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Warm Paleocene/Eocene climate as simulated in ECHAM5/MPI-OM

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We investigate the warm *late Paleocene / early Eocene* (PE) climate using the coupled atmosphere-ocean-sea ice model ECHAM5/MPI-OM. The simulated PE Earth surface is on average 297K warm and ice-free. Snow at high latitudes accumulates during local winters but melts entirely during summers. Although we use a moderate greenhouse gas forcing (only doubled preindustrial pCO_2), the PE Earth surface is on average 9.4K warmer than a preindustrial reference simulation (PR). While low latitudes are on average about 5 to 8K warmer, northern high latitudes are warmer by up to 20K, and southern high latitudes are warmer by up to 40K. This large high latitude PE-PR temperature difference is in line with proxy data, yet a comparison to sea surface temperature proxy data suggests that the PE Arctic surface temperatures are still too low.

To identify the main mechanisms that cause the large warming in the PE run compared to the PR, we fit a zero-dimensional energy balance model (EBM) to the ECHAM5/MPI-OM results. We find that about 6K of the warming are due to a reduction of the atmospheric longwave emissivity, and about 3K are due to a reduction of the planetary albedo. The lower PE longwave emissivity has several sources. According to the EBM, the prescribed doubled pCO_2 directly causes a warming of about 1K. The longwave cloud radiative forcing (CRF) is somewhat larger in PE than in PR, especially at high latitudes causing about 0.2K difference globally. Orographic differences such as the lower PE Antarctic continent cause almost 1K of the temperature difference. We ascribe the residual emissivity-related temperature increase of about 4K to an almost doubled water vapour content. The lower planetary albedo in PE is due to a darker land surface according to our vegetation choice. A more negative shortwave CRF in PE partly compensates for the surface albedo change (causing about -1K globally). This shortwave CRF difference is largest at high latitudes; clouds thus reduce the high latitude PE-PR temperature difference and work against a meridionally more equable climate. We also find that meridional heat transport does not add to the meridionally more equable climate in this PE simulation. While the PE atmospheric meridional heat transport hardly differs from the PR, the oceanic meridional heat transport is about 0.5PW smaller in PE than in PR. Our results give further support to the hypothesis that radiative effects, rather than enhanced meridional heat transports, were chiefly responsible for equable PE climates.