Evolution of the layout of tectonic plates through global reorganisation

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Since the 1980's, significant progress has been made to reconstruct global tectonics (Lithgow-Bertelloni and Richards, 1998; Seton et al., 2012; Muller et al 2017), but the increasing uncertainties going back in time make it difficult to constrain plate motions before Pangea breakup. For instance, the definition and number of small plates and past subduction zones can be biased. Using the underlying forces within the lithosphere and mantle to further refine them is for now impossible.

One way to move forward is to use spherical convection models (Tackley, 2008), which self-consistently generate plates and give access to a complete survey of data (temperature, velocities, viscosity) in order to better understand the physics governing the typical organization of the Earth's tectonic plates. Today, the Earth's surface is characterised by seven large plates and several smaller ones (Bird 2003; Morra et al 2013). By studying surface fragmentation with triple junctions, Mallard et al. (2016) showed that the formation of small plates is associated with oceanic trench curvature. It comes from the large variability of deformation induced by slab pull and suction along sinuous trenches. On the other hand, large plates reflect the dominant scale of convective flow in the mantle due to the initiation or shutdown of subduction. These two processes imply two different reorganisation times, which evolved either through global reorganisation of mantle flow (about 100 Myrs) or by trench motions. However, in those previous attempts the role of continents has been neglected, although they add relevant constraints on the coupled evolution of surface tectonics, mantle structure and dynamics (Rolf et al. 2017).

In this study, we add continents (Rolf et al., 2014) into our global mantle convection models to evaluate their impact on the plate size distribution through periods of continental aggregation and dispersal. Analysing plate boundaries in convection models is difficult since the model produces diffuse deformation and elusive plate boundaries – as on Earth. Hence, we use a quantitative tool to identify plate boundaries and automatically produce plate polygon layouts: Automatic Detection Of Plate Tectonics (ADOPT; Mallard et al. 2017). We then compare the plate layouts in convection models with the data extracted from plate tectonic reconstructions. Because our models allow to characterize plate layouts in both aggregation and dispersal periods, we propose plate size distributions for times before Pangea was formed.