

1 Supplementary data for “Enhancing the representation
2 of African vegetation in the JULES land surface model
3 through trait-informed parameterisation” by Akhabue et
4 al.

5 LMA and Nmass in the JULES photosynthesis and respiration formulation

6 In the JULES trait-based physiology scheme, leaf nitrogen content per unit mass (Nmass) and
7 leaf mass per area (LMA) are used to estimate area-based leaf nitrogen:

8
$$N_{area} = N_{mass} \times LMA \text{ ----- (Eq. S1)}$$

9 Area-based leaf nitrogen is then used to estimate the maximum rate of Rubisco
10 carboxylation at 25 °C (V_{cmax25}):

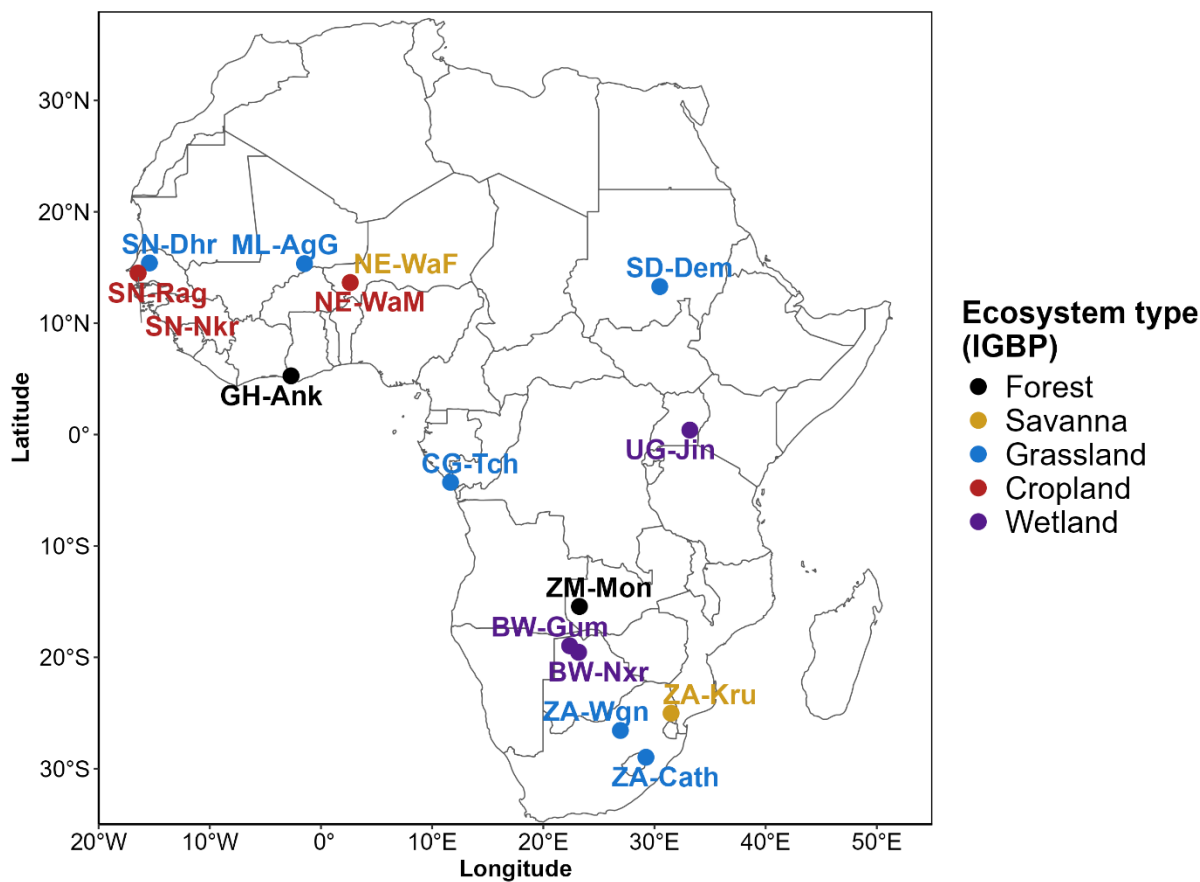
11
$$V_{cmax25} = v_{int} + v_{sl} \times N_{area} \text{ ----- (Eq. S2)}$$

12 V_{cmax25} has units $\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$

13 where v_{int} and v_{sl} are PFT-dependent parameters representing the intercept and slope of
14 the V_{cmax} –leaf nitrogen relationship. In this study, Nmass and LMA were updated using
15 African trait-derived PFT medians, while v_{int} , v_{sl} and other PFT-dependent photosynthetic
16 parameters were retained from the baseline JULES configuration.

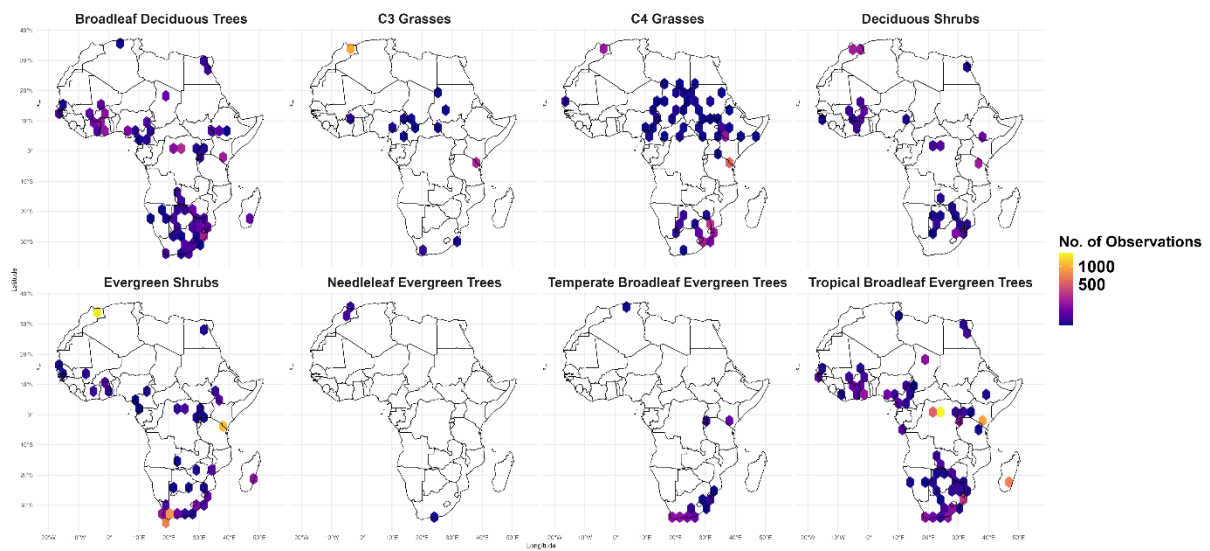
17

18 Site distribution



19
20 Figure S1. Location and ecosystem classification of the 16 African flux-tower sites used in this
21 study. Sites are coloured according to ecosystem type based on the International
22 Geosphere-Biosphere Programme (IGBP) classification.

23 Plant functional types and trait distribution



24

25 Figure S2. Sampling is uneven across space and PFTs, reflecting biogeography and
26 historical sampling biases.

Trait distribution across MAP-MAT space

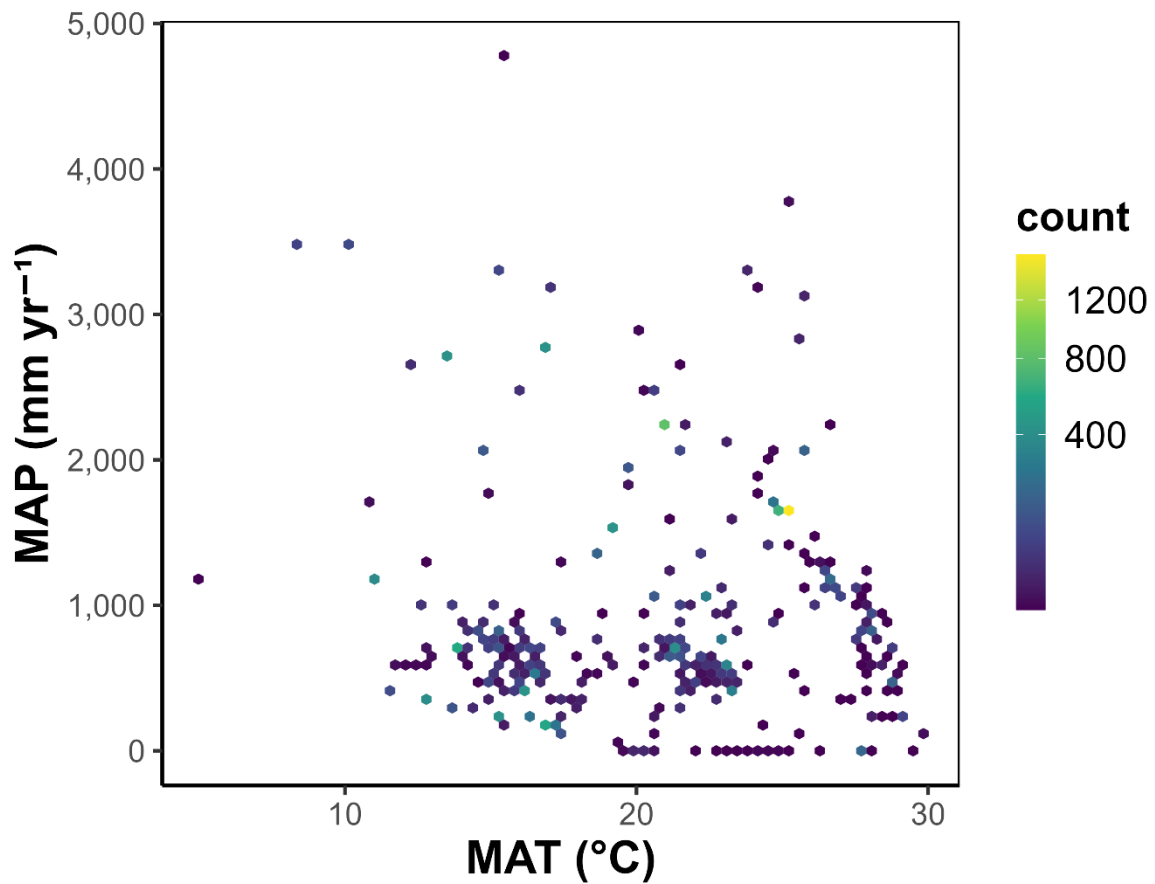
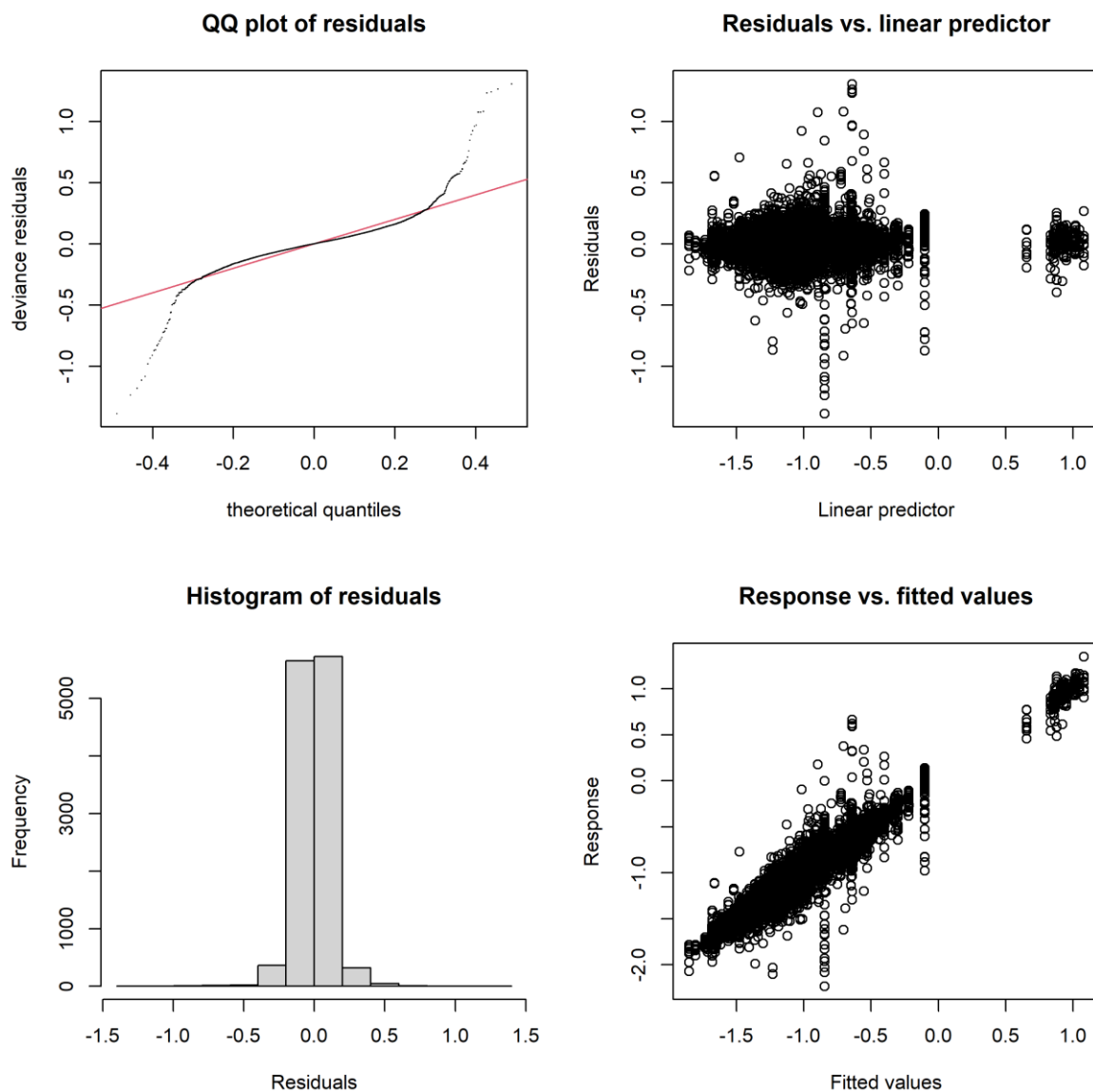
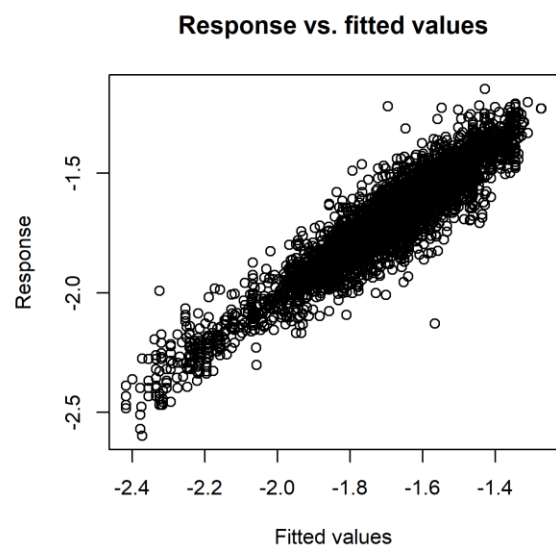
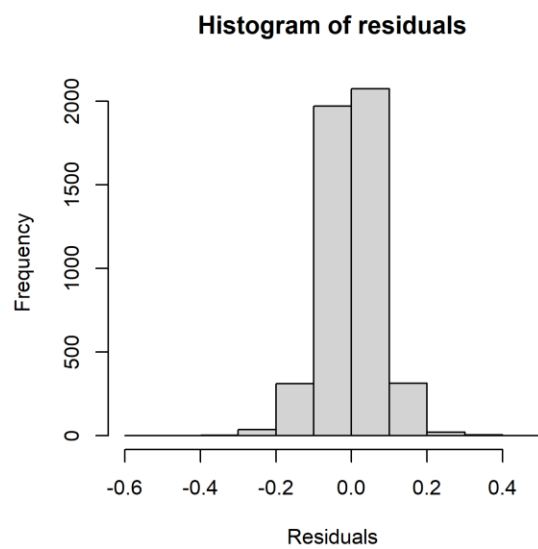
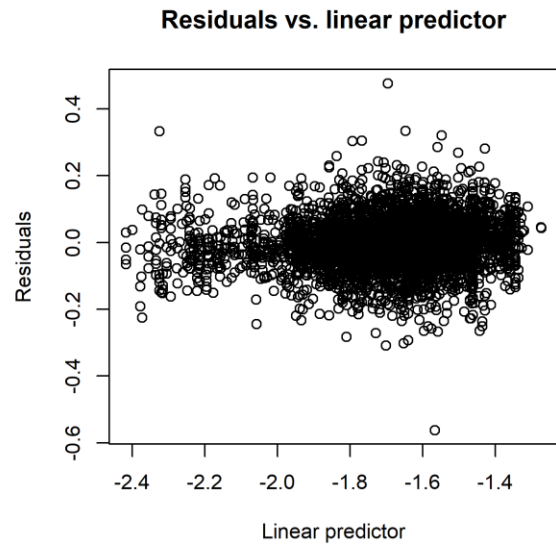
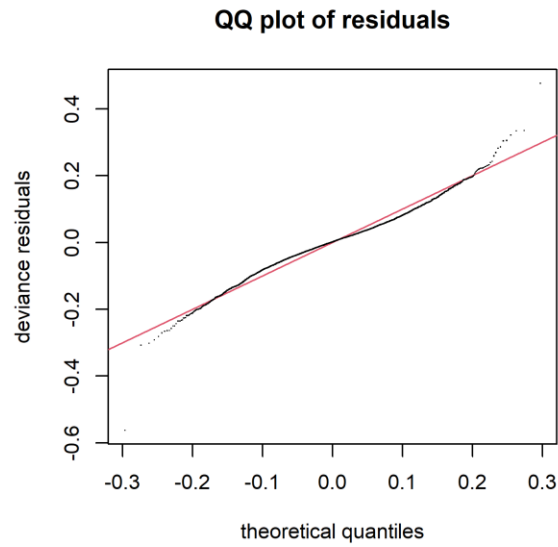


Figure S3. Trait observations occupy a broad but uneven climate envelope, with strong clustering in warm and moderately dry conditions. The distribution of observations in mean annual temperature (MAT, °C) and mean annual precipitation (MAP, mm yr⁻¹) space spans approximately 5–30 °C and 0–5000 mm yr⁻¹. Colour intensity indicates the number of observations per bin, highlighting a concentration in warm (15–25 °C) and moderately dry (~300–1000 mm yr⁻¹) climates, with comparatively sparse coverage in very wet (> 3000 mm yr⁻¹) and cooler (< 10 °C) regions.





42

43 Figure S5. Model diagnostic plots for the GAMM for Nmass

Table S1. GAMM summary table for LMA. Approximate significance of smooth terms: The joint climate smooth was highly significant, indicating that LMA varied systematically across the combined MAT–MAP–aridity climate space. The significant species random-effect smooth indicates substantial additional variation among species after accounting for climate.

term	edf	Ref.df	F	p-value
te(mat_c,map_mm,ai)	118.0	131.9	98.81	< 2e-06 ***
s(species_name)	764.9	849.0	32.83	< 2e-06 ***

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
R-sq.(adj) = 0.899, Deviance explained = 90.6%, n = 12170

Table S2. GAMM diagnostics check for LMA. The k-index for the MAT–MAP–aridity tensor smooth was close to 1 (1.02; $p = 0.76$), providing no evidence that the chosen basis dimension was insufficient. The k-index test is not applicable to the species random-effect smooth.

	k'	edf	k-index	p-value
te(mat_c,map_mm,ai)	511	118	1.02	0.76
s(species_name)	850	765	NA	NA

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S3. GAMM summary table for Nmass. Approximate significance of smooth terms: The joint MAT–MAP–aridity smooth was highly significant ($p < 2 \times 10^{-6}$), indicating systematic variation in Nmass across climate space. The significant species random-effect smooth indicates substantial additional variation among species after accounting for climate.

term	edf	Ref.df	F	p-value
te(mat_c,map_mm,ai)	111.7	125.5	8.939	< 2e-06 ***
s(species_name)	692.0	791.0	13.087	< 2e-06 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
R-sq.(adj) = 0.845, Deviance explained = 87.2%, n = 4735

Table S4. GAMM diagnostics check for Nmass. The k-index for the MAT–MAP–aridity tensor smooth was close to 1 (0.98; $p = 0.075$), providing no clear evidence that the chosen basis dimension was inadequate. The k-index test is not applicable to the species random-effect smooth.

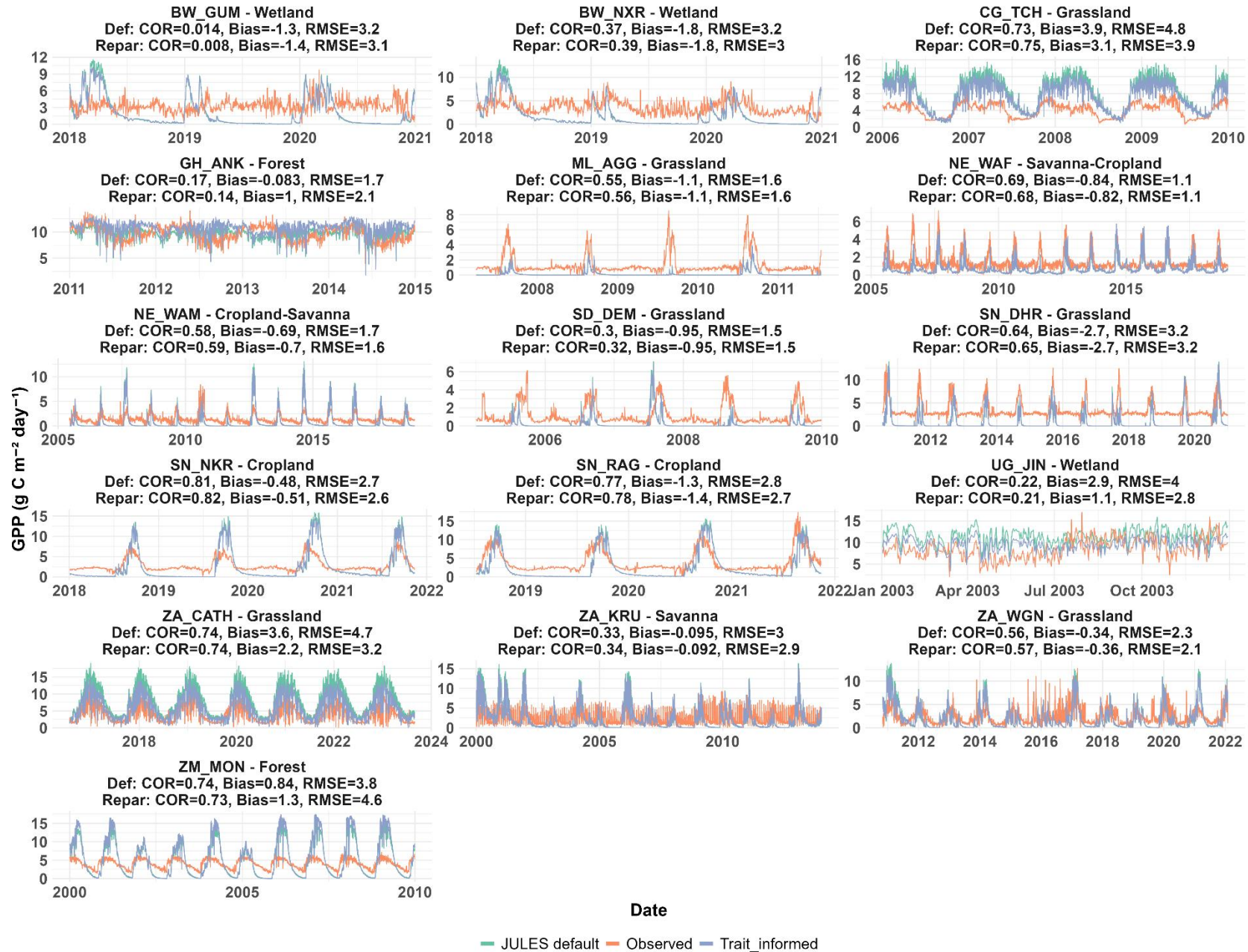
	k'	edf	k-index	p-value
te(mat_c,map_mm,ai)	511	112	0.98	0.075 .
s(species_name)	792	692	NA	NA

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

68 JULES simulation analysis

69 Table S5. Default and African trait-informed LMA, Nmass, derived Narea and implied
70 Vcmax25 for JULES PFTs. LMA = kg m⁻²; Nmass = g g⁻¹; Narea = g N m⁻²; Vcmax25 = μmol m⁻²
71 s⁻¹.

PFT	Default LMA	African TRY- derived LMA	Default Nmass	African TRY- derived Nmass	Default Narea	African TRY- derived Narea	Default Vcmax ₂₅	African TRY- derived Vcmax ₂₅
BET-Tr	0.1039	0.0898	0.017	0.025	1.7663	2.2459	41.1583	50.3753
BET-Te	0.1403	0.1069	0.0144	0.015	2.0203	1.6272	61.2771	50.1119
BDT	0.0823	0.0965	0.021	0.024	1.7283	2.2844	57.2506	73.8272
C3	0.0498	0.0724	0.0219	0.024	1.0906	1.7484	51.0918	78.0356
C4	0.137	0.0569	0.0113	0.017	1.5481	0.9678	31.7051	19.8215
ESH	0.1515	0.1306	0.0136	0.011	2.0604	1.4886	62.4083	49.1703
DSH	0.055	0.0702	0.0238	0.026	1.309	1.8248	45.0134	56.9533



74 Figure S6. Time series comparison of observed and simulated gross primary productivity (GPP) at the 16 African flux tower sites under
75 the default and reparameterized JULES configurations.