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Spatial and temporal variability of carbon fluxes in African ecosystems - a CarboAfrica synthesis study

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This study reports carbon and water fluxes between the land surface and atmosphere in eleven different ecosystems in Sub-Saharan Africa, as measured using eddy covariance (EC) technology. The ecosystems for which data were available ranged in mean annual rainfall from 320mm (Sudan) to 1150mm (Republic of Congo) and include a spectrum of land cover types (savannas, woodlands, croplands and grasslands). Data were analysed across the network, in order to understand the driving factors for ecosystem respiration and carbon assimilation, and to reveal the different water use strategies in these highly seasonal environments. In addition to the spatial pattern, the temporal pattern that connects carbon fluxes with water relations in savanna ecosystems were studied in detail in a savanna ecosystem at Kruger National Park, South Africa and a miombo woodland in Western Zambia.

Temporal variability: The regulation of canopy conductance was temporally changing in two ways: changes due to phenology during the course of the growing season and short-term (hours to days) acclimation to soil water conditions. The most constant parameter was water use efficiency. It was influenced by humidity (VPD) during the day, but the VPD response curve of water usage only changed slightly during the course of the growing season, and decreased by about 30% during the transition from wet to dry season. The regulation of canopy conductance and photosynthetic capacity were closely related. This observation meets recent leaf-level findings that stomatal closure triggers down-regulation of photosynthesis during drought. Our results may show the effects of these processes on the ecosystem scale.

Spatial variability: The same pattern was found at large spatial scales. Maximum carbon assimilation rates were highly correlated with mean annual rainfall (r^2=0.74) and were also positively correlated with satellite-derived fAPAR. Ecosystem respiration was dependent on temperature at all sites, and was additionally dependent on soil water content at sites receiving less than 1000 mm of rain per year. All the ecosystems studied that were dominated by C_3-plants showed a strong decrease in the 30-minute assimilation rates at low humidity (VPD $>$ 2.0 kPa), while ecosystems dominated by C_4-plants did not.