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On the question of investigation of variations of the solar constant during the period of the severe geomagnetic storms

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Abstract

Still actinometrical observations in the interplanetary space, scientific workers of the Smithsonian Astrophysical Institute (USA), under his guidance of C. Abbott, obtained conclusion during the period of the severe geomagnetic storms, solar constant, as a rule, is anomalously decreased. This phenomenon is explained by Abbott like this – due to strong solar flare in solar-terrestrial interplanetary space. corpuscular cloud is ejected from the Sun. Corpuscular clouds condition Raleigh scattering of photon emission of the Sun and correspondingly, decrease of solar constant.

Comparison of variations of solar constant and intensity of the geomagnetic field in the period of large and very large magnetic storm ($\Delta Dst \leq -150$ nT) demonstrated that all considered cases can be divided into five types, according to the character of solar constant variation. From above stated experimental data follows undoubtedly that the result of Abbot's scientific school ("in the day of very large magnetic storm solar constant value, as a rule, is anomalously decreased") should be corrected so: correlation between variations of solar constant and magnetic storm is not simple.

Comparison of variations of solar constant and plasma cloud concentration of interplanetary medium, with high level of density (PCIMWHLD, $n_d \geq 25$ pr.cm $^{-3}$), revealed that variations of solar constant do not at all react at changes of PCIMWHLD. From above-stated experimental data logically follows that there aren't connection between variations of solar constant and PCIMWHLD. Hence Abbot's conception that -"due to strong solar flare in solar-terrestrial interplanetary space corpuscular cloud is ejected from the Sun. Corpuscular clouds condition Raleigh scattering of photon emission of the Sun and correspondingly, decrease of solar constant", unfortunately proved to be incorrect.

Intrudaction

Still actinometrical observations in the interplanetary space, scientific workers of the Smithsonian Astrophysical Institute (USA), under his guidance of C. Abbott, obtained conclusion during the period of the severe geomagnetic storms, solar constant, as a rule, is anomalously decreased [1]. This phenomenon is explained by Abbott like this – due to strong solar flare in solar-terrestrial interplanetary space corpuscular cloud is ejected from the Sun. Corpuscular clouds condition Raleigh scattering of photon emission of the Sun and correspondingly, decrease of solar constant.

Above – stated results of C. Abbot and his scientific school logically demand answers for two following questions:

1. If at the time of severe magnetic storm value of solar constant, as a rule, is anomalously decreased, what is main connecting link between solar activity and meteorological phenomena – electromagnetic irradiation or corpuscular radiation of the sun?
2. If C.Abbot's conception, that decrease of solar constant during severe magnetic storms is conditioned by Raleigh scattering by corpuscular cloud which is ejected from the Sun into interplanetary

space, is true then it is necessary to make a correction for change of density of interplanetary space is solar constant data by space vehicles.

Now, measurements of solar constant, which have been made in circum terrestrial cosmic space, exclude effects, which are connected with transparence of Earth atmosphere, and received results of the investigation are quite trustworthy.

The goal of the work is the following: to make our modest contribution to specification of above mentioned questions on the bases of complex synchronous measurements of solar constant, solar wind concentration in interplanetary space, and by magnetic observatories intensity of the geomagnetic field.

The following initial data was used in the process of investigation:

1. Daily average values of solar constant (SI) according to measurements made by the satellite NIMBUS 7 [2];

2. in order to characterize geomagnetic field during magnetic storm hourly values Dst-index were used [3], because Dst-index describe temporal variations of intensity of extra ionosphere current systems which occur during magnetopause (DCF) and in radiation zone (DR);

3. in order to characterize density variations of plasma clouds of interplanetary space hourly values of proton concentration (n) were taken from King's catalogue [4] (it is obvious plasma density of interplanetary space is ρ = m pr n).

Part 1
Comparison of Variations of solar Constant and Intensity of the Geomagnetic Field during Severe Geomagnetic Storms

It is obvious, that, in order to solve the stated problem, it was necessary for investigation to compile the catalogue of severe magnetic storms during investigated period according to Dst-index. In the work [5] geomagnetic disturbances, which are classified in "Cosmic Data" [6] as magnetic storms of various intensity, during the period of 1965-1974 years, were compared with hourly values of Dst-index. It was established that cases, when Dst-index decrease in the main phase of storm fulfilled condition Δ Dst $\leq$ - 150 n.T, were attributed to very large geomagnetic storms (VLGS). Hence, for investigated period, according to hourly values of Dst-index the catalog of VLGS was compiled, when Dst-index decrease in the main phase of storm fulfilled condition Δ Dst $\leq$ - 150 n.T.

Comparison of variations of solar constant and intensity of the geomagnetic field in the period of VLGS revealed rather complex situation – it turned out that if in some cases VLGS value of solar constant was really decreased in a day, in other cases, its violation was observed. In order to understand such complex picture we have classified the cases according to groups, according to the character of solar constant variation in the period of VLGS duration. We have established that all considered cases could be divided into five types.

To the I types belong events, when in the period of the main phase of the geomagnetic storm, value of the solar constant undergo decreases (which coincides with results receiving by Abbott).

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* Basic results of investigation were presented on the International conference – "2009 UN/ NASA/ESA/JAXA Workshop on Basic Space Science and the International Heliophy - sical Year 2007. Septembe r 21-25, 2009 Daejeon, Korea," p. 92.

The period analyzed by us includes temporal interval of measurements of solar constant, which were made by NIMBUS-7 from 16.11.1978 to 17.6.1992. Temporal interval of measurements, which we have investigated, includes the period between maxima of 21and 22 cycles of solar activity.

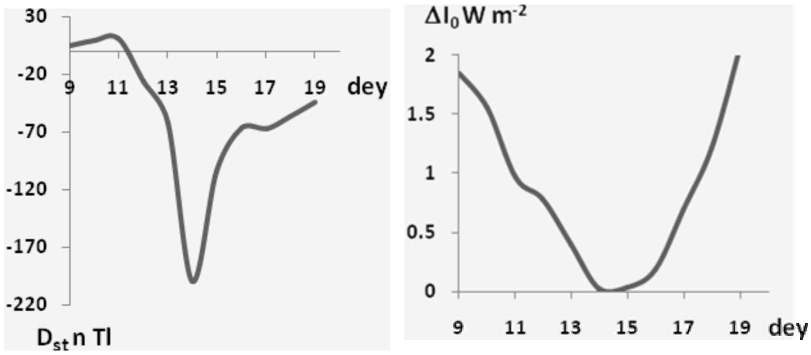

Fig.1.The example of I type interconnection (July 9-19, 1982 DR= -338 nT.)

Symbols: in figures 1-5, ordinate endwise average daily values intensity of the geomagnetic field of Dst-index; departure of solar constant (ΔI_o) from normal ($I_{o,norm}$=1370Wm^{-2}) are built up, and abscissa endwise – month days. DR is the value of Dst-index decrease in main phase of a storm, calculated according to hourly values of Dst-index.

To the II types belong events when in the period of the geomagnetic storm, value of the solar constant stays almost constant.

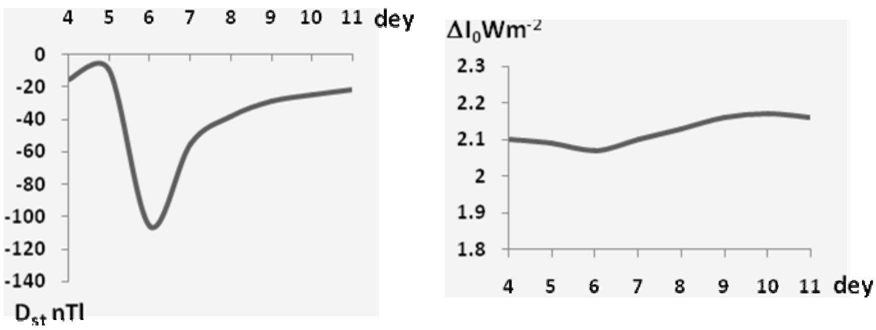

Fig.2. The example of II type interconnection (May 4-11, 1988). DR= -160 nT.

To the III types belong events, when in the period of the main phase of the geomagnetic storm, value of the solar constant undergo increases.

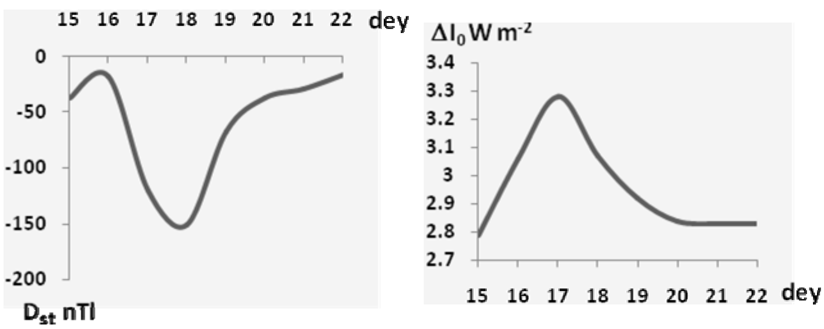

Fig.3. The example of III type interconnection (November 15-22, 1989). DR= -266 nT.

To the IV types belong events when in the period of the geomagnetic storm value of the solar constant gradually decreases.

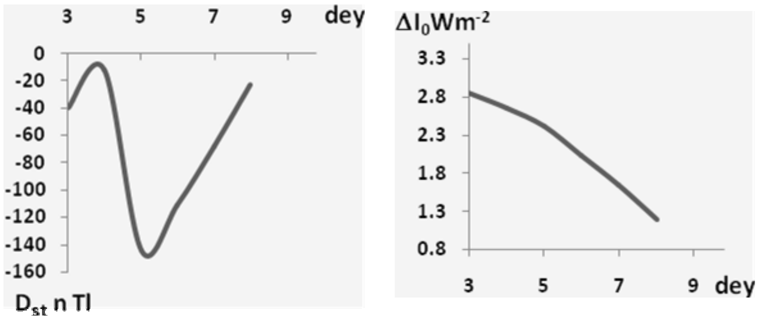

Fig.4. The example of IV type interconnection (June 3-8, 1991). DR= -219 nT.

To the V types belong events when in the period of the geomagnetic storm value of the solar constant gradually increases.

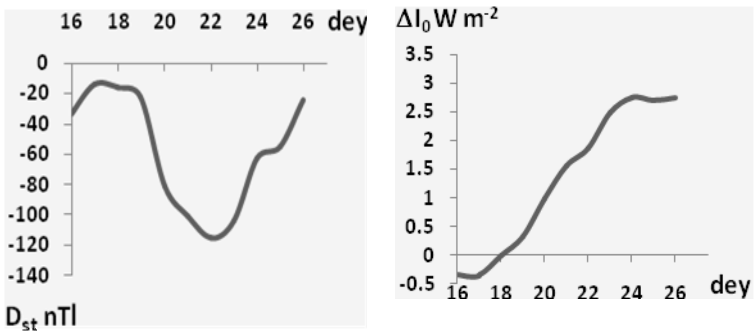

Fig.5. The example of V type interconnection (October 16-26, 1981). DR= -194 nT.

Analyzing curves of figures 1-5, we conclude that during VLGS definite, unambiguous interconnection between variations of solar constant and intensity of the geomagnetic field does not exist.

It is known that statistical method superposition of epochs (Chree's method [7,8]). is vide by used in analogous investigations in geophysics, astronomy and other sciences. Proceeding from above-said, we decided to use the method superposition of epochs too, in order to determine finally interconnection between variations of solar constant and intensity of the geomagnetic field during VLGS

In the process of the investigation, days of maximum decrease of geomagnetic field during main phase of magnetic storms were used as benchmark (zero) moment.

Fig.6 shows averaged (by the method superposition of epochs) variations of Dst-index and solar constant for VLGS observed in 1978-1992 years.

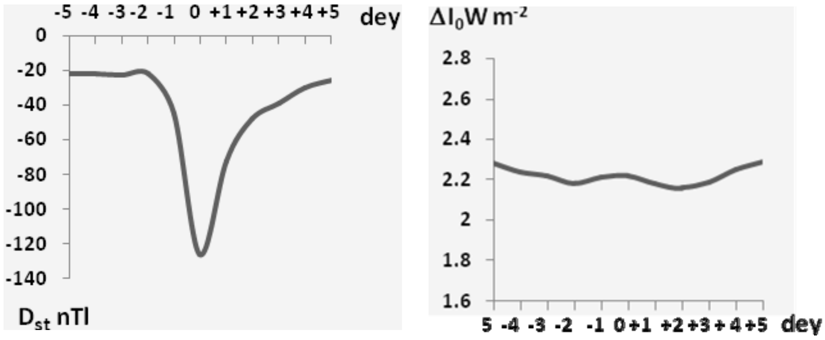

Fig.6. By the method superposition of epochs variations intensity of the geomagnetic field (Dst - index) and solar constant during VLGS in 1978-1992 years.

Fig. 6 shows that during VLGS solar constant value stays almost unchanged. Hence, the method superposition of epochs demonstrates again that during VLGS definite, unambiguous interconnection between variations of solar constant and intensity of the geomagnetic field does not exist.

Basic results of comparison of variations of solar constant and intensity of the geomagnetic field during very large geomagnetic storms (VLGS) are the following:

1. It was established that:

a) all considered cases of variations of solar constant during VLGS come to five types: in the period of main phase of the storm it decreases (I type); during storm is stays unchanged (II type); in the period of main phase of the storm it increases (III type); during the storm it gradually decreases (IV type); during the storm it gradually increases (V type).

b) By the method superposition of epochs variations intensity of the geomagnetic field and solar constant show that during VLGS value of solar constant stays almost unchanged.

Experimental facts demonstrate that during VLGS definite, unambiguous inter-connection between variations of solar constant and intensity of the geomagnetic field does not exist.

2. Conclusion of Abbot's school that "at the time of severe magnetic storms solar constant value is, as a rule, anomalously decreased", which was drown on the basis of actinometrical observations, was not corroborated.

3. It s known that VL magnetic storms (for example, E. Mustel [9]) and considerable variations of solar constant – 0,1-0,3% (for example, H. Volland [10]) may change atmospheric pressure appreciably and exert influence upon circulation processes of in terrestrial atmosphere.

Hence, when we study solar-atmospheric connection, it is logical and necessary to investigate separately those cases of observation of large and very large magnetic storms, which were not accompanied by considerable variations of solar constant and separately – considerable variations of solar constant which were not accompanied by large and very large magnetic storms.

Part 2
Comparison of variations of solar constant and plasma clouds of interplanetary medium with high level of density

Before we state results of the investigation concerning II part, we think it is necessary to clear up the role of plasma clouds of solar wind in magnetic storm formation.

It is known that classical geomagnetic storms, according to character of H – component change of geomagnetic field of middle latitude observatories (which are not influenced by auroral and equatorial electric stream), are characterized by initial phase main phase and recovery phase.

Initial phase (DCF-disturbance) is the period, during which level intensity of the geomagnetic field is higher than non-disturbance value. Amplitude of initial phase is $\Delta H \approx$ 20-40 nT and lasts from 2 to 8 hours. Basic key factor, that is responsible for DCF – disturbance formation, is plasma cloud of solar wind with high level of density [on condition that north-directed interplanetary magnetic field (I m F) $B_z > 0$].

Main phase (DR - disturbance) is characterized by sharp decrease intensity of the geomagnetic field below normal non-disturbance value. Depression difference is of the order of (50-200) nTl. Main phase of magnetic storm generally continues several hours. Basic key factor, that is responsible for DR – disturbance formation, is magnetic cloud with south-directed IMF $B_z <$- (3-5) nT.

According to S. Akasoff and S. Chepman [11], geomagnetic storms of classical type usually consist of two forms of elementary disturbances – DCF and DR. Theoretically, each form of elementary disturbance can exist independently from each other.

Physical bases of the role of plasma parameters of solar wind in geomagnetic storm formation can be seen in detail in A. Chkhetia's monograph [12].

It follows from above stated that plasma clouds of solar wind do not participate in formation of severe geomagnetic storms. Therefore, it can be supposed, that Abbot's conception that Raleigh scattering conditions solar constant decrease during severe magnetic storms, ejected from the Sun corpuscular cloud, may not be true.

It is obvious that, in order to solve the stated problem, it is necessary for investigation to compile the catalogue of plasma clouds of interplanetary medium with high level of density (PCIMWHLD). The catalogue of PCIMWHLD was compiled based on data analysis of hourly average values of proton concentration of interplanetary medium according to King's catalogue [4]. We selected PCIMWHLD according to the following succession:

1. For the investigated period, according to hourly average values of proton concentration (n_{ho}) of interplanetary medium, days were selected in which $n_{ho} \geq 40$ pr.cm $^{-3}$ (1).

Data selection criterion (1) indicates that in selected days increase of proton concentration exceeds minimum background average value approximately ten times.

2. Selected days which satisfied condition (1), according to King's catalogue should be full or should contain 2/3 or more hourly values (N_{ho}), it means $N_{ho} \geq 14$ .... (2).

Satisfaction of condition (2) means that calculated, according to King's catalogue, daily average values of proton concentration of interplanetary medium are trustworthy.

3. Finally, days of PCIMWHLD were selected according to daily average values of proton concentration of interplanetary medium (n_{da}), which satisfied the condition $n_{da} \geq 20$ pr.cm $^{-3}$ .... (3).

Satisfaction of condition (3) means that in selected days of PCIMWHLD there is no spontaneous (impulsive) increase of proton concentration of interplanetary medium.

On the basis of analysis of PCIMWHLD catalogue for investigated period we concluded the following:

1. PCIMWHLD may last 1-5 days;
2. It is advisable to divide PCIMWHLD into three subclasses:
a) Plasma clouds with high seals – 20 pr.cm $^{-3} \leq n_{da} <$ 25 pr.cm $^{-3}$;
b) Plasma clouds with very high seals – 25 pr.cm $^{-3} \leq n_{da} <$ 35 pr.cm $^{-3}$;
c) Plasma clouds with super high seals – $n_{da} \geq$ 35 pr.cm $^{-3}$.

Comparison of variations of solar constant and PCIMWHLD for investigated period revealed rather complex picture. It was found that in some cases in a day (or period) with high level density of interplanetary medium solar constant is really decreased, but in other cases its disturbances are observed. It is impossible to classify cases according to groups, character of solar constant variation in PCIMWHLD period. Picture 7 gives characteristic curves of comparison of variations of solar constant and plasma cloud concentration of interplanetary medium in the period of very high level of density ($n_{da} \geq$ 25 pr.cm $^{-3}$).

Symbols: in figures 7(a, b, c, d, e), ordinates endwise average daily values of plasma cloud concentration of interplanetary space (n pr.cm $^{-3}$); Departure of solar constant (ΔI_o) from normal ($I_{o,norm}$=1370Wm^{-2}) are built up, and abscissa endwise – month days. n^{max} are maximum hourly average values of proton concentration of plasma cloud, in day (d) and hour (h)

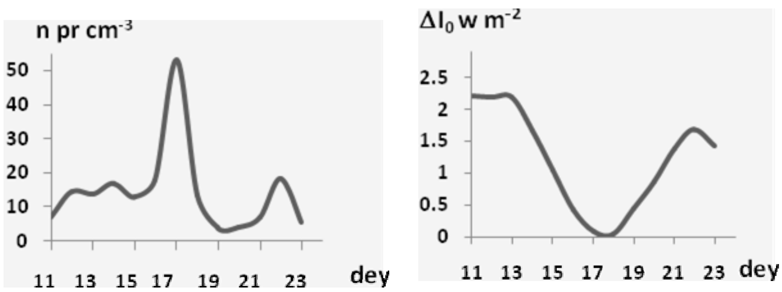

Fig.7a. Temporal interval 11-23 March, 1982 y. n^{max} =88,7 pr. см$^{-3}$, 17d, 14 h.

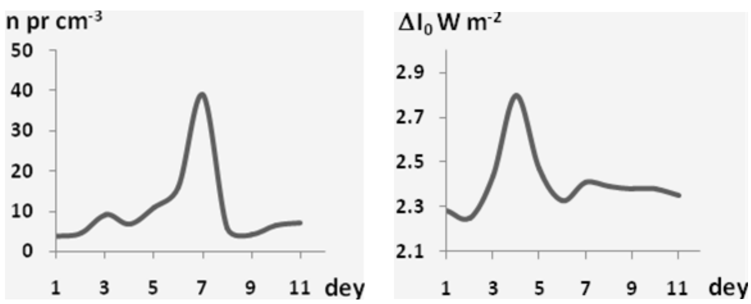

Fig.7b. Temporal interval 1-11 June, 1981 y. n^{max} =113 pr. см$^{-3}$, 7d, 18 h.

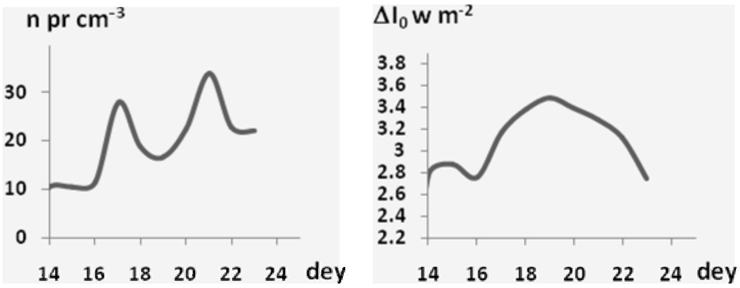

Fig.7c. Temporal interval 14-23 October, 1991 y. n^{max} = 62.2, pr. см$^{-3}$, 21d, 9 h.

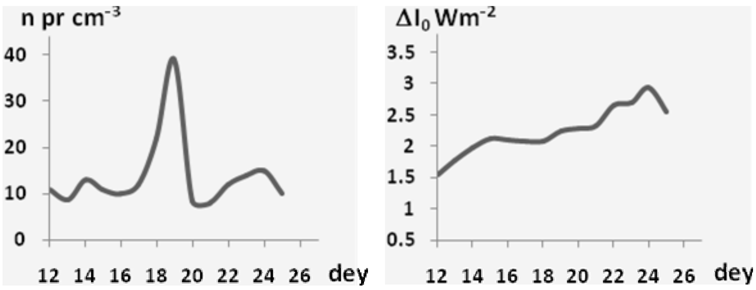

Fig.7d. Temporal interval 12-25 September, 1981 y. n^{max} =97.7, pr. см$^{-3}$, 19d, 3 h.

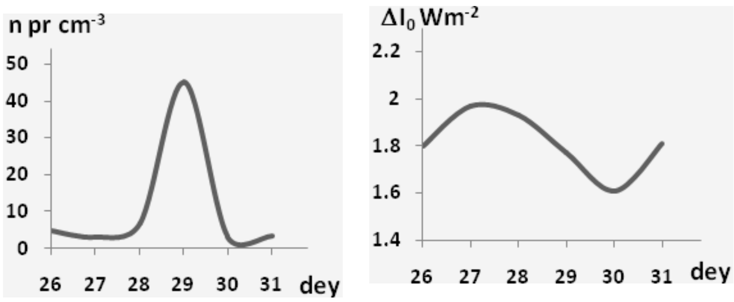

Fig.7e. Temporal interval 26-31 August, 1983 y. n^{max} =71.1, pr. см$^{-3}$, 29d, 22 h.

Fig.7 (a, b, c, d, e), Characteristic curves of comparison of variations of solar constant and plasma cloud concentration in the period of very high density level of interplanetary space.

Analyzing Fig.7 (a, b, c, d, e), we conclude that variations of solar constant do not at all react upon PCIMWHLD.

In order to solve finally the problem of relationship between variation of solar constant and plasma clouds of interplanetary medium, we decided to use the method superposition of epochs as well in our investigation, including variations intensity of the geomagnetic field level (Dst-index). In the process of investigation days with maximum values of concentration of plasma clouds of interplanetary medium, with seals $n_{da} \geq 25$ pr.cm $^{-3}$, were used as bench mark (zero) moment.

Fig.8 gives averaged (by the method superposition of epochs) variations - of plasma cloud concentration of interplanetary space, solar constant and intensity of the geomagnetic field of Dst-index (Dst-indices were investigated only in those days which were satisfying the criterion of data selection – in selected period vertical component of IMF - B_z>0).

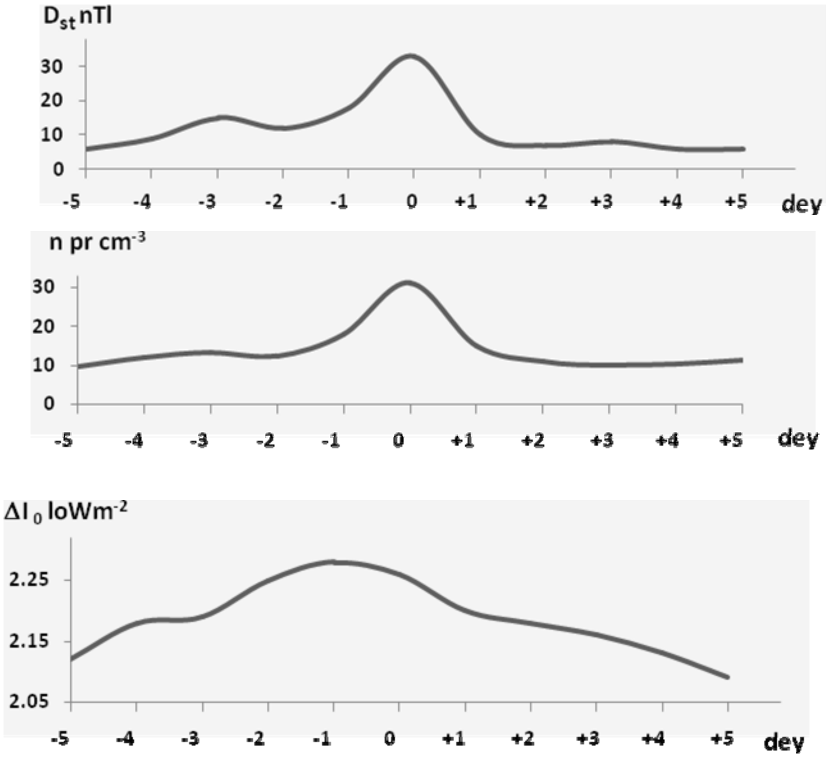

Fig.8. Averaged (by the method superposition of epochs) variations of Dst-index, of concentration PCIMWHLD ($n_{da} \geq 25$ pr.cm $^{-3}$) and solar constant for 1978-1992 years.

Curves, presented in Pic.8, allow us to conclude the following:

1. Evident correlation is observed between variations of Dst-index, PCIMWHLD and solar constant;

2. The authors think that

a) Correlation between variations of Dst-index and PCIMWHLD is casual-consequential;

b) there is no correlation between variations of solar constant and PCIMWHLD and only parallelism of proceeding of events which are called forth by third, mutual for them, reason – some X parameter, characterizing solar activity, is described (this question needs further thorough investigations).

Basic results of the authors' investigation of comparison of variations of solar constant and PCIMWHLD are the following:

1. On the basis of revealed experimental facts we conclude that:

a) Variations of solar constant do not at all react at changes of PCIMWHLD;

b) averaged (by the method superposition of epochs) variations of concentration PCIMWHLD and solar constant show that in PCIMWHLD period solar constant value, instead of decrease, increases insignificantly (ΔI_o=0,19 Wm^{-2});

We concluded that there aren't connection between variations of solar constant and PCIMWHLD;

2. it is established that Abbot's conception, that "decrease of solar constant during severe magnetic storms is conditioned by Raleigh scattering, ejected from the Sun into interplanetary space corpuscular cloud" unfortunately is not confirmed.

General Conclusions

1. Comparison of variations of solar constant and intensity of the geomagnetic field in the period of large and very large magnetic storm ($\Delta Dst \leq -150$ nT) demonstrated that all considered cases can be divided into five types according to the character of solar constant variation:

To the I types belong events, when in the period of the main phase of the geomagnetic storm, value of the solar constant undergo decreases (which coincides with results receiving by Abbott).

To the II types belong events when in the period of the geomagnetic storm, value of the solar constant stays almost constant.

To the III types belong events, when in the period of the main phase of the geomagnetic storm, value of the solar constant undergo increases.

To the IV types belong events when in the period of the geomagnetic storm value of the solar constant gradually decreases.

To the V types belong events when in the period of the geomagnetic storm value of the solar constant gradually increases.

2. With the help of the method superposition of epochs it was established that during very large magnetic storms the value of solar constant stays almost unchanged.

3. From above-stated experimental data follows undoubtedly that the result of Abbot's scientific school ("in the day of very large magnetic storm solar constant value, as a rule, is anomalously decreased") should be corrected so: correlation between variations of solar constant and magnetic storm is not simple and comes to 5 types.

4. Comparison of variations of solar constant and plasma cloud concentration of interplanetary medium, with high level of density (PCIMWHLD $n_{da} \geq 25$ pr.cm $^{-3}$), revealed that variations of solar constant do not at all react at PCIMWHLD.

5. It was established (with the help of the method superposition of epochs) that during PCIMWHLD solar constant value increases insignificantly instead of decrease (ΔI_o=0.19 Wm^{-2}).

6. From above-stated experimental data logically follows that there aren't connection between variations of solar constant and PCIMWHLD. Hence Abbot's conception that "decrease of solar constant during large magnetic storms is conditioned by Raleigh scattering, ejected from the Sun into interplanetary space corpuscular cloud", unfortunately proved to be incorrect.

7. Now it is established that solar corpuscular currents (geometric storms), as well as electromagnetic solar irradiance (change of solar constant 0.1 – 0.3%), can provoke marked changes of atmospheric pressure and influence circulation processes in terrestrial atmosphere.

Therefore, when we study solar – atmospheric connections it is logical and necessary to investigate separately cases of observation of large and very large magnetic storms which were not accompanied by solar constant considerable variations, and separately – considerable variations of solar constant which were not accompanied by large and very large magnetic storms.

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К вопросу об исследовании вариаций солнечной постоянной в период очень больших геомагнитных бурь

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Реферат

Еще до проведения актинометрических наблюдений в межпланетном пространстве Аббот и возглавляемая им научная школа Смитсонианского Астрофизического института (США), пришли к выводу, что в день очень сильной геомагнитной бури величина солнечной постоянной оказывается, как правило, аномально заниженной. Аббот поддерживал точку зрения о том, что падение солнечной постоянной во время очень больших геомагнитных бурь вызвано тем, что вдобавок к нормальному Релееву рассеянию фотонной радиации Солнца молекулами земной атмосферы, во время магнитных бурь происходит дополнительное рассеяние корпускулярным облаком плазмы, выброшенным Солнцем в межпланетное пространство.

Сопоставление вариаций - солнечной постоянной и напряженности геомагнитного поля в период больших и очень больших геомагнитных бурь (Δ Dst≤-150нТл) показало, что по характеру изменения солнечной постоянной, все рассмотренные случаи можно разбить на пять типов. Из вышеизложенного экспериментального факта несомненно следует, что результат, полученный научной школой Аббота о том, что “в день очень больших магнитных бурь величина солнечной постоянной оказывается, как правило, аномально заниженной”, должен быть заменен поправкой - между вариацией солнечной постоянной и магнитной бурей связь неоднозначная.

Сопоставление вариаций – солнечной постоянной и концентрации плазменных облаков межпланетной среды с высоким уровнем плотности (ПОМССВУП, $n_{ср.\ сут.}$ =25 пр.см$^{-3}$) выявило, что вариации солнечной постоянной на ПОМССВУП вовсе не реагируют. Из вышеизложенного экспериментального факта логически следует, что между вариацией солнечной постоянной и ПОМССВУП связи вовсе не существует. Следовательно, концепция Аббота о том, что “падение солнечной постоянной во время больших магнитных бурь обусловлено Релеевым рассеянием, выброшенным Солнцем в межпланетное пространство корпускулярным облаком”, к сожалению, не подтвердилась.

ძლიერ დიდი გეომაგნიტური ქარიშხლების მიმდინარეობის პერიოდში მზის მუდმივას ვარიაციის კვლევის საკითხებისათვის

ჩხეტია ა.მ., გიგოლაშვილი მ.შ., ებრალიძე მ. ო.

რეზიუმე

ჯერ კიდევ საპლანეტათშორისო სივრცეში აქტინომეტრიული დაკვირვების ჩატარე– ბამდე, აშშ-ის სმიტსონიანის ასტროფიზიკური ინსტიტუტის თანამშრომლების მიერ, აბოტის ხელმძღვანელობით, დადგენილ იქნა, რომ ძლიერ დიდი გეომაგნიტური ქარიშხლების მიმდინარეობის პერიოდში მზის მუდმივა, როგორც წესი, ანომალურად შემცირებულია. აბოტი ამ მოვლენას ასე ხსნიდა - მზეზე ძლიერი აფეთქების შემდეგ, მზიდან მზე-დედამიწის საპლანეტთაშორისო სივრცეში გამოტყორცნილი პლაზმური ღრუბელი განაპირობებს მზის ფოტონური გამოსხივების რელეისებურ გაფანტვას და შესაბამისად მზის მუდმივას შემცირებას.

ძლიერ დიდი გეომაგნიტური ქარიშხლების მიმდინარეობის პერიოდში (როდესაც ΔDst<-150nT), მზის მუმივას და გეომაგნიტური ველის დაძაბულობის ვარიაციათა შეპირისპირების ანალიზის შედეგად გამოვლენილ იქნა, რომ-ძლიერ დიდი გეომაგნიტური ქარიშხლების მიმდინარეობის პერიოდში მზის მუდმივასა და გეომაგნიტური ველის დაძაბულობის ვარიაციებს შორის განსაზღვრული, ერთმნიშ– ვნელოვანი კავშირი არ არსებობს. ყველა შესაძლო შემთხვევა დაიყოფილ იქნა 5 ტიპად. ზემოთ მოცემული ექსპერიმენტული ფაქტიდან უშუალოდ გამომდინარეობს, რომ აბოტის მეცნიერული ჯგუფის მიერ მიღებული შედეგი ასე უნდა ჩასწორდეს – ძლიერ დიდი გეომაგნიტური ქარიშხლების მიმდინარეობის პერიოდში მზის მუდმივასა და გეომაგნიტური ველის დაძაბულობის ვარიაციებს შორის, განსაზღვრული, ერთმნიშვნე– ლოვანი კავშირი არ არსებობს.

მზის მუდმივას და მაღალი სიმკვრივის საპლანეტათშორისო სივრცის პლაზმური ღრუბლების (სსპღ, რომელთა კონცენტრაციის საშუალო დღიური მნიშვნელობა n>25 სმ$^{-3}$) ვარიაციათა შეპირისპირების ანალიზის შედეგად გამოვლენილ იქნა, რომ მზის მუდმივას ვარიაციები მაღალი სიმკვრივის სსპღ არსებობას საერთოდ არ ეხმაურება. ზემოთ მოცემული ექსპერიმენტული ფაქტიდან უშუალოდ გამომდინარეობს, რომ მზის მუდმივას ვარიაციებსა და სსპღ შორის კავშირი საერთოდ არ არსებობს. ამგკარად, აბოტის კონცეფცია, რომ –"მზეზე ძლიერი აფეთქების შემდეგ, მზიდან მზე-დედამიწის საპლანე -ტთაშორისო სივრცეში გამოტყორცნილი პლაზმური ღრუბელი განაპირობებს მზის ფოტონური გამოსხივების რელეისებურ გაფანტვას და შესაბამისად მზის მუდმივას შემცირებას", სამწუხაროდ არ გამართლდა.