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Classification of European 500 mb patterns

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Zusammenfassung :

In der vorliegenden Arbeit wird die Mannigfaltigkeit europäischer 500 mb- Felder der Periode 1961 - 70 untersucht. Die täglichen Strömungsfelder werden miteinander verglichen und aufgrund der Häufigkeit ähnlichen Auftretens geordnet. Hernach wird ein Satz von 24 Basiskarten berechnet, mit dessen Hilfe die Strömungsfelder klassifiziert werden.

Résumé :

On étudie ici la diversité des images présentées par la surface de 500 mb au cours des années 1961 à 1970. On compare entre eux les champs journaliers de courants et on les classe selon la fréquence de présentations similaires. D'après cela, on a calculé 24 cartes de base selon lesquelles les champs de courant en altitude sont différenciés.

Riassunto :

Viene studiata la diversità delle configurazioni presentate in Europa della superficie di 500 mb nel periodo dal 1961 al 1970. Sono confrontati fra loro i campi giornalieri delle correnti, i quali vengono classificati secondo la frequenza delle situazioni simili. Dopo di ciò viene calcolata una serie di 24 carte di base, con l'aiuto delle quali sono classificati i diversi campi delle correnti in altitudine.

Classification of European 500 mb patterns

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Summary

The variation of European 500 mb patterns is investigated for the period 1961 - 70. The daily patterns are compared with each other and then ranked by their frequency of similar occurrence. A set of 24 basic patterns is derived and daily patterns are classified by comparing them with these basic patterns.

1. Introduction

The classification of analogous weather situations plays an important part in synoptic climatology. This work is an attempt to classify daily 500 mb geopotential fields over Europe. Similar patterns are selected and represented by a basic pattern.

The height of the 500 mb surface shows a considerable annual variation. Instead of subdividing the observational material into groups corresponding to seasons - a procedure which would have unduly reduced the number of available cases - the raw data are normalized first.

The 00 GMT 500 mb contour patterns are taken from the period 1961 - 70. Each pattern is represented by a 36 - point grid. The network covers the area from 35° N to 60° N at 5° and from 20° W to 30° E at 10° intervals. The grid point values have been extracted from the data bank of the Synoptic Climatology Branch and processed on the IBM 360/195 computer of the Meteorological Office, Bracknell.

2. Method and computation

(a) Normalization of data

The objective is to obtain a classification which is more or less seasonally independent. Therefore the general shape of each pattern is worked out first by normalizing its grid point values as follows :

$$z_i = (x_i - \bar{x}) / s$$

where z_i = normalized value of the i^{th} grid point
 x_i = original value of the i^{th} grid point
 \bar{x} = mean of the 36-point grid
 s = standard deviation of the 36-point grid

Example : 500 mb pattern of 1 January 1961.

Original 36 grid point values x_i in gdm :

522	519	523	531	538	544
531	526	529	534	540	538
550	538	535	543	545	544
565	546	546	552	551	551
571	552	559	563	553	550
573	561	569	572	551	551

Mean \bar{x} = 546.3, standard deviation s = 14.3

Normalized 36 grid point values z_i :

-1.7	-1.9	-1.6	-1.1	-0.6	-0.2
-1.1	-1.4	-1.2	-0.9	-0.4	-0.6
0.3	-0.6	-0.8	-0.2	-0.1	-0.2
1.3	0.0	0.0	0.4	0.3	0.3
1.7	0.4	0.9	1.2	0.5	0.3
1.9	1.0	1.6	1.8	0.3	0.3

Mean $\bar{x} = 0$, standard deviation $s = 1$

(b) Comparison of daily patterns

After normalizing the daily patterns, the intention is to find out how often patterns occur with a more or less similar shape.

The resemblance of two grid patterns can be estimated by computing the sum of squares of their grid point value differences, but it is important to know in which regions the contours differ most. Each pattern is therefore subdivided into 12 zones, six latitudinal and six longitudinal, each zone containing six grid points. So, in addition to the overall sum of squares, the sum of squares is calculated for each zone separately.

Each pattern (except those in the years 1963, 1964, 1967 and 1968, so as to reduce the computer time), starting from 1 January 1961, is compared with each of the remaining 3651 patterns from the period 1961 - 70. The individual sums of squares of the 12 zones are compared with the empirically determined threshold of 2.0 (that is two times the standard deviation of the normalized patterns). Two patterns are recognized as similar if none of these sums of squares exceed this chosen threshold.

When these comparisons are completed, a frequency table of the occurrence of similar daily patterns can be formed. These frequencies range from a maximum of 268, for the pattern of 30 July 1965, to a minimum of 0.

Example : The first two patterns are compared.
The grid point values of these normalized patterns are :

Z_1 : 1 January 1961

	20°W	10°W	0°	10°E	20°E	30°E
60°N	-1.7	-1.9	-1.6	-1.1	-0.6	-0.2
55°N	-1.1	-1.4	-1.2	-0.9	-0.4	-0.6
50°N	0.3	-0.6	-0.8	-0.2	-0.1	-0.2
45°N	1.3	0.0	0.0	0.4	0.3	0.3
40°N	1.7	0.4	0.9	1.2	0.5	0.3
35°N	1.9	1.0	1.6	1.8	0.3	0.3

Z_2 : 2 January 1961

	20°W	10°W	0°	10°E	20°E	30°E
60°N	-1.9	-1.7	-1.4	-1.1	-0.9	-0.6
55°N	-1.7	-1.4	-1.1	-0.8	-0.7	-0.2
50°N	-0.2	-0.5	-0.5	-0.4	0.0	0.1
45°N	1.0	0.8	0.1	0.1	0.6	0.4
40°N	1.6	1.2	0.4	0.6	0.9	0.6
35°N	2.0	1.4	0.4	0.9	1.3	0.8

The overall sum of squares of differences, $\sum_{j=1}^{36} (z_{1j} - z_{2j})^2$, is 7.4.

The sums of squares of differences of the individual zones,

$$\sum_{j=1}^6 (z_{1j} - z_{2j})^2, \text{ from W to E and from N to S respectively take}$$

the following values :

	60°N	55°N	50°N	45°N	40°N	35°N
From W to E	0.5	0.6	0.5	0.9	1.6	3.4
	20°W	10°W	0°	10°E	20°E	30°E
From N to S	0.8	1.4	1.8	1.3	1.3	0.7

Conclusion : These two patterns are not recognized as similar because from W to E at the latitude of 35°N the sum of squares of differences exceeds the threshold of 2.0.

(c) Computation of basic patterns

The frequency table of similarity plays an essential part in the attempt to reduce the variety of daily patterns to a small number of characteristic patterns, called basic patterns. These basic patterns are used to form classes which contain a reasonable number of similar daily patterns. The daily patterns are classified by comparing them with the basic patterns.

The computation of a basic pattern is based on a small number of daily patterns which show a high degree of similarity. The patterns with the largest frequencies of similar days are compared with each other. Within the limitation of the available computer working space a comparison of 100 patterns can be computed simultaneously. The sum of squares of the grid point value differences between each pair of patterns is calculated. A mean pattern is then formed of those two patterns which have the smallest sum of squares. The pattern with the next largest frequency of similar days is then extracted from the frequency table

to maintain the total of one hundred. The process of finding the two most similar patterns from this altered set is then repeated.

Although during each repetition mean patterns are treated as daily patterns, weighted means are used when new mean patterns are formed. The weights are the number of days involved.

A mean pattern is defined as a basic pattern when the number of days used to compute the mean reaches the empirically determined level of 5. The patterns forming such a basic pattern, together with those similar to them, are then replaced by the patterns with the next largest frequencies of similar days. After these replacements another basic pattern can be derived by repeating the described process with this altered set of patterns.

By using this procedure it is possible to extract 24 basic patterns, each forming a class containing a reasonable number of similar, time independent daily patterns.

Example : The daily patterns forming the first basic pattern are :

Date	Number of similar patterns
9. 01. 61	187
1. 02. 61	168
30. 07. 65	268
2. 11. 65	208
6. 12. 65	194
2. 01. 66	235

These patterns have been selected in the following sequences :

Date	$\sum \Delta^2$
(1) 30. 07. 65 ; 2. 11. 65	1. 08
(2) 9. 01. 61 ; 1. 02. 61	1. 20
(3) (9. 01. 61 ; 1. 02. 61) ; 2. 01. 66	1. 26
(4) (30. 07. 65 ; 2. 11. 65) ; 6. 12. 65	1. 37
(5) (30. 07. 65 ; 2. 11. 65 ; 6. 12. 65) ; (9. 01. 61 ; 1. 02. 61 ; 2. 01. 66)	1. 32

The rounded off values of this first basic pattern are :

- 1.05	- 1.30	- 1.55	- 1.55	- 1.30	- 1.15
- 0.80	- 1.10	- 1.35	- 1.30	- 0.90	- 0.65
- 0.20	- 0.40	- 0.50	- 0.35	- 0.25	- 0.15
0.65	0.70	0.50	0.45	0.40	0.25
1.30	1.35	1.15	1.00	0.60	0.55
1.60	1.55	1.50	1.25	0.70	0.60

With a sum of squares of differences of 0.7, the pattern of 1 February 1961 shows the best resemblance to this first basic pattern.

The largest sums of squares of differences between the daily or the grouped daily patterns used to form a basic pattern range from 1.37 (basic pattern No. 1) to 4.38 (basic pattern No. 23). But the sums of squares of differences between any pair of basic patterns range from a minimum of 5.39 (basic patterns No. 7 and No. 23) to a maximum of 92.10 (basic patterns No. 16 and No. 24).

3. Results

After these basic patterns have been calculated, the daily patterns can be classified. So each daily pattern of the period 1961 - 70 is compared with this set of basic patterns by computing the sums of squares of differences. These sums of squares are then ranked and the pattern is put into that class which has the smallest value.

The basic patterns are numbered in the sequence of their original computation because the frequency of occurrence does bear some relationship to it. They are shown in Figures 1 to 6. The dates of 20 classified patterns together with the sums of squares of differences ($\sum \Delta^2$) between these normalized daily patterns and their basic patterns are presented in Tables 1 to 6. In order to obtain samples of more or less independent days, only those daily patterns are chosen which have a time difference of at least ± 5 days.

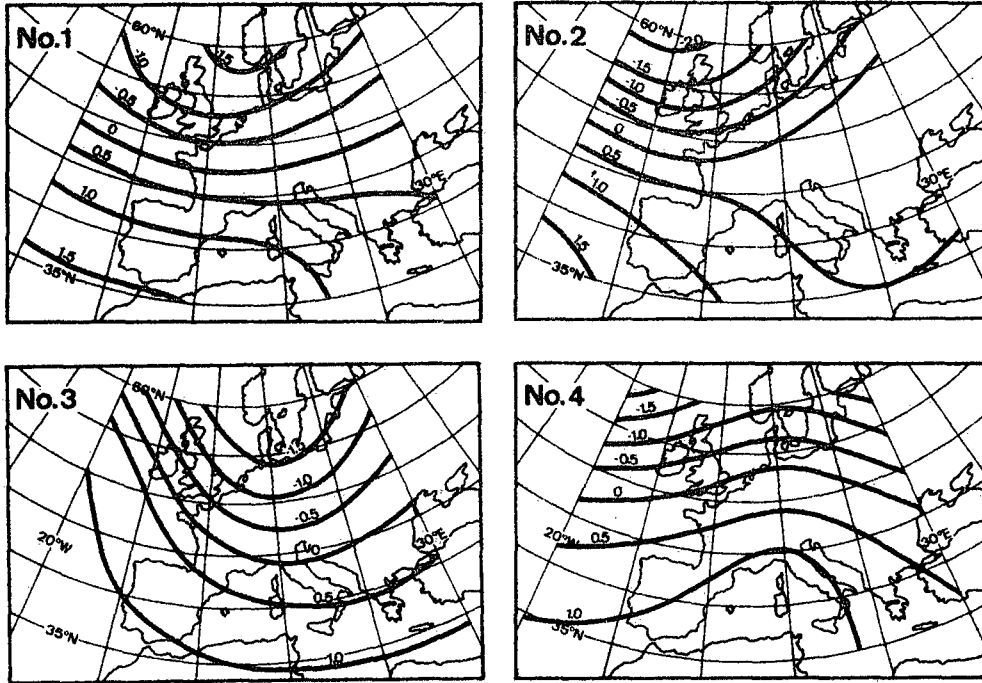


Figure 1. Basic patterns No. 1 to No. 4

Table 1. Classified daily patterns from the period 1961 - 70 with the highest ranking similarity to their basic patterns

No. 1 to No. 4.

No. 1		No. 2		No. 3		No. 4	
Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$
9. 01. 61	1.0	29. 01. 61	1.1	29. 07. 61	1.9	29. 06. 61	2.9
1. 02. 61	0.7	7. 05. 61	2.7	15. 08. 61	0.7	26. 08. 61	3.0
8. 05. 61	1.9	10. 01. 62	0.8	4. 11. 61	2.5	21. 01. 62	2.2
14. 01. 62	2.4	23. 05. 62	2.1	27. 06. 62	3.0	13. 06. 62	3.3
23. 01. 62	2.2	20. 06. 62	2.5	2. 10. 63	3.0	2. 08. 62	1.0
2. 04. 62	2.3	18. 07. 63	2.8	7. 10. 63	2.3	10. 09. 62	2.9
18. 08. 62	2.0	25. 09. 63	1.9	21. 09. 64	2.7	15. 09. 62	1.2
20. 11. 63	2.3	14. 04. 64	2.1	27. 05. 65	3.2	21. 06. 63	2.7
1. 05. 64	1.8	12. 07. 64	2.8	29. 03. 66	0.7	26. 08. 63	2.6
28. 11. 64	1.5	7. 10. 64	2.4	7. 07. 66	2.6	20. 06. 65	1.0
18. 01. 65	1.8	31. 12. 64	2.4	16. 07. 66	0.8	1. 11. 65	2.9
25. 03. 65	2.0	17. 01. 65	0.7	18. 05. 68	2.8	18. 12. 65	2.8
30. 07. 65	0.8	21. 08. 65	0.7	9. 02. 69	3.0	6. 02. 66	2.8
2. 11. 65	0.8	30. 12. 66	2.7	13. 04. 69	2.3	11. 09. 66	1.3
27. 11. 65	1.6	20. 02. 67	2.8	22. 08. 69	2.1	20. 03. 68	2.5
6. 12. 65	0.8	28. 02. 67	2.0	22. 05. 70	2.9	14. 10. 68	2.6
2. 01. 66	0.8	20. 05. 67	2.1	3. 07. 70	2.8	22. 03. 70	2.8
1. 03. 67	2.2	7. 06. 68	2.1	15. 07. 70	2.1	13. 07. 70	2.2
24. 12. 67	2.2	21. 12. 68	2.6	3. 10. 70	2.8	3. 11. 70	1.9
23. 09. 68	1.8	1. 09. 70	2.6	20. 10. 70	2.1	12. 11. 70	2.5

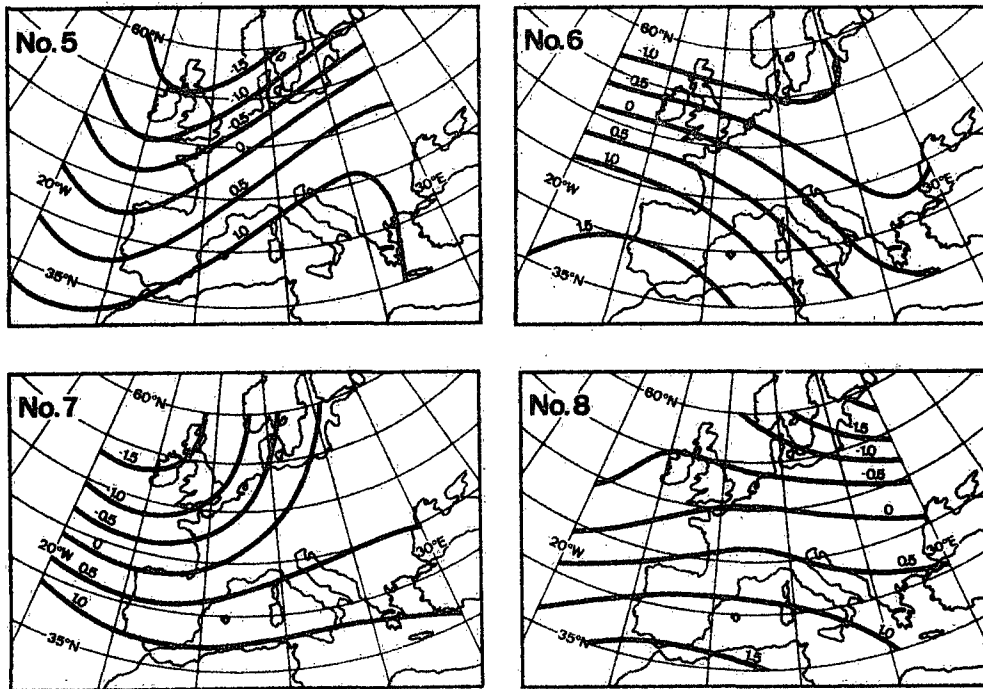


Figure 2. Basic patterns No. 5 to No. 8

Table 2. Classified daily patterns from the period 1961 - 70 with the highest ranking similarity to their basic patterns No. 5 to No. 8.

No. 5		No. 6		No. 7		No. 8	
Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$
10. 08. 61	0.5	8. 02. 61	3.5	25. 10. 61	4.0	9. 09. 62	4.1
26. 11. 61	2.4	10. 07. 61	2.2	9. 11. 61	1.0	14. 09. 62	3.5
5. 12. 61	3.0	28. 03. 62	3.6	5. 09. 62	4.1	9. 01. 63	3.6
18. 01. 62	3.0	8. 04. 62	3.9	28. 09. 62	3.2	13. 09. 64	4.8
22. 07. 62	3.6	22. 08. 62	3.5	18. 04. 63	2.7	23. 03. 65	3.0
7. 08. 62	3.2	2. 05. 64	4.1	25. 06. 63	3.8	16. 05. 65	3.4
24. 06. 63	3.7	27. 03. 65	3.9	22. 07. 65	3.8	7. 07. 65	5.1
27. 08. 63	2.8	9. 05. 65	4.0	21. 06. 66	2.4	4. 08. 65	3.6
16. 11. 63	2.9	30. 08. 65	3.3	2. 10. 66	1.1	9. 02. 66	0.4
17. 09. 64	3.7	13. 12. 65	1.3	19. 10. 66	3.9	27. 01. 67	4.8
7. 08. 65	1.3	27. 03. 66	3.0	18. 02. 67	3.2	16. 01. 68	4.9
6. 05. 66	3.6	27. 06. 66	2.9	10. 03. 67	2.5	21. 02. 68	4.2
23. 07. 67	2.4	12. 12. 66	3.2	25. 05. 67	3.1	13. 07. 68	3.8
17. 08. 67	3.1	31. 12. 66	4.1	4. 11. 67	3.6	13. 09. 68	4.4
21. 03. 68	2.6	6. 01. 68	3.0	22. 03. 68	3.5	8. 10. 68	3.3
16. 05. 69	1.3	15. 08. 68	3.0	20. 06. 68	2.1	18. 10. 68	4.7
13. 11. 69	1.1	23. 12. 68	3.5	1. 09. 68	3.1	12. 03. 69	1.4
22. 07. 70	2.8	3. 02. 70	3.4	16. 12. 68	4.0	6. 11. 69	4.8
15. 09. 70	0.9	24. 02. 70	0.7	14. 01. 69	3.2	5. 02. 70	3.7
13. 11. 70	2.0	26. 07. 70	4.1	19. 11. 70	0.8	12. 02. 70	4.6

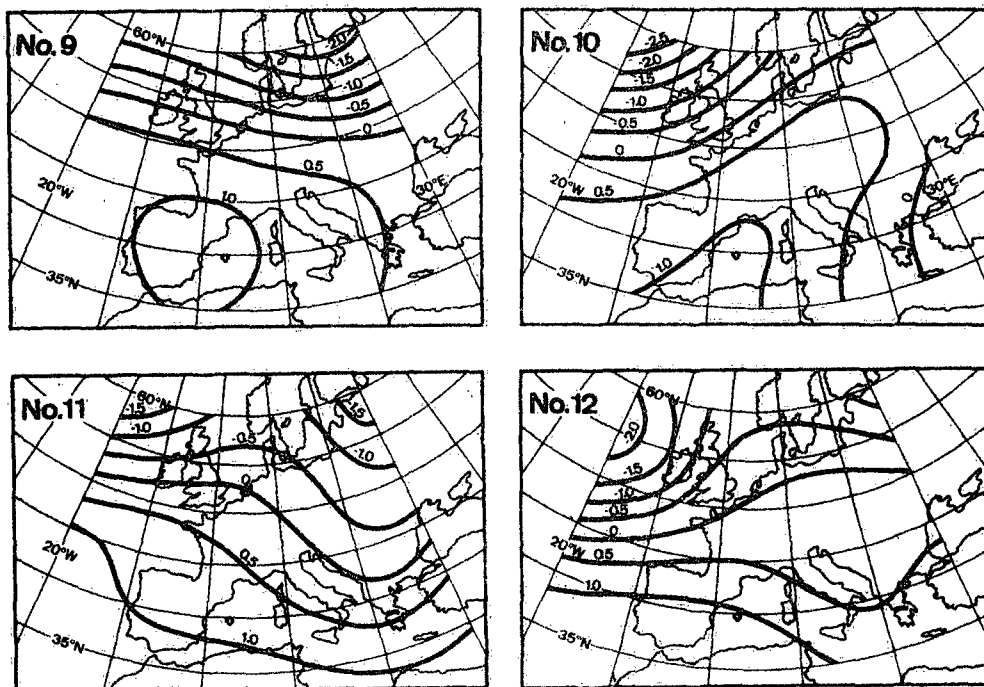


Figure 3. Basic patterns No. 9 to No. 12

Table 3. Classified daily patterns from the period 1961 - 70 with the highest ranking similarity to their basic patterns

No. 9 to No. 12.

No. 9		No. 10		No. 11		No. 12	
Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$
20. 06. 61	1.9	27. 02. 61	1.7	26. 07. 61	4.4	21. 04. 61	1.2
1. 11. 61	3.3	27. 09. 61	3.5	24. 08. 61	2.5	2. 05. 61	2.2
29. 08. 62	2.2	11. 10. 61	1.3	16. 05. 62	4.2	13. 09. 61	2.9
23. 11. 63	3.4	4. 10. 62	1.6	30. 07. 62	2.9	16. 01. 62	2.0
27. 12. 63	3.7	8. 05. 63	4.6	17. 06. 63	2.9	18. 06. 62	1.8
30. 07. 64	3.5	13. 05. 63	4.7	6. 08. 64	4.4	3. 09. 62	2.6
10. 09. 64	3.2	16. 07. 63	4.7	10. 01. 65	4.0	17. 04. 63	4.4
17. 11. 64	2.7	24. 07. 63	2.7	18. 08. 65	1.8	15. 07. 63	4.2
8. 09. 66	2.3	24. 09. 63	4.2	17. 12. 65	4.4	18. 11. 63	3.4
23. 03. 67	2.7	21. 10. 63	2.6	1. 07. 66	1.7	3. 05. 64	4.5
20. 04. 67	3.8	13. 05. 64	3.2	9. 07. 66	1.6	22. 05. 65	4.5
1. 02. 69	3.6	11. 06. 64	2.5	2. 02. 67	4.1	1. 01. 66	4.3
19. 07. 69	3.6	28. 08. 64	4.5	25. 08. 67	4.1	6. 04. 66	3.8
23. 09. 69	1.8	8. 12. 64	2.5	30. 01. 69	4.3	21. 01. 67	2.9
28. 09. 69	0.9	30. 01. 66	3.7	2. 07. 69	4.2	17. 07. 67	1.8
2. 11. 69	1.0	31. 07. 67	2.5	21. 09. 69	3.8	29. 09. 67	4.2
20. 11. 69	3.3	27. 11. 68	4.6	19. 02. 70	4.3	20. 09. 68	3.4
5. 09. 70	2.5	24. 07. 69	2.1	5. 10. 70	4.4	10. 10. 68	2.2
27. 10. 70	1.4	25. 09. 69	4.8	11. 11. 70	1.4	24. 04. 69	4.5
5. 11. 70	3.5	8. 10. 69	4.0	4. 12. 70	2.4	9. 09. 70	2.9

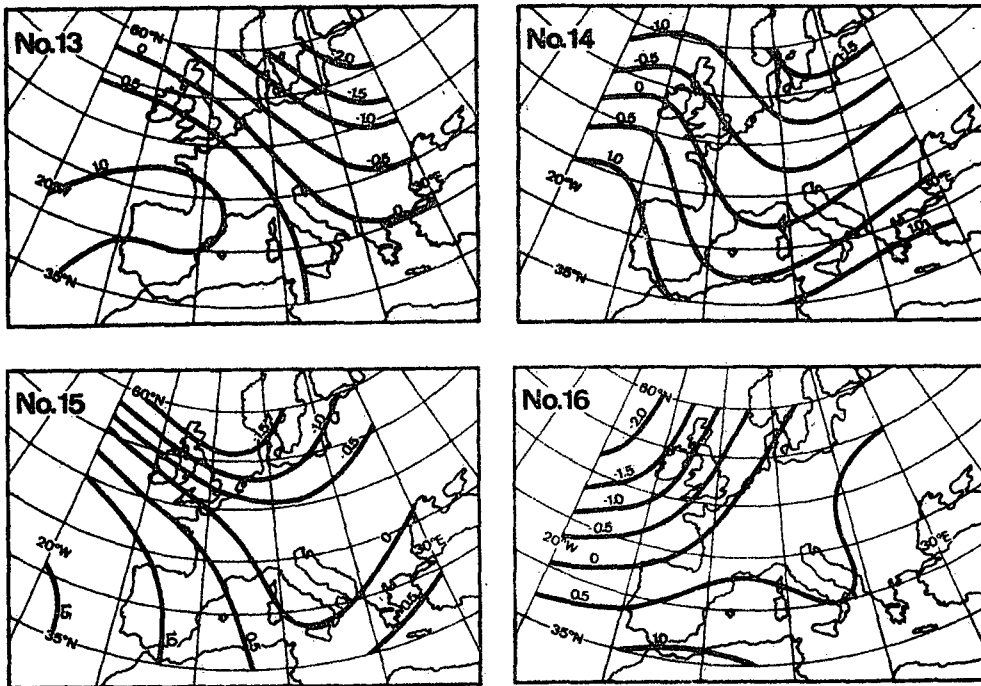


Figure 4. Basic patterns No. 13 to No. 16

Table 4. Classified daily patterns from the period 1961 - 70 with the highest ranking similarity to their basic patterns No. 13 to No. 16.

No. 13		No. 14		No. 15		No. 16	
Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$
13. 03. 61	3.6	24. 07. 61	4.1	9. 07. 61	2.9	28. 09. 61	4.0
29. 03. 61	1.1	20. 08. 61	1.6	3. 08. 61	3.8	6. 10. 61	5.2
27. 01. 62	2.1	1. 10. 63	3.1	10. 04. 62	2.5	24. 10. 61	5.5
17. 02. 62	3.3	21. 11. 63	3.3	18. 05. 63	3.6	21. 04. 62	4.8
31. 08. 62	3.1	7. 07. 64	3.8	6. 10. 63	3.1	1. 10. 62	1.1
29. 09. 63	3.1	10. 07. 65	3.3	31. 01. 64	2.5	22. 04. 63	4.2
15. 10. 63	3.2	13. 09. 65	2.4	8. 09. 64	3.5	25. 12. 63	4.4
5. 02. 64	4.3	24. 11. 65	3.0	23. 10. 64	3.8	25. 02. 64	5.2
3. 08. 64	4.1	9. 12. 65	2.8	13. 11. 64	4.0	6. 06. 64	3.1
18. 11. 64	2.3	29. 12. 65	1.3	16. 01. 65	2.7	14. 07. 64	4.1
5. 02. 67	2.7	1. 03. 66	2.6	26. 04. 65	1.9	15. 09. 64	5.6
3. 03. 67	4.3	26. 03. 66	2.8	11. 12. 65	3.8	24. 09. 65	1.3
24. 03. 67	1.8	8. 07. 66	2.2	28. 11. 66	1.4	27. 04. 66	4.6
19. 04. 67	4.4	24. 08. 66	4.1	9. 12. 66	2.2	7. 10. 66	2.8
6. 12. 67	1.6	1. 04. 67	3.5	24. 12. 66	3.7	17. 10. 66	4.6
18. 12. 67	2.6	18. 01. 68	3.4	29. 11. 67	3.5	8. 03. 67	2.6
3. 10. 69	4.6	18. 07. 68	3.5	18. 03. 70	4.0	12. 10. 67	4.8
31. 10. 69	1.0	2. 06. 69	1.3	21. 05. 70	2.4	24. 03. 68	4.7
6. 09. 70	3.5	10. 02. 70	3.3	11. 08. 70	2.2	11. 09. 69	1.2
6. 11. 70	3.0	2. 12. 70	3.9	2. 10. 70	3.8	14. 10. 69	1.9

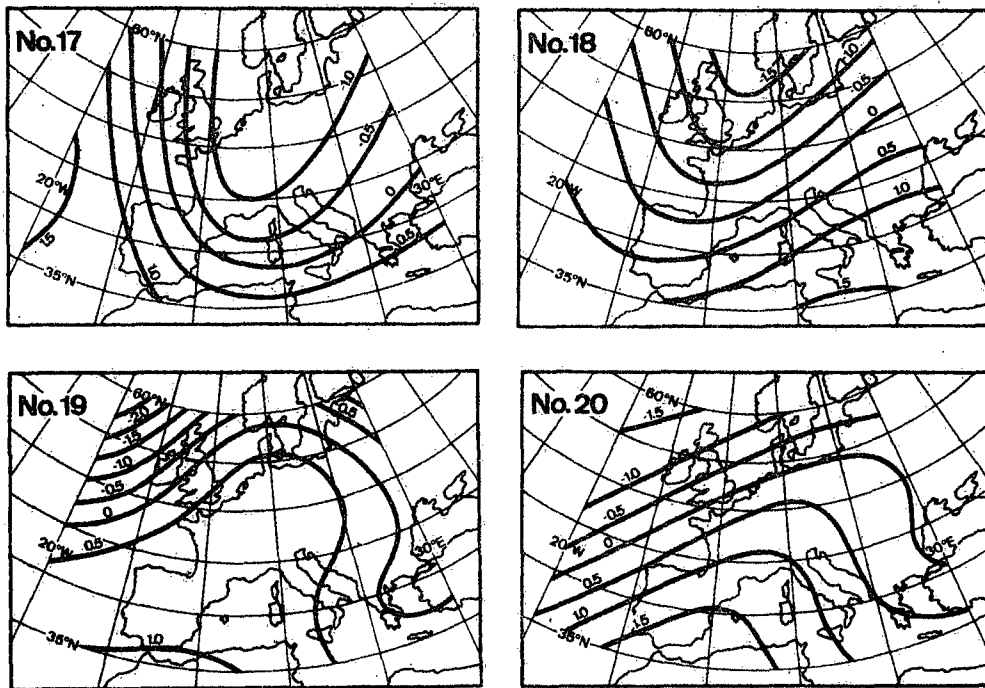


Figure 5. Basic patterns No. 17 to No. 20

Table 5. Classified daily patterns from the period 1961 - 70 with the highest ranking similarity to their basic patterns No. 17 to No. 20.

No. 17		No. 18		No. 19		No. 20	
Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$
14. 02. 62	3.0	12. 08. 61	2.8	10. 03. 61	5.3	4. 05. 61	2.1
14. 03. 62	4.6	7. 09. 61	4.1	1. 07. 61	0.6	8. 05. 62	3.6
12. 05. 62	1.7	5. 03. 62	3.5	30. 08. 61	4.0	17. 06. 62	5.2
5. 07. 62	4.0	8. 08. 62	4.1	8. 12. 62	1.9	20. 07. 62	4.3
22. 03. 63	4.3	13. 08. 63	2.3	6. 03. 63	5.2	14. 08. 62	4.5
24. 10. 64	4.8	2. 03. 65	3.9	22. 07. 63	4.9	11. 09. 62	4.1
2. 12. 64	2.5	19. 05. 65	2.3	20. 10. 63	3.1	7. 03. 63	5.0
3. 01. 65	3.0	8. 07. 65	2.8	29. 12. 63	5.4	15. 04. 64	3.9
28. 05. 65	1.4	26. 07. 65	1.5	12. 05. 64	4.7	7. 05. 64	3.9
17. 11. 66	1.6	21. 11. 65	2.7	19. 08. 65	5.3	12. 06. 64	4.5
9. 12. 67	2.4	30. 11. 65	3.6	16. 09. 65	4.5	17. 08. 64	4.1
26. 12. 67	1.6	7. 12. 65	3.4	3. 05. 66	4.1	13. 07. 65	4.8
2. 01. 68	4.2	28. 12. 65	4.2	5. 03. 67	5.5	25. 02. 66	1.9
29. 12. 68	2.6	23. 08. 66	4.1	12. 10. 68	5.1	12. 08. 66	0.7
4. 06. 69	4.4	5. 04. 68	3.2	26. 11. 68	4.9	23. 06. 67	2.9
5. 12. 69	1.0	2. 02. 69	4.3	4. 12. 68	3.9	21. 07. 67	3.6
16. 02. 70	2.2	31. 05. 69	2.1	16. 07. 69	2.1	20. 10. 67	3.4
3. 03. 70	4.3	17. 11. 69	2.2	23. 07. 69	1.7	26. 04. 69	4.5
16. 07. 70	4.6	5. 01. 70	2.0	7. 10. 69	4.1	11. 05. 69	3.8
21. 10. 70	2.4	1. 04. 70	2.5	21. 06. 70	5.5	26. 06. 70	5.3

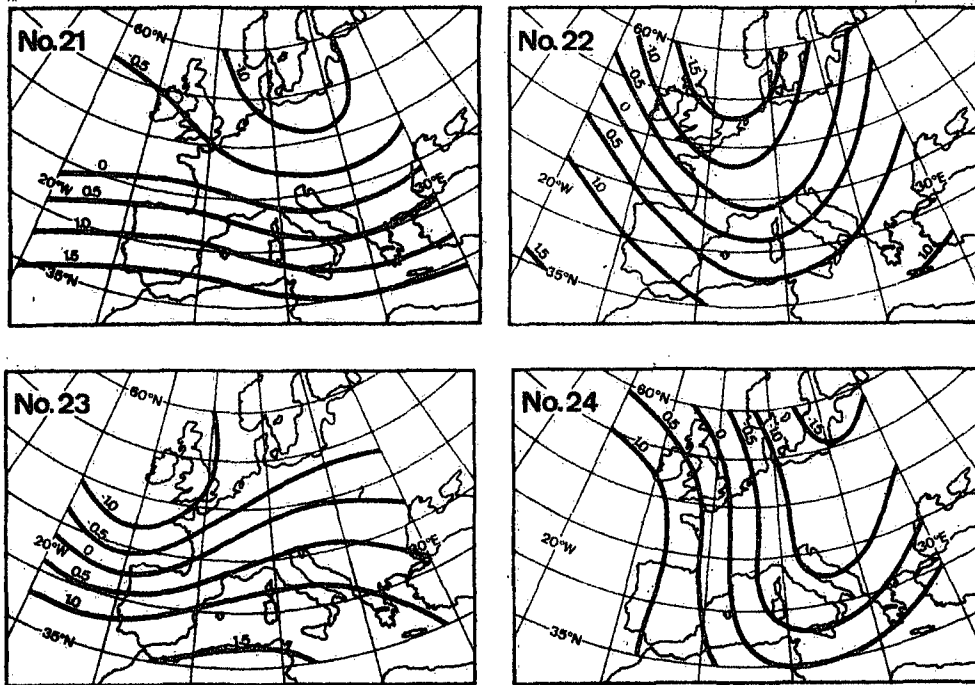


Figure 6. Basic patterns No. 21 to No. 24

Table 6. Classified daily patterns from the period 1961 - 70 with the highest ranking similarity to their basic patterns No. 21 to No. 24.

No. 21		No. 22		No. 23		No. 24	
Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$	Date	$\sum \Delta^2$
20. 07. 61	1.7	6. 01. 61	2.5	12. 07. 61	2.5	11. 05. 61	5.0
3. 03. 62	4.2	5. 04. 62	2.5	31. 03. 62	2.9	15. 02. 62	1.5
4. 05. 62	7.2	21. 05. 62	3.8	10. 05. 62	2.8	17. 12. 62	7.1
7. 07. 62	5.3	17. 09. 62	3.2	10. 03. 63	2.2	23. 03. 63	5.2
14. 07. 62	2.6	9. 08. 63	1.9	29. 03. 63	4.1	5. 12. 64	4.1
5. 01. 63	5.7	21. 08. 63	3.4	12. 11. 63	2.1	15. 02. 65	1.7
19. 02. 63	3.1	29. 08. 63	2.5	25. 11. 63	3.4	14. 03. 66	0.9
13. 03. 63	3.5	6. 09. 63	2.4	20. 03. 64	3.7	22. 12. 66	2.4
24. 04. 64	5.3	5. 10. 63	3.3	18. 08. 64	2.4	6. 01. 67	4.4
15. 08. 64	6.4	16. 10. 64	2.6	23. 07. 65	2.3	12. 01. 67	4.1
6. 07. 65	4.7	28. 11. 65	2.7	9. 09. 65	3.4	20. 03. 67	5.2
15. 11. 65	1.7	30. 07. 66	3.8	19. 04. 66	3.2	27. 12. 67	6.3
20. 11. 65	3.5	3. 12. 66	1.4	4. 08. 66	2.7	11. 01. 68	2.4
29. 11. 65	3.6	30. 03. 67	3.7	9. 08. 66	4.0	26. 01. 68	2.8
26. 12. 65	2.3	5. 10. 67	2.4	11. 08. 67	2.8	12. 03. 68	5.2
18. 01. 66	5.4	30. 10. 67	3.1	14. 07. 68	3.7	11. 02. 69	5.8
23. 01. 66	3.4	8. 07. 69	2.3	17. 08. 68	3.7	8. 12. 69	5.1
25. 08. 66	6.6	7. 03. 70	2.5	15. 08. 69	2.4	16. 03. 70	7.3
2. 05. 68	5.6	27. 04. 70	3.3	24. 07. 70	3.7	17. 07. 70	7.2
19. 05. 68	7.2	15. 11. 70	3.2	19. 08. 70	2.0	23. 12. 70	6.9

The resemblance between a basic pattern and its daily patterns is estimated by computing the sum of squares of their grid point value differences. The class formed by the final basic pattern, No. 24, has the largest range of sums of squares. In order to provide an example of the range of daily patterns within a group, the best and the worst patterns are chosen from this final class. The pattern with the smallest sum of squares, 14 March 1966 ($\sum \Delta^2 = 0.9$), is presented in Figure 7 as the pattern showing the best resemblance to its basic pattern, whereas Figure 8 presents the pattern of 16 March 1970, which has the largest sum of squares ($\sum \Delta^2 = 7.3$).

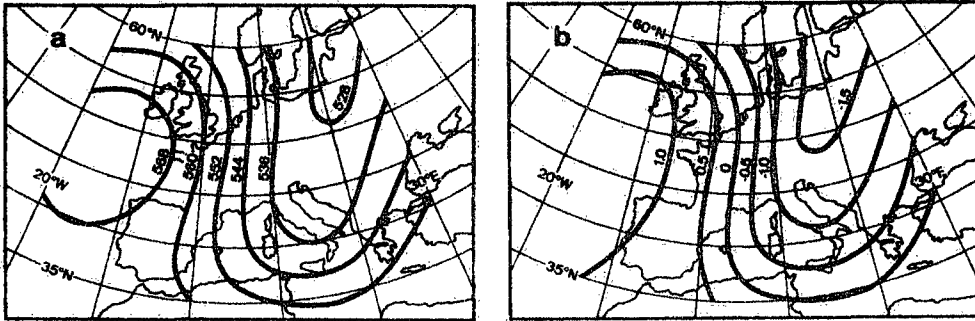


Figure 7. 500 mb pattern of 14 March 1966, classified in No. 24, $\sum \Delta^2 = 0.9$.

- (a) Contours in geopotential decameters at intervals of 8gdm ($\bar{x} = 551.1$; $s = 14.2$).
- (b) Pattern in normalized form ($\bar{x} = 0$; $s = 1$).



Figure 8. 500 mb pattern of 16 March 1970, classified in No. 24, $\sum \Delta^2 = 7.3$.

- (c) Contours in geopotential decameters at intervals of 8 gdm ($\bar{x} = 554.4$; $s = 13.2$).
- (d) Pattern in normalized form ($\bar{x} = 0$; $s = 1$).

Sometimes it is difficult to decide whether a daily pattern can be recognized as similar to a basic pattern. Assuming that the upper limit of the overall sums of squares of differences should not exceed the threshold of 12, it is then possible to classify 2681 patterns out of the total of 3652.

The seasonal distribution of the classified patterns is shown in Tables 7 and 8, where the months are grouped as follows :

Spring : March, April, May
 Summer : June, July, August
 Autumn : September, October, November
 Winter : December, January, February

Table 7. Frequency of the classified daily patterns for the period 1961 - 70. The percentage values are out of the total of 2681 days ($\sum \Delta^2 < 12$).

Basic pattern No.	Number of days		Spring	Summer	Autumn	Winter
	n	%	n	n	n	n
1	184	6.9	41	70	33	40
2	209	7.8	47	69	58	35
3	124	4.6	37	39	19	29
4	139	5.2	14	59	46	20
5	120	4.5	20	53	37	10
6	124	4.6	30	29	5	60
7	141	5.3	35	36	49	21
8	99	3.7	27	12	25	35
9	119	4.4	27	31	52	9
10	83	3.1	19	23	28	13
11	113	4.2	18	49	21	25
12	97	3.6	31	21	30	15
13	126	4.7	27	22	32	45
14	101	3.8	30	24	23	24
15	112	4.2	37	23	27	25
16	100	3.7	22	23	37	18
17	96	3.6	28	12	18	38
18	108	4.0	39	22	25	22
19	98	3.7	14	27	33	24
20	71	2.6	21	23	13	14
21	52	1.9	12	17	5	18
22	99	3.7	26	22	37	14
23	102	3.8	35	43	13	11
24	64	2.4	20	5	2	37

Table 8. Frequency of the daily patterns classified by the 24 basic patterns ($\sum \Delta^2 < 12$) for the period 1961 - 70.

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Spring	73	65	66	54	64	72	68	67	58	70
Summer	86	85	69	76	83	74	81	61	78	61
Autumn	70	63	73	60	59	66	68	66	68	75
Winter	62	60	37	57	62	70	66	68	56	64
Year	291	273	245	247	268	282	283	262	260	270

4. Concluding remarks

This work is a statistical approach to derive a set of basic patterns by which a large number of daily patterns can be classified. The deviations within a group of daily patterns forming a basic pattern are very small, and therefore their characteristic features are retained in their mean. Since the grid point values of each daily pattern are normalized, it is possible to apply the same threshold values in all seasons.

In order to obtain classes, each having a reasonable number of similar, time independent daily patterns, the number of basic patterns has to be restricted. But this classification can be extended to include further basic patterns, as for example blocking patterns, by applying the described procedure to an enlarged time period.

One of the future steps to be taken will be to associate these classes of patterns with regional weather types.

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