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Comparison of power-law models and ratio models for anomaly recognition of geochemical data

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The detection of data outliers and unusual data behavior is one of the main tasks in the statistical analysis of geochemical data. The calculation of [mean +- 2 standard deviation (std)] to estimate threshold values dividing background data from anomalies, still used almost 50 years after its introduction, delivers arbitrary estimates. This method is equivalent to the standardized transformation where k = 2 or 3 are often set as the threshold value. For regional-, national- and global-scale geochemical mapping, more and more peoples think that the geochemical index contains the spatial structure and spatial variability. The geochemical background should be taken as a fluctuation surface. Anomaly contrast, also called contrast value (CV), has been widely used in geochemical mapping as an index of anomaly clarity. Higher than 1 the CV is, the stronger the positive anomaly is. Recently, computer techniques, especially the GIS, are more and more popular and the non-linear methods are deeply applied in the exploration geochemistry researches, more methods are brought forward. The power-law models are greatly developed for anomaly recognition, such as C-AS-A model, local singularity analysis. For the local singularity analysis, the power exponent α, or denote $\Delta\alpha = E - \alpha$ where E is the spatial dimension, are used to characterize the spatial structure prosperities of the concentration values within small vicinity. $\Delta\alpha > 0$ implies a "convex" property and positive anomaly. Mapping CV or $\Delta\alpha$ is easy realizable in GIS environment employing the window-based algorithm. The area chosen for case study is the Gejiu area and its surrounding area located the suture zone among the India plate, the Pacific plate and the Eurasian plate on the southwestern edge of southwestern China sub-plate. The stream sediment samples from Gejiu area, Yunnan province, China is collected, which is 58 rows, 78 columns, and equally spaced at approximately 2km x 2km. The box-plots show the discrepant medians and different levels of outliers in the different strata and geotectonic zones. We calculate the CV values and $\Delta\alpha$ based on window-base algorithm for the raw Cu concentration data and the logarithmic Cu concentration (10 based). The neighborhood values can be calculated by removing the [mean +- 3 std] data, so two algorithms for CV are employed, one is CV1 whose neighborhood value doesn't remove some extreme values, the other one is called CV2 which adopts the stable strategy to estimate the neighborhood value as the local average background value. $\Delta\alpha$ can be obtained by the regression for a set of neighborhood values around each focus cell from the small scale to the big scale on the log-log plot. CV1, CV2 and $\Delta\alpha$ are re-computed by 8 times with different maximal neighborhood sizes (cells = 5x5, 7x7, 9x9, 11x11, 13x13, 15x15, 17x17 and 19x19). And then we order the raw Cu concentration values, CV1 values, CV2 values and $\Delta\alpha$ values, so that rank =1 for the maximum and rank = 4524(=58x78) for the minimum. Based on the order statistic, we find that comparing the ranks of the big raw data, most of the ranks of the CV1, CV2 and $\Delta\alpha$ change smaller; while comparing the ranks of the small raw data, most of the ranks of the CV1, CV2 and $\Delta\alpha$ increase. It implies that CV1, CV2 and $\Delta\alpha$ have the ability to lower the anomaly intensity level on the high background and enhance the anomaly intensity level covered in the weak background. For some interesting positions, we compare the CV1, CV2 and $\Delta\alpha$ on multi-scalesand the results show the fluctuation of $\Delta\alpha$ is small than CV1 and CV2. The Student's t-values by weights of evidence method for measuring spatial correlation between locations of 55 Cu mineral deposits and the area with the above ranks of raw data, CV1, CV2 and $\Delta\alpha$ on the same scale. The good effect of anomaly recognition employing CV1 and CV2 and $\Delta\alpha$ is approved by the results and $\Delta\alpha$ is the best index among them.