A - 146 Terracing and cluster analysis – new insights in potential field data prior to modelling

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Mountain Building Processes in 4D

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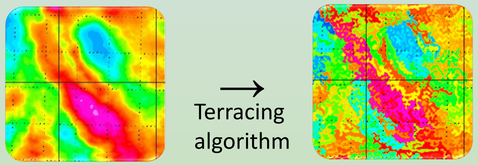
Introduction: Here we examine the automated procedure for terracing and cluster analysis of potential field data. As an example, the Ligurian-Provençal basin (Western Mediterranean Sea) is selected. By aid of a shape index-based terracing algorithm, the boundaries of anomalies are to be sharpened and regions with constant field amplitude are generated. The resulting data sets are then further processed by k-mean cluster analysis. This algorithm for domain classification helps to divide the data into groups (cluster) of similar properties. In the end, the maps show a similarity to the geological map of the area.

Brief methodology

Terracing sharpens anomalies and generates areas with constant field amplitude.



Gravity field before and after Terracing

Therefore, transition areas are eliminated and minor variations within the "terraces" disappeared.

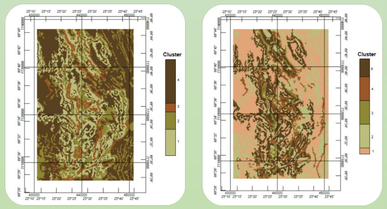
$$S = \frac{2}{\pi}\arctan\left(\frac{\frac{\partial^2 f}{\partial x^2}+\frac{\partial^2 f}{\partial y^2}}{\sqrt{4\left(\frac{\partial^2 f}{\partial x \partial y}\right)^2+\left(\frac{\partial^2 f}{\partial x^2}\right)^2+\left(\frac{\partial^2 f}{\partial y^2}\right)^2-2\frac{\partial^2 f}{\partial x^2}\frac{\partial^2 f}{\partial y^2}}}\right)$$

formula after Cooper (2020)

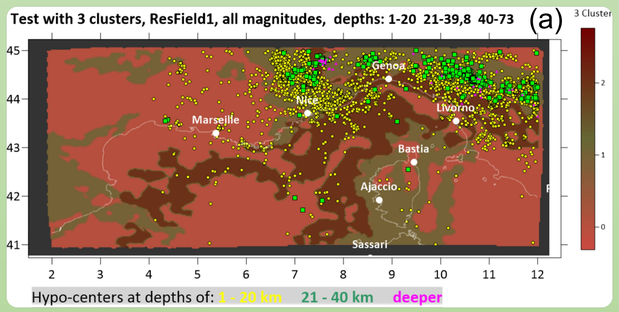
The shape index (S), calculated at each field point grades the function; data points are grouped by a 3 x 3 points moving window (W) and processed according to the rule (Γ = threshold parameter):

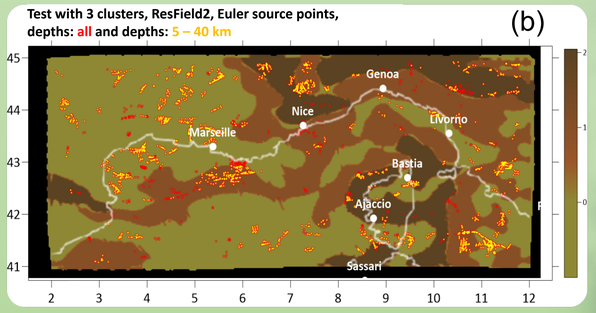
$S < -\Gamma \Rightarrow f = \min(W)$
$-\Gamma \le S \le \Gamma \Rightarrow f = \text{median}(W)$
$S > \Gamma \Rightarrow f = \max(W)$

The two figures on the right show the enhancement of terracing by the applied cluster analysis (left for 4 and right for 5 clusters). Clustering after terracing results in always finer and smaller structures. The fields were terraced by Γ=0.2 and 200 Iterations. ▷



Earthquake hypocentres (a), Euler points (b) and clustering.





References:
• Asch K (2005) IGME 5000: 1:5 million International Geological Map of Europe and Adjacent Areas - final version for the internet. BGR, Hannover. • Zahorec P, et al. (2021) The first pan-Alpine surface-gravity database, a modern compilation that crosses frontiers, Earth Syst. Sci. Data, 13, 2165–2209, DOI: 10.5194/essd-13-2165-2021. • Cooper, G. R. J. (2020). An improved terracing algorithm for potential-field data. Geophysics, 85(5):G109-G113. doi: 10.1190/GEO2019-0129.1. • Fugro (2011). FALCON Airborne Gravity Gradiometer Survey for Store Norske Gull AS, Processing Report.

Software:
• Geosoft (2021). Geosoft Oasis montaj. Version 9.10 (20210427.23). https://my.seequent.com • Skripts in Python

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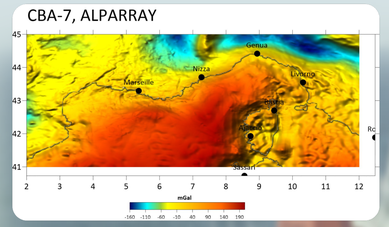
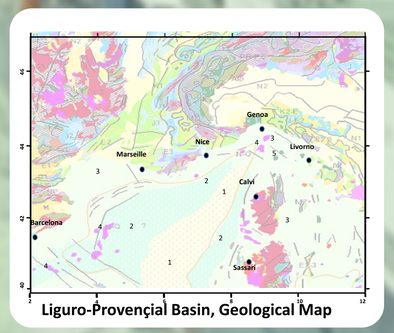
Processing results in the area of the Liguro-Provençial Basin

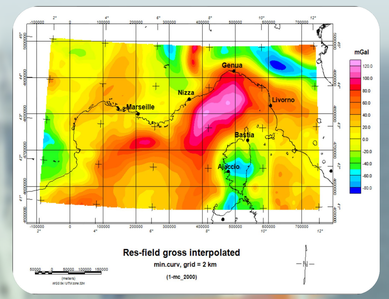


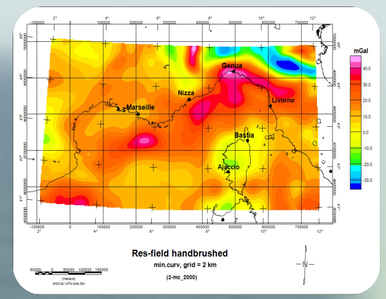
The new pan-Alpine Bouguer gravity map (Zahorec et al., 2021). Strong positive gravity was calculated in the Liguro-Provençial Basin.

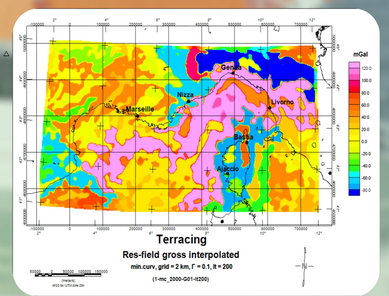


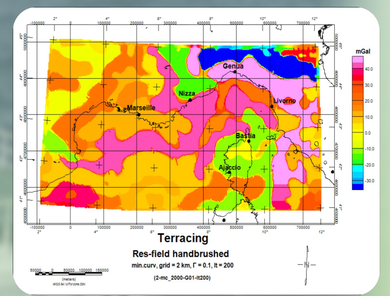
Liguro-Provençal Basin, Geological Map

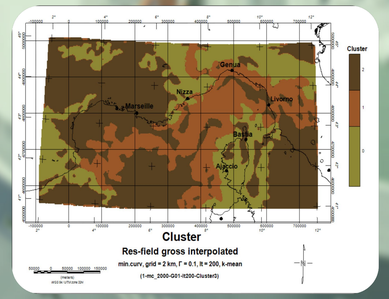
Submarine geological units (after Asch, 2005): 1 oceanic crust, that was formed during the rifting in the area; 2 thinned continental crust, that has been stretched during rifting; 3 undifferentiated continental crust; spots in 4 are intrusions of igneous rocks; 5 represents ophiolites.

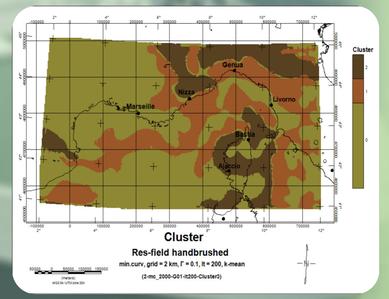












Two differently calculated residual gravity fields (upper row: ResField1, left & ResField2, right) were processed by the terracing algorithm. These fields have become smoother after this step (middle row), that is, values for the anomalies have been grouped together. In the bottom row, the fields were structured with three (left) and four (right) clusters and reflect the geological findings satisfactorily.

Conclusion

Terracing and k-means clustering are used to process gravity fields before their final 2D/3D modeling is started. After intensive testing both methods have been applied to residual fields in the Liguro-Provençial Basin and the results show a very satisfactory correlation with the geological features in the rifted part of the basin.