Major comments:

C1. The value of K_Index determines the iterative process of Jacobians. However, the threshold of K_Index is chosen by the distributions of the K_Index values for each iteration, which is dependent on the datasets used in the experiment. This affects the suitability of the fast retrieval algorithm. The authors should point this out. More discussions on this inadequacy of the proposed algorithm should be provided in Section 3.3.3 or in the conclusions.

R1: Thanks for the suggestion. The discussion of this issue is provided in Section 3.2.3. For your convenience, the corresponding part in our revised submission is given as follows:

It should be noted that the threshold of K_Index used in the Fast AERIoe algorithm is dependent on the datasets used in the retrieval. They are presented ‘as is’ and are not intended to be directly applied by the reader. We encourage readers to develop their own fast retrieval algorithms based on the atmospheric constituents they intend to retrieve.

C2. Figure 3: I am confused by the X-axis in the two panels. The authors said that IC and DFS change with K_Index are denoted with black lines, while the X-axis represents K_index is red. The illustrations of Figure 3 seems elusive to me and thus further clarification is needed in the figure caption or in the main text.

R2: We appreciate the suggestion. We admit that the logic here is indeed a bit confusing. Fig 3 and the analysis of this picture are reworked, which are given as follows:

The K_Index, ranged from 0 to 260, was obtained by multiplying the a prior profile by different scale factors. This range covers most of the K_Index during AERIoe retrieval process (see Fig. 4). The atmosphere dependent K was computed by LBLRTM with a prior profiles of different scale factors, and the SIC and DFS corresponding to the Jacobians above were calculated by equations (6) and (7), respectively. Fig. 3 shows the curve of SIC and DFS changed with K_Index. Both of them change slowly with K_Index, with the variation of SIC within 13.46% (from 13.89 to 16.05), and DFS within 4.38% (from 3.71 to to 3.88) for temperature and within 12.73% (from 1.44 to 1.65) for water vapor, which demonstrates that SIC and DFS remain almost unchanged on the condition that the value of K_Index is small. This provides an effective means to improve the retrieval speed of AERIoe by recalculating K selectively when X is not changing much or K_Index is small. This could be achieved by comparing the value of K_Index and its threshold at each iteration to determine whether K is recalculated or not.

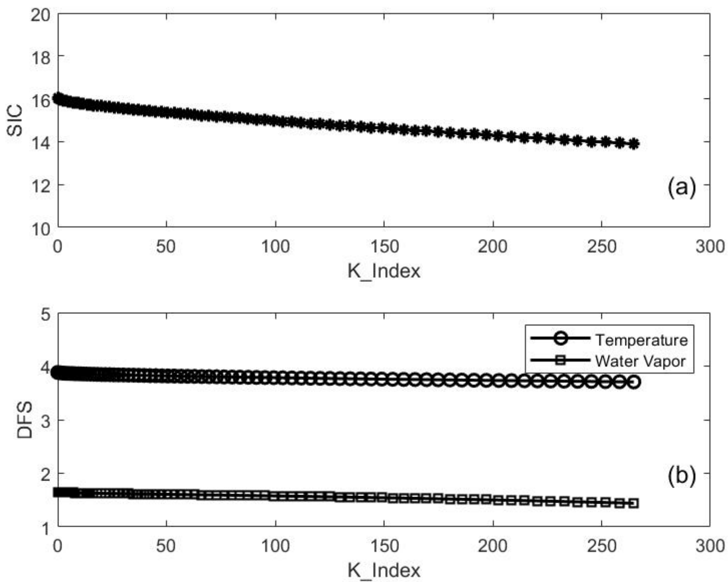

Figure 3. (a) The change of SIC with K_Index. (b) The change of DFS with K_Index for temperature (unfilled circles) and water vapor (open squares), respectively.

C3. 4.2.3 Accuracy:The smoothing error cannot be ignored when retrieved profiles are compared directly to radiosondes. Thus, the radiosonde observations should be smoothed with the averaging kernel to minimize the vertical representativeness error.

R3: Thanks for pointing this problem out. We've made two modifications to Fig. 9. One is that the radiosonde observations have been smoothed with the averaging kernel **A** to reduce the vertical representativeness errors.

$$\mathbf{X}_{sonde}^{smoothed} = \mathbf{A}\left(\mathbf{X}_{sonde} - \mathbf{X}_{a}\right) + \mathbf{X}_{a}, \tag{13}$$

Another modification is the transformation of water vapor into the form of log(ppmv). This is due to the fact that the unit of **K** output by LBLRTM is log (ppmv) during the retrieval, which means that the adjustment of the iterative profile is also in the form of log (ppmv). Therefore, we believe that it is more reasonable to compare water vapor profiles of different retrieval algorithms in the form of log(ppmv).

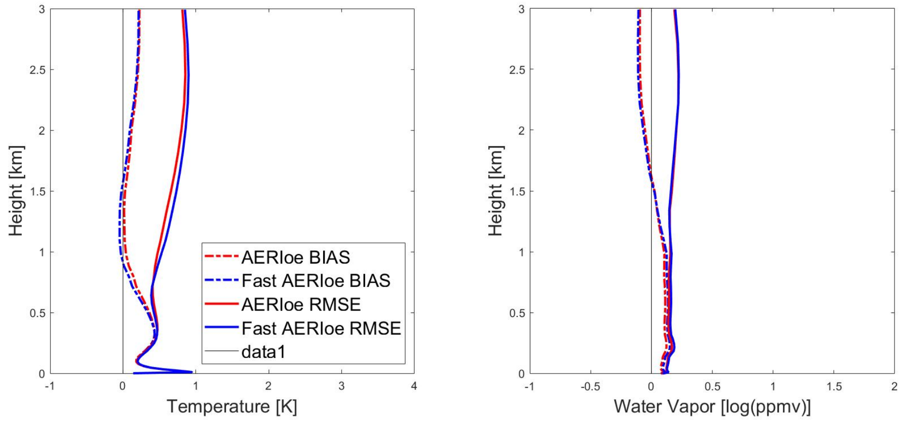

Figure 9. Bias (solid curves) and RMSE (dashed curves) profiles for the comparisons of AERIoe(red curves) and Fast AERIoe (blue curves) retrievals with radiosondes. (Left) Temperature profile, (right) Water Vapor profiles.

C4. One subject where the manuscript lacks is the discussion on the comparison between the retrieval time and the temporal resolution of AERI spectrum. If most of the AERIoe's retrieval time exceeds the temporal resolution, then the importance of the fast retrieval algorithm will be highlighted and vice versa. Please discuss this issue.

R4: Thank you for pointing out the problem. The comparison of the retrieval time with the temporal resolution of AERI spectrum is discussed as follows:

The average retrieval time of Fast AERIoe for the 826 cases used in the study is 3.69 min, which is more than 50% shorter than that of AERIoe, with an average retrieval time of 8.96 min, which is beyond the temporal resolution (about 8 min) of AERI observations. All of the samples of AERIoe consumed more than 8 minutes, while only 10 cases exceeded the temporal resolution of AERI for Fast AERIoe algorithm. Note that the retrieval time is dependent on the computing platform and the method used to compute Jacobians and are not intended to be directly applied by the reader.

Minor comments:

C5. For the title, may be "Ground-based infrared hyperspectral retrievals of temperature and humidity profile based on Adaptive Fast Iterative Algorithm" is better.

R5: Thanks for the suggestion. The title has been modified as follows:

Ground-based infrared hyperspectral retrievals of temperature and humidity profile based on Adaptive Fast

Iterative Algorithm

C6. Line10: “due to” is usually not placed at the beginning of a sentence

R6: Thank you for pointing out the problem. The sentence in line10 is rephrased as follows:

Two methods for retrieving temperature and water vapor profiles from the Atmospheric Emitted Radiance Interferometer (AERI) observations are physical and statistical retrieval algorithms. The physical retrieval algorithm, named AERI Optimal Estimation (AERIoe), outperforms statistical retrieval algorithms in many aspects except the retrieval time, which is significantly increased due to the complex radiative transfer process.

C7. Line12: “part” -> “step”; Line15: “is” -> “was”; Line17: suggest revising to “resulting in an average retrieval time reduction from 8.96 min to 3.69 min” instead of “with the average retrieval time reduced from 8.96 min to 3.69 min”; Line41: “FTIR” -> “The FTIR instrument”; Line45: “which is more advantageous” can be revised to “which makes it more advantageous”.

R7: Thanks for the constructive suggestions to improve our manuscript. We have modified the manuscript as suggested by the reviewers.

C8. Line57: this sentence should be reworked

R8: Thanks for the suggestion. The sentence in line57 is rephrased as follows:

However, the AERIprof algorithm has several significant drawbacks, such as its high sensitivity to the first-guess profile and the inability to provide uncertainty estimates for retrieval results.