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New estimates of global land photosynthesis using updated theories of CO_2-H_2O oxygen isotope exchange rates in land water pools

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Projected future climate change depends strongly on the formulation of terrestrial gross photosynthetic uptake in current climate models. This is because photosynthesis (and its counterpart respiration) is two orders of magnitude larger than the net ecosystem CO_2 exchange, which in turn determines projected climate change. Small uncertainties in projected photosynthesis can hence translate into large uncertainties in the future land carbon sink and consequently climate change projections. As a result, the land surface is currently the second largest uncertainty in modelled climate change signals after clouds. While $C^{18}OO$ represents about 0.2% of atmospheric CO_2, its seasonal fluctuations are measurable and mainly dictated by the amount of CO_2 that interacts with water reservoirs in foliage (usually rich in ^{18}O) and trunks and soils (usually poor in ^{18}O), and thus by the size of (foliar) photosynthesis and (trunk and soil) respiration. Provided that the ^{18}O exchange rates between CO_2 and land water pools are known, atmospheric budgets of CO_2 and $C^{18}OO$ can be performed to estimate land photosynthesis and respiration at large scales. The ^{18}O exchange between CO_2 and land water pools is catalysed by a class of enzymes ubiquitous in the living world, the carbonic anhydrases (CA). Understanding how CA activity is regulated in soils and plants is thus key to the utilisation of $C^{18}OO$ budgets as constraints to estimate land photosynthesis and respiration. Recent advances have been made regarding the regulation of CA activity in soils and leaves, leading to new parameterisations of the associated CO_2-H_2O isotopic exchange rates. Here we implemented these new parameterisations into a global scale climate-carbon model and performed CO_2 and $C^{18}OO$ budgets at the global scale, providing updated estimates of global land photosynthesis using this atmospheric tracer.