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Nonlinear Processes in Geophysics
Discussions

Interactive comment on "A Parallel Hybrid Intelligence Algorithm for Solving Conditional Nonlinear Optimal Perturbation to Identify Optimal Precursors of North Atlantic Oscillation" *by* Bin Mu et al.

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Dear Editor,

Thank you very much for your careful review and constructive suggestions concerning our manuscript. These comments are very valuable and helpful for us to revise and improve our paper. We have studied comments carefully and have made corrections. The response to the comments are as follows:

1. The optimization procedure of PSOGA has indeed been previously proposed [1-

4]. Our work combines it with principal component analysis (PCA) strategy, and the algorithm is applied in the research of the OPR for the NAO using the CNOP approach for the first time. The related references are attached according to your suggestion.

2. When the individuals in PSO are being mutated or crossed-over in the GA phase, the new individuals are generated with new positions. If these new positions have a better fitness value compared with the global best position, the global best position (X_gb) would be replaced by the new position. Then the population is updated.

3. As the common practice in previous works [5-8], a sample with multiple variables is reshaped into a vector with one dimension. For instance, the scale of U, V, T and Q is 26 * 192 * 288, and the scale of PS and PHIS is 192 * 288. Then one piece of sample is handled into a 1 (row) times 5861376 (column) vector, and the different variables are not weighted. We have 900 pieces of samples, we conduct PCA on the 900 (row) times 5861376 (column) matrix. Therefore, we can not separate these six variables from the output of the PCA, and we do not need to. Before the perturbations are superimposed on the input of the CESM, the position would be restored into the original dimensions via inverse transform.

4. Yes, the step corresponding to "compare parents and offspring" requires invoking CESM, and we have made corrections in the flow chart. Thank you for pointing it out.

5. The notation is corrected. Thank you.

6. Since the reference state is the result without perturbations, the reference flows displayed in the three panels are the same. We have added the description. The initial reference state is randomly selected from a winter day in the model year. Based on the series of experimental results, the NAOI value is related to the initial reference state, but the proposed algorithm can always obtain the optimal for both NAOˆ+ and NAOˆ- and find out the OPRs that can trigger the NAO events. To prove the results have universality, we have added an experiment with a different initial reference state, and illustrate the trend of the NAOI in perturbation states. To avoid repetitive analysis, the

pattern and nonlinear evolution are still illustrated according to the scenario in Figure 5.

7. The previous studies indicate that the NAO events can be viewed as a stochastic process with an intrinsic time scale of 2 weeks [9]. Very recently, the research result of our co-author in this paper suggested that the skillful forecast time of the NAO is about 2 weeks [10]. Longer simulation may contain multiple variation processes. Thus, we select the optimization time within 15 days.

8. The random perturbations are completely random in the search process. Due to the limitation of the chart, we can only display the general trend that most of the perturbations show. We want to explain that there are significant differences between the CNOPs obtained from the proposed algorithm and the random perturbations. It may be an inappropriate way to analysis using several random perturbations, and we have deleted this part from the section.

9. The parallel scheme can only enhance the efficiency and shorten the runtime of the calculation process. Since the parallel strategy just makes the multiple particles search concurrently, it would not influence the result of NAOI. With the same number of searches, the parallel OPR would have a similar structure and play an equal role compared with the serial OPR in theory.

10. The perturbations are restored into original space via multiplying the particle position and the components acquired from PCA, and the particle position is adjusted from the initial random position. Therefore, the perturbation field depends on the random seed. The range of the random position is chosen to ensure most of the perturbations in the original space obey the constraint. Besides, the random range should make the perturbation achieve better fitness value as possible. The random range is the empirical value obtained from multiple experiments and can affect the result of the algorithm.

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Please also note the supplement to this comment:
https://www.nonlin-processes-geophys-discuss.net/npg-2019-25/npg-2019-25-AC2-supplement.pdf

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