Supplementary Material

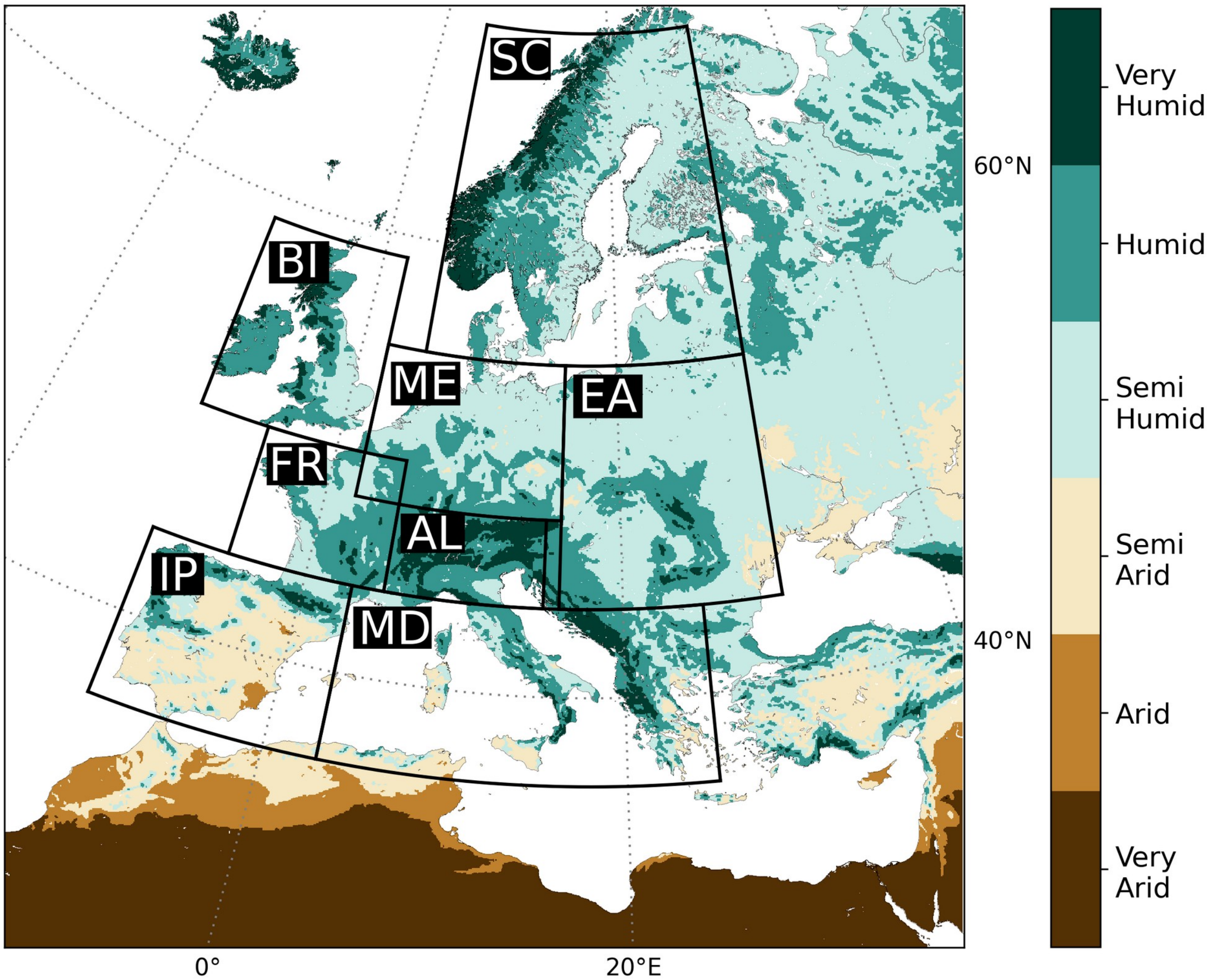

Fig. S5| Hydro climates (colormap, defined by annual precipitation thresholds, see Supplementary Table S1) and PRUDENCE[58] regions. IP: Iberian Peninsula, MD: Mediterranean, FR: France, AL: Alps, EA: Eastern Europe, BI: British Islands, ME: Mid / Central Europe, SC: Scandinavia.

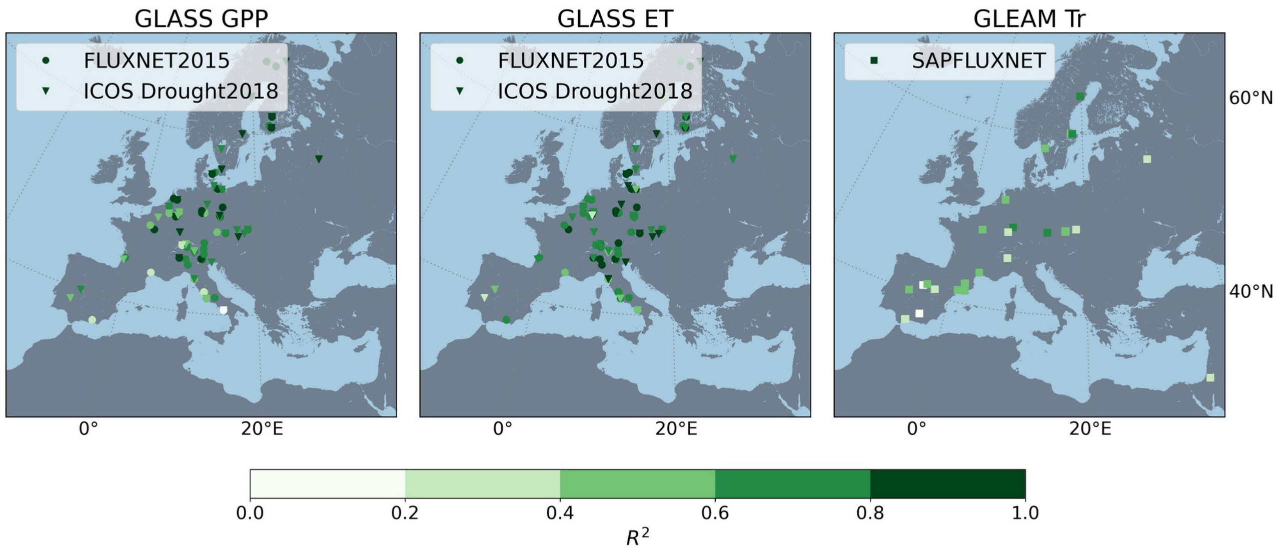

Fig. S6| Distribution of FLUXNET (circles), ICOS (triangles) and SAPFLUXNET (squares) stations. The color of the markers indicate the coefficient of determination R^2 (colormap) for gross primary production (GPP)(a), evapotranspiration (ET)(b) and transpiration (Tr)(c).

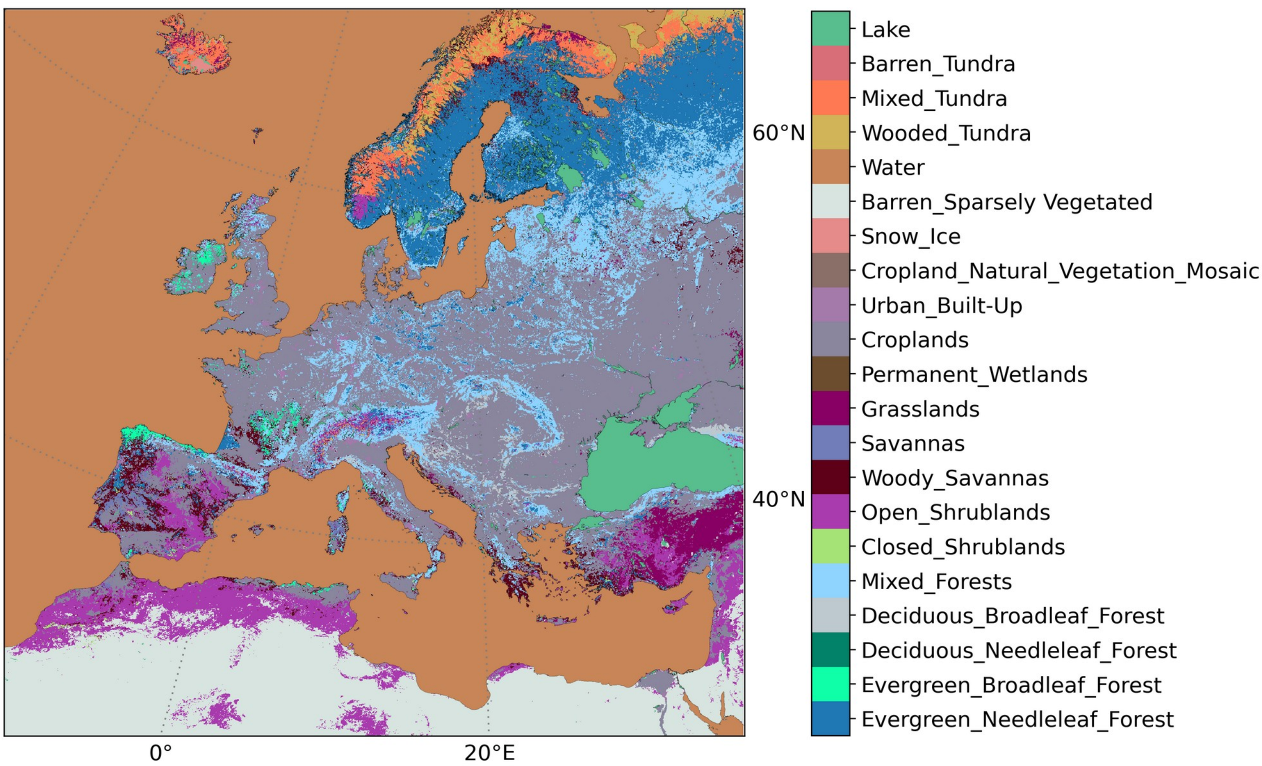

Fig. S7| Land cover over the study domain from IGBP-modified MODIS 20 land-use categories.

Table S1| Hydro-climates and defined annual precipitation (P_a) thresholds. Adapted from Jafari et al. 2018[46].

Hydro-climate	Annual precipitation (P_a) thresholds [mm]
Very humid	$P_a \geq 1200$
Humid	$700 \leq P_a < 1200$
Semi humid	$500 \leq P_a < 700$
Semi arid	$250 \leq P_a < 500$
Arid	$100 \leq P_a < 250$
Very arid	$P_a < 100$

Table S2| Drought categories by thresholds of a drought index (SXI). These thresholds were applied to both SPI and SSI values to determine the severity of the drought as used in Fig. 3.

Drought Category	Drought Index (SXI) Threshold
Extreme dry	SXI < -2
Very dry	-2 ≤ SXI < -1.5
Moderate dry	-1.5 ≤ SXI < -1
Normal	-1 ≤ SXI < 1
Moderate wet	1 ≤ SXI < 2
Very wet	1.5 ≤ SXI < 2
Extreme wet	SXI ≥ 2

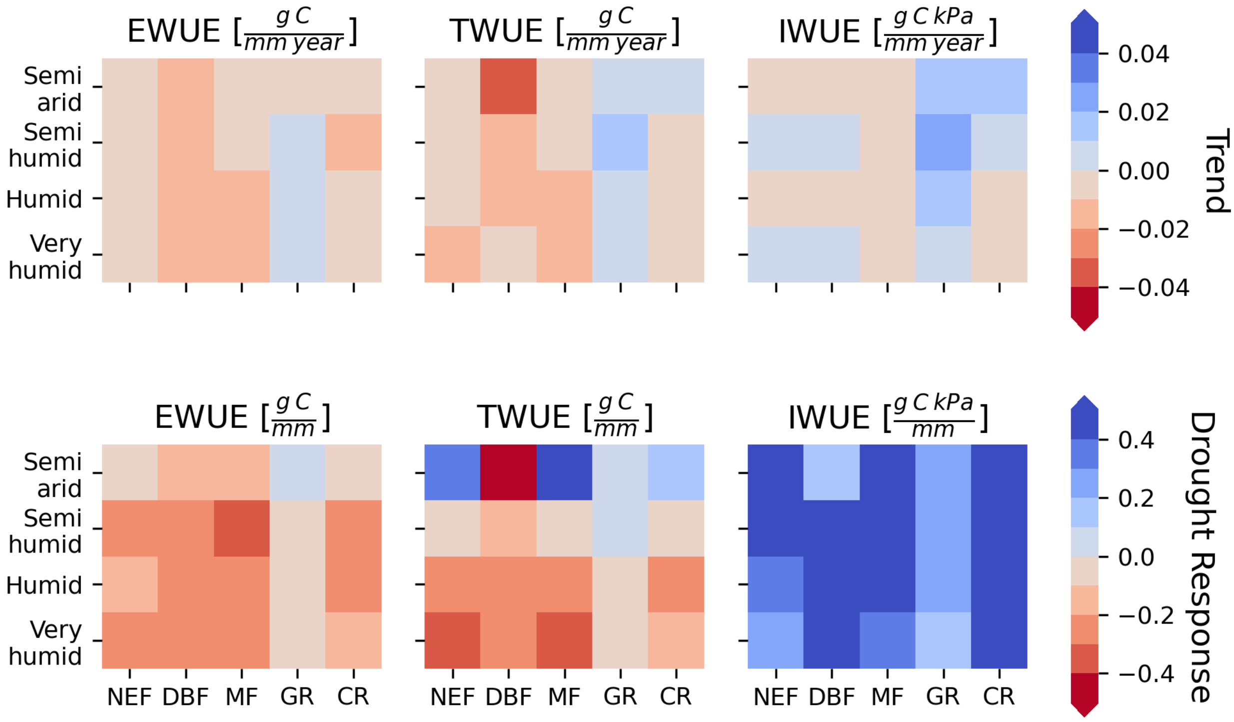

Fig. S8| The median trend (a, b, c) and median drought response (d, e, f) aggregated over grid cells along land cover (x-axes, NEF = Needleleaf Evergreen Forest, DBF = Deciduous Broadleaf Forest, MF = Mixed Forest, GR = Grasslands, C = Croplands) and hydro-climates (y-axes).

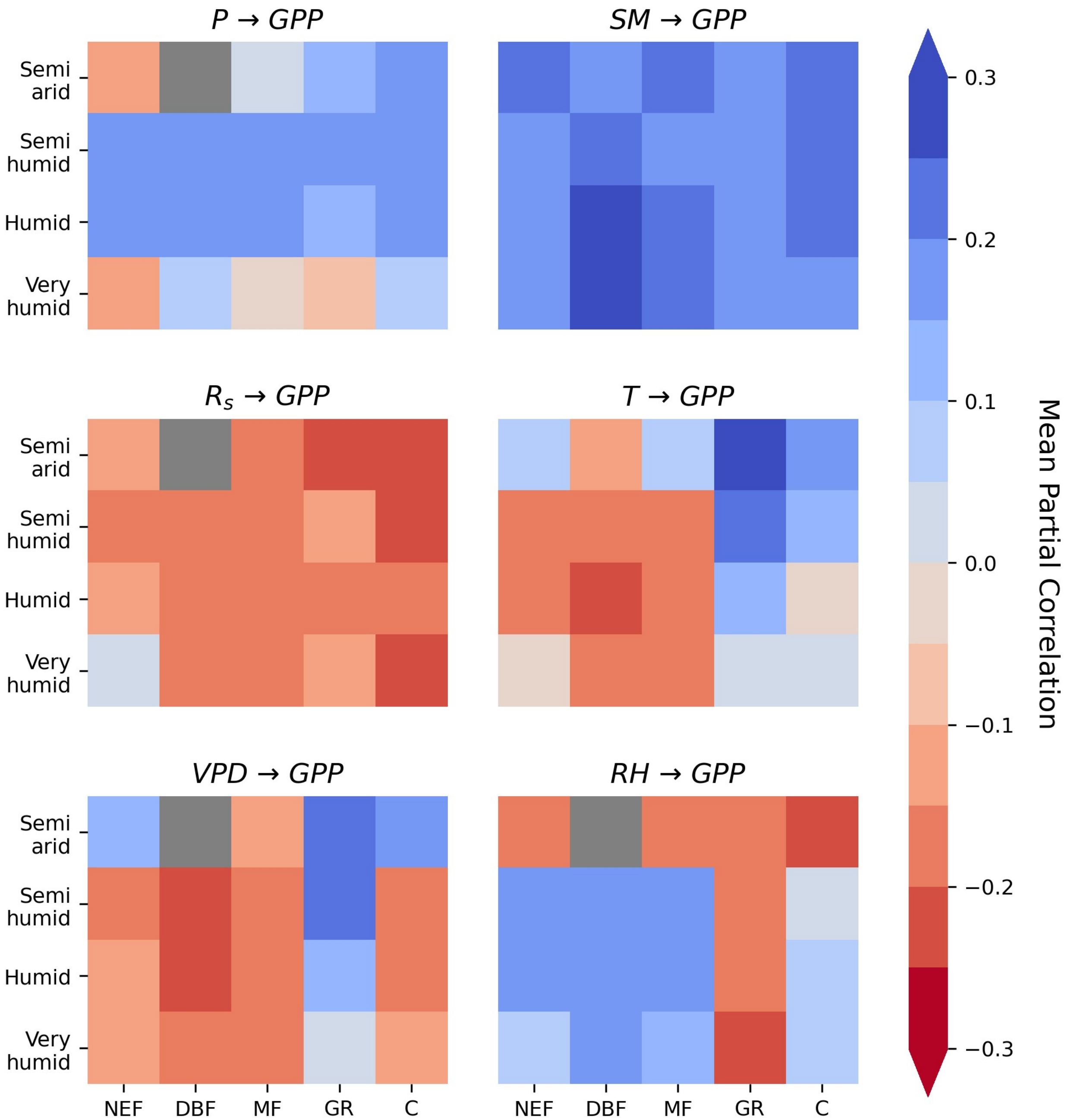

Fig. S9| Mean partial correlations (colormap) at detected directed links from the PCMCI+ analysis between hydrological (precipitation (P), soil moisture (SM)) and meteorological (shortwave incoming radiation (R_s), temperature (T), vapour pressure deficit (VPD), relative humidity (RH)) variables to Gross Primary Production (GPP) aggregated over land cover (x-axes, NEF = Needleleaf Evergreen Forest, DBF = Deciduous Broadleaf Forest, MF = Mixed Forest, GR = Grasslands, C = Croplands) and hydro-climates (y-axes).

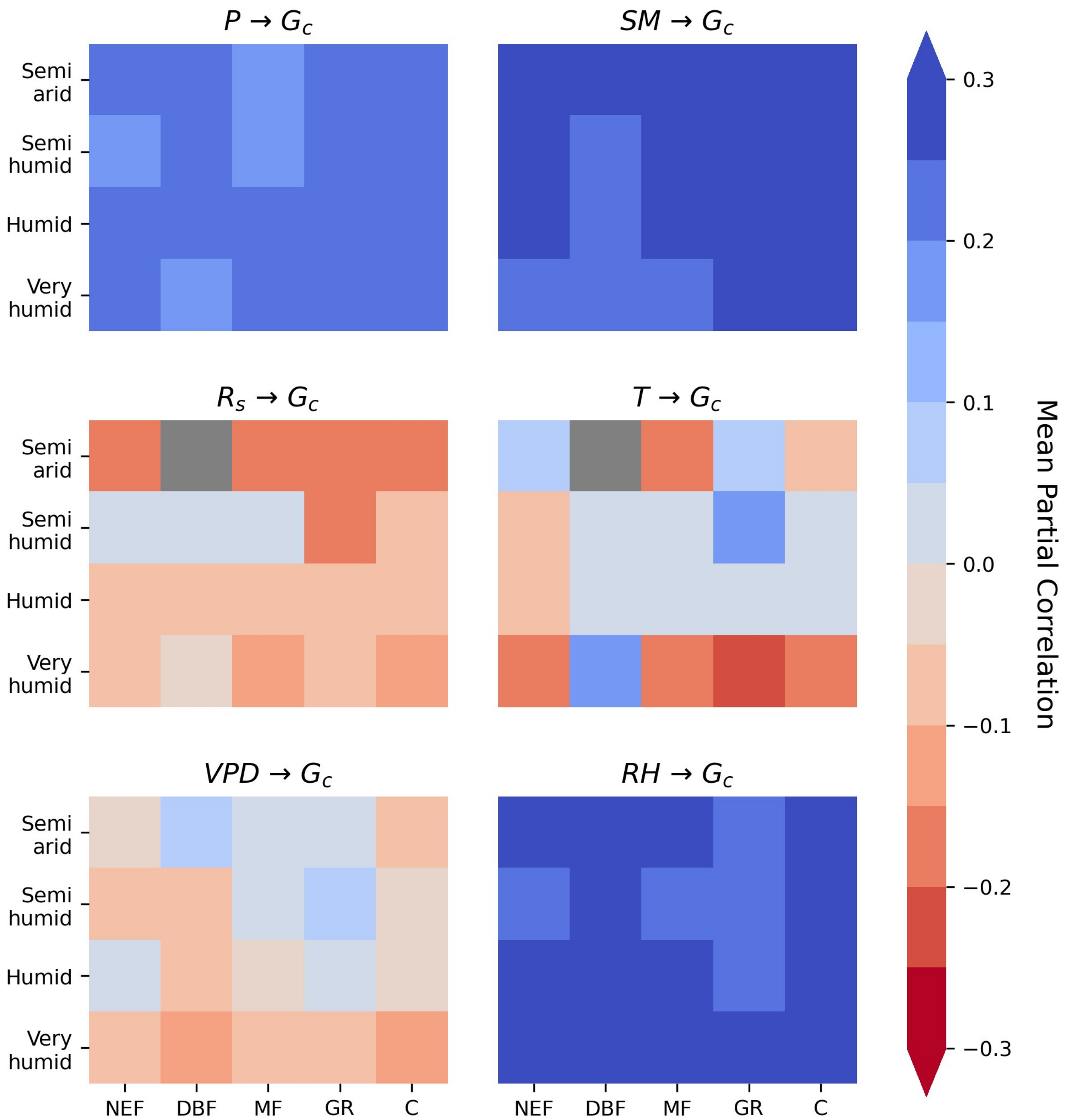

Fig. S10| Mean partial correlations (colormap) at detected directed links from the PCMCI+ analysis between hydrological (precipitation (P), soil moisture (SM)) and meteorological (shortwave incoming radiation (R_s), temperature (T), vapour pressure deficit (VPD), relative humidity (RH)) variables to canopy conductance (G_c) aggregated over land cover (x-axes, NEF = Needleleaf Evergreen Forest, DBF = Deciduous Broadleaf Forest, MF = Mixed Forest, GR = Grasslands, C = Croplands) and hydro-climates (y-axes).

Table S3| FLUXNET2015 site data availability information and coefficient of determination (R^2) with the interpolated GLASS gross primary production (GPP) and evapotranspiration (ET).

Site Code	Latitude	Longitude	Start Year	End Year	N Years	R^2 - GPP	R^2 - ET
AT-Neu	47.12	11.32	2002	2012	11	0.65	0.73
BE-Bra	51.3076	4.5198	1996	2014	19	0.7969	0.7498
BE-Lon	50.5516	4.7462	2004	2014	11	0.4158	0.6768
BE-Vie	50.3049	5.9981	1996	2014	19	0.8259	0.7544
CH-Cha	47.2102	8.4104	2005	2014	10	0.5779	0.8279
CH-Dav	46.8153	9.8559	1997	2014	18	0.6405	0.5675
CH-Fru	47.1158	8.5378	2005	2014	10	0.7134	0.7406
CH-Lae	47.4783	8.3644	2004	2014	11	0.725	0.7836
CH-Oe1	47.2858	7.7319	2002	2008	7	0.5537	0.7991
CH-Oe2	47.2864	7.7338	2004	2014	11	0.372	0.7057
CZ-BK1	49.5021	18.5369	2004	2014	11	0.7039	0.6453
CZ-BK2	49.4944	18.5429	2004	2012	9	0.7047	0.6735
CZ-wet	49.0247	14.7704	2006	2014	9	0.777	0.8101
DE-Akm	53.8662	13.6834	2009	2014	6	0.7967	0.833
DE-Geb	51.0997	10.9146	2001	2014	14	0.5494	0.7468
DE-Gri	50.95	13.5126	2004	2014	11	0.7394	0.7693
DE-Hai	51.0792	10.4522	2000	2012	13	0.8139	0.8466
DE-Kli	50.8931	13.5224	2004	2014	11	0.5183	0.6573
DE-Lkb	49.0996	13.3047	2009	2013	5	0.5941	0.7711
DE-Lnf	51.3282	10.3678	2002	2012	11	0.8058	0.8037
DE-Obe	50.7867	13.7213	2008	2014	7	0.7338	0.7647
DE-RuR	50.6219	6.3041	2011	2014	4	0.7825	0.8995
DE-RuS	50.8659	6.4471	2011	2014	4	0.6267	0.8024
DE-Seh	50.8706	6.4497	2007	2010	4	0.5818	0.7269
DE-SfN	47.8064	11.3275	2012	2014	3	0.749	0.8758
DE-Spw	51.8923	14.0337	2010	2014	5	0.8777	0.84
DE-Tha	50.9626	13.5652	1996	2014	19	0.8457	0.7349
DE-Zrk	53.8759	12.889	2013	2014	2	0.8265	0.8869
DK-Eng	55.6905	12.1918	2005	2008	4	0.7097	0.8365
DK-Sor	55.4859	11.6446	1996	2014	19	0.9202	0.858
ES-LgS	37.0979	-2.9658	2007	2009	3	0.2269	0.602
FI-Hyy	61.8474	24.2948	1996	2014	19	0.9093	0.8344
FI-Jok	60.8986	23.5135	2000	2003	4	0.6497	0.7566
FI-Let	60.6418	23.9595	2009	2012	4	0.8718	0.8641
FI-Lom	67.9972	24.2092	2007	2009	3	0.8537	0.7982
FI-Sod	67.3624	26.6386	2001	2014	14	0.8103	0.8082
FR-Fon	48.4764	2.7801	2005	2014	10	0.8276	0.8583
FR-Gri	48.8442	1.9519	2004	2014	11	0.4655	0.6215
FR-LBr	44.7171	-0.7693	1996	2008	13	0.6657	0.662

FR-Pue	43.7413	3.5957	2000	2014	15	0.3914	0.4659
IT-BCi	40.5238	14.9574	2004	2014	11	0.0259	0.51
IT-CA1	42.3804	12.0266	2011	2014	4	0.6549	0.6857
IT-CA2	42.3772	12.026	2011	2014	4	0.3282	0.3121
IT-CA3	42.38	12.0222	2011	2014	4	0.4748	0.7485
IT-Col	41.8494	13.5881	1996	2014	19	0.6799	0.7071
IT-Cp2	41.7043	12.3573	2012	2014	3	0.5305	0.7626
IT-Cpz	41.7053	12.3761	1997	2009	13	0.4681	0.6185
IT-Isp	45.8126	8.6336	2013	2014	2	0.742	0.8319
IT-La2	45.9542	11.2853	2000	2002	3	0.7812	0.6949
IT-Lav	45.9562	11.2813	2003	2014	12	0.7602	0.7545
IT-MBo	46.0147	11.0458	2003	2013	11	0.8252	0.8322
IT-PT1	45.2009	9.061	2002	2004	3	0.7463	0.8603
IT-Ren	46.5869	11.4337	1998	2013	16	0.7666	0.7354
IT-Ro1	42.4081	11.93	2000	2008	9	0.5296	0.7576
IT-Ro2	42.3903	11.9209	2002	2012	11	0.3693	0.7277
IT-SR2	43.732	10.2909	2013	2014	2	0.7706	0.8171
IT-SRo	43.7279	10.2844	1999	2012	14	0.5607	0.4291
IT-Tor	45.8444	7.5781	2008	2014	7	0.8306	0.825
NL-Hor	52.2404	5.0713	2004	2011	8	0.8252	0.6789
NL-Loo	52.1666	5.7436	1996	2014	19	0.8552	0.698

341

Table S4| ICOS Drought2018 site data availability information and coefficient of determination (R^2) with the interpolated GLASS gross primary production (GPP) and evapotranspiration (ET).

Site Code	Latitude	Longitude	Start Year	End Year	N Years	R^2 - GPP	R^2 - ET
BE-Bra	51.31	4.52	1996	2018	23	0.79	0.75
BE-Lon	50.5516	4.7462	2004	2018	15	0.4188	0.6574
BE-Vie	50.3049	5.9981	1996	2018	23	0.8295	0.7542
CH-Aws	46.5832	9.7904	2010	2018	9	0.6327	0.4476
CH-Cha	47.2102	8.4104	2005	2018	14	0.5837	0.8275
CH-Dav	46.8153	9.8559	1997	2018	22	0.5372	0.6758
CH-Fru	47.1158	8.5378	2005	2018	14	0.6628	0.7174
CH-Lae	47.4783	8.3644	2004	2018	15	0.4655	0.7584
CH-Oe2	47.2864	7.7338	2004	2018	15	0.359	0.6998
CZ-BK1	49.5021	18.5369	2004	2018	15	0.7139	0.6301
CZ-Lnz	48.6816	16.9464	2015	2018	4	0.8997	0.877
CZ-RAJ	49.4437	16.6965	2012	2018	7	0.7669	0.7075
CZ-Stn	49.036	17.9699	2010	2018	9	0.7893	0.8051
CZ-wet	49.0247	14.7704	2006	2018	13	0.7835	0.8295
DE-Akm	53.8662	13.6834	2009	2018	10	0.747	0.5106
DE-Geb	51.0997	10.9146	2001	2018	18	0.5273	0.7345
DE-Gri	50.95	13.5126	2004	2018	15	0.6702	0.7809
DE-Hai	51.0792	10.4522	2000	2018	19	0.802	0.8093
DE-HoH	52.0853	11.2192	2015	2018	4	0.7152	0.806
DE-Hte	54.2103	12.1761	2009	2018	10	0.6624	0.821
DE-Hzd	50.9638	13.4898	2010	2018	9	0.6875	0.7165
DE-Kli	50.8931	13.5224	2004	2018	15	0.4974	0.6684
DE-Obe	50.7867	13.7213	2008	2018	11	0.7272	0.6545
DE-RuR	50.6219	6.3041	2011	2018	8	0.755	0.8054
DE-RuS	50.8659	6.4471	2011	2018	8	0.4853	0.7272
DE-RuW	50.5049	6.331	2010	2018	9	0.5919	0.3929
DE-Tha	50.9626	13.5652	1996	2018	23	0.8262	0.7107
DK-Sor	55.4859	11.6446	1996	2018	23	0.9105	0.8605
ES-Abr	38.7018	-6.7859	2015	2018	4	0.4522	0.2721
ES-LM1	39.9427	-5.7787	2014	2018	5	0.561	0.545
ES-LM2	39.9346	-5.7759	2014	2018	5	0.6123	0.5113
FI-Hyy	61.8474	24.2948	1996	2018	23	0.9104	0.8369
FI-Let	60.6418	23.9595	2009	2018	10	0.8119	0.7951
FI-Sii	61.8327	24.1929	2016	2018	3	0.8426	0.7666
FI-Var	67.7549	29.61	2016	2018	3	0.8327	0.8588
FR-Bil	44.4937	-0.9561	2014	2018	5	0.5664	0.6605
FR-EM2	49.8721	3.0207	2017	2018	2	0.53	0.773
FR-Hes	48.6741	7.0647	2014	2018	5	0.8491	0.7584
IT-BCi	40.5238	14.9574	2004	2018	15	0.0172	0.4715

IT-Cp2	41.7043	12.3573	2012	2018	7	0.5443	0.5834
IT-Lsn	45.7405	12.7503	2016	2018	3	0.7726	0.8336
IT-SR2	43.732	10.2909	2013	2018	6	0.7066	0.8293
IT-Tor	45.8444	7.5781	2008	2018	11	0.8221	0.7769
NL-Loo	52.1666	5.7436	1996	2018	23	0.8503	0.6938
RU-Fy2	56.4476	32.9019	2015	2018	4	0.849	0.7957
RU-Fyo	56.4615	32.9221	1998	2018	21	0.8575	0.7646
SE-Deg	64.182	19.5565	2001	2018	18	0.8362	0.7623
SE-Htm	56.0976	13.419	2015	2018	4	0.8045	0.77
SE-Lnn	58.3406	13.1018	2014	2018	5	0.6429	0.6703
SE-Nor	60.0865	17.4795	2014	2018	5	0.8721	0.8426
SE-Ros	64.1725	19.738	2014	2018	5	0.8834	0.7261
SE-Svb	64.2561	19.7745	2014	2018	5	0.8847	0.5192

343

Table S5| SAPFLUXNET sites used in this study and further information as well as R^2 s of transpiration upscaled from sap flux with correspondent data from interpolated GLEAM and ERA5-Land.

Site Code	Latitude	Longitude	Start Year	End Year	N Years	R^2 -GLEAM	R^2 - ERA5L
CZE_BIK	49.49	18.53	2015	2016	1	0.31	0.3
CZE_BIL_BIL	49.25	16.69	2014	2017	3	0.38	0.37
CZE_KRT_KRT	49.32	16.75	2013	2017	4	0.55	0.57
CZE_LIZ_LES	49.07	13.68	2007	2009	2	0.63	0.57
CZE_SOB_SOB	49.25	16.69	2013	2017	4	0.3	0.33
CZE_UTE_BEE	49.28	16.65	2013	2017	4	0.59	0.58
CZE_UTE_BNA	49.28	16.65	2013	2017	4	0.58	0.56
CZE_UTE_BPO	49.28	16.65	2013	2017	4	0.53	0.48
CZE_UTE_SPR	49.28	16.65	2013	2017	4	0.43	0.27
DEU_MER_BEE_NON	49.27	7.81	2009	2012	3	0.28	0.21
DEU_MER_BEE_THI	49.27	7.81	2012	2015	3	0.53	0.52
DEU_MER_DOU_NON	49.27	7.81	2009	2012	3	0.42	0.37
DEU_MER_DOU_THI	49.27	7.81	2012	2015	3	0.57	0.59
DEU_MER_MIX_NON	49.27	7.81	2009	2012	3	0.53	0.37
DEU_MER_MIX_THI	49.27	7.81	2012	2015	3	0.62	0.62
ESP_ALT_ARM	40.78	-2.33	2009	2014	5	0.56	0.51
ESP_ALT_HUE	40.79	-2.29	2009	2013	4	0.45	0.35
ESP_ALT_TRI	40.8	-2.23	2008	2015	7	0.27	0.21
ESP_CAN	41.43	2.07	2011	2012	1	0.47	0.45
ESP_GUA_VAL	40.9	-4.03	2011	2013	2	0.02	0.21
ESP_LAH_COM	37.74	-3.38	2011	2013	2	0.11	0.46
ESP_LAS	28.31	-16.57	2008	2009	1	0.14	0.02
ESP_MAJ_MAI	39.94	-5.77	2015	2018	3	0.49	0.43
ESP_MAJ_NOR_LM1	39.94	-5.77	2015	2018	3	0.56	0.57
ESP_MON_SIE_NAT	41.12	-3.5	2010	2014	4	0.4	0.49
ESP_RON_PIL	36.69	-5.02	2011	2013	2	0	0.25
ESP_TIL_MIX	41.33	1.01	2010	2013	3	0.51	0.28
ESP_TIL_OAK	41.33	1.01	2010	2011	1	0.48	0.24
ESP_TIL_PIN	41.33	1.01	2010	2011	1	0.4	0.11
ESP_VAL_BAR	42.2	1.82	2003	2005	2	0.31	0.24
ESP_VAL_SOR	42.2	1.81	2003	2005	2	0.51	0.49
ESP_YUN_C1	36.72	-4.97	2009	2014	5	0.26	0.26
ESP_YUN_C2	36.72	-4.97	2011	2014	3	0.52	0.63
ESP_YUN_T1_THI	36.72	-4.97	2010	2014	4	0.42	0.47
ESP_YUN_T3_THI	36.72	-4.97	2009	2014	5	0.33	0.4
FRA_FON	48.48	2.78	2005	2014	9	0.45	0.37
FRA_HES_HE1_NON	48.67	7.06	1997	1999	2	0.35	0.32
FRA_HES_HE2_NON	48.67	7.06	2000	2006	6	0.34	0.3
FRA_PUE	43.74	3.6	1999	2015	16	0.56	0.5

ISR_YAT_YAT	31.35	35.05	2009	2015	6	0.32	0.21
ITA_TOR	45.82	7.56	2015	2016	1	0.38	0.52
NLD_LOO	52.17	5.74	2011	2015	4	0.58	0.48
RUS_FYO	56.46	32.92	1998	2004	6	0.27	0.22
SWE_NOR_ST1_AF1	60.09	17.48	2009	2010	1	0.31	0.41
SWE_NOR_ST1_AF2	60.09	17.48	2009	2010	1	0.6	0.58
SWE_NOR_ST1_BEF	60.09	17.48	2007	2009	2	0.01	0.03
SWE_NOR_ST2	60.09	17.48	2001	2002	1	0.35	0.26
SWE_NOR_ST3	60.09	17.48	2002	2008	6	0.36	0.28
SWE_NOR_ST4_AFT	60.08	17.48	1999	2001	2	0.57	0.52
SWE_NOR_ST5_REF	60.08	17.48	1998	2001	3	0.47	0.44
SWE_SKO_MIN	58.36	12.15	2014	2015	1	0.53	0.43
SWE_SKY_38Y	60.13	17.84	2001	2003	2	0.46	0.31
SWE_SKY_68Y	60.1	17.83	2001	2003	2	0.65	0.54
SWE_SVA_MIX_NON	64.26	19.77	2016	2017	1	0.71	0.66

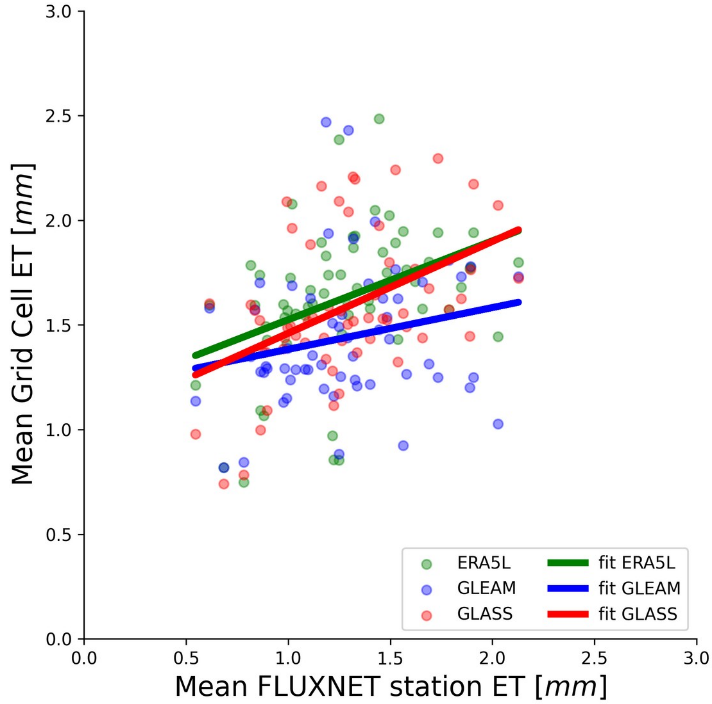

Fig. S11| Comparison of mean evapotranspiration (ET) values from FLUXNET2015 stations in the domain (see Table S3) and the mean of the corresponding grid cell of ERA5-Land (ERA5L, green markers), GLEAM (blue markers), and GLASS (red markers) ET. The solid lines correspond to a linear regression fit with a least squares method.

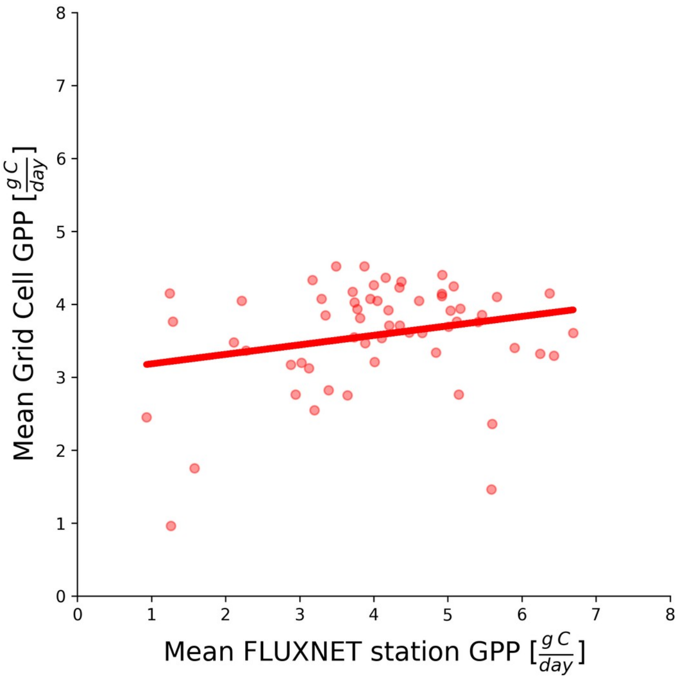

Fig. S12| Comparison of mean gross primary production (GPP) values from FLUXNET2015 stations in the domain (see Table S3) and the mean of the corresponding grid cell GLASS GPP. The solid line corresponds to a linear regression with least squares method.