

## ***Interactive comment on “Interhemispheric bias in earth’s climate response to orbital forcing” by R. Roychowdhury and R. M. DeConto***

### **Anonymous Referee #1**

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### **1 Summary**

The authors discuss 12 sensitivity experiments with a recent General Circulation Model, called GENESIS3.0. The model is in its atmosphere - slab version (no ocean dynamics). The 12 sensitivity experiments consist in four different idealised orbital configurations (testing different extreme cases of precession and obliquity), repeated three times:

- with modern configuration,
- with an artificial configuration consisting in the modern northern hemisphere mirrored into the southern hemisphere,

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- with an artificial configuration consisting in the modern southern hemisphere mirrored into the northern hemisphere.

The purpose of the authors is to document the effect of having, in the other hemisphere, something different than the mirror of the hemisphere being considered. This effect is termed ‘Land Hemisphere Bias’ (LHB). The authors consider two diagnostic quantities : the “Summer Metric” (essentially a growing-degree-days, or positive-degree-days), and the surface air temperature at 2~m. They conclude that geography has an “important control on the climate system’s response to insolation”.

### **2 Major comments**

There are three major concerns with this study:

- Misleading interpretation. True, the authors correctly point out that what is called the ‘LHB’ is in fact an effect of the *other* hemisphere being different than a mirror. So, for example, when they say that (p.11) “the Southern Ocean has a perennial positive bias”, it is in fact a reference to the fact that the northern hemisphere, with its reactive land masses, increases the temperature of the southern hemisphere compared to a situation where the northern hemisphere would be mainly ocean, like the southern hemisphere. . . A “bias” in the northern hemisphere is thus a southern-hemisphere effect; but a “bias” in the northern hemisphere is taken by reference to a land-dominated southern hemisphere. Consequently the biases in the southern and the northern hemisphere are calculated with respect to different references. The authors clarify and defend this approach but it may nevertheless be argued that these subtleties obscure the practical implications of these experiments for understanding palaeoclimate records. Consider the following example: “interglacial (warm summer) conditions are muted relative to those of a symmetric

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earth". At this stage one should already be aware of the fact that the 'symmetric earth' that we use as a reference differs whether we consider the southern or the northern hemisphere. The authors, yet, go on: "the 'land effect' causes an intensification of 'glacial' vs 'interglacial' conditions in both hemispheres when perihelion coincides with Southern Hemisphere summer". We have the same problem.

The following example might make the case more obvious: "At HIGH obliquity, there exists a negative bias on the Northern Hemisphere Continents". This *bias* is compared to an Earth where southern and northern hemisphere would be dominated by land. Wouldn't we expect a "positive bias" if we were to compare this situation with an earth dominated by oceans?

- Slab ocean. Slab ocean is practical to test different land configurations, but ocean heat transport changes are neglected. This may be acceptable for studying regional effects (monsoon), but the constrain of fixed heat transport becomes uncomfortable when it comes to study inter-hemispheric effects. At the very least caveats had to be given.
- The focus on temperature response obscures the interest of using an advanced general circulation model for this study. It seems that most if not all the conclusions presented here would have been similarly obtained with an Energy Balance Model. Nothing is said about atmospheric connections, hydrological budget, pressure response. Possible implications for moisture transport are evoked in the conclusions but they are not backed by proper analysis.

### 3 Minor comments

There are a few places with loose wording. E.g.:

- p. 4 line 19 : "should theoretically move equally north and south according to the  
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hemisphere experiencing summer". The theory precisely says that it should not be symmetric ! (given the asymmetry)

- p. 10 line 15 : "perennial positive bias" : in what sense is it perennial ?
- Use standard definitions when they exist. E.g.: "orbital precession" is in fact the heliocentric longitude of the perihelion.

References to literature:

- Recent landmark citations (Huybers (2006), Raymo (2006)) are valid, but proper credit should be given to Pollard for the use of PDD, and Berger for pioneering analysis of insolation.
- The introduction quotes earlier works on effects associated with Earth's geography on climate sensitivity, but little is said about how the results presented here compare with earlier findings.

Notation clash:

- $S$  is used both for the summer insolation metric, and for the south-symmetric simulation.

### 4 Conclusion

This review has questioned the relevance of the experiments, their implications for our understanding of palaeoclimates dynamics, and the depth of the analysis, without being able to conclude on a positive recommendation for publication.

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