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ENVISAT ICE-GDR
Re-processed data release v2.1
Quality Assessment Report

Annual

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Release 2012Sep

Laboratoire d'**E**tudes en **G**éophysique et **O**céanographie **S**patiales
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1 Introduction

The purpose of this document is to give a global view of the data quality from the ENVISAT mission over Antarctica and Greenland for all cycles.

The objectives of this document are :

- to provide a data quality assessment,
- to provide users with necessary information for data processing,
- to report any change that could impact data quality at any level, from instrument status to software configuration,
- to present the major useful results for the current cycle.

2 Validation process

2.1 Data and ice-validation software version

This cycle has been validated with the ice validation processing chain ICE-QA-09/2012. The content of this software version is described in a document available on the Centre de Topographie des Océans et de l'Hydrosphère (CTOH) web site [1]. The data have been obtained from the CTOH data base [2].

2.2 Area

The ice-validation has been performed over polar region, such as Antarctica and Greenland.

2.3 Ice-validation chain

The following Ice-2 parameters and corrections have been used in the ice-validation chain:

Ice-2 parameters:

- Altimeter range (m)
- Backscatter coefficient (dB)
- Width of the leading edge of the waveform (m)
- Slope of the logarithm of the trailing edge of the waveform (s-1)

Corrections:

- Atmospheric attenuation correction (model OSCAR) (dB)
- Ionosphere correction GIM (m) from CTOH
- Troposphere correction model (m) wet and dry from CTOH
- Doppler correction (m) from GDR
- Doppler slope correction (m) from GDR
- Earth tide (m) from GDR
- Ocean tide (m) from CTOH (FES2004)
- Pole tide (m) from GDR
- Tide load effect (m) from GDR
- Microwave Brightness 23.8GHz (K) from GDR
- Microwave Brightness 36.5GHz (K) from GDR

In a first stage of the ice validation process, Ice-2 parameters and corrections are computed at crossovers. Afterward, the ice validation process removes outliers by iterative cross-editing. Finaly, through a statistical sorting of valid crossovers, the valid and non-valid track are separated. In the following sections, figures present anomaly and standard derivation as a function of orbit and cycle resulting of the ice validation's cross-editing.
For more details about the validation chain just have look on the CTOH web site http://ctoh.legos.obs-mip.fr/quality-assessment/cryosphere/ice-validation-of-envisat-radar-altimetry.

[1] http://ctoh.legos.obs-mip.fr/quality-assessment/cryosphere
[2] http://ctoh.legos.obs-mip.fr/products/alongtrack-data

3 Antarctic area

3.1 Crossover validation

Here are figures of the number of crossovers at each step of the validation program.

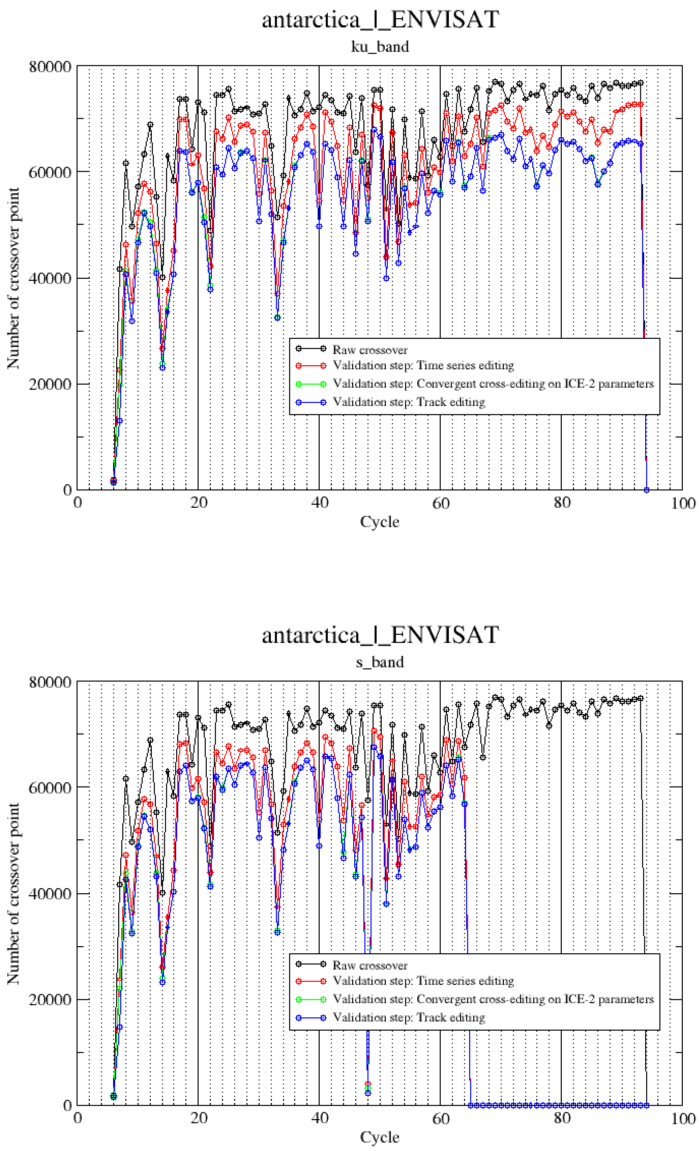


Figure 1: Crossovers number as a function of cycle (Ku band top and S band bottom)

For the ku band, the last re-processing of ENVISAT GDR (v2.1) is clearly positive.

- A large amount of crossovers are recovered in the cycle 47 and 48.
- The cyle 6, 7 and 8 had been added
- The cycles 16, 17, 18, 19, 20 and 21 have more crossovers (around of 5000 to 10000).
- In cycle 33, there are 20000 crossovers lost

For the s band, the re-processing is also a bit positive.

- There are more crossovers which pass successfully the validation process for the first 40th cycles.

- The cycle 6, 7 and 8 had been added.
- But the large amount of crossovers in the cycle 47 and 48 are definitely lost (due to witching maneuver between the altimeter A and B).
- And cycle 33, there are 20000 crossovers lost.
- Belong cycle 65, the s band is definitely lost.

All crossover points and paramters computed in this study are added of a flag of valaidation and disseminated on the CTOH web site http://ctoh.legos.obs-mip.fr/quality-assessment/crossing-points.

3.2 Validation table

The ice validation table gives a global view of the mission over Antarctica of the availability of tracks. The colour code gives the information of the major events met during the validation process (like the tracks missing, the tracks validated or not, ...).

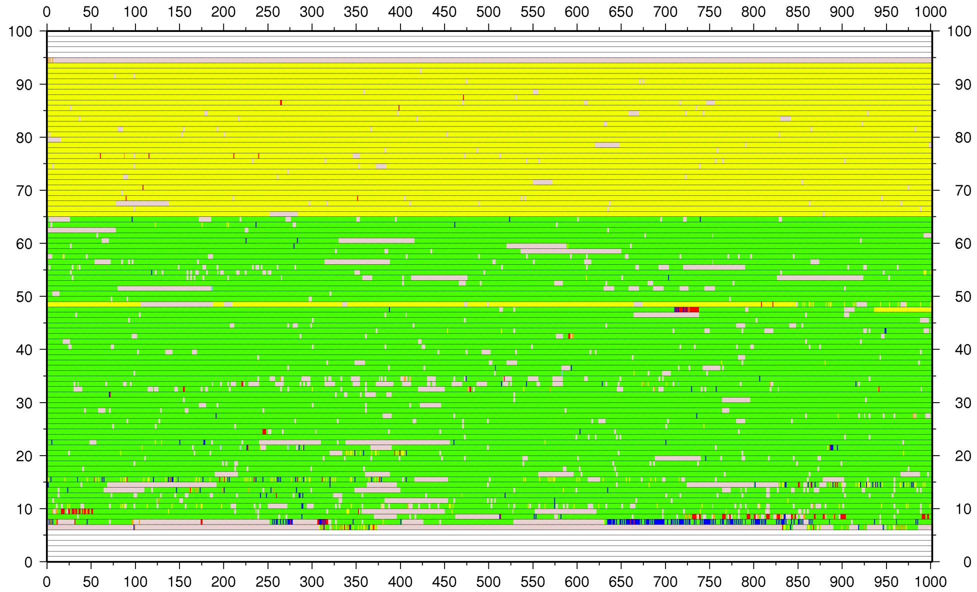


Figure 2: This table gives the state validation of the number of the track as function of the cycle of the mission. For each track and for each cycle the assessment result is given by a coding color. In green, the tracks validated simultaneously for the Ku and S band; in yellow, the tracks validated only for the Ku band; in blue, the tracks validated only for the S band; in red, the tracks none validated simultaneously for the Ku and S band; in gray the missing tracks and in white the tracks not available. This figure is available as ascii file (http://ctoh.legos.obs-mip.fr/quality-assessment/cryosphere/envisat/validation-table) and could be integrated to track selection procedure of a processing program.

From the validation table, we can see the re-processing benefice.

- Most of the tracks in ku band are recovered for cycle 48 (in yellow). The s band remains missing.
- For the cycles 6, 7 and 8 added, there are not lot of track. Most are missing (grey) in cycle 6, or partially edited (blue) for ku band in cycle 7, or definitely edited (red) in cycle 8.
- After the cycle 65 the s band is missing just remains the ku band (yellow).

3.3 Overview of main problems

In the following sections, it is presented all the output plots of the ice validation. Here are listed the problems detected for this quality assessment.

- **Dry troposphere correction:** We have noted a jump in the RMS anomaly at cycle 44 (section 3.3.6). The re-processing (v2.1) does not solve the previous jump problem. This correction remains bad. This problem had been investigated for the previous processing and the report is available on the CTOH web site. Base on these conclusions, an alternaltive correction is currently computed and it will be available by the end of 2012.

- **Doppler slope correction:** is now better. The shift of 30 km in the DEM is now corrected for this re-processing. But this correction remains unreliable on the coast and in the mountain areas due to nadir problem.This problem had been investigated for this re-processing (v2.1) and the report is available on the CTOH web site.Base on these conclusions, an alternaltive correction is currently computed and it will be available by the end of 2012.

- **USO:** Now very well integrated and already applied to the range.

- **ICE-2 parmeters:** ICE-2 parmeters:We had passed carefully in review each ICE-2 parameters to check their behaviors. For this GDR data release v2.1 no particular events had occurred. We would like just warm the users about the understanding the validation results of these parameters. In section 3.3.5, we can see for the ICE-2 parameters the RMS of the anomaly definitely change after cycle 60. In section 3.3.3, we also note for all the anomalies having like an amazing trend. And whatever the band. We had investigated it and it appears that the phenomena is in link with the orbit control of the mission. Before the cycle 60, the orbit drift seems to have been less binding than after. All the details of this phenomena is studied in a report available on the CTOH web site.

CTOH web site: http://ctoh.legos.obs-mip.fr/quality-assessment/cryosphere/envisat/particular-investigations.

3.3.1 ICE-2 parameters: Anomaly versus orbit

These figures are obtained from validated data

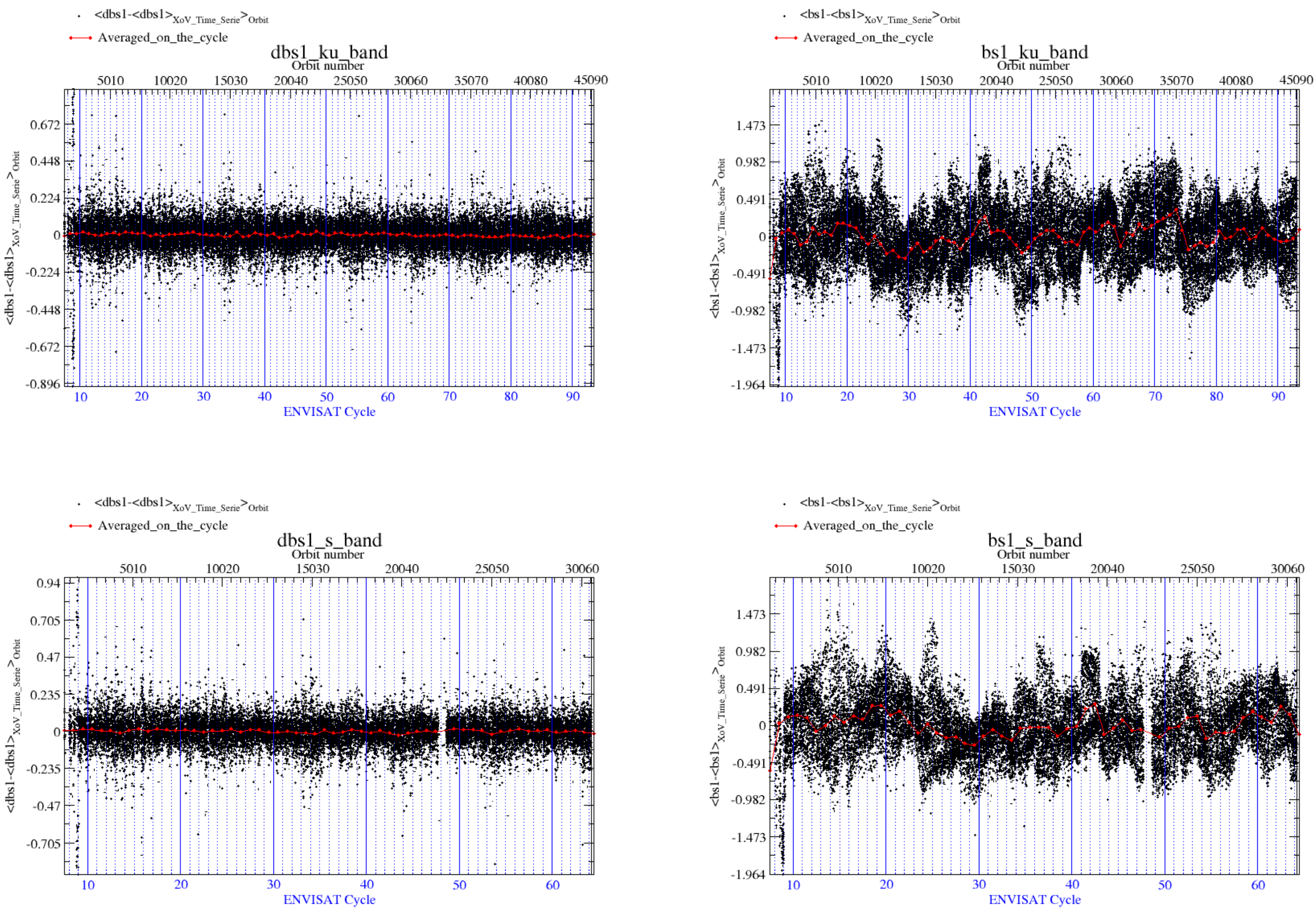


Figure 3: Backscatter anomaly (dB) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

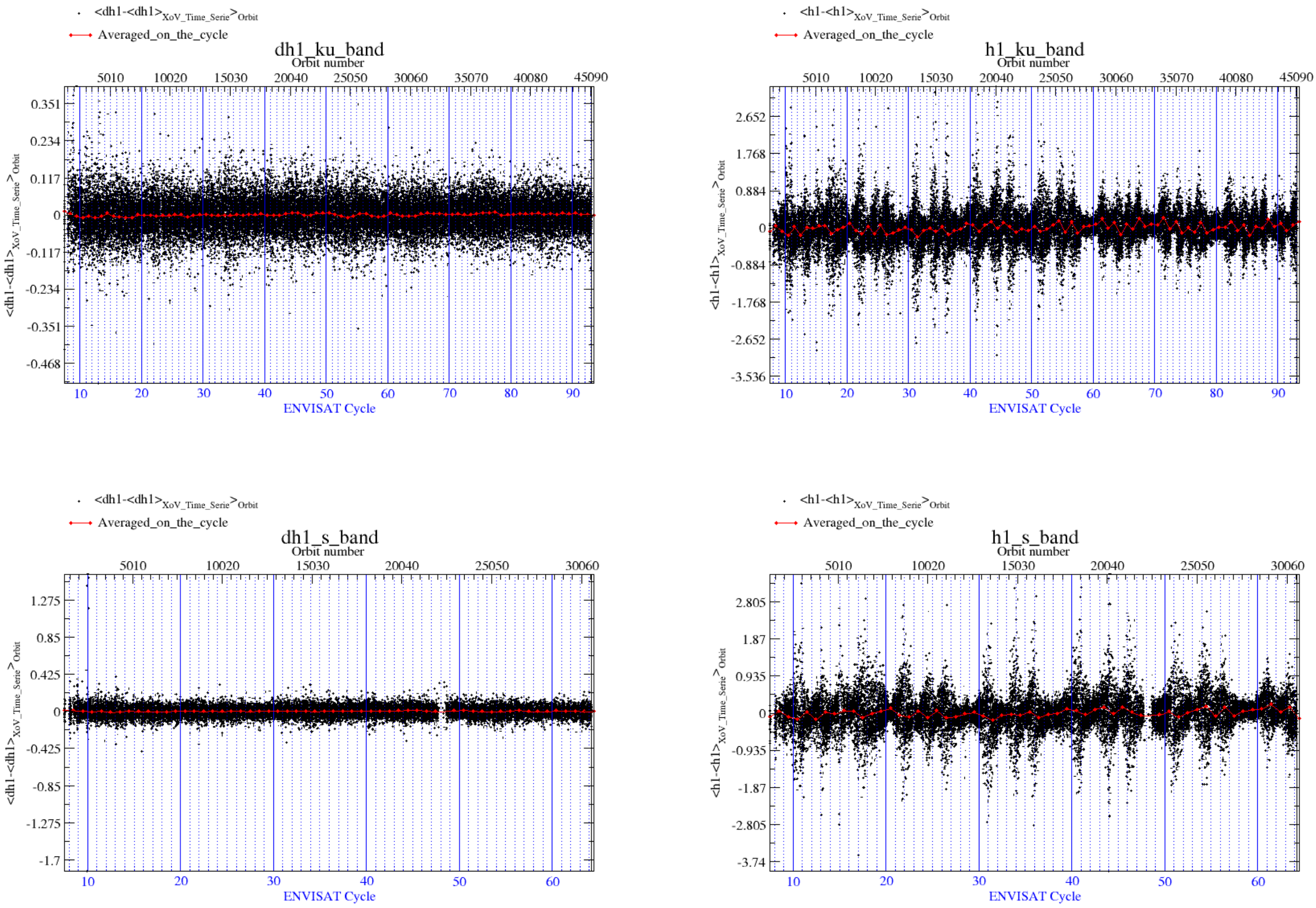


Figure 4: Surface height anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

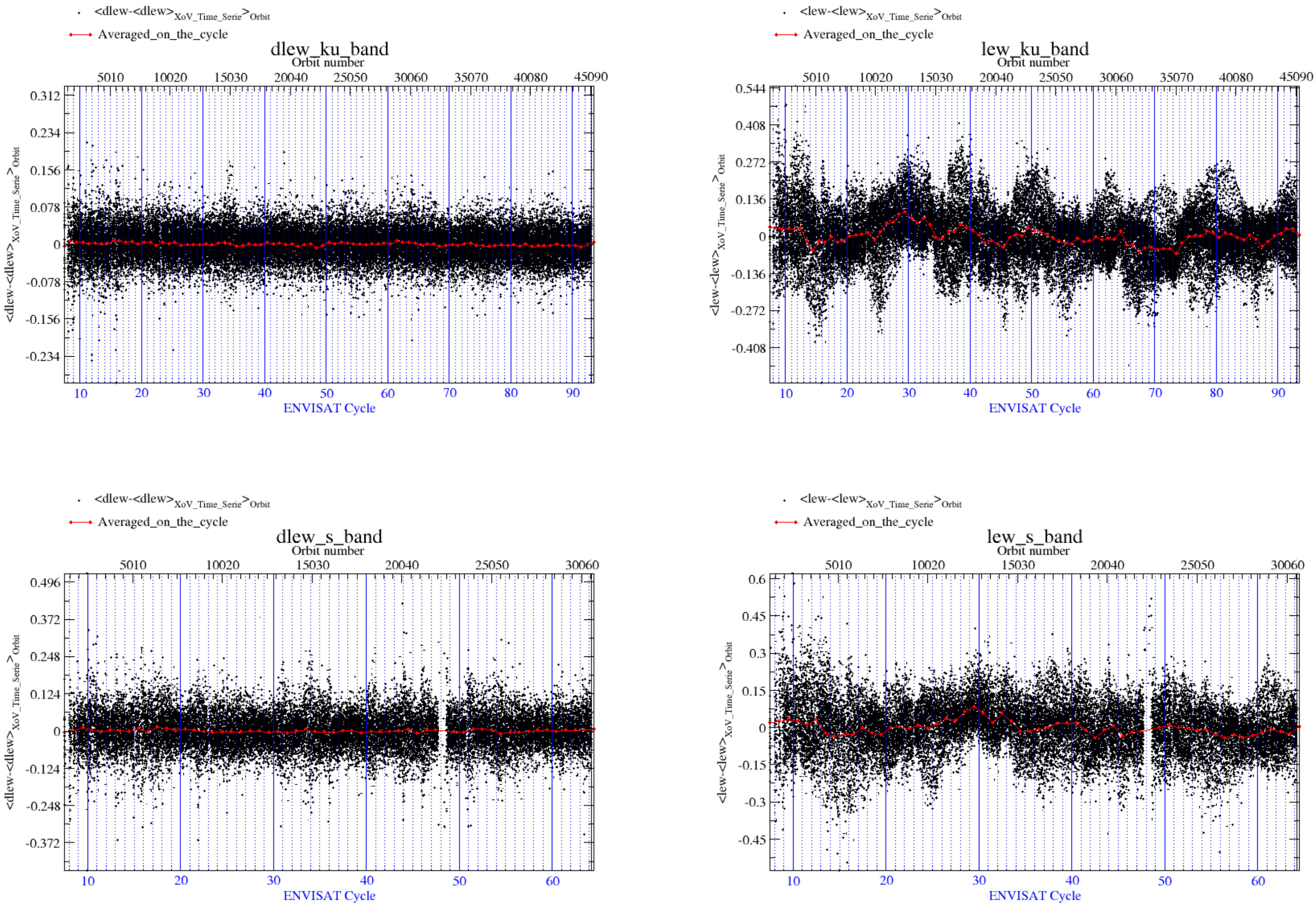


Figure 5: Leading edge width anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

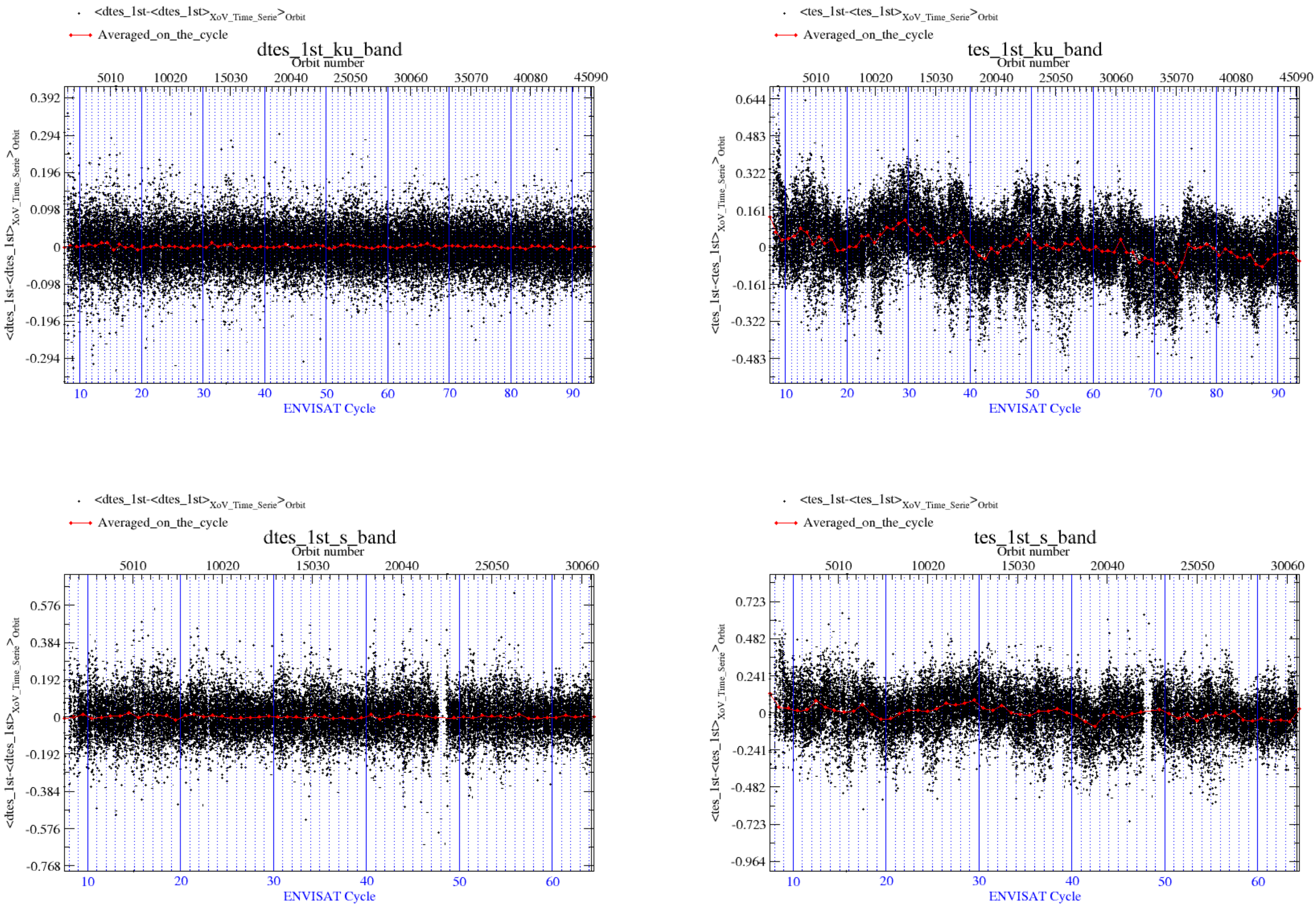


Figure 6: Trailing edge slope anomaly (10-6 s-1) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

3.3.2 Corrections: Anomaly versus orbit

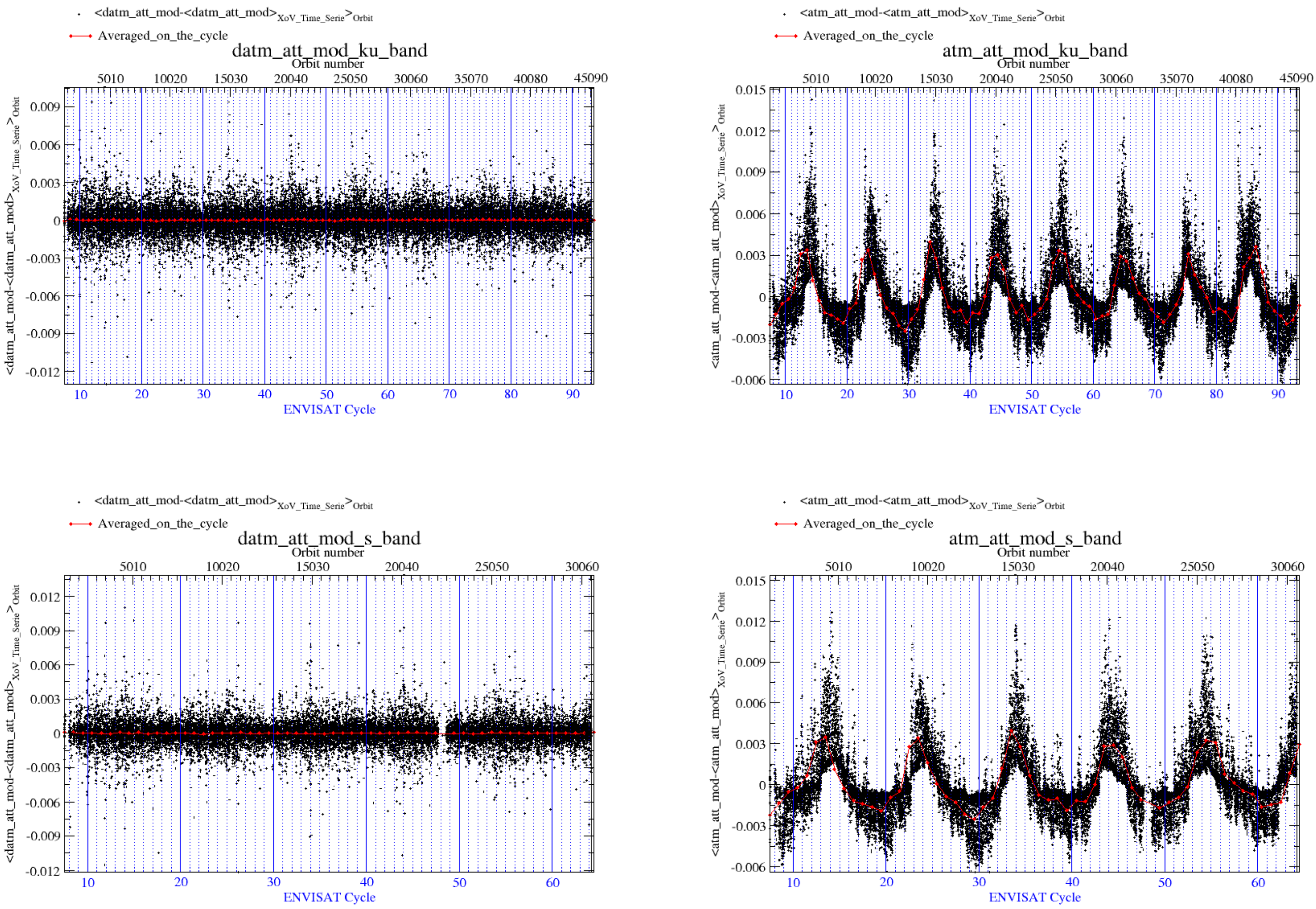


Figure 7: Atmospheric attenuation correction anomaly (dB) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

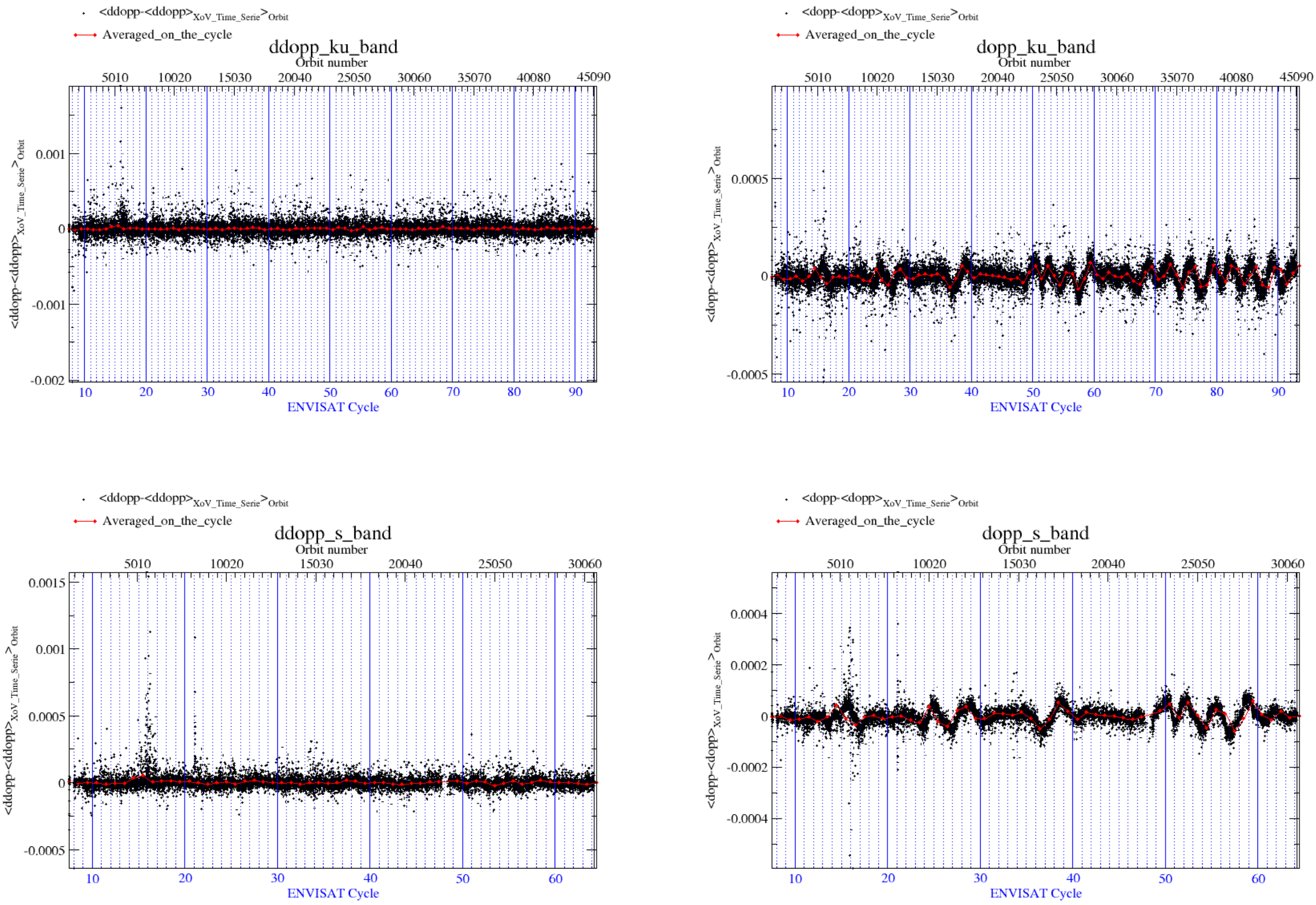


Figure 8: Doppler correction anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

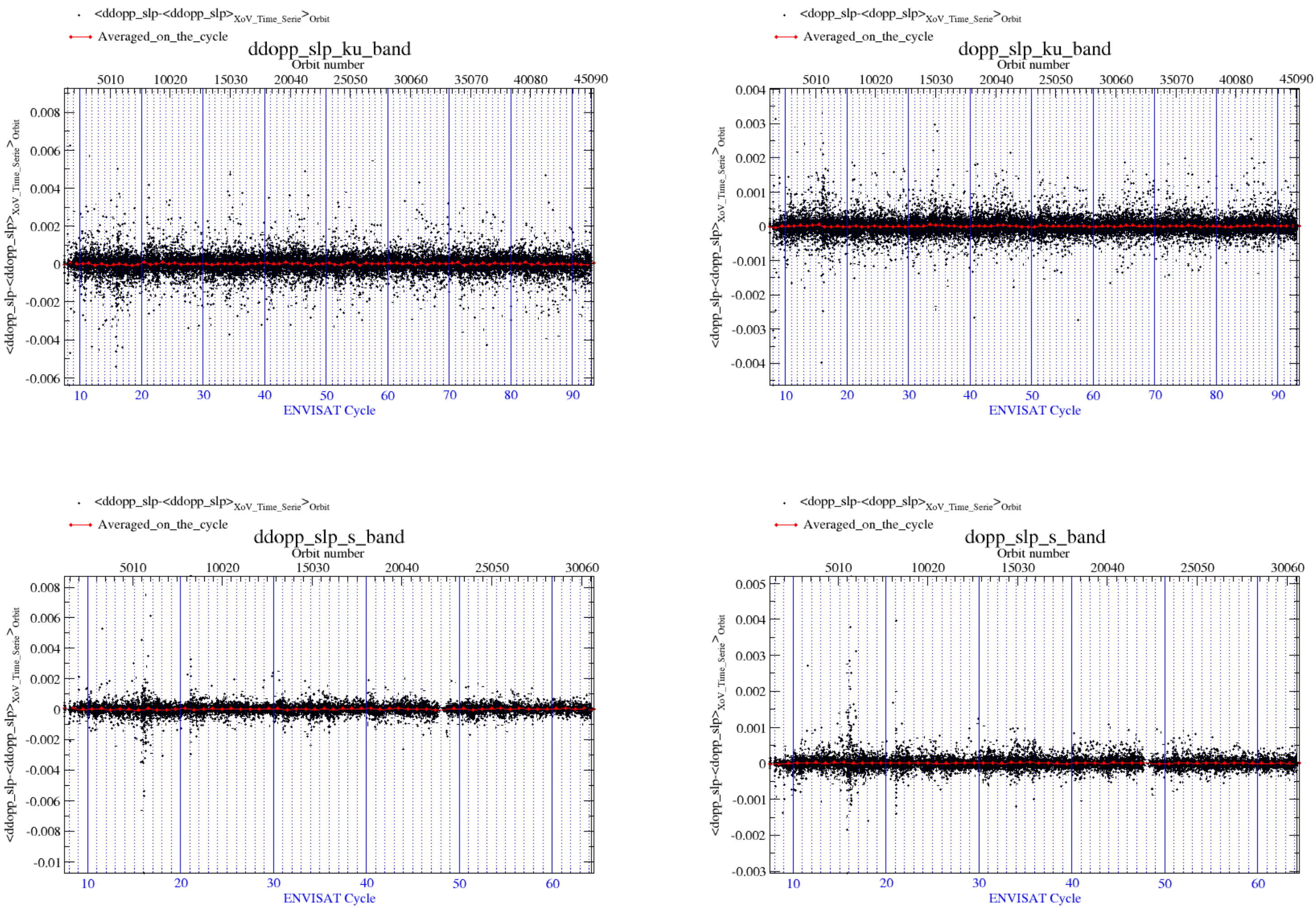


Figure 9: Doppler slope correction anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

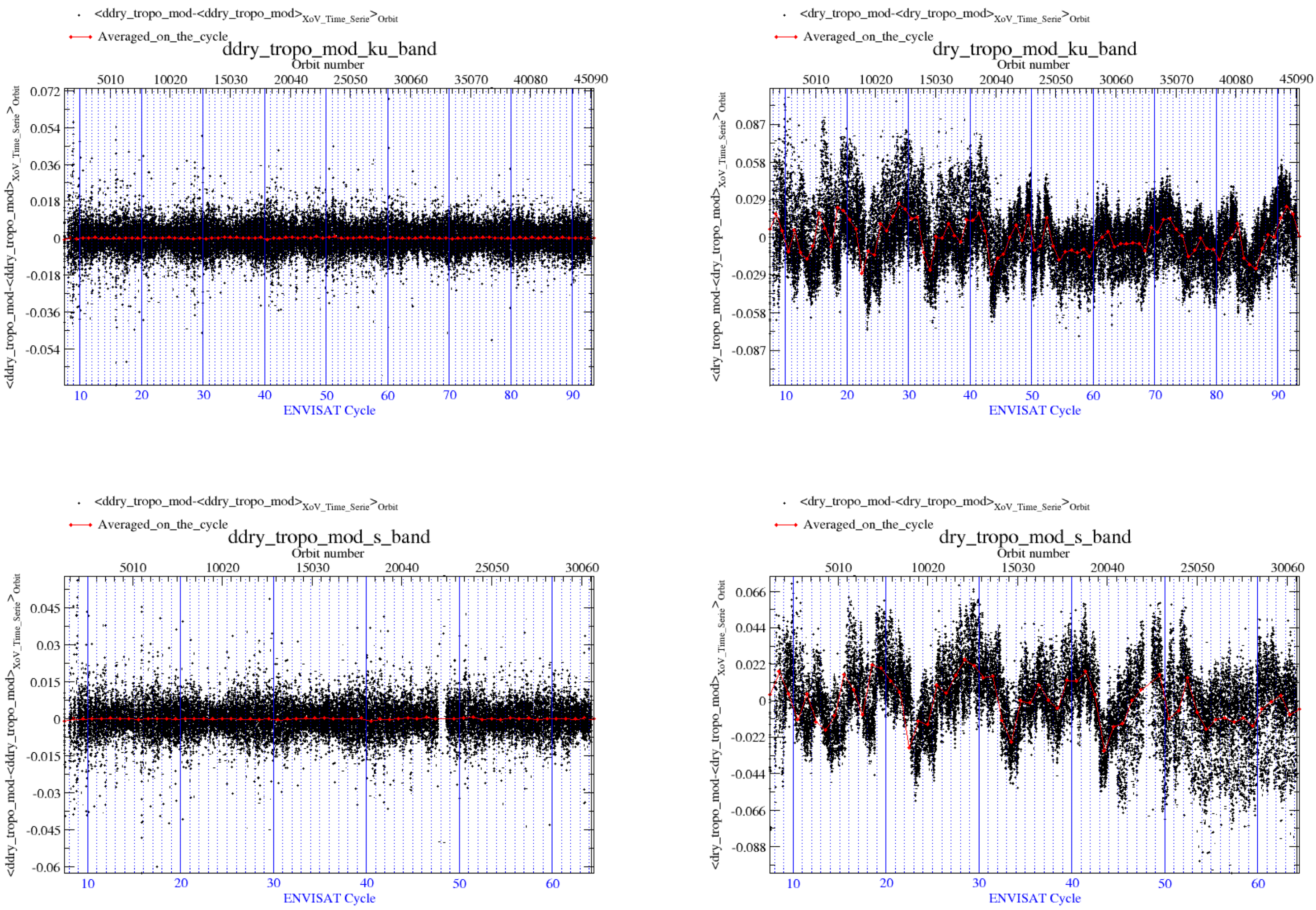


Figure 10: Dry troposphere correction anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

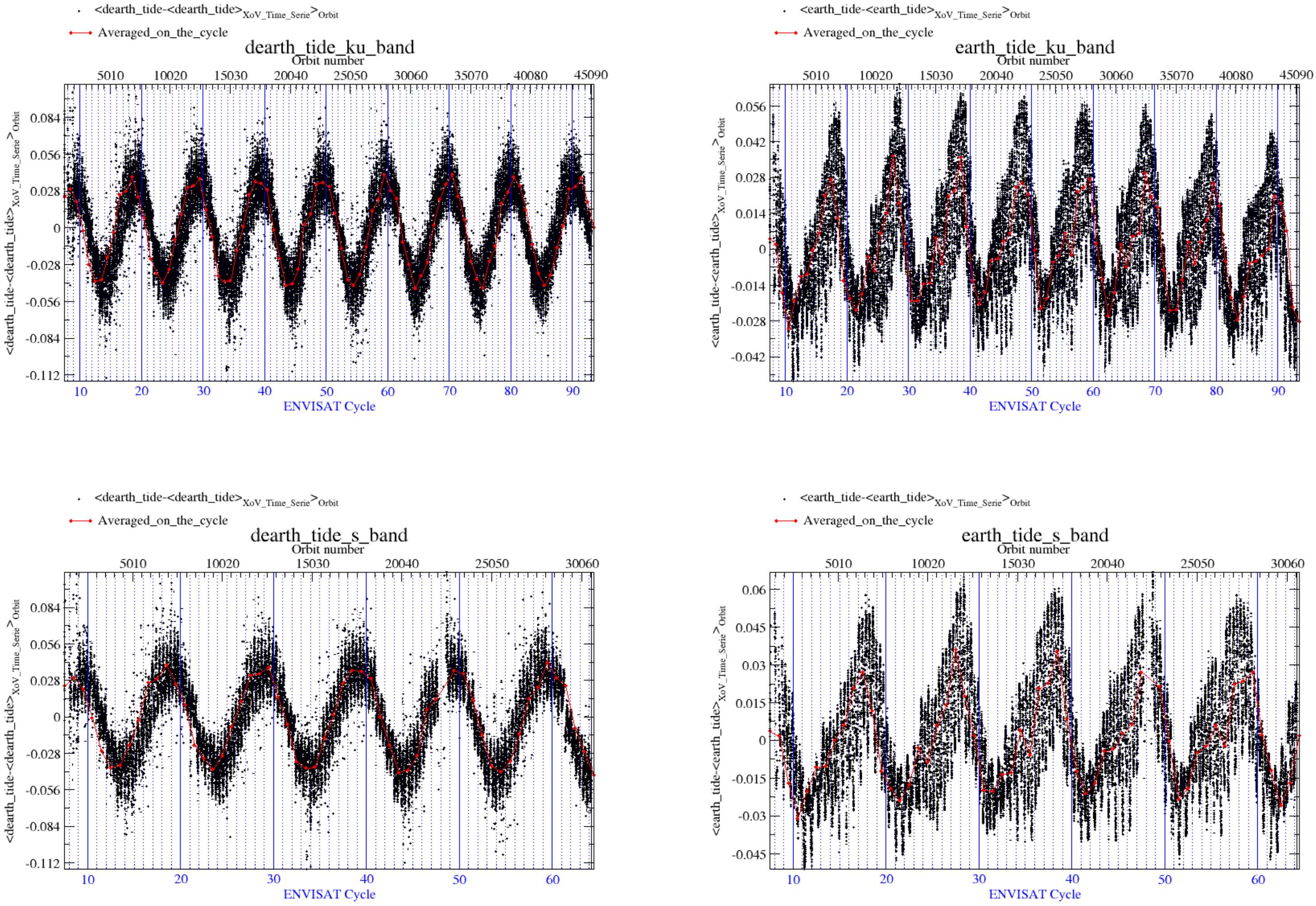


Figure 11: Earth tide correction anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

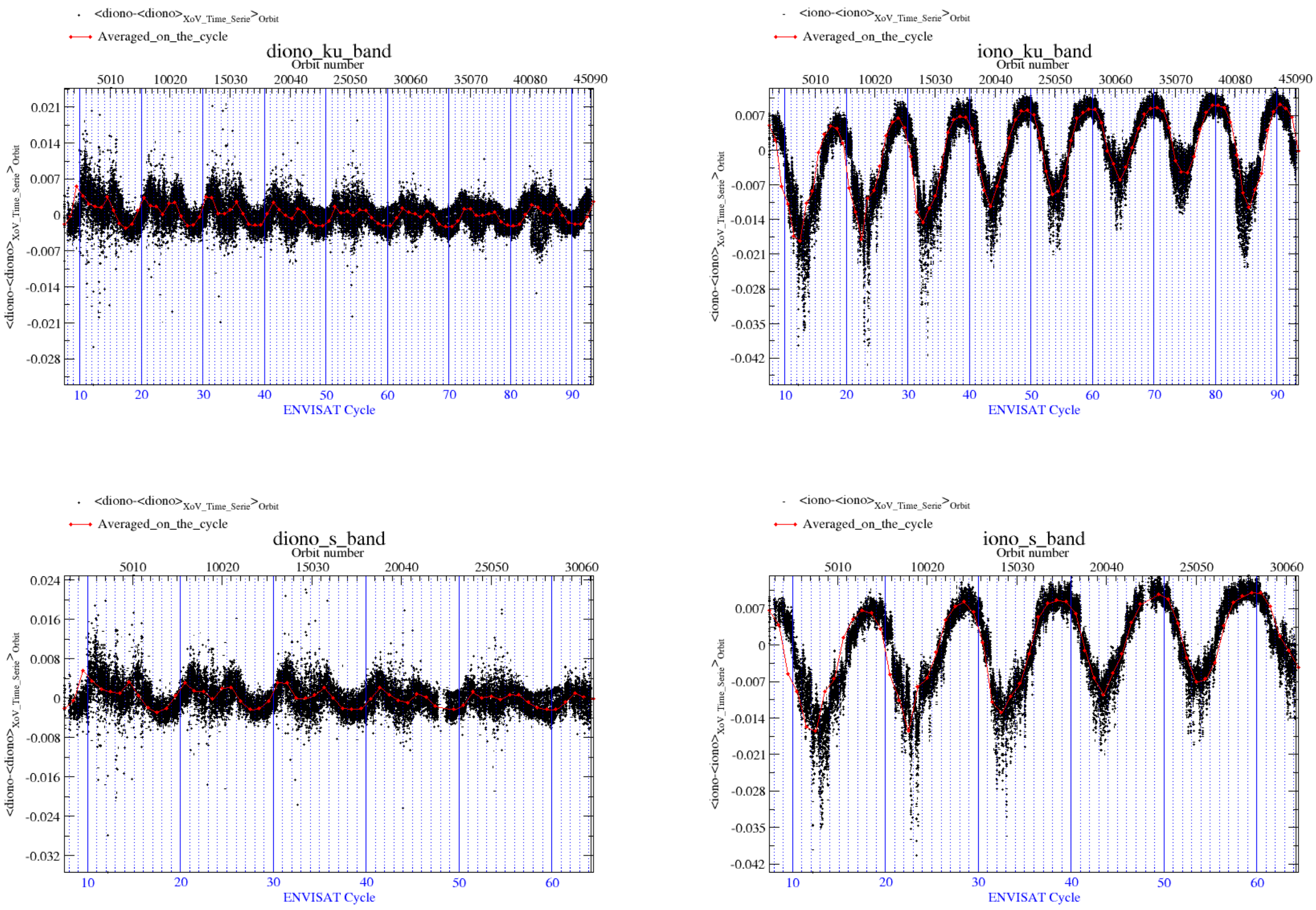


Figure 12: Ionospheric correction anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

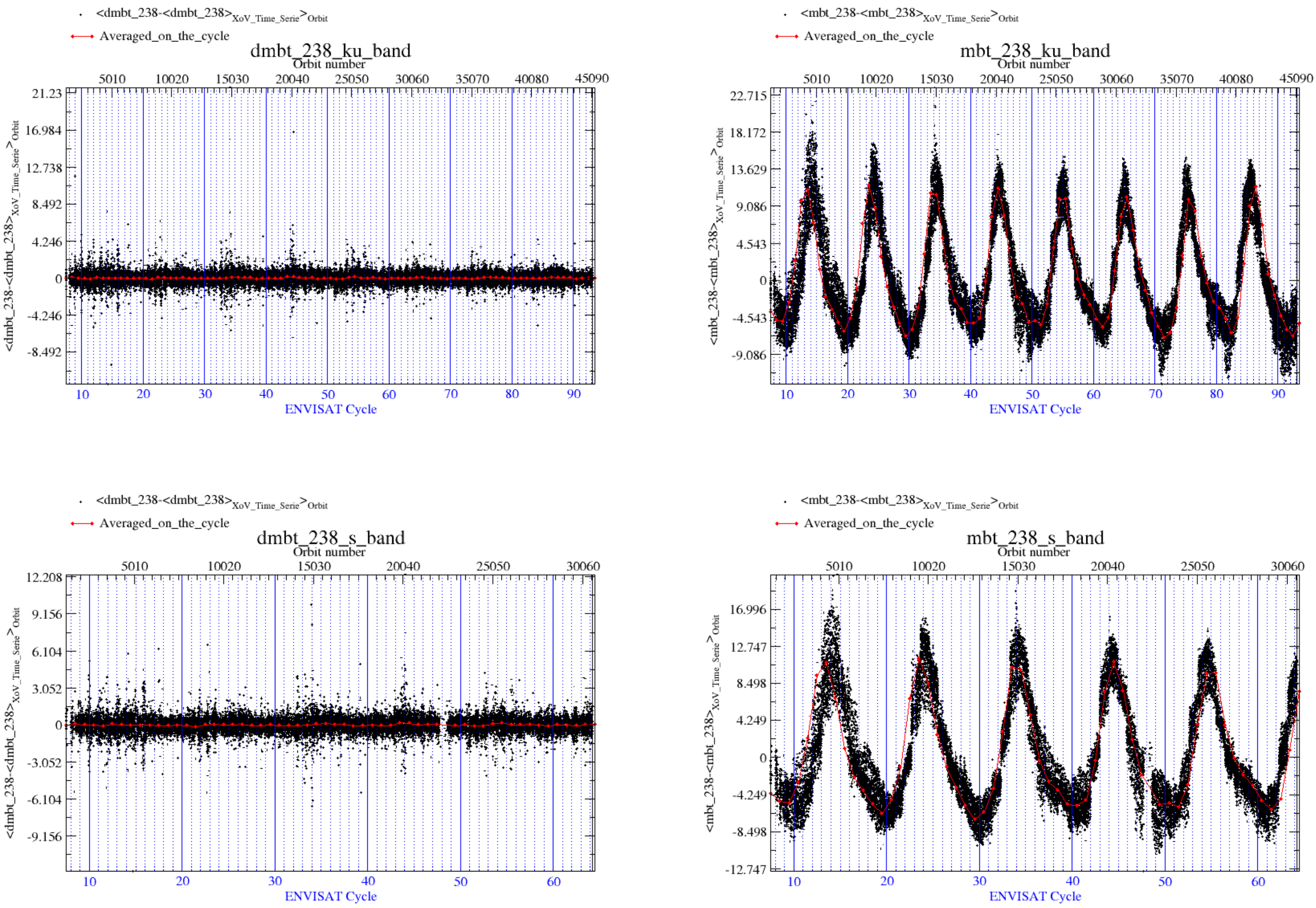


Figure 13: Microwave Brightness Temperature 23.8 GHz anomaly (K) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

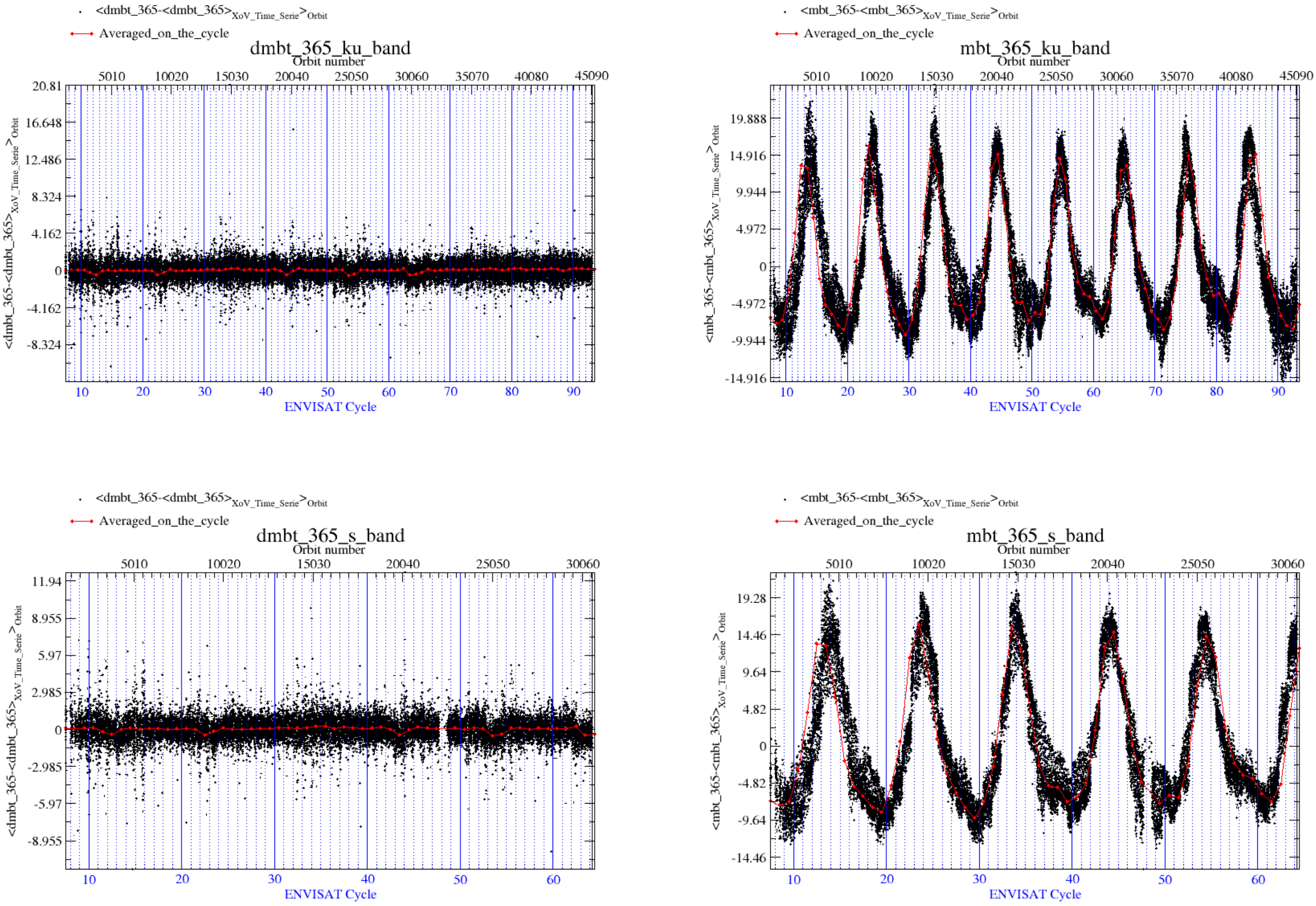


Figure 14: Microwave Brightness Temperature 36.5 GHz anomaly (K) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

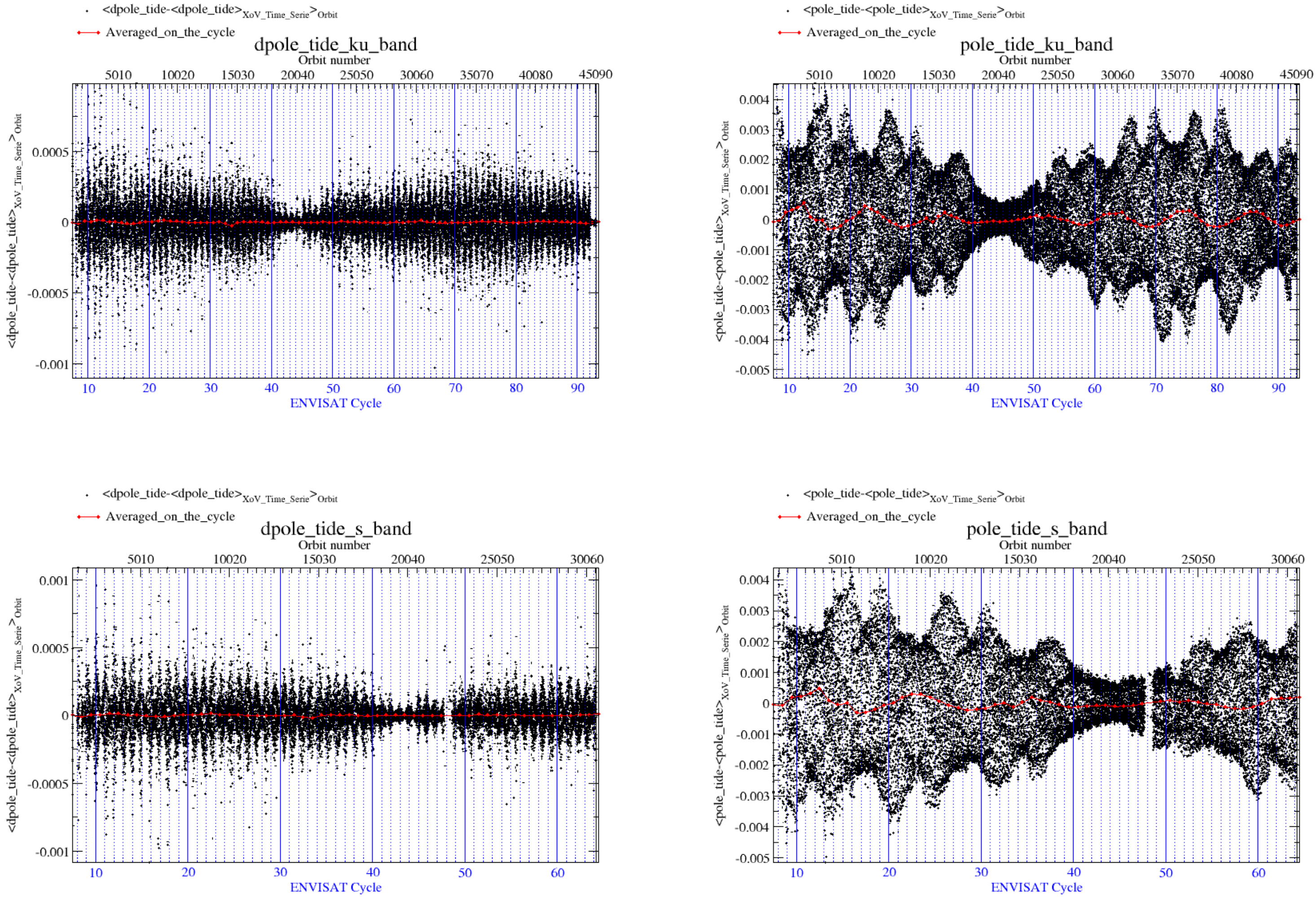


Figure 15: Pole tide anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

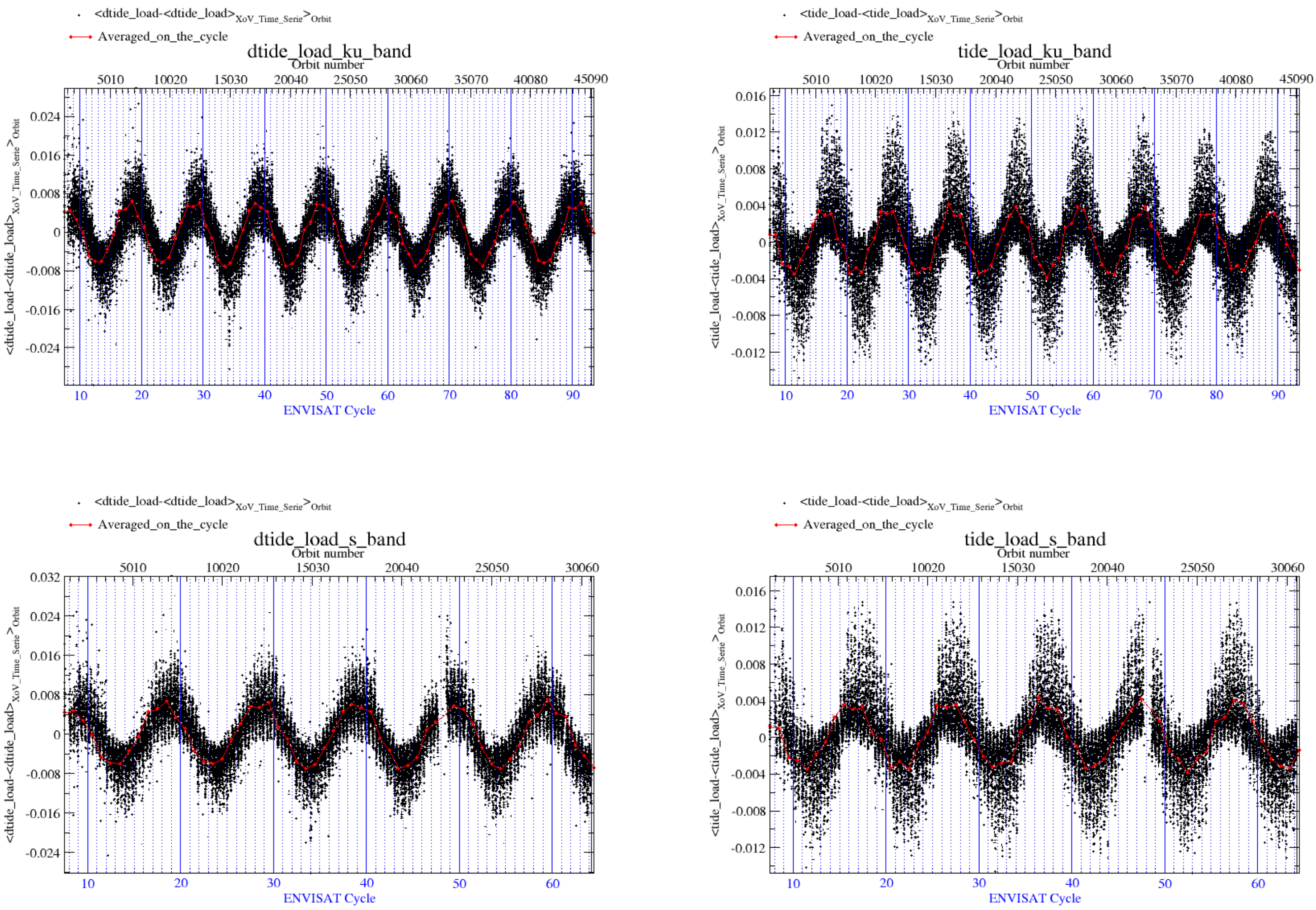


Figure 16: Tide load anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

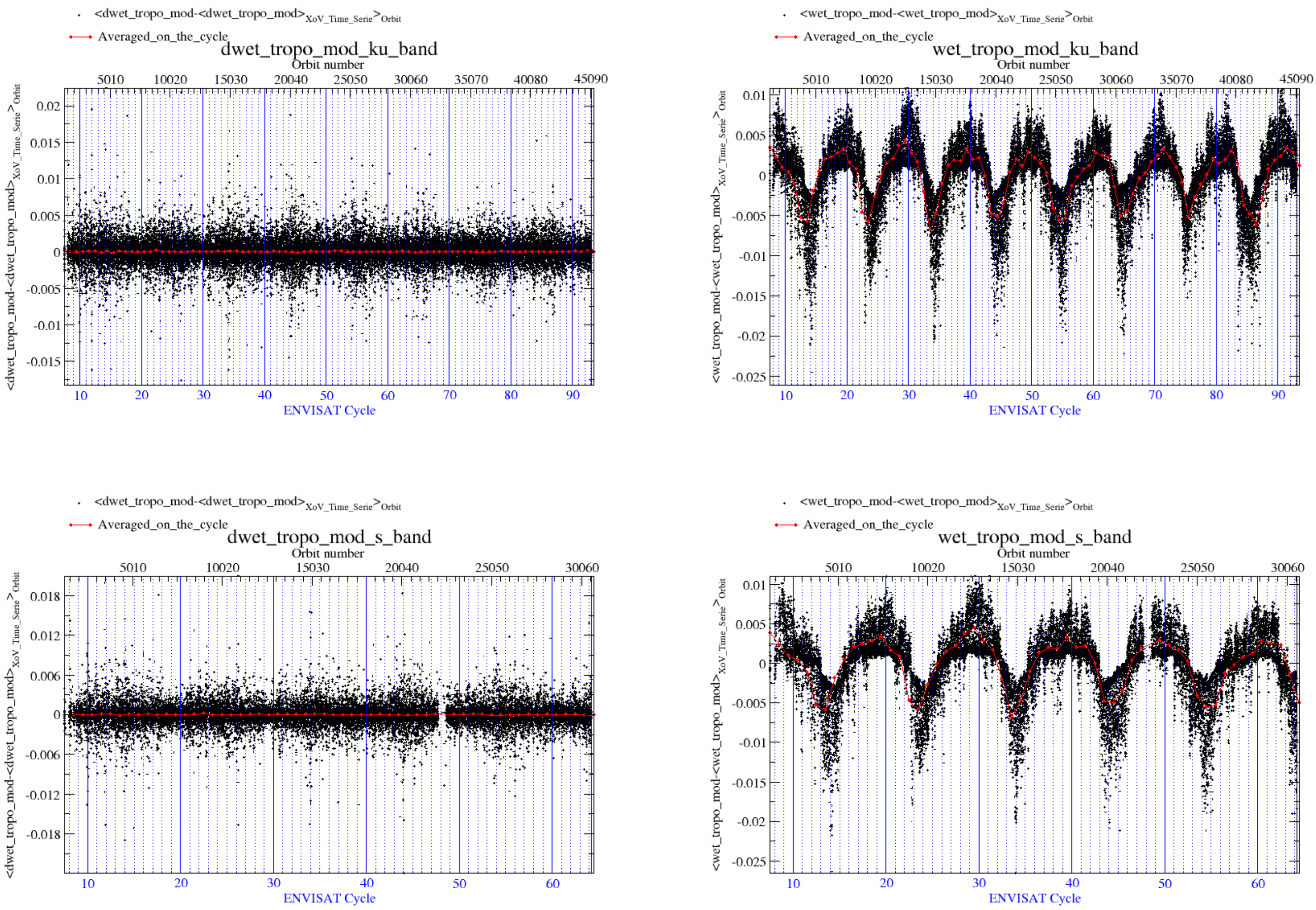


Figure 17: Wet tropospheric correction anomaly (m) for Ku (top) and S (down) band for each orbit over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

3.3.3 ICE-2 parameters: Anomaly versus cycle

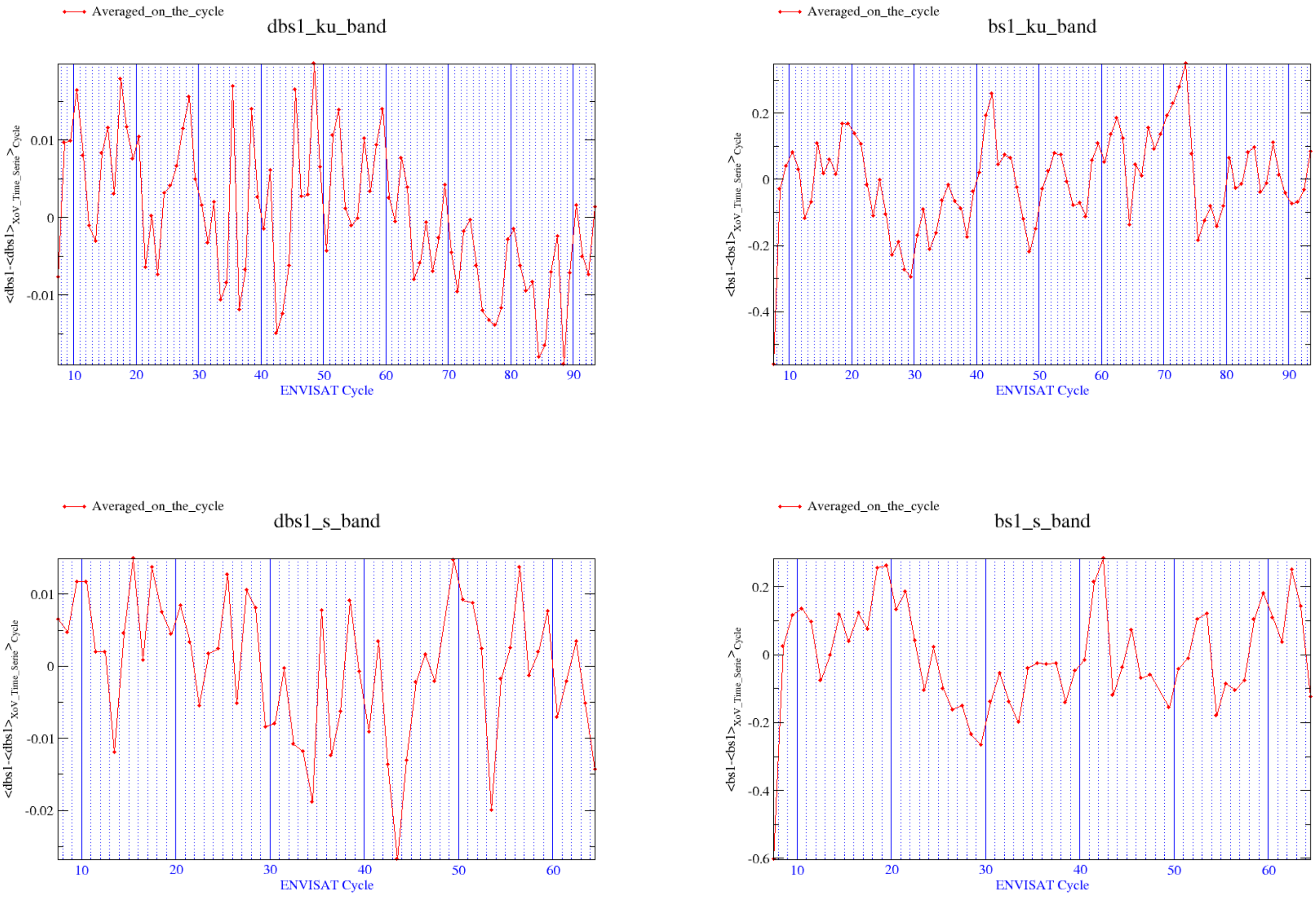


Figure 18: Backscatter anomaly (dB) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

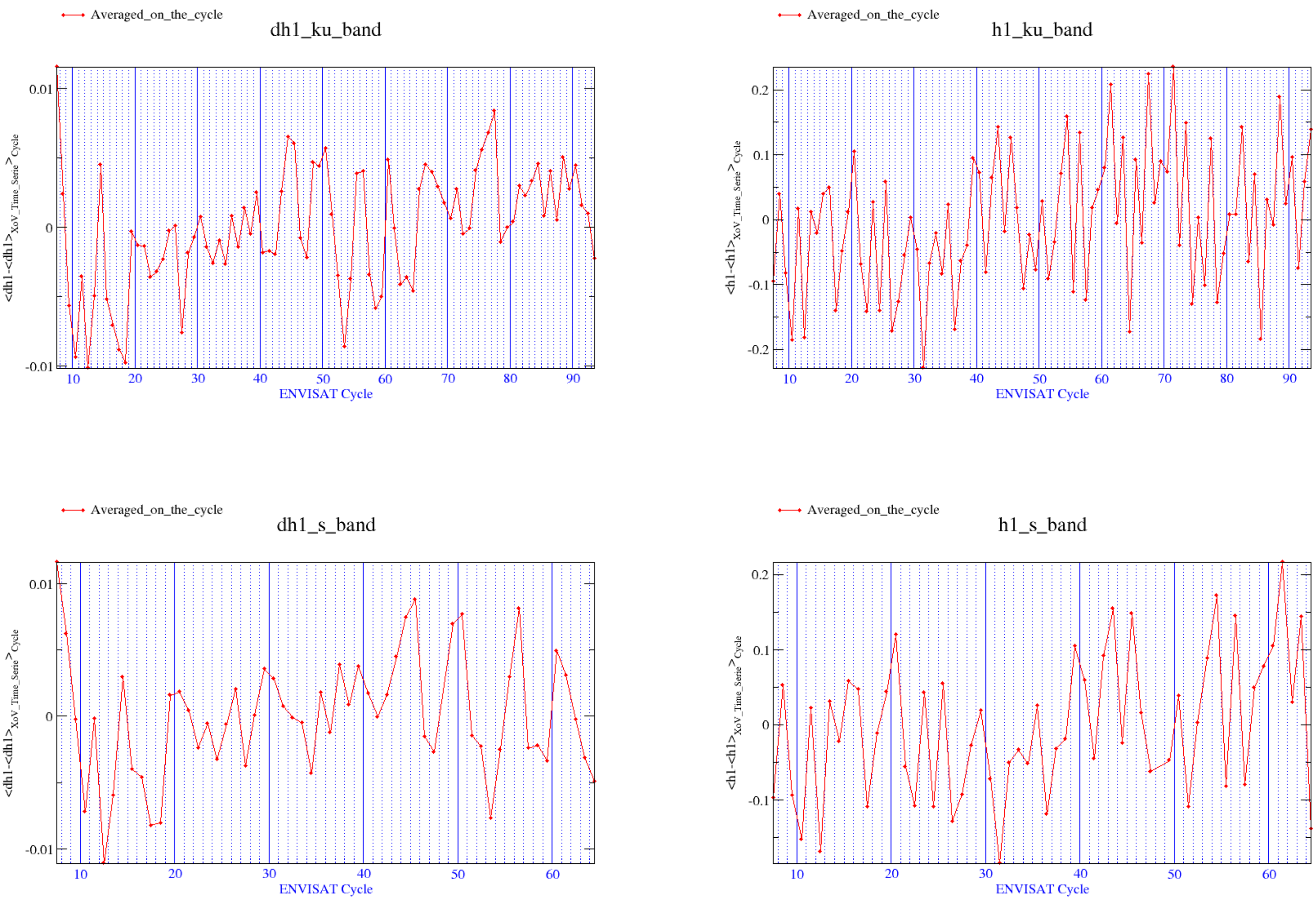


Figure 19: Surface slope anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

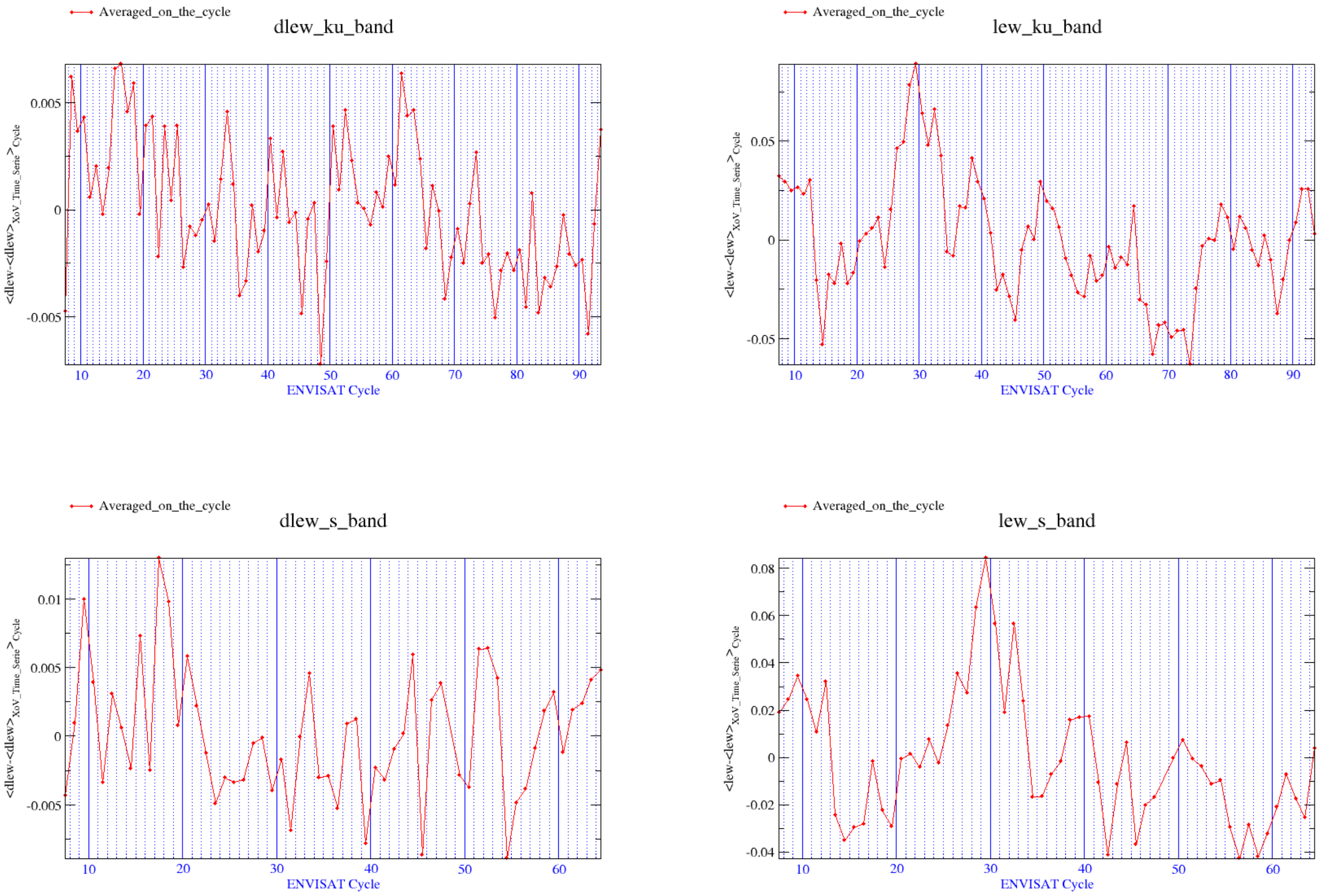


Figure 20: Leading edge width anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

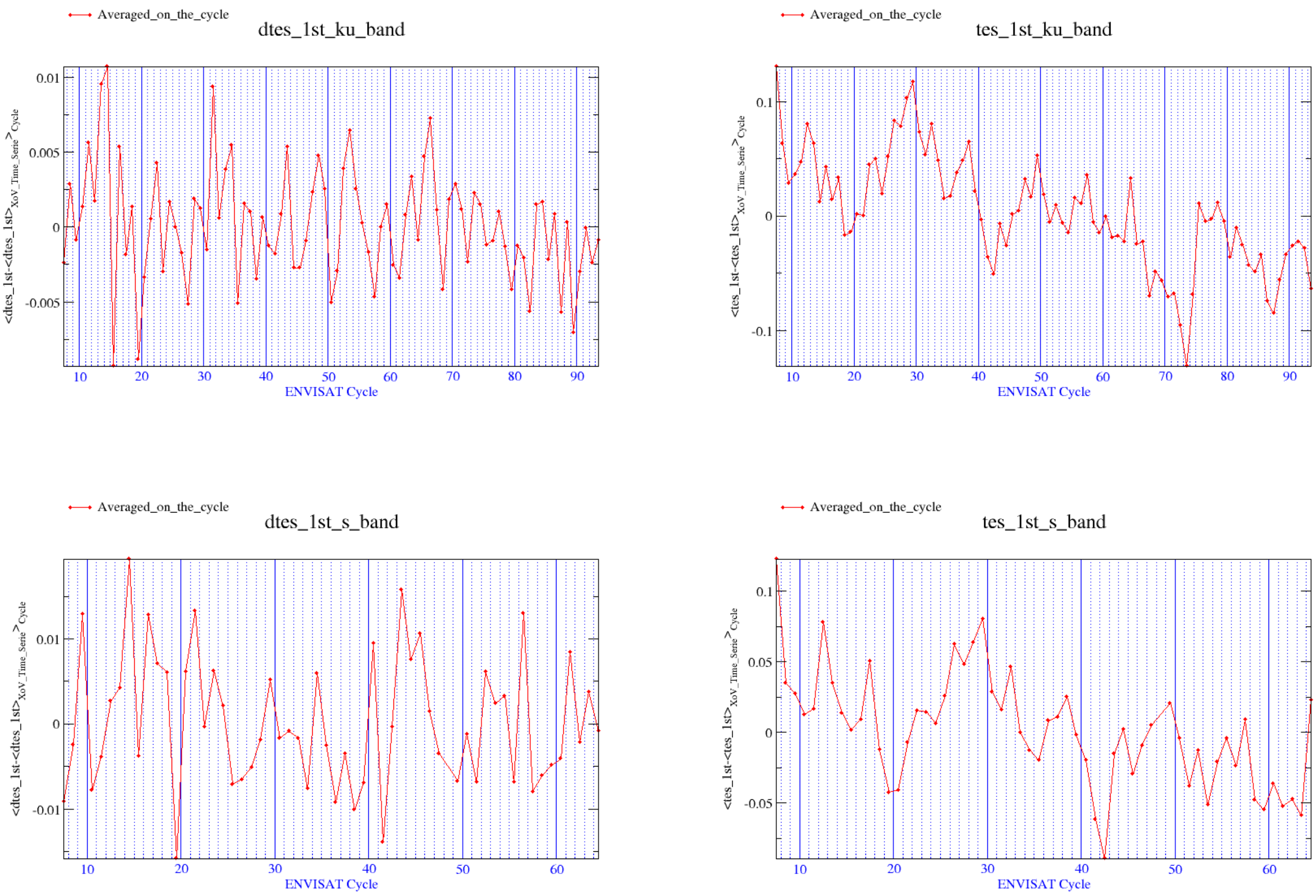


Figure 21: Trealing edge slope anomaly (10-6 s-1) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

3.3.4 Corrections: Anomaly versus cycle

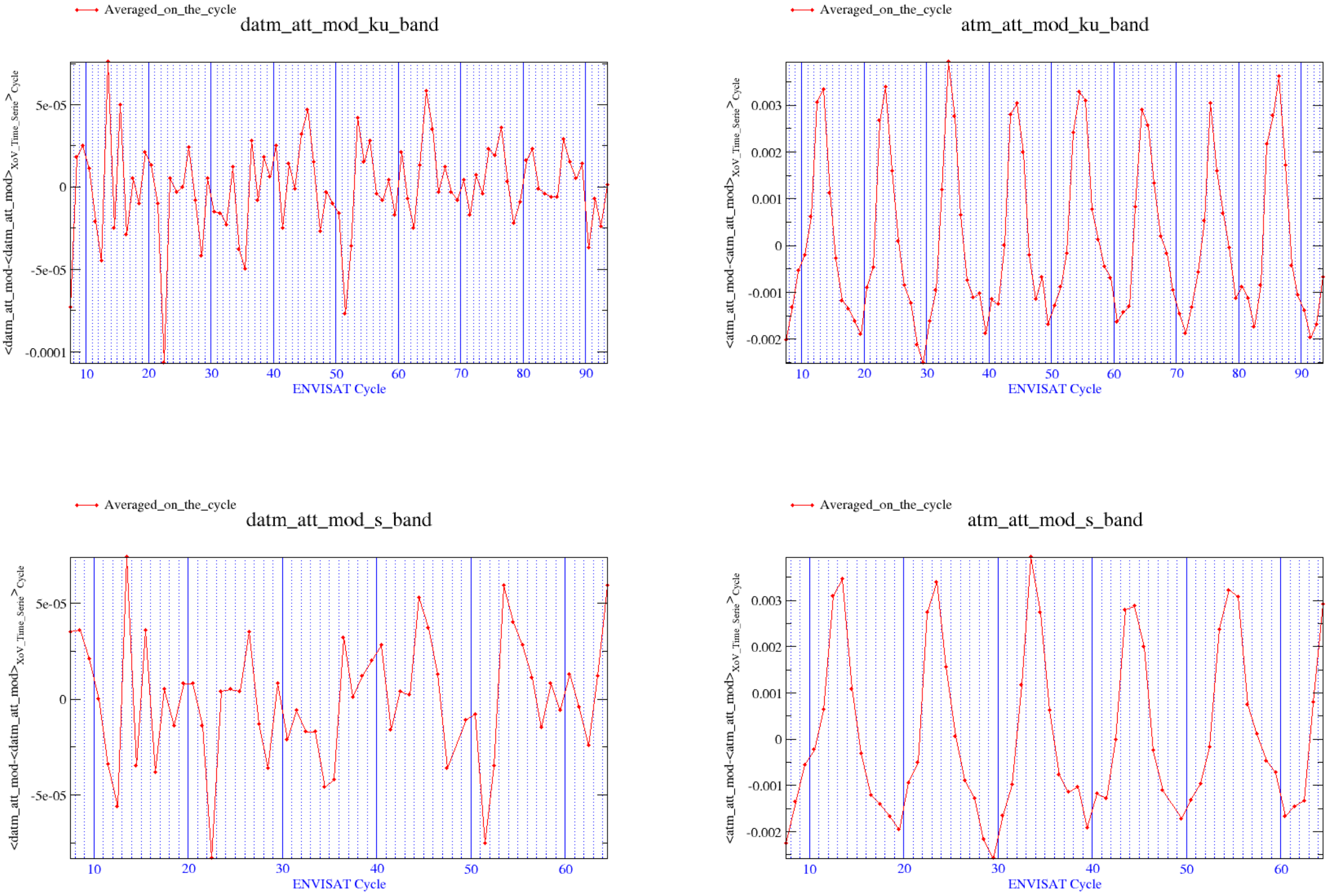


Figure 22: Atmospheric attenuation correction anomaly (dB) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

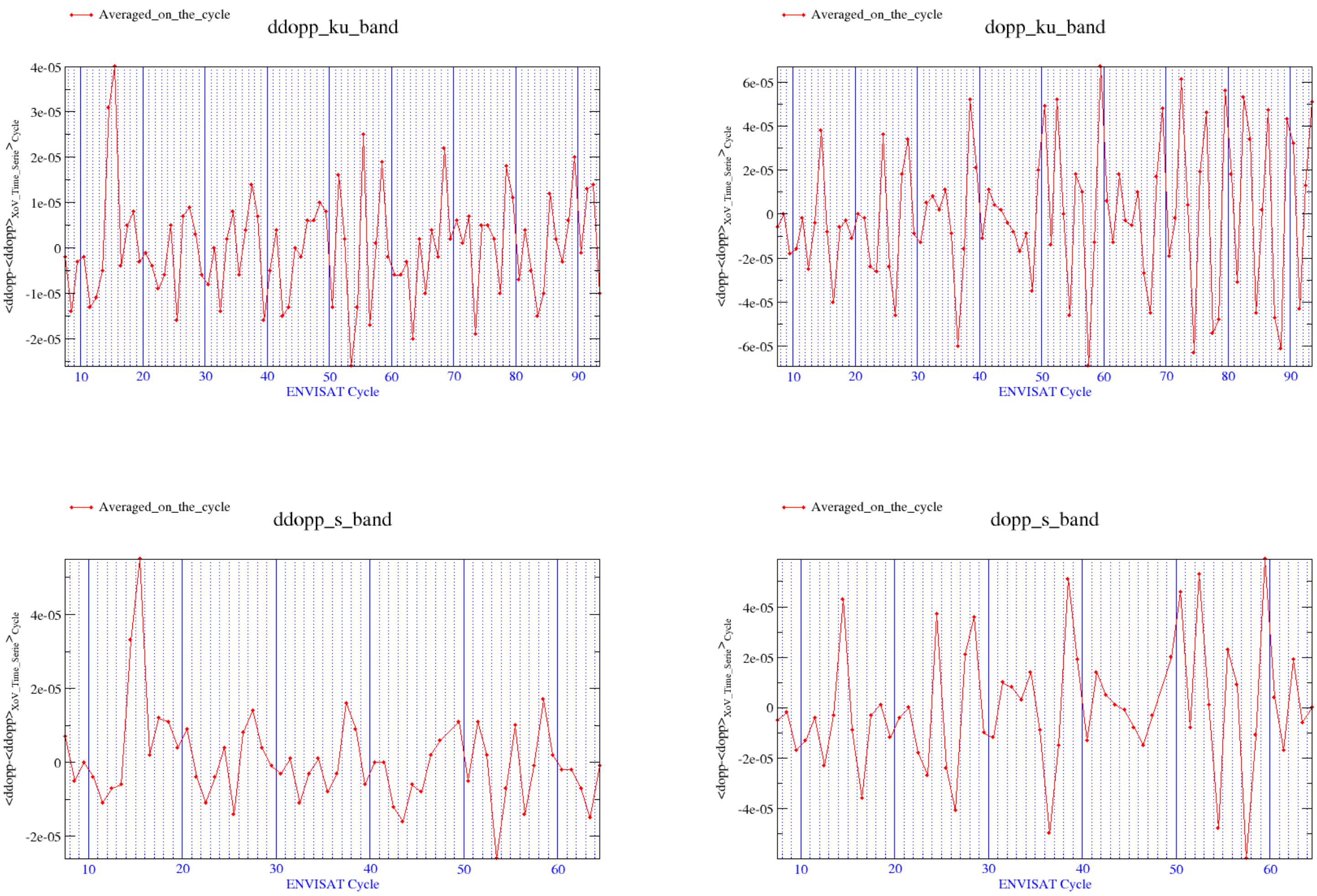


Figure 23: Doppler correction anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

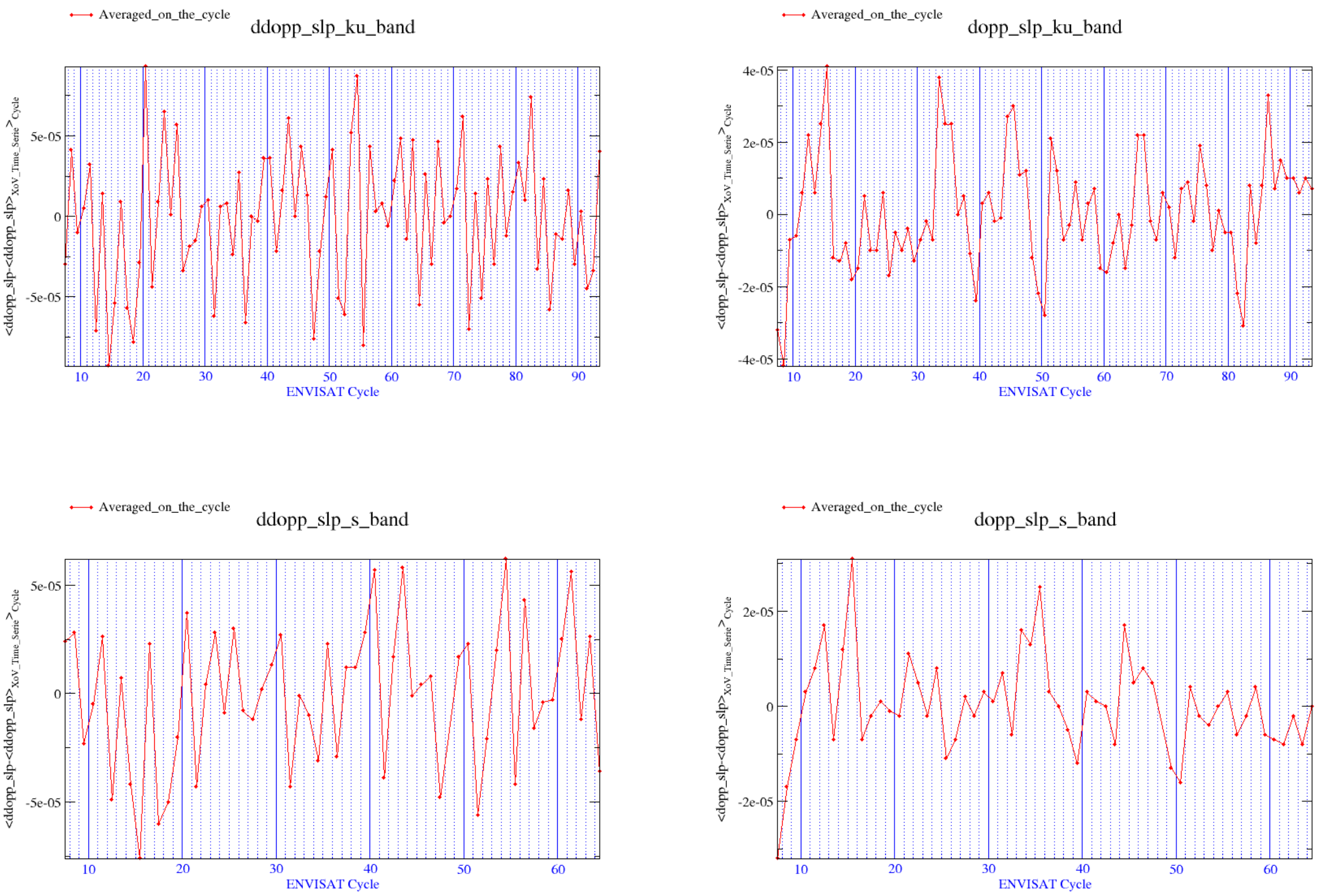


Figure 24: Doppler slope correction anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

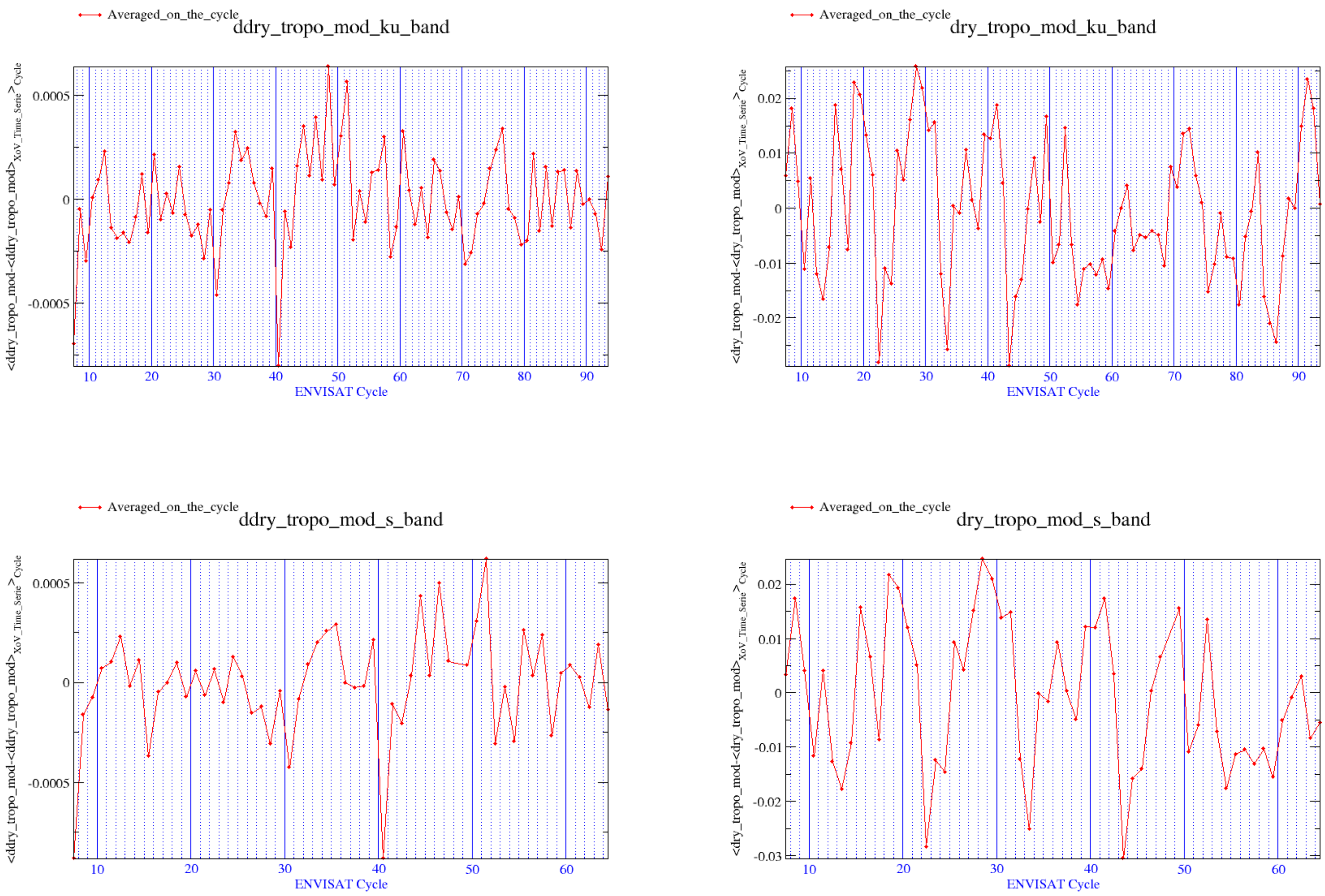


Figure 25: Dry tropospheric correction anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

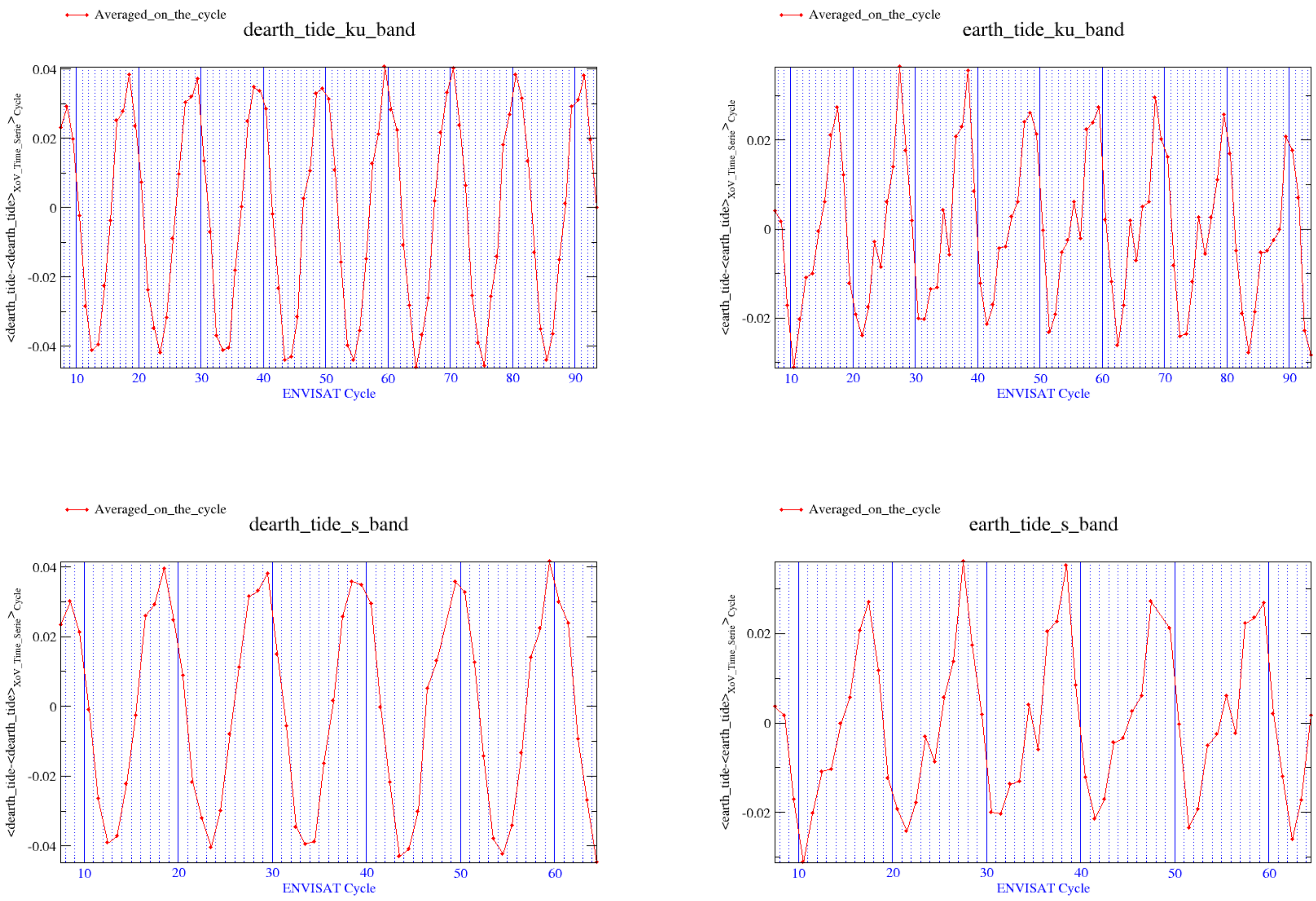


Figure 26: Earth tide anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

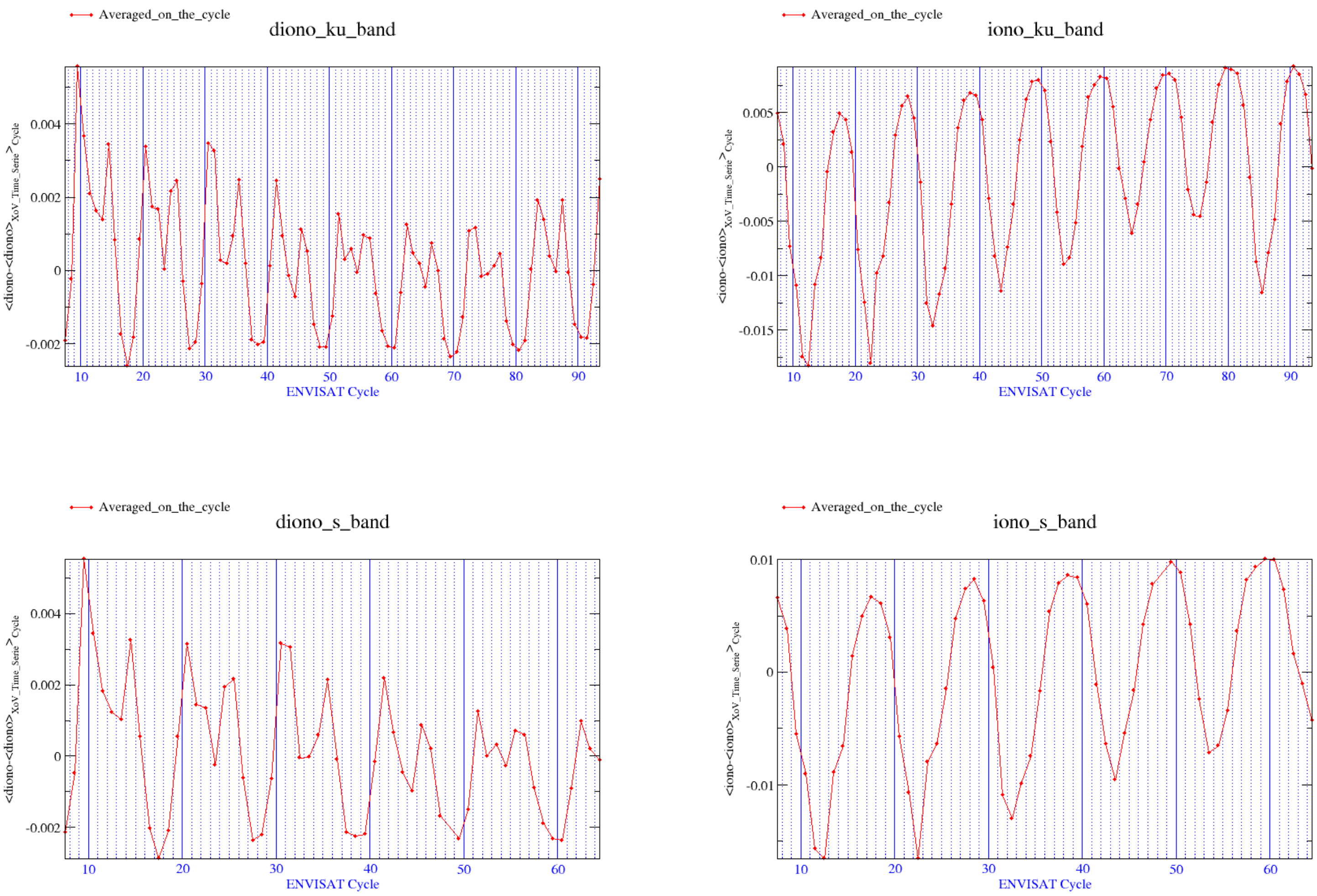


Figure 27: Ionospheric correction anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

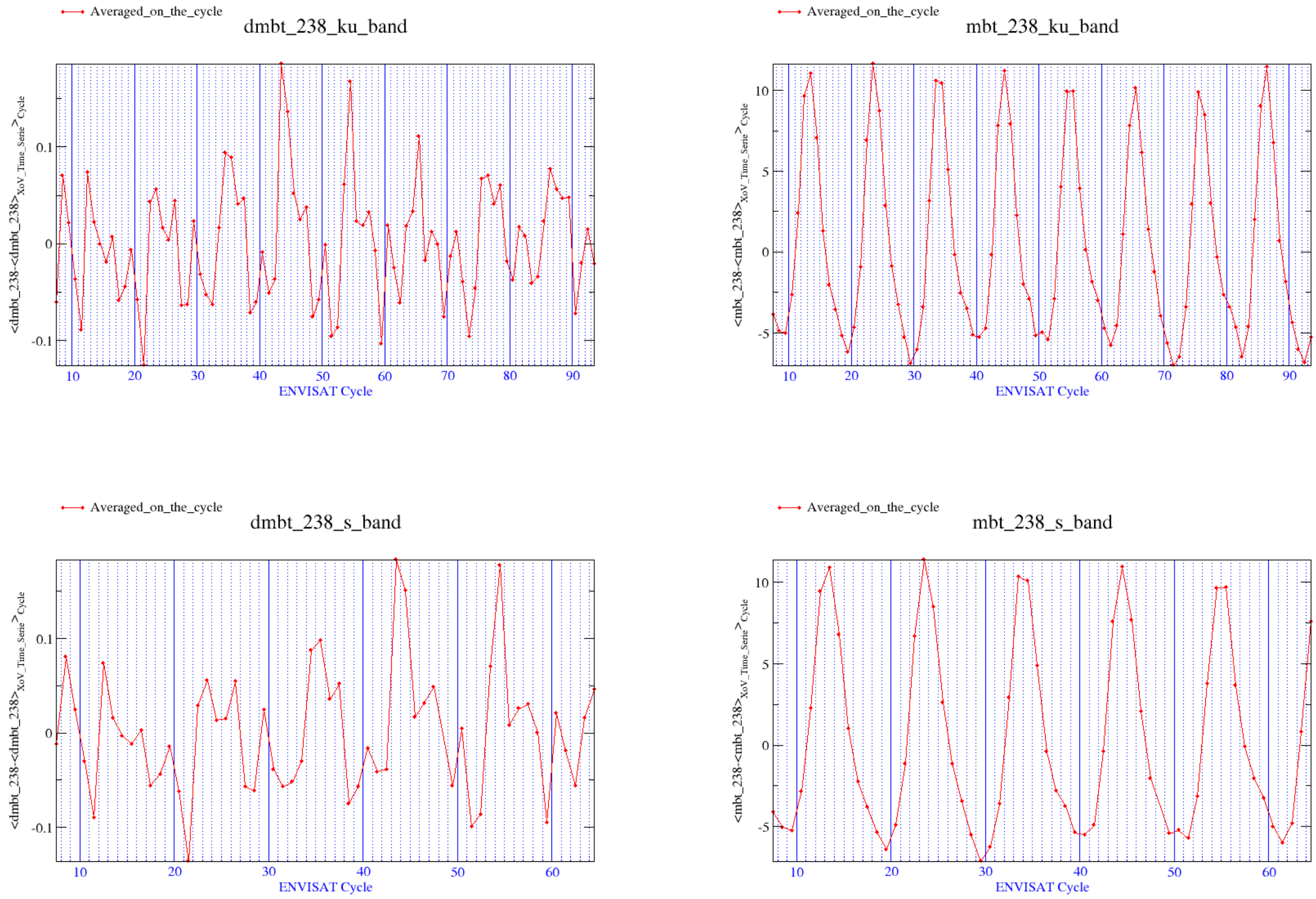


Figure 28: Microwave Brightness Temperature 23.8 GHz anomaly (K) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

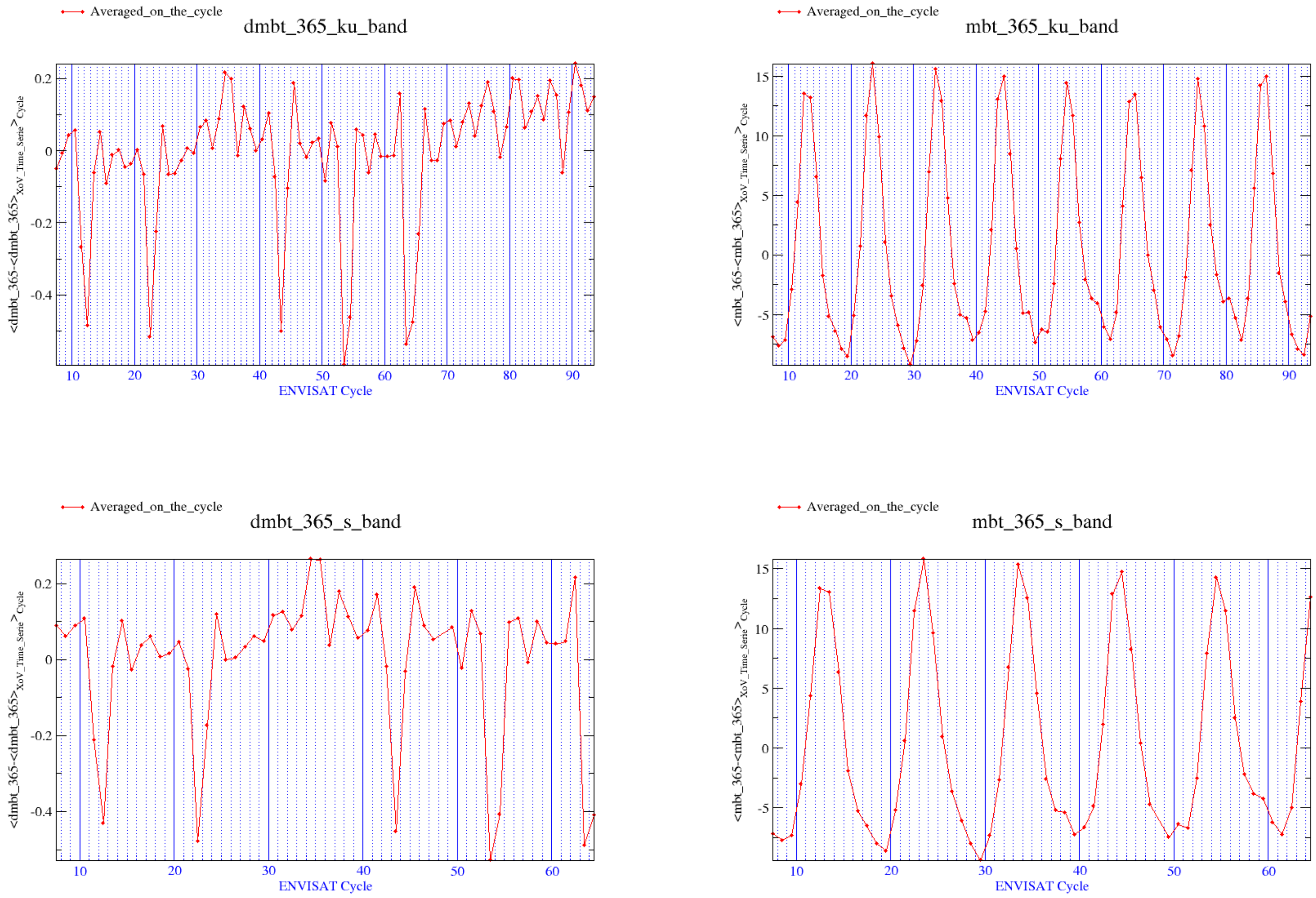


Figure 29: Microwave Brightness Temperature 36.5 GHz anomaly (K) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

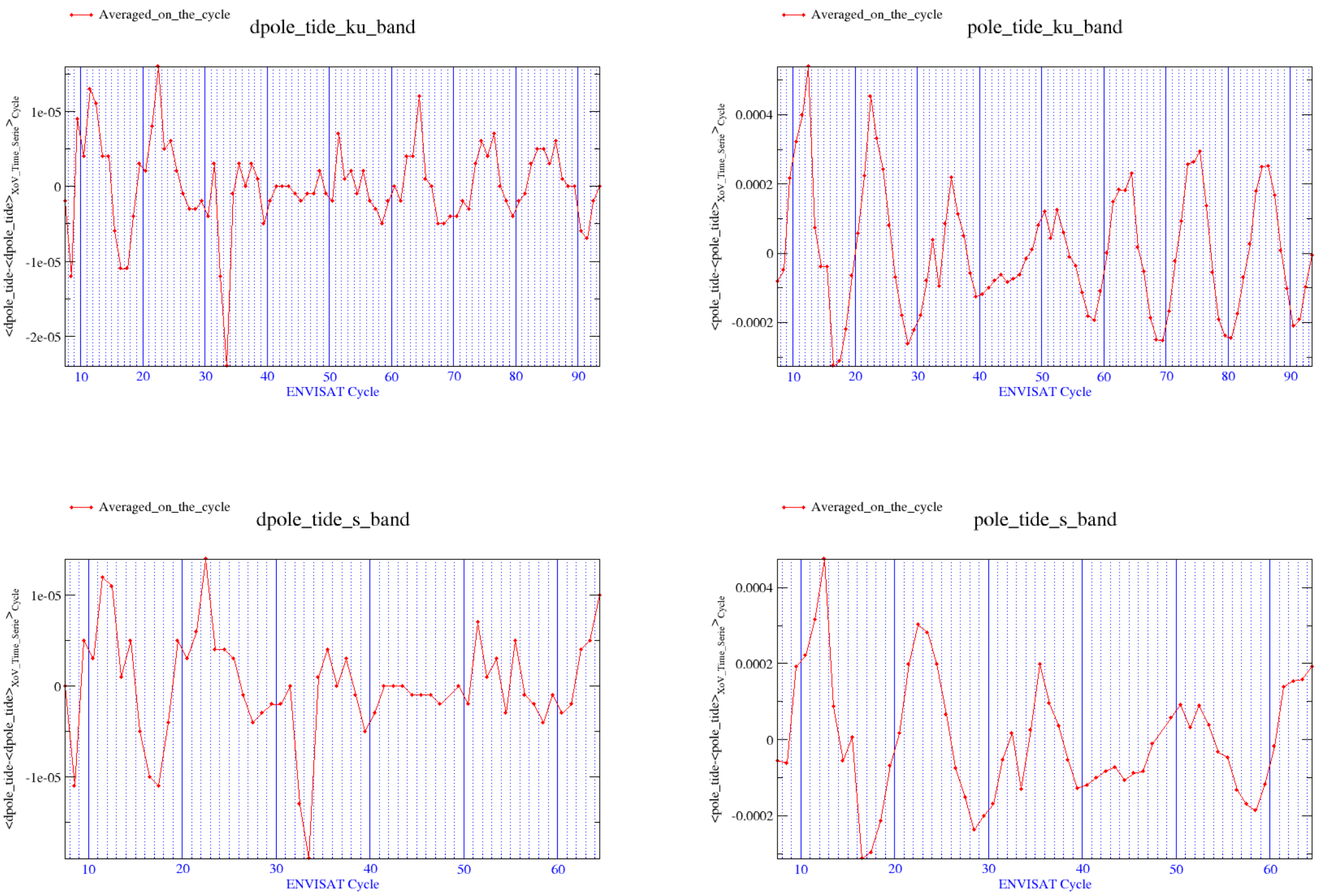


Figure 30: Pole tide anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

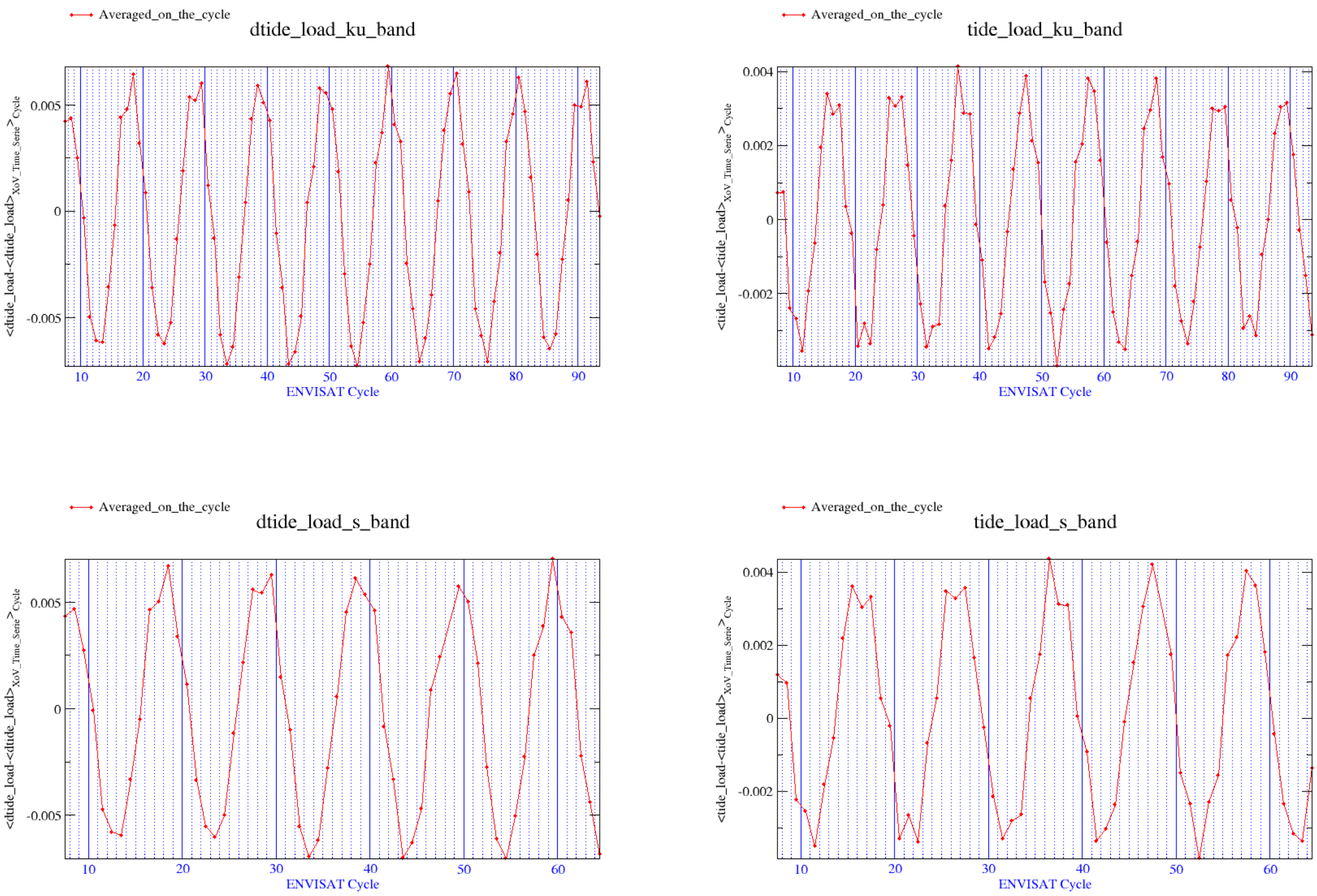


Figure 31: Tide load anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

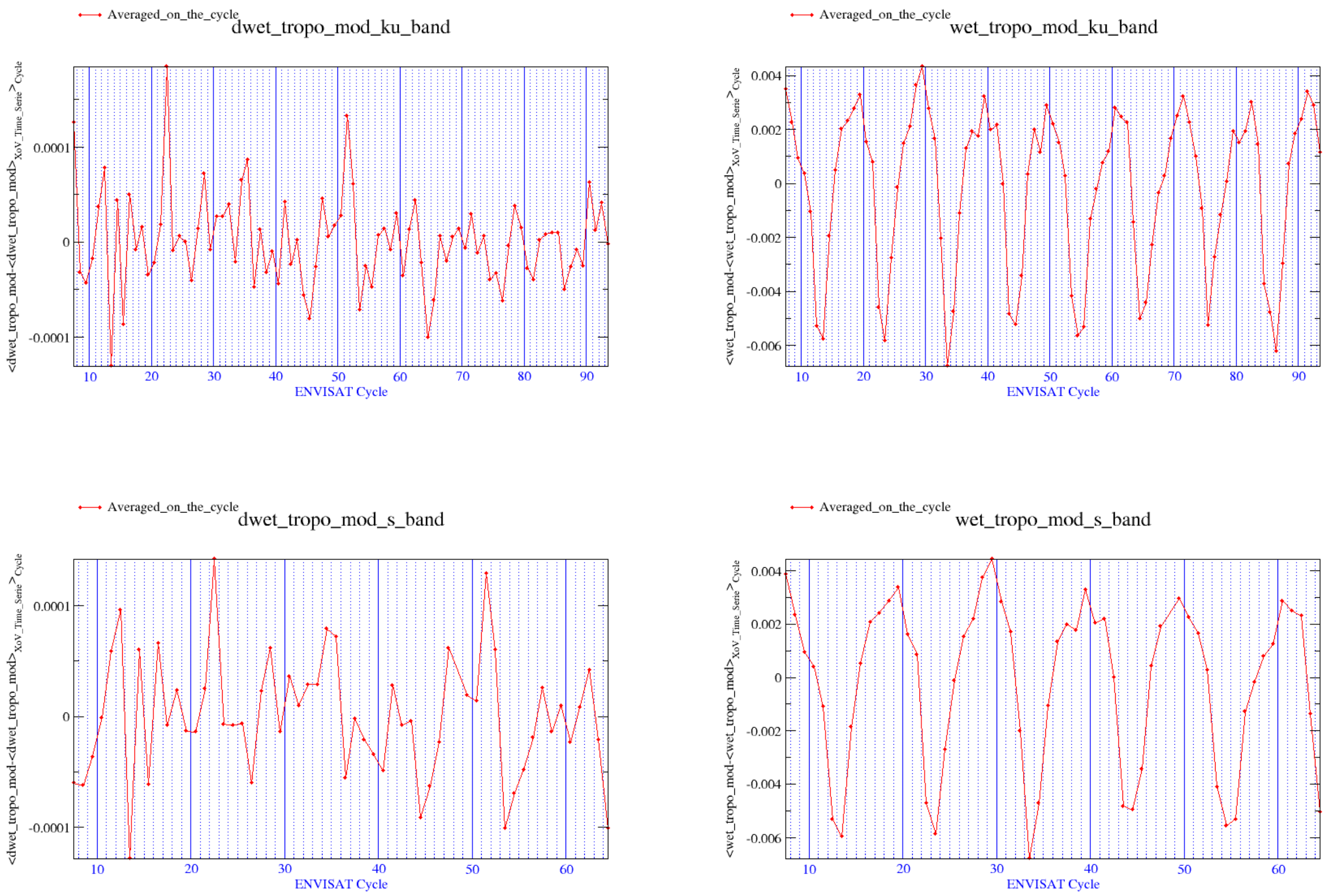


Figure 32: Wet tropospheric correction anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

3.3.5 ICE-2 parameters: RMS versus cycle

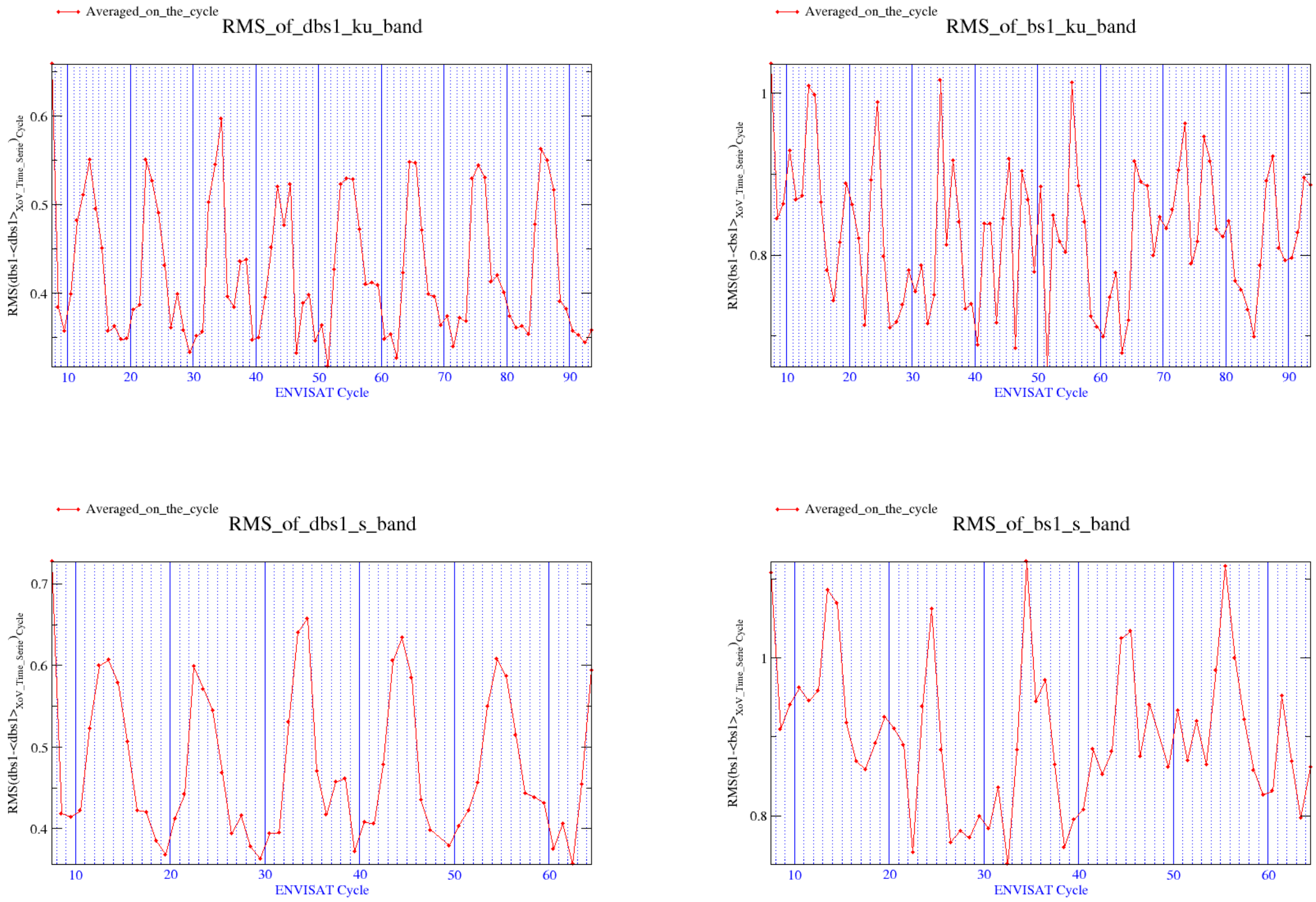


Figure 33: Backscatter RMS anomaly (dB) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

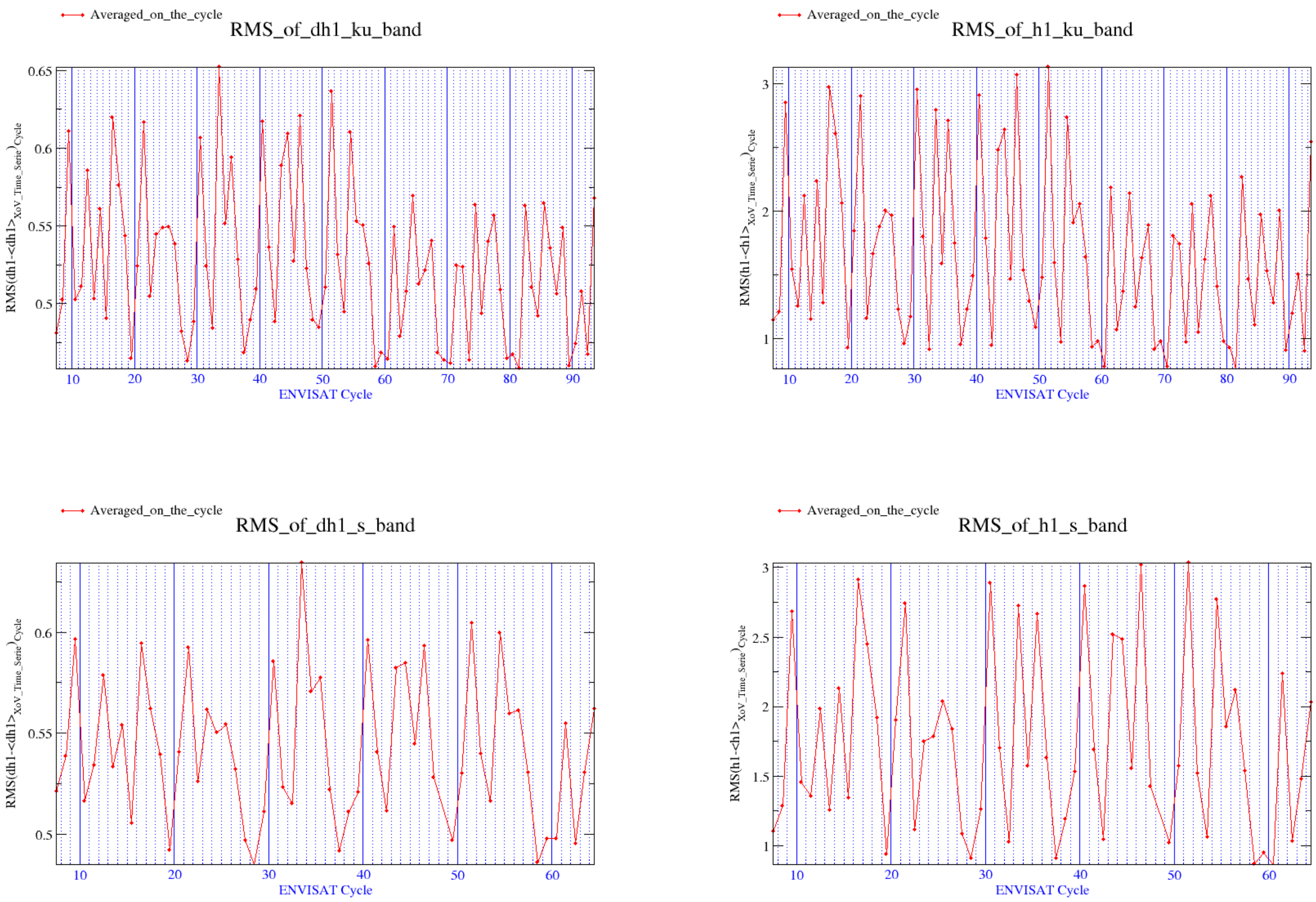


Figure 34: Surface heigth RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

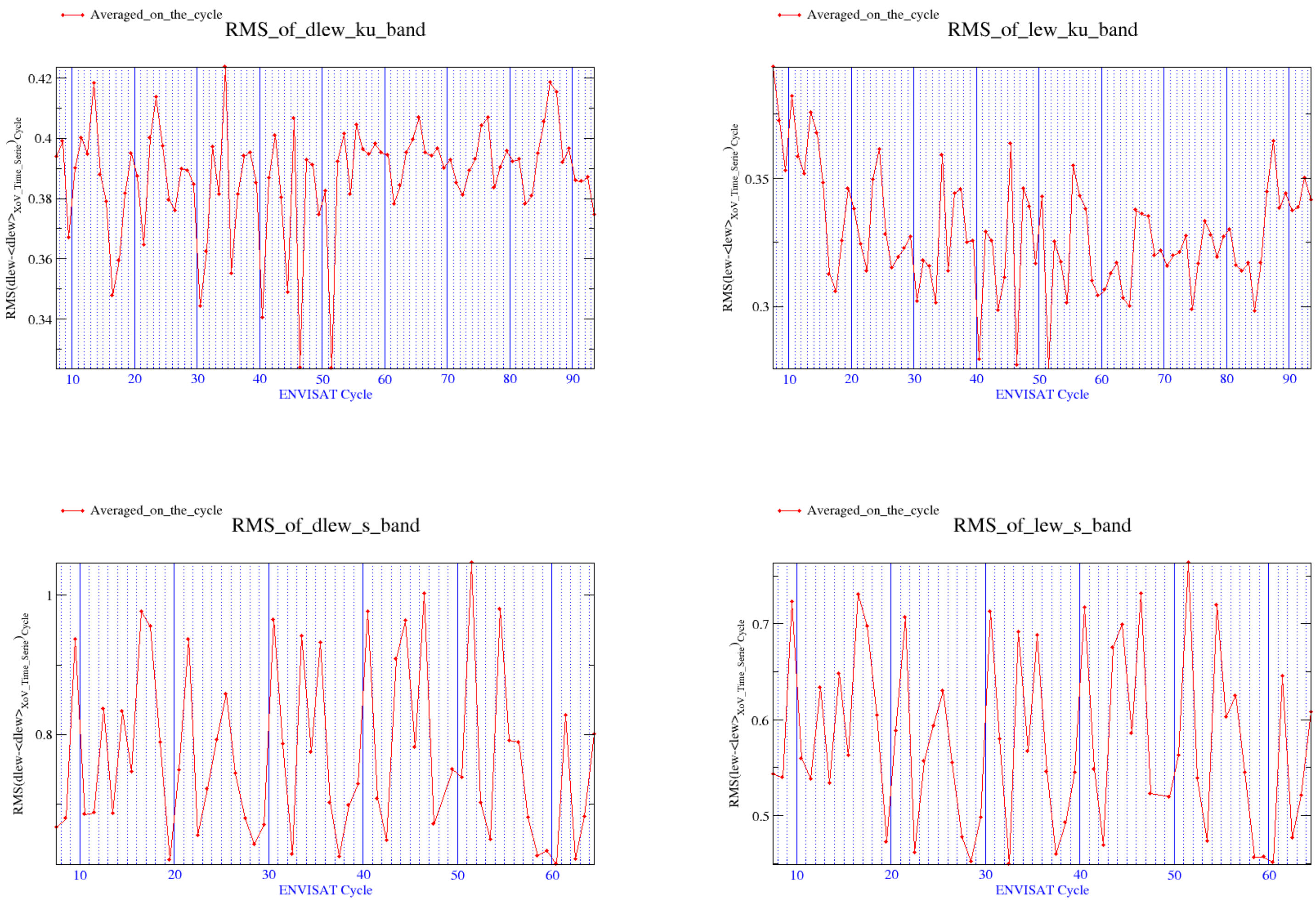


Figure 35: Leading edge width RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

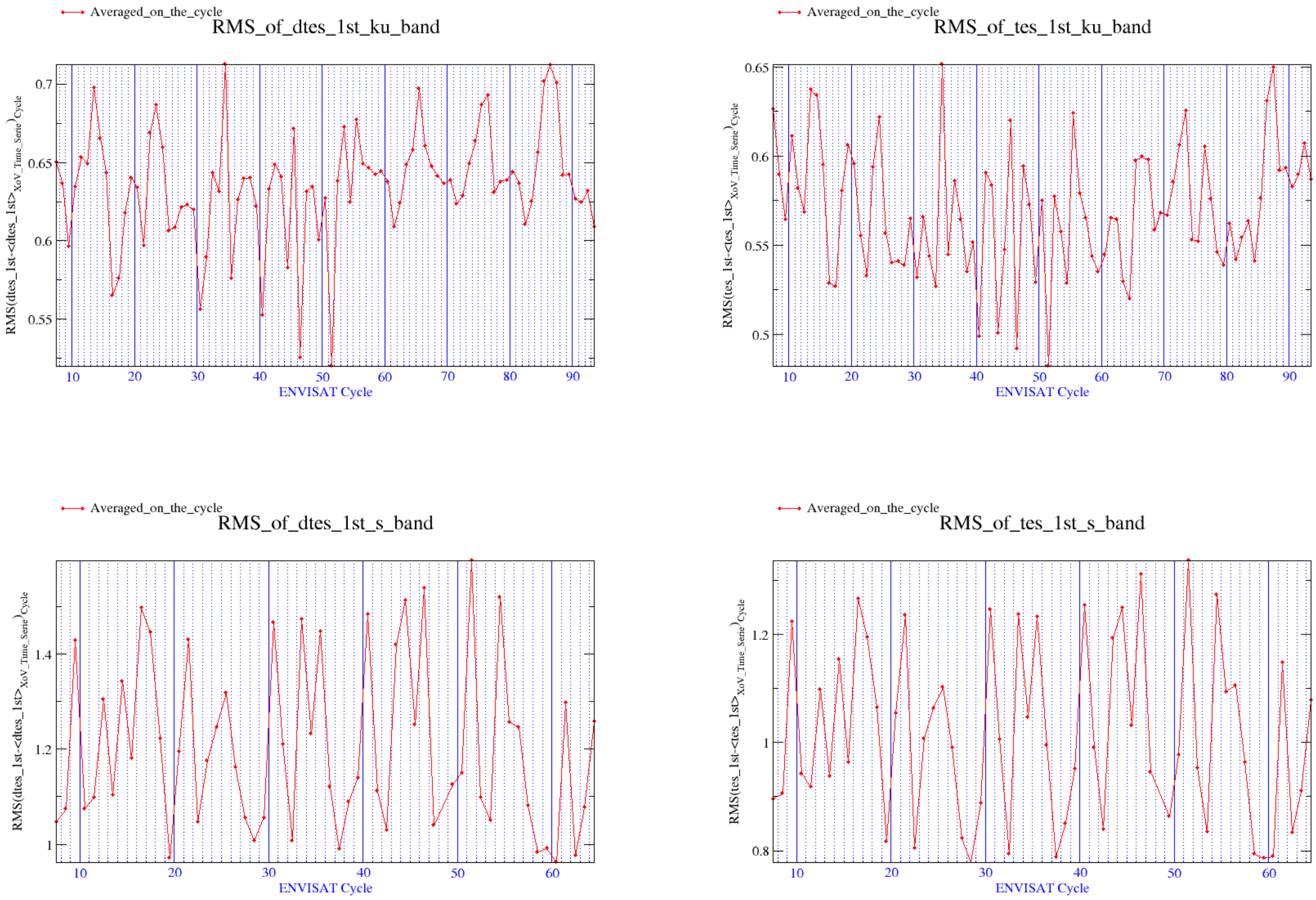


Figure 36: Trealing edge slope RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

3.3.6 Corrections: RMS versus cycle

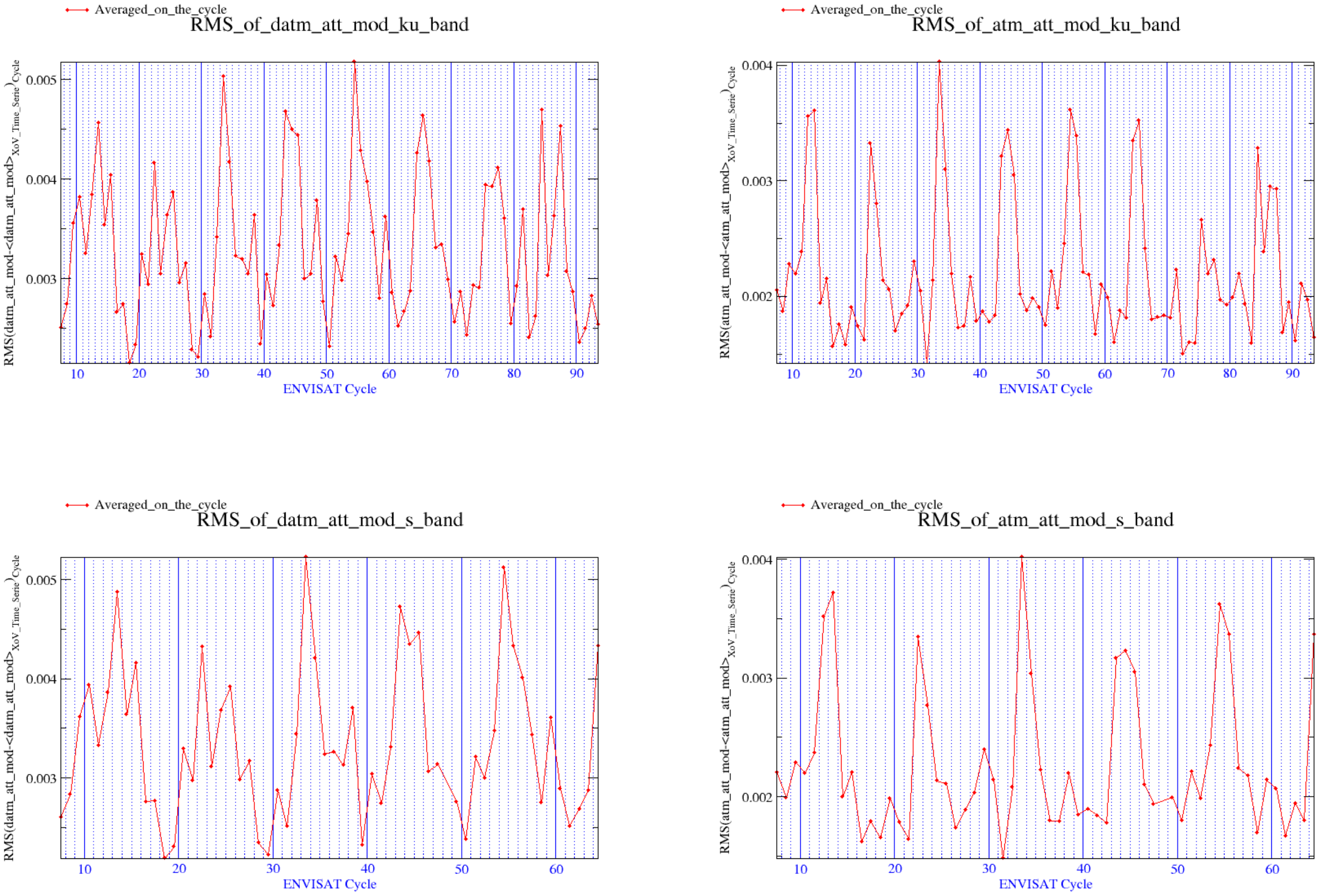


Figure 37: Atmospheric attenuation correction RMS anomaly (dB) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

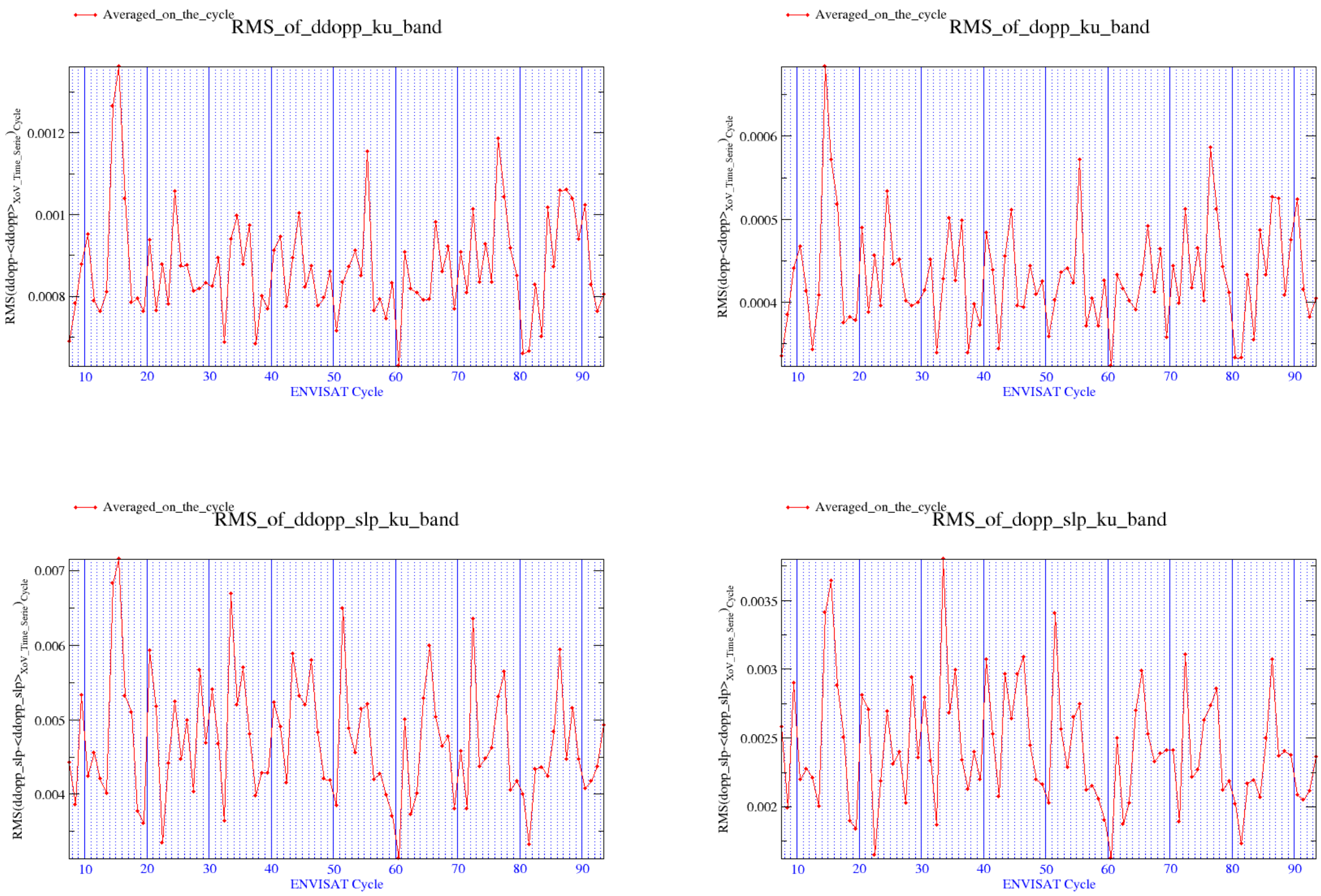


Figure 38: Doppler correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

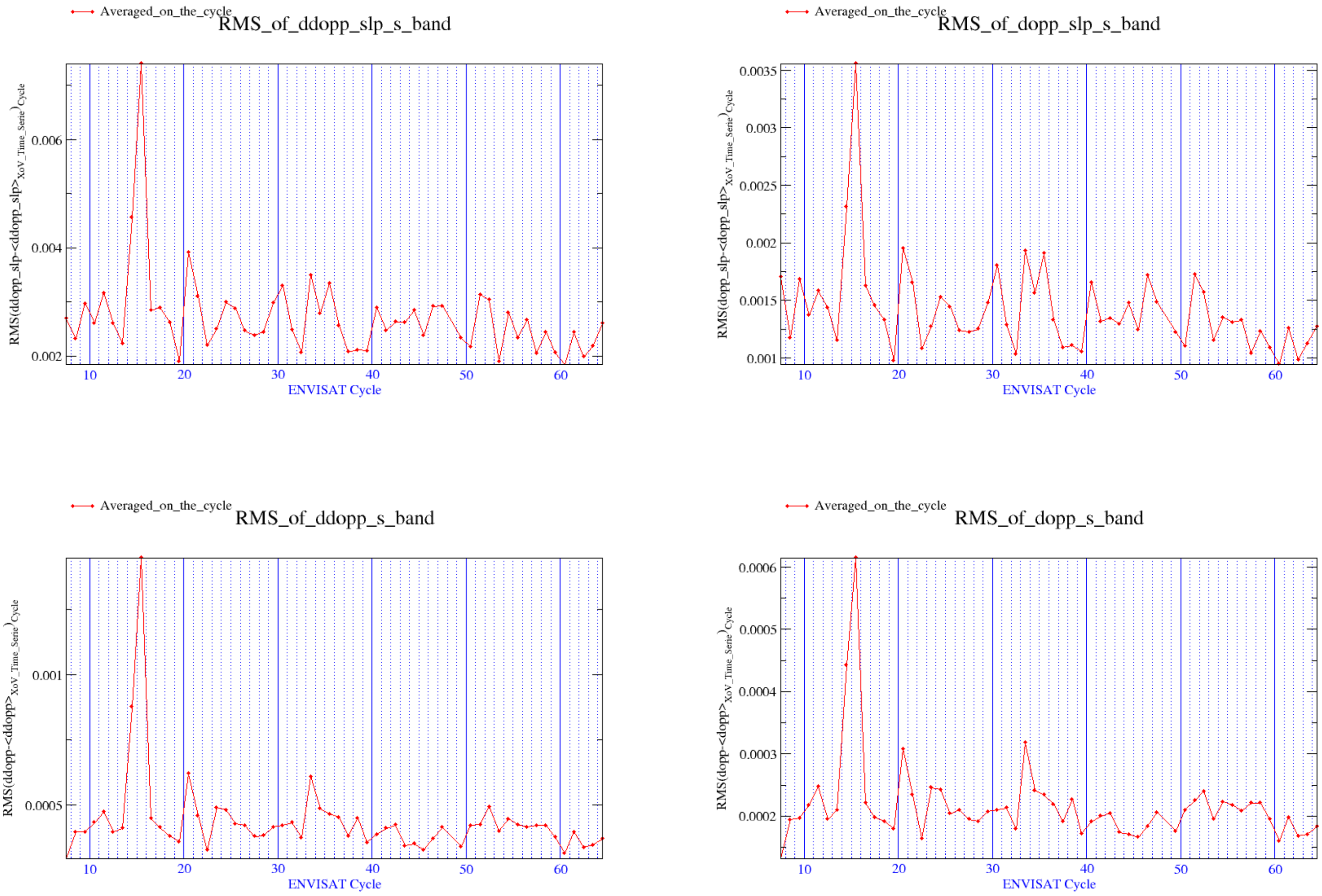


Figure 39: Doppler slope correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

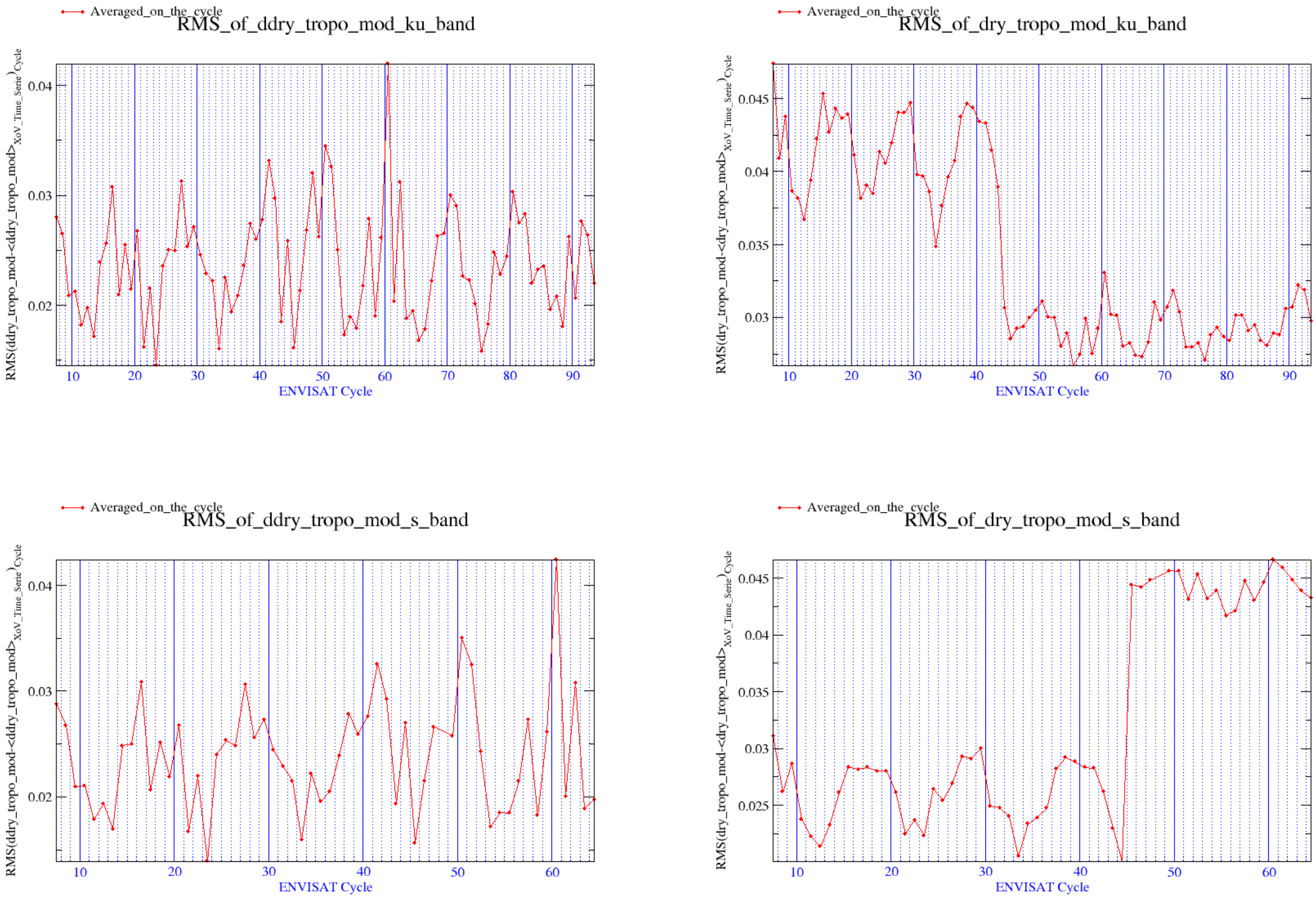


Figure 40: Dry tropospheric correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

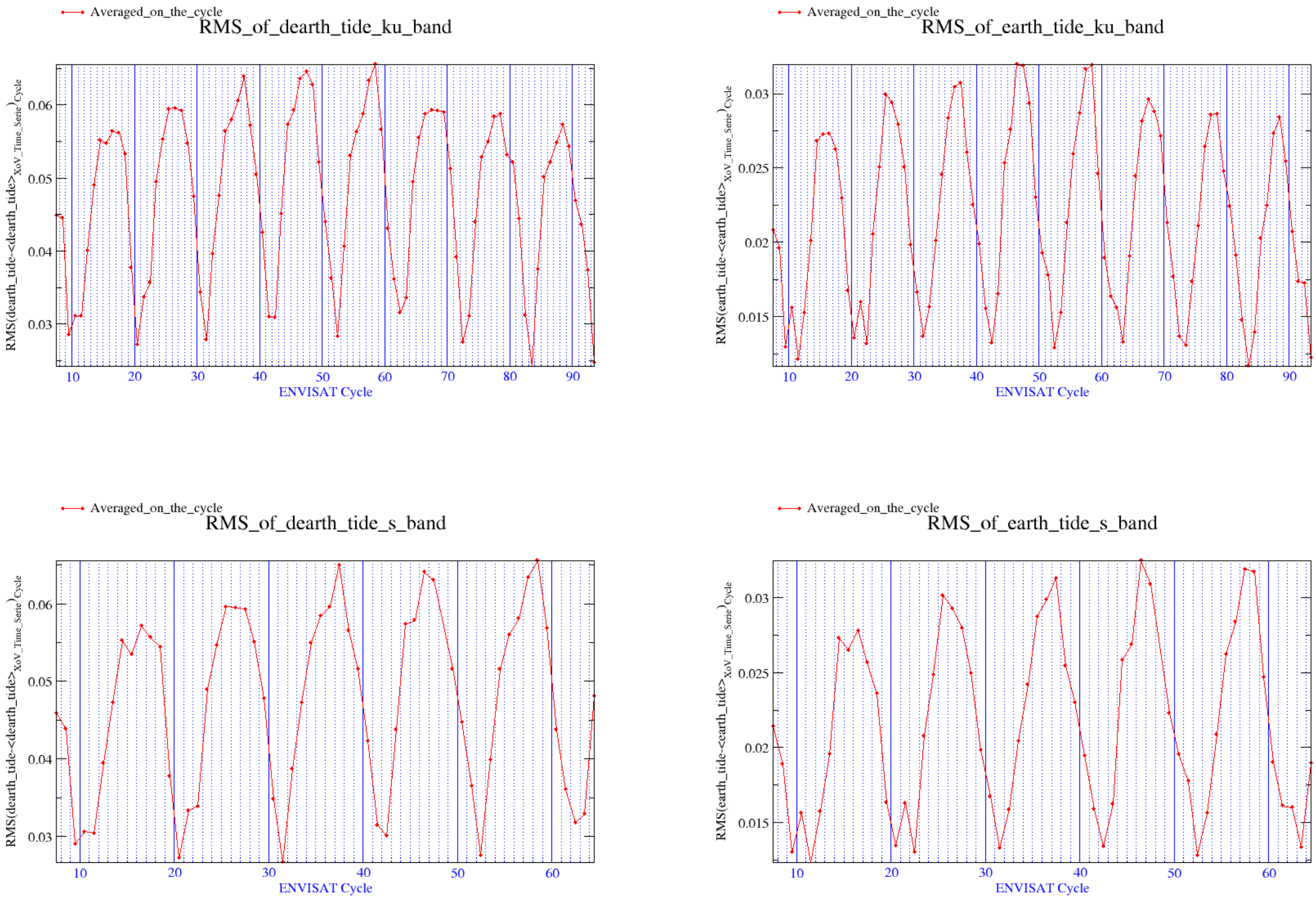


Figure 41: Earth tide RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

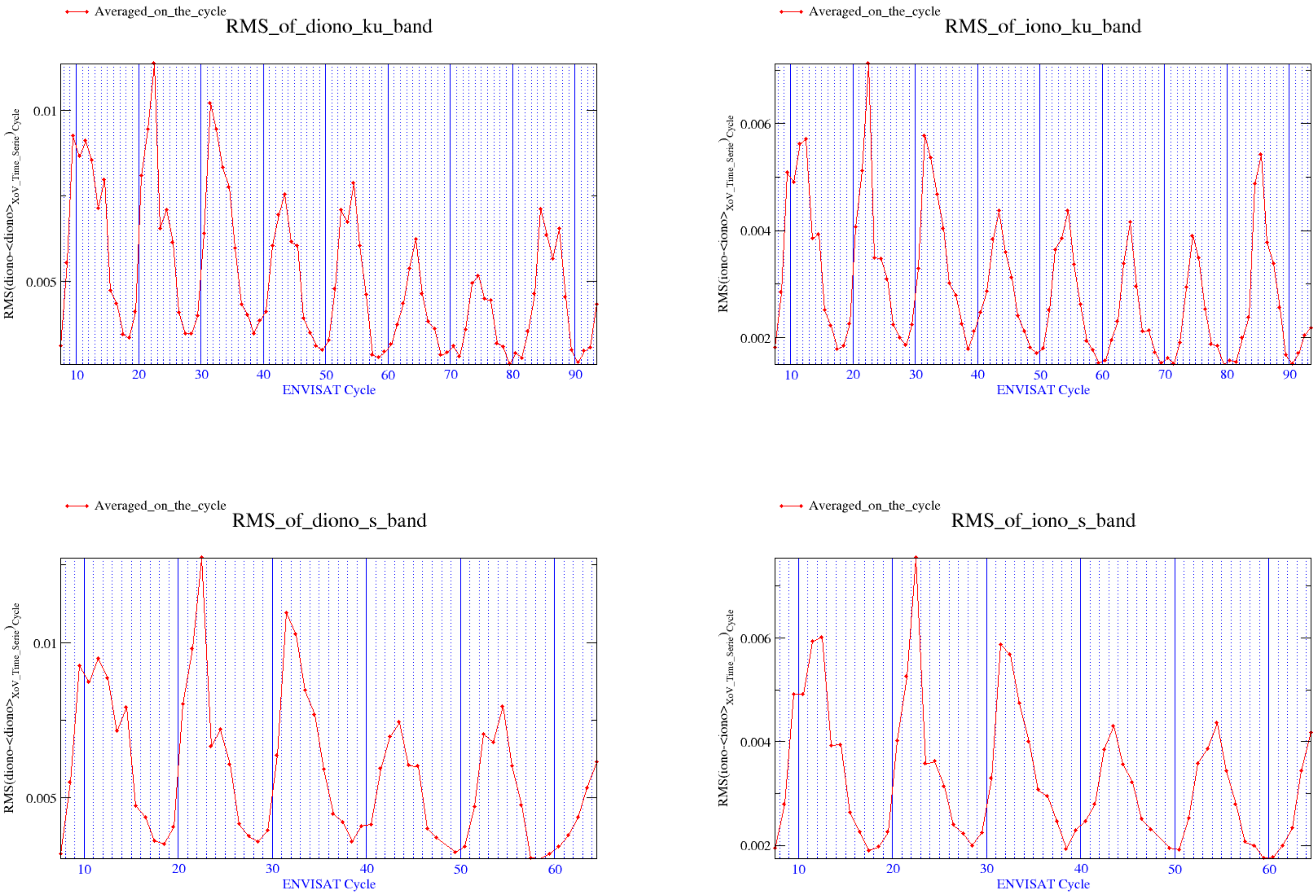


Figure 42: Ionosphereic correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

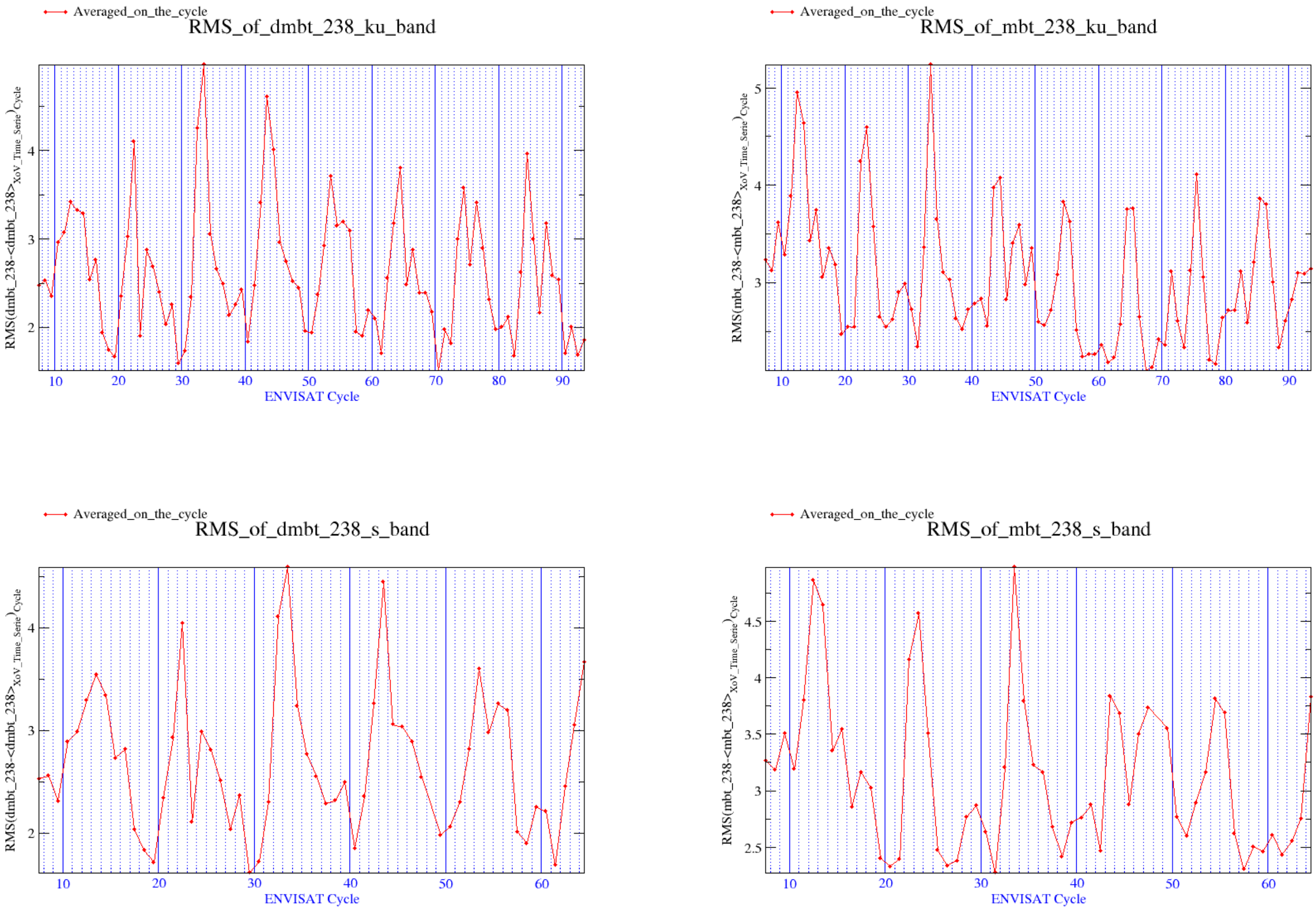


Figure 43: Microwave Brightness Temperature 23.8 GHz RMS anomaly (K) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

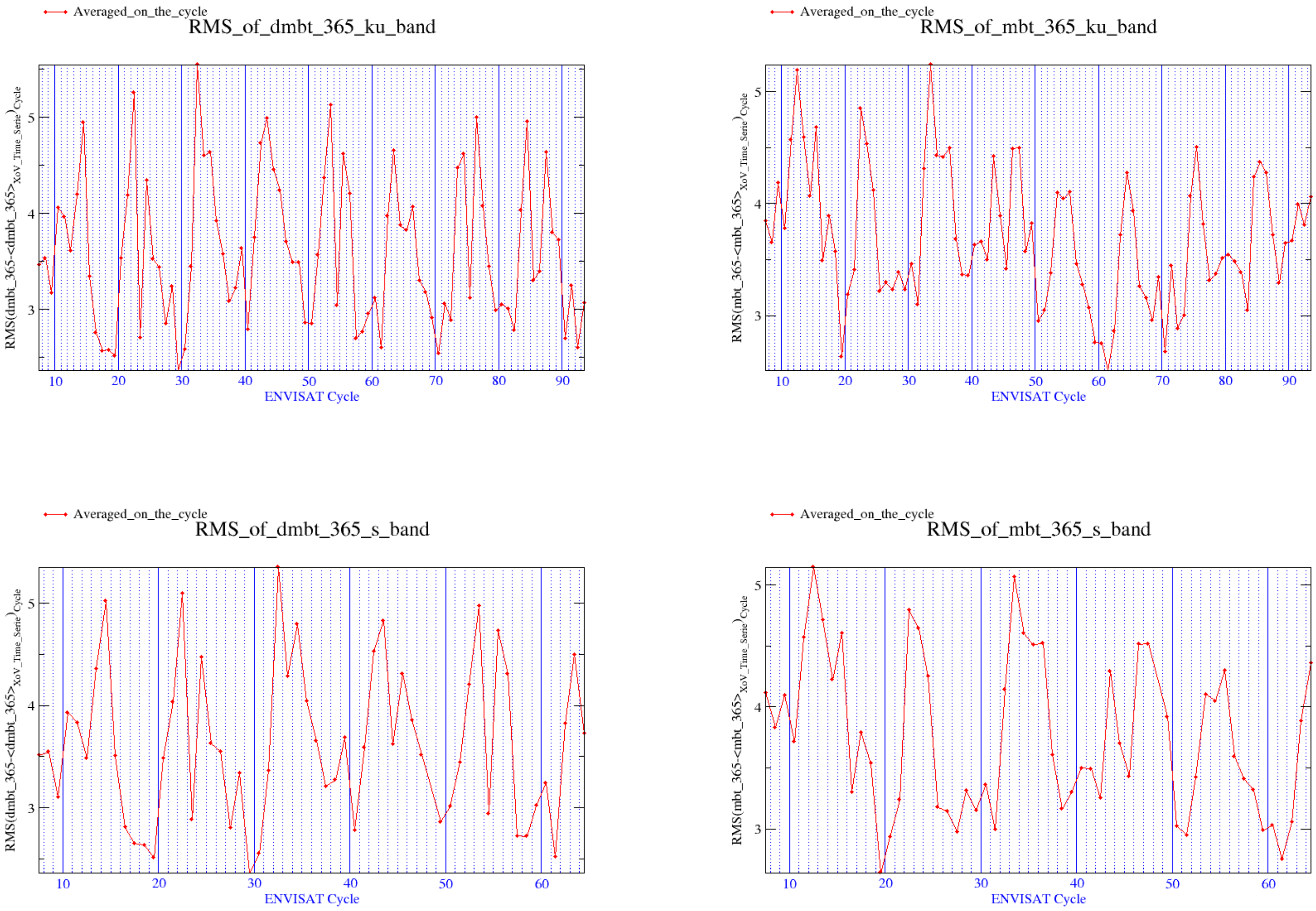


Figure 44: Microwave Brightness Temperature 36.5 GHz RMS anomaly (K) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

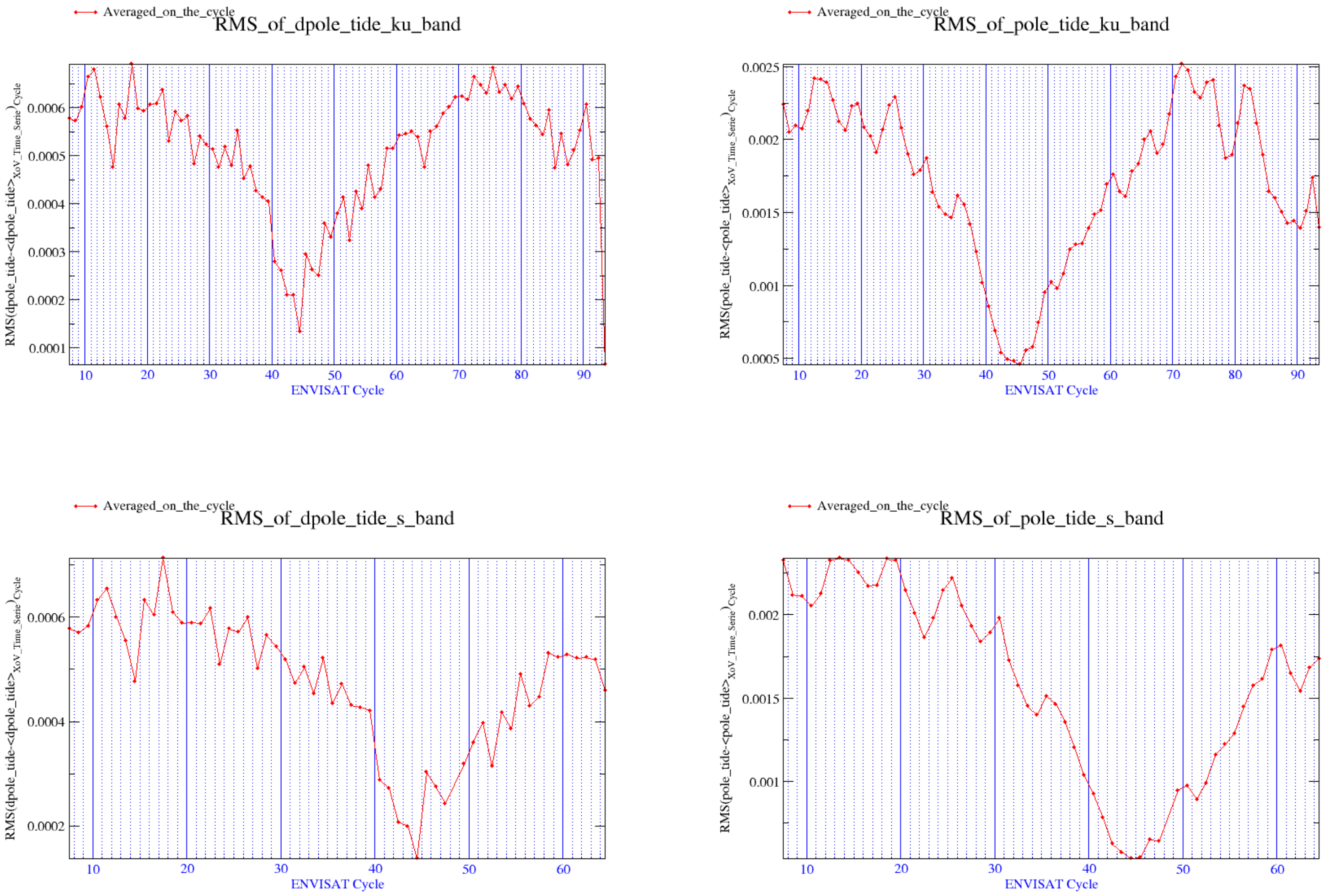


Figure 45: Pole tide RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

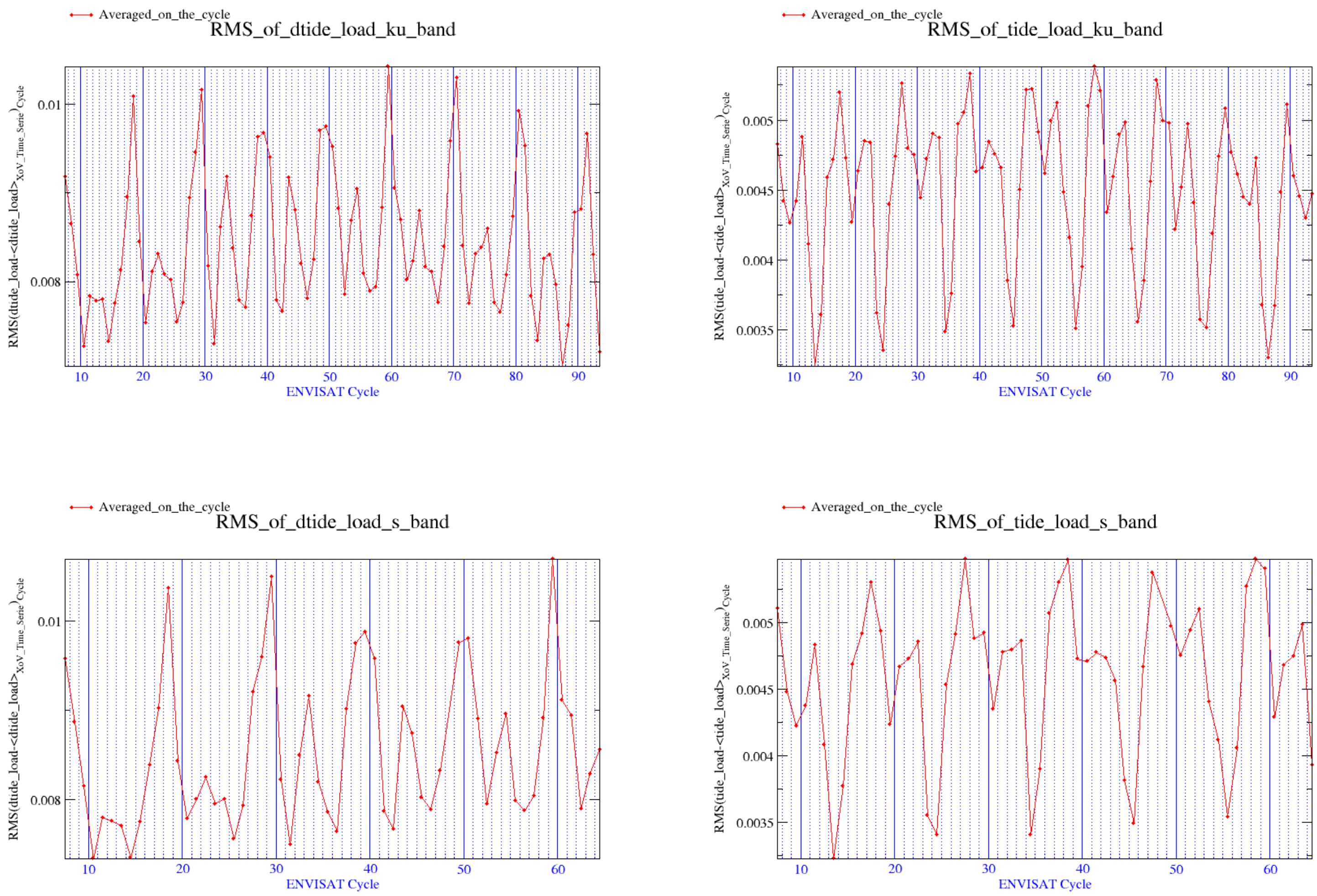


Figure 46: Tide load RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

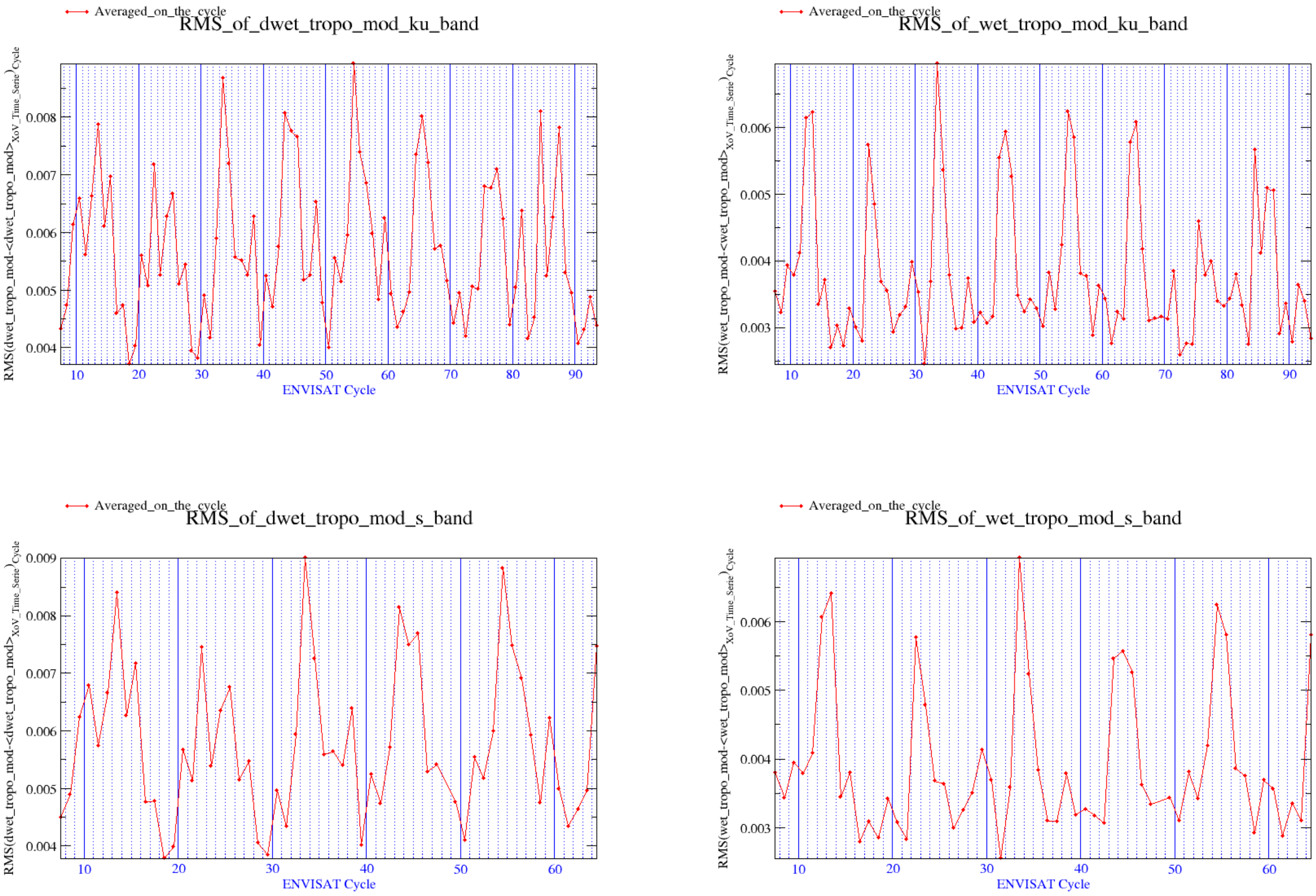


Figure 47: Wet tropospheric correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Antarctica. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

3.3.7 Annual tend of ICE-2 parameters anomaly

These trends have been evaluated form figures in the section 3.3.3 and 3.3.5.

ku band

Parameter	trend	error	correlation
h1 (m/year)	1.75e-04	1.28e-04	0.35
bs1 (dB/year)	1.48e-04	2.33e-04	0.23
lew (m/year)	-4.38e-05	1.01e-05	-0.31
tes_1st (10-6s/year)	-1.62e-04	1.48e-05	-0.71

Table 1: ICE-2 parameters anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

ku band

Parameter	trend	error	correlation
h1 (m/year)	-6.10e-04	5.05e-03	-0.2
bs1 (dB/year)	-3.75e-05	9.24e-05	-0.094
lew (m/year)	-2.73e-05	5.88e-06	-0.26
tes_1st (10-6s/year)	2.42e-06	1.57e-05	0.015

Table 2: RMS of ICE-2 parameters anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

s band

Parameter	trend	error	correlation
h1 (m/year)	3.88e-04	1.82e-04	0.39
bs1 (dB/year)	1.38e-04	6.03e-04	0.082
lew (m/year)	-6.80e-05	2.44e-05	-0.2
tes_1st (10-6s/year)	-2.20e-04	2.65e-05	-0.53

Table 3: ICE-2 parameters anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

s band

Parameter	trend	error	correlation
h1 (m/year)	-1.65e-04	1.00e-02	-0.024
bs1 (dB/year)	-9.39e-05	2.17e-04	-0.093
lew (m/year)	-8.03e-05	1.82e-04	-0.087
tes_1st (10-6s/year)	-7.06e-05	5.98e-04	-0.042

Table 4: RMS of ICE-2 parameters anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

ku band

Parameter	trend	error	correlation
dh1 (m/year)	9.96e-06	2.15e-07	0.46
dbs1 (dB/year)	-2.20e-05	8.18e-07	-0.51
dlew (m/year)	-5.42e-06	1.17e-07	-0.36
dtes_1st (10-6s/year)	-3.70e-06	1.72e-07	-0.21

Table 5: ICE-2 parameters delta anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

ku band

Parameter	trend	error	correlation
dh1 (m/year)	-4.48e-05	2.93e-05	-0.2
dbs1 (dB/year)	-2.68e-05	7.65e-05	-0.074
dlew (m/year)	1.73e-05	4.05e-06	0.2
dtes_1st (10-6s/year)	3.72e-05	1.57e-05	0.22

Table 6: RMS of ICE-2 parameters delta anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

s band			
Parameter	trend	error	correlation
dh1 (m/year)	8.56e-06	5.47e-07	0.17
dbs1 (dB/year)	-2.80e-05	2.09e-06	-0.27
dlew (m/year)	3.00e-06	7.24e-07	0.051
dtes_1st (10-6s/year)	-1.66e-06	1.74e-06	-0.018

Table 7: ICE-2 parameters delta anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

s band			
Parameter	trend	error	correlation
dh1 (m/year)	9.21e-07	3.20e-05	0.0024
dbs1 (dB/year)	-7.20e-05	1.97e-04	-0.075
dlew (m/year)	-6.09e-05	3.37e-04	-0.048
dtes_1st (10-6s/year)	-8.19e-05	7.35e-04	-0.044

Table 8: RMS of ICE-2 parameters delta anomaly trend calculcalted for antarctica from anomaly verus cycle figures in section.

3.3.8 ICE-2 parameters: Histogram versus class of surface slope

The histogram is obtained by computing for each class of surface slope the mean anomaly of the mean and difference at crossover. These figures are done from validated and averaged data over all cycles of the missions.

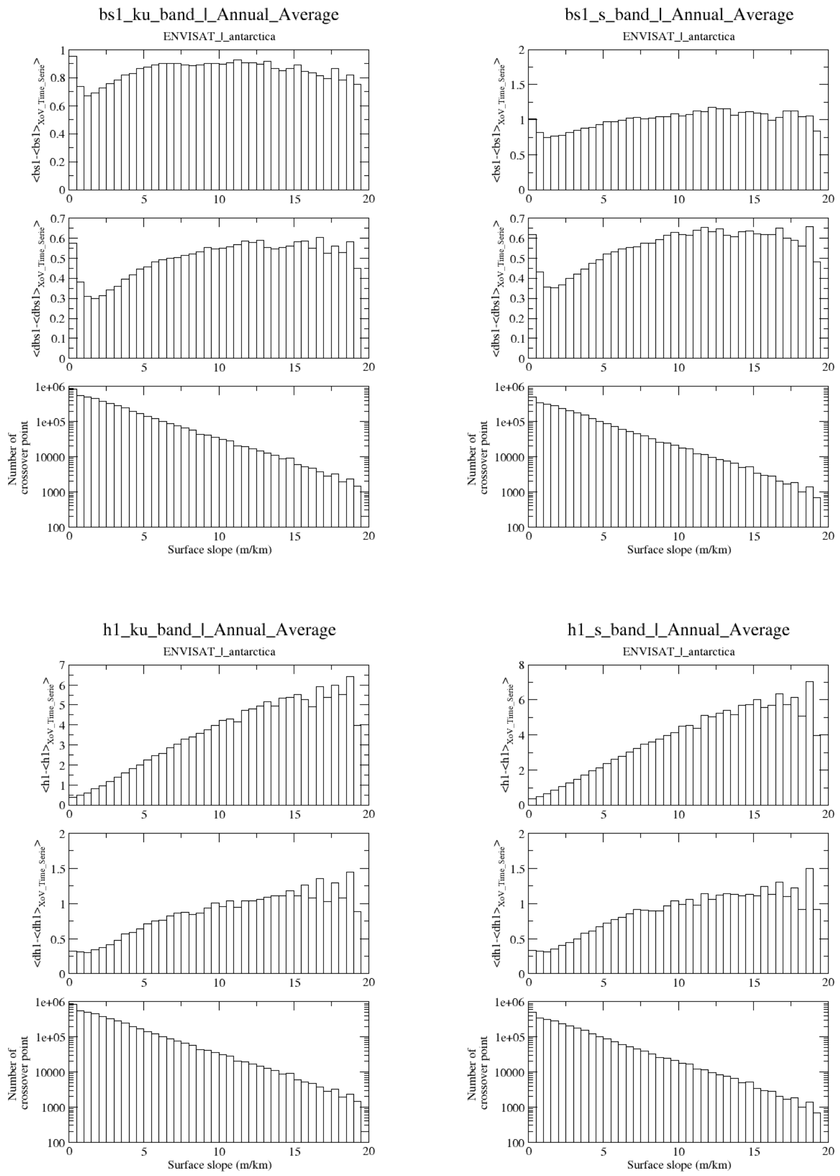


Figure 48: Histogram of crossover mean (top) and difference (middle) anomaly versus class of slope and below the crossover distribution. Backscatter (dB) for Ku (left) and S (right) band and below surface height (m) for Ku (left) and S (right) band over Antarctica.

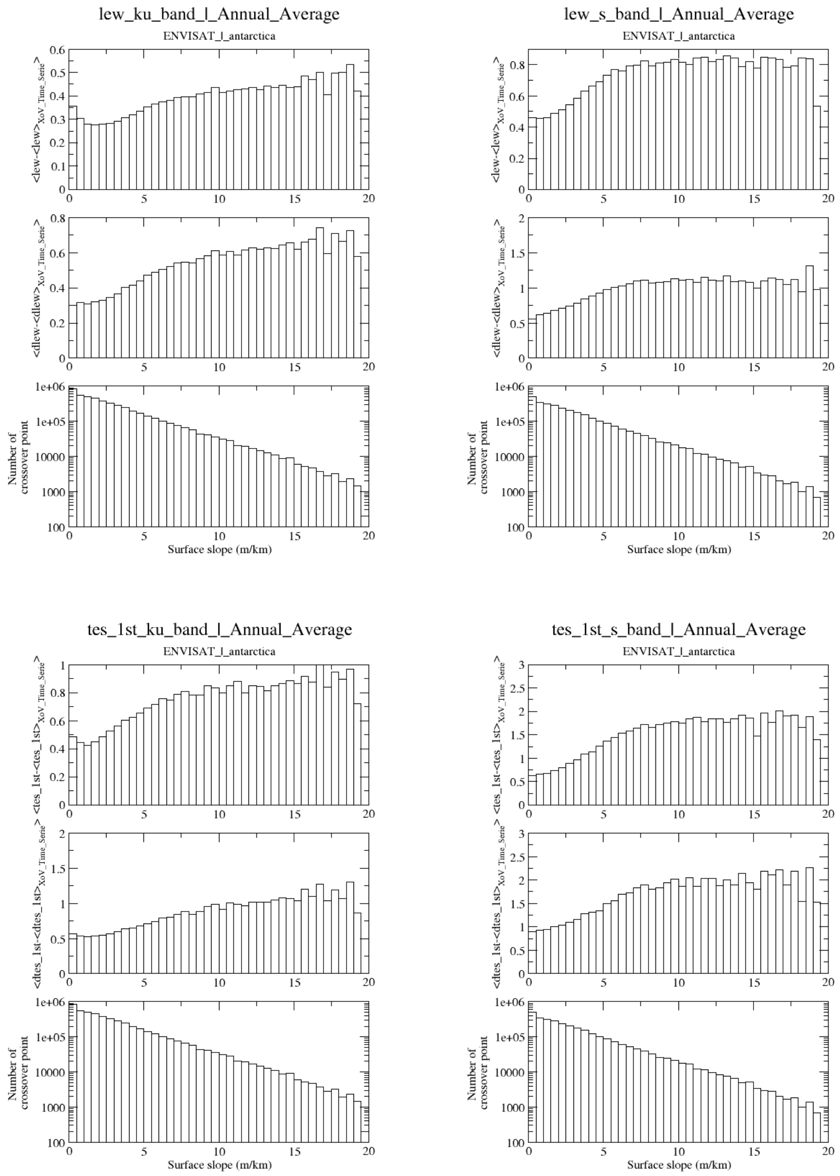
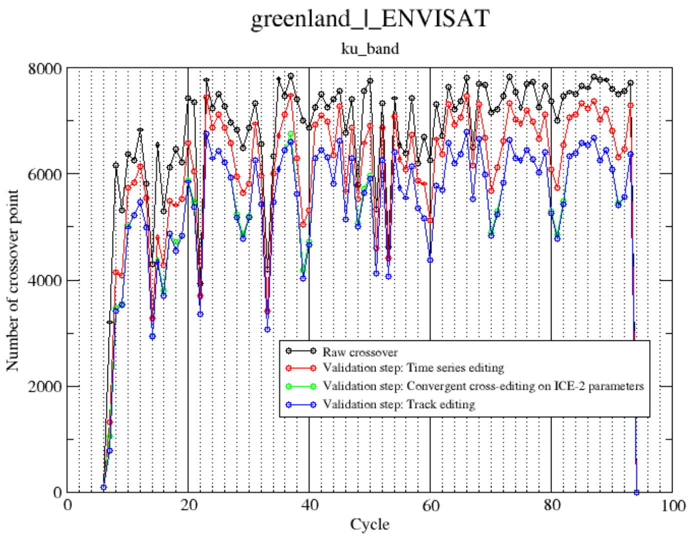


Figure 49: Histogram of crossover mean (top) and difference (middle) anomaly versus class of slope and below the crossover distribution. Leading edge width (m) for Ku (left) and S (right) band and below trealing edge slope (10-6 s-1) for Ku (left) and S (right) band over Antarctica.

4 Greenland area

4.1 Crossover validation

Here are figures of the number of crossovers at each step of the validation program.



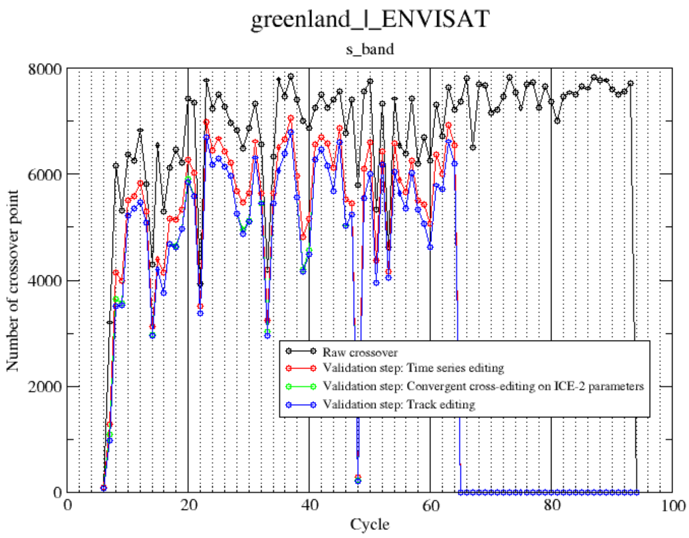


Figure 50: Crossovers number as function of cycle (Ku band top and S band bottom)

For the ku band, the last re-processing of ENVISAT GDR (v2.1) is clearly positive.

- A large amount of crossovers are recovered in the cycle 47 and 48.
- The cyle 6, 7 and 8 had been added
- The cycles 16, 17, 18, 19, 20 and 21 have more crossovers (around of 5000 to 10000).
- In cycle 33, there are 20000 crossovers lost

For the s band, the re-processing is also a bit positive.

- There are more crossovers which pass successfully the validation process for the first 40th cycles.

- The cycle 6, 7 and 8 had been added.
- But the large amount of crossovers in the cycle 47 and 48 are definitely lost (due to witching maneuver between the altimeter A and B).
- And cycle 33, there are 20000 crossovers lost.
- Belong cycle 65, the s band is definitely lost.

All crossover points and paramters computed in this study are added of a flag of valaidation and disseminated on the CTOH web site http://ctoh.legos.obs-mip.fr/quality-assessment/crossing-points.

4.2 Validation table

The ice validation table gives a global view of the mission over Greenland of the availability of tracks. The colour code gives the information of the major events met during the validation process (like the tracks missing, the tracks validated or not, ...).

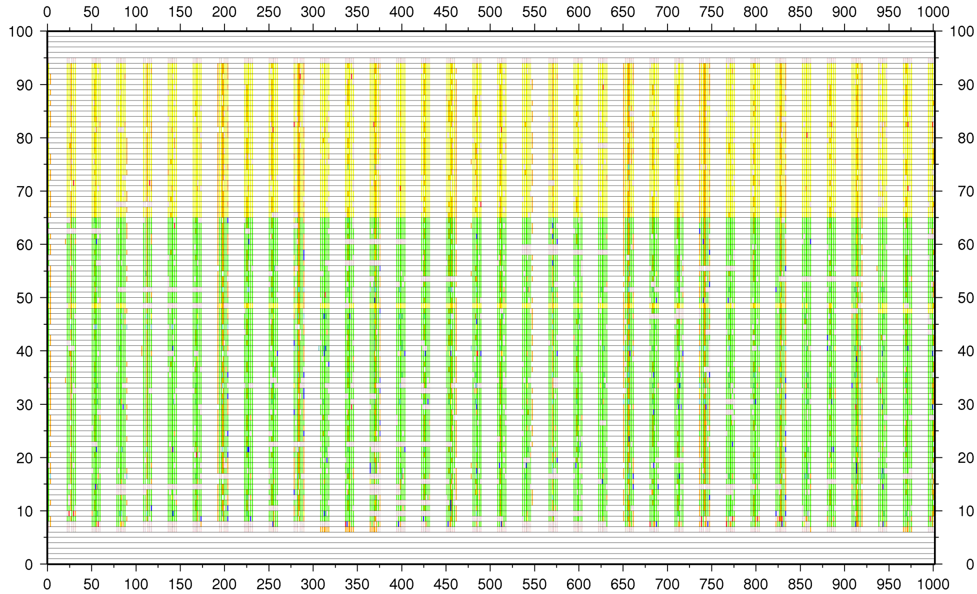


Figure 51: This table gives the state validation of the number of the track as function of the cycle of the mission. For each track and for each cycle the assessment result is given by a coding color. In green, the tracks validated simultaneously for the Ku and S band; in yellow, the tracks validated only for the Ku band; in blue, the tracks validated only for the S band; in red, the tracks none validated simultaneously for the Ku and S band; in gray the missing tracks and in white the tracks not available. This figure is available as ascii file (http://ctoh.legos.obs-mip.fr/quality-assessment/cryosphere/envisat/validation-table) and could be integrated to track selection procedure of a processing program.

From the validation table, we can see the re-processing benefice.

- Most of the tracks in ku band are recovered for cycle 48 (in yellow). The s band remains missing.
- For the cycles 6, 7 and 8 added, there are not lot of track. Most are missing (grey) in cycle 6, or partially edited (blue) for ku band in cycle 7, or definitely edited (red) in cycle 8.
- After the cycle 65 the s band is missing just remains the ku band (yellow).

4.3 Overview of main problems

In the following sections, it is presented all the output plots of the ice validation. Here are listed the problems detected for this quality assessment.

- **Dry troposphere correction:** We have noted a jump in the RMS anomaly at cycle 44 (section 3.3.6). The re-processing (v2.1) does not solve the previous jump problem. This correction remains bad. This problem had been investigated for the previous processing and the report is available on the CTOH web site. Base on these conclusions, an alternaltive correction is currently computed and it will be available by the end of 2012.

- **Doppler slope correction:** is now better. The shift of 30 km in the DEM is now corrected for this re-processing. But this correction remains unreliable on the coast and in the mountain areas due to nadir problem.This problem had been investigated for this re-processing (v2.1) and the report is available on the CTOH web site.Base on these conclusions, an alternaltive correction is currently computed and it will be available by the end of 2012.

- **USO:** Now very well integrated and already applied to the range.

- **ICE-2 parmeters:** ICE-2 parmeters:We had passed carefully in review each ICE-2 parameters to check their behaviors. For this GDR data release v2.1 no particular events had occurred. We would like just warm the users about the understanding the validation results of these parameters. In section 4.3.5, we can see for the ICE-2 parameters the RMS of the anomaly definitely change after cycle 60. In section 4.3.3, we also note for all the anomalies having like an amazing trend. And whatever the band. We had investigated it and it appears that the phenomena is in link with the orbit control of the mission. Before the cycle 60, the orbit drift seems to have been less binding than after. All the details of this phenomena is studied in a report available on the CTOH web site.

CTOH web site: http://ctoh.legos.obs-mip.fr/quality-assessment/cryosphere/envisat/particular-investigations.

4.3.1 ICE-2 parameters: Anomaly versus orbit

These figures are obtained from validated data

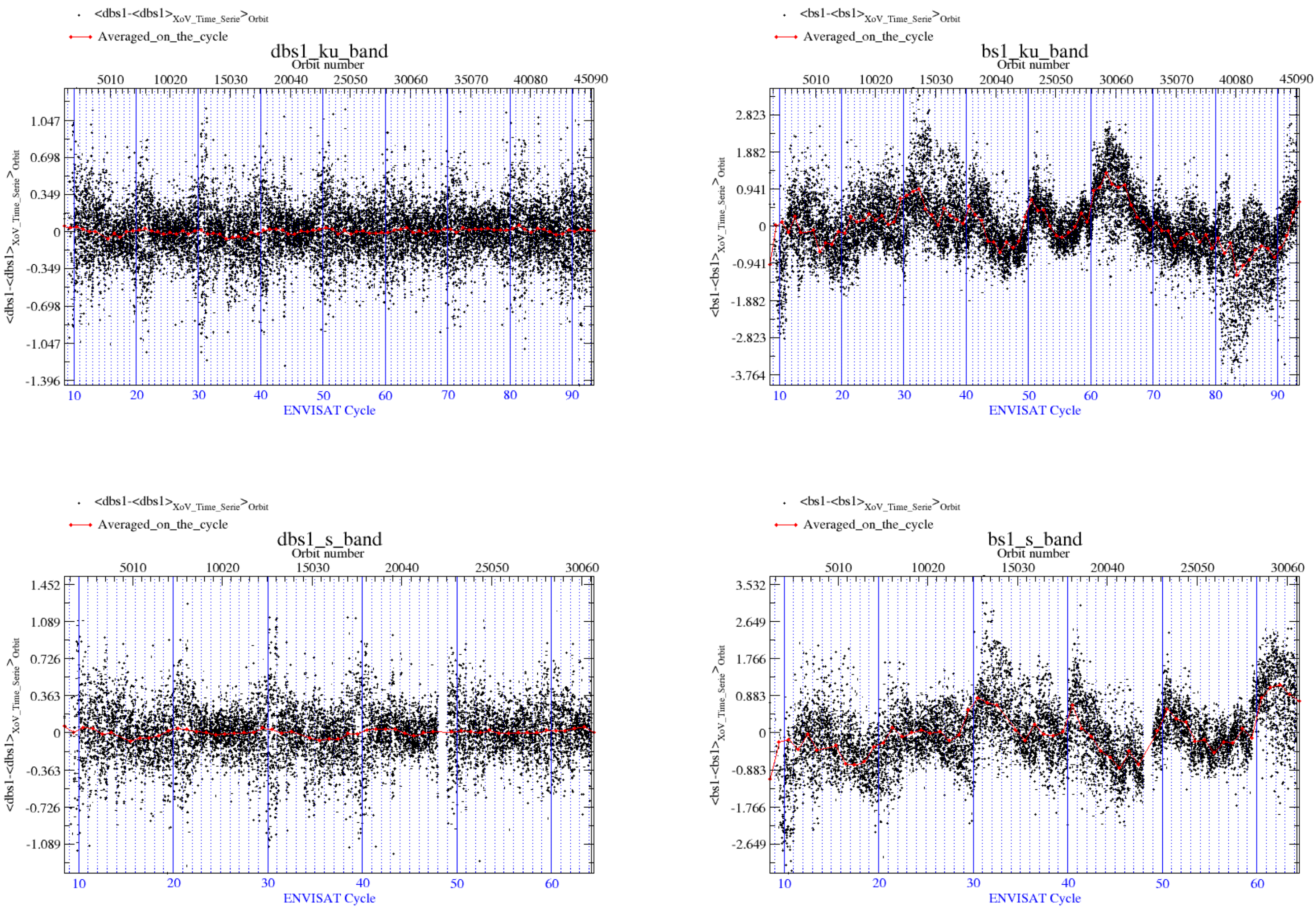


Figure 52: Backscatter anomaly (dB) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

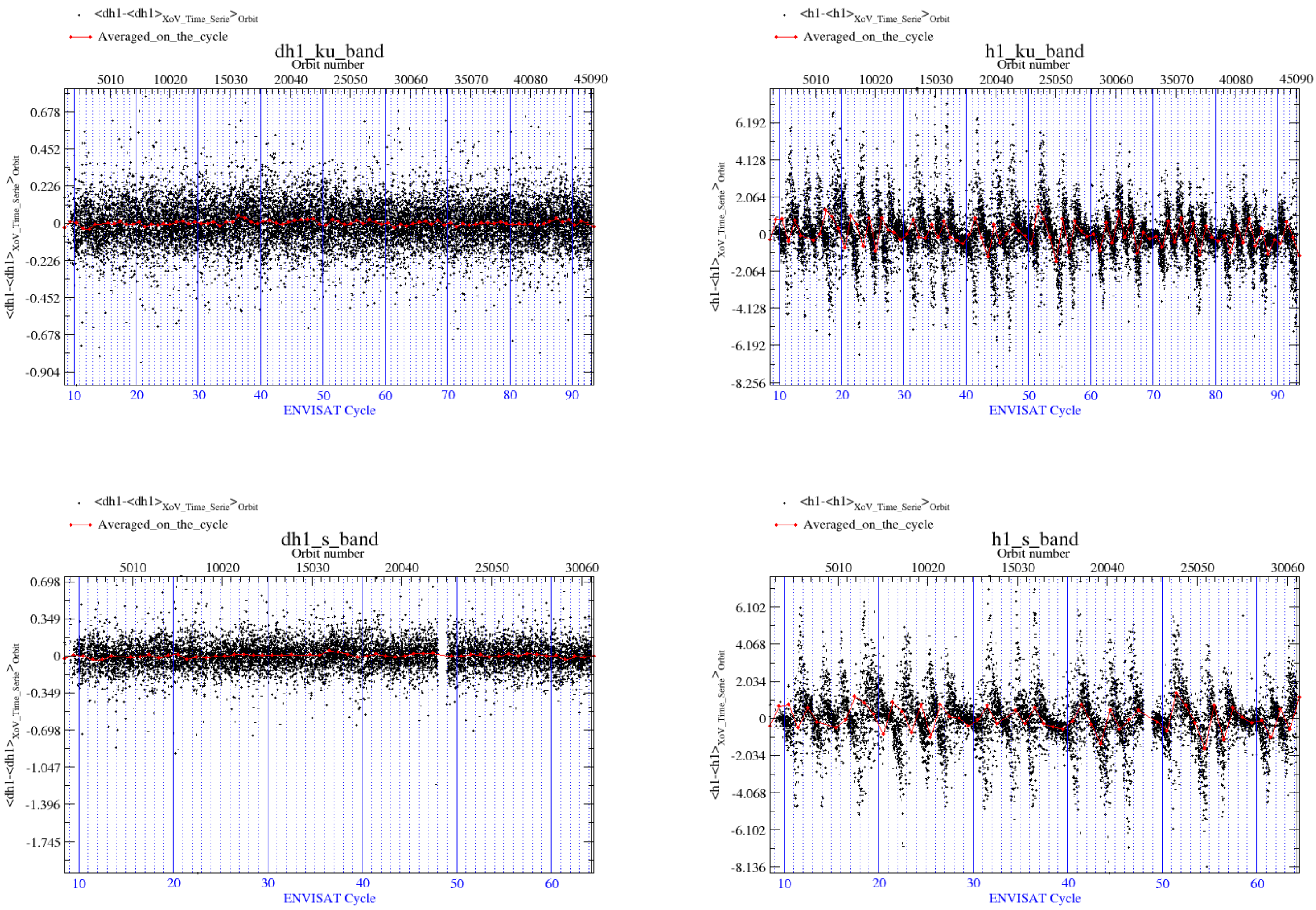


Figure 53: Surface height anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

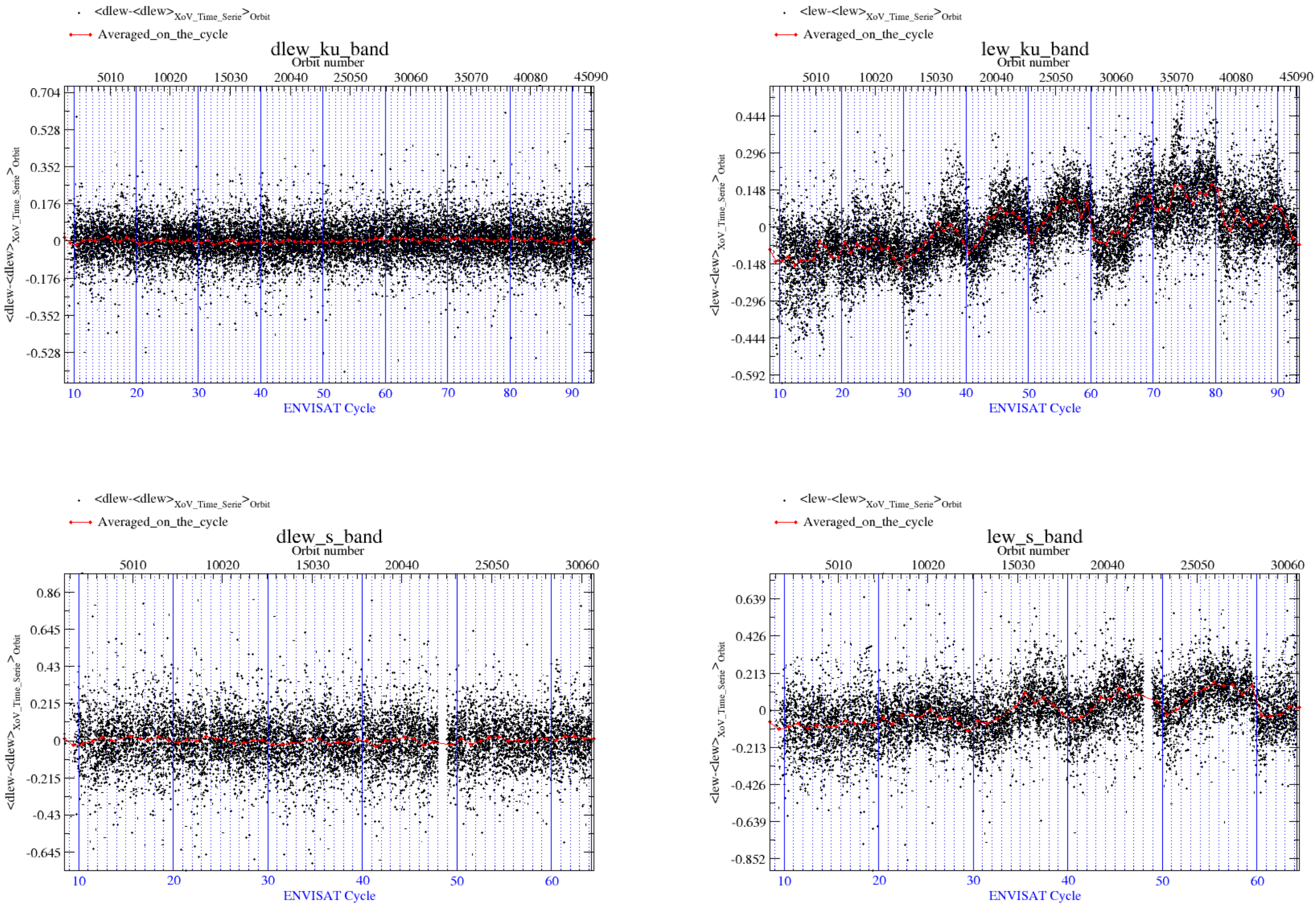


Figure 54: Leading edge width anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

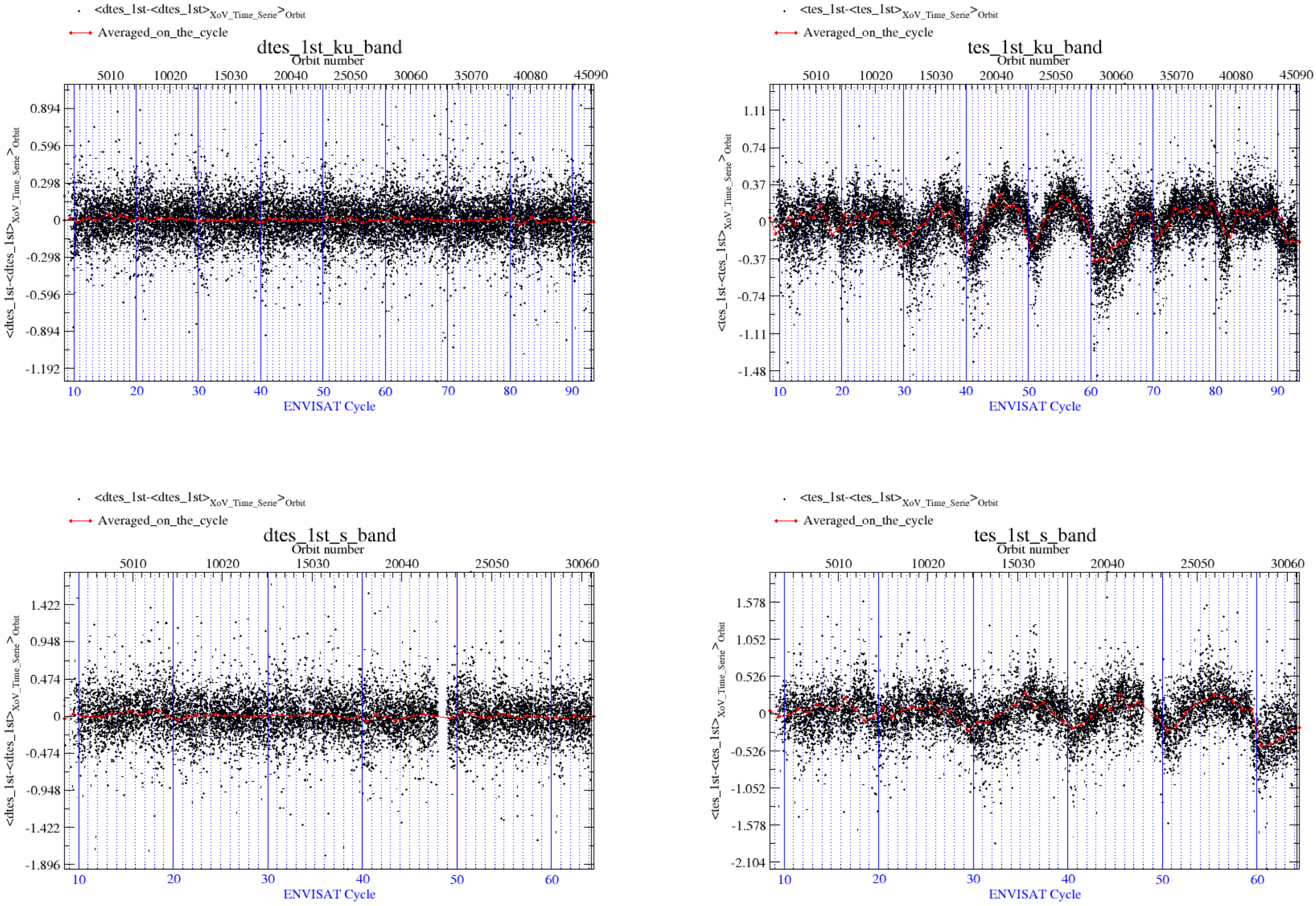


Figure 55: Trailing edge slope anomaly (10-6 s-1) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

4.3.2 Corrections: Anomaly versus orbit

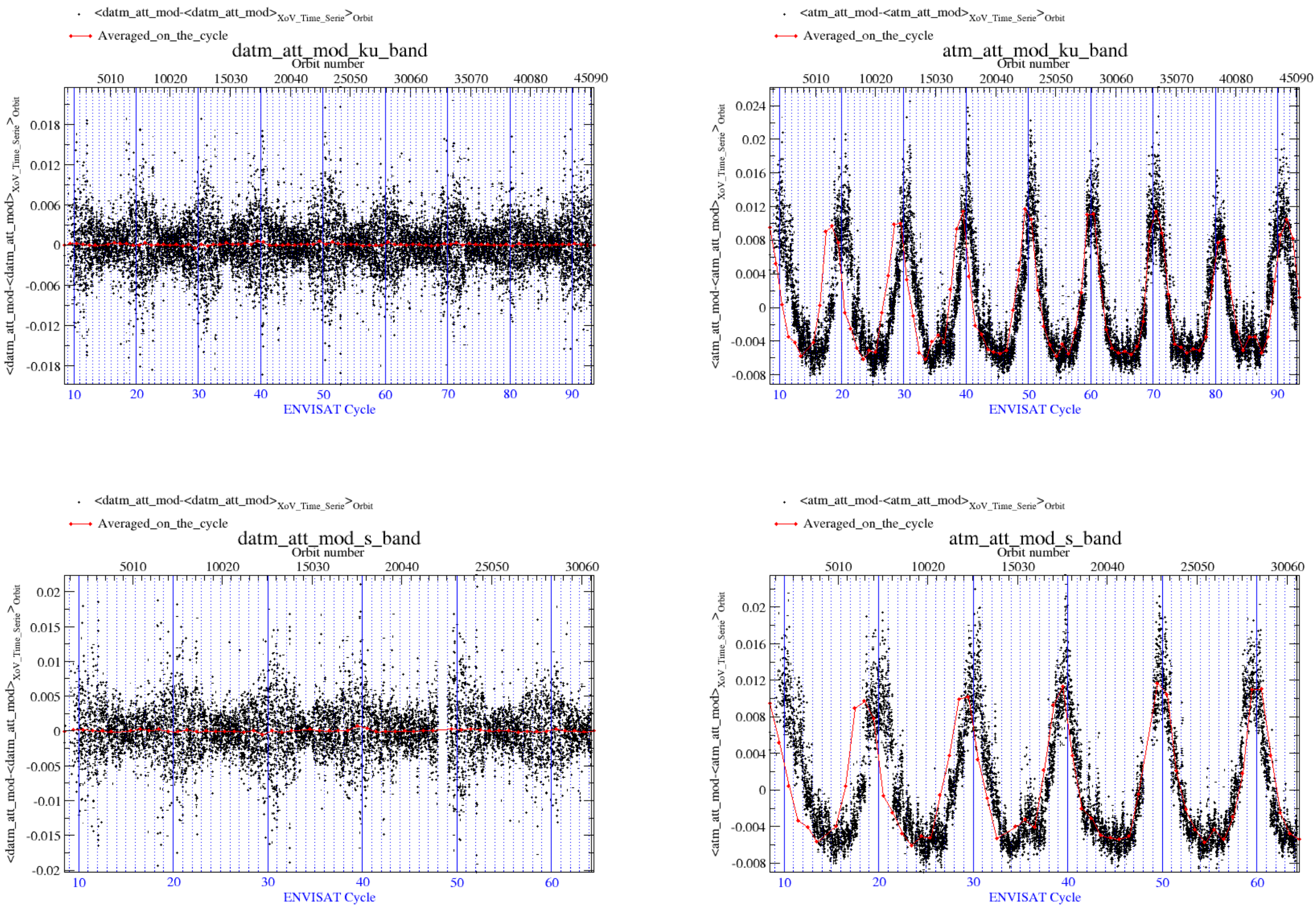


Figure 56: Atmospheric attenuation correction anomaly (dB) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

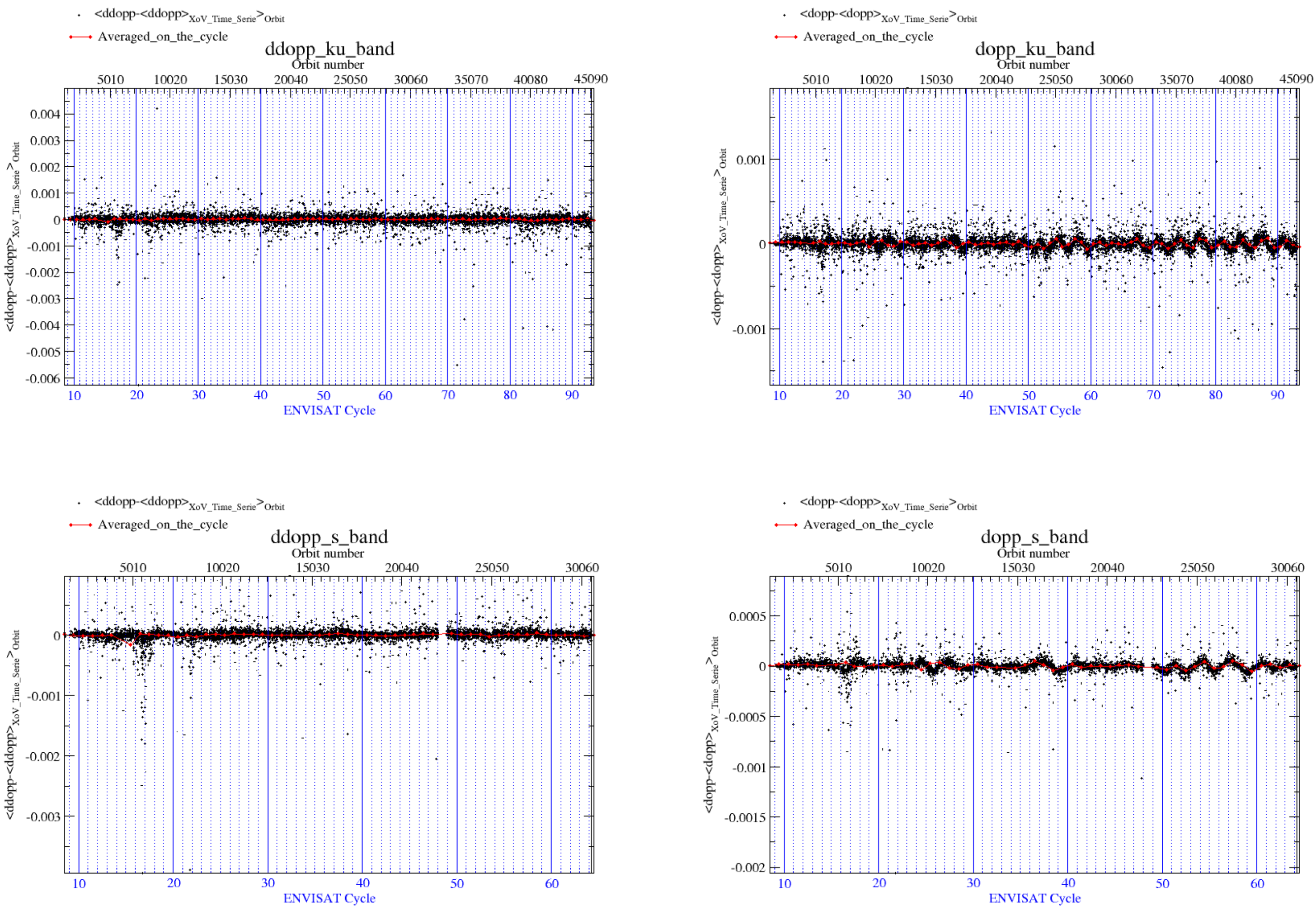


Figure 57: Doppler correction anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

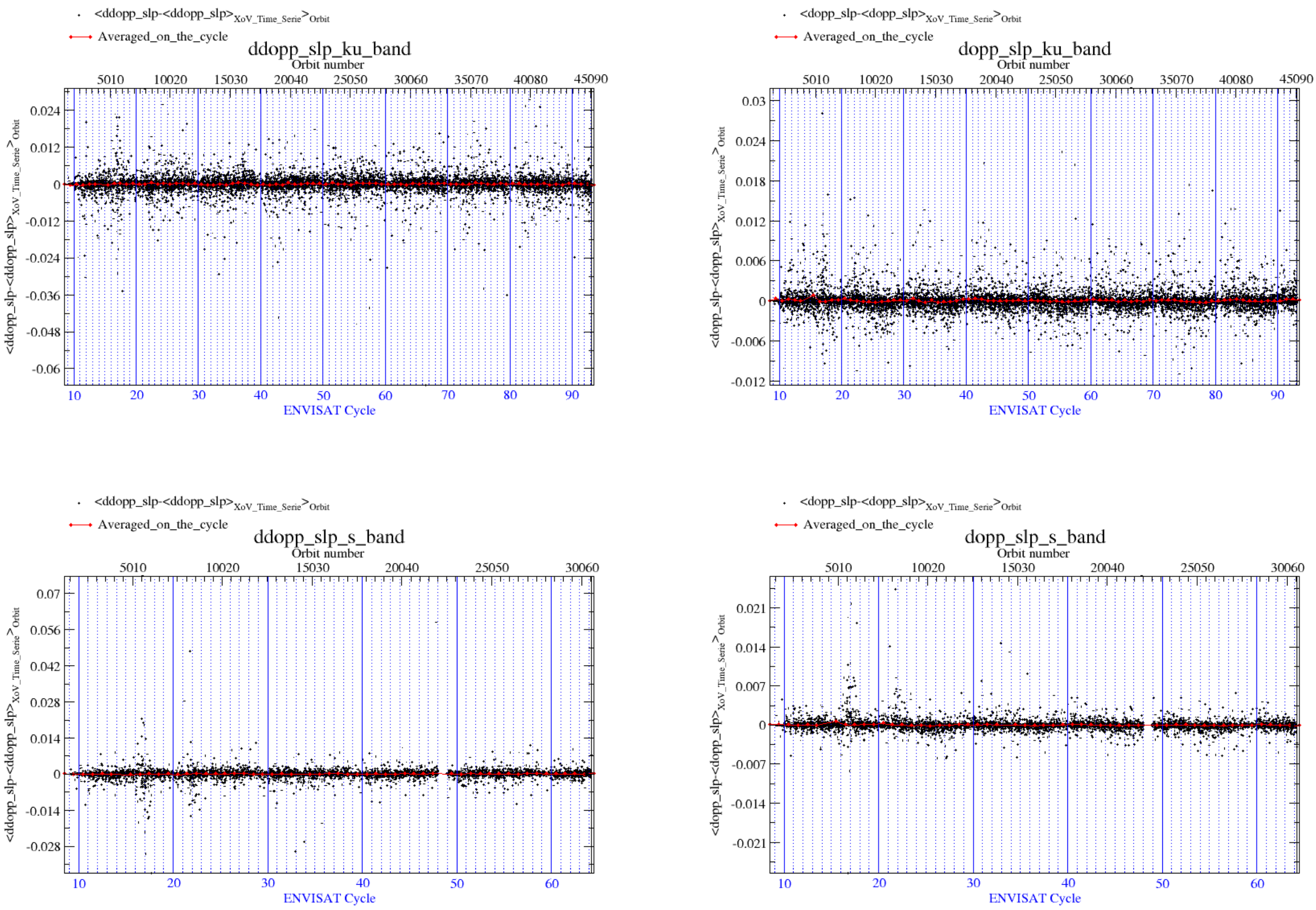


Figure 58: Doppler slope correction anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

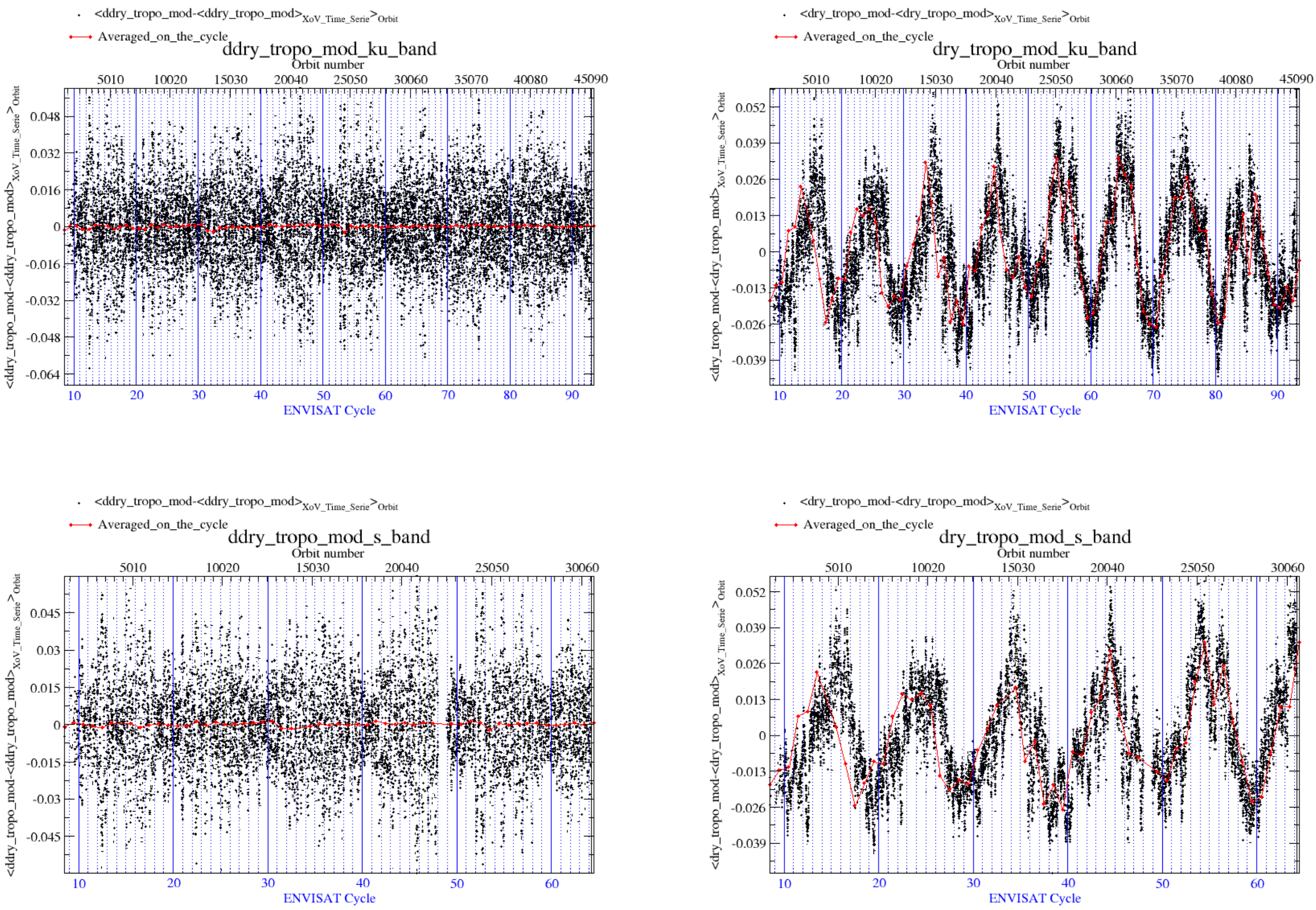


Figure 59: Dry troposphere correction anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

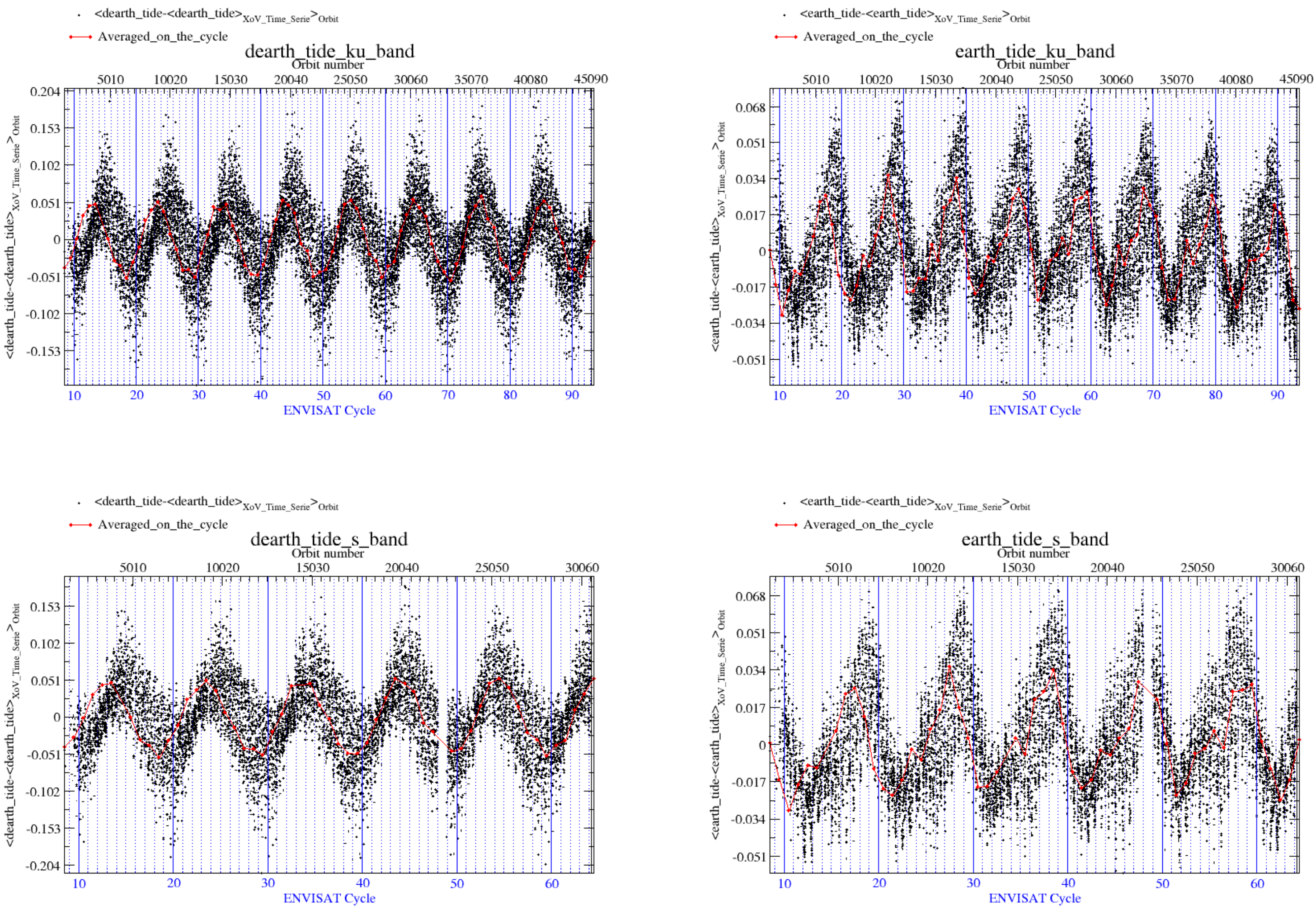


Figure 60: Earth tide correction anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

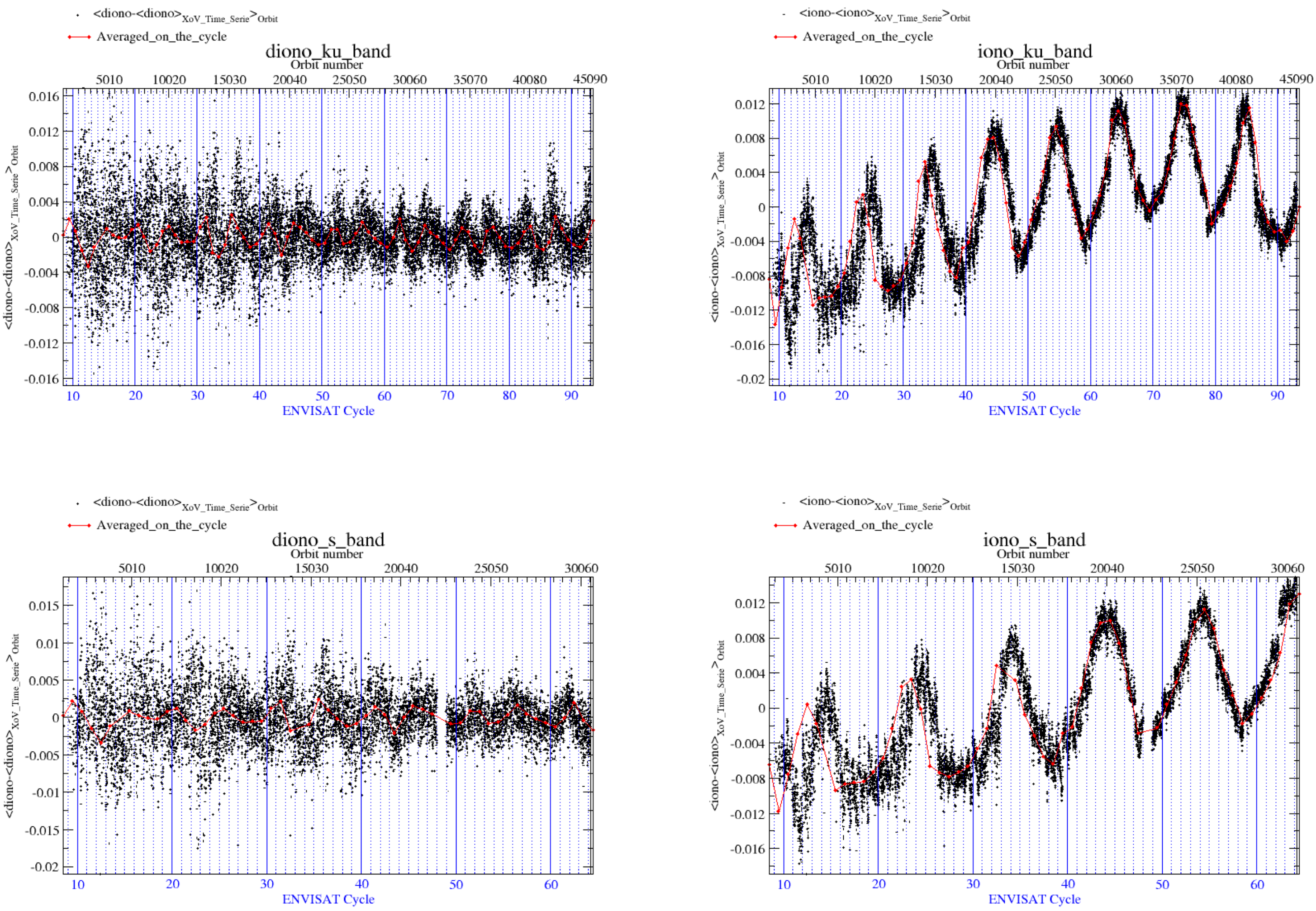


Figure 61: Ionospheric correction anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

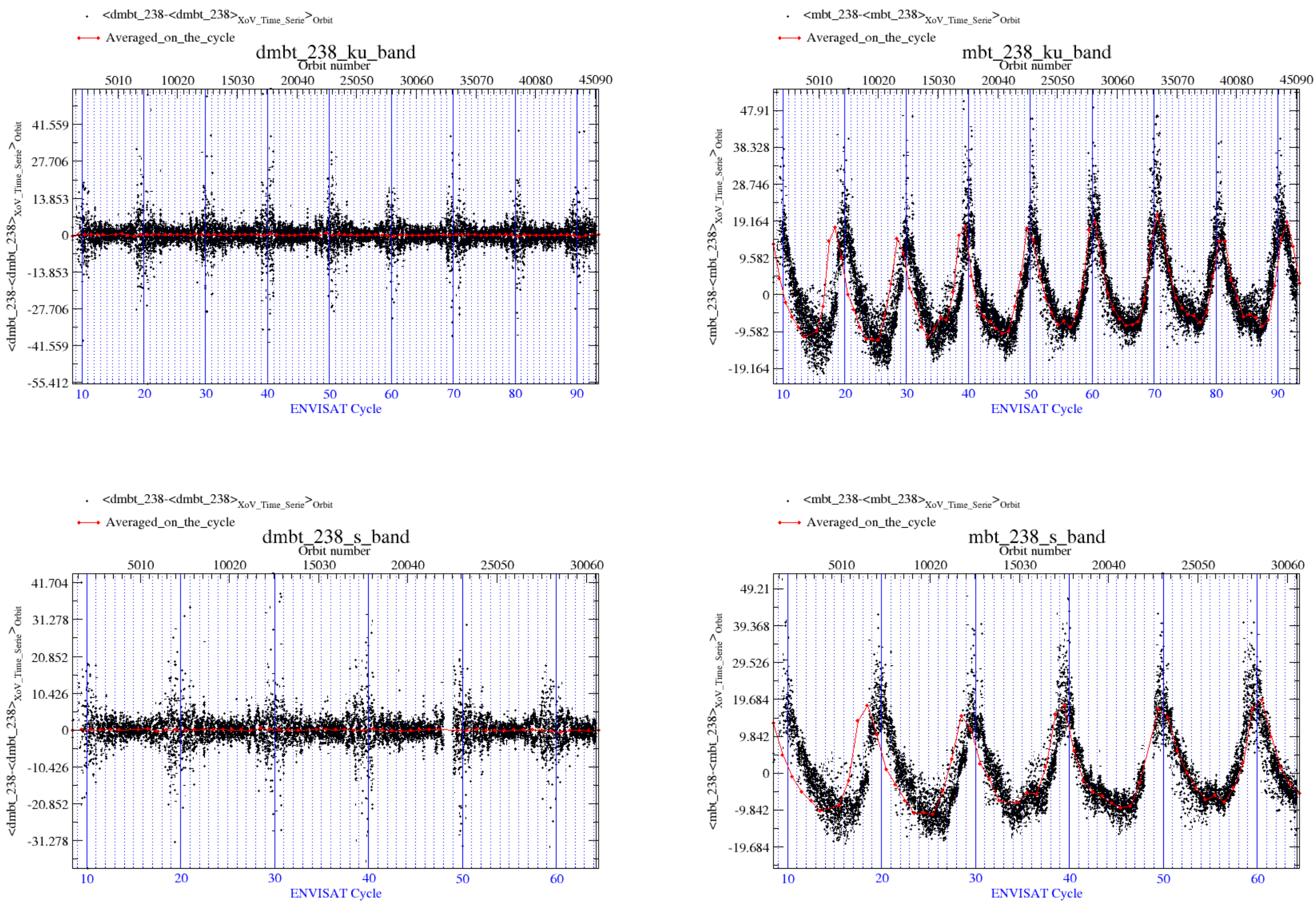


Figure 62: Microwave Brightness Temperature 23.8 GHz anomaly (K) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

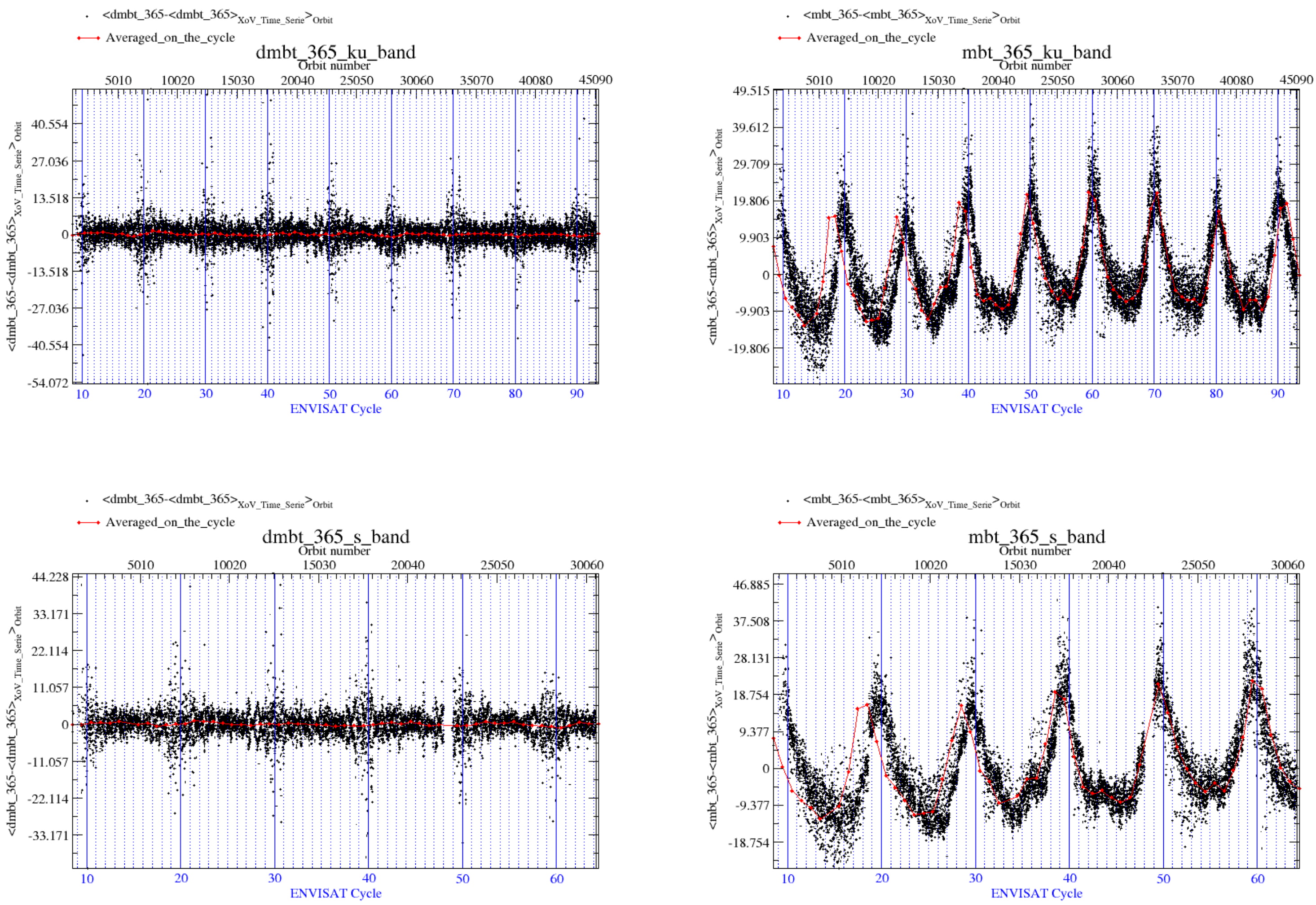


Figure 63: Microwave Brightness Temperature 36.5 GHz anomaly (K) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

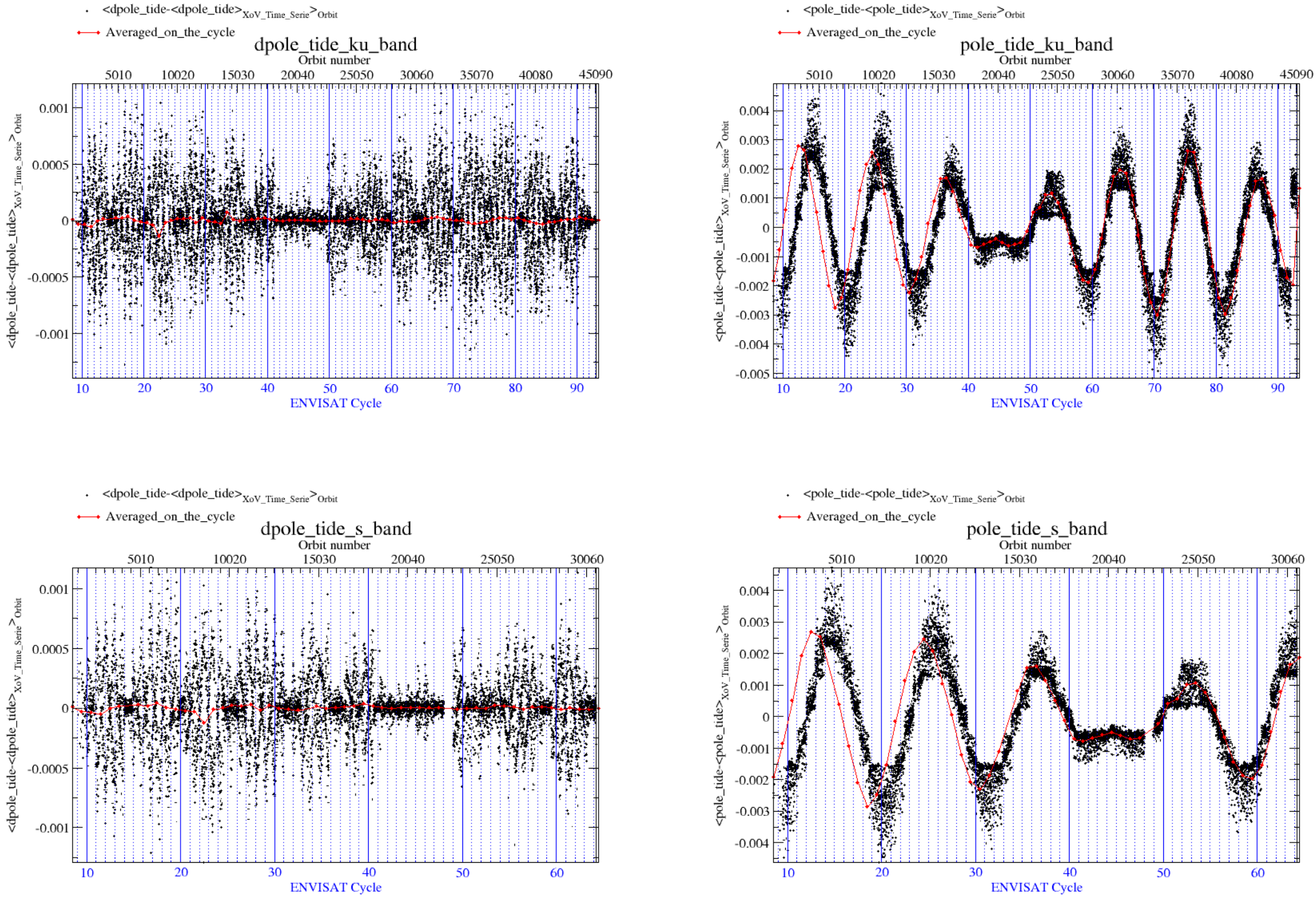


Figure 64: Pole tide anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

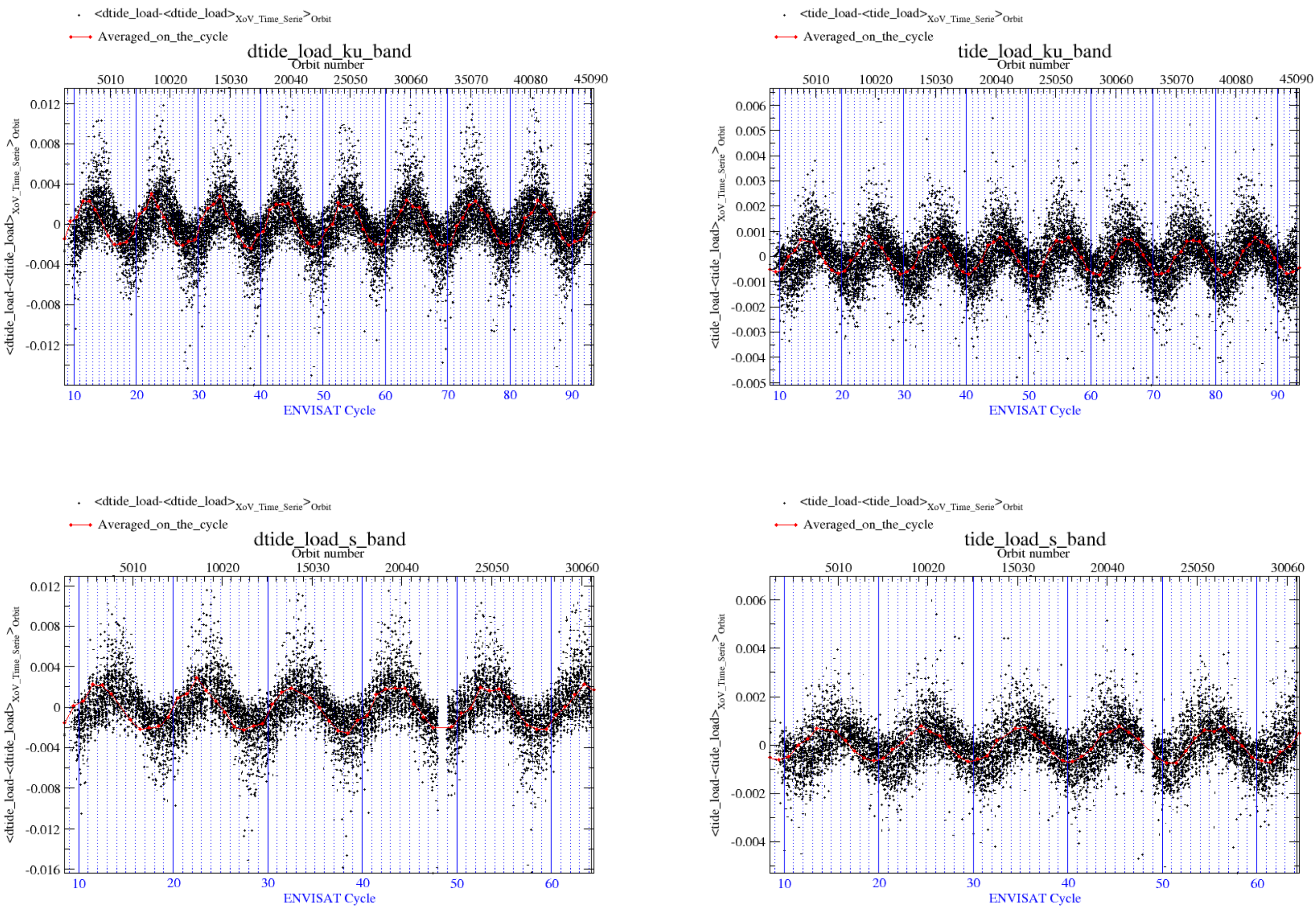


Figure 65: Tide load anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

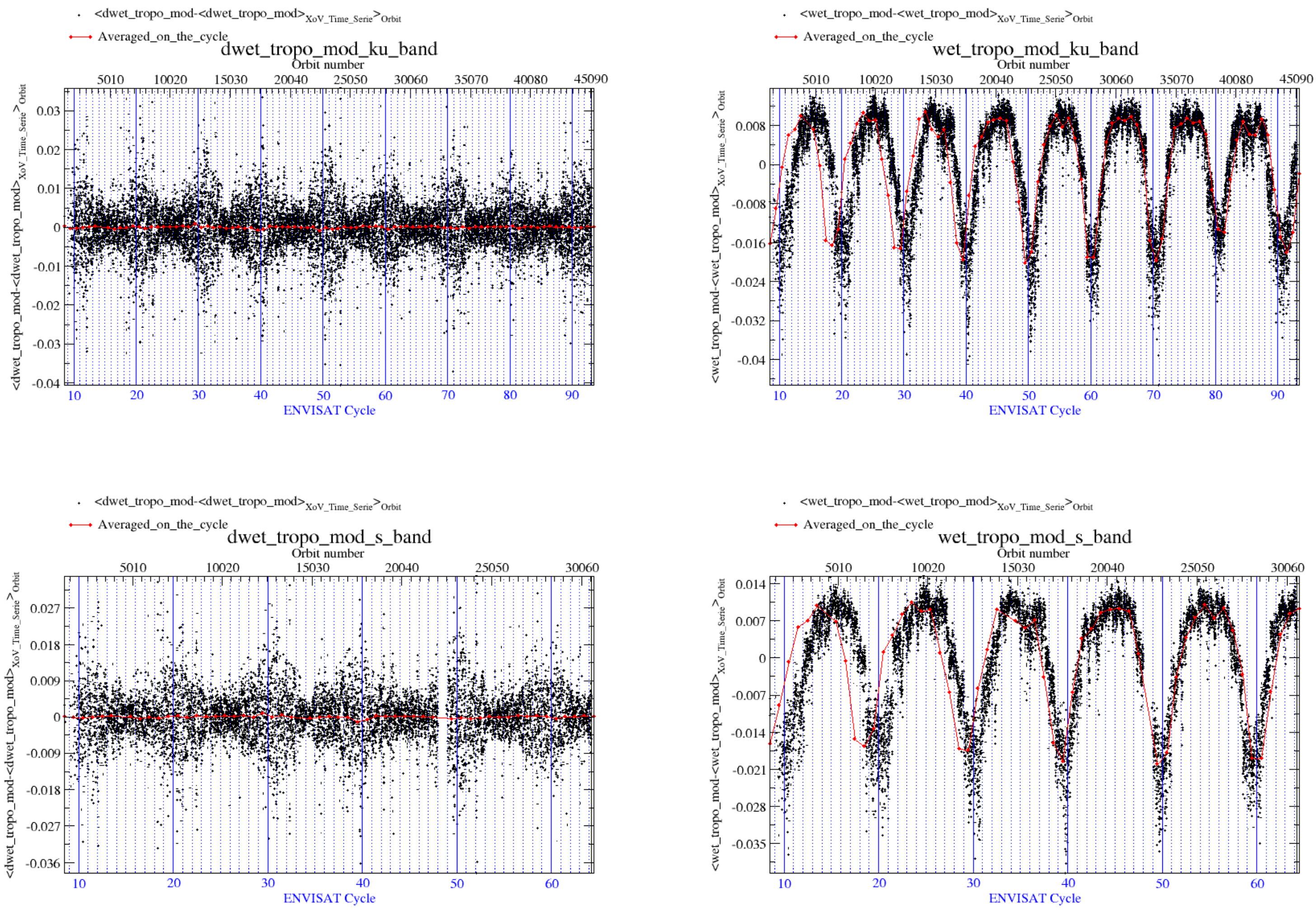


Figure 66: Wet tropospheric correction anomaly (m) for Ku (top) and S (down) band for each orbit over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

4.3.3 ICE-2 parameters: Anomaly versus cycle

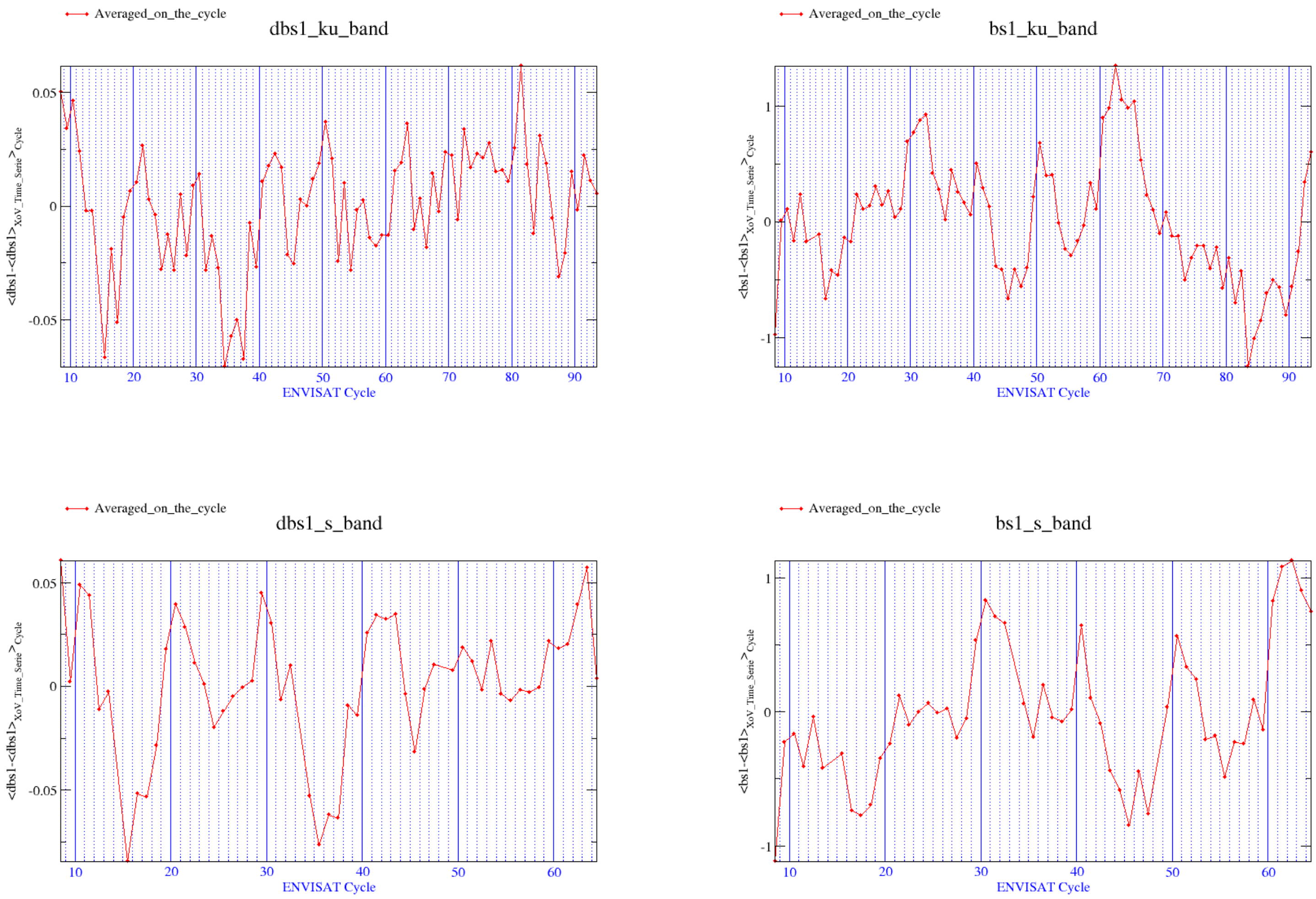


Figure 67: Backscatter anomaly (dB) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

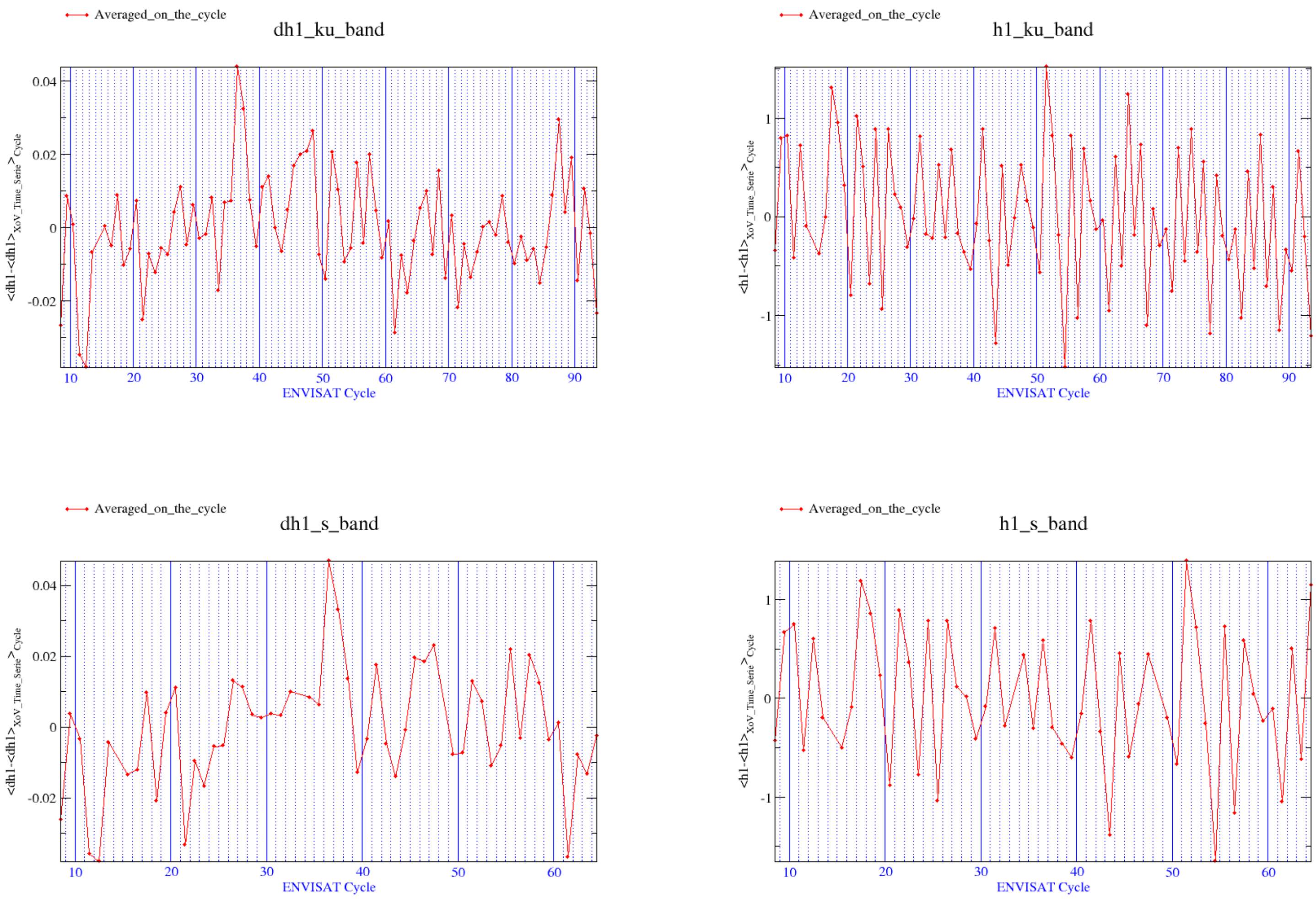


Figure 68: Surface slope anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

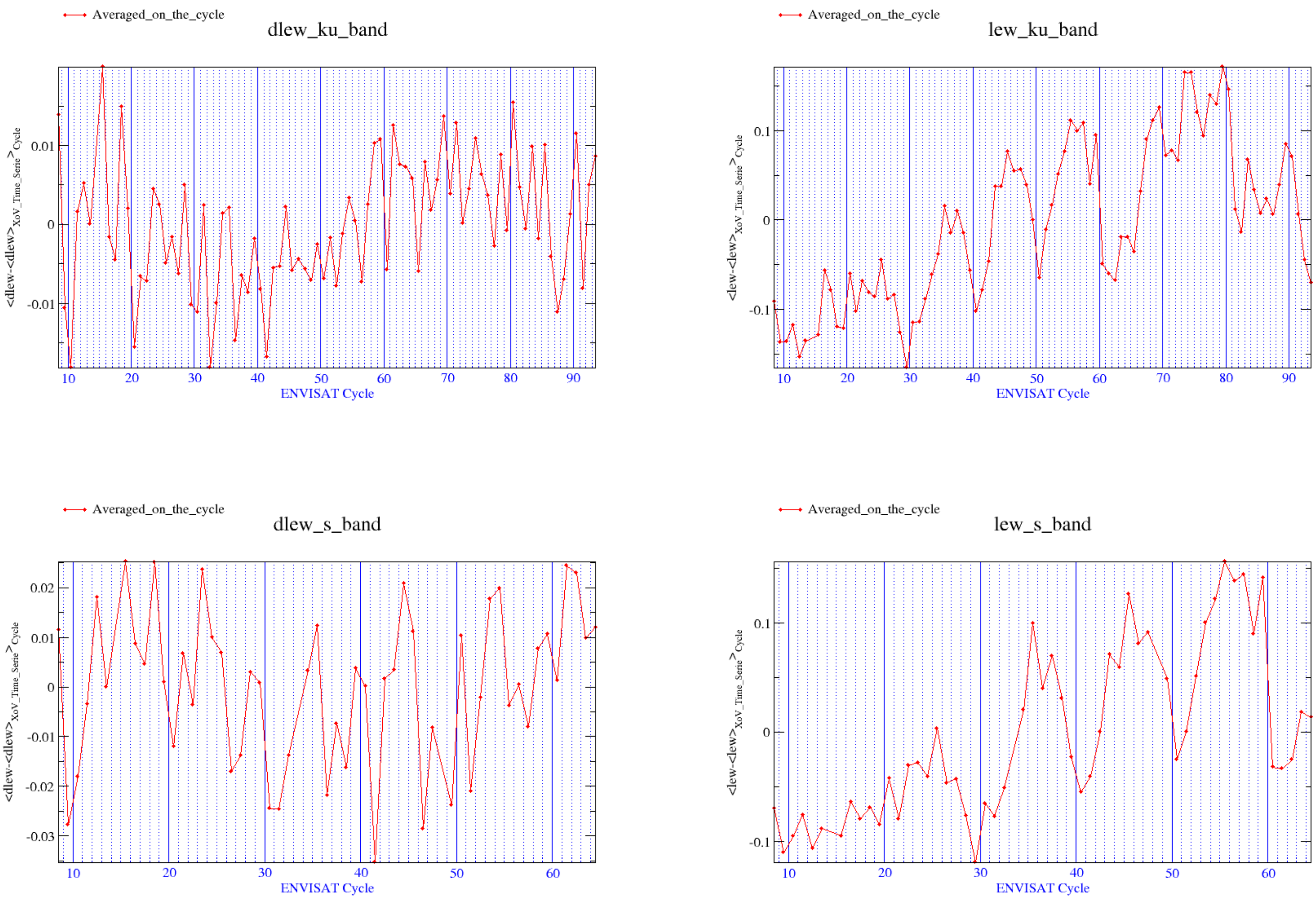


Figure 69: Leading edge width anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

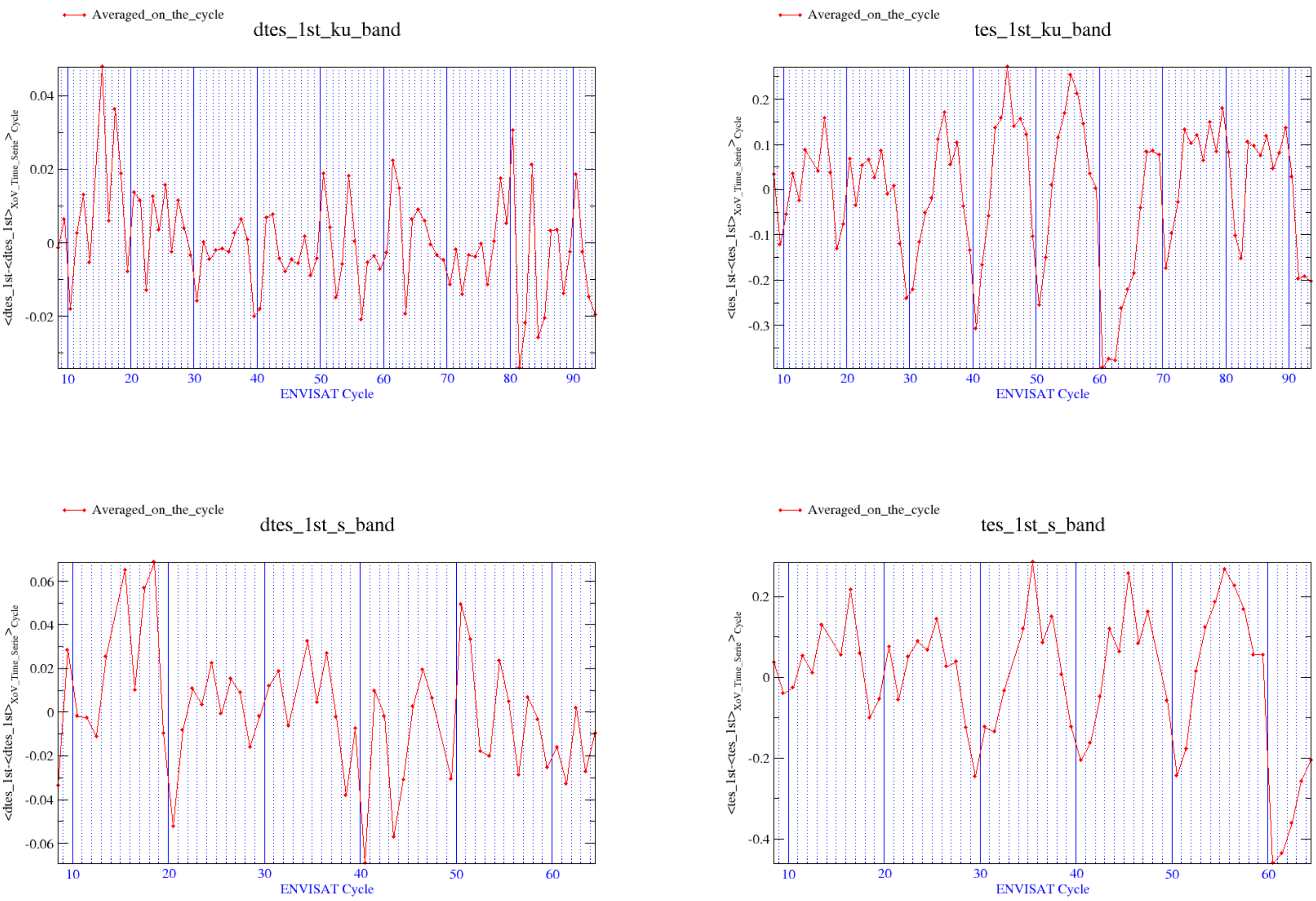


Figure 70: Trealing edge slope anomaly (10-6 s-1) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

4.3.4 Corrections: Anomaly versus cycle

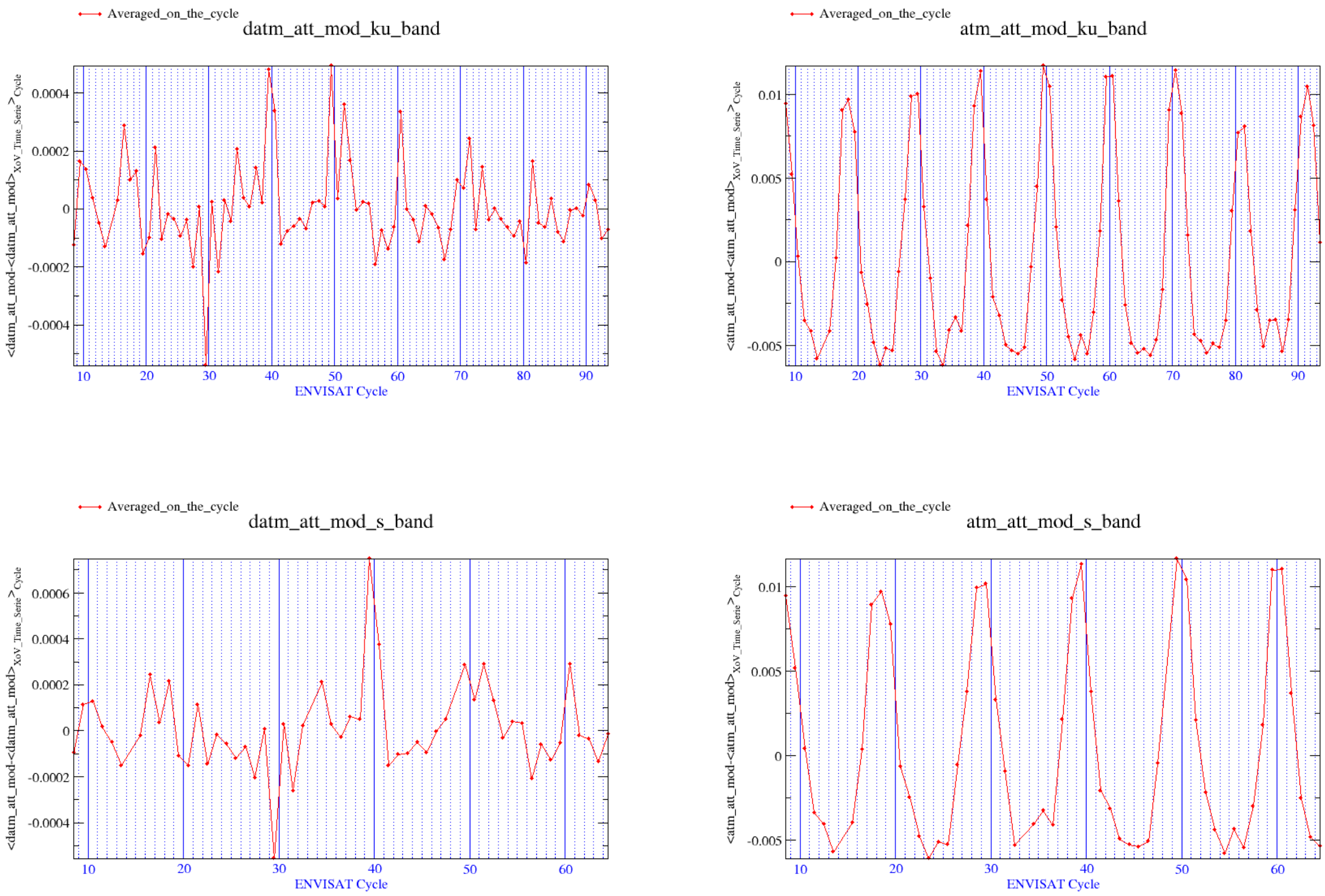


Figure 71: Atmospheric attenuation correction anomaly (dB) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

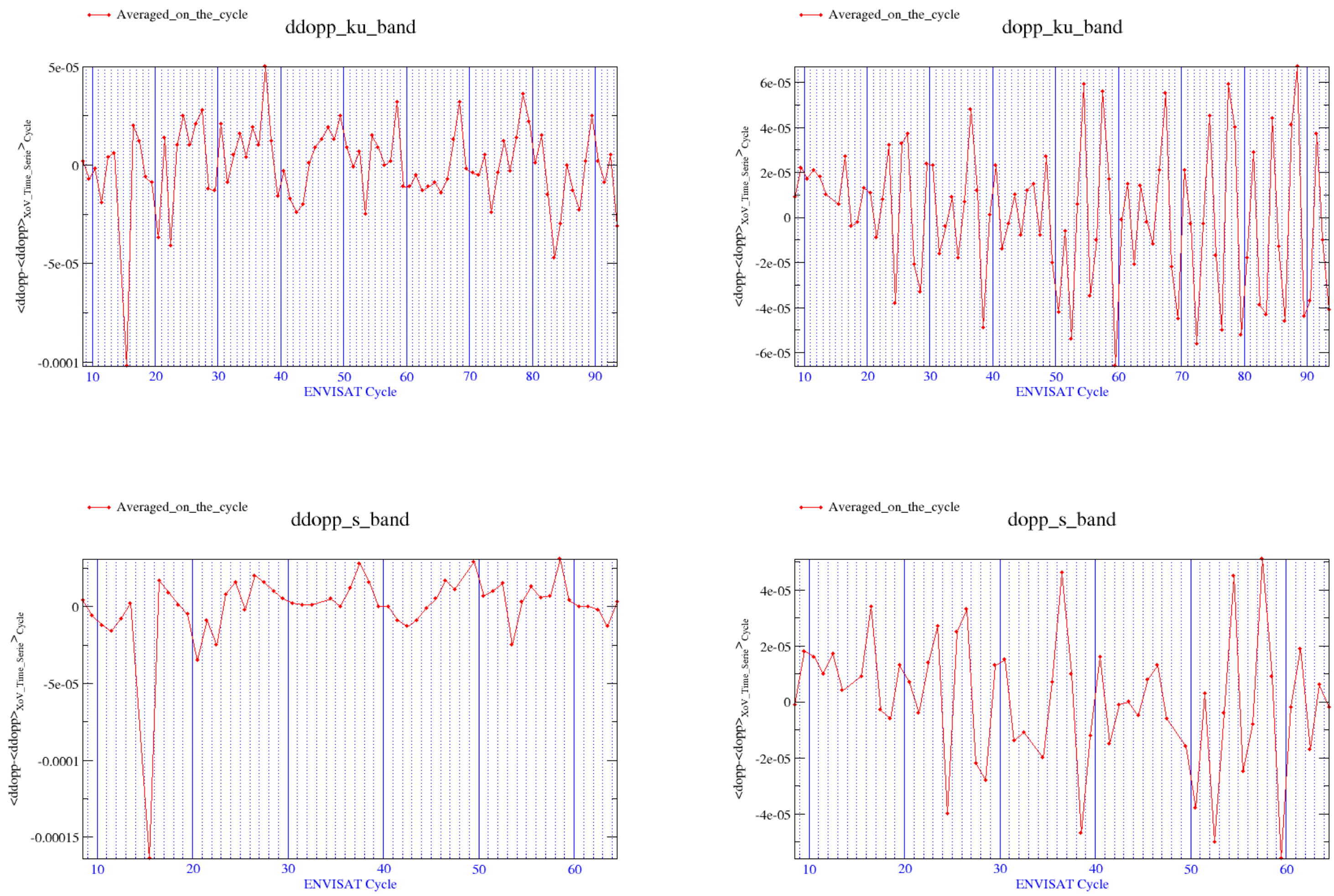


Figure 72: Doppler correction anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

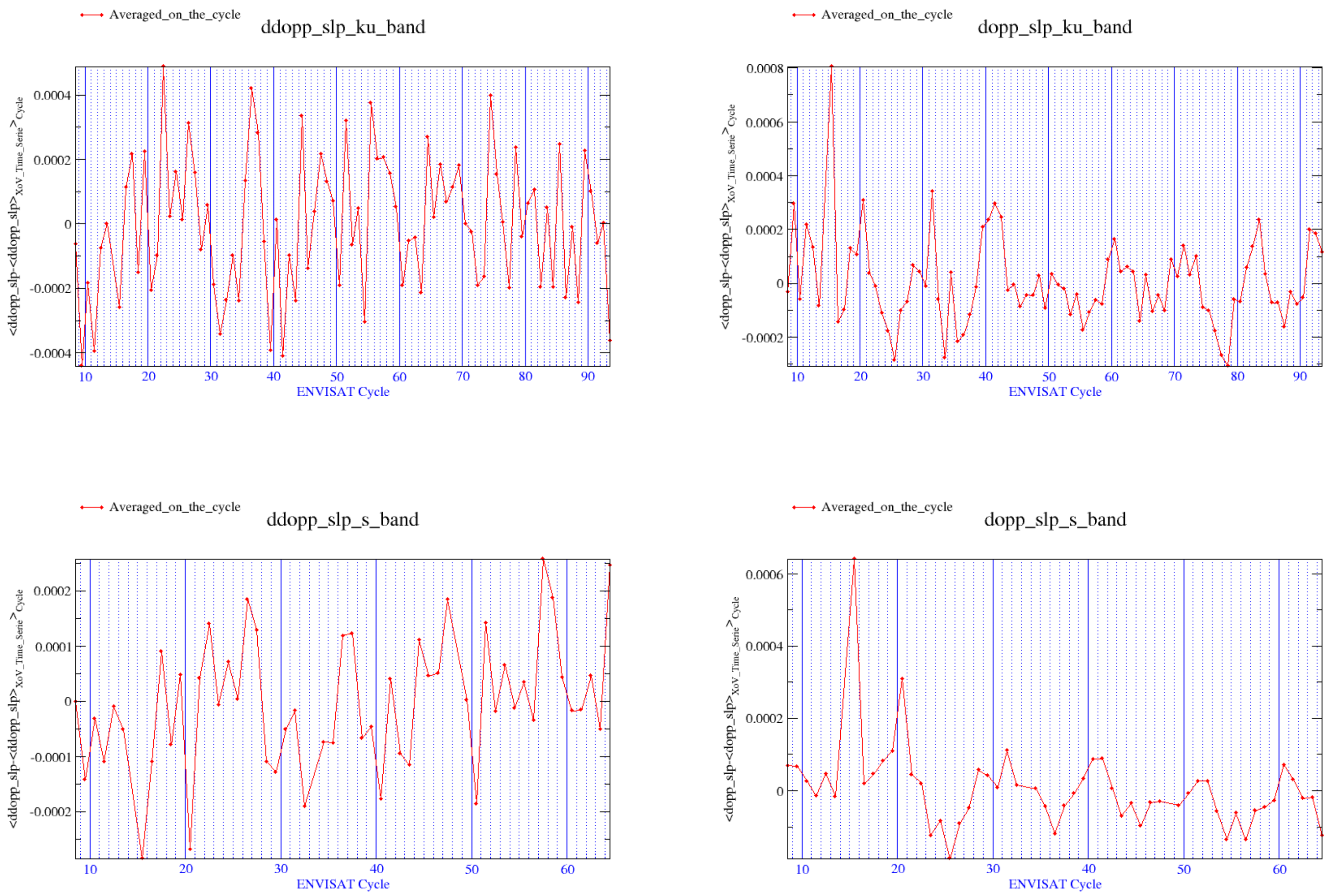


Figure 73: Doppler slope correction anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

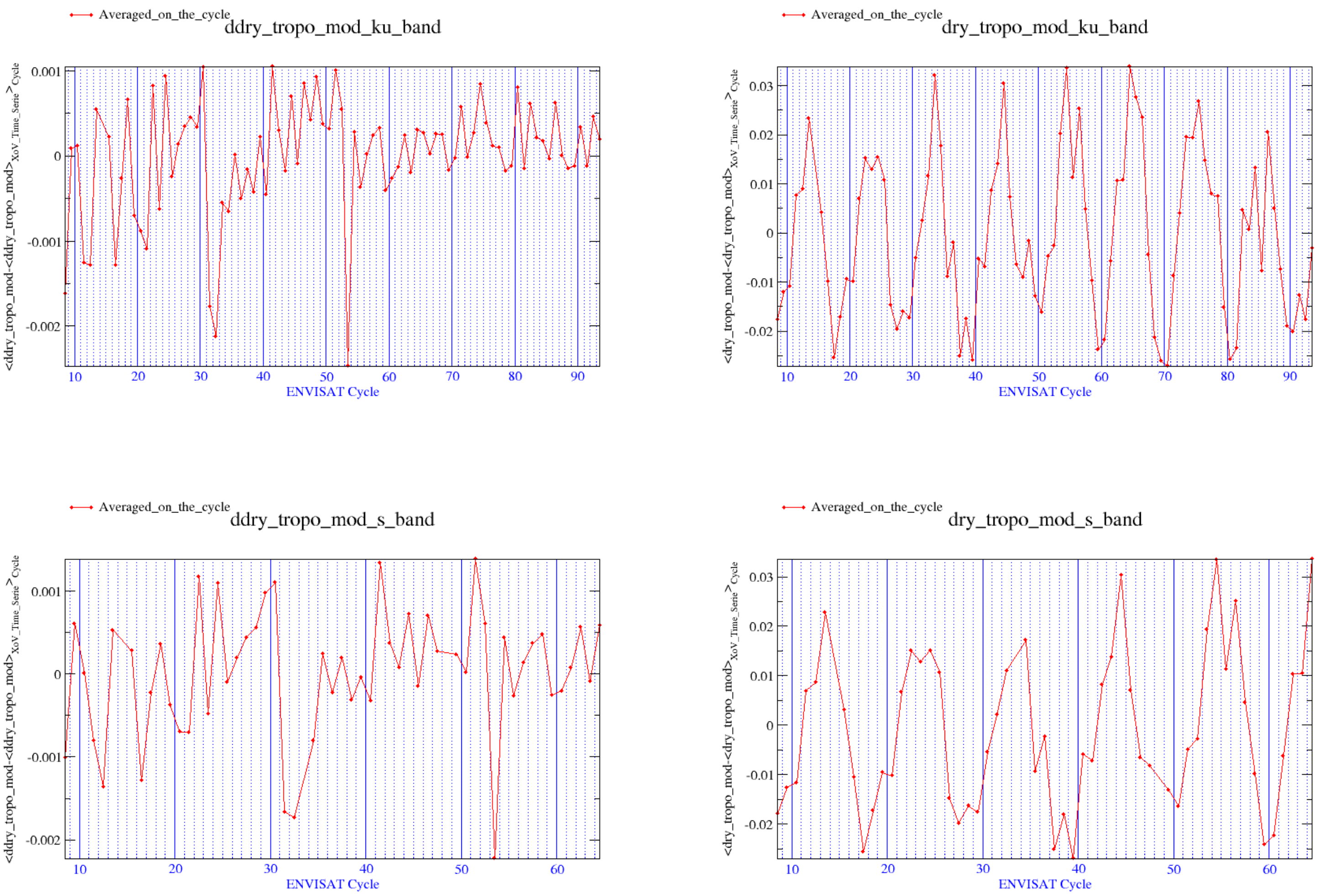


Figure 74: Dry tropospheric correction anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

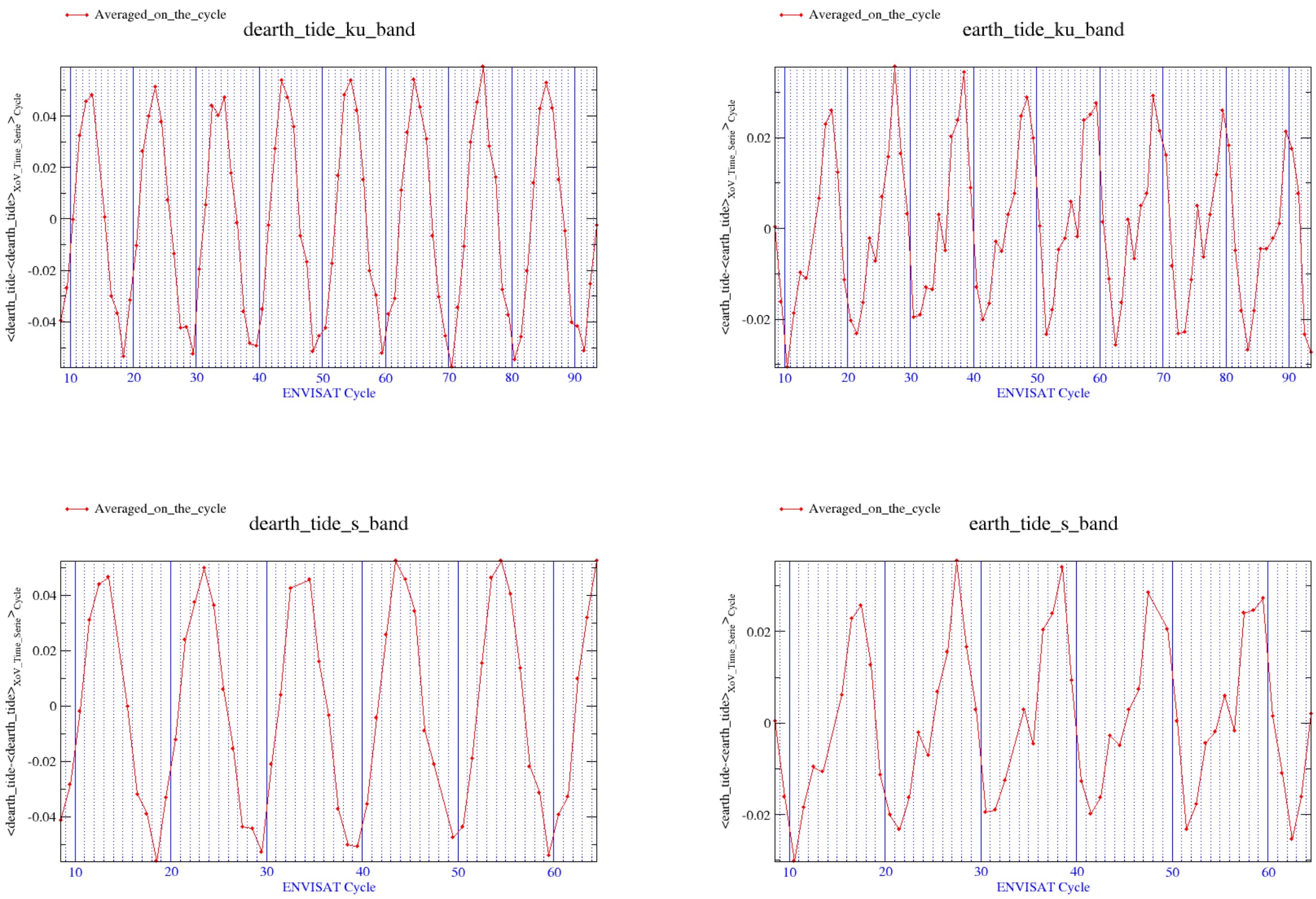


Figure 75: Earth tide anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

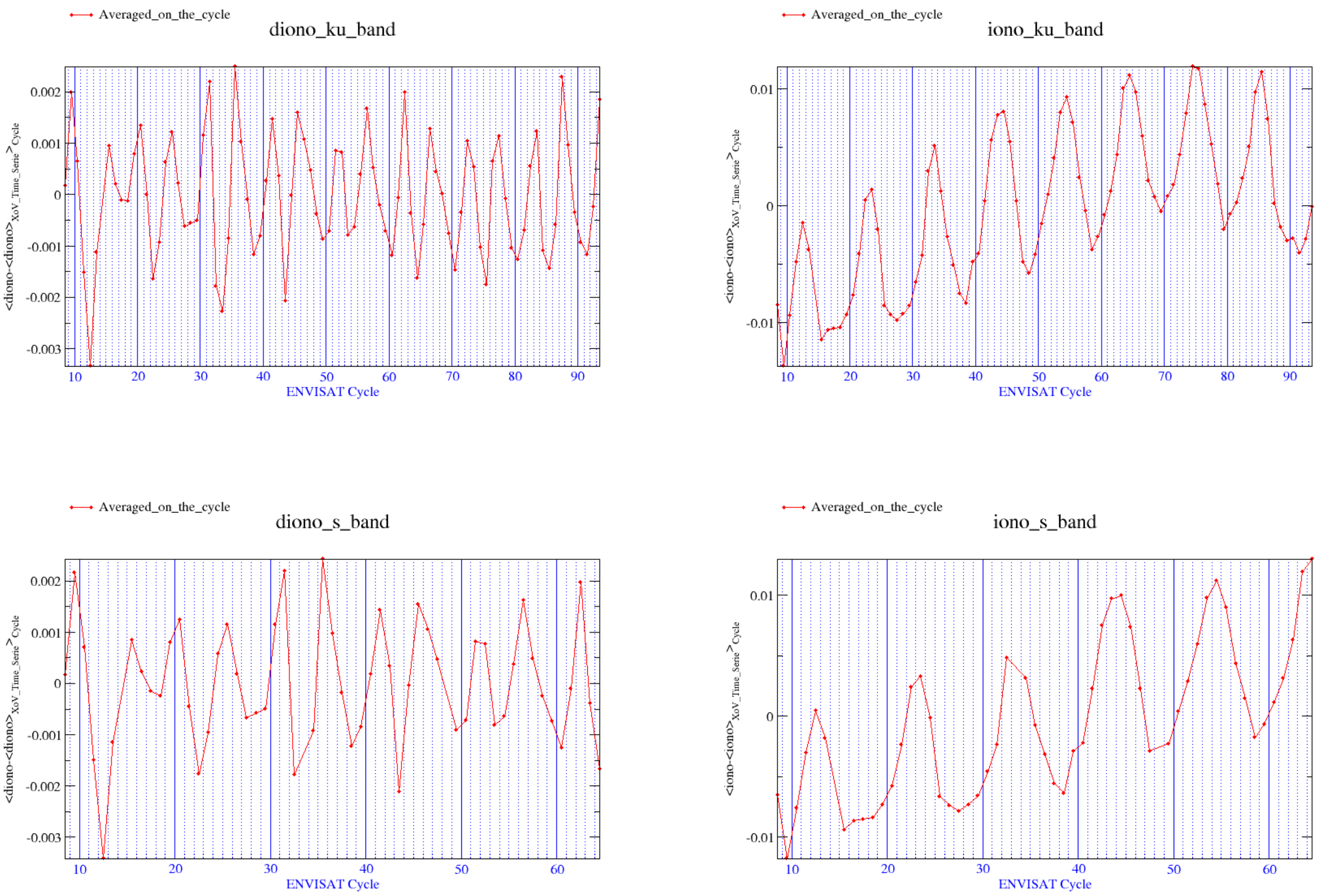


Figure 76: Ionospheric correction anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

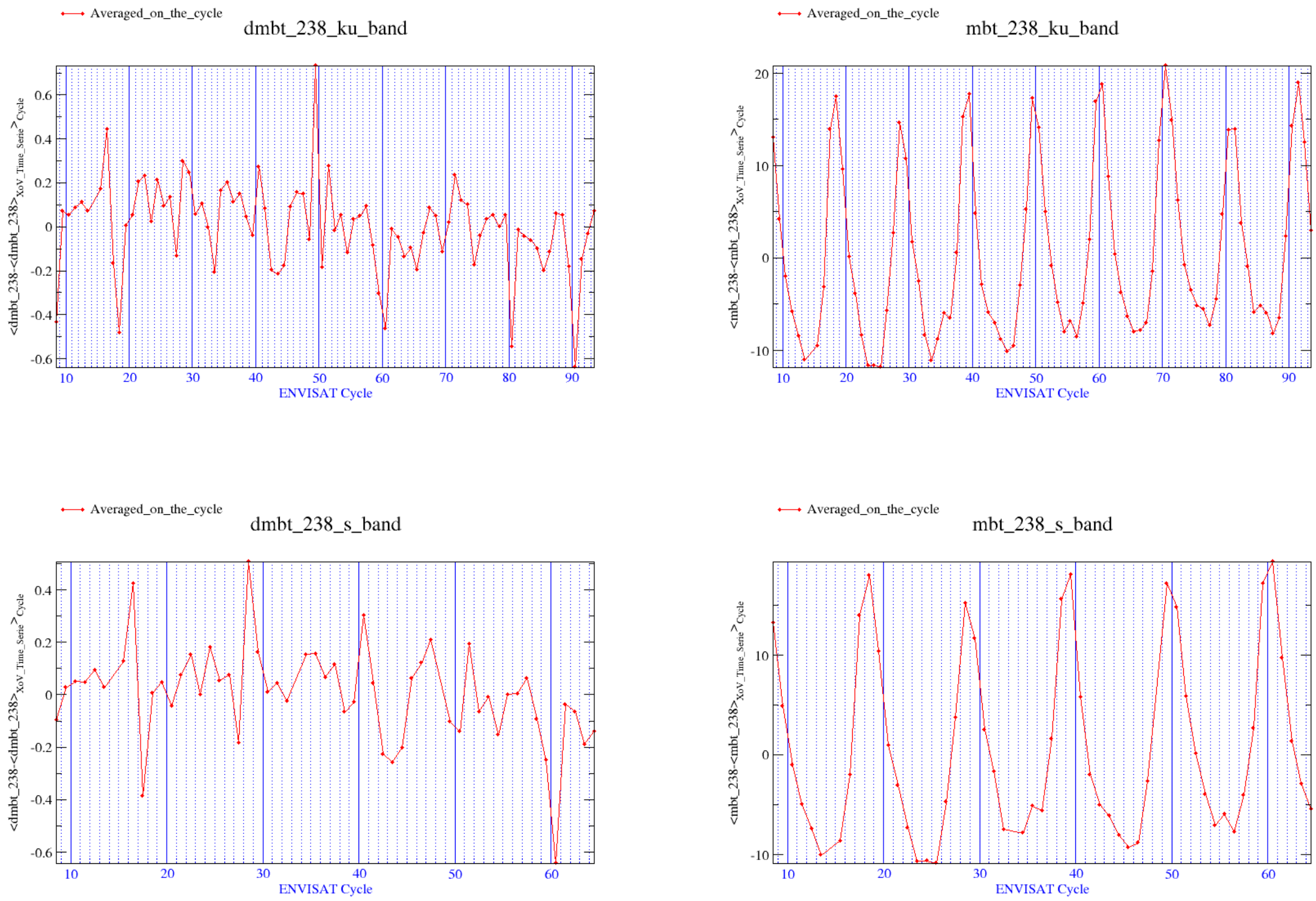


Figure 77: Microwave Brightness Temperature 23.8 GHz anomaly (K) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

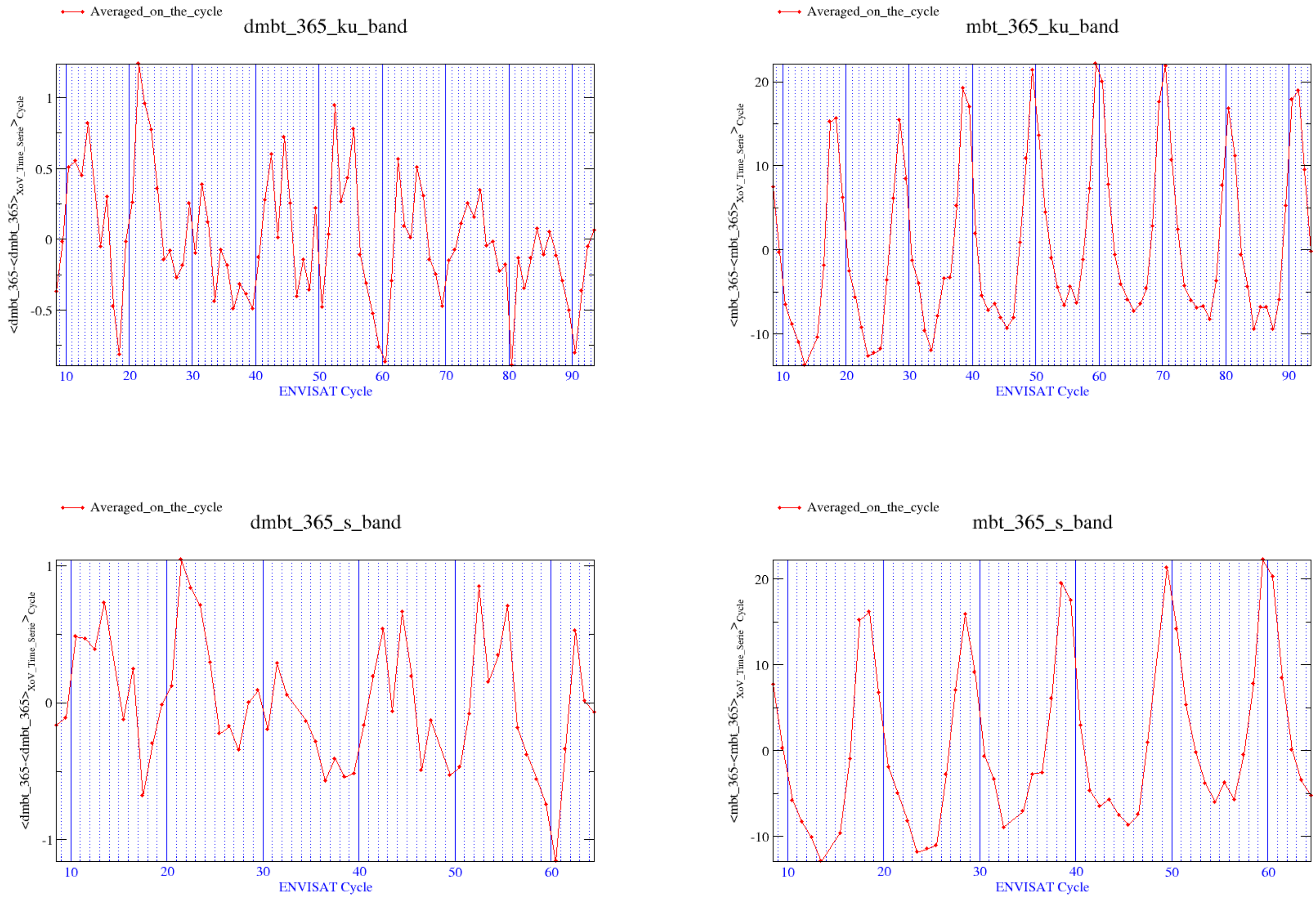


Figure 78: Microwave Brightness Temperature 36.5 GHz anomaly (K) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

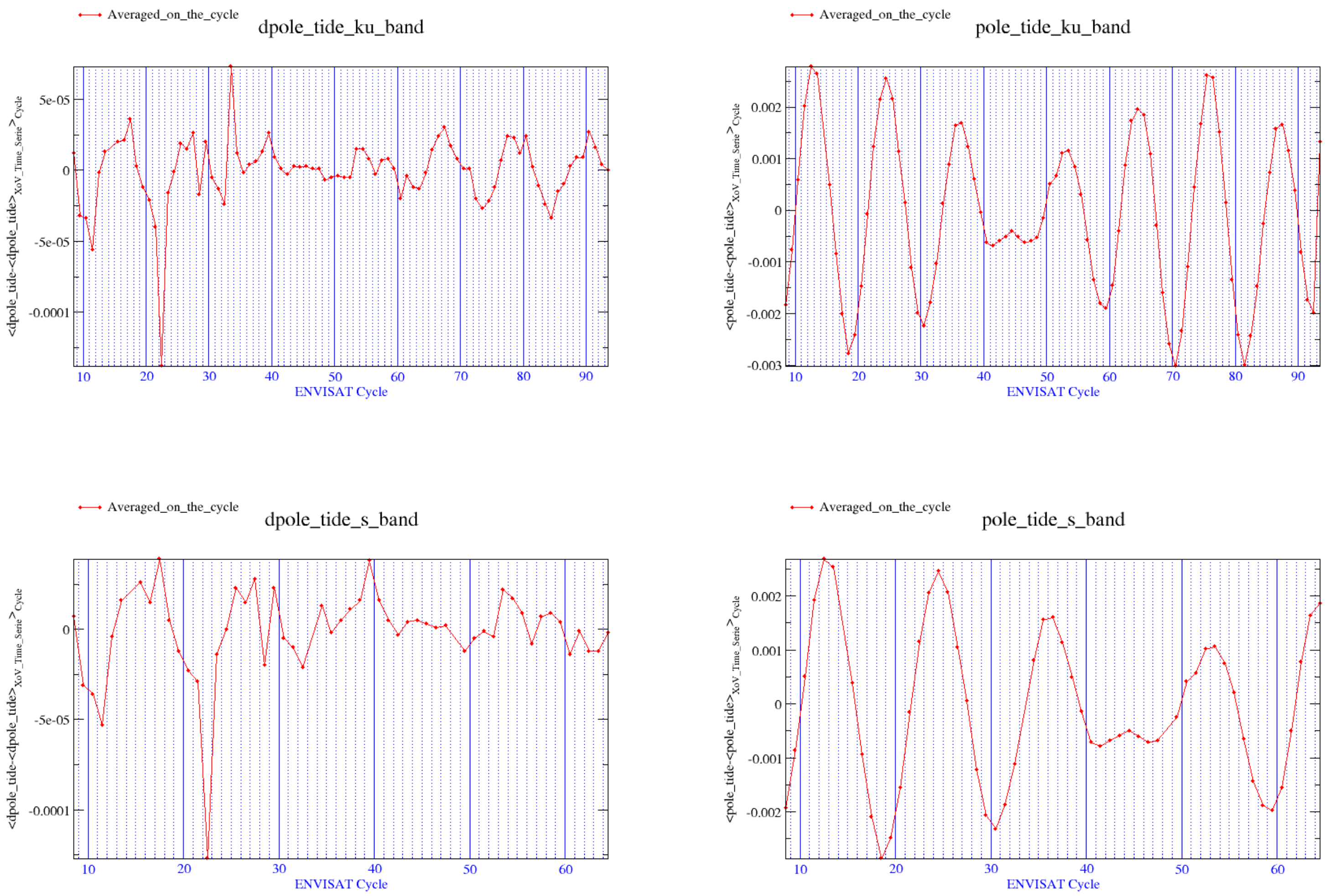


Figure 79: Pole tide anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

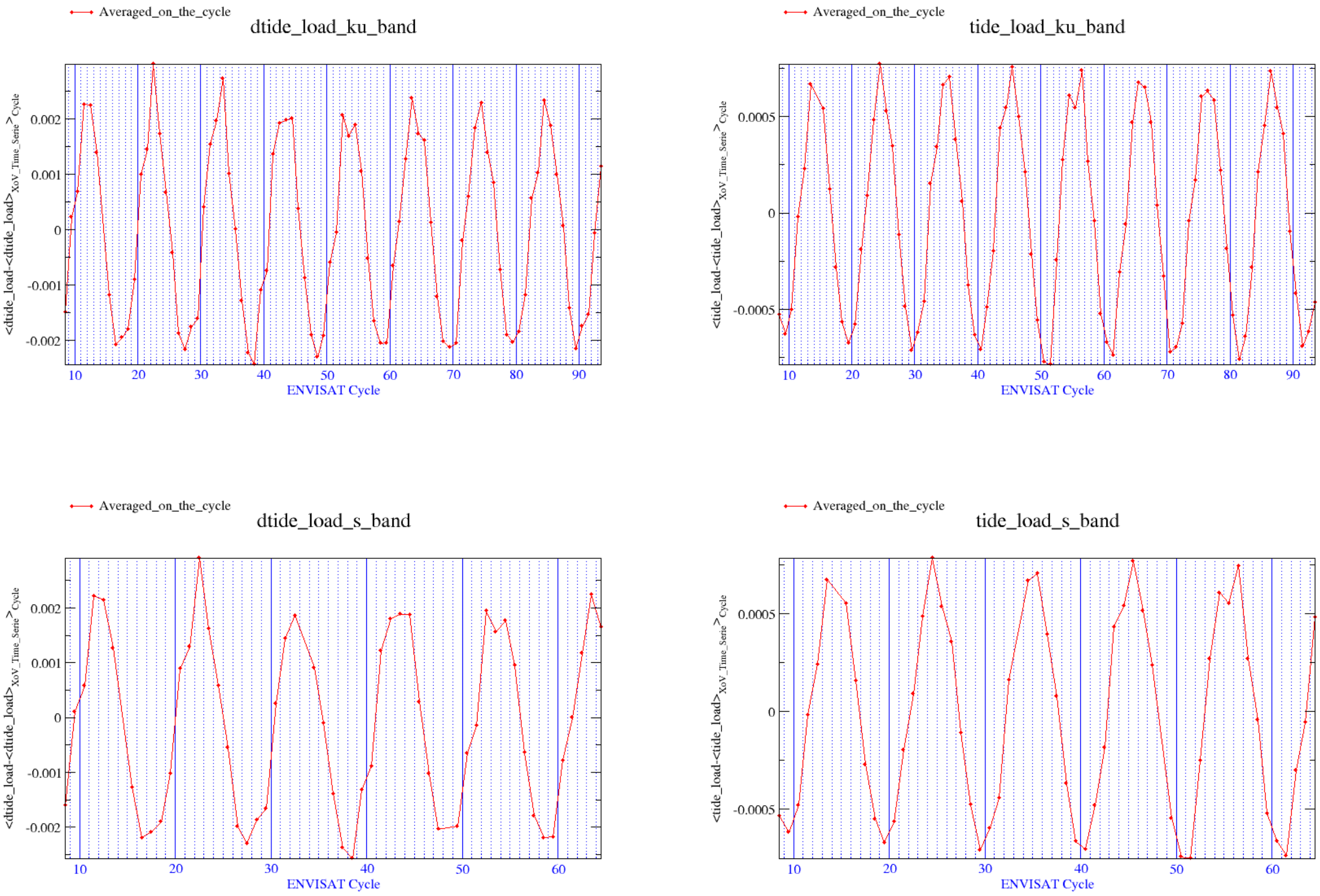


Figure 80: Tide load anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

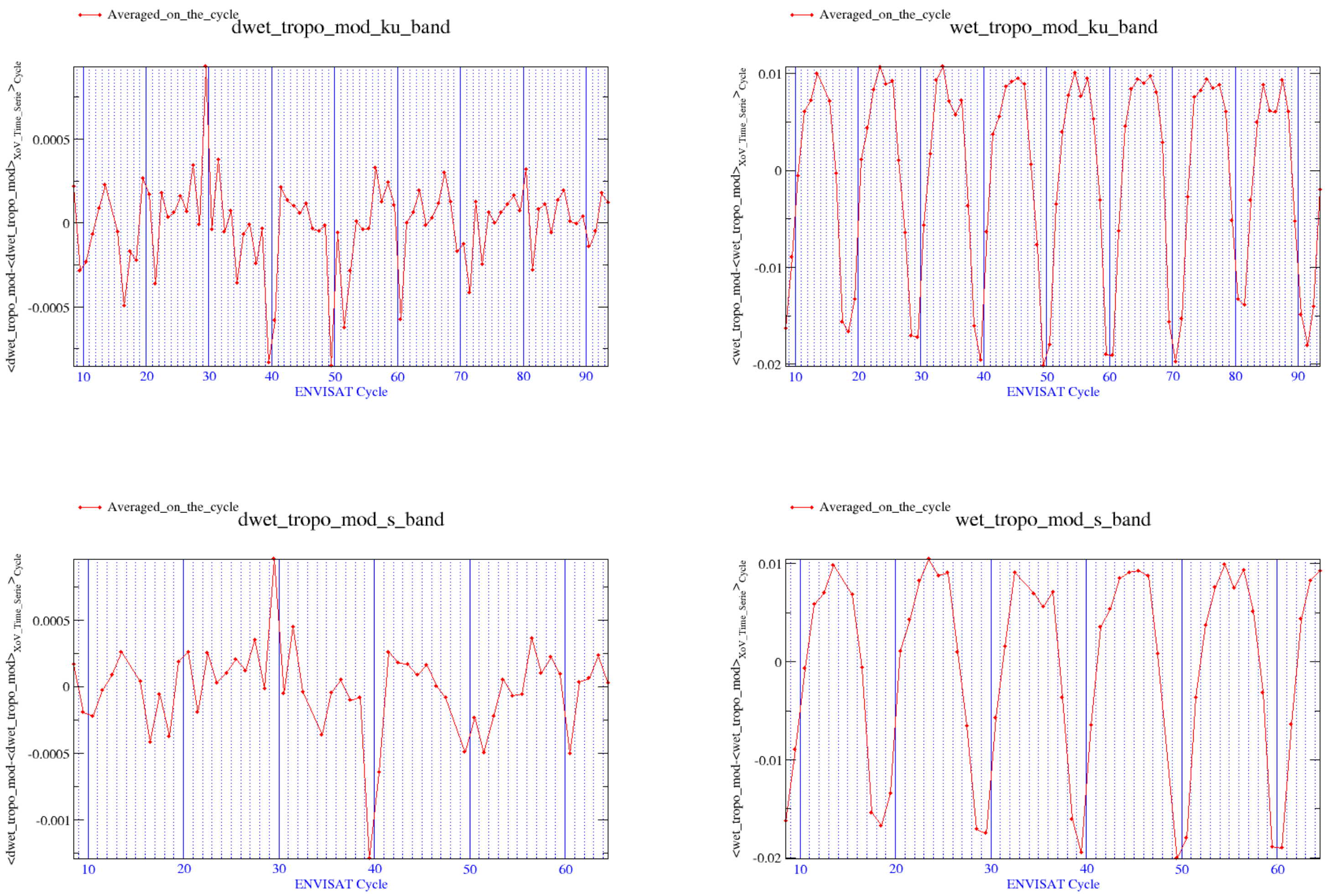


Figure 81: Wet tropospheric correction anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference anomaly. On the right hand side,crossover mean anomaly.

4.3.5 ICE-2 parameters: RMS versus cycle

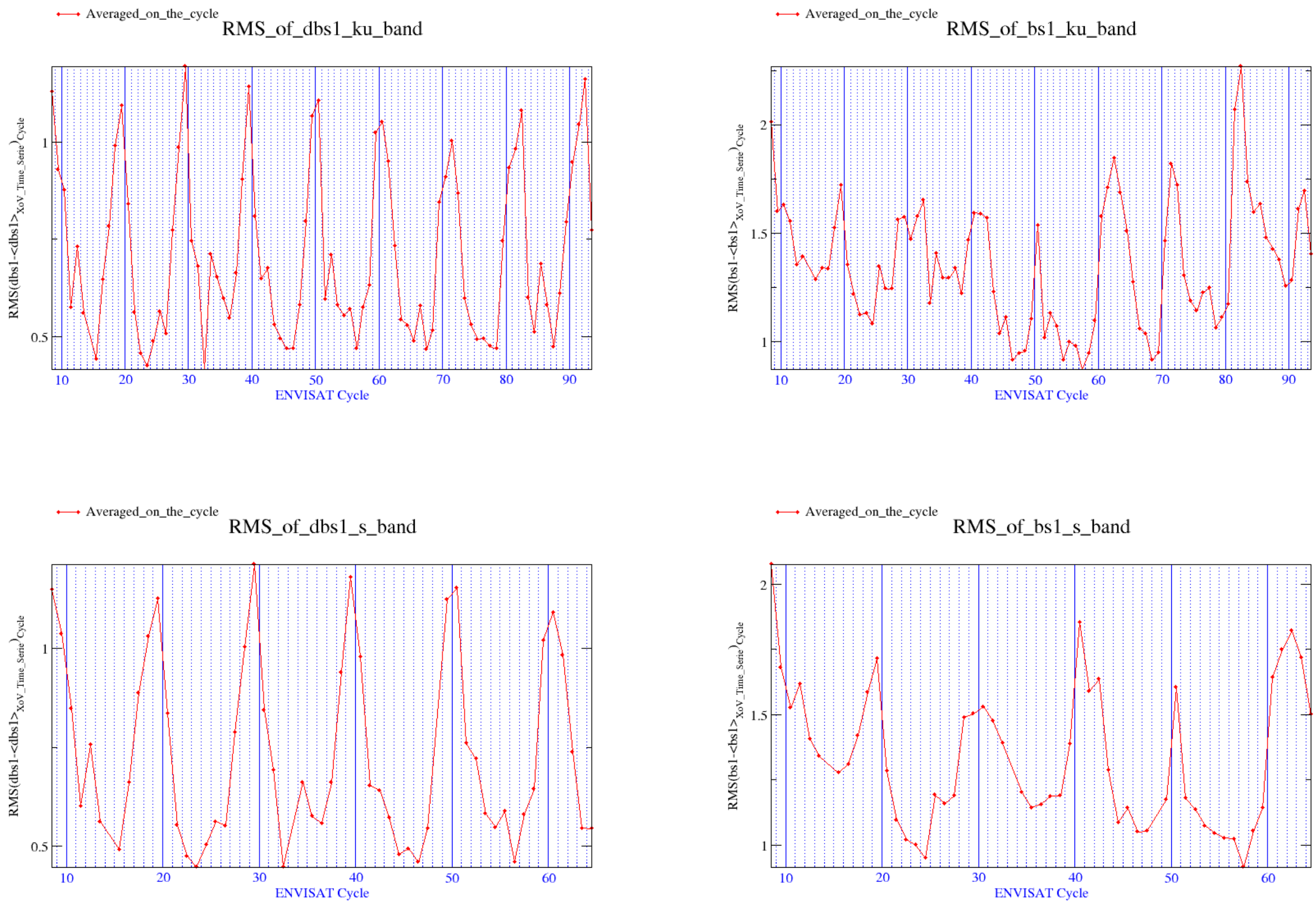


Figure 82: Backscatter RMS anomaly (dB) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

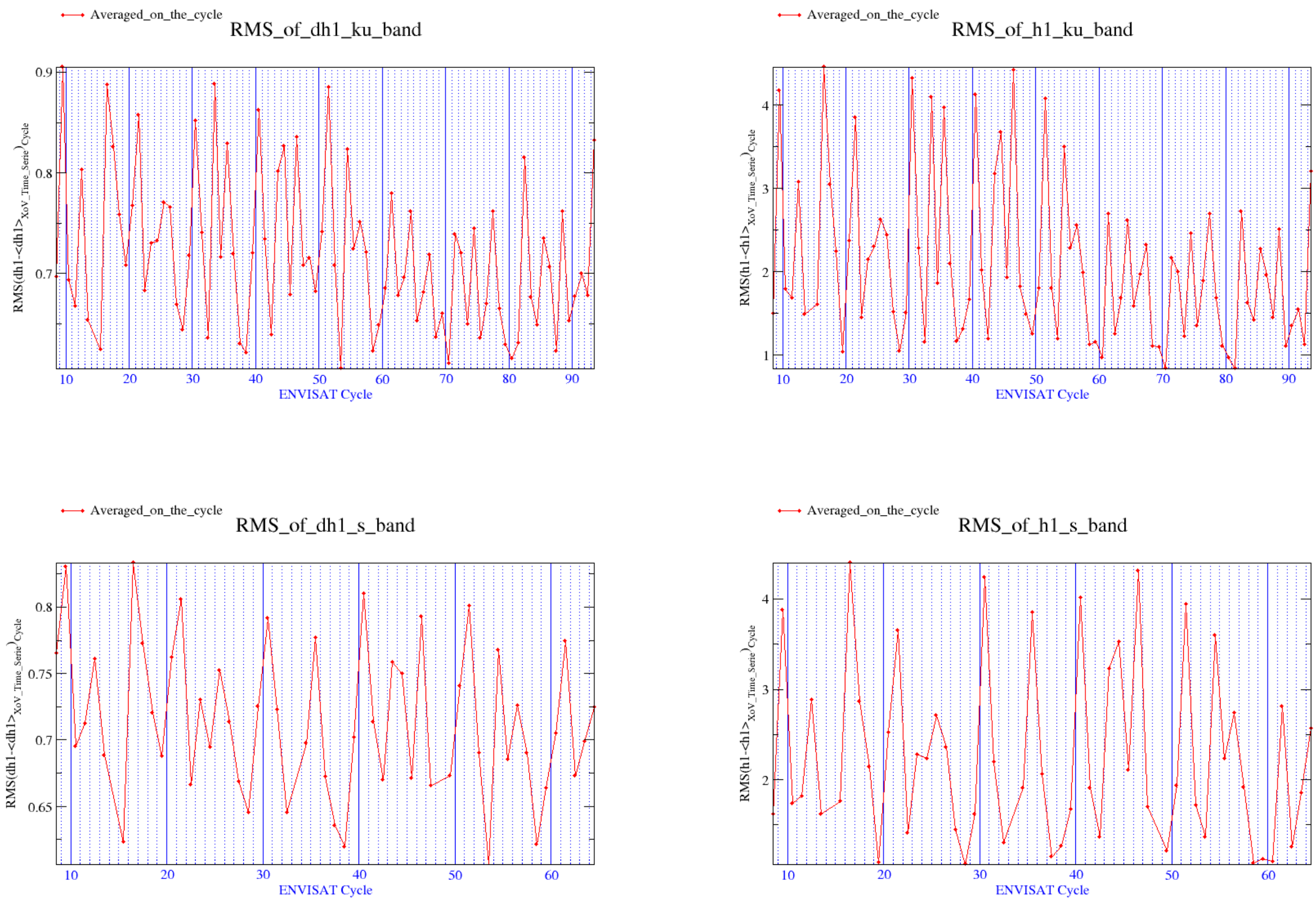


Figure 83: Surface heigth RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

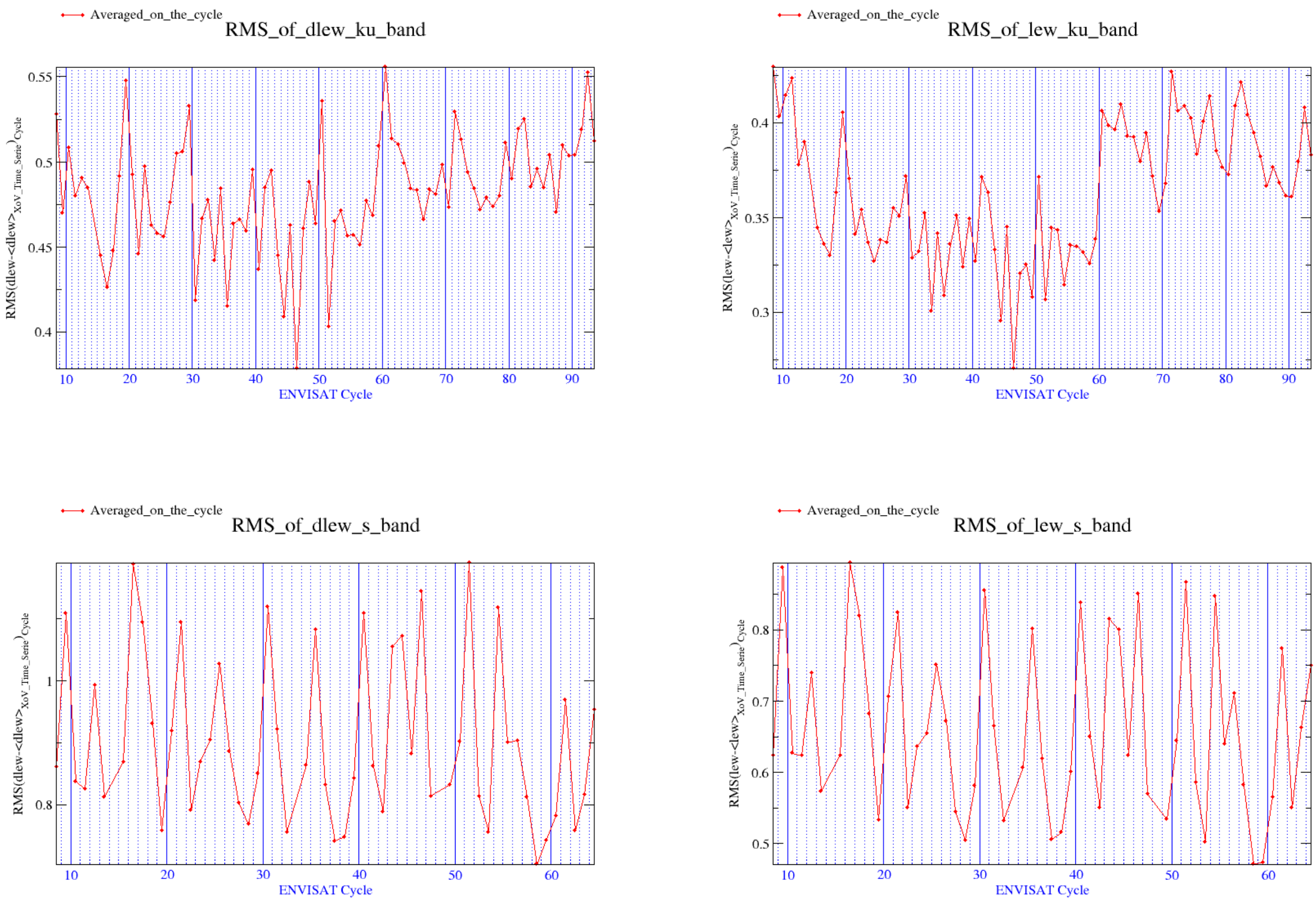


Figure 84: Leading edge width RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

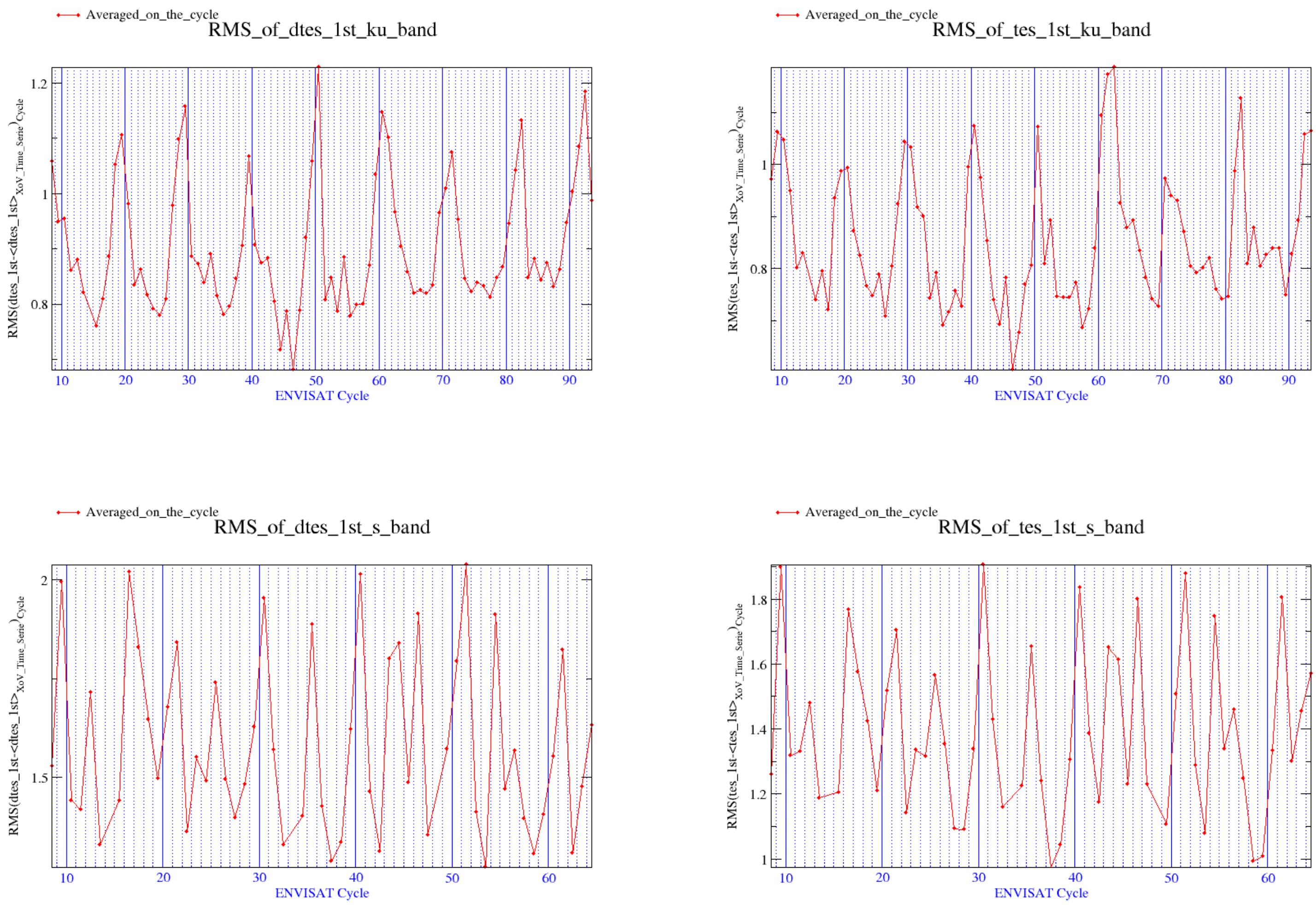


Figure 85: Trealing edge slope RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

4.3.6 Corrections: RMS versus cycle

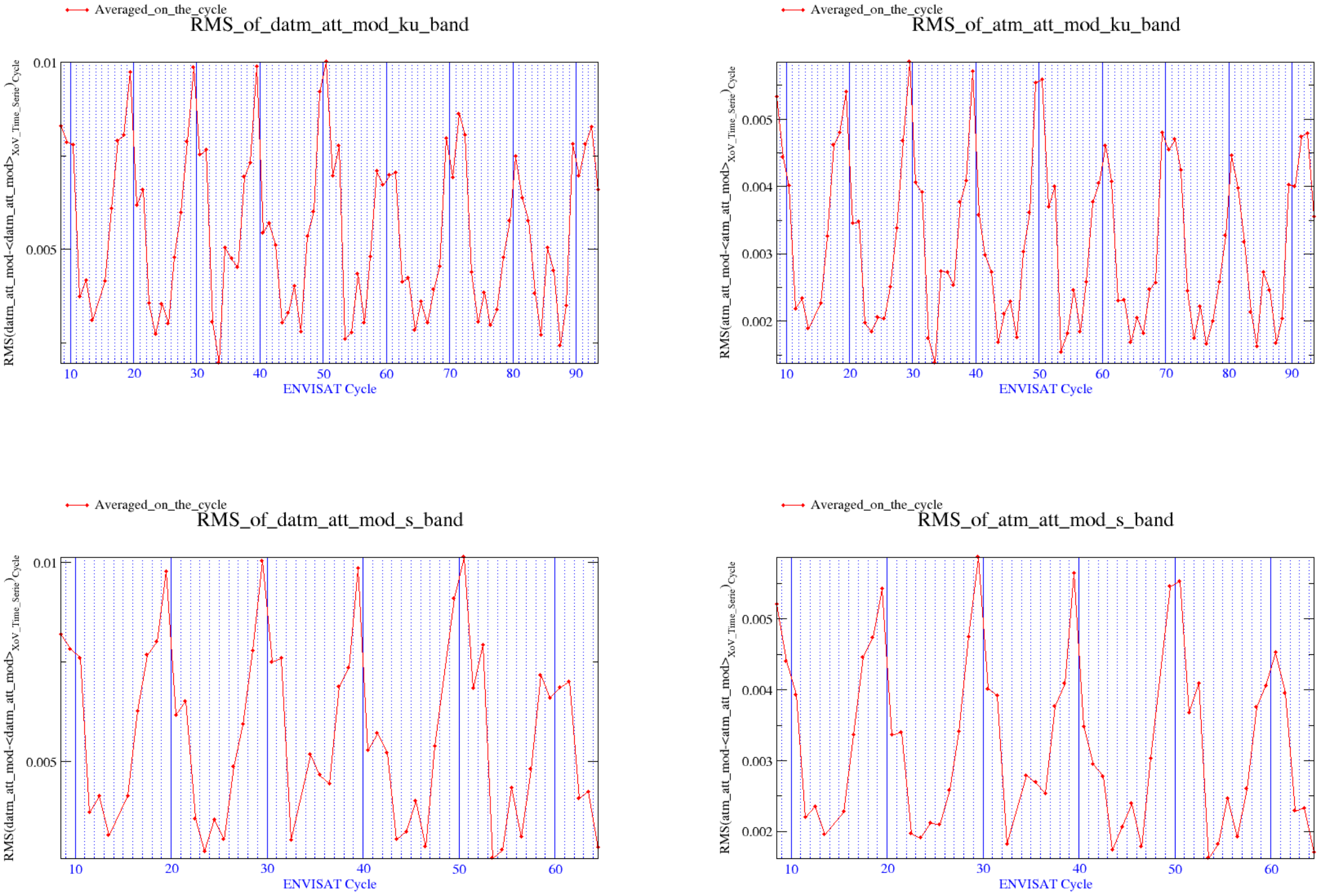


Figure 86: Atmospheric attenuation correction RMS anomaly (dB) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

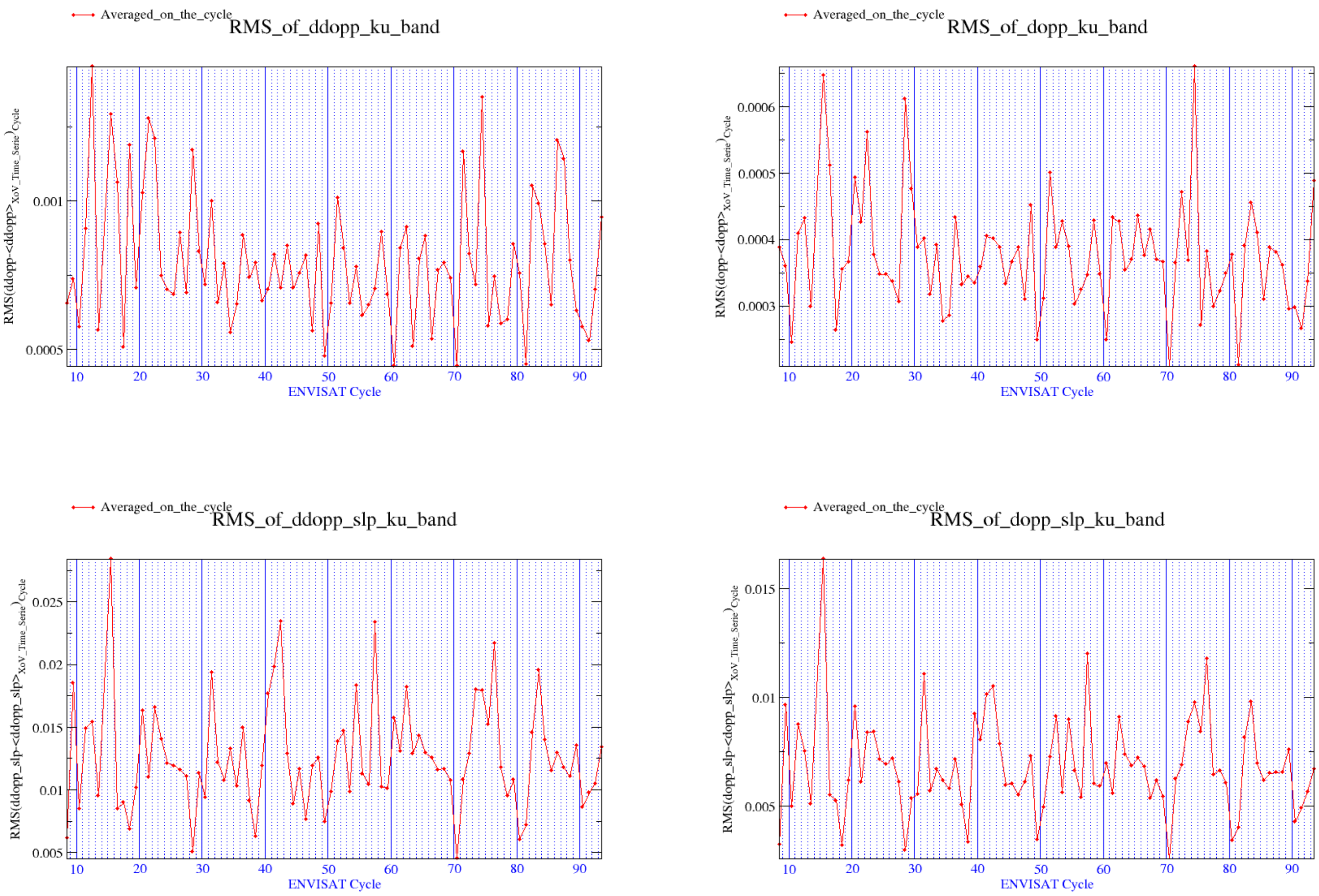


Figure 87: Doppler correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

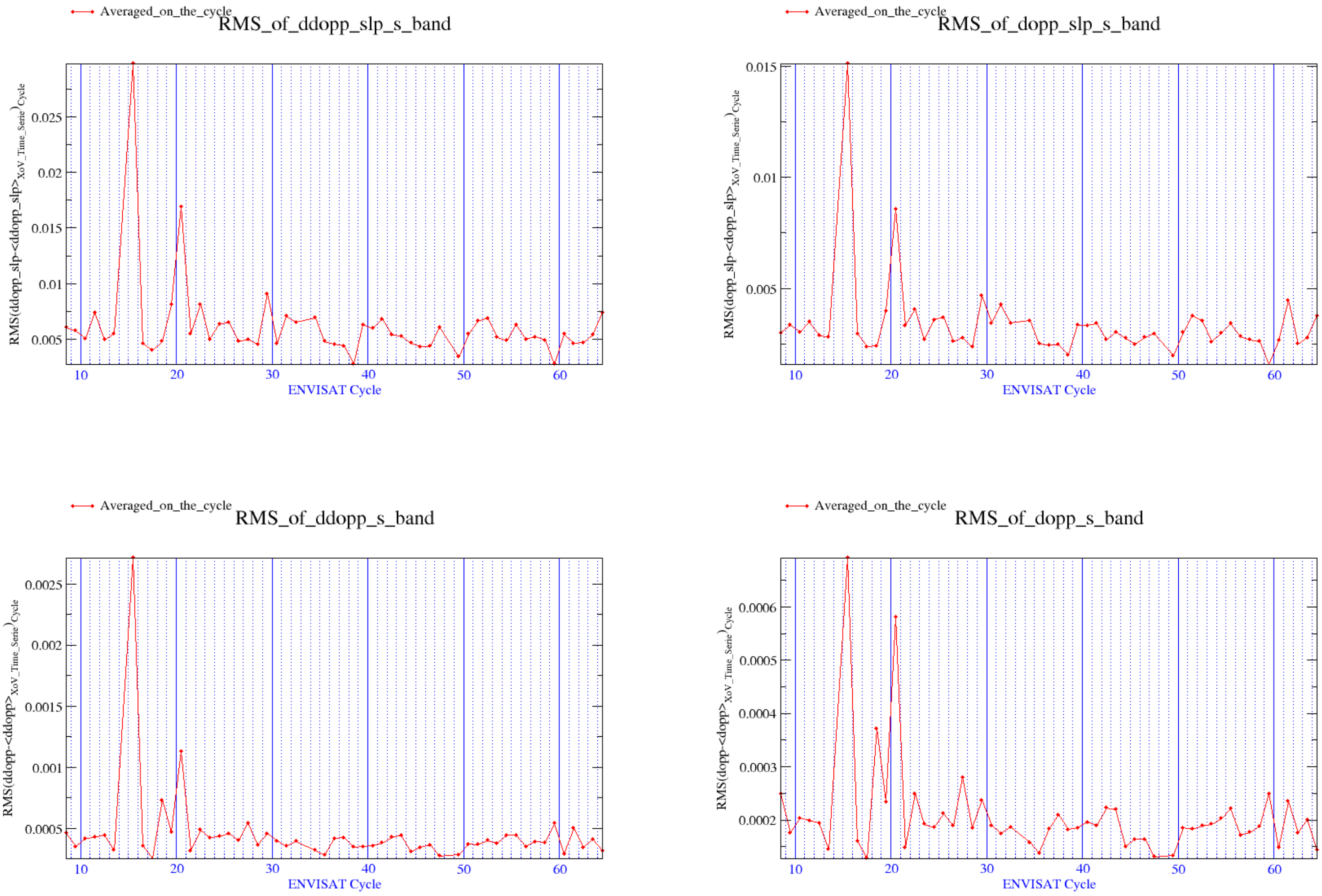


Figure 88: Doppler slope correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

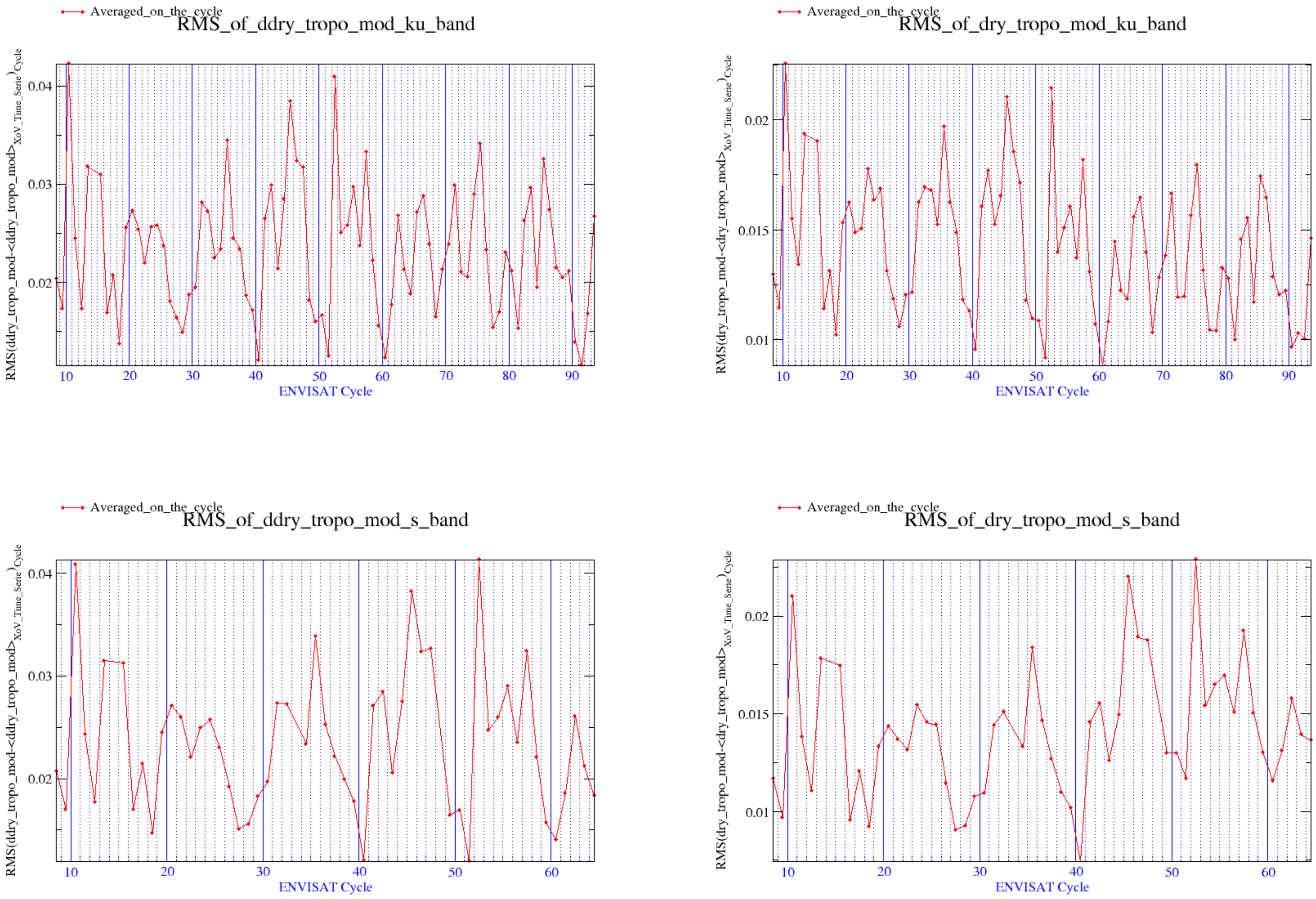


Figure 89: Dry tropospheric correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

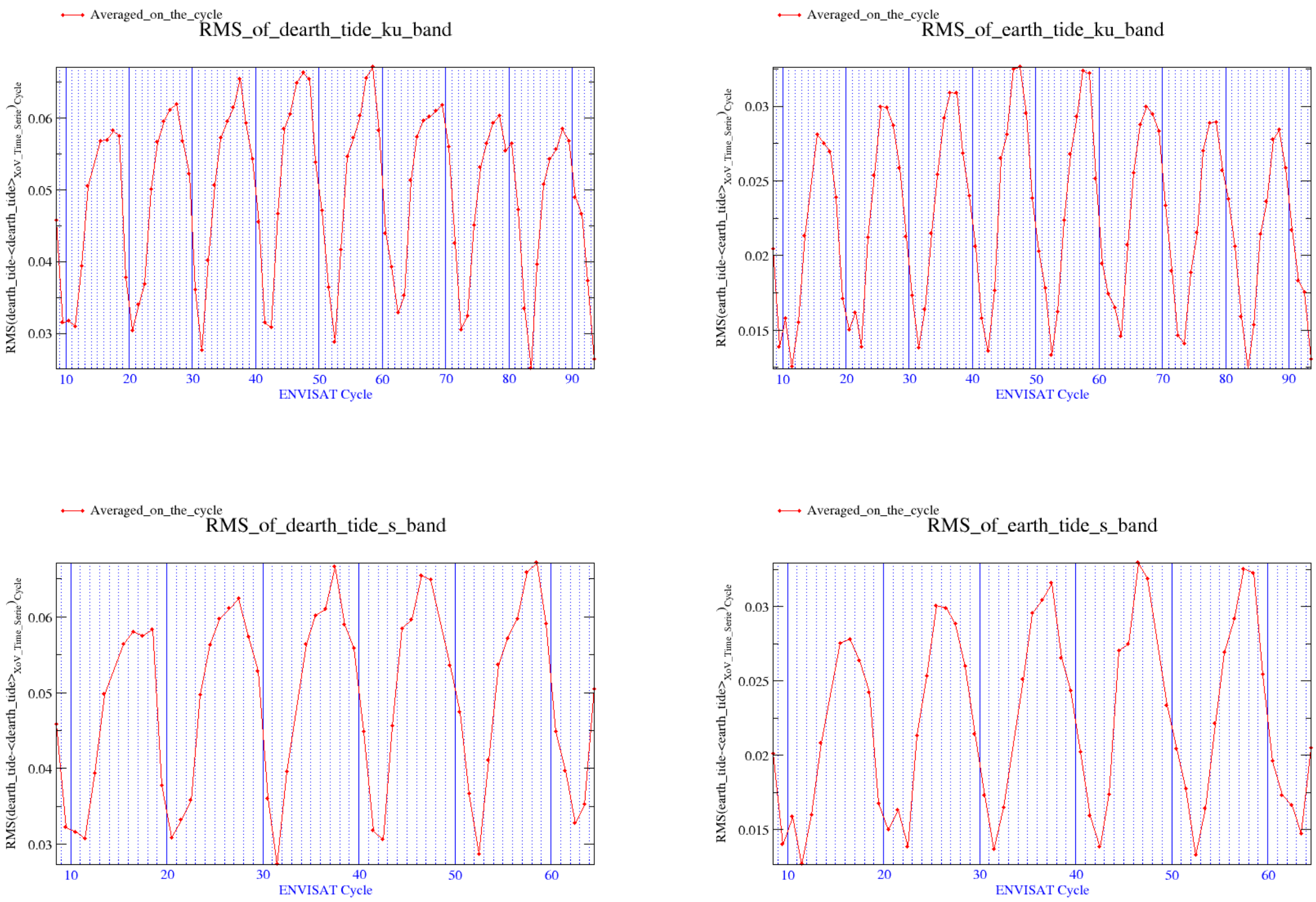


Figure 90: Earth tide RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

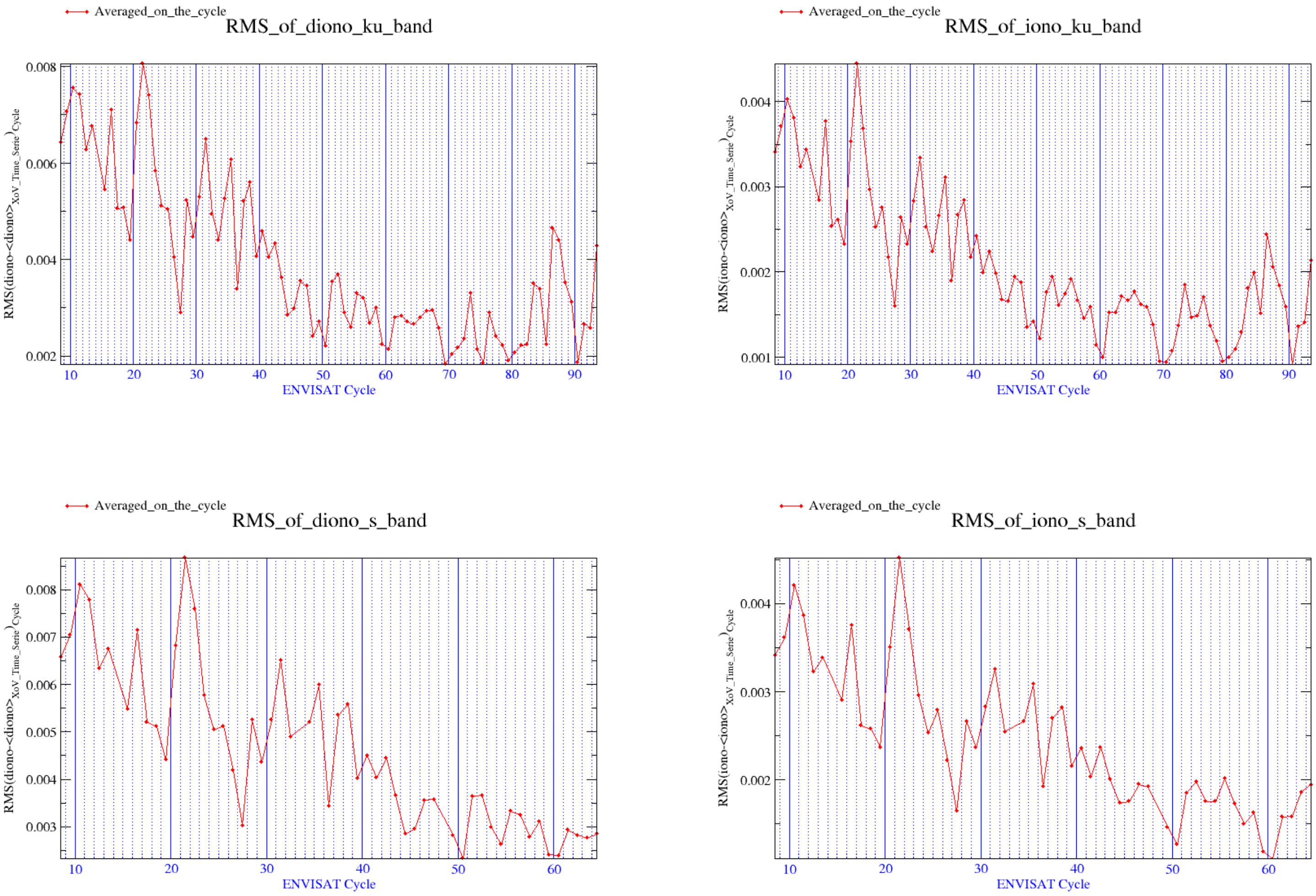


Figure 91: Ionosphereic correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

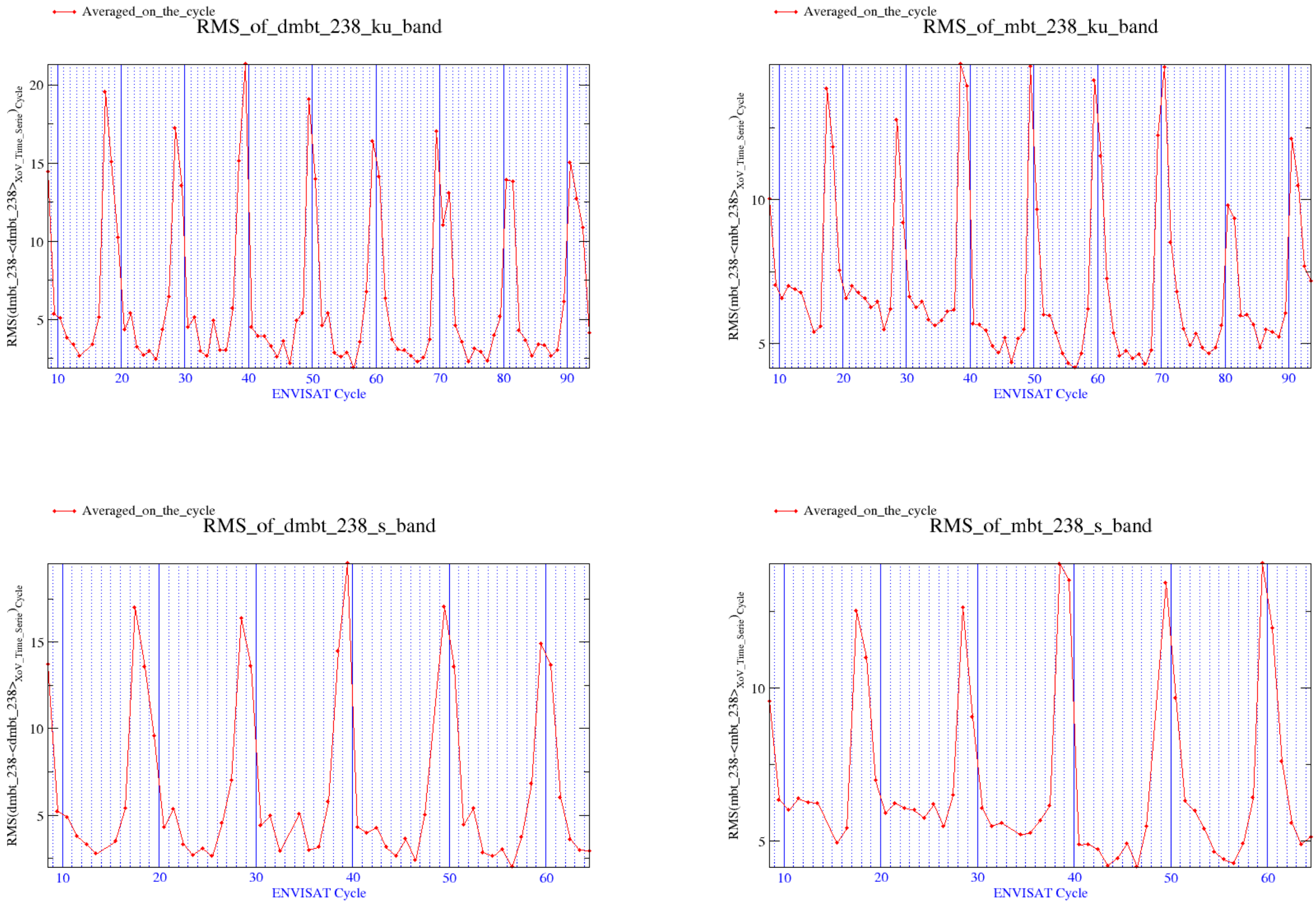


Figure 92: Microwave Brightness Temperature 23.8 GHz RMS anomaly (K) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

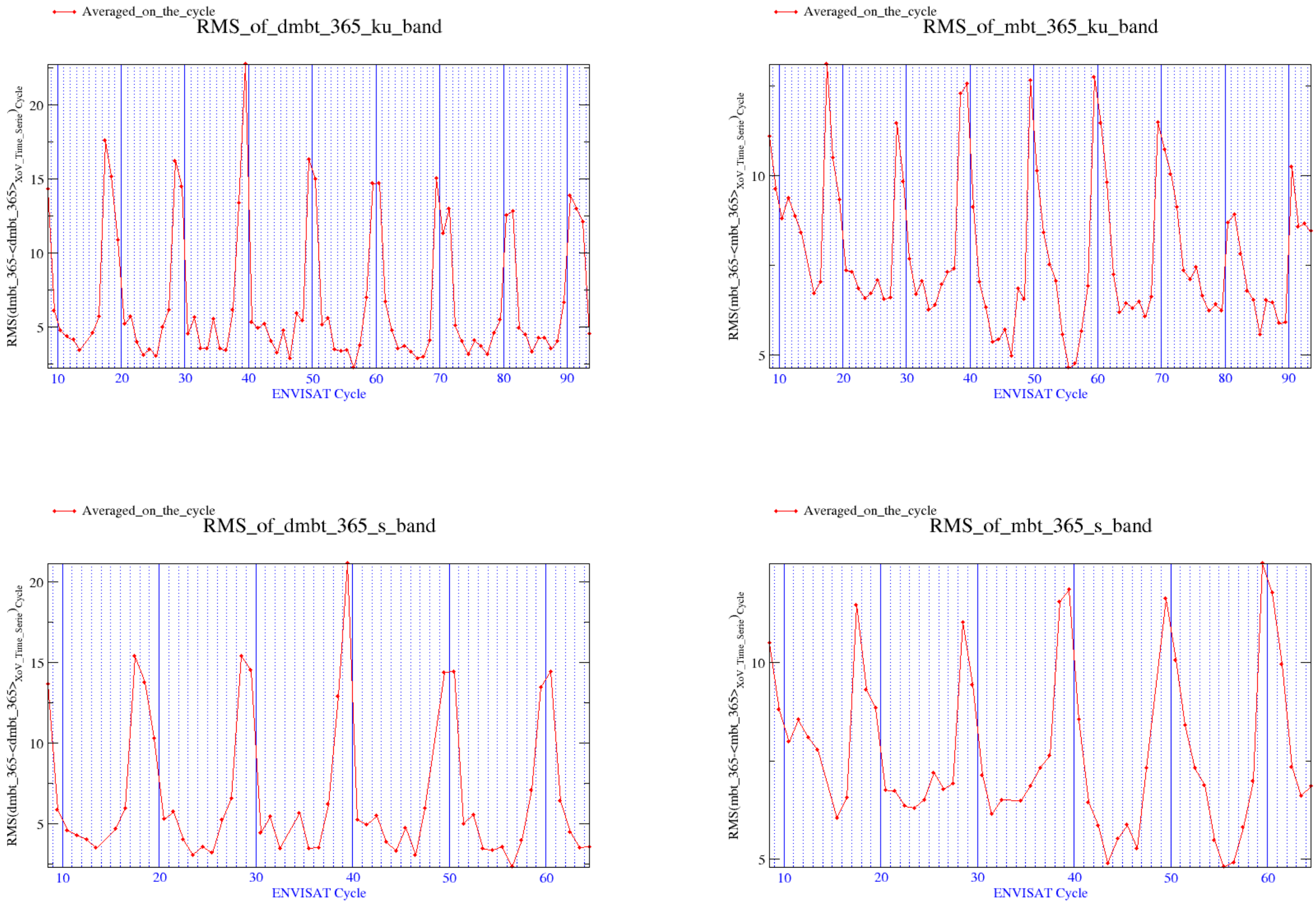


Figure 93: Microwave Brightness Temperature 36.5 GHz RMS anomaly (K) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

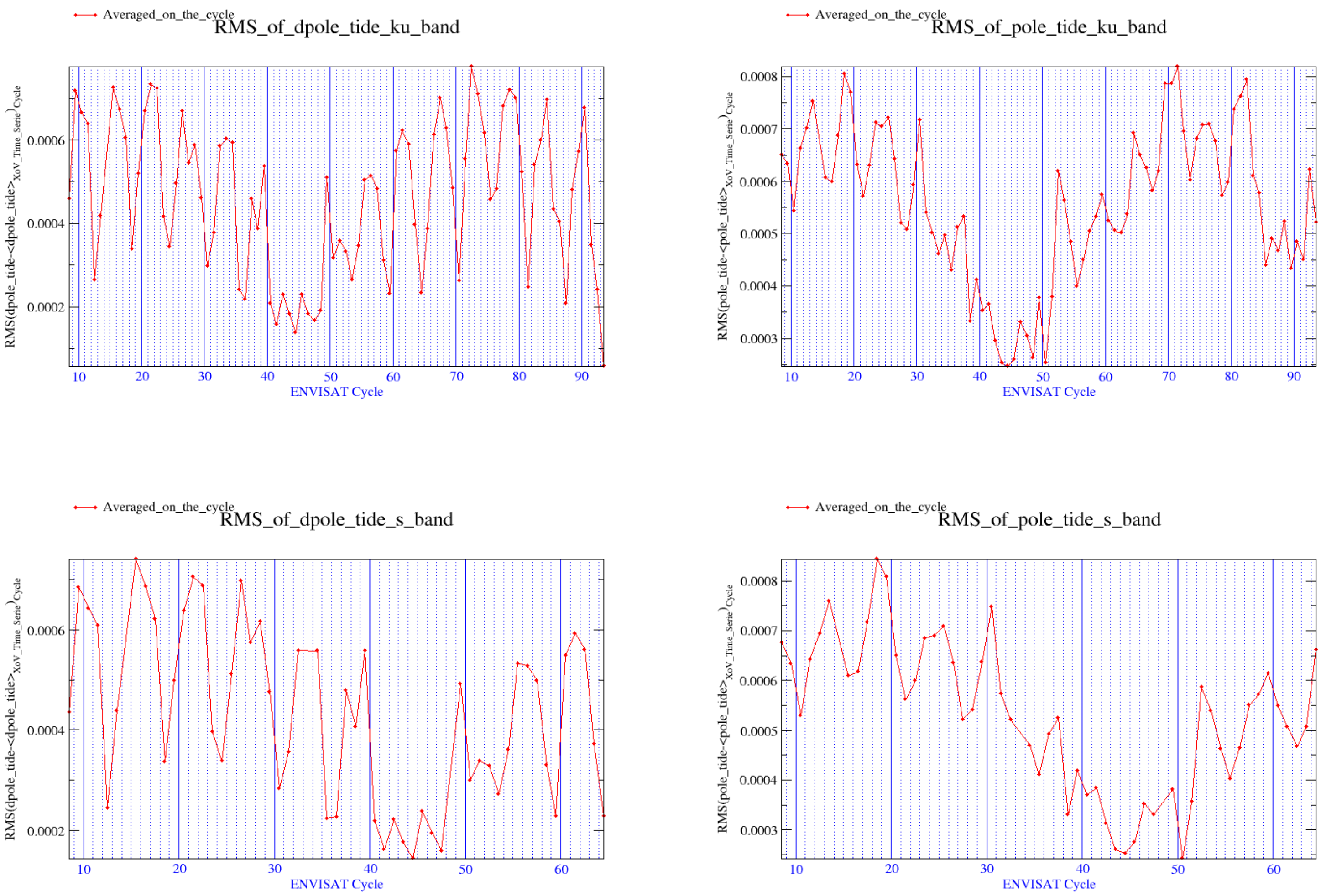


Figure 94: Pole tide RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

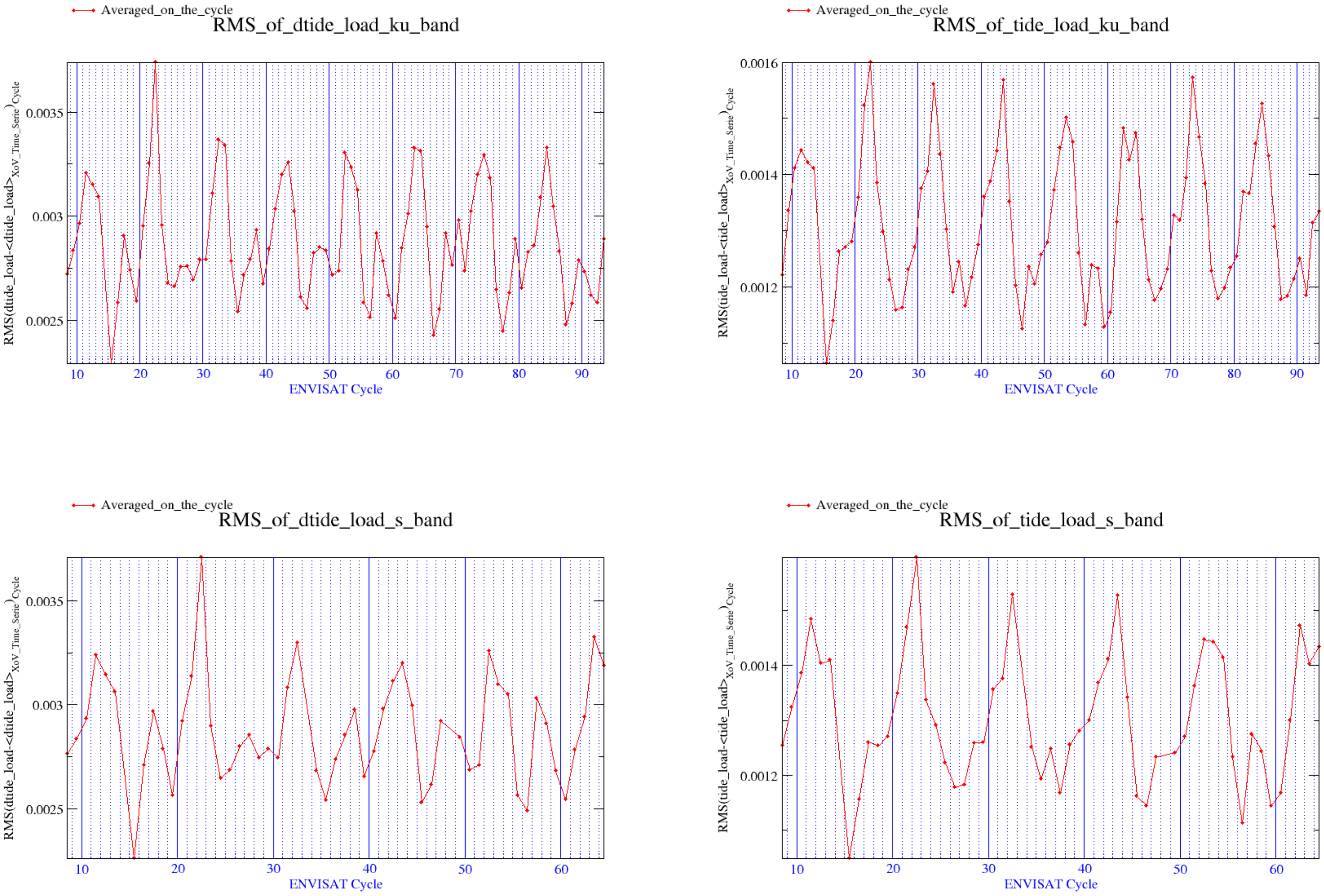


Figure 95: Tide load RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

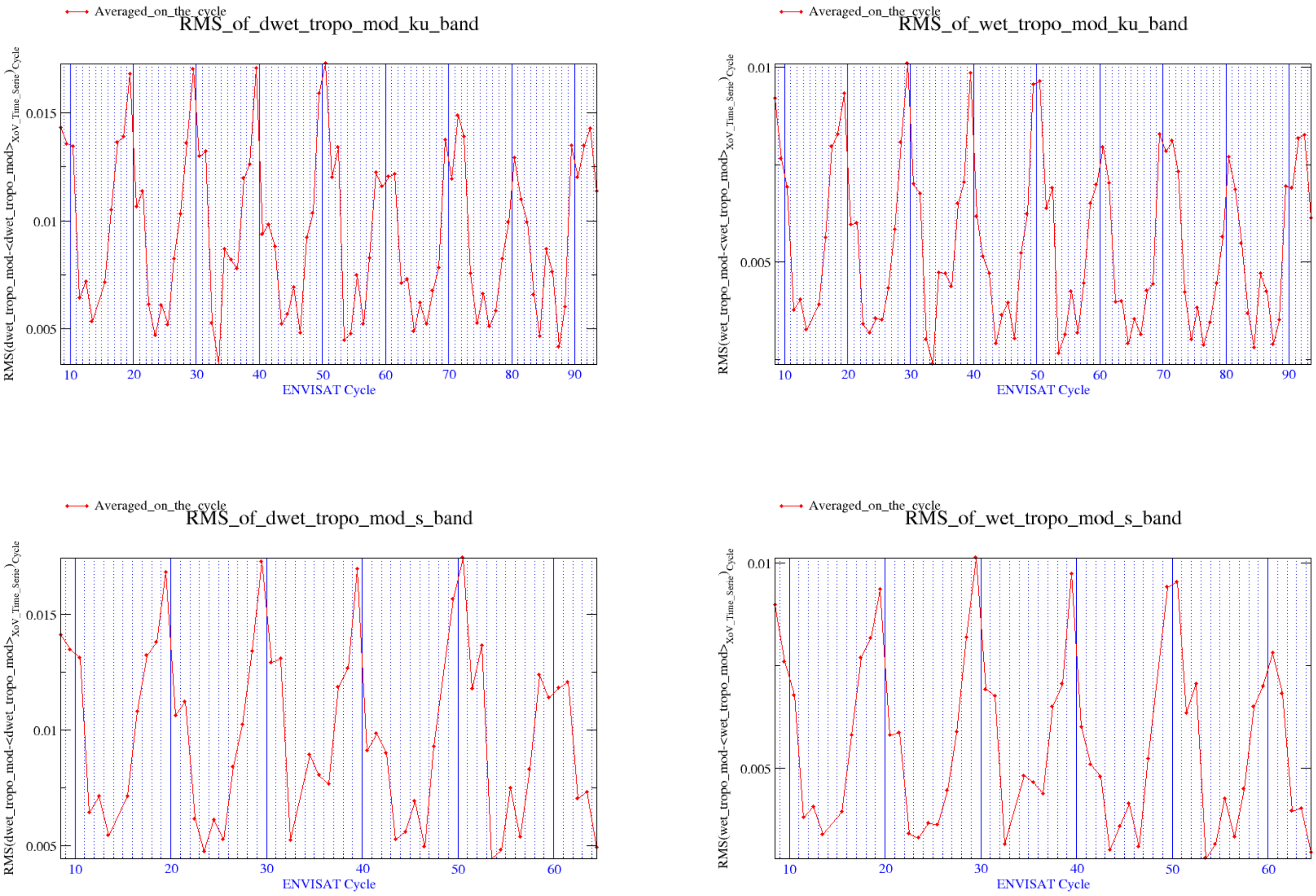


Figure 96: Wet tropospheric correction RMS anomaly (m) for Ku (top) and S (down) band for each cycle over Greenland. On the left hand side, crossover difference RMS anomaly. On the right hand side,crossover mean RMS anomaly.

4.3.7 Annual tend of ICE-2 parameters anomaly

These trends have been evaluated form figures in the section 4.3.3 and 4.3.5.

ku band

Parameter	trend	error	correlation
h1 (m/year)	-8.55e-04	5.72e-03	-0.26
bs1 (dB/year)	-5.09e-04	3.36e-03	-0.2
lew (m/year)	3.06e-04	5.00e-05	0.71
tes_1st (10-6s/year)	4.14e-06	2.84e-04	0.0058

Table 9: ICE-2 parameters anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

ku band

Parameter	trend	error	correlation
h1 (m/year)	-1.34e-03	1.08e-02	-0.29
bs1 (dB/year)	2.21e-05	1.07e-03	0.016
lew (m/year)	5.06e-05	1.42e-05	0.3
tes_1st (10-6s/year)	1.63e-05	2.06e-04	0.027

Table 10: RMS of ICE-2 parameters anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

s band

Parameter	trend	error	correlation
h1 (m/year)	-1.19e-03	1.14e-02	-0.15
bs1 (dB/year)	2.37e-03	4.85e-03	0.43
lew (m/year)	6.14e-04	7.04e-05	0.72
tes_1st (10-6s/year)	-4.18e-04	6.33e-04	-0.23

Table 11: ICE-2 parameters anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

s band

Parameter	trend	error	correlation
h1 (m/year)	-1.24e-03	2.30e-02	-0.11
bs1 (dB/year)	-4.99e-04	1.68e-03	-0.17
lew (m/year)	-2.01e-04	3.40e-04	-0.15
tes_1st (10-6s/year)	-9.98e-05	1.54e-03	-0.036

Table 12: RMS of ICE-2 parameters anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

ku band

Parameter	trend	error	correlation
dh1 (m/year)	5.66e-06	2.71e-06	0.08
dbs1 (dB/year)	3.51e-05	8.58e-06	0.27
dlew (m/year)	1.08e-05	8.21e-07	0.27
dtes_1st (10-6s/year)	-1.76e-05	2.28e-06	-0.26

Table 13: ICE-2 parameters delta anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

ku band

Parameter	trend	error	correlation
dh1 (m/year)	-1.08e-04	6.72e-05	-0.29
dbs1 (dB/year)	2.70e-05	6.06e-04	0.026
dlew (m/year)	4.95e-05	1.26e-05	0.31
dtes_1st (10-6s/year)	7.10e-05	1.69e-04	0.13

Table 14: RMS of ICE-2 parameters delta anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

s band			
Parameter	trend	error	correlation
dh1 (m/year)	4.38e-05	6.27e-06	0.24
dbs1 (dB/year)	6.66e-05	2.75e-05	0.18
dlew (m/year)	1.72e-05	5.81e-06	0.1
dtes_1st (10-6s/year)	-8.89e-05	1.71e-05	-0.29

Table 15: ICE-2 parameters delta anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

s band			
Parameter	trend	error	correlation
dh1 (m/year)	-1.26e-04	7.30e-05	-0.2
dbs1 (dB/year)	-1.89e-04	1.26e-03	-0.075
dlew (m/year)	-2.30e-04	4.11e-04	-0.16
dtes_1st (10-6s/year)	-2.46e-04	1.19e-03	-0.1

Table 16: RMS of ICE-2 parameters delta anomaly trend calculcalted for greenland from anomaly verus cycle figures in section.

4.3.8 ICE-2 parameters: Histogram versus class of surface slope

The histogram is obtained by computing for each class of surface slope the mean anomaly of the mean and difference at crossover. These figures are done from validated and averaged data over all cycles of the missions.

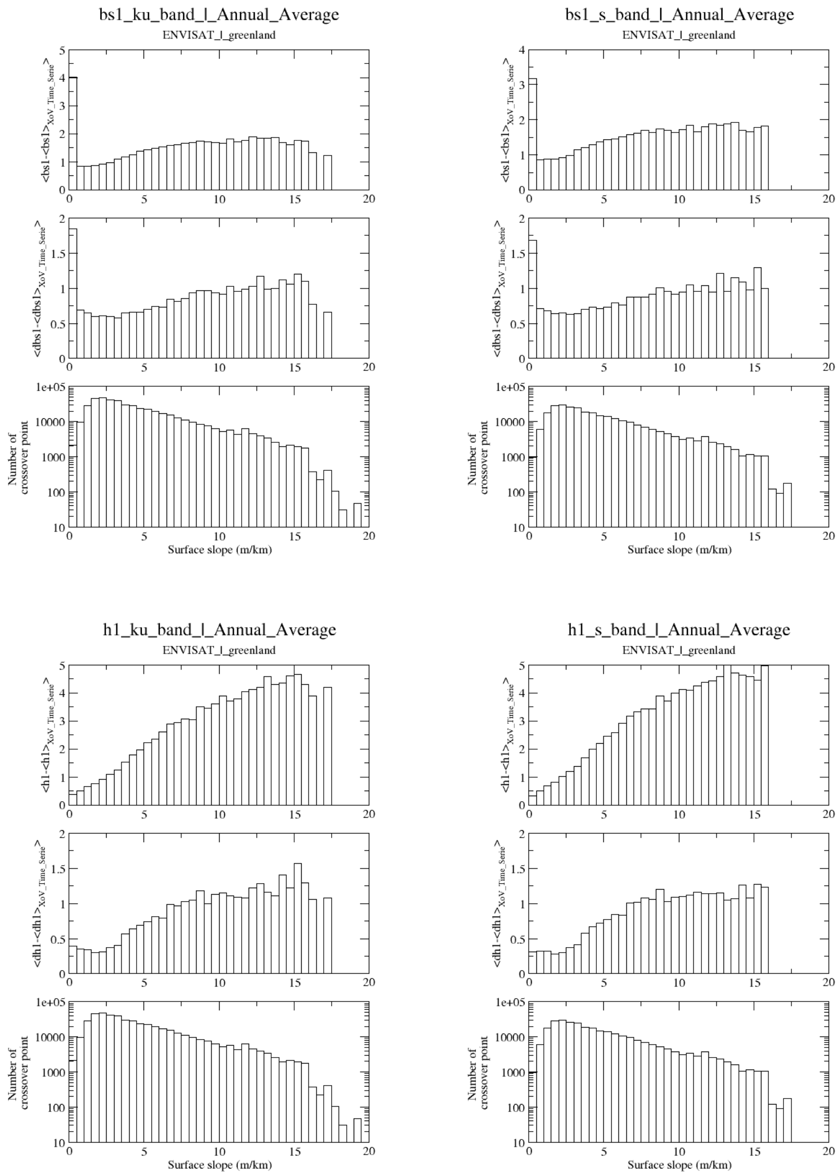


Figure 97: Histogram of crossover mean (top) and difference (middle) anomaly versus class of slope and below the crossover distribution. Backscatter (dB) for Ku (left) and S (right) band and below surface height (m) for Ku (left) and S (right) band over Greenland.

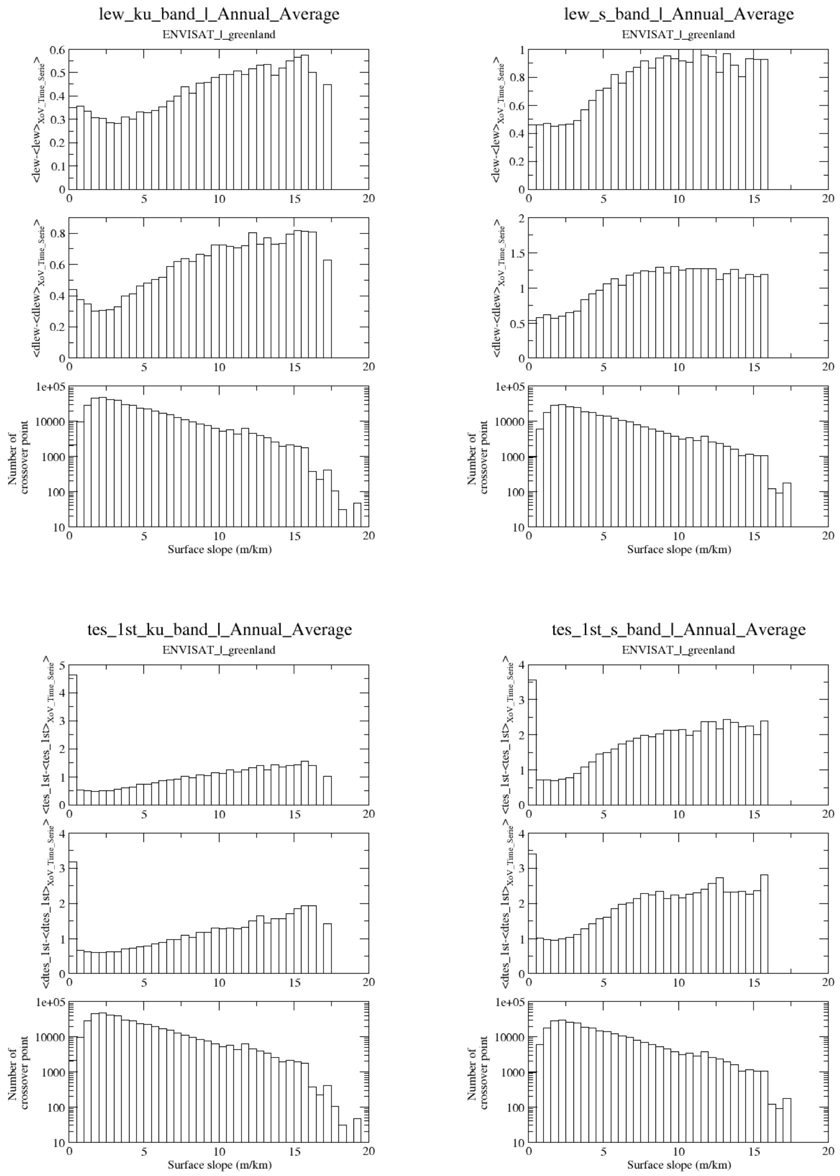


Figure 98: Histogram of crossover mean (top) and difference (middle) anomaly versus class of slope and below the crossover distribution. Leading edge width (m) for Ku (left) and S (right) band and below trealing edge slope (10-6 s-1) for Ku (left) and S (right) band over Greenland.

5 Cycle describtion

In this section, it is described long term monitoring of validated data from the figures above. All any particular events are reported and investigated.

5.1 Main events which have affected data aviability

From figures 3.1 and 4.1 we note note several depth due to events. Here it is summeray these events which have affected the data avability.

- Cycle 14,15: A wrong setting of RA-2
- Cycle 47 and 48: USO problem, several switches are performed to altimeter side A and B to solve the problem.
- Cycle 64: S band is lost and for the next cycles.

5.2 Particular investigations

Here is listed the investigations done concerning the ENVISAT mission about any problems. They are also on the CTOH web site http://ctoh.legos.obs-mip.fr/quality-assessment/cryosphere/envisat/particular-investigations.

- For the privious GDR data release: ENVISAT RA2 Dry Troposphere correction for ice sheets, ESA Living Planet Symposium, 28 June - 2 July 2010, Bergen, Norway. Proceeding available at http://www.legos.obs-mip.fr/blarel/Dry_tropo_proceeding_1872899.pdf
- For the GDR data release v2.1: Investigation on the ENVISAT RA2 doppler slope correction for ice sheets, ESA-CNES Symposium, 24-29 September 2012, Venise, Italy. Proceeding available at http://www.legos.obs-mip.fr/blarel/Doppler_slope_proceeding_2481686.pdf

6 References

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- Legresy B., F. Papa, F. Remy, G. Vinay, M. Van den Bossche and O.Z Zanife, 2005. ENVISAT Radar Altimeter measurements over continental surfaces and ice caps using the Ice2 retracking algorithm. Remote Sensing of Environment, Vol. 95, Issue 2, 150-163.
- Remy F.,B. Legresy, S. Bleuzen, P. Vincent, and J.F. Minster, 1996, Dual-frequency Topex altimeter observation of Greenland, J. of Electrom Waves and Apll., 10, 1505-1523.
- EOO/EOX, October 2005, Information to the Users regarding the Envisat RA2/MWR IPF version 5.02 and CMA 7.1 Available at http://earth.esa.int/pcs/envisat/ra2/articles/ENVISAT
- Validation of ENVISAT radar altimetry within the OSCAR project, ESA Living Planet Symposium, 28 June - 2 July 2010, Bergen, Norway. Proceeding available at http://www.legos.obs-mip.fr/blarel/Ice_validation_proceeding_1872909.pdf