Response to reviewers

This study evaluates relative humidity (RH) profiles at 47 stations in China using a synergetic multi-source algorithm (dynamic optimal stitching algorithm), comparing the results with radiosonde data. The results suggest that the synergetic algorithm outperforms individual instruments (lidar, microwave radiometer, and satellite) at various altitudes, particularly by leveraging lidar data in the lower atmosphere (<3000 m) and satellite data in the upper atmosphere (>3000 m). The study is valuable and aligns with the scope of the journal. But some concerns should be addressed before acceptance:

1. lines 57 and 60, the definition of MVR/MWR is conflict? Please make it clear, also in section 2.2.
Reply: We have corrected it as “MWR” through the paper.

2. The introduction could be enhanced. Although the introduction discusses the integration of Raman lidar and MWR for simultaneous RH profile retrieval, with multiple references cited, the authors do not clearly distinguish how their proposed method differs from existing techniques. The novelty should be emphasized.

Reply: Yes, some work has focused on the integration of Raman lidar and MWR for RH retrieval. However, most of their algorithms primarily utilize statistical methods, performing data fusion between different instruments based on long-term time-series data from individual locations. While these approaches are suitable for observations at single stations, they lack universality when applied to scenarios requiring data integration from multiple sites or broader geographical coverage. Moreover, replacing instruments or equipment may also introduce additional inconsistencies. Compared to these existing techniques, our new method not only incorporates satellite data but also dynamically determines optimal fusion coefficients, enabling device model independence and geographical adaptability. Thus it eliminates constraints imposed by equipment specifications or observation locations, ensuring broad applicability across diverse scenarios.

We have clarified it in the revised paper.

3. Section 3.1 requires more detailed explanation of the proposed method.

Specifically, the formula for calculating the correction coefficients should be included in the main text, not just in Figure 2. Furthermore, using radiosonde as a reference and applying deviations from other measurements as weighting coefficients—how does this differ from traditional data assimilation methods, and what are the advantages?

Reply: Thank you for the comments. We have included the calculation of the correction coefficients in the main text. Compared to the traditional data assimilation methods, the weighting coefficients are dynamically determined by comparing the deviations from other measurements with the reference of radiosonde, and it can guarantee the independence of each device and observing site. So the new algorithm is real-time calibrated. Besides that, it incorporates the satellite data which is more trustworthy in the higher layer of RH retrieval. Thus it can ensure broader applicability with higher precision.

We have clarified it in the revised paper.

4. Are the biases between other measurements and radiosonde data time-dependent? How do these biases differ from the theoretical measurement errors of the instruments? This can be further discussed.

Reply: Yes, the bias between other measurements and radiosonde data is time-dependent. In addition to the theoretical measurement errors of the instrument, the errors also stem from the other sources. First, although all instruments are co-located in the ground, radiosondes deviate at higher heights, and uncertainty increases if clouds are present. Second, satellites provide gridded data, requiring the selection of ground observation points closest to its grid's latitude and longitude, which introduces uncertainty. Finally, errors during the retrieval process (e.g., neural networks for MWR) are also unavoidable.

We have clarified it in the revised paper.

5. The results from the synergetic algorithm in Figure 5 appear to outperform the best observational data. How can this be explained in terms of the algorithm formula presented in Figure 2?

Reply: Yes, because each single instrument has its limitations. For example, Lidar has low signal-to-noise ratio and is greatly affected by clouds at higher altitudes, while MWR and satellites are passive remote sensing, resulting in high uncertainty in inversion results. So the core of the new-developed synergetic algorithm is to find the optical fusion combing the best performance of each instrument at different heights. For example, the lidar data is incorporated into the synergetic algorithm at lower heights. Thus the synergetic method retrieved RH could provide more accurate results compared to the other single source data. And its performance is superior to the best observational data as conventionally used in the experiment.

6. Some statements are unclear and confusing. For example: "But the signal-to-noise ratio (SNR) decreases with height, thus the threshold of SNR should be set." The purpose of setting an SNR threshold is to ensure signal reliability, not simply because SNR decreases with height. Furthermore, why is the threshold set to 3? Please provide references to support this choice.
Reply: Thank you for the comments. Based on our extensive comparisons with radiosonde data, empirical evidence from CMA's long-term observations indicates that selecting lidar signals with the signal-to-noise ratios (SNR) >3 can significantly improve the consistency between retrieved RH profiles and radiosonde measurements.

We have clarified it in the revised paper.

7. The font size in the figures is too small and should be adjusted for better readability.
Reply: We have redrawn the figures.