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The Antarctic Circumpolar Current: occasional or seasonal source of isotopically light CO_2 ?

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Despite the increasing production of human-induced CO_2 emissions, the CO_2 growth rate in the atmosphere is considerably lower than expected. According to recent estimates (Houghton et al., 2001; Sarmiento and Gruber, 2002) during the Eighties the average fossil-fuel emissions were estimated at 5.4±0.3 Petagrams of carbon per year (1 Petagram - Pg - is equal to 10^{15} g and synonymous with one gigaton - Gt - ; the addition of one Pg of carbon to the atmosphere increases the concentration of CO_2 by about 0.47 ppmv). The atmospheric growth rate was 3.3±0.1 PgC/yr, the difference of 2.1±0.3 PgC/yr being taken up by the oceans and land. During the Nineties, the emissions exceeded 6 PgC/yr (Battle et al.,2000) but the increase of the atmospheric burden of CO_2 during the same period was abot 2.8 PgC/yr. The balance of the CO_2 was taken up by the oceans and the land biosphere. The importance of the knowledge of the CO_2 global distribution in space and time and of its yearly growth rate is apparent. Continuous records of the CO_2 concentrations in the ocean atmosphere were carried out repeatedly during the last decade between Italy and Antarctica by means of a Siemens Ultramat 5E analyzer assembled for shipboard use. During the same expeditions discrete air samples were collected in 4 liter Pyrex flasks between New Zealand and Antarctica in order to carry out accurate measurements of the carbon isotope composition of atmospheric CO_2 over the circumpolar oceans and to compare them with the carbon isotope values obtained from the samples collected over the Indian Ocean from Africa to New Zealand.

Considerable differences were found between the samples collected during four expeditions (1998-'99, 2001-'02, 2002-'03 and 2003-'04). During the 1998-'99 expedition all but three of the samples collected exhibited $\delta^{13}C$ values close to -8.1 ‰, this value being almost identical to those measured on Indian Ocean samples. This value can

be considered characteristic for that period for "clean' areas, far away from a direct contribution of polluting emissions from continental areas. The three anomalous samples were collected between about 52°S and 60°S and show $\delta^{13}C$ values ranging from - 8.45 to - 9.59 ‰. The possibility of pollution from the ship engines has been discarded according to several reliable considerations. During the 2001-'02 expedition only two anomalous samples have been measured, both at a lower latitude (about 48°S and 52°S respectively) the $\delta^{13}C$ values being -11.2 and -10.5 ‰. During the 2002-'03 expedition nine anomalous samples have been measured, located between about 58°S and 67°S the $\delta^{13}C$ values ranging from about -8.7 to about -9.9 ‰ . The flask samples collected during the 2003-'04 expedition are expected at the Parma laboratory within the end of April and will be measured right away.

It should be pointed out that the isotopic changes in the carbon isotopic composition are not paralleled by detectable changes in the atmospheric CO_2 concentration. This involves the rate of the net air-sea CO_2 fluxes with no detectable deviation of $f\,CO_2$ from atmospheric equilibrium values. A seasonal variability of the regional CO_2 fluxes has been already recognized in the sub-Antarctic area but the number of anomalous samples collected during the 2002-'03 expedition is quite large to be only the effect of minor seasonal variabilities of regional CO_2 fluxes. The interpretation of these data is complicated by the results obtained by several authors measuring the carbon isotopic composition of DIC. Almost all the results reported are positive while the reported isotopic composition of the anomalous samples is definitely related to very negative CO_2 deriving from the oxydation of organic matter of marine origin. We hope that the samples collected during the last expedition will help to understand the conditions of the air-sea CO_2 fluxes during austral summer in the circum-polar Antarctic area.

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