REPLY TO SONG AND WANG:
Terrestrial CO\textsubscript{2} sink dominates net ecosystem carbon balance of the Tibetan Plateau

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We welcome the letter of Song and Wang (1) regarding aquatic carbon (C) export on the Tibetan Plateau (TP) and appreciate the opportunity to clarify our thinking. The net ecosystem C balance (NECB) includes CO\textsubscript{2} and CH\textsubscript{4} exchange, volatile organic C loss, and particulate and aquatic C transport. By contrast, our work focused on terrestrial CO\textsubscript{2} exchange (2), a subset of the NECB. We partly agree with Song and Wang regarding the importance of aquatic C loss, but their conclusion was reached based upon a catchment-scale case study (3). In an attempt to clarify how much the terrestrial CO\textsubscript{2} sink has been compromised at a regional scale, we expanded the NECB to incorporate rivers, lakes, thermokarst, wetlands, grasslands, and glaciers, thus forming a complete picture of the C cycle of the TP (Fig. 1).

The C entering into the river network was separated into three parts (4): outgassing (35%), burial (38%), and to the ocean (27%). For river outgassing, a recent study estimated 1.27 \text{ Tg CH\textsubscript{4}\text{y}^{-1}} (Tg = 10^{12} g) and 17.5 \text{ Tg CO\textsubscript{2}\text{y}^{-1}} for all of the TP’s rivers (5). A loss of \textasciitilde10.6 \text{Tg} C\text{y}^{-1} into the river burial and oceans through the river network was then estimated (4, 5). This estimate is at the high end of the NECB (net ecosystem C balance) = 108.2 \pm 53.8 \text{Tg} C\text{y}^{-1}.

Fig. 1. Schematic map of the regional net ecosystem C balance of the Tibetan Plateau. The uncertainty ranges of lake and river C loss is not given, since they are estimates rather than direct observations.

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The authors declare no competing interest.

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uncertainty range, since ~40% of the rivers are within the endorheic region, i.e., the C is merely transported from one place to another, but still within the domain of the TP. Lakes contribute 13.9 Tg CO$_2$ y$^{-1}$ (6) and 1.7 Tg CH$_4$ y$^{-1}$, assuming their waters release CH$_4$ rates similar to thermokarst lakes (7)—and this is at the high end of the uncertainty range given most lakes have lower organic C content than thermokarst lakes/ponds. The thermokarst lakes and ponds add another 0.6 Tg CO$_2$ y$^{-1}$ and 0.1 Tg CH$_4$ y$^{-1}$ to the atmosphere, based on our recent measurements across 32 thermokarst lakes (7).

Besides the CO$_2$ uptake in terrestrial ecosystems (2), they also regulate the CH$_4$ exchange. Our observations and simulations (8–10) have characterized alpine grasslands as a considerable CH$_4$ sink of 0.74 ± 0.06 Tg CH$_4$ y$^{-1}$, while alpine marshlands emit 0.96 ± 0.21 Tg CH$_4$ y$^{-1}$. For glaciers, a potential C source under the warming climate, our recent measurements of four glaciers observed a C loss of 0.002 ± 0.01 Tg CH$_4$ y$^{-1}$ (11), which is a negligible but highly uncertain component of the NECB.

Therefore, we arrived at an NECB of 108.2 ± 53.8 Tg C y$^{-1}$ on the TP, indicating only 16.8% of the terrestrial CO$_2$ sink was compromised by other C sources (including aquatic C loss). Therefore, the full picture of the C cycle suggests that the terrestrial CO$_2$ sink dominates the regional NECB, although large uncertainty still exists and more observations are needed in the near future.

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5 L. Wang et al., High methane emissions from thermokarst lakes on the Tibetan Plateau are largely attributed to ebullition fluxes. Sci. Total Environ. 801, 149692 (2021).