

Spring 2013 IceBridge P-3 Flight Plans
11 March 2013 Draft

compiled by

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Introduction to Flight Plans

This document is a translation of the NASA Operation IceBridge (OIB) scientific objectives articulated in the Level 1 OIB Science Requirements, at the January IceBridge Arctic planning meeting held at NASA GSFC, through official science team telecons and through e-mail communication and iterations into a series of operationally realistic flight plans, intended to be flown by NASA's P-3 aircraft, beginning in mid-March and ending in early May 2013. The material is shown on the following pages in the distilled form of a map and brief text description of each science flight. Google Earth (KML) versions of these flight plans are available via anonymous FTP at the following address: <ftp://atm.wff.nasa.gov/outgoing/oibscienceteam/>. Note that some users have reported problems connecting to this address with certain browsers. Command-line FTP and software tools such as Filezilla may be of help in such situations.

For each planned mission, we give a map and brief text description for the mission. The missions are planned to be flown from Thule and Kangerlussuaq, Greenland, and Fairbanks, Alaska. At the end of the document we add an appendix of composite maps portraying several distinct regions of Greenland with all missions shown in context with each other and superimposed on the Rignot et al InSAR surface velocity map. A careful reader may notice that some of the mission maps in the main part of the document highlight flightlines in green, yellow, and red colors, while other only show the black lines. The colors are a refinement added to the flight plans at a late stage of design which help the field team navigate the aircraft properly to achieve specific science goals. The colors represent the degree of “straightness” of each flight segment, where straight segments are steered using an automated technique and curved sections using a specialized manual method. Not all of the flight plans shown here have necessarily reached that mature stage of design.

In fact, as a general rule the flight plans depicted here are all at varying stages of completeness. For each mission we note “Remaining Design Issues” to be resolved, if any exist. In most cases these are minor. CryoSat underflights are a major exception, since these have to be re-planned for each potential flight day (for sea ice) or within a window of several potential flight days (for land ice).

Several of the Greenland missions can be configured either as round-trip missions originating and ending at the same base, or as transit flights between Thule and Kangerlussuaq. These are prominently identified in the text accompanying the missions. The field team will ensure that the highest-priority flights are completed as weather and logistical considerations allow, and the transit missions will be configured and selected accordingly.

Note that this document shows 39 planned land ice and 13 planned sea ice missions, which is more than we expect to fly this year. The extra flight plans give us operational flexibility to fly as much as possible, and scientifically productive, while we are in the field.

Each flight has a priority assigned to it by the OIB science team, either high, medium or low, and these are listed below with each mission. For the sea ice flights, these priorities should be sufficient to inform decision-making in the field. But for land ice, which usually has many more mission candidates for any given day, the field team may require more guidance regarding relative importance of the missions than these simple priorities alone provide. To address this, the science team has provided the following guidance regarding overall land ice priorities of the field campaign:

1. Complete a Jakobshavn resurvey each year.
2. Fill in elevation (and other coincident measurement) gaps.

3. Collect data which will enable, or assist with, interpretation of measured elevation changes.
4. Support other field programs as resources allow.

For the sea ice flights, a new consideration for the 2013 spring campaign is the possibility of conducting some of the flights during the field team's later stay in Thule, in the latter half of April. Since this is relatively late in the spring season for sea ice, the OIB science team identified three missions which are most suitable to be flown during this later window, given recent surface temperatures. These three missions are prominently identified in the text accompanying each mission. At the request of the OIB Project Science Office, the sea ice science team will review the status of the sea ice missions shortly after the P-3 transitions its base of operations from Thule to Kangerlussuaq in early April. The team will also assess a range of products to assess the state of surface temperatures. Based on this information, the sea ice science team will provide additional guidance regarding the feasibility and priority of conducting remaining flight lines during the later stay in Thule.

IceBridge Mission Statement

Operation IceBridge will employ aircraft to monitor the most sensitive and critical areas of sea ice, ice sheets and glaciers during the gap in satellite coverage caused by the failure of ICESat-1, in 2009, and the launch of ICESat-2, planned for 2016. Sensitive and critical areas include coastal Greenland and especially its outlet glaciers, coastal Antarctica including the Antarctic Peninsula and ice shelves, the sea ice of the Arctic and Antarctic and the southeast Alaskan glaciers. Data collected by IceBridge will improve our knowledge of the contribution of the Greenland and Antarctic ice sheets to sea level rise and will make fundamental contributions to the understanding of changes occurring in the extent and thickness of the polar sea ice cover. Given the societal importance of understanding changes in sea level rise and sea ice extent, IceBridge data will monitor and improve modeling efforts for sea ice, ice sheet and glaciers. IceBridge will also prepare for the future of airborne monitoring efforts of the cryosphere by adapting existing instruments for high altitude unmanned aerial systems such as the NASA Global Hawk.

IceBridge Science Objectives

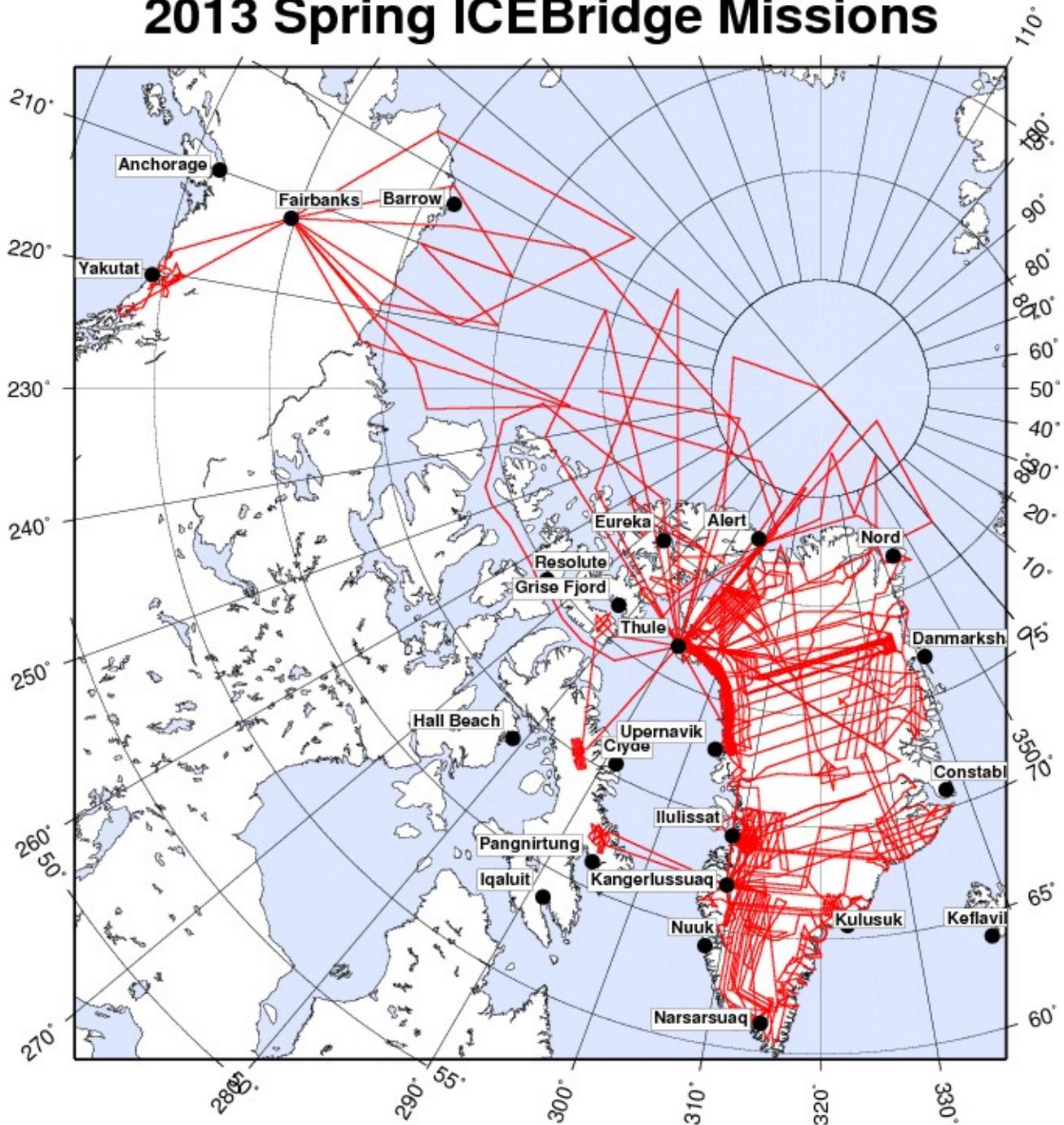
The following are the major science objectives of Operation IceBridge in priority order and are met by the following flight plans:

- 1) Make airborne laser altimetry measurements over the ice sheets and sea ice to fill in the data gap between the failure of ICESat-1 in 2009 and the launch of ICESat-2 planned for 2015.
- 2) Link measurements made by ICESat, ICESat-2, and CryoSat-2 to allow their comparison and the production of a long-term, ice sheet altimetry record.
- 3) Use airborne altimetry and radar to monitor key, rapidly changing areas of ice, including sea ice, ice sheets and glaciers, in the Arctic and Antarctic to maintain a long term observation record, improve understanding of glacial dynamics, and augment predictive models of sea level rise and sea ice cover.
- 4) In conjunction with altimetry measurements, collect other remotely sensed data to improve predictive models of sea level rise and sea ice cover, especially the following:
 - Ice sheet and sea ice thickness, structure and extent;
 - Bed topography underlying land-based ice;
 - Bathymetry beneath floating ice shelves;
 - Snow accumulation and firn structure; and

- Other geophysical constraints that will improve estimates of the geothermal and oceanic heat flux

5) Adapt existing instruments for airborne remote sensing of ice by high altitude unmanned aerial systems such as the NASA Global Hawk.

2013 Spring ICEBridge Missions



Sea Ice – Laxon Line / Thule - Fairbanks

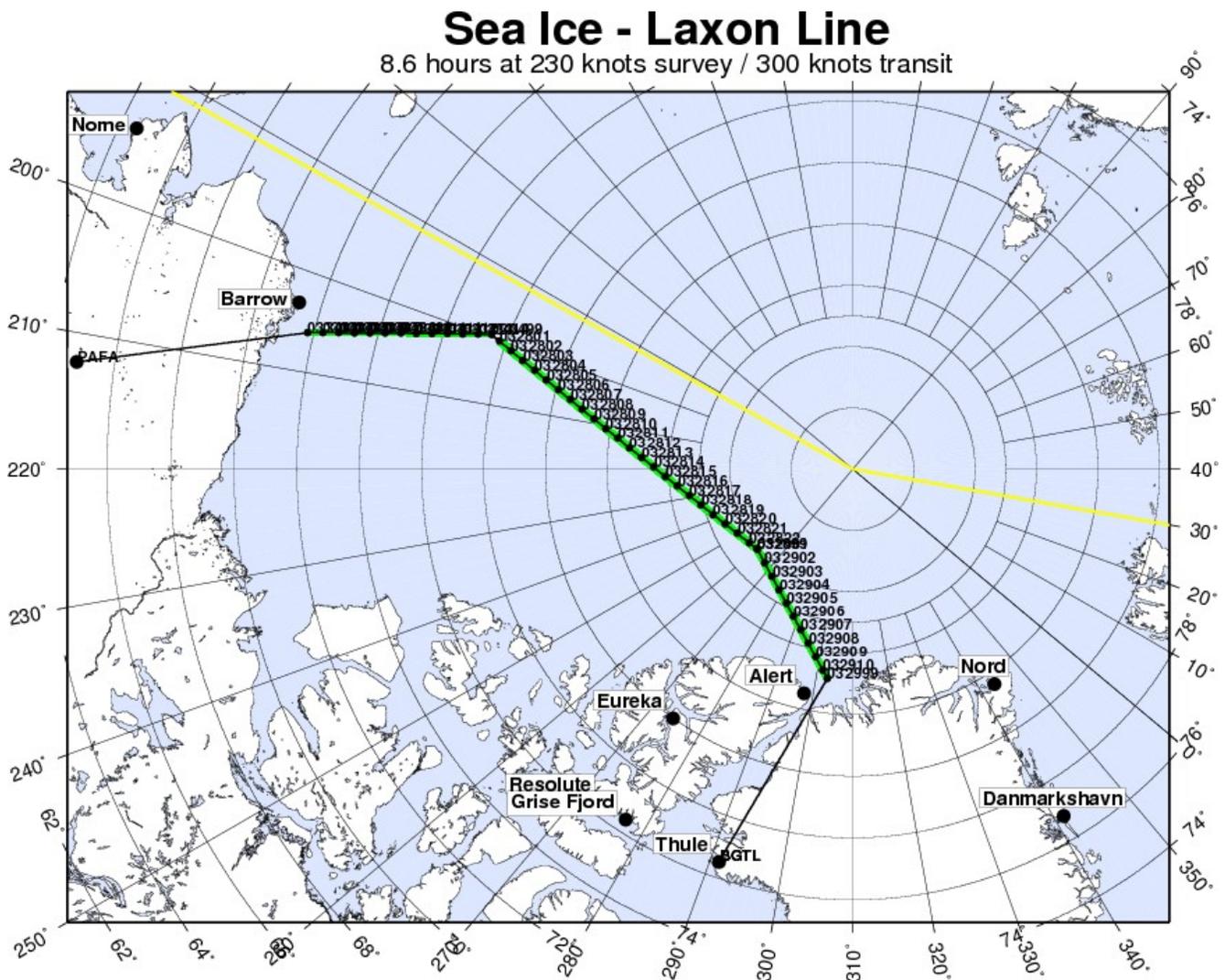
This mission is a near-exact repeat of similar missions flown each year of OIB beginning in 2009. In addition to Level-1 Requirements SI1 and SI2, the flight addresses sea ice level 1 baseline requirement SI3a by providing data on the thickness gradient and distribution of perennial and seasonal ice across the Arctic Basin. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: high

ICESat Tracks: 0329,0328,0334

Last Flown: 2012

Remaining Design Issues: none



Sea Ice – South Basin Transect / Thule - Fairbanks

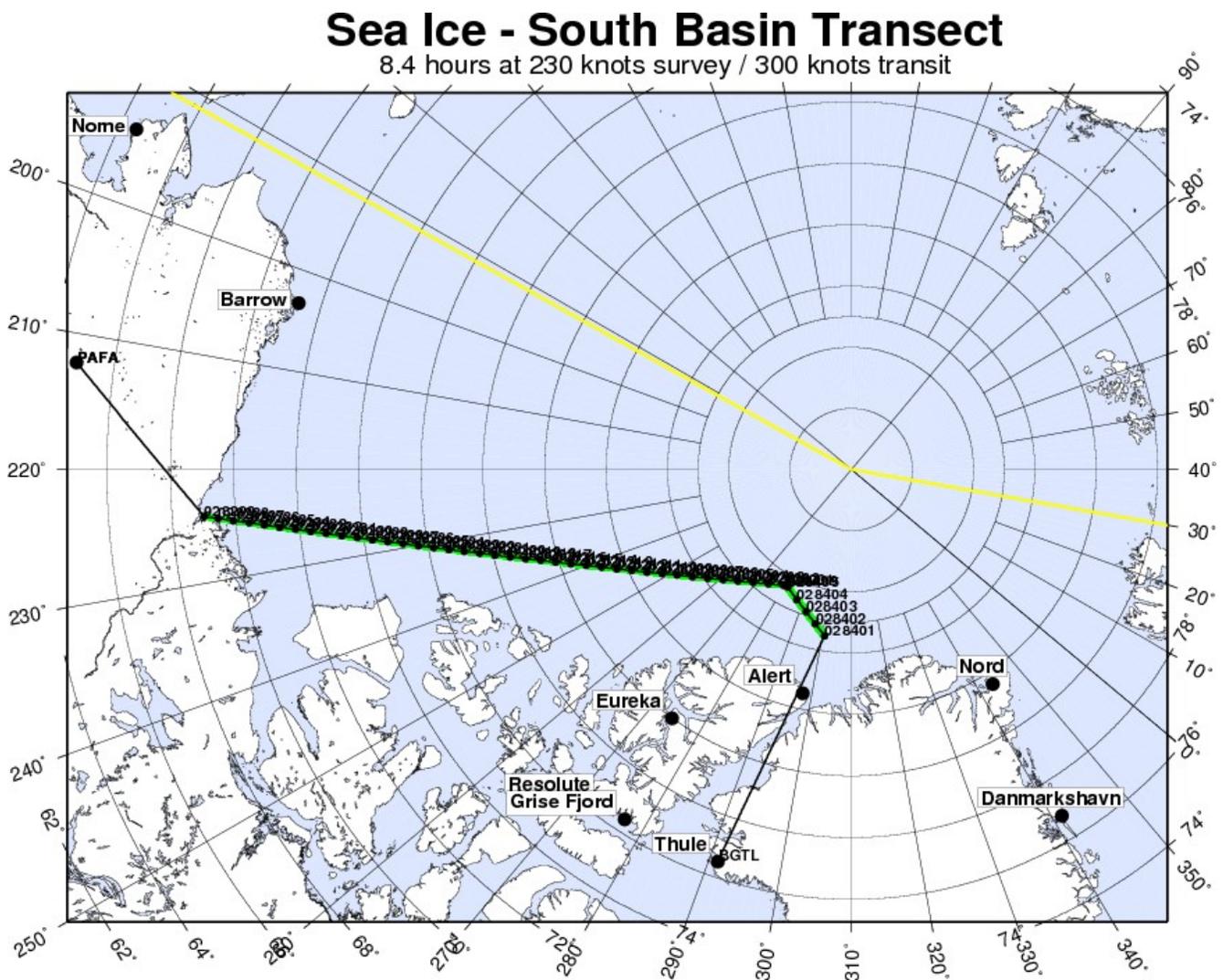
This mission is a repeat of missions flown each year of OIB beginning in 2009. Timing on this flight is very tight because we prefer at least predawn twilight lighting conditions for VFR flight once off the northern Alaska coast, but also must land at Thule before the airfield closes at 1600 local time, which is five hours ahead of Fairbanks local time. In addition to Level-1 Requirements SI1 and SI2, it addresses sea ice level 1 baseline requirement SI3a by providing data on the thickness gradient and distribution of perennial and seasonal ice across the Arctic Basin. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: high

ICESat Tracks: 0282,0284

Last Flown: 2012

Remaining Design Issues: none



Sea Ice – Beaufort-Chukchi Diamond / Fairbanks

This is a repeat of a mission first flown in 2012. It is designed to sample sea ice in the western Arctic Basin along north-south gradients in the Chukchi and Beaufort Seas. In addition to Level-1 Requirements SI1 and SI2, it addresses sea ice level projected requirement SIP2d by extending sea ice baseline observations to the southern Chukchi Sea north of the Bering Strait. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: high

ICESat Tracks: none

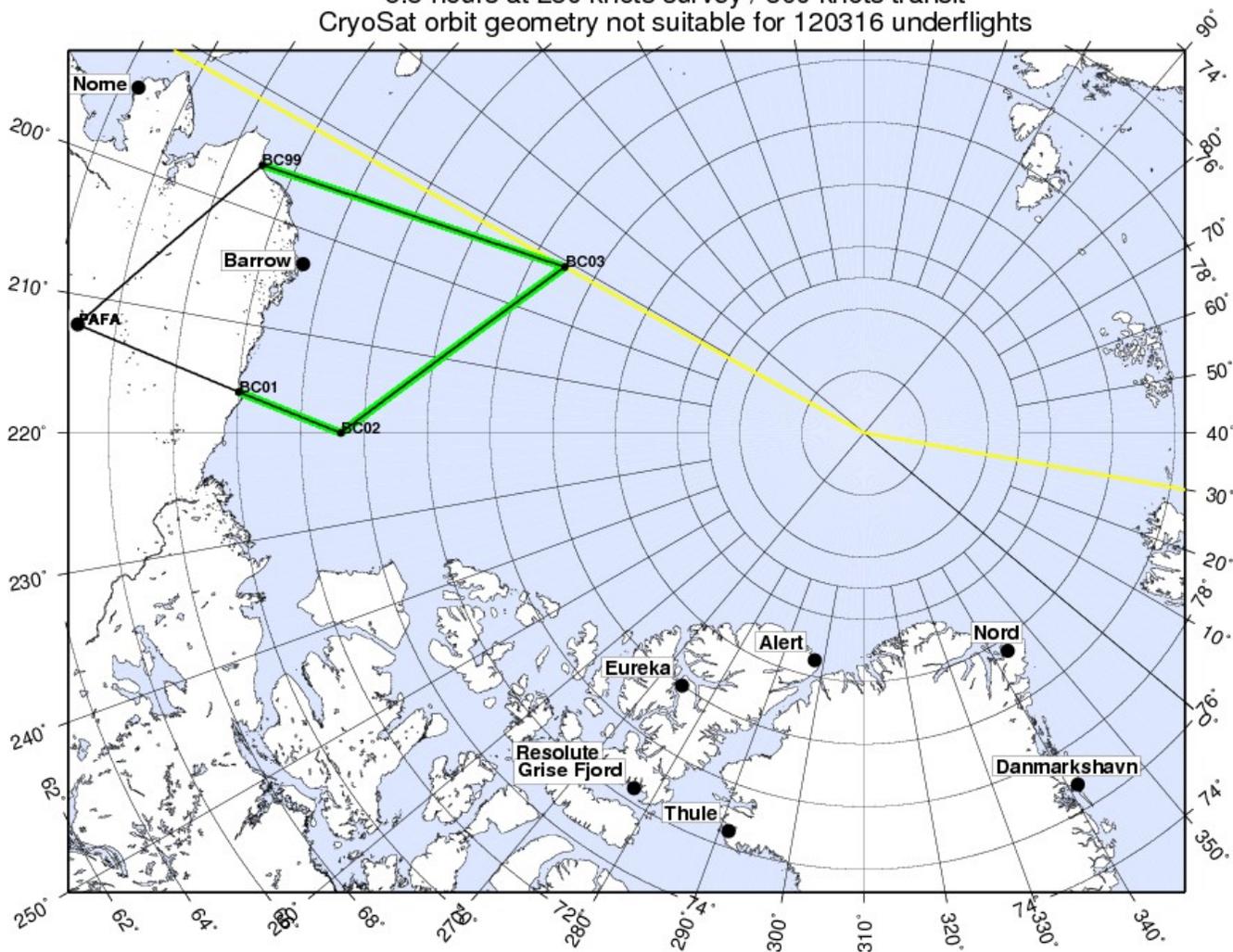
Last Flown: 2012

Remaining Design Issues: none

Sea Ice - Beaufort-Chukchi Diamond

8.5 hours at 230 knots survey / 300 knots transit

CryoSat orbit geometry not suitable for 120316 underflights



Sea Ice – East Beaufort / Fairbanks

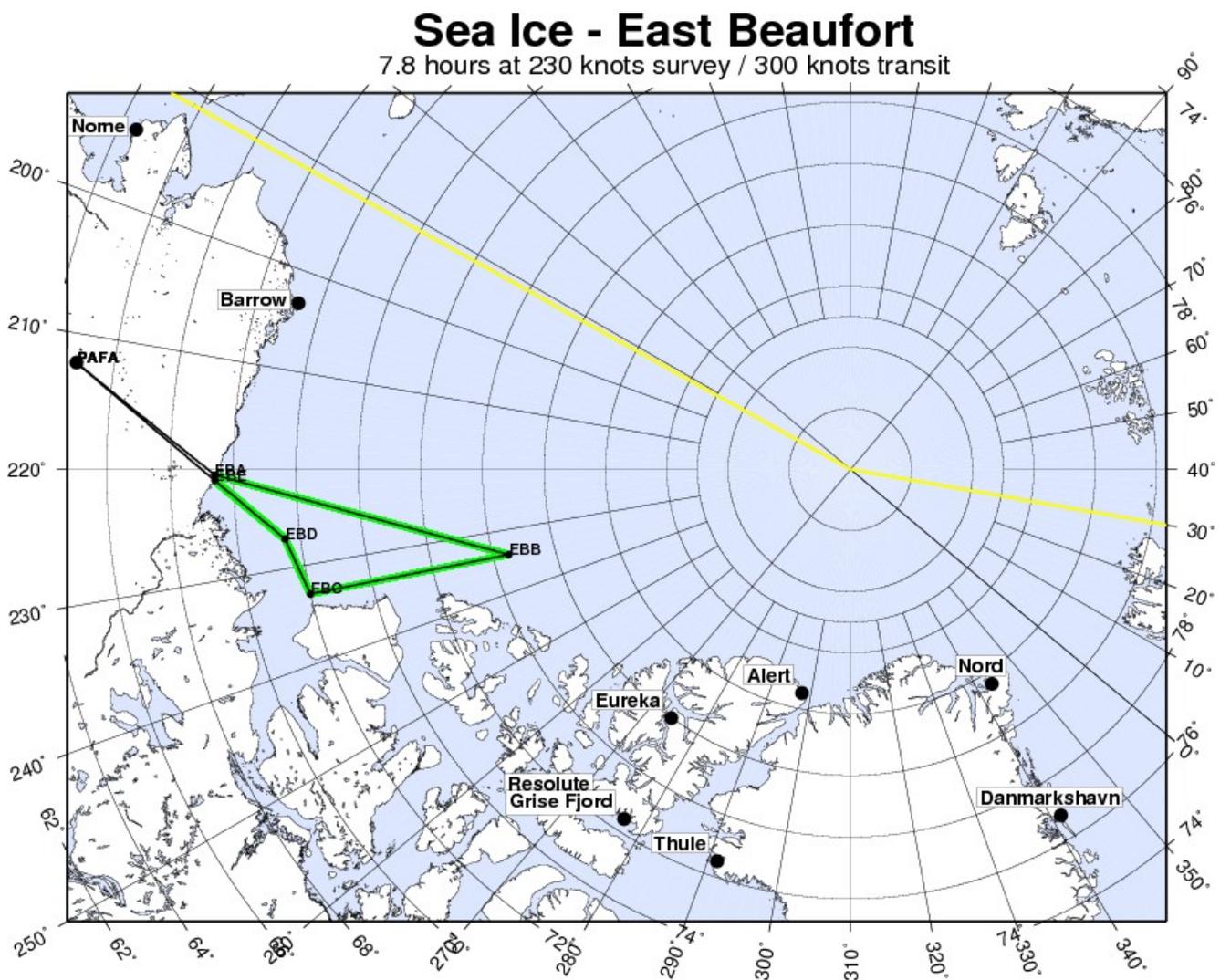
This is a new mission design for 2013. It is designed to sample sea ice in the eastern Beaufort Sea in an area which lacked OIB coverage prior to 2013, which is also of priority interest to the Canadian Space Agency. In addition to Level-1 Requirements S11 and S12, it addresses sea ice level 1 projected requirement SIP2b by extending sea ice baseline observations to the southern Beaufort Sea, west of Banks Island. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: high

ICESat Tracks: none

Last Flown: new flight

Remaining Design Issues: none



Sea Ice – SIZRS Zig-Zag / Fairbanks

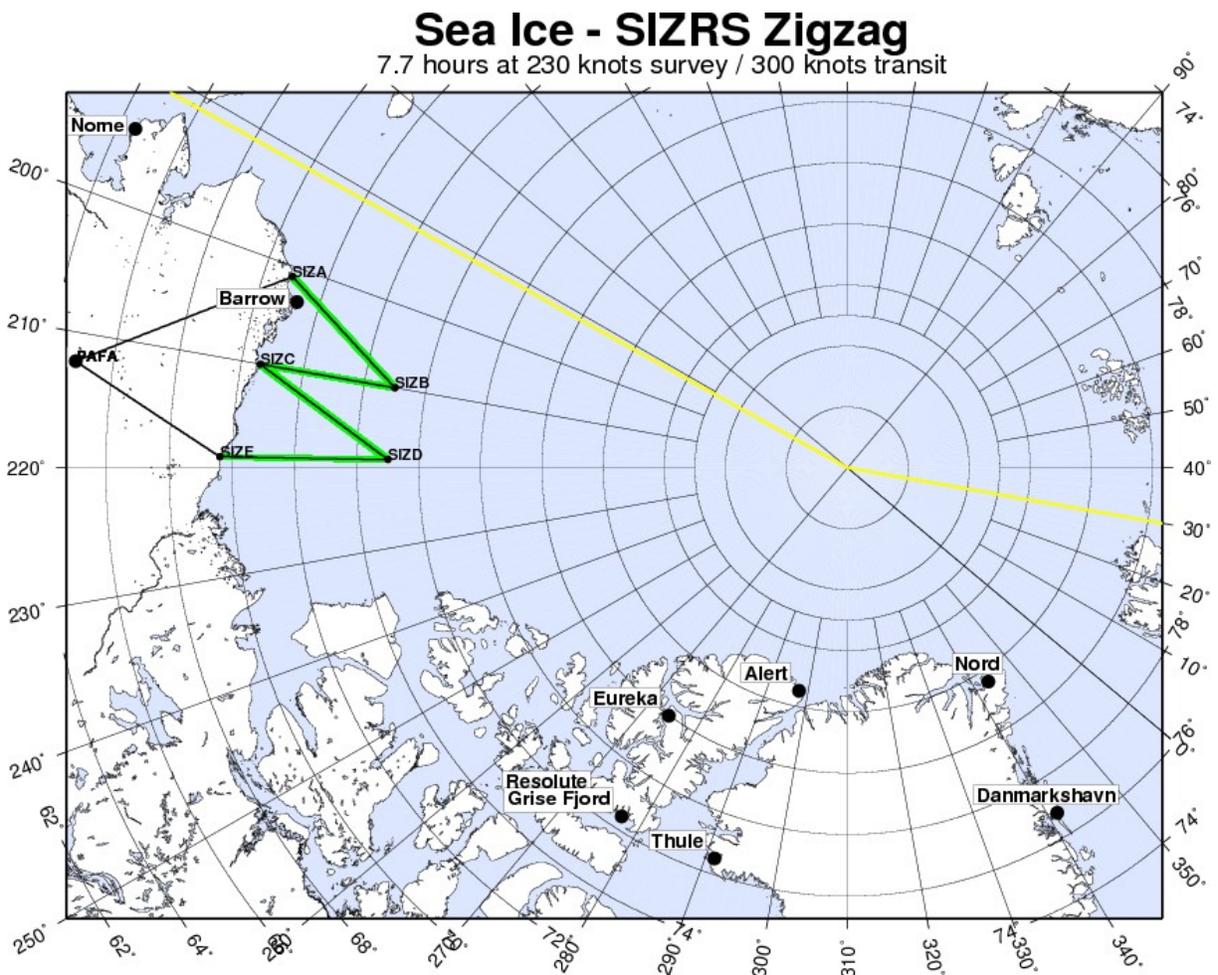
This is a new mission design for 2013, with similarities to the 2012 Alaskan Coastal Zigzag mission initiated in 2012. It is designed to sample sea ice along the north-south gradient in the southern Beaufort Sea. The leg flown along the 210th meridian facilitates a new collaboration between OIB and the Seasonal Ice Zone Reconnaissance Surveys (SIZRS) program, and it improves the temporal extent of the SIZRS time series into early spring. This mission also offers the best opportunity to conduct (a) an overflight of in-situ snow and ice property measurements being collected in the Barrow region and/or (b) a coordinated underflight of CryoSat-2 in conjunction with the Naval Research Laboratory (NRL). In addition to Level-1 Requirements SI1 and SI2, this mission addresses sea ice level 1 projected requirement SIP2d by extending sea ice baseline observations to the southern Beaufort and Chukchi Seas; sea ice level 1 baseline requirement SI4 by conducting a sampling mission that is time-coincident with a CryoSat-2 track; sea ice baseline level-1 requirement SI9 by coordinating with a field campaign the complements the IceBridge measurements. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: medium

ICESat Tracks: none

Last Flown: new flight

Remaining Design Issues: potential overflight of an NRL field site near Barrow, details TBD



Sea Ice – Wingham Box / Thule

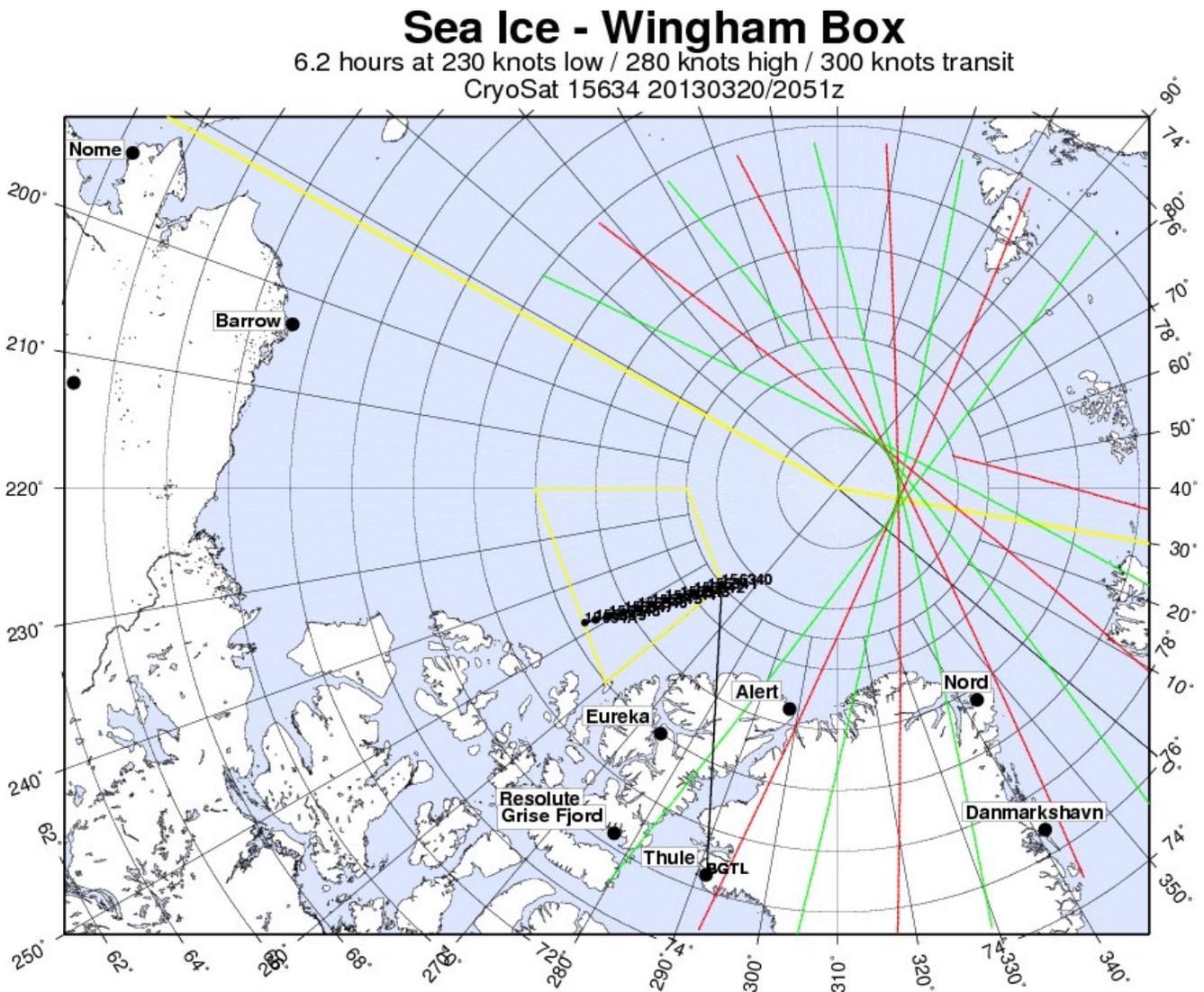
This mission is flown along a near-contemporaneous (preferably within 2 hours) CryoSat-2 groundtrack within the SARin mode box of the spacecraft. The purpose is to improve understanding of the impact of off-nadir leads on CS-2 range accuracy. We fly the track in both directions, at 1500' for the pass closest to the spacecraft overpass time, and at 15,000-22,000' for the remaining pass. The yellow box denotes where CryoSat-2 operates in SARin mode. In addition to Level 1 Requirements SI1 and SI2, this mission addresses sea ice level 1 baseline requirement SI4 by conducting a sampling mission that is time-coincident with a CryoSat track. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: low

ICESat Tracks: none

Last Flown: 2012

Remaining Design Issues: select contemporaneous CS-2 groundtrack



Sea Ice – Zigzag East – Nares Strait / Thule

This mission is a modified version of the similar Zigzag East flight flown in prior years. It is intended to sample the thick multi-year ice near the Greenland coast as well as the gradient to thinner ice closer to the pole. It also samples ice through the Nares Strait, which is of priority interest to the Canadian Space Agency. In addition to Level 1 Requirements SI1 and SI2, the mission addresses sea ice level 1 baseline requirement SI3b by sampling thick multi-year ice near the northern coast of Greenland and the poleward gradient towards thinner ice, and SI3c by sampling the ice in Nares Strait. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: high

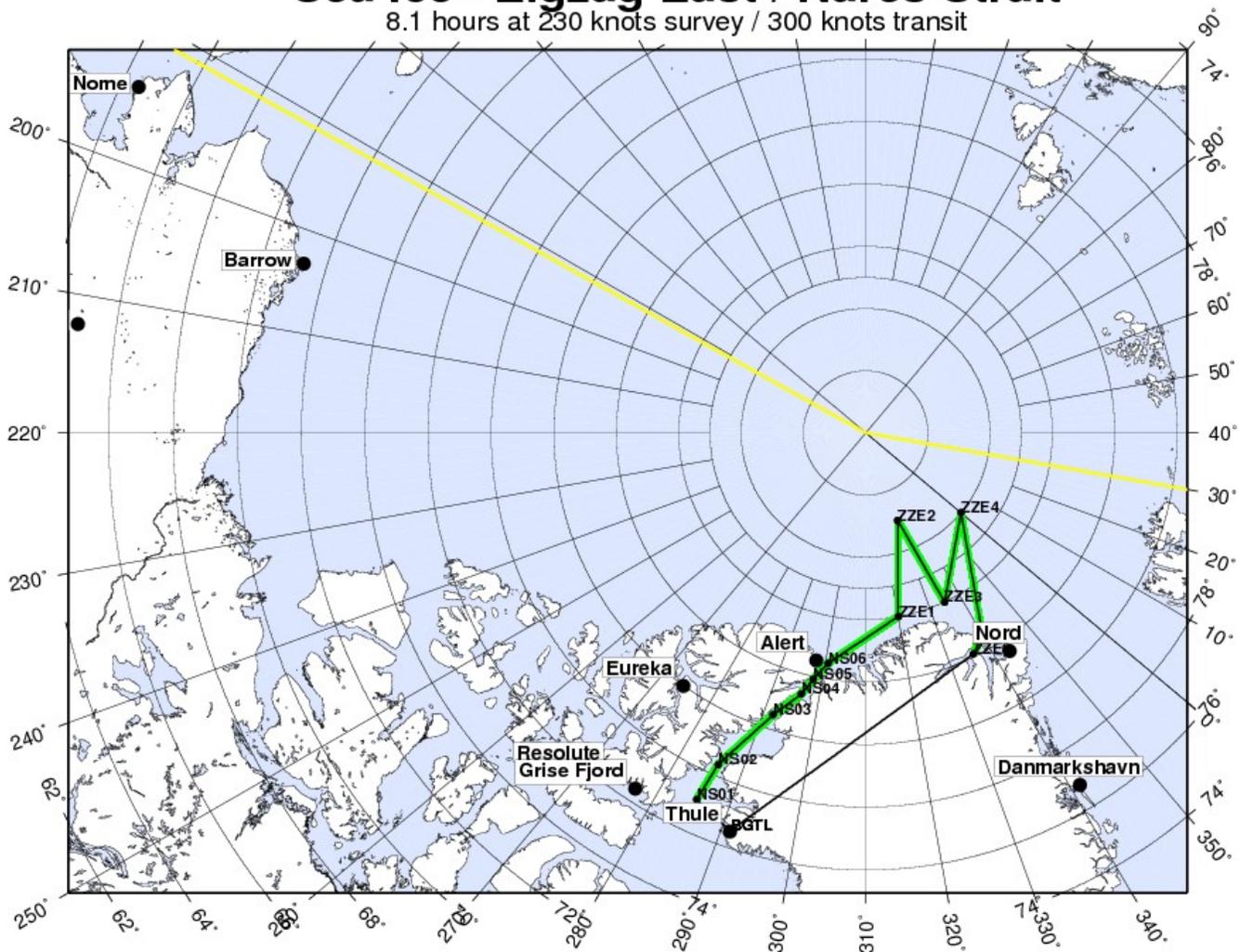
ICESat Tracks: none

Last Flown: 2012

Remaining Design Issues: none

Sea Ice - Zigzag East / Nares Strait

8.1 hours at 230 knots survey / 300 knots transit



Sea Ice – North Pole Transect / Thule

This mission is a repeat or near-repeat of a 2012 OIB flight. The intention is to sample ice in the vicinity of the Pole and also the gradient of that ice between the Pole and Ellesmere Island. This area had been undersampled by OIB prior to 2012. A nearby CryoSat-2 ground track may be substituted for one of the tracks shown below if a nearly contemporaneous one is available when this flight is conducted, preferably one close to the 10346 line. In addition to Level-1 Requirements SI1 and SI2, this mission addresses sea ice level 1 projected requirement SIP2a by extending sea ice baseline observations to the North Pole region, and sea ice level 1 baseline requirement SI4 by conducting a sampling mission that is time-coincident with a CryoSat-2 track. **This mission can be flown in either the March or April opportunities.** If flown in the later part of the campaign (late April), this provides the opportunity to conduct a coordinated mission north of Alert with the AWI Polar 5, which is instrumented with an EM31 (ice thickness) sensor and new snow radar system.

Flight Priority: high

ICESat Tracks: none

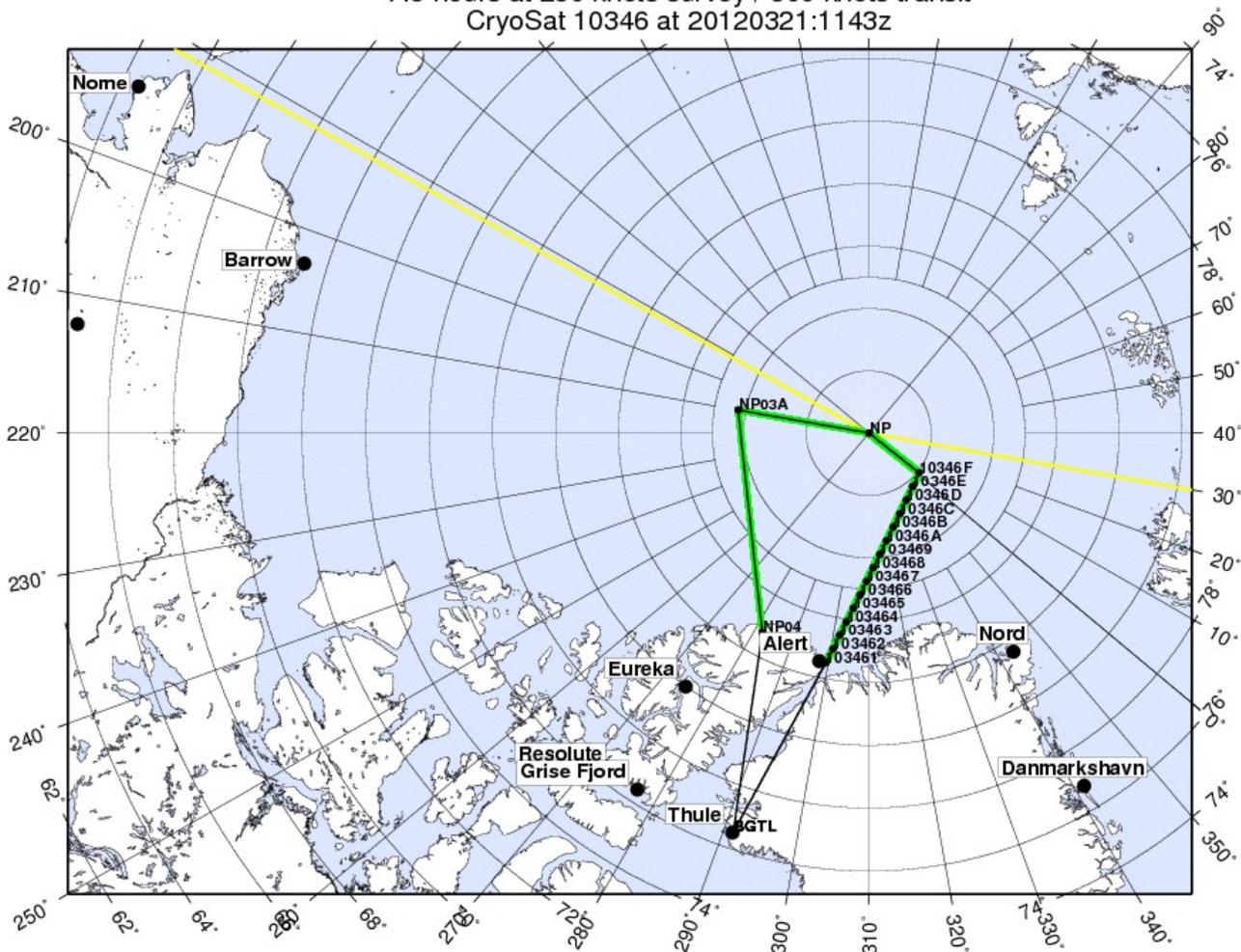
Last Flown: 2012

Remaining Design Issues: check for nearby CryoSat-2 groundtracks; Polar-5 coordination?

Sea Ice - North Pole Transect

7.8 hours at 230 knots survey / 300 knots transit

CryoSat 10346 at 20120321:1143z



Sea Ice – Canada Basin North / Thule

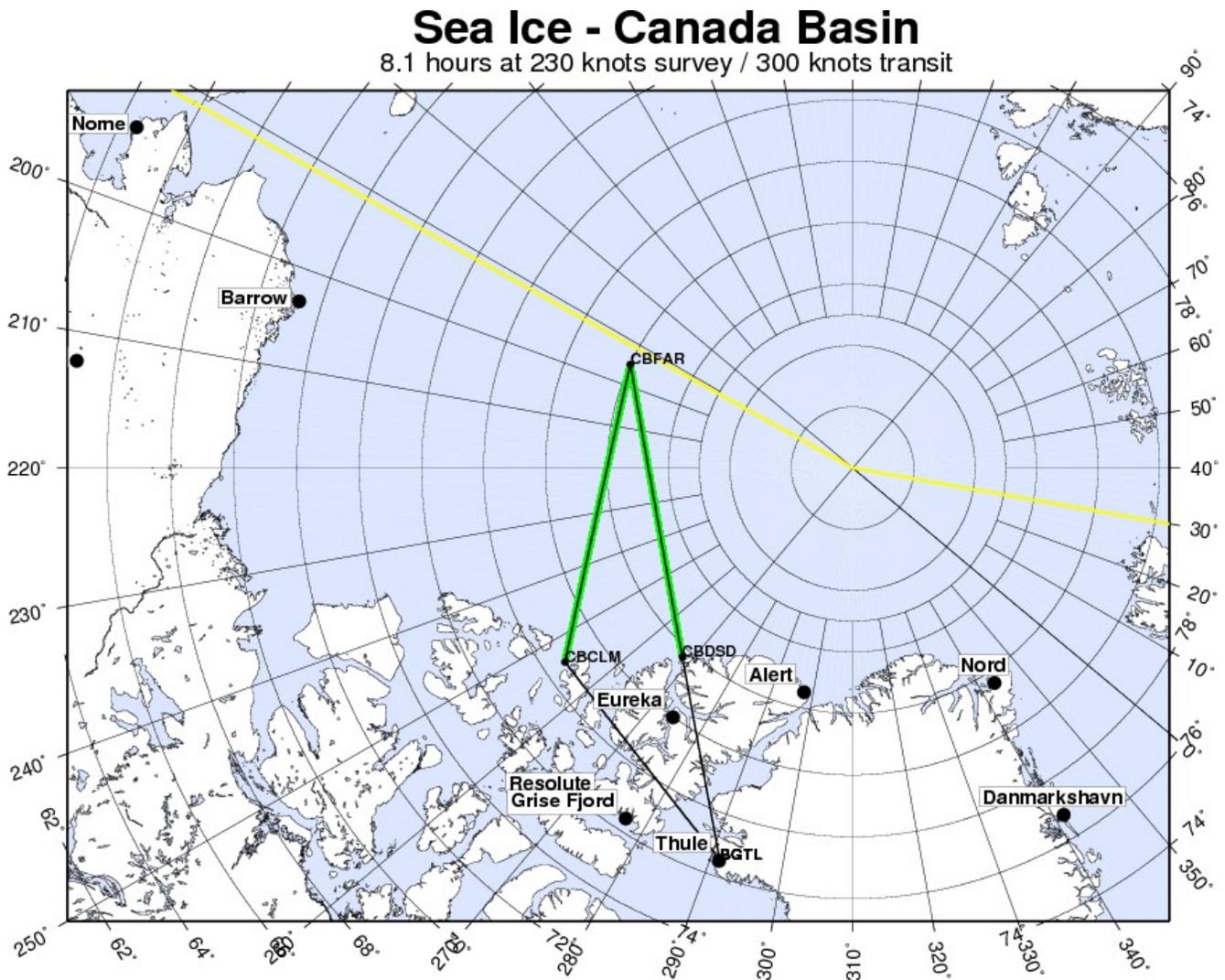
This is a repeat of a mission first flown in 2012. It is designed to sample sea ice in a large region between the North Basin Transect and the Beaufort-Chukchi Diamond that had been poorly sampled by OIB prior to 2012. In addition to Level 1 Requirements SI1 and SI2, the mission addresses sea ice level 1 projected requirement SIP2 by extending the baseline observations into other regions of the Arctic Basin. **This mission can be flown in either the March or April opportunities.**

Flight Priority: high

ICESat Tracks: none

Last Flown: 2012

Remaining Design Issues: none



Sea Ice – Canada Basin South / Thule

This is a new mission for 2013. It is designed to enhance the sampling in the large region between the North Basin Transect and the Beaufort-Chukchi Diamond that had been poorly sampled by OIB prior to 2012. This is a region of priority interest to the Canadian Space Agency. In addition to Level 1 Requirements SI1 and SI2, the mission addresses sea ice level 1 projected requirement SIP2 by extending the baseline observations into other regions of the Arctic Basin. **This mission can be flown in either the March or April opportunities.**

Flight Priority: high

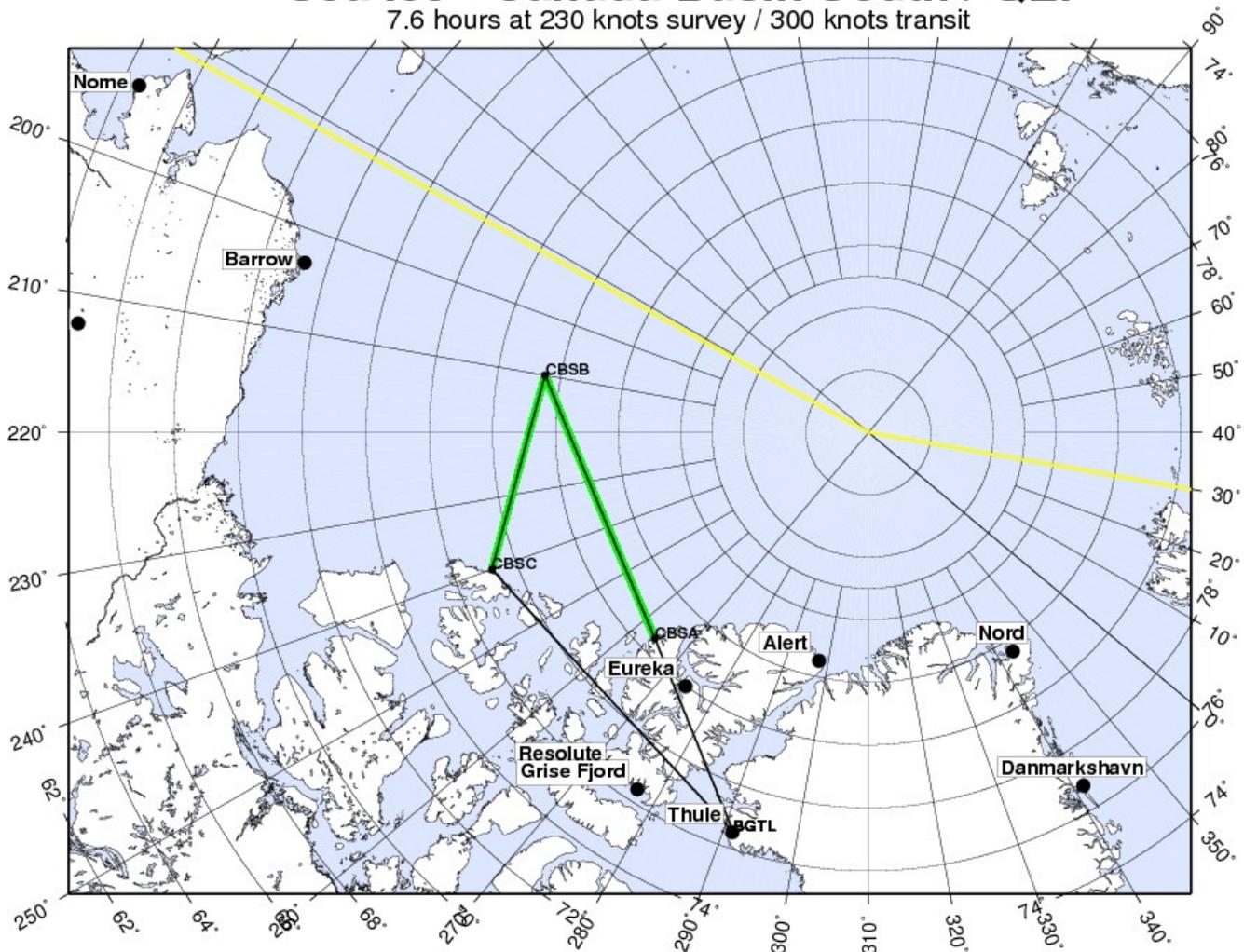
ICESat Tracks: none

Last Flown: new flight

Remaining Design Issues: none

Sea Ice - Canada Basin South / QEI

7.6 hours at 230 knots survey / 300 knots transit



Sea Ice – Fram Gateway Prime / Thule

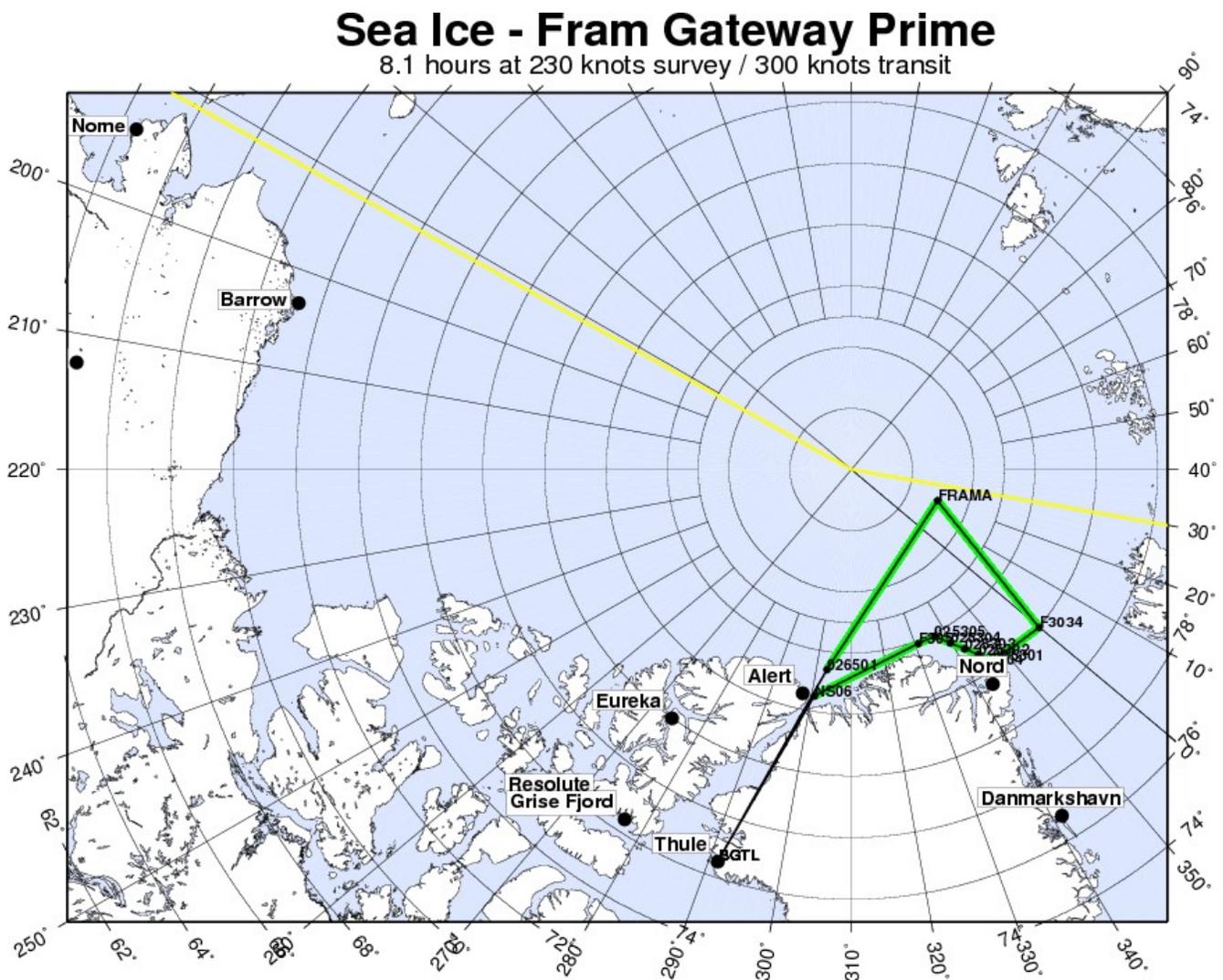
This is a modified version of the Fram Gateway missions flown in the past several years. It differs from the previous versions by sliding the easternmost leg north by approximately 100 km, thus sampling thicker poleward ice and avoiding the open water in the Fram Strait itself. Observations collected in the Nares Strait region are of priority interest to the Canadian Space Agency. In addition to Level 1 Requirements SI1 and SI2, this mission addresses sea ice level 1 baseline requirements SI3c and d by sampling ice at the top of Nares Strait crossing the Lincoln Sea ice arch (if present), and sea ice north of Fram Strait. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: medium

ICESat Tracks: 0253

Last Flown: 2012

Remaining Design Issues: none



Sea Ice – Clipped Connor Corridor / Thule

This is a highly-modified version of the Connor Corridor mission last flown in 2012. In this version we repeat the Envisat line from 2012, but with 200 km from the western end removed. In the place of that segment and instead of repeating the Envisat track for the return to Thule, we return along the Northwest Passage route last flown by OIB in 2010. This is a region of priority interest to the Canadian Space Agency. In addition to Level 1 Requirements SI1 and SI2, the flight addresses sea ice level 1 baseline requirement SI4 by conducting a sampling mission that is time-coincident with a historic Envisat track, and sea ice level 1 projected requirement SIP2f by extending sea ice baseline observations to the Canadian Archipelago. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: medium

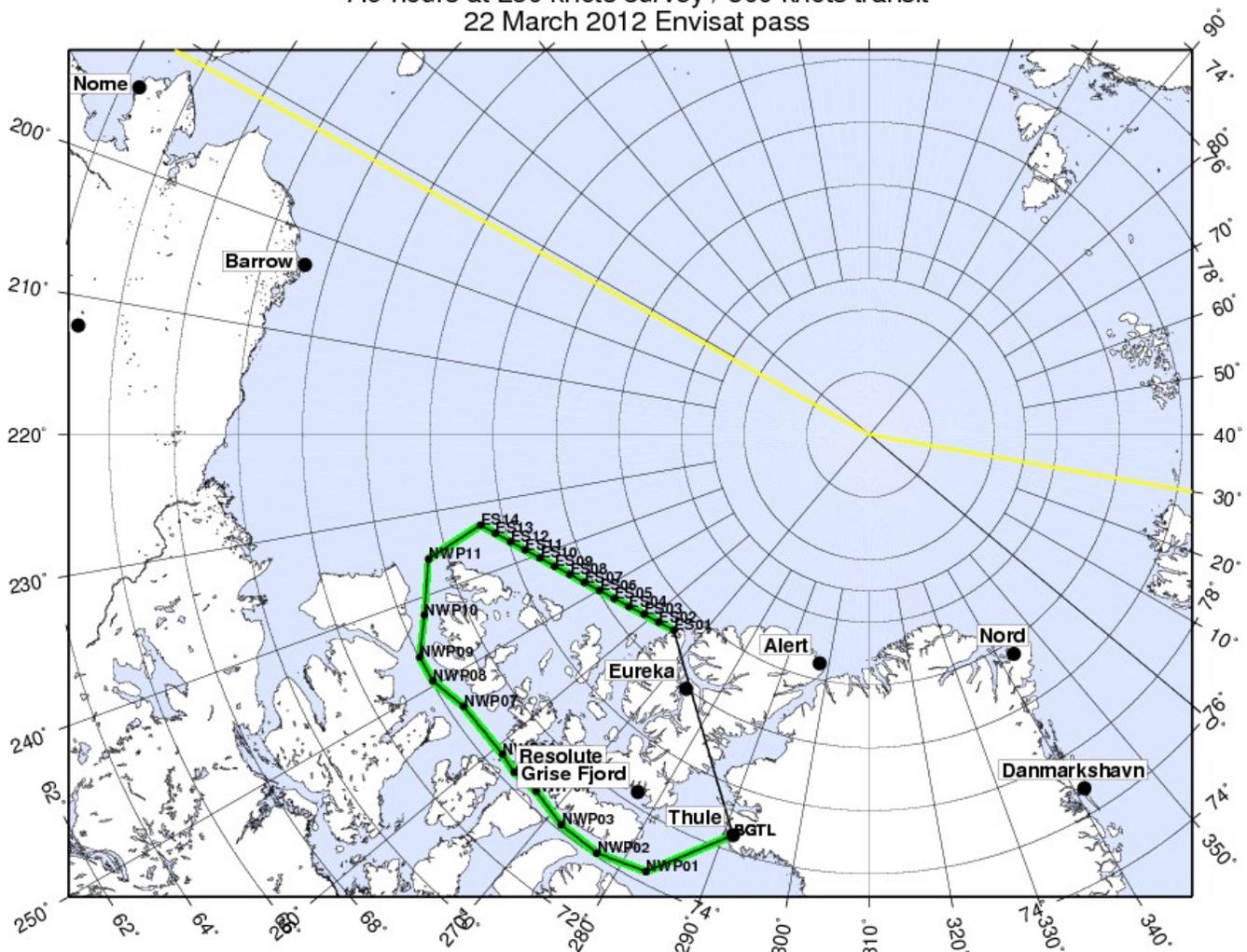
ICESat Tracks: none

Last Flown: portions in 2012

Remaining Design Issues: none

Sea Ice - Clipped Connor Corridor

7.9 hours at 230 knots survey / 300 knots transit
22 March 2012 Envisat pass



Sea Ice – Cryosat / Thule

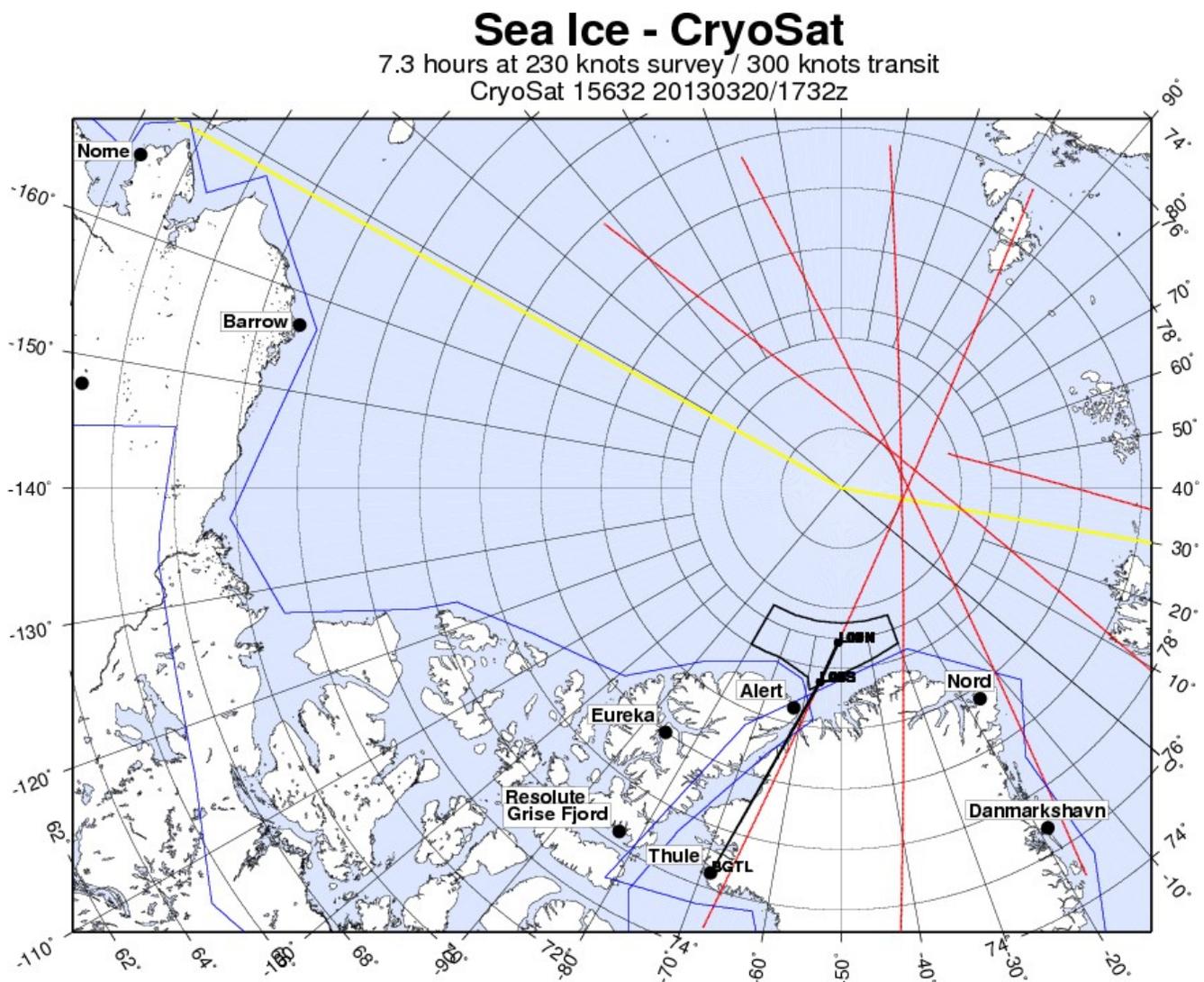
This mission is intended to underfly the Cryosat spacecraft, as nearly simultaneous with the spacecraft as possible, preferably within 2 hours. For 2013, we fly a grid centered on the ground track. The grid will be planned around a track within the black box depicted below, and as far south as possible within it. This box is outside the CryoSat-2 SARin mode boxes but in an area with relatively low ice drift rates. The grid will be flown at 1500 m altitude, and will be comprised of 10 lines of 160 km length spaced at 560 m. This yields a composite ATM swath of more than 5 km, with 25% overlap between swaths, and lies within the operating range of the snow radar. In addition to Level 1 Requirements SI1 and SI2, this mission addresses sea ice level 1 baseline requirement SI4 by conducting a sampling mission that is time-coincident with a CryoSat track. **This mission ideally should be flown during the March 2013 opportunity.**

Flight Priority: high

ICESat Tracks: none

Last Flown: 2012

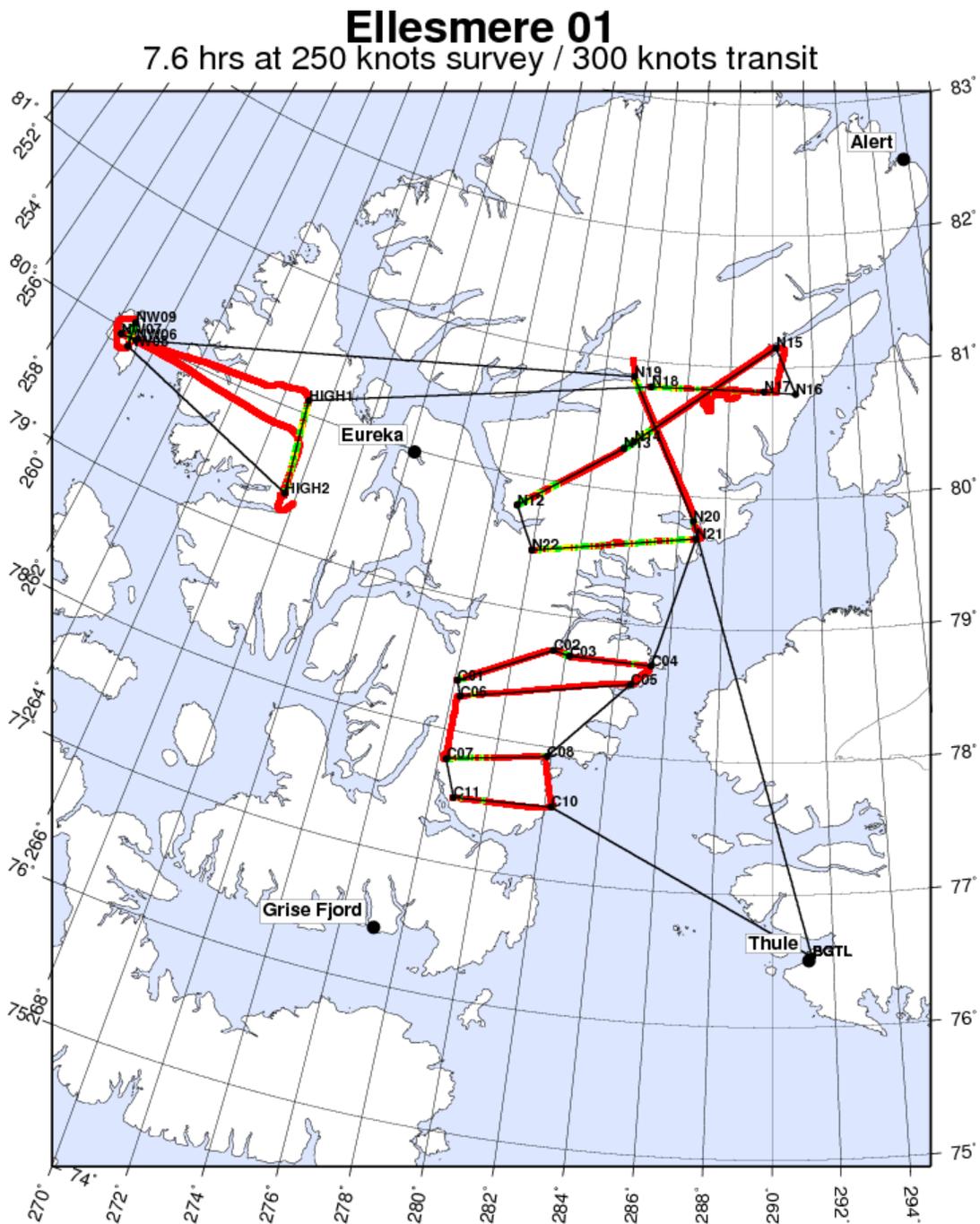
Remaining Design Issues: Select contemporaneous CryoSat-2 ground track.



Land Ice – Ellesmere 01 / Thule

This mission repeats survey lines over Ellesmere, Axel Heiberg and Meighen Islands previously surveyed by the ATM/KU teams in 1995, 2000, and 2005. Two lines over northern Ellesmere Island flown in those years were removed in order to shorten this mission to an acceptable length.

Flight Priority: low
ICESat Track: none
Last Flown: 2012
Remaining Design Issues: none



Land Ice – Baffin 01 / Thule

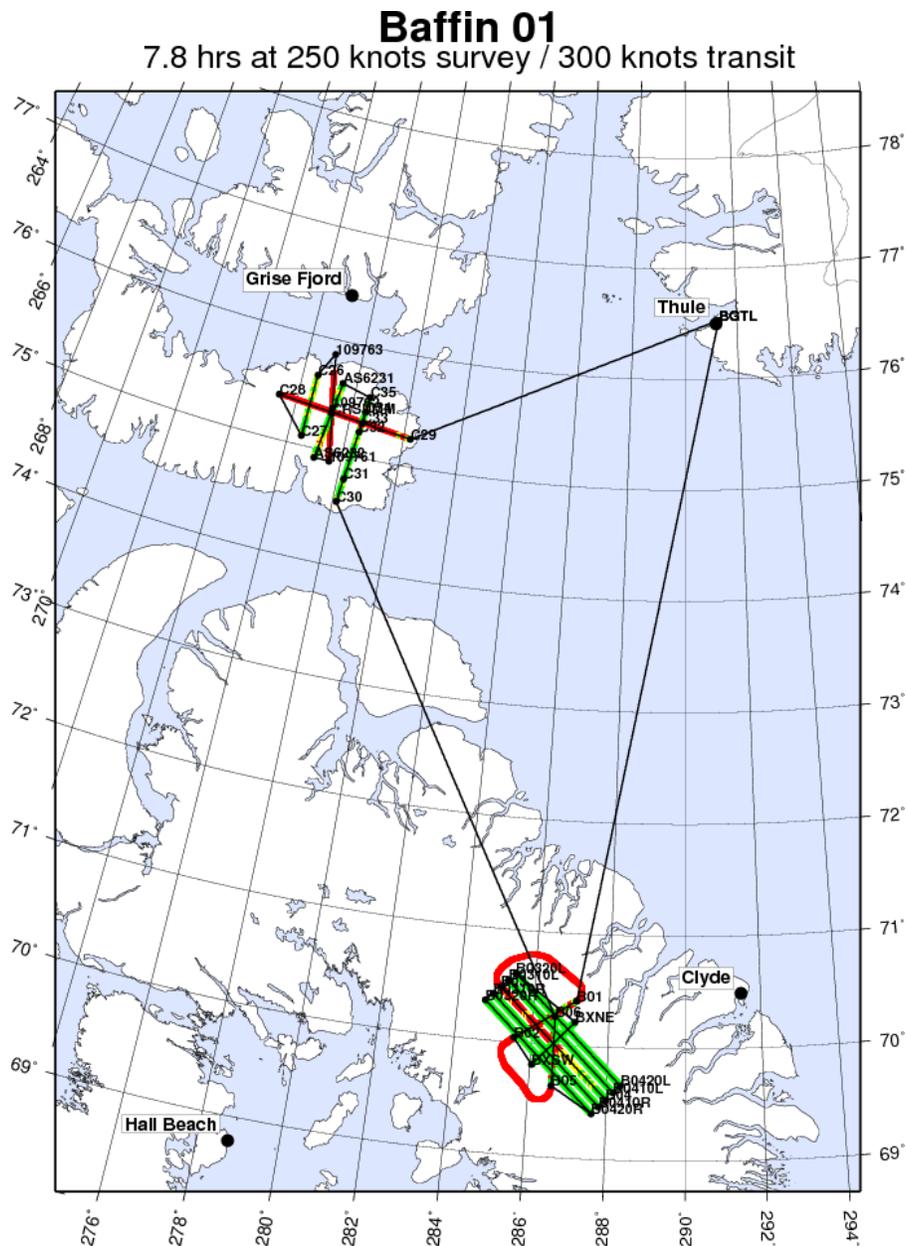
This mission repeats survey lines over the Barnes and Devon Ice Caps previously surveyed by the ATM/KU teams in 1995, 2000, and 2005, and adds several new lines over the Barnes Ice Cap. We also overfly 2012 CryoVex field sites on the Devon Ice Cap. These include the “623” line, the May 3rd CryoSat overpass (corresponding to the May 1st pass from 2011), and the April 22nd pass (corresponding to April 20 2011). Of these two the May 3rd overpass is the primary line, per the Dave Burgess email from 20120227.

Flight Priority: low

ICESat Track: none

Last Flown: 2011

Remaining Design Issues: none

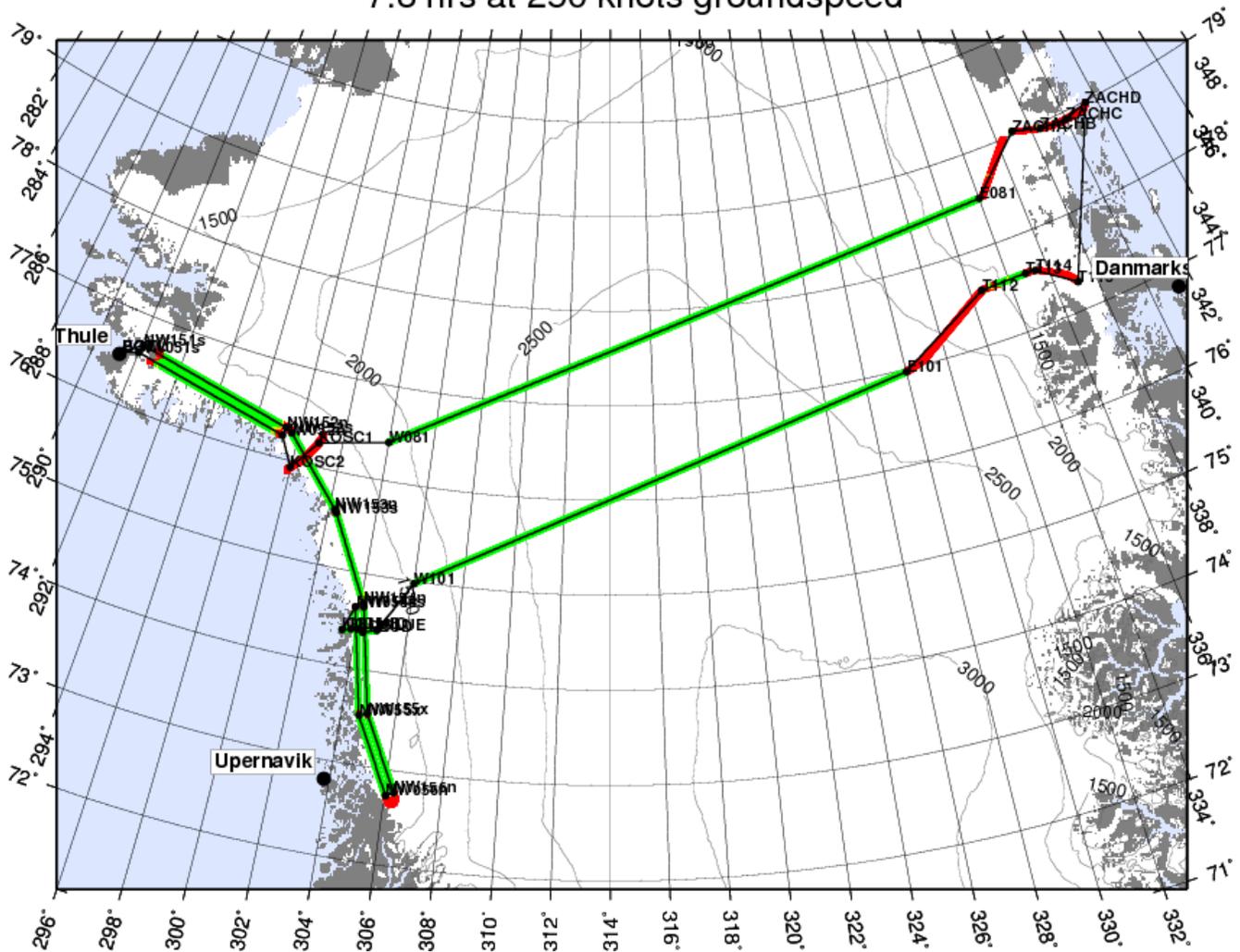


Land Ice – North Central Gap 01 / Thule

This mission, along with the North Central Gap 02 and 03 missions, are primarily designed to fill a gap in altimetry and radar coverage of the north-central portion of the ice sheet. In this flight, we also re-occupy centerlines of the Zacharaie, Storstrommen, Illulipsermia and Kong Oscar Glaciers, and we re-fly portions of the northwest coast-parallel grid flown from 2010-2012.

- Flight Priority:** high
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none

North-Central Gap 01 7.8 hrs at 250 knots groundspeed



Land Ice – North Central Gap 02 / Thule

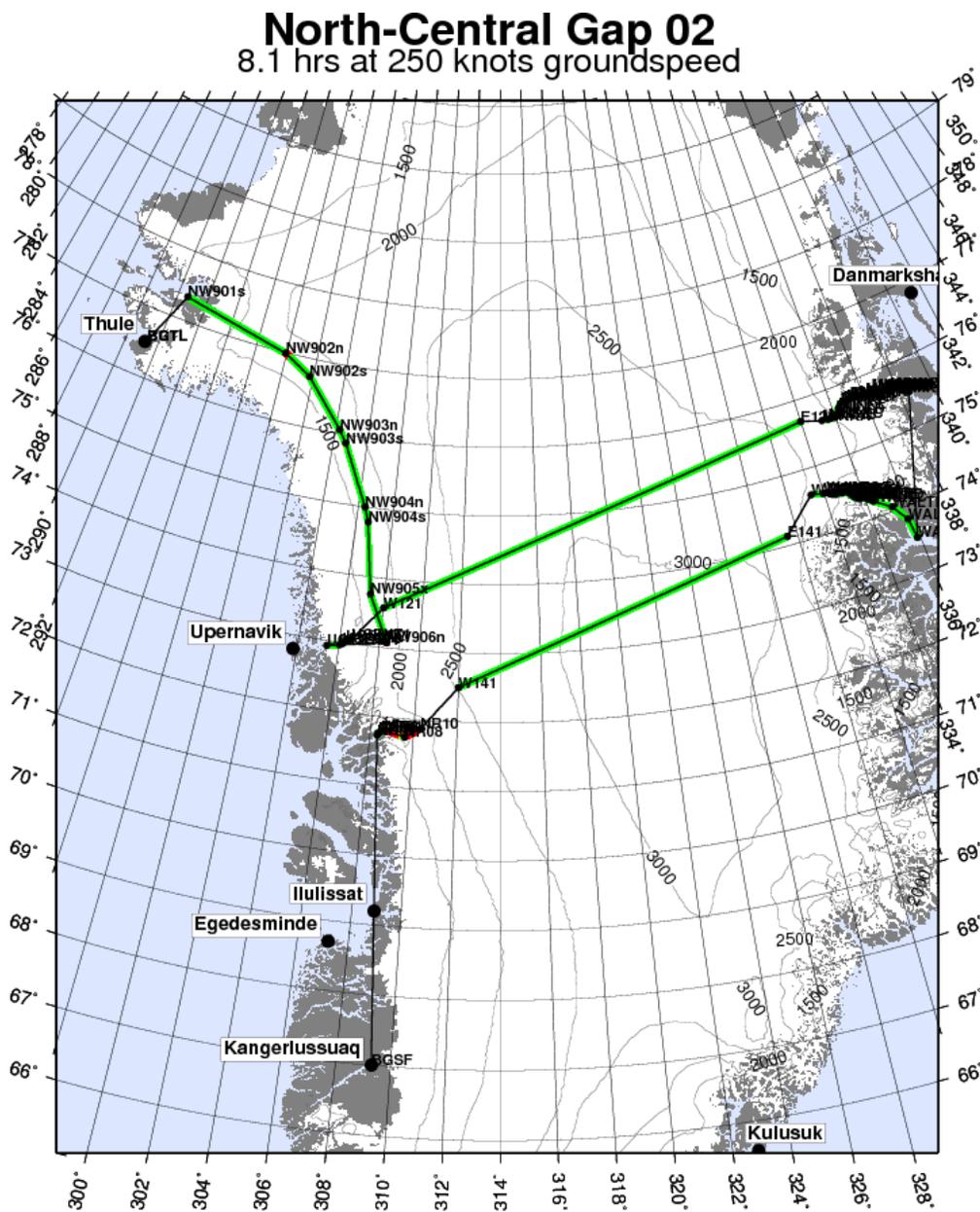
This mission, along with the North Central Gap 01 and 03 missions, are primarily designed to fill a gap in altimetry and radar coverage of the north-central portion of the ice sheet. In this flight, we also re-occupy centerlines of the Rink and Upernavik (central), glaciers, we establish new centerlines of the Mikkelsen and Waltershausen glaciers, and we refly portions of the northwest coast-parallel grid flown from 2010-2012. **This flight can be configured as a transit mission between Thule and Kangerlussuaq.**

Flight Priority: high

ICESat Track: none

Last Flown: new flight

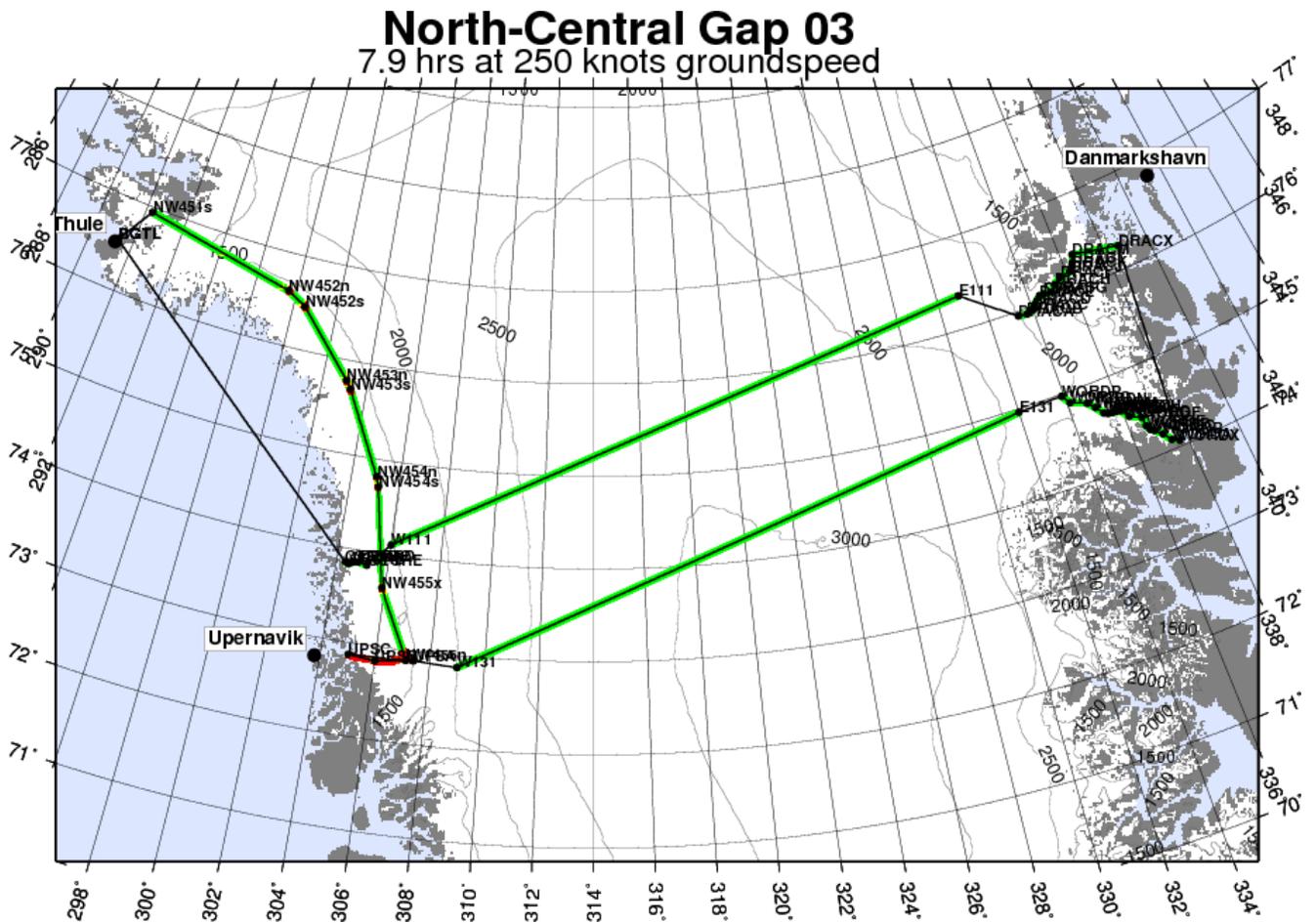
Remaining Design Issues: none



Land Ice – North Central Gap 03 / Thule

This mission, along with the North Central Gap 02 and 03 missions, are primarily designed to fill a gap in altimetry and radar coverage of the north-central portion of the ice sheet. In this flight, we also re-occupy centerlines of the Qeqertarsuap and Upernavik (south), glaciers, we establish new centerlines of the Drachmann and Wordie glaciers, and we refly portions of the northwest coast-parallel grid flown from 2010-2012.

- Flight Priority:** high
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Gap-Summit / Thule

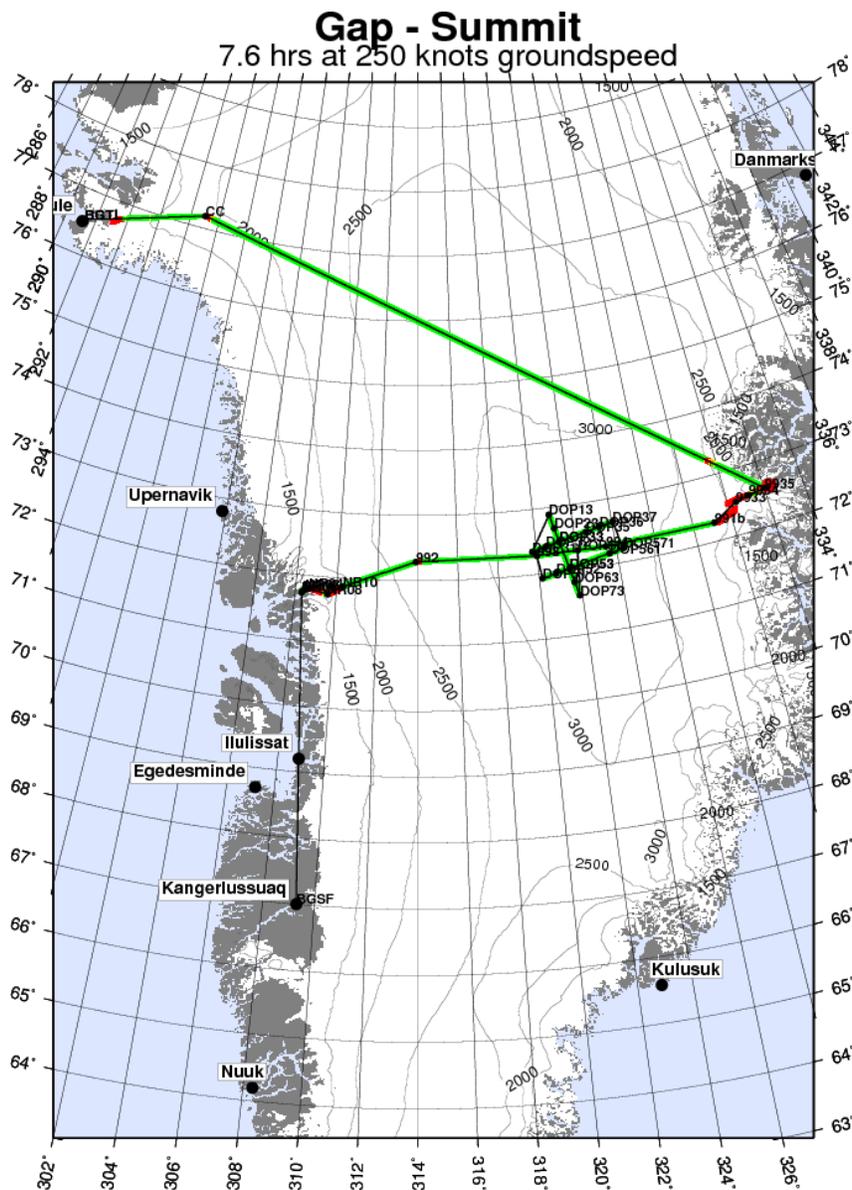
This mission was partially flown in 2012, and aborted due to a mechanical problem. Its primary purposes are twofold. First, we fly an east-west line all the way across the ice sheet from Rink Glacier in the west to Cecilia Nunatak in the east. This line also covers a gap in OIB coverage in central Greenland, and does so along a series of 1999 ATM lines to yield a lengthy dh/dt history. Second, we overfly a series of Doppler in-situ sites surveyed in 1987 near Summit, which again will yield an exceptionally long dh/dt history over these sites. We transit between Kangerlussuaq and Rink Glacier at high-altitude to save time, and we transit from Cecilia Nunatak to Thule along a 1999 ATM line. **This mission can be configured as a transit flight between Thule and Kangerlussuaq.**

Flight Priority: low

ICESat Track: none

Last Flown: 2012 (portions)

Remaining Design Issues: none



Land Ice – Northwest Glaciers 01 / Thule

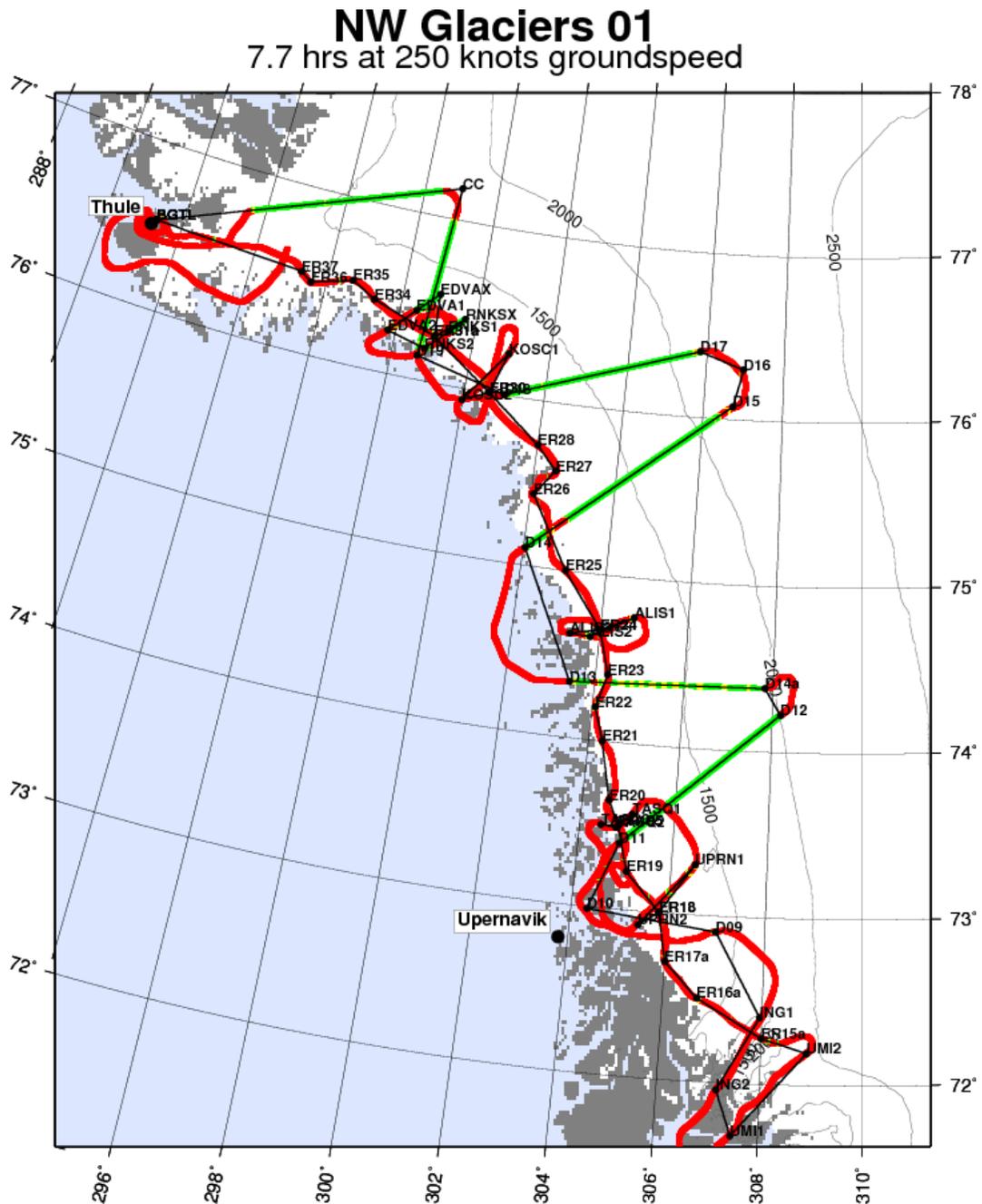
This mission is a repeat of a 2009, 2010, 2011 and 2012 ICEBridge mission. It focuses on the upper Baffin Bay coast, with targeted longitudinal surveys of 12 glaciers in the region and repeats of long-established ATM dh/dt lines which were not targeted at outlet glaciers, but instead were intended to track inland spread of coastal thinning.

Flight Priority: low

ICESat Track: none

Last Flown: 2012

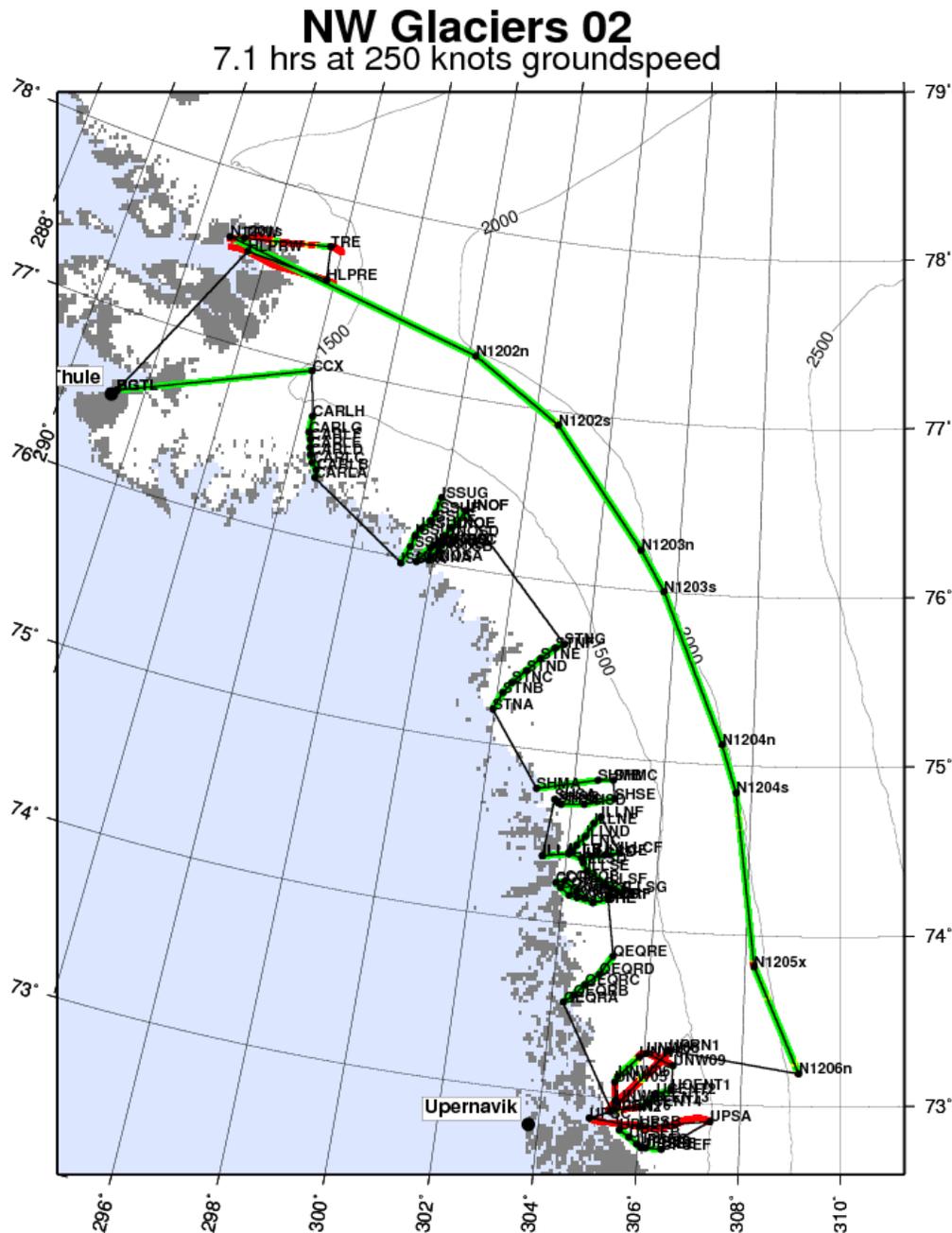
Remaining Design Issues: none



Land Ice – Northwest Glaciers 02 / Thule

This is a new mission. It focuses on the upper Baffin Bay coast, with targeted longitudinal surveys of the most significant glaciers in the region which have not been surveyed previously by OIB. We also resurvey the centerlines of the Tracy and Heilprin glaciers, and we re-fly a previously-flown inland line from the “northwest coastal” suite of missions.

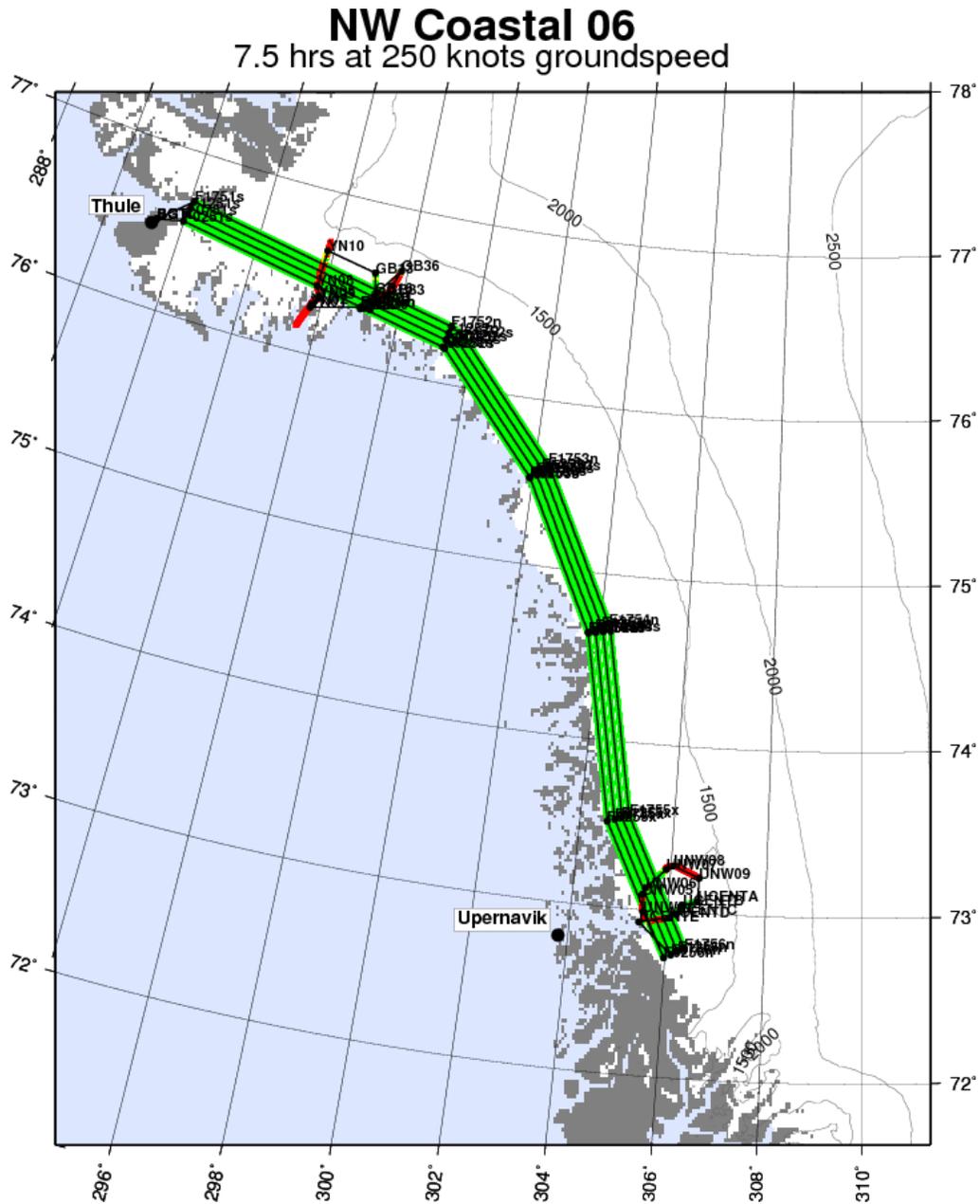
- Flight Priority:** high
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Northwest Coastal 06 / Thule

This is a new mission which interlaces the 2010-2011 Northwest Coastal coast-parallel grid, which had a spacing of 5 km, to 2.5 km. This flight also reoccupies the centerlines of the Upernavik Northwest and Yngvar Nielsen glaciers, and establishes new centerlines along the Upernavik middle ice stream, and both branches of the wishbone-shaped Gades Brae glacier. The companion Northwest Coastal 07 mission performs the same interlace strategy but farther inland.

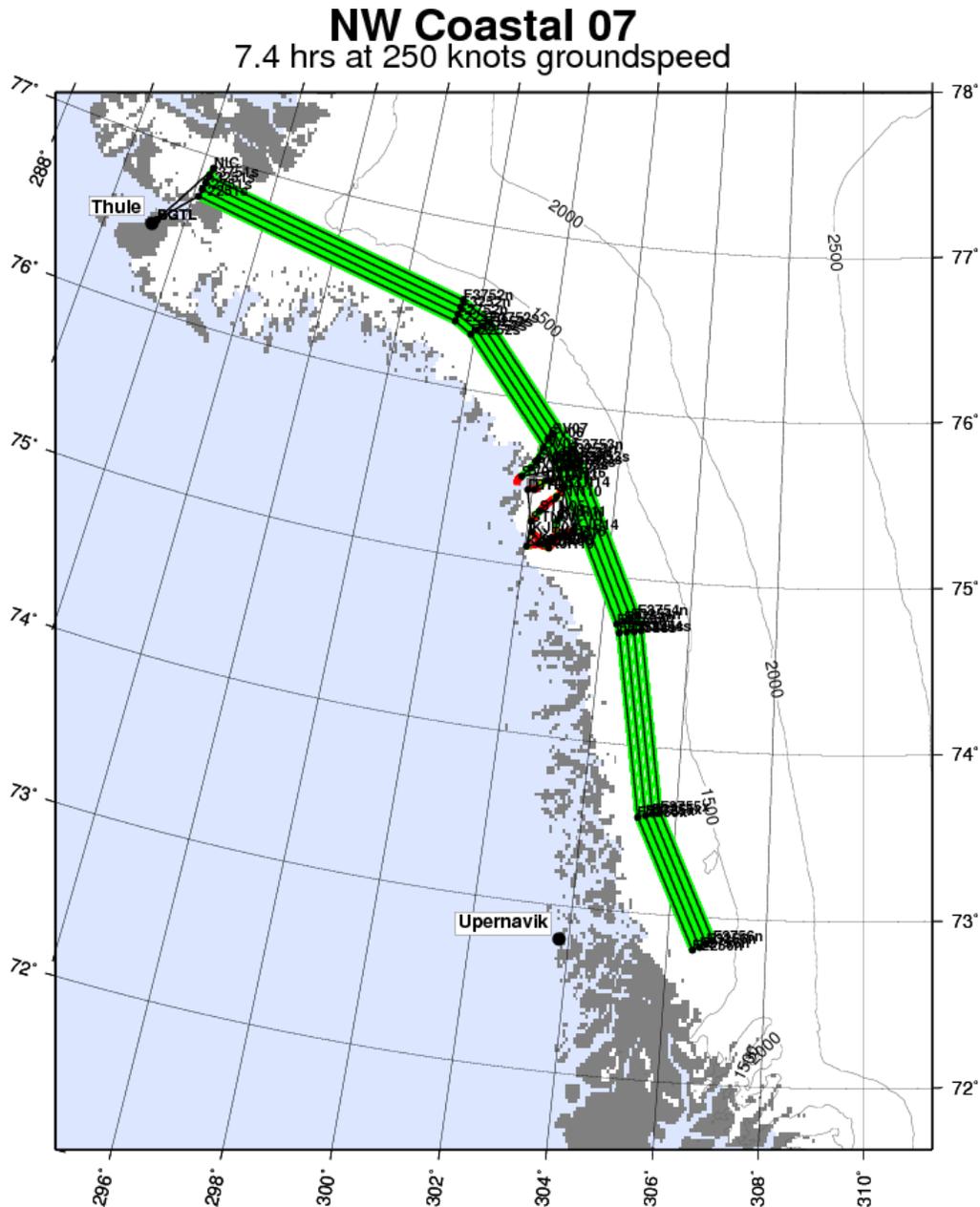
- Flight Priority:** medium
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Northwest Coastal 07 / Thule

This is a new mission which interlaces the 2010-2011 Northwest Coastal coast-parallel grid, which had a spacing of 5 km, to 2.5 km. The companion Northwest Coastal 06 mission does the same but farther to seaward. We also re-fly the centerline of the Sverdrup Glacier, and fly new centerlines on Dietrichson, Steenstrups, and a pair of centerlines on Kjaer Glacier. Finally we overfly a field site near Thule which will be occupied by Dartmouth colleagues in August 2012.

- Flight Priority:** low
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Humboldt-Petermann 01 / Thule

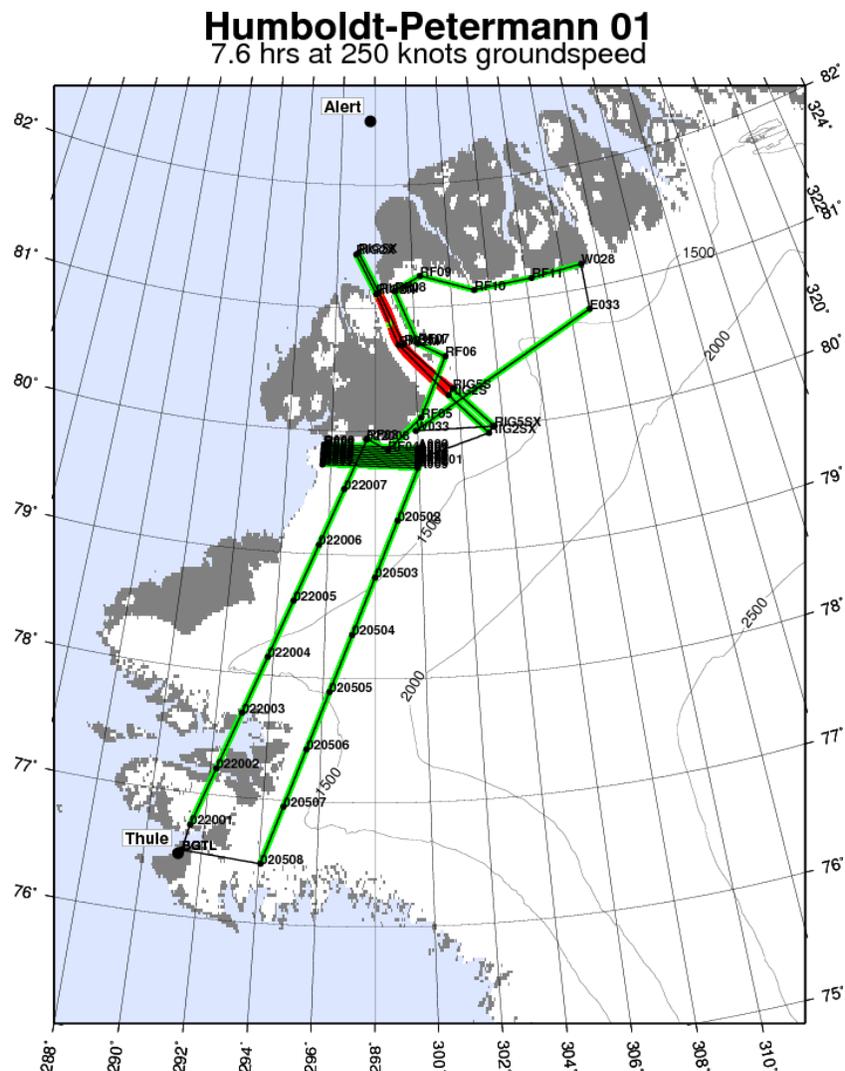
This is a new mission, designed to accomplish a number of goals. First, it flies a radar tomography grid on the fast-flowing part of the Humboldt Glacier trunk, with 10 lines spaced at 2 km. We also fly a part of a coastal flux line which connects with and is continued by the 2012 North Flux 01 mission. Third, we fly a pair of historical ATM longitudinal lines down the trunk of the Petermann Glacier for dh/dt purposes. The central-most of these two was flown in 2010 and 2011, while the western line was last flown in 2002. The Petermann trunk lines are extended well into the Hall Basin for connection with shipborne bathymetry data, and they are extended 50 km farther inland than flown previously as well. We transit between Thule and between the survey areas on a combination of ICESat ground tracks and one master grid line immediately to the north of the Petermann grid established in 2010 and 2011. The MCoRDS radar should be configured in tomographic mode (beamwidth +/- 35 deg, chirp length 10 us, one waveform with 10 us chirp) for the Humboldt grid, and in normal profiling mode for the rest of this flight. Flight elevation for the tomography portion should be 800 m, or 2600 ft AGL.

Flight Priority: high

ICESat Track: 0220,0205

Last Flown: new flight

Remaining Design Issues: none



Land Ice – Humboldt 01 / Thule

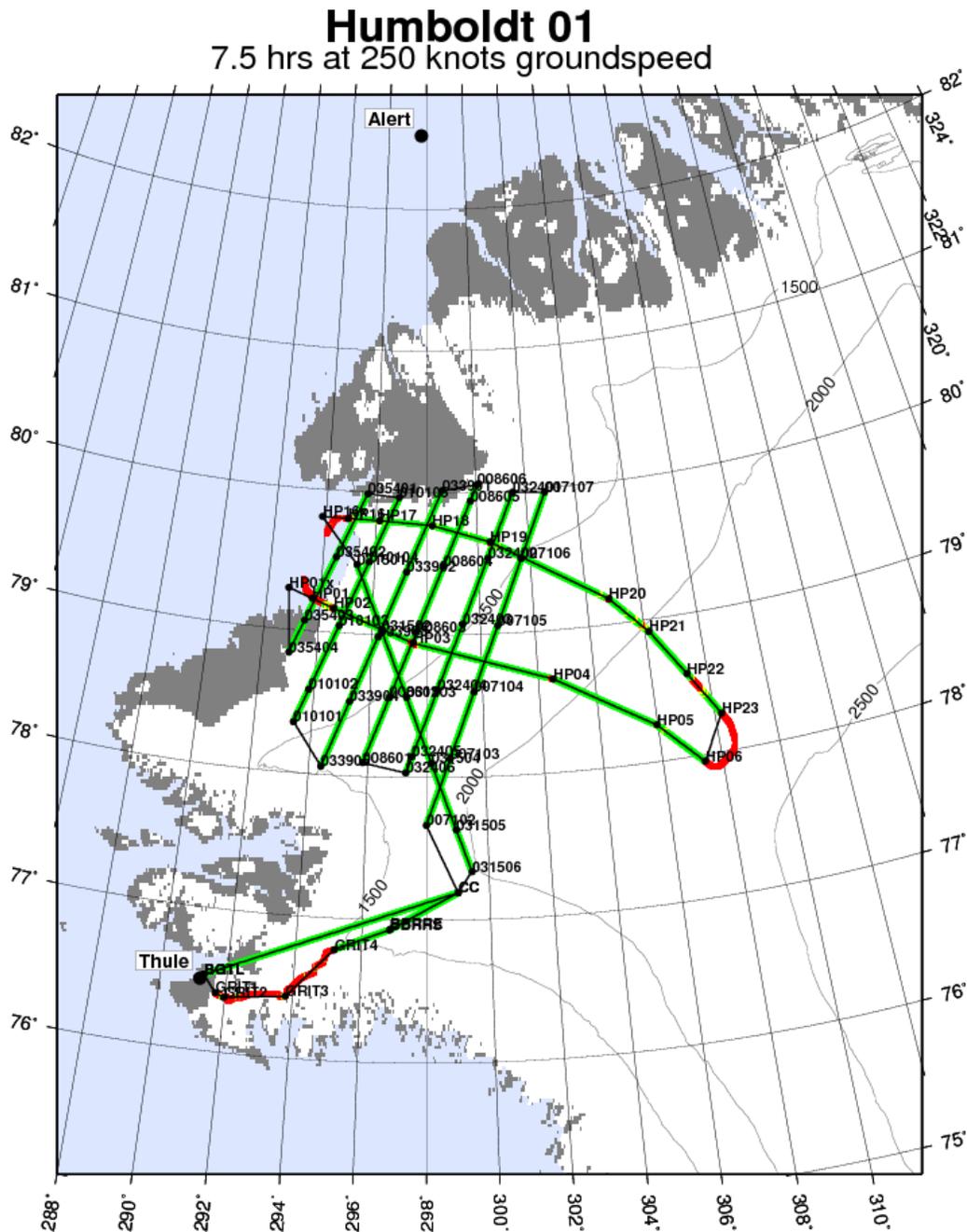
This is a new mission, designed to repeat two historical ATM lines which follow flowlines down the Humboldt Glacier, and several descending ICESat tracks which parallel the terminus. We also fly the GrIT traverse route between Thule and Camp Century, as well as an associated and collocated field site known as “2 Barrels”.

Flight Priority: medium

ICESat Track: 0071,0324,0086,0339,0101,0354,0315

Last Flown: new flight

Remaining Design Issues: none



Land Ice – Humboldt 02 / Thule

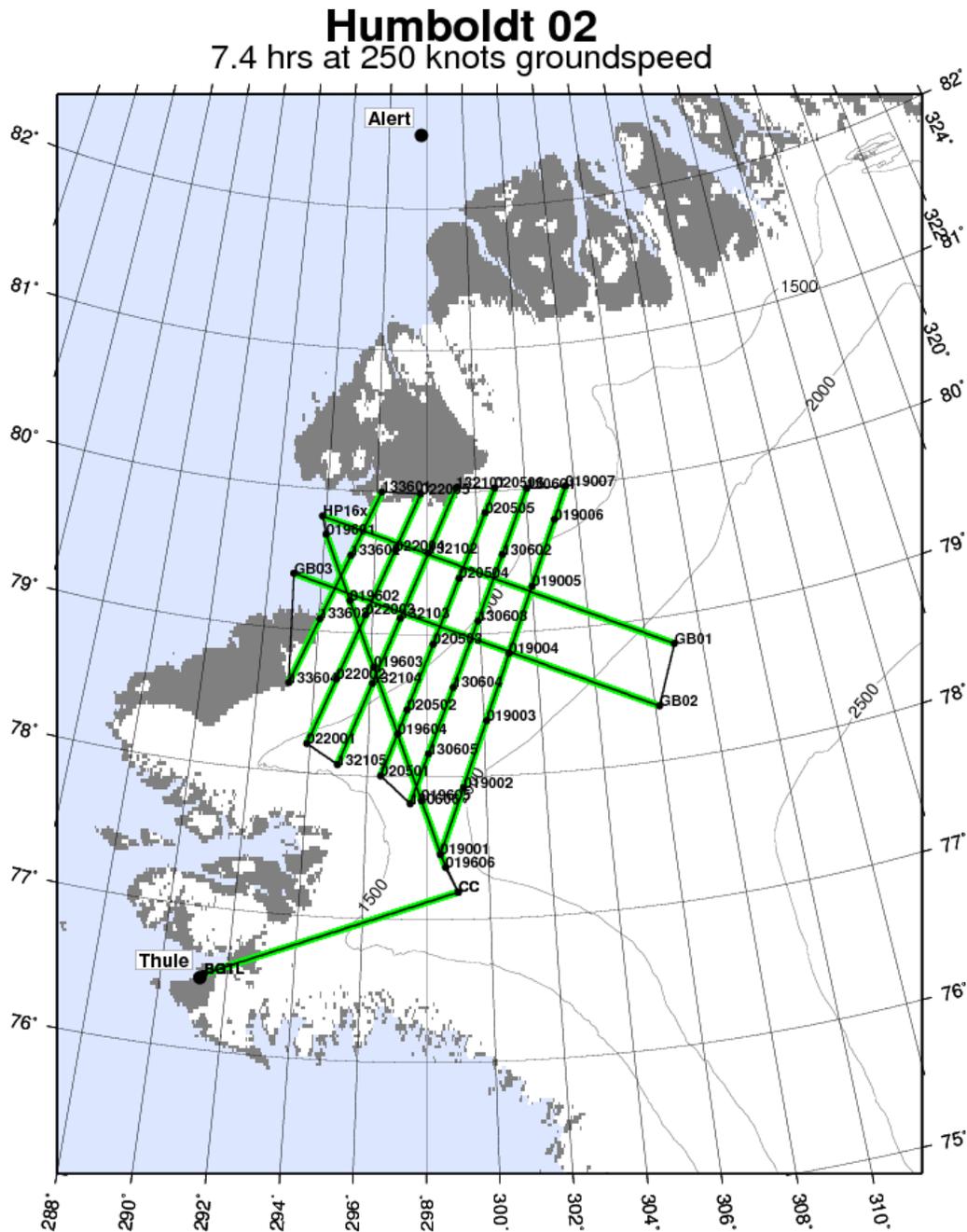
This is a new mission, designed to establish two new along-flow lines and interlace the ICESat lines flown in Humboldt 01 with the intervening ICESat tracks.

Flight Priority: low

ICESat Track: 0190,1306,0205,1321,0220,1336,0196

Last Flown: new flight

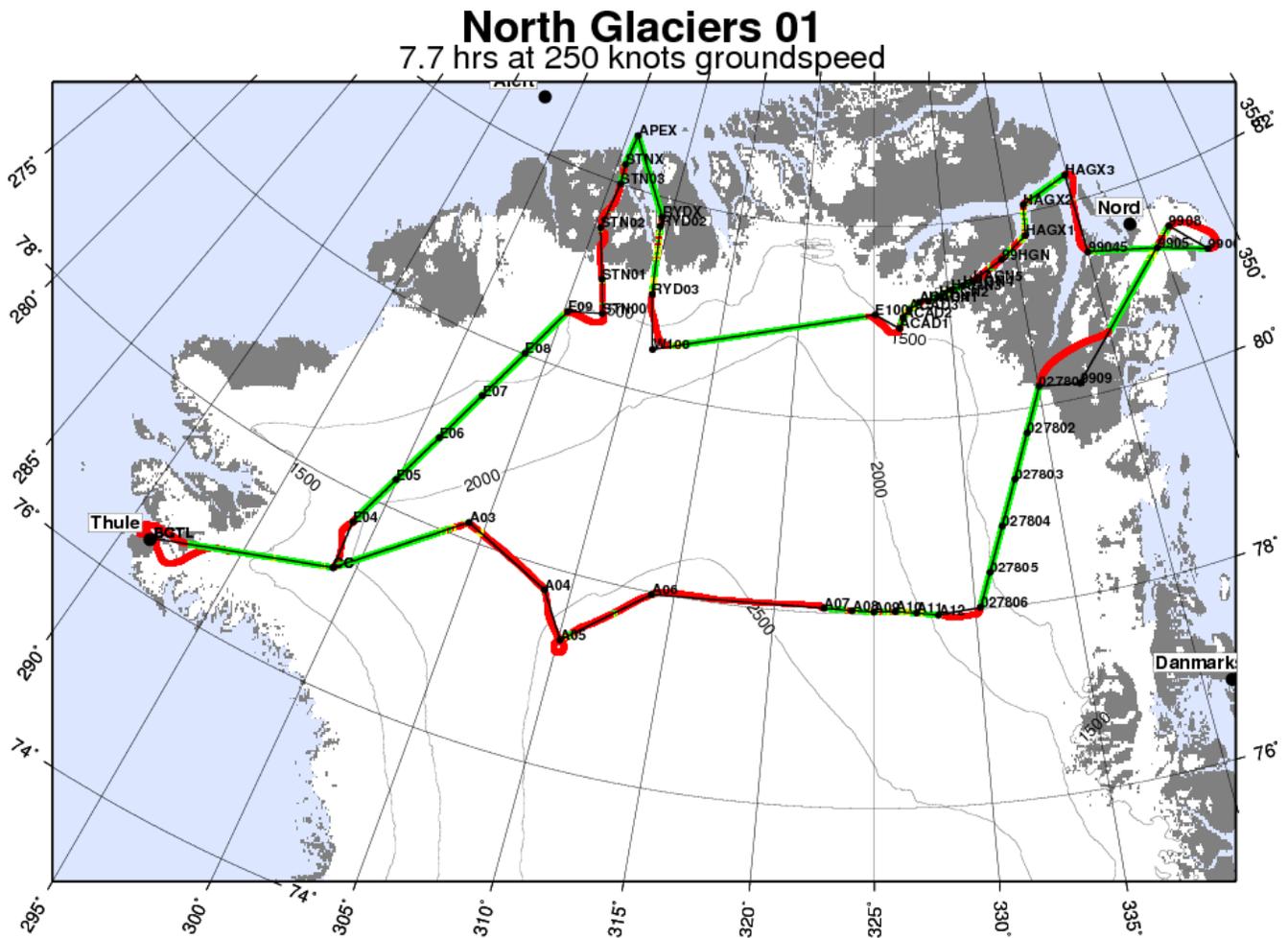
Remaining Design Issues: none



Land Ice – North Glaciers 01 / Thule

This mission is designed to resurvey historical ATM longitudinal surveys of several glaciers in northern Greenland, including Steensby, Ryder, and Hagen Glaciers. The maneuver connecting lower Steensby and Ryder glaciers has been modified to collect straight-line data over the fjords for better gravity data. It also re-occupies ATM lines on the Flade Ice Cap, near Station Nord, and returns to Thule along the British North Greenland Expedition traverse line, which was also flown by ATM in 2002.

Flight Priority: medium
ICESat Track: 0278
Last Flown: 2011
Remaining Design Issues: none



Land Ice – North Glaciers 02 Prime / Thule

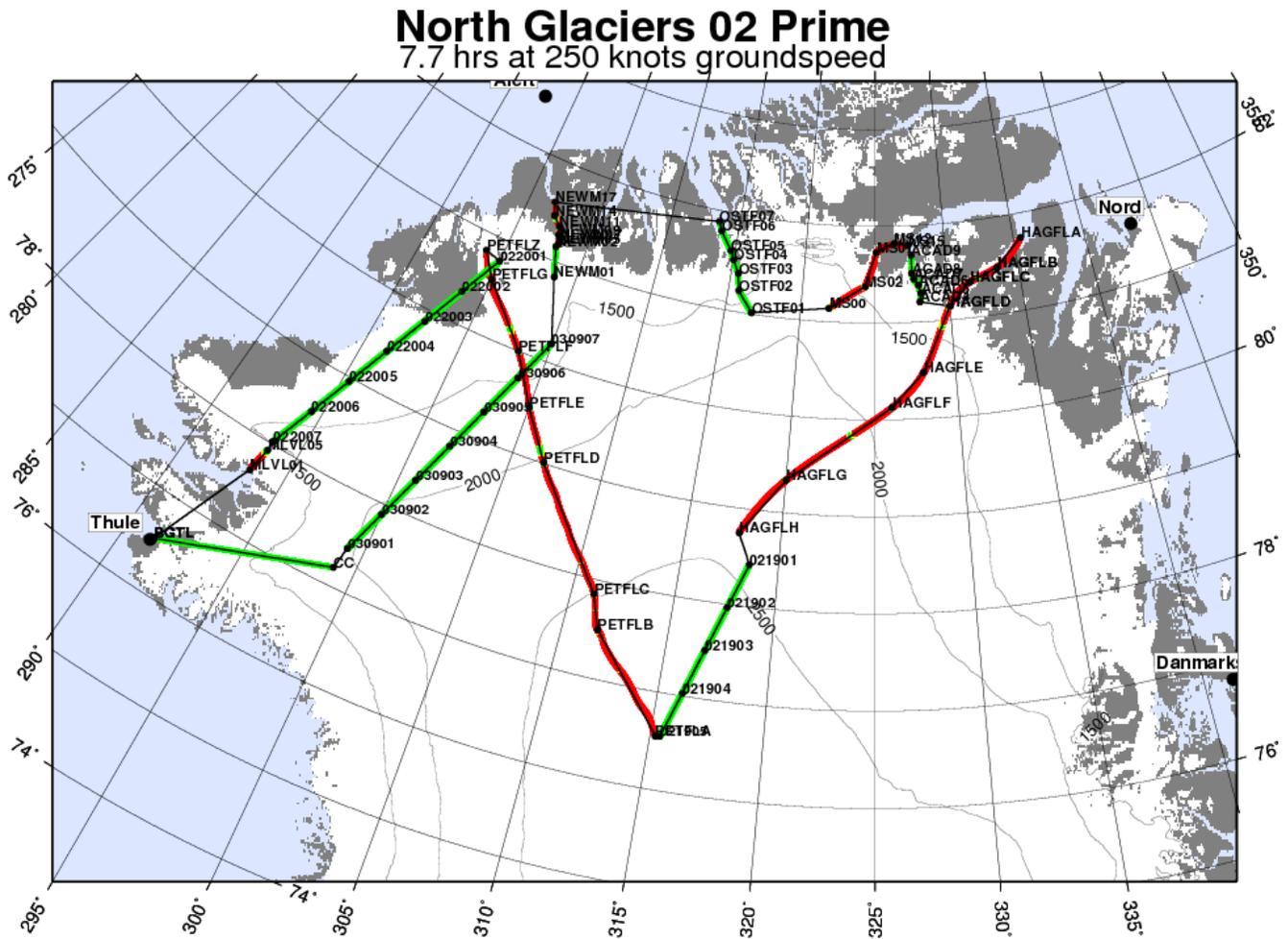
This mission is designed to resurvey a historical ATM longitudinal survey of Academy Glacier, plus several other glaciers. These include Ostfjord, Maria Sophia, and a (possibly unnamed) glacier emptying into Newman Bay. We also survey flowlines of the Hagen and Petermann glaciers all the way from their termini to the ice divide.

Flight Priority: low

ICESat Track: 0220,0309,0219

Last Flown: portions in 2012

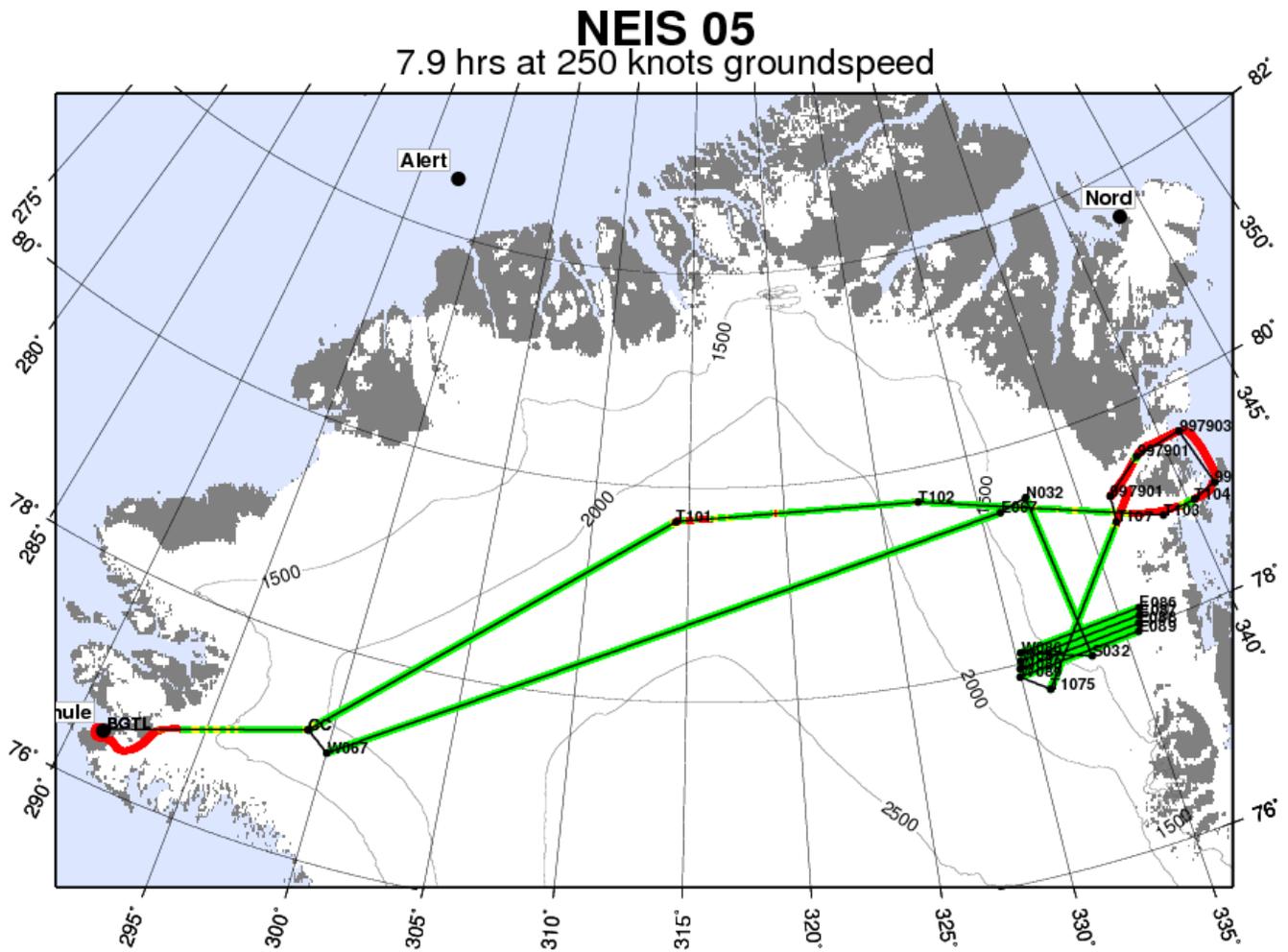
Remaining Design Issues: none



Land Ice – NEIS 05 / Thule

This is a new mission which extends the coverage of the Northeast Ice Stream 10 km grid upstream. It also resurveys the ATM centerlines of Zacharaie and 79N glaciers. One of the east-west transit lines from Thule also resurveys an old ATM line, which crosses through an area of the central ice cap which may be thickening slightly. We also fly the 1999 ATM centerline of 79N Glacier, which avoids a “kink” which caused the upper part of the 2010 flightline to miss the glacier centerline, and the resulting straightening of the centerline also improves gravity data collection there.

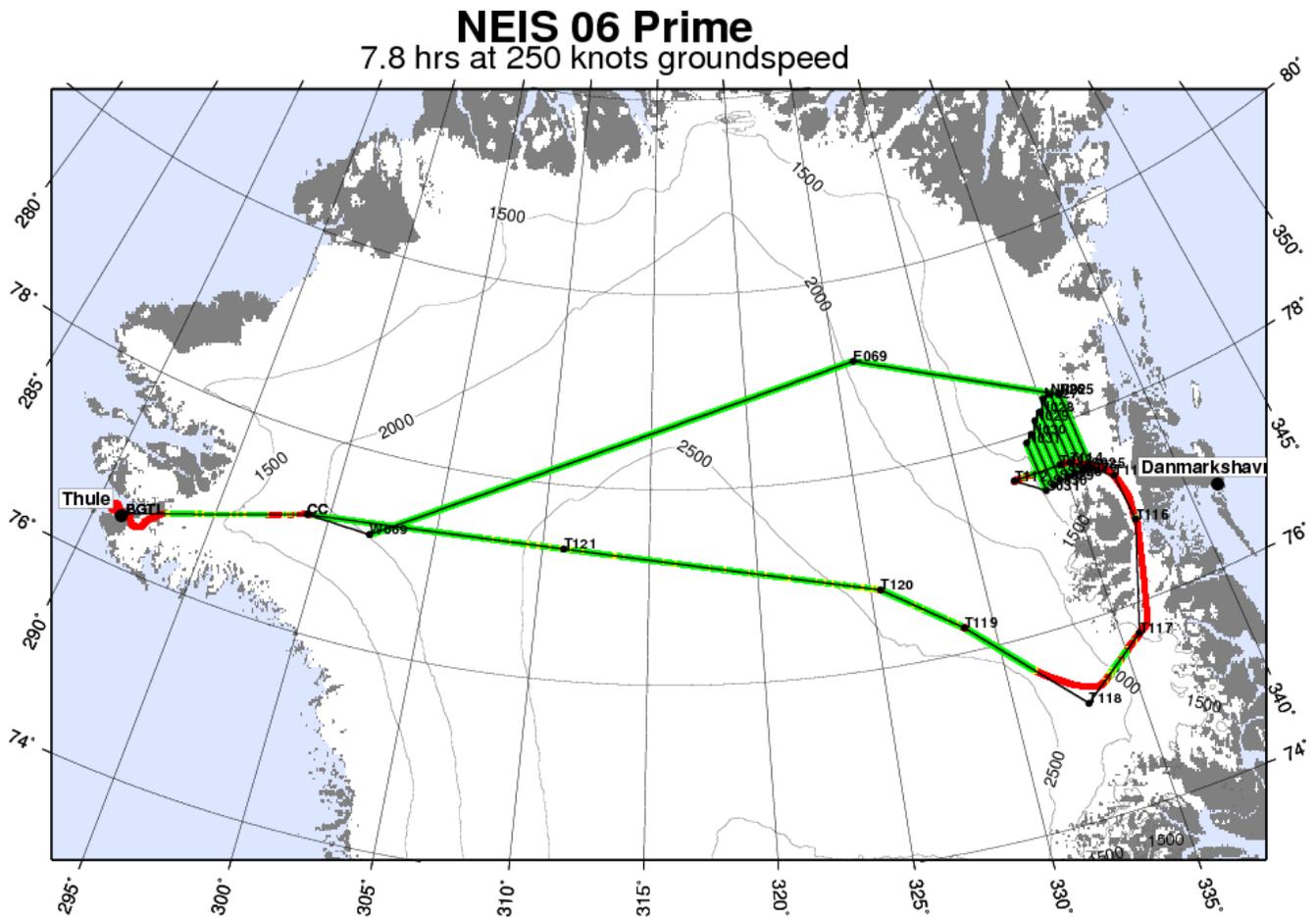
- Flight Priority:** low
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – NEIS 06 Prime / Thule

This is a new mission which extends the coverage of the Northeast Ice Stream 10 km grid upstream. It also resurveys the ATM centerlines of Bistrup and Storstrommen Glaciers. One of the east-west transit lines from Thule also resurveys an old ATM line, which crosses through an area of the central ice cap which may be thickening slightly. This mission differs from the original NEIS 06 designed for 2011 because the Northeast Grid suite of missions included all of the east-west grid lines on the southern approaches to Zacharaie glacier, so here we have replaced these with north-south lines to fill in what would otherwise be a gap in coast-parallel coverage in this area.

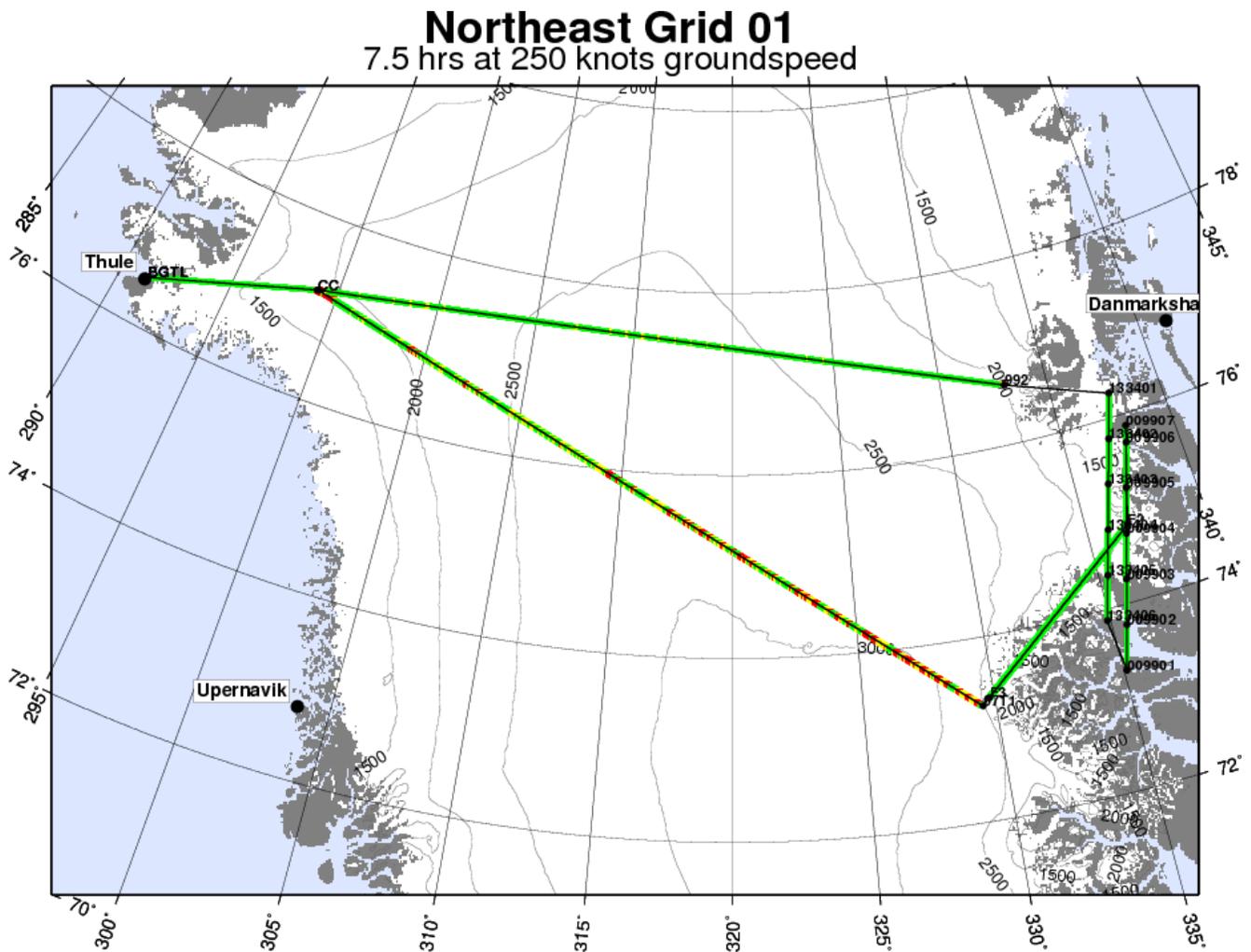
- Flight Priority:** medium
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Northeast Grid 01 / Thule

This is a new mission, one of a suite of six flights intended to thoroughly sample the bedrock topography of northeast Greenland along a series of nearly coast-parallel ICESat lines. At the same time we obtain altimetry measurements along the ICESat tracks which will enable the calculation of dh/dt over a broad area and a significant time span. This particular mission focuses on the easternmost of the coast-parallel lines, and it also samples a pair of 1990s ATM altimetry tracks over north central Greenland, which should yield an even longer dh/dt record over ice which may be thickening in the central part of the ice sheet.

Flight Priority: high
ICESat Track: 1334,0099
Last Flown: new flight
Remaining Design Issues: none

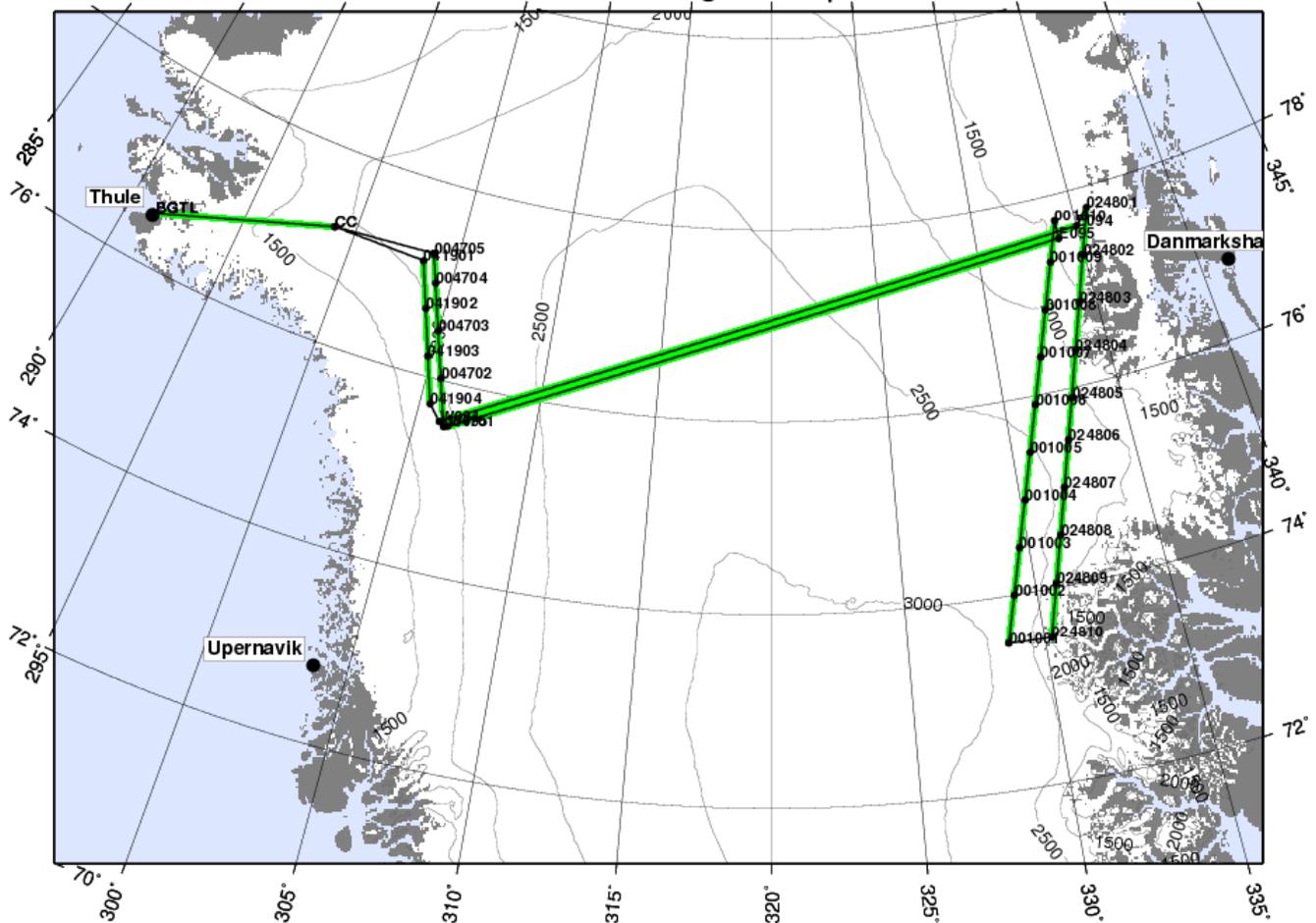


Land Ice – Northeast Grid 04 / Thule

This is a new mission, one of a suite of six flights intended to thoroughly sample the bedrock topography of northeast Greenland along a series of nearly coast-parallel ICESat lines. At the same time we obtain altimetry measurements along the ICESat tracks which will enable the calculation of dh/dt over a broad area and a significant time span. This particular mission complements the Northeast Grid 01/02/03 missions with the next two tracks in the inland direction. It transits to the area along short ICESat tracks in the west and new east-west master grid lines. This is a long mission, but we have several options to shorten the mission in real-time if necessary, including completing part of the return transit direct at high-altitude.

- Flight Priority:** high
- ICESat Track:** 0419,0248,0010,0047
- Last Flown:** new flight
- Remaining Design Issues:** none

Northeast Grid 04 8.0 hrs at 250 knots groundspeed



Land Ice – Northeast Grid 05 / Thule

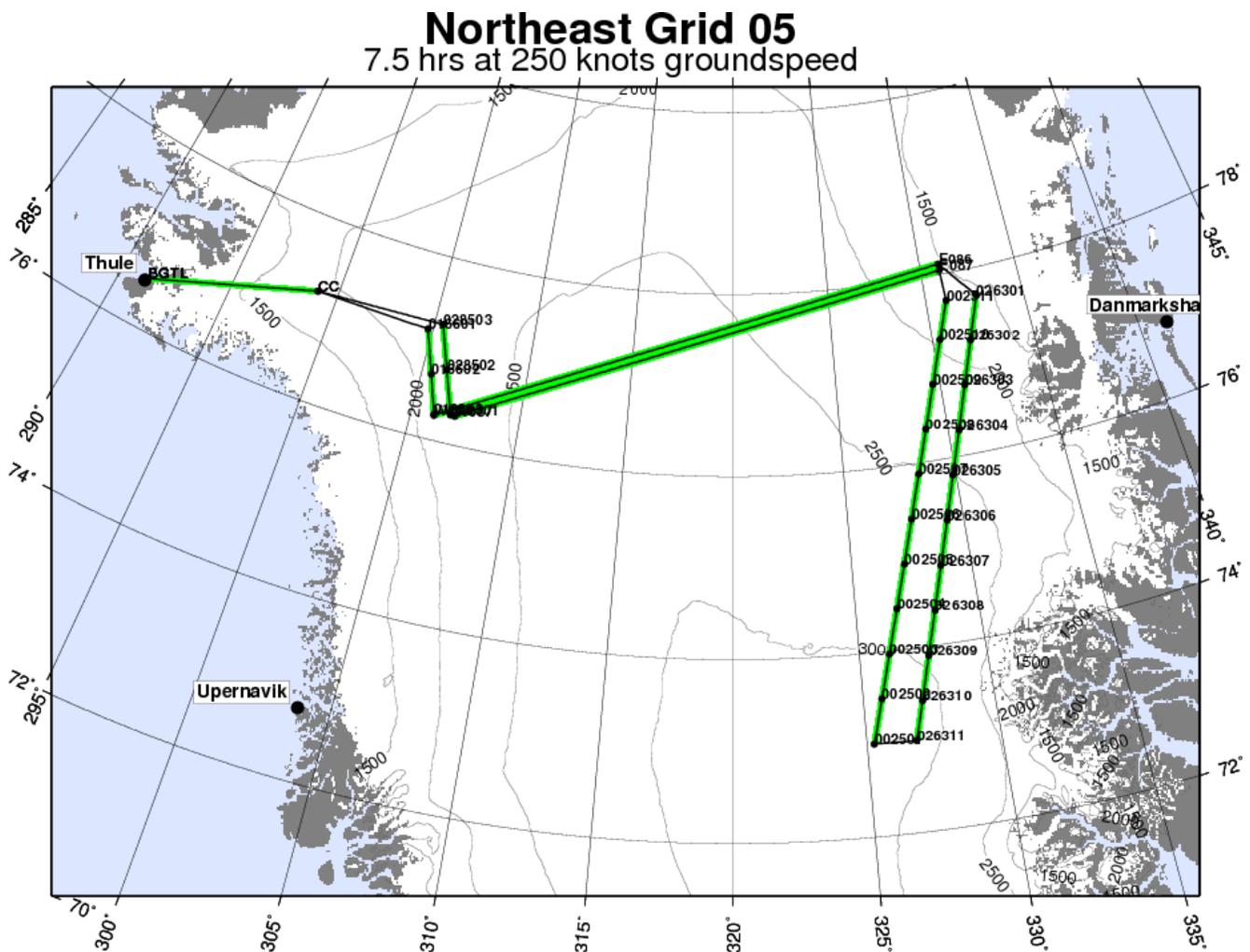
This is a new mission, one of a suite of six flights intended to thoroughly sample the bedrock topography of northeast Greenland along a series of nearly coast-parallel ICESat lines. At the same time we obtain altimetry measurements along the ICESat tracks which will enable the calculation of dh/dt over a broad area and a significant time span. This particular mission complements the Northeast Grid 01/02/03/04 missions with the next two tracks in the inland direction. It transits to the area along short ICESat tracks in the west and new east-west master grid lines.

Flight Priority: low

ICESat Track: 0166,0263,0025,0285

Last Flown: new flight

Remaining Design Issues: none



Land Ice – Northeast Grid 06 / Thule

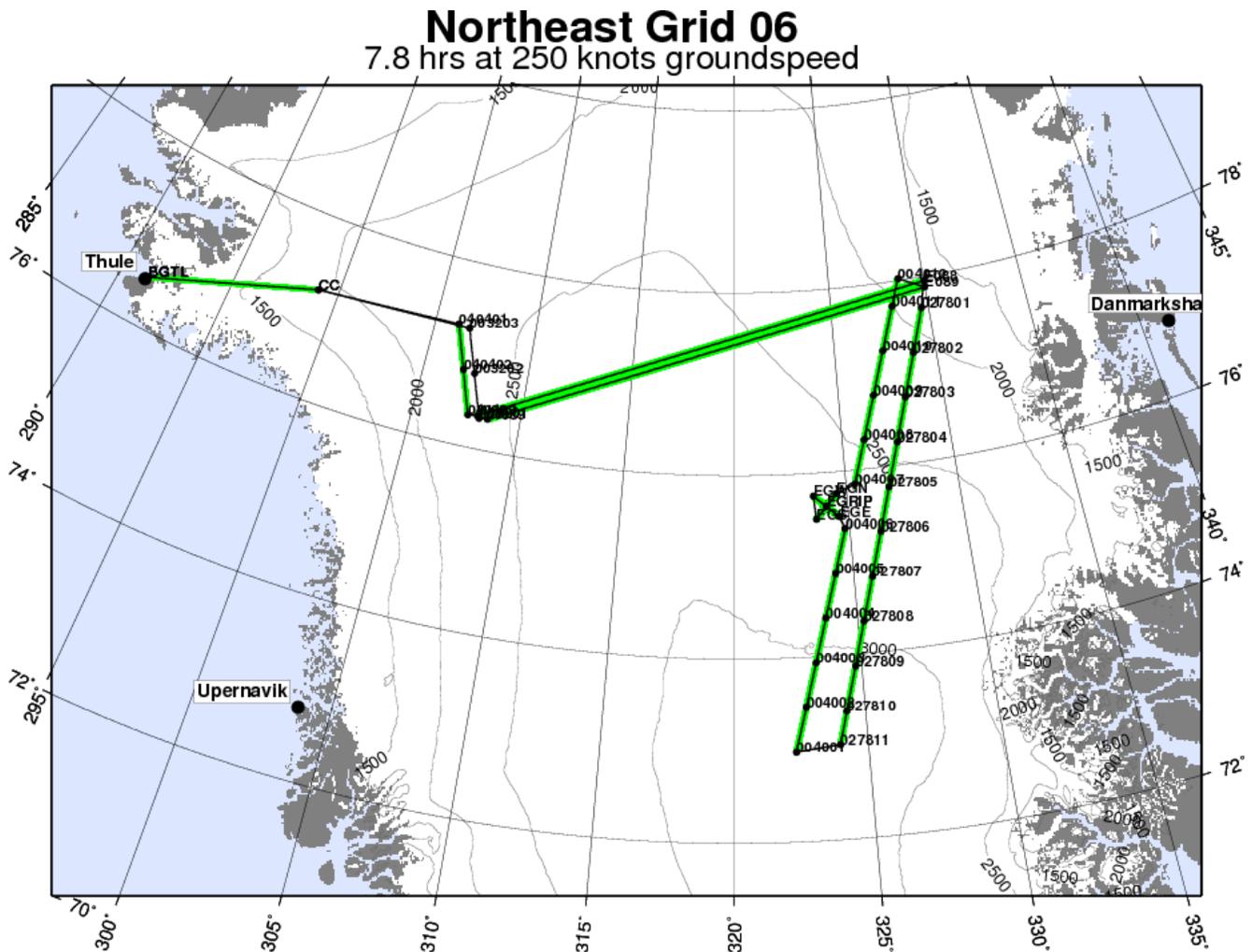
This is a new mission, one of a suite of six flights intended to thoroughly sample the bedrock topography of northeast Greenland along a series of nearly coast-parallel ICESat lines. At the same time we obtain altimetry measurements along the ICESat tracks which will enable the calculation of dh/dt over a broad area and a significant time span. This particular mission complements the Northeast Grid 01/02/03/04/05 missions with the next two tracks in the inland direction. It transits to the area along short ICESat tracks in the west and new east-west master grid lines.

Flight Priority: low

ICESat Track: 0404,0278,0040,0032

Last Flown: new flight

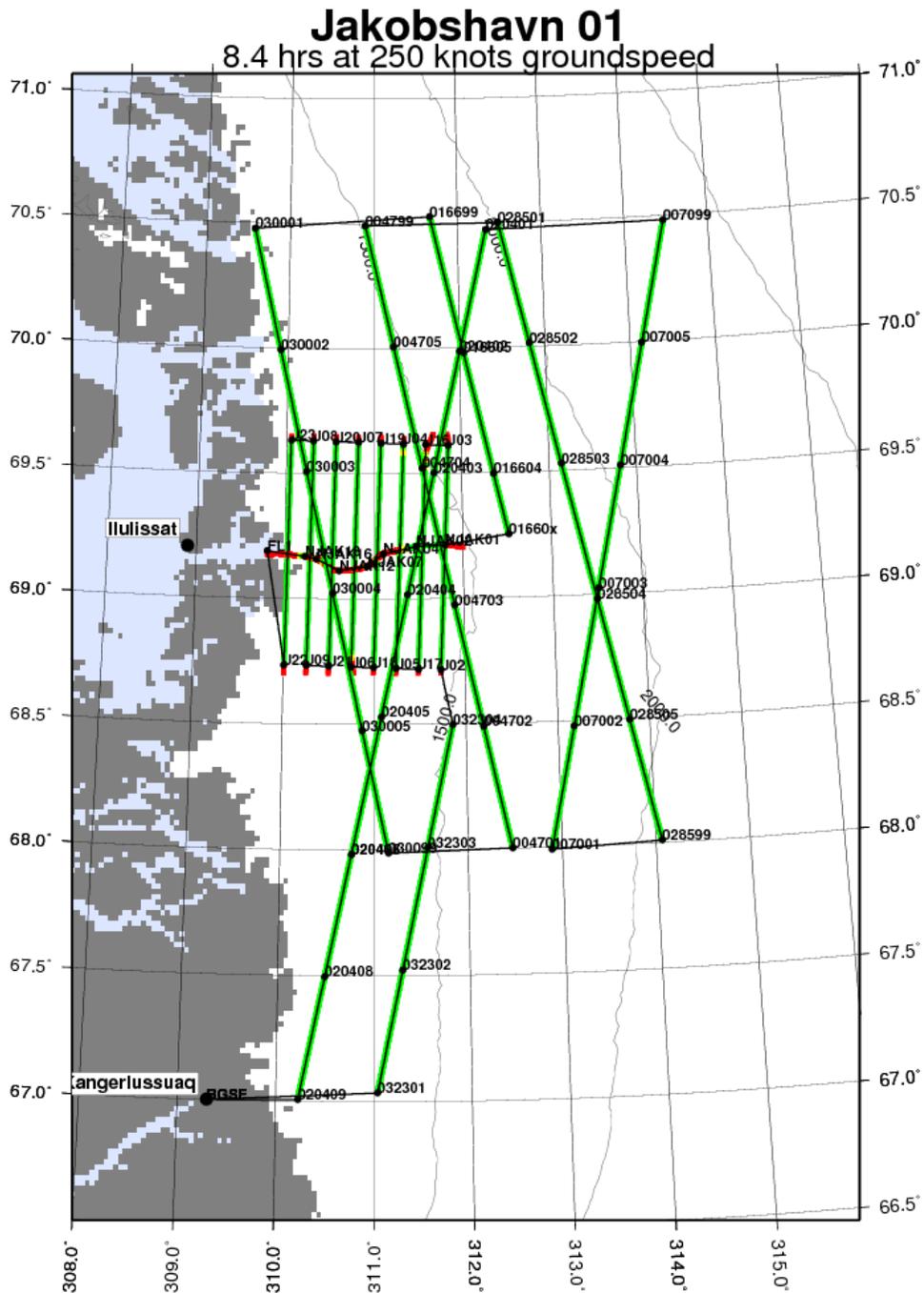
Remaining Design Issues: none



Land Ice – Jakobshavn 01 / Kangerlussuaq

This is a repeat of 2009, 2010, 2011 and 2012 IceBridge missions. Its purpose is to re-survey the highest-priority lines of the historical ATM 10-km Jakobshavn grid, the main flowline of Jakobshavn. It also extends that grid with a broader array of ICESat ground tracks over the larger Jakobshavn basin.

Flight Priority: high
ICESat Track: 0323,0300,0047,0285,0070,0204
Last Flown: 2012
Remaining Design Issues: none



Land Ice – Jakobshavn 02 / Kangerlussuaq

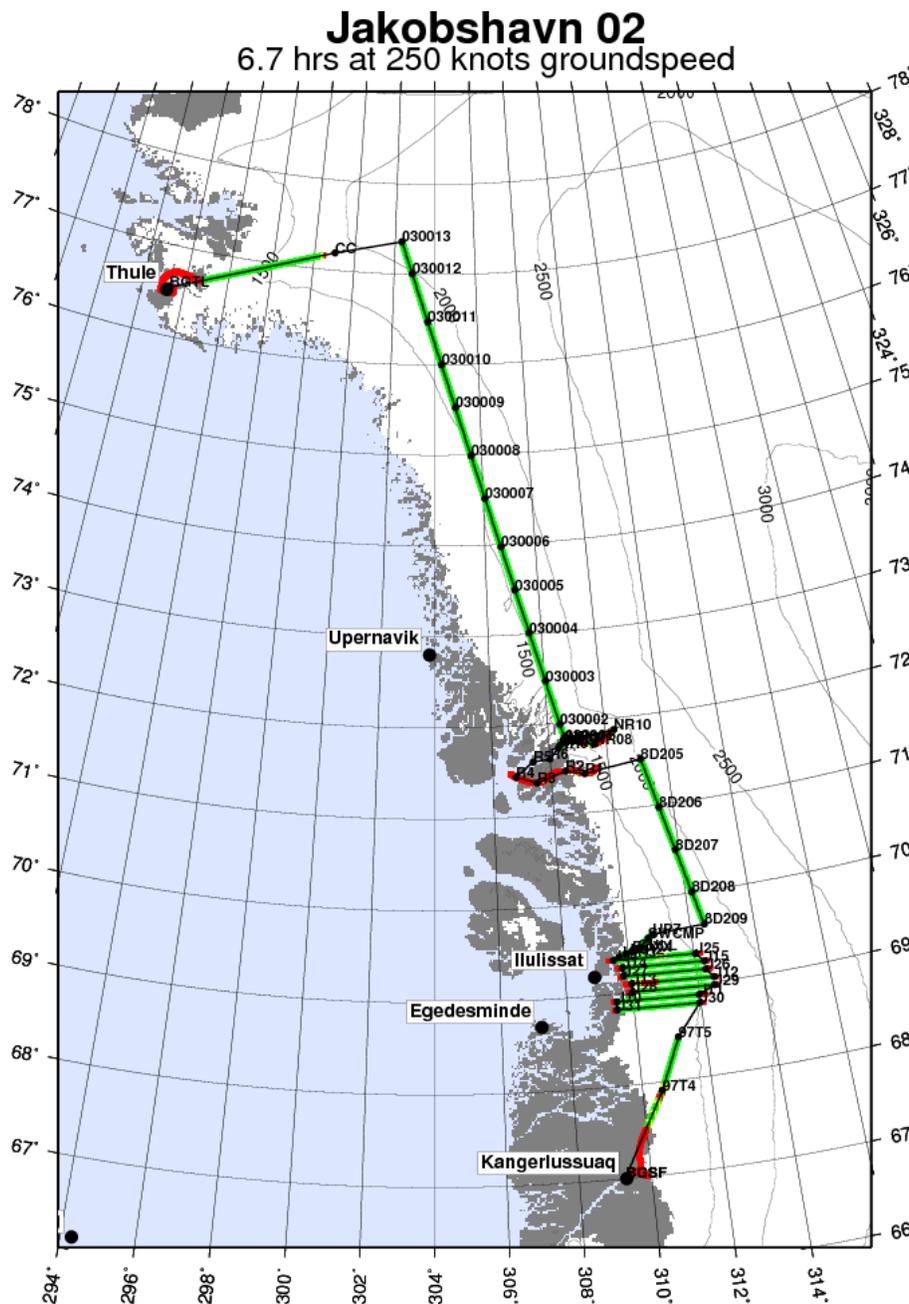
This mission is a repeat of similar 2009, 2010, 2011 and 2012 OIB flight. The primary science objectives are to (a) complete the basic Jakobshavn grid, specifically the east-west lines, (b) repeat longitudinal surveys of the Rink and Kangerdlugssup Glaciers, and (c) occupy ICESat ground track 0300. We also occupy a line connecting Swiss Camp and a pair of Eric Lutz-requested points nearby. **This mission can be configured as a transit flight between Thule and Kangerlussuaq.**

Flight Priority: high

ICESat Track: 0300

Last Flown: 2012

Remaining Design Issues: extend Kangerdlugssup line inland



Land Ice – Jakobshavn-Eqip-Store / Kangerlussuaq

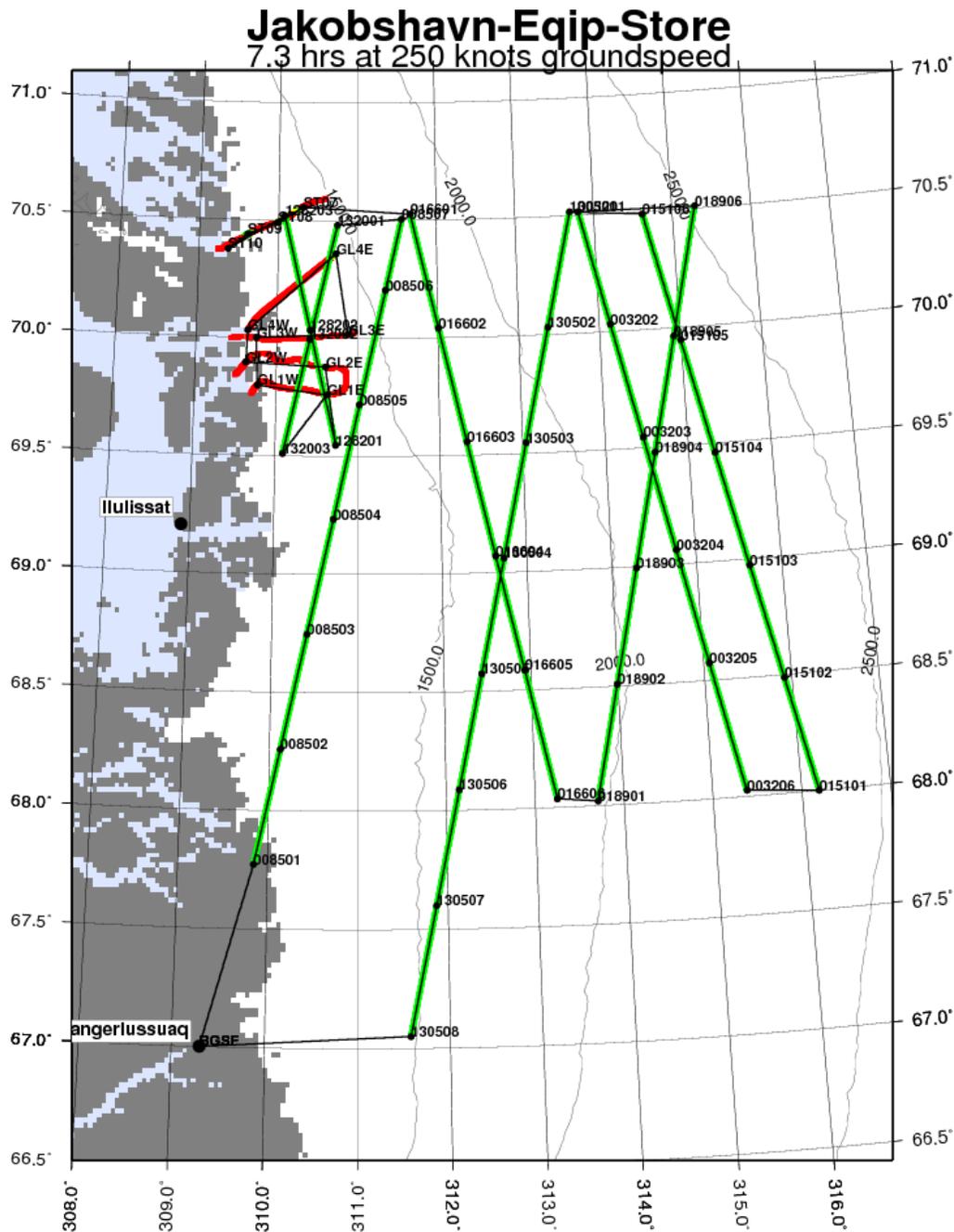
This is a modified version of the 2011 Jakobshavn-Lake mission, whose main purpose it to extend the ICESat grid begun with Jakobshavn 01 farther upstream. We also densify the ICESat grid over the Eqip Sermia catchment area north of Jakobshavn, and we refly the centerlines of Eqip Sermia, Kangilerngata Sermia, Sermeq Kujalleq and Store Glaciers,

Flight Priority: high

ICESat Track: 0085,1320,1282,0166,0189,0032,0151,1305

Last Flown: 2012

Remaining Design Issues: none



Land Ice – East-Central Grid 02 / Kangerlussuaq

This is a new mission, one of a series of three (the other two flown in 2012) intended to connect with and continue the east Greenland coast-parallel grid along ICESat lines to the south from the suite of Northeast Grid missions.

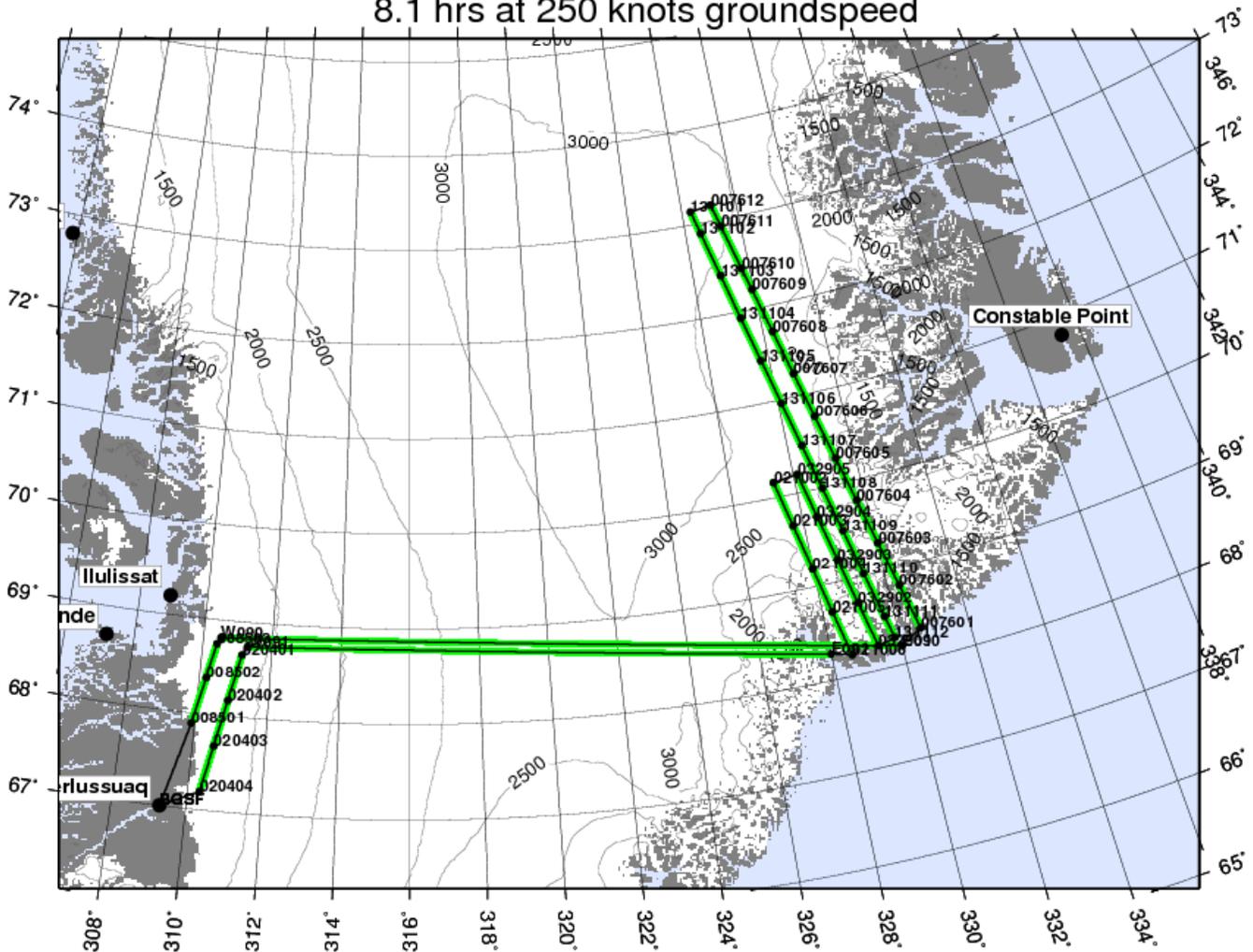
Flight Priority: high

ICESat Track: 0085,0076,1311,0329,0210,0204

Last Flown: new flight

Remaining Design Issues: none

East Central Grid 02 8.1 hrs at 250 knots groundspeed



Land Ice – Geikie 01 / Kangerlussuaq

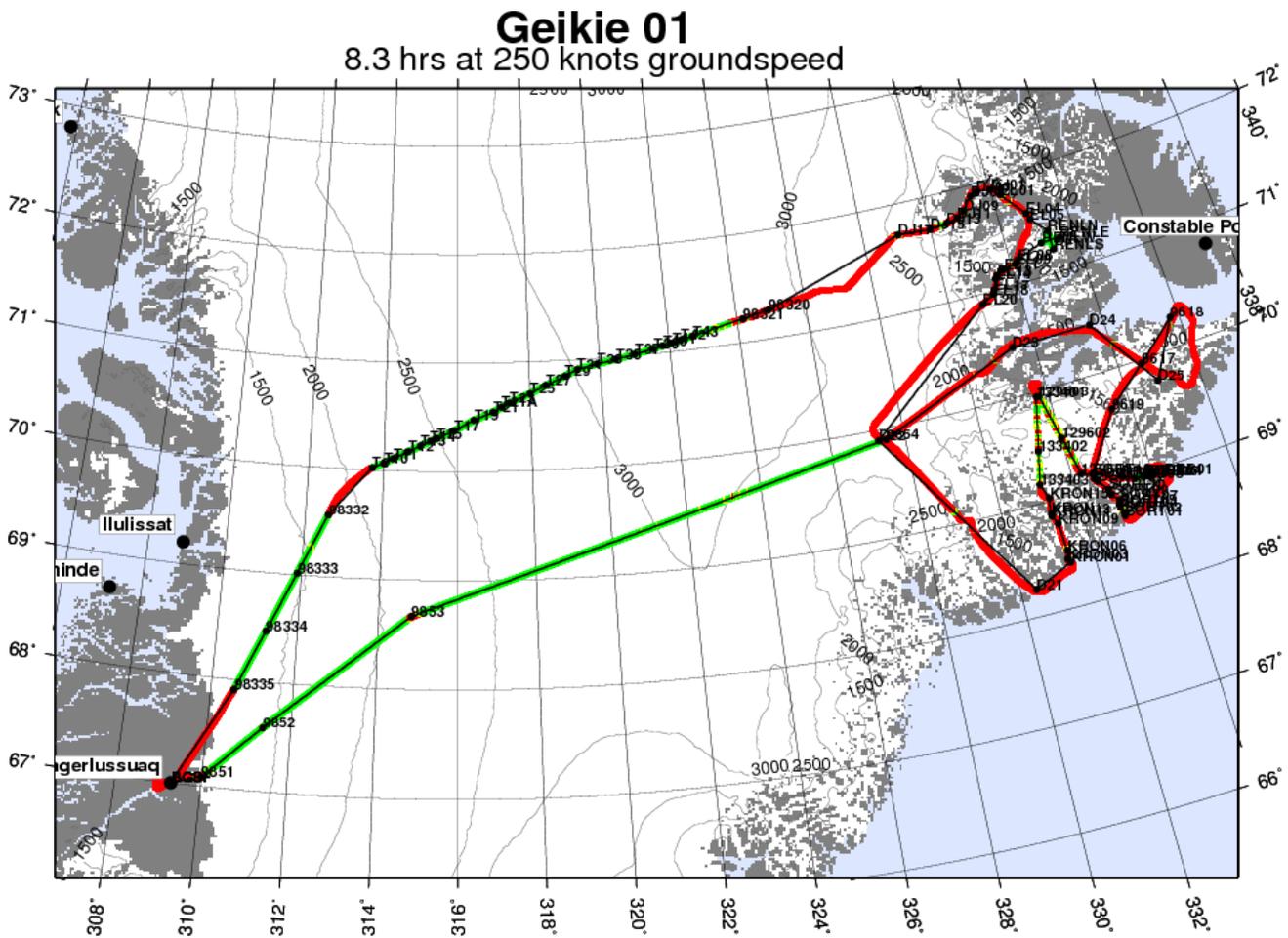
This mission is a repeat of 2010 and 2011 IceBridge missions. It includes reflights of the Daugard-Jensen, Vestfjord and Kong Christian IV glaciers, and the “X” pattern over the Geikie Plateau, all of which have pre-IceBridge altimetry from ATM. It also reflies the Eielson, De Reste Bugt, Sortebrae and Kronborg glaciers, first flown in 2010. Finally, the northern transit line across the ice sheet is the EGIG line, part of the 2011 CryoVex validation effort for CryoSat.

Flight priority: low

ICESat Track: none

Last Flown: 2011

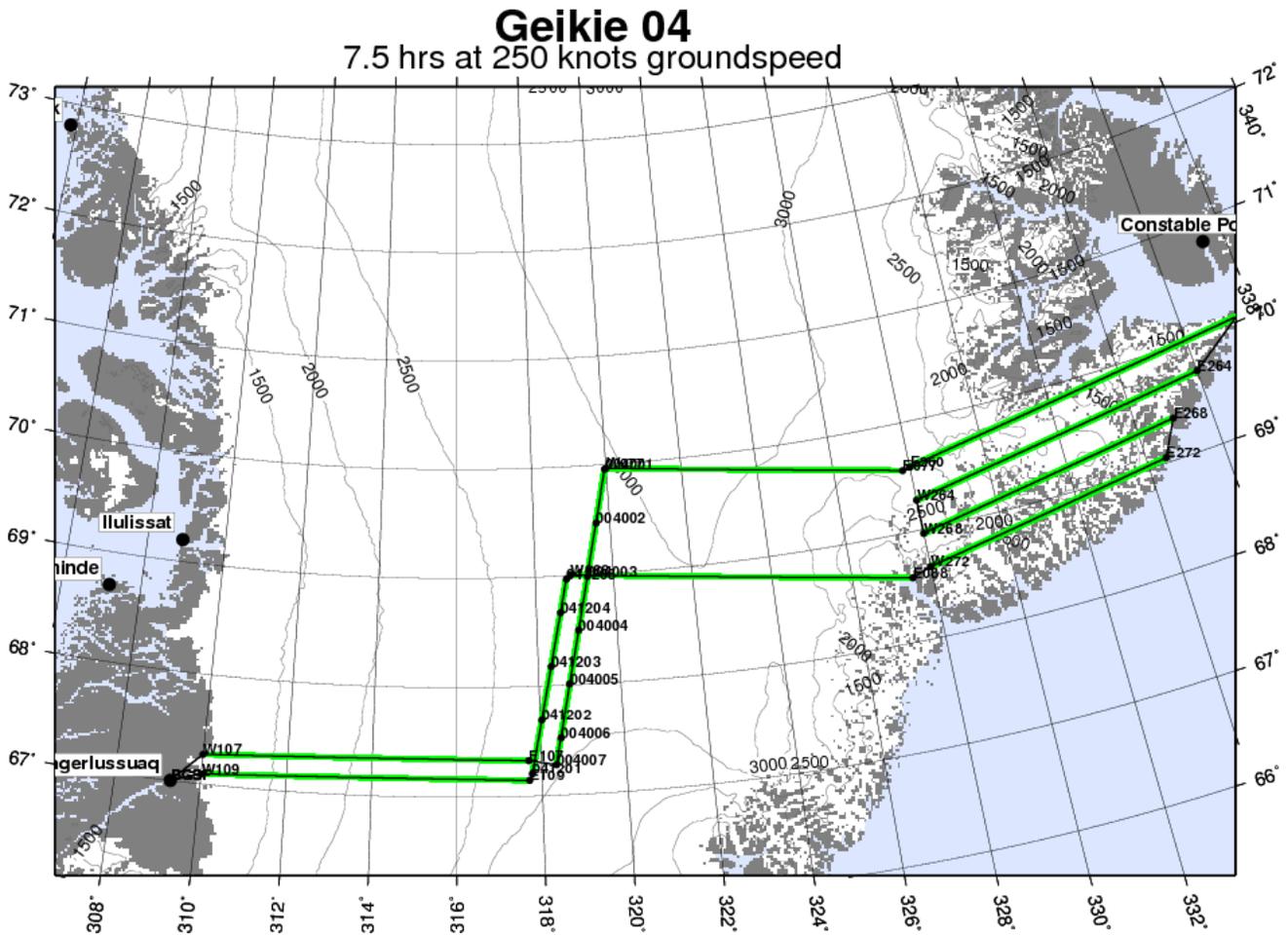
Remaining Design Issues: consider adjusting upper Vestfjord and Christian IV centerlines



Land Ice – Geikie 04 / Kangerlussuaq

This is a new mission. It flies a 40 km east-west grid pattern over the Geikie Peninsula, which are an extension of the north Greenland master grid pattern. This grid is offset by 20 km from the grid in the 2012 Geikie 03 and thus complements that mission by densifying the coverage.

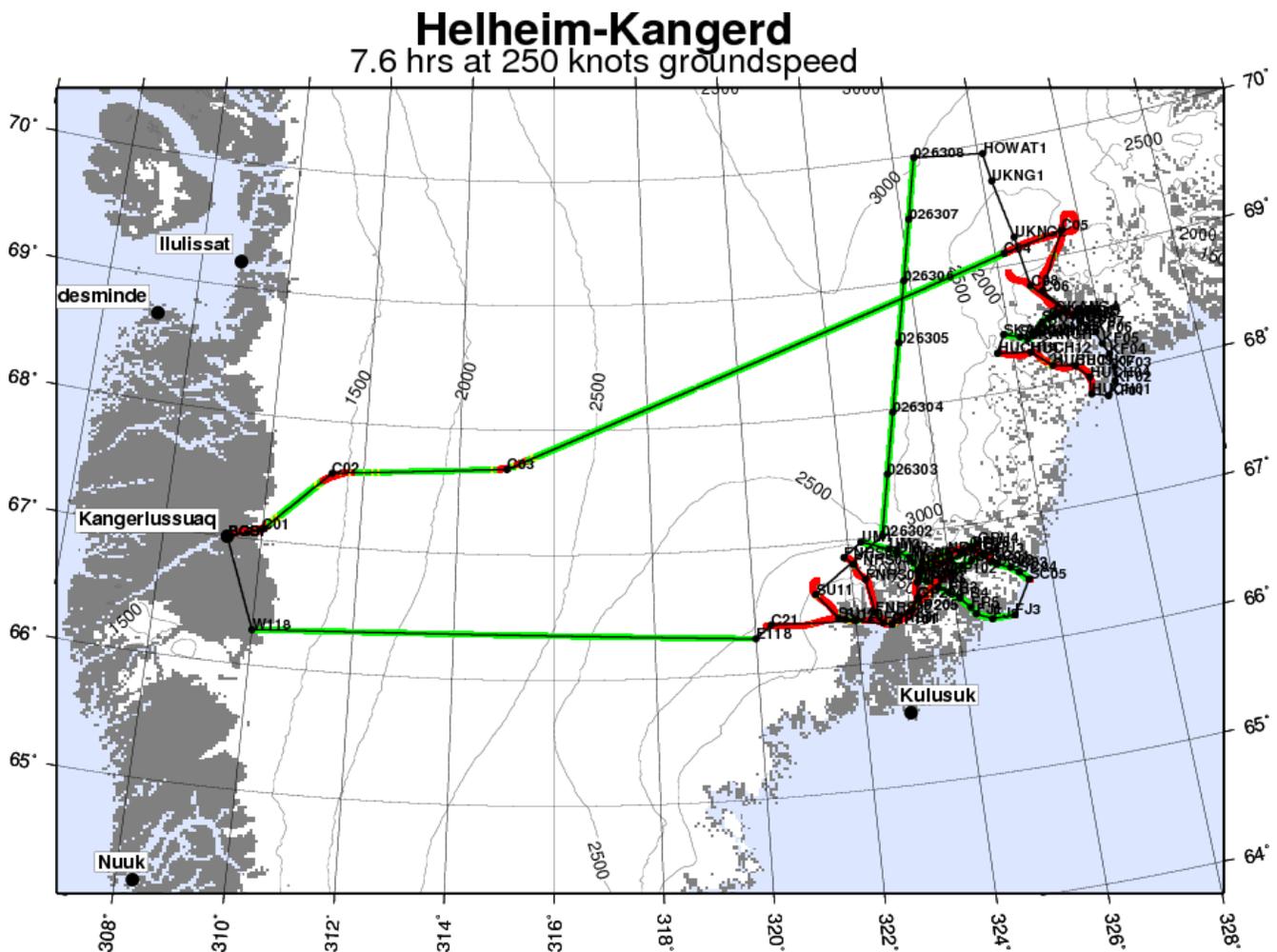
- Flight Priority:** high
- ICESat Track:** 0412,0040
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Helheim-Kangerdlugssuaq / Kangerlussuaq

This is a repeat mission, and is very similar to missions flown in 2010, 2011 and 2012. It captures centerline surveys of the two main branches of Helheim, of Kangerdlugssuaq, Fenris and of several branches of Midgard glaciers. We also re-fly the centerline of the Hutchinson Glacier, and establish a new centerline of a glacier which empties into the fjord of Kangerdlugssuaq Glacier just beyond its terminus.

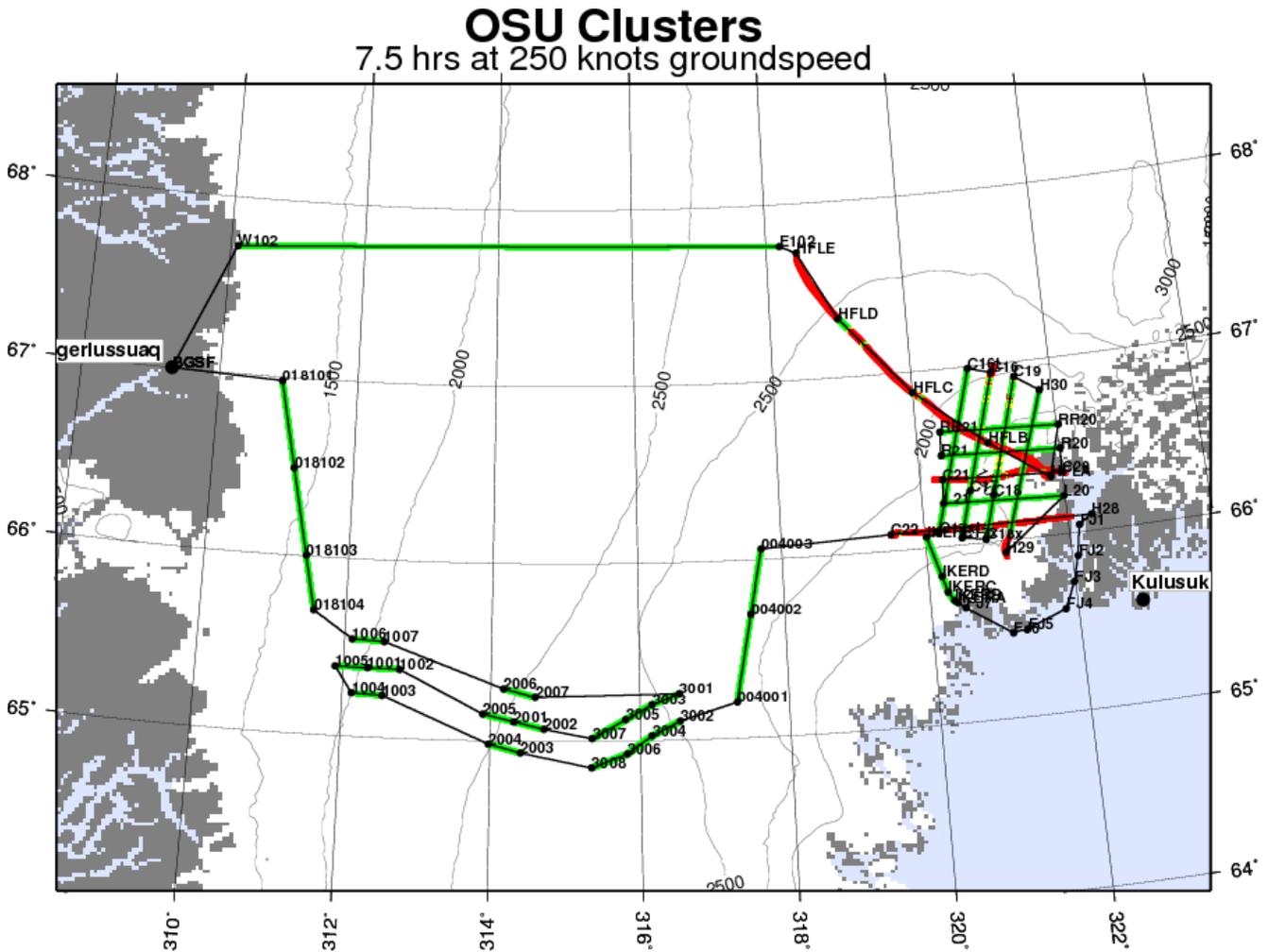
Flight Priority: high
ICESat Track: 0263
Last Flown: 2012
Remaining Design Issues: none



Land Ice – OSU Clusters / Kangerlussuaq

This is a new mission, designed with several goals in mind. First, we re-fly the OSU Cluster sites straddling the ice divide southeast of Kangerlussuaq. We also fly a centerline of Helheim Glacier from the terminus all the way to the ice divide. In addition, we establish an improved centerline of the Ikertivaq Glacier, and we re-fly a ~15-km grid pattern over the lower Helheim catchment last flown by the ATM/KU teams in 2008.

Flight Priority: medium
ICESat Track: 0040,0181
Last Flown: portions in 2012
Remaining Design Issues: none



Land Ice – Southeast Glaciers 01 / Kangerlussuaq

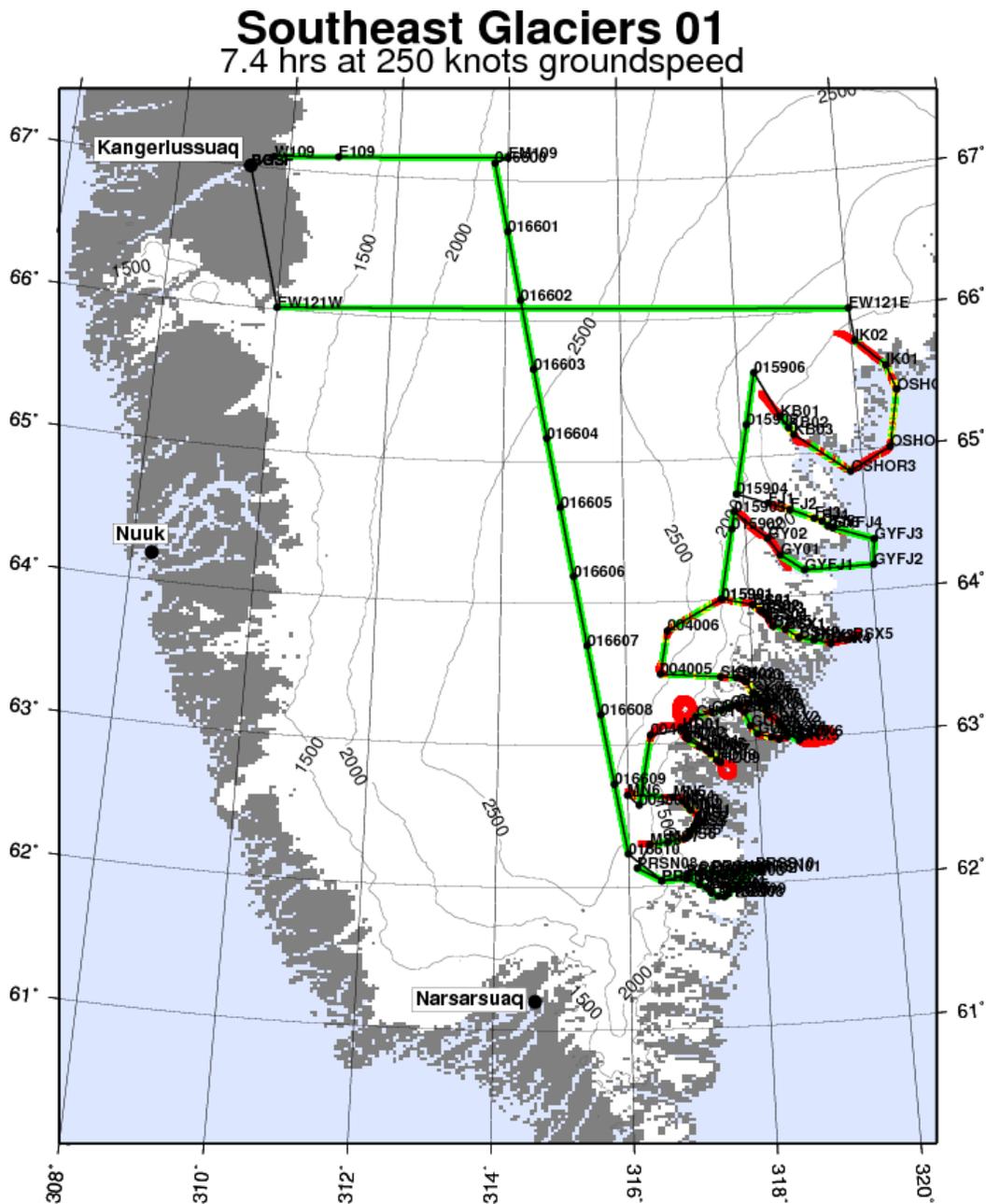
This mission is a repeat of the 2012 Southeast Glaciers mission. Its primary purpose is to continue dh/dt monitoring of 10 glaciers in the southeast which have been flown since 2008, and two additional glaciers in the south near the Pursortoq peninsula first flown in 2012. We also occupy an ICESat line between the southernmost glacier and Kangerlussuaq, and an east-west master grid line between the northernmost glacier and Kangerlussuaq.

Flight Priority: low

ICESat Track: 0166,0040,0159

Last Flown: 2012

Remaining Design Issues: none



Land Ice – Southwest Glaciers 01 / Kangerlussuaq

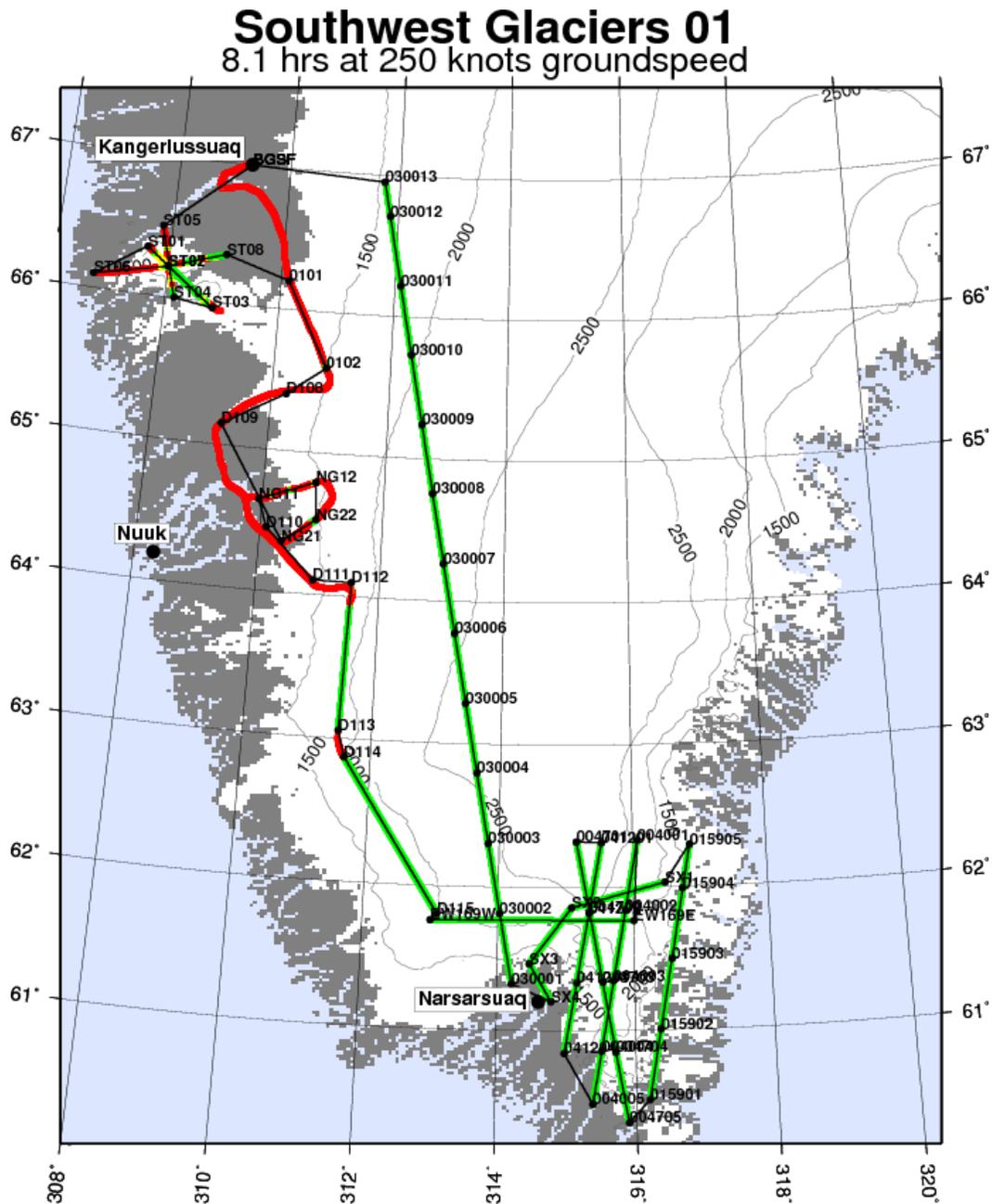
This mission incorporates previously-flown lines over Sukkertoppen Ice Cap and over four glaciers near Nuuk, including Kangiata Nunaata Sermia, Tasersuaq, Narsap Sermia, and Akugdlerupasermia. We also re-fly a series of ICESat lines covering the southernmost lobe of the Greenland Ice Sheet. We return to Kangerlussuaq along a lengthy ICESat track over southern Greenland.

Flight Priority: low

ICESat Track: 0040,0412,0047,0159,0300

Last Flown: 2012

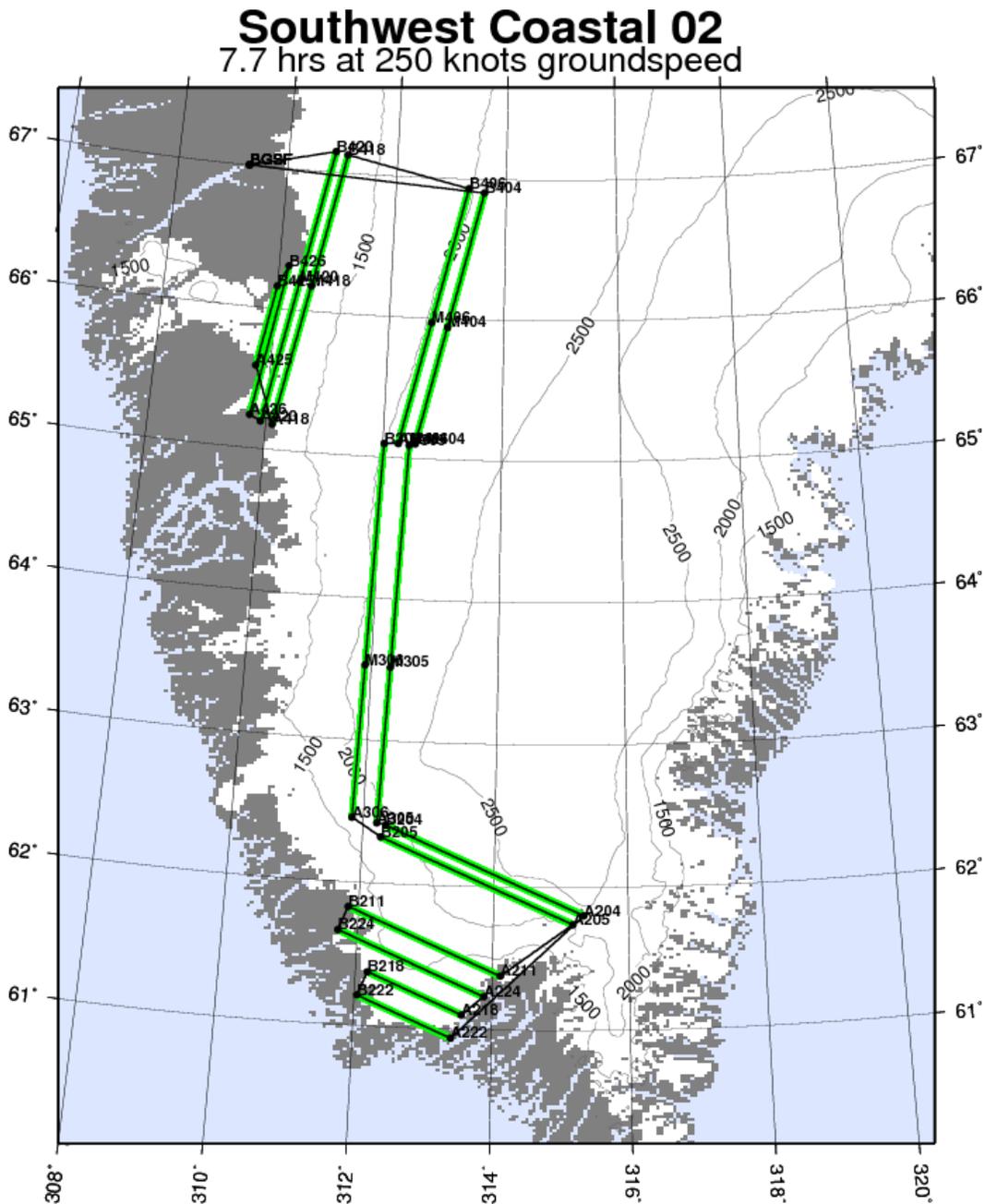
Remaining Design Issues: none



Land Ice – Southwest Coastal 02 / Kangerlussuaq

This is a new mission, one of a set of four which mirrors the coast-parallel coverage of the 2010-2011 Southeast Coastal missions in the southwest, along 2011 LVIS flight lines. This particular mission extends the main grid inland, and also extends the grid outward on smaller ice lobes just south of Kangerlussuaq and at the southern end of the ice sheet.

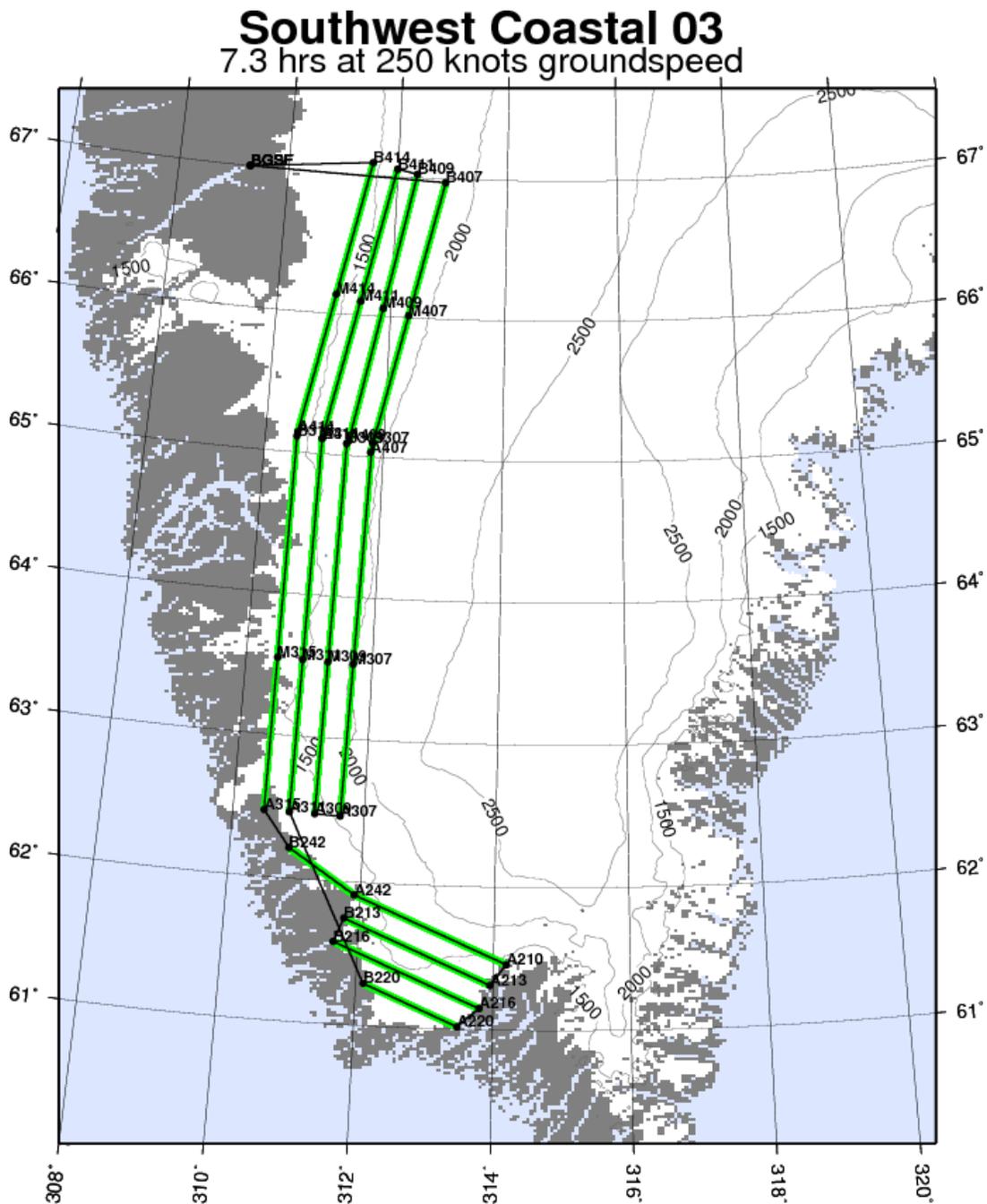
- Flight Priority:** medium
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Southwest Coastal 03 / Kangerlussuaq

This is a new mission, one of a set of four which mirrors the coast-parallel coverage of the 2010-2011 Southeast Coastal missions in the southwest. This particular mission interlaces the ~20 km grid established with Southwest Coastal 01 to a combined spacing of ~10 km.

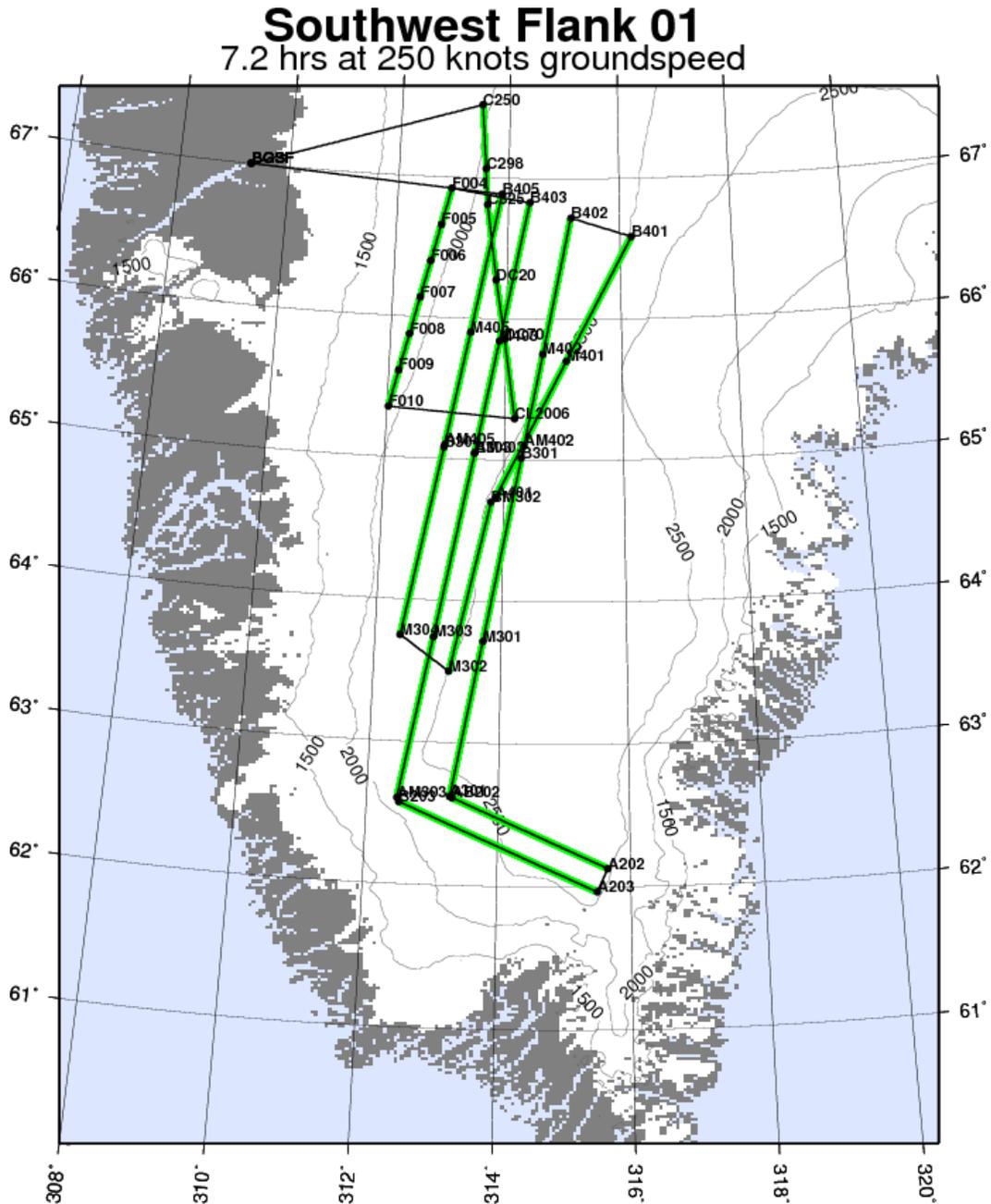
- Flight Priority:** high
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Land Ice – Southwest Flank 01 / Kangerlussuaq

This is a new mission, one of a set of four which mirrors the coast-parallel coverage of the 2010-2011 Southeast Coastal missions in the southwest. This particular mission extends the grid inland toward the ice divide. We also re-fly a series of several ground sites occupied by ground teams in the mid-1990s for long-term dh/dt determination.

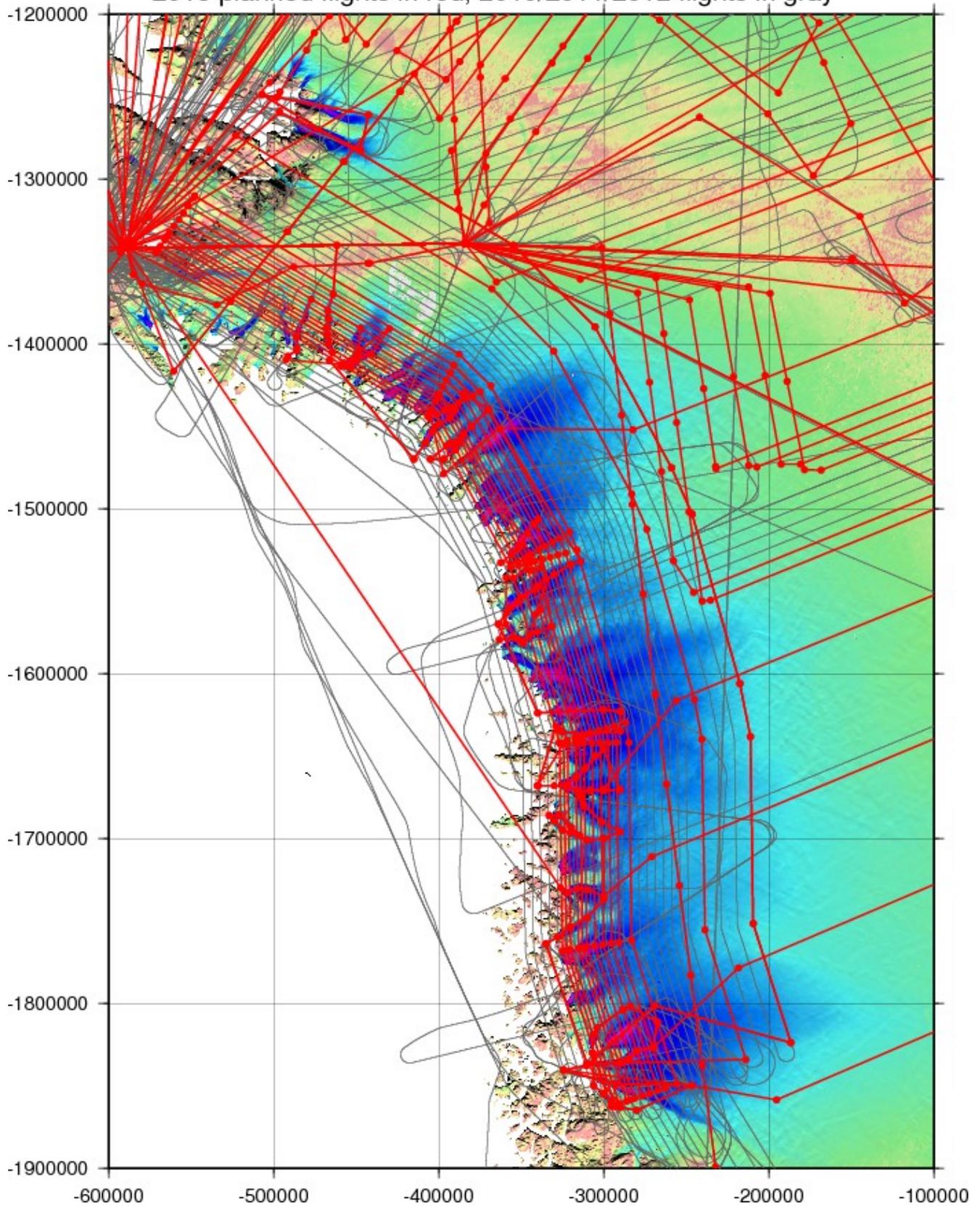
- Flight Priority:** medium
- ICESat Track:** none
- Last Flown:** new flight
- Remaining Design Issues:** none



Composite maps

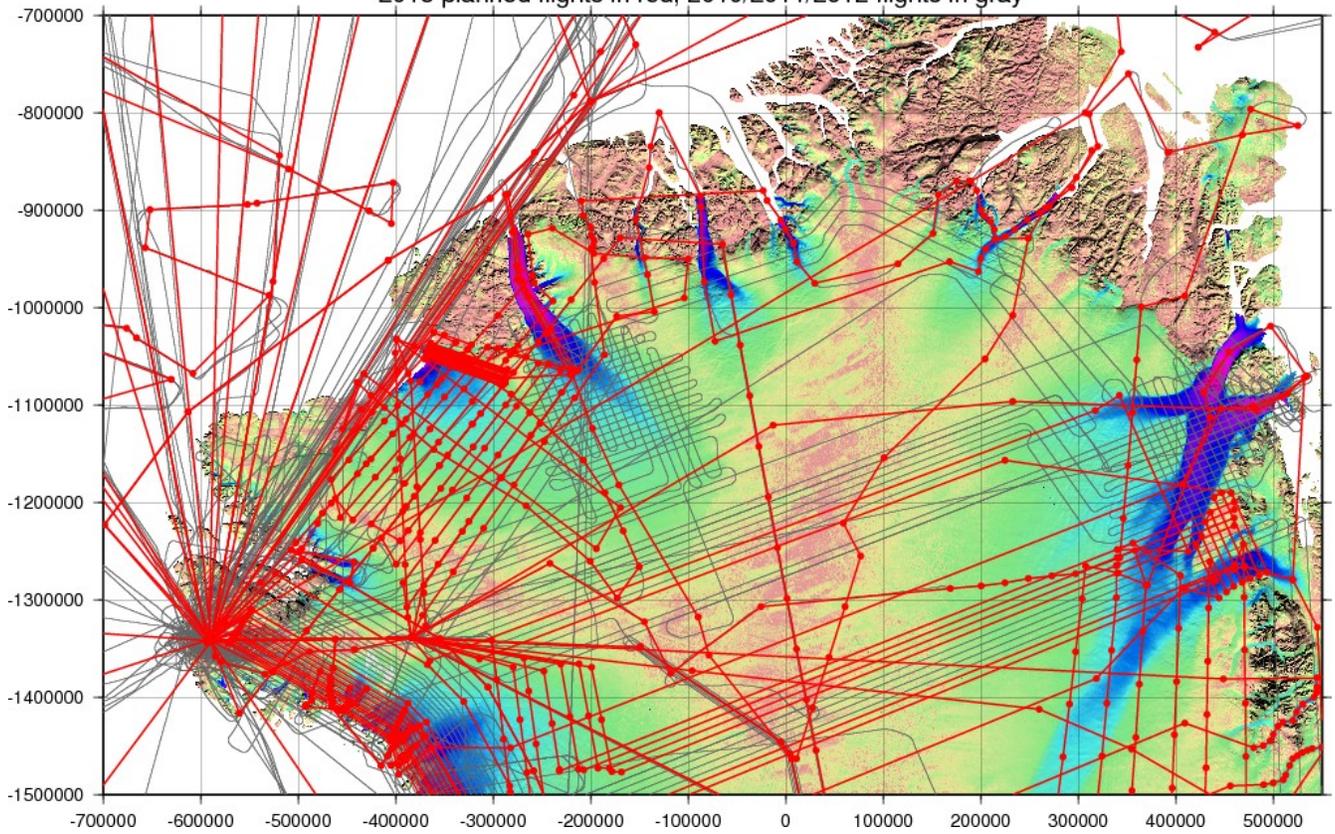
Northwest Composite

2013 planned flights in red, 2010/2011/2012 flights in gray



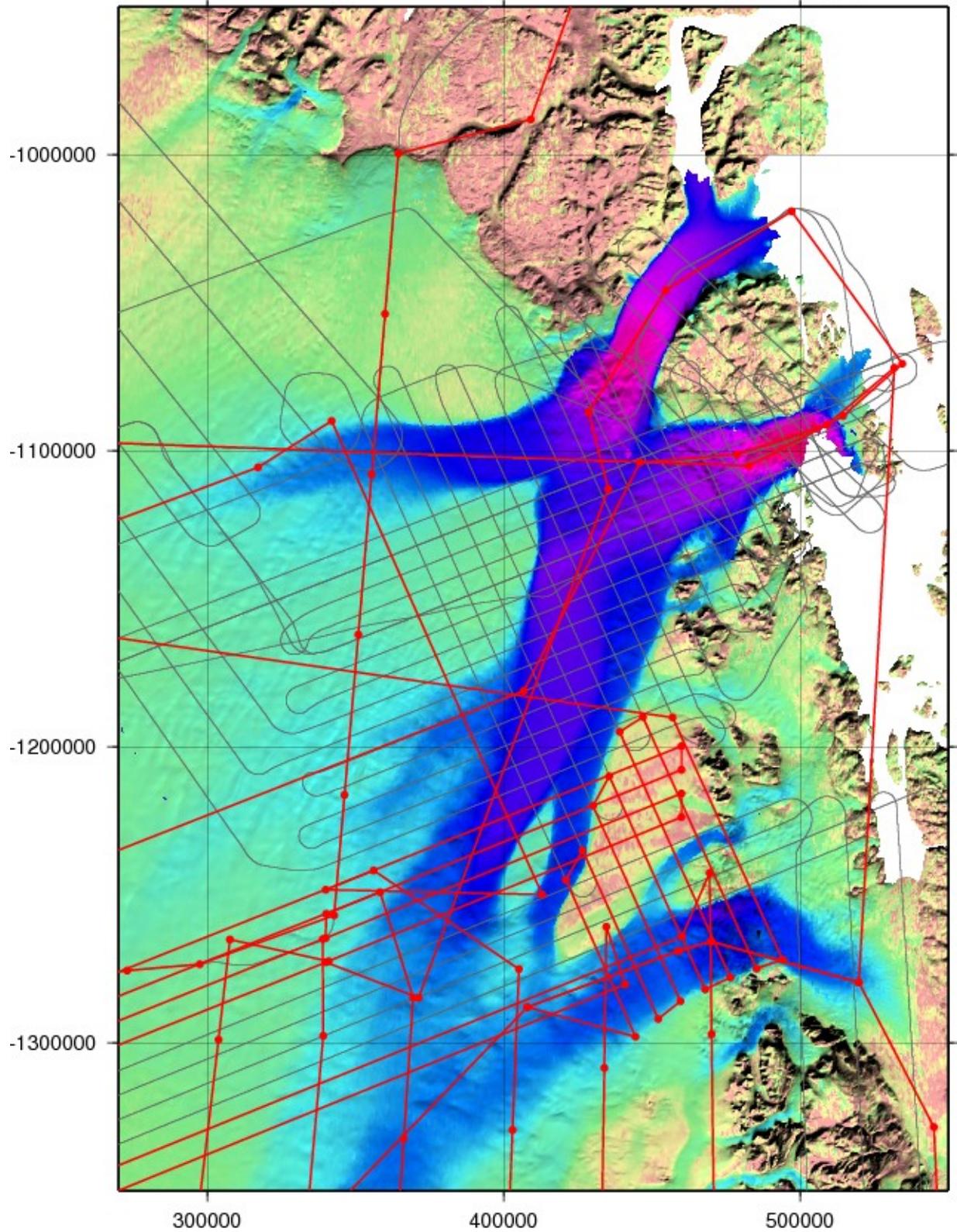
North Greenland Composite

2013 planned flights in red, 2010/2011/2012 flights in gray



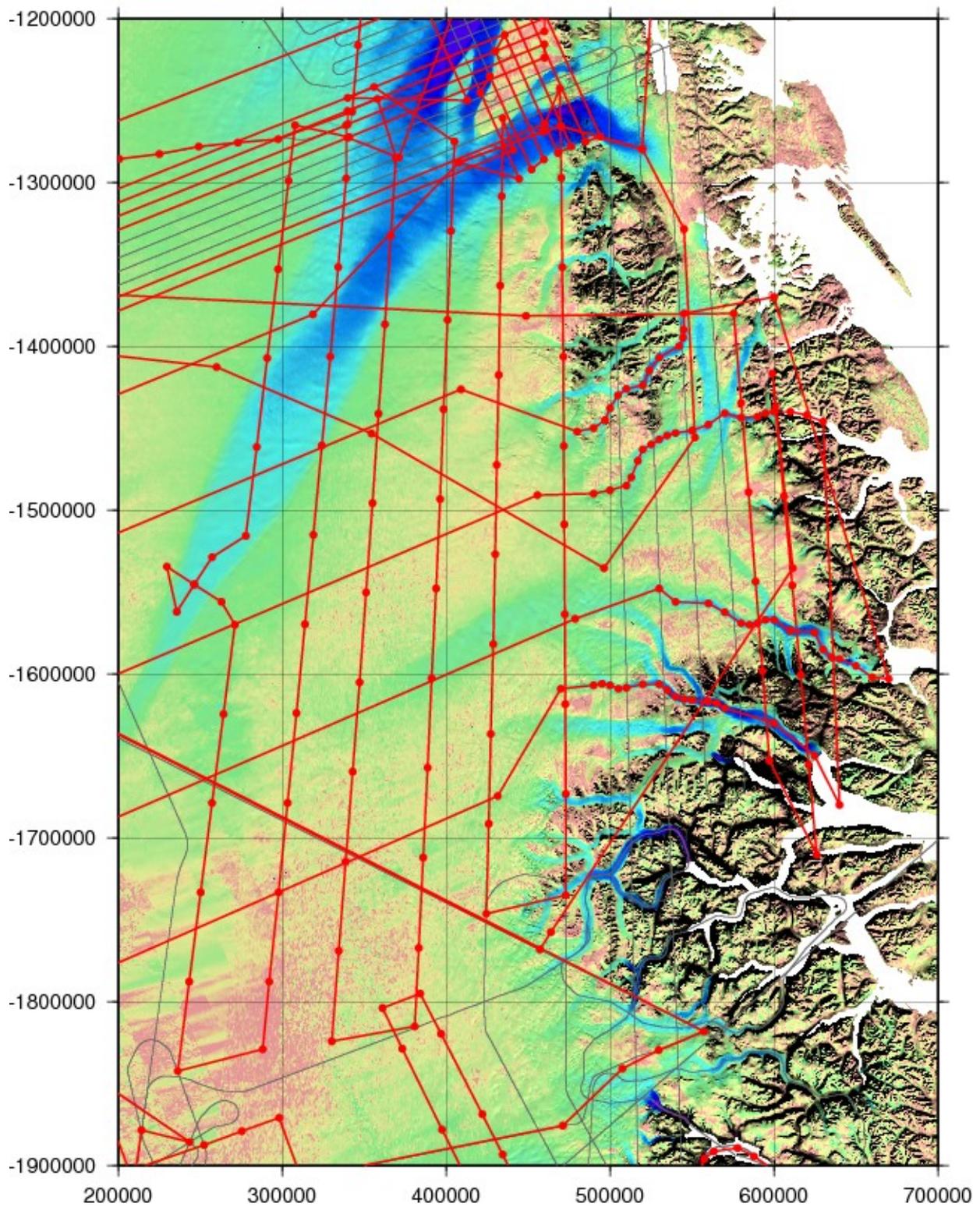
NEIS Composite

2013 planned flights in red, 2010/2011/2012 flights in gray



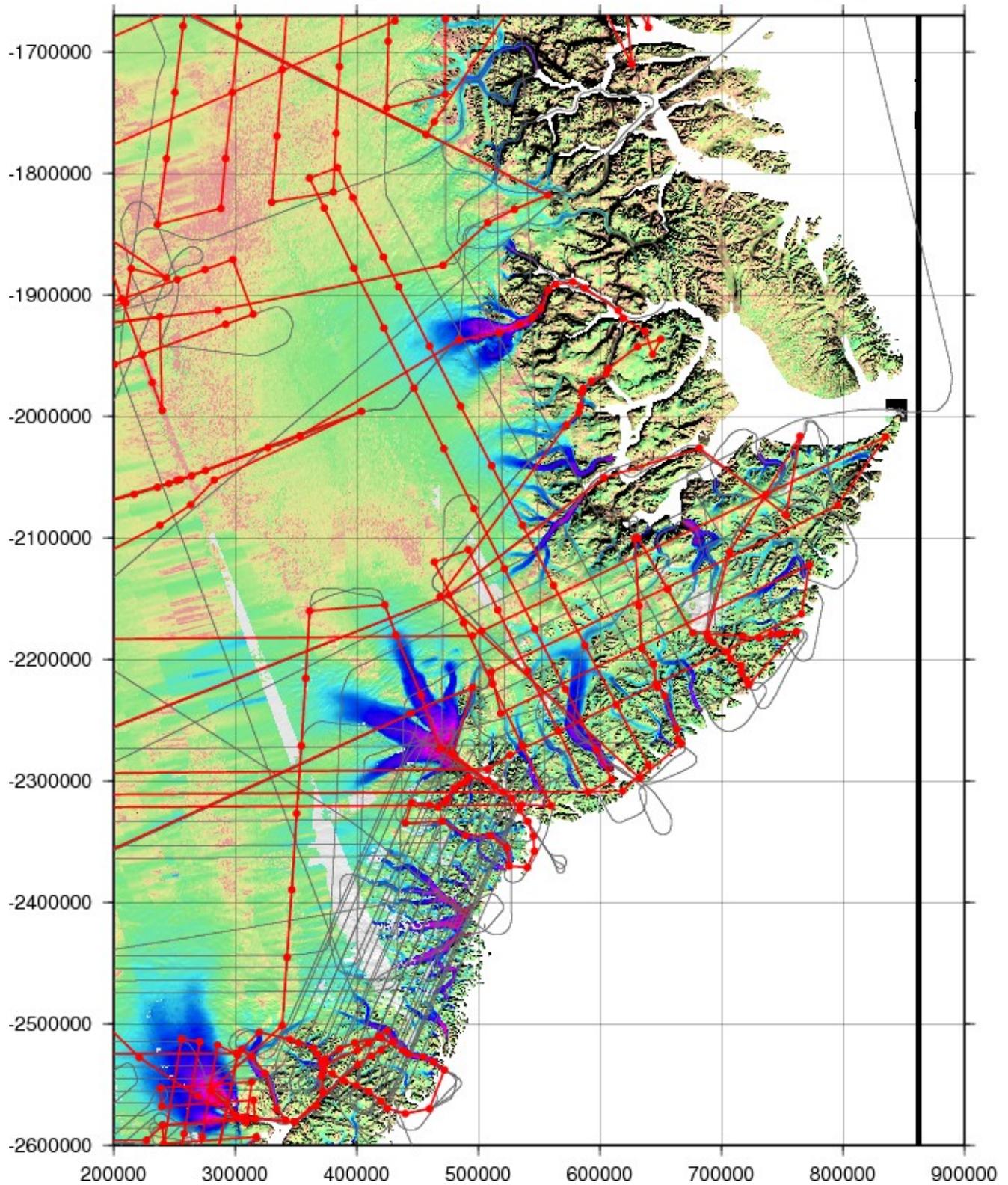
Northeast Greenland Composite

2013 planned flights in red, 2010/2011/2012 flights in gray



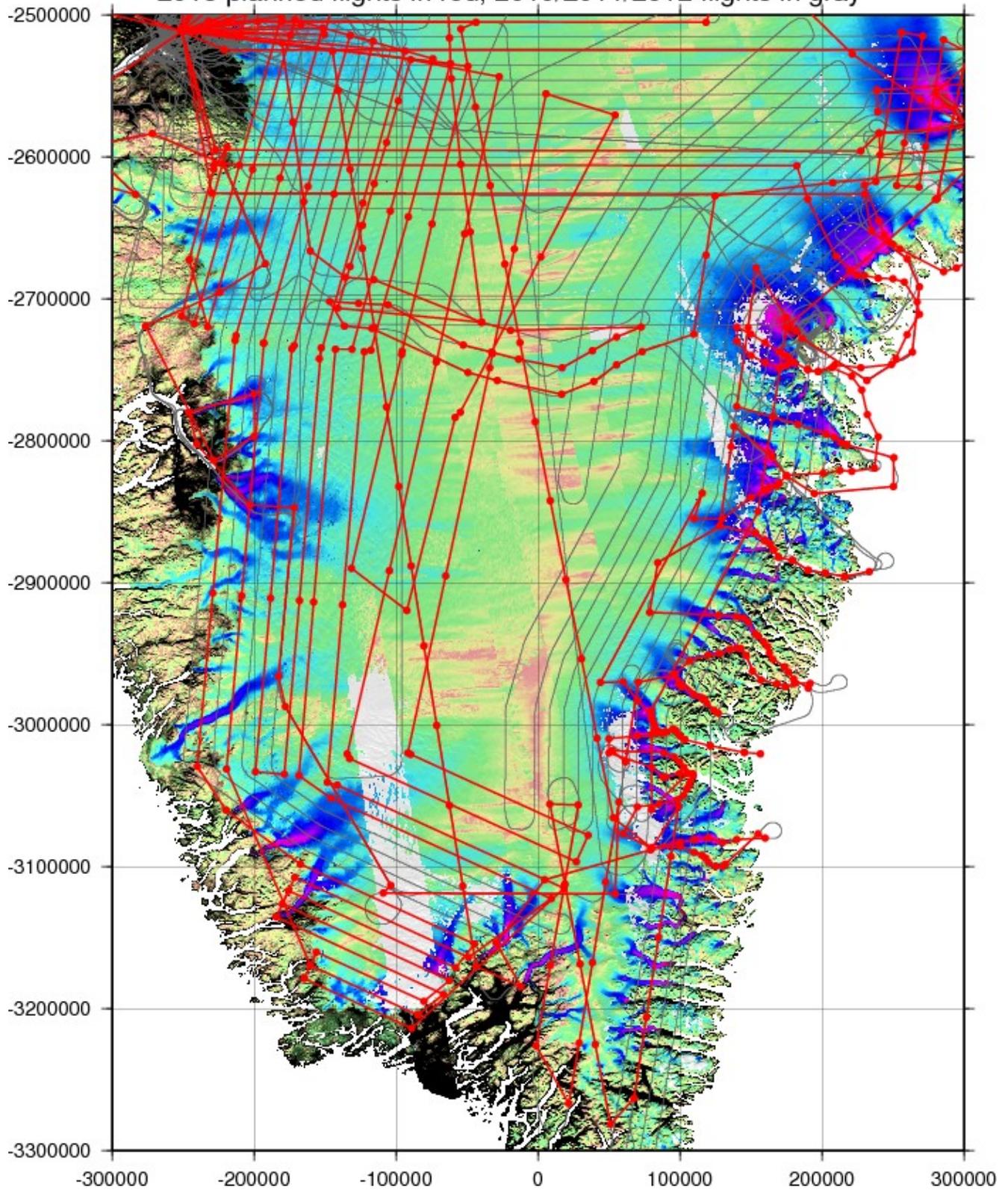
East Central Greenland Composite

2013 planned flights in red, 2010/2011/2012 flights in gray



South Greenland Composite

2013 planned flights in red, 2010/2011/2012 flights in gray



West-Central Composite

2013 planned flights in red, 2010/2011/2012 flights in gray

