Background and Objective:
Rapid environmental change in Alaska is projected to significantly decrease near-surface permafrost distribution across the state in the next century (Pastick et al., 2015, Pastick et al., 2017). Gelisols (permafrost-affected soils) are currently widely distributed across Alaska, occupying an estimated 7.34 x 10^9 km^2 or approximately 43% of the land area (Soil Survey Staff, 2018). Under current rules for soil taxonomy (Soil Survey Staff, 2014), Gelisols must have permafrost within 1m or (if materials indicating cryoturbation or ice segregation - gelic materials - are present) 2m of the soil surface. Therefore, near-surface permafrost change has the potential to have a large impact on Gelisol distribution. The three Gelisol suborders (Turbels, Histels, and Orthels) are not equally distributed across the state (Pastick et al., 2017) and differ in their susceptibility to taxonomic change due to near-surface permafrost changes. The objective of this work was to provide an estimate of potential changes in Gelisol distribution due to near surface permafrost change under the A1B emissions scenario.

Methodology:
We utilized the STATSGO dataset (Soil Survey Staff, 2018 - Figure 1) and two near-surface permafrost distribution datasets (Marchenko et al., 2008 - GIPL 1.3; Pastick et al., 2015; Marchenko et al., 2008) and 2m (Marchenko et al., 2008, 2009) depths at three different timepoints (2000-2009, 2050-2059, 2090-2099) (Figure 2) to estimate the potential for soil taxonomic change under the A1B emissions scenario. We assumed that the STATSGO dataset represented the current distribution of Gelisols across the state and that loss of permafrost within 2m of the soil surface would result in taxonomic change for all Gelisols, while loss of permafrost within 1m of the soil surface but retention at 2m would result in loss of Histels and Orthels (but not Turbels). Under these rules, we determined normalized changes in Gelisol distribution for each STATSGO mapping unit utilizing the three input distribution datasets and the component percentages for individual Gelisol suborders in STATSGO (Equations 1 and 2).

Results:
Our results indicate the potential for dramatic changes in Gelisol distribution due to near-surface permafrost loss by the end of this century under the A1B emissions scenario (Figure 3). These projections result in estimates of taxonomic change for 43-46% of currently mapped Gelisols by 2059 and 69-70% by 2099. The choice of differing combinations of dataset inputs and 1m or 2m near-surface permafrost requirements for Orthels and Histels had minimal impact on the final results (Figure 4). However, utilizing the Pastick et al. (2015) 1m dataset instead of the GIPL 1m dataset resulted in lower estimates of taxonomic change (1-3% statewide), largely because of increased retention of near-surface permafrost in the Histels of the Yukon-Kuskokwim Delta (Figure 3). Taxonomic change from Gelisols to other soil orders (Histosols, Inceptisols, Mollisols and Entisols) in the western interior and the southern Seward Peninsula is projected to be extensive by mid-century, while taxonomic changes by the end of the century may be widespread across the interior but minimal north of the Brooks Range.

Implications:
Widespread taxonomic change in Alaskan Gelisols has important implications for soil mapping and classification. When mapping in areas that are projected to undergo significant taxonomic change, soil survey leaders should consider adding non-permafrost classifications, properties, and interpretations as phases in the database to every Gelisol component to extend the lifetime and usefulness of the mapping product.

References: