

R E V I E W

of a PhD thesis for awarding of an educational and scientific degree "doctor"

Author of the dissertation: **Viktoria Lubomirova Kleshtanova**

Dissertation topic: **A complex approach to the research of atmospheric aerosols**

Research supervisor: **Assoc. Prof. Dr. Veselin Tonchev**

Professional direction **4.1 Physical sciences (Meteorology)**

The dissertation was prepared in: **Department of Meteorology and Geophysics – Faculty of Physics, Sofia University St. Kliment Ohridski .**

Reviewer: **Assoc. Prof. Dr. Elisaveta Lazarova Peneva** (Sofia University St. Kliment Ohridski)

I was appointed as a member of the scientific jury for this defense by the order of the Rector of SU "St. Kliment Ohridski" No. RD38-188 of April 25, 2023. The first meeting of the scientific jury took place on May 3, 2023, and I was selected as a reviewer. The package of documents submitted (dissertation, abstract, curriculum vitae, list of publications, the publications themselves) comply with the requirements of the law for the development of the academic staff in Bulgaria (ZRASRB), the Regulations for the Implementation of the ZRASRB of the Council of Ministers of the Republic of Bulgaria (PPZRASRB), and the Regulations for the Terms and Procedures for awarding Scientific Degrees and occupying academic positions at Sofia University. This gave me reason to review the dissertation.

I. General description of the presented materials

1. Biographical data about the candidate

The candidate Viktoria Kleshtanova fulfills the requirements of Art. 6 of ZRASRB, since she received the educational degree Master in Meteorology in 2018, in January 2019 she was enrolled as a doctoral student in the PhD program "Meteorology" of Sofia University "St. Kliment Ohridski" accredited by the NAOA in regular form with a study period of 3 years (until 2022), subsequently transformed into correspondence form and extended; the preparation was carried out according to the requirements of Section II of the PPZRASRB; a PhD thesis defense procedure has been opened.

Viktoria Kleshtanova graduated a bachelor's degree in "Astrophysics, meteorology and geophysics" in 2016, and after a master's degree in "Meteorology" in 2018 at Sofia University "St. Kliment Ohridski". For a short time in the period 2017-2018, she worked as a specialist-meteorologist at Energovia EOOD, where she applied her knowledge of numerical forecasting. In 2019, she started to work in the National Institute of Meteorology and Hydrology, in the Department "Forecasts and Information Service", where she has

been working until now. This gives her the opportunity to deepen her skills in operational weather forecasting and work on her dissertation in parallel. In 2019, she was enrolled as a full-time doctoral student, in 2021, the doctoral program was transformed into a correspondence form and extended by one year. The candidate has significant experience in the operational work as a forecaster, as well as in research work, participation in conferences and others.

According to the documents presented to me, I do not find any violations in the procedure, I consider the criteria for admissibility of the candidate for defense to be fulfilled to a sufficient extent, which gave me a reason to review the work.

2. General characteristics of the dissertation work

The material, volume and content of the dissertation submitted to me for review corresponds to the specific requirements of the primary unit in which it was prepared (Meteorology and Geophysics Department of the Faculty of Science).

Its total volume is 111 pages, structured in 8 chapters, the first two introducing the issues of the dissertation, ending with a conclusion, a list of scientific and scientific-applied contributions and a list of references. The bibliographic reference lists 129 papers, of which 3 are in Bulgarian and the rest in English; 4 sources from the world wide web are also indicated. 91 of the titles were published in the last 20 years; this indicates a good knowledge of the PhD student of both classic works on meteorology (there are articles from the 19th century as well) and the current state of scientific research related to the topic of the dissertation. The graphic material (50 figures in total) is of good quality. Introduced there are also 7 tables with a summary information .

Chapters 1 and 2 explain the relevance of the thesis topic: in recent years it has become increasingly clear that aerosols and their interaction with clouds should be studied as a climate factor. High-mountain observations of cloud condensation nuclei are particularly valuable because they represent the transport of air masses in the free atmosphere uninfluenced by the earth's surface. This study of the observations made in BEO Musala is the first of its kind. Information is given on the classification of aerosols, the specific characteristics of cloud condensation nuclei (CCNs), the theory of aerosol-cloud interactions and the prediction of CCNs. Twomey's law and Koehler's law are described, the first being the theoretical basis of the dissertation. The results of various observations of CCNs in different regions of the world are described, with special attention being paid to similar studies in the Balkan Peninsula and Bulgaria.

The main tasks addressed in the dissertation are formulated as follows:

- To show regularities in the distribution of CCNs, measured in BEO Musala;
- To determine minima and maxima in their concentration;
- To investigate the relationship between the distribution of CCNs and the synoptic situation with the corresponding circulation;
- To describe process of nucleation with empirical laws.

Chapter 3 describes the data used and their processing methods: details of the BEO Musala observations and the accumulated database are given. The HYSPLIT model, which is used to calculate the back trajectories, is also described. For representative synoptic maps, maps from the reanalysis of the US National Center for Environment Prediction were used; The classification of the circulation used to characterize the synoptic situations is also described. Chapters 4 to 8 present the actual results of the work. Chapters 4, 5 and 6 describe the results of the processing of the CCNs observations from BEO Musala, presenting statistics, extreme values and concentration evolution. An attempt was made to find the relationship of the CCN concentration with the synoptic processes, as well as of the extreme values with the type of circulation in the region; two well-known approaches for classification are used. Chapters 6 and 7 are contributions to the theoretical study of CCN in terms of concentration and nucleation. They add knowledge to help CCN concentration prediction, which I believe will be very relevant in the near future.

3. Relevance of the topic

Aerosols are an important component of the atmosphere, and for several decades it has become clear that many of the processes and feedbacks in the atmosphere cannot be described without them. In particular, they play a role in cloud formation, and numerical models often fail to capture the full complexity of microphysical processes by only parametrizing their effects. This made it necessary to build systems for their monitoring, which are specialized and expensive equipment, thus they are relatively rare. Ground-based and satellite observations of the aerosol composition are very valuable, especially the high-mountain observations, as representative of the free atmosphere. In Bulgaria, the unique system for determining the concentration of aerosols has been operating in BEO Musala, at almost 3000 m above sea level, for several years. These measurements have great potential to serve as a reference for satellite observations. These data are processed comprehensively for the first time, and I consider this to be the main contribution of the dissertation. In my opinion, this study marks the beginning of the systematic processing and operational use of this valuable information on air composition.

4. Basic scientific and scientific-applied contributions

According to paragraph 9 of the thesis, the candidate describes 4 main contributions that I refer to the group of scientific and applied.

- A correlation has been established between the maxima in the concentration of atmospheric aerosols, the backward trajectories of air masses, and the synoptic conditions during 2016; I believe that the bulk of the doctoral student's effort went into this task and that it was successful.
- Dependencies have been found between the extremes in the concentration of aerosols and the types of Jenkinson-Collison-Types circulation; Again, much of the

PhD student's work is on this topic, and although some results can be interpreted ambiguously, the material shown contributes to an understanding of the problem.

- High correlation coefficients have been found between a parameter from Twomey's equation and the temperatures at Moussala and Borovets; I think that these results are very interesting and useful as they prove the applicability of empirical laws to describe the relevant processes.
- A jump in the time scale from one nucleation mode to another is obtained; This study is very different in methodology, approach and scale from the previous chapters. It adds knowledge to laboratory nucleation that can potentially be applied to real-world cloud formation conditions. The conditions of the experiment are correctly presented and the results are described in detail. I can't judge how relevant it could be to the real life condition.

I would like to make a recommendation to the doctoral student, to think about how the observations at BEO Musala can be integrated into the operational practice of the National Institute of Meteorology and Hydrology. This would be a very significant contribution of the dissertation.

5. Scientific publications on the topic of the dissertation

There are 5 publications on the subject of the dissertation , of which 4 are in a journals with an impact factor and 1 is in the Bulgarian Journal of Meteorology and Hydrology. The author's check in the scientometric database Scopus shows 2 titles, one of which is published in the well-known high-impact journal Journal of Atmospheric and Solar-Terrestrial Physics, and the other is in the proceedings of the 10th Jubilee International Conference of the Balkan Physical Union. The other two titles are expected to be published soon. An individual rating for each of them is given below:

- V. Kleshtanova, VV Ivanov, F. Hodzhaoglu, JE Prieto, V. Tonchev, Model hierarchy to reanalyze results from an archetypical experiment on the kinetics of heterogeneous nucleation - the electrodeposition of Hg on Pt, by I. Markov and E. Stoycheva. Crystals (MDPI): article in a journal with quartile Q2; it is not presented in the package of documents and is available on the Internet as a preprint; it considers experiment on nucleation in laboratory conditions; It is described in Chapter 8, but it is a topic too different from the rest in the dissertation and doesn't follow the line in the main part on the dissertation .
- Kleshtanova, V., Tonchev, V., Angelov, Ch.: Extremes in the concentrations of CCN at Mt. Moussala and synoptic classifications, Proceedings of the Bulgarian Academy of Sciences, 2023, accepted for publication.; article in a journal with quartile Q2 ; It describes the relationship of extreme values of CCN concentration and the type of circulation over the Balkan Peninsula; in the dissertation, this material is placed in Chapter 6
- Kleshtanova, V., Stoycheva, A., Tonchev, V., Angelov, Ch.: Cloud condensation nuclei and backward trajectories of air masses at Mt. Moussala in two months of 2016, Journal of Atmospheric and Solar-Terrestrial Physics, 2023; article in a

journal with quartile Q3; describes the approach with the calculation of the back trajectories and the origin of the air masses, which is described in Chapter 5 in the dissertation.

- Kleshtanova, V., Angelov, Ch., Kalapov, I., Arsov, T., Guerova, G., Tonchev, V. What one can learn from the cloud condensation nuclei (CCN) size distributions as monitored by the BEO Moussala? , AIP Conference Proceedings. 2019; an extended abstract in the proceedings of the 10th Jubilee International Conference of the Balkan Physical Union, it presents in general the data from the observations of the OKA in BEO Musala and shows results of a preliminary study of their relationship with synoptic processes; in the dissertation, this topic is described in Chapter 4.
- Kleshtanova, V., Stoycheva, A., Tonchev, V.: Distributions of cloud condensation nuclei related to two synoptic situations in 2016. Bulgarian Journal of Meteorology and Hydrology 23, 17–30., 2019; article published in a refereed Bulgarian journal, well known among Bulgarian meteorologists; investigates the relationship of CCN concentration with synoptic processes, is described in Chapter 4.

Citations of these articles have not yet been reported (according to the scientometric database Scopus.com) , which is normal for a doctoral student's publication in the current and last year.

As for the assessment of the degree of personal involvement of the doctoral student in the contributions, I consider it very high. In the presented 5 publications on the subject, as well as 6 participations at conferences, V. Kleshtanova is the first author.

From what has been said so far, it can be seen that the minimum national requirements have been met, as well as the specific requirements of the Faculty of Physics of SU "St. Kliment Ohridski" regarding the publication activity of the doctoral student.

6. Questions and critical remarks

During the review of the dissertation, the following questions arose:

- In Chapter 6 it is said that, both at extremely low values of CCN concentration and at extremely high ones, the type of circulation is mostly NW and W. Doesn't this mean that the extremes are not affected by the circulation?
- For 2016, 38 cases with extremely low concentrations of CCN and 44 cases with extremely high concentrations were reported. What is the percentage of cases, the number alone does not provide useful information?
- Is it possible in a real situation that CCNs are not activated and at what saturation?
- How does what is described in Chapter 8 relate to what is described in Chapters 4-7, can observations from BEO Mussala be used to validate laboratory experiments on the electrodeposition of mercury on platinum cathodes?

I also have the following recommendations and critical remarks about the work:

- I would recommend that the names of the scientists should also be written in Bulgarian (in brackets Latin according to their native language), so that it is clear how they are pronounced in Bulgarian.
- The description of the satellite observation methods could be in a separate paragraph to separate them from the ground-based ones.
- It is good to give wind roses in percentages for comparability.
- When calculating back trajectories, it would be useful to have a “spaghetti” figure visualizing them, it would help the reader; such diagrams are shown in one of the doctoral student's articles.
- The data used is in 2016, but different periods are inconsistently chosen for different purposes, sometimes July and January, sometimes July and December, sometimes November or August are added. The complex approach implies a more general consideration, not limited within a month.
- Chapter 8 stands somewhat apart from the others and seems unrelated to the main line in the thesis.

7 . Personal impressions

I know the PhD student as a student in my Physics of Climate course. Even then, I was impressed by her persistence, perfectionism and determination to finish what she started. Over time, my good opinion solidified, and I believe that the work on the dissertation was also useful for her future career development.

8 . Abstract

The abstract on dissertation, presented on 56 pages, reflects correctly its content and includes the main conclusions, analytical and graphic material. Formulated contributions and publications by the topic correspond on those listed in the dissertation. A recommendation to pass a check for grammar and syntax errors could be done.

9. Conclusion

After having familiarized myself with the presented dissertation work, Abstract and other materials, and based on the analysis of their significance and the scientific and scientific-applied contributions contained in them, I confirm that the scientific achievements meet the requirements of ZRASRB and the Regulations for its application and the relevant Regulations of the SU "St. Kliment Ohridski" for awarding the educational and scientific degree "doctor". In particular, the candidate satisfies the minimum national requirements in the professional field 4.1 Physical Sciences (Meteorology) and no plagiarism has been found in the dissertation, abstract and scientific works submitted for the graduation.

I give my positive assessment of the dissertation work.

II. General conclusion

Based on the above, I recommend the scientific jury to award the educational and scientific degree "PhD" in professional field 4.1 Physical sciences (Meteorology) to Viktoria Kleshtanova.

Date: 25.06.2023

Reviewer: Assoc. Prof. Dr. E. Peneva