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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Are Atmospheric Updrafts a Key to Unlocking Climate Forcing and Sensitivity?" *by* L. J. Donner et al.

Anonymous Referee #1

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This paper reviews basic issues around vertical velocity arising from the truncation of the spectrum in numerical models, and argues that this is affecting current estimates of aerosol forcing and possibly cloud feedback. The paper is a useful essay but I believe a few weakness should be addressed in a revised version.

1. The resolution-dependence of w has been examined by Pauluis and Garner 2006, which is not cited. I suggest shortening the text by invoking their results and analysis.

2. I found that the somewhat wordy paper was a bit light in terms of analysis. For example, can't the scaling laws quoted combined with the results in Fig. 1 be used to make a back-of-the-envelope estimate of how indirect effects should depend on resolution? A study is quoted showing a 30% decrease when changing

the resolution from 2 degrees to 1/4 degree, but there could be many reasons for this. It would make the argument more powerful if a simple calculation corroborated the magnitude of the impact based on the w-scaling argument. Also I think there are more studies that should be marshaled here, at least those of Wang et al. 2011 and more recent ones by Hugh Morrison.

Also, the discussion of how vertical velocity might be important to climate sensitivity was much less convincing than the discussion of aerosol effects. The role of the convective entrainment rate for example probably has more to do with altering the spectrum of convective depth, or how active the convective scheme is relative to large-scale condensation, than by altering w values per se. Sherwood et al. 2014 is invoked, but does that paper ever mention vertical velocity? Can the authors sharpen the reasoning here (for example, would we expect stronger updrafts and downdrafts to increase or decrease climate sensitivity?)

On the other hand, w seems important for overshooting of convective cells and mixing near the top of the cloud layer, which could be important for troposphere-stratosphere transport, gravity waves, etc. It also seems that the degree of localization of updrafts (hence precipitation) within a large grid cell for a given mass flux would be of interest for local weather and climate impacts.

3. A similar comment holds about solutions to the problem. The lead author Donner has already represented vertical velocities in a climate model parameterization, and to his credit reveals in Fig. 5 that the scheme does not capture any of the near-doubling of extreme updraft speed observed between the 19 Jan to 23 Jan field cases. Yet the paper says zero about this. Why did updrafts strengthen and why didn't the scheme pick this up? What physical assumptions went into the Donner 2011 scheme and do Donner et al. still think they are the right ones? Why or why not? The "Outlook and Challenges" section is largely just a summary of the points made earlier, then a laundry list of things people should be thinking about, chief among them that model physics be made scale-aware. Yet,

scale-awareness in a parameterizations is only helpful when one wants it to work automatically at different resolutions; presumably the Donner 2011 parameterization (for example) was optimized for the resolution of the GFDL model in which it was used, and was therefore already "aware" of the scale—yet still seems to lack a key sensitivity. What is it missing? What has been learned from the efforts so far? Leo is in as good a position as anyone to tell us and his insights would be useful here.

4. There was a lot of repetition in the paper, where a concept is explained in one place and then explained again when the manuscript comes back to it. I urge the authors to go through and try to organize it a bit better so that all the ideas are noted at the beginning but discussed in further detail in only one place in the text.

Fig. 1: In my pdf at least, this figure has multiple glitches that must be fixed—missing subscripts in figure notations, garbled title of lower panel, no labels on color legend, negative signs missing on y-axis labels.

p5,25: "relatedly" not an English word

p5,30: what is meant by "vertical transport"? The total net upward mass transport should not increase since it is governed by energy and mass balance, but there should be stronger localized upward (and downward) transports.

p6,5: Wang et al. 2011 also seems relevant here.

Fig. 4: why are numbers on the x-axis increasing to the left? The way this caption and figure are constructed means one has to think very hard to figure out the direction of the effect. If I have it right, one obtains more particles at finer resolution (as expected).

p8,3-10 this text mostly restates things said earlier.

p8,28-33 ditto

Fig. 5: In the caption please specify that each panel represents a different day and that

the colors represent three percentiles of w.

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