Earth Syst. Dynam. Discuss., 4, C411–C413, 2013
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Earth System Dynamics Discussions

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4, C411–C413, 2013

Interactive Comment

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

Anonymous Referee #2

Received and published: 17 September 2013

This is an extremely interesting paper explaining with a very simple global energy balance method and an added assumption about the magnitude of convective exchange at the surface. Despite its apparent simplicity I had to read the paper more than once to comprehend the intricacies of the analysis and still I am not sure that my level of understanding is complete. Despite this, and despite the fact that I am not a boundary layer meteorologist, the paper is convincing and it is a stunning result that such a simple analysis yields the same results as the climate models. However, the explanation that is usually given as to why climate models present an increase in hydrological cycling of 2-3 % (of precipitation) instead of the 7% (Clausius Clapeyron) is very different and I will come back to that later.

In general I feel that the paper is suitable for publication in ESD. However, given that

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Interactive Discussion

Discussion Paper

the authors have decided to submit to a general Earth Science journal and not to an atmospheric science journal, they should take some more effort to explain things. Specxific points are:

âĂć The assumption that the generation of convective motion is such that it maximizes a state of power. It is probably derived from thermodynamic principles, not familiar to many of the readers. This should be explained better, if not in the main text in an appendix. Also, it should be justified. I realize that some of this has been done in previous papers of the authors, but it should be reiterated in a concise fashion here nonetheless. âĂć It is unclear to me how equation (7) is derived, so a derivation would be in order. o If E = E(T(R)) I get: dE/dT = (dE/dR)(deltaT/deltaR)ˆ-1 o If E = E(T(R),R), I get: dE/dT = (dE/dR - deltaE/deltaT)*(deltaT/deltaR)ˆ-1 Please provide the derivation. âĂć Equation (12): misses 1/w for both terms on the right side of the equation. âĂć Line 6,7 in Summary and Conclusions: what is meant by ”reduced by a factor that results from the surface energy balance constraint”. This is not clear. âĂć What is not clear to me: does an increase in radiation also lead to an increase in the greenhouse term (first term in equation 7), or does this term increase due to other mechanisms? Please clarify better the mechanisms behind this in the text. âĂć Finally, coming back to the increase in the intensity of the hydrological cycle not being 7% per degree K but 2-3% in climate models (measured in terms of rainfall increase): this is often explained differently. One starts by explaining that the atmosphere can hold more water because atmospheric temperature increases as well, at least in the lower parts. (This is not possible in this model here, because Ta is constant. However, as the gradient Ts-Ta increases one would expect that if T-stratification where to be taken into account Ta would increase in the lower atmosphere and hold more water). The fact that this does not lead to 7% more rainfall is explained by the inability of the atmosphere to radiate away the additional energy that is released when condensating this additional atmospheric moisture. This effect is strengthened by the reduced emissivity of an atmosphere with higher CO2 content. I would like the authors to reflect on how this presumed mechanism fits into their scheme of things. Is there a relationship between

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this explanation and theirs.

Interactive comment on Earth Syst. Dynam. Discuss., 4, 853, 2013.

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