atmosphere

MDPI

Editorial

Application of Homogenization Methods for Climate Records

Peter Domonkos

Independent Researcher, 43500 Tortosa, Spain; dpeterfree@gmail.com

Climate research requires a large amount of fairly accurate observed climatic data. Time series of climate observation records aim to satisfy this need, but the temporal comparability of data in long time series is almost always affected by non-climatic factors, such as station relocations, changes of the instrumentation, observer practices, microenvironment, etc. The impact of non-climatic factors on the observed data is called inhomogeneity. Inhomogeneities result in uncertainties in climate trend and climate variability estimations; therefore, they should be removed by homogenization as much as possible. Most of the occurring inhomogeneities are small, and the differences between the results of different homogenization methods are normally even smaller. Therefore, and also for the complexity of the topic, only moderate attention is generally dedicated to this scientific area, and the differences between the reliabilities and accuracies of individual homogenization methods have still not been fully explored.

The importance of accurate homogenization is higher than it would seem from the typical size of inhomogeneity biases. Climate models are tested against observed climate variations to check the appropriateness of their parameterization. The execution of such validations is indispensable, since the construction of climate models including all the physical processes of the atmosphere is impossible. If the spatial or temporal structures of climate data include inaccuracies, climate model validation results might be misinterpreted; hence, model development might turn to the wrong direction. Briefly, small errors of present climate trend estimations may cause much larger errors in climate change projections.

The aim of this Special Issue is to present recent research activities performed to facilitate high quality and homogeneous data for climate variability and applied climatological research. The Special Issue includes seven papers belonging to different areas of time series homogenization and data quality improvement.

The topic of the first paper [1] is general quality control of observed climatic data. There is a close relation between general quality control and time series homogenization, firstly because homogenization needs quality controlled data and secondly because both quality control and homogenization serve the minimization of possible non-climatic biases in climate records. The paper of Costa et al. presents a quality control algorithm performed for the time series of six kinds of climate variables observed in Northeastern Brazil.

The next topic is the development of homogenization methods. The most frequently applied methods of statistical homogenization include comparisons between the data series of neighboring observations, and they are named relative homogenization. However, relative homogenization cannot be applied when the distances between neighboring stations are too large. This is the case, for instance, with the homogenization of atmospheric integrated water vapor time series. The second paper [2] offers a solution for this task, which is attentive to the minute details of this homogenization problem. Time series of reanalysis data are used as reference series. As reanalysis data cannot be considered fully homogeneous either, documented technical changes (so-called metadata) are also considered in homogenization whenever possible, and neighbor series data are used as additional information when the proximity of observing stations permits it. As it is usual in time series homogenization, inhomogeneities are supposed to be related to sudden technical changes causing change points in time series. In the method of Nguyen et al., the change points are searched with a modern maximum likelihood method.

check for updates

Citation: Domonkos, P. Application of Homogenization Methods for Climate Records. *Atmosphere* **2022**, *13*, 481. https://doi.org/10.3390/atmos13030481

Received: 23 February 2022
Accepted: 14 March 2022
Published: 15 March 2022

Another difficult task, the homogenization of snow depth time series, is the topic of the third paper [3]. Snow depth is one of the essential climate indicators, because we need accurate snow depth data to find its trends with climate change, but the density of observing stations does not allow performing relative homogenization. Woody et al. offer a method in which the climate change signal is approached with a linear change, while the inhomogeneities are presumed to be caused by abrupt changes. Further interesting details of the method are that the homogenization is performed on the series of daily data, and change point combinations are detected by the use of a genetic algorithm.

The improvement of the accuracy of relative homogenization is the topic of the fourth paper [4]. Recent method comparison tests of the Spanish MULTITEST project showed that ACMANT (Applied Caussinus-Mestre Algorithm for the homogenization of Networks of Time series) is likely the most accurate homogenization method for a quite wide range of homogenization tasks. Domonkos shows details about the theoretical content of ACMANT reasoning its high performance, and the developments for the most recent version (ACMANTv5) are also presented. In particular, ACMANTv5 includes a novel time comparison method, which combines the positive features of pairwise comparisons and the use of composite reference series.

In the fifth paper [5], we turn to the testing of homogenization methods. O'Neill et al. compared different homogenization results for the same European station series obtained by the repeated performance of Pairwise Homogenization Algorithm during the development of the Global Historical Climatology Network (GHCN) dataset. Given that the GHCN dataset was developed and updated in a large number of steps, the homogenizations were repeated many times for the same stations. The change-point positions detected are highly varied, and a smaller but still notable variation of the trends for the homogenized series has been found. The authors conclude that the use of compiled metadata files together with climate records could considerably improve the reliability of homogenization results.

In the last two papers of the Special Issue, the examples for the use of homogenized datasets are presented. Data accuracy is important in many areas of climate research, of which one is the drought climatology. Drought is responsible for a notable portion of economical losses caused by extreme climatic events worldwide, and the global warming related drought tendencies are subjected not only to the changes of precipitation amount but also to the temporal distribution of precipitation falls. It is the topic of the sixth paper [6]. The authors use the precipitation data of a Chinese province, which was homogenized in earlier studies (references are provided).

The changes of the temperature and precipitation extreme indices are the topic of the seventh paper [7]. A climate variability study was performed for a central Mexican region, and the relations to some large-scale circulation indices are also examined. The study uses a dataset of daily time series homogenized by Climatol, which is a relatively new method and is characterized by high homogenization accuracy. In the Methods section of the study, the authors present some important characteristics of the Climatol method.

A word in this Special Issue is present, which I do not like personally. O'Neill et al. write "skepticism" (towards blind tests of homogenization methods). I do not like skepticism, firstly for its general societal and political meaning. I believe that skepticism tends to paralyze and render us introverted. By contrast, we can be unsatisfied. We may be unsatisfied with the present amount and level of completed method comparison tests, because to reach more solid conclusions about the performance of homogenization methods, more tests would be needed both with observed data and synthetic data, and both with and without the inclusion of metadata use. I believe that being unsatisfied is positive and encouraging. Being unsatisfied may inspire us to conduct more research, better research plans and projects, and infill a Special Issue with valuable studies, as we just have done the latter. Thanks to every author of this Special Issue for that.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Costa, R.L.; Gomes, H.B.; Pinto, D.D.C.; Júnior, R.L.D.R.; Silva, F.D.D.S.; Gomes, H.B.; da Silva, M.C.L.; Herdies, D.L. Gap Filling and Quality Control Applied to Meteorological Variables Measured in the Northeast Region of Brazil. *Atmosphere* **2021**, *12*, 1278. [CrossRef]
2. Nguyen, K.N.; Quarello, A.; Bock, O.; Lebarbier, E. Sensitivity of Change-Point Detection and Trend Estimates to GNSS IWV Time Series Properties. *Atmosphere* **2021**, *12*, 1102. [CrossRef]
3. Woody, J.; Xu, Y.; Dyer, J.; Lund, R.; Hewaarachchi, A. A Statistical Analysis of Daily Snow Depth Trends in North America. *Atmosphere* **2021**, *12*, 820. [CrossRef]
4. Domonkos, P. Combination of Using Pairwise Comparisons and Composite Reference Series: A New Approach in the Homogenization of Climatic Time Series with ACMANT. *Atmosphere* **2021**, *12*, 1134. [CrossRef]
5. O'Neill, P.; Connolly, R.; Connolly, M.; Soon, W.; Chimani, B.; Crok, M.; de Vos, R.; Harde, H.; Kajaba, P.; Nojarov, P.; et al. Evaluation of the Homogenization Adjustments Applied to European Temperature Records in the Global Historical Climatology Network Dataset. *Atmosphere* **2022**, *13*, 285. [CrossRef]
6. Wang, S.; Zhang, Q.; Wang, J.; Liu, Y.; Zhang, Y. Relationship between Drought and Precipitation Heterogeneity: An Analysis across Rain-Fed Agricultural Regions in Eastern Gansu, China. *Atmosphere* **2021**, *12*, 1274. [CrossRef]
7. Montero-Martínez, M.J.; Pita-Díaz, O.; Andrade-Velázquez, M. Potential Influence of the Atlantic Multidecadal Oscillation in the Recent Climate of a Small Basin in Central Mexico. *Atmosphere* **2022**, *13*, 339. [CrossRef]