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Geoscientific Model Development Discussions

Interactive comment on "Bayesian spatiotemporal inference of trace gas emissions using an integrated nested Laplacian approximation and Gaussian Markov random fields" *by* Luke M. Western et al.

Anonymous Referee #2

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Main comments: This article describes and evaluates a new approach to hierarchical Bayesian inversion that can improve the computational efficiency of the posterior sampling of trace gas emissions and hyperparameters used to define their prior probability distribution (pdf). While the proposed method is appealing to address current challenges in regional greenhouse gas inversions when a general framework is adopted (e.g., non-gaussian pdf, unregular mesh), the paper lacks a sufficient level of details in the description of the technique. Those methodological details are of significant importance for a journal such as GMD, which focuses on technical aspects of model

developments. Also, since the integrated nested Laplacian approximation seems to be the core of the methodological contribution of this paper, it is difficult to understand why its description is missing (even if proper references are given). Provided such information is added to the manuscript (see specific comments below), this article should be suitable for publication in GMD.

Specific comments: - P3, L9: "...which maps the surface emissions (x) to the measurements...". The variable x was not defined here. - P3, L16: I do not understand the discussion about the change of variable in x (which is simply a shift in the distribution), and in particular how this relates to the positiveness of the fluxes. It seems one issue here could be that a log-normal distribution may be more suitable than a Gaussian one (if positiveness needs to be enforced). Apart from a re-centering of the prior pdf around zero, I do not see what the transformation achieves. Please clarify. - P6, L1: "...measurements made at a given time are independent...". Would it be easy to generalize the approach for spatially correlated observations at a given time? This, for instance, would be useful for inversions based on satellite measurements. - P6, L6-9: Di you mean "emissions" instead of "measurements" here? You mention measurements (y) but then refer to emissions (x) in the equation. Please clarify. Also, could you briefly comment on the form taken by the error covariance in (8b)? For instance, the presence of phi here and its role is not very intuitive. - Section 2.5: This section should be entirely rewritten and much more details have to be provided. For instance, please explain the posterior sampling approach adopted here as well as the principle of the integrated nested Laplacian approximation used. This seems to be the core of the methodological contribution of this paper.

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