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Evaluation of geochemical anomaly classification models based on the relevant uncertainties and error propagation per class to select the most robust model(s) for the follow-up exploration

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A significant issue in all geochemical anomaly classification methods is uncertainty in the identification of different populations and allocation of samples to those populations, including the critical category of geochemical anomalies or patterns that are associated with the effects of mineralisation. This is a major challenge where the effects of mineralisation are subtle. There are various possible sources of such uncertainty, such as (i) gaps in coverage of geochemical sampling within a study area; (ii) errors in geochemical data analysis, spatial measurement, interpolation; (iii) misunderstanding of geological and geochemical processes; (iv) fuzziness or vagueness of the threshold between geochemical background and geochemical anomalies. In this research, the well-established concentration-area (C-A) and the newly established concentration-concentration (C-C) fractal models were applied to centered-logratio (clr) transformed data, and highly correlated elements of Cu-Te, respectively. Such models were applied to the available till samples (2578 samples) collected by the Geological Survey of Sweden (SGU) from 75% of the country area, to generate the Cu volcanic massive sulfide (VMS) geochemical anomaly classified map and define the highly promising areas for further exploration. However, to be confident more about the robustness of each class recognised by the thresholds obtained from the C-A and C-C log-log plots, Monte Carlo simulation (MCSIM) was applied to each class to simulate a higher number of values per class and consider the relevant error propagation. Under the MCSIM approach, the P50 value (the average 50th percentile of the multiple simulated distributions represents a neutral probability in decision-making) is defined as the expected 'return'. The uncertainty is calculated, in this approach, as 1/(P90-P10) for which P10 (lower decile) and P90 (upper decile) are the average 10th and 90th percentiles of the multiple simulated values, associated with each class. The most reliable classes are those with high returns and low risks. Based on the results obtained, C-A could not provide robust enough results since in the defined classes, the risk was almost equal or even higher than the return, however, the C-C model provided high returns and very low uncertainties, demonstrating the robustness of C-C compared to C-A. This approach can improve the quality of the decision-making in choosing the most robust classification models, and consequently getting more reliable results.