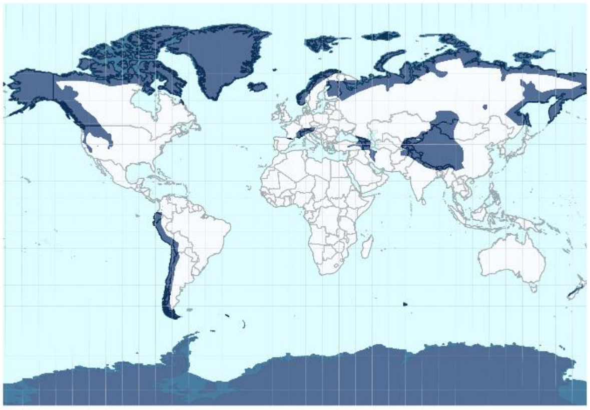
Copernicus Sentinel-3 Surface Topography Mission - Cyclic Performance Report

LAND ICE



S3A	S3B
Cycle No. 110	Cycle No. 091
Start date: 06/03/2024	Start date: 16/03/2024
End date: 02/04/2024	End date: 12/04/2024

Reference: S3MPC-STM_CPR_0007-110-091

Issue 1.0 – 18/04/2024

Contract: 4000136824/21/I-BG

Limited distribution/Diffusion limitée/Distribución limitada

CHRONOLOGY ISSUES

Issue	Date	Object	Written by	Checked by	Approved by
1.0	18/04/2024	Creation	DTU	J. Aublanc	A.Chamayou

ACCEPTANCE

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Function	ESA Technical Officer	MPC Service Manager

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1 Introduction

The purpose of this document is to report on the performance and data quality of the Copernicus Sentinel-3 Surface Topography Mission (STM) products. The constellation currently includes Sentinel-3A and Sentinel-3B altimetry satellites. This document is associated with data dissemination on a cyclic basis and is generated a few days after the end of Sentinel-3B cycle.

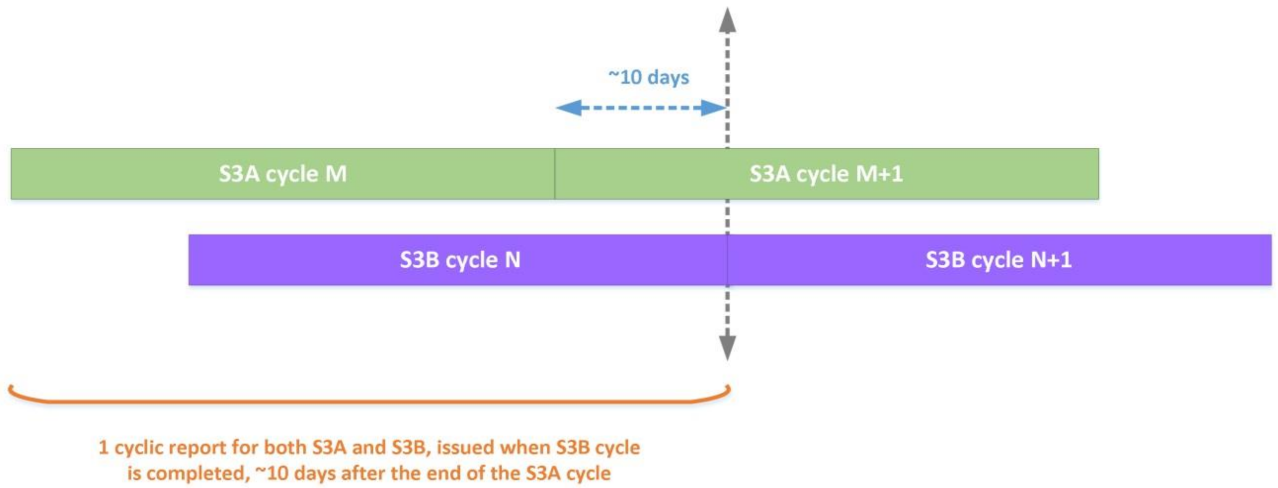


Figure 1.1: S3A and S3B cycles chronology

The thematic land ice Level 2 products assessed hereafter are produced by the ESA Sentinel-3 LAND Processing Centre. One of the main goals of the cyclic report is to detect and report as quickly as possible any events, or anomaly, impacting the data quality. Subsequently, the assessments are made on the Short Time Critical (STC) products, generally delivered 48 hours after data acquisitions. Differences are expected with the Non Time Critical (NTC) products, for which the orbit data and several geophysical corrections are consolidated.

The main objectives of this document are:

- To provide a data quality assessment of the Sentinel-3 thematic land ice Level 2 STC products
- To report on any changes likely to impact data quality at any level, from instrument status to software configuration.
- To present the major useful results for S3A cycle 110, from 06/03/2024 to 02/04/2024.
- To present the major useful results for S3B cycle 091, from 16/03/2024 to 12/04/2024.

2 Cycle overview

Sentinel-3A and Sentinel-3B SRAL operated in SAR mode over the ice sheets during these cycles. For Level-2 STC Land ice products over the polar ice sheets, the OCOG (Ice-1) retracker provides the largest amount of ice sheet elevation data, compared to the less stable ice_elevation retracker. Hence, the following Sentinel-3A and 3B assessment is based only on the OCOG retracker.

Parameter:	Sentinel-3A	Sentinel-3B
Orbit	Passes 450 to 454 are missing. Duplication of files. See more details in Section 3.1.1	Passes 163 to 168 are missing, and duplication of files. See more details in Section 3.1.1
Availability of geophysical corrections	A few ocean tides measurements are missing over the Antarctic Ice Shelves, within nominal limiters, see Table 4.4.	The GIM ionospheric correction is missing for two passes (260, 573). A few ocean tides measurements are missing over the Antarctic Ice Shelves, within nominal limits, see Table 4.4.
Availability of auxiliary data	Nominal	Nominal
Geophysical parameters	Nominal	Due to the missing ionospheric correction the elevation parameters are set to Not-A-Number, and the relocated position is also Not-A-Number. See Section 4.1.2
Specific investigations	N/A	See Section 4.1.2
Orbit cross-over statistics	For cross-overs, less than 1 meter shows a mean bias equal to or less than -1.0 cm and a standard deviation less than 36 cm. This is nominal	For cross-overs, less than 1 meter shows a mean bias equal to or less than -1.8 cm and a standard deviation less than 36 cm.
Status	Due to a power outage at the Svalbard ground station duplication of files arise due to reprocessing. See Section 3.1.1.	Due to a power outage at the Svalbard ground station several issues arise. See Section 3.1.1 and 4.1.2
	Some files have been reprocessed; please use the newest processed files.	

Table 2.1 General overview of the data availability and mission performances for the S3A and S3B cycles evaluated Colours indicate performance: OK (green), Warning (yellow), and Not ok (red)

(green)	OK 100%
(yellow)	Warning 95-100%
(red)	Not OK < 95%

The percentages are given from the mission requirements:
https://sentinels.copernicus.eu/fi/web/sentinel/missions/sentinel-3/mission-objectives

3 Processing baseline

Table 2 details the versions of the Processing Baseline (PB), and Level-1 and Level-2 Instrument Processing Facility software used for the products assessed. This is part of the Baseline Collection (BC) 005.

Table 2 Processing baseline and IPF details

Cycle		Processing Baseline	IPF SM2 version	IPF SR1 version	IPF MW1 version
Sentinel-3A	110	3.25	07.07	07.07	06.15
Sentinel-3B	091				

In December 2023, the Processing Baseline 3.25 was implemented. For this cycle 108/089 the IPF SM2 version was updated. The evolutions of the Sentinel-3 STM Processing Baseline are summarized in the SentiWiki website: https://sentiwiki.copernicus.eu/web/altimetry-processing .

4 Data availability and missing measurements

4.1.1 Orbit coverage and missing measurements

There may be delays in processing the data at the processing centre, which means that the data products assessed in the cyclic reports might represent less than 100% of the orbits in the full cycle. The percentage of L2 products of the full cycle, which this report builds on is presented in Table 4.1.

One file is expected to be generated per pass and two passes per orbit. Therefore, it can be anticipated that 770 files will be received.

Due to a power outage at the Svalbard ground station, there are missing ionospheric correction data gaps for S3A between 23/03/2024 and 25/03/2024 and for S3B between 24/03/2024 and 26/03/2024 and 06/04/2024. Some files have been reprocessed, and therefore, duplicate files from orbit 244 to 254 will exist; **please use the newest processed files**. For S3A, five passes are missing from 450 to 454, corresponding to orbits 225, 226, and 227. For S3B, six passes are missing from Pass 163 to 168. Moreover, two passes are split. and a pass is duplicated and has a large data gap. Orbits 087 and 116 have split files, whereas in orbit 095 over Antarctica is duplicated. The newest processed file has a large data gap.

Table 4.1 Data availability and the percentage of the full cycle of STC products

Cycle		Product type	Latency	Passes	Expected passes	% passes received
Sentinel-3A	110	SR_2_LAN	STC	765	770	99.48%
Sentinel-3B	091			767	770	99.22%

4.1.1.1 Modes of operations

The on-board tracker of the Sentinel-3 altimeter has three different possible modes:

- **Closed-loop mode**: autonomous positioning of the range window using the median algorithm
- **Open-loop mode:** range window position based on a priori knowledge of terrain altitude derived from a Digital Elevation Model (DEM).
- **Open-loop with fixed gain mode in addition to open-loop, constant acquisition gain values are applied**

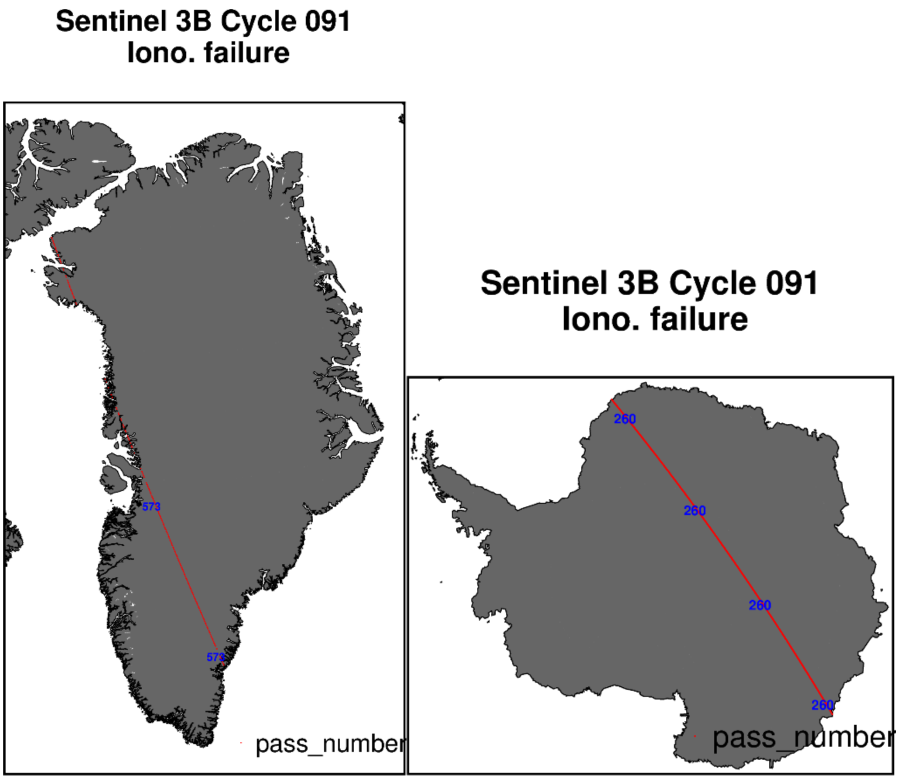
The satellite acquisition is mainly in closed-loop, except for Elephant Island and Coronation Island in the Southern Ocean, where the tracking modes are Open-loop. In addition, open-loop commands have been defined for S3A over several specific continental glaciers (for Himalaya, Patagonia, Alpes, Pyrénées, Andes and Tadjikistan).

Figures will be shown in case of changes or irregularities to the mode mask.

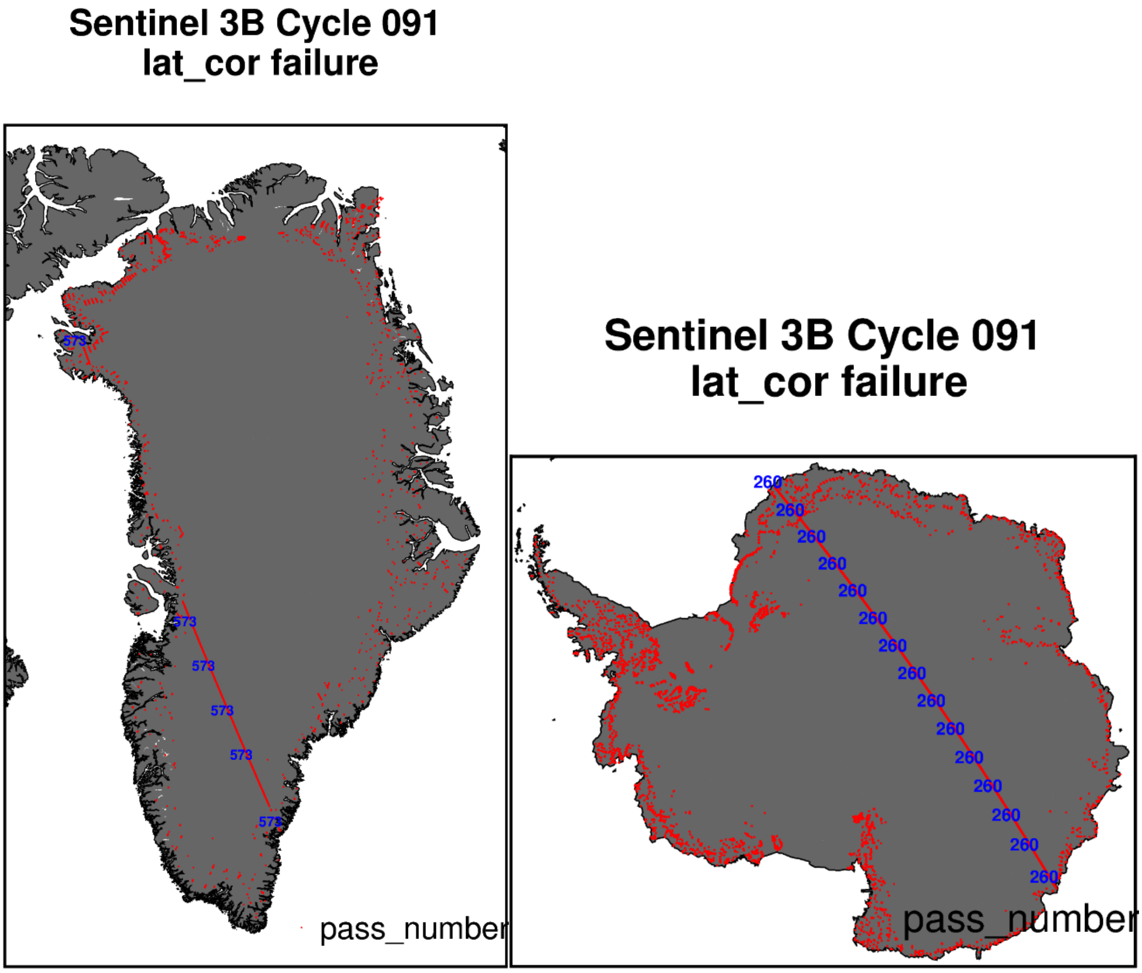
4.1.1.2 Specific investigation

Special investigations were carried out to showcase the troublesome passes in these cycles arising due to the power outage at the Svalbard ground station.

The plot below shows the passes of the missing GIM ionospheric correction. The ionospheric correction failed for two passes: one over Greenland, pass 573 in orbit 286, and: one over Antarctica, pass 260 in orbit 130.



As a consequence of the missing geophysical correction, the surface elevations cannot be computed and are set to Not-A-Number. The same is the case for the corrected position shown below for the lat_cor_20_ku parameter.



4.1.2 Availability of geophysical corrections

The range from the satellite to the surface for each measurement is computed by applying several geophysical corrections and internal delay to the initial uncorrected range. It is important to track the availability and validity of these corrections since they are required for the final L2 elevation parameters and the derived ice sheet surface elevation change. The data over ice sheets and shelves are selected using the *surface_class* flag (*Section 4.1.3.2*) over Greenland and Antarctica.

In this section the availability of geophysical corrections in the L2 products over ice sheets and ice shelves are analysed and presented.

4.1.2.1 Availability of Geophysical Corrections over Ice Sheets

The geophysical corrections usually relevant for range measurements over ice sheets are the dry and wet troposphere, ionosphere delays, solid Earth tide, ocean loading tide, and polar tide. *Table 4.2* and *Table 4.3* summarize the availability of the geophysical correction for the Greenland and Antarctica Ice Sheets for S3A and S3B.

Table 4.2 Percentage of Geophysical Correction availability over the Greenland ice sheet

S3A

Geophysical Corr.	(%)
iono_cor_gim_01_ku	100.00
load_tide_sol1_01	100.00
load_tide_sol2_01	100.00
mod_dry_tropo_cor_meas_altitude_01	100.00
mod_wet_tropo_cor_meas_altitude_01	100.00
pole_tide_01	100.00
solid_earth_tide_01	100.00

S3B

Geophysical Corr.	(%)
iono_cor_gim_01_ku	99.34
load_tide_sol1_01	100.00
load_tide_sol2_01	100.00
mod_dry_tropo_cor_meas_altitude_01	100.00
mod_wet_tropo_cor_meas_altitude_01	100.00
pole_tide_01	100.00
solid_earth_tide_01	100.00

Table 4.3 Percentage of Geophysical Correction availability over the Antarctic Ice Sheet

Geophysical Corr.	(%)
iono_cor_gim_01_ku	100.00
load_tide_sol1_01	100.00
load_tide_sol2_01	100.00
mod_dry_tropo_cor_meas_altitude_01	100.00
mod_wet_tropo_cor_meas_altitude_01	100.00
pole_tide_01	100.00
solid_earth_tide_01	100.00

S3A

Geophysical Corr.	(%)
iono_cor_gim_01_ku	99.63
load_tide_sol1_01	100.00
load_tide_sol2_01	100.00
mod_dry_tropo_cor_meas_altitude_01	100.00
mod_wet_tropo_cor_meas_altitude_01	100.00
pole_tide_01	100.00
solid_earth_tide_01	100.00

S3B

4.1.2.2 Availability of Geophysical Corrections over Ice Shelves

Over the Antarctic ice shelves, the usual corrections applied to the range are the same as for the ice sheets including ocean tide and inverse barometric corrections. *Table 4.4* summarizes the availability for S3A and S3B.

Table 4.4 Percentage of Geophysical Correction availability over the Antarctic Ice Shelves.

S3A

Geophysical Corr.	(%)
inv_bar_cor_01	100.00
iono_cor_gim_01_ku	100.00
load_tide_sol1_01	100.00
load_tide_sol2_01	100.00
mod_dry_tropo_cor_meas_altitude_01	100.00
mod_wet_tropo_cor_meas_altitude_01	100.00
ocean_tide_sol1_01	98.83
ocean_tide_sol2_01	99.53
pole_tide_01	100.00
solid_earth_tide_01	100.00

S3B

Geophysical Corr.	(%)
inv_bar_cor_01	100.00
iono_cor_gim_01_ku	99.98
load_tide_sol1_01	100.00
load_tide_sol2_01	100.00
mod_dry_tropo_cor_meas_altitude_01	100.00
mod_wet_tropo_cor_meas_altitude_01	100.00
ocean_tide_sol1_01	98.82
ocean_tide_sol2_01	99.54
pole_tide_01	100.00
solid_earth_tide_01	100.00

4.1.3 Availability of auxiliary data

The S3A and S3B products contain several geophysical parameters, which are derived from auxiliary data, and which are helpful for the end-user of the data products. These parameters include surface type, surface class, and slope correction. These geophysical parameters for the current S3A and S3B cycles are presented in the following.

4.1.3.1 20 Hz Ku Band Surface Type (surf_type_20_ku)

The 20 Hz Ku band surface type parameter (surf_type_20_ku) is derived from a static grid that provides four types: open oceans or semi-enclosed seas, enclosed seas or lakes, continental ice, and land. The surf_class_20_ku parameter for the current cycles of S3A and S3B are shown for Greenland in *Figure 4.1* and Antarctica in *Figure 4.2*. The figures also provide information on the percentage of data that falls into each surface class.

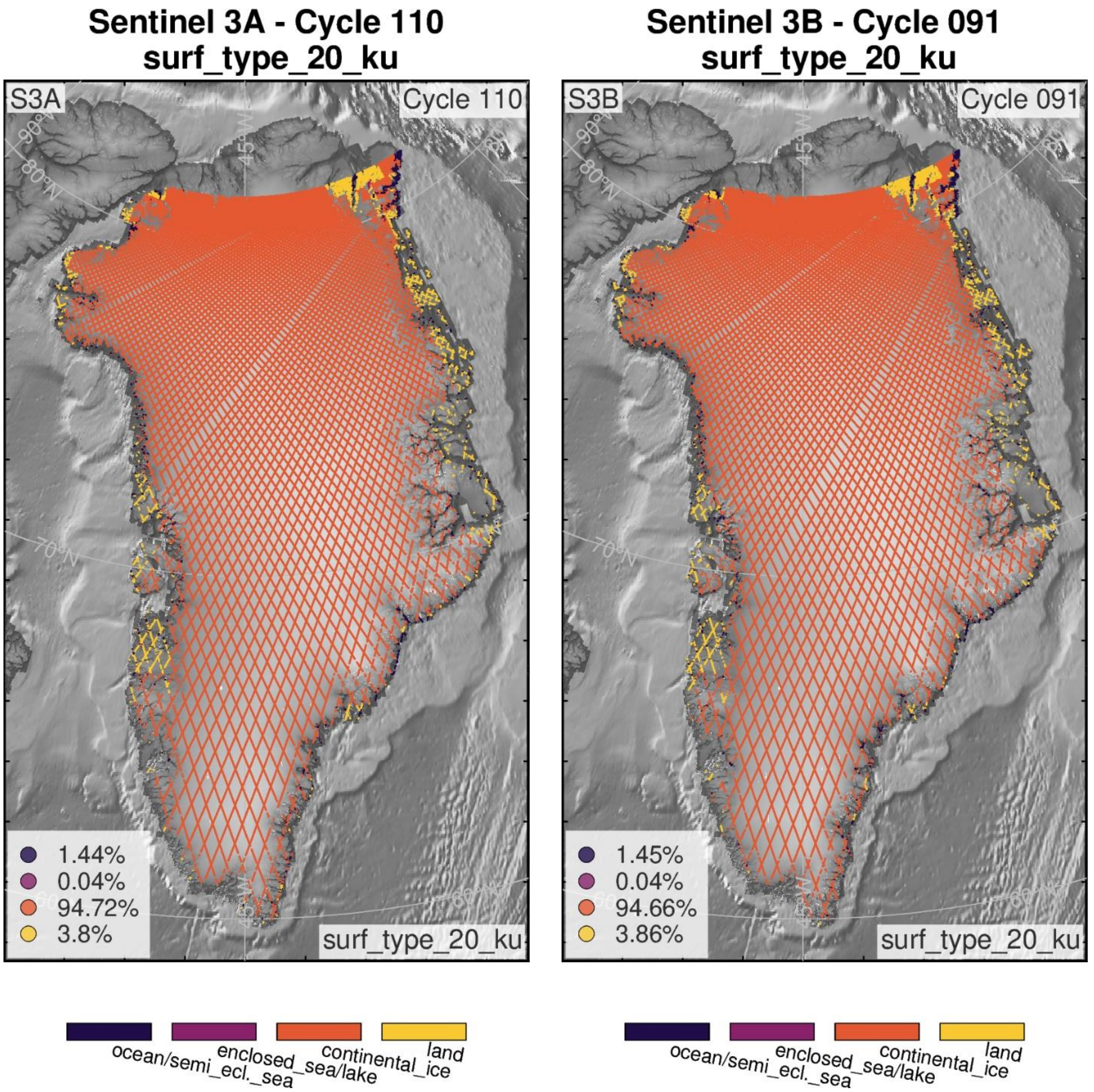


Figure 4.1 Surface Type for Greenland ice sheet from the surf_type_20_ku parameter

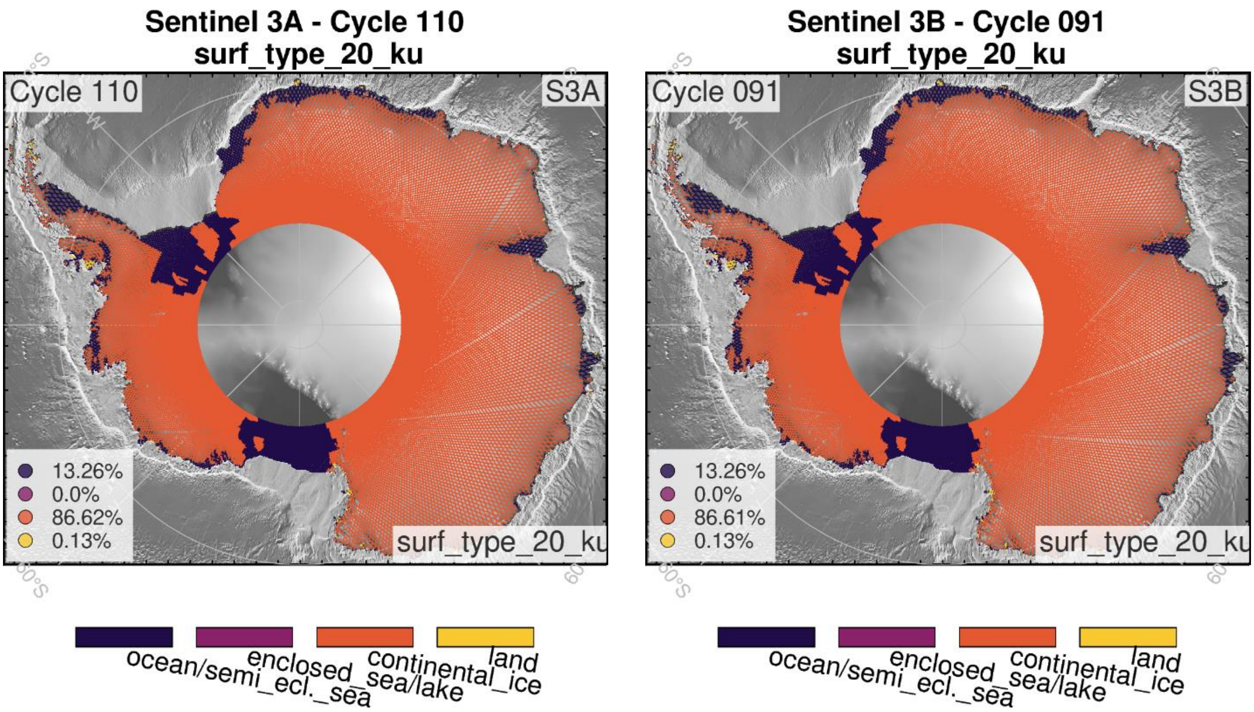


Figure 4.2 Surface Type for Antarctic Ice Sheet and Ice cap from the surf_type_20_ku parameter

4.1.3.2 20 Hz Ku Band Surface Class (surf_class_20_ku)

The 20 Hz Ku surface classification parameter (surf_class_20_ku) is derived from MODIS and GlobCover data. The possible surface classes are: Open Ocean, Land, Continental water, Aquatic vegetation, Continental ice, Floating ice, and Salt basins. The surf_class_20_ku parameter for the current cycles of S3A and S3B are shown for Antarctica in *Figure 4.3*, and in Greenland, only continental ice is observed (not shown). The figures also provide information on the percentage of data that falls into each surface class.

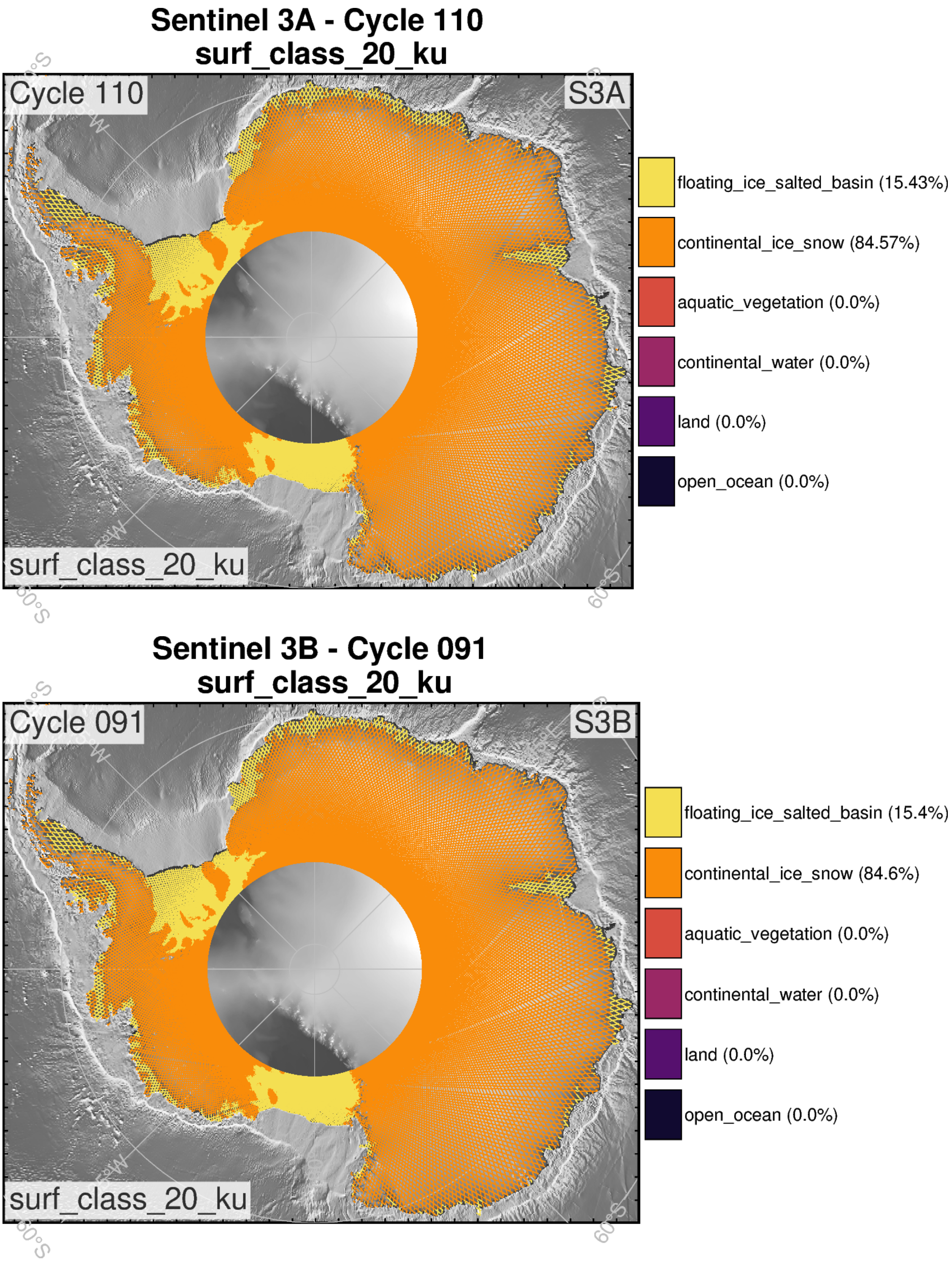


Figure 4.3 Surface Class for Antarctica from the surf_class_20_ku parameter

5 Geophysical parameters monitoring

5.1 Geophysical parameters derived from altimetry

Over land ice two different retrackers are implemented in the Sentinel-3 Instrument Processing Facilities (IPF) to retrieve geophysical parameters from SAR mode waveforms:

- The “OCOG/ICE-1 retracker” (Wingham D J, Rapley C G, and Griffiths H 1986; Bamber 1994) is an empirical algorithm commonly used over land surfaces. The OCOG/ICE-1 retracker is robust and will almost always return a topography estimation, even over rugged or steep topography, where the altimetry waveform may exhibit complex waveform shapes.
- The “UCL ice sheet retracker” is a model fit retracker, optimised for use over areas of low slope where the returned waveform has a classical shape typical of flat and smooth ice sheet surfaces. The echo model used has a modified gaussian form, corresponding to a six parameterizable function with 5-section modelling. It has a heritage from the CryoSat-2 mission’s Wingham/Wallis retracker (Wingham and Wallis 2010).

Two main geophysical parameters are derived from both retrackers:

- The surface elevation with respect to the reference ellipsoid (WGS-84). Parameter’s name in the level-2 LAND products are “elevation_ocog_20_ku” and “elevation_ice_sheet_20_ku”, respectively estimated with the “OCOG/ICE-1” and “UCL ice sheet” retrackers.
- The backscattering coefficient (Sigma-0). Parameter’s name in the level-2 LAND products are “sig0_ocog_20_ku” and “sig0_ice_sheet_20_ku”, respectively estimated with the “OCOG/ICE-1” and “UCL ice sheet” retrackers. The backscatter values are controlled by surface characteristics, such as slope, roughness, and surface properties (volume vs. surface scattering). It is an important parameter and is used for deriving accurate estimates of ice/snow surface elevation changes.

In addition, the altimeter range and backscattering coefficient derived from the Pseudo-LRM (PLRM) waveforms are also available in the level-2 products assessed. They are retrieved by the ICE-2 retracker (Legresy and Remy 1997). Parameter’s names are respectively “range_ice_20_plrm_ku” and “sig0_ice_20_plrm_ku”.

5.1.1 20 Hz Ku Band OCOG (Ice-1) Elevation (elevation_ocog_20_ku)

Figure 5.1 shows the elevation_ocog_20_ku parameter over the Greenland ice sheet for the S3A and S3B full cycles, while

Figure 5.2 shows the percentage of parameter failure (NaN reported) evaluated in 5x5 km grid cells.

Figure 5.3 shows the elevation_ice_sheet_20_ku parameter over the Antarctic ice sheets for the S3A and S3B full cycles, while

Figure 5.4 shows the percentage of parameter failure (NaN reported) evaluated in 10x10 km grid cells.

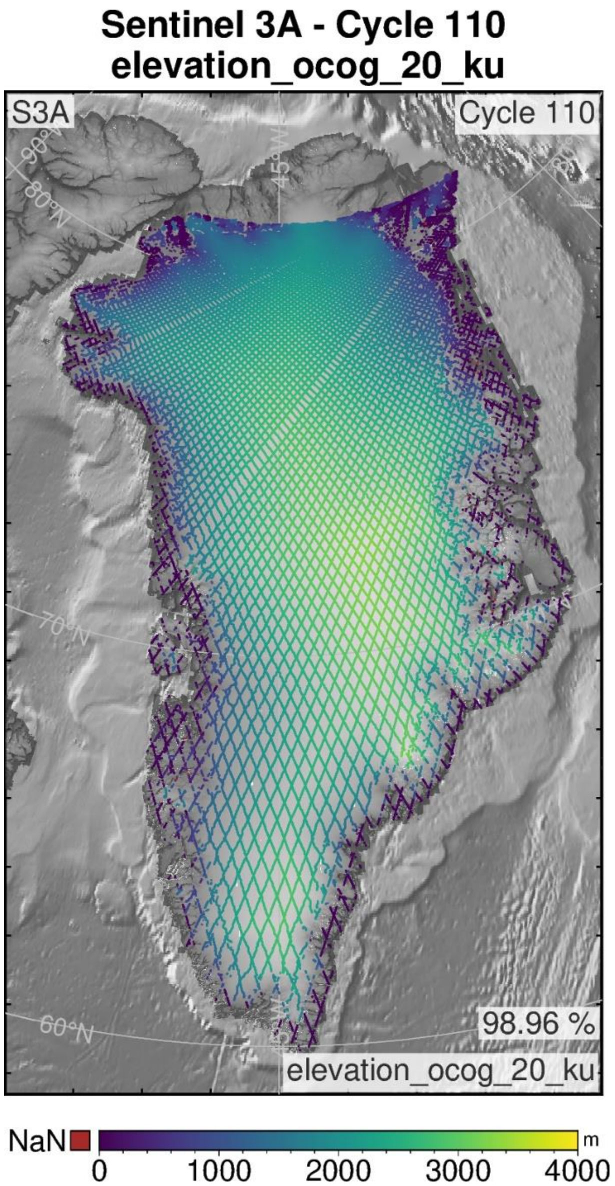


Figure 5.1 SAR mode elevation over the Greenland ice sheet from the elevation_ocog_20_ku parameter

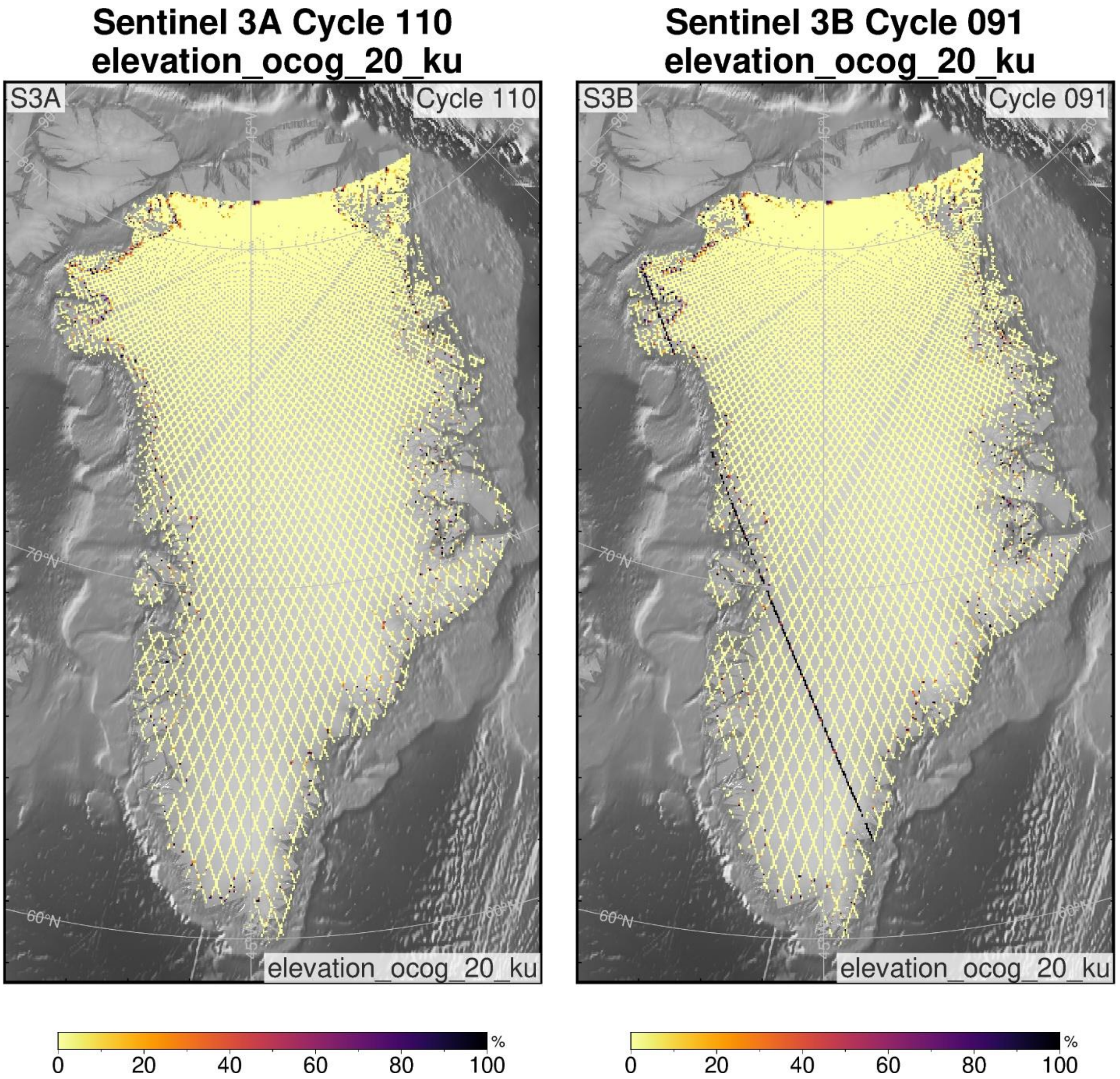


Figure 5.2 Percentage of failure over the Greenland ice sheet for the elevation_ocog_20_ku parameter

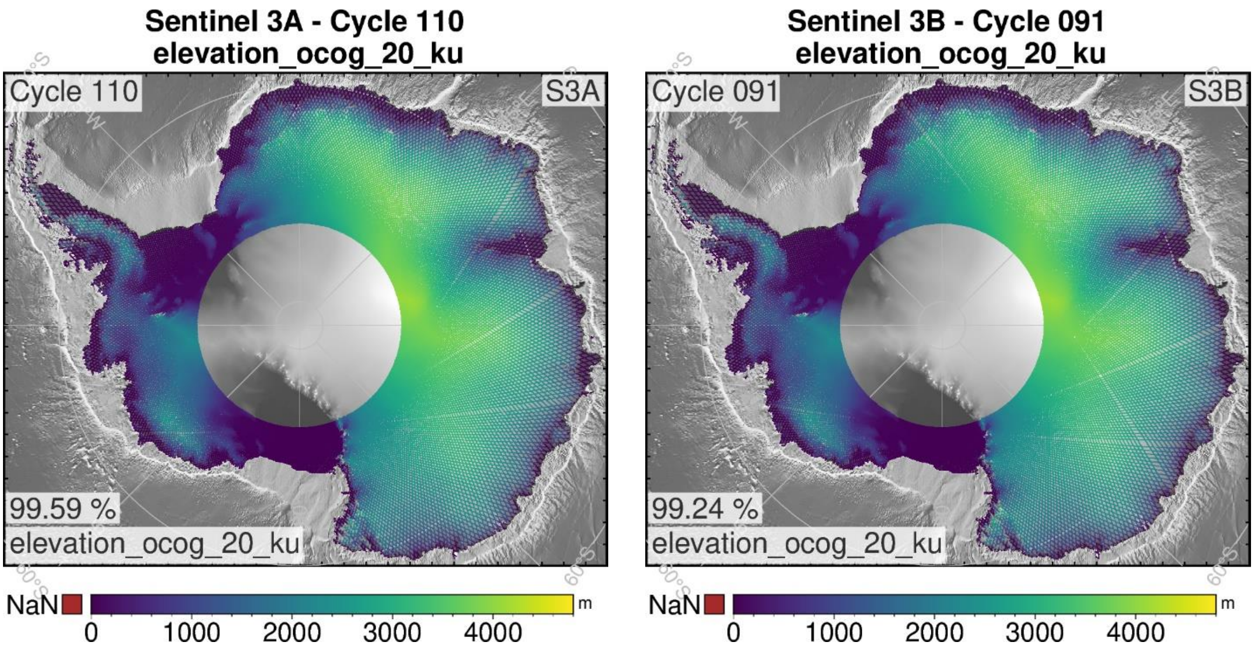


Figure 5.3 SAR mode elevation over Antarctica from the elevation_ocog_20_ku parameter

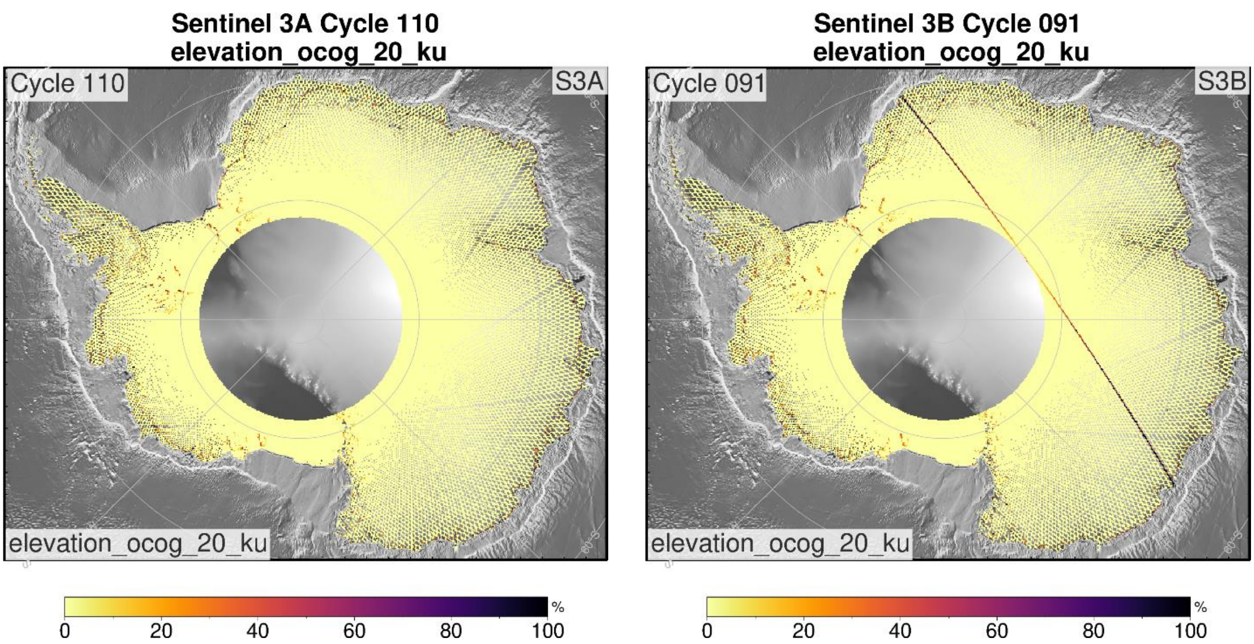


Figure 5.4 Percentage of failure over Antarctica for the elevation_ocog_20_ku parameter

5.1.2 8 20 Hz Ku Band OCOG (Ice-1) Sigma0 (sig0_ocog_20_ku)

Figure 5.5 shows the sig0_ocog_20_ku parameter over the Greenland ice sheet for the S3A and S3B full cycles, while

Figure 5.7 shows the percentage of parameter failure (NaN reported) evaluated in 5x5 km grid cells. Figure 5.8 shows the sig0_ocog_20_ku parameter over the Antarctic ice sheets for the S3A and S3B full cycles, while Figure 5.10 shows the percentage of parameter failure (NaN reported) evaluated in 10x10 km grid cells.

Figure 5.6 and

Figure 5.9 show the distribution and statistics of the sig0_ice_sheet_20_ku parameter for the Greenland Ice Sheet and Antarctica, respectively. For the Median Absolute Deviation (MAD) a non-normal distribution is assumed.

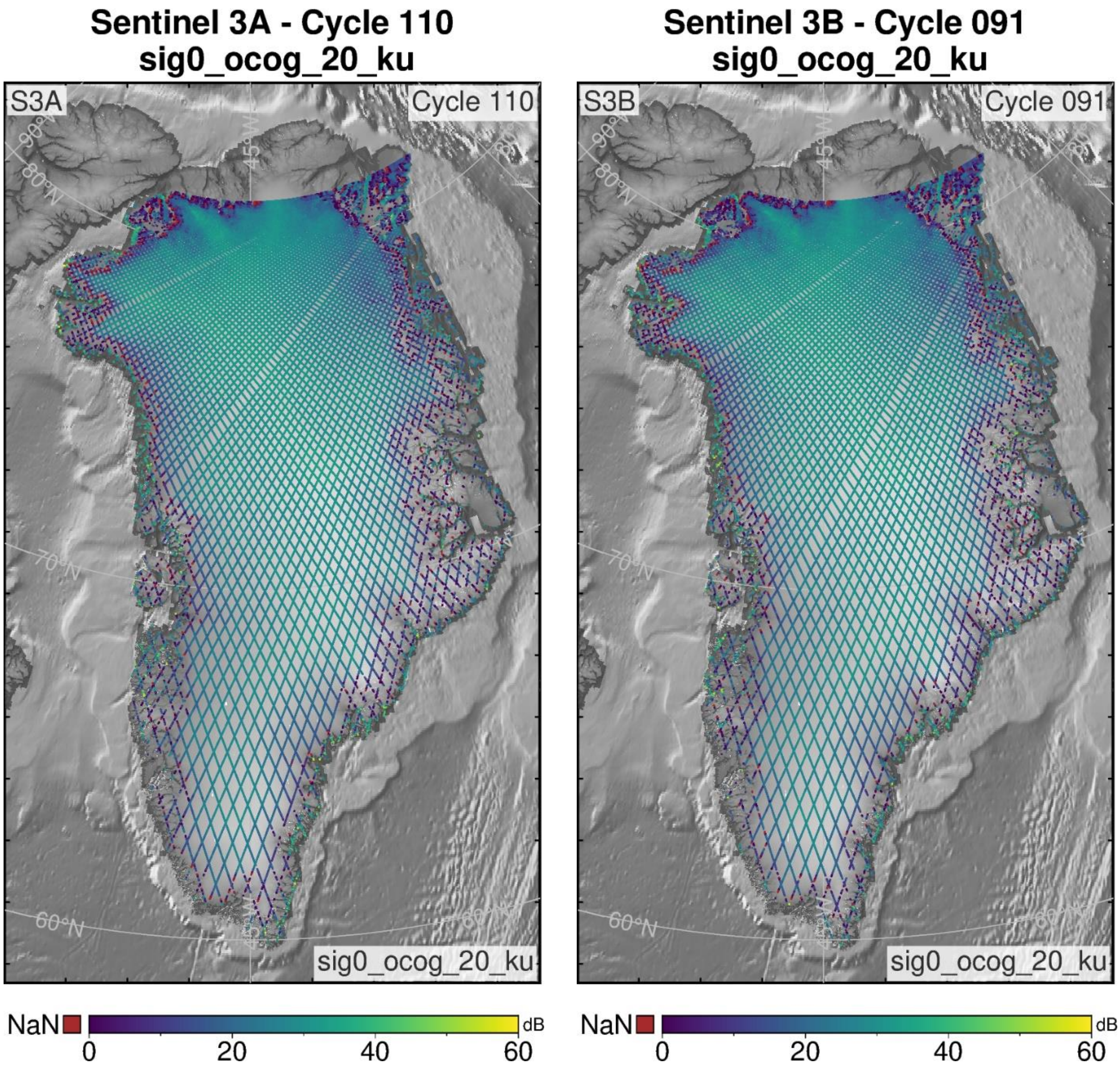


Figure 5.5 SAR mode backscatter coefficient over the Greenland ice sheet from the sig0_ocog_20_ku parameter

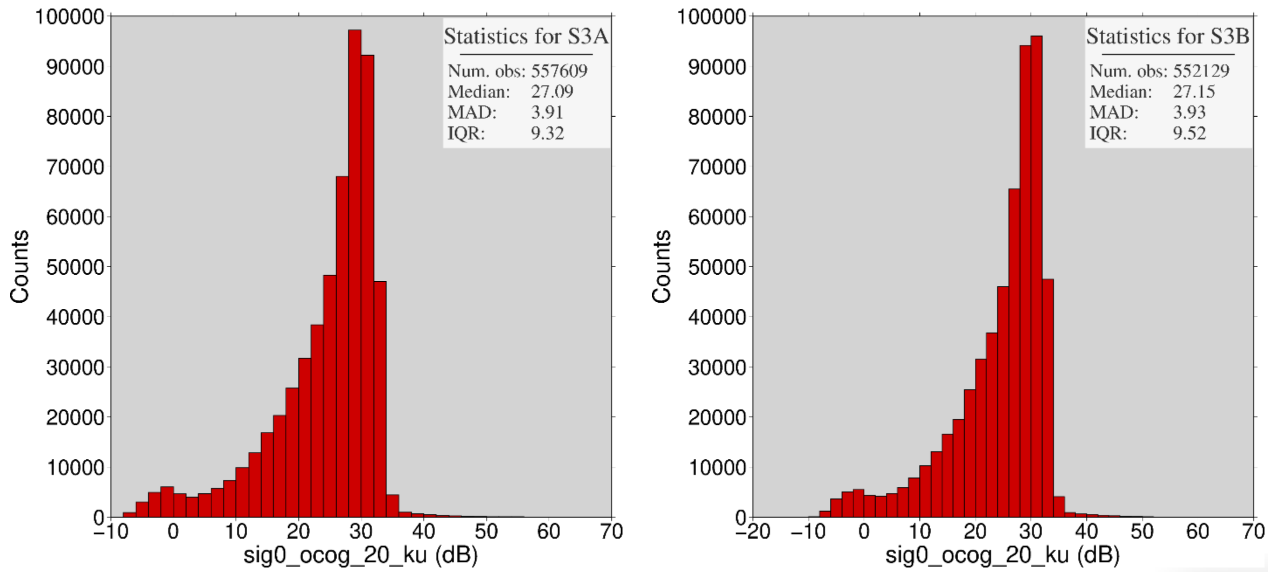


Figure 5.6 SAR mode backscatter coefficient (sig0_ice_ocog_20_ku) distribution over the Greenland Ice Sheet and statistics given by the Number of Observations, Median (dB), Median Absolute distribution (MAD) in dB, and the Interquartile Range (IQR) given in dB.

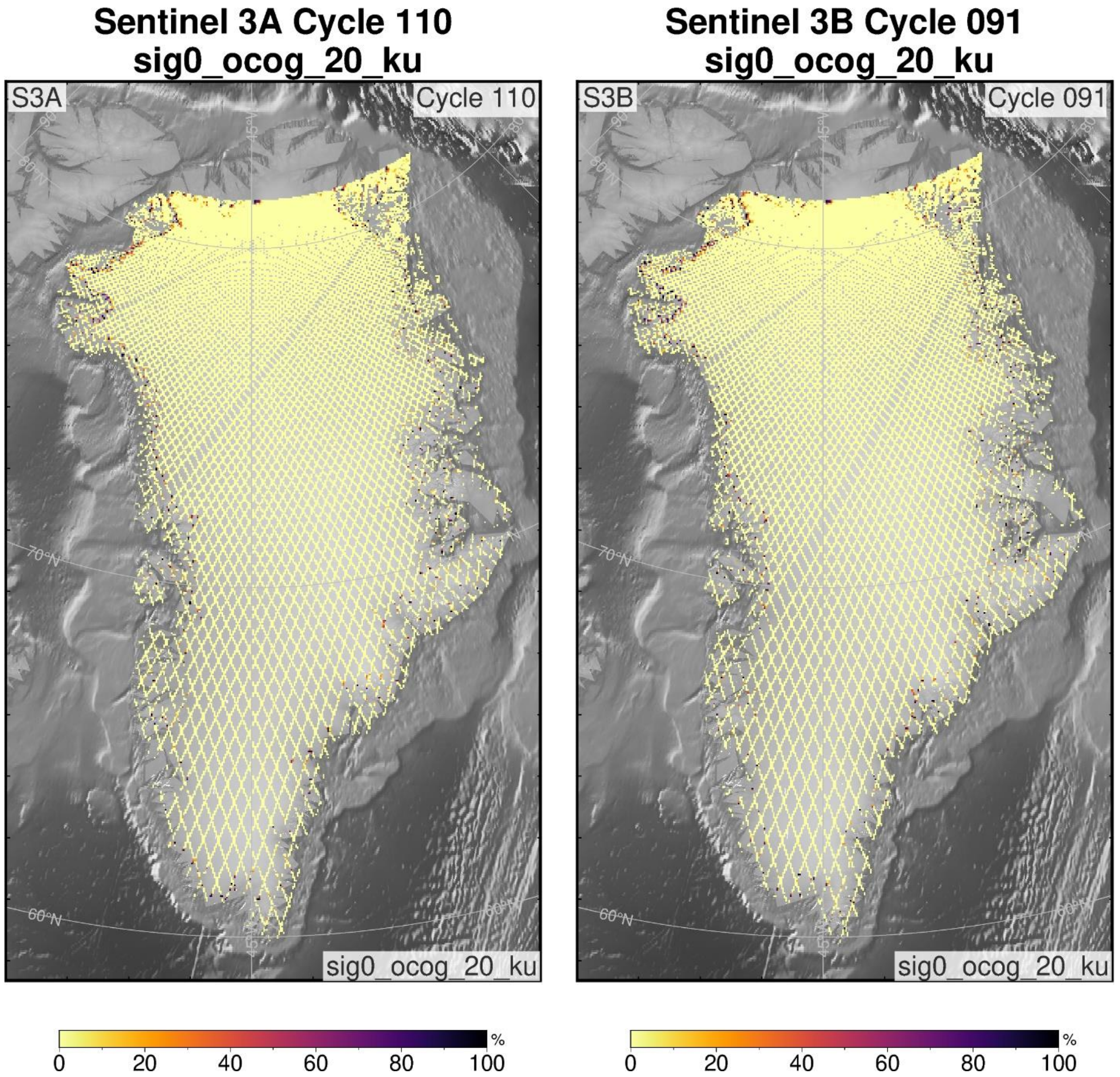


Figure 5.7 Percentage of failure over the Greenland ice sheet from the sig0_ocog_20_ku parameter

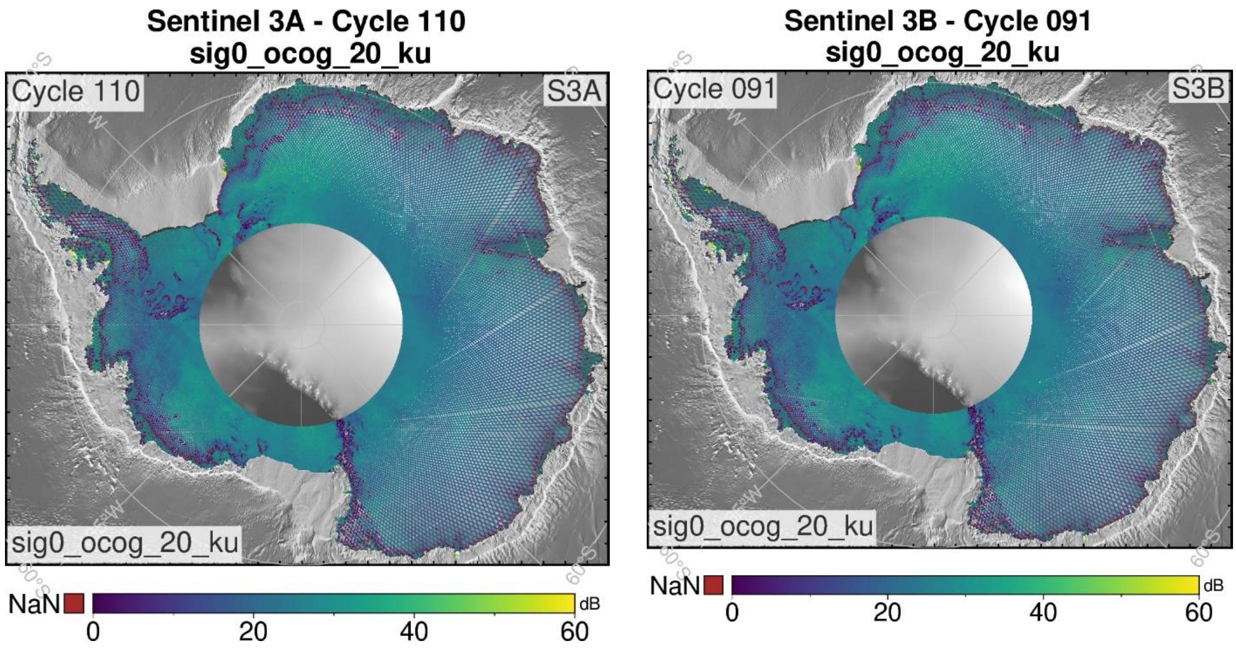


Figure 5.8 SAR mode backscatter coefficient over Antarctica from the sig0_ocog_20_ku parameter

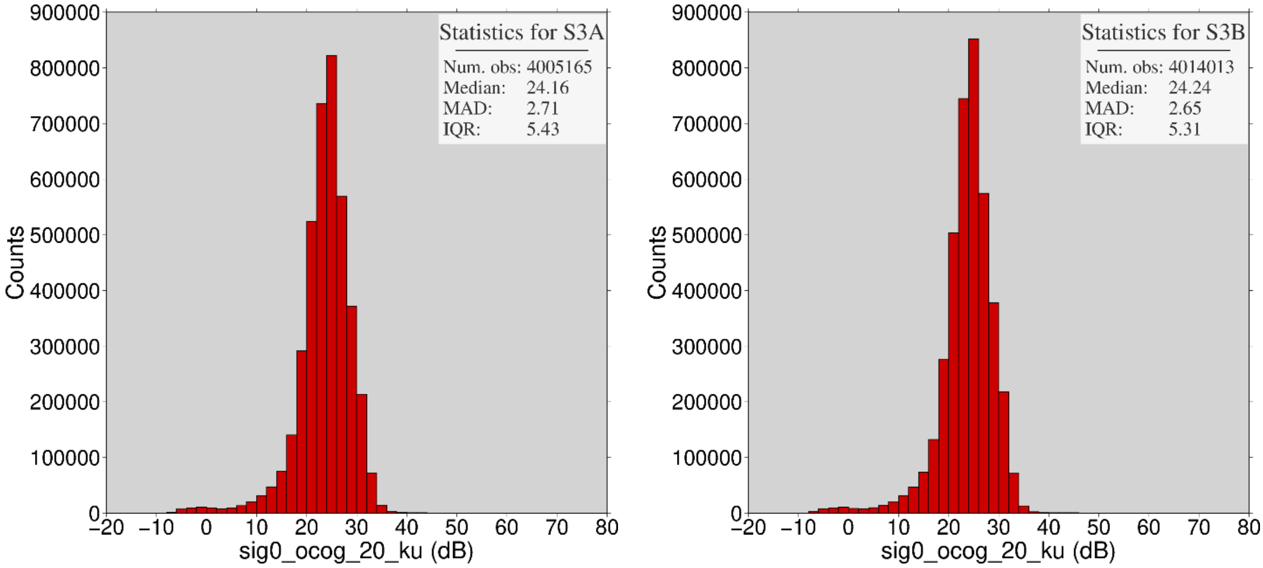
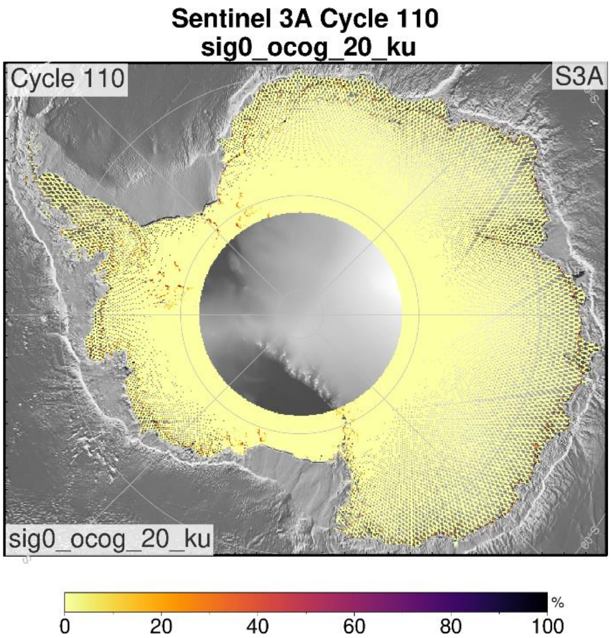


Figure 5.9 The backscatter coefficient (sig0_ocog_20_ku) distribution over Antarctica and statistics given by the Number of Observations, Median (dB), Median Absolute distribution (MAD) in dB, and the Interquartile Range (IQR) given in dB.



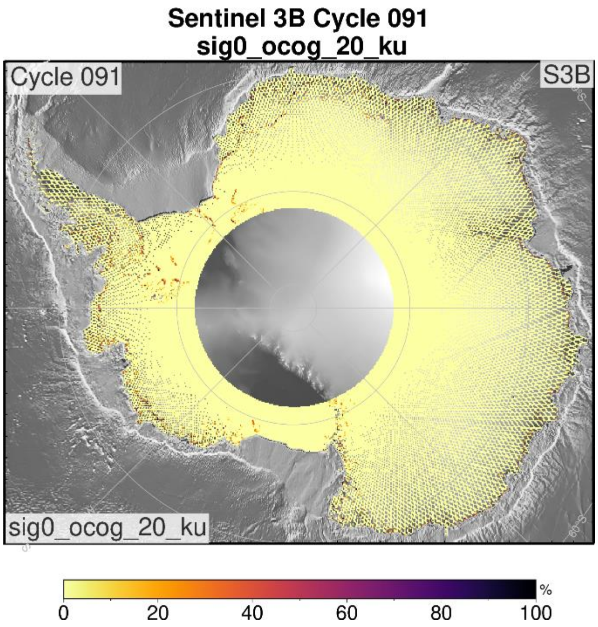


Figure 5.10 Percentage of failure over Antarctica for the sig0_ocog_20_ku parameter

5.1.3 20 Hz Ku Band OCOG (Ice-1) Range (range_ocog_20_ku)

Figure 5.11 shows the range_ocog_20_ku parameter over the Greenland ice sheet for the S3A and S3B full cycles, while

Figure 5.12 shows the percentage of parameter failure (NaN reported) evaluated in 5x5 km grid cells.

Figure 5.13 shows the range_ocog_20_ku parameter over the Antarctic ice sheets for the S3A and S3B full cycles, while

Figure 5.14 shows the percentage of parameter failure (NaN reported) evaluated in 10x10 km grid cells.

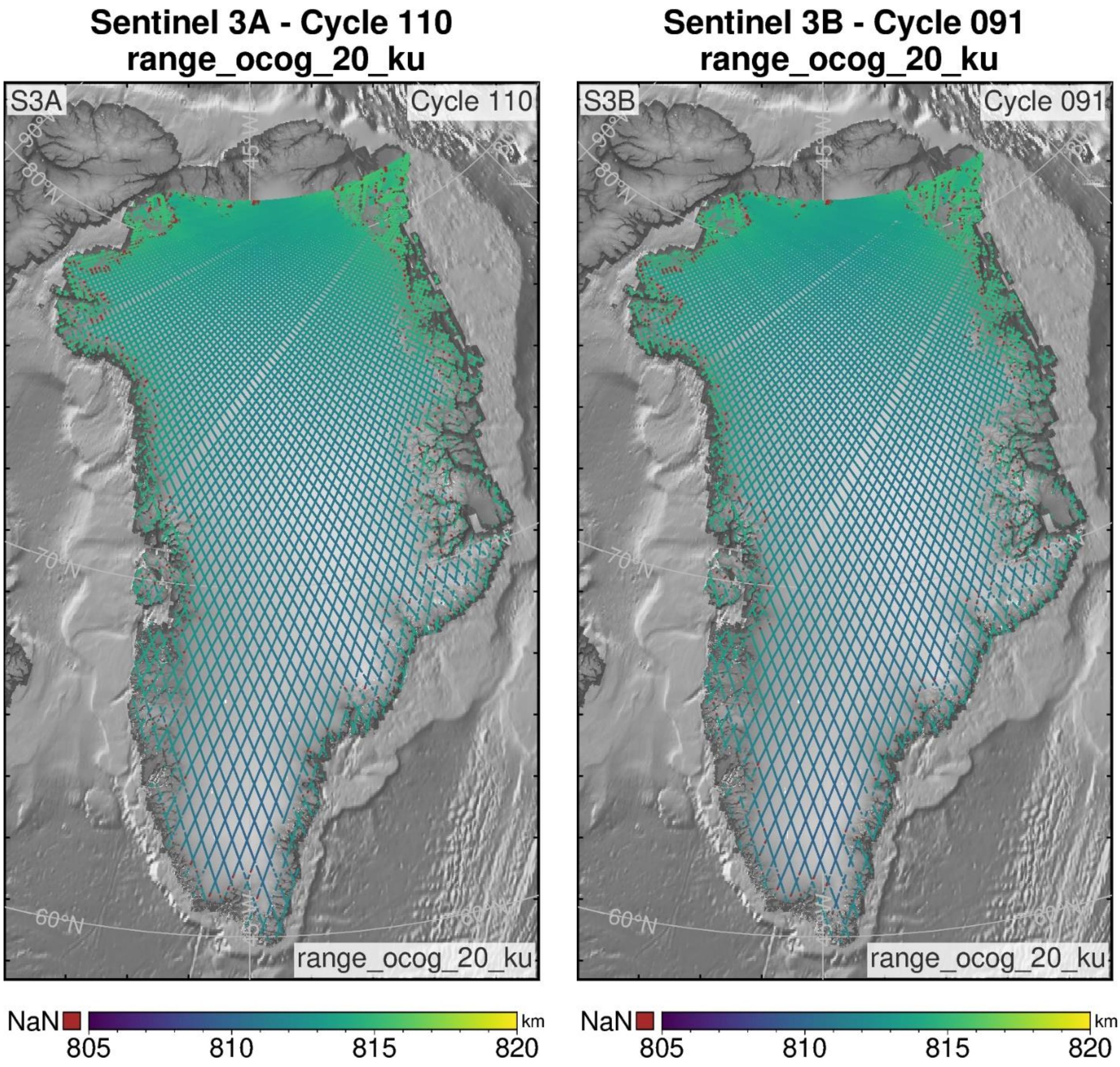


Figure 5.11 SAR mode range over the Greenland ice sheet from the range_ocog_20_ku parameter

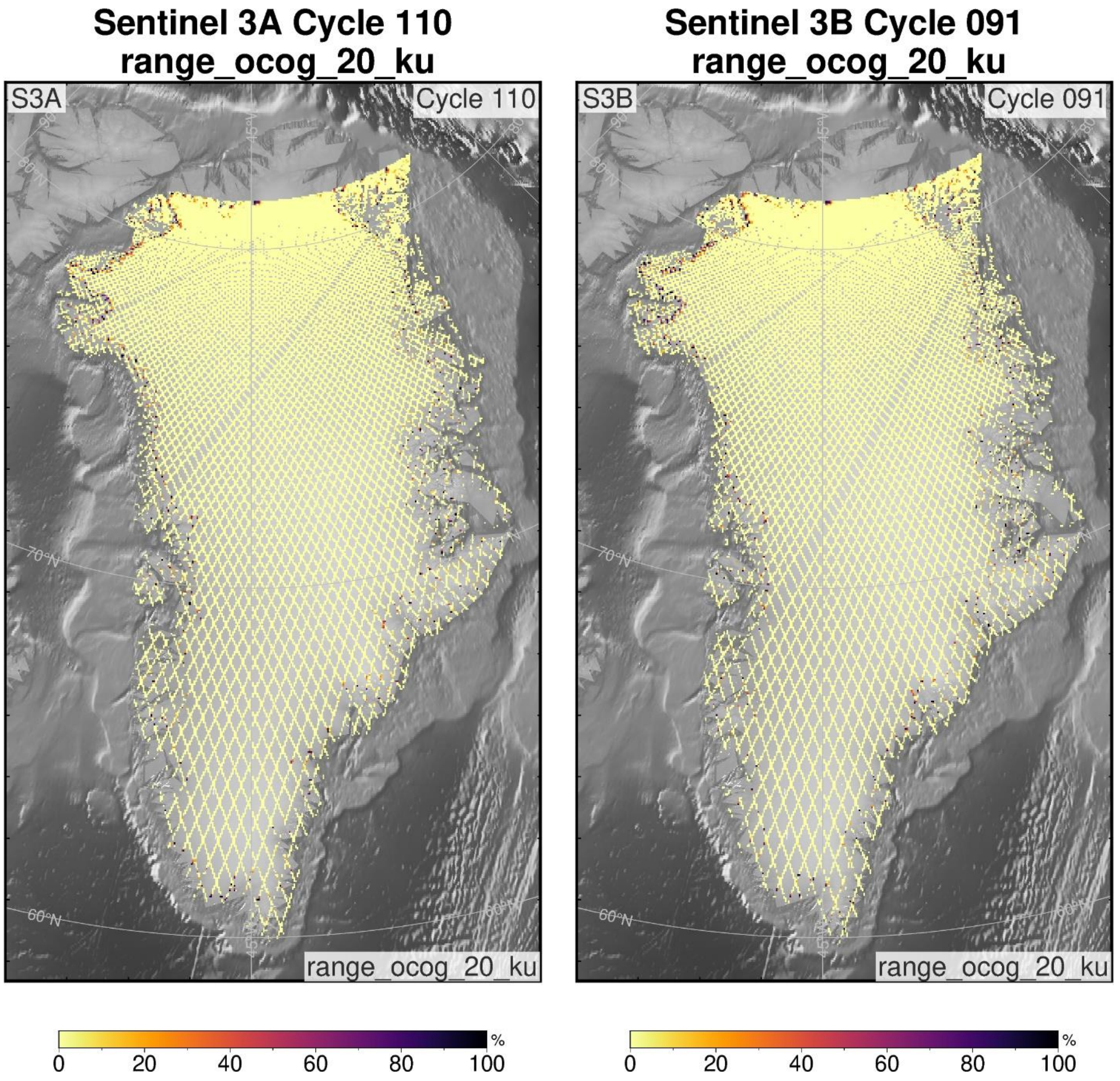


Figure 5.12 Percentage of failure over the Greenland ice sheet for the range_ocog_20_ku parameter

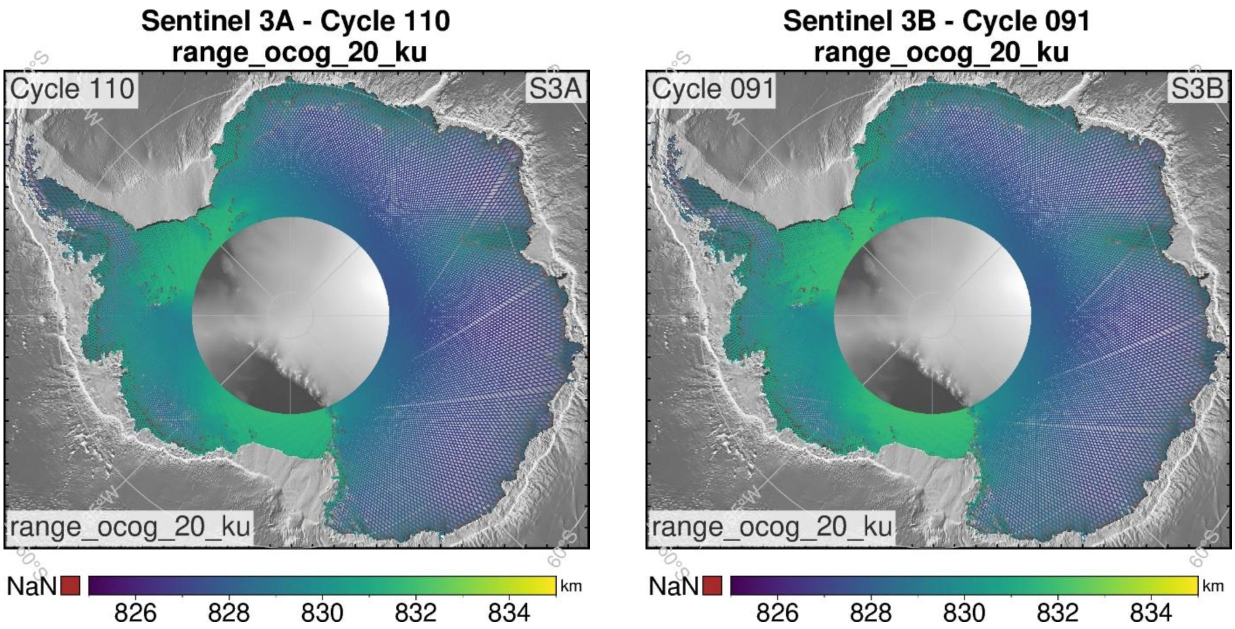


Figure 5.13 SAR Mode range over Antarctica from the range_ocog_20_ku parameter

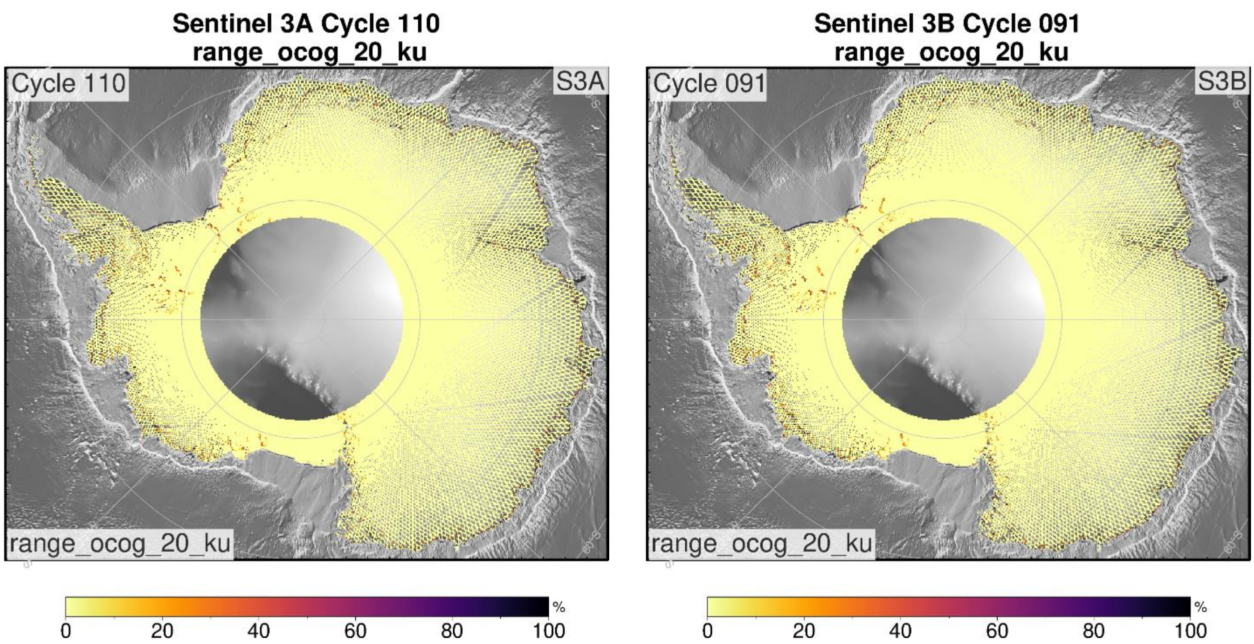


Figure 5.14 Percentage of failure over Antarctica for the range_ocog_20_ku parameter

5.1.4 PLRM Ice Sigma0 (sig0_ice_20_plrm_ku)

The backscatter coefficient (sigma0) derived from the 20 Hz Ku-PLRM waveform (sig0_ice_20_plrm_ku) parameter are shown below. The PLRM Sigma0 over the Greenland and the Antarctica ice sheets are shown in Figure 5.15 and Figure 5.18, respectively. Their respective percentage of parameter failure (NaN reported) are shown in

Figure 5.17 and Figure 5.20. The latter are evaluated in 5x5 km grid cells in Greenland and in 10x10 km grid cells in Antarctica.

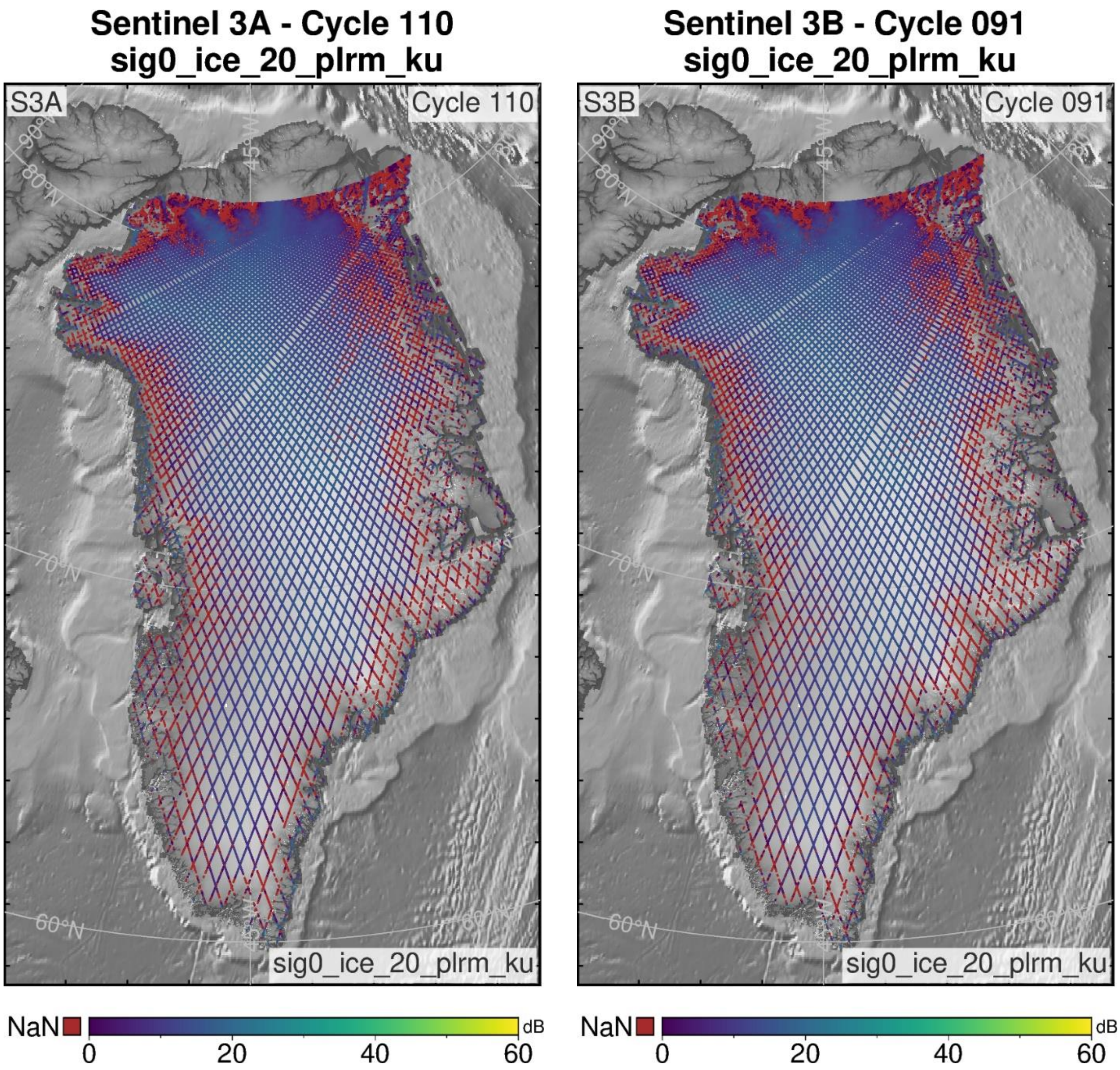


Figure 5.15 PLRM backscatter coefficient over Greenland from the sig0_ice_20_plrm_ku parameter

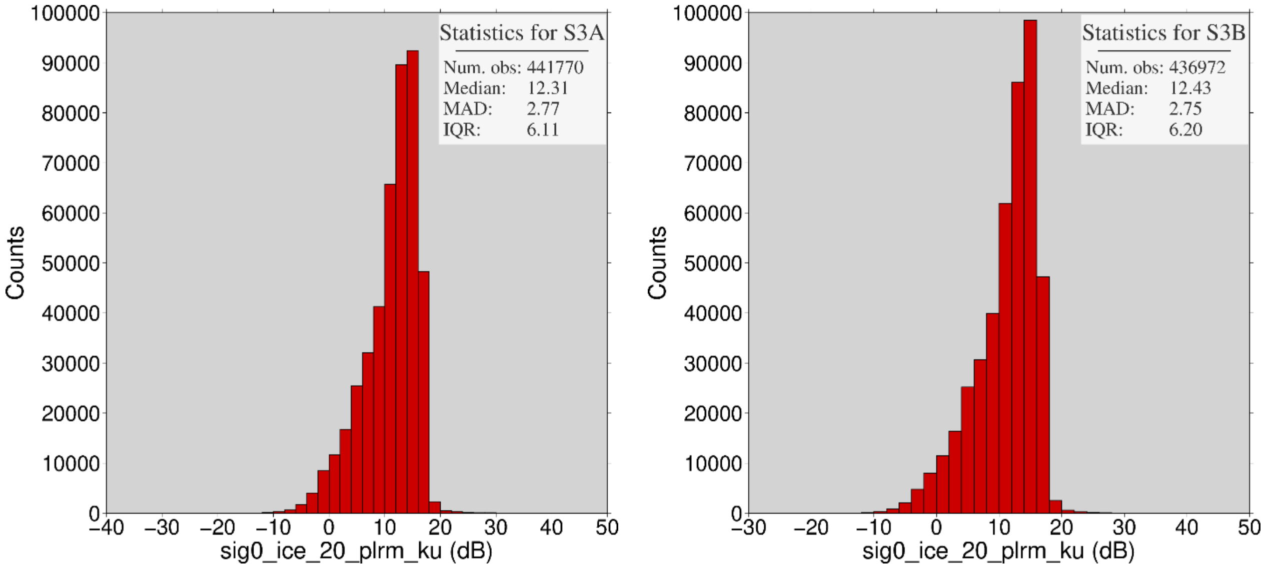


Figure 5.16 The backscatter coefficient (sig0_ice_20_plrm_ku) distribution over Greenland and statistics given by the Number of Observations, Median (dB), Median Absolute distribution (MAD) in dB, and the Interquartile Range (IQR) in dB.

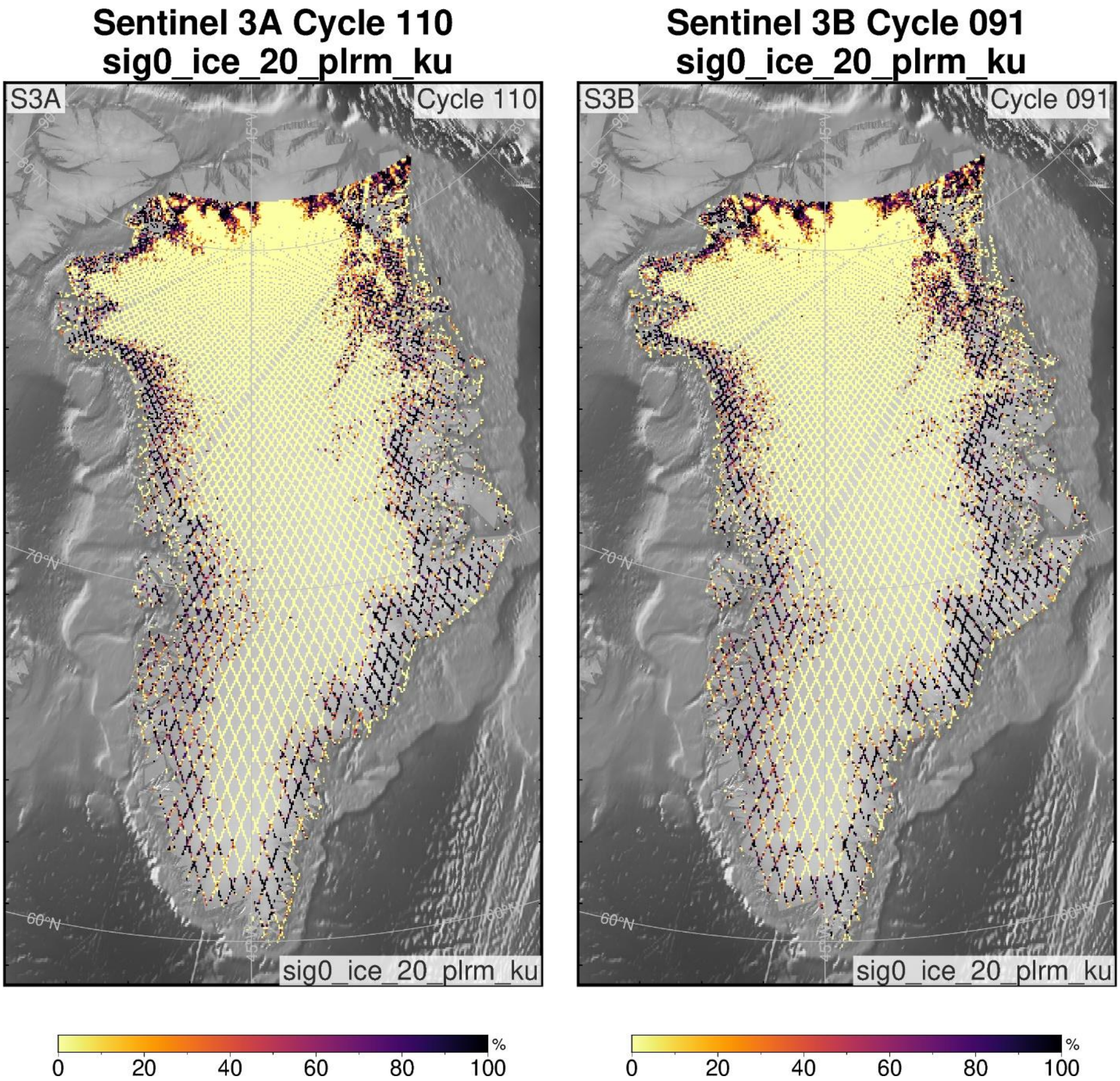


Figure 5.17 Percentage of failure over the Greenland Ice sheet from the sig0_ice_20_plrm_ku parameter

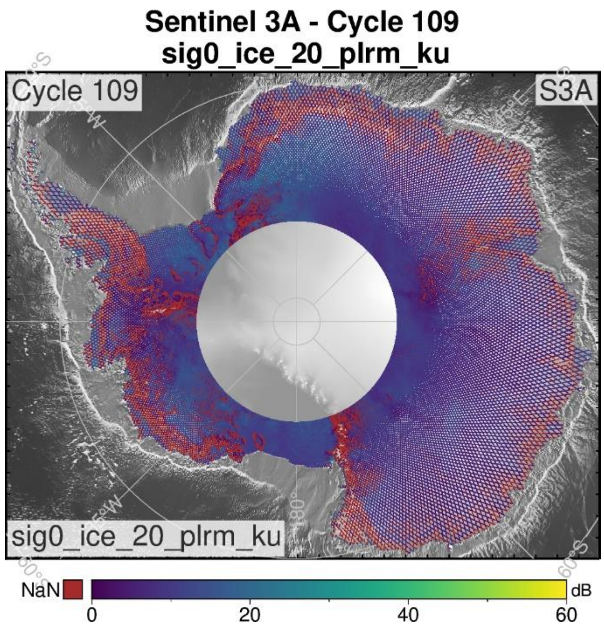


Figure 5.18 PLRM backscatter coefficient over Antarctica from the sig0_ice_20_plrm_ku parameter

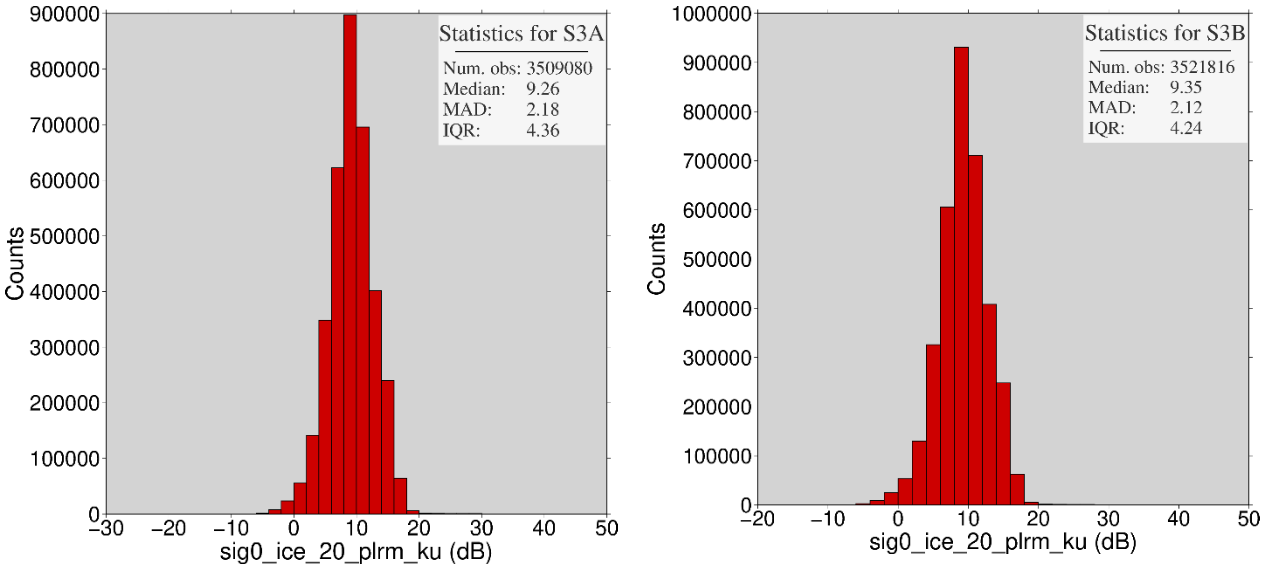


Figure 5.19 The backscatter coefficient (sig0_ice_20_plrm_ku) distribution over Antarctica and statistics given by the Number of Observations, Median (dB), Median Absolute distribution (MAD) in dB, and the Interquartile Range (IQR) given in dB.

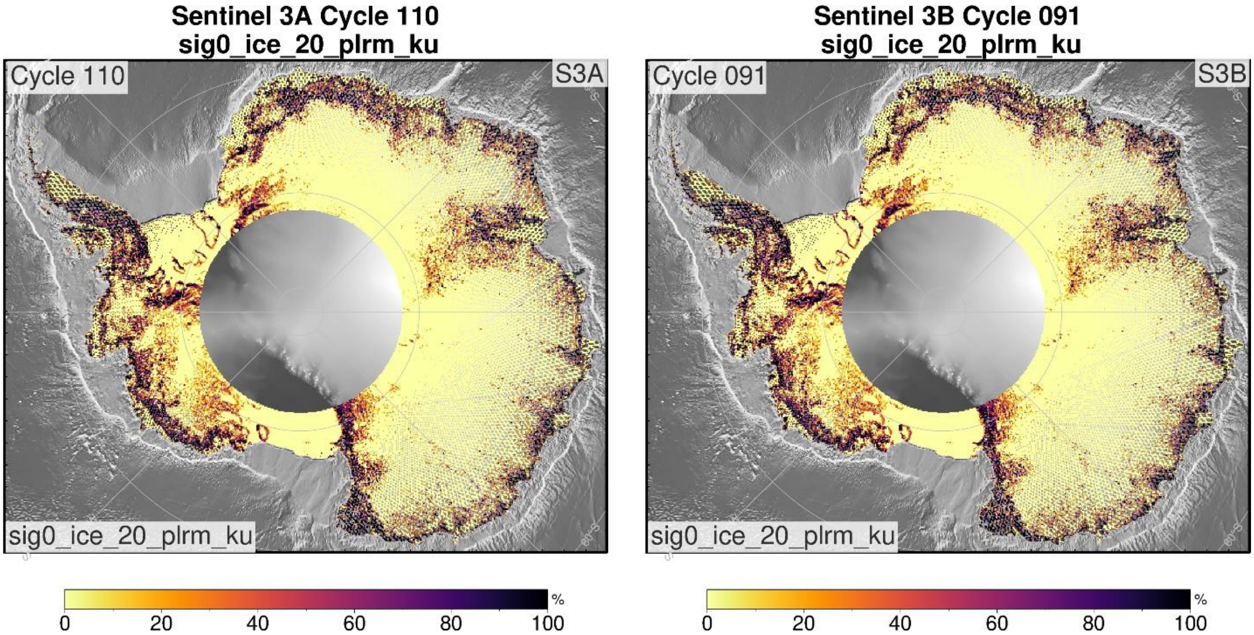


Figure 5.20 Percentage of failure over Antarctica for the sig0_ice_plrm_ku parameter

5.1.5 Waveform Quality Flag (waveform_qual_ice_20_ku)

The waveform quality flag gives the data users information about the quality of the waveforms for use in the calculation of range and elevation, and, hence on the useability of the data. The criteria applied to assess each waveform are listed below. The value of waveform_qual_ice_20_ku is zero (ok) if all tests are passed. The waveform quality flags for the present S3A and S3B cycles are summarized the table below and shown for the Greenland ice sheet in

Figure 5.21, and for Antarctica in

Figure 5.22.

Table 5 Waveform quality test. The two first rows give the percentage of OK or failures of the waveform quality test. This is like the percentages shown in the figures below. The remaining rows describe the percentage of failures. It is worth noting that one waveform can fail more than one test. These rows are as follows: The total Power in the waveform. Average noise power in gates 6-9, where noise gates start at 0. The Variance. The leading-edge test, where the flag is set when the power to the left of gate 42 is less than the threshold power to the right. Peakiness lower than low threshold. Peakiness is higher than the high threshold.

	Threshold	Bit	S3A (GL)	S3B (GL)	S3A (AA)	S3B (AA)
OK	-	-	84.01	83.89	92.92	93.13
Fail	-	-	15.99	16.11	7.08	6.87
Max Power < Threshold	2500	1	6.09	6.42	1.80	1.92
Noise power > Threshold	12.5	2	10.20	9.98	5.37	5.05
Variance > threshold	7.0	4	2.16	2.43	0.74	0.82
Leading edge > Threshold	1.0	8	0.48	0.53	0.15	0.16
Peakiness low < Threshold	0.9	16	0.03	0.03	0.01	0.01
Peakiness high > Threshold	1e12	32	0.00	0.00	0.00	0.00

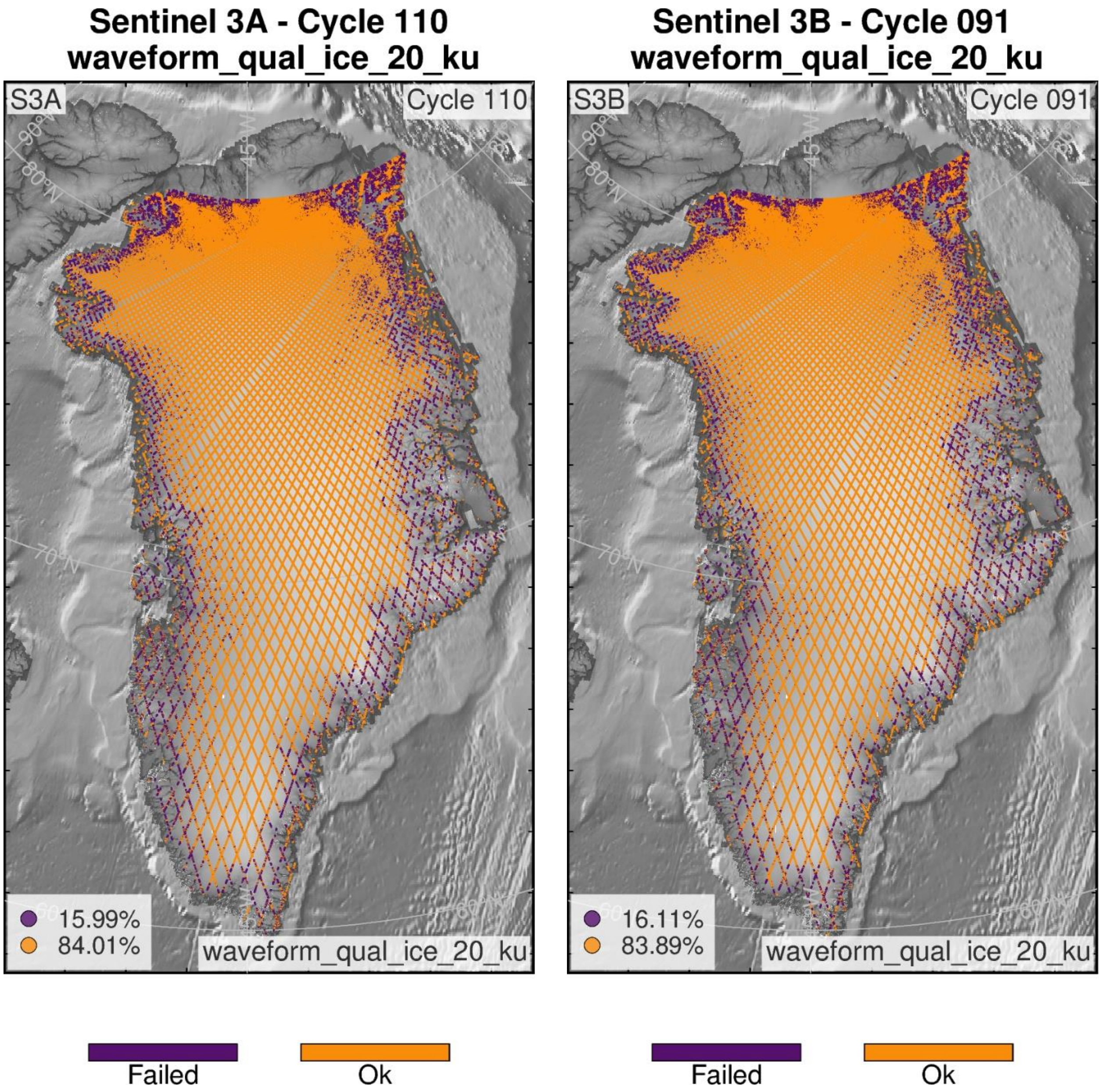


Figure 5.21 Waveform Quality Flag for the Greenland ice sheet

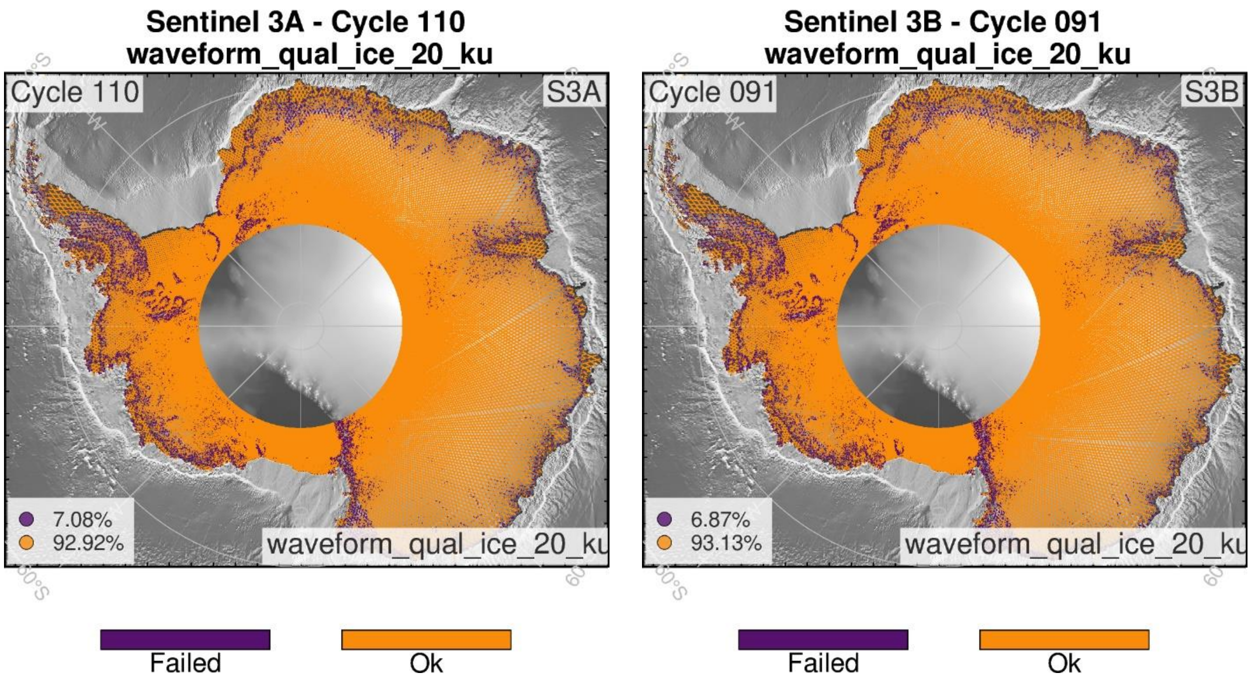


Figure 5.22 Waveform Quality Flag for Antarctica

5.1.6 Slope correction

A slope correction is applied to each measurement to relocate the SAR echo to the point of closest approach (POCA). The slope-corrected coordinates are given by the variables lat_cor_20_ku and lon_cor_20 ku for the 20 Hz Ku measurements. The figures below show whether the slope correction was successful or not over Greenland (Figure 5.23) and Antarctica (Figure 5.24).

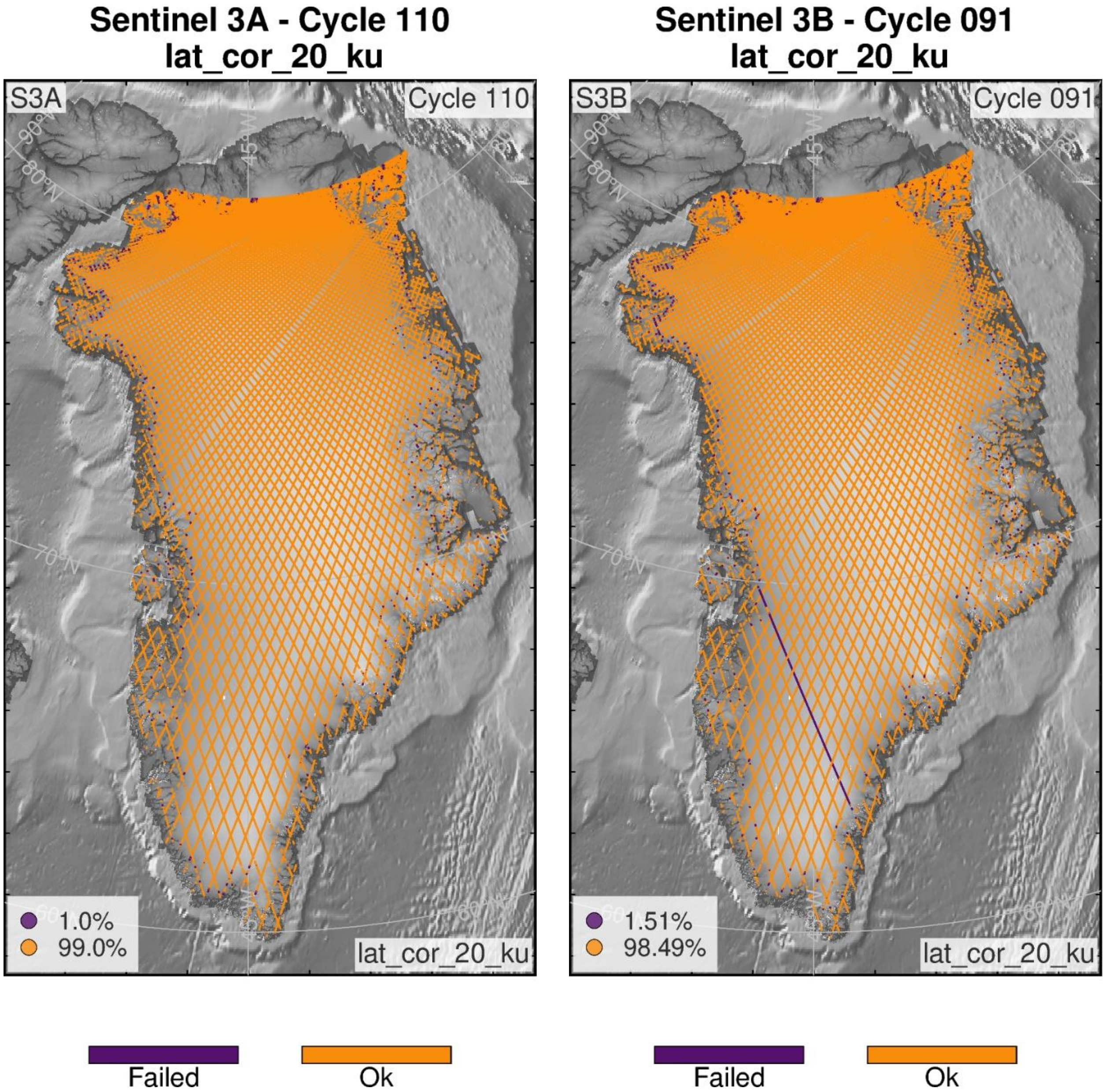


Figure 5.23 Slope correction failure for the Greenland ice sheet

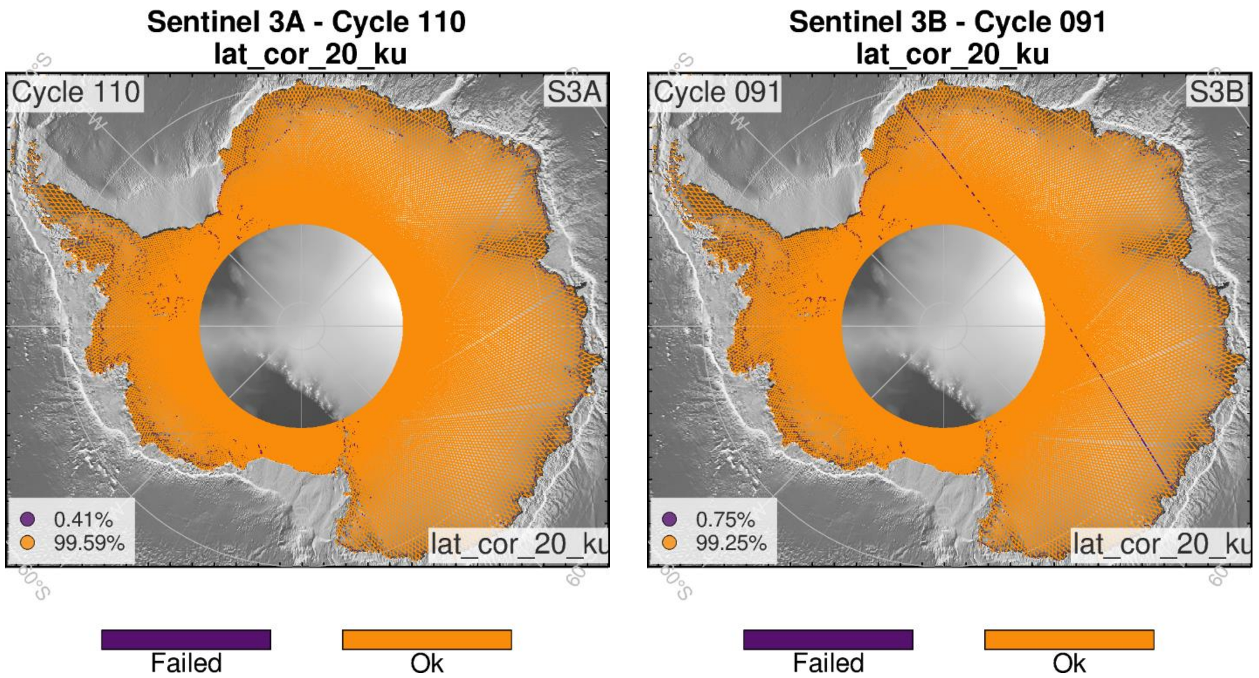


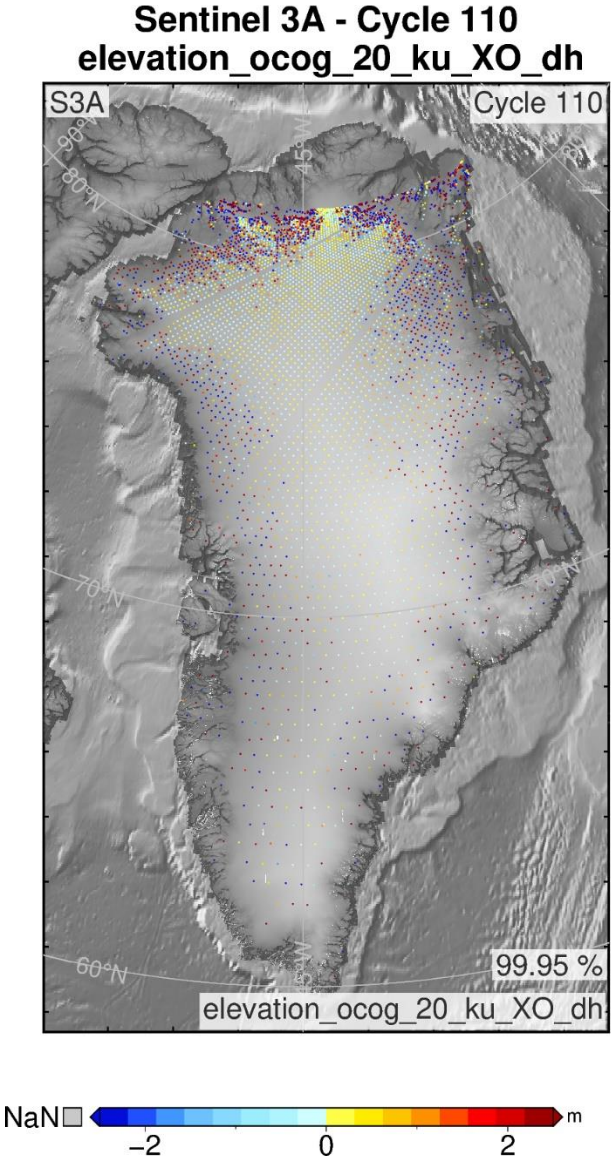
Figure 5.24 Slope correction failure for Antarctica

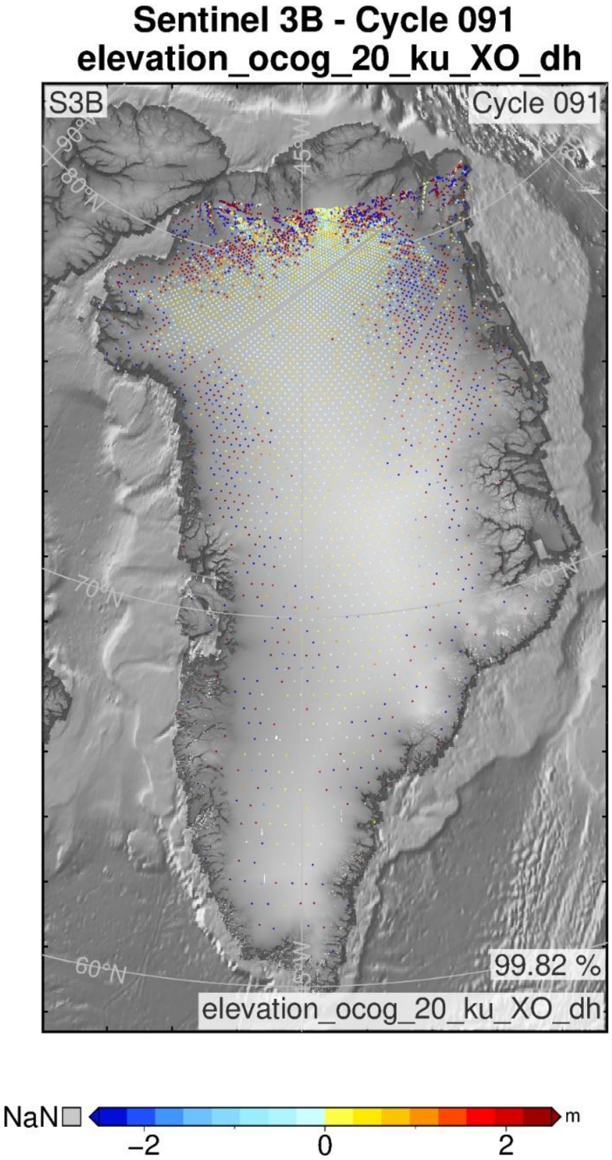
5.2 Data validation

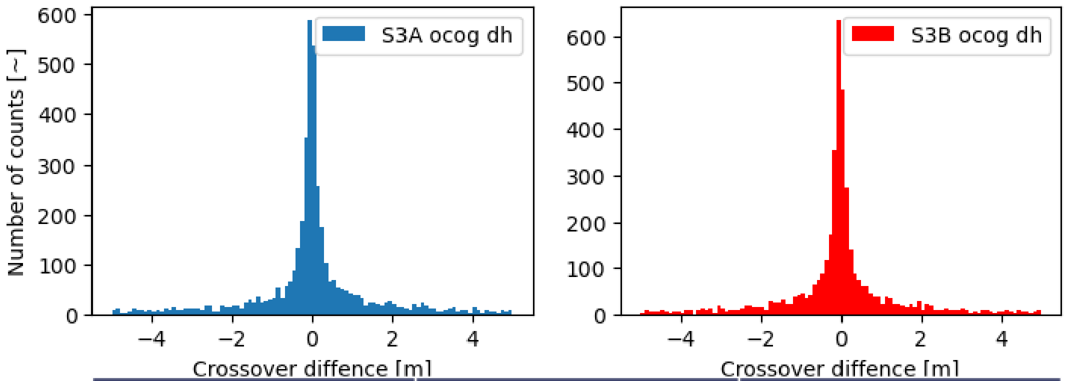
In addition to monitoring specific parameters provided in the product, we also assess the data regarding stability. This effort encompasses crossover analysis, validating elevation measurements in relation to external DEM, and long-term monitoring of the stability of key parameters. These critical components serve as the foundation for confirming the quality of our dataset.

5.3 Cross-over analysis

The observed elevation difference at ground-track crosses is a primary method of assessing the precision of L2 altimetry elevation data. Here, we assess the elevation difference for the OCOG/ICE-1 retracker (“elevation_ocog_sheet_20_ku"). The crossover difference of the elevation observations is derived for the full cycle of observations. It should be noted that the ice sheet surface elevation is changing in some areas over the cycle's timespan due to e.g. weather and snowpack properties. This may give raise to a natural crossover bias, which is not associated with the precision of L2 altimetry elevation data. Therefore, the timing between crossovers should be shortened for more in-depth analysis. The crossover statistics are below as tables, maps, and histograms.

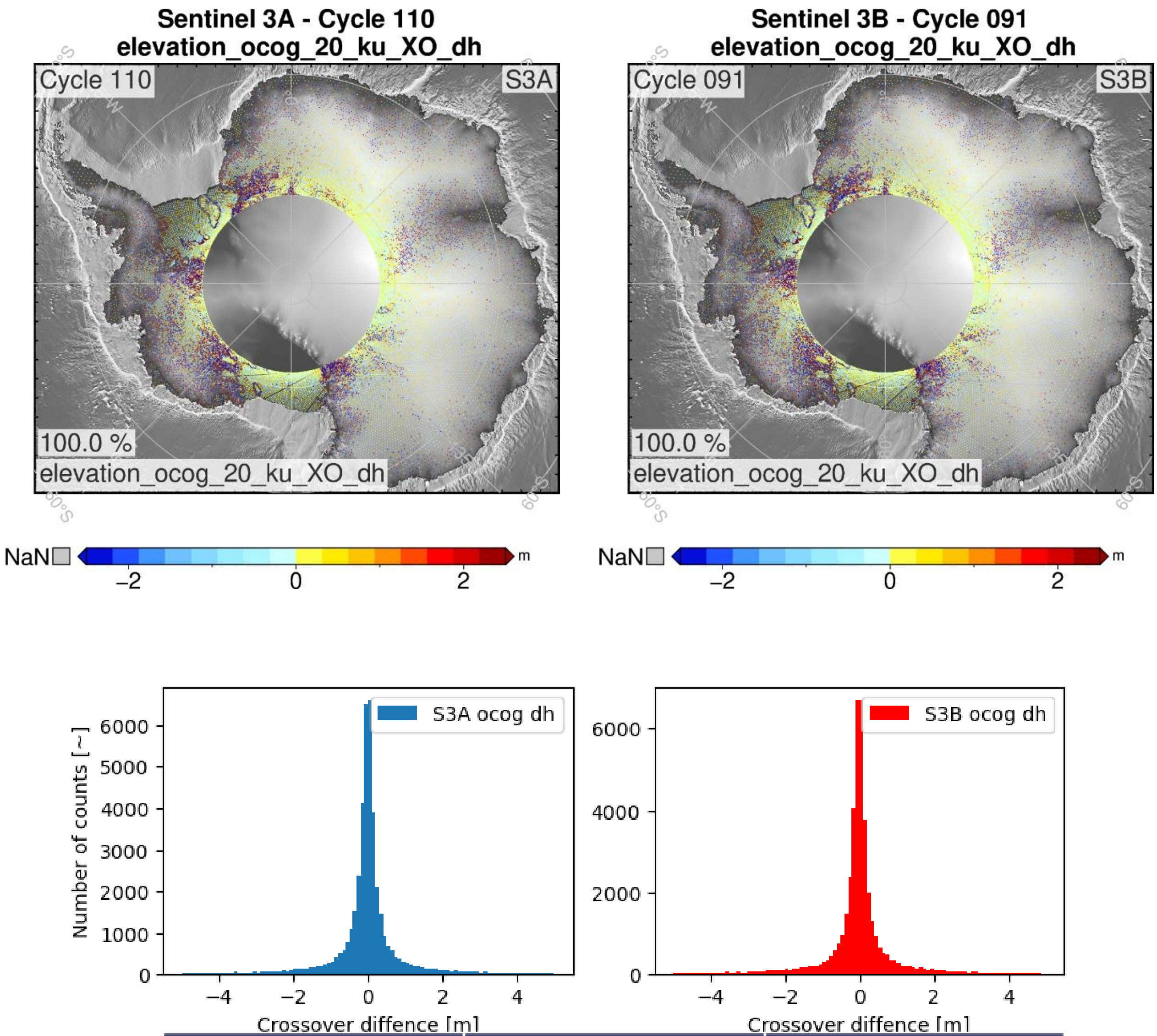

Sentinel 3A - Cycle 110
elevation_ocog_20_ku_XO_dh
S3A
Cycle 110
99.95 %
elevation_ocog_20_ku_XO_dh
NaN
m
–2
0
2


Sentinel 3B - Cycle 091
elevation_ocog_20_ku_XO_dh
S3B
Cycle 091
99.82 %
elevation_ocog_20_ku_XO_dh
NaN
m
–2
0
2



Statistics	S3A OCOG retracker	S3B OCOG retracker
Total number Observation [#]	5766.0	5585.0
Median [m]	-0.016	-0.031
Std [m]	75.821	82.346
Observ. [%] (dh < 1 m)	52.046	52.856
Mean [m] (dh < 1 m)	-0.008	-0.018
Std [m] (dh < 1 m)	0.355	0.355

Figure 5.25 Greenland SAR mode elevation differences at ground track crossovers for Sentinel-3A/B (upper panel). Histograms of crossover elevation differences (lower panel)



Statistics	S3A OCOG retracker	S3B OCOG retracker
Total number Observation [#]	48151.0	47710.0
Median [m]	-0.006	-0.007
Std [m]	35.683	34.243
Observ. [%] (dh < 1 m)	73.932	73.588
Mean [m] (dh < 1 m)	-0.01	-0.008
Std [m] (dh < 1 m)	0.329	0.326

Figure 5.26 Antarctica SAR mode elevation differences at ground track crossovers for Sentinel-3A/B (upper panel). Histograms of crossover elevation differences (lower panel)

5.4 Valid elevation measurements (elevation_ocog_20_ku) wrt. DEM

The observed elevation referenced to an external DEM model measures how far the observations deviate from a DEM. Note the color scale is set to ±50 m. In Figure 5.27 and Figure 5.28 the observed 20 Hz elevation shown referenced to the Arctic DEM (Poter et al. 2023) and REMA (Howat et al 2022) for Greenland and Antarctica, respectively.

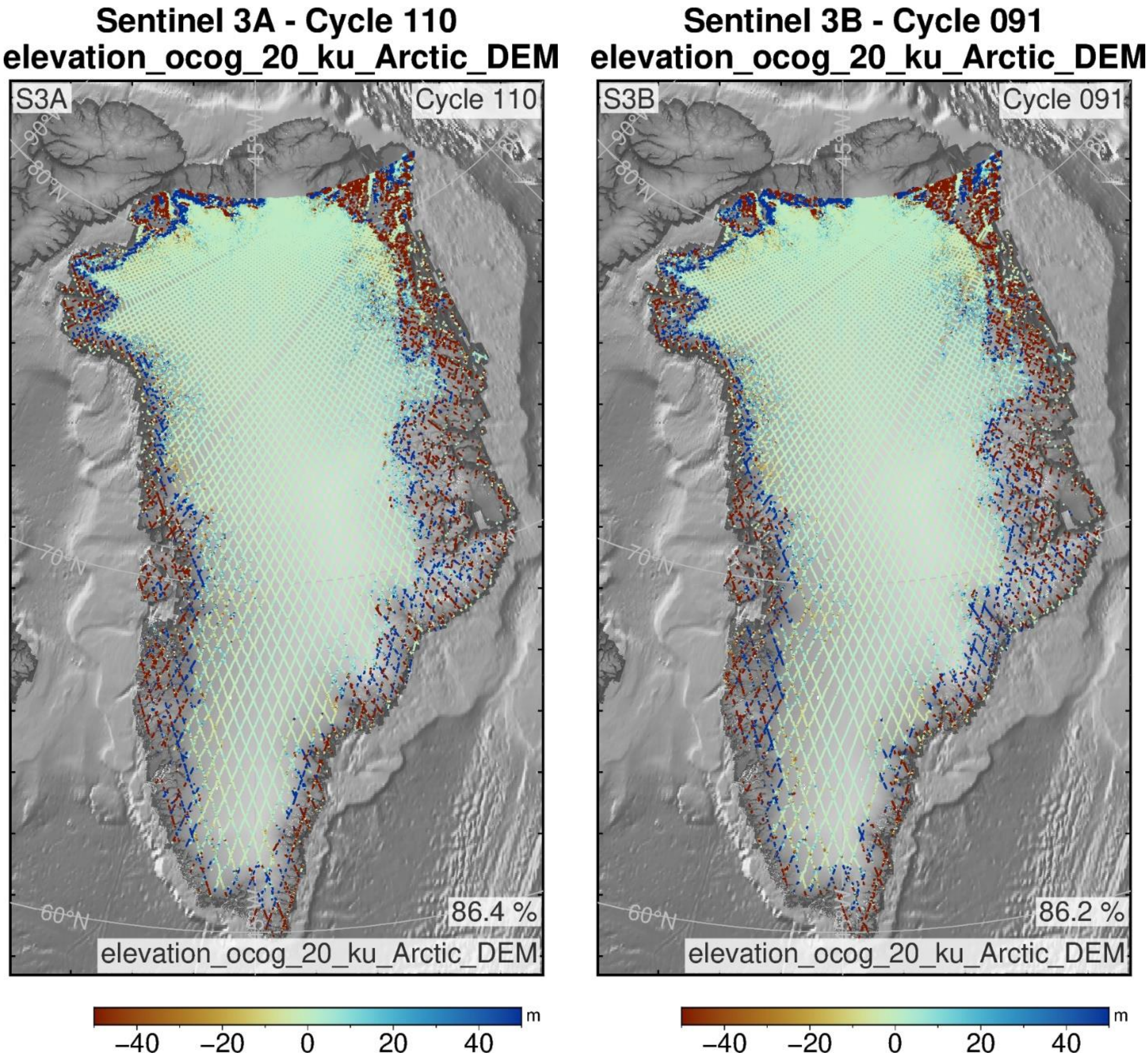


Figure 5.27 Elevation (elevation_ocog_20_ku) over the Greenland ice sheet wrt. The Arctic DEM. The valid measurements after outlier removal (±50 m) are shown in percentage in the figure. Not-A-Number values are not included.

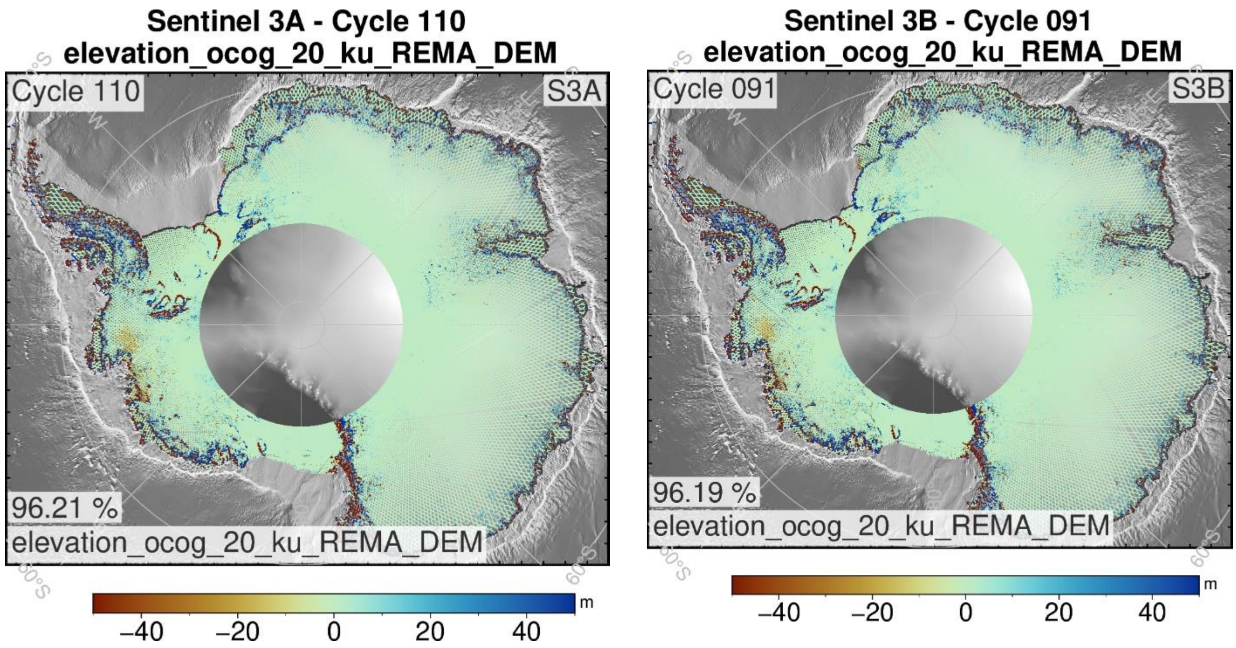


Figure 5.28 Elevation (elevation_ocog_20_ku) over Antarctica wrt. The REMA DEM. The valid measurements after outlier removal (±50 m) are shown in percentage in the figure. Not-A-Number values are not encountered.

5.5 Long-time monitoring

Analyzing the extended monitoring of satellite performance offers valuable information on the instrument's stability and potential performance issues in the current cycle. The validation site for Lake Vostok, depicted in Figure 5.29, is located in the central part of the East Antarctic Ice Sheet. This area is characterized by consistently gentle topographic slopes. The undisturbed ice surface over subglacial Lake Vostok serves as an established validation site for altimetry missions in high-inclination polar orbits, as emphasized in the studies conducted by Richter et al. (2014) and Schröder et al. (2017).

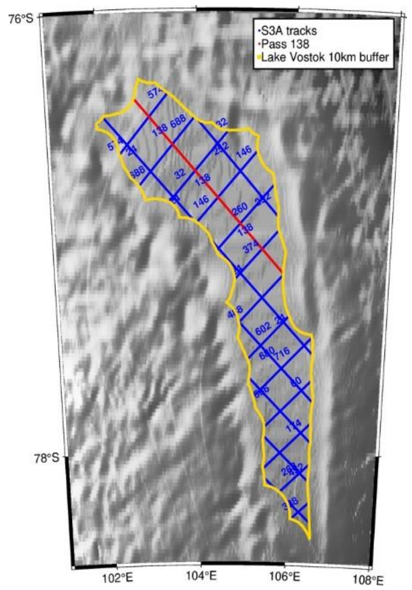


Figure 5.29 Overview of Lake Vostok

Figure 5.30 shows the repeated elevation anomaly of orbit 069 over Lake Vostok for all cycles. The current cycle is marked blue.

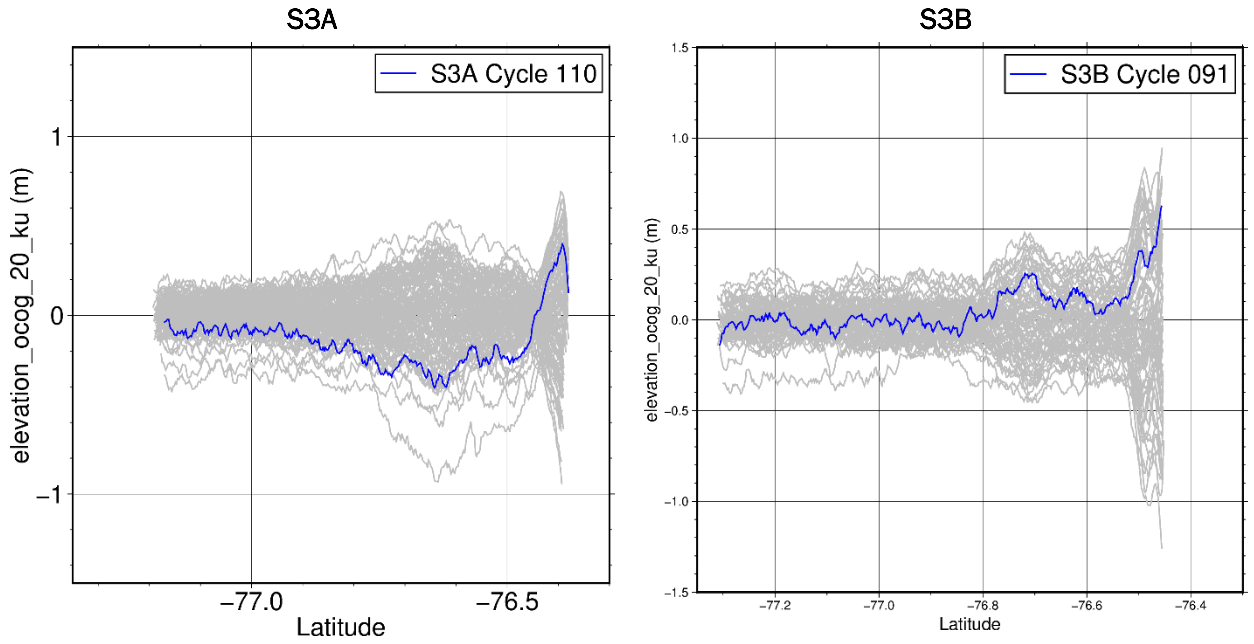


Figure 5.30 Stability of the elevation_ocog_20_ku parameter. The elevation for orbit 069 over Lake Vostok. The total mean elevation of all cycles and the average for latitudes are removed. grey lines are all the cycles from cycle 002 for S3A and from *Cycle 020 for S3B.*

Figure 5.31Figure 5.31 Temporal evolution in the median (top) and MAD (bottom) of the sig0_ocog_20_ku parameter for each S3A cycle over Lake Vostok displays the mean and MAD of the parameter sigma0_ocog_20_ku for each cycle in S3A, while Figure 5.32 depicts the same for S3B. In both figures, cycles in STC are highlighted with a red star, while the preceding cycles in NTC are represented by blue dots.

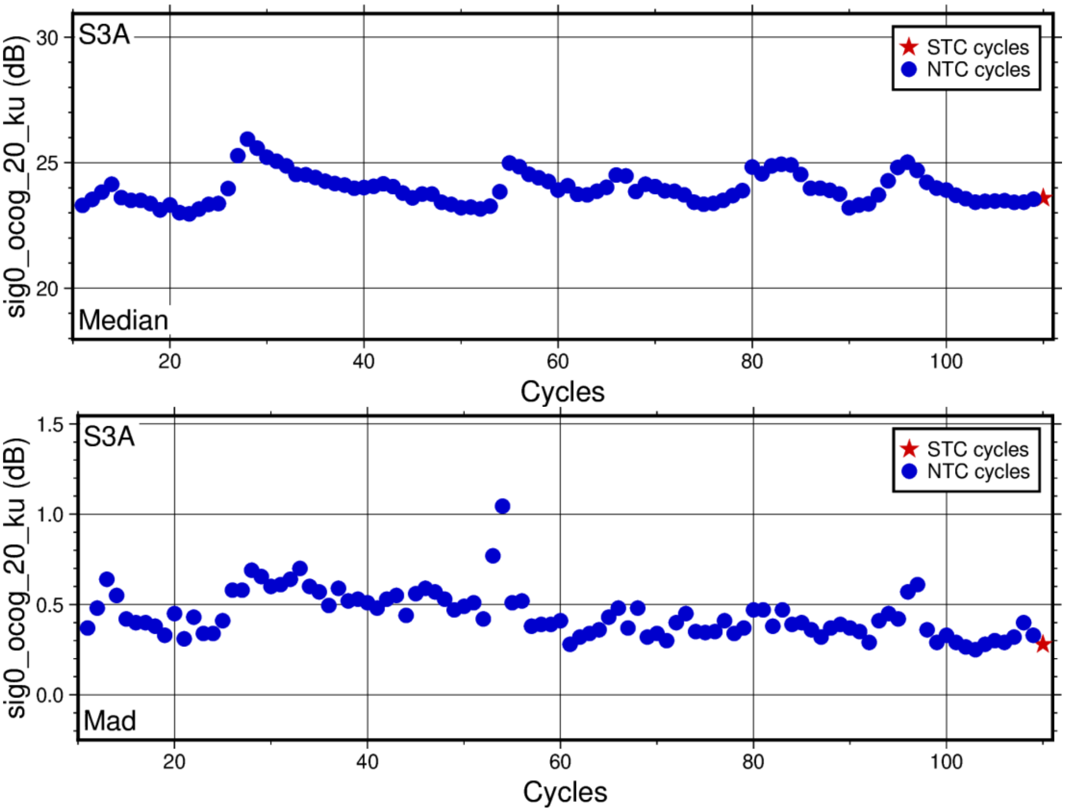


Figure 5.31 Temporal evolution in the median (top) and MAD (bottom) of the sig0_ocog_20_ku parameter for each S3A cycle over Lake Vostok

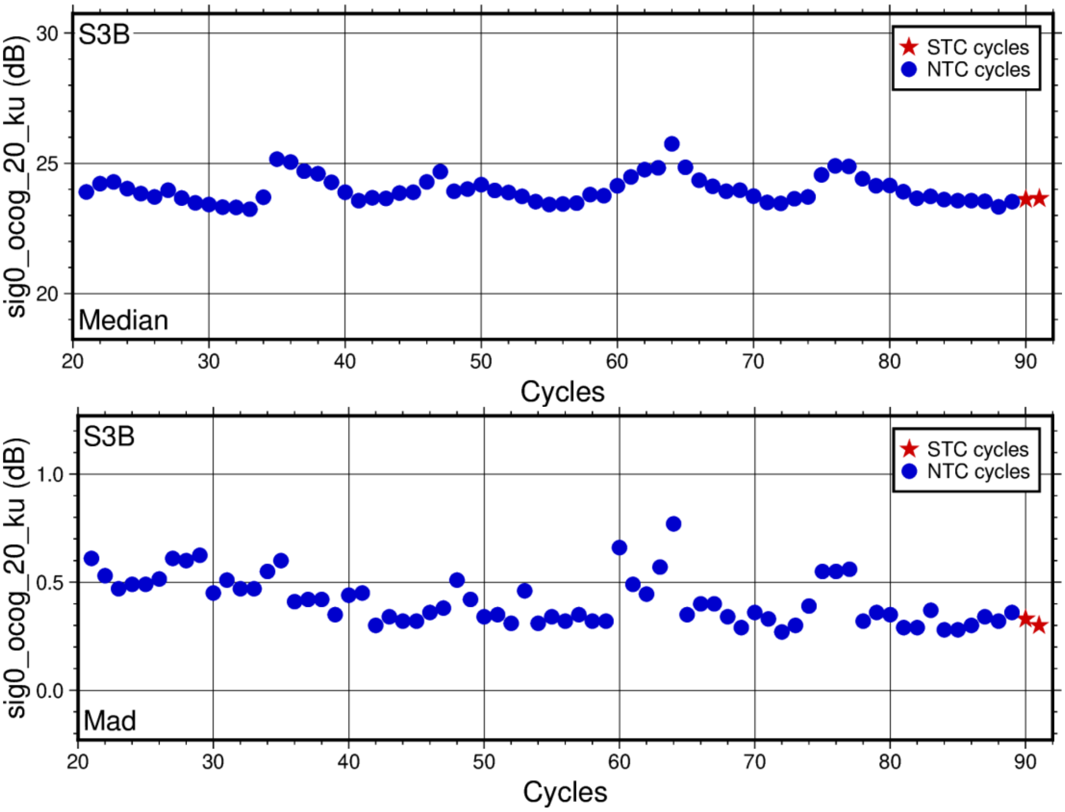


Figure 5.32 Temporal evolution in the median (top) and MAD (bottom) of the sig0_ocog_20_ku parameter for each S3B cycle over Lake Vostok

Appendix A - Useful links

For more information, related to Sentinel-3 Surface Topography Mission, please visit the SentiWiki website: https://sentiwiki.copernicus.eu/web/s3-altimetry-instruments

A User Handbook provides dedicated information to the Sentinel-3 STM Thematic Products.

The Product Format Specification applicable to the Level-2 Thematic Products assessed in this report is available on SentiWiki.

All plots were made using Python and PyGMT (2.12) a Python wrapper for The Generic Mapping Tools (GMT) Version 6.5.0 (Wessel et al. 2019; Uieda et al. 2021)

Appendix B - CPR Change log.

Effectuated cycle	Description
104/085	The CPR is updated to reflect the new Thematic product of PB005. • Removed all plots associated with the UCL retracker. These are available upon request to the ESL. • Removed the range and elevation plot associated with the PLRM retracker. These are available upon request to the ESL. • Added plots on valid elevation measurements, where the elevation is plotted as an anomaly to the Arctic DEM and REMA, for Greenland and Antarctic, respectively. • Added more diagnostics on the long-term monitoring of KPI • General update of figures
105/086	• Added time series plot of Sigma0 OCOG over Lake Vostok

Appendix C - References

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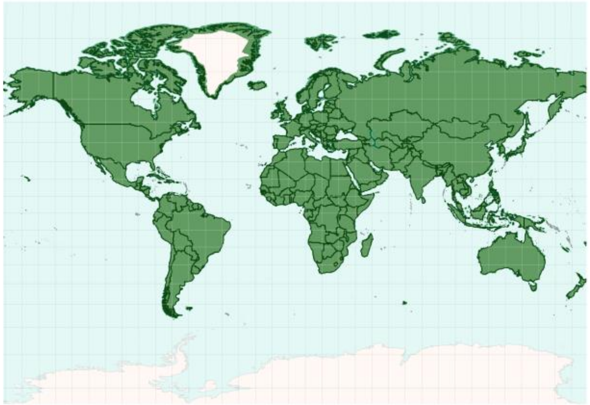
Wingham, D. J., and D. W. Wallis. 2010. "The Rough Surface Impulse Response of a Pulse-Limited Altimeter With an Elliptical Antenna Pattern." *IEEE Antennas and Wireless Propagation Letters* 9: 232–35. https://doi.org/10.1109/LAWP.2010.2046471.

Appendix D - Thematic Masks

Hydrology Mask



Sea Ice Mask

Land Ice Mask