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Impact of the global SST gradients changes on the Antarctic ice sheet surface mass balance through the Plio/Pliocene transition

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Sea Surface Temperatures (SST) reconstructions have shown that the Pliocene global zonal and meridional temperature gradients were different from today, implying changes of atmospheric and oceanic circulations, and thus of the main teleconnections. The impact of the main atmospheric teleconnections on the surface mass balance (SMB) of the Antarctic ice sheet (AIS) in the past has been seldom investigated. The ANDRILL marine record have shown that at the end of the Pliocene, the ice sheet expanded in the Ross Sea concomitantly with the expansion of the sea ice cover. This would have enhanced the formation of bottom waters that in turn, would have fostered upwelling along the West African coast and along the coast of Peru. The impact of Antarctica on the tropical climate dynamics has been shown by previous studies. To close the loop, this work investigates the impact of the tropical and high-latitude SST cooling on the main atmospheric teleconnections and then on the Antarctic SMB through the Plio/Pleistocene transition.
Idealized Atmospheric General Circulation Model simulations are performed, in which high-latitude and tropical SST cooling are prescribed starting from the Pliocene SST. The atmospheric conditions obtained are then used to force an ice sheet model and a stand-alone energy balance model to investigate the impact on the SMB of the two main atmospheric teleconnections active in the Southern Hemisphere, namely the Southern Annular Mode (SAM) and the Pacific-South-American oscillation (PSA. In agreement with ANDRILL marine records, results show that the Easterlies strengthen along the Antarctic coasts during the Plio/Pleistocene transition. This, however, occurs only after cooling the tropical SSTs in the AGCM simulations. More importantly, the cooling of the tropical SST, through the strengthening of the PSA, has the largest influence on the spatial distribution of the climatic anomalies over Antarctica. This explains most of the SMB patterns simulated by the ice sheet model. In particular, the PSA fosters positive SMB over the Victoria Land, the Wilson Basin, the Aurora Basin and Prydz Bay that were partly deglaciated during the warm Pliocene. While the amplitude of the ice thickness changes due to the SAM and the PSA remains of the same order of today, i.e, few tens of meters, the main impact occurs in strategic areas of the AIS dynamics.