Reviewer 2:

General Comments

With a timespan of only six years (with the potential to add four more up to 2012), it is debatable whether the article should titled "A Global Climatology", it could just as well be called "A Global Demonstration…". The use of only one MERIS sensor in cloud-free conditions results in 50% or more of the land not being sampled on any given day.

We have discussed this and came to the conclusion that, although we accept your point, it is still justified to keep the title as it is. To our knowledge there is no clear definition of how many years a dataset has to cover to be called a climatology. Concerning the coverage, the daily data has admittedly significant gaps over land, however, the monthly maps have a high coverage. Your proposal to include data of further instruments surely is very interesting but out of the scope of this publication.

The authors need to place the work into the framework of other similar datasets, and no mention is ever made of the similar NASA MODIS sensor which is on two spacecraft with a longer time period, and the related AIRS water vapor products dating back to 2002.

We will include references to these important data sets.

Specific comments

P 61 L 9: Omit "in recent years", state the specific years. Also, the work was published over six years ago so is not extremely recent.

The text will be modified according to this request.

P 61 L22: "also referred to as TCWV". Note that there are too many terms / acronyms for this variable in the field (TCWV, TPW, IPW, IWV, PWV, IPWV… –- TPW itself gets 139 hits in the the AMS journal search engine). I would add a sentence to say that this variable goes by many names in the literature, with a few acronyms to help future researchers search.

The updated manuscript will mention the different acronyms.

P 61 L21: I disagree that accurate measurements of TCWV are needed. They are great and helpful, but for water vapour feedback the profile, especially at upper levels, is important. You could have drying at low levels and moistening at high levels which would enhance feedback under less TCWV.

Thank you very much for this clarification, we modify the text with respect to this.

P 62 L12: Omit foreseen to be extended into 2020s and 2030s. This is very speculative. You could mention the successful launch on Feb 27 of the GPM core sensor, GMI is quite SSM/I-like.

EUMETSATs EPS-SG satellites (3 consecutive launches, first launch ~2021, 8 yr lifetime per satellite) wil carry SSM/I-like passive MW sensors, so the statement is not exactly speculative.

P 64 L 8: How much (if any) orbital drift occurred with ENVISAT?

There was no significant orbital drift during the ENVISAT lifetime.

Section 2.1 should mention the quite similar MODIS instrument, I was quite surprised to see no reference in the paper.

The citation will be included.

Section 2.2 should cite:
Sapiano, Mathew RP, et al. "Toward an intercalibrated fundamental climate data record of the SSM/I sensors." Geoscience and Remote Sensing, IEEE Transactions on 51.3 (2013): 1492-1503.
Berg, Wesley, et al. "Improved geolocation and Earth incidence angle information for a fundamental climate data record of the SSM/I sensors." Geoscience and Remote Sensing, IEEE Transactions on 51.3 (2013): 1504-1513.
P 65 1st para: Use the word "nominal" before the altitude and zenith angle. The works cited above discuss variability and its impact on TCWV retrievals.
P 65 L17: Add new sentence "Data is available at http://...".
P 65 L20: All references pretty old. Mention the two works above, and:
Elsaesser, Gregory S., and Christian D. Kummerow. "Toward a fully parametric retrieval of the nonraining parameters over the global oceans." Journal of Applied Meteorology & Climatology 47.6 (2008).

We propose to change section 2.2 into:

"The SSM/I (Hollinger, 1991) is a passive, seven-channel, four-frequency microwave radiometer which is operated within the DMSP satellite series, flying on sun-synchronous orbits at a nominal altitude of 830 km. The SSM/I is a conical scanner with a nominal scan angle (satellite view angle with respect to nadir) of 45° which corresponds to an earth incidence angle of 53°. The four bands at 19 GHz, 22 GHz, 37 GHz and 85 GHz have dual polarisation except the 22 GHz channel, resulting in seven channels. Depending on the channel, SSM/I has a footprint of a few tens of kilometres. The first SSM/I instrument was carried by the F08 satellite, launched in 1987, the last one was launched on F15 in December 1999. The SSM/I was replaced by the SSMIS (Special Sensor Microwave Imager/Sounder) starting from DMSP satellite F16. The available long-term data record of SSM/I observations together with its high sensitivity to atmospheric water vapour makes it a very valuable source for climate studies. The generation of the TCWV fields was based on inter-calibrated SSM/I brightness temperatures of the F13 and F14 DMSP satellites (Andersson et al., 2010). The data was provided by CM SAF as an early release of the CM SAF SSM/I FCDR edition 1. The data is available at http://www.cmsaf.eu/wui and is referenced under DOI: 10.5676/EUM_SAF_CM/FCDR_SSMI/V001. Other SSM/I FCDRs are described in Sapiano et al. (2013), Berg et al. (2013) or Semunegus (2011) and are available under http://www.ncdc.noaa.gov/cdr/operationalcdrs.html.

SSM/I has been and is used in various applications for the retrieval of atmospheric water vapour using physical (e.g. Phalippou, 1996; Elsaesser and Kummerow, 2008) and semi-physical schemes based on a statistical interpretation of a training dataset (e.g. Alishouse et al., 1990; Schlüssel and Emery, 1990; Schulz et al., 1993; Wentz, 1997)."

Missing reference:

Semunegus, H: Remote Sensing Systems Version-6 Special Sensor Microwave/Imager Fundamental Climate Data Record, Climate Algorithm Theoretical Basis Document, Climate Data Record (CDR) Program, CDRP-ATBD-0100, 2011

P 66 L6: Elaborate further on what "almost all" means.

We will explain this in more detail, i.e., we will elaborate on the different surface types (e.g. vegetation vs bare soil vs snow etc) and the range of 900nm surface reflectances occurring globally.

P 66 L24: What is the source / resolution of surface pressure? Is it static or dynamic?

It is calculated from a digital elevation model with no regard of day-to-day changes in sea level pressure. Since its use is to correct for the comparably small influence of pressure variations on the water vapour absorption line widths, the assumption of constant sea level pressure is well justified.

P 67 1st Para: Has there been any independent validation of the cloud mask? I found this not compelling. A reference would help, or create a map of your cloud frequency from your processing. For instance, are aerosols sometimes being typed as water clouds?

The cloud mask was developed in the frame of the MERIS Albedomap project, we will include a citation to the ATBD (see http://www.brockmann-consult.de/albedomap/pdf/atbd_cloud_detection_amap__5.pdf), where it is described in detail. The validation of the cloud mask is a pending issue.

P 67 L6: What is the justification for the 0.2 threshold? Do your results change significantly if it's changed?

The 0.2 threshold was found empirically by maximising the fraction of correctly identified cloudy pixels while minimising the fraction of clear sky pixels classified as cloudy. Your concern is justified. However, it holds true for each and every clear sky satellite dataset that relies on a cloud screening procedure. You will not be able to find two different cloud masks, even if operated on exactly the same input data, that are in perfect agreement everywhere on the globe (see for instance the results of the Cloud Retrieval Evaluation Workshop (CREW) on this). So, at the end of the day this is an unavoidable weakness inherent to such datasets. The sensitivty of the aggregated water vapour to changes in the cloud-mask-threshold should be assessed in a future study.

P 67 L23: Again, more detail on the source of the surface pressure data. What is the resolution mismatch between MERIS and the data used? Is this a static surface pressure, or does it change?

See above.

P 68 L1: More details about the "pre-defined threshold". Does it change spatially or seasonally?

The pre-defined threshold was defined by the sensor noise level

L7 "aerosol optical depth" and other variables. Again, do these vary in time or space? How are the uncertainties you used in your retrieval found? This is quite weak.

This is now explained in more detail: "...In order to account for the influence of scattering on the measured band ratio, a scattering correction factor is calculated from pre-calculated look-up tables at each retrieval iteration step. Here, over land, a continental aerosol model is used, assuming a constant optical depth of 0.15 at a wavelength of 900nm. Over the coastal ocean, a maritime aerosol model is used instead. Over both land and ocean, the aerosols are assumed to reside in the boundary layer. The cost function minimization is achieved by a simple secant method and is regarded successful as soon as the cost function falls below the sensor noise level. Except for the ERA Interim 2m temperature, the algorithm does not rely on any sort of prior knowledge. The uncertainty of the retrieved value of TCWV is calculated after the final iteration step, by taking into account uncertainties introduced by instrumental effects such as sensor noise and uncertainties in background knowledge of the influencing parameters such as surface albedo, aerosol optical depth, aerosol vertical distribution, temperature profile and surface pressure. Especially over dark surfaces, the aerosol optical depth and vertical distribution were found to be the largest sources of uncertainty, since static average values with rather large error bars were assumed globally. In contrast, the retrieval uncertainties introduced by the temperature profile and surface pressure uncertainies were found to be of secondary order. For a detailed description of the uncertainty calculcation, please see Lindstrot et al. (2012)."

Section 3.2: I found this section not compelling. It could just reference the earlier method and be very short, or you could go into detail to describe your new retrieval. I found it to be in the middle and not particularly satisfying. For the application here, I think any existing SSM/I record would work to show the merged product. It left me confused as to whether you used Deblonde, 2001 or just used the ideas from it.

I was left with the question – why did the group modify this SSM/I retrieval, they could have just downloaded widely used retrievals. The "standard" SSM/I portion of the paper left me with more questions, while the new MERIS part seemed better described.

The major motivations to update the existing algorithm (Schlüssel and Emery, 1990) were: 1) change the more than 20 year old retrieval into more up-to-date retrievals, 2) replace the statistical with a physical retrieval, also to allow a simultaneous retrieval of associated parameters such LWP and P, 3) provide a pixel based uncertainty estimate.

In order to do so we utilised the 1D-Var scheme from the NWP SAF which is described in Deblonde (2001). We agree with the reviewer comment and propose to motivate our approach and shorten the rest of the paragraph by only describing adaptations to the Deblonde 1D-Var.

We propose the following adaptations:

"(Semi-)statistical TCWV retrievals over oceans, based on recalibrated and homogenized radiance data records from SSM/I observations, are available from, e.g., Remote Sensing Systems (RSS - Wentz, 1997) and the Satellite Application Facility on Climate Monitoring (CM SAF - Schlüssel and Emery, 1990; Andersson et al., 2010; Schröder et al., 2013). Within the framework of the GlobVapour project the objective was to utilise a physical retrieval scheme which allows for consistency between parameters and BTs and which provides an uncertainty estimate at pixel level.

Such physical retrievals are described in, e.g., Phalippou (1996) and Elsaesser and Kummerow (2008). Here, the one-dimensional variational retrieval (1D-Var) scheme developed at ECMWF (Phalippou,1996) was utilized, including adaptations made by Deblonde (2001). The latter enable the application of the scheme to SSM/I, while the initial application of the scheme was for the SSMIS microwave imager/sounder and AMSU (Advanced Microwave Sounding Unit). The scheme is available from the Satellite Application Facility on Numerical Weather Prediction (NWP SAF) at http://research.metoffice.gov.uk/research/interproj/nwpsaf/1dvar/index.html. The scheme is used…."

P 68 L15: "is based on". So is it or isn't it this retrieval?

The retrieval used in our framework is the one of Phalippou (1996) including adaptations of Deblonde (2001). This has been clarified in the text (see our reply to previous reviewer comment).

P 69 L3: Where is your covariance matrix from?

The error covariance matrices is the one that was included in 1D-Var used. We will include this information in the manuscript:
"... and y the measurements. The matrices B and R are used as included in the used 1D-Var package."

P69 L6: Uses ERA-I as background information – What is the time period used? Morning only? What are these climatological averages, what time period, resolution and where are they from?

We used the ERA-Interim data at 12 UTC and with a spatial resolution of 0.5° to provide the background field for all observations taken at that day. The climatological value for water vapour are actually three year averages. This will be explain in the text by:
"In this framework, the 1D-Var scheme uses ERA-Interim atmospheric and surface fields valid at 12 UTC on a 0.5° longitude-latitude grid as background information for all observations processed on a specific day, with the exception of the background information for water vapour, for which spatially resolved, three-year averages are used."

There is no mention of how precipitation and ice are screened or detected.

By the internal application of an scattering index filter in the 1D-Var scheme, scenes with precipitation and cloud ice are filtered out. We will add the following at the end of section 3.2:
"Scenes with significant precipitation and/or cloud ice are filtered out by the application of an internal scattering index filter."

P 69 L14: Did you sample or average the MERIS retrievals to get to 0.05 degree resolution? Also, replace spatial resolution is 0.5 to "was chosen to be 0.5".

The MERIS data was averaged

P 69 L 23: What is the drift in ECT during these years? Sapiano et al have this figure.

P69 L23: We changed the sentence into: "In order to establish consistency between land and ocean, only morning measurements (descending swath) of SSM/I onboard the DMSP satellites F13 and F14 (equator crossing time between 6 a.m. and 9 a.m., see Sapiano et al., 2013 for details) were used for the retrieval of TCWV over ocean."

P 72 L 13: "can exceed 10%". Does this imply your cloud screen is failing (see comment above about cloud screen).

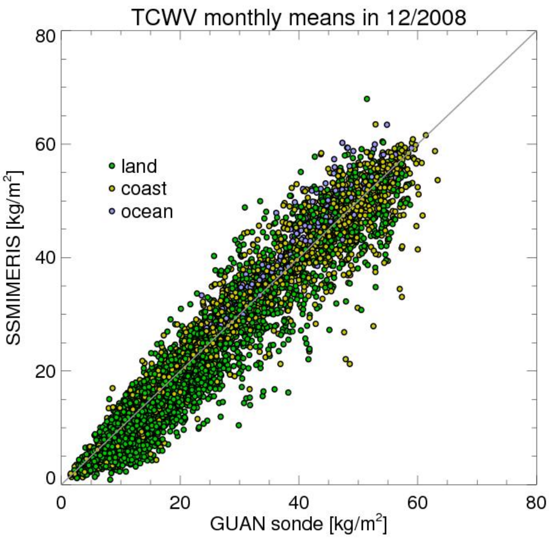
A failing cloud mask would not be visible in the calculated uncertainty but in the actual error found in a validation study. The parameter governing the uncertainty is the surface reflectance. Over darker surfaces, the influence of atmospheric scattering (and the unknown vertical distribution of scatterers) becomes more important and the uncertainty is increased.

P 73 L2: I suggest omitting "The MERIS retrieval…high accuracy and precision". This is very user dependent. Ground-based GPS is much more accurate for instance.

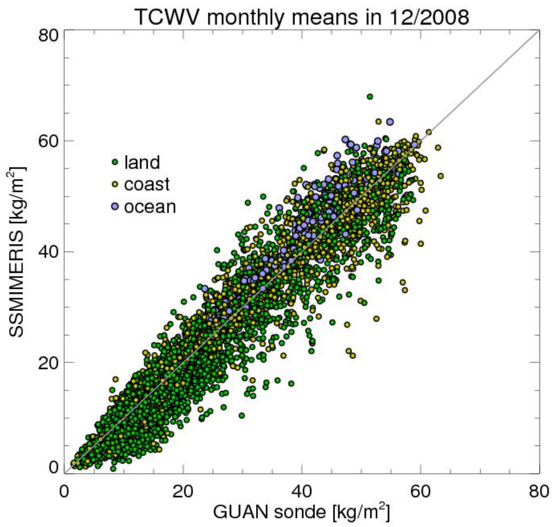
Will be rephrased.

P 73 L13: Fig 5. Would be easier to understand if it just had MERIS / GUAN matchups, can you redo this?

P73 L13: The SSM/I+MERIS product as a whole is evaluated here. Therefore, we propose not to change the figure as proposed. Instead the fraction of contributions from SSM/I will be mentioned: 5492 collocated cases; 67% land, 29% coast , 4% ocean (SSMI). The ocean symbols are enlarged to facilitate the distinction between land, ocean and coast samples:



Old Figure 5



New Figure 5

P 73 L11: Is set to 0.1. How reasonable is this assumption? AOT can vary downwind of source regions such as Africa in the Atlantic and east of Asia.

This might be true. However, over very bright surfaces (sun glint!) the AOT does not have a strong impact on the water vapour retrieval result.

P 75 L21: Please remove the "furthermore, …" sentence. There are significant cloud / clear sampling biases which affect the MERIS portion. For instance, consider the movement of the ITCZ over Africa. Much sampling in some months, none in others.

The paragraph is rephrased: "On a global average, no indication of any seasonal bias of the MERIS-SSM/I dataset was found. However, due to the clear-sky-only sampling over land, this might not be fulfilled regionally, especially in regions with strongly varying cloud cover during the year, such as the tropics."

P76 L4: I disagree with the process studies claim. This dataset looks to be mainly useful for monthly means. From Fig. 1, it appears over half of land is missed each day. This would make it difficult to track moisture plumes over land.

Is rephrased.

P 76 L10: Rather than rely on SSM/I, mention other conical MW instruments like GPM core. Again, what about combining MODIS into this record?

Will be mentioned. The inclusion of MODIS is an ongoing acitivity.

Fig 3: Why is MERIS uncertainty over S. America so high? Is this because of missed clouds, or the dark background?

See explanation above, concerning uncertainty over dark surface.

Fig 4: Explicitly define the colors. Saying "low" and "high" is not precise.

Figure will be updated

Fig 5: What time / space mathing criteria were used?

For these comparisons were selected the nearest neighboring grid box of the MERIS/SSMI monthly mean fields (on a regular lat-lon grid). Any further temporal criteria did not have to be applied. However, the monthly mean (of the radiosonde and in the selected MERIS/SSMI grid box) had to be based on at least 15 individual observations in that month to allow a comparison. We will include this in the text.

Fig 7: What is the date / time of this pass?

Now included.

Fig 8: This is an interesting result.

Thank you!

Technical Corrections ...
Have been corrected.