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Inter-annual variability of the global terrestrial water cycle

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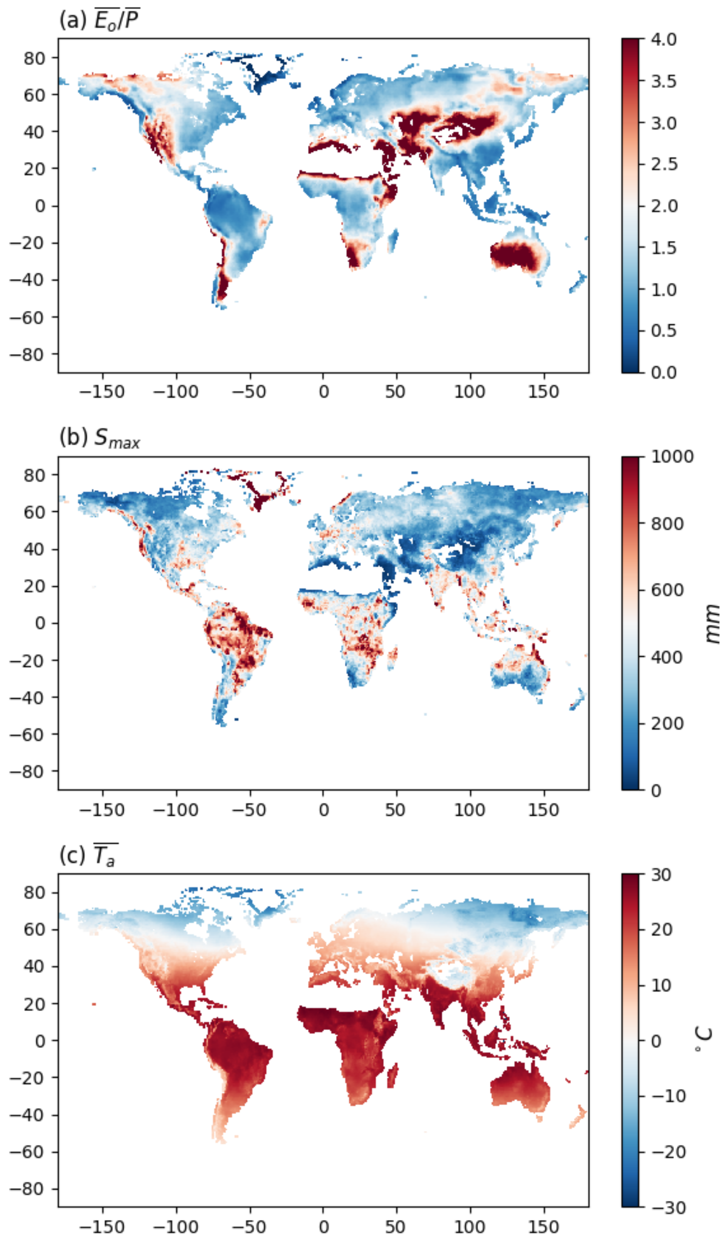

Figure S1. (a) Aridity index ($\overline{E_o}/\overline{P}$), (b) water storage capacity (S_{max}) and (c) mean annual air temperature ($\overline{T_a}$) used in the analysis.

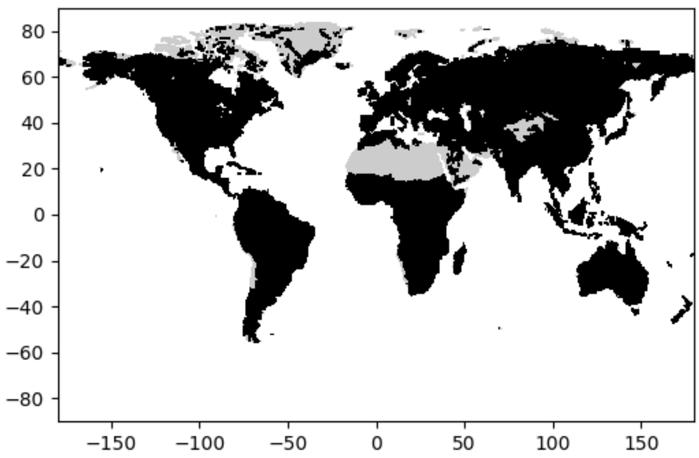

Figure S2. Spatial mask used in this study. Grey areas (e.g., Himalayan region, Sahara Desert, Greenland) have been masked out of the CDR database.

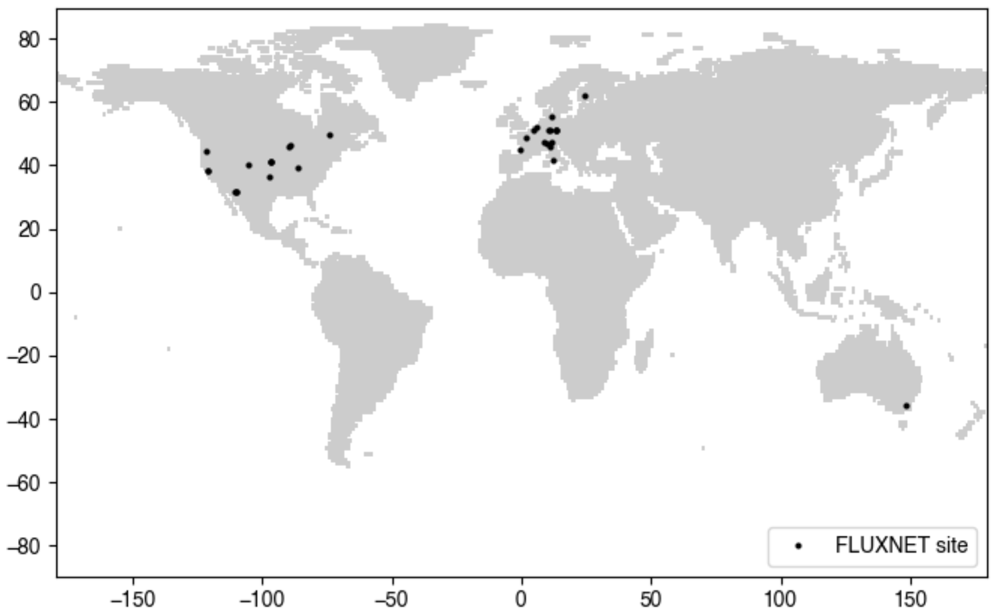

Figure S3. Location of the 32 FLUXNET sites used to evaluate the Climate Data Record (CDR).

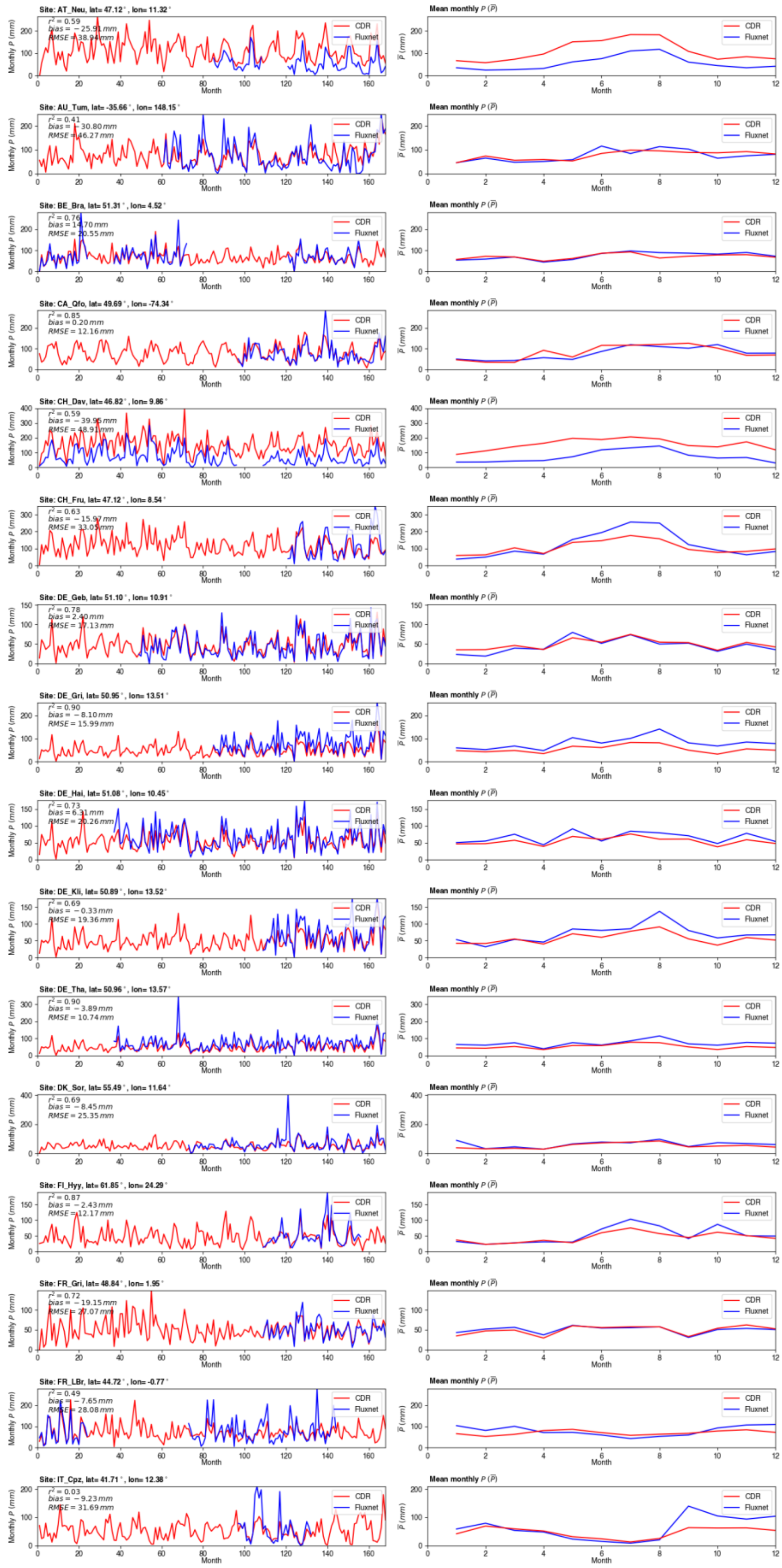

Figure S4. Comparison of monthly precipitation *P* time series (left panels) and mean monthly *P* (right panels) between FLUXNET observations at 32 sites (Table S1) and the Climate Data Record (CDR).

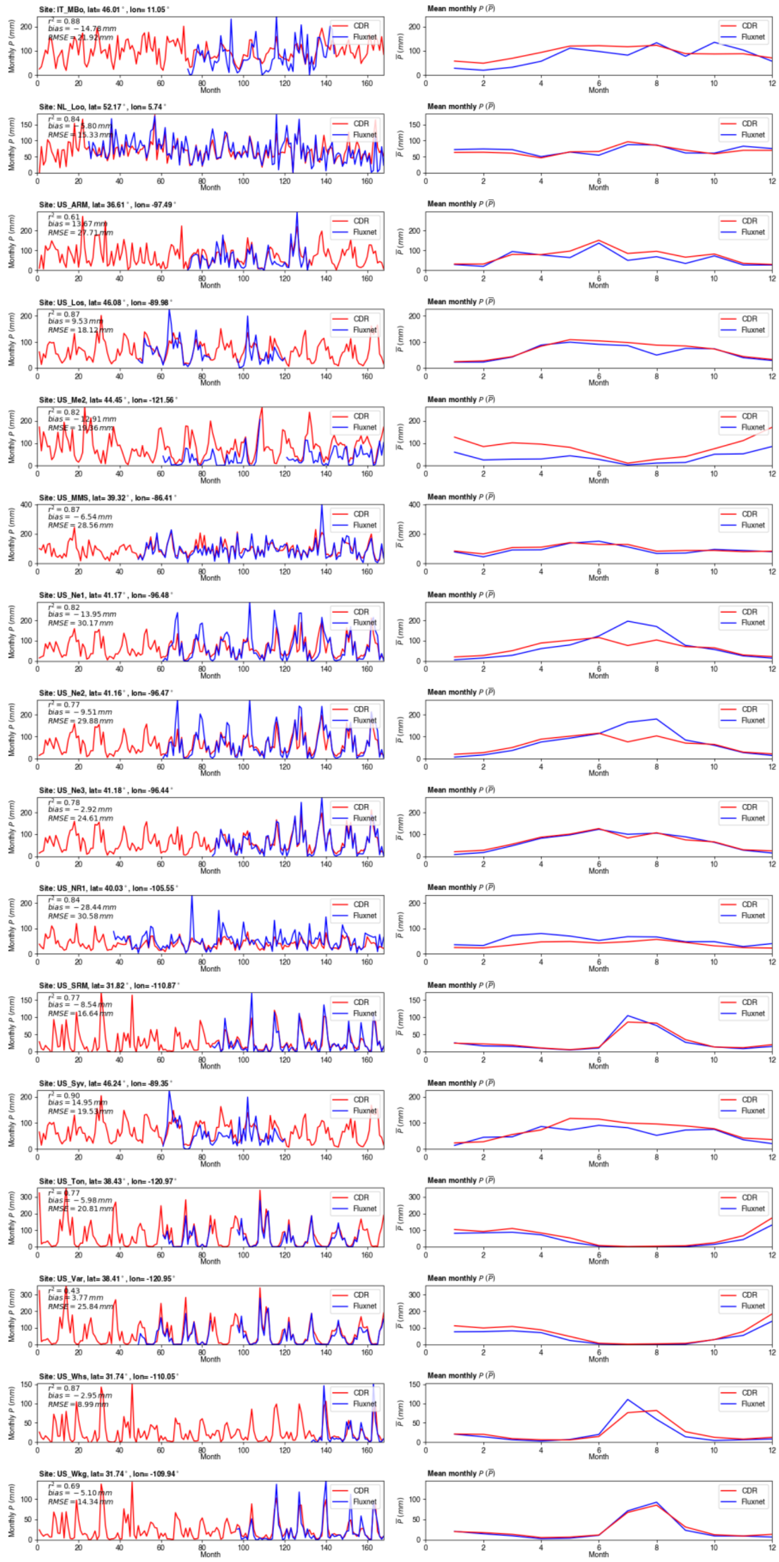

Figure S4 continued.

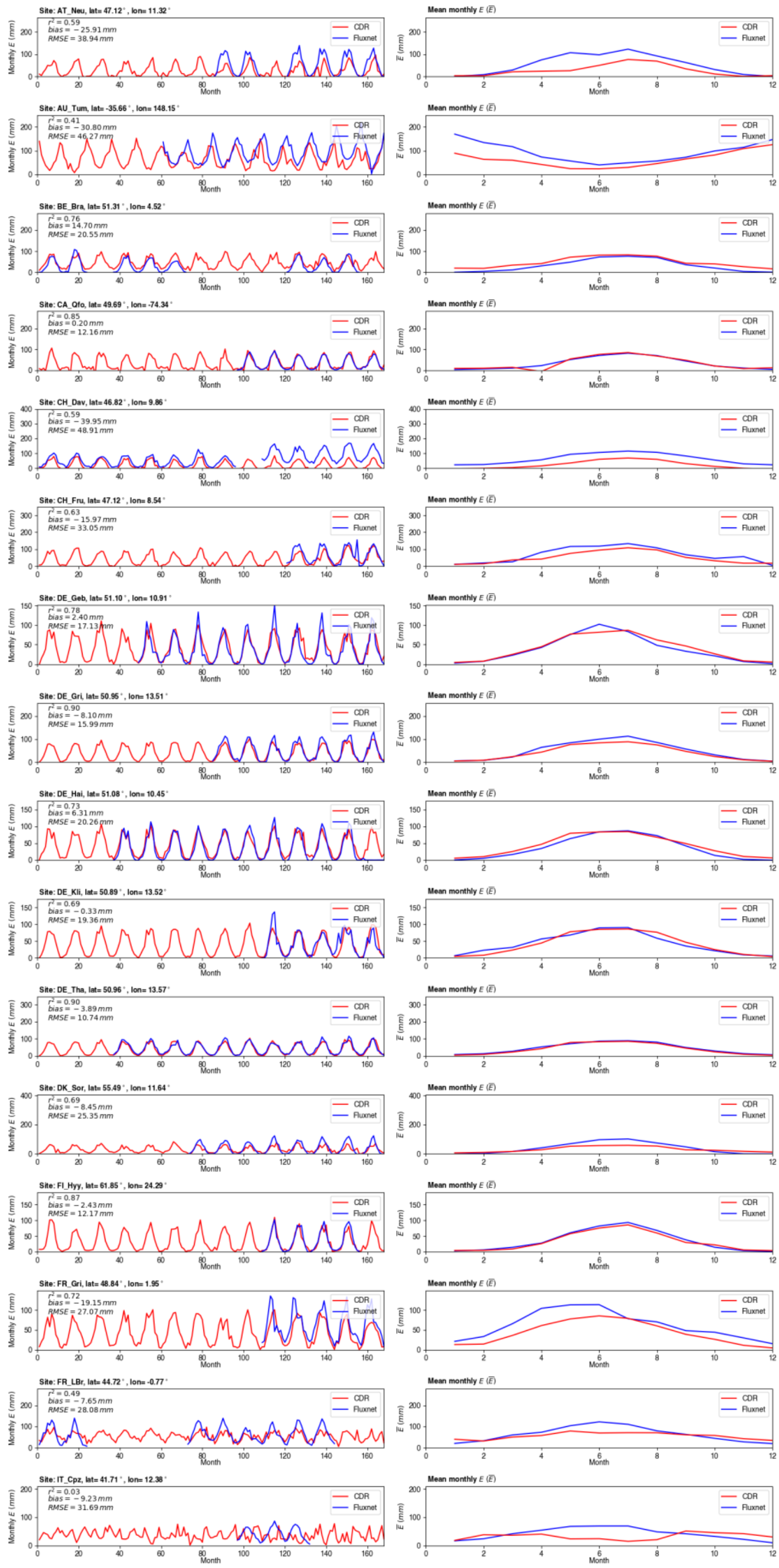

Figure S5. Comparison of monthly evapotranspiration *E* time series (left panels) and mean monthly *E* (right panels) between FLUXNET site observations and the Climate Data Record (CDR).

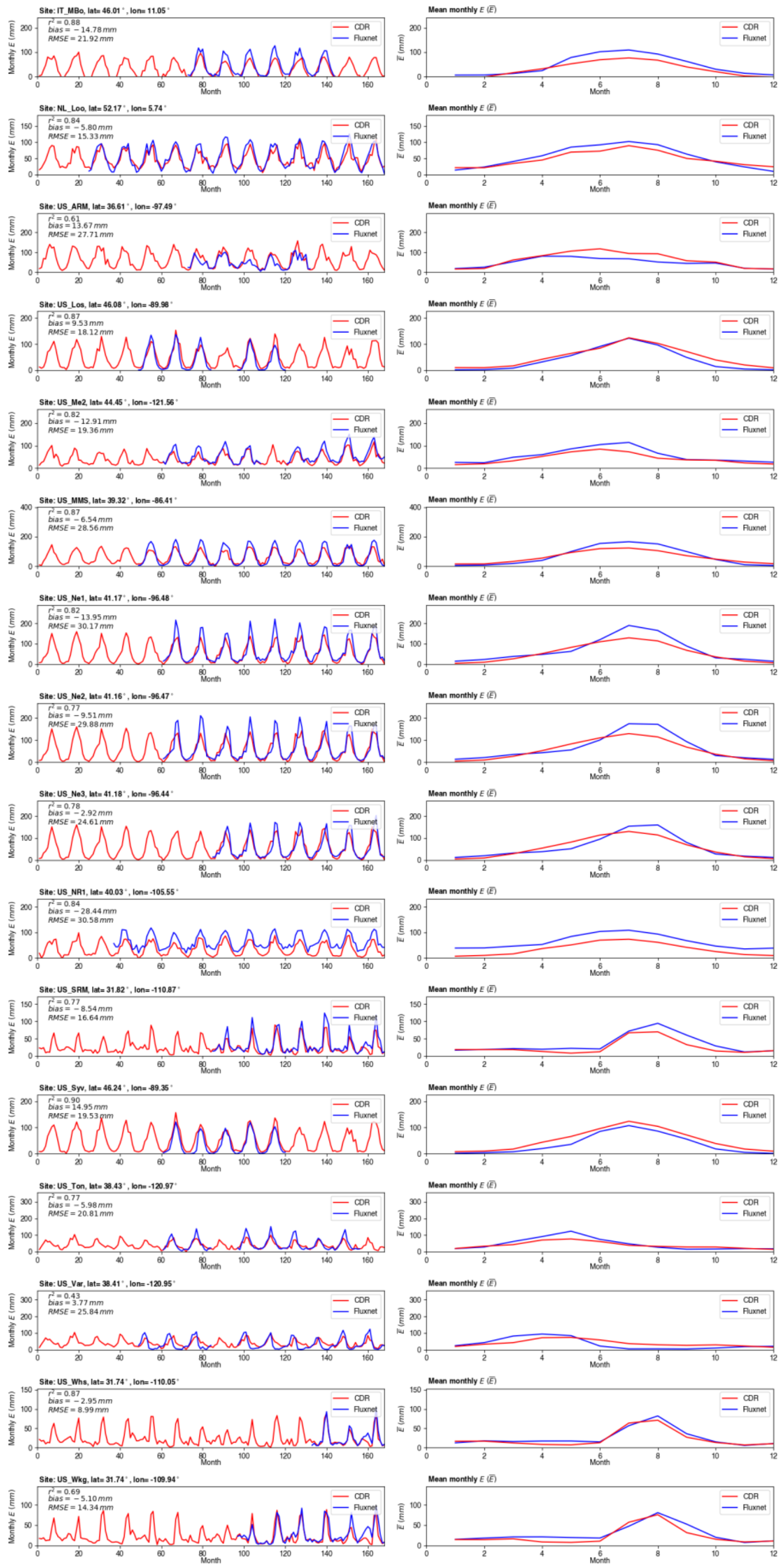

Figure S5 continued.

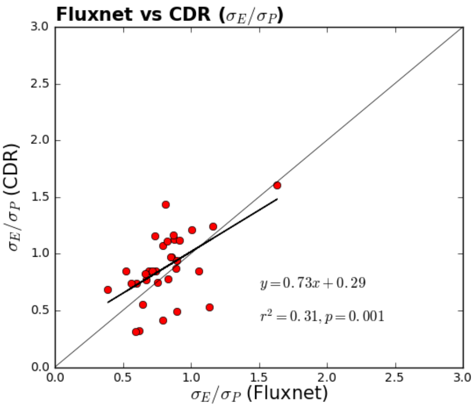

Figure S6. Comparison of ratio of standard deviation of monthly evapotranspiration *E* to precipitation *P* (σ_E/σ_P) between FLUXNET site observations and the Climate Data Record (CDR).

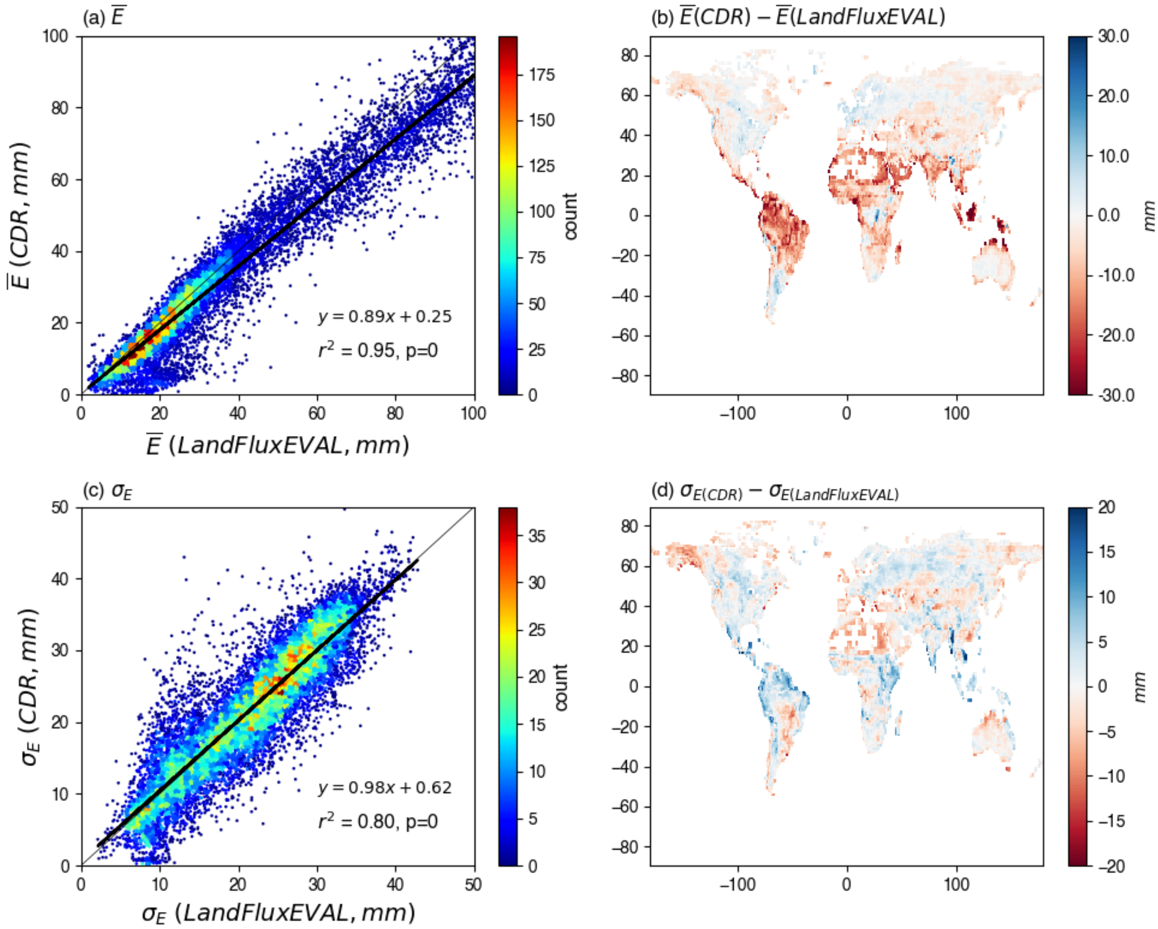

Figure S7. Comparison of monthly evapotranspiration *E* between LandFluxEVAL and Climate Data Record (CDR) databases. Top panels (a) (b) show comparison of the mean monthly ($\overline{E}$) while bottom panels (c) (d) show comparison of the standard deviation (σ_E) of monthly *E*.

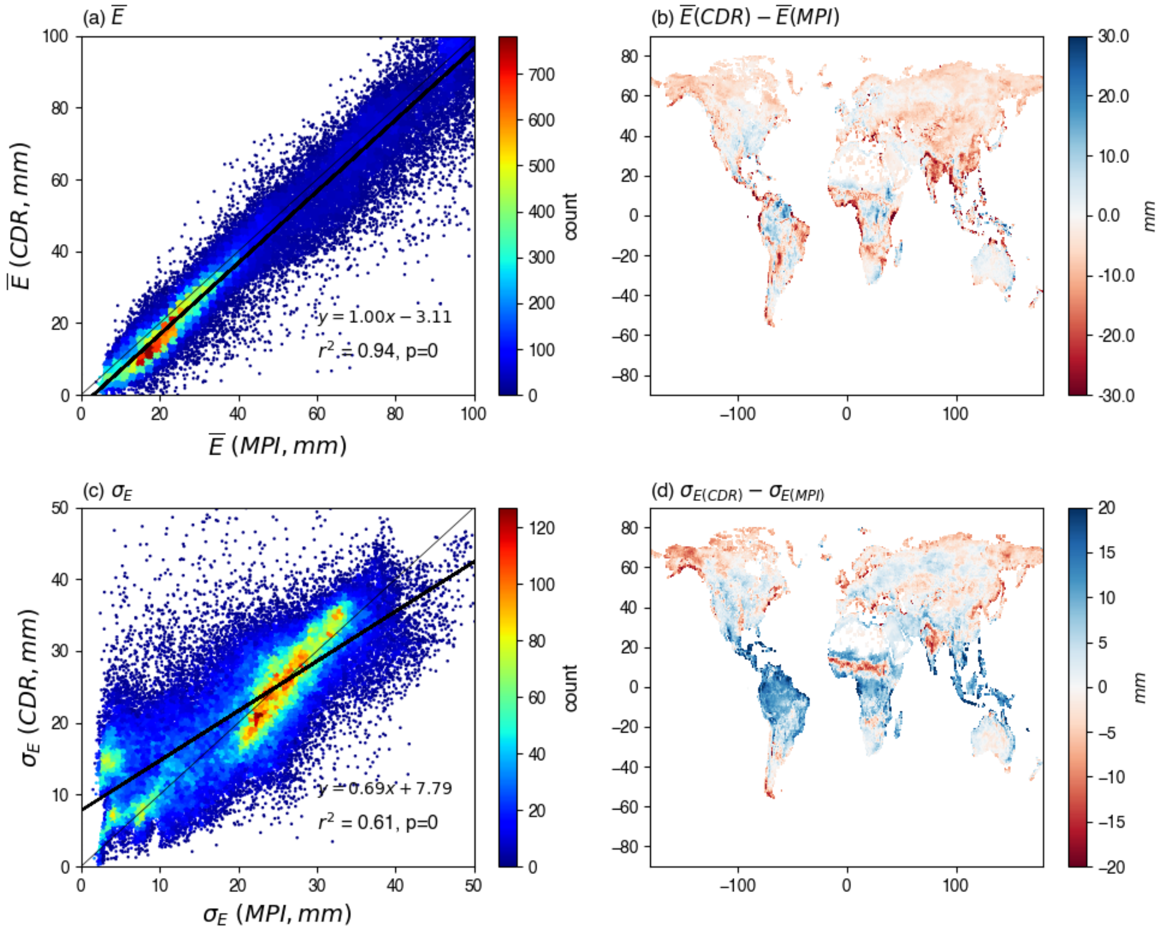

Figure S8. Comparison of monthly evapotranspiration *E* between Max Planck Institute (MPI) and Climate Data Record (CDR) databases. Top panels (a) (b) show comparison of the mean monthly ($\overline{E}$) while bottom panels (c) (d) show comparison of the standard deviation (σ_E) of monthly *E*.

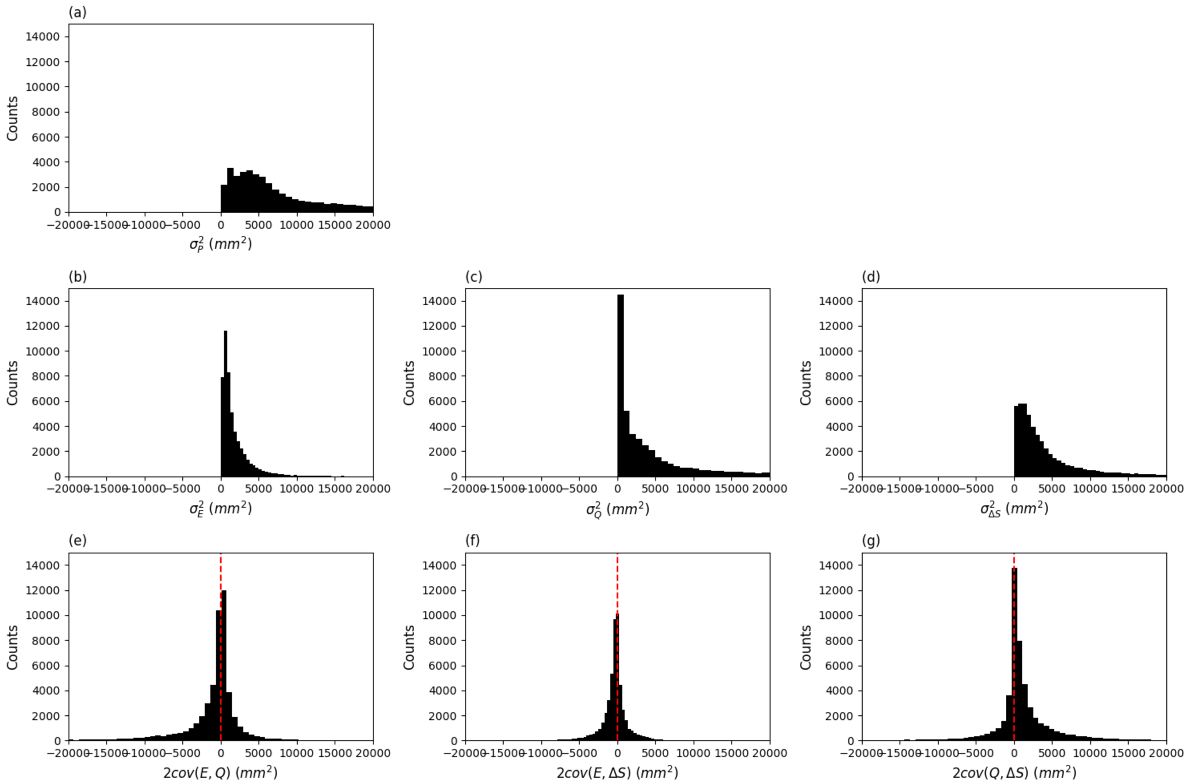

Figure S9. Distribution for each of the water cycle variances (σ_P^2, σ_E^2, σ_Q^2, $\sigma_{\Delta S}^2$) and covariances ($cov(E,Q)$, $cov(E,\Delta S)$, $cov(Q,\Delta S)$) shown in Fig. 3. Note that we have multiplied the covariances by two (see Eq. 2).

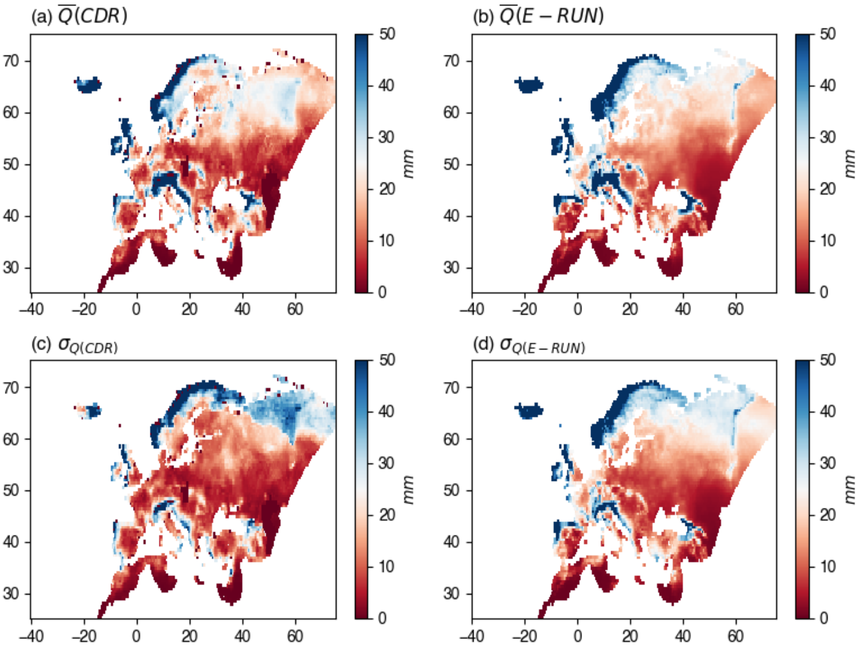

Figure S10. Mean ($\overline{Q}$) and standard deviation (σ_Q) of monthly runoff Q in the E-RUNOFF and Climate Data Record (CDR) databases in the area of spatial overlap (Europe). Top panels (a) (b) show the mean monthly ($\overline{Q}$) while bottom panels (c) (d) show the standard deviation (σ_Q) of monthly Q.

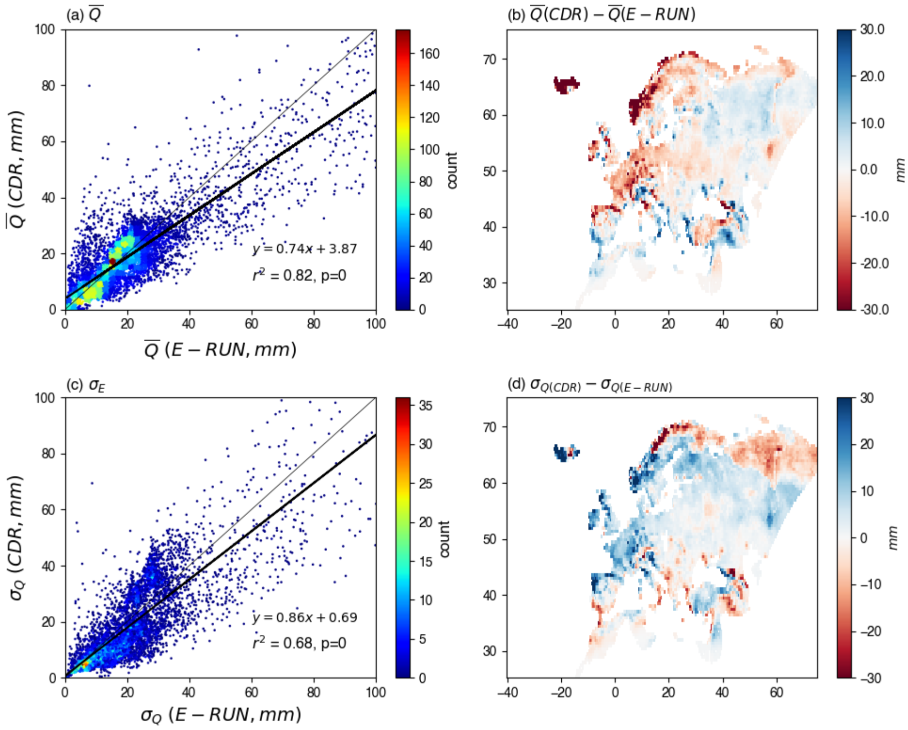

Figure S11. Comparison of monthly runoff Q between the E-RUNOFF and Climate Data Record (CDR) databases in the area of spatial overlap (Europe). Top panels (a) (b) show comparison of the mean monthly ($\overline{Q}$) while bottom panels (c) (d) show comparison of the standard deviation (σ_Q) of monthly Q.

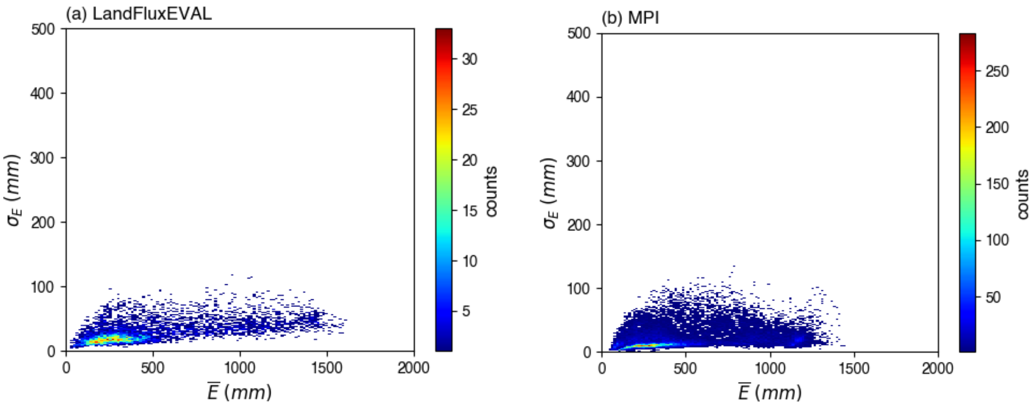

Figure S12. The same as Fig. 4b in main text but using evapotranspiration *E* data from the (a) LandFluxEVAL and (b) MPI databases.

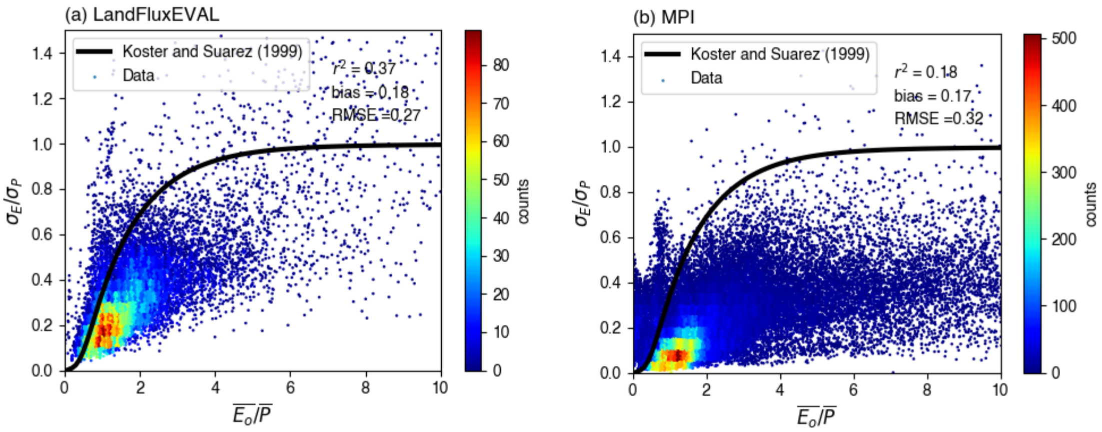

Figure S13. The same as Fig. 5a in main text but using evapotranspiration *E* data from the (a) LandFluxEVAL and (b) MPI databases.

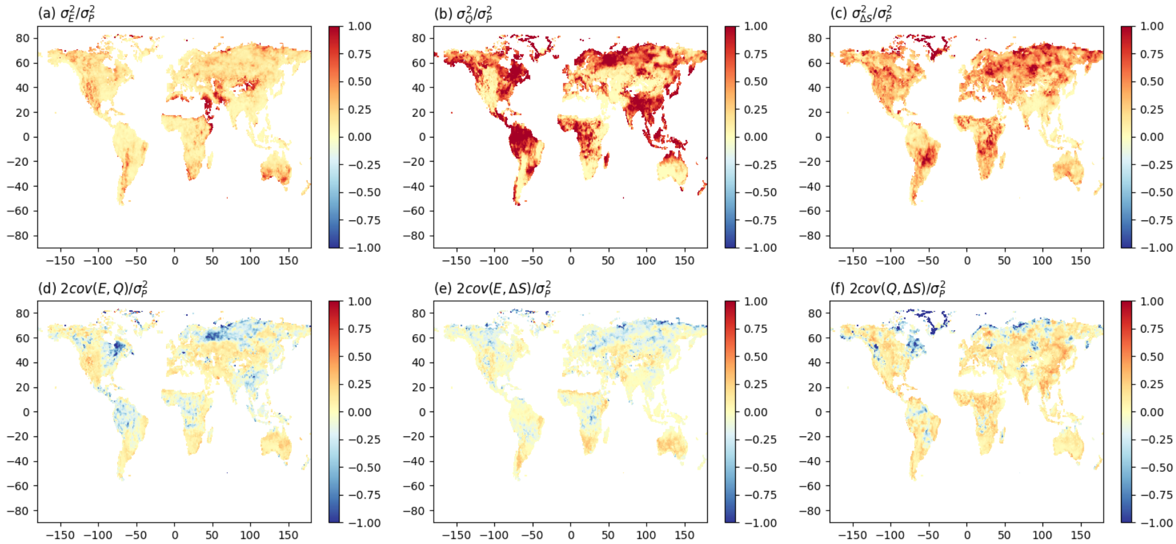

Figure S14. Inter-annual water cycle variances (σ_E^2, σ_Q^2, $\sigma_{\Delta S}^2$) and covariances ($cov(E,Q)$, $cov(E,\Delta S)$, $cov(Q,\Delta S)$) expressed as a fraction of the variance of P (σ_P^2). Note that we have multiplied the covariances by two (see Eq. 2).

Table S1. Summary of comparisons of monthly precipitation *P* and evapotranspiration *E* between observations at 32 FLUXNET sites and the CDR database.

Site ID	Site Name	Lat	Lon	Ref	Data period	r^2 (*P*)	bias (*P*, mm)	RMSE (*P*, mm)	r^2 (*E*)	bias (*E*, mm)	RMSE (*E*, mm)
AT_Neu	Neustift	47.1167	11.3175	Wohlfahrt et al., 2008	2004 - 2005, 2007 - 2010	**0.64**	53.54	61.53	**0.59**	-25.91	38.94
AU_Tum	Tumbarumba	-35.6566	148.1517	Leuning et al., 2005	2002 - 2010	**0.56**	1.08	39.34	**0.41**	-30.80	46.27
BE_Bra	Brasschaat	51.3076	4.5198	Carrara et al., 2004	1997 - 1998, 2000 -2002, 2007 - 2009	**0.64**	-3.05	26.66	**0.76**	14.70	20.55
CA_Qfo	Quebec - Eastern Boreal, Mature Black Spruce	49.6925	-74.3421	Bergeron et al., 2006	2005 - 2010	**0.57**	4.43	31.77	**0.85**	0.20	12.16
CH_Dav	Davos	46.8153	9.8559	Zielis et al., 2014	1997 - 2004, 2006 - 2010	**0.64**	82.53	91.39	**0.59**	-39.95	48.91
CH_Fru	Früebüel	47.1158	8.5378	Imer et al., 2013	2007 - 2010	**0.65**	-15.42	55.86	**0.63**	-15.97	33.05
DE_Geb	Gebesee	51.1001	10.9143	Anthoni et al., 2004	2001 - 2010	**0.69**	3.78	17.69	**0.78**	2.40	17.13
DE_Gri	Grillenburg	50.9500	13.5126	Prescher et al., 2010	2004 - 2010	**0.70**	-26.32	37.67	**0.90**	-8.10	15.99
DE_Hai	Hainich	51.0792	10.4530	Knohl et al., 2003	2000 - 2012	**0.70**	-10.35	23.17	**0.73**	6.31	20.26
DE_Kli	Klingenberg	50.8931	13.5224	Prescher et al., 2010	2006 - 2010	**0.68**	-13.61	28.05	**0.69**	-0.33	19.36
DE_Tha	Tharandt	50.9624	13.5652	Grünwald and Bernhofer, 2007	2000 - 2010	**0.66**	-18.71	32.35	**0.90**	-3.89	10.74
DK_Sor	Soroe	55.4859	11.6446	Pilegaard et al., 2011	2003 - 2010	**0.45**	-11.07	39.31	**0.69**	-8.45	25.35
FI_Hyy	Hyytiala	61.8474	24.2948	Suni et al., 2003	2006 - 2009	**0.78**	-7.07	20.43	**0.87**	-2.43	12.17
FR_Gri	Grignon	48.8442	1.9519	Loubet et al., 2011	2006 - 2010	**0.69**	-0.81	12.35	**0.72**	-19.15	27.07
FR_LBr	Le Bray	44.7171	-0.7693	Berbigier et al., 2001	1997 -1998, 2003 - 2008	**0.56**	-9.19	39.93	**0.49**	-7.65	28.08
IT_Cpz	Castelporziano	41.7053	12.3761	Garbulsky et al., 2008	2005 - 2007	**0.76**	-15.90	40.42	0.03	-9.23	31.69

IT_MBo	Monte Bondone	46.0147	11.0458	Marcolla et al., 2011	2003 - 2008	**0.36**	12.43	48.14	**0.88**	-14.78	21.92
NL_Loo	Loobos	52.1666	5.7436	Moors 2012	1999 - 2010	**0.56**	-2.16	24.78	**0.84**	-5.80	15.33
US_ARM	ARM Southern Great Plains site-Lamont	36.6058	-97.4888	Baldocchi and Sturtevant 2015	2003 - 2007	**0.71**	13.53	31.78	**0.61**	13.67	27.71
US_Los	Lost Creek	46.0827	-89.9792	Baker et al., 2003	2001 - 2003, 2005 - 2006	**0.52**	7.76	32.82	**0.87**	9.53	18.12
US_Me2	Metolius mature ponderosa pine	44.4523	-121.5574	Law (2002-2014)	2002 - 2005, 2007 - 2010	**0.54**	45.31	56.84	**0.82**	-12.91	19.36
US_MMS	Morgan Monroe State Forest	39.3232	-86.4131	Novick and Phillips (1999-2014)	2001 - 2010	**0.72**	6.60	31.44	**0.87**	-6.54	28.56
US_Ne1	Mead - irrigated continuous maize site	41.1651	-96.4766	Suyker (2001-2013a)	2002 - 2010	**0.45**	-6.64	51.86	**0.82**	-13.95	30.17
US_Ne2	Mead - irrigated maize-soybean rotation site	41.1649	-96.4701	Suyker (2001-2013b)	2002 - 2010	**0.56**	-8.77	46.45	**0.77**	-9.51	29.88
US_Ne3	Mead - rainfed maize-soybean rotation site	41.1797	-96.4397	Suyker (2001-2013c)	2004 - 2010	**0.88**	2.28	21.43	**0.78**	-2.92	24.61
US_NR1	Niwot Ridge Forest (LTER NWT1)	40.0329	-105.5464	Blanken (1998-2014)	2000 - 2010	**0.51**	-16.06	29.57	**0.84**	-28.44	30.58
US_SRM	Santa Rita Mesquite	31.8214	-110.8661	Barron-Gafford et al., 2011	2004 - 2010	**0.81**	1.34	15.40	**0.77**	-8.54	16.64
US_Syv	Sylvania Wilderness Area	46.2420	-89.3477	Desai et al., 2008	2002 - 2006	**0.33**	13.17	40.68	**0.90**	14.95	19.53
US_Ton	Tonzi Ranch	38.4316	-120.9660	Baldocchi et al., 2010	2002 - 2003, 2005 - 2009	**0.89**	14.68	27.44	**0.77**	-5.98	20.81

US_Var	Vaira Ranch- Ione	38.4133	-120.9507	Baldocchi et al., 2004	2001 - 2003, 2005 - 2010	**0.86**	16.91	30.92	**0.43**	3.77	25.84
US_Whs	Walnut Gulch Lucky Hills Shrub	31.7438	-110.0522	Biederman et al., 2016	2008 - 2010	**0.65**	1.89	21.26	**0.87**	-2.95	8.99
US_Wkg	Walnut Gulch Kendall Grasslands	31.7365	-109.9419	Biederman et al., 2016	2005 - 2010	**0.78**	1.59	15.66	**0.69**	-5.10	14.34

* Significant r^2 values (linear regression $p < 0.05$) are shown in bold.

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