EGU General Assembly 2020
Online | 4–8 May 2020

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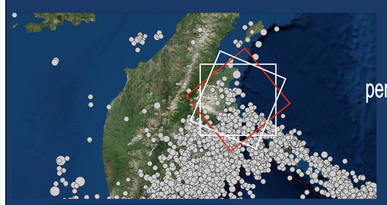
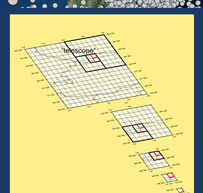
NP4.1 EGU2016-708

Unified Scaling Law for Earthquakes: space-time dependent assessment in Kamchatka region

Method

Estimates of the Unified Scaling Law for Earthquakes
(Nekrasova et al., 2011; Kossobokov and Mazhkenov, 1994)





The counts of earthquakes performed in a set of cascading squares, "telescope", permit accounting for the natural scaling of the spatial distribution of epicentres and provide evidence for rewriting the Gutenberg-Richter recurrence relation in the following generalised form:

$$log_{10}(N) = A + B \cdot (5.0 - M) + C \cdot log_{10}(L)$$

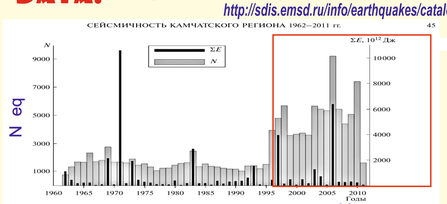
where N is the expected annual number of earthquakes with magnitude M in an area of linear dimension L.

The observed variability of seismic dynamics of Kamchatka Region is characterized in terms of several moving averages, including (i) seismic rate, (ii) the Benioff strain release, (iii) inter-event time, τ, and (iv) the USLE control parameter, η (where USLE stands for Unified Scaling Law for Earthquakes, i.e. a generalization of the Gutenberg-Richter relationship accounting for naturally fractal distribution of earthquake loci, which states that the distribution of inter-event times τ depends only on the value of variable η).

The variability of seismic dynamics have been evaluated and compared at each of the four out of ten separate seismic focal zones of Kamchatka Region and the adjacent areas defined by Levina et al. (2013), i.e., (1) seismic focal zone of Northern Kurils and South Kamchatka, (2) the northern part of the Kamchatka seismic focal zone, (3) the Commander segment of Aleutian arc; and (4) the continental region of Kamchatka. In particular, we considered all magnitude 4.0 or larger earthquakes in 1996-2019 available from open data catalog of the Kamchatka Branch of GS RAS, Earthquakes Catalogue for Kamchatka and the Commander Islands (1962–present) http://sdis.emsd.ru/info/earthquakes/catalogue.ph).

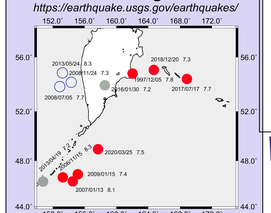
DATA: The system of seismological observation in Kamchatka

http://sdis.emsd.ru/info/earthquakes/catalogue.ph

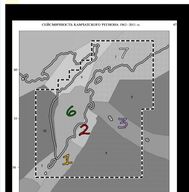


Levina, V.I.et all 2013, The seismicity of the Kamchatka region: 1962-2011, Journal of volcanology and seismology, V7, Iss. 1: 37-57, DOI: 10.1134/S0742046313010053

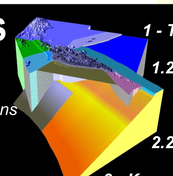
ANSS catalog Mw 7.0+
https://earthquake.usgs.gov/earthquakes/



Zones



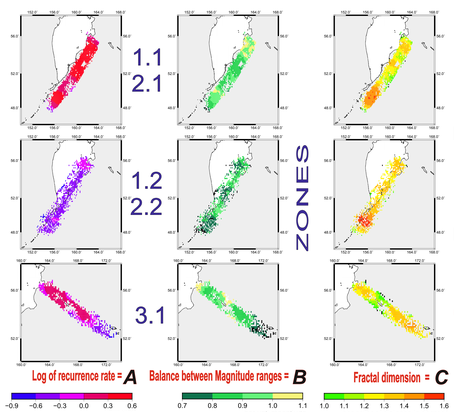
"Zones 1, 2, 3, 5, 6, and 10 have complex 3D configurations and the boundaries between them are dipping."
Levina, V.I.et all 2013,



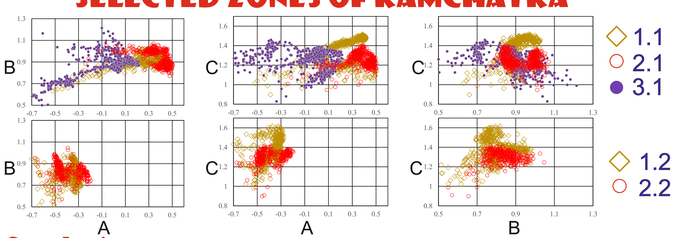
1 - The Kuril and South Kamchatka slab,
1.1 - shallow layer (h ≤ 70 km),
1.2 - intermediate layer (h = 71–350 km)

2 - North Kamchatka slab,
2.1 - shallow layer (h ≤ 70 km),
2.2 - intermediate layer (h = 71–380 km)

3 - Komandorskii segment of the Aleutian arc



USLE COEFFICIENTS ESTIMATION FOR SELECTED ZONES OF KAMCHATKA

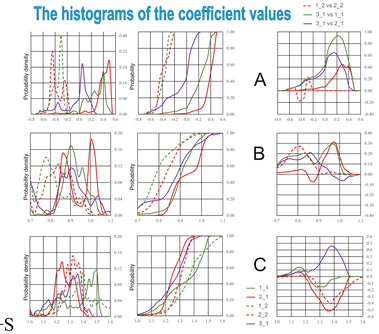


Conclusions

The nonparametric Kolmogorov-Smirnov λ_{K-S} statistic (Kolmogorov, 1933; Smirnov, 1948) confirm the difference of the USLE coefficients distributions characterizing the selected five zones of Kamchatka. For all pairwise samples the nul-hypothesis of the same statistical distribution is rejected with confidence above 99.9% .

The hierarchy of areas with linear size of
2°
1°
1/2°
1/4°
1/8°

The histograms of the coefficient values

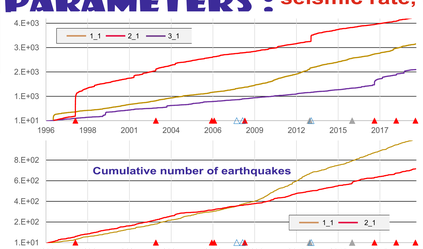


λ_{K-S}

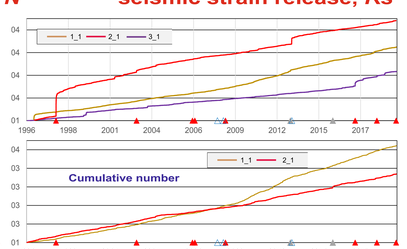
	1_1	1_2	3_1	1_1	1_2	3_1	1_1	1_2	3_1
2_1	7.305		15.594	5.017		4.864	8.522		2.677
2_2		3.335	A		4.026	B		6.004	C
3_1	10.884			3.546			7.743		

Next steps: Seismic hazard and risk estimation

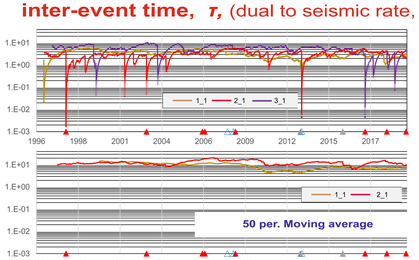
PARAMETERS : seismic rate, *N*



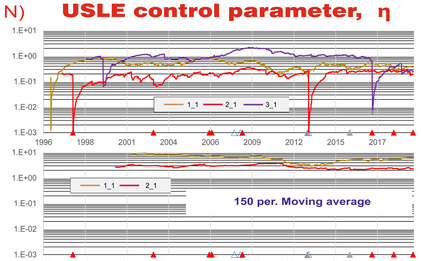
seismic strain release, *Ks*



inter-event time, *τ*, (dual to seismic rate, N)



USLE control parameter, η



ANSS Mw 7.0+ depth range : ▲ 0-70 km ▲ 71 - 380 km △ > 380 km

$$\eta = \tau \times 10^{B \times (5-M)} \times L^{C}$$

From a physical viewpoint, the scaling parameter η controls self-organized non-linear seismic system of a given region, so that the distribution of inter-event time τ depends only on this parameter.

Acknowledgments: This study was carried out as part of the RF State Task of Scientific Research Works No. 0143-2019-0006.