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Simulated temporal and spatial variations of Tibet Plateau permafrost carbon during 1960-2009

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The Tibet Plateau has the largest permafrost regions in the middle and low latitudes and contains about 160±87PgC soil organic carbon, which accounts for 10% of global permafrost soil organic carbon stocks, although its area accounts for 5% of global permafrost area, approximately. Under global warming, the microbial decomposition in thawing permafrost reduces the soil carbon stocks and releases the greenhouse gases, while the enhanced primary production of vegetation can increase soil carbon stocks. Here we use six land surface models from Permafrost Carbon Network Model Intercomparison Project (PCN-MIP) to analyze permafrost extent and related terrestrial carbon changes over the Tibet Plateau, including the active layer thickness (ALT), vegetation and soil carbon stocks, gross primary production (GPP) and soil respiration. The results show that Tibet Plateau permafrost has degraded during 1960–2009 with the declining rates ranging from 900 to 2400 km^2yr^{-1}, although the simulated permafrost area at 1960 has a value of 8.47±4.92 million square kilometers showing large uncertainty. Moreover, annual maximum ALT of the permafrost has increased from 1.48±0.35 m in 1960 to 1.51±0.44 m in 2009, and the increasing trends range from 0.2 to 1.2 $cmyr^{-1}$. Most models simulate increased soil and vegetation carbon stocks with warming during 1960–2009, soil and vegetation carbon stocks changed by -30.8–25.34 $gCm^{-2}yr^{-1}$ and -1.67–9.27 $gCm^{-2}yr^{-1}$ during the same period. Until 2009, average soil carbon stock was 4.49±2.56 gCm^{-2} and average vegetation carbon stock was 0.12±0.18 gCm^{-2} in the Tibet Plateau permafrost region. The increasing trends of GPP range from 0.24 to 2.20 $gCm^{-2}yr^{-2}$, and the soil respiration trends range from -0.13 to 0.58 $gCm^{-2}yr^{-1}$ between the models. The different sensitivities of GPP to increase in atmospheric CO_2, and respiration to increase in warming are the dominant causes of large uncertainties of the simulated Tibet Plateau soil carbon stocks. This study indicates that more emphasis should be put on improving contemporary land surface models to better simulate climate and environmental change over the Tibet Plateau.