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Multi-scale nature of fracture properties: outcrop to satellite scales

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Fracture networks observed at multiple scales, from thin section to satellite images, often show power-law distributions describing many of their properties across these scales. In this study fractures are measured from outcrop, terrestrial lidar, and satellite data spanning six orders of length-scale magnitude. Careful consideration of sampling methods was undertaken for each collection technique, as they all have different resolution and scale ranges. Results from this study show that at any one scale datasets are typically best described by exponential distributions, but when data from multiple scales are combined in a single plot of fracture length verses fracture intensity, the data produce an upper bounding envelope that follows a power-law distribution. This upper envelope represents the maximum observed intensity of fractures of a specific size. Below this upper envelope there exists a spread of data which represents the range of fracture intensities measured. These plots can be used to map the intensity for common sizes of fractures around the study area. Without appropriately considering scale and data resolution when analysing fractures, the results obtained will be misleading. A consequence is that when fracture data is inappropriately used to populate discrete fracture network (DFN) models, any future output will give a false picture of reservoir behaviour.