Geophysical Research Abstracts
Vol. 20, EGU2018-10836-1, 2018
EGU General Assembly 2018
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Tectonics and mantle convection controlling the long-term emergence and flooding of Southeast Asia since the Cretaceous

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The Sundaland continental promontory in Southeast Asia experienced a prolonged history of subduction, interrupted by a number of terrane accretion episodes during the convergence between the Eurasian, Indo-Australian and Pacific plates since Pangea breakup. At present Sundaland is also one of the lowest-lying regions on Earth with about half of the continental crust inundated by a shallow sea. A wide range of observations and models indicate that the present-day long-wavelength topography of Sundaland is dominated by mantle downwelling from subducted slabs in the mantle beneath the continent. By applying detailed plate tectonic reconstructions (using the open-source cross-platform GPlates software, www.gplates.org) to numerical models of mantle flow using CitcomS, we can track the evolution of the mantle structure and the influence of sinking slabs acting on the overriding plate. Our modelling indicates that the subduction, which initiated along Sundaland in the mid Jurassic, was interrupted in the Late Cretaceous by the collision and accretion of the Woyla terrane onto Sumatra at ~80 Ma. The arrival of the terrane at the active margin choked the subduction zone, and led to a ~10-15 Myr magmatic gap on the Sunda margin, as well as several hundreds of meters of long-term regional dynamic uplift (likely between ~80 and 60 Ma) due to the absence of sinking slabs. These results are consistent with a Late Cretaceous regional unconformity across Southeast Asia, indicating long-term emergence of the entire continental promontory. Re-initiation of subduction from ~60 Ma led to progressive dynamic subsidence acting on Sundaland, resulting in long-term flooding from ~40 Ma despite long-term falling sea levels. Accelerated regional subsidence, contemporaneous with regional basin inversions (since at least the mid Miocene, ~15 Ma) in the absence of tectonic collisions along the margin, suggest an influence of a mantle slab avalanche. As the accumulated Sunda slab entered the lower mantle, it triggered a component of trench advance that led to stress propagating into the overriding plate, contemporaneous with strong dynamic subsidence from the sinking slab. The results highlight the inextricable link between mantle and surface processes, with modelling results revealing previously-counterintuitive mechanisms that may help with the interpretation of regional uplift and erosional phases, as well as the resulting basin deposition and structural reactivation histories. Future work should aim to address the relative contributions of dynamic, tectonic and flexural topography acting on Sundaland, as well as applying new methods to model surface processes shaping the geography of Southeast Asia over geological timescales.