water

MDPI

SUPPLEMENTARY MATERIALS

Hydrological Alteration Index as an Indicator of the Calibration Complexity of Water Quantity and Quality Modeling in the Context of Global Change

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1. Urban Sewage set up

These equations were validated at the outlet of a set of French and Spanish watersheds, with good correlations between observed and simulated nitrogen loads ($r^2 = 0.87$, p-value < 0.01).

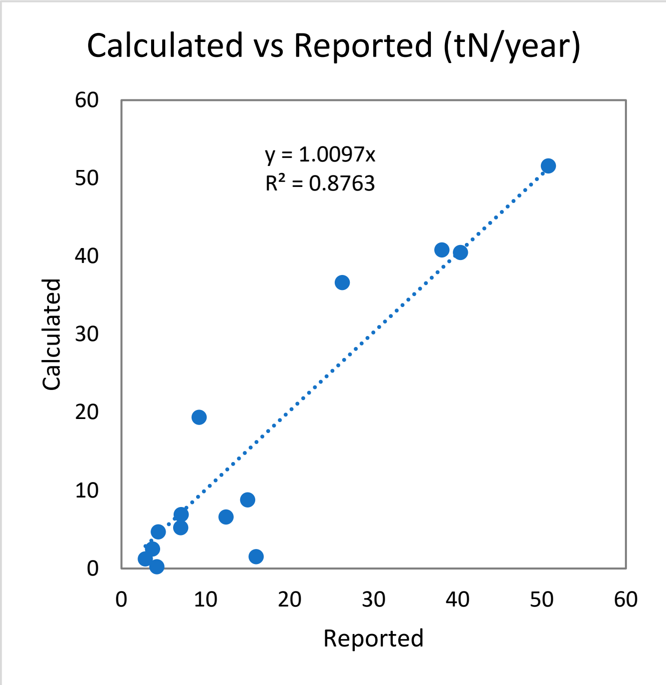

Figure S1: Comparison between observed nitrogen loads (coming from the UWWTP databases) and calculated one with the [1] method.

2. Parameters used to calibrate water quantity and quality in the SUDOE territory.

Table S1: Parameters used to calibrate water quantity and quality in the SUDOE territory. The parameters to calibrate irrigated volume and crop yield were used only for the AC calibration.

Parameters used to calibrate flow and nitrate of the SFHIF model					
File	Parameters	Definitions	Min. value	Max. value	Range of calibration
basins.bsn	ESCO	Soil evaporation compensation factor	0	1	0.6 - 0.95
	EPCO	Plant water uptake compensation factor	0	1	1
	SURLAG	Surface runoff lag time	0	10	10
	IPET	PET method: Hargreaves	0	3	2
*.gw	SHALLST	Initial depth of water in the shallow aquifer	0	5000	500-1000
	DEEPST	Initial depth of water in the deep aquifer	0	10000	100-2000
	GW_DELAY	Groundwater delay	0	500	31-50
	ALPHA_BF	Baseflow alpha factor	0	1	0.048-0.9
	GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur	0	5000	1200-2500
	GW_REVAP	Groundwater "revap" coefficient	0.02	0.5	0.02-0.4

	REVAPMN	Threshold depth of water in the shallow aquifer for "revap" to occur	0	1000	500-1000
	RCHRG_DP	Deep aquifer percolation fraction	0	1	0-0.1
*.sol	SOL_AWC	Available water capacity of the soil layer	0.01	0.5	37 -180
*.hru	SLSUBBSN	Average slope length	10	150	6.5 - 150
	HRU_SLP	Average slope stepness	0	0.6	0.002-0.6
	OV_N	Manning's "n" value for overland flow	0.01	0.15	0.01 - 0.18
*.mgt	CN2	SCS curve number	35	98	28 - 90
Parameters used to calibrate sediment					
*.rte	CH_Eq				
	CH_COV	Channel cover factor			
*.mgt	USLE_P	USLE support practice factor	0	1	0.3 - 1
*.bsn	SPCON	Linear parameter for calculating channel sediment routing	0.0001	0.01	0.0001
	SPEXP	Exponent parameter for calculating channel sediment routing	1	5	1
	PRF_BSN	Peak rate adjustment factor for sediment routing in the main channel	0	1	0.5
Parameters used to calibrate nitrate					
*.bsn	N_UPDIS	Nitrogen uptake distribution parameter	0	100	5 -20
	NPERCO	Nitrogen percolation coefficient	0	1	0.2 - 0.58
	CMN	Rate factor for humus mineralization of active organic nitrogen	0.0001	0.003	0.0003 - 0.0053
	BC2_BSN	Rate constant for biological oxidation NO2 to NO3	0.2	2	0.1 - 0.2
	RCN	Concentration of nitrogen in rainfall	0	15	0 - 5
*.chm	SOL_NO3	Initial NO3 concentration in the soil layer	0	100	0 - 19
	SOL_ORGN	Initial organic N concentration in the soil layer	0	100	0 - 30
Parameters used to calibrate volume irrigated					
*.mgt	WSTRS_ID	Water stress identifier (1) Plant water demand, (2) Soil water content	1	2	1 or 2
	AUTO_WSTRS	Water stress factor of cover/plant	0	1	0.9
	IRR_EFF	Irrigation efficiency (fraction)	0	1	0.6 or 0.9
	IRR_SCA	Irrigation source. (1) Streams, (2) Reservoirs, (3) Shallow aquifer , (4)	0	5	1, 2 or 5

		deep aquifer , (5) Outside o fthe watershed			
	IRR_MX	Amount of irrigation water applied each time auto irrigation is triggered	0	1000	0 - 500
Parameters used to calibrate crop yield					
crop.dat	BIO_E	Biomass/Energy Ratio	10	90	15 - 60
	HVSTI	Harvest index	0.01	1.25	0.05 -0.7
	BLAI	Max leaf area index	0.5	10	0.8 - 10
*.mgt	FERT_ID	Fertilizer identification number	0	99	1, 2, 18, 21, 22
	AUTO_NAPP	Maximum amount of NO3-N allowed in any one application	0	500	0 - 150
	AUT_NSTR	Nitrogen stress factor of cover/plant	0	1	0, 0.75, 0.95
	AUTO_EFF	Application efficiency	0	2	1.3 - 0.5
	AUTO_NYR	Maximum amount of NO3-N allowed to be applied on a year	0	9999	0 - 1000
	AFRT_SURFACE	Fraction of fertilizer applied to top 10mm of soil	0	1	0 - 0.2

3. Sensitivity analysis results ranking for water quantity and quality models outputs over the SUDOE territory.

Table S2: Parameters sensitivity ranking for streamflow model outputs for each part of SUDOE territory for CC and AC models.

Parameter Name[a]	CC			AC		
	Rank			Rank		
	Pyrenean	Mediterranean	Oceanic	Pyrenean	Mediterranean	Oceanic
V__GW_DELAY.gw	10	1	2	5	1	2
V__ALPHA_BF.gw	1	2	1	1	2	1
V__SURLAG.bsn	11	3	10	11	13	3
V__SHALLST_N.gw	9	4	15	9	11	5
V__GW_REVAP.gw	5	5	4	7	7	6
R__CN2.mgt	6	6	5	6	15	9
V__NPERCO.bsn	13	7	6	14	10	12
V__REVAPMN.gw	3	8	3	3	8	4
V__SDNCO.bsn	4	9	14	4	4	7
V__CMN.bsn	14	10	8	15	12	15
V__SHALLST.gw	15	11	13	13	5	10
V__GWQMN.gw	7	12	7	10	9	13
V__ESCO.bsn	2	13	12	2	3	14

V__RCHRG_DP.gw	8	14	11	8	6	11
V__EPCO.bsn	12	15	9	12	14	8

[a] parameters values is replaced by value from the given range.

Table S3: Sensitivity analysis for CC streamflow models outputs.

Parameter Name[a]	AC					
	Pyrenean		Mediterranean		Oceanic	
	t-test[b]	p-value[c]	t-test[b]	p-value[c]	t-test[b]	p-value[c]
V__ALPHA_BF.gw	9.98	0.00	-4.67	0.00	-7.53	0.00
V__ESCO.bsn	1.07	0.29	-1.97	0.06	0.65	0.52
V__REVAPMN.gw	0.95	0.35	-1.27	0.21	1.36	0.18
V__SDNCO.bsn	-0.91	0.37	1.73	0.09	0.98	0.33
V__GW_DELAY.gw	-0.84	0.41	5.01	0.00	5.35	0.00
R__CN2.mgt	0.77	0.45	-0.16	0.87	0.65	0.52
V__GW_REVAP.gw	-0.61	0.55	-1.45	0.16	1.32	0.19
V__RCHRG_DP.gw	0.58	0.57	-1.50	0.14	0.42	0.68
V__SHALLST_N.gw	0.57	0.57	-0.51	0.61	1.32	0.19
V__GWQMN.gw	0.48	0.63	0.75	0.46	-0.27	0.79
V__SURLAG.bsn	-0.32	0.75	0.24	0.81	2.45	0.02
V__EPCO.bsn	0.19	0.85	-0.24	0.81	0.65	0.52
V__SHALLST.gw	-0.11	0.91	1.71	0.10	-0.62	0.54
V__NPERCO.bsn	0.09	0.93	0.75	0.46	0.28	0.78
V__CMN.bsn	0.07	0.95	-0.43	0.67	0.09	0.93

[a] parameters values is replaced by value from the given range.

[b] t-value show a measure of sensitivity (the larger t-stat value, the more sensitive).

[c] parameters determines the significance of the sensitivity (the lower p-value, the more sensitive).

Table S4: Sensitivity analysis for AC streamflow models outputs.

Parameter Name[a]	AC					
	Pyrenean		Mediterranean		Oceanic	
	t-test[b]	p-value[c]	t-test[b]	p-value[c]	t-test[b]	p-value[c]
V__ALPHA_BF.gw	10.04	0.00	-3.39	0.00	-6.83	0.00
V__ESCO.bsn	0.99	0.33	0.25	0.80	-1.90	0.07
V__REVAPMN.gw	0.89	0.38	0.71	0.48	-1.28	0.21
V__SDNCO.bsn	-0.83	0.41	0.67	0.51	1.65	0.11
V__GW_REVAP.gw	-0.74	0.47	1.24	0.22	-0.93	0.36

R__CN2.mgt	0.73	0.47	1.02	0.31	-0.46	0.65
V__GWQMN.gw	0.60	0.55	-0.25	0.80	0.56	0.58
V__RCHRG_DP.gw	0.58	0.57	0.15	0.88	-1.36	0.18
V__SHALLST.gw	0.56	0.58	-0.27	0.79	1.36	0.18
V__GW_DELAY.gw	-0.50	0.62	5.99	0.00	4.12	0.00
V__SURLAG.bsn	-0.31	0.76	2.24	0.03	-0.01	0.99
V__EPCO.bsn	0.19	0.85	-0.14	0.89	0.11	0.91
V__NPERCO.bsn	0.19	0.85	0.74	0.46	0.67	0.51
V__CMN.bsn	0.05	0.96	0.27	0.79	-0.28	0.78
V__SHALLST_N.gw	0.01	0.99	1.62	0.11	1.36	0.18

[a] parameters values is replaced by value from the given range.

[b] t-value show a measure of sensitivity (the larger t-stat value, the more sensitive).

[c] parameters determines the significance of the sensitivity (the lower p-value, the more sensitive).

4. Validation of LOADEST and observations

The Figure S2 shows a good agreement between observed and simulated sediment loads at monthly scale (ϱ= 0.94, R^2 = 0.53 and pvalue < 0.001). This LOADEST simulation gives a sediment load closes to observation and could be used to compare with SWAT model at monthly scale. The interpolation of nitrate concentration with LOADEST gives good results with a rho of 0.99, an average of 0.88 for the correlation coefficient and a p-value under 0.001 (Figure S3).

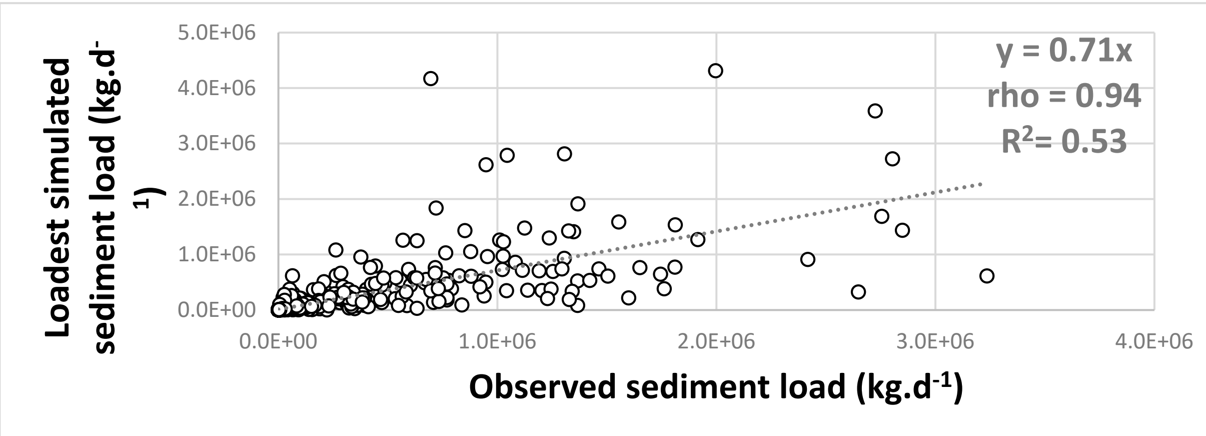

Figure S2: Sediment load regression between observation and LOADEST simulation at daily time step in kg.d-1.

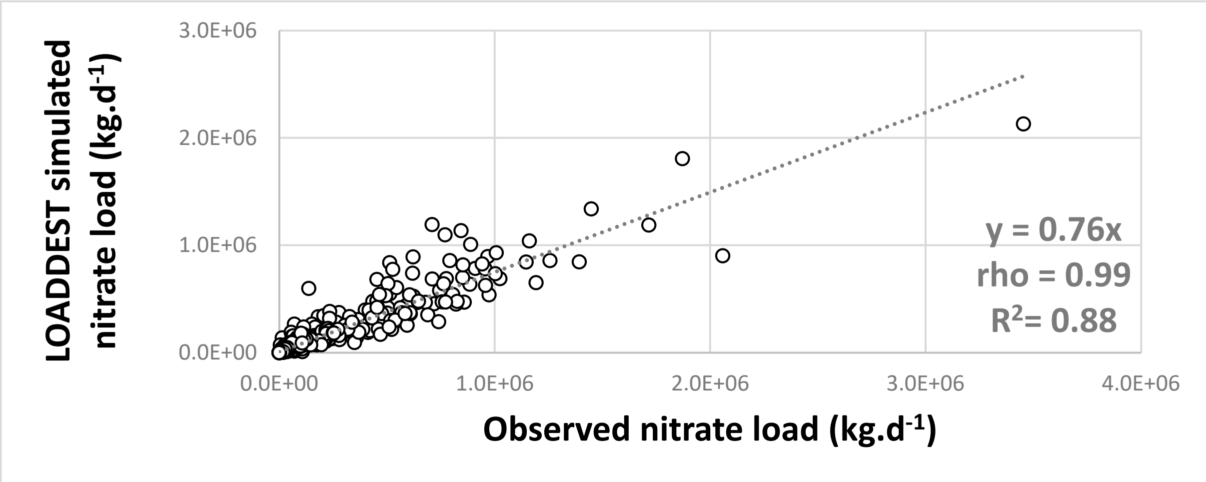

Figure S3: Nitrate load regression between observation and LOADEST simulation at daily time step in kg.d^{-1}.

References

1. Zessner, M.; Lindtner, S. Estimations of municipal point source pollution in the context of river basin management. *Water Sci Technol* **2005**, *52*, 175–182.