

## Article Review (egusphere-2023-2894)

### Reviewer

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### General Comments

The manuscript represents a significant advancement in understanding uncertainty associated with geochemical mapping and proposes a novel methodology for the effective delineation of geochemical anomalies. It is exceptionally well-written, thoroughly researched, and offers valuable insights that will undoubtedly stimulate further research in geochemical exploration. The overall presentation is clear, concise and well-structured. With very minor revisions to address the points raised below, the manuscript has the potential to make a substantial impact and deserves consideration for publication in this prestigious international journal.

### Summary

In this study, the concentration data of 15 elements in stream sediments were first interpolated using the inverse distance weighting (IDW) method. Then, an unsupervised soft clustering technique called fuzzy c-means (FCM) algorithm was applied to the interpolated maps. This resulted in the division of the grid cells into two clusters. Principal component analysis was applied separately to the data from the two clusters. From the resulting biplots of the first two principal components, the elemental association was determined for Cluster 1 and Cluster 2. The local singularity analysis (LSA) was performed on the IDW interpolated maps of nine elements that show strong correlations with Au in both clusters. To delineate the comprehensive anomaly, PCA was applied separately to the singularity maps of associated elements in Cluster 1 and Cluster 2. The resulting first principal component scores of both clusters that represent multi-element anomaly maps were further integrated using fuzzy membership values as weights to generate a comprehensive anomaly map which accounts for the uncertainty of

elemental association. This resulting map was then compared with the multi-element geochemical map of Au-As-Sb-Cu referred to as the “global reference case” whose element association was obtained by Zuo et al. (2021b) using Robust PCA without considering uncertainty. These two cases were compared using success rate curves and ROC-AUC plots. Further, the weights of evidence method was used to derive the statistical t-values for the multi-element anomaly scores derived from the case considering the uncertainty of elemental association and using the thresholds weak, moderate and strong anomaly regions were identified for guiding subsequent gold exploration exercise in the study area.

### Specific Comments

**1. Page 4, Section 2 Methods:** If the "Methods" part is placed after the "Study area" part just before the Results and Discussions section, I think there will be a better flow. The authors may consider reorganising this.

**2. Page 9, Figure 3:** Regarding the Cluster Validity Index, although Xie and Beni (1991) have been cited in the text, I suggest adding a few more sentences (2-3) to the text briefly explaining the significance of this Index and how it is calculated.

**3. Page 11, Section 4.2. Mapping single- and multi-element anomalies patterns, Line 4:**

Authors may please consider citing the following article on singularity mapping.

*Behera, S., & Panigrahi, M. K. (2021). Mineral prospectivity modelling using singularity mapping and multifractal analysis of stream sediment geochemical data from the auriferous Hutt-Maski schist belt, S. India. Ore Geology Reviews, 131, 104029.*

**4. Page 14, Figure 8 (a):** It seems the “global reference map” has been created using the PC1 scores of Au-As-Sb-Cu singularity maps. However, no mention is found in the text regarding how Figure 8 (a) was generated. I suggest adding 1-2 sentences in the text regarding how the multi-element anomaly map was obtained for the global reference case.

**5. Page 14, Figure 8 (c):**

More clarification or a simplified explanation is required in the text on how the cut-off values corresponding to points A and B (Fig. 8b) were used for cases with uncertainty and global reference to generate Fig. 8c. Also, what the grey colours shown in Fig. 8 (c) indicate is not mentioned. I suggest simplifying this part for more clarity and ease of understanding.

**6. Page 15, Figure 9 (b):** Is it a box plot showing medians at the depressions? Please mention it in the text. Further, when only the top four relevant elements were retained for the two clusters, that particular case exhibited superior performance compared to the other two cases. So, from this can it be said that the elemental association Au-W-As-Sb-Ba-Hg for Cluster 1 and Au-As-W-Sn-Sb-Hg-Pb-Bi for Cluster 2 are in the decreasing order of correlation. If it is so and evident in Fig. 5 from the angles between the vectors, then it should be mentioned in the text (Page 10).

These review comments aim to acknowledge the excellence of the manuscript while providing constructive feedback to enhance its clarity and overall impact.

Thank You

Dr. Behera