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Spatiotemporal patterns and drivers of terrestrial dissolved organic carbon (DOC) leaching into the European river network

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Supplementary Figures and Tables

Table S.1 List of the parameters for the new soil carbon module of ORCHILEAK with their description, value, units, and the parameterization used for each parameter.

PARAMETER	DESCRIPTION	VALUE	UNIT	PARAMETRIZATION
D_DOC	Molecular diffusion coefficient of DOC	$1.06*10^{-5}$	$m^2\ d^{-1}$	Ota et al., 2013
D_bio	Diffusion coefficient used for bioturbation litter and soil carbon	$2.74*10^{-7}$	$m^2\ d^{-1}$	Koven et al. (2013)
CUE	Partitioning between SOC production and respiration	0.3	-	This study
ω_L	Production of DOC by the decomposition of litter	0.2	%	This Study
ω_{SOC}	Production of DOC by the decomposition of SOC	1.2	%	This study
k_D	equilibrium partition coefficient	$8.05*10^{-5}$	m^3 water kg^{-1} soil	Moore et al. (1992)

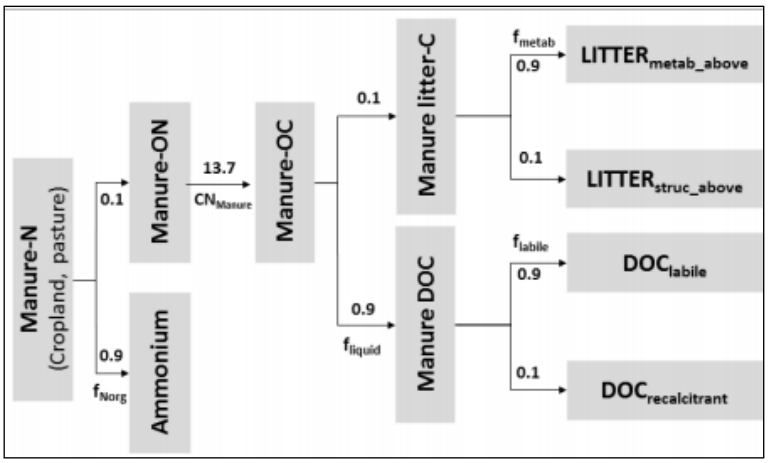

Figure S1. Implementation of the manure scheme in ORCHILEAK.

Table S2. Dominant pfts (%) for 5 large European river catchments.

BASINS	BOREAL FOREST %	TEMPERATE FOREST %	GRASSLAND %	CROPLAND %
Danube	27	8	22	39
Elbe	22	6	26	41
Rhine	10	20	35	24
Rhône	10	15	50	18
Seine	<0.1	12	35	49

Table S3. Hydrology results in multiple catchments across Europe. Comparison catchment areas, discharge observed vs modeled and statistics (Nash-Sutcliffe efficiency, mean error and coefficient of determination.

Station	REAL Catchment area km^2	OBS average (m^3/s)	MODELED Catchment area km^2	MOD average (m^3/s)	NSE	mean error %	R^2
Frankfurt	24760	201	31900	335	-0.95	66	0.55
Basel	35900	1084	35770	1190	0.35	12	0.62
Dresden	53100	340	45830	342	0.54	2	0.55
Beaucaire	95590	1745	77270	1698	0.4	3	0.57
Bratislava	131330	2078	133830	2400	0.01	17	0.49
Neu Darchau	131950	704	137820	1216	-1.5	73	0.6
Senta	140130	809	106220	882	0.53	11	0.58
Lobith	160800	2345	152140	2767	0.04	20	0.48
Svistov	658340	5793	651980	6965	0.19	18	0.43
Ceatal	807000	6456	787530	7302	0.07	18	0.44

Table S4 summarizes the yearly average NPP at the scale of the five selected European catchments. Simulated NPP is of the same order of magnitude as both observation based datasets, without any systematic bias towards an underestimation or overestimation. To provide error bounds for the observational products, we calculated the average standard deviation between yearly-mean values. For GIMMS, we also included the standard deviation induced by the use of the five distinct meteorological forcing files to assess the NPP (section 2.2.1). We find that our simulated catchment averaged NPP fall within the error bounds of the observational products for the Rhine and the Rhone while for the Danube, Elbe and Seine, simulated NPP is slightly above the upper error range.

Table S4 reports the biomass and soil carbon (SOC) stocks for the 5 river basins. SOC stocks are usually slightly overestimated compared to HWSD. Results have also been aggregated at the intermediate scale of broad climate zones to analyze how well our model performs for distinct climate regimes. Again the method to calculate the bulk density (section 2.2.2) leads to large uncertainties in observed SOC stocks. Nevertheless, we find that simulated SOC stocks for the warmer climates (Semi-arid and Mediterranean) match well the SOC stocks of the HWSD. However, for other regions, we systematically underestimate the SOC stock compared to HWSD using the Saxton Method, especially in the subarctic climate, but we are closer to the observed values relying on the SOTWIS method for the bulk density. This result is expected since the model does not represent peatlands, which contain important quantities of SOC (Leifeld and Menichetti 2018).

Table S4 Comparison of modeled NPP (1982-2006) against estimates from the CARDAMOM (2001-2010) and GIMMS (1982-2006) datasets. The mean of the two datasets, along with an assessment of the uncertainty (based on MODIS) and of the standard deviation are also reported. In addition, the modeled biomass stock and soil organic carbon (SOC) content (first 1m) are compared with values reported in the HWSD database, using two methods (Saxton and SOTWIS) to calculate the soil bulk density. All variables and processes are reported for the large-scale basins of focus in this study (see fig. 3 for location), the main climate zones of continental Europe and the whole model domain.

Basin	NPP gC m^{-2} yr^{-1} ORCHILEAK 1982-2006	NPP gC m^{-2} yr^{-1} Cardamom 2001-2010	NPP gC m^{-2} yr^{-1} GIMMS 1982-2006	Mean gC m^{-2} yr^{-1}	Uncertainty 20%	Standard deviation gC m^{-2} yr^{-1}	BIOMASS stock kgC m^{-2}	SOC kgC m^{-2}	HWSD SOC stock (Saxton) kgC m^{-2}	HWSD SOC stock (SOTWIS kgC m^{-2}
Danube	560	524	465	495	99	19	3.1	9.3	7.7	5.1
Rhine	527	601	482	542	108	55	1.5	9.5	9.1	5.7
Elbe	576	507	452	480	96	17	2	10.3	17.1	4.9
Rhone	497	593	504	549	110	38	1.4	8.2	5.3	4.5
Seine	667	484	485	484	97	0,5	1.3	9	4.4	3.6
Semi-Arid	264	199	246	222	44	32	0.4	3.3	3.9	4.1
Mediterranean	390	383	386	385	77	21	1.7	5.3	5.1	4.6
Oceanic	561	535	511	523	104	2	1.7	10	23.1	5.6
Humid continental	526	502	458	480	96	11	3.1	10.7	17.2	5.9
Subarctic	338	400	388	394	79	26	2.2	12.2	44.7	7.8
Tundra	344	451	347	399	80	18	2	9.1	5.2	4.3
Europe	445	460	430	441	88	11	2.3	9.5	22	6

Table S5. Comparison of modeled (MOD) versus observed (OBS) DOC concentrations measured at specific locations along the European river network. The table also reports the location ID (see figure 3), the original reference, and the sampling period.

RIVER	#ID	SOURCE	COVERED PERIOD	OBS mg C l^{-1}	MOD mg C l^{-1}
Douro	A1	Abril (2002)	09/1997	2.5	3.6
Sado	A2	Abril (2002)	04/1996 and 09/1997	6.7	3.2
Gironde	A3	Abril (2002)	11/1996 to 02/19998	3.1	3.2
Loire	A4	Abril (2002)	08/1998	3.9	4.9
Scheld	A5	Abril (2002)	07/1996 to 05/1998	6.8	7.2
Ems	A6	Abril (2002)	07/1997	6.8	6.4
Elbe	E1	Abril (2002)	04/1997	4.6	6.3
Rhine	Ri1	Abril (2002)	10/1996 to 03/1998	2.9	5.3
Thame	A7	Abril (2002)	09/1996 and 02/1999	5.8	2.5
Tech	M1	Mattsson (2008)	10/2001 to 09/2002	1.8	2.8
Wales	M2	Mattsson (2008)	01/2002 to 12/2002	5.5	2.6
Denmark	M3	Mattsson (2008)	10/2001 to 09/2002	7.2	10.3
Finland	M4	Mattsson (2008)	01/2001 to 12/2001	13	11.1
Rhine	Ri1	Glorich	1992 to 1996	4.3	4.7
Elbe	E1	Glorich	1998 to 2001	6.1	6.2
Seine	S1	Eau de France	2002 to 2006	6.9	4.5
Rhone	Ro1	Eau de france	1990 to 1995	4.1	4.4
England	-	Worrall 2012	2001 to 2007	4.8	7.4
Baltic	-	Fransner 2016		13	10

Table S6. Statistics for the simulated discharge, DOC concentration and DOC flux in four large rivers against measured values reported in the GLORICH dataset.

RIVER	DISCHARGE RMSE %	DISCHARGE R^2	CONCENTRATION RMSE %	CONCENTRATION R^2	FLUX RMSE %	FLUX R^2
Rhine	45	0.43	70	0.43	84	0.35
Elbe	114	0.43	334	0.04	121	0.5
Rhone	37	0.6	117	0.1	122	0.6
Seine	202	0.08	64	0.4	147	0.5