Some Remarks on the Climatology of Blocking Action

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Abstract

Based on the revised Catalogue of European Large-Scale Weather Patterns (1881—1950) the annual course and the secular variations of the frequency of blocking highs in Europe are treated. Regions of blocking action and those of frequent cold-air centers mutually exclude one another, both corresponding to the orographically influenced asymmetry of the polar vortex.

In his recent paper on the effect of blocking action upon regional climate D. F. REX (1950) gives a significant contribution to the problem of dynamic climatology. The following remarks will furnish some supplements based on the Catalogue of European Large-Scale Weather Patterns ("Grosswetterlage") as developed by BAUR (1947) and later revised and extended by HESS and BREZOWSKY (1951). The term "Grosswetterlage" is understood as defining a tropospheric pressure and/or current pattern lasting unchanged in its essential features for a minimum of 3 days, especially in the location of steering centers and frontal zones.

While the mean duration of Atlantic blocking situations as used by REX, a summarization of several large-scale weather patterns in our sense, is 16.6 days, our large-scale weather patterns contain also blocking situations continuing for at least 3 days. The duration of each large-scale weather pattern averages 4.1 days. Thus, the number of cases increases substantially although some non-typical situations, such as quasistationary anticyclonic wedges instead of isolated high centers, are included. With our statistics extending over the 70-year period 1881—1950, we can study in a more comprehensive manner the annual course and the secular variations of the frequency of Atlantic blocking highs.

We group the large-scale weather patterns of our Catalogue as follows, determining the anticyclonic centers from surface charts:

1) *Anticyclonic axis over Northeastern Atlantic* (20° W—10° E): *A*

High Norwegian Sea	HN
High Norwegian Sea and Fennoscandia	HNF
High British Isles	HB
Northerly type	N

2) *Anticyclonic axis over Northern Europe* (10°—50° E): *E*

High Fennoscandia	HF
Northeasterly type	NE
Southeasterly type	SE
Southerly type	S

It is assumed that the mechanism of the blocking action, according to SEILKOPF (1949) and BREZOWSKY (1951), consists of a combined

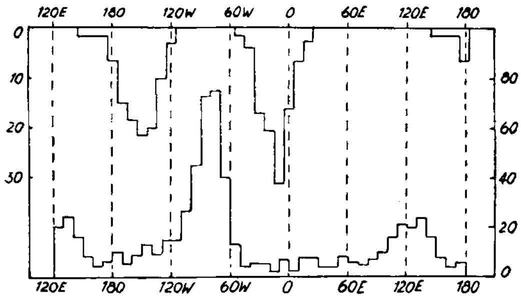

Fig. 1. Upper line; Frequency of blocking highs (according to REX, 1950). Lower line; Frequency of intense cold-air centers, $\Delta t \geqq 8°$ C (according to FLOHN 1950 a).

effect, first of the ageostrophic components of a cyclogenesis on the western side of anticyclogenesis and secondly of the convergence between the warm-air current accompanying the cyclogenesis and the polar outbreak already in progress on the eastern side of anticyclogenesis. In typical cases the warm-air current is caused by a polar outbreak in the rear of the cyclogenesis, reaching so far south as to break through the subtropical high zone and to tap the subtropical warm air source.

The restriction of the onset of blocking action to relatively small sectors of the northern hemisphere (REX 1950) corresponds to a similar restriction of intense tropospheric cold air centers on the intermediate sectors. By drawing a chart of all cold-air centers of 1949 and 1950 (FLOHN 1950 a), which in the average for the layer between 500 and 1,000 mb are at least 8° C colder than their surroundings, we can show their distribution by longitude in comparison with the distribution of blocking highs (see fig. 1). Regions of formation of warm, blocking anticyclones and of the occurrence of intense cold-air centers mutually exclude one another very nearly. If the investigation is restricted to the cold-air centers in latitudes 60° N or more, the mutual exclusion becomes even more distinct. This peculiar regional restriction corresponds closely to the asymmetry of the tropospheric polar vortex of the northern hemisphere. The regions of large upper troughs over eastern America and eastern Asia will encourage the formation of cold-air masses, while the regions of anticyclonic wedges near the western coasts of Europe and America are favoured by blocking highs. In our opinion (FLOHN 1950 b) these climatological facts can be explained by theoretical investigations (CHARNEY and ELIASSEN 1949, BOLIN 1950) of the influence of high mountain chains upon the direction of the tropospheric westerlies, especially of the jet stream (planetary frontal zone).

The annual course of blocking action has been derived already by REX (1950), with maxima in spring (April and May) and minima in late summer (August and September), in both the Atlantic and Pacific cases. Our catalogue permits a classification into two groups,

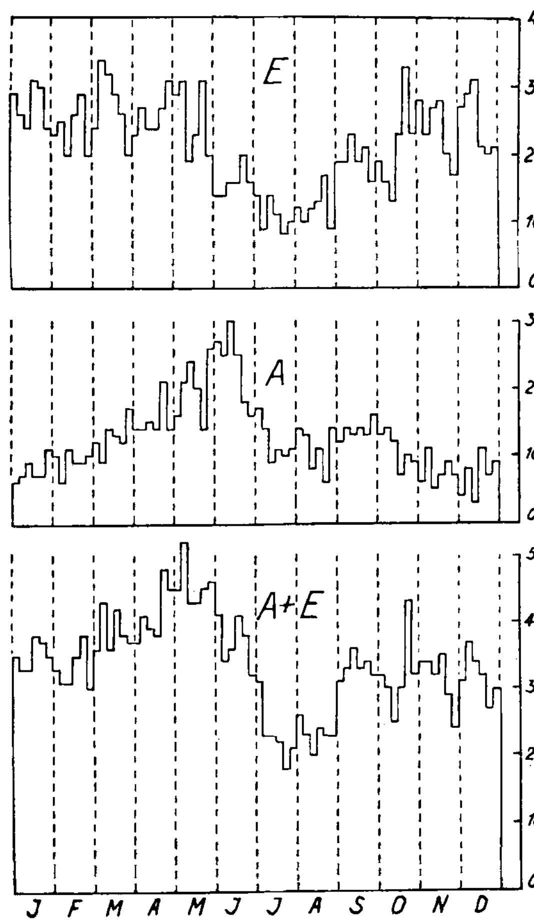

Fig. 2. Annual course of the frequency of blocking highs over northern Europe (E) and northeastern Atlantic (A), according to HESS and BREZOWSKY (1951), in percent (1881—1950).

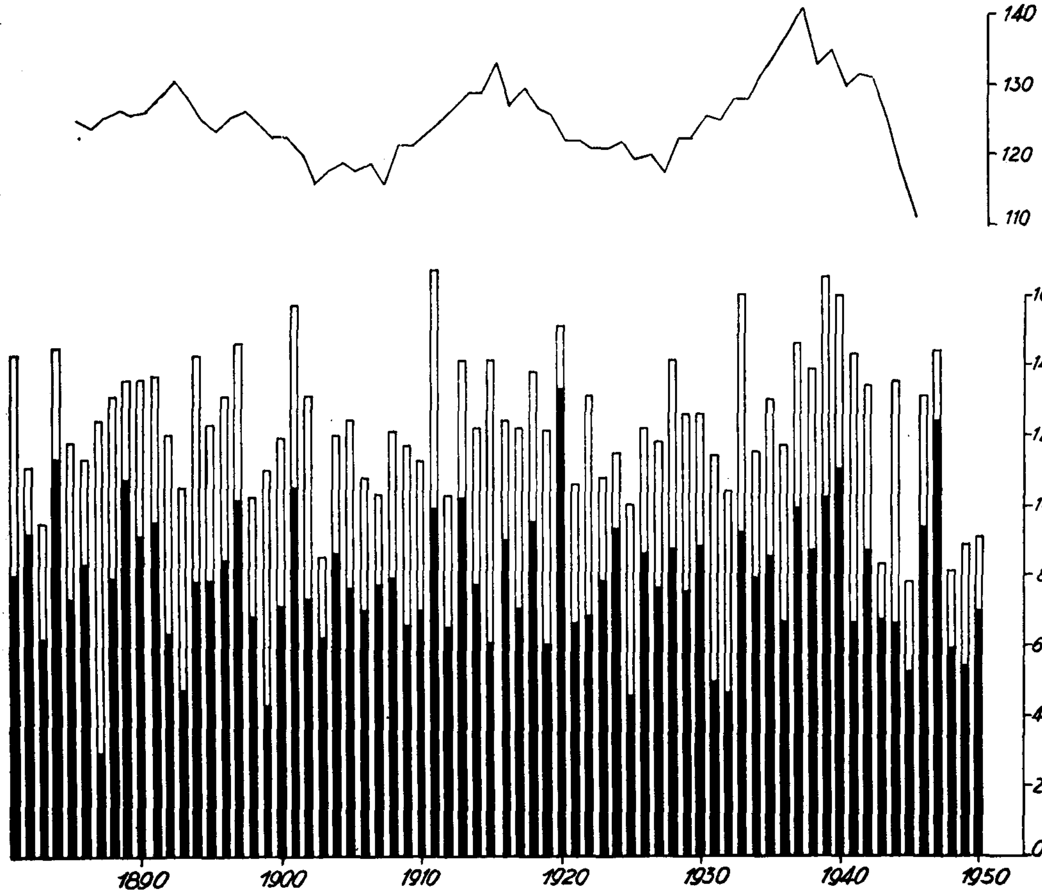

Fig. 3. Annual frequency of blocking highs (E-group black columns, A-group open columns) and overlapping 10-year means (upper line, A + E) in days (1881—1950).

A and E, and thereby an investigation of the influence of land and sea, and also the division of months into six pentades respectively, with the last pentade in February including 3, otherwise 5—6 days.

Fig. 2 shows that the E-group is most frequent from October to May, with weak maxima in the first half of March and in the second half of October, but is rather rare in summer. The anticyclones of the A-group, with centers at sea, are concentrated in the period, middle of April to middle of June, and rarely occur in summer and winter. The sum of both groups (A + E) confirms the annual course as estimated by Rex from the most typical cases during 13 years, with a frequency peak in the beginning of May (52 per cent of all days) and a clearly established minimum during July and August (only 18—26 per cent). A secondary peak is evident in fall, especially from October 21 to 25, and some minor minima from October to December.

The frequency distribution of high, zonal index situations (westerly types) shows a reverse two-fold annual course, with maxima in high summer and early winter, and minima in spring and (only weak) in fall. Obviously this two-fold annual course corresponds to the six-month pressure oscillation, a statistically verified climatological fact studied by Wahl (1941) and others. It has some amplitude maxima in sub-arctic latitudes which are difficult to explain. The remarkable difference between the annual courses of our groups A and E requires a physical explanation. The spring anticyclones over the Norwegian Sea obviously are associated with the warm polar anticyclones which are most frequent from March to May, partly extending to early June, and also with the low index circulation associated with them.

The frequency of Atlantic blocking highs varies somewhat from year to year (see fig. 3). In the years 1911 (46 %) and 1939 they were most frequent, in 1945 (21 %) most rare. Confining our attention to each single group the relative frequency of A-anticyclones (over sea) varies between 4 % (1943) and 26 % (1887); that of E-anticyclones (over the continent) between 8 % (1887) and 36 % (1920). The high frequency of blocking highs in the three years 1939—41 (A + E 43 per cent in the average) is most remarkable, just as is the striking decrease during the last three years (1948—50, in the average 24 per cent), during which period zonal index situations were predominant. The repeated revision during the last ten years of the aforementioned Catalogue will serve as a guarantee of the reliability of these data.

If one arranges the annual frequencies of blocking highs in accordance with the sun-spot maxima or minima, we obtain at best a small peak coinciding with the sun-spot minima (such as in 1889, 1901, 1913, 1933 and 1944), which cannot be verified statistically. Any influence of solar activity is weak and uncertain, as is also confirmed by WEXLER (1950) in his investigation of hemispheric pressure charts 1899—1939.

Overlapping 10-year averages (see fig. 3, upper part) show no secular trend, but a remarkable periodicity with maxima in 1892, 1915 and 1937, and minima about 1902 (or 1907), 1927 and in the last years, apparently pointing to a 22—23 year oscillation. Whether we are dealing with an effect of the solar activity period, the length of which is really about 23 years due to the alternating magnetic polarization of sun-spots (HALE), can only be disclosed through further investigations. The maxima of the above mentioned 22—23 year oscillation are situated close to the sun-spot maxima of 1893, 1917 and 1937.

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