

**Manuscript:** tcd-5-2197-2011: Multi-scale validation of a new soil freezing scheme for a land-surface model with physically-based hydrology

### Major remarks

The manuscript presents a new version of the ORCHIDEE land surface model that comprises melting and freezing processes. A strong point of the paper is that the validation of the new model version is conducted over a range of scales.

With regard to the comparison of model data to the Stefan solution, the motivation of this doesn't become fully clear to me. Isn't it a mere technical test that the programmed parameterizations have been done adequately? Especially as the validity of a process description working on the laboratory scale doesn't say anything about its usefulness on the grid scale and in real terrains. In this respect it seems to me that this comparison (Sect. 3) is taking too much space and may be shortened.

In Sect. 4.2.1, simulated snow data are compared to the snow depth product of Foster and Davy (1988) for the year 1987. This product comprises a long term snow data climatology.

Excerpt from dataset documentation: "3.1 Objective/Purpose. Create a global mid-monthly mean snow depth climatology with highest resolution possible using all available station data for the months of September through June." and "6.3 Temporal Characteristics. 6.3.1 Temporal Coverage. This is a climatology data set, therefore it is not year specific. 6.3.2 Temporal Resolution. Climatology represents an average snow depth value for mid-month."

Therefore, comparing only one year of simulated data to the climatology is essentially wrong. Consequently, this whole part of the manuscript focusing on the year 1987 has to be revised to take this into account.

In general the English needs some improvement, as some sentences are difficult to read. In addition, the use of singular and plural (see several suggestions for corrections below) may be enhanced. I recommend proof reading of a native English speaker.

In summary the paper may be accepted for publication after major revisions are conducted.

### Minor Comments

In the following suggestions for editorial corrections are marked in *Italic*.

Abstract - page 2198 - line 10

The word "centrimetric" doesn't seem to exist in the English language. Please rewrite!

Sect. 1 - page 2199 - line 13

Generally, *watersheds* underlain ...

Sect. 1 - page 2200 - line 6

"... is all the more crucial..."

No proper English. Please rewrite!

Sect. 1 - page 2200 - line 4-9

Too long sentence that is difficult to read. Please rewrite!

Sect. 2.1 - page 2203 - line 17/18

... for the *respective* USDA ...

Sect. 2.2 - page 2206 - line 4

... does not evolve ...”

What is meant by evolve? ... does not change?

Sect. 2.2 - page 2207 - line 18

... are detailed *in* Table 3, ...

Sect. 2.2 - page 2208 - line 17

... properties *in* the land ...

Sect. 2.2 - page 2210 - line 1

The use of upper case letters for the two approaches (linear and thermodynamical) looks awkward and is not necessary.

Sect. 2.2 - page 2210 - line 14

Results *yielded* by ...

Sect. 2.2 - page 2210 - line 22

...discarded as *too* difficult ...

Sect. 3.1 - page 2213 - line 13

... factor *of* more than 2 in *the* near future.

Sect. 3.1 - page 2213 - line 14

... the *vertical model* discretization ...

Sect. 3.1 - page 2213 - line 22-26

Use real verbs to construct your sentence, not symbols as ~.

Sect. 3.1 - page 2213 - line 27

The *default model* time step ...

Sect. 3.1 - page 2214 - line 18-19

*We consider an error in latent heat as significant* when ...

Sect. 3.1 - page 2215 - line 17

“all the more”

No proper English. Please rewrite!

Sect. 3.2 - page 2216 – line 10

... flux *transfer coefficient* mentioned ...

Sect. 3.2 - page 2216 – line 16-18

Sentence is difficult to read. Please rewrite!

Sect. 3.2 - page 2217 – line 1  
... by a *less drastic* reduction ...

Sect. 4.1 - page 2217 – line 26  
... evaluate the *performance* of ...

Sect. 4.1 - page 2218 – line 2  
... interesting *information* about ...

Sect. 4.1 - page 2218 – line 3  
... and *performance* of other land surface *models*.

Sect. 4.1 - page 2218 – line 4  
... measurements *are related* to the ...

Sect. 4.1 - page 2218 – line 8  
... incoming *radiation* used ... simulation *is* based ...

Sect. 4.1 - page 2218 – line 26  
... and *induced* latent energy *differences are* of ...

Sect. 4.1 - page 2220 – line 17  
It is written: "... as soil moisture is only modeled in terms of anomaly."

I don't understand this. In the model description, you specify, e.g., that you calculate actual soil water fluxes, and that "soil thermal properties depend on the water content", etc., which would not be possible with an anomaly approach. Please clarify!

Sect. 4.2 - page 2221 – line 11 and other places, e.g. line 13  
... river *discharge* measurements.

In most cases, the singular form of discharge is more appropriate!

Sect. 4.2 - page 2222 – line 12  
... only carried *out* with ...

Sect. 4.2.1 - page 2222 – line 21  
... over *into the* summer.

Sect. 4.2.1 - page 2222 – line 28  
...more *conductive* than ...

Sect. 4.2.1 - page 2223 – line 16-17, and other places  
These *datasets include* active... ...different *depths, respectively*.

The use of "respectively" is often wrong. It usually should come in the end of a sentence.

Sect. 4.2.1 - page 2224 – line 24, and other places  
... model *performance* ...

Sect. 4.2.1 - page 2225 – line 1

... of *gridded model* outputs ...

Sect. 4.2.1 - page 2225 – line 6-7

... boreholes *located ~15 km apart from each other* on the Yamal peninsula *differs by about 3 K*; ...

Sect. 4.2.2 - page 2225 – line 19-24

This last part of the section starting with “The likely increase ...” doesn’t belong to a result section. This should be part of the introduction/motivation of the study.

Sect. 4.2.3 - page 2226 – line 9

... are carried *out* over ...

Sect. 4.2.3 - page 2227 – line 19

... would *likely* maintain ...

Sect. 5 - page 2229 – line 5

... partly *attributed* to ...

Sect. 5 - page 2229 – line 10-11

... scheme *catches the* specific ... ..by permafrost *with an increased accuracy*.

Sect. 5 - page 2229 – line 13

This will ...

### **Table 3**

In the main text, it is written for the standard scheme:

“The first thermal layer is 4.3 cm thick and the thickness of 10 each layer is multiplied by 2 as the layers get deeper.”

And for water:

“The uppermost layer is 2mm thick and the thickness of the layers increases as a geometric sequence of ratio 2 with increasing depth, leading to a total default depth of 2m for hydrological processes.”

These values are not consistent with Table 3:

Assuming the values are valid for the middle of the layer, as an example:

Temperature:  $2 * 1.8 = 3.6$  is not equal to 4.3 cm

Water:  $2 * 0.05 = 1$  is not equal to 0.2 cm.

I also cannot identify the maximum depth of 2 m in the table. (I stopped here to check other values).

Please correct and check carefully!

Fig. 2

The lines are very difficult to separate. Lines are too thin and colours are too similar. Please improve!

Fig. 5

What do you mean with afferent? Why there are two curves at 12 h, which are difficult to distinguish (to thin, similar colour)?

... thick) *should be compared to* ...

Fig. 6 caption

... compared *to* available ... ... in *the DATA* and ...