DYNAMICS OF TWO-YEAR COSMIC RAY VARIATIONS INFERRED FROM THE DATA OF SPACECRAFT AND STRATOSPHERIC MEASUREMENTS AND FROM THE NEUTRON MONITOR DATA IN 1959-1981

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ABSTRACT

The two-year cosmic ray variations are studied using the spacecraft measurements of 1967-1976, the sonde measurements at high latitudes in the stratosphere (Murmansk, Mirny), and the neutron monitor data of 1959-1981. The two-year variations are most pronounced from 1967 to 1975. An anticorrelation is observed between the two-year variations in cosmic rays and in geomagnetic activity.

In work /1/ the two-year cosmic ray variations were singled out from the stratospheric sounding data and were shown to be of isotropic character. The variation amplitude and phase are the same in the southern and northern hemispheres, they are also the same for the global and vertical fluxes of cosmic rays. The nature of the two-year variations is still obscure. Although the energy spectrum of the variations is close to the energy spectrum of the 11-year variations, but their relevance to solar activity parameters is not so obvious as in case of the 11-year variations. The problem of the stability of the variation period and phase has not been resolved either. Therefore, the information derivable from the satellite measurements beyond the Earth's magnetosphere gets essential in understanding the nature of the variations.

In the present work, the two-year variation was sought in the low-energy cosmic ray intensity beyond the Earth's magnetosphere. We processed the ≥60 MeV proton detection data (the Explorer satellites data in May,1967- May 1973/2/ and, the Soviet space probes data in June 1973-March,1976/3/).

The method of mathematical selective filter used in/1,4/ can hardly be used to discriminate the two-year variations in such a comparatively small series of experimental data because the information for two years is lost at the ends of the series, so but a single period of the two-year variation may be singled out from the satellite data. Therefore, the peculiar method based on the difference in the approximation of the data by the Fourier series was developed /5/ for small data series. If the Fourier series with different numbers of harmonics are used, they will have different cut frequencies and the difference of transforms will discriminate a narrow frequency band. Such a transform is a selective filter. The method was used to process the spacecraft data. Fig. 1 shows the results of the processing.

Fig. 1 shows also the two-year cosmic ray variations inferred from the data of stratospheric sounding at a 20 g/ /cm^2 layer at Murmansk and Mirny (Antarctica) and the neutron component data at Deep River and Climax discriminated using the numerical selective filter /4/.

It is seen that the two-year cosmic ray intensity variation was in practice absent in 1959-1965 and was pronounced in 1966-1976 when its amplitude was 4-7% on spacecraft,2-4% in the stratosphere, and 1-1.4% in the neutron component. All the cosmic ray data show a good coincidence of the variation phases. The fact that the two-year variation appeared in the spacecraft data is worth noting because it demonstrates that the variation is actually due to the two-year variation of the interplanetary medium parameters rather than to some geophysical effect.

A change should be noted in the variation period which was 24-25 months in 1966-1972 and 19-20 months in

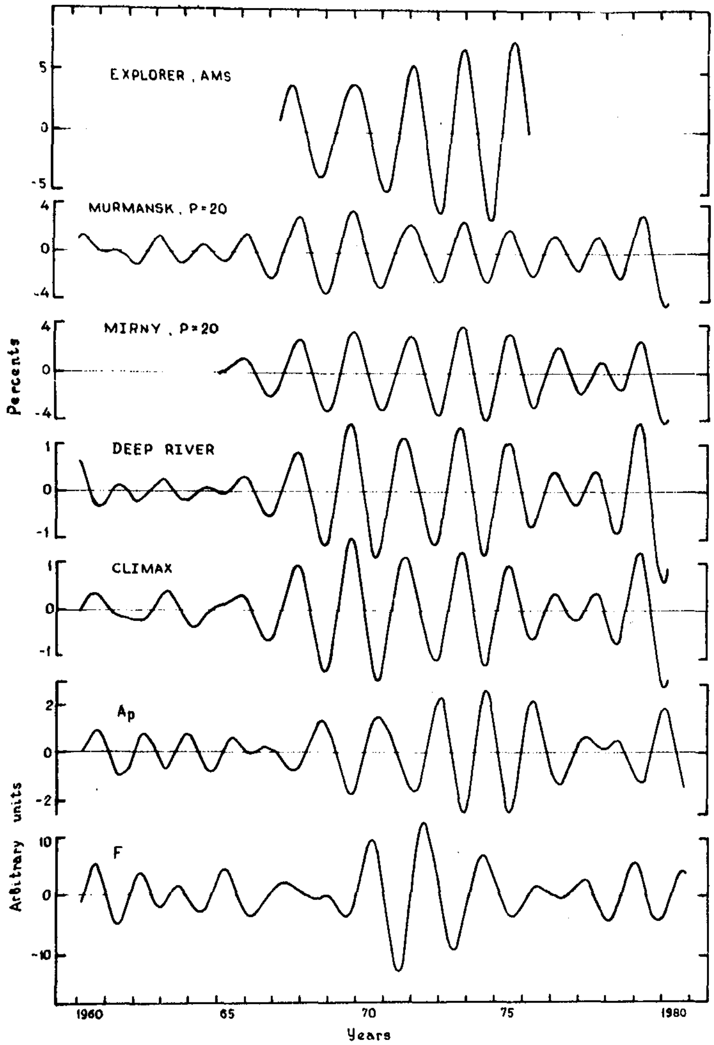

Fig. 1.

The twoyear variations obtained using the selective filter. The upper curve shows the data from the Explorer satellite and from the Soviet space probes. The stratospheric data at 20 g/cm^2 level over Murmansk and Mirny. The neutron component at Deep River and Climax. The Ap-index. F is the 10.7 cm radio emission from the Sun.

1973-1977. Since the change is seen in all the data,it is not accidental and reflects the real changes of the character of the variations in the interplanetary medium parameters. Fig. 1 also shows the two-year variations inferred from the solar 10.7 cm radio emission (F) and from the Ap-index. Although the two-year variation was felt in solar activity, its dynamics differs much from the two-year cosmic ray variation. The two-year wave in solar ativity was in practice absent in 1966-1969. Considering that the variations in solar activity and cosmic rays must be of opposite phase,the phase shift between solar activity and cosmic rays was about half-year in 1970-1975.This fact should have meant that a large modulation region is responsible for the cosmic ray variation,but such a conclusion is at variance with the data on the two-year geomagnetic activity variations.

From Fig. 1 it is seen that the pronounced two-year variation was observed simultaneously in the Ap-index and in cosmic rays. It is woth noting that the waves in the Ap--index and in cosmic rays are clearly of opposite phase. Both the Ap-index and cosmic rays exhibit the trend in the variation period to change from 24-25 months to 19-20 months. All the above means most probably that the two-year cosmic ray variation is due to the changes in the properties of the near region of interplanetary space and is contingent upon the variations of the same parameters which give rise to the geomagnetic activity variations (solar wind velocity and density,interplanetary magnetic field).

The preliminary processing of the data obtained before 1984 has shown that the amplitude of the two-year cosmic ray variation increased markedly after 1979,so in 1980-1983 it was closer to the variation amplitude in 1968-1974.

Thus, the two-year variation dynamics is characterized by significant changes in the amplitude,phase,and period of the variation. Since the significant decreases of the variation amplitude occur during the periods close to the solar minima (1964-1965,1975-1977)and in the periods close to the solar maximum (1959-1982),the dynamics of the two--year variations does not seem to depend on the phase of the 11-year solar activity cycle,but is most probably determined by the state of the heliosphere,the approach adopted, for example, in /6/.

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