Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-678-AC3, 2018

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Seasonally frozen soil modifies patterns of boreal peatland wildfire vulnerability" *by* Simon J. Dixon et al.

Simon J. Dixon et al.

s.j.dixon@bham.ac.uk

Received and published: 9 March 2018

We thank the reviewer for taking the time to read the paper and to provide comments on the manuscript to improve it, it is very much appreciated. We feel that their comments are helpful in identifying and improving areas of the manuscript, particularly in terms of clarifying some of our statements and in better explaining the aims and scope of the study to readers. We have addressed their specific numbered points below:

The model and model setup have several important limitations: 1) The model doesn't account for heat transfer in the soil profile but it is used for investigation of frozen layer influence on water transfer. 2) Frozen layer is assumed to be impermeable and permanent in time at the same depth for several weeks that is not a case in natural

conditions where thawing/freezingfront is constantly moving

Both of these first two points relate to a misinterpretation of the focused aims of the modelling study. The study is a reduced complexity, exploratory modelling study in which we are attempting to investigate the potential role of a seasonal frost layer on limiting vertical transfer of water from deeper in a soil profile to the evaporating surface, and whether this function has the potential to lead to enhanced drying at the near surface. We do not set out to (or claim to) simulate the actual water balance in a measured peatland. The limitations in the model set up and the potential effect of these limitations on the results are already discussed in the paper. However, in the response to S Carey we suggest that we need to make the scope of the study much clearer and to include a section after the aims where we explicitly state what is beyond the scope of the study, especially given that two readers have made the same comments assuming the study is predictive modelling. Furthermore, again also in response to S.Carey, we suggest an explicit statement in the abstract is needed regarding the exploratory modelling approach used so readers are aware right at the start of the paper, rather than it being introduced in the introduction and methods. In the response to S Carey we propose adding the following after the aims:

"It is important to emphasise that the numerical modelling in aims ii and iii uses a heuristic modelling framework, in which a simplified representation of the system is used to explore relative differences between modelling scenarios (Bankes, 1993). The purpose is to illuminate the role of different controls on the study system, and not to provide explicit quantitative predictions. In this respect, the results of the modelling should be treated in a comparative sense."

Bankes, S 1993 Exploratory Modeling for Policy Analysis. Operations Research 41 435-49.

3) Model outputs are not compared with any observed soil water content data to evaluate the model performance

This point is also raised, by S Carey and we copy our reply below: No model validation is performed, as this is an exploratory, not a predictive piece of modelling. With an exploratory modelling approach, concepts such as model validation and sensitivity analysis can be seen as nonsequiters (see Bankes, 1993). Because the initial model set and the scenarios used in exploratory modelling are not simulations of specific times and places there is nothing to validate model output to. This also relates to general concepts of verification and validation as discussed in the hydrology literature (and more widely – see Oreskes, N, Shrader-Frechette, K & Belitz, K 1994 Verification, validation, and confirmation of numerical models in the earth sciences. Science 263 641-46. for example). In the respect of exploratory hydrological modelling the key principle is that the model used is verified, that is to say there is confidence that the model is mathematically representing the processes it is designed to do (which is the case with Hydrus as an established hydrological model). In numerical modelling a model set-up can be both verified (which means it has been established that the model accurately represents the processes it is designed to, i.e. the equations are faithfully represented), and validated (which means the set-up of the model has been compared to known input and output data to establish it can accurately recreate an observed event). In this study the verification of the model is accomplished by use of a widely used numerical model/software package for simulating water movement in the unsaturated zone. But the model is not validated, as the purpose is not to recreate or simulate a known event and then extrapolate from it.

4) The model does not take into account changing weather conditions at the peat surface like air temperature, air moisture and rain

The purpose of the modelling exercise is to apply an evaporative forcing to the model over a prolonged period to look at the response of the system over time. Therefore, as this is not a simulation of a specific event or measured year we do not apply changing weather conditions, in a conceptual sense (as mentioned in the methods) the model runs can be thought of as representing a prolonged rain free period in Alberta, hence

there is no rainfall. The model does not directly include air temperature or relative humidity, but represents these through PET (which can be time variable). In the case of our model investigation, and in keeping with representing a conceptual period of prolonged drying, we apply a PET of 4.5mm/day on a diurnal cycle with hourly timesteps to represent the hourly change in PET during each daily cycle.

5) Fixed daily evaporation rate of 4.5 mm/day looks unrealistic

This is poorly worded and was also raised by S Carey, the figure is actually a fixed value for PET, not AET. We propose amending the start of the sentence in question to clarify this:

“We assume a fixed daily Potential Evaporation Rate (PET) of 4.5mm/day; this is a fairly high. . ..”

6) Initial conditions are set in arbitrary way. The soil just after the snowmelt is not necessarily thawed and fully saturated. It could be frozen with different degree of saturation depending on autumn weather conditions

We agree with the reviewer that the rationale for initial water conditions are not well defined in the methods. We propose to add the following section at line 160, and then break the paragraph following this section, to start a new paragraph at “The base and sides. . .”

“It is important to note that our initial model set up has a relatively shallow starting water table. Conceptually, this represents near saturation of the peat following spring snow melt, which depending on the preceding conditions each winter/spring may not always occur. The purpose of this exploratory modelling investigation is to determine the relative magnitude of low near-surface water contents, given different scenarios for seasonal frost lenses. In this respect we choose to initiate model runs with comparatively high near-surface water contents, to ensure that any low modelled water contents over the model run time reflect the dominant processes leading to water loss from the

system, and not as a result of dry initial conditions applied in model set-up."

7) Statement "all these assumptions (no thaw, evaporation rate, hritA and initial conditions) are within 1-2 mm/day, and are constant between scenarios" (lines 481-482) looks unfounded in terms of quantitative assessment.

We agree that this section is poorly worded and somewhat glosses over an important point, which could benefit from a more in depth exploration in the text. We propose to greatly expand this discussion of assumptions in the context of exploratory modelling:

"There are therefore four broad input parameters within the model set up which will affect the resulting water balance; either by providing more or less water to the soil profile (no thaw mechanism, and initial water contents), or result in a greater or lesser volume of water being removed at the evaporating surface per time step (hcritA, PET). It is important to note that over the length of a model run these assumptions in model set up are all in the range of $\pm$1-2mm/day. Furthermore, as explored in the discussion, making different decisions with respect to these parameters would not dramatically change the overall system behaviour, but instead would change the timings that the system reaches different stages of near surface GWC. These assumptions are justified within an exploratory modelling framework, as the objective is to determine the trajectory of system behaviour and the relative magnitude of response between different scenarios, not to deliver quantitative predictions."

As with review comments from S Carey and review 1, we feel that we have not set out the exploratory nature of the modelling investigation early enough in the manuscript and this has led to misunderstandings about the scope/aims of the investigation. We trust that expanding upon our explanations of the exploratory modelling concept and by proposing to add in clear statements of what is beyond the scope of the study after the aims we can demonstrate that simplified numerical modelling can deliver important insights into peat hydraulic behaviour that the community can build upon in the future.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2017-

678, 2018.