Diurnal and semidiurnal periodicities in results of local structural monitoring using global navigation satellite systems

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Introduction

Periodicities in GNSS observation results are studying just from the beginning of GPS operation. From week to year periodicities are studied thoroughly. The yearly or seasonal component is of highest amplitude. Real time observation and high frequency repetition techniques allow sensing some higher frequencies. Diurnal and semidiurnal variations of point coordinates are found in publications. It usually correspond to natural mechanisms such as earth tides [1,2].
Weiss [5] paid attention to high probability of daily fluctuations in SV clocks, ephemerides of GPS satellites and characteristics of ionospheric models.
There are some problems in high accuracy monitoring using GNSS where such oscillations can occur and prohibit from high accuracy receiving, if these are systematic errors, and, vice versa, demand studying as real object fluctuations.
The cause of intra-diurnal oscillations can be both real changes of monitored objects and technological features of the observation system.

Main observation data

GPS observations are performed at the sites of Sayano-Shushenskaya Dam monitoring network. Two sites of it are placed at the Yenisei river shore and two others are installed at the dam construction. Trimble two frequency GPS receivers were used. Hourly baseline vector solutions were determined by 4DControl software. Two addition baselines were selected from other geographical places and used for control of the main study. The shortest one was the control line of the Nizhnekamskaya Hidropowerstation Dam, and the next was taken from the PBO permanent Parkfield network. Baseline length were varied from 0.01 to 4.33 km.

Preliminary data analysis

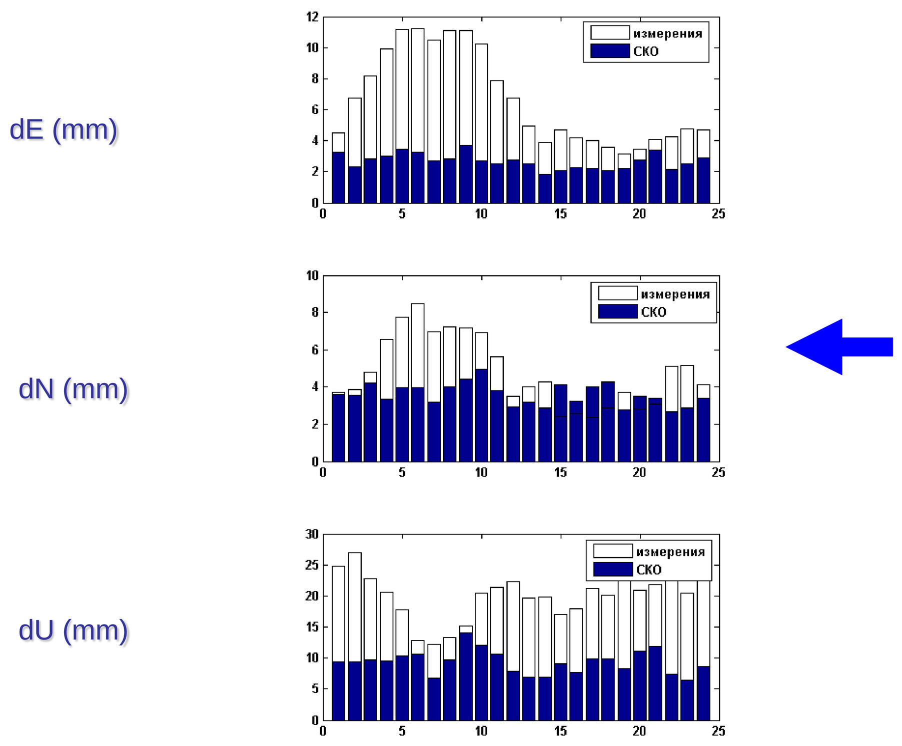


Fig.1 Mean vector component values for every hour of a day of two month observation at the 4.33 km baseline.

The values are white and the RMS are blue.

Lengthening of plan component in the first half of days, but reduction of vertical ones is observed during the same time of a day.

Spectral analysis techniques and results

Three independent spectral techniques were used in the analysis:

- Wavelet-analysis
- Fast Fourier transformation
- Sequential analysis of dominated harmonics (dominant-analysis) [4].

Fig.2. 4.33 km baseline

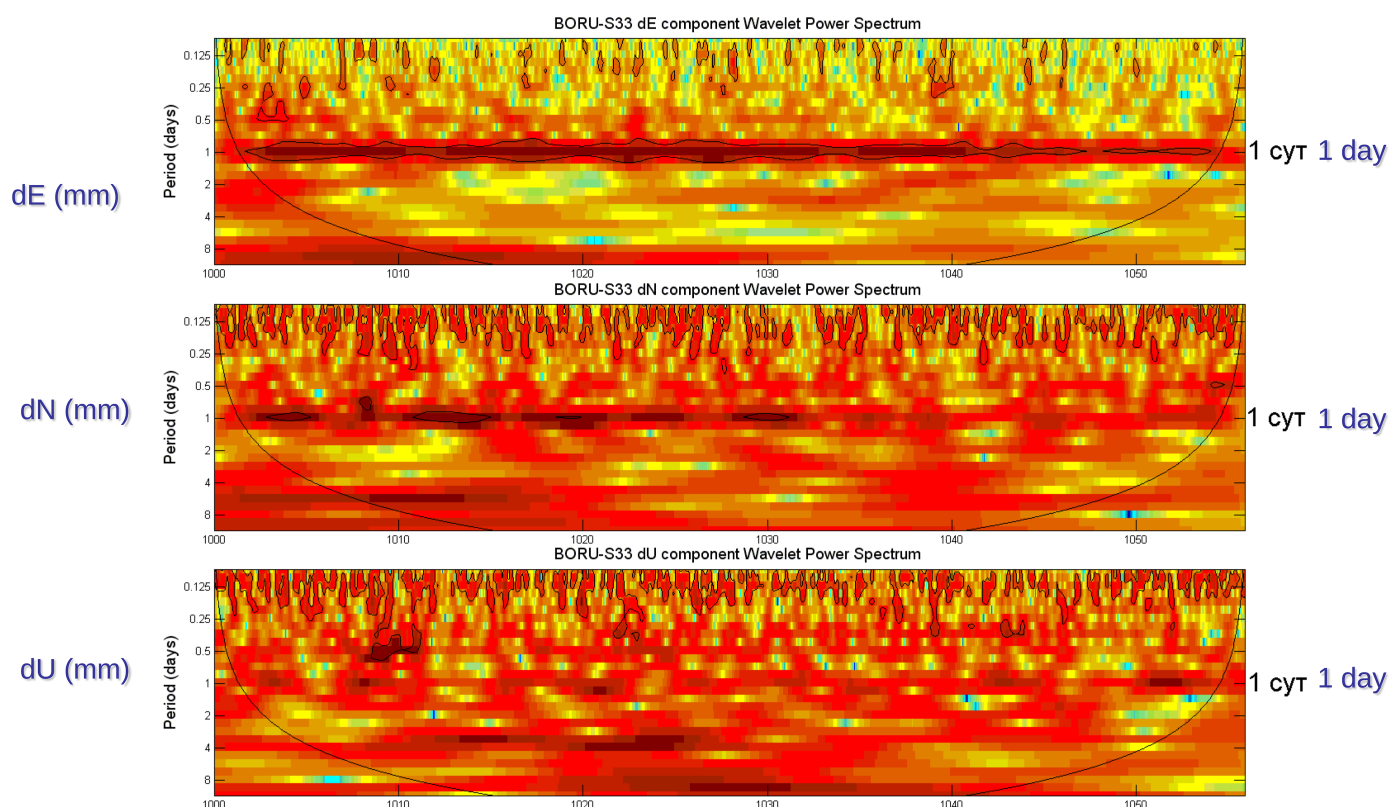


Fig. 4. 0.57 km baseline

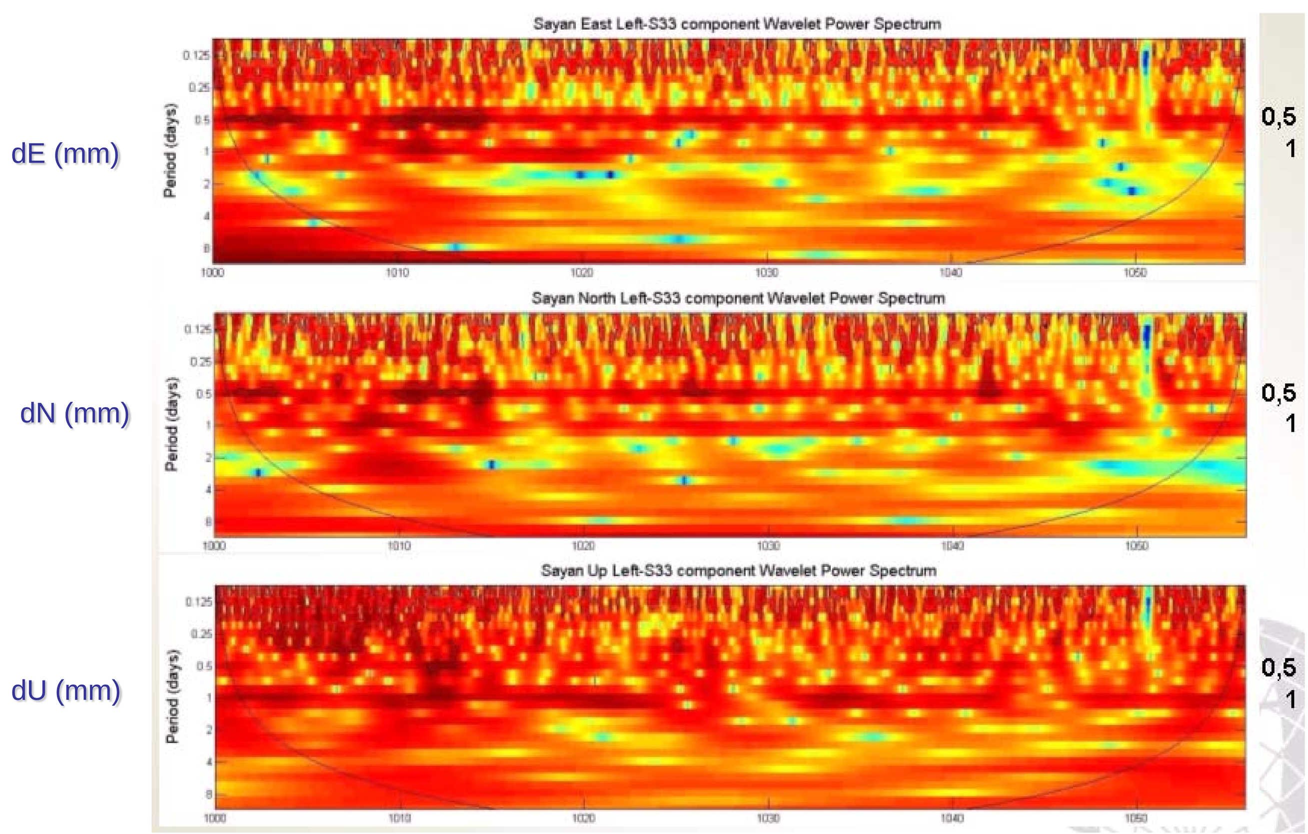
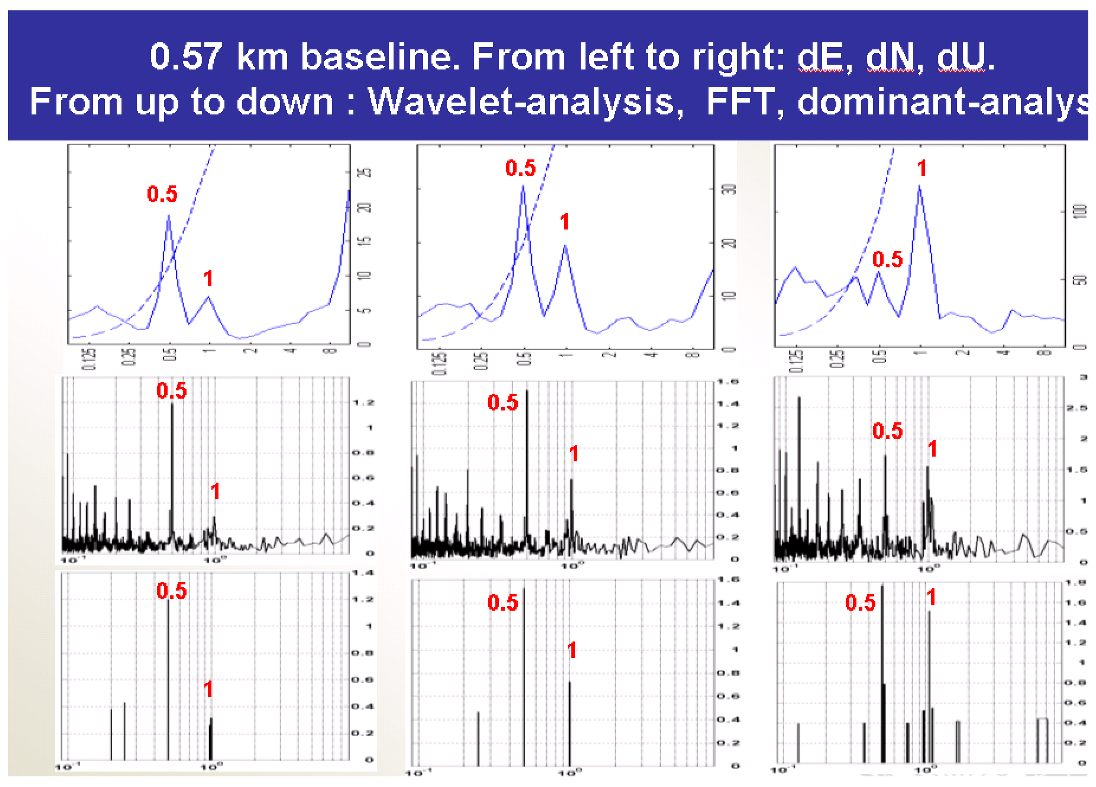


Fig. 5. Amplitude spectra



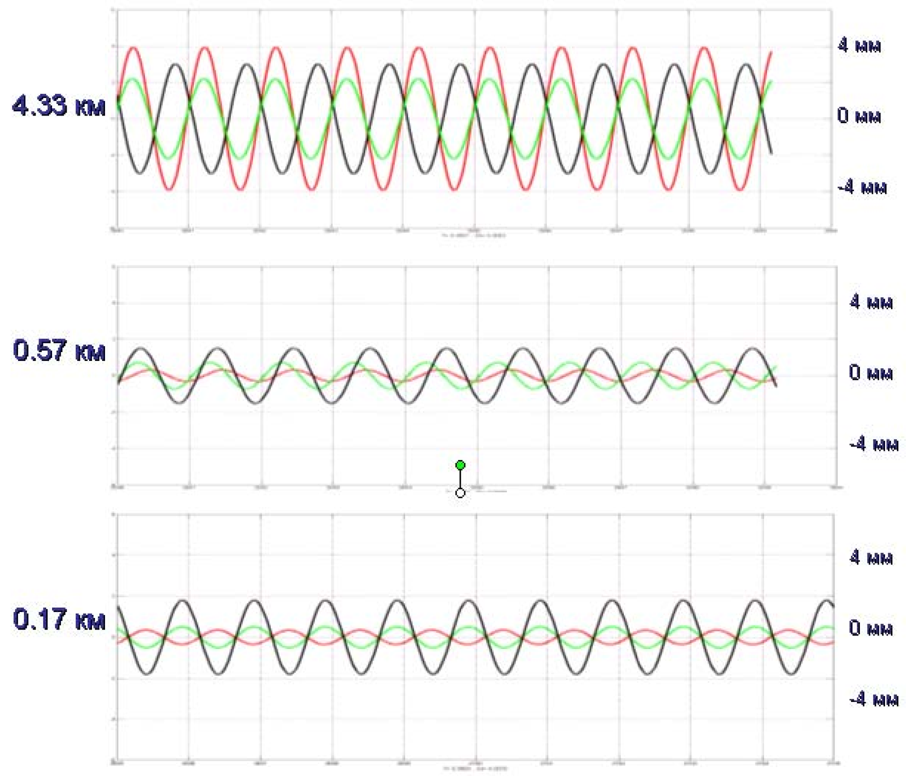


Fig.6. Main features of oscillations

- Amplitude of plane oscillations decreases with distance reduction.
- Plane oscillations of longer baselines run synchronously.
- Longer baseline variations have amplitudes lager than small ones.
- Diurnal oscillations have 1-4 mm amplitudes.
- Semidiurnal oscillations have 1-2 mm amplitudes.

Fig.7. Possible causes of oscillations

- Directions of the plane diurnal periodic "displacements" coincide with the water stream way and can be explained by daily regulation of loading.
- Some researches show high dam tilts along a stream.
- The fluctuation behavior can be explained by 2-nd order ionosphere errors [6].

General conclusions:

- Persuasive results of existence of diurnal and semidiurnal fluctuations in measurements are received.
- Possibility of modeling of these fluctuations for the purpose of an exception of the measured values is shown. Results of periodicity modeling show possibility of insignificant increase of accuracy to 2.6-3 mm in the plan and 7 mm down.
- The analysis of the possible reasons shows that fluctuations of the identical periods can be caused, both the natural reasons, and systematic errors.
- Today some researchers apply various methods of a filtration of data in local geodetic monitoring to reduce of similar "mistakes", achieving smooth trajectories of movement. Results of the analysis show that real movements (on the received examples) which should be studied can be thus "thrown out". The method of a filtration needs to be applied with care, having confidence that own fluctuations of object aren't present.

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