One Month DATA from MINOS HLS: First Analysis and Comparisons

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Jim has greatly improved data quality of the system of 3 HLSs in the MINOS hall (mostly by replacing water absorbing tubes with polyethelene ones and making PC running without breaks). As the result, we now have a 1-month-long, almost uninterrupted record of the HLS sensors. Fig.1 shows plot of level difference L0-L3 (probes #0 and #3, some 90 m apart) in Jan'06. One can easily see Earth tides ~6 micron (even their 2-week amplitude modulationdue to change in relative position of Moon and Sun), as well as ~1 micron big slow drifts over weeks.

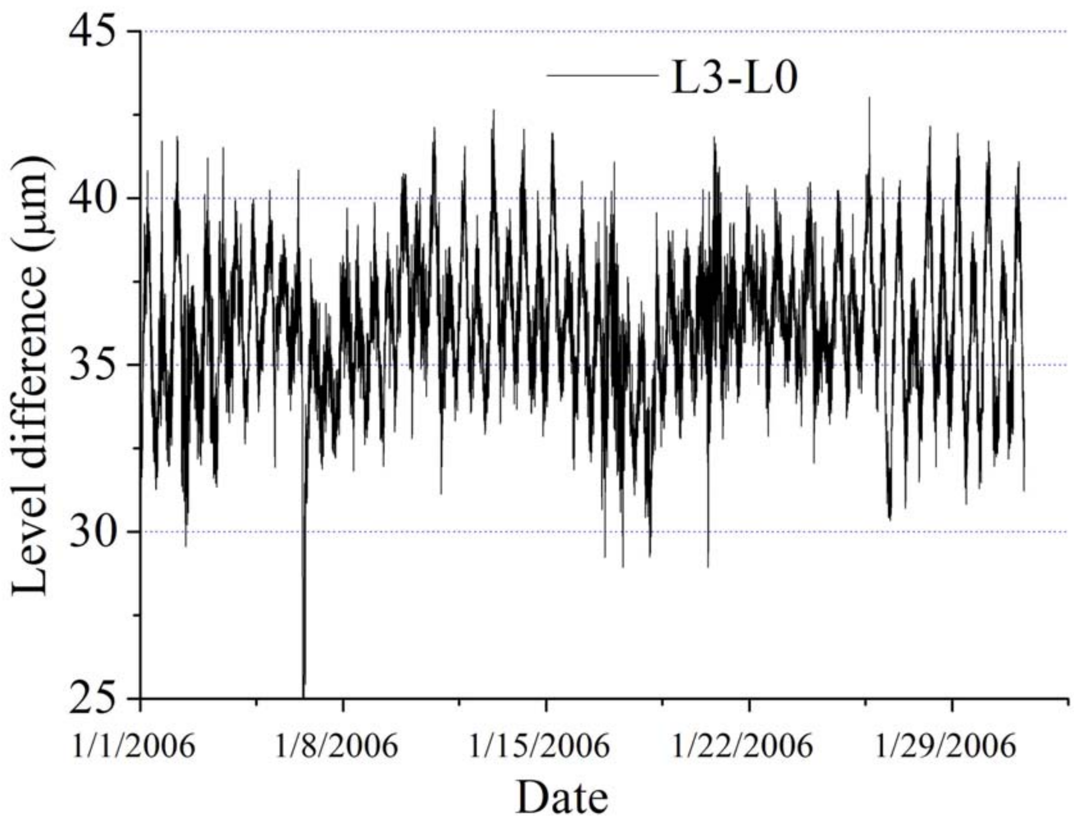

Fig.1: Difference of water levels 90 m apart in January 2006 (Sensor #3-Sensor#0).

The FFT of the difference is presented in Fig.2. The Hanning window was used for the FFT. Besides several remarkable peaks (see below), one can conclude that high-frequency rms noise of the system is about 0.07 micron (integral of amplitudes for frequencies greater than 0.2 hr-1), and that at low frequencies the amplitude of the ground drifts is about

$$RMS\_Y(f)=0.003\ [micron]/f[Hz] \qquad (1)$$

(that can be noise as well – to separate that one has to place two probes side by side and detect the difference, or make a correlation analysis of data from all 4 probes – straightforward but tedious exercise).

There is a handy “ATL law” [1] which predicts the variance (mean square) of random ground motion grows linearly with time interval and distance between observation points. For the point-to-point displacement Δy one has:

$$\langle \Delta y^2 \rangle = A \times T \times L \qquad (2)$$

where brackets <…> stay for average over all possible pairs of data points separated by time interval T and distance L, A is a coefficient. It was found that the diffusion coefficient is not much different for vertical and horizontal movements. Corresponding PSD of the diffusion y is equal to

$$\text{PSD\_}y = (6AL)/(\pi^2 f^2) \qquad (3)$$

Or, consequently, the rms amplitude of the FFT of the ground drift data is equal to

$$\text{RMS\_}Y(f) = (6AL/T)^{1/2}/(\pi f)\,. \qquad (4)$$

Comparing (4) and (1) one gets $A=0.18\times10^{-6}$ μm²/s/m. It is of interest to compare MINOS hall diffusion rates with data from other places and NLC ZDR requirement:

MINOS	2006	$A=0.18\times10^{-6}$ μm^2/s/m
Tevatron orbit	Nanobeam’02 [2]	$A=2.6\times10^{-6}$ μm^2/s/m
PW beamline	IEEE PAC’01 [3]	$A=(1.2\pm0.8)\times10^{-6}$ μm^2/s/m
Aurora mine	IEEE PAC’01 [3]	$A=(0.53\pm0.1)\times10^{-6}$ μm^2/s/m
MI-8 tunnel	Nanobeam’02 [2]	$A=(1.5\pm0.2)\times10^{-6}$ μm^2/s/m
NLC ZDR	1996[4]	$A<0.5\times10^{-6}$ μm^2/s/m

One can see that diffusion rates in deep facilities (MINOS and Aurora mine – both at the ~300 ft depth) are 3-10 times lower than for cut-and-cover tunnels (Tev, MI8, PW).

As for several remarkable peaks in spectrum – shown in better detail in Fig.3 – they have periods of 24 hrs, 12hrs, 8 hrs and 6 hours.

REFERENCES

[1] B.Baklakov, et. al, *Sov.Tech.Phys*, 38 (1998), 894. and V.Shiltsev, IWAA95,KEK-Proc-95/12(1996), p.352

[2] V.Shiltsev, et.al, Proc. “Nanobeam-2002” (2002).

[3] V.Shiltsev, Proc. IEEE PAC’01 (2001), p.1470.

[4] NLC ZDR, SLAC Report 474 (1996)

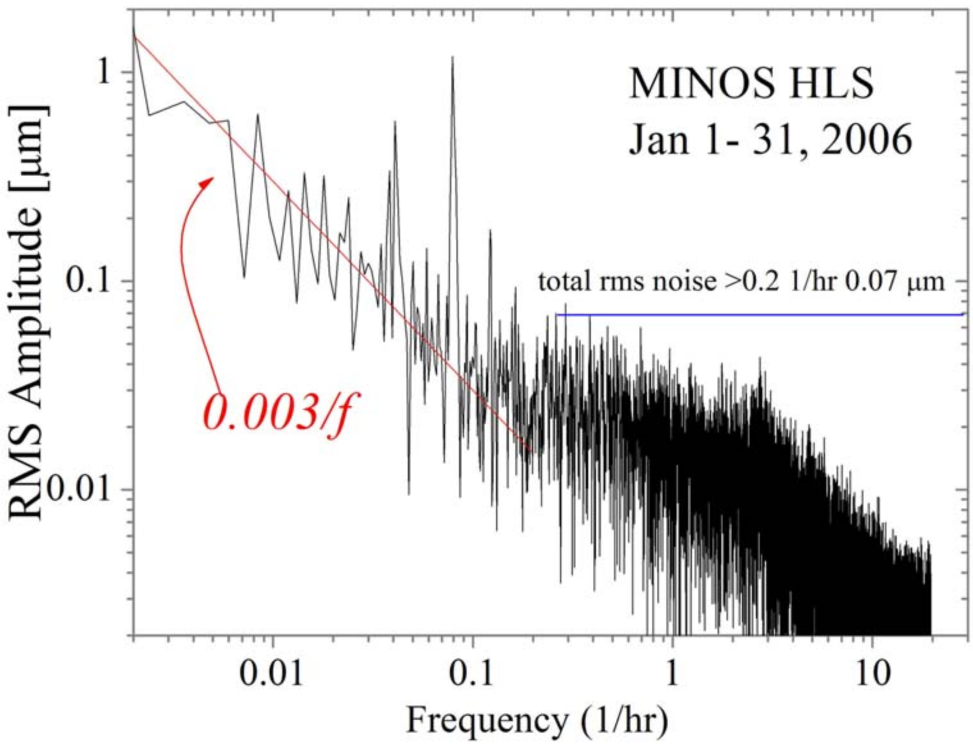

Fig.2: FFT of 1 month long MINOS HLS record (FFT of Fig.1 data).

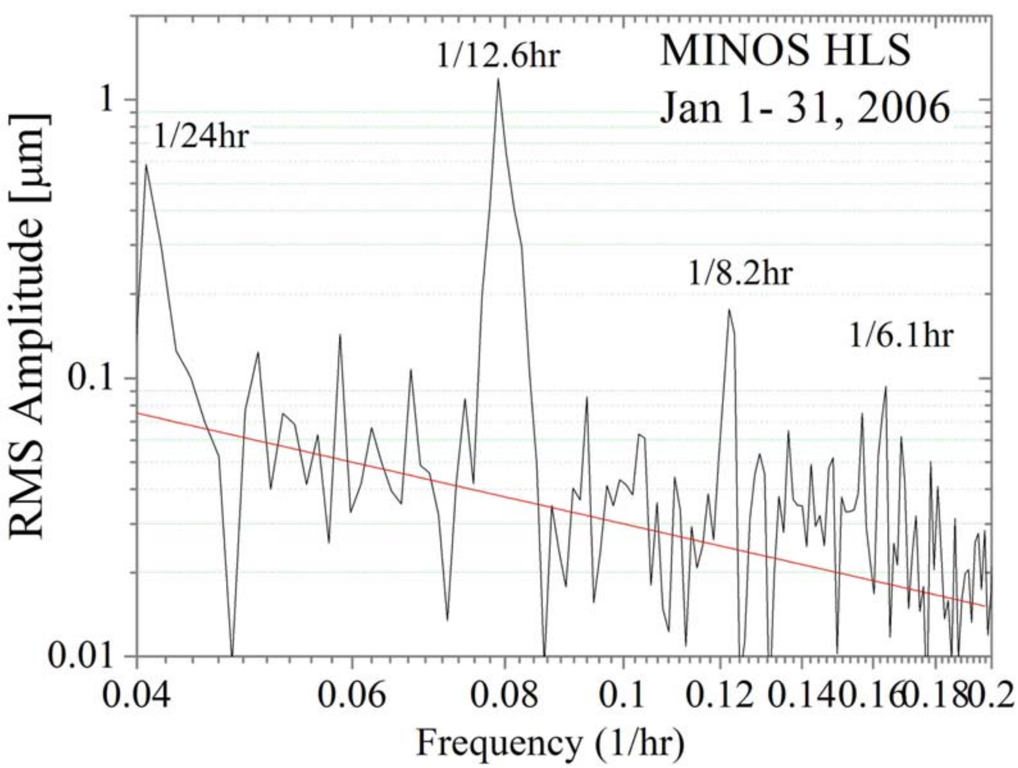

Fig.3: FFT of 1 month long MINOS HLS record (FFT of Fig.1 data) – shows peaks corresponding to tidal waves.