Geoscientific
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Interactive comment on "A two-layer canopy with thermal inertia for an improved modelling of the sub-canopy snowpack energy-balance" *by* I. Gouttevin et al.
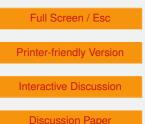
Anonymous Referee #1

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Dear authors,

congratulations, You are providing a significant scientific effort and advanced model to the community!

General remarks

(i) Your manuscript is a substantial contribution to snow-vegetation interaction research and the modelling of beneath-canopy snow cover evolution; the physically-based approach You realize makes the new model component transferable in space and time, and supports our understanding of relevant processes. However, the manuscript could be significantly improved in its quality by sharpening the focus, and concentrating on

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the innovative part of Your work (the paper should be shorter, but more concise). Suggested revisions are in between minor and major. The issue is fully in the scope of GMD.

(ii) The methods applied are appropriate and valid. However, concerning the related work, some additions should be included. Balance of what is presented and discussed can be improved, too.

(iii) Presentation and structure are in general clear and concise. The manuscript can, however, benefit from significant improvements regarding the choice of what it includes, and what not.

(iv) The English should be corrected.

Remarks in detail

(i) I recommend Your manuscript for publication in GMD after improvement/modification and respective revision.

(ii) Important work that has been previously published with respect to snow-vegetation interaction and the modelling of beneath-canopy snow cover evolution is missing. I recommend consideration of the work of Durot (1999), Liston and Elder (2006), Strasser et al. (2011) and a more comprehensive presentation of the SnowMIP2 project (Rutter et. al. 2009). You should clearly state in the beginning that Your work so far mostly refers to coniferous forests. It is not clear enough for the reader if the model component comprises summer process functionality (i.e., liquid water interception plus evaporation, drop-off, and consequent effective rainfall on the ground, transpiration), or if it is meant to be a snow model component only with some functionality to handle rain events. This aspect should be concisely clarified in the beginning. Eventually, the title of the paper could be improved by changing it to "A two-layer deciduous forest model with thermal inertia for improved simulation of the beneath-canopy snowpack energy balance" Even though You mainly focus on the energy balance, the most interesting variable for snow

and snow hydrological models (such as SNOWPACK and Alpine-3D) is the mass balance of the ground snow cover, i.e. the evolution of swe during the winter season. The paper would benefit from a more rigid concentration of the latter. The Alptal site data is perfectly suited for this, but Norunda not. Please consider whether You either concentrate on winter (snow) processes (i.e., use another site than Norunda to demonstrate transferability of the model), or You focus on transient simulation; in this case a comprehensive treatment of the forest summer water balance would be required (including the soil water balance, root water uptake, transpiration etc.). I urgently recommend the former approach; for that purpose You could e.g. make use of the SnowMIP2 data (which is available on request). I doubt that presenting all three model versions improves the scientific meaning of Your manuscript; obviously the 2-layer scheme (2LHM) performs best. Skipping the comparison with the 1-layer schemes and concentrating on what is the real innovation of Your (great) work would make the paper more focussed, sharp and clear. "No explicit simulation of snow melt or snow densification in the canopy is included in the model" (p217, ls18-20): why? At least the former is very important, and literature provides ways to do so. You should clearly figure out the effect of the necessary simplifications in the parameterization of Your model contrasting with its physical orientation, mainly cf and the unloading coefficient. You should sharpen the discussion about the value of the chosen validation criteria: first, You argue against the Nash-Sutcliffe efficiency (even though it does consider both magnitude and periodicity), but later You use the coefficient of correlation (which does not). See Krause et al. (2005). Please develop a concise, well-argued valdiation strategy.

(iii)

Suggestions to improve the language: Everywhere in Your manuscript: convert "radiations", "emissions" and "extinctions" to singular; replace "physics-based" with "physically based"; remove comma before "which"; replace "inner" and "innermost", and "outer" and "outermost" with "lower" and "upper"; replace "over the season" with "for the season" I assume "frozen precipitation" is "solid precipitation" Similarly, the "qual-

ity" of precipitation should be its "phase", right? Please use always "Figure" in the text, or always "Fig.", but don't mix Two hyphenations are wrong, but this should change with the further processing of the manuscript Please name the continuum in its correct order: atmosphere-through-canopy-to-soil (at several positions in the text, including p243 l8) P210 ls16-19: insert comma, or (better) make two sentences out of this P211 l28: remove comma P212 l5: insert "the" between "further complicate" and "matters" P212 l12: insert "a" between "respect to" and "climate" P212 l14: remove comma P212 l18: remove comma P213 l14: insert "of" between "consistent modelling" and "the sub-canopy" P214 ls24-25: remove both commas P217 l23: remove comma and "possibly" P220 l19: "t" and the second "n" are missing in "Stefan–Boltzmann" P221 l3: remove "in the case of longwave radiation" P221 l11: "liquid and frozen interception". Do You mean: "interception of liquid and solid precipitation"? P222 l15: insert "radiation" between "direct shortwave" and "which is" P222 l15: insert "which" between "solar direction and" and "can encounter" P222 ls12-22: a bit unclear: do You mean the shadow of the trees at the edge of the forest? P224 ls6-8: make two sentences out of "Transpiration is not allowed if the achieved LEcan is negative (i.e. condensation), therefore in such cases, the solution of the energy balance has to be re-calculated using fwet = 1" Ps223 onwards (mainly 2.4.2 and 2.4.3): You should point out clearer what is computed in summer for the atmosphere-canopy-soil continuum, and what in winter when snow is intercepted and/or on the ground. Does the model run continuously all through the seasons and close the water balance? P224 l19: remove "s" from "calls" P225 l4: replace "unit less functions" with "functions without unit" P225 l8: replace "at windless conditions" with "for windless conditions", remove comma P225 l10: replace "reported" with "given" P225 ls15-16: replace "excess resistances from the canopy surface, and from the soil/snow surface below, to the canopy level. . ." with "excess resistances from the canopy surface and from the soil/snow surface beneath to the canopy level. . ." P229 ls19-22: better make two sentences P231 ls 11 and 15: better only one single indication of the exact location P231 l19-20: use only one digit for LAI. Include "a" between "with" and "mean value" P232 l1: remove "-" in "35 m-high"

P233 l9: remove "-" in "radiometer-carrier" P233 l19: delete "comprised" P233 ls24-25: give and indication of the strucuture which is more than 100 m high (sic?!) P234 ls5-9: better make two sentences and remove the first pair of brackets P234 ls10-12: replace commas with brackets P234 l14: remove "-" in "heat-mass" P234 l16: include Pomeroy et al. (2009) as important reference P234 ls17-18: replace "In the present study we make use pine trunk temperature at 1.5m height, which have been measured close to the trunk surface" with "we make use of .. temperature which has been measured" PP235 l1: replace "best-performance set-up" with "best performance setup" P235 ls3/4: delete "which are specifically affected by the new developments" P235 l9: remove "-" from "down-welling" P235 l21: replace "over" with "to" P236 l15: what is a "natural modelling choice"? P237 ls1-2: better write "With the one-layered version such a performance can only be approached with an unrealistic canopy heat mass" P237 l4: insert "the" between "heat mass of" and "canopy" P238 l1: besser "In figure 3 .. is compared" P238 l9: "originate" should be "originates" P238 l10: better "More striking, however, is . . ." P238 l22: better "affecting" than "delivered to" P238/239: reformulate "SWE is the most important variable in snow hydrology. However, as underlined in the Introduction, snowpack modelling is a highly challenging task because untrustworthy inputs (mixed precipitation, snowfall amount) are fed into imperfect models (our attempt here at improving the energy balance in forested context should not conceal that modelled interception and unload do not always reflect ground truth), which additionally accumulate errors in SWE over the snow season. Specifically, Rutter et al. (2009) highlighted that precipitation phase, rain-on-snow events and the treatment of subsequent meltwater by the models, is an area of key sensitivity with respect to SWE modelling." - the entire paragraph is not concise and circumstantially formulated P239 l10: replace "on" with "in" P239 l19: remove comma after "snowpack", replace "more strongly" with "energy" P239 l23: replace "are" with "is" P239 l21: replace "to build" with "resulting in" P239 l27: delete "is that" and insert comma after "Noteworthy" P239 l29: delete comma P240 l22: replace "2LHM considerably reduces" with "is reduced when using 2LHM" P240 l22-23: better "radiative loss of energy from the lower layer"

P240 l26: replace "for" with "of" P241 l7: Lindroth et al.: include year P241 l8: replace "model" with "consider" P241 l9: include "the" between "Both" and "1LHM" P241 ls12-19: does this explain why the model reacts faster? According to Your explanation it could be expected that the model peaks later but higher? Please reconsider. P242 l5: delete comma P242 ls6-9: replace bulk with robust, and delete next speculative sentence ("This . . . slowly.") P242 l12: replace "canopy" with "scheme" P242 l14: replace "elements" with "layers" P242 l16: replace "had" with "has" P243 l23: delete "elements" P243 l28: replace "this result" with "the results" P244 l3: complete "two-layer formulations" - of what? P244 ls4-6: replace "The step from the big-leaf soil-vegetation-atmosphere transfer models to the dual-source models . . . is a typically illustration . . ." with "The step from big-leaf soil-vegetation-atmosphere transfer models to dual-source models . . . is a typical illustration . . ." PP244 l7: what is a ". . . domain more closely related to canopies"? P244 l16: replace "each-other" with "each other" P244 l24: improve "parameterization" to plural P245 l4: You should add here - significantly important - that by means of the enhanced model and process understanding the scientific community obtains better hydrological simulation tools for climate change impact assessment!

Table 1: "LAI6Snow" - sic? Table 3 : what means "upon calibration" here? Please make clear. Replace "is highlighted" with "in bold". Indicate site location Table 4: correct "model performances" to singular. Correct to "Best fit parameter" Figure 1: Circles are ellipses; "dashed" is more or less "dotted". Replace "mentioned" with "indicated". The "reflection factors at the border between layers" is albedo of the lower layer, right? Please correct. Write ". . . and Canopy. . ." better in lower case as ". . . and canopy. . ."

Good luck and my best wishes for Your improvements, I hope to get the revised version of Your paper soon!

Sincerely, and thank You for considering me as a reviewer!

References

Durot, K.: Modélisation hydrologique distribuée du bassin versant nivo–pluvial de Sarennes. Validation des données d'entrée et dévelopement d'un module de fonte nivale sous forêt. Ph.D. dissertation, LTHE, 332 p., Grenoble, 1999.

Krause, P., Boyle, D.P. and Bäse, F.: Comparison of different efficiency criteria for hydrological model assessment, Adv. Geosci., 5, 89-97, 2005.

Liston, G.E. and Elder, K.: A Distributed Snow-Evolution Modeling System (Snow-Model), J. Hydromet., 7, 1259–1276, 2006.

Strasser, U., Warscher, M., and Liston, G.E.: Modeling Snow Canopy Processes on an Idealized Mountain, J. Hydrometeor, 12, 663–677, http://dx.doi.org/10.1175/2011JHM1344.1, 2011.

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