Climate of the Past Discussions

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Comment on cp-2022-42

Anonymous Referee #1

Referee comment on "Precessional pacing of tropical ocean carbon export during the Late Cretaceous" by Ji-Eun Kim et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2022-42-RC1, 2022

The Shatsky Rise in the Northwest Pacific preserves high-quality deep-sea sediment spanning the whole period of the Cretaceous and the Cenozoic, being an ideal place to perform studies in the field of paleoceanography and paleoclimate. The previously well-known research work has been focused on the Cenozoic. However, the research works in the Cretaceous are all based on low time resolution proxy records that limits our understanding on a warmer than today climate condition.

Kim and co-authors presented a high-resolution composite record from ODP Leg 198 Sites 1209 and 1210 on Shatsky Rise, Northwest Pacific during the Maastrichtian Stage from the Upper Cretaceous Epoch that lasted from 71.5 to 66 Ma. The new dataset includes the high time resolution (3-4 kyr) bulk carbonate d13C and d18O measured in 1394 samples and ultra-high time resolution (~1 kyr) non-destructive X-ray-fluorescence (XRF) Core Scanning Barium data collected every 2 cm. For the first time, this high-quality and high time resolution dataset allows us to perform paleoceanographic studies on orbital time scale, probing the imprints of orbital forcing in the deep sea sediment of the Pacific Ocean during a warmer than today or greenhouse climate state.

The paper is well written with clear structure, which is easy to be understood. The supplementary information includes enough and detailed materials for evaluation. In summary, the newly presented dataset in the Shatsky Rise has great potential for improving our understanding on the forcing mechanism of the orbital scale climate change in a greenhouse world. I would encourage publication in Climate of the Past if they could consider a few of my major concerns as listed below.

The key point of this manuscript is “precessional pacing”. However, spectral analyses in both depth (independent of the tuned age model based on comparison of 405 ka cycle) and time (Figures S10, S12 and S13) display that the most prominent orbital cycle in the variability of planktonic d13C and d18O and the Ba is the 405 ka long eccentricity cycle, with strong 21 ka precession cycle, weak 41 ka obliquity cycle and relatively weak 100 ka short eccentricity cycle. The planktonic foraminiferal d13C is closely related to the biological pump and the carbon export production of the upper ocean. The Eccentricity modulates climate change through a nonlinear forcing because the eccentricity's contribution to insolation is too small to take effect in a linear insolation-climate system. The 405 ka long eccentricity cycle is also the most remarkable and stable orbital cycle for the past 250 million years. The 100 kyr short eccentricity cycle also modulates the amplitude of the climate precession. Therefore, why "the precessional pacing of tropical ocean carbon export"?

The traditional concept of "biological pump" was cited to interpret the ocean carbon export production in this study. In Figure S5, the authors compared the high time resolution bulk d13C and d18O with the low time resolution planktonic foraminiferal d13C and d18O. They concluded that the two kinds of d13C records resemble to each other. As far as I am concerned, only the bulk carbonate d13C shows similarity to the Rugoglobigerina rugosa (subsurface species, deeper) d13C (Figure S5, top, green) but big differences with the Pseudoguembelina costulata and P. kempensis (surface species, shallower) d13C (Figure S5, top, orange). In the greenhouse world of the Cretaceous, a time interval without global ice volume effect on the calcareous shells of planktonic foraminifers, the temperature and salinity are two major factors controlling the planktonic foraminiferal d18O. As seen in Figure S5, the d18O of the subsurface species (green) are obviously heavier than that of the surface species (orange), indicating cooler or saltier water mass. However, the d13C of the subsurface species (green) is also heavier than that of the surface species (orange), which is opposite to the vertical distribution of the water mass d13C caused by the traditional biological pump that decreases with water depth. The inconsistency probably indicates that the ocean carbon export production of the tropical Pacific Ocean during the greenhouse world of the late Cretaceous is different with that we have known today. The authors need to add a new paragraph to discuss this inconsistency before they could use the XRF core scanning Ba record as a proxy of the ocean carbon export production.

The last part of this manuscript "3.4" focuses on the discussion of direct response to precession during greenhouse world. An important content of this part is the discussion on whether the tropical Pacific was more like a permanent El Niño like state or robust ENSO-like variability existed in past greenhouse conditions. ENSO is El Niño-southern oscillation. The authors need to explain the difference in "El Niño like state" and "robust ENSO variability" in a greenhouse condition. Today, we usually use the changes of the gradients in both the SST (Sea Surface Temperature) and the Thermocline Depth of the east and west equatorial Pacific to depict the ENSO variability that is a typical climate phenomenon in the equatorial Pacific Ocean. The sites 1209 and 1210 were in the middle of the tropical open ocean in the late Cretaceous (Figure 1). Can we depict the ENSO variability if it really existed in the late Cretaceous without reconstructions of the gradients of the SST or thermocline depth in the east and west equatorial ocean? If not, the vague discussion based on non-proxy-derived discussion would lead to misunderstanding.