Comments on "Generalized Background Error covariance matrix model (GEN_BE v2.0)" by G. Descombes, T. Auligné, F. Vandenberghe, and D. M. Barker

This paper gives a detailed description of the GEN_BE 2.0 system including theoretical discussion, equations, options and the code. I found this paper is very useful for the readers who wants to learn and use this tool and for readers just want to learn more details on how to model a BE in variational analysis. Those details are necessary information when apply this tool in data assimilation but, on other hands, I think those details make this paper hard to follow and read through. My suggest is to do a major revision of the paper structure: put all the details on code and namelist options to the appendix as reference for readers who want to apply the tools but leave the theoretical analysis, practical discussions, and test results of modeling BE in the paper.

Detailed comments:

1. Page 2, Line 14-16: the statement on a "multivariate approach" is not clear. It can refer to adding new control variables for the cloud analysis, or to the GEN-BE for providing covariance among all the analysis variables.
2. Page 3, Line 2: change "or the UK Met office" to "and the UK Met office".
3. Page 3, Line 3: add "," after "techniques".
4. Page 3, Line 6: change "that minimize" to ", to minimize"
5. Page 3, Line 9-12: More available observations are not the only reason why cloud and chemical data analysis are needed. I think the needs of improving the cloud forecast and chemical (pollution) forecast are major drivers of the development of the cloud and chemical data assimilation.
6. Page 3, Line 27: "the two first sections". This is confusion.
7. Page 4, Line 14: Please give more details on which kind of "results" author will give in the Appendix to give reader an idea what in the Appendix.
8. Page 5, Line 9: "nor be stored" changes to " and to"
9. Page 5, Line 12: I think "parameterized" has the same meaning as "Modelling" in the next line. If this is the case, please use the "modeling" just as other part of the paper.
10. Page 5, last line" "linear operator" changes to " linear observation operator"
11. Page 6, equation 4. This equation can be expressed as square root of B equals to …
12. Page 7, Line 7: "and make to" changes to " and to make"
13. Page 7, Line 8-10: "the new version … a new model of B". I don't understand what this sentence means.
14. Page 7, Line 20: add 'the' before 'modeling'. The same line: add "background" before "error covariance" and change "become" to "becoming'.
15. Page 8 Line 4-8: please list the functions of each stage more clear the specific to help readers go through the details of each stage smoothly .

16. Page 8, Line 10-11: "sample of model forecasts" changes to " sample of perturbations"
17. Page 8, Line 20: " an ensemble of" changes to " ensemble perturbations of"
18. Page 11, Line 2: "After", should be "when"
19. Page 12, Line 24: "we estimate length scales" means horizontal or vertical or both. Needs to clear define which part of length scales here and in other parts of the paper.
20. Page 13, equation 8. Please define "r"
21. Page 13, the paragraph starts from "Usually, …": This is paragraph is very helpful for readers to understand the advantage and disadvantage of the each option in global_bin but it also mixed with too much details on exact number of the option. The other parts of the paper also have the same issue as I described in summary. Please think how to keep the useful discussion of the BE option in paper but leave the details to the appendix.
22. Page 15, Line 12-15: please revise this sentence to make it easy read and understand.
23. Page 15, Line 25-26: please give more explanation on the purpose of showing the correlation of T with both specific humidity and relative humidity.
24. Page 19, Line 2-3: RAP is not using NAM BE directly. The BE for RAP is a combination of the global BE and NAM BE with some tunings. Also, NAM BE should be 1 degree of the resolution instead of 0.1 degree.
25. Page 20, last line: " the pseudo observation of 1K": should be "the innovation of 1K.
26. Figure 1 caption: what is "DC3"? Please give explanation r delete it.
27. Figure 8 and 9 and 10 are whole domain results, right?