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Stratigraphic Modelling of Continental Rifting

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Interlinks between deformation and sedimentation have long been recognised as an important factor in the evolution of continental rifts and basins development. However, determining the relative impact of tectonic and climatic forcing on the dynamics of these systems remains a major challenge. This problem in part derives from a lack of modelling tools capable of simulated high detailed surface processes within a large scale (spatially and temporally) tectonic setting.

To overcome this issue an innovative framework has been designed using two existing numerical forward modelling codes: Underworld, capable of simulating 3D self-consistent tectonic and thermal lithospheric processes, and Tellus, a forward stratigraphic and geomorphic modelling framework dedicated to simulating highly detailed surface dynamics. The coupling framework enables Tellus to use Underworld outputs as internal and boundary conditions, thereby simulating the stratigraphic and geomorphic evolution of a realistic, active tectonic setting. The resulting models can provide high-resolution data on the stratigraphic record, grain-size variations, sediment provenance, fluvial hydrometric, and landscape evolution.

Here we illustrate a one-way coupling method between active tectonics and surface processes in an example of 3D oblique rifting. Our coupled model enables us to visualise the distribution of sediment sources and sinks, and their evolution through time. From this we can extract and analyse at each simulation timestep the stratigraphic record anywhere within the model domain. We find that even from a generic oblique rift model, complex fluvial-deltaic and basin filling dynamics emerge. By isolating the tectonic activity from landscape dynamics with this one-way coupling, we are able to investigate the influence of changes in climate or geomorphic parameters on the sedimentary and landscape record. These impacts can be quantified in part via model post-processing to derive both instantaneous and cumulative erosion/sedimentation.