Supplemental materials
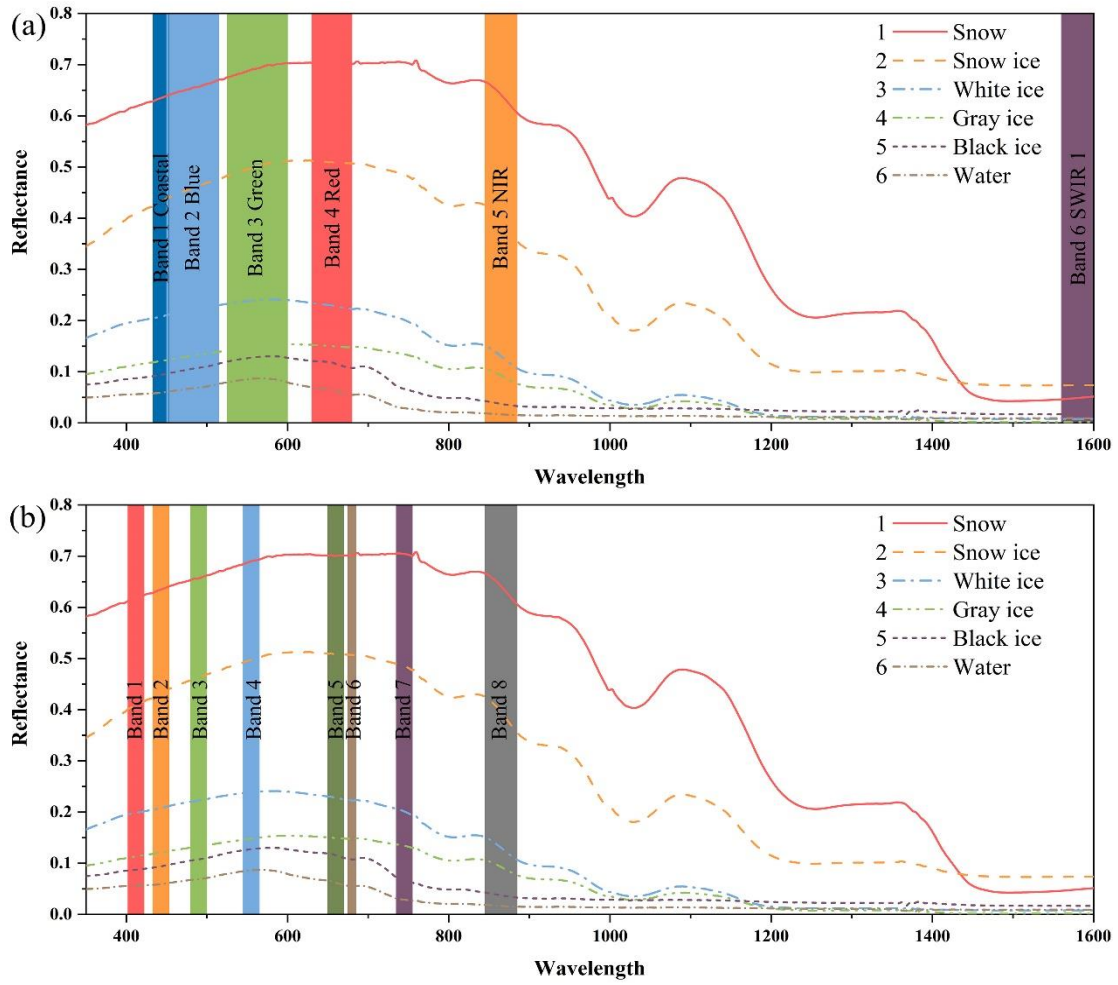
Figure S1 The band information of Landsat (a) and GOCI (b).
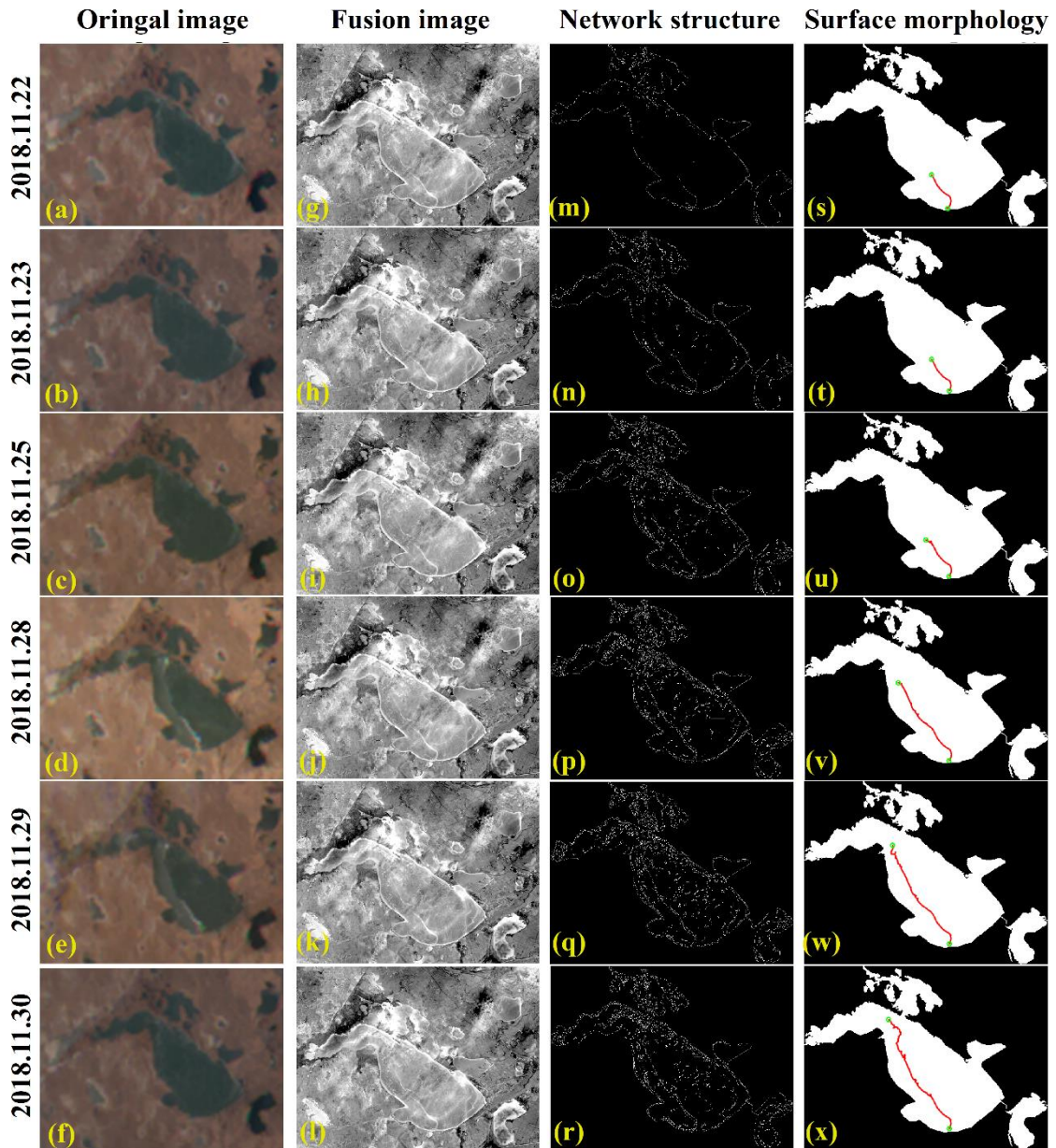
Figure S2 The changes of ice ridges during the freeze-up process from November 22 to November 30, 2019: (a-f) the original images from GOCI; (g-l) the fusion images from Landsat and GOCI; (m-r) the network structure of surface morphology; (s-x) the surface morphology.

	Oringal image	Fusion image	Network structure	Surface morphology
2019.03.15	(a)	(f)	(k)	(p)
2019.03.17	(b)	(g)	(l)	(q)
2019.03.18	(c)	(h)	(m)	(r)
2019.03.22	(d)	(i)	(n)	(s)
2019.03.24	(e)	(j)	(o)	(t)
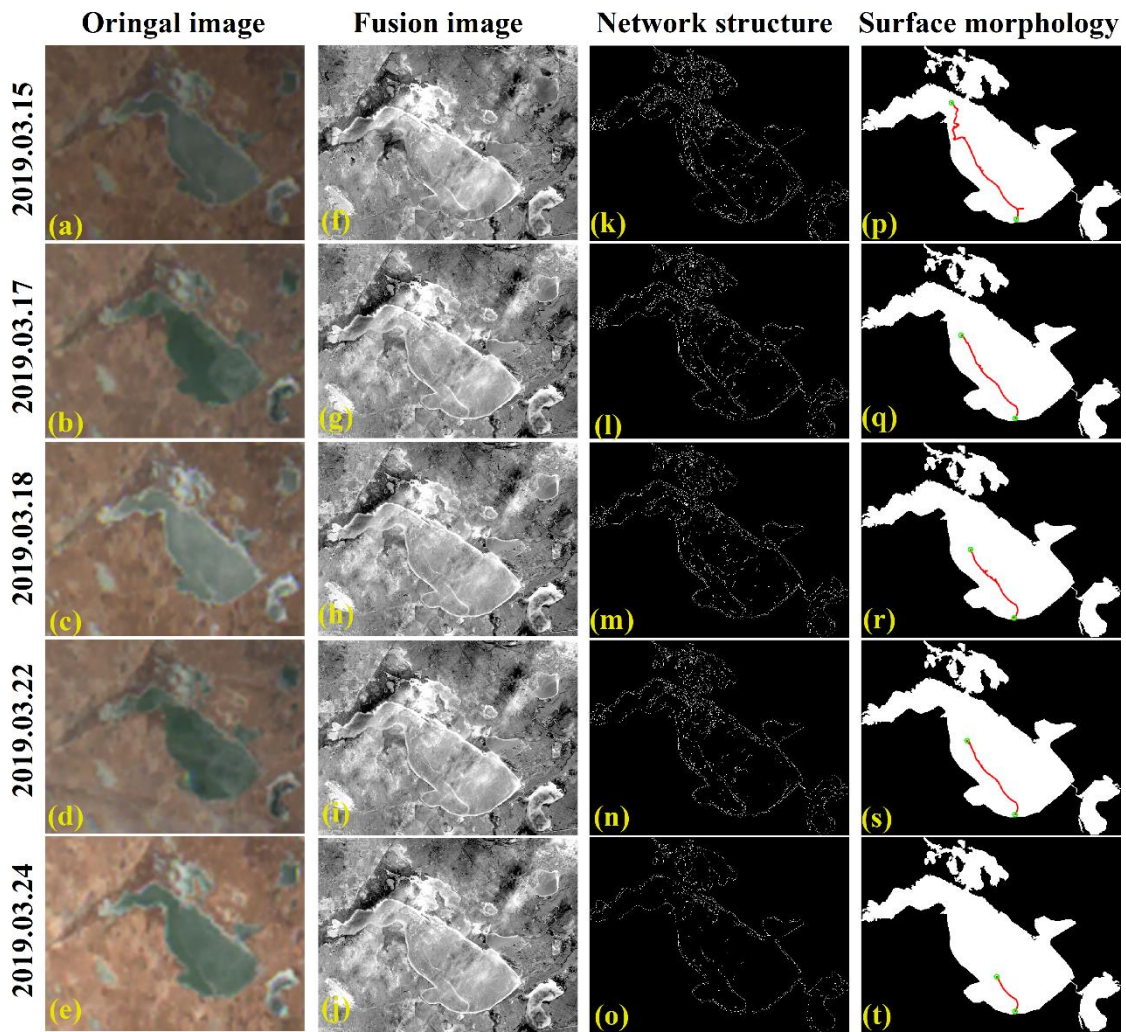
Figure S3 The changes of ice ridges during the break-up process from March 15 to March 24, 2019: (a-e) the original images from GOCI; (f-j) the fusion images from Landsat and GOCI; (k-o) the network structure of surface morphology; (p-t) the surface morphology.

Table S1 The freeze-up and break-up dates of Chagan Lake based on MODIS LST products for eight cold seasons from 2010 to 2021. The freeze-up date, break-up date, and ice cover duration are represented by FUD, BUD, and ICD.

Cold season	FUD	BUD	ICD (day)
2010	2009/11/10	2010/04/16	157
2011	2010/11/18	2011/03/31	133
2012	2011/11/02	2012/04/07	157
2013	2012/11/10	2013/04/16	157
2014	2013/11/17	2014/03/22	126
2015	2014/11/17	2015/04/07	142
2016	2015/11/09	2016/03/19	131
2017	2016/10/31	2017/03/30	151
2018	2017/11/17	2018/04/18	153
2019	**2018/11/17**	**2019/03/22**	**126**
2020	2019/11/17	2020/03/29	134
2021	2020/11/16	2021/03/30	135
Means	11/12	04/03	141.83