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Earthquakes and fault growth over a range of timescales

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Fault growth is typically achieved by discrete increments of slip which accrue during earthquakes. Comparison of short-term displacements from individual earthquakes or active scarps with long-term fault displacement patterns permits characterisation of fault growth from millennial to million-year timescales. Fault slip distribution during individual earthquakes is generally more variable than would be predicted from fault growth studies on geological timescales, which can indicate near-constant fault lengths and displacement rates. The long-term stability and short-term variability of displacement rates are both partly due to fault interactions, which may produce non-characteristic seismic slip, variable rupture lengths and aperiodic earthquake recurrence. Earthquake data suggest that rupture lengths are often shorter than finite fault lengths and typically support neither the characteristic earthquake nor fault propagation models. Earthquake observations are consistent with a constant-length growth model in which faults are part of kinematically coherent arrays and evolve along steep paths on displacement-length plots. The fault interactions inherent in coherent fault systems ultimately reflect stress transfer between faults, which can occur over timescales of seconds to thousands of years and on length scales of 10s to 100s of kilometres. Multi-fault ruptures during recent earthquakes indicate that these interactions can take place between different types of faults and across tectonic domain boundaries. Such long-range interactions are rarely inferred from million-year displacement analysis and support the notion that interactions take place between different fault systems.