**Review of:**

**“Approaches in Highly Parameterized Inversion – bgaPEST: A Bayesian Geostatistical Approach Implementation with Pest – Documentation and Instructions”**

**Overall Review**

In this work, Fienen et al. describe and provide instructions for use of a new computer code allowing the use of the Bayesian Geostatistical Algorithm (as originally formulated by Kitanidis and refined by Cirpka, Nowak, et al.) for performing highly-parameterized inverse modeling (imaging). Bayesian tools have many benefits relative to traditional parameter estimation strategies, but have seen relatively limited adoption by practicing hydrogeologists. As such, this work represents an important contribution that can help to move some traditionally “research-focused” tools into the realm of practical application

In reviewing this work, I focused primarily on reviewing the theory and readability of the documentation. With regards to this part of the work, I feel that only minor edits are necessary. I have suggested some edits below, which I believe will help to both improve the readability and rigor. In addition, I have a few thoughts / suggestions on the capabilities of the code that may improve its utility, which are discussed below.

I wish the authors the best of luck with editing this manuscript which – along with the accompanying code – will help to bring some important research-grade tools into practical application.

**Minor Concerns**

I have included numerous small comments within the PDF manuscript. Below I highlight a few general “theme areas” that represent broader-scale comments about the manuscript or ideas for program extensions.

1) Introduction – The introduction is nice as is, but it may help to present a simple example here in order to engage the reader early on. It is also much easier to discuss geostatistical concepts and inverse modeling in the context of a presented example with pictures.

2) Choices on the bgaPEST control variable structural\_conv (p. 14-15): Some of this seems somewhat arbitrary, and may not give good convergence with the given default values. The key problem is formula 4. A relatively small default value is given (0.001), but since the metric considered is not unitless, it may perform well in some cases and poorly in others. I have included a suggestion on how to change the computation of this metric in the PDF comments.

3) Parameter Anisotropy – It would be extremely useful (and not too difficult to code, maybe) if users were given the ability to decide whether or not parameter anisotropy variables are allowed to be optimized in addition to variances. Also, would it not be possible to include a second rotation so that non-horizontal layering could be considered (e.g., a y-z rotation angle?)

4) Two notable techniques that help to make bga algorithms practical for large-scale (e.g., 100K + parameters) inversion on non-parallel computers are circulant embedding / fast fourier transform techniques for computing Toeplitz matrix-vector products (see, e.g., the work of Nowak), and adjoint-state Jacobian calculations. It sounds to me from reading the documentation that the former is not implemented. The authors may consider discussing these techniques, though, and/or discussing in what future software they may be implemented. As for the adjoint-state Jacobian calculations (p. 19), it may be a good idea to just direct readers to a few relevant publications on the subject, in case they are faced with large-scale problems and/or have an intellectual curiosity in the area.

5) In the original theory of Kitanidis, no prior information was assumed about betas. Is it possible / planned for a future version to implement this formulation (i.e., where Q\_beta,beta is replaced with 0 and similar edits to the formulas are made elsewhere)? It is not a major concern, since many users will probably **want** to specify some degree of prior information about assumed mean-values within facies, for example.