

INVESTIGATION OF IMPACT OF SOLAR-TERRESTRIAL CONNECTIONS ON CLOUDINESS IN NORTHERN ASIA ON REMOTE SENSING DATA

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ABSTRACT:

On NOAA satellite data the cloudiness in Northern Asia region (80°-175°E; 40°-74°N) was obtained and the research of impact of solar-terrestrial connections on cloudiness has been carried out. The examined region was divided into three latitudinal zones (“southern” zone 40°N-56°N, “central” zone 56°N-66°N and “northern” zone 66°N-74°N) and influence of variations of cosmic rays intensity on values and latitudinal dynamics of cloudy cover in these zones were analyzed. Depending on level of geomagnetic disturbances the correlation of cloudiness with the decreases of cosmic rays intensity (Forbush-decrease) was various. It is shown that when Auroral Index (AE) was more 300 nT the sign of correlation was positive, whereas at $AE < 300$ nT the correlation was negative. For strong Forbush-decreases, when AE was more 300 nT, the latitudinal displacement dependence of a cloudy cover from intensity of cosmic rays was observed.

1. INTRODUCTION

The many articles (for example: Veretenenko, Pudovkin, 1999; Thejll, Morozova, 2002) are devoted to investigation of the variations of cloudiness in dependence on changes of intensity of cosmic rays. In result of these investigations the influence of long-term and shortly periodical variations of solar activity on the low atmosphere, weather and climate was established. Mentioned above investigations were carried out on the ground-based data obtained on meteorological stations. Satellite methods in comparison with ground-based methods of a visual estimation of cloudiness on meteorological stations allow obtaining a quantitative map of cloudy cover over large area.

Researches of influence of cosmic rays on changes of cloudiness of Northern Asia were carried out on base of NOAA satellite data obtained in Yakutsk, Russia (Solovyev, Kozlov, 2005; Solovyev, Kozlov, et al. 2006a; Solovyev, Kozlov, 2006b).

2. METHODS

The climate of Northern Asia is a continental. The latitudinal and longitudinal width of examined region are 34° (40°N-74°N) and 95° (80°E-175°E) respectively. The satellite data were processed for three latitudinal zones determined by orographical features: “southern” zone (40°N-56°N), “central” zone (56°N-66°N) and “northern” zone (66°N-74°N). The detection of “cloudy” pixels in multichannel images of AVHRR radiometer has been executed by means of standard procedures recommended by NOAA. Cloudiness of each zone was calculated as the ratio of the area covered by clouds to the full area of a zone. The cloudiness obtained within day from several satellite passes was averaged.

The analysis of variations of a cloudy cover depending on change of intensity of cosmic rays (CR) is carried out by a method of imposing of epochs. For consideration of impact of CR on cloudiness the 18 events when $AE < 300$ nT and 12

events when $AE > 300$ nT has been selected. The 1st day of Forbush-decrease was determined as zero day ($t=0$). Data of neutron monitors in Moscow (IZMIRAN) and Yakutsk (IKFIA SB RAS) have been used.

RESULTS & DISCUSSION

The cloudiness variations of three zones for considered Forbush-decreases are presented in figure 1(a,b).

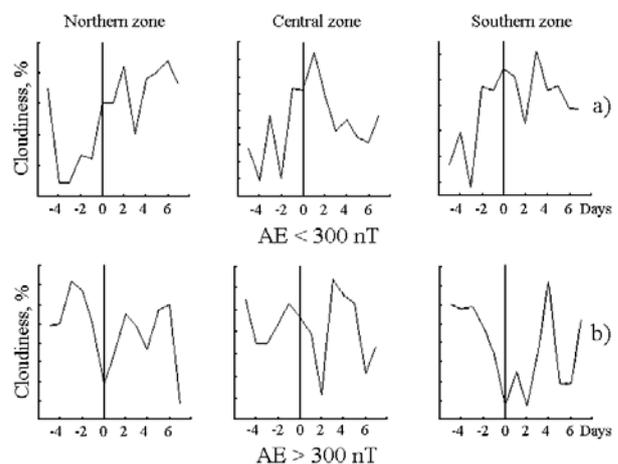


Figure 1. The averaged cloudiness variations in examined latitudinal zones during Forbush-decreases for $AE < 300$ nT (a) and $AE > 300$ nT (b). The zero day is a day of Forbush-decrease beginning

As follows from figure 1, for events when $AE < 300$ nT the weak decrease of cloudiness is observed after beginning of Forbush-decrease (statistically doubtfully), but basically the increasing is observed in comparison with days before Forbush-decrease. There is a temporal distinction in variations of cloudiness of different zones. For events when $AE > 300$ nT (Fig. 1b) the

cloudiness depression is observed in all latitudinal zones, this situation corresponds to results of article (Veretenenko, 1999). The more significant dependence of cloudiness with intensity of cosmic rays was observed in the "central" zone in July-August, 2000 (Fig. 2). It is known, that the effect of influence of Forbush-decreases on cloudiness is inertial and lasts several days. As in July-August 2000 a long series of Forbush-decreases was registered the common reaction of cloudiness demonstrated the complex picture caused by superposition of separate Forbush-decreases. Therefore the coefficient of correlation has appeared not large, i.e. 0.4 ($p < 0.05$).

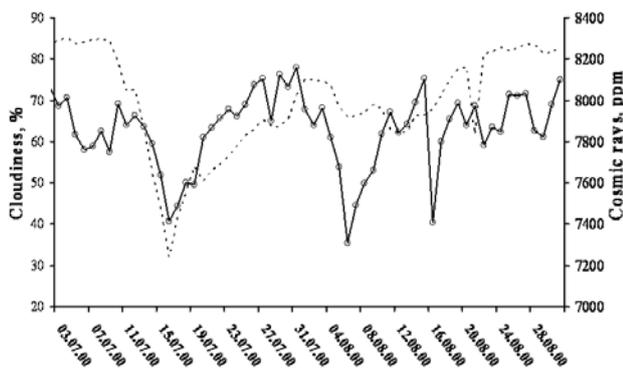


Figure 2. Variations of cloudiness in "central" zone (solid line with open circles) and the intensity of cosmic ray (dashed line) for 03.07.2000-29.08.2000

In more details the behavior of cloudy cover of examined region depending on intensity of cosmic rays is presented on an example of a case of Forbush-decrease taken place on 19-29.05.2000 when $AE < 300$ nT (Fig. 3).

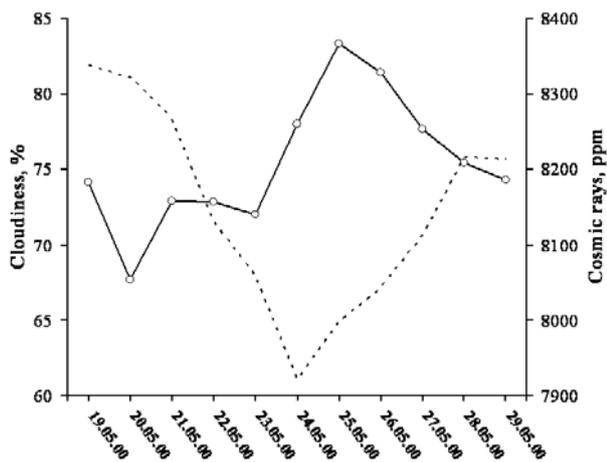


Figure 3. Variations of the common cloudiness (solid line) and intensity of cosmic rays (grey line with dots) on 19-29.05.2000

In this event the correlation coefficient of intensity of cosmic rays and cloudiness for all latitudinal zones is -0.68 . Thus the negative correlation of cloudiness and cosmic rays is observed. For event 19-21 May 2000 the variations of cloudiness in three latitudinal zones are presented on Fig. 4, where dashed line is cosmic rays, dashed line with triangles is cloudiness in "central" zone, grey solid line with squares is cloudiness in

"northern" zone, and solid line with open circles is cloudiness in "southern" zone.

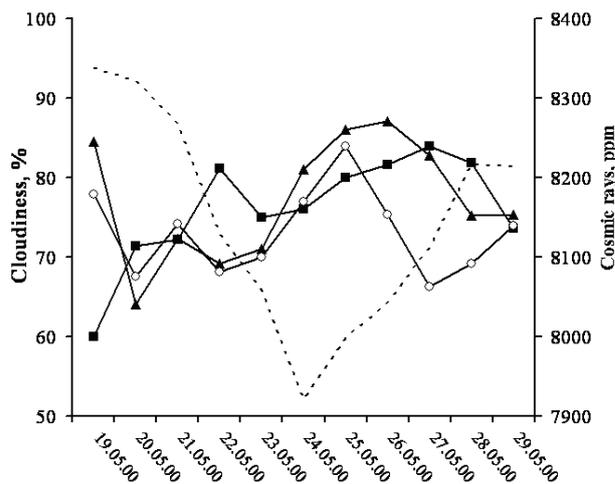


Figure 4. The variations of cloudiness in three zones and intensity of cosmic rays on 19-29 May 2000

As shown on figure 4 the increase of cloudy cover in "northern" zone coincides with the beginning of Forbush-decrease and the maximum of cloudiness is reached after one day. In two day after the beginning of Forbush-decrease the increase of cloudiness in the "central" and "southern" zones begins. The maximum of cloudiness in a "southern" zone is reached in fourth day, and in central - in fifth day. Maybe the increase of cloudiness during five days after the Forbush-decrease and its soft decrease is caused by latitudinal displacement of cloudiness from "northern" and "southern" zones to "central" zone.

For investigation of possible latitudinal shifts the ratios of cloudiness in the "central" zone to cloudiness in "northern" and "southern" zones has been calculated. From obtained ratios the average values of cloudiness have been subtracted. The results of these calculations are presented in Fig. 5, where dashed line is cosmic ray variations, solid line with triangles is ratio of "central" and "southern" cloudiness, solid line with open circles is ratio of "central" and "northern" cloudiness.

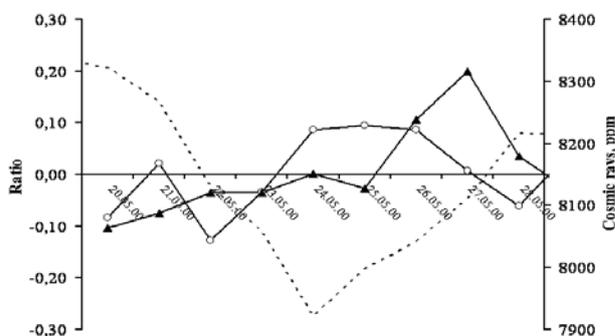


Figure 5. The transformed ratios of cloudiness of latitudinal zones

As follows from figure the moving of cloudiness from "northern" zone into "central" zone has begun in the third day after the beginning of Forbush-decrease. During first day after

Forbush-decrease the small moving from the central zone into northern zone was observed. The moving of cloudiness from “southern” zone to the “central” zone was observed after four days. It can explain softer decrease of cloudiness in central zone after a maximum. In different latitudinal zones the time of reaction of cloudiness movement on Forbush-decrease is various.

The averaged ratios of cloudiness in three latitudinal zones for the 12 events of Forbush-decreases, when $AE > 300$ nT, are presented on Fig. 6. The latitudinal displacement of reaction of cloudy cover on change of intensity of cosmic rays from northern and southern zones into central zone is observed.

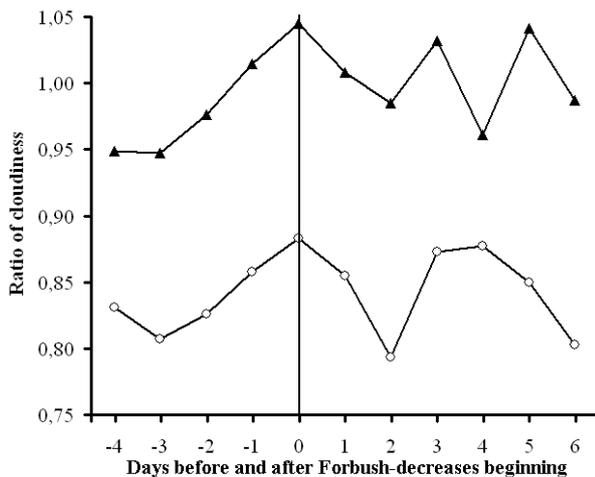


Figure 6. The averaged ratios of cloudiness in latitudinal zones for 12 events of Forbush-decreases ($AE > 300$ nT). The zero day is the day of beginning of Forbush-decrease

3. RESUME

Basically the conclusion about latitudinal displacement of cloudiness, made in this paper, corresponds to conclusions of work (Morozova, 2000) made on data of meteorological net in Northern Eurasia for thirty-year period before. Latitudinal displacement of cloudiness was detected in European region too (Svensmark, Friis-Christensen, 1997). It can be explained by latitudinal displacement of ways of the western cyclones depending on solar activity.

Research of 18 events of Forbush-decreases with a level of geomagnetic activity $AE < 300$ nT and 12 cases with $AE > 300$ nT has shown, that reaction of cloudiness was various. The positive

correlation is observed for strong Forbush-decreases (when $AE > 300$ nT) and negative correlation is observed for weaker Forbush-decreases ($AE < 300$ nT).

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