Supporting Information for

Li et al.

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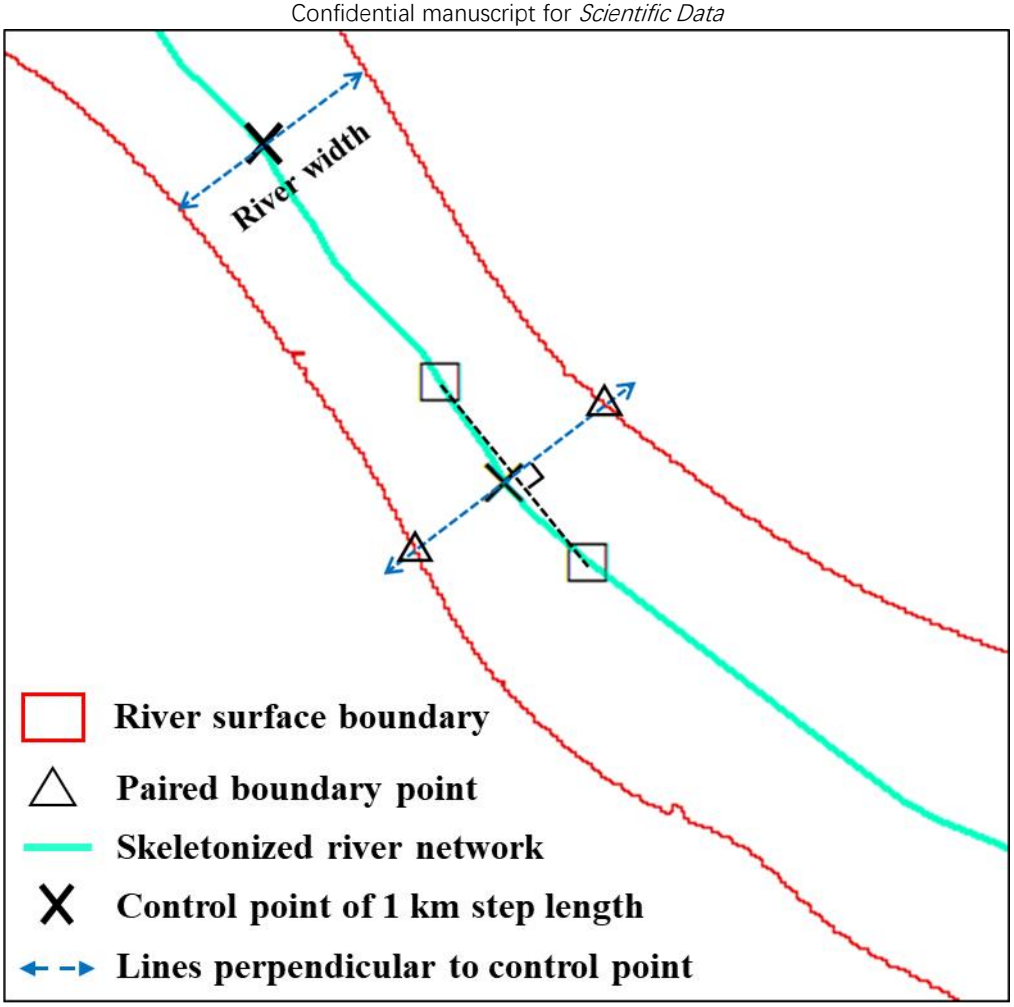

Figure 1 Visualized steps in river width extraction.

Table 1 Basic information of the cross sections used to select remote sensing imagery in the study

ID	River system	River name	Flow to	Cross section name	Longitude (°)	Latitude (°)	Altitude (m)	Slope (‰)	Contributing area (km^2)	Distance to estuary (km)	ORD_STRA[1]	HYRIV_ID[1]
1	Yellow River	Yellow River	Bohai Sea	Huangheyan	98.169	34.890	4214	2.46	20930	5194	5	40517255
2	Yellow River	Yellow River	Bohai Sea	Mentang	101.046	33.767	3636	1.10	59655	4618	6	40555516
3	Yellow River	Yellow River	Bohai Sea	Jungong	100.651	34.688	3081	4.41	98414	4057	6	40524713
4	Yellow River	Yellow River	Bohai Sea	Xunhua	102.450	35.868	1864	1.71	145333	3563	6	40481104
5	Yellow River	Yellow River	Bohai Sea	Lanzhou	103.817	36.067	1518	2.25	222551	3345	7	40474207
6	Yellow River	Huangshui River	Yellow River	Minhe	102.809	36.337	1761	6.32	15342	75	5	40465133
7	Yellow River	Tao River	Yellow River	Minxian	104.033	34.445	2303	1.76	14108	254	5	40532345
8	Yellow River	Daxia River	Yellow River	Shuangcheng	103.050	35.483	2040	8.01	6144	55	5	40494988
9	Jinsha River	Tongtian River	Jinsha River	Zhimenda	97.217	33.033	3541	1.35	137704	No data	7	40578521
10	Jinsha River	Jinsha River	East Sea	Gangtuo	98.583	31.633	3042	1.22	149072	4830	7	40623877
11	Jinsha River	Jinsha River	East Sea	Benzilan	99.305	28.236	2005	1.82	203320	4345	7	40776220
12	Jinsha River	Jinsha River	East Sea	Shigu	99.954	26.906	1818	0.70	214184	4175	7	40862398
13	Jinsha River	Jinsha River	East Sea	Panzhihua	101.712	26.590	987	1.88	259177	3658	7	40881184
14	Yalong River	Yalong River	Jinsha River	Ganzi	99.967	31.617	3347	1.96	32925	923	6	40624311
15	Yalong River	Yalong River	Jinsha River	Yajiang	101.017	30.033	2566	6.74	66871	621	6	40683047
16	Yalong River	Yalong River	Jinsha River	Luning	101.867	28.450	1433	1.54	108083	269	7	40760868
17	Yarlung Zangbo River	Yarlung Zangbo River	Brahmaputra River	Nugesha	89.712	29.330	3769	2.17	106378	1139	7	40714334
18	Yarlung Zangbo River	Yarlung Zangbo River	Brahmaputra River	Yangcun	91.883	29.276	3543	1.84	153191	891	7	40716701
19	Yarlung Zangbo River	Yarlung Zangbo River	Brahmaputra River	Nuxia	94.567	29.459	2918	0.63	189843	530	7	40708561
20	Yarlung Zangbo River	Lasa River	Yarlung Zangbo River	Lasa	91.148	29.639	3653	2.38	26225	61	6	40700489
21	Yarlung Zangbo River	Nianchu River	Yarlung Zangbo River	Jiangzi	89.604	28.903	4025	4.02	6216	97	5	40735047
22	Lantsang River	Lantsang River	Mekong River	Jiuzhou	99.219	25.783	1292	6.24	88051	774	6	40927476
23	Nu River	Nu River	Salween River	Daojieba	98.883	24.983	664	1.98	110224	153	6	40974100

[1] Lehner, B., Grill G. (2013). Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. Hydrological Processes, 27(15): 2171–2186. https://doi.org/10.1002/hyp.9740

Table 2 Bankfull discharge (BD), in-situ measured ($W_{bf\text{-}m}$) and extracted bankfull river width ($W_{bf\text{-}e}$) and relevant information of the cross sections that are used to select remote sensing imagery in the study

ID	Recurrence interval of BD	BD ($m^3 s^{-1}$)	Expanded BD in the view of incomplete imagery coverage	Lower bounds of BD ($m^3 s^{-1}$)	Higher bounds of BD ($m^3 s^{-1}$)	In-situ measured $W_{bf\text{-}m}$ (m)	Lower bounds of $W_{bf\text{-}m}$ (m)	Higher bounds of $W_{bf\text{-}m}$ (m)	Lower bounds of $W_{bf\text{-}m}$ (%)	Higher bounds of $W_{bf\text{-}m}$ (%)	Extracted $W_{bf\text{-}e}$ in the BGD* (m)	Relative error between the measured $W_{bf\text{-}m}$ and extracted $W_{bf\text{-}e}$ (%)
1	2.05	55	±20%	44	65	81	78.5	84.0	-3.1	3.7	85.0	4.9
2	1.15	592	±20%	474	710	143	140.0	143.0	-2.1	0.0	141.2	-1.3
3	1.05	1209	±10%	1088	1329	171	161.0	178.0	-5.8	4.1	176.3	3.1
4	1.35	1680	±10%	1512	1848	128	127.0	129.0	-0.4	1.2	118.1	-7.4
5	1.15	1880	±15%	1598	2162	206	205.0	226.0	-0.5	9.7	200.7	-2.6
6	2.34	265	±10%	238	291	35	34.6	36.3	-0.1	4.8	37.5	8.2
7	3.08	408	±15%	347	470	171	136.0	172.0	-20.7	0.4	172.7	0.8
8	1.27	80	±10%	72	87	42	38.0	46.0	-9.7	9.3	44.9	6.7
9	2.00	2532	±20%	2025	3038	183	179.0	186.5	-2.2	1.9	172.3	-5.8
10	2.00	2785	±20%	2228	3342	107	106.0	109.0	-0.9	1.9	104.0	-2.8
11	2.00	4800	±20%	3840	5760	146	140.0	149.0	-4.4	1.8	143.7	-1.9
12	2.00	4821	±20%	3857	5785	267	262.0	272.0	-1.9	1.9	263.3	-1.4
13	2.00	6905	±20%	5524	8286	174	171.0	179.0	-1.7	2.9	166.3	-4.4
14	1.99	1361	±40%	817	1905	201	197.0	204.0	-2.0	1.5	187.3	-6.8
15	1.99	3555	±40%	2133	4977	93	82.7	96.4	-11.1	3.7	90.7	-2.5
16	1.99	6036	±50%	3018	9054	143	131.0	145.0	-8.4	1.4	137.3	-4.0
17	2.51	3078	±20%	2463	3694	124	119.0	126.0	-3.7	1.9	126.6	2.4
18	2.51	5380	±20%	4304	6456	362	335.0	368.0	-7.5	1.7	349.7	-3.4
19	2.51	8970	±40%	5382	12558	326	311.0	334.0	-4.6	2.5	343.3	5.3
20	1.91	1680	±50%	840	2520	413	250.0	457.0	-39.5	10.7	439.0	6.3
21	1.98	136	±20%	109	163	120	108.0	130.0	-10.0	8.3	104.0	-13.3
22	2.73	3864	±40%	2318	5410	158	156.0	161.0	-1.3	1.9	150.3	-4.9
23	2.92	6982	±50%	3491	10473	256	222.0	259.0	-13.3	1.2	249.7	-2.5

*BGD: Bankfull Geometry Dataset

Table 3 Comparison of RivWidth, RivaMap, RivWidthCloud and ARWE in account of their application ranges, automation degrees, application difficulties and extraction processes and results

Algorithms	Key parameters and data	Extraction method	Comparisons			
			Application ranges	Automation degrees	Application difficulties	Extraction processes and results
RivWidth	Binarized river surface with single flow path; Empirically determined gradient threshold	Threshold value method	A*: single-thread rivers; W**: not applicable for multi-thread rivers	W: low automation degree, manual judgement of the directions of river centerline and width, low parallel computation degree	A: easily operation, high softwareization and visualization; W: high threshold for secondary development	W: highly depend on the accurate extraction of river surface
RivaMap	Original Landsat imagery; Multiscale singularity index	Multiscale singularity index	A: low-land river, coastline, lakeshore; W: poor extraction results for mountain rivers located in complex terrain	A: quasi real time water surface extraction; W: manual judgement of MNDWI during pretreatment of RS imageries	A: river surface and width be extracted by preset MNDWI and pretreated RS imageries. W: Less applicable for high-resolution satellite images which contain large amount of texture information.	A: no need to extract river surface; W: dataset contain no river width information without postprocessing; empirical determination of the singularity index range
RivWidth Cloud	Binarized river surface; Empirically determined gradient threshold from GRWL; 9×9 - pixel kernel in degrees	Machine learning	A: single-thread and multi-thread rivers	A: high computational capacity and efficiency based on GEE; W: automation degree decreases because of the empirical determination of gradient threshold in extracting river centerline.	W: multiple preexperiments are required for different study areas.	A: accurate river surface and width extraction based on convolving river centerline with 9×9 - pixel kernel in degrees; W: empirical determination of a pair of 3×3 - pixel kernels during the river centerline extraction; wider extracted river width due to the not exactly perpendicular of river width to the river centerline.

ARWE	Binarized river surface	Machine learning	A: single-thread and multi-thread rivers; small mountain rivers; W: poor extraction results for rivers with extreme irregular banks	A: high automation degree due to the algorithm of correcting river centerlines automatically. Combination of the above algorithm and the central axis transformation contribute to accurate extraction of the river centerline.	W: compiling environment is Matlab, not be able to use in the GEE platform at present	A: accurate river width due to the exactly perpendicular of river width to the river centerline

[*]A: advantages; [**]W: weakness

Table 4 Basic information, in-situ measured ($W_{bf\text{-}m}$) and extracted bankfull river width ($W_{bf\text{-}e}$) of the cross sections that are not used to select remote sensing imagery in the study

ID	River system	Station name	Longitude (°)	Latitude (°)	Contributing area (km^2)	In-situ measured $W_{bf\text{-}m}$ (m)	Extracted $W_{bf\text{-}e}$ in the BGD (m)	Relative error between the measured $W_{bf\text{-}m}$ and extracted $W_{bf\text{-}e}$ (%)
24	Jinsha River	Xiaqiaotou	100.050	27.183	1920	29.2	23.3	-20.1
25	Jinsha River	Xinzhai	97.053	33.019	2298	37.5	36.3	-3.1
26	Jinsha River	Shangqiaotou	99.399	28.166	2432	44.4	43.0	-3.2
27	Jinsha River	Guxue	99.254	28.417	12160	53.9	49.0	-9.1
28	Jinsha River	Tuouohe	92.450	34.217	15924	272.0	296.0	8.8
29	Jinsha River	Batang	99.011	29.767	180055	200.0	206.7	3.3
30	Jinsha River	Ahai	100.506	27.333	235400	123.8	119.7	-3.3
31	Jinsha River	Zhongjiang	100.414	26.500	241452	219.7	207.0	-5.8
32	Lantsang River	Taipingguan	100.298	24.492	2910	65.7	61.7	-6.1
33	Lantsang River	Tiankou	100.010	25.351	9394	95.0	89.7	-5.6
34	Lantsang River	Xiangda	96.538	32.154	17909	148.5	151.3	1.9
35	Lantsang River	Changdu	97.187	31.183	53800	105.0	97.3	-7.3
36	Nu River	Jiucheng	99.259	24.442	6306	92.1	92.7	0.6
37	Yalong River	Zhuosang	100.383	29.700	3104	82.0	73.7	-10.2
38	Yalong River	Zhuba	100.691	31.433	6860	52.0	48.3	-7.1
39	Yalong River	Daofu	101.068	31.031	14465	84.0	86.2	2.6
40	Yarlung Zangbo River	Yangbajing	90.546	30.087	2633	35.2	45.3	28.8
41	Yarlung Zangbo River	Gongbujiangda	93.250	29.885	6417	94.2	110.0	16.8
42	Yarlung Zangbo River	Shigatse	88.895	29.283	11121	75.7	78.0	3.0
43	Yarlung Zangbo River	Jiuba	94.150	29.742	15600	174.0	184.3	5.9
44	Yarlung Zangbo River	Pangduo	91.382	30.141	16370	119.0	109.3	-8.1
45	Yarlung Zangbo River	Tangjia	91.781	29.888	20367	134.0	137.3	2.5
46	Yellow River	Qingshui	102.551	35.834	689	29.4	30.9	5.1
47	Yellow River	Jiuzhi	101.491	33.433	1248	46.6	53.2	14.2
48	Yellow River	Tongren	102.022	35.516	2832	34.6	32.5	-6.1
49	Yellow River	Huangyuan	101.267	36.682	3027	43.5	35.7	-17.9
50	Yellow River	Luqu	102.459	34.601	5043	39.5	46.3	17.2
51	Yellow River	Tangke	102.452	33.417	5374	242.0	237.8	-1.7
52	Yellow River	Xining	101.783	36.632	9022	30.5	34.0	11.5
53	Yellow River	Jimai	99.650	33.767	45019	172.5	170.3	-1.3
54	Yellow River	Maqu	102.083	33.958	86048	262.0	281.7	7.5

55	Yellow River	Tangnaihai	100.150	35.500	121972	150.0	146.7	-2.2
56	Yellow River	Guide	101.405	36.045	133650	191.0	217.3	13.8
57	Yellow River	Xiaochuan	103.333	35.933	181770	146.0	147.0	0.7
58	Yellow River	Shangquan	103.245	36.027	182821	208.0	211.7	1.8