Review AMT :
Passive ground-based remote sensing of radiation fog

Overview:
This paper investigates the capability of two passive instruments, the AERI and HATPRO MWR to detect shallow surface-based temperature inversions and to provide good retrievals of LWP under thin radiative fog events. I think the paper is very well written and of a very good scientific quality. It is also very interesting and important for the scientific community as this is the first time the benefit of the AERI instrument for fog forecast is evaluated. However, there are a few points that I think are important to clarify before the publication of this manuscript. I would recommend a more moderated conclusion through the manuscript instead of trying to prove that AERI is better than the MWR for fog forecast improvements. In fact, I think the major issue of the lack of visibility data should really limit the conclusions that AERI can really detect fog onset before the MWR. To be more objective, with the current dataset used in the paper, what is demonstrated is an increase signal in LWP detected earlier with AERI compared to the MWR but without « real » proof that this is related to fog presence. Secondly, I think the discussion on the temperature lapse rate should also be more widely discussed in the paper because in-situ temperature surface from the MWR should be integrated in the 0-10m lapse rate comparisons. I also believe that the temperature inversion over a thicker layer might already be a good proxy for radiative fog and the comparison considering only a 10m thick layer is clearly penalizing the MWR.
Finally, I think a discussion about the use of LWP retrievals for fog nowcasting dissipation (Toledo et al 2021, ACP) would be beneficial to the article. In fact, even if AERI might detect fog formation a bit earlier due to very low LWP values, what about potential limitations for fog dissipation when the fog is thicker and might reach the saturation signal of the AERI ? Would the AERI be a good candidate to apply the conceptual model described in Toledo et al 2021 or the MWR would be a better candidate this time ?
This question might probably lead to a more balanced conclusion not trying to put the AERI against the MWR but to open the perspective of the instrumental synergy highlighting the benefit of each instrument depending on the fog stages.

Major points :

Lack of visibility data :
One of the major issues for me is the lack of visibility measurements which is the « reference » instrument to detect fog events. This is for me especially problematic for figures 10 and 11. I think, lacking this important reference measurements, the authors are going a bit too fast concluding that AERI is able to detect fog onset 4 hours before the MWR. What is true is that we detect a signal of LWP increase in the AERI earlier than observed in the MWR. However, as there is no reference instrument to give the exact time of fog formation, we cannot rely on the fact that an increase of 0.1 g/m² in the AERI LWP determines the true time of fog formation. I think it is particularly important as, if I understood well, the AERI LWP increase could also be due to the presence of ice crystals in the atmosphere that can't be detected by the MWR for example.
To help clarifying this point, can the authors provide with figure 10, the time serie of ceilometer CBH / vertical visibility for that specific day and the time serie of relative humidity observed at the ground and 10m on the tower ? In fact, I would expect even thin radiative fogs to be detected by the ceilometer which should provide a CBH lower than 50m within these conditions or a vertical visibility and could be a first good validation of when the fog really forms. You could also look at the time series of relative humidity (RH) from the tower measurements : though a RH > 95 % is not always a good proxy of the presence of fog, a RH < 95 % would easily show that there is little chance of fog.

I think this lack of visibility data might also be problematic for the definition of the 13 fog cases provided in table 3. I understand that only two criteria have been used : an increase in the downwelling infrared radiances representative of a cloud presence and no cloud detected above 200m by the MMCR. However, as mentioned later in the manuscrit, the ceilometer CBH should be used to detect clouds with CBH below 50m or ceilometer data providing a vertical visibility in general informing of fog presence to at least avoid wrongly classifying low clouds (with a CBH < 200 m) in fog if they do not reach the ground.
It would be interesting to specify for each of the 13 fog events identified the maximal CBH or vertical visibility height within each fog event detected by the CT25K to be sure that no potentially « low louds » have been wrongly classified as fog.

The current methodology used in the paper is particularly questioning when looking at figure 3 which shows the ceilometer CBH for an identified radiative fog starting at 2 UTC and ending at 12 UTC. Here the ceilometer CBH is around 1300 m until 3h30 while table 3 specifies a starting fog time at 2 UTC : could you explain how fog could form even in the presence of this low cloud and why the MMCR does not detect any cloud at that altitude ?

The definition of the fog events used in this study is also questionable when it is mentioned line 223 that, for some fog events, no CBH or vertical visibility is provided by the ceilometer : in that case how can we be sure that the increase in downwelling infrared radiances is not due to ice particles instead of fog presence that would not be detected by the ceilometer ?

Temperature lapse rate :
It is well known that MWRs can not provide two independent informations of temperature at surface and 10m a.g.l as their vertical resolution is approximately higher than 50m. This is a common approach to combine the MWR with an in-situ surface station (either the one provided with the HATPRO or an external station as MWRs are often deployed in instrumented sites). This combination is used for atmospheric boundary layer height detection and the detection of stable boundary layer conditions from MWR measurements often based on the temperature difference between a higher altitude level and 50m (and not the MWR retrievals at 0m). In that sense, I think figure 6 is not entirely objective in the way the MWR lapse rate is evaluated and compared against the AERI. However, this figure demonstrates the capability of the AERI to retrieve this lapse rate while the MWR can’t without integrating the surface station. For a more balanced conclusion, I would first recommend to include in figure 6, the comparison with the MWR lapse rate calculated with the in-situ surface temperature station integrated with the MWR (as it is shown in Appendix B).
Additionally, I think the authors should also compare the AERI lapse rate and MWR lapse rates together with higher altitude levels (like T100m-T50m). This is important because even if the figure demonstrates the capability of the AERI to better capture the 0-10m temperature inversion, I am not entirely convinced that the 0-10m lapse rate is the « key » proxy of fog formation. I expect temperature inversions during radiative fog to spread over a larger atmospheric layer, where there is a high chance that the MWR can detect the inversion as well as the AERI and could already be an information sufficient to improve fog nowcasting. As for data assimilation, an improved lapse rate between 0 and 10m seems too resolved compared to the capability of current data assimilation systems (and knowing that surface stations are already assimilated in NWP models, I think it is really pertinent to investigate the MWR capability versus AERI on a larger layer than only 10 m…).

Minor points :

line 84 : large error during thin fogs → large **relative** errors during thin fogs line 154 : plus the current and temperature of Stirling cooler : I don’t entirely understand the sentence as if one word is missing after « current ».

line 388 : It looks like « Results of Appendix B » should appear within parenthesis and the « ... » before and after should be removed.