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SOLAR-DIURNAL ANISOTROPY OF COSMIC RAYS FOR 71 YEARS OF OBSERVATIONS

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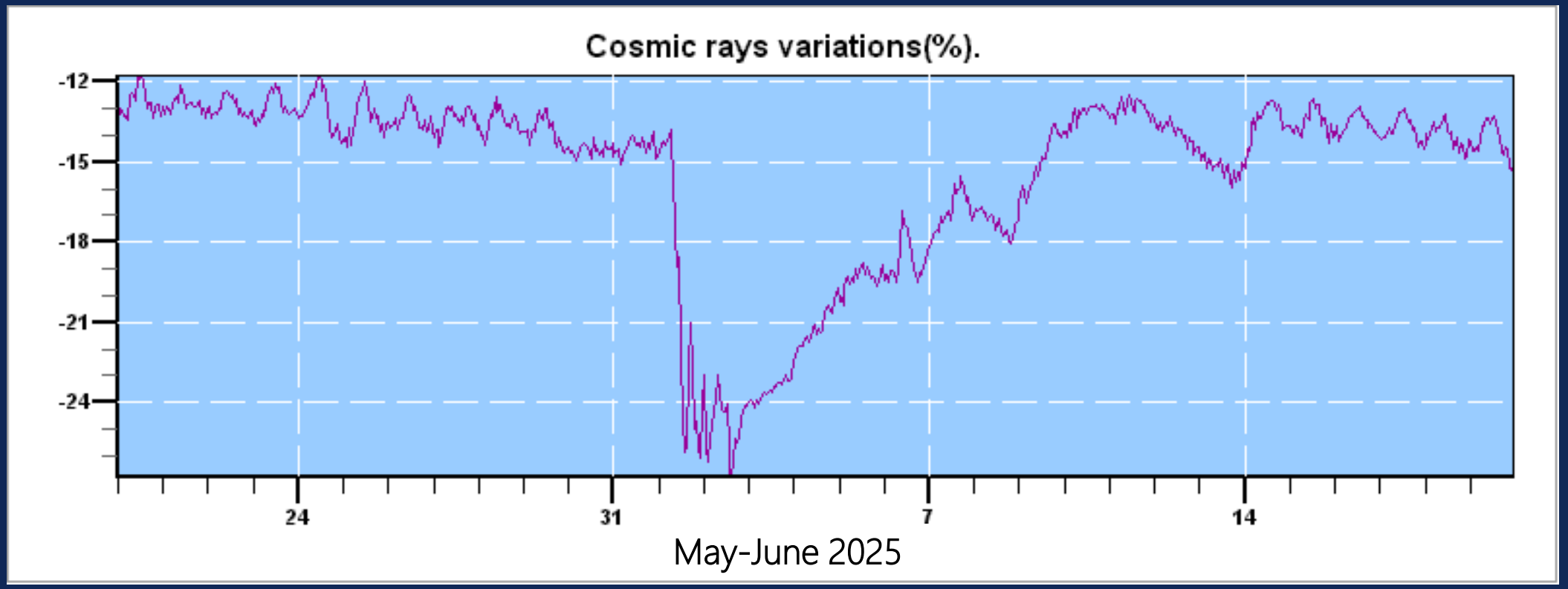
IZMIRAN

SOLAR-DIURNAL ANISOTROPY OF CRs

- From Thompson (1939), Duperier (1946), Forbush (1969) to present
- Manifestations of solar cyclicity (11- and 22-year, 27-day) and Forbush effects
- Data from ground-based detectors, ionization chambers and balloons



NM Moscow, http://cr0.izmiran.ru/mosc/

METHODS OF CR SOLAR-DIURNAL ANISOTROPY SELECTION

Local

- Harmonic/Fourier analysis of the data from one or several detectors
- Patel et al., 1968; Forbush, 1973; Mathews et al., 1969 …

Global

- Modeling on the basis of data from the entire network of NMs
- Krymsky et al., 1966; Nagashima, 1971; Belov et al., 1973

THE AIM

- To create and describe a method for selecting the solar-diurnal anisotropy of CR flux using the data of Moscow and/or Climax NMs for quiet days from 1953 to 2023
- To obtain the longest possible and sufficiently homogeneous series of solar-diurnal CR anisotropy data during quiet periods
- To compare the characteristics with the results of the global survey method (GSM) for 10 GV particles

See more details in

- Belov et al. *Selection of the Solar-Diurnal Anisotropy of Cosmic Rays by Local and Global Methods* // Geomagnetism and Aeronomy. – V. 63. – N. 3. – P. 268-282. – 2023
- Belov et al. S*olar-diurnal anisotropy of cosmic rays over 71 years of observations* // Geomagnetism and Aeronomy. – in print – 2025

MAIN STEPS

Smoothing the NM count rate

Harmonic analysis (2 harmonics)

Calculating dispersion between expected and observed variation

Excluding days with large dispersion

Excluding nonlinearity of the isotropic part

HARMONIC ANALYSIS AND SEARCH FOR QUIET DAYS

$$\delta_k = c_0 + c_1\cos(\varphi_k) + c_2\sin(\varphi_k) + c_3\cos(2\varphi_k) + c_4\sin(2\varphi_k),$$

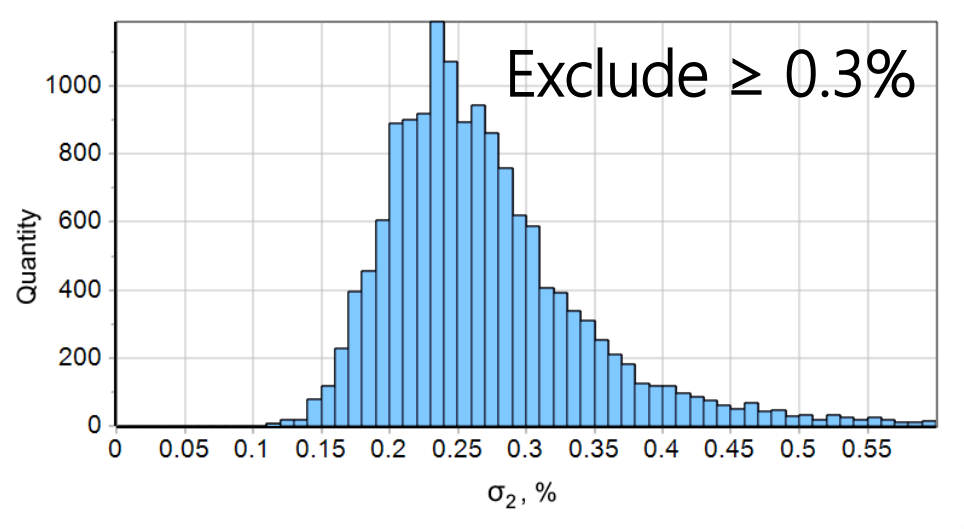
$$\delta_k^{obs} = \frac{N(k) - N_R(k)}{N_R(k)} \times 100\%.$$

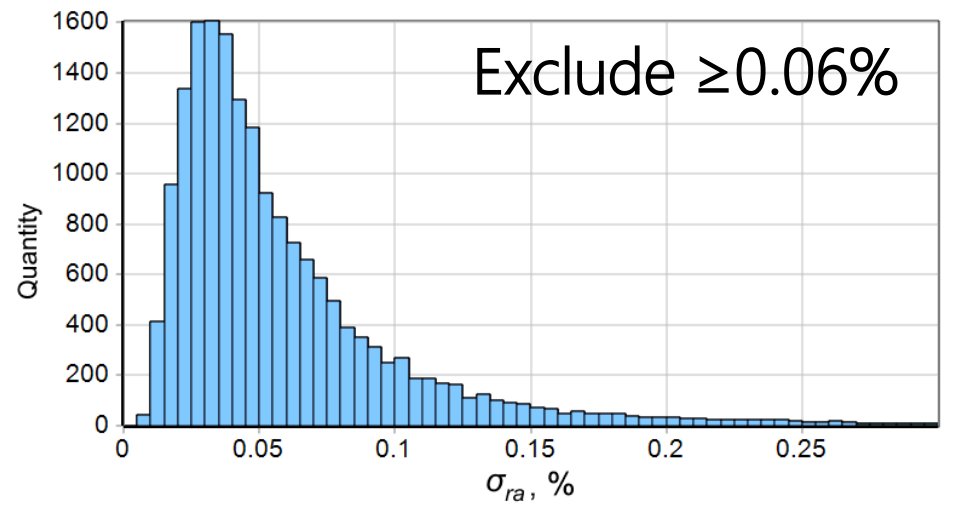
$$D = \sigma_2^2 = \frac{1}{19}\sum_{k=1}^{24}\left(\delta_k^{obs} - \delta_k\right)^2$$

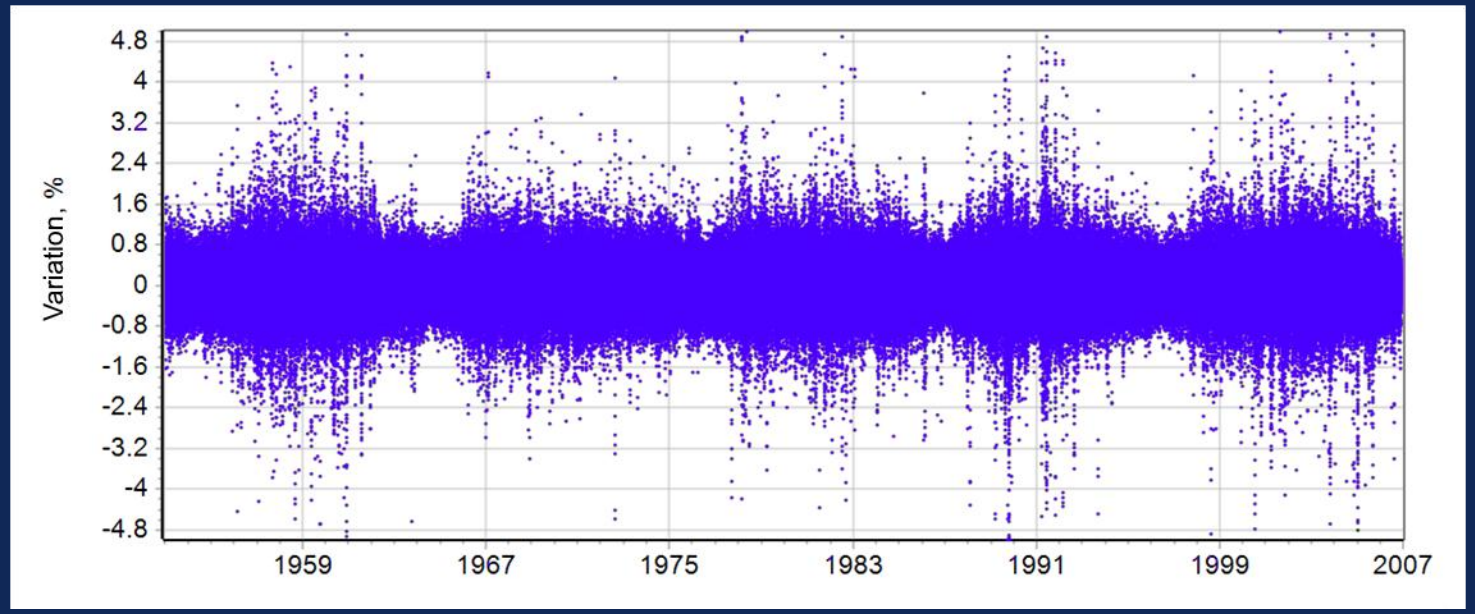
$$N = N_0 + b * (t_k - 12)$$

$$\delta_r = \frac{N - N_0}{N_0} * 100\%$$

$$\sigma_{ra}^2 = \frac{1}{22}\sum_{k=1}^{24}\delta_r^2(t_k)$$

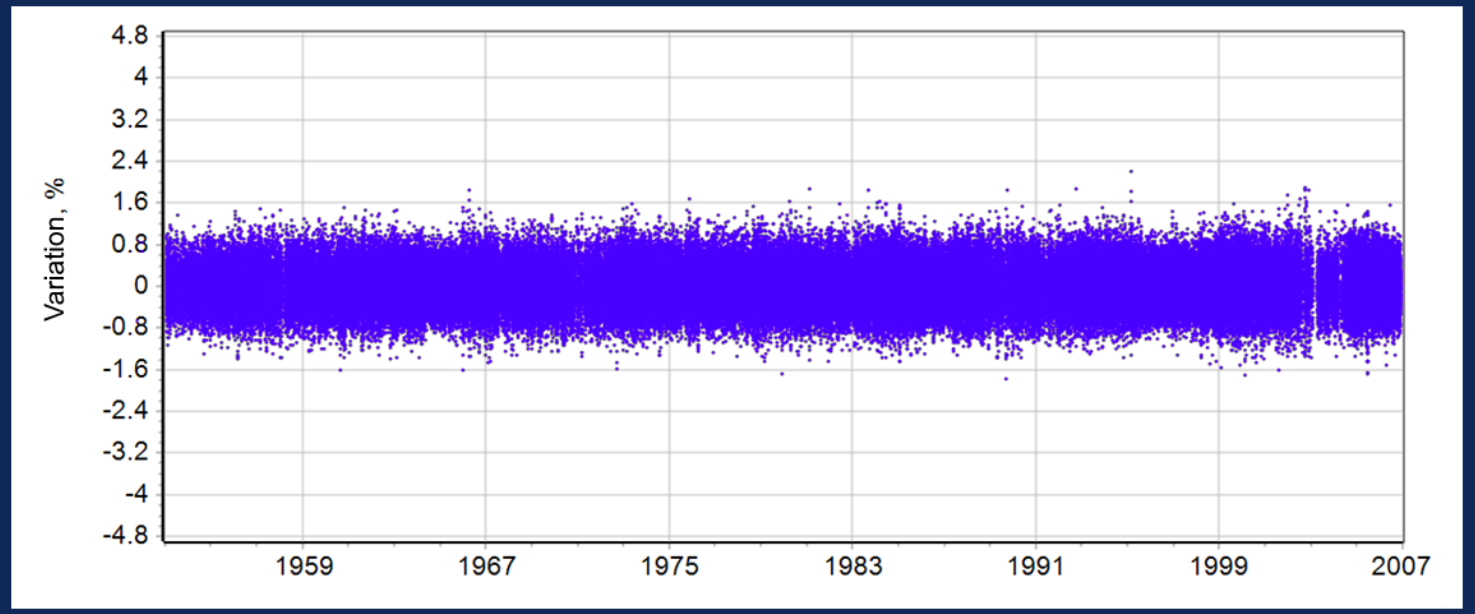






for all days

Hourly variations in the NM CLMX count rate from the sliding daily average



for quiet days

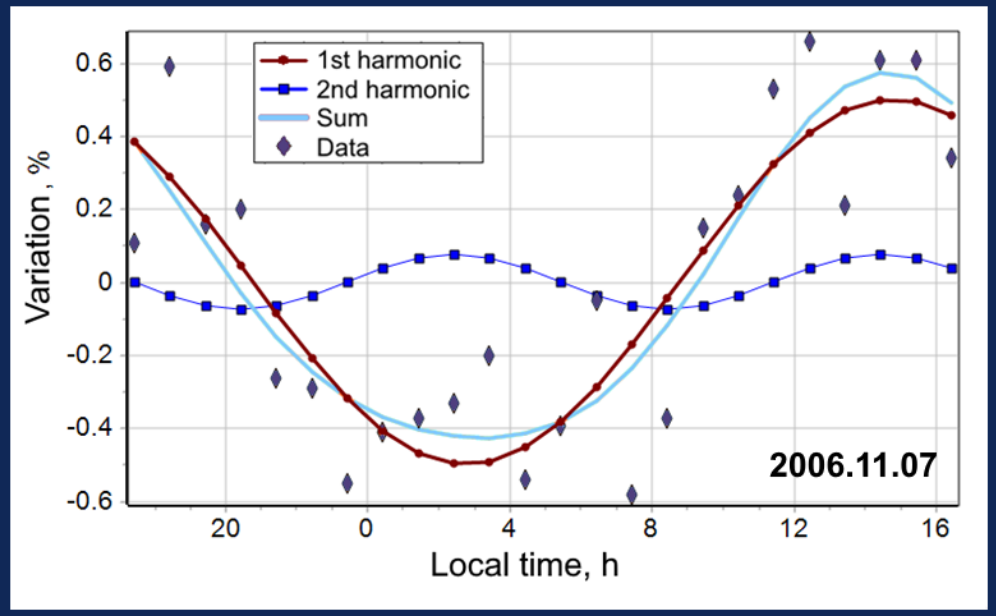
41.6% of initial data = 8184 days

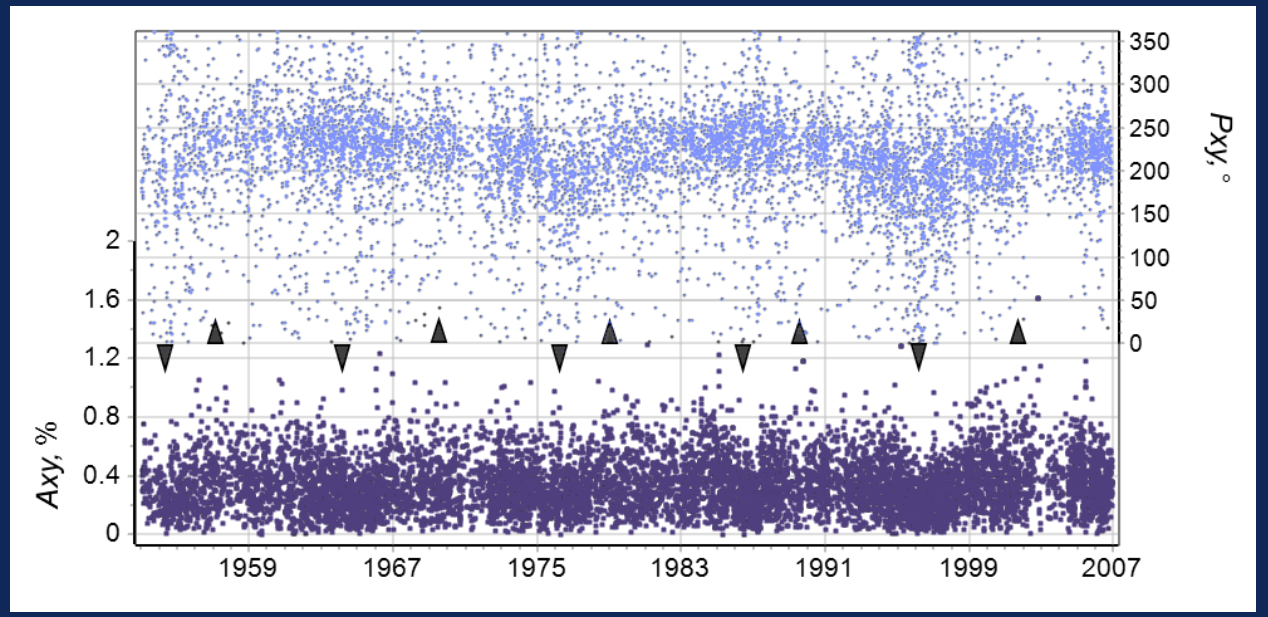
AVERAGED DAILY CR VARIATION

$$Axy = \sqrt{A_x^2 + A_y^2},$$

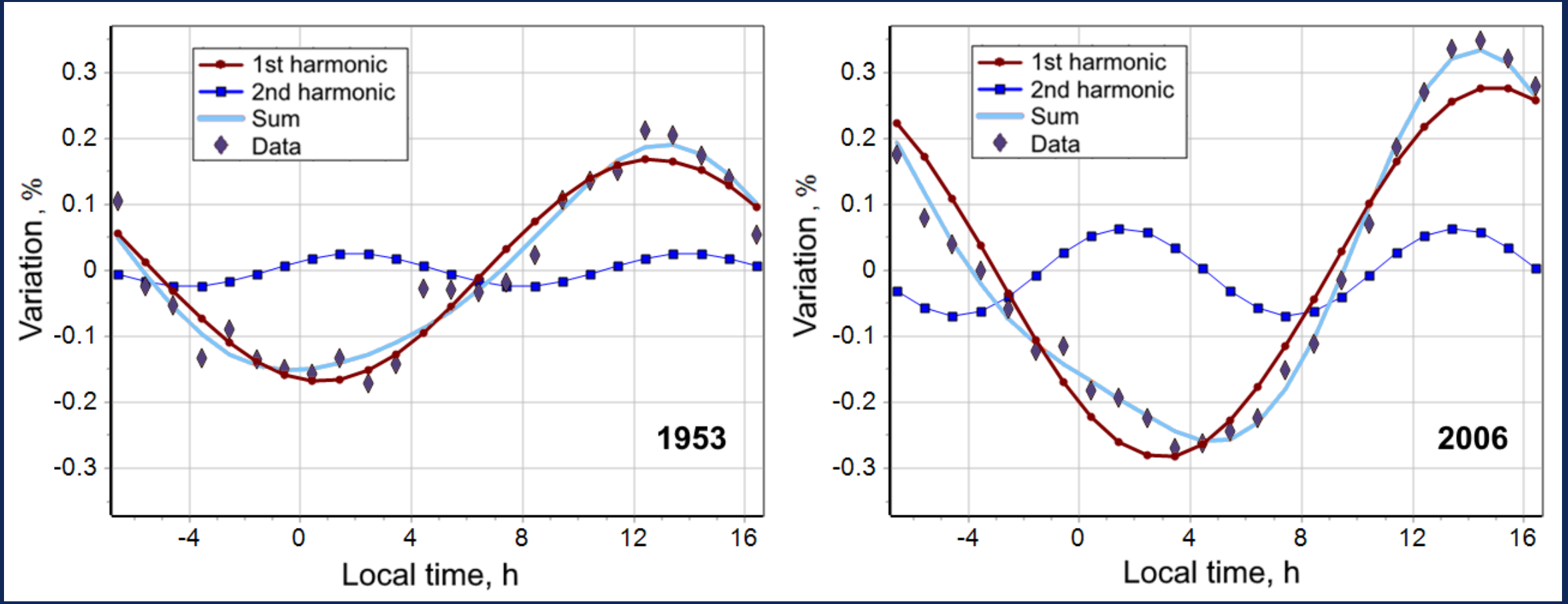
$$Pxy = \arctan\frac{A_y}{A_x},$$

	NM CLMX
Axy	0.34±0.02 %
Pxy	212±0.68 °

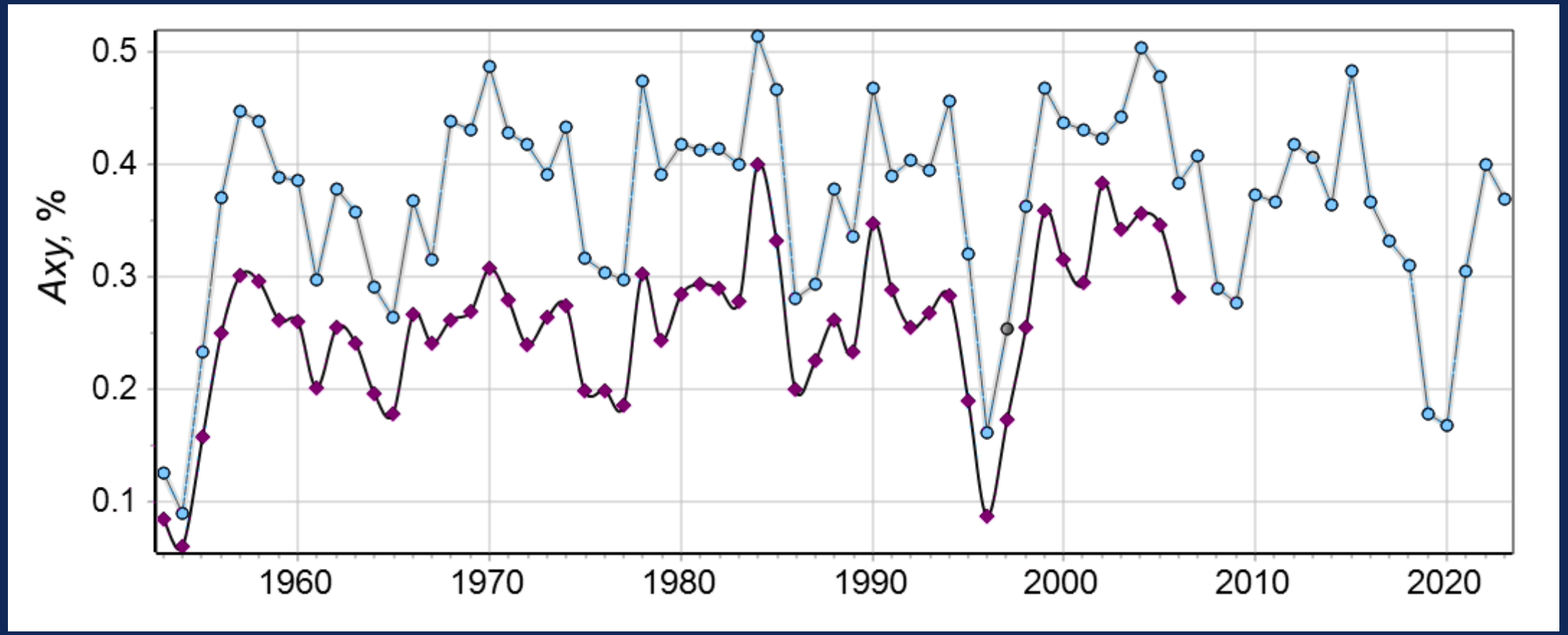




YEARLY AVERAGED DAILY CR VARIATION

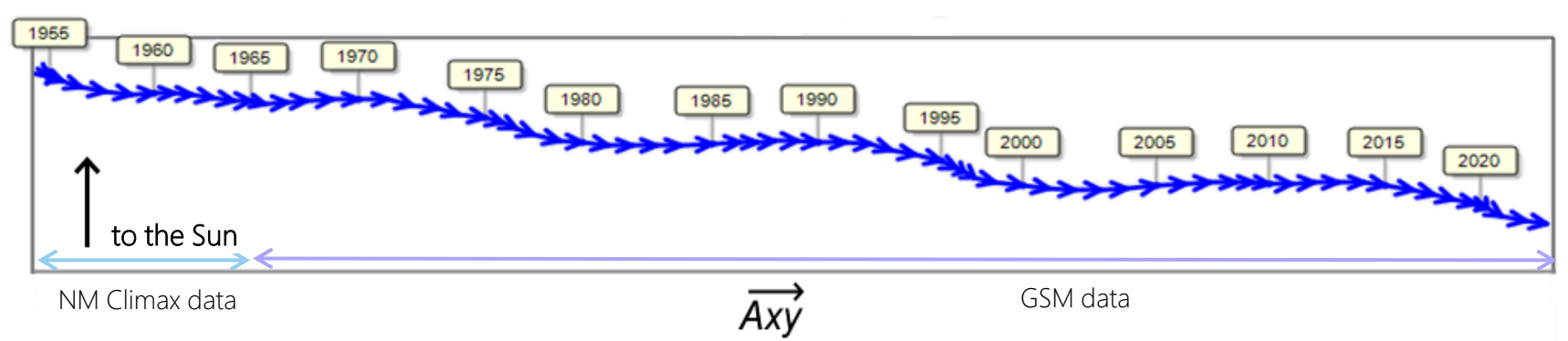


COMPARISON OF THE LOCAL (NM CLMX) AND GLOBAL (GSM) RESULTS



- NM CLMX *yearly averaged* Axy data (violet) in comparison to GSM data (blue)

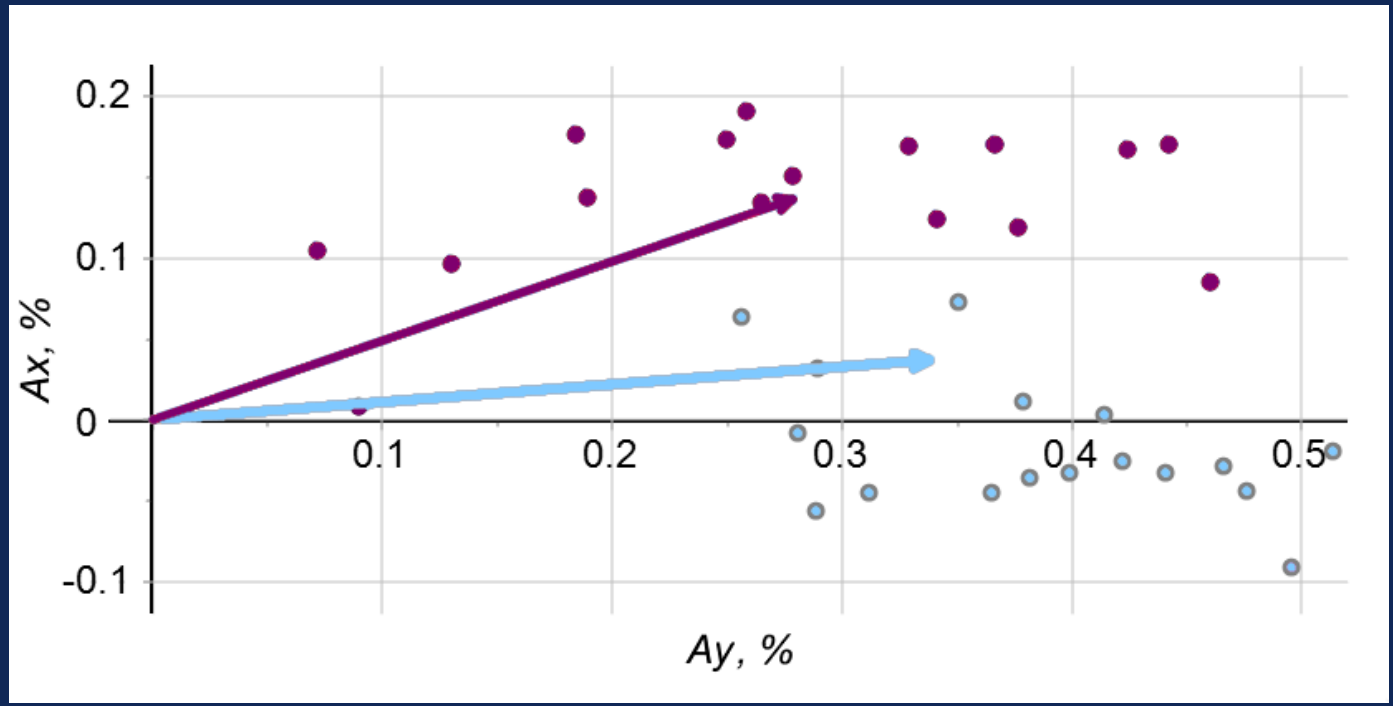
YEARLY AVERAGED CR VARIATION



- "Coupled vectors" diagram of solar-diurnal CR anisotropy

(NM CLMX+GSM data)

- Average annual values of solar-diurnal CR anisotropy in vector form (dots) and averaged values for periods of the same Sun's magnetic field polarity (arrows, blue=negative polarity)



CONCLUSIONS

1. The characteristics of the solar-diurnal variation of CRs observed at the NM CLMX were obtained on quiet days for the 1953–2006.
2. A comparison with the GSM results showed a good agreement.
3. Due to the small area of the detectors, before 1965, the Climax station provided more reliable information on the CR anisotropy than GSM.
4. Combining the GSM with the normalized NM CLMX data made it possible to obtain a reliable series of the average annual behavior of solar-diurnal anisotropy for 71 years of observations during quiet periods.
5. The amplitude of the solar-diurnal anisotropy clearly correlates with solar activity and long-term CR modulation
6. The phase of the solar-diurnal anisotropy is clearly related to the polarity of the Sun's magnetic field, with strong effects on its radial component and almost no effect on the azimuthal component.

THANK YOU

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- Belov et al. ***Selection of the Solar-Diurnal Anisotropy of Cosmic Rays by Local and Global Methods*** // Geomagnetism and Aeronomy. – V. 63. – N. 3. – P. 268-282. – 2023
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