BULGARIAN ACADEMY OF SCIENCES

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REVIEW

of

The dissertation of *Valcho Petrov Pophristov*, part-time doctoral student at the Department of Climatology, Hydrology and Geomorphology of the Sofia University "St. Kliment Ohridski", speciality 01.08.09 "Climatology", in the field 4.4 "Earth Sciences", with the topic:

Classification of atmospheric circulation types for the region of Bulgaria and their relation to large-scale circulation processes

for the award of the PhD degree

Reviewer: *prof. DSc. Natalya Kilifarska*, Climate, Atmosphere and Water Research Institute of Bulgarian Academy of Sciences (CAWRI-BAS)

The report was prepared in accordance with the Rector’s Order No. RD-38-3/7.1.2025 of Sofia University "St. Kliment Ohridski", Prof. Dr. Georgi Valchev.

1. General remarks

Valcho Pophristov holds two Master's degrees:

- The first - Engineer in "Information and Control Technologies", awarded by the University of Chemical Technology and Metallurgy in Sofia in 1997.
- The second - meteorologist, awarded by the Sofia University " St. Kliment Ohridski " in 2016.

Valcho has 7 years experience as a meteorologist at NIMH (National Institute of Meteorology and Hydrology), Sofia, and since 2022 he is working as a meteorologist at CAWRI-BAS. In

January 2020 he was enrolled as a part-time PhD student at Faculty of Geology and Geography, Sofia University.

The examination of his documents showed that he had passed the required exams and that he had fulfilled all the conditions of the Sofia University regarding doctoral training and the submission of a thesis. In March 2024 he was released with the right to defend himself.

The submitted dissertation is 173 pages long, including an introduction, 5 chapters, a bibliography and an appendix of 50 pages. The abstract is 47 pages long and correctly reflects the content of the thesis.

2. Characteristics of the dissertation

The chosen research topic is in line with the increased interest in the contemporary climate change and the study of the factors driving these changes. It is proposed that climate change causes distortion in the frequency of occurrence of certain circulation types, which in turn lead to an increase in temperatures on the territory of Bulgaria. This approach requires a typification of the synoptic processes influencing the main climatic variables (temperature, pressure, precipitation) and subsequently a classification of these processes with a focus on Bulgaria.

The *introduction* to the thesis gives a brief assessment of the relevance of the research problem, the aims and objectives of the research, and information on the structure of the thesis. Some limitations of the chosen methodology are outlined, mainly related to the relatively low resolution of the synoptic maps analysed, the seasonality in the intensity of the Synoptic systems, etc.

The *first chapter* provides a summary of the existing classifications of the different types of circulation. It is noted that the subjective approach chosen by the PhD student V. Pophristopv for the analysis and evaluation of the main synoptic types comes closest to the classification of circulation types for the region of Greece.

Chapter two presents in more detail the approach used to typify the synoptic situations in Europe that influence the weather over our country. Due to the complex topography of the Balkans, the classification of the synoptic situations is based on the determination of the direction of the centres of the synoptic formations with respect to the location of Bulgaria. A huge amount of pressure field maps at two pressure level – 500 hPa and ground level, consisting of hourly maps published 4 times a day, for every day and every year in the period 1871-2020 (i.e. about 438076

maps) - has been subjectively analysed. As a result of this analysis, 13 types of synoptic conditions are distinguished at 500 hPa level and 16 types at ground level. The climatic manifestations of each circulation type are described and illustrated with colour maps.

The *third chapter* is devoted to the study of the frequency of occurrence of different circulation types at both levels (surface and 500 hPa), based on annual and seasonal means. Trends in the frequency of occurrence of the different circulation types are analysed, both for the entire 150-year period and for individual 30-year climatic epochs. The relationships of the different circulation types with temperature and precipitation measured at the meteorological station of NIMH – Sofia, by season are studied. The statistical relationships of surface temperature and measured precipitation with some anticyclonic/cyclonic conditions were found, which could be used in the future to improve the medium-range forecast of these meteorological variables for Sofia.

However, the presumed long-period correlation between precipitation in Sofia and the western cyclonic circulation should be treated with caution, as it is evident from Fig. 82 that such a correlation could not be traced in the years before 1945.

The *fourth chapter* investigates the existence of statistical connectivity between some large-scale climate modes: NAO (North Atlantic Oscillation), AMO (Atlantic Multidecadal Oscillation), AO (Arctic Oscillation), IOD (Indian Ocean Dipole), PDO (Pacific Decadal Oscillation), SOI (South Atlantic Oscillation), MOI (Mediterranean Oscillation Index) - on the one hand, and the different circulation types influencing the weather over Bulgaria - on the other hand. The assessment of the statistical connectivity is based on the calculated Pearson correlation coefficients using annual averages of the variables under study.

However, the estimated correlation coefficients are not large enough, mainly because of the higher frequency of variability of most of the selected climate indices. For example, the stronger influence of the AO on some of the circulation types from the classification is apparently due to the fact that this index is not seasonally dependent, unlike the NAO, whose influence is strongest during the cold half of the year. For this reason, it is more useful to analyse the monthly rather than the annual values of the variables considered (pressure, temperature, precipitation). This is the case for all climatic modes (indices) with a period of variation of less than one year. In order to reduce the internal variability of the monthly mean time series, it is usually necessary to create

two sub-samples corresponding respectively to the positive and negative phases of the climate index. This approach could help to identify the factors that have a decisive influence on the respective types of circulation.

I should also note the PhD student's misinterpretation of the “correlation coefficient” and the statistical “significance” of the results. According to him, "statistical significance" is of paramount importance (p. 101, middle). In fact, the degree of association between two or more variables is measured by the size of the correlation coefficient, or better still, its square. Statistical significance, on the other hand, is only an indication of the reliability of the result obtained. For example, correlation coefficients calculated on long series of data are always statistically significant, even if the coefficient is very small. However, this does not mean that the correlated variables are closely related.

My earlier comment (regarding the relatively low correlation coefficients between circulation types, temperature, precipitation, large-scale climate modes, etc.) is therefore related to a proper understanding of the degree of association. In other words, statistically significant but small correlation coefficients can be safely ignored because their contribution to the overall variability of the dependent variable is small.

Chapter five systematises the findings of the study. Overall, the conclusions are a logical summary of the findings in chapters 2, 3 and 4. However, I would like to draw attention to the accuracy of the formulations. It should be emphasised that the meridional transport, unlike the zonal transport, is never dominant over the Atlantic-Europe region. The meridional circulation is sporadically in favour during the negative phase of the NAO.

3. Significance of the author's scientific contributions to science and practice

- Undoubtedly, the most important contribution of Valcho Popchristov is the typification of the synoptic conditions influencing the weather over our country, based on data for a period of 150 years (1871-2020). This typification is the basis for created by him classification of the main circulation types for Bulgaria. The author himselfs has qualified this contribution as *scientific-methodological*. I would also add that it is a contribution *aimed at the practice and needs of the society.*
- On the second place I would put the statistical analysis of the potential link between individual circulation types and large-scale climate modes (indices). This analysis needs

to be refined to derive specific empirical relationships, as these could be used in the future to improve medium-range weather forecasting. I classify this contribution as *scientifically applied*.

- In third place I put the statistical study of the relationship between temperature and precipitation in Sofia and certain synoptic conditions. I classify this contribution as an *enrichment of scientific knowledge*.

4. Promotion of the dissertation results

The results of the thesis have been presented to the scientific community. Three oral presentations have been given: (i) at the European Meteorological Society Conference (Bratislava, September 2023), (ii) at the 5th CAWRI-BAS National Conference (Sofia, October 2023) and (iii) at the 6-th International CAWRI-BAS International conference (Hisarya, september, 2025).

3 papers were also published in the proceedings of 3 conferences:

(i) 21st International Multidisciplinary Scientific Conference (SGEM), Albena, Bulgaria, June, 2021]

(ii) 5th National Conference of CAWRI-BAS, Sofia, October 2023;

(iii) 6th International Conference of CAWRI-BAS, Hisarya, Bulgaria, September 2024.

5. Critical remarks

In the opinion of the reviewer, the lack of a chapter detailing the data used and the methods of analysis is an omission in the construction of the thesis, that significantly hinders its perception and understanding. For example, the classification of different types of synoptic events is based on the analysis of hourly maps produced by NCEP reanalyses 4 times a day. Furthermore, the determination of the frequency of occurrence of each circulation type is likely to be based on daily mean maps, but this is not sufficiently clear from the proposed text. It is also not clear enough on what basis the trend of each circulation type has been determined - annual/seasonal averages, hourly, daily or monthly?

Furthermore, the formula for calculating the Pearson correlation is written incorrectly - formula (3.2). The strange thing is that in the source cited by the author, the formula is written correctly. This suggests that this is a distraction error made by the author.

I also have some terminological notes about imprecise language making the text difficult. For example, the annual progression of the frequency of occurrence of circulation types is described as the 'annual distribution' of a given type (both in the text and in Figures 68, 70, 71, 72, 73, 74, 75). This is somewhat confusing, as distribution has a different meaning in statistics. In addition, climate indices are referred to as 'circulation indices' throughout the text, which, together with the circulation types, makes reading difficult in some places.

I would like to emphasise that these remarks, as well as the clarifications made in some places of this review, are not intended to diminish or question the contributions of the doctoral student. Valcho Pophristov is a serious researcher, hard-working and ambitious, so my comments are only intended to show that (i) precision in the language and layout of the text, facilitates the reader's understanding; (ii) statistical interpretation of the results obtained is not a simple and unambiguous process, but requires special attention and multiple, versatile checks.

6. Conclusion

The thesis presented for review is relevant and defensible. The doctoral candidate demonstrates good skills in processing different types of data, analysing and summarising the results obtained. The thesis shows that its author has acquired extensive knowledge in the methodology of analysis and typification of different synoptic environments, as well as in the search for statistical relationships between the variables analysed. This knowledge and skills are essential for his further work as a researcher.

Considering the author's scientific contributions and taking into account the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria and the Regulations for its implementation, I can conclude that the candidate has the necessary qualities and experience for the acquisition of the scientific and educational degree "Doctor" (PhD). This gives me reason to recommend to the esteemed scientific jury to vote in favour of awarding the degree of "Doctor" to Valcho Petrov Pophristov in the scientific field of "Climatology".

Author of the review: .....

/ Professor, DSc. N.A. Kilifarska/

18.03.2025г.
Sofia