

Опыт прогноза в реальном времени сильнейших землетрясений мира:

M 7.8 - 27 km E of Nurdağı, Turkey
M 7.5 - 4 km SSE of Ekinözü, Turkey



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Abstract

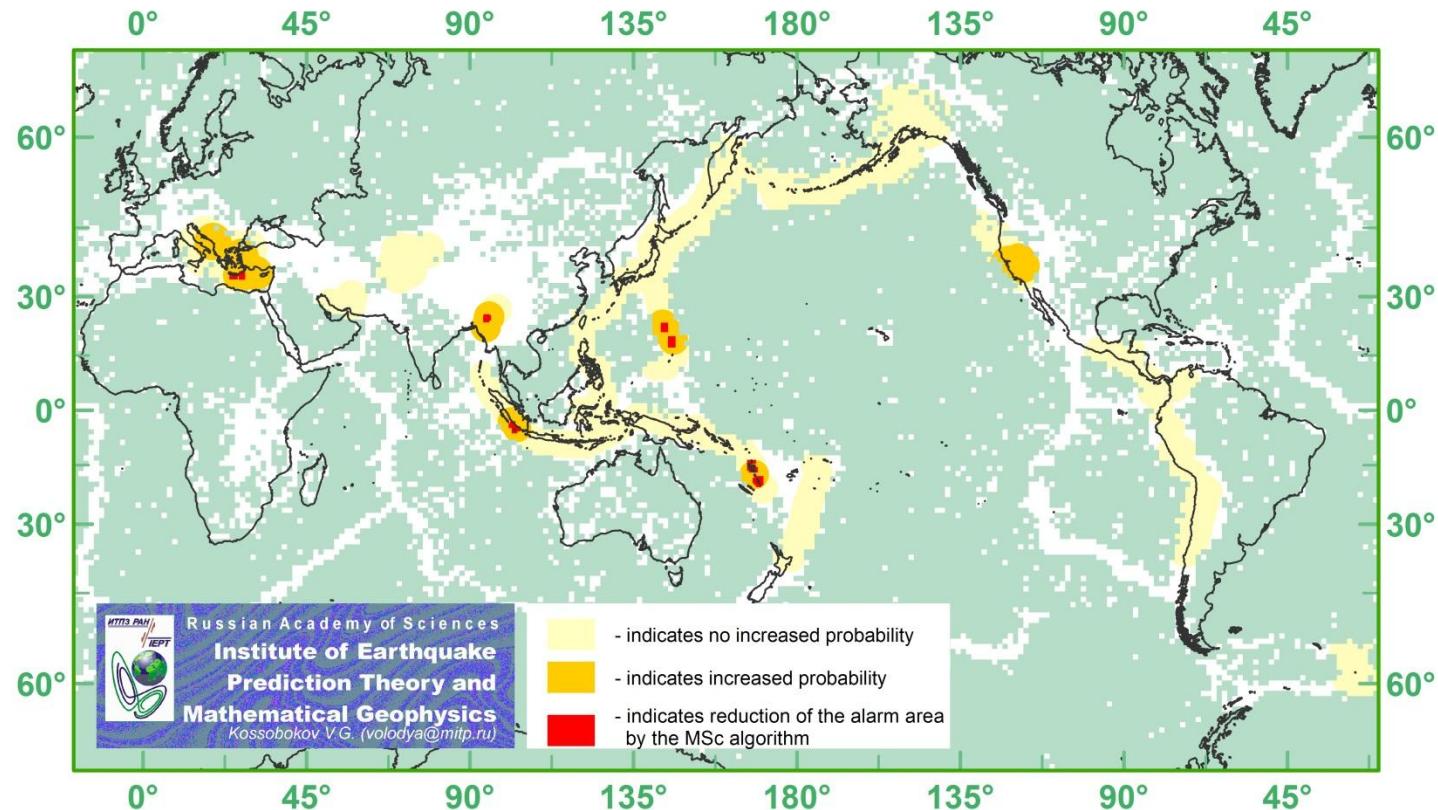
- The recent M7.8 - 27 km E of Nurdağı and M7.5 - 4 km SSE of Ekinözü, Turkey earthquakes provide another case history of the intermediate-term real-time prediction by the M8 algorithm.
Healy et al. 1992, <https://pubs.er.usgs.gov/publication/ofr92401>;
Kossobokov & Soloviev 2021, <https://doi.org/10.1007/s12594-021-1907-8>
- The algorithm aimed at magnitude range M8.0+ determined Times of Increased Probability (TIP's) starting from July 2021 in the only three out of 262 circles of investigation that spread over most of the global seismic belts; the alert in one of them was confirmed in the next semi-annual updates, most recently in January 2023, eventually being marked by devastating earthquakes that hit Turkey on February 6, 2023.
- Note that (i) the epicentres of the two coupled events and their aftershocks are just outside the territory, where M8 algorithm aimed at M7.5+ magnitude range is applicable, while (ii) well inside the area of TIPs alerted for M8.0+ events, and (iii) some determinations of the first shock magnitude are 8.0 (e.g. GEOSCOPE Mw8.0, GS RAS Ms8.0, RETMC Mwp8.0).

Глобальное тестирование алгоритмов М8 и МSc: Обновление прогнозов 2023а

(Subject: The 2023a Update of the M8-MSc predictions)

Date: Wednesday, January 4, 2023)

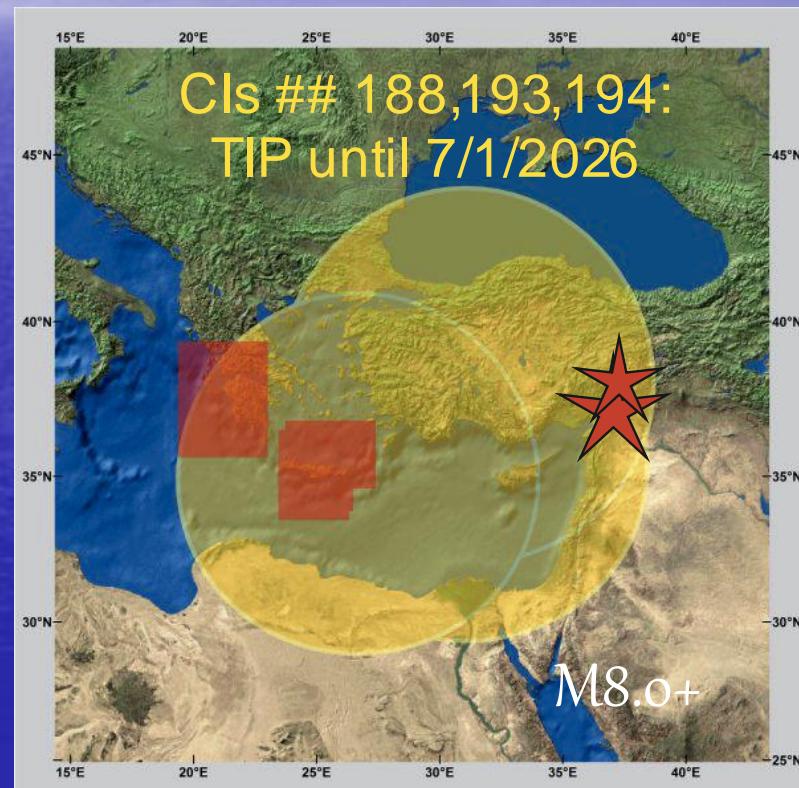
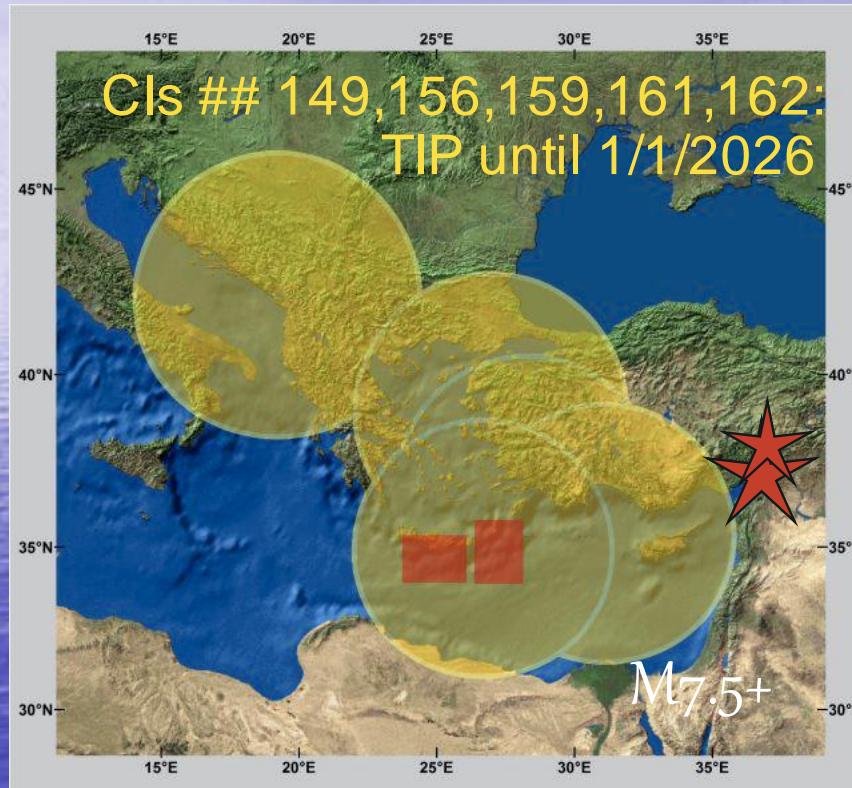
Regions of Increased Probability of Magnitude 7.5+ Earthquakes as on January 1, 2023 (subject to update on July 1, 2023)



Глобальное тестирование алгоритмов M8 и MSc: Обновление прогнозов 2023а

(Subject: The 2023a Update of the M8-MSc predictions)

Date: Wednesday, January 4, 2023)



2023-02-06 01:17:35 (UTC) | 37.166°N 37.042°E | 17.9 km | M 7.8 - 27 km E of Nurdağı, Turkey

2023-02-06 10:24:49 (UTC) | 38.024°N 37.203°E | 10.0 km | M 7.5 - 4 km SSE of Ekinözü, Turkey

Testing Earthquake Prediction Algorithms

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²International Seismic Safety Organization, Arsita, Italy

[!]Passed away on 23rd of September, 2021

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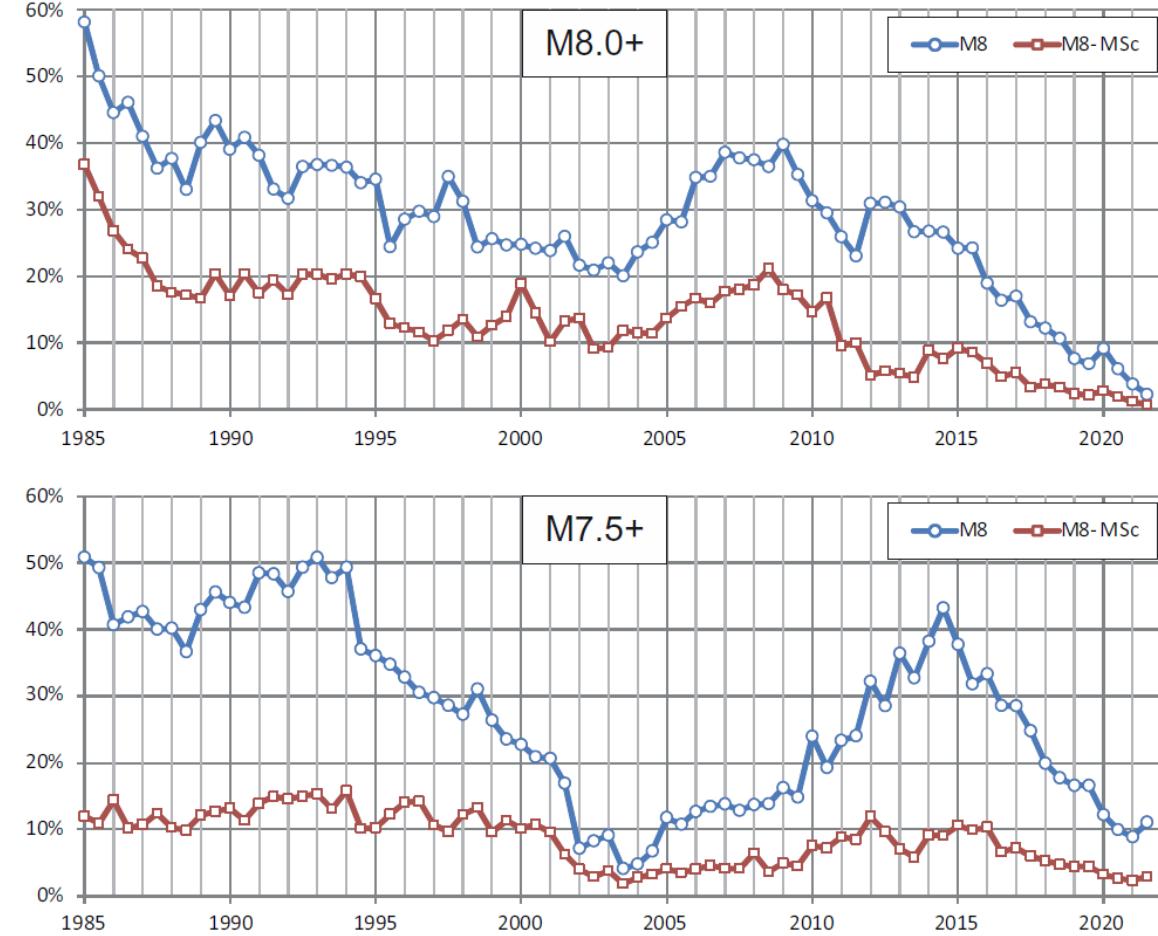
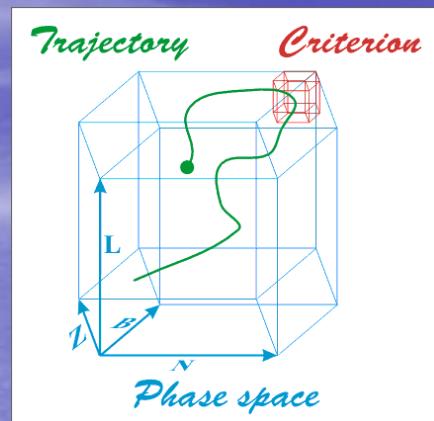
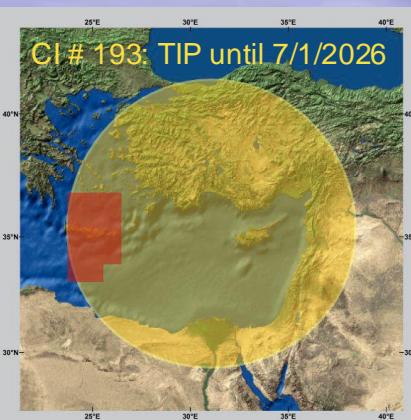


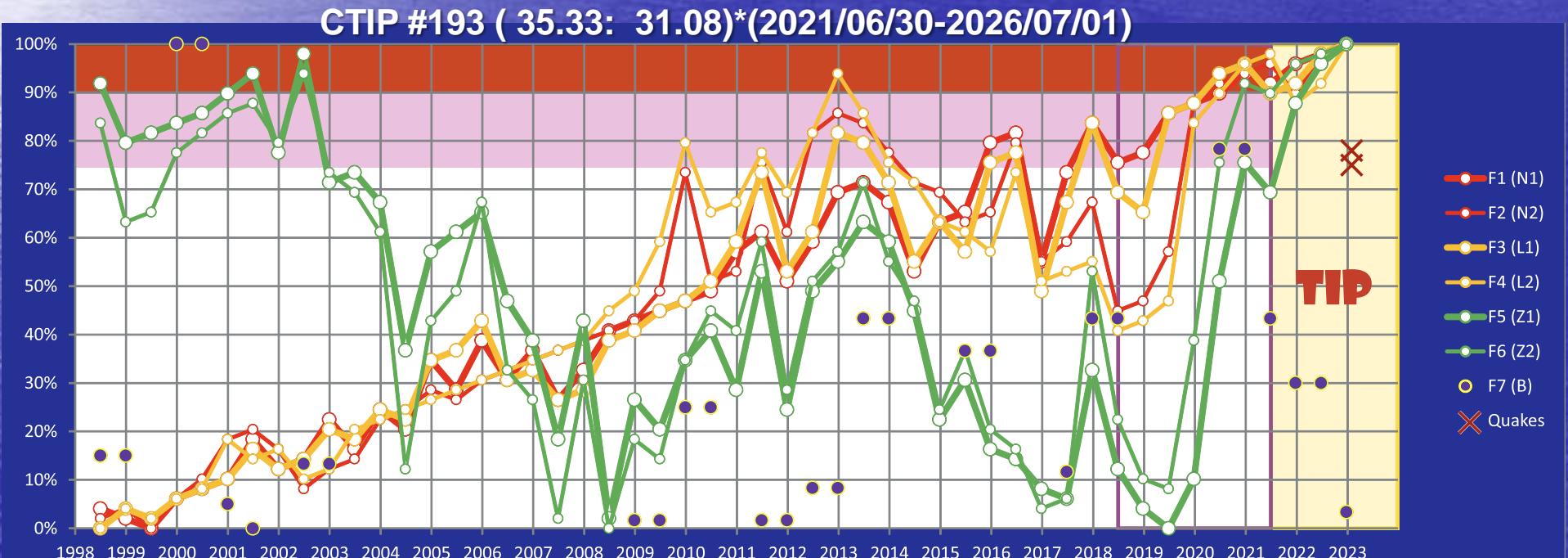
Fig.3. Changes over time in the μ -volume of M8 and M8-MSc alarms targeting earthquakes in the M8.0+ and M7.5+ ranges.

Kossobokov, V. G. (1997). Chapter 4. User Manual for M8. In Healy, J.H., Keilis-Borok, V. I., Lee, W. H. K. (Eds), *Algorithms for earthquake statistics and prediction*. IASPEI Software Library, Vol. 6. Seismol. Soc. Am., El Cerrito, CA, 167–221, with Disk #4: M8 Programs and Test Data Files



M8 algorithm

- Each of the functions N , L , Z is calculated twice for $m = M_{\min}(\tilde{N})$, $\tilde{N} = 20$ and $\tilde{N} = 10$.
- As a result, the earthquake sequence is given a robust averaged description by seven functions: N , L , Z (twice each), and B – $N_1, N_2, L_1, L_2, Z_1, Z_2, B$



УДК 550.343.62

ГЕОФИЗИКА

Член-корреспондент АН СССР И. М. ГЕЛЬФАНД, Ш. А. ГУБЕРМАН,
М. П. ЖИДКОВ, М. С. КАЛЕЦКАЯ, В. И. КЕЙЛИС-БОРОК,
Е. Я. РАНЦМАН

**ОПЫТ ПЕРЕНОСА КРИТЕРИЕВ ВЫСОКОЙ СЕЙСМИЧНОСТИ
СО СРЕДНЕЙ АЗИИ НА АНАТОЛИЮ И СМЕЖНЫЕ РЕГИОНЫ**

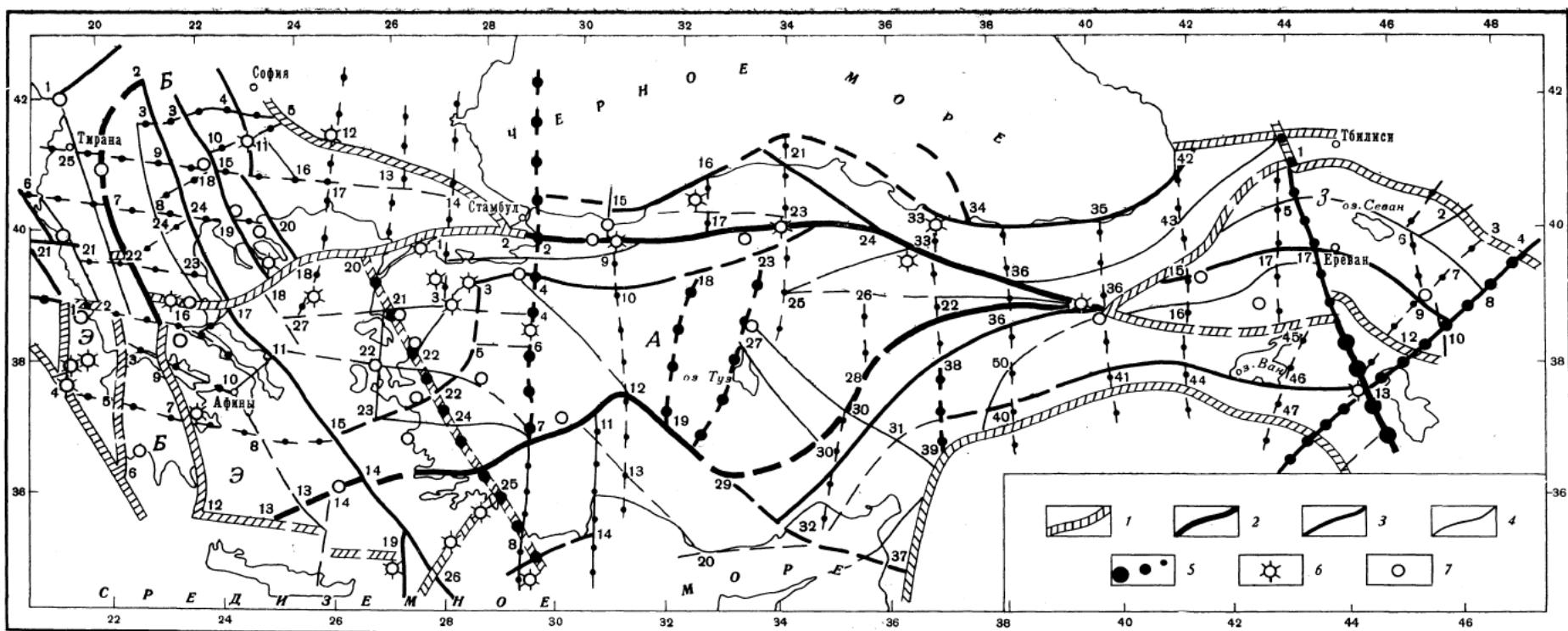
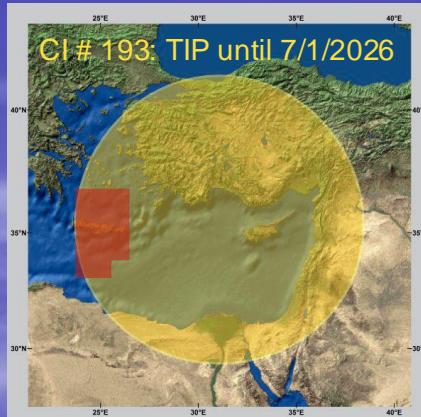
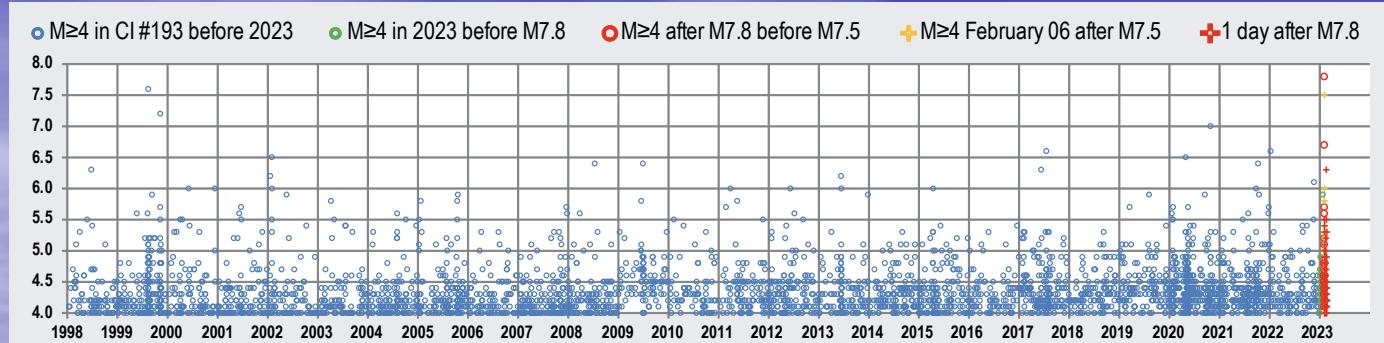
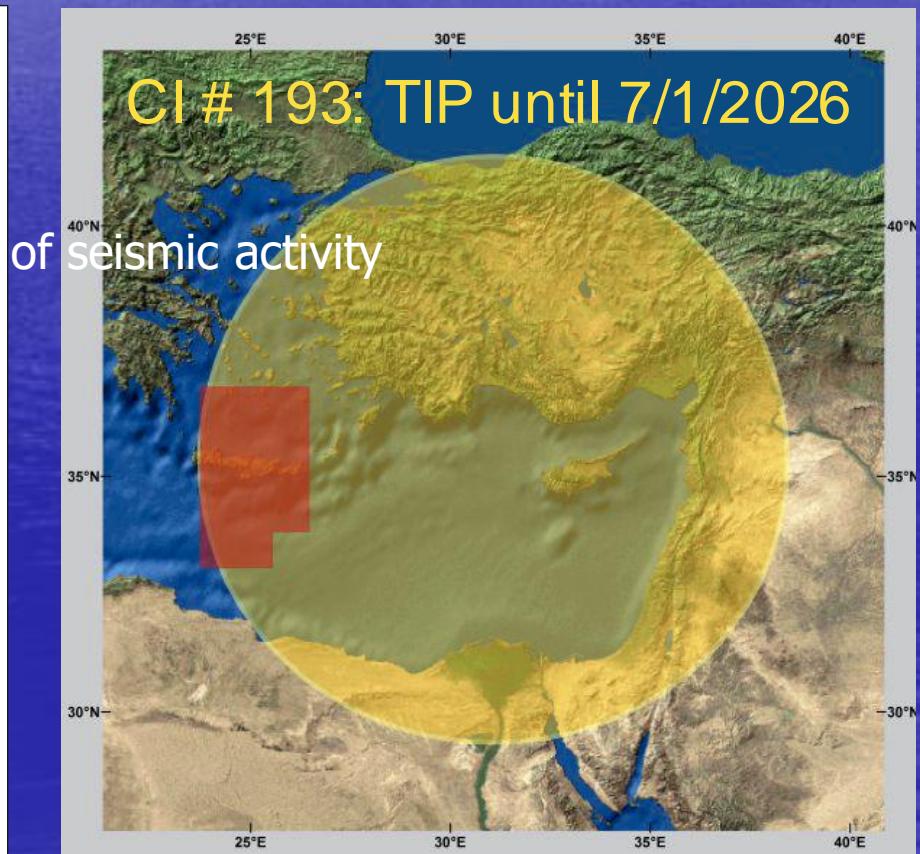
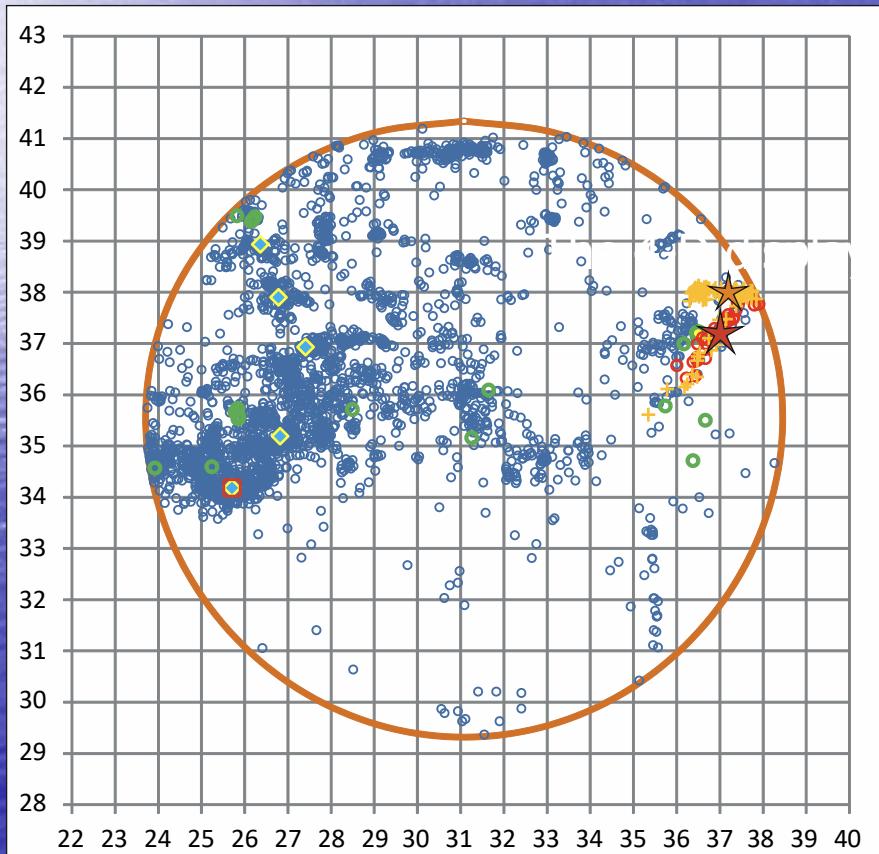


Рис. 1. Морфоструктурная схема Юго-Восточной Европы и Малой Азии. 1—5 — морфоструктурные границы (1—4 — продольные, 5 — поперечные к простирианию основных форм рельефа): 1 — регионов; 2 — морфоструктурных стран; 3 — областей; 4 — районов. 6—7 — эпицентры сильных землетрясений с магнитудой $6,5 \leq M \leq 6,9$ (7), $M \geq 7$ (6); цифры — номера дизъюнктивных узлов



CTIP #193 (35.33: 31.08)*(2021/06/30-2026/07/01)



Epicenters of the $M \geq 4$ earthquakes at angular distance of 2.5° from the epicenter of $M 7.8$ - 27 km E of Nurdağı, Turkey

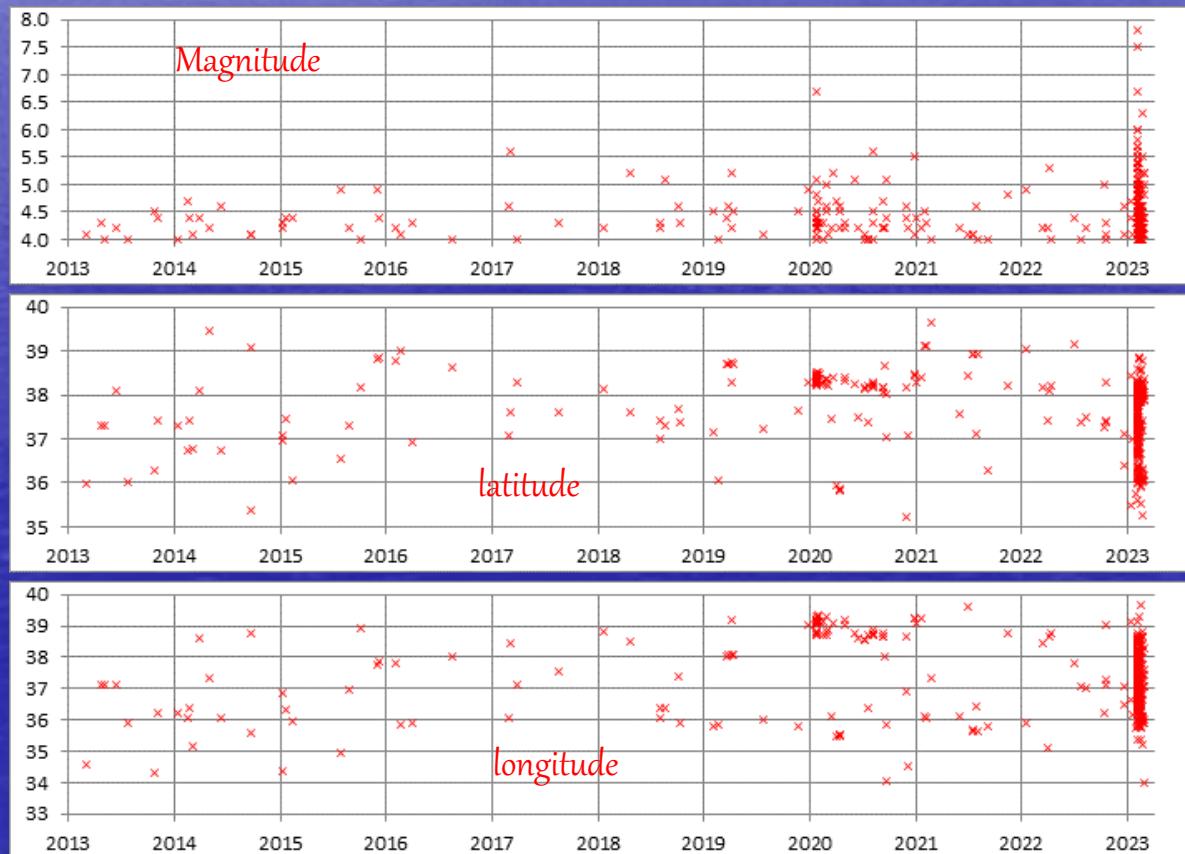
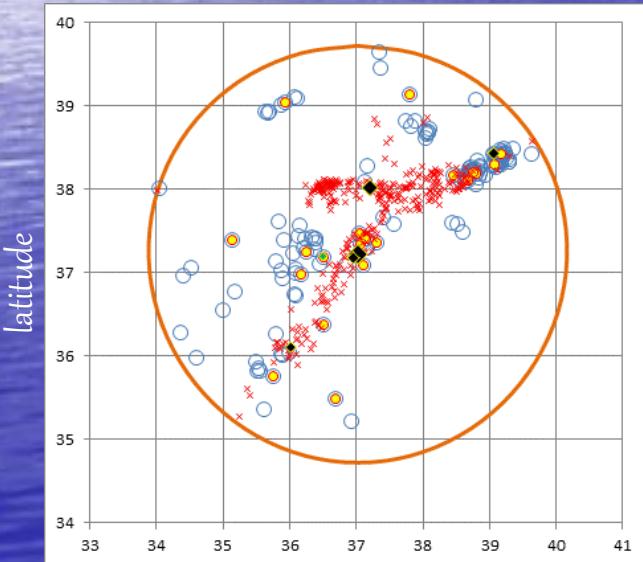
Note: open blue circles are epicenters of earthquakes in February 6, 2013–February 05, 2023; yellow circles and red crosses mark those events occurring within 512 days before and 21 days after the origin time (2023/02/06 01:17:34 UTC) of the major event, respectively.

Bukchin BG, Fomochkina AS, Kossobokov VG and Nekrasova AK (2020) Characterizing the Foreshock, Main Shock, and Aftershock Sequences of the Recent Major Earthquakes in Southern Alaska, 2016–2018.

Front. Earth Sci. 8:584659. <https://doi.org/10.3389/feart.2020.584659>

The 4-D display >>>
of seismic activity

longitude



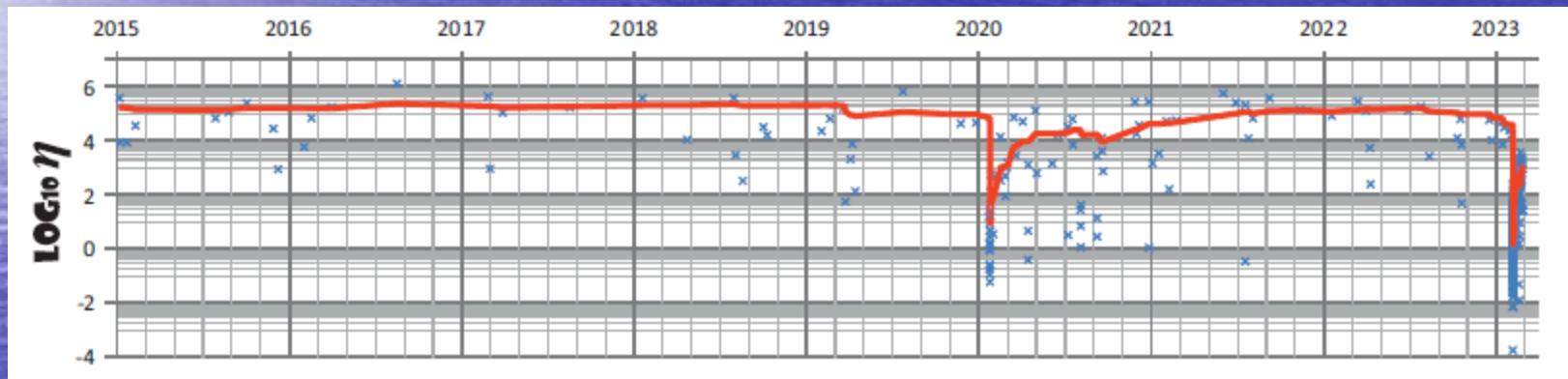
Variation of the USLE control parameter η at angular distance of 2.5° from the epicenter of M 7.8 - 27 km E of Nurdağı, Turkey

$$\begin{array}{ccc} A & B & C \\ -0.87 & 0.97 & 1.23 \end{array}$$

Bukchin BG, Fomochkina AS, Kossobokov VG and Nekrasova AK (2020) Characterizing the Foreshock, Main Shock, and Aftershock Sequences of the Recent Major Earthquakes in Southern Alaska, 2016–2018.

Front. Earth Sci. 8:584659. <https://doi.org/10.3389/feart.2020.584659>

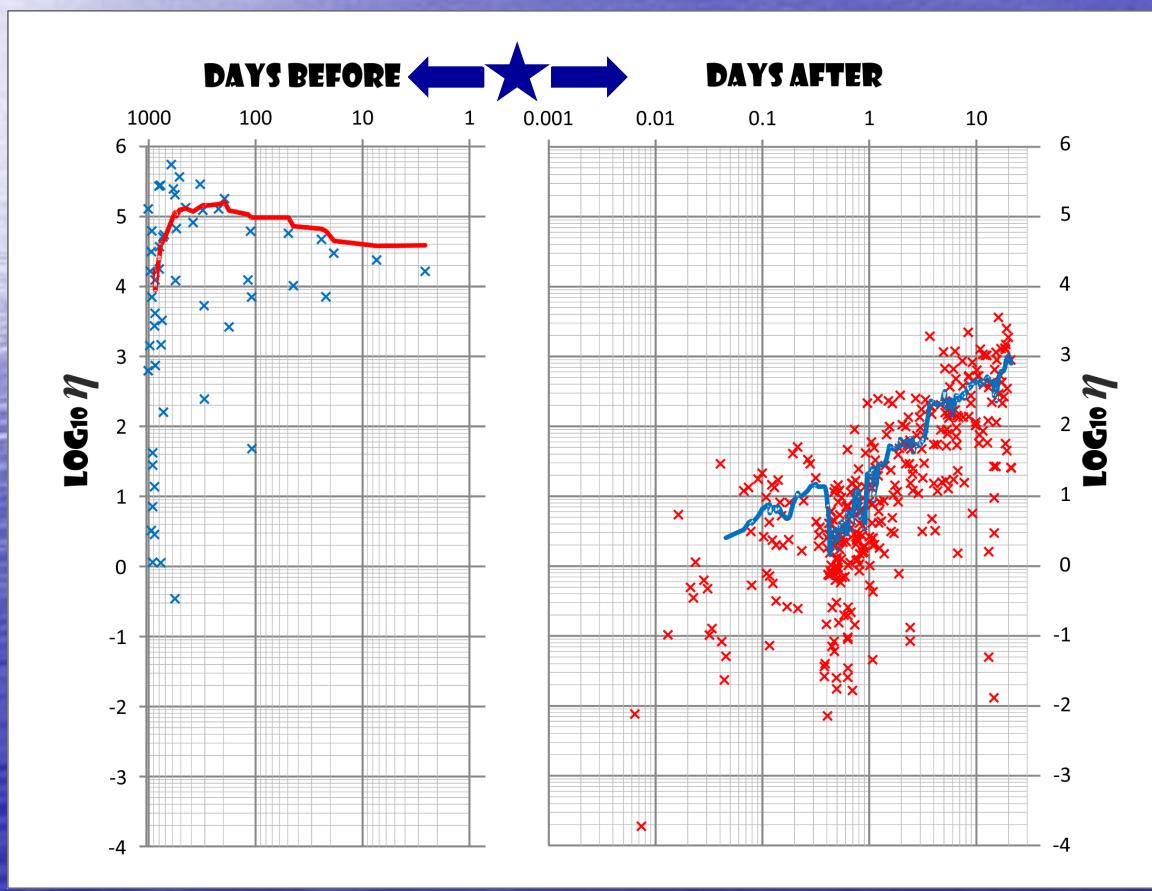
Averages of the USLE control parameter η per 15 events vs.
time before and after the M 7.8 main shock



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

where τ is the time between the two successive earthquakes, M is magnitude of the 2nd one, and L is the distance between the two.

Variation of the USLE control parameter η at angular distance of 2.5° from the epicenter of M 7.8 - 27 km E of Nurdağı, Turkey



Averages of the USLE control

parameter η per 15 events vs.
time before and after the M 7.8 main
shock

$\eta = \tau \times 10^{B \times (5-M) \times L^C}$,
where τ is the time between the
two successive earthquakes, M is
the magnitude of the second one,
and L is the distance between
the two.

$$\begin{array}{ccc} A & B & C \\ -0.87 & 0.97 & 1.23 \end{array}$$



Top deadliest earthquakes since 2000 (at least 1,000+ fatalities including victims of tsunami and other associated effects)

$\Delta I_0 = I_{0\text{ EVENT}} - I_{0\text{ GSHAP}}$ computed as in (Kossobokov & Nekrasova, 2012) rounded to the closest integer;
updated to the present from (https://en.wikipedia.org/wiki/Lists_of_21st-century_earthquakes)

Region	Date	M	Fatalities	ΔI_0
Sumatra-Andaman Islands (“Indian Ocean Disaster”)	26 December 2004	9.0	227,898	4
Port-au-Prince (Haiti)	12 January 2010	7.3	222,570	2
Wenchuan (Sichuan, China)	12 May 2008	8.1	87,587	3
Kashmir (northern border India-Pakistan region)	8 October 2005	7.7	87,351	2
Nurdağı (Turkey)	6 February 2023	7.8(8.0) 7.5(7.7)	42,001+	1(2) 1(2)
Ekinözü (Turkey)				
Bam (Iran)	26 December 2003	6.6	26,271	0
Bhuj (Gujarat, India)	26 January 2001	8.0	20,085	3
Off the Pacific coast of Tōhoku (Japan)	11 March 2011	9.0	19,759+	3
Bharatpur (Nepal)	25 April 2015	7.8	8,964	2
Yogyakarta (Java, Indonesia)	26 May 2006	6.3	5,782	0
Sulawesi Island (Indonesia)	28 September 2018	7.5	4,340	2
Southern Qinghai (China)	13 April 2010	7.0	2,968	2
Boumerdes (Algeria)	21 May 2003	6.8	2,266	2
Nippes (Haiti)	14 August 2021	7.2	2,248	2
Nias Island (Indonesia)	28 March 2005	8.6	1,313	3
Padang (Southern Sumatra, Indonesia)	30 September 2009	7.5	1,117	1
Hindu Kush (Afghanistan)	25 March 2002	6.1	1,000+	-1



Comparison of the 2018 GEM “10% poe in 50 years” and the 1999 GSHAP Final Map at the sites of Top deadliest earthquakes since 2000.

(i) $\Delta I_0 = I_0_{\text{EVENT}} - I_0_{\text{GSHAP}}$ computed as in (Kossobokov & Nekrasova, 2012) rounded to the closest integer;

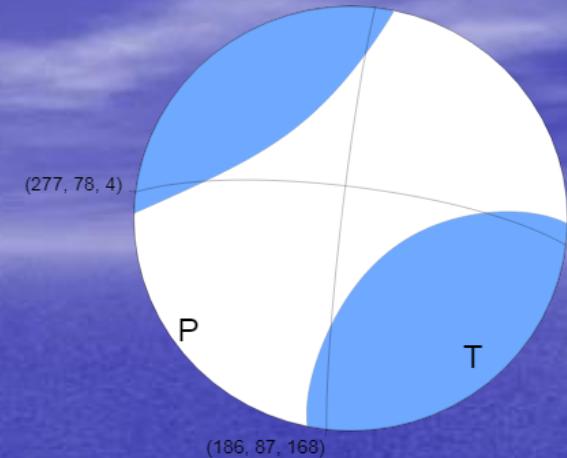
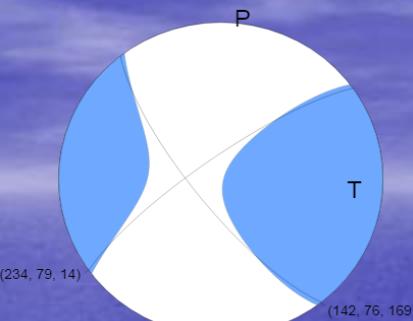
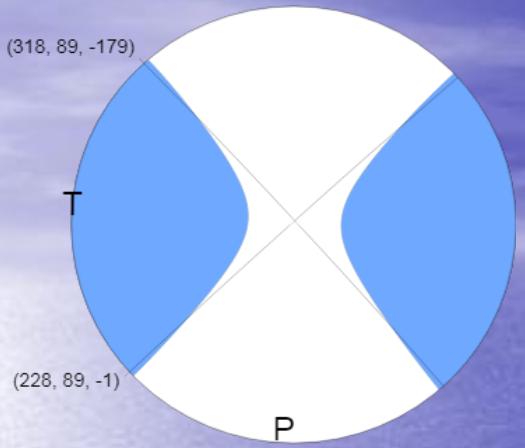
updated to the present from (https://en.wikipedia.org/wiki/Lists_of_21st-century_earthquakes); (ii) GEM model values from OpenQuake Map Viewer [M. Paganini et al. (2018). Global Earthquake Model (GEM) Seismic Hazard Map (version 2018.1 - December 2018), DOI: 10.13117/GEM-GLOBAL-SEISMIC-HAZARD-MAP-2018.1] at <https://maps.openquake.org/map/global-seismic-hazard-map/>

Region	ΔI_0 , GEM	ΔI_0 , GSHAP	$mPGA_{\text{GEM}}/mPGA_{\text{GSHAP}}$
Sumatra-Andaman Islands (“Indian Ocean Disaster”)	3	4	2.45
Port-au-Prince (Haiti)	1	2	4.06
Wenchuan (Sichuan, China)	3	3	1.41
Kashmir (northern border India-Pakistan region)	2	2	1.80
Nurdağı (Turkey)	2	1	0.80
Ekinözü (Turkey)	2	1	0.57
Bam (Iran)	1	0	0.67
Bhuj (Gujarat, India)	2	3	2.15
Off the Pacific coast of Tōhoku (Japan)	3	3	1.03
Bharatpur (Nepal)	2	2	0.85
Yogyakarta (Java, Indonesia)	0	0	1.50
Sulawesi Island (Indonesia)	2	2	1.15
Southern Qinghai (China)	1	2	1.52
Boumerdes (Algeria)	0	2	4.33
Nippes (Haiti)	1	2	3.34
Nias Island (Indonesia)	3	3	2.09
Padang (Sumatra, Indonesia)	1	2	2.02
Hindu Kush (Afghanistan)	-1	-1	0.64

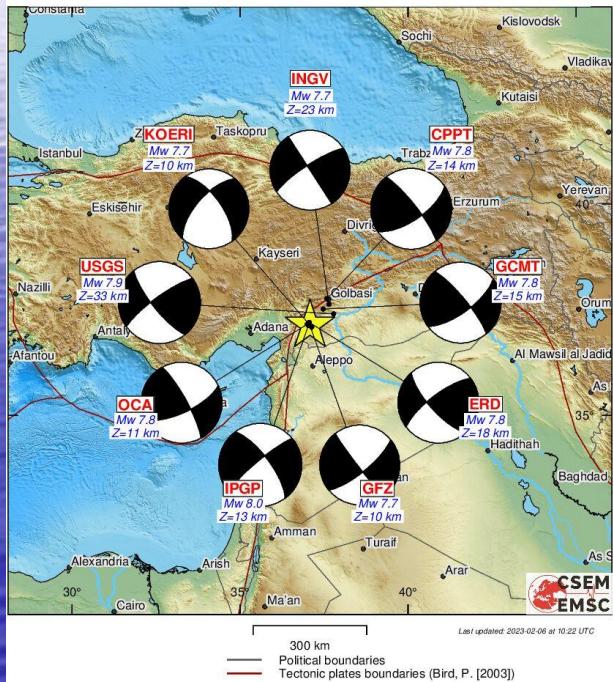
GS RAS:

2023-02-06 01:17:35 37.29 36.99 10 Ms 8.0 mb 6.8 Turkey

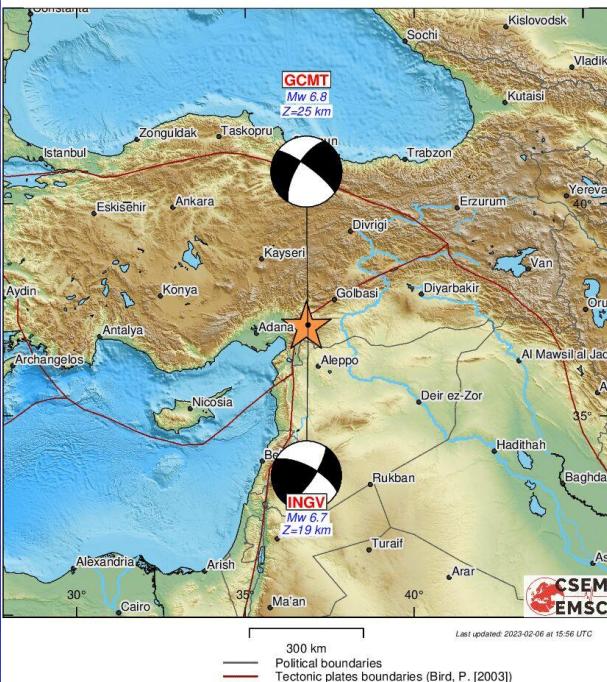
2023-02-06 10:24:49 38.04 37.18 10 Ms 7.8 mb 6.9 Turkey



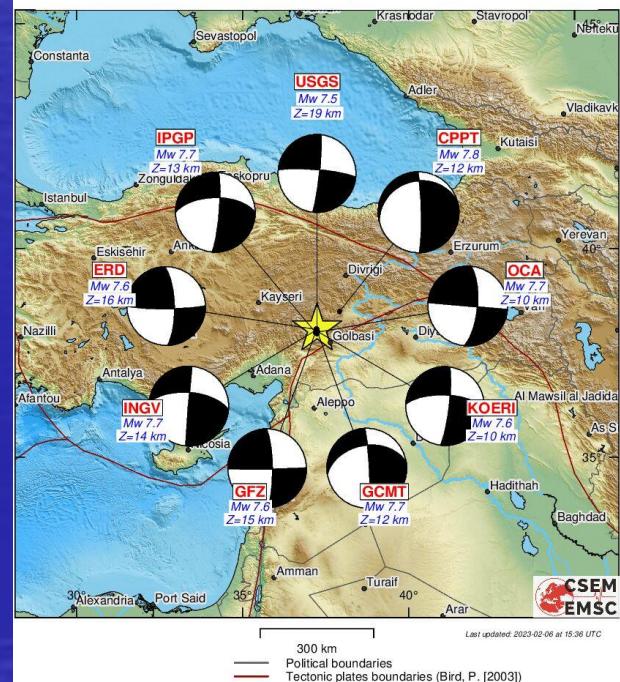
Moment Tensor map of earthquake:
Mag: 7.8 2023-02-06 01:17:36 UTC
Lat: 37.17 Lon: 37.08 Depth: 20.0 km



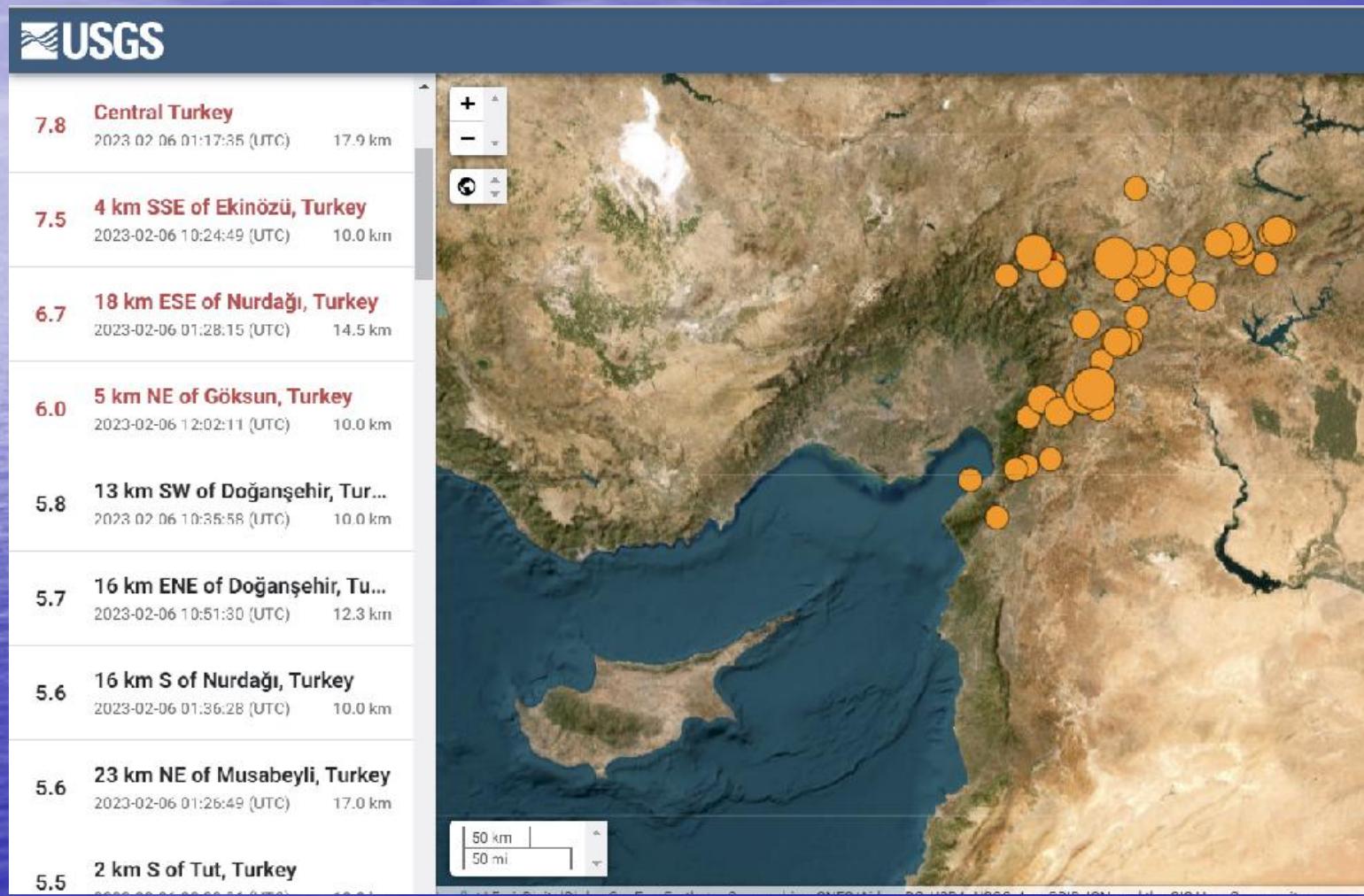
Moment Tensor map of earthquake:
Mag: 6.7 2023-02-06 01:28:19 UTC
Lat: 37.13 Lon: 36.81 Depth: 40.0 km



Moment Tensor map of earthquake:
Mag: 7.5 2023-02-06 10:24:49 UTC
Lat: 38.11 Lon: 37.24 Depth: 10.0 km



Первые афтершоки



The Turkey-Syria Earthquake Sequence

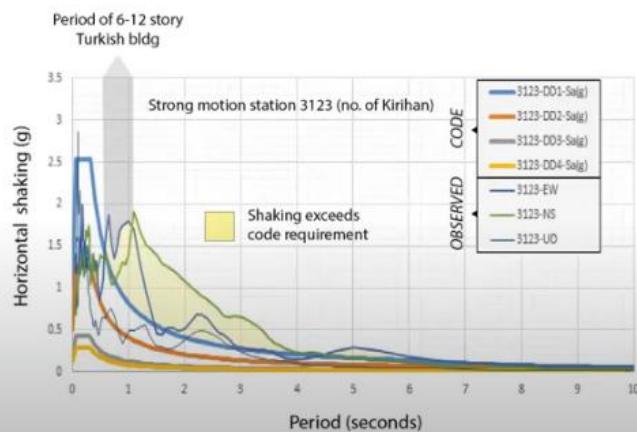
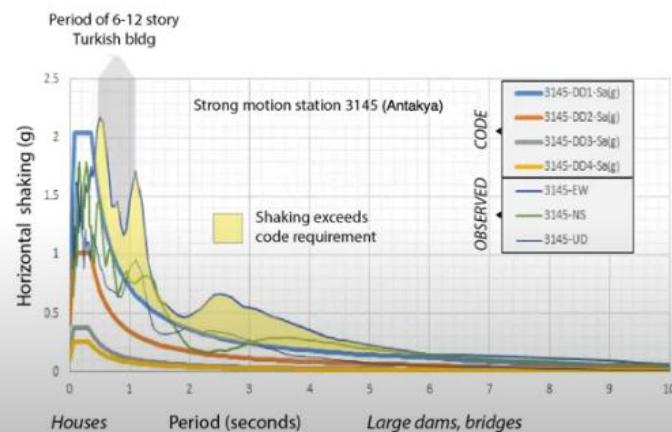
But stress is

Out of 172,000 inspected buildings:

- 12,000 collapsed
- 25,000 need to be demolished
- 123,000 received light or no damage
- 9 base-isolated hospitals fully functional

Achievements:

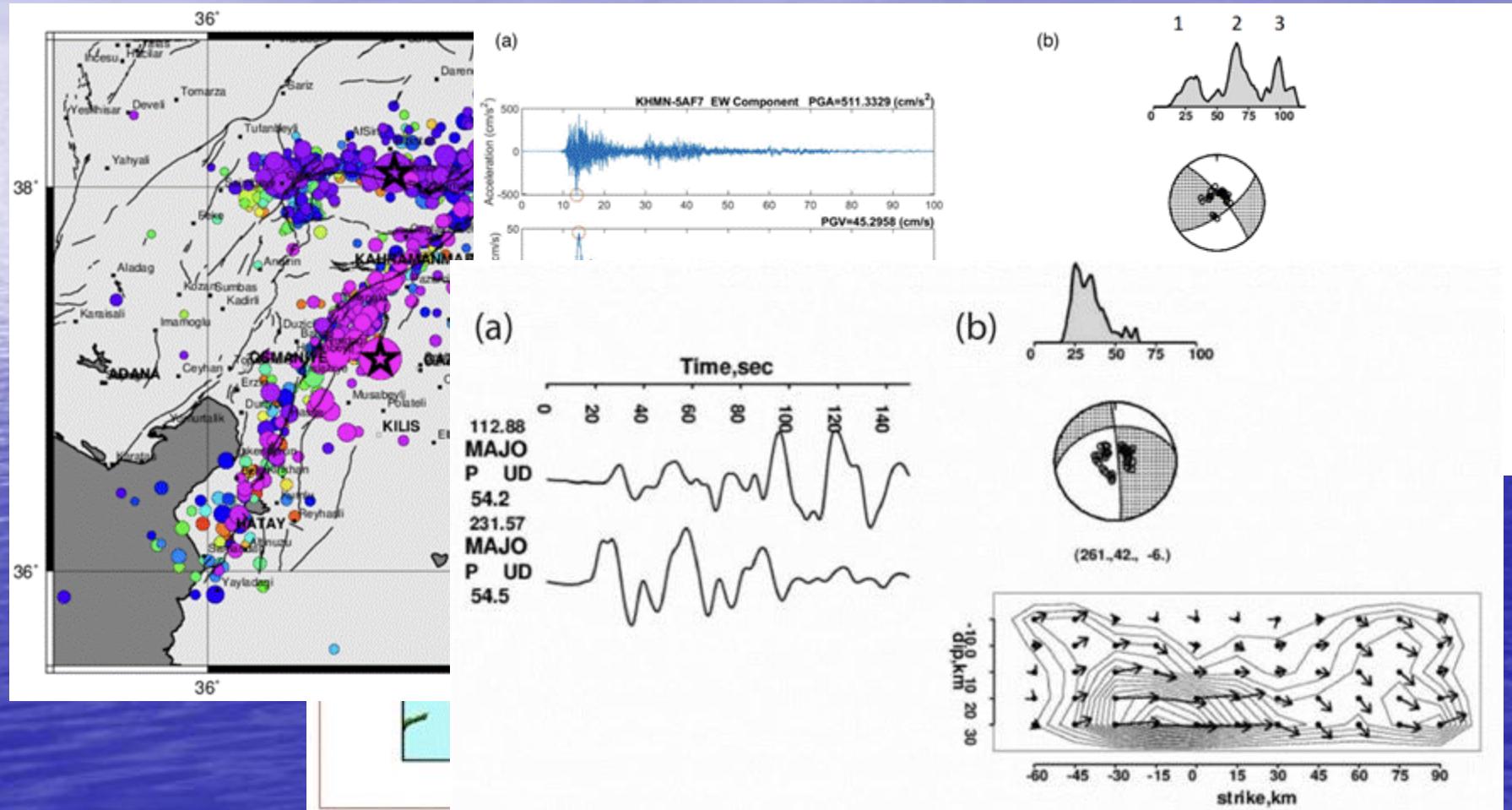
- Mandatory nationwide earthquake insurance
- Excellent seismic and geodetic monitoring networks
- Extensive fault mapping and seismic hazard modeling
- Advanced earth science and engineering community

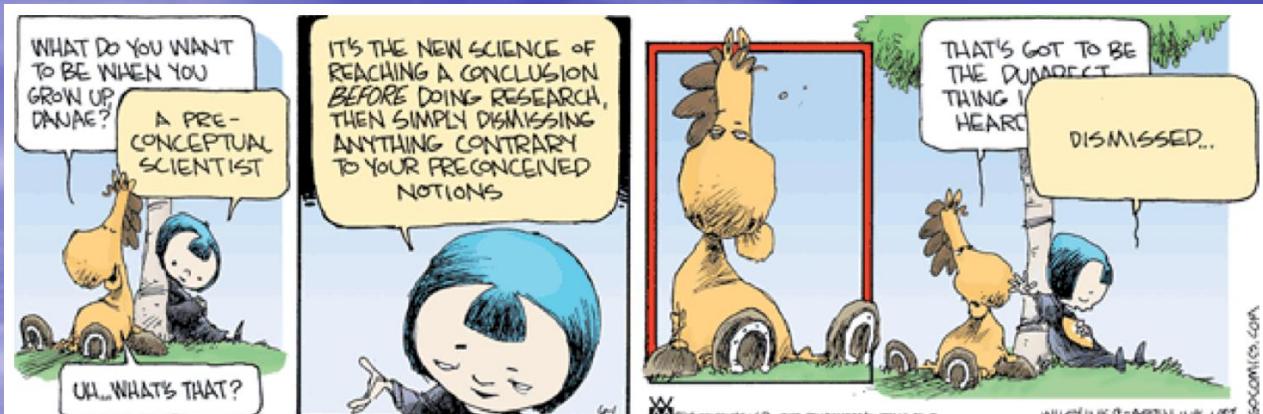


Webinar: The 2023 Turkey-Syria Earthquake Sequence

Webinar: The 2023 Turkey-Syria Earthquake Sequence by Ross Stein, CEO, Temblor, Inc.

Erdik, M., Tümsa, M. B. D., Pınar, A., Altunel, E., and Zülfikar, A. C. (2023)
A preliminary report on the February 6, 2023
Earthquake in Türkiye. <http://doi.org/10.32858/temblor.297>





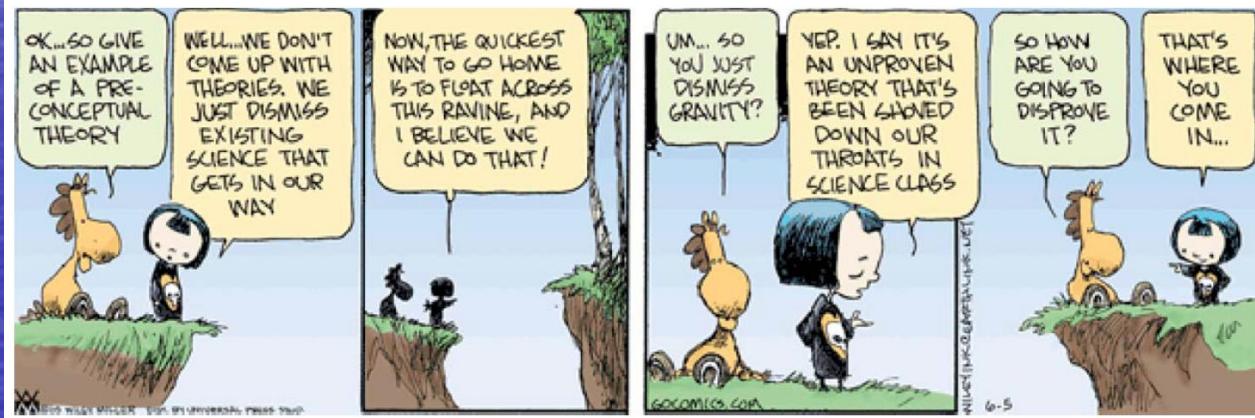
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Спасибо за внимание!

"When sorrows come, they come not single spies, but in battalions"
(William Shakespeare, 1564-1616)

