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MIS M2 initiation and termination link to the shallow CAS open and close?

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The Marine Isotope Stage M2 (3.264 -3.312 Ma) occurred just prior to the well documented warm mid-Pliocene (mPWP). With a 0.5‰ benthic foraminiferal δ180 shift (Lisiecki and Raymo, 2005), MIS M2 is thought to be a glacial comparable period associated with huge but uncertain sea-level records of 20-60m below present levels (Naish et al. 2009; Miller et al. 2012; Dwyer et al. 2009). However, the mechanism of M2 initiation and termination are still an enigma, since CO_2 records were relatively higher than the Quaternary glaciation period and the minima summer insolation during M2 was stronger than other glacial periods. By inferring from data records, De Schepper (2013) proposed that the shallow open Central American Seaway (CAS) observed during M2 could play as a trigger in M2 initiation, then the closure of this shallow CAS resulted from M2 large ice sheet build-up terminates this glacial period. But this assumption has not been test by the model.
In this study, we apply IPSL-CM5A Atmosphere-Ocean coupled General Circulation Model (AOGCM) and GRISLI ice sheet model to investigate mechanisms of M2 initiation and termination. We firstly investigate the role of “shallow open CAS” (De Schepper et al. 2013) on M2 initiation. In the mean time we also take into account the main forcing during M2, which includes astronomical parameters, Greenhouse gases and vegetation. Our results show that shallow open CAS plays an important role in reducing northward heat transport in Atlantic low latitudes by 0.05 – 0.1 PW, but it is not a key factor in NH ice sheet build-up; Astronomical parameters and CO_2 concentration are essential to create a basic global cooling environment for M2 (cooling by $\sim$3.65 K than mPWP); Cold vegetation replacement amplifies the cooling in north high latitudes by $\sim$ 8 K, which finally allows large ice sheet building up in Northern Hemisphere (12.25 m sea level drop is simulated with considering ice sheet feedback on the climate). The simulated ice sheet locations and areas correspond well to the terrestrial ice evidence. The diagnostics in the Atlantic Ocean also suggest a better agreement with data especially in terms of sea surface temperature and North Atlantic Current change. The huge estimation of sea level records of M2 also attributes to the rise of Antarctic ice sheet volume. Thus we also quantify the change of Antarctic ice sheet volume with model. Finally, to explore the relationship between M2 termination and the closure of shallow CAS, we close CAS based on the simulation with large ice sheet built-up scenario. However, the closure of Panama seaway does not trigger a great decrease of ice sheet in NH. This result indicates that the termination of M2 is not determined only by the change of Panama seaway, it could be a result of different climate feedbacks and interactions between climate systems. Our study enables to confirm the links between M2 process and shallow CAS context, to explore the role of main forcing in M2 initiation and to quantify sea level drops provided by the model.