

Thomas Lavergne (Referee #1)**Review of essd-2019-146: A Fundamental climate data record of SMMR, SSM/I, and SSMIS brightness temperatures by Fennig et al.**

This paper introduces an homogenized and inter-calibrated data record of conically scanning passive microwave radiometer brightness temperature data covering 1978 – 2015. The paper provides a thorough description of the various steps involved, an analysis of the random and systematic uncertainties, and some results of an evaluation. The dataset itself is already made available by the CM SAF, along with ample documentation (ATBD, PUM, Validation Report). Although most of the material in the paper is extracted from the documentation, the paper is useful as a one-stop-shop reference.

The manuscript is very clear and comprehensive, and -as a user of the data record- I can only praise the attention to details and thoroughness of the paper. I highly recommend the publication of this manuscript in ESSD.

I include below some comments that will hopefully be useful for improving the manuscript further.

High-level comment:

The manuscript explains very well how the data record is prepared (ATBD), give some example of evaluation results (Validation Report) but does not touch into how to use the product (PUM). A PUM exists so this is not critical, but I would still encourage the authors to add a short section describing what the data record consists of (e.g. daily aggregated files per sensor, use of groups in the netCDF files, quality flags, etc...). Along those lines, as a user of the dataset, it took me some time to understand that the data read from the netCDF files was the homogenized (but NOT intercalibrated) data, and that an extra step was required to build the intercalibrated record. You have in this paper the opportunity to clearly (re-)state what the data files contain, and how to use them (adding the various correction layers). This terminology (homogenised, inter-calibrated) is anyway needed to understand the evaluation results, e.g. in Figure 8. Maybe the same terms can appear on Figure 1?

Author's response

We had not included these details yet but referenced the PUM for further information. We can add more details about the data record. We want to avoid adding more terms in Figure 1, but explain the terms in the text.

Author's changes to the manuscript

We include more detailed information about the data file content and usage in section 3. The definition of the used terminology is added where Figure 1 is explained (also in section 3).

Detailed minor comments:**Referee comment**

Line 35: This is the 1st time you introduce CM SAF. Define the acronym, or refer to the FCDR differently.

Author's response

OK

Author's changes to the manuscript

We add a sentence explaining the role of CM SAF and define the acronym accordingly.

Referee comment

Line 60: Suggest to rephrase ("This is not the only FCDR of passive microwave radiometry...").

Author's response

OK

Author's changes to the manuscript

Changed accordingly.

Referee comment

Line 61: remove "respective"

Author's response

OK

Author's changes to the manuscript

Changed accordingly.

Referee comment

Line 66: "This" data record... The GPM one, or the CM SAF one?

Author's response

The GPM one is meant.

Author's changes to the manuscript

Clarified accordingly.

Referee comment

Line 72: please finalize your introduction with: 1) a discussion as to why the CM SAF FCDR was at all needed when others exist (e.g. wasn't the Wentz FCDR non-traceable and not free?) and 2) a short introduction to the structure of your paper.

Author's response

The structure of the paper is summarized from L67-L71. The FCDR was initiated because the Version 6 FCDR from RSS had deficiencies, was not available as TA and not documented/traceable. Also the FCDR from CSU was not available yet.

Author's changes to the manuscript

A short discussion for the need of the FCDR is added to introduction.

Referee comment

Line 89: the high-frequency channels of F08 went bad quickly, maybe this can be noted here?

Author's response

OK

Author's changes to the manuscript

Changed accordingly.

Referee comment

Line 90: Please note that the "footprint" is an instantaneous field-of-view. Also that you refer to the diameters of the 3dB ellipses. Cross- and along-track terminology could be introduced.

Author's response

OK

Author's changes to the manuscript

Changed/added accordingly.

Referee comment

Line 106: F19 being launch in 2014 (before the end of the FCDR), your statement in the Abstract ("all SSM/I and SSMIS instruments") is not strictly correct. But this is probably ok.

Author's response

Yes, strictly speaking you are right with "all", but we would like to keep the statement.

Author's changes to the manuscript

none

Referee comment

Line 197: Suggest to refer here to section 3.4 for further details on the sea-ice concentration and masking.

Author's response

OK, we missed this reference.

Author's changes to the manuscript

Add the reference.

Referee comment

Line 283: Could you add a reference/citation for the 13 leap seconds?

Author's response

The current list of leap seconds is available in Bulletin-C from this website:

<https://www.iers.org/IERS/EN/Publications/Bulletins/bulletins.html>

Author's changes to the manuscript

The reference to the IERS bulletin is added.

Referee comment

Line 285: "It can take up to 7 days before a leap second is introduced to the data record" is this in the original RDR? Also, at how many occasions (out of 13) was the leap second introduced inconsistently between observation and ephemeris? If not many, mention the years?

Author's response

Yes the leap second correction is done in the RDR, mostly several days after the official introduction of the leap second. This is quite complicated, because in some years the correction of ephemeris time and scan time is just a few seconds apart or for one sensor it is ok but not for the other one. It would be difficult to write a simple description without being too detailed. As we have corrected the times we think it is not necessary to list all the years.

Author's changes to the manuscript

None

Referee comment

Line 314: Consider changing heading to "Antenna pattern matching for high-frequency channels".

Author's response

OK

Author's changes to the manuscript

Heading changed accordingly.

Referee comment

Line 315: Change "it is important" to something like "it can be desirable"... many data producers choose to retain the high(er) resolution of the channels, at the cost of increase retrieval uncertainties.

Author's response

OK

Author's changes to the manuscript

Changed as suggested.

Referee comment

Line 320: remove comma after "both"

Author's response

OK

Author's changes to the manuscript

Changed accordingly.

Referee comment

Line 557: the «fence is working well»: add «(not shown here)» in this sentence already.

Author's response

OK

Author's changes to the manuscript

Changed accordingly.

Referee comment

Line 674: Suggest to change header to «Intercalibration of sensors»

Author's response

OK

Author's changes to the manuscript

Changed accordingly.

Referee comment

Line 683: please add a citation/reference for the F11 wind retrieval stability results.

Author's response

Add citation Andersson et al. (2010).

Author's changes to the manuscript

Add citation.

Referee comment

Line 698: «highly elliptical orbit» (HEO) is often used for a spacecraft with Molniya orbit. Reformulate to «orbit with higher ellipticity» ?

Author's response

OK

Author's changes to the manuscript

Sentence is reformulated to “.. due to an orbit with higher ellipticity.”

Referee comment

Line 716: Use the exact frequencies for the instruments. Do we really want to mention 85 GHz here (SSMIS had 91 Ghz)? Re-formulate so that to make clear what you do with the high-frequency channels.

Author's response

Yes, the change from 85 to 91 GHz Channel is not a seamless data record.

Author's changes to the manuscript

Remove 91GHz from sentence and add: “The 85 GHz channels on the SSM/I are replaced with 91 GHz channels on the SSMIS. In order to allow the continued usage of existing algorithms, synthetic 85 GHz TBs are estimated from the 91 GHz TBs, inter-calibrated to the SSM/I time series and provided in the FCDR data files. Details can be found in the ATBD.”

Referee comment

Eq 25: Can you name what the «#» Ts are? Should you add a sentence below this equation to re-name the various terms? For example <Th> is defined in Eq 6 which was quite some pages ago.

Author's response

These are the antenna/brightness temperatures with applied non-linear corrections.

Author's changes to the manuscript

Add a sentence to explain the terms.

Referee comment

Eq 26: I could not find other occurrences of «APC» used as an operator in the text, and am unsure what APC(T#A) means in practice. Does Tic means «inter-calibrated»? By adding text around Eq 25 and 26 you will help the reader.

Author's response

The term APC is explained on L657 when the antenna pattern corrections are explained. Tic mean inter-calibrated.

Author's changes to the manuscript

Add a description of the terms and referencing the definition of the APC in section 4.

Referee comment

L736: «on the lower SSMI(S) resolutions» do you mean «frequencies» here?

Author's response

No, it means that we used the 91GHz channels after antenna pattern matching to the lower resolution, not the high resolution feedhorn for gridding.

Author's changes to the manuscript

Add a sentence for clarification.

Referee comment

L742: Should the two sentences: «This selection of TBs uses the Earth ... thus no extrapolation is required.» be moved at the end of the paragraph? Currently they seem to fall in the middle of the description of your matchup-database (first described as morning/afternoon maps, then to monthly).

Author's response

From our point of view It would be better to move the sentence “Each channel ... orbits.” behind these two sentences.

Author's changes to the manuscript

Change sentence ordering.

Referee comment

L744: would it be more correct to say that «little interpolation is needed»? One could imagine that the averaging in monthly 1x1deg grids will damper extremes that will be (slightly) outside the vicarious calibration range...

Author's response

We agree that there is certainly some averaging of extreme values and there will be some minor scale extrapolation at these extreme ends. However, the intention here is to argue about a significant extrapolation over a range of 50K.

Author's changes to the manuscript

Add a sentence: “Extrapolation is limited with respect to extreme values which are damped due to the averaging process.”

Referee comment

L751: so if I understand correctly, the ocean scenes entering the inter-calibration (cold vicarious target) use the angle correction, but not the sea-ice or land (hot vicarious target). I suggest you add a sentence to make this explicit to the reader, and maybe discuss why this is a viable approach.

Author's response

Yes, just the ocean scenes are EIA normalised.

Author's changes to the manuscript

Add a sentence for clarification that only ocean scenes are EIA normalised

Referee comment

L781: So contrarily to SSMI(S) only a cold vicarious calibration target is used, correct?

Author's response

Yes, that is correct. Here we follow Njoku (1998) as explained in L808-L810.

Author's changes to the manuscript

None

Referee comment

L1046: where does the range 0.7 K to 1.1 K comes from? Add a citation, or a crossreference to one of your sections.

Author's response

These numbers are from the uncertainty analysis in section 6.

Author's changes to the manuscript

Add a reference to section 6.

Referee comment

L1037: «EIA normalisation and diurnal cycle». I get what the EIA normalization is, but what is the correction for diurnal cycle? Where is it described?

Author's response

We have developed a method to fit a diurnal cycle correction for the SSM/I, which is described in the corresponding ATBD. However, as we are now using the daily mean gridded values to fit the inter-calibration coefficients, this method is not described in the paper. In the validation figures it is used to check the homogenisation for ascending/descending orbits.

Author's changes to the manuscript

We add a sentence explaining the correction and referencing the ATBD for detailed information.

Referee comment

L1038 to L1064: a suggestion is to refer to Figure(s) from the ATBD when referring to «not shown» results.

Author's response

OK

Author's changes to the manuscript

Modifying the manuscript as suggested.

Referee comment

L1065: suggestion to rename this heading to something like «double differences for SMMR» (I am aware SSM/IF08 results are shown, but the core is SMMR?).

Author's response

OK

Author's changes to the manuscript

Modifying the manuscript as suggested.

Referee comment

L1156: This is commented here, but should probably be addressed at an early stage in the manuscript. What do you mean with RDR exactly? Is it the SSM/I and SSMIS data you first accessed as a source to building your FCDR? Can you refer to it with a

Author's response

Unfortunately, your sentence is not complete. The RDR are the raw data records as downloaded without any modification.

Author's changes to the manuscript

We add a description of RDR in the beginning of section 3 where the data processing is explained.

Referee comment

L1171: ... and Lavergne et al. (2019) used the full FCDR for building their sea-ice concentration data record.

Author's response

OK

Author's changes to the manuscript

Modify manuscripts as suggested.

Referee comment

L1175: Since no AMSRs are currently on-board you could refer to the family of AMSRs rather than the specific AMSR-3 (which is not firmly committed at time of writing). An FCDR of AMSRs compatible with the SMMR+SSM/I+SSMIS CMSAF FCDR would be greatly beneficial for many applications, including sea-ice.

Author's response

We are not planning to release a full FCDR for instruments when agencies have their own reprocessing activities. However, we are working on the inter-calibration of these sensors to homogenise these with our FCDR.

Author's changes to the manuscript

We will add a sentence describing our future plans with the AMSR series.

Referee comment

L1175: You spent a lot of efforts (and text) due to accessing Njoku's SMMR L1B (instead of Tas) which was a limitation to your harmonization process. Are you aware of plans for someone to release the «raw» SMMR data record, so that you could improve the first part of your FCDR? I would have added here some sentences calling for such a release, especially if (funded) data rescue activities must be activated.

Author's response

The RDR is still not available and we are not aware of any plans to recover these.

Author's changes to the manuscript

We add a sentence highlighting the need of the original data for an improved inter-calibration.

Referee comment

L1250: you could add an acknowledgement for ERA20C.

Author's response

OK

Author's changes to the manuscript

Modify manuscripts as suggested.

Referee comment

Figure 2. Because some colors are rather similar (e.g. plum and violet) it would help if a legend box was added in the plot area. Consider using thicker lines.

Author's response

OK

Author's changes to the manuscript

Modify accordingly and add a legend box.

Referee comment

Figure 2. What causes the up-and-down variations for some channels (seemingly the highfrequency ones). Is it because the along-scan correction is different for A- and B-scans? If the case, would it be better to show 2 lines per high-frequency channel? If needed, add a sentence L474 about this feature.

Author's response

From the technical description of the SSMIS we get the information that there always 2 sets of integrators for each channel, one for the odd and one for the even numbered positions. They are not perfectly matched and must be calibrated each scan. So the assumption is that the SSM/I 85GHz channels are similar and small differences between these two integrators remain.

Author's changes to the manuscript

Add a sentence to offer an explanation of this behaviour.

Referee comment

Figure 3, left panel. «The x-axis represents the time of the orbit start at ascending equator crossing». Is the x-axis with unit «day»? If so, add it. Did you consider using a red-gray-blue colormap to avoid the rainbow one? On right panel, thicker lines would help.

Figure 4, same remarks as Figure 3.

Figure 5, same remarks as Figure 2.

Author's response

We will change the colour bar to avoid the rainbow colour bar.

Author's changes to the manuscript

Change the colour bar and use thicker lines.

Referee comment

Figure 6, same remarks as Figure 3. In panel 6b you do not show sections that are detected by the Laplace filter, nor the smoothed spline. Is it intentional?

Author's response

Yes, this is intentional. Here we just want to show the different regions with sunlight intrusions not showing the correction, which is already done in the SSM/I figure.

Author's changes to the manuscript

None

Referee comment

Figure 7, same remarks as Figure 2. According to the caption, you use cyan for h18 (horizontal pol) while you were using it for v19 (vertical pol) for SSM/I (Fig 2) and SSMIS (Fig 5). Is this intentional? It would be better to use the same colors for all sensors.

Author's response

OK

Author's changes to the manuscript

We change the figure colours as suggested.

Referee comment

Figure 8: add a legend box for the line colors. I do not understand what the grey lines are. Do they show a spread value (1-standard deviation?) between the available sensors within one day, while the colored lines are the mean daily anomalies? Please clarify.

Author's response

The grey line are the maximum differences observed between any 2 sensors (sensor ensemble spread).

Author's changes to the manuscript

Clarify in manuscript.

Referee comment

Figure 9 and 10: add a legend box for the line colors.

Author's response

OK

Author's changes to the manuscript

Add legend box.