

CLIMATOLOGY

Permafrost thawing puts the frozen carbon at risk over the Tibetan Plateau

Taihua Wang¹, Dawen Yang^{1*}, Yuting Yang^{1*}, Shilong Piao², Xin Li^{3,4}, Guodong Cheng^{5,6}, Bojie Fu⁷

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Soil organic carbon (SOC) stored in permafrost across the high-latitude/altitude Northern Hemisphere represents an important potential carbon source under future warming. Here, we provide a comprehensive investigation on the spatiotemporal dynamics of SOC over the high-altitude Tibetan Plateau (TP), which has received less attention compared with the circum-Arctic region. The permafrost region covers ~42% of the entire TP and contains ~37.21 Pg perennially frozen SOC at the baseline period (2006–2015). With continuous warming, the active layer is projected to further deepen, resulting in $\sim 1.86 \pm 0.49$ Pg and $\sim 3.80 \pm 0.76$ Pg permafrost carbon thawing by 2100 under moderate and high representative concentration pathways (RCP4.5 and RCP8.5), respectively. This could largely offset the regional carbon sink and even potentially turn the region into a net carbon source. Our findings also highlight the importance of deep permafrost thawing that is generally ignored in current Earth system models.

INTRODUCTION

Permafrost is a natural feature of high-latitude and high-altitude regions, storing large amounts of soil organic carbon (SOC) (1, 2). The Tibetan Plateau (TP) is the largest permafrost region in the Northern Hemisphere, covering ~42% of the entire plateau and containing ~37.21 Pg of perennially frozen SOC at the baseline period (2006–2015) (3). With continuous warming, the active layer is projected to further deepen, resulting in $\sim 1.86 \pm 0.49$ Pg and $\sim 3.80 \pm 0.76$ Pg permafrost carbon thawing by 2100 under moderate and high representative concentration pathways (RCP4.5 and RCP8.5), respectively (4, 5). This could largely offset the regional carbon sink and even potentially turn the region into a net carbon source (6, 7). Our findings also highlight the importance of deep permafrost thawing that is generally ignored in current Earth system models (8–15).

The TP is a high-altitude plateau with an average elevation of ~4000 m, covering an area of ~2.5 million km² (16, 17). It is the largest permafrost region in the Northern Hemisphere, covering ~42% of the entire plateau and containing ~37.21 Pg of perennially frozen SOC at the baseline period (2006–2015) (3). With continuous warming, the active layer is projected to further deepen, resulting in $\sim 1.86 \pm 0.49$ Pg and $\sim 3.80 \pm 0.76$ Pg permafrost carbon thawing by 2100 under moderate and high representative concentration pathways (RCP4.5 and RCP8.5), respectively (4, 5). This could largely offset the regional carbon sink and even potentially turn the region into a net carbon source (6, 7). Our findings also highlight the importance of deep permafrost thawing that is generally ignored in current Earth system models (8–15).

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¹State Key Laboratory of Hydrosience and Engineering, Department of Hydraulic Engineering, Tsinghua University, Beijing 100084, China. ²College of Urban and Environmental Sciences, Peking University, Beijing 100871, China. ³National Tibetan Plateau Data Center, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China. ⁴CAS Center for Excellence in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, Beijing 100101, China. ⁵Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000, China. ⁶Institute of Urban Study, Shanghai Normal University, Shanghai 200234, China. ⁷State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.

*Corresponding author. Email: yangdw@tsinghua.edu.cn (D.Y.); yuting_yang@tsinghua.edu.cn (Y.Y.)

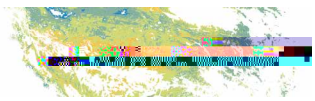
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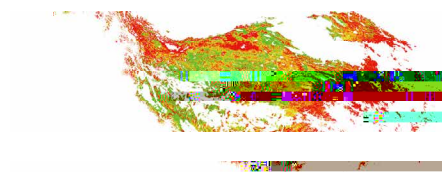
RESULTS

Permafrost and ALT distribution

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SOC distribution





Future changes in ALT

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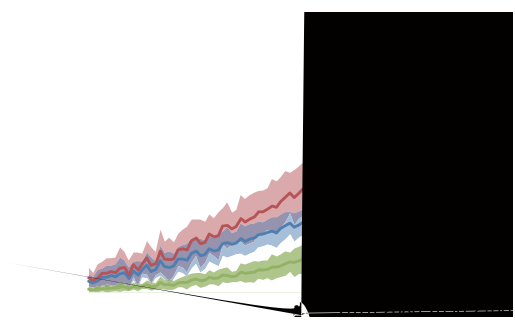
Permafrost carbon dynamics under future climate

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DISCUSSION

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MATERIALS AND METHODS

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Data-driven mapping of MAGT and ALT

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Data-driven mapping of SOC

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SUPPLEMENTARY MATERIALS

Supplementary material for this article is available at <http://advances.sciencemag.org/cgi/content/full/6/19/eaaz3513/DC1>

of layers where it used to be permafrost in the baseline period but is not anymore. Actual T for BDC sciencemag.org

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