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Estimates of the biological oxygen productivity of the ocean from triple oxygen isotope measurements from the Vostok ice core

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The oxygen isotope signature of atmospheric O_2 is linked to the isotopic signature of seawater (H_2O) through photosynthesis and respiration. Fractionation during these processes is mass dependent, affecting $\delta^{17}O$ about half as much as $\delta^{18}O$. An "anomalous" fractionation process, which changes $\delta^{17}O$ and $\delta^{18}O$ of O_2 about equally, takes place during isotope exchange between O_2 and CO_2 in the stratosphere. The relative rates of biologic O_2 production and stratospheric processing determine the relationship between $\delta^{17}O$ and $\delta^{18}O$ of O_2 in the atmosphere. Variations of this relationship thus allow us to estimate changes in the rate of mass dependent O_2 production by photosynthesis versus the rate of O_2-CO_2 exchange in the stratosphere with about equal fractionations of $\delta^{17}O$ and $\delta^{18}O$.

With a box model we calculate oxygen productivities from the oxygen isotope signature measured on the Vostok ice core back to 380,000 year before present. Crucial for this exercise are the fractionation factors for biological processes and the hydrological cycles. All these fractionation factors have lately become available. We find as a robust result of our calculation that the ocean productivity was generally higher that today in the past. During ice ages the ocean productivity was about 20% higher than today.