Supplementary Information for: ***A comparison of supraglacial meltwater features throughout contrasting melt seasons: Southwest Greenland***

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Supplementary Methods

Supplementary Methods 1: Sensor resolution

An evaluation between meltwater feature areas derived from L8 and S2 images was undertaken to determine whether sensor resolution impacts SGL detection accuracy. Individual lake areas of overlapping lake polygons across the whole catchment, derived from L8 and S2 images from 8 June, 3 July and 29 August 2019, were compared. We found a strongly significant relationship between both lake area datasets on all of these three dates (with R^2 values of 0.98 on 8 June, 0.93 on 3 July and 0.98 on 29 August; Figure S1). There were no overlapping S2 and L8 images in the 2018 melt season to compare. Although it has previously been shown that S2 imagery can detect meltwater at the boundaries of hard to distinguish lakes more accurately than L8 (i.e. Arthur et al., 2020a), here we conclude that sensor resolution does not have a significant impact on our ability to accurately detect meltwater or calculate SGL area, and both sensors can be used in conjunction for such analysis.

Supplementary Methods 2: Partitioning of lake drainage events into rapid vs. slow

We use our 2019 dataset of SGLs to highlight the influence of the time-scale of image availability on rapid and slow SGL drainage events. An SGL was determined to drain rapidly if > 80% of its volume was lost over a period of 1-5 days, and an SGL was determined to drain slowly if it lost 20% of its volume over any time period (Figure S2a). The proportion of rapid drainage events changes when the time threshold changes, highlighting how the number of drainage days used to determine a rapid drainage event can alter results considerably; the difference between 3 days and 4 days is particularly notable. The typical time that previous studies have used to determine a rapid SGL drainage event is 4 days (Figure S2b).

Supplementary Methods 3: Refreezing cross referencing

To provide some validation for our approach to determine if an SGL has refrozen or not, we cross referenced a subset of our refreezing lakes with two independent datasets of buried lakes acquired from SAR imagery in both years (Dunmire et al., 2021; Zheng et al., 2023) (Figure S3). This is undertaken under the assumption that refrozen lakes essentially become buried lakes after refreezing. We find good agreement in the locations of refreezing lakes in our dataset when compared to the other two datasets. We suggest that differences in the locations of these refrozen lakes are due to differing NDWI thresholds used to produce the three datasets.

Supplementary Figures

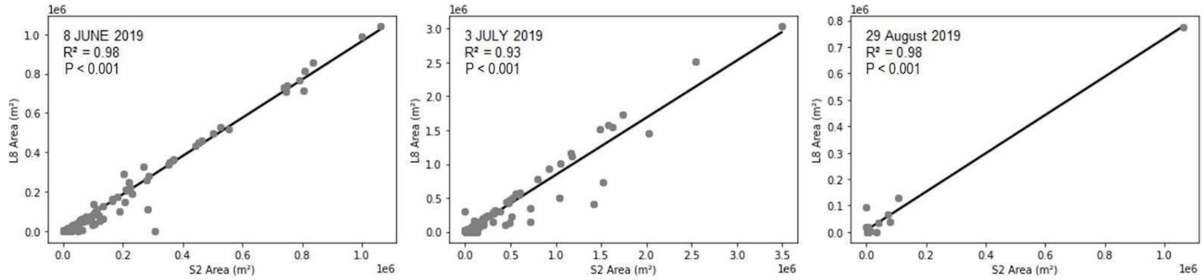

Figure S1: Lake area frequency distribution from three overlapping Landsat 8 and Sentinel-2 image scenes throughout the 2019 melt season.

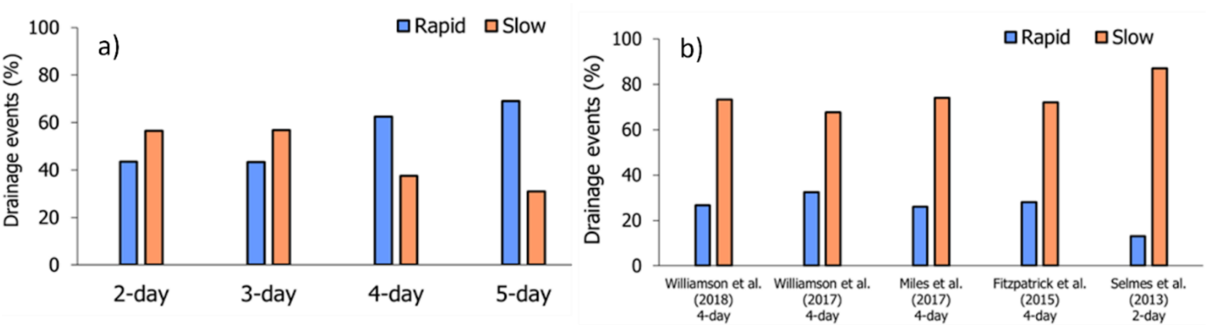

Figure S2: Partitioning of lake drainage events. a) Percentage of rapid and slow SGL drainage events in 2019 (y axis) and the number of days determining rapid drainage (x axis). b) Frequency of rapid and slow SGL drainage events from previous SW Greenland studies.

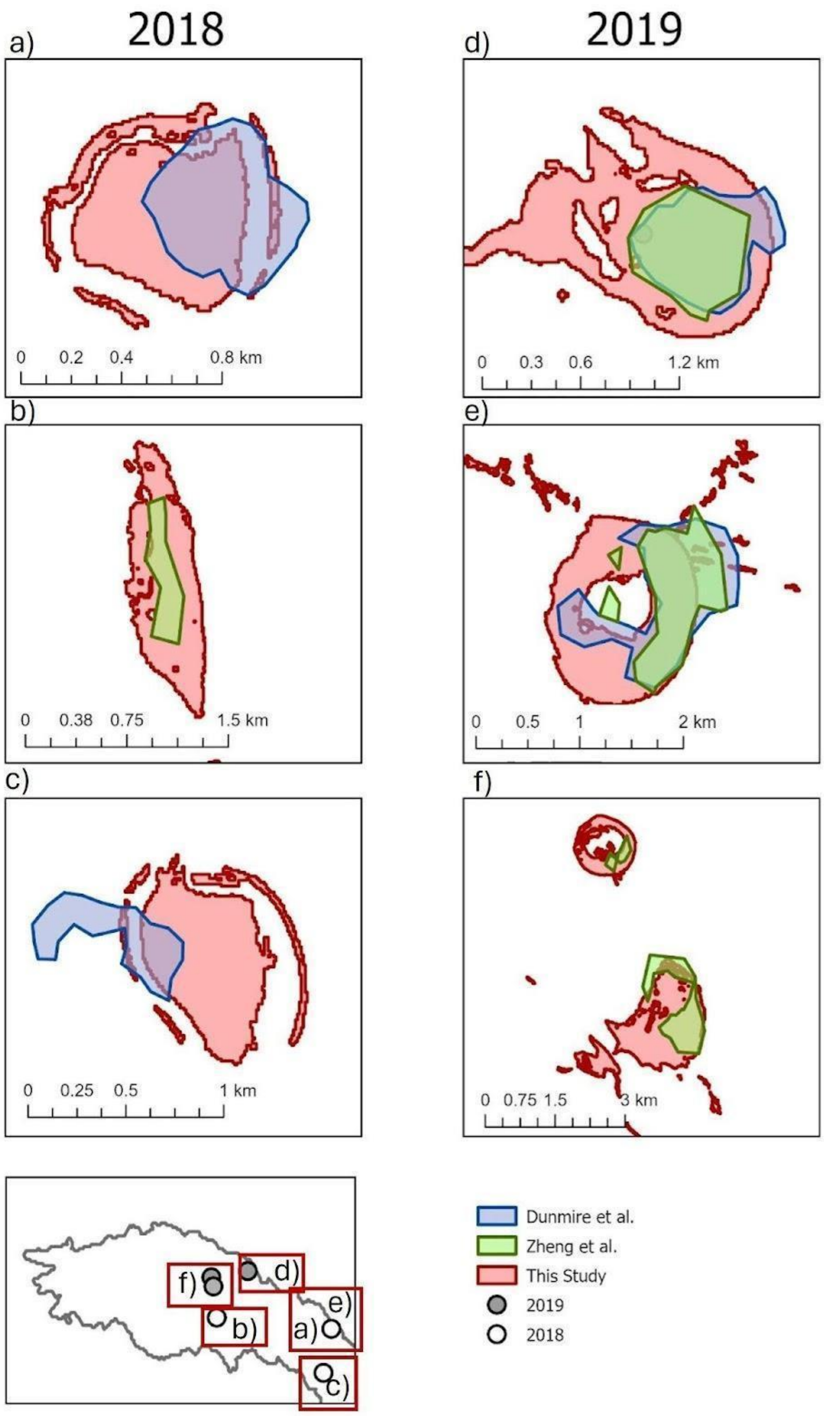

Figure S3: Cross referencing a subset of refreezing lakes in this study with maps of subsurface lakes acquired from SAR imagery in both 2018 (left) and 2019 (right). Blue: dataset from Dunmire et al. (2021); green: dataset from Zheng et al. (2023); red: Data from this study. Coordinates of lakes in WGS 1984 UTM Zone 22N: a) 47.3861245°W 66.9952765°N, b) 48.4755826°W 67.0147779°N, c) 47.4456300°W 66.8319809°N, d) 48.2075289°W 67.1934572°N e) 47.3873357°W 66.9953815°N , f) 48.5521200°W 67.1620352°N.

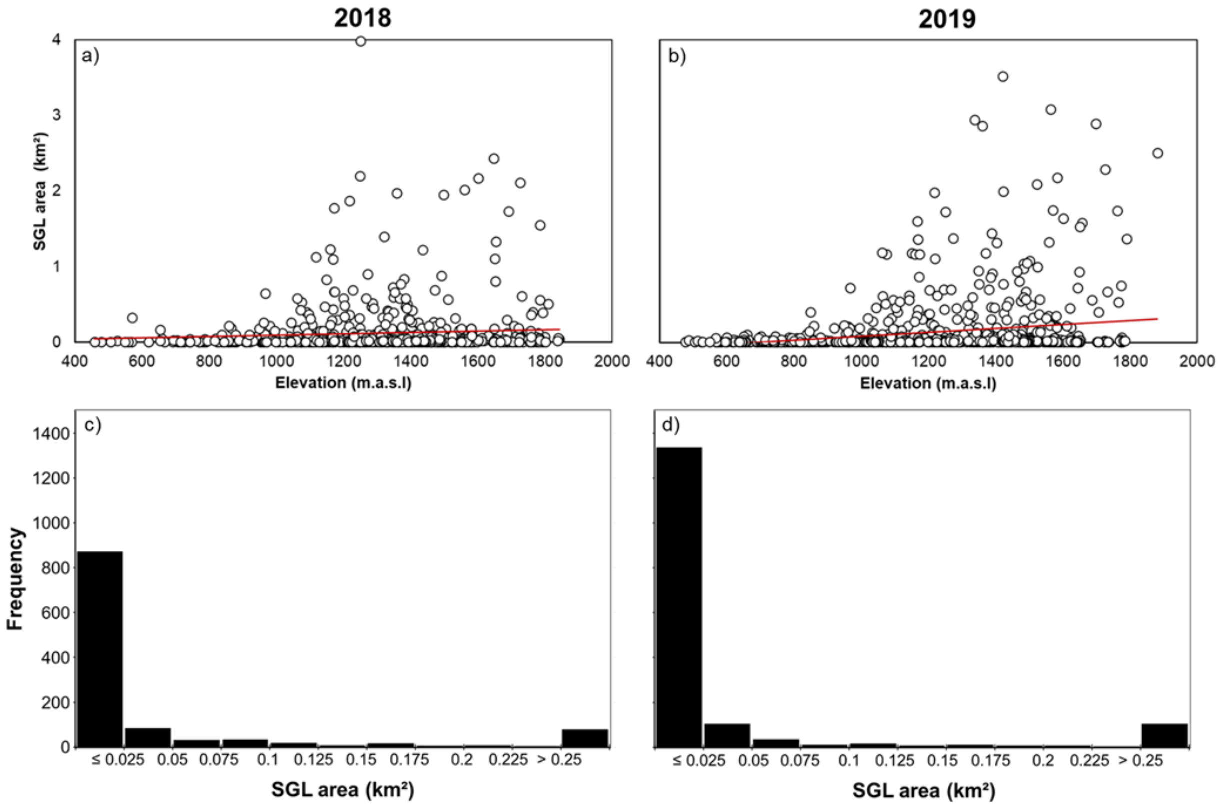

Figure S4: Scatter plots (a) and (b) displaying the relationship between SGL area and elevation for 2018 and 2019, respectively. Histograms (c) and (d) showing the frequency distribution of SGL areas separated into 10 different bins for 2018 and 2019, respectively.

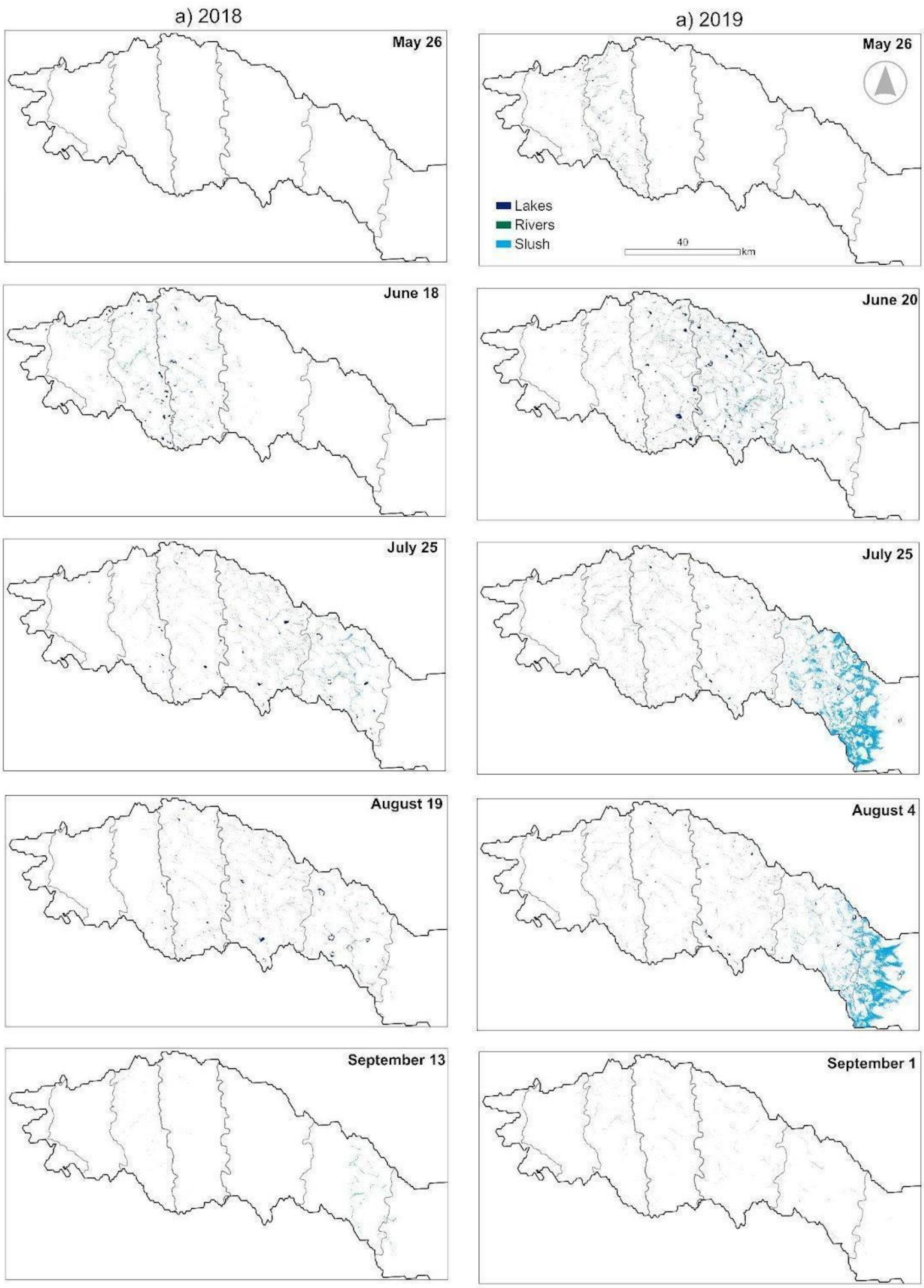

Figure S5: Areal extent monthly snapshots of supraglacial meltwater features in 2018 (a) and 2019 (b) within the Russell/Leverett Glacier catchment derived from ArcticDEM (black outline). Slush is light blue, channels are green, and lakes are dark blue. Elevation contours from the ArcticDEM are shown in grey.

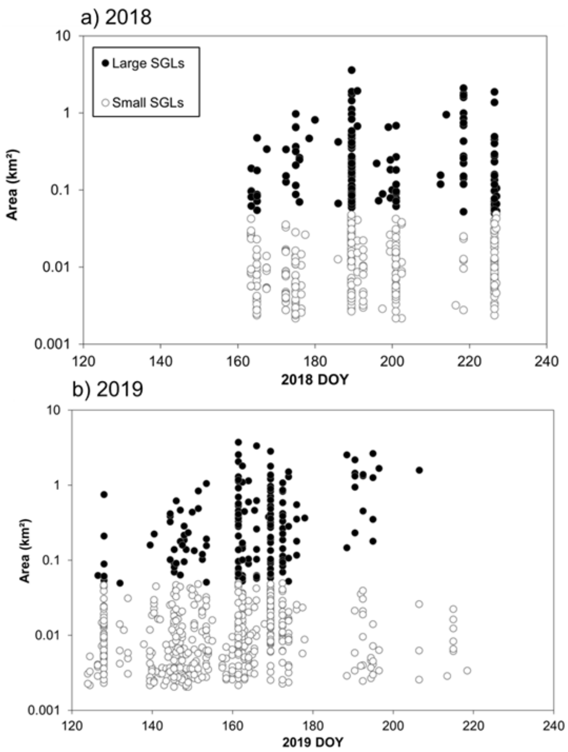

Figure S6: Seasonal variation in the area of draining SGLs in 2018 (a) and 2019 (b). The area of large draining SGLs (>0.0495 km²; solid black circles) and small draining SGLs (≥ 0.0018 and ≤ 0.0495 km²; open circles) is plotted on a logarithmic scale against the day of the year (DOY).

Supplementary Animations

Animations are provided as a separate file.

Supplementary Animation 1:

Animated monthly progression of supraglacial meltwater features in 2018 within the Russell/Leverett Glacier catchment, derived from ArcticDEM (black outline). Slush is represented in light blue, channels in green, and lakes in dark blue. Elevation contours from the ArcticDEM are shown in grey.

Supplementary Animation 2:

Animated monthly progression of supraglacial meltwater features in 2019 within the Russell/Leverett Glacier catchment, derived from ArcticDEM (black outline). Slush is represented in light blue, channels in green, and lakes in dark blue. Elevation contours from the ArcticDEM are shown in grey.

73 ## Supplementary Tables

74 **Table S1: details of all Sentinel-2 (S2) and Landsat 8 (L8) satellite imagery used in this study.**

Scene ID	Date	Satellite	Cloud Cover (%)
S2A_MSIL1C_20180516T150041_N0206_R125_T22WEV_20180516T170011	16-May-18	S2	9.8
S2A_MSIL1C_20180516T150041_N0206_R125_T22WFV_20180516T170011	16-May-18	S2	87.7
S2A_MSIL1C_20180526T145921_N0206_R125_T22WEV_20180526T201815	26-May-18	S2	68.6
S2A_MSIL1C_20180526T145921_N0206_R125_T22WFV_20180526T201815	26-May-18	S2	60.2
LC08_L1TP_008013_20180605_20200831_02_T1	05-Jun-18	L8	35.4
S2B_MSIL1C_20180610T150009_N0206_R125_T22WEV_20180610T183746	10-Jun-18	S2	16.1
S2B_MSIL1C_20180610T150009_N0206_R125_T22WFV_20180610T183746	10-Jun-18	S2	82.8
S2A_MSIL1C_20180615T145911_N0206_R125_T22WEV_20180615T170226	15-Jun-18	S2	34.3
S2A_MSIL1C_20180615T145911_N0206_R125_T22WFV_20180615T170226	15-Jun-18	S2	43.1
S2A_MSIL1C_20180618T150911_N0206_R025_T22WEV_20180618T185402	18-Jun-18	S2	4.9
S2A_MSIL1C_20180618T150911_N0206_R025_T22WFV_20180618T185402	18-Jun-18	S2	22.6
S2B_MSIL1C_20180703T150909_N0206_R025_T22WEV_20180703T201427	03-Jul-18	S2	71.9
S2B_MSIL1C_20180703T150909_N0206_R025_T22WFV_20180703T201427	03-Jul-18	S2	19.6
LC08_L1TP_008013_20180707_20200831_02_T1	07-Jul-18	L8	31.2
S2B_MSIL1C_20180710T150009_N0206_R125_T22WEV_20180710T202212	10-Jul-18	S2	5.0
S2B_MSIL1C_20180710T150009_N0206_R125_T22WFV_20180710T202212	10-Jul-18	S2	94.5
S2B_MSIL1C_20180713T151139_N0206_R025_T22WEV_20180713T200909	13-Jul-18	S2	4.3
S2B_MSIL1C_20180713T151139_N0206_R025_T22WFV_20180713T200909	13-Jul-18	S2	0.3
S2A_MSIL1C_20180725T145911_N0206_R125_T22WEV_20180725T185310	25-Jul-18	S2	89.9
S2A_MSIL1C_20180725T145911_N0206_R125_T22WFV_20180725T185310	25-Jul-18	S2	25.1
S2B_MSIL1C_20180730T150009_N0206_R125_T22WEV_20180730T202856	30-Jul-18	S2	0.1
S2B_MSIL1C_20180730T150009_N0206_R125_T22WFV_20180730T202856	30-Jul-18	S2	0.2
S2A_MSIL1C_20180810T151911_N0206_R068_T22WEV_20180810T202556	10-Aug-18	S2	2.5
S2A_MSIL1C_20180810T151911_N0206_R068_T22WFV_20180810T202556	10-Aug-18	S2	0.0
S2B_MSIL1C_20180819T145959_N0206_R125_T22WEV_20180819T200111	19-Aug-18	S2	26.2
S2B_MSIL1C_20180819T145959_N0206_R125_T22WFV_20180819T200111	19-Aug-18	S2	9.3
S2A_MSIL1C_20180824T145911_N0206_R125_T22WEV_20180824T190305	24-Aug-18	S2	59.8
S2A_MSIL1C_20180824T145911_N0206_R125_T22WFV_20180824T190305	24-Aug-18	S2	65.3
S2A_MSIL1C_20180913T145911_N0206_R125_T22WEV_20180913T171024	13-Sep-18	S2	0.0
S2A_MSIL1C_20180913T145911_N0206_R125_T22WFV_20180913T171024	13-Sep-18	S2	0.0
S2B_MSIL1C_20180918T145959_N0206_R125_T22WEV_20180918T200337	18-Sep-18	S2	0.0

S2B_MSIL1C_20180918T145959_N0206_R125_T22WFV_20180918T200337	18-Sep-18	S2	6.9
S2A_MSIL1C_20180919T151911_N0206_R068_T22WEV_20180919T191221	19-Sep-18	S2	17.2
S2A_MSIL1C_20180919T151911_N0206_R068_T22WFV_20180919T191221	19-Sep-18	S2	0.0
S2B_MSIL1C_20180921T151119_N0206_R025_T22WEV_20180921T201342	21-Sep-18	S2	28.2
S2B_MSIL1C_20180921T151119_N0206_R025_T22WFV_20180921T201342	21-Sep-18	S2	95.4
S2B_MSIL1C_20180924T152029_N0206_R068_T22WEV_20180924T202449	24-Sep-18	S2	1.2
S2B_MSIL1C_20180924T152029_N0206_R068_T22WFV_20180924T202449	24-Sep-18	S2	0.0
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S2A_MSIL1C_20190501T145921_N0207_R125_T22WFV_20190501T165756	01-May-19	S2	45.5
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S2B_MSIL1C_20190502T151809_N0207_R068_T22WFV_20190502T190011	02-May-19	S2	0.0
S2B_MSIL1C_20190506T150019_N0207_R125_T22WEV_20190506T195836	06-May-19	S2	2.4
S2B_MSIL1C_20190506T150019_N0207_R125_T22WFV_20190506T195836	06-May-19	S2	0.7
LC08_L1TP_008013_20190507_20200828_02_T1	07-May-19	L8	3.8
S2B_MSIL1C_20190509T150809_N0207_R025_T22WEV_20190509T184714	09-May-19	S2	0.6
S2B_MSIL1C_20190509T150809_N0207_R025_T22WFV_20190509T184714	09-May-19	S2	13.4
S2A_MSIL1C_20190517T151911_N0207_R068_T22WEV_20190517T171614	17-May-19	S2	29.3
S2A_MSIL1C_20190517T151911_N0207_R068_T22WFV_20190517T171614	17-May-19	S2	0.0
S2B_MSIL1C_20190519T150809_N0207_R025_T22WEV_20190519T184819	19-May-19	S2	6.3
S2B_MSIL1C_20190519T150809_N0207_R025_T22WFV_20190519T184819	19-May-19	S2	7.9
S2B_MSIL1C_20190522T151919_N0207_R068_T22WEV_20190522T171829	22-May-19	S2	0.0
S2B_MSIL1C_20190522T151919_N0207_R068_T22WFV_20190522T171829	22-May-19	S2	0.0
LC08_L1TP_008013_20190523_20200830_02_T1	23-May-19	L8	4.5
S2A_MSIL1C_20190524T150911_N0207_R025_T22WEV_20190524T170812	24-May-19	S2	7.9
S2A_MSIL1C_20190524T150911_N0207_R025_T22WFV_20190524T170812	24-May-19	S2	17.3
LC08_L1TP_006013_20190525_20200828_02_T1	25-May-19	L8	0.7
S2B_MSIL1C_20190526T150019_N0207_R125_T22WEV_20190526T183734	26-May-19	S2	0.6
S2B_MSIL1C_20190526T150019_N0207_R125_T22WFV_20190526T183734	26-May-19	S2	79.1
S2A_MSIL1C_20190527T151911_N0207_R068_T22WEV_20190527T202622	27-May-19	S2	0.1
S2A_MSIL1C_20190527T151911_N0207_R068_T22WFV_20190527T202622	27-May-19	S2	0.0
S2B_MSIL1C_20190529T150809_N0207_R025_T22WEV_20190529T201431	29-May-19	S2	7.6
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S2A_MSIL1C_20190531T145921_N0207_R125_T22WFV_20190531T165832	31-May-19	S2	22.6
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S2B_MSIL1C_20190605T150019_N0207_R125_T22WFV_20190605T200407	05-Jun-19	S2	94.0
S2B_MSIL1C_20190608T150809_N0207_R025_T22WEV_20190608T184815	08-Jun-19	S2	10.1
S2B_MSIL1C_20190608T150809_N0207_R025_T22WFV_20190608T184815	08-Jun-19	S2	14.1
LC08_L1TP_006013_20190610_20200828_02_T1	10-Jun-19	L8	1.2
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S2A_MSIL1C_20190613T150911_N0207_R025_T22WFV_20190613T170639	13-Jun-19	S2	0.9
LC08_L1TP_007013_20190617_20200828_02_T1	17-Jun-19	L8	10.5
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S2A_MSIL1C_20190620T145921_N0207_R125_T22WFV_20190620T183937	20-Jun-19	S2	0.0
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S2A_MSIL1C_20190703T150921_N0207_R025_T22WFV_20190703T184907	03-Jul-19	S2	31.8
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S2A_MSIL1C_20190707T144921_N0207_R082_T22WFV_20190707T164746	07-Jul-19	S2	3.8
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S2B_MSIL1C_20190725T150019_N0208_R125_T22WEV_20190725T183725	25-Jul-19	S2	21.1
S2B_MSIL1C_20190725T150019_N0208_R125_T22WFV_20190725T183725	25-Jul-19	S2	0.8
S2B_MSIL1C_20190801T144759_N0208_R082_T22WEV_20190801T164915	01-Aug-19	S2	0.0
S2B_MSIL1C_20190801T144759_N0208_R082_T22WFV_20190801T164915	01-Aug-19	S2	1.8
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S2A_MSIL1C_20190802T150921_N0208_R025_T22WFV_20190802T170710	02-Aug-19	S2	7.3
S2B_MSIL1C_20190804T150019_N0208_R125_T22WEV_20190804T165643	04-Aug-19	S2	4.2
S2B_MSIL1C_20190804T150019_N0208_R125_T22WFV_20190804T165643	04-Aug-19	S2	17.7
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S2A_MSIL1C_20190809T145921_N0208_R125_T22WFV_20190809T165708	09-Aug-19	S2	0.0
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S2A_MSIL1C_20190812T150921_N0208_R025_T22WFV_20190812T201743	12-Aug-19	S2	11.3

S2B_MSIL1C_20190817T150809_N0208_R025_T22WEV_20190817T202054	17-Aug-19	S2	52.7
S2B_MSIL1C_20190817T150809_N0208_R025_T22WFV_20190817T202054	17-Aug-19	S2	16.4
LC08_L1TP_007013_20190820_20200827_02_T1	20-Aug-19	L8	11.1
S2B_MSIL1C_20190824T150009_N0208_R125_T22WEV_20190824T201004	24-Aug-19	S2	5.2
S2B_MSIL1C_20190824T150009_N0208_R125_T22WFV_20190824T201004	24-Aug-19	S2	27.8
S2A_MSIL1C_20190825T151911_N0208_R068_T22WEV_20190825T185502	25-Aug-19	S2	3.4
S2A_MSIL1C_20190825T151911_N0208_R068_T22WFV_20190825T185502	25-Aug-19	S2	0.0
LC08_L1TP_008013_20190827_20200826_02_T1	27-Aug-19	L8	42.5
S2A_MSIL1C_20190829T145921_N0208_R125_T22WEV_20190829T183408	29-Aug-19	S2	11.2
S2A_MSIL1C_20190829T145921_N0208_R125_T22WFV_20190829T183408	29-Aug-19	S2	99.5
S2B_MSIL1C_20190830T151809_N0208_R068_T22WEV_20190830T185641	30-Aug-19	S2	33.3
S2A_MSIL1C_20190901T150911_N0208_R025_T22WEV_20190901T170819	01-Sep-19	S2	34.5
S2A_MSIL1C_20190901T150911_N0208_R025_T22WFV_20190901T170819	01-Sep-19	S2	24.2
S2B_MSIL1C_20190909T151809_N0208_R068_T22WEV_20190909T202539	09-Sep-19	S2	14.6
S2A_MSIL1C_20190918T150011_N0208_R125_T22WEV_20190918T201931	18-Sep-19	S2	24.1
S2A_MSIL1C_20190918T150011_N0208_R125_T22WFV_20190918T201931	18-Sep-19	S2	98.3
S2B_MSIL1C_20190923T150009_N0208_R125_T22WEV_20190923T200537	23-Sep-19	S2	21.1
S2B_MSIL1C_20190923T150009_N0208_R125_T22WFV_20190923T200537	23-Sep-19	S2	26.7
S2B_MSIL1C_20190926T150949_N0208_R025_T22WEV_20190926T184849	26-Sep-19	S2	0.5
S2B_MSIL1C_20190926T150949_N0208_R025_T22WFV_20190926T184849	26-Sep-19	S2	0.0
S2A_MSIL1C_20190928T150011_N0208_R125_T22WEV_20190928T165931	28-Sep-19	S2	0.0
S2A_MSIL1C_20190928T150011_N0208_R125_T22WFV_20190928T165931	28-Sep-19	S2	18.8

Table S2: Maximum areal coverage and median elevation a.s.l. of all SGL, channel and slush features in 2018 (left) and 2019 (right).

	2018	**2019**
Maximum areal coverage		
SGLs	1.5%	2.1%
Channels	4.5%	6.4%
Slush	0.3%	12.3%
Median elevation		
SGLs	1350 m	1250 m
Channels	1350 m	1500 m
Slush	1600 m	1700 m