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dr hab. inż. Krzysztof Kochanek, prof. PW
Wydział Instalacji Budowlanych, Hydrotechniki i Inżynierii Środowiska,
Politechnika Warszawska
ul. Nowowiejska 20, 00-653 Warszawa

Review of the doctoral thesis
‘Detection of changes in river floods and flood generating mechanisms in Poland’
by
Nelson Venegas Cordero, MSc.
from
Warsaw University of Life Sciences
Department of Hydrology, Meteorology and Water Management
Institute of Environmental Engineering
Supervised by dr hab. Mikołaj Piniewski, prof. WULS

The review was prepared based on the decision of The Science Discipline Board – Environmental Engineering, Mining and Energy – Warsaw University of Life Sciences (SGGW) on April 24, 2024.

Nelson Venegas Cordero, the author of the PhD thesis, received his Bachelor's Degree in Geography from the University of Costa Rica in 2017. Two years later, he graduated from the Water and Global Change Observatory at the University of Costa Rica, focusing on downscaling and correcting global hydrometeorological data products for local-scale applications. Since October 2020, Mr. Venegas Cordero has pursued his scientific career as a PhD candidate at the Department of Hydrology, Meteorology, and Water Management at Warsaw University of Life Sciences (SGGW). Despite his relatively short scientific career, he has managed to lead research within the PRELUDIUM 21 National Science Centre grant programme. In 2023, he was awarded the title of Best International Doctoral Student and received the Helmholtz Visiting Researcher Grant. He also presented his research at renowned international conferences such as AGU, IUGG, EGU, and IAHS-AISH, among others.

Basic information on the PhD thesis

This thesis, titled ‘Detection of changes in River Floods and Flood Generating Mechanisms in Poland,’ consists of three single-topic scientific articles published between 2022 and 2024. In these articles, the PhD candidate investigates flood indicators in Polish rivers using annual and seasonal block maxima and peak-over-threshold flow time series, as well as flood generation mechanisms in Poland through techniques based on observed and simulation datasets. The PhD candidate argues that climate-related drivers have a stronger influence on current trends in river flood indicators in Poland than urbanization.

The author emphasizes the need to consider flood phenomena in Poland in the context of climate and anthropogenic changes. The doctoral student uses available tools such as mathematical

modeling, statistical methods, and long-term data from state environmental monitoring to obtain a comprehensive multi-scale picture of spatial and temporal changes in maximum flows in many Polish rivers, practically covering the entire country. The results confirm changes in the flood regime of Polish rivers over the last few decades, demonstrating that these changes result from both climate change and urbanization of the catchments.

Scientific value of the research

The issues Mr. Nelson Venegas Cordero addresses are central to contemporary hydrological research, both in Poland and internationally. Despite the rapid development of in-field analysis and modeling techniques, the interdisciplinary aspects of climate change impact on hydrological phenomena, particularly on extreme events, remain a focus of intensive research globally. This is exemplified by the first of the 23 Unsolved Problems in Hydrology posed by Blöschl et al. (2019): "Is the hydrological cycle regionally accelerating/decelerating under climate and environmental change, and are there tipping points (irreversible changes)?" Addressing the effects of climate change is crucial, as it impacts many aspects of environmental and economic functioning, necessitating stable and predictable behaviour of extreme hydrological phenomena.

Unfortunately, observed climate changes do not offer stability, with increasing frequency and intensity of heavy rainfall and longer periods without rainfall exacerbated by ongoing urbanization and farming in catchments. In this context, the PhD student's research on the stability and processes generating maximum flows in Poland is important both from a cognitive perspective and significant potential of practical application. It also has utmost utilitarian importance due to the large, regional scale of their use. It should be underlined that the topic covered by Nelson Venegas Cordero's research is in line with the directions of research conducted within the disciplines of environmental engineering, mining and energy.

Apart from the utilitarian and cognitive importance of the dissertation, the effort to conduct a critical analysis of measurement data and model results and their consistent use in subsequent publications of the series should also be positively assessed.

Due to the changing and growing evaluation requirements of science, this method of pursuing a PhD seems pragmatic, but also requires good planning and adherence to the adopted publication strategy and time regime.

Formal characteristics of the dissertation

The doctoral dissertation submitted for review is a collection of three thematically coherent scientific articles with a self-report. These articles are:

1. Venegas-Cordero, N., Kundzewicz, Z. W., Jamro, S., & Piniewski, M. (2022). Detection of trends in observed river floods in Poland. *Journal of Hydrology: Regional Studies*, 41, 101098 (IF = 4.7). <https://doi.org/10.1016/j.ejrh.2022.101098>
2. Venegas-Cordero, N., Cherrat, C., Kundzewicz, Z. W., Singh, J., and Piniewski, M. (2023). Model-based assessment of flood generation mechanisms over Poland: The roles of precipitation, snowmelt, and soil moisture excess. *Science of the Total Environment*, 891, 164626 (IF = 9.8). <https://doi.org/10.1016/j.scitotenv.2023.164626>
3. Venegas-Cordero, N., Mediero, L., and Piniewski, M. (2024). Urbanization vs climate drivers: investigating changes in fluvial floods in Poland. *Stochastic Environmental Research and Risk Assessment* (IF = 4.2). <https://doi.org/10.1007/s00477-024-02717-z>

The collection of articles was preceded by an extensive 42-page self-report in which the doctoral student presents an abstract of the dissertation, briefly describes the motivation behind the research, scientific theses, and summaries of the articles constituting the doctoral dissertation, along with the most important results and thorough conclusions. In his self-report, Mr. Nelson Venegas Cordero also presents his five publication achievements that were not included in his doctoral dissertation, as well as a list of grants (four scientific and implementation projects, one of which he led as the principal investigator) and five internships and training sessions. This division is logical and consistent with the generally accepted principles of creating doctoral theses.

Since the self-report is an interesting but succinct reflection of the articles constituting the core of the doctoral dissertation, the rest of the review will focus primarily on the articles, referring to the self-report only when necessary.

The PhD student is the first author of all three articles, and his individual contribution to the creation of the works is significant. Based on the attached authorship statements, Mr. Venegas Cordero was the leading researcher in the research team, responsible for conceptualization, investigation, development of the research methodology, programming of the necessary software, validation, formal analysis, visualization, and, of course, writing and editing the manuscript for all three articles. In the first article, the PhD candidate also handled data curation.

All three articles were published within two years, from 2022 to 2024, in renowned scientific journals, namely the *Journal of Hydrology: Regional Studies* (IF = 4.7), *Science of the Total Environment* (IF = 9.8), and *Stochastic Environmental Research and Risk Assessment* (IF = 4.2). This means the cumulative impact factor of the PhD thesis is 18.7 (total of 400 points, according to the Announcement of the Minister of Science of January 5, 2024, on the list of scientific journals and peer-reviewed materials from international conferences), which is an impressive achievement, especially for a young researcher at the beginning of his scientific career.

Assessment of the thesis

It should be stated that the three articles constituting Mr. Nelson Venegas Cordero's doctoral dissertation undoubtedly form a logical whole and should be read as such—a series of successive steps in uncovering the mechanisms governing the occurrence of floods and their temporal and spatial variability in Poland. This was accomplished, among other things, by using the same data and the same statistical methods in the research, with the results from previously published articles serving as a basis for subsequent articles. As I have already mentioned, all three articles were published in renowned scientific journals and have undergone rigorous reviews by eminent scientists. However, in my review, I will focus on several aspects that, in my opinion, require clarification and minor corrections. In the substantive assessment of the work, I found it appropriate to evaluate them in the order of implementation intended by the doctoral student.

Detection of Trends in Observed River Floods in Poland

M.Sc. Nelson Venegas Cordero and co-authors analyzed a representative sample of 146 flow gauges located in 12 major Polish semi-natural river basins. They investigated trends in three river flood indicators, namely magnitude, frequency, and timing, using the annual maximum daily flows (block maxima) and peak-over-threshold approaches. The selected data cover periods from 1956 to 2019.

The topic of trend analysis in hydrological datasets is a classical scientific problem investigated by many hydrologists worldwide, as recognized by the authors in the literature review in the first chapter of the paper. It is not a new issue in Poland either. However, the great advantage of

Venegas Cordero et al. (2022) lies mainly in the country-wide scale of the research, whereas previous works concentrated on one or, at most, a few rivers and/or cross-sections (see, e.g., Kundzewicz et al. 2005; Strupczewski et al. 2016; Romanowicz et al. 2016; Piniewski et al. 2018; Grygoruk et al. 2021).

Venegas Cordero et al. (2022) used simple, well-established, non-parametric statistical techniques to analyse trends in the central tendency of flow magnitudes, frequency, and timing, namely the Mann-Kendall test (MK) and Sen's slope, as well as the chi-square test on Poisson regression. Paradoxically, although far from being original and novel, this choice is one of the strengths of the research because these techniques are well-known and approved by the hydrological community, which enables comparison of the results with those of other authors.

The first issue that, in my opinion, requires comment (and perhaps a second part of the article), is the choice of datasets for the research. The authors selected daily data from the periods 1956-2019 and 1981-2019, justifying it by maximizing temporal and spatial coverage, respectively. Although 30 years is considered the shortest period for revealing tendencies in hydrology, it would be advisable to extend the datasets beyond the data offered by electronic IMGW repositories. Some Polish rivers have records much longer than 60 years, and some tendencies revealed by the authors would be even more visible and, by all means, more interesting. I also wonder why the authors extracted block maxima from the daily measurements instead of referring directly to (semi-)annual extreme ones, which are not the same, especially during extremely large floods when the floodwave changes dramatically. The trend analysis by the POTM approach obviously leads to slightly different results than the QmaxM approach. However, there is no explanation for these differences. The authors also did not mention the trends in higher moments than central tendency (e.g., standard deviation or skewness), which by all means influence central tendency and thus may lead to different conclusions. To calculate such trends, parametric methods would be advisable (e.g., Debele et al., 2017abc).

The results obtained by Venegas Cordero et al. (2022) align with intuition, observations, and earlier research. Furthermore, the temporal (over six decades) and spatial (covering the entire Poland) scope makes them unique and worth citing.

Model-Based Assessment of Flood Generation Mechanisms over Poland: The Roles of Precipitation, Snowmelt, and Soil Moisture Excess

In the second article of the PhD thesis, the authors study the daily dataset of water balance components in Polish sub-basins for the period 1952–2020. Unlike in the previously discussed paper, here the data used for analysis are synthetic, derived from the Soil & Water Assessment Tool (SWAT) model for over 4000 sub-basins. Venegas Cordero et al. (2023) applied simple statistical tests combined with a circular statistics approach on annual maximum floods and various potential flood drivers to estimate trends, seasonality, and the relative importance of each driver. Similar to Venegas Cordero et al. (2022), the datasets are divided into two time periods (1952–1985 and 1986–2020), ensuring the continuation of the research and enabling the comparison of changes in flood mechanisms over recent decades.

In this paper, Venegas Cordero et al. (2023) continue country-scale research on flood issues from the perspective of flood-generating indicators. Among many mechanisms, they concentrate on three: precipitation, snowmelt, and soil moisture excess. I believe that the choice of these mechanisms was dictated by the possibilities offered by the SWAT model. Nevertheless, in the introduction, the authors discuss other possible mechanisms for generating floods and their mutual interaction, which may strengthen or weaken the flood-generating factors. The authors used the same tests, as in the previously discussed paper, for detecting trends in synthetic Qmax as well as in flood-generating

indices. They also analyzed the timing of the flood-generating mechanisms. Using both model-based and measurement data (Q_{max} in both cases) constituted an excellent condition for analyzing the uncertainty of the modeled results, which, unfortunately, the authors omitted. Additionally, there was no comprehensive explanation of why the relative importance of flood-generating factors and their mutual independence was exemplified as linear functions (Eqs. 9-11), as flood-generating mechanisms are strongly non-linear.

In conclusion, Venegas Cordero et al. (2023) discuss the geographic variability of the obtained results (which was intuitively expected) within a climatic context, but I lack synthetic conclusions pointing clearly at the particular underlying hydromorphological and geological conditions in various catchments that influence such spatial and temporal variability of flood-generating conditions and, consequently, floods themselves. The authors claim that the results obtained are largely in line with their previous research (Venegas Cordero et al., 2023), but they do not mention where the differences lie and what causes them (measurement errors, modeling uncertainty, or perhaps stemming from the applied methodology).

Although the techniques used for analysis are not new, the results obtained by means of them are original and unique. In the second paper of the series, Mr Venegas Cordero, confirms his scientific intuition and compliance with the strict rules of the scientific method.

Urbanization vs. Climate Drivers: Investigating Changes in Fluvial Floods in Poland

In their third paper, Venegas Cordero et al. (2024) analyze the influence of urbanization on the generation of floods in Poland. The authors selected four pairs of urban and rural hydrologically similar catchments, located close to each other, and, together with other flood-generating mechanisms (see Venegas Cordero et al. 2023), compared the trends in long records of flood flows in these river basins. They employed the same set of statistical methods as in the previously discussed articles, and the selection of the catchments was supported by aerial photographs.

The authors used information about pervious/impervious areas from post-processed aerial photography with a resolution of 100x100 meters. Bearing in mind that roads are highly impervious and their width hardly ever exceeds 20 meters or that an impervious detached house in Poland is usually smaller than 20x20 meters, I wonder how Venegas Cordero et al. (2024) accounted for such cases. These, collectively, may constitute a significant proportion of all impervious areas in catchments, potentially leading to misleading conclusions.

The authors obtained results that comply with intuition, observations, and other research findings. The weak influence of imperviousness on the increase/decrease of floods may stem from the choice of case study catchments, as noted by Venegas Cordero et al. (2024).

Summary and conclusions

The dissertation submitted for review, titled 'Detection of Changes in River Floods and Flood Generating Mechanisms in Poland,' demonstrates M.Sc. Nelson Venegas Cordero's comprehensive theoretical knowledge and ability to conduct independent scientific research within the discipline of environmental engineering, mining, and energy. The doctoral student also demonstrated the ability to independently conduct scientific work. His work contributes original insights into the study of hydrological extreme phenomena, aligning with the field's current research directions.

The series of scientific articles collectively form a research project in which Mr. Venegas Cordero played a leading role. His substantial individual contributions to the publications are well-documented and indicate his primary role in the research process.

I certify that the doctoral dissertation of M.Sc. Nelson Venegas Cordero meets all the requirements for doctoral theses as specified in The Act of 20 July 2018 – Law on higher education and science (consolidated text of 10 March 2023, Polish Journal of Laws 2023, item 742, as amended).

I recommend that The Science Discipline Board – Environmental Engineering, Mining, and Energy – Warsaw University of Life Sciences (SGGW) proceed with awarding the scientific degree of doctor to M.Sc. Nelson Venegas Cordero.

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Krzysztof Kochanek