ANL Terrestrial Ecosystem Science SFA: Capturing the spatial heterogeneity of soil organic carbon stocks using soil-forming factors

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Spatial heterogeneity of land surface affects energy, moisture, and greenhouse gas exchanges with the atmosphere. However, representing the spatial heterogeneity of terrestrial hydrological and biogeochemical processes in earth system models remains a critical scientific challenge. Here, we present a geospatial approach to capture the existing spatial heterogeneity of soil organic carbon (SOC) stocks across the State of Alaska. We used secondary information of soil-forming factors such as topography, climate, land cover types, and surficial geology to represent the spatial heterogeneity of SOC stocks. Using the standard deviation (38.2 kg C m^{-2}) of observed SOC stocks (n= 557 existing pedons with sampled depths ranging from 0.3 to 4.5 m) and a margin of error 5% (± 2.5%), we calculated that 906 randomly distributed pedons would be needed to quantify the mean value of SOC stocks across Alaska. We used a conditioned Latin hypercube sampling approach to distribute the calculated number of pedons across Alaska in a manner that captured the spatial heterogeneity of soil forming factors. We then used the range of a variogram of observed SOC stocks to further refine the number of samples required to appropriately capture the spatial heterogeneity of SOC stocks across Alaska. Our results suggest 484 new observations would be needed to sufficiently quantify the spatial heterogeneity of Alaskan SOC stocks. Calculated variograms demonstrated that the spatial structures of soil-forming factors were appropriately captured by the identified sampling sites. However, given the difficulties and costs associated with accessing remote sites in Alaska, the total number of required observations could be reduced by accepting a greater margin of error (e.g., 227 pedons would be needed to capture the heterogeneity with a 10% margin of error). We also investigated whether stratifying our analyses by ecoregions within the State of Alaska would be a viable strategy for reducing both the margin of error and the required number of new observations. The results of this analysis will help to identify future sampling sites for research efforts that are intended to capture land surface heterogeneity and appropriately quantify Alaskan SOC stocks.