Until recently it was widely believed that the so-called pre-industrial concentration of CO\textsubscript{2} in the atmosphere was near an annual average value of 290–300 parts per million (ppm) by volume — compared to about 340 ppm today. It was also widely believed, as the term 'pre-industrial' implies, that the increase in CO\textsubscript{2} over the past century was largely attributable to the burning of fossil fuels — the power behind the industrial revolution. By estimating the CO\textsubscript{2} changes and fossil fuel burning rates over the past century, it was found that the atmospheric CO\textsubscript{2} increase was about half that which would have occurred had all the fossil-fuel-injected CO\textsubscript{2} remained in the air. Thus, it appeared, empirically at least, that the airborne fraction of CO\textsubscript{2} emissions over the past century was about 50% — that is, half the injected CO\textsubscript{2} remained airborne, the rest going to some presumed sinks. The most likely sinks were absorption of CO\textsubscript{2} into the ocean (for ultimate deposition as carbonate sediments) and net expansion of the global biospheric mass from ‘CO\textsubscript{2}-fertilization’ of green plants.

However, in the mid-1970s some biologists suggested that the biosphere was probably a net source of CO\textsubscript{2}, largely as a result of deforestation. Some even suggested that the magnitude of CO\textsubscript{2} from biotic sources was of the order of the fossil fuel injections. If true, this extra biotic CO\textsubscript{2} injection implied that the airborne fraction was much less than 50%; closer to 25%. The implications of this, of course, are very significant to those concerned with estimating future CO\textsubscript{2} levels and their potential climatic impacts, for the airborne fraction is a very important parameter in the projection of CO\textsubscript{2} buildup rates. Debates, sometimes quite heated, broke out between a number of biologists and chemical oceanographers over whether the oceans could possibly have absorbed enough CO\textsubscript{2} to be consistent with a 25% airborne fraction over the twentieth century. [1] Several years later Seiler and Crutzen [2] helped close the gap somewhat between these biologists and oceanographers with their suggestion that perhaps a few tens of percent of the carbon in the burned trees of deforested lands may have gone to a charcoal sink, thus not appearing as injected CO\textsubscript{2} into the atmosphere. Still, the airborne fraction would have been well below a half.

It is only in the past few years that direct evidence has been uncovered that may help resolve this problem of the airborne fraction and oceanic intake of CO\textsubscript{2}. This evidence suggests that one previous central assumption of carbon cycle models should be revised: that the pre-industrial CO\textsubscript{2} level was near 300 ppm. If this number could be lowered, then a significant biotic source of CO\textsubscript{2} could be postulated along with an airborne fraction consistent with what many oceanographers believed to be appropriate for oceanic uptake of CO\textsubscript{2}. One such line of evidence was given in Climatic Change by Stanhill [3] based upon a re-examination of the Montsouris Observatory series of CO\textsubscript{2} measurements near Paris between 1877–1910. Some of these suggested values of CO\textsubscript{2} levels far below 300 ppm, as well as considerable variation over the last thirty years of the 19th century. In this issue of Climatic Change there is a comment by Lee Waterman which is skeptical of
the reliability of the Montsouris record. Stanhill defends some of his earlier inferences in a subsequent reply, and also presents some new data that he believes strengthens the conclusion that CO₂ levels in the 1880s were well below 300 ppm. Although I don't believe the uncertainties are yet satisfactorily resolved, I do think this important exchange between Waterman and Stanhill underlines the urgency of determining the levels of CO₂ in the previous century. (I also wish people would cease using the vague phrase 'pre-industrial level of CO₂', for it is quite possible, as Stanhill’s results suggest, that there was up to several tens of parts per million variations in CO₂ levels just in the last few decades of the 19th century.)

Additional evidence for 19th century CO₂ levels is also brought out in this issue of *Climatic Change* by Tom Wigley in the form of a critical review of a number of CO₂ measurements, both historic and modern. He concludes that 260–270 ppm is a more likely level than 290–300 ppm for this 'pre-industrial' CO₂ concentration.

The best direct evidence for pre-20th century CO₂ levels is probably the analyses of gas bubbles trapped in glacial ice preserved in Greenland or Antarctica. Groups in Grenoble, France and Bern, Switzerland have been major contributors to the process of deciphering these glacial chemical archives. Their many analyses suggest that CO₂ has varied by up to 100 ppm since late Pleistocene times some 15 000 years ago, with mid-19th century values around 260 ppm. Furthermore, results presented in June 1983 in Evanston, Illinois to the Ice and Climate Modelling Symposium of the International Glaciological Society [4] by several authors from these laboratories suggested that variations of several tens of parts per million may have occurred within the 19th century. (This adds further weight to my earlier-expressed prejudice that we should drop the term 'pre-industrial' from our CO₂ vocabularies, substituting instead specified dates and corresponding time series of CO₂ concentrations.)

To be sure, as new evidence comes in, the airborne fraction may again change from the 40% or so figure often cited at present. [5] But, I at least, am quite impressed that in a matter of some half dozen years the airborne fraction/carbon cycle issue was first thrown open to great uncertainty and then quickly brought back to within what now appear to be reasonable bounds. New difficulties may yet turn up in tomorrow’s mail, of course. But it is still gratifying to see how quickly progress has been made towards quantifying sources and sinks of airborne CO₂, thanks to the kinds of multidisciplinary research efforts just cited.

I eagerly await the mail bag.

*National Center for Atmospheric Research**
P.O. Box 3000,
Boulder, CO 80307, U.S.A.

STEPHEN H. SCHNEIDER*

* Any opinions, findings, conclusions or recommendations expressed in this editorial are those of the author and do not necessarily reflect the views of the National Science Foundation.

** The National Center for Atmospheric Research is sponsored by the National Science Foundation.