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Hydro-thermal Conditions for Paleopermafrost Distribution by Climate Modeling

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Near-surface conditions for the frozen ground distribution under the paleoclimate environments are investigated which were derived from the Paleoclimate Model Intercomparison Project II (PMIP2). Total of twenty-two realizations from ten participating climate models (CCSM, CNRM, CSIRO, ECBILTCLIO, ECHAM, FGOALS, HadCM, IPSL, MIROC, MRI) were used for the analysis.
Freeze index (FI) and thaw index (TI) are calculated from the monthly near-surface air temperature field that was taken from Climate Research Unit dataset for the present-day condition, and from the model output for the pre-industrial (0K), Holocene Optimum (6K), and the Last Glacial Maximum (21K) conditions. When an model integration is longer than ten years, only the last ten years of the output were used for the calculation.
A simple classification method for the frozen ground zones, namely, continuous/discontinuous permafrost (PF), seasonal frost (SF; excluding PF), and no frost (NF) zones, by use of FI and TI was constructed from the observation-based present-day frozen ground distribution compiled by International Permafrost Association (IPA). PF is the areas whose TI is less than the threshold TI0 (1700. in this study). Similarly, SF is the area whose FI is less than the threshold value FI0 (2625. in this study) and TI is less than TImax (7255). If the TI is greater than TImax it is NF. The overall misclassification rate, that is the ratio of the areas falsely classified to PF or SF compared to the original IPA map, was 19.1% in this methodology.
The identical classification scheme was used to infer the paleopermafrost distribution for the three periods. For 0K, PF and SF zones occupy, in average and range in parentheses, respective 18.4% (14.1% - 26.0%) and 40.1% (31.4% - 52.2%) of the Northern Hemisphere ice-free land area, among the eight different realizations, whereas the observational counterparts are ca. 17.8% and 32.0%, respectively. Similarly, 18.8% (12.2% - 26.4%) and 38.4% (32.8% - 44.0%) of the ice-free land are underlain by respective PF and SF zones for the 6K simulation (with six realizations), and 24.1% (21.0% - 31.5%) and 34.4% (26.9% - 43.8%) for 21K (with six realizations). In addition to the thermally-based methodology, influence of precipitation and seasonal snow cover to the subsurface thermal regime will be discussed.