Supplement of

Relative humidity gradients as a key constraint on terrestrial water and energy fluxes

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Detailed data processing

The sugar cane eddy-covariance tower site in Guanacaste, Costa Rica (10°25′07.60″N; 85°28′22.22″W) has a wet-dry tropical climate, with median monthly air temperature ranging from 27 °C to 30 °C at the nearest climate station in Santa Cruz, 25 km away from our study site, from 1996 to 2018. The dry season lasts from December to March (7 mm/month on average at the climate station in Santa Cruz) and the wet season from April to November (203 mm/month at the climate station in Santa Cruz). The Province of Guanacaste experienced significant drought in 2015 (Morillas et al., 2019), the first year of eddy-covariance observational data (1127 mm/year in 2015 at the study plot vs. 1652 mm/year long-term average at the climate station).

A ratooning practice is applied in growing sugarcane, a perennial plant. Ratooning refers to cutting most of the above-ground biomass when harvesting the crop, but leaving the roots intact to allow the sugarcane to regrow from the established roots. This ratooning is conducted once a year at the study site. About 5 years after initial planting, regrowth becomes less vigorous and the field is re-established (i.e., new sugarcane plants are planted). In the middle of 2016, a new planting was started in the flux tower footprint area. The growing season length at the site is about a full year, but it varies with regrowth times after the initial planting. Therefore, harvest timing varied from December to May during the study period. Crop canopy height varied from 0.01 m to 3.8 m above ground during each harvest cycle. Sugarcane was watered in the dry season via furrow irrigation events, with the exception of 2016 when there was no irrigation due to the replanting.

An eddy-covariance (EC) flux tower was installed 6 m above ground inside a sugarcane plot. The study plot is located in a homogenous landscape where about 200 km^2 around study site is devoted to sugarcane agriculture. The EC system included an open-path infrared gas analyzer (LI-7500A, LI-COR Biosciences, Lincoln, NE, USA) and a sonic anemometer (model 81000, R.M. Young, Traverse City, MI, USA). A soil heat flux plate (HFP01SC-L, Campbell Scientific, Logan, UT, USA) was installed 8 cm below ground, and two net radiometers (2015-2016: NR-LITE, Campbell Scientific, Logan, UT, USA; 2017-2018: SN-500, Apogee Instruments, Logan, UT, USA) were sequentially installed at 5.7 m height. For complementary meteorological measurements, two Vaisala WXT520 weather transmitters (Vaisala Inc. Helsinki, Finland) were installed at 3.6 m and 1.6 m heights. The 1.6 m height Vaisala transmitter was installed within the canopy next to the tower while the 3.6 m height Vaisala weather transmitter located about 25 m from the EC tower but sharing the same fetch with the EC system. The volumetric soil water content and soil temperature were measured at several depths at the site (GS3, Decagon Devices, Pullman, WA, USA); here we report only values at the 8 cm depth. Normalized difference vegetation index (NDVI) was also measured by proximal tower-mounted sensors (SRS, Decagon Devices) beginning in 2017. NDVI values presented for context in Fig. 4 (b), (c), and (d) were measured at the tower, while the NDVI value in Fig. 4 (a) was retrieved from Landsat7 as that time interval preceded installation of the proximal NDVI sensor.

High frequency raw EC data were processed and block averaged using EddyPro software (versions 6.0.0 to 6.2.1, LI-COR Biosciences, Lincoln, NE, USA). The processes includes double rotation coordinate correction (Wilczak et al., 2001), frequency response correction (Moncrieff et al., 1997), and density correction (Webb et al., 1980). Block averaged fluxes at 30-min intervals went through a quality control procedure from which fluxes were removed when any of the following conditions occurred, following Morillas et al. (2019): periods of heavy rain, low signal strength (signal strength < 60%), measurements flagged as low quality by the EddyPro software, or during conditions with low friction velocity (u_*) based on the moving point method (Papale et al., 2006;Wutzler et al., 2018). The resulting gaps in 30-min turbulent fluxes were gap-filled using the marginal distribution sampling method (Reichstein et al., 2005;Wutzler et al., 2018).

Vapour pressure (e_a) measured by the open-path infrared gas analyzer (IRGA) was used to calculate rh_a. To ensure data quality of e_a, data were also filtered out when any of the following conditions occurred: periods of heavy rain, low signal strength (signal strength <60%), measurements flagged as low quality by the EddyPro software, and unrealistic values recorded by the IRGA compared to Vaisala measurements (more than 20% difference when calculating relative humidity). The resulting IRGA gaps in the e_a time series were replaced by the corresponding measurements made using the Vaisala sensor at the 3.6 m height.

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Supplement figures

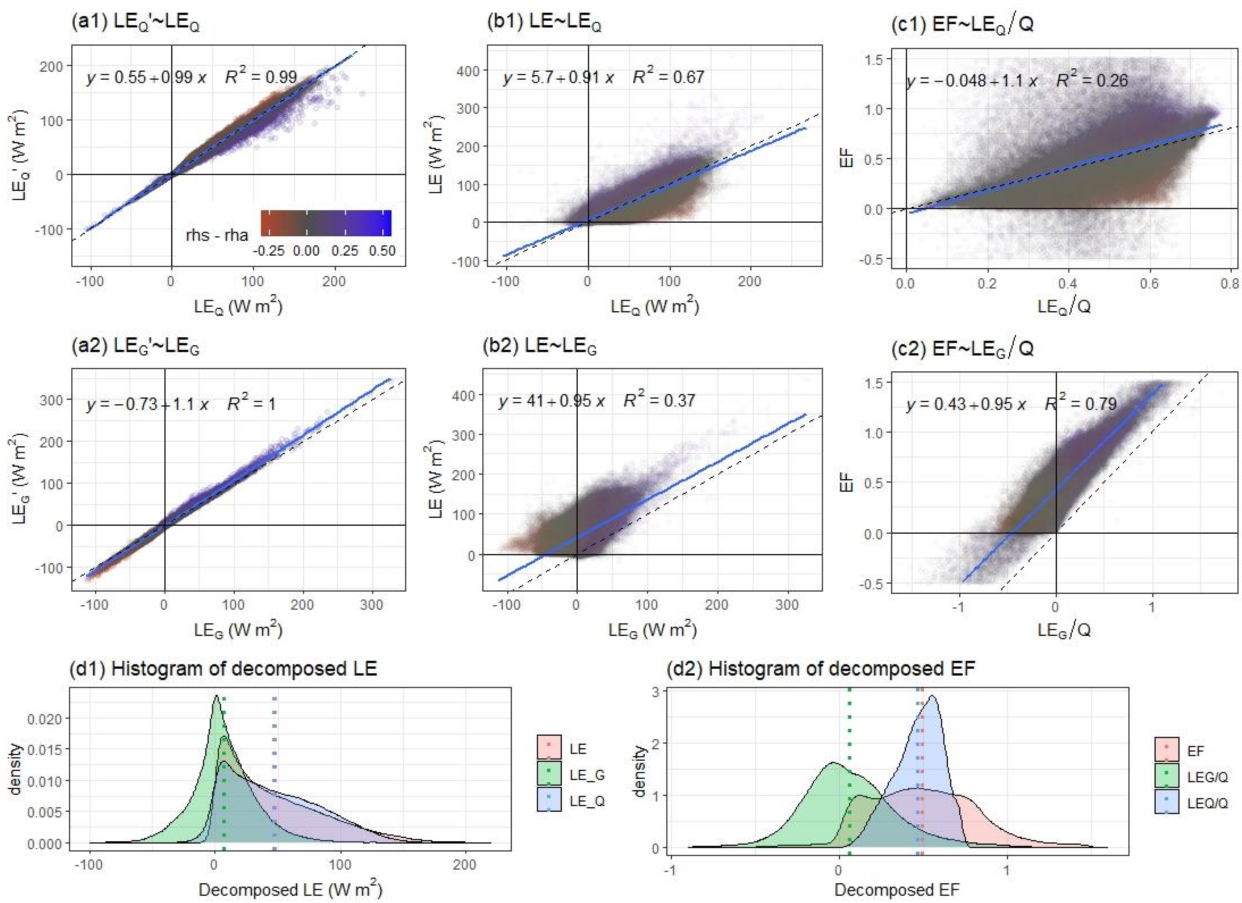

Figure S1: FLUXNET2015 daily *LE*, LE_Q, and LE_G (energy balance corrected). Panels (a1) and (a2) are linear regressions of LE_Q' on LE_Q and LE_G' on LE_G. Panels (b1) and (b2) are linear regressions of *LE* on LE_Q and *LE* on LE_G. Panels (c1) and (c2) are linear regressions of EF on LE_Q/Q and *LE* on LE_G/Q. Here, dashed lines are one-to-one lines, blue lines are regression lines, and color represent $rh_s - rh_a$. Panel (d1) and (d2) are histograms of decomposed *LE* and EF with mean values (dotted line).