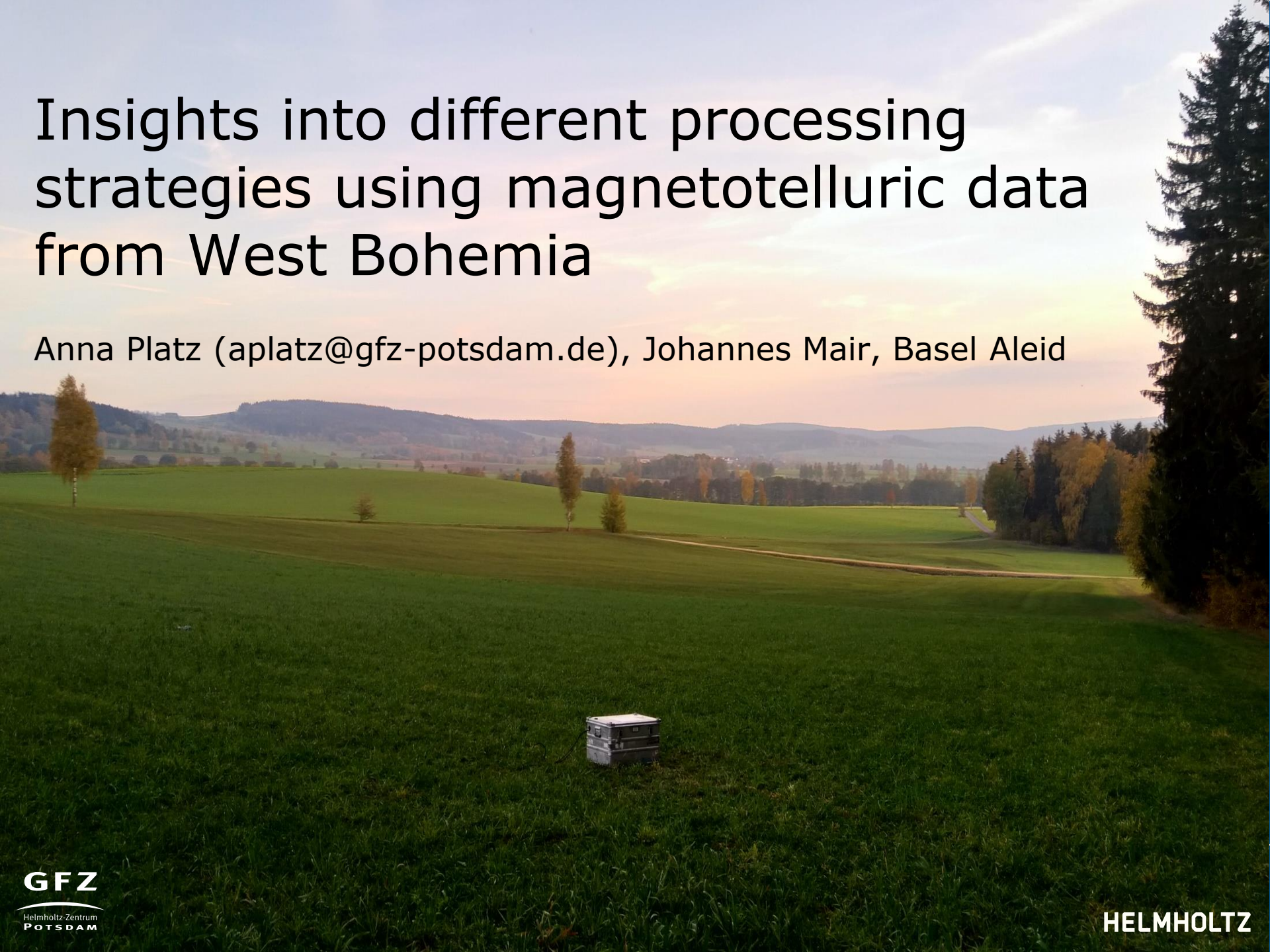
Insights into different processing strategies using magnetotelluric data from West Bohemia

Anna Platz (aplatz@gfz-potsdam.de), Johannes Mair, Basel Aleid

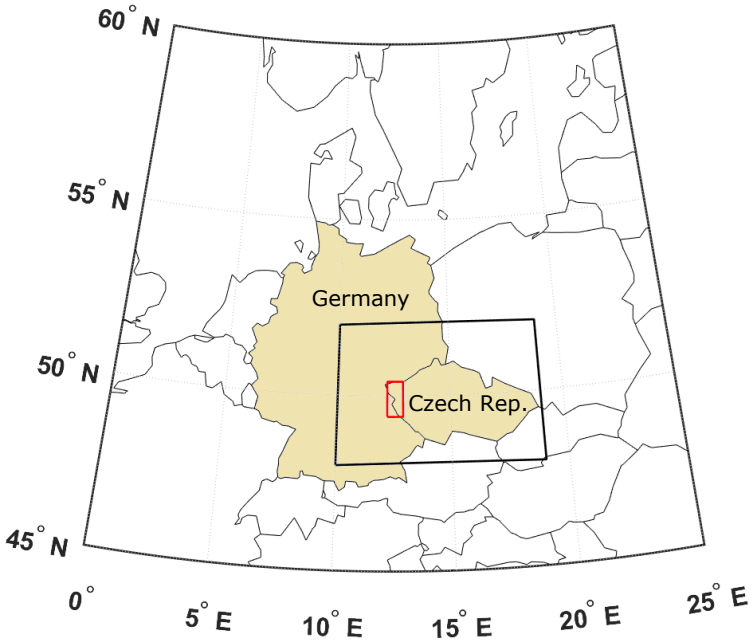


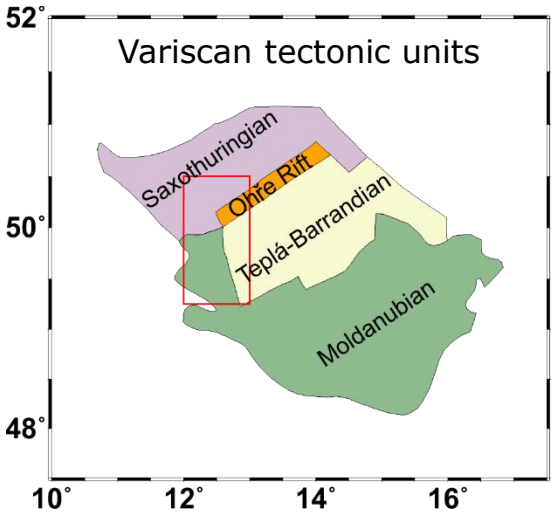
GFZ Helmholtz-Zentrum Potsdam

HELMHOLTZ

Region of interest

- The target area belongs to the western part of the Bohemian Massif
- The West Bohemian Massif represents the easternmost part of the geodynamically active European Cenozoic Rift System
- The Bohemian Massif was formed during the Variscan cycle between 500 and 250Ma

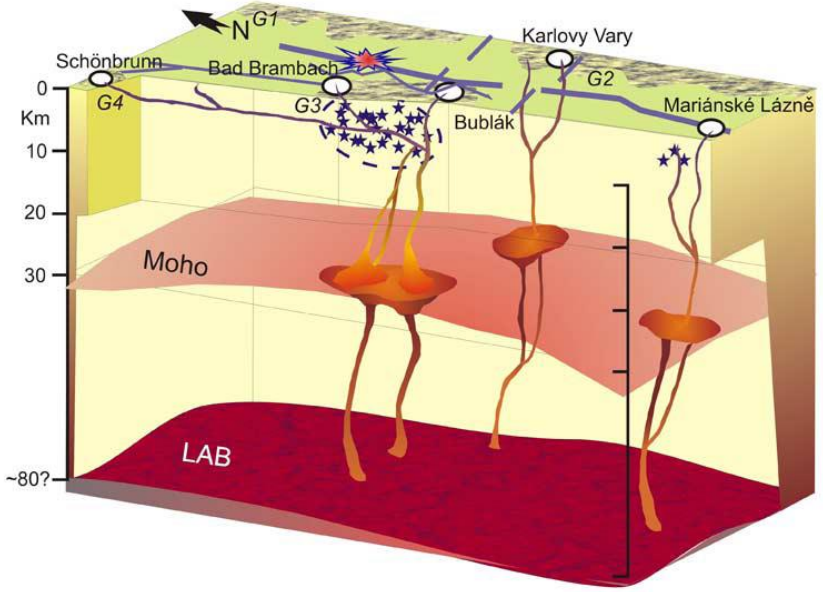




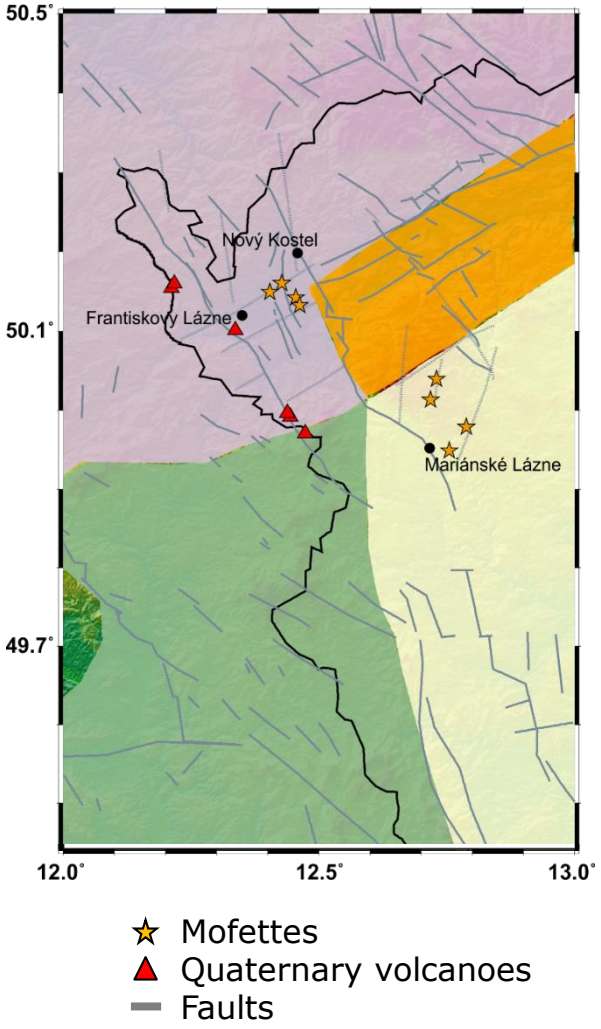
Platz et al. (2022)

Region of interest

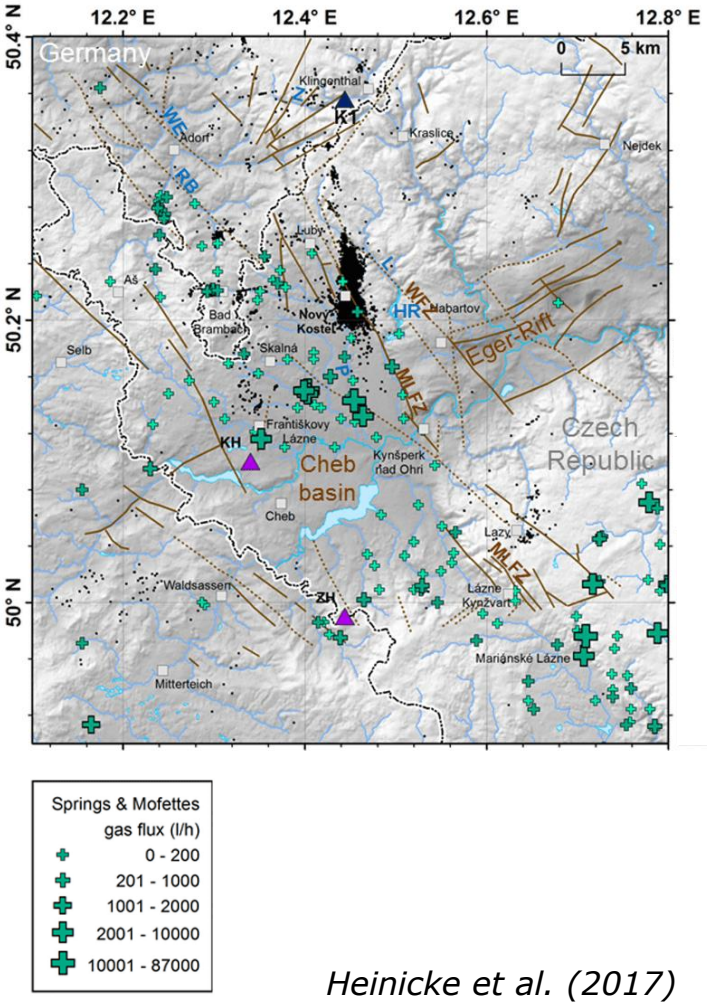
- The region is characterized by ongoing magmatic processes in the intra-continental lithospheric mantle



Bräuer et al. (2008)

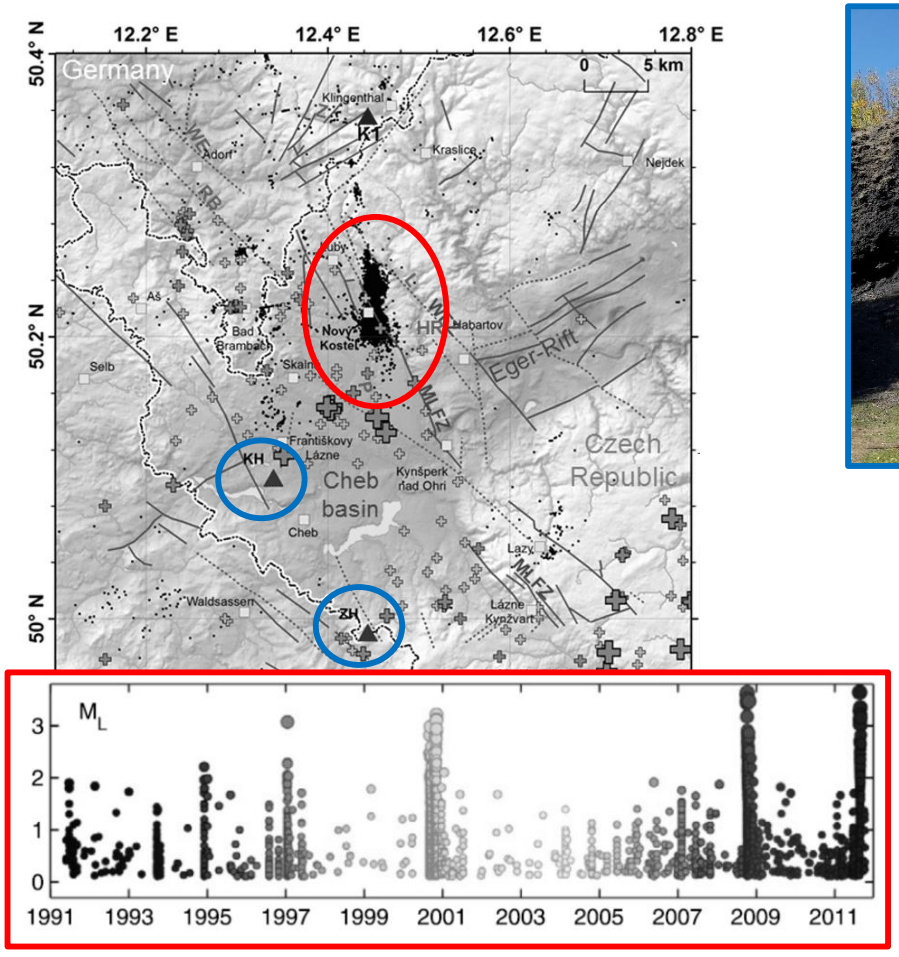


Degassing of mantle dervied CO_2



Heinicke et al. (2017)

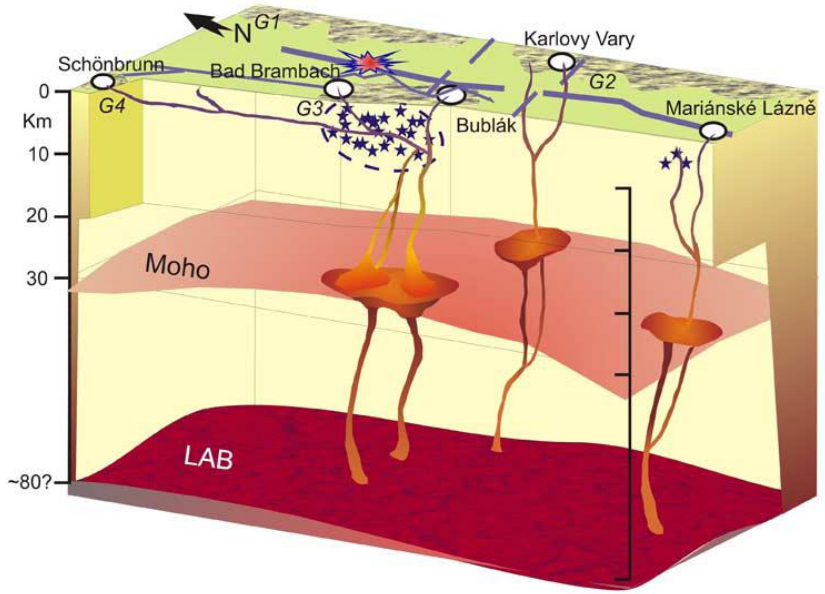
Earthquake swarms/ Volcanic structures



Heinicke et al. (2017), Fischer et al. (2014)

Request questions

- **Identification of pathways for fluids from the upper mantle to the surface**

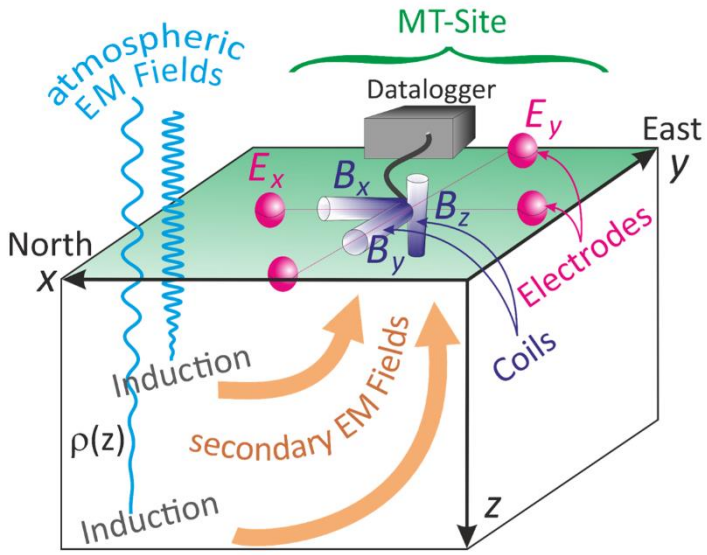


Bräuer et al. (2008)

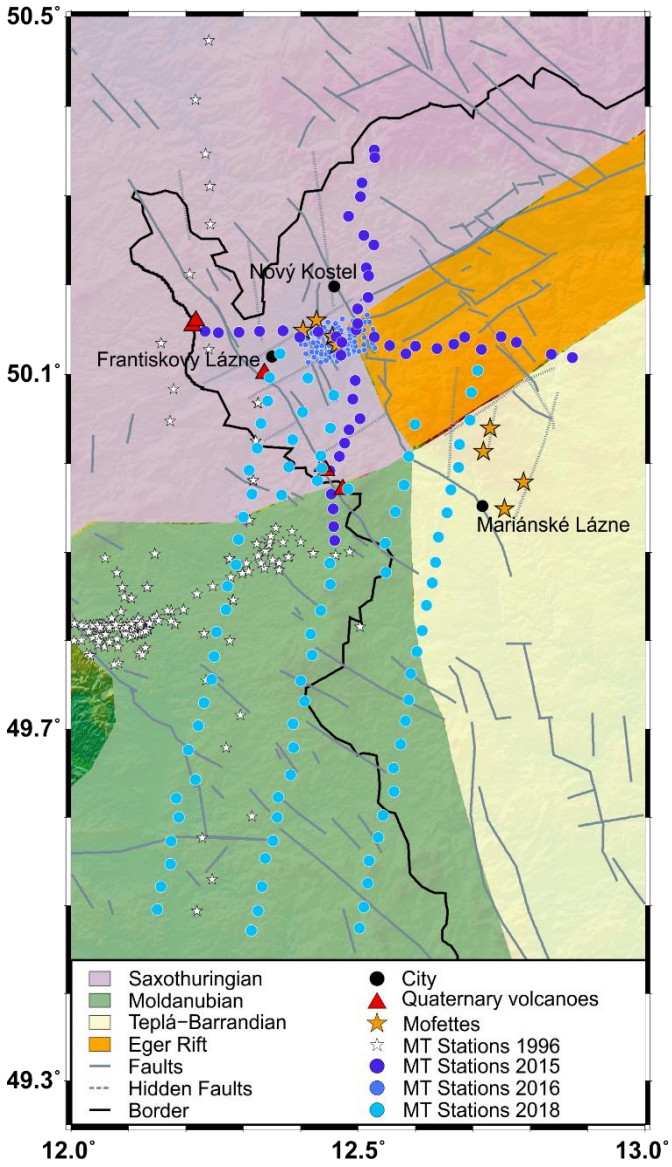
- Correlation between mofette degassing, gas composition and swarm and microbial activity
- Fault-valving mechanisms and their relevance for seismic hazard, degassing and the deep biosphere
- Triggering mechanism of fluid-induced earthquake swarms
- …

Measurements

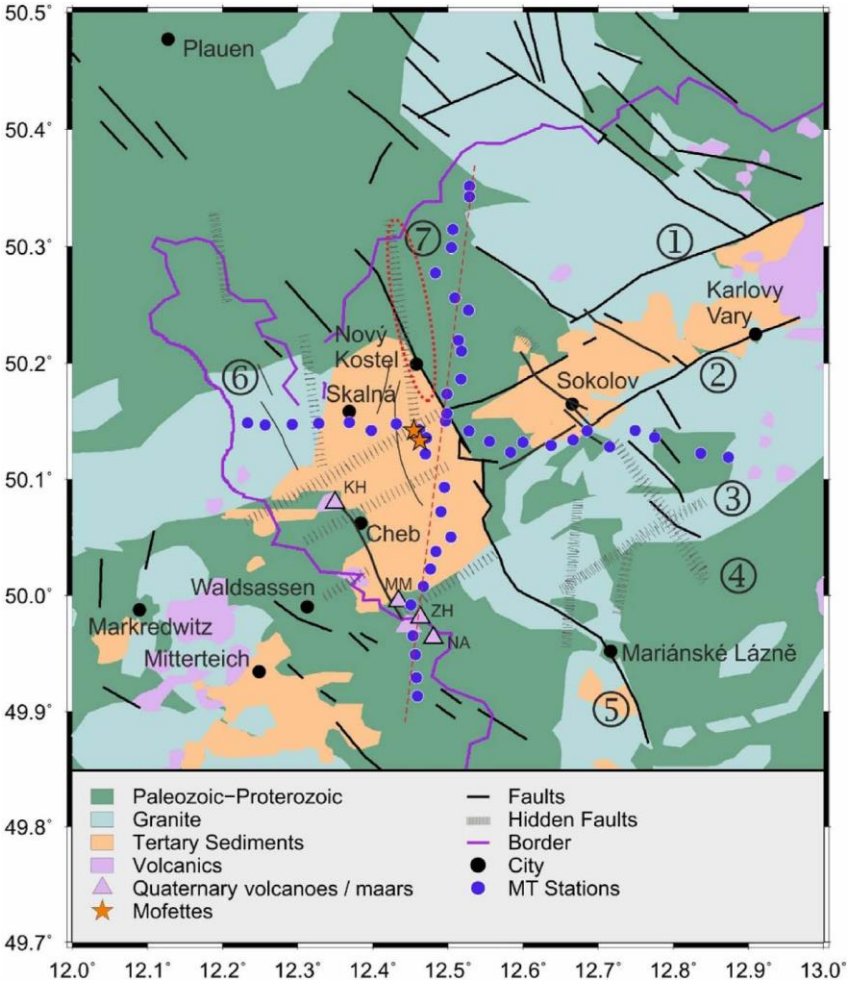
- Three broadband (10^{-4}-10^{3}s) five-component MT field campaigns using instruments from the Geophysical Instrumental Pool Potsdam (GIPP)
- 2015: two profiles in the Cheb Basin
- 2016: station grid close to mofette fields
- 2018: three profiles in the southern part



Modified after Sass (2013)



Data set I (2015)



Muñoz et al. (2018)

Tectonophysics 727 (2018) 1–11

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Regional two-dimensional magnetotelluric profile in West Bohemia/ Vogtland reveals deep conductive channel into the earthquake swarm region

Gerard Muñoz[a,*], Ute Weckmann[a,b], Josef Pek[c], Světlana Kováčiková[c], Radek Klanica[c,d]

[a] GFZ German Research Centre for Geosciences, Potsdam, Germany
[b] Institute of Earth- and Environmental Science, University of Potsdam, Germany
[c] Institute of Geophysics of the Czech Academy of Sciences, Prague, Czech Republic
[d] Faculty of Sciences, Charles University, Prague, Czech Republic

INTERPRETATION OF MT DATA IN THE EGER RIFT ALONG THE REGIONAL PROFILES

Department of Earth Sciences
Institute of Geological Sciences Free University of Berlin

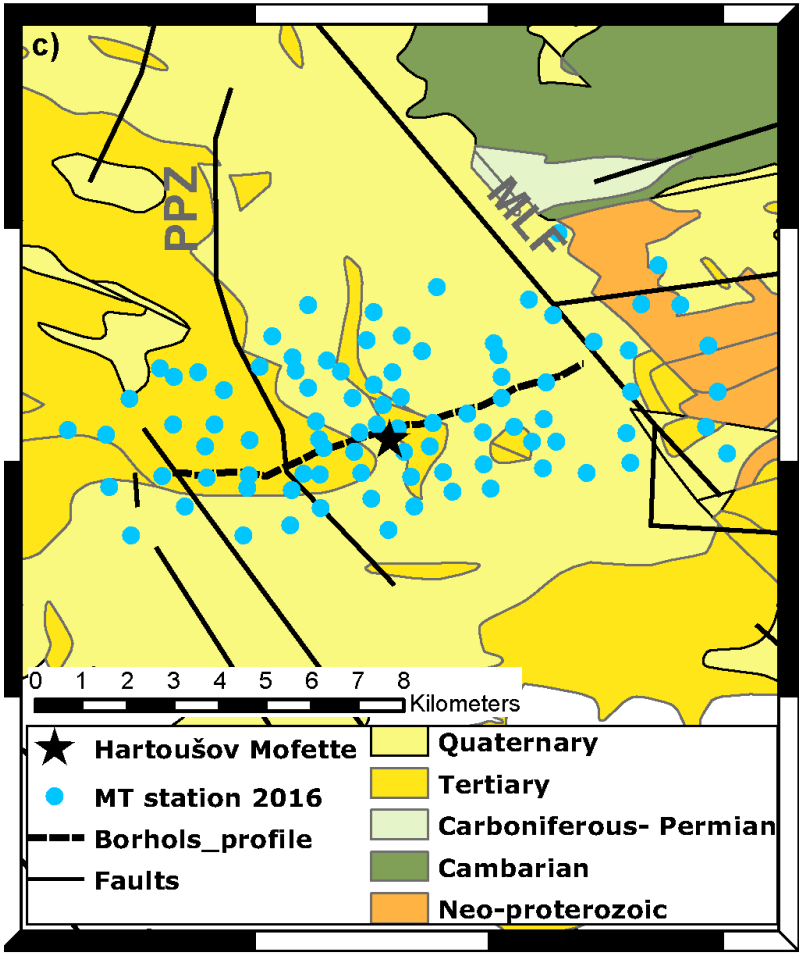
Master Thesis

to receive the academic degree
Master of Science

submitted by

Johannes Mair

Data set II (2016)



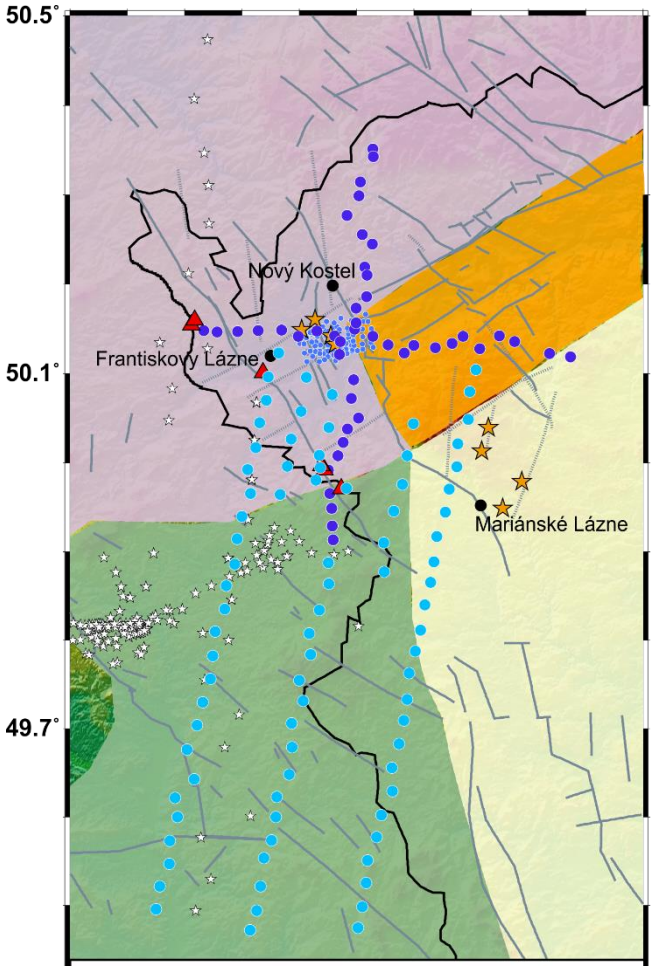
Three-dimensional imaging of electrical conductivity structures in the Eastern Cheb Basin across the Bublàk and Hartoušov Mofettes

Basel Alcid[a,b,*], Ute Weckmann[a,b], Anna Platz[a], Josef Pek[c], Svetlana Kovàčikovà[c], Radek Klanica[c]

[a] *GFZ German Research Centre for Geosciences, Potsdam, Germany.*
[b] *University of Potsdam, Institute of Earth and Environmental Science, Potsdam, Germany*
[c] *Institute of Geophysics of the Czech Academy of Sciences, Prague, Czech Republic*

(in prep.)

Data set III (2018)



Tectonophysics 833 (2022) 229353

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journal homepage: www.elsevier.com/locate/tecto

3D imaging of the subsurface electrical resistivity structure in West Bohemia/Upper Palatinate covering mofettes and Quaternary volcanic structures by using Magnetotellurics

Anna Platz [a,*], Ute Weckmann [a,b], Josef Pek [c], Světlana Kováčiková [c], Radek Klanica [c], Johannes Mair [a,d], Basel Aleid [a,b]

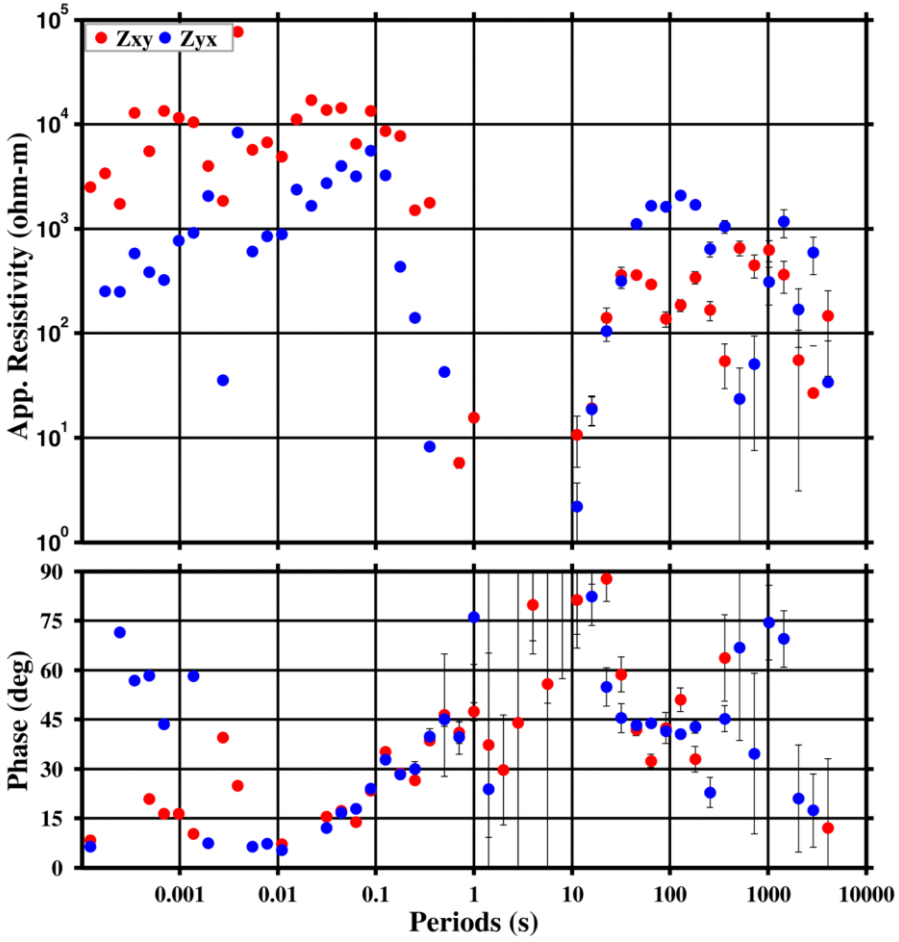
[a] GFZ German Research Centre for Geosciences, Potsdam, Germany
[b] University of Potsdam, Institute of Earth and Environmental Science, Potsdam, Germany
[c] Institute of Geophysics of the Czech Academy of Sciences, Prague, Czech Republic
[d] Freie Universität Berlin, Department of Earth Sciences, Berlin, Germany

General processing details

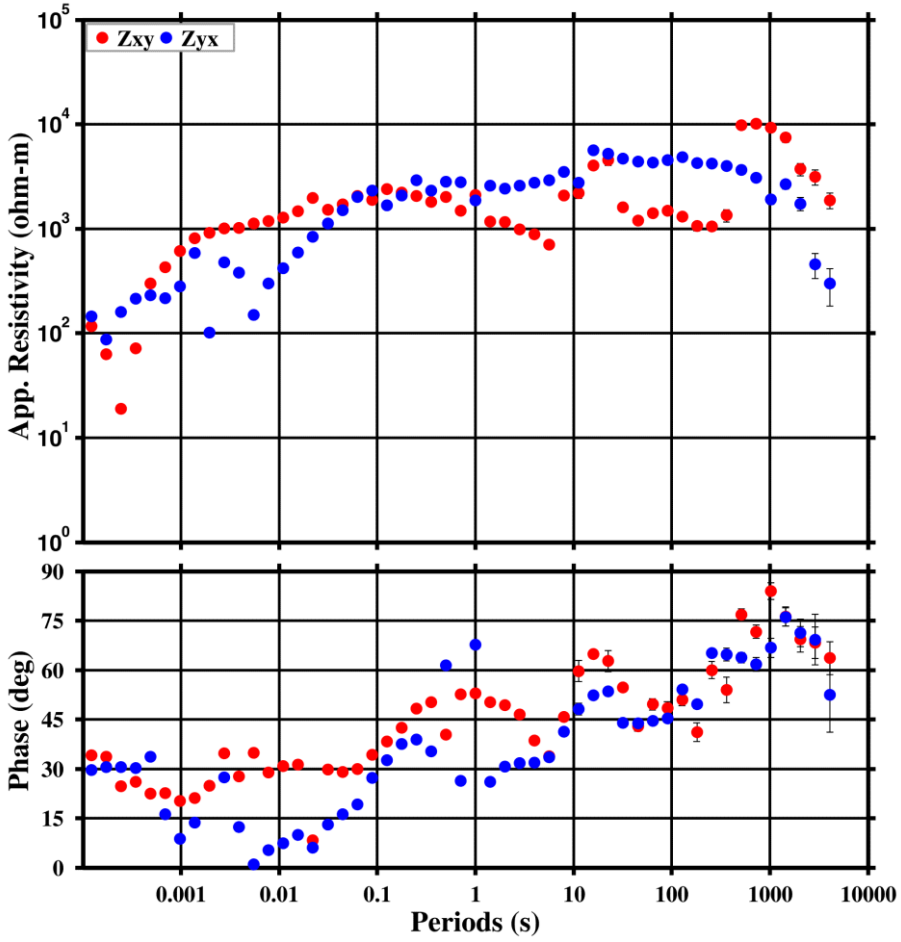
- The data were processed using the *EMERALD* software suite (Ritter et al., 1998; Weckmann et al., 2005; Krings, 2007; Platz & Weckmann, 2019)
- Supports single site, remote reference and pseudo remote processing
- Selection of pre-stack selection criteria, e.g.
  - Coherence criterion
  - Phase criterion
  - Mahalanobis distance criterion
  - Magnetic polarization direction criterion
- Robust stacking algorithm based on Huber and Tukey weights
- Tools for notch and delay line filter
- Tools to remove spikes in time series based on short time average/ long time average filter
- Tool for manual data selection based on different physical and statistical parameter

Robust single site processing

Poor data quality (station A)

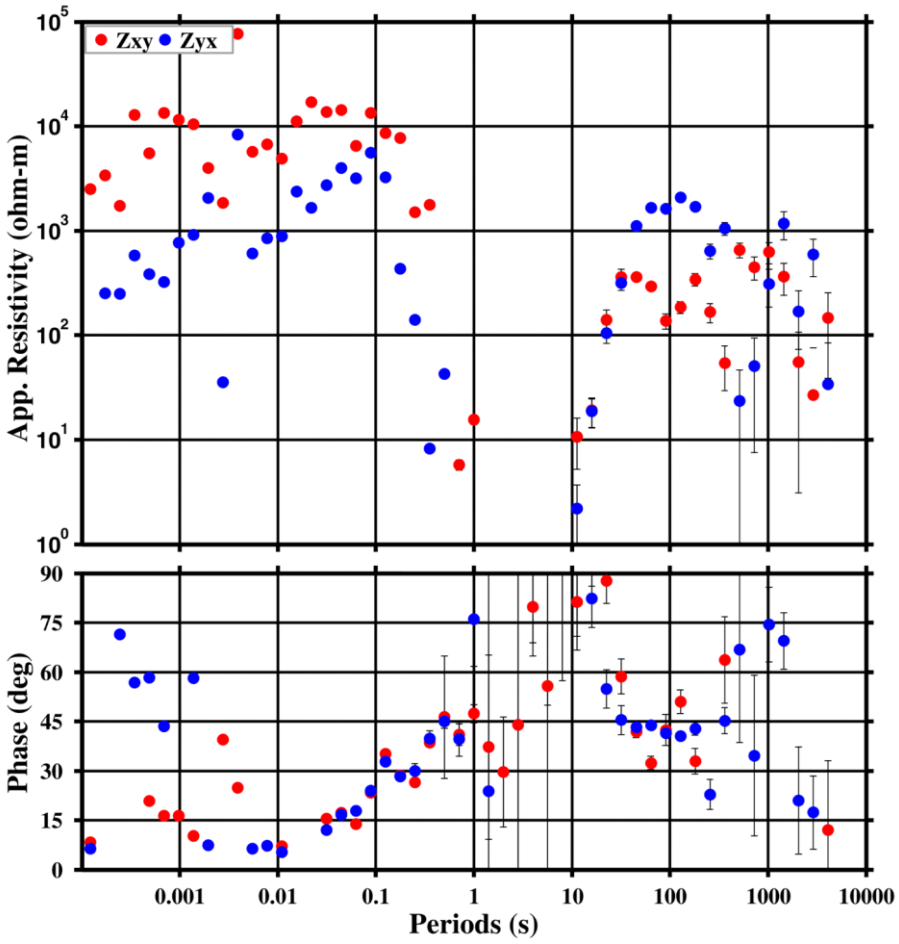


Good data quality (station B)

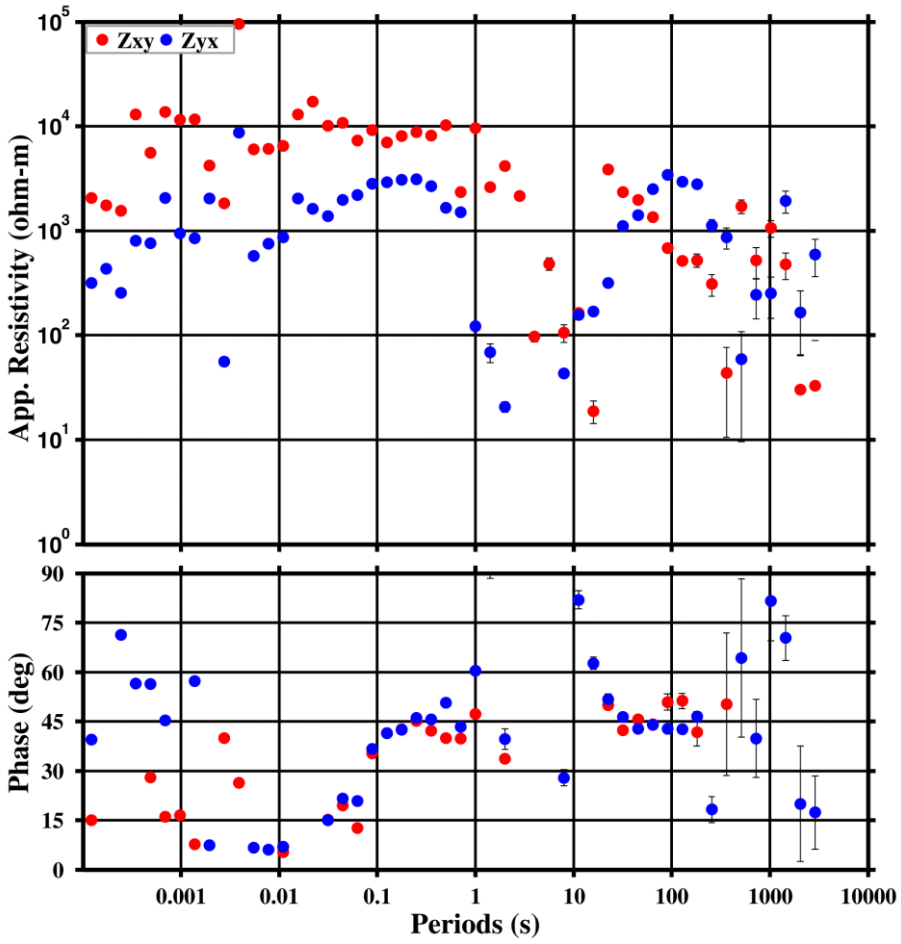


Coherence criterion - station A

Without coherence criterion

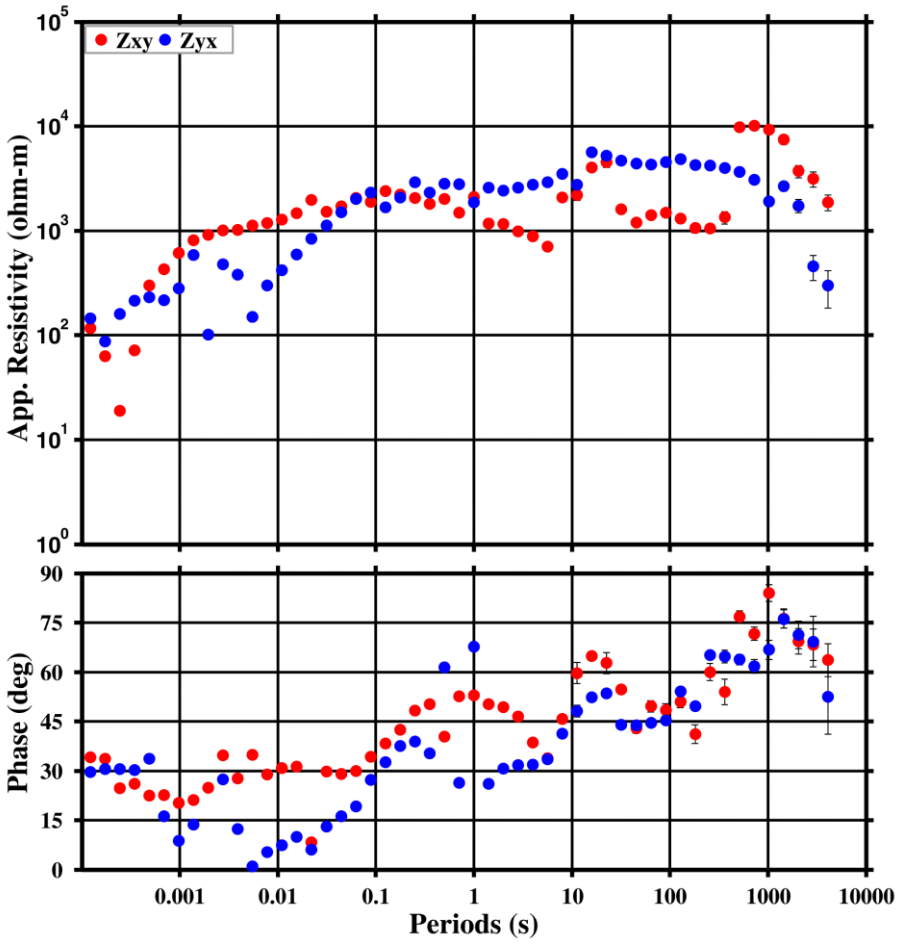


With coherence criterion

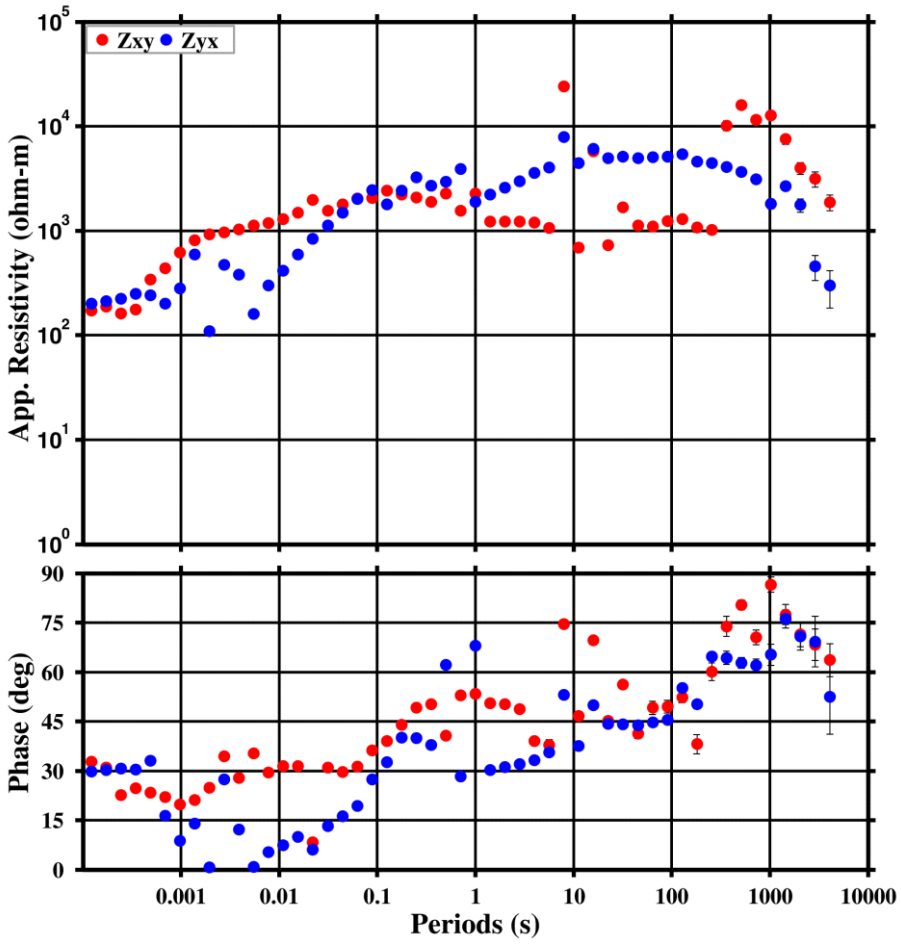


Coherence criterion – station B

Without coherence criterion

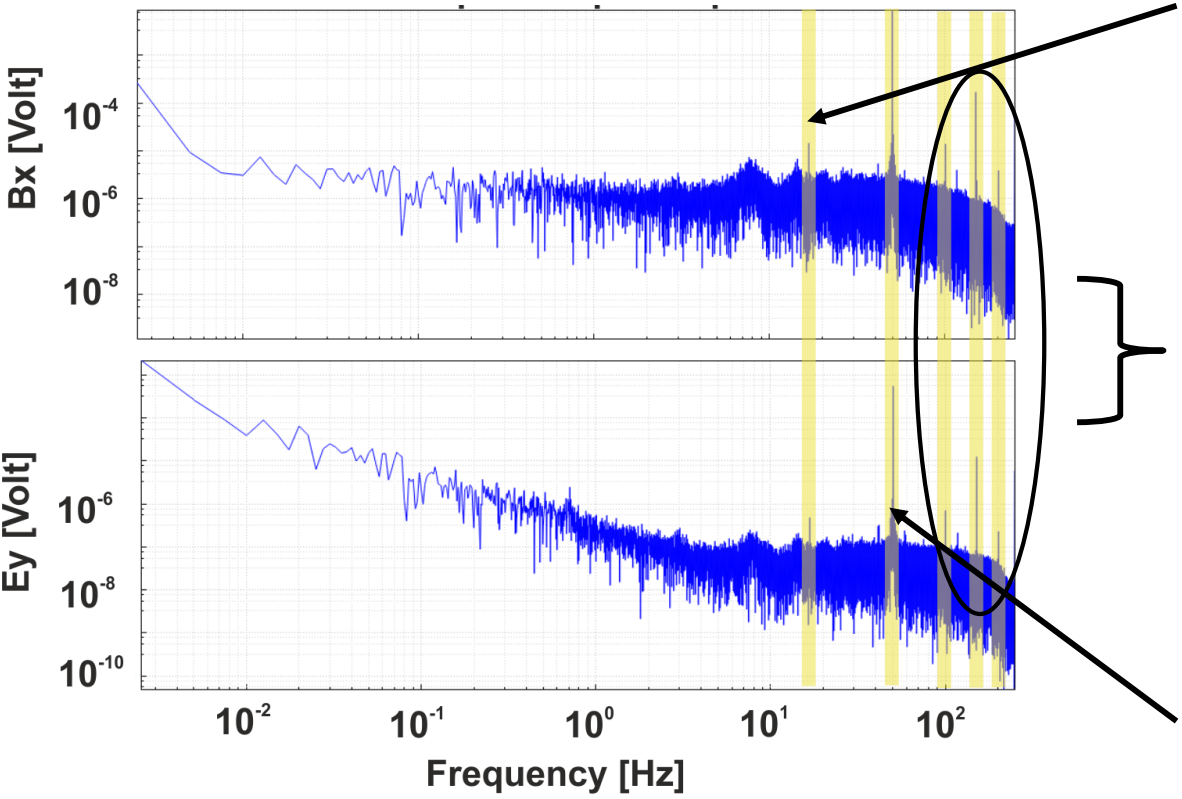


With coherence criterion



Notch filter – station C

- Possibility to remove monochromatic noise and its harmonics



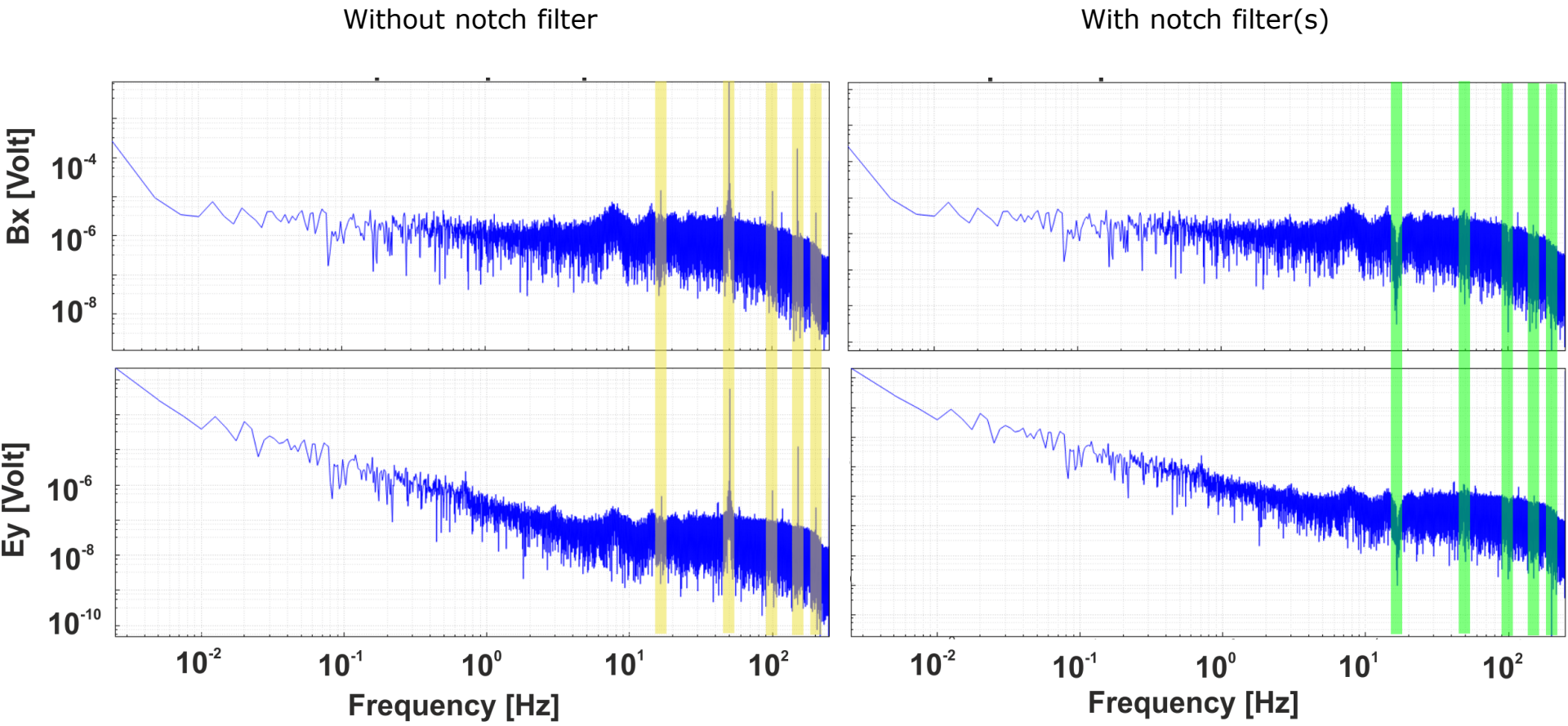
16.7Hz signal from the (German) railways

harmonics

50Hz signal from the power grid

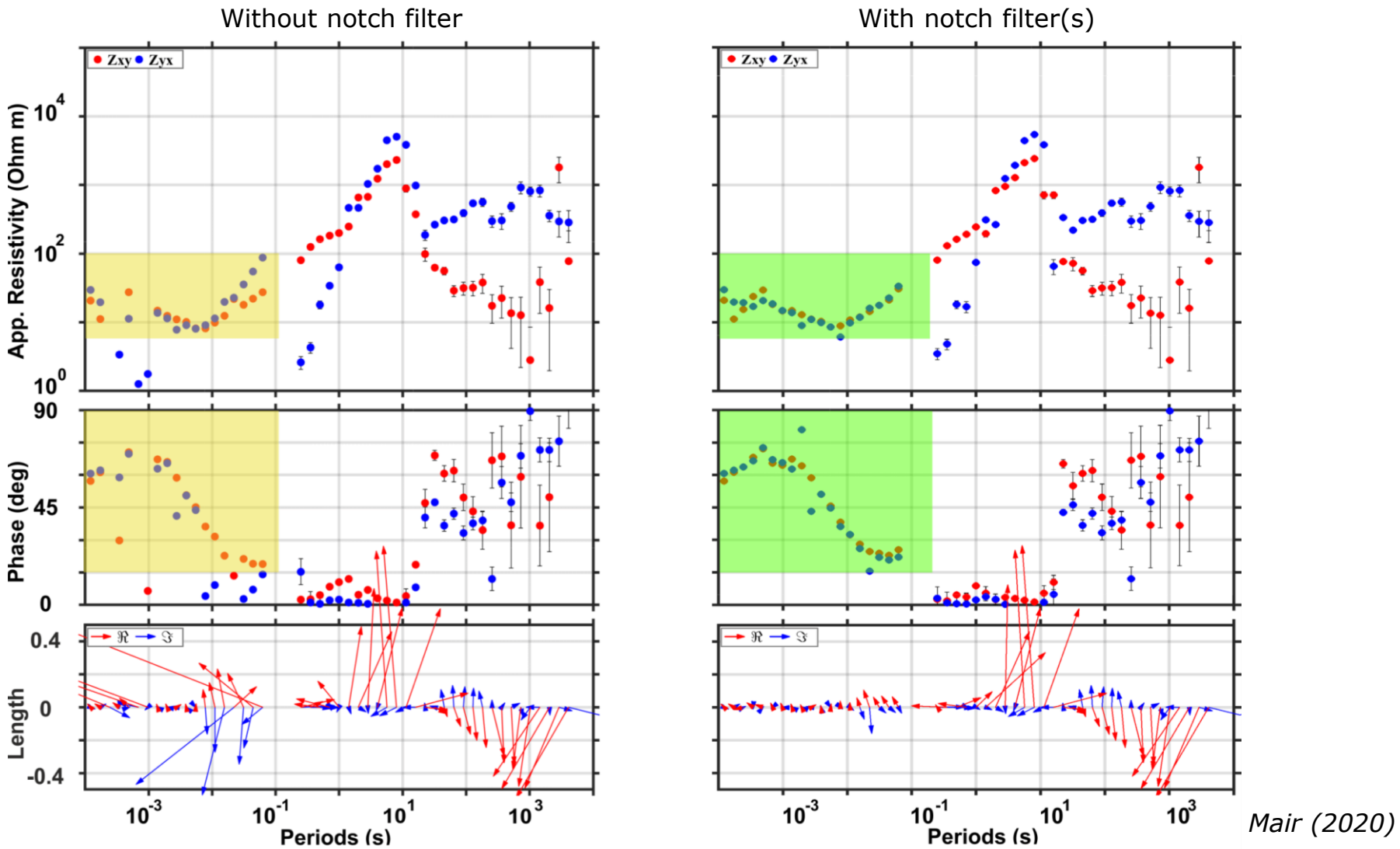
Mair (2020)

Notch filter – station C



Mair (2020)

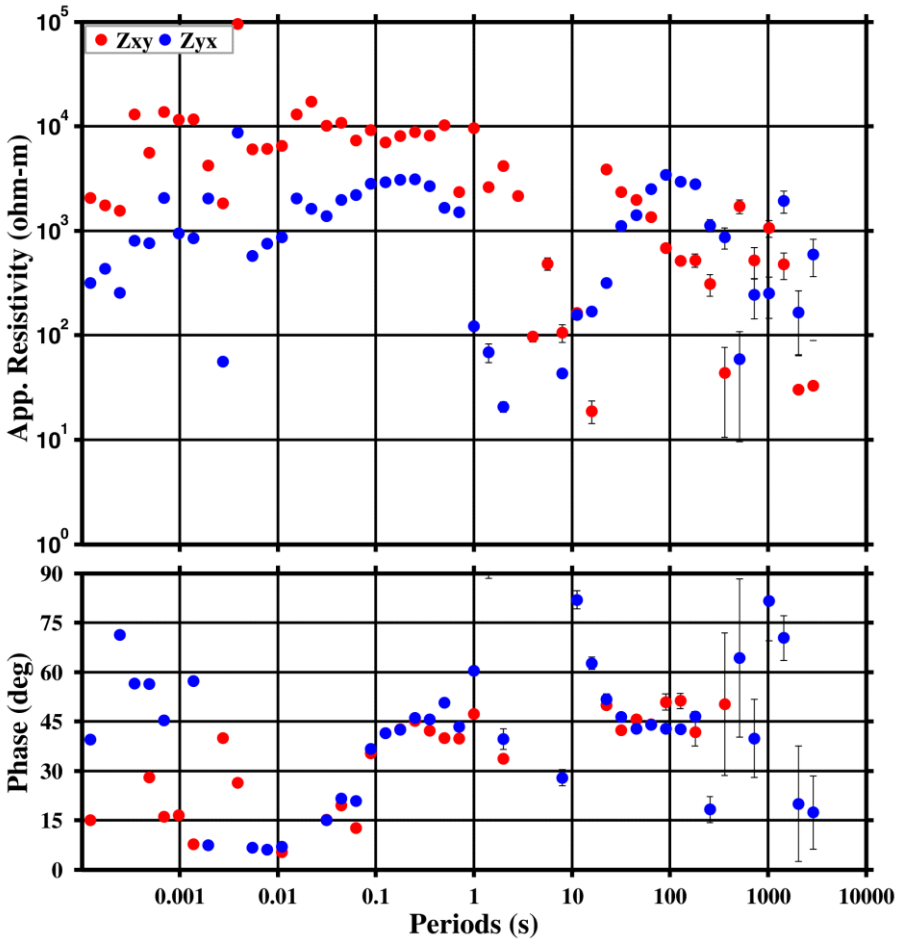
Notch filter – station C



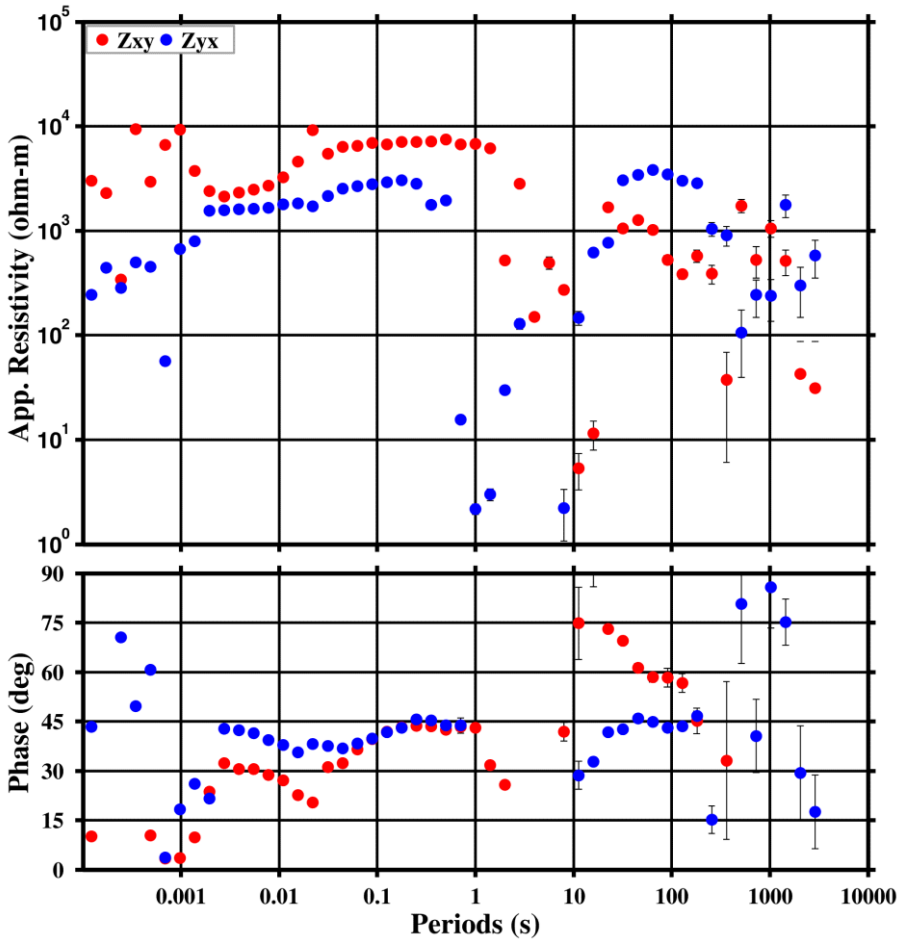
Mair (2020)

Notch filter– station A

Without notch filter

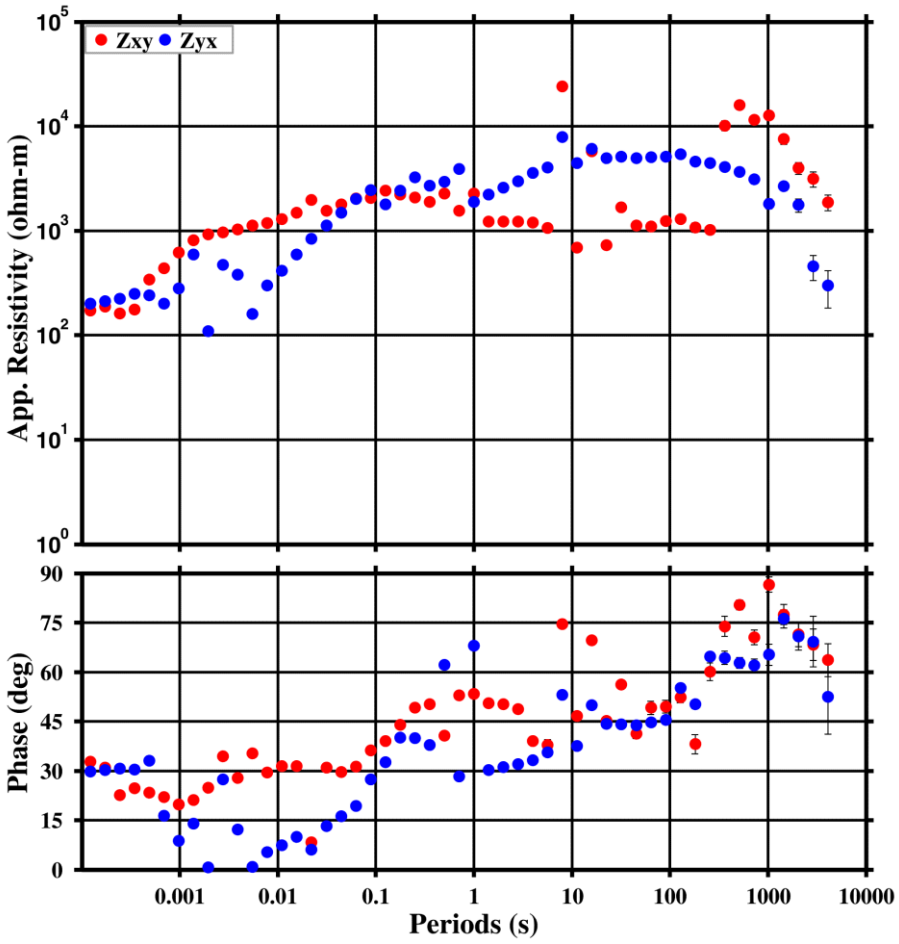


With notch filter

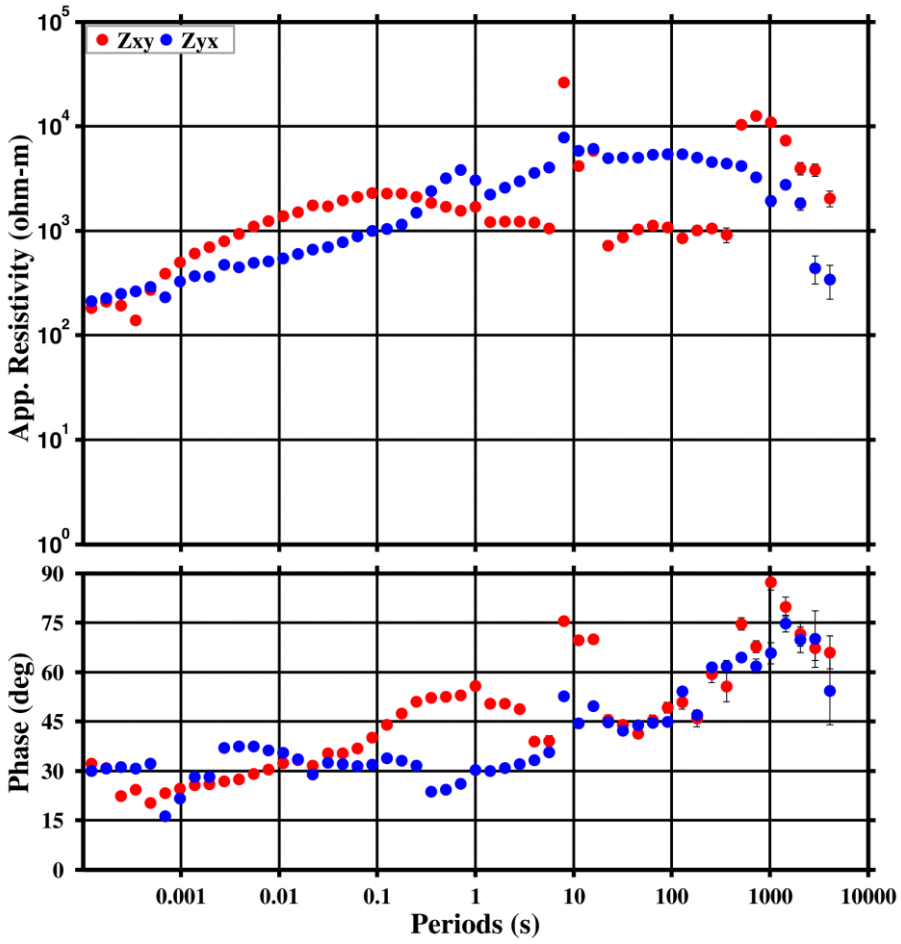


Notch filter– station B

Without notch filter

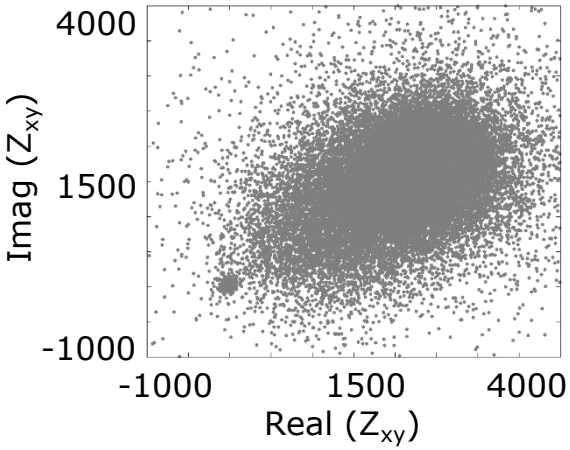


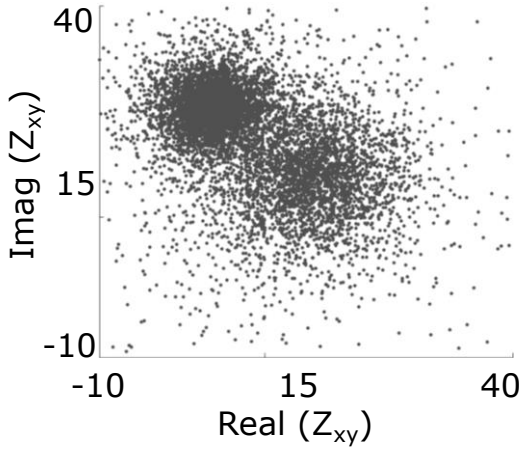
With notch filter



Mahalanobis distance (MD) criterion

- Statistical criterion based on advanced distance measure





Mahalanobis distance (MD):

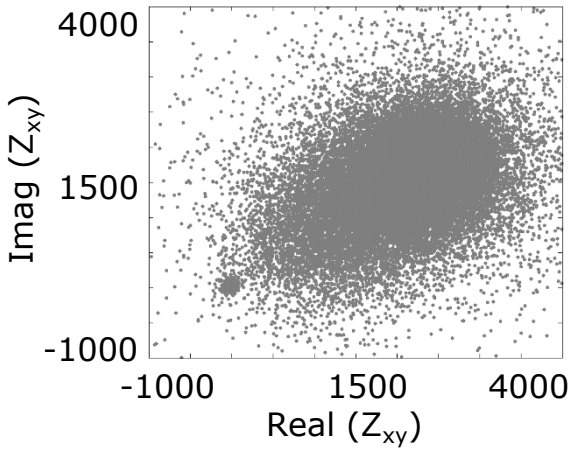
$$MD_i = \sqrt{(x_i - \bar{x})C_x^{-1}(x_i - \bar{x})^T}$$

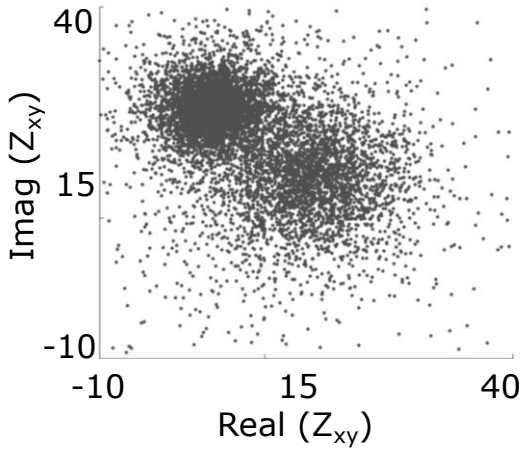
x_i: Data of the i-th observation (event)
$\bar{x}$: Data centre
C_x^{-1}: Inverse of the covariance matrix

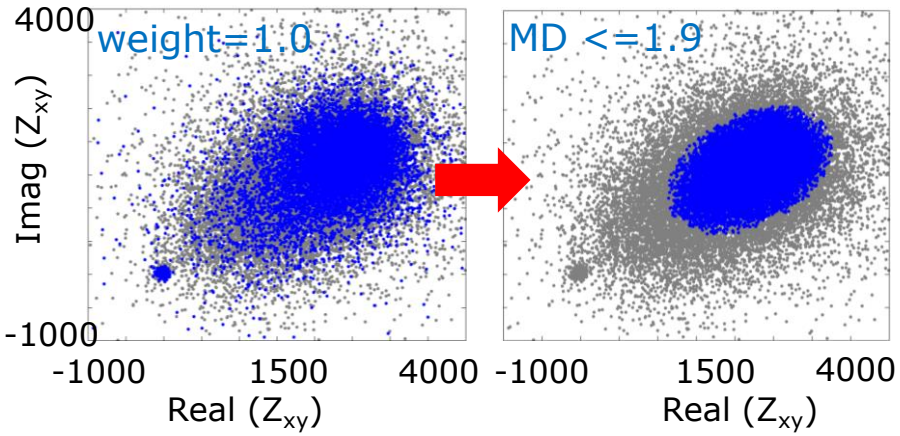
Platz & Weckmann (2019)

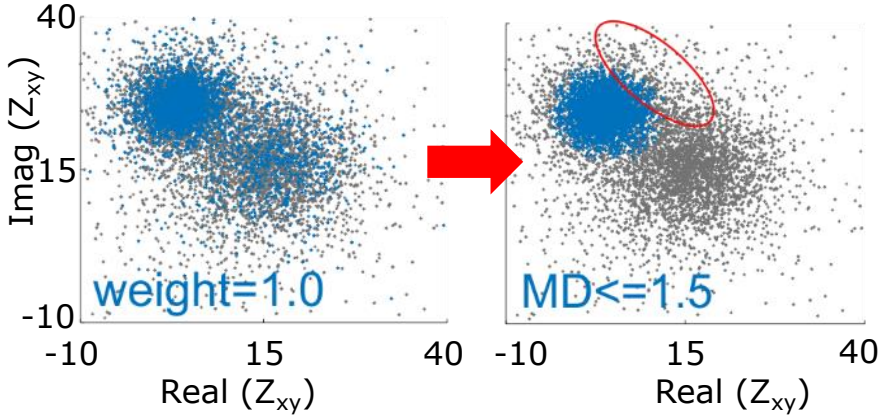
Mahalanobis distance (MD) criterion

- Statistical criterion based on advanced distance measure



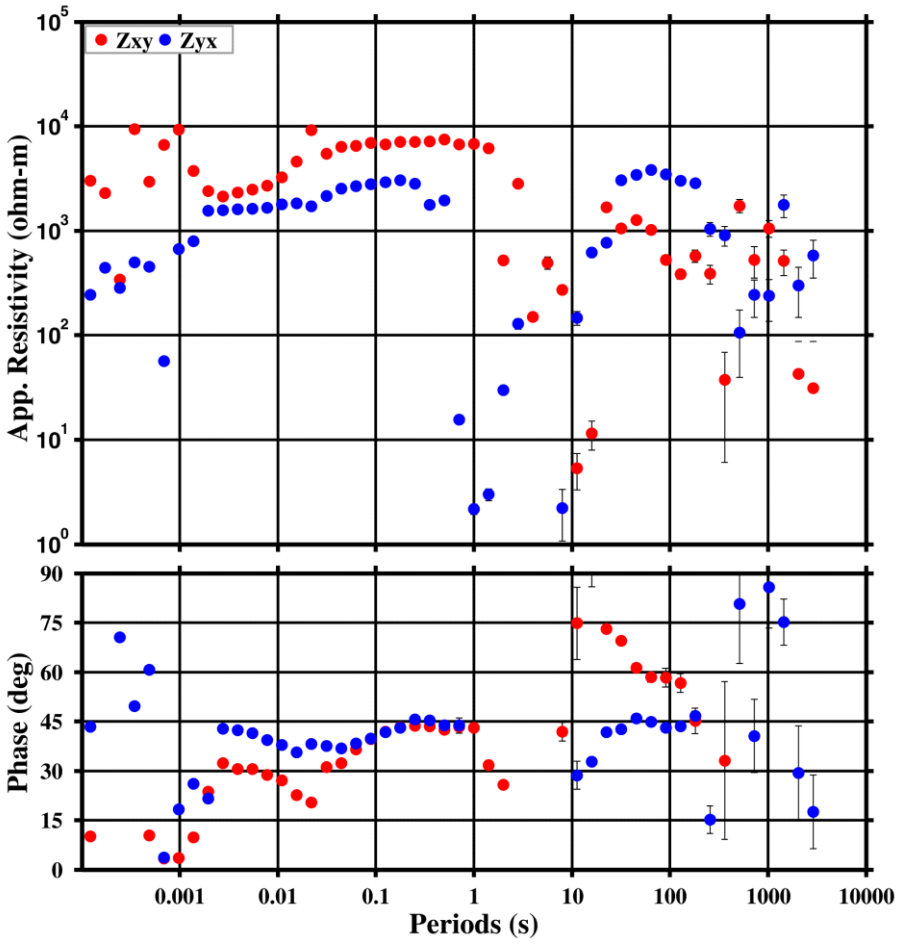




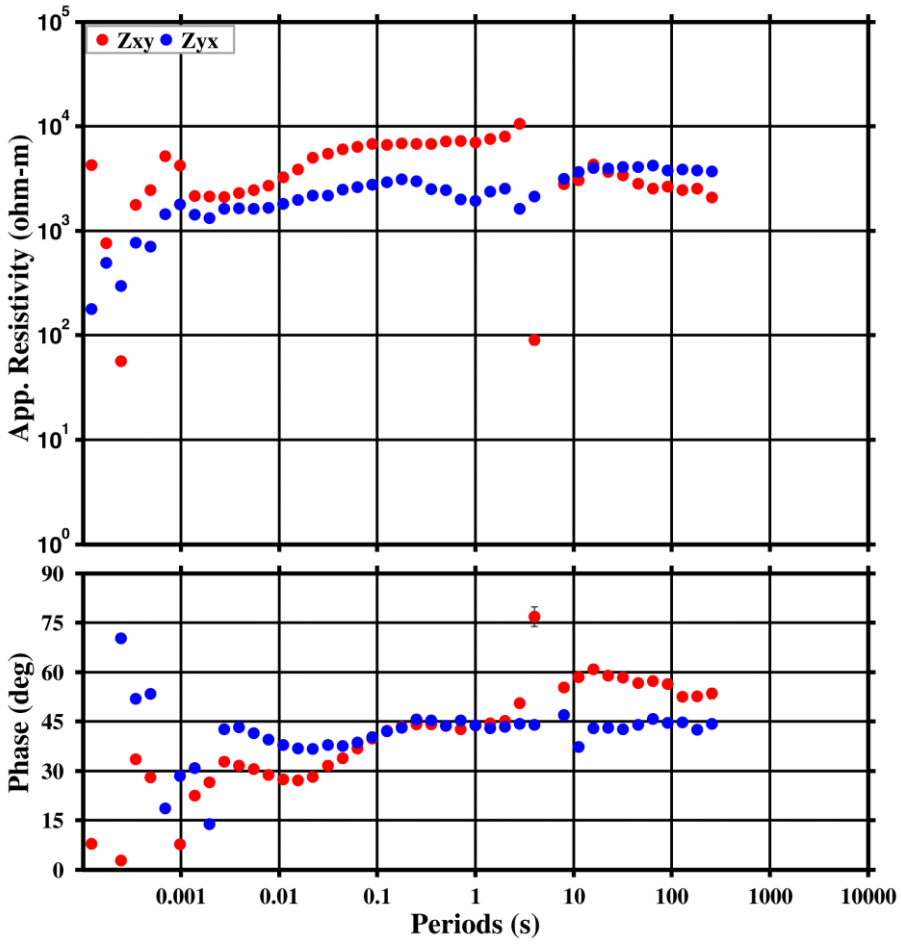


MD criterion – station A

Without MD criterion

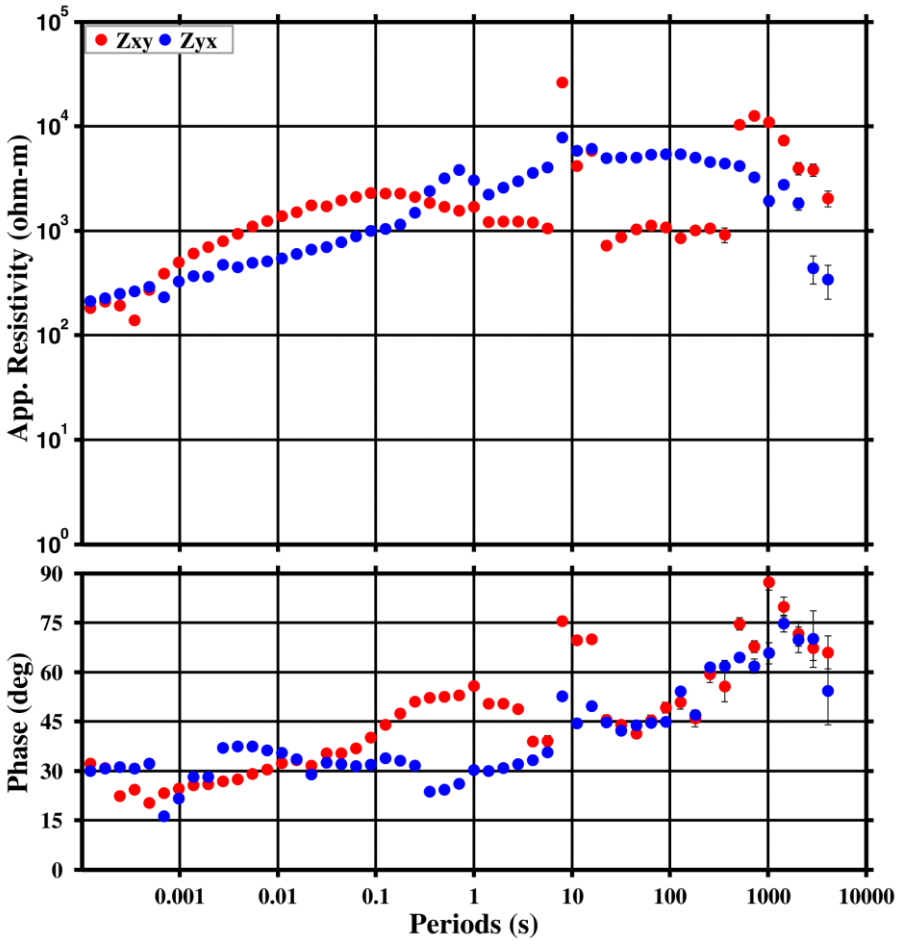


With MD criterion

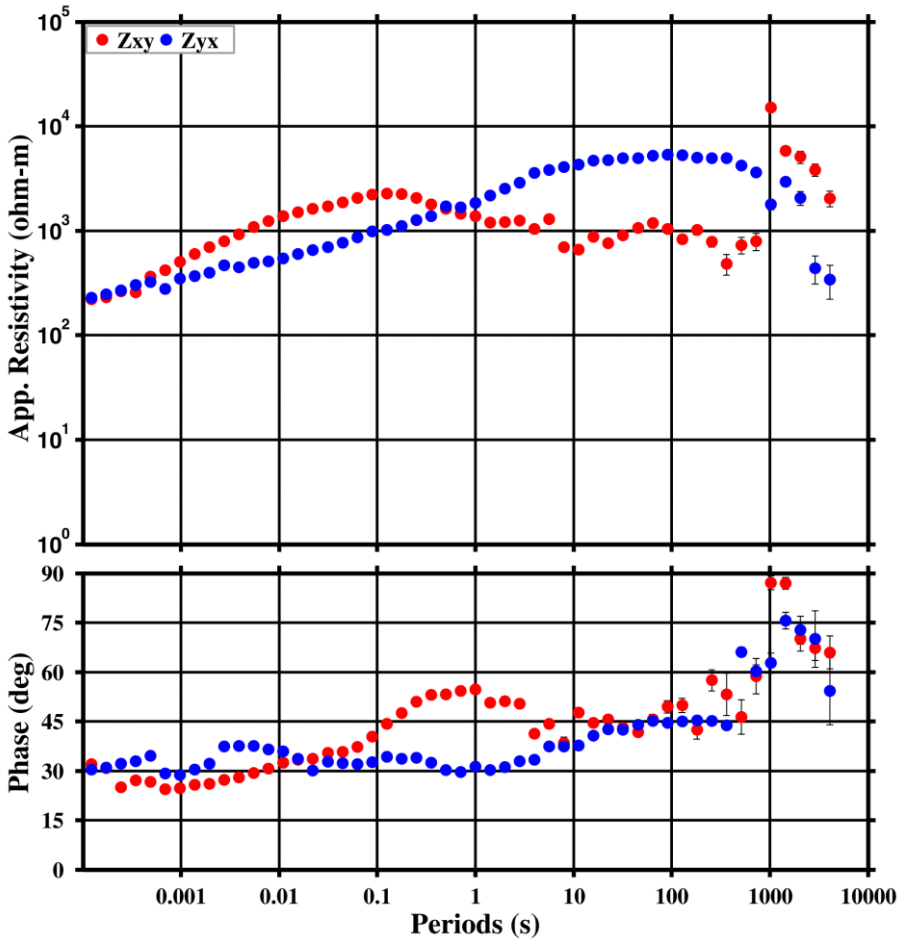


MD criterion – station B

Without MD criterion

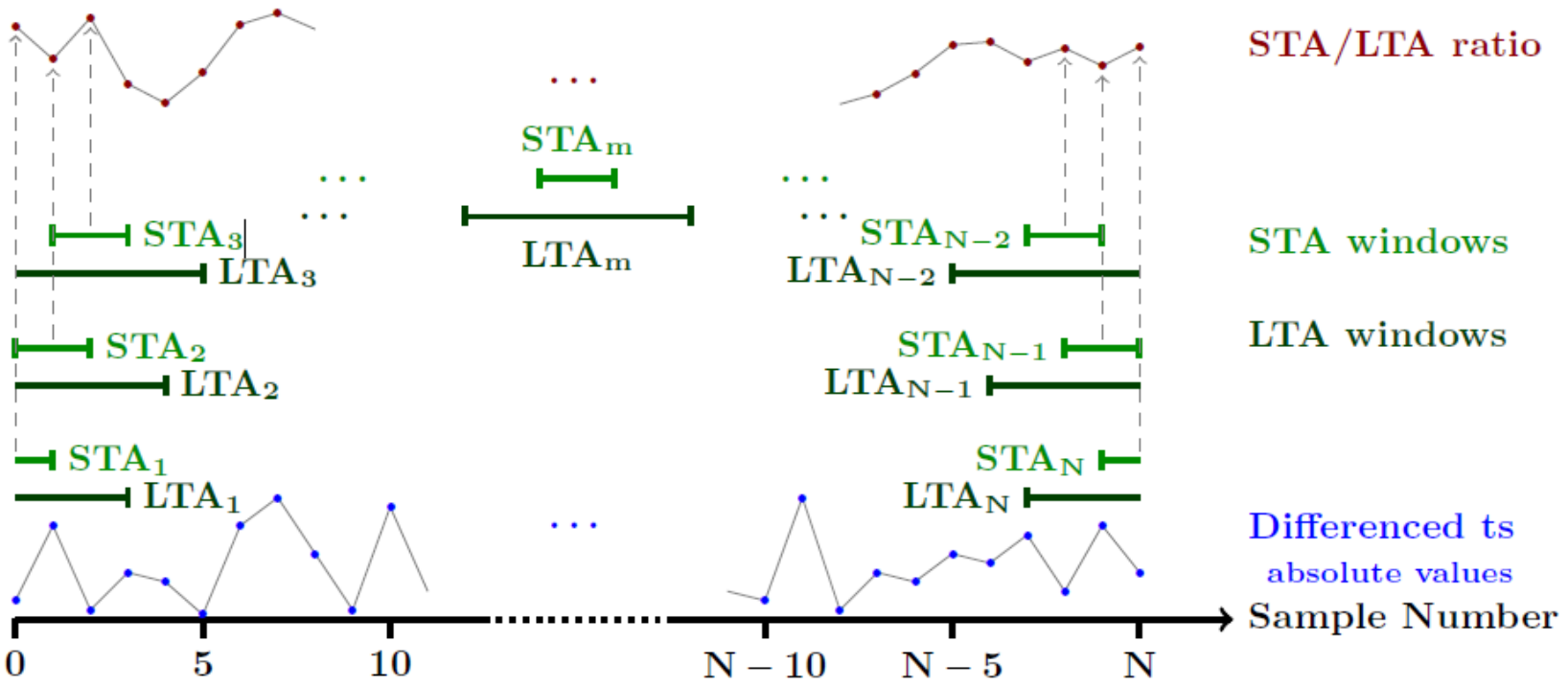


With MD criterion



Short time average/ Long time average (STA/LTA) filter

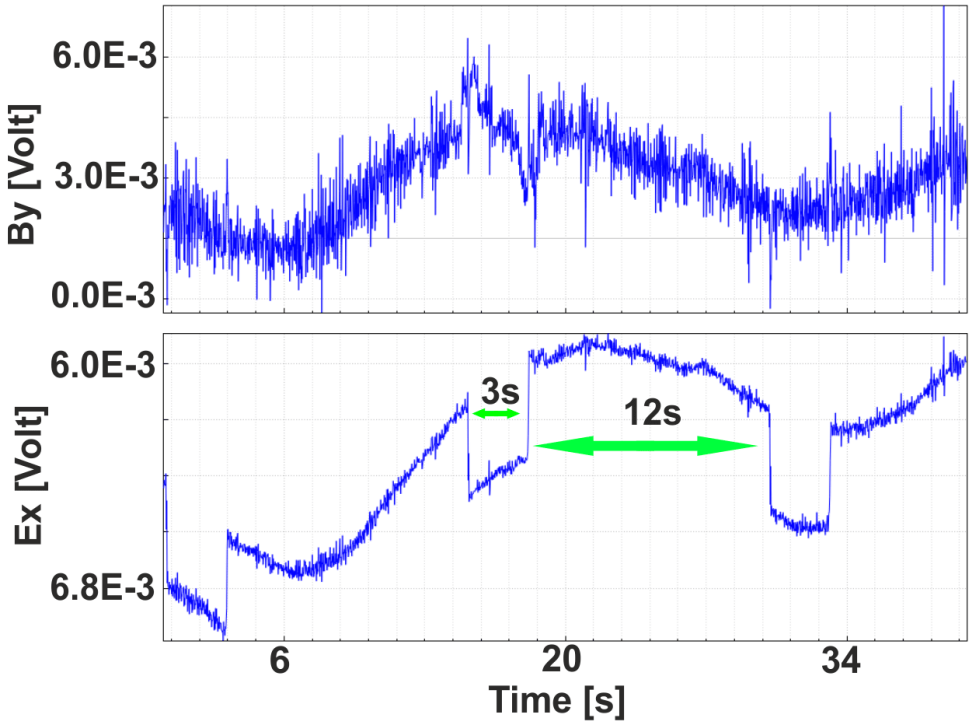
- Tool to remove spikes (and steps) in time series



Kütter (2015)

STA/LTA filter

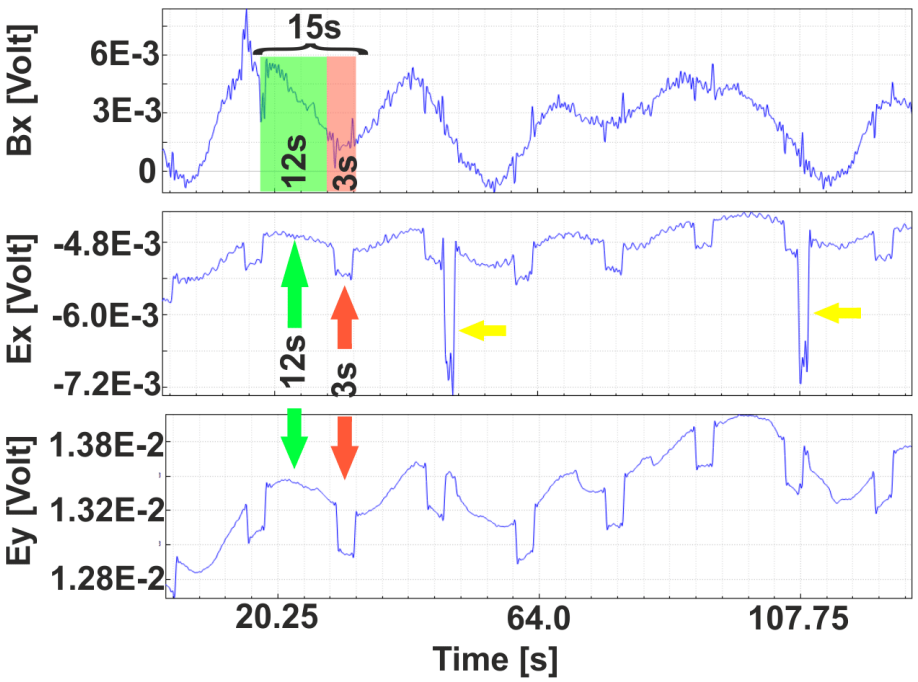
- Pipeline anti-corrosion pulse noise (so called impressed current cathodic protection systems): step like perturbations in electric channels and spikes in magnetic channels



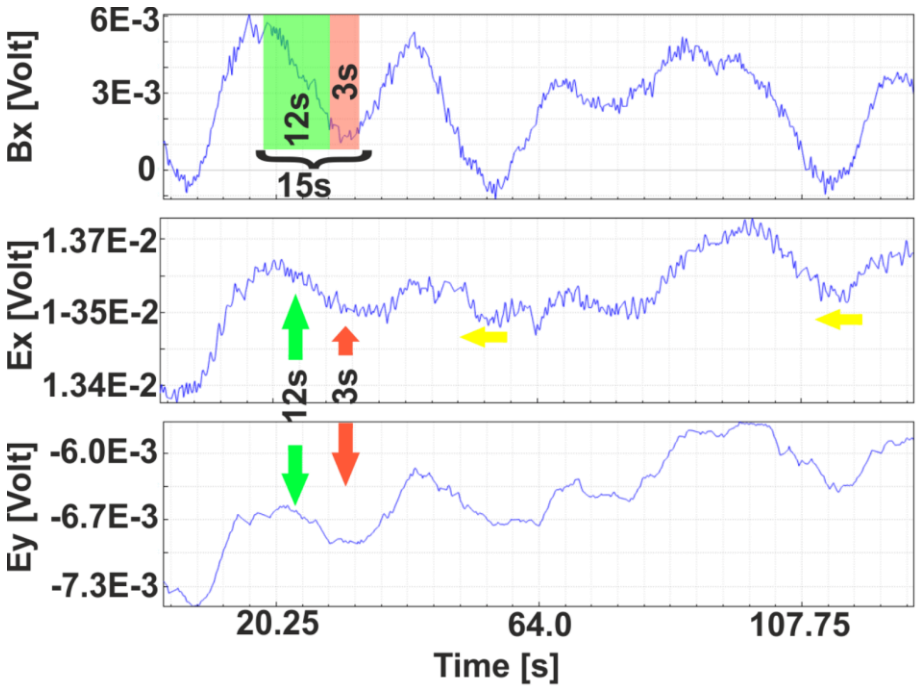
Mair (2020)

STA/LTA filter

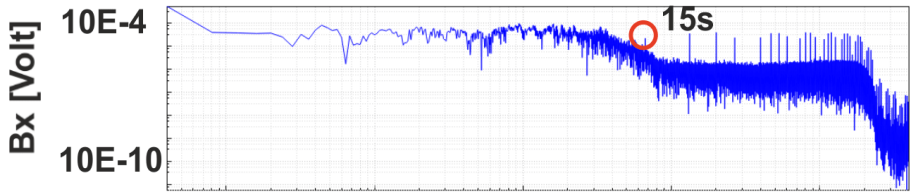
Original time series



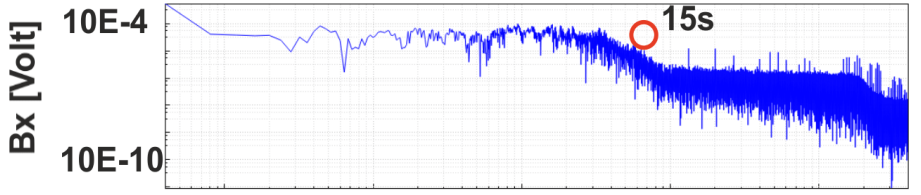
Time series after filtering



Original frequency spectrum

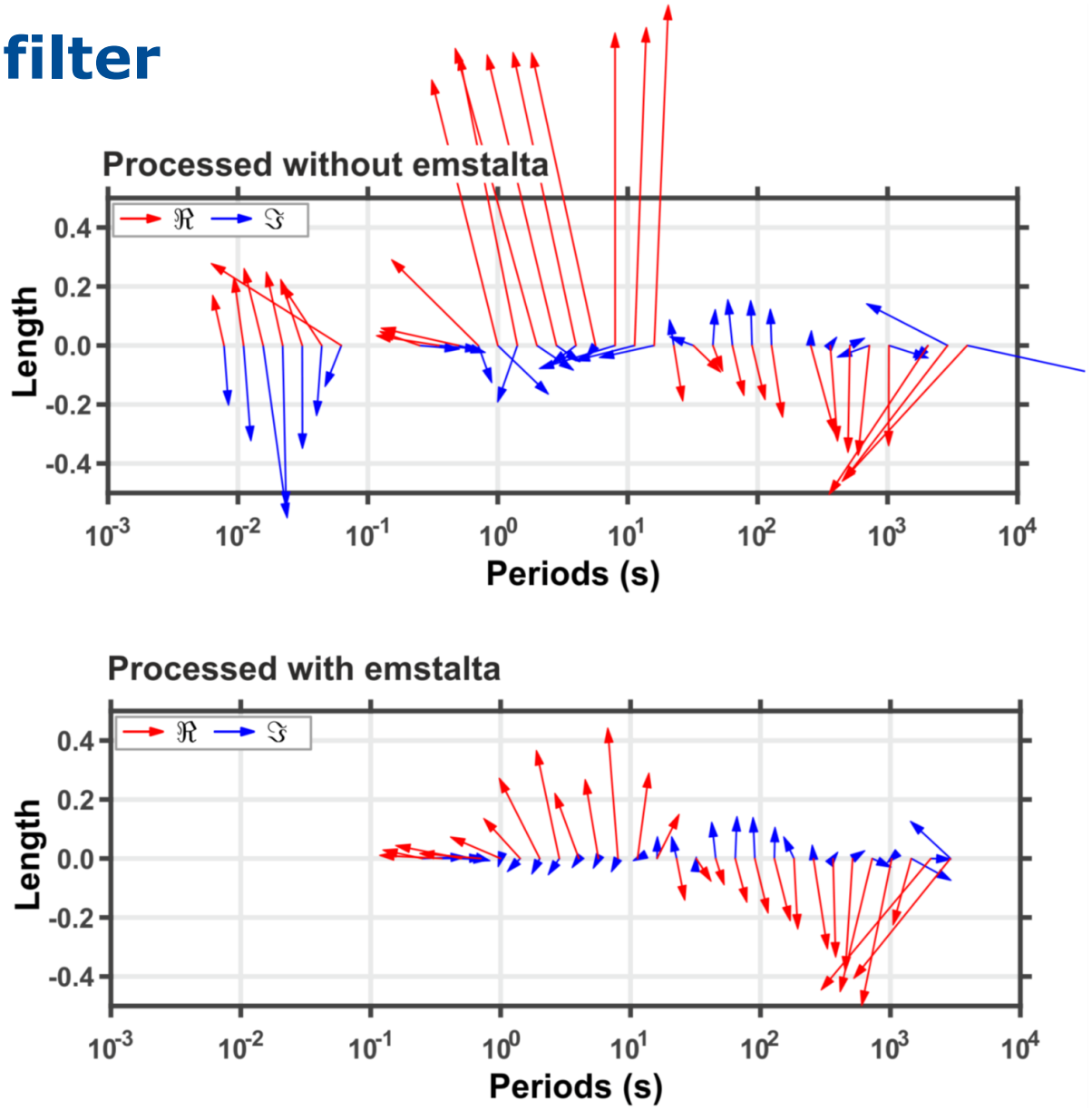


Frequency spectrum after filtering



Mair (2020)

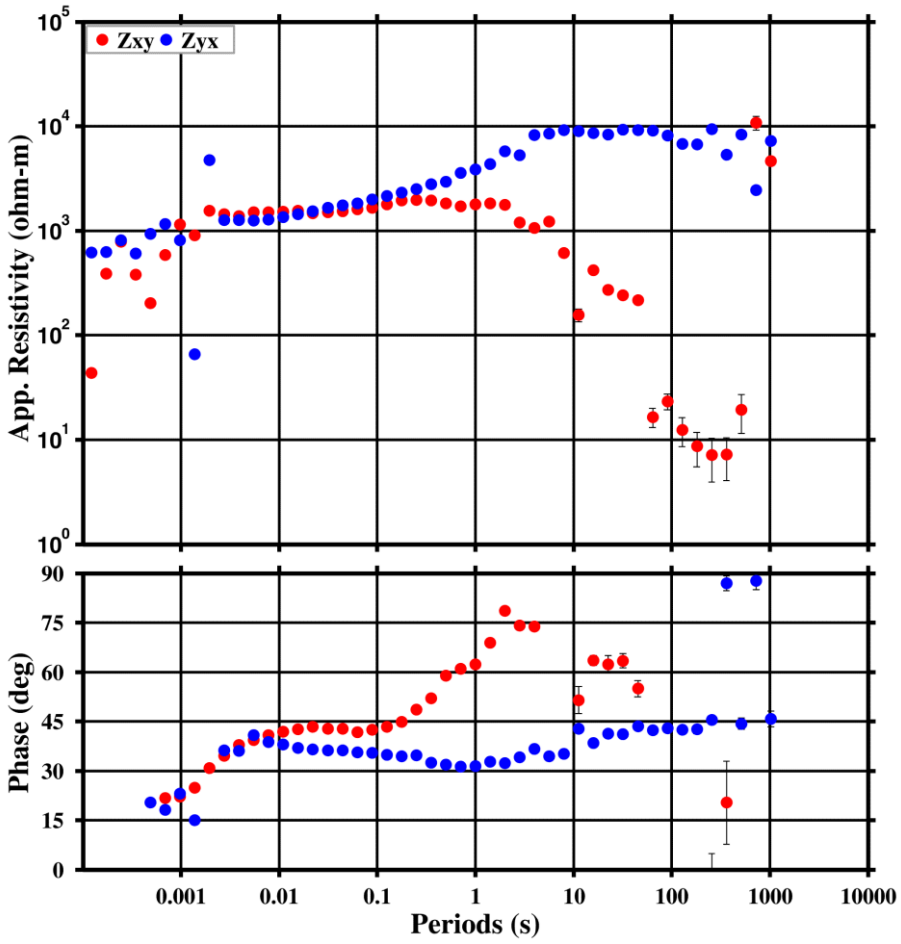
STA/LTA filter



Mair (2020)

Pseudo remote processing

- Single site processing approach
- The horizontal magnetic fields of the local site are simply replaced with those from a local remote site
- Processing option for station without own magnetic or with defect magnetic channels

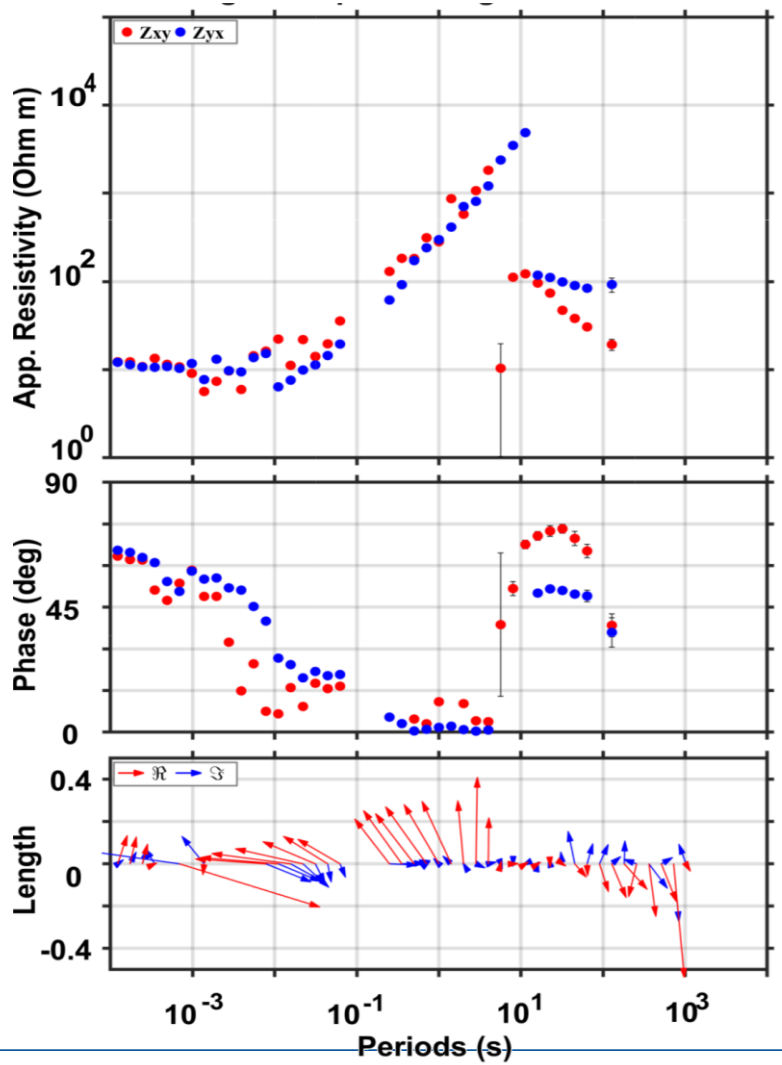


Remote reference processing

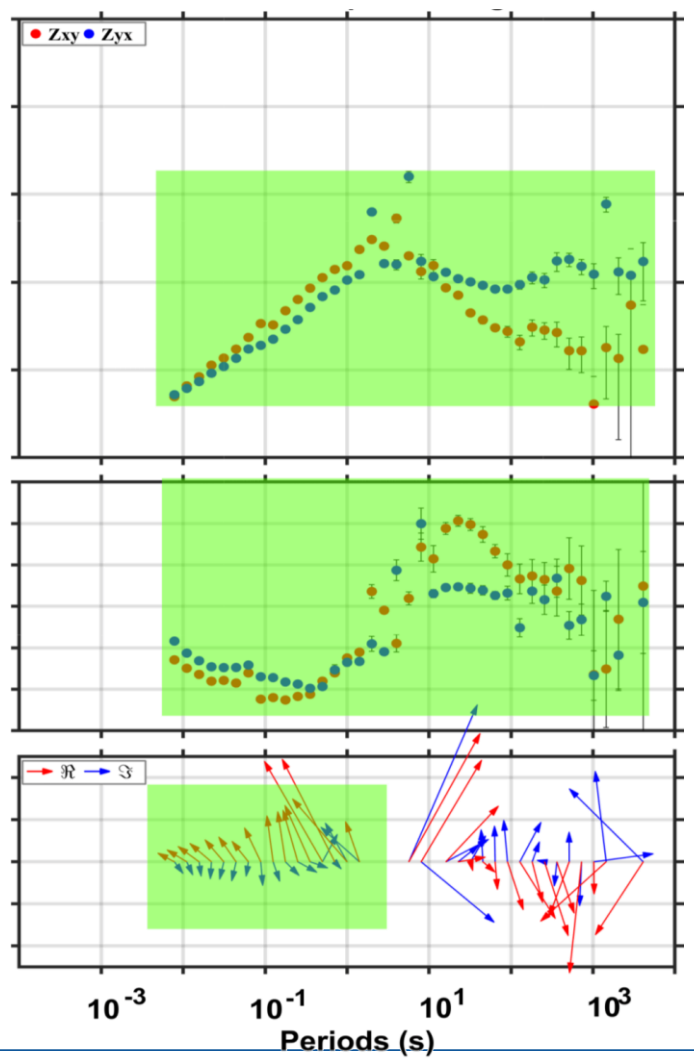
Distance
>300km

Remote reference processing – station D

Single site processing

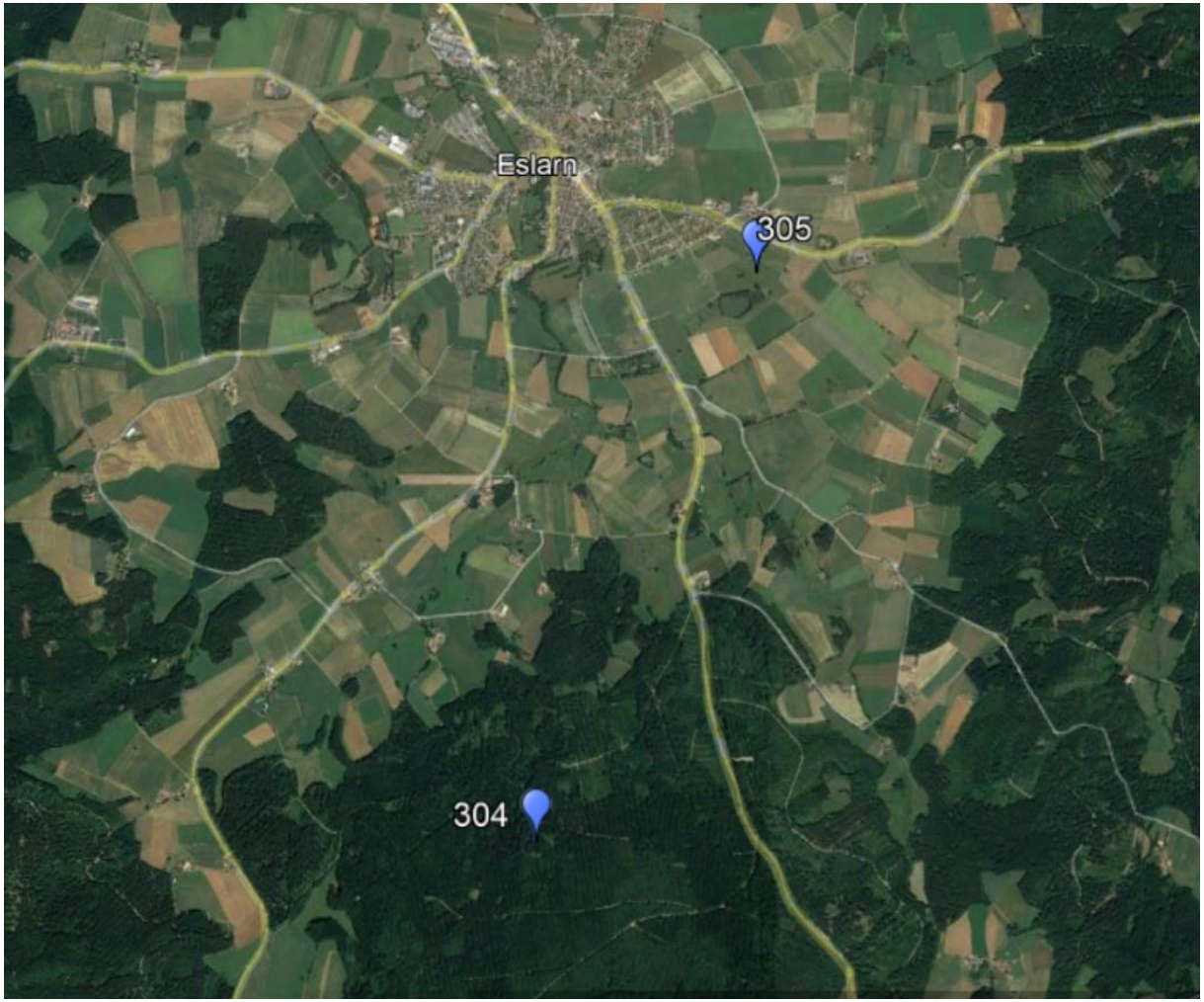


Remote reference processing



Mair (2020)

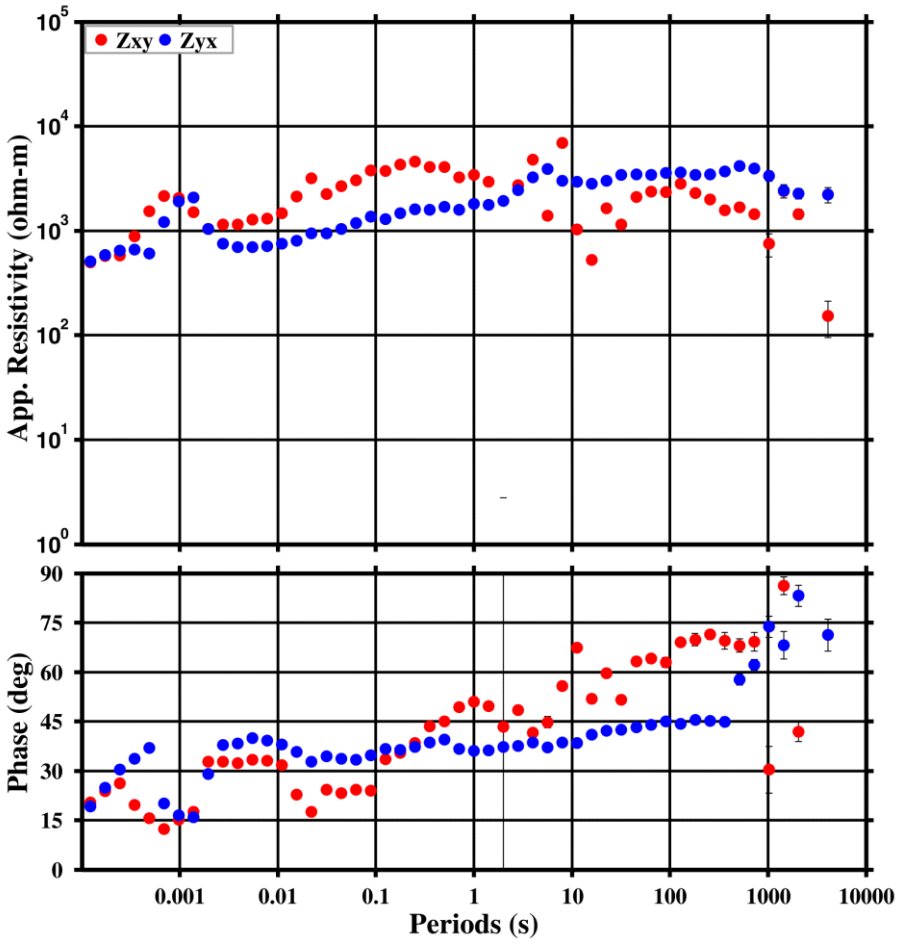
Local remote reference processing – station E



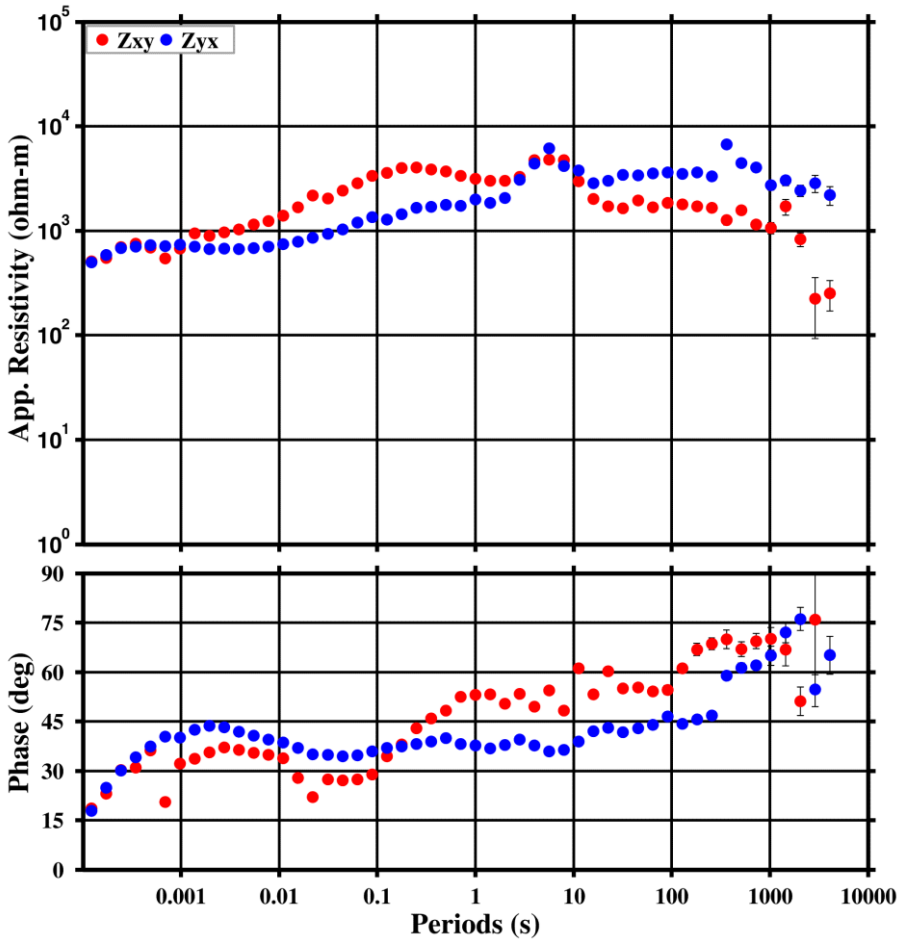
Distance
~3km

Local remote reference processing – station E

Single site processing



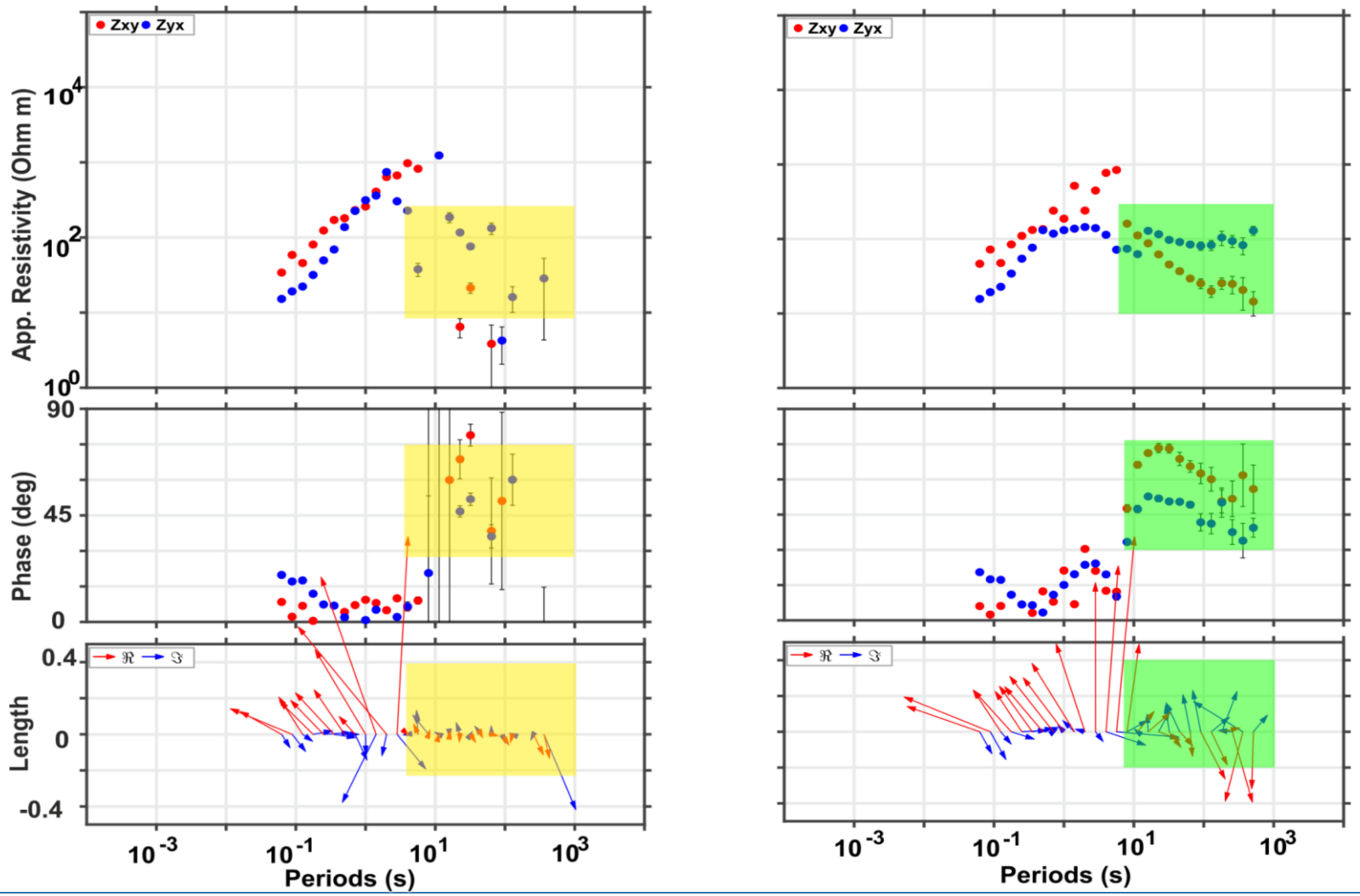
Remote reference processing



Day and night processing– station D

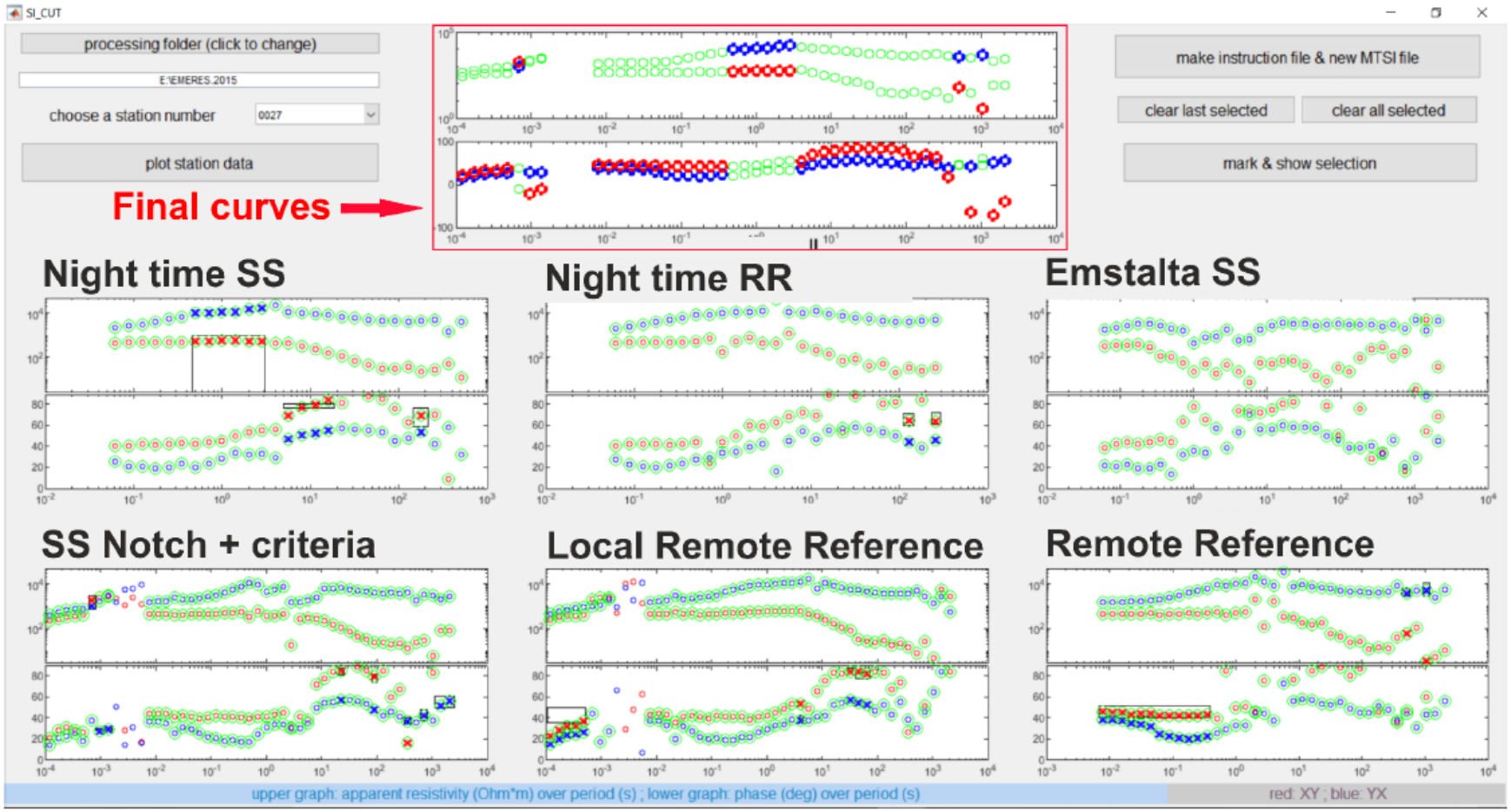
Day (8am-7pm) data

Night (8pm-7am) data



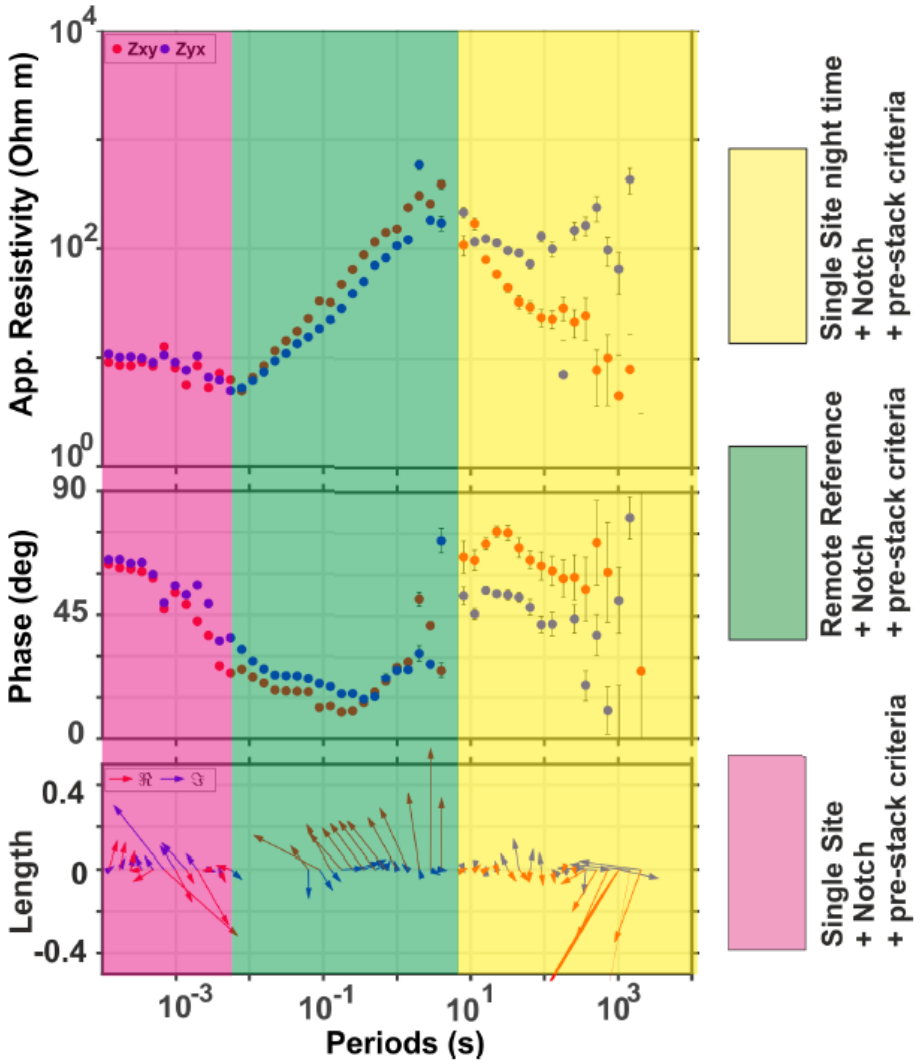
Mair (2020)

Combining different processing results



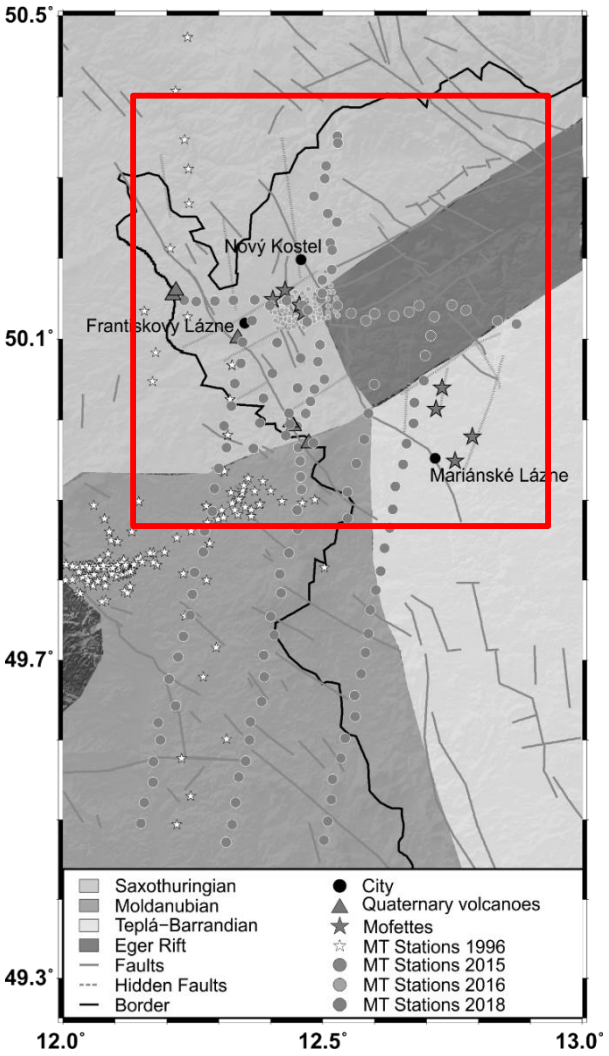
Mair (2020)

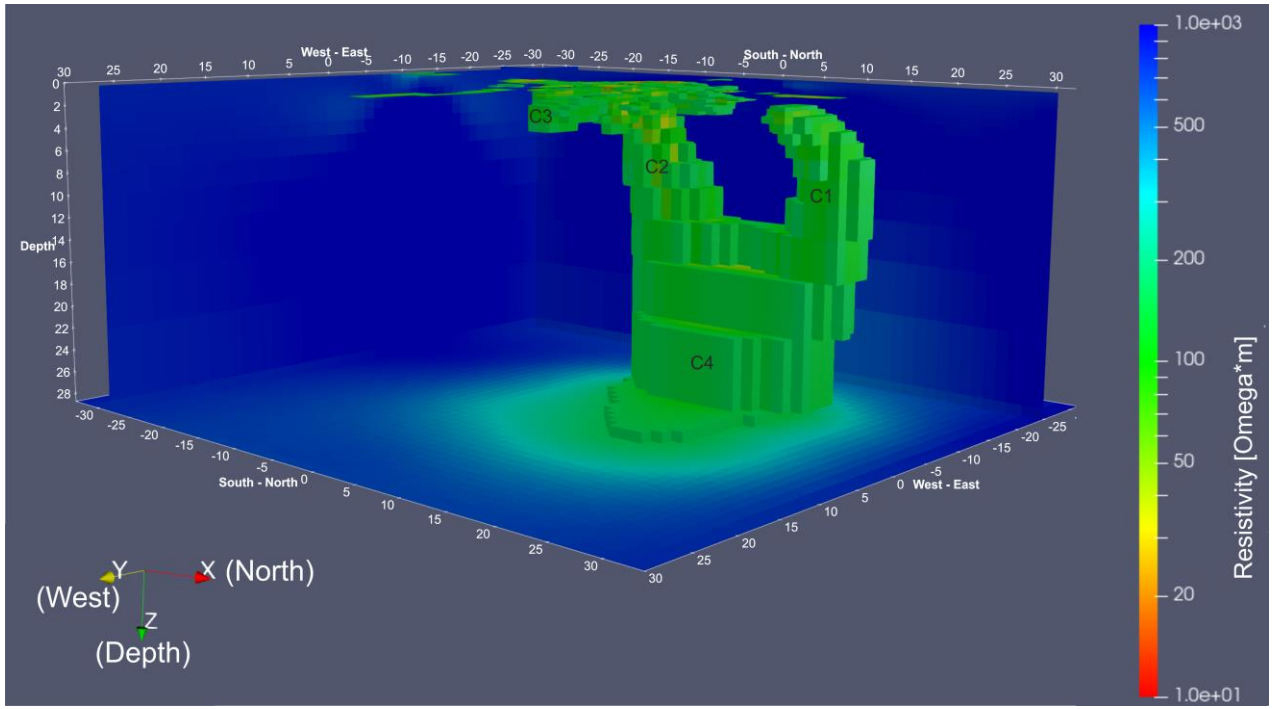
Summary processing



Mair (2020)

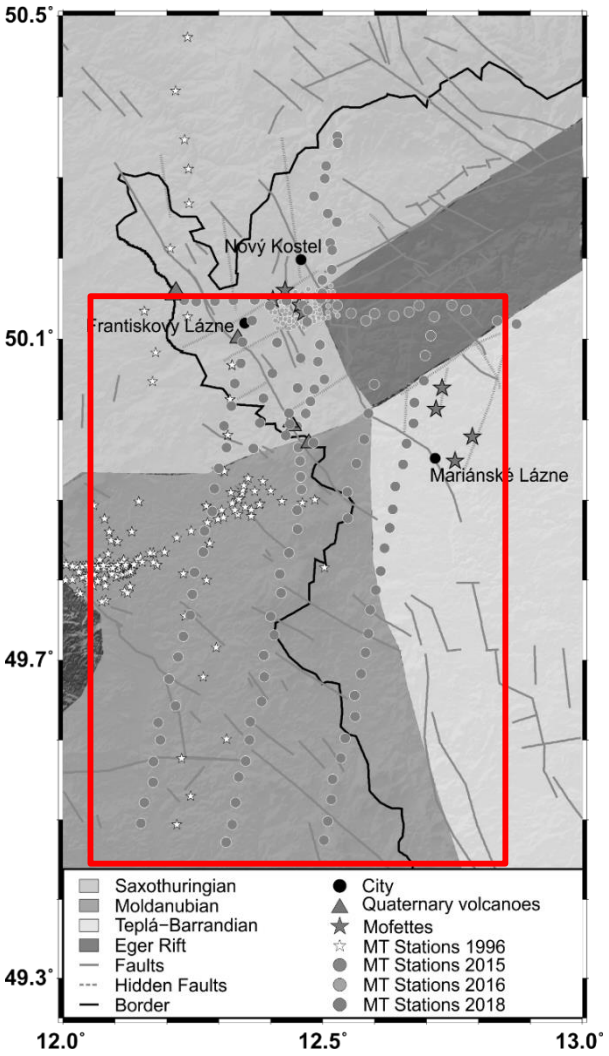
Regional 3D model in the north

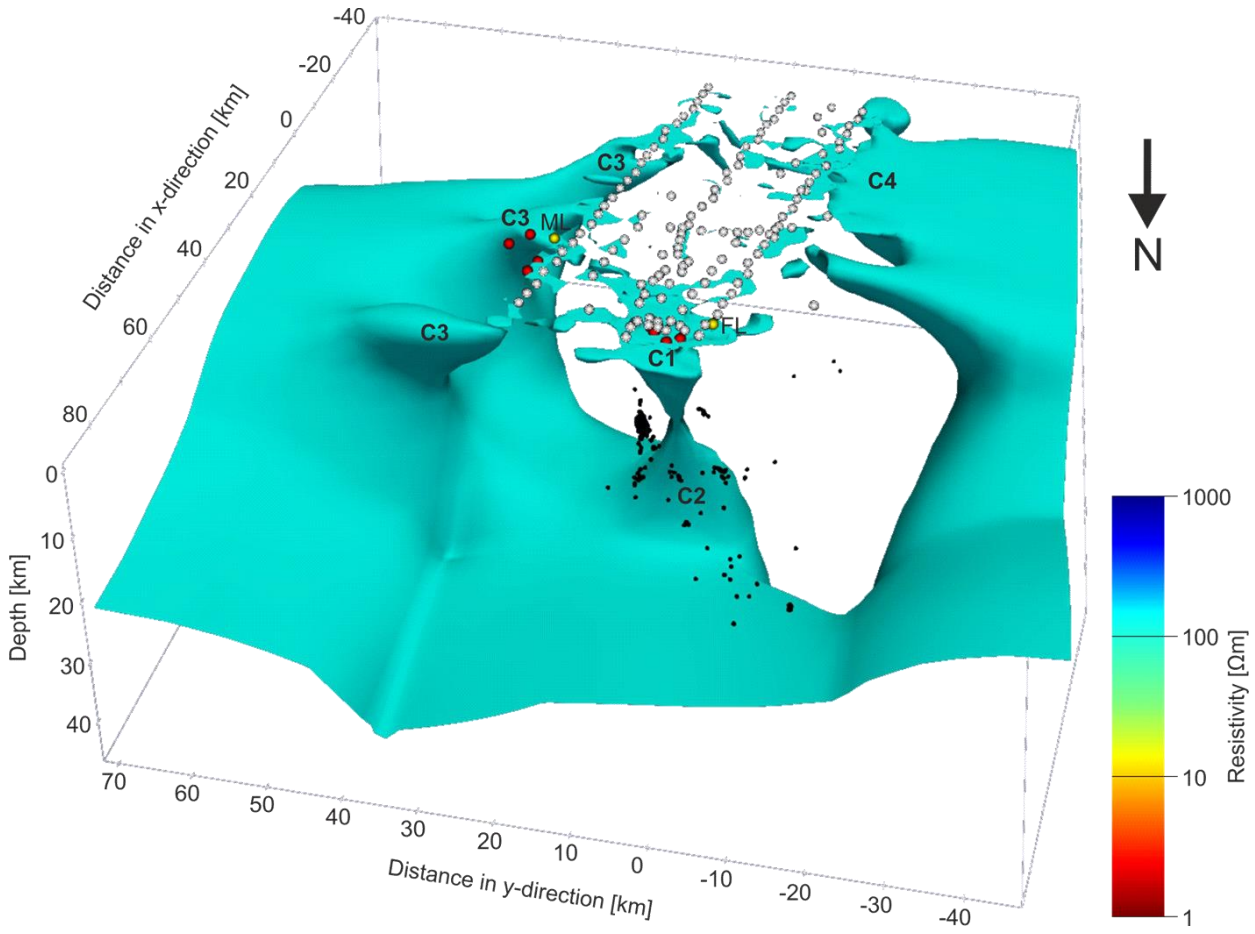




Mair (2020)

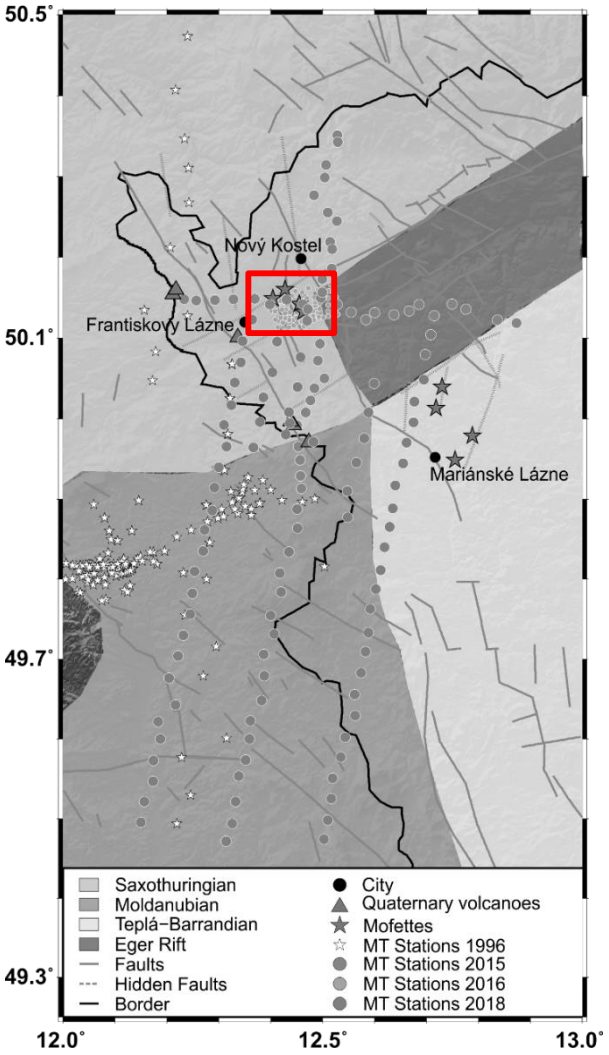
Regional 3D model in the south

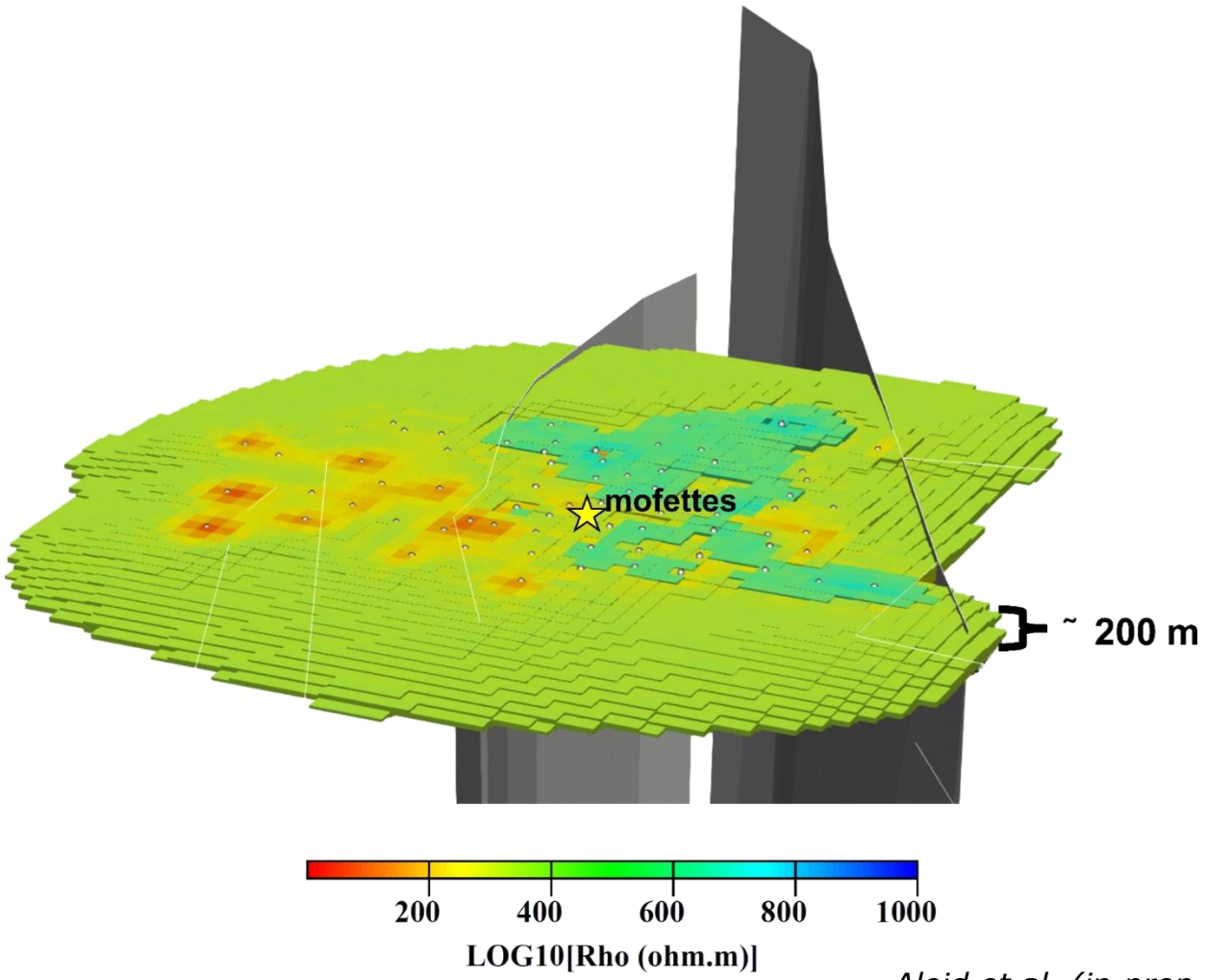




Platz et al. (2022)

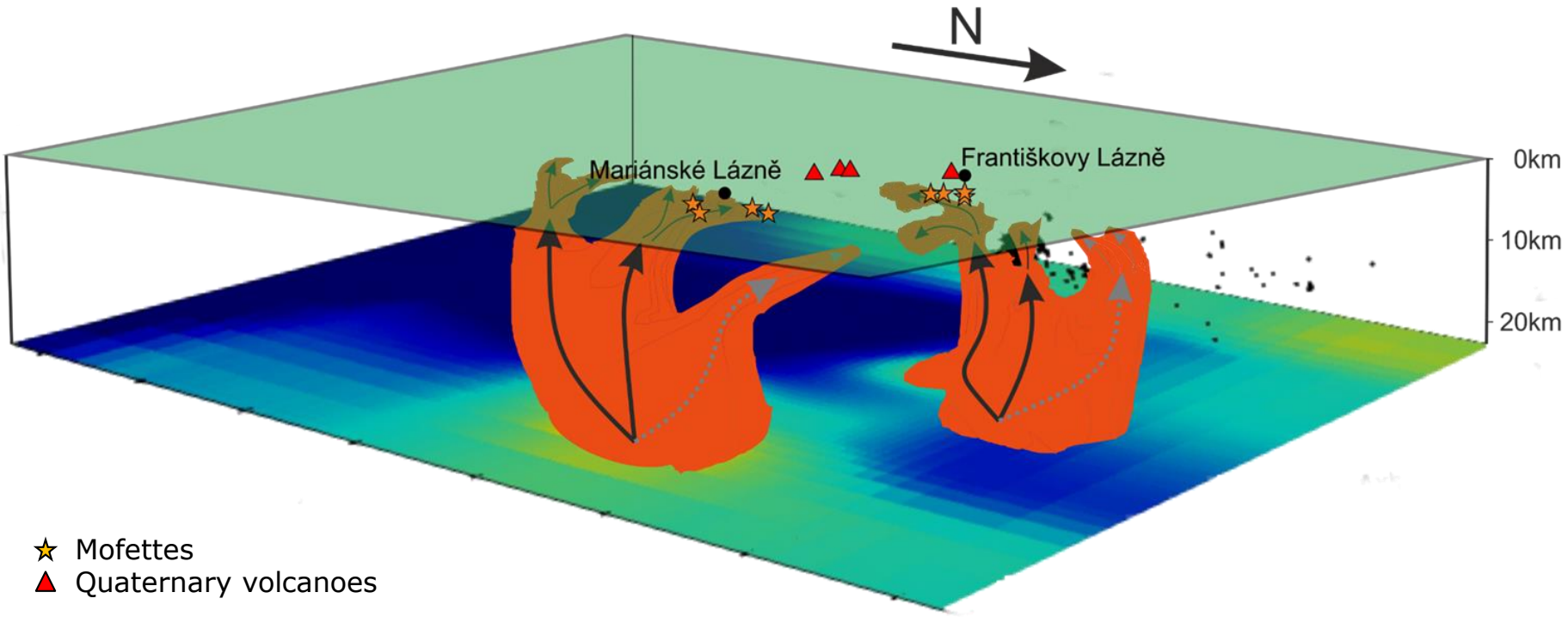
Local 3D model across mofette fields





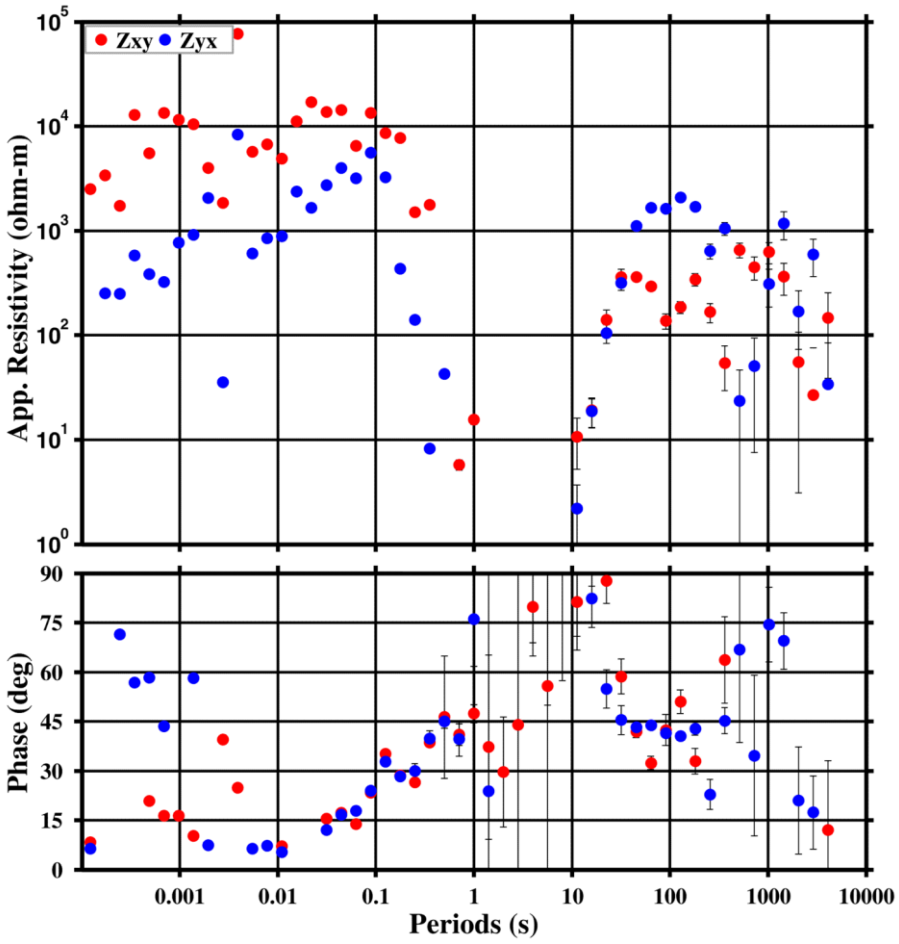
Aleid et al. (in prep.)

Conceptual model

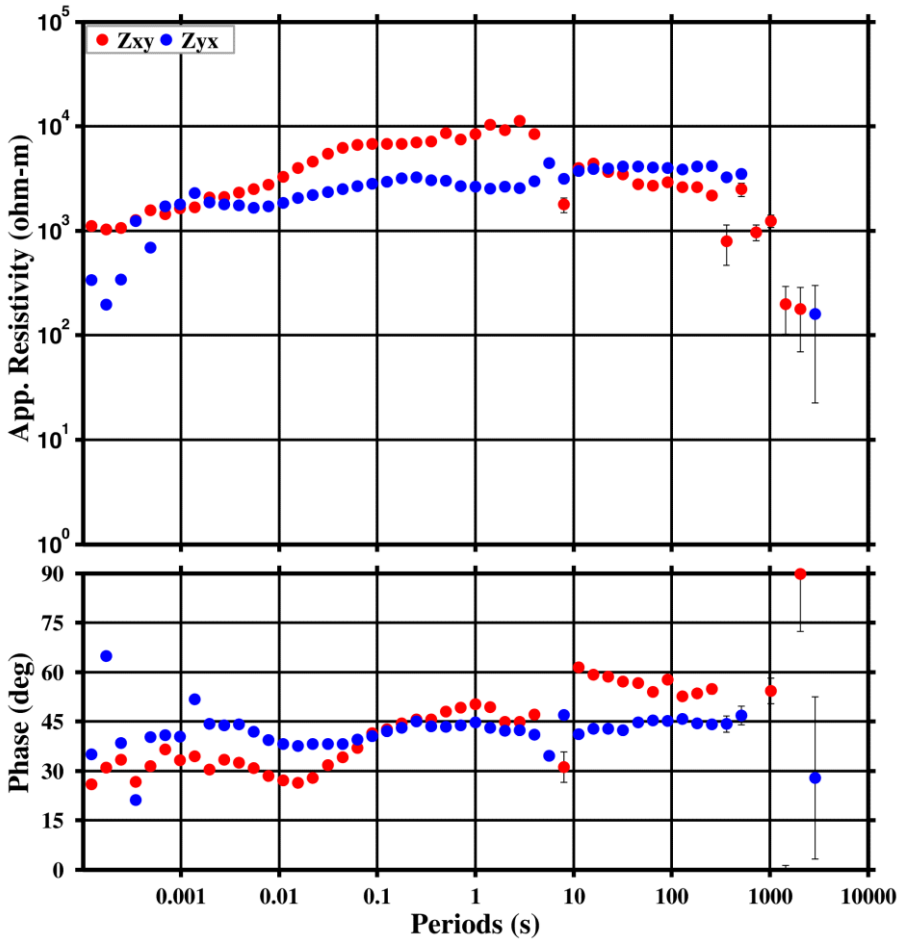


Platz et al. (2022)

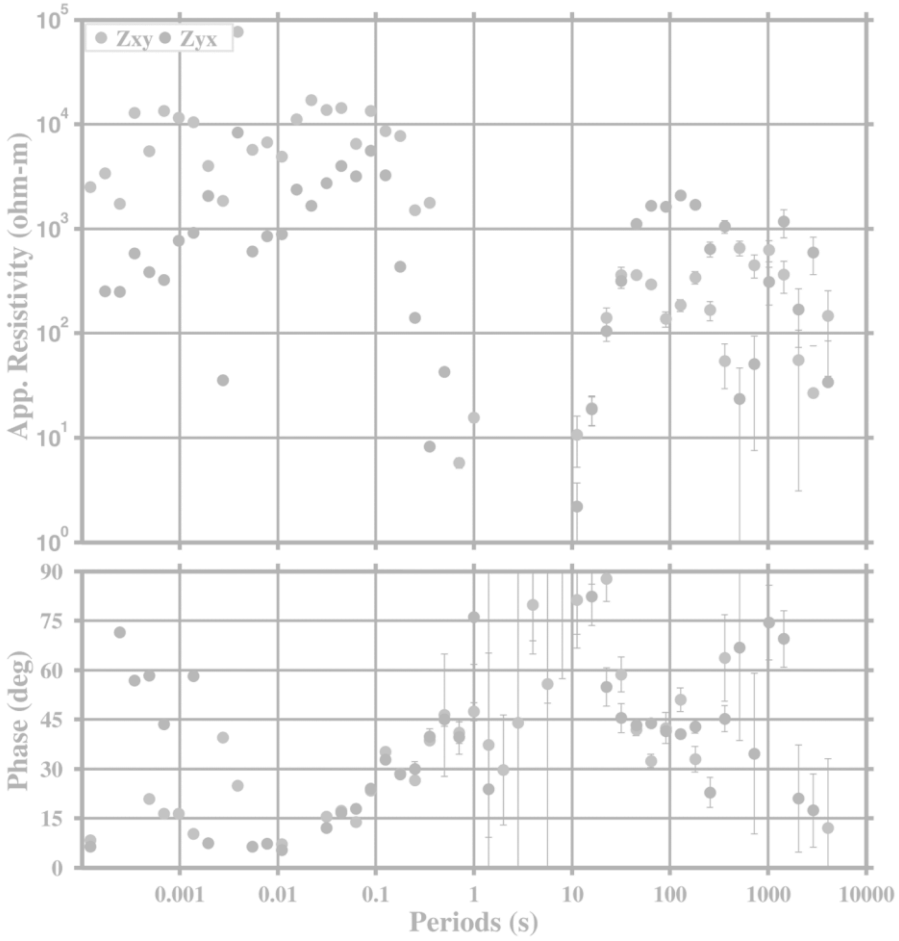
Field processing result

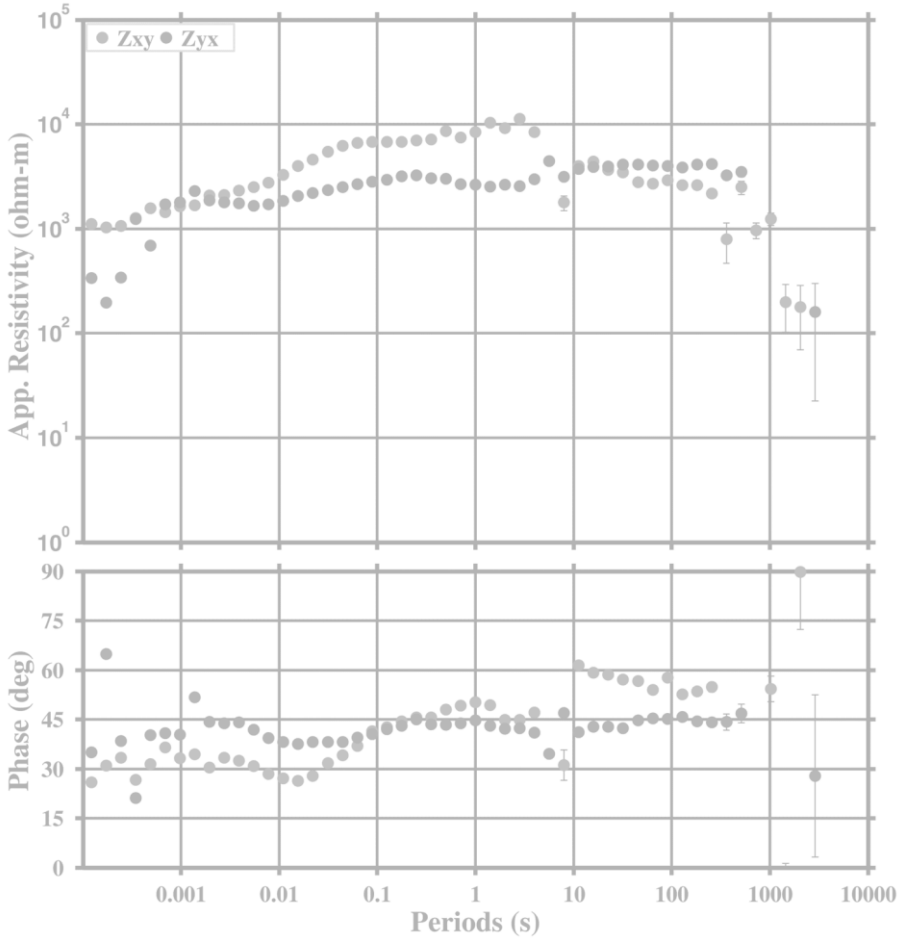


Final processing result



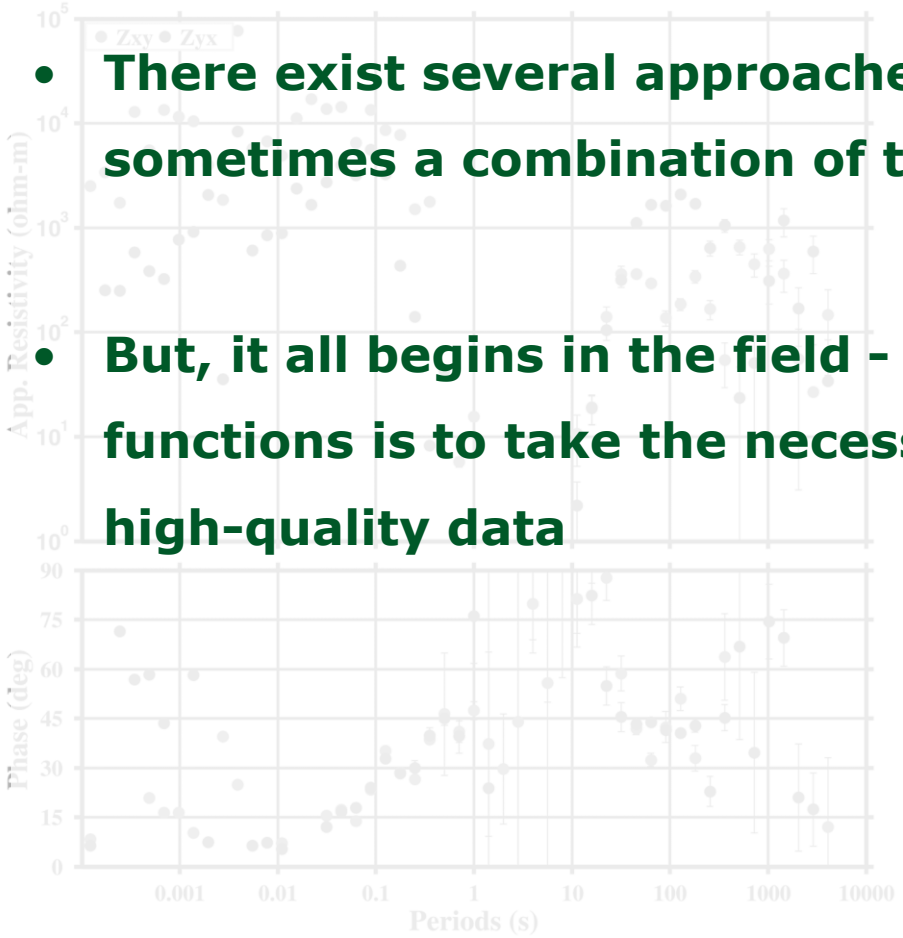
- Transfer functions of good quality are the basis of meaningful models

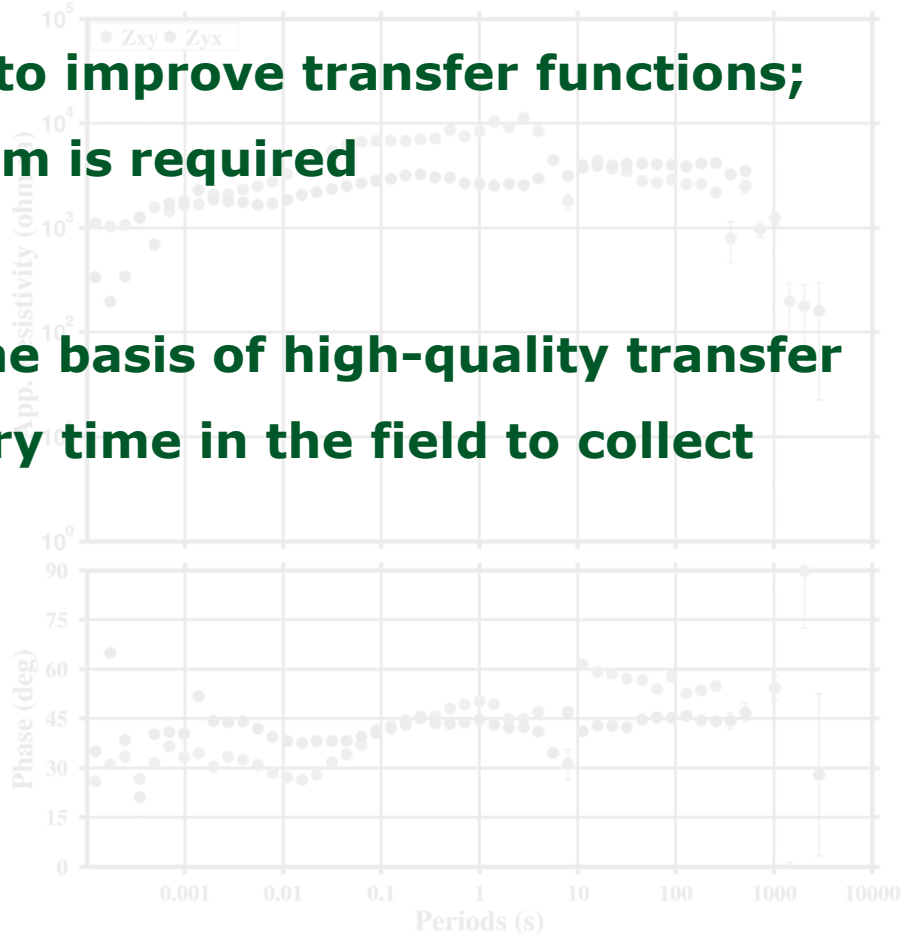




Take-home message

- Transfer functions of good quality are the basis of meaningful models





- **There exist several approaches to improve transfer functions; sometimes a combination of them is required**
- **But, it all begins in the field - the basis of high-quality transfer functions is to take the necessary time in the field to collect high-quality data**

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