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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 #1

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"An explanation for the different climate sensitivities of land and ocean surfaces based on the diurnal cycle" by Kleidon and Renner introduces a simple conceptual model to understand why surface temperatures over land respond more strongly than those over ocean to climate change. The mechanism is based on differences in the diurnal energy budgets over land and ocean and is found to agree well with predicted land-ocean warming contrasts from CMIP5 models.

I find this paper to be a novel and interesting addition to the literature on the land-ocean warming contrast. My main comments (outlined below) relate to the formulation of the simple model and the validity of these assumptions. If the authors can address these concerns, I will be delighted to recommend publications.

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Discussion paper

Specific comments: -Page 1, Line 2: "...with the cause for this difference being still unclear." I do not agree with this statement: Much research on the land-ocean contrast has been conducted over the last 10 years and in particular, the convective quasi-equilibrium theory by Byrne & O'Gorman (2013) [cited in this text] can quantitatively capture the warming contrast in CMIP5 models. So I, and many others in the field, strongly believe that we now do have a good understanding of the processes driving the warming contrast and I suggest that the authors might refine this statement in the abstract to reflect this developing consensus. -Page 1, Line 20: Spelling: "be found" -> "been found" -Page 1, Line 23: Byrne & O'Gorman (2013) identified that the land-ocean warming contrast depends not only on changes in relative humidity, but also on the climatological relative humidity over land. -Figure 1: "loosing heat" -> "losing heat"

-Pages 2,3: The following passage of text contains many statements that are key assumptions for the simple model derived in this study, yet are not supported by references. I strongly recommend that the authors better justify these statements by citing observational (preferably) or modeling studies:

"For ocean surfaces, these heat storage changes take place in the surface ocean. Solar radiation penetrates the surface ocean to quite some depth before it is absorbed. Combined with the large heat capacity of water, this results in diurnal heat storage changes that take place below the ocean surface (sketched by the red line on the left of Fig. 1). The build-up of heat storage during the day then maintains radiative cooling and turbulent heat fluxes during the night, resulting in little diurnal variations in surface temperature and turbulent fluxes. Over land this situation is quite different. Solar radiation is absorbed at the surface (or above in a canopy), but not below the surface. This is because land surfaces are not transparent as water, and because the heat conductivity of soils is generally so low that heat fluxes in and out of the ground are generally small. The strong diurnal variation in solar radiation is thus not buffered below, but rather above the surface in the lower atmosphere. These changes in heat storage manifest themselves in the diurnal growth of the convective boundary layer.

This buffering above the surface has an important consequence for the fluxes of the surface energy balance. Turbulent fluxes only take place when the surface is heated by solar radiation during the day that causes the near-surface air to become unstable, while the nighttime is characterised by stable conditions near the surface as little heat can be drawn from the heat storage below the surface. This prevents turbulent fluxes to take place at night and the cooling at night is thus determined only by radiative exchange. Turbulent cooling of the surface thus takes place during half of the whole day, while the other half it is cooled by radiative exchange."

-Page 5, line 7: "which is typically small on a diurnal time scale" -> reference needed to support this statement -Page 7, line 14: "For the land surface, we assume that the heat storage changes take place in the lower atmosphere" -> is this a reasonable assumption? Reference needed again. Land surfaces can get very hot during the daytime so it is not obvious to me that the surface storage term should be negligible. -Page 7, line 20: Is it reasonable to assume a net LW radiative flux of zero overnight over land? Are there observations to support this key assumption? -Page 8, section 3.1 & Table 2: Various numbers are assigned to parameters in the simple model here but it is not clear which are based on observations and which are tuned so as for the simple model to give a reasonable climatology. A but more detail behind these choices is requested. -Page 8, line 26: The change in LW optical depth is chosen to be 0.11 - how does this compare to observed/modeled radiative forcings? It is important that this number is reasonable as this would validate the simplified radiation parametrisation used. -Page 13, lines 10+11: " First, our results show that the diurnal dynamics of the surface energy balance of ocean and land surfaces are distinctively different." -> I would argue that you assume the diurnal dynamics are different when constructing the simple model. More justification for these assumptions is greatly needed in order to make the results more compelling.

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