# Response to Reviewers' Comments

***Before addressing the comments, we thank the editors and two (or three) anonymous reviewers for their thoughtful and constructive comments and suggestions, which significantly help improving the quality of our manuscript. In this revised manuscript, we have tried our best as much as possible to address all concerns and have revised the manuscript accordingly. The reviewers' comments are written in plain font, and our point-to-point responses to the reviewers' comments are in italics.***

## Reviewer #2 Evaluations:

"Investigation of near-global daytime boundary layer height using high-resolution radiosondes: First results and comparison with ERA-5, MERRA-2, JRA-55, and NCEP-2 reanalyses" provides validations of simulated boundary layer heights from four commonly used reanalysis products on a near-global scale. The manuscript is nicely organized and comprehensive. Given the important role of reanalysis products in climatological analyses, in energy-focused resource assessments, and as inputs to higher-resolution models, validations such as the one presented here are essential for understanding reanalysis biases and limitations. Comments and suggestions for enhancement of this manuscript

follow.

***Response:*** *Many thanks for your positive recommendations. The concerns have been addressed as possible as we can in this revised manuscript.*

The discussion on the vertical resolution limitations of IGRA and the reanalysis products (Lines 96-99) would improve by including the numerical vertical resolutions (exact, on average, or a range) for each of these products, instead of simply stating that

they are sparse. This information is provided in Section 2, but since the manuscript defines the resolution of GPS RO on Line 92 it would be helpful for comparison to have this information for IGRA and the reanalyses in this location as well.

***Respons:*** *Per your kind suggestion, the statement has been revised as:*

*"Compared with high-resolution soundings, IGRA is sparsely sampled in the vertical (about 10-30 layers below 500 hPa), which could result in large uncertainties in estimating BLH. Likewise, additional errors could be introduced in reanalysis products for their sparse vertical resolutions (about 6-42 layers below 500 hPa), which are equivalent to or bigger than IGRA."*

The authors are disregarding the packaged BLH parameter from MERRA-2 and recalculating BLH in a more similar fashion to the ERA5 definition (Lines 202-207). For the benefit of reanalysis users, it is highly recommended that the MERRA-2 packaged BLH parameter is also validated along with the author-derived version. Can this comparative analysis be included?

***Response:*** *Good point! Following your thoughtful comments, the related contents have been added to this revised manuscript. As a matter of fact, the packaged BLH (in unit Pa) in MERRA2 is defined by the critical value of* heat diffusiv*ity which is different from the method used in present analysis. The results in Figs. S3,S4 show that the packaged BLH in MERRA2 is considerably overestimated by around 0.8 km over eastern China. BLH over other regions are slightly or moderately overestimated by around 50 m.*

*"*In this product, the BLH is packaged and defined by identifying the lowest level at which the heat diffusivity drops below a threshold value (McGrath-Spangler and Denning, 2012). The formula for calculating BLH is as follows:

$$\mathrm{BLH(MERRA2\_packaged)} = 44308 \times (1 - \left(P_{PBLtop}/P_{Surface}\right)^{0.1903} \qquad (1)$$

where $\mathrm{BLH(MERRA2\_packaged)}$ is in unit of meter, $P_{PBLtop}$ the BLH (packaged

parameter in MERRA-2, in unit Pa), and $P_{Surface}$ the surface pressure (in unit Pa). However, to preclude the uncertainty raised by different methods adopted, the BLH by MERRA-2 is extracted by bulk Richardson number method, by utilizing the parameters of horizontal wind, temperature, geopotential height, relative humidity (RH), and surface pressure as inputs. These input data are provided on a grid of 576×361 points with 0.625° longitude and 0.5° latitude resolution and has 42 pressure levels (about 16 layers below 500 hPa), with a temporal resolution of 3 h.*"*

*"In addition, the packaged BLH in MERRA-2 is also evaluated with radiosonde. BLH is as high as 3 km over the TP region at 0600 UTC (Figure S3), corresponding to an overestimation of 0.8 km over this region (Figure S4). Over the rest regions, BLH is slightly or moderately overestimated by around 50 m. However, The BLH difference among various methods could reach up to a kilometer or even more (Seidel et al., 2010), which is probably owing to the variety of kinetic or thermodynamic theories applied in different algorithms."*

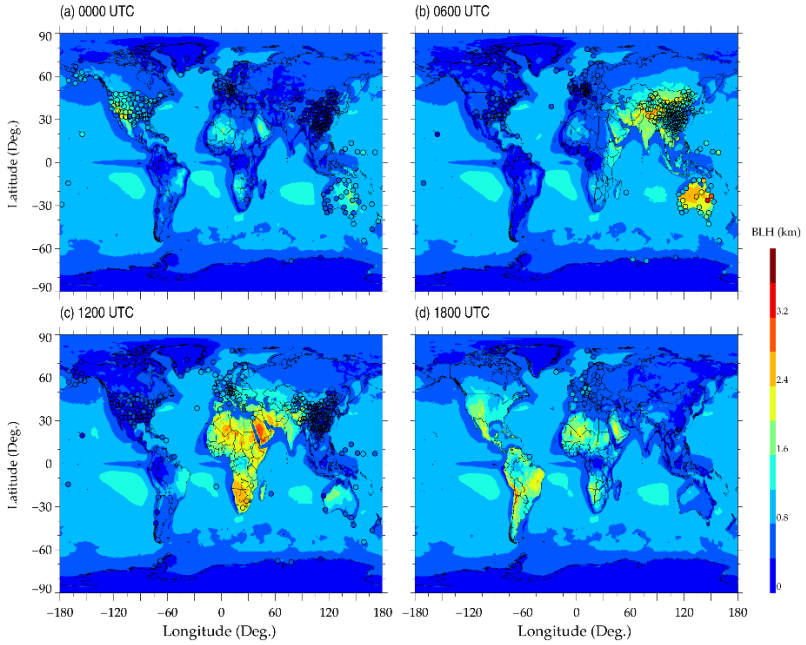


***Figure S3****. The mean packaged BLH in MERRA-2 at (a) 0000 UTC, (b) 0600 UTC, (c) 1200 UTC, (d) 1800 UTC. The dots with gray marginal lines in each map denote the mean BLH derived by sondes.*

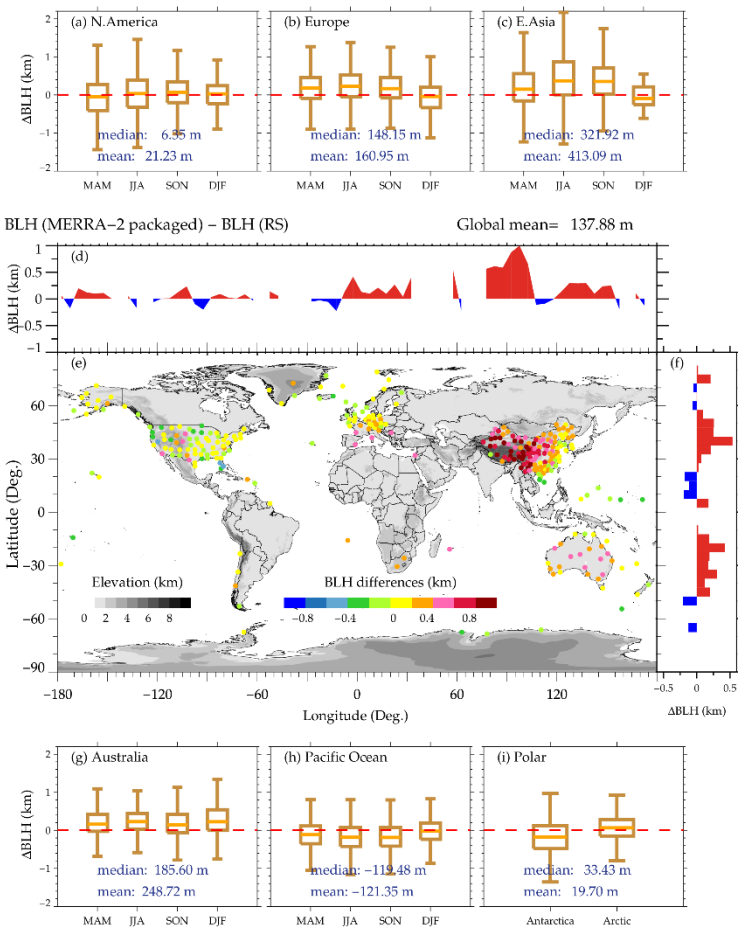


***Figure S4***. *Differences between BLH(RS) and* $BLH(MERRA2\_packaged)$. *The spatial distribution of mean differences is highlighted in (e). Also shown are the distributions of mean BLH differences as a function of longitude (d) and latitude (f). The box and whisker plot of BLH differences over the six regions of interest (i.e., North America, Europe, East Asia, Australia, Pacific Ocean, Polar) over four seasons are displayed in (a-c), (g-i). The seasons are defined as follows: MAM, March–April–May; JJA, June–July–August; SON, September–October–November; DJF, December–January–February.*

Figure 1 is a helpful case study to assist the reader in the methodology. Could ERA5 be included in the graphic as well, instead of a brief mention in the figure caption?

***Response:*** *Per your suggestion, in the present analysis, we use the packaged BLH in ERA5 since it is estimated by the bulk Ri method. In the revised Fig.1, we added black dash lines to mark the BLH derived from ERA5.*

Section 3.3 provides an interesting attempt to correlate BLH with near surface measurements, however it should be moved to a different location in the manuscript, as it does not involve the reanalysis products and therefore does not flow with the surrounding sections. Additionally, the enthusiasm over the correlation results in this section should be tempered. 0.39 is not a "relatively high positive correlation coefficient". Perhaps "moderate" might be a better choice.

***Response:*** *Per your suggestion, section 3.3 has moved forward as section 3.2. The phrase has been modified as:*

*"Moderate positive (negative) correlation coefficients can be noticed between BLH and* $T_{2m}$ *(RH), with mean values of 0.39/-0.51 (Figure 5a, c)…".*

I second Anonymous Reviewer #3 in suggesting that presenting results according to reanalysis minus radiosondes is much more easily understood that radiosondes minus reanalysis.

***Response:*** *Amended as suggested.*

Specific comments:

Line 33: Suggest adding "analysis" after "air quality, weather and climate".

***Response:*** *Amended as suggested.*

Line 85: Suggest rewording "And notable diurnal and seasonal cycles have been revealed" to Notable diurnal and seasonal cycles in BLH variation have been revealed".

***Response:*** *Point taken.*

Line 113: Elaborate numerically on "a rough consistency".

***Response:*** *As suggested, the sentence has been rephrased as:*

*"Some inter-comparisons between instruments or model data, such as radiosonde, CALIOP, and ERA-interim reanalysis have been previously conducted, and a good*

*consistency has been yielded in seasonal and spatial variation (e.g., Guo et al., 2016; Zhang et al., 2016).”*

Line 184: Suggest rewording "As a result, ..." to "Using this definition, 190,013 profiles including soundings launched at both synoptic times and during IOP, spanning January 2012 to December 2019, are used to obtain the BLH in the daytime."
***Response:*** *Done as suggested.*

Line 190: Reword "undergo" to "has undergone".
***Response:*** *Point taken.*

Lines 205, 382, 384, 460: Change "MERR-2" to "MERRA-2".
***Response:*** *Amended as suggested.*

Line 213: Give NCEP-2 its own paragraph beginning here, as was done for the other reanalysis products.
***Response:*** *Point taken.*

Line 363 and Figures 5-8: "Austria" should be "Australia"?
***Response:*** *Yes. Very thanks for the correction. All fixes have been made.*

Line 377: Recommend numerically describing the seasonal differences in the bias.
***Response:*** *As suggested, it has been rephrased as:*
*“The bias seems to exhibit a seasonal dependence, and it is around 62 m larger in the warm seasons compared to cool seasons in both hemispheres.”*

Line 394: Reword "acceptable" to "more in line with the observations". Acceptable is too subjective.
***Response:*** *Point taken.*

Line 425, Figure 11: Change "EAR-5" to ERA5.

***Response:*** *Point taken.*