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Year-to-year changes in atmospheric CO_2

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ABSTRACT

The atmospheric CO_2 increase rate has decreased from figures generally between 1 and 2 ppmv per year, typical of the years 1982 to 1990, to less than 1 ppmv per year in 1992–1993. This corresponds to a CO_2 accumulation in the whole atmosphere, from mid-1991 to December 1992, of 2.6 Gt C instead of 4.8 Gt C, as expected from the preceding average increase rate. A comparison between both hemispheres shows that the decrease of the increase rate was smaller, and lagged by about one year, in the southern hemisphere relative to the northern. This enables one to attribute these particularly low accumulation rates to the explosion of the mount Pinatubo in June 1991.

CO_2 has been monitored at Amsterdam Island since 1980. The site and method were described by Gaudry et al. (1983; 1984). The station, situated in the southern Indian Ocean (37°47′S; 77°31′E), is part of the BAPMoN network of WMO. CO_2 concentrations are referred to CFR 90 scale, intercompared with the 1990 SIO scale within 0.1 ppm (Monfray et al., 1990), and with the NOAA scale within $-0.04/+0.02$ ppm (unpublished results). Owing to the isolated situation of the sampling point, and to the severe criteria of data selection, the CO_2 concentrations taken into consideration correspond to pure marine air masses. As a consequence, it could be assumed that the CO_2 concentration increase, as registered at Amsterdam Island, is generally representative of the atmospheric global trend, at least for the southern hemisphere.

One of the most striking characteristics of this station data is the weakness of the seasonal variations, which are always within a ± 0.7 ppmv range. This enables one to deduce the general trend directly from the mean monthly values, without statistical treatment, and, therefore, to follow its possible changes almost in real time. This property was previously used to show the influence of El Niño events on the CO_2 increase rate (Gaudry et al., 1987, 1991).

A record of atmospheric CO_2 at Amsterdam Island, from May 1980 to December 1993, is shown in Fig. 1. The 12-month running means of these values are then utilized to calculate the annual increase rates, the 12-month running mean of which is shown in Fig. 2. It may be observed that, after figures generally between 1 and 2 ppmv per year, typical of the years 1982 to 1990, the increase rate has decreased to about 1 ppmv per year from 1991 to mid 1992, dropped down to 0.7 ppmv per year in early 1993, and increased again to around 1 ppmv per year from mid-1993. A similar result was obtained in the northern hemisphere, at the NOAA station of Mauna Loa, until December 1992 as shown in Fig. 2.

Further information can be drawn from the comparison between these stations of Amsterdam Island and Mauna Loa, as shown in Fig. 2.

(i) The variations of the CO_2 increase rate are generally parallel in both hemispheres.

(ii) For practically all variations of the increase rate, from 1980 to mid-1991, and especially in 1983 and 1987–88, the Amsterdam Island

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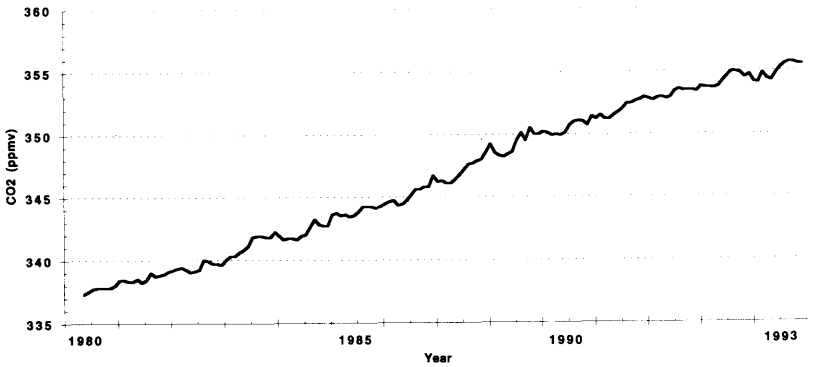

Fig. 1. The CO_2 Amsterdam Island 1980–1993 monthly record.

station, situated in the southern hemisphere, was in advance relative to the northern hemisphere. This is in agreement with the conclusions of Gaudry et al. (1987; 1991), that these strong increase rates were trigged by the occurence of El Niño events in the South Pacific ocean.

(iii) In contrast, from the middle of 1991 until the end of 1992, the variations of the CO_2 increase rate are definitely different for both hemispheres. In the southern hemisphere, the decrease lags by about one year relative to the northern hemisphere. Moreover, in the southern hemisphere, the variations are smooth, and the increase rate figures between 0.7 and 1 ppmv per year. In the northern hemisphere, the decrease is sharp and drops to values as small as 0.5 ppmv per year at mid-1992, then increases again.

This abnormal situation agrees rather well with the observation by Dutton and Christy (1992), that the ground mean temperature of the northern hemisphere was lowered by 0.7°C from mid-1991, following the explosion of Mount Pinatubo, at 15°N, in June 1991. In effect, a lower temperature increases the CO_2 solubility in sea water, and decreases the emissions of CO_2 due to the respiration of the vegetation. This effect faded away, as stratospheric aerosols from Pinatubo scattered and eventually falled out.

In conclusion, it seems quite reasonable to ascribe the smaller than usual CO_2 atmospheric accumulation, from mid-1991 to December 1992, to the occasional occurrence of a particularly strong volcanic explosion. It may be tentatively forcast that, in 1993 and 1994, the CO_2 increase rate should be realized again, in both hemispheres: typical values of about 1.5 ppmv per year. These lower increase rates correspond, from mid-1991 to December 1992, to a CO_2 atmospheric accumulation of 1.1 Gt C in the northern hemisphere and 1.5 Gt C in the southern hemisphere, instead of 2.4 Gt C in each hemisphere, as expected from the preceding average increase rate of 1.5 ppmv per year, i.e., for the global atmosphere, a deficiency of 2.2 Gt C.

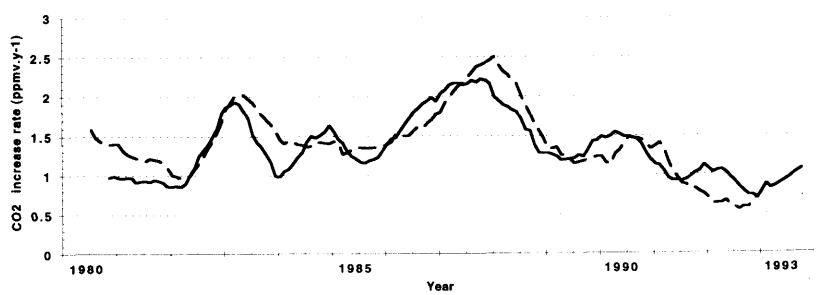

Fig. 2. Comparison of atmospheric CO_2 12-month running mean increase rates at Amsterdam Island station (bold curve) and Mauna-Loa/NOAA station (dashed curve). See text for statistical procedures.

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