VARIATIONS OF THE COSMIC RAY GENERAL COMPONENT IN ANTARCTICA

T.N. Charakhchyan, A.F. Krasotkin, A.I. Kurguzova
Institute of Nuclear Physics, Moscow State University, Moscow 119899, USSR

N.S. Svirzhevsky
P.N.Lebedev Physical Institute of the Academy of Sciences of the USSR, Moscow, USSR

ABSTRACT

The report treats the cosmic ray variations connected with the changes of atmospheric temperature and solar activity level and the variations which are probably due to zonal cosmic ray modulation.

A new type of cosmic ray variations, so called zonal cosmic ray modulation, was found in the lower atmosphere from the sonde measurement results /1/. The new variations give rise to anomalies in the latitude distributions of the cosmic ray charged component and the anomalous north-south asymmetry. To find the nature of the variations, we began measuring the cosmic ray general component with the same detectors as in the sonde measurements (the STS-6) gas-discharge counters and the counter telescopes with 7-mm Al filters detecting the electrons of energy above 200 keV and 5 MeV).

In this report the measurement data obtained in Antarctica (Mirny) in the years 1978-1983 are presented and discussed.

Measurement results. Two B-1 instruments described in /2/ are in operation at Mirny. The measurements are taken daily for two hours (0800-1000 UT). The data on the time dependence of the cosmic ray global component are obtained using six independent units (the unit consists of ten STS-6 counters with a 16 cm^2 geometric factor each). The monthly means of charged-particle number per minute corrected for barometric effect (-0.16%/mb) are shown in Fig. 1 (curve C). The data on time dependence of the cosmic ray vertical component are obtained using three independent units. These data corrected for barometric effect (-0.24%/mb) are shown in Fig. 1 (curve T).

Considering that radioactive background is in practice absent at Mirny /3/(the charged particle flux is

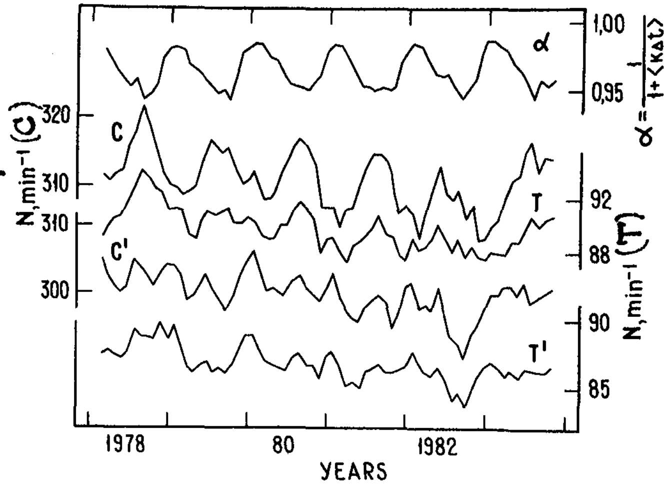

Fig.1. Time dependences at Mirny (x=1030 g/cm^2). C and T- cosmic ray global and vertical components correlated for barometric effect; α -correction coefficient for tempereture; C' and T'-cosmic ray global and vertical components corrected for barometric and temperature effects.

about 300 $m^{-2}s^{-1}$), the observed variations are mainly due to cosmic ray variations.

Seasonal cosmic ray variations. As it should be expected, the main variations of the measured particle number on the Earth's surface in Antarctica are due to the seasonal temperature variations. The seasonal variation amplitude (3-4%) is in a good agreement with the calculated values because of the muon component intensity variations /4/. Curve α in Fig. 1 presents the values of the correction factors calculated allowing for the atmospheric temperature distribution inferred from meteorological sounding data and of the partial temperature coefficients for the cosmic ray general component at sea level. The correction factor $\alpha = 1/(1+K\Delta t)$, where K is a partial temperature coefficient, Δt is the difference between the temperature measured at a given isobaric level and the temperature of the standard atmosphere at the same level; $\langle K\Delta t\rangle$ is the mean of the 10 isobaric levels in the 10-1000 g/cm^2 interval. Curves C' and T' in Fig. 1 show the data corrected for the temperature effect. It is seen that, apart from the temperature-induced variations, the general component suffers other types of variations.

The variations due to changes of solar activity level. From 1978 to 1982, the mean level of the charged-particle number at Mirny has changed by $\sim 3\%$. The same change of the particle number was inferred from the data of the vertical telescope with the 7-mm Al filter at Murmansk. The changes are in a good agreement with the nucleon component variations inferred from the data of high-latitude neutron monitors (see Fig. 2).

During the above mentioned period the sunspot number increased markedly, so the observed cosmic ray intensity decrease was mainly due to the rise of solar activity level. From Fig. 2 it may be seen that the amplitude of these variations in the nucleon component (NM) is 4 times greater than the amplitude in the general component (T) of cosmic rays at sea

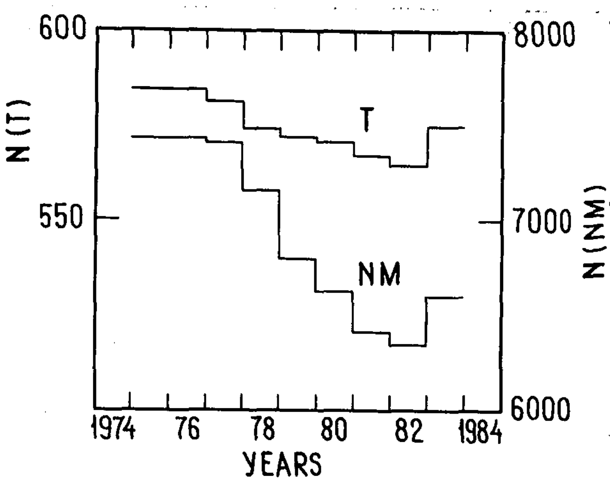

Fig. 2. The yearly means of the detected particle number at sea level. T-charged component (7-mm Al filter); NM-nucleon component (the data of the Apatity neutron monitor).

level. Once the continuous series of the nucleon component data from Apatity are available, the cosmic ray variations due to solar activity changes may be excluded from the data shown in Fig. 1 C' and T'. The time dependences of cosmic rays at Mirny after excluding the temperature variations and the variations due to solar activity are shown in Fig. 3 (Curves C'' and T''). The residual variations may be thought to be due mainly to the measurement errors and to the errors in introducing the corrections for the barometric and temperature effects. It should be noted, however, that the found variations resemble the variations in the lower atmosphere inferred from the sonde measurements of cosmic rays.

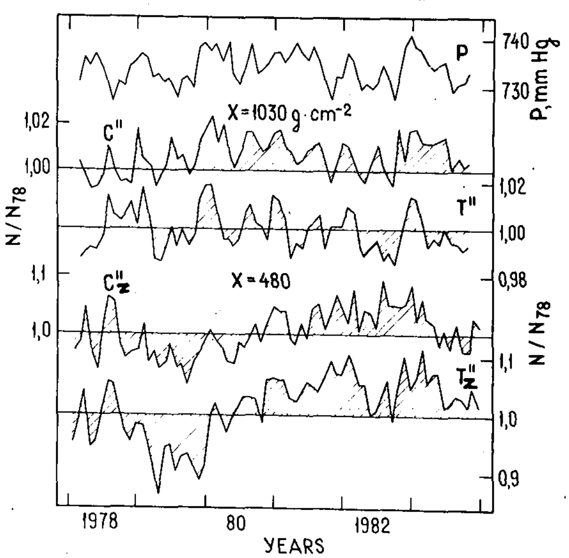

Fig. 3. The corrected time dependences of the cosmic ray charged component at Mirny. C'' and T'' – at sea level; C''_z and T''_z – at the level $x=480$ g/cm^2; P – atmospheric pressure at Mirny.

The variations due to the zonal cosmic ray modulation. During the studied period, the zonal cosmic ray modulation was clearly expressed in the lower atmosphere over Mirny, which can be seen in Fig. 3 where curves C''_Z and T''_Z show the time dependence of the cosmic ray charged component inferred from the gas-discharge counter and telescope measurements at the level x=480 g/cm^2 over Mirny after excluding the variations due to solar activity changes. Here the cosmic ray intensity variations are significant. The particle number changes by up to 10%. The changes at sea level are 1-2%, i.e. 5 times as small as the changes at 500 g/cm^2 level. In both cases, however, we can clearly see the variations of some half-year period with 1-1.5% amplitude at sea level and 2-5% amplitude at 480 g/cm^2 level. At the same time, the variations with characteristic times of 2-3 years can be seen. The found variations can hardly be accounted for by incorrect inclusion of the barometric and temperature effects because such variations are absent both in pressure (curve P in Fig. 3) and temperature (curve α in Fig. 1). In this case the annual variations would have been most probably found because they show the largest amplitudes in both pressure and temperature.

Thus, the measurements of the cosmic ray charged component at Mirny have shown that the zonal cosmic ray modulation seems to exist also at sea level, but its amplitude is about an order as low as at $\sim$500 g/cm^2 level. The same conclusion can essentially be drawn from the analysis of the neutron monitor data made in /5/ for the solar minimum of 1964-1965.

References

1. Charakhchyan A.N., et al.(1979), Proc. 16th ICRC, Kyoto, v. 3, p. 277.
2. Altukhov A.M. et al. (1984), Geomagn. i Aeron., 24, 386.
3. Charakhchyan A.N. et al. (1979), Proc. 16th ICRC, Kyoto, v. 4, p. 253.
4. Kurguzova A.I., Charakhchyan T.N. (1983), Geomagn. i Aeron., 23, 715.
5. Charakhchyan A.N. et al. (1979), Proc. 16th ICRC, Kyoto, v. 3, p. 271.