Referee: Dr. Jens Reichardt, MOL/RAO, DWD, Germany.

Summary: The authors report on the effect of aerosol fluorescence on water vapor measurements in the lower stratosphere with high-performance lidars of the global NDACC, and on an instrumental method for correcting it. First, long time series of monthly means of water-vapor measurements with lidar and radiosonde at three sites are correlated with satellite aerosol data to make the case that lidar-derived stratospheric humidity exhibits a significant moist bias if biomass-burning aerosol (BBA) is present. It is concluded that this systematic error is caused by BBA fluorescence. To correct for this adverse effect, an instrumental technique is developed that is based on an interference filter with center wavelength close to the dominant water-vapor Raman line which is alternatingly exchanged for the water-vapor interference filter for quasi-simultaneous fluorescence detection. First measurements after a careful characterization of the technical upgrade show a significant reduction of the wet bias in the lower stratosphere. However, it comes at a price, which is a non-negligible increase in measurement uncertainty. For this reason, alternative approaches to a fluorescence correction are discussed.

General comments: The study presents interesting and important results, is well written and deserves publication after only some minor corrections. Some additional thoughts on the matter: (1) The authors had to expend great effort to establish the working hypothesis that fluorescence by stratospheric BBA caused the wet bias. Monthly averages and satellite aerosol data seem to be sufficient, but how much easier would the study have been if some simultaneous lidar aerosol data had been available. All lidar described are extremely potent instruments, so it should be relatively easy to augment the lidar data set with aerosol parameters, if budgets permit. (2) The referee fully agrees with the assessment given concerning the shape of the BBA fluorescence spectrum and the potential use of a spectrometer (or at least two discrete detection channels on both sides of the main water-vapor Raman line) to account for spectral gradients around 407 nm. Measurements with the spectrometric RAMSES lidar reveal just that in BBA filaments at the tropopause (see figure). At 11.5 km (red curve), the spectral backscatter coefficient at 407.5 nm is 7%-8% smaller than at 410.5 nm. So in this case the current correction scheme would have introduced a dry bias to the mixing-ratio results.

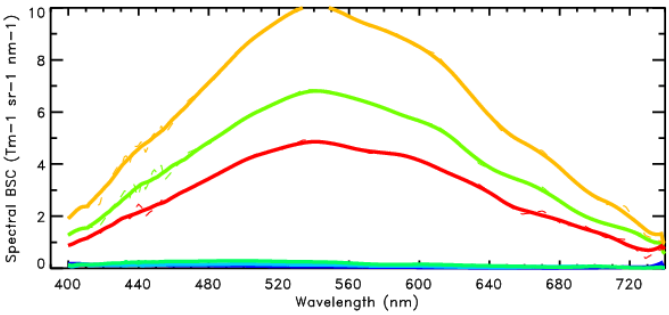

Fig.: RAMSES measurement on 29 Sep 2021. The upper three curves depict spectra at different altitudes in a BBA filament at the tropopause (~11 km). BSC – backscatter coefficient

Specific comments:

l. 248: Given the scarcity of stratospheric measurements a slightly more defensive wording would be warranted. Probably, the reason why there are data points at all is that the additional fluorescence signal pushes the statistical errors of apparent water vapor mixing ratio below the error threshold.

l. 253: Here the fluorescence is missing, hence, no (additional) signal in the water-vapor detection channel and thus the statistical errors remain high and above the error threshold. Maybe this should be mentioned.

ls. 293, 301: See ‘general comments’ above. If fluorescence increases with wavelength, the corrected water vapor mixing ratio will be too low.

Fig. 6: It is quite amazing that the aerosol effect is seen in the entire lower stratosphere up to almost 20 km. Did BBA get up that high in California? For instance, in northern Germany the maximum height of BBA detection reached ~16 km only once in 2020 and was always below ~13 km in 2021. A similar plot for a time period without stratospheric BBA contamination would probably be worthwhile. Further, mixing ratios in the upper troposphere over California are already so small that significant BBA fluorescence should interfere here with the humidity measurement as well. The reviewer observes this phenomenon in Germany quite often. Do you have such measurement cases? Finally, is the RS41 data product in the stratosphere actually good enough for this comparison?

Technical corrections:

l. 58: Aerosol typing is also discussed in: Reichardt, J., R. Leinweber, and A. Schwebe, 2018: Fluorescing aerosols and clouds: Investigations of co-existence. EPJ Web Conf., 176, 05010, https://doi.org/10.1051/epjconf/201817605010.

l. 171: … product from…

l. 189: trustworthily

l. 200: … of the with… (Something is missing here.)

l. 330 ff.: Subscripts that are not variables must be in normal text style, not italic.

l. 343: See ‘general comments’ above.

Fig. 5c), l. 393: Is the range 6-8 km or 9-11 km?