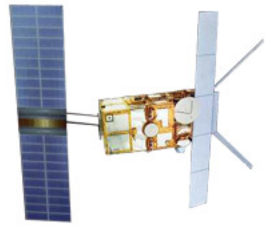

ERS2 Microwave Radiometer

Reports on activities performed in 2003

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CLS.DOS/03.845
Edition 1.0, October 2003

Contents

1 Introduction

The statement of work for the long term survey of the ERS2 microwave radiometer (MWR) by CETP and CLS includes the following issues:

- continuous monitoring of the key instrumental parameters to detect any anomaly, detail analysis of anomalies if observed, then update of the calibration;
- long term analysis of the brightness temperatures over stable natural targets, to evaluate the instrument stability and quantify any drift.

The following report summarizes the work performed in the framework of this contract since September 2003. Part of this work has also contributed to validate the Envisat MWR calibration activity. For each activity, we will give the status, main steps and results.

2 Cyclic monitoring

The ERS-2/MWR has proven its good stability with time, and it provides good quality measurements. Our work on this instrument is consequently mainly a routine monitoring. Data from the Kiruna, the Maspalomas, the Prince Albert, and the Gatineau stations (only since cycle 86 for the three latter) are extracted from the ESRIN server (odisseo.esrin.esa.it) then automatically processed at CETP. At the end of every cycle, a report is provided to ESA. This document aims to provide an instrumental status and to report any change at the instrumental level likely to impact the quality of the measured brightness temperatures with a checking on the stability of the instrument.
It is divided into the following topics:

- Maps of the brightness temperatures over South Pole
- Monitoring of the radiometer internal parameters
- Monitoring of cold ocean brightness temperatures
- Conclusion on the cycle assessment and long term monitoring

As announced by the agency, due to a failure of the ERS-2 tape recorder on 22 June 2003 the recording capabilities are permanently unavailable. The ERS-2 tape recorders were used to record the ERS-2 Low Rate mission globally, after 8 years of continuous acquisition this service is now discontinued. The ERS-2 Low Rate mission will be continued within the visibility of ESA ground stations over Europe, North Atlantic, the Arctic and western North America. ESA has the intention to extend the coverage of Real Time Low Rate acquisition over the North Atlantic in the near future.
Since the monitoring is kept going with the remaining available data. One repercussion is that since cycle 086, the maps of the brightness temperatures over South Pole are no more available. The last available report at the time of this summary of the activities performed in 2003 is the report on cycle 087 that ended in mid-September. Some plots from it are reproduced in the followings.

2.1 Monitoring of the radiometer internal parameters

To monitor the instrument behaviour during its lifetime, the key parameters that are plotted are: the gain (after correction of the thermal variations, modeled as a parabolic function), the hot load and sky horn counts, and the residual term TE (residual temperature contribution due to errors in the estimated coefficients). The instrument stability is ensured if none of these parameters do vary with time.
The figure 1 (top) shows the gains of the two channels 23.8 and 36.5 GHz, after multiplying the 23.8 GHz gain by 10, and figure 1 (bottom) is a zoom on the last 10% of time. They show that the gain is very stable on both channels, despite the strong anomaly which occured on channel 1 (23.8 GHz) in June, 1996. Since this failure the gain on this channel has been stabilized at approximately one tenth of its original value. Note that, a slow trend can be detected on calibration counts and on the residual temperature for both channels (figures 2 and 3). The different plots show gaps in the monitoring due to the problem with the tape recorder.

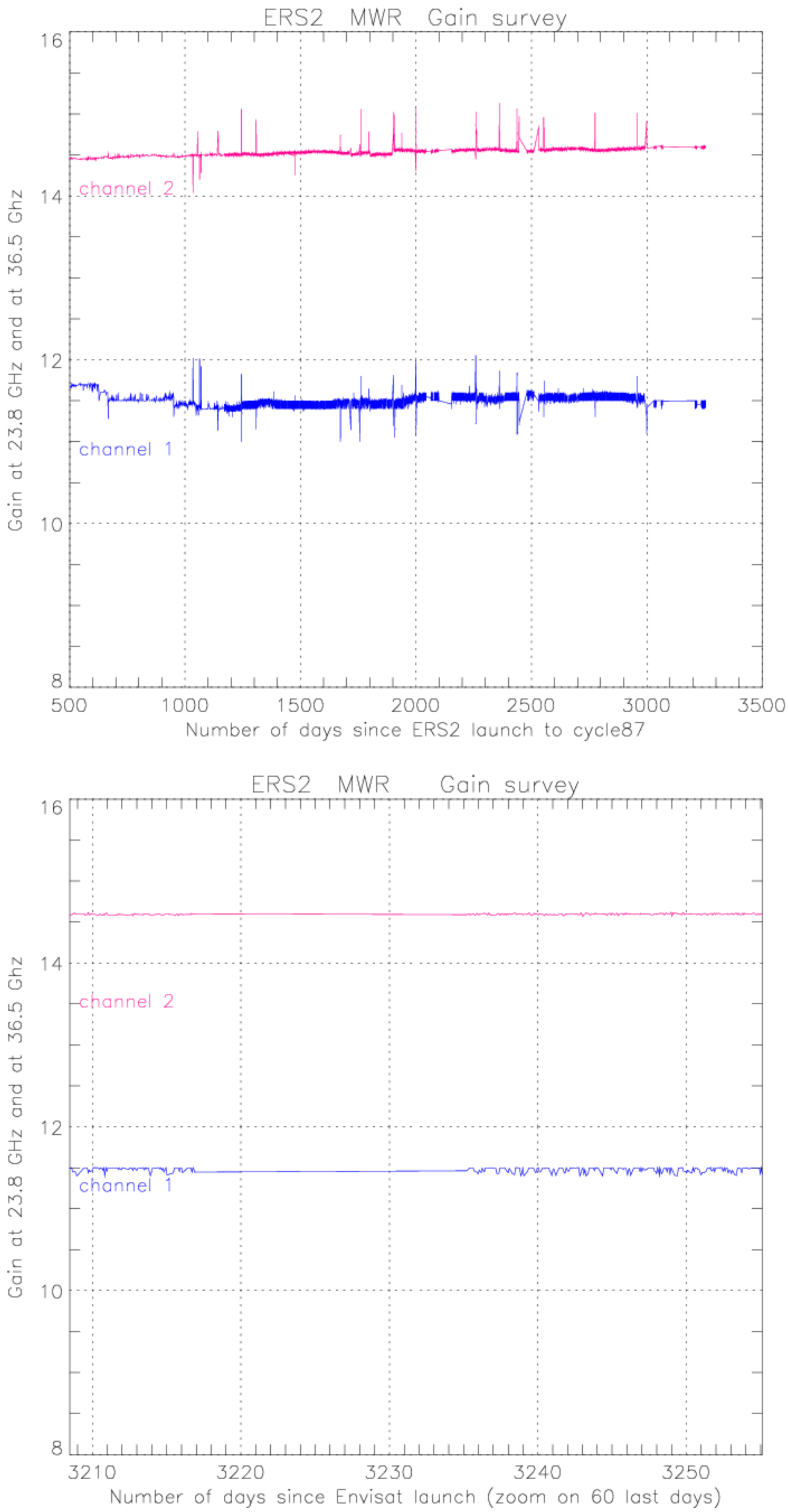
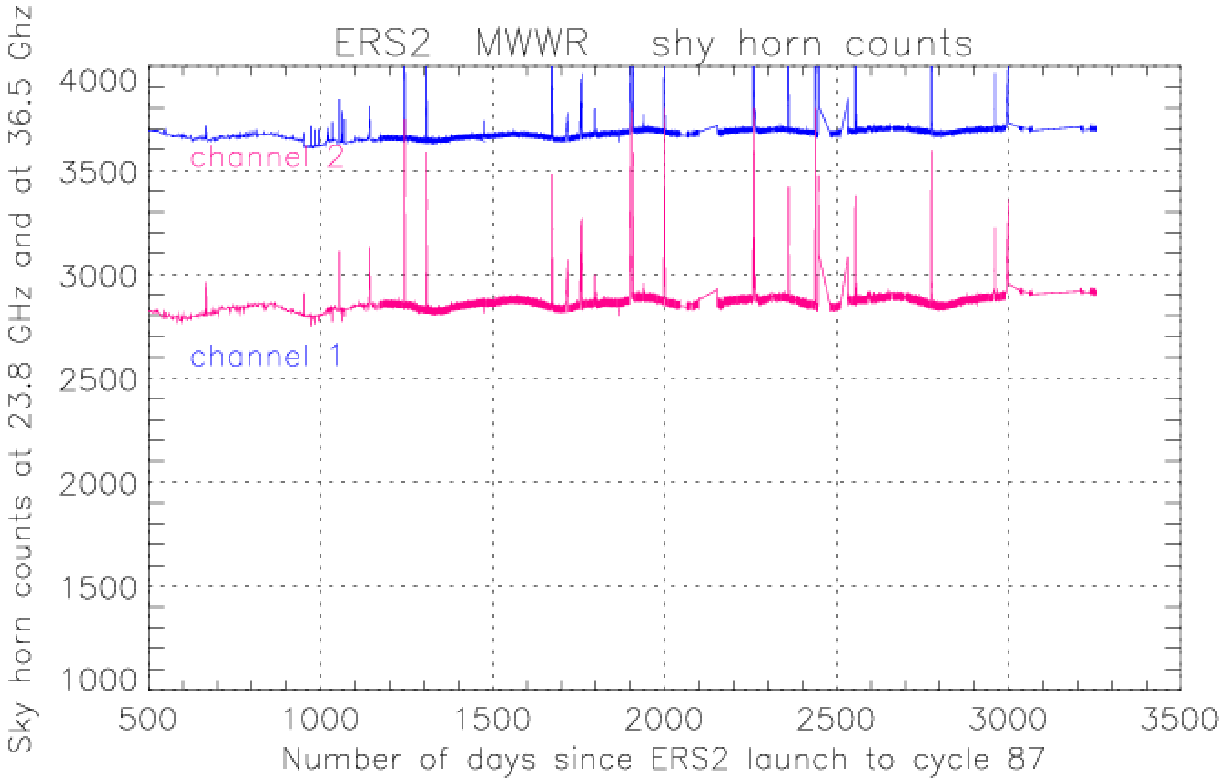


Figure 1: Time evolution of the gain since June, 1996.



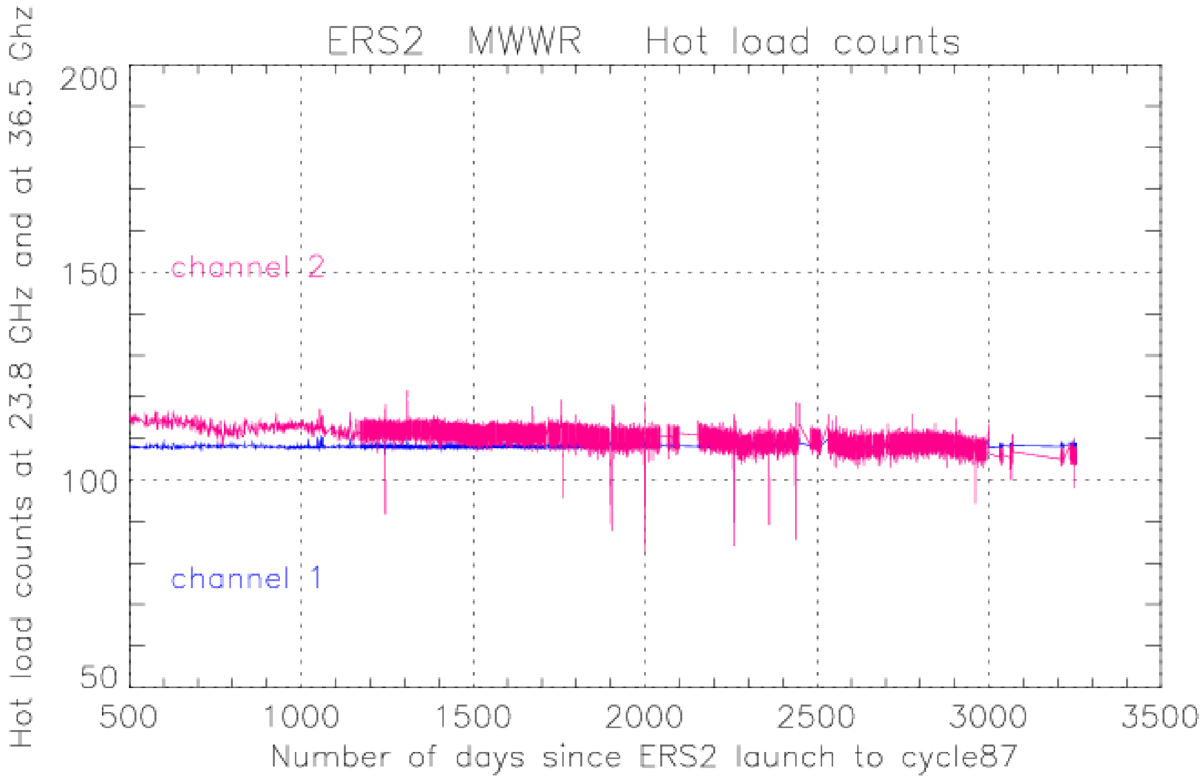


Figure 2: Time evolution of the sky horn count and the hot load count since June, 1996.

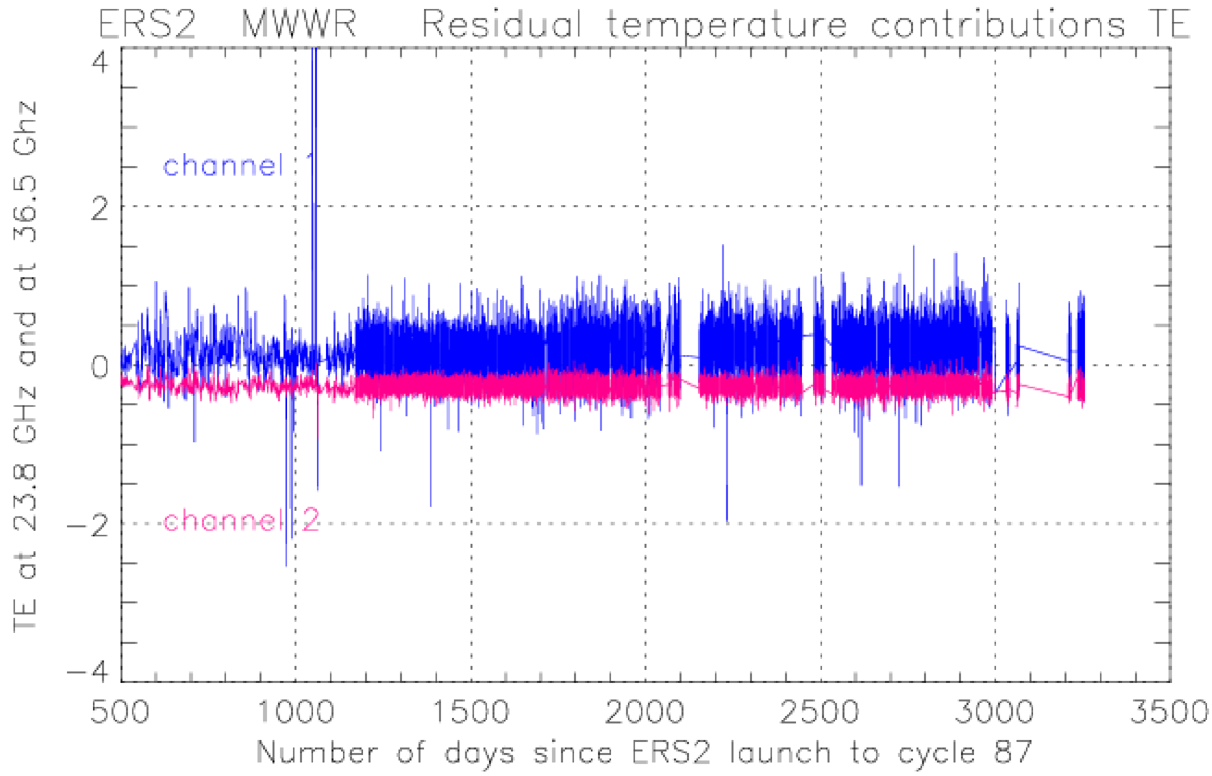


Figure 3: Time evolution of the residual temperature TE, since June, 1996.

2.2 Monitoring of cold ocean brightness temperatures

To assess the long term stability of the radiometer, monitoring of the two brightness temperatures was performed by selecting the coldest measurements over ocean. This method, derived from Ruf's one for TMR (Ruf, 2000), was found to be the most efficient to point out the slight trend of channel 1. It consists of first filtering out data with value higher than a given threshold, then filtering out again the remaining data with values above the cycle average minus 1.5 times the standard deviation. The resulting time series is plotted in figure 4. Validation of the method was performed by checking its consistency on TMR data (in comparison with Ruf's results). The perfect stability of channel 2 is confirmed, and a trend is clearly depicted on channel 1.

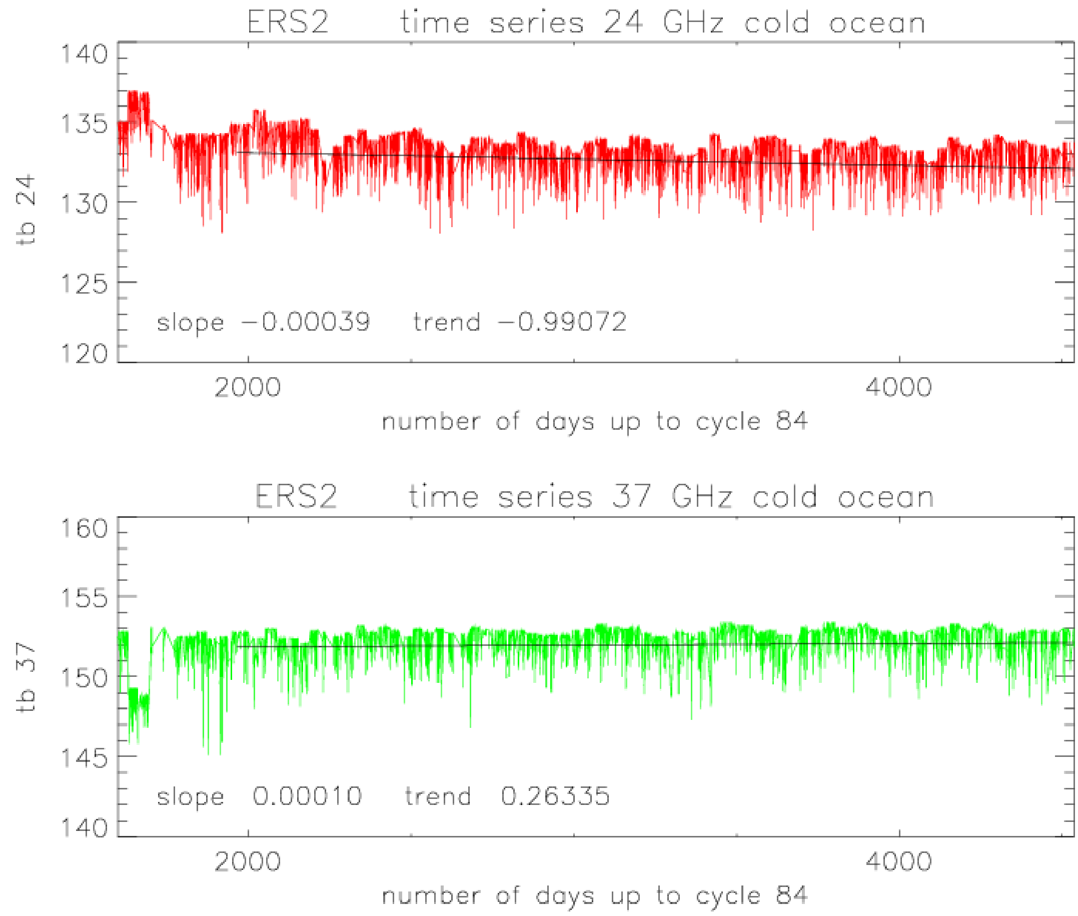


Figure 4: time series of the coldest brightness temperatrues over ocean. Data are taken from launch to the cycle available at the time of the preparation of this report due to the used of the VLC tapes. Dates are referenced to January 1st, 1991.

To conclude this part, the monitoring up to the cycle 087 does not present any anomaly. Data gaps appear due to the recording problem. All internal parameters are nominal. The slight drift of channel A is constant and performances are still within the nominal limits. A linear correction is nevertheless available for the brightness temperature to allow the user to get a better stability of the tropospheric correction for the entire instrument lifetime (the following section will describe the drift evaluation and correction).

3 Drift evaluation and correction on 23.8 GHz TBs

As mentioned previously, the time evolution of the coldest brightness temperature over ocean allows us to perform a monitoring of the stability of the measured brightness temperatures. This method allows an absolute determination of a drift for one particular channel. And once the stability of a given channel has been established, it can be used as a reference for further studies. As the Topex MWR 18 GHz channel, the ERS-2 MWR 23.8 GHz channel has drifted with time. These drifts must be compensated for to ensure the best accuracy, particularly for estimation of the long-term sea level variation. Therefore in both cases, a linear correction (function of both time and brightness temperature amplitude) has been determined. In a technical note (Obligis et al., 2003) provided in February 2003, we detailed the evaluation and correction of the drift observed on the 23.8 GHz channel of the ERS2 Microwave Radiometer. The three different methods used to detect and evaluate this drift are presented along with the correction proposed to the users to correct the 23.8 GHz channel brightness temperature for this drift.

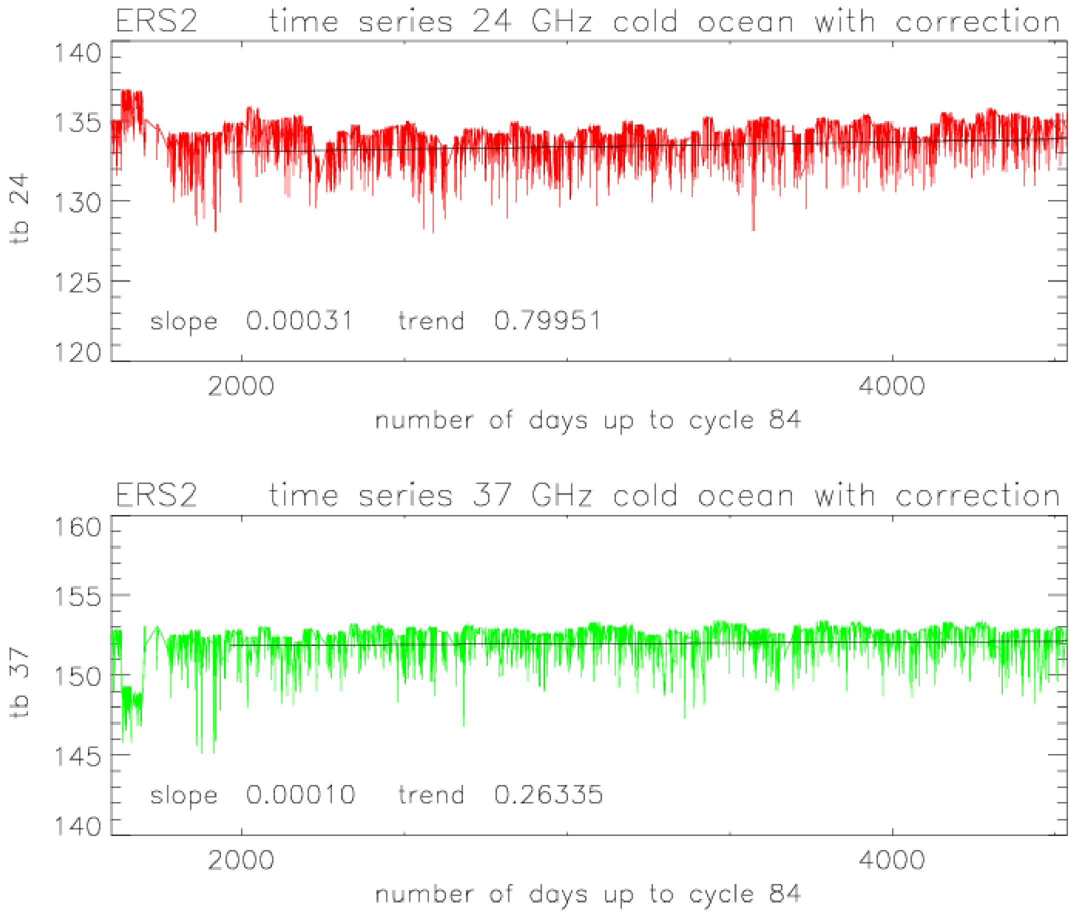


Figure 5: Same as figure 6 after correction of the 23.8 GHz TBs drift.

To summarise this analysis, the drift has been estimated to be -1.6 K between the gain drop in June 1996 and the end of September 2002 (date of the study performed by Pilon (2003)) for low brightness temperatures. For hot brightness temperatures, the long-term monitoring over hot continental areas (Amazon Forest and Sahara Desert) did not show any drift. This drift of channel A was also confirmed by comparing the ERS-2 data with TMR data at crossover points, and a linear correction was determined and is available to ERS2 users. Since then this latter has been applied on the monitoring of the cold brightness temperatures in the cyclic report. Figure 5 shows the long-term monitoring of the 23.8 GHz brightness temperatures after applying the proposed correction on data from figure 4. A slight increase of the cold ocean TB values is observed with the application of the correction on the new additional data since the determination of this correction. Note that we need to be careful because the variation we observed is also due to the seasonal temperature variation. One recommendation is to reprocess this correction that would be evaluated only on an integer number of years in order to really get rid of the annual cycle in the proposed correction and only after that any variation of the slope value of the regression line on the time series would be attributed to only the annual cycle.

4 Validation of the use of ENVISAT neural algorithms on ERS-2 data

Our recent progresses on retrieval method (updated regression algorithm, and use of neural network) suggests that an update of the ERS-2 processing could be made, to keep the ERS-2 retrieved data comparable to Envisat ones. Furthermore the ERS-2 algorithm for the wet tropospheric correction was found to be biased at very low water vapour, and the algorithm developed for Envisat corrects for this bias as showed in the following results. A technical note that explains how to apply the ENVISAT algorithm on ERS-2 data and fortran and C routines are available to ERS2 users (Tran and Obligis, 2003) to implement them. This analysis did also serve to validate the ENVISAT neural algorithm and products with radiosonding data to check the quality and reliability of the new retrieval. Because at this time, we do not have enough colocations between radiosonde and ENVISAT wet tropospheric correction measurements. In order to provide a first assessment of the quality of ENVISAT wet tropospheric correction (neural algorithm) with radiosonde measurements, we computed the new ERS2 wet tropospheric correction and then use a previous compilation of ERS2/radiosondes.

Cycle 010	TB 23.8 GHz (K)	TB 36.5 GHz (K)	attenuation (dB)
ENV/ERS2	2.98	2.39	2.09 ers2 + 0.09

Table 1: Biases and correction to apply on ERS2 data.

In summary, biases and correction have to be applied on ERS2 data as a pre-processing step to have algorithm inputs as similar as possible between the two instruments to allow optimum use of the algorithms and provide less biased retrieved products. The ERS2 TBs at 23.8 GHz were corrected for the drift as proposed in Obligis et al (2003) in all presented results. Table 1 provides the biases between ENVISAT and ERS2 TBs for both channels computed on ENVISAT cycle 010. These values have to be added to the respective ERS2 TB products. A linear relationship for the Ku-band atmospheric attenuation correction between the two instruments is also provided because ENVISAT sigma-naught has been calibrated on ERS2 corrected values and the radiometric algorithms were evaluated on uncorrected ones. In the formulation of ERS2 attenuation correction model only the absorption by cloud liquid water has been taken into account, while for ENVISAT a more complex model has been used that takes also into account gaseous absorption by oxygen and water vapor. So this linear relationship provides a new attenuation correction term that has to be removed from the ERS2 corrected sigma-naught product.

Figure 6 shows the comparison between radiosonding and ERS2 wet tropospheric corrections for a 6-year period (07/1996-06/2002) with the current product (no drift correction on 23.8 GHz TB and ERS2 algorithm), a zoom is also presented. Plots on Figure 7 were obtained with the drift correction applied and the ENVISAT neural algorithm. The slopes and intercepts for the orthogonal distance regression line are provided. We get a better agreement with the radiosonding measurements when the drift correction and the ENVISAT algorithm are applied. The improvement due to both the drift correction and the neural algorithm is better pointed out by the bin averaging also computed. It is specially obvious for wet tropospheric correction lower in absolute value than 0.1 m, which represents most of the data.

Recomputation of the ERS2 products with ENVISAT neural algorithms shows a good agreement with ENVISAT products. As shown on figure 8 with data corresponding to cycle 015 of ENVISAT. The biases are small. The imperfection of ERS2 retrieval algorithm at very low water vapour is also removed as seen in figures 9 and 10 when comparing with ECMWF wet tropospheric correction. We recommend to the ERS2 users to correct the ERS2 TB 23.8 GHz for its time drift and to use the ENVISAT neural algorithms in order to obtain better retrieved radiometric products.

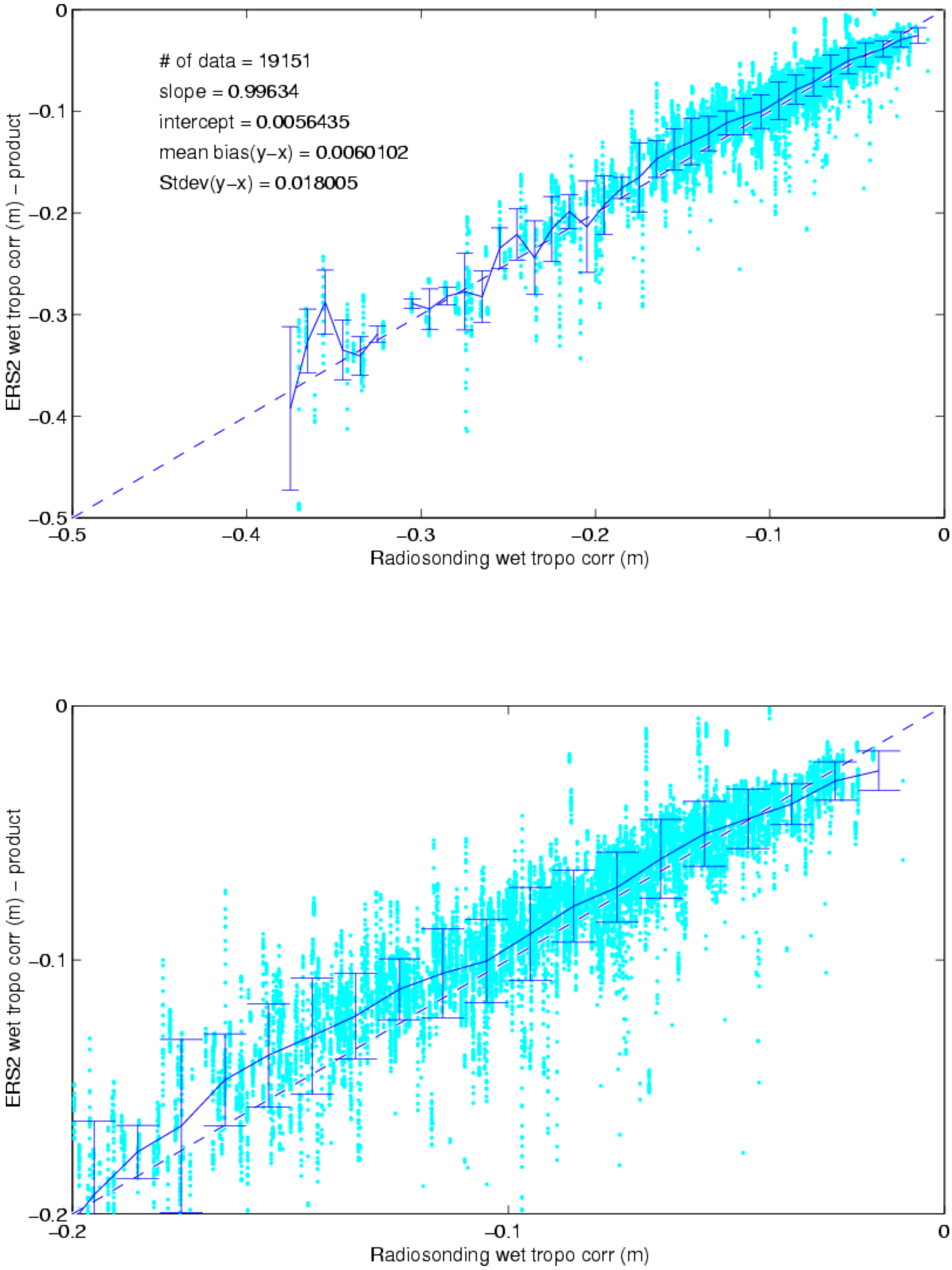
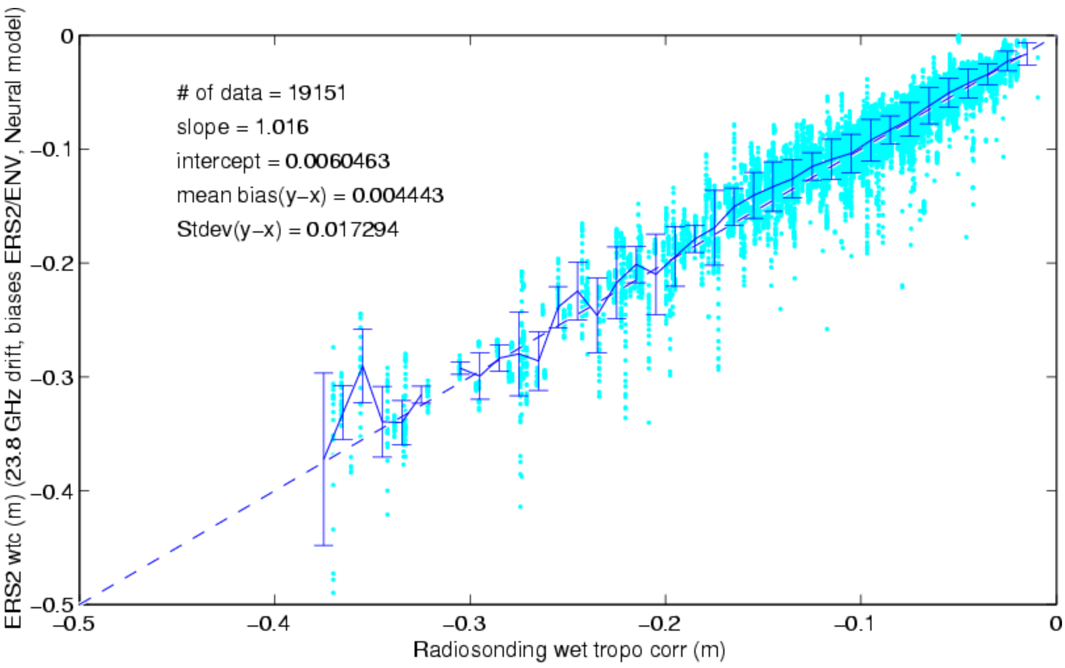


Figure 6: Comparison between ERS2 and radiosondes wet tropospheric corrections. The ERS2 data are the actual products. A zoom on the small absolute correction values is also provided in the bottom panel.



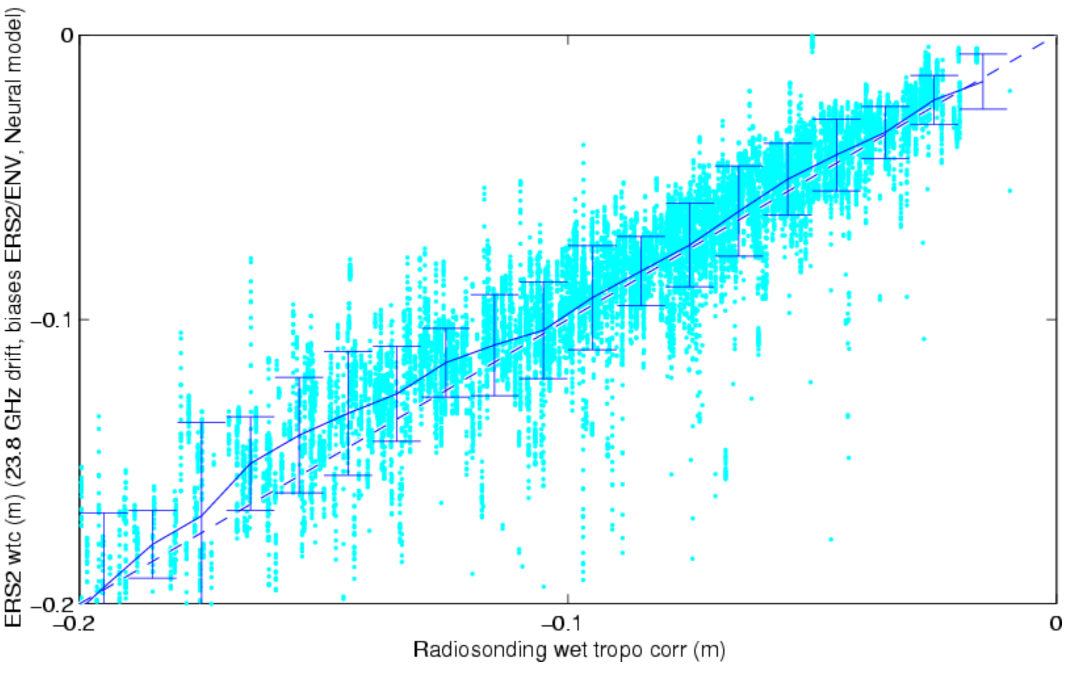


Figure 7: Same as Figure 2, the ERS2 data have been recomputed with ENVISAT neural algorithm instead of current ERS2 one after correction of the TB 23.8 GHz drift.

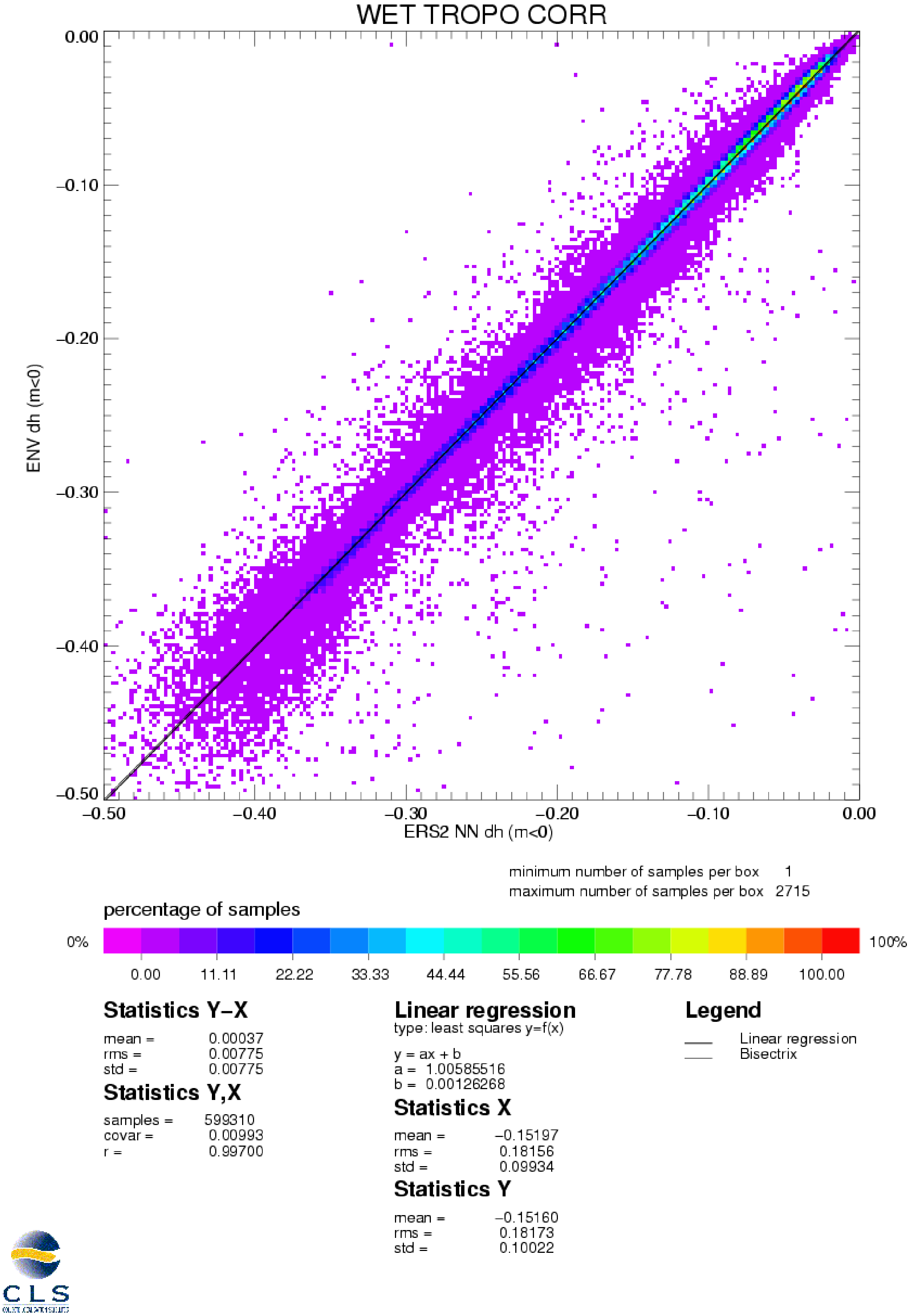


Figure 8: Scatterplot of ENVISAT wet tropospheric corrections with respect to neural estimates of ERS2 ones on ENVISAT cycle 015.

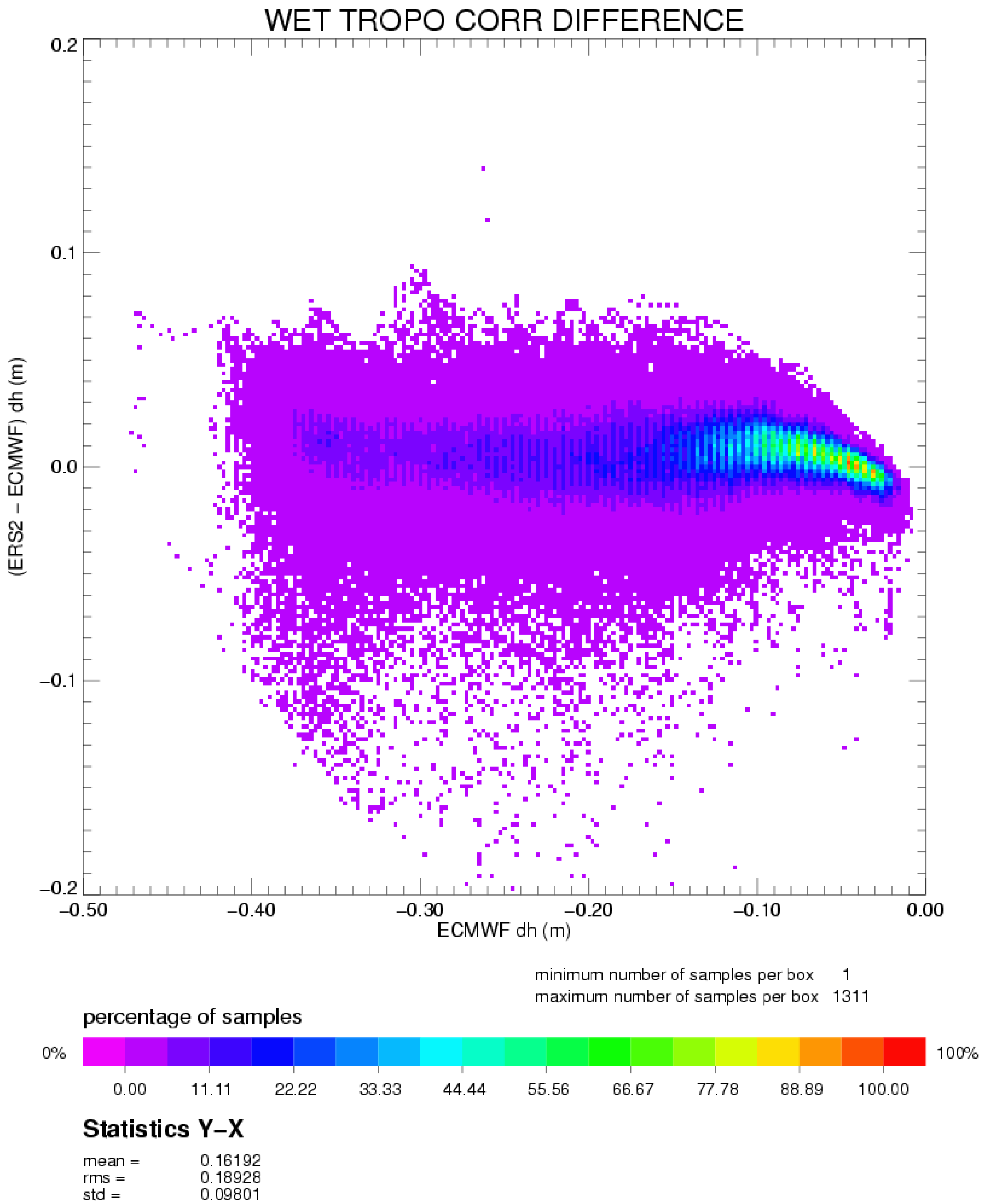


Figure 9: Difference between ERS2 current products and ECMWF ones with respect to ECMWF ones on corresponding ENVISAT cycle 015.

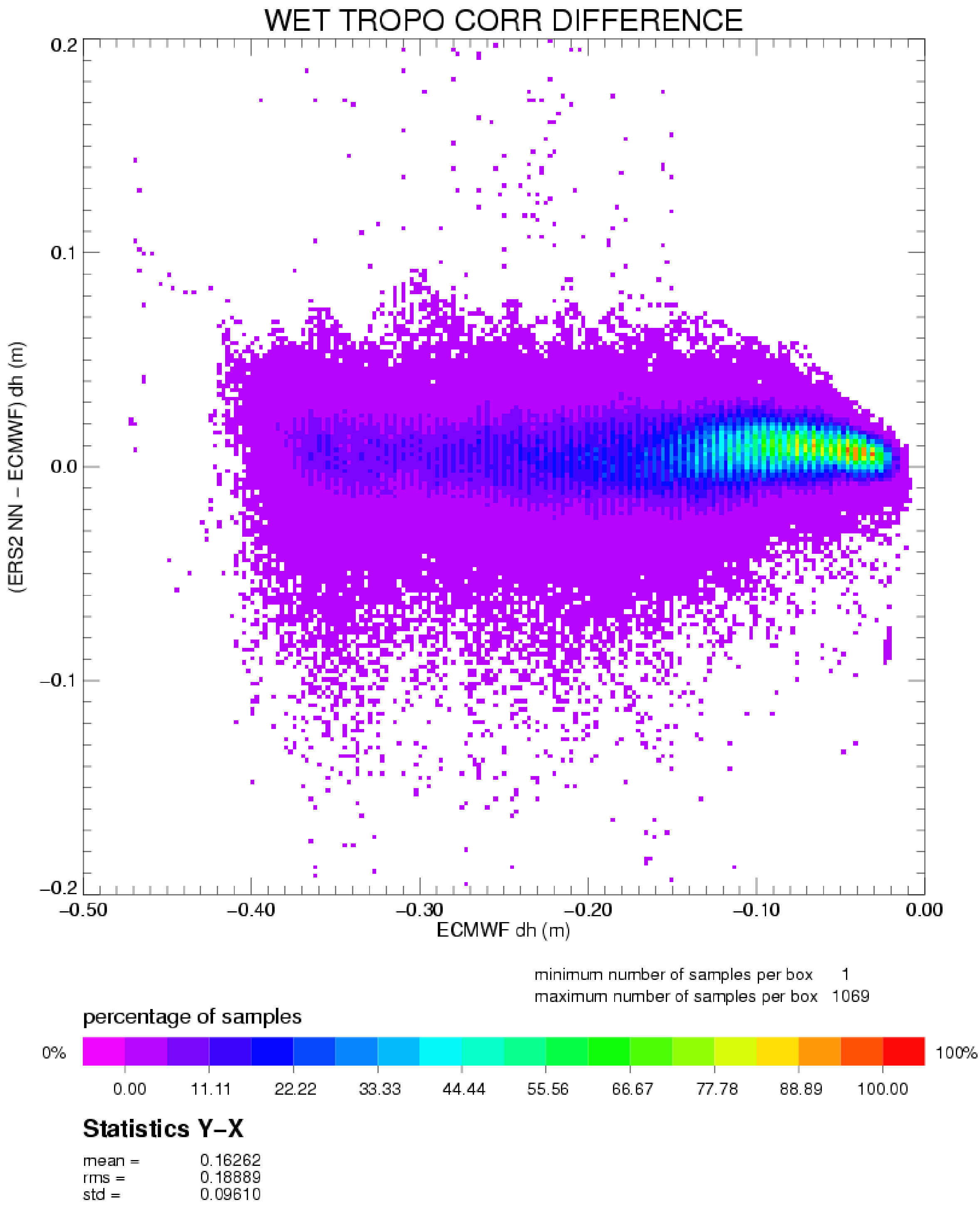


Figure 10: Difference between ERS2 neural products and ECMWF ones with respect to ECMWF ones on corresponding ENVISAT cycle 015.

5 Final comments and recommendations

Studies performed in the context of this contract show a good stability of the instrument and good performances in term of retrieved products.

Survey of the coldest points over ocean pointed out a drift of the 23.8 GHz channel and a correction is now proposed to the users to correct the brightness temperatures for this drift. One recommendation is to reprocess the drift correction that would be evaluated only on an integer number of years in order to minimize the effects of annual variation.

We also propose to use the Envisat algorithms to take advantage of the algorithmic improvements performed for the Envisat mission preparation : use of a more complete database, of a more accurate surface model and of a neural inversion.

6 Reference documents

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