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Interactive comment on "The HadGEM3-GA7.1 radiative kernel: the importance of a well-resolved stratosphere" *by* Christopher J. Smith et al.

Anonymous Referee #2

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This manuscript documents a new set of "radiative kernels," calculations of the sensitivity of radiative flux to atmospheric state, developed from a current-generation climate model with a domain reaching well into the stratosphere. The construction of the kernels was motivated by a desire to understand the fast response of stratospheric temperature to changes in carbon dioxide concentration and the authors demonstrate the value added by the new kernels. The construction of the kernels is described and their accuracy and generality assessed.

The data are well worth publishing. They require substantial computational resources to produce, extend the vertical domain in an almost-unique way, and use an accurate radiative transfer code. The free availability of the data has been verified. The manuscript is effective at documenting how the kernels are produced, providing enough

details for readers to understand and potentially replicate the steps. It is also effective at motivating why this implementation is useful, noting that the diagnosis of the fast climate response (the adjustment) to increased concentrations of carbon dioxide depends importantly on having a deep vertical domain. Beyond a few small points of expression noted below the manuscript could be most improved by more context for the uninitiated and a more general treatment of some ideas.

The introduction, which introduces the concept of and motivation for a radiative kernel, may be more general than is needed for the present manuscript. The generality makes it open to objections as to how the ideas are expressed. The general idea of a kernel is the ability to compute flux perturbations from state perturbations. As originally implemented by Soden, Shell, and others, these were restricted to specific characteristics of atmospheric state (air and surface temperature, water vapor, surface albedo, and excluding clouds) based partly on prioritization and partly on based on the availability of data. The does not establish a "standard" (line 47) nor does it exclude in principle other variables from being relevant (line 28). Readers may also wonder how the general material on the use of kernels (lines 39-54) is directly relevant to the construction of the present kernels.

The authors might revisit the introduction and focus it more tightly on the subject of the manuscript. This might include a not too profound explanation of how kernels can be used to diagnose both feedbacks and adjustments, and and explanation as to why yet another set of kernels might be desirable (i.e. the material that begins section 4). Care should be taken not to confuse routine practice with standardization.

Section 2:

It would be worth noting explicitly that these kernels rely on two almost distinct aspect of HadGEM: the radiation code SOCRATES run at low spectral resolution, and the climatology of atmospheric state including clouds, even if experience shows relatively weak dependence on the background state.

The authors might also explain some of their choices and any expected impacts. These might include the choice to develop kernels for pre-industrial conditions, the relatively highly-resolved vertical structure and coarse horizontal resolution of the simulations, and the high time resolution.

Section 4 illustrates the added value of the new kernels quite nicely. The use case is important but a little narrow. Is the value also added for other greenhouse gas forcings?

Section 5 is the least organized and clear and the section seems to assume a lot of background knowledge. The point of the section is to demonstrate the accuracy and applicability of the kernels. The narrative should be constructed to as to make this goal clear, explain how accuracy and applicability can be assessed, and finally to demonstrate the results.

Lines 2-3: "the utility of radiative kernels... is most appropriate" The last word isn't quite right. Utility can be greater or less but not appropriate.

Line 23: Kernels represent derivatives of flux with respect to state, not differential equations

Line 32: climate model (not mode)

Line 84: the equation should have units

Line 113: The sudden appearance of PDRMIP may confuse the uninitiated

Line 125: the limitations of low-topped kernels are presumably independent of whether the state comes from a "climate model" or any other source

Line 161: cars break down - what is meant here is "decomposition" or similar

Line 163: "ways of calculating the residual can be obtained" is a confusing phrasing.

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