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Cluster analysis applied to velocity and attenuation tomography: the case study of Mt. Vesuvius

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The interpretation of the results of seismic velocity and attenuation inversion are usually based on the qualitative observation and comparison of the different tomographic images. A promising tool to jointly interpret tomographic models based on different parameters resides in the application of statistical classification methods, such as the k-means clustering method, which minimizes the logic distance among each group of observations having homogeneous physical properties and maximizes the same quantity between groups. The correlation between the models is subsequently examined and significant classes (volumes of high correlation) are identified. Such technique is able to spatially clusterize the zones having similar characteristics in a statistical sense.
Each zone is finally identified by the barycenter (centroid) of the corresponding cluster.
The Vp velocity and Qp and Qs attenuation structures of Mt. Vesuvius, Italy, have been already qualitatively interpreted by a comparison with other similar investigations. To obtain a more quantitative interpretation gathered in a unified model consistent with the entire dataset, a cluster analysis was applied to this models. An optimizing study on the proper number of classes recognizes five clusters corresponding to separate zones inside the volcano structure.
- The first cluster can be considered as a "background" cluster, and corresponds to the areas with "average" seismic properties (mainly located below the topographical interface).
- The second cluster defines a spatial pattern corresponding to the residual part of the feeding conduit of the volcano.
- The third cluster corresponds to two volumes, the first vertically extended between -1000 and -3000 m above the sea level, North-Eastward the cone; the second, in the same depth range Westward the central cone, and linked to the first one at -2000 m. These two volumes may be associated with hydrothermal basins.
- The fourth and fifth clusters are described both by positive Vp, Qp and Qs anomalies. Anyway, the five parameter cluster analysis evidences a peculiar feature of the attenuation properties: the Qp of the fourth cluster is notably higher than the Qs, while the attenuation features of the fifth one are opposite. They are spatially contiguous along a SW-NE strip between -1000 and -3000 m above the sea level. The fourth cluster has been interpreted by other authors as a cracked zone.
The performed analysis permitted to define a simplified model of the Vesuvius complex in terms of velocity and attenuation.