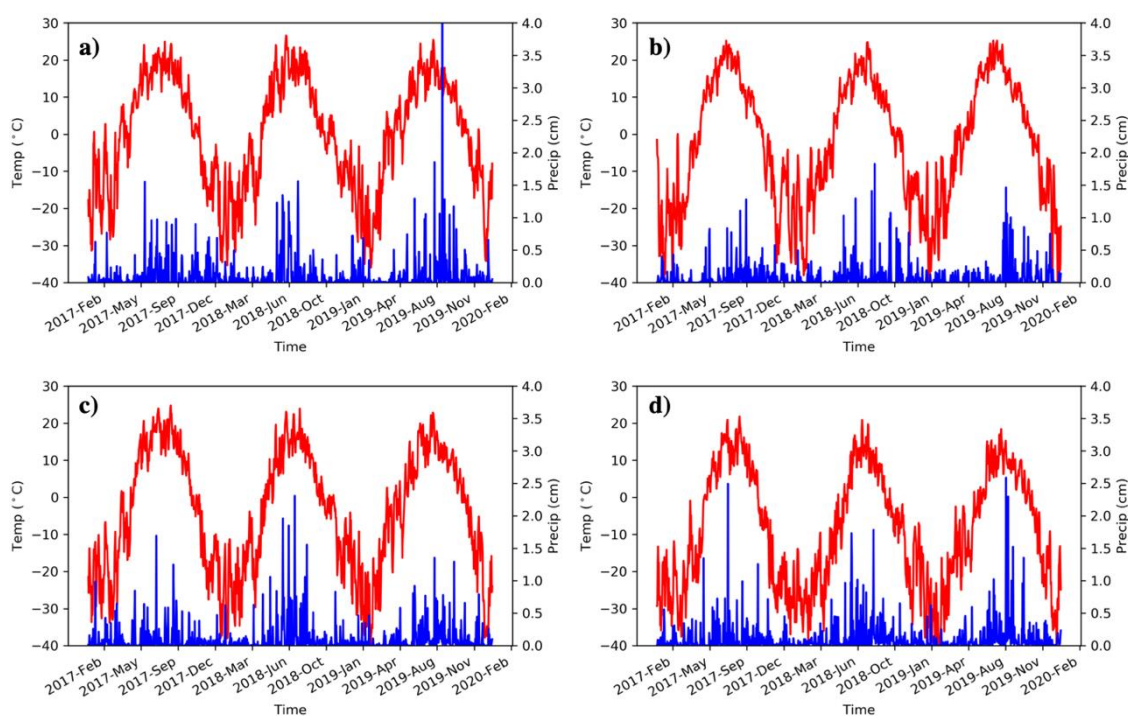
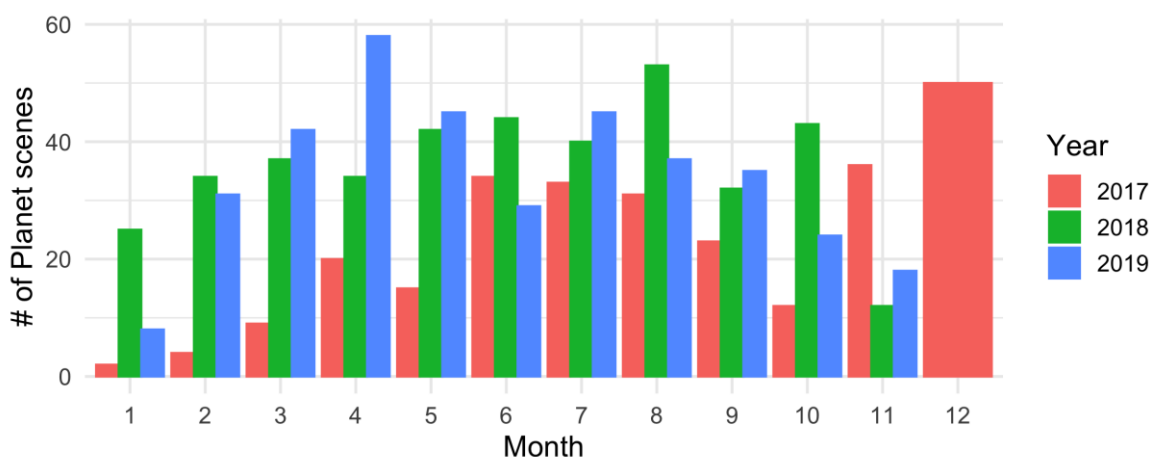


# CubeSat Phenologies of Arctic-Boreal Lakes Show Earlier Lake Ice-Out and Later Green-Up

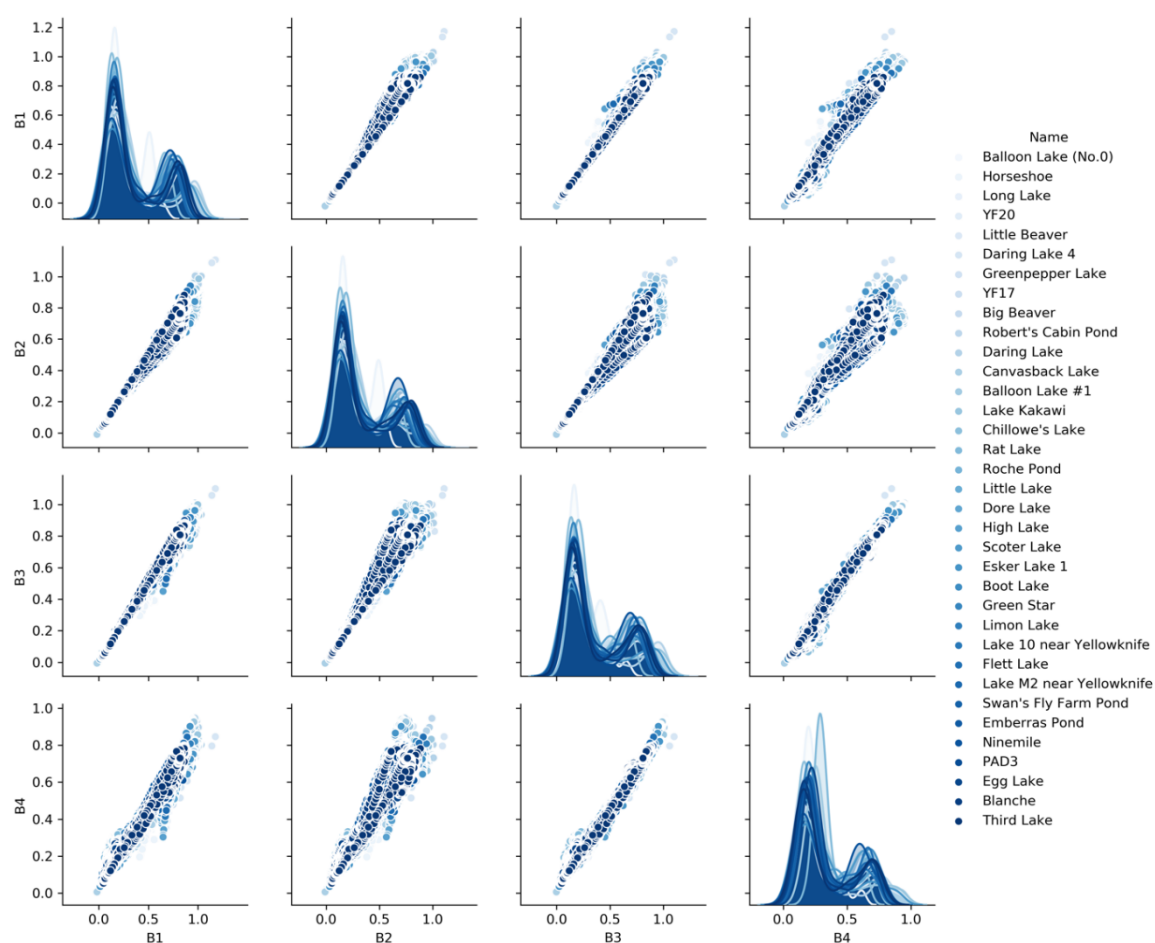
Catherine Kuhn <sup>1,\*</sup>, Aji John <sup>2</sup>, Janneke Hille Ris Lambers <sup>3</sup>, David Butman <sup>1</sup> and Amanda Tan <sup>4</sup>



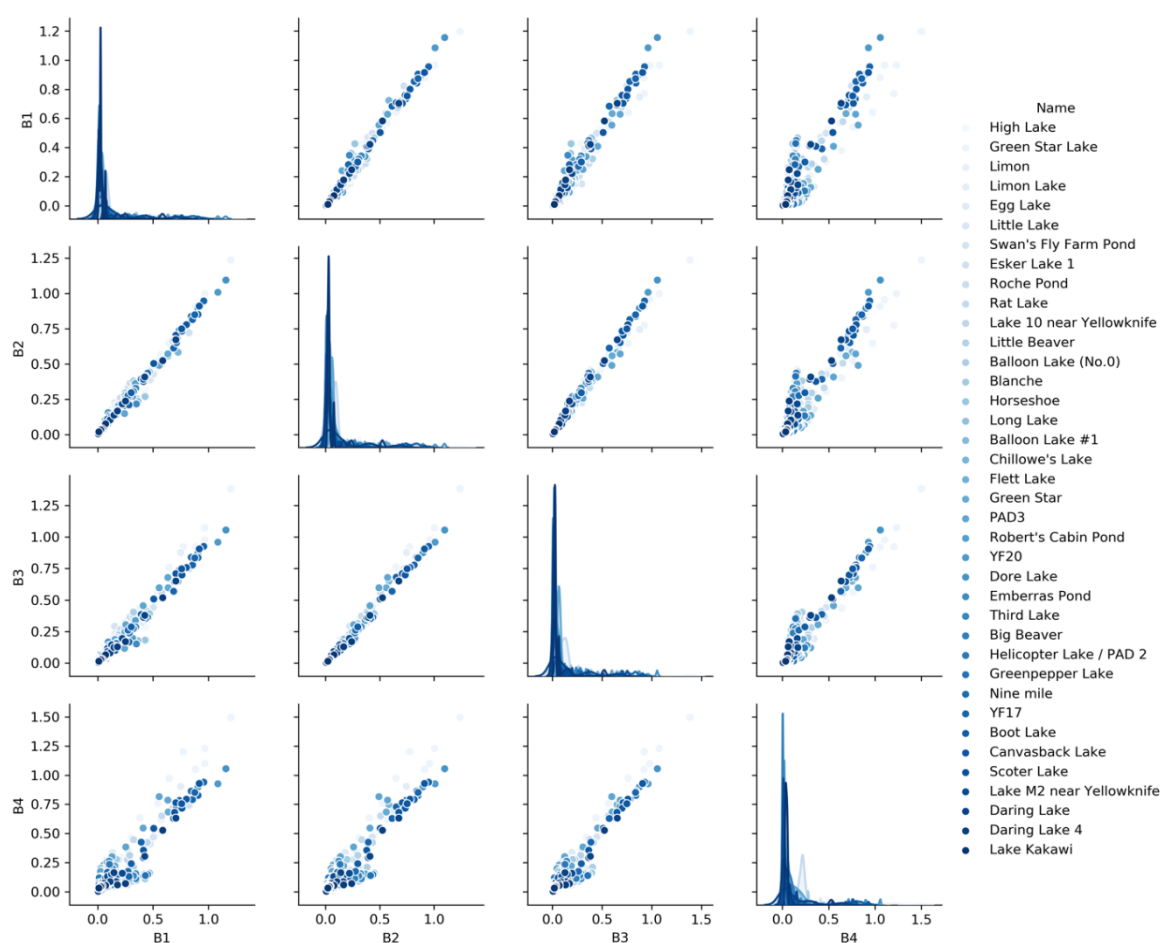
**Figure S1.** ERA5 data for the (a) PAD (b) Yukon Flats (c) Yellowknife (d) Daring Lake. Mean annual air temperature was -0.2, -2.35, -3.9, and -8.8 °C for the PAD, Yukon Flats, Yellowknife and Daring Lake region respectively. The red lines represent temperature (left x-axis) and the blue bars represent precipitation (right x-axis).



**Figure S2.** Bar plot showing the number of PlanetScope scenes by month.



**Figure S3.** Matrix plot showing correlations between the blue (B1), green (B2), red (B3) and near-infrared bands (B4) for PlanetScope using all available data (2017 – 2019, n = 31,616). This plot shows the pairwise scatter between bands. Histograms of the distribution of reflectance values for each band are shown on the diagonal (for example, the distribution of reflectance values for Band 1 is shown in the uppermost top left plot). Correlations ranged from  $r^2 = 0.94$  (green and NIR) to  $r^2 = 0.99$  (blue and green).



**Figure S4.** Matrix plot showing pairwise correlations between the blue (B1), green (B2), red (B3) and near-infrared bands (B4) for Sentinel-2 Level 2A surface reflectance product (2019,  $n = 1,350$ ). Figure conventions are the same as S3.

**Table S1.** Packages used in this analysis.

Platform	Package	References
Python	numpy	Harris et al., (2020)
	pandas	McKinney (2010)
	matplotlib	Hunter (2007)
	seaborn	Waskom et al., (2008)
R	stats	[78]
	tidyverse	[79]

**Table S2.** Absolute band differences between PlanetScope and Sentinel-2 for year 2019. “\*” indicates the month with no PlanetScope scenes available.

	Blue		Red		Green		NIR	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Annual	0.164	0.099	0.167	0.094	0.158	0.083	0.184	0.120
Jan	0.165	*	0.206	*	0.223	*	0.078	*
Feb	0.131	0.107	0.189	0.095	0.199	0.105	0.346	0.288
March	0.234	0.223	0.230	0.179	0.209	0.128	0.236	0.170
April	0.246	0.159	0.249	0.158	0.194	0.140	0.201	0.145
May	0.105	0.073	0.107	0.072	0.092	0.055	0.148	0.122
June	0.114	0.063	0.115	0.068	0.111	0.055	0.137	0.065
July	0.135	0.057	0.133	0.057	0.136	0.051	0.170	0.058
August	0.197	0.047	0.191	0.051	0.196	0.052	0.218	0.050
September	0.163	0.037	0.156	0.035	0.165	0.036	0.172	0.030
October	0.183	0.089	0.173	0.093	0.171	0.095	0.172	0.086
November	0.123	0.064	0.120	0.054	0.102	0.062	0.106	0.115
December	*	*	*	*	*	*	*	*

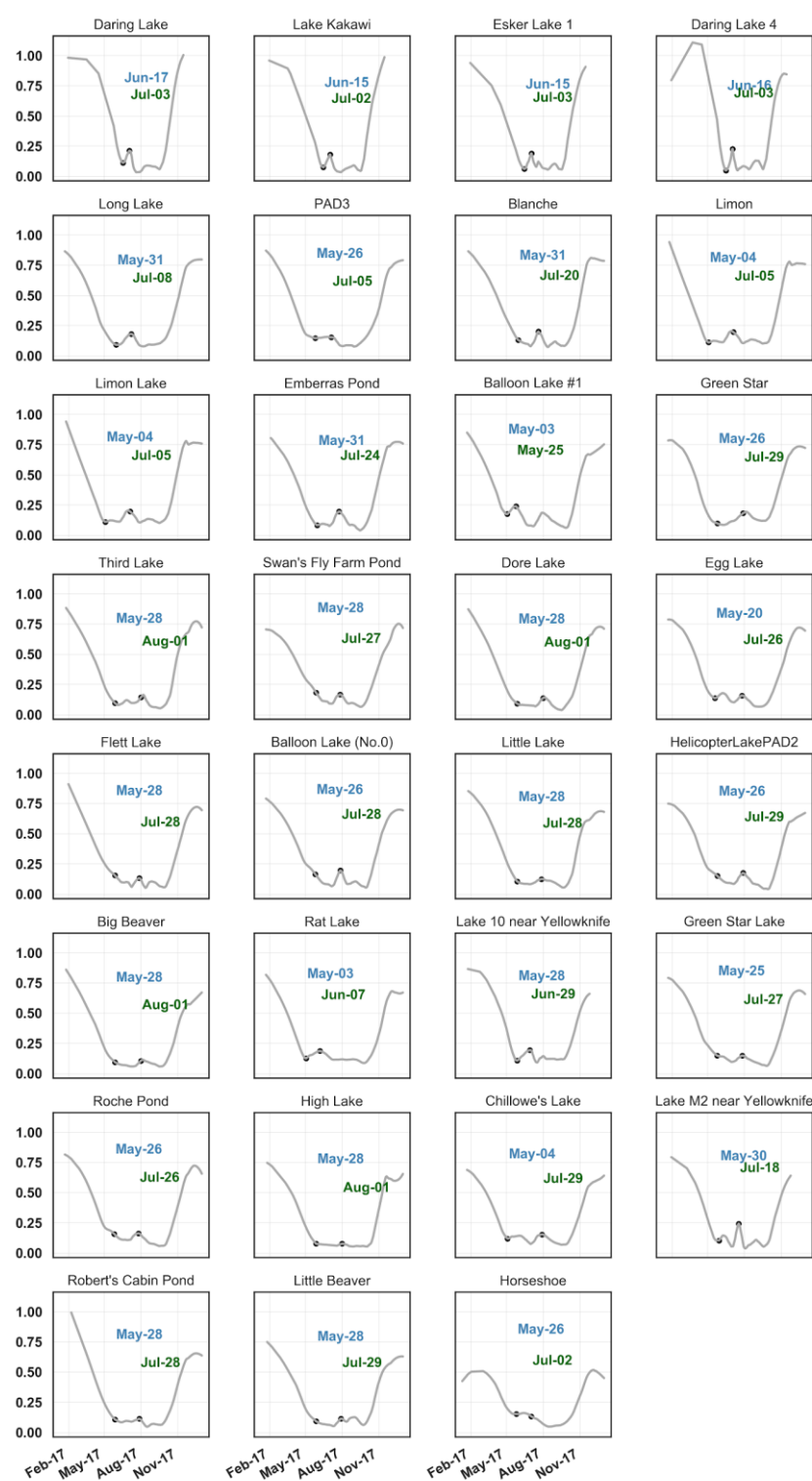


Figure S5. PlanetScope ice-out and green-up for 2017.

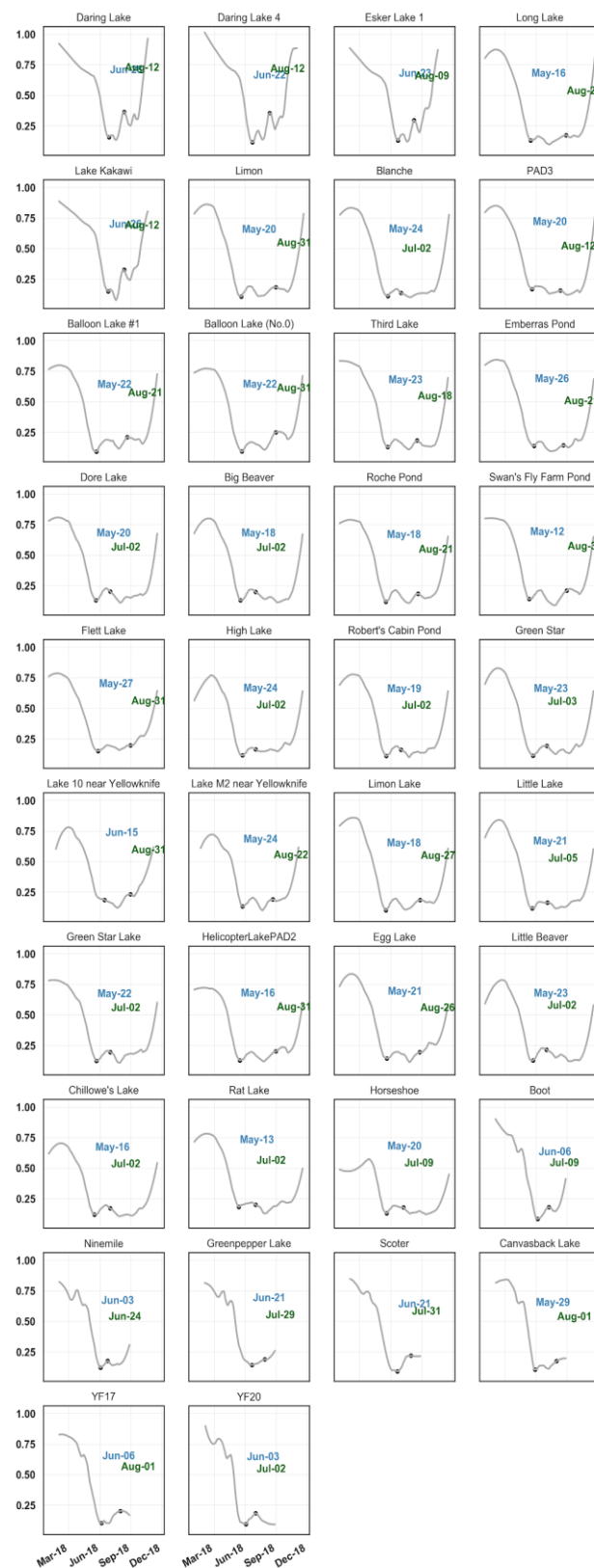


Figure S6 PlanetScope ice-out and green-up for 2018.

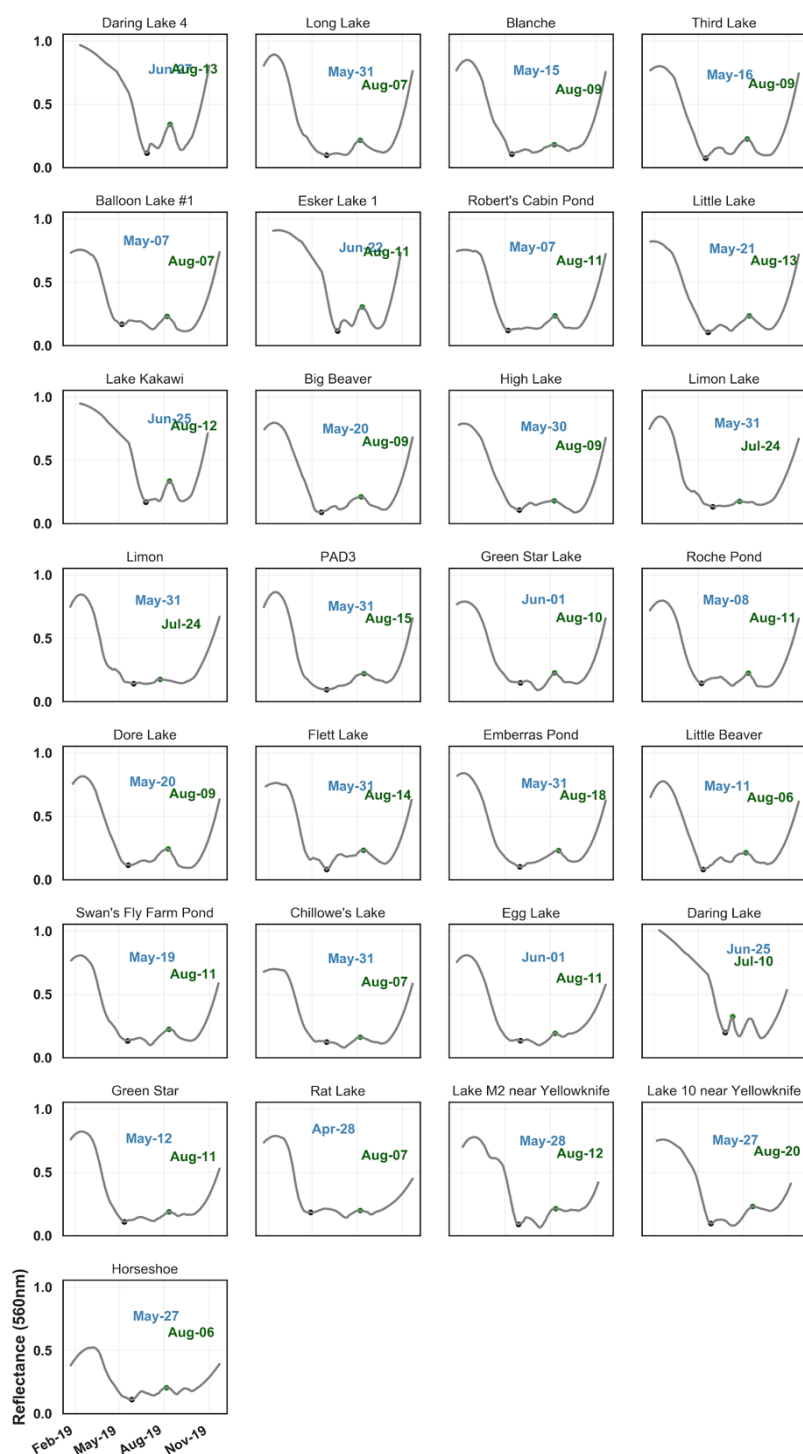
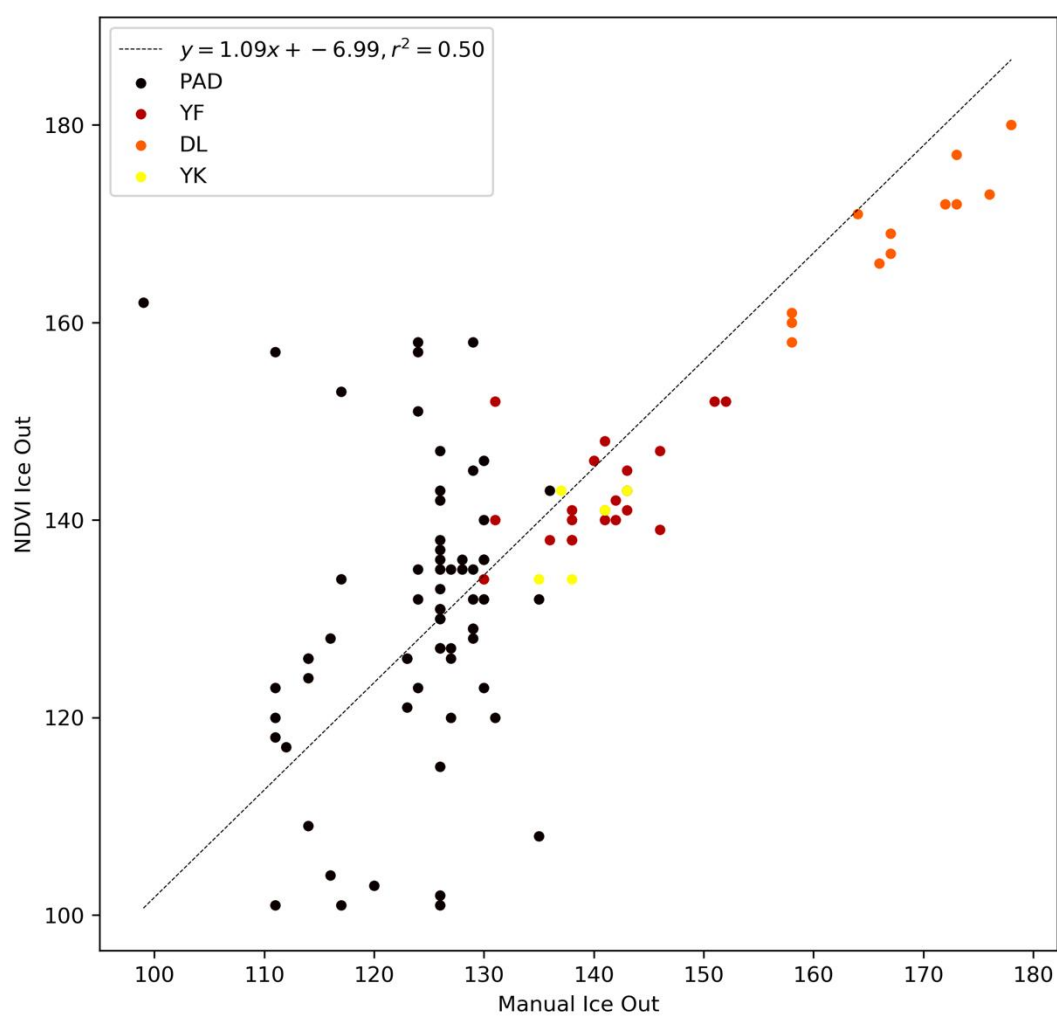
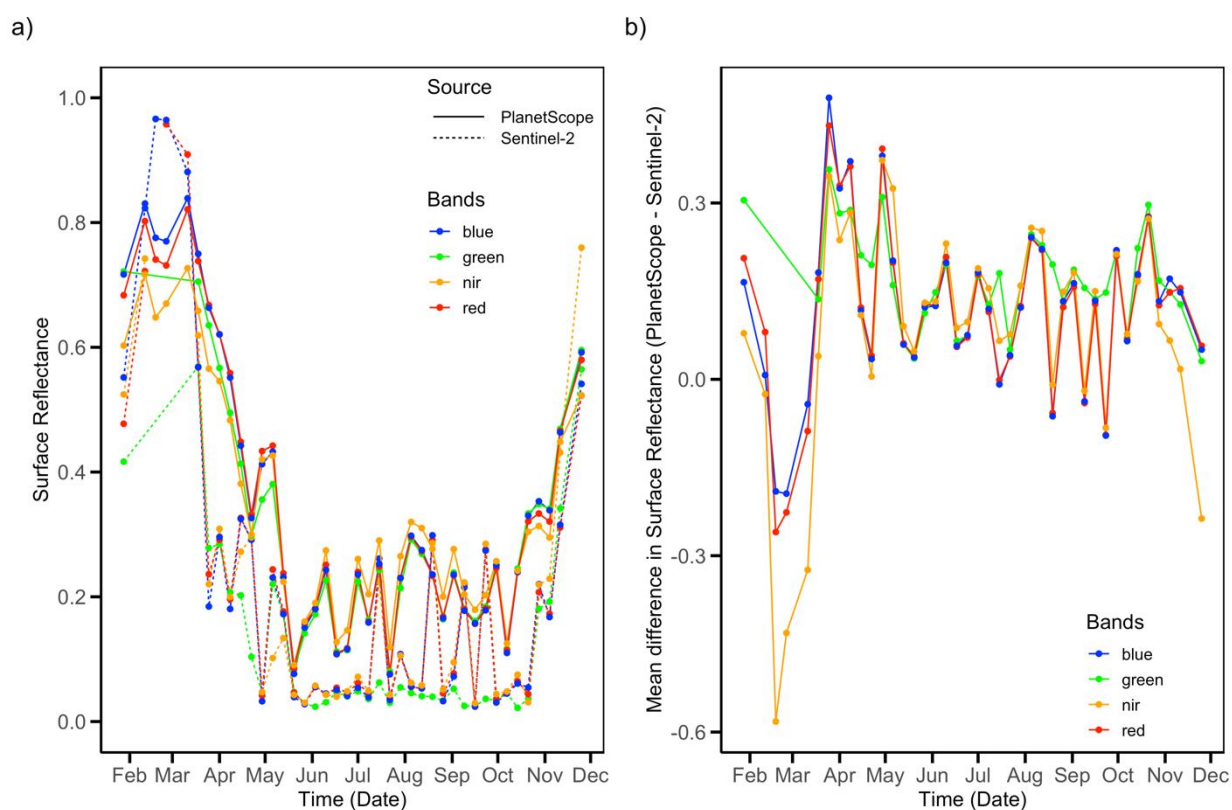


Figure S7 PlanetScope ice-out and green-up for 2019.







**Figure S9** a) Mean surface reflectance of PlanetScope and Sentinel-2 for year 2019 averaged across lakes. b) Weekly mean difference in surface reflectance between PlanetScope and Sentinel-2.



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