general comments :

Dear authors,
This paper evaluated the Land Model Surface (SVS) to simulated water component in cold climates. Authors implemented a soil-freezing scheme in the model. This evaluation is realized on two lysimeters. The results show that the model reproduces snow depths correctly in general, but is still failing to correctly simulate percolation.

Although I generally like the study and also think that more direct measurements from lysimeters should be used, I have some critical comments on the manuscript.

The main shortcomings are:

- **The title is not appropriate and does not correspond to the conclusions of the study.**
- **The introduction needs to be more improved**
- **Description of lysimeters, soils, datas and parameters are incomplete**
- **There is no comparison with the initial version**
- **Analysis between variables (periods and criterias) are confusing**
- **Results not presented in enough detail**
- **Discussion should be improved**
- **Other Comments**

- **The introduction needs to be more improved**

I find the introduction disorganized and incomplete. Preferential flows need to be mentioned, and also add more details on LSMs and lysimeters.

To facilitate the reader's understanding of the impact of your study, I suggest an organization similar to the below: i) context : groundwater, complications and challenges of cold climates, characteristic and properties of landfill soils (this last part is really missing); ii) models can be used, including Lsm (give more details: their history, why they were developed, aren't they mainly used on a regional or global scale? What's the point of looking at an LSM on the scale of a lysimeter?); iii) Talking about lysimeters: this part is too limited and needs more details.

I find the literature search interesting: however, it is also necessary to give some values in the text (and not only in the Figure). Also, if the values correspond to frequencies, then why does the sum not equal 100? And I also don't understand why there are 57 cases in fig 1a while there are 28 in fig 1b; Be coherent.

Line 15 : Why are they important?

Line 35 :There are many other limitations (Vereecken et al., 2019).

Line 53 : “This study aims to improve deep percolation simulation”. I cannot see the improvement, as there is no comparison with the initial version…

Line 58 : Not soil matric potential?

Line 60 : Maybe for SVS, but not for LSMs (Boone et al., 2001 ; Decharme et al., 2016)

- **Description of lysimeters, soils, datas and parameters are incomplete**

The description of the soils and lysimeters is really incomplete, which makes it difficult to interpret the results. What are the characteristics of these "landfill" soils? What makes them special? And is the soil covered with vegetation? Please comment texture values when you describe soil. 0% of Clay ?

There is a wide diversity of lysimetric devices and methods. What are the dimensions, the installation procedures...? I later learn that there are runoff measurements... Is there an imposed slope on these lysimeters? Explain the differences between the lysimeters used in this study, etc…

The scheme in fig. 2c could be improved and made bigger with more detail. For me, figs. 2a and 2b are not visible and not necessary.

Some suggestions for Table 1 :

- Add the heading "Observation" for the 1st column and "Model" for the 2nd column
- Illustrate the variability of soil (textures+parameters) for the two lysimeters
- What is N ?

As you mentioned in your introduction, model parameters are extremely important for the quality of simulations. However, no comment is given in the text on the values obtained. Are these values comparable with these soils ? Are they the same as those generally estimated by LSMs? A value of b equal to 1 is surprising, especially in comparison with pedotransfer functions used by LSMs. Please comment, especially given its importance in the dynamics of percolation simulation.

Moreover, the parameters are estimated for the period between April to September 2019. Some studies recognised that changes to the soil and its structure can be significant in lysimeters (Weihermüller et al., 2007; Séré et al., 2012; Seneviratne et al., 2012). Have you performed this protocol at other periods? If so, are the parameters measured different? If not, this could be something to consider, especially in view of the low scores obtained after 2020, and would be a point for discussion.

If there is vegetation, please explain how you set the parameters.

Comment on the quality of your data, the gaps, and how you integrate it into your analysis.

For me, the "Methods" section is not simply a Methods section, in particular the model description. Find a more appropriate name for this section or a better structure.

- **There is no comparison with the initial version**

As I said earlier, in order to assess the contribution of the gel to this model, we need to compare it with the original version. This procedure is essential to highlight this work.

- **Analysis between variables (periods and criterias) are confusing**

It's very complicated to compare Figs 3, 4, 5, 7 and 8, because they don't have the same evaluation periods. I can understand Fig 3, but not for the others. You have to be consistent. It is very confusing for me.

In addition, evaluation metrics are not always identical from one analysis to another, especially correlation. This is a criterion to be included in each analysis.

- **Results not presented in enough detail**

You never mention two essential concepts: ETP and water balances. However, these are still key aspects of hydrology and can be estimated using lysimeters. An assessment of the model's capacity to reproduce these two elements would be advisable.

Then, I find there is very poor comment on the observations, yet observations are also a result in themselves. Also, in the observations, it would be good to highlight the variability between lysimeters, as you did for Fig 8. That would make it possible to assess heterogeneity, the influence of the size of the lysimeters, changes in the soil over time, etc.

I also think it would be interesting to have a seasonal cycle, in addition to Fig 6. in order to have a temporal dimension in the differences between observation and model.

In the Figs 3, 4, 5, 7 and 8, it would also be good to include the statistical values over the complete period (although this is included in the text).

Snow Depth :

Where is the year 2022?

Comment the very similar dynamics (sensitivity) of the model at the end of winter. For example, the maximum peak is almost always at the same time of year, with a value very close to 50 cm.

Near-surface Soil Temperature :

Do you have an estimation of the depth of frost?

Near-surface Soil moisture :

Please add the correlation in your analyse. I guess the correlation is not very good. Comment. And notably in summer when the observation is very low until model is stable. This may illustrate the fact that the model does not represent ETP very well. Is there any vegetation that can increase ETP?

Deep percolation :

Please comment the observation! What do the periods without observation lines mean (e.g. 2020-11 to 2021-03); Is this a period without drainage? or a period without observation? How is this taken into account in your statistical evaluation?

I don't agree with your comment when you say the model correctly reproduces the observations. Perhaps the CRPS is good, but the dynamics are not good, with significant dephasing and a model that reacts too quickly and too intensely.

Is it possible that the low scores after 2021 are due to a transformation of the environment within the lysimeters over time? in structure and hydrodynamic parameters?

- **Discussion should be improved**

I rather like the discussion, which is well constructed and well developed.

I think an analysis of the sensitivity of the parameters could be useful for this study. For example, if we only perturbed one parameter, or only the meteorological forcing, how will the simulations be affected?

Figures should be improved with the use of hovmoller diagram. These diagrams are often used on lysimeters to follow the movement of water in the soil and to help comprehension (depth vs time) (Abdou et al., 2004, Decharme et al., 2016, Sobaga et al., 2023).

For the example you are using in this section, please use a symbol (a star?) on the previous chronicles (Fig 3 - 8).

Limitations of SVS in simulating soil moisture and deep percolation in winter

Can you examine how many events the model does not react to while the observations do react? And give a statistic for the cases where preferential flows are observed?

Furthermore, don't you think that these preferential flows would not be due (or at least reinforced) by the lysimeters? Either by edge effects? or by a modification of the soil?

Influence of Capillary Barrier on Simulated Subsurface Soil Moisture

Do you try to change the thickness of the last layers ?

Are these results also verified on the Lysi L2? If not, why not?

Please comment the Fig 10.a,

A simple simulation with the same parameters and a free LBC would be welcome to confirm these observations, and to check if this is only the effect of the LBC.

- **Other Comments**

Conclusions

Lsm are generally used on a regional or global scale. In your opinion, what would be the main challenges of the change of scale for these cold climates? And how would you integrate preferential flows on a larger scale?

Appendix 2 :

When you use LBC seepage for hydraulic conditions, how do you define LBC for Temperature?

Minor Corrections :

Be consistent with the units : ex. m^3/m^3 or $m^3.m^{-3}$

Abstract :

Line 4 : Please precise what is “SVS”.

Line 23 : ‘This is …’ : This sentence is not necessary and complicates the message.

Line 24 : which cover ? “Land Cover” ?

Line 29 : “well” is not necessary.

Line 30-32 : what is “they” ? This part is very hard to follow. Please Improve.

Line 37: “in such model”.

Line 40 : “Figure 1-c maps the location of these case studies” → “Figure 1-c locates the sites used in this study.”

Ligne 85 : with which formula?

Line 108 : not ‘soil suction’ but ‘soil water potential’.

Line 109 : (ms−1)

Line 119 : how many spinups did you use? 1 time? Several times?

Line 191-195 : to move in the method

Line 196 ; Please give a value

Fig 3 : the vertically shaded areas are not visible

Fig 3 : Name of the label ‘Field Snow’ is write both twice for different symbol.

Fig 6 : Please add the number of point.

Line 244 : should be placed at the beginning of this sub-section.

Line 248 : “at local scale”

Fig 9 : For the snow, show also the point.

Do you have the Temperature at 225 mm ?

Please add in the label : (No percolation simulated)

Please add the model simulated for Soil Moisture at 225 mm.

I suggest you to replace this plot as a Hovmoller diagram.

Ligne 278: Please add some statistic evaluations.

Line 280 : How long does it take to infiltrate?

Line 292-295 : not clear for me.

Line 297 : explain what is the Fig 10.c before to interpret the data.

Line 330 : Could you be more specific? By what means?

References :

Abdou, H. M., and M. Flury. "Simulation of water flow and solute transport in free-drainage lysimeters and field soils with heterogeneous structures." European Journal of Soil Science 55.2 (2004): 229-241.

Boone, A., & Etchevers, P. (2001). An intercomparison of three snow schemes of varying complexity coupled to the same land surface model: Local-scale evaluation at an Alpine site. Journal of Hydrometeorology, 2(4), 374-394.

Decharme, B., Brun, E., Boone, A., Delire, C., Le Moigne, P., & Morin, S. (2016). Impacts of snow and organic soils parameterization on northern Eurasian soil temperature profiles simulated by the ISBA land surface model. The Cryosphere, 10(2), 853-877.

Seneviratne, Sonia I., et al. "Swiss prealpine Rietholzbach research catchment and lysimeter: 32 year time series and 2003 drought event." Water Resources Research 48.6 (2012).

Séré, G., Ouvrard, S., Magnenet, V., Pey, B., Morel, J. L., & Schwartz, C. (2012). Predictability of the evolution of the soil structure using water flow modeling for a constructed technosol. Vadose Zone Journal, 11(1).

Sobaga, Antoine, et al. "Assessment of the interactions between soil–biosphere–atmosphere (ISBA) land surface model soil hydrology, using four closed-form soil water relationships and several lysimeters." Hydrology and Earth System Sciences 27.13 (2023): 2437-2461.

Vereecken, H., Weihermu¨ uller, L., Assouline, S., Simuunek, J., Verhoef, A., Herbst, M., Archer, N., Mohanty, B., Montzka, C., Vanderborght, J., et al. (2019). Infiltration from the pedon to global grid scales: An overview and outlook for land surface modeling. Vadose Zone Journal, 18 (1), 1–53.

Weihermüller, L., et al. "In situ soil water extraction: a review." Journal of environmental quality 36.6 (2007): 1735-1748.