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Properties and effects of measurement errors on 2D resistivity imaging surveying

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ABSTRACT

Electrode spacing errors and errors correlated with the magnitude of the observed potential are two key factors that affect the data quality for DC resistivity imaging measurements. This paper investigates the properties and effects of these two kinds of error on 2D resistivity imaging or inversion for practical applications. By analytic analysis and numerical simulations, the off-line and in-line electrode spacing errors were quantitatively estimated for all common electrode arrays (pole-pole, pole-dipole, pole-bipole, Wenner, Schlumberger, dipole-dipole, γ-array, Wenner-β) in 2D resistivity imaging surveys. Meanwhile, the spreading patterns of the spacing errors in the pseudosection and the possible artefacts in the imaging (inverted model) are evaluated. We show that the magnitude of the spacing errors are quite different with these arrays, being largest for dipole-dipole, Wenner-β and γ-array surveys, for which a 10% in-line spacing error may cause twice as large an error (>20%) in the observed resistance or apparent resistivity, which in turn will produce some artefacts in the inverted model. The observed potential errors obtained with the reciprocity principle and collected from different sites and with different electrode arrays, were analysed to show the properties of the potential error caused by many aspects in the field. Using logarithmic plots and error pseudosections, we found that with different electrode arrays and at different sites the potential errors demonstrate a general property, which may be regarded as a negative-power function of potential reading. Power net transients, background telluric variation and instrument malfunction are possible sources that may cause the large errors present as outliers deviating from this function. We reaffirm the fact that the outliers are often correlated with high contact resistances for some of the electrodes used in a measurement, but this may also be caused by an unsatisfactory connection between the electrode and the cable due to, for example, dirt or oxide on the connectors. These outliers are often the main part of the errors affecting the imaging results. Furthermore, a robust inversion and a smoothness-constrained inversion were applied to the investigation of the effects of the measurement errors. Using two real data sets, we show that the smoothness-constrained least-squares inversion is much more sensitive to the potential errors than the robust inversion, but the two inversion schemes produce very similar models with a high data quality. Artefacts or indefinite parts in the inverted models correlate with the distribution zones of the outliers in the potential error pseudosection.

INTRODUCTION

In the last decade, there has been great progress in computerized data acquisition systems and 2D and 3D inversion software for DC resistivity measurements. Resistivity tomography or imaging is now widely employed in environmental investigation and civil engineering (i.e. Van *et al.* 1991; Dahlin 1996; Olayinka and Yaramanci 1999; Chambers *et al.* 1999). As is well known, the quality of the observed data or noise contamination mainly affects the resolution and reliability of the technique and it depends on all aspects of the fieldwork. To apply the imaging technique success-

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