Supplementary material for

Detecting the Lake Area Seasonal Variations in the Tibetan Plateau from Multi-sensor Satellite Data Using Deep Learning

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Appendix A: Example of SAR and Landsat image of the same area

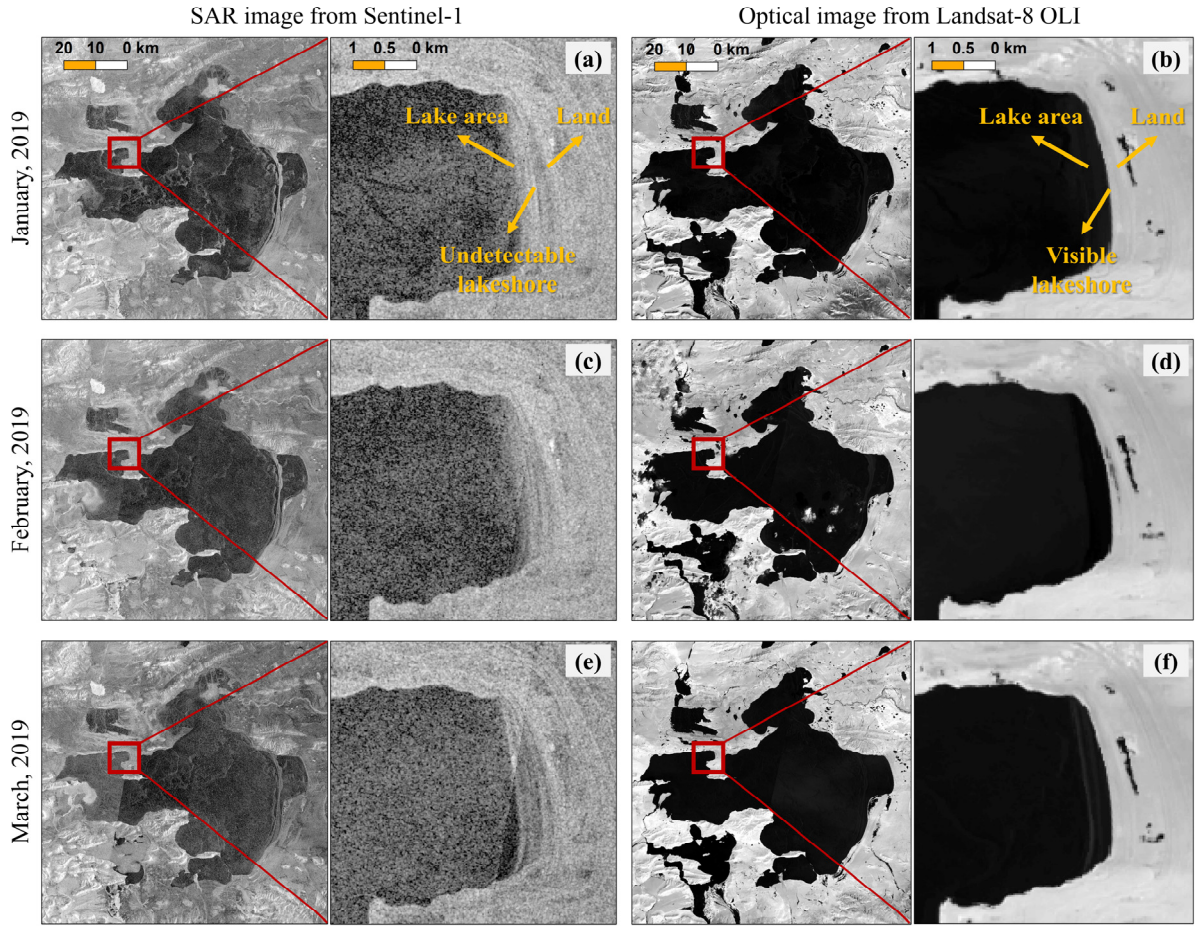


Figure S1. (a) A Sentinel-1 image of the Selin Co region in January 2019 (left) and zoom-in of the red box region (right); (b) A Landsat-8 OLI image in the same time and zoom-in of the red box region; (c and d) and (e and f) are examples in February and March for the same area, respectively.

Appendix B: The comparison of model rubustness

Table S1. The different performances of the AttCloudNet+, DeepLabv3+, and UNet when using complementary optical images of different times in combined image data.

Model	Comparison sites	2015		2017		2020	
		RMSE (m)	MAE (m)	RMSE (m)	MAE (m)	RMSE (m)	MAE (m)
AttCloudNet+	Selin Co	47.9	34.5	30.0	21.8	24.2	16.6
	Nam Co	22.7	17.0	16.7	12.7	21.4	16.1
	Yamzho Yumco	16.9	12.9	18.2	15.2	15.9	12.0
	Mean	29.2	21.5	21.6	16.6	20.5	14.9
DeepLabv3+	Selin Co	199.8	142.4	229.1	173.5	67.6	53.6
	Nam Co	14.7	12.1	13.2	10.6	13.2	10.6
	Yamzho Yumco	16.7	14.1	56.3	43.9	12.8	10.1
	Mean	77.1	56.2	99.5	76.0	31.2	24.8
UNet	Selin Co	294.9	236.4	232.9	162.2	87.4	61.9
	Nam Co	15.6	12.7	24.6	19.4	15.5	12.3
	Yamzho Yumco	20.7	16.0	15.8	13.0	20.3	15.7
	Mean	110.4	88.4	91.1	64.9	41.1	30.0

Appendix C: Correlation between seasonal lake area changes and water level changes

Table S2. The correlation between seasonal lake area changes and water level changes in other data sets is compared.

Lake name	R^2	
	AttCloudNet+	WHU (Zhang et al. 2020)
Ulan Ul Lake	0.95	0.25
Yamzho Yumco	0.94	0.14
Selin Co	0.87	0.46
Tangra Yumco	0.84	0.29
Zhari Namco	0.83	0.05
Ayakkum Lake	0.82	0.32
Har Lake	0.79	0.62
Nam Co	0.75	0.14
ErLing Lake	0.75	0.08
Aqqikkol Lake	0.73	0.01
Chibzhangco	0.72	0.09
Qinghai Lake	0.70	0.56
Mean	**0.81**	**0.25**

Appendix D: Lake area seasonal variation over 2015 – 2020

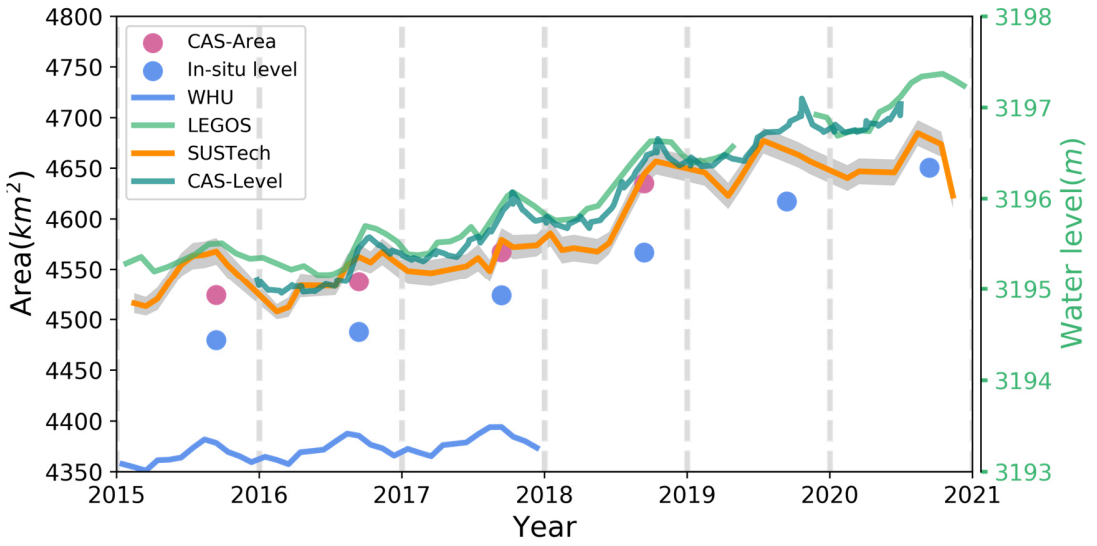


Figure S2. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual in-situ measurement water level values from CAS (blue dots), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Qinghai Lake.

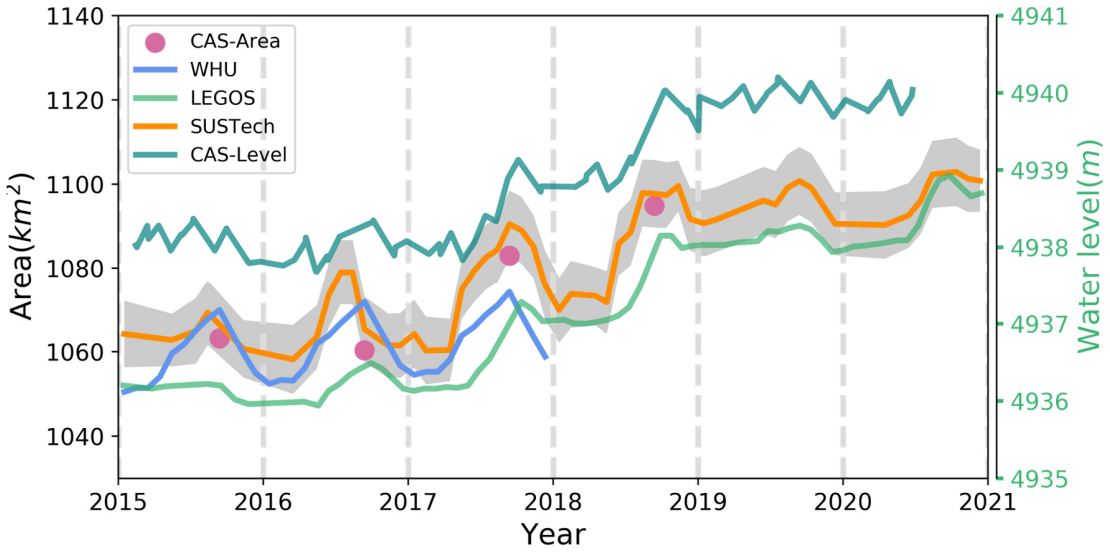


Figure S3. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series

from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Chibzhang Co.

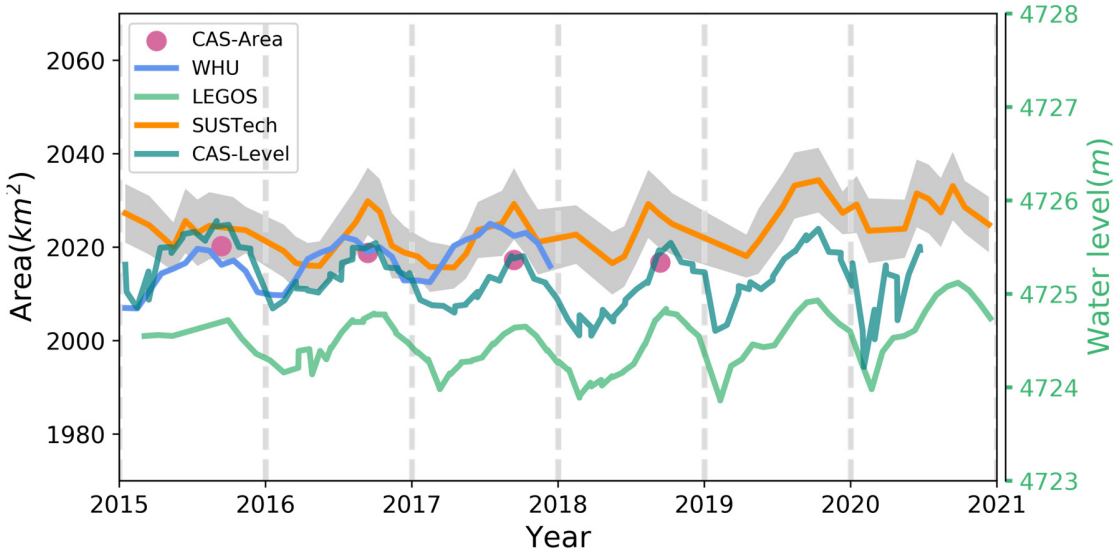


Figure S4. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Nam Co.

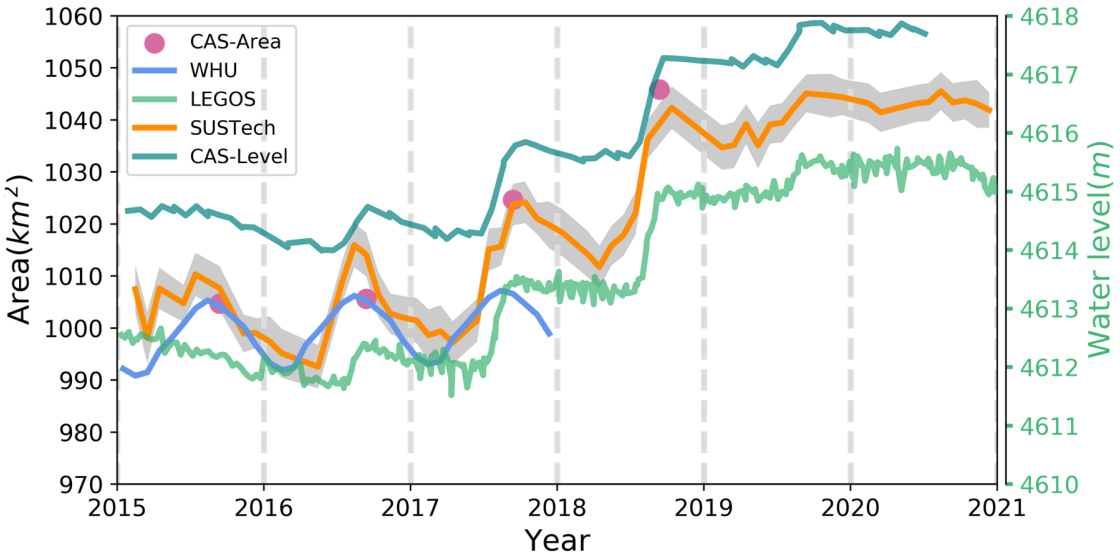


Figure S5. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Zhari Namco.

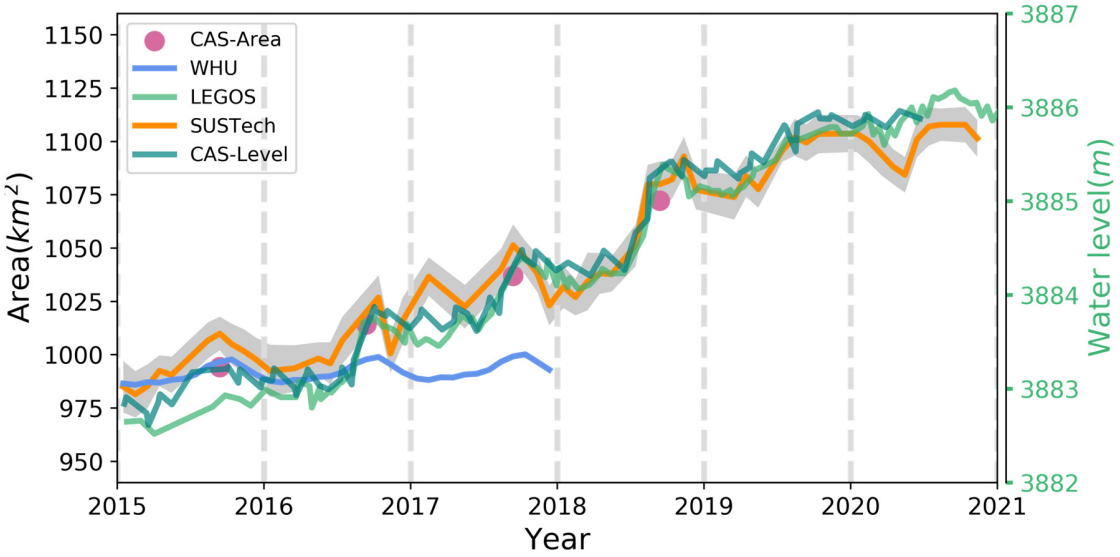


Figure S6. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Ayakkum Lake.

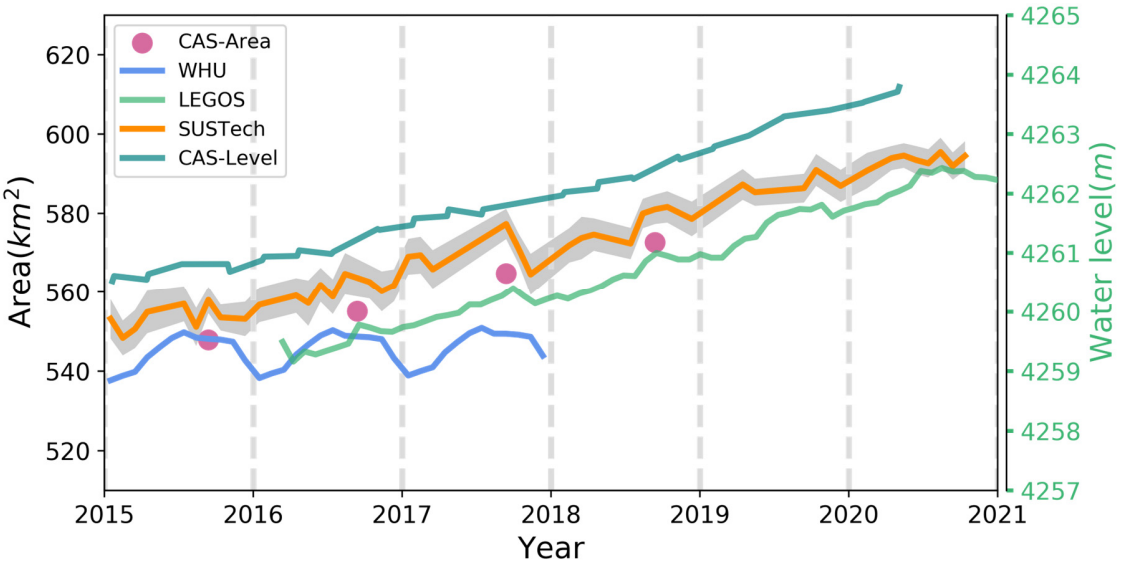


Figure S7. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Aqqikkol Lake.

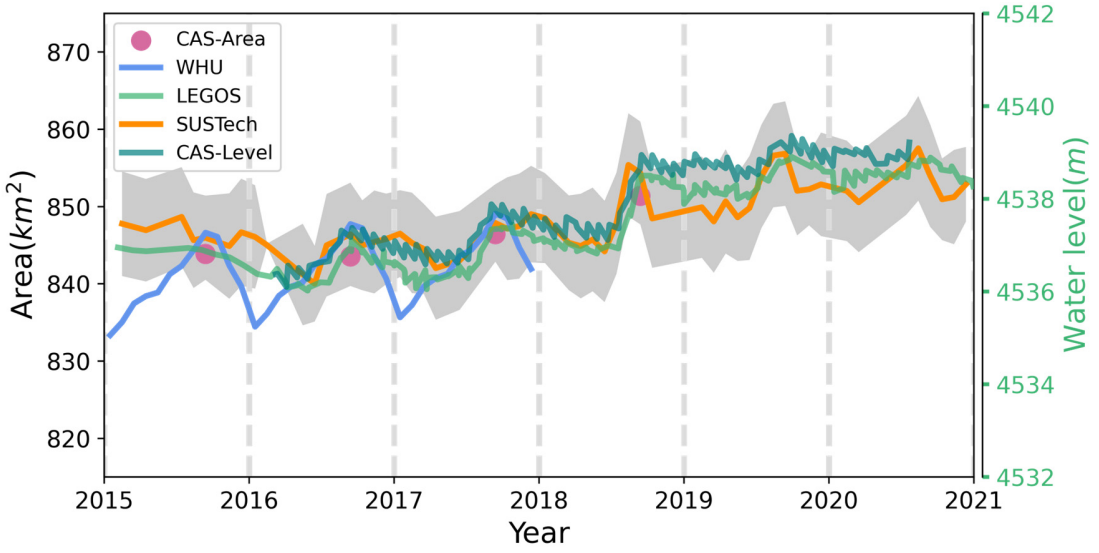


Figure S8. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Tangra Yumco.

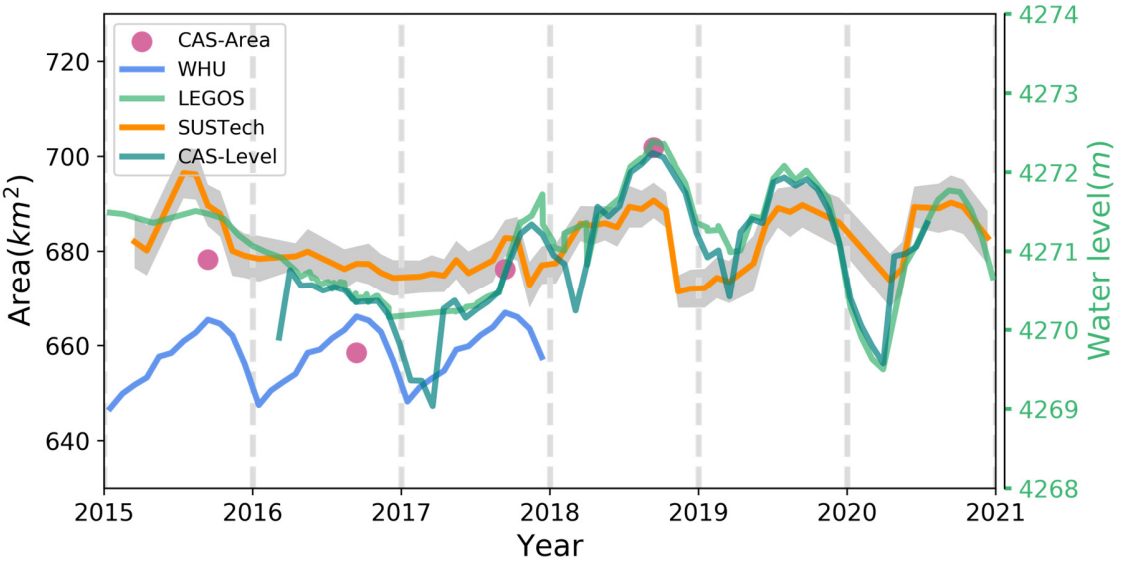


Figure S9. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Erling Lake.

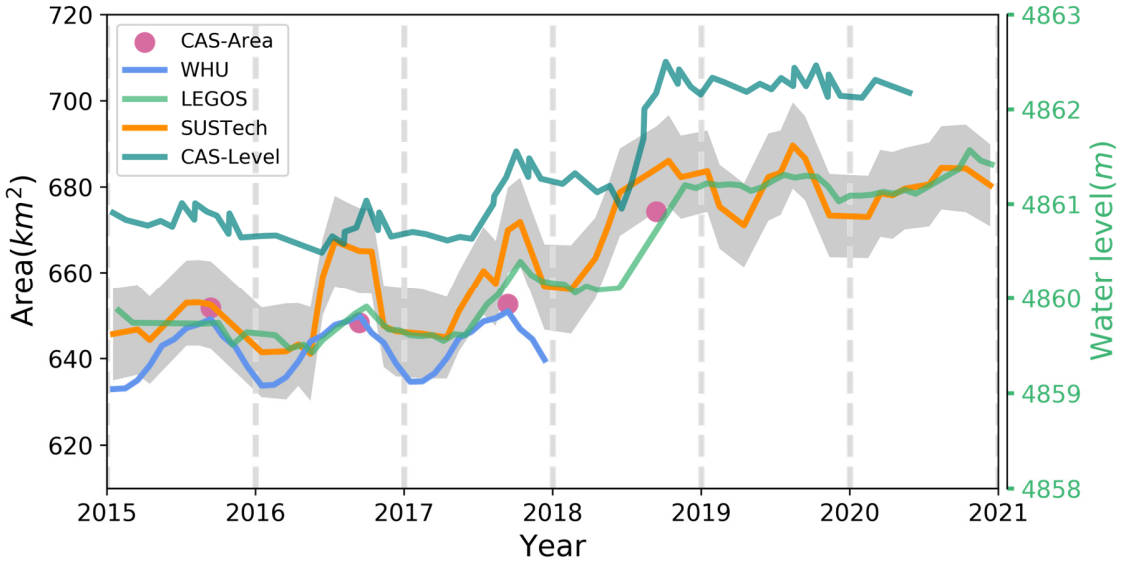


Figure S10. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Ulan Ul Lake.

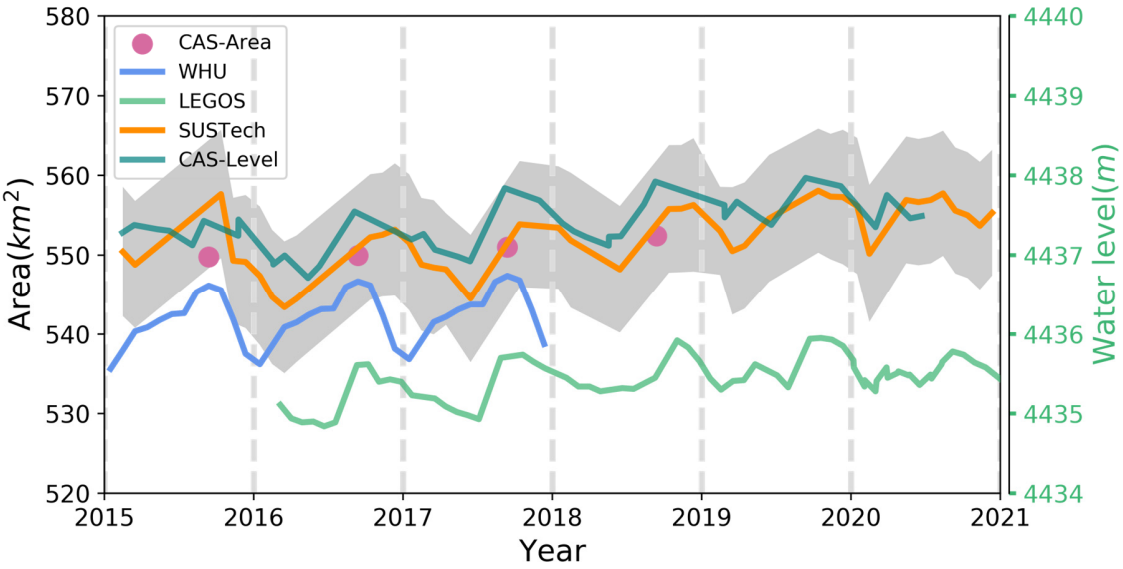


Figure S11. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Yamzho Yumco.

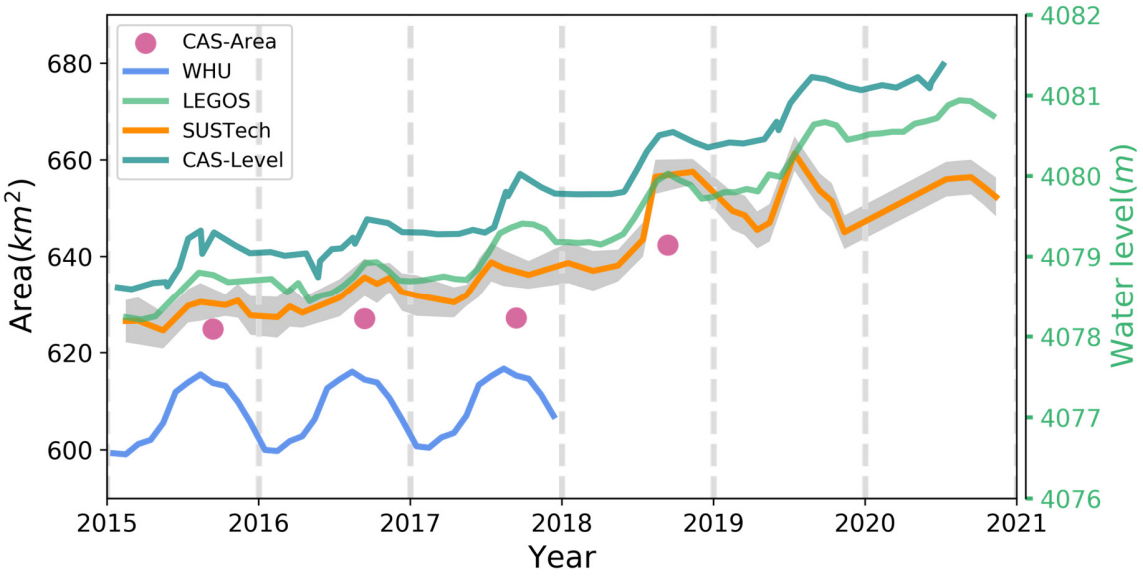


Figure S12. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Har Lake.

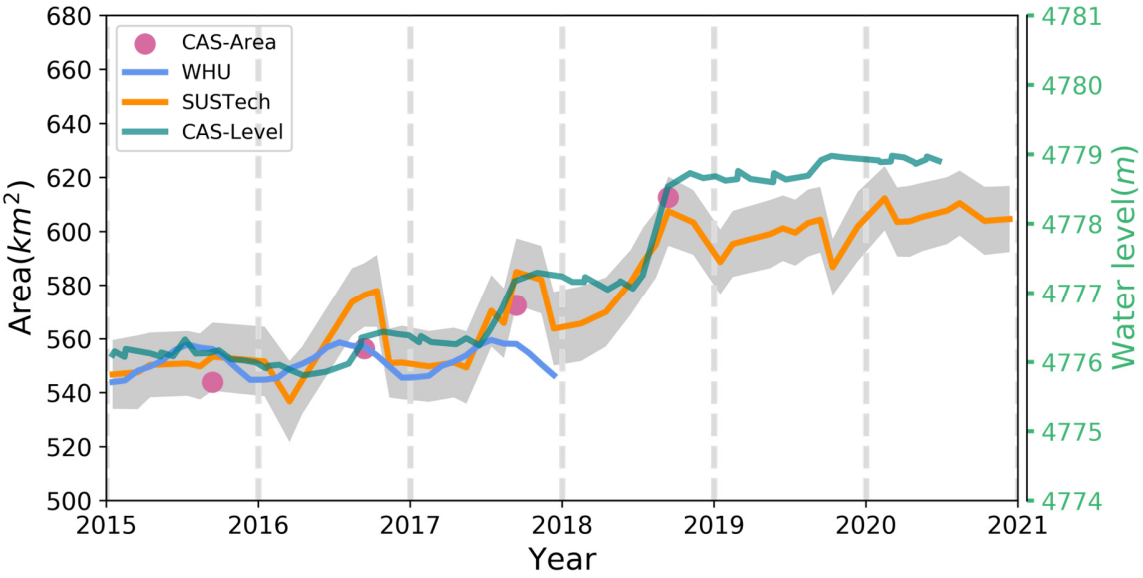


Figure S13. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Xijir Ulan Lake.

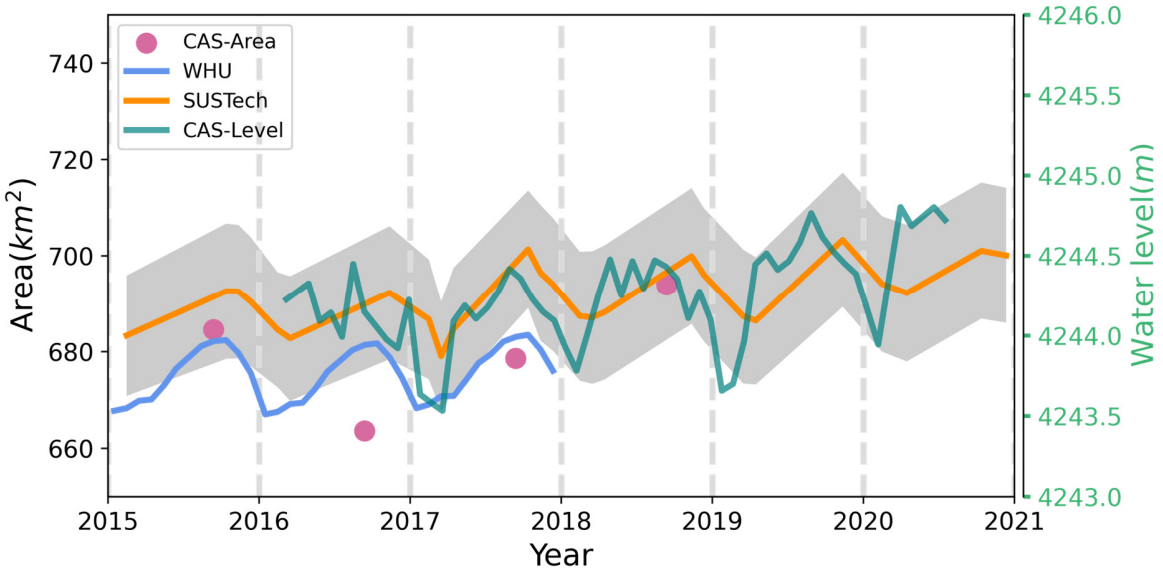


Figure S14. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Bangong Co.

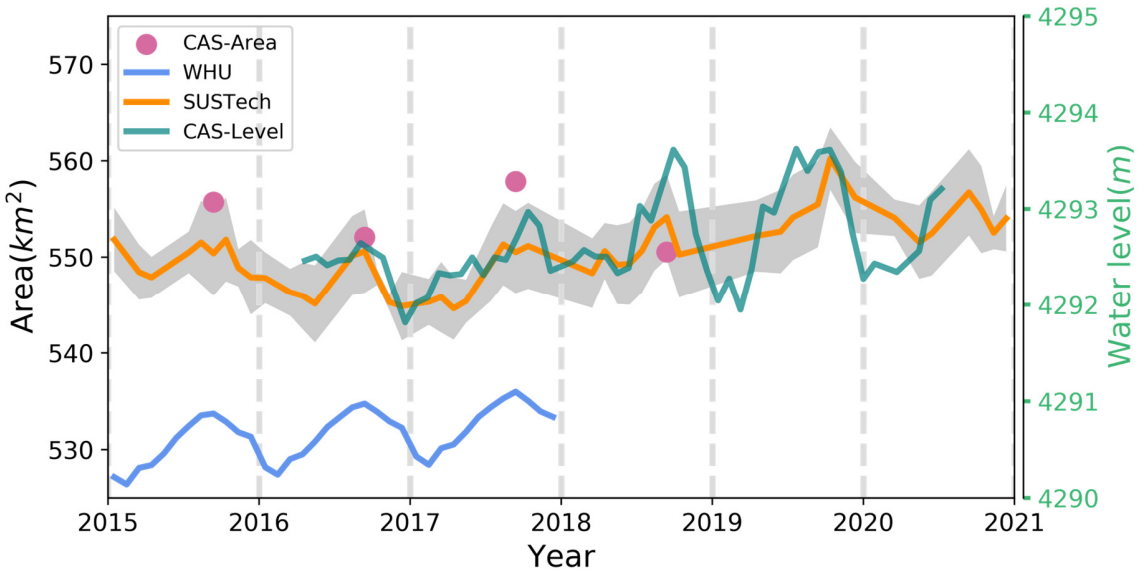


Figure S15. The comparison between our extracted lake area series (orange line, with the shaded area represents the uncertainties), the LEGOS water level series (light green line), the seasonal water level series from CAS (dark green line), the annual lake area from the CAS (purple dots), and the lake area series of the WHU (blue line) in Gyaring Lake.

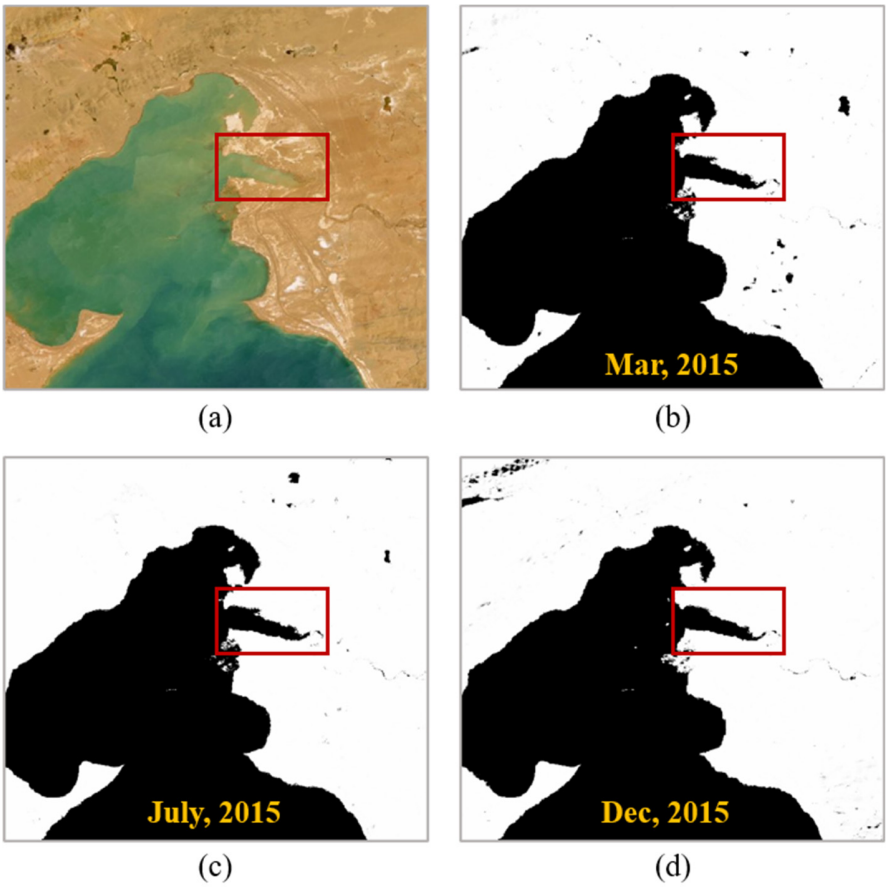


Figure S16. Example of water surface range change at estuarine zones in different seasons.