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The 1991 southern hemisphere complex of activity

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Abstract. — We have investigated the development of a complex of activity which took place in the southern hemisphere of the Sun between July 1991 and April 1992. The whole process culminated with the successive formation of two large active regions with sunspot groups NOAA 6850 (September/October) and NOAA 6891 (October/November 1991), both having complicated magnetic fields, but the former without heavy flare activity. We observed the appearance of the individual active regions as the consequence of the development stage of large-scale magnetic fields in the given area of the solar surface, in connection with their longitudinal and latitudinal distribution. We have studied the dynamics of this development on magnetic synoptic charts, as well as on spectroheliograms taken in the K-line of ionized calcium. Our new observations confirm the regularities found earlier and connection of global and local developments with convection. We think that they could become a tool for solar activity prediction and that they could be used for comparative studies of stellar complexes of activity.

Key words: Sun: activity — Sun: magnetic field — convection

1. Introduction

Recently we studied magnetic and velocity fields in several active regions, which occurred during 1991 almost in the same place of the southern solar hemisphere during three subsequent solar rotations. The most interesting of them was NOAA 6850, magnetically an inactive delta-configuration (Bumba et al. 1995a), and NOAA 6891, a very active complex group (Kálmán 1995). We noticed that we photoelectrically had measured the same region of the solar surface one rotation prior to the formation of NOAA 6850 (Fig. 1). Concerning the photoelectric measurements we remind that they were obtained using the classical scanning magnetograph (Klvaňa & Bumba 1994). At the same time, the study of the whole history of the mentioned groups' evolution showed that they were parts of one complex of activity, the life and formation of which might be indicative of the behaviours of interconnections between the global and local solar magnetic fields.

Accidentally, in connection with the investigation of coronal holes and their relations to the background and local magnetic fields in 1991 and 1992, we observed a characteristic large-scale distribution of solar background fields, forming long-lasting longitudinal regularities in both polarities (Bumba et al. 1994a-c; 1995b). We also observed that the magnetic fields of the above-mentioned complex of activity represented a considerable and important part of this longitudinal magnetic field disribution.

The regularity of forms in the organization of CaII flocculi on CaII K-line spectroheliograms during the passage of the complex over the disk in Carrington's rotation No. 1847 (see Fig. 7 in Bumba et al. 1995a) prompted us to investigate these forms subsequently for all disk passages, i.e. during all stages of development of the complex.

These were briefly the reasons for thinking that a more detailed investigation of the dynamics of the complex's evolution, in relation to individual active regions as its constituents, might yield some new information about the interrelations of the physics of global and local activity phenomena.

There exists one more motive for this study: recently, it has been indicated (for example, Chugainov 1991) that stellar spots seem to be concentrated in two active longitudes, usually separated by 180°, and, as seen from the dynamics of their development, they might also form certain type of activity complexes, as on the Sun.

2. Long term evolution of the complex at ($L = 180°$) from July 1991 to April 1992

The history of evolution of the long-lived complex of activity described below is based on information taken from the Solar-Geophysical Data (NOAA, Boulder, Colo., U.S.A.),

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the Kitt Peak Observatory magnetograms and the Debrecen Observatory photoheliograms.

The solar surface in the southern hemisphere around Carrington's longitude 180° was void in Carrington's rotation No. 1845 (July-August 1991; Figs. 2 and 3). No significant magnetic field concentrations were visible at $L = 180°$, $S = 12°$. Only background field areas of following (f) negative polarity, and of preceding (p) positive polarity were visible to the west. In the next rotation magnetic fields emerged between the two large unipolar areas at $L = 190° - 220°$, $S = 30°$ (active regions: NOAA 6810, 6811, 6814) and a small dipole appeared (already on Aug. 28) in the middle of the f-polarity area (L= 205°, S = 08°), as the region rotated onto the disk. On Sept. 1, around 14:00 UT, pores developed there (E24°, S08°) and a small bipolar group (NOAA 6815) evolved near the central meridian, thereafter slowly dissolving toward the western limb (Sept. 8).

The first sign of the very active complex group, NOAA 6818, appeared behind this small active region as a strongly inclined dipole on the Mt. Wilson magnetogram of Sept. 2. The development can also be observed in our photoelectric measurements (Fig. 1). The next day the dipole already assumed correct orientation and pores were visible in Debrecen's afternoon observations. By Sept. 6 it had already become an EKI group, with spots arranged along an ellipse, at the supergranular border. On Sept. 7, a double leading umbra was formed, and the magnetic configuration was given as delta. The plage of NOAA 6818 was in touch with one of the preceding NOAA 6815. The group disappeared behind the western limb on Sept. 10, as a fairly large one. On Sept. 9, at W67° it had an area of about 800 10^{-6} (millionths) of the solar hemisphere (m.s.h.). Significant flare-activity had also been observed in the NOAA 6818, especially on and after Sept. 7 (appearence of the delta configuration, formation of the double leading umbra). The 4 class M and 1 class X flares during Sept. 7, 1 M, 1 X during Sept. 8, and 1 M on Sept. 9, and 6 imp. 2 flares in (Hα) were seen during this time interval. To the south of NOAA 6818, where NOAA 6853 appeared in the next rotation, no activity was seen.

The situation during Carrington's rotation No. 1847 has been studied in (Bumba et al. 1995a). Active region NOAA 6850 remained stable during this transit (Sept. 24 - Oct. 8), of class FKC and with a delta magnetic configuration throughout, its area around 1500 m. s. h.. A significant change occurred around Sept. 29-30, when a new group began to develop in its middle part, inbetween the multi-umbra delta spot and an old f-polarity spot. The newly developed p-polarity spots in their forward motion collided and merged with an older p-polarity umbra in the delta spot, then pushed and distorted the umbrae of f-polarity to the west. The slowly backwards drifting double p-polarity umbra slid northwards under the influence of the neighbours and also became distorted. To the south of this region NOAA 6853 developed during Sept. 26 - Oct. 3, and its f-part then dissolved. At the west limb (Oct. 7) only the stable p-spot remained. Contrary to the complex magnetic field configuration and emergence of a new magnetic flux, no significant flares were observed in either active region. In (Hα) only subflares and imp. 1 flares occurred, in X-rays there were mostly class C and 10 class M flares, but the latter mostly only around M 1,. One M 6.1 flare was observed on Sept. 24, when NOAA 6850 was at E88°. The only significant flare in this area was the 3B/M7.3 flare on Sept. 29, at 15:13 UT, but it was located between NOAAs 6853 and 6850 (see Fig. 4 in Bumba et al. 1995a), and was probably the result of interaction between the evolving NOAA 6853 and the emerging magnetic flux in the middle of NOAA 6850. The occurrence of a large flare inbetween the spotgroups is another argument for grouping together these groups in a complex of activity.

During the following Carrington's rotation (No. 1848) this area of the solar surface became very active. The returning NOAA 6850 appeared as NOAA 6891 in the form of a very complex sunspot group at S12°, with newly emerging spots of mostly p-polarity, flowing around the old, stable divided umbra, composed of the p-polarity leading umbrae of the previous rotation. The interesting sunspot motions in this group will be described elswhere (Kalman 1995, in preparation). This group was of class FKC, with a delta configuration throughout and an area of about 2300 m. s. h. on Oct. 28. On the magnmetograms the configuration of the magnetic field in this area was very complicated (see Fig. 2). It seems that the old and new p-magnetic polarity areas of NOAAs 6850 and 6853 had coalesced, but in the middle part the squeezed f-polarity remained. Also on the eastern side of the complex the f-polarity areas had coalesced, but a new f-polarity appeared on its northwestern side. This complex magnetic structure with large magnetic gradients and fast spot motions probably accounts for the large flare activity. Many energetic flares were observed in this group: 25 class M and 4 class X during this transit; 2 of these flares were observed also in the white-light by YOHKOH (Hudson et al. 1993). To the south, the successor of NOAA 6853, NOAA 6892, was a wide bipolar class FIK-FKO group, with a stable area of around 400 m. s. h.. This group was less active, and produced only 4 class M flares.

In the subsequent rotations this magnetic field complex evolved further, but with dramatically reduced intensity. In this area mostly simple spotgroups or p-spots with accompanying pores were observed, as remnants of the magnetic field dispersed. But the flare activity of these smaller groups was still remarkable, almost all of them producing flares of class M in X-rays, and Imp. 2 in (Hα) (NOAA 6929, Nov. 17-23, 1991: 2, Imp. 2, 3 class M; NOAA 6972, Dec. 15-27, 1991: 2 Imp. 2, 2 class M; NOAA 7008, Jan. 11-24, 1992, no large flares). A new, strong dipole emergence in this place represented the complex group NOAA

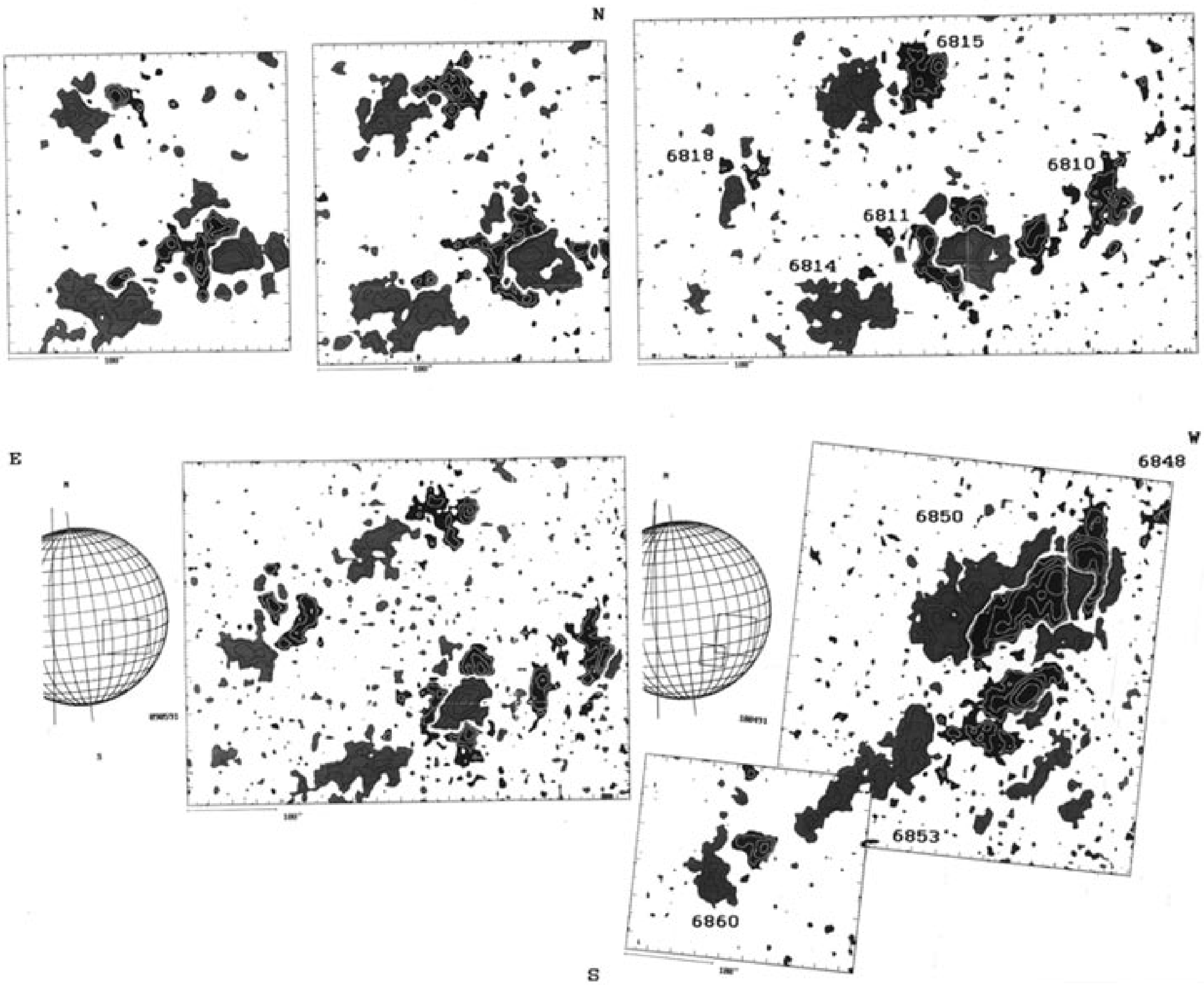

Fig. 1. In the top row from left to right: magnetic maps of NOAA 6818 and of the surrounding area, as measured on September 2, 1991 (08:21:27-08:39:59 UT), yet without NOAA 6818, on Sept. 3 (07:39:07-07:59:44 UT), with the first trace of the new region (close to the left frame-line in its middle part), on Sept. 4 (13:49:10-14:28:33 UT), already with the fast developing NOAA 6818. In the bottom row, to the left: on Sept. 5 (11:24:52-11:56:53 UT), (all 4 September maps are from Carrington's rotation No. 1846); to the right: the same area one rotation later (No. 1847) on October 10 (13:54:36-14:25:19 and 13:23:09-13:33:23 UT). The numbers of NOAA are indicated in the third and last maps; positive magnetic polarity is black. The positions of both measured areas on the disk are also shown

7056 (Feb. 8-21, 1992: 3 Imp. 2, 8 class M and 1 class X, Carrington's rotation 1852) which returned as NOAA 7091 (Mar. 5-18, 1992: 1 flare of Imp. 2 and 1 flare of class M), a wide bipolar pair of spots, and one rotation later as NOAA 7123 (Apr. 1-14, 1992) which did not produce large flares, but a large number of smaller ones (9 Imp. 1 and 47 subflares, in X-rays 25 class C flares). This probably signifies the final disappearance of the complex's magnetic field. In the next rotation (Carrington's rotation No. 1855) this long-lived perturbation of the solar photospheric magnetic field finally disappeared.

The whole above described evolution of activity in the studied region of the solar surface can be seen in Fig. 2, constructed from the Kitt Peak synoptic magnetograms and He I 1083 nm spectroheliograms. In Fig. 2 an area of 90° by 34° is shown, centred at $L = 180°$, $B = -16°$, for eleven consecutive Carrington's rotations - i.e. during the life-time of the investigated complex.

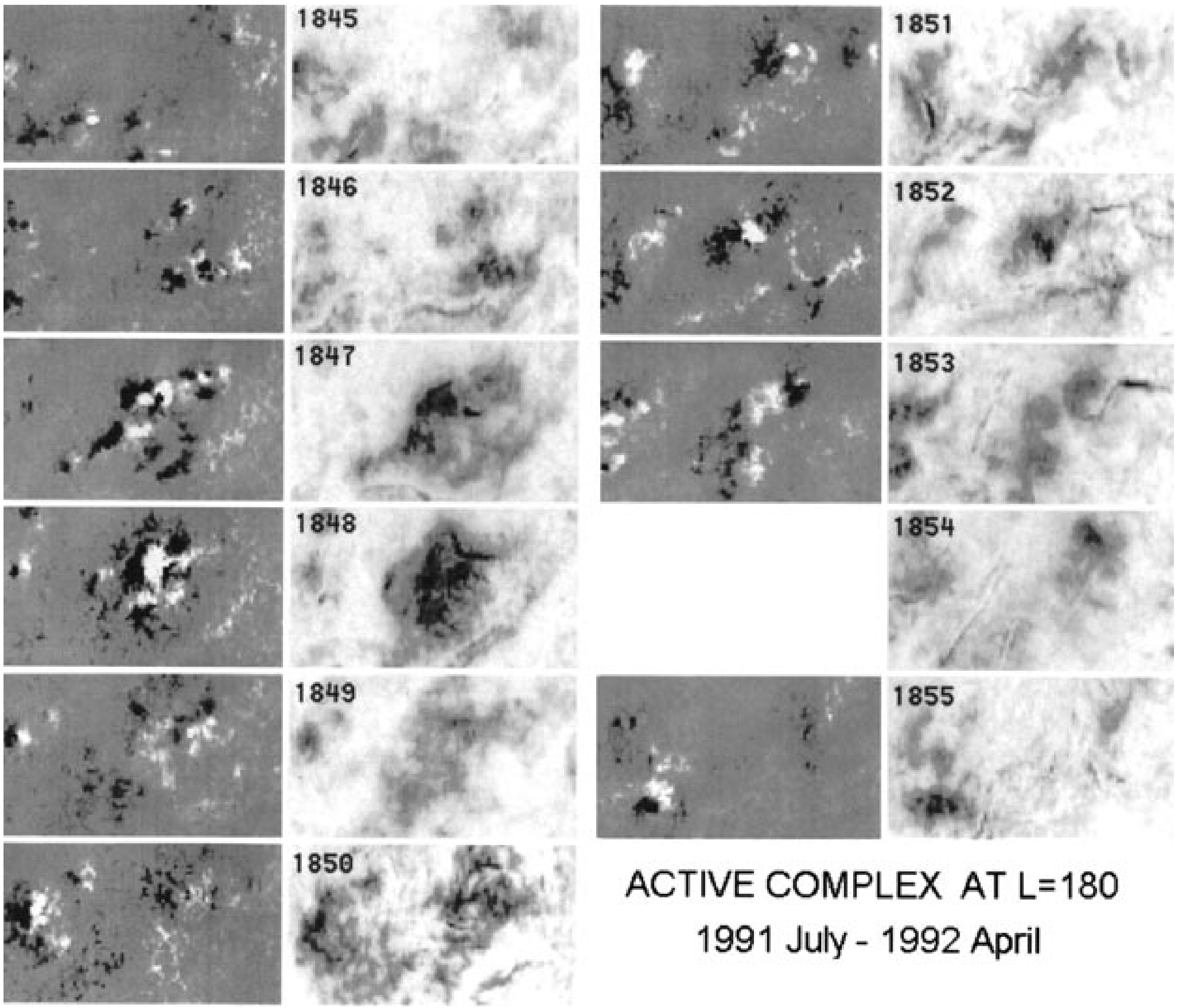

Fig. 2. Evolution of the southern activity complex at Carrington's longitude $L = 180°$ on the Kitt Peak Observatory synoptic magnetograms and the He I 1083 nm spectroheliograms. The area displayed lies between heliographic longitudes $135° - 225°$ and latitudes $0°$ (top) and $-34°$ (bottom). The first and third columns display magnetograms, the second and fourth He spectroheliograms. Carrington's rotation numbers are indicated on the helium images

3. Longitudinal and global distribution of large-scale magnetic fields

To understand better the history of the spot group developments described above, we have to investigate the kind of evolution of the individual local magnetic fields of these groups in their interrelations with the background fields and its dependence on the global stage of activity. As already said, just recently, accidentally, studying the interconnection of solar coronal holes with the distribution of background magnetic fields (Bumba et al. 1994b, c, 1995b), we not only saw a strong relation between the formation of coronal holes and the latest stages of evolution of complexes of activity, closely connected with the regularities in the longitudinal distribution of solar magnetic fields, but our studies directly involved the complex in question, demonstrating the full development of its magnetic field and photospheric activity up to the formation of a coronal hole (Bumba et al. 1995b).

In this study we again arranged the equatorial strips (±20°) from the Stanford Wilcox Observatory Solar Magnetic Field Synoptic Charts from 1991 and 1992 into consecutively mounted series, starting with Carrington's rotation No. 1834 and ending with No. 1860 (See Fig. 4). In this figure we see, as usual, the well-pronounced longitudinal organization of opposite magnetic field polarity areas

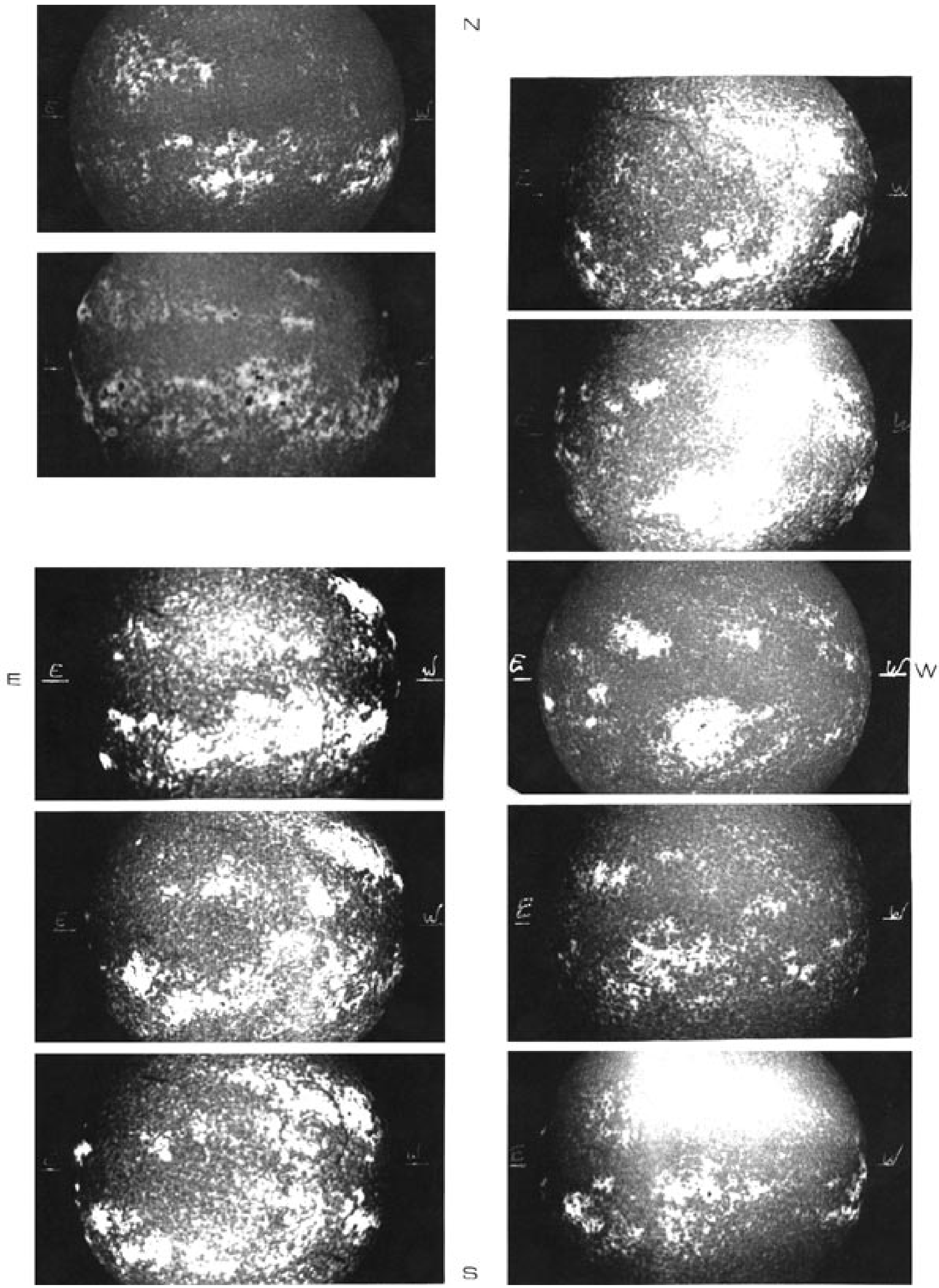

Fig. 3. Ca II K3 spectroheliograms in subsequent rotations demonstrating the development of the complex during each CMP. The relevant data are in Table 1. The first two photographs represent rotations Nos. 1837 and 1838, the separate series of photographs shows rotations Nos. 1843 till 1850

into the well-known patterns, we have called "Magnetic Active Longitudes - MALs" (see for example Bumba & Hejna 1981). The dynamics of this longitudinal polarity distribution displayed changes from a sixfold alternation of polarities at the beginning of our series to an almost pure dipole developed during the fall of 1991, when development of the studied complex had reached its maximum phase, to be transformed into a quadruple to the end of the two-years interval involved. We have to mention that the same change of four sectors of the background field into two and later again into four accompanied the formation of the large white-light flare region NOAA 4474 from April 1984 (Bumba & Gesztelyi 1988a, b). All this is also reflected in the maps demonstrating the Stanford measurements of the mean field, and even better, in the source surface field (see Fig. 5). Source surface is the region where currents in the corona cancel the transverse magnetic field. The magnetic field existing on the surface boundary is thus oriented approximately the radial direction, and serves as a source for the interplanetary magnetic field (Schatten & Wilcox 1969; Altschuler & Newkirk 1969; Schatten 1972). Here we also see the well-pronounced flattening of the surface field around the equator with time (the successive diminishing of amplitudes of gulfs in which the single polarity fields of each hemisphere cross the equator to the opposite hemisphere).

From Fig. 5 we also see the exceptional position of the complex in relation to the global magnetic field. It developed directly in the center of the main boundary of the solar global bipol. (We have already observed a similar situation in studying the two large active regions NOAA 3763 and 3776 of June 1982 (Bumba & Klvaňa 1995)). This fact also coincides with the asymmetry of the distribution of magnetic activity between the northern and southern hemispheres, distinctly reflected also in the global distribution of coronal holes. It is characterized by the shift of the center of gravity of the negative polarity fields more northwards (in the first half of the interval of solar longitudes) and of the positive polarity fields southwards (in the second half of solar heliographic longitudes). Again this can best be seen on the Stanford synoptic chart demonstrating the source surface field distribution. The only conclusion we can draw from this is the new accent on the global behaviour of the process of the studied complex formation, the engagement of the whole solar magnetic field in it.

As regards the MALs, we see in Fig. 4 the same dynamics of MALs and complex of activity development as many times before (for example, Švestka 1968; Ambrož et al. 1974; Bumba & Hejna 1981, etc.): The complex with its mighty active regions develops at a place and time, where two MALs intersect. It is the MAL running with a very slow shift in longitude throughout Carrington's rotations, formed from stronger fields, with the synodic rotation rate of about 27,16 days and the MAL constructed from weaker

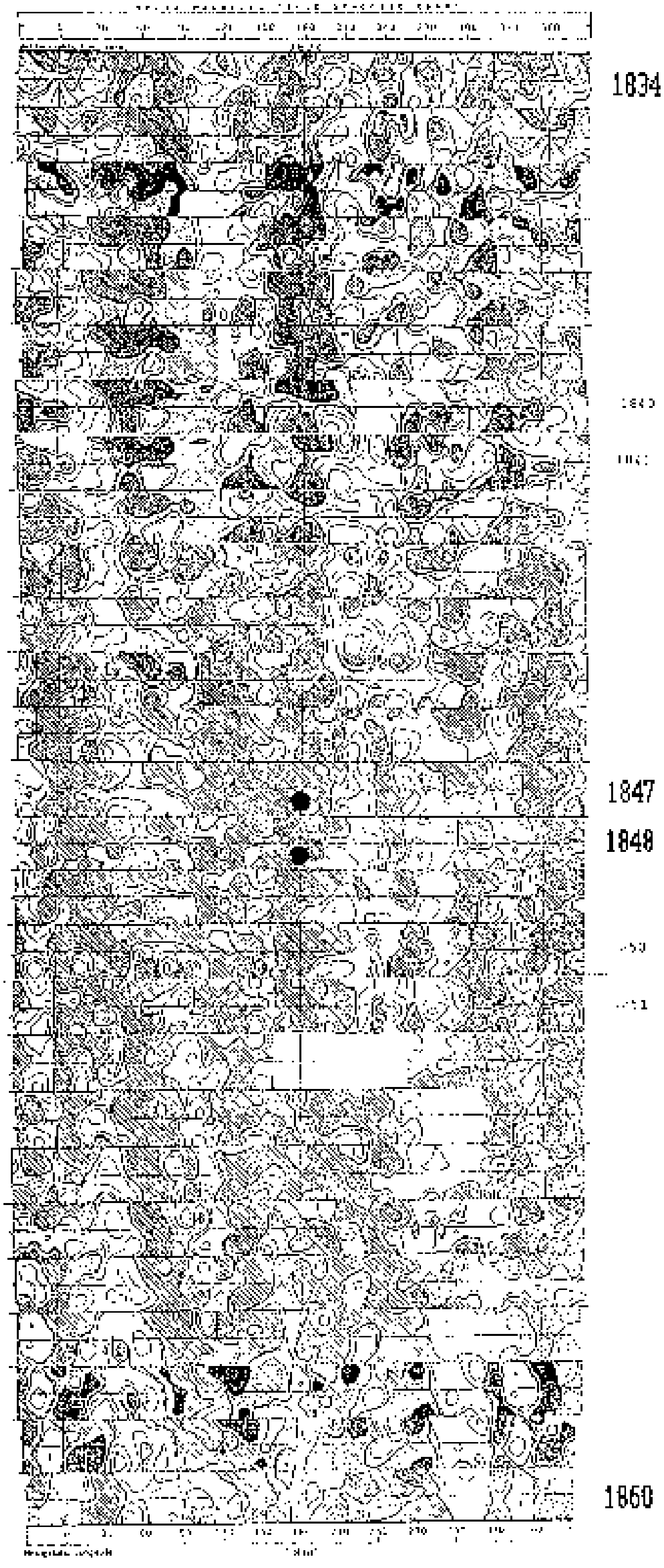

Fig. 4. Equatorial parts of Stanford's magnetic maps (Carr. Rots. 1834 - 1860) demonstrating Magnetic Active Longitudes. The negative polarity fields are indicated by hatching. Positions of NOAAs 6850+6853 in rotation No. 1847 and NOAAs 6891+6892 in rotation 1848 are indicated by black circles

fields, inclined toward the previous one (with a rotation rate of around 26,77 days; Bumba & Hejna 1991). And again, as usual, it is the negative polarity fields which seem to play a more important role in both MALs.

4. Dynamics of rebuilding the background magnetic field

4.1. *Derived from magnetic synoptic charts*

McIntosh (1992) demonstrated that very large active regions are accompanied by the formation of coronal holes. In our previous paper concerning active region NOAA 6850 (Bumba et al. 1995a), we connected this rule, proved by McIntosh, with the global behaviour of the process of coronal hole evolution, depending on the global distribution of solar background magnetic fields. Reverting to the concrete case of coronal holes related to the complex containing NOAA 6850, we see that during the rotation in which this region (No. 1847) occurred, two coronal holes developed (No. 64 and Nos. 66+65) about 40° to the west and about 50° to the east, as extensions of the polar coronal holes: in the first case the positive polarity northern polar hole (No. 64) and in the second case of the negative polarity southern polar hole (Nos. 66 and 65; Bumba et al. 1995b). They could be observed over several subsequent rotations. The Stanford Observatory magnetic maps, show a well-defined coincidence of both coronal holes with the sectors of the background field of proper polarities.

This comparison with the Wilcox Solar Observatory maps brings us back to a more detailed study of the trends in the development of the synoptic situation in the region of the photosphere containing the investigated complex. The best way of analyzing the dynamics of evolution of the background field patterns is again the construction of a series of maps. In this case (see Fig. 6) we mounted consecutively each third Stanford synoptic magnetic map to capture the individual phases of the successive changes of these patterns.

As already stated above, the complex evolves in the prevailing large-scale negative polarity feature. If we study this pattern over the time interval of 21 solar rotations (Nos. 1838-1859), we can see not only the successive shift of the center of gravity of magnetic activity from the northern toward the southern hemispheres, but also its slow transition from the prevailing negative toward the positive magnetic polarity. And moreover, this transition seems to play the role of a natural constituent in the global rebuilding of the background field, the most remarkable phases of which seem to be (if we consider the situation on the solar globe as a whole), at the beginning of the interval (rot. No. 1838) the three negative polarity sectors crossing the equator from the southern hemisphere, with the negative polarity still not occupying most of the polar regions; the negative polarity fields then retreat through a temporary feature in the form of the letter S in rotation No. 1841 from the western half of the solar surface (relative to the complex) to the eastern half (rot. No. 1844). This configuration lasted for several rotations, to be slowly re-formed by differential rotation, as the strength of the negative fields weakened (rot. No. 1853). Towards the end of the investigated time interval (rot. No. 1856) we see that both magnetic polarities mutually divided the solar globe so that the positive polarity occupied the northern hemisphere, from the pole to about the latitude of 50°, forming a large bulge in the southern hemisphere in the longitudinal interval from about 90° to about 230°, in which the studied complex is also located. In the remaining longitudes it is the negative polarity that bulges out from the southern into the northern hemisphere.

This process of slow rebuilding of the background field patterns through successive development of large-scale cellular structures of positive polarity (see again Fig. 6) of highly probably convectional origin (Bumba 1987a, b) speaks in favour of the dominant role of convection in the process of solar magnetic field and activity development.

Table 1. CaII K_3 line spectroheliograms used

No of Carrington's rotation	*Date* 1991	*Time* UT	*Heliogr. longitude of C. M.* L°
1837	Jan. 1	$10^{\rm h}\ 44^{\rm m}$	186.5
1838	Jan. 28	$10^{\rm h}\ 54^{\rm m}$	190.9
1843	June 14	$8^{\rm h}\ 23^{\rm m}$	184.1
1844	July 11	$16^{\rm h}\ 29^{\rm m}$	182.3
1845	Aug. 7	$10^{\rm h}\ 20^{\rm m}$	188.5
1846	Sep. 3	$9^{\rm h}\ 13^{\rm m}$	192.3
1847	Oct. 1	$11^{\rm h}\ 08^{\rm m}$	181.6
1848	Oct. 28	$16^{\rm h}\ 14^{\rm m}$	182.7
1849	Nov. 23	$10^{\rm h}\ 53^{\rm m}$	202.8
1850	Dec. 21	$10^{\rm h}\ 16^{\rm m}$	194.2

4.2. *Derived from CaII K-line spectroheliograms*

To support the decisive role of large-scale cellular convective elements in the process of global organization of solar magnetic fields and the activity related there to, we shall show the development of global magnetic patterns as they are reflected in the distribution of the emission features seen on spectroheliograms obtained in the ionized calcium line K_3. These patterns are much better and more plastically visible on spectroheliograms obtained in ($K_{\rm IV}$), but the contrast in such spectroheliograms is very low and their quality is mostly worse than of those obtained in K_3. This is the reason we are only using the K_3 spectroheliograms.

We have already made several attempts (Bumba 1970; 1987a) to identify the large-scale cellular structures

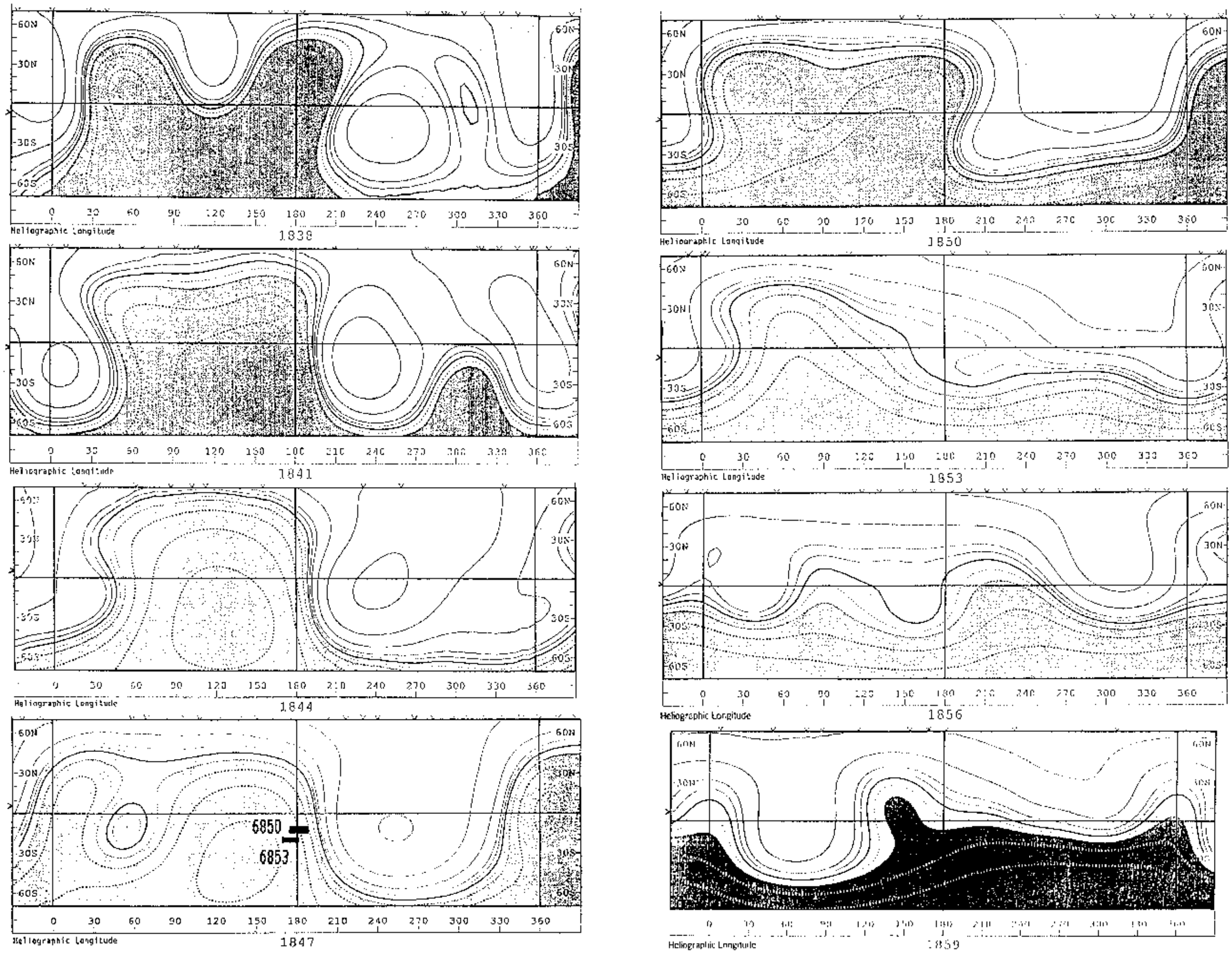

Fig. 5. Stanford source surface field charts for each third Carrington's rotation from Nos. 1838 till 1859. The general trend of global magnetic field development is clearly visible. The positions of NOAAs 6850 and 6853 during rotation No. 1847 are indicated

observed during certain evolutionary stages of solar activity in the distribution of background magnetic fields, ionized calcium emission, etc., as large convectional elements. But we feel that the presented arguments have not been generally accepted, probably due to their predominantly morphological character.

Now, in studying the series of CaII K_3 line spectroheliograms from the Coimbra Observatory (Fig. 3), we can again see the dynamics of the development of the global situation in the magnetic field and activity distribution we discussed in the previous chapters, but from another point of view. And, in our opinion we now have an even better opportunity of observing the studied process in its global extension.

Table 1 and Fig. 3 demonstrate how we arranged the CaII K_3 spectroheliograms to show the studied portion of the solar disk during subsequent rotations as close to the central meridian (C. M.), as the observational conditions and the time of exposure allowed.

As can be seen in Fig. 3 (sunspot activity in the same part of the photosphere during 1991 - 1992) of Bumba et al. (1995b), the studied complex of activity was not the first to occur in this part of the solar atmosphere. About ten rotations earlier there was another mighty complex. But the whole history of the activity development in this solar region must be discussed elswhere. To indicate the highly probable connection of the studied complex with the former, we have used two disk passages of the first complex in its maximum and postmaximum phases as in Table 1, as well as in Fig. 3. We see its main morphological characteristics (the first two upper pictures in the left row of spectroheliograms), then its last evolutionary phases

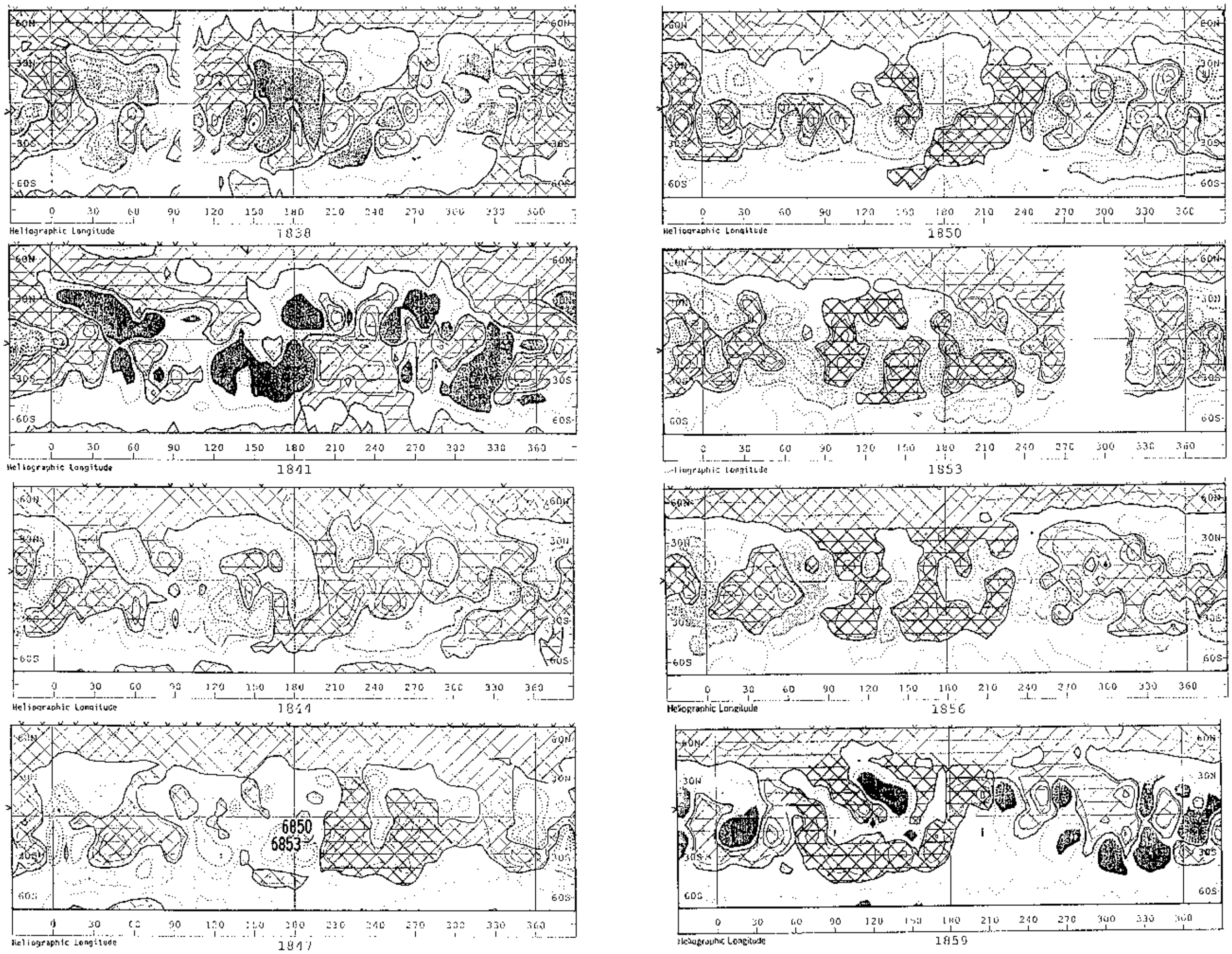

Fig. 6. Each third Stanford synoptic magnetic map (starting with Carrington's rotation No. 1838 to No. 1859) was mounted into this series to demonstrate the development of large-scale positive field patterns. Positive polarity is indicated by hatching, emphasized in the discussed large-scale structures. The position of NOAAs 6850 and 6853 in rotation No. 1847 are indicated too

(the next three pictures in the same left row), which enable us to distinguish clearly the beginning of the second complex, investigated in this paper (first upper spectroheliogram in the right row).

Figure 3 shows several features worth drawing attention to. First of all, we believe that it is possible in some spectroheliograms to distiguish the calcium emission organized into peripheries of large cellular-like structures. As we have already mentioned, the visibility of cellular forms of these patterns is better on ($K_{\rm IV}$) spectroheliograms, where the emission filling in the interiors of large cells is less striking, thus allowing to the structures concentrated at the rims of the large cells to be more prominent.

If we take into account this fact, we may say that the activity of the complex commenced in the middle part of the patterns, usually inbetween two large cells, in the corner closer to the equator. Further new activity then develops even farther from this place, in quantized distances. As we have already demonstrated many years ago (Bumba & Howard 1965), the intensity of activity in the complex grows during the first to three rotations and then slowly subsides during several more rotations. All that has been said can be seen in both the complexes visible in Fig. 3.

We think that the striking similarity of the first and last spectroheliograms in our series (including both hemispheres), separated by a time interval of nearly one year, may be explained in the same way as we explained McIntosh's (1992) results in the preceding chapters, i.e. by the quasisymmetrical distribution of the background magnetic field patterns, due to their global behaviours.

5. Discussion of results

5.1. *How and where does a solar complex develop*

The solar complex of activity performs the role of one specific unit of solar activity in the hierarchy of solar activity patterns, temporaly much longer (around one year) and spatially much more extensive (a part of the solar activity zone) than a single active region. During its development, we see the effect of an impulse of solar activity in the whole volume of the solar atmosphere, in which successively, following certain rules, a number of individual active regions evolve, reaching its maximum quickly in terms of numbers, as well as importances, with continually increasing area they cover, then to decline slowly with possible post-maximum oscillations of activity (Bumba & Howard 1965).

Observations like these ones are of big importance for theoretical calculations concerning the physical processes on the Sun, e.g. paper and video by Caligari et al. (1995). Their numerical simulations of magnetic flux tubes emerging from the storage region below the convective zone give a possible scenario of the appearance of active regions on the solar surface.

The investigated southern complex of activity, extended around $L = 180°$, represented a long-lived disturbance in the solar atmosphere which appeared in the form of several consecutively developed sunspot groups. In the course of their evolution, these groups moved together, or new groups appeared in the middle of the old ones in such a way that the magnetic fields in the area became rather complex. The largest complexity was achieved in Rotation No. 1848, when new spots streamed westward, flowing around the large p-spot remnant from the previous rotation. Although NOAA 6891 was superactive, and in the next rotation the magnetic field of the complex weakened considerably, its disappearance was not as fast as it used to be in the case of superactive regions, as, for example, the August 1972 region (Zirin & Tanaka 1973; Zirin & Liggett 1987) or the June 1991 regions (Bumba et al. 1993). The complex's magnetic field continued to evolve during the next six rotations, and its later spotgroups were almost all more active than the average groups.

It is also worth mentioning that in the course of its evolution, to the east of the large unipolar p-polarity background field structure, the perturbation in the photosphere moved slightly toward the equator: while NOAAs 6810, 6811 and 6814 developed around latitude S 30°, the superactive NOAA 6891 appeared at S 21° and NOAA 7123 finally at S 06°.

The study of the mutual relation of this impulse of activity, the magnetic fields of which occupies a part of the solar activity zone, to the global magnetic field, indicates the following: during the maximum stage of the complex's development, the global magnetic field represented practically almost a pure dipole, while during its final stage it rather formed a quadrupole. However, what seems to be very important, is the unique position of the complex in this global field: it was formed close to the center of symmetry of the main boundary separating both magnetic polarities of the dipole. And this position also represents the place where two different modes of active longitudes intersected at the beginning of the process.

The investigation of the dynamics of rebuilding the magnetic field during the complex development shows that it takes place through the successive appearance, restructularization, and disappearance of large, characteristic, nearly elliptical magnetic field structures (in this case of positive polarity), whose origin is very probably in convection (Bumba 1987a, b). Their evolution, if compared with the longitudinal shift of active longitudes, is retrograde, i.e. in the direction of diminishing heliographic longitudes. At the same time, these patterns function evidently as one of the main agents in the global reconstruction of the background magnetic field, together with the global redistribution of activity in the solar zone of activity.

The ionized calcium spectroheliograms first of all show that the investigated complex developed in a region in which several rotations ago the evolution of a similar complex went through its final stage. The new complex in the same area therefore means a practical renewal of the complex activity. The spectroheliograms exhibit that some of the emission seems to be organized again into circular or elliptical patterns. And the new complex appears to evolve from the crossings of these structures, more active when crossing closer to the equator. The new individual active regions then appear further and further away from the place of the first appearance, but in quantized distances, equal roughly to the diameter of the structures. At later stages, the emission diffuses from the originally well defined patterns, and these in turn lose their forms.

The elliptical structures mentioned, visible on the Stanford Observatory synoptic magnetic charts and on the ionized calcium spectroheliograms, seem to demonstrate that the process of continuous restructuralization of the solar global magnetic field, in which the development of complexes of activity represent well-defined phases, witness the important role convection plays therein, and simultaneously in the evolution of the solar magnetic field and activity.

5.2. *What could be expected from an analogous stellar complex*

Depending on the phase of the solar activity cycle, several complexes of activity may exist simultaneously on the Sun. But their developments are always shifted in phase, never proceeding parallel. If there are only two of them, usually during the late declining phase of the cycle, they are formed at almost opposite heliographic longitudes and their evolutionary phases are also in opposite phases. The same might be expected of stellar complexes. In addition to this, during the maximum phase of a stellar complex we might find traces of larger photospheric, and, above all, of chromospheric activity, possibly of flare phenomena in the spectrum of the star.

The asymmetry of the evolutionary curve of the complex could also be reflected in the modulation of stellar brightness due to the presence of spots: much faster growth and then slow, gradual diminishing of the complex could mean a faster decrease of the brightness at the beginning and its slower increase toward the end of the process. If the analogy with the Sun is to be full, then variation curves of stellar brightness should display also changes connected with the changing number, position and phase of activity complexes during different evolutionary stages of stellar cycles, caused, above all, by the unequal effects of the individual complexes.

We could even observe a successive long-lasting shift of the center of gravity of activity from one hemisphere to the other. Due to the changes of its heliographic latitude, the velocity of its differential rotation varies, and this could influence the lengths of the time intervals in stellar brightness variations.

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