TO THE QUESTION OF THE ORIGIN OF DIURNAL AND SEPTAN VARIATIONS IN THE SEISMIC ACTIVITY

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Abstract. The paper analyzes the origin of diurnal and septan (so-called weekend effect – WEEF) periodicities in the seismic activity. The observed features of the distributions show that the both periodicities are the real geophysical phenomena. The analysis rejects the null-hypothesis of the origin of these periodicity associated with the weekly and daily variation in the sensitivity of the global or local seismic network, due to the variation of seismic noise. Accept the alternative hypothesis about the real impact of industrial activities on the seismic activity.

For the present statistical study we have used:
The catalog of earthquakes by International Seismological Centre (ISC), 1964-2003 y. , http://www.isc.ac.uk

The diurnal variation (daily cycle) in seismic activity is well-known [Ivanov-Kholodnyi, Boyarchuk et al, 2004; Deshcherevskaya and Sidorin, 2005; Zhuravlev and Sidorin, 2005; Zotov, 2007]. The diurnal variations shown in Fig. 1. The synchronous detection method analysis has been used. Method is effective way to detect a weak periodic signal on a background of noise. In these cases period of synchronous detection (epoch duration) is 24 hours.

Fig. 1. Diurnal variation in regional seismic activity obtained by using the data NC (1967 – 2007, left) and in the global seismic activity obtained by using the data USGS/NEIC (1973 – 2007, right).

The nature of diurnal variation is discussed in various papers. The basic question - whether the diurnal variation reflects real changes in seismic activity and what is the cause of this variation?

Fig. 2. Dependence of the diurnal variation in the global seismic activity obtained by using the data USGS / NEIC (1973 - 2007) on the day of week. The vertical gray columns indicate the weekend.
Fig. 2 is proof that diurnal variation at least partially has anthropogenic origin. In this case the period of synchronous detection (epoch duration) is 168 hours = 7 days. We see that the diurnal variation in the Saturday and Sunday is different from the variation in the other days of the week.

Little is known the **septan variation** (weekly cycle) in seismic activity (so-called weekend effect) [Zotov, 2007]. Weekend effect has anthropogenic origin because natural variations with a period of strictly equal to 7 days are not known.

![Fig. 3. Weekend-effect in the seismic activity by ISC catalog data. The number of earthquakes within the 40-yr accumulation interval is plotted on the vertical axis. Days of week are plotted on the horizontal axis. The number of epochs (seven-day intervals) is 2000.](image)

So, both effects have the anthropogenic nature but the physical mechanism of the weekly/daily variation while understandable.

A large number of studies devoted to the presentation of experimental results related to the influence of different sources of natural and artificial origin on seismic activity. The natural processes whose dynamics are evident in seismic activity well known. Also known the phenomena of human origin affecting to seismicity (see Fig. 4).

![Fig. 4. Influence on earthquakes the different sources of natural and artificial origin.](image)

The experiments demonstrate the influence on seismic activity of the physical fields of different nature. The industrial activity characterized by variety of types of generated physical fields which have the same periodicities which we find in the lithosphere.
The diurnal and septan variations in seismic activity - what is the cause of origin of these periodicities? Whether the changes recorded by seismic activity reflect real changes in seismic activity?

Technosphere obviously has the characteristic periodicities, such as daily and weekly.

**One of the hypotheses:** the origin of septan/diurnal periodicity in seismic activity associated with the weekly/daily variation of the sensitivity of the global/local seismic network, due to the variation of industrial seismic noise.

**Alternative hypothesis:** exist the real impact of industrial activities on the seismic activity.

**Important note:** As is known, representative part of catalog contains the earthquakes with magnitude $M > M_t$, which are presented in catalog without gaps. Unrepresentative part of catalog reflects only a general population samples. General population includes all occurred earthquakes with magnitudes $M < M_t$.

**Will formulate a null-hypothesis:**

Assume the earthquakes are distributed uniformly on days of week (on hours of day) really. Assume the seismic noise associated with industrial activity in weekend (night) less than on weekday (day).

Then the number of earthquakes recorded in the weekend (night) in unrepresentative part of catalog will be greater because the signal to noise ratio (SNR) at the input seismic stations is greater. **The number of earthquakes depends on the SNR** in unrepresentative part of catalog.

But the number of earthquakes in representative part of the catalog in which, as it commonly believed, present all the seismic events without omissions will be not changes. **The number of earthquakes does not depend on the SNR** in representative part of catalog.

But even if for some reason, a representative part of the catalog is not complete, with a decrease of noise should be expected to **increase the number of earthquakes in a representative part of the catalog also.**

**Verify this null hypothesis.**

Consider first the **diurnal variation** in regional seismic activity obtained by using the data NC (1967 – 2007, Fig. 5, top left). Calculate separately the distribution of $M$ for earthquakes that occurred in the hours of maximum (denotes max and max1, black columns at the Fig. 5, top left) and minimum (denotes min, gray columns at the Fig. 5, top left) of diurnal variation. These distributions on a logarithmic scale are shown in the Fig. 5, top right. Compare the distribution of $M$ for hours of maximum and minimum of the diurnal variation as max/min (see Fig. 5, bottom left).

![Fig. 5. Diurnal variation in regional seismic activity obtained by using the data NC (1967 – 2007, top left); the distributions of $M$ for earthquakes that occurred in the hours of maximum (max and max1) and minimum (min) of diurnal variation (top right); compare the distribution of $M$ for hours of maximum and minimum of the diurnal variation as max/min (bottom left); the control experiment (bottom right, see text).](image-url)
We see that when weak earthquakes (unrepresentative part of the catalog) more then strong earthquakes (representative part of the catalog) less. This result contradicts the null hypothesis according to which the numbers of earthquakes in representative part of the catalog in which present all the seismic events without gaps will be not changes or will be increases. So, accept the alternative hypothesis about the real impact of industrial activities on the seismic activity. Fig. 5, bottom right, illustrated the control experiment - compare the distribution of M for hours of maximum (max) and maximum (max1) of the diurnal variation as max/max1. We see that number of weak and strong earthquakes approximately equal in unrepresentative and representative parts of the catalog.

Now consider the septan variation in the global seismic activity obtained by using the data ISC (1964 – 2003, Fig. 6, top left). Calculate separately the distribution of M for earthquakes that occurred in the day of maximum (day of the week Sunday, dark gray column at the Fig. 6, top left) and minimum (day of the week Wednesday, light gray column at the Fig. 6, top left) of septan variation. These distributions are shown in the Fig. 6, top right. Compare the distribution of M for days of maximum and minimum of the septan variation as Su/We (see Fig. 6, bottom left).

Fig. 6. Septan variation in the global seismic activity obtained by using the data ISC (1964 – 2003, top left); the distributions of M for earthquakes (top right) that occurred in the day of maximum (day of the week Sunday, dark gray column, top left) and minimum (day of the week Wednesday, light gray column, top left) of septan variation; compare the distribution of M for days of maximum and minimum of the septan variation as Su/We (bottom left); the control experiment (bottom right, see text).

We see that when weak earthquakes (unrepresentative part of the catalog) more then strong earthquakes (representative part of the catalog) less. This result contradicts the null hypothesis according to which the numbers of earthquakes in representative part of the catalog in which present all the seismic events without gaps will be not changes or will be increases. So, accept the alternative hypothesis about the real impact of industrial activities on the seismic activity. Fig. 6 (bottom right) illustrated the control experiment - compare the distribution of M for day of minimum (Wednesday) and minimum (Thursday) of the septan variation as We/Tu. We see that number of weak and strong earthquakes approximately equal in unrepresentative and representative parts of the catalog.

The effect of such differences of distributions is not accidentals because such differences increase monotonically in the process of catalog analysis. Let Smax – the number of earthquakes in the maximum septan/diurnal variation and Smin – the number of earthquakes in the minimum septan/diurnal variation. We shall calculate the difference Smax–Smin for representative and unrepresentative parts of catalog separately and in the process of catalog analysis. Corresponding curves are shown in Fig. 7. We see monotonically
increase $S_{\text{max}} - S_{\text{min}}$ for unrepresentative parts of catalog (gray vertical axis and the curves) and monotonically decrease $S_{\text{max}} - S_{\text{min}}$ for representative parts of catalog (black vertical axis and the curves). This analysis is presented in Fig. 7 (left) for diurnal periodicity and in Fig. 7 (right) for septan periodicity.

![Fig. 7. Accumulation of differences in the distributions of $M$ for representative (black vertical axis and the curves) and unrepresentative (gray vertical axis and the curves) parts of catalog separately and in the process of catalog analysis; left - for diurnal periodicity (catalog NC, 1967-2007) and right - for septan periodicity (catalog ISC, 1964-2003).](image)

**CONCLUSION**

On the one hand it is impossible to exclude, that septan/diurnal periodicity are partly generated weekly/daily variation of the sensitivity of the global/local seismic network, due to the variation of industrial seismic noise.

On the other hand decrease of number of strong earthquakes at simultaneous increase of earthquakes in a weak magnitude range can not be connected to a variation of the relation signal/noise. This fact directly specifies that the considered variations are the real response seismic environment on the influence of physical fields of the various nature generated technosphere.

At the same time from the given analysis follows that septan/diurnal periodicity also are connected to real change of seismicity under influence of noise of an industrial origin. It is possible, that the specified two factors operate simultaneously. The observed features of the distributions show that the both periodicities are the real geophysical phenomena. The analysis rejects the null-hypothesis of the origin of these periodicities only associated with the weekly and daily variation in the sensitivity of the global of local seismic network due to the variation of seismic noise. There are the grounds for accepting the alternative hypothesis about the real impact of industrial activities on the seismicity of the Earth.

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