Integrating Field Measurements in Fine Scale Model Development for Understanding Future Active Layer Thickness Dynamics

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Projections of active layer thickness (ALT) – the annual maximum depth of soil with above 0°C temperatures – is a proxy for the volume of carbon-rich stores available for decomposition and therefore potential greenhouse gas release into the atmosphere from Arctic tundra. However, projections of ALT in polygonal tundra is challenging due to the complex nature of hydrothermal atmospheric-surface-subsurface interactions in freezing/thawing soil, which then requires extensive calibration to field observations and model refinement to capture the key processes necessary to simulate fine scale thermal hydrology. Soil temperature and snow data from the Barrow Environmental Observatory, Alaska are used to calibrate hydrothermal properties of moss, peat, and mineral soil in the multiphysics Arctic Terrestrial Simulator (ATS) models. When calibration failed to match measured data or produced calibrated parameters that are physically unrealistic, conceptual understanding was reassessed and model structure was refined. This iterative model refinement procedure that cycled between observations and model development (ModEx) was used to create models that simulate ALT in polygonal tundra permafrost environments. Applications of the model are being used to understand the interplay between micro-topography in ice-wedge polygon landscapes and thermal hydrologic response and its evolution with warming climate that then informs how physical characteristic such as peat thickness, saturation, and snow depth influence ALT formation. The calibrated model and increased process understanding was then used to examine the role of subsurface thermal properties on uncertainty in predicted ALT in the year 2100.