Method of noise detection in magnetic data based on wavelet-transformation and adaptive thresholds

Papsheva S.Yu., Mandrikova O.V., Khomutov S.Yu.
Institute of Cosmophysical Research and Radio Wave Propagation FEB RAS

Метод обнаружения помех в геомагнитных данных на основе вейвлет-преобразования и адаптивных порогов

Папшева С.Ю., Мандрикова О.В., Хомутов С.Ю.

Институт космофизических исследований и распространения радиоволн ДВО РАН

Algorithm for detecting noises from natural and technogenic origin

1) mapping data to wavelet space

$$(W_\Psi f)(b,a) = |a|^{-1/2} \int_{-\infty}^{\infty} f(t)\Psi\left(\frac{t-b}{a}\right) dt,$$

где Ψ– wavelet, $f \in L^2(R)$, $a, b \in R'$ $a \neq 0$, a– scale, b – time.

2) estimation of the intensity of interference on an informative scale

$$E_b = \sum_{a_i} e_{b,a_i} ,$$

$$e_{b,a_i} = |(W_\Psi f)(b, a_i)|.$$

3) noise isolation based on the use of adaptive values of threshold functions

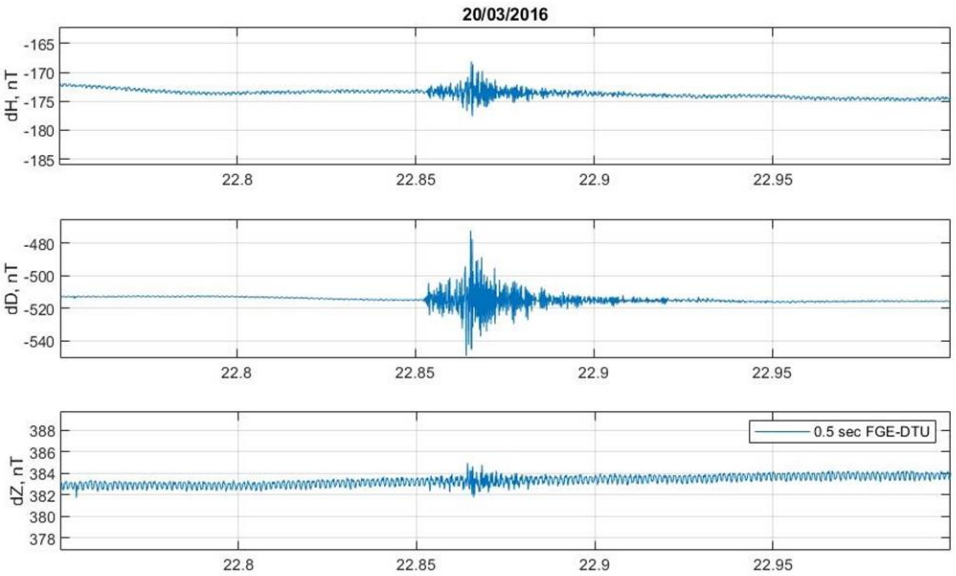
$$P_{T_a}(E_b) = \begin{cases} 1, \text{если } E_b > T_a \\ 0, \text{если } E_b \leq T_a \end{cases},$$

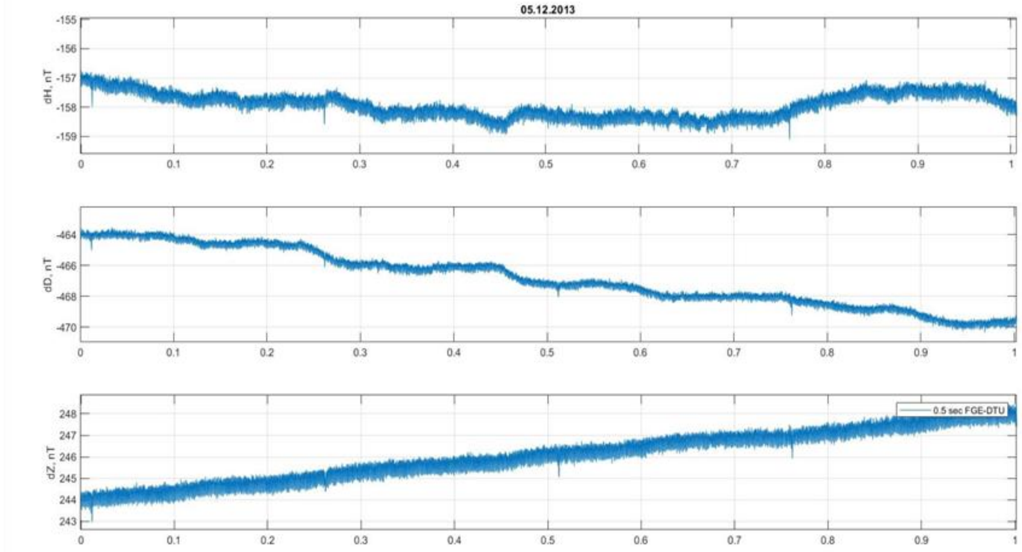
где T_a – scale range threshold $1, \ldots, a$. Value $P_{T_a}(E_b) = 1$ indicates the presence of noise.

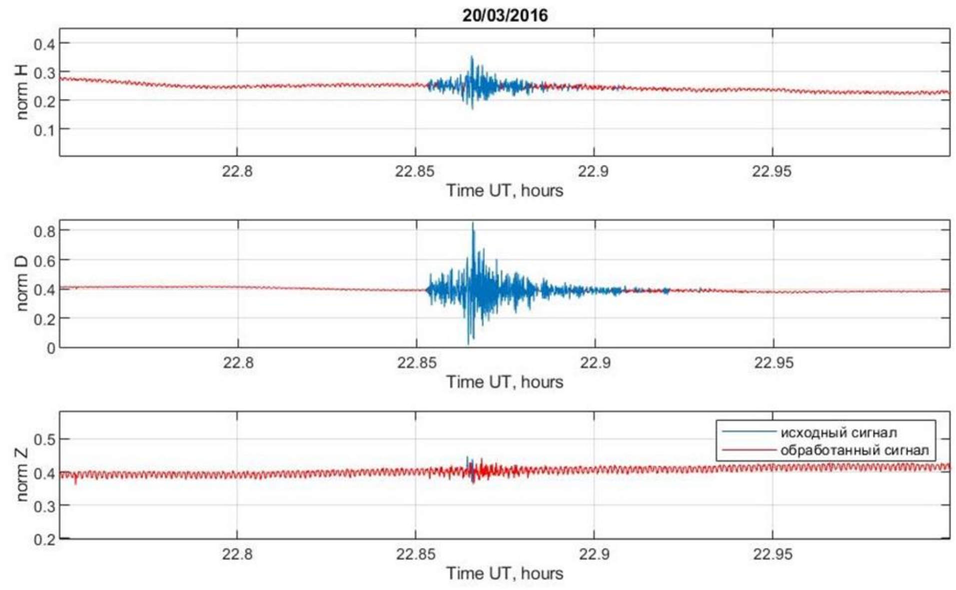
The study used data of fluxgate magnetometer FGE-DTU measurements at Observatory Paratunka, Kamchatka, IKIR FEB RAS (2 Hz) for 2009-2019.

The work was carried out as part of the implementation of the state task AAAA-A21-121011290003-0.

The results of the method when detecting noises from natural and technogenic origin







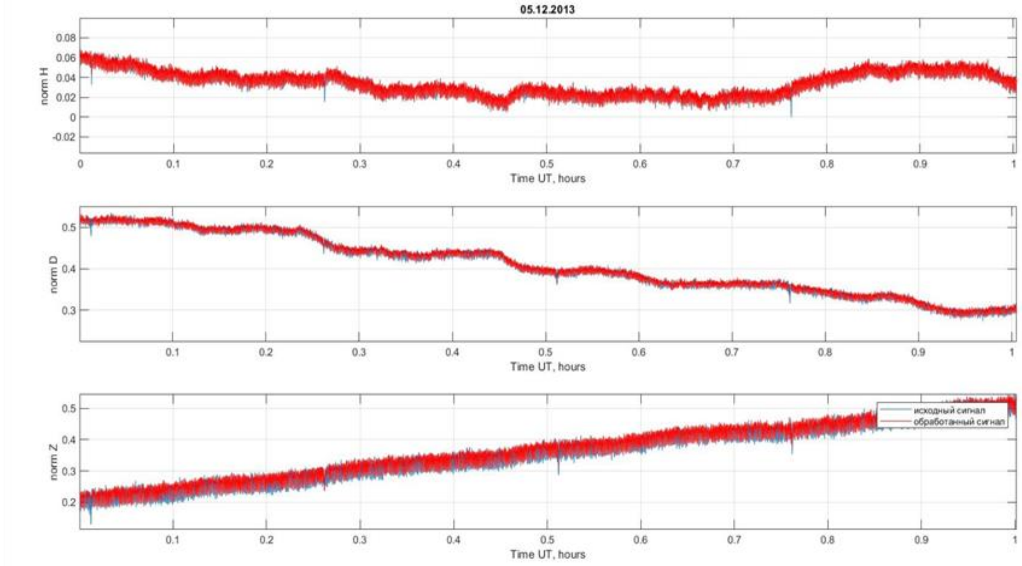


Table 1. ***The error of the method in the selection of noises of natural origin at T = E_{max}***

$$\delta = \frac{N_e}{N} * 100\%,$$

N_e- number of natural noises not detected by the method at $T = E_{max}$,

N- total number of natural noises per year.

	2010	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***
δ, %	4,5	0	0	4,3	0	0	6,2

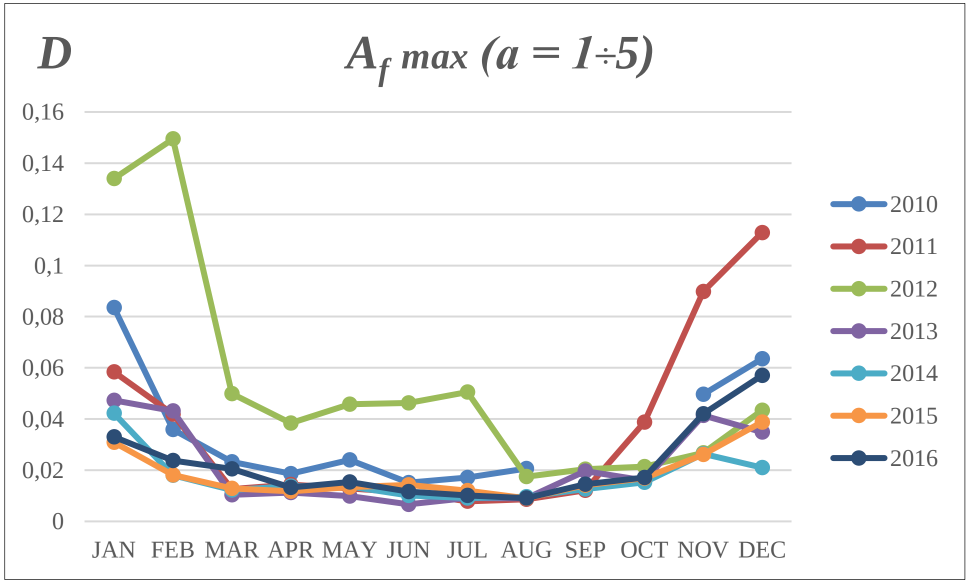
Table 2. ***Analysis of unidentified noises of natural origin for 2016***

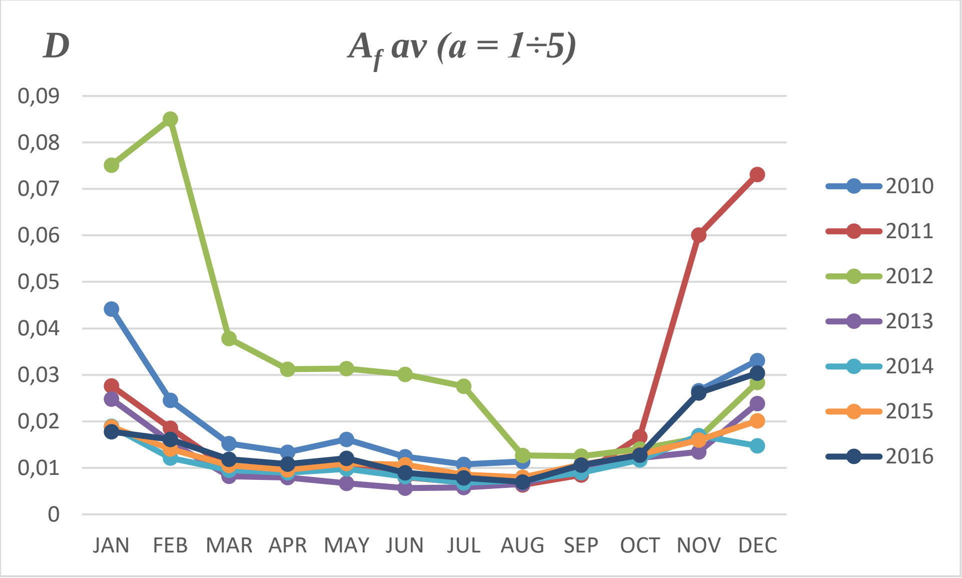
date	***k_p***	***A_zem***	***A_f_date***	***A_f_month***	***E_max***
22.08.2016	1	0,042540	0,006973	0,009074	0,05706278
05.08.2016	2	0,028140	0,006860	0,009074	0,05706278
16.04.2016	2	0,041810	0,010314	0,013251	0,05706278
05.02.2016	2	0,037630	0,012074	0,023767	0,05706278
07.09.2016	2	0,032650	0,006994	0,014456	0,05706278
04.09.2016	3	0,036360	0,005438	0,014456	0,05706278
29.07.2016	3	0,029370	0,005314	0,010075	0,05706278
22.01.2016	3	0,042870	0,010526	0,033005	0,05706278
03.08.2016	5	0,012090	0,003230	0,009074	0,05706278
30.01.2016	-1	0,005859	0,000648	0,033005	0,05706278

Table 3. ***The number of days containing "quiet" periods with Kp = 0 ÷ 1, for 2010-2016***

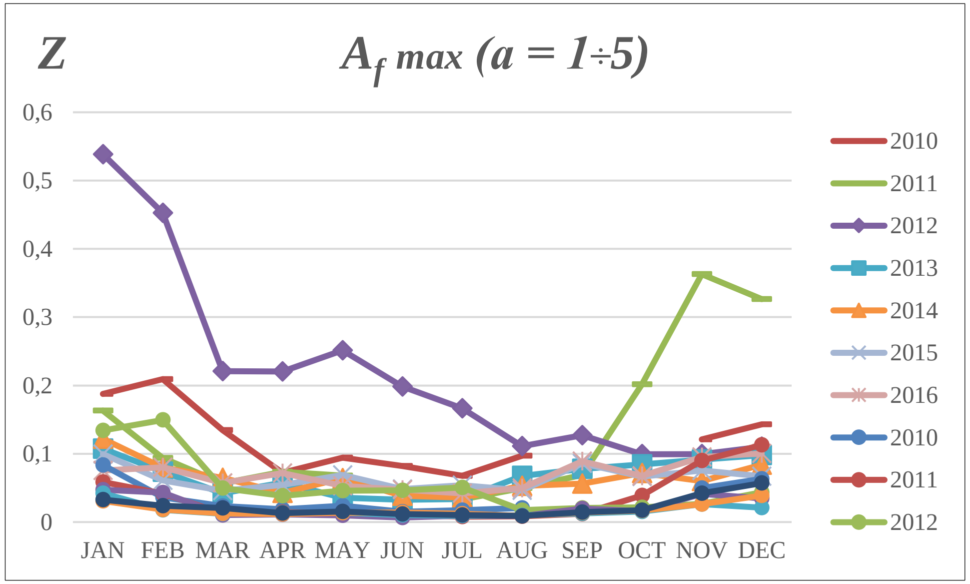
	JAN	***FEB***	***MAR***	***APR***	***MAY***	***JUN***	***JUL***	***AUG***	***SEP***	***OCT***	***NOV***	***DEC***
2010	24	21	26	19	19	20	22	22	0	0	23	28
2011	28	21	23	15	17	7	6	25	18	21	22	29
2012	22	19	12	16	21	16	10	18	21	21	23	29
2013	28	23	19	23	13	13	17	18	23	21	24	29
2014	27	20	28	19	25	19	25	16	14	14	15	15
2015	17	16	9	14	16	12	20	9	10	13	19	12
2016	18	19	12	17	12	16	11	17	14	10	14	19

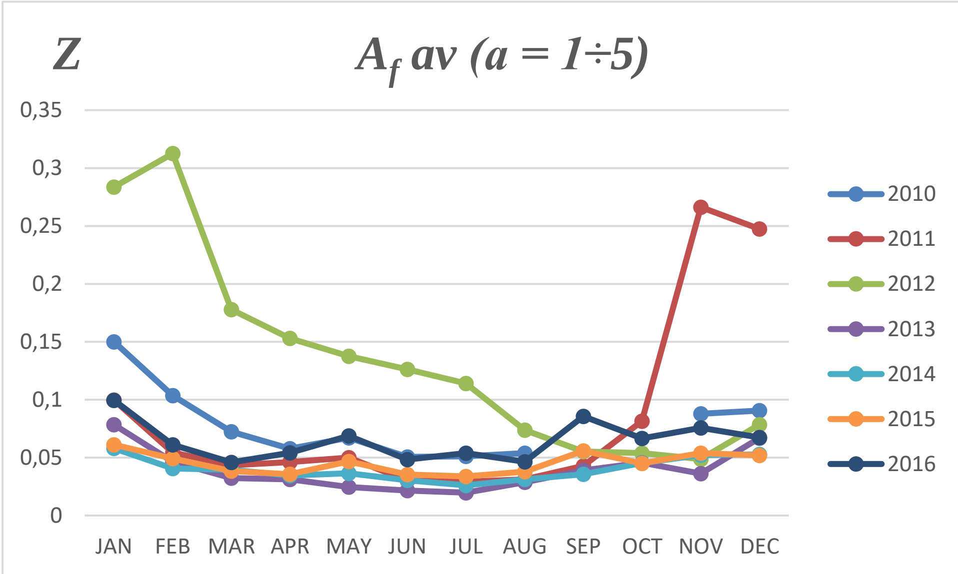
The intensity of the magnetic background in the D-component on the scales a=1÷5 for 2010-2016





The intensity of the magnetic background in the Z-component on the scales a=1÷5 for 2010-2016





The intensity of the magnetic background in the H-component on the scales a=1÷5 for 2010-2016