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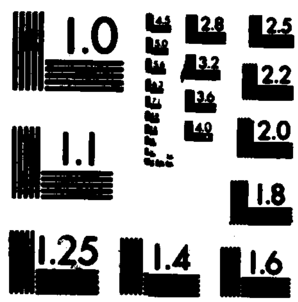

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ASSERTION OF A CENTRAL EUROPEAN SINGULARITY IN THE AREA OF YUGOSLAVIA

by

D. Furlan

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

FTD-ID(RS)T-1642-81 19 January 1982

MICROFICHE NR: FTD-82-C-000047

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English pages: 18

Source Geografski Vestnik, Ljubljana, Vol. 31, 1939, pp. 121-130

Country of origin: Yugoslavia
Translated by: LEO KANNER ASSOCIATES
F33657-81-D-0264
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ASSERTION OF A CENTRAL EUROPEAN SINGULARITY IN THE AREA OF YUGOSLAVIA

Danilo Furlan

The lines connecting daily average temperature for the time span of 1947-1956 and so on were analyzed for the following meteorological stations: Ljubljana in Slovenia, which occupies the northwestern part of Yugoslavia; Palitj-Subotica in Vojvodina, which lies in the northeast; and Skoplje in Macedonia, which belongs in the southeastern part of Yugoslavia. Although the stations cited lie in climatically very different regions, the connecting lines at all three stations show us an entirely consistent temperature progression. The Central European singularity also is expressed in the southeastern part of Yugoslavia.

In the domestic professional literature, there are two discussions going on, which involve circulation in the atmosphere, extending beyond the boundaries of our own country and occupying the area of a large part of Europe, the North Atlantic, and the Mediterranean Sea. These are the discussions by B. Bork [1] and D. Furlan [2]. As is evident from the title, the authors have selected opposite baric formations, the first anticyclonic, and second cyclonic: both, however, deal with factors pertaining to circulation.

Upon observing the average positions of cyclones and anticyclones on maps presented in both works, it appears to be a well-known fact [3, 4, 5, 6, 7] that at the higher levels of distribution (500 mb) with which we are dealing in Yugoslavia, they do not play a very clear role. It would be practical to mention that in the daytime, the entire area of Yugoslavia is dominated by the same or at least related air masses and the same basic baric formations, which must have expressed differences or transitional significance.

We get the opposite assertion in the literature; likewise, we recognize them from everyday living. Van Bebber [8] established the path of depressions. Based on his conclusions, which were also confirmed later [9, 10], there are also, among others, the paths 5b, 5c, 5d, and 5e, as well. If, let us say, we clearly show a weather development during the passage of a cyclone along path 5c, i.e. from Trzhashk Bay through Slovenia and along the Sava further to the east, this means that polar air flows in the area north of the line indicated, while tropical air remains south of this line. Statistical examination of precipitation samples in 1956 [2] also show that in 25% of the cases, precipitation involved only the northern area and in 12% of the cases only the southern area of Yugoslavia. It is emphasized here that the cases in which the precipitation involved only northern Yugoslavia were without exception in the summertime, and the opposite cases were in the winter. Similar results were obtained as well in the analysis of gaps in cold air in the summer of 1951 and 1952 [11, 12]. These both speak for the non-uniformity of weather occurrences in the area of Yugoslavia.

Finally, we stll have everyday practice! Central

Europe is in the winter months an area of predominant anticyclones, while southern Europe, like the southern part of the Balkan peninsula, is a major frontal area in the wintertime. The time of the beginning of beautifuly "summer weather", however, depends, on the average, primarily on how far south this fixed area extends. This is a matter which we recognize more by experience than from any climatological textbook. These facts stand in perfect opposition to the assertions we spoke of in the preceding paragraph.

Within the framework of modern climatology, to begin with, the problem must not remain unsolved.

In the past 30 years, we have succeeded in expressing dynamic, synthetic, synoptic climatology [13] as opposed to analytical or statistical climatology more and more frequently than in the past. The differences between these two climatologies we may draw from examples of the oldest and newest definitions of climate, as was stated almost 80 years ago by Julius Hann. According to the oldest definition, climate is the average state of the atmosphere [14]; but according to the most modern, it is the assemblage of weather regimes, which occur on the average at a fixed time of year [15]. The latter definition was refined by Bergeron and Flohn [13], but the words were changed, the content remaining the same (Bergeron [16]: the description of the frequency and intensity of ultimate systems, defined dynamically and thermodynamically; Flohn [13]: the temporal continuity, frequency, and local expression of characteristic weather regimes. The essence of modern climatology lies in the fact that dynamically and thermodynamically, the conclusions are treated as one: that thus there is no advantage to splitting up a unit of weather into individual elements (temperature, humidity, visibility, etc.). However, all the climatic elements which are associated with a specific type of weather remain, which represent a climatic element of a higher order. Meteorological elements are indicated in mutual associations, which is a principal rule in the dialectical concept of nature, and therefore also of processes in the atmosphere. The first characteristic of modern climatology lies, accordingly, in the replacement of the analytical representations for individual meteorological elements with the synthetic notion of weather or a weather element as an element of climate.

Another essential feature is its temporal definition. Analytical climatology tries to show the climatic causes of average and extreme values for the entire year, for separate places, and, in modern times, for a decade as well. These are arbitrary distinctions. Synthetic climatology must not make such distinctions, but arrives, with a high probability, at the development of a single weather type from two calculation units, be it for two decades or for two months. Likewise, it is necessary to add into the calculation units for average values occurring for all the calculated baric formations; thus, such average values are conceptually without foundation.

In dealing with the same or very similar weather regimes, we quickly arrive at the notion of a singularity, i.e. for a specified period of time for the same associated weather type. But because we call temperature, air pressure, humidity, etc. meteorological elements, the designation "climatological elements" would be satisfactory for individual singularities, and therefore without a supplement of a "higher order". But climate is the actual assemblage of cyclonic and anticyclonic singularities and the transitions between them.

The main question of a singularity is that of its reality, that is to say, the frequency of its occurrence. At first glance, it seems to be a unique thing, but it is satisfactory if we add up how many times a singularity occurs in a specified time, and we can readily express the level of its probability in a percentage. It is not such a unique thing! The essence of a singularity is its certain association with a fixed time, but temporal deviations do occur, due to which the expression "fixed time" is relative, with a deviation of from three to perhaps five days from the most frequent calendar date. For this very reason, we are content with some deviation, but both its frequency and its reality depend on how many singularities.

Schmaus [17] spoke the most about the Central European singularities, and later Hess and Brezowski [18], Bauer [19], and Schuepp [20]. In the domestic literature, Manohin [21] and Bernot [22] presented their investigations. Individual authors have arrived at greatly differing numbers of singularities, and therefore this permits greatly different temporal deviations and different frequencies as well. Schaus [17] established over 60 for Central Europe, while Flohn [13] arrives at the number 25, of which 12 were anticyclonic. Paradoxically, it turns out that in defining individual singularities, we can make use of analytical methods once more, namely representations with individual meteorological elements.

We emphasize, however, that single meteorological elements have no independent role. They serve only as indicators, as constituent parts of a whole: their proper representation makes possible a clear picture of a specific singularity as a weather unit.

The most usual indicators are: the number of days of precipitation, average daily temperature, average daily cloudiness, number of days with a foehn wind, and so on. The main thing in defining a meteorological element as an indicator is the type of singularity; however, the duration or the observation period plays a very important role. For a brief series of observations, there is no primary element which displays greater conservativeness than any other. Among such inapproriate elements are cloudiness and the number of precipitation days. Much more suitable is a representation of the temperature relationships; but temperature is a so-called associated element, while the previously mentioned one is unassociated and therefore is also given for smaller groups of observations.

In certain regions in the northern parts of Yugoslavia, such as Ljubljana, Zagreb, and Belgrade, we already know the average daily values for the whole year, while we do not have these for the southern area. We have also calculated these for Skoplje, but only for a period of ten years and this for the number of days of precipitation, and further for the number of clear days, average cloudiness, and daily temperature. With regard to our assertions in the preceding paragraph, we shall base our discussion on the average daily temperature and shall attempt with its help to state the degree to which the Central European singularities, which appear in the area of Slovenia, as is no longer in question, also appear over the entire region of Yugoslavia.

Figure 1 is presented mainly for our investigation, on which we have indicated average daily temperatures (for the period of 1947-1956) for three representative stations. These stations are: Ljubljana, for the extreme northwestern part of Yugoslavia, Palitj-Subotica, for the extreme northeastern part, and finally Skoplje, for the extreme south or southeast.

Even a transitory glance at the temperature associations convinces us that our first hypothesis concerning the relatively simultaneous exchange of air masses above the entire area of Yugoslavia was correct. But we must state that large deviations occur from the ideal temperature distribution at all three stations at the same time. A comparison of the relationships shows the following characteristics:

a) in winter, there are contrasts, with warm and cold periods sharply expressed in the north of Yugoslavia. This is true both for the December cooling and for the January warming and finally for the major cooling for the whole year, in the transition from January to February. The contrast is expressed more in duration than in the degree of deviation from ideal temperature distributions;

b) in the spring, the contrasts are much more obvious in the south, where there are four periods expressed of above-average warmth: the last ten days in

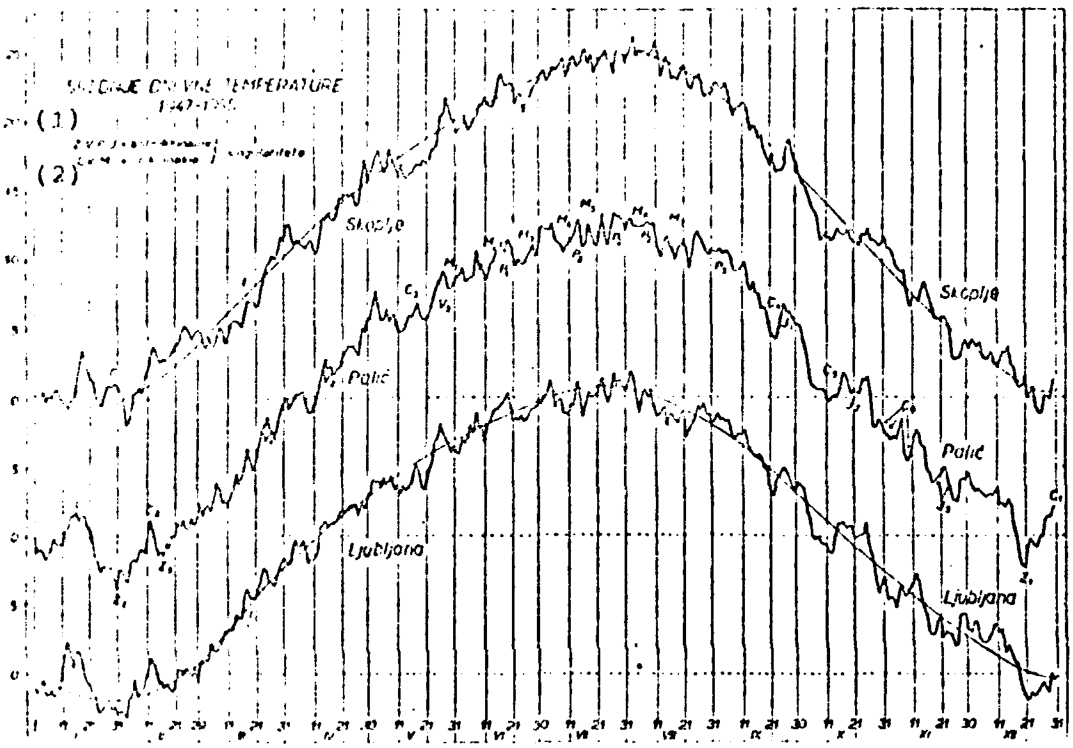

Fig. 1. Average daily temperatures, 1947-1956. Key: (1) Z, V, P, J = anticyclonic singularities; (2) C and M = cyclonic singularities.

of February and the first of March, the transition from March to April, the transition from April to May, and finally, at the end of May. The intermediate periods are relatively cold;

c) in the summer, the contrasts are strongly expressed in the south, while they are not expressed in the north. In any case, however, the differences between the hottest and coldest groups of days are less than in the spring;

d) in the autumn, contrasts are expressed the same in the north and south. The deviations are approximately the same as we established for the spring in the south of the country.

We must look for an interpretation of the differences cited between the north and south in individual years in the different geographic latitudes of our extreme areas and thus in the different distances from the frontal region.

The less expressed temperature contrast in the south of the country in wintertime is the result of frequent cyclonic activity over the eastern Mediterranean. Central Europe, by virtue of its predominant continental nature, would have low temperatures. The proximity of the Atlantic Ocean and the associated cyclonic activity, however, makes impossible such a stabilization of the weather as occurs in the middle of large continents like North America and Asia, as well as Eastern Europe. As in the West, so the peninsular halves of Europe operate, with successive continental and oceanic types of weather. From the graph, we see that it is not a matter of continual change, but rather of the relatively long-term domination of either polar or tropical air (relative to polar-tropical).

The increased equalization, which we see in the spring in connection with Subotice and particularly Ljubljana, speaks of a continual change in cyclonic and anticyclonic weather. It is known that winter anticyclones, which expand their dominance from the heart of Eurasia or at least from northeastern Europe toward the west, are long-term formations, while the lifetime of the Azores anticyclones is 6-8 days on the average [24]. We consider, therefore, the time between the summer and winter monsoons to be of transitional significance, like the area: the western half of Europe is a real peninsula. Thus, it is understandable that the spring in our northern regions ought to display systematically the most lasting baric formations. It is otherwise in the south. While the major frontal region kept south of Macedonia in the wintertime, above the eastern Mediterranean [25, 26], in the springtime, it lies north or northwest of Macedonia [2, 9]. While in the winter period it brought an anticyclonic type of cooling weather, being rarer, it brings spring cooling of the cyclonic type. The distance of the frontal region, however, was approximately the same in the winter as in the springtime, though the frontal region lies in the south in the winter, and in the north in the spring, on the average [2, 9]. Therefore, the contrast in the south of the country is approximately the same in both of the seasons being discussed. The oscillation expressed extends into the second half of June.

In the summertime, the polar front leaves the eastern Mediterranean [24, 6]. It lies above the North Sea, but it approaches the monsoon invasions to the southeast [13, 23, 27]. There invasions frequently stop on the northern slopes of the Alps; they also frequently flow over the Alps or go around them from the southwest [2].

The path which the cold air takes to reach us is shorter by half than that to Macedonia, and there is also much less chance of transformation. Thus, the temperature differences in the south must be much less, as well as the effect on weather development being immediately less.

The development of temperature relationships in the fall are not solely a repetition of the springtime relationships. But the same contrast is expressed between the cold and warm periods in the south as in the north, while it was so expressed in the spring only in the south. An attempt to prove this phenomenon is not simple.

Because the temperature relationships are based on the surface of the sea or the continent, the most decisive factor in the origin and duration of baric formations [13, 23, 28], forming over the European continent in the winter is expressed by anticyclones; in the summer, however, it is considerably inclined toward cyclonic. For our region, the anticyclone above Europe is important in the wintertime, while the eastern half of the North Atlantic represents an cyclonic region. This situation is known as the winter monsoon [6, 13, 24]. In the spring, the continent heats up rapidly, and while in the winter, the major activity of the polar front is in the latitude south of Atlas and from there into the southeastern Mediterranean [29] in spring it is concentrated in the central and northern Mediterranean [13, 23, 30]. Thus, the position of the polar front in the spring months also corresponds to the most frequent retention of the central cyclone or at least mountain valleys above Central Europe [23, 30]. In the summer, as is known, there is great cyclonic activity in the form of summertime monsoon invasions over the heart of Europe. In the fall, Central Europe cools more rapidly and severely than than the Baltic region or the North Sea [31]. There is an essential difference between the weather development in the spring and fall. In comparing the North Sea with the Baltic and Central Europe, **the latter is warmer in the spring and cooler in the fall than the sea surfaces lying to the north. Thus, anticyclonic weather is more common above Central Europe in the** fall and cyclonic weather in the spring.

The period of beautiful weather expressed is therefore the result of frequent and temporally adequate fixed anticyclones, which make it impossible for polar air to pass over Central and Southern Europe. But when there are none of these blocking anticyclones, then there are invasions deep into the south, so that its intensity rapidly becomes the same on the northern shores of the Aegean Sea as in our Alpine land.

Now, as we have described the main features of temperature development in Yugoslavia and have also attempted to verify them, we shall take up the next task, namely to find a connection between singularities which appear as secular observations in Central Europe and their possible manifestation in 10 years of our series. Here we shall take as the basis of comparison those singularities which Flohn chose in his modern description of the climate of Central Europe.

The anticyclonic singularity "of early winter" (Z_1), that from the beginning of the last ten days of December, is expressed in all three geographical units which are represented by the stations at Ljubljana, Subotica, and Skoplje. The time of onset corresponds to the time of the secular average for Central Europe. Somewhat more complicated is the second anticyclonic singularity, "of true winter", (Z_2), which must occupy the beginning of the third decade, thus in January. In our ten-year average, it began on time. It lasted until the end of the first ten days of February, when the anticyclonic singularity "of late winter" began (Z_3), which began alternately from February 8 to 10 or from February 19 to 24. From the temperature relationships at all three stations, it is evident that in the north, the singularities of "true winter" and "late winter", the first alternative, are connected by about 20 days of a lasting period of the lowest temperatures of the whole year. In the south of the country, in the period being discussed, we see the same development as in the secular average. Between the two anticyclonic singularities there is inserted a short cyclonic period.

The "late winter" singularity (Z_3) begins about 5 days too early, namely in the time between February 14 and 20 and is very evident in the area of all three geographic units. A cyclonic singularity (C_2) is very evident between the last anticyclonic singularities.

In the spring and also in part of the fall months (November, December), the average daily temperatures do not show expressed contrasts. This is the result of relatively rapid changes in the baric situations; also the cyclonic and anticyclonic singularities are beginning, which are rather difficult for us to recognize from the analysis of temperature relationships. Particularly in the valley bottoms, the winter anticyclonic singularities mean a severe drop in temperature, but in the summer it rises. Cyclonic singularities affect both major seasons in the opposite way. In the transitional seasons, it is more involved, but subtropical anticyclones occur with explicitly high temperatures, while cyclonic activity in the first phase is characterized by a flood of warm air, and in the second phase by cold air. This is the reason why in the months of March, April, and May and in November and December, the temperature relationships are not a good representative of individual singularities.

In March, there is the anticyclonic singularity "of early spring" (V_1 - vesna Translator's Note: vesna is Slovenian for "spring") in the beginning of the last ten days, well expressed only in the north (it occurs punctually). "True spring" (V_2) at the end of the first ten days of April is weakly expressed, because it is in force over the whole of Central Europe [13, 17, 19]. "Late spring (V_3) in the last ten days of May occurred at the normal fixed time in the 10 years under consideration. In between "true" and "late" spring comes a cyclonic singulaity "of the Arctic Ocean" (C_3) with alternative dates about the 13th and 19th of May, while Flohn cited for the last decade the dates of May 9 and 17, thus there is a delay in our period of about 3 days.

From the discussions of the same name, its major purposes are not entirely evident. It would establish the degree to which we may use the Central European singularities, which without question arise in Slovenia, for interpretation, and how ten day and monthly average and extreme values etc. arise, not only in Slovenia, but also in the entire area of Yugoslavia. In dealing with temperatures, such a distribution, for which our graph is most persuasive, has been proven. Would analyses for the remaining meteorological elements give a similar result?

Each change in an air mass, or in its continued strength, creates a specific weather regime, which through the physical properties of the air masses, deals with the following factors: relief (in connection with the direction of flow), absolute and relative height, distance from the sea, geographical latitude. It is necessary that the development be more or less consistent for the same air masses and mainly for the same baric situations, when the two are associated at the same season. This is indeed an essential feature of singularities. The question is the same, how single factors of the ones cited affect individual elements and the assemblage of them, the weather regime. But this is another and the next task we shall recognize, what delays we must calculate for the occurrence of individual singularities between the far north and far south of the country and, probably, to the most expressive degree, between the extreme east and extreme west of the area.

For the summer months, the monsoon invasions are significant, as has been mentioned. The anticyclonic singularities "of early summer" (P_1 from June 15 to 18; delay of 3 days) and "true summer" (P_2 from July 25 to August 12; on time) are weakly expressed. Much better expressed is the singularity "of late summer" (P_3 at the August to September transition, early by about 3 days). The monsoon singularities in June (M_1 from May 28 to June 6, punctual; M_2 from June 10 to 14, early by about 2 days; M_3 from June 22 to 29, early by about 2 days) were well expressed. It is worthwhile to emphasize particularly the third monsoon singularity, which is also expressively felt in Macedonia. The Yugoslav monsoon singularities are well expressed in the north. This is true particularly of the first (M_4) about July 11, which occurs with a delay of 4 days. Like the last singularity in July (M_5), the monsoon singularity in the first ten days in August (M_6), around August 6 (punctual occurrence) is weakly expressed, while the last monsoon singularity of all (M_7) occupies the period from August 13 to 26, thus two weeks. In spite of the interruptions, it was particularly well expressed in the north. The cyclonic singularity in the first half of the last ten days in September (C_4) and the following one around October 11 (C_5) (delayed about 3 days) brou ht much cooling. Between them there is the anticyclonic singularity "of early fall" (J_1) from September 24 to 28 (punctual). The singularity "of indian summer" or "true fall" (J_2) extends from the middle of October (normal time) to the end of the month. In all of Yugoslavia, especially in the north, there is cyclonic weather expressed at the end of October and even more at the beginning of November (C_6) with the highest number of precipitation days of the year, in the west 9 out of 10 wet days, in the east 7. Finally, there is an anticyclonic singularity "of late fall" (J_3), at the transition between the 2nd and 3rd ten days of November (delay of about 5 days).

Thus the calendar of major anticyclonic (12) and cyclonic singularities (with the monsoons, 13) is concluded.

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