a new surface model that represents both the water and energy budgets, including vapor diffusion, intended for cold regions. The model is tested using weather data from a station in Mongolia. The model is available online in a single excel spreadsheet. This is a rather unique example of reproducibility. However, scientifically I have several concerns regarding the model formulation and its lack of validation (see comments below), which are crucial to meet the high standards of HESS publications. Therefore, my recommendation is that the manuscript requires major revisions.

Considering the content of the manuscript, I wonder if it would be better suitable for the Geoscientific Model Development journal. Another option, would be to take ad-

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vantage of the model being freely available in a excel spreadsheet and focus on the educational aspect of the work, as this could be easily used in many graduate (even under-graduate) courses to demonstrate the different processes.

Detailed comments:

Line 37:38 “Water and energy balances are the basic building blocks for any hydrological model and specifically of land surface schemes (also called large area hydrological models) linking meteorological data with runoff, and thus water availability.” The authors use a term “land surface schemes” and “large area hydrological models” as if they are the same. Although it is just question of definition, I find that this can be confusing to the reader. Typically, land surface models (LSM) can be coupled to atmospheric models, and therefore need to solve the energy balance on the sub-daily time-scale (i.e. time-steps typically bellow 1 hour). On the other hand, global hydrological models (GHM) are traditionally more focused on water resources and lateral transfer of water. See for example the work of Haddeland et al. (2011) which is an important reference in the community for a multi-model evaluation.

Line 54: “For our purposes we need to take into account vapor diffusion flux”: Why? At this point in the text it is not clear why you need to consider the vapor diffusion? Did other studies suggested that? Is it a hypothesis? If it is a hypothesis, it should be mentioned.

Line 62: Most, if not all, land surface model have multiple soil layers (e.g. JULES, SURFEX, ORCHIDEE, HTESSEL, CLM, NOAH-MP).

Section 2.3: In particular the sensible heat formulation: It is the first time I see such an approach using a daily time-step, from my knowledge, such formulations are typically used to solve the diurnal cycle. It this is in fact new, the authors should highlight it.

Sections 2.2/2.3: There is no separate evolution for snow on top of the soil. Considering that snow is a key in cold regions component, this could be a limitation of the model?

How is the Albedo and Roughness changed from snow to snow-free conditions? I just understood that once I opened the model in the excel file, and realized that snow depth is input. This raise some concerns since snow depth observations are not widely available. Furthermore, for the energy budget, the snow thermal insulation and heat fluxes between the snowpack and soil are not considered.

Section 2.4 Numerical implementation: Does it means that that the surface temperature used for the longwave and sensible heat flux for T+1 are taken from T? Considering that in 1 day temperature can change significantly, and fully implicit formulation could be more appropriate, as the explicit formulation could introduce phase errors. This should be at least discussed.

Results: The authors do not provide any independent validation. This raises a significant concern, as we do not know if the model structure and parameters selection is able to represent reality. The detailed results of the different component and phase changes is important, but without any kind of validation does not provide any evidence if these are real process or just model characteristic. At least some component such as the radiation could be compared with atmospheric reanalysis (e.g. ERA-Interim). There are also river discharge observations available (e.g. GRDC) with very small upstream areas in other cold regions areas that could be used to evaluate the model's runoff (see for Beck et al. 2016).

References:

Haddeland, I., and Coauthors, 2011: Multimodel Estimate of the Global Terrestrial Water Balance: Setup and First Results. J. Hydrometeorol., 12, 869-884.

Beck, H. E., van Dijk, A. I. J. M., de Roo, A., Dutra, E., Fink, G., Orth, R., and Schellekens, J.: Global evaluation of runoff from ten state-of-the-art hydrological models, Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-124, accepted, 2016.

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