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Earth System Dynamics
Discussions

Interactive comment on "ESD Ideas: The stochastic climate model shows that underestimated Holocene trends and variability represent two sides of the same coin" *by* Gerrit Lohmann

Anonymous Referee #1

Received and published: 10 August 2018

Recommendation: I recommend that the paper not be accepted in its present form, but that it could be accepted after major revision.

Referee's General Comments This paper briefly summarizes some observational (Alkenone proxy) and modelling (GCM and ESM) results on trends and variability of global mean SST over the period 6 kyrs to present. During this period, the orbital forcing varied significantly as a function of latitude and season, but the global mean insolation remained constant. The results show that the observational SST trends are poorly defined, varying from -4K to +2K over the 6 kyr period. The modelled trends

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are considerably smaller, being confined mainly to the range -1K to +1K over the same period (Figure 1(a)). The observational results also show large variability of the global mean SST with periods from 2 yr to 3000 yr, increasing towards the longer periods. It is unknown how much of this variability is externally forced and how much of it is internal. The corresponding model results show smaller variability on multidecadal to millennial periods (Figure 1(b)). In view of the poor definition of the observational trends and the lack of knowledge regarding the partitioning of the observational variability, very strong caveats should be placed on any conclusions drawn from this observational/modelling comparison. In particular, since there is no global mean orbital forcing over the 6 kyr period studied, extreme care should be exercised in drawing any conclusions from the study as to the value of climate sensitivity to greenhouse gas increase.

Referee's Specific comments

In the theoretical part of the study, a zero-dimensional stochastic model represented by Equation (1) is used in an attempt to gain conceptual understanding of the observational and modelling results described above. The term f(t) is used to describe the deterministic forcing and this is assumed to be of the form f(t) = c u(t), where c is a constant and u(t) is a unit Heaviside step function. This means that a non-zero global average forcing is assumed, in contrast to the situation prevailing in the late Holocene period 6 kyrs to present, where the global average orbital forcing is zero. From this conceptual model, it is concluded that an underestimation of variability forced by a white noise stochastic forcing implies an underestimation of climate sensitivity to the c u(t) forcing. However, this form of conceptual model does not adequately describe the climate system as forced by the late Holocene orbital forcing. A conceptual model of minimum complexity to do this would be a three-box model such as used by Stap et al. (2018) to study paleoclimate sensitivity. I recommend that such a model instead of that represented by Equation (1) be used to gain theoretical insight into the observational and modelling results described above.

Stap, L. B. et al. (2018). Modeled influence of land ice and CO2 on polar amplification

and paleoclimate sensitivity during the past 5 million years. Paleoceanography and Paleoclimatology, 33. https://doi.org/10.1002/2017PA003313.

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