Reviewers comments are in black text; *our replies are in blue italics*.

Anonymous Referee #1

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Summary:

This paper evaluates the synergies between ground-based infrared, microwave, and WV-DIAL measurements to constrain boundary layer thermodynamic profiles. The focus of the paper is on the additional information contributed by the DIAL as these systems are rapidly advancing and will soon be commercially available. Optimal estimation retrievals from SGP and the Perdigao field campaign are evaluated and compared. The MW instrument is found to add little additional information above the infrared, with the exception of a small contribution to the water vapor retrieval above ~2 km. In contrast, the DIAL adds significant information to the derived water vapor profile, but also helps add information to the temperature retrieval, presumably by constraining the cross-talk between temperature and water vapor sensitivity in the passive observations.

The paper is clearly presented and the optimal estimation methodology is appropriate to address the issues of information content. I have only one major request of the authors below and a handful of minor comments.

Major comments:

The paper focuses entirely on the retrieval diagnostics (error variance, degrees of freedom, etc.). There is no direct validation of the retrieval itself. I would ask that the authors compare the retrieved profiles to the available radiosondes in a statistical manner. For example, does the observed difference between the retrieved profiles and the radiosondes have similar variance/covariance as the optimal estimation estimate. Are the retrievals biased in any systematic way? If there are biases or the estimated co-variances are different than the observed validation, what implications would that have on your theoretical results and the measurement utility.

To address this concern, we have added a new section with a new figure that describes the bias profiles for temperature and humidity from the various retrievals.

Minor Comments:

Line 161 and line 516: 'coadded' – is this a common terminology? I infer that this is incoherent averaging but am unaware of this terminology.

It is a common term in lidar remote sensing. It means to add photons from multiple laser shots as a function of range.

Lines 280 – 289: I can't reconcile lines 280-282 which state the Perdigao had a DIAL and line 290 that state that the vDIAL was not part of the Perdigao campaign. Am I missing something or is this misstated?

The NCAR water vapor DIAL (nDIAL) was deployed during Perdigao, and this was the first campaign that had an AERI, multi-channel MWR, and DIAL all collocated. However, there are currently no plans nDIAL commercially available, but the Vaisala DIAL (vDIAL) will soon be available commercially. Thus, we wanted to evaluate the impact of combining the nDIAL with the AERI and MWR data so we had to use Perdigao, and also to demonstrate the impact of the vDIAL (which has different performance characteristics) which required that we use the SGP dataset.

Figure 1: I find it useful to add the a-priori mean profiles to these kinds of plots. For example, I would like to know if the a-priori includes the inversion or if the remote sensors are able to add that information.

We added the prior profiles used in the retrieval as dotted black lines in panels A and B for figures 1 and 2.

Lines 599-607: It would be appropriate here to mention the PBL targeted observable from the decadal survey and the NASA incubation activities for a PBL mission, which will likely be composed of similar instruments.

Good suggestion: this was added along with a reference to the Decadal Survey