Supplement of Hydrol. Earth Syst. Sci., 28, 163–178, 2024
https://doi.org/10.5194/hess-28-163-2024-supplement

Hydrology and Earth System Sciences
Open Access
EGU

Supplement of

Evaporation and sublimation measurement and modeling of an alpine saline lake influenced by freeze–thaw on the Qinghai–Tibet Plateau

Fangzhong Shi et al.

Correspondence to: Xiaoyan Li (xyli@bnu.edu.cn)

Figures

Fig. S1.

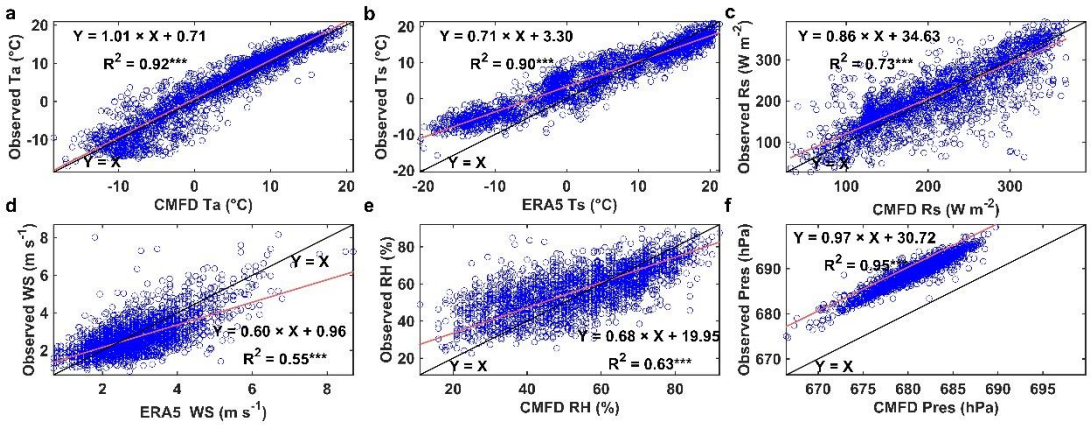


Fig. S1. Relationship between the daily air temperature (Ta) from the China Regional High–Temporal–Resolution Surface Meteorological Elements–Driven Dataset (CMFD), lake surface temperature (Ts) from the interim reanalysis dataset v5 (ERA5), downward shortwave radiation (Rs) from CMFD, daily wind speed (WS) from ERA5, daily relative humidity (RH), and air pressure (Pres) from CMFD with the observed Ta (a), Ts (b), Rs (c), WS (d), RH (e), and Pres (f) in Qinghai Lake.

Fig. S2.

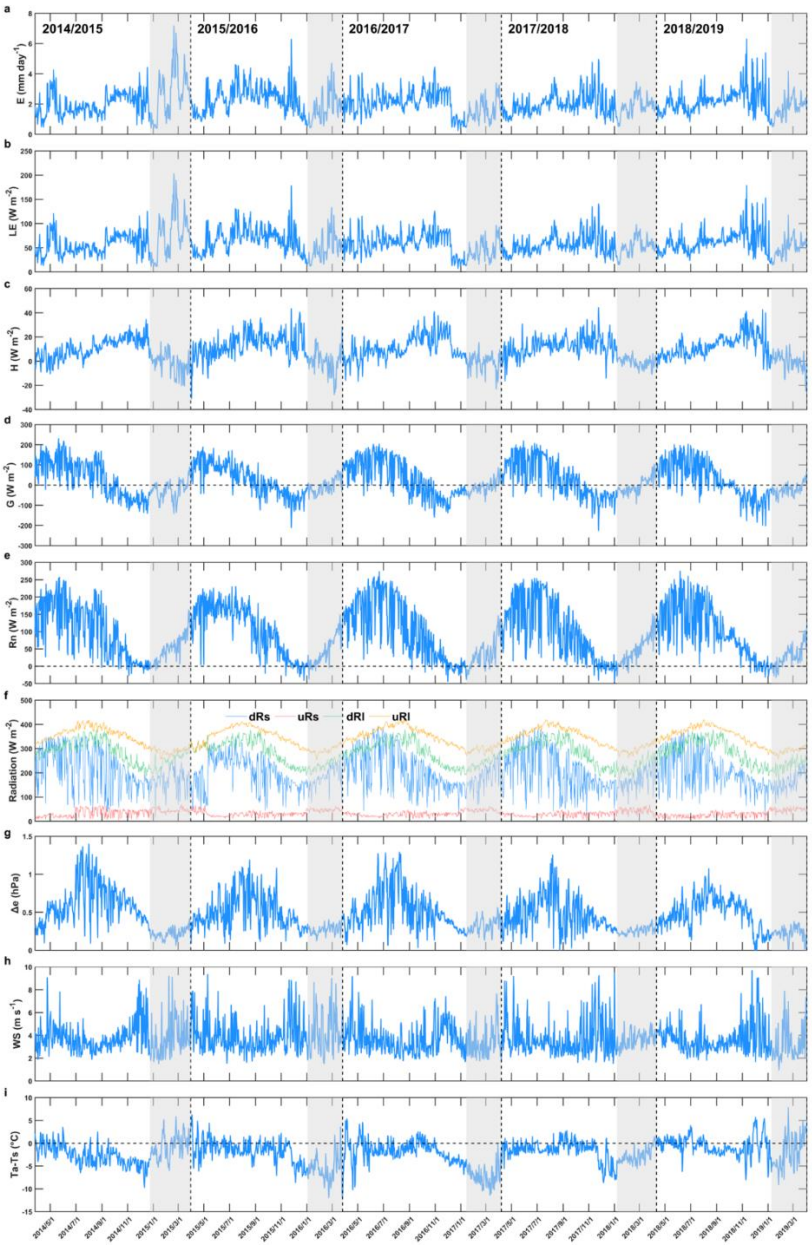


Fig. S2. The time series of the daily lake evaporation (E), latent heat (LE), sensible heat (H), heat storage change (G), net radiation (Rn), four radiation components (incoming shortwave: dRs, reflected shortwave: uRs, and incoming and outgoing longwave radiation: dRl and uRl), vapor pressure difference (Δe), wind speed (U), and the difference between air temperature and lake surface temperature (Ta−Ts) of Qinghai Lake (QHL) during the ice–free and ice–covered periods (IFP and ICP) from 2014 to 2018. The gray area indicates ice–covered period. The labels 2014/2015, 2015/2016, 2016/2017, 2017/2018, and 2018/2019 indicate the cycle year of freeze–thaw cycling

Fig. S3.

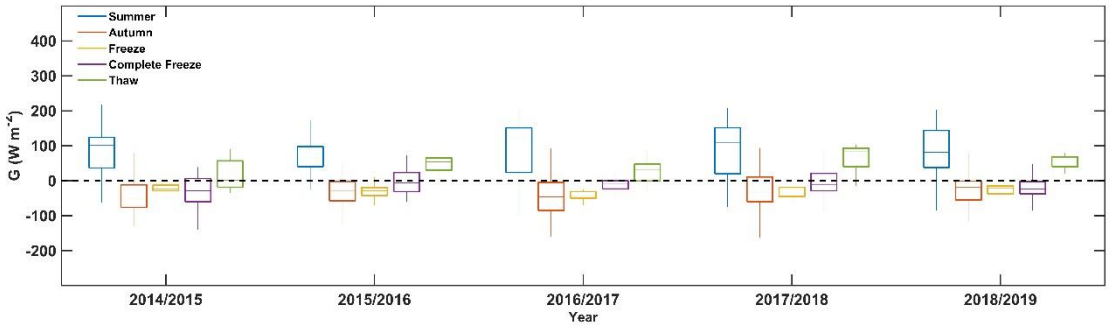


Fig. S3. Heat storage change (G) in Qinghai Lake during summer, autumn, freeze, complete freeze, and thaw periods in each year from 2014 to 2018. The whiskers indicate the 1.5 interquartile range. Summer and autumn last from June to August and September to November, respectively. The labels 2014/2015, 2015/2016, 2016/2017, 2017/2018, and 2018/2019 indicate the cycle year of freeze–thaw cycling.

Fig. S4.

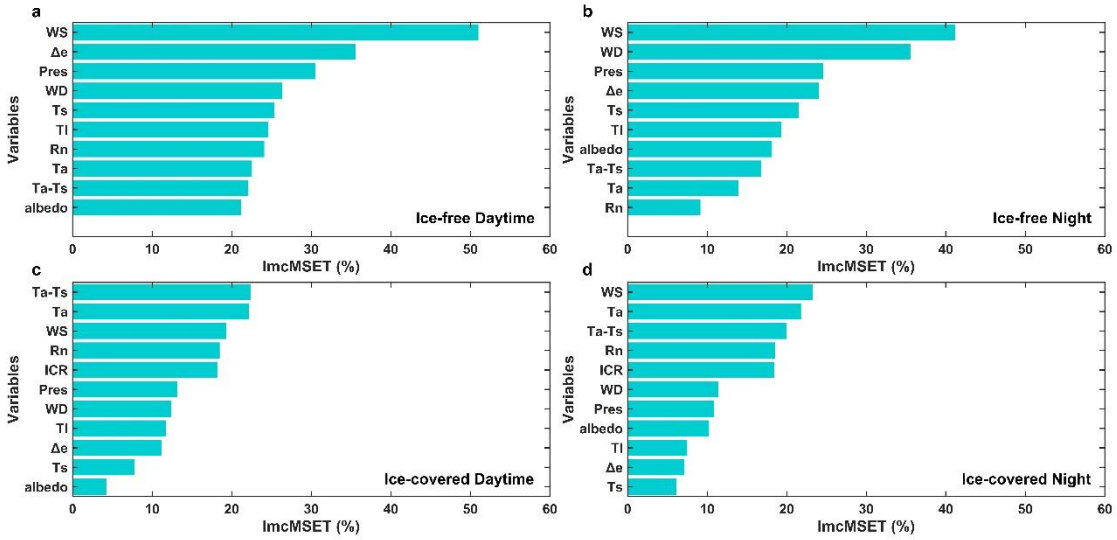


Fig. S4. Importance of the daytime and nighttime climate factors to the evaporation (E) rate of Qinghai Lake during the ice–free and ice–covered periods (IFP and ICP). Rn, Δe. WS, WD, Pres, Ta−Ts, Tl, and ICR denote the net radiation, vapor pressure difference, wind speed, wind direction, surface air pressure, difference between the air and lake surface temperatures, average temperature of the lake body from 0 to 300 cm, and ice coverage rate, respectively.

Fig. S5.

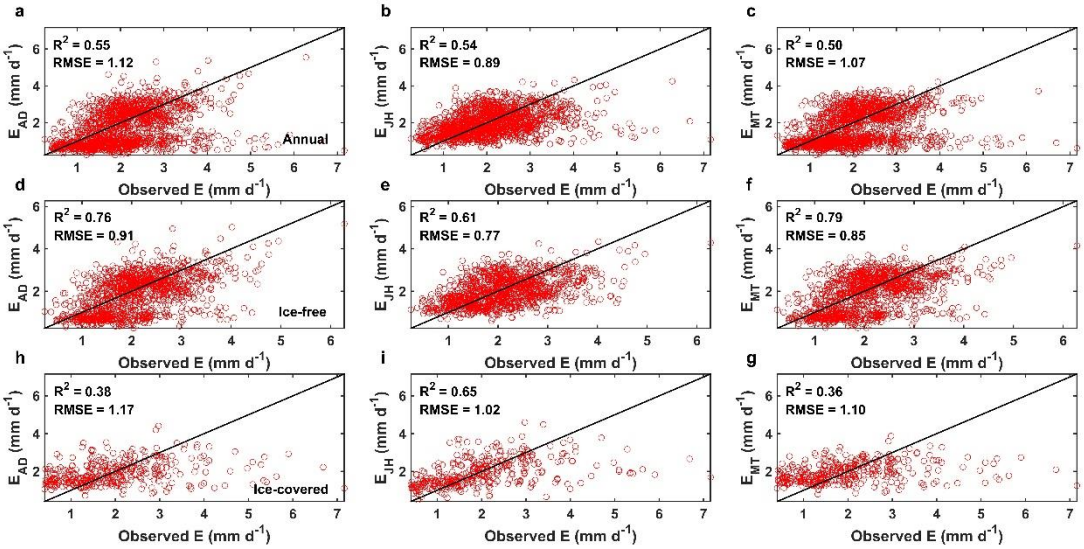


Fig. S5. Relationship between the daily observed and simulated evaporation (E) with the atmospheric dynamics model (E_{AD}), mass–transfer model (E_{MT}), and Jensen–Haise model (E_{JH}) in the cycle year (annual: a~c), ice–free (d~f) and ice–covered (h~g) periods (AN, IFP and ICP) from 2014 to 2018.

Fig. S6.

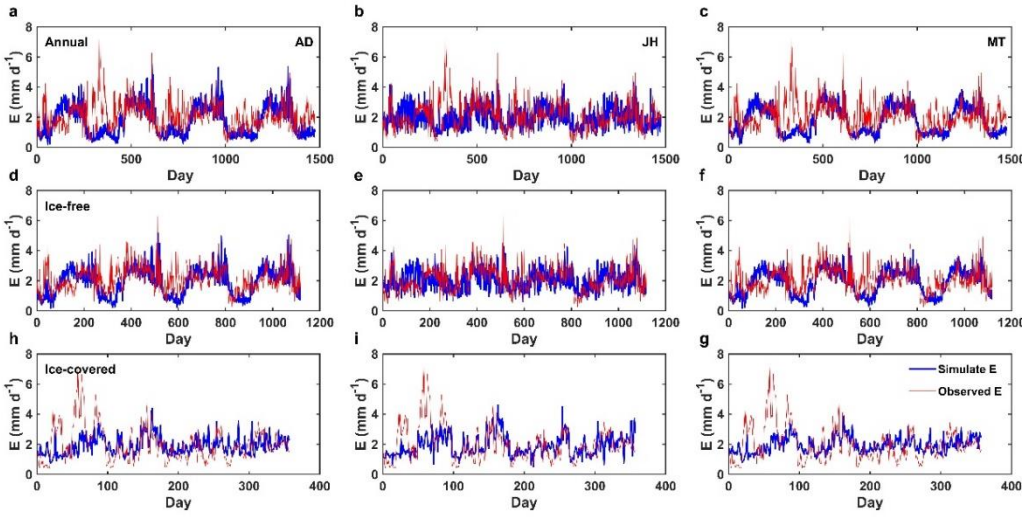


Fig. S6. Daily observed and simulated evaporation (E) with the atmospheric dynamics model (E_{AD}), mass–transfer model (E_{MT}), and Jensen–Haise model (E_{JH}) in the cycle year (annual: a~c), ice–free (d~f) and ice–covered (h~g) periods (AN, IFP and ICP) from 2014 to 2018.

Fig. S7.

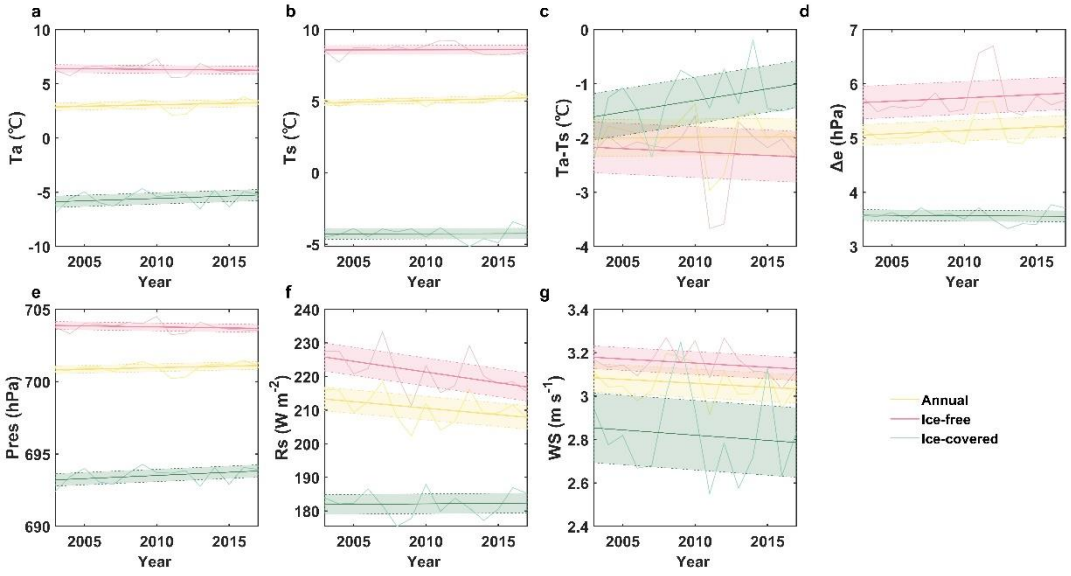
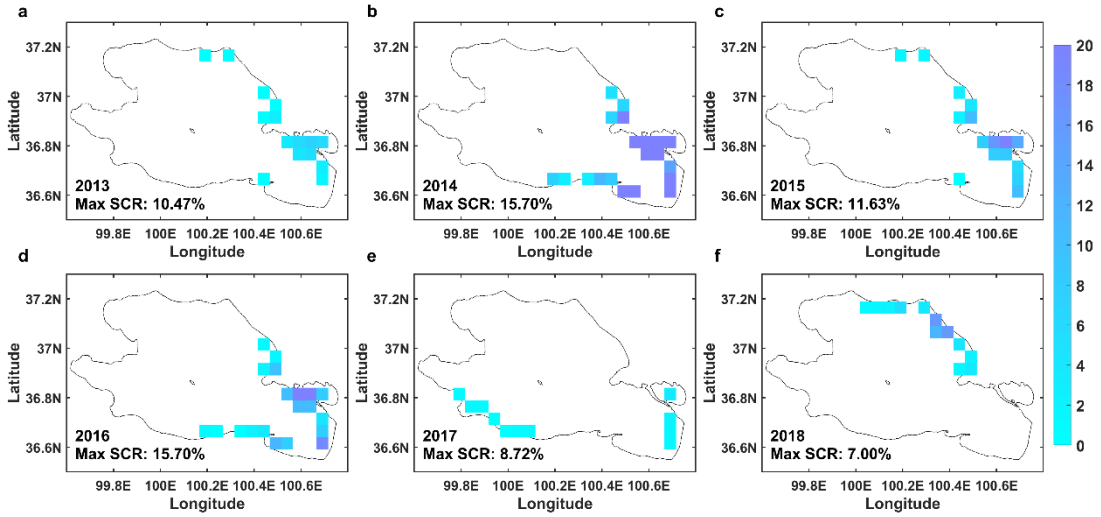


Fig. S7. Interannual variability in the air temperature (Ta), lake surface temperature (Ts), difference between Ta and Ts (Ta−Ts), vapor pressure difference (Δe), air pressure (Pres), downward shortwave radiation (Rs), and wind speed (WS) in the cycle year (annual: AN), ice–free and ice–covered periods (IFP and ICP) from 2003 to 2017. The shading indicates the 95% confidence interval of the trend line.

89 **Fig. S8.**



90

91 **Fig. S8. Spatial distribution of average snow depth (cm) in Qinghai Lake from 2013 to 2018.**

92 Max SCR means the maximal snow coverage rate**.**

TABLES

Table S1. The information about variables from observed, reanalysis, model and remote sensing datasets.

Dataset	Instrument type	Height from the lake surface/Spatial resolution	Time resolution	Purpose
Observed H and LE	EC system (Three–dimensional sonic anemometer: CSAT3, Campbell, USA, and open–path infrared gas analyzer: EC150, Campbell, USA)	17.3 m	30 min	Evaporation and energy calculation, and model calibration and verification
Observed Ta, RH and Pres	HMP155, Vaisala, Finland	12.5 m	30 min	Analysis of evaporation influence factors
Observed WS and WD	05103, R.M. Young, USA	12.5 m	30 min	
Observed Ts	SI−111, Campbell, USA	0	30 min	
Observed Tl	109L, Campbell, USA	−0.2 to −3.0 m	30 min	
Observed precipitation	TE525, Campbell, USA	10 m	30 min	
Observed four-component radiometer	CNR4, Kipp&Zonen, Netherlands	10 m	30 min	
ERA5 Ts	\	0.1°	hourly	Model input
ERA5 WS	\	0.1°	daily	
CMFD Ta, Pres, RH and Rs	\	0.1°	daily	
Lake ice coverage	\	\	daily	Lake ice phenology dividing

Notes: H, LE, Ta, RH, Pres, WS, WD, Ts, Tl, and Rs are the abbreviation of sensible heat, latent heat, air temperature, relative humidity, air pressure, wind speed, wind direction, lake surface temperature, water temperature, and downward shortwave radiation, respectively. ERA5 and CMFD mean the interim reanalysis dataset v5 and China Regional High–Temporal–Resolution Surface Meteorological Elements–Driven Dataset, respectively. Four-component radiometer is the incoming shortwave, reflected shortwave, and incoming and outgoing longwave radiation.

Table S2. Daily mean evaporation of Qinghai Lake (QHL) in the cycle year (annual: AN), ice–free and ice–covered periods (IFP and ICP) from 2014 to 2018.

Daily mean evaporation (mm d^{-1})					
Periods	2014	2015	2016	2017	2018
AN	2.16 ± 1.07	2.21 ± 0.93	2.02 ± 0.81	1.96 ± 0.69	2.10 ± 0.81
IFP	1.96 ± 0.73	2.34 ± 0.89	2.15 ± 0.79	1.99 ± 0.70	2.24 ± 0.81
ICP	2.71 ± 1.55	1.77 ± 0.93	1.57 ± 0.72	1.85 ± 0.62	1.72 ± 0.67
Daytime mean evaporation (mm d^{-1})					
AN	1.21 ± 0.60	1.30 ± 0.62	1.11 ± 0.46	1.11 ± 0.43	1.18 ± 0.48
IFP	1.10 ± 0.44	1.36 ± 0.61	1.18 ± 0.44	1.12 ± 0.45	1.23 ± 0.49
ICP	1.52 ± 0.83	1.08 ± 0.59	0.87 ± 0.45	1.09 ± 0.37	1.01 ± 0.41
Night mean evaporation (mm d^{-1})					
AN	0.95 ± 0.56	0.91 ± 0.45	0.91 ± 0.48	0.84 ± 0.36	0.93 ± 0.42
IFP	0.87 ± 0.38	0.98 ± 0.43	0.97 ± 0.49	0.87 ± 0.37	1.00 ± 0.42
ICP	1.18 ± 0.85	0.69 ± 0.46	0.70 ± 0.38	0.77 ± 0.32	0.72 ± 0.36

Table S3. Multiyear average contributions of the changes in air temperature (Ta), lake surface temperature (Ts), downward shortwave radiation (Rs), and wind speed (WS) to the simulated evaporation of Qinghai Lake in the cycle year (annual: AN), ice–free and ice–covered periods (IFP and ICP) from 2003 to 2017.

	Ta	Ts	Rs	WS
E Rate in AN (mm)	0.02 ± 0.03	0.02 ± 0.06	−0.02 ± 0.01	−0.03 ± 0.05
E Rate in IFP (mm)	0.01 ± 0.04	0.05 ± 0.07	0.00 ± 0.00	−0.01 ± 0.03
E Rate in ICP (mm)	0.05 ± 0.05	−0.06 ± 0.03	−0.06 ± 0.05	−0.11 ± 0.14
Sum E in AN (mm)	7.21 ± 12.34	8.26 ± 20.78	−6.48 ± 5.03	−12.87 ± 17.82
Sum E in IFP (mm)	2.54 ± 9.72	13.58 ± 20.75	0.00 ± 0.00	−1.71 ± 7.07
Sum E in ICP (mm)	4.67 ± 5.44	−5.32 ± 3.02	−6.48 ± 4.77	−11.17 ± 14.29
Percentage in AN (%)	1.54 ± 1.20	2.21 ± 2.46	0.91 ± 0.65	2.46 ± 1.63
Percentage in IFP (%)	1.31 ± 1.31	3.54 ± 3.55	0.00 ± 0.00	1.01 ± 0.87
Percentage in ICP (%)	3.09 ± 2.22	2.94 ± 1.14	3.23 ± 2.28	7.56 ± 4.26

Table S4. Lake ice phenology of Qinghai Lake from 2002 to 2018.

	IFS	FUS	FUE	BES	BUE	LIF	LIC	LCY
2002		2002/12/25	2003/1/4	2003/3/26	2003/3/30		96	
2003	2003/3/31	2003/12/25	2004/1/3	2004/3/13	2004/3/28	270	95	365
2004	2004/3/29	2004/12/27	2005/1/8	2005/3/14	2005/3/30	274	94	368
2005	2005/3/31	2005/12/16	2005/12/24	2006/3/28	2006/4/6	261	112	373
2006	2006/4/7	2006/12/26	2007/1/11	2007/3/30	2007/4/3	264	99	363
2007	2007/4/4	2007/12/27	2008/1/17	2008/3/31	2008/4/11	268	107	375
2008	2008/4/12	2008/12/22	2009/1/1	2009/3/20	2009/3/30	255	99	354
2009	2009/3/31	2009/12/24	2010/1/1	2010/3/20	2010/4/2	269	100	369
2010	2010/4/3	2010/12/16	2010/12/31	2011/4/5	2011/4/15	258	121	379
2011	2011/4/16	2011/12/21	2012/1/6	2012/4/1	2012/4/14	250	116	366
2012	2012/4/15	2012/12/12	2012/12/27	2013/3/24	2013/4/3	242	113	355
2013	2013/4/4	2013/12/20	2014/1/8	2014/3/3	2014/3/25	261	96	357
2014	2014/3/26	2014/12/23	2015/1/4	2015/3/14	2015/3/29	273	97	370
2015	2015/3/30	2015/12/31	2016/1/22	2016/3/12	2016/3/22	277	83	360
2016	2016/3/23	2017/1/9	2017/1/23	2017/3/18	2017/4/1	293	83	376
2017	2017/4/2	2017/12/31	2018/1/10	2018/3/29	2018/4/3	274	94	368
2018	2018/4/4	2018/12/31	2019/1/10	2019/3/29	2019/4/3	272	94	366

Note: IFS, FUS, FUE, BUS, and BUE show the dates of ice–free start, freeze–up start, freeze–up end, break–up start, and break–up end, respectively. LIF, LIC, and LCY means the length of the ice–free period, ice–covered period, and the cycle year (annual: AN), respectively. The ice–covered rate data are from the National Tibetan Plateau Data Center (https://data.tpdc.ac.cn/zh–hans/data/c242394c–fe1a–4840–9beb–0bf4a95d1231/?q=%E6%B9%96%E5%86%B0%E7%89%A9%E5%80%99).