We thank the Referee for the review of the manuscript, and valuable suggestions to improve it. Below you can find the original comments from the Referee (marked with boldface) and our responses to those.

This manuscript describes the application of a statistical method of reducing errors in a parameterization. The statistical method is trained on a large dataset of more accurate solutions, and then applied to an independent set of solutions. Although the method reduces mean squared error by an order of magnitude, the cost is a large fraction of the cost of the accurate solution.

Major Comments.

I do not find the choice of the sectional ARG scheme for both the accurate and approximate models to be optimal. The modal ARG scheme is used much more extensively in global and regional models, and hence would be of greater interest to the modelling community. Of greater concern is the use of the ARG scheme for the accurate model. Because it relies on many of the same assumptions as the modal ARG scheme, it is not necessarily more accurate, except perhaps because of truncation errors in the sectional scheme when the number of sections is small. If you really want to reduce the number of sections, why not use a modal scheme. A much more valuable test of the methodology would be to use a detailed numerical model of aerosol activation to provide the reference solutions. I can provide such a numerical model, which is orders of magnitude slower than the sectional parameterization, but also much more robust, complete, and flexible.

The aim of the paper is to propose a novel, computationally low-cost scheme for compensating the approximation errors in simulations and introduce the approximation error approach to the geoscientific modelling community. Here we employ the method to reduce the model error that is caused by using coarse size resolution instead of a sufficiently dense size resolution in the sectional ARG model only as one example of the possibilities of what the method can be used for. The proposed approach could be used similarly to treat modelling errors in modal parameterizations, which we think is an insightful suggestion. However, the procedure would be very similar if, say, a modal parameterization was compensated to match an explicit numerical model. We consider it a subject for a future study.

The selection of the present test problem was also motivated by our plans to extend the approach for compensation of the approximation errors in a computationally low-cost, coarse size resolution sectional aerosol model with reduced number of variables. If the approximation errors in the low-cost model could be compensated for, it would enable the use of the sectional aerosol model in large-scale simulations.

We do not agree that the cost of compensation is a large fraction of the cost of the accurate solution. The reduction in computation times of the approximation error compensated models was in the range of 31-89 % compared to the run time of the accurate model. If an explicit numerical model was used, the reduction in computation times compared to the accurate model run would be even more significant.

The other major comment is that I would like to see an explanation for why the Random Forest method reduces errors. Presumably it is because it brings training data to the scheme, but perhaps a statement about how the training data provides more information about parameter dependencies that the approximate model misses.

In the approximation error approach, the accurate model output is decomposed into two parts: the output of the approximative model and the approximation error part. The proposed approximation error compensation scheme constructs a computationally low-cost stochastic predictor model for the approximation error part. The predictor model is constructed based on a training set that includes statistical information (e.g. correlations between the approximation error and model input variables) about the approximation errors thus adding more information into the approximative model outputs and reducing the errors. It should be noted that instead of random forest model any other suitable model, such as a neural network, could have been used as well. In this paper, the random forest model was selected based on good performance in preliminary tests and computationally low-cost evaluation.

Minor Comments

Page 2553, Line 13. Replace is increasing with has increased.

Corrected as requested.

Page 2553, Line 16. Remove comma.
Comma was removed.

Page 2553, Line 17-20. I know of only one climate model that uses a sectional activation parameterization. Modal aerosol schemes, i.e., Abdul-Razzak and Ghan (2000) and Fountoukis and Nenes (2005) are used much more extensively. Note that since the latter scheme cited is for modal, if you want to cite sectional schemes you should cite Abdul-Razzak and Ghan (2002) and Nenes and Seinfeld (2003).
We will use the correct references in the revised paper.

Page 2554, line 3. New paragraph beginning with The main
Corrected as requested.

Page 2554, line 25. Remove comma.
Comma was removed.

Page 2555, line 11. Remove of.
Corrected as requested.

Page 2555, lines 26-28. The approximation errors for the parameterization are not just caused by the limited number of sections. The key challenge of all activation schemes is determining the maximum supersaturation. If that is not diagnosed accurately the number of sections makes little difference. Why is this application expressed in terms of number of sections? In is full numerical model the number of sections is the only remaining approximation, but that is not true for activation parameterizations. Why not just say that the parameterization produces an approximate estimate with errors due to a number of assumptions and approximations?
See reply in major comments.

Page 2558 line 9. Add a after as.
Corrected as requested.

Pager 2560. A motivation for the distinction between Algorithms 2 and 3 is needed. I had to reread the text to find that Algorithm 2 is for training, and Algorithm 3 is for application.
The Algorithm 2 caption "The modified algorithm for growing a Random Forest model." was changed to "The modified algorithm for training a Random Forest model." to make it clearer that the Algorithm 2 is for training an RF model and Algorithm 3 for evaluating a model.

Page 2562, line 8. For completeness list the modal schemes Abdul-Razzak and Ghan (2000) and Fountoukis and Nenes (2005). I strongly urge you to focus your analysis on a modal scheme, as the sectional schemes are not used in climate models (I know that sectional models are used in some global aerosol models, but the computational cost of sectional models is so high that they are never used in climate simulations, which are run for one hundred years or more.
The suggested references were added.

Page 2562, line 9 page 2563, line 17. Now I see why the sectional parameterization Abdul-Razzak and Ghan (2002) was chosen for the analysis.

Page 2563, lines 20-25. Why is a many-bin version of the Abdul-Razzak and Ghan (2002) sectional model chosen to be the reference model? It is still a parameterization that relies upon many assumptions to determine the maximum supersaturation. Is there any evidence that it is more accurate with 70 bins than with 7? On what basis do you claim that the 70-bin ARG parameterization is sufficiently accurate. A more accurate reference model is needed here, to really put your correction methodology to the test. I can provide you with a numerical model that solves the time-dependent Kohler equations with a large number of bins. I urge you to use it or a comparably accurate model.
The aim of the paper is to propose a novel scheme for compensating the approximation errors in simulations and introduce the approximation error approach to the geoscientific modelling community. The approach proposed is rather general and the test case to be evaluated was chosen to be a simple one. The proposed approach was applied only to the errors due to the small

number of bins approximation in the Abdul-Razzak and Ghan sectional parameterization. The extension of the approach to other parameterizations is straightforward. By "sufficiently accurate" we mean that the results do not significantly change if more bins are added to the parameterization. This "idea" is based on numerical analysis point of view, i.e., assuming that the model output has a limiting estimate and that the numerical approximation approaches asymptotically the limiting estimate as the number of discretization points is increased. We clarified the selection of the accurate simulation model by adding the sentence: "By sufficiently accurate, it is meant that the output of the parameterization do not significantly change if more size sections were added."

Page 2565, line 17. Both the accurate and approximate models use the ARG parameterization. The choice of words is only appropriate if the accurate model is based on numerical simulations rather than the ARG parameterization.
The authors have clarified this by adding a sentence: "As the aim of the simulations was to compensate only for the errors caused by the coarse size resolution, the model based on the ARG parameterization with dense particle size resolution is in the sequel referred to as the accurate model."

Page 2568, lines 5-9. These reductions are not impressive to me, particularly since the accurate solution is not necessarily that accurate. I suspect the results would be much more impressive if a full numerical model is used for the accurate solution. It is much slower, so the speedup would be considerable. It remains to be seen how much more accurate the RF model would be.
See our reply to first major comment.