# PREPARATION AND OPERATIONS OF THE MISSION PERFORMANCE CENTRE (MPC) FOR THE COPERNICUS SENTINEL-3 MISSION

# **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

**Start date: 27/10/2017** 

End date: 23/11/2017



Mission
Performance
Centre

SENTINEL 3



Ref. S3MPC.UCL.PR.08-025

**Issue:** 1.0

**Date:** 06/02/2018

Contract: 4000111836/14/I-LG

Customer:	ESA	Document Ref.:	S3MPC.UCL.PR.08-025
Contract No.:	4000111836/14/I-LG	Date:	06/02/2018
		Issue:	1.0

Project:	PREPARATION AND OPERATIONS OF THE MISSION PERFORMANCE CENTRE (MPC) FOR THE COPERNICUS SENTINEL-3 MISSION			
Title:	S3-A Land and Sea Ice Cyclic Performance Report			
Author(s):	Land and Sea Ice ESLs			
Approved by:	G. Quartly, STM ESL Coordinator  Authorized by Sylvie Labroue, STM Technical Performance Manager			
Distribution:	ESA, EUMETSAT, S3MPC consortium			
Accepted by ESA	P. Féménias, MPC TO			
Filename	S3MPC_LandSealce-CyclicReport-Cycle25			

#### Disclaimer

The work performed in the frame of this contract is carried out with funding by the European Union. The views expressed herein can in no way be taken to reflect the official opinion of either the European Union or the European Space Agency.









## S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: iii

## **Changes Log**

Version	Date	Changes
1.0	06/02/2018	First Version

# **List of Changes**

Version	Section	Answers to RID	Changes



## S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: iv

### **Table of content**

1	INT	RODUCTION	1
2	CYC	CLE OVERVIEW	2
3	PRO	OCESSING BASELINES	3
4	DA <sup>-</sup>	TA AVAILABILITY & INSTRUMENT MODES	4
	4.1	Data Availability	
	4.2	SRAL Instrument Mode	
5	AV	AILABILITY OF POLAR GEOPHYSICAL CORRECTIONS	9
	5.1	AVAILABILITY OF GEOPHYSICAL CORRECTIONS OVER ICE SHEETS (NTC PRODUCTS)	9
	5.2	AVAILABILITY OF GEOPHYSICAL CORRECTIONS OVER ICE SHELVES (NTC PRODUCTS)	
	5.3	AVAILABILITY OF GEOPHYSICAL CORRECTIONS OVER SEA ICE	
	5.4	AVAILABILITY OF SNOW DENSITY, SNOW DEPTH AND SEA ICE CONCENTRATION OVER SEA ICE	13
6	GEO	OPHYSICAL PARAMETER MONITORING FOR LAND ICE	14
	6.1	20Hz Ku Band Waveform Quality Flag for Ice Sheets (waveform_qual_ice_20_ku)	14
	6.2	20Hz Ku Band Elevation (elevation_ice_sheet_20_ku)	
	6.3	20Hz Ku Band Ice Sheet Range (range_ice_sheet_20_ku)	
	6.4	20Hz Ku Band Ice Sheet Sigma0 (sig0 ice sheet 20 ku)	
	6.5	20Hz Ku Band OCOG (Ice-1) Range (range_ocog_20_ku)	28
	6.6	20Hz Ku Band OCOG (ICE-1) SIGMAO (SIGO_OCOG_20_KU)	
	6.7	20Hz Ku Band PLRM Ice Range (range_ice_20_plrm_ku)	32
	6.8	20Hz Ku Band PLRM Sigma0 (sig0_ice_20_plrm_ku)	34
	6.9	20Hz Ku Band Surface Class (surf_class_20_ku)	36
7	SLC	PPE CORRECTION ASSESSMENT	38
8	GEO	OPHYSICAL PARAMETER MONITORING FOR SEA ICE	41
	8.1	20Hz Ku Band Altimeter Derived Surface Type (surf_type_class_20_ku)	41
	8.2	20Hz Ku band Freeboard ( freeboard_20_ku)	
	8.3	20Hz Ku Band Interpolated Sea Surface Height Anomaly (int_sea_ice_ssha_20_ku)	44
	8.4	Sea Surface Height Anomaly (sea_ice_ssha_20_ku)	46
	8.5	20Hz Ku Band Sea Ice Concentration (SEA_ICE_CONCENTRATION_20_KU)	48
9	CRO	DSSOVER ANALYSIS	51
1(	O REF	PEAT TRACK ANALYSIS	52
1:	1 LOI	NG TERM MONITORING	53
1	2 EVE	ENTS	54
13	з соі	NCLUSIONS	55
1	4 ADI	DENIDIV A	F.C



# S3-A Land and Sea Ice Cyclic Performance Report Cycle No. 025

Issue: 1.0

Date: 06/02/2018

Ref.: S3MPC.UCL.PR.08-025

Page: v

# **List of Figures**

Figure 1: Map of SRAL mode over Antarctic ice sheet and ice shelves for cycle 25 NTC	5
Figure 2: Map of SRAL mode over Greenland ice sheet for cycle 25 NTC	6
Figure 3: Map of SRAL mode over the Antarctic sea ice for cycle 25 NTC	7
Figure 4: Map of SRAL mode over the Arctic sea ice for cycle 25 NTC	8
Figure 5: Percentage of Geophysical Correction Non-availability over Antarctic Ice Sheets	9
Figure 6: Percentage of Geophysical Correction Non-availability over the Greenland Ice Sheet	10
Figure 7: Availability of Geophysical Corrections over Antarctic Ice Shelves	11
Figure 8: Map of % 20Hz Ku Waveform Quality Flag Failure Density (in 10 km <sup>2</sup> grid) for cycle Antarctic Ice Sheet	
Figure 9: Maps of % 20Hz Ku Waveform Quality Flag Test Failure Densities (in 10 km <sup>2</sup> grid) for cycle Antarctic Ice Sheet	
Figure 10: Map of % 20Hz Ku Waveform Quality Flag Failure Density (in 10 km <sup>2</sup> grid) for cycle Greenland	
Figure 11: Map of % 20Hz Ku Waveform Quality Flag Test Failure Density (in 10 km <sup>2</sup> grid) for cycle Greenland	
Figure 12: Maps of 20Hz Ku band Ice Sheet Elevation over Antarctica for cycle 25	20
Figure 13: Maps of 20Hz Ku band Ice Sheet Elevation over Greenland for cycle 25	21
Figure 14: Maps of 20Hz Ku band Ice Sheet Elevation over Dome-C, a low slope region of Antarctica cycle 25	
Figure 15: Maps of 20Hz Ku band Ice Sheet Elevation over the SPIRIT Zone, a high slope region Antarctica for cycle 25	
Figure 16: Maps of 20Hz Ku Band Ice Sheet Range (range_ice_sheet_20_ku)	25
Figure 17: Maps of 20Hz Ku Band Ice Sheet Sigma0 (sig0_ice_sheet_20_ku)	27
Figure 18: Maps of 20Hz Ku Band OCOG (Ice-1) Range (range_ocog_20_ku)	29
Figure 19: Maps of 20Hz Ku Band OCOG (Ice-1) Sigma0 (sig0_ocog_20_ku)	31
Figure 20: Maps of 20Hz Ku Band PLRM Ice Range (range_ice_20_plrm_ku)	33
Figure 21: Maps of 20Hz Ku Band PLRM Sigma0 (sig0_ice_20_plrm_ku)	35
Figure 22: Maps of 20Hz Ku Band Surface Class (surf_class_20_ku)	37
Figure 23: Maps of % Slope Correction Failure Density in a 10km grid	38
Figure 24: Maps of Slope Correction Failure Locations	40
Figure 25: Maps of 20Hz Ku Band Altimeter Derived Surface Type (surf_type_class_20_ku)	42



# S3-A Land and Sea Ice Cyclic Performance Report

#### Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: vi

Figure 26: Maps of 20Hz Ku band Freeboard (freeboard_20_ku)	44
Figure 27: Maps of 20Hz Ku band Interpolated Sea Ice SSHA (m)	46
Figure 28: Maps of 20Hz Ku band Sea Ice SSHA (m)	48
Figure 29: Maps of 20Hz Ku band Sea Ice Concentration (sea_ice_concentration_20_ku)	50
List of Tables	
Table 1: Data Availability for NTC	4
Table 2: % Non Availability of Geophysical Corrections over Sea Ice (NTC)	12
Table 3: % Availability of Snow Density, Snow Depth, Sea Ice Concentration over Sea Ice	13



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 1

### 1 Introduction

This document provides a report of the performance and data quality of the Sentinel-3A SRAL Level 2 data products over land ice (polar ice sheets, ice shelves, and ice caps) and sea ice surfaces.

For land ice the SR\_2\_LAN Level 2 NTC (Non Time Critical) products which contain the final orbit and geophysical corrections are assessed. These are produced by the S3 Instrument Processing Facility (IPF) at CNES.

For sea ice, we assess the SR\_2\_WAT Marine Level 2 NTC (Non Time Critical) products, produced by the S3 Marine Centre.

The objectives of this document are:

- To provide a data quality assessement.
- 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 cycle 25, from 23 November 2017 to 20 December 2017.



# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 2

# **2** Cycle Overview

This is 27-day cycle 25 (23-Nov-2017 to 20-Dec-2017), the 12th cycle since Sentinel-3A entered its routine operational phase following commissioning. Sentinel-3A was launched on 16-February-2016.

During this cycle, Sentinel-3A SRAL operated in SAR mode over land ice and sea ice surfaces.



# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 3

# 3 Processing Baselines

During this cycle there was a single Instrument Processing Facility (IPF) software version used for SR\_2\_LAN and SR\_2\_WAT NTC products.

The version of the IPF were used to compute the altimeter parameters for the L2 Land (SR\_2-LAN) NTC dataset during this cycle was:

SR_2_LAN NTC			
Cycle	Processing Baseline	L2 IPF Versions	L1 IPF Versions
25	PB 2.24	SM2 6.10	SR1 06.12

The version of the IPF used to compute the altimeter parameters for the L2 Land (SR\_2-WAT) NTC dataset during this cycle was:

SR_2_WAT NTC			
Cycle	Processing Baseline	L2 IPF Versions	L1 IPF Versions
25	PB 2.24	SM2 6.10	SR1 06.12



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 4

# 4 Data Availability & Instrument Modes

### 4.1 Data Availability

The percentage of L2 product orbits received during this 27 day cycle by the MPC and contributing to this report were:

Product Type	Latency	% Orbits Received
SR_2_LAN	NTC	100%
SR_2_WAT	NTC	100%

Table 1: Data Availability for NTC

Note that these are percentages of products received by the Mission Performance Centre at the time of report issue, and may be lower than the final data availability if there have been processing centre delays.



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 5

#### 4.2 **SRAL Instrument Mode**

Over land ice surfaces the SRAL instrument operated in SAR closed loop during this cycle. Closed-loop is the autonomous form of surface tracking typically used for altimetry missions, as compared with openloop which depends on a pre-computed DEM stored onboard.

Flag: instr op mode 20 ku

Mode: all

Cycle: 25 NTC SR\_2\_LAN

Rel. Orbits: 1 to 385 First Time: 2017-11-23T22:22 Last Time: 2017-12-20T21:32 IPF Version: IPF-SM-2 06.10

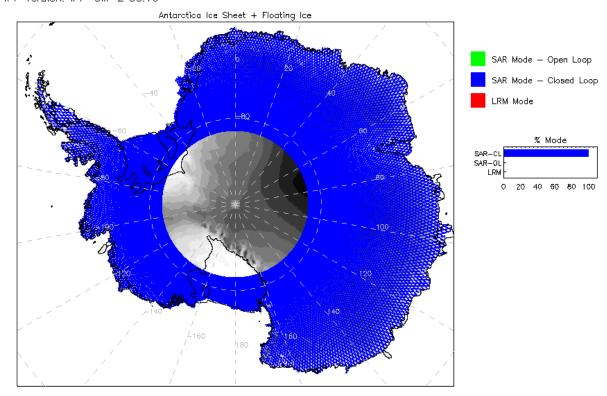


Figure 1: Map of SRAL mode over Antarctic ice sheet and ice shelves for cycle 25 NTC



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 6

Flag: instr\_op\_mode\_20\_ku

Mode: all

Cycle: 25 NTC SR\_2\_LAN

Rel. Orbits: 1 to 385 First Time: 2017-11-23T22:22 Last Time: 2017-12-20T21:32 IPF Version: IPF-SM-2 06.10

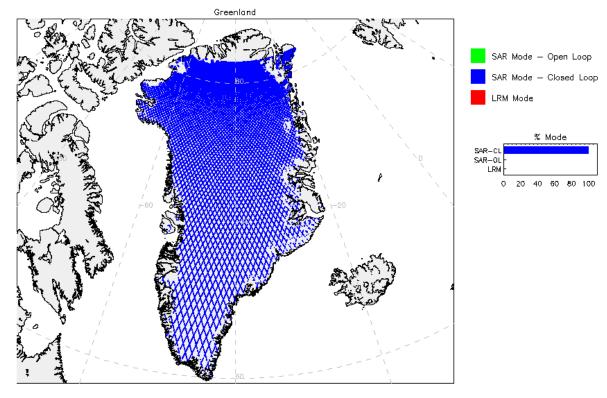


Figure 2: Map of SRAL mode over Greenland ice sheet for cycle 25 NTC

For sea ice and ocean surfaces the SRAL instrument operated in SAR open loop mode during this cycle. Note that the mode mask is fixed and does not dynamically change from cycle to cycle. In open loop the range window is positioned using a 1-D along track DEM with a-priori knowledge of the surface height.

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 7

Flag: instr\_op\_mode\_20\_ku

Mode: all

Cycle: 25 NTC SR\_2\_WAT

Rel. Orbits: 1 to 385 First Time: 2017-11-23T22:22 Last Time: 2017-12-20T21:27 IPF Version: IPF-SM-2 06.10

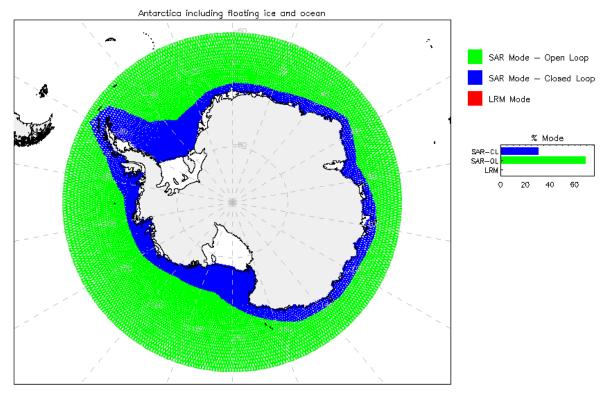


Figure 3: Map of SRAL mode over the Antarctic sea ice for cycle 25 NTC

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 8

Flag: instr\_op\_mode\_20\_ku

Mode: all

Cycle: 25 NTC SR\_2\_WAT

Rel. Orbits: 1 to 385 First Time: 2017-11-23T22:22 Last Time: 2017-12-20T21:27 IPF Version: IPF-SM-2 06.10

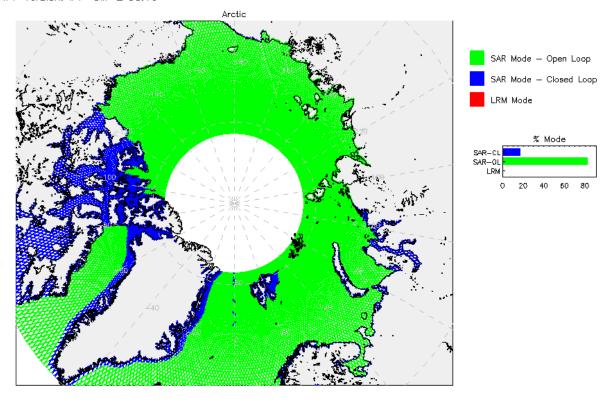


Figure 4: Map of SRAL mode over the Arctic sea ice for cycle 25 NTC



# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 9

# **5** Availability of Polar Geophysical Corrections

In this section the availability of geophysical corrections to altimeter range contained in the L2 products over ice sheets, ice shelves and sea ice are analysed for this cycle. Missing or invalid geophysical corrections can cause errors in the final L2 elevation parameters, and erroneous steps in derived time series of ice sheet surface elevation change or sea ice freeboard.

#### 5.1 Availability of Geophysical Corrections over Ice Sheets (NTC Products)

For polar ice sheets, the primary geophysical corrections applied to the range are model dry tropospheric, model wet tropospheric, GIM ionospheric, solid earth tide, pole tide and ocean loading tide. We would normally expect 100% availability of all corrections except the altimeter derived ionospheric corrections (iono\_cor\_alt\_01\_ku, iono\_cor\_alt\_20\_ku).

For cycle 25 NTC the percentage of non-available geophysical corrections over Antarctic ice sheets was:

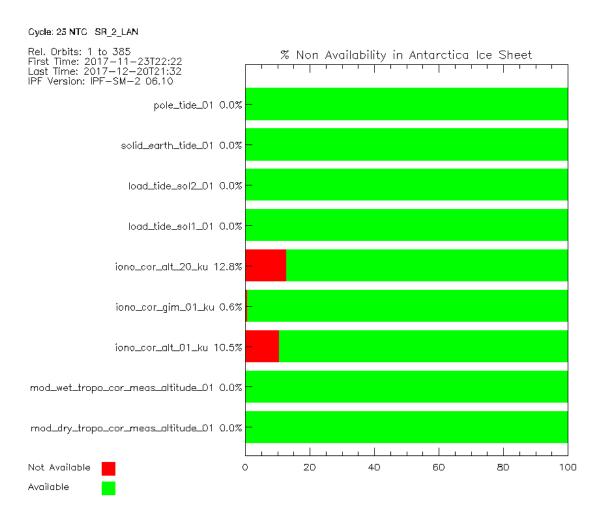


Figure 5: Percentage of Geophysical Correction Non-availability over Antarctic Ice Sheets

In this cycle the GIM ionospheric correction was missing from several orbits over Antarctica:



#### S3-A Land and Sea Ice Cyclic Performance Report

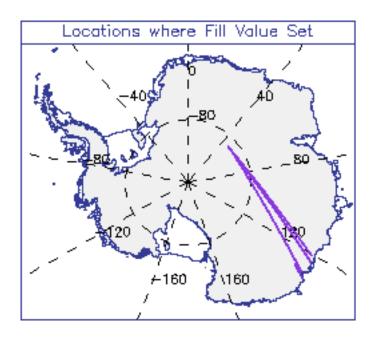
Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 10



For cycle 25 NTC the percentage of non-available geophysical corrections over the Greenland ice sheet was:

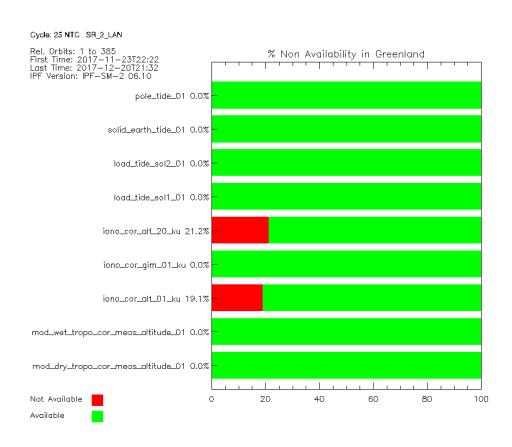


Figure 6: Percentage of Geophysical Correction Non-availability over the Greenland Ice Sheet



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 11

#### 5.2 Availability of Geophysical Corrections over Ice Shelves (NTC Products)

For polar ice shelves, the primary geophysical corrections applied to the range are as for ice sheets plus ocean tide and inverse barometric corrections.

For cycle 25 NTC the percentage availability of geophysical corrections over Antarctic ice shelves was:

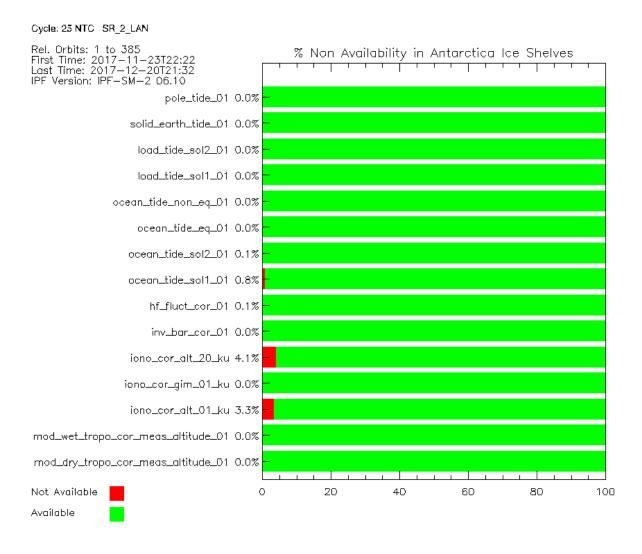


Figure 7: Availability of Geophysical Corrections over Antarctic Ice Shelves

<sup>1</sup>For ice shelf studies it is recommended that users replace the ocean tide correction (Ocean Tide Solution 2 in cycle 25) where it is valid in the L2 NTC products over Antarctic ice shelves with a more accurate high resolution circumpolar ocean tide model correction such as the Circum Antarctic Tidal Simulation (CATS 2008a), *Padman et al* (2008).

\_



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 12

#### 5.3 Availability of Geophysical Corrections over Sea Ice

Over sea ice the model dry tropospheric, model wet tropospheric, ionospheric, solid earth tide, pole tide and ocean tide and inverse barometric corrections are applied in the STC L2 Marine product.

For cycle 25 NTC the percentage availability of geophysical corrections over sea ice was:

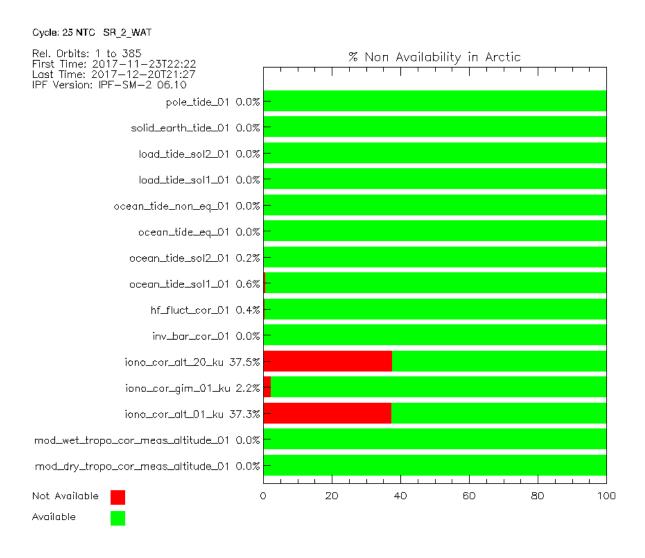


Table 2: % Non Availability of Geophysical Corrections over Sea Ice (NTC)



# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 13

# 5.4 Availability of Snow Density, Snow Depth and Sea Ice Concentration over Sea Ice

Correction	% Availability Arctic Sea Ice	% Availability Antarctic Sea Ice	
Sea Ice Concentration <sup>3</sup>	100	100	
Snow Density <sup>1</sup>	100	100	
Snow Depth	100	100 <sup>2</sup>	

Table 3: % Availability of Snow Density, Snow Depth, Sea Ice Concentration over Sea Ice

<sup>&</sup>lt;sup>1</sup>Snow Density is set to a single value of 400 Kg/m<sup>3</sup> as expected.

<sup>&</sup>lt;sup>2</sup> Snow depth over Antarctic sea ice is set to zero as expected.

<sup>&</sup>lt;sup>3</sup>Sea Ice Concentration is derived from a dynamic 3 day average of sea ice concentration calculated from SSM/I daily brightness temperature data.



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 14

# 6 Geophysical Parameter Monitoring for Land Ice

This section shows results and analysis of the primary L2 NTC parameters relating to land ice in cycle 25.

# 6.1 20Hz Ku Band Waveform Quality Flag for Ice Sheets (waveform\_qual\_ice\_20\_ku)

20Hz Ku band ice sheet wave form quality flag is the output of tests performed upon the radar echoes to determine their suitability for further land ice processing. Waveforms that fail one or more of these tests are not processed further to calculate the primary ice sheet elevation parameter (elevation\_ice\_sheet\_20\_ku) as their echo shape does not fit the physical model used by the retracker.

#### The tests comprise:

- Total power test to detect low power in the echo.
- Noise power test to detect high levels of noise at the start of the echo.
- Variance test to detect unstructured waveforms
- Leading edge detection to check waveform power distribution indicates a leading edge.
- Peakiness test to detect waveforms of too low or high peakiness value.

No filtering from these tests is applied to the Ice-1 (OCOG) empiricial retracker output (range\_ocog\_20\_ku) which is less sensitive to waveform shape. However, users are advised to consider the value of the waveform quality flag when using OCOG derived parameters.

Users should note that in this product baseline, SAR radar echoes are not centered in the extended range window during L1 processing as required by the waveform test specification and the SAR ice margin retracker, and subsequently over regions of high slope such as the ice sheet margins the position of the waveform can move around the range window causing waveform truncation and higher rates of test failure than would be expected. This will be corrected in a future evolution of the L1 processing.

An anomaly relating to the calculation of noise power is also present in this product baseline, causing higher than expected failure rates of the noise power test. This will be fixed in the next baseline.

Overall % quality flag failure rates shown below are higher in Greenland than in Antarctica because Greenland has a higher % area of high slope margins to low slope ice sheet in the areas shown.

#### **Sentinel-3 MPC**

# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

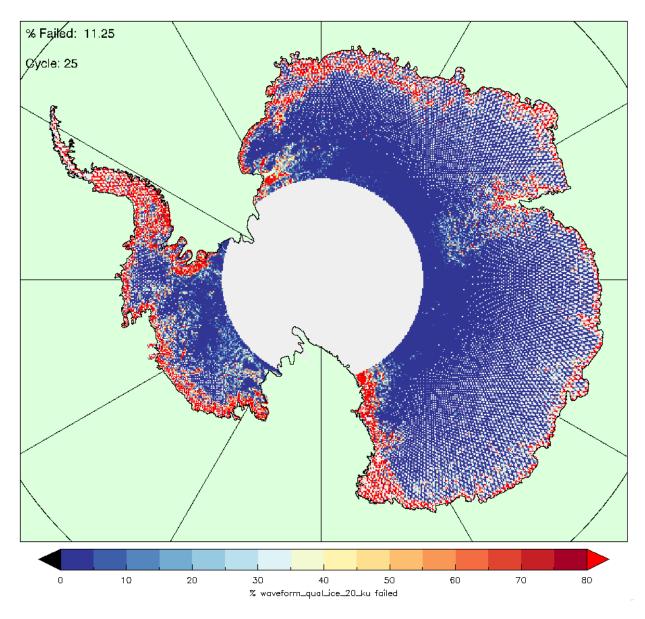


Figure 8: Map of % 20Hz Ku Waveform Quality Flag Failure Density (in 10 km² grid) for cycle 25, Antarctic Ice Sheet

# Mission Performance Centre

#### **Sentinel-3 MPC**

#### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

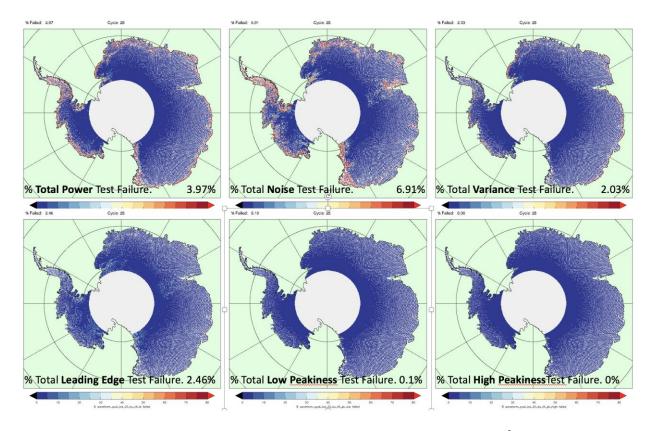


Figure 9: Maps of % 20Hz Ku Waveform Quality Flag Test Failure Densities (in 10 km² grid) for cycle 25, Antarctic Ice Sheet

# Mission Performance Centre

#### **Sentinel-3 MPC**

### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

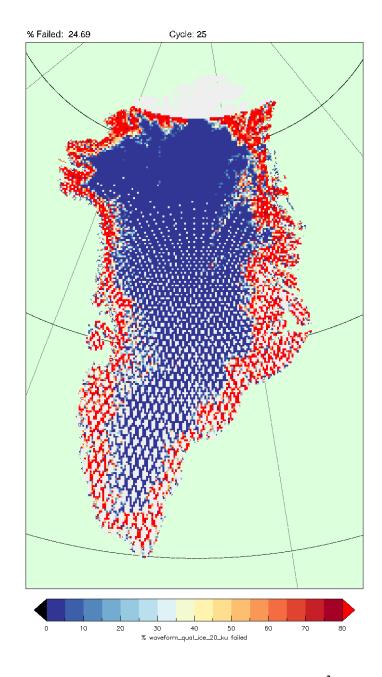


Figure 10: Map of % 20Hz Ku Waveform Quality Flag Failure Density (in 10 km² grid) for cycle 25, Greenland

#### **Sentinel-3 MPC**

## **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 18



% Total Power Test Failure (11.53%)



% Total Noise Test Failure (14.69%)



% Total Variance Test Failure (5.7%)







% Total Leading Edge Test Failure (3.96%) % Total Low Peakiness Test Failure (0.31%) % Total High Peakiness Test Failure (0%)

Figure 11: Map of % 20Hz Ku Waveform Quality Flag Test Failure Density (in 10 km² grid) for cycle 25, Greenland



#### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 19

#### 6.2 20Hz Ku Band Elevation (elevation\_ice\_sheet\_20\_ku)

20Hz Ku band ice sheet elevation is the primary output of the land ice products over continental ice sheets and ice shelves using the altimeter range from the SAR ice margin physical model retracker and a slope correction to the point of closest approach.

Analysis of this parameter shows that the map of elevation is as expected but there is a high rate of parameter failure (22-31%), particularly over the ice sheet margins (40%) in both Antarctica and Greenland. This is currently under investigation but it is believed to be partially due to an issue with the L1 SAR processing over areas of sloping terrain which will be corrected in a future evolution. This affects the stability of the waveform positioning within the range window, particularly in the continental margins. This results in waveforms being being truncated or located towards the edge of the range window, outside the ice margin retracker's central fit window. Over areas of low ice sheet slope such as Dome-C or Lake Vostok failure rates are much lower (1%) as the waveform shape and position are much more stable.

Additionally, tests indicate that an error in the SAR slope correction is present in this version of the IPF processing which will cause a resulting error in the elevation (of 30cm to several meters, dependent on slope) and to the location of the echo.

The following maps show the 20Hz Ku band Elevation parameter plotted for the complete cycle over Antarctica, Greenland, Dome-C (low slope) and the SPIRIT marginal zone (high slope).

#### **Sentinel-3 MPC**

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

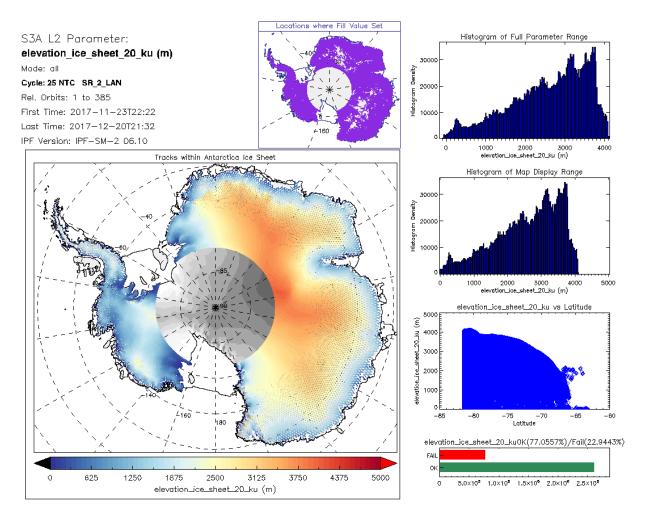


Figure 12: Maps of 20Hz Ku band Ice Sheet Elevation over Antarctica for cycle 25

#### **Sentinel-3 MPC**

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

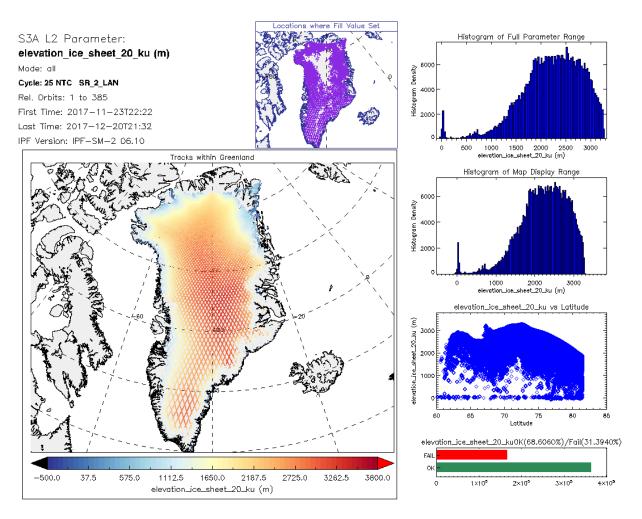


Figure 13: Maps of 20Hz Ku band Ice Sheet Elevation over Greenland for cycle 25

#### **Sentinel-3 MPC**

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

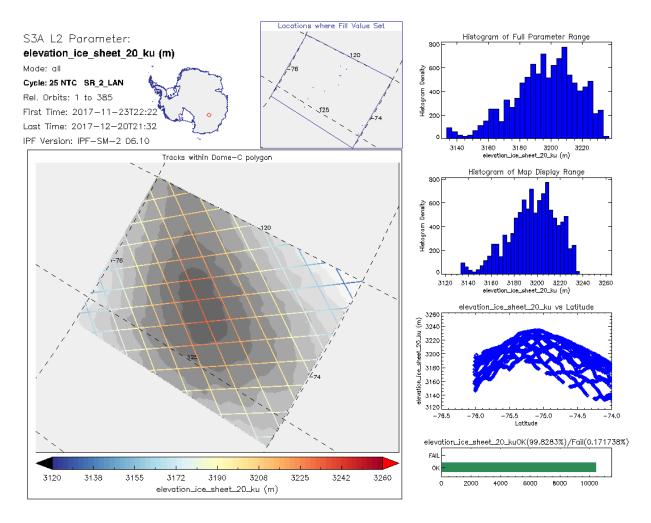


Figure 14: Maps of 20Hz Ku band Ice Sheet Elevation over Dome-C, a low slope region of Antarctica for cycle 25

#### **Sentinel-3 MPC**

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

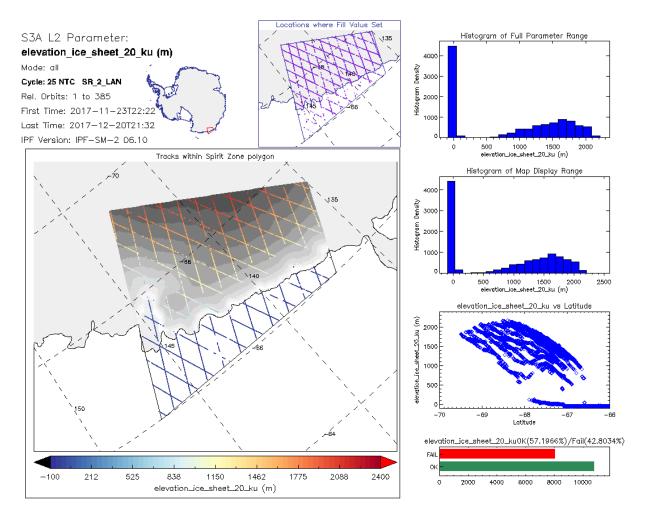


Figure 15: Maps of 20Hz Ku band Ice Sheet Elevation over the SPIRIT Zone, a high slope region of Antarctica for cycle 25



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

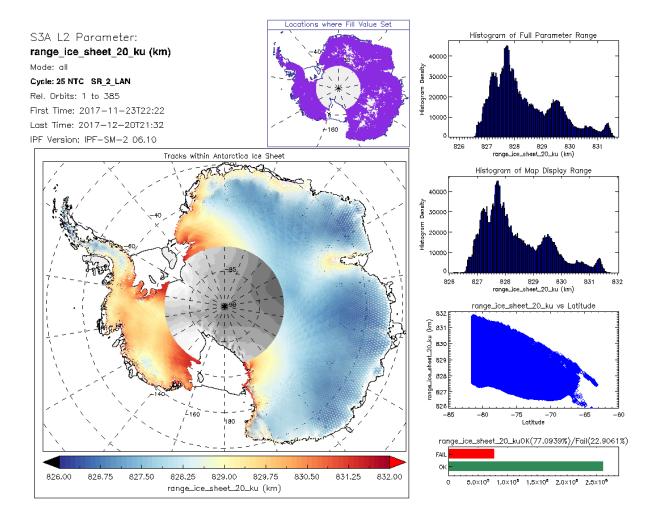
Date: 06/02/2018

Page: 24

### 6.3 20Hz Ku Band Ice Sheet Range (range\_ice\_sheet\_20\_ku)

The ice sheet range is retracked using the SAR ice margin physical model retracker and is the primary range used to calculate elevation in the L2 product.

There are higher than expected rates of failure in this parameter over the ice sheet margins. An explanation of this is given in the preceding section on ice sheet elevation.



#### **Sentinel-3 MPC**

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

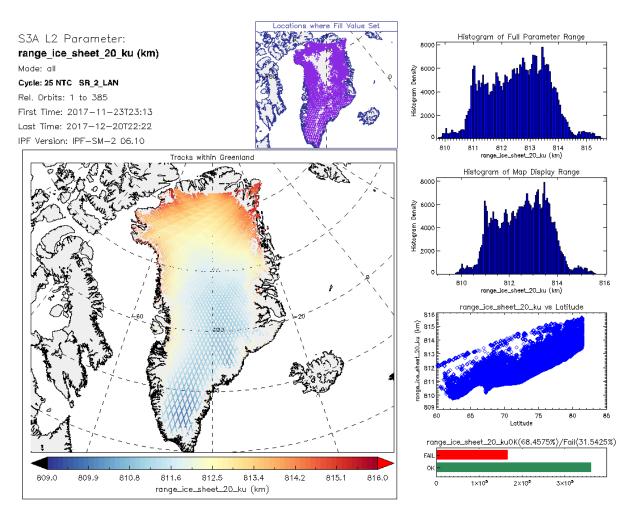


Figure 16: Maps of 20Hz Ku Band Ice Sheet Range (range\_ice\_sheet\_20\_ku)



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

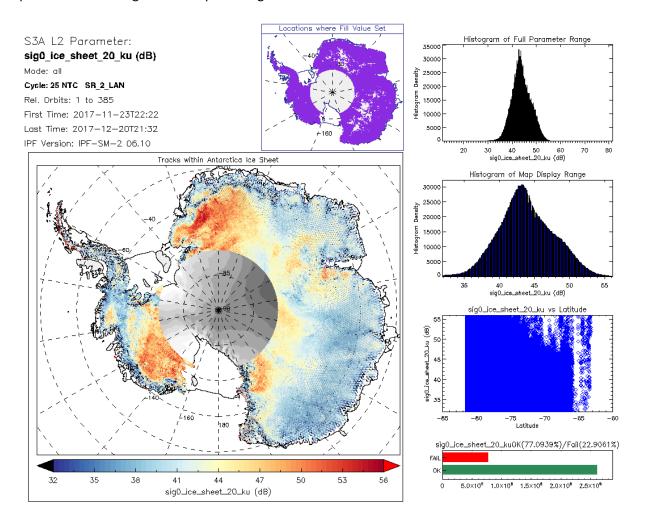
Date: 06/02/2018

Page: 26

#### 6.4 20Hz Ku Band Ice Sheet Sigma0 (sig0\_ice\_sheet\_20\_ku)

The Ku band ice sheet sigma0 backscatter parameter is derived from the SAR ice margin retracker. The map of sigma0 over the ice sheets shows similar patterns of backscatter values to previous missions. Backscatter values are controlled by surface roughness characteristics, surface slope and differences in surface and volume echo. Over the ice sheet margins backscatter is low due to high surface slope, and over the East Antarctic ice sheet it is also low due to strong winds causing high surface roughness. Over the West Antarctic ice sheet and areas of Dronning Maud land there are high backscatter returns due to very smooth surfaces. In Greenland the ice sheet surface is smoother due to lower winds and regular melt events causing higher backscatter values.

There are higher than expected rates of failure in this parameter over the ice sheet margins. An explanation of this is given in the preceding section on ice sheet elevation.



#### **Sentinel-3 MPC**

#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

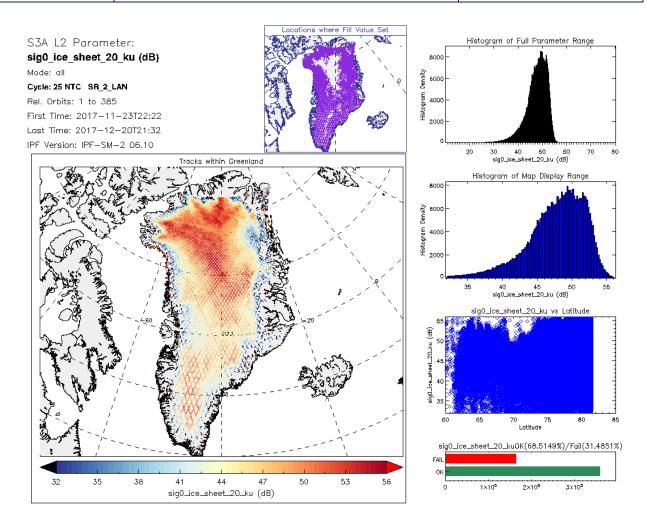


Figure 17: Maps of 20Hz Ku Band Ice Sheet Sigma0 (sig0\_ice\_sheet\_20\_ku)



#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

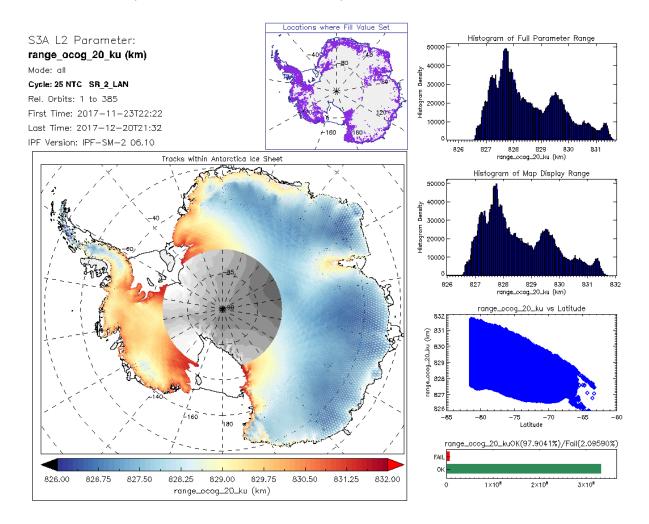
Issue: 1.0

Date: 06/02/2018

Page: 28

### 6.5 20Hz Ku Band OCOG (Ice-1) Range (range\_ocog\_20\_ku)

This parameter is the range derived from the OCOG (Ice-1) empirical retracker. Note that there are are much lower failure rates (~2-4%) than for the SAR ice margin retracker (32%) . This is because the OCOG centre of gravity retracking algorithm will retrack a wider range of waveform shapes and leading edge positions than the model fit approach used by the SAR ice margin retracker. This results in greater measurement density, but in some areas lower accuracy.





#### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 29

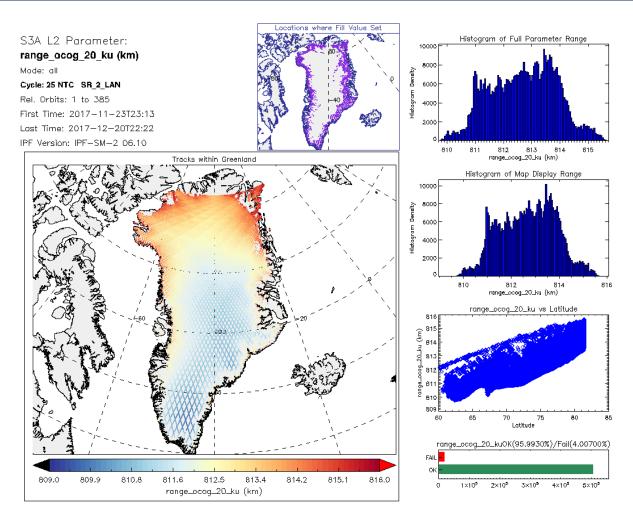


Figure 18: Maps of 20Hz Ku Band OCOG (Ice-1) Range (range\_ocog\_20\_ku)

### 6.6 20Hz Ku Band OCOG (Ice-1) Sigma0 (sig0\_ocog\_20\_ku)

The Ku band OCOG sigma0 backscatter parameter is derived from the OCOG (Ice-1) retracker. The map of sigma0 over the ice sheets shows similar patterns of backscatter values to previous missions. Backscatter values are controlled by surface roughness characteristics, surface slope and differences in surface and volume echo. Over the ice sheet margins backscatter is low due to high surface slope, and over the East Antarctic ice sheet it is also low due to strong winds causing high surface roughness. Over the West Antarctic ice sheet and areas of Dronning Maud land there are high backscatter returns due to very smooth surfaces. In Greenland the ice sheet surface is smoother due to lower winds and regular melt events causing higher backscatter values.

There are higher than expected rates of failure in this parameter over the margins, West Antarctica and the Antarctic Peninsula, but much lower failure rates than for the SAR ice margin retracker. This is because the OCOG centre of gravity retracking algorithm will retrack a wider range of waveform shapes than the model fit approach used by the SAR ice margin retracker. This results in greater measurement density, but in some areas lower accuracy.

#### **Sentinel-3 MPC**

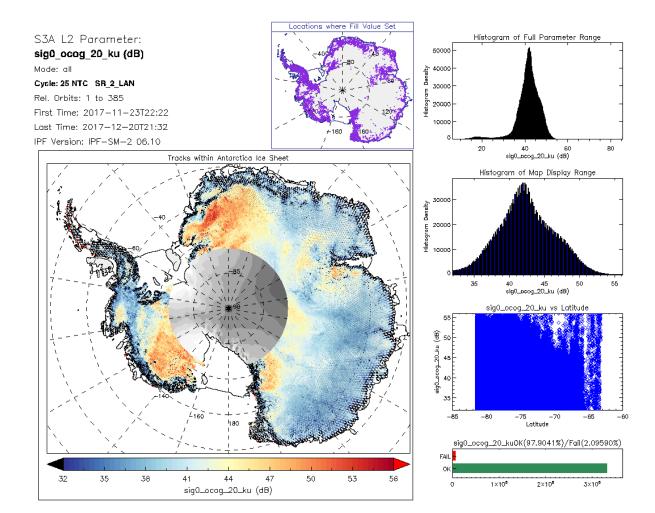
#### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018



# SENTINEL 3 Mission Performance Centre

### **Sentinel-3 MPC**

### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

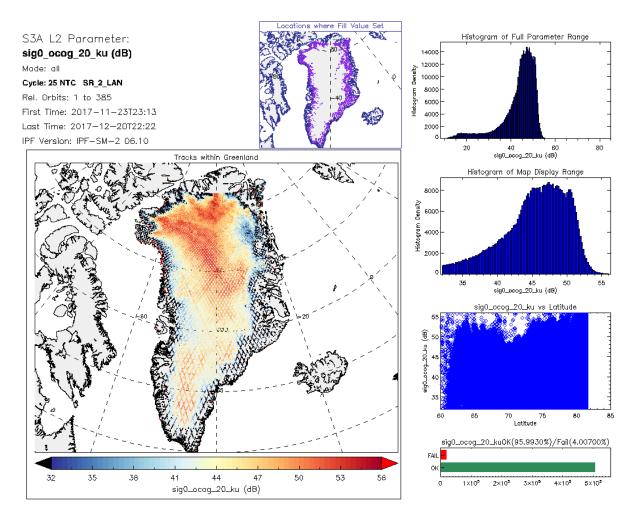


Figure 19: Maps of 20Hz Ku Band OCOG (Ice-1) Sigma0 (sig0\_ocog\_20\_ku)



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

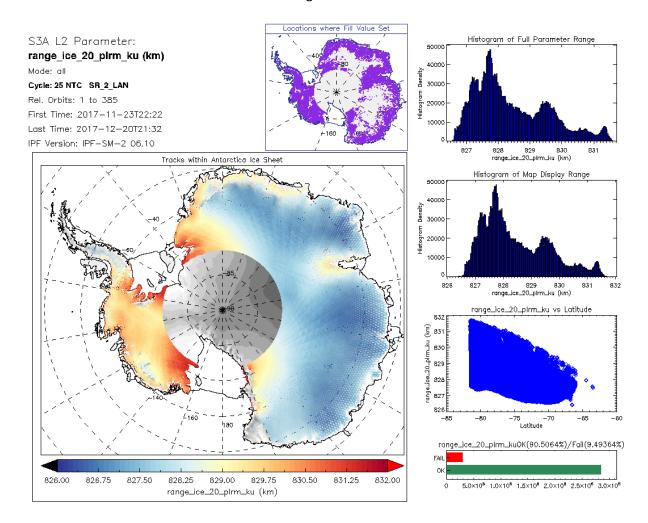
Issue: 1.0

Date: 06/02/2018

Page: 32

### 6.7 20Hz Ku Band PLRM Ice Range (range\_ice\_20\_plrm\_ku)

Range measurements derived from the PLRM waveforms and retracker show similar but slightly higher failure rates than for the SAR OCOG retracked range.



# Mission Performance Centre

### **Sentinel-3 MPC**

### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

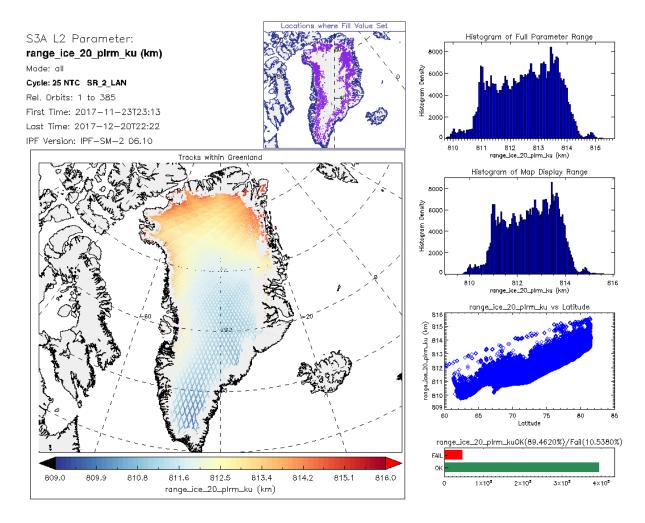


Figure 20: Maps of 20Hz Ku Band PLRM Ice Range (range\_ice\_20\_plrm\_ku)

# SENTINGE 3 Mission Performance Centre

### **Sentinel-3 MPC**

### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

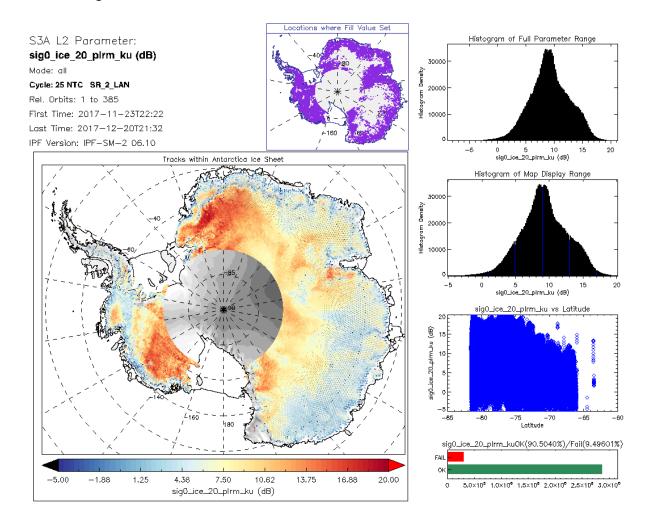
Issue: 1.0

Date: 06/02/2018

Page: 34

### 6.8 20Hz Ku Band PLRM Sigma0 (sig0\_ice\_20\_plrm\_ku)

Backscatter sigma0 derived from the 20Hz Ku PLRM waveforms are shown below.



# Sentinel 3 Mission Performance Centre

### **Sentinel-3 MPC**

### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

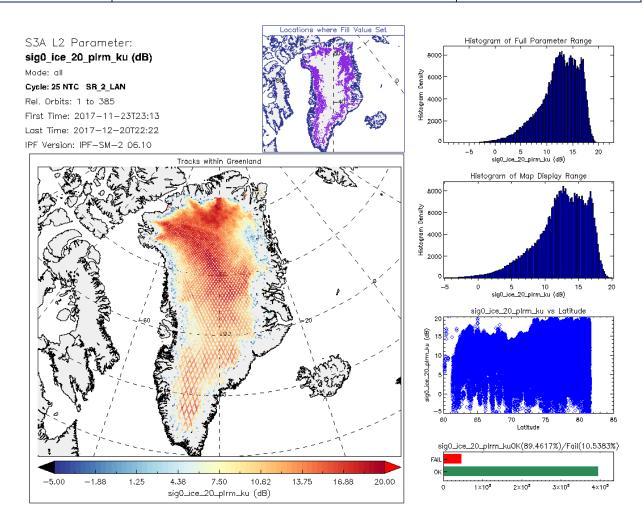


Figure 21: Maps of 20Hz Ku Band PLRM Sigma0 (sig0\_ice\_20\_plrm\_ku)



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 36

### 20Hz Ku Band Surface Class (surf\_class\_20\_ku)

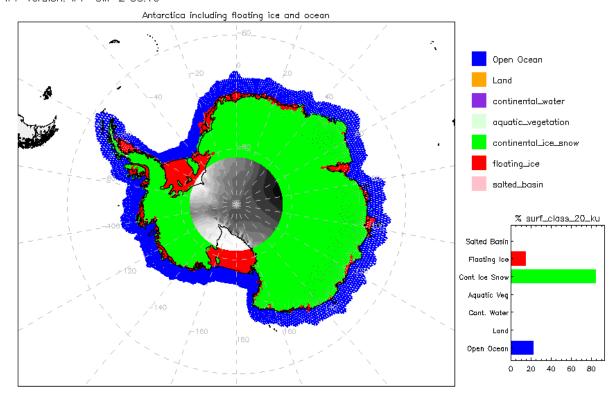
The 20Hz Ku surface classification parameter is derived from MODIS and GlobCover data. Users of the data requiring high resolution ice sheet glacier grounding line and calving front locations should consider applying their own surface type masks.

Flag: surf class 20 ku

Mode: all

Cycle: 25 NTC SR\_2\_LAN

Rel. Orbits: 1 to 385 First Time: 2017-11-23T22:22 Last Time: 2017-12-20T21:32 IPF Version: IPF-SM-2 06.10



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 37

Flag: surf\_class\_20\_ku

Mode: all

Cycle: 25 NTC SR\_2\_LAN

Rel. Orbits: 1 to 385 First Time: 2017-11-23T22:22 Last Time: 2017-12-20T21:32 IPF Version: IPF-SM-2 06.10

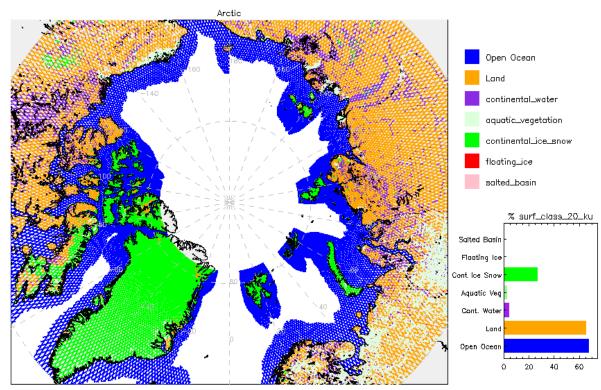


Figure 22: Maps of 20Hz Ku Band Surface Class (surf\_class\_20\_ku)



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 38

# **7 Slope Correction Assessment**

A slope correction is applied to 20Hz Ku band elevation over ice sheets to relocate the SAR echo to the point of closest approach across track.

In cycle 25, due to the high failure rate of the SAR Ice Margin retracker, the slope correction is not performed on more than 28-40% of range measurements over the ice sheets.

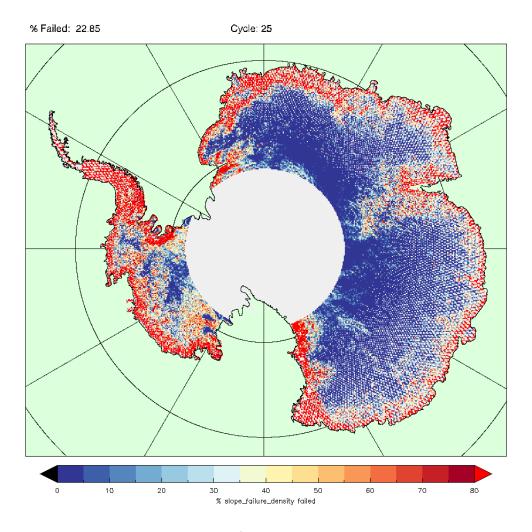


Figure 23: Maps of % Slope Correction Failure Density in a 10km grid

### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

% Slope Failed

Issue: 1.0

Date: 06/02/2018

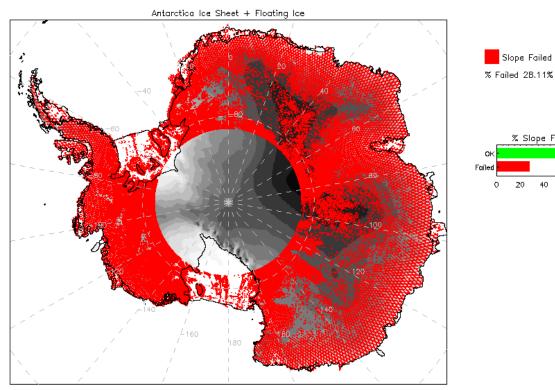
Page: 39

Flag: slope\_failure

Mode: all

Cycle: 24 NTC SR\_2\_LAN

Rel. Orbits: 1 to 385 First Time: 2017-10-27T22:22 Last Time: 2017-11-23T21:32 IPF Version: IPF-SM-2 06.10





### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 40

Flag: slope failure

Mode: all

Cycle: 24 NTC SR\_2\_LAN

Rel. Orbits: 1 to 385 First Time: 2017-10-27T23:13 Last Time: 2017-11-23T22:22 Version: IPF-SM-2 06.10

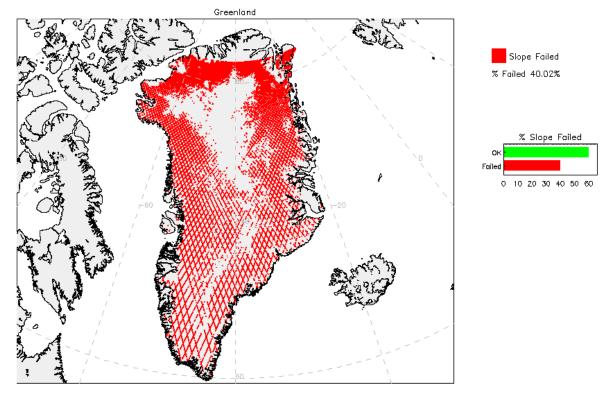


Figure 24: Maps of Slope Correction Failure Locations

Tests of the SAR mode slope correction (of measurements that are retracked) in this cycle indicate that there is an error in the echo direction calculation in the current IPF processing. This results in an erroneous relocation down slope of the nadir track. As a result a slope dependent error in the resulting elevation measurement of approximately 30cm to several meters is present. Users are advised to consider this additional error if using the 20Hz elevation parameter over land ice. This slope error should be fixed in the next IPF version.

A full assessment of the slope correction will be added to the report once the failure rate has been reduced.



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

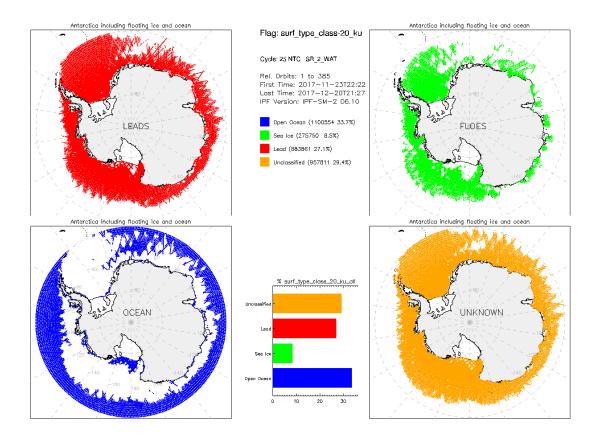
Page: 41

# 8 Geophysical Parameter Monitoring for Sea Ice

This section shows results and analysis of the primary L2 NTC parameters relating to sea ice in cycle 25.

### 8.1 20Hz Ku Band Altimeter Derived Surface Type (surf\_type\_class\_20\_ku)

This parameter is the output of the sea ice echo discriminator which classifies SAR echoes as either leads, floes, open ocean or unclassified, based on their waveform shape (peakiness), SAR beam behaviour statistics and % sea ice concentration.



# SSATINEL 3 S3-A Land and S

### **Sentinel-3 MPC**

### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

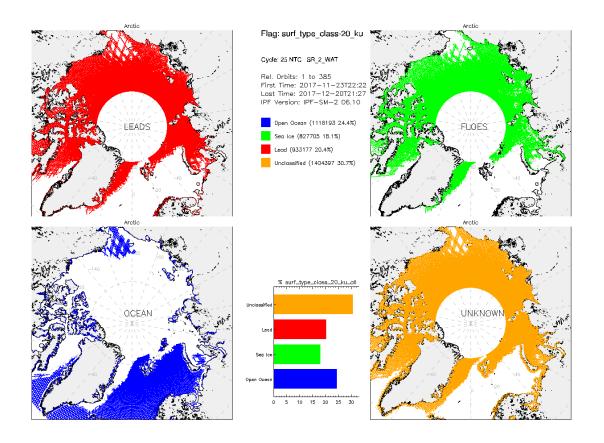


Figure 25: Maps of 20Hz Ku Band Altimeter Derived Surface Type (surf\_type\_class\_20\_ku)



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

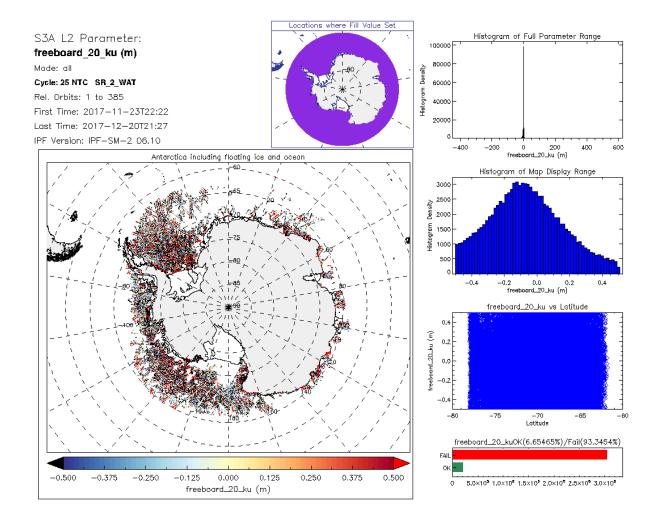
Issue: 1.0

Date: 06/02/2018

Page: 43

### 8.2 20Hz Ku band Freeboard (freeboard\_20\_ku)

The histogram of freeboard results from this cycle show a greater proportion of negative freeboard values and a wider spread of freeboard than would be expected. Although negative freeboard is possible due to snow loading, this spread of values is likely to be erroneous. This is most likely to due to an unresolved sea ice lead and floe retracker bias.





### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 44

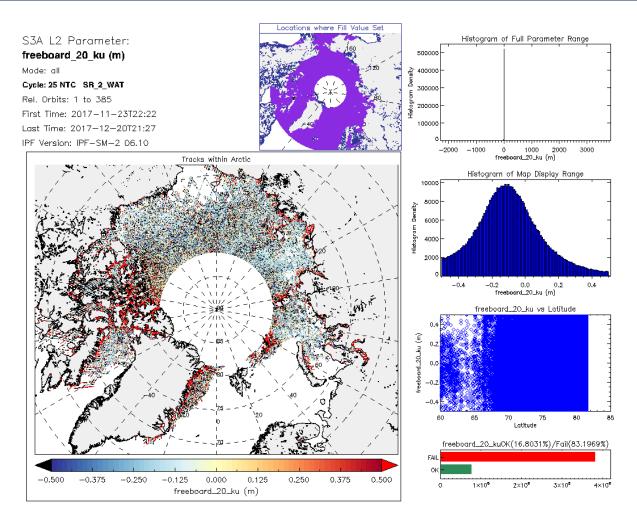


Figure 26: Maps of 20Hz Ku band Freeboard (freeboard\_20\_ku)

# 8.3 20Hz Ku Band Interpolated Sea Surface Height Anomaly (int\_sea\_ice\_ssha\_20\_ku)

This parameter is the sea surface height with respect to the mean sea surface interpolated between leads in the sea ice (ie represents the SSHA underneath the sea ice floes).

Plots of this parameter show an anomalous region to the west of Greenland where incorrect values of the GIM ionospheric correction have been used. This will be corrected in the next IPF version.

# SENTINEL 3 Mission Performance Centre

### **Sentinel-3 MPC**

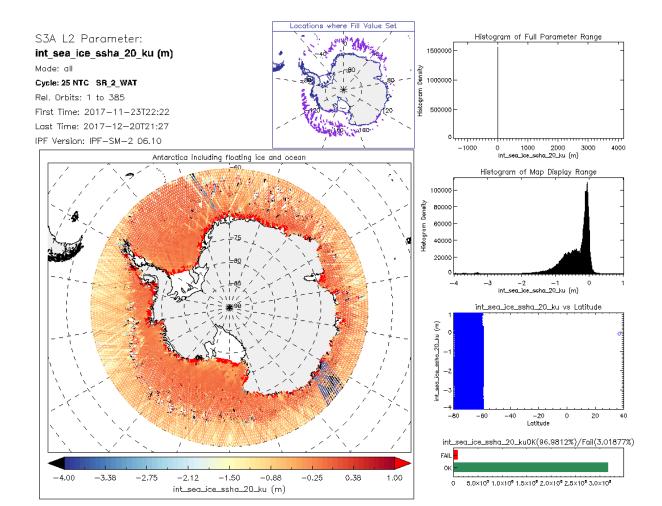
### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018





### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 46

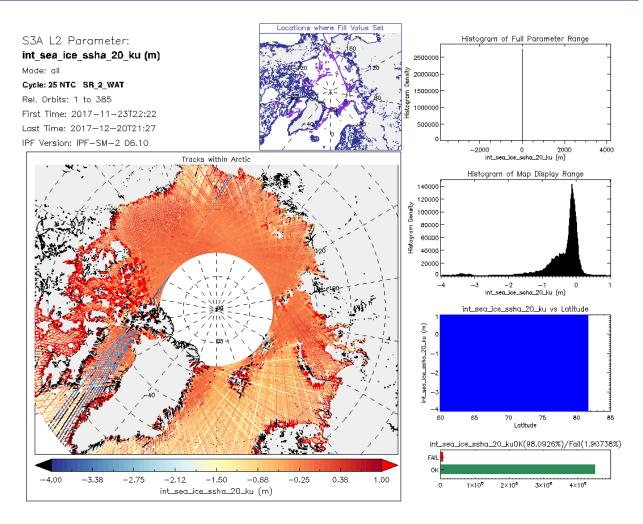


Figure 27: Maps of 20Hz Ku band Interpolated Sea Ice SSHA (m)

## 8.4 Sea Surface Height Anomaly (sea\_ice\_ssha\_20\_ku)

This parameter is the sea surface height with respect to the mean sea surface.

Analysis of this parameter will be added in future cycles cycles once the sea ice discrimination has been tuned.

Note that an anomalous band exists to the west of Greenland and east of Antarctics is due to an error in processing the GIM ionopheric correction. This will be corrected in the next IPF version.

# SENTINEL 3 Mission Performance Centre

### **Sentinel-3 MPC**

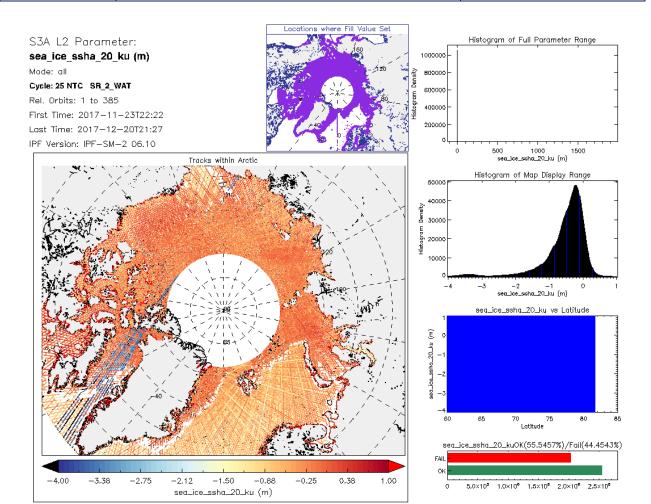
# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018





### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 48

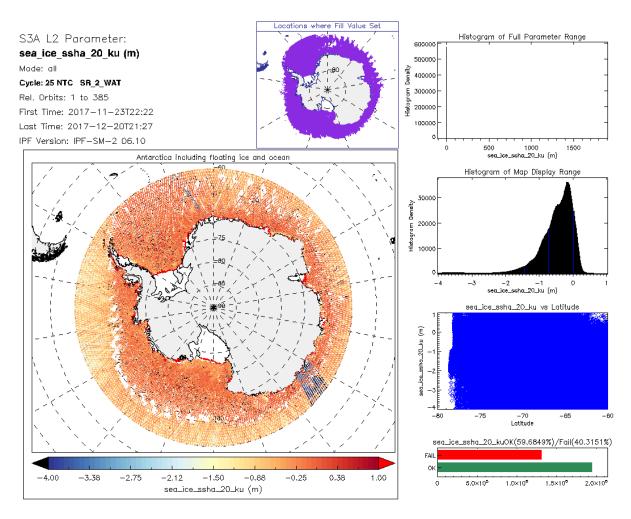


Figure 28: Maps of 20Hz Ku band Sea Ice SSHA (m)

# 8.5 20Hz Ku band Sea Ice Concentration (sea\_ice\_concentration\_20\_ku)

Sea ice concentration data is available in 100% of records in the NTC product in cycle 25. Sea Ice Concentration is derived from a dynamic 3 day average of sea ice concentration calculated from SSM/I daily brightness temparature data and this map is consistent with external sea ice extent maps for this period.

# SENTINEL 3 Mission Performance Centre

### **Sentinel-3 MPC**

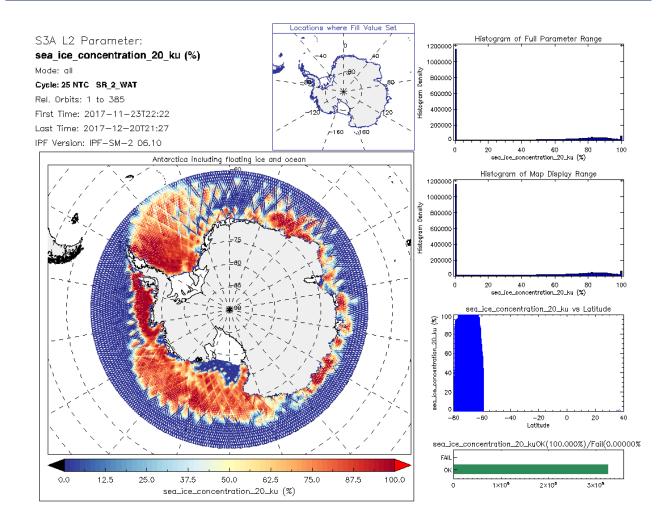
# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018



# SENTINEL 3 Mission Performance Centre

### **Sentinel-3 MPC**

### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

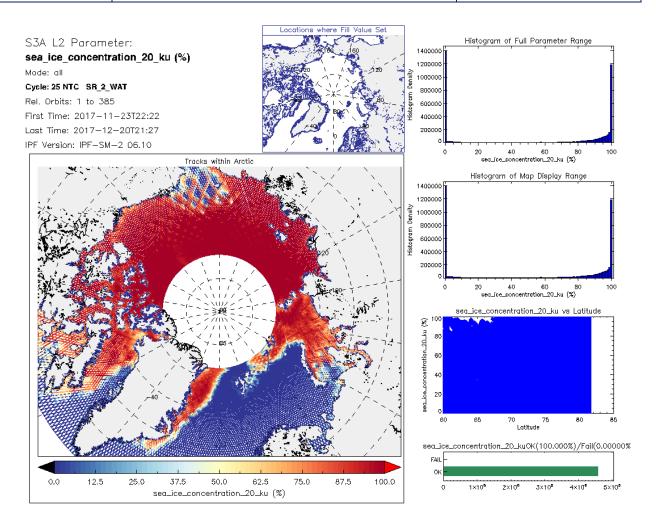


Figure 29: Maps of 20Hz Ku band Sea Ice Concentration (sea\_ice\_concentration\_20\_ku)



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 51

### 9 Crossover Analysis

Measuring the elevation residual at orbit crossover points is a primary method of assessing the performance of the altimeter and the processing chain. Over time intervals where there is no expected change in the surface elevation, the elevation difference at a crossover provides a measure of altimeter and chain performance, height error and antenna polarity issues.

Due to the reported high failure rates and slope correction error with the 20Hz Ku band Elevation parameter in this cycle, the density and accuracy of measurements is too low to produce meaningful crossover results that can be compared with previous missions. As soon as the failure rate is reduced to nominal levels comparative with other missions then a crossover analysis result will be reported in this section for this cycle.



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 52

# **10 Repeat Track Analysis**

Repeat track analysis is a method of processing several years of operational altimetry data to produce gridded maps of temporal change in the ice sheet's surface elevation and mass balance since the start of mission. These can be validated against known ice sheet dynamics and other external sources of temporal change data.

Since cycle 25 is the 12th cycle since the start of the operational phase there is not a long enough time series of stable measurements from a single product baseline to produce a repeat track analysis. This analysis will be added to reports from cycles in 2018 once at least a year of stable data is available.



### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 53

# **11 Long Term Monitoring**

In this section the long term performance statistics of Sentinel-3A parameters over land ice and sea ice will be analysed to indicate the stability of the instrument and ground processing. As cycle 25 is the 12th cycle in the routine operations phase, no long term statistics from a single product baseline are available for this cycle.



### **S3-A Land and Sea Ice Cyclic Performance Report**

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 54

### **12 Events**

List of all events happened during the cycle affecting the Land and Sea Ice validation:

- Cycle 25 is the first complete cycle processed with IPF version v6.10/PB 2.24.
- ❖ IPF v6.10 (PB 2.24) introduced several processing changes which will effect land ice and sea ice parameters:

Product	L2 IPF	Operational	Land Ice/	Change Description
Baseline		Since	Sea Ice	
PB 2.24	6.10	13/12/2017	L	New L2 Parameter: waveform_qual_ice_20_ku
				A flag related to the quality of the waveforms over land ice. This is of
				interest mainly over land ice to discard data that have corrupted waveforms.
			L	Anomaly relating to large negative elevation values present around
			L	ice shelves fixed.
			L/S	New Parameters: Three additional parameters to facilitate the
				connection between the 1 Hz and 20 Hz fields
				short index_1hz_meas_20_ku(time_20_ku);
				int index_first_20hz_meas_01_ku(time_01);
				short num_20hz_meas_01_ku(time_01);
			S	Implementation of a new Mean Sea Surface model for sea ice SSHA
				processing: DTU15 models.
				The DTU15 has been selected due to the extended coverage that
				includes values over some of the large lakes and a small region in the
				Arctic Ocean whereas the CNES-CLS15 does not provide any value.
				The use of the DTU15 Mean Sea Surface model in sea_ice_ssha
				parameters because this model performs better over the Arctic
				Ocean.
			S	Implementation of the FES2014 model in replacement of the FES2004
				model, for the computation of the solution 2 tide heights.
			S	the availability of the GIM ionospheric correction in STC products.
				The systematic coverage now available for this correction allows
				retrieving the expected values of the sea_ice_ssha parameters.
			S	the evolution of the sea ice classification (Discrimination) parameter
				(surf_type_class_20_ku).
			L	the increase of the coverage of the outputs of the ice sheet retracker
				by extending the SAR ice margin retrackers fit window.



### S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 55

### **13 Conclusions**

For Level-2 NTC Land products over polar ice sheets, maps of L2 ice sheet elevation and sigma0 backscatter show expected patterns of spatial variability over the ice sheet topography and surface types as compared to previous missions, but there are 22-31% higher than expected levels of retracker failure in the primary 20Hz Ku band ice sheet elevation and range parameters resulting in lower than expected measurement density. Failure rates are slope dependant, with low failure (~1%) over the flat areas of the ice sheet, and high failure over the ice sheet margins (~40%). There is also an error in the slope correction in the current IPF affecting accuracy of the calculated elevation over sloping surfaces. This is currently under investigation by the MPC and ESA.

For Level-2 NTC Marine products, the sea ice freeboard and SSHA parameters requires further tuning and we recommend that they are not used for this product baseline.



# S3-A Land and Sea Ice Cyclic Performance Report

Cycle No. 025

Ref.: S3MPC.UCL.PR.08-025

Issue: 1.0

Date: 06/02/2018

Page: 56

# 14 Appendix A

Other reports related to the STM mission are:

- S3-A SRAL Cyclic Performance Report, Cycle No. 025 (ref. S3MPC.ISR.PR.04-025)
- S3-A MWR Cyclic Performance Report, Cycle No. 025 (ref. S3MPC.CLS.PR.05-025)
- S3-A Ocean Validation Cyclic Performance Report, Cycle No. 025 (ref. S3MPC.CLS.PR.06-025)
- S3-A Land and Sea Ice Cyclic Performance Report, Cycle No. 025 (ref. S3MPC.UCL.PR.08-025)

All Cyclic Performance Reports are available on MPC pages in Sentinel Online website, at: <a href="https://sentinel.esa.int">https://sentinel.esa.int</a>

**End of document**