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Interactive comment on "Calibration and validation of water vapour lidar measurements from Eureka, Nunavut using radiosondes and the Atmospheric Chemistry Experiment fourier transform spectrometer" *by* A. Moss et al.

Anonymous Referee #3

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Water vapour is an important climate gas. Instruments like the CEC lidar, that measure water vapour in the high Arctic, are rare and are, therefore, potentially important for our global observing system. Unfortunately the authors show no convincing evidence that the CEC does measure water vapour any better than the Vaisala radiosondes.

To get overall agreement with the radiosondes (and with ACE) the authors introduce large and purely empirical corrections (exceeding 50% of the measured values below 1 km and exceeding the radiosonde values by more than 100% above 8 km). However, there is no physical explanation and there is no quantitative estimate from physical principles for these very large corrections. Instead the large corrections are introduced ad hoc, are fudged to match the sondes and are "explained" with a bit of "arm-waving" only.

After reading the manuscript, I get the impression that the CEC lidar does not really measure water vapour (certainly not better than the radiosondes), and that the authors do not know why. This is not sufficient for an AMT paper.

Section 3.2.3, Fig. 1: Where does the large difference come from, that is corrected here? Is it from pulse pileup in the detection system (Donovan et al. 1993)? If so, then this should be measured and quantified. Or is it from the lack of overlap between receiver field of view and transmitted laser beam? In the latter case the correction would change all the time with changing system alignment, and a meaningful correction can probably not be obtained. Water vapour profiles, that are accurate to a few percent, can probably not be obtained in this "lack-of-overlap" range.

Section 3.2.3, Fig. 3: Again, where does this huge difference come from? Above 8 km the lidar values are 2 to 5 times higher than the radiosonde values, which are likely not good and too high at these altitudes. With such a large and unexplained correction, the lidar simply does not measure water vapour at these altitudes, it sees something else.

Contrary to what the authors claim, I don't think it can be the transmission ratio. There is little atmosphere, and hardly any water vapour above 8 km over Eureka in late winter. There would be no significant altitude dependence of the transmission ratio above 8 km. Certainly it would never explain a correction by factors of 2 to 5.

The same goes for the temperature dependence of the effective Raman scattering cross-section, wrongly claimed by the authors. When the temperature of the scattering layer goes up, higher Stokes orders become more probable, but may not be transmitted by the interference filter. This depends on filter bandwidth (what is used in the CEC Dial?), but is usually a small effect. It would be even smaller above the polar tropopause

(8 to 10 km), where temperature changes little with altitude.

I rather think that there is a problem with the background measured and subtracted from the lidar return signals. How have the authors handled the background. Is there significant fluorescence or signal-induced noise? These things need to be addressed.

Without a better handle on the lidar measurements, the comparison with ACE (Figs. 6 to 8) is hardly meaningful. Why not use the radiosondes? They have errors too, but there are many routine radiosonde launches, and there is ample documentation of radiosonde humidity accuracy in the literature.

Given these major deficiencies, I feel that a substantially deeper new investigation is needed. After that, it would be worthwile to re-submit. The CEC lidar should be able give accurate water vapour measurements in the higher Arctic troposphere.

Reference:

D.P. Donovan, J.A. Whiteway, and A.I. Carswell,"Correction for Nonlinear Photon-counting Effects in Lidar Systems", Applied Optics, 32, 6742-6753 (1993).

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 5665, 2012.

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Interactive Comment