

1 Summary of the ABoVE L-band and P-band Airborne SAR Surveys

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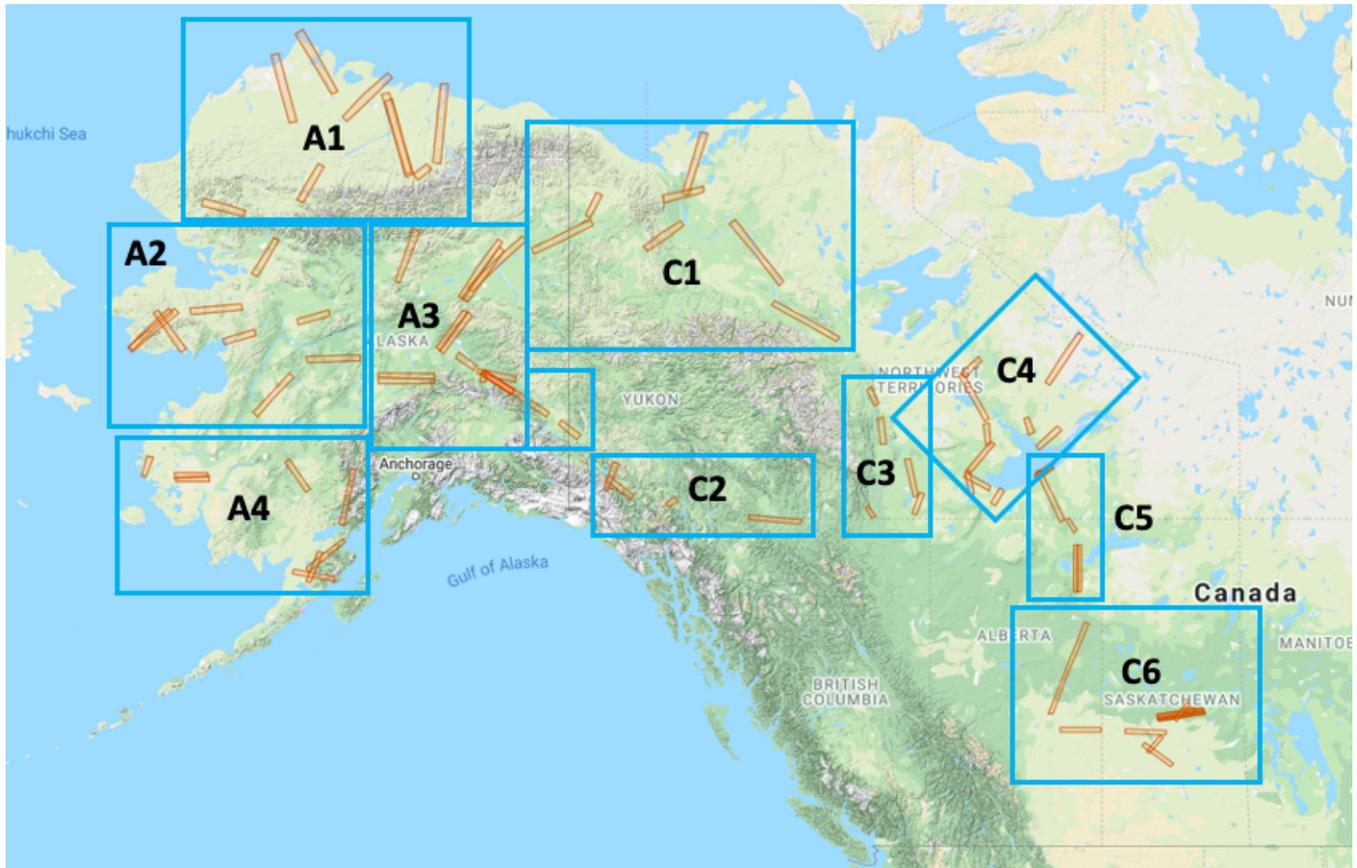
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42 **Summary**

43 NASA's Arctic Boreal Vulnerability Experiment (ABoVE) conducted airborne synthetic aperture radar
44 (SAR) surveys of over 120,000 km² in Alaska and northwestern Canada during 2017, 2018, 2019, and
45 2022. Here, we present an annotated guide to the L-band and P-band airborne SAR data acquired during
46 the ABoVE airborne campaigns [Miller 2019]. We provide a detailed description of the ~80 SAR flight
47 lines and how each fits into the ABoVE experimental design. Extensive maps, tables, and hyperlinks
48 give direct access to every flight plan as well as individual flight lines. This entry is a guide to enable
49 interested readers to fully explore the ABoVE L- and P-band SAR data.
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53 **Figure 1. Flight lines for L-band and P-band PolInSAR measurements capture critical bioclimatic, permafrost, and**
54 **geographic gradients as well as key field sites and long-term measurement records across the 4 Mkm² ABoVE**
55 **domain. The flight lines are collected into 10 composites which roughly correspond to the Alaskan (A1-A4) and**
56 **Canadian (C1-C6) regions sampled on individual flight days. © Google Maps.**

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- 79 7. Acknowledgments
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82 **1. Dataset Overview**

83 The L-band and P-band SARs are foundational measurements in the ABoVE airborne campaign
84 strategy [Miller 2019]. The ~80 flight lines described here form the framework for the remainder of
85 ABoVE airborne remote sensing acquisitions. The baseline L-band campaigns were flown in June
86 (DOY 164-173, Table 1) and September (DOY 251-263, Table 2) of 2017 to characterize the land
87 surface during periods of minimum and maximum active layer thickness, respectively. Subsequent L-
88 band campaigns in 2018 (DOY 231-241, Table 3), 2019 (DOY 247-260, Table 4), and 2022 (DOY 226-
89 237, Table 5) provide a time series synched to maximum annual active layer thickness. P-band
90 campaigns were conducted in May-June (DOY 142-157, Table 6) and August (DOY 219-227, Table 7)
91 of 2017. There was a 2-day P-band mini-campaign in October 2017 to extend the legacy time series of
92 early cold season acquisitions over the Seward Peninsula, NW Alaska and North Slope Alaska (DOY
93 280-283, Table 8).

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95 ABoVE SAR flight lines (Figure 1) leverage legacy L- and P-band SAR transects acquired during the
96 pre-ABoVE period; remotely-sensed permafrost active layer thickness time series derived from satellite
97 interferometric SAR observations (ReSALT) [Schaefer 2015]; SAR data from PALSAR, PALSAR-2,
98 RadarSat, RadarSat-2, and Sentinel-1; historic or planned airborne LiDAR acquisitions; and data from
99 existing field sites [Hoy 2018]. Legacy airborne SAR flight lines include the L-band grid acquired over
00 the Boreal Ecosystem Research and Monitoring Sites (BERMS) area near Prince Albert, SK during
01 SMAP CanEx 2010 [Magagi 2012], the P-band lines over the BERMS area acquired from 2012-2015

02 during the Airborne Microwave Observatory of Subcanopy and Subsurface ([AirMOSS](#)) Earth Ventures
 03 Sub-orbital (EV-S1) investigation [Allen 2010; Moghaddam 2016], and a collection of 10 L- and P-
 04 band flight lines acquired over the Seward Peninsula, Northwestern Interior, and North Slope of Alaska
 05 during 2014 and 2015 [Chen 2019a, 2019b]. The BERMS area observations link ABoVE to the Boreal
 06 Ecosystem–Atmosphere Study ([BOREAS](#)) studies of the 1990s [Sellers 1995; 1997].

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08 **1.1 L-band and P-band Campaign Summaries**

09 The baseline L-band campaigns were flown in June (DOY 164-173, Table 1) and September (DOY
 10 251-263, Table 2) of 2017 to characterize the land surface during periods of minimum and maximum
 11 active layer thickness, respectively. Subsequent L-band campaigns in 2018 (DOY 231-241, Table 3),
 12 2019 (DOY 247-260, Table 4), and 2022 (DOY 226-235, Table 5) provide a time series synched to
 13 maximum annual active layer thickness. P-band campaigns were conducted in May-June (DOY 142-
 14 157, Table 6) and August (DOY 219-227, Table 7) of 2017. There was a 2-day P-band mini-campaign
 15 in October 2017 to extend the legacy time series of early cold season acquisitions over the Seward
 16 Peninsula, NW Alaska and North Slope Alaska (DOY 280-283, Table 8).

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18 **Table 1. ABoVE L-band PolInSAR Campaign #1**

Flight Plan	Sortie Date	Regions Sampled (hyperlink to flight line map)
17062	2017-06-13	PAD-Transboundary Watershed
17063	2017-06-14	Great Slave Lake Region
17064	2017-06-15	Yellowknife – Fairbanks Transit
17065	2017-06-16	Southwest Alaska
17066	2017-06-17	Southwest Alaska & YK Delta
17067	2017-06-19	Seward Peninsula & NW Alaska
17068	2017-06-20	Mackenzie Valley & Upper Yukon Territory
17069	2017-06-21	North Slope Alaska & Yukon Flats
17070	2017-06-22	Mackenzie Valley Reflight

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21 **Table 2. ABoVE L-Band PolInSAR Campaign #2**

Flight Plan	Sortie Date	Regions Sampled (hyperlink to flight line map)
17093	2017-09-08	BERMS - PAD-Transboundary Watershed
17094	2017-09-09	Great Slave Lake Region & Upper Mackenzie Valley
17095	2017-09-10	Yellowknife – Fairbanks Transit
17096	2017-09-12	Mackenzie Valley & Upper Yukon Territory
17097	2017-09-15	Seward Peninsula & NW Alaska

17098	2017-09-16	North Slope Alaska & Yukon Flats
17099	2017-09-17	Southwest Alaska & YK Delta
17100	2017-09-19	Interior Alaska
17101	2017-09-20	Delta Junction AK TomoSAR

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Table 3. ABoVE L-Band PolInSAR Campaign #3

Flight Plan	Sortie Date	Regions Sampled (hyperlink to flight line map)
18046	2018-08-19	BERMS TomoSAR
18047	2018-08-21	PAD & Great Slave Lake 1
18048	2018-08-22	Great Slave Lake Region & Scotty Creek
18049	2018-08-24	Yellowknife – Fairbanks Transit
18050	2018-08-26	North Slope Alaska
18051	2018-08-27	Interior Alaska
18052	2018-08-28	Southwest Alaska & YK Delta
18053	2018-08-29	Mackenzie Valley & Upper Yukon Territory

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Table 4. ABoVE L-Band PolInSAR Campaign #4

Flight Plan	Sortie Date	Regions Sampled (hyperlink to flight line map)
19059	2019-09-04	PAD & Great Slave Lake 1
19060	2019-09-05	Great Slave Lake Region & Scotty Creek
19061	2019-09-11	Yellowknife – Fairbanks Transit
19062	2019-09-12	Seward Peninsula & NW Alaska
19063	2019-09-13	North Slope Alaska
19064	2019-09-14	Interior Alaska
19065	2019-09-16	Mackenzie Valley & Upper Yukon Territory
19066	2019-09-17	Southwest Alaska & YK Delta

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Table 5. ABoVE L-Band PolInSAR Campaign #5

Flight Plan	Sortie Date	Regions Sampled
22031	2022-08-14	BERMS TomoSAR
22032	2022-08-15	PAD & Great Slave Lake 1
22033	2022-08-16	Great Slave Lake Region & Scotty Creek
22034	2022-08-18	Yellowknife – Fairbanks Transit

22035	2022-08-19	Seward Peninsula & NW Alaska
22036	2022-08-20	North Slope Alaska
22037	2022-08-22	Mackenzie Valley & Upper Yukon Territory
22038	2022-08-23	Southwest Alaska & YK Delta
22039	2022-08-24	Interior Alaska
22040	2022-08-25	British Columbia

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32 **Table 6. ABoVE P-band PolInSAR Campaign #1**

Flight Plan	Sortie Date	Regions Sampled (hyperlink to flight line map)
17051	2017-05-22	PAD-Transboundary Watershed
17052	2017-05-23	Great Slave Lake Region & Upper Mackenzie Valley
17053	2017-05-25	Yellowknife – Fairbanks Transit
17054	2017-05-26	Interior & Southwest Alaska
17055	2017-05-27	YK Delta & NW Alaska
17056	2017-05-29	Seward Peninsula, NW Alaska & Yukon Flats
17057	2017-06-05	Mackenzie Valley & Upper Yukon Territory
17058	2017-06-06	North Slope Alaska

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35 **Table 7. ABoVE P-Band PolInSAR Campaign #2**

Flight Plan	Sortie Date	Regions Sampled (hyperlink to flight line map)
17075	2017-08-07	BERMS & Southern Boreal Forest
17076	2017-08-08	PAD-Transboundary Watershed & Great Slave Lake 1
17077	2017-08-09	Great Slave Lake Region & Upper Mackenzie Valley
17078	2017-08-11	Daring & Yellowknife – Fairbanks Transit
17079	2017-08-13	North Slope Alaska
17080	2017-08-14	Southwest Alaska & YK Delta
17081	2017-08-15	Delta Junction, AK tomoSAR
17082	2017-08-17	Seward Peninsula, NW Alaska, & Yukon Flats
17083	2017-08-18	Mackenzie Valley & Upper Yukon Territory

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38 **Table 8. ABoVE P-Band PolInSAR Campaign #3**

Flight Plan	Sortie Date	Regions Sampled (hyperlink to flight line map)
17109	2017-10-07	North Slope Alaska
17110	2017-10-10	Seward Peninsula

39 2 Alaskan Flight Lines

40 The Alaskan SAR flight lines are broken into four
41 main regional collections: A1) North Slope Alaska,
42 A2) Seward Peninsula and Northwest Alaska, A3)
43 Eastern Interior, and A4) Southwest Alaska and the
44 Yukon-Kuskokwim Delta (**Figure 1**). Legacy L- and
45 P-band flight lines from the AirMOSS EV-S1
46 investigation [Allen 2010; Moghaddam 2016] in the
47 Seward Peninsula, NW Alaska, and the North Slope
48 were adapted for ABoVE use. The P-band
49 acquisitions are designed to overlap with the near
50 field portions of the L-band lines. Line IDs for the L-
51 band and P-band flight lines differ slightly because
52 they acquire data with slightly different off-nadir
53 viewing geometries [Miller 2019]. Acquisition of P-
54 band flight lines in the central Interior was not
55 possible due to a military radar keep-out zone
56 centered near Clear, AK (**Figure 2**).



Figure 2. The military radar at Clear, AK creates a large P-band operations keep-out zone in the central Interior (red areas). The aircraft symbol marks our Fairbanks International Airport (PAFA) base of operations. Data acquisitions (blue bars) are from Flight Plan 17054. © Google Maps

58 2.1 Region A1: North Slope Alaska

59 **Figure 3** shows the flight lines
60 for Region A1: North Slope
61 Alaska. Details for individual
62 L-band SAR flight lines are
63 given in Table 9; the P-band
64 flight line details are given in
65 Table 21. The North Slope
66 region features several
67 important legacy flight lines
68 established by AirMOSS
69 (Table 34, Table 35). Of note
70 are the lines covering
71 Utqiagvik (Barrow, 15018)
72 and the Dalton Highway from
73 Deadhorse on the Arctic
74 Coastal Plain to the Brooks
75 Range foothills (18519). Both
76 lines leverage long-term
77 ground-based measurements
78 and provide critical calibration
79 and validation data for higher level data products.

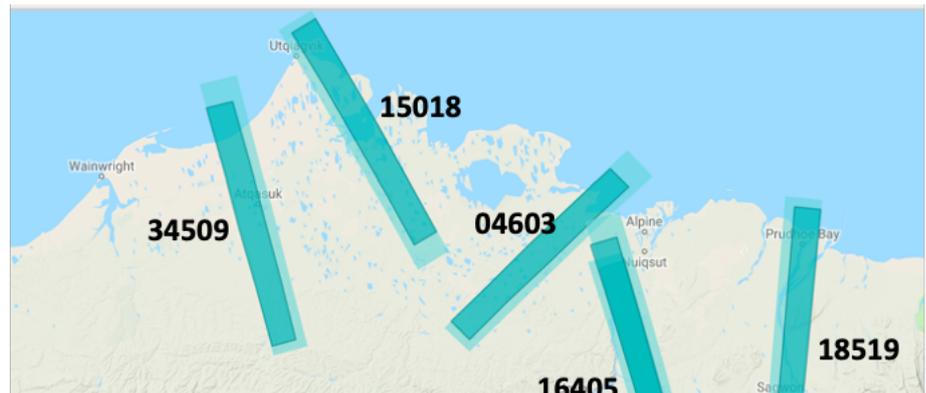


Figure 3. L-band SAR flight lines (light blue bars) collected during ABoVE for Region A1: North Slope Alaska. Flight line IDs are listed next to each line. These lines provide regional sampling for many areas where ground-based measurements have characterized local landscapes such as Atkasuk (Line 34509), Utqiagvik (Line 15018), Deadhorse and the Dalton Highway (Line 18519), and Toolik Lake (Line 05300). © Google Maps



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Line 03111: Ivotuk. The Ivotuk flight line overlaps the legacy line 03109 (Table 35) and is anchored by the Ivotuk flux tower ([US-IVO](#)) [Zona 2016; Davidson 2017], a CALM 1 km grid (Ivotuk, site [U26](#)), and three GTN-P permafrost boreholes near Ivotuk. The flight line extends ~135 km from the southern edge of the Brooks Range foothills in the south to the Colville River in the north. Vegetation cover is mostly upland tundra with increasing soil saturation closer to the river.

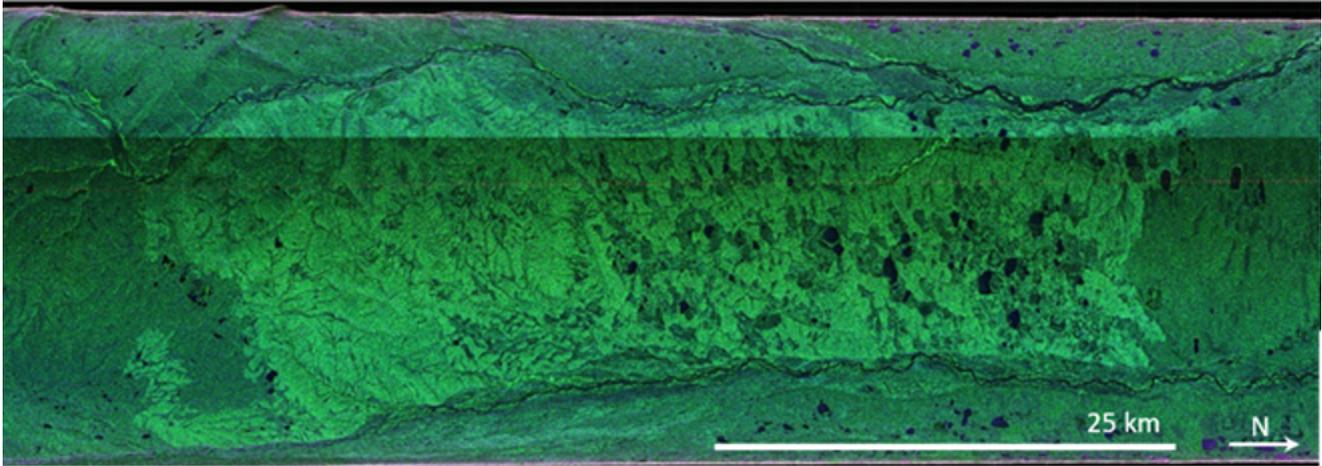
Line 34509: Atqasu. The Atqasuk flight line overlaps the legacy line 34506 (Table 35) and is anchored by the Atqasuk flux tower ([US-ATQ](#)) [Zona 2016], CALM 1 km grid at Atqasuk (site [U3](#)), and a UNAVCO GPS base station at Atqasuk. The flight line extends ~160 km from the southern edge of the Arctic Coastal Plain across the Meade River to the Arctic Ocean coast. It overflies numerous lakes with known CH₄ seeps [Walter Anthony 2016]. Vegetation cover consists of mostly graminoid and tussock tundra with many dried lake beds distributed across the landscape.

Line 15018: Barrow. The Barrow (Utqiaġvik) flight line overlaps the legacy line 15008 (Table 35). It is anchored by the extensive science infrastructure in and around the Barrow Peninsula including: DOE [NGEE-Arctic](#) experimental sites; Barrow area flux towers ([US-BRW](#), [US-BES](#), [US-BEO](#), [US-NGB](#)) [Oechel 2000; Dengel 2020]; the NEON Utqiaġvik D18 tundra relocatable terrestrial site ([BARR](#)) and Airborne Observation Platform ([AOP](#)) box; the NOAA-CMDL Barrow Atmospheric Baseline Observatory ([BRW](#)); DOE Atmospheric Research and Monitoring [North Slope Alaska](#) (NSA) site; Barrow area CALM sites [U1](#) and [U2](#); a cluster of a dozen GTN-P boreholes on the Barrow Peninsula and one at Kuyanak (TSP.[814](#)); the Barrow Domain remotely sensed active layer thickness (ReSALT) time series [Schaefer 2015; Liu 2015a]; ground penetrating radar transects for active layer thickness and volumetric water content [Jafarov 2017]; In situ soil moisture and thaw depth measurements [Wilson 2018]; and numerous long-term experimental plots. The flight line extends southeast ~165 km from Point Barrow over the Elson Lagoon and terminates south of Teshekpuk Lake. It samples a multitude of lakes, dry lakebeds, small rivers and tundra polygons.

Line 04063: Inigok. The Inigok flight line is anchored by the CALM sites at Inigok ([U21](#)) and Fish Creek ([U22](#)) as well as GTN-P boreholes at North Inigok (NING, TSP.[813](#)), West Fish Creek 1 (FCK, TSP.[825](#)), Atigaru (ATI, TSP.[827](#)), and South Harrison (SOH, TSP.[828](#)). The flight line extends northeast ~150 km from the southern edge of the Arctic Coastal Plain to the Arctic Ocean coast halfway between Teshekpuk Lake and the Colville Delta.

Lines 34408 and 16405: AnaktE and AnaktW. The Anaktuvuk flight lines map the 2007 Anaktuvuk River fire scar [Jones 2009; Mack 2011], running ~200 km from near Toolik Lake in the south to the Colville River in the north ([Figure 4](#)). The fire scar is bounded by the Anaktuvuk and Kuparuk Rivers on the east and west, respectively, and ranges from 15 to 20 km in width. More than 50% of the area burned severely [Jones 2009] and it is thought to be the largest Arctic tundra fire in the last 5,000 years [Hu 2010]. Anchor points include three flux towers in the southern end of the scar [Rocha 2011a,b], and numerous ABoVE field plots [Chen 2016]. The spacing of the L-band flight lines is based on the narrower P-band swath and allows complete mapping of the complete fire scar by both L-band and P-

22 band SARs. These lines are used to study changes in soil moisture, surface roughness, ALT, etc in
23 disturbed vs undisturbed areas. Interferometric SAR will be used to map surface elevation changes and
24 track the evolution of permafrost degradation within the scar compared to LiDAR surface elevation data
25 [Jones 2015] and PALSAR time series [Liu 2014; Iwahana 2016].
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28 **Figure 4.** P-band PolSAR composite image showing complete mapping of the 2007 Anaktuvuk River fire scar (light
29 green area in the center of the image) on 13 August 2017. Intrinsic resolution of the P-band PolSAR imagery is
30 approximately 12 meters and reveals shaper features along the fire scar boundaries as well as indications of increased
31 surface roughness and permafrost degradation within the fire scar compared to the adjacent undisturbed areas
32 (darker green). Lakes, ponds, and rivers appear as black areas in this image.
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35 **Line 18519: Dhorse.** The Deadhorse flight line overlaps the legacy line 18516 (Table 35). It extends
36 ~190 km from Prudhoe Bay south over the energy exploration infrastructure in Deadhorse and then
37 south along the Dalton Highway. It is anchored by seven CALM sites, including the 1 km grids at West
38 Dock ([U5](#)), Betty Pingo ([U7A](#)), and Happy Valley ([U9B](#)); the ReSALT thermokarst time series and
39 GPR transects along the Pipeline approximately 15 km south of Deadhorse [Liu 2015]; and myriad field
40 sites that have been established adjacent to the highway over the years. In particular, ABoVE
41 researchers monitored high resolution soil moisture and soil dielectric constant vertical profiles along
42 the highway to validate L- and P-band retrievals of active layer properties [Chen 2016; 2018; 2019 a,b;
43 Bakian-Dogaheh 2020] and enable modeling [Yi 2018]. Schaefer and coworkers also acquired
44 numerous ground penetrating radar (GPR) transects to validate the ReSALT and airborne SAR active
45 layer thickness retrieval algorithms [Chen 2016].
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47 **Line 05300: Toolik.** The Toolik flight line extends ~80 km along the Dalton Highway from Pump
48 Station #3 over Innnavit Creek to Toolik Lake. It is anchored by the extensive scientific infrastructure
49 surrounding the [Arctic Long Term Ecological Research](#) (LTER) site at Toolik Lake; the NEON D18
50 tundra sites Toolik ([TOOL](#), core terrestrial), Oksrukuyik Creek ([OKSR](#), core aquatic), and Toolik Lake
51 ([TOOK](#), relocatable aquatic) as well as the northern portion of the Toolik AOP flight box; CALM active
52 layer thickness measurements at Innnavit Creek WET ([U11B](#)) and MAT ([U11C](#)), Toolik MAT ([U12B](#)),

53 and Toolik LTER ([U13](#)) as well as the Toolik 1 km grid ([U12A](#)); ground penetrating radar (GPR)
 54 [Gusmeroli 2015; Chen 2016]; in situ soil measurements including soil dielectric properties,
 55 temperature, and moisture profiles, ALT, and measurements of soil organic matter, bulk density,
 56 porosity, texture, and coarse root biomass [Bakian-Dogaheh 2020]; in situ active layer thickness
 57 measurements [Chen 2020]; high-resolution shrub biomass maps [Greaves 2018]; and three Imnavait
 58 Creek flux towers [Euskirchen 2012]. Road access and proximity to many long-term data records made
 59 this a high priority area for many ABoVE field activities.

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Table 9. Region A1 (North Slope Alaska) L-band Line Summary Data

Line ID	Short Name	Flight Plan	Date	Comments
03111	Ivotuk	22036 19063 17097 17067	2022-08-20 2019-09-13 2017-09-15 2017-06-19	Ivotuk flux tower, CALM site, GTN-P boreholes
34509	Atqasu	22036 19063 18050 17098 17069	2022-08-20 2019-09-13 2018-08-26 2017-09-16 2017-06-21	Atqasuk flux tower; CALM site
15018	Barrow	22036 19063 18050 17098 17069	2022-08-20 2019-09-13 2018-08-26 2017-09-16 2017-06-21	Legacy line; NGEE-Artic, NEON, BEO flux towers, CALM sites
04603	Inigok	22036 19063 18050 17098 17069	2022-08-20 2019-09-13 2018-08-26 2017-09-16 2017-06-21	North Slope CALM sites, boreholes
34408	AnaktE	22036 19063 18050 17098 17069	2022-08-20 2019-09-13 2018-08-26 2017-09-16 2017-06-21	Anaktuvuk River fire scar, eastern transect
16405	AnaktW	22036 19063 18050 17098 17069	2022-08-20 2019-09-13 2018-08-26 2017-09-16 2017-06-21	Anaktuvuk River fire scar, western transect

18519	Dhorse	22036 19063 18050 17098 17069	2022-08-20 2019-09-13 2018-08-26 2017-09-16 2017-06-21	North-South transect running from the Arctic Ocean coast through Deadhorse and south along the Dalton Highway; covers numerous calibration sites
05300	Toolik	22036 19063 18050 17098 17069	2022-08-20 2019-09-13 2018-08-26 2017-09-16 2017-06-21	Toolik Lake Research area, NEON box

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2.2 Region A2: Seward Peninsula and the Northwest Interior

Figure 5 shows the transects for Region A2: Seward Peninsula and the Northwest Interior. Details for individual L-band SAR flight lines are given in Table 10; the P-band acquisition details are given in Table 22. The Seward Peninsula region features flight lines over the NGEA-Arctic Council, Kougarok, and Teller watersheds where intensive ground-based measurements provide critical validation data for the SAR products as well as other geophysical characterizations that can be used to help contextualize the SAR data [Wilson 2018]. The other northwestern Alaska flight lines extend the time series from legacy acquisitions [Table 34, Table 35; Chen 2016] and surveys of fire disturbance in the Noatak River Valley [Higuera 2011].

Line 25516: Huslia. The Huslia flight line overlaps the legacy line 25509 (Table 35). Located south of Huslia, AK in the Koyukuk NWR, it extends ~100 km parallel to the Yukon River. It samples low mountains, taiga, and boreal wetlands.

Line 25517: Koyuk. The Koyuk flight line overlaps the legacy line 25510 (Table 35). It starts about 60 km west of Koyukuk, AK and extends ~125 km over the coastal mountains to Koyuk, AK on Norton Bay. It is anchored by the GTN-P borehole at Koyuk (TSP.768).

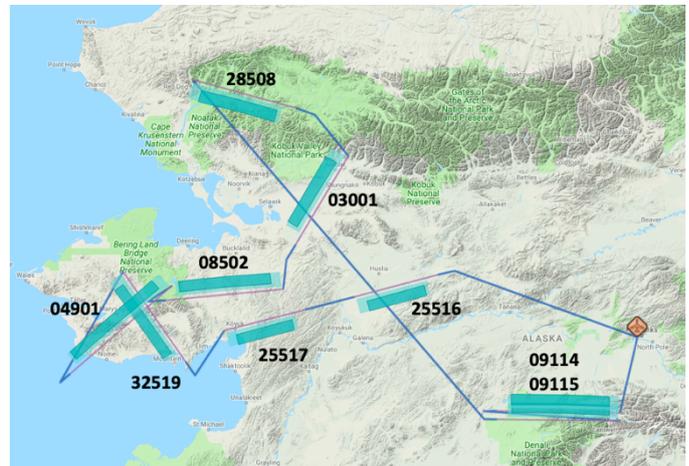


Figure 5. L-band SAR flight lines (light blue bars) collected during ABoVE for Region A2: Seward Peninsula and Northwest Interior. Flight line IDs are listed next to each line. Flight lines 09114 and 09115 are part of the Eastern Interior (Region A3) collection but were acquired during this sortie due to extra available flight time. © Google Maps

94 **Line 32519: Council.** The Council flight line overlaps the legacy line 32511 (Table 35). It extends
95 ~160 km from Golovin, AK on the Norton Sound over Council and past Kougarak, AK into the heart of
96 the Seward Peninsula, overlapping with the Teller lines (04806 and 04901) near Kougarak, AK. It is
97 anchored by the DOE [NGEE-Arctic](#) Council watershed; CALM sites at Council ([U27](#)) and Kougarak
98 ([U28](#)); GTN-P boreholes at White Mountain (TSP.[771](#)) and Last Bridge (TSP.[1188](#)); and the Council
99 flux tower ([US-NGC](#)) [Dengel 2020]. Detailed digital elevation maps, soil moisture, active layer
00 thickness, and surface classification data from the NGEE-Arctic team provide same day validation for
01 the ABoVE airborne SAR measurements and joint analysis of these data constitute a major component
02 of the ABoVE – NGEE-Arctic scientific partnership [Wilson 2018].

03
04 **Lines 04806 and 04901: Teller.** The Teller flight lines start in the Norton Sound just north of Sledge
05 Island and extend inland ~190 km northeast past Kougarak towards Upper Hanum Creek, overlapping
06 with the Council flight line (32519) near Kougarak. Flight line 04901 is anchored by the DOE [NGEE-](#)
07 [Arctic](#) Teller and Kougarak watersheds; GTN-P boreholes at Pilgrim Hot Springs (TSP.[1803](#)), Kuzitin
08 River (TSP.[1189](#)), and Last Bridge (TSP.[1188](#)). Flight line 04806 overflies the Teller watershed and the
09 Kougarak ([U28](#)) CALM site. This line also captures fire scars in the Kougarak area [Liljedahl 2007;
10 Iwahana 2016; Tsuyuzaki 2018]. Similar to the Council flight line (32519), these lines are key
11 contributors to the ABoVE – NGEE-Arctic scientific partnership [Wilson 2018].

12
13 NOTE: In 2017 there was a mismatch between the P-band and the L-band lines covering the Teller and
14 Kougarak sites due to geographic projection errors on the Seward Peninsula present in the online flight
15 planning system. As a consequence, L-band line 04806 created for the 2017 campaign captured Teller
16 to some extent but missed Kougarak entirely, and it did not align with P-band line 04900. To correct
17 this error, we created L-band line 04901 which was properly aligned with P-band line 04900. L-band
18 line 04901 was acquired in 2018 and 2019. We lost year-to-year change detections compared to L-band
19 04806 but gained alignment with P-band 04900 and achieved better coverage of the NGEE-Arctic
20 intensive field sites.

21
22 **Line 08502: Kougarak.** The Kougarak flight line overlaps the legacy line 08534 (Table 35). It extends
23 ~145 km from the center of the Seward Peninsula to the edge of the western Interior. It overflies a mix
24 of mountainous terrain and low-lying Bering Taiga.

25
26 **Line 03001: Ambler.** The Ambler flight line overlaps the legacy line 03108 (Table 35). It starts about
27 50 km southeast of Selawik, and extends ~145 km northeast past Ambler and into the southern Brooks
28 Range. It is anchored by GTN-P boreholes at Kugurak Cabin Tundra (TSP.[1802](#)) and Ambler
29 (TSP.[780](#)). This line samples areas of continuous permafrost.

30
31 **Line 28508: Noatak.** The Noatak flight line travels ~100 km parallel to the southern edge of the Brooks
32 Range along the upper Noatak River from Kelly Bar Airport to Mount Angayukaqsaq. This flight line
33 monitors post-fire recovery recorded at ~80 ground plots [Loboda 2017] and classified for fractional
34 cover of fuel types [He 2019a,b]. It was not collected in 2019.

35

Table 10. Region A2: Seward Peninsula and Northwestern Interior L-band Line Summary Data

Line ID	Short Name	Flight	Date	Comments
25516	Huslia	22035 19062 18054 17097 17067	2022-08-19 2019-09-12 2018-09-01 2017-09-15 2017-06-19	Interior Alaska, Huslia village
25517	Koyuk	22035 19062 18054 17097 17067	2022-08-19 2019-09-12 2018-09-01 2017-09-15 2017-06-19	Interior Alaska, boreal forest, coastal mountains
32519	Council	22035 19062 18054 17097 17067	2022-08-19 2019-09-12 2018-09-01 2017-09-15 2017-06-19	NGEE-Arctic Council watershed and flux tower; Kougarok watershed
04806	Teller	22035 19062 17097 17067	2022-08-19 2019-09-12 2017-09-15 2017-06-19	NGEE-Arctic Teller watershed, Kougarok watershed, Kougarok area fire disturbance/recovery
04901	Teller	22035 19062 18054	2022-08-19 2019-09-12 2018-09-01	NGEE-Arctic Teller watershed, Kougarok watershed, Kougarok area fire disturbance/recovery
08502	Kougar	22035 19062 18054 17097 17067	2022-08-19 2019-09-12 2018-09-01 2017-09-15 2017-06-19	Seward Peninsula CALM sites, boreholes
03001	Ambler	22035 19062 18054 17097 17067	2022-08-19 2019-09-12 2018-09-01 2017-09-15 2017-06-19	Boreal forest-foothills gradient, boreholes
28508	Noatak	22035 18054 17097 17067	2022-08-19 2018-09-01 2017-09-15 2017-06-19	Fire disturbance/recovery

39 2.3 Region A3: Eastern Interior

40 Figure 6 shows the transects for Region
41 A3: The Eastern Interior. Details for
42 individual L-band SAR flight lines are
43 given in Table 11; the P-band acquisition
44 details are given in Table 23. ABoVE
45 flight lines in the Eastern Interior capture
46 the dense concentration of ground-based
47 science infrastructure including: the
48 NEON sites at Delta Junction, AK, the
49 Caribou/Poker Creek Research
50 Watershed, and Healy, AK; the NSF
51 Boreal Forest LTER site at Bonanza
52 Creek; and National Park Service sites in
53 the Denali National Preserve.

54 Additionally, the flight lines in the Yukon
55 Flats NWR overlap legacy acquisitions of
56 permafrost state [Minsley, 2012] as well
57 as water surface elevation (WSE)
58 observations by AirSWOT [Pitcher

59 2019a,b]. ABoVE SAR data provide characterizations of the boreal forest and enable comparisons and
60 fusion with the extensive airborne LiDAR data acquired throughout the Eastern Interior, particularly by
61 NASA's LVIS [Blair 2018] and G-LiHT [Alonzo 2020; Chen 2020] systems. A detailed analysis of the
62 tomographic SAR (tomoSAR) flights over Delta Junction, AK (Error! Reference source not found.,
63 Table S9) is given in Section 6.

64
65 **Line 20026: Coldfo.** The Coldfoot flight line overlaps the legacy line 20015 (Table 35). It extends ~175
66 km from the southern edge of the Brooks Range near Linda Creek Airport southwest along the Dalton
67 Highway over the villages of Coldfoot and Prospect Creek, terminating in the mountains north of the
68 Yukon River. It is anchored by the CALM site at Old Man (U16) and GTN-P boreholes at Coldfoot
69 (TSP.834) and Old Man (TSP.749). Vegetation is a combination of upland tundra and boreal forest
70 covering discontinuous permafrost.

71
72 **Lines 21508 YFlatW and 21609 YflatE; 04707: FtYuko.** These three flight lines survey the Yukon
73 Flats NWR and its complex permafrost wetland systems. Flight lines 21508 and 21069 sample along
74 AEM reconnaissance lines collected by Minsley et al [Minsley 2012] to characterize areas of
75 continuous and discontinuous permafrost. Flight line 04707 covers the Fort Yukon area where Minsley
76 et al acquired high density AEM survey lines. These lines also overlap with the AirSWOT airborne Ka-
77 band survey of over 3300 km² acquired in June 2015 [Pitcher 2019a,b] and the ABoVE AirSWOT
78 airborne Ka-band data acquired in June and Aug 2017 [Fayne 2019, 2020; Kyzivat 2019]. Extensive on-
79 water validation data were acquired in 2017 and 2018.

80

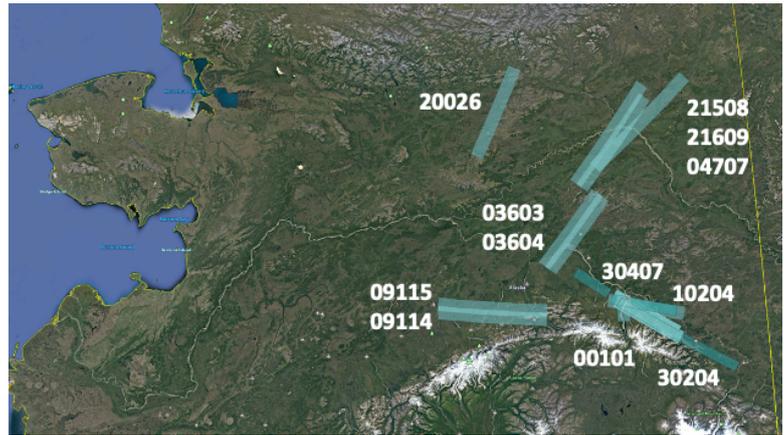


Figure 6. L-band SAR flight lines (light blue bars) collected during ABoVE for Region A3: Eastern Interior. Flight line IDs are listed next to each line. Given the proximity to the PAFA base of operations, these flight lines were typically acquired on multiple sorties during each campaign. The Delta Junction tomoSAR flight lines (Table 11) overlap with the northern end of Line 30204. © Google Earth

81 **Lines 03603 BonanW and 03604 BonanE.** The Bonanza Creek lines extend ~150 km over the city of
82 Fairbanks, Alaska within the interior boreal forest, an area of discontinuous permafrost. This area
83 supports extensive scientific infrastructure due to its proximity to Fairbanks and its road network.
84 The lines are anchored by the Bonanza Creek Experimental Forest and Caribou Poker Creek Watershed
85 (both associated with the NSF Bonanza Creek Long Term Ecological Research ([BNZ LTER](#)) area); the
86 NEON D19 taiga field site at the Caribou-Poker Creek Research Watershed ([BONA](#)); the US Army
87 Corps of Engineers Cold Regions Research and Engineering Laboratory ([CRREL](#)) [Permafrost Tunnel](#)
88 [Research Facility](#) [Douglas et al, 2019; Douglas, 2019; 2020; 2021]; multiple boreal flux towers (see
89 [Euskirchen and Edgar 2014-2016a,b.; Euskirchen and Edgar, 2015-2016; Kobayashi et al, 2011-;]);
90 and the NOAA Global Monitoring Laboratory Earth System Research Laboratories Tall Tower in Fox,
91 AK ([CRV](#)) [Karion 2016]. Additional field measurements within the lines include multiple US Forest
92 Service Cooperative Alaska Forest Inventory (CAFI) field sites [Malone et al, 2009]; measurements of
93 carbon flux, winter respiration, and thaw depth [see Minions et al, 2019; and Natali et al, 2018];
94 numerous CALM sites; and a U.S. Climate Reference Network site ([Fairbanks 11 NE](#)). This region also
95 contains a rich fire history with multiple burned areas. These survey lines have also been imaged by
96 LVIS, AVIRIS, AirSWOT, CFIS and G-LiHT as part of the ABoVE airborne campaign [Miller 2019].
97

98 *Mitigation due to a no-fly implemented in 2022:* The BonanW_03603 L-band flight line images ground
99 sites where long-term observations are made by multiple state and federal agencies. ABoVE acquired L-
00 band data along this flight line in 2017, 2018, and 2019, creating a time series that captures rapid
01 change across these sites. Following the 2019 flights, a FAA no-fly zone centered on Murphy Dome
02 was created at the request of DOD. ABoVE requested a waiver so that NASA could continue this time
03 series of airborne observations with L-band SAR flights in August 2022. The request was not granted.
04 Consequently, we designed two new lines to mitigate the impact of the exclusion zone and to cover the
05 established ground sites: **BonanW_03603b** and **BonanA_05605**. BonanW_03603b is a shorter version
06 of BonanW_03603. Data acquired in 2022 (and any subsequent years) image about 86 km of the
07 northeast end of the original line and are suitable for InSAR or other intercomparisons with pre-2022
08 acquisitions of bonanW_03603. BonanA_05605 covers the ground sites that were lost from the
09 southwest end of BonanW_03603, but at a different look angle. BonanA_05605 also provides a new
10 look angle for some of the key sites imaged in BonanE_03604.
11

12 **Lines 09115: DenalN and 09114: DenalS.** The Denali lines run east-west for ~180 km from near Lake
13 Minchumina in the west, across the Denali National Preserve, and past Healy, AK. These lines are
14 anchored by vegetation structure and composition inventory and monitoring sites managed by the
15 National Park Service (<https://www.nps.gov/im/cakn/dena.htm>); the NEON D19 taiga field site at
16 Healy, AK ([Healy](#)); and the Eight Mile Lake flux tower ([US-EML](#); Schuur 2008-). The SAR
17 acquisitions support ABoVE field teams investigating winter respiration [Minions et al, 2019; and
18 Natali et al, 2018] and permafrost dynamics [Schuur 2009; Natali 2014; Plaza 2019].
19

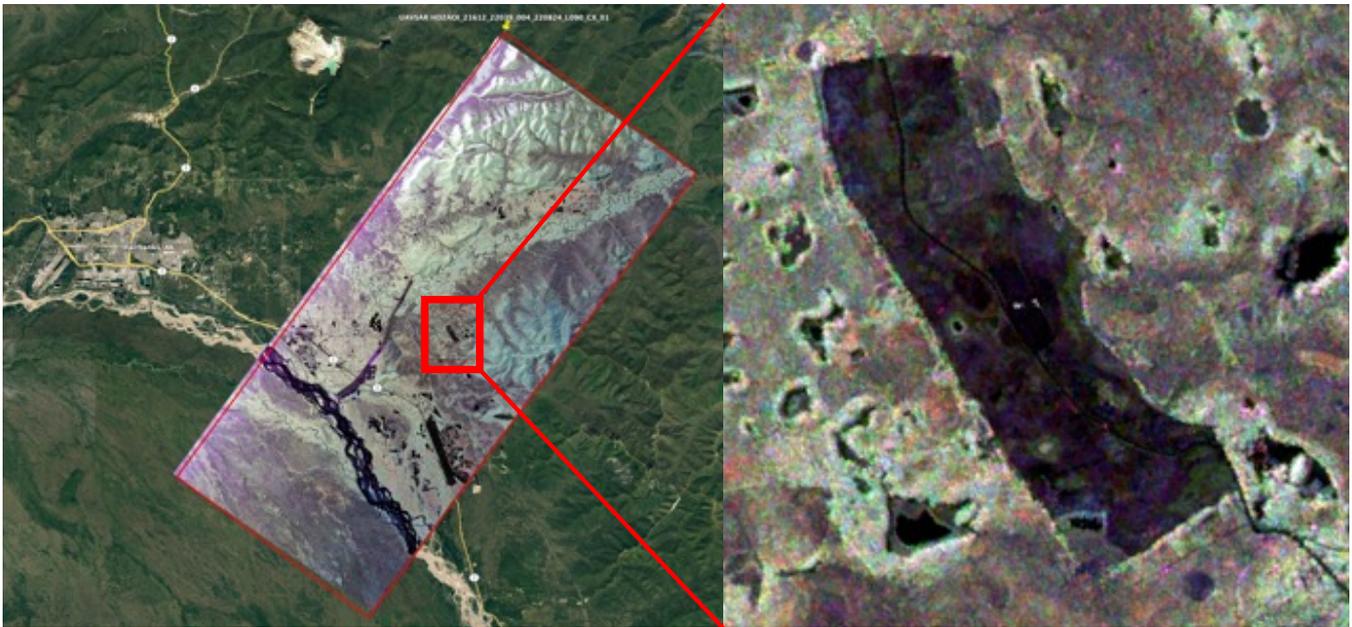
20 **Lines 00101: DJNEON, 30407: DeltJA, 10204: DeltJB, and 30204: DeltJC.** The Delta Junction lines
21 survey extensively studied boreal forest sites in Interior Alaska clustered near Delta Junction, AK. This
22 is an area of discontinuous permafrost extent with low ground ice content, blanketed by a mosaic of fire

23 disturbances. The Delta Junction lines are anchored by the NEON D19 taiga field site at Delta Junction,
24 AK ([DEJU](#)); airborne electro-magnetic (AEM) surveys conducted by the Alaska Division of Geological
25 and Geophysical Surveys [Burns 2008]; and numerous US Forest Service Cooperative Alaska Forest
26 Inventory (CAFI) field site locations [Malone 2009]. Additionally, both L- and P-band tomoSAR data
27 were acquired over Delta Junction to test boreal forest structural characterization algorithms (Table 12).
28 The tomoSAR data are described in detail in Section 6.

29

30 **Line 21612: HDZAOI (new in 2022).** The Husky Drop Zone line covers an area of interest ~25 km
31 southeast of Fairbanks. The Husky Drop Zone exhibits signs of active permafrost degradation and
32 disturbance (clearing) in the area has led to top-down thaw of permafrost. Drilling in the summer of
33 2022 confirmed that the top of near-surface permafrost in the Husky Drop Zone clearing is ~10m below
34 the ground surface while the top of near-surface permafrost in undisturbed forested areas nearby is 1-3
35 m depth. Each summer new thaw pits are exposed and polygonal ground features expand. The area has
36 been extensively studied by the US Army Corps of Engineers Cold Regions Research and Engineering
37 Laboratory (CRREL) for the past ten years. Activities include repeat acquisitions of airborne LiDAR,
38 electrical resistivity tomography, ground penetrating radar, drilling, and manual thaw depth
39 measurements [Douglas 2016].

40



41

42 **Figure 7. LEFT: Quicklook image for the L-band SAR acquisition over Husky Drop Zone (HDZAOI_21612).**
43 **Fairbanks is seen on the left side of the image. RIGHT: Detail showing the distinctly different surface reflectance**
44 **properties inside the HDZ due to permafrost degradation. The image is ~1000 m x 1000 m. © Google Maps.**

45

46

47

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Table 11. Region A3: Eastern Interior L-band Line Summary

Line ID	Short Name	Flight Plan	Date	Comments
20026	Coldfo	22036 19063 18050 17097 17067	2022-08-20 2019-09-13 2018-08-26 2017-09-15 2017-06-19	CALM and GTN-P sites; tundra-taiga ecotone
21508	YflatW	22037 19064 17098 17069	2022-08-22 2019-09-14 2017-09-16 2017-06-21	Overlap with AEM surveys, AirSWOT and in situ water surface elevation measurements
21609	YflatE	22037 19064 18051 17098 17069	2022-08-22 2019-09-14 2018-08-27 2017-09-16 2017-06-21	Overlap with AEM surveys, AirSWOT and in situ water surface elevation measurements
04707	FtYuko	22037 19064 18051 17098 17069	2022-08-22 2019-09-14 2018-08-27 2017-09-16 2017-06-21	Overlap with AEM surveys, AirSWOT and in situ water surface elevation measurements
03603	BonanW	22039 19065 19064 19063 19062 19061 18051 17100 17065	2022-08-24 2019-09-16 2019-09-14 2019-09-13 2019-09-13 2019-09-12 2018-08-27 2017-09-19 2017-06-16	Bonanza Creek LTER site, LiDAR over burn recovery scars
03604	BonanE	22039 19064 19063 19062 18051 17100 17065	2022-08-24 2019-09-14 2019-09-13 2019-09-13 2018-08-27 2017-09-19 2017-06-16	Bonanza Creek LTER site, LiDAR over burn recovery scars
05605	BNZalt	22039	2022-08-24	Additional Bonanza Creek area line collected in 2022 to mitigate against omissions in truncated line 03603 due to a temporary no broadcast rule

09115	DenalN	19064 18052 17100 17066	2019-09-14 2018-08-28 2017-09-19 2017-06-17	National Park Service ground sites
09114	DenalS	22039 22038 19064 18052 17100 17065	2022-08-24 2022-08-23 2019-09-14 2018-08-28 2017-09-19 2017-06-16	National Park Service ground sites
00101	DJNEON	22034 19064 18051 17095 17064	2022-08-18 2019-09-14 2018-08-27 2017-09-10 2017-06-15	NEON D19 taiga field site near Delta Junction, AK
30407	DeltJA	22034 19061 18049 17095 17064	2022-08-18 2019-09-12 2018-08-24 2017-09-10 2017-06-15	Delta Junction, AK boreal forest
10204	DeltJB	22034 19061 18049 17101 17100 17095 17064	2022-08-18 2019-09-12 2018-08-24 2017-09-20 2017-09-19 2017-09-10 2017-06-15	Delta Junction, AK boreal forest
30204	DeltJC	22034 19061 18052 17100 17066	2022-08-18 2019-09-12 2018-08-28 2017-09-19 2017-06-17	Delta Junction, AK boreal forest
21612	HDZAOI	22039	2022-08-24	Husky Drop Zone AOI – Permafrost degradation

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59 **Table 12. Delta Junction L-band TomoSAR Flight Lines**

Line ID	Short Name	Flight Plan	Date	Comments
12237	DeltaA	17101	2017-09-20	TomoSAR offset 36 meters
30232	DeltaA	17101	2017-09-20	TomoSAR offset 36 meters
12239	DeltaC	17101	2017-09-20	TomoSAR offset 50 meters
30234	DeltaC	17101	2017-09-20	TomoSAR offset 50 meters
12240	DeltaD	17101	2017-09-20	TomoSAR offset 57 meters
30235	DeltaD	17101	2017-09-20	TomoSAR offset 57 meters
12241	DeltaE	17101	2017-09-20	TomoSAR offset 64 meters
30236	DeltaE	17101	2017-09-20	TomoSAR offset 64 meters
12242	DeltaF	17101	2017-09-20	TomoSAR offset 71 meters
30237	DeltaF	17101	2017-09-20	TomoSAR offset 71 meters
12243	DeltaG	17101	2017-09-20	TomoSAR offset 83 meters
30238	DeltaG	17101	2017-09-20	TomoSAR offset 83 meters
30239	DeltaH	17101	2017-09-20	TomoSAR offset 119 meters
12227	DeltaR	17101	2017-09-20	TomoSAR Reference Line 41k
30221	DeltaR	17101	2017-09-20	TomoSAR Reference Line 41k

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66 **2.4 Region A4: Southwest Alaska and the Yukon-Kuskokwim Delta**

67 **Figure 8** shows the transects for Region A4:
68 Southwest Alaska and the Yukon-Kuskokwim
69 Delta. Details for individual L-band flight
70 lines are given in Table 13; the P-band
71 acquisition details are given in Table 25.
72 ABoVE surveys in southwest Alaska were
73 anchored by climate monitoring sites from the
74 Southwest Alaska Inventory & Monitoring
75 Network ([SWAN](#)). SWAN consists of five
76 parklands in Southwest Alaska: Alagnak
77 National Wild River, Aniakchak National
78 Monument and Preserve, Katmai National
79 Park and Preserve, Kenai Fjords National
80 Park, and Lake Clark National Park and
81 Preserve [Bennett 2006]. Surveys in the
82 Yukon-Kuskokwim Delta were designed to
83 capture field sites where ABoVE researchers
84 were measuring the impacts of fire disturbance
85 on active layer thickness, soil moisture, and
86 other permafrost state variables [Liu 2014;
87 Michaelides 2019] as well as CO₂ and CH₄
88 fluxes [Natali 2018]. The Innoko Flats NWR
89 flight line in the lower Yukon Valley surveyed a vast palsa-wetlands complex with permafrost in
90 various stages of degradation [Johnston 2104; Jones 2017]. The Poorman (08911) flight line covered a
91 forested area of the western Interior with extensive tree ring data [Hoy et al., 2018].

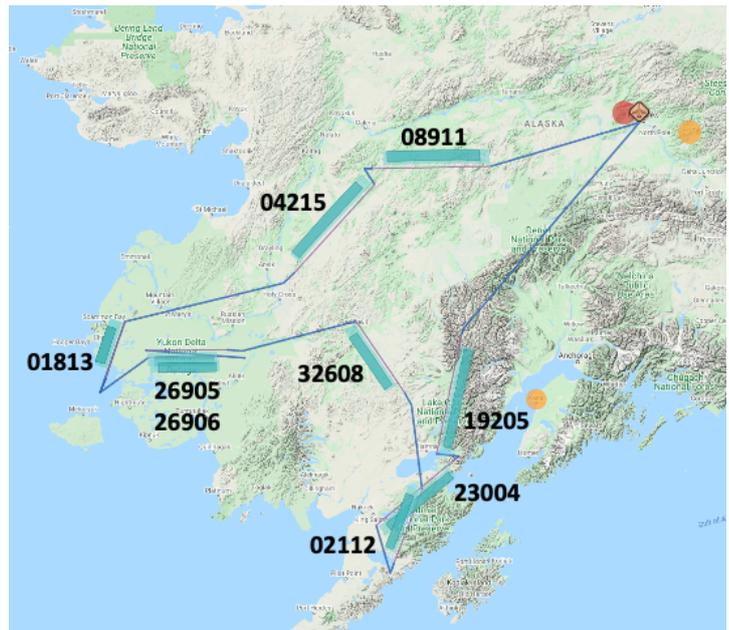


Figure 8. Flight Plan 19066, flown 17 Sep 2019, showing the L-band SAR flight lines in Southwest Alaska and the Yukon-Kuskokwim Delta. Line 28020 (KatmaB) was omitted from this plan due to aircraft endurance limitations. © Google Maps

92
93 **Line 19205: Lclark** The Lake Clark line extends ~200 km from the Chigmit Mountains southwest
94 across the Lake Clark National Park and Preserve to the shores of Iliamna Lake, terminating near
95 Iliamna, AK. The line is anchored by the SWAN/Lake Clark inventory and monitoring sites ([LACL](#))
96 and the U.S. CRN site at Port Alsworth, AK ([AK Port Alsworth 1 SW](#)). It is covered by an assortment
97 of conifer forests, sedge meadows, salt marshes and lagoons.

98
99 **Lines 23004: KatmaA; 28020: KatmaB; 02112: KatmaC** These three lines crisscross the Katmai
00 National Park and Preserve, on the northern portion of the Alaska Peninsula, survey portions of two
01 physiographic provinces—the Aleutian Range and the Nushagak-Bristol Bay Lowlands, and overpass
02 the Naknek Lake. These lines are anchored by ~50 SWAN inventory and monitoring sites ([KATM](#))
03 and the [U.S. CRN](#) site at King Salmon, AK ([AK King Salmon 42 SE](#)). The 29 May – 3 July 2022 Copper
04 Creek fire destroyed one of the SWAN network sites in July 2022, but observations were continued and
05 the 02112 line captured immediate post-fire conditions in August 2022.

06
07

08 **Line 32608: Sriver.** The Sleetmute line extends ~130 km from the Nushagak Hills of southern Alaska
09 northwest over the Kuskokwim and Holitna Rivers past Sleetmute, AK and terminates near Red Devil
10 Airport. This line is anchored by ~130 tree core sampling sites and supports boreal forest remote
11 sensing studies [Saatchi 2019].
12

13 **Lines 26905 YKDeIA and 26906 YKDeIB.** The Yukon-Kuskokwim Delta lines extend ~130 km each,
14 surveying east-west transects of discontinuous permafrost in the Bering Tundra ecoregion northwest of
15 Bethel, AK. These lines are specifically designed to map large tundra fire scars from 2015 to evaluate
16 the impacts of fire on the permafrost state and carbon fluxes. The lines are anchored by CO₂ and CH₄
17 summer flux and winter respiration measurements [Minions et al, 2019; and Natali et al, 2018]; ground
18 penetrating radar transects [Michaelides 2019]; and vegetation composition across fire history gradients
19 [Frost et al., 2020].
20

21 **Line 01813: Chevak.** The Chevak line extends ~85 km from the Bering Sea coast just west of Hazen
22 Bay north over Chevak, AK across the Yukon-Kuskokwim Delta, ending just east of Scammon Bay.
23 The line is anchored by a 2009 LiDAR survey conducted for the US Fish and Wildlife Service
24 [Airborne Imaging, 2011] and field data collected in 2016 to map sporadic permafrost in the area
25 [Whitley et al., 2018ab]. This region is defined by its flat coastal plain with elevated permafrost plateaus
26 throughout the floodplain and is a critical waterfowl habitat.
27

28 **Line 04215: Innoko** The Innoko line extends ~175 km northwest from Shageluk, AK across the Innoko
29 Flats National Wildlife Refuge. The line is anchored by field sites established to study permafrost thaw
30 chronosequences [Jorgenson 2013] and carbon fluxes [Johston 2014; Jones 2017]. Much of the area is
31 underlain by permafrost, and over half is covered by wetlands, thermokarst bogs, and fens [Woodward
32 2011]. Over 100,000 ha of the Lower Innoko River area burned in 2015 [Potter 2018], making this an
33 area for potential long-term study.
34

35 **Line 08911: Poorma** The Poorman line extends ~170km, starting south of the Yukon River near
36 Galena, AK and running west through discontinuous permafrost and boreal forest of the [Nowitna
37 National Wildlife Refuge](#), slightly north of the village of Poorman, AK. This line is anchored by more
38 than 250 tree core sampling sites [Hoy 2018]. It is an acquisition of opportunity, lying along the return
39 route from the Yukon-Kuskokwim Delta back to Fairbanks, AK.
40

41 **Table 13. Region A4: Southwest Alaska and the Yukon-Kuskokwim Delta L-band Flight Line**
42 **Summary**

Line ID	Short Name	Flight Plan	Date	Comments
19205	Lclark	22038	2022-08-23	National Park Service SWAN ground sites
		19066	2019-09-17	
		17099	2017-09-17	
		17066	2017-06-17	

		17065	2017-06-16	
23004	KatmaA	22038 19066 17099 17065	2022-08-23 2019-09-17 2017-09-17 2017-06-16	National Park Service SWAN ground sites
28020	KatmaB	17099 17065	2017-09-17 2017-06-16	National Park Service SWAN ground sites
02112	KatmaC	22038 19066 17099 17065	2022-08-23 2019-09-17 2017-09-17 2017-06-16	National Park Service SWAN ground sites
32608	Sriver	22038 19066 18052 17099 17066	2022-08-23 2019-09-17 2018-08-28 2017-09-17 2017-06-17	Snake River tree rings sampling
26905	YKDelA	22038 19066 18052 17099 17066	2022-08-23 2019-09-17 2018-08-28 2017-09-17 2017-06-17	YK Delta 2015 fire scars; POLARIS portable flux towers/flux chambers; GPR transects; soil moisture measurements
26906	YKDelB	22038 19066 18052 17099 17066	2022-08-23 2019-09-17 2018-08-28 2017-09-17 2017-06-17	YK Delta 2015 fire scars; POLARIS portable flux towers/flux chambers; GPR transects; soil moisture measurements
01813	Chevak	22038 19066 18052 17099 17066	2022-08-23 2019-09-17 2018-08-28 2017-09-17 2017-06-17	YK Delta wildlife survey; USGS LiDAR survey; ground measurements
04215	Innoko	22038 19066 18052 17099 17066	2022-08-23 2019-09-17 2018-08-28 2017-09-17 2017-06-17	Permafrost surveys; extensive bog/fen/wetland complex
08911	Poorma	22038 19066 18052 17099 17066	2022-08-23 2019-09-17 2018-08-28 2017-09-17 2017-06-17	Interior Alaska, boreal forest

45 3 Canadian Flight Lines

46 The Canadian SAR flight lines are broken into six regional collections: C1) Lower Mackenzie Valley
47 and Northern Yukon Territory, C2) Southern Yukon Territory, C3) Upper Mackenzie Valley, C4) Great
48 Slave Lake Region, C5) Transboundary Watershed, and C6) Southern Boreal Forest/BERMS. Legacy
49 L- and P-band flight lines in the BERMS area from the CANEX 2010 campaign [Magagi 2012] and the
50 AirMOSS EV-S1 investigation [Chapin 2012, 2018] provide the potential to establish longer time
51 series.

52

53 3.1 Region C1: Lower Mackenzie Valley and Northern Yukon Territory

54 **Figure 9** shows the flight lines for Region C1: Lower Mackenzie Valley and Northern Yukon Territory.

55 Details for individual L-band PolInSAR flight
56 lines are given in **Table 14**; the P-band
57 acquisition details are given in Table 26. Region
58 C1 features flight lines that overlap the
59 Mackenzie River Valley transects for the CALM
60 and GTN-P networks, annual GNWT/CFS forest
61 health surveys, megaslumps on the Peel Plateau
62 [Kokelj 2015; Kokelj 2017], and multiple legacy
63 LiDAR surveys. The Mackenzie Delta and the
64 Inuvik-Tuktoyaktuk corridor have been
65 extensively targeted by RadarSat and RadarSat-2
66 [Touzi 2019] and include the Havipak and Trail
67 Valley Creek [Wilcox 2019; Walker 2020] field
68 sites. The lines in the northern Yukon Territory
69 survey the Old Crow Flats/Porcupine River
70 wetlands complex.

71

72 **Line 29904: Nwells.** The Norman Wells flight line begins about 20 km southeast of Tulita and extends
73 ~225 km northwest along the Mackenzie River past Norman Wells and terminates north of Mountain
74 River. It is anchored by CALM sites at Mountain River (thaw tube, [C9A](#)), Pump Station/Norman Wells
75 ([C10](#)), Norman Wells grid and thaw tube ([C11](#)), and Great Bear River/Tulita ([C12](#)) as well as GTN-P
76 boreholes clustered in and around Norman Wells: Pump Station-1 ([TSP.257](#)), KP2 offrow ([TSP.278](#)),
77 KP5 offrow ([TSP.279](#)), Kee Scarp ([TSP.276](#), [TSP.288](#)), and Canyon Creek ([TSP.258](#), [TSP.259](#),
78 [TSP.260](#), [TSP.261](#), [TSP.262](#)). Oil exploration and production facilities fan out from Norman Wells. The
79 landscape is dominated by coniferous forest atop discontinuous permafrost.

80

81 **Line 32200: FtGood.** The Fort Good Hope flight line begins southeast of Fort Good Hope and then
82 extends ~225 km northwest along the Mackenzie River past the bend at Thunder River. This flight line
83 provides critical coverage of bioclimatic gradients along the lower Mackenzie River Valley even though
84 there are no long-term monitoring sites in this transect. The landscape is dominated by coniferous forest
85 atop discontinuous permafrost.

86

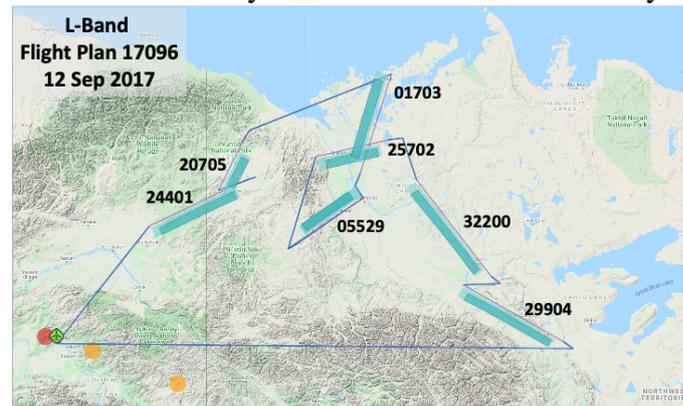


Figure 9. L-band Flight Plan 17096 flown on 12 September, 2017 over Region C1. These lines cover the Lower Mackenzie Valley, the Mackenzie Delta, and the Old Crow/Porcupine River wetlands in the Northern Yukon Territory. © Google Maps

87 **Line 25702: Aklavik.** The Aklavik flight line begins east of Inuvik and extends ~125 km west across
88 the middle of the Mackenzie Delta past Aklavik and then onto the Peel Plateau. It is anchored by a 2008
89 legacy LiDAR survey [Marsh 2009] which can be used to assess changes over time in the digital
90 elevation map [Whalen 2009], water surface elevation [Hopkinson 2011], and open water masks [Craστο
91 2015] as well as to characterize vegetation cover gradients across the Delta and into the neighboring
92 tundra environments. Comparisons are also possible with the extensive RadarSat and RadarSat-2
93 acquisitions.

94
95 **Line 05529: FtMcPh.** The Fort McPherson flight line begins in the Yukon Territory, ~25 km east of
96 Yukon – Northwest Territories border, then extends ~135 km northeast following the Dempster
97 Highway across the Peel Plateau past Fort McPherson to the main channel of the Mackenzie River. It is
98 anchored by a legacy LiDAR survey along the Dempster Highway [NWT Center for Geomatics,
99 personal communication]. This line offers opportunities to quantify mass flow and expansion of the
00 numerous megaslumps – retrogressive thaw slumps greater than 10 ha – that have formed in the Peel
01 Plateau’s Stony Creek watershed as a result of catastrophic permafrost degradation [Kokelj 2015;
02 Kokelj 2017]. Additionally, this flight line enables the study of the transition from dense boreal forest in
03 the southern edge of the Mackenzie Delta to the tundra of the Peel Plateau. Of particular interest are the
04 fluvial drainages that extend tree lined tendrils deeper into the Peel Plateau than observed in adjacent
05 terrain. Access from the Dempster Highway to many sites along this flight line offer the potential for
06 future ground-based work to complement the SAR acquisitions.

07
08 **Line 01703: TukHwy.** The Tuktoyaktuk Highway flight line begins ~25 km southwest of Inuvik, NT
09 then extends ~170 km northeast following the Inuvik-Tuktoyaktuk Highway past Tuktoyaktuk, NT to
10 the Arctic Ocean. It is anchored by a series of RadarSat-2 acquisition tiles, a legacy LiDAR survey
11 along the Highway [NWT Center for Geomatics, personal communication], and a legacy LiDAR survey
12 over Trail Valley Creek [Marsh 2010]. Intensive field data collections were conducted by members of
13 the Canada Centre for Remote Sensing ([CCRS](#)) along the ITH in 2016 and again in 2017 during the
14 airborne P-band and L-band overflights. iButton temperature data loggers were installed in many sites
15 along the ITH to measure the annual variations of near-surface soil temperature. These measurements
16 enabled estimates of the active layer thickness [Zhang 2021] and were combined with the field data
17 collected in 2017 to validate the ALT retrievals from polarimetric L-band (ALOS2 and UAVSAR) and
18 P-band (AIRMOSS). Preliminary results using the Touzi decomposition (Touzi21a, Touzi 2009) to
19 analyze these data suggests that polarimetric L-band measurements permit the characterization of
20 permafrost ALT at depths up to 50 cm, while P-band measurements permits the characterization of even
21 deeper permafrost (Touzi 21b). Similar results were found for enhanced mapping discontinuous
22 permafrost and peatlands North Alberta (Touzi 2019b, Touzi 2018). The airborne SAR data
23 complement studies of Arctic Ocean shoreline degradation near Tuktoyaktuk [Banks 2012; 2014] and
24 lake drainage events [Marsh 2009]. Tundra vegetation cover on the Tuktoyaktuk Peninsula has also
25 been characterized using multi-frequency X-, C-, and L-bands [Ullmann 2017]. This flight line also
26 captures the Canadian Changing Cold Regions Network ([CCRN](#)) site at [Trail Valley Creek](#) and the
27 [ShrubTundra](#) sites about 28 km north of Inuvik used to study shrub expansion [Myers-Smith 2011].

28 Access from the Inuvik-Tuktoyaktuk Highway to many sites along this flight line offer the potential for
 29 ground-based work to complement the SAR acquisitions.

30
 31 **Lines 20705: OldCrA and 24401: OldCrB.** The Old Crow A flight line travels ~80 km across the Old
 32 Crow Flats, a Ramsar wetland of International Importance in the northern Yukon Territory, terminating
 33 near the village of Old Crow, YT. This line covers multiple long-term field sites used to assess
 34 thermokarst induced changes in lake area [Lantz 2015]. The Old Crow B flight line originates northeast
 35 of Old Crow and then extends ~185 km southwest along the Porcupine River towards Chaklytsik, AK.
 36

37 **Table 14. Region C1: Lower Mackenzie Valley and Northern Yukon Territory L-band Flight**
 38 **Line Summary**

Line ID	Short Name	Flight Plan	Date	Comments
29904	Nwells	17096 17068	2017-09-12 2017-06-20	CALM and GTN-P borehole sites; oil exploration and production near Norman Wells
32200	FtGood	22037 19065 17096 17070 17068	2022-08-22 2019-09-16 2017-09-12 2017-06-22 2017-06-20	Boreal forest and fire disturbance; wetlands and water surface elevation (WSE)
25702	Aklavi	22037 19065 18053 17096 17070	2022-08-22 2019-09-16 2018-08-29 2017-09-12 2017-06-22	Legacy LiDAR and RadarSat data; Makenzie Delta WSE
05529	FtMcPh	22037 19065 18053 17096 17070	2022-08-22 2019-09-16 2018-08-29 2017-09-12 2017-06-22	Legacy LiDAR data; retrogressive thaw megaslumps
01703	TukHwy	22037 19065 18053 17096 17068	2022-08-22 2019-09-16 2018-08-29 2017-09-12 2017-06-20	Legacy LiDAR and RadarSat data; Trail Valley Creek site; ShrubTundra sites
20705	OldCrA	22037 19065 18053 17096 17068	2022-08-22 2019-09-16 2018-08-29 2017-09-12 2017-06-20	Long-term monitoring of thermokarst-driven lake change
24401	OldCrB	22037 19065	2022-08-22 2019-09-16	Old Crow; Porcupine River

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		18053	2018-08-29	
		17096	2017-09-12	
		17068	2017-06-20	

42 3.2 Region C2: Southern Yukon Territory

43 **Figure 10** shows the flight lines for
44 Region C2: Southern Yukon Territory.
45 Details for individual L-band SAR flight
46 lines are given in Table 15; the P-band
47 acquisition details are given in Table 27.
48 These lines form a transect across the
49 Boreal Montaigne ecoregion linking
50 Boreal Interior (A3) and Continental
51 Boreal (C3) – an important bioclimatic
52 gradient. They also cover intensively
53 studied field sites at Watson Lake, YT,
54 Wolf Creek, YT, and Kluane Lake, YT.
55 They are typically acquired during transit
56 between Yellowknife, NT and Fairbanks,
57 AK.

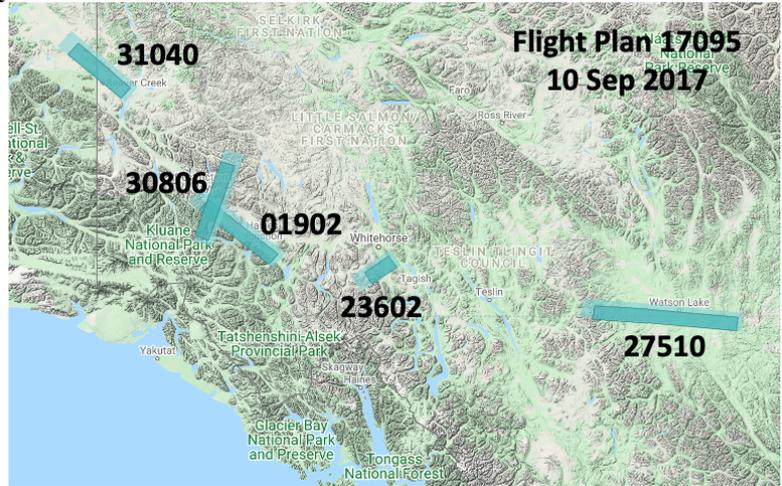


Figure 10. Flight lines across the southern Yukon Territory (Region C2) link the Eastern Interior of Alaska (Region A3) with the upper Mackenzie River Valley in the Northwest Territories (Region C3). © Google Maps

58
59 **Line 27510: Watson.** This ~200 km
60 flight line is centered on Watson Lake, YT and travels east-west along the highway corridor. It is
61 anchored by more than 50 permanent sampling plots from the Yukon Geological Survey Permafrost
62 Monitoring Network [Lipovsky 2014; Smith 2017]. Land cover is predominantly boreal forest over
63 sporadic discontinuous permafrost zone, where 10-50% of the terrain is underlain by permafrost, and
64 permafrost appears to be degrading rapidly (mean annual temperature > -0.5° C) [Lipovsky 2014].

65
66 **Line 23602: WolfCr.** The Wolf Creek flight line extends for ~55 km over the [Wolf Creek Research](#)
67 [Basin](#) just south of Whitehorse, YT. This line is anchored by the four Wolf Creek flux towers and three
68 permanent sampling plots from the Yukon Geological Survey Permafrost Monitoring Network [Smith
69 2017]. Surface land cover consists of dense boreal forest at lower elevations, sparse forest, open
70 meadow and shrub tundra at the higher elevations, and exposed alpine areas with mostly bare rock at
71 the highest elevations. The trees in the lower elevation forests are some of the largest in the ABoVE
72 domain (R. Janowicz, personal communication). Similar to Watson Lake, permafrost appears to be
73 degrading rapidly (mean annual temperature > -0.5° C). Drunken forests surrounding the Whitehorse
74 monitoring station are additional visual indicators of thawing or degrading permafrost [Lipovsky 2014].

75
76 **Lines 30806: KluanA and 01902: KluanB.** The Kluane Lake flight lines are anchored by the Kluane
77 Lake Research Station ([KLRS](#)) [Danby 2014]. Flight line 30806 extends ~120 km along the length of
78 Kluane Lake along the Alaska Highway past Haines Junction. It captures ~20 permanent sampling plots
79 from the Yukon Geological Survey Permafrost Monitoring Network [Smith 2017] as well as forests
80 recovering after devastating spruce beetle infestation in the 1990s [Campbell 2019]. Flight line 01902 is
81 oriented perpendicular to the southern edge of the lake and extends ~110 km into the forest on the
82 eastern shore. This line captures Hyperion and Landsat imagery that has been used to study forest

83 structure and treeline dynamics [Danby 2003]. It also captures the Kaskawulsh Glacier as it feeds Slims
84 River and Kluane Lake (**Figure 11**).
85
86



87
88 **Figure 11.** L-band SAR imagery from line 01902 collected 15 June 2017 clearly shows water flowing from the
89 Kaskawulsh Glacier into the Slims River and Kluane Lake. “River Piracy” occurred abruptly in Spring 2016 when
90 the Kaskawulsh Glacier retreated, triggering a shift in its melt which began flowing into the Kaskawulsh River rather
91 than the Slims River. This resulted in a drop of ~1 meter in Kluane Lake level and radically altered the regional
92 drainage pattern [Shugar 2017].
93

94 **Line 31040: SnagYK.** The Snag flight line originates southeast of Snag, YT and travels ~95 km
95 northwest along the Alaska Highway past Beaver Creek and across the border into Alaska. This line is
96 anchored by five permanent sampling plots from the Yukon Geological Survey Permafrost Monitoring
97 Network [Smith 2017]. This line continues the series of flight lines that capture the bioclimatic
98 gradients from Fairbanks, AK to Whitehorse, YT.
99

00 **Lines 21611: GaribA and 03606 GaribB (new in 2022; not shown in Fig 9?).** At the request of The
01 Geological Survey of Canada, we added two new lines in British Columbia as the NASA aircraft
02 transitioned from the ABoVE domain back to AFRC in Palmdale CA (Lines GaribA_21611 and
03 GaribB_03606). These lines run parallel to each other for ~150 km on a NE-SW course which surveys
04 from the Squamish River Delta to Lillooet. These lines characterize a particularly valued corridor in the

05 Coast Mountains of BC that is defined by varied geology, receding alpine glaciers, active fluvial
 06 processes, varied and changing vegetation. SAR imagery will be utilized by a variety of stake holders
 07 for the assessment of volcanic risks, active faulting, rapid onset alpine geohazards and ongoing glacier
 08 mass balance monitoring. Airborne hyperspectral imagery and LiDAR have been acquired over parts of
 09 the corridor to explore glacier change and other active geological processes in the area. The flight path
 10 prioritizes the high alpine setting including Warren Glacier, Overlord Glacier, Weart Glacier and Matier
 11 Glacier which are presently undergoing rapid retreat as a consequence of recent climate change.

12
 13
 14

Table 15. Region C2: Southern Yukon Territory L-band Flight Line Summary

Line ID	Short Name	Flight Plan	Date	Comments
27510	Watson	22034 19061 17095 17064	2022-08-18 2019-09-12 2017-09-10 2017-06-15	Watson Lake YT research nexus; YGS Permafrost Monitoring Network
23602	WolfCr	22034 19061 18049 17095 17064	2022-08-18 2019-09-12 2018-08-24 2017-09-10 2017-06-15	Wolf Creek Research Basin; YGS Permafrost Monitoring Network
30806	KluanA	22034 19061 18049 17095 17064	2022-08-18 2019-09-12 2018-08-24 2017-09-10 2017-06-15	Kluane Lake Research Station; legacy Hyperion data
01902	KluanB	17095 17064	2017-09-10 2017-06-15	Kluane Lake Research Station; legacy Hyperion data
31040	SnagYK	22034 18049 17095 17064	2022-08-18 2018-08-24 2017-09-10 2017-06-15	Snag YT and Alaska/Canada border region; YGS Permafrost Monitoring Network
21611	GaribA	22034	2022-08-18	BC Coast Mountains; active faulting; glacier mass balance
03606	GaribB	22034	2022-08-18	BC Coast Mountains; active faulting; glacier mass balance

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17 3.3 Region C3: Upper Mackenzie Valley

18 Figure 12 shows the flight lines for Region C3: the Upper
19 Mackenzie Valley. Details for individual L-band PolInSAR flight
20 lines are given in Table 16; the P-band acquisition details are
21 given in Table 28. The Upper Mackenzie Valley region features
22 flight lines over long-term boreal forest inventory data from the
23 Canadian Forestry Service's CIPHA and HELCIA plots; long-
24 term permafrost, hydrology and ecology time series records from
25 the [CCRN](#) site at [Scotty Creek, NWT](#); and the [Scotty Creek](#) and
26 [Smith Creek](#) flux towers. Together, these sites provide data
27 critical to understanding the performance of airborne SAR for
28 investigating boreal forests and peatlands.

29
30 **Line 33021: Fliard.** This ~60 km flight line is centered on Fort
31 Liard, NT and captures landscapes on either side of the Liard
32 River. It is anchored by ~45 HELCIA and CFS NWT inventory
33 plots. This line enables studies of boreal forest structure and
34 above ground biomass in the most productive forests in the
35 Northwest Territories [R. Hall, personal communication].
36

37 **Lines 20027: ScottyIOP and 16713: Scotty.** These flight lines
38 sample the [Scotty Creek Research Watershed](#) [Quinton 2019] and
39 the surrounding taiga plains. Flight line 20027 extends northeast
40 ~95 km from the British Columbia border and terminates east of
41 Trout Lake, NT. It overflies remote sensing areas of interest
42 (AOI) 9, 7, 6, and 5 established by the Consortium for Permafrost
43 Ecosystems in Transition ([CPET](#)). Each of the AOIs has a 6 x 6
44 km² footprint. Imagery stacking over these sites includes recent Landsat (30 m resolution) and World
45 View ½ (50 cm resolution) datasets and historical aerial photographs acquired in 1970/71 (1.2 m
46 resolution). Detailed statistical characterization of the land covers within these AOIs is being developed
47 at high resolutions, providing information on proportions of major land cover types and changes to the
48 land cover types over a 40-year period. Flight line 16713 begins east of Trout Lake and extends
49 northwest ~165 km towards Fort Simpson, NT overflying AOIs 6, 5, 4, 3, and 2 as well as the Scotty
50 Creek watershed and flux towers (Scotty Creek Landscape, [CA-SCC](#), and Scotty Creek Bog, [CA-SCB](#)).
51 These lines will enable multi-disciplinary investigations into permafrost ecosystem vulnerability and
52 change [Quinton 2016]. A late season wildfire devastated the Scotty Creek Research Station in October
53 2022. Future L-band SAR acquisitions will characterize changes in the permafrost and land surface as
54 well as its recovery from this unfortunate disturbance.
55

56 **Lines 17402: FtSimp and 15406: Wringle.** Flight line 17402 starts north of Fort Simpson, NT, crosses
57 the Mackenzie River between Miles 255 and 270, then extends north parallel to the river on the eastern
58 bank to Mile 326. It is anchored by the Willowlake River CALM sites ([C14A,B](#)). Flight line 15406

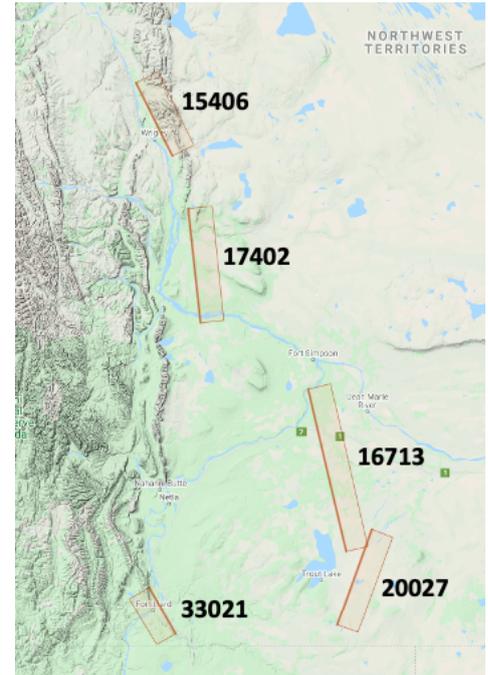


Figure 12. Flight lines for the Upper Mackenzie Valley (Region C3) cover the flux towers at Scotty Creek (16713) and Smith Creek (17402) as well as the boreal forest near Fort Liard (33021), the most productive region in the NWT. © Google Maps

59 starts near Mile 336 and proceeds ~75 km northwest over Wrigley, NT. It is anchored by the Smith
 60 Creek flux tower ([CA-SMC](#)) and the Ochre River CALM site ([C13](#)). These lines link the Upper and
 61 Lower Mackenzie Valley (Region C1), defining a transect between the Taiga Plains and the Subarctic
 62 Tundra ecoregions.

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 64
 65

Table 16. Region C3: Upper Mackenzie Valley L-band Flight Line Summary

Line ID	Short Name	Flight	Date	Comments
33021	Fliard	22034 19061 17099 17066 17065	2022-08-18 2019-09-11 2017-09-17 2017-06-17 2017-06-16	Fort Liard NT; HELCIA plots; highly productive boreal forest
16713	Scotty	22033 19061 17099 17065	2022-08-16 2019-09-11 2017-09-17 2017-06-16	Scotty Creek Research Watershed; permafrost monitoring; flux towers
20027	ScottyIOP	22034 17099 17065	2022-08-18 2017-09-17 2017-06-16	Scotty Creek Intensive Observation sites near Trout Lake
17402	FtSimp	19066 18052 17099 17066	2019-09-17 2018-08-28 2017-09-17 2017-06-17	Fort Simpson NT area; HELCIA and CALM site
15406	Wrigle	19066 17099 17065	2019-09-17 2017-09-17 2017-06-16	Wrigley NT area; Smith Creek flux tower; CALM site

66
 67

68 **3.4 Region C4: Great Slave Lake**
69 **Region**

70 Figure 13 shows the flight lines for
71 Region C4: the Great Slave Lake Region.
72 Details for individual L-band SAR flight
73 lines are given in Table 17; the P-band
74 acquisition details are given in Table 29.
75 Many of these lines are anchored to road-
76 accessible ground sites where research is
77 being conducted on fire severity and the
78 post-fire recovery of areas burned during
79 the 2014-15 wildfire seasons [Walker
80 2018a,b; 2019a,b; Bourgeau-Chavez et al.
81 2016, 2017, 2019a,b, French et al.
82 2020a,b] as well as soil moisture, ALT,
83 peatland mapping and biomass
84 [Bourgeau-Chavez et al. 2016, 2017,
85 2019a,b], and long-term boreal forest
86 inventory data from the Canadian Forestry
87 Service’s CIPHA and HELCIA plots. Soil
88 moisture was sampled for both L- and P-
89 band at 6, 12, 20 and 50 cm depths
90 [Bourgeau-Chavez et al. 2019, Schaefer
91 2021]. Other research in this area focuses
92 on wetland inundation monitoring [French
93 2018], lake and river WSE, studies of the
94 tundra-taiga ecotone, and exploiting long
95 term flux measurements at Daring Lake,
96 NT ([CA-DL1](#), [CA-DL2](#)) [Lafleur 2018;
97 Meyer 2020].

98
99 **Line 03402: HayRiv.** The Hay River line
00 begins southwest of Enterprise, NT, then
01 follows the Mackenzie Highway and the river northeast for ~60 km, terminating at Hay River, NT on
02 the shores of Great Slave Lake. It is anchored by numerous CIPHA and HELCIA plots, and caribou
03 tracking data [Serrouya 2021]. This line was added in 2019 to complement intensive field work [G.
04 Castilla, private communication] and LiDAR acquisitions [C. Hopkinson, private communication] along
05 the Hay River corridor.

06
07 **Lines 11703: Kakisa1 and 34809: Kakisa2.** The Kakisa Lake lines were designed to cover sites where
08 field work was conducted in peatlands and 2014-15 burn scars [Bourgeau-Chavez et al. 2016, 2017,
09 2019a,b; Walker 2019a,b]. Line 11703 follows NT Highway 1 from Enterprise, NT northwest for ~110

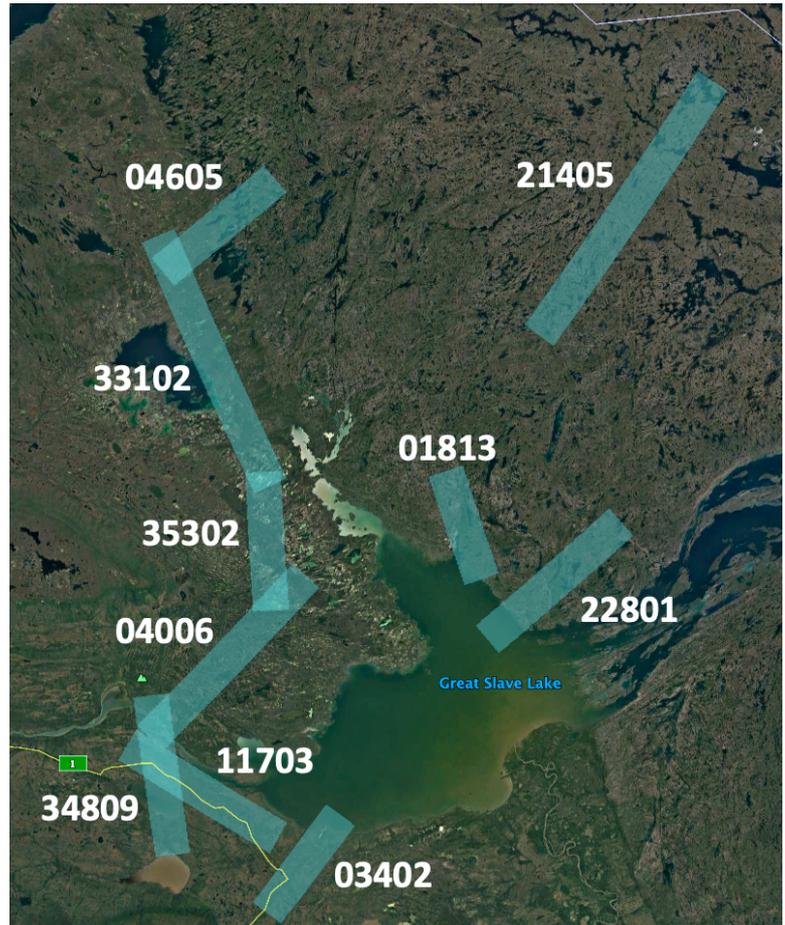
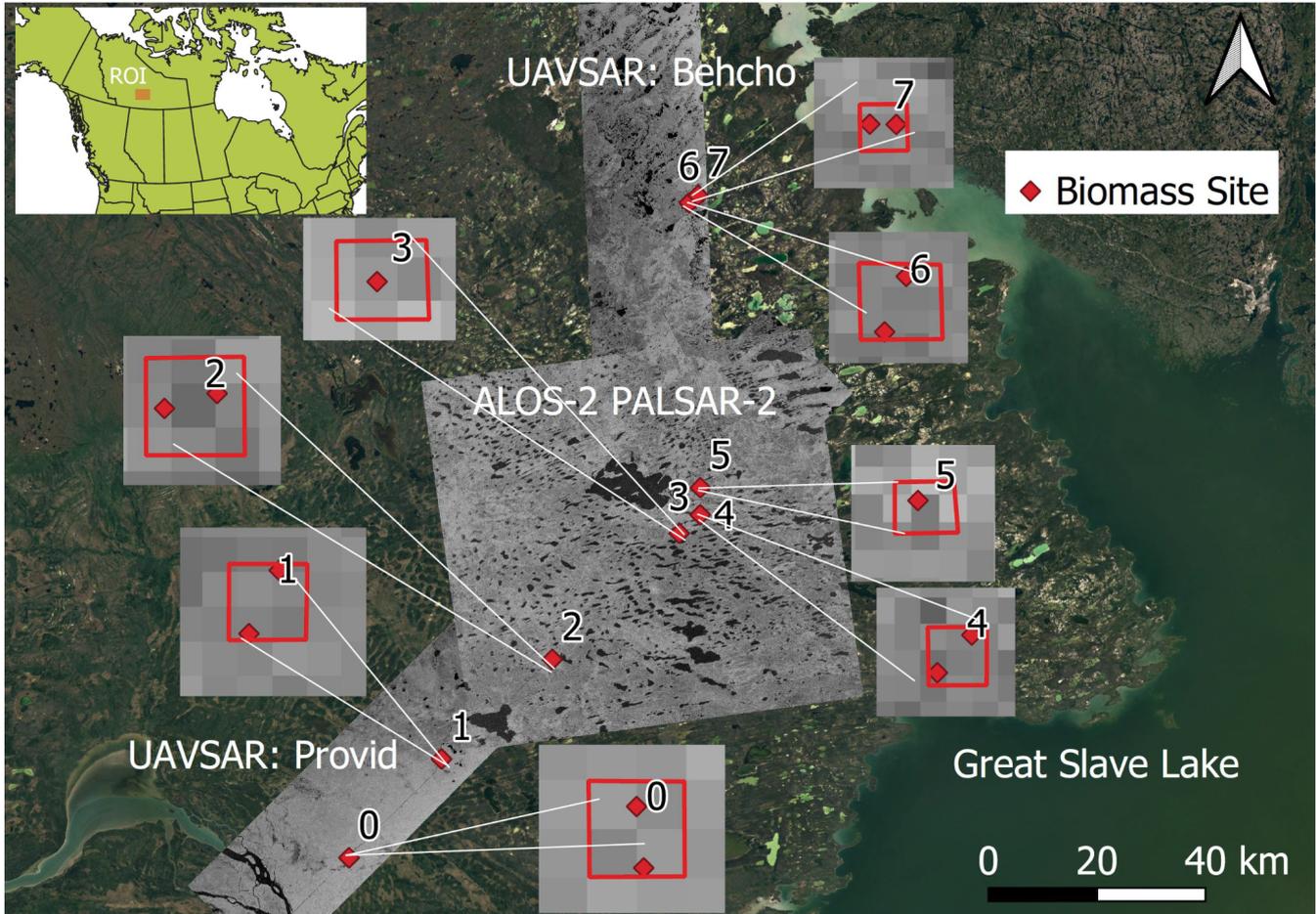


Figure 13. L-band SAR lines in the Great Slave Lake Region (C4) sample fire disturbance, long-term forest inventory plots, the tundra-taiga ecotone (TTE), and water surface elevation in the boreal forest and onto the Canadian Shield. Extensive ground-based measurements are available to validate the airborne SAR collections. Multiple flight days are required to acquire all of these lines. © Google Earth

10 km towards Fort Providence, NT. Line 34809 extends ~100 km north from the northern shore of
11 Tathlina Lake over Kakisa Lake and ends north of Fort Providence. These lines overfly areas severely
12 burned in the 2014 wildfire season. Ground sites include CFS HELCIA plots and burn study sites from
13 various ABoVE. Preliminary analyses show changes in ALT and soil moisture within the burn scars
14 compared to adjacent unburned areas [Schaefer 2019].
15
16



17
18 **Figure 14.** The western extent of the Great Slave Lake region between Fort Providence (Line 0406) and Behchoko
19 (Line 35302) was the focus of coordinated ground, satellite, and airborne activities. This image shows the location of
20 ground-validation sites for biomass and soil moisture with overlapping imagery obtained from ALOS-2 and
21 UAVSAR L-band SAR observations. © Google Earth
22

23 **Line 04006: FtProv.** This line originates southwest of Fort Providence, NT and extends ~140 km
24 northeast along the Mackenzie Highway. It is anchored by numerous CFS long term forest inventory
25 sites [Hoy 2018] and electrical resistivity tomography (ERT) transects [M. Turetsky, private
26 communication]. **Figure 14** shows that this line overflies areas severely burned in the 2014 wildfire
27 season and was extensively sampled by ABoVE research teams [Bourgeau-Chavez et al. 2016, 2017,

28 2019a,b, 2021; Walker 2019a,b]. Post fire vegetation changes have made this an attractive area for
29 wintering woodland caribou [A. Kelly, private communication].

30

31 **Line 35302: Behcho.** The Behchoko line extends ~85 km on a north-south axis along the Mackenzie
32 Highway to the west of Behchoko, NT. It overflies two severely burned areas from the 2014 wildfire
33 season ([Figure 14](#)). It is anchored by ERT transects and long term forest inventory plots, and was
34 extensively sampled by ABoVE research teams [Bourgeau-Chavez et al. 2016, 2017, 2019a,b, 2021;
35 Walker 2019a,b].

36

37 **Line 33102: SnareR.** This line follows the Snare River northwest for ~170 km from Great Slave Lake
38 over the village of Whati, NT. Water surface elevation (WSE) investigations in this region inform
39 hydroelectric power potential for Yellowknife, NT [A. Applejohn, private communication] and
40 complement AirSWOT acquisitions [Pitcher 2019a,b; Kyzivat 2020]. In situ measurements have been
41 collected to validate ABoVE SAR soil moisture and ALT products [Schaefer 2019]. The Snare River
42 line was not acquired in 2018.

43

44 **Line 04605: FaberL.** The Faber Lake line extends ~90 km across two large 2014 burned areas on the
45 northern shore of Great Slave Lake. Field work by ABoVE research teams assessed the severity of the
46 burns [Walker 2019a,b]. The Faber Lake line was acquired only in 2017; it was replaced by higher
47 priority acquisitions.

48

49 **Line 21405: Daring.** The Daring Lake flight line extends nearly 200 km southwest from the Daring
50 Lake Tundra Ecosystem Research Station ([TERS](#)) across the Canadian Shield. It is anchored by TERS
51 field sites and flux towers ([CA-DL1](#), [CA-DL2](#)) [Lafleur 2018; Meyer 2020]. This line complements
52 AirSWOT acquisitions [Pitcher 2019a,b; Kyzivat 2020] and creates a transect across the tundra-taiga
53 transition. The Daring Lake line was not acquired in 2018.

54

55 **Line 22801: Yellow.** This line southeast of Yellowknife extends ~110 km from Great Slave Lake
56 northeast. It is anchored by a number of Northern Contaminated Sites Program ([INAC](#)) mine
57 remediation sites [Hoy 2018] as well as peatland and fire disturbance ground sites [Bourgeau-Chavez et
58 al. 2016, 2017, 2019a,b, 2021; Walker 2019a,b; French et al. 2020a,b]. These sites are accessible via
59 helicopter, floatplane, or boat. The Yellowknife line was not acquired in 2018.

60

61 **Line 16008: BakerC.** This line begins north of the Yellowknife airport and extends ~60 km to the
62 southeast. It is anchored by long-term hydrological monitoring sites associated with the Baker Creek
63 Research Watershed [Spence 2018], as well as a short-term study of water-inundated vegetation [B.
64 Chapman, personal communication, French 2018]. Acquisitions for the Baker Creek line began in 2018;
65 it was not acquired in 2017 and, therefore, has no P-band counterpart.

66

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Table 17. Region C4: Great Slave Lake Region L-band Flight Line Summary

Line ID	Short Name	Flight Plan	Sortie Date	Comments
03402	HayRiv	22032 19060	2022-08-15 2019-09-05	Canadian Forest Service Permanent Sampling Plots near Highway NT 2 along the Hay River
11703	KakisaA	22033 19060 18048 17094 17063	2022-08-16 2019-09-05 2017-08-22 2017-09-09 2017-06-14	Burn study sites near Kakisa Lake
34809	KakisaB	22032 19060 18048 17094 17063	2022-08-15 2019-09-05 2017-08-22 2017-09-09 2017-06-14	Burn study sites near Kakisa Lake
04006	Provid	22032 19060 19059 18048 18047 17094 17063	2022-08-15 2019-09-05 2019-09-04 2017-08-22 2017-08-21 2017-09-09 2017-06-14	Burn study sites accessible from Highway NT 3 near Fort Providence
35302	Behcho	22032 19060 18048 17094 17063	2022-08-15 2019-09-05 2017-08-22 2017-09-09 2017-06-14	Burn study sites accessible from Highway NT 3 near Behchoko
33102	SnareR	19060 17094 17063	2019-09-05 2017-09-09 2017-06-14	Snare River hydrology and water surface elevation
04605	FaberL	17094 17063	2017-09-09 2017-06-14	Faber Lake burn study sites
21405	Daring	22033 19060 17094 17063	2022-08-16 2019-09-05 2017-09-09 2017-06-14	Taiga-tundra transition from Yellowknife to the Daring Lake Research Station
22801	Yellow	22033 19059 17094 17063	2022-08-16 2019-09-04 2017-09-09 2017-06-14	Burn study sites southeast of Yellowknife

16008	BakerC	22032	2022-08-15	Baker Creek Watershed sites north of the Yellowknife Airport
		19060	2019-09-05	
		19059	2019-09-04	
		18048	2018-08-22	
		18047	2018-08-21	

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79 **3.5 Region C5: Peace-Athabasca Delta (PAD) and the Trans-Boundary Watershed**

80 **Figure 15** shows the L-band SAR flight lines for
81 the Peace-Athabasca Delta and Transboundary
82 Watershed (Region C5). These flight lines extend
83 from the Peace-Athabasca Delta in northern
84 Alberta to the Slave River Delta near Fort
85 Resolution, NT on the southern shore of Great
86 Slave Lake. Details for individual L-band SAR
87 flight lines are given in Table 18; the P-band
88 acquisition details are given in Table 30.

89
90 Multiple ABoVE research groups and Canadian
91 partner organizations engage in research projects
92 across the Peace-Athabasca Delta (PAD) and the
93 Slave River watershed. The PAD has been
94 declared a Ramsar Convention Wetland and a
95 UNESCO World Heritage site based on its high
96 biological diversity. The Slave River and Delta
97 are monitored under the [NWT Water Stewardship
98 Strategy](#), in which Traditional Knowledge and
99 western science are merged to create state of the
00 art understanding of the hydrology, ecology, and
01 biodiversity of the Slave River watershed. The
02 ABoVE flight lines were designed in close
03 consultation with the GNWT Science Advisor to
04 help quantify and understand trans-boundary
05 water flow. The L-band SAR acquisitions
06 described here complement the LVIS LiDAR and
07 AirSWOT Ka-band, thermal and optical data acquired in 2017 to study trans-boundary WSE and
08 hydrologic dynamics in detail [Fayne 2019; Kyzivat 2019] (See Section 8).

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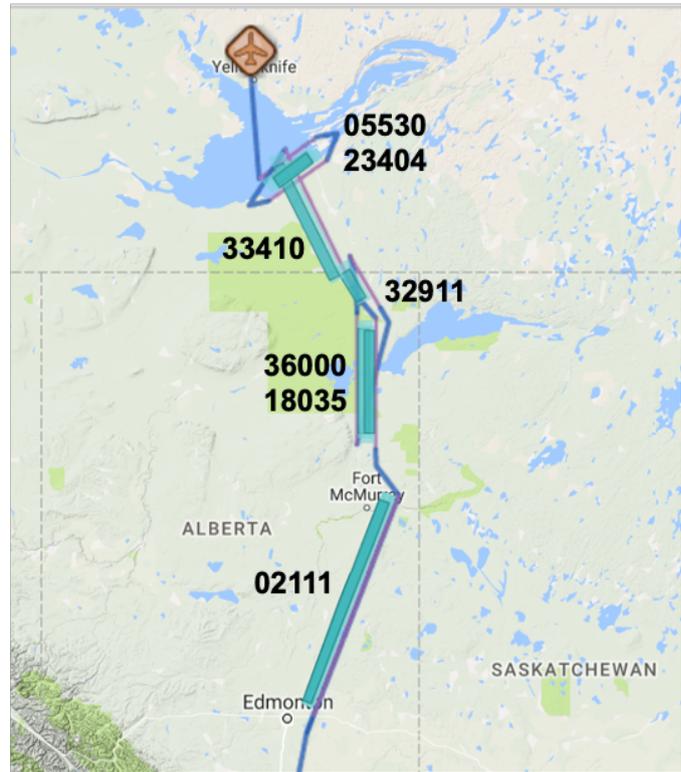


Figure 15. L-band flight lines in the Transboundary Watershed sample from the Peace-Athabasca Delta along the Slave River to the Slave Delta on the on the southern shore of Great Slave Lake. These flight lines help characterize wetlands extent and type as well as water surface elevations. © Google Maps

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Lines 36000: PADelE and 18035: PADelW.

The Peace-Athabasca Delta (PAD), a 5200 km² freshwater delta at the confluence of the Peace and Athabasca Rivers with Lake Athabasca (58.7N, 111.5W; Figure 16), is the largest inland river delta in the world, among the world's most globally significant boreal wetlands, and a critical habitat for millions of water fowl. Aside from some exposed bedrock features in the northern sector, the PAD consists of hundreds of interconnected wetlands, shallow lakes (<2 m depth), and active and relict distributary channels. [Pavelsky and Smith 2008]. The SAR flight lines are centered on the PAD and run north-south for ~180 km. Both L-band and P-band swaths were designed to overlap with AirSWOT Ka-band WSE data acquired in June and August 2017 [Miller 2019; Fayne 2019; Kyzivat 2019]. The L-band swaths overlap substantially as they were placed for optimized near-field coverage of the narrower P-band and Ka-band swaths. ABoVE researchers coordinated on-water WSE and optical property measurements with the SAR swaths. Figure 16 shows overlap of L-band image with on the water measurements made in August 2018. ABoVE researchers are also using the PAD L-Band SAR imagery to develop wetland waterfowl habitat classification methods [French 2018].

Lines 32911: FSmithS and 33410: FSmithN.

The Fort Smith flight lines provide imagery of the Slave River from northern Alberta to the Great Slave Lake. Flight line 32911 starts about 40 km south of the Alberta-Northwest Territories border and follows the river north past Fort Smith, NT. Flight line 33410 continues the survey from the border to the Slave River Delta near Fort Resolution, NT, extending several kilometers into the Great Slave Lake to characterize Slave River outflow into the lake. These lines are anchored by numerous river gauges to calibrate WSE, and also a part of wetland waterfowl habitat assessment for ABoVE [French 2018].

Lines 05530: FtResS and Line 23404: FtResN. The Fort Resolution flight lines are parallel transects designed to map the Slave River Delta. Each extends ~80 km perpendicular to the Slave River to map

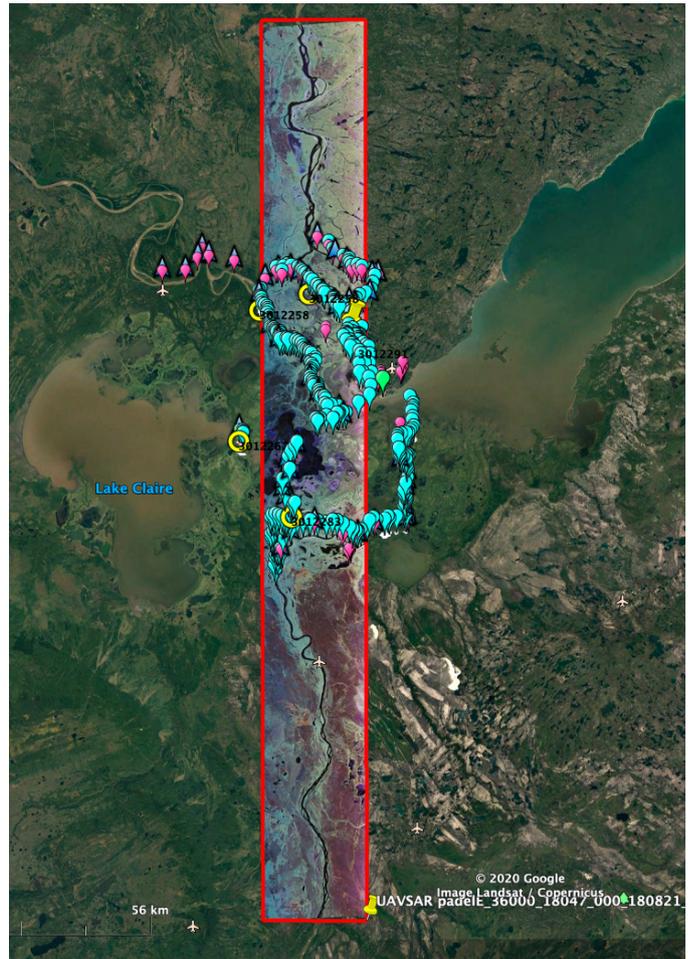


Figure 16. L-band SAR flight line 36000 (PADelE) overlaps with on-water measurements made by ABoVE ecohydrology researchers [Smith-Pavelsky-Butman]. SAR data will help quantify water surface elevations (WSE) and provide wetlands classifications for the world's largest inland delta. © Google Earth

59 the entire Fort Resolution Peninsula. As with the PAD flight lines 36000 and 18035, the spatial offset in
60 flight lines 05530 and 23404 optimizes overlap for the narrower P-band swath. The Slave River Delta is
61 a critical waterfowl habitat, and the SAR imagery will deliver important information on its structure and
62 interannual variability [French 2018].
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65 **Table 18. Region C5: Peace-Athabasca Delta and Trans-Boundary Watershed L-band Flight Line**
66 **Summary**

Line ID	Short Name	Flight	Date	Comments
36000	PADelE	22033 22032 19059 18047 17093 17062	2022-08-16 2022-08-15 2019-09-04 2018-08-21 2017-09-08 2017-06-13	Water Surface Elevation (WSE) and habitat classification in the Peace-Athabasca Delta; overlap with AirSWOT Ka-band acquisitions
18035	PADelW	22033 18047 17093 17062	2022-08-16 2018-08-21 2017-09-08 2017-06-13	Water Surface Elevation (WSE) and habitat classification in the Peace-Athabasca Delta; overlap with AirSWOT Ka-band acquisitions
32911	FSmitS	17093 17062	2017-09-08 2017-06-13	Water Surface Elevation (WSE) for the Slave River trans-boundary watershed
33410	FSmitN	22033 19059 17093 17062	2022-08-16 2019-09-04 2017-09-08 2017-06-13	Water Surface Elevation (WSE) for the Slave River trans-boundary watershed
05530	FtResN	22033 19059 18047 17093 17062	2022-08-16 2019-09-04 2018-08-21 2017-09-08 2017-06-13	Water Surface Elevation (WSE) and habitat classification in the Slave River Delta
23404	FtResS	22033 19059 17093 17062	2022-08-16 2019-09-04 2017-09-08 2017-06-13	Water Surface Elevation (WSE) and habitat classification in the Slave River Delta

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71 **3.6 Region C6: Southern Boreal Forest/BERMS**

72 **Figure 17** shows the flight lines for Region C6:
73 Southern Boreal Forest/BERMS. Details for
74 individual L-band SAR flight lines are given in
75 Table 19; the P-band acquisition details are given
76 in Table 31.

77
78 Region C6 covers the southern edge of the boreal
79 plains ecozone which was intensively studied
80 during NASA’s BOREAS field campaigns in the
81 1990s [Sellers 1994; 1997]. Revisits to the area
82 during ABoVE allow for an assessment of change
83 over the last 20 years. This region features the
84 Boreal Ecosystem Research and Monitoring Sites
85 (**BERMS**) covering flux towers at Old Jack Pine
86 (**OJP**), Old Black Spruce (**OBS**), and Old Aspen
87 (**OAS**) vegetation types [Barr 2006]. ‘Old’ refers
88 to the monitoring site being located within a
89 mature stand of trees. The Old Aspen site ended
90 operations in 2017 shortly after the ABoVE
91 flights that year. The BERMS area has been the
92 target of previous L- and P-band SAR campaigns.

93 Legacy acquisitions from CanEx 2010 [Magagi 2012] and AirMOSS (2013-2015) [Tabatabaenejad
94 2020] provide the opportunity to extend the ABoVE time series and investigate decadal-scale ecosystem
95 change. ABoVE SAR flight lines also leverage the extensive forest inventory plots, HELCIA, and
96 CIPHA sites maintained by the Canadian Forestry Service, as well as legacy LiDAR acquisitions. The
97 region also spatially overlaps with extensive PALS airborne L-band retrievals acquired during the
98 NASA SMAPVEX-16 campaign [McNairn 2017; Colliander 2019] and tower mounted L-band
99 radiometer acquisitions at the OBS site [Roy 2020]; these data provide opportunities to investigate L-
00 band active/passive microwave synergy for mapping vegetation biomass, freeze-thaw, and soil moisture
01 conditions.

02
03 Since this region lacks permafrost, there was no reason to acquire an early season baseline and all
04 acquisitions have been acquired near DOY 240 (late-August to early-September). In 2018 L-band
05 tomoSAR data were acquired over the BERMS grid in conjunction with DLR’s F-SAR multi-frequency
06 airborne SAR (see Section 6 for additional details).

07
08 **Line 30704: Redber.** The Redberry Lake flight line starts southeast of Saskatoon and travels ~130 km
09 northwest and terminates north of Hafford, SK. It is anchored by the Redberry Lake WSE calibration
10 site [Pietroniro 2019] and is an important line for cross calibration with AirSWOT Ka-band radar
11 acquisitions [Smith 2017]. It includes Environment & Climate Change Canada monitoring sites; GPS

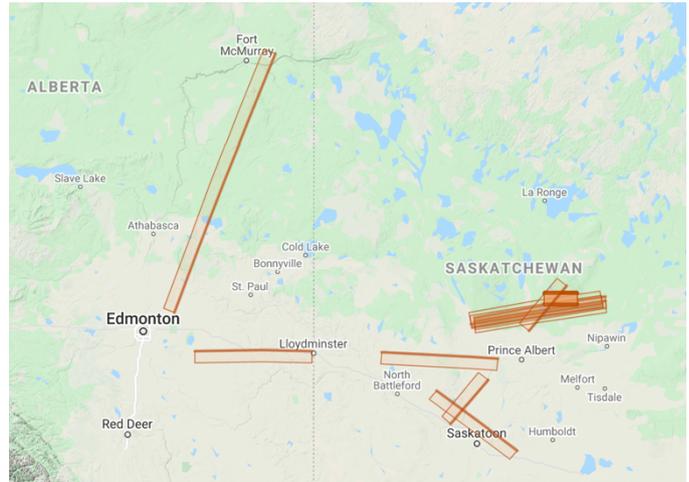


Figure 17. L-band SAR flight lines in Region C6 sample the southern boreal forest, including the BOREAS-era BERMS sites. Both NASA’s L-band SAR and DLR’s multi-frequency F-SAR flew tomoSAR grids over the BERMS site in 2018. Legacy data from CANEX 2010 (L-band) and the AIRMOSS EV-S investigation (P-band, 2013-2015) provide the opportunity to investigate decadal-scale ecosystem change. © Google Maps

12 water level surveys of prairie pothole wetlands; and geomorphic changes along the North Saskatchewan
13 River.

14

15 **Line 04016: SaskS.** The Saskatoon South flight line begins northeast of Radisson, SK then travels ~70
16 km northeast over Blaine Lake to end near Leask, SK. It is anchored by several CFS plots and also
17 captures large agricultural areas. It includes ECCC sites; GPS water level surveys; prairie pothole
18 wetlands; and geomorphic changes along the North Saskatchewan River.

19

20 **Line 04018: SaskN.** The Saskatoon North flight line begins ~20 km southwest of Candle Lake, SK,
21 then travels ~70 km northeast over Candle Lake and the BERMS research area. It is anchored by the
22 Old Black Spruce (OBS) flux tower and numerous CFS/HELICA plots.

23

24 **Lines 26107 BERMSA, 26106: BERMSB, 08111: BERMSC, and 08108: BERMSD.** The BERMS
25 area flight lines BERMSA-D create a 30 km x 175 km grid over the OBS, OJP, FEN, and OAS flux
26 towers and Candle Lake. These lines overlap substantially with the legacy L-band lines from the
27 CANEX 2010 campaign [Magagi 2012] and the P-band lines from the AirMOSS EV-S1 investigation
28 (2012-2015) [Chapin 2018].

29

30 **Line 27037: BERMSR.** The BERMSR flight line covers an east-west transect of ~55 km and is
31 anchored by the OBS and OJP flux towers. It is a reference acquisition for the tomoSAR experiment
32 performed in August 2018 (Flight Plan 18046) in conjunction with the German Space Agency's multi-
33 frequency F-SAR [Pichierri 2018]. Flight line details are given in Table 20 and the results are described
34 in Section 6 below. This line was reacquired in 2019 to evaluate interannual variability.

35

36 **Lines 27304 LloydE and 27304 LloydW.** The two Llyodminster flight lines establish a long east-west
37 transect across the prairie in an area known to be permafrost free and provide a critical test for water
38 mask and water surface elevation retrieval algorithms adapted for permafrost ecosystems [L. Smith,
39 private communication]. The Llyodminster East flight line begins near Sherbrook, SK and travels ~150
40 km west to Edam, SK. After a gap of ~100 km, data collection was restarted for the Llyodminster West
41 line and continued for another ~150 km along the same heading.

42

43 **Line 02111: FtMacM.** The Fort McMurray flight line originates north of Edmonton and travels nearly
44 400 km north, terminating north of Fort McMurray. It is anchored by multiple clusters of CFS long-
45 term plots, studies of boreal forest reclamation, and provides a south-north transect through the 2016
46 Horse River burn scar. Field data on fire severity and pre-fire biomass were sampled at several sites in
47 the 2016 fire [Bourgeau-Chavez et al. 2017]. This flight line covers the prairie-boreal forest ecotone.

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Table 19. Region C6: Southern Boreal Forest/BERMS L-band Flight Line Summary

Line ID	Short Name	Flight	Date	Comments
30704	Redber	19057 17092	2019-08-16 2017-09-07	Calibration for AirSWOT and Water Surface Elevation (WSE) at Redberry Lake
04016	SaskaS	19057 17092	2019-08-16 2017-09-07	AirSWOT field sites
04018	SaskaN	19057 17092	2019-08-16 2017-09-07	Transect through the BERMS research area, BOREAS Old Black Spruce (OBS) flux tower, HELICA sites
26107	BERMSA	17093	2017-09-08	BERMS area grid; OBS, OJP, FEN, and OAS flux towers
26106	BERMSB	17093	2017-09-08	BERMS area grid; OBS, OJP, FEN, and OAS flux towers
08111	BERMSC	17093	2017-09-08	BERMS area grid; OBS, OJP, FEN, and OAS flux towers
08108	BERMSD	17093	2017-09-08	BERMS area grid; OBS, OJP, FEN, and OAS flux towers
27037	BERMSR	19057	2019-08-16	TomoSAR reference line; interannual variability
27304	LloydE	17092	2017-09-07	Test for ecohydrology algorithms (permafrost free zone)
27304	LloydW	17092	2017-09-07	Test for ecohydrology algorithms (permafrost free zone)
02111	FtMacM	17093 17062	2017-09-08 2017-06-13	Horse River burn transect; prairie – boreal forest ecotone

Table 20. BERMS L-band TomoSAR Flight Lines

Line ID	Short Name	Flight Plan	Date	Comments
09041	BERMSA	22031 18046	2022-08-14 2018-08-19	TomoSAR 40m Baseline
26107	BERMSA	22031 18046	2022-08-14 2018-08-19	TomoSAR 40m Baseline
09043	BERMSB	22031 18046	2022-08-14 2018-08-19	TomoSAR 80m Baseline
27043	BERMSB	22031 18046	2022-08-14 2018-08-19	TomoSAR 80m Baseline
09039	BERMSC	22031 18046	2022-08-14 2018-08-19	TomoSAR 120m Baseline
27039	BERMSC	22031 18046	2022-08-14 2018-08-19	TomoSAR 120m Baseline
09044	BERMSD	22031 18046	2022-08-14 2018-08-19	TomoSAR 160m Baseline
27044	BERMSD	22031 18046	2022-08-14 2018-08-19	TomoSAR 160m Baseline
09040	BERMSE	22031	2022-08-14	TomoSAR 200m Baseline

		18046	2018-08-19	
27040	BERMSE	22031 18046	2022-08-14 2018-08-19	TomoSAR 200m Baseline
09042	BERMSF	22031 18046	2022-08-14 2018-08-19	TomoSAR 240m Baseline
27042	BERMSF	22031 18046	2022-08-14 2018-08-19	TomoSAR 240m Baseline
09038	BERMSG	22031 18046	2022-08-14 2018-08-19	TomoSAR 280m Baseline
27038	BERMSG	22031 18046	2022-08-14 2018-08-19	TomoSAR 280m Baseline
09037	BERMSR	22031 18046	2022-08-14 2018-08-19	TomoSAR Reference Line
27037	BERMSR	22031 18046	2022-08-14 2018-08-19	TomoSAR Reference Line
TM090	BERMSR	18046	2018-08-19	TomoSAR 280m Baseline
TM270	BERMSR	18046	2018-08-19	TomoSAR 80m Baseline

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62 **4 P-band Flight Lines**

63 The ABoVE P-band SAR data were acquired during campaigns in May/June, August, and October of
 64 2017 (Tables 6-8). Tables 21-31 provide the details for individual flight lines for the Alaskan and
 65 Canadian Sectors.

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Table 21. Region A1 (North Slope Alaska) P-band Flight Line Summary

P-band Line ID	Short Name	Flight Plan	Date	Comments
03107	Ivotuk	17109 17079 17056	2017-10-09 2017-08-13 2017-05-29	Legacy line; Ivotuk flux tower, CALM site, GTN-P boreholes Matches L-band line 03111
34505	Atqasu	17109 17079 17058	2017-10-09 2017-08-13 2017-06-06	Legacy line; Atqasuk flux tower; CALM site Matches L-band line 34509
15010	Barrow	17109 17079 17058	2017-10-09 2017-08-13 2017-06-06	Legacy line; NGEE-Artic, NEON, BEO flux towers, CALM sites Matches L-band line 15018
04600	Inigok	17079 17058	2017-08-13 2017-06-06	North Slope CALM sites, boreholes Matches L-band line 04603
33410	AnaktE	17079 17058	2017-08-13 2017-06-06	Anaktuvuk River fire scar, eastern transect Matches L-band line 33408
16404	AnaktW	17079 17058	2017-08-13 2017-06-06	Anaktuvuk River fire scar, western transect Matches L-band line 16405
18517	Dhorse	17109 17079 17058	2017-10-09 2017-08-13 2017-06-06	North-South transect running from the Arctic Ocean coast through Deadhorse and south along the Dalton Highway; covers numerous calibration sites Matches L-band line 18519
05406	Toolik	17109 17079 17056	2017-10-09 2017-08-13 2017-05-29	Toolik Lake Research Station, Arctic LTER, NEON box Matches L-band line 04300
28608	Noatak	17079 17056	2017-08-13 2017-05-29	Fire disturbance/recovery

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Table 22. Region A2 (Seward Peninsula and Northwestern Interior P-band Flight Line Summary

Line ID	Short Name	Flight	Date	Comments
25507	Huslia	17109 17082 17055	2017-10-09 2017-08-17 2017-05-27	Interior Alaska, Huslia village Matches L-band line 25516
25508	Koyukk	17110 17082 17055	2017-10-10 2017-08-17 2017-05-27	AirMOSS legacy line; Koyuk village, boreal forest, coastal mountains Matches L-band line 25517
32510	Counci	17110 17082 17056	2017-10-10 2017-08-17 2017-05-29	Legacy line; Ngee-Artic Council watershed and flux tower, Kougarok watershed Matches L-band line 32519
04900	Teller	17110 17082 17056	2017-10-10 2017-08-17 2017-05-29	NGEE-Arctic Teller watershed, Kougarok watershed, Kougarok area fire disturbance/recovery Matches L-band lines 04806, 04901
08509	Kougar	17110 17082 17056	2017-10-10 2017-08-17 2017-05-29	AirMOSS legacy line; Seward Peninsula CALM sites, boreholes Matches L-band line 08502
03106	Ambler	17109 17082 17055	2017-10-09 2017-08-17 2017-05-27	AirMOSS legacy line; boreholes, boreal forest-foothills gradient Matches L-band line 03101
28608	Noatak	17079 17056	2017-08-13 2017-05-29	Fire disturbance/recovery Matches L-band line 28508

Table 23. Region A3: Eastern Interior P-band Flight Line Summary

Line ID	Short Name	Flight Plan	Date	Comments
20007	Coldfo	17109 17082 17079 17055	2017-10-09 2017-08-17 2017-08-13 2017-05-27	CALM and GTN-P sites; tundra-taiga ecotone Matches L-band line 20026
21507	YflatW	17082 17056	2017-08-17 2017-05-29	Overlap with AEM surveys, AirSWOT and in situ water surface elevation measurements
21608	YflatE	17082 17056	2017-08-17 2017-05-29	Overlap with AEM surveys, AirSWOT and in situ water surface elevation measurements
04707	FtYuko	17082 17056	2017-08-17 2017-05-29	Overlap with AEM surveys, AirSWOT and in situ water surface elevation measurements
00100	DJNEON	17078	2017-08-11	NEON D19 taiga field site near Delta Junction, AK
30406	DeltJA	17078	2017-08-11	Delta Junction, AK boreal forest

10203	DeltJB	17078	2017-08-11	Delta Junction, AK boreal forest
30203	DeltJC	17078	2017-08-11	Delta Junction, AK boreal forest

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*** Interior Alaska P-band lines forbidden due to radar keep out zone at Clear AK – See Fig 4 in Main Text. Therefore, there are no P-band lines corresponding to the BonanW, BonanE, DenalN, DenalS L-band lines ****

Table 24. Delta Junction, AK P-band tomoSAR Flight Line Summary

Line ID	Short Name	Flight Plan	Date	Comments
12216	DeltaR	17081	2017-08-15	TomoSAR Reference Line 9000 mASL
30210	DeltaR	17081	2017-08-15	TomoSAR Reference Line 9000 mASL
12217	DeltaA	17081	2017-08-15	TomoSAR offset 120 meters
30211	DeltaA	17081	2017-08-15	TomoSAR offset 120 meters
12218	DeltaB	17081	2017-08-15	TomoSAR offset 135 meters
30212	DeltaB	17081	2017-08-15	TomoSAR offset 135 meters
12219	DeltaC	17081	2017-08-15	TomoSAR offset 105 meters
30213	DeltaC	17081	2017-08-15	TomoSAR offset 105 meters
12220	DeltaD	17081	2017-08-15	TomoSAR offset 150 meters
30214	DeltaD	17081	2017-08-15	TomoSAR offset 150 meters
12221	DeltaE	17081	2017-08-15	TomoSAR offset 75 meters
30215	DeltaE	17081	2017-08-15	TomoSAR offset 75 meters
12222	DeltaF	17081	2017-08-15	TomoSAR offset 175 meters
30216	DeltaF	17081	2017-08-15	TomoSAR offset 175 meters
12223	DeltaG	17081	2017-08-15	TomoSAR offset 250 meters
30217	DeltaG	17081	2017-08-15	TomoSAR offset 250 meters
12224	DeltaH	17081	2017-08-15	TomoSAR offset 90 meters
30218	DeltaH	17081	2017-08-15	TomoSAR offset 90 meters
12216	DeltaR	17081	2017-08-15	TomoSAR Reference Line 9000 mASL, Take 2
30210	DeltaR	17081	2017-08-15	TomoSAR Reference Line 9000 mASL. Take 2

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Table 25. Region A4: Southwest Alaska and the Yukon-Kuskokwim Delta P-band Flight Line Summary

Line ID	Short Name	Flight Plan	Date	Comments
19204	Lclark	17080 17054	2017-08-14 2017-05-26	National Park Service SWAN ground sites Matches L-band line 19205
23002	KatmaA	17080 17054	2017-08-14 2017-05-26	National Park Service SWAN ground sites Matches L-band line 23004
28019	KatmaB	17080 17054	2017-08-14 2017-05-26	National Park Service SWAN ground sites Matches L-band line 28020
02110	KatmaC	17080 17054	2017-08-14 2017-05-26	National Park Service SWAN ground sites Matches L-band line 02112
32607	Sriver	17080 17054	2017-08-14 2017-05-26	Snake River tree rings sampling Matches L-band line 32608
27030	YKDelA	17080 17055	2017-08-14 2017-05-27	YK Delta 2015 fire scars; POLARIS portable flux towers/flux chambers; GPR transects; soil moisture measurements; Matches L-band line 26905
27031	YKDelB	17080 17055	2017-08-14 2017-05-27	YK Delta 2015 fire scars; POLARIS portable flux towers/flux chambers; GPR transects; soil moisture measurements; Matches L-band line 26906
01811	Chevak	17080 17055	2017-08-14 2017-05-27	YK Delta wildlife survey; USGS LiDAR survey; ground measurements; Matches L-band line 01813
04214	Innoko	17080 17055	2017-08-14 2017-05-27	Permafrost surveys; extensive bog/fen/wetland complex Matches L-band line 04215
08919	Poorma	17080 17054	2017-08-14 2017-05-26	Interior Alaska, boreal forest Matches L-band line 08911

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Table 26. Region C1: Lower Mackenzie Valley and Northern Yukon Territory P-band Flight Line Summary

Line ID	Short Name	Flight Plan	Date	Comments
30013	Nwells	17083 17057	2017-08-18 2017-06-06	CALM and GTN-P borehole sites; oil exploration and production near Norman Wells; Matches L-band line 29904
32203	GdHope	17083	2017-08-18	Boreal forest and fire disturbance; wetlands and water surface elevation (WSE) Matches L-band line 32200
31616	GdHope	17057	2017-06-06	Boreal forest and fire disturbance; wetlands and water surface elevation (WSE) Matches L-band line 32200
25701	Aklavi	17083 17057	2017-08-18 2017-06-06	Legacy LiDAR and RadarSat data; Makenzie Delta WSE Matches L-band line 25702
05604	McPher	17083 17057	2017-08-18 2017-06-06	Legacy LiDAR data; retrogressive thaw megaslumps Matches L-band line 05529
01812	TukHwy	17083 17057	2017-08-18 2017-06-06	Legacy LiDAR and RadarSat data; Trail Valley Creek site; ShrubTundra sites; Matches L-band line 01703
20605	OldCrA	17083 17057	2017-08-18 2017-06-06	Long-term monitoring of thermokarst-driven lake change Matches L-band line 20705
24400	OldCrB	17083 17057	2017-08-18 2017-06-06	Old Crow; Porcupine River Matches L-band line 24401

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02 **Table 27. Region C2: Southern Yukon Territory P-band Flight Line Summary**

Line ID	Short Name	Flight Plan	Date	Comments
27509	Watson	17078 17053	2017-08-11 2017-05-25	Watson Lake YT research nexus; YGS Permafrost Monitoring Network; Matches L-band line 27510
23601	WolfCr	17078 17053	2017-08-11 2017-05-25	Wolf Creek Research Basin; YGS Permafrost Monitoring Network; Matches L-band line 23602
30805	KluanA	17078	2017-08-11	Kluane Lake Research Station; legacy Hyperion data Matches L-band line 30806
01901	KluanB	17078 17053	2017-08-11 2017-05-25	Kluane Lake Research Station; legacy Hyperion data Matches L-band line 01902
31030	SnagYK	17078 17053	2017-08-11 2017-05-25	Snag YT and Alaska/Canada border region; YGS Permafrost Monitoring Network; Matches L-band line 31040

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Table 28. Region C3: Upper Mackenzie Valley P-band Flight Line Summary

Line ID	Short Name	Flight	Date	Comments
33020	Fliard	17077 17053	2017-08-09 2017-05-25	Fort Liard NT; HELCIA plots; highly productive boreal forest; Matches L-band line 33021
16712	Scotty	17077 17052	2017-08-09 2017-05-23	Scotty Creek Research Watershed; permafrost monitoring; flux towers; Matches L-band line 16713
20025	ScoAOI	17077 17053	2017-08-09 2017-05-25	Scotty Creek Intensive Observation sites near Trout Lake Matches L-band line 20027
17401	WrigIS	17077 17052	2017-08-09 2017-05-23	Fort Simpson NT area; HELCIA and CALM site Matches L-band line 17402
15405	WrigIN	17077 17052	2017-08-09 2017-05-23	Wrigley NT area; Smith Creek flux tower; CALM site Matches L-band line 15406

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11 **Table 29. Region C4: Great Slave Lake Region P-band Flight Line Summary**

Line ID	Short Name	Flight Plan	Sortie Date	Comments
11702	KakisaA	17077 17052	2017-08-09 2017-05-23	Burn study sites near Kakisa Lake Matches L-band line 11703
34808	KakisaB	17077 17053	2017-08-09 2017-05-25	Burn study sites near Kakisa Lake Matches L-band line 34809
04005	Provid	17077 17052	2017-08-09 2017-05-23	Burn study sites accessible from Highway NT 3 near Fort Providence; Matches L-band line 04006
35301	Behcho	17076 17052	2017-08-08 2017-05-23	Burn study sites accessible from Highway NT 3 near Behchoko; Matches L-band line 35302
33101	SnareR	17077 17052	2017-08-09 2017-05-23	Snare River hydrology and water surface elevation Matches L-band line 33102
04601	FaberL	17077 17052	2017-08-09 2017-05-23	Faber Lake burn study sites Matches L-band line 04605
21404	Daring	17078 17052	2017-08-11 2017-05-23	Taiga-tundra transition from Yellowknife to the Daring Lake Research Station; Matches L-band line 21405
22800	Yellow	17076 17052	2017-08-08 2017-05-23	Burn study sites southeast of Yellowknife Matches L-band line 22801

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13 **Table 30. Region C5: Peace-Athabasca Delta and Trans-Boundary Watershed P-band Flight Line**
14 **Summary**

Line ID	Short Name	Flight	Date	Comments
00026	PADelE	17076 17051	2017-08-08 2017-05-22	Water Surface Elevation (WSE) and habitat classification in the Peace-Athabasca Delta; overlap with AirSWOT Ka-band acquisitions; Matches L-band line 36000
18034	PADelW	17076 17051	2017-08-08 2017-05-22	Water Surface Elevation (WSE) and habitat classification in the Peace-Athabasca Delta; overlap with AirSWOT Ka-band acquisitions; Matches L-band line 18035
32910	FSmitS	17076 17051	2017-08-08 2017-05-22	Water Surface Elevation (WSE) for the Slave River trans-boundary watershed; Matches L-band line 32911
33409	FSmitN	17076 17053	2017-08-08 2017-05-25	Water Surface Elevation (WSE) for the Slave River trans-boundary watershed; Matches L-band line 33410
05528	FtResN	17076 17053	2017-08-08 2017-05-25	Water Surface Elevation (WSE) and habitat classification in the Slave River Delta; Matches L-band line 05530
23403	FtResS	17076 17053	2017-08-08 2017-05-25	Water Surface Elevation (WSE) and habitat classification in the Slave River Delta; Matches L-band line 23404

17 **Table 31. Region C6: Southern Boreal Forest/BERMS P-band Flight Line Summary**

Line ID	Short Name	Flight	Date	Comments
30703	Redber	17075	2017-08-07	Calibration for AirSWOT and Water Surface Elevation (WSE) at Redberry Lake; Matches L-band line 30704
04011	SaskaS	17075	2017-08-07	AirSWOT field sites Matches L-band line 04016
04015	SaskaN	17075	2017-08-07	Transect through the BERMS research area, BOREAS Old Black Spruce (OBS) flux tower, HELICA sites Matches L-band line 04018
26105	BERMSA	17075	2017-08-07	BERMS area grid; OBS, OJP, FEN, and OAS flux towers Matches L-band line 26107
26104	BERMSB	17075	2017-08-07	BERMS area grid; OBS, OJP, FEN, and OAS flux towers Matches L-band line 26106
08107	BERMSC	17075	2017-08-07	BERMS area grid; OBS, OJP, FEN, and OAS flux towers Matches L-band line 08111
08106	BERMSD	17075	2017-08-07	BERMS area grid; OBS, OJP, FEN, and OAS flux towers Matches L-band line 08108
27303	LloydE	17075	2017-08-07	Test for ecohydrology algorithms (permafrost free zone) Matches L-band line 27304
27303	LloydW	17075	2017-08-07	Test for ecohydrology algorithms (permafrost free zone) Matches L-band line 27304
02109	FtMacM	17076 17051	2017-08-08 2017-05-22	Horse River burn transect; prairie – boreal forest ecotone Matches L-band line 02111

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*** No permafrost in this region, so early season lines not acquired, except for FtMacM, which exists in an area of sporadic permafrost ***

22 **5 Legacy Flight Lines**

23 Numerous legacy flight lines for both L- and P-band SAR were available prior to the ABoVE Airborne
 24 Campaigns. Most notably, the SMAP CANEX 2010 validation experiment acquired an intensive L-
 25 band time series over the BERMS site in northern Saskatchewan during June 2017 [ref]. These lines
 26 were revisited with P-band acquisitions during the AIRMOSS EV-S1 investigation (2012-2015).
 27 Additionally, the AIRMOSS team executed 1 L-band and 4 P-band campaigns in Alaska during the
 28 2014-15 period.

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31 **Table 32. Legacy L-band SAR Flight Plans**

Flight Plan	Date	Regions Sampled (hyperlink to flight line map)
15147	2015-10-05	Seward Peninsula, NW Alaska, & North Slope
10051	2010-06-17	BERMS-C flight line ; SMAP CanEx 2010 Campaign
10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
10049	2010-06-15	Kenaston SK Daily Time Series ; SMAP CanEx 2010 Campaign
10048	2010-06-14	Kenaston SK Daily Time Series ; SMAP CanEx 2010 Campaign
10047	2010-06-13	Kenaston SK Daily Time Series ; SMAP CanEx 2010 Campaign
10046	2010-06-09	Kenaston SK Daily Time Series ; SMAP CanEx 2010 Campaign
10045	2010-06-06	Kenaston SK Daily Time Series ; SMAP CanEx 2010 Campaign
10044	2010-06-05	Kenaston SK Daily Time Series ; SMAP CanEx 2010 Campaign
10043	2010-06-02	Kenaston SK Daily Time Series ; SMAP CanEx 2010 Campaign

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42 **Table 33. Legacy P-band SAR Flight Plans**

Flight Plan	Date	Regions Sampled (hyperlink to flight line map)
PLAN 15142	2015-10-01	Seward Peninsula, NW Alaska, & North Slope
PLAN 15124	2015-08-29	Seward Peninsula, NW Alaska, & North Slope
PLAN 15039	2015-04-08	Seward Peninsula, NW Alaska, & North Slope
PLAN 14144	2014-10-09	Seward Peninsula, NW Alaska, & North Slope
PLAN 14117	2014-08-16	North Slope
PLAN 14116	2014-08-16	Seward Peninsula, NW Alaska, & North Slope
PLAN 15139	2015-09-28	BERMSA-D
PLAN 15137	2015-09-25	BERMSA-D
PLAN 15135	2015-09-22	BERMSA-D
PLAN 15121	2015-08-26	BERMSA-D
PLAN 15119	2015-08-23	BERMSA-D
PLAN 15117	2015-08-19	BERMSA-D
PLAN 15102	2015-07-05	BERMS & SAFIRE, Northern Saskatchewan
PLAN 15101	2015-07-02	BERMSA-D
PLAN 15101	2015-07-02	BERMSA-D
PLAN 15099	2015-06-29	BERMSA-D
PLAN 14141	2014-10-07	BERMSA-D
PLAN 14138	2014-10-04	BERMSA-D
PLAN 14136	2014-10-01	BERMSA-D
PLAN 14114	2014-08-15	BERMSA-D
PLAN 14111	2014-08-12	BERMSA-D
PLAN 14084	2014-06-14	BERMSA-D
PLAN 14080	2014-06-11	BERMSA-D
PLAN 14078	2014-06-08	BERMSA-D
PLAN 13141	2013-08-02	BERMSA-D
PLAN 13139	2013-07-29	BERMSA-D
PLAN 13137	2013-07-27	BERMSA-D
PLAN 13084	2013-05-01	BERMSA-D
PLAN 13078	2013-04-26	BERMSA-D
PLAN 13070	2013-04-22	BERMSA-D
PLAN 12101	2012-10-11	BERMSA-D
PLAN 12095	2012-10-07	BERMSA-D
PLAN 12090	2012-10-04	BERMSA-D

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47 5.1 Alaska SAR Legacy Flight Lines

48 The Alaska P-band SAR legacy data (Figure 18)
49 are available via the ORNL DAAC [Lou 2019;
50 <https://doi.org/10.3334/ORNLDAAC/1678>].
51 This data set provides level 1 (L1) polarimetric
52 radar backscattering coefficient (σ_0), multi-
53 look complex, polarimetrically calibrated, and
54 georeferenced data products from the Airborne
55 Microwave Observatory of Subcanopy and
56 Subsurface (AirMOSS) radar instrument
57 collected over 10 study sites across Northern
58 Alaska (Figure 18). Flight campaigns took place
59 in August 2014, October 2014, April 2015,
60 August 2015, September 2015, and October
61 2015 (Table 34). The L1 P-band radar
62 backscatter data can be used to derive estimates
63 of soil water content and permafrost state. P-
64 band flights over the North Slope during the
65 early cold season (\sim DOY 280) have the promise
66 of retrieving zero curtain layer and increasing
67 understanding of non-growing season CO_2 and
68 CH_4 fluxes [Zona 2016; Natali 20xx]

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70 Corresponding Alaska legacy L-band data were
71 acquired during a single sortie on 5 October 2015
72 (Figure 19, Table 35). Note the slightly different
73 line IDs between L-band and P-band acquisitions
74 for the same locations.

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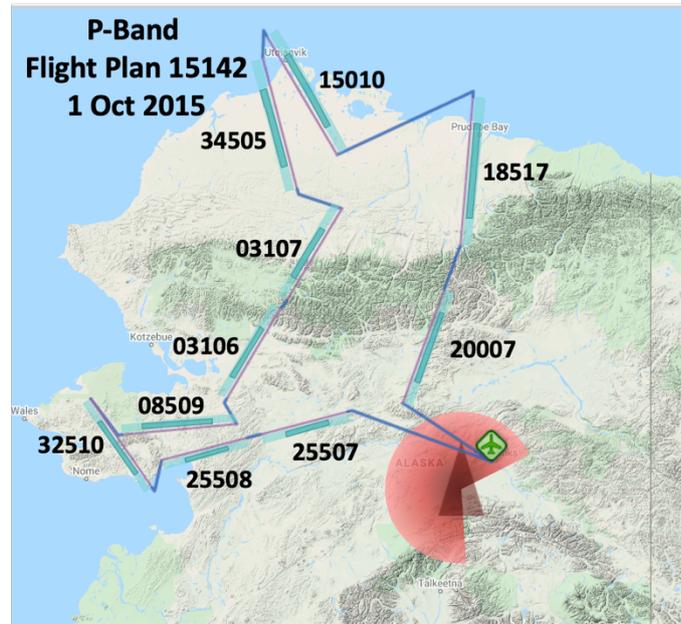


Figure 18. Alaska P-band SAR legacy lines from flight plan 15142 flown on 1 October 2015. Line IDs are given next to the lines. The large red areas in the Interior show P-band radar keep-out zones associated with the military radar at Clear, AK. © Google Maps

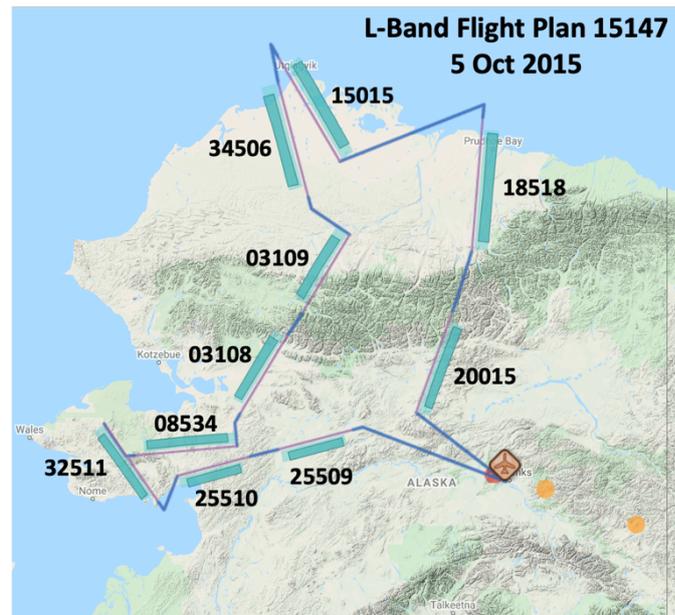


Figure 19. Alaska L-band legacy Flight Plan 15147 flown on 5 October, 2015. Flight line IDs are given next to each line. See Figure 18 for the corresponding P-band legacy flight lines. © Google Maps

80 **Table 34. Alaska Legacy P-band SAR Data**

Line ID	Short Name	Flight Plan	Date	Comments
25507	huslia	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 25509
27059	permaf	14116	2014-08-16	Legacy P-band line; Matches L-band legacy line 25509
25508	koyukk	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 25510
25504	permaf	14116	2014-08-16	Legacy P-band line; Matches L-band legacy line 25510
32510	counci	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 32511
33008	permaf	14116	2014-08-16	Legacy P-band line; Matches L-band legacy line 32511
08509	kougar	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 08534
08601	permaf	14116	2014-08-16	Legacy P-band line; Matches L-band legacy line 08534
03106	ambler	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 03108
03101	permaf	14116	2014-08-16	Legacy P-band line; Matches L-band legacy line 03108
03107	ivotuk	15142 15124 15039	2015-10-05 2015-08-29 2015-04-08	Legacy P-band line; Matches L-band legacy line 03109

		14144	2014-10-09	
03102	permaf	14116	2014-08-16	Legacy P-band line; Matches L-band legacy line 03109
34505	atqasu	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 34506
34503	permaf	14116	2014-08-16	Legacy P-band line; Matches L-band legacy line 34506
15010	barrow	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 15015
18517	dhorse	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 18518
20007	coldfo	15142 15124 15039 14144 14117	2015-10-05 2015-08-29 2015-04-08 2014-10-09 2014-08-16	Legacy P-band line; Matches L-band legacy line 20015

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Table 35. Alaska Legacy L-band Flight Line Summary Data

Line ID	Short Name	Flight Plan	Date	Comments
25509	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 25507
25510	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 25508
32511	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 32510
08534	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 08509
03108	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 03106
03109	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 03107
34506	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 34505
15015	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 15010
18518	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 18517
20015	Permaf	15147	2015-10-05	Legacy L-band line; Matching P-band legacy line 20007

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84 **5.2 L-band SAR Legacy Flight Lines - BERMS**

85 Boreal Forest sampling over the BERMS sites and
 86 Kenaston SK- CanEx 2010 boreal forest field
 87 campaign for SMAP [Maggai 2012; Djamai 2015] and
 88 AirMOSS regular sampling site [Moghaddam]

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Figure 20. Legacy L-band flight lines acquired over the BERMS site during the SMAP CANEX-2010 campaign. These lines link L-band SAR acquired during ABoVE to BOREAS era measurements [Sellers 1994, 1997]. See Table S3 for flight line details. © Google Maps

Table 36. BERMS-C Grid Legacy L-band Flight Line Summary Data

Line ID	Short Name	Flight Plan	Date	Comments
00901	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00902	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00903	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00904	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00905	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00906	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00907	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00908	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00909	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign
00910	bermsC	10050	2010-06-16	BERMS boreal forest grid ; SMAP CanEx 2010 Campaign

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01 **6 Acronyms and Abbreviations**02 **Table 37. List of Acronyms and Abbreviations**

Acronym	Name	Description
ABoVE	Arctic Boreal Vulnerability Experiment (ABoVE)	NASA Terrestrial Ecology Program’s 10-year community field experiment designed to evaluate the vulnerability/resilience of Arctic ecosystems to change
AirMOSS	Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS)	An EV-S1 investigation deploying an airborne P-band SAR based on the UAVSAR/L-band system (PI M. Moghaddam). AirMOSS made flights over BERMS (2012-2015) and Alaska (2014, 2015) providing legacy data for ABoVE.
AirSWOT	Airborne instrument for supporting the SWOT mission (AirSWOT)	AirSWOT is an airborne instrument for supporting the SWOT mission. AirSWOT is designed to make interferometric measurements similar to those that will be made in space by SWOT. AirSWOT data will also be used to help calibrate and validate SWOT data and can be used additionally for science studies in their own right.
ALT	Active Layer Thickness (ALT)	Active Layer Thickness (ALT), defined as the maximum depth of seasonally thawed soil overlying permafrost, is critical for understanding the effects of climate warming, disturbance, and hydrologic changes on permafrost degradation in cold regions
BERMS	Boreal Ecosystem Research and Monitoring Sites (BERMS)	The Boreal Ecosystem Research and Monitoring Sites (BERMS) are located in the southern edge of the boreal plains ecozone in Saskatchewan, Canada. The four BERMS sites, covering 4 different forest vegetation types common to the Boreal Plains are: Fen, Old Jack Pine (OJP), Old Black Spruce (OBS), and Old Aspen (OA). ‘Old’ refers to the monitoring site being located within a mature stand of trees.
BIOMASS	BIOMASS (mission name)	Carrying a novel P-band synthetic aperture radar, the Biomass mission is designed to deliver crucial information about the state of our forests and how they are changing, and to further our knowledge of the role forests play in the carbon cycle. planned for launch by the European Space Agency (ESA) in August 2023.
BOREAS	Boreal Ecosystem–Atmosphere Study (BOREAS)	The Boreal Ecosystem-Atmosphere Study (BOREAS) was a large-scale international interdisciplinary experiment in the boreal forests of central Canada. Its focus was improving our understanding of the exchanges of radiative energy, sensible heat, water, CO2 and trace gases between the boreal forest and the lower atmosphere.
CALM	Circumpolar Active Layer Monitoring network (CALM)	The primary goal of the Circumpolar Active Layer Monitoring (CALM) program is to observe the response of the active layer and near-surface permafrost to climate change over long (multi-decadal) time scales.
CanEx	SMAP CanEx 2010	2010 Canadian soil moisture field campaign run by the SMAP team over the BERMS sites [Magagi 2012]
CCRN	Canadian Changing Cold Regions Network (CCRN)	CCRN’s overall aims were to integrate existing and new sources of data with improved predictive and observational tools to understand, diagnose and predict interactions amongst the cryospheric, ecological, hydrological, and climatic components of the changing Earth system at multiple scales, with a geographic focus on Western Canada’s rapidly changing cold interior. CCRN operated from 2013-2018.
CFS	Canadian Forest Service (CFS)	The Canadian Forest Service is the national and international voice for Canada’s forest sector. We are part of Natural Resources Canada, a federal government department, and have an office in Ottawa and 6 research centres across the country. We collaborate closely with Canada’s provinces and territories to ensure our forests are sustainable and healthy

CIPHA	Climate Impacts on Productivity and Health of Aspen (CIPHA)	The Canadian Forest Service’s Climate Impacts on Productivity and Health of Aspen (CIPHA) study includes a network of 180 research plots aimed at tracking dieback and changes in the growth of aspen forests across the boreal forest. Trembling aspen , also known locally as “white poplar,” is the most abundant deciduous tree in Canada’s boreal forest, where it is important both ecologically and commercially. Recent severe droughts have led to widespread dieback and decline of aspen and other types of forests across large areas of west-central Canada, prompting concerns for the future in a changing climate.
DAAC	Distributed Active Archive Center	The NASA TE program data, including ABoVE data , are archived at the ORNL DAAC
DLR	German Space Agency (DLR)	DLR is the Federal Republic of Germany's research centre for aeronautics and space. We conduct research and development activities in the fields of aeronautics, space, energy, transport, security and digitalisation.
DOY	Day of Year (DOY)	The Day-of-Year (DOY) numbering system is a common format used in research data and by the military. The Day-of-Year system ignores the existence of months and numbers each day of the year consecutively.
EV-S1	Earth Ventures Sub-orbital (EV-1)	The EV-S1 airborne-science investigations are Principal Investigator-led, temporally-sustained, airborne-science investigations. They are broader in scope than typical airborne-science missions due to multiple deployments, sustained science data collection and operations spanning several years. The AirMOSS EV-S1 mission and ABoVE precursor ran from 2010-2015
F-SAR	F-SAR – DLR’s New Airborne SAR System	DLR’s advanced airborne SAR testbed for technology and remote sensing applications. F-SAR operates fully polarimetric at X-, C-, S-, L- and P-bands and features single-pass polarimetric interferometric SAR (PolInSAR) capabilities in X- and S-bands [Reigber 2013].; flew over the ABoVE domain in August 2018
FMS	Flight Management System (FMS)	A Flight Management System (FMS) is an on-board multi-purpose navigation, performance, and aircraft operations computer designed to provide virtual data and operational harmony between closed and open elements associated with a flight from pre-engine start and take-off, to landing and engine shut-down.
GeoSAR	Geographic Synthetic Aperture Radar (GeoSAR)	GeoSAR was an airborne state-of-the-art, dual-band (P-band and X-band), dual-sided, single-pass interferometric mapping radar, designed to efficiently map wide-area, both top vegetation canopies and the terrain beneath the canopy. GeoSAR was a precursor of the UAVSAR instrument.
GNWT	Government of the Northwest Territories (GNWT)	GNWT supports ABoVE activities in the NWT, especially via its Climate and Environment & Energy programs. See the 2030 NWT Climate Change Strategic Framework
GPS	Global Positioning System (GPS)	The Global Positioning System (GPS) is a U.S.-owned utility that provides users with positioning, navigation, and timing (PNT) services. This system consists of three segments: the space segment, the control segment, and the user segment. The U.S. Space Force develops, maintains, and operates the space and control segments.
GTN-P	Global Terrestrial Network for Permafrost (GTN-P)	The Global Terrestrial Network for Permafrost (GTN-P) is the primary international programme concerned with monitoring permafrost parameters. GTN-P was developed in the 1990s by the International Permafrost Association (IPA) under the Global Climate Observing System (GCOS) and the Global Terrestrial Observing Network (GTOS) , with the long-term goal of obtaining a comprehensive view of the spatial structure, trends and variability of changes in the active layer thickness and permafrost temperature.
HEL CIA	High Elevation & Latitude Climate Change Impacts & Adaptation (HEL CIA)	A collaborative initiative under the NRCAN-CFS Forest Change Program

InSAR	Interferometric Synthetic Aperture Radar (InSAR)	Interferometric Synthetic Aperture Radar (InSAR) is an effective way to measure changes in land surface altitude. InSAR makes high-density measurements over large areas by using radar signals from Earth-orbiting satellites to measure changes in land-surface altitude at high degrees of measurement resolution and spatial detail. Synthetic Aperture Radar (SAR) imagery is produced by reflecting radar signals off a target area and measuring the two-way travel time back to the satellite. The SAR interferometry technique uses two SAR images of the same area acquired at different times and "interferes" (differences) them, resulting in maps called interferograms that show ground-surface displacement (range change) between the two time periods.
ISRO	Indian Space Research Organization (ISRO)	ISRO's vision is to harness space technology for national development, while pursuing space science research and planetary exploration. ISRO owns the LS-ASAR airborne instrument and is NASA's partner in the NISAR mission.
KaSPAR	Ka-band SWOT Phenomenology Airborne Radar (KaSPAR)	The core of AirSWOT is the Ka-band SWOT Phenomenology Airborne Radar (KaSPAR). It collects two swaths of across-track interferometry data - between nadir and 1 km and between 1 km and 5 km, respectively - which can be used to obtain centimeter-level topographic maps of water surfaces. In addition, KaSPAR has an along-track interferometer that can be used to measure the temporal decorrelation of water surfaces, as well as the water radial velocity.
LiDAR	Light Detection and Ranging (lidar)	Lidar is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses—combined with other data recorded by the airborne system — generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.
LS-ASAR	L- and S-Band-Airborne SAR (LS-ASAR)	As a precursor to the NISAR mission, ISRO has developed a L- and S-Band-Airborne SAR (LS-ASAR) to prepare the community to maximize the scientific and societal benefits of NISAR data [Ramanujam 2016; 2019; Mehra 2019]. LS-ASAR operates in Dual, Quad, and Hybrid and Polarization modes in both L- and S-bands. It covers incidence angles from 24°-77°
LTER	Long Term Ecological Research (LTER)	The LTER Network was founded in 1980 by the National Science Foundation with the recognition that long-term research could help unravel the principles and processes of ecological science, which frequently involves long-lived species, legacy influences, and rare events. LTER's mission is to provide the scientific community, policy makers, and society with the knowledge and predictive understanding necessary to conserve, protect, and manage the nation's ecosystems, their biodiversity, and the services they provide.
LVIS	Land, Vegetation, and Ice Sensor (LVIS)	LVIS is an airborne, full waveform scanning laser altimeter which produces topographic maps with decimeter accuracy as well as vegetation vertical height and structure measurements [Blair 1999a,b]. LVIS became a NASA Facility Instrument in 2019.
NEON	National Ecological Observatory Network (NEON)	NSF's National Ecological Observatory Network (NEON) program provides open, continental-scale data across the United States that characterize and quantify complex, rapidly changing ecological processes. Its Tundra (D-19) and Taiga (D-18) observatories in Alaska are key ground truth sites for ABoVE airborne SAR data collections
NGEE-Arctic	Next Generation Ecological Experiment-Arctic (NGEE-Arctic)	The Next-Generation Ecosystem Experiments (NGEE Arctic) is a 10-year project (2012—2022) to improve our predictive understanding of carbon (C)-rich Arctic system processes and feedbacks to climate. This is achieved through experiments, observations, and synthesis of existing datasets that strategically inform model process representation and parameterization, and that enhance the knowledge base required for model initialization, calibration, and evaluation. The NGEE-Arctic Seward Peninsula and Barrow area sites provide critical ground truth data for ABoVE airborne SAR data

NISAR	NASA-ISRO SAR (NISAR) mission	NISAR is a joint Earth-observing mission between NASA and the Indian Space Research Organization (ISRO) with the goal to make global measurements of the causes and consequences of land surface changes using advanced radar imaging. To be launched in early 2023, NISAR will employ L- and S-band SARs to measure Earth's changing ecosystems, dynamic surfaces, and ice masses. NISAR will observe Earth's land and ice-covered surfaces globally with 12-day regularity on ascending and descending passes, sampling Earth on average every 6 days for a baseline 3-year mission [Rosen 2017]
NoFC	Northern Forestry Centre (NoFC)	The Northern Forestry Centre is one of five research centres operated by the Canadian Forest Service. It is located in Edmonton, Alberta. It's primary research areas are: Boreal ecosystem ecology, Climate Change and forests research, Land reclamation, and Wildland fire. ABoVE SAR flight lines target many of its forest inventory, CIPHA and HELCIA sites for ground truth measurements
NWT	Northwest Territories (NWT)	Northwest Territories, region of northern and northwestern Canada encompassing ~1.35 Mkm ² of forests and tundra. The NWT are bordered by Nunavut to the east, the provinces of Saskatchewan , Alberta , and British Columbia to the south, and Yukon to the west. NWT lands are a focal point for ABoVE airborne SAR campaigns, with Yellowknife serving as a base of operations
OAS	Old Aspen (OAS)	BERMS Flux tower site; CA-Oas: Saskatchewan - Western Boreal, Mature Aspen; 53.62889° N, 106.19779° W, elevation of 600.63 m, BOREAS 1994, 1996, BERMS climate and flux measurements began Dec. 1996. The Old Aspen site ended operations in 2017 and has since been decommissioned.
OBS	Old Black Spruce (OBS)	BERMS Flux tower site; CA-Obs: Saskatchewan - Western Boreal, Mature Black Spruce; 53.98717° N, 105.11779° W, elevation of 628.94 m, BOREAS 1994, 1996, BERMS climate measurements began Dec. 1996 and flux measurements in Apr. 1999
OJP	Old Jack Pine (OJP)	BERMS Flux tower site; CA-Ojp: Saskatchewan - Western Boreal, Mature Jack Pine; 53.91634° N, 104.69203° W, elevation of 579.27 m, BOREAS 1994, BERMS climate measurements began Mar. 1997 and flux measurements Aug. 1999
ORNL	Oak Ridge National Laboratory (ORNL)	Home of the ABoVE DAAC and NGEA-Arctic leadership
PALSAR	Phased Array type L-band Synthetic Aperture Radar (PALSAR)	The Phased Array type L-band Synthetic Aperture Radar (PALSAR, launched in 2006) is an active microwave sensor using L-band frequency to achieve cloud-free and day-and-night land observation. PALSAR provides 10m resolution in a conventional mode, but can acquire a 250 to 350 km width of SAR images (depending on the number of scans) at the expense of spatial resolution. The development of the PALSAR is a joint project between JAXA and the Japan Resources Observation System Organization (JAROS). PALSAR acquisitions across the ABoVE domain provide a valuable baseline for ABoVE airborne SAR comparisons.
PALSAR-2	Phased Array type L-band Synthetic Aperture Radar 2 (PALSAR-2)	PALSAR-2 (launched in 2014 aboard ALOS-2) is the successor to JAXA's Phased Array type L-band Synthetic Aperture Radar (PALSAR). ALOS-2/PALSAR-2 has a spotlight mode (1m × 3m resolution in azimuth × range direction) as well as right and left viewing capabilities.
PDO	Permafrost Dynamics Observatory (PDO)	The PDO algorithm uses L-band InSAR to measure seasonal surface subsidence due to the thawing of the active layer and the P-band backscatter to measure soil moisture. The combined PDO algorithm estimates seasonal subsidence, ALT, and the vertical soil moisture profile [Michaelides 2021; Chen 2021a,b]
PermASAR	permafrost airborne SAR experiment (PermASAR)	DLR's permafrost airborne SAR experiment (PermASAR) deployed F-SAR to northern Canada in August 2018 and April 2019. F-SAR flight lines sampled many ABoVE L-band transects

POLAR	Polar Knowledge Canada (POLAR)	Polar Knowledge Canada (POLAR) is responsible for advancing Canada’s knowledge of the Arctic, strengthening Canadian leadership in polar science and technology, and promoting the development and distribution of knowledge of other circumpolar regions, including Antarctica. POLAR operates the Canadian High Arctic Research Station (CHARS) campus and conducts world-class cutting edge Arctic research out of this extraordinary facility. POLAR is ABoVE’s primary Canadian partner.
PolInSAR	Polarimetric Interferometric Synthetic Aperture Radar (PolInSAR)	Known by the unwieldy acronym, POLinSAR, the technique combines varying the orientation, or polarisation, of radar signals (POLarimetry) with the analysis of the phase differences in the signal to produce differential range and range-change measurements (interferometry) from two or more images captured by synthetic aperture radars (SARs). Taken together, polarimetry and interferometry offers the potential to see the Earth in three dimensions.
PPA	Platform Precision Autopilot (PPA)	The real-time platform control system that confines the repeat flight path to within a 10 m tube over a 200 km course in conditions of calm to light turbulence; enables repeat-pass SAR interferometry for the airborne L- and P-band sensors
RADARSAT	RADARSAT (mission name)	RADASAT-1 (launched 4 November 1995 by the Canadian Space Agency) was a C-band radar with 8m x 8m spatial resolution. RADASAT-2 (launched 14 December 2007) was a C-band radar with 1m x 3m spatial resolution in spotlight mode. It has routine left- and right-looking operation and increased re-visit frequency for improved monitoring efficiencies. It offers enhanced marine surveillance, ice monitoring, disaster management, environmental monitoring, resource management and mapping in the Arctic.
RCM	RADARSAT Constellation Mission (RCM)	The RADARSAT Constellation Mission (RCM) is Canada's new generation of Earth observation C-band radars. Launched on June 12, 2019 by the Canadian Space Agency, the three identical satellites are capable of scanning Earth day or night and in any weather conditions with 1m x 3m spatial resolution in spotlight mode. The three-satellite configuration allows for daily revisits of Canada's vast territory and maritime approaches, as well as access to the Arctic up to four times a day.
ReSALT	remotely sensed active layer thickness (ReSALT)	An algorithm which uses spaceborne InSAR measurements of the seasonal deformation of the thawing active layer to estimate the total active layer thickness [Schaefer 2015]
RH100	Relative Height 100 th percentile (RH100)	LVIS canopy height is provided as the mean height (in meters) above ground of the received waveform signal that was the first reflection off the top of the canopy (RH100). RH100 or relative height is the 100 th percentile of waveform energy relative to ground elevation. Derived from the L2B LIDAR metric RH100 data product.
ROSE-L	Copernicus Radar Observation System for Europe in L-band (ROSE-L)	With launch planned in 2028, the new high-priority Copernicus Radar Observation System for Europe in L-band (ROSE-L) environmental monitoring mission will provide information for monitoring forest type and cover in support of biomass estimation, as well as soil moisture, vegetation and land ice – as part of Europe’s Copernicus programme. The mission will automatically map and monitor sea and land ice, greatly helping climate change research. ROSE-L will provide continuous day-and-night all-weather monitoring of Earth’s land, oceans and ice, and offer frequent images at a high spatial resolution.
SAR	Synthetic Aperture Radar (SAR)	Synthetic-aperture radar (SAR) remote sensing is usually implemented by mounting, on a moving platform such as an aircraft or spacecraft, a single beam-forming antenna from which a target scene is repeatedly illuminated with pulses of microwaves at wavelengths anywhere from a meter down to millimeters. A sequence of acquisitions from a shorter antenna are combined to simulate a much larger antenna (the synthetic aperture), thus increasing the spatial resolution data

SDC	Surface Deformation and Change (SDC)	The Surface Deformation and Change (SDC) Targeted Observable will use deformation measurements, such as Synthetic Aperture Radar Interferometry (InSAR), to understand the dynamics of earthquakes, volcanoes, landslides, glaciers, groundwater and the deep interior; for quantifying the rates and driving processes of sea-level change and landscape change; and for supporting hazard forecasts and disaster impact assessments. SDC architectures are being studied for a potential launch in the late 2020s.
Sentinel-1	Sentinel-1 (mission name)	The Sentinel-1 mission is the European Radar Observatory for the Copernicus joint initiative of the European Commission (EC) and the European Space Agency (ESA). The Sentinel-1 mission comprises a constellation of two polar-orbiting satellites, operating day and night performing C-band synthetic aperture radar imaging, enabling them to acquire imagery regardless of the weather. The Sentinel-1 mission includes C-band imaging operating in four exclusive imaging modes with different resolution (down to 5 m) and coverage (up to 400 km). It provides dual polarisation capability, very short revisit times and rapid product delivery. Sentinel-1A was launched on 3 April 2014. Sentinel-1B was launched on 25 April 2016. Each has an operational lifespan of seven years with consumables for 12 years. Sentinel-1C and Sentinel-1D are planned to replace the first two satellites at the end of their operational lifespan.
SMAP	Soil Moisture Active/Passive (SMAP)	SMAP is an Earth satellite mission designed to measure and map Earth's soil moisture and freeze/thaw state to better understand terrestrial water, carbon and energy cycles
SnowEx	Snow Experiment (SnowEx)	SnowEx is a five-year program initiated and funded by the NASA Terrestrial Hydrology Program to address the most important gaps in snow remote sensing knowledge. A joint SnowEx-ABOVE tundra-taiga snowscapes campaign is planned for Alaska during the January – May 2023 period.
SWOT	Surface Water and Ocean Topography (SWOT)	The SWOT mission will be NASA's first global survey of Earth's surface water. SWOT is being jointly developed by NASA and Centre National D'Etudes Spatiales (CNES) with contributions from the Canadian Space Agency (CSA) and United Kingdom Space Agency .
TomoSAR	tomographic SAR (tomoSAR)	Synthetic aperture radar tomography (TomoSAR) at lower frequencies allows the reconstruction of the 3-D radar reflectivity of volume scatterers allowing access to their physical 3-D structure by means of multiangular SAR acquisitions. The performance of the reconstruction critically depends on the number and (spatial) distribution of the tomographic acquisitions (tracks).
UAVSAR	Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)	NASA's airborne L-band SAR; a compact pod-mounted polarimetric instrument for interferometric repeat-track observations
VWC	Volumetric Water Content (VWC)	The volumetric water content is the ratio of the volume of water to the unit volume of soil. Volumetric water content can be expressed as ratio, percentage or depth of water per depth of soil (assuming a unit surface area), such as inches of water per foot of soil.

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