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Oxygen isotopes of individual planktic foraminifers reveal Pliocene-Pleistocene change of seasonal upper ocean stratification in the northern South China Sea

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Most paleoceanographic studies using planktic foraminifera focus on annual means, but seasonal signals buried by the analyses of lumped specimens could be very valuable. Surface ocean feedbacks on climate change may be more significant in the seasonal realm than annual mean in the northern South China Sea, a region being strongly affected by Asian monsoons and tropical cyclones. Here we use oxygen isotope measurements on individual specimens of surface and subsurface planktic foraminiferal species to reconstruct surface seasonality and seasonal upper ocean stratification in this region. Many studies have shown that the thermocline was deeper in the tropical Pacific during the Pliocene than the Pleistocene, but the mechanism remains unclear. Several processes could lead to changes in the upper ocean stratification, such as changes in sea surface temperature and upper ocean mixing by tropical cyclones. Our results show that the upper ocean stratification was weaker during the Late Pliocene than the Early Pleistocene, with the change more significant in summer than winter, while no systematic offset is observed in the surface seasonality. The observations suggest that enhanced mixing by tropical cyclones might be the major cause of the deeper thermocline during the Pliocene.