

REVIEWER'S REPORT

of a thesis submitted for awarding the scientific degree "Doctor"

Author of the Thesis: **Mirna Matov**

Title of the Thesis: "Climate change and projections for the 21st century in the Black Sea region and the Balkans. "

Thesis supervisor: Assoc. Prof. Dr. Elisaveta Peneva, SU

Reviewer: Assoc. Prof. Dr. Guergana Guerova, SU

Field of higher education: 4. Natural sciences, mathematics and informatics,

Professional field: 4.1. "Physical Sciences" (Meteorology)

By order No. 38-127/16.03.2023 of the rector of the SU, I have been designated as a member of the scientific jury for awarding the educational and scientific degree "doctor" in professional field 4.1. "Physical Sciences" (Meteorology) by full-time doctoral student Mirna Matov.

The documents submitted to me (dissertation, abstract, list of publications, publications as well as a curriculum vitae) meet the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria (ZRASRB), the Regulations for the implementation of ZRASRB of the Council of Ministers of the Republic of Bulgaria and the Regulations for the conditions and procedures for acquiring scientific degrees and academic positions in the Faculty of Physics of Sofia University "St. Kliment Ohridski (SU), which allowed me to review the dissertation work.

1. General characteristics of the dissertation work

The dissertation work presented to me for review in terms of style, volume and content corresponds to the specific requirements of the primary unit in which it was prepared. Its total volume is 127 pages, structured in 8 chapters. The bibliography lists 150 titles and Internet sources. The graphic material consists of 67 figures and 14 tables of very good quality.

The aim of the dissertation is to assess the changes of four meteorological elements for the Black Sea and Balkan Peninsula region in the 21st century, using satellite observations and numerical experiments with a regional climate model for two scenarios from the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC AR5). In Chapter I, the relevance of the problem is presented and the observed changes in global temperature, precipitation, general atmospheric circulation, sea level pressure and surface wind are indicated. It makes a good impression that, in addition to the fifth assessment report of the IPCC, the assessments from the new sixth report published in 2022 are also indicated. In addition, it is pointed out that there are fundamental differences in the assessments by regions, such as for the Balkan Peninsula and the Black Sea, this type of research is not yet sufficiently detailed despite the active work in the last two decades. Chapter II presents the method of work and the observations used. It should be noted here that the combination of 1) global climate reanalyses and projections, 2) a regional climate model with high spatial resolution, and 3) ground-based observations and indices is the

modern approach for this type of study and deserves admiration. Chapter III reviews the state of the climate system in the period 1979-2005 for the Balkan Peninsula-Black Sea region. This chapter is an important element of the dissertation because it quantitatively analyzes the current state of the climate in the region and evaluates the ability of the regional numerical model Aladin v5.2 to reproduce the seasonal values of the four selected meteorological elements. It should be noted that the numerical model significantly overestimates the measured precipitation values, as for the summer season it is almost double. The dissertation rightly notes that this is a common problem of this type of model, but I do not agree that the reasons are mainly due to the parameterization. I believe that they are complex and are related to the representation of the model's hydrological cycle, and I recommend that in future work, attention is given not only to precipitation, but to water vapor, which is a major factor in cloud formation and the likely primary source of this significant flaw in the model. Chapter IV presents the results of numerical experiments on future trends in climate change under two scenarios (Representative Concentration Pathway RCP4.5 and RCP8.5) and three periods, namely 2011-2040, 2041-2070 and 2071-2100. RCP4.5 and RCP8.5 are climate scenarios for radiative forcing to a maximum of 4.5 and 8.5 W/m² by the end of the 21st century. In chapter V a complex analysis and evaluation of the Black Sea freeze-up and a connection with an index of winter severity is made. This chapter is of particular interest for Bulgaria and the region and could serve in the future operational forecast of freeze-up of Black sea. Chapters VI, VII and VIII present the conclusion, summarize the main contributions of the PhD and list the publications and presentation of the results.

The tasks set in the dissertation can be formulated as:

- 1) Investigation of 1) air temperature (2 m), 2) precipitation amount, 3) wind speed (10 m) and 4) atmospheric pressure at sea level for the Balkan Peninsula-Black Sea region for the period 1979-2005 and climate projections for the 21st century.
- 2) Quantitative analysis of regional climatic factors related to the freezing of the Black Sea.
- 3) Projections of possible changes in the seasonal climatic centers of action Siberian maximum and Mediterranean minimum during the cold half-year.
- 4) A qualitative analysis of possible future trends in extreme weather and climate events with a focus on wind speed.

2. Relevance of the topic

Climate change and its impact on socio-economic life are undoubtedly one of the most complex tasks to be solved. For this purpose, the European Commission is developing policies to make Europe climate neutral by 2050 (Green Deal). The policies underlying the "Green Deal" are based on a new generation of numerical models, analyzes and observations of the earth from space developed in the "Digital Twin of the Earth" project by leading European centers such as the European Space Agency, the European Center for Medium-Range Weather Forecasts and the European Organization to develop meteorological satellites. In this context, the research done in this dissertation is essential to improve the understanding of the current state of climate in the region. In addition, the use of a regional climate model is of key importance as one of the shortcomings of the currently developed national policies in this area is the use of mainly global climate models with low spatial resolution.

3. Major scientific and scientific-applied contributions

The main scientific contributions in Mirna Matov's dissertation work can be summarized in the following directions:

- 1) A trend of increasing temperature and decreasing pressure has been established for the Balkan peninsula in the Black Sea region for three decades.
- 2) It is found that under the RCP4.5 scenario, by the end of the 21st century, a decrease in the intensity of the Mediterranean Center of Action and an increase in the frequency of stormy wind events can be expected.
- 3) Satellite observations of the area and duration of freeze-up in the Black Sea were used for the first time in a renewed classification of the intensity of winters by means of a severity index.
- 4) It has been established that freeze-up in the northern part of the Black Sea are related to specific synoptic conditions, and the influence of the Mediterranean depression has been significantly assessed.

The significance of the scientific contributions to science and operational forecasting is indisputable, and part of the obtained results were used in a World Bank report for the preparation of a National Disaster Risk Profile in Bulgaria.

4. Scientific publications on the topic of the dissertation

The results of scientific research related to the topic of M. Matov's dissertation have been published in 4 scientific works, 2 of them in a journal with an impact factor, and 2 published in conference proceedings. As for the PhD student's personal contribution, she is the lead author in three of the publications. The scientific publications included in the dissertation cover the minimum national requirements (according to Art. 2b, paras. 2 and 3 of the RSARB) and the additional requirements of SU "St. Kliment Ohridski" for obtaining the educational and scientific degree "doctor", in the scientific field and professional direction. No plagiarism was found in the submitted dissertation and abstract.

Due to the mode of presentation, it cannot be assessed whether the results of the dissertation have been reported at national/international conferences.

5. Critical remarks and recommendations

I have the following remarks about the work:

- 1) On the structure: Chapters VI, VII and VIII are short and could easily be combined into one chapter with three sections.
- 2) On the content: the use of only one climate model is a shortcoming of the work.
- 3) About the figures: the text to the figures is short and often lacks a detailed description of each figure when they are in a panel of 3 or 5 (see fig. 3.4, 3.7, 3.10, 4.1, 4.2, 4.3, 4.5, 4.6/71, 4.6/ 73, 4.8, 4.9, etc.). Figure 4.6 is repeated twice on pages 71 and 73. Other inaccuracies are also found, which are not desirable in a PhD thesis.
- 4) Other

4.1) The participation of the doctoral student in scientific forums is reflected incompletely. It is not stated whether it is an oral presentation or a poster. The information about the forum is also scarce. This does not allow for evaluation of this type of activity.

4.2) Regarding the style in the text, there are inaccurate translations from English such as "model simulations" which has a more than good Bulgarian equivalent "numerical experiments". The term "1030 isobar" is not used correctly, I recommend using "1030 hPa isobar". A large number of spelling errors are found (almost on every page). Careful editing of the text is mandatory.

4.3) The use of measurement units is indiscriminate. Wind is written in Bulgarian while pressure is in SI units. In the scientific style, only SI units are used, both in Bulgarian and in English. It is recommended to edit the text in this part.

I have the following questions for the PhD student:

1) The choice of a regional climate model organizes the reliability of the climate projections made. Is it possible to overcome this shortcoming and how?

2) Is it possible to make corrections to the detected overestimate of precipitation using machine learning?

3) Based on the research, what recommendations could be made for updating the "National Disaster Risk Profile in Bulgaria".

6. Abstract

The abstract of the dissertation is in Bulgarian and English. It is laid out on 57 pages and correctly reflects its content, including the main graphic material. Formulated contributions and publications on the topic correspond to those listed in the dissertation.

7. Summary

Taking into account the presented facts, I consider that the dissertation of M. Matov meets the requirements of ZRASRB, the Regulations for the conditions and procedures for acquiring scientific degrees and academic positions of the SU and the Recommended requirements for candidates for acquiring scientific degrees and the academic positions in the Faculty of Physics. This gives me the reason to give a positive assessment of the dissertation work of the doctoral student and to propose to the respected scientific jury to award Mirna Matov the educational and scientific degree "Doctor" in professional field 4.1. "Physical Sciences" (Meteorology).

28.05.2023 г.

Reviewer:

Sofia

(assoc. prof. Guergana Guerova)