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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Aerosol model selection and uncertainty modelling by adaptive MCMC technique" *by* M. Laine and J. Tamminen

Anonymous Referee #2

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Summary

This paper presents a new method for considering model selection as part of statistical inversion algorithms. The technique is based upon Markov chain Monte Carlo methods and is applied to retrieval of line densities from the GOMOS instrument. Much of the paper is a summary of this approach to inverse modeling, which is generally applicable to many problems in geophysics. As such, this work benefits from a sound introduction to Bayesian methods. In contrast to Referee 3, I think Sections 2 and 3 are warranted, and they do a good job of balancing a rigorous description of the approach with appropriate references to details of the underlying theory and practice in existing literature. While there are some exceptions, noted below under "Minor comments" and also mentioned by Referee 3, and further explication of such detail will surely be beneficial, I feel the manuscript primarily needs to address some larger science-based concerns in order to fall securely within the scope of ACP. Specifically, the ability of the proposed technique to improve our understanding the chemical state of the atmosphere should be explored through: (1) evaluation of the accuracy of the retrievals obtained using the proposed method and (2) discussion of the possible physical interpretations of the resulting selection of aerosol models.

Major comments

1. As shown in Fig. 5, the technique presented here clearly gives different retrieved line densities than would be obtained using any single model of aerosol extinction. What remains to be demonstrated is whether (or how much) these retrievals are actually improved over a single-model based statistical retrieval, or over the existing operational GOMOS retrieval. The authors could measure such an improvement by comparing the retrieved line densities (or associated constituent densities) to those observed from independent measurements, or to pseudo observations simulated with the forward model from a known constituent profile (i.e. the twin-experiment framework for evaluating inverse modeling techniques). Such comparisons seem to be a basic requirement of validating new inversion methodologies.

2. What can be learned about the physical nature of the atmospheric aerosol distribution from the posterior model probabilities? For example, are the individual aerosol models representative of particular types of aerosols (e.g., PM2.5 vs dust) or are they simply statistical fitting parameters? What is the significance of the variation of the preferred aerosol model as a function of altitude?

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Minor comments

1. The abstract could use expanding. There is room for more precise descriptions of the physical problem being addressed and the aerosol models being considered (i.e. what data? error estimates of what? what type of formulations? what are the parameters? what is the aerosol model?).

2. Vanhellemont et al. (2006) found that the GOMOS retrievals above 30 km were not significantly influenced by choice of the aerosol model. How is this reconciled with the results shown here (i.e., Fig 3)?

3. There are a few places where technical aspects could use further clarification:

   - "burn-in time" on page 10798
   - "minimum χ^2 statistic criteria"
   - Although a reference is given, it would be helpful to say what a "weakly informative inverse Gamma" (page 10805) prior is, and why it was selected.
   - 10804: "positivity prior"
   - 10801: Please explain the factor of 2.4^2 in the definition of s. How critical is definition of s to the results?

4. 10806, 1st paragraph. A reference for the operational GOMOS algorithm should be included here. The difference between the results obtained via the operational method and the method presented here should be expanded upon at this point and in the conclusions.

5. 10804: Despite reference to the supporting literature, an expanded introduction of the underlying physics of the GOMOS application, and the nature of the inversion problem, would be appreciated.

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6. 10804: Description of the aerosol model parameterizations is not clear. How could the second model, which has 3 free parameters, be fit to a single value of the aerosol extinction at 500 nm? I think this is probably just a technical error: do you mean to say models 1 and 3 were fit at 500 nm, and models 2 and 4 were fit at the three wavelengths? Overall, the actual equations and parameters, as given in the heading of the figure panels in Fig 6, should be presented in the text at this point, preferably as an equation array.

Technical comments

1. 10791, line 1: “on” –> “to”
2. 10791, line 2: “motif” –> “motive”?
3. 10792, line 24: “incorporated statistically correctly” is awkward
4. 10792, line 26: suggest omit “the”
5. 10794, lines 1, 10: these introductory sentences seem overly simple.
6. 10794, line 26: missing a comma and “the” before “symbol”
7. 10808, line 1: “aerosols” –> “aerosol”
8. Fig 2: The caption is not clear. Also, here the aerosol parameters are a_0, a_1, and a_2, while in Fig 6 they are b_0, b_1 and b_2.
9. Fig 4: “witch” –> “which”
10. Figs 4,5,6: could the titles of the panels (i.e., NO2, Air, etc.) be made larger, and units provided directly on the axis?

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