ON THE SOLAR CYCLE VARIATION IN THE BAROMETER COEFFICIENTS OF HIGH LATITUDE NEUTRON MONITORS

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ABSTRACT

Evaluation of barometer coefficients of neutron monitors located at high latitudes has been performed by using the results of the spherical harmonic analysis based on the records from around twenty stations for twelve years from January 1966 to December 1977. The average of data at eight stations, where continuous records are available for twelve years, show that the absolute value of barometer coefficient is in positive correlation with the cosmic ray neutron intensity. The variation rate of the barometer coefficient to the cosmic ray neutron intensity is influenced by the changes in the cutoff rigidity and in the primary spectrum.

1. Introduction

Many authors[1)] have indicated an eleven year change of the barometer coefficients of the cosmic ray neutron monitors. Since there was no unique technique for determing the coefficient, the results obtained by different authors may be different. We developed a systematic method to examine the barometer coefficient[2-4)] and clarified the solar cycle variation of the barometer coefficient more precisely.

To evaluate the barometer coefficient of neutron monitor, it is necessary to separate strictly the cosmic ray intensity variation induced by the primary cosmic ray variation from the one caused by the atmospheric pressure variation. For this purpose, we used the results obtained by the spherical harmonic analysis[5)] which is performed on the basis of the neutron monitor records from around twenty stations at high latitudes where the cutoff rigidities Rc's are below 2.3 GV.

2. Residual barometer coefficient

The difference ΔI_p between the pressure corrected neutron monitor data I_p (percentage value) and the estimated neutron intensity $\overline{Y}$ calculated from the spherical harmonic analysis is expressed as

$$\Delta I_p = I_p - \overline{Y}.$$

This subtraction enables to eliminate the effect of the intensity variation of the primary cosmic rays outside the magnetosphere. The residual barometer coefficient $\Delta\beta$ is obtained as a linear regression coefficient by the statistical analysis of correlation be tween the pressure p and the diffrednce ΔI_p . Results of $\Delta\beta$ for the period, from 1966 to 1977 are presented in the reference(4). The corrected pressure coefficient β_{cor} is derived according to the equation

$$\beta_{cor} = \beta_o + \Delta\beta,$$

where β_o is the reported barometer coefficient from each station.

3. Solar cycle variation of the barometer coefficient

Figure 1 shows the year-to-year variation of cosmic ray intensity $\bar{I}$ and barometer coefficient $\bar{\beta}$. where $\bar{I}$ and $\bar{\beta}$ are the averages of yearly mean data of eight stations (Alert, Deep River, Goose Bay, Inuvik, Kerguelen, Kiel, Oulu and Sanae) where the continuous data are available through twelve years from 1966 to 1977. Mean intensity of neutron component $\bar{I}$ is normalized to 100 percent at the point of the year 1966. C_0 is the yearly mean value of the isotropic component of spherical harmonic coefficients and normalized to the value of 1966, but plotted 4% higher level, and Rz, the sunspot number which is an index of solar activity is plotted inversely.

In order to investigate the solar modulation of barometer coefficient, we analyzed the relation between the barometer coefficient and the cosmic ray intensity. Figure 2 shows the relation between the barometer coefficient $\bar{\beta}$ and the cosmic ray intensity $\bar{I}$. The linear regression coefficient throughout the whole period is $\alpha_\gamma=(1.83\pm0.24)\times10^{-3}$ mmHg with a correlation coefficient, r=0.92.

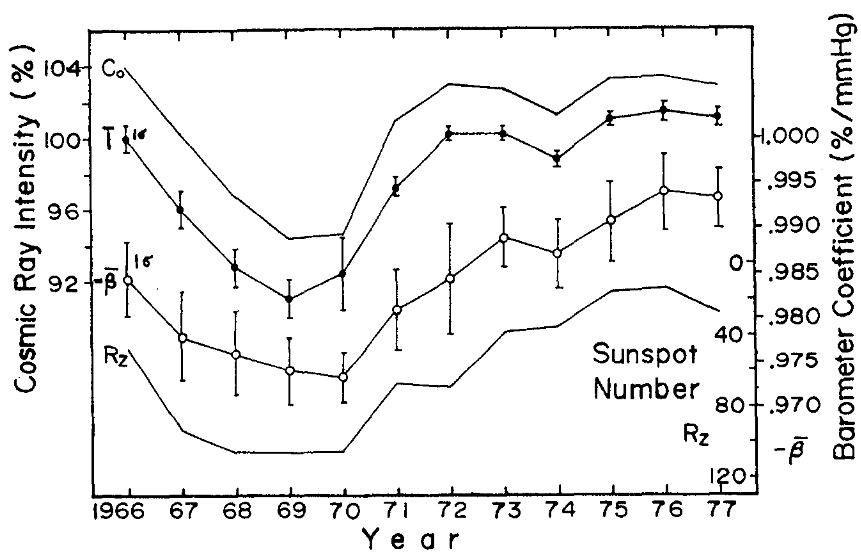

Fig.1. The yearly variation of C_0: the isotropic component of the spherical harmonic coefficients. $\bar{I}$: cosmic ray neutron intensity and $\bar{\beta}$ barometer coefficient, they all are averages of eight stations and error bars indicate the scatter of individual station, and Rz: the sunspot number.

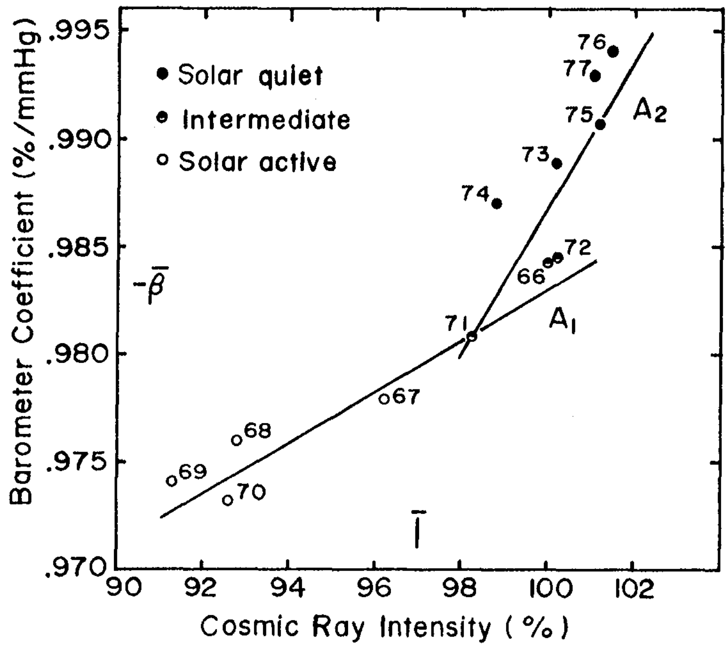

Fig.2. Relation between the barometer coefficient and cosmic ray intensity variations. Lines A_1 and A_2 represent the linear regression line between the barometer coefficient and the cosmic ray intensity in the solar active and the solar quiet period respectively.

4. Relation between the barometer coefficient and the cosmic ray primary spectrum variation

In a previous paper,[4] it was reported that the variation rate of the barometer coefficient to the cosmic ray intensity is larger in the solar quiet period than in the solar active period. About the quantitative relation between the barometer coefficient variation and primary cosmic ray rigidity spectrum, an analysis is performed. The present report is concerned with the numerical calculation to clarify the relation between the barometer coefficient and the cosmic ray primary spectrum variation.

We calculated the variation rate of the barometer coefficent α_γ which is defined as $\alpha_\gamma=\delta\beta/\delta I$. The ratio $\delta J/J_o$ represents the variation of the primary cosmic radiation. For a primary variational spectrum, we assumed as

$$\frac{\delta J(R)}{J_o(R)} = \begin{cases} AR^{-\gamma} & for \quad R \leq Ru \\ 0 & for \quad R > Ru \end{cases}$$

The calculations[6,8] were performed for several different values of power γ, where A=constant and Ru = 40GV are assumed. The curve in Fig.3 represents the distribution of α_γ, where γ = 1.7 is assumed. It is clearly illustrated by the changes in the cutoff rigidity and in the primary spectrum. As for the computation of α_γ when the solar activity is high, it is necessary to estimate the rigidity dependence of barometer coefficient.

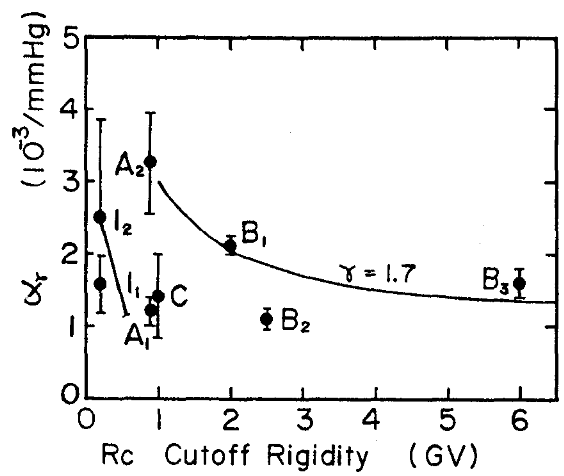

Fig.3. Distribution of α_γ is plotted in absolute value. The abscissa is the cutoff rigidity, where the neutron monitor is located, or the mean rigidity at several stations. Curve represents the distribution of α_γ, which is the result of numerical calculation[8], where γ=1.7 is assumed. A_1 and A_2 (Averages of eight high latitude stations)[4]; I_1 and I_2 (Inuvik)[7]; B_1, B_2 and B_3 (Averages of several stations)[9]; C(Deep River)[10].

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