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GEMAS: Spatial pattern analysis of Ni by using digital image processing techniques on European agricultural soil data

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Several studies have investigated the spatial distribution of chemical elements in topsoil (0-20 cm) within the framework of the EuroGeoSurveys Geochemistry Expert Group's 'Geochemical Mapping of Agricultural and Grazing Land Soil' project . Most of these studies used geostatistical analyses and interpolated concentration maps, Exploratory and Compositional Data and Analysis to identify anomalous patterns. The objective of our investigation is to demonstrate the use of digital image processing techniques for reproducible spatial pattern recognition and quantitative spatial feature characterisation. A single element (Ni) concentration in agricultural topsoil is used to perform the detailed spatial analysis, and to relate these features to possible underlying processes. In this study, simple univariate statistical methods were implemented first, and Tukey's inner-fence criterion was used to delineate statistical outliers. The linear and triangular irregular network (TIN) interpolation was used on the outlier-free Ni data points, which was resampled to a 10*10 km grid. Successive moving average smoothing was applied to generalise the TIN model and to suppress small- and at the same time enhance significant large-scale features of Nickel concentration spatial distribution patterns in European topsoil. The TIN map smoothed with a moving average filter revealed the spatial trends and patterns without losing much detail, and it was used as the input into digital image processing, such as local maxima and minima determination, digital cross sections, gradient magnitude and gradient direction calculation, second derivative profile curvature calculation, edge detection, local variability assessment, lineament density and directional variogram analyses. The detailed image processing analysis revealed several NE-SW, E-W and NW-SE oriented elongated features, which coincide with different spatial parameter classes and alignment with local maxima and minima. The NE-SW oriented linear pattern is the dominant feature to the south of the last glaciation limit. Some of these linear features are parallel to the suture zone of the Iapetus Ocean, while the others follow the Alpine and Carpathian Chains. The highest variability zones of Ni concentration in topsoil are located in the Alps and in the Balkans where mafic and ultramafic rocks outcrop. The predominant NE-SW oriented pattern is also captured by the strong anisotropy in the semi-variograms in this direction. A single major E-W oriented north-facing feature runs along the southern border of the last glaciation zone. This zone also coincides with a series of local maxima in Ni concentration along the glaciofluvial deposits. The NW-SE elongated spatial features are less dominant and are located in the Pyrenees and Scandinavia. This study demonstrates the efficiency of systematic image processing analysis in identifying and characterising spatial geochemical patterns that often remain uncovered by the usual visual map interpretation techniques.