Ecosystem water fluxes in Sub-Saharan Africa

Merbold L.[1,*], Kutsch W.L.[2], Scholes R.J.[3] and the CarboAfrica Fluxtower PI's

* ETH Zurich - Institute of Agricultural Sciences, Grassland Sciences Group - 8092 Zurich - Switzerland - merboldl@ethz.ch

Background

Savanna ecosystems are characterized by seasonal changes of water availability.

Up to date, only few single site studies have investigated physical and physiological controls of savanna functioning at the ecosystem scale.

Aim & Methodology

We investigate water fluxes, measured by eddy covariance (EC), across a variety of ecosystems along a precipitation gradient across Sub-Saharan Africa (Fig 1).

We aim to identify drivers of evapotranspiration at temporal (I) and spatial scales (II).

Results (I)

Based on a previous study, focusing on the carbon exchange of these ecosystem, we reporte similar large daily and seasonal variations in evapotranspiration rates (Fig. 1).

Canopy conductance and water use efficiencs clearly decreased with increasing values of vapour pressure deficit (Fig. 2b and c - miombo woodland in Zambia).

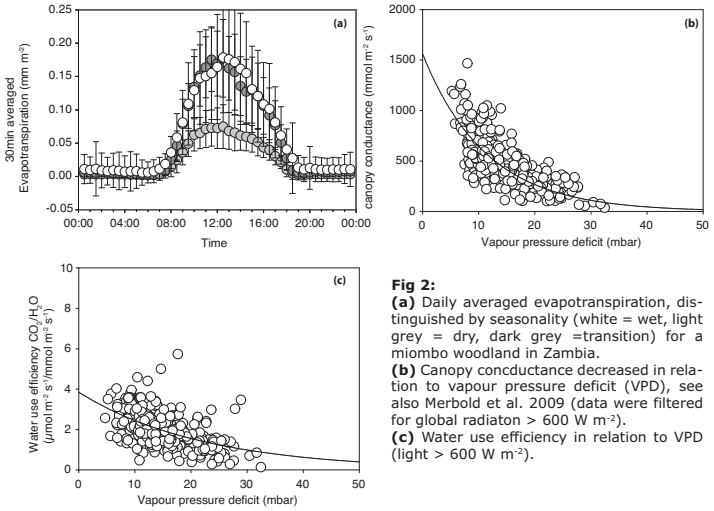

Fig 2:
(a) Daily averaged evapotranspiration, distinguished by seasonality (white = wet, light grey = dry, dark grey =transition) for a miombo woodland in Zambia.
(b) Canopy concductance decreased in relation to vapour pressure deficit (VPD), see also Merbold et al. 2009 (data were filtered for global radiaton > 600 W m^{-2}).
(c) Water use efficiency in relation to VPD (light > 600 W m^{-2}).

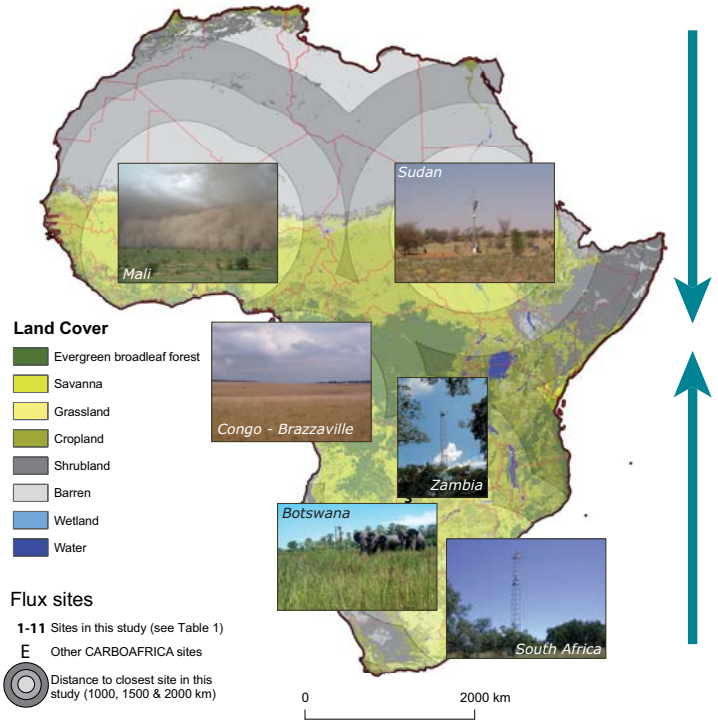

Fig 1: Research sites representing the major ecosystem types found in Sub-Saharan Africa along a precipitation gradient indicated by the blue arrows (300 - 1100mm).

Results (II)

Average daily evapotranspirative water losses are strongly correlated to daily averages of gross primary production across African ecosystems (Fig. 3a).

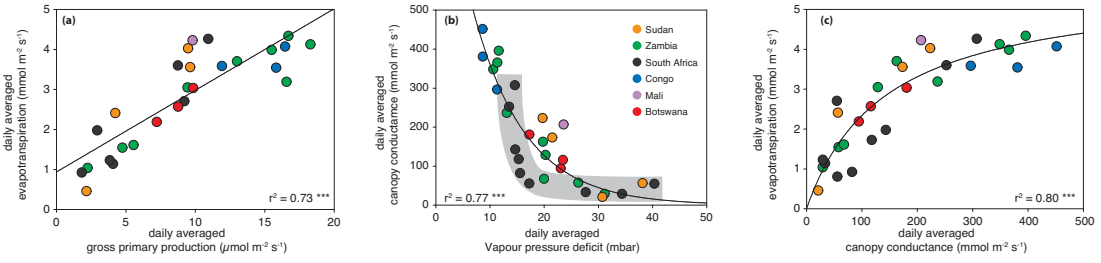

Fig 3: (a) Evapotranspiration in relation to gross primary production, **(b)** Decreasing evapotranspirative water losses in relation to canopy conductance and **(c)** evapotranspiration in relation to canopy conductance for 6 natural ecosystems in Sub-Saharan Africa. (sites are colour coded)

Similarly to findings from the site level, canopy conductance (gc) decreases with larger values of vapour pressure deficit (VPD) are visualized in Figure 3b. However, relationships found at the site level may vary largely from the across-site relation, e.g. the savanna ecosystem in Kruger NP, South Africa, shows a much stronger down-regulation of gc with increses in VPD (Fig 3b, grey highlighted area - no curve fit).

Strong stomatal control of ecosystem evapotranspirative water fluxes is shown in Figure 3c, where evapotranspirative water losses saturate at high gc, and decrease with low values of gc.

ETH Zurich
*corresponding author
Dr. Lutz Merbold
Grassland Sciences Group
Universitätsstr. 2
8092 Zurich
phone: +41 (0) 44 632 2518
email: merboldl@ethz.ch

Merbold L, J. Ardoe, A. Arneth, R.J.Scholes, Y. Nouvellon, A. de Grandcourt, S. Archibald, J.M Bonnefond, N. Boulain, N. Brueggemann, C. Bruemmer, B. Cappelaere, E. Ceschia, H.A.M El-Khidir, B.A. El-Tahir, U.Falk, L. Kergoatz, J. Lloyd, Valerie Le Dantec, E. Mougin, M. Muchinda, M. M. Mukelabai, D. Ramier, O. Roupsard, F. Timouk and W.L. Kutsch: Precipitation as driver of carbon fluxes in 11 African ecosystems (2009) Biogeosciences 6, 1027-1041 doi:10.5194/bg-6-1027-2009

Kutsch, W. L., Hanan, N., Scholes, B., McHugh, I., Kubheka, W., Eckhardt, H., and Williams, C.: Response of carbon fluxes to water relations in a savanna ecosystem in South Africa, Biogeosciences, 5, 1797-1808, doi:10.5194/bg-5-1797-2008, 2008

Williams CA, Hanan NP, Neff JC, Scholes RJ, Berry JA, Denning AS, Baker DF (2007) "Africa and the global carbon cycle", Carbon Balance and Management, 2:3, doi:10.1186/1750-0680-2-3.