



## Assessing Spatial and temporal heterogeneity of Soil Carbon emissions across anthropized land use Gradient in the Sudanian savanna

Francis E. Oussou<sup>1</sup> and the WASCAL CONCERT Team\*

<sup>1</sup>Akure, Ondo State, Nigeria (francisoussou@gmail.com)

\*A full list of authors appears at the end of the abstract

Field-based observations of Carbon dioxide (CO<sub>2</sub>) exchange between soils and atmosphere are critical to accurately account for terrestrial carbon cycling in data-scarce West African savanna ecosystems. This study quantified soil CO<sub>2</sub> fluxes over two consecutive years (2023–2024) using a static chamber approach across four contrasting land-use systems namely forest, grassland, cropland, and rice fields. Measurements were conducted on weekly basis using replicated chambers to assess both spatial heterogeneity and interannual variability. Soil CO<sub>2</sub> fluxes were analysed in relation to key environmental drivers, including water-filled pore space (WFPS) and soil temperature, using mixed-effects statistical models to account for repeated chamber measurements. Across all land uses, CO<sub>2</sub> emissions increased markedly in 2024 compared to 2023. Median seasonal CO<sub>2</sub> fluxes ranged from 0.59 to 1.46 t C ha<sup>-1</sup> season<sup>-1</sup> in forest systems, 1.91 to 5.07 t C ha<sup>-1</sup> season<sup>-1</sup> in grasslands, 1.75 to 5.09 t C ha<sup>-1</sup> season<sup>-1</sup> in croplands, and 1.84 to 2.61 t C ha<sup>-1</sup> season<sup>-1</sup> in rice fields. Grasslands and croplands consistently exhibited the highest CO<sub>2</sub> emissions, with maximum values reaching 7.18 and 5.38 t C ha<sup>-1</sup> season<sup>-1</sup>, respectively, highlighting the strong influence of land management and disturbance intensity. Forest soils showed comparatively lower CO<sub>2</sub> fluxes, reflecting reduced soil disturbance and more stable microclimatic conditions. Statistical analyses revealed that soil temperature was a dominant driver of CO<sub>2</sub> emissions across all ecosystems, while soil moisture exerted a secondary but significant control, particularly in managed systems. Higher WFPS and elevated soil temperatures during the wet season were associated with enhanced CO<sub>2</sub> release, indicating intensified microbial respiration and root activity. Interannual contrasts suggest that wetter and warmer conditions in 2024 amplified soil respiration across all land uses. Overall, our results demonstrate pronounced spatial and temporal variability in soil CO<sub>2</sub> fluxes in the Sudanian savanna and underscore the sensitivity of carbon emissions to land-use change and hydro-climatic variability. These findings provide critical baseline data for improving regional carbon budgets and for informing mitigation strategies in data-scarce tropical savanna regions.

**WASCAL CONCERT Team:** Francis E. Oussou\*, Ralf Kiesed, Souleymane Sy, Jan-Geert Bliedernicht, Ines Spangenberg, Samuel Guug, Anja Schäffler-Schmidt, Rainer Steinbrecher, Frank Neidl, Michael Ayamba, Luitpold Hingerl, Emmanuel Quansah, Alex Frempong, Patrick Davies, Windmanagda

Sawadogo, Christiana F. Olusegun, Ricky. M. Mwanake, Nicaise Yalo, Yinusa A. Asiwaju-Bello, Moussa Boukari, Leonard K. Amekudzi, Kehinde Ogunjobi, and Harald Kunstmann