Determination of the Earth's mantle structure from low-period seismic surface waves recorded by superconducting and spring gravimeters at the Borowa Gora Observatory

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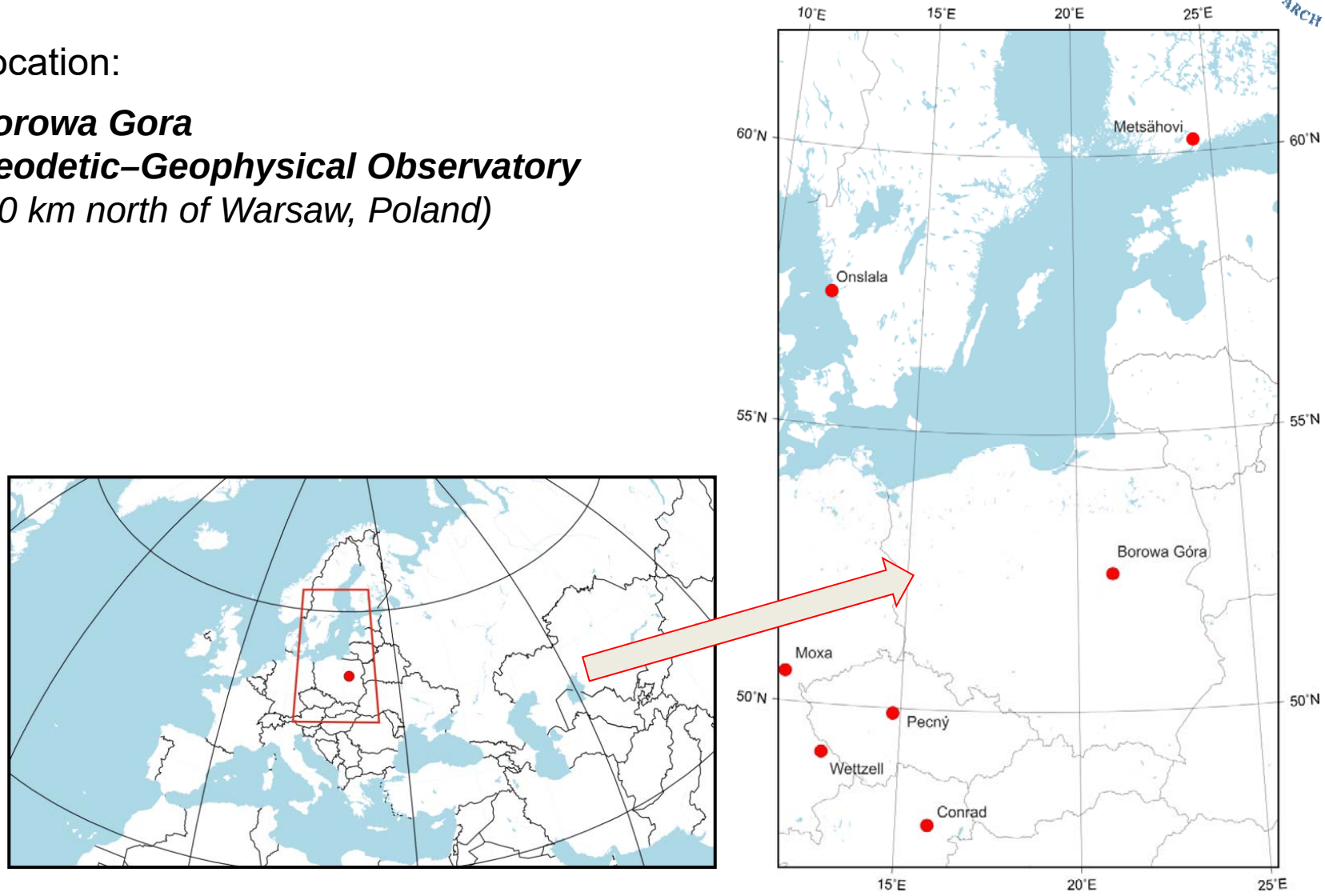
IGETS Workshop 2018.06.18-20, Potsdam

1st Workshop on the International Geodynamics and Earth Tide Service (IGETS)
18-20 June 2018, Potsdam (Germany)

BG location

Location:

Borowa Gora
Geodetic–Geophysical Observatory
(50 km north of Warsaw, Poland)



Gravity and seismic instruments in BG

- 2016.12 – **installation of two seismometers** on the same pillars with the LCR G-1036 and iGrav-027 (REFTEK 151B/120) in cooperation with Institute of Geophysics, University of Warsaw (100 Hz registration);
- 2017.08 – seismometer at LCR G-1036 taken down, seismometer at **iGrav-027** remains up to now.

Transfer function of LCR G-1036

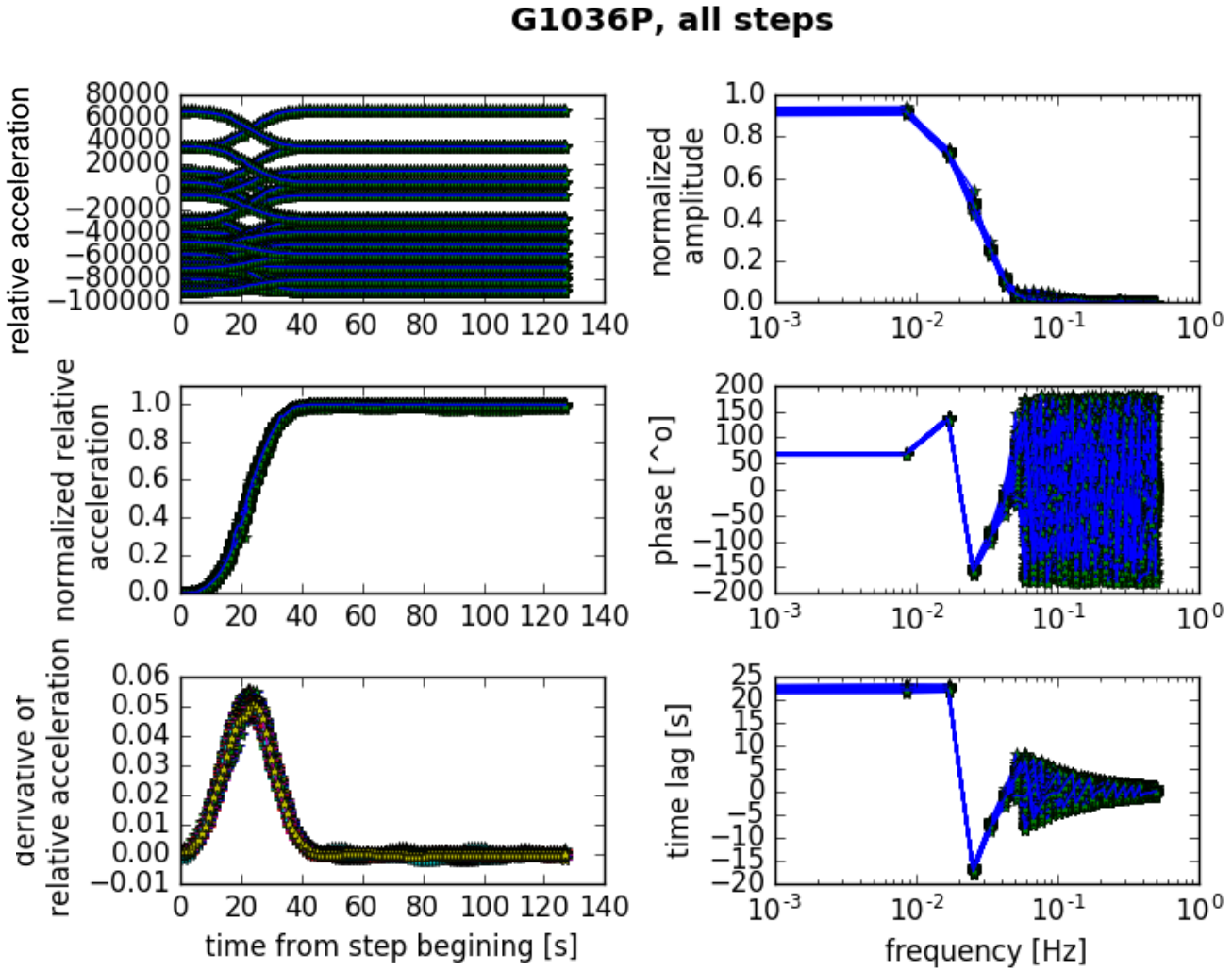
- Step method (Richter and Wenzel, 1991) – machine for automatic screw turns was built with Raspberry-Pi for precise control of step generation;

- Testing window length:
  128 s (129 steps),
  256 s (129 steps),
  512 s (129 steps),
  1024 s (20 steps);

- Used programs for transfer function calculation:
  - Etstep – differentiation of step response by polynomial fit (Wenzel, 1995);
  - DFT – smoothing of step response by sample summation, numerical differentiation, discrete Fourier transform (FFTW package).

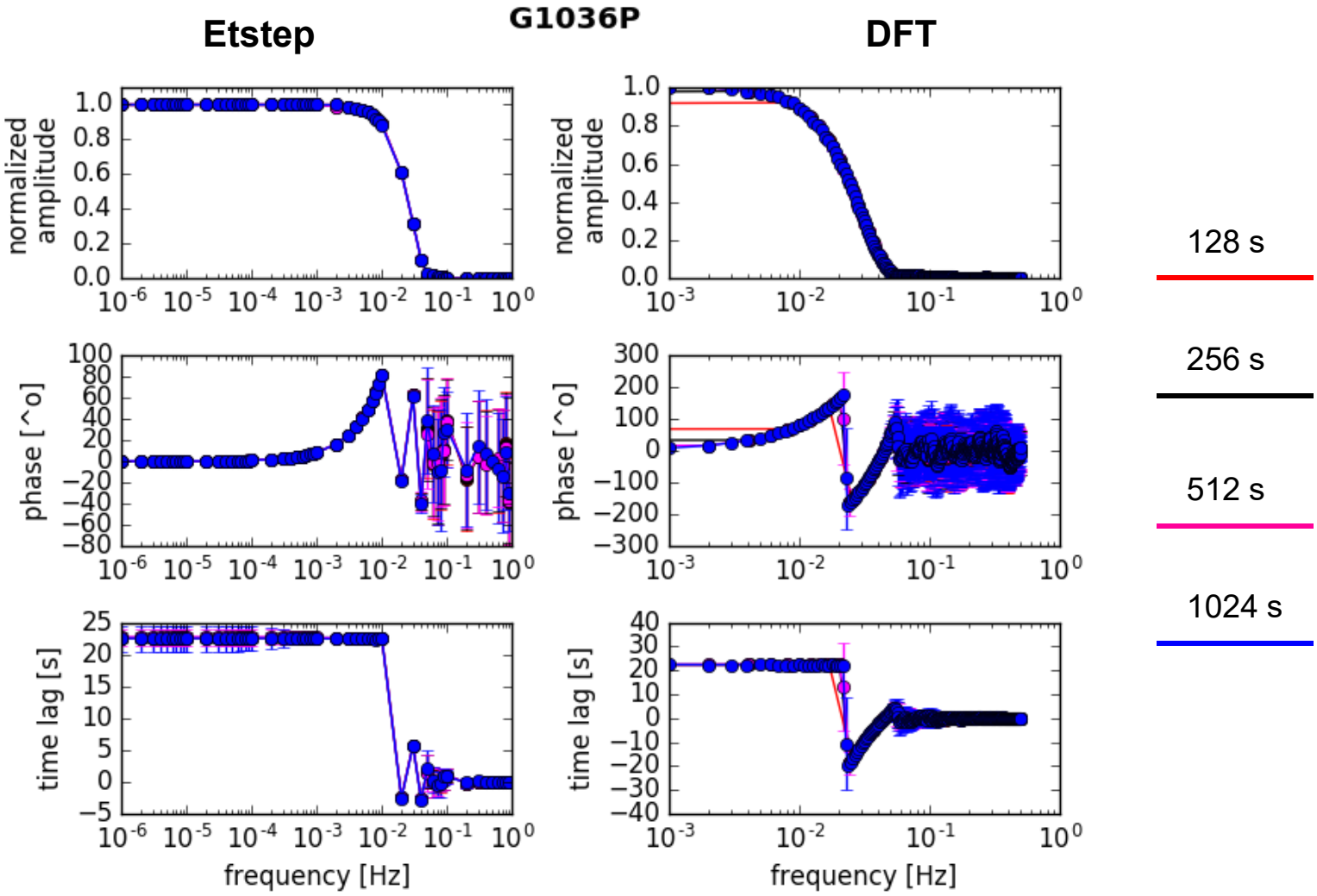
Transfer function of LCR G-1036 (R-T-OTL)

DFT, window length 128 s



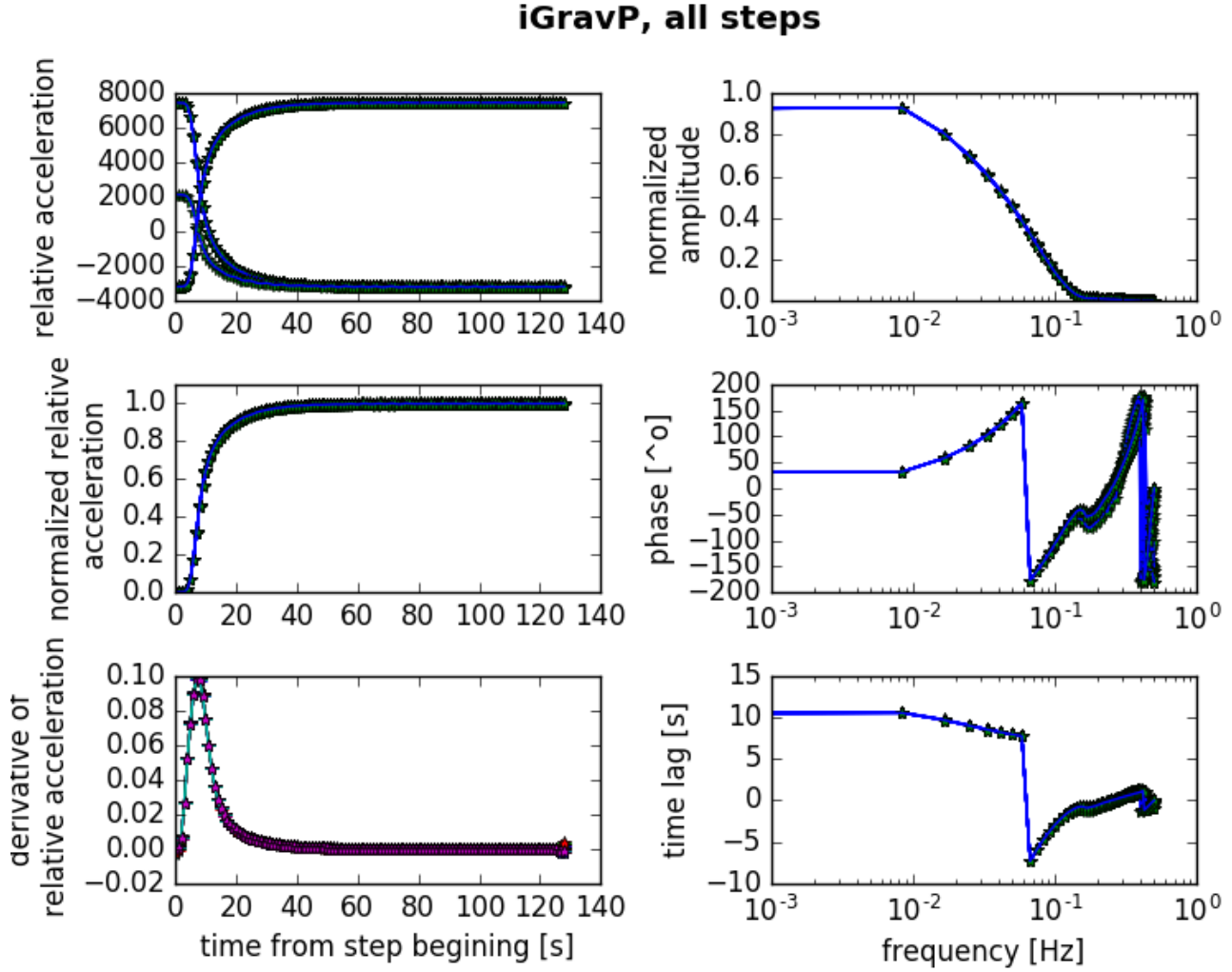
Transfer function of LCR G-1036 (R-T-OTL)

Mean transfer function of each window length



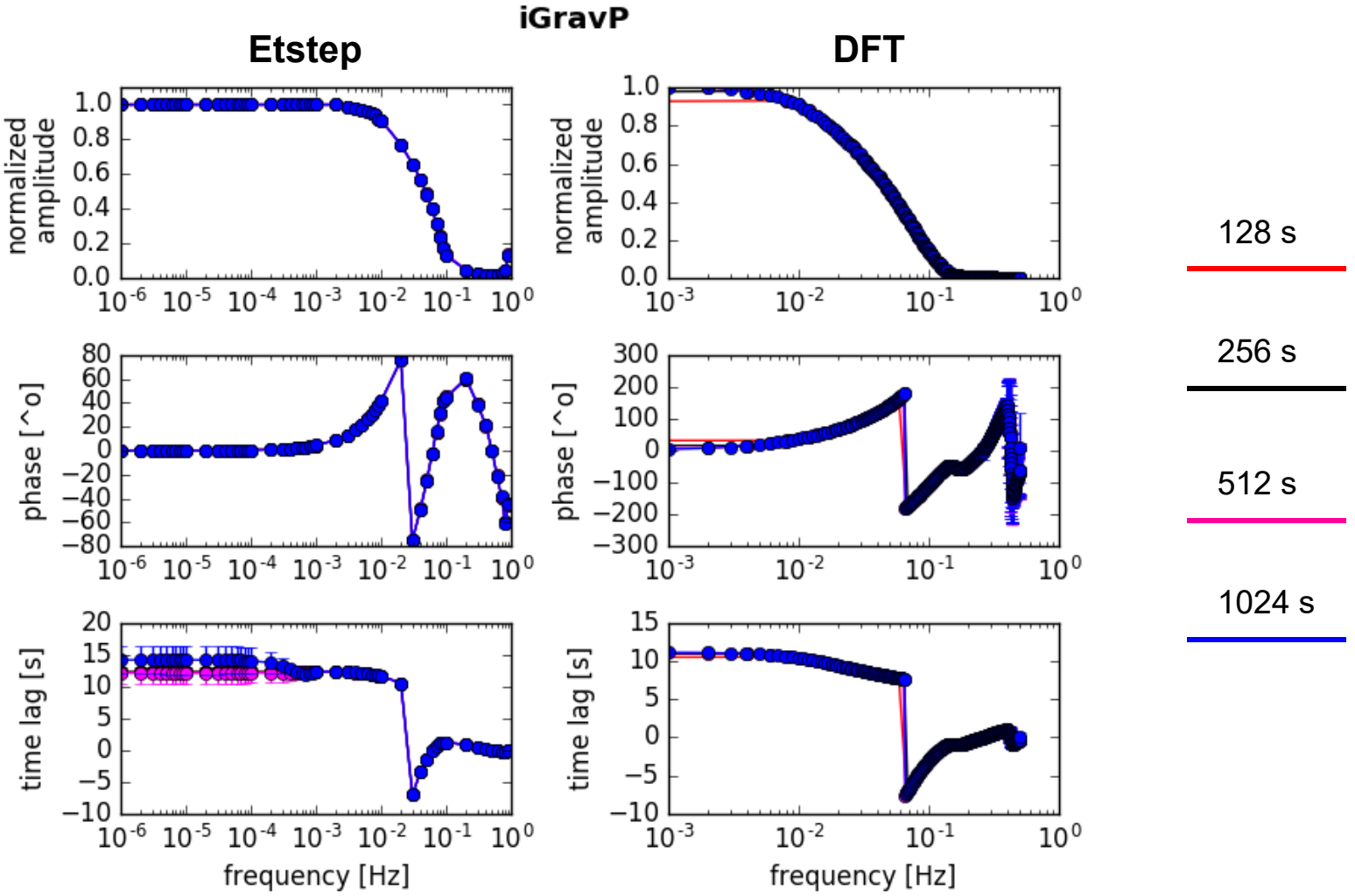
Transfer function of iGrav-027 (R-T-OTL-B)

DTF, window length 128 s



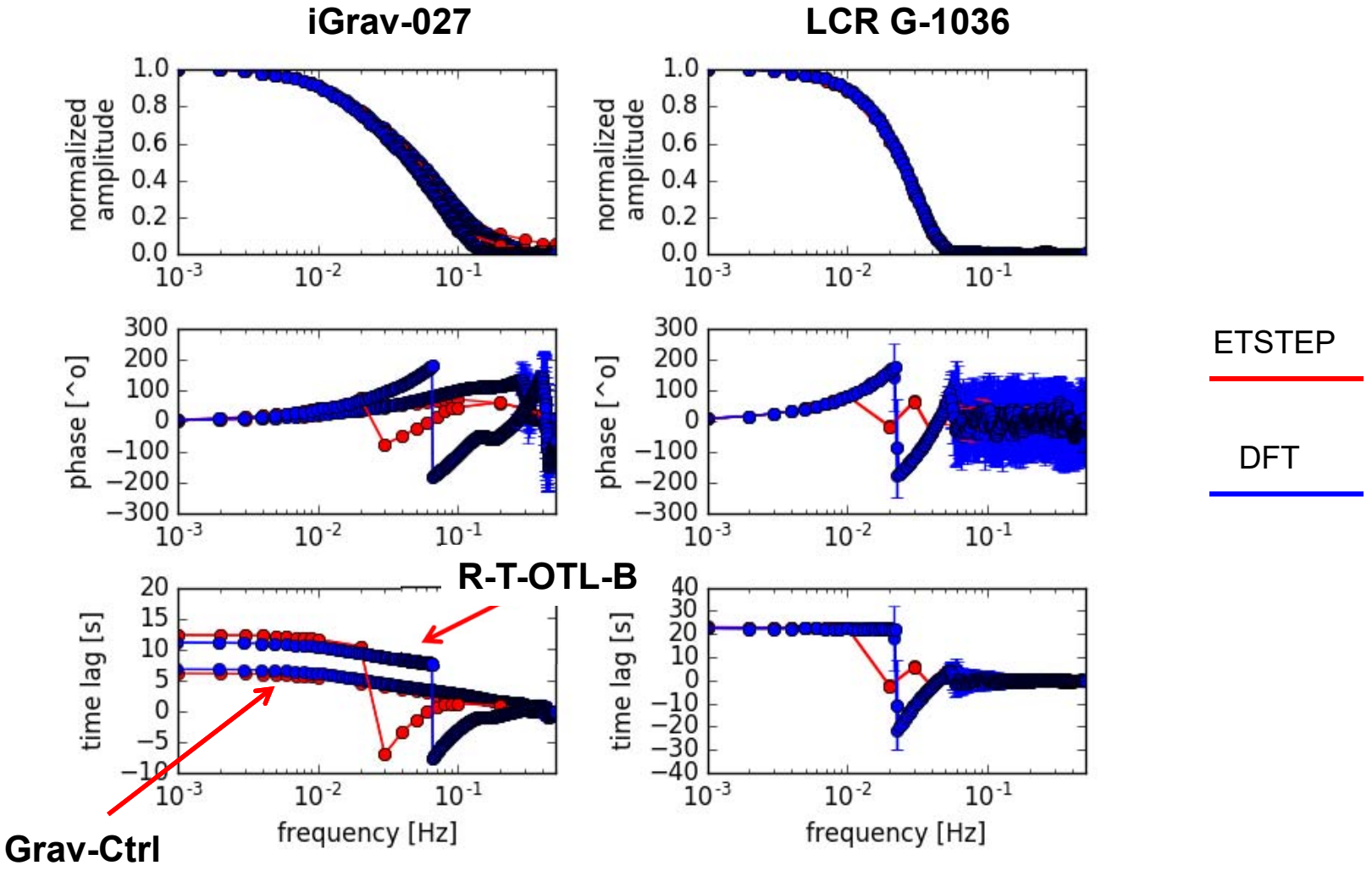
Transfer function of iGrav-027 (R-T-OTL-B)

Mean transfer function of each window length



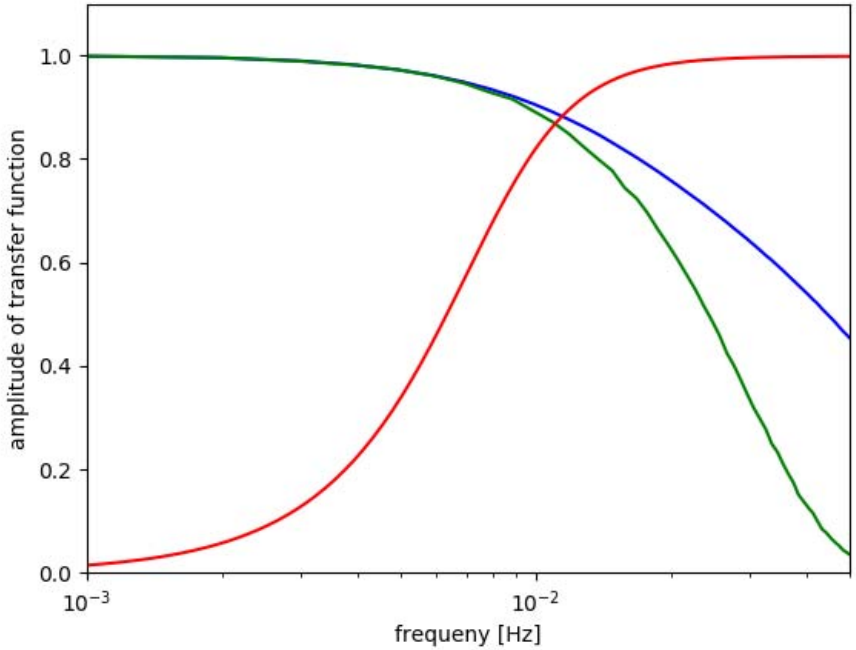
Transfer function of iGrav-027 and LCR G-1036

Mean transfer function of 1024 s window length
(raw and processed signal)

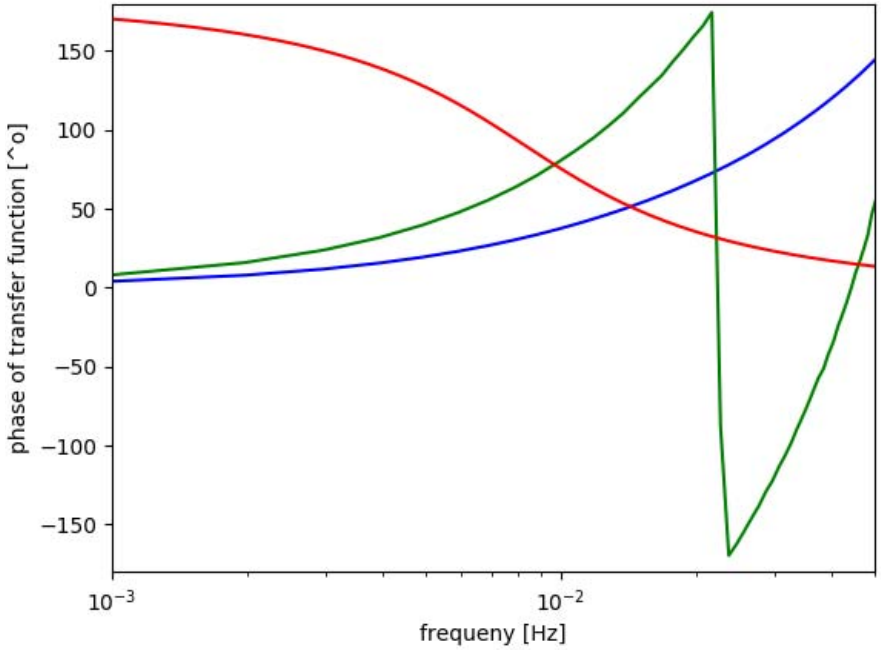


Transfer function of iGrav-027, LCR G-1036 and REFTEK151B/120 used for earthquake analysis

Gain



Phase



REFTEK 151B/120 **LCR G-1036** **iGrav-027**

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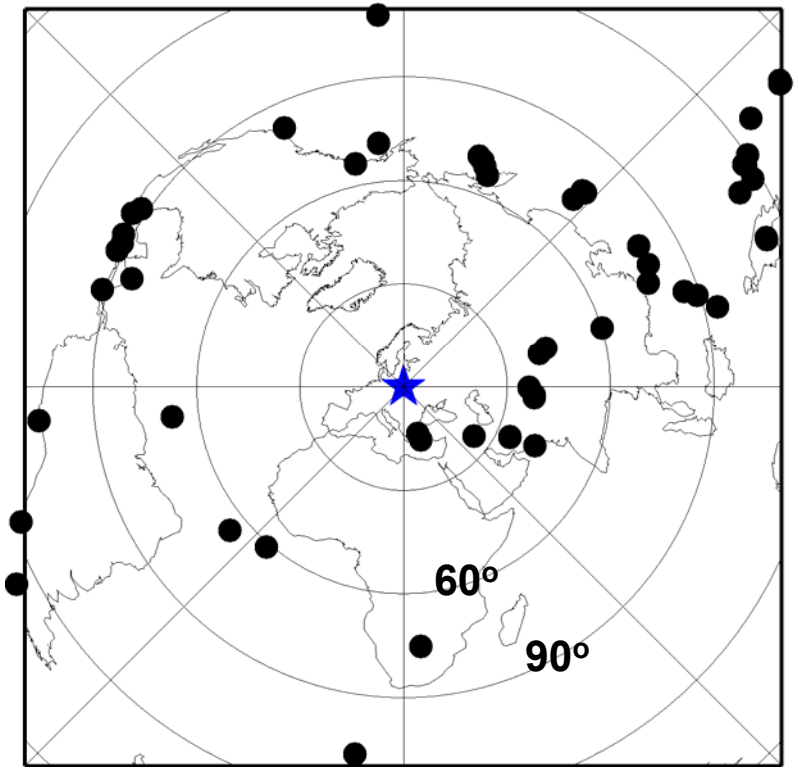
Epicentral distribution of earthquakes and data reprocessing



Epicentral distribution of earthquakes of M > 5.8, time period 12.2016 – 03.2018

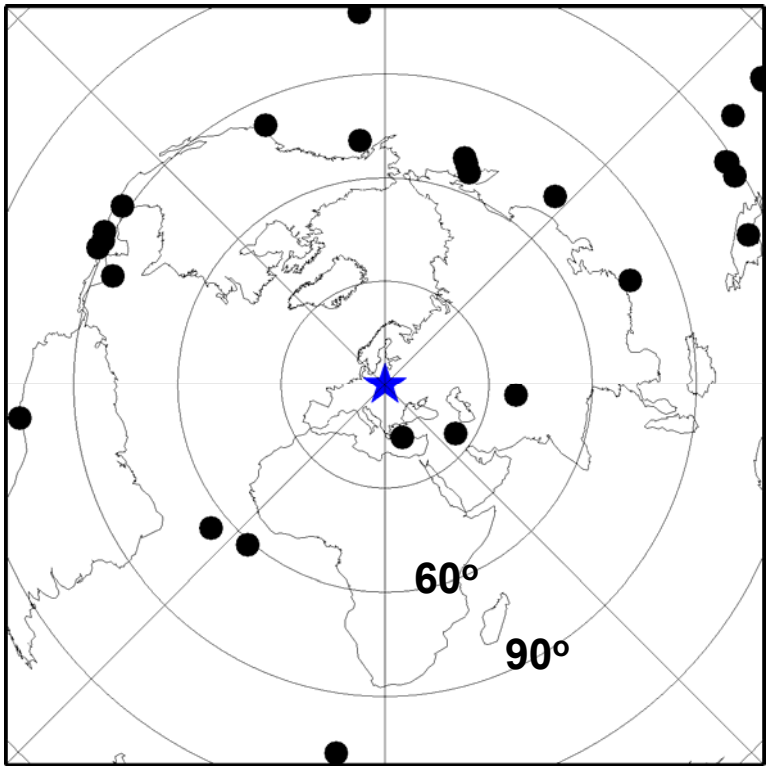
Gravity data (Tsoft software package):

- unification to 1 s sampling intervals;
- gaps below 10 s were filled by interpolation;
- correction for the Earth tides using the Tamura potential catalogue (Tamura, 1987) with tidal parameters for the inelastic non-hydrostatic Earth model WDD (Dehant et al., 1999);
- correction for ocean tidal loading (FES04);
- correction for barometric pressure with a standard coefficient of -3.0 nm/s2/hPa – only for iGrav-027;
- correction for polar motion – only for iGrav-027;
- detrending of selected time window;
- transfer function deconvolution of selected time window with band-pass filtering (0.001 – 0.05 Hz).

Seismic data (ObsPy software package):

- detrending of selected time window;
- transfer function deconvolution of selected time window with band-pass filtering (0.001 – 0.05 Hz) and differentiation to receive acceleration units;
- resampling to a 1 s sampling interval.

Epicentral distribution of earthquakes and data reprocessing



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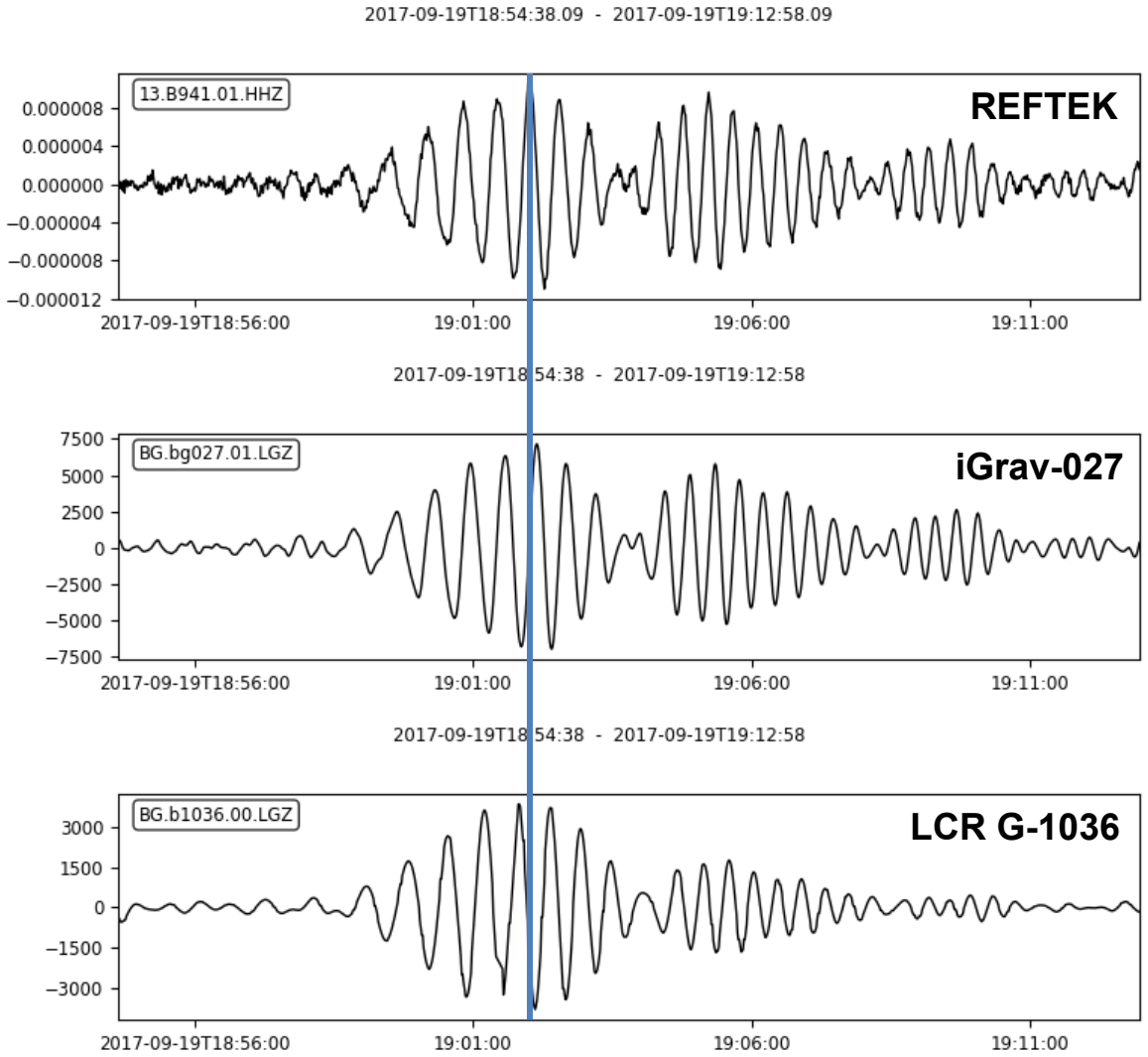
Earthquake 2017-09-19 18:14:38 UTC, h=48 km, M=7.1, Mexico

BEFORE TRANSFER FUNCTION DECONVOLUTION



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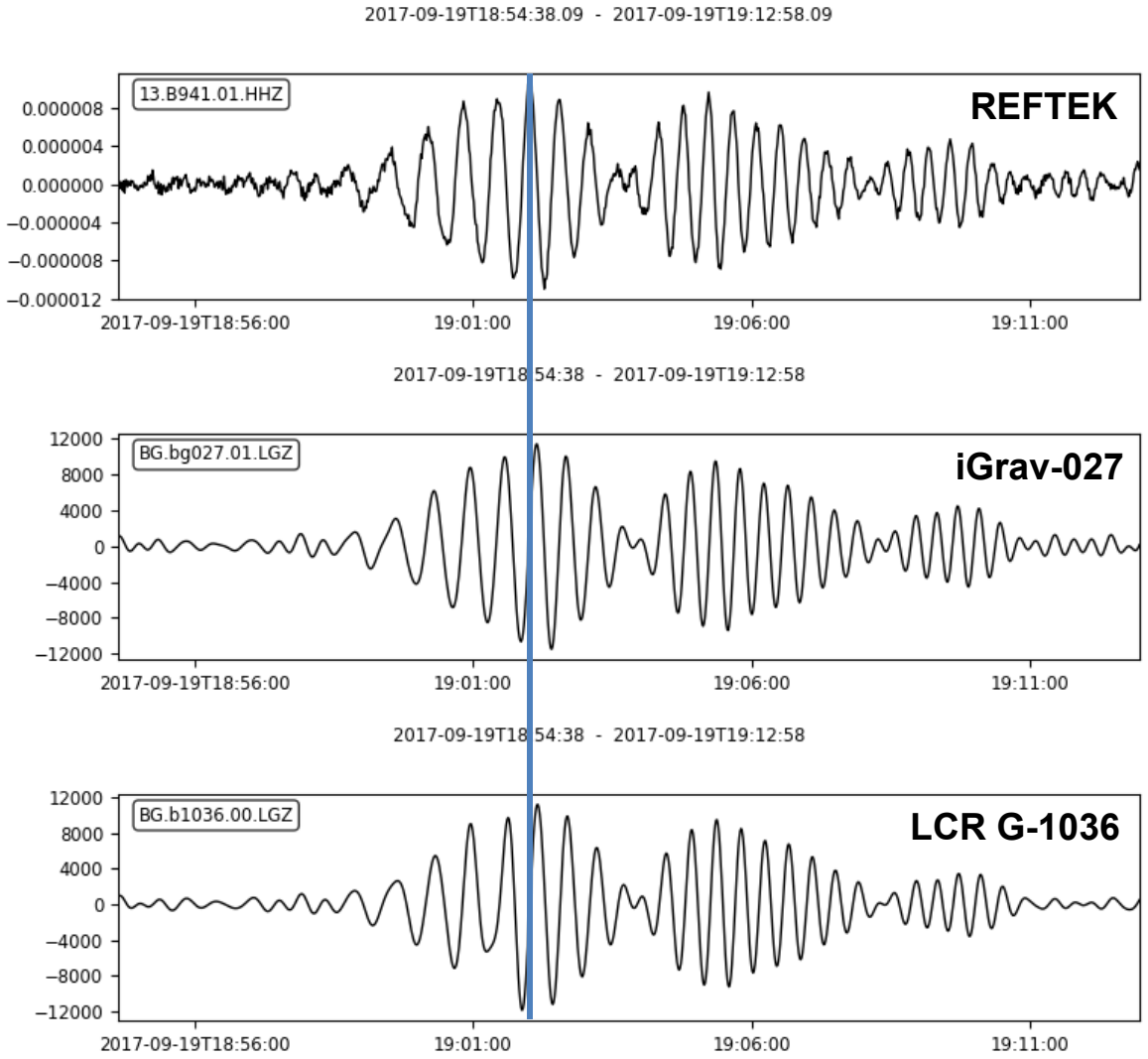
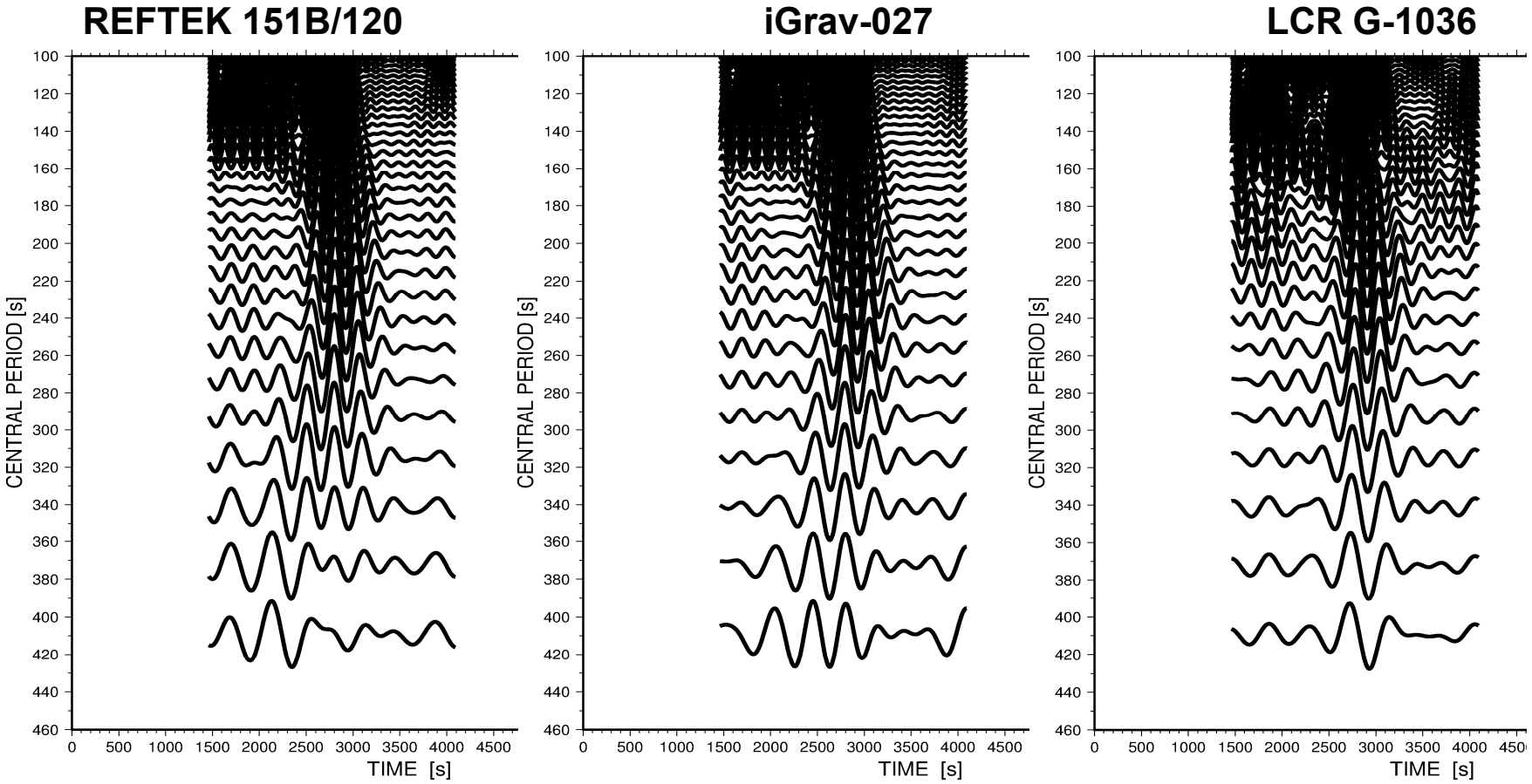


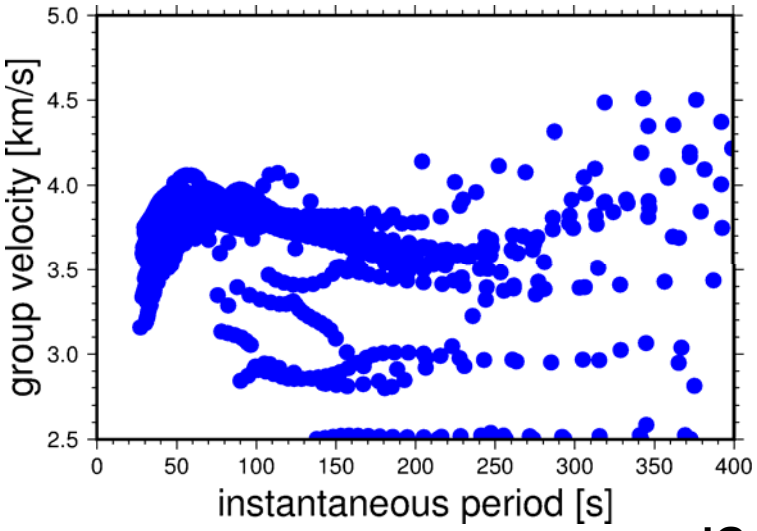
Dispersion of surface waves

- Earthquake: 2017-09-19 18:14:38 UTC, **h=48 km, M=7.1, Mexico**
- Method: **non-constant relative resolution filtering** with linear dependence of the filter coefficient on a period (Dziewonski et al., 1969)

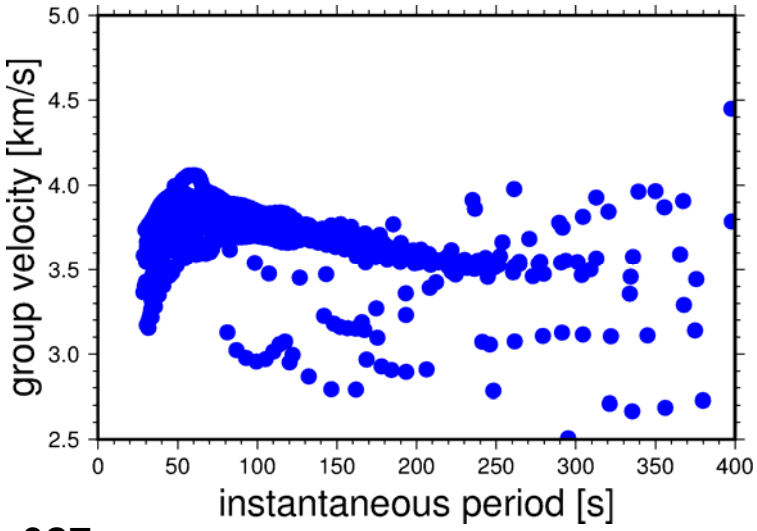


Dispersion curves of Rayleigh wave of fundamental mode (selected events)

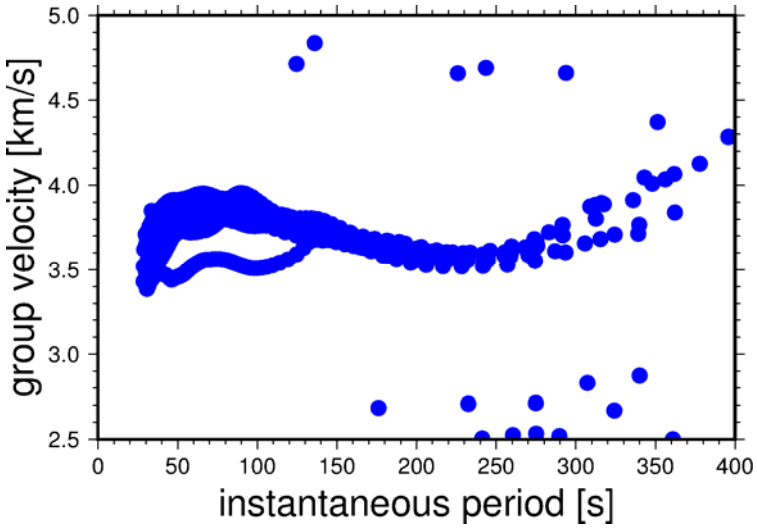
REFTEK 151B/120



LCR G-1036



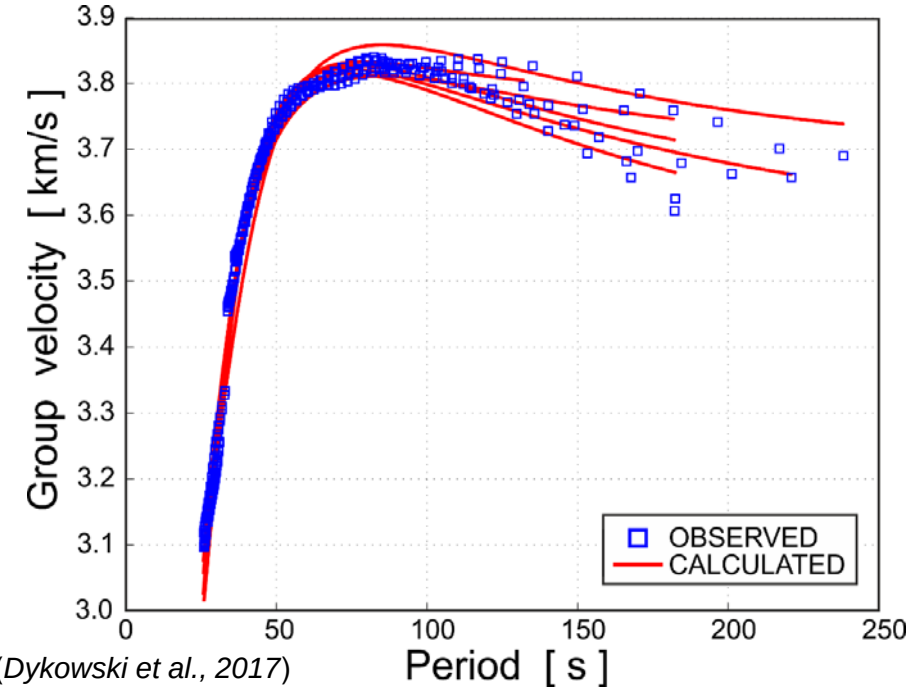
iGrav-027



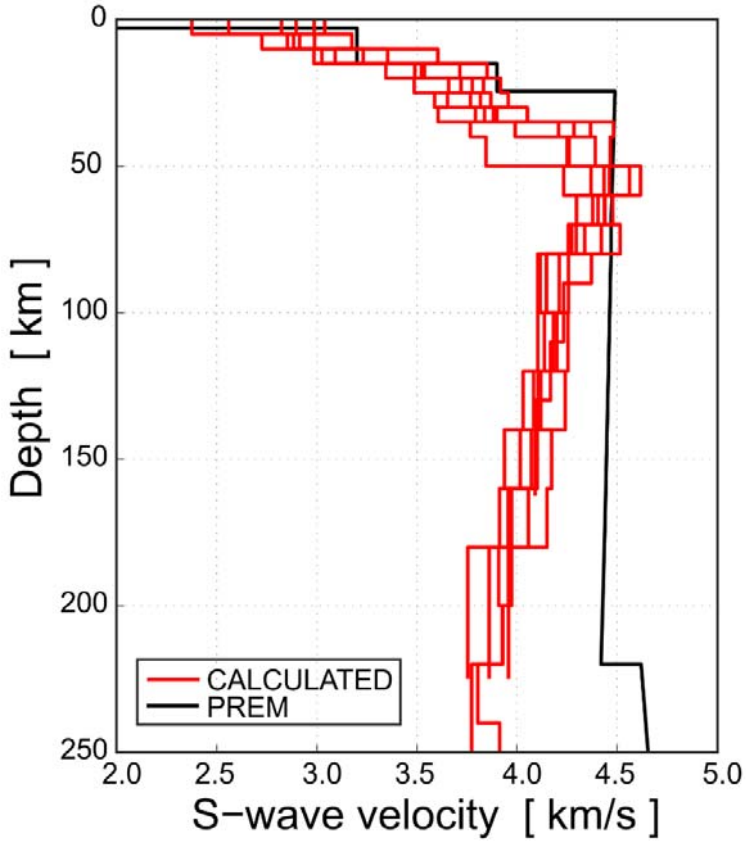
Example of inversion of dispersion curves

- Linearized inversion was used for 1-D model (constant Vp, Vs and density in each layer over the halfspace);
- Only S-wave velocity (Vs) was inverted (Vp=1.8 Vs, density and thickness of layers are kept unchanged during the inversion);
- Forward problem was solved by Thomson-Haskell matrix method (Thomson, 1950; Haskell, 1953).

2017-03-29 04:09:24 UTC, **M=6.6**, **h=17 km**, **Kamchatka**



(*Dykowski et al., 2017*)



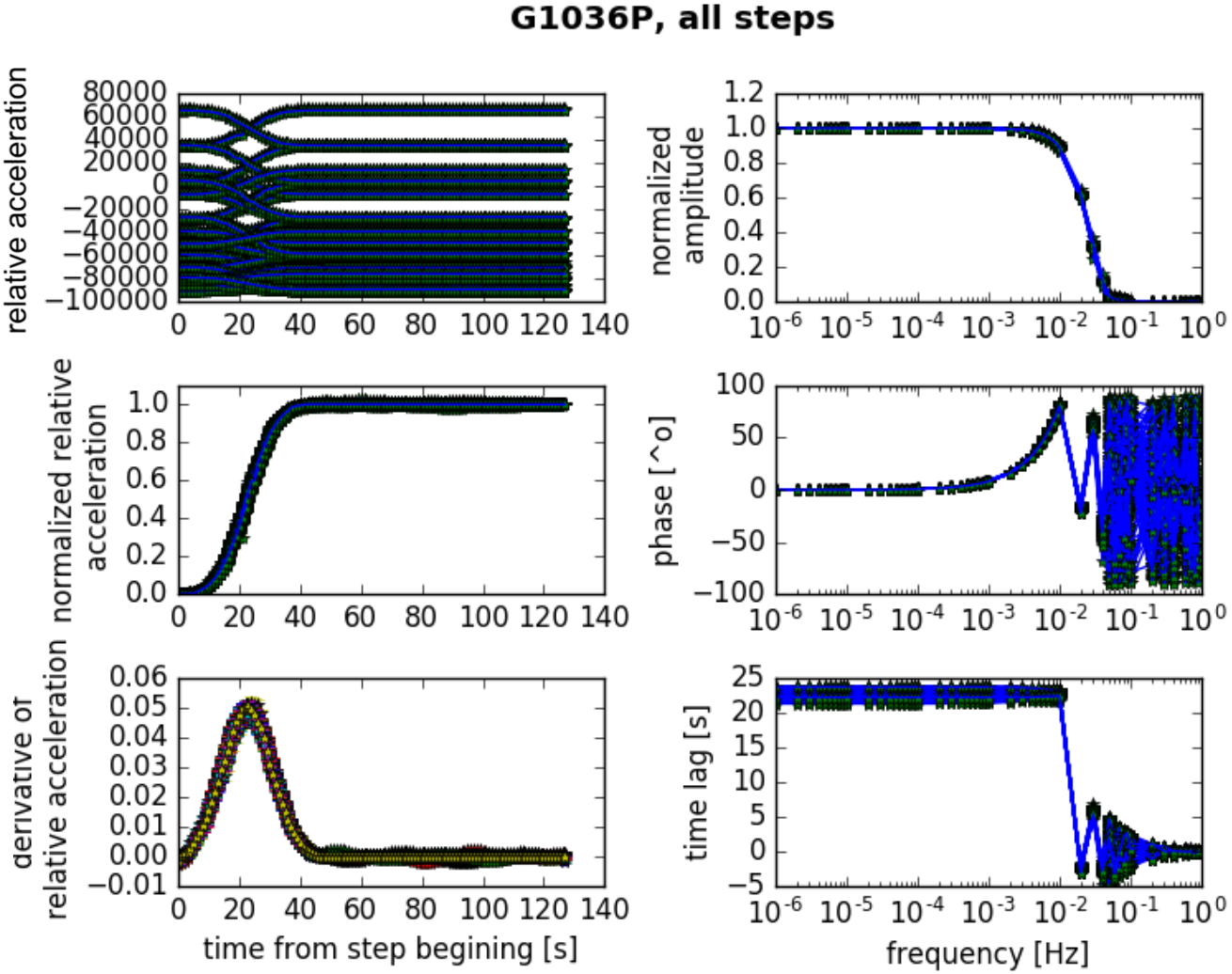
Future plans

- Determination of poles and zeros of transfer functions of gravimeters;
- Detailed analysis of uncertainties of transfer function determination;
- More events and stations will be analysed;
- Estimation of phase dispersion curves;
- Determination of seismic structure of the mantle based on gravimetric measurements (funding from the National Science Centre for three years).

***Acknowledgements**:*
SVAL program (Kolinsky et al., 2011) was used for calculation of dispersion curves and inversion.

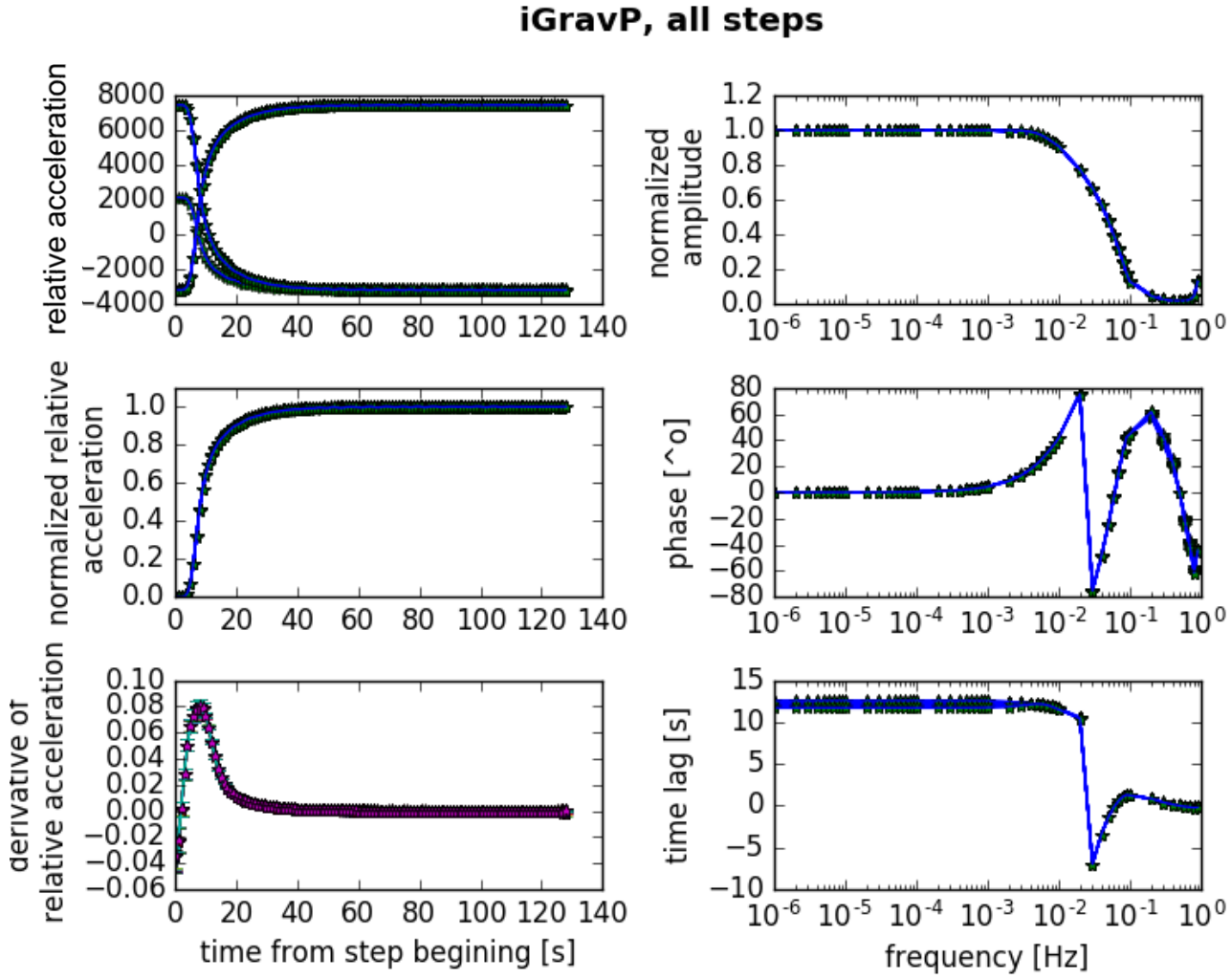
Transfer function of LCR G-1036 (R-T-OTL)

ETSTEP, window length 128 s



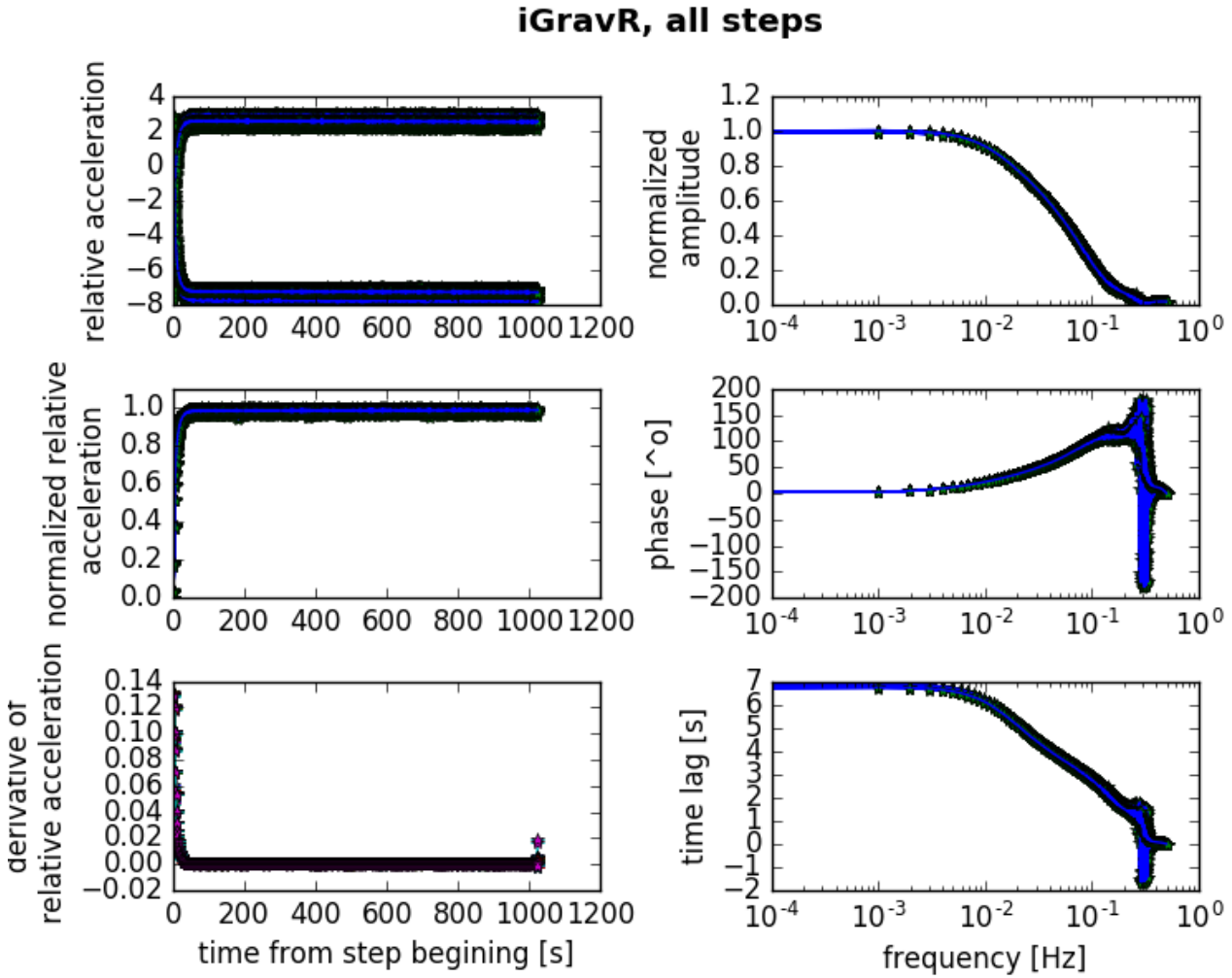
Transfer function of iGrav-027 (R-T-OTL-B)

ETSTEP, window length 128 s



Others activities

First results of transfer function determination of iGrav-027 (Grav-Ctrl)



Others activities

First results of transfer function determination of iGrav-027 (R-T-OTL-B)