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Testing vertical influences on greenhouse gases fluxes (CO2, CH4 and N2O) along tropical tree stems

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Our knowledge of how greenhouse gas (GHG) fluxes vary from the soil to the tree canopy is limited, particularly in upland tropical rainforests. In this case study, we show changes in the fluxes of the primary GHGs (carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)) along the soil - stem continuum, and their relationships with corresponding stem traits at different heights. To do this, we used static chambers to measure the GHG fluxes from three stems, both on the surrounding forest floor and at eight heights ranging from 0.5 m to 30 m, while also assessing tree traits at these heights. We selected representative emergent trees from a tropical forest in French Guiana, South America. We found no clear pattern in the GHG fluxes along the stems, with highly variable CO_2 emissions and alternating CH_4 and N_2O emissions and uptake. Regression analysis showed that stem traits related to the tree's surface area, bark, and sapwood partly explain the measured fluxes along the stem height. For CO_2 fluxes, the best explanatory variables are identified as bark surface temperature, bark water content, and sapwood density; for CH_4 fluxes, the key drivers are tree diameter, bark water content, and bark surface temperature; and for N_2O fluxes, the more influential variables are sapwood density, and sapwood water content. We concluded that the variability in GHG fluxes along the stems was not only specific to tree traits, but also to individual trees. These findings pose a challenge for scaling efforts - it will not be trivial to create bottom-up estimates of tree-impacted fluxes, and a convergence of approaches will be needed to generate a complete GHG balance for these ecosystems.

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