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Modeling Study of Orbital-scale Precipitation Variations in Mid-latitude Asian Monsoon and Arid Areas over the Last Glacial-interglacial Period

Xiaodong Liu and Xinzhou Li

Institute of Earth Environment, Chinese Academy of Sciences, Xi'an, China (liuxd@loess.llqg.ac.cn)

Based on a 150-ka transient numerical simulation with the Community Climate System Model version 3 (CCSM3) of the National Center for Atmospheric Research (NCAR) and the orbital acceleration technique, comparative analyses are made to reveal orbital-scale precipitation variations induced by changes in insolation related to Earth's orbital parameters in humid monsoon areas and arid inland regions of mid-latitude Asia during the last glacial-interglacial period. The results show that there are significant quasi-20ka precession cycles for the annual precipitation in both East Asian monsoon region and Central Asia arid zone during the past 150 ka, in phase with the summer insolation of Northern Hemisphere (NH). However, the rainy season appears in summer and winter for East Asia and Central Asia, respectively. And thus, the annual precipitation mainly depends on summer rainfall brought by the summer monsoon over East Asia, while the annual precipitation is mostly decided by the westerly-controlled winter precipitation. Composite analyses of seven precession cycles show that the precession-induced reverse changes in the boreal summer and winter insolation control precipitation variations of rainy season over East Asia and Central Asia, respectively. When the NH summer insolation is intensified by the effect of precession, the warming over Asian continent is more significant than that near the ocean, resulting in increased land-sea thermal contrast, significantly enhanced and northward shifted East Asian summer monsoon, finally causing increased precipitation in East Asian monsoon region. Meanwhile, during the period of weakened winter insolation, corresponding to the period of enhanced summer insolation in the NH due to the precession cycle, the tropospheric temperature is generally lower in the NH middle and low latitudes, causing a decrease of temperature gradient between the polar and equatorial regions, resulting in weakened and southward moved mid-latitude westerly circulation, forming an abnormal moisture conveyor belt from southern Europe to Central Asia, ultimately bringing more precipitation in the arid region of Central Asia. Therefore, simultaneous responses of the monsoon and westerly circulation systems determining the rainy season precipitation to the precession-induced summer and winter insolation changes are the main reason for the in-phase variations of the orbital-scale annual precipitation in the East Asian monsoon region and Central Asia arid area.