Hydrogen isotopes link plant waxes to rapid atmospheric transfer and deposition

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Sedimentary plant wax $^{2}H/^{1}H$ values are an important tool for understanding hydroclimate and environmental changes. Wax transport from the numerous plants in an ecosystem to sediments results in preservation of mixed regional values. However, large uncertainties exist about the mechanisms of transport and averaging, as well as the spatial and temporal scales over which these processes occur. Based on molecular distributions and $^{2}H/^{1}H$ values from plants and atmospheric dust collected over a two-year period at four sampling locations within a radius of ~60 km, we demonstrate how atmospheric plant waxes relate to surface sediments from six lakes in the same region. The major period of fresh plant wax aerosol production occurs shortly after leaf unfolding in the early summer when plants synthesize waxes in large quantities. These wax aerosols mix over a regional spatial scale, and are superimposed on an atmospheric background of degraded hydrocarbons that lack the chain length preferences diagnostic of recent biosynthesis. Nevertheless, depositional flux-weighted average $^{2}H/^{1}H$ values of long chain biomarkers primarily reflect fresh plant sources. While direct deposition to lake or coastal ocean surfaces must play a role in transporting waxes to sediments, atmospheric deposition on land and subsequent transport by surface runoff and in rivers may be more important due to the large surface area of catchments relative to the lakes or deltaic systems that they contain. These processes represent a mechanism by which large quantities of plant waxes that reflect the $^{2}H/^{1}H$ signal of the current growth season can be rapidly mobilized as fine-grained material and transported to low energy open water sedimentary depositional environments within a single season, even in areas with limited topographic relief. Transfer of waxes to the atmosphere in the early summer well before widespread leaf senescence also highlights the importance of early growth season water isotope values for plant waxes in temperate climate zones in the geologic record.