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Research Note

Secondary polar zone of prominence activity revealed from Lomnicky Štít observations

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Abstract. The time-latitude distribution of the number and area of prominences observed at Lomnicky Štít Coronal Station during the period 1967–1991 has been studied in order to check if multiple structure of the prominence polar zones can be traced. The results obtained show that a secondary polar zone appears in the northern hemisphere during the maximum phase of solar cycle 20, which confirms the result obtained by Waldmeier (1973). During the ascending phase of solar cycle 22 a triple structure developed in the southern hemisphere. No multiple structure is observed during solar cycle 21.

Key words: Sun prominences – Sun activity – Sun magnetic fields

1. Introduction

The fundamental regularities of the time-latitude distribution of the prominences and their projection on the disc, the filaments, have been described as far back as 1948 by L. and M. D'Azambuja (see Kiepenheuer 1953). Now it is well known (see for a contemporary review Martin 1989) that these phenomena are concentrated into three relatively narrow zones which show different behavior in the course of solar cycle. The first zone, consisting of the so-called sunspot-type prominences, is situated in the sunspot zone and it has the time-latitude behavior of this zone. The second zone, consisting of long-living prominences, is situated at a distance about 15° higher than the sunspot zone and migrates towards the equator parallel with it. The third zone, which is of particular interest in this study, is the polar zone of prominences. It forms at latitudes higher than 45° and contrary to the above-mentioned zones it migrates to the poles and it is phase-shifted compared to the sunspot zone and to the other two prominence zones. The polar zone starts some years ahead of sunspot minimum and until the following maximum migrates towards the pole, reaches it and disappears.

It seems that these two types of prominence zones have different dynamics and probably also different physics, especially if we take into account the observational fact (see e.g. Waldmeier 1960; Makarov et al. 1983; Ribes 1986) that the change of the polarity of the general magnetic field of the Sun occurs when prominences (filaments) reach the circumpolar regions.

Waldmeier (1973), pointed out that cycle No. 20 has shown as anomaly in polar prominences surface distribution, since two zones had formed in the northern hemisphere, the second zone following the first one at a time interval of 2.5 years, Here we study the time-latitude distribution of the number and area of prominences observed at Lomnicky Štít Coronal Station during the period 1967–1991. Our main goal is to check if these observations reveal such secondary polar zone for cycle 20, as well as for the next two cycles 21 and 22.

2. Observational data and method of analysis

We used the data of regular limb observations of solar prominences carried out at Lomnicky Štít Coronal Station with the 20 cm coronograph in the years 1967–1991 (Rušin et al. 1988; Dermendjiev et al. 1993).

In studying the time-latitude distribution of the prominences (number and area) we used the method of contour maps construction with different degree of smoothing.

3. Results and discussion

Since the results obtained for the distribution of prominence number and area are quite similar we present and discuss here only the time-latitude distribution of the area of the

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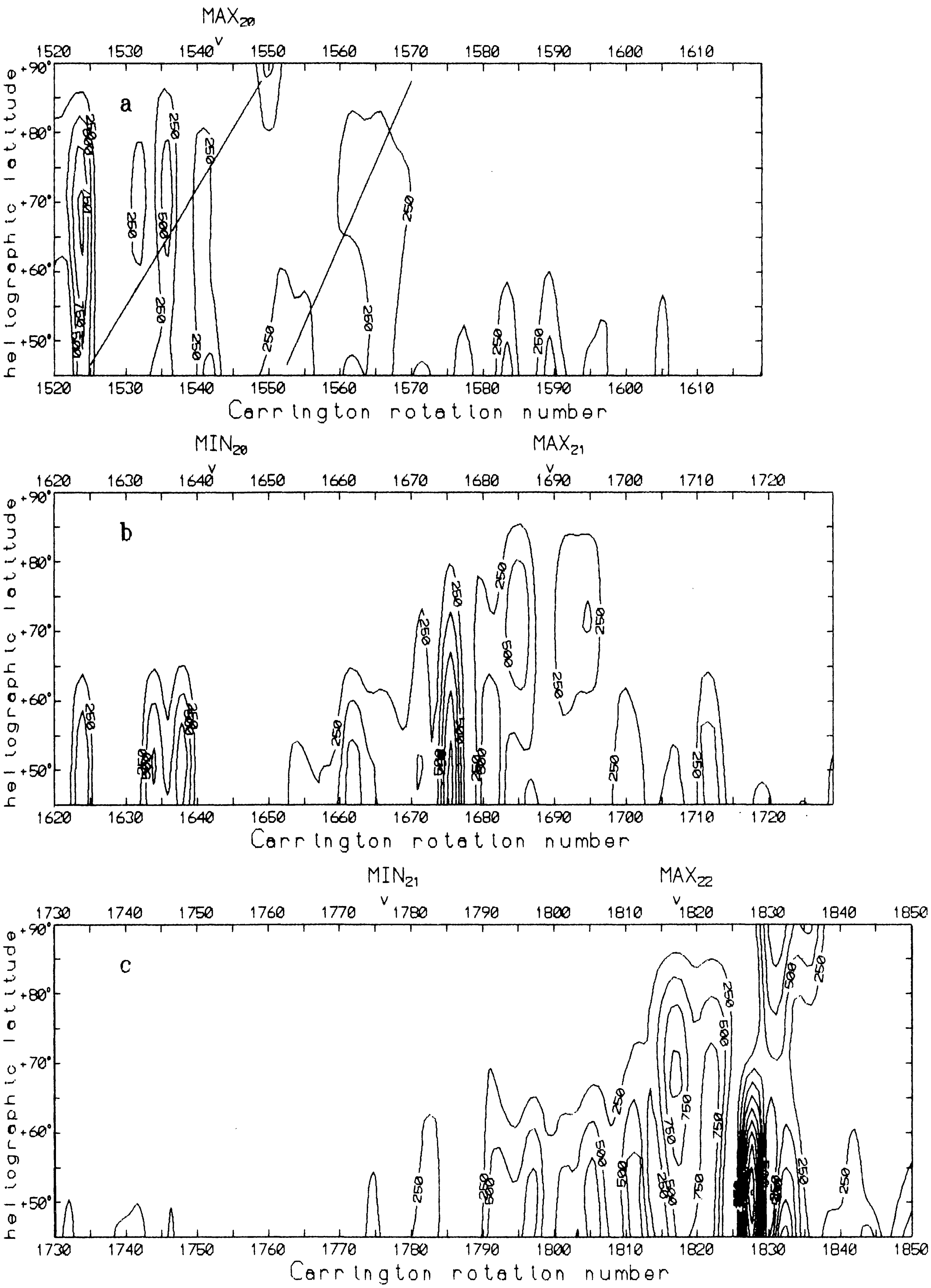

Fig. 1a–c. Time-latitude distribution of the area of prominences for the years 1967–1991 for the northern polar region. Prominence area has been computed for time interval of 1 Carrington rotation in 5° latitude strips. The minimum contour level shown in 250 units per grid cell (1 unit = degree × arcsec). The contour interval in 250 units: *a* solar cycle 20, *b* cycle 21, *c* cycle 22

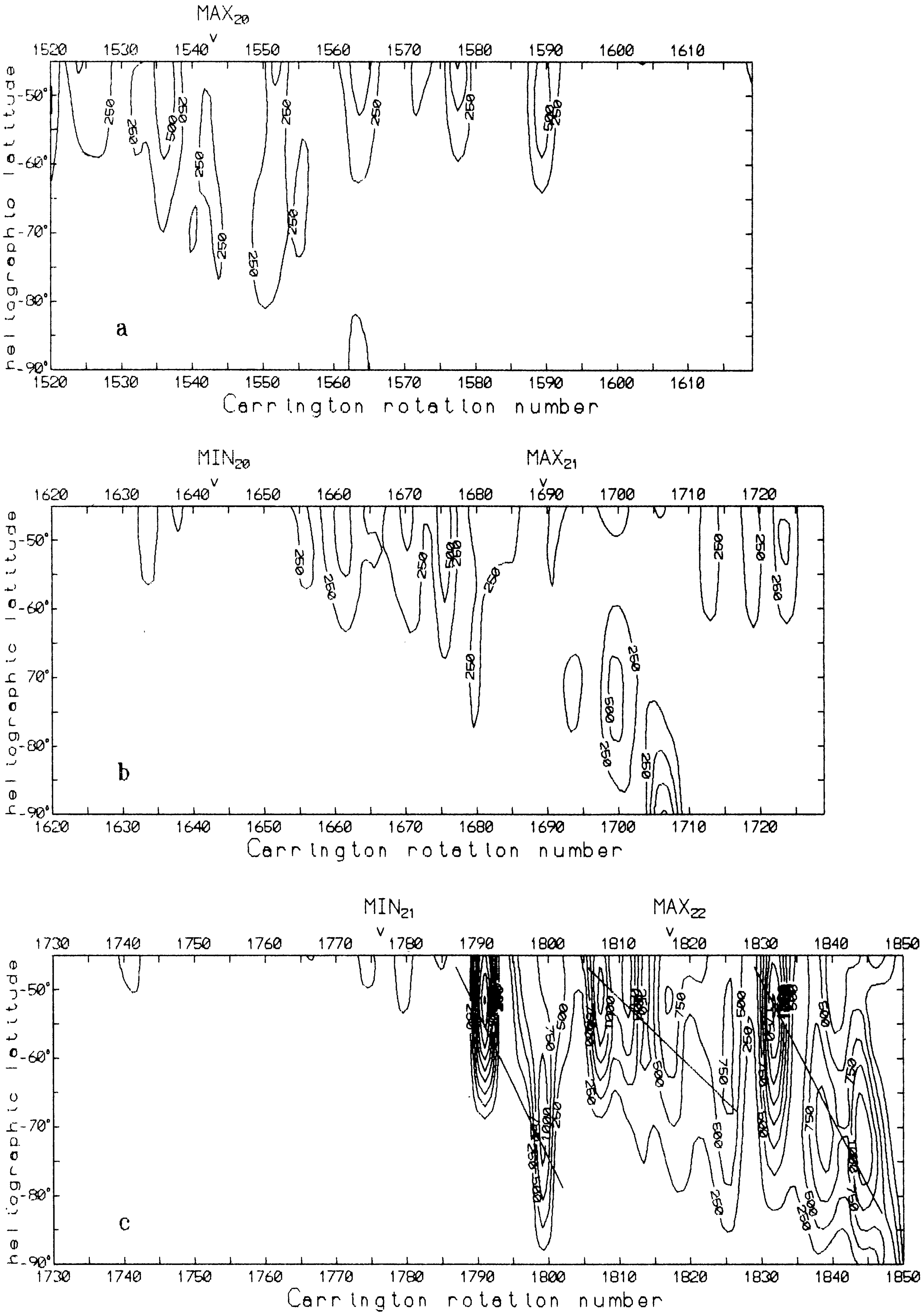

Fig. 2a–c. Same as in Fig. 1a–c but for the southern polar region

polar zone prominences (Figs. 1, 2). The smoothing degree and the contour levels are taken in such a manner that the tendency to possible formation of double structure in the polar zone be well seen.

As can be seen in these figures, secondary polar zones form during the ascending phase of cycle 20 in the northern hemisphere and of cycle 22 in the southern hemisphere. Only one polar zone in each hemisphere forms during cycle 21.

The northern polar zone of cycle 20 (Fig. 1a) shows two branches: the first one reaches the pole at the time from rotations 1535–1540 to about rotation 1550, i.e, at the beginning of the sunspot maximum (whose duration is 3 yr), and the second branch reaches the pole at the end of sunspot maximum (at the time after rotation 1560 to about 1570). The time interval between these two branches is about 20–25 rotations.

The structure of the southern polar zone during the ascending phase of cycle 22 shows more than two branches (Fig. 2c). The first branch appears after rotation 1765 (in the epoch of the solar cycle minimum), reaches its maximum value around rotation 1790 still at heliographic latitude near $-50°$ and after that quickly drifts to the pole approaching it at rotation 1800, much time before the sunspot maximum. The second branch forms after rotation 1805 and moves to the pole till rotation 1825, at the beginning of the sunspot maximum. This branch, however, is not so pronounced as the first one. Shortly after rotation 1930 a third branch forms and quickly reaches the pole.

The time-latitude distribution of the polar zone prominences shows N/S asymmetry of different degree for each of the studied cycles. For cycles 20 and 22 this asymmetry is partly due to the appearance of double- or multi-structure of the polar zone of prominence activity. As for cycle 21, a strong N/S asymmetry appears at the maximum and especially after the maximum at high latitudes. It is interesting to note that this asymmetry occurs at the beginning of the extended cycle 22.

Taking into account the observational fact that the change of the polarity of the solar magnetic field occurs when the prominence polar zone reaches the circumpolar regions, we suppose that the double- or multi-structure of the prominence polar zone is intimately correlated with the three-fold reversals of the high-latitude magnetic field. This phenomenon has been studied in detail (Makarov et al. 1983, 1985, 1988) by means of tracers like H-alpha filaments and polar faculae. According to Ribes (1986) the counter-rotating azimuthal rolls moving poleward are responsible for such reversals of the polar magnetic field. Recently an attempt was made (Benevolenskaya & Makarov 1990; Benevolenskaya 1991) to explain the three-fold reversals phenomenon as a result of interaction of a low-frequency component (with a period of 20 yr), describing a mean cyclic background field, and a high frequency component (with a period of 1.7–2.5 yr) with a slowly varying phase.

Our results for cycle 20 show that the secondary polar zone of prominences follows the first one at a time interval of 20–25 rotations (1.5–2 yr) which is within the period of magnetic reversals. Waldmeier's estimate of 1.5–2.5 years (Waldmeier 1973) is within this period, too.

It is striking that for cycle 22 the three branches revealed in the time-latitude distribution of the areas of quiescent prominences in the southern polar region follow one after the other with nearly the same time interval of 20–25 rotations.

4. Conclusion

The phenomenon second polar branch or zone of prominence distribution in the ascending phase of the solar cycle is not characteristic for each cycle and each hemisphere. Probably its formation reflects the appearance of a high frequency component of the background high-latitude magnetic field during the ending phase of the extended solar cycle.

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References

Benevolenskaya E.E., 1991, in: Tuominen I., Moss D., Rüdiger G. (eds.) Proc. IAU Coll. No. 130, The Sun and Cool Stars: activity, magnetism, dynamics. Springer, Berlin. p. 235
Dermendjiev V.N., Rušin V., Stavrev K.Y., 1993 (in preparation)
Kipenheuer K.O., 1953, in: Kuiper G.P. (ed.) The Sun. The University of Chicago Press, Chicago, p. 282
Makarov V.I., Fatianov M.P., Sivaraman K.R., 1983, Sol. Phys. 85, 215
Makarov V.I., Makarova V.V., Koutchmy S., 1985, Soln. Dannye. Byull. 8. 53
Makarov V.I., Makarova V.V., Koutchmy S., Sivaraman K.R., 1988, in: Altrock R.C. (ed.) Solar and Stellar Coronal Structure and Dynamics. NSO/Sacramento Peak Summer Workshop, p. 362
Martin S.F., 1990, in: Ruzdjak V., Tandberg-Hanssen E. (eds.) Proc. IAU Coll. No. 117, Dynamics of Quiescent Prominences. Springer, Berlin, p. 6
Ribes E., 1986, C.R. Acad. Sci. Ser. II, Paris, 302, 871
Rušin V., Rybansky M., Dermendjiev V., Stavrev K.Y., 1988, Contrib. Astron. Obs., Skalnate Pleso 17, 63
Waldmeier M., 1960, Z. Astrophys. 49, 176
Waldmeier M., 1973, Sol. Phys. 28, 389