A simple-model simulation of Late Quaternary Arctic ground ice and soil organic carbon changes

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Permafrost is a large reservoir of soil organic carbon (SOC), about half of all the terrestrial storage. Therefore, its degradation (i.e., thawing, erosion) under global warming may lead to a substantial amount of additional greenhouse gas (GHG) release. Understanding of the processes, geographical distribution of such hazards, and enhancement of climate models regarding the relevant processes are, however, still insufficient so that it remains one of the large sources of uncertainty in climatic and biogeochemical assessment and projections of the Arctic. Knowledge on the "vulnerability distribution" of high potential to ice-rich permafrost degradation is important for the purpose. The currently accessible in-situ data are limited.

Current ice-rich permafrost has evolved on a long timescale (i.e., hundreds to tens of thousands of years), gone through glacial and interglacial stages since the Last Interglacial period (ca. 130 thousand years ago, or 130ka). In this study, conducted as a part of three-year research project (2-1605, ERTDF of ERCA), a simple numerical model is developed to simulate the long-term evolution of ground ice and SOC in the circum-Arctic region (north of 50° N). The model has two compartments, above-ground and ground. The former is driven by annual mean air temperature and total precipitation (Figure 1) to calculate the carbon input to the ground (i.e., litter fall) and regulate subsurface thermal conditions, whereas the latter calculates carbon and water budget, including ice content, of the ground. The driving data and boundary conditions are produced based on ICE-6G_C (Argus et al. 2014), and the SeaRISE project product (http://websrv.cs.umt.edu/isis/index.php/SeaRISE_Assessment), and modified through the present-day reanalysis data (ERA-Interim; Dee et al. 2011), and outputs from global climate models (CMIP5/PMIP3).

The preliminary simulation of the transient changes in ground ice (mm), soil moisture (mm), and soil carbon content (gC m^{-2}) from 125ka to the present illustrate reasonable geo-characteristic differences, as well as the contrast between the glacial and post-glacial periods of the region. The results from 8 selected points of different circum-Arctic characteristic are shown in Figure 2. The resulting map for the entire region will aide to understand the evolution of the distribution of vulnerable areas.

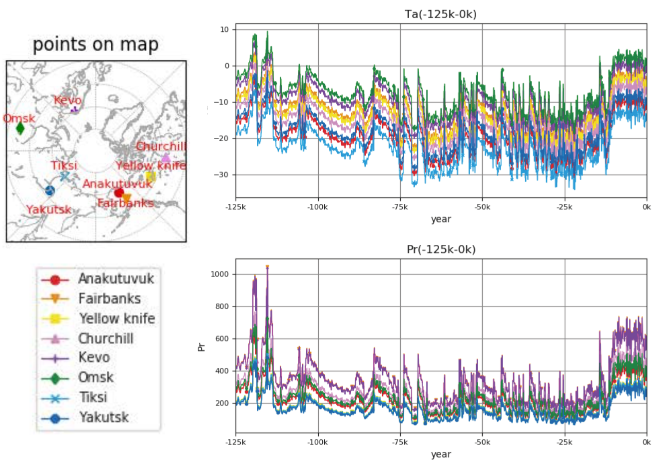

Figure 1. Driving data for temperature and precipitation for the selected 8 points.

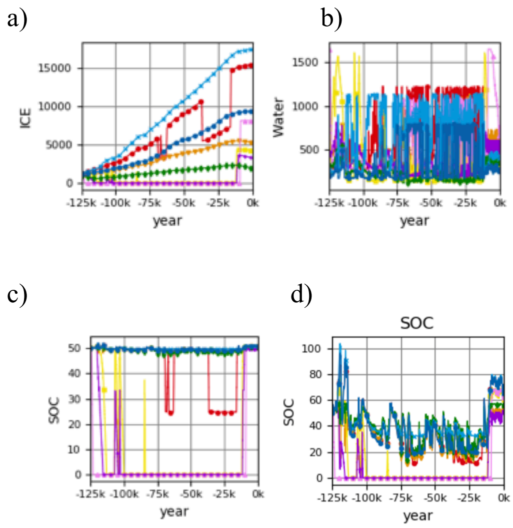

Figure 2. 125 thousand year simulation: a) ground ice (mm), b) soil moisture (mm), c) soil organic carbon content (SOC; gC m^{-2}) for fast-decaying soils, and d) SOC for slow-decaying soil.

References

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