Evolution of the ocean monsoon regions over the past 250 million years

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A set of deep-time climate simulations each 10Ma years from 250Ma to PI are conducted by using the NCAR-CESM1.2, for understanding the evolution of the ocean monsoon regions driven by tectonic dynamics over the past 250 million years and exploring its variation mechanisms. In recent years, scientists have proposed the concept of a global monsoon system, which includes not only typical monsoon regions (such as the African monsoon region and South Asian monsoon region), but also the atypical Northwest Pacific Ocean monsoon region. Research on the ocean monsoon is very limited, especially in the field of paleoclimate. The results in this paper show that the horizontal gradients of the thickness of the ocean mixed layer may be more important for the formation of the ocean monsoon than land-sea thermal contrast, which is confirmed by the aquaplanet simulations with various gradients of the ocean mixed-layer thickness. Near the Pacific monsoon region in the northern hemisphere, the thickness of the ocean mixed layer has obvious meridional and zonal gradients, which will correspond to the meridional and zonal thermal contrasts. In addition, there are obvious seasonal reversals in the gradients of the ocean mixed-layer thickness in summer and winter, and the corresponding longitudinal and zonal thermal contrast produce seasonal reversals. Over the past 250 million years, the thickness of the ocean mixed layer on the east side of the Pacific Ocean Basin in the Northern Hemisphere has deepened, and the corresponding ocean monsoon area on the east side of the Pacific Ocean has decreased. The changes in the thickness of the ocean mixed layer are closely related to the changes in the surface wind field. Examining the changes in the atmospheric circulations, we find that the Pacific subtropical high strengthens and extends from east to the west bank of the ocean basin, where the atmospheric low-level anticyclonic circulation causes the ocean surface layer to converge and sink and thus causes the ocean mixed layer to deepen. The changes in the Pacific subtropical high are related to changes in the continental monsoon region. Since the 170Ma, the Pangea supercontinent splits up, causing the supercontinent's inland water vapor to increase, the land monsoon area to increase, and the ocean monsoon area to decrease. According to the "monsoon-desert mechanism" of Rodwell and Hoskins, we can understand the relationship between the strengthening of land monsoon condensation heating and the formation of subtropical high over the western ocean.