

Late Pliocene Ice Sheets as an Analogue for Future Climate: A Sensitivity Study of the Polar Southern Hemisphere

The authors set out to assess the impact perturbing Antarctic and Greenland albedo has on the polar Southern Hemisphere climate. The paper includes no analysis of any GrIS_{ANOM} impacts; this should be reflected in both the introduction and results sections.

The description of the experimental design is lacking key details.

1. Considering Table 1; are all simulations initialised using the same spun-up pre industrial (PI) ocean state? Thus, E400 is an instantaneous $N \times PI$ increase in CO₂? This would mean that Ei280 is also not spun up (a simulation which doesn't seem to be analysed anyway; does it need to be included?).
2. The Pliocene Antarctic and Greenland ice extents are mapped onto PI model states via adjustments land surface albedo. It is not clear how, by reducing snow depth, the albedo is modified. As I understand it, EC-Earth3 considers snow over certain depth to be perennial; with a fixed albedo and no accumulation allowed (a proxy for ice sheet surface conditions). If the snow depth is reduced below this threshold, is the surface considered to be seasonal, with albedo a weighted function of α_{snow} and α_{rock} ? With WAIS orographic height retained, I would expect multi-year snow to accumulate (unless this is inhibited, as per the perennial snow); maybe that is what is happening (see Fig.2(d), WAIS $d\alpha = 0$ regions).
3. The authors need to justify the usefulness of effectively transforming ice into rock (change of albedo, but no change of orography). What physical information does this provide (beyond what could be obtained from a simple energy-balance model)?

Results

1. The comparison of E400 with E280 is essentially a comparison of contemporary climate with PI (albeit, with an instantaneous CO₂ increase). The resulting Antarctic temperature changes are large when compared to observations or other modelling studies; this seems to be a result of excessive sea-ice loss. Is this similar to that seen previous EC-Earth3 historical simulations? The changes observed in Ei400 are harder to interpret without fully understanding the albedo adjustment (see above). The inland signals are dominated by the warming over the Ross, Ronne and Amery ice shelves; this is understandable as these are low altitude (warm) regimes that have been transformed into storage heaters.
2. Differencing of same field regressed principal component loading patterns (Fig 3(a,b)) is unusual, and difficult to interpret without any measure of significance. Does EOF1 in the three regimes represent a similar percentage of variance? If not, these differences would be problematic. Rather than (or in addition to) the EOF formulation, SAM indices of the $P_{lat1} - P_{lat2}$ form would be easier to compare. Figure 3(c) shows an apparent intensification of SAM, but without the normal peninsular warming; the following ocean analysis also shows a decrease in on shelf CDW (the opposite to that expected). It is suggested that E400i has a more chaotic pattern; this isn't reflected in Figure 4(c) (again variance measures are required). The wind pattern (Fig. 3(d)) is indicative of a weaker SAM, with a shift of the jet to more northern latitudes.
3. The AABW recovery in Ei400 is of interest, and the mechanisms should be analysed further. There is an increase in salinity at depth, but this is associated with an increase in temperature; it would be beneficial to see the density profiles.

General:

1. When showing difference plots, show some measure of significance.
2. Line #199; missing figure number.