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Plate tectonics and Earth System Science

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Over the last 25 years the theory of plate tectonics and a growing set of geo-databases have been used to develop global plate models with increasing sophistication, enabled by open-source plate reconstruction software, particularly GPlates. Today's editable open-access community models include networks of evolving plate boundaries and deforming regions, reflecting the fact that tectonic plates are not always rigid. The theory of plate tectonics was originally developed primarily based on magnetic anomaly and fracture zone data from the ocean basins. As a consequence there has been a focus on applying plate tectonics to modelling the Jurassic to present-day evolution of the Earth based on the record of preserved seafloor, or only modelling the motions of continents at earlier times. Modern plate models are addressing this shortcoming with recently developed technologies built upon the pyGPlates python library, utilising evolving plate boundary topologies to reconstruct entirely destroyed seafloor for the entire Phanerozoic. Uncertainties in these reconstructions are large and can represented with end-member scenarios. These models are paving the way for a multitude of applications aimed at better understanding Earth system evolution, connecting surface processes with the Earth's mantle via plate tectonics. These models allow us to address questions such as: What are the causes of major perturbations in the interplay between tectonic plate motion and Earth's deep interior? How do lithospheric deformation, mantle convection driven dynamic topography and climate change together drive regional changes in erosion and sedimentation? How are major perturbations of the plate-mantle system connected to environmental change, biological extinctions and species radiation?