Inverting Dublin secret dataset 2 with *x*3D*i*

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31 March 2011

Outline

1 Modifications to 3D MT Inversion Code *X3DI*
- Inverting for Distortion Matrix

2 Inversion of Dublin Secret Model 2 dataset
- Inversion without distortion correction
- Inverting for full distortion matrix

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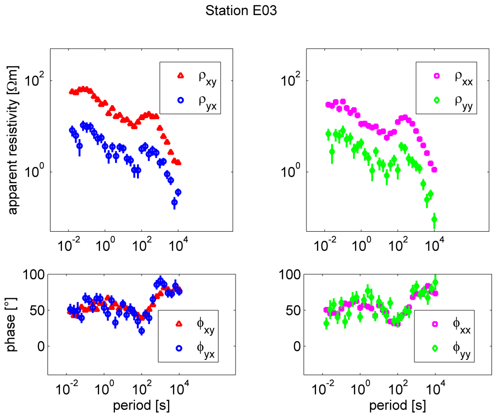
Data Example: Station E03



- $\phi_{xy} \approx \phi_{yx}$, but $\rho_{xy} \approx S * \rho_{yx}$
- shapes of ρ_{xx} and ρ_{yy} similar to ρ_{xy}

$$\Downarrow$$

Looks like effect of full distortion matrix

$$\mathbf{C} = \begin{pmatrix} C_{xx} & C_{xy} \\ C_{yx} & C_{yy} \end{pmatrix}$$

$$\tilde{\mathbf{Z}} = \mathbf{CZ}$$

Sasaki and Meju (2006) demonstrate encouraging results with their joint inversion of MT resistivity and static shifts(not full distortion matrix).

Data Misfit

$$\varphi_d(\boldsymbol{\sigma}, \mathbf{C}) = \frac{1}{2} \sum_{i=1}^{N_S} \sum_{j=1}^{N_T} \beta_{ij} \; tr\left[\bar{\mathbf{A}}_{ij}^T(\boldsymbol{\sigma}, \mathbf{C}) \mathbf{A}_{ij}(\boldsymbol{\sigma}, \mathbf{C})\right] \qquad (1)$$

$\mathbf{A}_{ij} = \mathbf{C}_i \mathbf{Z}_{ij} - \mathbf{D}_{ij}$ 2×2 matrices

$\mathbf{Z}_{ij}$ complex-valued predicted $\mathbf{Z}(\mathbf{r}_i, \omega_j)$ impedance

$\mathbf{D}_{ij}$ complex-valued observed $\mathbf{D}(\mathbf{r}_i, \omega_j)$ impedance

$\mathbf{C}_i$ real-valued $\mathbf{C}(\mathbf{r}_i)$ distortion matrix

$$tr\left[\bar{\mathbf{A}}^T \mathbf{A}\right] = \bar{A}_{11} A_{11} + \bar{A}_{12} A_{12} + \bar{A}_{21} A_{21} + \bar{A}_{22} A_{22}$$

Penalty functional

$$\varphi(\boldsymbol{\sigma}, \mathbf{C}, \lambda, \nu) = \varphi_d(\boldsymbol{\sigma}, \mathbf{C}) + \lambda\varphi_s(\boldsymbol{\sigma}) + \nu\psi_s(\mathbf{C}) \xrightarrow[\boldsymbol{\sigma},\mathbf{C}]{} \min \qquad (2)$$

$\varphi_d(\boldsymbol{\sigma}, \mathbf{C})$ Data misfit

$\varphi_s(\boldsymbol{\sigma})$ Roughness measure

$\psi_s(\mathbf{C})$ To impose constraint on the distortion

$\psi_s(\mathbf{C}) = \frac{1}{2}\sum_{i=1}^{N_S} tr\left[(\mathbf{C}-\mathbf{I})^T(\mathbf{C}-\mathbf{I})\right]$, $\mathbf{I}$ - identity matrix

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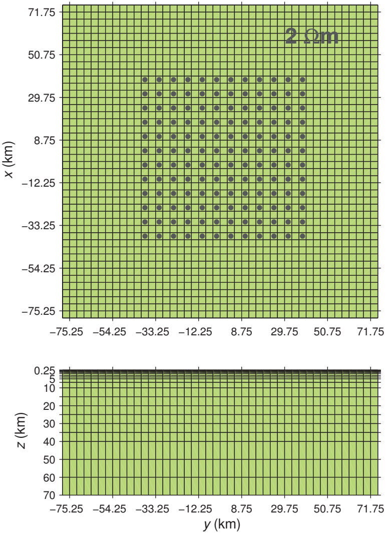
Grid and MT sites


2 Ωm
71.75
50.75
29.75
8.75
−12.25
−33.25
−54.25
−75.25
x (km)
−75.25 −54.25 −33.25 −12.25 8.75 29.75 50.75 71.75
0.25
5
10
20
30
40
50
60
70
z (km)
y (km)

N= 44 × 44 × 20 cells

$dx = dy = 3.5$ km

N_S= 144 MT sites

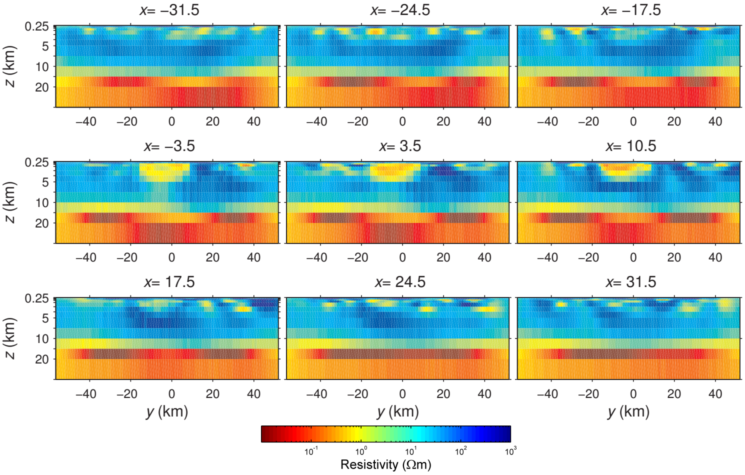
N_T=9 periods:

0.063, 0.25, 1., 3.98, 15.85, 63, 251, 1000, 3981 s

initial guess model:

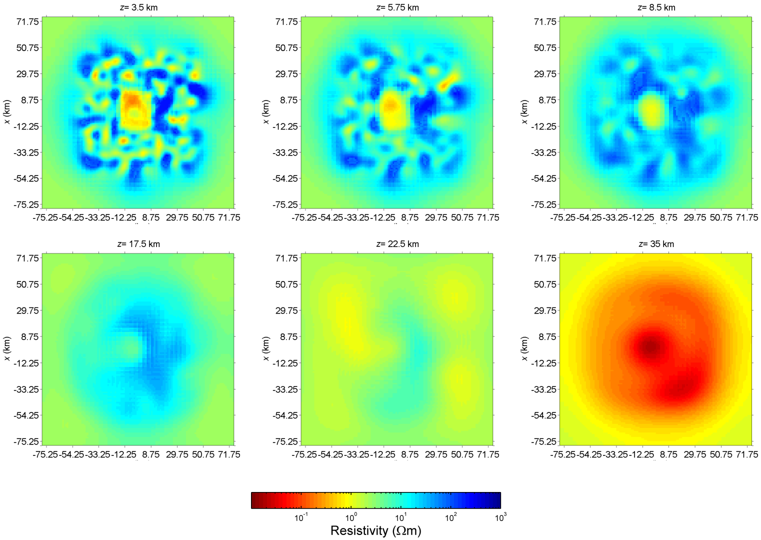
2 Ωm halfspace

Inversion without correction for distortion: vertical slices

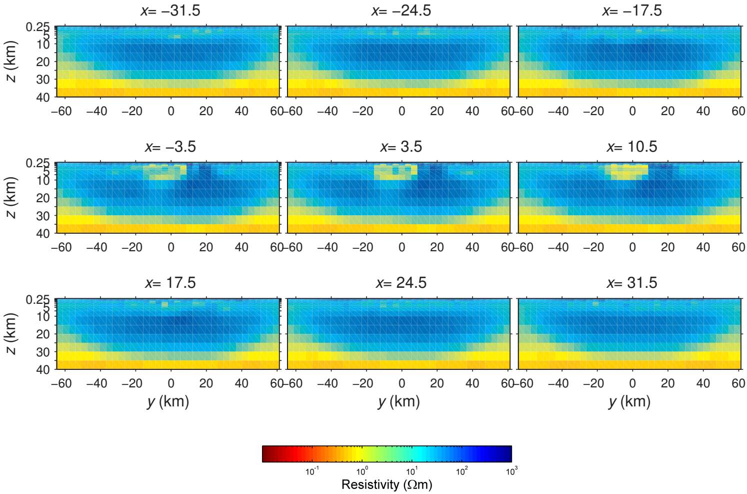


$RMS = 3.5$

Inversion without correction for distortion: horizontal slices

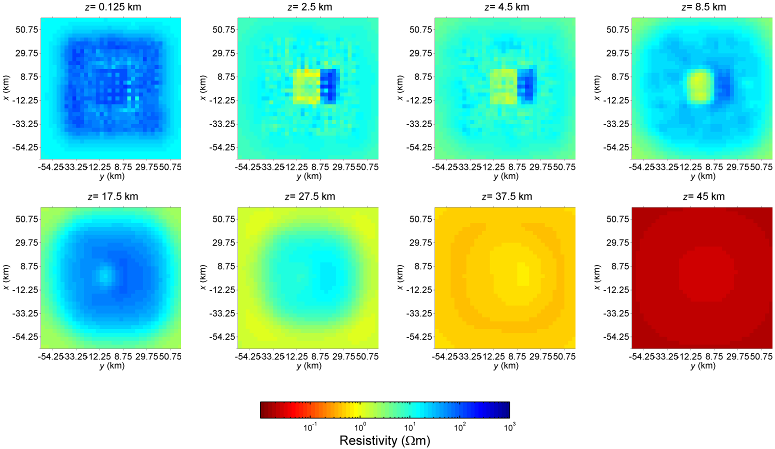


Inverting for full distortion matrix: vertical slices



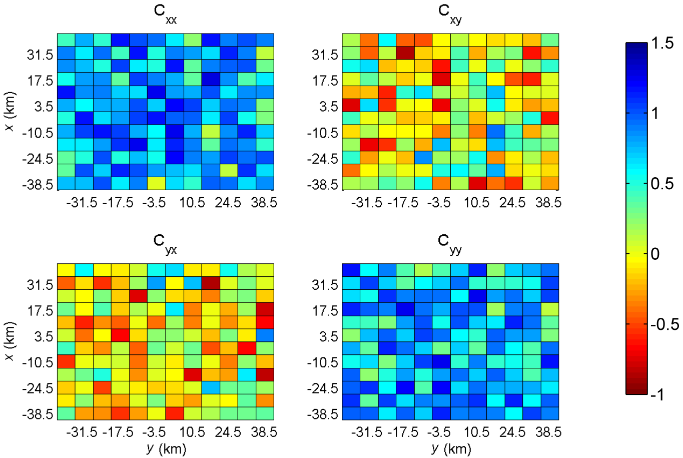
$RMS = 1.1$

Inverting for full distortion matrix: horizontal slices

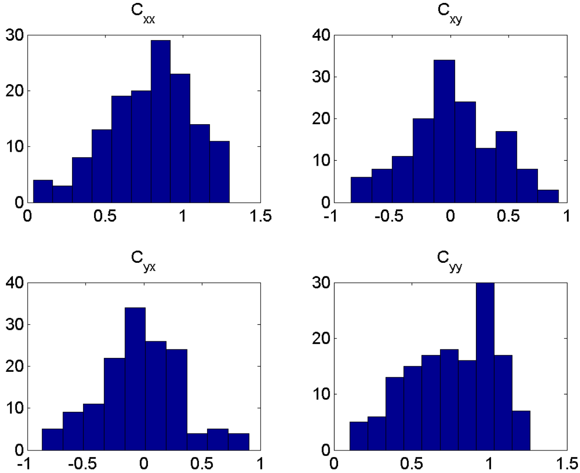


$RMS = 1.1$

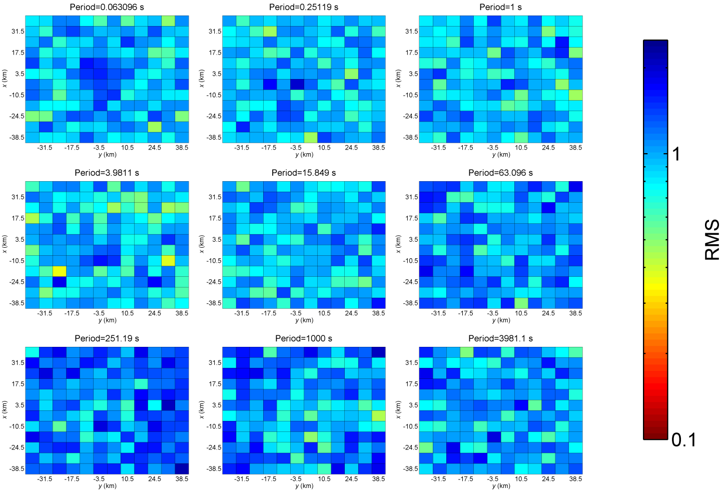
Distortion Matrix Elements



Distortion Matrix Elements Histograms



RMS distribution



Thanks for your attention

Avdeev, D. B. and Avdeeva, A. D. (2009). Three-dimensional magnetotelluric inversion using a limited-memory QN optimization. *Geophysics*, **74(3)**, F45–F57.

Avdeeva, A. D. and Avdeev, D. B. (2006). A limited-memory quasi-newton inversion for 1D magnetotellurics. *Geophysics*, **71**, G191–G196.

Sasaki, Y. and Meju, M. A. (2006). Three-dimensional joint inversion for magnetotelluric resistivity and static shift distributions in complex media. *Journal of Geophysical Research*, **111**, B05101.