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Atmospheric Carbon Dioxide in the 19th Century

In his study of $^{13}C/^{12}C$ ratios of tree rings, Stuiver (*1*) adds to a growing body of evidence that the biosphere as well as the combustion of fossil fuels may have contributed to the recent rise in atmospheric CO_2. He appears, however, to have misinterpreted 19th-century measurements of atmospheric CO_2 in finding that they support his deduction of an atmospheric CO_2 increase between 1850 and 1900.

From isotopic data and oceanic modeling considerations, Stuiver deduces that the atmosphere had a CO_2 content of only about 268 parts per million (ppm) in 1850, whereas the generally accepted value is about 290 ppm (*2*). In support of his deduction, Stuiver quotes a 19th-century "measurement" of 274 ± 5 ppm, which he attributes to Brown and Escombe (*3*). Actually, Brown and Escombe reported a mean of 294 ppm based on 92 observations which they made at Kew, England, between 1898 and 1901. The curiously low figure of 274 ppm appeared, however, in a review of 19th-century data published nearly four decades later by Callendar (*4*). Stuiver evidently relied on Callendar's value without examining the original publication.

At first glance, Callendar's value cannot be dismissed as an error, since he rejected some of Brown and Escombe's observations to arrive at a mean which he regarded as representative of the "free air of the North Atlantic region." Nevertheless, it seems highly unlikely that he arrived at a "representative" value of 274 ppm when all but 7 of Brown and Escombe's 92 measurements were higher than 274 ppm. Furthermore, in a second article (*5*), Callendar explained in detail how he obtained "representative" values by the use of weather maps. He reported then that 54 of Brown and Escombe's observations, during southwest to northwest winds, yield a mean of 286 ppm, while 20 observations, during southeast to northeast winds, yield a mean of 313 ppm. The latter mean very likely reflects urban contamination because of the proximity of Kew to the "great city" of London to the east, and should be rejected in establishing "free air" values. Air movements could not be definitely established for the remaining observations. Finally, in a still later article (*6*), Callendar quoted for Brown and Escombe a mean of 286 ppm, which he labeled a "preferred 19th century CO_2 average." Thus Callendar's reference to 274 ppm is probably a copy error or miscalculation which he later revised upward.

Actually, Stuiver's isotopic data and modeling considerations suggest that the annual mean CO_2 content of the air rose at nearly a constant rate from 268 ppm in 1850 to 312 ppm in 1950. A content near 290 ppm is thus indicated for 1900, in close accord with Brown and Escombe's observations.

But what do earlier historic observations tell us about a linear rise before 1900? Callendar's careful analysis (*5*) of 19th-century data suggests a steady content near 290 ppm. But all the data are of questionable accuracy, and data before 1870 are hopelessly unreliable. Thus, whether Stuiver's conclusions about the biosphere are correct will probably depend on the integrity of isotopic data and not on historic atmospheric CO_2 observations.

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I fully agree with Keeling that the accuracy of the conclusions about anthropogenic biospheric carbon fluxes depend on the integrity of the isotopic data and not on historical atmospheric CO_2 observations.

By using ^{13}C and ^{14}C isotopic data, an atmospheric CO_2 content of 268 ppm was obtained for mid-19th-century air (*1*). One short paragraph in (*1*) was devoted to a comparison of this result with CO_2 contents measured during the last century. It was noted that most measured values were higher for the 19th century. For the quoted value of 274 ppm, ascribed to Brown and Escombe (*2*), I indeed relied on Callendar's article summarizing historical CO_2 measurements (*3*).

Brown and Escombe reported the measurement of 91 (not 92) samples. Several of these samples were contaminated by CO_2 from local sources. Perhaps one should attach major significance to lower values because these may represent the smallest possible additions. Brown and Escombe reported 15 samples with a CO_2 content below 280 ppm, of which one, at 243 ppm, is clearly anomalous. The others all fall in the range 265 to 280 ppm and average 274 ppm. Although I make no claim about the accuracy of those early measurements, these remarks illustrate that the 290-ppm value inferred from historical measurements should be considered with caution.

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