Holocene environmental and hydrological changes in Congo Basin using sediment $\delta^{13}C$

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Predicting the effects of global change on forest biodiversity in the Congo Basin

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Introduction

Long-term ecological records are essential to understanding past responses of vegetation to climate change and human activity. In the frame of Coforchange, we aim to reconstruct past conditions that prevailed during the Holocene in a region holding currently the world's second largest rainforest. Tropical Moist Forest (TMF) extension in Central Africa has experienced dramatic changes over the last millennia(1), related to variation in rainfall patterns or to anthropogenic pressure. These disturbances are thought to still influence today's repartition of forest and savannas, and species distributions. Are the light-demanding canopy plants in large TMF a recovery phase from past anthropogenic disturbances or from dry episodes?

Lake and peat sediments contain a variety of paleoenvironmental proxies to reconstruct local to continental climate histories. Here we focus on carbon stable isotopes ($\delta^{13}C$) and Carbon/Nitrogen indicators of modern surface soil, plants and 10 sedimentary cores in Central Africa to reconstruct spatial and temporal ecosystem perturbations and savanna corridors.

Material & Methods

Principle: $\delta^{13}C$ in soil organic matter reflect the balance between plants with C3 and C4 photosynthetic pathways (PP). All trees and ~ 50% of grasses possess C3 and C4 PP respectively (2). In tropical environments, most savanna grasses are C4 plants with typical $\delta^{13}C$ of -13‰ very different compared with C3 plant (-27‰) (3). Soil $\delta^{13}C$ is a potential indicator of C3/C4 balance widely used for the qualitative description of forest savanna dynamics and grassland/woodland boundaries (4). This proxy has already been calibrated quantitatively in savanna against plant biomass (5) to reconstruct past vegetation. Carbon isotope discrimination ($\Delta^{13}C$) is also used as a measure of intrinsic water-use efficiency (WUE photosynthesis divided by stomatal conductance, A/gs) which can be calculated from carbon isotope values.

Limitation: Lake sedimentary OM may results from a complex combination of autochtonous and/or allochtonous material. Hence the $\delta^{13}C$ may reflect these diverse sources. Autochthonous OM has low C/N ratios (<10) while terrestrial plants have C/N >20 (6). Hence we measured $\delta^{13}C$ and C/N ratios of modern surface sediment and plants from CAR, Gabon and Cameroon for calibrating our proxies needed to reconstruct past vegetation changes archived in 15 well dated (7) sedimentary cores (See Fig 1&2) .

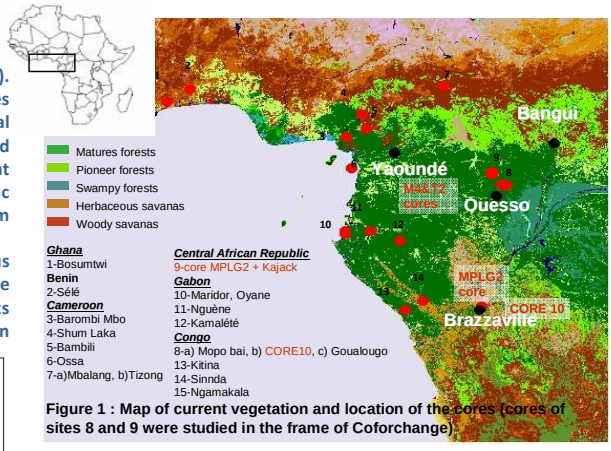
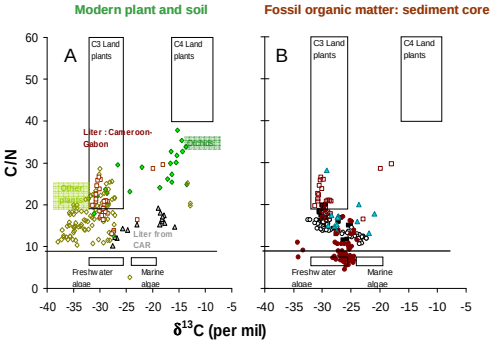
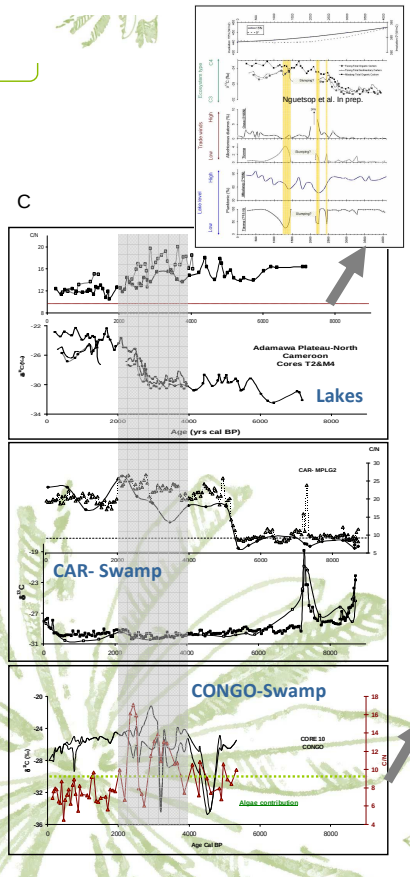


Figure 1 : Map of current vegetation and location of the cores (cores of sites 8 and 9 were studied in the frame of Coforchange).

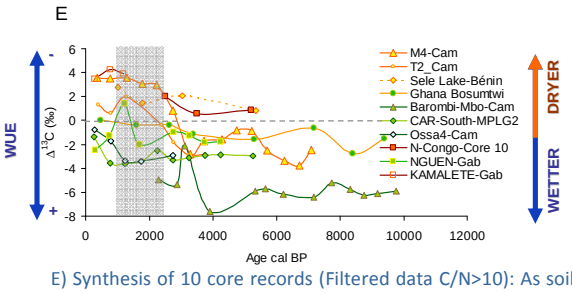
Results



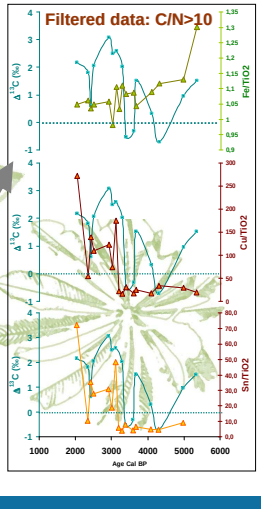
A) C/N versus $\delta^{13}C$ of plants of Cameroon and modern soil of CAR (8) and Gabon show lower C/N compared with expected terrestrial plants and are well above aquatic plants typical values (Rectangles). C/N>10 may be typical of African TMF ecosystems. Hence relatively low C/N ratios of terrestrial material show intermediate values of C/N (10-20) not necessarily linked to a mixture of aquatic and terrestrial sources (9; Grey triangles: CAR liters). B) C/N ratios of the lacustrine or swamp sediments are above 10 except CORE 10 (Congo) of which half the samples have C/N<10. Black Open circles : Mbalang core N-Cam; Black filled square: Tizong core N-Cam; Blue triangle: MPLG2-CAR; Filled Diamonds: Core10-Congo.



C) C/N and isotope ratios of 3 sediment cores D) Decrease of the Fe/TiO2: less iron transport, less rain→ Climate shift towards dryer conditions. In phase with ecosystem water stress. Increase of the Cu and Sn during the dryer episode? Hypothesis: Atmospheric input, higher NE trade winds? Changes in rain belt movements. Higher seasonality of precipitation



E) Synthesis of 10 core records (Filtered data C/N>10): As soil water becomes less available, the carbon isotope ratio increases ($\delta^{13}C$), discrimination decreases ($\Delta^{13}C$), and plant intrinsic water-use efficiency goes up (WUE).



Conclusion & perspectives

- $\delta^{13}C$ useful indicator of water availability to the ecosystem. C/N potential indicator of the water table level (still need calibration)
- Responses of ecosystems to the dryer climate (ITCZ shift) ~ 3Kyrs are spatially variable (Savanna in Northern Cameroon; swamp in CONGO is less humid and a semi-deciduous forest might develop).
- Current savanna of the Adamawa plateau began about 3 kyr, open forest in Congo and Benin were present 5Kyrs ago. Some areas did not changed except the last 1000 years (Ossa, CAR).
- Not all forest ecosystems are equally resilient to the climatic disturbance: Nguen, BarombiMbo forest resisted to environmental changes.
- Links with archeology: Bantu expanssion during the drying phase

Scientific partners
CIRAD : French Agricultural Research Centre for International Development, France
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University of Bangui, Central African Republic
University of Yaoundé I, Cameroon
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CIFOR : Centre for International Forestry Research, Indonesia

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