Comment on gmd-2021-396
Anonymous Referee #2

Referee comment on "Simulation, Precursor Analysis and Targeted Observation Sensitive Area Identification for Two Types of ENSO using ENSO-MC v1.0" by Bin Mu et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-396-RC2, 2022

The study constructed a multichannel deep neural network to predict the spatial-temporal evolution of SSTA for the two types of ENSO. Meanwhile, the saliency map method was introduced to the analysis of ENSO precursors and identification of targeted observation sensitive areas, which bring added value to the current state of Climate-AI research. The study applied interpretable algorithms to the exploration of ENSO physical mechanisms, providing a new idea for future research on the predictability of ENSO. The article is well organized and the results sound feasible. However, I still have some ambiguous that should be addressed before acceptance.

**Major comments:**

- Based on deep neural network, an ENSO prediction model with multiple physical variables is constructed in this manuscript to simulate the changes of SSTA, analyze the precursors and identify the sensitive areas in the equatorial Pacific. It is a good attempt to broaden the application field of neural network in climate research. And the description of the prediction model should be complete enough to reproduce. However, in the second section of the paper, the description of ENSO-MC model is somewhat brief. I suggest the authors add descriptions of specific configurations through experiments, such as how to determine the model hyperparameters.

- For the prediction results of EP, CP and La Nina events, the authors select one case to analyze respectively in the third section. It is suggested to add cases or discuss the overall forecasting performance of different types of ENSO, for example, the forecast results of different types of events in the validation set can be summarized into a table.

- In the fourth section, based on the proposed ENSO-MC model, saliency map method is used to analyze the subsurface precursors. Since the changes of ENSO originate from the strong interactions between oceanic and atmospheric changes, it is recommended to analyze the changes of SST and wind field while analyzing the changes of precursors in heat content. For example, the process can be further elaborated according to the influence of ocean wave and Walker circulation on ENSO.
Minor comments:

- Lines 28-29: For the predictability study of two types of El Nino, Tian and Duan (2015) demonstrated that the spring predictability barrier is weaker in CP-El Nino than in EP-El Nino when model error effects can be negligible. Tao et al. (2020) used the nonlinear forcing singular vector (NFSV)-tendency assimilation approach to improve ENSO model and showed the ability of recognizing the types of El Nino at least six months in advance in predictions (also see Tao and Duan, 2019).

  (1) Ben Tian and Wansuo Duan, Comparison of the initial errors most likely to cause a spring predictability barrier for two types of El Nino events, Clim Dyn, 2015, DOI:10.1007/s00382-015-2870-0

  (2) Tao Lingjiang, and Wansuo, Duan, Using a nonlinear forcing singular vector approach to reduce model error effects in ENSO forecasting. Weather and Forecasting. 2019. 1321-1342. DOI: 10.1175/WAF-D-19-0050.1


- Lines 31-38: Using the NFSV-tendency assimilation approach, Duan and Tian (2013) revealed the dominant roles of zonal advection process in the development of CP-El Nino and the thermocline feedback process in the development of EP-El Nino events; then Duan et al. (2017) first demonstrated that the diversity of El Nino is closely related to changes in the nonlinear characteristics of the tropical Pacific.


- Line 32: GFDL abbreviation error.

- Lines 51-52: Duan et al. (2004) is one of the earliest papers that explored the precursory disturbance of ENSO events (also see Duan et al., 2013)


  (2) Duan W., Y. Yu, H. Xu, and P. Zhao. Behaviors of nonlinearities modulating El Nino events induced by optimal precursory disturbance. Climate Dynamics: 2013,40 ,1399–1413
- Line 108: The descriptions of skip-layer connection structure and its attention mechanism are insufficient, and it is recommended to add implementation details.
- Line 140: Specific explanation should be given for the meaning represented by SSIM, and clarify why it should be used as a loss function in ENSO prediction.
- Line 147: For “gradient information of gridded variables is important for the model to understand changes in the sea temperature”, how does this conclusion come? Please explain why gradient information is necessary.
- Line 225: It is suggested to clarify whether the precursor analysis is based on a multi-step forecast strategy model or a one-step model.
- Line 273-274: Here the first two areas with the highest sensitivity are selected as sensitive areas. If the first three or more are selected, will the benefit be higher?
- Figure 5: How can we know that the forecasting skills of this model decline fastest in the late boreal spring? please provide a clear analysis. In Fig. 5(d), the forecasting skills improve slightly after 12 months in the one-step strategy model. Why does this happen?
- Figure 7, 8: It is suggested to further clarify whether the saliency value in the figure is the result after standardization or the original perturbation amplitude of SST and heat content.