

Geosci. Model Dev. Discuss., referee comment RC2  
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## Comment on gmd-2022-136

Anonymous Referee #2

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Referee comment on "Inclusion of a cold hardening scheme to represent frost tolerance is essential to model realistic plant hydraulics in the Arctic–boreal zone in CLM5.0-FATES-Hydro" by Marius S. A. Lambert et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-136-RC2>, 2022

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In this manuscript, the authors attempted to incorporate the effect of cold hardening on the hydrological and physiological processes of trees into the CLM5.0-FATES-Hydro. The scheme of cold hardening consists of the hardening scheme (Rammig et al., 2010; some modifications) and the physiological scheme (maximum conductance, parameters for stomatal conductance, hydraulic failure mortality, pressure-volume curve, and carbon starvation mortality). They showed that the inclusions of cold hardening schemes are vital for reproducing the biomass of two boreal forests in Farstanas and Spasskaya Pad. Otherwise, the trees die due to hydraulic failure during the winter, caused by the low water potential of frozen soil and the resulting dehydration of the trees. Therefore, I think their schemes are successfully developed and valuable for many readers who want to model the processes in boreal forests.

I recommend this article be accepted after the revisions listed below.

On the modifications to the scheme by Rammig et al. (2010)

For example, the authors modified the maximum hardiness level (H\_MAX) from a constant (i.e., -30 deg C) by Rammig et al.(2010) to the variable changing with the running mean of the annual minimum air temperature of the past 5 years. This may result in a big difference in the simulations, particularly in Spasskaya Pad, but such a result is not shown in the present manuscript. I'd suggest showing the results when the original schemes by Rammig et al.(2010) are adopted so that the importance of the modifications in this study will be emphasized.

Citations of equations

Throughout the manuscript, the citations of equations look strange and probably do not fit the style of GMD. In the case of this manuscript, all the "Eq. XX" should be put in parentheses. For example, in L182, "TH Eq. (1), HR Eq. (2) and DR Eq.(3)" should be "TH (Eq. (1)), HR (Eq. (2)), and DR (Eq.(3))". Please revise all of them.

### Symbols in equations

Throughout the manuscript, the symbols differ between the text and the equations. For example, H\_MIN and H\_MAX in the text are presented as M\_min and H\_max, respectively, in equations (1), (2), and (3). Please maintain the integrity of symbols.

### Section 2.2

I strongly suggest the authors provide the model description of HD (i.e., L191-202) in advance of those of TH, HR, and DR for better readability.

Besides, the description L191-202 seems not sufficient. For example, HD takes the maximum value H\_MIN in summer, but it is not explained. This corresponds to equations (1) and (3) of Rammig et al (2010). Here, Rammig et al. (2010) adopted agg5 (the accumulated growing degree days), but the authors did not mention it in the manuscript. Is that OK?

Since this hardening scheme is the core of this study, the authors should describe it entirely, even if it is nearly the same as Rammig et al. (2010).

Otherwise, the reader would have to refer to Rammig et al. (2010) when reading this paper.

In addition, according to equations (4) to (6), HD is determined depending on the interrelations between HDP and TH. I'd suggest showing the example of the temporal variation of HD and TH to show how these variables are interrelated.

### Figures

As reviewer 1 pointed out, most of the figures are difficult to distinguish between lines, and the legend obstructed the figure. Please try to make it easy to see, and put the legend outside the plot.

L61: It is unclear what "it" stands for here. Is it "plant hydraulics"? If so, I suggest rewriting this sentence as follows.

"Plant hydraulics, apart from its critical role in the survival of plants during droughts, is also a major driver of species distribution."

L110-111: Lawrence et al. (2019) --> (Lawrence et al., 2019)

L178 and the caption of Table 1: Does "the minimum 2m daily temperature" mean the "annual minimum of daily mean air temperature at 2m height"? Describe it clearly.

L192: "the hardiness of the previous day (HDP)" --> "the hardiness level of the previous day (HDP)" or "the HD of the previous day (HDP)"

L245 (Eq. 12): The variables "HFMortScalar" and "percentage" appear here for the first time without any explanation. What are these?

L262: Hd --> HD (italic)

L342: 0.55% --> 55%

L342: (Fig. 8b and c) --> (Fig. 8a and b) Note that Fig. 8c shows the CSM, not HFM.

L356: Insert "(Eq. (10))" to read "since HFM is a function of flc (Eq. (10))".

L359-360: I could not get the meaning of this sentence. Does it mean "The contribution of the changes in K\_MAX, g0, and g1 to the reduction of HFM can be seen by comparing Fig. 8b and Fig. S12."?

L439: green --> red

L439: brown --> green

L440: dark green --> (light) blue

Figures 8a and b, S5a and b, S12a and b, S13a and b: "Hydraulic mortality" in the vertical axis should be "Hydraulic failure mortality" to maintain the integrity of the terms.