Response to reviewer comment 4:

Major issues

1. The assumption for the proposed equation may not be correct. The authors assumed that decreased micro topography distribution (microsigma) represents increased surface inundation (fh2osfc). However, from equation 1, it seems that the assumption is true only when surface water level d is greater than 0, hence fh2osfc is greater than 0.5.

- We are not sure if the reviewer is asking about negative water level conditions, but the model does not allow negative surface water levels (d), so the Eq. 1 does indeed show an inverse relation between microsigma and fh2osfc. We hope this clarifies the reviewer's concern.

2. When the subsidence value surpasses the 0.5 m threshold, microsigma suddenly increases as shown in the lower middle panel of figure 5. Does this sudden change represent any physical processes?

- Yes it does actually. The increase in microsigma represents the extreme cases where soil subsidence leads to drying of the surface (Liljedahl et al. 2016), which is explained in the text (P3: last paragraph, P6: last paragraph).

3. Is there any feedback from surface water fraction to other hydrology variables (e.g. soil moisture) in the model?

- The surface water fraction does affect the evapotranspiration and soil moisture but the effects are small when compared to other factors such as precipitation and permafrost thaw. So, yes, there are feedbacks between surface water fraction and other hydrological variables, but not big enough compared to our new parameterization.

4. The initial conditions seem to be important for the simulations. How was the spin up period determined? Is 100-years enough for spin up?

- The spinup period of 100 years is chosen to make sure the soil physical variables (soil temperature/moisture) are equilibrated. And it was long enough to avoid any big drifts in these variables. However, for the soil subsidence it is hard to determine an optimum spin up period since the contemporary or past soil excess ice data is very uncertain and hard to constrain the initial conditions. However, the soil excess ice melt also stabilizes with the spin up climate so the spin up period was long enough to have an initial condition for our simulations.

5. There are not enough validations performed. It is not clear for me which simulation is better when comparing with the observation. Is it possible to validate time series of surface water fraction using GIEMS dataset?

- Unfortunately it was not possible to use GIEMS dataset to compare the temporal dynamics, since the dataset period was too short to see any major

differences. Also as discussed in response to other reviewers' comments, this paper merely aims to show that the new parameterization is in line with the current model and does not create extreme conditions. We did not expect big changes compared to the Control simulation, but we do plan to use this for future climate warming scenarios, where higher subsidence levels (Lee et al., 2014) will certainly create more distinguished results to Control simulation.

Minor issues

P1 L28-31: Is this true? The authors say "The largest increases in fh2osfc are observed in central Siberia and southeastern Russia" on line 27 of page 6.

- The text in abstract is about the general increases in fh2osfc, whereas the text in P6:L27 is related to the difference between Exice and Control simulations and more about the direct effects of dynamic parameterization. In the end, Fig6 shows that the higher inundated fractions are actually around western Siberia and around the Hudson Bay.

P3 Equation 2: What is eta?

- "eta" here is just an adjustable parameter.

P5 L11-15: This is confusing. sigma_micro is defined as microtopography distribution on line 9 of page 3. Why does lower sigma_micro represent increased variability in surface microtopography?

- This is related to the distribution of surface microtopography. There is increased variability on surface of gridbox but the distribution of different levels is lowered, hence a lower microsigma.

P8 L10: "higher microsigma" should be "lower microsigma"?

- We thank the reviewer for the correction, the mistake is corrected now.