SGNoise and AGDas - tools for processing of superconducting and absolute gravity data

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SGNoise

- ❑ Web tool primarily oriented for SG data quality control in near real time

- ❑ Written in PHP5 using the GD graphical library

- ❑ Data are processed on daily basis from raw SG data (1 sec sampling rate)

- ❑ Inspired by the previous works of ***Rosat et al. (2003b, 2004, 2011, 2013)***, which established a standard feature of the noise spectrum analysis of SGs in the GGP network.

- ❑ The data quality quantification is represented by the evaluation of ambient noise level at SG stations by spectral analysis of gravity residuals and its visualization through spectrograms and probability density functions.

http://oko.pecny.cz/grav/

SGNoise - methodology

1 sec data, consisting of gravity and air pressure signal **(in ASCII or mseed format)**

Two basic steps based on ***Banka and Crossley (1999)***:

- ❑ computing residual gravity series
- ❑ spectral analysis of residuals

The ambient noise levels at SG stations are quantified by Power Spectral Densities of gravity residuals from 0.15 mHz (111 min) up to 61.5 mHz (16 s) .

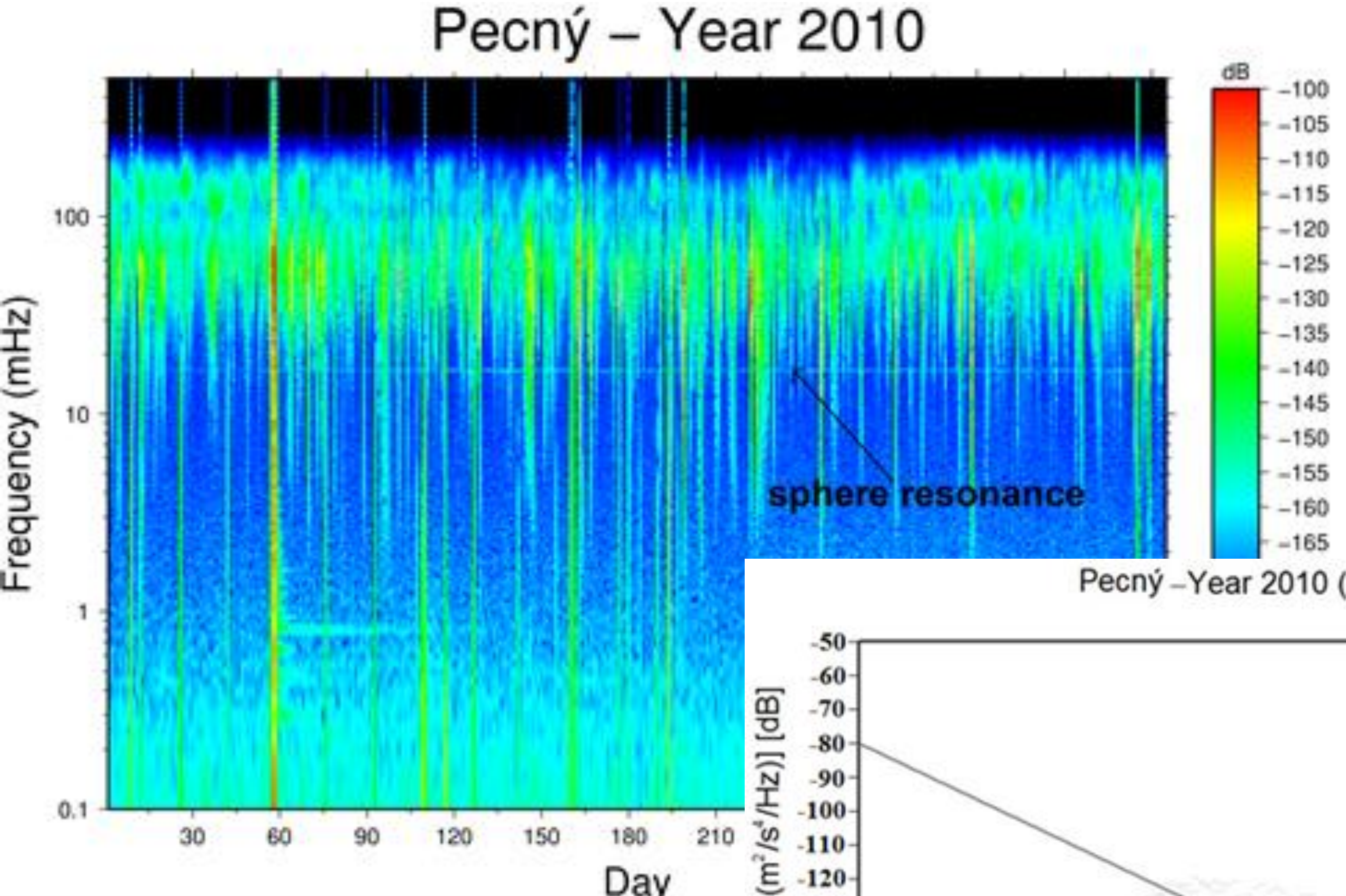
Visualisation:

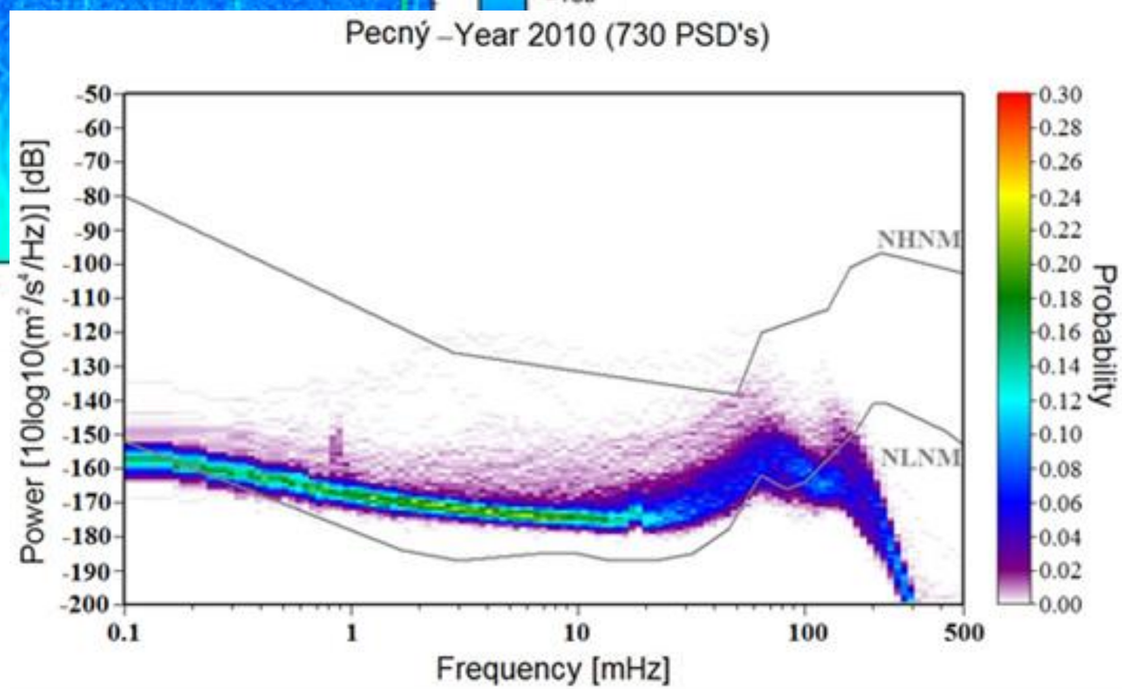
- ❑ Spectrograms
- ❑ Probability density functions (PDFs using algorithms given by ***McNamara and Buland 2004*** for seismic data)

• Calibration of gravity data; Subtraction of the tides using the observed or synthetic tidal parameters; Reduction for the redistribution of atmospheric masses using local air pressure data; Subtraction of a best fitting 9^{th} degree polynomial to eliminate the instrumental drift and any residual tidal signal.

• Windowing with a Hann window; Power Spectral Density (PSD) estimation according to *Cooley and Tukey, (1965)*; PSD smoothing using the 11-point Parzen frequency window and its expression to decibels relative to 1 $(m/s^2)^2/Hz$ through 10 $\log_{10}$ PSD, where PSD is expressed in units $(m/s^2)^2/Hz$.

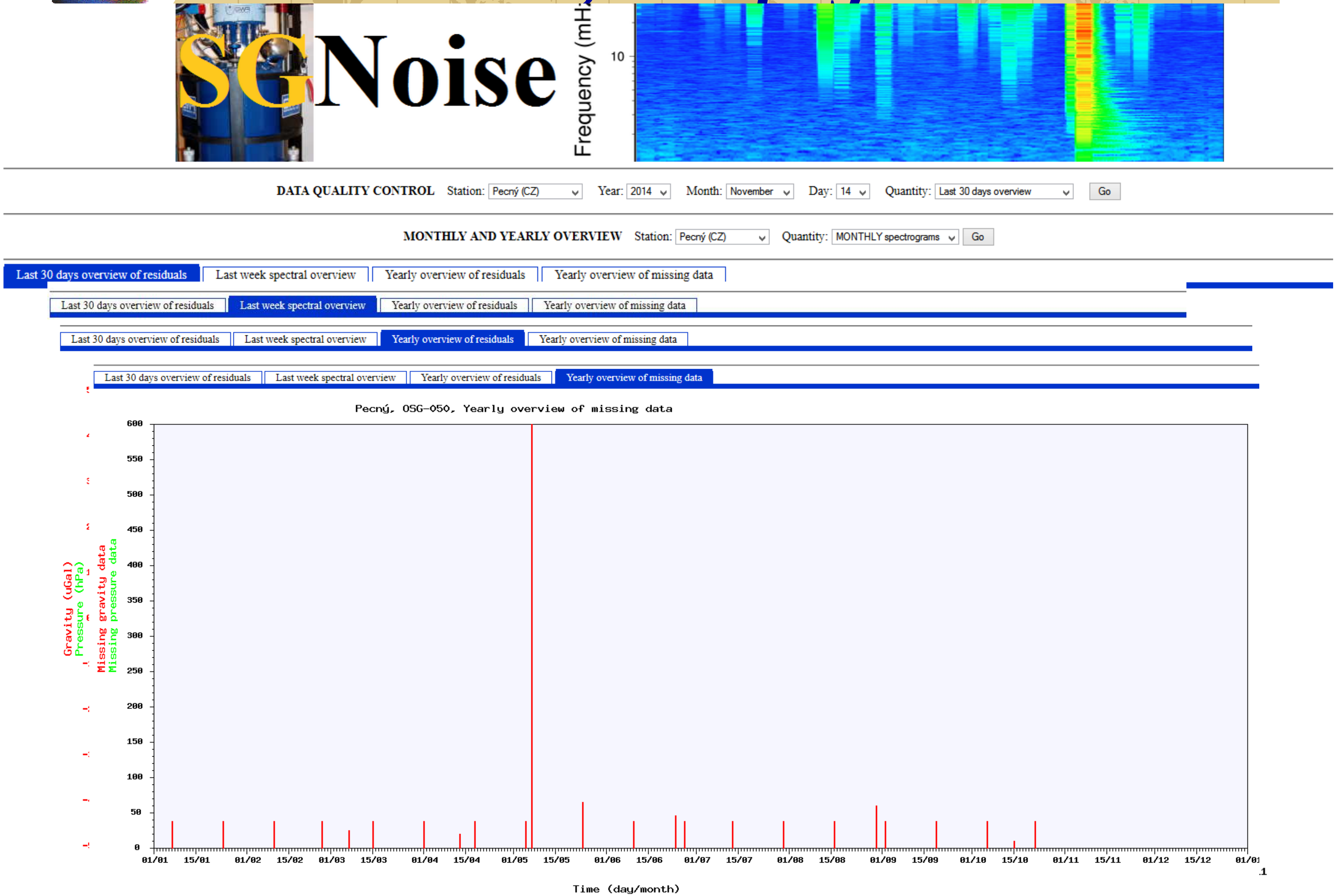
SGNoise, Visualization





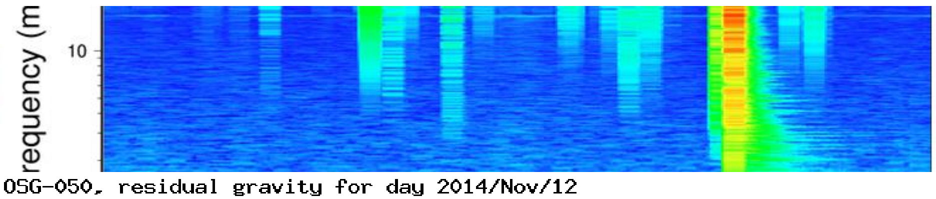
http://oko.pecny.cz/grav/

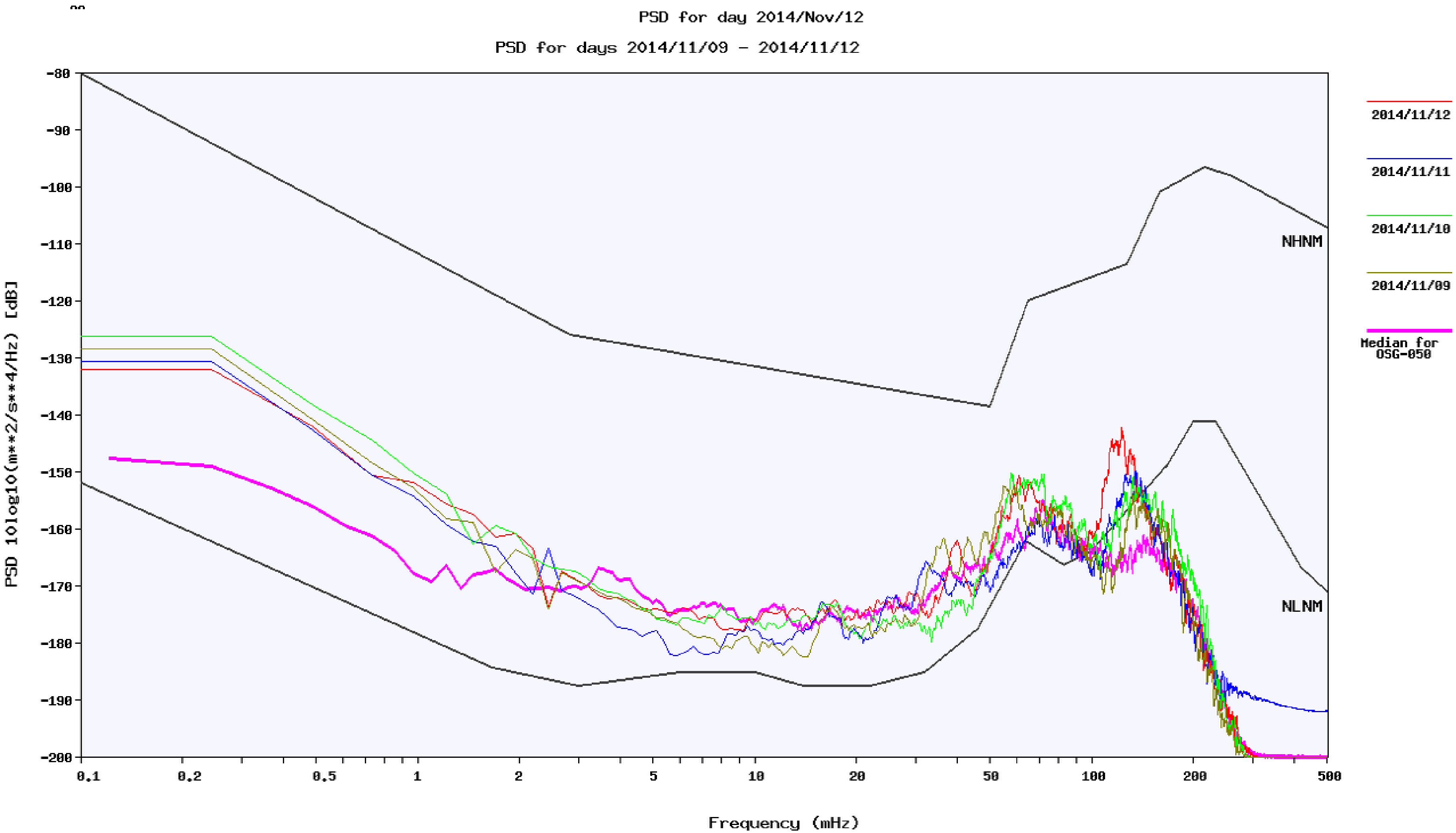
SGNoise, web page



SGNoise, Daily outputs

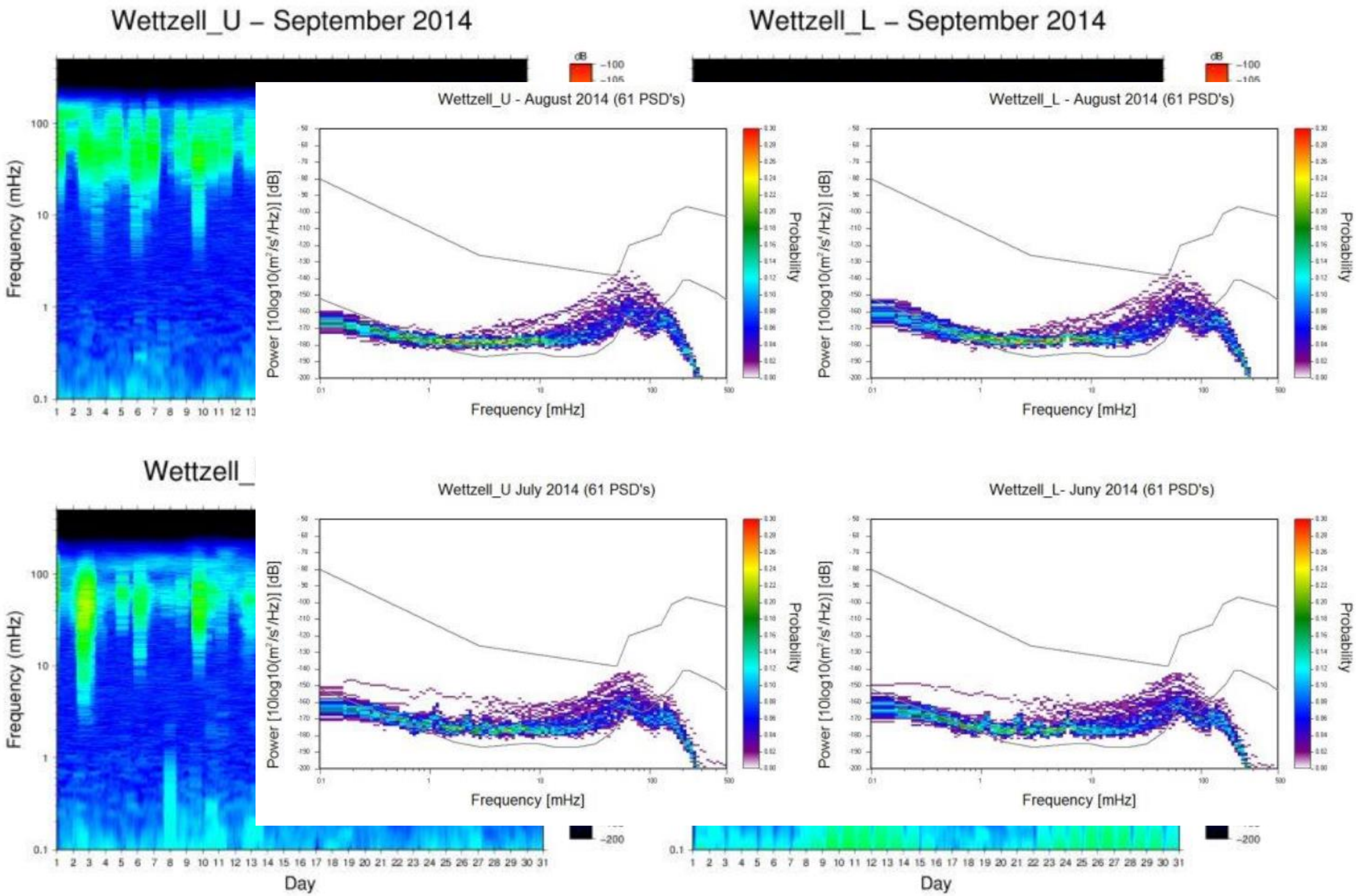
SGNoise



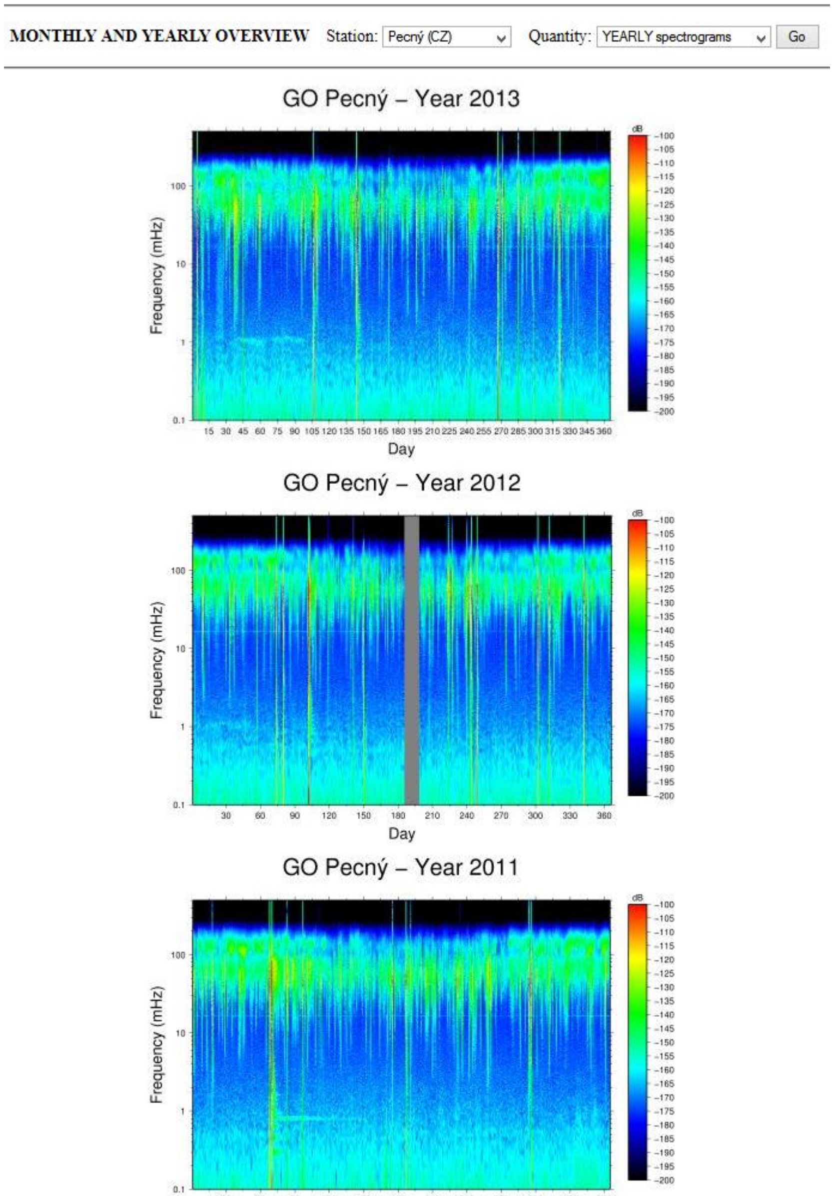


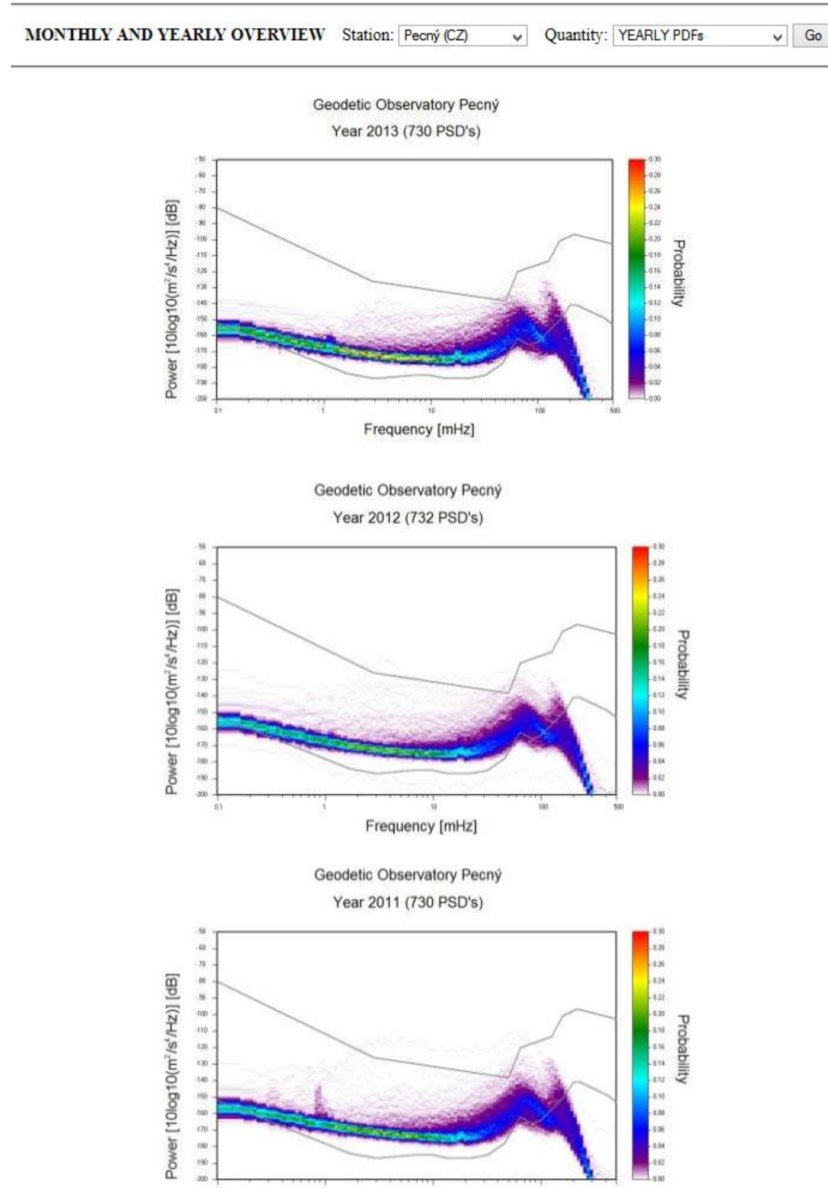
Monthly overview

MONTHLY AND YEARLY OVERVIEW Station: Wettzell (GER) Quantity: MONTHLY spectrograms Go

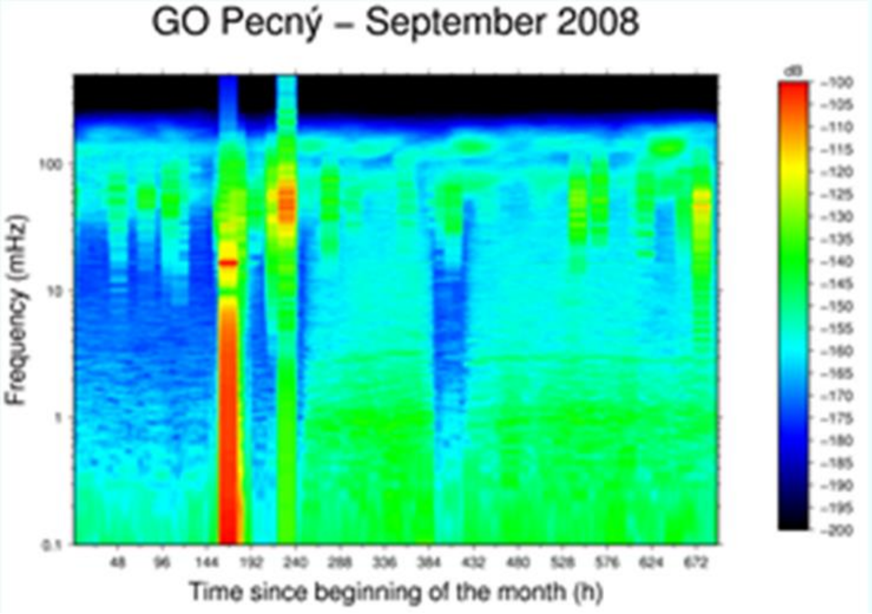


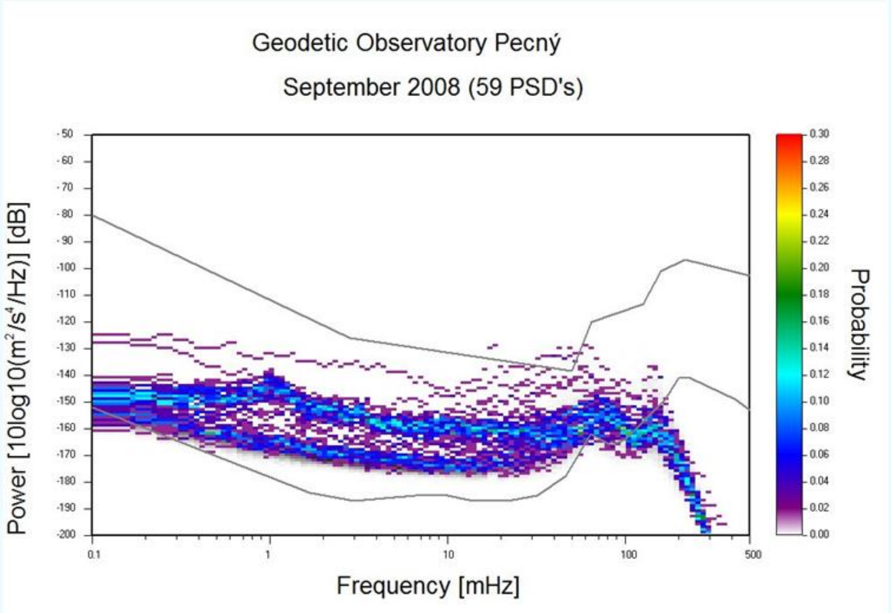
Yearly overview



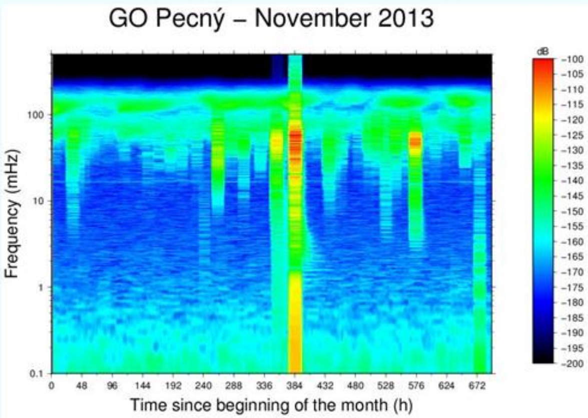


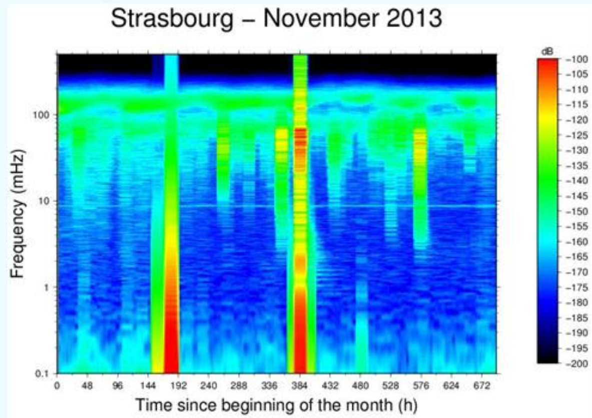
SGNoise, problem detection

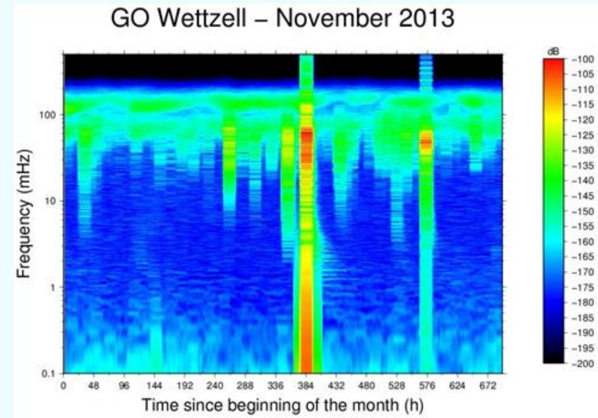


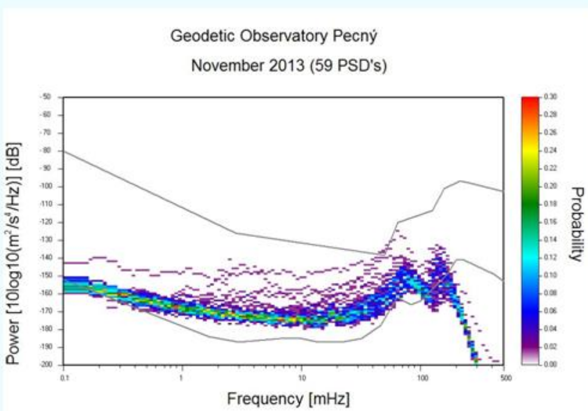


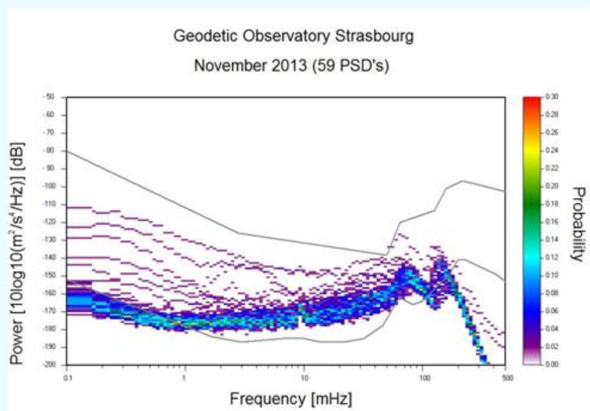
SGNoise, Comparison

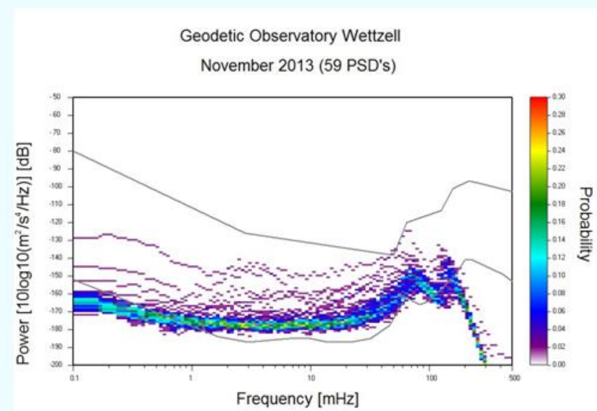












AGDAS, objective

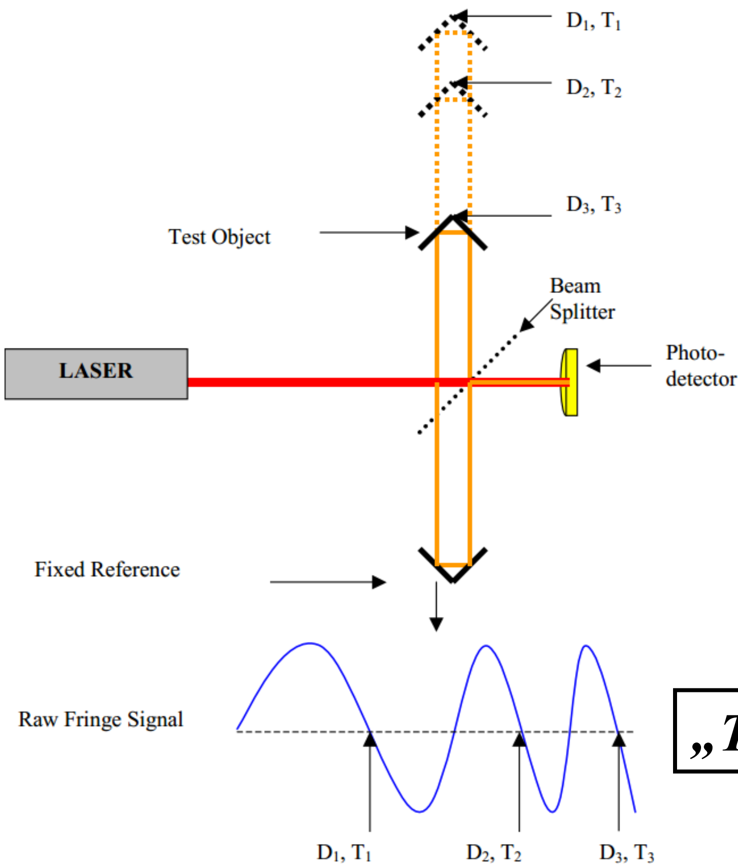
Asolute **G**ravimeter **D**ata **A**nalysis **S**oftware
written in Matlab

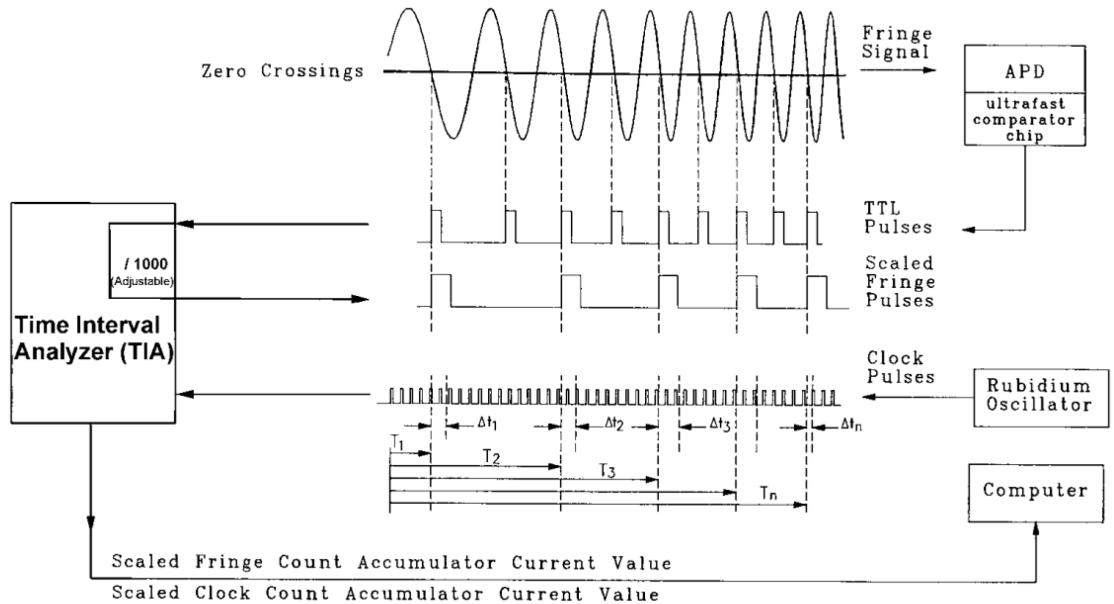
Why the AGDAS has been developped?

- ❑ validation of the “g“ software
- ❑ accurate definition of the reference instrumental height
- ❑ complex analysis of gravity residuals in spectral and time domain
- ❑ experimental evaluation of the questionable correction from the finite speed of light.

AGDAS, raw AG data

Micro-g LaCoste FG5 User's Manual





„***Time – Distance***“ pairs for at least 700 zero crossings

$$t_i' = t_i + z_i / c$$

t = 0 sec : $z_i = z_0 + v_0 \left(t_i' + \frac{\gamma}{6} t_i'^3\right) + g_0 \left(\frac{t_i'^2}{2} + \frac{\gamma}{24} t_i'^4\right) + a \sin(2\pi f_{\text{mod}}\, t_i) + b \cos(2\pi f_{\text{mod}}\, t_i),$

AGDAS, positioning

acceleration to the top of the drop g_{top} $(z = 0)$, rather than report g_0 for time $t = 0$. The relation between these two terms is

$$g_t = g_0 - \gamma z_0 .$$

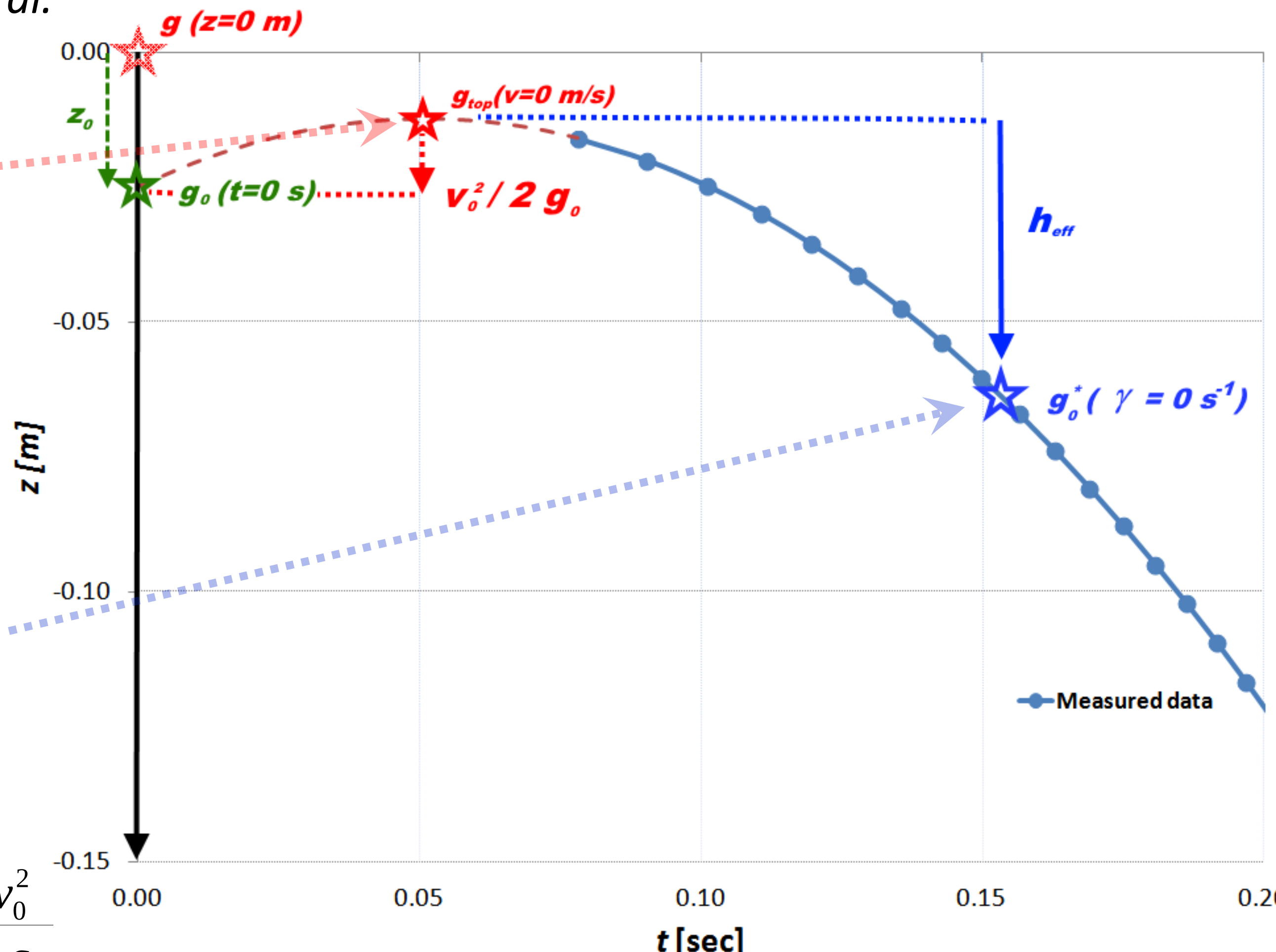
Niebauer et al. (1995)

Top of the drop

$$\boxed{v = \frac{dz}{dt} = 0}$$

$$z = z_0 - \frac{v_0^2}{2 g_0}$$

$$g_{top} = g_0 - \gamma \frac{v_0^2}{2 g_0}$$



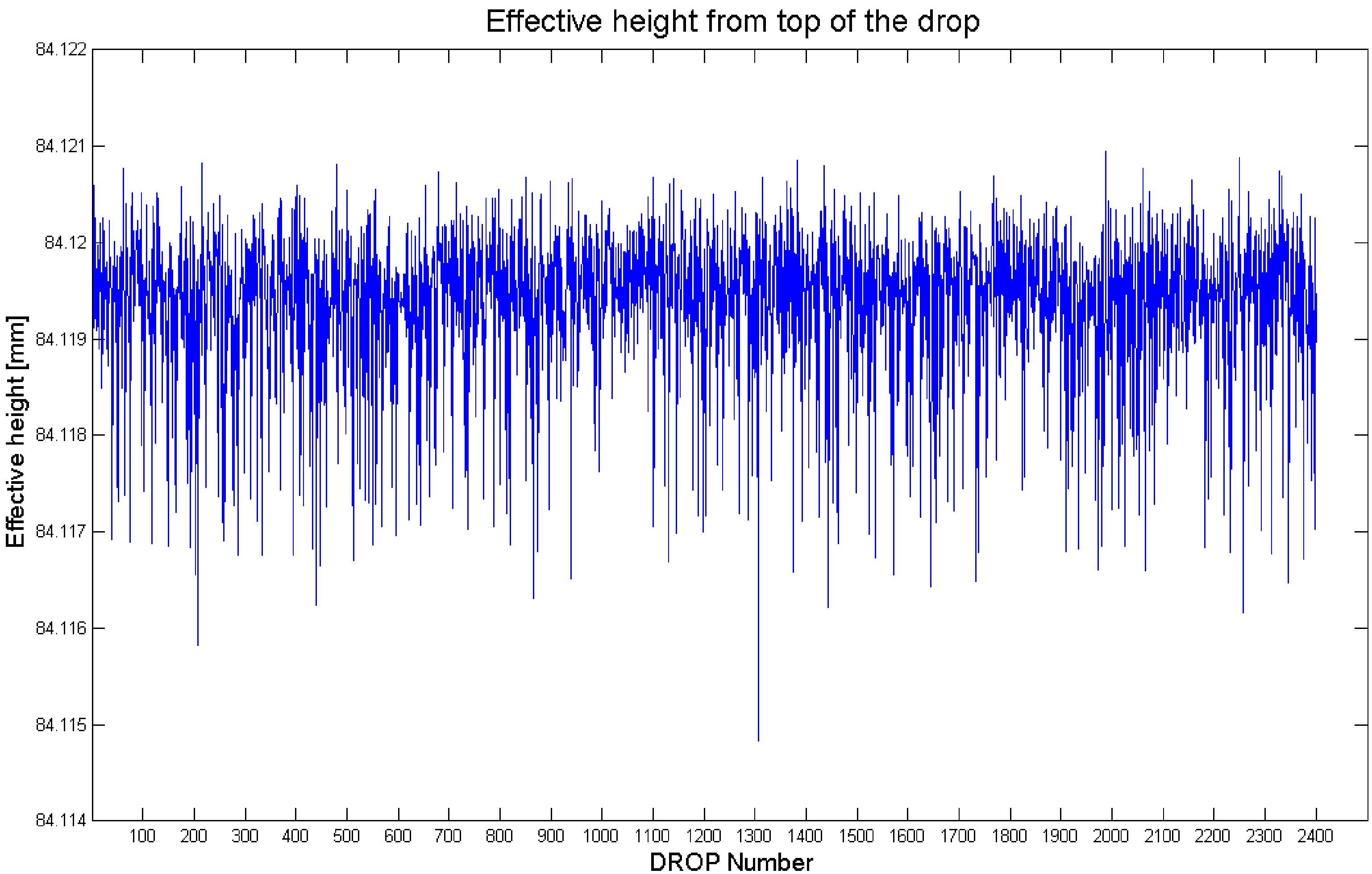
Effective position

$$z_i = z_0^* + v_0^* t_i + g_0^* \frac{t_i^2}{2}$$

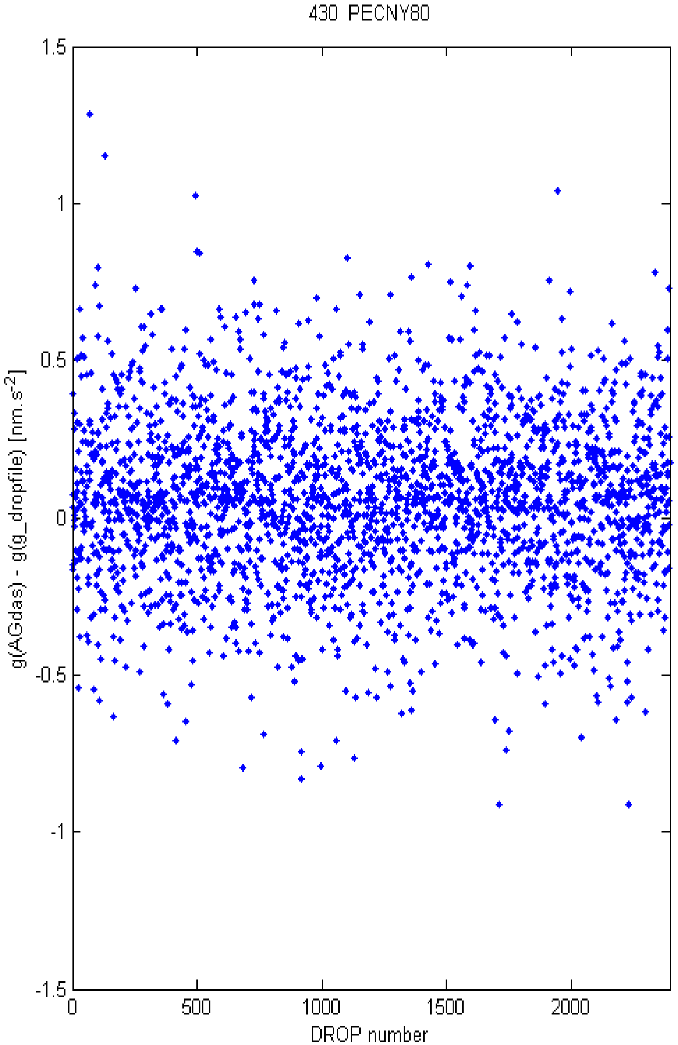
$$h_{eff} = \frac{g_0(\gamma_A) - g_0^*(\gamma = 0)}{\gamma_A} + \frac{v_0^2}{2 g_0}$$

Palinkas et al. (2012)

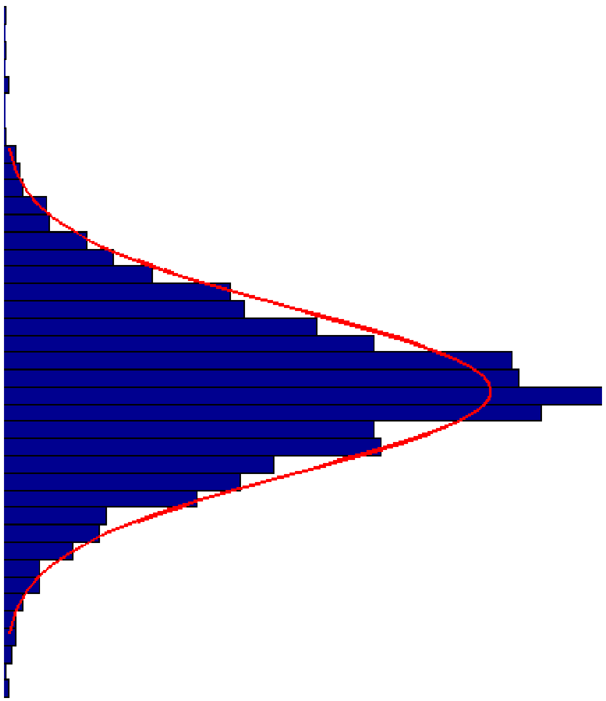
AGDAS, effective height



AGDAS vs. g

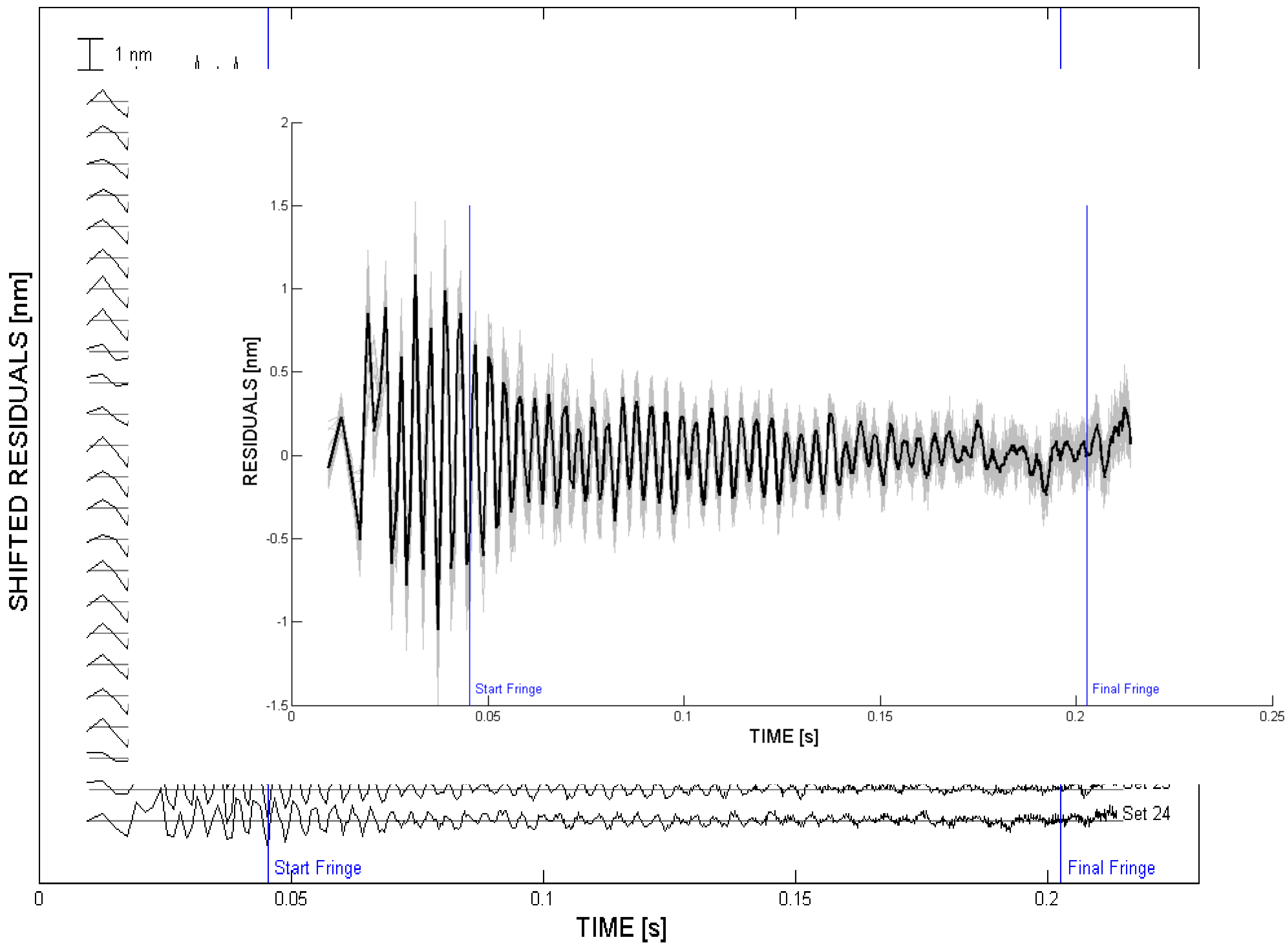


RefX0: Difference of 0.03 nm s^{-2}

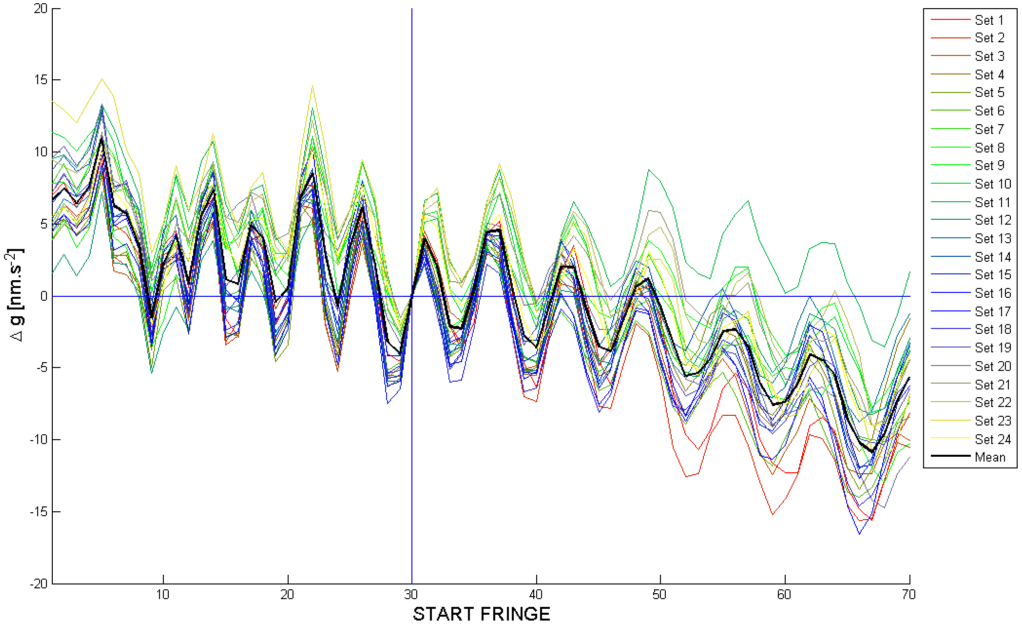


mean = 0.061 nm.s^{-2}, std = 0.0052 nm.s^{-2}

AGDAS, residuals

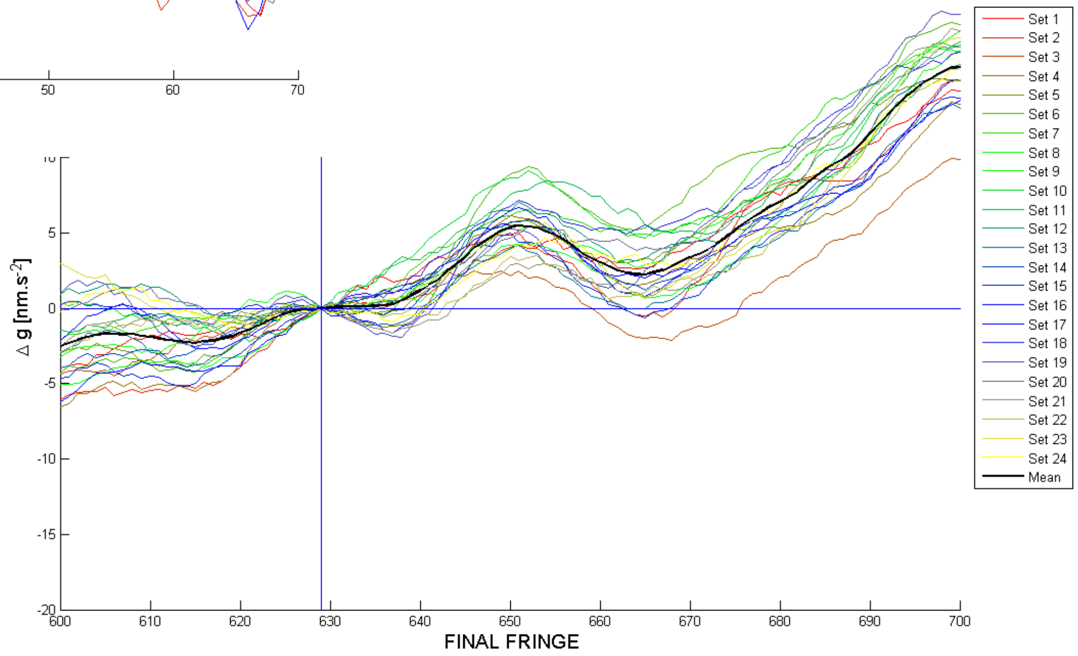


AGDAS, fringe choice

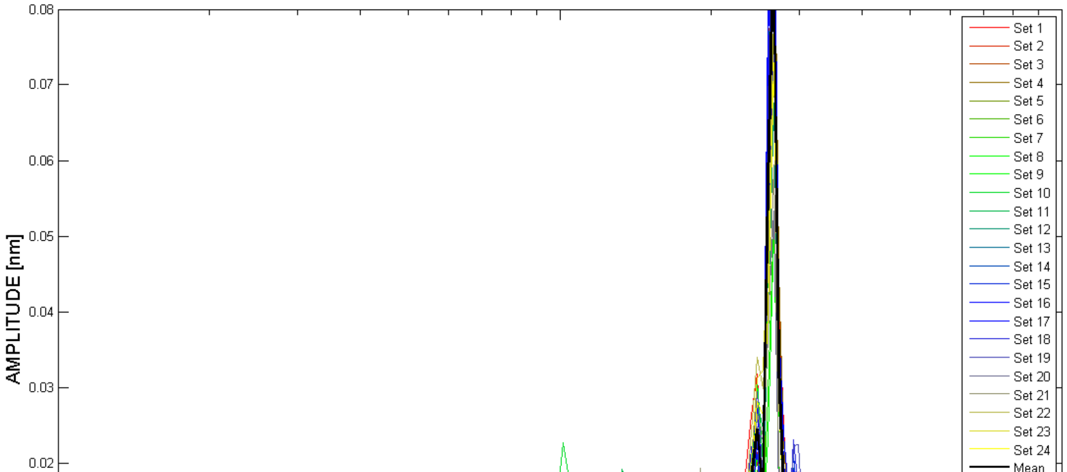


Reference solution

Fringes: 30-629



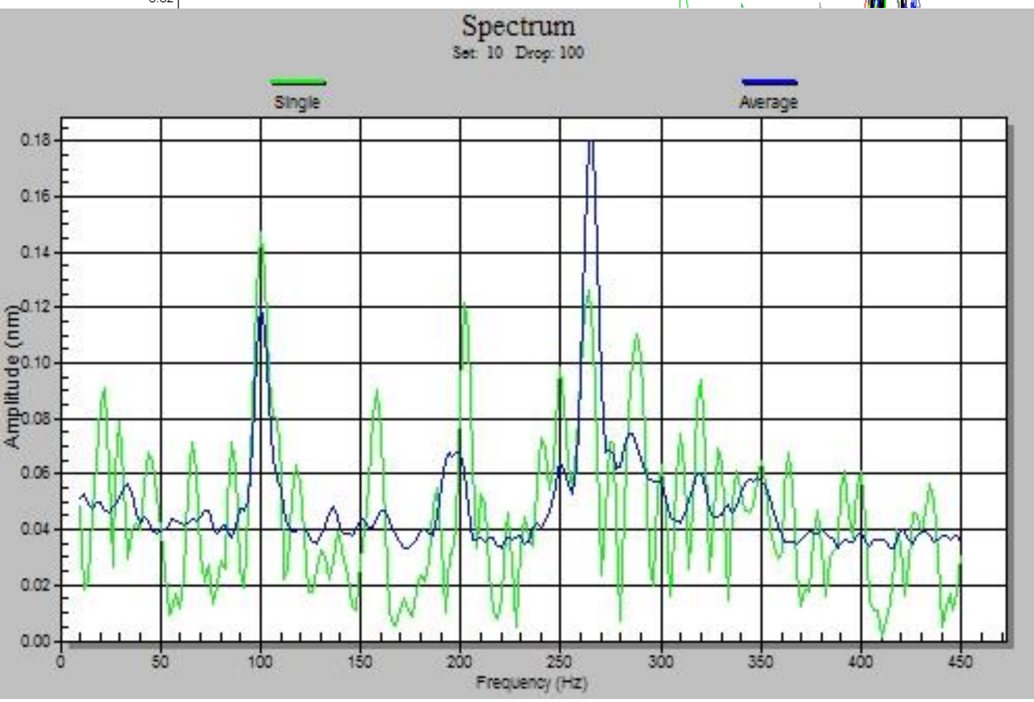
AGDAS, spectrum

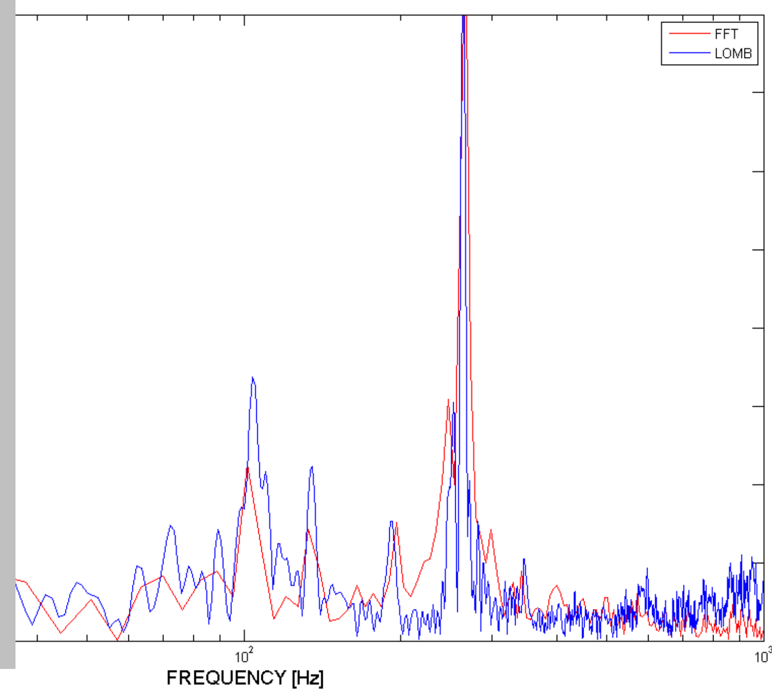


Equally spaced data

Non-equally timed data

1) *Interpolation*
2) *Least –squares spectral analysis*



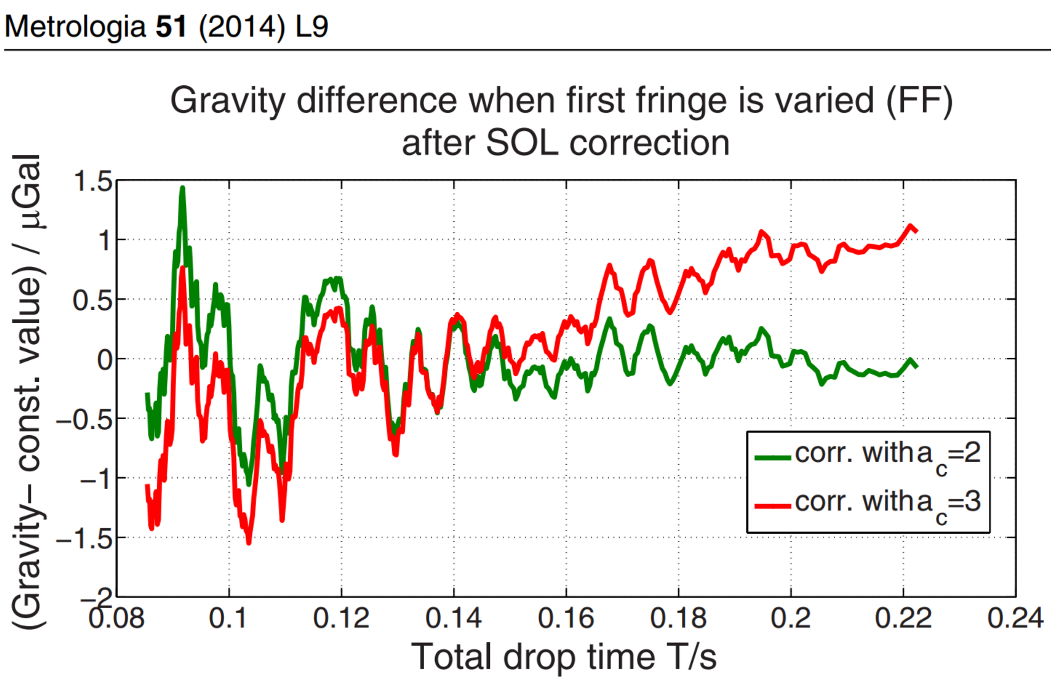


AGDAS, experiment

Correction due to finite speed of light

Surprising theoretical (Rothleitner and Francis 2011) and experimental results (Rothleitner et al. 2014), which should lead to correct FG5 (and gravity reference too) for 4 Gal.

AGDAS is easy to use for detection if measured „g“ is dependent on the velocity of the test mass



Summary and conclusions

SGNoise is providing useful information related to the quality of SG data. Repeated absolute measurements at the station might be inmediately compared with gravity residuals.

There is a possibility to extend the noise level analysis to the sub-seismic and tidal bands.

The next work will be oriented for improvement of automatic data processing.

AGDAS is a powerful tool for advanced analysis of AG data as verification of the correction due to finite speed of light. Furher, AGDAS has some advantages with respect to the „g“ outputs as 1) analysis of residuals for a given campaign, 2) accurate referencing of the results.

Thank you for your attention!