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*Supplement of*

# Dynamics and environmental drivers of methane and nitrous oxide fluxes at the soil and ecosystem levels in a wet tropical forest

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**Table S1.** Results of the Kolmogorov-Smirnov tests comparing $CH_4$ and $N_2O$ flux distributions at ecosystem and upland-soil level between wettest and driest seasons. Significant terms at p level < 0.05 are shown in bold. Corresponding data are presented in Figure 3.

| | **$CH_4$** | | **$N_2O$** | |
|---|---|---|---|---|
| | **Alternative hypothesis** | **p value** | **Alternative hypothesis** | **p value** |
| | | **Ecosystem fluxes** | | |
| **Driest vs. Wettest** | Greater | **< 0.001** | Less | 0.051 |
| | | **Upland soil fluxes** | | |
| **Driest vs. Wettest** | Greater | **< 0.001** | Greater | **< 0.001** |

**Table S2.** Fluxes from Table 1 transformed into the most commonly used units in the literature for data contextualisation. Means, standard deviations (SD) and medians of ecosystem and upland soil $CH_4$ and $N_2O$ fluxes per season (wettest and driest) in the Guyaflux tropical forest, French Guiana.

Conversion factors: from $nmolCH_4$ to $mgCH_4$ x $1.604 \times 10^{-5}$, from $nmolN_2O$ to $mgN_2O$ x $4.4013 \times 10^{-5}$.

| | Ecosystem flux | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Wettest | | | Driest | | | Global average | | |
| **Fluxes** | **Mean** | **SD** | **Median** | **Mean** | **SD** | **Median** | **Mean** | **SD** | **Median** |
| | **nmol $m^{-2}$ $s^{-1}$** | | | | | | | | |
| **$CH_4$** | 4.9 | 11.2 | 3.5 | -1.6 | 6.4 | -1.7 | 2.5 | 9.8 | 2.0 |
| **$N_2O$** | 0.6 | 1.0 | 0.5 | 0.5 | 1.3 | 0.7 | 0.7 | 1.3 | 0.5 |
| | **mg $m^{-2}$ $day^{-1}$** | | | | | | | | |
| **$CH_4$** | 6.7 | 15.6 | 4.8 | -2.2 | 8.9 | -2.4 | 3.5 | 13.6 | 2.7 |
| **$N_2O$** | 0.8 | 1.5 | 0.7 | 0.7 | 1.8 | 1.0 | 0.9 | 1.8 | 0.7 |
| | **kg $ha^{-1}$ $yr^{-1}$** | | | | | | | | |
| **$CH_4$** | 24.6 | 56.4 | 17.8 | -8.2 | 32.5 | -9.0 | 12.8 | 49.7 | 9.9 |
| **$N_2O$** | 2.9 | 5.3 | 2.4 | 2.7 | 6.4 | 3.7 | 3.3 | 6.6 | 2.7 |
| | **Upland soil flux** | | | | | | | | |
| | **nmol $m^{-2}$ $s^{-1}$** | | | | | | | | |
| **$CH_4$** | -0.4 | 0.9 | -0.6 | -1.4 | 1.2 | -1.8 | -0.7 | 1.5 | -0.7 |
| **$N_2O$** | 0.3 | 0.3 | 0.3 | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 |
| | **mg $m^{-2}$ $day^{-1}$** | | | | | | | | |
| **$CH_4$** | -0.6 | 1.2 | -0.9 | -2.0 | 1.7 | -2.5 | -0.9 | 2.1 | -1.0 |
| **$N_2O$** | 0.4 | 0.4 | 0.4 | 0.3 | 0.4 | 0.2 | 0.4 | 0.4 | 0.4 |
| | **kg $ha^{-1}$ $yr^{-1}$** | | | | | | | | |
| **$CH_4$** | -2.2 | 4.4 | -3.2 | -7.1 | 6.1 | -9.2 | -3.3 | 7.6 | -3.8 |
| **$N_2O$** | 1.6 | 1.3 | 1.5 | 1.2 | 1.6 | 0.8 | 1.6 | 1.4 | 1.4 |

**Table S3.** Results of generalised additive models (GAM) assessing the relationships between environmental variables, i.e. global radiation (Rg), soil water content (SWC), soil temperature (Ts), and 1st - 99th percentile range of daily mean ecosystem and upland soil $CH_4$ and $N_2O$ fluxes during the wettest and driest seasons from 17 May, 2016 to 2 August, 2018 in the Guyaflux tropical forest, French Guiana. The effective degrees of freedom (edf) and the reference number of degrees of freedom (Ref. df) of the fitted models, with values for each spline term, are shown. Significant terms at p level < 0.05 are shown in bold. See Figure S6 for the 1st - 99th percentile range of data.

| | Fluxes | Best model predictors | $R^2$ | Intercept | Coefficients | | F value | p value |
|---|---|---|---|---|---|---|---|---|
| | | | | | edf | Ref. df | | |
| **Ecosystem level** | | | | | | | | |
| Daily | $CH_4$ | | 0.15 | 2.613 | | | | |
| | | Rg: Wettest | | | 1.2 | 9 | 1.00 | **0.001** |
| | | Rg: Driest | | | 0.6 | 8 | 0.19 | 0.113 |
| | | Ts: Wettest | | | 0.9 | 9 | 0.14 | 0.226 |
| | | Ts: Driest | | | 0.0 | 8 | 0.00 | 0.955 |
| | | SWC: Wettest | | | 1.2 | 9 | 0.71 | **0.006** |
| | | SWC: Driest | | | 0.7 | 6 | 0.36 | 0.079 |
| Daily | $N_2O$ | | 0.03 | 0.933 | | | | |
| | | Rg: Wettest | | | 0.8 | 9 | 0.43 | **0.024** |
| | | Rg: Driest | | | 0.4 | 8 | 0.09 | 0.193 |
| | | Ts: Wettest | | | 0.3 | 9 | 0.04 | 0.251 |
| | | Ts: Driest | | | 0.0 | 9 | 0.00 | 0.892 |
| | | SWC: Wettest | | | 2.2 | 9 | 0.90 | **0.012** |
| | | SWC: Driest | | | 0.0 | 6 | 0.01 | 0.306 |
| **Upland soil level** | | | | | | | | |
| Daily | $CH_4$ | | 0.20 | -0.760 | | | | |
| | | Rg: Wettest | | | 0.0 | 9 | 0.00 | 1.000 |
| | | Rg: Driest | | | 1.2 | 8 | 0.81 | **0.006** |
| | | Ts: Wettest | | | 0.0 | 9 | 0.00 | 0.427 |
| | | Ts: Driest | | | 0.0 | 8 | 0.01 | 0.287 |
| | | SWC: Wettest | | | 1.2 | 9 | 5.14 | **< 0.001** |
| | | SWC: Driest | | | 1.5 | 7 | 1.56 | **< 0.001** |
| Daily | $N_2O$ | | 0.05 | 0.310 | | | | |
| | | Rg: Wettest | | | 0.2 | 9 | 0.02 | 0.293 |
| | | Rg: Driest | | | 0.9 | 7 | 1.42 | **0.001** |
| | | Ts: Wettest | | | 0.0 | 9 | 0.00 | 1.000 |
| | | Ts: Driest | | | 0.6 | 7 | 0.20 | 0.123 |
| | | SWC: Wettest | | | 0.0 | 9 | 0.00 | 0.721 |
| | | SWC: Driest | | | 0.0 | 6 | 0.00 | 0.539 |

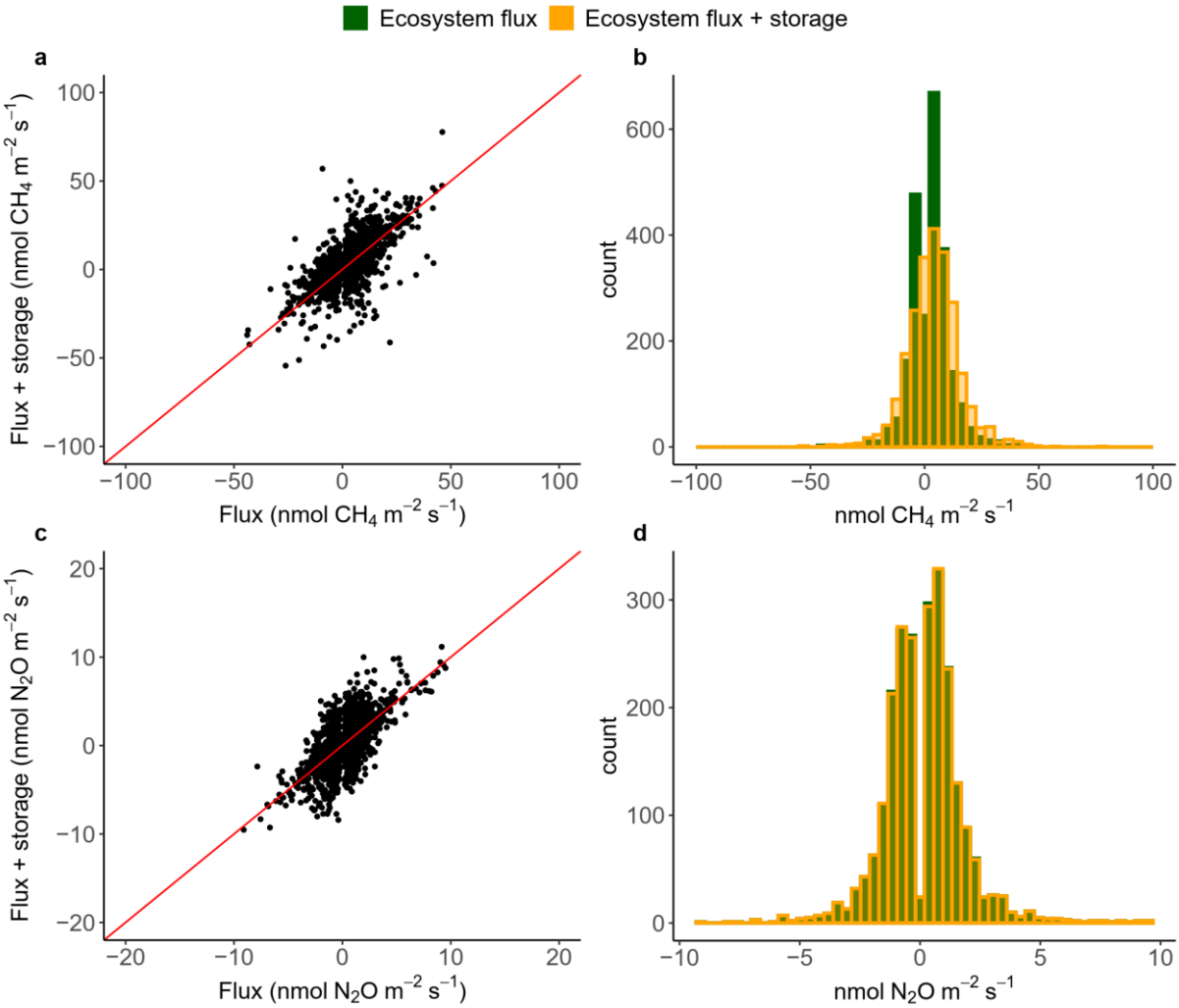


**Figure S1.** Relationships between the half-hourly fluxes of (a) $CH_4$ and (c) $N_2O$, as measured by the eddy covariance technique, and the same fluxes corrected by the storage term (i.e. the accumulation of $CH_4$ and $N_2O$ within the forest canopy at night when Rg < 5 W $m^{-2}$).The line represents the 1:1 relationship. Corresponding density plots of corrected and non-corrected half-hour fluxes of (b) $CH_4$ and (d) $N_2O$. Data from the Guyaflux tower from 1 January, 2017 to 11 January, 2018, French Guiana.

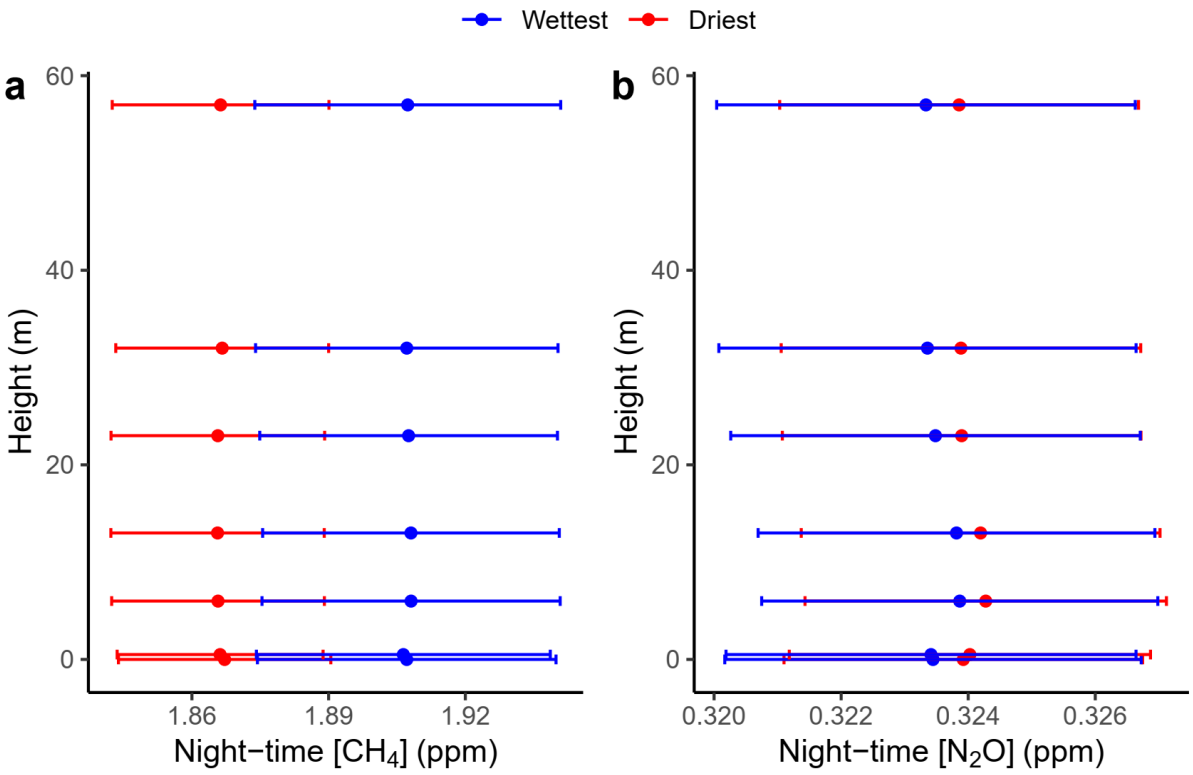


**Figure S2.** Night-time (Rg < 5 W $m^{-2}$) averaged vertical profiles for (a) [$CH_4$] and (b) [$N_2O$] measured on an upland forest near the Guyaflux tower for the wettest (blue) and driest (red) seasons from 1 January, 2017 and 11 January, 2018, French Guiana.

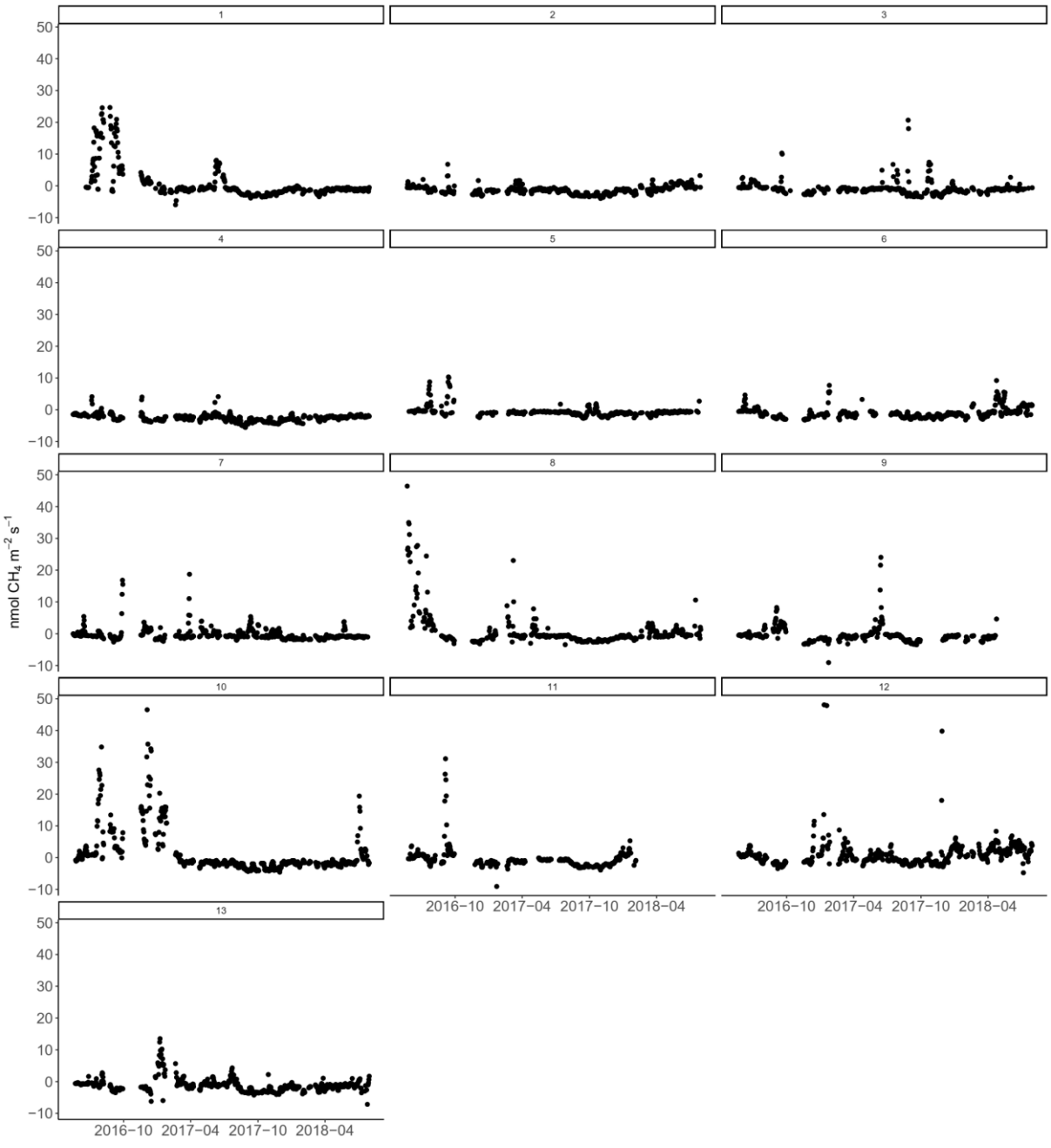


**Figure S3.** Average daily upland soil $CH_4$ fluxes per soil chamber (1 to 13) from 17 May, 2016 to 2 August, 2018 in the Guyaflux tropical forest, French Guiana. Fluxes were estimated with a 2-min and 25-min closure time (see Sect. 2.5, "Chamber-based $CH_4$ and $N_2O$ flux computation", for more details). All panels have the same limits on the y-axis.

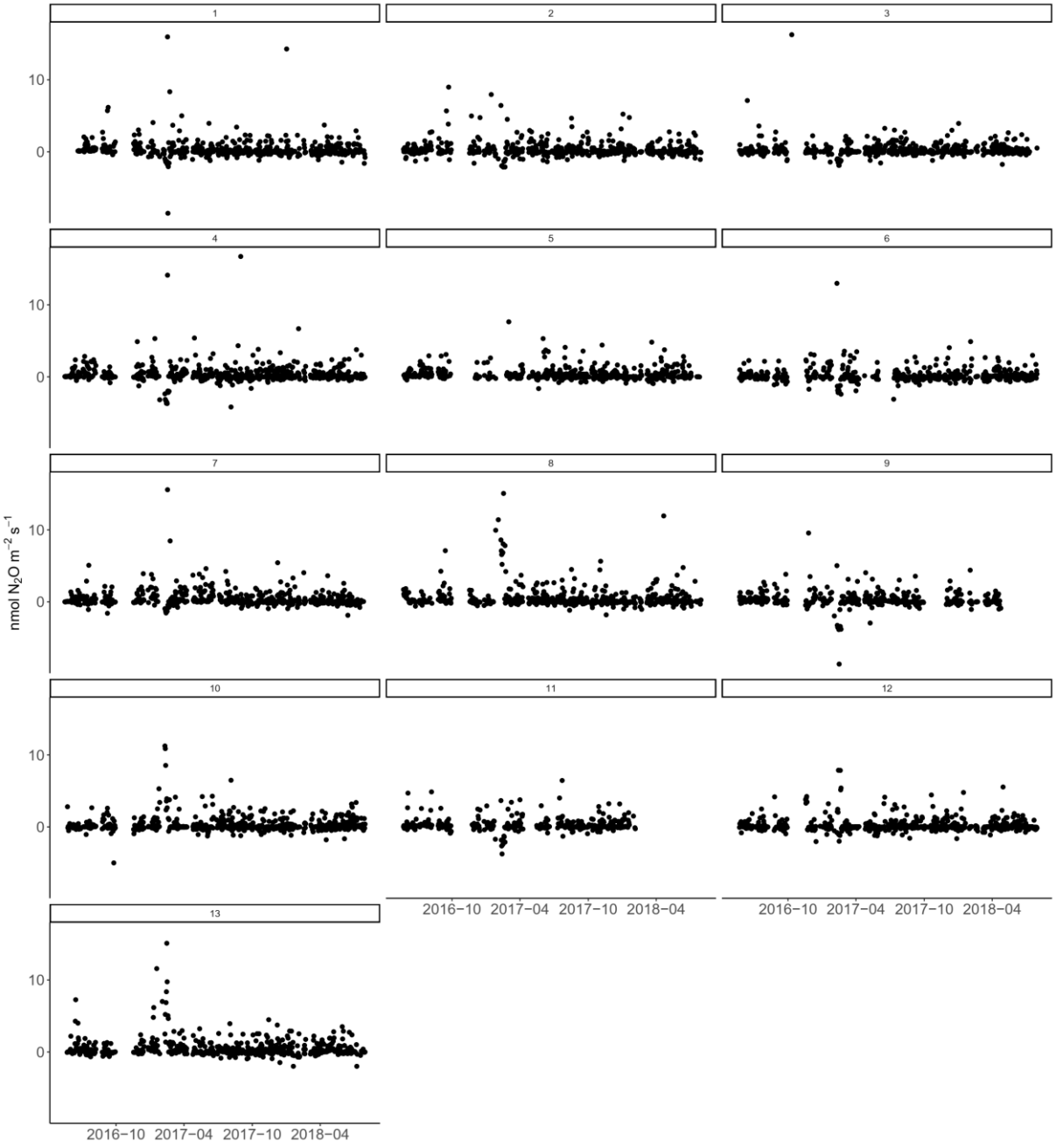


**Figure S4.** Average daily upland soil $N_2O$ fluxes per soil chamber (1 to 13) from 17 May, 2016 to 2 August, 2018 in the Guyaflux tropical forest, French Guiana. Fluxes were estimated with a 2-min and 25-min closure time (see Sect. 2.5, "Chamber-based $CH_4$ and $N_2O$ flux computation", for more details). All panels have the same limits on the y-axis.

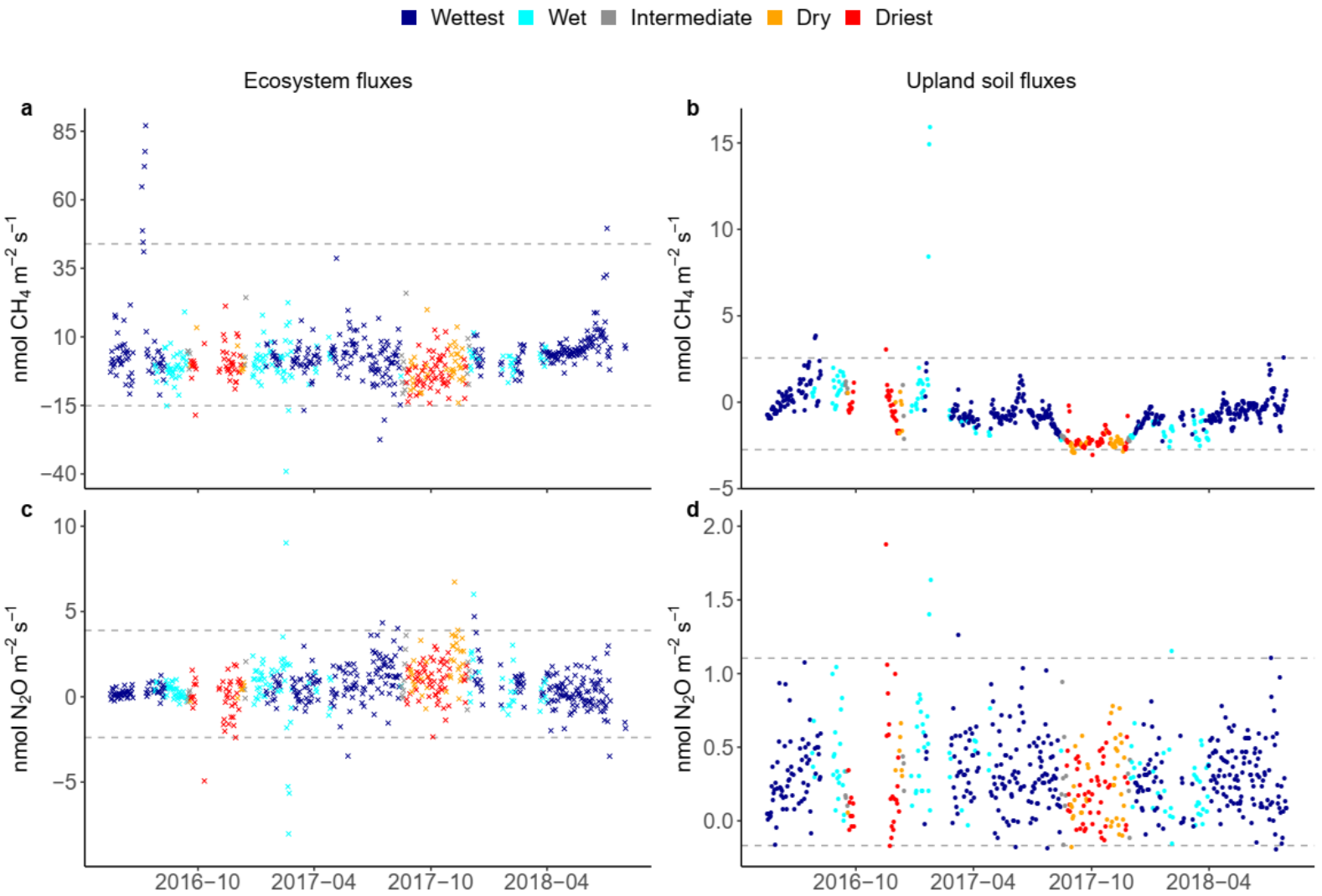


**Figure S5.** Seasonal courses of the raw average daily a) ecosystem and b) soil fluxes for $CH_4$ (top panels) and $N_2O$ (bottom panels) for the full datasets from 17 May, 2016 to 2 August, 2018 in the Guyaflux tropical forest, French Guiana. The 1st - 99th percentile ranges of the flux values are represented by the horizontal dashed lines. Colours illustrate the wet, intermediate, and dry seasons, and for two contrasted seasons, defined as the wettest (dark blue dots) and the driest (red dots). Note that the scale of the y-axis has been adjusted for each gas and compartment to improve clarity.

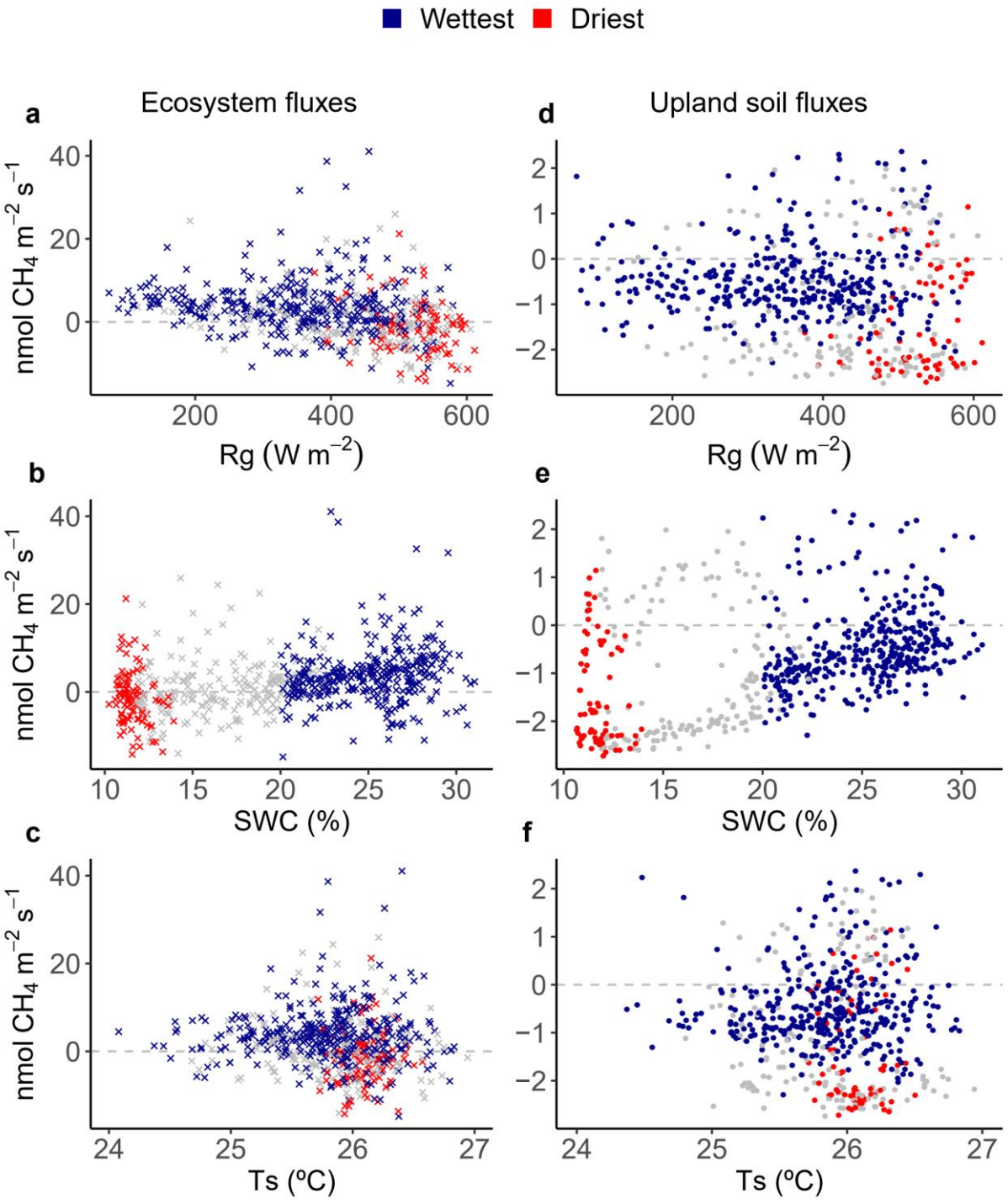


**Figure S6.** Relationships between environmental drivers (global radiation (Rg), soil water content (SWC) and soil temperature (Ts)) and daily average ecosystem (crosses on the left) and upland soil (solid dots on the right) $CH_4$ fluxes for the wettest (blue) and driest (red) seasons, with remaining data in grey, from 17 May, 2016 to 2 August, 2018 in the Guyaflux tropical forest, French Guiana. Positive fluxes above the horizontal "0" line indicate $CH_4$ emissions and negative fluxes below the horizontal "0" line indicate $CH_4$ uptake. Comparable relationships with the full range of $CH_4$ data are shown in Fig. 4.

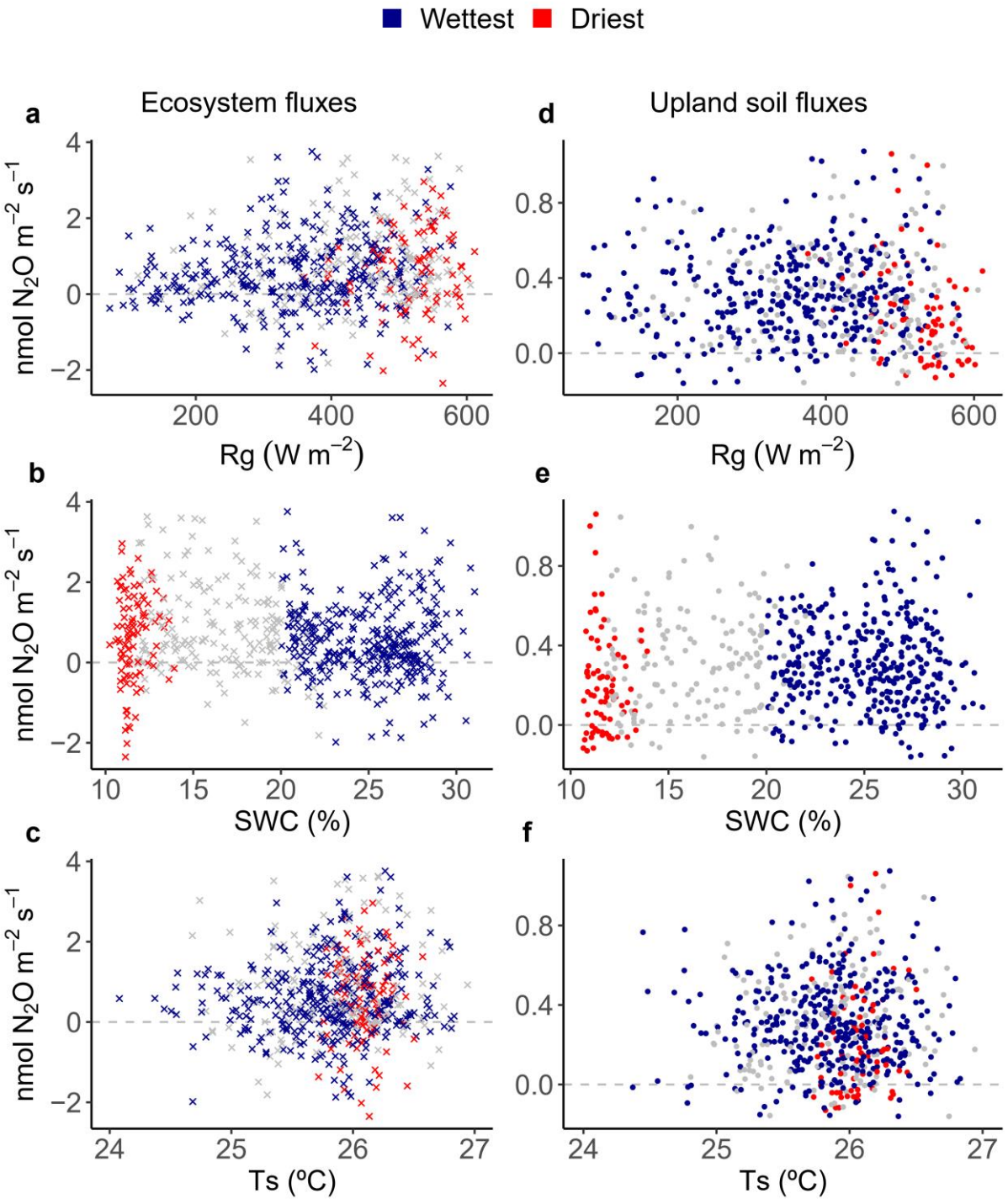


**Figure S7.** Relationships between environmental drivers (global radiation (Rg), soil water content (SWC) and soil temperature (Ts)) and daily average ecosystem (crosses on the left) and upland soil (solid dots on the right) $N_2O$ fluxes for the wettest (blue) and driest (red) seasons, with remaining data in grey, from 17 May, 2016 to 2 August, 2018 in the Guyaflux tropical forest, French Guiana. Positive fluxes above the horizontal "0" line indicate $N_2O$ emissions and negative fluxes below the horizontal "0" line indicate $N_2O$ uptake. Comparable relationships with the full range of $N_2O$ data are shown in Fig. 5.

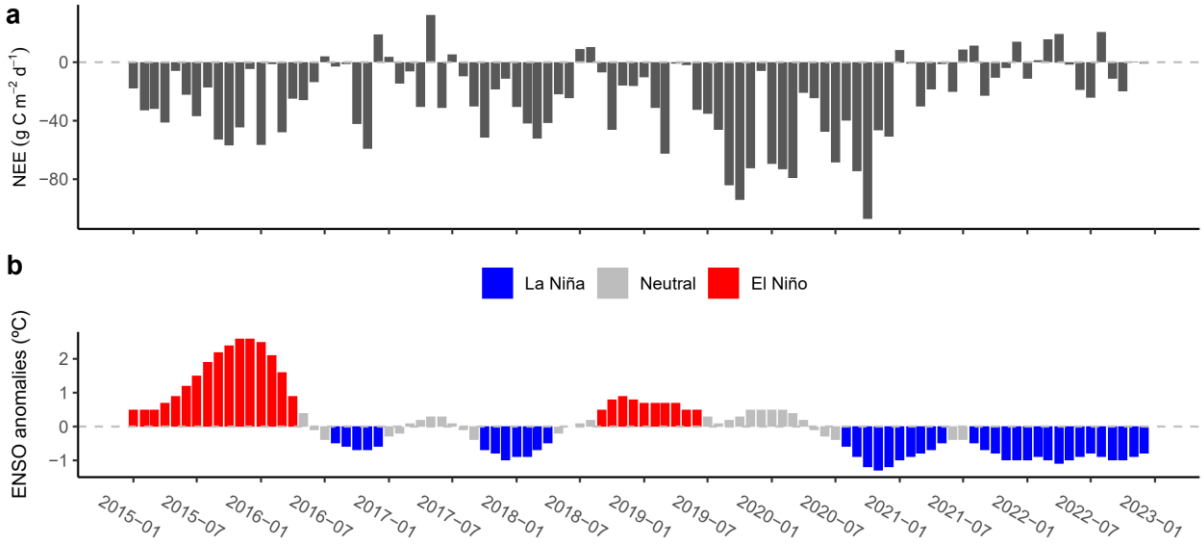


**Figure S8.** (a) Monthly accumulated net ecosystem exchange (NEE) and (b) El Niño-Southern Oscillation Event (ENSO) anomalies: cold (blue, known as La Niña) and warm (red, known as El Niño) periods based on a threshold of +/- 0.5°C for the Oceanic Niño Index (https://origin.cpc.ncep.noaa.gov).