Comments on the manuscript entitled "Reducing manipulations in control simulation experiment based on instability vectors with Lorenz-63 model"

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The authors extend the control simulation experiments (CSEs) by Miyoshi and Sun [2022] wherein the state of the Lorenz-63 model is constrained in its positive regime. Growth rates of bred vector (BV) and singular vector (SV) have been assessed to explore the instability properties of the dynamical system in the CSEs. The SV results in reducing the total control times and perturbation magnitude (i.e. Euclidean norm of perturbations) than the BV and constant-magnitude perturbation [Miyoshi and Sun, 2022]. This study suggests substituting perturbations with a constant magnitude [Miyoshi and Sun, 2022] to adaptive values based on the growth rates of the SV in CSEs. The presentation of the current manuscript is concise and easy to follow overall. However, I expect that the authors will address major questions/comments before further decisions for publication. First, the authors should improve the Introduction which will better show the motivations of their study and facilitate the readers to capture its novelty. More importantly, the manuscript is lacking an intensive analysis of the experiments presented therein. Section Results almost focuses on the experiment description rather than the results' interpretation. Details of my general comments can be found below. Some other points are also listed for consideration in the manuscript revision.

1. **Abstract**: The authors have mentioned the BV-based method in the abstract but do not provide it a conclusion. I suggest adding a sentence for comparing its performance to the SV or removing the term 'bred vector' from the abstract.

2. **Introduction**: Reading the Introduction, I feel it is like a brief review of BV and SV. Highlights of CSEs' applications in practice and the pros and cons of the previous proposed approaches would be more appropriate. From these points, the authors could suggest to use BV and SV...

   (a) Lines 16-19: Please split these sentences precisely. Miyoshi and Sun [2022] tested the experiments on the L63 model and Sun et al. [2022] proposed CSEs on the L96 model.

(b) Lines 21-23: There exist any other approaches which can be used to learn the instability properties of chaotic models (e.g. Lyapunov Exponents)? Why should BV and SV be the first candidates to be examined? Refer to Norwood et al. [2013] for general ideas.

3. **Method**:

   (a) Line 48: Nature runs for 208000 time steps: can you give a hint for this number?

   (b) Line 49: "with the width of each time step (dt) equal to 0.01" → "with a time step increment (dt) of 0.01"

   (c) Lines 55-56: Please double-check! Miyoshi and Sun [2022] used EnKF while this study has employed ETKF. Do different data assimilation methods impact the results of CSEs? And ensemble forecasts with a larger ensemble size (3 in this study) would challenge the CSEs as it gives a higher probability for the forecasts to switch between the two L63 regimes?

   (d) Lines 111-112: The growth rate of SV is not formulated precisely?

4. **Results**

   (a) Figure 2: Can you plot the observations as points in the same plot with the time series? I am curious to see their illustration in the CSEs.

   (b) Lines 129-134: Please elaborate the analysis for Figure 3. Four of the five sentences describe the experiment and figure details...

   - Personally, I think the successful rate of CSEs would highly depend on the starting point of the control activation. It would be interesting to verify the sensitivity of CSEs on the starting points (e.g. the state x is between 0-5, between 5-10, 10-15, etc).
   - It is necessary to interpret the different performances of BV and SV in Figures 3b and 3c as they are the core of this study.

   (c) Lines 140-146 (Table 1): The total numbers of hit, miss, and false alarm events are not the same for BV (412) and SV (387). Were the experiments executed on the same trajectory? I suggest to verify the forecast with different time series of L63 and then computing the confidence interval of Hits, Misses, False Alarms, and threat Scores.

   (d) Line 148: "Fig.4d" → "Fig.4c"

   (e) Line 150: "Fig.4e" → "Fig.4d", 0.0312 does not appear on the color bar.

5. **Discussion**: Line 168: "2.96" → "0.0296". It is not convinced that the maximum growth rate of SV (0.0296) is fixed for any starting point in CSEs. The authors could plot the maximum growth rate of SV as a function of the starting point to see whether the maximum growth rate varies or not.

6. For figures, please increase the line width for better visualization.

References

T. Miyoshi and Q. Sun. Control simulation experiment with lorenz's butterfly attractor. *Nonlinear Processes in Geophysics*, 29(1):133–139, 2022.

A. Norwood, E. Kalnay, K. Ide, S.-C. Yang, and C. Wolfe. Lyapunov, singular and bred vectors in a multi-scale system: an empirical exploration of vectors related to instabilities. *Journal of Physics A: Mathematical and Theoretical*, 46(25):254021, 2013.

Q. Sun, T. Miyoshi, and S. Richard. Control simulation experiments of extreme events with the lorenz-96 model. *Nonlinear Processes in Geophysics Discussions*, pages 1–18, 2022.