

Quantifying the response of water and carbon balances to land cover and climate extremes across Germany.

Karim Pyarali^{1,2*}, Lulu Zhang^{2*}, Ning Liu⁴, Abdulhakeem Al-Qubati^{1,2} and Ge Sun^{3*}

¹Technische Universität Dresden, Helmholtzstr. 10, 01069, Dresden, Germany.

²United Nations University, Institute for Integrated Management of Material Fluxes and of Resources, Ammonstrasse 74, 01067, Dresden, Germany.

³Eastern Forest Environmental Threat Assessment Center, Southern Research Station, USDA Forest Service, Research Triangle Park, NC 27709, USA.

⁴CSIRO Environment, Canberra ACT 2601.

*Corresponding authors: Karim Pyarali (karim.pyarali@tu-dresden.de); Lulu Zhang (lzhang@unu.edu); Ge Sun (Ge.Sun@usda.gov)

Contents of this file

Tables S1 to S6

Introduction

This supporting information provides the tables that supplements the main scientific conclusions of the paper.

Table S1: Regression coefficient parameters for GPP and Re estimated using eddy covariance measurements collected from the works of Zhang et al, (2016) and Sun et al., (2011).

Land Cover	IGBP	GPP parameter (a)	Ecosystem Respiration (Re) parameter	
			Intercept (m)	Slope (n)
Urban	Urb	0	0	0
Croplands	CRO	2.533	40.6	0.43
Deciduous Broadleaf Forest	DBF	3.28	30.8	0.45
Evergreen Needleleaf	ENF	2.71	9.9	0.68
Mixed Forests	MF	3.349	24.4	0.62
Grasslands	GRA	2.333	18.9	0.64
Closed Shrublands	CSH	1.734	11.4	0.69
Open Shrublands	OSH	1.679	9.7	0.56
Wetlands	WET	1.66	7.8	0.56
Water	WAT	0	0	0

Table S2: Land cover reclassification and share of new classes in German landscape.

IGBP Description	IGBP Abbreviations	Reclassification	CORINE Class Range	Percentage of Germany (%)
Urban	Urb	1	111 - 133	8.90
Croplands	CRO	2	141 - 243	57.8
Deciduous Broadleaf Forests	DBF	3	311	10.2
Evergreen Needleleaf Forests	ENF	4	312	16.6
Mixed Forests	MF.	5	313	3.70
Grasslands	GRA	6	321	0.40
Closed Shrubland	CSH	7	322 - 324	0.90
Open Shrubland	OSH	8	331 - 335	0.04
Wetlands	WET	9	411 - 423	0.30
Water Bodies	WAT	10	511 - 523	1.20
* CORINE: Coordination of Information on the Environment				
** IGBP: International Geosphere-Biosphere Programme				

Table S3: Monthly resolution model validation results of discharge for 12 representative watersheds across Germany.

Station Name	Simulated Watershed ID	Observed Station ID	NSE	RMSE	KGE
Bentfeld	302	6335082	0.32	15.53	0.53
Colnrade OP	186	6337050	0.79	6.33	0.78
Wasserthaleben	357	6340220	-7.47	16.98	-1.48
Treuchlingen	632	6342522	0.34	10.90	0.53
Bad Rotenfels	664	6335710	0.68	32.56	0.83
Kirchen-Hausen	766	6342980	0.69	20.12	0.83
Treia	4	6338800	0.64	12.68	0.76
Goeritzhain	429	6340625	0.73	13.90	0.80
Lohmar	427	6335048	0.76	18.69	0.79
Kleinbengerstorf	58	6340070	0.00	07.09	0.20
Schoenach	639	6342640	-0.66	10.75	0.09
Niedertrebra	424	6340320	0.03	13.35	0.47

Table S4: Overall model validation for discharge comparing mean annual values for 12 watersheds across Germany. Station names are linked to the same station and watershed ID presented in Table S3.

Station Name	Mean Annual runoff				Predicted vs Observed R ²	
	Observed	Predicted	Model bias	Model bias	Annual R ²	Monthly R ²
	mm	mm	mm	%		
Bentfeld	338.72	358.37	19.66	5.80	0.82	0.70
Colnrade OP	227.99	181.63	-46.36	-20.33	0.93	0.87
Wasserthaleben	70.14	162.60	92.46	131.81	0.18	0.30
Treuchlingen	183.39	202.51	19.11	10.42	0.70	0.70
Bad Rotenfels	979.44	926.96	-52.48	-5.36	0.85	0.73
Kirchen-Hausen	553.40	521.76	-31.65	-5.72	0.88	0.73
Treia	439.24	352.85	-86.39	-19.67	0.75	0.79
Goeritzhain	412.82	345.10	-67.72	-16.40	0.85	0.75
Lohmar	683.65	584.69	-98.96	-14.48	0.91	0.84
Kleinbengerstorf	152.63	158.53	5.91	3.87	0.95	0.83
Schoenach	206.31	214.90	8.59	4.17	0.63	0.60
Niedertrebra	204.75	203.89	-0.86	-0.42	0.55	0.50

Table S5: Land cover specific ET validation for WaSSI ET data using corrected and uncorrected eddy flux ET data across thirteen different sites in Germany.

Eddy Flux Tower	WS ID	Land cover	Period	Uncorrected Observed ET (mm mon ⁻¹)						Corrected Observed ET (mm mon ⁻¹)					
				R2	Correlation	Obs Annual Mean	Sim Annual Mean	Bias %	KGE	R2	Correlation	Obs Annual Mean	Sim Annual Mean	Bias %	KGE
Selhausen Juelich	457	CRO	2011 - 2015	0.74	0.86	653.35	542.58	-16.95	0.67	0.74	0.87	755.82	518.88	-31.35	0.53
Klingenberg	394		2004 - 2015	0.57	0.76	343.24	536.49	56.30	0.38	0.62	0.79	491.34	533.62	8.60	0.63
Gebsee	415		2001 - 2015	0.77	0.88	363.54	490.24	34.85	0.58	0.75	0.87	415.84	490.24	17.89	0.60
Hainich	390	DBF	2001 - 2011	0.85	0.92	379.93	469.26	23.51	0.70	0.86	0.93	414.78	454.79	9.65	0.70
Leinefelde	390		2002 – 2006 & 2010 - 2013	0.81	0.90	397.09	500.78	26.11	0.67	0.85	0.92	447.64	500.78	11.87	0.70
Lackenberg	631	ENF	2009 - 2015	0.64	0.80	494.10	608.61	23.17	0.54	0.76	0.87	377.05	574.46	52.36	0.43
Oberbärenburg	394		2008 - 2015	0.83	0.91	372.56	577.34	54.97	0.43	0.85	0.92	473.79	577.34	21.86	0.72
Tharandt	394		2001 - 2015	0.85	0.92	387.96	575.36	48.31	0.46	0.90	0.95	463.02	575.36	24.26	0.75
Grillenburg	394	GRA	2004 - 2015	0.79	0.89	367.44	439.02	19.48	0.68	0.80	0.90	615.46	427.31	-30.57	0.39
Rollesbroich	457		2011 - 2015	0.74	0.86	558.22	558.15	-0.01	0.80	0.71	0.85	694.15	547.05	-21.19	0.65
Schechenfilz Nord	737	WET	2012 - 2015	0.32	0.58	610.97	642.85	5.22	0.53	0.11	0.37	868.83	635.76	-26.83	0.17
Spreewald	269		2010 - 2014	0.74	0.86	432.02	524.12	21.32	0.70			NA			
Anklam	23		2009 - 2014	0.26	0.54	628.52	527.12	-16.13	0.39			NA.			

Table S6: Mean annual comparison between WaSSI-ET and $P - Q_{\text{observed}}$

Station ID	Period	Mean Annual					
		Precipitation	PET_{hamon}	$P - Q_{\text{obs}}$	WaSSI-ET	Model bias	Model bias
		mm	mm	mm	mm	mm	%
Bentfeld	2001 - 2016	908.56	631.57	569.84	554.45	-15.39	-2.7
Colnrade OP	2001 - 2015	722.75	666.29	494.76	539.25	44.49	8.99
Wasserthaleben	2001 - 2016	666.00	622.17	598.21	508.6	-89.61	-14.98
Treuchlingen	2001 - 2016	735.39	634.80	551.99	533.97	-18.02	-3.26
Bad Rotenfels	2001 - 2016	1544.69	598.57	565.25	633.25	68.01	12.03
Kirchen-Hausen	2001 - 2008	1127.43	571.81	574.03	566.28	-7.75	-1.35
Treia	2001 - 2016	901.89	635.48	462.66	564.34	101.68	21.98
Goeritzhain	2001 - 2015	868.60	629.38	455.79	516.94	61.15	13.42
Lohmar	2001 - 2011	1193.33	619.96	540.98	583.38	42.4	7.84
Kleinbengerstorf	2001 - 2012	691.67	645.23	542.51	532.74	-9.77	-1.8
Schoenach	2001 - 2016	768.07	643.80	561.76	551.53	-10.24	-1.82
Niedertrebra	2001 - 2016	720.57	620.55	521.22	516.47	-4.75	-0.91