

Plant leaf wax aerosols as estimators of terrestrial photosynthetic isotopic discrimination of carbon dioxide on large regional space scales

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Change in the concentration and carbon isotopic composition of atmospheric CO₂ can be used to partition terrestrial and ocean carbon sinks because terrestrial photosynthesis strongly discriminates against ¹³C whereas discrimination during ocean uptake is negligible. This approach depends upon the accurate knowledge of the temporal and large spatial scale variation in terrestrial photosynthesis discrimination (Δ), a formidable challenge due to heterogeneity of terrestrial ecosystems. A promising atmospheric tracer approach (Conte and Weber 2002) uses the isotopic composition of higher plant-derived leaf wax aerosols to derive direct estimates of Δ on large regional space scales and at ~monthly resolution.

Studies at Howland Forest, Maine USA (a transitional boreal forest) focused upon processes linking photosynthetic discrimination with the isotopic composition of wax aerosols in boundary layer air. We measured canopy foliage and also above canopy aerosols over the growing season. Wax aerosol composition indicated contributions from both mixed hardwood forests upwind and local coniferous forests, confirming that the wax aerosol "footprint" is of a regional scale. Our wax aerosol-based estimate of Δ (18.0 ± 0.5 per mil) closely agreed with model estimates of northern mixed forest ecosystem Δ , providing further evidence that the weighted isotopic composition of plant waxes in the atmosphere reflects that of the source vegetation.

References

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Stable carbon isotopic composition of water-soluble dicarboxylic acids in the remote marine aerosols over the western and central Pacific

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Atmospheric organic aerosols can act as cloud condensation nuclei and thus play an important role in radiative forcing of the Earth. Water-soluble dicarboxylic acids have been proposed as a key compound class to enhance hygroscopic property of atmospheric particles. Previous study of remote marine aerosols over the Pacific Ocean showed that low molecular weight dicarboxylic acids (C₂-C₁₀) with a predominance of oxalic acid are abundantly present with their relative abundance to aerosol total carbon being maximized in the tropical Pacific due to a photochemical production (Kawamura and Sakaguchi, 1999).

In this study, we report stable carbon isotopic composition ($\delta^{13}\text{C}$) of individual diacids in the remote marine aerosols (n=32) from the Pacific (34°N-14°S, 140°E-150°W) using a capillary GC/isotope ratios mass spectrometer (GC/irMS). Diacids were extracted from the aerosols with pure water and then derivatized with BF₃ in n-butanol to dibutyl esters, which were determined for $\delta^{13}\text{C}$ using GC/irMS (Kawamura and Watanabe, 2004). The $\delta^{13}\text{C}$ values of individual diacids were calculated from $\delta^{13}\text{C}$ values of n-butanol and butyl ester derivative using a mass balance equation.

$\delta^{13}\text{C}$ values for C₂-C₉ saturated and some unsaturated diacids were determined in the marine aerosols as follows: oxalic acid (av. +10.3 ‰), malonic (-7.3 ‰), succinic (-17.6 ‰), glutaric (-23.0 ‰), adipic (-16.0 ‰), pimelic (-22.1 ‰), suberic (-16.3 ‰), azelaic (-22.4 ‰), fumaric (-17.2 ‰), and phthalic (-22.2 ‰) acids. Heavier $\delta^{13}\text{C}$ values were obtained for C₂ and C₃ diacids especially in the aerosols collected over the tropical Pacific, suggesting an isotopic fractionation caused by photochemical processes (possibly photochemical decomposition).

References

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