Long term stability of ERS2 and TOPEX microwave radiometer in-flight calibration

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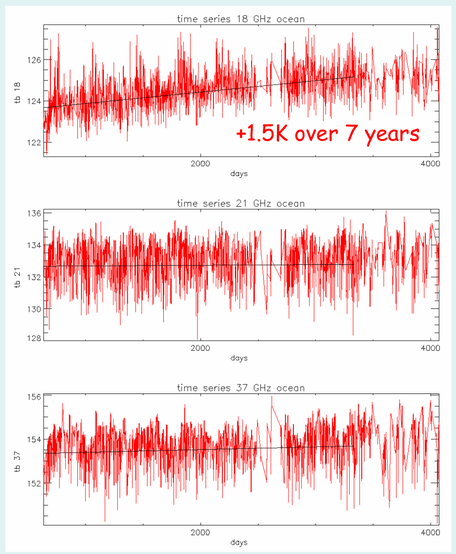
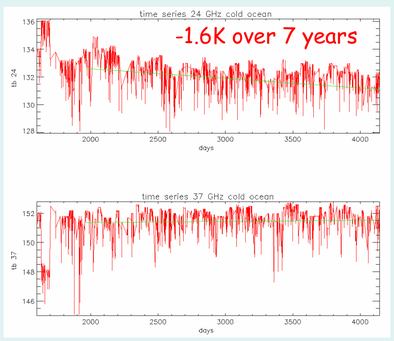
1. Cold Ocean

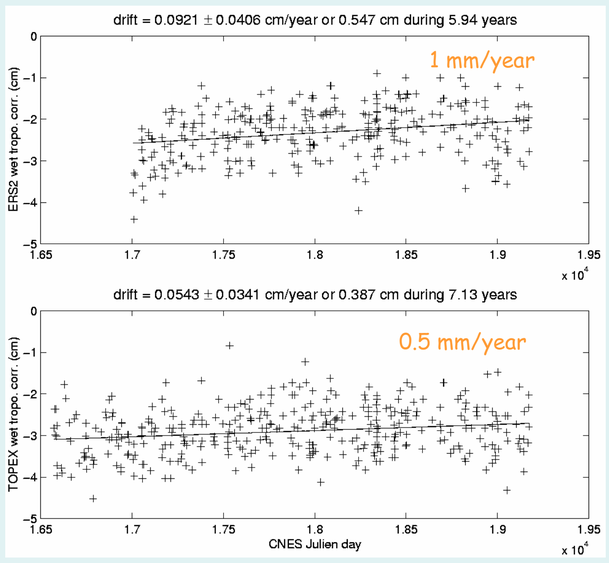
To analyze the ERS2/MWR and TOPEX/TMR drifts,
we developed a method similar to Ruf (2000),
based on the coldest ocean points (cold water, no wind, dry atmosphere).



Long term monitoring of the coldest TBs over the ocean for TMR (August 1993 - December 2001).



Long term monitoring of the coldest TBs over the ocean for EMR (May 1995 - January 2002).

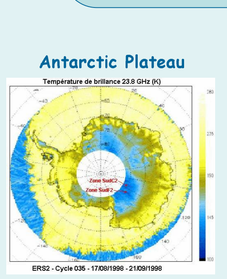


Drift of the ERS2 and TOPEX wet tropospheric correction, using cross-over points selecting the coldest TMR 21 GHz TBs over ocean.

With respect to initial specifications
both radiometers are still compliant.

2. Continental areas

To check the brightness temperature values,
selection of hot and cold continental areas characterized by
a large horizontal homogeneity, a small time variability
and a low atmosphere effect (except Amazon).



Mean TBs and differences (K)

	TMR 9 years			MWR 7 years		TMR-MWR	
Channel GHz	18	21	37	23.8	36.5	21-23.8	37-36.5
Greenland	160.98	166.22	180.321	167.55	182.56	-1.33	-2.25
Sahara night	276.25	275.12	276.19	281.41	288.64	-6.29	-12.45
Sahara day	276.71	275.91	277.93	283.33	291.33	-7.42	-13.40
Amazon night	279.55	278.91	278.74	285.46	291.49	-6.55	-12.76
Amazon day	283.72	282.42	282.76	289.13	295.54	-6.71	-12.78

Good agreement over Greenland

Over hot targets 6 - 7 K difference at 21 - 23.8

Over hot targets 12 -13 K difference at 36.5 - 37

Comparison between TMR and EMWR mean brightness temperatures over the 3 selected areas for EMWR overpass times.

The comparison between TMR and EMWR reveals a similar behavior over Greenland. Over Sahara and Amazon forest, the difference between the 21 and 23.8 GHz channels is 6 – 7K, and it is 12-13K for 36.5/37 GHz channels, which should be nearly similar !

Thus, contrary to low temperatures, for which modeling and path delay validation may be used to check the instrument absolute calibration, no method has yet been established to assess the calibration in the upper range. The question that arises is which reference could we use to analyze the calibration of both sensors at high temperatures?

OVERVIEW

The microwave radiometers on board altimeter satellites are specified to provide the "wet" troposphere path delay with an uncertainty of 1 cm or lower, at the location of the altimeter footprint (any bias in the tropospheric correction directly impacts the sea level determination). The quality of the retrieval relies on an accurate in-flight calibration, both in terms of absolute mean values and of time stability.

In this paper, we present a comparative study of the calibration of the microwave radiometers on board ERS2 and TOPEX. The purpose of this study is therefore to examine the absolute calibration of both radiometers along their life, using measurements over natural targets. First we revisit the previous long term drift studies, then we investigate the interest of continental targets to evaluate and compare the radiometer calibration at moderate to high brightness temperatures.

CONCLUSION

Ruf's method has been revisited and results confirm the 18 GHz channel drift and show the good stability of the 21 GHz channel. The same method, applied to EMWR, revealed a drift on the 23.8 GHz channel, but a good stability of the 36.5 GHz one. Cross-track comparisons allow to evaluate the drift impact on the wet tropospheric path delay in both cases. With respect to initial specifications, both radiometers are still compliant.

In a second part, the absolute calibrations of both radiometers are compared over stable continental areas. Over Greenland, measurements from TMR and EMWR were found consistent, within 2 – 3 K. However, "hot" targets revealed anomalously large differences between the two radiometers for both couples of frequencies (21 / 23.8 and 36.5 / 37 GHz).

A direct comparison of TMR, EMWR, AMSU-A and SSM/I brightness temperatures over one year for the same area in the Amazon forest evidenced a "warm" bias on the EMWR 36.5 GHz and suggested a "cold" bias on TMR channels.

A comparison of derived land surface emissivities for the same channels was performed to remove all external error sources. The "warm" bias on EMWR 36.5 GHz and "cold" bias on TMR 18 and 21 GHz are again evidenced, with respect to SSM/I and AMSU-A derived emissivities.

Nevertheless, the absolute calibration of a radiometer is not necessary to guarantee a good wet tropospheric correction retrieval. In fact, it is the consistency between calibration and retrieval methods, which will assure the quality of the product.

Mean TB (K)

Freq	18.0	18.7	21.0	23.8	31.4	34.0	36.5	37.0	#
AmsuA	-	-	-	285.8	282.7	-	-	-	641
TMR	278.6	-	278.1	-	-	-	-	277.6	2160
JMR	-	283.5	-	283.4	-	280.2	-	-	227
SSM /I	-	284.2	-	283.4	-	280.5	-	-	14564
ERS-2	-	-	-	285.7	-	-	291.9	-	3937

TMR too low at each frequency

Very good agreement at 23.8 GHz

ERS2 too high at 36.5 GHz

Means of the brightness temperatures over the frequency range from 18.0 to 37.0 GHz at nadir and for nighttime hours.

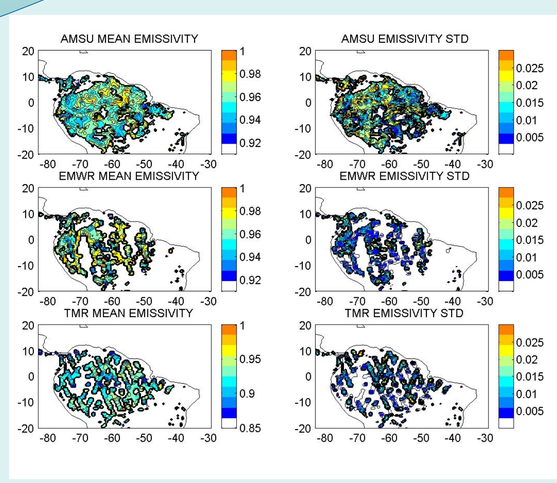
External causes of discrepancy could be:
- the difference in frequency between channels compared
- differences in local measurement time, which can lead to 6 K variation, but was minimized by taking night hours only (less than 2K variation).
- effects of atmosphere variations (water vapor, clouds and rain) could also contribute to the discrepancy.
- the horizontal heterogeneity of the area : the TMR and EMWR overpasses occur on specific portions of the area

3. AMSU-A brightness temperatures as a common reference over the Amazon forest

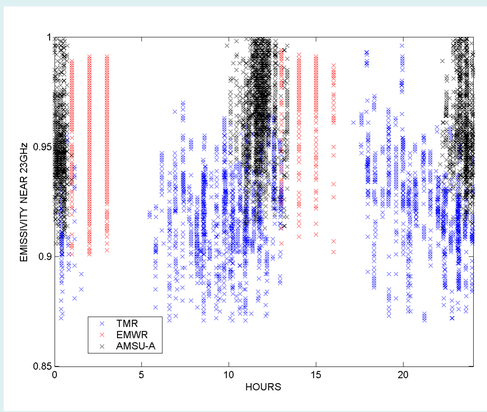
-> channels close to the ERS2/MWR and TMR ones
-> measurements close to nadir
-> accurate : cold calibration on cosmic background

Freq (GHz)	18.7 and 19	21.0	23.8	31.4	36.5 and 37.0
AMSU-A			0.960 (0.020)	0.947 (0.019)	
TMR	0.851 (0.023)	0.921 (0.022)			0.927 (0.022)
EMWR			0.962 (0.018)		0.974 (0.022)
SSM/I	0.952				0.933

Mean emissivity over Amazon forest for January 2000 for AMSU-A, TMR, EMWR and SSMI channels in the 18 – 37 GHz range



Monthly mean/stdev maps.



mean diurnal cycle of the retrieved emissivities at 210/023.8 GHz, over the month

With respect to the AMSU-A / SSM/I mean values, TMR emissivities are lower (at 18 and 21 GHz), and the EMWR 36.5 GHz channel one is higher. For these three channels, the calculated emissivity differ by more than 2% from the mean AMSU-A value, this discrepancy being thus larger than expected from any external cause.
In conclusion, comparisons over the Amazon forest both in brightness temperature and emissivity confirm the anomalous discrepancy between radiometers in the 21 – 37 GHz range, and suggest that these discrepancies are due to after launch calibration adjustments.

4. Comparison of surface emissivities

to remove most of the unknown external effects.