Triple-isotope composition of atmospheric oxygen as a tracer of biosphere productivity

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Abstract:
Oxygen has three naturally occurring isotopes, of mass numbers 16, 17 and 18, Their ratio in atmospheric O-2 depends primarily on the isotopic composition of photosynthetically produced O-2 from terrestrial and aquatic plants(1-3), and on isotopic fractionation due to respiration(4). These processes fractionate isotopes in a mass-dependent way, such that O-17 enrichment would be approximately half of the O-18 enrichment relative to O-16. But some photochemical reactions in the stratosphere give rise to a mass-independent isotope fractionation, producing approximately equal O-17 and O-18 enrichments in stratospheric ozone(5) and carbon dioxide(6,7), and consequently driving an atmospheric O-2 isotope anomaly. Here we present an experimentally based estimate of the size of the O-17/O-16 anomaly in tropospheric O-2, and argue that it largely reflects the influences of biospheric cycling and stratospheric photochemical processes. We propose that because the biosphere removes the isotopically anomalous stratosphere-derived O-2 by respiration, and replaces it with isotopically 'normal' oxygen by photosynthesis, the magnitude of the tropospheric O-17 anomaly can be used as a tracer of global biosphere production. We use measurements of the triple-isotope composition of O-2 trapped in bubbles in polar ice to estimate global biosphere productivity at various times over the past 82,000 years. In a second application, we use the isotopic signature of oxygen dissolved in aquatic systems to estimate gross primary production on broad time and space scales.

KeyWords Plus:
VOSTOK ICE CORE, CARBON-DIOXIDE, OZONE, STRATOSPHERE, EXCHANGE, CO2, FRACTIONATION, TRANSPORT, MODEL, MASS

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