Review on the dissertation of Martin Hynčica with the title „Nonstationarity of the effects of modes of atmospheric circulation variability on surface climate elements“

The submitted doctoral thesis consists of five essential sections. The main part of the work consists of chapters 2, 3, and 4, which contain four original scientific papers. The main and corresponding author of all papers is Martin Hynčica. Three papers have already been published in high-quality climatological journals: Journal of Climate, International Journal of Climatology, and JGR Atmospheres, all in Q1 rank in Meteorology and Climatology. The fourth article is under review. The introductory chapter clarifies the motivation, main goals, and basic terminology; on the other hand, the final fifth chapter summarizes the main results achieved and outlines the possible expansion of the studied issue in the future. The individual parts organically follow each other and the work forms a logical whole.

Topicality of the thesis

The thesis deals with the circulation modes and with their links to the variability of the surface air temperature and precipitation fields. The main scientific topic is the investigation of the variability in the action centers of individual circulation modes and its impact on surface climatic variables in space (NH – extratropics) and time (mostly 20th century),

The initial symptom of the current global climate change has been relatively well detectable soon in the air temperature fields and was referred to as global warming. However, its manifestations in the fields of other main meteorological elements are more challenging to detect as it can often be overshadowed by the natural variability of the climate system. This is the case with atmospheric circulation and variability of the main circulation modes. For this reason, I consider the topic of the submitted doctoral thesis to be very current.

Main goals, used data and methods

The author sets three main goals, which he explicitly mentions at the end of the first chapter. The fulfillment of these goals is successively achieved in the four mentioned publications. All four scientific papers use practically the same primary input datasets. Also, the basic methodological approaches are common to all articles. The data are represented primarily by the fields of the 500-hPa heights coming from six re-analyses. Temperature and precipitation fields come from the CRU database.

The main circular modes for the NH extratropic are calculated from these fields using the PCA method. Common descriptive and inferential statistics methods are used subsequently to find and quantify differences between individual circulation modes, the location of their action centers, the development of linkages between circulation modes, and the variability of air temperature and precipitation. Each of the following articles uses the results of the previous articles and clearly advances the level of results achieved.

Main results

Even though the individual studies use similar data and analysis methods, outputs from each of the four studies provide original scientific results that advance the debated issue of circulation modes toward their more detailed understanding. The achieved results are valuable from the point of view of basic research in climatology. In addition to this main contribution, I appreciate that some results

also indicate the need for closer communication between climatology and other disciplines in the field of methodology (see my comments and questions on spatial interpolation problems discussed in JGR2020 below). Here I positively evaluate the author's suggestions regarding spatial interpolation. Regarding this topic, it is appropriate to state that several indicated problems have been solved by geostatistics. But the question of "correct" spatial interpolation is far more complicated. For example, what to do if there is a lack of spatial autocorrelation in the data? Interpolation of the precipitation fields can be mentioned as an example.

In the case of the fourth publication, a description of the methods used and a presentation of the results would deserve more precision, in my opinion. It is not explained why the PAM non-hierarchical clustering method was chosen. It would be appropriate to indicate how the optimal number of clusters could be determined objectively. An excellent presentation of the clustering results in Figs 2 and 3 (p. 76 and 78) is given as "Clusters with similar temporal evolution of relationships between …". However, the second paragraph on p. 73 states "… some clusters cover areas with opposite relationships with circulation modes". I see a certain inconsistency in these statements. I wonder how to deal with the fact that many of the results are based on correlations far from the statistical significance of the relationships being studied (for instance, page 75, the first paragraph).

Three of the four scientific articles passed the review process successfully. For this reason, I do not deal in detail with individual aspects of published articles in this review. Instead, I raise some questions where these results deserve – according to my opinion – more detailed explanation and clarification.

Questions and comments

1) Nonstationarity is a statistical term that has an exact definition. Moreover, there are at least two types of (non)stationarity. What is the meaning of this term in your doctoral thesis?
2) JCLI2020, Fig. 1 - In scree plots; it is very hard to identify any clear drop, determining the number of significant components. To what extent were these numbers “influenced” with *a priori* knowledge of existing circulation modes? Did you try to apply any other criterion?
3) Changes in the relationship between the circulation modes and temperature in time were measured with running correlations. These correlations were calculated “with a one month shift” (JGR2020) or “the one-month step” (JCLI2022). Could you please explain more deeply? Does it mean a time lag between the circulation modes and temperature? If so, was one month set somewhat arbitrary? And who lags? And finally, according to You, who is the primary diver of changes in circulation modes?
4) JGR2020 – In climatology, homogenization means especially „homogenization in time.“ However, would it be possible to define the rules of „homogenization in space“? What could be the principles?
5) One of the results of the presented work is the identification of changes in the position of the action centers of some circulation modes. Have you considered whether these position changes are statistically significant? That is, whether they represent an actual signal distinguishable from a random noise, which may be related to the spatial resolution of the input data, interpolation methods, etc.

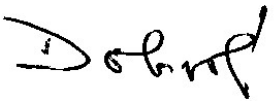
6) In JCLI2022, section 2.3 Cluster analysis: “The time series adjusted for the strength of correlation are concatenated, which results in one series of running correlations with all nine circulation modes at each gridpoint.” Please explain more clearly.
7) JCLI2022 - Your analysis identified 18 temperature and 11 precipitation clusters. This is somewhat surprising considering the fact that air temperature is spatially more homogeneous than precipitation. Can you please comment on this?

Formal comments

- Czech abstract: Reading “gridované datasety” I get goosebumps.
- English abstract states that the 20CRv2c reanalysis „… contains biases“. However, the abstract in Czech „… obsahuje chyby“. I don't think it means the same thing.
- In JCLI2022, p. 73 – “island stations“ – Should not be “grids”?
- In JCLI2022, p. 73 – Where is the definition of the “intensity of circulation mode“?
- In JCLI2022, p. 73 – “larger than +1 and lower than -1.” Should not be “or” instead of “and”? What are the units?

Final assessment

Despite the comments and questions above, I state that Martin Hynčica's dissertation represents a valuable contribution to synoptic climatology. The submitted thesis fully meets the requirements for similar works in the Ph.D. study program Physical Geography and Geoecology regarding form and content. I recommend the dissertation for defense.



Brno, 23 May 2023 prof. Petr Dobrovolný