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Uncertainty analysis for the characterisation of the discontinuity networks

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A common method to evaluate the degree of fracturing in the subsurface is the sampling of fracture characteristics at analogue outcrops or from well cores. These characteristics allow the generation of discrete discontinuity networks (DDN), which are used to predict the transport through the considered fractured rock mass. Key parameters for the generation of DDN are density (the number of discontinuities per unit area), length (e.g. fractal dimension for power-law distribution) and orientations. The evaluation of density and length distributions are however strongly influenced by sampling bias. Almost all discontinuity data are to some degree censored and/or truncated. Censoring encompasses all effects that prevents the complete sampling of a discontinuity length, for example discontinuities which might be eroded at the edge of an outcrop. If an outcrop includes covered parts, due to vegetation or debris, the bias due to censoring is even higher. Truncation encompasses resolution limitations, for example for remote sensing, and sensitivity problems of the applied method. Here we investigate how censoring and truncation, together with cover, influence statistical distributions of density and length.

Before investigating natural discontinuity systems we quantify the effects of sampling bias and cover using 2D artificial discontinuity networks with known input parameters. We compare the results by applying commonly used sampling methods: 1) areal/window sampling, 2) scanline samplings, and 3) circular scanlines. Each method is affected differently by sampling bias. The window sampling is mainly subjected to censoring effects, whereas the scanline sampling is highly affected by truncation, since shorter discontinuities have a lower chance of being intersected by the scanline in comparison to longer ones. This causes a systematic under-sampling of shorter discontinuities. The circular scanline and window sampling is not subjected to sampling bias, since it is a maximum likelihood estimator. However, it can only provide information on density, intensity and mean length.

First, percentages of biased discontinuities, either due to censoring or truncation, are determined for a specific sampled volume. Furthermore, the deviations of the estimates for the density or length distribution parameters are calculated. This allows the assessment of the degree in uncertainty based on the percentage of sampling bias, which can be evaluated during the sampling process. Thus, applying different sampling methods enables the development of a guideline for the best performance of a specific sampling method. This guideline is then applied to different natural discontinuity systems.