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2D/3D interpretation of controlled-source Radio-Magnetotelluric far field data from Alexandrovka, Russia

S. Fadavi Asghari[1], M. Smirnova[1], A. Shlykov[2], B. Tezkan[1], A. Saraev[2], P. Yogeshwar[1]*

[1] Institute of Geophysics and Meteorology, University of Cologne;
[2] Institute of Earth Sciences, St. Petersburg State University
*Contact: sfadavia@smail.uni-koeln.de

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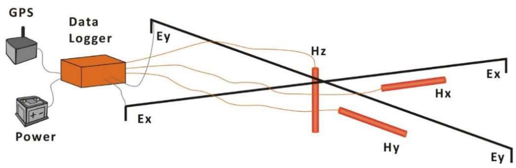
RMT

- Is a passive EM induction method
- Sources are the radio stations and/or VLF antennas (10-300 kHz)
- Skin depth is calculated as $\delta = 500\sqrt{\frac{\rho}{f}}$
- MT assumption is valid for 1-1000 kHz and < 1000 Ωm



Measurement bands	D2 (both)	D4 (both)
Frequency range (kHz)	10-100	100-1000
Sampling frequency (kHz)	312	2496

Solution?

a) RMT receiver device, b) Magnetic coils

Weak points:

- No strong signals far from the antennas in remote areas
- Low depth of penetration

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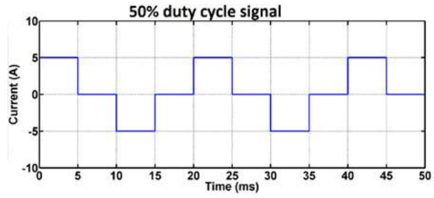
CSRMT



- 2 HED sources (horizontal electric dipole)
- Rectangular current = 1 A
- Base frequencies and their subharmonics are used
- Base frequencies: D1 = 512 Hz , D2 = 4.4 kHz , D4 = 44 kHz

1-10 kHz | 10-100 kHz | 100-1000 kHz

Advantages:

- High signal to noise ratio
- Deeper depth of penetration

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Far-field setup, Alexandrovka, Russia

A paleo-valley in the vicinity of Alexandrovka, about 180 km away from Moscow.

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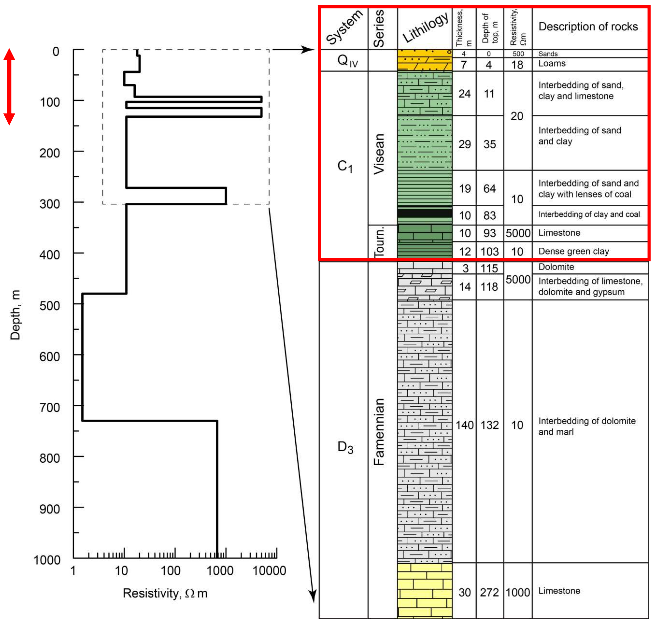
Geology description

150 m



Sedimentary rocks form a paleo-valley with a high resistivity lens of roughly 15 m thickness at about 15 m depth.

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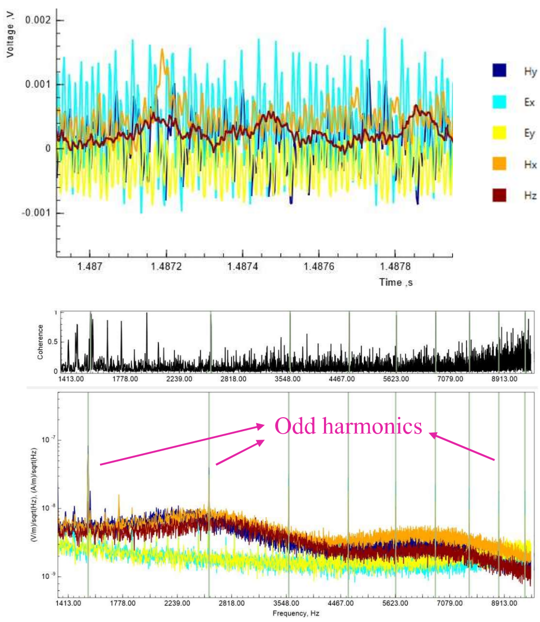
Data processing

- Fourier transform of the time-series
- Window length : $\begin{cases} D1, 2^{14} \approx 16000 \\ D2, 2^{15} \approx 32000 \\ D4, 2^{16} \approx 65000 \end{cases}$
- Window type : Blackman
- Calibration addition
- Coherency level : $\begin{cases} RMT\ ,\ 0.6 - 1 \\ CSRMT\ ,\ 0.8 - 1 \end{cases}$
- Azimuth : $\begin{cases} RMT\ ,\ 30 - 40 \\ CSRMT\ ,\ better\ to\ set\ 0 \end{cases}$
- Frequency selection



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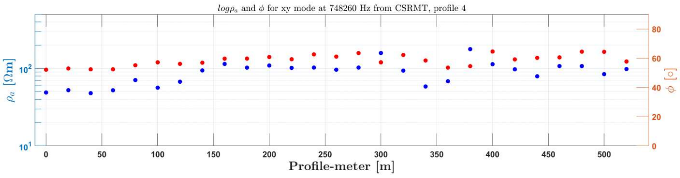
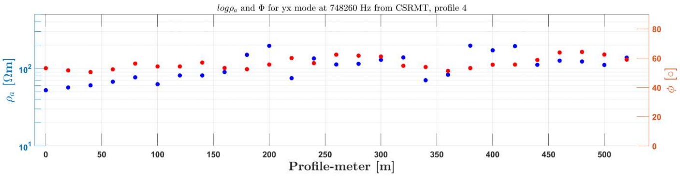
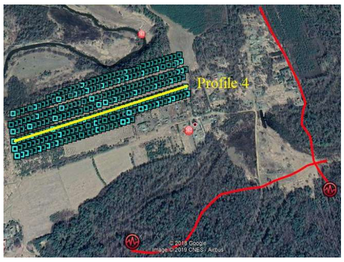
Data presentation: profile 4 at 748 kHz

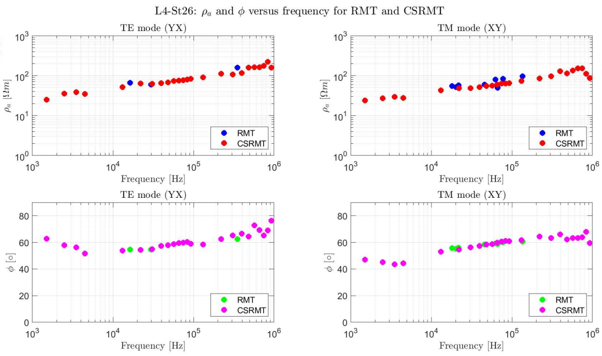






$$\rho_{a_{xy}} = \frac{1}{\omega\mu_0}.\left|Z_{xy}\right|^2$$

$$\varphi_{xy} = arctan\left(\frac{ImZ_{xy}}{ReZ_{xy}}\right)$$



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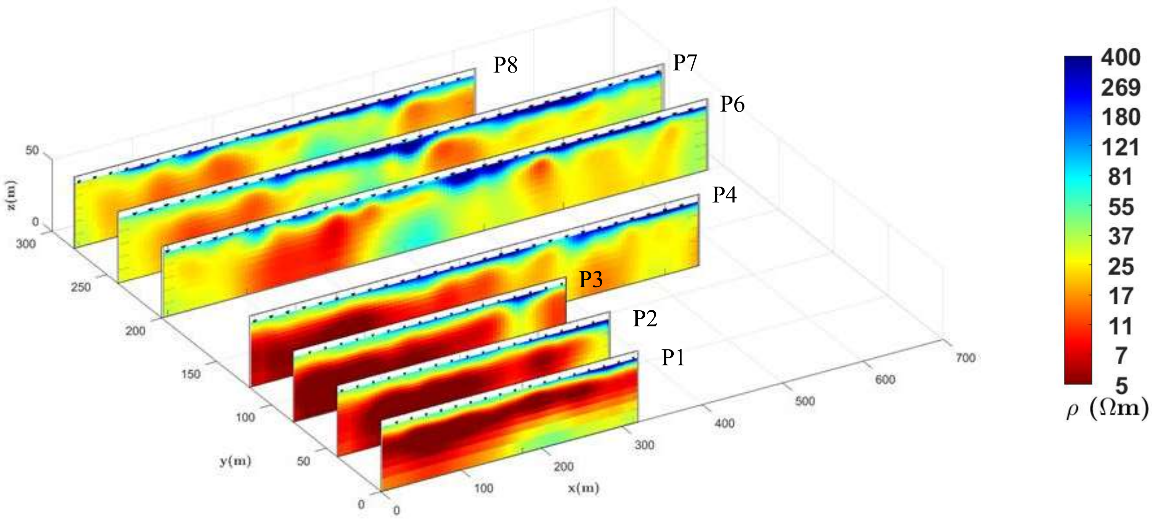
2D conductivity models: CSRMT

(Mackie , Rodi , 1997)



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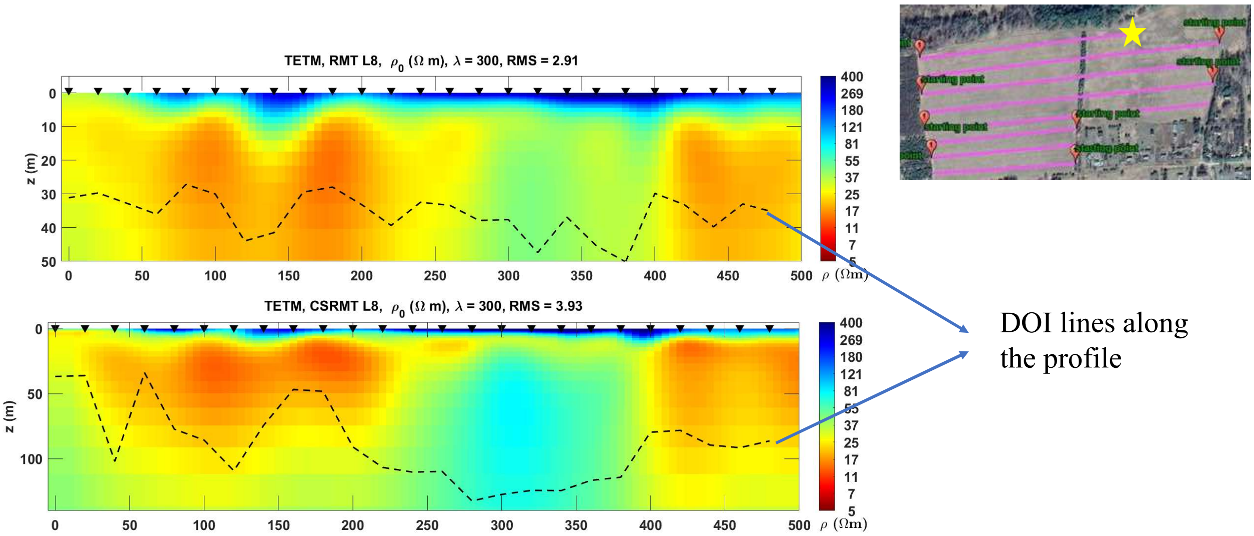
2D conductivity model: profile 8



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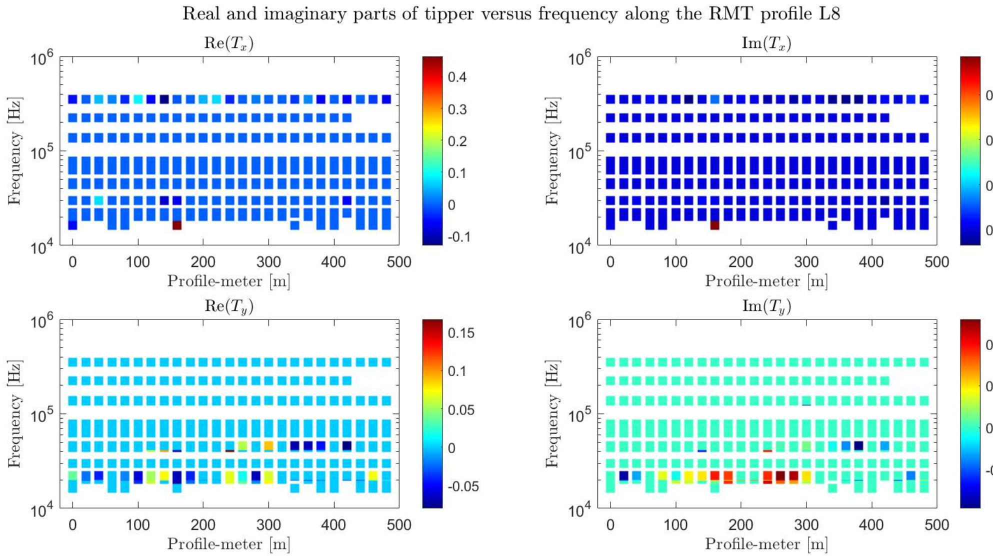
Tipper evaluation



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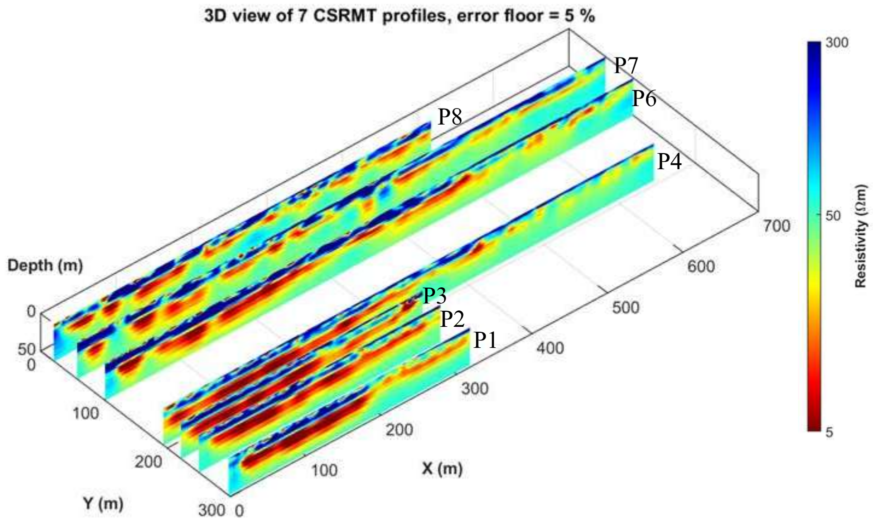
3D conductivity models

(ModEM by Egbert , Kelbert , Meqbel)



Properties	RMT	CSRMT
Starting model resistivity	60 Ωm	
Error	$0.05 * \sqrt{\lvert Z_{xy}\rvert \lvert Z_{yx}\rvert}$	
Grid dimensions	155×82×30	
Number of frequencies	6	13
Initial RMS	4.4147	5.2338
Final RMS	1.0004	2.4235

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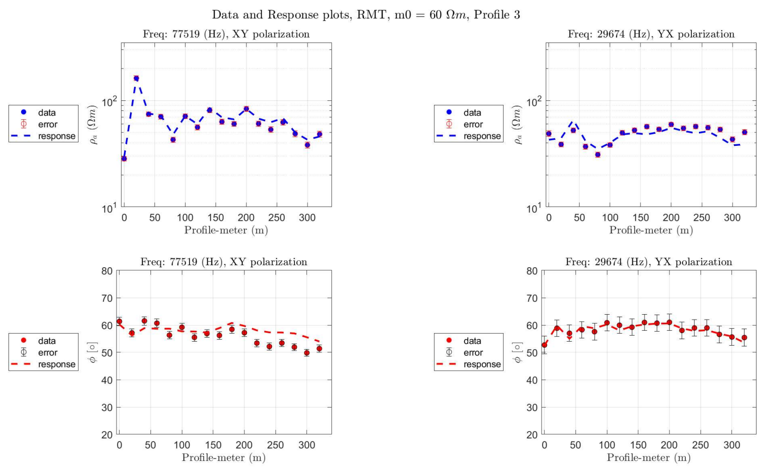
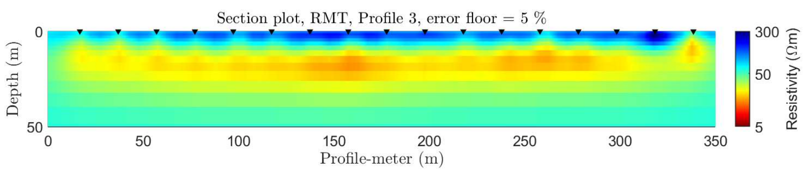
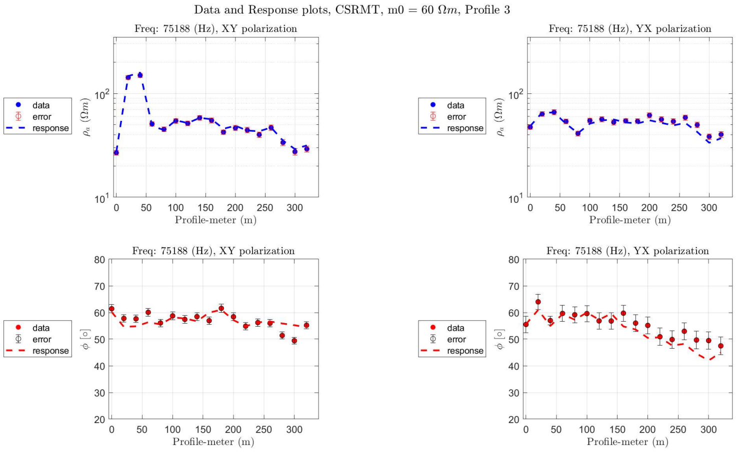
3D conductivity model: RMT, profile 3

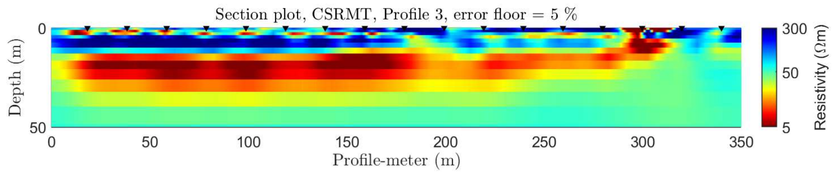




RMS = 1.0004

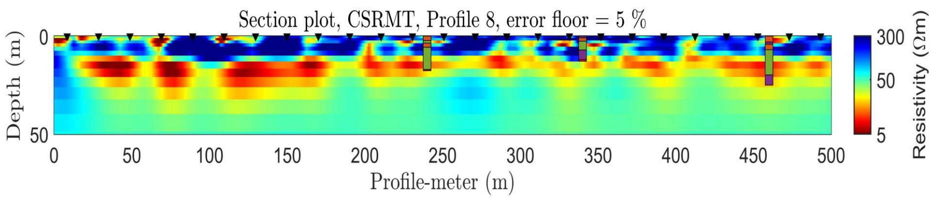
3D conductivity model: CSRMT, profile 3

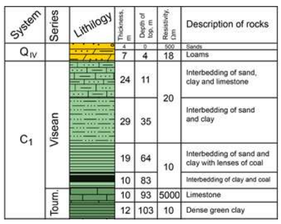


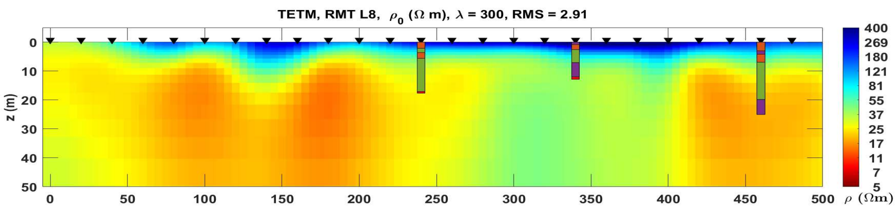


RMS = 2.4235

Comparison with borehole results







Sand ~500 Ωm
Loams ~18 Ωm
Loams + gravel

Summary:

- Successful RMT and CSRMT measurements made in the frequency range of 1 to 1000 kHz.
- 2D Mackie inversion results, highly support the previously obtained models from the test area and its Geological characteristics.
- 3D inversion using ModEM software is accomplished successfully and are in a good agree with the 2D results.
- The aim of tensor realization of the data is achieved, however, due to the 1D nature of the area, the advantages of CSRMT could not be so much highlighted; Yet, CSRMT results indicate more details in compare with the RMT ones.

Future plans:

- As a 3D target, data acquisition in a waste-site is planned to be made in October.
- All the steps will be repeated over the new data leading to 2D/3D interpretation.

Shiva Fadavi Asghari, Institute of Geophysics and Meteorology,
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