Geophysical Research Abstracts
Vol. 20, EGU2018-483, 2018
EGU General Assembly 2018

Characteristics of permafrost-climate in the source areas of the Yangtze and Yellow rivers, Qinghai-Tibet Plateau, SW China

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As the southernmost largest permafrost area across the northern hemisphere, the Qinghai-Tibet Plateau (QTP) possesses an extremely warm and dry permafrost that is sensitive to climate change and anthropogenic activities. Located on the northeast part of the QTP, the source areas of the Yangtze and Yellow rivers (SAYYR) is characterized by close association between ecology, hydrology, and natural resources and climate and permafrost. However, a comprehensive study among interactions and cryospheric features is currently hampered by the sparsely- and unevenly-distributed monitoring sites and limited field investigations. In this study, we report a synthetic study of the thermal regime of warm-dry permafrost in the SAYYR based on a newly-established monitoring network consisting of the observations of air temperature (Ta), ground surface temperature (GST) and ground temperature across a range of areas with contrasting land-surface characteristics. Regionally mean annual Ta (MAAT) and mean annual GST (MAGST) were averaged at -3.19 ± 0.71 °C and $-0.40\pm$ 1.26 °C. There is a close relationship between GST and Ta (R2=0.8477) as obtained with all available daily averages. Mean annual temperature at the permafrost table (TTOP) was regionally averaged at -0.72 ± 1.01 °C and mostly in the range of $^{-1}$.0°C and 0 °C except at Chalaping (~ -2.0 °C). The difference between MAGST and MAAT (surface offset) was regionally averaged at 2.54 ± 0.71 °C, while the difference between TTOP and MAGST (thermal offset) was regionally averaged at $-0.17\pm$ 0.84 °C, which was generally within -0.5 °C and 0.5 °C. When compared with other regions that is characterized by ice-rich and cold permafrost, the thermal offset is particularly smaller, presumably due to comparable thermal conductivity between the thawed and frozen states of the soils. Active layer thickness was generally smaller at Chalaping than that on other parts of the QTP. Under the presence of smaller climatic continentality index and the thermal dampening of surface temperature variability with dense vegetation and thick peaty substrates, the difference between MAGST and the temperature at the depth of zero annual amplitude is not too large, probably in the range of –0.3 °C and 0.9 °C. Therefore, we may infer the thermal state of permafrost or accurate map permafrost on the rugged elevational QTP by correlating the parameters of GST, thermal offset, and the temperature gradient in the shallow permafrost.