Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC1
https://doi.org/10.5194/amt-2022-30-RC1, 2022

Comment on amt-2022-30

Anonymous Referee #1

Referee comment on "An optimal estimation algorithm for the retrieval of fog and low cloud thermodynamic and micro-physical properties" by Alistair Bell et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-30-RC1, 2022

This paper describes an optimal-estimation based physical retrieval that uses ground-based cloud radar and microwave radiometer observations to get profiles of temperature, humidity, and cloud liquid water content in fog layers. It applies the algorithm first to synthetic data to provide a characterization of the algorithm by discussion how the different instruments change the sensitivity / accuracy / information content of the results. It then provides a detailed evaluation of a long case study, comparing the retrieved quantities against radiosonde and tethersonde profiles.

This is a very nice paper. It is well-written, flows logically, and contributes to our understanding of how accurately we can measure atmospheric properties in foggy conditions. I have relatively few concerns, and think the paper only needs minor revisions to address them.

Line 278: I thought it was interesting that you assumed a diagonal observation covariance matrix, especially since the Cimini et al. 2018 study showed important off-diagonal values in the MWR forward model (esp between 51, 52, and 53 GHz channels). Would adding off diagonal elements change the results much at all?

Line 354: I think adding a reference that demonstrates that the MWR is only sensitive to LWP (not LWC) here would be good. You might add: Crewell, S., K. Ebell, U. Loehnert, and D.D. Turner, 2009: Can liquid water profiles be retrieved from passive microwave zenith observations? Geophys. Res. Lett., 36, L06803, doi:10.1029/2008GL036934.

Figure 3e: why is the radar-only bias smaller than the MWR-only bias? And why is the synergistic bias the worst of all? Given this is a synthetic study, this can and should be understood.

Figure 3f: Accidentally repeated the humidity bias figure, when you meant to show the humidity STD panel.

Line 411: You state "The measurement error will also mean that the information content from the observations will also decrease" – this is an odd phrasing. I think it would be better to say something like "The information content from the observations depends upon the measurement uncertainty in the observations, with larger uncertainties resulting in smaller amounts of information content."

Line 429: This finding (i.e., that the DFS from a cloud radar is about 35% for LWC) agrees very well with an earlier study by Ebell, and should be referenced: Ebell, K., U. Loehnert, S. Crewell, and D.D. Turner, 2010: On characterizing the error in a remotely sensed liquid water content profile. Atmos. Res., 98, 57-68, doi:10.1016/j.atmosres.2010.06.002.

Line 431: The total DFS for temperature and humidity depends on the vertical layer over which the DFS was computed. Please add the height range (e.g., surface up to 2 km) in this sentence please.

Table 3: why is the DFS for temperature from dual retrieval (1.99) less than for the MWR-only (2.31)? This does not make sense to me.

Line 446: You indicate that most of the information for water vapor is in the 1 to 3 km range. I think it would be useful to indicate that this is well above the top of fog layers, and thus that the MWR really offers only limited water vapor information within a low-lying fog layer.

Line 630: I totally agree with the commend on how proper cross-correlations between variables in the background will improve the retrieval. I think this is a great opportunity to also include the need to have improved measurements of the layer-to-layer covariance in fog (and cloud) properties directly from observations.

Fig 12: please add that the bias and RMSE are computed relative to radiosondes in the caption

Line 683: the temperature retrievals are more accurate in terms of a smaller RMS, but the bias is worse. I think that is worth mentioning here.