Supporting material

Gas transfer velocities of CO_2 in subtropical monsoonal climate streams and small rivers

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Appendix Table A1. Dataset in relation to our study.

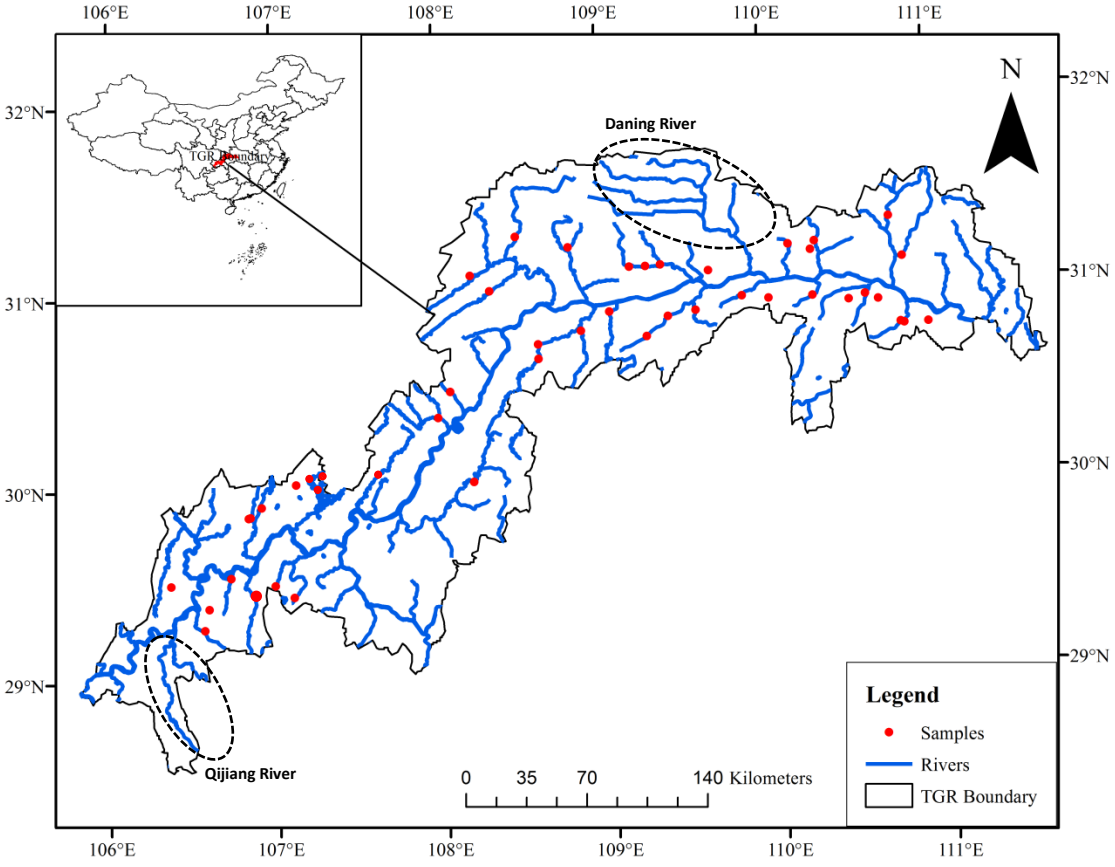

Fig. S1. Map of sampling locations of major rivers and streams in the Three Gorges Reservoir region, China.

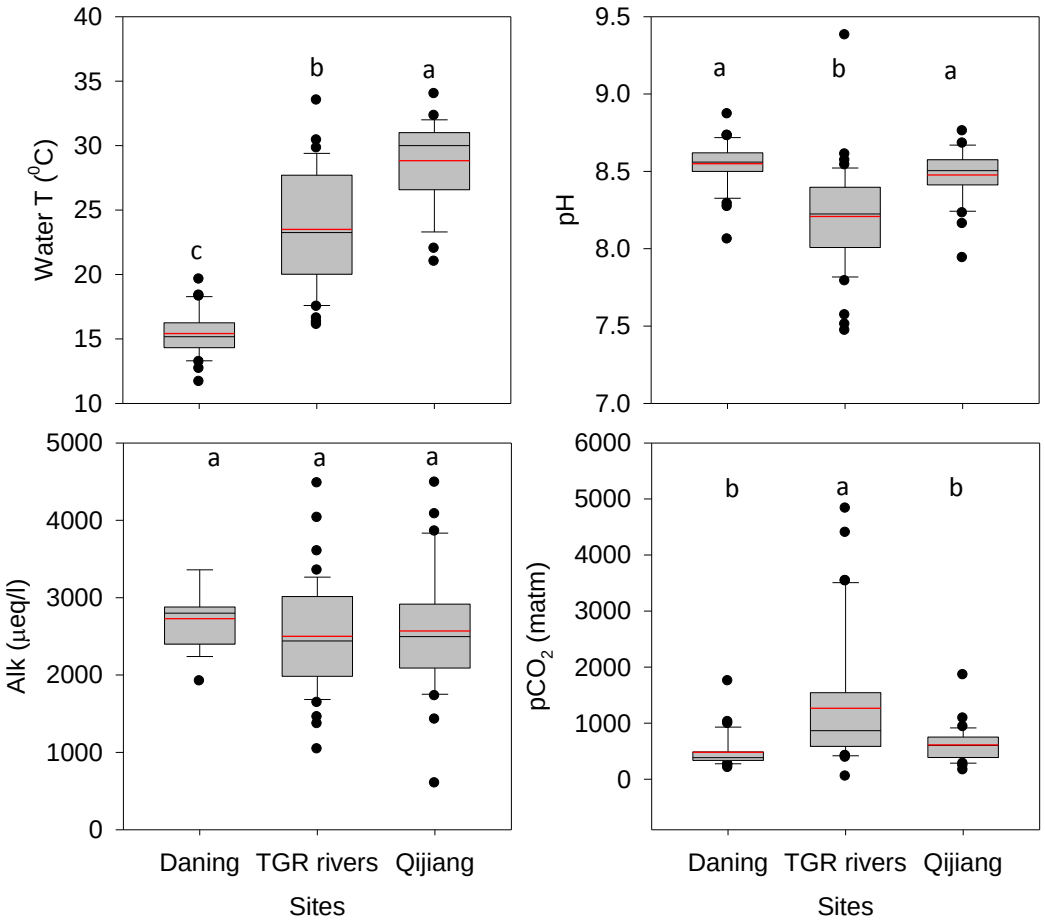

Fig. S2. Boxplots of water temperature, pH, alkalinity and pCO2 in the subtropical rivers (different letters represent statistical differences at $p<0.05$). (the black and red lines, lower and upper edges, bars and dots in or outside the boxes represent median and mean values, 25th and 75th, 5th and 95th, and <5th and >95th percentiles of all data, respectively). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).

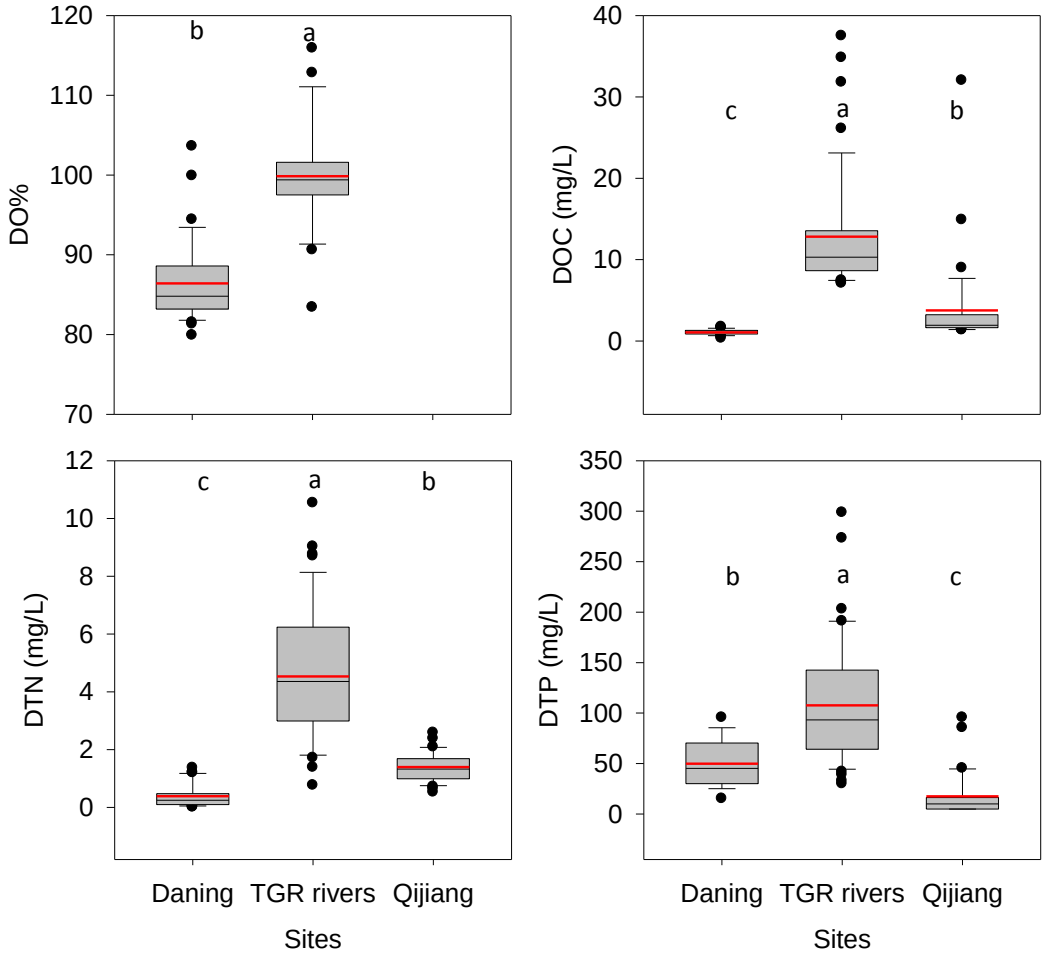

Fig. S3. Boxplots of organic carbon and nutrients in the subtropical rivers (different letters represent statistical differences at $p<0.05$). (the black and red lines, lower and upper edges, bars and dots in or outside the boxes demonstrate median and mean values, 25th and 75th, 5th and 95th, and <5th and >95th percentiles of all data, respectively). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).

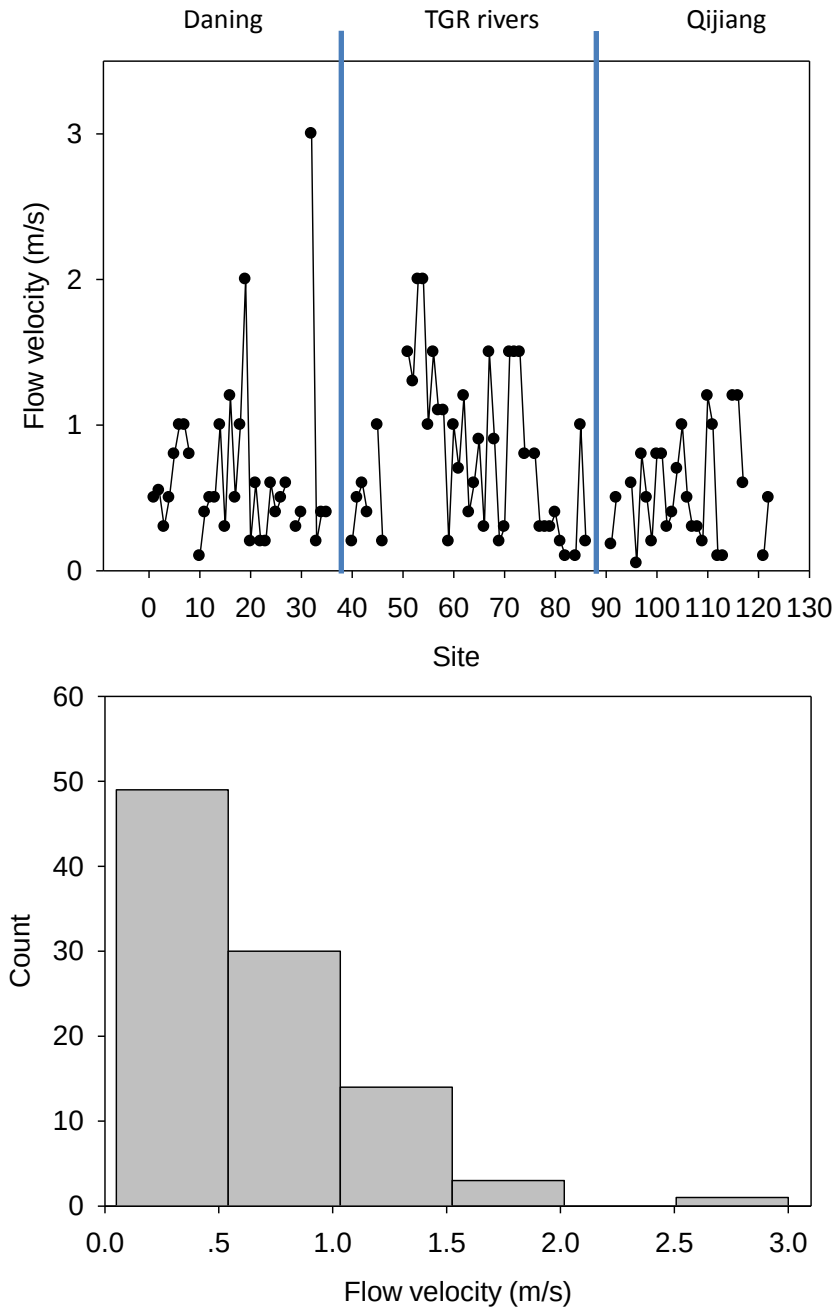

Fig. S4. Current velocity in our studied rivers.

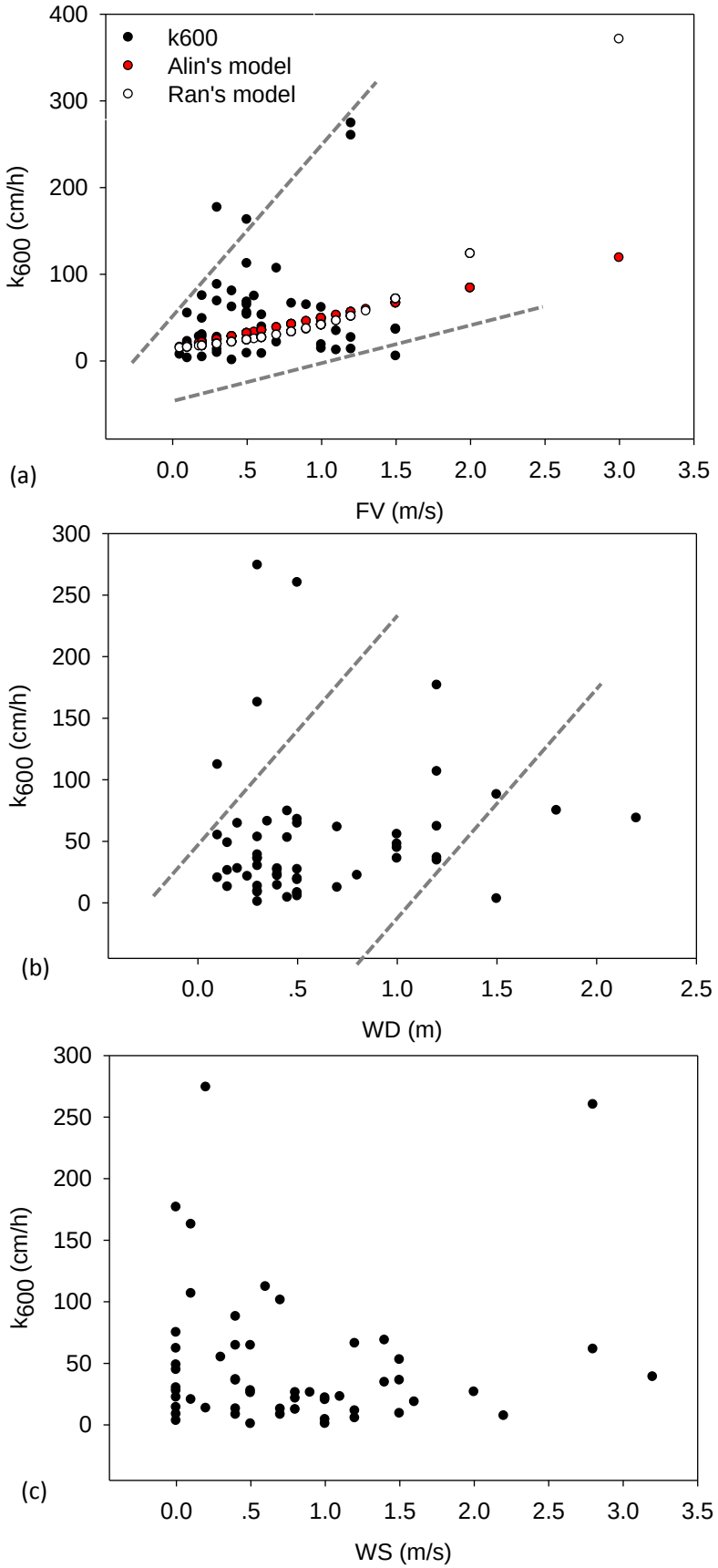

Fig. S5. Plots of k_{600} and flow velocity (FV, unit in m/s) (a), WD (water depth, unit in m) (b), and WS (wind speed, unit in m/s) (c). The circle and red-dotted lines in Fig. 3a

represent the model developed by Ran et al. (2015) and Alin et al (2011), respectively.

Table S1. Estimated k_{600} levels in our rivers.

		Daning	TGR rivers	Qijiang	Total
Mean		50.23	40.36	60.20	48.41
Median		50.46	30.04	25.81	32.22
Std. Deviation		20.10	37.60	78.85	53.20
Minimum		19.48	0.75	4.22	0.75
Maximum		80.50	176.71	274.12	274.12
Percentiles	25	35.809	12.628	13.213	16.303
	75	67.754	61.537	64.827	63.194
95% CI for Mean	Lower Bound	35.86	27.02	24.31	35.12
	Upper Bound	64.61	53.69	96.10	61.70

CI-Confidence Interval

Table S2. Comparison of k values adopted by previous studies.

River	Sites	Climate	k cm/h	Mean pCO_2 (μatm)	CO_2 degassing flux mmol/m^2/d	References
Longchuan River	China	Subtropic	8	2100	156.2	Li et al., 2012
Upper stream of Maotiao River	China	Subtropic	10	3740	294.5	Wang et al., 2011
Pearl River	China	Humid subtropic	8-15	2600	189-356	Yao et al., 2007
Yangtze (Datong)	China	Subtropic	8	1297	38-148	Wang et al., 2007
Rivers in TGR area*	China	Subtropic	48.4±53.2	846 ±819	133.1 ±269.1	This study
Yangtze*	China	Subtropic	38 ±40	1000-2035		Liu et al., 2017
Yellow river network*	China	Temperate	42.1± 16.9	2810±1985	856±409	Ran et al., 2015
Wuding*	China	Temperate	29-37	881	116-218	Ran et al., 2017

*k levels are from measurements

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Dataset APPENDIX TABLE A1

(Daning River)

Time	River	Latitude	Longitude	Air pressure	a.s.l.	T(water)	pH	EC(Cond)	EC(SPC)	TDS	DO	DO	River width	River depth	Water velocity	Alkalinity	DOC	TDN	TDP
				hPa	m	^{0}C		μs/cm	μs/cm	mg/L	%	mg/L	m	m	m/s	μeq/L	mg/L	mg/L	μg/L
2016.5.19;9:21	XJH1	31°23'54"	109°31'25"	979	290	15.58	8.27	266.8	325.3	211	81.3	8.09	5	0.5	0.5	3200	1.09	1.37	30.15
2016.5.19,10:25	XJH2	31°23'48"	109°30'48"	982.1	240	18.294	8.06	353.1	405	263	88.9	8.36	10	0.45	0.55	3360	1.57	1.21	25.13
2016.5.19,11:00	XJH3	31°24'20"	109°31'26"	988	160	18.138	8.29	347.2	399.5	260	86.1	8.12	10	0.5	0.3	3360	1.74	1.07	45.23
2016.5.19,11:42	XJH4	31°23'54"	109°33'33"	989	210	18.275	8.39	349	400.4	260	83.7	7.87	10	0.3	0.5	3360	1.32	1.20	30.15
2016.5.19,15:20	HXH1	31°27'48"	109°21'14"	967	340	14.326	8.58	151.5	190.2	124	87	8.91	15	0.5	0.8	2320	1.15	0.54	30.15
2016.5.19,16:00	HXH2	31°28'49"	109°26'0"	973	320	14.136	8.53	159.1	200.7	130	84	8.63	8	2	1	2240	0.71	0.16	75.38
2016.5.19,16:32	HXH3	31°27'54"	109°30'8"	979	260	14.473	8.53	162.9	203.8	132	84.4	8.61	10	0.5	1	2240	0.67	0.38	55.28
2016.5.19,17:07	HXH4	31°27'46"	109°36'49"	987	260	15.177	8.55	211.7	260.6	169	84.8	8.51	20	0.8	0.8	2400	1.28	0.36	40.20
2016.5.19,17:32	DNH1	31°27'35"	109°38'6"	1000	230	15.221	8.56	220.4	271.1	176	84.6	8.48				2400	1.39	0.12	85.43
2016.5.20;10:19	DXH1	31°39'48"	109°33'7"	958	540	16.248	8.53	218.4	262	170	84.1	8.25	0.5	0.1	0.1	2800	1.41	0.18	40.20
2016.5.20;10:55	DXH2	31°39'46"	109°33'6"	965	560	15.106	8.55	226.3	279	181	84.4	8.49	50	0.3	0.4	2800	1.21	0.33	50.25
2016.5.20;11:20	DXH3	31°39'3"	109°39'46"	970	430	14.55	8.62	222.6	278.1	181	83.6	8.51	2	0.3	0.5	2880	0.89	0.26	75.38
2016.5.20;11:54	DXH4	31°38'3"	109°40'11"	973	130	16.153	8.6	241	289.5	188	82.5	8.12	25	0.5	0.5	2800	1.20	0.17	55.28
2016.5.20;14:09	DXH5	31°36'16"	109°40'34"	974	360	16.389	8.71	242.2	289.9	188	87.6	8.57	20	1	1	2720	0.98	0.66	15.08
2016.5.20;14:40	DXH6	31°34'23"	109°39'11"	981	320	16.417	8.71	238.5	285.2	185	88.6	8.66	25	0.5	0.3	2800	1.34	0.33	30.15

2016.5.20;15:03	DNH2	31°31'31"	109°37'18"	985	270	14.886	8.62	189.4	234.7	153	89.7	9.07	50	1	1.2	2880	0.66	0.12	40.20
2016.5.20;15:35	DNH3	31°28'1"	109°38'9"	987	260	16.689	8.73	193.5	229.9	149	94.4	9.16	50	1	0.5	2480	0.97		40.20
2016.5.20;16:23	XXH1	31°32'16"	109°37'5"	983	260	14.772	8.67	176.2	219	142	92.8	9.4	25	1.5	1	2400	1.02	0.21	95.48
2016.5.20;16:53	DXH7	31°32'13"	109°36'39"	984	280	15.984	8.61	228.9	276.5	180	89	8.78	8	1.5	2	2560	0.99	0.08	50.25
2016.5.20;18:15	DXH8	31°39'48"	109°40'15"		500	15.84	8.56	279.1	338.2	220	82.8	8.2	2	0.2	0.2	3120	1.19	0.24	75.38
2016.5.21;10:18	XXH2	31°39'48"	109°10'8"	922	860	11.671	8.54	131.5	176.4	115	81.5	8.84	4	0.5	0.6	2640	0.95	0.04	45.23
2016.5.21;10:57	XXH3	31°38'11"	109°11'58"	888		15.278	8.73	239.1	293.5	191	82	8.22	1.5	0.1	0.2	2400	0.78	0.42	30.15
2016.5.21;11:11	XXH4	31°37'46"	109°14'17"	947	670	13.934	8.71	187.7	238	155	85.8	8.85	15	1	0.2	2880	1.62	0.46	55.28
2016.5.21;13:15	XXH5	31°37'12"	109°4'31"	912	930	13.93	8.57	187.6	237.9	155	79.9	8.24	4	0.2	0.6	2800	0.87	0.45	70.35
2016.5.21;13:47	XXH6	31°36'10"	109°7'53"	934	780	12.688	8.5	135.8	177.6	115	83.2	8.82	8	0.5	0.4	2800	0.33	0.17	85.43
2016.5.21;14:24	XXH7	31°37'7"	109°8'27"	929	780	13.358	8.56	200.5	257.9	168	82.8	8.65	3	0.5	0.5	2960	1.59	0.07	85.43
2016.5.21;14:55	XXH8	31°36'29"	109°9'59"	939	700	14.696	8.46	210.7	262.4	171	83	8.42	3	0.3	0.6	2880	0.53	0.08	25.13
2016.5.21;15:21	XXH9	31°35'21"	109°12'16"	944	660	14.319	8.57	151.7	190.6	124	83.9	8.58	25	0.3		2240	0.87	0.11	30.15
2016.5.21;15:43	XXH10	31°35'23"	109°16'4"	951	600	15.092	8.6	155.3	191.6	125	85	8.55	25	0.4	0.3	2240	0.69	0.08	25.13
2016.5.21;16:16	XXH11	31°35'23"	109°17'28"	945	660	13.219	8.46	125.9	162.5	106	84.9	8.9	4	0.2	0.4	1920	0.70	0.01	35.18
2016.5.21;17:05	XXH12	31°34'37"	109°25'54"	967	490	16.142	8.87	198.9	239.5	156	103.6	10.19				2720	0.95	0.01	65.33
2016.5.21;18:07	XXH13	31°33'54"	109°34'13"	982	340	14.455	8.46	176.3	220.8	144	92.1	9.39	8	2.5	3	2560	1.13	0.33	65.33
2016.5.22;9:26	DNH4	31°23'25"	109°37'27"	997	210	16.187	8.5	213.2	256.2	166	86.8	8.54	25		0.2	2800	1.19	0.09	30.15
2016.5.22;9:44	XJH5	31°23'26"	109°37'25"	997	180	18.37	8.35	358.7	410.7	267	86.1	8.08	8		0.4	3360	1.32	1.16	70.35
2016.5.22;10:15	DNH5	31°23'38"	109°37'49"	997	230	19.618	8.68	292	325.5	212	99.9	9.15	2	0.2	0.4	3200	1.10	0.72	45.23

(TGR rivers)

Time	Code	Latitude	Longitude	asl	T(air)	Wind speed	T(water)	pH	ORP	EC	DO	DO	River width	River depth	Water velocity	Alk	DOC	DTN	DTP
				m	^{0}C	m/s	^{0}C		mv	μs/cm	mg/L	%	m	m	m/s	μeq/L	mg/L	mg/L	μg/L
2016.6.21;13:41	BLXX	29°30'30"	106°59'26"	432	39.1	0.6	29.1	7.57		233						1880	26.08	3.88	76.12
2016.6.21;15:00	BLTH	29°26'47"	107°06'11"	700	33.2	1.1	24.7	7.47		225			15	0.4	0.2	1976	37.48	7.03	120.89
2016.6.22;09:04	BNB	30°01'50"	108°11'32"	616	28.2	0	20	7.96		125.8			11	0.3	0.5	1040	14.31	1.94	82.84
2016.6.22;10:00	BLH	29°17'53"	108°55'00"	518	29.9	0.4	23.5	7.84		202.3			80	0.5	0.6	1840	22.03	3.09	143.28
2016.6.22;12:00	BHJH	30°22'07"	107°59'10"	181	33.5	1	29	7.79		418			4	0.3	0.4	3128	13.56	3.09	138.81
2016.6.22;13:14	BRXH	30°30'10"	108°03'45"	215	36.1	0.5	33.5	7.82		344						3112	31.80	7.19	108.95
2016.6.22;18:00	BDH	31°18'07"	108°28'52"	193	32.5	2.8	29.3	8.25	128	976	8.49	115.9	6	0.7	1	2152	10.30	1.71	44.78
2016.6.23;10:00	BNH	31°06'21"	108°12'02"	43	31.9	0	30.4	8.06	159.3	359	6.61	90.6	6	0.15	0.2	4032	34.82	3.45	140.30
2016.6.23;11:25	BPLH	31°01'18"	108°18'58"	152	33.3	0.9	29.4	8.15	155.9	269	6.07	83.4				1688	10.47	2.96	140.30
2016.6.23;15:47	BMDX	30°44'15"	108°36'07"	217	31.6	0.8	22.2	8.42	115.2	203	8.34	101				1640	7.54	3.22	29.85
2016.6.23;16:22	BSBH	30°39'42"	108°36'07"	256	32.5	0	28.9	8.61	81	240	7.63	104.1				2536	16.56	3.58	62.69
2016.6.23;18:56	BDXH	30°48'04"	108°51'47"	132	31.2	0.7	29.4	8.21	58.9	870	8.36	112.8				3256	10.00	1.81	41.79
2016.6.24;14:34	BCTH	30°53'48"	109°02'20"	138	25.4	1.2	22.2	7.89	99.1	102.3	8.43	99.2	4	0.5	1.5	1368	9.95	2.66	95.52
2016.6.25;12:00	BMXH	30°45'40"	109°15'37"	558	22.3	2.8	17.7	8.14	85.5	211	8.98	98.9	20	0.4	1.3	2488	7.30	6.34	77.61
2016.6.25;13:30	BMXH-2	30°51'44"	109°23'34"	317	23.5	0.6	17.8	8.19	92.2	320	9	96.7	25	0.5	2	2704	8.68	4.43	71.64
2016.6.25;15:10	BJPH	30°53'19"	109°33'38"	149	23.3	1.4	17.6	8.38	64.1	265	8.89	99.4	30	1	2	2392	10.23	4.34	50.75
2016.6.26;12:23	BGDH	30°57'15"	109°50'36"	366	27	0	16.1	8.26	38.3	278	9.44	98.3	30	1.5	1	3016	9.92	1.97	59.70
2016.6.26;15:36	BBLH	30°56'09"	110°00'17"	197	25.1	0	16.6	8.36	7.9	279	8.54	94.3	30	0.5	1.5	3112	7.45	4.66	98.51
2016.6.27;11:32	BWFH	30°56'26"	110°16'15''	402	28.1	1.4	16.3	8.4	9.03	303	9.03	101.2	6	1.2	1.1	2520	8.53	5.42	57.46
2016.6.27;14:07	BLFD	30°56'16"	110°35'19''	216	30.4	0.8	21.3	8.35	48.6	290	8.56	99.5	4	0.7	1.1	2216		4.39	68.66
2016.6.27;15:00	BQGH	30°54'45"	110°29'20''	237	31.2	0	22.8	8.45	29.1	324	8.61	101.4	7	0.4	0.2	2904	9.81	6.88	80.60
2016.6.27;16:48	BJZH	30°54'30"	110°39'58''	220	29.5	0	22.1	8.45	33.5	320	8.14	101.2	7	0.4	1	2664	8.64	6.18	47.76
2016.6.27;18:00	BJWX	30°46'41"	110°49'00''	152	28.3	0.1	18.3	8.39	25.5	280	9.52	103.8	25	1.2	0.7	2616	8.33	4.76	104.48

2016.6.27;18:30	BJWX-2	30°47'04"	110°47'44''	242	29.2	2	20.1	8.33	21.8	314	8.63	98.2	3	0.4	1.2	2616	8.65	4.07	73.13
2016.6.28;10:20	BMPH	30°46'47"	110°57'44''	137	29.3	1	21.1	8.35	32.5	353	8.63	96.8	1.2	0.4	0.4	3352	11.20	3.61	161.19
2016.6.28;14:40	BGLH	31°07'27"	110°49'21''	120	33.9	3.2	21.5	8.52	-1.6	321	8.3	101.8	15	0.3	0.6	3008	22.38	8.76	44.78
2016.6.28;16:20	BXXH	31°20'07"	110°45'02''	185	33.1	1.5	19.9	8.51	31.9	330			12	0.3	0.9	3200	11.82	2.34	176.12
2016.6.29;10:44	BLTH-XXGQ	30°13'32"	110°32'47''	745	26.9	1.1	17.6	8.57	64.3	208	8.26	98.7	7	1.2	0.3	2616	7.08	1.81	191.04
2016.6.29;11:32	BSNX	31°13'22"	110°17'39''	125	33.7	0.4	19.3	9.38	8.6	232			22	1.2	1.5	2368	7.44	1.91	32.84
2016.6.29;14:32	BLXB	31°10'45"	110°16'07''	171	37.8	0.4	29.8	8.49	-2	378			6	0.2	0.9	3600	11.09	4.63	58.21
2016.6.29;16:31	BBCH	31°12'47"	110°08'03''	631	33.8	0	27.7	8.24	3.5	438			5	0.3	0.2	4480	21.81	9.03	86.57
2016.6.29;17:29	BCaoT	31°05'31"	109°38'46''	193	33.6	1.5	28.7	8.54	96.8	501			4	0.3	0.3	3176	11.23	8.70	202.98
2016.6.30;10:40	BCJH	31°07'56"	109°21'21''	129	30.7	0.4	22.8	8.5	20.3	371			22	1	1.5	2616	8.35	3.61	128.36
2016.6.30;11:10	BMeiXH	31°07'37"	109°15'54''	140	27.3	5	21.6	8.38	22.7	218			30	0.4	1.5	1968	9.53	4.60	85.82
2016.6.30;11:40	BCJB	31°07'35"	109°10'06''	288	27.8	0.5	22.9	8.34	23.8	162.8			35	1.2	1.5	1456	7.22	6.24	73.13
2016.6.30;15:21	BTXH	31°14'17"	108°48'00''	164	25	0.8	17.5	8.3	9.7	162			25	1,5	0.8	1936	8.28	0.76	38.81
2016.7.01;10:31	BGaoTH	30°17'31"	107°27'33''	331	25.9	0.7	23.3	7.93	32.3	249						2290	9.28	6.93	273.13
2016.7.01;11:28	BGJH	30°12'35"	107°29'47''	354	28.5	0	23.3	8.14	29.9	274			15	2.2	0.8	2270	12.18	3.52	101.49
2016.7.01;12:30	BQXH	30°06'21"	107°31'06''	378	29.2	1.4	23.4	8.17	69.3	258			25	2.2	0.3	2260	11.80	4.57	147.76
2016.7.01;14:41	BLXH	29°50'30"	107°08'58''	190	33.3	0	25.9	7.51	54.6	379			30	1.2	0.3	2340	12.30	8.08	191.04
2016.7.01;15:54	BTXH	30°01'59"	107°07'23''	328	29.6	0.4	24.7	7.86	40.7	377			15	1.5	0.3	2100	13.95	10.54	298.51
2016.7.02;10:50	BWTH	29°51'42"	106°50'08''	194	32.2	0	23.3	8.16	36.3	300			30	1.2	0.4	2664	10.59	2.01	89.55
2016.7.02;11:17	BYLH	29°51'54"	106°50'49''	149	34.6	0	24.4	8.17	37.6	264			45	1.8	0.2	1880	9.13	1.38	144.78
2016.7.02;11:37	BDH-YB	29°54'59"	106°54'51''	134	33.9	0	27.6	7.99	59.1	322			45	1.5	0.1	2296	10.86	4.93	94.78
2016.7.02;14:49	BCTH-YL	29°32'59"	106°43'35''	181	35.5	0.4	27.7	8.18	44	270						2008	10.72	4.57	135.82
2016.7.02;16:04	BHXH	29°23'19"	106°35'37''	208	31.2	0	23.2	8.08	73.2	303			20	0.8	0.1	2176	9.86	6.37	144.78
2016.7.02;17:25	BYPH	29°16'46"	106°34'01''	118	31	0	24.2	8.1	74.9	232			35	1	1	1912	8.43	3.55	91.79
2016.7.02;18:23	BLTH-BSY	29°30'35"	106°22'00''	271	31.3	0.4	28.1	7.87	12.6	462			6	0.6	0.2	3144	14.15	6.24	159.70

(Qijiang River)

Date	Time	River	T(air) ^{0}C	Wind speed m/s	T(water) ^{0}C	pH	EC µs/cm	TDS mg/L	River width m	River depth m	Water velocity m/s	Alk µeq/L	DOC mg/L	TDN mg/L	TDP mg/L
2016.8.15	13:30	BZD1	39.6	0.5	30	8.41	351.6	229	3	20	0.18	2920	1.34	2.58	10.05
	14:30	BZD2	40.5	1	25	8.59	317	206	20	40	0.5	2472	1.61	2.09	10.05
	15:30	BZD3	37.3	0.7	31	8.67	301.8	196				2656	2.32	1.99	5.03
	15:40	BZD4	34.4	0.6	31	8.52	269.1	175				1824	14.88	0.53	5.03
	16:10	BZD5	33.7	1.6	32	8.52	282.5	184	20	80	0.6	2336	1.48	0.87	5.03
	16:45	BZD6	34.4	2.2	30	8.3	448.2	292	2	50	0.05	2216	1.65	1.89	5.03
2016.8.16	9:10	BSY1	31	0.4	22	8.64	322.3	210	3	60	0.8	3056	2.00	1.01	5.03
	9:50	BSY2	33.1	0.5	23.3	8.49	345	224	6	50	0.5	2896	1.65	0.97	10.05
	10:25	BSY3	31.6	1	23.5	7.94	374.7	244	20	45	0.2	2520	1.39	1.12	
	13:40	BSK1	32.2	1	26.8	8.63	513.8	334	1	15	0.8	2552	4.46	1.99	5.03
	14:20	BSK2	36.1	1.2	21	8.27	338.6	220	2	35	0.8	2288	32.01	2.05	10.05
	15:00	BSK3	41.8	0.5	30.5	8.67	286.7	186	12	50	0.3	2600	3.72	0.97	10.05
	15:40	BSK4	35.4	1.3	31	8.16	416.2	271	1.5	60	0.4	1896	1.88	0.99	5.03
	16:00	BSK5	38.3	0.8	26.5	8.68	334.5	218	3	25	0.7	2048	2.53	1.57	10.05
	16:20	BSK6	40	0.8	29	8.56	381.2	248	2	50	1	1728	1.50	1.29	20.10
	17:00	BSK7	38.1	0.6	32.3	8.76	335.2	218	2	10	0.5	1984	1.65	0.86	5.03
2016.8.17	9:30	BSK8	30.2	0.8	23.3	8.48	368.9	240	11	15	0.3	3112	1.64	1.55	10.05
	10:00	BSK9	32.3	0.4	26	8.4	362.9	236	11	15	0.3	2632	1.72	1.45	45.23
	11:00	BSK10	34.4	0.2	29	8.56	367.4	239	20	35	0.2	2368	1.86	1.29	
	11:24	BSK11	35.5	2.8	29.1	8.52	410.8	207	5	50	1.2	2544	1.40	0.71	5.03
	12:45	BSK12	38.5	1.6	30	8.46	474.8	309	12	50	1	2904	1.44	1.33	40.20
	15:00	BYD1	35	0.3	29.5	8.45	663.6	431	1	10	0.1	2240	2.25	2.38	10.05
	16:30	BYD2	32.7	0.8	30	8.58	217.6	142	4	10	0.1	1808	4.74	1.03	5.03

	17:45	BYD3	33	0.5	29	8.45	1087.9	707				4488	2.00	1.62	15.08
	18:14	BYD4	32.6	0.2	32	8.55	1099.5	716	5	30	1.2	3592	2.49	1.58	15.08
	17:00	BYD5	32	0.2	30.5	8.53	1051.9	684	4	30	1.2	4080	1.73	1.26	5.03
	19:30	BQJ1	32.3	1.5	30	8.56	623	405	40	45	0.6	3784	1.83	1.43	15.08
2016.8.18	10:00	BQJ2	37	1.2	29.5	8.35	396.4	258				2416	2.99	1.26	95.48
	11:20	BPH1	33.2	0.7	31.9	8.49	1350.3	878				3856	8.98	1.47	25.13
	15:00	BSX1	41.4	0.1	32	8.42	150.9	98				600	3.46	0.64	5.03
	16:00	BSX2	41.2	1	34	8.23	179.9	117	8	10	0.1	1424	3.31	1.33	30.15
	16:30	BQG3	37.1	0.1	32	8.43	422.2	274	15	30	0.5	2376	2.46	1.71	85.43