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# Global long-term mean triple oxygen isotope composition of tropospheric $CO_2$

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**Introduction:** The oxygen and carbon isotope composition ($^{18}O/^{16}O$ and $^{13}C/^{12}C$) of tropospheric $CO_2$ is an excellent tool to investigate the atmospheric $CO_2$ cycle. Hoag et al. [1] suggested that the triple oxygen isotope composition ($^{17}O/^{16}O$ and $^{18}O/^{16}O$) of tropospheric $CO_2$ is a potential new tracer for terrestrial gross primary production (GPP). Here, we investigate in detail the global long-term mean triple oxygen isotope composition of tropospheric $CO_2$ and discuss its sensitivity to the major $CO_2$ fluxes, in particular GPP and stratospheric $CO_2$ influx.

**Method:** We conduct mass balance calculations for both $\delta^{18}O$ and $\Delta^{17}O_{TFL}$ of tropospheric $CO_2$ in order to reconcile the assumptions for $^{18}O/^{16}O$ and $^{17}O/^{16}O$ fractionation of atmospheric $CO_2$. In doing so, we carefully assign triple oxygen isotope signatures to the main $CO_2$ sources and sinks. For $CO_2$-water exchange, we implement the triple oxygen isotope exponent $\theta_{CO2}$/water $= 0.522 \pm 0.002$ [2] and we take into account that the main water reservoirs that exchange with atmospheric $CO_2$ (ocean, soil and leaf water) have a distinct $\Delta^{17}O_{TFL}$ signature [3, 4]. For kinetically fractionated $CO_2$ sources and sinks we assume that the exponent $\lambda_{kinetic}$= 0.509 [5]. We test the sensitivity to the main carbon fluxes and fractionation processes by carrying out a Monte Carlo simulation. We also compare the mass balance calculations to the long-term mean triple oxygen isotope composition of ambient air sampled in Göttingen (NW Germany) and with samples from remote locations. The triple oxygen isotope composition of these $CO_2$ samples was analyzed using a $CO_2$-$CeO_2$ equilibration technique published previously [2, 6]. All triple oxygen isotope data are reported relative to the terrestrial fractionation line (TFL) with a slope $\lambda_{TFL}$=0.5251 and zero intercept.

**Results:** For our base scenario, we calculate a global triple oxygen isotope composition of tropospheric $CO_2$ with $\delta^{18}O_{VSMOW}$ = 41.3‰ and $\Delta^{17}O_{TFL}$ = -0.12‰Àmbient air $CO_2$ from Göttingen has a long-term mean triple oxygen isotope composition with $\delta^{18}O_{VSMOW}$ = 41.5±0.9‰ (SD) and $\Delta^{17}O_{TFL}$ = -0.12±0.06‰ (SD).

**Discussion:** Several studies on $\delta^{18}O$ of atmospheric $CO_2$ demonstrated that assimilation and respiration are the two opponents controlling the global mean $\delta^{18}O$ of tropospheric $CO_2$ [7-10]. Here, we show that assimilation is the main driver that tends to decrease the $\Delta^{17}O_{TFL}$ of tropospheric $CO_2$ whereas both soil respiration and stratospheric influx are the main drivers that tend to increase the $\Delta^{17}O_{TFL}$ value. The model output for our base scenario is in excellent agreement with the long-term mean triple oxygen isotope composition of ambient air from Göttingen. The sensitivity tests show that $\Delta^{17}O_{TFL}$ of tropospheric $CO_2$ is slightly sensitive to changes in GPP and stratospheric $CO_2$ influx, and thus, has the potential to complement $\delta^{18}O$ modeling of atmospheric $CO_2$.

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