SHORTER CONTRIBUTION

Carbon dioxide concentration in the upper troposphere and lower stratosphere. II

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Air sample collection for CO_2 analysis using the compression system of commercial aircraft (i.e. "bleed air" from the jet engine or air from a separate turbocompressor as on the DC-8) was introduced in 1962 (Bischof, 1970). By this method, measurements from higher altitudes and over larger distances became possible. Results from longdistance flights in 1963 gave the result that marked differences in the CO_2 concentration exist between the troposphere and the stratosphere (Bischof, 1965; Bischof & Bolin, 1966), showing that the lowest part of the stratosphere acts as a damping layer for vertical mass exchange. During May, the time of tropospheric CO_2 maximum, the CO_2 content in the lower stratosphere was found to be about 4 ppm *lower* than in the upper troposphere while in October, the time of CO_2 minimum in the troposphere it was about 3 ppm *higher*.

From a data presentation including all data collected during 1963–68 (Bolin & Bischof, 1970), it can be seen that the annual cycle at the 12 km level is quite different from that at 10 km. However, stratospheric air samples from summer months were missing in the data collection because of the fact that commercial aircraft in general do not operate at levels high enough to reach the stratosphere at this time of the year, when the tropopause is highest.

In order to study summer conditions, measurements from a small jet aircraft were made on August 23, 1971, 15.10–16.20 LT (14.10–15.20 GMT) at altitudes up to about 14 000 m, about 50 km north of Stockholm. A total number of 40 samples were collected and analyzed. (The sampling and analysis technique has been described by Bischof, 1970.) At the same time as the flask samples for CO_2 determination were collected, ozone concentrations were recorded by a Komhyr ECC meter

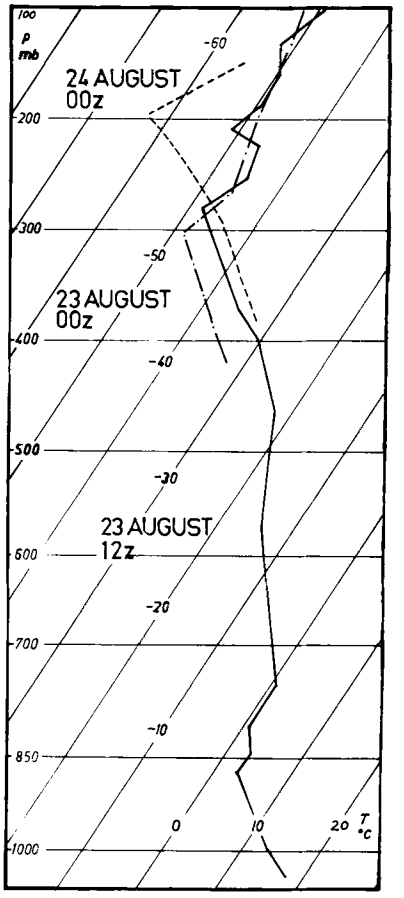

Fig. 1. Radiosonde data from Stockholm–Bromma. August 23 and 24, 1971.

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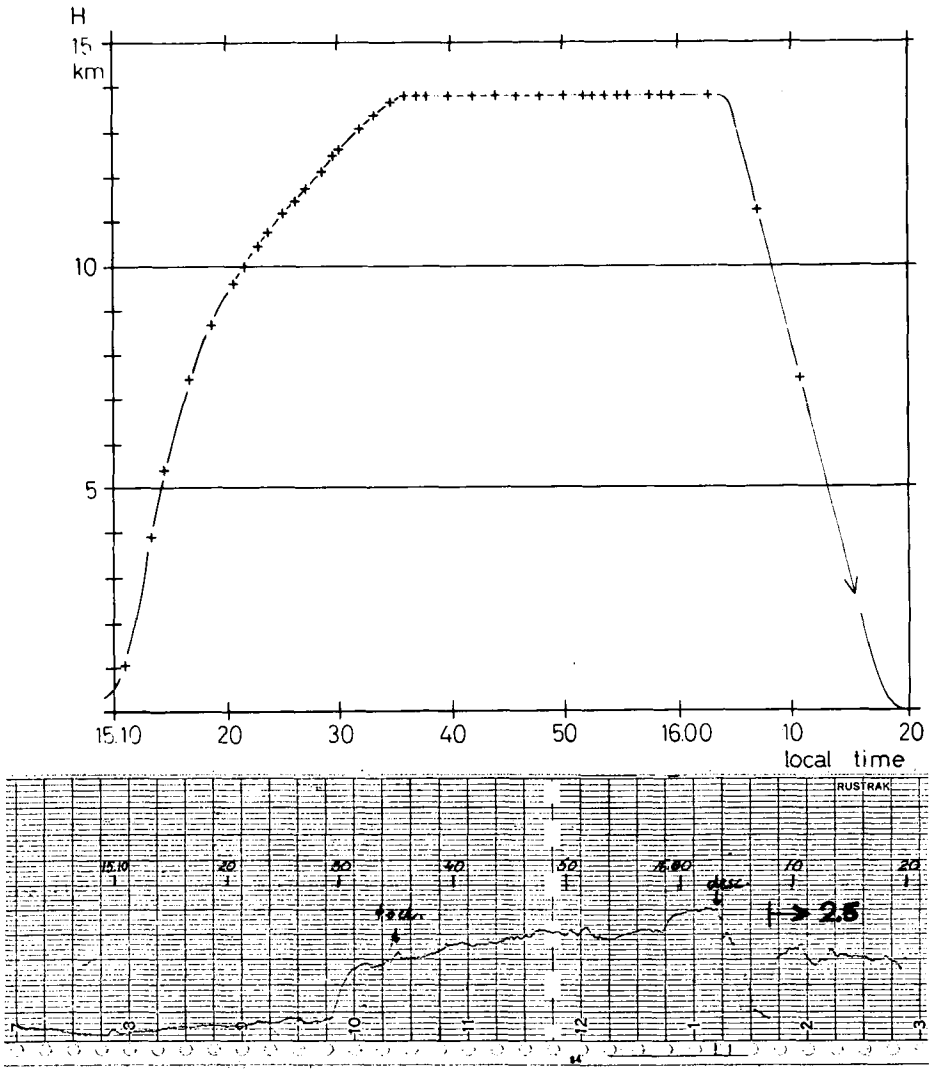

Fig. 2. Altitude of the flight of August 23, 1971, and ozone recorder sheet. CO_2 samples are marked by +. At 16.08 the ozonemeter was changed to a higher sensitivity range.

(Komhyr, 1968). Fig. 1 shows radiosonde data for Stockholm for August 23 and 24. The results of the measurements are shown in Figs. 2 and 3.

It can be seen from the ozone recorder sheet that the tropopause probably was reached at 15.29 LT, the altitude being 12 000 m. This altitude is somewhat different from that obtained from the radiosonde data at 12z, which shows a tropopause at 9 500 m. However, a marked rise of the tropopause can be observed between 12z and the following midnight.

The CO_2 data show a rapid change at the same time as the ozone increases. During the climb from this level to a cruising level of 13 800 m, the CO_2 content remains almost constant. The value 322.9 ppm given at this height in Fig. 3 is the mean of 17 samples having a standard deviation of 0.2 ppm.

The CO_2 data from this flight clearly demonstrate the vertical distribution at this time of the year when CO_2 is removed from the atmosphere by plant activity, which is indicated by the downward decrease of the CO_2 content

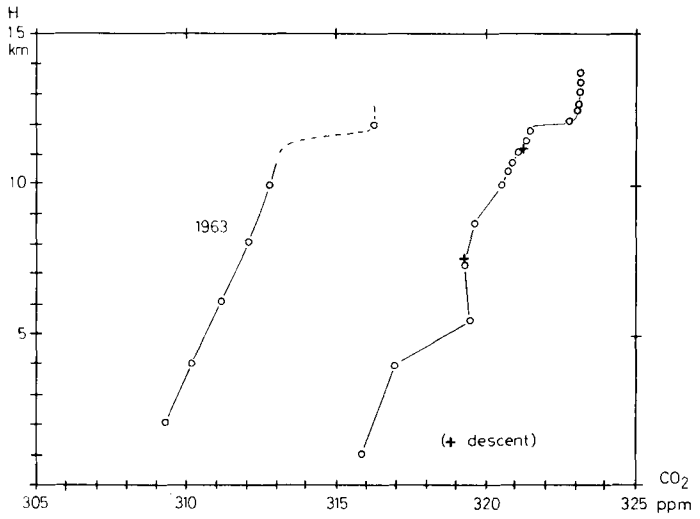

Fig. 3. Vertical CO_2 distribution of August 23, 1971, and average vertical CO_2 distribution for August 1963, from data 1963–68 (reduced to January 1, 1963) according to Bolin & Bischof (1970).

(it should be noted here that the value at 1 000 m in Fig. 3 is obtained over the city of Stockholm and may be contaminated). They confirm the mean vertical distribution from the 1963–68 data from August reduced to 1963, values as deduced by Bolin & Bischof (1970), see fig. 3. The distance between these profiles indicates an increase of about 8 ppm from 1963 to 1971. A marked change in the increase rate from about 0.7 ppm/year during 1963–68 to more than 1 ppm/year has occurred during the last few years, a fact that will be dealt with in more detail separately by the author, and which is in agreement with measurements on Mauna Loa, Hawaii, as reported by Keeling & Bainbridge (1971).

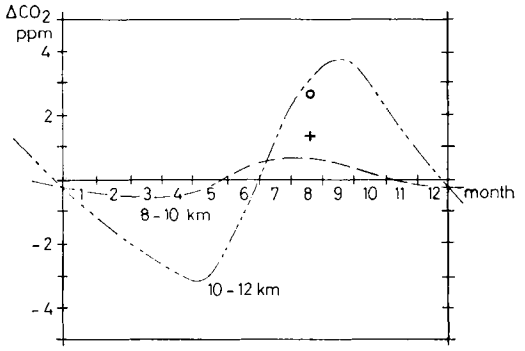

Fig. 4. Deviations from the annual mean of CO_2 concentration in the intervals 10–12 km and 8–10 km respectively, from average data 1963–68 (Bolin & Bischof, 1970). The present results are marked by O for the 10–12 interval and by + for the 8–10 km interval.

Fig. 4 is a comparison between the present data and computed average data from 1963–68. It can be seen that deviations from the annual mean concentration in the interval 10–12 km generally are much larger than in the 8–10 km interval. Data from the flight of August 23, 1971, show a somewhat smaller deviation in the 10–12 km interval (circle) and a larger deviation in the 8–10 km interval (cross) as compared with the curves given by Bolin & Bischof (1970). Jost (1971), on the other hand, found less CO_2 content in the stratosphere than in the troposphere in all seasons, which is in disagreement with our findings and the consistent picture given by Bolin & Bischof (1970).

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