HEMISPHERICAL ASYMMETRIES IN SUNSPOT AREAS AND AURORAL FREQUENCIES

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(Received 18 February, 1991; in revised form 28 May, 1991)

Abstract. One thousand and fifty-two aurorae boreales and 554 aurorae australes recorded during the nineteenth century at medium latitudes \( \leq 55^\circ \text{N} \) or \( \leq 55^\circ \text{S} \) are compared statistically with the known hemispherical asymmetry of the sums of the areas of sunspots. According to the present study, the solar hemispherical asymmetry may be accompanied by an analogous pattern of the hemispherical frequency of auroral days. For the number of auroral days in each hemisphere beyond the two auroral ovals, a remarkable degree of phase equality with the sunspot areas during the second Gleissberg cycle can be demonstrated.

1. Introduction

A parallelism between the frequency of northern lights and of sunspots was discovered as long ago as 1862 by Fritz (1878). The sunspot frequency fluctuates with the Wolf period of about eleven years (Wolf, 1852), with the amplitudes of the maxima varying with the Gleissberg (1944) cycle of about eighty years. The nineteenth century encompasses the Wolf cycles 5 to 13, and the Gleissberg cycle II (Figure 1). With the world catalogue of Křivský and Pejml (1988) for the aurora borealis, and Boller's (1898) list for the aurora australis, auroral statistics today have a statistical population of nineteenth-century solar-terrestrial events comparable to the sunspot statistics (Waldmeier, 1961).

The Royal Greenwich Observatory (1889) published the total sunspot areas since the beginning of its \textit{Photoheliographic Results} in 1874, as the mean areas and heliographic latitudes of sunspots, separately for the Sun's northern and southern hemispheres. In these data, Brunner-Hagger and Liepert (1941) discovered a rhythm of northern or southern preponderances in the sums of the sunspot areas. Sunspot cycles with a southern excess were demonstrated for the period from 1856 to 1907, and ones with a northern excess from 1907 to 1932. Total areas with reciprocal variations of amplitude on the two sides of the solar equator might control the expansion of Bartels' \( M \) regions (Bartels, 1932) cyclically. This would mean that the number of coronal holes feeding the solar wind would be subject to long-period fluctuations. As a result, there might also be a noticeable differentiation by hemisphere of secular auroral frequency on the Earth. Therefore, this paper examines whether the phases of the eighty-year cycle of hemispheric sunspot area totals are reflected in the hemispheric auroral frequency at medium latitudes.

2. Frequency of Aurorae Boreales and Australes

To derive the annual frequency of auroral days during the nineteenth century in Figure 1(b), for the northern hemisphere up to 55\(^\circ\) N, a total of 1152 auroral days were


taken from the catalogue of sightings compiled by Krivsky and Pejml (1988), and for the southern hemisphere, down to 55° S, a total of 554 auroral days from the listing by Boller (1898). Due to uncertain dating, 46 northern lights (3.8%) were disregarded, and 55 southern lights (9.0%) were not used, because sighted at southern latitudes greater than 55° S.

![Fig. 1. (a) Top half: data of the epochs of Gleissberg cycles I to III; bottom half: sunspot cycles from 1760 to 1960, with the annual mean of their relative number $R$. (b) Auroral cycles of the nineteenth century, and number of days when northern or southern lights were observed per year at medium latitudes, ≤ 55° N or ≤ 55° S.](image)

Sunspot cycles 5 to 13 in the usual Zürich numbering cover the entire nineteenth century to a close approximation. Their cyclic frequency curve shows a pronounced shift in the hemispherical predominance, from northern to southern lights, in the latter half of the century. In the first half of the century, during cycles 5 to 9, 628 (93.6%) days with aurorae boreales, and only 43 (6.4%) with aurorae australes were counted. In the second half, by contrast, during cycles 10 to 13, 524 (50.6%) days with aurorae boreales, and 511 (49.4%) with aurorae australes were counted. Thus the percentage in the northern hemisphere was reduced by a factor of 2 from the former to the latter half, while the percentage in the southern hemisphere increased about eightfold.

Cycles 12 and 13 deviate markedly from the expected north/south distribution by their southern surplus. A plausible explanation cannot be found in a deficiency of observational activity in southern latitudes. From 1857 on, regular land-based observation of aurorae australes was initiated by G. von Neumayer (Boller, 1898), with the foundation of geophysical stations in Australia and New Zealand. So organizational differences in the registration of northern and southern lights cannot be advanced as