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Understanding the body's rejection mechanisms boosts understanding of our natural defences

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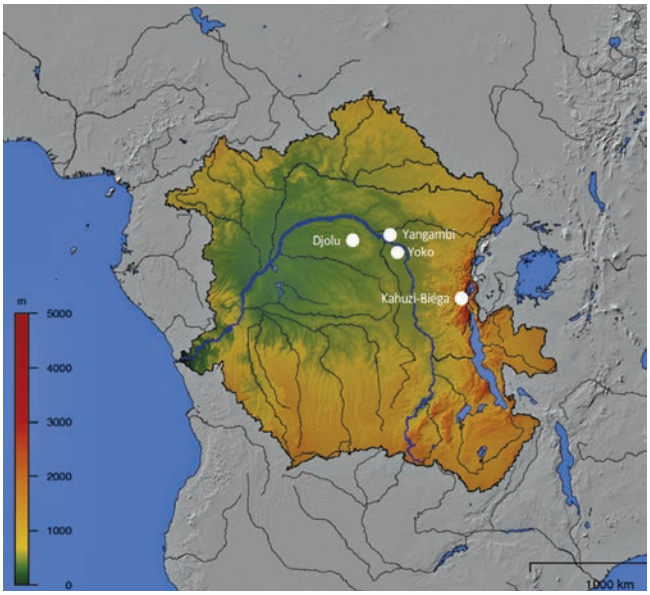
BIOGEOCHEMISTRY IN THE CONGO

The group of Sustainable Agroecosystems in the Department of Environmental Systems Science at ETH Zurich, Switzerland, presents its efforts to shed light on the dark matter of the Congo Basin

The Congo Basin Rainforest is the second largest rainforest in the world covering an area of 3.7 million square kilometres. However, due to political instability and infrastructure, this vast forest ecosystem was mainly inaccessible for environmental scientists. Thus it remains a blank spot concerning its role in global biogeochemistry, despite representing one of the most important terrestrial ecosystems in the world.

The understanding of the carbon (C) and nitrogen (N) cycles in these forests are of utmost importance as they are associated with the release and uptake of radiatively active trace gases, namely CO_2, CH_4 and N_2O. Generally, tropical forests are important players within these cycles because of the fast turnover of C and N in such ecosystems. However, long-term observations of greenhouse gas emissions from tropical forests are completely under-represented in global attempts to monitor greenhouse gas exchange. While there is a dense network of long-term observatory sites for greenhouse gas fluxes in industrialised countries, observations on the African continent are especially sparse for infrastructural, political and economic reasons.

So far, there are only about 15 CO_2 flux sites operational across the African continent (compared to more than 550 globally), and only a handful of datasets exist that include *in situ* N_2O emissions from African tropical rainforests. This situation is especially problematic given that the continent is currently undergoing dramatic land-use change through deforestation for agriculture, which has drastic environmental consequences regarding hydrology, soil degradation, biodiversity and greenhouse gas emissions. As such anthropogenic pressures continue to grow throughout the Congo Basin, it is similarly important to understand the impacts of agriculture on C and N dynamics and to successfully replace traditional 'slash and burn' agriculture with sustainable alternatives in order to help protect the primary forest.



Map of the Congo River watershed with current field sites (white dots): Kahuzi-Biéga National Park; Yangambi Man and Biosphere Reserve; Yoko Forest Reserve; and Djolu agricultural fields and forest sites. Map modified after Wikimedia commons

Manual chambers placed on the forest floor in Kahuzi-Biéga National Park to measure temporal and spatial dynamics of greenhouse gas emissions

Sustainable Agroecosystems

For the aforementioned reasons, the Sustainable Agroecosystems group at ETH Zurich is co-establishing several observation sites in the Democratic Republic of Congo in a concerted effort between the International Institute for Tropical Agriculture and Catholic University of Bukavu, DRC; the University of Ghent and Catholic University of Louvain-la-Neuve, Belgium; and Florida State University, US. More specifically, the consortium is installing a long-term greenhouse gas observation site in the Tshuapa province of the DRC, which is complemented by several short chamber-based measurement campaigns at various forest sites throughout the Congo Basin, as well as several longer term campaigns in agricultural and forest watersheds around Bukavu to measure C fluxes from terrestrial to aquatic ecosystems.

Typical landscape in eastern DRC showing small scale farming bordering the rainforest of Kahuzi-Biega National Park. Photo: M. Barthel

Specifically, the aims of the group are to:

- Conduct exploratory manual chamber-based measurement campaigns to characterise CO_2, CH_4 and N_2O emissions from various forest sites in the Congo Basin;
- Establish long-term observation of CO_2, CH_4 and N_2O fluxes from tropical rainforests in the Congo Basin using micrometeorological techniques;
- Gain a mechanistic understanding of N_2O emissions using state-of-the-art isotope analysis to partition source processes;
- Estimate the effect of land-use change from natural to agricultural ecosystems on the cycling of C and N; and
- Assess how forest conversion to agriculture might augment the flow of C from terrestrial to aquatic ecosystems.

Active projects

Spatial and temporal dynamics of N_2O fluxes and their isotopic composition released from tropical forest soils in the Congo Basin

Within the last year several exploratory manual chamber-based measurement campaigns in different forest ecosystems throughout the DRC have been completed (primary, secondary, monodominant, mixed, lowland, montane) to characterise the general magnitude of N_2O fluxes and its isotopic composition. First results show that there is a wide range of N_2O fluxes, which are in some cases comparable to emissions released from intensively fertilised agricultural fields. In a second step, the measurement of the intramolecular distribution of isotopes within the N_2O molecules will be used to identify the specific microbial processes driving these soil-derived N_2O emissions, namely nitrification and denitrification. The collected data will add to the very small body of studies on greenhouse gas exchange conducted in this vast ecosystem.

Sustainable agricultural intensification for improving livelihoods and forest conservation in the Congo Basin

In the region of Djolu in the heart of the DRC, community co-designed demonstration trials are conducted to test and show various agricultural techniques alongside local traditional practices in order to promote sustainable agriculture and thereby help to protect the primary forest.

A paired-watershed approach to assess the impact of agriculture on carbon export and processing in the highlands of eastern DR Congo

Around Bukavu, eastern DRC, the group assesses how agriculture and land-use conversion might augment the flow of C from terrestrial to aquatic ecosystems. Thus, agricultural and pristine watersheds are compared to estimate the quantity, quality and seasonality of both organic and inorganic C exported from these systems and how much C is lost as CO_2 or CH_4 to the atmosphere.

Looking forward

So far, the conducted manual chamber-based measurement campaigns have been only several weeks long and have missed changes in seasonality and coverage of a larger sampling area. While continuing these short campaigns at various forests to understand spatial variability of greenhouse gas exchange, a micrometeorological eddy covariance tower will be set up to also capture seasonal and annual changes from a representative forest site.

Such a dataset would be the first long-term observation of greenhouse gas fluxes from the Congo Basin Rainforest and would greatly help to fill the current knowledge gaps on these ecosystems. Long-term ecological measurements are crucial to understand the dynamic Earth system, and the integration of understudied regions is key to obtaining a more complete picture of global greenhouse gas exchange.

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