

Supplementary Material

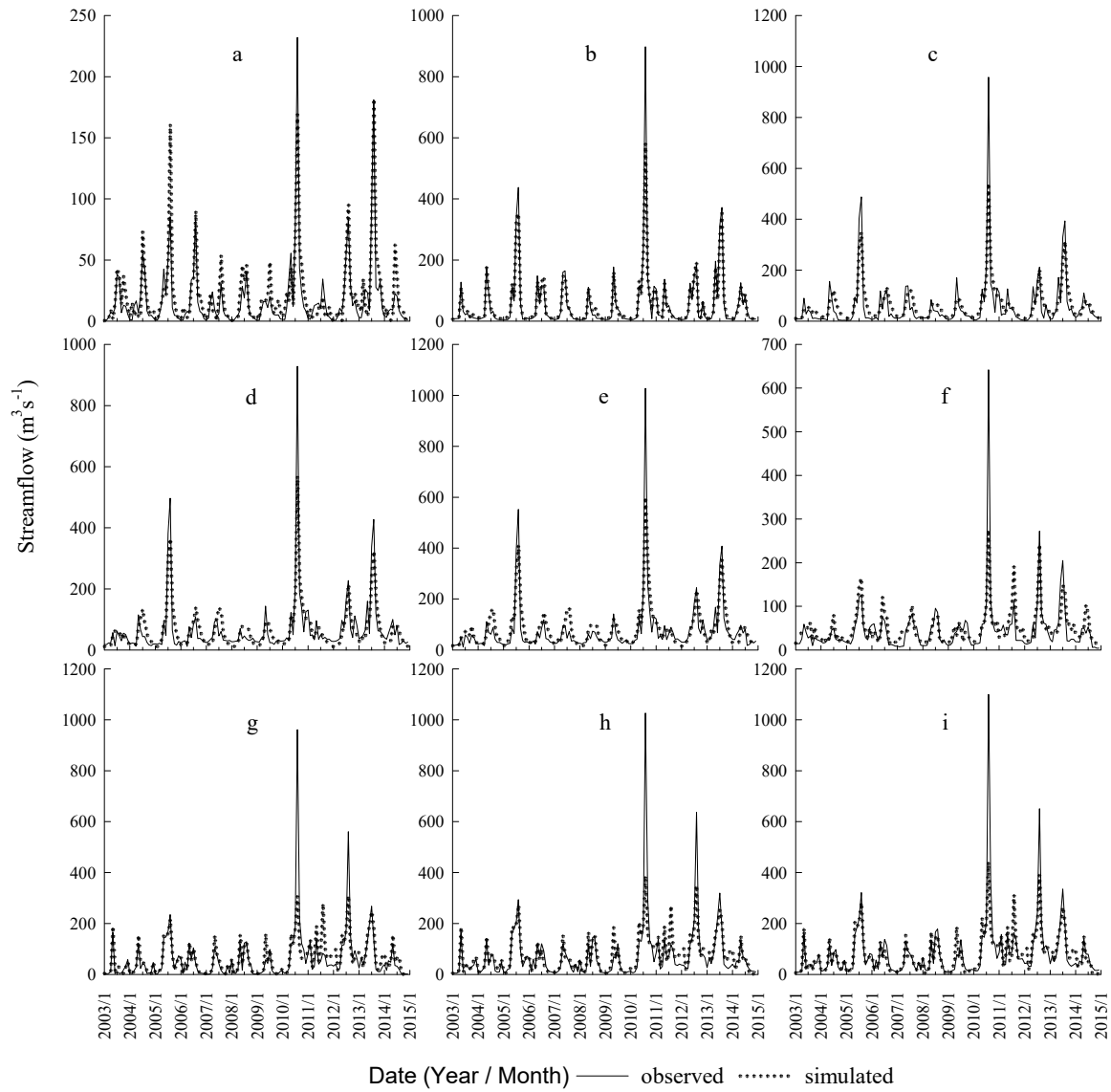


Figure 1. Comparison between the observed and simulated monthly streamflow values at nine stations for the calibration period (2001–2010) and validation period (2011–2014). (a) Beikouqian station; (b) Fushun station; (c) Shenyang station; (d) Huanglatuo station; (e) Xingjiawopeng station; (f) Benxi station; (g) Liaoyang station; (h) Xiaolinzi station; and (i) Tangmashai station.

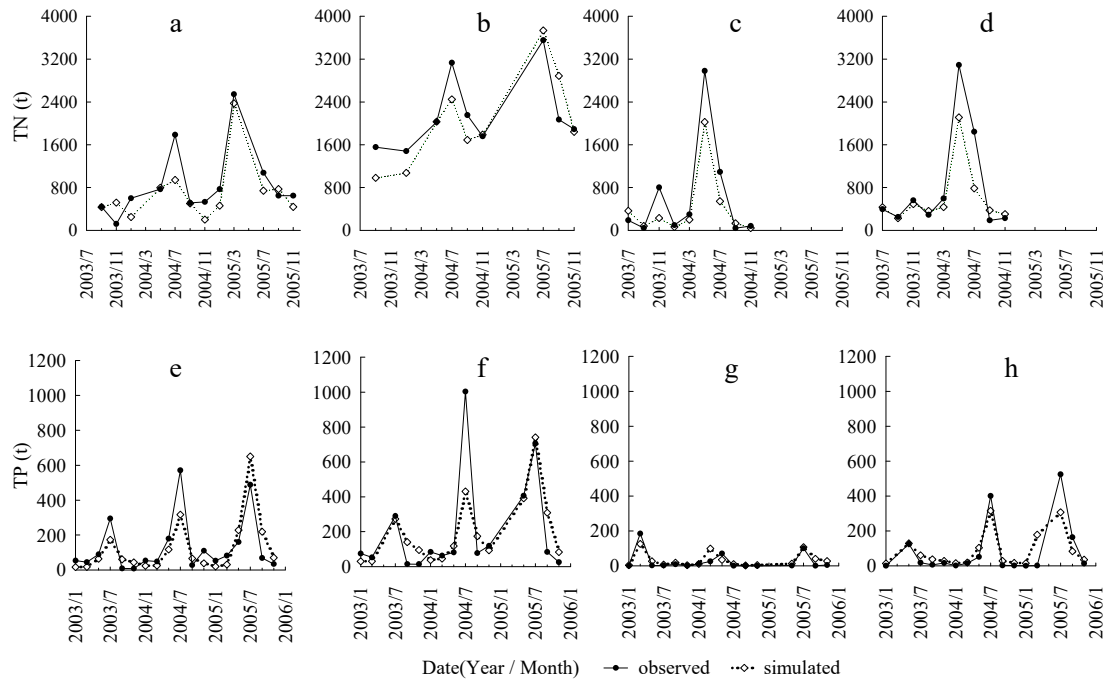


Figure 2. Comparison between the observed and simulated monthly nutrient yields at four stations for the calibration period (2003–2004) and validation period (2005). (a) Shenyang station; (b) Xingjiawopeng station; (c) Liaoyang station; (d) Xiaolinzi station; (e) Shenyang station; (f) Xingjiawopeng station; (g) Liaoyang station; (h) Xiaolinzi station.

Table 1. Rainfall runoff samples collected from different functional zones of Shenyang city in 2018.

Functional zones	7/8/2018		8/14/2018		9/2/2018	
	Rainfall	Samples	Rainfall	Samples	Rainfall	Samples
Business zone	17.3	15	8.5	7	14.5	13
Educational zone	19.7	15	14.5	18	17.5	23
High density resiDential zone	12.4	12	12.3	11	21.4	19
Industrial zone	10.9	21	8.1	12	6.6	6
Preservation zone	18.5	21	15.4	-	15.5	20

Table 2. Soil and Water Assessment Tool (SWAT) model parameters.

Data	Data format	Data description	Data source
Digital elevation model (DEM)	Grid (cell size, 30×30 m)	Elevation	Liaoning Surveying and Mapping Bureau
Soil map and properties	Grid (cell size, 0.008333333°)	Physical and chemical properties of soils	Harmonized World Soil Database (version 1.2) (http://www.fao.org/nr/land/soils/harmonized-world-soil-database/en/)
Land use map	Grid (cell size, 30×30 m)	Land use classification in 2015 (Figure 1c)	Landsat 8 Operational Land Imager (https://earthexplorer.usgs.gov/)
Weather	Database file (DBF)	Includes daily data of precipitation, maximum and minimum temperature, humidity and wind speed	China Meteorological Administration (https://data.cma.cn/); Local Bureau of Meteorology
Hydrology and water quality data	Database file (DBF)	Monthly observed streamflow data, maximum and minimum discharge data of the four reservoirs, and monthly observed nutrient yields	Local hydrographical station and environmental monitoring station

Agricultural management	Database file (DBF)	Including crop planting time, fertilization, and harvested time	Liaoning statistical bureau and field survey
Point and nonpoint source data	Database file (DBF)	PS: Urban population and industrial production NPS: Rural population and livestock rearing	Liaoning statistical yearbooks (http://www.ln.stats.gov.cn/tjsj/sjcx/ndsj/)

Table 3. ENS and R² values for the Soil and Water Assessment Tool (SWAT) calibration and validation. "-" means missing observed data in the validation period.

	Stations	Calibration	Validation		
		R ²	ENS	R ²	ENS
Streamflow	Beikouqian	0.80	0.77	0.88	0.87
	Fushun	0.95	0.90	0.99	0.98
	Shenyang	0.86	0.77	0.80	0.78
	Huanglatuo	0.85	0.80	0.82	0.80
	Xingjiawopeng	0.82	0.77	0.78	0.78
	Benxi	0.72	0.63	0.68	0.65
	Laioyang	0.64	0.58	0.67	0.64
	Xiaolinzi	0.70	0.64	0.72	0.69
	Tangmazhai	0.73	0.66	0.76	0.74
TN	Shenyang	0.63	0.39	0.95	0.87
	Xingjiawopeng	0.76	0.36	0.78	0.58
	Liaoyang	0.94	0.78	-	-
	Xiaolinzi	0.91	0.73	-	-
TP	Shenyang	0.92	0.66	0.91	0.61
	Xingjiawopeng	0.77	0.55	0.90	0.81
	Liaoyang	0.66	0.65	0.90	0.72
	Xiaolinzi	0.96	0.90	0.66	0.58

Table 4. Optimal parameters of the hydrological module in the SWMM model.

Parameters	Optimal parameters	Parameters	Optimal parameters
Width-K	4	Condit Roughness	0.012
N-Imperv	0.013	Max. Infl. Rate	40
N-Perv	0.15	Min. Infl. Rate	5
Destore-Imperv	1	Decay Constant	7
Destore-Perv	3	Drying Time	7

Table 5. Optimal parameters of the water quality module in the SWMM model.

Parameters	TSS	TN	TP	COD
Road Max Buildup	370	4	0.2	96
Road Rate Constant	0.5	0.7	0.1	0.2
Road Coefficient	0.003	0.07	0.02	0.002
Road Exponent	1.9	1.7	1.8	1.8
Roof Max Buildup	300	2	0.14	54
Roof Rate Constant	0.4	0.5	0.2	0.3
Roof Coefficient	0.005	0.001	0.003	0.009
Roof Exponent	1.4	1.3	1.9	1.5
Green Max Buildup	100	9	0.4	25
Green Rate Constant	0.3	0.5	0.3	0.1
Green Coefficient	0.005	0.004	0.001	0.01
Green Exponent	1.6	1.2	2	1.3