Supplement of Geosci. Model Dev., 15, 7809–7833, 2022
https://doi.org/10.5194/gmd-15-7809-2022-supplement

Geoscientific Model Development
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Supplement of

Forest fluxes and mortality response to drought: model description (ORCHIDEE-CAN-NHA r7236) and evaluation at the Caxiuanã drought experiment

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Table S1 Model performance of transpiration evaluated by R (correlation), RMSE (root mean square error, mm day^{-1}), and MAPE (mean absolute percentage error) against observed transpiration.

	TFE			CTL		
	R	RMSE	MAPE	R	RMSE	MAPE
ORCHIDEE-CAN	0.60	0.95	0.46	0.75	0.49	0.14
ORCHIDEE-CAN-RS	0.49	0.90	0.44	0.71	0.54	0.16
ORCHIDEE-CAN-NHA	0.48	0.74	0.35	0.76	0.79	0.24

Table S2 Comparison of modelled GPP from 2001 to 2003. Since SPA-GPP is based on model simulation as well, here we just compare the magnitude of GPP, without using correlation and other errors metrics.

Unit: gC m^{-2} day^{-1}	CTL		TFE	
	Wet	Dry	Wet	Dry
SPA	8.1	8.0	7.8	7.0
ORCHIDEE-CAN	7.6	9.4	6.9	7.3
ORCHIDEE-CAN-RS	8.0	9.3	7.5	7.5
ORCHIDEE-CAN-NHA	6.2	7.3	6.0	6.3

Table S3 Model performance in simulation of biomass loss. Here the values in the table refer to relative change to the beginning of the experiment (2001).

	CTL	TFE
Observation	+1%	-12.1%
ORCHIDEE-CAN	+0.6%	-1.1%
ORCHIDEE-CAN-RS	+0.6%	-0.8%
ORCHIDEE-CAN-NHA	-0.7%	-19%

Table S4 Tree height and diameter of each cohort (take CTL as example).

# of cohort	tree diameter (m)	tree height (m)
1	0.02	6
2	0.03	8
3	0.18	18
4	0.32	23
5	0.46	27
6	0.60	31
7	0.73	34
8	0.87	37
9	1.00	40
10	1.14	42
11	1.28	44
12	1.42	46
13	1.56	49
14	1.71	51
15	1.85	53
16	2.01	55
17	2.18	57
18	2.38	59
19	2.63	62
20	3.06	67

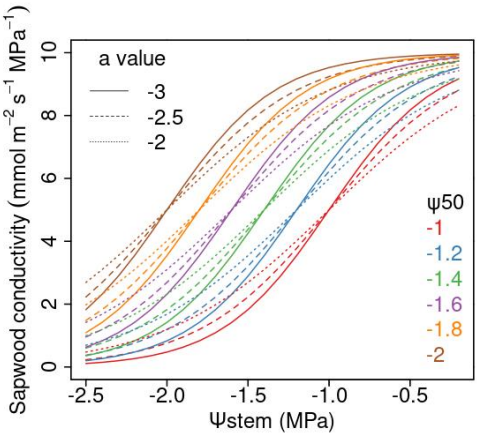

Figure S1Sigmoidal relationship between stem sapwood conductance (normalized by total leaf area) and stem water potential. Line colors correspond to different Ψ_{50} values. The line types (continuous, dashed and dotted line) denote different curvature parameters (a_{stem}).

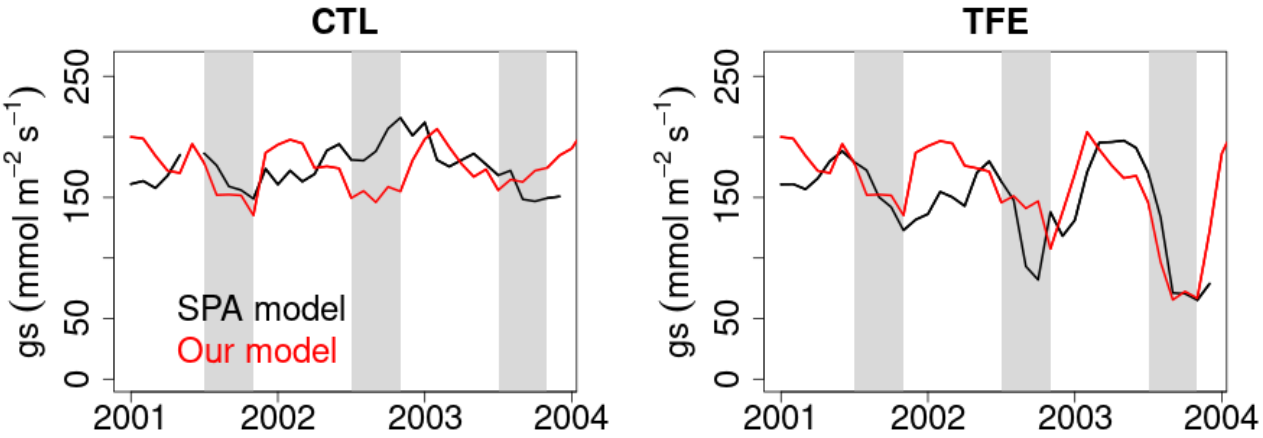

Figure S2 Comparison of our simulated stomatal conductance (gs) with SPA model output in Fisher et al (2007) at Caxiuana site. The gray bands indicate dry season from July to November. We use gs of cohort #10 in model output as an example here.

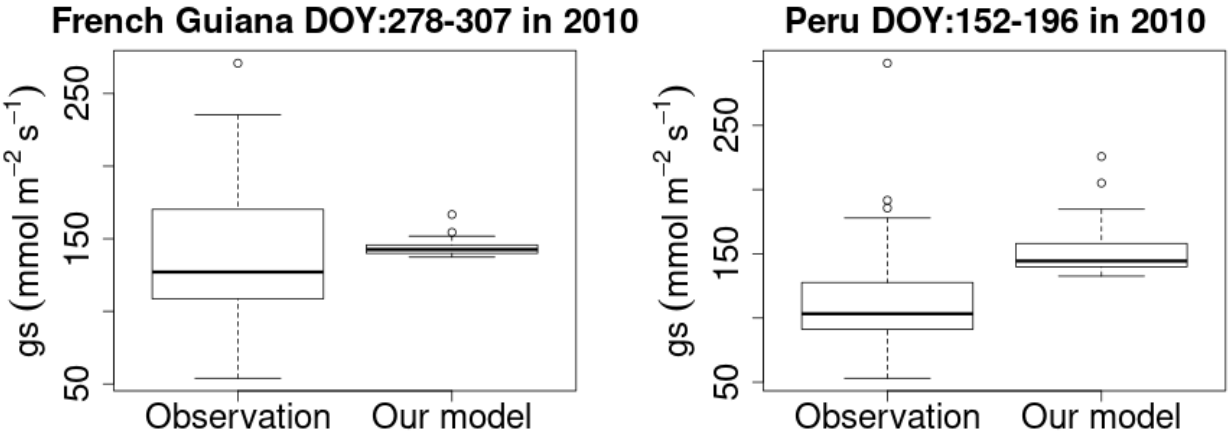

Figure S3 Comparison of our simulated stomatal conductance (gs) at (a) French Guiana and (b) Peru site. The gs

observation data at French Guiana and Peru site are from Lin et al (2015). We use gs of cohort #10 in model output as an example here.

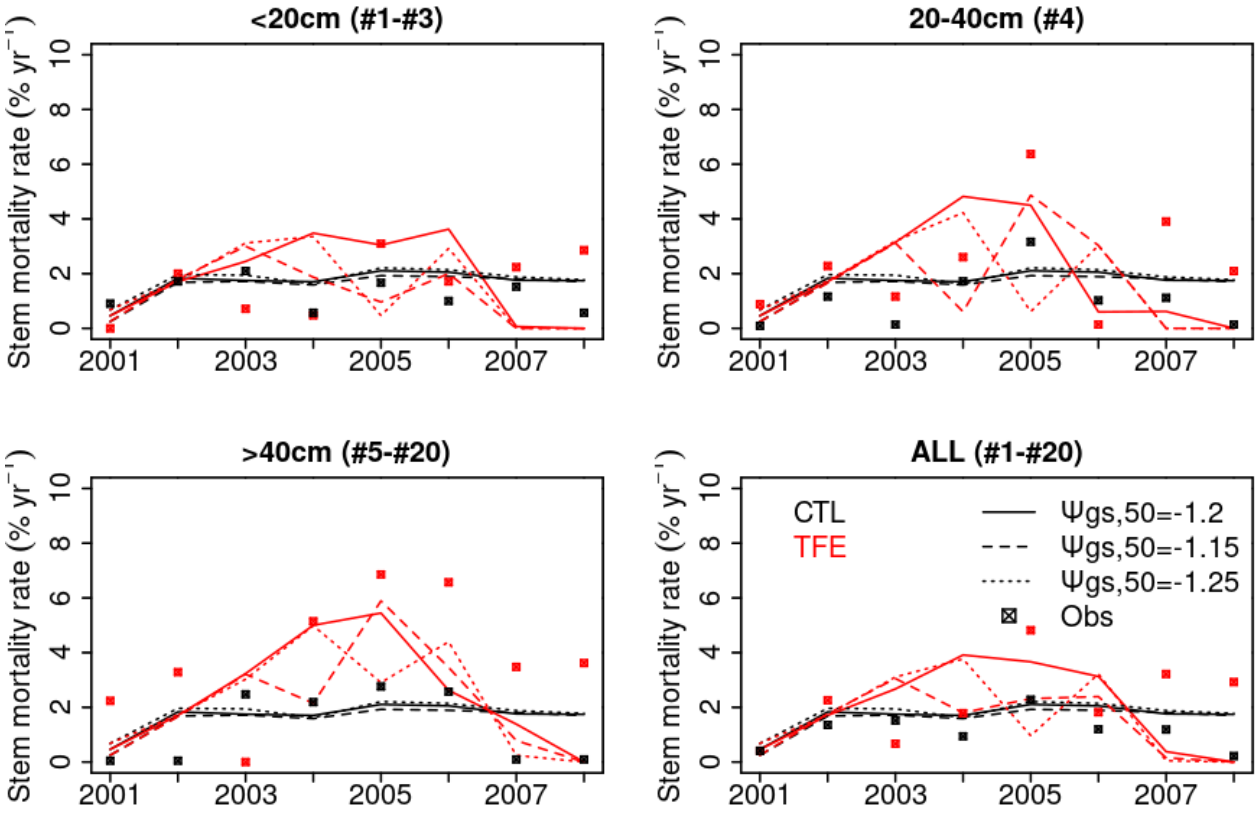

Figure S4 Modeled stem mortality rate with regard to different $\Psi gs_{,50}$ values. All 20 cohorts have been aggregated to three classes according to DBH (<20cm, 20-40cm, >40cm). The value in bracket in title of each panel corresponds to the No. of cohorts falling in the class.

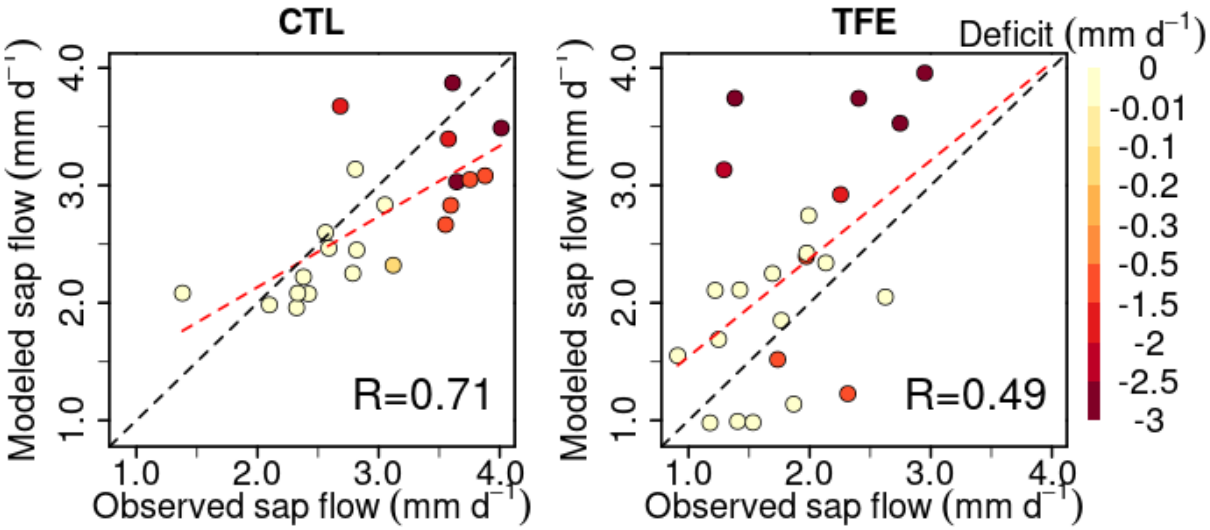

Figure S5 Modeled (ORCHIDEE-CAN-RS) versus observed sap flow (monthly average values are displayed). The color of points indicates water deficit (negative difference between precipitation and evapotranspiration) with darker color meaning more severe water deficit. The black dashed line is the 1:1 line. The red dashed line is the best fit between modeled and observed sap flow.

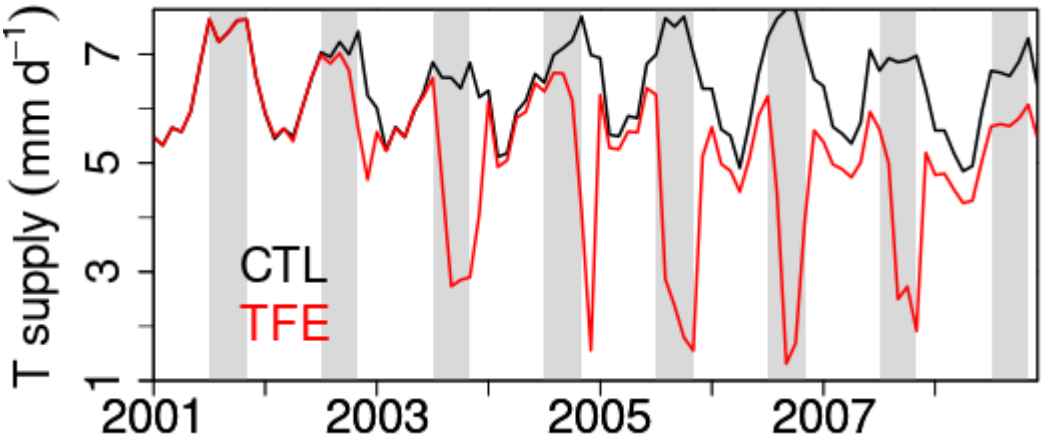

Figure S6 Transpiration supply simulated by ORCHIDEE-CAN-NHA during 2001-2008. In Caxiuanã site, dry season is deemed from July to November, as shown by gray bands here.

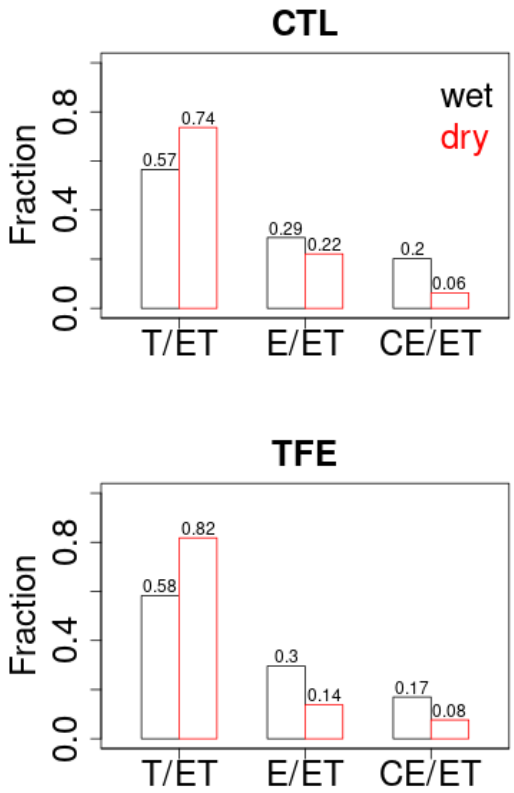

Figure S7 Simulated T/ET, E/ET and CE/ET during 2001 to 2008 under CTL and TFE from ORCHIDEE-CAN-NHA. T, transpiration. ET, evapotranspiration. CE, intercepted canopy water or dew re-evaporation. In Caxiuanã site, dry season is deemed from July to November.

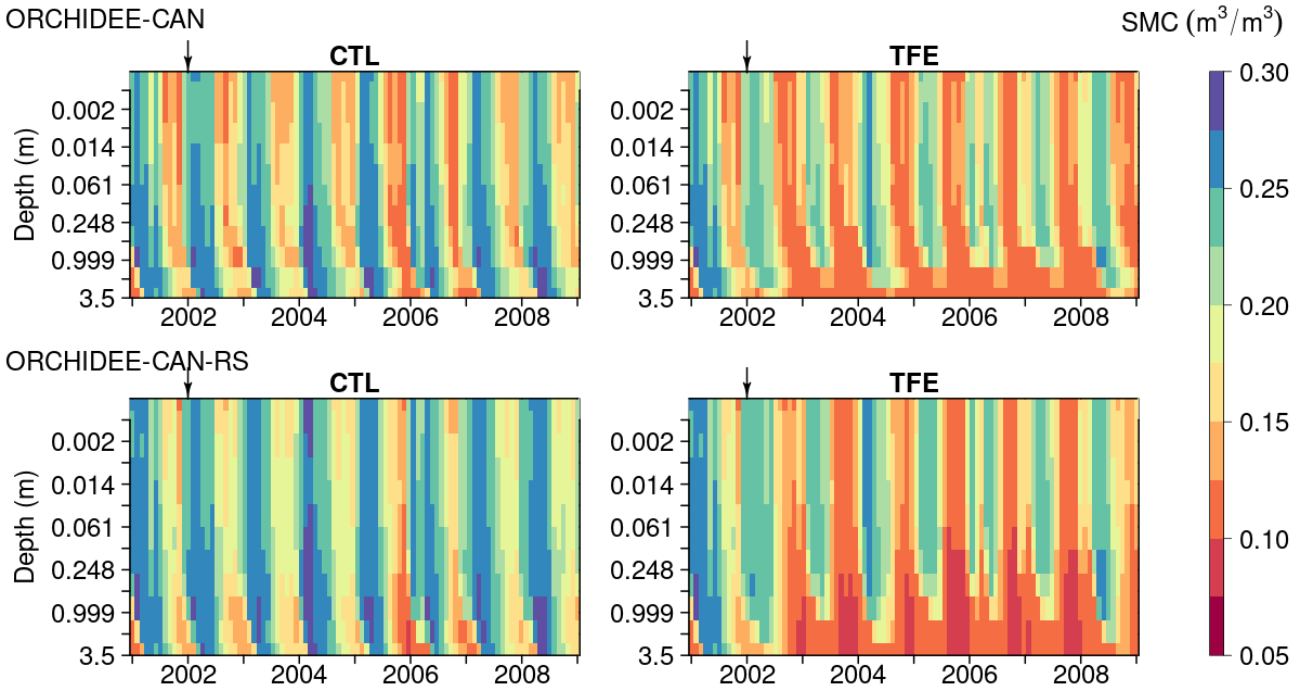

Figure S8 Soil moisture content simulated by ORCHIDEE-CAN and ORCHIDEE-CAN-RS during 2001 to 2008 under CTL and TFE. It should be noted the 12 soil layers have different thicknesses and here we show the SMC in same depth interval to present the change in SMC in top layers clearly.

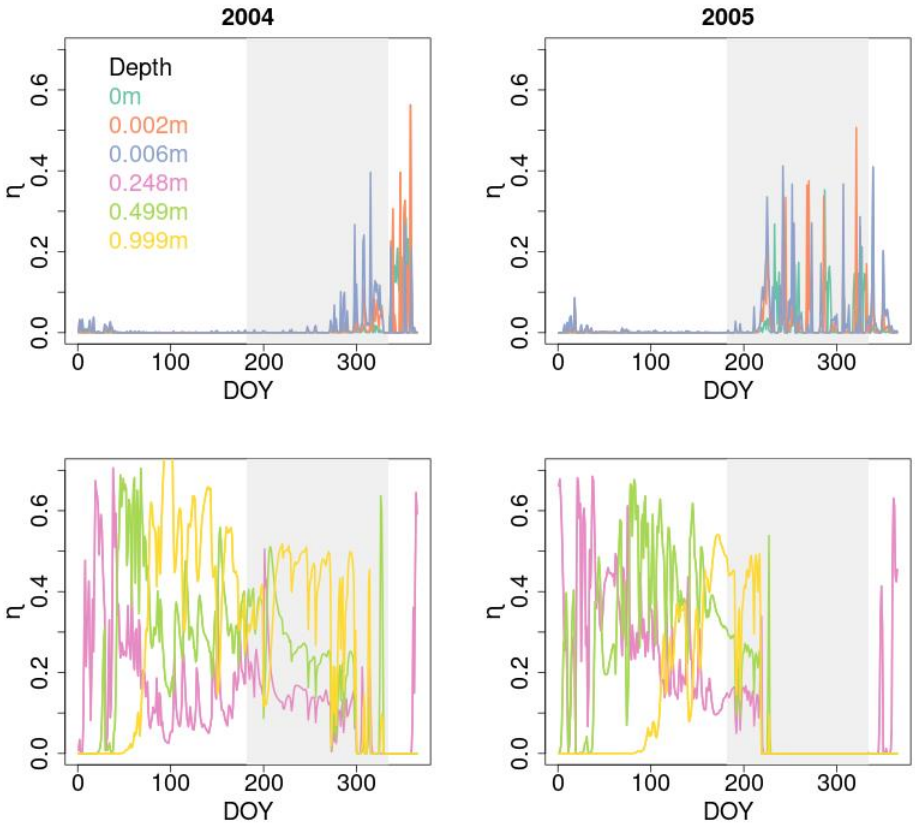

Figure S9 Distribution of η in each soil layer (year 2004 and 2005 were taken as examples here). Top panels show η in top three layers, and bottom panels show η in lower layers. The period with shading corresponds to the dry season from July to November.

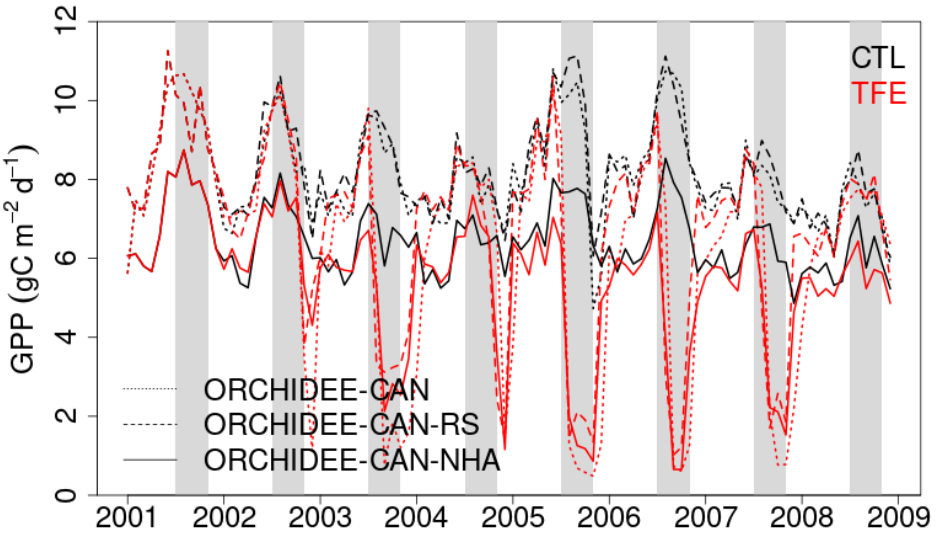

Figure S10 Simulation of GPP dynamics during 2001 to 2008. Gray bands correspond to dry season between July and November. Line types differ among three model versions.

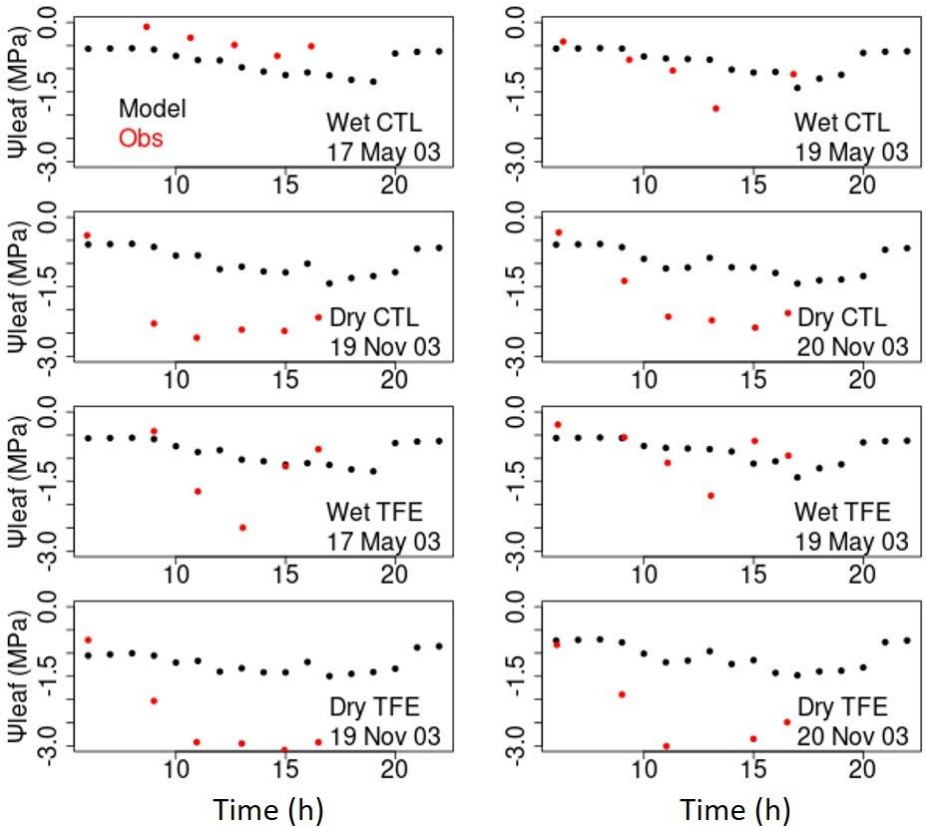

Figure S11 Modeled (black dots) and measured (red dots) Ψ_{leaf} in the control (CTL) and throughfall exclusion (TFE) for wet and dry seasons. Measured leaf water potential comes from Fisher et al (2006). Here Ψ_{leaf} from cohort #10 in model simulation is used as an example here.

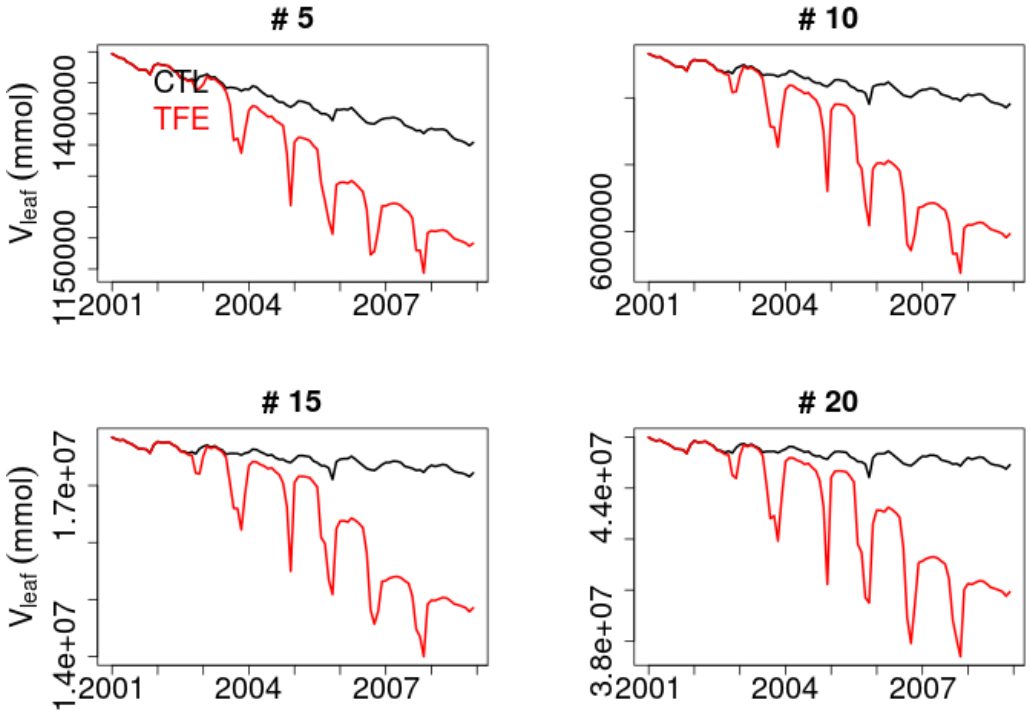

Figure S12 Change in leaf water storage during 2001-2008. Cohorts of #5, #10, #15, and #20 are taken as examples here.

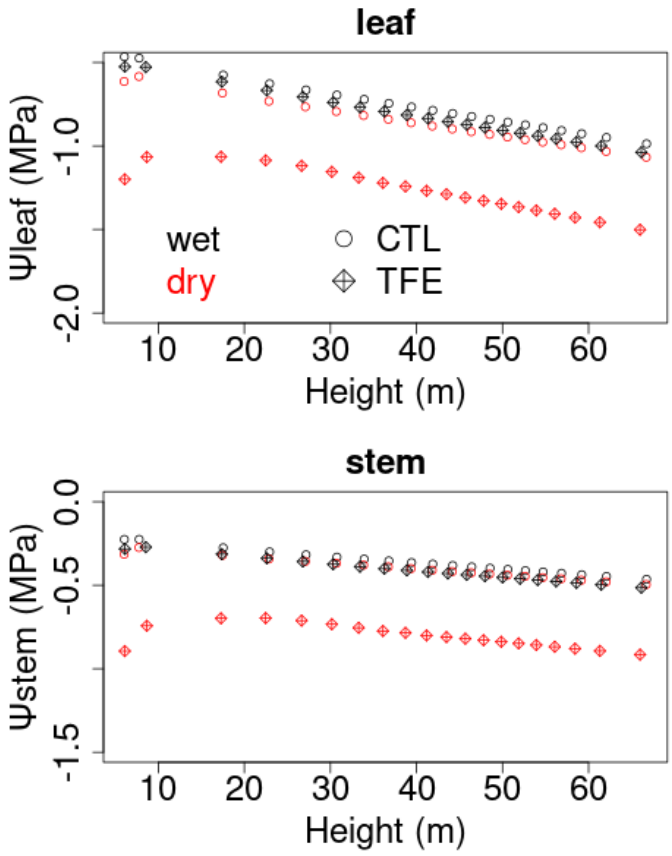

Figure S13 Relationship between Ψ_{leaf}, Ψ_{stem} and tree height. The color of black and red correspond to wet and dry season. The marker type corresponds to experiments of CTL and TFE.

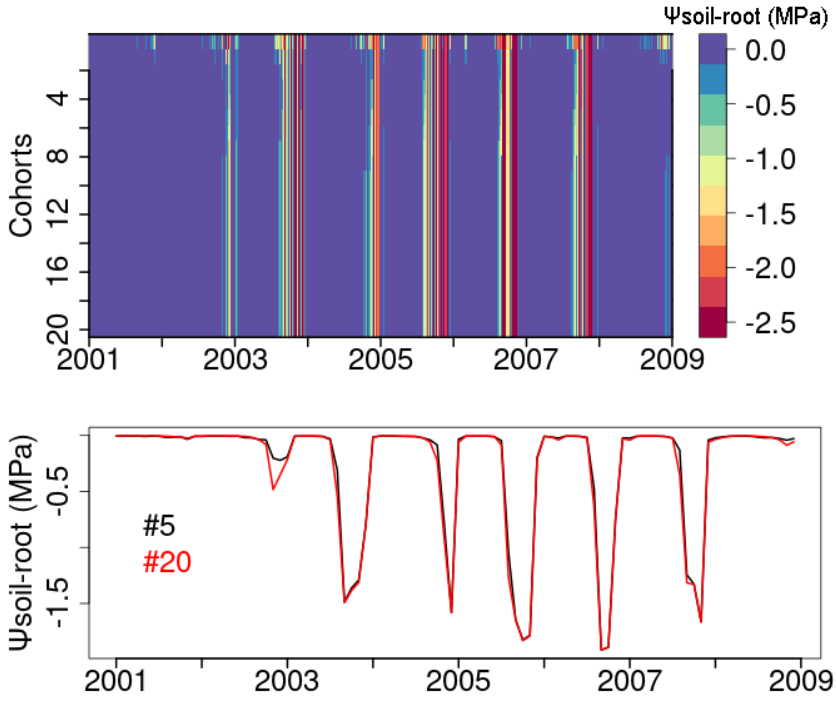

Figure S14 Soil water potential in root zone ($\Psi_{soil\text{-}root}$). The top panel shows the temporal distribution of $\Psi_{soil\text{-}root}$ at daily

time scale. The bottom one shows monthly $\Psi_{soil\text{-}root}$ in cohort #5 and #20.

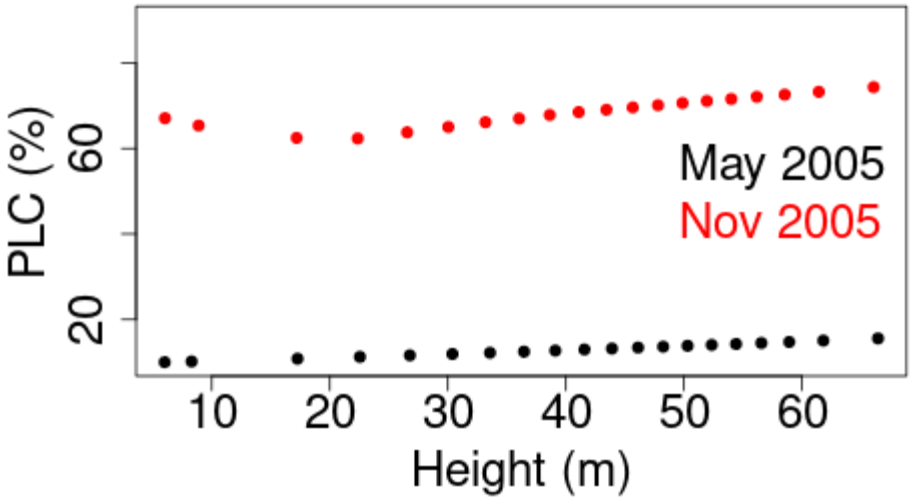

Figure S15 Relationship between percentage loss of conductance (PLC) and tree height. Here May 2005 and Nov 2005 correspond to wet and dry season, separately.

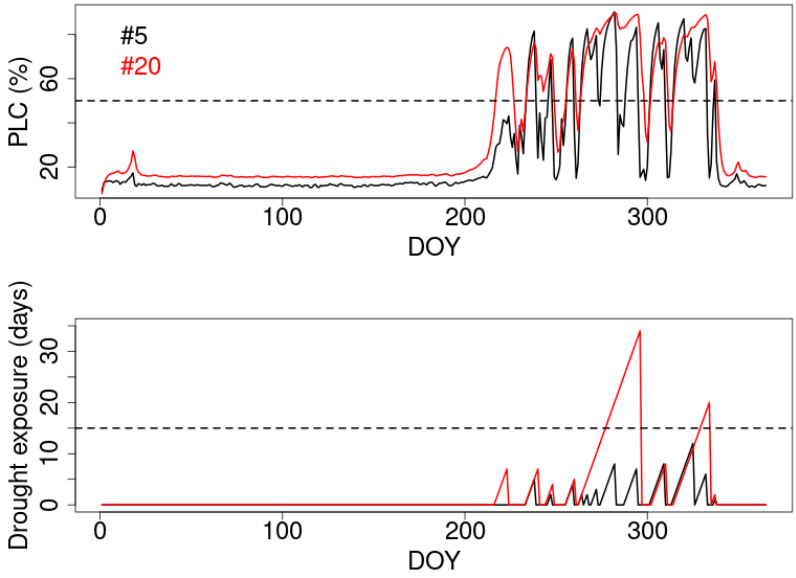

Figure S16 Percentage of loss in stem hydraulic conductance (at daily time scale) and drought exposure in year 2005. Here cohorts #5 and #20 are taken as example.

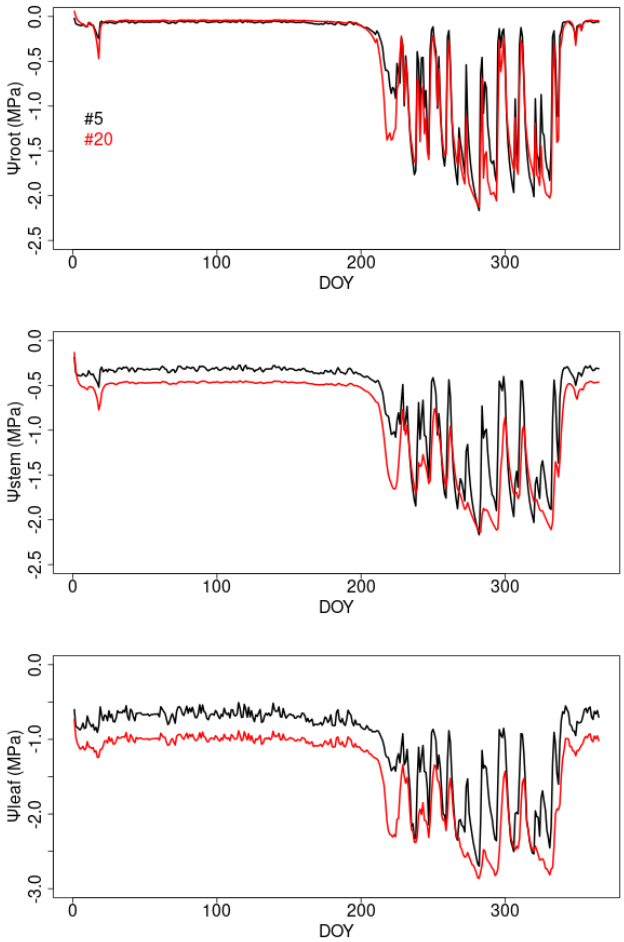

Figure S17 The temporal dynamics of Ψ_{leaf}, Ψ_{stem} and Ψ_{root} in year 2005 at daily time scale. Here cohorts #5 and #20 are taken as example.

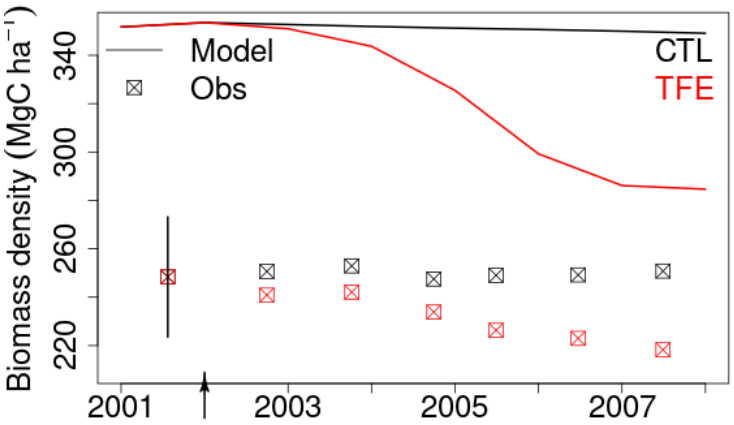

Figure S18 Absolute values of change in biomass simulated by ORCHIDEE-CAN-NHA after mortality being triggered. Since there is a noticeable difference of biomass in 2001 between CTL and TFE observation, we made a shift on CTL biomass to let it to be consistent with TFE in the beginning of experiments (the amount of shift = 25 MgC ha^{-1}).

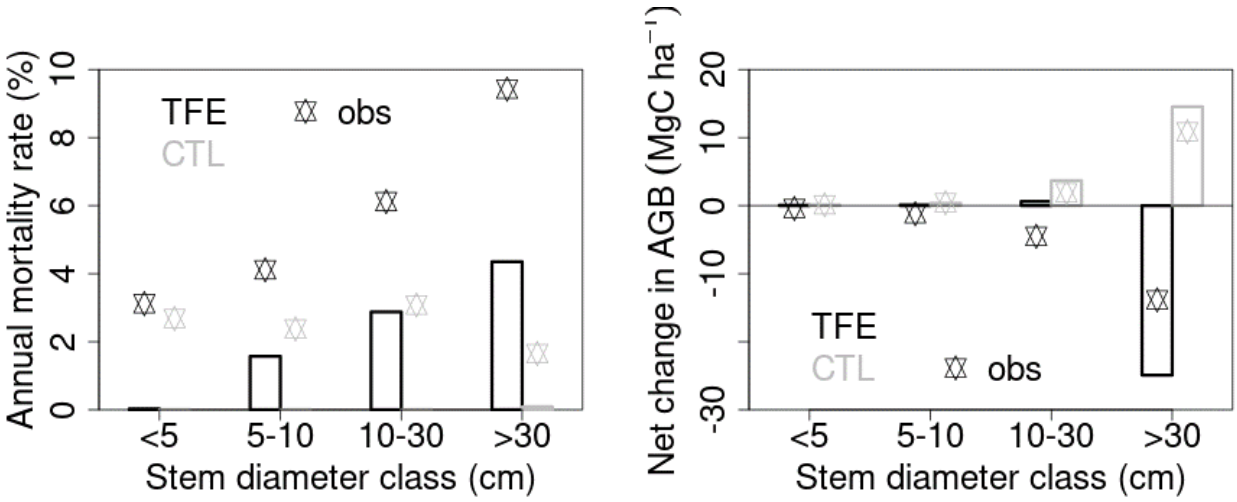

Figure S19 Comparison of (a) annual mortality rates in different diameter size classes and (b) net change in aboveground biomass (AGB) between our model simulation and observation at Tapajos site from 1999 to 2003. CTL: control. TFE: throughfall exclusion experiment. At Tapajos site, TFE only happened in wet season from 2000 to 2003. The net change in AGB accounts for the period from 1999 to 2003.

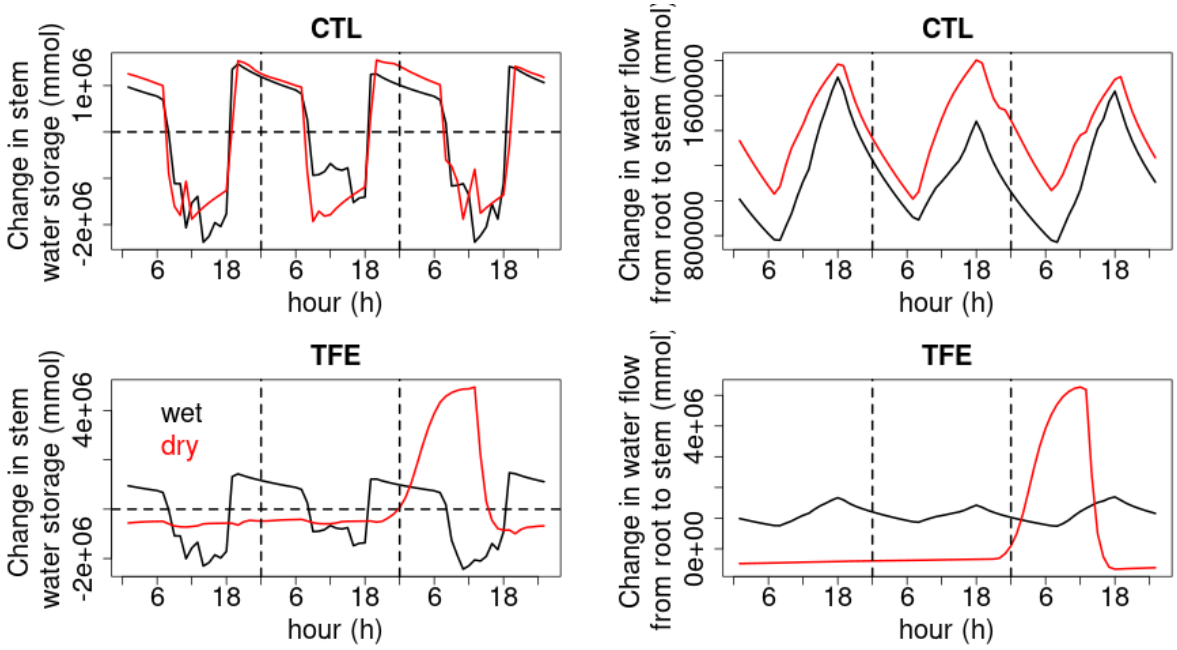

Figure S20 Diurnal cycles of stem water flux and storage change. Here, 'wet' denotes the first three days in May (1-3 May) in 2005, and 'dry' denotes the first three days in November (1-3 Nov) in 2005. Cohort #10 is used here as an example. Positive change in stem water storage means water charge to stem and vice versa. The dashed horizontal lines in the two left panels indicate 0.

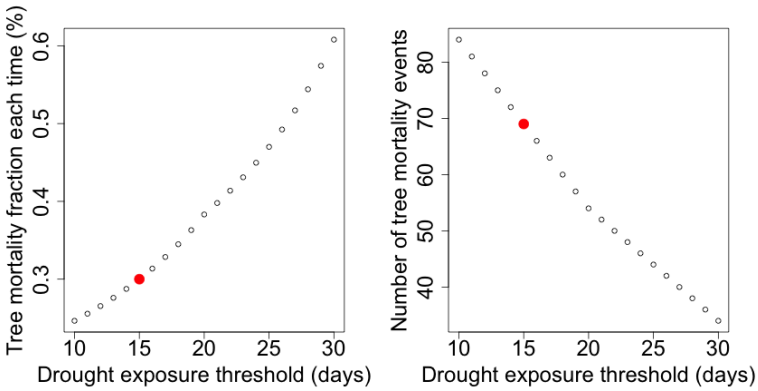

Figure S21 The combination of different drought exposure threshold and tree mortality fraction upon each event. Here, the drought exposure threshold from 10 to 30 days is shown as an example here. Higher drought exposure threshold would lead to less frequent tree mortality events. The red point denotes the parameter we used in the main text for the Caxiuana experiment.

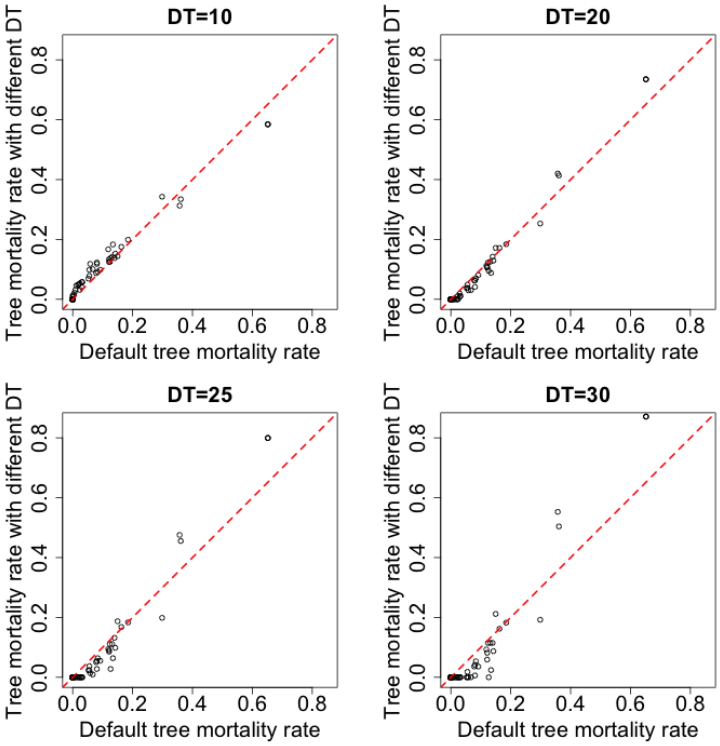

Figure S22 The effect of varying drought exposure threshold (DT) on tree mortality estimation. 'Default tree mortality rate' is calculated by the DT used in the main text. 'Tree mortality rate with different DT' is calculated by the DT labeled on top of each panel. Each point represents one pixel in western Amazon. The red dashed line is 1:1 line. When points distribute on top of the 1:1 line, the tree mortality rate calculated by another DT is higher than the default one. Cohort #20 is used here as an example.