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Large-scale retreat and advance of shallow seas in Southeast Asia driven by mantle flow

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The Indonesian islands and surrounding region represent one of the most submerged, low-lying continental areas on Earth. Almost half of this region, known as Sundaland, is presently inundated by a shallow sea. The role of mantle convection in driving long-wavelength topography and vertical motion of the lithosphere in this region has largely been ignored when interpreting regional stratigraphic sections, despite a consensus that Southeast Asia presently situated on a "dynamic topography low" resulting from long-term post-Pangea subduction. However, dynamic topography is typically described as a temporally and spatially transient process, implying that Sundaland may have experienced significant vertical motions in the geological past, and thus must be considered when interpreting relative sea level changes and the paleogeographic indicators of advancing and retreating shallow seas. Although the present-day low regional elevation has been attributed to the massive volume of oceanic slabs sinking in the mantle beneath Southeast Asia, a Late Cretaceous to Eocene regional unconformity indicates that shallow seas retreated following regional flooding during the mid-Cretaceous sea level highstand. During the Eocene, less than one fifth of Sundaland was submerged, despite global sea level being ~200 m higher than at present. The regional nature of the switch from marine to terrestrial environments, that is out-of-sync with eustatic sea levels, suggests that broad mantle-driven dynamic uplift may have led to the emergence of Sundaland in the Late Cretaceous and Paleocene. We use numerical forward modelling of plate tectonics and mantle convection, and compare the predicted trends of dynamic topography with evidence from regional paleogeography and eustasy to determine the extent to which mantle-driven vertical motions of the lithosphere have influenced regional basin histories in Southeast Asia. A Late Cretaceous collision of Gondwana-derived terranes with Sundaland choked the active margin, leading to slab breakoff and a weakened mantle down-welling acting on the overriding plate, which resulted in regional dynamic uplift and emergence from a ~10-15 Myr-long subduction hiatus along the Sunda active margin. This explains the absence of sediment deposition across Sundaland and the emergence of Sundaland between ~80-60 Ma. Renewed subduction from ~60 Ma reinitiated dynamic subsidence of Sundaland, leading to submergence from ~40 Ma despite falling long-term global sea levels. Our results highlight a complete 'down-up-down' dynamic topography cycle experienced by Sundaland over 100 million years, with the transience of topography revealed in sedimentary basin stratigraphy punctuated with regional unconformities. Subduction-driven mantle convection models are now able to transform the geological record of basins into a dynamic surface history, enabling a deeper understanding of mechanisms that control landscape evolution across spatial and temporal scales.