

## ***Interactive comment on “Using field observations to inform thermal hydrology models of permafrost dynamics with ATS (v0.83)” by A. L. Atchley et al.***

### **Anonymous Referee #1**

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This study presents application of the Arctic Terrestrial Simulator (ATS) to simulate ice wedge dynamics near Barrow, Alaska. The subject matter is timely as the ability to model the complex interactions between water and heat in arctic grounds is currently lacking. As such, the study presents a nice step forward in advancing the science and our ability to model permafrost dynamics. Further, the study does well to combine observational data with modeling simulation. The study is well presented and well written. With that, I have only some minor comments for the authors to consider.

In general, I appreciate the use of the ModEx cycle approach. An a priori assumption of a modeling structure is ubiquitous and often clouds the potential for process insight across the current generation of hydrological (let alone permafrost) models. It would be good to see a bit more reference in discussion to other approaches (e.g., FUSE

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modeling from Clark or FLEX from Fenicia) that allow for model structure flexibility. This will make for a richer consideration of the current field of modeling and increase connection to existing research beyond arctic regions.

It is interesting to settle on a root mean square error response function. Were any other functions considered? There is marked bias in the RMSE toward high-end errors in estimates that could impact the calibration procedure. It warrants consideration of various response functions or optimization approaches here. For example, limits of likelihood or Pareto front approaches could be interesting in a multi-objective sense. That said, such full optimization procedure consideration is outside the scope of this study. However, the potential impacts or limitations of selecting RMSE could be presented and discussed.

It is somewhat interesting that there is no consideration of the impact of uncertainty in the parameter definitions on the modeling performance. Clearly, this is a complex model with various interactions (hence the ModEx approach adopted). With that, it would be interesting to understand better the role of uncertainty in defining a given parameter on the subsequent model performance. Specifically, this is the case with regards to taking field observations into the modeling environment. A simple sensitivity analysis would be helpful in this regard. As it is currently presented, the modeling comes across as extremely site specific. Of course, there is some consideration of a mixed-scale approach to couple this detailed modeling into a larger scale system. However, without understanding the uncertainty impacts associated with defining the parameterization in ATS (let alone how it can shift across scale) there may be difficulty in generalization of the findings. Since the manuscript is rather dense and should not be overly extended, I recommend the authors take up some more discussion on these aspects (in particular surrounding parameter identifiability and observational uncertainty).

Specific Comments

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Page 3243: It is not completely clear to me why a constant temperature of  $-6^{\circ}\text{C}$  is set for the bottom boundary at 50m depth. Is this based on some observation, was it somehow calibrated, and how could this affect the results?

Pages 3245-3246: The two models for thermal conductivity were calibrated for fully saturated conditions and the BPC model resulted in unrealistic parameter values and was discarded. However, the next section tells that unsaturated conditions are likely for two of three boreholes and that this would affect the resulting simulated temperatures. It is not clear from the text why it is enough to evaluate the two thermal conductivity models against each other for only fully saturated conditions, if unsaturated/surface energy balance processes do indeed affect these results.

Page 3248, line 17: "...a single layered of snowpack...", should read "...a single layer of snowpack...?"

Page 3251, line 7: "... consistently lower then..." should read "...consistently lower than...?"

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Interactive comment on Geosci. Model Dev. Discuss., 8, 3235, 2015.