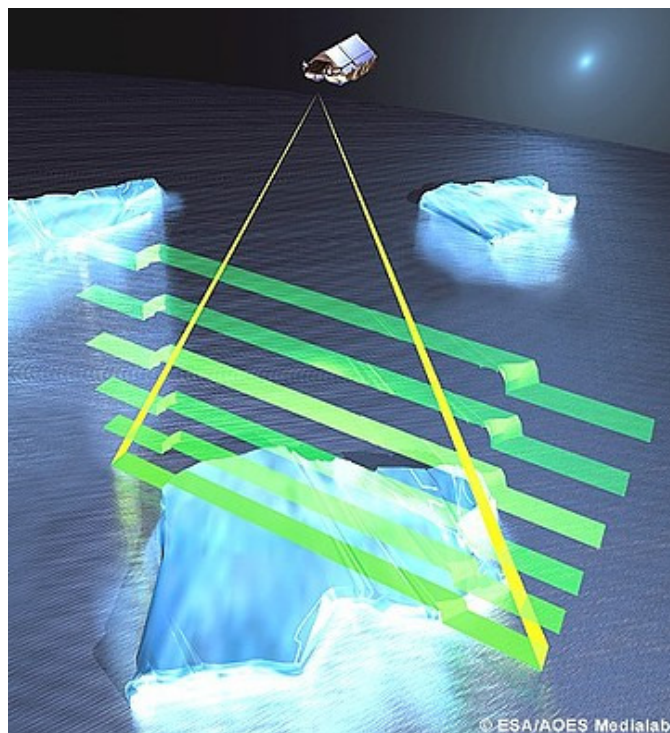


# **CRYOSAT**

## **CYCLIC REPORT**



### **CYCLE #9**

**15TH JUNE 2011 – 14TH JULY 2011**

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|                                 |                     |
|---------------------------------|---------------------|
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# 1 INTRODUCTION

CryoSat is an altimetry satellite built by the European Space Agency and dedicated to polar observation. It embarks on a three-and-a-half-year mission to determine variations in the thickness of the Earth's continental ice sheets and marine ice cover, and to test the prediction of thinning Arctic ice due to climate change.

CryoSat is designed to acquire continuously, switching automatically between its three measurement modes according to a Geographical Mode Mask:

- Synthetic Aperture Radar (SAR) is operated over sea-ice and over some ocean basins and coastal zones.
- SAR Interferometric (SARIn) mode is used over steeply sloping ice-sheet margins, small ice caps and areas of mountain glaciers. It is also used over some major hydrological river basins and some ocean areas with important mesoscale variability.
- Low Resolution Mode (LRM) is operated over the areas of the continental ice sheets, over oceans and over land not covered by other modes.

This CryoSat Cyclic Report is distributed by IDEAS team to keep the CryoSat community informed of the overall mission performance and the status of the SIRAL instrument.

The report is based on a 30-day reporting period, which has been defined by UCL/MSSL since the Transfer to Operations (TTO), as part of the routine QA monitoring activity. This 30-day cycle has been defined purely for the purpose of statistic reporting and does not correspond to an official 30-day sub cycle. The actual repeat cycle for CryoSat is 369 days, which consists of 5344 orbits.

This document is available online at: <http://earth.eo.esa.int/missions/cryosat/reports/cyclic/>.

## 1.1 Acronyms and Abbreviations

|        |   |
|--------|---|
| AR     | Anomaly Report  |
| CFI    | Customer Furnished Item                                 |
| CNES   | Centre National d'Études Spatiales                      |
| CPOM   | Centre for Polar Observation Modelling                  |
| DEM    | Digital Elevation Model                                 |
| ECMWF  | European Centre for Medium-term Weather Forecasting     |
| ESA    | European Space Agency                                   |
| ESOC   | European Space Operation Centre                         |
| FDM    | Fast Delivery Mode                                      |
| GDR    | Geophysical Data Record                                 |
| GIM    | Global Ionospheric Map                                  |
| GPS    | Global Positioning System                               |
| IDEAS  | Instrument Data quality Evaluation and Analysis Service |
| IPF    | Instrument Processing Facilities                        |
| L1B/L2 | Level 1B/Level 2  |
| LRM    | Low Resolution Mode                                     |
| LTA    | Long Term Archive                                       |
| MF     | Monitoring Facility                                     |
| MSSL   | Mullard Space Science Laboratory                        |
| NRT    | Near Real Time  |
| OCM    | Orbit Control Manoeuvre                                 |
| PCONF  | Parameter Configuration File                            |
| PDS    | Payload Data System                                     |
| QA     | Quality Assurance                                       |
| QCC    | Quality Control for CryoSat                             |
| RMS    | Root Mean Square  |
| SSALTO | Système au Sol d'Altimétrie et d'Orbitographie          |
| SAR    | Synthetic Aperture Radar mode                           |
| SARIn  | SAR Interferometric mode                                |
| SID    | SARIn Degraded  |
| SIRAL  | SAR Interferometric Radar Altimeter                     |
| SPR    | Software Problem Report                                 |
| SW     | Software  |
| TTO    | Transfer to Operations                                  |
| UCL    | University College London                               |
| WGS84  | World Geodetic System of 1984                           |

## 1.2 Reference Documents

RD.1 CRYOSAT Ground Segment Instrument Processing Facility L1b Products Format Specification, CS-RS-ACS-GS-5106, 4.9

RD.2 CRYOSAT Ground Segment Instrument Processing Facility L2 Products Format Specification, CS-RS-ACS-GS-5123, 2.8

RD.3 Updated List of CryoSat IPF Anomalies. Latest version is available online at:  
[http://earth.eo.esa.int/missions/cryosat/data\\_status/](http://earth.eo.esa.int/missions/cryosat/data_status/).

## 2 CYCLE OVERVIEW

**Cyclic Number:** 9  
**Cycle Start:** 15th June 2011  
**Cycle End:** 14th July 2011

This report covers the analysis of reprocessed CryoSat data for June and July 2011.

The health of the SIRAL instrument and the quality of all Level 1B and Level 2 data products was nominal throughout this cycle.

### 3 SOFTWARE & AUX FILE VERSION CONFIGURATION

#### 3.1 IPF Software Version

The versions of the Instrument Processing Facilities (IPF) software installed within the Long Term Archive (LTA) and used for reprocessing of cycle 9 data are listed below:

CryoSat IPF for Level 1 (IPF1):                      Version **Vk1.0**

CryoSat IPF for Level 2 (IPF2):                      Version **Vj1.2**

#### 3.2 Processor Versions for IPF1 and IPF2

The current versions of each processor versions within IPF1 and IPF2 are listed below:

| L1B Products             | Processor Version |
|--------------------------|-------------------|
| L1B LRM                  | SIR1LRM/4.0       |
| L1B SAR                  | SIR1SAR/4.0       |
| L1B SARIN                | SARIN/4.0         |
| L1B FDM                  | SIR1FDM/2.3       |
| CAL1 LRM                 | SIR1LRC1/3.9      |
| CAL1 SAR                 | SIR1SAC1/3.9      |
| CAL1 SARIN               | SIR_SIC1/3.9      |
| CAL2 SAR                 | SIR1SAC2/4.0      |
| CAL2 SARIN (RX1 and RX2) | SIR1SIC2/3.9      |

**Table 3-1 IPF1 Processor versions.**

| L2 Products | Processor Version |
|-------------|-------------------|
| L2 FDM      | IPF2FDM/2.1       |
| L2 LRM      | IPF2LRM/2.4       |
| L2 SAR      | IPF2SAR_A/2.4     |
| L2 SARIN    | IPF2SRN/2.4       |
| L2 GDR      | IPF2GDR_A/2.4     |

**Table 3-2 IPF2 Processor versions.**

The complete historic IPF baseline is available online at:  
[http://earth.eo.esa.int/missions/cryosat/ipf\\_baseline/](http://earth.eo.esa.int/missions/cryosat/ipf_baseline/).

### 3.3 Auxiliary Files

#### 3.3.1 STATIC AUXILIARY FILES

CryoSat processing for this reporting period used the following static auxiliary files:

| Static Auxiliary File                            | Current ADF in use                                     |
|--|--|
| Cartwright Table (Solid Earth Tide)              | CS_OPER_AUX_CARTWR_0000000T000000_9999999T999999_0002  |
| Digital Surface Model                            | CS_OPER_AUX_DEMMSL_0000000T000000_9999999T999999_0005  |
| Bent Modified Dip Map Model                      | CS_OPER_AUX_DIPMAP_0000000T000000_9999999T999999_0002  |
| Geoid  | CS_OPER_AUX_GEOID__0000000T000000_9999999T999999_0002  |
| Surface Identification Grid                      | CS_OPER_AUX_LS_MAP_0000000T000000_9999999T999999_0001  |
| Bent Ionospheric Correction File                 | CS_OPER_AUX_MICOEF_0000000T000000_9999999T999999_0002  |
| Mean Sea Surface                                 | CS_OPER_AUX_MSSURF_0000000T000000_9999999T999999_0005  |
| Ocean Tides                                      | CS_OPER_AUX_OCTIDE_0000000T000000_9999999T999999_0003  |
| Ocean Depth/Land Elevation grid                  | CS_OPER_AUX_ODLE___0000000T000000_9999999T999999_0002  |
| Climatology pressure grids for each month at 00h | CS_OPER_AUX_PRSS00_0000000T000000_9999999T999999_0001  |
| Climatology pressure grids for each month at 06h | CS_OPER_AUX_PRSS06_0000000T000000_9999999T999999_0001  |
| Climatology pressure grids for each month at 12h | CS_OPER_AUX_PRSS12_0000000T000000_9999999T999999_0001  |
| Climatology pressure grids for each month at 18h | CS_OPER_AUX_PRSS18_0000000T000000_9999999T999999_0001  |
| S1 tide grid of monthly mean of global amplitude | CS_OPER_AUX_S1AMPL_0000000T000000_9999999T999999_0001  |
| S2 tide grid of monthly mean of global amplitude | CS_OPER_AUX_S2AMPL_0000000T000000_9999999T999999_0001  |
| S1 tide grid of monthly mean of global phase     | CS_OPER_AUX_S1PHAS_0000000T000000_9999999T999999_0001  |
| S2 tide grid of monthly mean of global phase     | CS_OPER_AUX_S2PHAS_0000000T000000_9999999T999999_0001  |
| Snow Depth Climatology File for June             | CS_OPER_AUX_SDC_06_0000000T000000_9999999T999999_0005  |
| Snow Depth Climatology File for July             | CS_OPER_AUX_SDC_07_0000000T000000_9999999T999999_0005  |
| Sea Ice Concentration Climatology for June       | CS_OPER_AUX_SICC06_0000000T000000_9999999T999999_0005  |
| Sea Ice Concentration Climatology for July       | CS_OPER_AUX_SICC07_0000000T000000_9999999T999999_0005  |
| Sea State Bias                                   | CS_OPER_AUX_SSBIAAS_0000000T000000_9999999T999999_0003 |
| Tidal Loading                                    | CS_OPER_AUX_TDLOAD_0000000T000000_9999999T999999_0003  |
| Altimeter Wind Speed table (Abdalla2007 Model)   | CS_OPER_AUX_WNDCHE_0000000T000000_9999999T999999_0001  |

**Table 3-3 List of current static auxiliary files in use.**



### 3.3.2 DYNAMIC AUXILIARY FILES

CryoSat processing for this reporting period also used the following dynamic auxiliary files:

| Dynamic Auxiliary File         | Current ADF in use  |
|--------------------------------|---|
| Solar Activity Index           | CS_OPER_AUX_SUNACT_19910101T000000_20131101T000000_0001                           |
| Gaussian Altimetric Grid       | CS_OPER_AUX_ALTGRD_20110504T100000_20301231T235959_0002                           |
| GPS Ionospheric Map            | CS_OPER_AUX_IONGIM_YYYYMMDDT000000_YYYYMMDDT235959<br><i>Updated daily</i>        |
| Polar Location                 | CS_OPER_AUX_POLLOC_19870101T000000_YYYYMMDDT000000<br><i>Updated twice a week</i> |
| Wet Troposphere                | CS_OPER_AUX_WETTRP_YYYYMMDDTxx0000_YYYYMMDDTxx0000<br><i>Meteo File *</i>         |
| Wind U-component               | CS_OPER_AUX_U_WIND_YYYYMMDDTxx0000_YYYYMMDDTxx0000<br><i>Meteo File *</i>         |
| Wind V-component               | CS_OPER_AUX_V_WIND_YYYYMMDDTxx0000_YYYYMMDDTxx0000<br><i>Meteo File *</i>         |
| Surface Pressure               | CS_OPER_AUX_SURFP_YYYYMMDDTxx0000_YYYYMMDDTxx0000<br><i>Meteo File *</i>          |
| Sea Mean Pressure              | CS_OPER_AUX_SEAMPS_YYYYMMDDTxx0000_YYYYMMDDTxx0000<br><i>Meteo File *</i>         |
| Dynamic Atmospheric Correction | CS_OPER_AUX_MOG_2D_YYYYMMDDTxx0000_YYYYMMDDTxx0000<br><i>Meteo File *</i>         |
| Dynamic Sea Ice Concentration  | CS_OPER_AUX_SEA_IC_YYYYMMDDT000000_YYYYMMDDT235959<br><i>Updated every 3 days</i> |

**Table 3-4 List of dynamic auxiliary files in use.**

\*Meteo files are provided daily for each 6 hour grid (00h, 06h, 12h and 18h). Each product requires at least two, or sometimes three, of each Meteo file from the two grids between which the product validity lies.

### 3.3.3 CHANGES OF AUXILIARY FILES DURING THE CYCLE

During the reporting period, there were no static auxiliary file updates.

## 4 PDS STATUS

### 4.1 SIRAL Instrument Unavailability

There were no unavailability periods noted for SIRAL data during this cycle.

The historic list of all SIRAL data unavailability periods is available online at: [http://earth.eo.esa.int/missions/cryosat/unavailability\\_periods/](http://earth.eo.esa.int/missions/cryosat/unavailability_periods/).

### 4.2 SIRAL Level 0 Data Availability

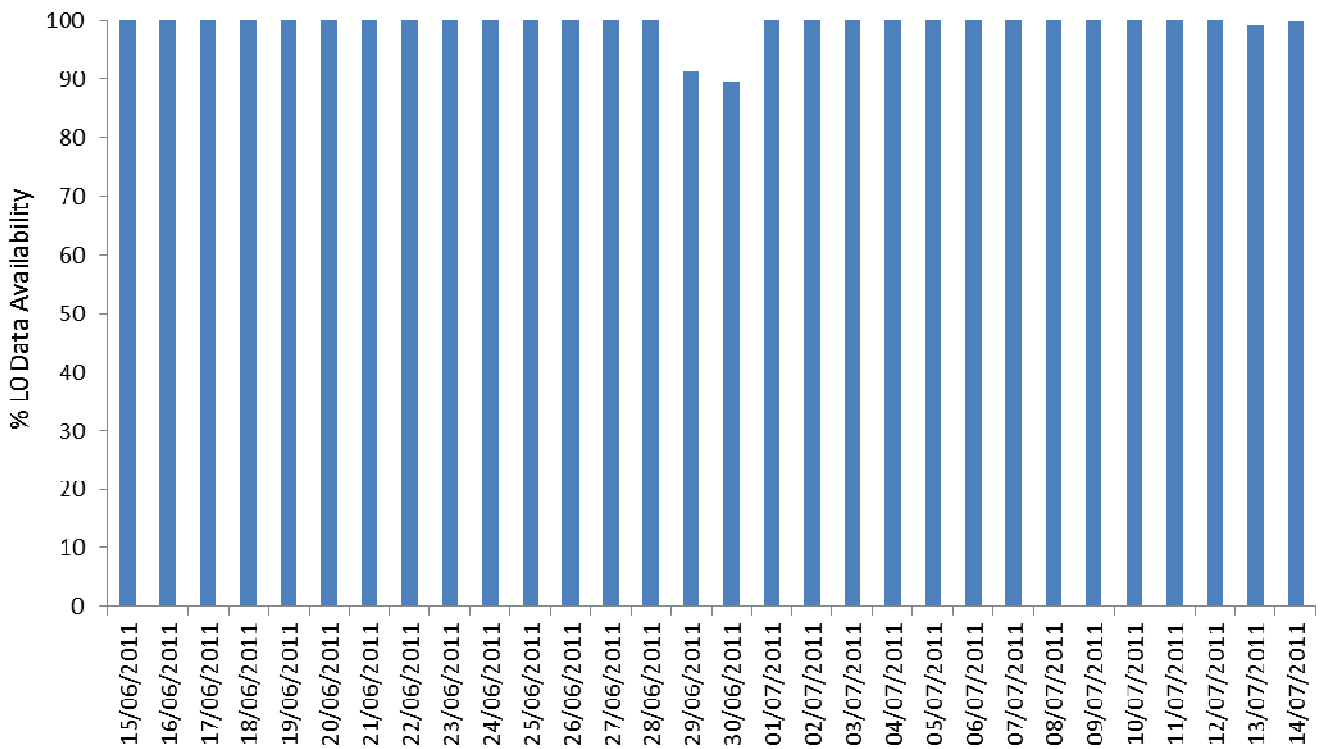


Figure 4-1 SIRAL L0 Data Availability for cycle 9.

SIRAL Level 0 data was available at all times throughout this cycle, except for those periods when the instrument was unavailable due to planned or unplanned activities.

### **4.3 SIRAL Level 1B and Level 2 Data Availability**

Level 1B and Level 2 CryoSat data, for the period 16<sup>th</sup> July 2010 to 31<sup>st</sup> January 2012, is currently in the process of being reprocessed with the Baseline B processors.

As the cycle covered by this report falls within the period of the CryoSat reprocessing campaign, the following information concerning the availability of higher level reprocessed products is provided by the team performing the reprocessing of Level 1B and Level 2 data at the LTA in CNES.

The availability of each level of data is calculated with respect to the available data from the preceding processing level:

Availability of reprocessed Level 1B data for 1<sup>st</sup> – 30<sup>th</sup> June 2011: **99.8%**

Availability of reprocessed Level 2 data for 1<sup>st</sup> – 30<sup>th</sup> June 2011: **99.7%**

Availability of reprocessed Level 1B data for 1<sup>st</sup> – 31<sup>st</sup> July 2011: **99.2%**

Availability of reprocessed Level 2 data for 1<sup>st</sup> – 31<sup>st</sup> July 2011: **99.8%**

## 5 DATA QUALITY CONTROL

### 5.1 Product Format Checks

As part of the Quality Control activities carried out on reprocessed CryoSat data, a check is conducted to ensure that all expected Level 1B and Level 2 data products have been generated with the correct format and that each CryoSat product is composed of two files; XML Header (.HDR) and Product File (.DBL).

| Product Filename | Format Check Discrepancy |
|------------------|--------------------------|
| None             | N/A                      |

During cycle 9, there were no product format errors detected through this check.

### 5.2 Software Version Checks

As part of the Quality Control activities carried out on reprocessed CryoSat data, a check is conducted to ensure that all CryoSat products have been generated with the correct software version, listed in Table 3-1 and Table 3-2.

| Product Filename | Incorrect SW version detected |
|------------------|-------------------------------|
| None             | N/A                           |

During cycle 9, there were no software version errors detected through this check.

### 5.3 Auxiliary Data File Usage Checks

All Level 1B and Level 2 data products are routinely checked to ensure the process has used all the relevant auxiliary data files in order to provide all the necessary geophysical corrections.

| Product Filename | Missing ADF |
|------------------|-------------|
| None             | N/A         |

During cycle 9, there were no data products flagged through this check.

## 5.4 Product Parameters

### 5.4.1 MONITORING OF SIRAL MODE CHANGES

CryoSat is designed to acquire continuously whilst switching automatically between its three nominal measurement modes, LRM, SAR and SARIn, according to a Geographical Mode Mask. Additionally, if one SIRAL receiver chain should fail then the instrument can operate in SARIn mode with one channel and this is referred to as SARIn Degraded (SID) mode. As the mode mask is updated regularly primarily to account for changes in sea-ice extent, between the different CryoSat cycles changes are expected in the SAR and LRM mode extents in areas of sea-ice.

Figure 5-1 shows the daily percentages of each SIRAL mode for cycle 9.

Further trends on both a cyclic and weekly basis are available on the MSSL Quality Monitoring website: [http://cryosat.mssl.ucl.ac.uk/qa/view\\_mode\\_trend.php?dtlength=7](http://cryosat.mssl.ucl.ac.uk/qa/view_mode_trend.php?dtlength=7).

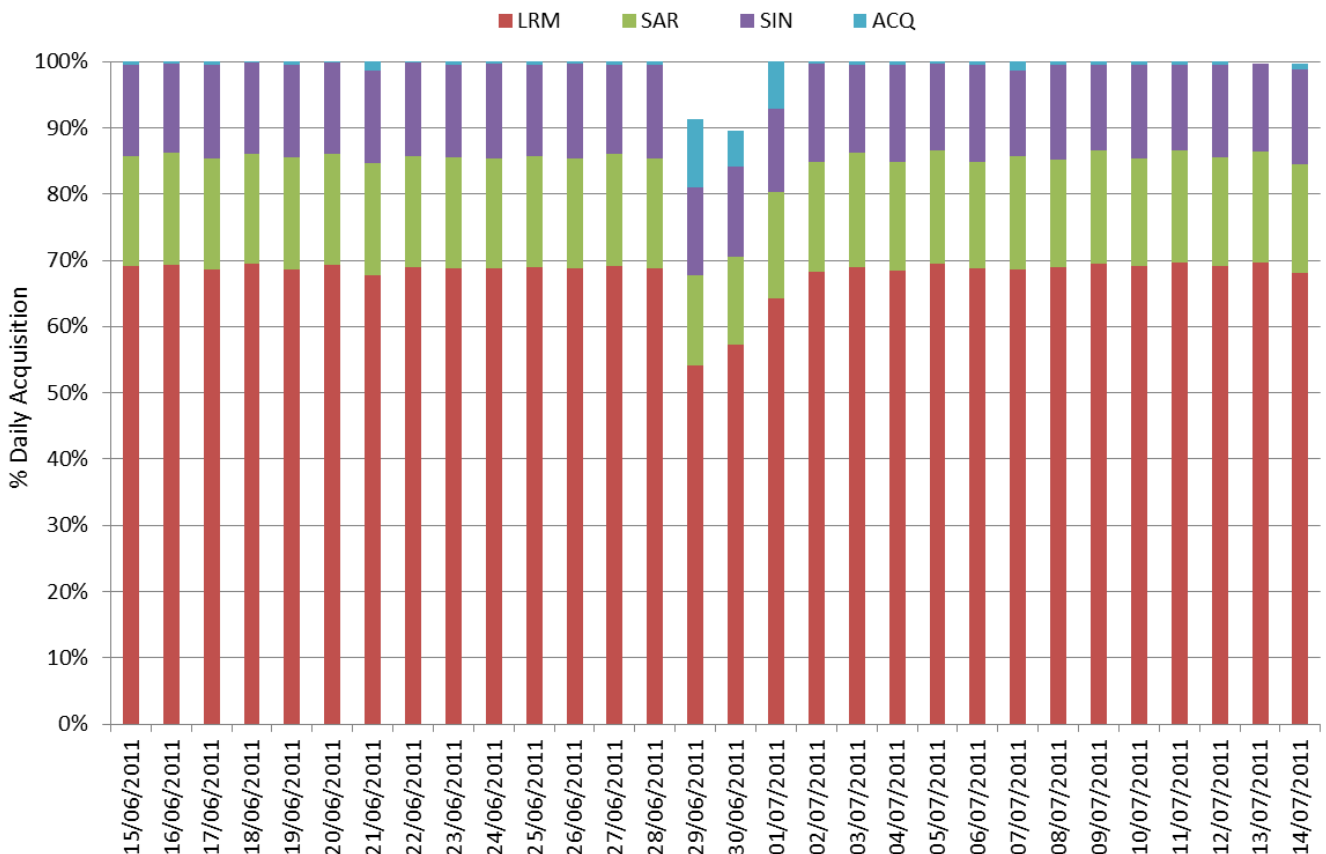


Figure 5-1 Daily percentages of SIRAL modes for cycle 9.

Figure 5-2 shows global and polar plots of the SIRAL Modes acquired during cycle 9. These plots are generated from Level 2 GDR data, which includes a SIRAL Mode indicator for each 20 Hz record.

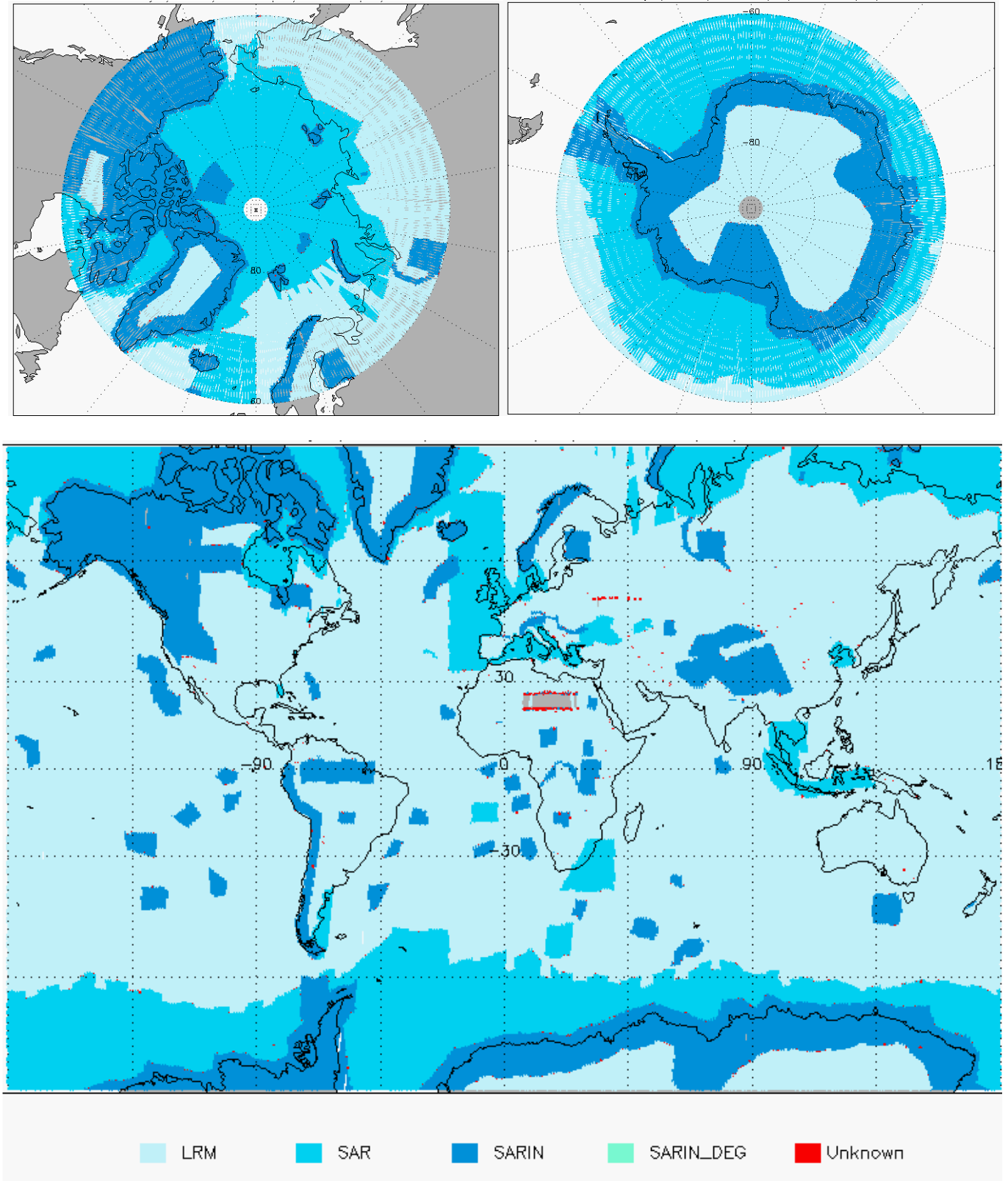


Figure 5-2 Global and Polar plots of SIRAL Modes for cycle 9.

### 5.4.2 SURFACE TYPE

Figure 5-3 shows the surface type for cycle 9 over a global plot. The data is extracted from the Level 2 data products, which includes a surface type flag. The bit values of this flag provide a classification for the different surface type at nadir for the corresponding measurement location.

The classification originates from a model provided by the ESA Geophysical CFI library.

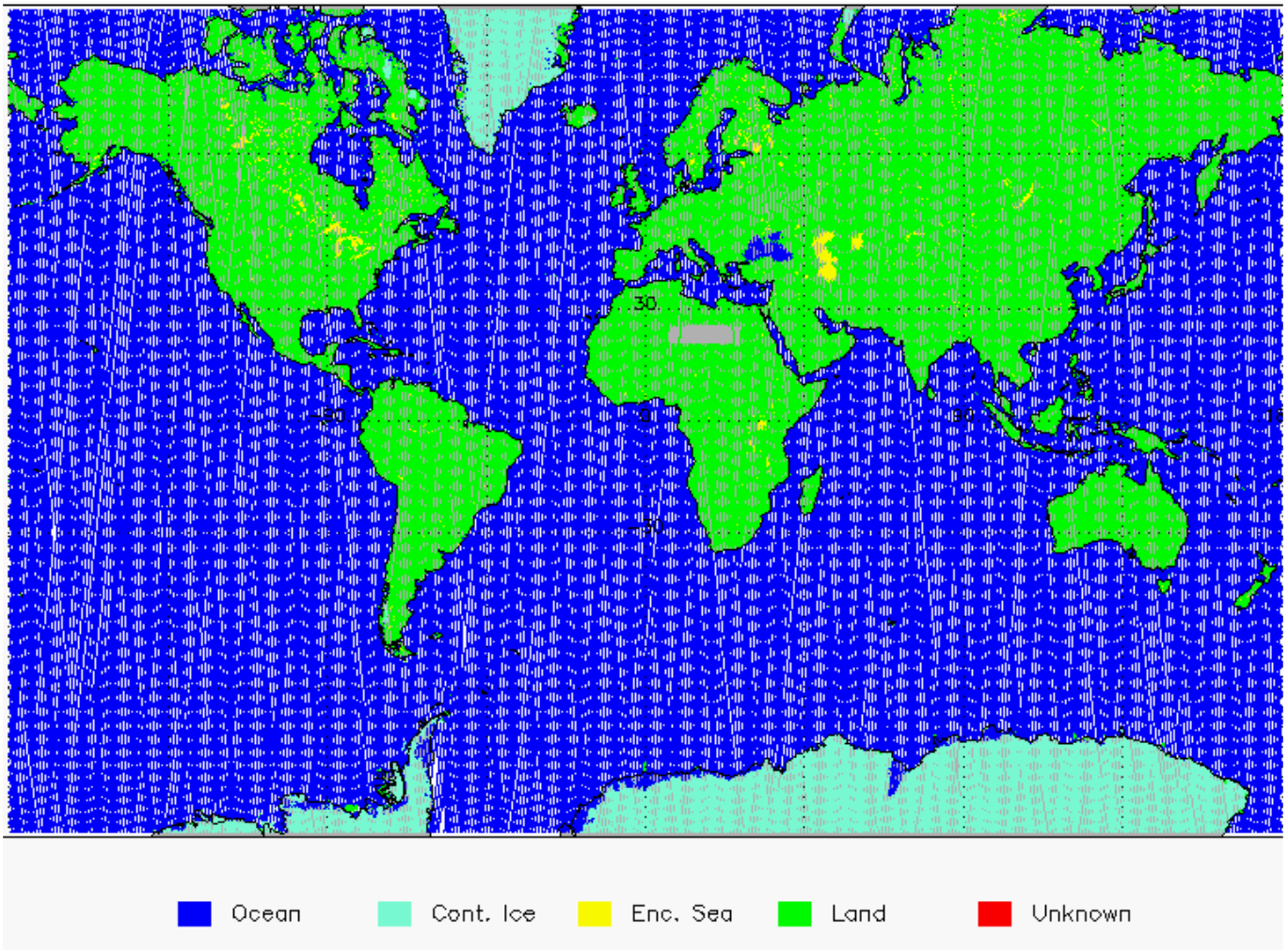


Figure 5-3 Global plot of Surface Type for cycle 9.

| % Open Ocean | % Land | % Continental Ice | % Enclosed Sea | % Unknown |
|--------------|--------|-------------------|----------------|-----------|
| 67.29        | 21.69  | 10.65             | 0.35           | 0.02      |

Table 5-1 Surface Type statistics for cycle 9.

There is currently an Anomaly Report open to investigate occurrences of the 'Surface Type' flag incorrectly flagging ocean. This investigation is on-going and is due to be closed with the next IPF update.



### 5.4.3 BACKSCATTER (SIGMA0)

Each 20 Hz measurement record includes a radar backscatter ( $\sigma_0$ ) value which provides information about the observed surface. It is a function of the radar frequency, polarisation and incidence angle and the target surface roughness, geometric shape and dielectric properties.

Figure 5-4 shows global and polar plots of this parameter for cycle 9, for all three SIRAL modes. At Level 2, the backscatter coefficient is fully corrected, including instrument gain corrections and bias.

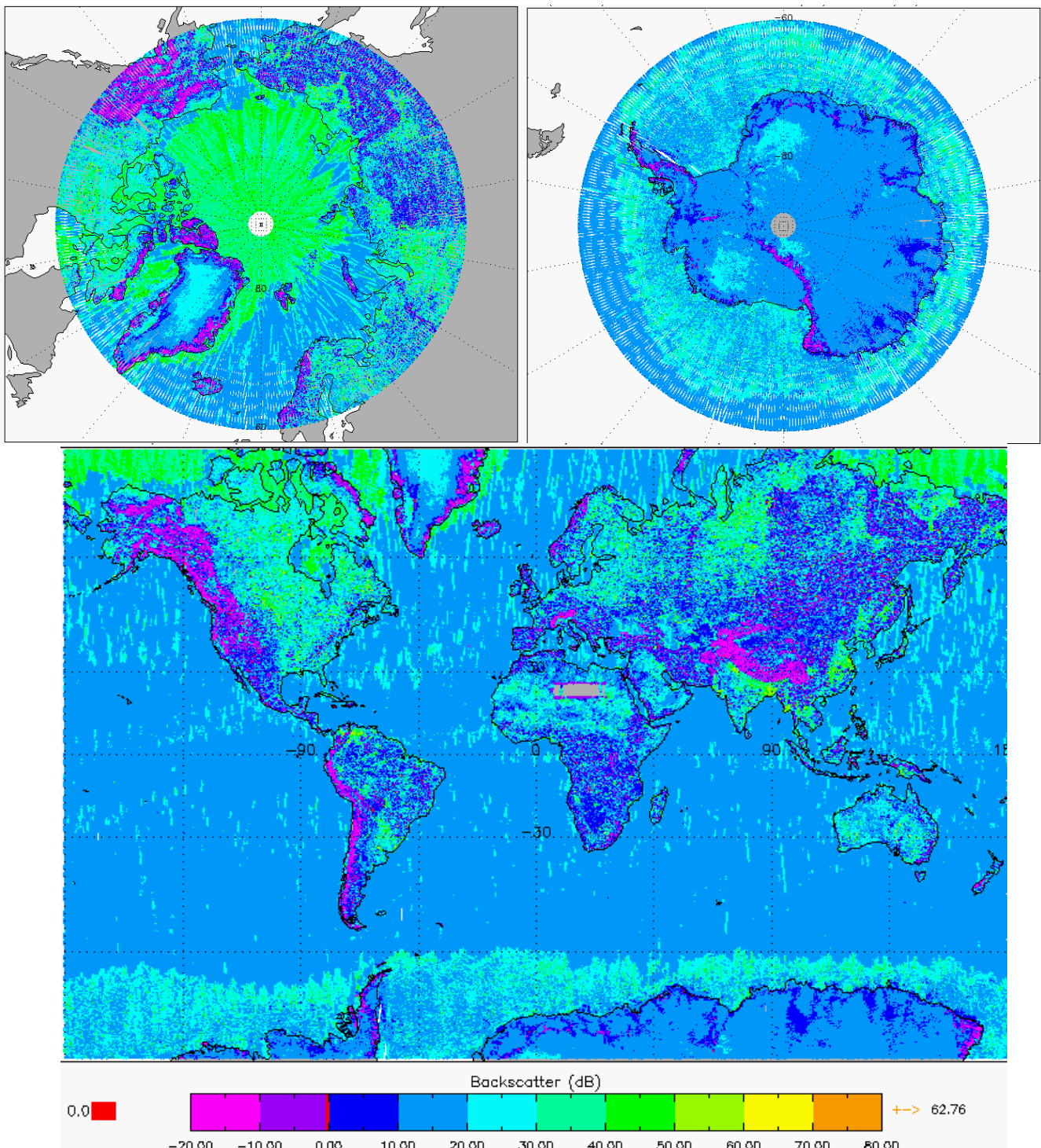
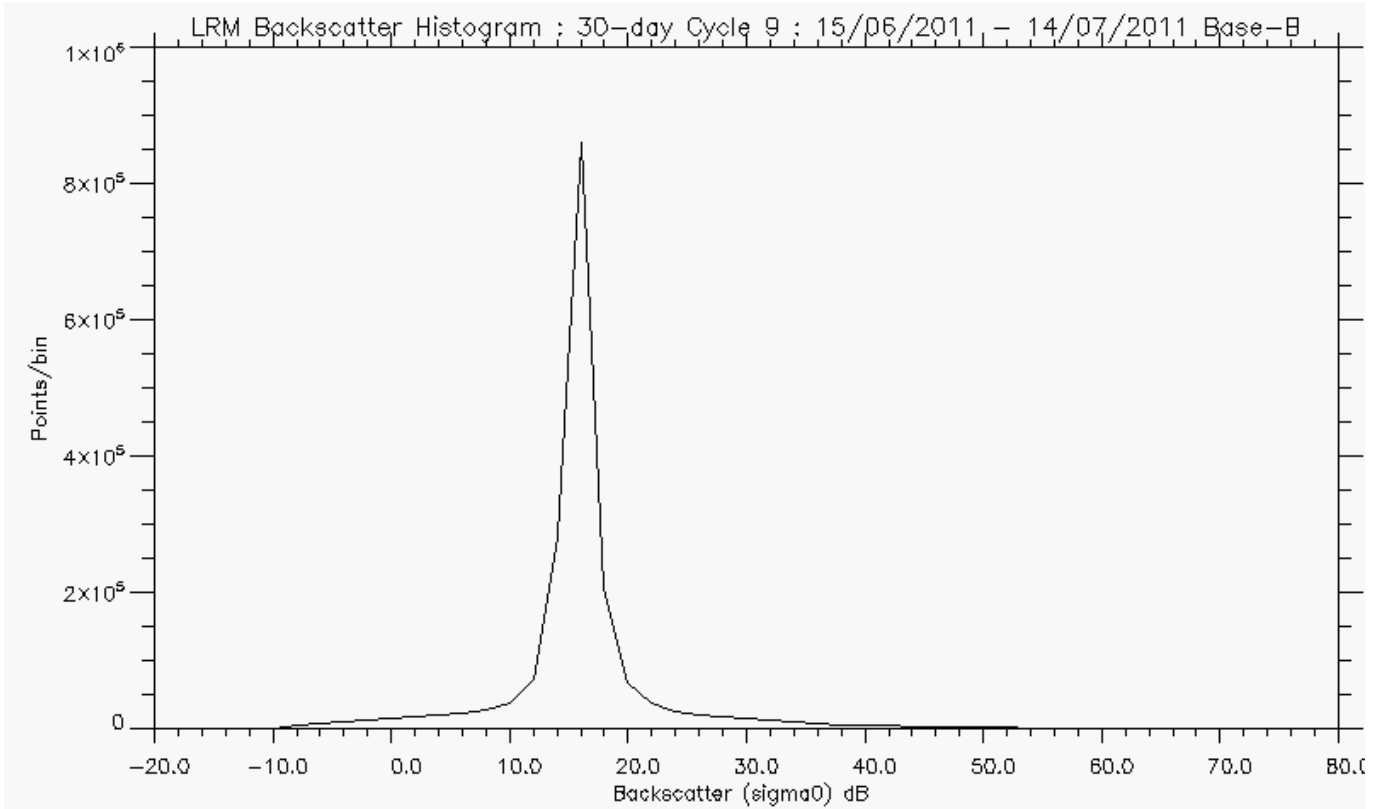


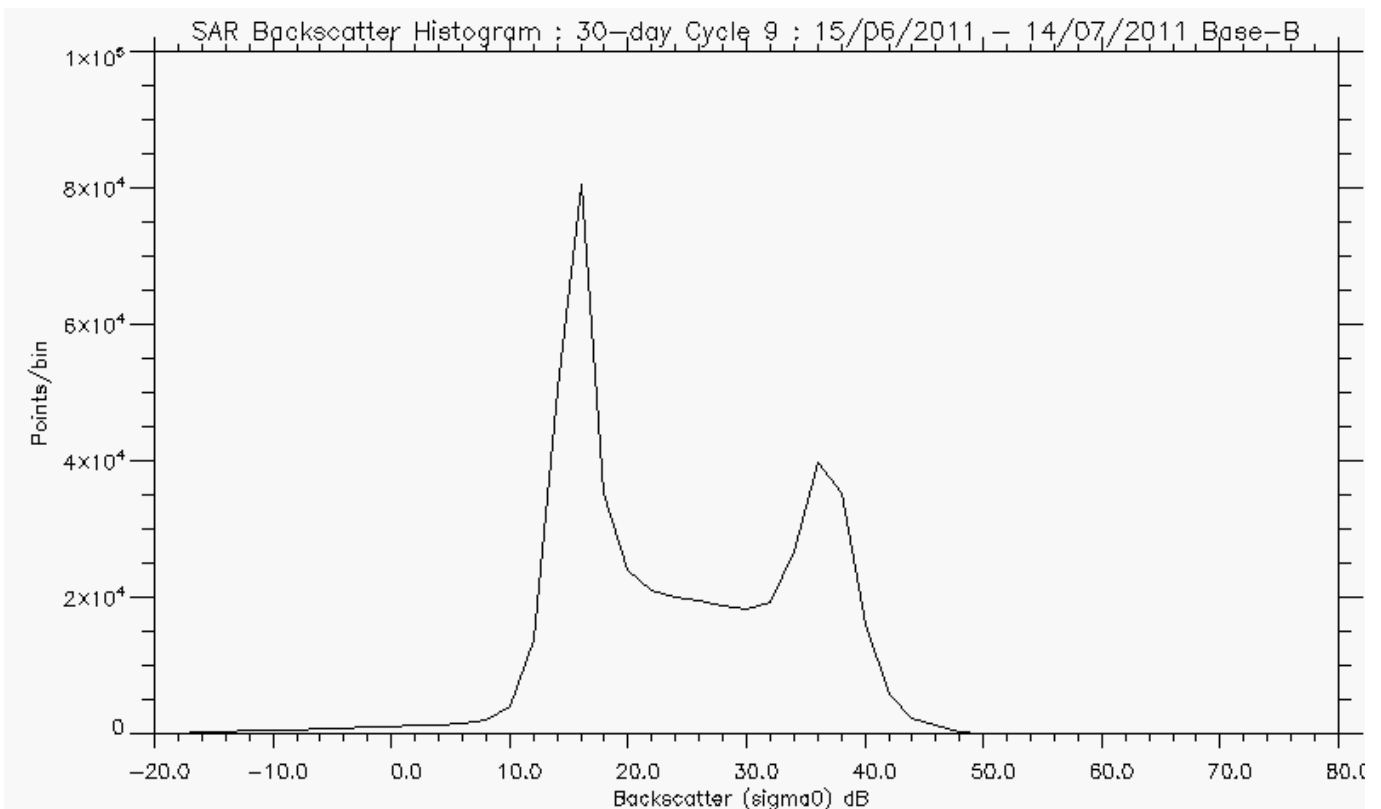
Figure 5-4 Global and Polar plots of Backscatter for cycle 9.



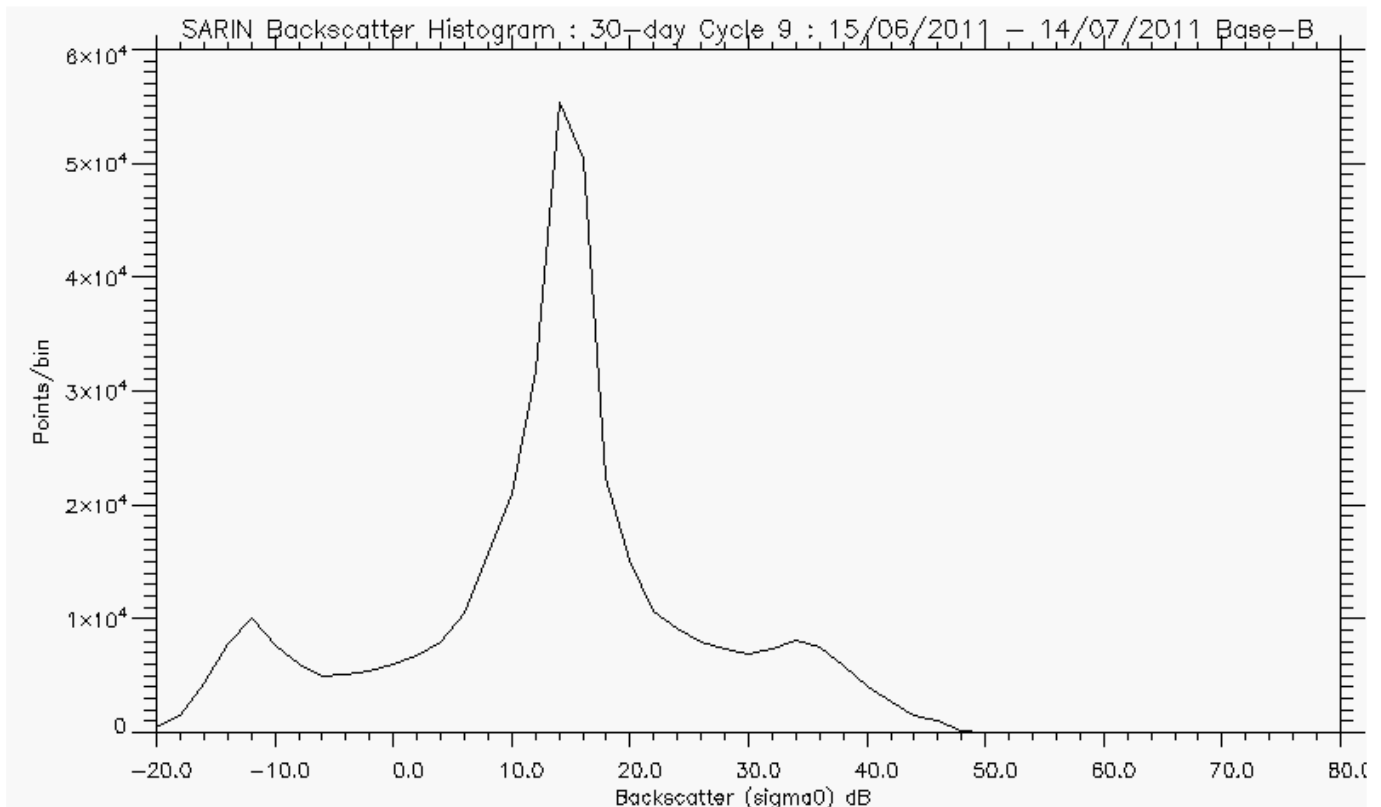
Figure 5-5, Figure 5-6 and Figure 5-7 below provide histograms for the Backscatter ( $\sigma_0$ ) parameter, for each of the SIRAL modes.



**Figure 5-5 Backscatter Histogram for LRM, cycle 9.**



**Figure 5-6 Backscatter Histogram for SAR, cycle 9.**



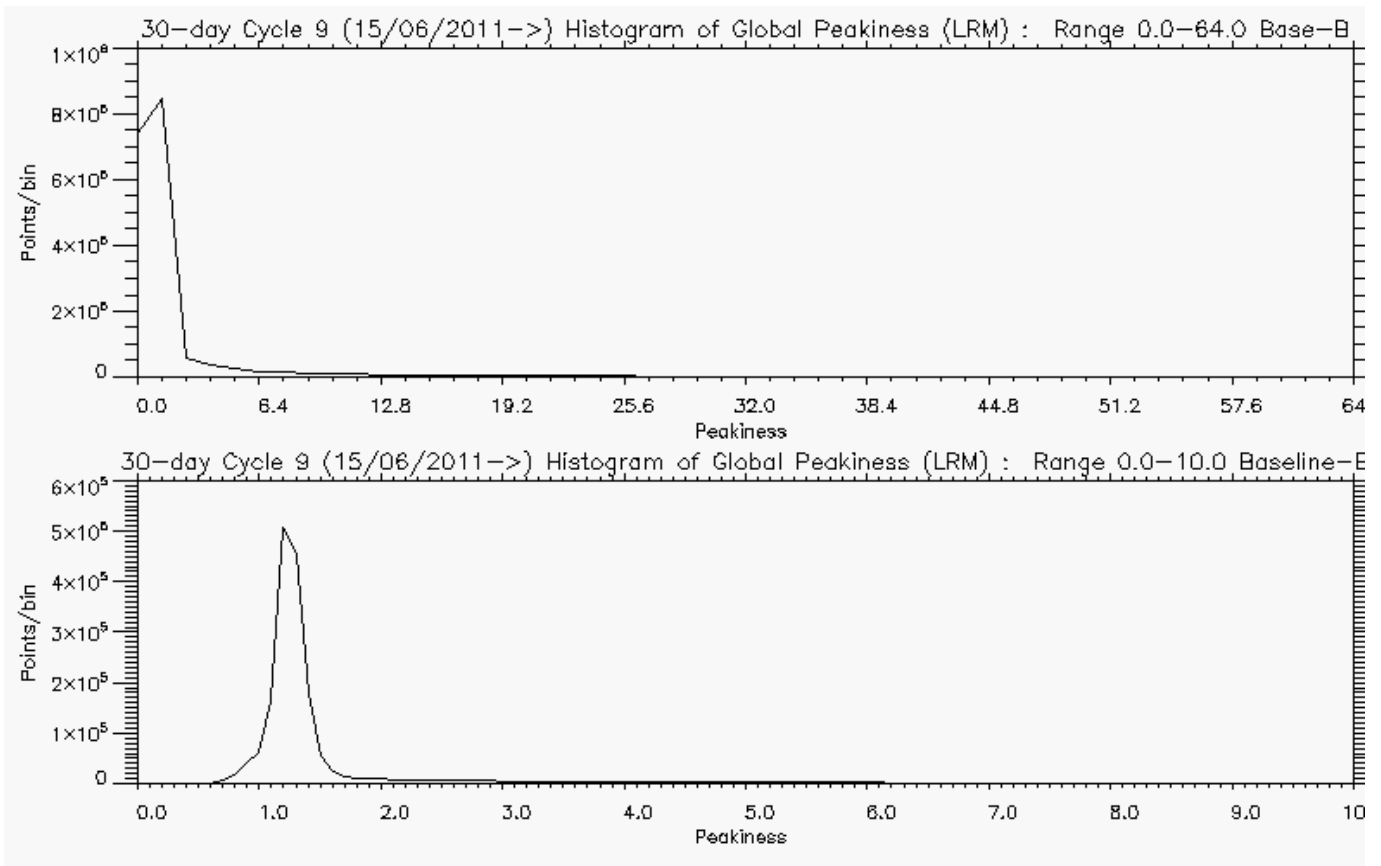
**Figure 5-7 Backscatter Histogram for SARin, cycle 9.**

It has been noted that in recent months backscatter values have been declining by ~0.1 dB per month. The power level transmitted by SIRAL has also been declining by a few 100ths of a dB per month. Nominally the CAL1 mode detects this and provides a correction to the sigma0 values, however there is currently an Anomaly Report open on this issue as this CAL1 correction is currently being applied with the wrong sign, hence the apparent drop in power. This problem is currently under investigation but CryoSat data users should be aware as this can in turn affect wind speed and sea state bias correction values.

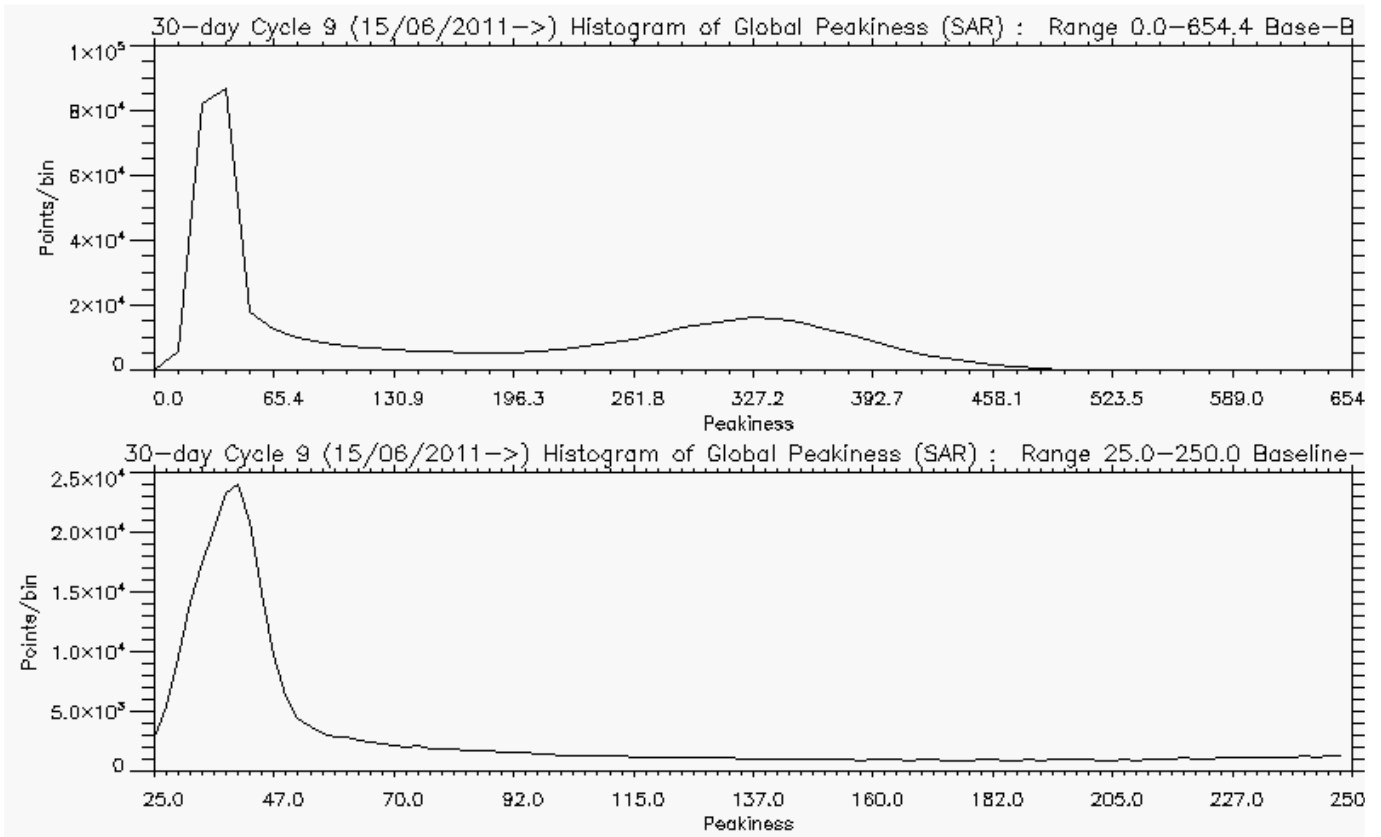
#### 5.4.4 WAVEFORM PEAKINESS

CryoSat Level 2 data includes a Waveform Peakiness value (field 39) for each 20 Hz measurement record. Peakiness is a ratio of the maximum waveform sample (bin) value to the mean value of the bins to the right of the tracking point. It is used to discriminate specular returns from diffuse returns and is used to estimate sea ice thickness.

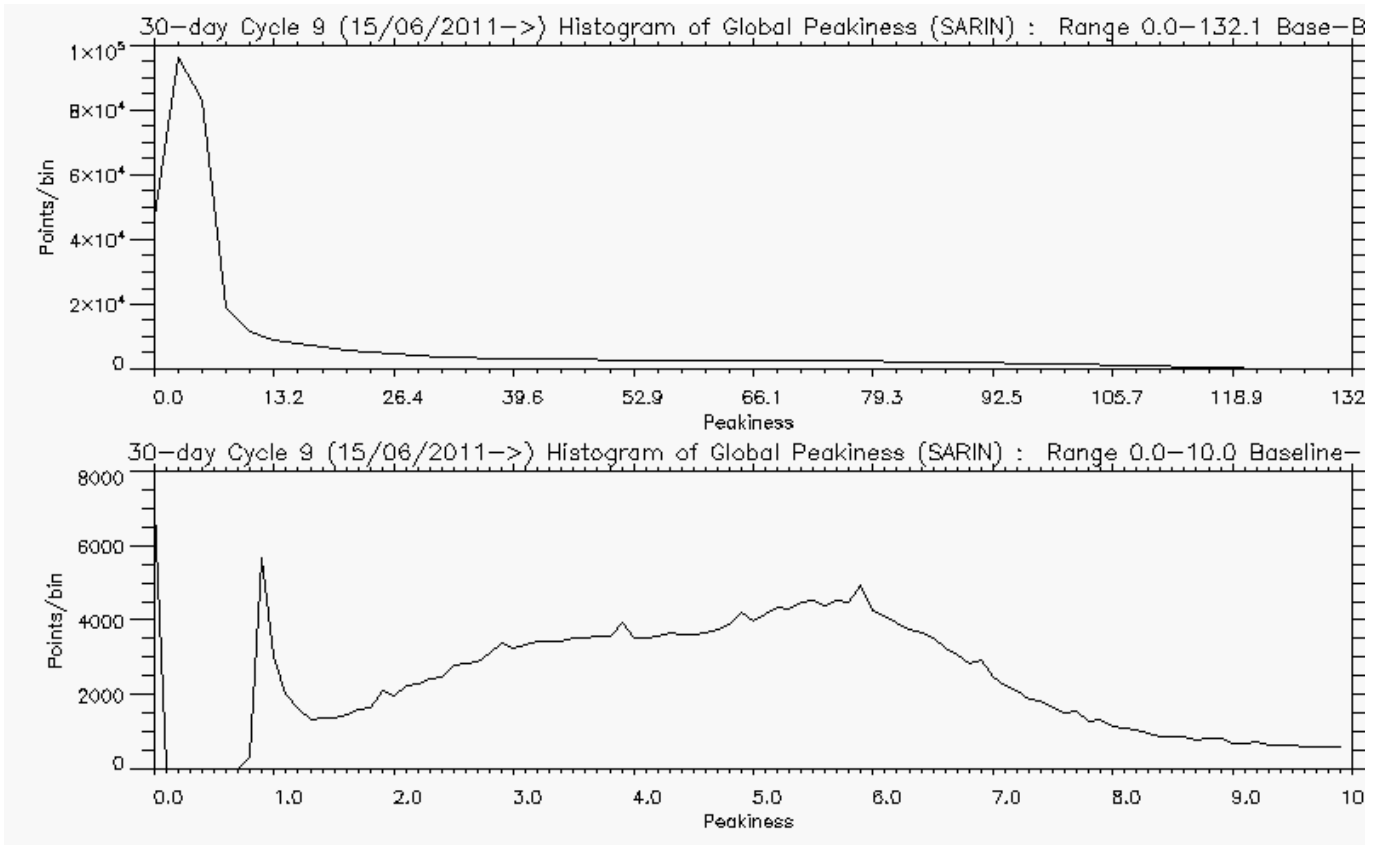
Figure 5-8, Figure 5-9 and Figure 5-10 below provide global Peakiness histograms for each of the SIRAL modes.



**Figure 5-8 Histogram of global Peakiness for LRM, for cycle 9.**



**Figure 5-9 Histogram of global Peakiness for SAR, for cycle 9.**



**Figure 5-10 Histogram of global Peakiness for SARIn, for cycle 9.**

Figure 5-11 shows the Waveform Peakiness for cycle 9, plotted over global and polar plots.

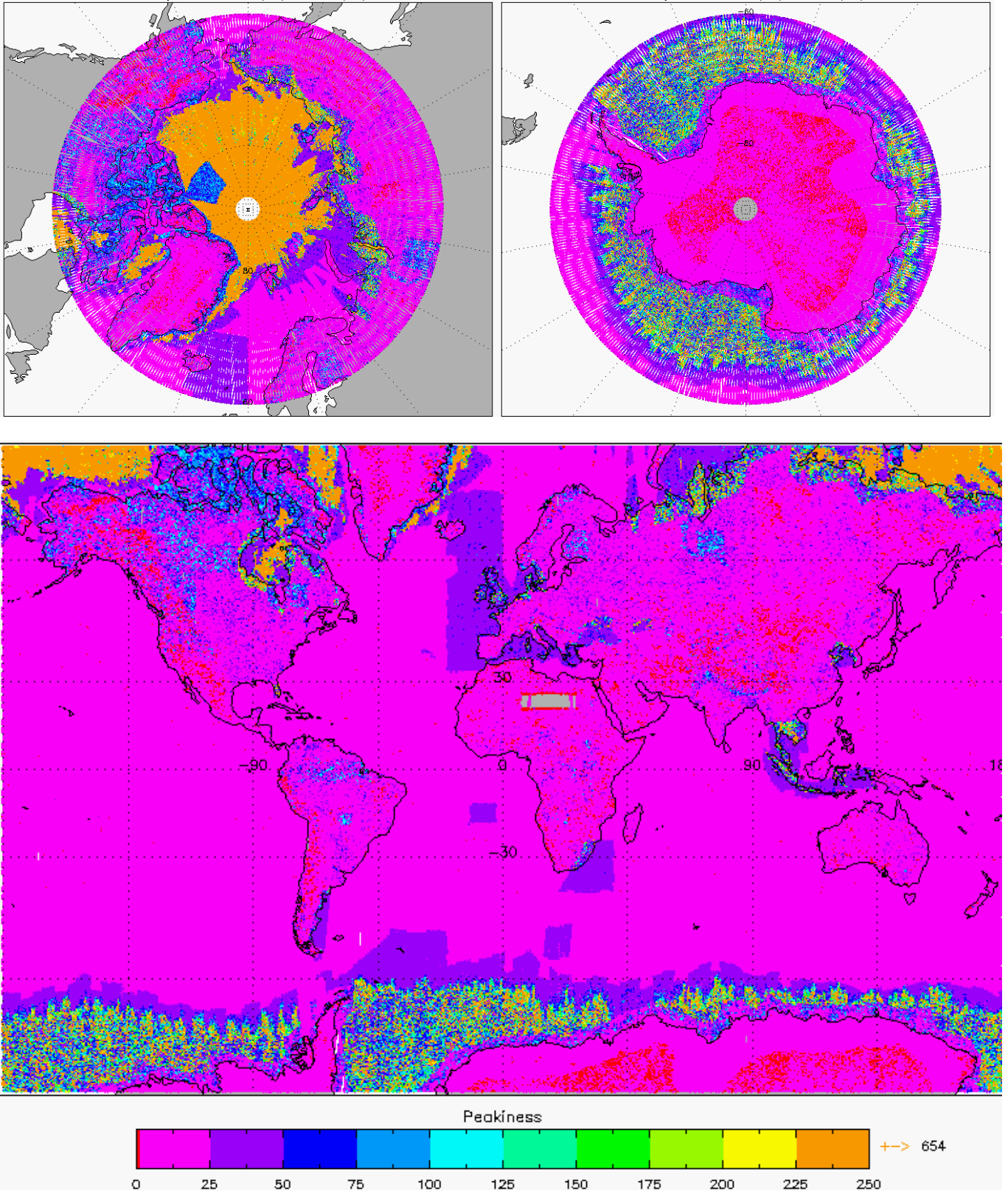


Figure 5-11 Global and Polar plots of Waveform Peakiness for cycle 9.

#### 5.4.5 FREEBOARD

CryoSat Level 2 data also includes a calculation for the Sea Ice Freeboard, which is the height by which an ice floe extends above the mean sea surface. This value can possibly be negative if there is heavy snow load on thin ice. At Level 2 it is calculated using UCL04 model values for snow depth and density.

Presently, the freeboard values are not computed and a default value of -9999 is provided in the products by specification. The freeboard will be computed in the Level 2 products when there is a greater confidence in the knowledge of the Arctic Mean Sea Surface with the launch of the SIR\_SAR\_2B and SIR\_GDR\_2B products.

#### 5.4.6 SNOW DEPTH

CryoSat Level 2 data includes a snow depth field (field 24) for each 1 Hz record. The snow depth values (in mm) are extracted from a climatology model, UCL04, and can be used to adjust the freeboard estimate to account for snow-loading. Currently Level 2 products only include snow depth values for the Arctic Region as a climate model for the Antarctic Region is not available.

Figure 5-12 shows a plot of the Snow Depth values, for the Arctic region, extracted from Level 2 products from cycle 9.

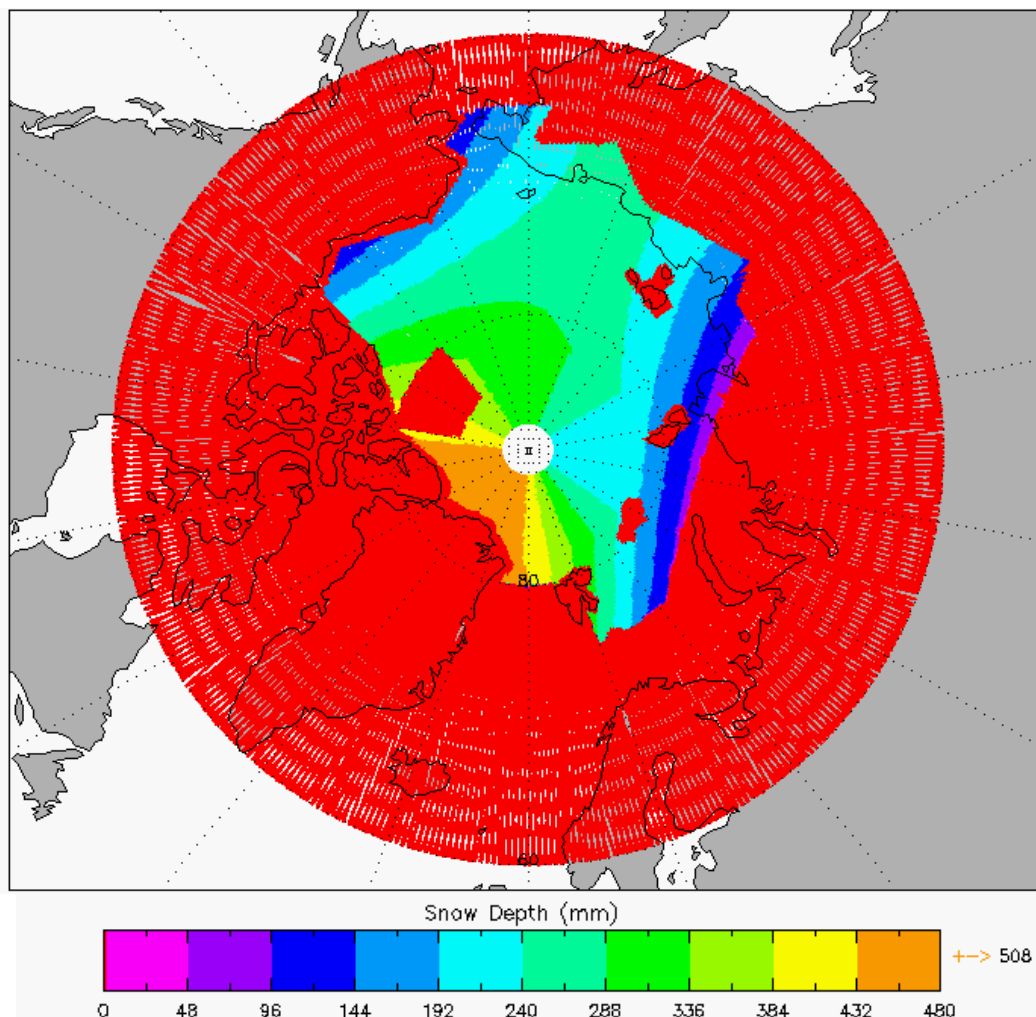


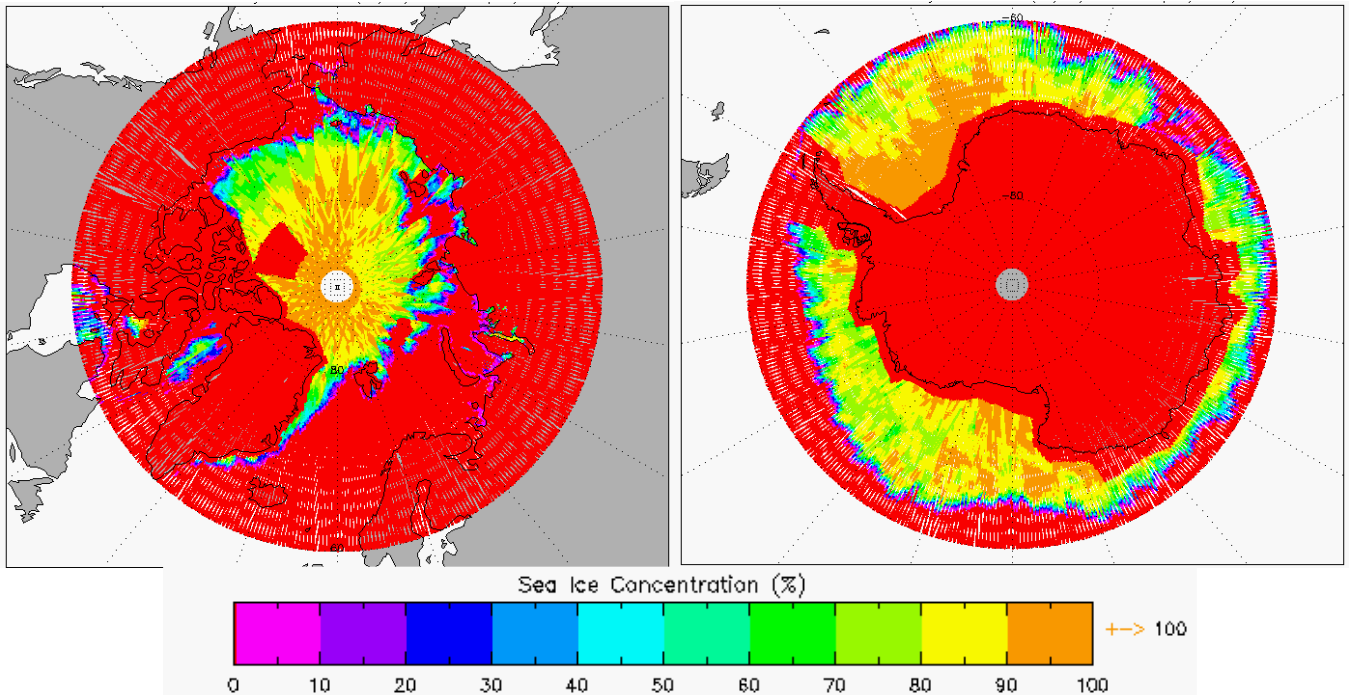
Figure 5-12 Arctic plot of Snow Depth for cycle 9.



#### 5.4.7 SEA ICE CONCENTRATION

CryoSat Level 2 data includes a percentage value for the sea ice concentration field (field 23) for each 1 Hz record.

Figure 5-13 shows the Sea Ice Concentration values extracted from the Level 2 products from cycle 9.



**Figure 5-13 Polar plots of Sea Ice Concentration for cycle 9.**

#### 5.4.8 SNOW DENSITY

CryoSat Level 2 data also includes a snow density field (field 25) for each 1 Hz record. The snow density value is a constant value which is extracted by the processor from a Parameter Configuration File (PCONF) and this value can be used to adjust the freeboard estimate to account for snow-loading.

The current snow density value used in the CryoSat Level 2 products is  $400 \text{ kg/m}^3$ .

#### 5.4.9 SURFACE HEIGHT

CryoSat Level 2 data provides the calculated Surface Height (Level 2 field 34) with reference to the ellipsoid WGS84 for each 20 Hz measurement record. Figure 5-14 shows polar plots of the Surface Height values extracted from the Level 2 products, over land and ocean areas, for cycle 9. Figure 5-15 shows a global plot of the Sea Surface Height values extracted from the Level 2 products over ocean areas for cycle 9.

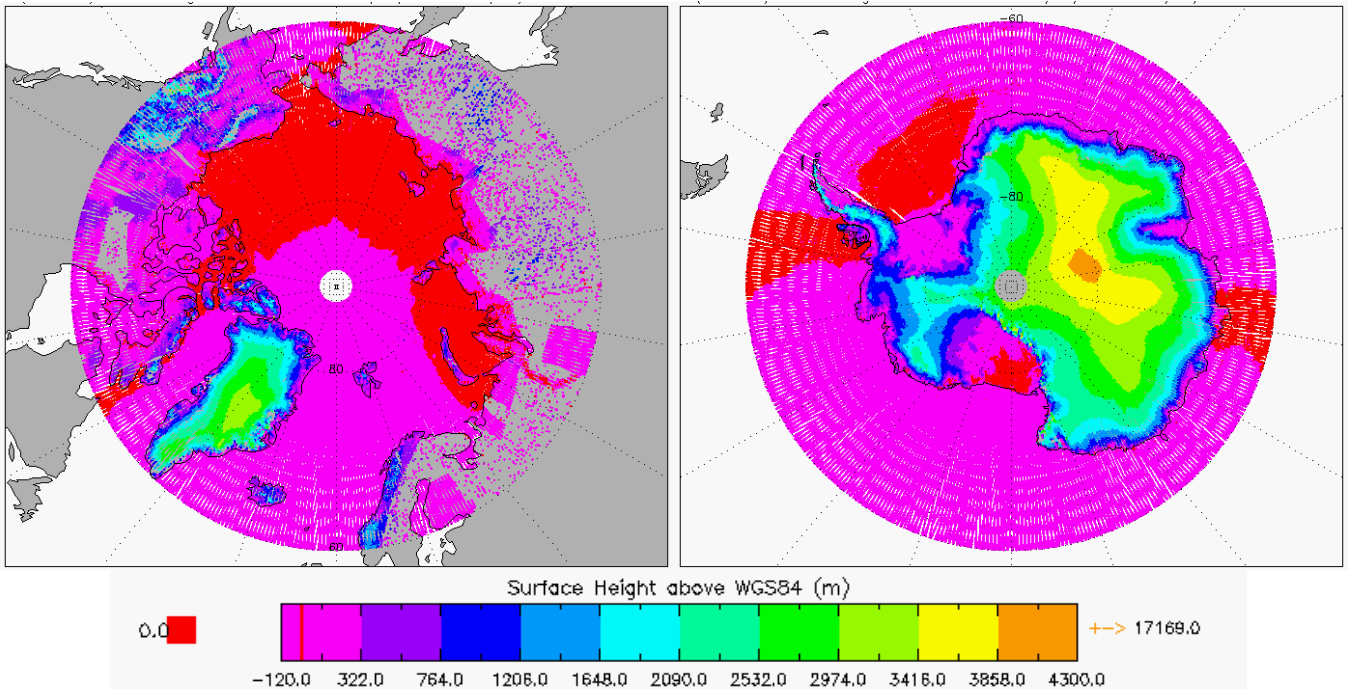


Figure 5-14 Polar plots of Surface Height over land and ocean areas for cycle 9.

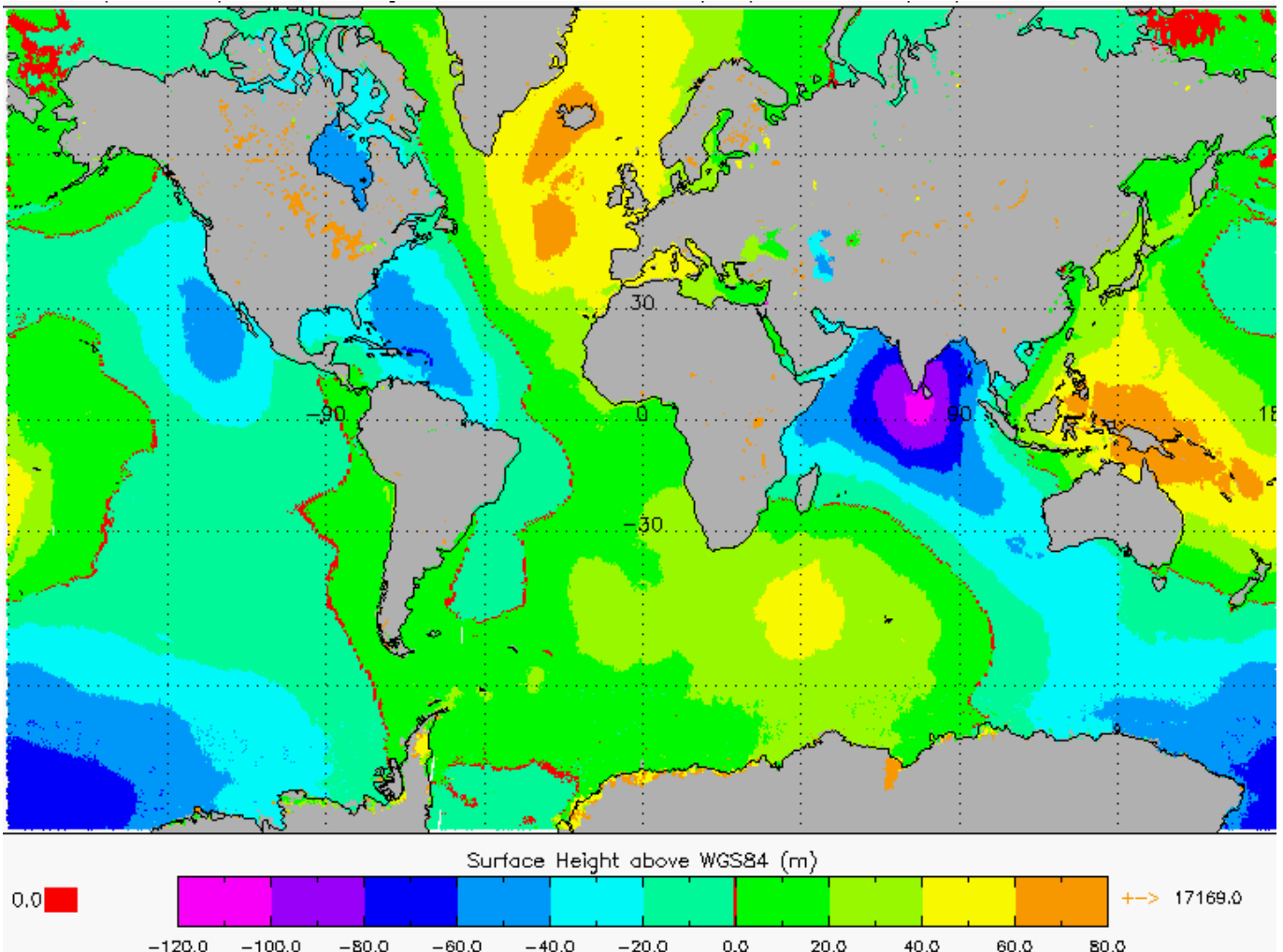


Figure 5-15 Global plots of Sea Surface Height over ocean areas only, for cycle 9.



## 5.5 Quality Flags

The CryoSat Level 2 data products include a Quality Flag word (field 43) for each 20 Hz measurement record. The bit values of this flag indicate an assessment of the measurement quality by the PDS processing chains.

Table 5-2 provides the statistics for each Quality Flag, from Field 43, for each mode during cycle 9. The results are provided for each mode and surface type. For SARIn mode the Quality Flag results are provided for Ice and Land. Although SARIn mode is predominantly used over steeply sloping ice-sheet margins, small ice caps and areas of mountain glaciers, there are also additional areas where this mode is also operated over land areas such as over Africa and along the Chilean coast.

| Quality Flag              | LRM – Ice | LRM – Land | LRM – Ocean | SARIn – Ice | SARIn – Land | SAR - Ocean |
|---------------------------|-----------|------------|-------------|-------------|--------------|-------------|
| BLOCK DEGRADED            | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| ORBIT ERROR               | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| ORBIT DISCONTINUITY       | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| HEIGHT ERROR              | 18.02%    | 82.49%     | 0.41%       | 8.65%       | 22.49%       | 0.01%       |
| SSHA INTERP ERROR         | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| CALIBRATION WARNING       | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| BACKSCATTER ERROR         | 16.53%    | 80.53%     | 0.4%        | 0%          | 0.01%        | 0.01%       |
| PEAKINESS ERROR           | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| FREEBOARD ERROR           | 100%      | 100%       | 100%        | 100%        | 100%         | 100%        |
| SAR DISCRIM = OCEAN       | 0%        | 0%         | 0%          | 0%          | 0%           | 19.76%      |
| SAR DISCRIM = LEAD        | 0%        | 0%         | 0%          | 0%          | 0%           | 28.3%       |
| SAR DISCRIM = SEA ICE     | 0%        | 0%         | 0%          | 0%          | 0%           | 13.47%      |
| SAR DISCRIM = UNKNOWN     | 0%        | 0%         | 0%          | 0%          | 0%           | 38.47%      |
| SARIN XTRACK ERROR        | 0%        | 0%         | 0%          | 70.52%      | 98.88%       | 0%          |
| SARIN RX1 ERROR           | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| SARIN RX2 ERROR           | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| SIRAL IDENTIFIER          | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| SURFACE MODEL UNAVAILABLE | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| MISPOINTING ERROR         | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |
| DELTA TIME ERROR          | 0%        | 0%         | 0%          | 0%          | 0%           | 0%          |

Table 5-2 Quality Flag results for cycle 9.

Currently the Quality Flag for 'Freeboard Error' is set in all products as this parameter is currently not provided in the Level 2 products and the value is presently set to the default value of -9999 (please refer to section 5.4.5 for more details).

It has been noted that the number of errors arising from the 'Backscatter Error' and 'Height Error' Quality Flag is much higher than expected over land-ice areas and this is currently part of an on-going investigation by expert teams.

The SARIn Xtrack Error flag is used to indicate records flagged as ambiguous. In Level 2I SARIn products, an Ambiguity Flag (field 73) is used to indicate ambiguity and is also used to indicate why the record has been flagged as ambiguous. Within the corresponding Level 2 SARIn products, there is only one bit available within the record structure to show this, so it is currently set if the difference between the computed surface elevation and the DEM is >50 m or if there isn't a DEM at the current location to check.

As the DEM is only available for Greenland and Antarctica, the SARIn Xtrack flag can be ignored in all other regions. Currently there is an on-going investigation into the high number of errors from the 'SARIn X-track Error' Quality Flag over Antarctica.

## 5.6 Crossover Analysis

This section provides results from crossover processing of Level 2 data from cycle 9.

### 5.6.1 CROSSOVER STATISTICS

The crossover statistics for cycle 9, from each mode, is provided in Table 5-3 for Antarctica, Greenland and the Global Oceans.

| Location      | Mode  | No of crossovers       | RMS    | Mean    | XTT Mean |
|---------------|-------|------------------------|--------|---------|----------|
| Antarctica    | LRM   | 49147 (63.8%) < 10.0 m | 0.43 m | -0.01 m | 4.96 ms  |
|               | SARIn | 11070 (79.0%) < 10.0 m | 1.97 m | 0.06 m  | -1.01 ms |
| Greenland     | LRM   | 328 (76.1%) < 1.0 m    | 0.42 m | 0.18 m  | 3.21 ms  |
|               | SARIn | 1454 (61.6%) < 1.0 m   | 2.00 m | 0.03 m  | 2.30 ms  |
| Global Oceans | LRM   | 9664 (93.7%) < 1.0 m   | 0.21 m | -0.10 m | 4.31 ms  |

Table 5-3 Cycle 9 Crossover statistics.

### 5.6.2 ELEVATION MAPS

Figure 5-16 and Figure 5-17 show spatial polar maps of elevation differences at crossover per 10 km<sup>2</sup> grid cells for Level 2 products from cycle 9.

Over central Antarctica, there is an unexpected pattern which is clearly visible between -82 and -88 degrees. Crossover differences have a static and time varying component; this pattern is linked to the static component of the crossover difference and is meteorological in origin due to wind-induced features. The pattern can be removed by applying an elevation correction that is a function of the sigma0 crossover difference, see Armitage *et al.*, 2013, “Meteorological Origin of the Static Crossover Pattern Present in Low-Resolution-Mode CryoSat-2 Data Over Central Antarctica”.

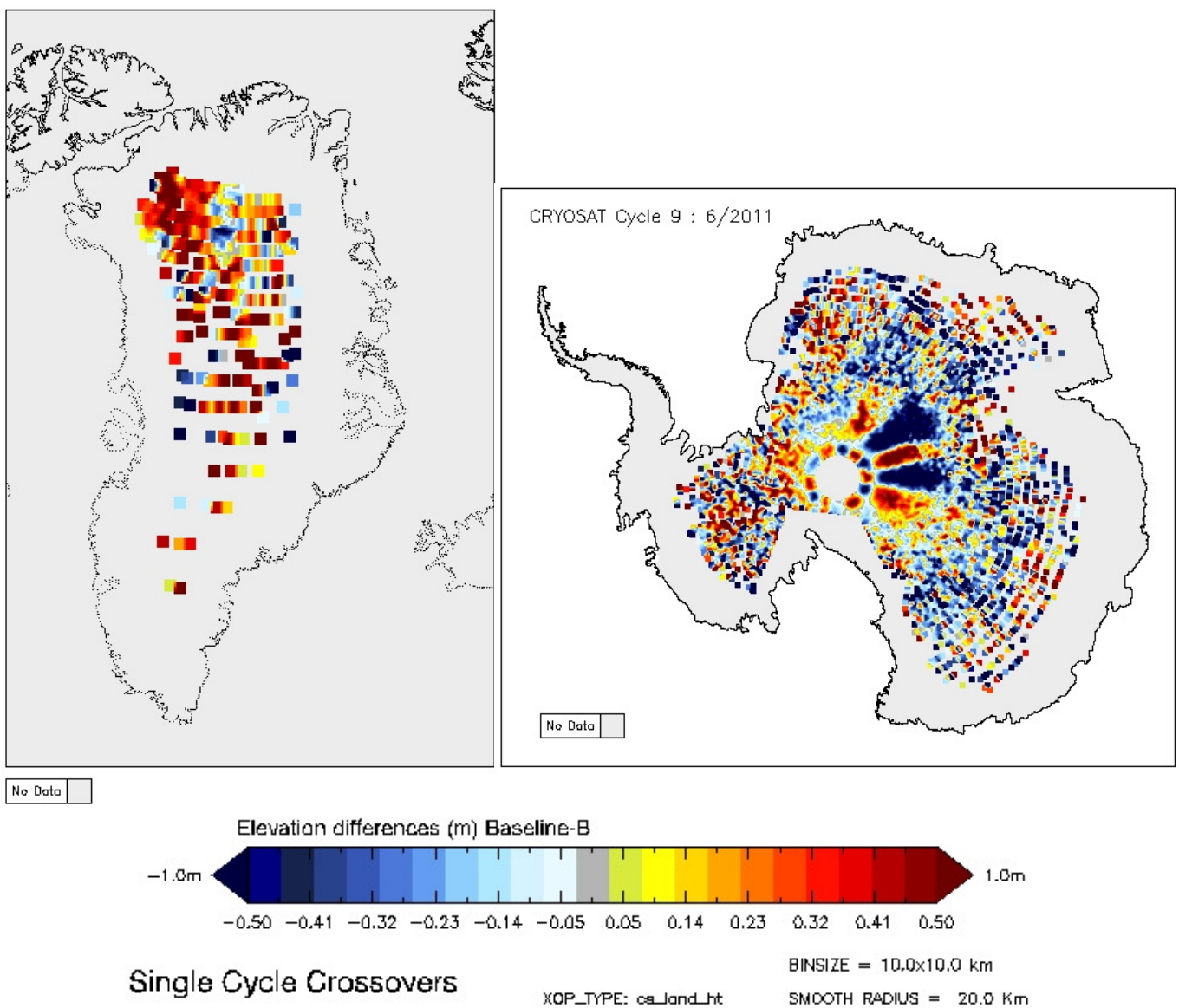


Figure 5-16 Greenland and Antarctica maps of LRM elevation differences for cycle 9.

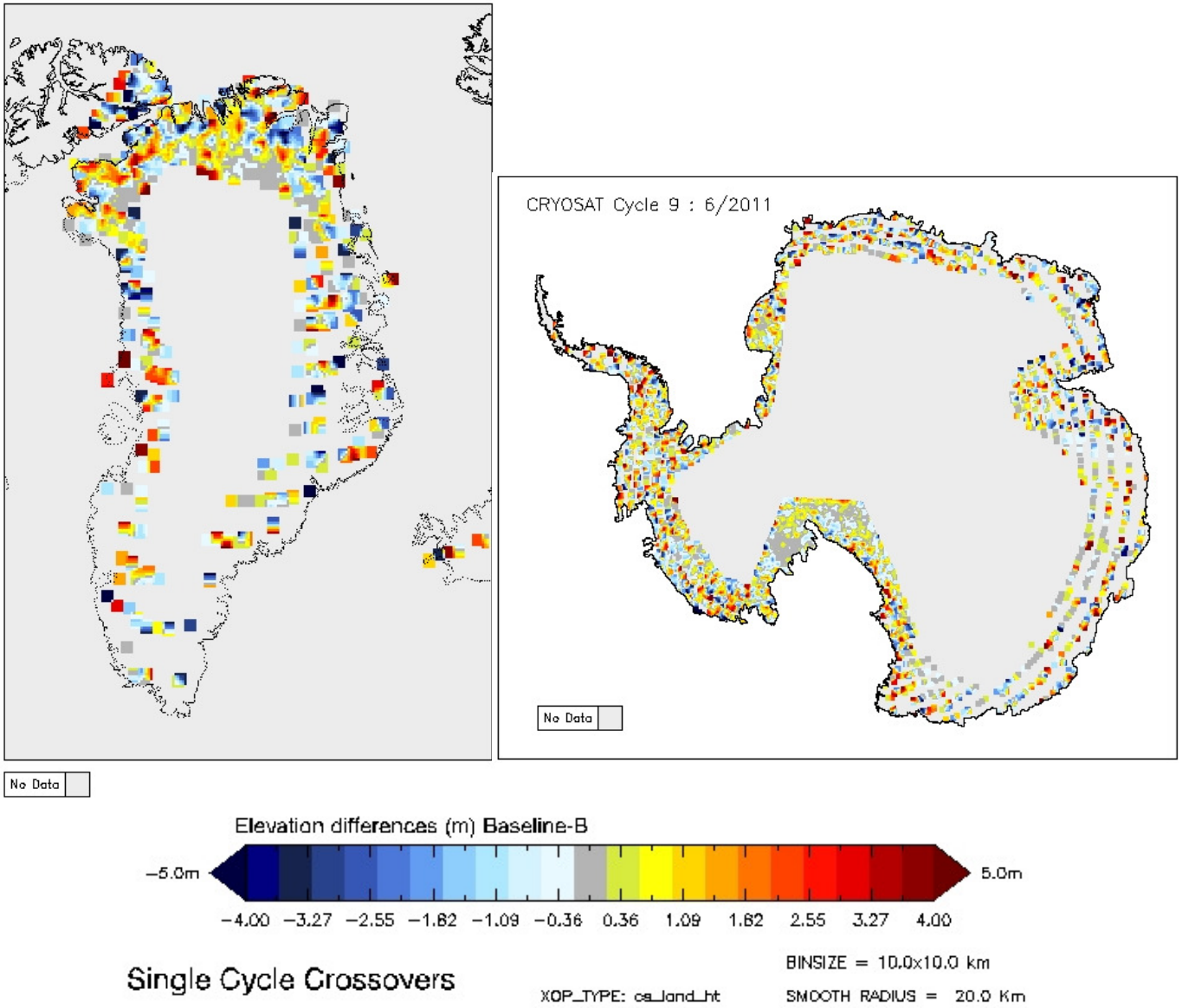


Figure 5-17 Greenland and Antarctica maps of SARIn elevation differences for cycle 9.

### 5.6.3 BACKSCATTER (SIGMA0) MAPS

Figure 5-18 and Figure 5-19 provide spatial polar maps of power differences at crossover per 10 km<sup>2</sup> grid cells for Level 2 products from cycle 9.

Over central Antarctica, there is an unexpected pattern which is clearly visible between -82 and -88 degrees. Crossover differences have a static and time varying component; this pattern is linked to the static component of the crossover difference and is meteorological in origin due to wind-induced features. The pattern can be removed by applying an elevation correction that is a function of the sigma0 crossover difference, see Armitage *et al.*, 2013, "Meteorological Origin of the Static Crossover Pattern Present in Low-Resolution-Mode CryoSat-2 Data Over Central Antarctica".

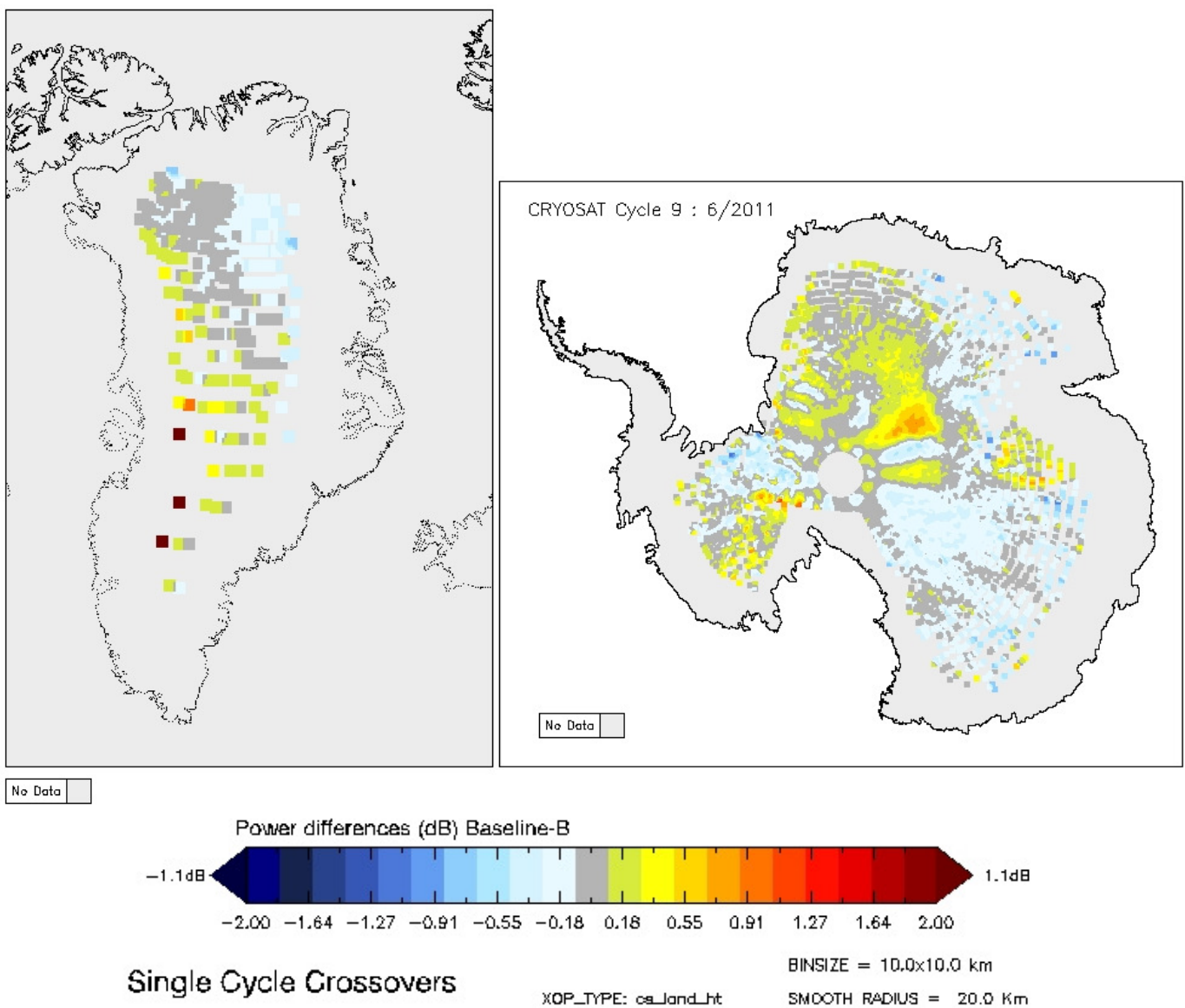
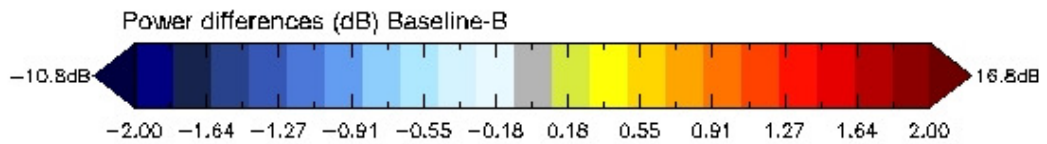
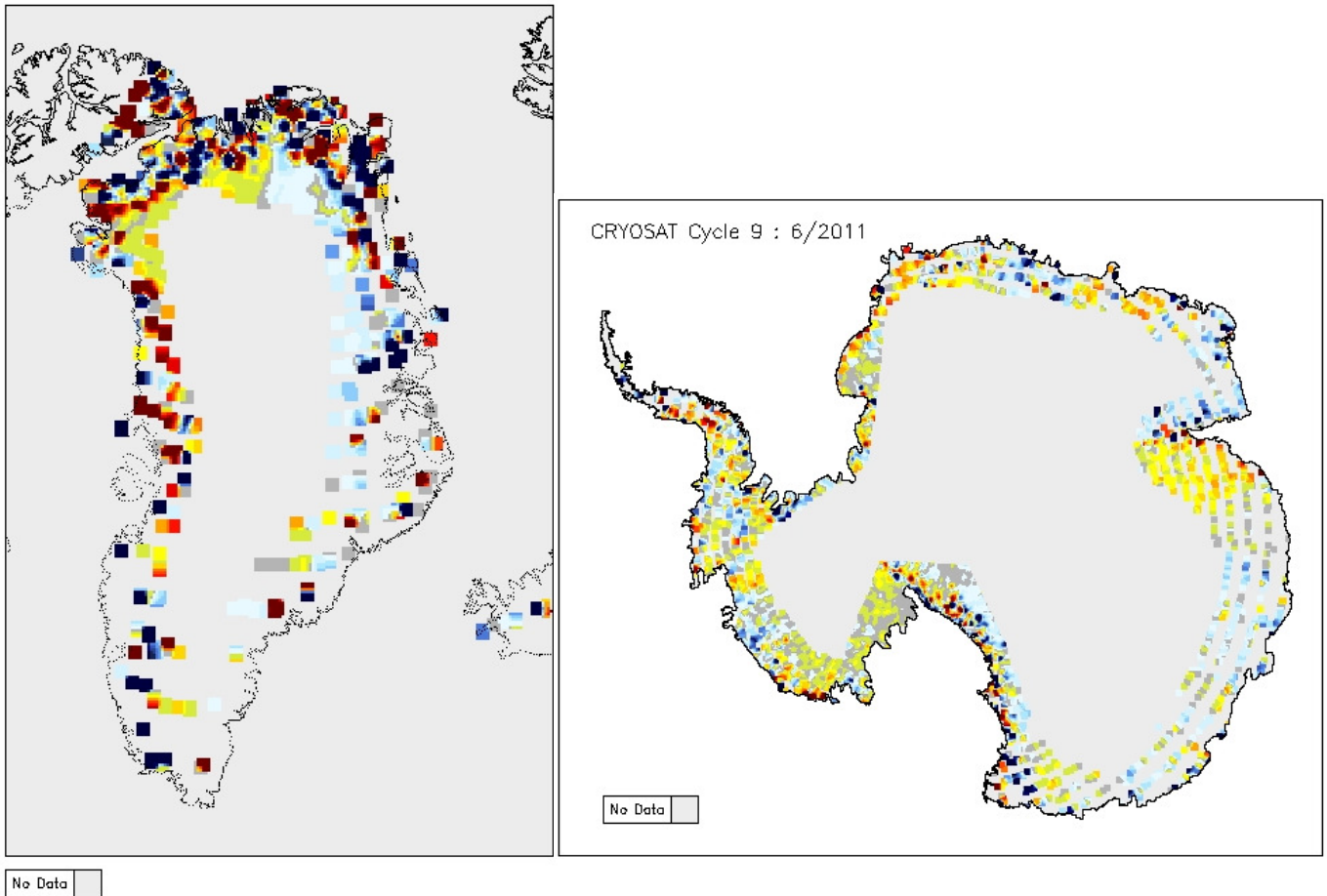


Figure 5-18 Greenland and Antarctica maps of LRM power differences for cycle 9.





Single Cycle Crossovers

XOP\_TYPE: cs\_Land\_Ht

BINSIZE = 10.0x10.0 km

SMOOTH RADIUS = 20.0 Km

Figure 5-19 Greenland and Antarctica maps of SARIn power differences for cycle 9.

## 5.7 External Auxiliary Corrections

Surface Height measurements, which are provided in the SIRAL Level 2 products, are corrected for atmospheric propagation delays and geophysical surface variations. This section provides global maps of the value of each correction for cycle 9.

### 5.7.1 DRY TROPOSPHERIC CORRECTION

This is the correction for the path delay in the radar return signal due to the dry gas component of the atmosphere. It has a typical range from 1.7 to 2.5 m.

For CryoSat processing the Dry Tropospheric Correction is not provided via a specific auxiliary data file but is computed by the processors using ECMWF surface pressure files.

Figure 5-20 shows, geographically, the value of the Dry Tropospheric Correction, applied to the Level 2 data from cycle 9. The global RMS value of this correction for this cycle is **2216 mm**.

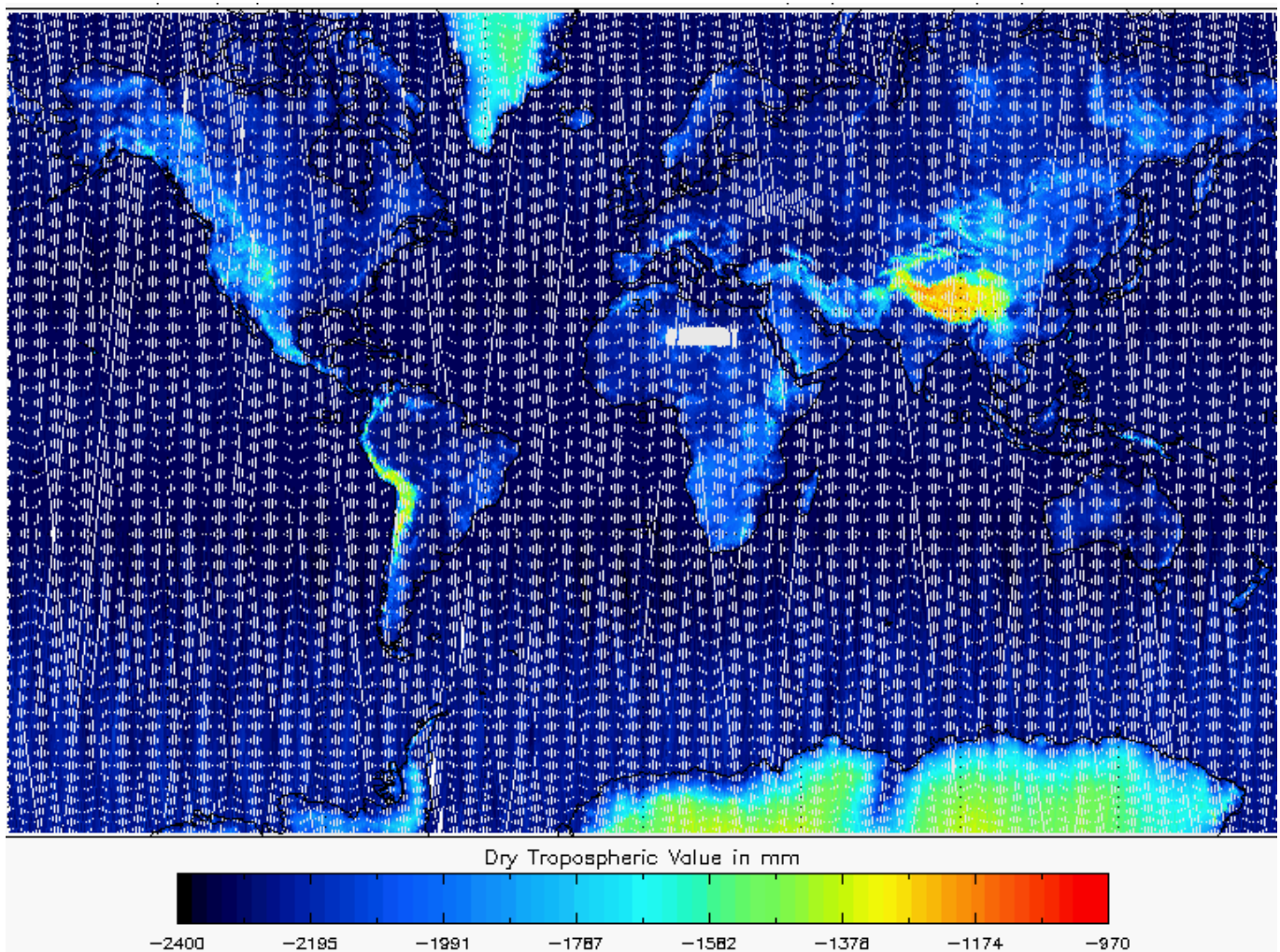


Figure 5-20 Global plot of Dry Tropospheric Correction for cycle 9.

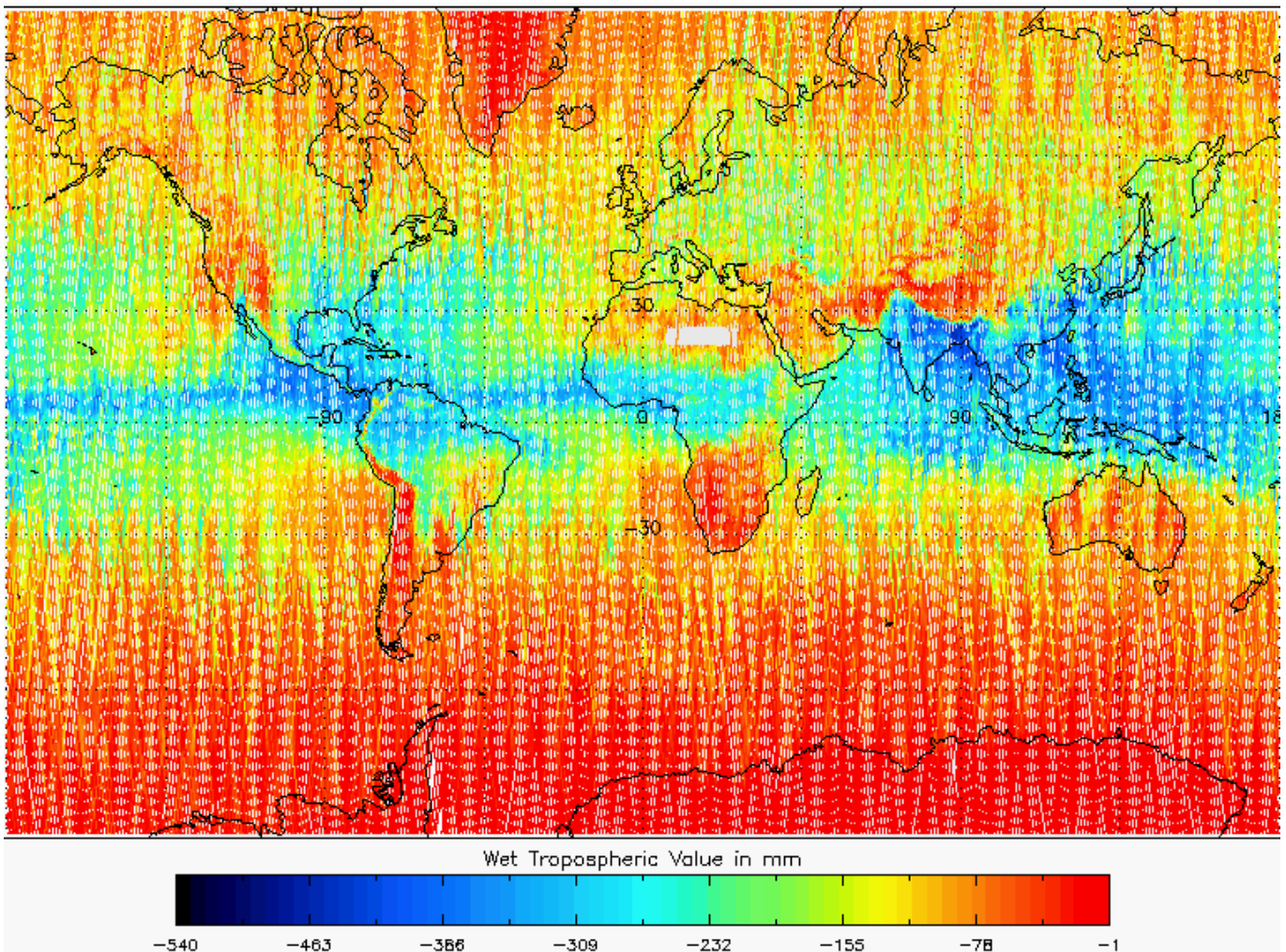


## 5.7.2 WET TROPOSPHERIC CORRECTION

The wet troposphere correction is the correction for the path delay in the radar return signal due to liquid water in the atmosphere. It is calculated from radiometer measurements and meteorological models and has a typical range from 0 to 50 cm.

Unlike the Dry Tropospheric Correction, the Wet Tropospheric Correction is retrieved directly from ECMWF analysed grids. These correction files are then simply formatted to the CryoSat PDS file standard before being directly used in the processor.

Figure 5-21 shows, geographically, the value of the Wet Tropospheric Correction, applied to the Level 2 data. The global RMS value of this correction for cycle 9 is **161 mm**.



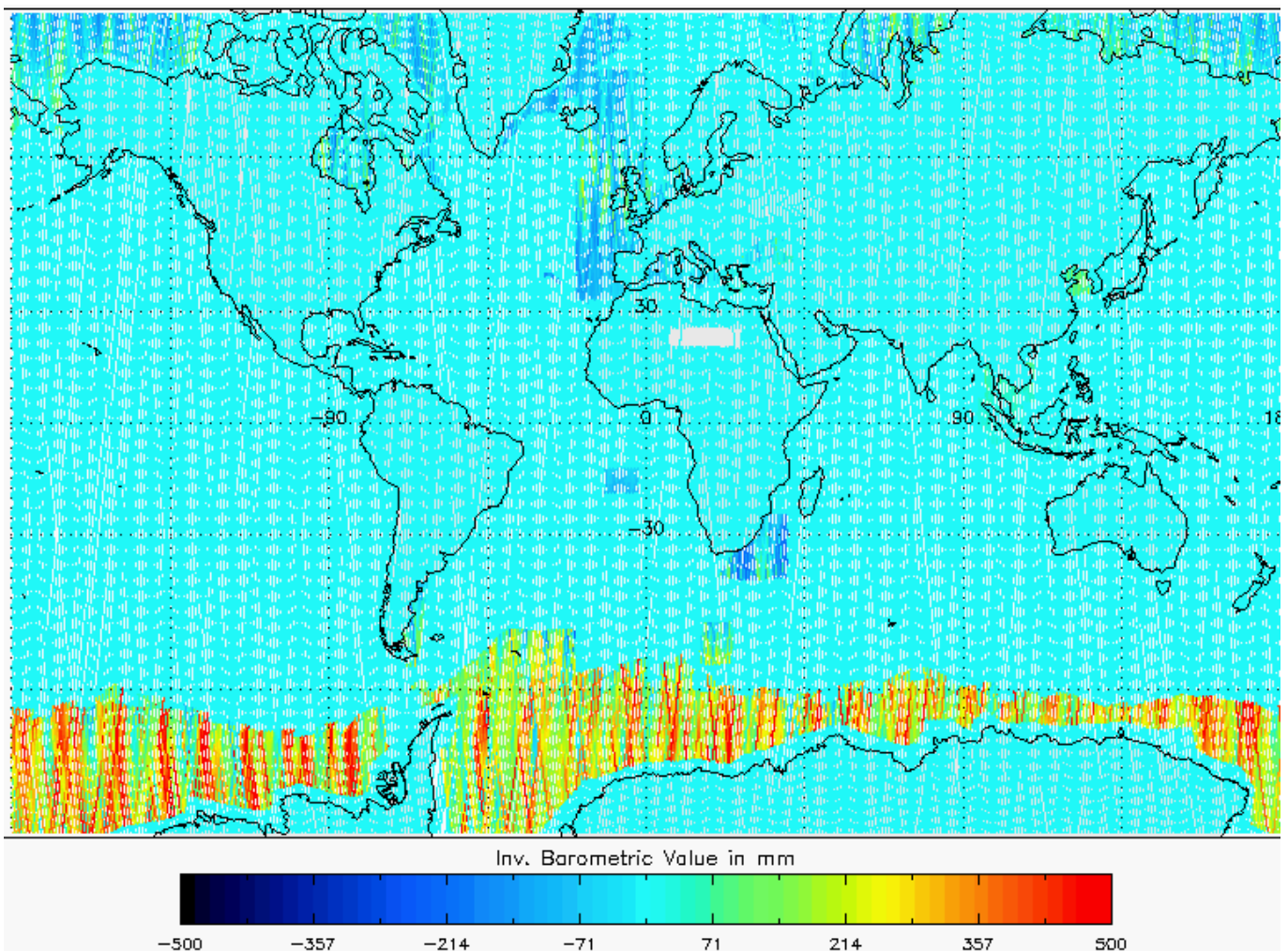
**Figure 5-21 Global plot of Wet Tropospheric Correction for cycle 9.**



### 5.7.3 INVERSE BAROMETRIC CORRECTION

The Inverse Barometric Correction compensates for variations in sea surface height due to atmospheric pressure variations, which is known as atmospheric loading. It has a typical range from -15 to +15 cm, and is calculated from data provided by Meteo France via the CNES SSALTO system. This correction is only used over sea ice, in SAR mode, and when the surface type is 'open ocean'.

Figure 5-22 shows, geographically, the value of the Inverse Barometric Correction applied to the Level 2 data. The global RMS value of this correction for cycle 9 is **173 mm**.

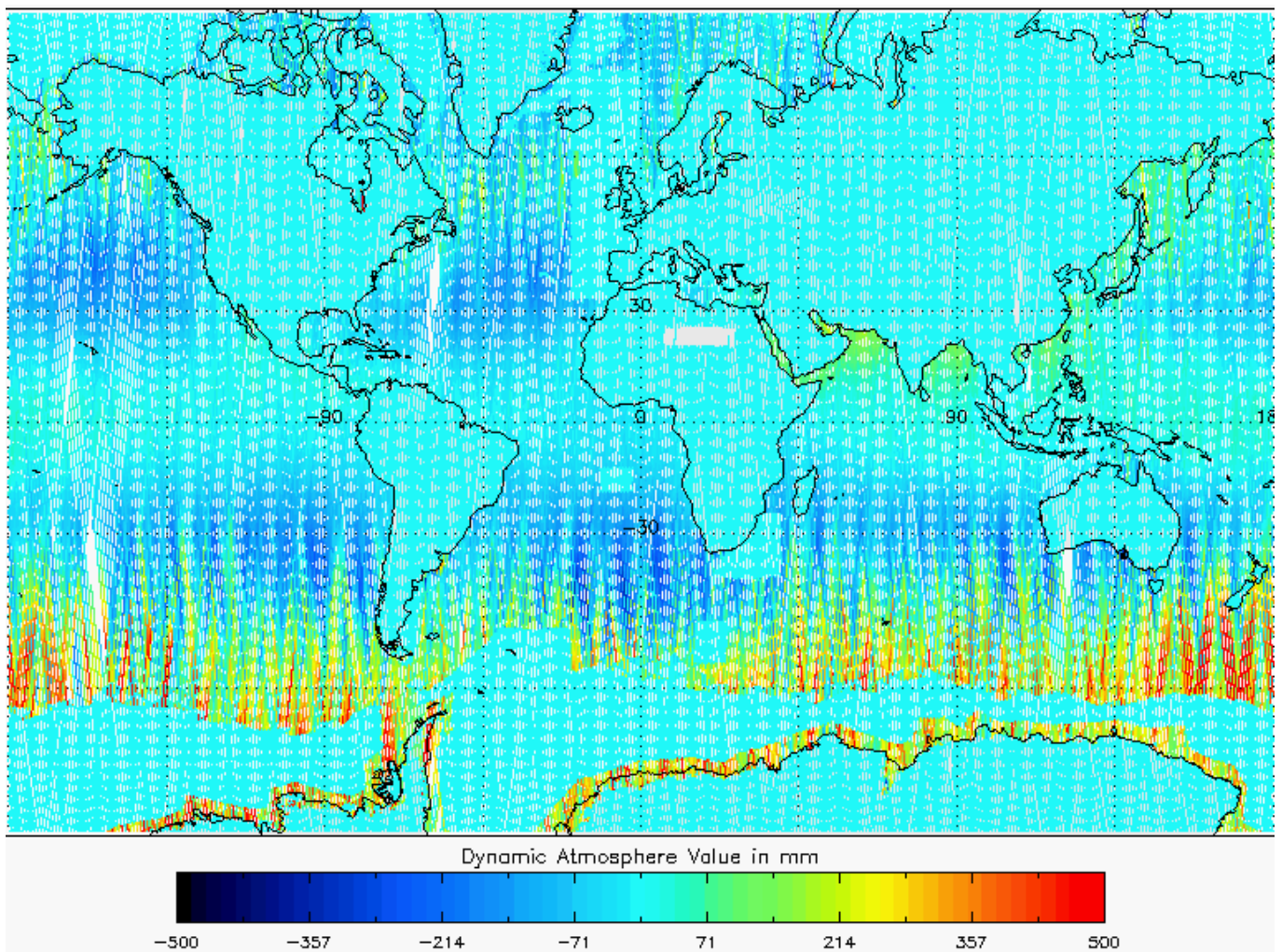


**Figure 5-22 Global plot of Inverse Barometric Correction for cycle 9.**

#### 5.7.4 DYNAMIC ATMOSPHERE CORRECTION

The dynamic atmospheric correction compensates for variations in sea surface height due to atmospheric pressure and winds. It has a typical range from -15 to +15 cm and is taken from the MOG2D model data provided by Meteo France via the CNES SSALTO system. This correction is only used over ocean, without sea-ice cover, in SARIn and LRM mode, when the surface type is 'open ocean'.

Figure 5-23 shows, geographically, the value of the Dynamic Atmospheric Correction, computed and applied to the Level 2 data. The global RMS value of this correction for cycle 9 is **120 mm**.



**Figure 5-23 Global plot of Dynamic Atmosphere Correction for cycle 9.**



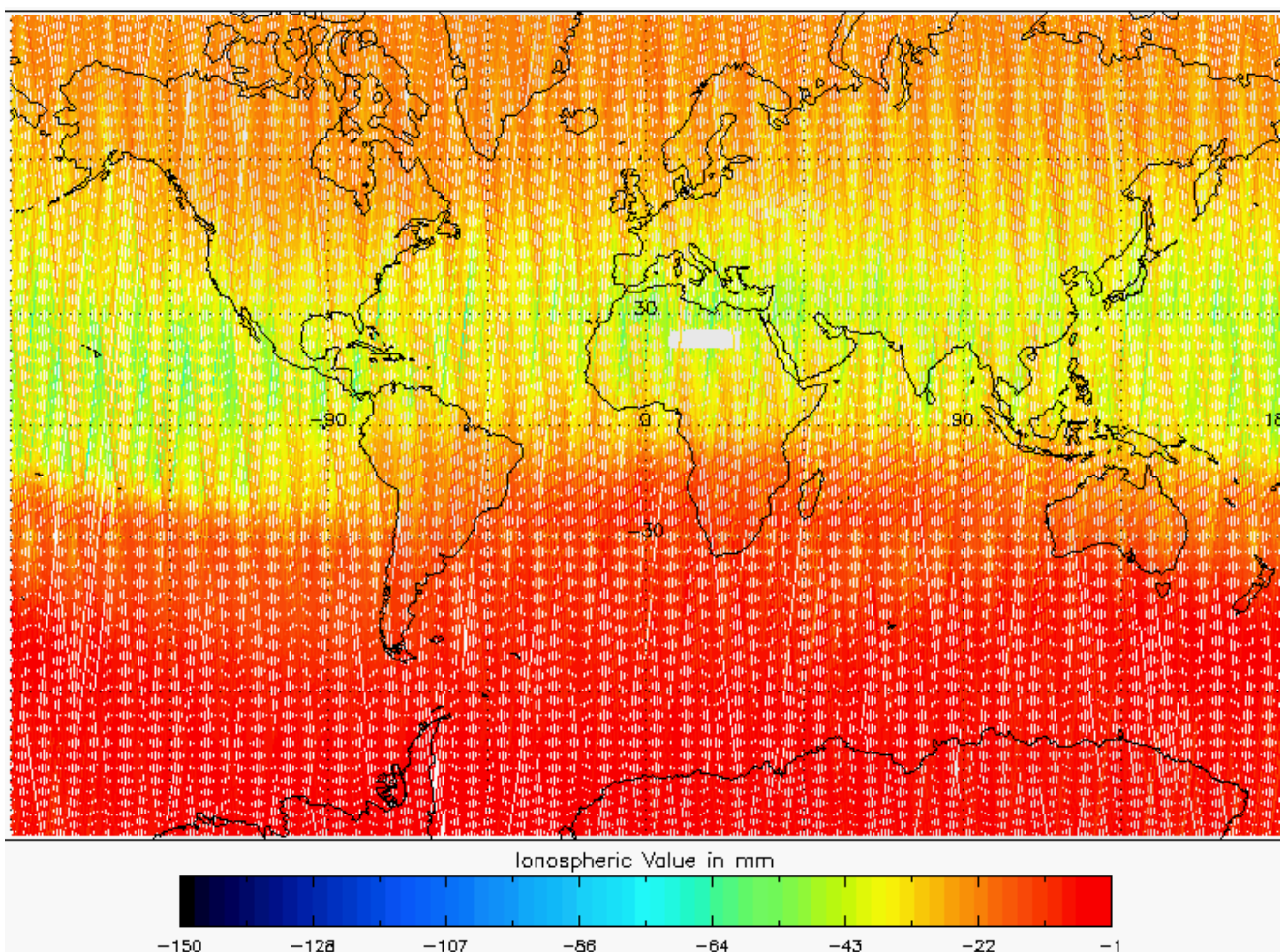
### 5.7.5 IONOSPHERIC CORRECTION

The Ionospheric Correction compensates for the free electrons in the Earth's ionosphere slowing the radar pulse. Solar control of the ionosphere leads to geographic and temporal variations in the free electron content, which can be modelled, or measured, for example using the GPS satellite network.

There are two sources currently used to derive this correction for CryoSat, the Global Ionospheric Map (GIM) and the Bent model. The GIM correction uses GPS measurements and is sourced from CNES via SSALTO as a dynamic daily file. The Bent Model is derived from a static file and is based on knowledge of a solar activity index, such as sunspots.

The correction has a typical range from 6 to 12 cm. CryoSat Level 1B products currently contain the Ionospheric Correction values derived from both the GIM and Bent Model. At Level 2, only the Ionospheric Correction value applied to the range is provided. This is nominally derived using the GIM by default, however when this is unavailable the Bent model is used as an alternative.

Figure 5-24 shows, geographically, the value of the Ionospheric Correction applied to the Level 2 data. The global RMS value of this correction for cycle 9 is **168 mm**.



**Figure 5-24 Global plot of Ionospheric Correction for cycle 9.**

Currently, the Bent Model does not provide values for latitudes >82 degrees. However, this should not affect the nominal science data as, during offline Level 2 processing, the Ionospheric Correction, as shown in Figure 5-24, is taken from the GIM model by default and the Bent Model is only used as an alternative when this GIM is not available.

## 6 ANOMALY REPORTS

An updated list of all known anomalies which have been opened and tracked on the IPF and affect the quality of the distributed data products, is provided at the link below:

<https://earth.esa.int/web/guest/missions/cryosat/product-status>.

This list of anomalies is complete and up to date as of 11 February 2014 and is updated on a regular basis.

## **7 README DOCUMENTS ON PERFORMANCE AND QUALITY**

This section lists any current readme documents or notifications which have been issued and are relevant to the quality of CryoSat data.

There were no readme documents issued during the period covered by this cycle.