RC1: 'Comment on gmd-2022-136', Tim Artlip, 06 Sep 2022

This manuscript addresses the lack of a cold hardiness component in equations designed to assess water flow and fitness in landscape-level vegetation models, which don't work for low temperature climates, particularly with trees that potentially continue photosynthesis/ transpiration during winter.

The paper advances a logical addition of a cold hardiness component and includes novel data generated from simulations.

The logical addition of a cold hardiness component may not be considered a substantial advance by some readers.

The methods and assumptions are valid and clearly outlined. See also comments to the authors.

The results are sufficient the interpretations and conclusions. See also comments to the authors.

The model appears replicable by others in the field. See also comments to the authors.

The authors clearly state which contributions to the model are prior work by other authors and what their contributions are.

The title clearly indicates the contents of the manuscript including model name and number.

The abstract is clear and concise.

The presentation is well structured and clear.

The language is fluent and precise.

Mathematical formulae, symbols, abbreviations, and units are defined and precise.

The manuscript cannot be reduced.

The references are appropriate. See also comments to the authors.

The supplementary materials are sufficient and appropriate.

Authors response: *Thank you for the positive comments. Our responses are given in blue text under each comment.*

Comments to authors:

Line 175: I suggest the authors consider providing a supplementary file with these data (if possible).

Authors response: *Thank you for this comment. We added a table in the supplementary that includes the parameters used by Rammig et al. (2010) which were not specified in the paper (Please see Table S1 in the revised version of the manuscript).*

A crucial point is whether the authors will verify the model, particularly the hardiness estimations, with real experimental (biological) data as opposed to data from the literature. While the simulations and conclusions look appropriate, I think confidence in the conclusions would be strengthened with a subsequent publication that tests the algorithms with actual biological data.

Authors response: *This is a good point, and it is mentioned in the conclusion and outlook of the manuscript. We highlight the need for plant hydraulic observations in cold regions, especially conductivities and fluxes in and out of the leaves/roots, but also the bulk elastic modulus and the* *osmotic potential at full turgor, plant mortality due to hydraulic stress and carbon starvations, and various levels and thresholds useful to the hydro-hardening scheme. It would be very helpful to obtain more data on this and be able to evaluate and better constrain the hardening scheme and its effect on plant hydraulics. We do have a follow-up publication aimed at testing the role of cold hardening for vegetation survival and mortality during an extreme winter event in northern Norway, where we compare to observations of vegetation damage. Since that study frequently refers to this paper, we aim to submit that one once this manuscript has reached its final form.*

Line 175: The authors should consider the findings of Kuprian et al. (Tree Physiology 38, 591–601 doi:10.1093/treephys/tpx142) who examined the relationship between winter desiccation and bud primordia supercooling (hardiness) in Picea abies. Their results "suggest that there is no causal relationship between desiccation and the supercooling capacity of bud primordia in P. abies, but rather it involves other compounds within the cells of the bud primordium that reduce the water potential". This may be an important consideration in terms of biomass production as new needles arise from bud primordia.

Authors response: *Thank you for the reference. The findings by Kuprian et al. (2018) are indeed relevant and important to represent winter processes more accurately in models, and better estimate biomass changes. As explained by Kuprian et al., it seems, however, that there is no agreement yet on whether desiccation impacts supercooling or not (https://doi.org/10.1093/treephys/18.7.451). What most papers agree on is that desiccation decreases the risks of mechanical freezing damage by reducing the amount of water that may crystalize.*

Here we added two extracts of Kuprian et al., (2018) where they explained their hypothesis on why/how the supercooling capacity of plants may be affected by frost-hardening:

"Total water potential of a tissue is determined by water content. Therefore, dehydration will decrease Ψ_t, but an osmotic component (Ψ_o) and cell wall turgor pressure (Ψ_p) also are contributing factors. Our results indicate that dehydration per se does not affect the supercooling capacity of bud primordia. Thus, the two other potentially relevant components of total water potential must be considered."

"A lesser cell wall turgor pressure (Ψ_p), resulting from alterations in cell wall elasticity, could also reduce Ψ_t during winter. Seasonal changes in the composition of cell walls of bud primordia could also be possible, however cells in the primordia are composed of undifferentiated cells with only primary cell walls that are thin and not fully developed with potentially little leeway for changes in elasticity."

Based on these statements we cite their work at L264 in the revised version of the manuscript : "To maintain turgor during stress (Beck et al., 2007) or during hardening (Valentini et al., 1990), plant organs increase their solute concentration which decreases pinot and they increase the elasticity of their cell walls which corresponds to a decrease in epsil (Bartlett et al., 2012; Kuprian et al., 2018)."

Figures: Many of the figures are difficult to make out as is the lettering within the figures. I suggest making the line/ symbols heavier and the colors bolder.

Authors response: *We thank you for this observation and suggestions. The figures have been made clearer by making the lines thicker and by putting the legends outside of the graphs in the revised version of the manuscript.*