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# *Interactive comment on* "On the mechanisms of warming the mid-Pliocene and the inference of a hierarchy of climate sensitivities with relevance to the understanding of climate futures" *by* Deepak Chandan and W. Richard Peltier

**Anonymous Referee #1**

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General Comments

The authors present the results of a modeling study evaluating the mechanisms that may have sustained Pliocene warmth and how these mechanism affect climate sensitivity on several timescales. Their effort to diagnose the mechanisms supporting the polar amplified warming within their simulation is impressively comprehensive. The factorization technique based on eight sensitivity simulations is used to diagnose the relative contribution of changes in orography, ice sheets and CO2, and a 1-D energy balance model based analysis is used to diagnose the specific mechanism



(albedo/emissivity/heat transport). The authors find that CO2 and the water vapor feedback are responsible for around 2 thirds of their Pliocene warming and albedo changes the remaining third. The majority of the warming occurs polewards of 50N&S and subsequently the discussion focuses on the mechanisms behind this. The paper is clearly written particularly given its length and the breath of analysis employed.

There are however several aspects of Pliocene climate and areas of uncertainty the deserve mention and/or more discussion in the manuscript:

Specific Comments

Pg. 2 last paragraph and the subsequent climate sensitivity assessment - That aerosols and their indirect effects are assumed to have been similar to modern while in fact the proxy data currently provides little constraint on this. Some mention should be made of this caveat.

Pg. 3 third paragraph & Pg 4 second paragraph & Fig. 9 - While the mid-Pliocene simulation "reasonably accurately capture features of the proxy-inferred enhanced warming in the high-latitudes during the mid-Pliocene." it does not appear to be capturing the structure and amplitude tropical to subtropical warming as is the case for most models and also the zonal SST gradient along the equator e.g. see Fig. 1 in Brierley et al. 2015. What is amazing in Fig. 9 is just how uniform the zonal mean warming is equatorward of 45N&S and we know from the data this is not the case e.g. Dowsett et al. 2013 Figs 2 & 3 Fig OR Fig. 3b in Haywood et al. 2016. Some mention should be made of this shortcoming and the fact that the result are perhaps more relevant to high latitude Pliocene climate than tropical and subtropical Pliocene climate.

Pg. 18 lines 29-30 - This weak cloud forcing outside of the high latitudes is the reason why there is no weakening of the meridional SST gradient between the mid-latitudes and the deep tropics and the zonal SST gradient along the equator - e.g. see Fedorov et al. 2015, Burls and Fedorov 2014

Pg. 19 lines 5-7 - This result is consistent with Feng et al. (2017).

Pg. 19 lines 30-32 - Another noteworthy reference that highlights the potential importance of mixed-phase clouds is Sagoo and Storelvmo (2017)

Technical Comments

Pg. 7 end of paragraph two - Does this mean that the Eo experiments represents not only the effects associated with changing to Pliocene orography but also bathymetry? In which case changes in ocean-gateways? This needs to be clarified.

On a related note some discussion is needed of the recent paper by Otto-Bliesner et al., 2017 pointing to changes in Pliocene gateways as a mechanism supporting Arctic warmth during the Pliocene. Could this help explain some of the hemispheric asymmetry discussed in paragraph 1 on page 17?

Pg. 26 lines 17 - 18 - Any ideas of the mechanisms behind why the situation is the opposite with SH sea ice displaying a greater response under higher CO2? This is an interesting result.

The second last sentence on page 30 is unclear.

References mentioned

Brierley, C., Burls, N., Ravelo, C., & Fedorov, A. (2015). Pliocene warmth and gradients. Nature Geoscience, 8(6), 419–420. http://doi.org/10.1038/ngeo2444

Haywood, A. M., Dowsett, H. J., & Dolan, A. M. (2016). Integrating geological archives and climate models for the mid-Pliocene warm period. Nature Communications, 7, 10646. http://doi.org/10.1038/ncomms10646

Dowsett, H. J., Foley, K. M., Stoll, D. K., Chandler, M. A., Sohl, L. E., Bentsen, M., et al. (2013). Sea Surface Temperature of the mid-Piacenzian Ocean: A Data-Model Comparison. Scientific Reports, 3, 2013–2018. http://doi.org/10.1038/srep02013



Dowsett, H. J., Robinson, M. M., Haywood, A. M., Hill, D. J., Dolan, A. M., Stoll, D. K., et al. (2012). Assessing confidence in Pliocene sea surface temperatures to evaluate predictive models. Nature Climate Change, 2(5), 365–371. http://doi.org/10.1038/nclimate1455

Otto-Bliesner, B. L., Jahn, A., Feng, R., Brady, E. C., Hu, A., & Löfverström, M. (2017). Amplified North Atlantic warming in the late Pliocene by changes in Arctic gateways, 44(2), 957–964. http://doi.org/10.1002/2016GL071805

Fedorov, A. V., Burls, N. J., Lawrence, K. T., & Peterson, L. C. (2015). Tightly linked zonal and meridional sea surface temperature gradients over the past five million years. Nature Geoscience, 8(12), 975–980. http://doi.org/10.1038/ngeo2577

Burls, N. J., & Fedorov, A. V. (2014). Simulating Pliocene warmth and a permanent El NiñoâĂŘlike state: The role of cloud albedo. Paleoceanography, 29(10), 893–910. http://doi.org/10.1002/2014PA002644

Feng, R., Otto-Bliesner, B. L., Fletcher, T. L., Tabor, C. R., Ballantyne, A. P., & Brady, E. C. (2017). Amplified Late Pliocene terrestrial warmth in northern high latitudes from greater radiative forcing and closed Arctic Ocean gateways. Earth and Planetary Science Letters, 466, 129–138. http://doi.org/10.1016/j.epsl.2017.03.006

Sagoo, N., & Storelvmo, T. (2017). Testing the Sensitivity of Past Climates to the Indirect Effects of Dust. Geophysical Research Letters, 44(11), 5807–5817. http://doi.org/10.1002/2017GL072584

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