Tellus (1993), 45B, 479–481
Printed in Belgium – all rights reserved

Copyright © Munksgaard, 1993
TELLUS
ISSN 0280–6509

SHORT CONTRIBUTION

A ten-year record of the different levels of the ^{14}C activities over Sweden and the Arctic

By INGRID U. OLSSON, *Department of Physics, Uppsala University, Box 530, S-751 21 Uppsala, Sweden*

(Manuscript in final form 16 April 1993)

1. Introduction

Carbon dioxide from the atmosphere has been collected at Abisko, northern Sweden (68°N, 19°E), and Kapp Linné, Svalbard (Spitsbergen) (78°N, 14°E), for the last three decades. The ^{14}C excess over the standard was studied at the conventional ^{14}C laboratory in Uppsala. Knowledge of the steady decrease in different regions, especially at these high latitudes where the pollution from fossil fuel should be less than in Central Europe, is essential for global studies of the CO_2 cycle. The ^{14}C excess is indeed a net effect of the ^{14}C supply, primarily from test of nuclear weapons, and dilution by ^{14}C free, fossil-fuel consumption. Results for the last decade of ^{14}C-activity measurements are presented as a working report. Some samples from this decade remain to be measured. The selection of the last decade was based on the fact that obvious latitudinal differences were observed long after the maximum ^{14}C excess in 1963 and 1964 due to the nuclear-bomb tests. These latitudinal differences had almost disappeared by about 1978. The small persistent effects in the northern latitudes are studied in this paper.

2. Sampling and measurements

Carbon dioxide is collected by static absorption in diluted (0.5-N) NaOH on trays, 30 × 30 cm. In Abisko and at Kapp Linné, the trays are heated when necessary to avoid freezing. The trays are also equipped with roofs, normally preventing rain from penetrating to the hydroxide, resting on perforated walls, to restrain birds from reaching the liquids. An exposure of three days and nights usually yields enough carbon dioxide for a detector of 0.5 litre later filled to 2.7 bars. The tray at Abisko stands on top of a building at the Abisko Naturvetenskapliga Station 390 m above sea-level. The tray at Kapp Linné is placed on top of a house at the radio and meteorological station.

The ^{14}C activity is measured in a proportional counter filled with CO_2. Only one counter was used for the present study. The samples from the different collection sites were measured alternately to eliminate the risk of bias. Many samples from 1983 and 1984 were measured immediately after samples from 1987 to 1989. The trend for the decay, and the difference between Abisko and Kapp Linné are thus real. The statistical uncertainties are between 6 and 9‰ for most of the single measurements.

$\delta^{13}C$ is measured by normal mass spectrometry, and the ^{14}C content is normalized in the conventional manner (Olsson and Klasson, 1970). In this study, no consideration was given to the fact that part of the CO_2 was of fossil origin with a $\delta^{13}C$ value some 18‰ below that of the CO_2 in the atmosphere. The global $\delta^{13}C$ values for the atmospheric carbon dioxide have changed significantly during the last century.

The long-term stability of the counting equipment was checked by statistical analysis as given by Olsson (1989) using the principle described by

Stuiver (1982). Further technical details are given by Olsson (1989).

3. The ^{14}C results

The two long series from Abisko and Svalbard are presented in Fig. 1. No regular seasonal variations such as those indicated for Schauinsland (Levin et al., 1989) can be detected for Abisko and Svalbard. The values for Abisko and Svalbard fall almost exclusively within a band with a width of $\pm 2\%$ from the general trend of the curve for the decrease for each of the two sites. The ^{14}C excess has decreased until 1988 to about 16% at these high latitudes. From being higher than that in Central Europe for many years (Olsson, 1989) it now seems to be approximately the same (see Levin et al., 1989). The difference between Abisko and Kapp Linné did not decrease significantly during the decade studied here.

The decrease has often been mathematically described with an exponential decay curve. Since the surface water of the ocean currently has an activity corresponding to an excess of about 10% the exponential curve should approach a value close to this but slightly higher. This may explain the decreasing difference between various sites. Is is, however, very difficult to describe the observed decrease over Sweden and the Arctic as an exponential function without superimposing other effects. The fit of the atmospheric data to exponential functions is very poor (Fig. 2). The exponential curves, obtained by iterations on a computer, even indicate a higher activity after 1989 (year 9 in Fig. 2) at Kapp Linné than at Abisko. Straight lines were constructed by the least square method (Fig. 1). The obtained deviations from these lines were compared with the expected (σ_R/σ_{exp}). The 10 lines are drawn without consideration of the different sigma values for the single measurements. A detailed separate statistical analysis reveals appreciable deviations from the straight lines until end of 1983. The next 2-year period is characterized by a decrease of 1 ± 10, and an increase of $7 \pm 6\,^{\circ}/_{oo}$ per year for Abisko and Kapp Linné respectively. For the straight lines the ratios between the realistic sigma value to the expected value are 1.72 and 1.18 respectively. The corresponding values for the next period of about 1 year are, taken as a decrease, $-7 \pm 15\,^{\circ}/_{oo}$, $20 \pm 10\,^{\circ}/_{oo}$, 1.44 and 0.86. Indeed, the present results indicate minor variations from a constant activity from the end of 1983 until the begin of 1986 and a distinct decrease from early 1987 until early 1988 (Fig. 1). Results from 1982 and 1983 are still missing. It is suggested that a relationship may exist between

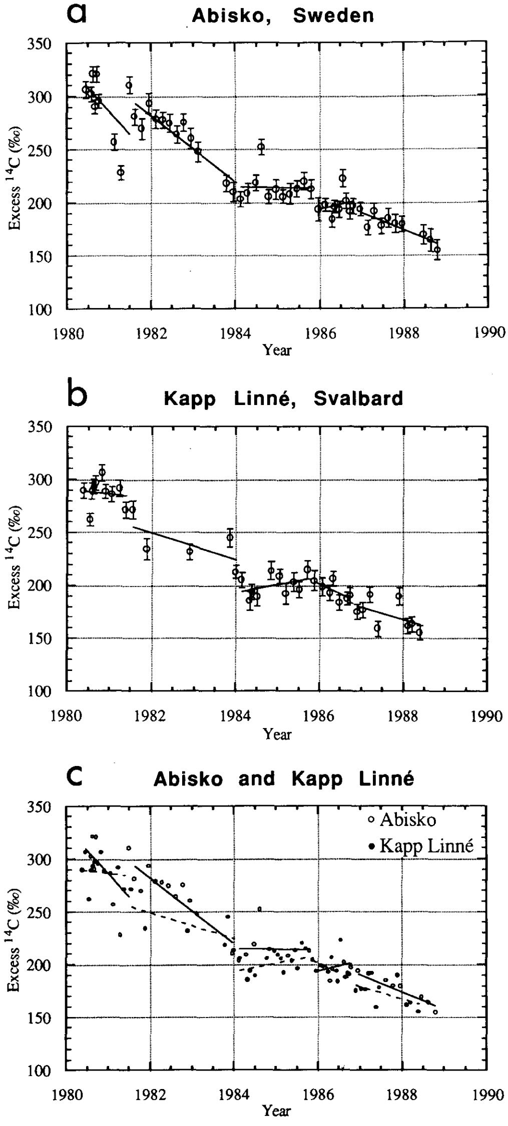

Fig. 1. The atmospheric ^{14}C excess from 1980 to spring 1989 for (a) Abisko, Sweden; (b) Kapp Linné (Svalbard); (c) an attempt to fit the ^{14}C excess data to a rapid decrease, a plateau and a later rapid decrease. The 10-year period is here divided into 5 periods.

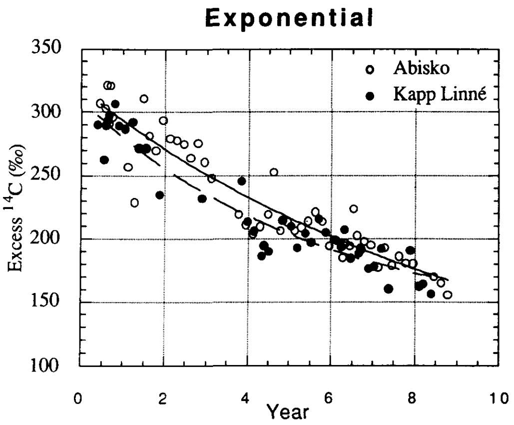

Fig. 2. An attempt to fit the data to exponential functions. For convenience, the same weight was given to all values.

the atmospheric data from this area and events affecting the oceanic circulation.

4. Acknowledgements

This summary is based on experience over a long period in the laboratory with many technicians and students. I wish to thank all of them, especially Maud Söderman, who took part in the routine work on all the samples used for this study and Lars Björnfot for his help with the first computer drawings. Special thanks are due to the personnel at Isfjord radio, Kapp Linné and to Nils Åke Andersson at Abisko, who helped us to collect the samples for many years. I am most grateful for the continuous support which I received from the Swedish Natural Science Research Council.

REFERENCES

Levin, I., Hesshaimer, V., Glöckler, R., Kromer, B., Münnich, K. O. and Francey, R. 1989. Radiocarbon in atmospheric CO_2: global distribution and trends. *Environmental pollution monitoring and research programme*. Extended abstracts of Papers, 3rd International Conference on Analysis and evaluation of atmospheric CO_2 data present and past, Hinterzarten, Germany, 16–20 October 1989, 55–60.

Olsson, I. U. 1989. Recent ^{14}C activity in the atmosphere, "clean air" and the Chernobyl effect. *Radiocarbon 31*, 737–744.

Olsson, I. U. and Klasson, M. 1970. Uppsala radiocarbon measurements X. *Radiocarbon 12*, 281–284.

Stuiver, M. 1982. A high-precision calibration of the AD radiocarbon time scale. *Radiocarbon 24*, 1–26.