Nonlinear Processes in Geophysics Discussions

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Comment on npg-2021-20

Davide Faranda (Referee)

Referee comment on "Using neural networks to improve simulations in the gray zone" by Raphael Kriegmair et al., Nonlin. Processes Geophys. Discuss., https://doi.org/10.5194/npg-2021-20-RC2, 2021

I have read with interest the manuscript: "Using neural networks to improve simulations in the gray zone" by Raphael Kriegmair et al. and found it of potential interest for the public of Nonlinear Processes of Geophysics. However, before the paper could be considered for publication, I would like the authors to answer/consider the following specific comments on their work. I would be very happy to read a revised version of their paper

Specific Comments

1) Introduction: While reading the introduction I was surprised that the authors talk about "gray zone" always avoiding mentioning the concept of turbulence (which is, by the way, mentioned in the title of one of the references provided). In my own view, and I do hope that the authors agree, the gray zone is an effect of coexisting turbulence cascades (direct and inverse) and the emergence of specific phenomena at certain scales due to the physical and geometrical constraints of the system. For exemple, in atmospheric motions, cumulus clouds and more generally convective atmospheric phenomena are constrained, in scale, by the height of the tropopopause. Similarly cyclones and anticyclones have a radius depending on Earth rotation and so on. The authors could discuss this issue and provide additional references for the gray zone with repsect to the concepts of turbulent cascades. See for exemple:

*Lovejoy, S., and D. Schertzer. "Towards a new synthesis for atmospheric dynamics: Space–time cascades." Atmospheric Research 96.1 (2010): 1-52.

*Marino, Raffaele, et al. "Inverse cascades in rotating stratified turbulence: fast growth of large scales." EPL (Europhysics Letters) 102.4 (2013): 44006.

*Faranda, Davide, et al. "Computation and characterization of local subfilter-scale energy transfers in atmospheric flows." Journal of the Atmospheric Sciences 75.7 (2018): 2175-2186.

2) Experiment set-up: Here the authors attempt to describe their model largely using other existing references but, even digging into the cited literature, it is complicated to understand what is the exact model used. I strongly advise to: i) write the full equations of the model (if it is too long, you can think of doing an appendix), ii) when you say "We pick one simulation from each extreme and compare results to identify general and flow dependent aspects", please show some trajectory of your model in space & time (at least part of it when the system has settled in a stationary states). Figure 12 indeed shows some space snapshot of the system's stat but it comes too late in the manuscript to be useful for the casual reader.

3) Parameters used in this study:

-"The coarse graining factor in this study is set to 4" why is that? the authors should provide a jutification of this value. Any reviewer or reader would question the choice of the value 4 as the only one explored in the paper. I strongly reccomend to see what happens for power-2 values, at least to some extent. In the cited paper by Faranda et al. we have seen that the coarse-grain factors can greatly affect the performances of ML methods. This item should deserve particular attention in the revision of the paper.
-"T=200000 time steps". How can we say that this time series is long enough? what is the Lyapunov time of the system? please justify this value as, again, the length of the available dataset is a crucial parameter in ML studies.
-"The ANN structure used in this research is described in the following. 5 hidden layers are applied, each using the ReLU
activation function. The input layer uses ReLU as well, while the layer uses a linear activation function. All hidden
layers have 32 filters. The input and output layer shapes are defined by input and target data. The kernel size is set uniformly to 3 grid points." Please justify the choices "5 layers"; "32 filters" and " 3 grid points". Ideally, you should include additional tests to show that these parameters are a good choice for your analyses and why you have not attempted other combinations.

4) Convolutional ANN: as for the model used, The convolutional ANN should be defined with equations, with explicetely defined parameters. Again, if this makes the main text too long, you can move this important information in the appendix.

5) Results:

-Figure 2: 5 epochs do not seem enough to conclude anything on the variability. Why using only 5 epochs? you can use 30 and make boxplots instead of just showing 5 points. Otherwise please justify your choice 5x5
-Figure 3: define RMSE
-Section 3.2: it is very difficult to follow the exact way you actually train your ANN with w_mass because you never provided the original equations. Again, my suggestion is to add the relevant equations to understand the ANN dynamics and the way you add w_mass to improve the performances.

6) Conclusions:

The authors' conclusion are consistent with the material presented in the paper. I have however suggested (see my previous comments) several way for the authors to largely improve their manuscript. In particular, I would expect to see a better model description, as well as additional analyses on the meta-paraemeters used (coarse grain factor, input layers, kernel size, and grid points numbers.

best regards,
Davide Faranda