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Earth System Dynamics
Discussions

Interactive comment on "An explanation for the different climate sensitivities of land and ocean surfaces based on the diurnal cycle" *by* Axel Kleidon and Maik Renner

Anonymous Referee #2

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Review of paper "An explanation for the different climate sensitivities of land and ocean surfaces based on the diurnal cycle" by Kleidon and Renner.

First please accept my apologies for taking over a month to return this review.

This paper is related to a key feature of the Earth system, which is noted in both measurement record and in Earth System Model projections. That is under increasing atmospheric greenhouse gas concentrations, the land surface is in general warming faster than that of the oceans. This has important implications for society. For instance, any stabilisation target (such as global warming capped to two degrees) will be related to higher final temperatures over land, and this needs to be planned for. A sentence to

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Discussion paper

this effect could be added to the Conclusions maybe?

Despite the land-sea warming contrast being one of the few robust findings between GCMs, there has been relatively little explanation of this to date. Here, a fascinating process description is given, based on differential abilities of the land and ocean to distribute heat over the diurnal cycle. In particular, the lack of turbulent transfer above the land surface makes this more sensitive to radiation changes, adjusted by rising GHG concentrations.

Possibly the only request for additional work is as follows. If this is possible (as no wish to delay the publication) - would it be possible to solve the equation set and present daily profiles? In other words, a diagram with x-axis as hours 0-24, along with a y-axis that plots dUs/dt. Could this be achieved in 4 cases? Pre-industrial for land and ocean, and (say) 4xCO2 also for land and ocean? This would then compliment what I assume are stylised lines, for dUs/dt in Figure 1.

In terms of technical description and completeness, then a couple more lines describing the equation closure might help? So around Section 2.3, p6 lines 10- p7 lines 3. This depends strongly on the "maximum power" assumption for closure. Details are in Kleidon and Renner 2013a, but at little more description might help here. Also, is there a more general theoretical physics reference from before 2013?

In many ways, this paper opens more questions than it answers. But that's not to complain, and simply an indication that it has strong potential to be cited. Some of these questions the authors could hint at in their Conclusions? (indeed they state "These aspects would seem to provide ample opportunity to extend this research in the future"). This could be:

(i) Is there any compatibility between the analysis here and other earlier work and explanations mentioned in Introduction?

(ii) Can the seasonal cycle be analysed in more detail – for instance, towards the poles,

there will be a large differentiation between winter and summer day length, which might be seen in the data? Presumably temperature differentiation would become bigger in summer months?

(iii) Can sub-daily data be analysed from ESMs to verify more the model presented here?

(iv) If the model description, concept and formulation is accurate, then could it be inverted to tell us (based on temperature measurements) better parameterisations of turbulent transport?

(v) Are the equations sufficiently simple that there might even be room for analytical solution, especially if conceptual descriptions were given to the solar drivers. These could be as the positive part of a sin wave, or a parabolic description for solar forcing during daytime hours.

The paper is to be applauded for providing a complete model, along with all variables defined with units (in Table 1). This allows other researchers to try and build the model components if needed.

In summary, there I think this paper should be published, and it contributes strongly to the discussion surrounding why both measurements and ESMs indicate differential and higher warming over land than oceans. There are a few points above if the authors were interested in making a new manuscript version, with minor revisions.

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