ICG2022-542, updated on 08 Jun 2023
https://doi.org/10.5194/icg2022-542
10th International Conference on Geomorphology

Derivation of palaeo-air temperature conditions from past periglacial features

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Permafrost repeatedly occurred across central Europe during cold periods of the Pleistocene, as evidenced by a number of past periglacial features that are present in both highland and lowland areas. Many of those periglacial features, such as frost wedges and other kinds of patterned ground, cryoturbations, or pingo scars, have been widely utilized to estimate past air temperature conditions. However, the reconstructions have only relied on temperature thresholds of active periglacial features that are now mostly found in high-latitude periglacial environments. Such empirical interpretations have thus often been considered problematic and of limited validity.

Nevertheless, periglacial features mostly form as a result of recurrent freeze-thaw processes that act within the active layer over permafrost, the base of which is commonly sharply defined and limits the subsurface extent of periglacial features. The active-layer thickness (~depth of maximum annual thaw) usually attains several decimetres to metres, which mainly depends on summer and annual temperature conditions. Since the thickness of palaeo-active layer can be determined based on past periglacial features, it can thus also be used to estimate the temperature conditions that gave rise to an active layer of a given thickness.

Here, we present a novel model we have devised that uses the above principles. The palaeo-mean annual air temperature modelled so far at two lowland sites in the Czech Republic where Last Glacial cryoturbations occur ranged between −7.0±1.9 °C and −3.2±1.5 °C, and its corresponding decline compared to the 1981–2010 period was between −16.0 °C and −11.3 °C, which agrees well with reconstructions utilizing various palaeo-archives. These initial results are promising and suggest that the model could become a useful tool for reconstructing Quaternary palaeo-air temperatures across vast areas of mid-latitudes and low latitudes where relict periglacial features frequently occur, but their full potential remains to be exploited. Additionally, it could help us refine existing and/or provide new insights into past periglacial environments that cannot be unveiled by other abiotic or biotic indicators.

The research is supported by the Czech Science Foundation, project no. 21-23196S.