Exploring the atmospheric record of δ13C in CO_2 at the Amazon Tall Tower Observatory to disentangle fire signals and ecosystem processes

MSc Thesis

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The are multiple ecosystem processes that can be studied using the carbon isotope composition (δ13C) of atmospheric CO_2. For example, δ13C has been used to quantify ecosystem respiration (Bowling et al., 2001) or to partitioning the contribution of C3 and C4 plants to the total Net Ecosystem Exchange (NEE) (Torn et al., 2011). Along the same lines, the type of vegetation (C3/C4) that is combusted in forest or savana fires, although a challenging task, could potentially be identified using δ13C (Vernooij et al., 2022). Furthermore, seasonal or inter-annual changes in δ13C have been linked to water use efficiency by plants at global and continental scales (Randerson et al., 2005, Peters et al., 2018, Joos et al., 2024). However, a limiting factor to perform these analysis is the precision of the measurements, as changes in δ13C signatures of interest can be on the order of only a few per mil. At the Amazon Tall Tower Observatory (ATTO), the concentration and δ13C of atmospheric CO2 were measured from May 2022 until December 2024 using a cavity ring down spectrometer (G2201-i, Picarro Inc.) at several heights within and above the canopy. In this project, we aim to investigate whether this record and its precision allows to disentangle seasonal fire signals, changes in water use efficiency and/or quantify ecosystem respiration. For this we will use the Keeling plot approach and/or the Miller-Tans method to determine if the diurnal, seasonal and inter-annual changes in δ13C are detectable. Additionally, we will use an atmospheric transport model to track fire plumes and by coupling it to a vegetation model we can simulate expected changes in δ13C.

Usefull skills:

- Programming skills in Python
- Knowledge on environmental physics and atmospheric dynamics
- Experience or willingness to learn atmospheric transport modeling
- Basic knowledge on isotope biogeochemistry

References:

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