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RELATION BETWEEN METRIC AND DECAMETRIC NOISE STORM SOURCES AND MICROWAVE S-COMPONENT EMISSIONS

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Recently Kai and Sekiguchi (1973)[1] proposed an idea about the relation of metric continuum noise storms often called type I storms, with the S-component of microwave radio emissions. Their result indicates that these noise storms are developed as a result of the growth of the S-component emissions associated with active sunspot groups. As an example, they showed the time variation of both noise storms and S-component emissions associated with the active region MacMath No. 11294, which passed through the central meridian of the solar disk on the late 6 of May 1971. According to Gergely (1974)[2], this region was quite active on the generation of both decametric type III burst storms and noise storms during its passage over the solar disk.

In this paper, we consider various activities reported by Kai et al. (1973)[1] and Gergely (1974)[2] by taking into account the properties of this active region and its relation to low-frequency radio burst emissions observed by the IMP-6 satellite. In so doing, we examine the relation of metric noise continuum storms (200 MHz) with the S-component of microwave emissions (2800 MHz). Taking the results analyzed here into consideration, we propose a model on the growth of radio noise continuum sources in metric and decametric frequencies and its relation to microwave and other solar active phenomena.

In order to study the relation between metric noise continuum storms and S-component of microwave emissions, we have selected the radio data recorded at Hiraiso (200 MHz) and Ottawa (2800 MHz) as respresentatives for metric and microwave emissions, respectively. Since the decametric emission activity observed at Clark Lake has been analyzed by Gergely (1974)[2] in greater detail, this paper refers to his results in the discussion on this activity in relation to the activity in other wave frequencies. The data obtained by the IMP-6 satellite are also considered in studying low-frequency type III burst activity.

The active region MacMath No. 11294 appeared at the east limb of the sun on 1 May 1971, and then passed through the central meridian on the late 6 of May 1971. The CMP of the active region at 169 MHz on 6-7 May has been reported in the Solar Geophysical Data (1971)[3]. As shown in Fig. 1(a), the S-component of microwave emission at 2800 MHz began to increase on 3 and reached maximum on 9 of May. At metric wave region (200 MHz), the radio flux intensity started to abruptly increase on 6 and then reached maximum intensity on 8 of May. The decametric continuum noise emissions also showed an activity similar to that at 200 MHz (see Gergely, 1974)[2]. When we consider the sunspot characteristics of this active region, we find that the sunspot type changed from βP to $\beta\gamma$ types on 6 of this month. (Fig. 1(b)). This spot group is also classified as the E type when it became the $\beta\gamma$ configuration.

It may be here remarked that the association of metric noise continuum emissions with sunspot groups of E and F types has been well established[4]. One day later (7th), type III burst activity in decametric frequencies became most intense above this region[2] (Fig. 2). Furthermore, Gergely (1974)[2] found that this intense activity was seen above the active region under discussion and was mainly restricted in the frequency range below 45 MHz. This activity seems to have been extended into the frequency region less than $\sim$ 5 MHz since type III burst activity observed by the IMP-6 satellite indicates that these low frequency burst storms were associated with the activity in decametric wave frequencies. Furthermore, these storms were observed between 7 to 10 of this month by means of this satellite. These results indicate that the intensification of metric and decametric noise continuum storms might have occurred in association with the growth of the sunspot group into the complex types such as $\beta\gamma$. Furthermore, it should be remarked that the mean field intensity of this sunspot group also reached maximum on 6 of May, as shown in Fig. 1(b).

As understood from the results shown in Fig. 1, the activation of the S-component emission began on 3 of May and therefore occurred three days earlier than that of metric continuum emission (see Kai et al., 1973)[1] This difference between metric and microwave emissions is clearly seen in Fig. 3 since it turns out that S-component emissions tend to increase first several days before the beginning of sharp increase of metric noise continuum flux. In this figure, we show the observational results for two active regions, MacMath Nos. 11294 and 12094. It is clear that the tendency of the variation of radio flux intensity is very similar between these two active regions. This tendency is usually seen for almost all the cases analyzed though slightly different from each other.

It is clear from Figs. 1 and 3 that the maximum flux intensity at 2800 MHz was reached on 8, one day later after the metric flux intensity reached maximum on 7. However, in general, the maximum in metric noise continuum flux intensity is reached on the same day or one day later when S-component emission reaches maximum, as indicated in Fig. 4. A similar result has been obtained by Kai et al. (1973)[1). With the result of Fig. 3, this result strongly suggests that the growth of S-component emission at microwave frequency is very important to the development of metric and decametric continuum noise storms. When considering the fact that the S-component activity begins several days earlier than that of metric continuum emissions (Fig. 1(a)), we may say that the change of sunspot activity as shown in Fig. 1(b) is very important on the fast growth of metric and decametric noise continuum storm sources.

Although causal relationship between sunspot activity change and the formation of these noise storm sources has not been found yet, it seems natural that energetic electrons responsible for these noise continuum emissions are very effectively generated when sunspot groups grow into complex configurations such as $\beta\gamma$ type in magnetic polarity distribution. When we consider that these noise continuum emissions are generated by plasma processes from these electrons,[5)-7)] the relation obtained in this paper would be reasonably explained. In this case, we should recognize that the S-component activity is not much dependent on the metric noise continuum emssions, but this activity and its growth tend to produce the sources of metric and decametric noise continuum emissions. Type III burst storms would also be produced as a result of the escape of the electrons mentioned above from the top region of metric and decametric noise continuum sources. This interpretation would also be useful to explain the cause of the highest observed frequencies of type III bursts associated with continuum noise sources in metric and decametric frequencies.[2),8)-9)] The on-fringe type III bursts,[2)] therefore, seem to be generated by those electrons described above.

In summary, it is concluded that the growth of sunspot groups into very complex type such as $\beta\gamma$ is very important to the development of metric and decametric noise continuum storm sources associated with type III burst storm activity in low frequencies.

Caption of Figures

Fig. 1 Growth of the active region MacMath No. 11294 and associated various radio emissions. (a) S-component microwave emission, (2800 MHz), noise continuums (200 MHz) and type III activity in decametric frequencies are shown. (b) sunspot type and field intensity change are shown as a function of day.

Fig. 2 Type III burst activity in decametric frequencies or less associated with the active region MacMath No. 11294. As a reference, noise continuum flux change (200 MHz) is also shown.

Fig. 3 Relation between metric noise continuum (200 MHz) and S-component emission (2800 MHz) fluxes. Numbers indicate the variation of these fluxes since the enhanced microwave S-component emission is first observed.
Filled and open circle show these flux variations associated with the active regions, MacMath Nos. 11294 and 12094.

Fig. 4 Time delay of the maximum activity of metric noise continuum emissions (200 MHz) from that of microwave S-component emissions (2800 MHz).

References

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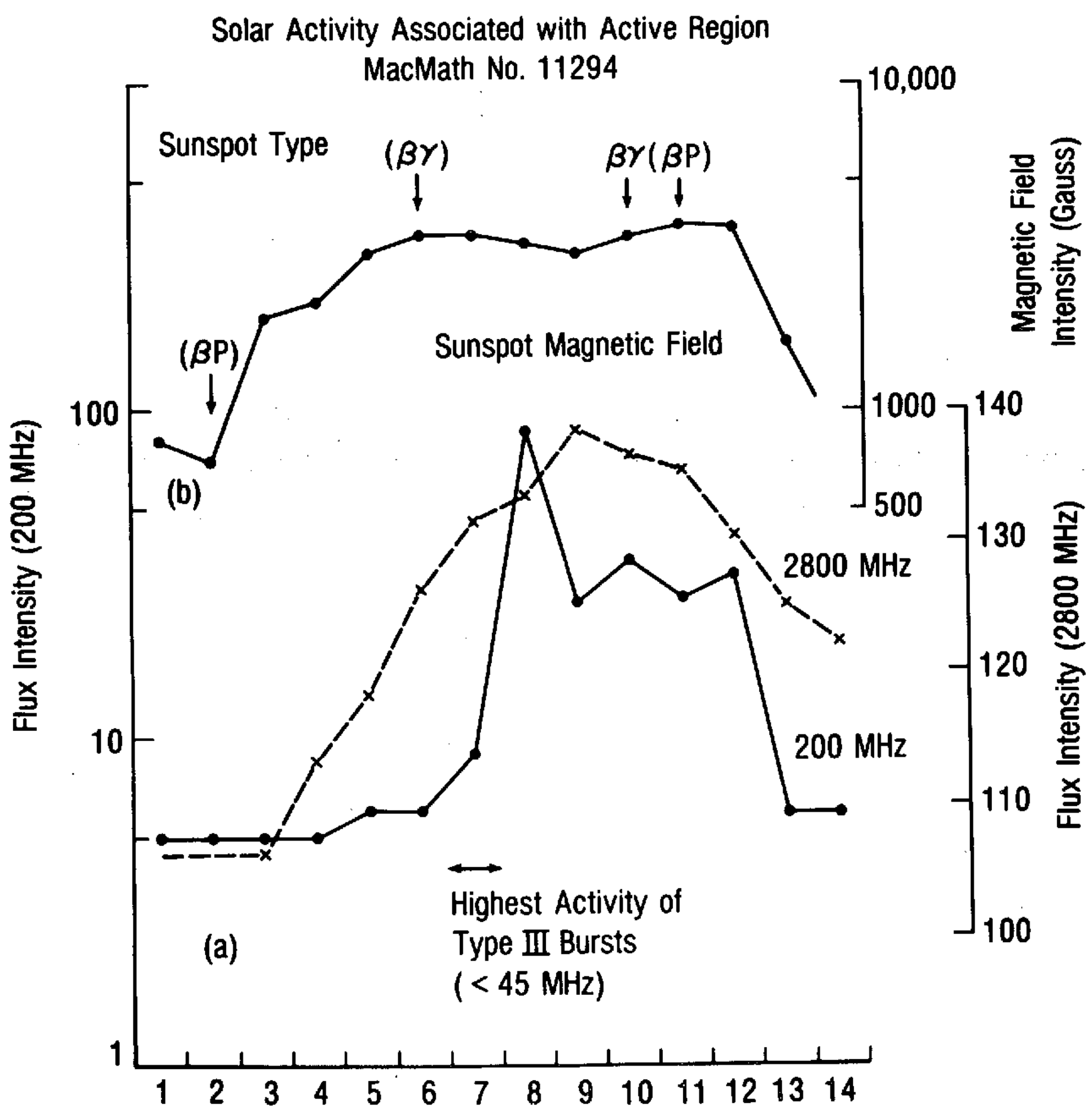
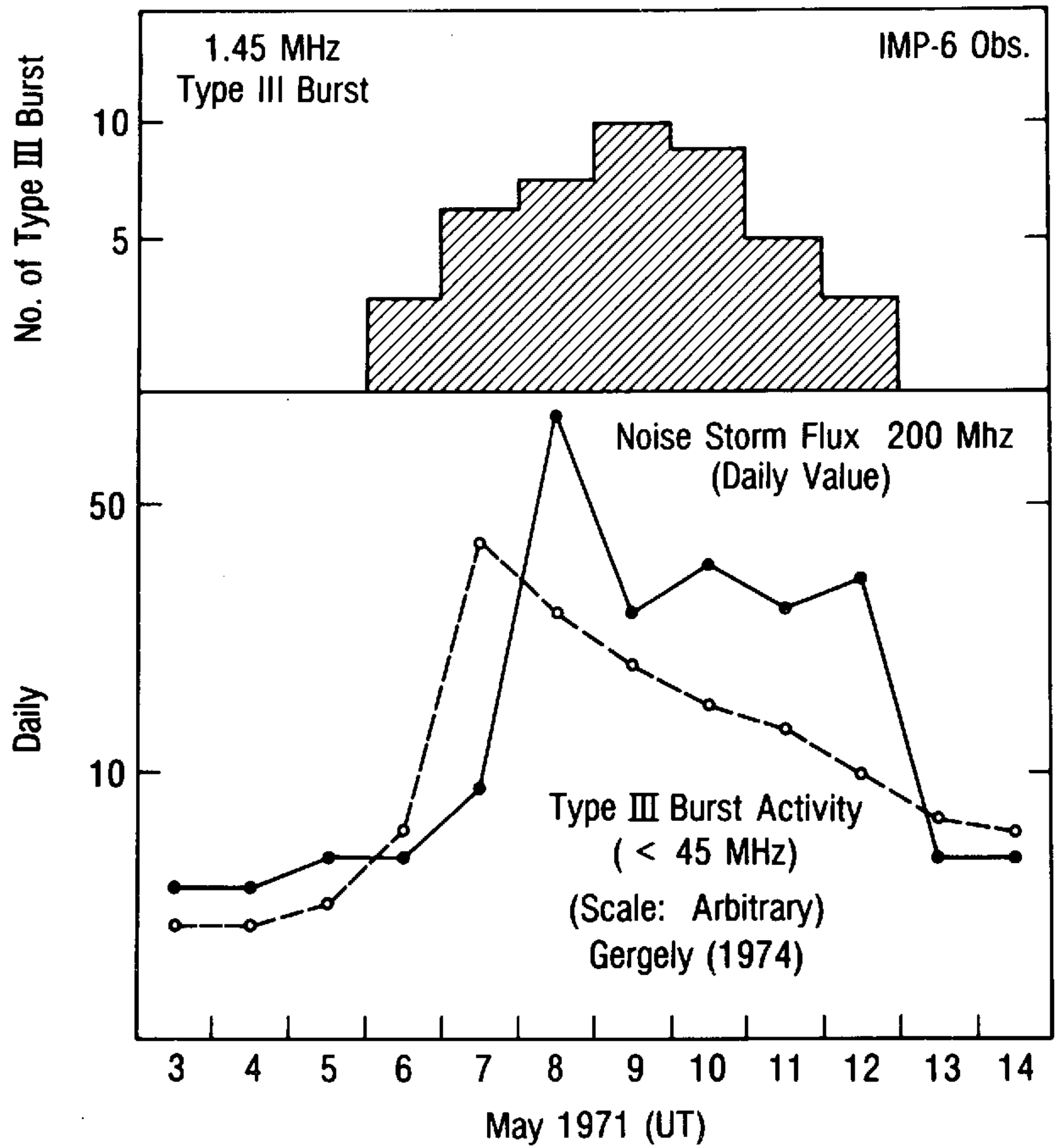
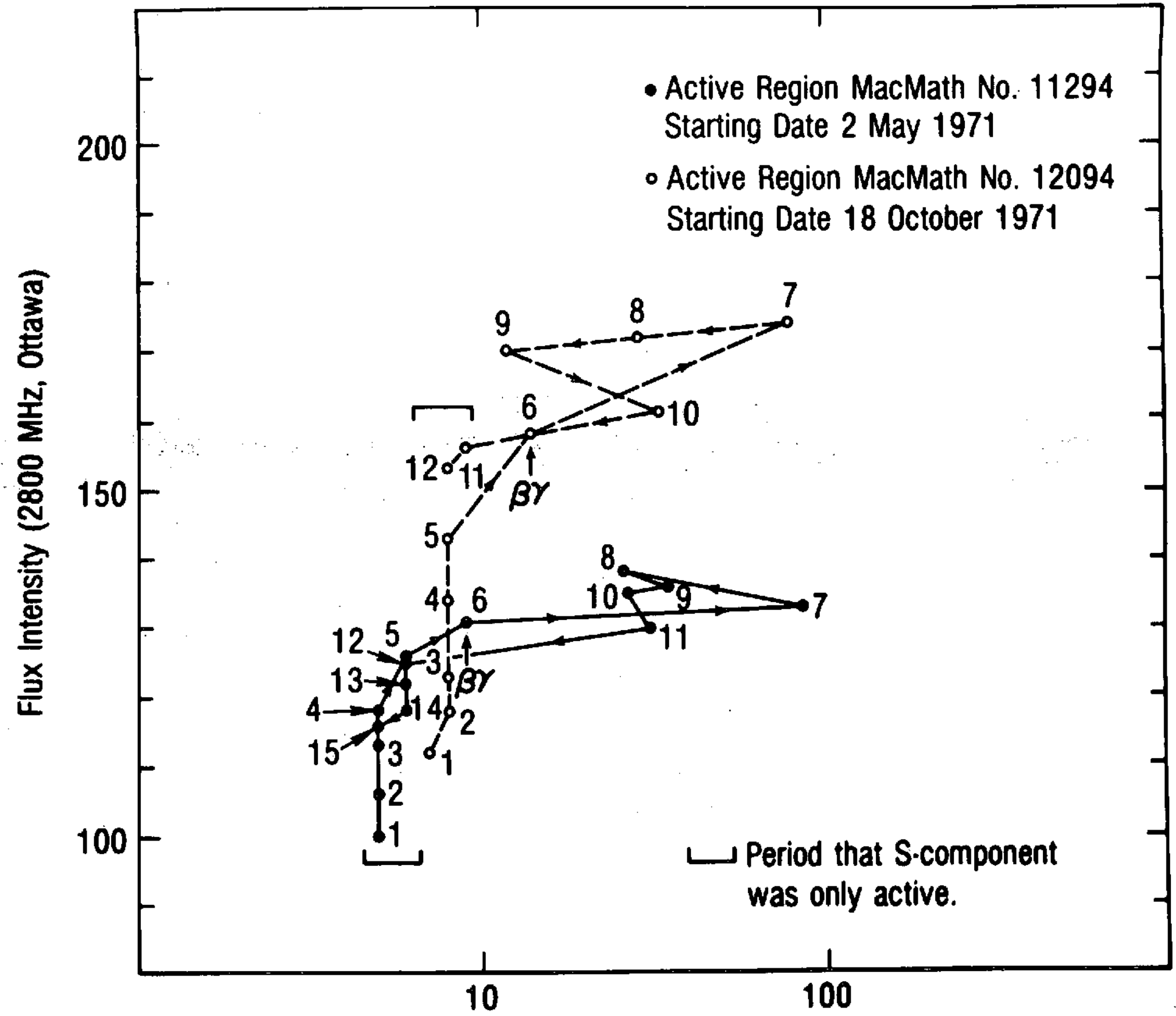


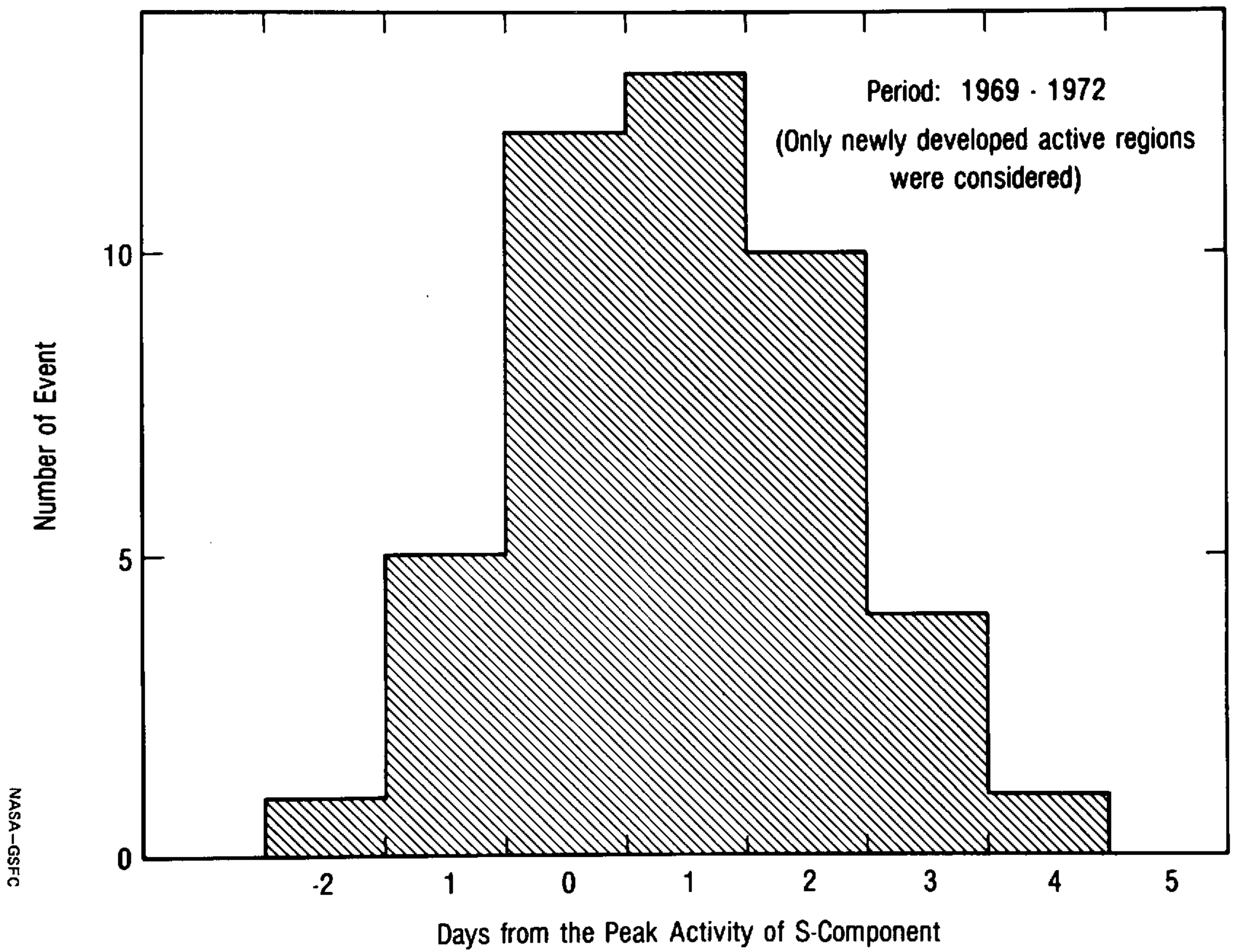
Solar Activity Associated with Active Region
MacMath No. 11294
Sunspot Type
(βγ)
βγ(βP)
(βP)
Sunspot Magnetic Field
(b)
2800 MHz
200 MHz
Highest Activity of
Type III Bursts
(< 45 MHz)
(a)
Flux Intensity (200 MHz)
Magnetic Field Intensity (Gauss)
Flux Intensity (2800 MHz)
100
10
1
10,000
1000
500
140
130
120
110
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14



1.45 MHz
Type III Burst
IMP-6 Obs.
No. of Type III Burst
10
5
Noise Storm Flux 200 Mhz
(Daily Value)
50
10
Daily
Type III Burst Activity
(< 45 MHz)
(Scale: Arbitrary)
Gergely (1974)
3
4
5
6
7
8
9
10
11
12
13
14
May 1971 (UT)



● Active Region MacMath No. 11294
Starting Date 2 May 1971
○ Active Region MacMath No. 12094
Starting Date 18 October 1971
Period that S-component was only active.
Flux Intensity (2800 MHz, Ottawa)
200
150
100
10
100
βγ
βγ


Period: 1969 - 1972
(Only newly developed active regions
were considered)
Number of Event
10
5
0
-2
1
0
1
2
3
4
5
Days from the Peak Activity of S-Component
NASA–GSFC