

Responses to Reviewers' Comments

We are sincerely grateful to the editor and reviewers for their valuable time spent on reviewing our manuscript. The comments are constructive and valuable, and we have tried our best to address the issues raised by the reviewers in revised manuscript. Please find our item-by-item response (in bold) to the comments (in black) raised by the reviewers, and the paragraphs added in the revised manuscript (in red).

Reviewer #1

General Comments: This paper conducts research on a new temperature profile retrieval method using simulated data from China's new-generation geostationary microwave satellite scheduled for launch. Channel optimization is performed based on information contribution, and an all-weather temperature profile retrieval algorithm is finally established. The proposed algorithm fully leverages the advantages of the geostationary microwave satellite and meets the requirements for rapid operational retrieval. Meanwhile, this paper intensively analyzes the improvement brought by the hyperspectral channels of the geostationary microwave satellite to temperature retrieval results, which provides valuable references for further instrument optimization research. The research outcomes possess strong practical value. Nevertheless, this study needs further elaboration on the variation characteristics of retrieval product accuracy under different weather systems. In addition, the current retrieval accuracy should be compared with existing operational retrieval methods to better clarify the application prospect of the proposed algorithm.

Reply: We thank the reviewer for the valuable time and constructive comments, which have helped us to improve our manuscript. All specific comments have been addressed item by item. In response to the two issues raised in the General Comments, we have further evaluated the retrieval performance under different weather systems by adding a typhoon case study to the 'Results' section. Further details of this case analysis are provided in our responses to the relevant specific comments below. For the second issue, we have also added a comparison with the operational FengYun-3E (FY-3E) vertical atmospheric sounding system (VASS) product. Considering the interpretation of this comparison is closely related to the limitations raised by another reviewer, we have added the following paragraph to the 'Results' section as follows:

Liu et al. (2026) reported temperature RMSEs of 3.07, 3.56, and 3.26 K for the FengYun-3E (FY-3E) vertical atmospheric sounding system (VASS) product under clear-sky, cloudy, and all-sky conditions, respectively, based on validation against radiosonde observations. The lower RMSEs obtained in the present study demonstrate the potential of the proposed algorithm. Considering the used plane-parallel MWRT model cannot fully represent three-dimensional scattering effects, however, the

retrieval errors for real FY-4M observations may be larger than those indicated by the present simulation experiments. Therefore, the actual retrieval performance should be further evaluated using real on-orbit FY-4M observations in the future.

Liu, S., Xu, J., Chen, L., Liu, H., Wang, W., He, J., Zhu, S., and Shi, J.: Comprehensive validation of temperature and humidity profile retrievals from FengYun-3E, *IEEE Trans. Geosci. Remote Sens.*, 64, 4102214, <https://doi.org/10.1109/TGRS.2026.3658572>, 2026.

Specific Comments:

Q1: Line 33-35: “The closer the frequency is to the center line of the oxygen absorption band, the stronger the absorption, and the higher the peak altitude of the weighting function.”

I fail to understand this sentence. Is there a direct correlation between the peak height of the weighting function and strong absorption?

Reply: Thank you for raising this point. We agree that the original sentence could be misinterpreted as implying a simple direct correlation between absorption strength and the peak altitude of the weighting function. We intended to explain that, near an oxygen absorption band, channels closer to the absorption-line center generally have larger absorption coefficients and optical depths, so radiative contributions from the lower atmosphere and surface are more strongly attenuated. As a result, these channels are mainly sensitive to radiation from higher atmospheric layers, leading to higher peak altitudes of their temperature weighting functions. We have revised the sentence in the manuscript as follows:

Near an oxygen absorption band, channels closer to the center line generally have larger absorption coefficients and optical depths, so radiative contributions from the lower atmosphere and surface are more strongly attenuated. As a result, these channels are mainly sensitive to radiation from higher atmospheric layers, leading to higher peak altitudes of their temperature weighting functions (Rodgers, 2000; Aires et al., 2015).

Aires, F., Prigent, C., Orlandi, E., Milz, M., Eriksson, P., Crewell, S., Lin, C.-C., and Kangas, V.: Microwave hyperspectral measurements for temperature and humidity atmospheric profiling from satellite: the clear-sky case, *J. Geophys. Res. Atmos.*, 120, 11334-11351, <https://doi.org/10.1002/2015JD023331>, 2015.

Rodgers, C. D.: Inverse methods for atmospheric sounding: Theory and practice, World Scientific, Singapore, <https://doi.org/10.1142/3171>, 2000.

Q2: All figures are relatively blurry, which affects the analysis of the results. It is recommended to adjust the figure types.

Reply: We sincerely apologize for the insufficient resolution of the figures in the original manuscript. In the revised manuscript, all figures have been regenerated and replaced with high-quality versions. All revised figures have a resolution of 300 dpi. In addition, we enlarged the font sizes of the axis labels, legends, color bars, and annotations to ensure that all information is clear.

Q3: Line 135-137: “the Global Precipitation Measurement (GPM) Microwave Imager (GMI) Level 1C-R Version 05 TB product (Wentz and Draper, 2016) and GMI Level 2 retrieval product (Version 07) derived via the Goddard profiling algorithm (GPROF) (Kummerow et al., 2015).”

Specific descriptions should be provided to illustrate the applications of these two datasets; otherwise, the introduction of the two datasets will appear abrupt.

Reply: We appreciate this helpful comment. The following description has been added to the revised manuscript:

Specifically, ERA5 was used to obtain atmospheric temperature, relative humidity, pressure, SST, and WS; the GMI L1C-R product provides observed TBs served as the observation vector in the subsequent one-dimensional variational (1D-Var) adjustment; and the GPROF L2 product supplies hydrometeor profiles, including CLWC, RWC, and IWC, as part of the a priori state vector, together with auxiliary precipitation information such as SPR.

Q4: Line 158-159: “ S_a and S_y denote the error covariance matrices of and, respectively, with off-diagonal elements set to zero.”

How are these errors defined in this study? Is it static or dynamically variable? The authors are suggested to discuss these issues.

Reply: Thank you very much for pointing this out. We agree that the description of S_a and S_y in the original manuscript was insufficient. We have added the following description to the revised manuscript:

$\mathbf{S}_a$ and $\mathbf{S}_y$ denote the background error covariance matrix and the observation error covariance matrix, respectively. In this study, both matrices were prescribed as static matrices. The standard deviations in $\mathbf{S}_a$ were specified according to the type of state variable. For hydrometeor contents, the standard deviation was set to 0.2 after the logarithmic transformation (base 10). For surface emissivity, the standard deviation was set to 0.5 after the inverse hyperbolic tangent (arctanh) transformation. $\mathbf{S}_y$ was calculated from the instrument noise of each GMI channel (Wu et al., 2026; Yin and Liu, 2017). Although error correlations may exist among different state variables and vertical layers, both matrices were treated as diagonal matrices to improve computational efficiency and numerical stability.

Wu, B., Li, X., Wang, Y., Fan, X., Zhang, P., Chen, L., and Fu, Y.: A prototype precipitation retrieval algorithm for passive microwave observations from the FY-3G satellite, *J. Remote Sens.*, 6, 1057, <https://doi.org/10.34133/remotesensing.1057>, 2026.

Yin, M. and Liu, G.: Developing an a priori database for passive microwave snow water retrievals over ocean, *J. Geophys. Res. Atmos.*, 122, 12960-12981, <https://doi.org/10.1002/2017JD027636>, 2017.

Q5: Line 162-164: “In this study, the observation vector includes TBs from nearly all GMI channels, except for the horizontally polarized channels at 89 GHz and 166 GHz.”

Does this mean that these two channels will no longer be used in subsequent retrieval processes? If so, what are the reasons?

Reply: Thank you for pointing out this unclear statement. The exclusion of the horizontally polarized channels at 89 and 166 GHz was only applied to the 1D-Var adjustment step for constructing the a priori database, and these channels were still considered in the subsequent FY-4M channel optimization and Bayesian retrieval. As shown later in Table 2, the corresponding FY-4M channels at 89.0 and 165.5 GHz are both retained in the final recommended channel configuration. We have added the following clarification to the revised manuscript:

It should be noted that this exclusion applies only to the GMI observation vector used in the 1D-Var adjustment of the a priori database and does not preclude the corresponding FY-4M frequency channels from being considered in the subsequent channel selection and retrieval experiments.

Q6: Figure 3: The interpretation of Figure 3 is unclear. Does the black straight line represent the mean profile? What do the error bars stand for?

Reply: We have added these details to the legend of Fig. 3 and revised the caption of it as follows:

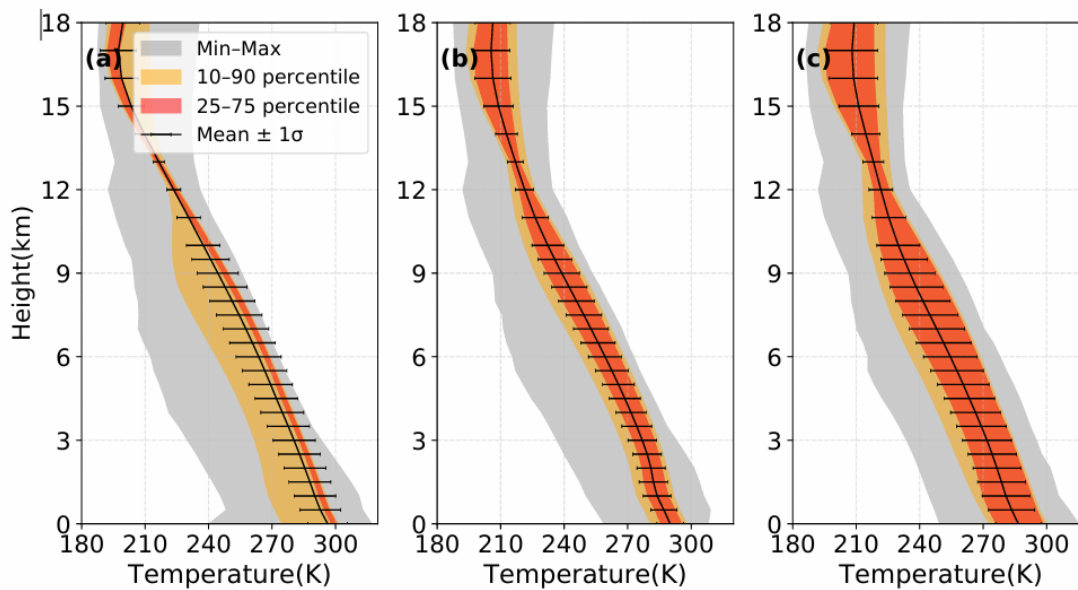


Figure 3. Temperature profiles used for IC analysis over the ocean under (a) clear-sky, (b) cloudy, and (c) precipitating conditions. The grey, yellow, and orange shading indicates the min-max, 10th-90th, and 25th-75th percentile ranges, respectively. The solid black line denotes the mean profile calculated from all samples under each weather condition, and the error bars represent the corresponding standard deviation.

Q7: Line 270: “with the findings of Aires et al. (Kangas et al., 2015)”

The citation format adopted in this manuscript is unconventional, and revision is recommended.

Reply: We apologize for the incorrect citation format in the original manuscript. This citation has been corrected in the revised manuscript. Also, we have carefully checked and revised all in-text citations and reference entries throughout the manuscript to ensure their consistency with the journal requirements.

Q8: Line 339-340: “the temperature bias profiles for different channel configuration schemes are generally distributed around the zero line, with root mean square error (RMSE) below 1 K.”

If the study only focuses on typhoon-affected areas, can the temperature retrieval still achieve such accuracy? The authors are suggested to discuss these points to further clarify the application scenarios of the proposed method.

Reply: We fully agree with the reviewer that the application in typhoon-affected areas should be further discussed. We have added a typhoon case study to the

‘Results’ section of the revised manuscript to further evaluate the retrieval performance under an extreme weather condition:

To further evaluate the retrieval performance under extreme weather conditions, moreover, the simulation results of Typhoon Doksuri at 25 July 2023 were used for a representative case study. The typhoon atmospheric fields were first simulated using the Weather Research and Forecasting (WRF) model, and treated as the reference truth. The corresponding FY-4M channel brightness temperatures were then calculated using the MWRT model and used as the input observations for the retrieval evaluation. As in the preceding simulation experiments, Gaussian random noise with a mean of 0 K and a standard deviation of 0.5 K was also added to represent instrumental noise. Fig. 9 shows the spatial distributions of the reference and retrieved temperature fields at 850, 500, and 250 hPa. Overall, the retrieved temperature fields reproduce the main spatial patterns of the reference fields at the three pressure levels. The warm-core structure near the typhoon center is clearly captured and the surrounding horizontal temperature gradients are also reasonably represented. Fig. 10 further shows vertical profiles of temperature retrieval errors for different channel configuration schemes in the typhoon case. Except for the NHC90 scheme, the biases of the other schemes are still generally distributed around 0 K, with RMSE values below 1 K at most vertical levels. This indicates that the proposed retrieval algorithm can maintain good performance even under strong convective weather conditions such as typhoons. Consistent with the results discussed above, the AC schemes generally show higher retrieval accuracy than the NHC schemes, with smaller RMSE values. This further highlights the important contribution of the hyperspectral channels to atmospheric temperature profile retrievals.

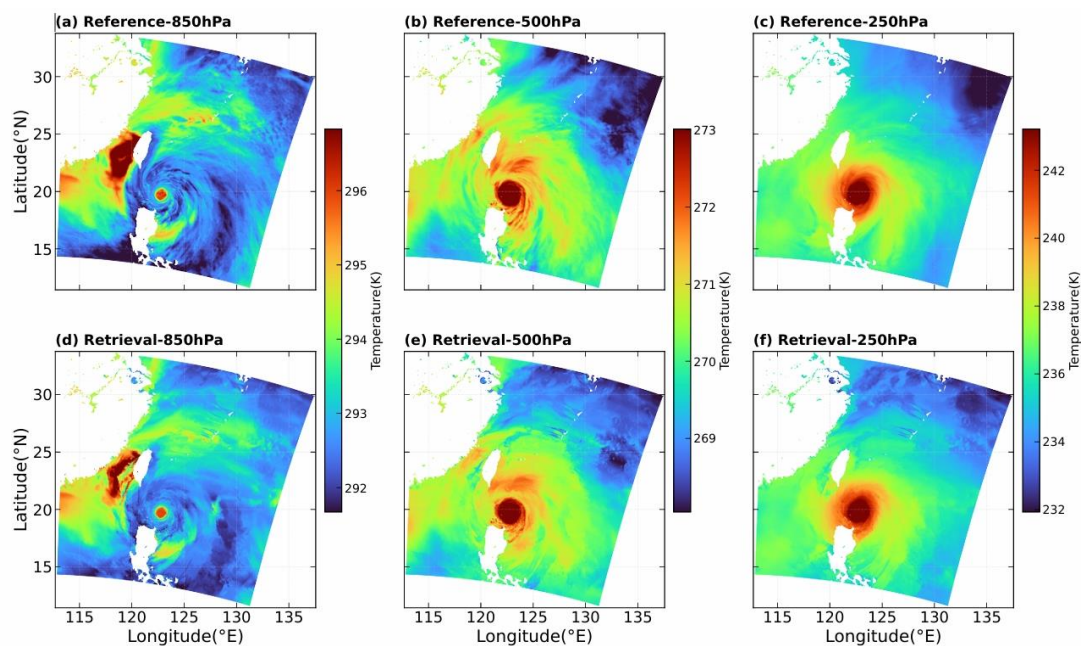


Figure 9. Spatial distributions of the simulated temperature fields by the WRF model (upper row) , and retrieved temperature fields (bottom row) at different pressure levels (from left to right: 850 hPa, 500 hPa, and 250 hPa) for the Typhoon Doksuri case at 25 July 2023.

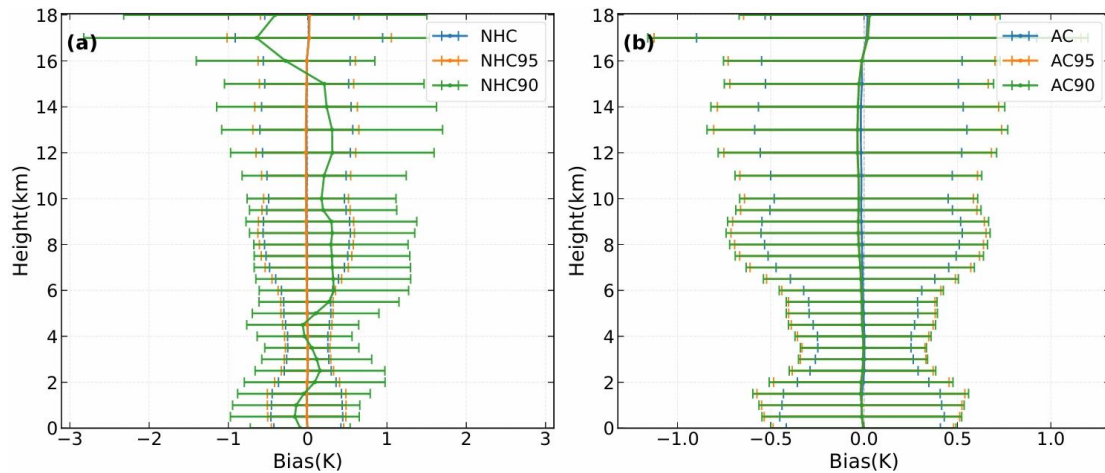


Figure 10. The statistical results of temperature profile retrieval errors for the typhoon case with (a) only non-hyperspectral channels and (b) all channels including hyperspectral channels. Error bars indicate RMSE.

Q9: Line 346-347: “the RMSE values of NHC95 and NHC90 increase by approximately 19% and 47% relative to the full NHC set, respectively. Especially”

Does the value of the optimal channel selection method mainly lie in cloudy and rainy conditions? Is it because the eliminated channels would introduce more errors under cloudy and precipitation circumstances?

Reply: Thanks for pointing this out. The value of the channel selection method does not mainly lie in cloudy and precipitating conditions. Rather, it provides a balance between retrieval accuracy and computational efficiency under different weather conditions including clear-sky. The eliminated channels were excluded mainly because their incremental information contribution was relatively small under the current channel configuration. Of course, under cloudy and precipitating conditions, hydrometeor absorption and scattering can make the temperature sensitivity and brightness temperature interpretation of some channels more complex. The excluded channels might also be linked to the factor that they aren’t helpful for separating cloud and rain signals during temperature retrieval.

Q10: Figure 8: The biggest challenge of retrieval research based on simulated data lies in the inability to reasonably take instrumental errors into account. Will the

retrieval errors in this study be affected by instrumental observation errors? The authors are suggested to discuss this issue.

Reply: We appreciate this suggestion. The instrument noise had already been included in our retrieval experiments, but this was not clearly described in the original manuscript. We have clarified it in the revised manuscript:

To simulate instrumental noise, Gaussian random noise with a mean of 0 K and a standard deviation of 0.5 K was added to the simulated brightness temperatures of all FY-4M channels.

Reviewer #2

General Comments: This manuscript presents a timely and valuable contribution to the field of satellite remote sensing of thermodynamic profiles of the atmosphere, focusing on the upcoming FY-4M geostationary microwave satellite. The authors propose a complete retrieval algorithm with an information-content-based channel optimization scheme, specifically designed for all-weather atmospheric temperature profiling over the ocean. The work is methodologically sound, well-structured, and addresses a critical operational challenge, balancing retrieval accuracy with computational efficiency for a sensor with over 100 channels. The novelty lies in the comprehensive analysis of the FY-4M's unique hyperspectral temperature channels and several high-frequency channels, and in the comparative assessment of their performance under clear, cloudy, and precipitating conditions. The results are promising, showing that the optimized AC95 channel configuration can achieve a favorable balance. I recommend the manuscript for publication after the authors address the following comments and suggestions.

Reply: We thank the reviewer for the encouragement and the valuable comments to improve our manuscript. All the comments have been addressed in the revised manuscript.

Specific Comments:

Q1: The sequential forward selection method in Sec. 2.3 is clearly described. However, the process of treating all hyperspectral channels as a superchannel (Section 3) is a simplification that merits more discussion. While it demonstrates the overall importance of this band, it does not provide a ranking of individual hyperspectral channels. This is a minor limitation, as the operational algorithm (AC95) includes the entire band. I suggest the authors briefly acknowledge this point in the discussion or conclusions, noting that future work might explore internal optimization within the hyperspectral set.

Reply: We appreciate this constructive suggestion. We agree that treating all hyperspectral channels as a superchannel is a simplified approach. Although this treatment effectively demonstrates the irreplaceable value of this band for temperature sounding, it does not provide an independent ranking of the individual hyperspectral channels. We have changed the ‘Conclusion’ section to ‘Conclusions and Discussion’ and added the following statement:

Also, it should be noted that treating the hyperspectral band as a single superchannel effectively demonstrates the irreplaceable value of this band for temperature sounding, but the differences in information contribution among individual hyperspectral channels haven’t been further quantified here. Future work will focus on channel selection within the hyperspectral band, with the aim of identifying the most critical sounding channels without substantially degrading retrieval accuracy.

Q2: Treatment of observation error (sec. 2.3 & 2.4) needs some discussion. The authors state that R_{atm} and R_{surf} are diagonal matrices, yet the final R_f is constructed using a Gaussian correlation matrix with a 1 GHz correlation length. This creates confusion for the reader. Are the forward model errors assumed to be correlated or uncorrelated? I suspect the authors' actual intent is that the diagonal matrices are intermediate constructs used solely to store the estimated error variances for each channel, while the 1 GHz correlation matrix is subsequently applied to impose spectral error correlations, yielding the final full covariance matrix R_f . If this is the case, the manuscript would benefit from explicitly describing this two-step construction process to resolve the apparent contradiction. In addition, please clarify the basis for selecting 1 GHz as the correlation length. Is this value physically motivated (e.g., based on the spectral spacing of the channels or the oxygen absorption line width), or is it adopted from previous studies? A brief justification or reference would suffice.

Reply: We fully agree with the reviewer that the treatment of observation error should be clarified. According to the method by Aires et al. (2015), the two-step construction process of the R_f matrix and the basis for selecting 1 GHz as the correlation length have been clarified in the revised manuscript:

The radiative transfer error covariance matrix R_f was constructed in two steps (Aires et al., 2015). First, the atmospheric and surface modeling error variances were estimated separately for each channel and stored as diagonal matrices, R_{atm} and R_{surf} , respectively. R_{atm} is assumed to increase linearly with frequency and R_{surf} is defined as $\Delta e T_s \tau^2$, where $\Delta e = 0.01$ is the surface emissivity error, T_s is the surface temperature, and τ is the atmospheric transmittance. Second, to represent the spectral correlations of these errors, a Gaussian function truncated at ± 2 standard

deviations, with a correlation length of 1 GHz, was applied to these variance estimates to construct the final non-diagonal matrix R_f .

Aires, F., Prigent, C., Orlandi, E., Milz, M., Eriksson, P., Crewell, S., Lin, C.-C., and Kangas, V.: Microwave hyperspectral measurements for temperature and humidity atmospheric profiling from satellite: the clear-sky case, *J. Geophys. Res. Atmos.*, 120, 11334-11351, <https://doi.org/10.1002/2015JD023331>, 2015.

Q3: The retrieval RMSE for the AC95 scheme during precipitation is reported as within 0.8 K, which is a very good result. However, the text mentions that retrieval errors increase noticeably due to complex scattering. The Bayesian algorithm relies on a comprehensive a priori database that includes simulated brightness temperatures from a plane-parallel MWRT model. This model has known limitations in representing 3D scattering effects. How might these model limitations affect the generalizability of the retrieval to more intense or convective precipitation systems that are not well represented in the training database? A short note on this would be valuable for the reader.

Reply: We appreciate this suggestion. We agree that the plane-parallel MWRT model could not fully capture the complexity and variability of precipitating scenes because of its limitations in representing 3D scattering effects, which may reduce retrieval accuracy. In response to a related comment from another reviewer, we conducted a simulation-based retrieval experiment for Typhoon Doksuri and added the results to the “Results” section. The results show that the main temperature structures of the typhoon were reasonably reproduced. Except for the NHC90 scheme, the retrieval biases were generally close to 0 K, with RMSE values below 1 K at most vertical levels. These results support the potential applicability of the proposed algorithm under simulated strong convection conditions. Nevertheless, this simulation-based experiment does not eliminate the limitation identified by the reviewer. As this issue is also closely related to another reviewer’s request, we have added the following paragraph to the ‘Results’ section as follows:

Liu et al. (2026) reported temperature RMSEs of 3.07, 3.56, and 3.26 K for the FengYun-3E (FY-3E) vertical atmospheric sounding system (VASS) product under clear-sky, cloudy, and all-sky conditions, respectively, based on validation against radiosonde observations. The lower RMSEs obtained in the present study demonstrate the potential of the proposed algorithm. Considering the used plane-parallel MWRT model cannot fully represent three-dimensional scattering effects, however, the retrieval errors for real FY-4M observations may be larger than those indicated by the present simulation experiments. Therefore, the actual retrieval performance should be further evaluated using real on-orbit FY-4M observations in the future.

Liu, S., Xu, J., Chen, L., Liu, H., Wang, W., He, J., Zhu, S., and Shi, J.: Comprehensive validation of temperature and humidity profile retrievals from FengYun-3E, IEEE Trans. Geosci. Remote Sens., 64, 4102214, <https://doi.org/10.1109/TGRS.2026.3658572>, 2026.

Q4: The 14% reduction in computational time for AC95 compared to the full AC configuration is a key finding. However, it is not entirely clear whether the training phase or the retrieval phase is the main cost driver. In operational scenarios, the retrieval is the time-critical step. Could the authors clarify which part of the algorithm benefits most from the channel reduction? This would help assess the real-world operational advantage.

Reply: Thank you for your valuable comment. The 14% reduction in computational time reported in this study mainly comes from the retrieval phase, rather than the training phase, namely the construction of the a priori database. The training phase is an offline process that only needs to be performed once, whereas the retrieval process must be repeatedly performed for each observed pixel. Its computational cost is therefore directly affected by the number of channels used and represents the main computational burden in operational applications. By reducing the number of channels involved in brightness temperature matching and probability calculation, the AC95 scheme reduces the computational cost of each retrieval. We have added the following clarification to the corresponding part of the ‘Results’ section in the revised manuscript:

It should be noted that this reduction in computational time mainly comes from the retrieval phase. The AC95 scheme uses fewer channels in brightness temperature matching and probability calculation, thereby reducing the computational cost of each retrieval while preserving retrieval accuracy.

Minor Technical Corrections:

Q1: The formula of Eq.4 is correct, but it would benefit from a definition of the integration time (t). Is this the dwell time per channel, or the overall integration time? I assume it is the dwell time, but clarifying this in the text would be helpful.

Reply: We appreciate this suggestion. The integration time (t) is the dwell time and we have clarified in the revised manuscript:

Here, t denotes the dwell time for each channel.

Q2: The caption of Fig. 7 says "Similar to Fig. 6, but including hyperspectral channels..." This could be more explicit. I suggest: "Similar to Fig. 6, but ranking all FY-4M channels, with the entire hyperspectral band (52.6-57.3 GHz) treated as a single predefined channel with the highest priority.

Reply: Thank you for this helpful suggestion. We have revised the caption of Fig. 7 accordingly to make the treatment of the hyperspectral band more explicit.

Q3: The English is generally fluent and readable. A few sentences are slightly convoluted; a minor stylistic edit by a native English speaker would further improve clarity.

Reply: We appreciate this suggestion. We have carefully proofread and polished the language throughout the manuscript to improve clarity. All revised parts have been marked in red in the revised manuscript.

Reviewer #3

General Comments: As the world's first passive microwave instrument uploaded on Chinese geostationary meteorological satellite FY-4M, it will open a new era of continuous three-dimensional observations of various key geophysical parameters under all skies. In this study, channel optimization for atmospheric temperature profile retrieval over ocean was performed based on information entropy theory, and then the retrieval was done using a Bayesian algorithm. The topic of this paper has great practical value. Although this research is based on simulation research, it is urgently needed for China's meteorological satellite operations. This new PMW sounder adds some channels never be used before, especially the hyperspectral and Y1&2 bands is uniquely available on meteorological satellites. An original study on its contribution to temperature profile retrieval is conducted in this paper.

Overall, the paper is written smoothly, and the content is organized reasonably. It is recommended for acceptance after minor revisions. Specific suggestions and comments are as follows.

Reply: We sincerely thank the reviewer for the assessment of our work and for recognizing its practical value for future FY-4M satellite applications. We also appreciate the constructive comments and suggestions, all of which have been carefully addressed in the revised manuscript.

Specific Comments:

Q1: The emphasis in the title is on the all-sky atmospheric temperature profile retrieval over ocean.

Reply: Thank you for this helpful suggestion. We agree that the title should more clearly emphasize the focus of this study on all-sky atmospheric temperature profile retrieval over ocean. Therefore, we have revised the title as follows:

A Prototype Algorithm for All-Sky Atmospheric Temperature Profile Retrieval over Ocean Based on Channel Optimization for the FY-4M Satellite

Q2: In abstract: “several high-frequency channels in the high-precision detection of atmospheric temperature profiles over ocean”, gives the specific center frequency.

What is the ‘true value’ used for temperature profile validation?

Reply: Thanks for pointing this out. Regarding the first question, we have revised the abstract to specify the center frequencies of these high-frequency channels as follows:

especially the potential application of its unique temperature hyperspectral channels (52.6-57.3 GHz) and several high-frequency channels (380 and 424 GHz) in the high-precision detection of atmospheric temperature profiles over ocean

Regarding the second question, during the retrieval validation stage, independent test samples were randomly selected from the a priori database, and the atmospheric temperature profiles provided by ERA5 reanalysis were used as the reference truth for comparison. We have added the following clarification to the retrieval validation part of the ‘Results’ section in the revised manuscript:

To evaluate the retrieval performance of different channel configuration schemes in the Bayesian algorithm, 100,000 samples each for clear-sky, cloudy, and precipitating conditions were randomly selected from the a priori database to form an independent test dataset, while the remaining samples were used as the training dataset. The corresponding atmospheric temperature profiles obtained from ERA5 in the a priori database for these test samples were used as the reference truth and compared with the Bayesian retrieval results for validation. In addition, retrieval results using the full set of FY-4M channels are also provided as a reference.

Q3: In table 1: channel 5&6 the characteristics are the same. It is suggested to add one column to specify the purpose of each channel. Based on Table 1, provide the distribution of the weight function for all channels.

Reply: Thank you for the careful review of our manuscript. We have corrected the polarization of channel 5 in Table 1 and Table2, and added a new column to Table 1 to specify the purpose of each channel as follows:

Table 1. Channel characteristics of the FY-4M satellite.

Band	Number	Frequency (GHz)	Bandwidth (MHz)	Polarization	Design Purpose
K/Ka	1	23.8	270	V	Total water vapor sounding
	2	23.8	270	H	
	3	31.4	180	V	Surface radiation correction
	4	31.4	180	H	
V	5	50.3	180	V	Atmospheric temperature profile sounding
	6	50.3	180	H	
	7	51.76	400	H	
	8	52.8	400	H	
	9	53.246±0.08	2*140	H	
	10	53.596±0.115	2*170	H	
	11	53.948±0.081	2*142	H	
	12	54.4	400	H	
	13	54.94	400	H	
	14	55.5	330	H	
	15	57.290334(f0)	330	H	
	16	f0±0.217	2*78	H	
	17	f0±0.322±0.048	4*36	H	
	18	f0±0.322±0.022	4*16	H	
	19	f0±0.322±0.01	4*8	H	
	20	f0±0.322±0.0045	4*3	H	
Hyperspectral	21-32	52.6-55	200	V	Hyperspectral atmospheric temperature profile sounding
	33-109	55-57.3	30	V	
W	110	89.0	3000	V	Surface radiation correction and ice particle
F	111	118.75±0.08	2*20	H	Atmospheric temperature and humidity profile sounding
	112	118.75±0.2	2*100	H	
	113	118.75±0.3	2*165	H	
	114	118.75±0.8	2*200	H	
	115	118.75±1.1	2*200	H	
	116	118.75±2.5	2*200	H	
	117	118.75±3.0	2*1000	H	
	118	118.75±5.0	2*2000	H	
G	119	165.5	3000	V	Quasi-window channel
	120	183.31±11	2*2000	H	Mid-level atmospheric humidity profile sounding and ice cloud detection
	121	183.31±7	2*2000	H	
	122	183.31±4.5	2*2000	H	
	123	183.31±3	2*1000	H	
	124	183.31±1.8	2*1000	H	
	125	183.31±1	2*500	H	
J	126	229	2000	V	Experimental ice cloud remote sensing

Y1	127	380.197±18	2*2000	H	Atmospheric humidity sounding	profile
	128	380.197±9	2*2000	H		
	129	380.197±1.5	2*500	H		
	130	380.197±0.4	2*200	H		
Y2	131	424.763±4	2*1000	H	Middle- upper-level atmospheric temperature sounding	and profile
	132	424.763±1.5	2*600	H		
	133	424.763±1	2*400	H		
	134	424.763±0.6	2*200	H		
	135	424.763±0.3	2*100	H		

Regarding the second question, the temperature-sensitivity distributions of all channels have already been presented in the form of temperature Jacobians in Fig. 4 for the non-hyperspectral channels and Fig. 5 for the hyperspectral channels. To avoid redundant presentation, we therefore did not provide separate weighting-function distributions. Also, FY-4M contains 135 channels, presenting the weighting function of each channel individually would make the figure difficult to read.

Q4: Line 138“... within the full-disk coverage of FY-4M, resulting in approximately 200 million collocated samples”, in this paper you just use the samples over ocean according Line 108-109, right? If it is true, the later prior probability distributions of Bayesian and so on will be explained over ocean.

Is this database newly developed by this paper or already exist? The aim of section Line 151-169 is to adjust the retrieved GPROF hydrometeor products, if this work is not be done by this paper, suggest deletion.

Reply: Thank you for your valuable comment. We have clarified in the revised manuscript that the collocated samples used for the subsequent analysis and retrieval experiments are oceanic samples:

Here ERA5 gridded data were matched to GMI pixels using a nearest-neighbor approach within the full-disk coverage of the FY-4M satellite, resulting in approximately 200 million collocated **oceanic** samples **for the subsequent analysis and retrieval experiments.**

Regarding the second question, the a priori database construction and the 1D-Var adjustment procedure were performed following Wu et al. (2026). Therefore, following the reviewer’s suggestion, we have removed the detailed description of Eq. (2) from the revised manuscript:

The minimization of the cost function was performed following Wu et al. (2026).

Wu, B., Li, X., Wang, Y., Fan, X., Zhang, P., Chen, L., and Fu, Y.: A prototype precipitation retrieval algorithm for passive microwave observations from the FY-3G

satellite, J. Remote Sens., 6, 1057, <https://doi.org/10.34133/remotesensing.1057>, 2026.

Q5: Line 158: S_a is the error covariance matrices of x_a state vector, state variables are correlated, so it is a non-diagonal matrix with non-zero off-diagonal elements.

Reply: Thanks for pointing this out. We fully agree that correlations may exist among different state variables and vertical layers in the real atmosphere, and therefore the background error covariance matrix S_a may contain non-zero off-diagonal elements. In this study, however, following Yin and Liu (2017), S_a was simplified as a static diagonal matrix in the 1D-Var adjustment. This simplification reduces the computational cost of matrix inversion and improves numerical stability. In response to this comment and related comments from other reviewers, we have revised the description of S_a and S_y in the revised manuscript as follows:

S_a and S_y denote the background error covariance matrix and the observation error covariance matrix, respectively. In this study, both matrices were prescribed as static matrices. The standard deviations in S_a were specified according to the type of state variable. For hydrometeor contents, the standard deviation was set to 0.2 after the logarithmic transformation (base 10). For surface emissivity, the standard deviation was set to 0.5 after the inverse hyperbolic tangent (arctanh) transformation. S_y was calculated from the instrument noise of each GMI channel (Wu et al., 2026; Yin and Liu, 2017). Although error correlations may exist among different state variables and vertical layers, both matrices were treated as diagonal matrices to improve computational efficiency and numerical stability.

Wu, B., Li, X., Wang, Y., Fan, X., Zhang, P., Chen, L., and Fu, Y.: A prototype precipitation retrieval algorithm for passive microwave observations from the FY-3G satellite, J. Remote Sens., 6, 1057, <https://doi.org/10.34133/remotesensing.1057>, 2026.

Yin, M. and Liu, G.: Developing an a priori database for passive microwave snow water retrievals over ocean, J. Geophys. Res. Atmos., 122, 12960-12981, <https://doi.org/10.1002/2017JD027636>, 2017.

Q6: In Equ.(5) what is the meaning of A and B ?

Reply: We appreciate this suggestion. The meanings of A and B are consistent with their definitions in the preceding equation. We have added the following explanation to the revised manuscript:

A and B denote the retrieval error covariance matrix and the background error covariance matrix, respectively.

Q7: In Fig.4 the temperature Jacobian spectrum is calculated from just one sample under different weather conditions or the average of many samples?

Reply: Thank you for raising this question. The temperature Jacobians shown in Fig. 4 were not calculated from a single sample, but represent the average results from a large number of samples. Specifically, 1,000,000 samples were randomly selected for each of the clear-sky, cloudy, and precipitating conditions. For each sample, the Jacobians of each channel with respect to the atmospheric temperature profile were calculated, and the results were then averaged within the same weather condition. We have added the following clarification to the revised manuscript:

Figure 4 first shows the atmospheric temperature Jacobians across all non-hyperspectral channels under various weather conditions. For each weather condition, the Jacobians were calculated separately for each of the 1,000,000 samples described above and then averaged.

Q8: Fig.8 is not clear, especially label of 90、95, AC.

Reply: We apologize for the unclear labels in Fig. 8. We have redrawn Fig. 8 by enlarging the font sizes of the labels and legends. We also checked the other figures and ensured that all information is clearly legible.

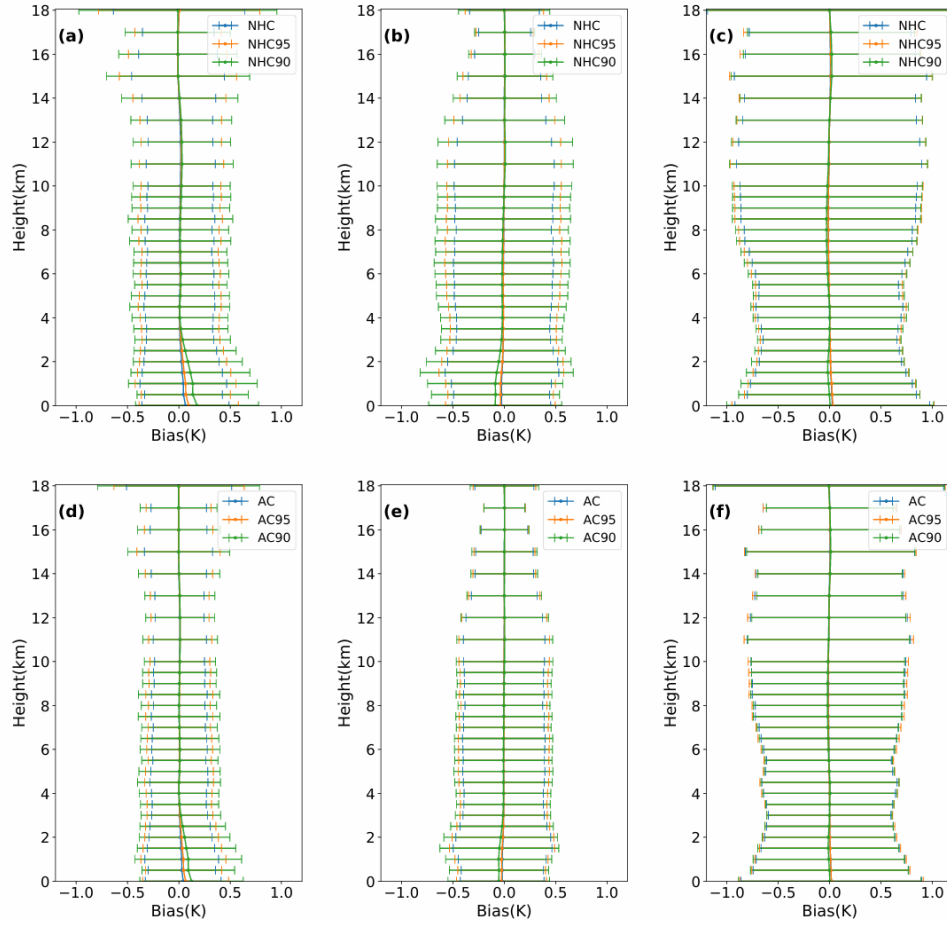


Figure 8. The statistical results of temperature profile retrieval errors for different channel configurations with only non-hyperspectral channels (upper row), and those including hyperspectral channels (bottom row). Columns from left to right correspond to clear, cloudy, and precipitating conditions. Error bars indicate RMSE.