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Atmospheric Measurement Techniques Discussions

Interactive comment on "Quality assessment of Izaña's upper-air water vapour measurement techniques: FTIR, Cimel, MFRSR, GPS, and Vaisala RS92" *by* M. Schneider et al.

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Thanks, to both Anonymous Referees for reviewing our paper. Their efforts allow improving our manuscript.

Anonymous Referee #1:

General comments:

(1)

"Although other studies have been cited, the results obtained elsewhere are not mentioned in this study. In order to establish a record of quality checks, the results found in this study should be related to other results": Yes, we agree, but we would like to add that there are many different studies that compare PWV measured by different techniques. Our study is the first that compares many different ground-based techniques with the FTIR technique, which according to theoretical estimations has a precision of better than 4% (Schneider et al., 2006a). We will add a table with the results of some other studies. This table will give an overview of the empirical and theoretical precisions derived for the different techniques by a selection of different authors. It cannot be a complete review.

(2)

"This study does not exploit the possibilities of the large number of different sensors, [. . .]. For a quality assessment a detailed discussion of all the failures or contradictions in the results presented would be expected. This contradiction between the title and the abstract on the one side and the contents of the publication should be resolved in a final version": Yes, the title and the abstract talk about a quality assessment for the different techniques. Thereby the reader can expect a discussion about the pros and contras of the different techniques, which is provided in many different aspects:

(a) required measurement conditions: are discussed in Sect. 2.

(b) geographical coverage: is discussed in Sect. 2.

(c) data availability: Fig. 3 and Fig. 4 and Sect 2, Sect. 3.1 and Sect. 3.2 discusses the availibility of historic data, the measurement frequency and the typical data availability of the different techniques.

(d) MFRSR, Cimel, and FTIR data quality depend mainly on the strength of the spectroscopic signature, which is discussed in Sect. 3.3.

(e) MFRSR and Cimel also depend on the effectiveness of the cloud screening algorithm, which is qualitatively discussed at the end of Sect 3.2 by comparing only for 100% cloud screened observations.

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(f) The GPS technique is relatively erroneous under very dry conditions, which is discussed in Sect. 3.3 and documented in Fig. 6.

(g) vertical resolution of FTIR and RS92: Sect. 4.

(h) dry bias of MFRSR, Cimel, and FTIR: has its own Section (Section 5).

We understand this comment as an advice to put even more emphasize on these discussions (which we will do in the final version).

Specific comments:

(1)

“The standard deviation when the Cimel and the MFRSR are compared to each other is much larger than the standard deviation of the comparison of each instrument to the FTIR. This result is used to bolster the argument that the FTIR data are more precise than the measurements of both instruments, the Cimel and the MFRSR. The authors did not, however, make sure, that all three instruments measure under the same conditions” A comparison for the same conditions as suggested by the referee is reported in the last paragraph of Section 3.2. The conclusion that the FTIR is more precise than Cimel and MFRSR is drawn from this comparison. To make this point clearer, we will introduce an extra Table at the end of in Section 3.2 collecting the corresponding values.

(2)

Comparison of Cimel and MFRSR for clear sky conditions: Such a comparison already exists and we will add a table with the respective values (see reply to (1)).

(3)

SZA dependence: The analyzed signal of MFRSR, Cimel, and FTIR is the absorption signature (or optical depth) which depends on the slant column of the absorber. The slant column is the product of the cosine of the solar elevation angle and the PWV

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amount. The slant column dependence of the differences is examined in Fig. 5 and Sect. 3.3. A pure correlation with the solar elevation angle would appear if there was an error between the real solar elevation and the solar elevation assumed by the retrieval algorithm. This would be the case by assuming incorrect coordinates or an incorrect measurement time. We will check if this is the case and mention it in the text.

(4)

“The authors write, that the dry bias for the MFRSR data is not significant. The reasons for this judgement are not made clear”: This judgement is the result of the dry bias estimations according to Gaffen and Elliot (1993) (see Equation (2)). The calculations produce no clear dry bias in case of the MFRSR (see Table 2). This point is discussed at the end of the second paragraph of Sect. 5.

(5)

“Why is the Cimel dry bias considerably smaller than the FTIR dry bias?” The dry bias is exclusively produced by the atmospheric conditions that are prevailing when performing the measurements. It has nothing to do with experimental imperfections, but with the atmospheric conditions that are required for performing the measurement (Equation (2) works exclusively with radiosonde data). We will make this point clearer in the text. Cimel measurements are performed in an automated mode, and flagged cloud free whenever there is no cloud along the line between the Cimel instrument and the sun during the short instant of a Cimel measurement (time range of seconds). An FTIR measurement takes about 10 minutes. It is performed manually. The operator decides if the atmospheric conditions are worth preparing the experiment for a measurement. A decision for measuring is typically made when there are significant probabilities for a clear view to the sun during several minutes, i.e. when most of the sky is cloud free. Under such conditions the atmosphere is especially dry.

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Random uncertainty of the radiosonde data and how it is affected by the smoothing with the averaging kernel: Yes, we agree with the concerns of the referee and will add a discussion to the final version of the manuscript. It is important to distinguish between RS92 errors without correlations between different altitudes (time-lag error and round-off errors (Miloshevich et al., 2009)) and RS92 errors which are similar over the whole profile (variation in the Vaisala calibration reference, random production variability, solar radiation error, and ground-check related uncertainties (Miloshevich et al., 2009)). The former are much reduced after smoothing with the averaging kernels, while the latter are hardly affected by vertically smoothing. They are estimated to be 5% RH, i.e. 20% for an atmosphere of 25% RH.

Technical corrections: Many thanks! We agree with the referee and will improve the mentioned issues in the final version.

Anonymous Referee #2:

General comments:

(1)

“Although the article is an empirical assessment focusing on the scatter among PWV measurements a table showing the expected precision for each technique from the data provider would help the reader to know the data quality on the onset”, “Sec. 2: Although references are given a short discussion of the expected precisions for each technique should be given“: Yes, we agree. This will be done in form of a table (see reply (1) to the general comments of referee #1)

(2)

“Introducton line 25 [. . .]”: We will exclude the whole sentence as suggested by the referee.

(3)

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"Figure 1 [. . .]": The information required by the referee will be added in the final version

(4)

"Sec. 3.2 lines 18-23 [. . .]": So far we are not aware of any other study that compares GPS data to high quality data like the FTIR data. We will make this situation clearer in the text. So to our knowledge this is a new finding, which is discussed in Section 3.3 and again in the Summary. In this context we would also like to remark that most of the GPS data used for the intercomparison study represent very dry conditions (winter measurements at a high altitude station). This is a very demanding test for the GPS measurements.

(5)

"Conclusion line 3 [. . .] real values [. . .]": Real values are never known. Here we mean that the GPS underestimates the values of all the other experiments, thus indicating to an error in the GPS data. We will clarify this in the final version.

(6)

"References: Romero et al. 2009 [. . .]": Romero et al. (2009) is in particular relevant since it describes in detail the instruments, experimental setups, and the methodologies used at the Izana Observatory. The technical information collected in Romero et al. (2009) is important but cannot be published in a scientific journal like AMT. Its main goal is to document the implementation of the measurement program and it does not necessarily contain new developments of international importance. There are a lot of sketches, formulae, and photographs that are understandable also for non-Spanish readers.

Specific Technical Comments: Many thanks! These issues will be corrected in the final version.

Interactive comment on Atmos. Meas. Tech. Discuss., 2, 1625, 2009.