State of the art forward modeling mountain belt and rifted passive margin formation

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The last 3 decades have seen the development and use of process based forward models applied to solid earth processes including tectonics, landscape evolution, deposition, magmatism. Forward numerical model experiments play an increasingly important role for understanding complex non-linear process interactions and feedback relations that at first sight may be counter intuitive and challenging to understand. As such they can serve to train and enhance our physical intuition. While in the early stages computational power limited spatial and temporal resolution, current computational infrastructure and smart algorithms allow resolving these processes over a large range of scales in 2 and 3 dimensions. Current challenges and focus areas of the geodynamics community include resolving tectonic deformation from seismic to long term time scale over a large range of scales, interaction of tectonics with surface processes, magmatism, fluid flow, and phase changes, and high resolution 3D forward modelling.

Here I will present the current state of the art in modelling mountain belt and rifted margin formation. I will focus on relationships between tectonic deformation and sedimentary basin formation. Resolving the interaction and feedback between tectonic crust-lithosphere scale deformation and surface processes through erosion of elevated areas and formation of sedimentary basins over multiple scales has been a long-standing challenge. While forward process based models have been successful at showing that a feedback is expected between tectonic deformation and redistribution of mass at the earth's surface by erosion, transport, and deposition, demonstrating this coupling for natural systems has been an even greater challenge and is strongly debated. Observational constraints on crust-lithosphere deformation and surface processes are typically collected at highly varying spatial and temporal scales, while forward process based models are typically run at either very large lithosphere-mantle scale, or at the scale of the sedimentary basin making it difficult to investigate and explore the detailed interaction and feedback between these systems. I will report on recent advances in forward modelling linking crust-lithosphere deformation with surface processes over a large range of scales resolving tectonic plate scale deformation and sedimentary basin formation at stratigraphic scales. The forward numerical models indicate a linkage and interaction between the structural style of thick-skinned large-scale mountain belt and rift-passive margin formation, erosion-transport-deposition processes operating at the surface, and the thin-skinned deformation occurring in the associated sedimentary basins.