Potential evaporation at eddy-covariance sites across the globe

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Supplement

S1. Calculation of kB^{-1} when radiance fluxes are not separately measured

In 15 sites, the incoming and outgoing short- and longwave fluxes were not available and a different approach was needed to calculate kB^{-1}. The roughness length r_{aH} and canopy conductance g_c were calculated of daily values for four difference parameterisations of the Stanton number, and the parameterisation which gave the highest correlation between g_c and λE_a was selected. The four tested parameterisations of the Stanton number were:

- kB^{-1}=2 after Brutsaert [1]
- kB^{-1} was a fixed value for each ecosystem, except croplands, after Rigden and Salvucci [2]. The Stanton number for all forest ecosystems was fixed at kB^{-1}=8, those of grassland and wetlands was kB^{-1}=2. For the savannah-type biomes, the fixed Stanton number was taken based on the general definition of each biome of the amount of tall (>2m) and low (<2m) woody cover. For instance, open shrubland is defined as a vegetation in which the woody cover is less than 2 m and covers 10-60% of the area. Based on a fixed Stanton number of kB^{-1}=5 for low woody vegetation covering an average of 35% of the area and a Stanton number of kB^{-1}=2 for the remaining 60% of the low grass cover, the resulting Stanton number was estimated as kB^{-1}=0.35 5 + 0.65 2=3.05. Similarly, the kB^{-1} values for closed shrubland, savannah and woody savannah were 5, 3.2 and 4.7, respectively. For croplands, the value is not fixed but is a function of the vegetation height. The kB^{-1} was equal to 2 when vegetation heights were below 0.5m, ranging between 2 and 5 when the vegetation was between 0.5m and 1m, and 5 when the vegetation height was taller than 1m.
- kB^{-1} ranges between 2 and 8, depending on the vegetation height, with a value between 2 and 5 for ecosystem with vegetation height between 0.5 and 1m, and a value between 5 and 8 for ecosystems with vegetation height between 1 and 20 m.
- kB^{-1} is a function of the Reynolds number Re, with kB^{-1}=k (5.7 $Re^{1/4}$ -5) [1]

S2. Correct estimations of E_p when conditions are not unstressed

The best performing E_p models (MD_b, PT_b, see Section 3.2) rely heavily on the available energy, $(R_n - G) = \left((1-\alpha)\, SW_{in} + \varepsilon\, LW_{in} - \varepsilon\, \sigma\, T_s^4 - G\right)$ (See Eqs. 3, 4). In the calculations of E_p for comparison with E_{unstr} (Section 3.2), the values of albedo (α), surface temperature (T_s) and ground heat flux (G) were also reflecting those of unstressed ecosystems – we'll refer to these values as α_{unstr}, T_{s_unstr} and G_{unstr}. Since these are not forcing variables but ecosystem properties, correct E_p estimates in other conditions should also use α_{unstr}, T_{s_unstr} and G_{unstr} rather than the actual α, T_s or G. Here we provide a method to estimate α_{unstr}, T_{s_unstr} and G_{unstr} based on the unstressed records of the eddy flux observations and using the MD_b method to estimate E_p:

$$\lambda E_p = \alpha_{MD} \left((1-\alpha_{unstr})\, SW_{in} + \varepsilon\, LW_{in} - \varepsilon\, \sigma\, T_{s\_unstr}^4 - G_{unstr}\right) \qquad \text{(S1)}$$

In this study, we used a site-specific approach to estimate α_{unstr}. If the observed albedo was lower than 10^{th} percentile albedo values of the unstressed subset or larger than the 90^{th} percentile of this subset, α_{unstr} was estimated as the 10^{th} or 90^{th} percentile, respectively. The calculation of G_{unstr} was done similarly: if the actual $G\, R_n^{-1}$ was larger than the 90^{th} percentile of $G\, R_n^{-1}$ of the unstressed dataset, G_{unstr} was calculated from this 90^{th} percentile; else, the actual G was used to estimate G_{unstr}. Obtaining α_{unstr} and G_{unstr} globally could be done using a biome-specific calibration of 10^{th} and 90^{th} percentile of α and the 90^{th} percentile $G\, R_n^{-1}$, similar as the way the key parameters were identified per biome.

From $H = \rho_a\, c_p\, \frac{(T_0 - T_a)}{r_{aH}}$ and $H_{unstr}=(1-\alpha_{MD})(R_{n\_unstr}-G_{unstr})$ and in the assumption that $T_0=T_s$, T_{s_unstr} is given by

$$T_{s\_unstr} = T_a + \frac{r_{aH}\,(1-\alpha_{MD})\left(R_{n\_unstr} - G_{unstr}\right)}{\rho_a\, c_p} \qquad \text{(S2)}$$

T_{s_unstr} and R_{n_unstr} can be calculated by iterating Eqs. S1 and S2 for flux sites of which SW_{in}, SW_{out} and LW_{in} were available.

S3. Tables

Table S1 Overview of the flux tower, their location, period with available data, the number of records of the final daily table, availability of soil moisture measurements and the reference or PI.

Biome	Site	Lat	Lon	Alt	Country	From	Until	# days	SWC	Ref/PI
Cropland (CRO)										
	BE-Lon	50.55	4.75	167	Belgium	04/2004	12/2014	809	x	[3]
	DE-Geb	51.10	10.91	162	Germany	01/2001	12/2014	2472	x	[4]
	DE-Kli	50.89	13.52	478	Germany	05/2004	12/2014	910	x	[5]
	IT-CA2	42.38	12.03	200	Italy	07/2011	12/2014	244		B. Gioli
	US-ARM	36.61	-97.49	314	USA	01/2003	12/2012	2084	x	[6]
	US-CRT	41.63	-83.35	180	USA	01/2011	12/2013	667	x	[7]
	US-Lin	36.36	-119.84	131	USA	11/2009	11/2010	310		[8]
	US-Ne1	41.17	-96.48	361	USA	05/2001	05/2013	2854		[9]
	US-Ne2	41.17	-96.47	362	USA	06/2001	05/2013	2921		[9]
	US-Ne3	41.18	-96.44	363	USA	06/2001	05/2013	2912		[9]
Grassland (GRA)										
	AU-DaP	-14.06	131.32	71	Australia	09/2007	09/2013	803	x	[10]
	AU-Emr	-23.86	148.48	176	Australia	06/2011	12/2013	723	x	[11]
	AU-Rig	-36.65	145.58	151	Australia	01/2011	12/2014	552		[10]
	AU-Stp	-17.15	133.35	250	Australia	08/2008	12/2014	1503	x	[10]
	AU-Ync	-34.99	146.29	126	Australia	10/2012	12/2014	439	x	[10]
	CN-HaM	37.37	101.18	4003	China	01/2002	12/2004	437		[12]
	DE-Gri	50.95	13.51	385	Germany	01/2004	12/2014	1438	x	[5]
	IT-Tor	45.84	7.58	2160	Italy	06/2008	12/2014	513	x	[13]
	RU-Ha1	54.73	90.00	446	Russia	06/2002	12/2004	303		D. Papale
	US-AR1	36.43	-99.42	611	USA	04/2009	12/2012	931	x	D. Billesbach
	US-AR2	36.64	-99.60	646	USA	04/2009	08/2012	816	x	D. Billesbach
	US-ARb	35.55	-98.04	424	USA	03/2005	10/2006	424	x	M. Torn
	US-ARc	35.55	-98.04	424	USA	03/2005	10/2006	442	x	M. Torn
	US-Cop	38.09	-109.39	1520	USA	04/2001	11/2007	741		[14]
	US-Goo	34.26	-89.87	87	USA	05/2002	12/2006	775		T. Meyers
	US-IB2	41.84	-88.24	227	USA	10/2004	12/2011	1474	x	R. Matamala
	US-LWW	34.96	-97.98	365	USA	01/1997	12/1998	513		[15]
	US-SRG	31.79	-110.83	1291	USA	03/2008	12/2014	1969	x	[16]
	US-Var	38.41	-120.95	129	USA	11/2000	12/2014	3804	x	[17]
	US-Wkg	31.74	-109.94	1531	USA	05/2004	12/2014	3366	x	[18]
Deciduous Broadleaf Forest (DBF)										
	AU-Lox	-34.47	140.66	45	Australia	08/2008	06/2009	189		[19]
	CA-TPD	42.64	-80.56	260	Canada	01/2012	12/2014	422	x	A. Arain
	DE-Hai	51.08	10.45	430	Germany	01/2000	12/2009	1597	x	[20]
	DK-Sor	55.49	11.65	40	Denmark	04/2001	12/2014	1315		[21]
	IT-CA1	42.38	12.03	200	Italy	06/2011	12/2014	223		D. Parpale
	IT-CA3	42.38	12.02	197	Italy	11/2011	12/2014	333		D. Parpale
	IT-Col	41.85	13.59	1560	Italy	06/1996	12/2014	976	x	G. Matteuci
	IT-Isp	45.81	8.63	210	Italy	01/2013	12/2014	220		[22]
	IT-PT1	45.20	9.06	60	Italy	03/2002	10/2004	350		G. Seufert

Biome	Site	Lat	Lon	Alt	Country	From	Until	# days	SWC	Ref/PI
	IT-Ro2	42.39	11.92	160	Italy	01/2002	12/2012	839	x	D. Parpale
	US-MMS	39.32	-86.41	275	USA	01/1999	12/2014	3235	x	[23]
	US-Oho	41.56	-83.84	230	USA	01/2004	12/2013	1681	x	[24]
	US-WCr	45.81	-90.08	520	USA	02/1999	12/2014	1754	x	[25]
	US-Wi8	46.72	-91.25	348	USA	05/2002	11/2002	84		[26]
	ZM-Mon	-15.44	23.25	1053	Zambia	03/2000	07/2009	510		W. Kutsch
Evergreen Broadleaf Forest (EBF)										
	AU-Cum	-33.61	150.72	29	Australia	10/2012	12/2014	512		[11]
	AU-Rob	-17.12	145.63	709	Australia	01/2014	12/2014	110		[11]
	AU-Tum	-35.66	148.15	1259	Australia	02/2001	12/2014	2824	x	[11]
	AU-Wac	-37.43	145.19	110	Australia	08/2005	12/2008	147		[10]
	AU-Wom	-37.42	144.09	705	Australia	01/2010	12/2014	804	x	[11]
	BR-Sa3	-3.02	-54.97	100	Brazil	06/2000	03/2004	399		[27]
	FR-Pue	43.74	3.60	270	France	08/2002	12/2014	1556		[28]
	GH-Ank	5.27	-2.69	124	Ghana	02/2011	11/2014	91		R. Valentini
	MY-PSO	2.97	102.31	147	Malaysia	01/2003	12/2009	1271	x	[29]
Evergreen Needle Forest (ENF)										
	AU-ASM	-22.28	133.25	606	Australia	09/2010	12/2014	1082	x	[30]
	CA-Obs	53.99	-105.12	629	Canada	04/1999	02/2002	104		[31]
	CA-Qfo	49.69	-74.34	382	Canada	09/2003	12/2010	1013	x	[32]
	CA-SF1	54.49	-105.82	536	Canada	07/2003	09/2006	613	x	[33]
	CA-SF2	54.25	-105.88	520	Canada	07/2001	09/2005	641		[33]
	CA-TP1	42.66	-80.56	265	Canada	01/2003	12/2014	967	x	[34]
	CA-TP4	42.71	-80.36	184	Canada	05/2002	12/2014	1210	x	[34]
	DE-Lkb	49.10	13.31	1308	Germany	05/2009	12/2013	197		[35]
	DE-Obe	50.78	13.72	735	Germany	01/2008	12/2014	964		[36]
	DE-Tha	50.96	13.57	380	Germany	07/1996	12/2014	2694	x	[37]
	FI-Hyy	61.85	24.30	181	Finland	12/2002	12/2014	564	x	[38]
	IT-Lav	45.96	11.28	1353	Italy	01/2003	12/2014	1454	x	D. Gianelle
	IT-Ren	46.59	11.43	1730	Italy	11/1999	12/2013	792	x	[39]
	IT-SR2	43.73	10.29	12	Italy	01/2013	12/2014	306		[40]
	IT-SRo	43.73	10.28	6	Italy	01/1999	05/2010	933	x	[41]
	NL-Loo	52.17	5.74	25	The Netherlands	07/1996	11/2014	2345	x	[42]
	RU-Fyo	56.46	32.92	265	Russia	07/1998	12/2014	1408	x	[43]
	US-Blo	38.90	-120.63	1315	USA	06/1997	10/2007	1928	x	[44]
	US-GLE	41.37	-106.24	3197	USA	04/2005	12/2014	661	x	[34]
	US-Me1	44.58	-121.50	896	USA	06/2004	05/2005	140	x	[45]
	US-Me2	44.45	-121.56	1253	USA	01/2002	12/2014	2402		[46]
	US-Me4	44.50	-121.62	922	USA	02/2000	11/2000	171		[47]
	US-Me5	44.44	-121.57	1188	USA	04/2000	12/2002	434	x	[47]
	US-NR1	40.03	-105.55	3050	USA	05/1999	12/2014	3157	x	[48]
	US-Prr	65.12	-147.49	210	USA	10/2010	12/2014	225		[49]
	US-Wi4	46.74	-91.17	352	USA	05/2002	10/2005	83		[50]
Mixed Forest (MF)										
	AR-SLu	-33.47	-66.46	505	Argentina	12/2009	03/2011	347		[51]
	BE-Vie	50.31	6.00	493	Belgium	08/1996	12/2014	1847	x	[52]
	CA-Gro	48.22	-82.16	340	Canada	09/2003	05/2014	848		[53]

Biome	Site	Lat	Lon	Alt	Country	From	Until	# days	SWC	Ref/PI
	US-Syv	46.24	-89.35	540	USA	09/2001	06/2007	846	x	[54]
Closed Shrubland (CSH)										
	IT-Noe	40.61	8.15	28	Italy	04/2004	10/2014	1401	x	[55]
	US-KS2	28.61	-80.67	3	USA	04/2003	12/2006	603	x	[56]
Woody Savannah (WSA)										
	AU-Gin	-31.38	115.71	51	Australia	10/2011	12/2014	724		[11]
	AU-How	-12.49	131.15	64	Australia	09/2001	12/2014	1683	x	[10]
	AU-RDF	-14.56	132.48	188	Australia	09/2011	07/2013	466	x	[10]
	US-SRM	31.82	-110.87	1120	USA	01/2004	12/2014	3313	x	[18]
	US-Ton	38.43	-120.97	177	USA	05/2001	12/2014	3322	x	[57]
Savannah (SAV)										
	AU-Cpr	-34.00	140.59	62	Australia	08/2010	12/2014	1193	x	[11]
	AU-DaS	-14.16	131.39	75	Australia	01/2008	12/2014	1008	x	[10]
	AU-Dry	-15.26	132.37	176	Australia	09/2008	12/2014	943		[10]
	AU-GWW	-30.19	120.65	449	Australia	01/2013	12/2014	296		[11]
	SD-Dem	13.28	30.48	500	Sudan	02/2005	11/2009	575		[58]
	ZA-Kru	-25.02	31.50	359	South Africa	04/2000	02/2013	1015	x	[59]
Open Shrubland (OSH)										
	AU-TTE	-22.29	133.64	553	Australia	07/2012	12/2014	647		[60]
	CA-SF3	54.09	-106.01	540	Canada	04/2001	09/2006	760		[33]
	ES-Amo	36.83	-2.25	58	Spain	06/2007	12/2012	1274	x	F.D. Poveda
	US-SRC	31.91	-110.84	991	USA	03/2008	06/2014	1382	x	[61]
	US-Whs	31.74	-110.05	1370	USA	06/2007	12/2014	2373	x	[62]
	US-Wi6	46.63	-91.30	371	USA	05/2002	10/2003	81		[50]
Wetland (WET)										
	DE-SfN	47.81	11.33	590	Germany	07/2012	12/2014	252		[63]
	US-Atq	70.47	-157.41	15	USA	04/2003	09/2008	445		[64]
	US-Ivo	68.49	-155.75	568	USA	01/2004	10/2007	230		[64]
	US-Los	46.08	-89.98	480	USA	09/2000	12/2010	1459		[65]
	US-Tw4	38.10	-121.64	-5	USA	11/2013	12/2014	245		[66]

Table S2. Mean correlations per biome between the measured E_{unstr} and the different E_p methods. The methods with the highest correlation per biome are highlighted in bold and underlined. Based on unstressed days only defined using the soil moisture criterion.

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (5)	0.73	0.80	0.79	0.69	0.77	0.74	**0.85**	**0.85**	0.68	0.85	0.85	0.68	0.68	0.69	0.69
GRA (15)	0.62	0.79	0.79	0.50	0.73	0.69	**0.88**	**0.88**	0.56	0.87	0.87	0.66	0.66	0.66	0.66
DBF (8)	0.74	0.85	0.85	0.70	0.72	0.74	**0.87**	**0.87**	0.58	0.81	0.81	0.78	0.77	0.80	0.80
EBF (3)	0.71	0.82	0.82	0.71	0.80	0.71	**0.83**	**0.83**	0.64	0.80	0.80	0.66	0.66	0.60	0.60
ENF (18)	0.68	0.77	0.77	0.65	0.72	0.70	**0.81**	**0.81**	0.56	0.74	0.74	0.77	0.77	0.76	0.76
MF (2)	0.65	0.73	0.73	0.63	0.71	0.68	0.78	0.78	0.58	0.75	0.75	**0.80**	0.80	0.75	0.75
CSH (2)	0.82	**0.85**	0.83	0.80	0.81	0.77	0.81	0.81	0.73	0.83	0.83	0.46	0.49	0.48	0.48
WSA (3)	0.60	0.74	0.76	0.50	0.57	0.65	**0.86**	**0.86**	0.54	0.84	0.84	0.65	0.66	0.65	0.65
SAV (3)	0.57	0.68	0.64	0.58	0.72	0.59	0.77	0.77	0.57	**0.78**	**0.78**	0.45	0.45	0.42	0.42
OSH (3)	0.58	0.80	0.85	0.35	0.66	0.64	**0.86**	**0.86**	0.46	0.84	0.84	0.68	0.73	0.73	0.73
Overall (62)	**0.67**	**0.79**	**0.78**	**0.61**	**0.72**	**0.70**	**0.84**	**0.84**	**0.58**	**0.81**	**0.81**	**0.69**	**0.69**	**0.70**	**0.70**

Table S3. Unbiased Root Mean Square Error (UnRMSE) (in mm day^{-1}) for the E_p methods per biome. The methods with the lowest UnRMSE per biome are indicated in bold and are underlined. Based on unstressed days only defined using the soil moisture criterion.

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (5)	1.30	1.03	1.25	1.77	1.65	1.57	1.00	0.85	1.44	0.86	**0.84**	1.24	1.24	1.21	1.18
GRA (15)	1.55	0.91	0.89	2.27	1.27	1.65	0.76	**0.74**	1.62	0.74	0.85	1.02	1.07	1.00	0.99
DBF (8)	1.52	1.19	1.19	1.77	2.20	1.74	1.17	1.26	2.01	1.32	1.53	1.15	**1.14**	1.35	1.43
EBF (3)	0.89	0.65	0.67	1.10	0.91	1.06	0.84	**0.59**	1.03	0.77	0.62	0.73	0.72	0.71	0.76
ENF (18)	1.30	1.08	0.98	1.63	2.19	1.60	1.18	**0.73**	1.64	1.10	0.85	0.86	0.86	0.84	0.83
MF (2)	1.59	1.21	1.05	1.83	1.57	1.89	1.25	0.92	1.67	1.12	1.03	**0.72**	0.73	0.94	0.94
CSH (2)	0.73	0.60	0.56	0.95	0.98	1.16	0.90	**0.54**	1.13	0.78	0.55	0.94	0.97	0.82	0.73
WSA (3)	1.25	0.84	0.74	1.63	1.95	1.42	0.70	**0.58**	1.40	0.64	0.65	0.89	0.89	0.81	0.79
SAV (3)	1.33	0.94	0.80	1.67	1.66	1.56	0.84	**0.57**	1.31	0.67	0.57	0.97	0.94	0.98	0.87
OSH (3)	1.35	0.69	0.54	2.16	1.06	1.57	0.62	**0.53**	1.55	0.55	0.63	1.03	1.00	0.74	0.63
Overall (62)	**1.36**	**0.98**	**0.94**	**1.80**	**1.71**	**1.58**	**0.97**	**0.78**	**1.59**	**0.93**	**0.89**	**0.96**	**0.97**	**0.97**	**0.96**

Table S4. Mean bias (in mm day^{-1}) for the E_p methods per biome. The best performing method per biome is indicated in bold and is underlined. Based on unstressed days only defined using the soil moisture criterion.

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (5)	2.07	0.48	1.15	3.83	1.83	2.93	1.02	0.08	3.03	0.90	**0.08**	0.28	0.38	-0.33	-0.48
GRA (15)	3.08	0.97	0.82	4.89	2.16	4.06	1.41	**-0.03**	3.91	1.15	-0.13	0.21	0.48	0.11	-0.55
DBF (8)	1.92	0.82	0.60	2.96	4.15	3.14	2.13	-0.22	3.37	2.09	-0.35	-0.10	**0.02**	-0.44	-0.83
EBF (3)	1.61	0.35	0.62	2.60	1.81	3.06	1.85	0.08	2.94	1.57	-0.02	-1.36	-0.74	-1.06	**0.00**
ENF (18)	2.70	1.43	0.97	3.95	4.75	3.92	2.62	**0.03**	4.28	2.71	-0.04	0.36	0.45	-0.50	-0.52
MF (2)	3.17	1.66	0.57	4.51	3.36	4.58	2.51	**-0.04**	5.04	2.60	-0.15	1.03	1.01	0.01	-0.55
CSH (2)	1.93	0.83	**0.04**	2.87	2.35	2.74	1.62	-0.05	2.49	1.30	-0.08	-0.41	-0.14	-0.03	-0.37
WSA (3)	2.64	1.07	**0.13**	3.54	3.97	3.59	1.51	-0.21	3.32	1.13	-0.32	-0.25	0.21	0.14	-0.42
SAV (3)	2.66	1.28	0.19	3.55	3.26	3.48	1.54	-0.14	2.82	0.96	**-0.10**	0.56	0.53	1.15	-0.62
OSH (3)	3.94	1.39	0.14	5.54	2.49	4.64	1.39	**0.01**	4.52	1.19	-0.12	0.32	0.69	0.63	-0.28
Overall (62)	**2.64**	**1.07**	**0.72**	**4.00**	**3.33**	**3.71**	**1.89**	**-0.04**	**3.77**	**1.77**	**-0.12**	**0.12**	**0.33**	**-0.16**	**-0.52**

Table S5 Mean correlations per biome between the measured E_{unstr} and the different E_p methods. The methods with the highest correlation per biome are highlighted in bold and underlined. Based on unstressed days only defined using the energy balance criterion, but only for the sites for which soil moisture data were available.

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (5)	0.86	0.93	0.94	0.75	0.93	0.88	0.96	0.96	0.86	**0.96**	**0.96**	0.79	0.79	0.78	0.78
GRA (15)	0.76	0.86	0.85	0.73	0.83	0.79	0.92	0.92	0.76	**0.93**	**0.93**	0.52	0.51	0.54	0.54
DBF (8)	0.79	0.86	0.88	0.80	0.86	0.78	**0.89**	**0.89**	0.75	0.89	0.89	0.53	0.52	0.53	0.53
EBF (3)	0.94	0.98	0.97	0.94	0.97	0.93	**0.98**	**0.98**	0.89	0.98	0.98	0.83	0.88	0.81	0.81
ENF (18)	0.88	0.88	0.89	0.87	0.88	0.90	0.94	0.94	0.87	**0.95**	**0.95**	0.73	0.75	0.75	0.75
MF (2)	0.89	0.93	0.92	0.89	0.94	0.89	**0.94**	**0.94**	0.88	0.93	0.93	0.77	0.76	0.73	0.73
CSH (2)	0.90	0.94	0.93	0.89	0.90	0.90	0.95	0.95	0.89	**0.95**	**0.95**	0.80	0.78	0.75	0.75
WSA (3)	0.77	0.78	0.78	0.75	0.73	0.80	0.89	0.89	0.79	**0.89**	**0.89**	0.37	0.38	0.42	0.42
SAV (3)	0.77	0.77	0.76	0.75	0.74	0.84	0.93	0.93	0.82	**0.93**	**0.93**	0.53	0.52	0.56	0.56
OSH (3)	0.69	0.75	0.77	0.62	0.70	0.79	0.91	0.91	0.78	**0.92**	**0.92**	0.48	0.45	0.54	0.54
Overall (62)	**0.82**	**0.87**	**0.87**	**0.80**	**0.85**	**0.84**	**0.93**	**0.93**	**0.82**	**0.93**	**0.93**	**0.60**	**0.60**	**0.64**	**0.64**

Table S6. Unbiased Root Mean Square Error (UnRMSE) (in mm day^{-1}) for the E_p methods per biome. The methods with the lowest UnRMSE per biome are indicated in bold and are underlined. Based on unstressed days only defined using the energy balance criterion, but only for the sites for which soil moisture data were available.

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (5)	1.15	0.86	0.93	1.66	1.32	1.23	0.73	0.69	1.22	0.71	**0.67**	1.42	1.42	1.53	1.42
GRA (15)	1.24	0.72	0.83	1.83	1.09	1.32	0.56	0.47	1.09	**0.46**	0.46	1.12	1.07	1.03	1.02
DBF (8)	1.04	0.84	0.83	1.09	1.25	1.20	0.79	**0.75**	1.13	0.77	0.77	1.38	1.38	1.37	1.34
EBF (3)	0.85	0.51	0.74	1.09	0.99	1.22	0.75	0.49	1.05	0.44	**0.44**	1.16	1.05	1.25	1.23
ENF (18)	1.01	0.79	0.94	1.22	1.60	1.27	0.82	0.53	1.11	0.61	**0.53**	0.97	0.96	0.98	0.99
MF (2)	0.92	0.61	0.61	1.17	0.89	1.26	0.72	**0.52**	0.95	0.58	0.57	0.95	0.93	0.96	1.01
CSH (2)	0.82	0.59	0.59	0.98	0.92	1.12	0.75	**0.48**	0.91	0.55	0.49	0.90	0.96	0.83	0.81
WSA (3)	1.11	0.94	0.82	1.33	1.74	1.30	0.71	0.58	1.01	0.58	**0.57**	1.10	1.10	1.04	1.05
SAV (3)	1.16	1.01	0.86	1.44	1.75	1.33	0.71	**0.45**	1.05	0.52	0.46	1.21	1.20	1.07	0.97
OSH (3)	1.38	0.75	0.62	1.89	1.08	1.69	0.57	0.34	1.32	0.36	**0.29**	1.14	1.07	0.77	0.63
Overall (62)	**1.09**	**0.78**	**0.84**	**1.41**	**1.33**	**1.29**	0.72	0.54	**1.11**	**0.57**	**0.54**	**1.17**	**1.14**	**1.09**	**1.07**

Table S7. Mean bias (in mm day^{-1}) for the E_p methods per biome. The best performing method per biome is indicated in bold and is underlined. Based on unstressed days only defined using the energy balance criterion, but only for the sites for which soil moisture data were available.

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (5)	1.09	-0.40	0.62	3.07	1.56	2.06	0.40	**-0.06**	1.50	-0.17	0.20	-0.78	-0.72	-1.68	-0.74
GRA (15)	2.76	0.58	1.30	4.59	2.13	3.84	1.15	**-0.02**	2.56	0.15	-0.19	-0.25	-0.52	-0.68	-0.81
DBF (8)	0.17	-0.62	0.66	1.02	2.31	1.69	1.02	**0.03**	0.60	-0.08	-0.10	-1.96	-2.07	-2.26	-0.51
EBF (3)	0.76	**-0.07**	0.69	1.59	1.23	1.58	0.93	0.20	0.88	0.21	-0.14	-1.25	-0.76	-0.96	-0.79
ENF (18)	1.26	0.38	1.11	2.02	2.70	2.04	1.14	-0.06	1.86	0.89	**0.02**	-0.34	-0.22	-0.78	-0.59
MF (2)	1.51	0.49	0.15	2.45	1.75	2.61	1.28	-0.28	2.01	0.74	-0.20	0.36	**-0.03**	-0.52	-1.44
CSH (2)	1.01	0.49	**0.00**	1.61	1.79	1.46	1.10	-0.04	0.92	0.51	-0.14	0.18	0.39	0.14	-0.56
WSA (3)	2.66	1.15	**0.05**	3.62	4.22	3.94	1.57	-0.08	2.39	0.35	-0.34	-0.20	-0.29	-0.31	-0.53
SAV (3)	2.24	1.22	0.26	3.10	3.50	3.04	1.51	-0.06	2.05	0.65	**0.00**	0.15	0.11	0.53	-0.77
OSH (3)	4.11	1.59	0.90	5.50	2.78	4.85	1.50	0.33	3.85	0.84	**0.01**	1.15	0.86	1.00	0.11
Overall (62)	**1.70**	**0.37**	**0.85**	**2.86**	**2.44**	**2.69**	**1.12**	**-0.02**	**1.89**	**0.41**	**-0.08**	**-0.47**	**-0.55**	**-0.81**	**-0.65**

Table S8 Mean correlations per biome between the measured E_{unstr} and the different E_p methods. The methods with the highest correlation per biome are highlighted in bold and underlined. Based on a unstressed days only defined using the energy balance criterion. The data are based on a validation dataset of 1/3rd of the sites per biome, a calibration dataset comprising 2/3rd of the sites per biome were used to calibrate the key parameters. This process was repeated 100 times, and the mean correlation per biome of the 100 repetitions is given. The number between brackets of each biome is the number of validation sites used per repetition.

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (4)	0.85	0.91	0.89	0.76	0.81	0.86	0.96	0.96	0.82	**0.96**	**0.96**	0.77	0.77	0.74	0.74
GRA (7)	0.79	0.87	0.87	0.76	0.84	0.82	0.93	0.93	0.80	**0.94**	**0.94**	0.55	0.55	0.56	0.56
DBF (5)	0.79	0.87	0.88	0.80	0.85	0.79	0.91	0.91	0.76	**0.91**	**0.91**	0.58	0.57	0.59	0.59
EBF (3)	0.88	0.89	0.88	0.87	0.85	0.87	**0.91**	**0.91**	0.83	0.90	0.90	0.69	0.76	0.53	0.53
ENF (9)	0.89	0.90	0.91	0.88	0.86	0.90	0.95	0.95	0.88	**0.95**	**0.95**	0.77	0.79	0.76	0.76
MF (2)	0.90	0.93	0.92	0.90	0.93	0.91	**0.94**	**0.94**	0.89	0.94	0.94	0.79	0.75	0.74	0.74
CSH (1)	0.90	0.94	0.93	0.89	0.90	0.90	0.95	0.95	0.89	**0.95**	**0.95**	0.80	0.77	0.75	0.75
WSA (2)	0.76	0.78	0.77	0.73	0.74	0.80	0.89	0.89	0.79	**0.89**	**0.89**	0.39	0.38	0.44	0.44
SAV (2)	0.79	0.83	0.82	0.77	0.80	0.83	**0.91**	**0.91**	0.81	0.91	0.91	0.52	0.52	0.55	0.55
OSH (2)	0.72	0.80	0.77	0.63	0.77	0.79	0.89	0.89	0.78	**0.90**	**0.90**	0.54	0.53	0.56	0.56
WET (2)	**0.87**	0.82	0.75	0.86	0.69	0.79	0.84	0.84	0.69	0.86	0.86	0.56	0.56	0.61	0.61
Overall (39)	**0.83**	**0.88**	**0.87**	**0.81**	**0.83**	**0.85**	**0.93**	**0.93**	**0.82**	**0.93**	**0.93**	**0.65**	**0.65**	**0.64**	**0.64**

Table S9. Unbiased Root Mean Square Error (UnRMSE) (in mm day^{-1}) for the E_p methods per biome. The methods with the lowest UnRMSE per biome are indicated in bold and are underlined. Based on the validation dataset and on unstressed days only defined using the energy balance criterion (See Table S8 for details).

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (4)	1.16	0.79	1.06	1.58	2.85	1.27	0.62	0.58	1.20	0.57	**0.55**	1.25	1.25	1.30	1.30
GRA (7)	1.23	0.70	0.81	1.77	1.03	1.40	0.58	0.47	1.13	**0.45**	0.45	1.07	1.04	1.04	1.04
DBF (5)	1.13	0.86	0.88	1.22	1.31	1.30	0.74	0.71	1.19	0.71	**0.71**	1.37	1.39	1.32	1.27
EBF (3)	0.84	0.62	0.90	1.07	1.26	1.10	0.76	0.60	0.96	0.56	**0.55**	1.05	1.01	1.16	1.16
ENF (9)	0.97	0.77	0.98	1.19	14.66	1.25	0.84	0.52	1.09	0.59	**0.50**	0.91	0.88	0.95	0.96
MF (2)	1.24	0.69	0.73	1.60	1.15	1.65	0.86	0.65	1.28	0.65	**0.64**	1.13	1.07	1.05	1.13
CSH (1)	0.81	0.59	0.68	0.97	0.93	1.10	0.75	**0.53**	0.90	0.54	0.63	0.90	0.96	0.86	0.91
WSA (2)	1.12	0.91	0.80	1.37	1.66	1.24	0.67	0.54	0.98	0.54	**0.53**	1.11	1.12	1.01	1.01
SAV (2)	1.20	0.97	0.82	1.51	1.79	1.36	0.75	**0.53**	1.05	0.57	0.54	1.19	1.17	1.08	1.00
OSH (2)	1.33	0.72	0.63	1.93	0.93	1.60	0.67	**0.42**	1.26	0.48	0.43	1.10	1.04	0.88	0.80
WET (2)	1.21	1.18	1.37	1.35	3.70	1.64	1.21	1.08	1.82	1.07	**1.04**	1.97	2.07	1.58	1.94
Overall (39)	**1.11**	**0.79**	**0.90**	**1.42**	**4.62**	**1.33**	**0.75**	**0.58**	**1.15**	**0.59**	**0.56**	**1.14**	**1.13**	**1.11**	**1.12**

Table S10. Mean bias (in mm day^{-1}) for the E_p methods per biome. The best performing method per biome is indicated in bold and is underlined. Based on the validation dataset and on unstressed days only defined using the energy balance criterion (See Table S8 for details).

	Radiation, Temperature, VPD					*Radiation, Temperature*			*Radiation*			*Temperature*			
	Penman-Monteith			**Penman**		**Priestley and Taylor**			**Milly and Dunne**			**Thornthwaite**		**Oudin**	
	Ref. crop	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Ref. crop**	**Standard**	**Biome**	**Ref. crop**	**Standard**	**Biome**	**Standard**	**Biome**	**Standard**	**Biome**
CRO (4)	1.14	-0.49	0.82	2.83	2.64	2.20	0.47	**-0.01**	1.43	-0.24	0.11	-0.65	-0.59	-1.62	-0.61
GRA (7)	2.65	0.53	1.17	4.37	1.90	3.69	1.11	**0.02**	2.57	0.22	-0.11	-0.14	-0.42	-0.61	-0.73
DBF (5)	0.30	-0.48	0.87	1.30	2.63	1.81	0.94	**-0.06**	0.74	-0.13	-0.16	-1.94	-2.03	-2.44	-0.71
EBF (3)	0.70	**0.04**	0.96	1.39	1.74	1.39	0.79	0.17	0.79	0.17	-0.13	-0.83	-0.24	-0.53	-0.34
ENF (9)	1.28	0.45	1.22	2.03	1.04	2.06	1.17	-0.05	1.88	0.90	**0.02**	-0.15	-0.04	-0.73	-0.53
MF (2)	2.22	0.65	0.16	3.31	2.04	3.26	1.46	-0.10	2.53	0.87	-0.06	0.73	0.20	**-0.01**	-0.82
CSH (1)	1.01	0.49	-0.33	1.61	1.79	1.46	1.10	-0.16	0.92	0.51	-0.37	0.18	0.43	**0.14**	-0.71
WSA (2)	2.67	1.16	0.11	3.68	3.88	3.63	1.42	**-0.04**	2.33	0.40	-0.24	-0.14	-0.24	-0.20	-0.39
SAV (2)	2.56	1.30	0.30	3.57	3.78	3.34	1.47	-0.19	2.21	0.54	-0.18	0.03	**0.00**	0.40	-0.98
OSH (2)	4.32	1.68	0.36	6.20	2.73	5.08	2.00	0.13	3.89	1.15	**-0.03**	1.13	0.91	0.81	-0.43
WET (2)	2.34	1.28	1.87	4.17	4.51	3.45	2.00	1.27	3.29	1.43	1.04	1.42	0.80	**-0.52**	-1.94
Overall (39)	**1.69**	**0.40**	**0.92**	**2.88**	**2.21**	**2.67**	**1.14**	**0.04**	**1.92**	**0.45**	**-0.02**	**-0.38**	**-0.43**	**-0.80**	**-0.68**

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