

DECADAL-SCALE CHANGES OF THE TEMPERATURE
AND PRECIPITATION IN BULGARIA
FOR THE PERIOD 1961–1990

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Елисавета Пенева, Николай Рачев. ДЕКАДНИ ИЗМЕНЕНИЯ НА ТЕМПЕРАТУРАТА И ВАЛЕЖИТЕ В БЪЛГАРИЯ ЗА ПЕРИОДА 1961–1990

На базата на средномесечни данни за температурата и месечните суми на валежите в 135 метеорологични станции на територията на България са определени средногодишните и средносезонните температури и съответно суми на валежите за периода 1961–1990 г. Същите характеристики са определени отделно и за трите декади с цел да се оцени стабилността на климатичните стойности. Изследвани са отклоненията от климатичните норми на средните температура и суми на валежите за трите декади и е потърсена връзка между тях. Анализирано е и пространственото разпределение на средногодишните и средносезонните аномалии за трите разглеждани декади.

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The monthly mean data for temperature and precipitation in 135 stations in Bulgaria are used to determine the annual and seasonal mean values for the period 1961–1990 and for the three separate decades in order to estimate the changes of the averaged values. The maps of these meteorological elements are given also as decadal anomalies of the temperature and precipitation and their relationships are investigated.

Keywords: temperature and precipitation variability, climate of Bulgaria

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1. INTRODUCTION

The climate conditions are usually defined as a mean for a longterm period (at least 30 years) and several periods are determined as normal from the World Meteorological Organization: 1901–1930, 1931–1960 and 1961–1990 [1, 2]. However, inside these periods decadal variations are observed and it is useful to look how stable the mean estimate of the climate condition is and what interannual oscillations can be identified. Further more, the spatial variability is not usually considered, it is enough complicated to investigate the regional mean tendencies only.

Bulgaria is located in very interesting from climate point of view region. The annually averaged position of the global frontal system of temperate latitudes (the polar front) passes through its territory separating our country in two different climatic zones: in the northern one the climate shows a typical character of continental temperate zone; whereas the southern part is influenced by the Mediterranean [2–4]. As a consequence the precipitation is differently distributed over the seasons in different parts of Bulgaria and in order to understand and identify better the reasons for climate variations it is necessary to distinct in seasons and locations in Bulgaria. Average estimates for the whole region are useful but also the spatial distribution of anomalies must be examined.

In this paper we analyse the long-term observations of temperature and precipitation for the period 1961-1990 in regard to their decadal variations. We look at the area mean values for the whole Bulgaria, separately for the 30-years period and the 3 decades. The spatial distribution of decadal mean anomalies is also discussed.

2. DATA USED IN THE ANALYSIS

The data we use are kindly provided by E. Koleva from the National Institute of Meteorology and Hydrology, Bulgaria. They consist of monthly mean values for the temperature and precipitation, measured in 135 station over Bulgaria and cover the period 1961–1990. The Table 1 shows a list of these stations and indicates the type of data, used in the analysis. In summary the estimates for the average temperature and precipitation are based on the observations in 130 stations, because in several point both variable were not systematically measured.

In more details these data are described in [5] and [6]. In order to achieve representative monthly values needed in the horizontal variations analysis for

the whole Bulgaria, the data are interpolated in a regular grid with spatial resolution of 0.2x0.2 degree in zonal and meridional directions, using Cressman optimal analysis. As seen from Fig. 1 the cover of the area of interest is quite good and can serve as a representative estimation of the spatial variations.

Table 1. List of the stations, where the measurement are taken: the letters *T* and *P* indicate that either Temperature or Precipitation data are used in the analysis

1. Novo selo – <i>P</i>	39. Krushary – <i>T, P</i>	77. Dospat – <i>T, P</i>
2. Vidin – <i>T, P</i>	40. Gen.Toshevo – <i>T, P</i>	78. Persenk – <i>T, P</i>
3. Belogradchik – <i>T, P</i>	41. Varna – <i>T, P</i>	79. Sadovo – <i>T, P</i>
4. Montana – <i>T</i>	42. S. Oriahovo – <i>T, P</i>	80. Asenovgr – <i>T, P</i>
5. Varshetz – <i>T, P</i>	43. Goren chiflik – <i>T, P</i>	81. Boykovo – <i>T, P</i>
6. Lom – <i>T, P</i>	44. Suvorovo – <i>T, P</i>	82. Brezovo – <i>T, P</i>
7. Vratza – <i>T, P</i>	45. Burgas – <i>T, P</i>	83. Karlovo – <i>T, P</i>
8. Gabare – <i>T, P</i>	46. Ahtopol – <i>T, P</i>	84. Hisar – <i>T, P</i>
9. Kneja – <i>T, P</i>	47. Emine – <i>T, P</i>	85. Botev – <i>T, P</i>
10. Oriahovo – <i>T, P</i>	48. Karnobat – <i>T, P</i>	86. Dimitrovgrad – <i>T, P</i>
11. Pleven – <i>T, P</i>	49. Lulakovo – <i>T</i>	87. Jundola – <i>T, P</i>
12. Somovit – <i>T, P</i>	50. Grudovo – <i>T, P</i>	88. Velingrad – <i>T, P</i>
13. Lovech – <i>T, P</i>	51. Nesebar – <i>T, P</i>	89. Panagiuirishte – <i>T, P</i>
14. Teteven – <i>T, P</i>	52. Pomorie – <i>T, P</i>	90. Kozarsko – <i>T, P</i>
15. Trojan – <i>T, P</i>	53. Tzarevo – <i>T, P</i>	91. Peshtera – <i>T, P</i>
16. Benkovski – <i>T, P</i>	54. Kameno – <i>T, P</i>	92. Bratija – <i>T, P</i>
17. Taja – <i>T, P</i>	55. Aitos – <i>T, P</i>	93. Blagoevgrad – <i>T, P</i>
18. Ambaritza – <i>T, P</i>	56. Obzor – <i>T, P</i>	94. Semkovo – <i>T, P</i>
19. Sevlievo – <i>T, P</i>	57. Jambol – <i>T, P</i>	95. Belitza – <i>T, P</i>
20. Gabrovo – <i>T, P</i>	58. Elhovo – <i>T, P</i>	96. Bansko – <i>T, P</i>
21. Stoletovo – <i>T, P</i>	59. Nedjalsko – <i>T, P</i>	97. h.G. Delchev – <i>T, P</i>
22. V. Tarnovo – <i>P</i>	60. Topolovgrad – <i>T, P</i>	98. Kresna – <i>T, P</i>
23. Pavlikeni – <i>P</i>	61. Sliven – <i>T, P</i>	99. Pirin – <i>T, P</i>
24. Elena – <i>P</i>	62. h. S. kamani – <i>T, P</i>	100. Sandansky – <i>T, P</i>
25. Svishtov – <i>P</i>	63. Sadiovo – <i>T, P</i>	101. Petrich – <i>T, P</i>
26. Ruse – <i>T, P</i>	64. Kotel – <i>T, P</i>	102. G. Delchev – <i>T, P</i>
27. Obr. chiflik – <i>T, P</i>	65. Stara Zagora – <i>T, P</i>	103. Kiustendil – <i>T, P</i>
28. Bjala – <i>T, P</i>	66. Chirpan – <i>T, P</i>	104. Nikolich – <i>T, P</i>
29. Silistra – <i>T, P</i>	67. Kazanlak – <i>T, P</i>	105. Osogovo – <i>T, P</i>
30. Alfatar – <i>T, P</i>	68. Haskovo – <i>T, P</i>	106. Dupnica – <i>T, P</i>
31. Razgrad – <i>T, P</i>	69. Harmanly – <i>T, P</i>	107. Rila – <i>T, P</i>
32. Isparih – <i>T, P</i>	70. Kardjaly – <i>T, P</i>	108. Rilski man. – <i>T, P</i>
33. Kubrat – <i>T, P</i>	71. Djebell – <i>T, P</i>	109. Sap. bania – <i>T, P</i>
34. Omurtag – <i>T, P</i>	72. Krumovgrad – <i>T, P</i>	110. Pernik – <i>T, P</i>
35. Shumen – <i>T, P</i>	73. Ivailovgrad – <i>T, P</i>	111. Tran – <i>T, P</i>
36. Shabla – <i>T, P</i>	74. Chepelare – <i>T, P</i>	112. Breznik – <i>T, P</i>
37. Kaliakra – <i>T, P</i>	75. Raikovo – <i>T, P</i>	113. Divlia – <i>T, P</i>
38. Tervel – <i>T, P</i>	76. Zlatograd – <i>T, P</i>	114. h. Selimitza – <i>T</i>

115. h. Matnitza – <i>T</i>	122. Cherny vrah – <i>T, P</i>	129. Salzitza – <i>T, P</i>
116. Petrohan – <i>T, P</i>	123. Murgash – <i>T, P</i>	130. Boeritza – <i>T, P</i>
117. Botevgrad – <i>T</i>	124. Musala – <i>T, P</i>	131. Sofia – <i>T, P</i>
118. Ihtiman – <i>T, P</i>	125. Samokov – <i>T, P</i>	132. Bov – <i>T, P</i>
119. Koprivshtica – <i>T, P</i>	126. Borovetz – <i>T, P</i>	133. Iscretz – <i>T, P</i>
120. Pirdop – <i>T, P</i>	127. Sitniakovo – <i>T, P</i>	134. Dragoman – <i>T, P</i>
121. Sofia_NIMH – <i>T, P</i>	128. Govedartsy – <i>T, P</i>	135. Vakarel – <i>T, P</i>

The maps of annual mean temperatures and annual precipitation are obtained (Fig. 2), and also seasonal mean maps (Fig. 3 and 4) for the whole period 1961–1990. The seasons are defined as follows: winter value is an average for the months January, February and December from the previous year; spring is – March, April and May, summer is – June, July and August, and fall is – September, October, November.

Then, decadal anomalies are calculated as a difference between decadal mean and the one for the whole period 1961–1990 correspondingly to the annual and 4 seasonal averages (Fig. 5–9).

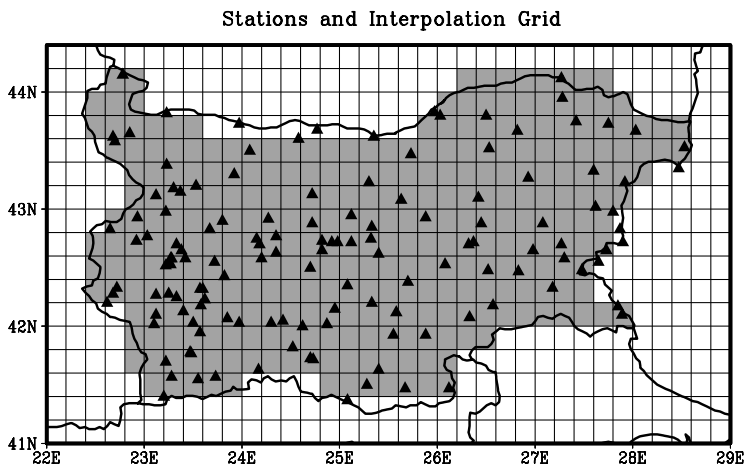


Fig. 1. Locations of the stations where the measurements have been taken (denoted with triangles) and the grid of interpolated fields (0.2x0.2 degrees in meridional and zonal direction)

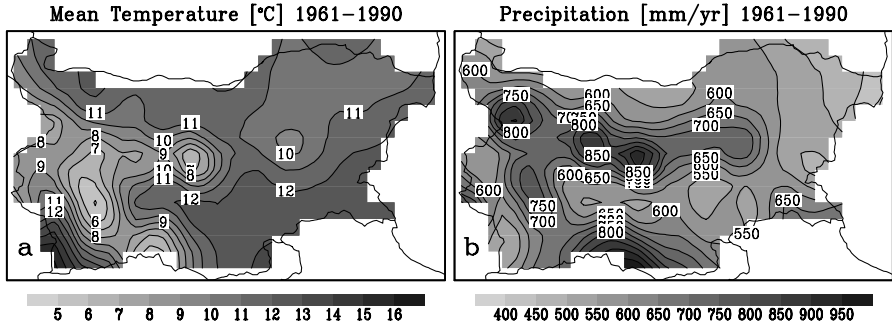


Fig. 2. Climate for the period 1961-1990: (a) the mean temperature [°C] and (b) annual precipitation [mm/year]

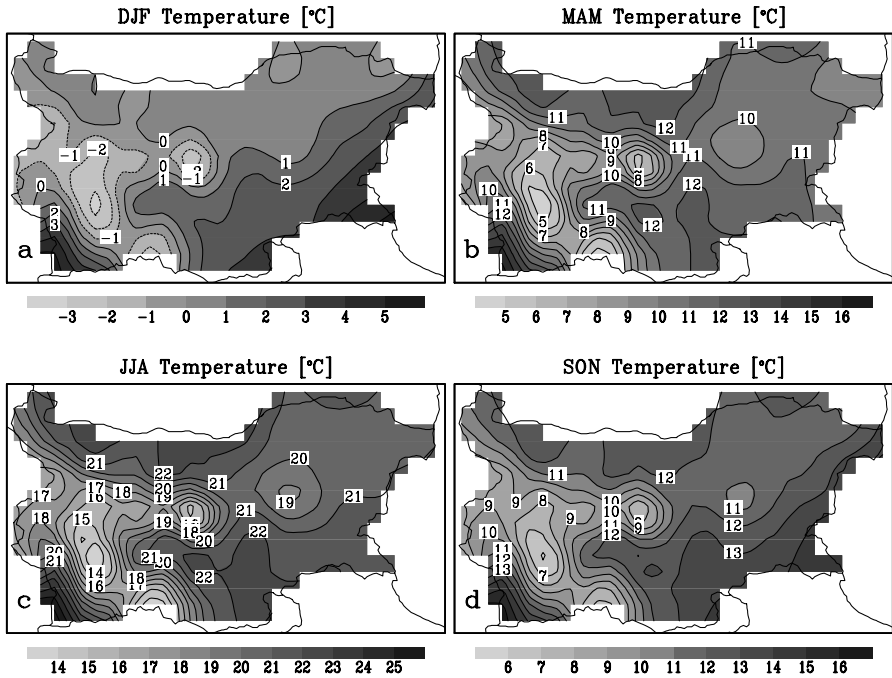


Fig. 3. Mean seasonal temperatures for the period 1961-1990 [°C]: (a) winter, defined as December, January and February; (b) spring, defined as March, April and May; (c) summer, defined as June, July and August; (d) fall, defined as September, October and November

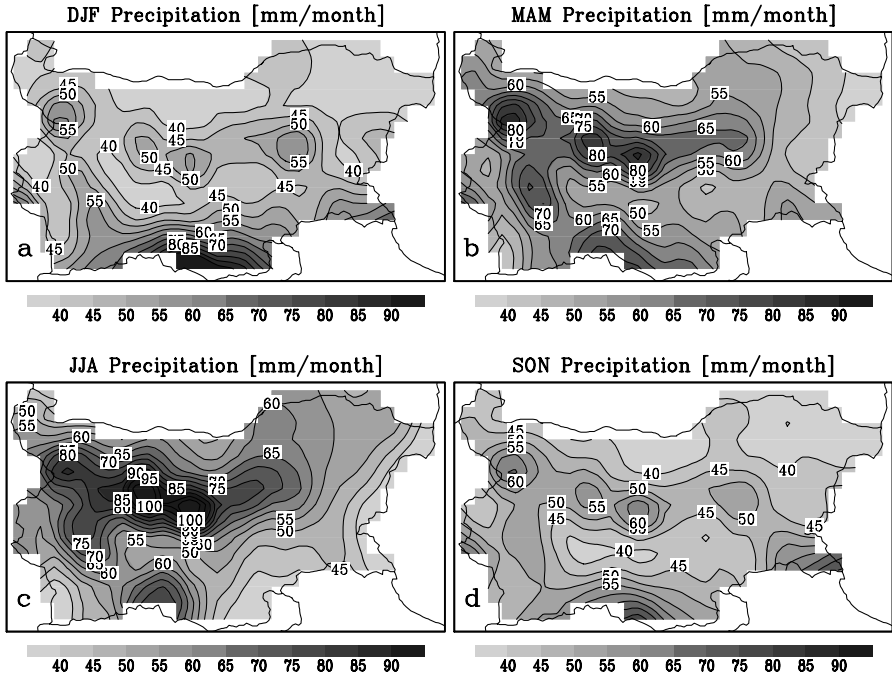


Fig. 4. Seasonal precipitation for the period 1961-1990 [mm/month]: (a) winter, defined as December, January and February; (b) spring, defined as March, April and May; (c) summer, defined as June, July and August; (d) fall, defined as September, October and November

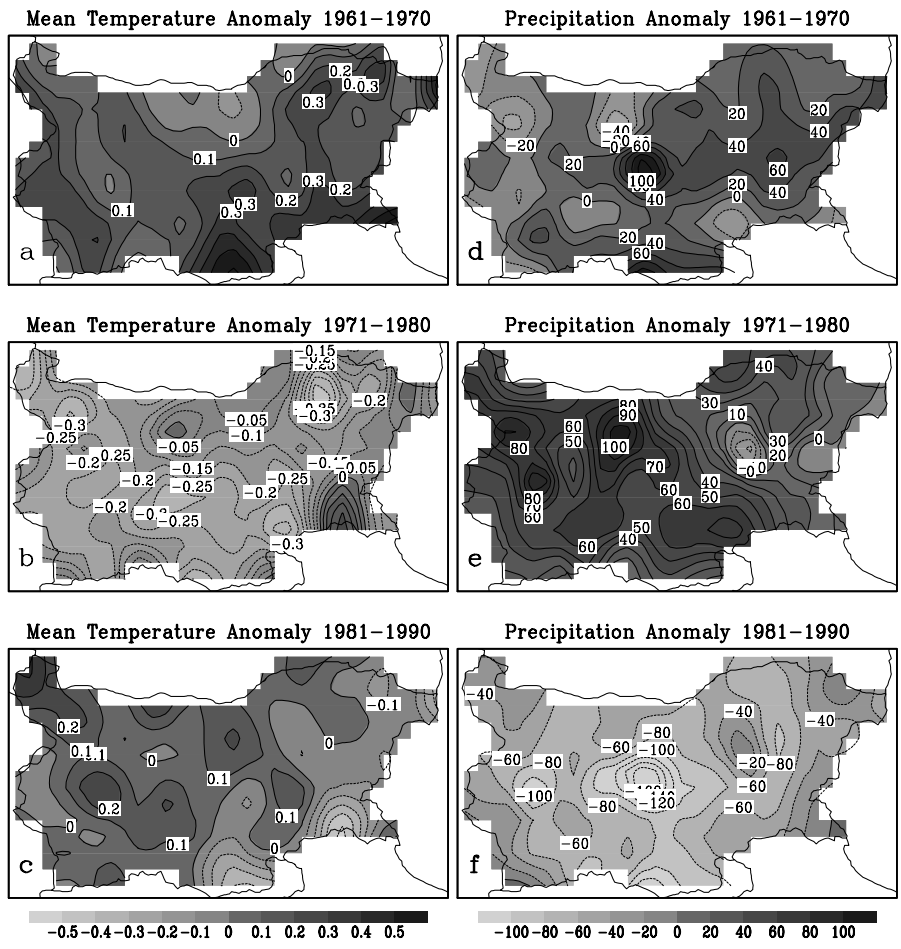


Fig. 5. Decadal mean Temperature [°C] (left column) and Precipitation [mm/month] (right column) in regard to the three decades 1961–1970 (upper panels), 1971–1980 (middle panels) and 1981–1990 (lower panels)

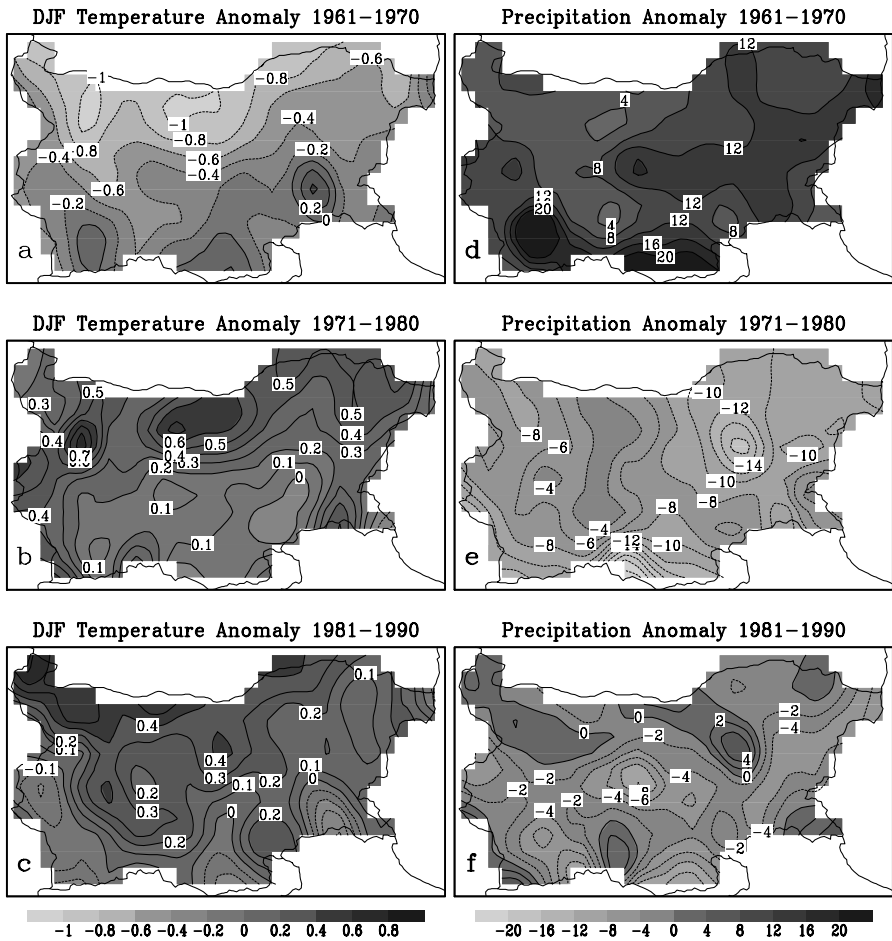


Fig. 6. Winter anomaly of the Temperature [$^{\circ}\text{C}$] (left column) and Precipitation [mm/month] (right column) in regard to the three decades 1961–1970 (upper panels), 1971–1980 (middle panels) and 1981–1990 (lower panels)

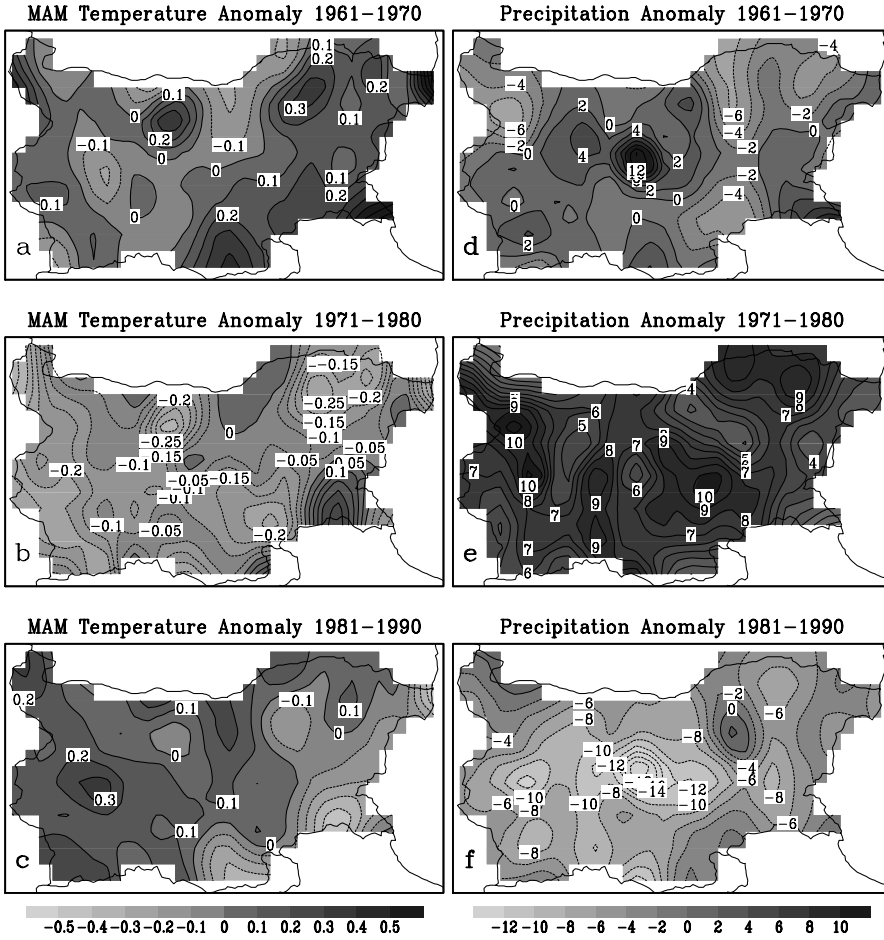


Fig. 7. Spring anomaly of the Temperature [°C] (left column) and Precipitation [mm/month] (right column) in regard to the three decades 1961–1970 (upper panels), 1971–1980 (middle panels) and 1981–1990 (lower panels)

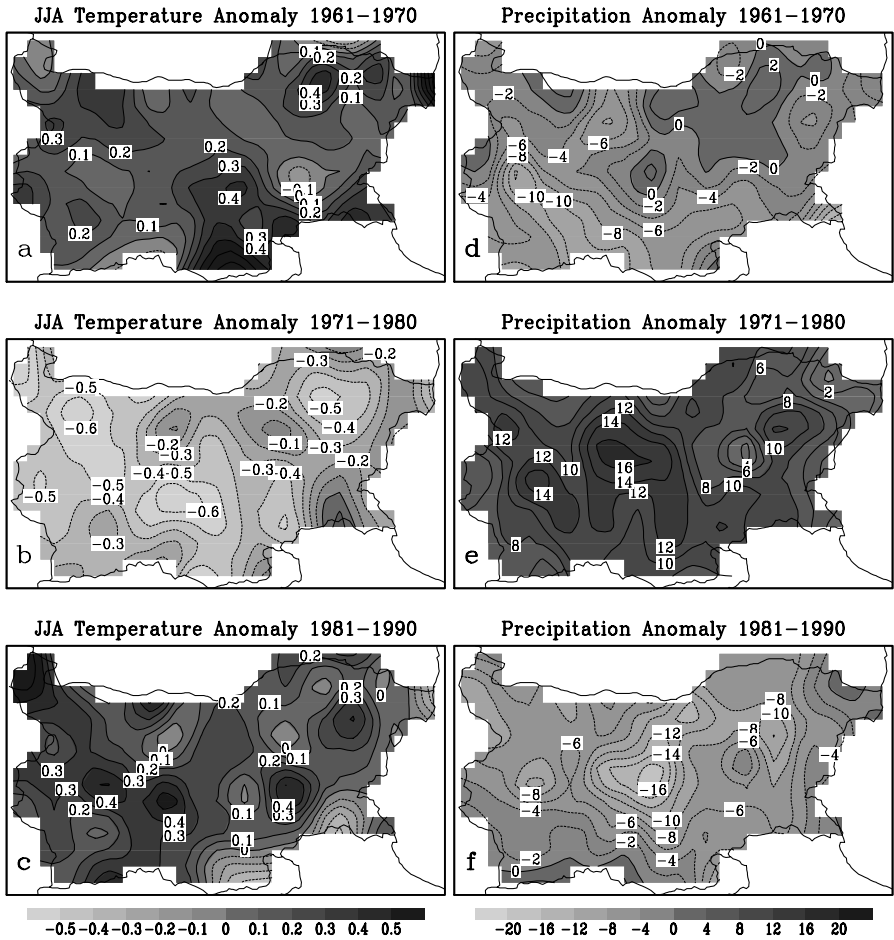


Fig. 8. Summer anomaly of the Temperature [$^{\circ}\text{C}$] (left column) and Precipitation [mm/month] (right column) in regard to the three decades 1961–1970 (upper panels), 1971–1980 (middle panels) and 1981–1990 (lower panels)

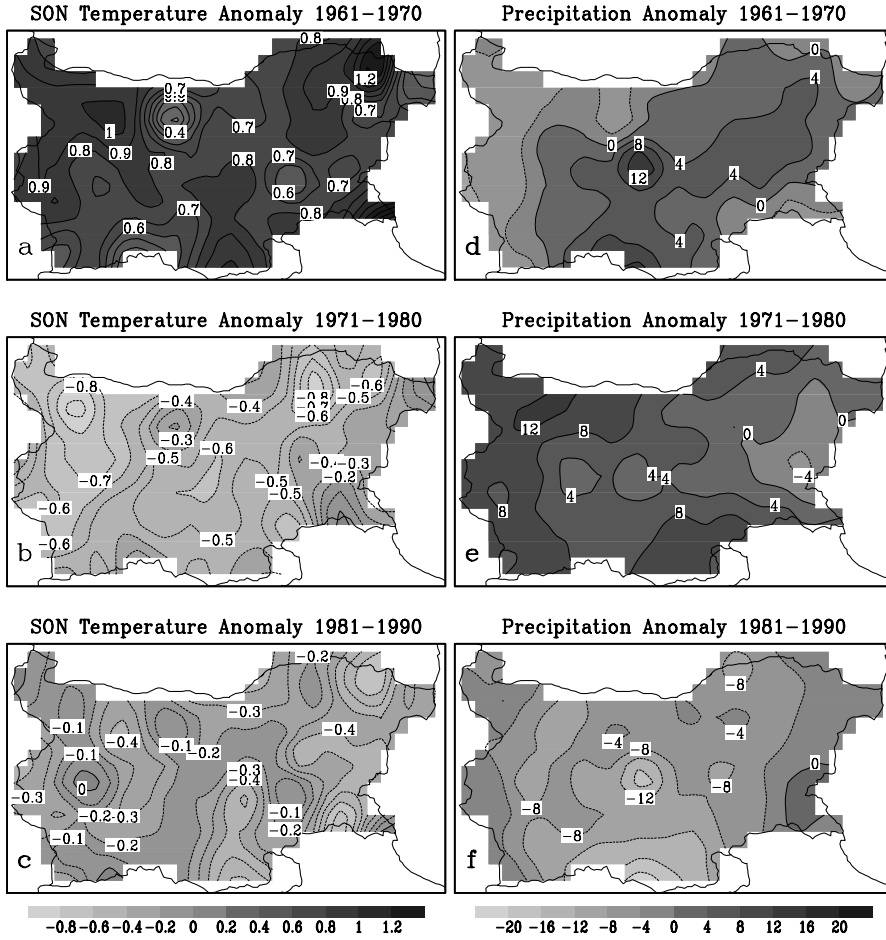


Fig. 9. Fall anomaly of the Temperature [°C] (left column) and Precipitation [mm/month] (right column) in regard to the three decades 1961-1970 (upper panels), 1971-1980 (middle panels) and 1981-1990 (lower panels)

3. ANALYSIS OF THE RESULTS

3.1. ANNUAL AND SEASONAL MEAN VALUES

Tables 2 and 3 summarize the mean values for temperature and precipitation in regard to the whole period 1961–1990 and the three separate decades. First to mention is the widely discussed Earth global warming, assessed by the report [7], to 0.1–0.2 °C/decade. In Bulgaria during this period such a tendency can not be identified in the data we use. The first decade 1961–1970 was generally warmer, followed by relatively colder decade of 1971–1980, and then we had again warmer decade during 1981–1990. Interesting facts arrive when we look at the seasonal mean values. The first decade 1961–1970 was warmer because of warmer spring, summer and fall, but the winter was the coldest. The second decade 1971–1980 is the opposite: the coldest one from the three, but with warmest winter, and relatively colder spring, summer and fall (Table 2).

Regarding the precipitation we see a sequence of two relatively rainy decades (1961–70, 1971–80) followed by a drier one (1981–1990). It is worth mentioning the fact that in the first decade the winter precipitation is maximal, whereas during the second decade the winter is drier but the other seasons show precipitation ~10% above the average which led to a larger annual sum. During the period 1981–1990 the precipitation was about 10% below the average annual sums for the whole period (Table 3). Knowing the reasons for precipitation distribution over the year one can speculate that during the second decade the climate in Bulgarian region showed more characteristics of a continental temperate type and during the first decade – the influence of Mediterranean Sea was more pronounced.

Table 2. Annual and seasonal mean values of the temperature in Bulgaria for the period 1961–1990 and the three decades

Temperature [°C]	Annual mean	DJF mean	MAM mean	JJA mean	SON mean
1961–1990	10.7	0.8	10.3	20.0	11.5
1961–1970	10.8	0.4	10.4	20.2	12.3
1971–1980	10.5	1.1	10.2	19.7	11.0
1981–1990	10.7	1.0	10.3	20.2	11.2

Table 3. Annual and seasonal values of the precipitation in Bulgaria for the period 1961–1990 and the three decades

Precipitation	Annual mm/year	DJF mean mm/month	MAM mean mm/month	JJA mean mm/month	SON mean mm/month
1961–1990	624	47	56	57	46
1961–1970	640	58	56	54	47
1971–1980	667	39	62	66	52
1981–1990	565	45	50	51	40

It is an interesting fact that the decade with the lowest mean annual temperature is also the decade with increased annual precipitation. The different seasons show different behaviour: the temperature in the warm part of the year is quite stable especially in spring, but differs in winter and fall.

To explain the observed seasonal variations of temperature and precipitation in the different decades it is necessary to compare additionally with atmospheric circulation characteristics. One of the possible reasons is a change in the activity of the four basic climatic centers which affect the weather in the Balkan region – Iceland lows, Cyberia highs, Azores highs and Mediterranean lows centers. Interesting aspect is the influence of the NAO (North Atlantic Oscillation) phase, but in order to identify a correlation we need more investigations to be carried out using longer time series, also.

3.2. MAPS OF ANNUAL AND SEASONAL MEAN TEMPERATURE AND PRECIPITATION

Figures 2, 3 and 4 give the annual and seasonal averaged maps of temperature and precipitation. In all figures the orographic influence is easily identified, the lower temperatures and increased precipitation are over the mountains. In general, the regions with lower temperature are related to the regions with more rainfall. An exception of this rule is the area of Western Balkan mountain where such correlation can not be identified. Maximal temperatures are observed around the southwestern and southeastern regions. The precipitation shows maximal values in the high mountain areas and minimal – in the northeastern part.

Fig. 3 shows in more details the above mentioned variables spreaded in seasons. The temperature annual amplitude indicates lower values ($\sim 17^{\circ}\text{C}$) in the mountain areas and larger ($\sim 20^{\circ}\text{C}$) in the plains with maximal value in the north part of the Danube plain. The horizontal gradients of temperature are maximal during the warm part of the year and minimal – during the cold one.

The influence of the near sea basins (Black Sea, Mediterranean Sea) is more pronounced in the winter season. The main temperature field patterns are similar to those in Fig. 2 due to the orography.

The seasonal mean precipitation maps are given in Fig. 4 and the fields show significant horizontal variability in regard to the zones with minimal and maximal rainfall. The spring and summer season are characterized by maximal values of precipitations over the high mountains (Fig. 4b, c) and the patterns are similar to the annual mean ones (Fig. 3b). However in winter season, when the Mediterranean influence is more significant, the maximal rainfall is in the central southern Bulgaria (Fig. 4a) and in fall – in general the precipitation is uniformly distributed (Fig. 4d).

3.3. DECADAL ANOMALIES

Figures 5 to 9 show the anomaly in temperature and precipitation for the three separated decades in respect to the whole period mean. The interesting fact is that periods with decreased temperatures are usually associated with periods of increased precipitation.

Fig. 5 indicates the characteristics valid throughout the year. It is seen that the temperature maximal anomalies (-0.5 to 0.6°C) are observed in southeastern and eastern part of Bulgaria, while the precipitation maximal anomalies (-160 to 100 mm/year) are over the mountains. The decade 1971–1980 is characterized by significant precipitation anomalies in the central Danube plain. There can not be distinguished a clear correlation between the anomalies in temperature and precipitation fields. One might conclude that the causes for the anomalies are with different origin, e.g. the precipitation regimes are not influenced by the thermal conditions only.

More details about the decadal anomalies can be found in the maps for different seasons. During the whole period in winter (Fig. 6) there is a clear tendency that the high temperature anomalies are associated with low precipitation anomalies. Same clear tendency is observed also in summer (Fig. 8). However, in the transitional periods spring and fall this relation is not so well pronounced (Fig. 7 and 9): the period 1981–1990 was characterized by cold autumn with less precipitation, and the 1961–1970 one – with warm autumn and more precipitations. Thus the negative correlation between temperature and precipitation anomalies is well pronounced in all decades and seasons except for the falls in 1961–1970 and 1981–1990.

4. CONCLUSIONS

The mean temperature and precipitation in Bulgaria during the normal climatic period 1961–1990 show significant decadal oscillations. The first decade 1961–1970 was relatively warmer with rainfull winter, while the second 1971–1980 was colder and rainfull, and the third one 1981–1990 was generally drier. However these tendencies are not valid for all seasons: the winter in 1961–1970 was colder and more wet, whereas the winter in 1971–1980 was unusually warm and dry.

In addition to the area mean values interesting fact arrives when we look at the spatial distribution of decadal anomalies – there is a well pronounced negative correlation between temperature and precipitation anomalies in all decades and seasons except for the falls in 1961–1970 and 1981–1990.

The possible reason for the observed variations is a change in the activity of the basic climatic centers, affecting the weather in the Balkan region – Iceland lows, Cyberia highs, Azores highs and Mediterranean lows centers. However, to explain in more details the observed decadal and seasonal variations of temperature and precipitation it is necessary to compare additionally with atmospheric circulation characteristics and most probably to use longer time series.

REFERENCES

1. Peixoto, J., A. Oort. *Physics of Climate*. AIP press Springer, 1992.
2. Sirakova, M. *Atmosphere and Climate*, Heron Press Sofia, 2002 (in Bulgarian).
3. Sabev, L., M. Kuchukova, S. Lingova. *The climate of Bulgaria*, Bulgarian Academy of Science, Sofia, 1991 (in Bulgarian).
4. Sabev, L., S. Stanev. *Climate regions in Bulgaria and their climate*, Institute of Hydrology and Meteorology, **5**, 1959 (in Bulgarian).
5. Koleva, E. K., L. Krastev, E. L. Peneva, E. V. Stanev. *Bulg. J. Meteorol. and Hydrol.*, **7**, 3–4, 1996, 73.
6. Peneva E., E. V. Stanev, E. K. Koleva, L. Krastev, J. V. Staneva. *Bulg. J. Meteorol. and Hydrol.*, **7**, 3–4, 1996, 84.
7. IPCC, *Fourth Assessment Report (AR4) of United Nations Intergovernmental Panel on Climate Change*, 2007.

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