ABSTRACT: Modeling of earth surface processes requires the discretization and characterization of the landscape. Discretization is needed to both define model grid cells and to characterize the properties and processes that govern landsurface dynamics. In the Next Generation Ecosystem Experiment (NGEE) – Arctic, we face the challenge of characterizing a unique and complex landscape currently not represented in Earth System Models (ESMs): polygonal ground on the North Slope of Alaska. A primary goal of NGEE is to improve climate simulations across model scales, from fine (less than a meter per pixel) up to coarse (on the order of 10 to 30 km) resolutions. For terrain with ice-wedge polygons, fine scale characterization is critically important because the processes that govern the carbon cycle and hydrological dynamics are controlled by landscape features on the order of a few to tens of meters. To characterize the polygonal ground in Barrow, Alaska we have combined remotely sensed data from high-resolution LiDAR-derived topography and Worldview 2 satellite imagery with subsurface data derived from geophysics and snow coverage data. Using the topographic data we have developed quantitative metrics that allow for the discretization and characterization of polygons. These metrics include standard topographic variables such as elevation, slope, curvature, and a novel “directed distance” metric. This analysis has allowed us to delineate polygon boundaries, discriminate individual polygon features (rims, troughs, and centers), and broadly classify polygons into types (high versus low). These efforts enable the generation of high resolution modeling grids (pixels ~ 0.25 m) that capture the actual Barrow topography and coarser resolution grids based on a synthetic representation of polygon attributes. In addition to model grid development, we have been able to use distributed measurements of topographic properties and multispectral data to extrapolate point and transect based geophysical data of the subsurface and snow distribution to make landscape-scale predictions of active layer thicknesses (ALT), soil moisture, and snow distribution. Using data fusion approaches, we have successfully developed a methodology for combining topographic metrics with Normalize Difference Vegetation Index (NDVI) and probe measurement of ALT to predict ALT values across our model domain. Similarly, using topography and snow depth measured by point probes and ground penetrating radar we are able to make an estimate of snow depth distributions across the polygonal network accounting for the effects of microtopographic features on the snow redistribution and accumulation. These examples highlight the potential for coupling remotely sensed dataset with ground based observations to discretized, parameterize, and test both fine and medium resolution land surface models in polygonal terrain.