Review of https://doi.org/10.5194/essd-2024-608 A climate data record of atmospheric moisture and sea surface temperature from satellite observations

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Overall Recommendation

This paper presents a new climate data record of column water vapor and sea surface temperature from microwave instruments covering the period 2002-2022. The quality of the CDR was evaluated against several reference datasets, i.e., radiosonde, radio occultation, and alternative remote sensing-based retrievals, reanalysis, and climate model simulations. The evaluation results confirm that the data record meets the specifications of a climate data record in terms of bias and noise against reference observations and trends against reanalysis and model simulations.

In general, the manuscript is well understandable and complete. The manuscript is very exhaustive in terms of references to other paper and use of evaluation data. Still, the paper can be written more focused and to the point. Right now, it not fully clear how all information is linked together. To address this, the authors could, among others:

- Provide a pointwise description of what validation metric is evaluated with what reference data.
- Explain to what extent the reference data are independent of, and superior to, the CDR.
- Explain to what extent the CWV and SST products are independent of each other.
- Explain how uncertainties from input data and processing steps propagate into the CDR product
- Discuss, and if possible assess, the role of validation uncertainties arising from collocation, synchronization, and representation differences between the reference data and the CDR.

The manuscript needs minor revisions before it can be published. The following are some general criticisms followed by a chronological list of minor criticisms

General criticisms

Independence of the WV and SST products

To what extent can the WV and SST data be considered independent of each other. Both retrievals are based on TB data from the same instruments and same FCDR, are these products not consistent by design? I expect the difference is in the fact that CWV is based on cloudy cases and SST based on cloud free cases. Thus, an important aspect in the retrievals is the cloud decision, which is coming from the cloud parameter input. Please comment and explain in text more on the role of the cloud parameter input in the retrieval.

Independence of the validation data

To what extent are the validation data independent of the CDR data, please explain.

Validation Data

Different source of in-situ validation data is used. The authors should make clearer that these are of superior quality, independent, and consistent with each other.

Especially, I am sceptical about using CMIP simulations as validation data. To underpin the value of using CMIP simulations in this article, the authors should clearly explain for what statistical metrics the CMIP simulations contribute to the validation of observations.

The authors correctly indicate that the CWV and SST variables of CMIP relate to each other by design, via the Clausius Clapeyron law. This predetermined relationship makes that one cannot use both variables as independent sources of validation data. In the paper only one variable can be used for validation. Please comment on this.

Uncertainty and error propagation

The authors spend little words on the uncertainty of the CWV and SST products, and do not provide uncertainty bars in their figures. Literature describes approaches to estimate uncertainties of level 1 and level 2 satellite data, using metrological principles. Relevant work on this was done in the framework of the FIDUCEO project

FIDUCEO method paper

Giering, R.; Quast, R.; Mittaz, J.P.D.; Hunt, S.E.; Harris, P.M.; Woolliams, E.R.; Merchant, C.J. A Novel Framework to Harmonise Satellite Data Series for Climate Applications. *Remote Sens.* **2019**, *11*, 1002. https://doi.org/10.3390/rs11091002

FIDUCEO example paper

Hans, I.; Burgdorf, M.; Buehler, S.A.; Prange, M.; Lang, T.; John, V.O. An Uncertainty Quantified Fundamental Climate Data Record for Microwave Humidity Sounders. *Remote Sens.* **2019**, *11*, 548. <u>https://doi.org/10.3390/rs11050548</u>

More general descriptions for performing error propagation for Essential Climate Variables (ECVs) of the Global Climate Observing System, involving systematically tracking and quantifying uncertainties through all stages of the data processing, i.e., from raw observations to final climate data products, are, described in the following papers.

Roebeling, R. A., S. Bojinski, P. Poli, V. O. John, and J. Schulz, 2025: On the Determination of GCOS ECV Product Requirements for Climate Applications. *Bull. Amer. Meteor. Soc.*, **106**, E868–E893, https://doi.org/10.1175/BAMS-D-24-0123.1.

Merchant, C. J., Paul, F., Popp, T., Ablain, M., Bontemps, S., Defourny, P., Hollmann, R., Lavergne, T., Laeng, A., de Leeuw, G., Mittaz, J., Poulsen, C., Povey, A. C., Reuter, M., Sathyendranath, S., Sandven, S., Sofieva, V. F., and Wagner, W., 2017: Uncertainty information in climate data records from Earth observation, Earth Syst. Sci. Data, 9, 511–527, <u>https://doi.org/10.5194/essd-9-511-2017</u>

Climate data records temporal coverage

Climate studies often ask for data that covers the standard 30-year reference period defined by WMO, eg 1991-2020 (current reference period) or 2000-2030 (next reference period). Are there any plans to expand further back in time, e.g., back to 1997 by using TMI data, to cover the next reference period?

Minor criticisms

Section 3: CDR Data: Add a table listing what data were used to construct the CDR, ie, name instrument the start date, end date, and discuss what steps were taken to harmonize and homogenise (see definitions <u>https://research.reading.ac.uk/fiduceo/glossary/</u>) these data over the entire CDR period, so as to use them for trend analysis

Satellite	Instrument	Start date	End date
FY3b	MWRI	2010	2021
Aqua	AMSR-E	2002	2016
GCOM-W1	AMSR2	2012	2025

Page 9, line 232: replace "thereby eliminated" by "thereby empirically correcting"

Equation (1), (4), (5): For consistency with the other notations, can you replace

D(X,m,L), TB(X,t,m,L), and TB'(X,t,m,L)with $D_{MWRI}(X,m,L)$ and $TB_{MWRI}(X,t,m,L)$, and $TB'_{MWRI}(X,t,m,L)$

Figure 3: is the blue line in this figure not the difference of the two instruments before correction, thus:

 $TB_{MWRI}(X,t,m,L) - TB_{AMSR}(X,t,m)$ Instead of $\Delta TB' = TB'_{MWRI}(X,t,m) - TB_{AMSR}(X,t,m)$

This is what I expect, because then the figure demonstrated that the difference between the instruments before corrections resemble those of the diurnal anomalies and thus seems to prove that a correction is needed. Please explain.

Figure 6 (and similar figures later): Indicate in the caption that the numbers given in the legend for each validation result represent BIAS and RMSE

Figure 8 & 9: The compared datasets are partly based on the same observational datasets (AMSR-E and AMSR2) and thus cannot be considered independent of each other. I realize that complete independence is difficult to achieve, still the authors discuss and provide evidence of the degree of independence of the compared datasets. This is

especially important in determining the climatological significance of jumps in the time series.

Figure 8 & 9: With reference to my above point, there is a clear jump in values between the period 2002-2012 and 2016-2022. This jump seems rather to be related to a change in instrument than to a change in climate. Please comment.

Line 375: The statement "*Different datasets show overall similar trend patterns for both CWV and SST.*" is very qualitative. Can you provide some statistics to make it more quantitative.

Figure 11: Why are there more crosses for the CMIP trends. Are these different CMIP scenarios?

Line 452 Conclusions: Is the statement "*The most encouraging result is that the covariance between our retrieved CWV and SST over the tropical oceans is close to the expectations from CMIP6 model simulations.*" true?

CMIP is an ensemble of model simulations, matching with CMIP does not say much about the quality of the observational data. May be one could reason the other way around and write that it is encouraging that the CMIP simulations seem to be able to reproduce the observed relationships. This would, however, be a statement about the quality of CMIP and not about the quality of the CWV and SST observations! Please comment.