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Interactive comment on "A simple explanation for the sensitivity of the hydrologic cycle to global climate change" *by* A. Kleidon and M. Renner

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The response of global precipitation to a change in surface temperature is a fundamental and important aspect of climate change. The direct and indirect impact of radiative forcing agents on driving changes in the global water cycle are becoming appreciated in terms of energy balance constraints (e.g. Allen and Ingram 2002, Andrews et al. 2009, both cited in Kleidon and Renner, 2013, ESDD: KR13b). Building on an earlier study (Kleidon and Renner, 2013 ESD; KR13a) KR13b propose an interesting and potentially valuable explanation for the response of global precipitation to surface temperature through the development of a simple modelling approach. This is a potentially important contribution to the discussion of this fundamental aspect of climate change.

Not being familiar with the maximum power concept, I consider that the impact of this

work could be somewhat enhanced by explaining this more fully in terms of physical processes. For example, it is often argued that enhanced radiative cooling of a warmer atmosphere, constrained by thermodynamics and radiative transfer, is the fundamental control on global precipitation changes; stronger radiative cooling is primarily balanced by more latent heat flux (e.g. O'Gorman et al. 2012, Surv. Geophys). This of course is manifest through both atmospheric energy and surface energy balance processes. Specifically, more evaporation can only be sustained if this evaporated water is efficiently removed from the boundary layer through uplift into the free troposphere, determined to a large extent by radiative convective balance. Therefore some discussion of how the surface energy balance parameters chosen and the maximum power assumption are physically linked with the enhanced radiative cooling of a warmer troposphere would be valuable in making the results of the study accessible to a broader section of the climate community.

This perspective is merely a suggestion to the authors; I apologize that I was unfortunately short of enough time to fully understand the author's ideas but look forward to reading the final published version.

I have a number of further minor comments on the manuscript which I found interesting and challenging.

1) p.855, line 13: discussion of the paleoclimate hydrological sensitivity would benefit from reference to the study of Li et al. (2013) GRL.

2) Section 2: I found this section challenging. While the reference to KR13a is useful, a little more explanation of the terms and their physical meaning would be beneficial.

3) Equation 2: The simple model assumes an opaque atmosphere of temperature Ta. in reality of course, emission to space originates from various levels of the atmosphere depending on the opacity of the spectral region. Indeed in cooler, drier climates, some emission can originate from the surface in window regions of the spectrum. Have the authors tested the sensitivity to this assumption?

4) Equation (3): The optimum vertical exchange velocity parameter, w_opt, is derived in the authors previous work KR13a but some more physical explanation would be useful here.

5) Equation (4) I was unsure why the surface longwave radiation, Rl,opt is equal to half the shortwave flux, Rs? Although KR13a find realistic energy fluxes, the Rl seems rather large compared to values estimated from observations, about 45 Wm-2 (Wild et al. 2013 Clim Dyn). Is this an artifact of the assumption that there is no solar absorption by the atmosphere?

6) Some diagrams illustrating how the flux terms respond to a warming or change in greenhouse effect may be useful for the reader. In reality there is a strong decrease in Rl with warming as the atmosphere becomes more opaque with extra water vapour. Is this represented by the model (this is implied on p.863, line 20-23)?

Additional references:

Li et al. (2013) Precipitation scaling with temperature in warm and cold climates: An analysis of CMIP5 simulations, Geophys Res. Lett.,40, 4018–4024, 10.1002/grl.50730

O'Gorman et al.(2012) Energetic constraints on precipitation under climate change, Surv. Geophys., 33, 585-608, doi: 10.1007/s10712-011-9159-6

Wild et al. (2013) The global energy balance from a surface perspective, Climate Dynamics, 40, 3107-3134, doi: 10.1007/s00382-012-1569-8

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