Generalized Minimum Support Norm for automatic data processing

Gianluca Fiandaca[1], Line M. Madsen[2], Anders Kühl[2], Thue S. Bording[2]

   (1) Department of Earth Sciences "Ardito Desio", University of Milano, Milan, Italy
   *(2) HydroGeophysics Group, Department of Geoscience, Aarhus University, Aarhus, Denmark*

keywords: automatic processing, minimum support, inversion

Data outliers significantly affect the inversion process, often forbidding to reach reasonable inversion models and misfits. This is particularly problematic when the L2 norm is used in data space, because in this case outliers play a dominant role in the objective function of the inversion.

In this study we propose to use a generalization of the minimum support norm, namely the asymmetric generalized minimum support (AGMS) norm, for defining the data misfit in the objective function of an iterative reweighted least squared (IRLS) gauss-newton inversion. The AGMS norm in the data misfit puts a cap on the weight of non-fitting data points, allowing for the inversion to focus on the data points that can be fitted. Outliers can be identified after the AGMS inversion computing a classic L2 misfit from the final inversion model.

Synthetic data from a 2D DC sequence comprising 1000 quadrupoles were generated and perturbed, adding random noise on 20% of the quadrupoles, with noise factor (i.e. the ratio between the changed data and the noise-free data) comprised between 0.5 to 0.9 and 1.1 to 2.0. Fifty realization of noised data (i.e. 50 datasets with 1000 quadrupoles, with 200 outliers in each dataset) were generated and processed following the AGMS automatic processing scheme.

As shown in the figure, more than 95% of the outliers were recognized in each noise realization, with only a small number of noise-free data erroneously identified as outliers. Furthermore, the inversion models were minimally affected by the outliers. This automatic processing scheme is very robust and works well also with a significant number of outliers; moreover, this it is fully general and can be applied not only to DC data, but to any geophysical problem simply using the appropriate forward modelling.
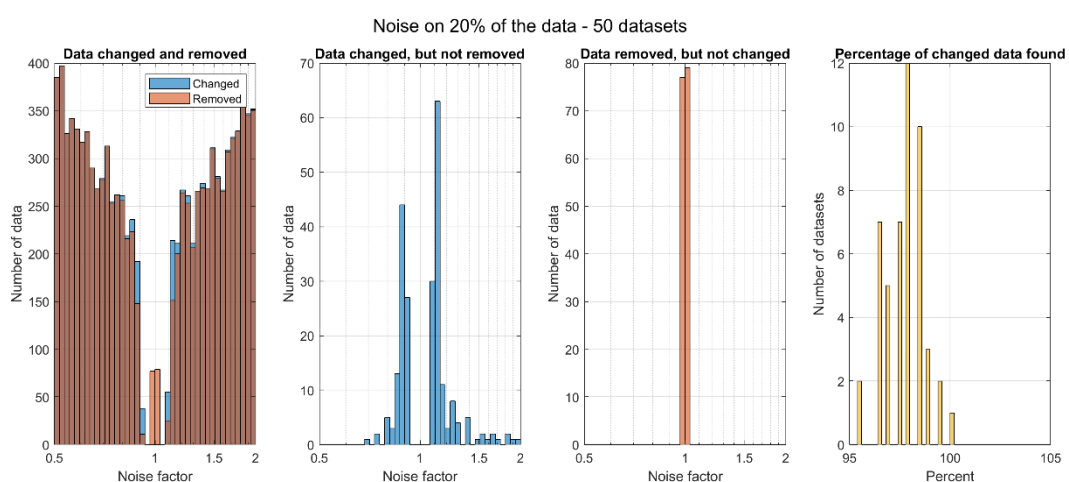
Figure caption: Data rejection based on the asymmetric minimum support norm for fifty realization of a 2D DC data sequence comprising 1000 quadrupoles. From left to right: changed data and removed data as a function of noise factor; data changed but not recognized as outliers; data erroneously identified as outliers; percentage of outlier recognition in the 50 datasets.