

The Amount of Non-Fossil-Fuel CO₂ in the Atmosphere

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Stable ¹³C/¹²C isotope ratios (expressed as $\delta^{13}\text{C}_{\text{PDB}}$) can be used to compute the composition of atmospheric CO₂. The natural atmospheric CO₂ reservoir has $\delta^{13}\text{C} \approx -7\text{‰}$ when in isotopic equilibrium with marine HCO₃⁻ and CaCO₃. CO₂ from burning of fossil-fuel and biogenic materials has $\delta^{13}\text{C} \approx -26\text{‰}$. $\delta^{13}\text{C}$ reported for atmospheric CO₂ was -7.489‰ in Dec. 1978, decreasing to -7.807‰ in Dec. 1988 (Keeling et al. 1989; AGU Geophys. Mono. 55, 165-236). In ~300 years old Antarctic ice $\delta^{13}\text{C} = -6.31$ of trapped CO₂ (Friedli et al. 1986; Nature 324, 237-238). If the decreasing $\delta^{13}\text{C}$ was only caused by mixing natural CO₂ with CO₂ from burning of fossil fuels or plants (current ~79%/~21% CO₂ mix; lifetime 50-200 years; IPCC 1989), the current atmospheric CO₂ $\delta^{13}\text{C}$ should be much lower than reported. The December 1988 atmospheric CO₂ composition was computed for its 748 GT C (GT = 10¹⁵ g) total mass and $\delta^{13}\text{C} = -7.807\text{‰}$ for 3 components: (1) natural fraction remaining from the pre-industrial atmosphere; (2) cumulative fraction remaining from all annual fossil-fuel CO₂ emissions; (3) carbon isotope mass-balanced natural fraction. The masses of component (1) and (2) were computed for different atmospheric lifetimes of CO₂. The result fits a lifetime of ~5 (5.4) years, in agreement with ¹⁴C studies. The mass of all past fossil-fuel and biogenic emissions remaining in the current atmosphere was ~30 GT C or less, i.e. maximum ~4%, corresponding to an atmospheric concentration of ~14 ppmv. The implication of the ~5 year lifetime is that ~135 GT C (~18%) of the atmospheric CO₂ is exchanged each year. At least 96% of the current atmospheric CO₂ comes from non-fossil-fuel sources, i.e. natural marine and juvenile sources. Hence for the atmospheric CO₂ budget marine degassing and juvenile degassing from e.g. volcanic sources must be much more important, and burning of fossil-fuel and biogenic materials much less important, than hitherto assumed.

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