

Referee report: “spectral neutrality of climate reductions: an operator perspective.

The manuscript introduces the idea of “spectral neutrality” which compares the operator structure of an approximation (by averaging, expansion in a small parameter or projection) and the original problem. Several examples used in climate related reductions are discussed in this context.

My main concern is that I did not find any new result that was derived/obtained in the paper, it reads more like a note or a comment with some rather general, non-specific, statements.

Specifically, the paper provides no example of where their neutrality definition is useful. The idea that approximations do not capture the full structure of the problem seems rather obvious. Approximations are often used to capture qualitative features/mechanisms not quantitative ones (as pointed out repeatedly in the manuscript). The author should provide concrete examples where the difference between approximate and exact problems and their operator structure gave some new or interesting insight/conclusion. The given examples seem obvious, is it not well known that: if one does not keep geometric factors correctly the frequencies will be off (section 4.3), the Laplacian on the plane and sphere have different eigenfunctions (section 5.1) or that the average of T^4 is not equal to the averaged T to the 4th power (section 1)? Sections 5.3 and 5.4 that discuss boundary modes/effect of boundaries come closest to discussing situations where the introduced idea could be useful, but they remain very general and vague.

Finally, the introduced conditions seem very broad, are there examples where they are not broken by approximating the problem? If not, the notion does not seem useful. Is there some claim beyond the fact that approximations are not exact?

Minor points

There is a sudden switch from discussing spatial to temporal variability in section 1 where the radiative balance is discussed, please clarify.

What is the connection between the operator examples and the radiative balance example within the stated framework? What is the operator whose neutrality is being examined? The connection seems rather forced.

A sentence stating that reductions are useful where they are applicable is repeated many times throughout the text