RA-2

S-Band Anomaly Investigation

Technical Note

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1 Scope

The scope of this report is to give a detail explanation of the RA-2 S-band anomaly found after the investigations performed within the RA-2 In-flight Instrument Calibration and Level 1b Verification activities.

2 Introduction

This document describes anomalous behaviour as seen in the S-Band echoes during March/April 2002. The anomalies occur at a variable time following instrument switch on and their origin is still not understood. We first detail the onset time of these anomalies and then provide examples and evidence for the likely source of the anomalous echoes observed.

3 S-Band Anomaly Periods

The S-Band anomaly is characterised by periods of normal operation (12/3, 16/3–23/3, 25/3-) and periods of anomalous operation (13/3-16/3, 23/3-1/4, 16/4-25/4). The cause of a switch between normal and anomalous operation is unknown. The switch between anomalous and normal operation occurs only following an instrument mode change, in particular to some mode lower than measurement mode.

The precise onset times and periods of anomalous S-Band operation have been identified as follows:

1 UTC: 13 March 2002: 10:26:28, Orbit 176 record 98377 until 16 March 2002 when an instrument mode change occurred.

2 UTC: 23 March 2002: 22:03:09, Orbit 326 record 111023 until 1 April 2002 when the instrument ICU anomaly occurred.

3 UTC: 16 April 2002:, Orbit 659 until 25 April when an instrument mode change occurred.

4 S-Band Anomaly - Evidence of echo accumulation

The S-Band anomalies are characterised as distorted echoes characterised with very high fft counts up to and above 64000. A notable feature of the S-band echo during anomalous periods is the behaviour immediately following and acquisition, when the S-Band echo is reset to zero. Two examples are presented below.

4.1 Example 1

The first example shows the behaviour of the S-Band echoes immediately following an acquisition north of Russia just prior to transition over an area of sea ice:

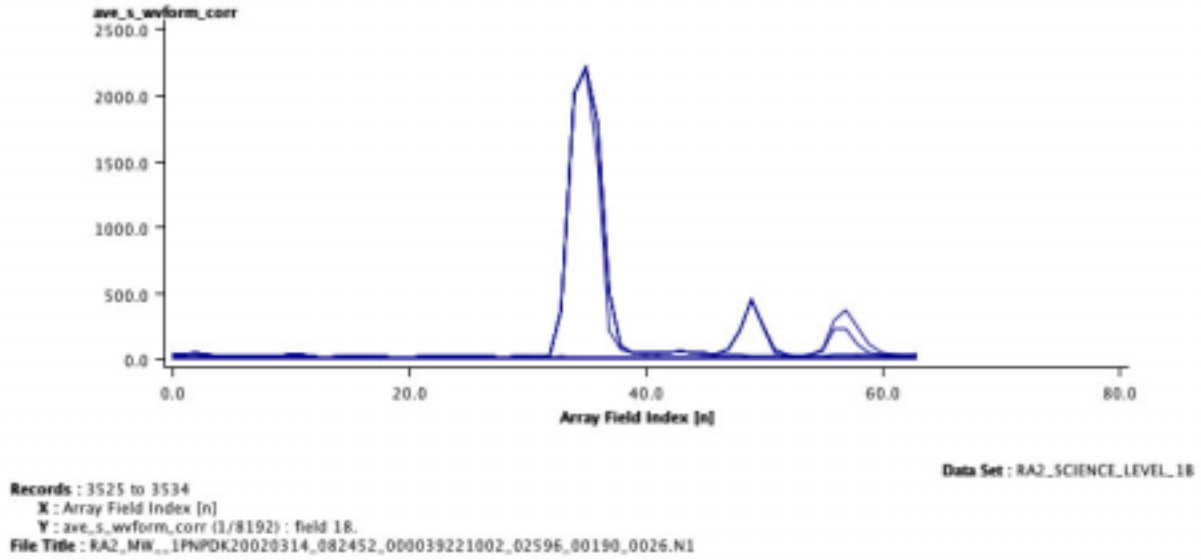

Figure 1.Sequence of 10 S-Band echoes following the acquisition sequence at record 3525. The value in each fft sample is observed to increase for each of the S-Band echoes.

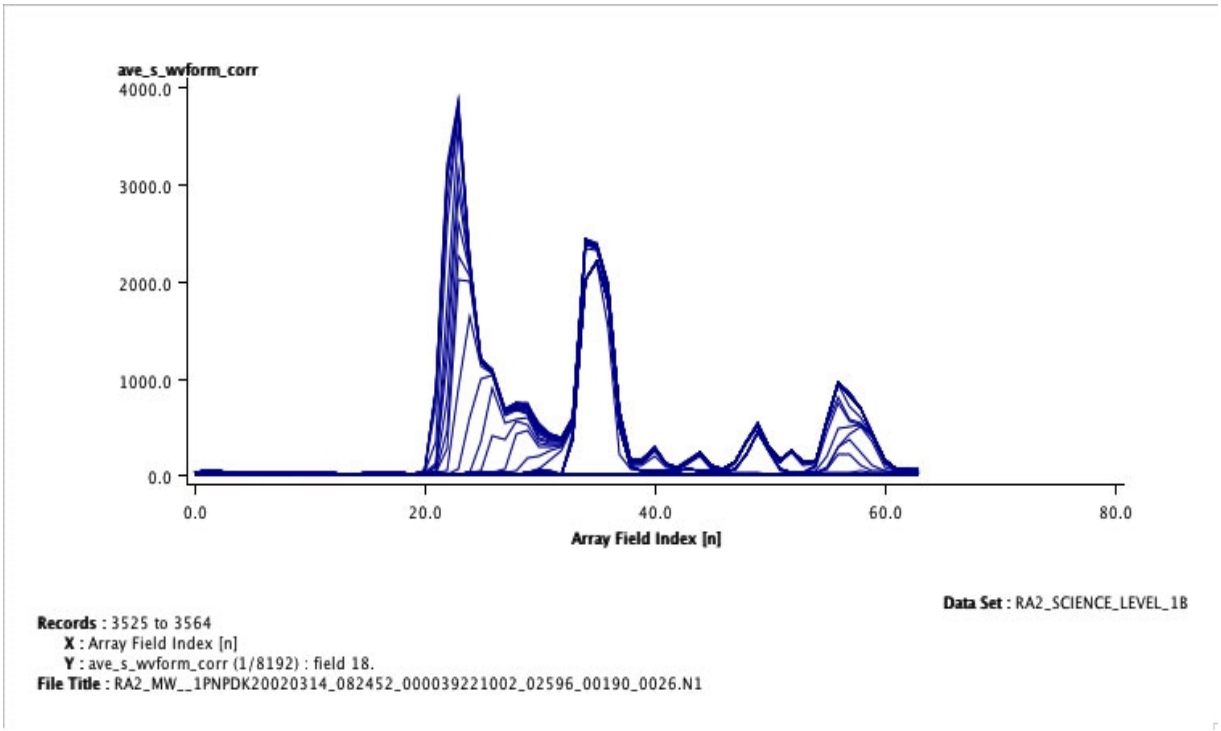

Figure 2.Sequence of 40 S-Band echoes following the acquisition sequence at record 3525. The value in each fft sample is observed to increase for each of the S-Band echoes in a cumulative manner.

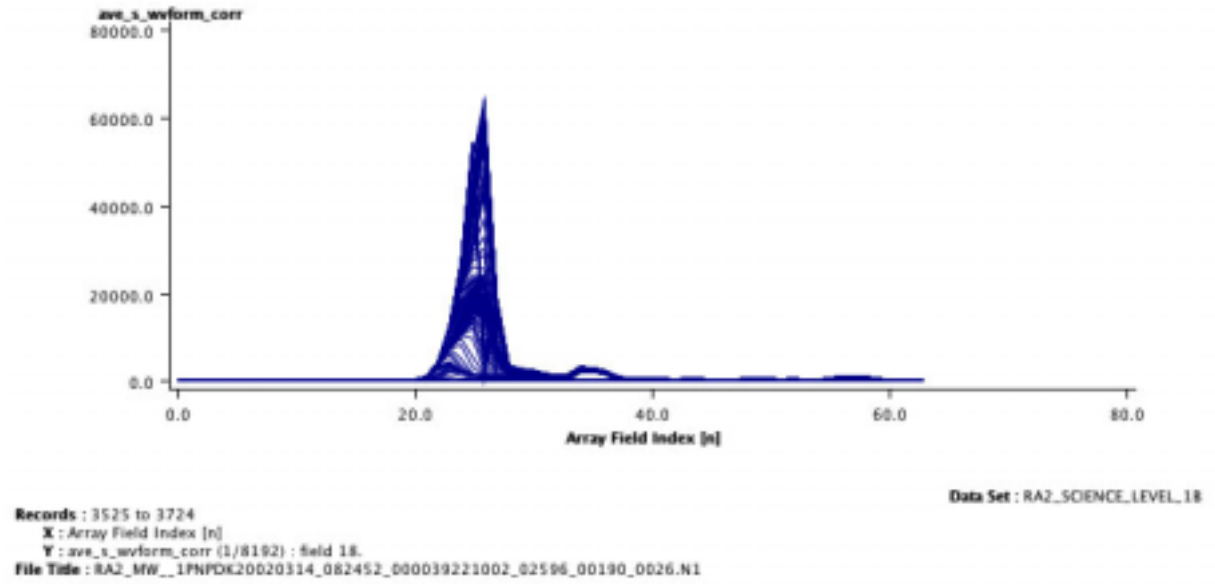

Figure 3.Sequence of 200 S-Band echoes following the acquisition sequence at record 3525. The value in each fft sample is observed to still increase for each of the S-Band echoes in a cumulative manner with the peak power now approaching 64000.

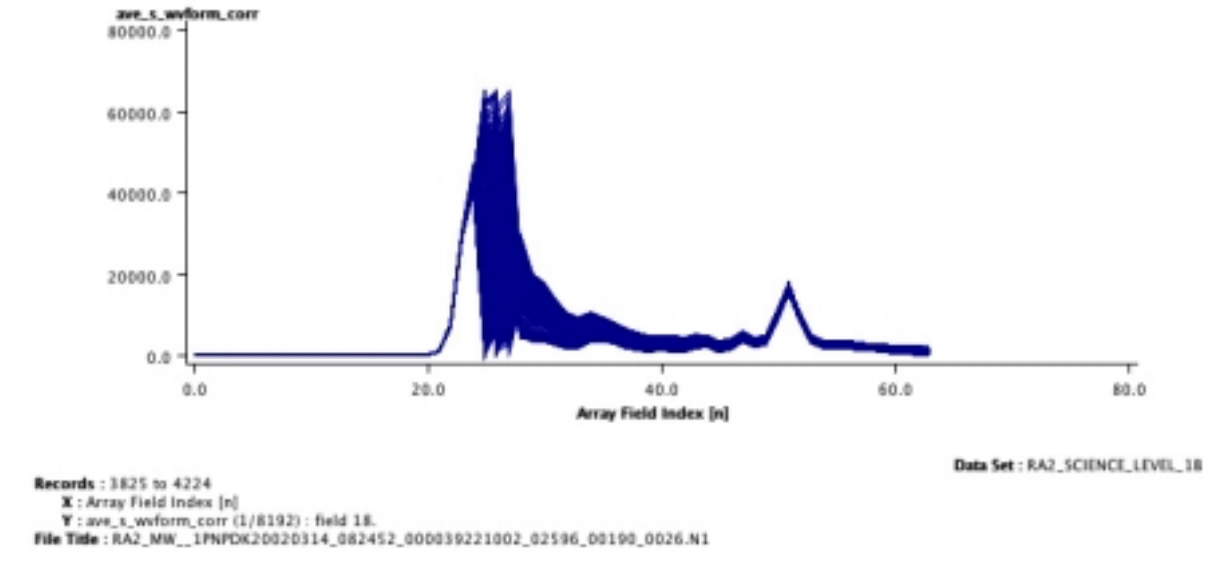

Figure 4.Sequence of 400 S-Band echoes following the acquisition sequence at record 3525. The value in each fft sample is observed to still increase for each of the S-Band echoes in a cumulative manner as individual fft sample values exceed 64000 wrapping of the samples is observed.

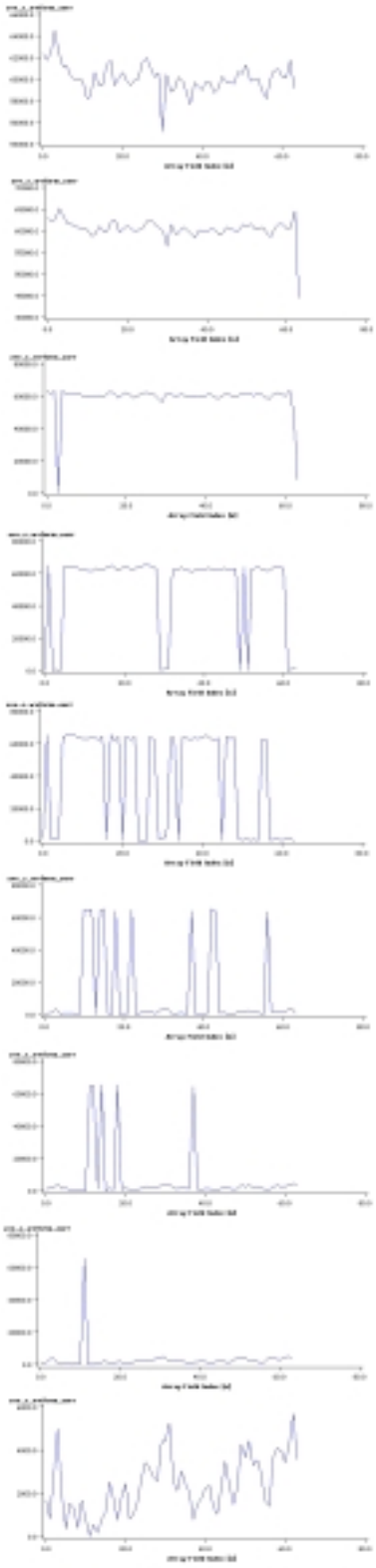

Figure 5.Showing detailed sequence of fft sample wrapping. As each sample exceeds 65000 it is observed to 'wrap' back to a lower value.

4.2 Example 2

The second example shows examples of S-Band waveforms accumulated following an acquisition on a descending pass over central America and then over the Pacific Ocean.

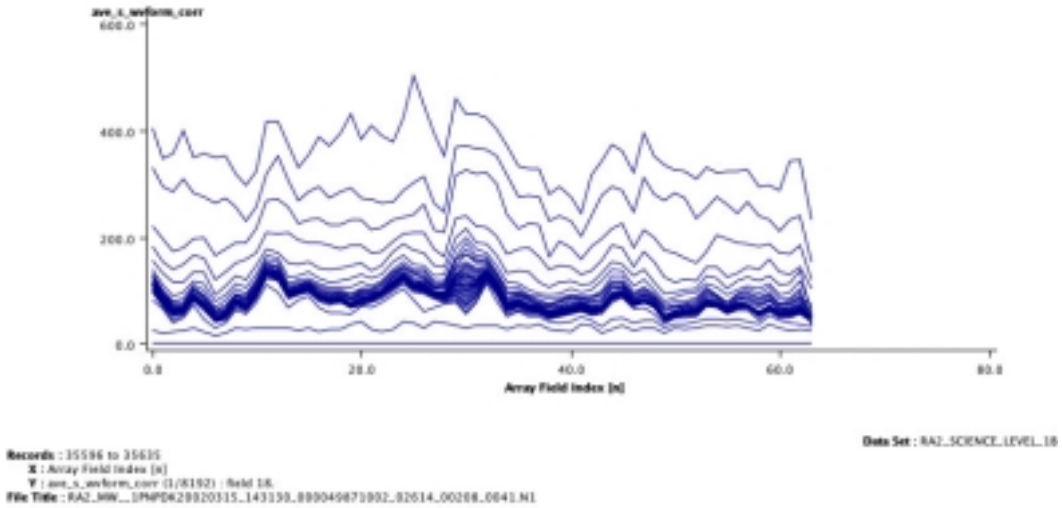

Figure 6.Sequence of 40 S-Band echoes following the acquisition sequence at record 35596. The land echoes are seen to accumulate with the power in each fft sample increasing with each echo received.

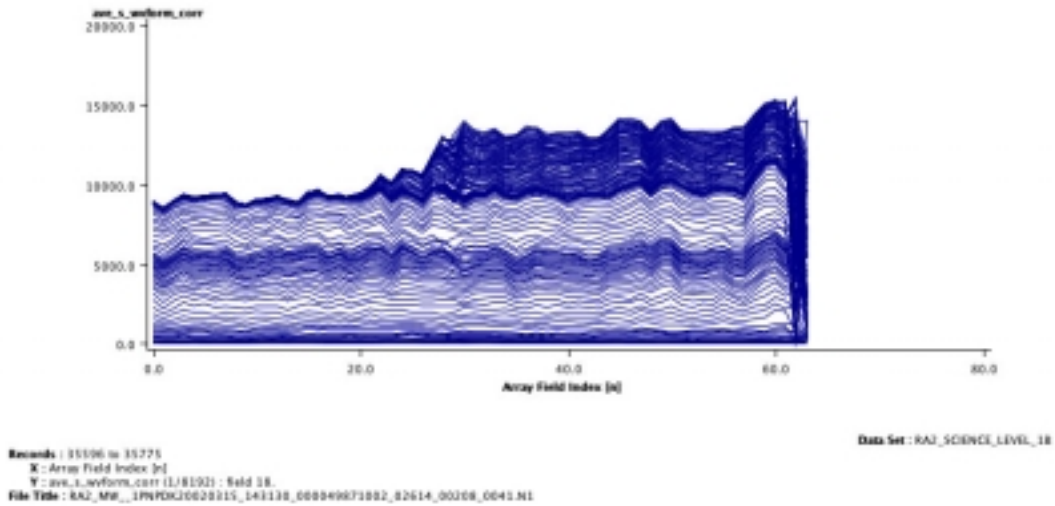

Figure 7.Sequence of 180 S-Band echoes following the acquisition sequence at record 35596. The land echoes are seen to accumulate first with the power in each fft sample increasing with each echo received. Following transition to the ocean the characteristic S-Band ocean echoes are seen to be added on top of the land echoes already received.

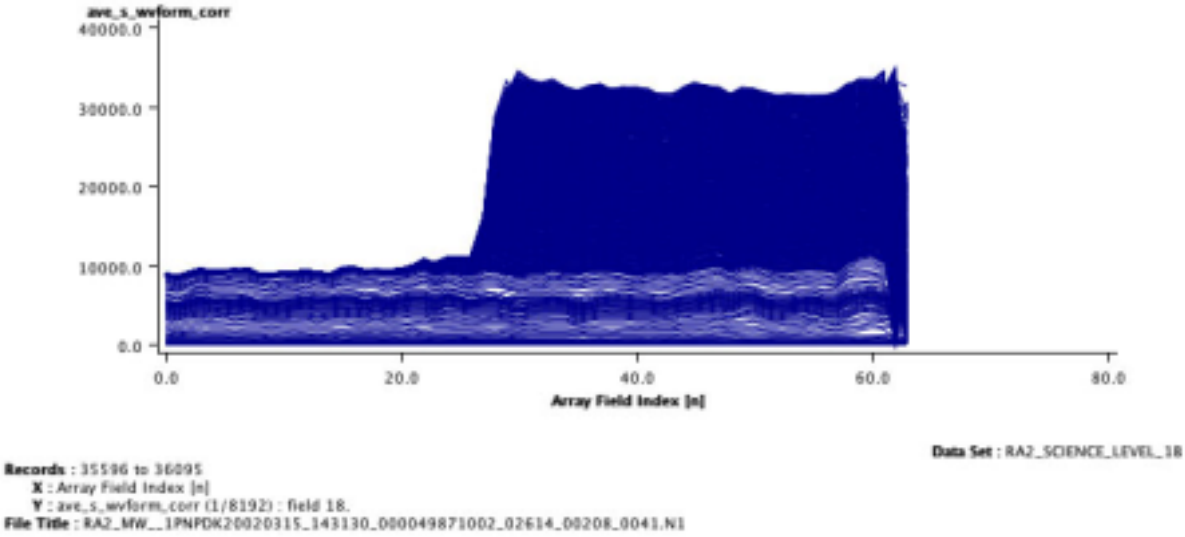

Figure 8.Sequence of 500 S-Band echoes following the acquisition sequence at record 35596. The land echoes are seen to accumulate first with the power in each fft sample increasing with each echo received. As more S-Band echoes are added the echo received at record 36095 takes the appearance of an averaged S-Band Echo. The fft sample counts exceeds 35000 as compared to the 60-120 maximum normal observed in S-Band echoes over the ocean.

The examples shown above provide evidence that the S-Band anomalies are, in part, as result of accumulation of S-band echoes into the fft samples. Once the limit of > 65000 counts is reached the bins wrap resulting in 'apparently' random patterns. At first sight the phenomenon appears to be the result of a 'simple' accumulation of S-Band echoes. Closer examination however reveals that the accumulation is somewhat more complex in nature.

4.3 Accumulation

The hypothesis of S-Band echo accumulation can be tested by simply subtracting the current S-Band echo from the previous echo, to observe the echo accumulated. The expected shape of the result waveform shall be a single waveform, that, if looking over ocean surfaces, this is a Brown model.

The example below originate from one minute of data gathered during orbit 326 at UTC 23-March-2002:22:03, in particular from data block 111750 to data block 111932, in order to ensure it contains only ocean waveforms. Figure 9 shows the result of this operation. A clear ocean waveform is retrieved, which confirm the assumption of accumulation.

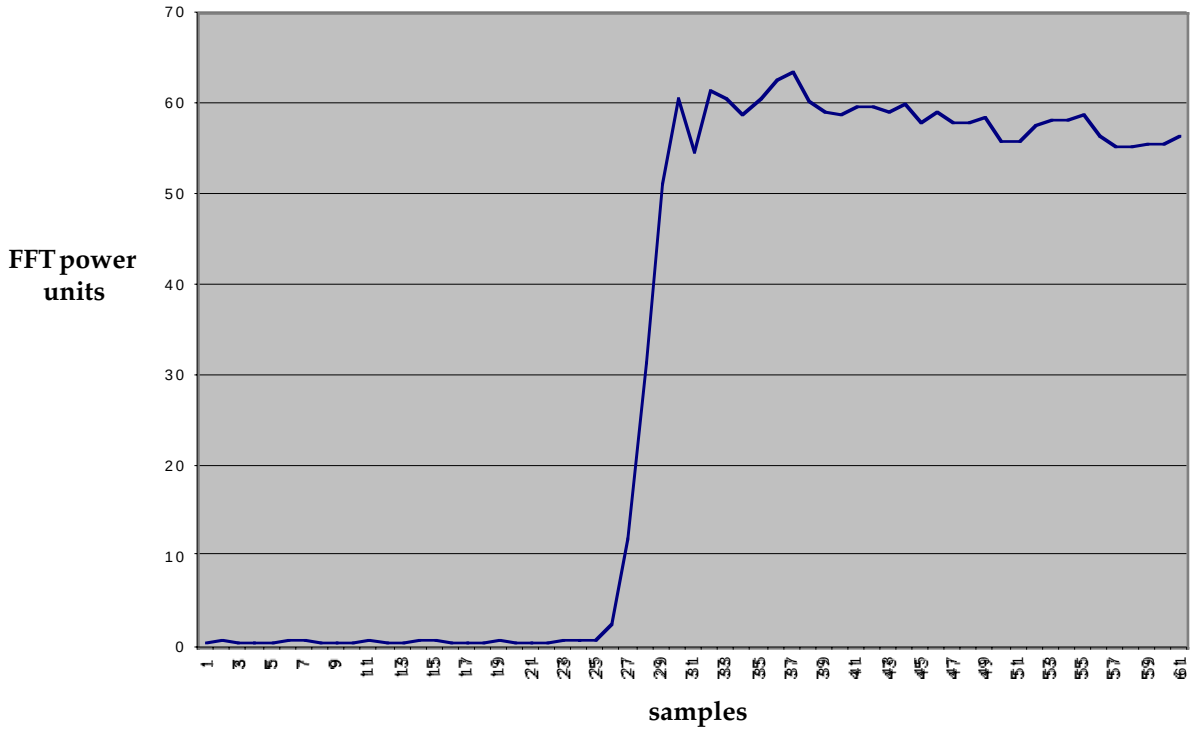

Figure 9. S-band waveform retrieved by subtracting from each waveform, n, the previous waveform reported in the Source Packet, n-1, and averaged over 150.

5 Conclusions

In summary the findings of the S-Band anomalies can be summarised as follows:

- S-Band anomalies have been seen to start on the 13 March, 23 March and 16 April and to stop on the 16 March, 1 April and 25 April, when the instrument was placed in a lower mode than measurement mode.
- The anomaly appears as the 'accumulation' of S-band echoes
- The accumulation starts following each acquisition during the anomalous periods