Summary

This manuscript presents an approach to reduce the complexity of radiative transfer modeling in RTTOV v13 by combining statistical thresholding with LASSO-induced sparsity for automatic gas selection and predictor reduction. The method is applied to VIIRS channels, with validation against LBLRTM for transmittance and brightness temperatures.

Major Comments

The manuscript presents a technically sound implementation of LASSO-based sparsity within RTTOV v13, but the scientific contribution and practical validation fall short in several areas.

First, while the authors provide general background on radiative transfer models and cite CRTM and previous versions of RTTOV, there is no direct comparison or benchmarking of their approach against existing fast RTMs. This omission limits the reader's ability to evaluate the benefits or drawbacks of the proposed method relative to established techniques.

Second, the method relies on threshold parameters to determine the relevance of gases, yet there is no guidance or sensitivity analysis provided on their selection. Since the method's validity depends on safely discarding certain absorbers, this is a critical omission. Additionally, the manuscript does not discuss scenarios where the assumptions of the method might break down — for example, in unusual atmospheric compositions, extreme pollution events, or volcanic emissions.

Third, LASSO parameter tuning is conducted via a basic grid search, but the authors do not provide any justification for this choice nor discuss why alternative standard methods (such as cross-validation) were not pursued.

Finally, while the authors claim that their approach leads to a "substantial reduction in computational cost," no quantitative analysis is provided to support this. There are no measurements or estimates of runtime or memory savings, nor is there any discussion of what constitutes an acceptable or unacceptable reduction in accuracy for practical applications. The results show mixed performance — with improved RMSE in some VIIRS bands but increased errors in others — but there is no clear guidance on when the method is expected to perform well or poorly.

Structural Comment

The manuscript currently devotes substantial space in Sections 2 and 3 to background material on radiative transfer theory, line-by-line modeling, and general Fast-RT model formulations. While this content is clearly written and technically accurate, much of it summarizes well-established concepts that are not essential for understanding the specific methodological contribution of this paper. The level of detail presented here feels more appropriate for a thesis or tutorial-style document rather than a journal article focused on a specific methodological advance. To improve readability and focus, I recommend substantially condensing these sections in the main text or moving parts of them to an appendix. This would allow the reader to reach the core methodological development (Section 4) more efficiently, without sacrificing completeness for readers who may need additional background.

Minor Comments

L.10: retrieval -> retrievals

L.28: model -> modeling

L.38: add PCRTM: "Liu, X., Smith, W. L., Zhou, D. K., Larar, A. M., Huang, H.-L., Ma, X., & Strow, L. L. (2006). Retrieval of atmospheric profiles and cloud properties from IASI spectra using super-channels. Atmospheric Chemistry and Physics, 6, 255–265. https://doi.org/10.5194/acp-6-255-2006"

L.39: Even though RTTOV is more efficient than line-by-line models, it remains prohibitively expensive for operational ~~use in small to medium-sized agencies~~ **use cases.**

L.42: RT model~~, similar to models based on neural networks~~.

L.43: model ~~further~~ less computationally

L.44: These decisions must account for the multitude of possible combinations and trade-offs, ~~which is why large meteorological agencies rely on~~ **and are typically made by** expert teams ~~to identify an optimal configuration of parameters and gases for the Fast RT model~~.

L.50: cite or remove 'various large-scale applications'

L.51 – 57: mentiones multiple papers that perform 'variable selection' without much context. Not sure what to do with this information.

L.58: specify what those ‘parameters’ are in Fast RT models.

L.64: Has LASSO been applied to other RTM models?

L.65: Remove section 1.1 title.

L.82: what is ‘carbon powder’?

L135: ml is ~~de~~ **the** number

L245: how that value chose? mse(lambda) < **2** mse(0)

L291 – 299: move to appendix

L375: “This suggests that the inclusion of statistical thresholds and LASSO regression in RTTOV v13 slightly affects the accuracy of the transmittance approximation, either improving or worsening it, but the overall variation in error remains negligible.” The error in M7 and M8 increases by about 40% with the LASSO method. Why is that negligible?

L395: Don’t understand the ‘order of magnitude’ comparison. For M10 the error increases from 0.89 to 1.4

L406: “These findings suggest that while the proposed methods are generally comparable to RTTOV v13 in terms of accuracy, there are specific channels where improvements or further adjustments in the statistical threshold parameters may be necessary to enhance precision if needed.” This work should have been part of this study.