Does Japan approach great earthquake (the question since middle of 2008)? Yes, this prediction was true (after 11 of March 2011).

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The question in the title arises as the result of processing microseisms data from 83 broadband seismic stations of the network F-net http://www.fnet.bosai.go.jp (Fig.1) by different methods. The vertical seismic records with sampling rate 1 Hz were analyzed by estimating their multifractal singularity spectra parameters (the width of singularity spectra support $\Delta\alpha$ and generalized Hurst's exponent α^*, i.e. argument providing maximum to singularity spectra) within adjacent "short" time windows of the length 30 minutes and 1 day. Within papers [1-3] it was shown that the averaged (smoothed in 1 year time window) value of the parameter $\Delta\alpha$ (calculated as median over all stations of the network) significantly decreased before the Hokkaido earthquake of September 25, 2003 (M=8.3), and was not restored subsequently to its previous level (Fig.2).

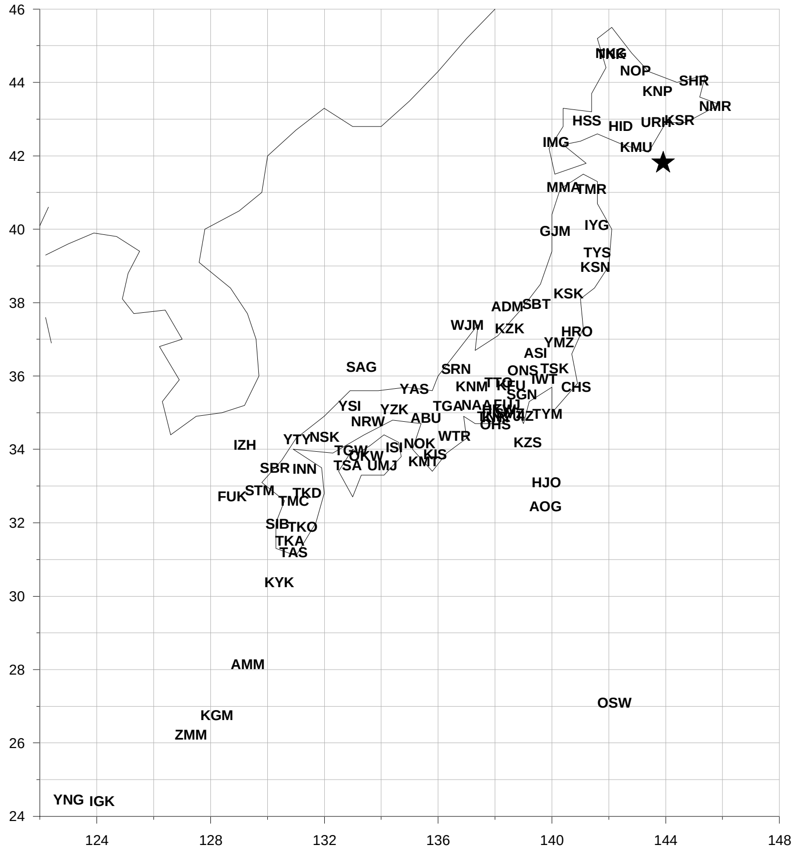


Fig.1. Positions of 83 F-net seismic stations and hypocenter of earthquake 25.09.2003, M=8.3 (star)

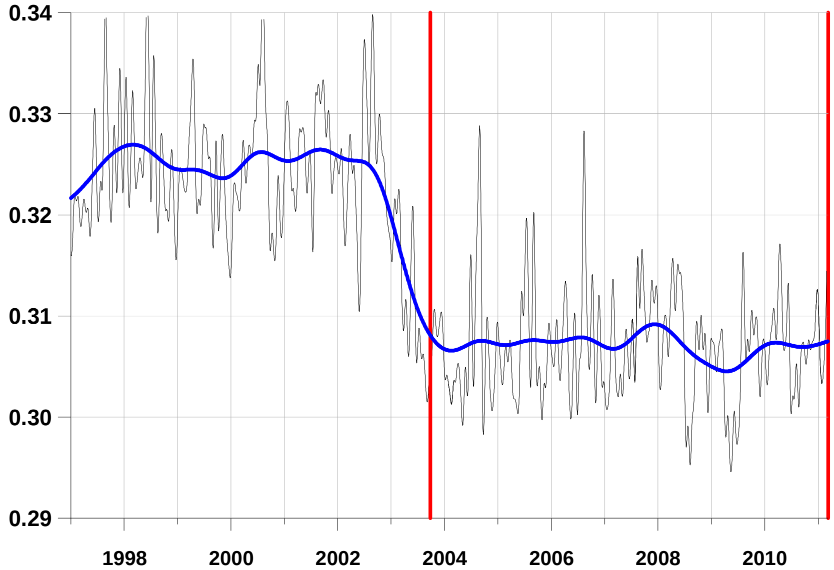


Fig.2. Median value of multi-fractal singularity spectra parameter $\Delta\alpha$.
Thin black line - Gaussian kernel smoothing with radius 13 days.
Bold blue line - Gaussian kernel smoothing with radius 0.5 year.
Vertical red lines indicate earthquakes: 25.09.2003, M=8.3 & 11.03.2011, M=9.0

The quantity $\Delta\alpha$ reflects the degree of diversity of the random behavior of the signal, and therefore, its decrease is an indirect indicator of the suppression (decrease) of certain degrees of freedom of the medium.

In the paper [4] the vertical components measured initially with a sampling rate of one second and subsequently converted into the signals sampled at 1 minute intervals by means of averaging and decimation are used in the analysis. Six statistics are taken as the parameters: the support width $\Delta\alpha$ of the multi-fractal singularity spectrum; the generalized Hurst exponent α^*; the asymmetry coefficient γ of the spectrum of singularity; the logarithmic variance $\lg(Var)$; the spectral exponent β; and the linear predictability index ρ. These parameters are calculated from the realizations contained within consecutive daily time intervals. When using the moving time window with a width of 1 year for evaluating the multiple correlation κ, the daily variations in the median values of the statistics of the noise measured at 5 spatial clusters of stations exhibit a stable increase in the synchronization not long before the Hokkaido earthquake, subsequently passing to the new level of high synchronization (Fig.3).

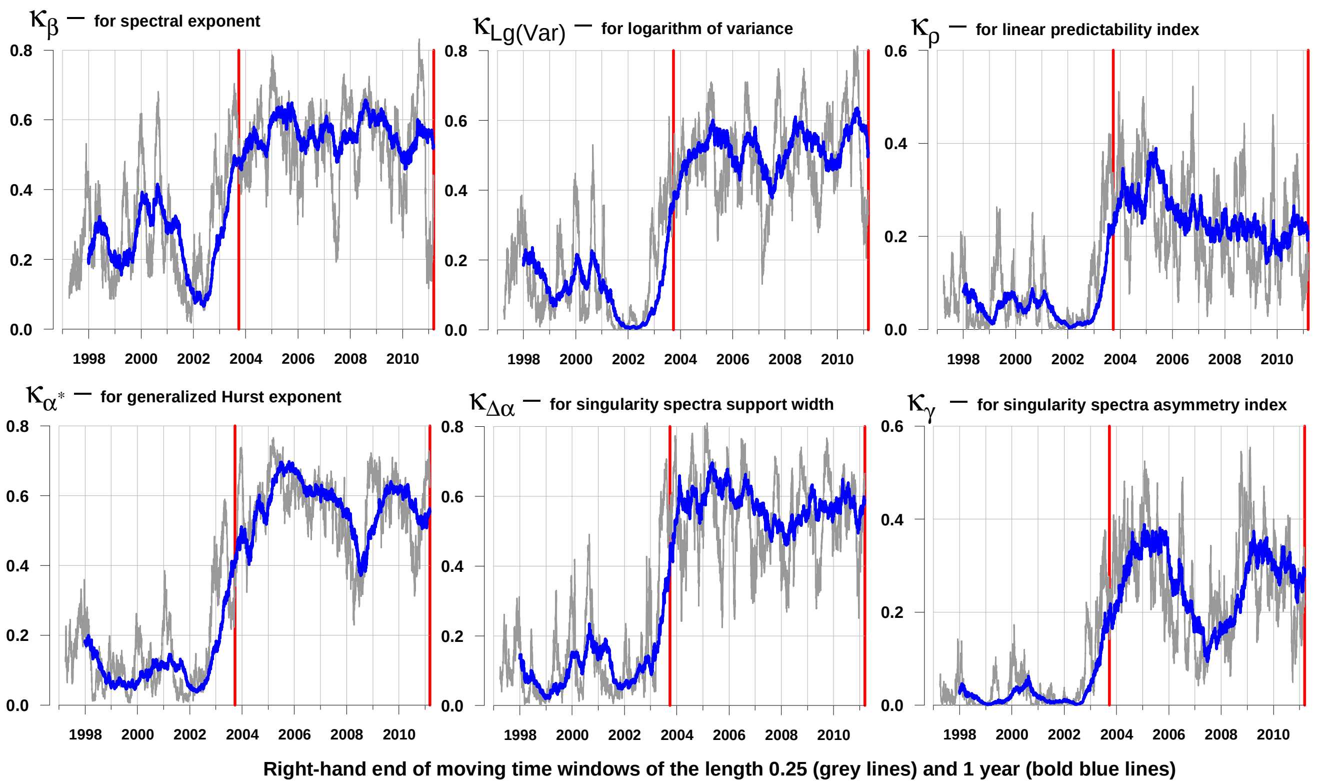


Fig.3. Multiple correlation measures κ (product of abs. canonical correlations) estimated within moving time window of the length 91 days (0.25 year - grey lines) and 365 days (1 year - bold blue lines) for increments of variations of medians of daily estimates of different statistical parameters of seismic records within adjacent 1 day time intervals for 1-minute data for 5 spatial clusters of stations.
Vertical red lines indicate earthquakes: M = 8.3, 25.09.2003 and M = 9.0, 11.03.2011

The analysis of the trends in the index of linear predictability gives a possibility to estimate the beginning of the enhancement in the synchronization with rather high accuracy as the middle of 2002. The effect revealed for the variations in the different parameters of microseisms is an independent argument for the conclusion about the synchronization in the field of the microseismic noise on the Japan Islands. Based on the well-known statement of the theory of catastrophes that synchronization is one of the flags of an approaching catastrophe, it may be suggested that the Hokkaido event, notwithstanding its power (M = 8.3), was the only a foreshock of a still stronger earthquake forming in the region of Japan's islands which occurred at 11 of March 2011, M = 9.0.

Another statistics which is estimated using different approach allows make a statement about anomalous behavior of microseisms field in Japan starting from the middle of 2008 as well. It is based on cluster analysis of the first 4 principal component of the 7D cloud of vector $\vec{\varsigma}$ composed of following scalar components: $\Delta\alpha$, α^*, γ, β, $\lg(Var)$, ρ and SI – waveform smoothing index, which is defined as median value of the number of vanishing moments for optimal orthogonal wavelet found from minimum of entropy of distribution of squared wavelet coefficients [5]. All these components are estimated for microseisms waveforms after coming to 1 minute sampling time interval within adjacent time windows of the length 1 day. Parameters β, $\lg(Var)$ and SI were calculated after removing trend by polynomial of 8th order within each "short" daily time window.

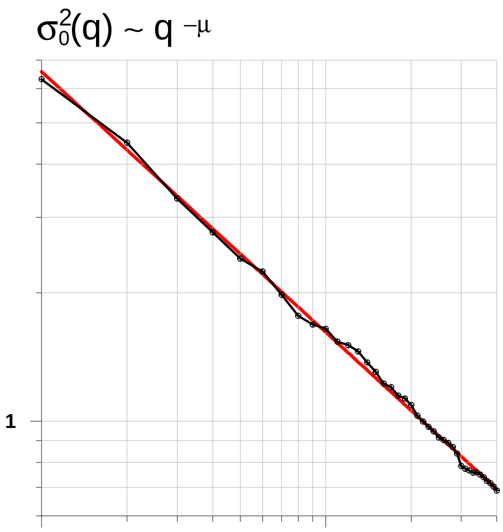


Fig.4. The dependence of clusters compactness functional on the number q of probe cluster.

Thus, from each day we have one 7D vector $\vec{\varsigma}$. Let us consider a "long" moving time window of the length 2 years (730 days) taken with mutual shift 7 days and perform a cluster analysis of these subsequent 7D sub-clouds of 730 vectors $\vec{\varsigma}$. The cluster analysis is done for the first 4 principal components by K-means approach for probe number of clusters q varying from maximum value 40 down to minimum value 1 (which means trivial case of no clustering of the current sub-cloud). The usual preliminary operations before performing cluster analysis within each "long" 2-years time window were done: winsorizing (iterative suppressing outliers) and normalizing each scalar component of the vector $\vec{\varsigma}$ to have a zero mean value and unit standard deviation. Let $\vec{\xi}$ be a 4D vector of the first 4 principal components of the 7D vector $\vec{\varsigma}$ within each 2-years window (the first 4 principal components carry 91-95% of general $\vec{\varsigma}$-variance after winsorizing and normalizing for different 2-years windows). For each probe number of clusters q the K-means approach minimizes the compactness functional $\sigma_0^2(q)=\sum_{k=1}^{q}\sum_{\vec{\xi}\in\Gamma_k}|\vec{\xi}-\vec{\eta}_k|^2$ with respect to positions $\vec{\eta}_k$ of centers of clusters Γ_k, $k=1,\ldots,q$.

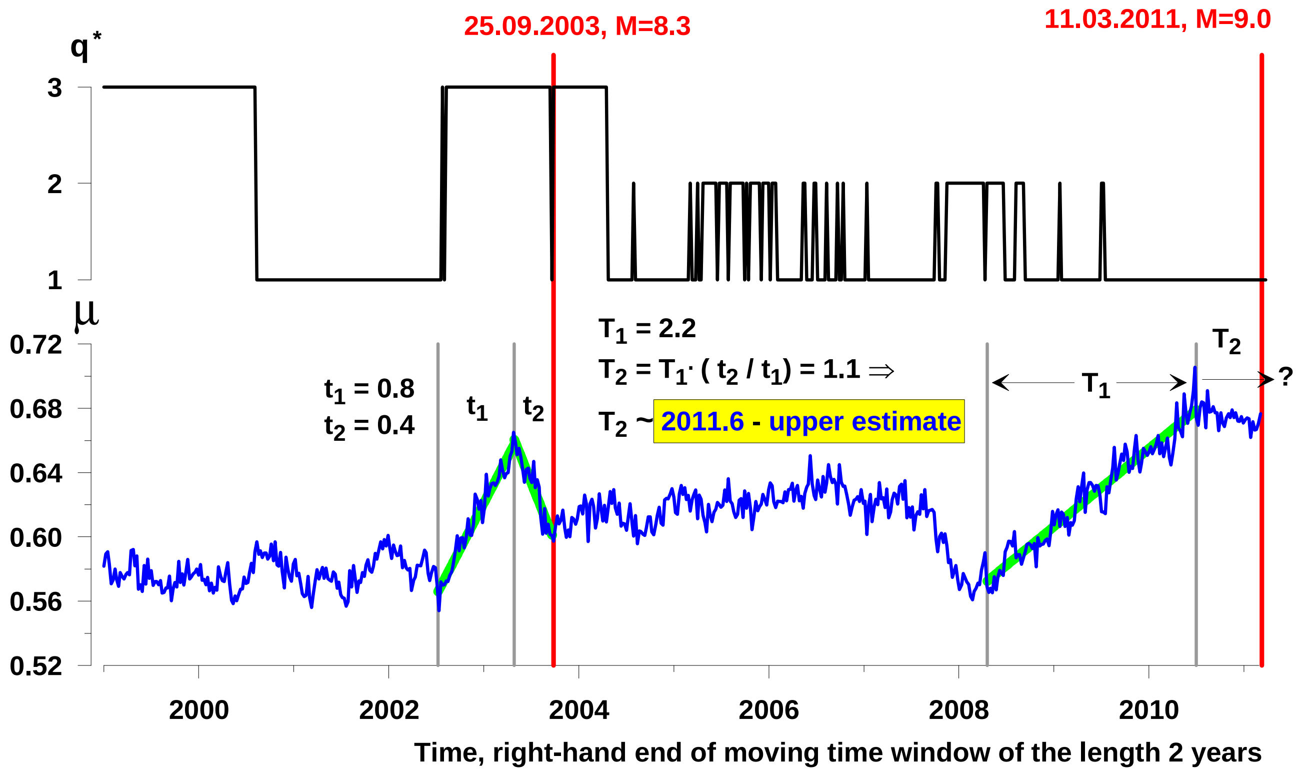


Fig.5. Optimum number of clusters q* and cluster exponent μ within dependence $\sigma_0^2(q) \sim q^{-\mu}$. Upper estimate of catastrophe time moment could be done at the end of 2010.

The value of $\sigma_0^2(q)$ monotonously increases with decreasing of clusters number q. At the same time the graphics of $\log(\sigma_0^2(q))$ in dependence on $\log(q)$ is very close to linear, i.e. $\sigma_0^2(q) \sim q^{-\mu}$ with some scaling exponent $\mu > 0$ which could be called a "cluster exponent" (Fig.4, red straight line presents linear best fit).

Let us estimate variations of cluster exponent μ in dependence on position of right-hand end of the "long" 2-years moving time window – Fig.5.

Except the high level of multiple coherence measures at the Fig.3 there is an intrigue behavior of cluster exponent for the whole F-net system at the Fig.5. It could be noticed that for a few nearest years a strong positive linear trend is observed which is similar to those before the earthquake 25 of Sept 2003 but this trend is more persistent. Moreover just before the seismic catastrophe at 11 of march, 2011 the behavior of cluster exponent was similar to the behavior before 25 of Sept 2003. Comparing 2 parts of linear trends of μ before Hokkaido event 25.09.2003 and the linear trend of μ for time interval [2008.3, 2010.5] provided a possibility at the end of 2010 to give 2011.6 as the upper estimate of time moment of future earthquake (see Fig.5).

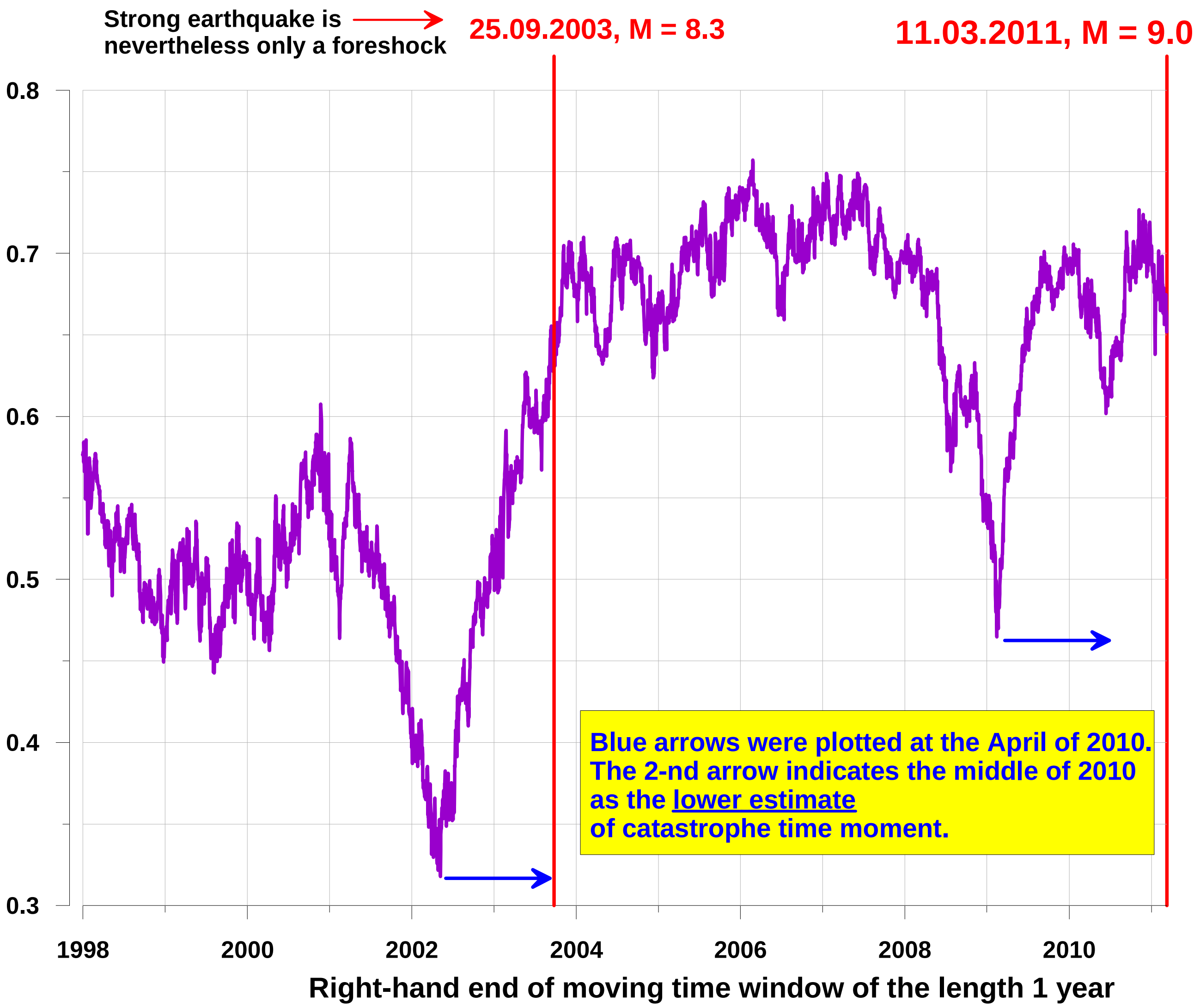


Fig.6. Squared robust correlation between $\Delta\alpha$ and α^*

The peculiarities of correlation coefficient estimate within 1 year time window between median values of singularity spectra support width $\Delta\alpha$ and generalized Hurst exponent α^* gave a possibility at the April of 2010 indicate middle of 2010 as the lower estimate of future earthquake (see Fig.6).

References. Papers and abstracts with prediction of strong earthquake at Japan Islands.

1. Lyubushin A.A. Mean Multifractal Properties of Low-Frequency Microseismic Noise - Proceedings of 31st General Assembly of the European Seismological Commission ESC 2008, Hersonissos, Crete, Greece, 7-12 September 2008, pp. 255-270. http://geoph-sync.org/MultiFractal_Properties_of_MicroSeismic_Noise_ESC-2008_Short_Paper.pdf
2. Lyubushin A.A. Multifractal Properties of Low-Frequency Microseismic Noise in Japan, 1997-2008. - Book of abstracts of 7th General Assembly of the Asian Seismological Commission and Japan Seismological Society, 2008 Fall meeting, Tsukuba, Japan, 24-27 November 2008, p.92.
3. Lyubushin A.A. Synchronization Trends and Rhythms of Multifractal Parameters of the Field of Low-Frequency Microseisms – Izvestiya, Physics of the Solid Earth, 2009, Vol. 45, No. 5, pp. 381–394. http://alexeylyubushin.narod.ru/Trends_and_Rhythms_of_MicroSeisms_Synchronization.pdf http://www.springerlink.com/content/u0m8666021127077/
4. Lyubushin A.A. The Statistics of the Time Segments of Low-Frequency Microseisms: Trends and Synchronization – Izvestiya, Physics of the Solid Earth, 2010, Vol. 46, No. 6, pp. 544–554. http://alexeylyubushin.narod.ru/LowFrequency_Microseisms_Statistics.pdf http://www.springerlink.com/content/dg574m78q2861006/
5. Lyubushin A.A. Cluster Analysis of Low-Frequency Microseismic Noise – Izvestiya, Physics of the Solid Earth, 2011, Vol. 47, No. 6, pp. 488–495. http://alexeylyubushin.narod.ru/Cluster_Analysis_LowFrequency_Microseisms.pdf http://www.springerlink.com/content/bp714871l218287m/
6. Lyubushin A., Multifractal Parameters of Low-Frequency Microseisms // V. de Rubeis et al. (eds.), Synchronization and Triggering: from Fracture to Earthquake Processes, GeoPlanet: Earth and Planetary Sciences 1, DOI 10.1007/978-3-642-12300-9_15, Springer-Verlag Berlin Heidelberg 2010, 388p., Chapter 15, pp.253-272. http://www.springerlink.com/content/hj2l211577533261
7. Lyubushin A.A. Synchronization of multifractal parameters of regional and global low-frequency microseisms – European Geosciences Union General Assembly 2010, Vienna, 02-07 of May, 2010, Geophysical Research Abstracts, Vol. 12, EGU2010-696, 2010. http://meetingorganizer.copernicus.org/EGU2010/EGU2010-696.pdf
8. Lyubushin A.A. Synchronization phenomena of low-frequency microseisms. European Seismological Commission, 32nd General Assembly, September 06-10, 2010, Montpelier, France. Book of abstracts, p.124, session ES6. http://www.esc2010.eu/cd/documents/Abstracts.pdf

The detailed description of all methods and results could be found within presentation by the address:

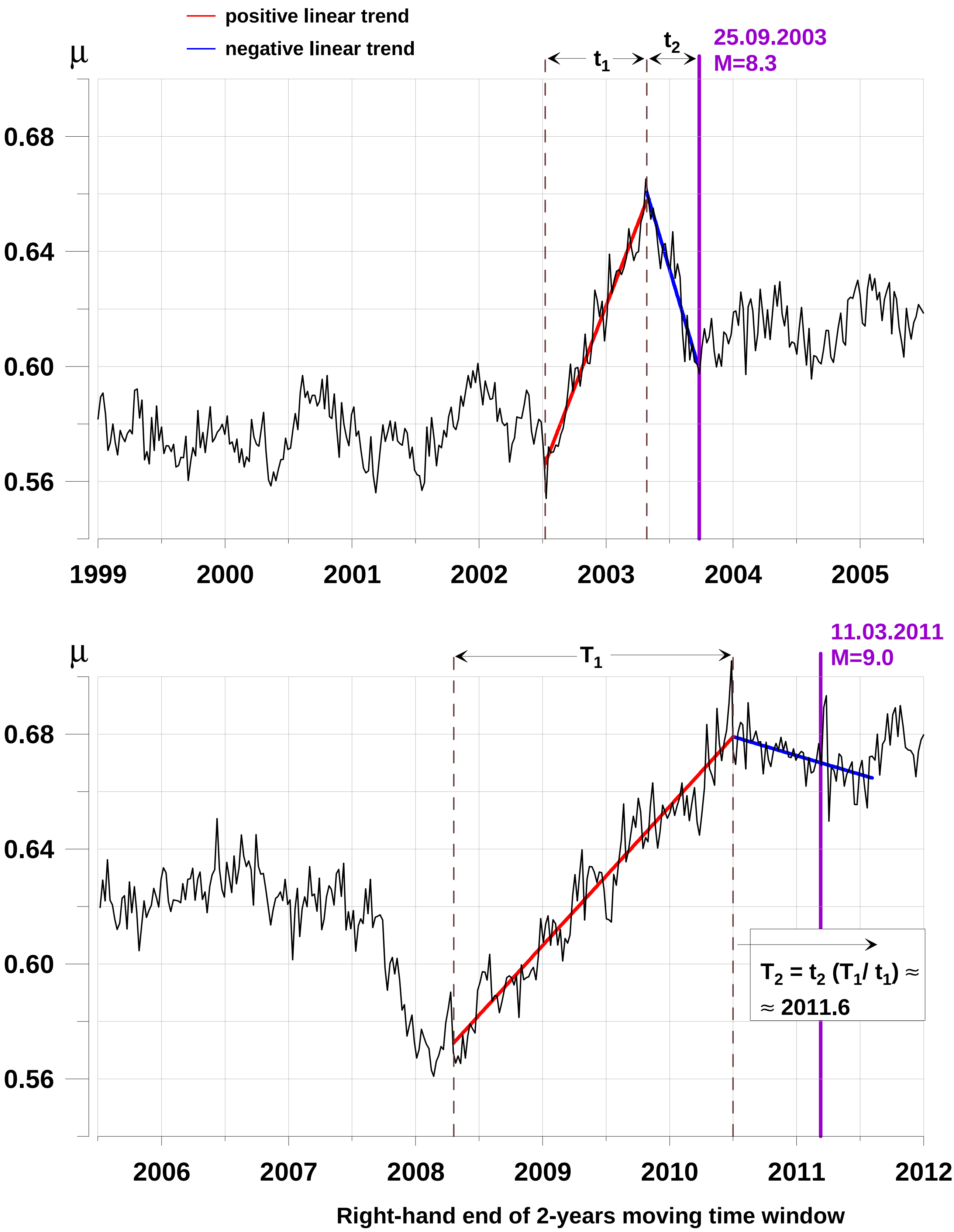
http://alexeylyubushin.narod.ru/Lyubushin_Japan_2011.03.11_Prediction_F-net_ENG.pdf

Publications after the earthquake:

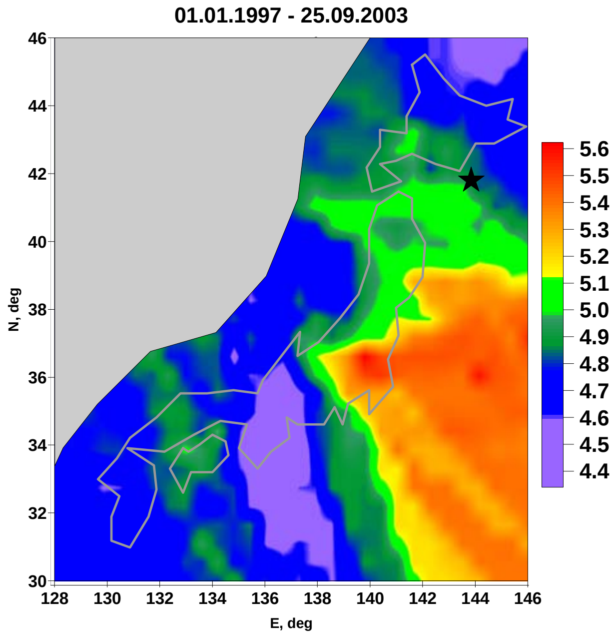
Lyubushin A.A. (2011) Seismic Catastrophe in Japan on March 11, 2011: Long-Term Prediction on the Basis of Low-Frequency Microseisms – Izvestiya, Atmospheric and Oceanic Physics, 2011, Vol. 46, No. 8, pp. 904–921. http://alexeylyubushin.narod.ru/Long-Term_Prediction_Tohoku_Catastrophe.pdf http://www.springerlink.com/content/kq53j2667024w715/

Lyubushin A.A., 2011, Prediction of Tohoku Seismic Catastrophe by microseismic noise multi-fractal properties, Abstract S53A-2273 presented at 2011 Fall Meeting, AGU, San Francisco, CA, 5-9 Dec.

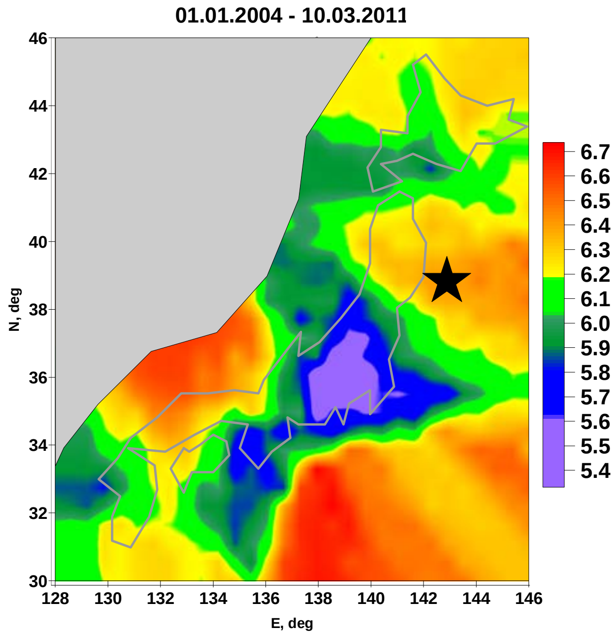
Cluster exponent μ before and after 11.03.2011 (up to 31.12.2011)



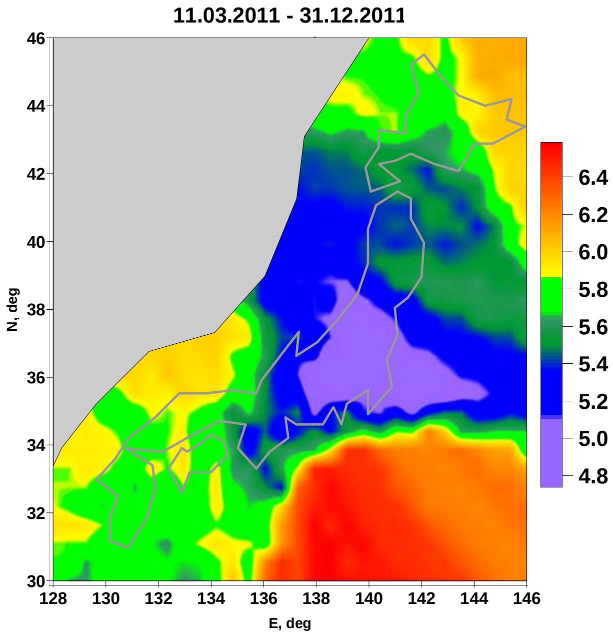
Maps of low-frequency seismic noise waveforms smoothness index, i.e. median value of the number of vanishing moments for the “best” orthogonal wavelet which is found for each station within each daily time window from the minimum of entropy.



From the beginning of 1997 up to 25 of September 2003: the area of future seismic catastrophe is characterized by relatively high values of smoothness index and it is not split into North and South parts.

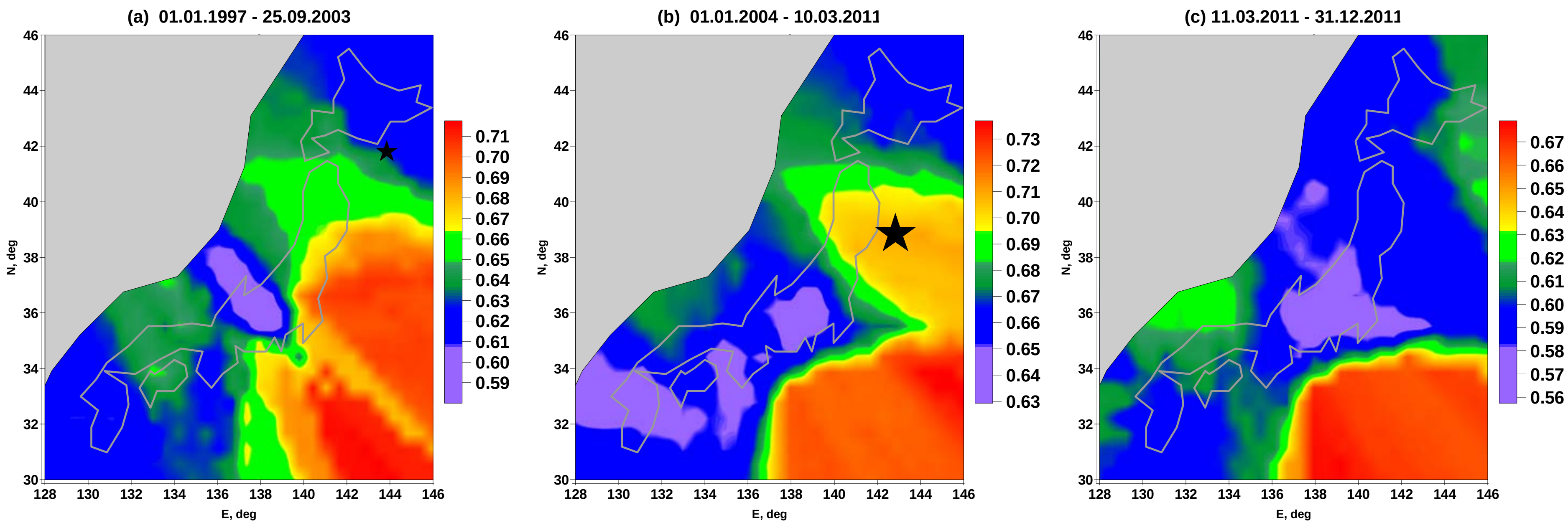


From the beginning of 2004 up to 10 of March 2011: the area of future seismic catastrophe is characterized by relatively high values of smoothness index and the previous area of high smoothness index values is split into North and South parts.



From 11 of March 2011 up to 31 of December 2011: the North part of the relatively high values of smoothness index before 25.09.2003 was realized as the area of Great Japan Earthquake 11 of March 2011, M=9.0, whereas the South part is still characterized by high smoothness index.

Maps of low-frequency seismic noise <u>wavelet-based normalized entropy</u>, i.e. normalized entropy of the noise waveforms squared wavelet coefficients for the "best" orthogonal wavelet which is found for each station within each daily time window from the minimum of entropy.



From the beginning of 1997 up to 25 of September 2003: the area of future seismic catastrophe is characterized by relatively high values of normalized entropy and it is not split into North and South parts.

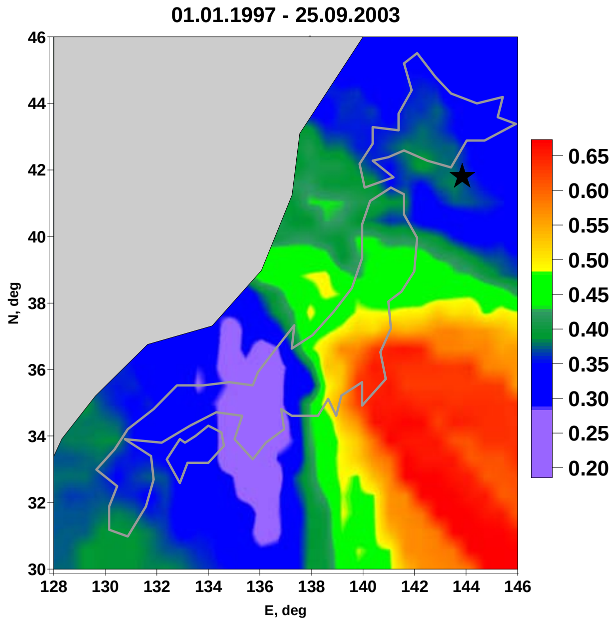
From the beginning of 2004 up to 10 of March 2011: the area of future seismic catastrophe is characterized by relatively high values of normalized entropy and the previous area of high entropy values is split into North and South parts.

From 11 of March 2011 up to 31 of December 2011: the North part of the relatively high values of normalized entropy before 25.09.2003 was realized as the area of Great Japan Earthquake 11 of March 2011, M=9.0, whereas the South part is still characterized by high entropy values.

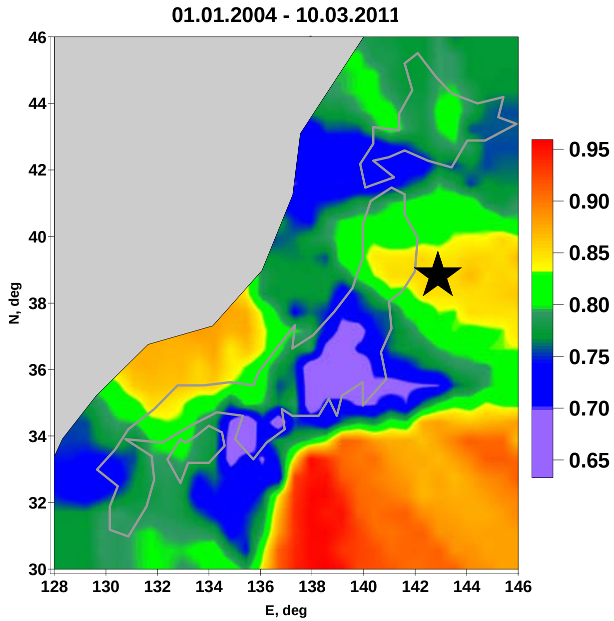
$$\text{Norm. entropy:} \quad En = -\sum_{k=1}^{N} p_k \cdot \log(p_k)/\log(N), \quad 0 \le En \le 1$$

$$p_k = c_k^2 / \sum_{j=1}^{N} c_j^2, \quad c_j \text{ - wavelet coeff. for the best orth. wavelet}$$

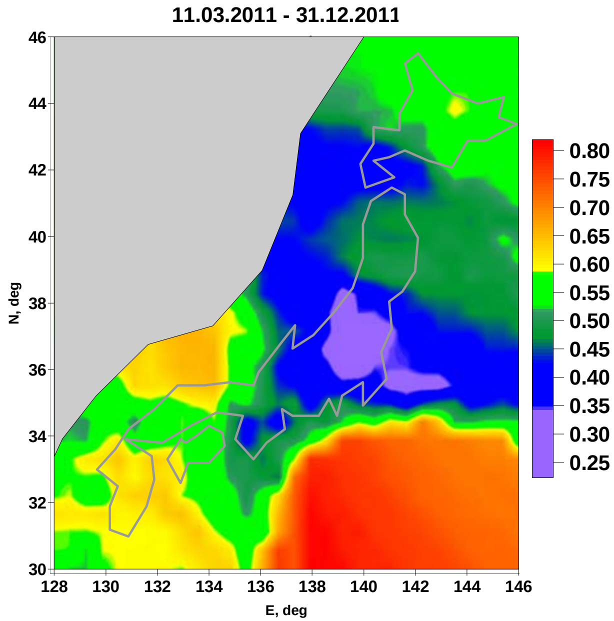
Maps of low-frequency seismic noise waveforms linear predictability index



From the beginning of 1997 up to 25 of September 2003: the area of future seismic catastrophe is characterized by relatively high values of seismic noise waveforms linear predictability index and it is not split into North and South parts.

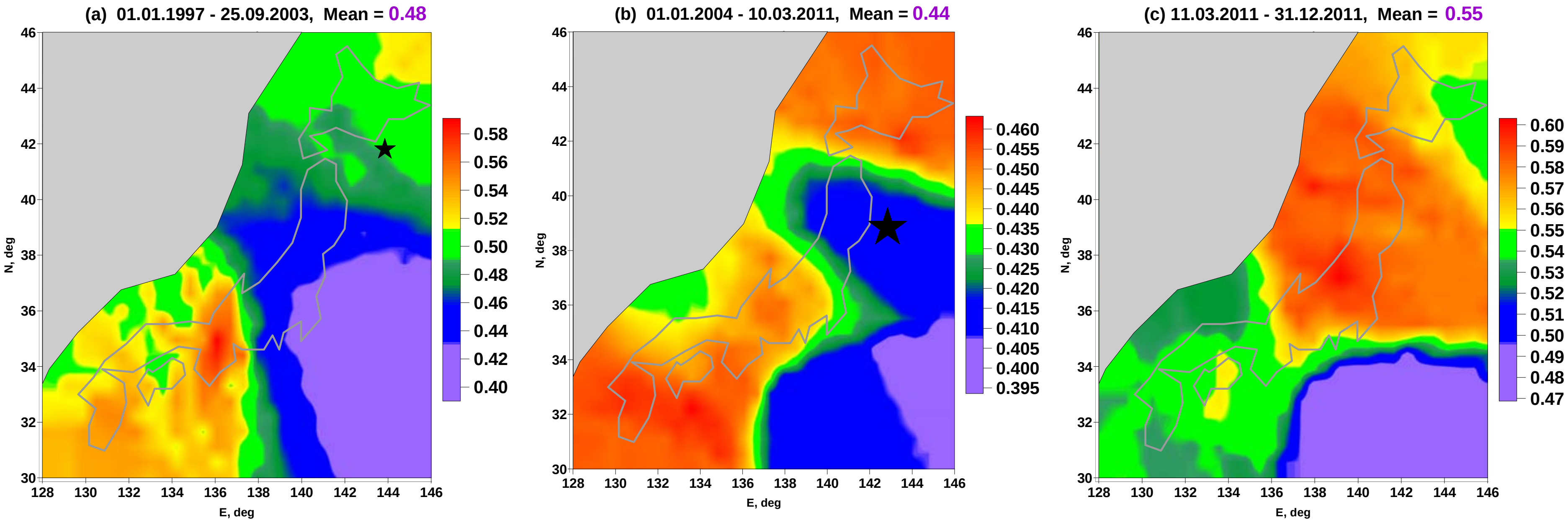


From the beginning of 2004 up to 10 of March 2011: the area of future seismic catastrophe is characterized by relatively high values of seismic noise waveforms linear predictability index and the previous area of high predictability index is split into North and South parts.



From 11 of March 2011 up to 31 of December 2011: the North part of the relatively high values of seismic noise waveforms linear predictability index before 25.09.2003 was realized as the area of Great Japan Earthquake 11 of March 2011, M=9.0, whereas the South part is still characterized by high predictability index values.

Maps of multi-fractal singularity spectra support width $\Delta\alpha$.
Low $\Delta\alpha$ values ("blue and violet regions") indicate synchronization and danger.



From the beginning of 1997 up to 25 of September 2003: the area of future seismic catastrophe is characterized by relatively low $\Delta\alpha$ and it is not split into North and South parts.

From the beginning of 2004 up to 10 of March 2011: the area of future seismic catastrophe is characterized by relatively low $\Delta\alpha$ and the previous area of low $\Delta\alpha$ values is split into North and South parts.

From 11 of March 2011 up to 31 of December 2011: the North part of the relatively low $\Delta\alpha$ values before 25.09.2003 was realized as the area of Great Japan Earthquake 11 of March 2011, M=9.0, whereas the South part is still characterized by low $\Delta\alpha$ values

The next pages contain some scans and copies of pages from articles and abstracts confirming the real forehead (not retrospective!) prediction of Great Japan Earthquake, M = 9.0, 11 of March, 2011.

PROGRAMME AND ABSTRACTS

The 7th General Assembly of Asian Seismological Commission

and

The 2008 Fall meeting of Seismological Society of Japan

24 (Mon.) - 27 (Thu.) November, 2008
Tsukuba International Congress Center
Tsukuba, Japan

Organizers
Asian Seismological Commission (ASC), IASPEI
Seismological Society of Japan

Cosponsors
Japan Society for the Promotion of Sciences
International Association of Seismology and Physics of the Earth's Interior
International Union of Geodesy and Geophysics
Tokio Marine Kagami Memorial Foundation
City of Tsukuba
Commemorative Organization for the Japan World Exposition('70)
Tsukuba Expo'85 Memorial Foundation
Tokyo Geographical Society
Association for the Development of Earthquake Prediction

C41-04

Multifractal Properties of Low-Frequency Microseismic Noise in Japan, 1997-2008.

Alexey Lyubushin (Institute of the Physics of the Earth, B.Gruzinskaya, 10, Moscow, 123995, Russia, lyubushin@yandex.ru)

The results of investigating properties of multifractal singularity spectra of low-frequency microseismic noise based on the analysis of broadband seismic stations F-net data in Japan, 1997 – June, 2008, are presented. Singularity spectra were estimated by DFA-method for vertical components with 1-sec sampling (LHZ-records) within adjacent time intervals of 0.5 hour length. Two parameters are analyzed: $\Delta\alpha$ – a width of singularity spectra argument interval and α^* – an argument providing maximum to singularity spectra. For each of 0.5-h time interval a median values (over all stations which have registration) of $\Delta\alpha$ and α^* were calculated forming an averaged time series of $(\Delta\alpha, \alpha^*)$-variations, gathering information from all stations. The time series of $\Delta\alpha$-variations has a statistically significant change of its mean value which began 0.5 years before Hokkaido earthquake M=8.3, 25.09.2003. Time series of α^*-variations estimated for seismic records after coming to 1 minute sampling has a 1-year periodicity before Hokkaido earthquake which disappears after this event. Using analogies with singularity spectra behavior of return-time sequences produced by a system of coupled chaotic oscillators these results are interpreted as a synchronization of low-frequency microseismic noise after Hokkaido event in 2003 which is continuing till now. A question arises whether Hokkaido 2003 earthquake could be a foreshock of future even more strong event in Japan?

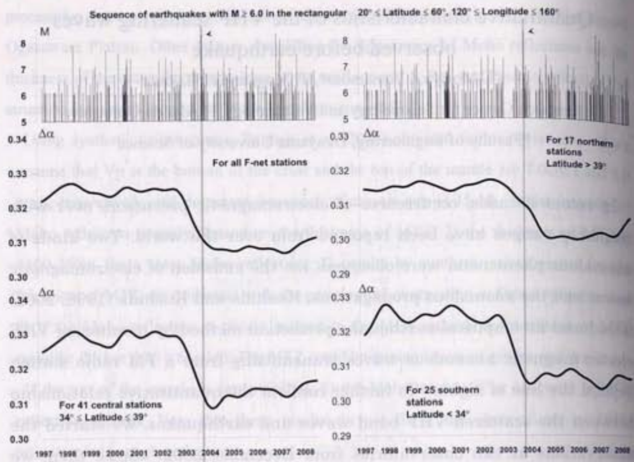


Fig. 1. Upper graphics: sequence of strong earthquakes, arrow indicates Hokkaido earthquake. Mean values: bold lines – computed by Gaussian kernel smoothing with radius 0.5 year, light grey lines – with smoothing radius 13 days, of medians of singularity spectra parameter $\Delta\alpha$ estimated for 1-sec seismic records for singular spectra estimated within adjacent time intervals of 30 minutes length.

Lyubushin A.A. Multifractal Properties of Low-Frequency Microseismic Noise in Japan, 1997-2008. - Book of abstracts of 7th General Assembly of the Asian Seismological Commission and Japan Seismological Society, 2008 Fall meeting, Tsukuba, Japan, 24-27 November 2008, p.92.

The earliest prediction (at the middle of 2008): the magnitude of oncoming catastrophe will be more than 8.3.

strong coupling, these oscillators become synchronous. It turned out that the synchronization of oscillators substantially decreases the singularity spectrum support width $\Delta\alpha$. Consequently, the set of results presented as plots in Figs. 3, 6, and 8 indicate that the field of microseismic oscillations in Japan after the 2003 event became synchronous, and this state is retained to the present day.

Based on the well-known statement of the theory of catastrophes that synchronization is one of the flags of an approaching catastrophe [Gilmore, 1981], it may be suggested that the Hokkaido event, notwithstanding its power ($M = 8.3$), could be only a foreshock of a still stronger earthquake forming in the region of Japan's islands.

As for the sharp decrease in seasonal variations of the parameter α^* for 1-min data after the September 25, 2003, earthquake, the interpretation of this result is not so transparent as for $\Delta\alpha$. We can only suggest that this decrease also reflects a blocking of some degrees of freedom of the medium, which were previously responsible for annual changes in the state of the lithosphere. On the other hand, the situation for 1-s data on $\Delta\alpha$ is the opposite: after the September 25, 2003, event, the annual variations became more clearly pronounced.

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I am grateful to Dr. Furumura Takashi (Earthquake Research Institute, University of Tokyo) for attracting my attention to the F-net database.

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REFERENCES

1. E. M. Lin'kov, *Seismic Phenomena* (LGU, Leningrad, 1987) [in Russian].
2. E. M. Lin'kov, L. N. Petrova, and K. S. Osipov, "Seismogravitational Pulsations of the Earth and Disturbances of the Atmosphere as Possible Precursors of Strong Earthquakes," Dokl. Akad. Nauk SSSR **313**(5), 1095–1098 (1990).
3. A. A. Lyubushin, "Analysis of Canonical Coherences in the Problem of Geophysical Monitoring," Fiz. Zemli, No. 1, 59–66 (1998) [Izvestiya, Phys. Solid Earth **34**, 52–58 (1998)].
4. A. A. Lyubushin, "Outbursts and Scenariosof Synchronization in Geophysical Observations," in *Sketches of Geophysical Investigations. To the 75th Anniversary of the Schmidt United Institute of Physics of the Earth* (OIFZ RAN, Moscow, 2003) pp. 130–134 [in Russian].
5. A. A. Lyubushin and G. A. Sobolev, "Multifractal Measures of Synchronization of Microseismic Oscillations in a Minute Range of Periods," Fiz. Zemli, No. 9, 18–28 (2006) [Izvestiya, Phys. Solid Earth **42**, 734–744 (2006)].
6. A. A. Lyubushin, *Analysis of Data of Geophysical and Ecological Monitoring* (Nauka, Moscow, 2007) [in Russian].
7. A. A. Lyubushin, "Microseismic Noise in a Minute Range of Periods: Properties and Possible Prognostic Indicators," Fiz. Zemli, No. 4, 17–34 (2008) [Izvestiya, Phys. Solid Earth **43** (2008)].
8. L. N. Petrova, "Seismogravitational Oscillationsof the Earth from Observations by Spaced Vertical Pendulums in Eurasia," Fiz. Zemli, No. 4, 83–95 (2002) [Izvestiya, Phys. Solid Earth **38**, 325–336 (2002)].
9. L. N. Petrova, E. G. Orlov, and V. V. Karpinskii, "On the Dynamics and Structure of Earth's Oscillations in December 2004 from Seismic Gravimeter Observations in St. Petersburg," Fiz. Zemli, No. 2, 12–20 (2007) [Izvestiya, Phys. Solid Earth **43**, 111–118 (2007)].
10. G. A. Sobolev, "Microseismic Variations Prior to a Strong Earthquake," Fiz. Zemli, No. 6, 3–13 (2004) [Izvestiya, Phys. Solid Earth **40**, 455–464 (2004)].
11. G. A. Sobolev, A. A. Lyubushin, and N. A. Zakrzhevskaya, "Synchronization of Microseismic Variations within a minute Range of Periods," Fiz. Zemli, No. 8, 3–27 (2005) [Izvestiya, Phys. Solid Earth **42**, 599–621 (2005)].
12. G. A. Sobolev and A. A. Lyubushin, "Microseismic Impulses As Earthquake Precursors," Fiz. Zemli, No. 9, 5–17 (2006) [Izvestiya, Phys. Solid Earth **42**, 721–733 (2006)].
13. G. A. Sobolev and A. A. Lyubushin, "Microseismic Anomalies before the Sumatra Earthquake of December 26, 2004," Fiz. Zemli, No. 5, 3–16 (2007) [Izvestiya, Phys. Solid Earth **43**, 341–353 (2007)].
14. G. A. Sobolev, A. A. Lyubushin, and N. A. Zakrzhevskaya, "Asymmetric Impulses, Periodicities and Synchronization of Low-Frequency Microseisms," Vulkanol. Seismol., No. 2, 135–152 (2008).
15. G. A. Sobolev, "Series of Asymmetric Impulses in a Minute Range of Microseisms As Indicators of a Metastable State of Seismically Active Zones," Fiz. Zemli, No. 4, 3–16 (2008) [Izvestiya, Phys. Solid Earth (2008)].
16. G. Currenti, C. del Negro, V. Lapenna, and L. Telesca, "Microfractality in Local Geodynamic Fields at Etna Volcano, Sisily (Southern Italy)," Natural Hazards and Earth System Sciences **5**, 555–559 (2005).
17. R. O. Duda and P. E. Hart, *Pattern Classification and Scene Analysis* (John Wiley and Sons, New York, London, Sydney, 1973; Mir, Moscow, 1976).
18. G. Ekstrom, "Time Domain Analysis of Earth's Long-Period Seismic Radiation," J. Geophys. res. **106**, N B11, 26483–26493 (2001).
19. J. Feder, *Fractals* (Plenum Press, New York, 1988; Mir, Moscow, 1991).
20. A. Friederich, F. Krüder, and K. Klinge, "Ocean-Generated Microseismic Noise Located with the Gräfenberg Array," Journal of Seismology **2**, No. 1, 47–64 (1998).
21. R. Gilmore, *Catastrophe Theory for Scientists and Engineers* (John Wiley and Sons, New York, 1981; Mir, Moscow, 1984).
22. W. Hardle, *Applied Nonparametric Regression* (Cambridge Univ. Press, Cambridge, New York, New Rochell, Melbourne, Sydney, 1989; Mir, Moscow, 1993).

From: Lyubushin A.A. Synchronization Trends and Rhythms of Multifractal Parameters of the Field of Low-Frequency Microseisms – Izvestiya, Physics of the Solid Earth, 2009, Vol. 45, No. 5, pp. 381–394.
http://alexeylyubushin.narod.ru/Trends_and_Rhythms_of_MicroSeisms_Synchronization.pdf
http://www.springerlink.com/content/u0m8666021127077/

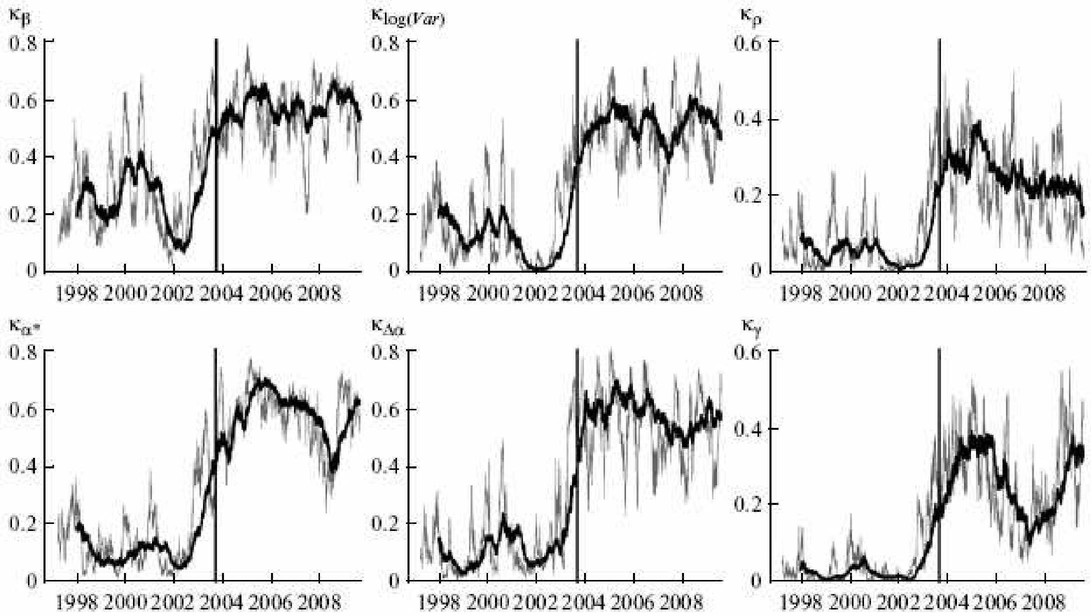

Fig. 4. The graphs of the robust multiple measure for correlation κ, evaluated for the increment of the median values of six statistics $\overline{\beta}$, $\overline{\log(Var)}$, $\overline{\rho}$, $\overline{\alpha}^*$, $\overline{\Delta\alpha}$, and $\overline{\gamma}$ (the subscript of value κ), calculated for the seismic stations within the five spatial clusters (Fig. 1) for one-minute data in the consecutive days. The gray lines correspond to the estimates of κ in the window with a length of 0.25 year (91 counts), and the black lines correspond to the estimates of κ in the window with a length of one year (365 counts). The vertical solid lines correspond to the time of the earthquake of September 25, 2003.

CONCLUSIONS

The method for calculating spatial averages over the clusters of the observation points of the monitoring systems is developed and implemented. This method allows one to calculate efficiently the measure of correlation and coherence of variations in any statistics, determined on consecutive time intervals in the presence of interruptions in the operation of separate stations.

The analysis showed that the use of time windows with large lengths (one year) makes the identification of the effects of synchronization very stable and statistically significant. This paper presents an independent (based not only on the parameters of the spectra of singularity) validation of the main conclusion of the work [Lyubushin, 2009] about synchronization in the parameters of a low-frequency microseismic field on the Japanese islands related with the Hokkaido earthquake of September 25, 2003; the use of the new statistics, namely the index of linear predictability, allowed me to determine with rather high accuracy the starting time of the systematic increase in the synchronization as July 2002.

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REFERENCES

1. J. Berger, P. Davis, and G. Ekstrom, "Ambient Earth Noise: A Survey of the Global Seismographic Network," J. Geophys. Res. **109**, B11307 (2004).
2. G. E. P. Box and G. M. Jenkins, *Time Series Analysis. Forecasting and Control* (Holden-Day, San Francisco, 1970; Mir, Moscow, 1974).
3. D. R. Cox and D. V. Hinkley, *Theoretical Statistics* (Chapman and Hall, London, 1974; Mir, Moscow, 1978).
4. G. Currenti, C. del Negro, V. Lapenna, and L. Telesca, "Multifractality in Local Geomagnetic Field at Etna Volcano, Sicily (Southern Italy)," Natural Hazards and Earth System Sciences 5, 555–559 (2005).
5. G. Ekstrom, "Time Domain Analysis of Earth's Long-Period Background Seismic Radiation," J. Geophys. Res. **106** (B11), 26483–26493 (2001).
6. J. Feder, *Fractals* (Plenum Press, New York, 1988; Mir, Moscow, 1991).
7. A. Friedrich, F. Krüger, and K. Klinge, "Ocean-Generated Microseismic Noise Located with the Grafenberg Array," Journal of Seismology 2 (1), 47–64 (1998).

From: Lyubushin A.A. The Statistics of the Time Segments of Low-Frequency Microseisms: Trends and Synchronization – Izvestiya, Physics of the Solid Earth, 2010, Vol. 46, No. 6, pp. 544–554.
http://alexeylyubushin.narod.ru/LowFrequency_Microseisms_Statistics.pdf
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Independent and direct confirming of synchronization increasing by estimating robust multiple correlation coefficient between 5 spatial groups of stations within 1 year moving time window.

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Cluster Analysis of Low-Frequency Microseismic Noise

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Abstract—A method is proposed for describing low-frequency microseismic noise from the network of broadband seismic stations in a large seismically active region of the Japan Islands. The median values of daily estimates from each station for seven parameters (three characteristics of the multifractal singularity spectra of the waveforms, their spectral exponents and the smoothness indices, the logarithmic variance and the linear predictability index) are used for the description. These parameters are determined for consecutive daily time intervals from the beginning of January 1997 through the end of February 2010. Since these parameters are taken as the median values of the estimates from each station, they are, actually, the integral statistics of the microseismic field. The present paper is the continuation of two previous works [Lyubushin, 2009; 2010], where the effects of synchronization in the low-frequency microseismic field on a large time scale were analyzed on the data from the *F*-net stations. In the present work, the number of different "behavior modes" of the microseismic field are sought as the number of clusters in the optimal partition of the cloud of 7-dimensional vector parameters, estimated within a moving time window with a width of 2 years. A new characteristic of the geophysical field is introduced, namely, the notion of the cluster exponent, which is the power exponent in the dependence of the value of the compactness function of a cloud of vector parameters on the number of clusters in the optimal partition of this cloud. Previously, a relatively rapid increase was revealed in the level of synchronization of the microseismic field, which started in the middle of 2002 and lasted for approximately one year. The level of synchronization remains high up to now. During the past 4 years (taking into account the width (2 years) of the time window within which the estimates were made), the cluster exponent exhibits a long trend which is similar to the shorter trend before the Hokkaido event ($M = 8.3$) that occurred on September 25, 2003. These facts, together with the pattern of variations in the coefficient of correlation between two multifractal parameters of the field, suggest a hypothesis of the enhancement of the seismic hazard in the region of the Islands of Japan from the second half of 2010.

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http://www.springerlink.com/content/bp714871l218287m/

CONCLUSIONS

A method is proposed for the analysis of microseismic noise by studying the clustering of its parameters, averaged over the network stations in a moving time window. As applied to the analysis of the field of microseismic oscillations on the Japan Islands, this technique revealed an anomaly before the Hokkaido earthquake of September 25, 2003, as well as a recent anomaly that started in 2007–2008. Supposedly, the latter feature is a sign of a noticeable enhancement of seismic hazard in Japan starting from the second half of 2010.

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REFERENCES

Aivazyan, S.A.,Bukhshtaber, V.M., Enyukov, I.S., and Meshalkin, L.D., *Prikladnaya statistika. Klassifikatsiya i snizhenie razmernosti* (Applied Statistics: Classification and Dimension Reduction), Moscow: Finansy i Statistika, 1989.

Box, G.E.R. and Jenkins, G.M., *Time Series Analysis: Forecasting and Control,* San Francisco, CA: Holden-Day, 1970.

Duda, R.O. and Hart, R.E., *Pattern Classification and Scene Analysis,* New York: Wiley, 1973.

Ekstrom, G., Time Domain Analysis of Earth'S Long-Period Background Seismic Radiation, *J. Geophys. Res.,* 2001, vol. 106, no. B11, pp. 26 483–26 493.

Feder, J., *Fractals*, New York: Plenum, 1988.

Friedrich, A., Kruger, F., and Klinge, K., Ocean-Generated Microseismic Noise Located with the Gr@afenberg Array, *J. Seismol.,* 1998, vol. 2, no. 1, pp. 47–64.

Kantelhardt, J.W., Zschiegner, S.A., Konscienly-Bunde, E., et al., Multifractal Detrended Fluctuation Analysis of Nonstationary Time Series, *Phys. A (Amsterdam, Neth.),* 2002, vol. 316, pp. 87–114.

Kashyap, R.L. and Rao, A.R., *Dynamic Stochastic Models from Empirical Data,* New York: Academic Press, 1976.

Kobayashi, N. and Nishida, K., Continuous Excitation of Planetary Free Oscillations by Atmospheric Disturbances, *Nature,* 1998, vol. 395, pp. 357–360.

Kurrle, D. and Widmer-Schnidrig, R., Spatiotemporal Features of the Earth's Background Oscillations Observed in Central Europe, *Geophys. Rev. Lett.,* 2006, vol. 33, p. L24304.

Lyubushin, A.A. and Sobolev, G.A., Multifractal Measures of Synchronization of Microseismic Oscillations in a Minute Range of Periods, *Fiz. Zemli,* 2006, no. 9, pp. 18–28 [*Izv. Phys. Earth* (Engl. Transl.), 2006, vol. 42, no. 9, pp.?734–744].

Lyubushin, A.A., *Analiz dannykh sistem geofizicheskogo i ekologicheskogo monitoringa* (Geophysical and Ecological Monitoring Data Analysis), Moscow: Nauka, 2007.

Lyubushin, A.A., Microseismic Noise in the Low Frequency Range (Periods of 1–300 min): Properties and Possible Prognostic Features, *Fiz. Zemli,* 2008, no. 4, pp. 17–34 [*Izv. Phys. Earth* (Engl. Transl.), 2008, vol. 44, no. 4, pp. 275–290].

Lyubushin, A.A., Synchronization Trends and Rhythms of Multifractal Parameters of the Field of Low-Frequency Microseisms, *Fiz. Zemli,* 2009, no. 5, pp. 15–28 [*Izv. Phys. Earth* (Engl. Transl.), 2009, vol. 45, no. 5, pp. 381–394].

Lyubushin, A.A., The Statistics of the Time Segments of Low-Frequency Microseisms: Trends and Synchronization, *Fiz. Zemli,* 2010, no. 6, pp. 86–96 [*Izv. Phys. Earth* (Engl. Transl.), 2010, vol. 46, no. 6, pp. 544–554].

Mallat, S.A, *A Wavelet Tour of Signal Processing,* San Diego: Academic Press, 1998.

Pavlov, A.N., Sosnovtseva, O.V., and Mosekilde, E., Scaling Features of Multimode Motions in Coupled Chaotic Oscillations, *Chaos, Solitons Fractals,* 2003, vol. 16, pp. 801–810.

Rhie, J. and Romanowicz, B., Excitation of Earth's Continuous Free Oscillations by Atmosphere-Ocean-Seafloor Coupling, *Nature,* 2004, vol. 431, pp. 552–556.

Sobolev, G.A. and Lyubushin, A.A., Microseismic Impulses as Earthquake Precursors, *Fiz. Zemli,* 2006, no. 9, pp. 5–17 [*Izv. Phys. Earth* (Engl. Transl.), 2006, vol. 42, no. 9, pp. 721–733].

Sobolev, G.A., Lyubushin, A.A., and Zakrzhevskaya, N.A., Asymmetrical Pulses, the Periodicity and Synchronization of Low Frequency Microseisms, *Vulkanol. Seismol.,* 2008, no. 2, pp. 135–152 [*J. Volcanol. Seismol.* (Engl. Transl.), 2008, vol. 2, no. 2, pp. 118–134].

Sobolev, G.A., Lyubushin, A.A., and Zakrzhevskaya, N.A., Synchronization of Microseismic Variations within a Minute Range of Periods, *Fiz. Zemli,* 2005, no. 8, pp. 3–27 [*Izv. Phys. Earth* (Engl. Transl.), 2005, vol. 41, no. 8, pp. 599–621].

Stehly, L., Campillo, M., and Shapiro, N.M., A Study of the Seismic Noise from Its Long-Range Correlation Properties, *J. Geophys. Res.,* 2006, vol. 111, p. B10306.

Tanimoto, T. and Um, J., Cause of Continuous Oscillations of the Earth, *J. Geophys. Res.,* 1999, vol. 104, no. B12, p. 28 723–28 739.

Tanimoto, T., Continuous Free Oscillations: Atmosphere–Solid Earth Coupling, *Annu. Rev. Earth Planet. Sci,* 2001, vol. 29, pp. 563–584.

Tanimoto, T., The Oceanic Excitation Hypothesis for the Continuous Oscillations of the Earth, *Geophys. J. Int.,* 2005, vol. 160, p. 276–288.

Tanimoto, T., Um, J., Nishida, K., and Kobayashi, N., Earth'S Continuous Oscillations Observed on Seismically Quiet Days, *Geophys. Rev. Lett.,* 1998, vol. 25, pp. 1553–1556.

Vogel, M.A. and Wong, A.K.C., PFS Clustering Method, *IEEE Trans. Pattern Analysis. Mach. Intell.,* 1979, vol. PAMI-1, no. 3, pp. 237–245.

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Synchronization of multifractal parameters of regional and global low-frequency microseisms

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Low-frequency microseismic oscillations is an important source of information about processes within Earth's crust although their origin is mostly due to atmospheric and oceanic processes. The Earth's crust is a propagation media for such oscillations and the changes within Earth's crust follows in changing of statistical properties of microseisms.

The vertical seismic records with sampling rate 1 Hz obtained from global IRIS broad-band seismic network (2004-2005, 123 stations) and Japan F-net (1997-2010, 83 stations) were analyzed by estimating their multifractal singularity spectra parameters (the width of singularity spectra support and generalized Hurst's exponent, i.e. argument providing maximum to singularity spectra) within adjacent "short" time windows of the length 30 minutes.

The seismic stations were split into a number of spatial clusters (7 clusters for global IRIS network and 5 clusters for Japan F-net). The median values of singularity spectra parameters were taken from stations in each cluster within 30 minutes time windows - this operation is a spatial smoothing and give a possibility to get rid of gaps within registration on some stations. Thus, a multi-dimensional time series of medians of singularity spectra parameters with uniform sampling time interval 30 minutes were obtained.

A multiple correlation measure (as the product of absolute values of by-component robust canonical correlations) estimated within "long" moving time window (4 months for global IRIS, 2004-2005, network data and 1 year for Japan, 1997-2010, F-net records) was estimated for these median time series. Using of long time windows for estimating multiple correlation measure allows to average influence of storms and hurricanes.

The main results are the following: 1) a synchronization of global microseisms multi-fractal parameters was observed during 160 days prior to catastrophic Sumatra earthquake, M=9.1, 26 of December, 2004; 2) a synchronization of regional microseisms multi-fractal parameters in Japan started 0.5 year before Hokkaido earthquake, M=8.3, 25 of September and the level of synchronization remains high since the end of 2003 till now - this could be a flag of approaching catastrophic earthquake in Japan.

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FIELD VERIFICATION AND MATHEMATICAL SIMULATION OF TRANSIENT SEISMIC PROCESSES

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The transient processes in seismicity are considered as a response to the quite powerful influences of different origin, which disturb stationary state of seismicity. Investigation of the transient process allows to study regularities of seismicity excitation and relaxation and to reveal physical factors controlling the dynamics of seismicity. A series of laboratory experiments for modeling of transient processes in seismicity was carried out. Laboratory results was verified by field experiment in Soultz-sous-Forets (France) hot dry rock area and analysis of natural seismic swarms in Corinth rift. Physical interpretation and mathematical simulation for found regularities was suggested. The aim of the experiments was to understand the character of excitation and relaxation of the failure, triggered by the external influence. The failure initiated by step-wise strain or force impacts results in transient acoustic emission similar to aftershocks and swarms. When increasing quickly, such impact generates processes similar to aftershock sequences; when increasing gradually, it generates swarm-like activity. The parameters of the induced activity change in a regular manner with increasing acting stress level: the stronger the stress, the later the activity starts to decay; Gutenberg-Richter b-value decreases with stress increasing; parameters of the Omori's law changes too. b-value varies in time during excitation and relaxation of acoustic activity (for given stress level): it decreases when activity is increasing and increases when activity is decreasing. This indicates a transition of failure at the increase stage from lower to higher levels (crack grows and fusion scenario) and from higher to lower levels at the decay stage (aftershock scenario). Similar regularities was found in natural conditions: in the experiment of seismicity generation by the water injection into a borehole (Soultz-sous-Forets, France) and in seismic swarms in Corinth rift. A hypothesis of excitation and depletion of some «failure reservoir» is suggested for explanation of obtained regularities. Mathematical simulation has confirmed the validity of this hypothesis. The work is supported by RFBR grant 08-05-00248 and project 08-05 of IPGP - IPGM collaboration.

ES6/TH/O10 - SYNCHRONIZATION PHENOMENA OF LOW-FREQUENCY MICROSEISMS.

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The vertical seismic records with sampling rate 1 Hz obtained from global IRIS broadband seismic network (1988-2009, 131 stations) and Japan F-net (1997-2010, 83 stations) were analyzed by estimating their multi-fractal parameters: the width of singularity spectra support, generalized Hurst's exponent and coefficient of singularity spectra asymmetry. Besides that linear predictability index of waveforms, spectral exponent and logarithm of variance were estimated as well. These statistics were calculated within adjacent «short» time windows of the length 30 minutes for initial 1 Hz data and for time windows of the length 1 day for records after coming to 1 minutes sampling.The seismic stations were split into a number of spatial clusters (7 clusters for global IRIS network and 5 clusters for F-net). The median values of all parameters were taken from stations in each cluster. A multiple correlation measures for different combinations of parameters were estimated within moving time window of the length 1 and 2 years for these median time series with uniform sampling time interval 1 day. Using of long time windows for estimating multiple correlation measure allows to average influence of storms and hurricanes.The sequence of waves of microseisms noise essential global synchronization was extracted. The most strong synchronization effects correspond to time interval 2003-2007 and the 2nd one started at the beginning of 2008 and is continuing till now. The microseisms field at Japan islands transfers to high level synchronization of its parameters starting from the middle of 2002, one year before the Hokkaido earthquake, 25 of September, 2003, M=8.3. This high level of synchronization keeps rather constant up to the current time. Based on the statement of the theory of catastrophes that synchronization is one of the flags of an approaching catastrophe, it may be suggested that the Hokkaido event, notwithstanding its power (M=8.3), could be only a foreshock of a still stronger earthquake at the region of Japan's islands. The cluster analysis of 7 median daily statistics from the whole network indicates a strong linear trend of cluster exponent starting from 2007 which is continuing till now. This trend peculiarity is similar to the trend before 2003 event. The peculiarities of correlation coefficient estimate within 1 year time window between median values of singularity spectra support width and generalized Hurst exponent indicates that starting from July of 2010 Japan islands come to the state of waiting strong earthquake.

ES6/TH/O11 - A STUDY OF TEMPORAL VARIATIONS IN 'B' VALUE AND MAGNITUDE OF COMPLETENESS FOR THE HIMALAYAN REGION.

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The Himalayan arc region is one of the most seismically active region of the world. An earthquake catalog containing over 3812 earthquake events with 622 events having more than 5.0 magnitude for the Himalayan region for the period 1964-2007 is considered. In this study, earthquake data are collated for the period 1964-2007 from International Seismological Center (ISC), National Earthquake Information Centre (NEIC) and HRVD. This catalog is analyzed to determine the variations in the seismic parameters and magnitude of completeness in time. Seismic parameters have been determined by two different methods namely, Maximum Curva-

The latest prediction: dangerous time for waiting catastrophe begins at the middle of 2010

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