

# ***Interactive comment on “Bayesian statistical modeling of spatially correlated error structure in atmospheric tracer inverse analysis” by C. Mukherjee et al.***

## **Anonymous Referee #1**

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### **1 General comments**

This paper presents an original vision of a classical problem: the “inversion” of surface fluxes based on atmospheric measurements. Two innovations in this application can be seen: a MCMC method for the computation of the posterior probability density, and the representation of observation error correlations by the direct assignment of a tunable precision matrix. The method is illustrated in the case of carbon monoxide with real MOPITT measurements. The paper is well-written and clearly deserves publication in this journal. However, some limitations should be lifted before then. The first one concerns the inversion set-up for the MOPITT illustration, that yields overly-optimistic

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posterior uncertainties. The second one is the absence of any discussion about the computational performance of the MCMC approach for real-size application: one may doubt that Monte Carlo methods are appropriate for very large ( $\geq 10^5$ ) state vectors, while coarse-resolution state vectors (like the one defined for the MOPITT illustration) induce aggregation errors.

## 2 Detailed comments

- p. 1672, l.11: ‘know’ should be ‘known’
- p. 1674, l.23: The time scale for this numbers should be given. If they refer to a year worth of data for instance, the four powers of ten should be at least multiplied by 10 for real applications ( $m \approx 10^5 - 10^6$ ,  $n \approx 10^2 - 10^5$ )
- p. 1675, l.24: disproportionate with respect to what?
- p. 1676, l.26-28: is the computational situation really better with MCMC?
- Eq. (4):  $\tau_c$  has not been defined
- p. 1681: the sentence is not clear. Why are the missing rows interpolated and does this procedure introduce any artificial information to the inversion system?
- p. 1682, l.16: the expression ‘non-spatial’ here relates to the absence of spatial correlations but may be not clear enough for some readers. The distinction with the CAP vs. GP comparison of Section 2.2 should be made more obvious.
- Section 3.1: Only 15 degrees of freedom for the CO emission fields are adjusted by the 9-month inversion. Doing so, the system combines temporal and spatial aggregation errors, even though they do not seem to be taken into account. It

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- should be stated at the beginning or at the end of the section that the set-up defined is very crude.
- p. 1684, l.22: two-sigma errors bars are shown, but one-sigma figures are more common in this field. This should be mentioned.
  - p. 1685, l.12: ‘accuracy’ should be ‘precision’.
  - p. 1686, l.26: it would be interesting to report the equivalent e-folding lengths of the set-up.
  - p. 1687, l.12: it may be appropriate to warn the reader that some of the correlated structures may be caused by the very coarse space-time resolution of this inversion (that may induce severe aggregation errors).
  - p. 1688, l.2: the authors seem to suggest that the previous studies missed the obvious. The computational cost of MCMC methods has actually prevented some scientists from using it.
  - p. 1688, l. 15: the effective dimension of the CO<sub>2</sub> application is even larger than for CO because the fluxes are much more diffuse and can be negative. It is not clear from the paper how MCMC methods can be efficiently applied in this case.
  - p. 1690, l.16: this was debated in the statistical community decades ago, but a prior is always informative, to some extent.
  - p.1692, l.14: extra ‘.
  - References: Parasite numbers appear at the end of each citation.
  - Figure 1: it would be good to give the mesh size (in km) in the legend, together with the found values of  $\rho$  and  $\tau_c$ .

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- Figure 7: it is confusing to see the truth plotted on a bar that represents the prior credible interval. At least this is not consistent with the way the posterior results are represented.
- Figure 7: the posterior error bars are way too small for this observation type, which indicates that the inversion configuration is not well defined.
- Figure 8: Same. As a result, NS posterior results for source category 7 are not statistically consistent with the truth.
- Figure 12: the squares are undefined here.

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