PNAS LETTER

Reply to Wang et al.: Uncertainty of terrestrial ecosystem CO_2 exchange of the Tibetan Plateau

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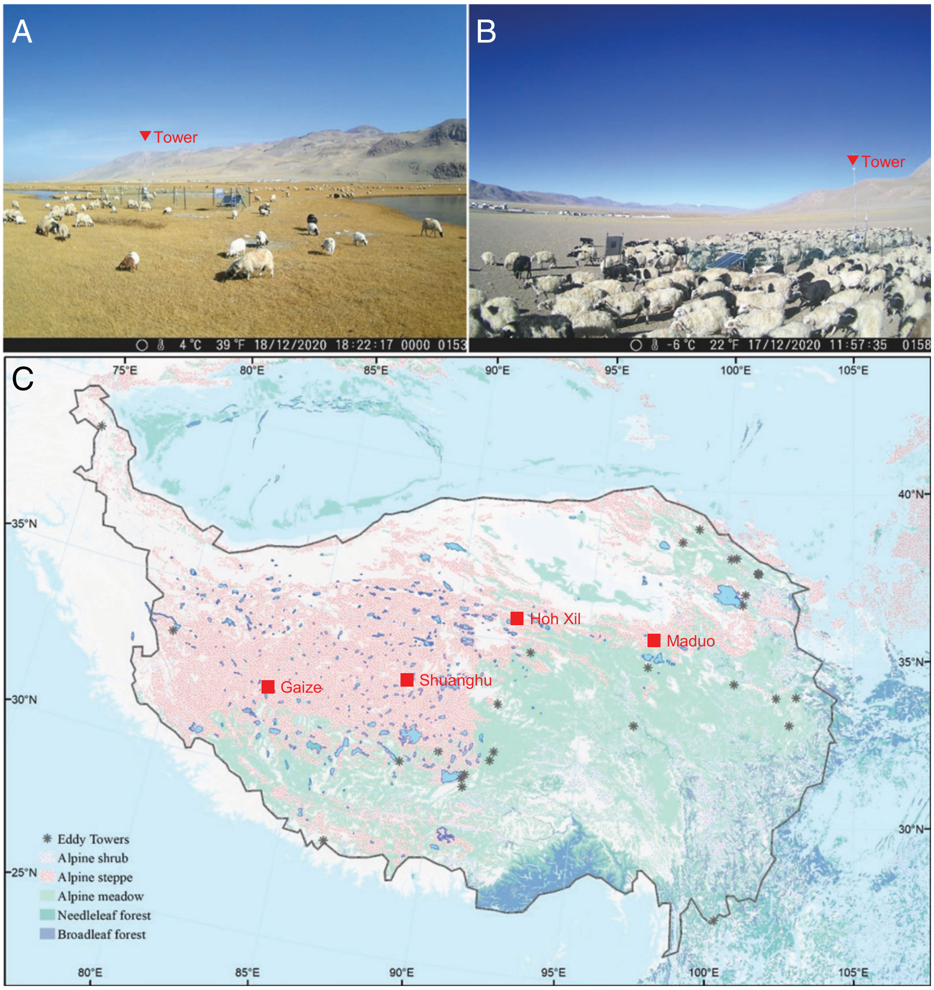

Fig. 1. Existing and newly established EC towers in the alpine steppe ecosystem of the TP: (*A* and *B*) grazing activities reordered by infrared-triggered cameras adjacent to EC towers (UTC +8); (*C*) recently established EC towers, in which the gray asterisks (*) denote existing EC towers used in previous estimations.

We welcome the letter from Wang et al. (1) regarding the uncertainty in eddy covariance (EC) measurements on the Tibetan Plateau (TP) and appreciate the opportunity to clarify our thinking. Our study focuses on the CO_2 exchange between the air and plants/soil on the TP (2), rather than the carbon (C) balance of the whole region; for instance, we did not measure the C sources/sinks in water bodies (3). Furthermore, different approaches tend to yield inconsistent results regarding the CO_2 sink of a region—for example, in the Arctic (4, 5). Our estimate, based upon 32 EC towers, which challenges previous estimates in this region, is not necessarily an overestimation.

The EC technique provides the scientific community with an almost ideal approach to measuring the CO_2 exchange, although it still has limitations. For example, EC will occasionally yield a CO_2 sink in winter, and the imputation models used for day/night are different, so it is necessary to artificially determine the growing/nongrowing season and day/night to make the result reasonable (6). Taking the division of day/night as an example, given the phenomenon of

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low-temperature restriction in the TP region (7), the duration of daily C uptake will not be properly interpreted if the solar time method of Wang et al. (1) is enforced to define day and night. Therefore, no method can be assumed to be the best; only the one that best suits the particular situation is the optimal solution. Regarding data postprocessing, such as PyFluxPro, REddyProc, and MDI Meteo can be used (8). However, a unified technical approach is very important to correctly measure the C budget, which is why we employed the ChinaFLUX procedure. Outlier diagnosis is a basic step defined in our study as data points that were 3 times the SD at five continuous steps. However, these outliers should not simply be eliminated, as nature itself does not always proceed smoothly, and some data spiking may reflect an important disturbance to C exchange, for example, large-scale grazing or precipitation-induced C uptake. For example, we established several infrared-triggered cameras adjacent to EC towers to capture these disturbances (Fig. 1 *A* and *B*), and it seems that there was no reason to exclude these data given they are actually part of the C cycle (9–11).

The alpine steppe covers 72 million hectares on the TP, which is roughly 3 times the size of the United Kingdom, but there are only six available EC sites (2). In fact, the large uncertainty regarding CO_2 exchange on the TP is stated in our study (2). This is why we continue to establish EC towers in the depopulated areas (Fig. 1*C*), and new data have revealed a similar result to our previous estimate (e.g., a net C sink of 68.2 g $C{\cdot}m^{-2}{\cdot}y^{-1}$ in Gaize). Expanding the observational network into the depopulated area of the TP, where most alpine steppe is situated, will further reduce the uncertainty. Future efforts should also focus on comparisons among various data processing approaches, which would help toward a better characterization of the size of the CO_2 sink of the alpine steppe.

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