

Supplementary Materials for
Critical soil moisture thresholds of plant water stress in terrestrial ecosystems

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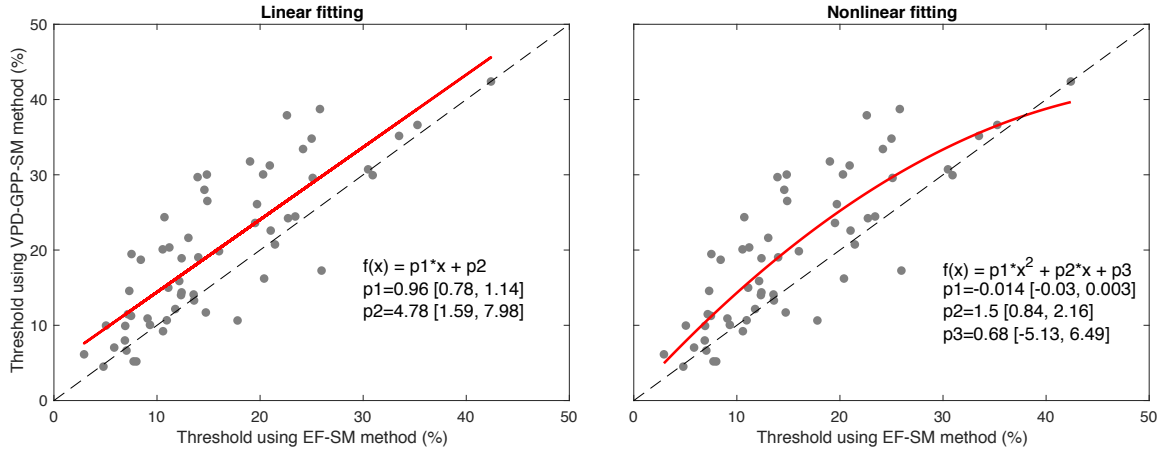


Fig. S1. Fitting the soil moisture thresholds from EF–SM method and VPD–GPP–SM method using linear ($f(x) = p1 \times x + p2$) and nonlinear ($f(x) = p1 \times x^2 + p2 \times x + p3$) functions. The 95% confidence intervals are shown in parenthesis.

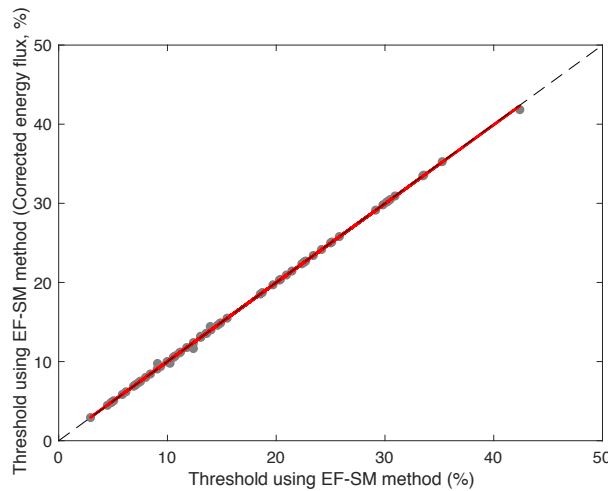


Fig. S2. The effect of different energy fluxes (LE and H vs. LE.CORR and H.CORR) on SM thresholds estimated from EF–SM method across all sites with corrected energy fluxes. Both the ‘LE’ (or ‘H’) and ‘LE.CORR’ (or ‘H.CORR’) variables were reported by the FLUXNET database for latent (or sensible) energy exchange. LE.CORR and H.CORR are the “energy balance corrected” version of latent and sensible heat flux, based on the assumption that the Bowen ratio is correct.

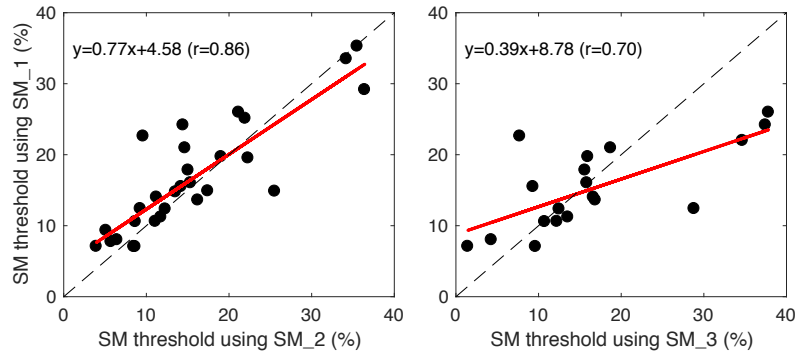


Fig. S3. Relationships between estimated SM thresholds using the SM in the first depth (SM₁) and the SM in second (SM₂) or third depth (SM₃) provided by each research site.

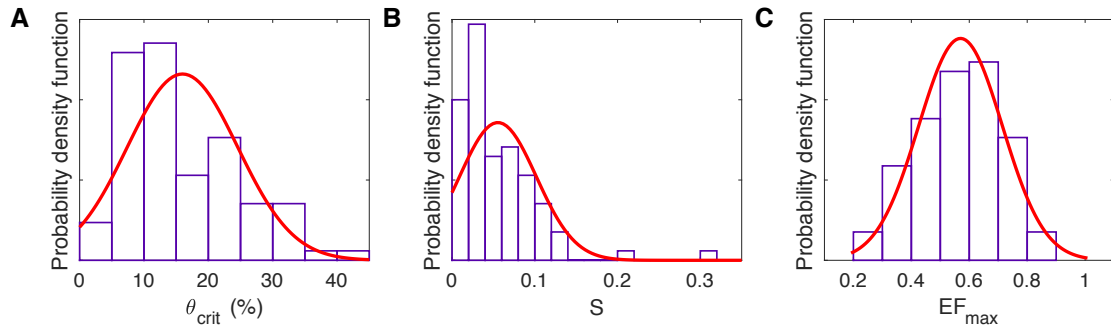


Fig. S4. Probability distributions of θ_{crit} , S and EF_{max} across all sites (A-C).

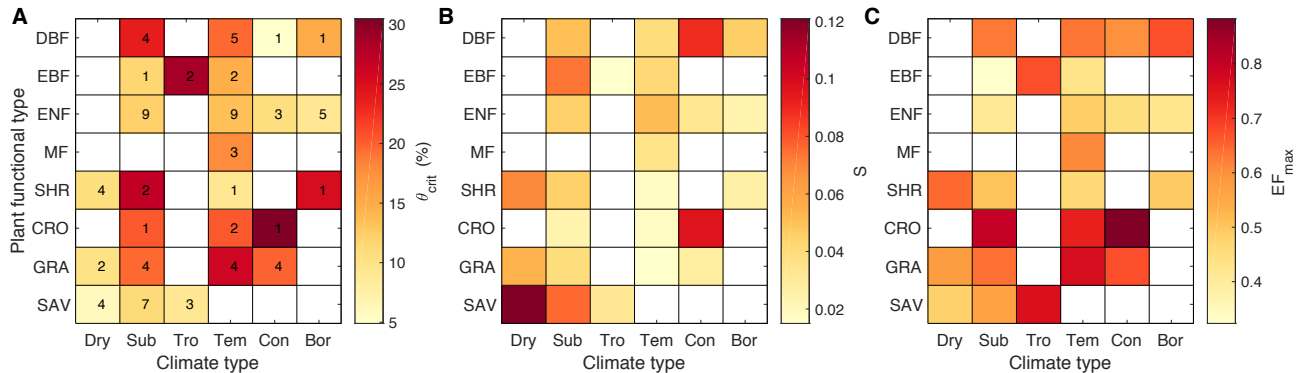


Fig. S5. Values of θ_{crit} , S and EF_{max} in a matrix of plant functional types and climate types. The number in the first panel indicates the number of sites in each bin. SAV: savannas; SHR: shrublands; ENF: evergreen needleleaf forests; EBF: evergreen broadleaf forests; DBF: deciduous broadleaf forests; MF: mixed forests; GRA: grasslands; CRO: croplands. Sub: sub-tropical; Tro: tropical; Tem: temperate; Con: continental; Bor: boreal.

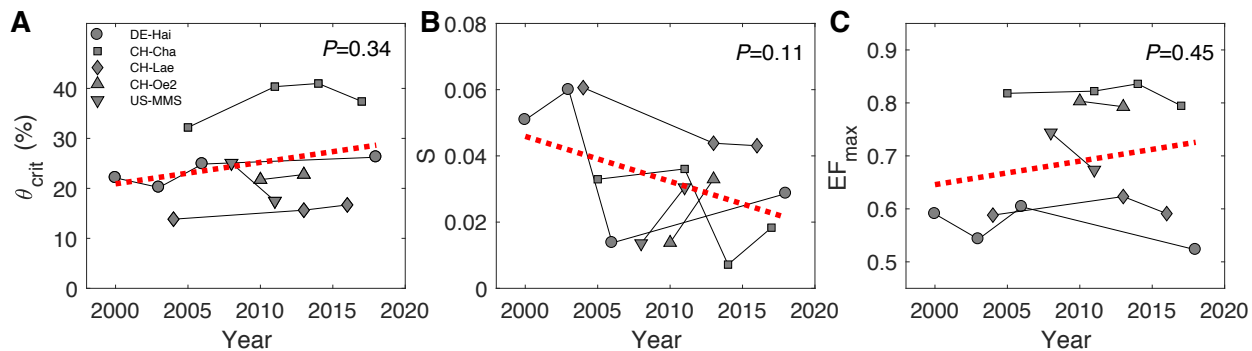


Fig. S6. The temporal change of θ_{crit} , S and EF_{max} at five sites with at least 15 years of measurements (A-C). The red line represents the linear fitting over all site-years. Different sites were shown in different marks. P values indicate statistical significance of the linear trend.

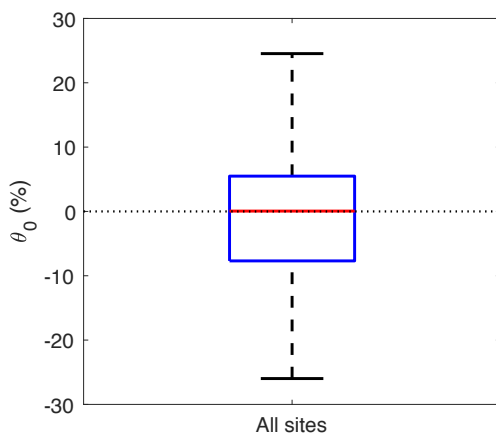


Fig. S7. Values of θ_0 (the value of SM at which EF equals zero) across sites. The θ_0 is not significantly differ from zero ($P > 0.05$).

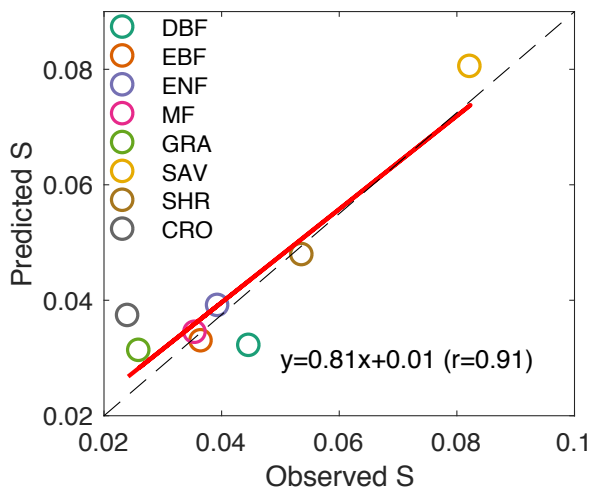


Fig. S8. The relationship between observed and predicted S across biomes.

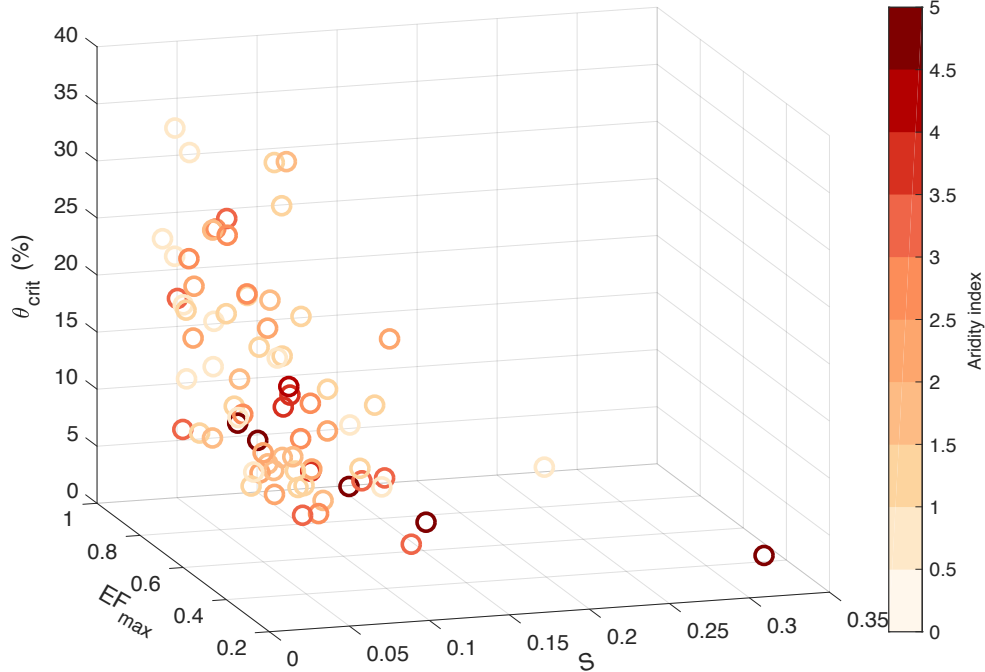


Fig. S9. The distribution of θ_{crit} , S and EF_{max} across all sites with aridity index.

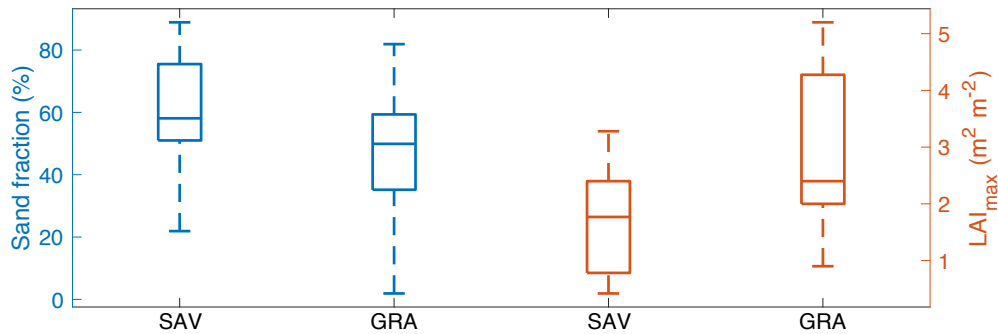


Fig. S10. Sand fraction and maximum leaf area index (LAI_{max}) in savannas and grasslands. Both sand fraction and LAI_{max} in savannas (SAV) and grasslands (GRA) are significantly different (Kruskal-Wallis test, $P < 0.05$). For each box plot, the middle line indicates the median; the box indicates the upper and lower quartiles, and the whiskers indicate the 5th and 95th percentiles of the data.

Table S1. Eddy covariance sites used in this study. Site identifier (ID), latitude (Lat, °), longitude (Long, °), plant functional type (PFT), climate type, and study periods are listed. Plant functional types were defined according to the IGBP classification, including SAV (savannas); SHR (shrublands); ENF (evergreen needleleaf forests); EBF (evergreen broadleaf forests); DBF (deciduous broadleaf forests); MF (mixed forests); GRA (grasslands) and CRO (croplands). Climate types were defined according to the Köppen-Geiger classification.

Site ID	Lat	Long	PFT	Climate	Periods
AU-ASM	-22.28	133.25	SAV	bsh	2010-2014
AU-Cpr	-34.00	140.59	SAV	bsk	2010-2014

AU-DaS	-14.16	131.39	SAV	aw	2008-2014
AU-Dry	-15.26	132.37	SAV	aw	2008-2014
AU-Gin	-31.38	115.71	SAV	csa	2011-2014
AU-How	-12.49	131.15	SAV	aw	2001-2014
AU-Rig	-36.65	145.58	GRA	cfb	2011-2014
AU-Whr	-36.67	145.03	EBF	cfb	2011-2014
AU-Wom	-37.42	144.09	EBF	cfb	2010-2014
BE-Bra	51.31	4.52	MF	cfb	2012-2019
BE-Maa	50.98	5.63	SHR	cfb	2016-2020
CA-Ca2	49.87	-125.29	ENF	cfb	1999-2010
CA-Ca3	49.53	-124.90	ENF	cfb	2001-2010
CA-NS6	55.92	-98.96	SHR	dfc	2001-2005
CA-Oas	53.63	-106.20	DBF	dfc	1997-2010
CA-Qfo	49.69	-74.34	ENF	dfc	2003-2010
CA-SF2	54.25	-105.88	ENF	dfc	2001-2006
CA-SJ2	53.95	-104.65	ENF	dfc	2002-2010
CA-TP1	42.66	-80.56	ENF	dfb	2002-2014
CA-TPD	42.64	-80.56	DBF	dfb	2012-2014
CH-Cha	47.21	8.41	GRA	cfb	2005-2020
CH-Dav	46.82	9.86	ENF	cfb	2006-2014
CH-Lae	47.48	8.37	MF	cfb	2004-2020
CH-Oe1	47.29	7.73	GRA	cfb	2002-2008
CH-Oe2	47.29	7.73	CRO	cfb	2004-2018
CN-Cng	44.59	123.51	GRA	dwa	2007-2010
CN-Dan	30.50	91.07	GRA	dwc	2004-2005
CN-Du2	42.05	116.28	GRA	dwb	2006-2008
CN-Du3	42.06	116.28	GRA	dwb	2009-2010
CN-Qia	26.74	115.06	ENF	cfa	2003-2005
CZ-Lnz	48.68	16.95	MF	cfb	2015-2020
CZ-RAJ	49.44	16.70	ENF	cfb	2012-2018
DE-Gri	50.95	13.51	GRA	cfb	2007-2020
DE-Hai	51.08	10.45	DBF	cfb	2000-2020
DE-HoH	52.09	11.22	DBF	cfb	2015-2020
DE-Hzd	50.96	13.49	DBF	cfb	2010-2020
DE-Kli	50.89	13.52	CRO	cfb	2005-2018
DE-Lnf	51.33	10.37	DBF	cfb	2002-2012
DE-Obe	50.79	13.72	ENF	cfb	2008-2020
ES-Abr	38.70	-6.79	SAV	csa	2015-2018
ES-LM1	39.94	-5.78	SAV	csa	2014-2020
ES-LM2	39.93	-5.78	SAV	csa	2014-2020

FR-Bil	44.49	-0.96	ENF	cfb	2014-2020
FR-Hes	48.67	7.06	DBF	cfb	2014-2020
FR-LBr	44.72	-0.77	ENF	cfb	1996-2008
GF-Guy	5.28	-52.92	EBF	am	2004-2014
IT-BFt	45.20	10.74	DBF	cfa	2019-2020
IT-CA1	42.38	12.03	DBF	csa	2011-2014
IT-Col	41.85	13.59	DBF	csa	2006-2014
IT-Cpz	41.71	12.38	EBF	csa	1997-2009
IT-Lsn	45.74	12.75	SHR	cfa	2016-2020
IT-Noe	40.61	8.15	SHR	csa	2004-2014
IT-SRo	43.73	10.28	ENF	csa	1999-2012
MY-PSO	2.97	102.31	EBF	af	2003-2009
NL-Loo	52.17	5.74	ENF	cfb	1999-2016
RU-Fyo	56.46	32.92	ENF	dfb	2007-2017
SE-Htm	56.10	13.42	ENF	cfb	2015-2020
SE-Nor	60.09	17.48	ENF	dfb	2014-2020
SE-Ros	64.17	19.74	ENF	dfc	2014-2020
SN-Dhr	15.40	-15.43	SAV	bwh	2010-2013
US-AR1	36.43	-99.42	GRA	cfa	2009-2012
US-Dk1	35.97	-79.09	GRA	cfa	2001-2008
US-Dk3	35.98	-79.09	ENF	cfa	2001-2008
US-FR2	29.95	-98.00	SAV	cfa	2005-2008
US-Fmf	35.14	-111.73	ENF	csb	2005-2010
US-Fuf	35.09	-111.76	ENF	csb	2005-2010
US-GLE	41.37	-106.24	ENF	dfc	2004-2014
US-Goo	34.25	-89.87	GRA	cfa	2002-2006
US-MMS	39.32	-86.41	DBF	cfa	1999-2014
US-Me1	44.58	-121.50	ENF	csb	2004-2005
US-Me3	44.32	-121.61	ENF	csb	2004-2009
US-Me4	44.50	-121.62	ENF	csb	1996-2000
US-Me6	44.32	-121.61	ENF	csb	2010-2014
US-Rls	43.14	-116.74	SHR	bsh	2014-2017
US-Rms	43.06	-116.75	SHR	bsh	2014-2017
US-Ro5	44.69	-93.06	CRO	dfa	2017-2017
US-SRG	31.79	-110.83	GRA	bsk	2008-2017
US-SRM	31.82	-110.87	SAV	bsk	2004-2014
US-Sta	41.40	-106.80	SHR	bsh	2005-2009
US-Ton	38.43	-120.97	SAV	csa	2001-2014
US-Tw3	38.12	-121.65	CRO	csa	2013-2014
US-Var	38.41	-120.95	GRA	csa	2001-2014

US-Whs	31.74	-110.05	SHR	bsk	2007-2014
US-Wkg	31.74	-109.94	GRA	bsk	2004-2014
ZA-Kru	-25.02	31.50	SAV	cwa	2000-2013

Table S2. Temporal dynamics of θ_{crit} , S and EF_{max} at DE-Hai. The standard error values are shown in parenthesis. NA means no θ_{crit} estimated.

Year	θ_{crit}	S	EF_{max}
2000-2002	22.10 (0.59)	0.05 (0.01)	0.59 (0.01)
2003-2005	20.17 (0.47)	0.06 (0.01)	0.54 (0.01)
2006-2008	24.86 (2.06)	0.01 (0.01)	0.60 (0.01)
2009-2011	NA	NA	NA
2012-2014	NA	NA	NA
2015-2017	NA	NA	NA
2018-2019	26.23 (1.28)	0.03 (0.004)	0.52 (0.02)
Mean	23.34 (1.36)	0.04 (0.01)	0.56 (0.02)
2000-2019	24.17 (0.46)	0.03 (0.003)	0.55 (0.01)