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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 Reviewer,

Thank you very much for your attention and the comments on our paper. We have studied these comments carefully and tried our best to revise the manuscript. Responds to the comments are listed as follows:

1. In previous studies, the geopotential height is used to quantify the NAO due to the feature of the T21 quasigeostrophic (QG) global spectral (T21L3) model. In our

work, with a more complex physical process in the ocean-atmosphere coupled model, sea level pressure (SLP) is selected as the characterized variable of the North Atlantic Oscillation (NAO). The sentence on page 3, line 1-2 is not very accurate, and we would rewrite this part and make it well articulated.

2. In this paper, we propose a parallel hybrid algorithm to investigate the optimal precursor (OPR) of the NAO using conditional nonlinear optimal perturbation (CNOP) method. In the related works, the algorithm for studying the OPR of the NAO is based on the gradient, such as spectral projected gradient 2 (SPG 2). In the solving process of the SPG 2, the gradient information is obtained by calling the corresponding adjoint model. Therefore, the gradient-based algorithm can not solve a similar problem in the numerical models which do not have an adjoint model (such as CESM). We adopt the swarm intelligent algorithm based on the dimensionality reduction strategy to implement the CNOP method. The algorithm is suitable for solving such the nonlinear initial value problem in any numerical model. Besides, the algorithm has been optimized with a parallel framework to enhance performance. The major difference between related works (Jiang et al. and Dai et al.) and our works are summarized as follows: Model: T21L3 (with adjoint model) / CESM (has no adjoint model) Quantified variable: Geopotential height / SLP Perturbation variable(s): Potential vorticity / Zonal wind, meridional wind, temperature, specific humidity, surface pressure and surface geopotential Algorithm thought: gradient projection / swarm intelligent search The resolution and space structure (layer number, grid points) are also different in our work and related works.

3. The component set we selected for this case is F_2000 (F for short), with CAM, CLM, CICE and DOCN components. By default, the CAM component is stand-alone. As for the frequency, we set the parameter 'nhtfrq' to -24, which denotes the daily average. The variables of model input are listed in Table 2. They are zonal wind, meridional wind, temperature, specific humidity, surface pressure and surface geopotential.

4. Page 5, line 1: Yes, the NAOI stands for the NAO index, and the abbreviation is mentioned in Page 1, line 22.

5. Page 5, line 10: m is the number of spatial points, and n is the length of the time series.

6. Page 6, line 8-18: The constraint given in the initial value problem is to ensure the reasonability of these variables and avoid the appearance of abnormal values. Our work and the research of identifying sensitive areas for tropical cyclones have the same variables. The feasibility of restraining these variables using the constraint defined in equation (4) has been proved in [1-3].

7. Page 7, line 7-8 & Page 11, line 9: We run the component set F of CESM for 10 model years (only for winter, DJF) without perturbations, and gather the output of SLP on a daily average. Then the centralization SLP is obtained by subtracting the mean value of these 10 years and weighting according to its latitude.

8. Page 8, line 25: We are very sorry for our incorrect writing, and it was corrected.

9. Page 9, line 6: The original sentence is not accurate enough, thank you for pointing it out. The function of the CAM is to simulate the variation of the atmosphere.

10. Page 9, line 27: The asynchronous stream is the main carrier of asynchronous parallelism, and each stream can execute an independent task. The replication operation of memory corresponds to the replication engine of the hardware, and the function call corresponds to the execution engine of the kernel function. Therefore, these two operations can be conducted concurrently. To express the meaning more clearly, the sentence is modified into 'The function execution and data replication are overlapped using asynchronous streams'.

11. Page 17, line 19-22: The incorrect reference was corrected. Thank you.

12. Page 18, line 1: Sorry for the limited vocabulary, and we use other words instead.

13. Page 18, line 2: This sentence means that when the number of CPU nodes increases, the frequent communication would make the runtime of the CESM increase. We would try our best to improve the expression of this paper.

14. Page 19, line 15: It was corrected, thank you.

15. Page 21, line 2: We have replaced 'observably' by 'significantly' according to your suggestion.

We are truly grateful for your thoughtful comments. Based on these comments, we have tried our best to revise our manuscript. We would like to express our great appreciation to you for your comments on our paper.

References:

[1] Zhou F , Mu M . The impact of verification area design on tropical cyclone targeted observations based on the CNOP method[J]. Advances in Atmospheric Sciences, 2011, 28(5):997-1010.

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[3] Zhang L, Mu B, Yuan S, et al. A novel approach for solving CNOPs and its application in identifying sensitive regions of tropical cyclone adaptive observations[J]. Nonlinear Processes in Geophysics, 2018, 25(3): 693-712.

Please also note the supplement to this comment:
https://www.nonlin-processes-geophys-discuss.net/npg-2019-25/npg-2019-25-AC3-supplement.pdf

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