

Monitoring Lake Ice and Snow in the Canadian High Arctic Using Digital Camera Imagery

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(Received 4 October 2025; accepted in revised form 5 March 2026)

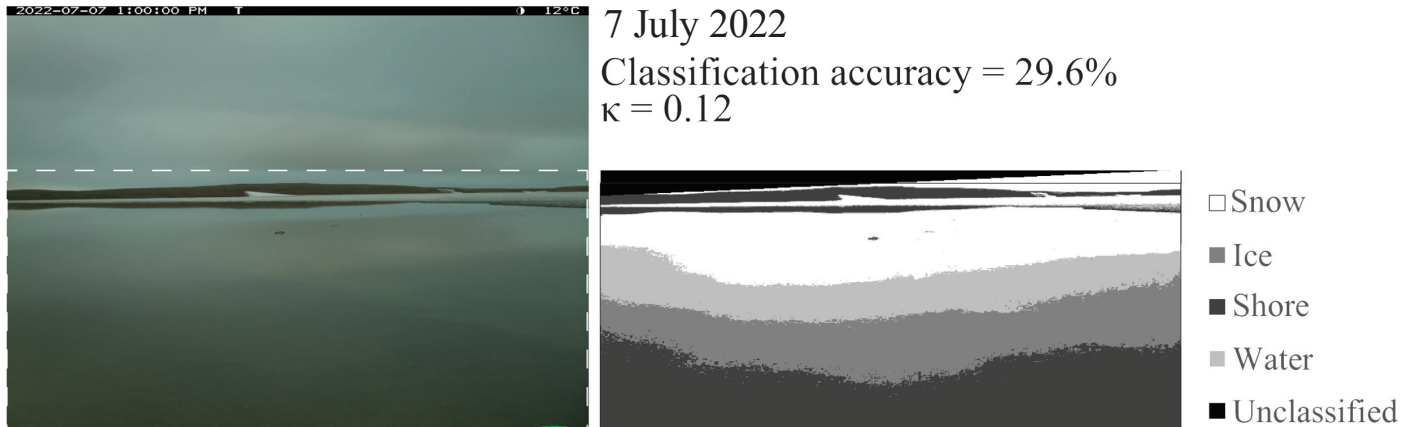


FIG. 1. Example of a poor classification outcome, Small Lake 7 July 2022.

TABLE S1. Image classification settings, option selected, and reasoning for option selection.¹

Classification setting	Options selected	Reasoning
Clustering options	• K means • Use signature means	• Number of classes was decided in advance and fixed. • Supervised training samples used.
Processing options	• Maximum iterations: 10 • Zero classification: no • Convergence threshold: 0.95 • Skip factor: X = 1, Y = 1	• Both time efficiency and computer running capacity were taken into consideration for the ability to reach convergence threshold. • This decision resulted in the Unclassified class but prevented the misclassification of pixels into an inappropriate class. • This level was selected to mimic a significance level of 0.05. • This selection processes all pixels, rather than skipping some for maximum accuracy (Hexagon, 2024).

¹ Command line used: \$FileIn \$Classified \$Sig -n Ppd -o Par -u Par -p Max -prob 0 -a none 0 -best 1 -dsc 0 0 0 0 0 0 0 -dsco 0 -aoi 'C:\[file name of area of interest].aoi' -z 0 -m classify

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TABLE S2. Accuracy assessment results for all five lakes across different years.

Lake	Conditions	Date	Classification accuracy (%)	Kappa Coefficient (κ)
Resolute	Sunny, clear	5 August 2020	95.20	0.90
Resolute	Snow, low visibility	8 October 2019	95.60	0.93
Resolute	Snow, sunny, transition (ice melt started)	14 June 2018	61.60	0.34
Resolute	Cloudy	31 August 2020	94.00	0.88
Resolute	Cloudy, snowy, low visibility	6 October 2017	95.20	0.90
Resolute	Ice/snow transition, low visibility	5 October 2021	93.20	0.90
Small	Cloudy, ice/snow transition	19 June 2018	42.0	0.29
Small	Cloudy, water and shore	15 August 2018	92.40	0.89
Small	Sunny, snowy	12 March 2020	86.40	0.82
Small	Cloudy, snowy	27 April 2020	73.60	0.65
Small	Cloudy, snowy	16 October 2016	98.80	0.98
Small	Cloudy, ice/snow transition	7 July 2022	29.60	0.12
North	Cloudy, ice and snow, low visibility,	27 September 2019	80.00	0.73
North	Cloudy, water and shore	1 September 2020	94.40	0.92
North	Sunny, water and shore	13 August 2020	76.00	0.70
North	Cloudy, ice and snow, low visibility	18 October 2021	96.40	0.95
North	Sunny, ice and snow	22 March 2022	97.60	0.97
North	Sunny, water and shore	23 July 2022	83.60	0.79
Plateau	Cloudy, water and shore	7 September 2020	91.20	0.88
Plateau	Sunny, snow and shore (view pointed away from lake)	23 June 2022	92.00	0.89
Plateau	Cloudy, water and shore	8 September 2019	92.40	0.89
Plateau	Sunny, water and ice	24 July 2020	62.40	0.51
Plateau	Snow, low visibility	26 October 2021	90.80	0.88
Plateau	Sunny, water and shore	30 August 2021	93.20	0.91
Hunting Camp	Cloudy, snow (view pointed away from lake)	16 October 2016	83.20	0.79
Hunting Camp	Cloudy, shore, water and ice, transition	12 August 2017	88.00	0.85
Hunting Camp	Cloudy, shore, water and ice, transition	3 August 2018	94.80	0.93
Hunting Camp	Cloudy, partial sun, snow	16 March 2019	92.80	0.91
Hunting Camp	Cloudy, shore, water and ice, transition	17 July 2020	94.00	0.92
Hunting Camp	Cloudy, partial sun, snow, water, shore, transition	23 August 2021	73.60	0.65
Average			85.93	0.79

TABLE S3. Annual dates and rates for classified extracted ice phenology.

Lake	Season	First-on	Final-on	Freeze-up duration	First-off	Final-off	Break-up duration	Ice cover duration
Small Lake	2015–16				16 June	19 July	33	
	2016–17	12 September	27 September	15		27 July		303
	2017–18	09 September	19 September	10	10 June	25 July	45	310
	2018–19	16 September	19 September	3	10 June	09 July	29	294
	2019–20	26 September	26 September	0	16 June	10 July	24	289
	2020–21	15 September	15 September	0		15 July		303
	2021–22	13 September	13 September	0	25 June	16 July	31	307
Resolute Lake	2016–17			0		06 August		
	2017–18	14 September	14 September	0	09 July	21 August	43	343
	2018–19	21 September	23 September	2	27 June	17 July	19	298
	2019–20	30 September	30 September	0	23 June	25 July	32	301
	2020–21	26 September	26 September	0	17 July	26 July	9	303
	2021–22	25 September	26 September	1	28 June	29 July	31	308
	2019–20	14 September	26 September	12	17 June	16 July	29	295
North Lake	2020–21	09 September	12 September	3				
	2021–22	13 September	13 September	0	17 June	17 July	30	309
	2019–20	27 September			19 June	4 July	35	
Plateau Lake	2020–21			0				
	2021–22	30 September	30 September	0				
	2015–16				09 June	21 July	42	
	2016–17					12 August		
	2017–18	01 September	24 September	23	12 June	11 August	60	322
	2018–19	14 September	14 September	0	27 June	27 July	30	317
	2019–20	13 September	13 September	0		22 July		314
Hunting Camp Lake	2020–21	19 September				31 July		
	2021–22	06 September	06 September	0	26 June	24 July	28	322
	Average	15 September	20 September	4	22 June	25 July	32	308
	Standard deviation	7.8	7.0	6.4	10.0	10.3	10.7	12.6
	Range	29	24	23	37	44	51	54
	Minimum	244	249	0	161	190	9	289
	Maximum	273	273	23	198	234	0	343

TABLE S4. Annual dates and rates for manually extracted lake ice phenology.

Lake	Season	First-on	Final-on	Freeze-up duration	First-off	Final-off	Break-up duration	Ice cover duration
Small Lake	2015–16				16 June	21 July	35	
	2016–17	12 September	28 September	16		01 August		306
	2017–18	07 September	12 September	5	13 June	06 August	54	328
	2018–19	15 September	17 September	2	14 June	14 July	30	300
	2019–20	14 September	22 September	8	21 June	16 July	25	298
	2020–21	15 September	19 September	4	25 June	25 July	30	308
Resolute Lake	2021–22	11 September	20 September	9	19 June	23 July	47	306
	2016–17					18 August		
	2017–18	13 September	18 September	5	07 July	25 August	49	341
	2018–19	16 September	21 September	5	01 July	25 July	24	307
	2019–20	12 September	04 October	22	27 June	28 July	31	298
	2020–21	24 September	27 September	8	05 July	02 August	28	308
North Lake	2021–22	18 September	25 September	7	15 June	01 August	47	310
	2019–20	13 September	24 September	11	19 June	17 July	28	297
	2020–21	10 September	23 September	13				
Plateau Lake	2021–22	04 September	19 September	15	18 June	24 July	36	308
	2019–20	20 September	30 September	10	17 June	26 July	39	300
	2020–21	12 September	24 September	12				
Hunting Camp Lake	2021–22	16 September	25 September	9				
	2015–16				23 June	25 July	32	
	2016–17	10 September	12 September	3		14 August		334
	2017–18	01 September	30 September	28	28 June	13 August	46	318
	2018–19	04 September	26 September	22	03 July	02 August	30	310
	2019–20	30 August	26 September	27	24 June	24 July	30	302
Average	2020–21	04 September	13 September	10	20 June	04 August	45	323
	2021–22	04 September	14 September	9	03 July	27 July	24	317
	Standard Deviation	11 September	22 September	11	23 June	30 July	36	311
	Range	6.3	6.0	7.7	7.3	10.4	9.3	12.5
Minimum		26	22	27	24	42	30	44
		30 August	12 September	2	13 June	14 July	24	297
Maximum		25 September	04 October	29	07 July	25 August	54	341

TABLE S5. Annual dates and rates for classified extracted snow phenology.

Lake	Season	First-on	Final-on	Freeze-up duration	First-off	Final-off	Break-up duration	Ice cover duration
Small Lake	2015–16				20 June	13 July	23	
	2016–17	10 September	10 September	0				
	2017–18	31 August	31 August	0	30 May	20 June	21	293
	2018–19	07 September	15 September	8	04 June	12 June	8	270
	2019–20	22 September	22 September	0	07 June	18 June	11	270
	2020–21	30 August	15 September	16	05 May	21 June	47	278
Resolute Lake	2021–22	20 September	20 September	0	08 May	12 July	65	295
	2016–17							
	2017–18	02 September	02 September	0	13 June	12 August	60	344
	2018–19	07 September	07 September	0	11 June	01 July	20	297
	2019–20	22 September	22 September	0	15 June	02 July	17	284
	2020–21	15 September	15 September	0	09 June	26 July	47	313
North Lake	2021–22	04 September	25 September	21	11 June	11 July	30	289
	2019–20	23 September	23 September	0	13 May	28 June	46	279
	2020–21	08 September	08 September	0				
Plateau Lake	2021–22	03 September	03 September	0	30 May	19 July	50	319
	2019–20	27 September	27 September	0	28 May	03 July	36	280
	2020–21							
Hunting Camp Lake	2021–22	03 September	21 September	18				
	2015–16				26 May	16 July	51	
	2016–17	21 August	10 September	20		15 July		307
	2017–18	30 August	30 August	0	16 May	11 August	87	346
	2018–19	03 September	07 September	4	15 May	22 July	68	318
	2019–20	27 August	22 September	26	17 May	15 July	59	297
Average	2020–21	31 August	10 September	10	23 May	17 July	55	309
	2021–22	03 September	22 September	19	11 May	25 June	45	276
	Standard deviation	07 September	14 September	06 Jan	28 May	09 July	43	298
	Range	9.9	8.6	9.1	13.3	16.6	21.1	22.5
Minimum		36	28	26	47	61	79	76
		22 August	30 August	0	05 May	12 June	8	270
Maximum		27 September	27 September	26	21 June	12 August	87	346

TABLE S6. Annual dates and rates for manually extracted snow phenology.

Lake	Season	First-on	Final-on	Freeze-up duration	First-off	Final-off	Break-up duration	Ice cover duration
Small Lake	2015–16				04 June	17 July	43	
	2016–17		10 September					
	2017–18	31 August	31 August	0	23 May	05 July	43	308
	2018–19	19 August	07 September	19	30 May	07 July	38	303
	2019–20	25 August	14 September	20	27 May	06 July	40	296
	2020–21	30 August	08 September	9	16 May	05 July	50	299
Resolute Lake	2021–22	04 September	21 September	17	18 May	21 July	64	303
	2016–17							
	2017–18	02 September	02 September	0	11 June			
	2018–19	19 August	07 September	19	10 June	07 July	27	303
	2019–20	22 September	22 September	0	12 June	10 July	28	292
	2020–21	06 September	14 September	8	07 June	30 July	53	318
North Lake	2021–22	03 September	25 September	22	06 June	15 July	39	293
	2019–20	22 September	22 September	0	16 May	01 July	46	283
	2020–21	30 August	08 September	9				
Plateau Lake	2021–22	20 August	03 September	14	25 May	16 July	52	316
	2019–20	30 August	26 September	27	14 May	08 July	55	286
	2020–21	08 September	08 September	0				
Hunting Camp Lake	2021–22	03 September	21 September	18				
	2015–16				25 May	07 July	43	
	2016–17	21 August	07 September	17	12 May	08 July	57	303
	2017–18	28 August	31 August	3	29 May	10 July	42	313
	2018–19	19 August	07 September	19	22 May	05 July	44	301
	2019–20	27 August	22 September	26	14 May	29 June	46	281
	2020–21	23 August	10 September	18	16 May	15 July	60	307
Average	2021–22	03 September	12 September	9	12 May	03 July	52	294
		31 August	12 September	12	25 May	10 July	46	300
	Standard deviation	9.6	8.1	9.2	10.5	7.2	9.6	10.6
	Range	34	26	27	32	30	37	37
	Minimum	19 August	31 August	0	12 May	30 June	27	281
	Maximum	22 September	26 September	27	13 June	30 July	64	318