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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Retrieval of characteristic parameters for water vapour transmittance in the development of ground based sun-sky radiometric measurements of columnar water vapour" *by* M. Campanelli et al.

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GENERAL ANSWER TO BOTH REVIEWERS:

After the comments received by both the Reviewers, we realized that to validate our work, GPS estimation of columnar water vapor was necessary. Fortunately we were able to find GPS measurements for two sites close to Chiba University (respectively 10 and 19 km far from the site used in this paper), and the entire paper was substantially changed in the following points:

1. We recognized that both the reviewers misunderstood the presented methodology with the Surface Humidity Method, and it was surely our fault. Therefore we changed the mail Sections of the paper as follows: 1. Introduction. 2. Equipment. 3. Methodology. 3.1Preliminary check of dataset. 4 Parameters estimation. 5. Water vapor estimation. 6 . Discussion. 7 Conclusions.

2. GPS water vapor data (W) were used as an independent dataset, needed for applying the proposed methodology, in addition to the Surface Humidity Method already described in the previous version. This allowed us also to validate: i) the proposed methodology, based on the hypothesis that calibration parameters characterizing the atmospheric transmittance (a, b) are dependent on vertical profiles of pressure, temperature and moisture occurring at each site of measurement; ii) the SHM that is a cheap procedure, easy to implement for retrieving the needed independent W dataset using measurements of surface temperature, pressure and relative humidity, when other measurements are not available.

3. Thanks to GPS measurements we discovered that Microwave radiometer estimation of water vapor was affected by a bias. Therefore we corrected it, and the validation of water vapor from sun-sky radiometer was largely improved.

4. The behaviour of a and b parameters as function of W was validate by the analysis of the available radiosonde measurements, by introducing two indices to describe the W vertical distribution and having different sensitivity to the shape of the distribution. The improvement in the retrieval of W from sun-sky radiometer when such dependence of a and b on W is introduced, was also presented.

5. Old Figure 7 was removed. Infact it was previously used to provide an explanation of why some points of W, retrieved from SHM, underestimated the measurements from RDS. With the introduction of GPS dataset we noticed that the problem was conversely due to an overestimation by RDS measurements, identified also in the comparison against GPS measurements.

Answer to reviewer #1

"General comments: In this work, the authors describe a detailed methodology for the estimation of calibration parameters (three in this case: a, b and Vo) for solar-radiometers to determine the columnar water vapour. The methodology was already described and applied in Campanelli et al., 2010, as the authors referenced. Also the authors say that the novelties or improvements of this new article are: a) The application of a Monte Carlo Method for the evaluation of errors affecting to the “a” and “b” parameters b) The application of the methodology to an entire year of data The paper cannot be published in the present form because substantially the methodology is the same, and a main part of the paper is repeated. "

It is true that the main formulas on which the presented procedure are based, are repeated from the 2010 paper, but this was necessary because they didn’t change. Respect to the work of 2010 this new paper has many innovations in all the following topics:

1. Procedure

2. Application

3. Validation

4. Valuable information given from the relative values of WV from sun-photometer

Particularly:

1. Procedure. The main difference are now in the:

a) use of GPS data

b) pre-selection of dataset, described in section 3.1, necessary in order to reject data than can’t be properly analyzed by the presented procedure;

c) introduction of the Monte Carlo Method for evaluating errors in the retrieval of a and

b parameters.

2. Application. The philosophy heading the application of the procedure was completely re-formulated. In fact in 2010 paper, data were analyzed “monthly” and calibration constants a, b and V0 were retrieved for each month. This idea was good for the case of only one season dataset, (summertime as it was in 2010) but it can’t be applied for a one year dataset. Infact the main assumption of the entire procedure is that (a, b) depends on the vertical profile of temperature, pressure and moisture at the various sites that can largely vary within the same month, especially during most unstable seasons (spring, winter and autumn). This makes necessary to calculate the calibration parameters not on a monthly base, but on WV amount base, allowing to make available a calibration table proper of the site of measurement and of the instrument.

Furthermore in the revised version the behaviour of a and b parameters as function of W was validated using the analysis of the available radiosonde measurements, by introducing two indices to describe the W vertical distribution and having different sensitivity to the shape of the distribution.

3. Validation. In the previous paper results were validated using Water vapor from MODIS Terra / Aqua and Radiosonding. The satellite validation at that time received some criticism because the methodology adopted (passive remote sensing at 940 nm) is the same for both ground based sun-photometer and satellite. A validation against results obtained from a completely different methodology was suggested for the proposed methodology. In this paper we selected a site where Microwave radiometer is co-located in order to improve our validation following the suggestion received in the previous paper, and we introduced in this second revision the GPS dataset.

4. Valuable information given from the relative values of WV from sun-photometer. The improvement in the retrieval of W from sun-sky radiometer when the dependence of a and b on W is introduced, is better presented in this revised version (new Figure 8), and the SHM was also validated.

However from the comment of the reviewer we understand that all the improvements done in the new paper are not clear so we added a summary of the above innovations in the new text.

"The main problems in the application of the described methodology are not solved in this new issue. Certainly new data are incorporated, i.e, microwave data of water vapour, but the validation of the method is clearly not sufficient. The use of a year of data does not add any valuable improvement in the application of the method. In Campanelli et al., 2010, the parameter a,b and Vo are determined in a monthly basis, but that is not done here. Precisely this was proposed in that 2010 paper but this is not carried out here. Thus, what is the advantage of using 1 year of W data?"

As explained in the above answer, point 2, the philosophy heading the application of the procedure was completely re-formulated. In the paper of 2010, calibration constants a, b and V0 were retrieved for each month, that was a good strategy for the case of only one season dataset, (summertime). But the main assumption of the entire procedure is that (a, b) depends on the vertical profile of temperature, pressure and moisture at the various sites and they can largely vary within the same month, especially during most unstable seasons (spring, winter and autumn). This makes necessary to calculate the calibration parameters not on a monthly base, but on WV amount base, allowing to make available a complete calibration table proper of the site of measurement and of the instrument. To do this, it is necessary using 1 year of W data.

"On the other hand the new methodology is proposed as an alternative to transmittance simulation in order to avoid errors of the simulation. However if the W values used in the determination of a,b,Vo have low quality, that would mean that the a,b,Vo would have low quality too. It is obvious from the method that a, b and also Vo parameters are in some way dependent on the goodness of the water vapor data used for its determination. This reviewer does not agree with the use of the SHM method to retrieve water vapour values in the atmosphere, to be used in the calibration procedures. The data used for calibration must be of high quality and the SHM method does not provide

them. "

Answer to this comment is provided by the new version of the paper, were GPS data were also used for the application of the proposed methodology, and SHM was validated. The accordance between retrievals from sun-sky radiometer and simultaneous measurements from the other instruments (GPS, MWR, and RDS) was found always within the error both in the case of SHM and of GPS independent dataset.

"The figure 3 is sufficiently illustrative to show the goodness of this type of data. If at a level of monthly means the disagreement with microwave values (or other type of data) is so high, the values used for near-instantaneous calibration, as it is the case of solar-radiometer,do not accomplish the required quality. Here, we come back to the unclear sentence about its necessity to “initiate the procedure” (see below)."

Thanks to the comparison against GPS, we found that MWR was affected by an unknown bias, that we corrected before using these measurements for validation. However we retain Figure 3 of the old version of the paper confusing for the reader, because in that Figure data are treated “monthly” whereas in the entire methodology data are divided by water vapor classes. The introduction of GPS measurements provided a new strong means for validating SHM that makes the information given by figure 3 no more necessary and misleading. Therefore we decided to remove it.

"Therefore, some points are not clear in the reported methodology. 1. Why the authors say that they need a previous data set of water vapour to initiate the method (In Campanelli et al., 2010, the authors say “at least a week of data”), in this case the SHT method or other valid data set. Reading the paper, they need water vapour data all the time because the method is an “in situ” method. Thus, what does it mean “to initiate the procedure”? Do they mean to validate?"

“Initiate” the procedure doesn’t mean “validate”, neither providing a “first guess” for the application of methodology. “Initiate” was used in the text with the meaning of “beginning”. However in order to avoid any misunderstanding we deleted the word “initiate” from the paper and we explained that the proposed methodology needs independent water vapor dataset to be applied. As independent datasets, data from GPS and SHM were used in the text. The scheme of the proposed procedure is as follow :

1. Aim: creation of a table of calibration constants for each of the 4 classes of W, typical of the site where the instrument is operating (a, b are supposed to be dependent on W amount)

2. Method: a, b must be retrieved for each of the 4 classes using Eqs 2a and 2b and the method based on the maximization of correlation between x,y. To do this, we need the unknown W in Eq 2b. provided by an independent W dataset.

3. The type of “independent” W dataset: W independent dataset can be obtained from every kind of instrument, provided that measurements are taken over a large range of solar zenith angle. In Campanelli et al, 2010 we had few days of Radiosonding measurements taken 3 times a day and it was enough for calculating a,b for the restricted interval time of summer. This explain why we said that we need at least “one week “ of independent W. In the present case we want to retrieve a,b coefficients for each of the 4 W classes, so that we need W independent measurements filling the 4 classes. This is the reason why we can’t say anymore that we need “at least one week of data” , but the more independent W data we have, the better is for improving the statistical analysis. In this revised version we used both GPS measurements for the application of the methodology, and SHM useful in the case when independent measurements of W from different instruments are not available. For what concern the “in situ” words, they only want to highlight that the calibration is performed not in a laboratory, but in the same site where the instrument is located.

However we understand that the general scheme of the proposed methodology was not clearly explained so we improved it in the new version, also by changing the title and structure of some sections.

"2. In page 8078, paragraph between lines 5-10 in step (i) for the determination of b

parameter. I cannot understand the method. The authors say that they need to form the pairs (x, y) and take the correlation coefficient to optimize the determination of the best b value. How is that made? It seems that only equation (2a,b) may be used to obtain the 3 parameters, a, b and Vo. Please clarify this point."

In the text (lines 7-10 pag 8078 of the old version) it is written: “(i) x values are calculated for 30 different values of b from 0.4 to 0.7 with a step of 0.01 and each time the (x, y) squared correlation coefficient is calculated; then the maximization of the (x, y) squared correlation coefficient is used to determine the best exponent b;”. This means that from Eq 2b we calculated x1. . .x30 (being x=(m*W)ˆb), using the 30 b values (from 0.4 to 0.30 with step of 0.01). Then the correlation coefficient is calculate for each of the pair (xi,y) (y is known). The maximum of the correlation coefficient identify the optimal b value.

Then it is written (lines 10- 12 pag 8078 of the old version): “(ii) once the optimal b exponent is retrieved, the series of x values is computed and the coefficient a and V0 can be found from Eq. (2a) by determining the regression line of y vs. x.” This means that the xi values corresponding to the optimal b value (retrieved in the step i)) , is inserted in eq 2a. Now in Eq 2a we have both y and x series known and we can perform the regression line to obtain slope and intercept that are respectively a, and lnV0.

We modified that sentence as follows: “(i) from Eq 2b x values are calculated for 30 different values of b from 0.4 to 0.7 with a step of 0.01 and each time the (x, y) squared correlation coefficient is calculated; then the maximization of the (x, y) squared correlation coefficient is used to determine the best exponent b; “(ii) once the optimal b exponent is retrieved, the series of x values is computed and used in Eq. (2a) where the regression line of y vs x allows the retrieval of the coefficients a and V0 .”

"3. The authors remove when necessary those data that do not fit the requirements to make the results look nicer. This is not a regular way of scientific working. "

Data are removed according to specific scientific criteria that are explained in the new Section 3.1. The first criterion is based on the rejection of points having optical depth at 940 nm > 0.4. As explained in the text the cloud screening procedure adopted in this work does not assure that data are really not contaminated by clouds. The presence of thin clouds is also a problem for the AERONET cloud screening. In our case, considering the values of aerosol optical thickness measured at the other wavelengths and the calculated Angstrom exponent, it makes sense improving the cloud screening by adding this criterion, even if we know that some good data will be lost. We corrected the sentence in the text as follws: " Being the maximum average value of AOD (500 nm) about 0.6, and considering the calculated values of Angstrom exponent, it is likely that data having AOD (940 nm)>0.4 are contaminated by clouds, and for this reason they must be rejected, even if some good data will be probably lost. "

The second criterion is better explained in the new Section 3.1: "This is likely related to the fact that in these months and in this time of the day (conversely to summer season) more time is needed to break the stable conditions characterizing the low atmosphere after the nocturnal cooling period. As a consequence, the vertical distribution of water vapour is anomalous respect to the profiles generally used in the in the development and/or initialization of retrieval methods (e.g. microwave radiometer, GPS, SHM) and an error can be introduced in the estimation of W. For these months we decided, as first approximation, to select only measurements initiating from 13:00 local time in order to reduce the problem to a linear behaviour".

The third criterion is generally adopted to select outliers.

"4. Another problem is that the three parameters (a, b and Vo) are determined for 4classes of W values. This also complicates the method, because now we have 12 constants of calibration instead of 3. What do the authors try to demonstrate with Figure 6? The dependence of a,b, and Vo with water vapor content? With fixed values of a,b, during a long period, will these variations be translated to the Vo values?. Is not the high variation of a and b for low values produced by the bad W values used for their

retrievals?"

Figure 4 (Figure 6 in the old version) shows calibration parameters a, b and V0 for each W class retrieved using both W from GPS and W from SHM as independent dataset needed to apply the proposed methodology. It must be remembered that the main hypothesis of this methodology is that characteristic parameters of the atmospheric transmittance are dependent on vertical profiles of pressure, temperature and moisture occurring at each site of measurement. The behaviour of b and a as function of W was found to be nearly parabolic with an opposite curvature. The lowest and highest W classes have similar behaviour probably because they are characterized by a W vertical structure having a well mixed layer at the bottom and a rapid decrease upward. This hypothesis was confirmed by the analysis of the available radiosonde measurements. Looking at the water vapour dependence of the a,b and V0 parameters in Fig. 4, is noticeable that their behaviours are somehow connected since the increase of one parameter is balanced by the decrease of another. This is due to the fact that in the applied methodology of maximization these variables are not calculated independently one from the other. It implies that the slight dependence of V0 on the water vapour class is a fictitious tendency, and therefore, at the present stage, the retrieved V0 should be considered as an effective calibration constant whose temporal variation could not be related to a real instrumental drift. The improvement in the W estimation from sun-sky radiometer brought by the assumption of a, b dependent on W was validated calculating water vapour (WS) by using the most common procedure adopted for example by AERONET network, that consists in retrieving fixed a and b parameters from a fitting procedure of simulated transmittance versus the product mW. W from our methodology and WS were compared against GPS retrievals and results showed a clear improvement when dataset obtained by the present methodology are used. This is shown in the new Figure 8. All the above explanation are in the text of the revised version of the paper.

"5. The authors prefer the proposed method instead of simulations because of less associated errors, but the problem in the application of the method is not the associated error but the values themselves of the quantities to be retrieved To merit a new publication, I recommend at least a year of comparative work with the water vapour data provided by a Cimel instrument with the AERONET methodology, but at the same time applying the proposed method to the Cimel and PREDE instruments simultaneously"

We demonstrated in the present revised version that the use of a,b parameter dependent on W respect to keeping them fixed, improves the agreement with GPS retrievals. For this reason we don't retain the comparison with AERONET methodology a validation of our procedure but an important intercomparison to be performed. In Chiba site actually there isn't any co-located Cimel instrument, but as stated in the conclusion, the present procedure "will also be tested on AERONET sun-sky radiometers in order to compare the two methodologies" once a proper site is found.

"Furthermore, high quality W data are necessary, such as radiosonde data and the most suitable values of GPS data for a definitive validation of the method, or at least to solve the problem now open in the proposed methodology. I encourage the authors because they are in the deep of the open problems of the method, but it is clear that for a final validation of the method they require a good database of W, provided today by high time resolution GPS data, among others."

Done.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/6/C4152/2014/amtd-6-C4152-2014-supplement.pdf

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