Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2020-71-RC3, 2020

Earth System Dynamics
Discussions

Interactive comment on "Spectral nudging in the Tropics" *by* Breogán Gómez and Gonzalo Miguez-Macho

Anonymous Referee #3

Received and published: 22 December 2020

This manuscript presents an interesting contribution in the area of limited area modelling. It discusses the optimal spectral nudging setup for downscaling reanalyses over domains centred in the tropical regions. The manuscript also discusses the impact of nudging configurations on the simulation of tropical storms. It thus provides important technical information for configuring the downscaling experiments in the tropics. The paper is overall very well written and is a pleasant read but, in my opinion, some parts still need to be improved before the paper is ready for publication. I recommend a major revision.

Major comments:

1. Please specify the units of kinetic energy spectra, where appropriate (e.g., Fig. 2). Are the spectra calculated from wind components as (S(u)+S(v))/2 or from kinetic

energy field as S((uˆ2+vˆ2)/2)?

2. The method to estimate the optimal value of the cut-off wave number from inflection points in Fig 4, seems to me to be presented in an upside-down manner. In GM2017, you used a geometric method to obtain the wave number that corresponds to the inflection point of the RMSD curve, whereas in the present manuscript you rely on considerations in Jung and Leutbecher (2008), where it was found that the size of error was 7 times larger for the synoptic scales than for the mesoscales. Based on this finding, the present manuscript proposes a definition of the wavelength delimiting the synoptic scales and mesoscales as the one where the RMSD is reduced to 15 % ($\sim$1/7) of the maximum RMSD value. Such a breakdown seems to me arbitrary and unconvincing. Even Jung and Leutbecher (2008) clearly state that "the actual choice of the wavenumbers used for the breakdown is somewhat arbitrary given that there is no clear gap in the spectrum of meso-scale to planetary-scale atmospheric motions in the extratropics." It seems more natural to me to present the findings in the opposite way: use the geometric method (as in GM2017) to find the inflection point and then quantify how close it is to the point where the RMSD is reduced to 15 %. This would be a more appropriate approach to try to understand the physical meaning of the inflection point and the corresponding change of RMSD slope. The paper could also benefit if more details are provided about the comparison of the two methods.

3. I found the systematic presence of inflection points at different levels and variables in Fig. 4 quite interesting. There may be multiple explanations for this phenomenon. First, spectral slopes flatten between the synoptic and mesoscales (e.g., steep -3 towards a less steep -5/3 slope of kinetic energy spectrum). Could the slope change in RMSD be explained by the slope change in the field itself? Second, in experiments where the cut-off wave number is small, only the scales well resolved by the reanalyses are nudged and RMSD dependence on the cut-off wavenumber is likely governed by error reduction via improving the shapes and timing of large-scale features. On the other hand, when the cut-off wave number is large, beyond the effective resolution of the

reanalyses, RMSD slope in the range of high cut-off wavenumbers could be governed merely by the degree of smoothing of fine scales induced by the spectral nudging, which, I guess would result in a less steep slope. It would be nice to hear your thoughts on these ideas.

4. Have you experimented with the nudging e-folding time? Does the optimal cut-off wave number for the position, centre pressure and max wind speed depend on the e-folding time?

5. Does this study have any relevance for downscaling GCM simulations of the present or future climate? The conclusion section could benefit from a short discussion on this topic.

Specific comments:

1. Please specify the units of kinetic energy spectra, where appropriate (e.g., Fig. 2). Are the spectra calculated from wind components as (S(u)+S(v))/2 or from kinetic energy field as S((uˆ2+vˆ2)/2)?

2. Pg.5, L12: “a large as” -> “as large as”.

3. Pg.5, L16: “the domain, which is” -> “the domain, which is” or “the domain; this is. . .”

4. Pg.5, L25: “Power Spectrum” (no need for capital letters).

5. Pg.5, L26-27: “The non-nudged scales develop a similar amplitude to those in the free run case, while the nudged scales are-closer to their counterparts in the grid nudging case.” This seems to be true only in the upper air (level 23). In the lower troposphere there is a flat amplitude increment affecting all scales in all experiments SP>=2000. I guess this is due to the bogus cyclones that develop when the cut-off wavenumber is too low.

6. Pg.7, L9: “WRF gets most of the reduction of the temperature RMSD against ERA-interim for a larger wavenumber”. Did you mean larger wavelength? There seems to

be a similar confusion in the caption and annotations of Fig. 4.

7. Pg.8, L27: “nudging only the larger parts of the spectrum”. Do you mean nudging only the larger wavelengths?

8. Pg.11, L6: “intensity ,” please remove the blank.

9. Fig. 2: Should the meaning of line types and colouring be given in the figure caption?

10. Fig. 2: What is ‘db’ in the caption of Fig. 2?

11. Fig. 3: Not clear which row corresponds to which level. Please annotate the panels properly. Also, I think it would be more elegant to have a unique y-axis range for comparisons against GDAS and ERA-Int.

12. Fig. 3: Is the unit here really Joule? I think we are talking about energy per unit mass or unit volume, right?

13. Fig. 3: A small inconsistency – the authors state the colours and symbols are the same as in Fig. 2 but here we have dashed-dotted and dotted lines for SP750-4000 vs. dashed and dotted in Fig. 2.

14. Fig. 4: The quality of this figure should be improved. Annotations are too small and blurred (almost unreadable, at least for me). In the figure you printed “Wn” – does it stand for wave number or wavelength? If the latter, please add units.

15. Fig. 4: Please consider revising the figure caption. “Panels a & c show results theta”. Why not “Panels a & c show results for potential temperature”? Also, what are “WL numbers” and how are they related to Wn in the figure? Such inconsistencies make the read a bit difficult. Also, levels printed are 10,18,22 and not 11,19,23. Vertical staggering?

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