Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2015-350-RC1, 2016

Atmospheric Measurement Techniques Discussions

Interactive comment on "A semi-empirical error estimation for PWV derived from atmospheric radiosonde data at the Canary Islands" *by* J. A. Castro-Almazán et al.

Anonymous Referee #2

Received and published: 7 March 2016

The paper investigates the error in Precipitable Water Vapor (PWV) derived from radiosonde profiles. Two error terms are considered: the measurement errors and the sampling error. It is found that the effect of the measurement errors increases with the number of levels sampled by the radiosonde, while the sampling error decreases with more levels sampled. Thus an optimum number of samples to be used in the PWV calculations is obtained. The subject is relatively interesting and the paper could be an good reference work for the accuracy of PWV from radiosondes. However, I have some doubt related to some parts of the results.

First of all, in principle you should expect that the more measurement points you include in the PWV calculations, the better the results ought to be, as long as an appropriate

method is used for the calculations. For example, I would expect that if the radiosonde measurements are smoothed to a lower resolution, the resulting PWV would be of higher accuracy compared to when reducing the resolution through sub-sampling. This ought to be discussed in the paper.

I have strong doubts relating the validity of equation (8), which is used for calculating the effect on PWV of the measurement errors. Applying the trapezoid method for calculating the PWV from eq. (3), we get:

$$PWV = \frac{10^5}{\rho g} \sum_{n=0}^{N-1} \frac{1}{2} \left(r_{i+1} + r_i\right) \left[p_{i+1} - p_i\right] \tag{1}$$

Thus the uncertainty of the contribution of the i:th layer to the PWV is (assuming r and p are uncorrelated) :

$$\sigma_i^2 = \frac{10^5}{\rho g} \left[\frac{1}{4} \left(\sigma_{r_{i+1}}^2 + \sigma_{r_i}^2\right) \left[p_{i+1} - p_i\right]^2 + r_{i_a vg}^2 \left(\sigma_{p_{i+1}}^2 + \sigma_{p_i}^2\right)\right] \tag{2}$$

By adding σ_i^2 of all levels, eq. (8) of the paper is obtained. However, this will only give the correct PWV uncertainty if the contributions from all layers can be considered independent. This is clearly not true, since the measurements at the top of one layer is also the ones used for the bottom of the next. Thus the layers are clearly not independent, thus eq (8) is incomplete. For a more proper derivation, we can use:

$$\sum_{i=0}^{N-1} (r_{i+1} + r_i)\Delta p_i = \sum_{i=1}^{N} r_i \Delta p_{i-1} + \sum_{i=0}^{N-1} r_i \Delta p_i \tag{3}$$

$$= \sum_{i=1}^{N-1} r_i (\Delta p_{i-1} + \Delta p_i) + r_0 \Delta p_0 + r_N \Delta p_{N-1} \tag{4}$$

Thus the contribution σ^2_{mix} of the mixing ratio errors to the total uncertainty is:

$$\sigma^2_{mix} = \left(\frac{10^5}{2\rho g}\right)^2 \left[\sum_{i=1}^{N-1} \sigma^2_{r_i}(p_{i+1} - p_{i-1})^2 + \sigma^2_{r_0}\Delta p^2_0 + \sigma^2_{r_N}\Delta p^2_{N-1}\right] \quad (5)$$

Similarly the contribution from the pressure errors is:

$$\sigma^2_{pres} = \left(\frac{10^5}{\rho g}\right)^2 \left[\sum_{i=1}^{N-1} (r_{i-1,avg} - r_{i,avg})^2\sigma^2_{p_i} - r^2_{0,avg}\sigma^2_{p_0} + r^2_{N-1,avg}\sigma^2_{p_N}\right] \quad (6)$$

And the total uncertainty is obtained by $\sigma^2 = \sigma^2_{mix} + \sigma^2_{pres}$, what differs significantly from the expression in eq. (8) in the paper.

The authors need to correct their expression for the uncertainty and redo all calculations.

Equation (9) in the paper ignores the contribution of the pressure measurement error to the error in the mixing ratio. Is this appropriate? Furthermore, in the denominator the approximation $p_i - e_i \approx p_i$ is made.

If the uncertainties of the saturation water vapor coefficients a_j are taken into account when calculating the uncertainty of the partial pressure of water vapor (and hence also PWV), it should also be considered that the errors in these coefficients probably are the same for all measurements, thus these errors are highly correlated. Right now, the calculations assume that these error are uncorrelated.

Page 7, line 204: "Therefore, σ increases with the number of levels in the profile": I do not necessary believe this is true. Of course, with each measurement you add some amount of error, however, on the other hand the contribution of each measurement to the total PWV error decreases.

I think the empirical expressions derived in eqs. (18) and (19) are only valid for the investigated location (Canary Islands). I would assume that, especially, the sampling

errors depend (at least slightly) on the location. Locations where, e.g., the humidity varies rapidly with height requires higher sampling than locations with more smooth variations.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2015-350, 2016.