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Climate of the Past Discussions

Interactive comment on "Evaluating the dominant components of warming in Pliocene climate simulations" *by* D. J. Hill et al.

Anonymous Referee #2

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The manuscript by Hill et al. is based on results of the Pliocene Modeling Intercomparison Project (PlioMIP). The manuscript presents an attempt to analyze contribution of different climate factors to surface temperature change using a simple energy balance approach. Similar approach has been used by Lunt et al. (2012) but for the Eocene climate. I believe, this is a potentially interesting and useful paper but in the view of problems discussed below the manuscript requires major revision.

General comments

1. The authors formulate the goal of the manuscript as to "evaluate the cause of the increased temperature and difference between the models". While this goals is important, I do not believe that the manuscript made a great advance in this direction. Analysis of inter-model differences in the PlioMIP experiments has been described al-

ready in Haywood et al. (2012). The only difference between Fig. 1 in the manuscript by Hill and Fig. 2 in Haywood et al. (2012) is in using of normalized standard deviation. These two papers also have almost identical Tables 2. One of the main conclusions of the manuscript by Hill et al. is that in the tropics warming is dominated by GHGs change. This is rather trivial. The statement that "cloud albedo feedback enhances the warming" is probably correct but I doubt that the method used in this study is adequate to quantify the contribution of cloud albedo change (see my next comment). The statement that "dominant warming [in the high latitudes] comes from the clear sky albedo" is probably also correct but the role of clear sky albedo is grossly exaggerated by the method employed in this manuscript. I also found it strange that the cloud emissivity contribution is essentially zero in the tropics (Fig. 3) while it is known that LW cloud feedback in the tropics is strongly positive.

2. Energy balance approach used in Heinemann et al. (2009) represents a useful tool for better understanding results of complex climate models. However, I strongly believe that separation of albedo effect on "clear sky" and "cloud" components made in Lunt et al. (2012) and used in a similar form in Hill et al. contains a serious error. The radiative forcing of clear sky albedo change, that is primarily determined by the surface albedo change, only operates under clear sky conditions. Since in the high latitudes cloud fraction typically is larger than 0.5, the contribution of the clear sky albedo to temperature change (deltaT_csa) is overestimated by the fourth formula on page 1607 by more than a factor of two. At the same time, "cloud albedo" component (deltaT_ca) is calculated as a residual between the effect of planetary albedo change on temperature and the exaggerated effect of surface albedo. As the result, the "cloud albedo" component has nothing to do with cloud albedo change or cloud feedback. For example, in the case when cloud fraction n=0.5, deltaT_ca will be approximately equal to -0.5 deltaT_csa. Indeed, individual models and their average (Fig. 3, 4, 5) show that the "cloud albedo" curves mirror the "clear sky albedo" curves. None of these two curves has physical meaning, only the sum of them represents the true effect of planetary albedo change on temperature. If the authors want to separate the effects of

surface albedo and cloud albedo on temperature, they should take into account both cloud fraction and its change.

Specific comments

P. 1601, L. 10 “Cloud albedo feedbacks enhancing the warming” The manuscript contains no discussion of cloud feedback.

P. 1607-1610. Section 6 is hard to read because it plainly describes what one can see in Fig. 2. A short summary would be sufficient.

P.1613, L. 27. “simulations with particularly good representation of low latitude clouds” What “particularly good representation” means?

P. 1614, L. 3. Vegetation and ice sheets are prescribed in PlioMIP and therefore cannot be named feedbacks. Whether prescribed changes in ice sheets and vegetation really represent feedbacks to enhanced CO2 is an open question.

P. 1615, L. 9. “From the PlioMIP Experiment 2 simulations it appears that higher CO2 concentration warmed the planet. . .” This of course was known before PlioMIP.

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