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MODELLING ORBITAL CLIMATE SIGNALS IN FLUVIAL STRATIGRAPHY

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There are certain orbital cycles influencing the relative position and location of the earth towards the sun, resulting in the cyclic insolation received on the earth, which causes climate changes and subsequent environmental response in the catchment, including precipitation, temperature, and vegetation, and so on. Furthermore, such catchment responses induce cyclic variation of source materials, including sediment supply and water discharge in the entry of a fluvial basin. Climate change related to the 21-kyr precession cycle was proposed as the driver of regularly-alternating river avulsion and overbank phases in the Eocene Willwood Formation, Bighorn Basin, Wyoming, USA [1-2]. This study aims to simulate the building-up process of fluvial stratigraphy under the action of precession.
Based on the 3D numerical forward model of Karssenberg and Bridge (2008) [3], we run several scenarios with constant/cyclic sediment supply (Q_s) and water discharge (Q_w) as well as continuously increasing base level. It is found that the absolute values of Q_s and Q_w are not the key drivers of river avulsion and bifurcation. Instead, the ratio between them is. In the scenarios with constant Q_s/Q_w including the constant Q_s and Q_w scenario and the in-phase one, there are no regular/cyclic step-like avulsion and overbank alternation, while in the other scenarios with cyclic Q_s/Q_w we can clearly see those step-like patterns with periodicity identical to precession, where the out-of-phase scenario has the largest Q_s/Q_w variation. Specifically, the increasing Q_s/Q_w triggers the avulsion, which lasts until the peak of Q_s/Q_w, corresponding to white heterolithic avulsion deposits. Then with the decreasing Q_s/Q_w from the peak, overbank phase starts, which is favourable for soil development. Overall, such cyclic Q_s/Q_w derives from the phasing shift between Q_s and Q_w, which can be attributed to the differential response delays of them to the climate change and further orbital forcing. Moreover, it is found that the signal weakens in the transmission process due to the destruction of autogenic forcing, suggesting that only those orbital forcing with strong amplitude and long periodicity can be possibly transmitted. Relevant literature suggests the smaller basin size and higher Q_s/Q_w contributes to the shorter autogenic time scale, which, to a certain degree, more favours the orbital signal transmission.

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