Available online at www.sciencedirect.com
SCIENCE DIRECT®
Advances in Space Research 34 (2004) 376–378
ADVANCES IN SPACE RESEARCH (a COSPAR publication)
www.elsevier.com/locate/asr

Weather reacting to geomagnetic storms

E. Illés-Almár *

Konkoly Observatory, Hungarian Academy of Sciences, Box 67, H-1525 Budapest, Hungary

Received 19 October 2000; received in revised form 12 December 2002; accepted 20 December 2002

Abstract

In the first 15 years of the Space Age satellite position measurements derived from visual and photographic observations helped to determine the decay rate of satellites, by means of which the first models of the upper-atmosphere have been calculated. Our group concentrated on the study of the geomagnetic effect and collected several ten thousand observations from Europe and from Asia before and after geomagnetic storms. It was already conspicuous during data gathering that there are considerably less satellite observations in the time periods following almost every geomagnetic storm than in the preceding ones – indicating that the cloudiness might increase considerably after geomagnetic storms. The paper presents the statistical treatment of this phenomenon.

Keywords: Geomagnetic storms; Cloud cover; Satellite observations

1. Retrospection

In a series of papers, a mechanism was suggested by B.A. Tinsley how the solar wind causes weather and climate change (Tinsley, 2000 and the references therein). Reading this paper, I remembered our effort in the 1970s when we were controlling the geomagnetic term of the CIRA model on the basis of visual observations of artificial satellites. In the present investigation I took the old observational material to control one of the consequences of Tinsley's mechanism: is it real, that after geomagnetic storms the number of visual observations decreases because of the general increase in the cloud cover?

The basis of our investigation in the 1970s was a special "equivalent duration" parameter defined by Almár and Illés-Almár (1971) as the integral (D) of the density curve during a geomagnetic storm, characterizing the total effect of the storm (Fig. 1). As there were no frequent enough observations to draw the real profile of the density curve during the storms, Almár suggested a simple method to determine the D values from the parallel shift of the period curve of a decaying satellite (Fig. 2) – as the increased geomagnetic activity causes an increased drag during a geomagnetic storm. This simple method made possible to use the not precise but numerous visual observations (Figs. 3 and 4) of many satellites, collected by different networks of satellite observers, to investigate the total density change in the neutral upper atmosphere during geomagnetic storms.

In our country I was the person who collected the visual observations in order to determine as many D values as possible for statistical investigations. We could determine more than 90 D values, that pointed to the fact, that the CIRA-72 model significantly underestimates the geomagnetic effect (Almár and Illés-Almár, 1973).

For the present investigation, we used not only all observations collected in the East European countries (Bulgaria, East Germany, Poland, Rumania, Soviet Union) but also from France, Finland, Holland, Italy, Malta, United Kingdom, that is, countries from Europe and the Western part of Asia. Therefore the conclusions from the present paper refer to the Eurasian continent.

2. Statistical analysis

Altogether 14 geomagnetic storms have been taken into consideration between 1966 and 1972 (namely 1 September in 1966, 25 May and 20 September in 1967,

* Tel.: +36-1375-4122; fax: +36-1275-4668.
E-mail address: illes@konkoly.hu (E. Illés-Almár).

0273-1177/$30 © 2004 COSPAR. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.asr.2002.12.006

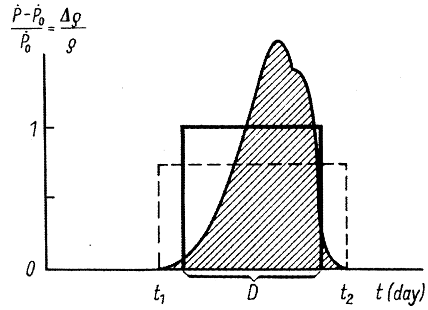
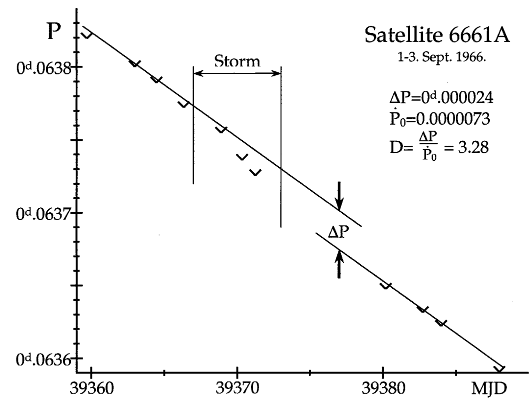


Fig. 1. Definition of the "equivalent duration" D of an atmospheric disturbance.



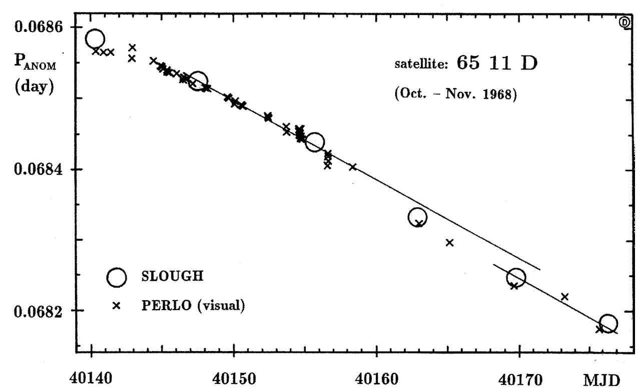


Fig. 2. Orbital period change of artificial satellites 6661A and 6511D during geomagnetic storms.

10 June and 1 November in 1968, 13 May and 30 September in 1969, 5 March, 20 April, 8 July, 17 August and 15 December in 1970, 15 June, 4 August and 2 November in 1972). All the observational events were counted, when any of the above mentioned stations observed a transit of a satellite (independently of the number of the observed positions on the track). Then for all geomagnetic storms a superposed epoch method was applied to the number of the observed daily transits. The marker day (0 day) was the storm maximum day on the basis of the Ap geomagnetic index. Finally the average number of daily transits – observed before and after the storms – were compared. "Before" means: 10 days before the storms, ending at the preceding day of the storm onset; "after" means: 10 days after the storms, starting with the 4. day (in order to leave time for the storm itself and for the Tinsley-mechanism to develop). The average number of observed daily transits is 84.9±3.2 in the preceding period, but is only 62.8±2.0 after the storm. The result is plotted on Fig. 5 that confirms the working hypothesis of Tinsley on the level of 2σ. The decrease in the number of the observed transits can be the consequence of a cloud cover (over Eurasia) only. On the one hand because the storms are spread over 5 years and over all seasons, so the

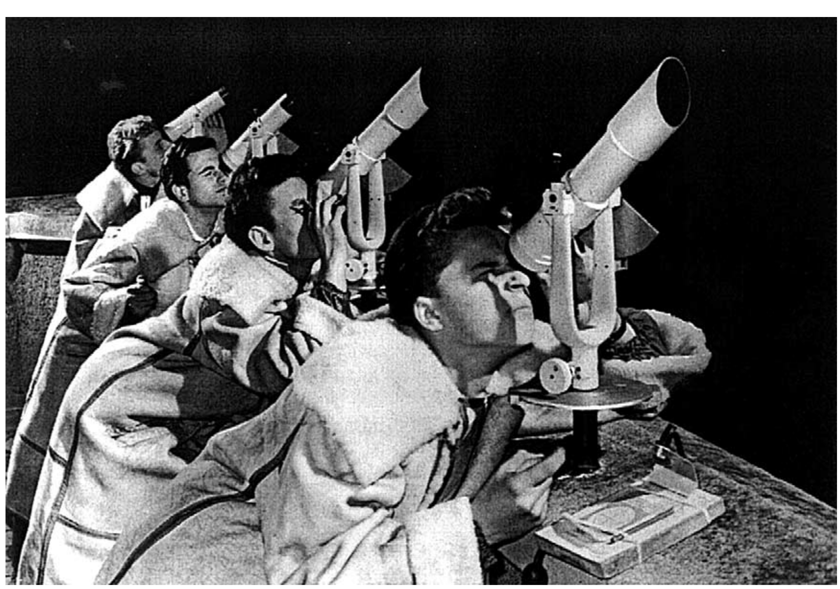


Fig. 3. Visual satellite tracking in the early 1960s.

Fig. 4. Different kinds of kinetheodolites have been used for tracking the transits of artificial satellites.

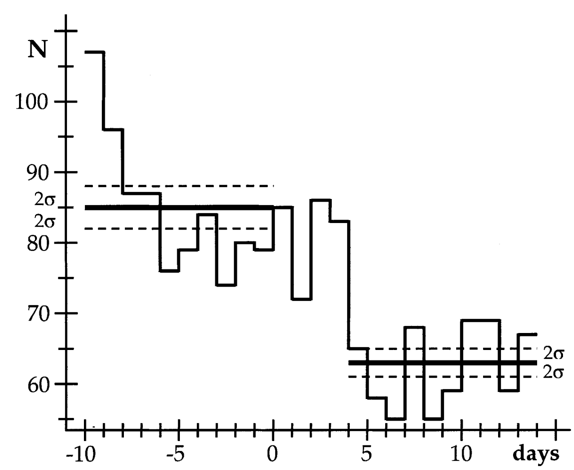


Fig. 5. Number of visually observed transits (N) before and after geomagnetic storms (day 0) confirms the working hypothesis of Tinsley. The superposed epoch method has been applied to 14 storms between 1966 and 1972.

full-Moon effect and other weather-independent effects can be excluded. On the other hand because at that time the observation of artificial satellites was a service, independent of possible scientific applications. The observers were not aware even of the appearance of a geomagnetic storm in real time.

References

Almár, I., Illés-Almár, E. An "Equivalent Duration" to Characterize Atmospheric Disturbances Connected with Geomagnetic Storms. Space Research XI. Akademie-Verlag, Berlin, pp. 975–979, 1971.

Almár, I., Illés-Almár, E. An Analysis of the Altitude Dependence of the Geomagnetic Effect by Means of "Equivalent Durations". Space Research XIII. Akademie-Verlag, Berlin, pp. 364–368, 1973.

Tinsley, B.A. Influence of the solar wind on the global electric circuit, and inferred effects on cloud microphysics, temperature, and dynamics in the troposphere. Space Sci. Rev. 94, 231–258, 2000.