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Late Neogene East Asian monsoon: from winter to summer dominated sub-regime and periodicity transition from 100 kyr to 41 kyr

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More and more evidence indicates that the onset of the East Asian (EA) monsoon can be traced back to the Oligocene-Miocene boundary (at about 23 Ma). However, the process of its evolution is still less well known until now. Here we investigate its late Neogene evolution by analyzing a terrestrial mollusk sequence, from the Chinese Loess Plateau (CLP), covering the period between 7.1 and 3.5 Ma. Considering the modern ecological requirements of these organisms, we were able to define two groups of cold-aridiphilous (CA) and thermo-humidiphilous (TH) species, representing the EA winter and summer monsoon variations, respectively, as previously defined in the Quaternary glacial-interglacial cycles. Variations in these two groups indicate two different monsoon dominated periods during 7.1-3.5 Ma. First, between 7.1 and 5.5 Ma, the EA winter monsoon, with a 100 kyr periodicity, was dominant. Second, between 5.1 and 4 Ma, the EA summer monsoon dominated, with a 41 kyr periodicity. Furthermore, our mollusk record yields valuable evidence for a late Miocene-Pliocene transition of about 400 kyr from winter monsoon dominated towards summer monsoon dominated, associated with a periodicity transition from weak 100 kyr to 41 kyr. The strengthened winter monsoon interval, with a 100 kyr periodicity, is coeval with orbital-scale global ice volume changes, in conjunction with the uplift of the Tibetan Plateau which probably reinforced the winter monsoon sub-regime. Conversely, closures of the Panama and Indonesian seaways, associated with changes in obliquity between 5.1 and 4 Ma, are probably major forcing factors for the observed dominant summer monsoon with 41 kyr frequency, favoring heat and moisture transports between low and high latitudes to allow TH mollusks to grow and develop in the CLP. The transition from a 100 kyr dominated interval towards a 41 kyr dominated one is contrary to the mid-Pleistocene transition (MPT), which corresponds to ice volume expansion at high latitude and show a shift in the periodicity from 41 kyr to 100 kyr.