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Atmospheric CO2 and 14CO2 observations at the northern foot of the Qinling Mountains in China: temporal characteristics and source quantification

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A two-year (March 2021 to February 2023) continuous atmospheric CO2 and a one-year regular atmospheric 14CO2 measurement records were measured at the northern foot of the Qinling Mountains in Xi' an, China, aiming to study the temporal characteristics of atmospheric CO2 and the contributions from the sources of fossil fuel CO2 (CO2ff) and biological CO2 (CO2bio) fluxes. The two-year mean CO2 mole fraction was 442.2 ± 16.3 ppm, with a yearly increase of 4.7 ppm (i.e., 1.1%) during the two-year observations. Seasonal CO2 mole fractions were the highest in winter (452.1 ± 17.7 ppm) and the lowest in summer (433.5 ± 13.3 ppm), with the monthly CO2 levels peaking in January and troughing in June. Diurnal CO2 levels peaked at dawn (05:00–07:00) in spring, summer and autumn, and at 10:00 in winter. 14C analysis revealed that the excess CO2 (CO2ex, atmospheric CO2 minus background CO2) at this site was mainly from CO2ff emissions (67.0 ± 26.8%), and CO2ff mole fractions were the highest in winter (20.6 ± 17.7 ppm). Local CO enhancement above the background mole fraction (ΔCO) was significantly (r=0.74, $p < 0.05$) positively correlated with CO2ff in a one-year measurement, and ΔCO:CO2ff showed a ratio of 23 ± 6 ppb/ppm during summer and winter sampling days, much lower than previous measurements and suggesting an improvement in combustion efficiency over the last decade. CO2bio mole fractions also peaked in winter (14.2 ± 9.6 ppm), apparently due to biomass combustion and the lower and more stable wintertime atmospheric boundary layer. The negative CO2bio values in summer indicated that terrestrial vegetation of the Qinling Mountains had the potential to uptake atmospheric CO2 during the corresponding sampling days. This site is most sensitive to local emissions from Xi' an and to short distance transportation from the southern Qinling Mountains through the valleys. Conducting measurements of atmospheric CO2 and Δ14CO2 in the geographically and ecologically crucial area of the Qinling Mountains and quantifying the sources of CO2 can help to improve the accuracy of the inverse carbon emission data, assess the regional carbon emissions, and formulate the carbon emission reduction measures.

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