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Earth System Dynamics
Discussions

Interactive comment on "The Half-order Energy Balance Equation, Part 1: The homogeneous HEBE and long memories" *by* Shaun Lovejoy

Anonymous Referee #2

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Review of "The Half-order Energy Balance Equation, Part 1: The homogeneous HEBE and long memories" by Lovejoy

Recommendation: Major revisions

This study derived a new version of the energy balance model based on non-integer derivatives. These models seamlessly contain long memory characteristics. This manuscript might be acceptable for publication in ESM after a major revision.

1) Certain parts of the paper are confusing. For instance, the model is called a "zero dimensional" model though it has a vertical dimension. I assume this is because traditionally the vertical axis has been neglected and only a horizontal average considered. I strongly suggest to find a different terminology for this.

2) You refer many times to Part II. I think this is distracting; in my opinion it would make the paper easier to read to remove those references or to just have a short outlook on Part II in the conclusions section.

3) Is your approach valid for all time scales? A long memory climate response should lead to infinite climate sensitivity. So your climate response operator is probably only valid for certain time scales.

4) Line 15: BC needs to be defined.

5) Line 26: I do not think "macroweather" is a widely known term. So please define.

6) Line 32: "latitudinally" probably should be "zonally"

7) I am confused by the z-coordinate system. It is not clear to me what z=0 means? Surface or top of the atmosphere? Also all z values seem to be negative. Also Figure 1 does not help at all in that respect.

8) Line 175: Your linearization is either accurate or not, but not both.

9) Line 266: What do you exactly mean by "top"?

10) in (33) you develop an asymptodic expansion. Why do you stop at the $\frac{1}{2}$ term? There are also higher order term which might lead to different orders on fractional derivatives.

11) Line 350: I am not sure many ESM readers are very familiar with long memory. I suggest that explain why (37) implies long memory.

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