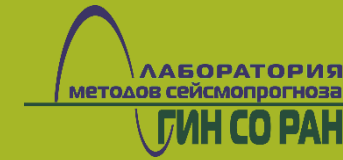




THE INTERNATIONAL CONFERENCE ON THE 120TH
ANNIVERSARY OF THE BULNAY EARTHQUAKE:
ADVANCES IN ASTRONOMY AND GEOPHYSICS



MACROSEISMIC INTENSITY OF EARTHQUAKES IN ULAN-UDE CITY (REPUBLIC OF BURYATIA) IN 1992-2021

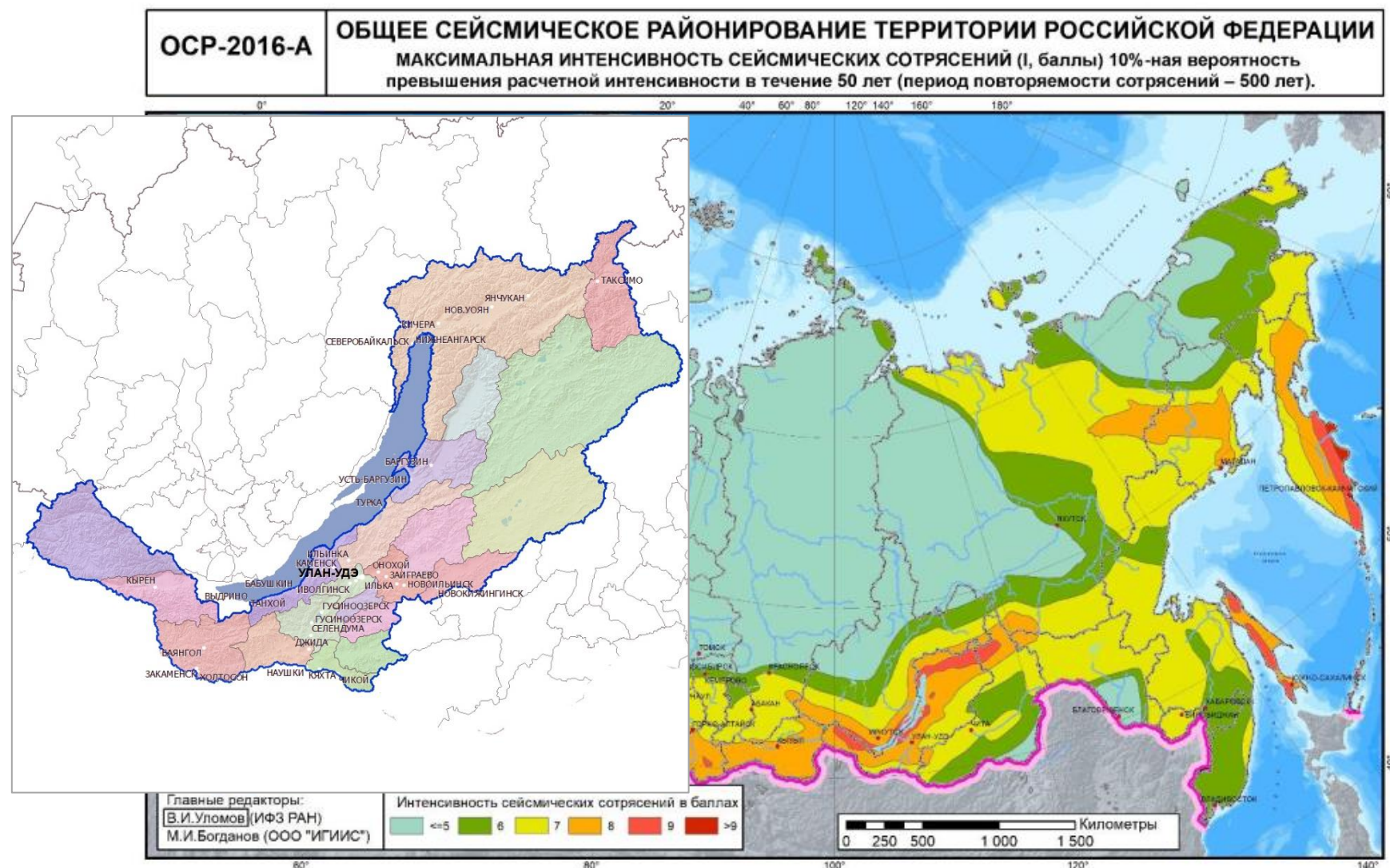
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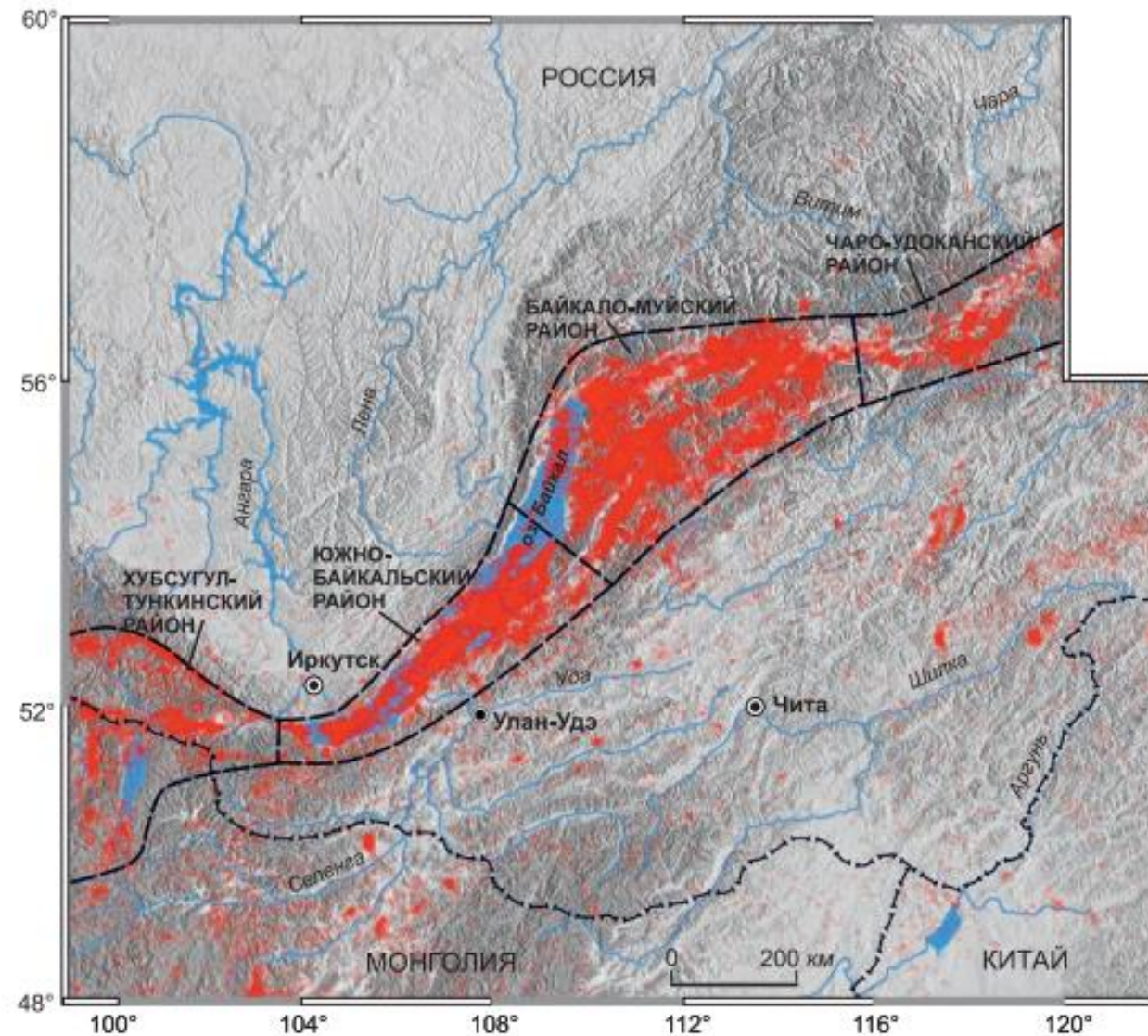
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General seismic zoning of the territory of the Russian Federation 2016 (ОСР-2016)



Change № 1 (2019) to СП 14.13330.2018

Map of earthquake epicenters in the Baikal region (Gileva, Khritova, 2023)





Previous earthquakes felt in Ulan-Ude with an intensity of V points or more

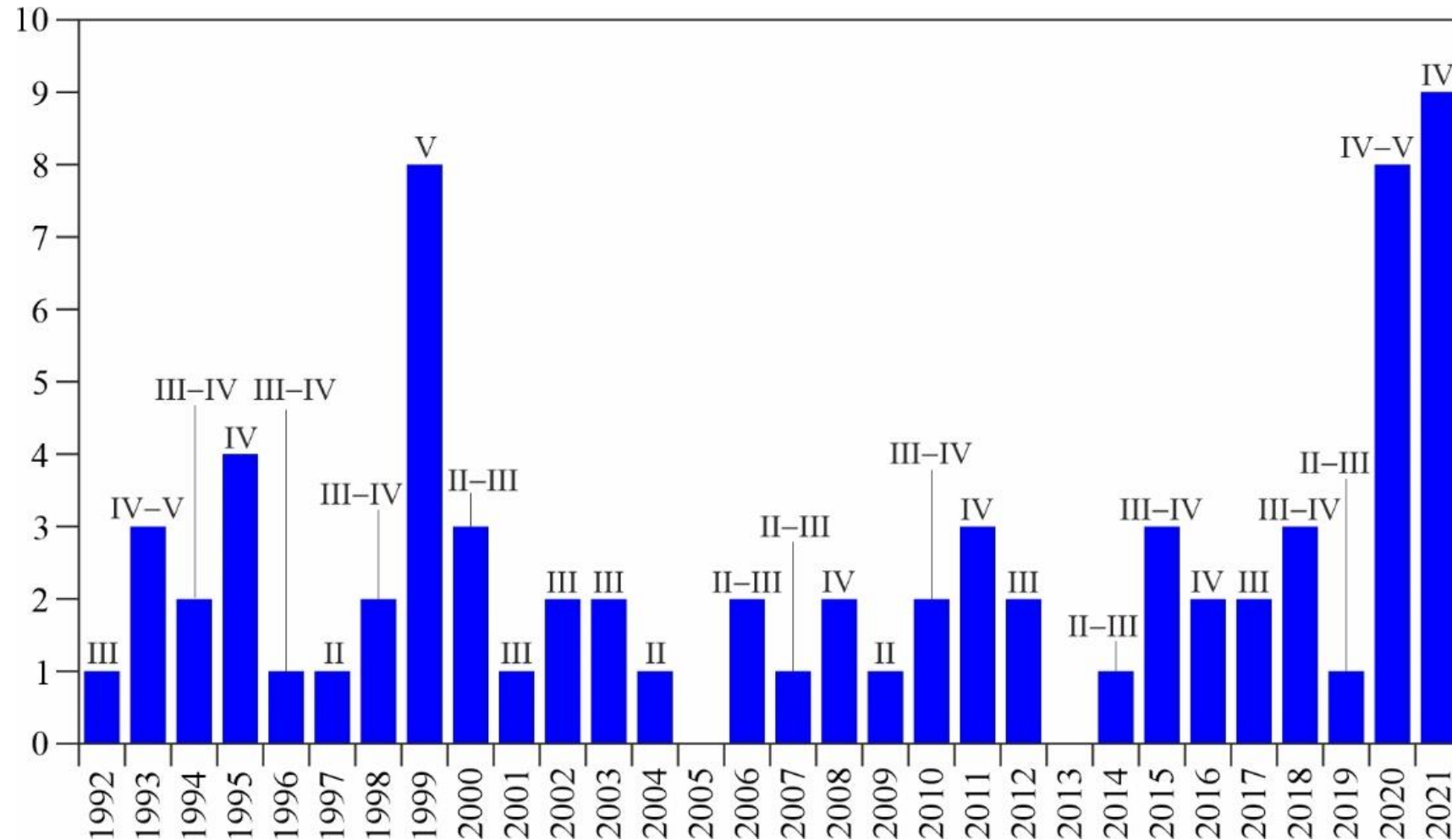
During the instrumental period (since 1952), 8

The existing probability of a repeat of such events forces us to pay close attention to macroseismic data, which provides direct information about the effects resulting from significant earthquakes

30.08.1966	51.76	104.61	5.5	V	
05.01.1967	48.1	102.9	7.1	V	Mogod Earthquake
11.02.1967	52.09	106.46	5.2	V	
28.03.1970	52.20	105.92	5.5	V	
02.10.1980	51.62	107.04	5.1	V	
25.02.1999	51.64	104.82	5.9	V	South Baikal Earthquake
08.06.2022	52.05	105.67	5.3	V	Goloustnaya-II

The territory of Western Transbaikalia, within which the Ulan-Ude city is located, is directly adjacent from the south and east to the lake basin. Lake Baikal also geodynamically forms the periphery of the Baikal seismic belt. The seismic regime of this area is determined by the nature of the latest tectonic movements inherent in the Trans-Baikal region of moderate mountain formation, and geodynamic processes occurring in the Baikal rift zone as a whole [Seminsky, Radziminovich, 2011].

The number of significant earthquakes in Ulan-Ude from 1992 to 2021 (according to the data given in the yearbooks "Earthquakes of Northern Eurasia" and "Earthquakes in Russia")



73 earthquakes

Magnitude 2.4-7.1

Epicentral distance
27-801 km

*Roman numerals indicate the maximum observed intensity of the tremors during the year.

Comparison of the number of earthquakes were actually felt and could be felt

In the Baikal region and Transbaikalia, N.V. Shebalin's macroseismic equation is used [Shebalin, 1972] with a regional set of coefficients [Novy..., 1977]:

$$I = bM - vLg\sqrt{\Delta^2 + h^2} + c, \quad (1)$$

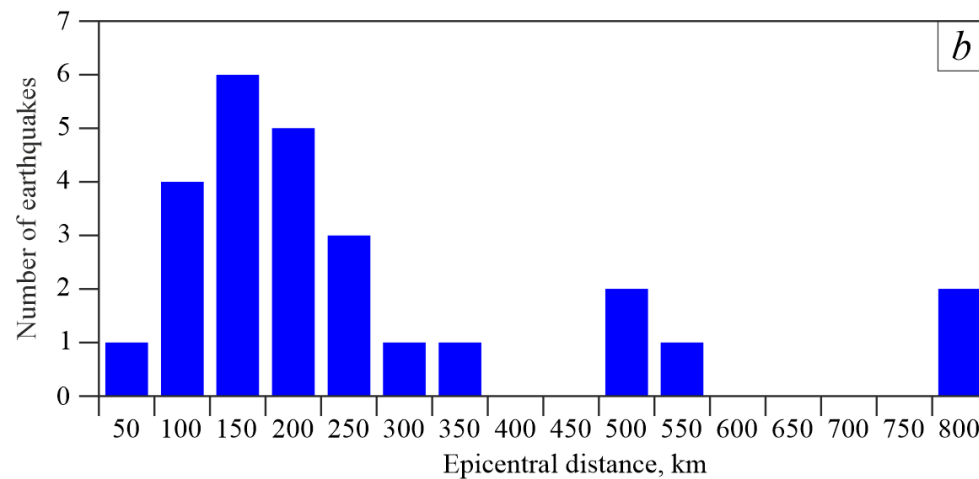
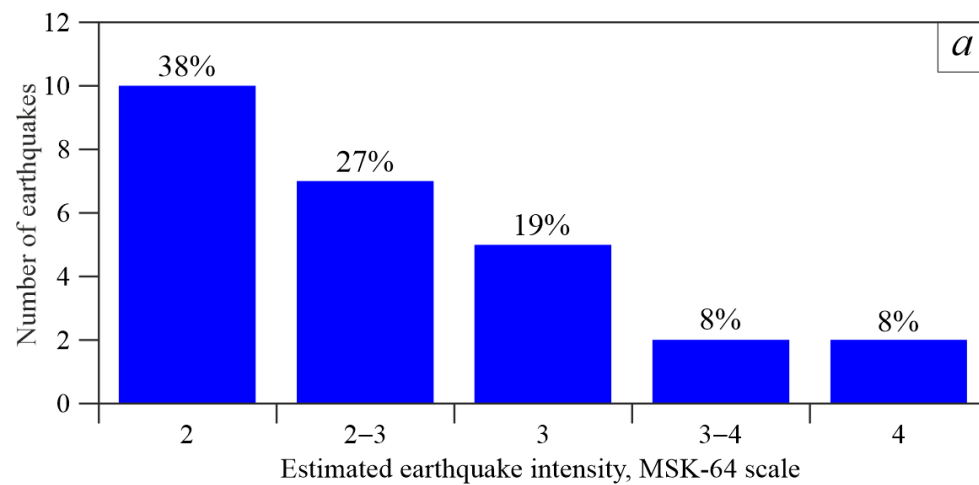
where I – shaking intensity; M – magnitude of the earthquake; Δ – epicentral distance; h – depth of the hypocenter, b , v and c – coefficients equal to 1.5, 4 and 4.

Equation (1) assumes the use of magnitude MS , the values of which for each earthquake we borrowed from the bulletin of *the International Seismological Center (ISC)*. In the absence of direct definitions of MS for weak earthquakes, we calculated its values from the energy class K_R according to the ratio from [Rautian et al., 2007]:

$$M = 5.54 + 0.828(K_R - 14), \quad (2)$$

where M – magnitude MS , K_R – energy class according to T.G. Rautian's nomogram.

Distribution of the number of earthquakes according to the estimated intensity of the earthquakes in Ulan-Ude (in absolute numbers and as a percentage) (a) and by epicentral distance (b)



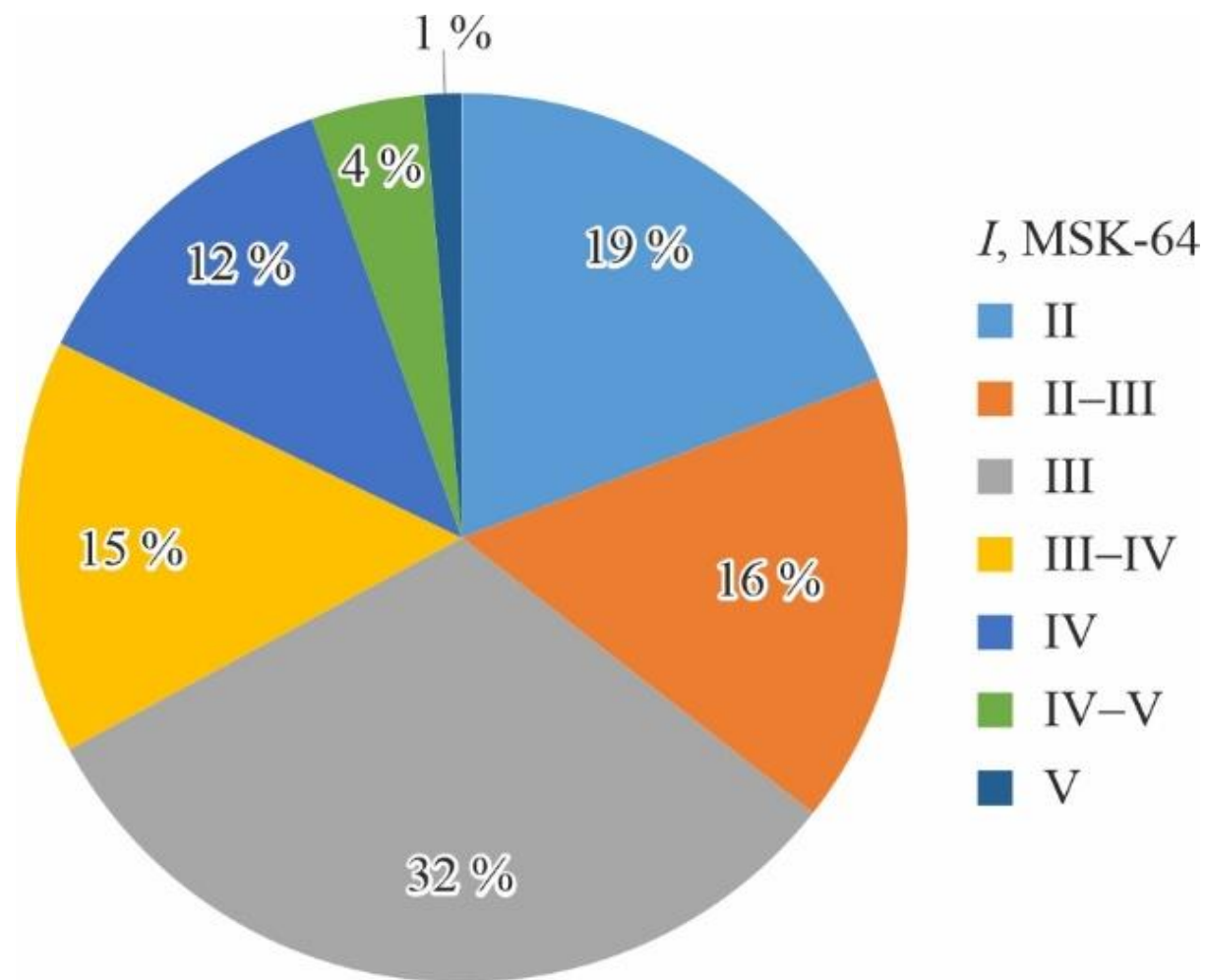
26 earthquakes with an estimated intensity 2 or higher **could be felt in Ulan-Ude**

Magnitude range 2.5 - 7.1

Intensity range 2 – 4

The majority of earthquakes (about 84%) are hardly felt by citizens

The distribution of earthquakes felt in Ulan-Ude in 1992-2021, according to the intensity of the tremors (according to the yearbooks "Earthquakes of Northern Eurasia" and "Earthquakes in Russia").



- **73 significant earthquakes** were registered in Ulan-Ude city
- **83% earthquakes** with intensities **II, II-III, III, III-IV**
- **17% earthquakes** with intensities **IV, IV-V, V**

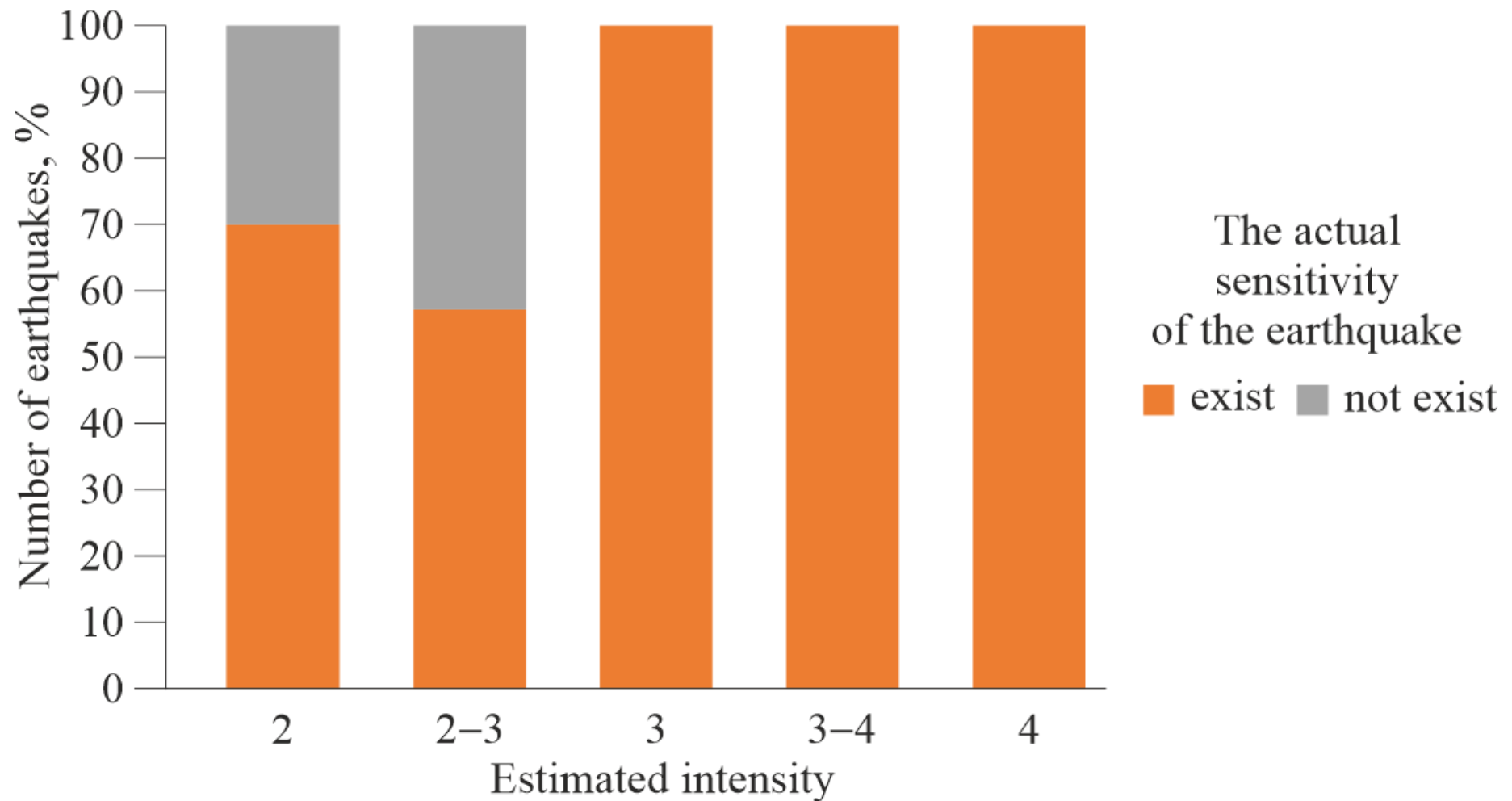
Comparison of the number of earthquakes were actually felt and could be felt: result

20 of 26 earthquakes with a theoretically calculated intensity events based on real macroseismic manifestations and presented in the yearbooks "Earthquakes in Russia" and "Earthquakes of Northern Eurasia".

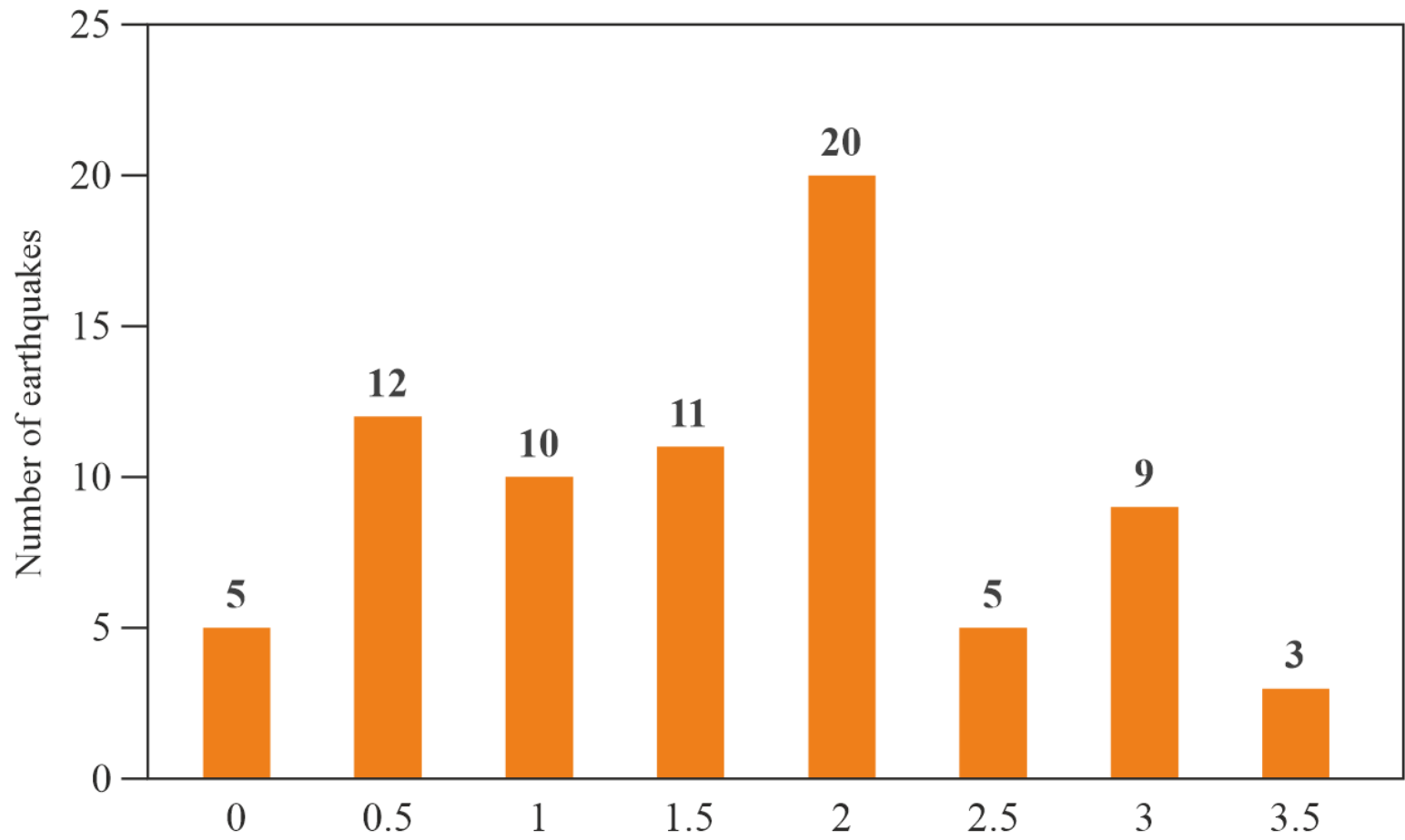
50 events, the estimated intensity of which lies below the threshold of perceptibility, actually revealed in Ulan-Ude, with an observed intensity II to IV.

In addition, three events with epicenters outside the Baikal and Transbaikalia region and not included in the regional catalog were felt in Ulan-Ude with intensity II–III, III at epicentral distances $\Delta = 440\text{--}801$ km.

The ratio of the earthquakes actually felt in Ulan-Ude and the earthquakes that could theoretically be felt in the city, depending on the estimated value of the intensity of the earthquakes



Distribution of the number of earthquakes felt in Ulan-Ude from 1992 to 2021,
by the difference between the observed and estimated intensity



- In 93% cases (70 out of 75 felt earthquakes) – the observed intensity > the theoretically calculated one
- In 7% cases – the estimates coincide

On average, the theoretically calculated intensity is underestimated by 1.5–2.0 grades compared to the observed one.

The difference between the actual and calculated intensity of the earthquake

CONCLUSIONS

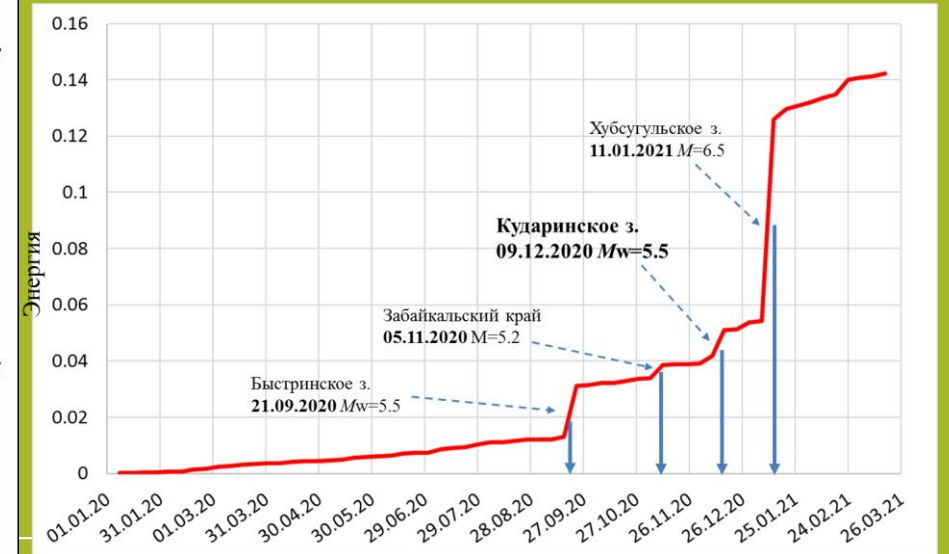
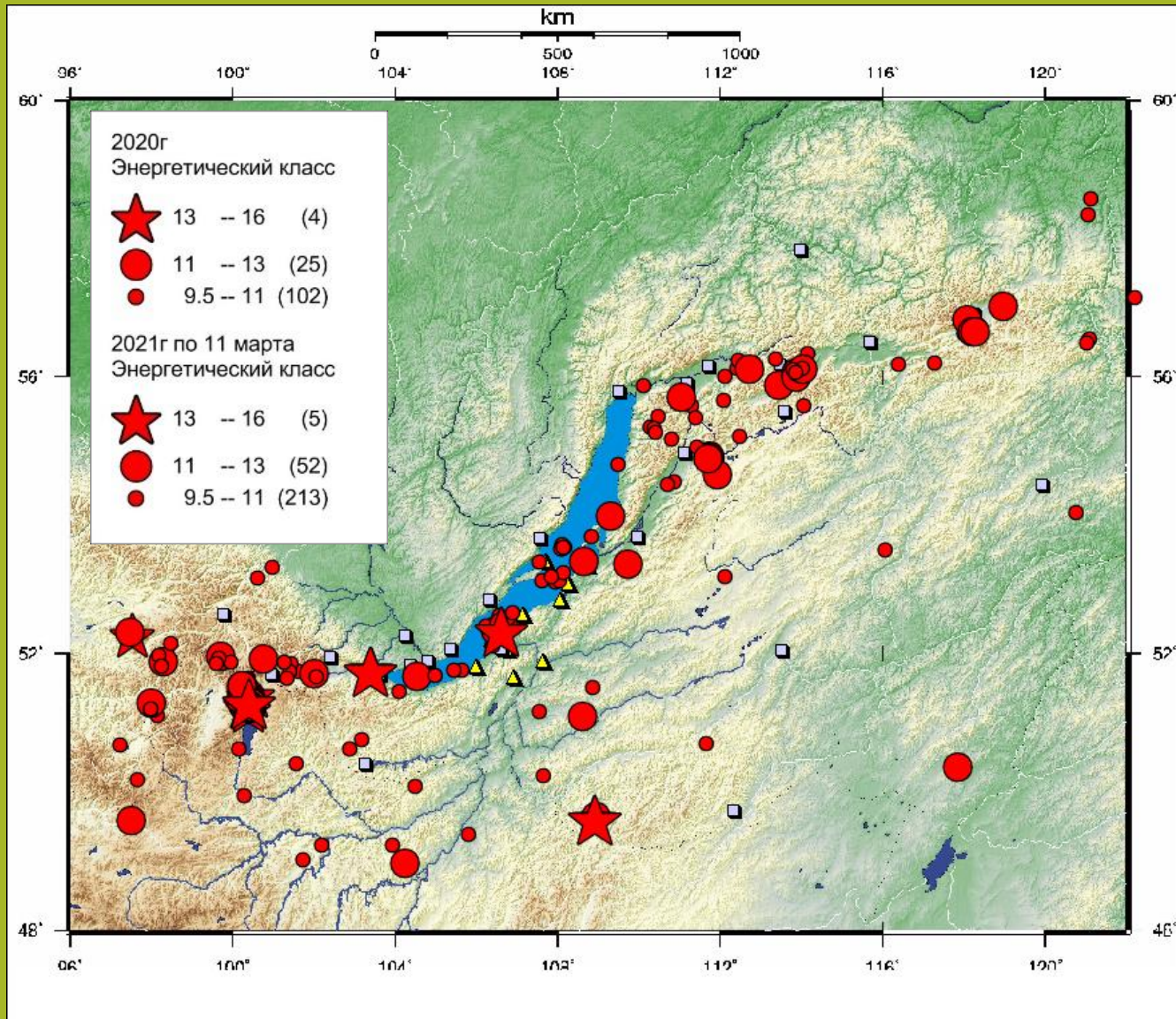
- Although 99% of perceptible events with an intensity of less than V, the current state of the city of Ulan-Ude, its densification, sprawl and high-rise buildings allow us to raise the question of a detailed macroseismic survey of any perceptible regional earthquake, even those that caused formally weak tremors. Despite the fact that the city has a long history of development and has repeatedly suffered by strong earthquakes, there are no publications on detailed macroseismic surveys. It should be noted that the assessment of the seismic hazard of a large city, such as Ulan-Ude, requires detailed information about the soil conditions of the territory [Dzhurik et al., 2015], as well as taking into account regional patterns of seismic wave attenuation [Pavlenko, Tubanov, 2017]. It is obvious that the best results can be achieved by using macroseismic data in combination with geological and instrumental seismological information [Barannikov et al., 2024].
- An analysis of the regional earthquake catalog showed that in the period 1992-2021, 26 earthquakes occurred with a theoretically calculated intensity of $I \geq 2$. Of these, 20 earthquakes were accompanied by real macroseismic manifestations, 12 of which were felt with an intensity of IV grade. Another 50 events, the estimated intensity of which lies below the threshold of perceptibility, actually manifested themselves in Ulan-Ude with an observed intensity from II to IV. In addition, 3 events with epicenters outside the region "Baikal and Transbaikalia" and not included in the regional catalog were felt in Ulan-Ude with intensity II–III, III points at epicentral distances $\Delta = 440$ –801 km.
- Thus, in the future it seems necessary to conduct detailed macroseismic surveys on the territory of Ulan-Ude not only after earthquakes, the estimated intensity of which reached V and higher, but also after less severe events. The threshold intensity at which a mass examination should be carried out can be determined by the value of III–IV grade.

THANK YOU FOR YOUR ATTENTION

SEE YOU IN ULAN-UDE



Earthquakes in the Baikal region from 01.01.2020 to 11.03.2021



- (IV) the Bystrinskoe Earthquake **21.09.2020** $M_w=5.5$
- (III) Trans-Baikal Territory **05.11.2020** $M=5.2$
- (IV-V) the Kudara earthquake **09.12.2020** $M_w=5.5$
- (IV) the Khubsugul Earthquake **11.01.2021** $M=6.5$

Macroseismic data was obtained as a result of:

direct survey of settlements in the near zone,

online filling out of questionnaires by the population
by calling village administrations and the unified duty dispatch
service (EDDS).