VARIATION OF THE SOLAR CONSTANT IN CONNECTION WITH THE SOLAR ACTIVITY

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ABSTRACT. Decreases of the solar constant were caused by the "active" sunapot groups. At the time of the irradiance dips there were some peaks in have values of the X-ray and radio flux intensity. It would be possible that MHD-waves, generated during the unteraction of the magnetic fields of the active groups with the convection, could transport the "missing" energy in the solar constant decreases.

ВАРИАЦИИ СОЛНЕЧНОЙ ПОСТОЯННОЙ В СВЯЗИ СО СОЛНЕЧНОЙ АКТИВНОСТЬЮ: Уменьшение солнечной постоянной возникает в связи с "активными" группами солнечных пятен на Солнце.

VZŤAH VARIÁCIÍ SLNEČNEJ KONŠTANTY K SLNEČNEJ AKTIVITE: Znenšenie slnečnej konštanty vzniká pri výskyte "aktívnych" skupín slnečných škvŕn na disku Slnka.

1. SOLAR CONSTANT VARIATIONS CONNECTED TO THE DEVELOPMENT OF THE ACTIVE REGIONS

Figure 1 shows the solar constant values measured by the SMM/ACRIM radiometer, in 1980 (1a) in comparison with the projected areas of the different types of the sunspot groups (1b) and faculae (1c). As we can see the large irradiance dips occurred when the projected areas of the active groups and the surrounding faculae were large. The active groups have earlier been defined as newly formed groups with areas larger than 0.04 % of the solar disk and quickly developing groups with complex structure (γ or/and δ magnetic configurations) (Pap, 1985a). The remaining pld groups with simple structure (α or β configurations) were named as "passive" groups. From Figure 1 we can see when the passive groups and the surrounding faculae were dominant the value of the solar constant increased slightly or they could reduce the effect of the active ones.

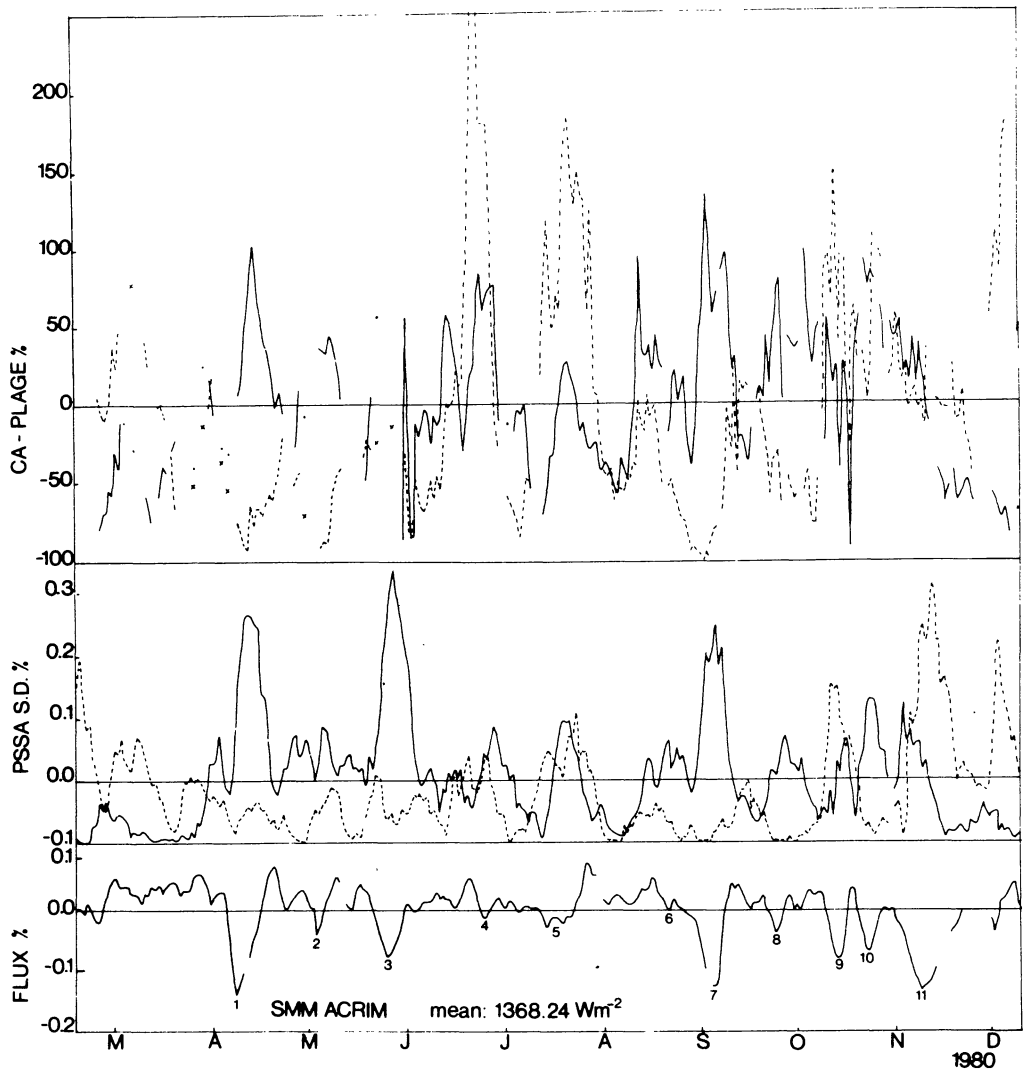

Fig. 1: Fig. 1a shows the solar constant values measured by the SMM/ACRIM radiometer. The full line of Figs. 1b and 1c shows the projected areas of the active sunspot groups and the surrounding faculae. The dashed line of Figs. 1b and 1c shows the passive spot and facular projected areas. The values of all the parameters are shown between 14 February and 31 December, 1980 as the percentage variation of their means.

Our investigations show that the facular excess flux can not compensate fully the irradiance decreases due to the sunspot deficit. It seems that the missing energy in the solar constant decreases should be storaged in the convection zone (Willson, 1982) and later it could be emitted with the growing

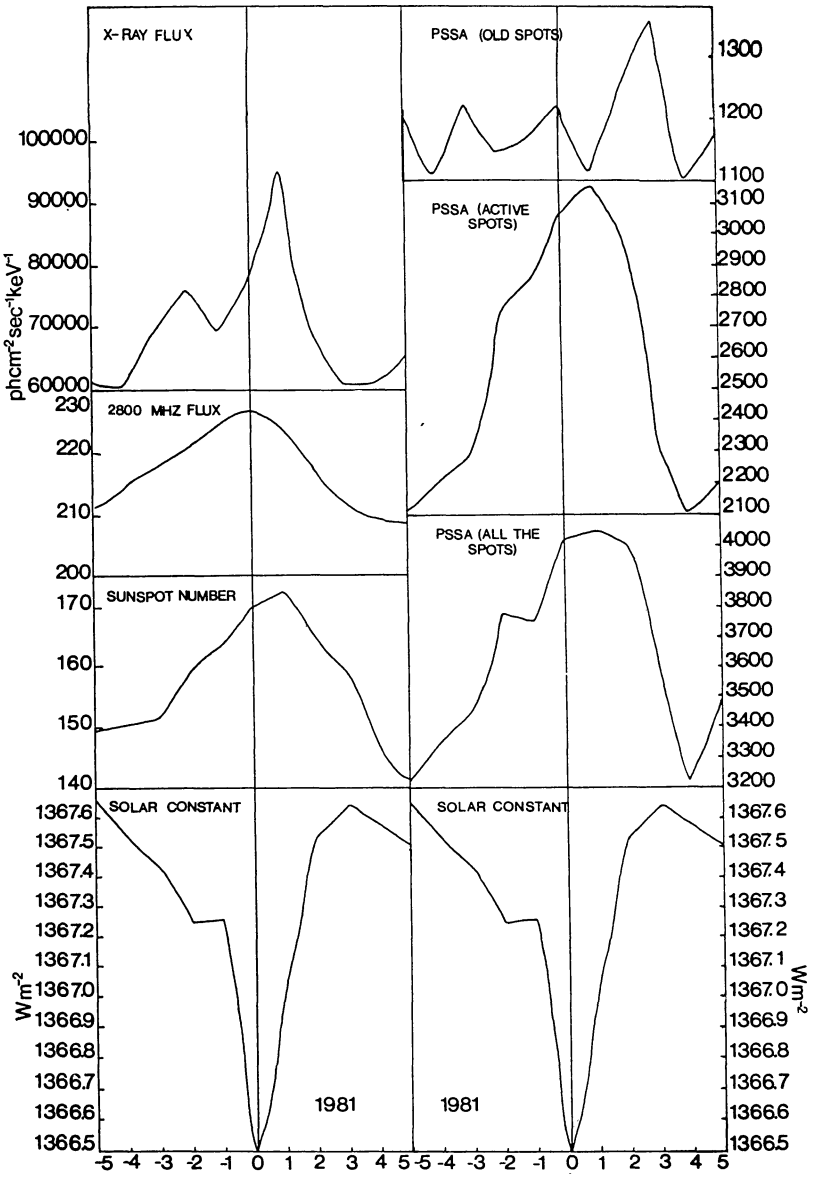

Fig. 2: The connection between the decrease of the solar constant observed by the SMM/ACRIM radiometer in 1981 and the different solar activity parameters on the basis of the method of the superposed epoch analysis.

old of the active regions (Pap, 1985a,b). However it is questionable that is it only the way of the transportation of the missing energy? There were some

suggestions that the Alfven-waves also can be suitable for transporting the energy missing in the solar constant decreases (Foukal, 1981). Marik's earlier investigations (1966, 1975) have showed that during the interaction of the magnetic fields of the sunspot groups with the convection MHD-waves could be generated which would play an important role in the heating of the chromosphere and corona. Because of this possibility we have investigated the connection between the solar constant variation and those solar indices which can be characteristic parameters of the upper solar atmosphere.

The radio flux on 2800 MHz and X-ray flux between 2 and 4 keV were used as solar indices. The X-ray flux was measured by the "fifth Czechoslovak X-ray photometer" on board of Prognoz-8 satelite (Valnicek et al., 1983), between 1 January and 21 September, 1981. The connection between the solar constant variation measured by the SMM/ACRIM radiometer in 1981 and the different solar activity parameters can be seen on Figure 2, on the basis of the superposed epoch analysis. The zero-day of this analysis was the date of the maximal amplitude of the irradiance dips larger than the 3 error limit of the solar constant dataset. The resulting curves were determined from 22 individual events. As we can see, there is no connection between the solar constant decreases and the old spot areas and the connection seems to be very weak in the case of the 2800 MHz radio flux. All the spot and active spot areas as well as the sunspot number have their maxima 1-day later than the minimal irradiance decrease. This 1-day time shift also exists in the case of the X-ray flux. For the explanation of the connection between the solar constant decreases and the X-ray flux our idea is that during the interaction of the magnetic fields of the active groups with the convection MHD-waves could be generated, as Marik (1966, 1975) suggested earlier. These MHD-waves could transport some amounts of energy from the convective zone and could heat the upper solar atmosphere. The increased flux of the X-ray could indicate the higher temperature of the solar corona. Here we would like to mention that the preliminary investigations also show that there is a strong connection between the solar constant decreases and the 260 MHz radio flux, measured in the Ondrejov Observatory, which can be used as a good index of the coronal activity (Tlamicha, 1986).

3. CONCLUSIONS

Our results show that the large decreases of the solar constant were caused by the active sunspot groups. It seems that the magnetic fields of the active groups can stop the convection thus less energy is transported to the photosphere. During the interaction of the magnetic fields with the convection MHD-waves could be generated, which could transport one part of the missing energy in the total solar flux. The increased intensity of the X-ray and radio flux emitted from the corona could indicate this procedure. The remaining part of the missing energy could be emitted with the growing old of the active regions.

ACKNOWLEDGEMENTS

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DISCUSSION

J. Staude
This are very interesting results which could really help to improve our understanding physical processes in subphotospheric layers of sunspots. In the convective zone the turbulent diffusion is so large, that the blocked energy from the suppresion of convection below sunspots would be very effectivelly redistributed over a large area (see, e.g. several papers by Spruit) and emitted after some time from a larger area around the spot. Your results could help to develop models of this energy redistribution in more detail.

M.A. Могилевский
В работе Хадсон и Вилсон сообщалось что для 13 больших долгодлительных рентгеновских вспышек отмечался рост солнечной постоянной. Имеются ли новые данные о связи вариаций солнечной постоянной со вспышками?

J. Pap
Our investigations show that in the active regions containing the active sunspot groups, large flares causing the sudden ionospheric disturbances have occurred. However, the total energy released during the flares is only the 10^{-4} - 10^{-6} part of the total solar energy emitted by the photosphere. This energy increasing during the flares is now just near to the measuring limit of the radiometers used for the solar constant observations, moreover, it can compensate only partly the effect of the sunspot groups.

F. Fárník
The X-ray data, used in the analysis, represent the total flux emitted per day.

It means these data reflect the number and importance of the X-ray events, mostely flares, and not the emission of the quiet corena.

A. Antalová
Can you compare your results to the results obtained by Dr. Willson's group?

J. Pap
Dr. Willson has used for his calculations sunspot groups with areas larger than 0.01 % of the solar disk. The correlation coefficient between the solar constant and Dr. Willson's spot areas was -0.73. The correlation coefficient between the solar constant values and active spot areas was -0.84 (for 1980).

A. Krüger
Did you find a significantly better correlation between the solar constant decreases and the radio emission at meter waves than at cm-waves?

J. Pap
A strong connection was found between the decreases of the solar constant and the radio flux on 260 MHz, which can be regarded as a good index of coronal intensity. These results will be published in detail later.

M. Sobotka
Have you any special idea about the energy storage mechanism in the convective zone?

J. Pap
There are same possibilities for the energy storage mechanism. The missing energy in the total irradiance can heat the convective zone. In this case the energy is storaged near to the photosphere. The calculations show that the storaged energy can be emitted very slowly, during 83 days. Another possibility, that the energy storaged is taken place in the magnetic field of the sunspot groups. In this case, the sunspot groups can modify the value of the total irradiance only at the time of their borning and the storaged energy have to be store in a deep flux tube beneath the spots. However this model gives too large deep for these tubes.