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# Using field observations to inform thermal hydrology models of permafrost dynamics with ATS (v0.83)

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**Abstract.** Climate change is profoundly transforming the carbon-rich Arctic tundra landscape, potentially moving it from a carbon sink to a carbon source by increasing the thickness of soil that thaws on a seasonal basis. However, the modeling capability and precise parameterizations of the physical characteristics needed to estimate projected active layer thickness (ALT) are limited in Earth system models (ESMs). In particular, discrepancies in spatial scale between field measurements and Earth system models challenge validation and parameterization of hydrothermal models. A recently developed surface–subsurface model for permafrost thermal hydrology, the Advanced Terrestrial Simulator (ATS), is used in combination with field measurements to achieve the goals of constructing a process-rich model based on plausible parameters and to identify fine-scale controls of ALT in ice-wedge polygon tundra in Barrow, Alaska. An iterative model refinement procedure that cycles between borehole temperature and snow cover measurements and simulations functions to evaluate and parameterize different model processes necessary to simulate freeze–thaw processes and ALT formation. After model refinement and calibration, reasonable matches between simulated and measured soil temperatures are obtained, with the largest errors occurring during early summer above ice wedges (e.g., troughs). The results suggest that properly constructed and calibrated one-dimensional thermal hydrology models have the potential to provide reasonable representation of the subsurface thermal response and can be used to infer model input parameters and process representations. The models for soil thermal conductivity and snow distribution were found to be the most sensitive process representations. However, information on lateral flow and snowpack evolution might be needed to constrain model representations of surface hydrology and snow depth.

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