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Nonlinear apparent susceptibility mapping

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Digital enhancement of maps is one of the most useful tool to drive the interpretation of potential fields data. Among the many techniques available in literature, apparent susceptibility mapping provides a good qualitative picture of the actual magnetic susceptibility distribution. Essentially the approach consists of an inversion based on the following assumptions. First, there is no remanent magnetization. Second, the subsoil is modeled as a set of vertical prisms with the top at a given depth and infinitely extended downward. Because the standard magnetometers commonly employed in surveys measure the modulus of the total field, which components depend on the susceptibility by means of affine operators, the relation with respect to susceptibility results nonlinear. We developed a new algorithm based on a nonlinear forward model that is a better approximation of the real case than the standard linearized one. In fact, there are some significant drawbacks in the case of linearized inversion, decreasing the resolution power and creating some artifacts in the solution. So we solve the inverse problem corresponding to the completely nonlinear forward model. The inverse problem is transformed in a minimization of a functional derived from the maximum likelihood principle. Minimization is carried on by an iterative scaled and projected gradient algorithm that improves the speed of convergence and includes a line search for the step-length parameter reducing considerably the number of iterations required. Moreover we impose the solution to be nonsmooth applying a Total-Variation–like regularization. This edge–preserving regularization allows the solution to have a blocky structure, as often occurs in real cases. We first tested the method on a synthetic case, simulating a distribution of susceptibility in the subsurface and then inverting the calculated data having previously added some noise. Then we applied the described methodology to a real dataset acquired in East Antarctica during the 2003-2004 WIBEM campaign. The survey covers the the western flank of the Wilkes Subglacial Basin, a major morphological feature recognized in the hinterland of the Transantarctic Mountains. Evidences from the enhanced aeromagnetic anomaly maps show a strong structural control on the western side of the basin, suggesting that the previously hypothesized purely flexural origin for the basin is unlikely.