Combined multi-site MT processing for Phoenix and Metronix measurement systems

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Introduction

Phoenix Geophysics and Metronix are two leading companies offering measurement systems for audio magnetotelluric (MT) measurements. So far data acquired on a field survey with Phoenix and Metronix systems in use had to be processed separately. This can pose a problem in areas with strong anthropogenic noise since multi-site processing is limited to the number of devices running simultaneously from each company.
A combined processing of Metronix and Phoenix raw data will improve transfer function quality on joint field surveys using both measurement systems. However, Phoenix only provides an implemented data-processing software and calibration curves without instrument response while Metronix data can be calibrated to input signal.
This study presents a graphical user interface that is implemented to the multivariate MT processing routine EGstart[1] for calculating Phoenix response functions. Furthermore we show calibration results from a survey at Kasane (Botswana) using Phoenix MTU-5A with MTC-150L coils and Metronix ADU07 and ADU07e with MFS07e coils.

Calibration Measurement

For combined processing instrument response functions are essential. Therefore a calibration measurement setting up Metronix and Phoenix stations at the same spot and recording the same signal simultaneously (see fig. 1) is necessary in order to calculate empirical instrument response functions.
The following aspect regarding field work using Metronix and Phoenix systems and their calibration measurement should be considered:

1. Plan for one calibration measurement at the beginning and one at the end of the survey.
2. The setup should be identical to field setup so conventional MT processing can be applied to the data.
3. Phoenix systems need to record using the same sampling rate as in the field
4. Phoenix coils must be fixed to the components they were connected to in the calibration measurement.
5. Use identical settings (gain factors, filters) for calibration and field measurements.

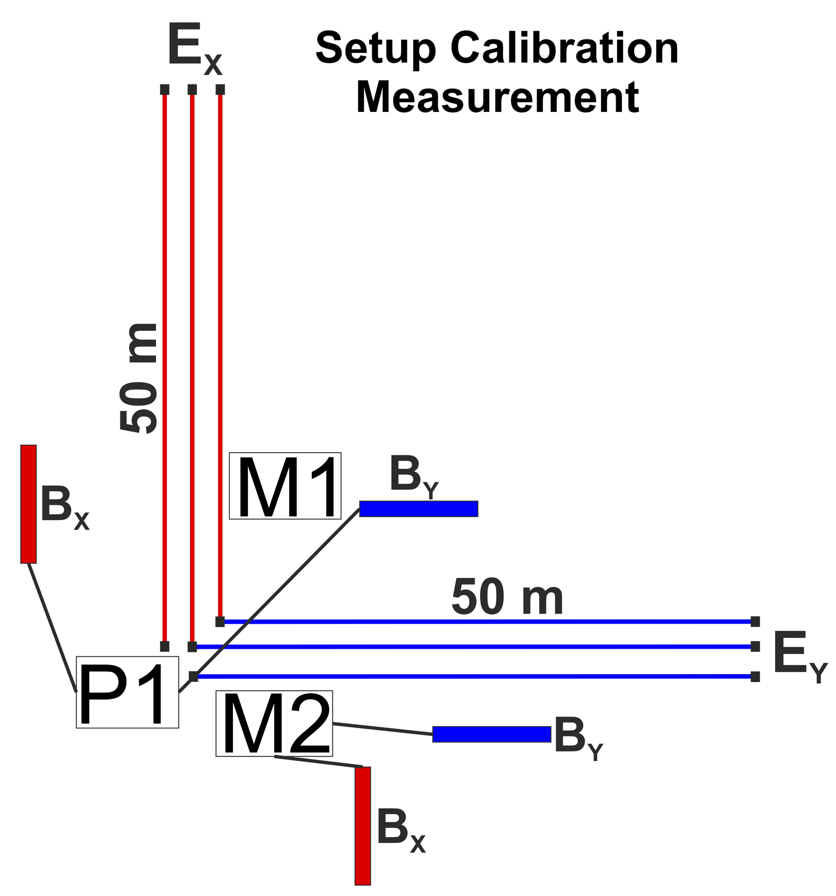


Figure 1: Sketch of the field setup for a calibration measurement with parallel E-lines and coils on a field survey at Kasane (Botswana). M1 was used as a telluric station only, M2 and P1 measured horizontal E- and B-field components. M and P refer to Metronix and Phoenix devices, respectively.

The Metronix/Phoenix-Calibration Graphical User Interface

We present how to create calibration files with the graphical user interface for data acquired with 2.4 kHz (TS3, Phoenix) and 2048 Hz (Metronix) using the scheme shown in figure 1.

Each Phoenix recording band has to be read in separately but the output files can be concatenated to one calibration file.

Insert E-line length, Metronix coil numbers and Phoenix gain factors. Afterwards calibration and resampling to the lowest sample frequency will be performed

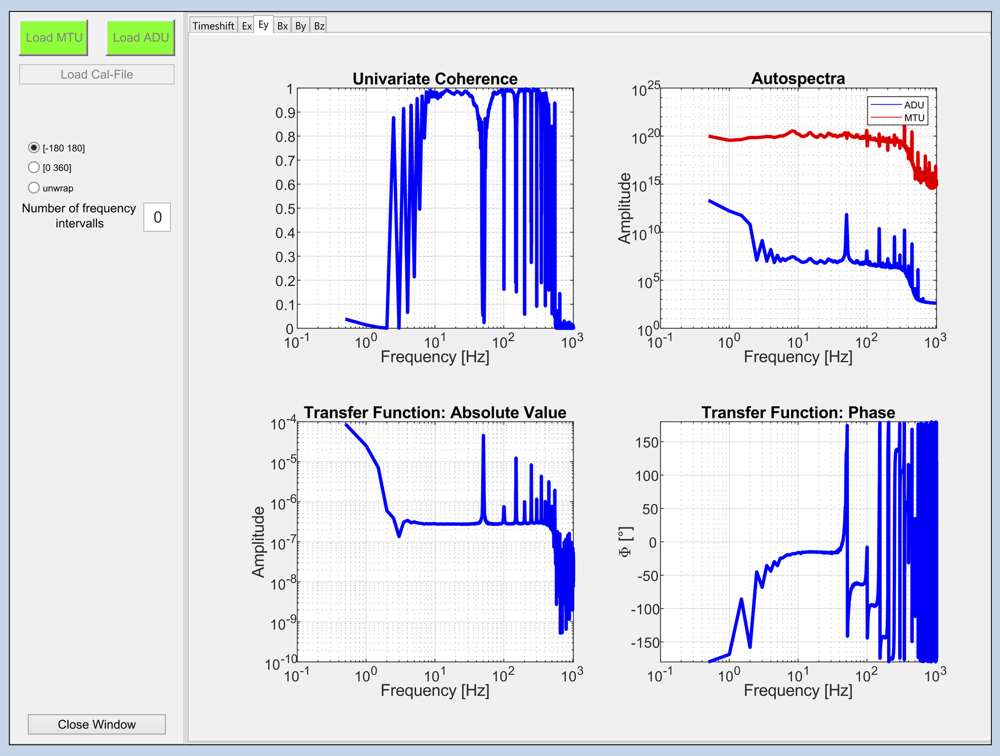


Figure 2: Only frequency ranges with high coherency on all channels can be used for calibration curve calculation (keep in mind that filter and gain settings can reduce the frequency ranges).

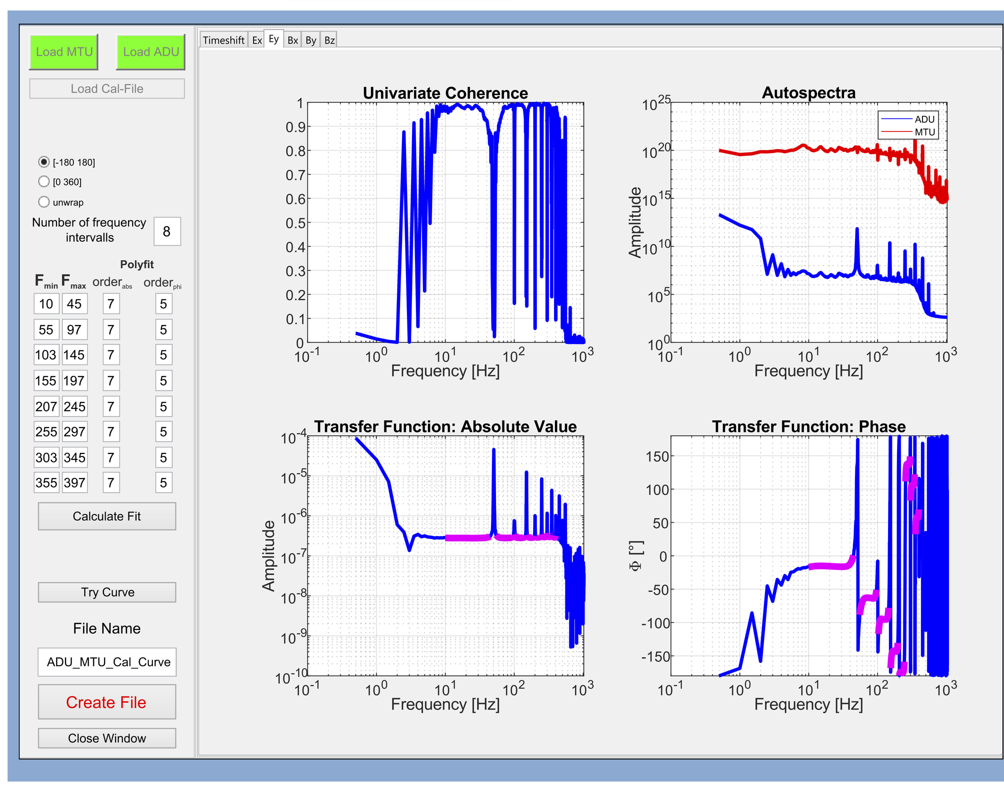


Figure 3: Determine frequency ranges and the order of polynomial fit for amplitude and phase and calculate calibration curves. If the fit is inaccurate, frequency ranges and polynomial orders can be reset.

Read in Metronix & Phoenix Raw Data → **Convert Raw Data into nT and mV** → **Determine Constant Timeshift** → **Select Frequency Windows & Polynomial Order** → **Improve Settings** → **Try Curve** → **Create File**

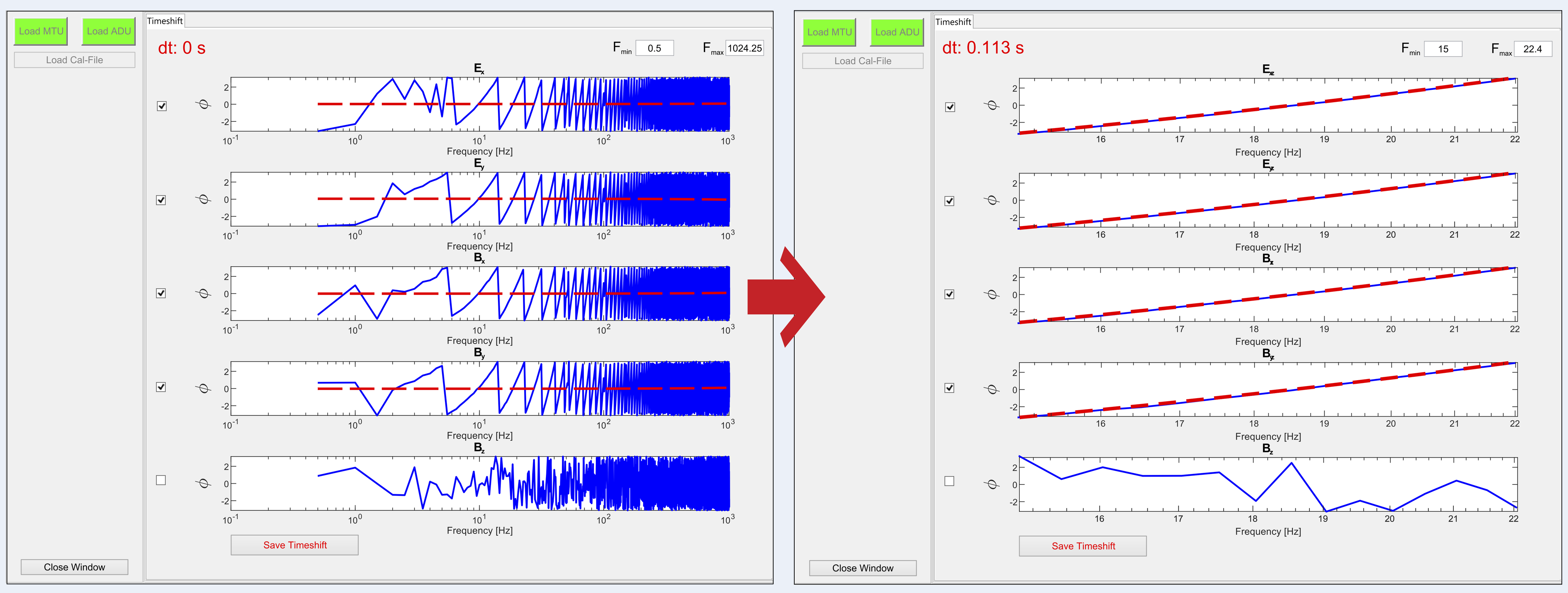
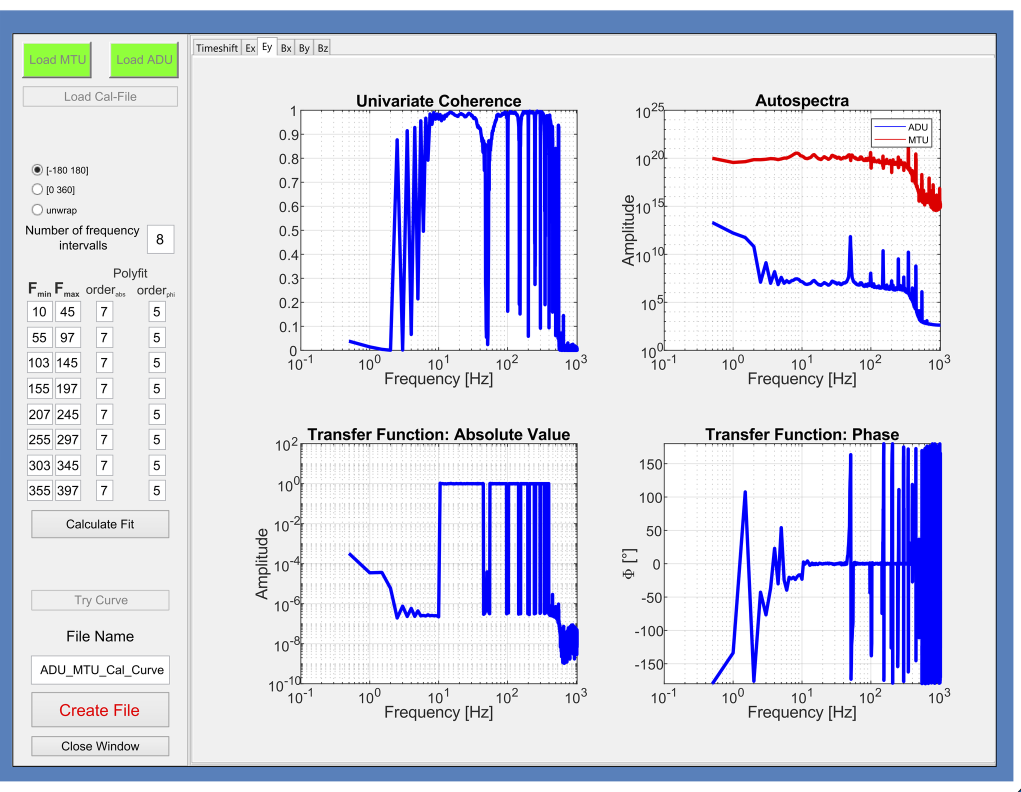


Figure 4 & 5: We observe a constant timeshift between Phoenix and Metronix devices depending on the Phoenix recording band (Fig. 4). By fitting (red dashed line) the phase (blue line) of the frequency-dependent transfer functions between parallel channels of B and E fields, respectively, we can determine the delay.

Figure 6: Test calibration curves by applying them to calibration measurement data. The autospectra of both stations should be identical then, amplitudes of the transfer function should be equal to 1 and the phase equal to 0.



Calibration Site Results

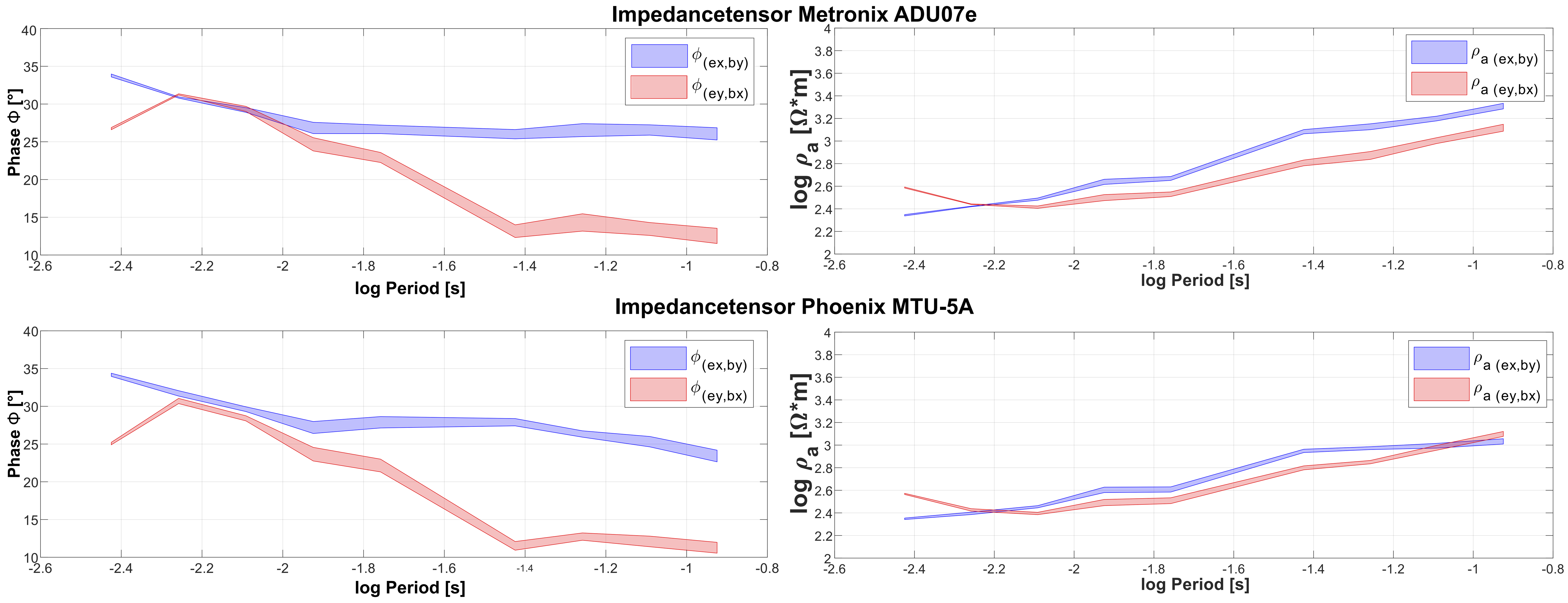


Figure 7: The rows show results for the Impedancetensor of the Metronix (top) and Phoenix (bottom) device of calibration measurement data using FFMT software jointly for Metronix and Phoenix data. Processing was performed with TS3 and TS4 Phoenix recording bands and 2048 Hz sample frequency for the Metronix device. Data at both sites yield similar phase values. Low phases indicate coherent cultural noise between all stations. On the right side ρ_a for off-diagonal elements of the impedance tensor are shown giving similar ρ_a-curves for both stations as well.

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References:

[1] Hering, P. (2019), Advances in Magnetotelluric Data Processing, Interpretation and Inversion, illustrated by a three-dimensional Resistivity Model of the Ceboruco Volcano, PhD-Thesis, University of Frankfurt

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