Interactive comment on "Observations of water vapor within a mid-tropospheric smoke plume using ground-based microwave radiometry" by D. R. Clabo

Anonymous Referee #1

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This manuscript presents several case studies of smoke plumes observed by a microwave radiometer, also using visible satellite imagery to identify the plume locations. The study is interesting and potentially useful, but conclusions on the presence of elevated moisture in smoke plumes are not fully convincing and require further analysis.

Thank you for your comments and I appreciate the time you've taken to review this paper. I have addressed each point you've made and my responses to each point are given in bold text below the individual comments. I primarily focused on improving the statistic rigor of the paper.

Major comments

1) The comparison between moisture values inside and outside the plume needs to be done with more statistical and scientific rigour. There are two tests that need to be passed:

(i) Statistical significance. This should be relatively easy to determine using a Student's t-test on the hypothesis that mean moisture values are higher inside than outside the plume. In general it would be helpful to see some tables giving the exact time periods considered 'inside' and 'outside' the plume as this is not always easy to glean from the text. Also the tables could contain the mean, standard deviation, and number of samples in each period, from which it will be possible to compute the statistical significance of the difference in water vapour between inside and outside the plume.

Thank you for making this comment as I believe the paper is now in much better shape. I have added the results of a Student's t-test for the 20 August case.

(ii) Physical significance. As illustrated by the various timeseries of water vapour from the radiometer, there is a lot of background temporal variability in WV as different airmasses are advected over the observation site. The task the authors face (possibly difficult) is to show that the plume moisture values have been elevated above and beyond this natural variability. In the absence of any smoke plumes or cloud, on days with similar weather conditions to those in the case studies, if we were to pick a number of 2-hour periods at random and compute the difference in WV between the first and second hour in that time period, what size WV difference could be expected? The in-plume WV elevation has to fall outside the PDF of this background variability to be significant.

This is a very interesting point and this study does beg the question of "what is the natural variability of water vapor over western South Dakota." However, I do believe that answering this question is outside the scope of the present paper and may likely be worthy of a study on its own. I do not disagree that the issue of physical significance is important but a thorough examination of the natural water vapor variability would not be possible with the limited radiometer data collected.

2) In general it would be good to see more information on the quality and characteristics of the radiometer observations. In particular one of the conclusions of the study is that a radiometer is useful for evaluating elevated moisture levels in plumes. To support this conclusion, it would be good to evaluate the error in the water vapour retrieval by comparison to the nearby radiosonde ascents (i.e. to give the mean and standard deviations of typical difference between the radiometer retrieval and the sonde). Since the authors are examining 3-6km average mixing ratio, it would be most useful to know the error characteristics of this average.

This comment has been partially addressed in regards to the quality of the radiometer observations with the inclusion of several more references. Direct comparisons between the radiometer and the nearby radiosonde are given as Figs 1-4 but the error statistics are not. Because this study examines the changes in time, the relative quality of the radiometer observations as compared to the radiosondes is not particularly useful information for this study. If the temporal frequency of the radiosondes were higher, I would agree that an error evaluation may be helpful.

Minor commments

1) Section 2, on the radiometer: Although the WV retrievals are performed on a 0.25km grid in the vertical, as the comparisons to radisonde profiles illustrate, the true vertical resolution is likely to be much lower. It would be useful to give this true resolution (noting that a neural network retrieval cannot supply this information, but there must have been studies using physical inversion techniques applied to similar radiometers that can supply this information).

This is a very good point and has now been addressed with the inclusion of several more references.

2) Is anything known about the radiative impact of smoke aerosol at frequencies used by the microwave radiometer? Presumably it is minimal, but it would be good to see some physical confirmation of this.

This is an interesting question and one that did come to mind when I was first writing the paper but I could not find information related to the radiative impacts of the aerosols themselves with the frequencies used by the MWR. However, those frequencies are used because they do respond well to water vapor.

3) Figure 6: Some explanation of the meaning and units of the colour scale needs to be given here. In particular the significance of the grey areas is not clear.

This has been addressed.

4) Figure 11: It is impossible to distinguish the aerosol zone from the ambient air, specially in panels b-d. Some adjustments may need to be made (e.g. to the colour scale?) on these figures.

Thank you for pointing this out. The color was enhanced on this figure to make the smoke more obvious in the panels and I hope that it is now more easily seen.

5) Figure 14, caption: Are panels (a) and (b) really both 1345 UTC?

This was an error and has been fixed.