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A tentative attempt to better trace the late Pleistocene oxygen cycle

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Atmospheric abundance of oxygen (O_2) has been co-evolved with different aspects of the Earth system since appearance of oxygenic photosynthesis by cyanobacteria around 2.4 10^9 years before present (Ga). Therefore, much attention has been paid to understand the changes in O_2 and the underlying mechanisms over the Earth's history. The pioneering work by Stolper et al. (2016) revealed the long-term decreasing trend of O_2 mixing ratios over the last 800,000 years using the ice-core composite record of molar ratios of O_2 and nitrogen ($\delta(O_2/N_2)$), implying a slight imbalance between sources and sinks. Over geological time scale, O_2 is mainly controlled by burial and oxidation of organic carbon and pyrite, but also by oxidation of volcanic gases and sedimentary rocks. Nevertheless, the O_2 cycle of the late Pleistocene has not been well understood, partly due to the lack of knowledge about the individual sources and sinks. Since then, Kölling et al. (2019) proposed a simple model to estimate the O_2 release/uptake fluxes due to the pyrite burial/oxidation that predicts up to ~70% of the O_2 decrease of the last 800,000 years could be explained by pyrite burial/oxidation.

Building on this, we present here our preliminary, tentative attempt for reconstruction of the net organic carbon burial flux over the last 800,000 years by combining available information (including new $\delta(O_2/N_2)$ data) and assuming constant O_2 fluxes associated with volcanic outgassing and rock weathering. The long-term organic carbon burial flux trend obtained with our new calculations is similar to the global ocean $\delta^{13}C$ records but also to simulations using a conceptual carbon cycle model (Paillard, 2017). These results partly support the geomorphological hypothesis that the major sea-level drops during the earlier period of the last 800,000 years lead to enhanced organic carbon burial, and that significant changes in the net organic carbon happen around Marine Isotopic Stage (MIS) 13. In addition, we present the long-term decreasing trend of the global biosphere productivity, or gross photosynthetic O_2 flux, reconstructed from new measurements of triple-isotope composition of atmospheric O_2 trapped in ice cores. As the largest O_2 flux, the observed decrease in gross photosynthesis requires to be compensated by parallel reduction of global ecosystem respiration.