

# RA-2 S-BAND ANOMALY: DETECTION AND WAVEFORMS RECONSTRUCTION

A. Martini<sup>(1)</sup>, P. Femenias<sup>(2)</sup>, G. Alberti<sup>(3)</sup>, M.P. Milagro-Perez<sup>(1)</sup>

<sup>(1)</sup> SERCo S.p.a., Via Sciadonna, 24, 00044 Frascati, Rome, Italy, [amartini@serco.it](mailto:amartini@serco.it), [maria.milagro@esa.int](mailto:maria.milagro@esa.int)

<sup>(2)</sup> ESA/ESRIN, via G. Galilei, 1, 00044 Frascati, Rome, Italy, [pierre.femenias@esa.int](mailto:pierre.femenias@esa.int)

<sup>(3)</sup> CO.RI.S.T.A., Viale Kennedy, 5, 80125 Naples, Italy, [alberti@unina.it](mailto:alberti@unina.it)

## ABSTRACT

As widely known the RA-2 data are affected by the so-called "S-Band anomaly" discovered in the early days of the Commissioning Phase. As described in [1] it consists in the accumulation of the S-Band echo waveforms that starts, apparently randomly, after an instrument Acquisition phase. Investigation is on going to try and find the instrumental cause of this behavior but in the meantime the data affected by this anomaly are completely unusable. For this reason the need has arisen for the users to be able to detect the anomalous data and eventually reconstruct a usable signal from them. This paper describes the algorithm developed for the L1b processor that allows to set a flag identifying the data affected by the "S-Band anomaly" and reconstruct normal echo waveforms to be then ingested in the nominal re-tracking procedure at L2. It presents also the results obtained after the implementation in the L1b reference processor.

## 1. INTRODUCTION

The data acquired by RA-2 on board ENVISAT are randomly affected by the so-called "S-Band anomaly" (see [1]) that prevents the usage of all the parameters recorded in the secondary band of the instrument (the S-Band).

The anomaly happens randomly after an acquisition sequence without any apparent reason as far as known at present. The anomaly does not stop occurring by itself but for it to stop the instrument has to go in one of the Stand-By modes that is Heater-2 or lower, see [2].

In order to decrease the impact of the problem on the data, a work-around solution has been implemented during the commissioning phase. This consists in commanding the instrument in the Heater-2 mode once per day in such a way that at maximum a day of data will be corrupted by the anomaly itself.

On the other hand, the user has at present no mean of discriminating the data affected by this anomaly and thus discarding them from further processing. The only available tool is an algorithm based on the relative values of some L2 parameters valid only over ocean surfaces, see [3].

## 2. ALGORITHM FOR FLAG DEFINITION

### 2.1. Algorithm for L1b

For each SPR of the L0 product extract:

1. The OBDH Datation
2. The Block Type for the 20 DBs
3. The S-Band Echo waveforms for the 20 DBs

Considering  $N_{SP}$  being the number of SPRs in the L0 product create three arrays as follows:

4. OBDH\_dat: unsigned long long array of  $N_{SP} * 20$  elements, where:  
 $j=0, 19$   
 $i=0, N_{SP}-1$   
OBDH\_dat( $i*j$ )=OBDH datation of SP  $i$
5. Block\_type: unsigned integer array of  $N_{SP} * 20$  elements, where:  
 $j=0, 19$   
 $i=0, N_{SP}-1$   
Block\_type( $i*j$ )=Block type of DB  $j$  of SP  $i$
6. Samples\_s: two dimensional double array with dimensions of 64 and  $N_{SP} * 20$ , where:  
 $j=0, 19$   
 $i=0, N_{SP}-1$   
Check Block\_type( $i*j$ ), in case it assumes one of the following values [2 OR 3 OR 6 OR 7], then Samples\_s( $0..63, (i*j)$ )=S-Band echo waveforms of DB  $j$  of SP  $i$

Considering  $N_{SP}$  being the number of SPRs in the L0 product create another array as follows:

7. Samples\_s\_f: two dimensional double array with dimensions of 64 and  $N_{SP} * 20$ , where:  
Samples\_s\_f( $0..63, 0$ )=Samples\_s( $0..63, 0$ )  
 $k=1, N_{SP} * 20 - 1$   
Check (OBDH\_dat( $k$ )-OBDH\_dat( $k-1$ )), in case it assumes a value LE 58047, then  
Samples\_s\_f( $0..63, k$ )=Samples\_s( $0..63, k$ )  
Samples\_s( $0..63, k-1$ ) otherwise  
Samples\_s\_f( $0..63, k$ )=Samples\_s( $0..63, k$ )

Considering  $N_{SP}$  being the number of SPRs in the L0 product create another array as follows:

8. Flag\_S\_band: integer array with dimension  $N_{SP} * 20$
9. Create a loop on  $k=n\_buffer, N_{SP} * 20$  and evaluate the number of elements for which: Samples\_s\_f( $0..63, h$ ) where  $h=k-n\_buffer...k$  is LT 0. This number will be named count( $k$ )

10. For  $k=n\_buffer$ ,  $N\_SP*20$  in case count( $k$ ) LT  $n\_count$  then  $Flag\_S\_band(k)$  is set:  $Flag\_s\_band(k)=1$

The two variables  $n\_buffer$  and  $n\_count$  will have to be considered as external variables.

## 2.2. Algorithm for L2

For each SP ( $N\_SP$ ) of the L2 product consider all the 20 DBs .

1. If at least  $n\_count\_L2$  DBs have the S-Band flag set, then the SP has the S-Band flag set (S-Band flag of SP  $N\_SP$  is set)

## 2.3. Tuning of variables

In the algorithm previously described, three variables have to be tuned in order to obtain the best performances of the algorithm both at L1b and at L2. Those are  $n\_buffer$ ,  $n\_count$  and  $n\_count\_L2$ .

A test case of four orbits has been chosen to perform this exercise; one of them does not contain S-Band anomaly (8568), two of them do contain S-Band anomaly (8667 and 10910) and the last one is affected by the S-band anomaly starting from a certain point (8557).

The criterion chosen to select the proper values for the three variables is the minimum percentage of data at both levels, for which the S-Band flag will be wrongly set (i.e. 1 if the S-Band anomaly won't be present, 0 otherwise).

Hereafter the results are reported and they suggest that the best values for the three parameters are:  $n\_buffer=6$ ,  $n\_count=10$  and  $n\_count\_L2=14$ .

Tab. 1: Percentage of L1b products (per orbit) with wrongly set S-Band flag for the different parameters combinations

Percentage of data with wrongly set S-Band flag	Orbit 8568	Orbit 8557	Orbit 8567	Orbit 10910
$n\_buffer=4$ $n\_count=10$	0.676	0.044	0.030	0.034
$n\_buffer=5$ $n\_count=10$	0.237	0.045	0.038	0.058
$n\_buffer=6$ $n\_count=10$	0.676	0.055	0.052	0.077

Tab. 2: Percentage of L2 products (per orbit) with wrongly set S-Band flag for the different parameters combinations

Percentage of data with wrongly set S-	Orbit 8568	Orbit 8557	Orbit 8567	Orbit 10910

Band flag				
$n\_buffer=4$ $n\_count=10$ $n\_count\_L2=15$	0.095	0.050	0.072	0.045
$n\_buffer=5$ $n\_count=10$ $n\_count\_L2=15$	0.019	0.083	0.091	0.099
$n\_buffer=6$ $n\_count=10$ $n\_count\_L2=15$	0.095	0.083	0.113	0.116
$n\_buffer=6$ $n\_count=10$ $n\_count\_L2=14$	0.019	0.083	0.076	0.098

## 3. ALGORITHM FOR S-BAND WAVEFORMS RECONSTRUCTION

### 3.1. Algorithm for L1b

For each SPR of the L0 product extract:

1. The OBDH Datation
2. The Block Type for the 20 DBs
3. The S-Band Echo waveforms for the 20 DBs

Considering  $N\_SP$  being the number of SPRs in the L0 product create three arrays as follows:

4. OBDH\_dat: unsigned long long array of  $N\_SP*20$  elements, where:  
 $j=0, 19$   
 $i=0, N\_SP-1$   
OBDH\_dat( $i*j$ )=OBDH datation of SP  $i$
5. Block\_type: unsigned integer array of  $N\_SP*20$  elements, where:  
 $j=0, 19$   
 $i=0, N\_SP-1$   
Block\_type( $i*j$ )=Block type of DB  $j$  of SP  $i$
6. Samples\_s: two dimensional double array with dimensions of 64 and  $N\_SP*20$ , where:  
 $j=0, 19$   
 $i=0, N\_SP-1$   
Check Block\_type( $i*j$ ), in case it assumes one of the following values [2 OR 3 OR 6 OR 7], then Samples\_s( $0..63, (i*j)$ )=S-Band echo waveforms of DB  $j$  of SP  $i$

Considering  $N\_SP$  being the number of SPRs in the L0 product create another array as follows:

7. Samples\_s\_f: two dimensional double array with dimensions of 64 and  $N\_SP*20$ , where:  
Samples\_s\_f( $0..63, 0$ )=Samples\_s( $0..63, 0$ )  
 $k=1, N\_SP*20-1$   
Check (OBDH\_dat( $k$ )-OBDH\_dat( $k-1$ )), in case it assumes a value LE 58047, then Samples\_s\_f( $0..63, k$ )=Samples\_s( $0..63, k$ )-Samples\_s( $0..63, k-1$ ) otherwise  
Samples\_s\_f( $0..63, k$ )=Samples\_s( $0..63, k$ )

For each of the  $N_{SP} * 20$  datablocks, excluding the first and the last datablock in the file, check if some of the 64 samples assumes a value lower than  $diff\_threshold$ :

8.  $k=1, N_{SP} * 20 - 2$   
 $j=0, 63$

Check if  $Samples\_s\_f(j, k) < diff\_threshold$

The variable  $diff\_threshold$  will have to be considered as external variable.

Assign to those samples for which the previous check was successful ( $jj, kk$ ) a value calculated as follows:

9. Check  $(OBDH\_dat(k) - OBDH\_dat(k-1))$ , in case it assumes a value LE 58047, then  $Samples\_s\_f(jj, kk) = (Samples\_s\_f(jj, kk-1) + Samples\_s\_f(jj, kk+1)) / 2$  otherwise  $Samples\_s\_f(jj, kk) = Samples\_s\_f(jj, kk-1)$

## 4. RESULTS

The results hereafter presented have been obtained by setting the  $n\_buffer$ ,  $n\_count$  and  $diff\_threshold$  respectively to 6, 10 and  $4 * 10^8$  Power Units.

### 4.1. Detection

In Fig. 3 and Fig. 4 the S-Band anomaly flag is plotted for cycle 27. This cycle presents the highest percentage of affected data during the past year.

It is evident that some data present a wrong setting of the flag; in this example those data represent about the 0.1% of the total and they are mostly located over Land and Sea Ice surfaces. The performance shall be improved by a finer tuning of the three algorithm variables. In any case this amount can be considered a fair price to pay to detect and cure an anomaly, which affects, in average, between 2% and 6% of data per cycle.

### 4.2. Waveforms reconstruction

In Fig. 5 an example is reported of a case in which the S-Band anomaly has occurred and the waveforms have been reconstructed using the algorithm described in the previous paragraph.

Comparisons have been made between original and reconstructed S-Band waveforms over several types of surfaces: Open Ocean, Ice Sheet, Sea Ice and Land.

## CONCLUSIONS

The paper presents an algorithm targeted to the detection of the so-called RA-2 "S-Band anomaly" from the L0 data products as well as an algorithm to reconstruct the affected waveforms in such a way that they can be directly ingested in the L2 re-tracking processing. The present results shall be further improved by tuning of the algorithm but can be anyway considered as an already clear improvement respect to the current situation (99.9% of the S-Band anomalies

detected). The tuning and validation of the algorithm shall be soon completed before its final implementation in the Envisat RA-2 & MWR IPF operational processing chain. In a first step, only the S-band anomaly detection algorithm shall be implemented

## REFERENCES

1. ENVISAT RA-2: S-BAND PERFORMANCE, S. Laxon and M. Roca, Proceedings of the ENVISAT Calibration Workshop, Noordwijk, September 2002
2. RA-2 Instrument Operation Manual, PO-MA-ALS-RA-0006, Issue 6.1, 16 February 2002
3. Defining a Rain Flag for the Envisat Altimeter, G. Quartly
4. Algorithm for Flag identification and waveforms reconstruction of RA-2 data affected by "S-Band anomaly", A. Martini, ENVI-GSEG-TN-04-0004, Issue 1.2, July 2004

## ACRONYMS

SPR	Source Packet Record
DB	Data Block
OBDH	On-Board Data Handling
L0	Level 0
L1b	Level 1b
CW	Continuous Wave

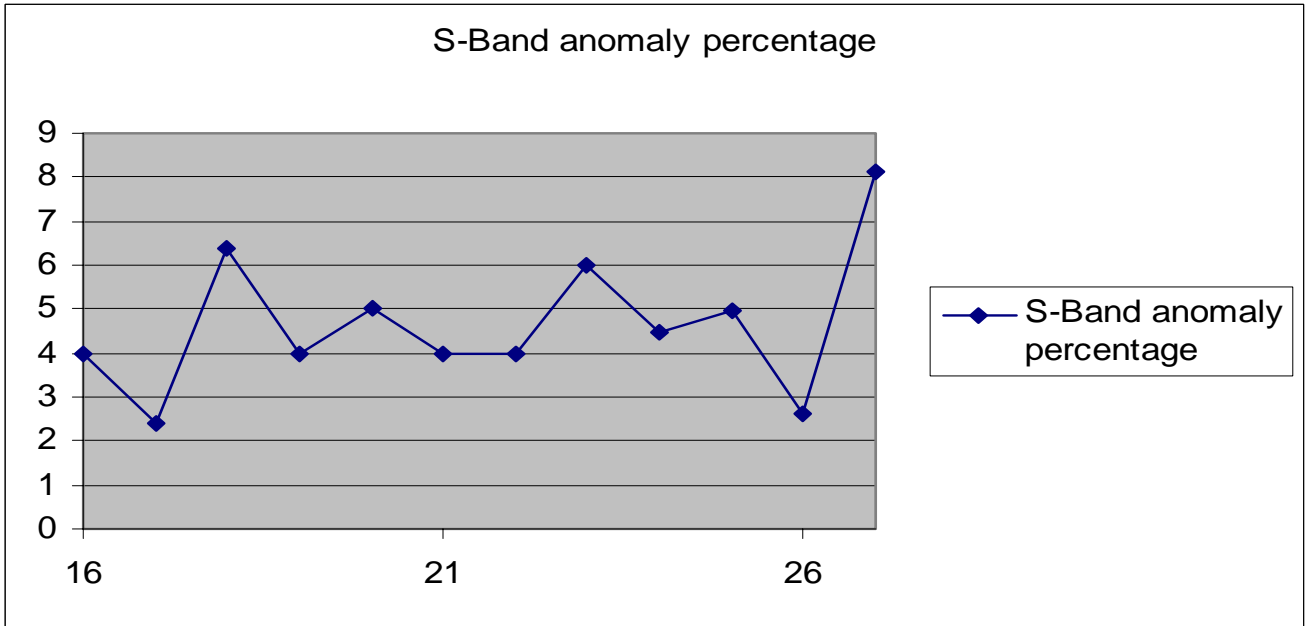


Fig. 1: Percentage of data affected by the S-Band anomaly per cycle

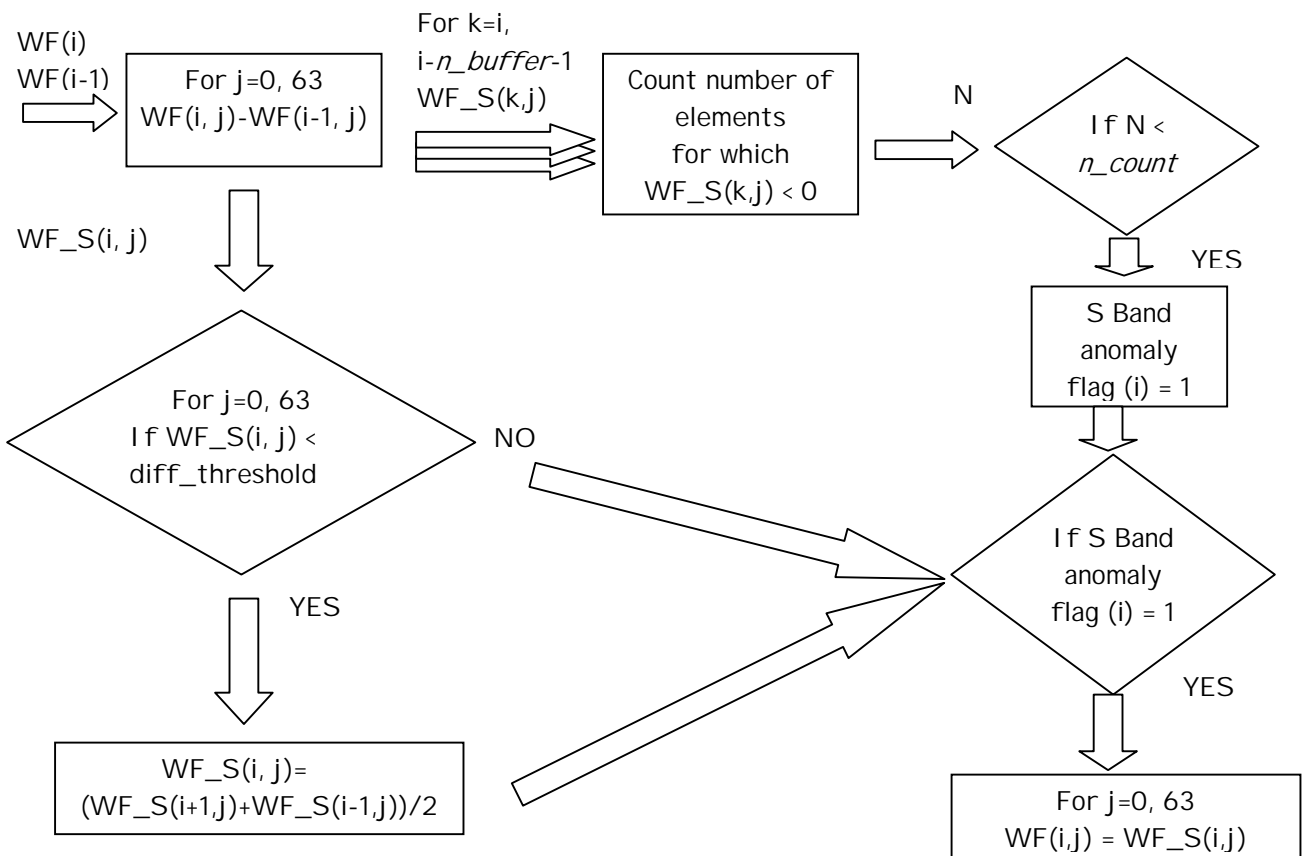


Fig. 2: Block diagram of S-Band anomaly flag detection and waveforms reconstruction algorithm

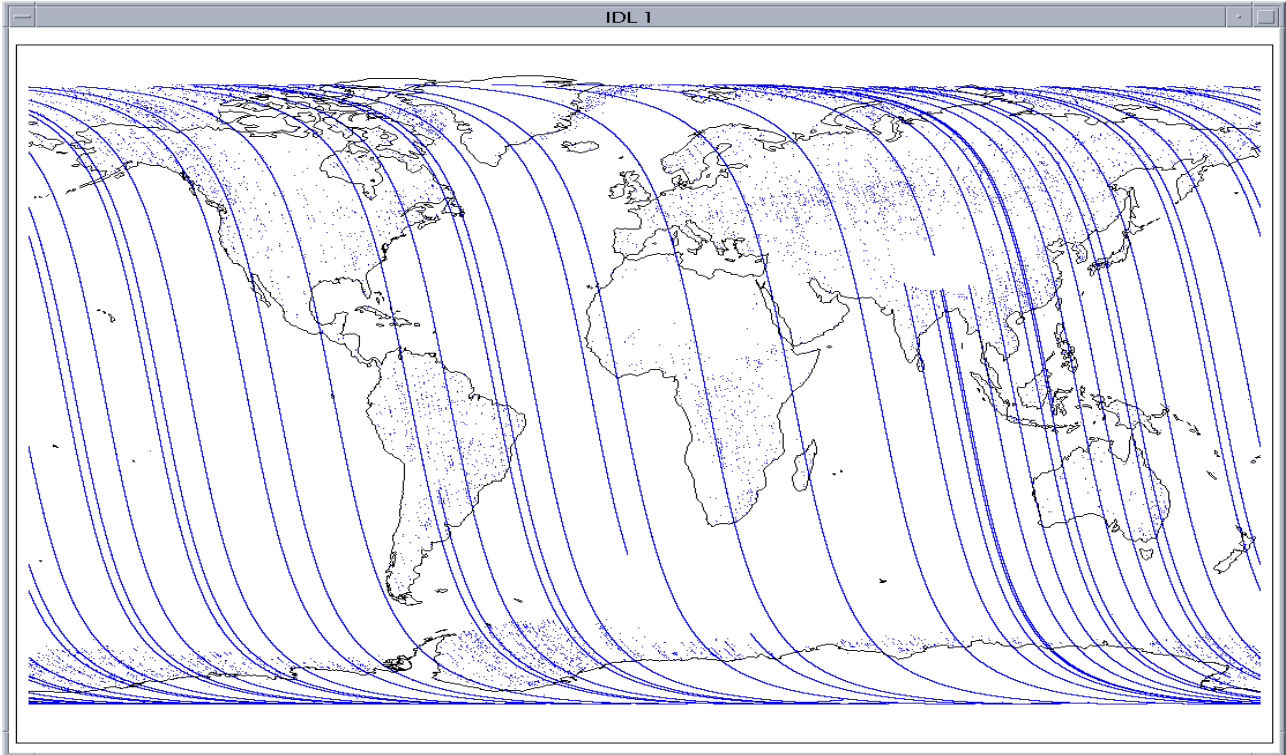


Fig. 3: S-Band anomaly flag for cycle 27 (ascending tracks)

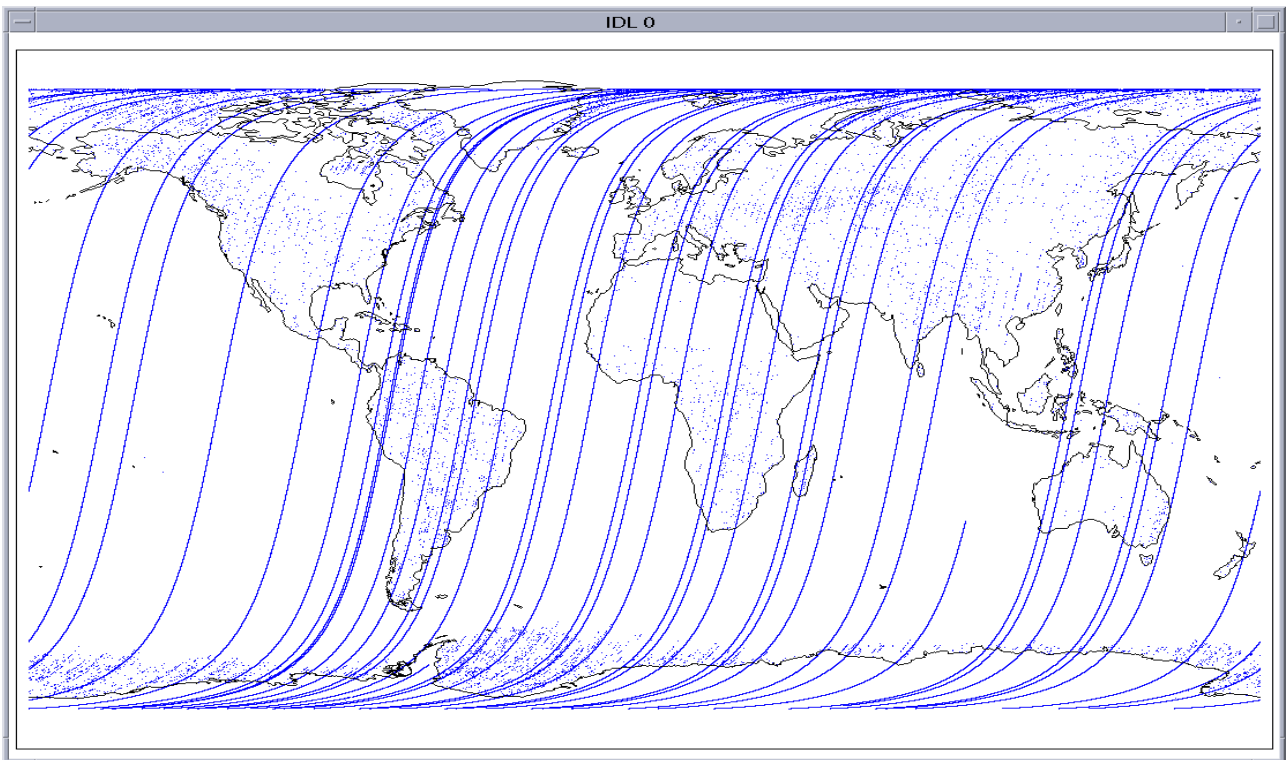


Fig. 4: S-Band anomaly flag for cycle 27 (descending tracks)

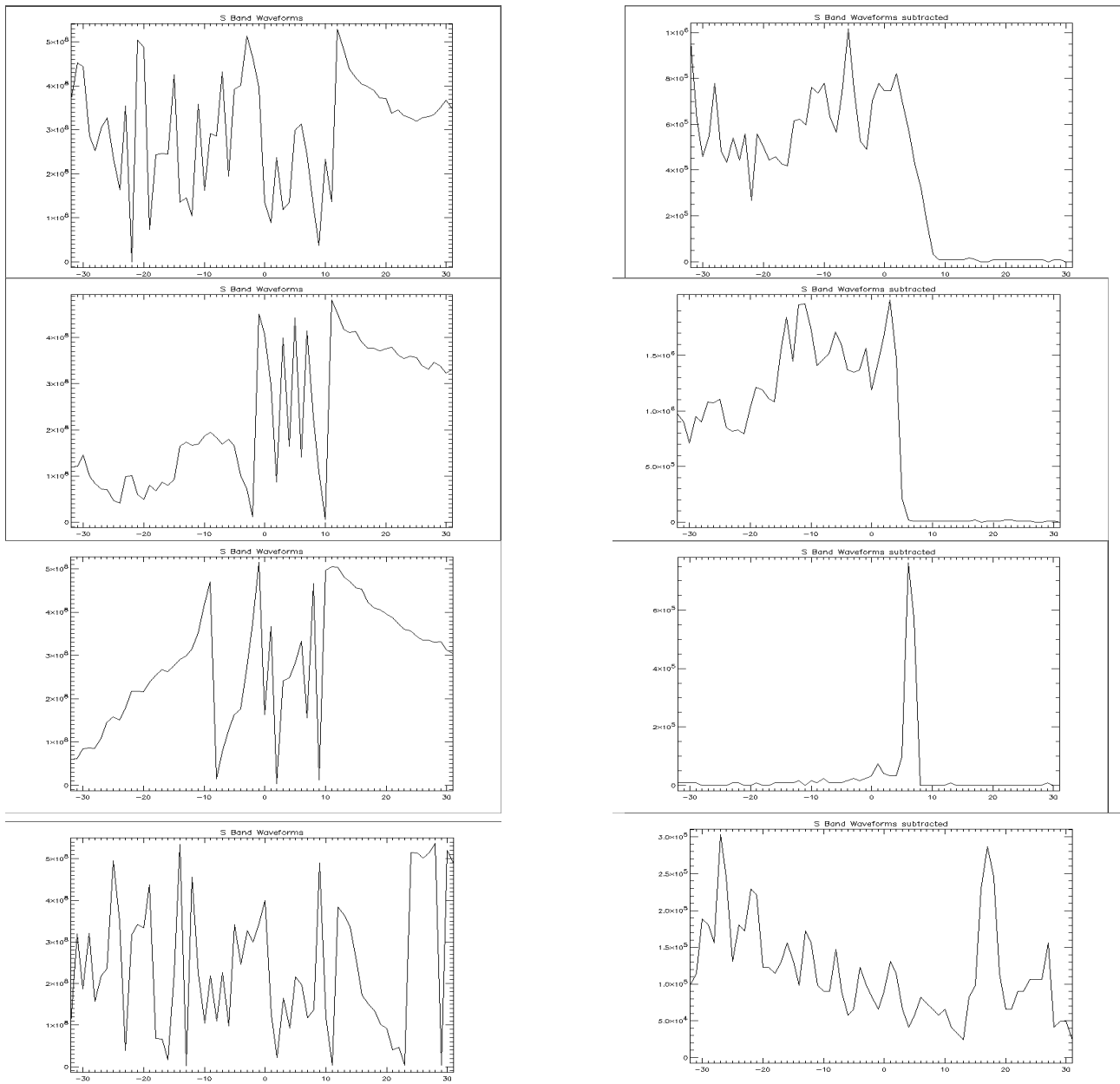


Fig 5: Comparison between original (left) and reconstructed (right) waveforms for different surfaces: Open Ocean, Ice Sheet, Sea Ice and Land