Chiral monoterpenes reveal forest emission mechanisms and drought responses

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Monoterpenes ($C_{10}H_{16}$) are emitted in large quantities by vegetation to the atmosphere (>100 TgC year $^{-1}$), where they readily react with hydroxyl radicals and ozone to form new particles and, hence, clouds, affecting the Earth's radiative budget and, thereby, climate change [1,2,3]. Although most monoterpenes exist in two chiral mirror-image forms termed enantiomers, these (+) and (−) forms are rarely distinguished in measurement or modelling studies [4,5,6]. Therefore, the individual formation pathways of monoterpene enantiomers in plants and their ecological functions are poorly understood. Here we present enantiomerically separated atmospheric monoterpene and isoprene data from an enclosed tropical rainforest ecosystem in the absence of ultraviolet light and atmospheric oxidation chemistry, during a four-month controlled drought and rewetting experiment [7]. Surprisingly, the emitted enantiomers showed distinct diel emission peaks, which responded differently to progressive drying. Isotopic labelling established that vegetation emitted mainly de novo-synthesized (−)-α-pinene, whereas (+)-α-pinene was emitted from storage pools. As drought progressed, the source of (−)-α-pinene emissions shifted to storage pools, favouring cloud formation. Pre-drought mixing ratios of both α-pinene enantiomers correlated better with other monoterpenes than with each other, indicating different enzymatic controls. These results show that enantiomeric distribution is key to understanding the underlying processes driving monoterpene emissions from forest ecosystems and predicting atmospheric feedbacks in response to climate change.
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