ERS2/MWR long-term survey
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ERS2/MWR drift evaluation and correction

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APPLICABLE DOCUMENTS / REFERENCE DOCUMENTS

RD 1 : Long-term monitoring of the OPR altimeter data quality, Stum et al, January 2001.

RD 2 : Long-term monitoring of the OPR altimeter data quality, Stum et al, January 2002.

RD 3 : Long-term monitoring of the OPR altimeter data quality, Stum et al, January 2003.

RD 4 : Intercomparison of TMR and ERS/MWR calibrations and drifts, Eymard et al, SWT TOPEX-JASON, New Orleans, Oct. 2002.

RD 5 : Preliminary report on long-term stability of ERS2/MWR over continental areas, Eymard and Obligis, 1999.

RD 6 : "Altimeter and Microwave Radiometer ERS Products User Manual" (Ref. C2-MUT-A-01-1F, issue 2.2).

RD 7 : ERS2/MWR drift evaluation/correction, Obligis et al, 2003.

CONTENTS

1. INTRODUCTION

This technical note is dedicated to the evaluation and correction of the drift observed on the 23.8 GHz brightness temperatures of the ERS2 Microwave Radiometer.

Chapter 2 presents the different methods used to detect and evaluate this drift.

Chapter 3 presents the correction proposed to the users to correct the 23.8 GHz brightness temperature for this drift.

An illustration of the application of this correction is presented in chapter 4.

Finally, chapter 5 provides users guideline on this correction to be added in the validation report of the OPR.

2. DRIFT EVALUATION

The observation of the drift of the brightness temperatures measured by the ERS2 radiometer at 23.8 GHz was first suggested in RD 1 (Stum et al) in January 2001, by looking at the difference between ERS2 and TOPEX wet tropospheric corrections at cross-over points. The drift was confirmed in the 2 following annual reports (RD 2 and RD 3). The mean value for this drift was estimated to be around 1.5 K (TBs at 23.8 GHz 1.5 K lower than at the beginning of the mission), corresponding to a wet tropospheric correction about 5 mm lower.

In 2002, Eymard et al (RD 4) performed a long-term survey of the radiometer using 3 different methods. These independent methods led to similar results for the estimation of the 23.8 GHz brightness temperatures drift.

2.1. STABLE CONTINENTAL AREAS

In case of polar orbits, a direct comparison can be achieved over poles, where the atmosphere variability is much lower than over open oceans, and the annual cycle is quite stable. The use of measurements over warm targets (Sahara, Amazon forest) completes this analysis for high brightness temperatures. On these continental regions, we expect that any natural variation should affect all channels in a near-similar way and a drift on one particular channel would thus be easily pointed out.

The method used for ERS2-MWR is the following:

- selection of less spatially variable areas over one year (small area with at least two orbits overpasses)
- analysis of the time variations (annual and diurnal cycles) and estimation of the trend.

The major problem was to filter out the annual cycle, which masks the interannual variation. Table 1 summarizes the results of the ERS2-MWR survey over 6 years. The difference between night and day temperatures made necessary to separate the corresponding overpasses over Sahara and the Amazon forest. The difference between trends at 36.5 and 23.8 GHz is positive and significant over cold targets, and it is weakly negative over warm areas. This confirms the relative drift of one channel with respect to the other.

Area	***TB36.5 – TB23.8 trends***
Antarctic 1 (coldest)	1.90
Antarctic 2	1.50
South Greenland	0.17
Sahara night	-0.15
Sahara day	-0.15
Amazon forest night	0.15
Amazon forest day	0.52

Table 1 : Long-term relative trends between TB36.5 and TB23.8 measured by the ERS2-MWR over stable continental areas. The two Antarctic areas (areas of a few degrees square) are on the plateau (140 160°E ; 78 81°S), the Sahara area is located in Eastern Mauritania (19 21N ; 6.5 4.5W), and the area in the Amazon forest (6.5 4S ; 67.5 65.5W) was chosen as an area large enough to be overflown by both TMR and ERS2 MWRs and small enough to not include the rivers (which appear significantly colder than forest).

2.2. COLDEST OCEAN BRIGHTNESS TEMPERATURES

Ruf (2000) established that the TMR 18 GHz brightness temperatures drifted with time, by comparing the time evolution of the coldest brightness temperatures over ocean for the three channels. The drift was confirmed indirectly by other studies, based on validation of the tropospheric path delay (or water vapor content) at the beginning and at recent periods of the TOPEX mission. The drift was estimated to be 0.17K per year.

A similar analysis was therefore performed on the ERS2-MWR data, using a method derived from Ruf's. The Figure 1 shows the results obtained for ERS2-MWR. As the TMR 18 GHz channel, the ERS2-MWR 23.8 GHz channel presents a drift in its measurements with time, the total trend being about -1.6K since the gain drop in June 1996. Again, the drift was smaller at higher temperature, and could only be suspected by looking at the South pole relative variations of the two channels.

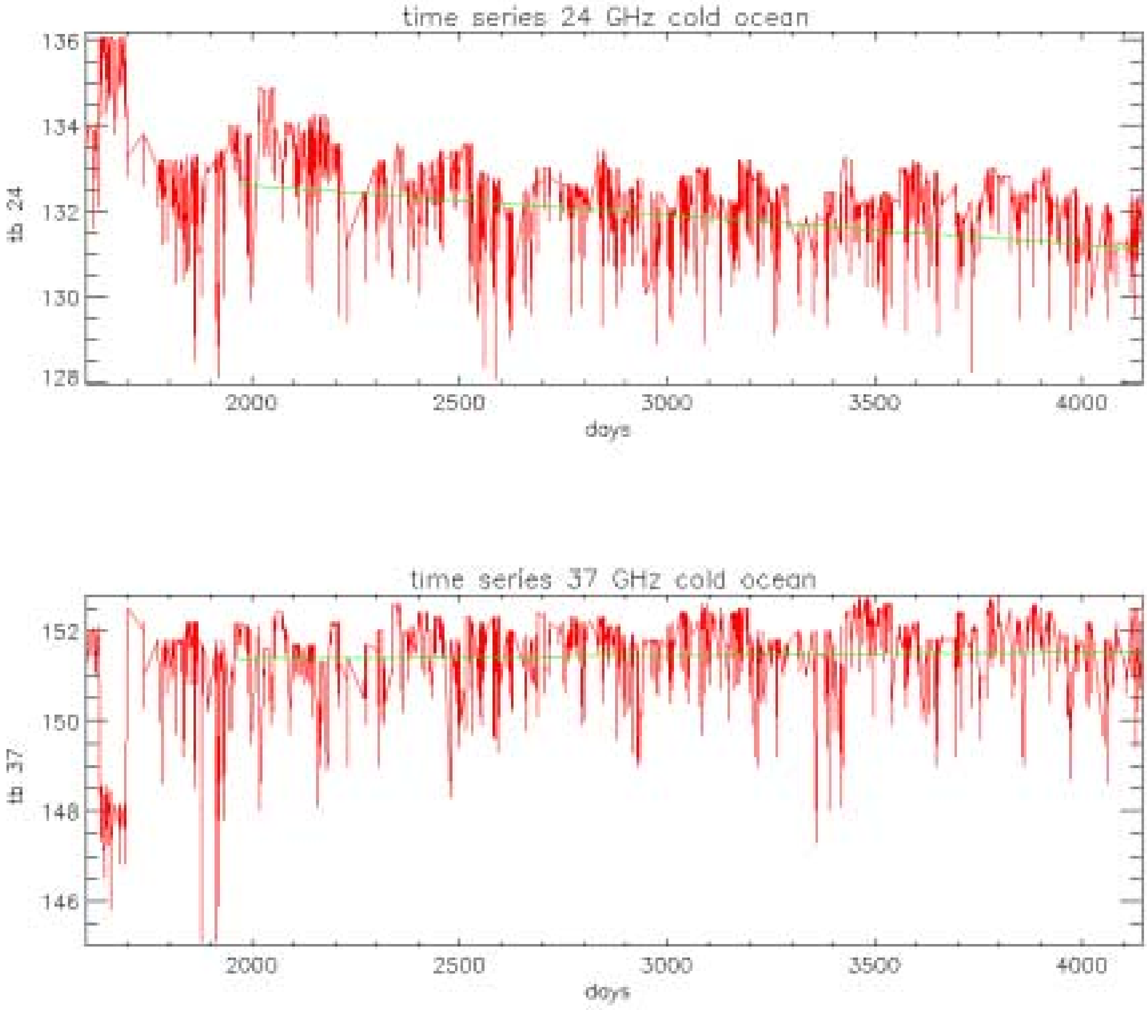

Figure 1 : Long term monitoring of the coldest TBs over the oceans for ERS2-MWR. Mean and standard deviation of data (lower than a given threshold) were computed for each cycle, then we kept the data lower than the mean minus two times the standard deviation were kept. Dates (in days) are referenced to January 1st, 1991. TBs are in Kelvin, thetwo channels are labeled by their respective frequency.

2.3. SURVEY AT CROSS-OVER POINTS

The previous method allows an absolute determination of a drift for one particular channel but does not allow an evaluation of the impact of the brightness temperature drift on the wet tropospheric correction. Once the stability of a given channel has been established, it can be used as a reference to select coldest ocean cross-over points.

Figure 2 shows how we estimated the drift on the ERS2 23.8 GHz brightness temperatures, by using cross-over points between the two missions and selecting the coldest TMR 21 GHz brightness temperatures over ocean (identified as very stable). The analysis of the wet tropospheric corrections at the same points (Figure 3) shows a weak drift (here less than 1mm per year).

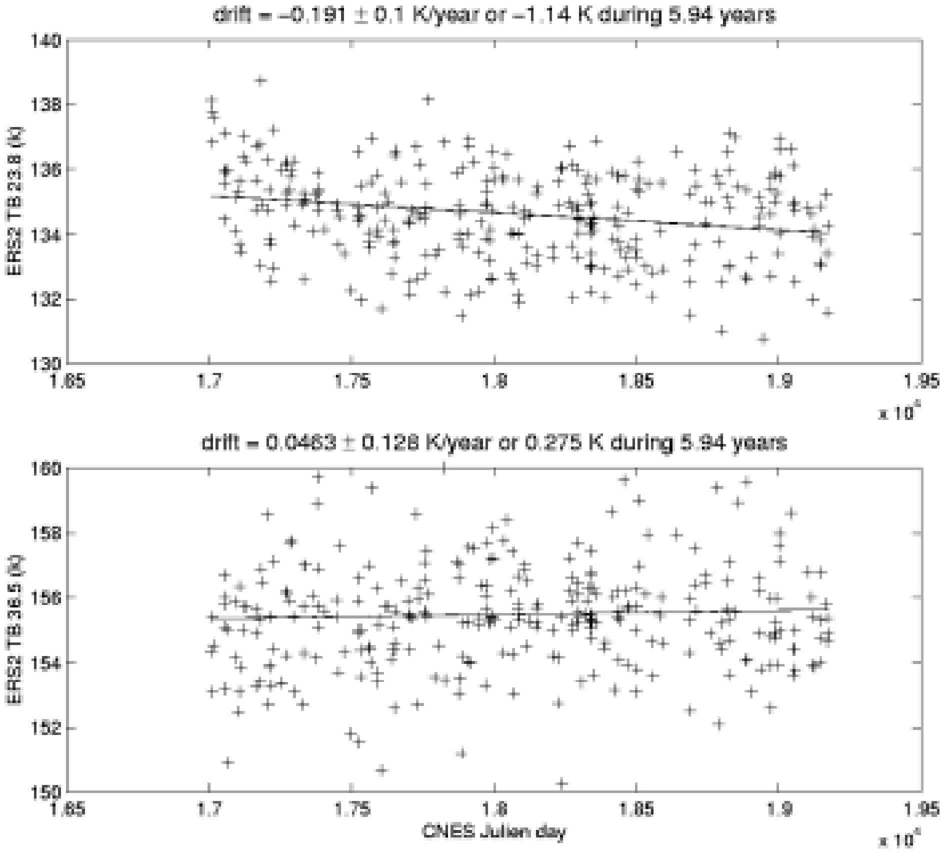

Figure 2 : Drift of the ERS2 brightness temperatures, using cross-over points between the two missions with selection of the coldest TMR 21 GHz brightness temperatures over ocean.

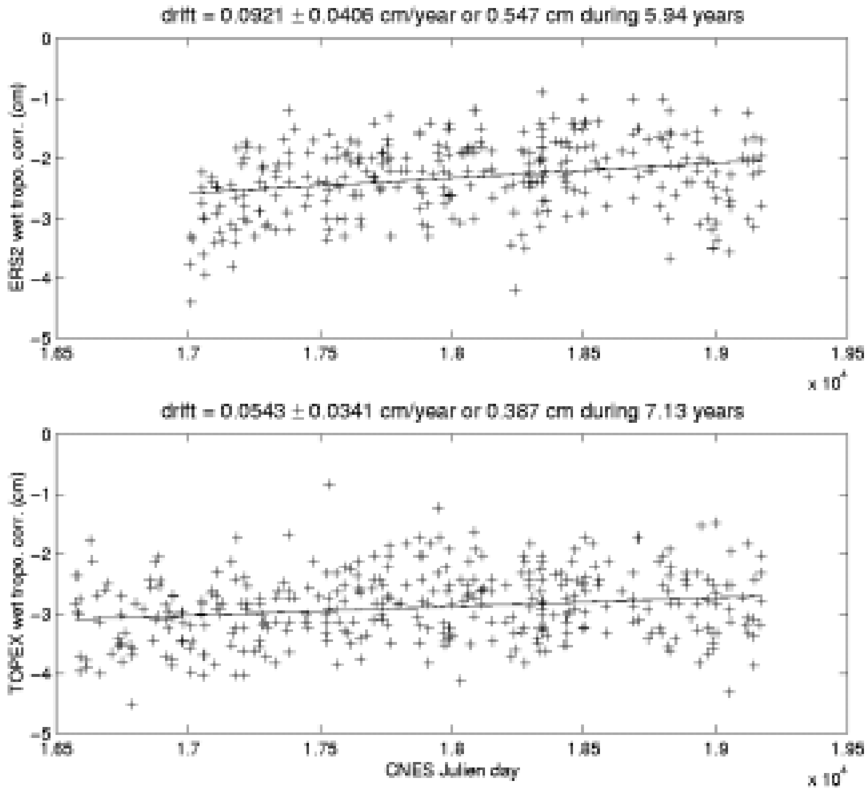

Figure 3 : Same points as on figure 2 but for the wet troposheric correction.

3. CORRECTION FOR THE TBS AT 23.8 GHZ

3.1. CORRECTION OF THE DRIFT

The drift of the 23.8 GHz brightness temperatures has been detected and evaluated using different methods. The most reliable one is the long-term survey of the coldest ocean points since there is no need to use other channels/instruments and it is the most accurate. With this method we estimate the drift to be –1.6 K since the gain drop in June 1996 for low brightness temperatures. This value is estimated for very cold brightness temperatures. For hot brightness temperatures, the long-term survey over hot continental targets (Amazon Forest and Sahara Desert) did not show any drift.

The correction that we propose is therefore a correction of the 23.8 GHz brightness temperatures depending on the time and on the TB value.

We therefore use the 6 following assumptions to formulate a correction for this drift :

- No correction for TBs measured before the 26 June 1996
- (1) No correction for cold TBs (132 K) measured on June 26, 1996
- (2) No correction for hot TBs (300K) measured on June 26, 1996
- (3) A correction of +1.6 K for cold TBs (132 K) measured on September 30, 2002 (date of the study performed by Eymard et al)
- (4) No correction for hot TBs (300 K) measured on September 30, 2002
- Due to the linear form of the calibration model, the correction is a linear function of the time and of the TB value :

$$TB23.8_{Corrected\_for\_the\_drift}=TB23.8+corr(t,TB23.8)$$

With t is the elapsed time since launch in decimal year, TB23.8 is the brightness temperature at 23.8 GHz before correction and $TB23.8_{corrected\_for\_the\_drift}$ corresponds to corrected TB23.8.

And corr(t,TB23.8)=(a1*t+a2)*TB23.8 + (b1*t+b2)

Using the following conditions :

(1) corr(1.18,132)=0 K

(2) corr(1.18,300)=0 K

(3) corr(7.44,132)=+1.6 K

(4) corr(7.44,300)=0 K

1.18 : elapsed time between launch and the gain drop in decimal year

7.44 : elapsed time between launch and the date of the study in decimal year

With these conditions we obtain the following values for the 4 coefficients :

a1=-0.001521

b1=0.4564

a2=0.001795

b2=-0.5386

To summarize, the correction we propose to the users is :

$TB23.8_{Corrected\_for\_the\_drift}$=TB23.8+corr(t,TB23.8)

With corr(t,TB23.8)=0 for t ≤ 1.18

corr(t,TB23.8)= (a1*t+a2)*TB23.8 + (b1*t+b2) for t > 1.18

t is the elapsed time since launch in decimal year.

3.2. COMPLETE CORRECTION FOR THE TBS AT 23.8 GHZ

Note that the 23.8 GHz brightness temperature drift is independent from the gain drop observed in June 1996. Thus, the user has to add the two corrections successively to compute the correct brightness temperature.

<u>Step 1 : correct the TBs from the gain drop using the formula</u> :

$TB23.8_{Corrected\_for\_he\_gain\_drop}$ = 0.93 * $TB23.8_{Not\_corrected\_for\_the\_gain\_drop}$ + 19.18

<u>Step 2 : correct this new TB from the TB drift using :</u>

$TB23.8_{corrected\_from\_the\_gain\_drop\_and\_from\_the\_TBs\_drift}$ = $TB23.8_{Corrected\_for\_he\_drop}$ +corr(t, $TB23.8_{Corrected\_for\_he\_drop}$)

With :

corr(t, $TB23.8_{Corrected\_for\_he\_gain\_drop}$)=0 for t ≤ 1.18

corr(t, $TB23.8_{Corrected\_for\_he\_gain\_drop}$)= (a1*t+a2)* $TB23.8_{Corrected\_for\_he\_gain\_drop}$ + (b1*t+b2) for t > 1.18

4. CORRECTION VALIDATION

To validate the correction we propose, we have applied it on the brightness temperatures corresponding to Figure 1. *Figure 4* shows the long-term survey of the 23.8 GHz brightness temperatures after applying the propose correction. The drift has been completely corrected.

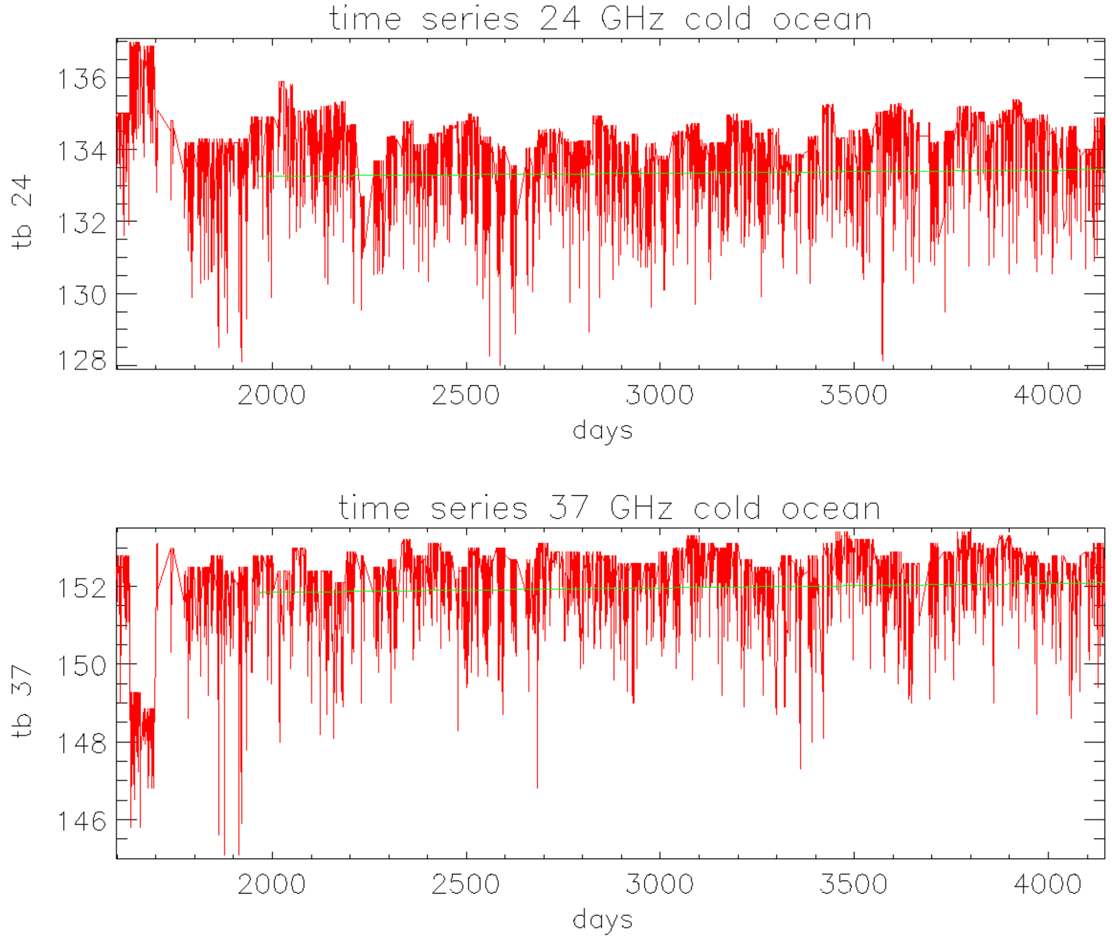

Figure 4 : same as figure 1 after correction of the 23.8 GHz TBs drift.

5. SUMMARY FOR OPR USERS

The §4 of the « Validation of the OPR Report » will be updated with the following text :

On June 26th, 1996, the ERS-2 microwave radiometer 23.8 GHz channel experienced a large gain fall, probably due to an amplifier break down.

Comparisons between ERS2 brightness temperatures before and after this event lead to the proposition of different corrections to be applied to the 23.8 GHz brightness temperatures (in K). In RD 5, Eymard et al showed that the correction proposed by Eymard and Boukabara and obtained by comparing data over the two polar areas, in order to have a wide range of values, was the most accurate :

$TB23.8_{corrected\_for\_the\_gain\_drop} = 0.93 \times TB23.8 + 19.18$.

Since this gain drop in June 1996, a drift appeared on the 23.8 GHz brightness temperatures cold brightness temperatures first pointed out in RD 1 and evaluated in RD 7.

The correction proposed for this drift is the following :

$TB23.8_{corrected\_for\_the\_gain\_drop\_and\_from\_the\_TBs\_drift} = TB23.8_{corrected\_for\_the\_gain\_drop} + corr(t, TB23.8_{corrected\_for\_the\_gain\_drop})$

With :

- $corr(t, TB23.8_{corrected\_for\_the\_gain\_drop}) = 0$ for $t \leq 1.18$
- $corr(t, TB23.8_{corrected\_for\_the\_gain\_drop}) = (a1*t+a2)* TB23.8_{corrected\_for\_the\_gain\_drop} + (b1*t+b2)$

for t > 1.18

- a1=-0.001521
- b1=0.4564
- a2=0.001795
- b2=-0.5386
- t the elapsed time in decimal year since ERS2 launch.

OPR users have to correct brightness temperature data after June 26th, 1996 (after pass number 650 in cycle 12) from the gain drop and from the TBs drift, and then to recompute the radiometer geophysical parameters using the algorithms given in RD 6 ("Altimeter and Microwave Radiometer ERS Products User Manual").