PCIC UPDATE September 2023

PROJECT AND RESEARCH UPDATES

Data Portal for Canada's Western Arctic Released

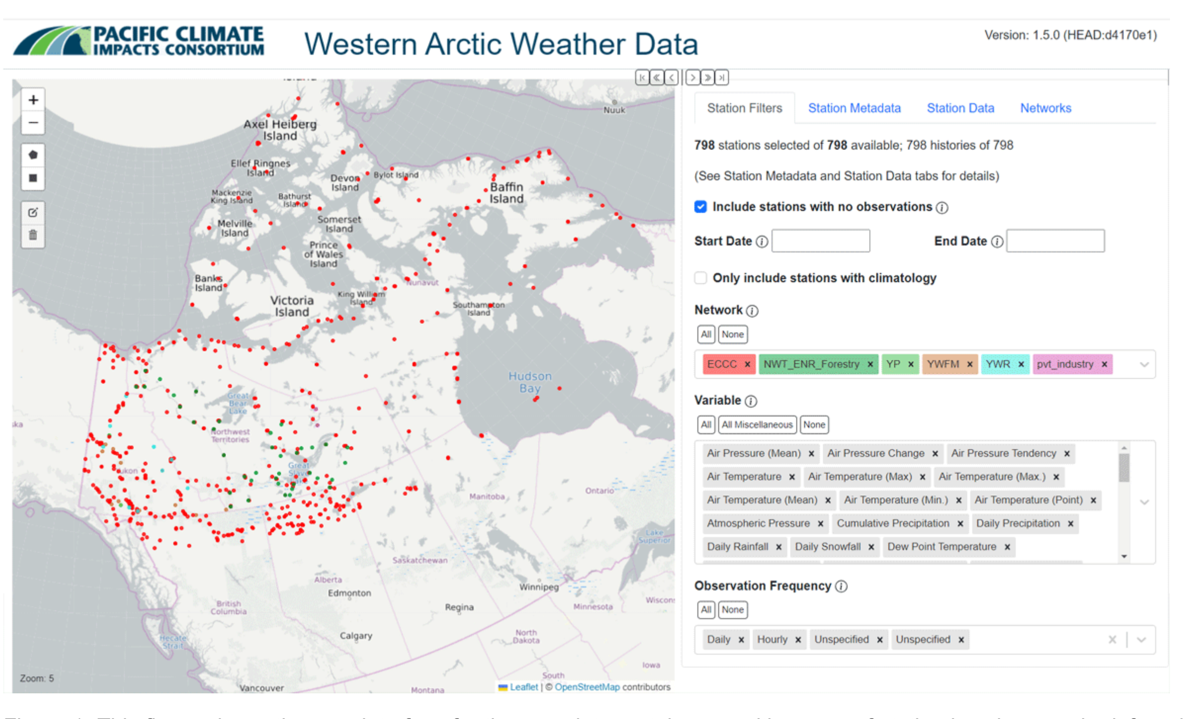

Figure 1: This figure shows the user interface for the new data portal page, with a map of station locations on the left and the station filter options on the right, showing the options to filter stations by network, variable and observation frequency.

PCIC is pleased to announce the release of a new station data portal for Canada's Western Arctic. The Western Arctic Weather Data Portal is focused on providing data for the regions of Yukon and the Northwest Territories, and it also contains data for Nunavut and the most northerly portions of western and central Canada, from BC to Manitoba. The portal allows users to filter stations by variable, network and observation frequency. It also provides easy access to station metadata, such as the stations' locations and elevations. Currently, more than 302 million observations are available from 798 stations. It uses Yukon Albers map projections specific for the region that allows for a better representation of the local area and geography, with minimal distortions. The portal allows for the selection of stations by an intuitive web interface by which users can draw polygons to select the stations that they wish to access data from.

- Visit the new data portal

Supporting the Management of BC Salmon Habitats

PCIC researchers have simulated streamflow and water temperature under present and projected future climate conditions in across 400,000 square kilometres of river basins that serve as habitat for salmon during part of their lifecycles. PCIC's team used these to produce a set of exposure indicators for salmon that will be delivered to fisheries managers and the public via an online tool, to inform science-based policies and decisions in support of wild salmon conservation.

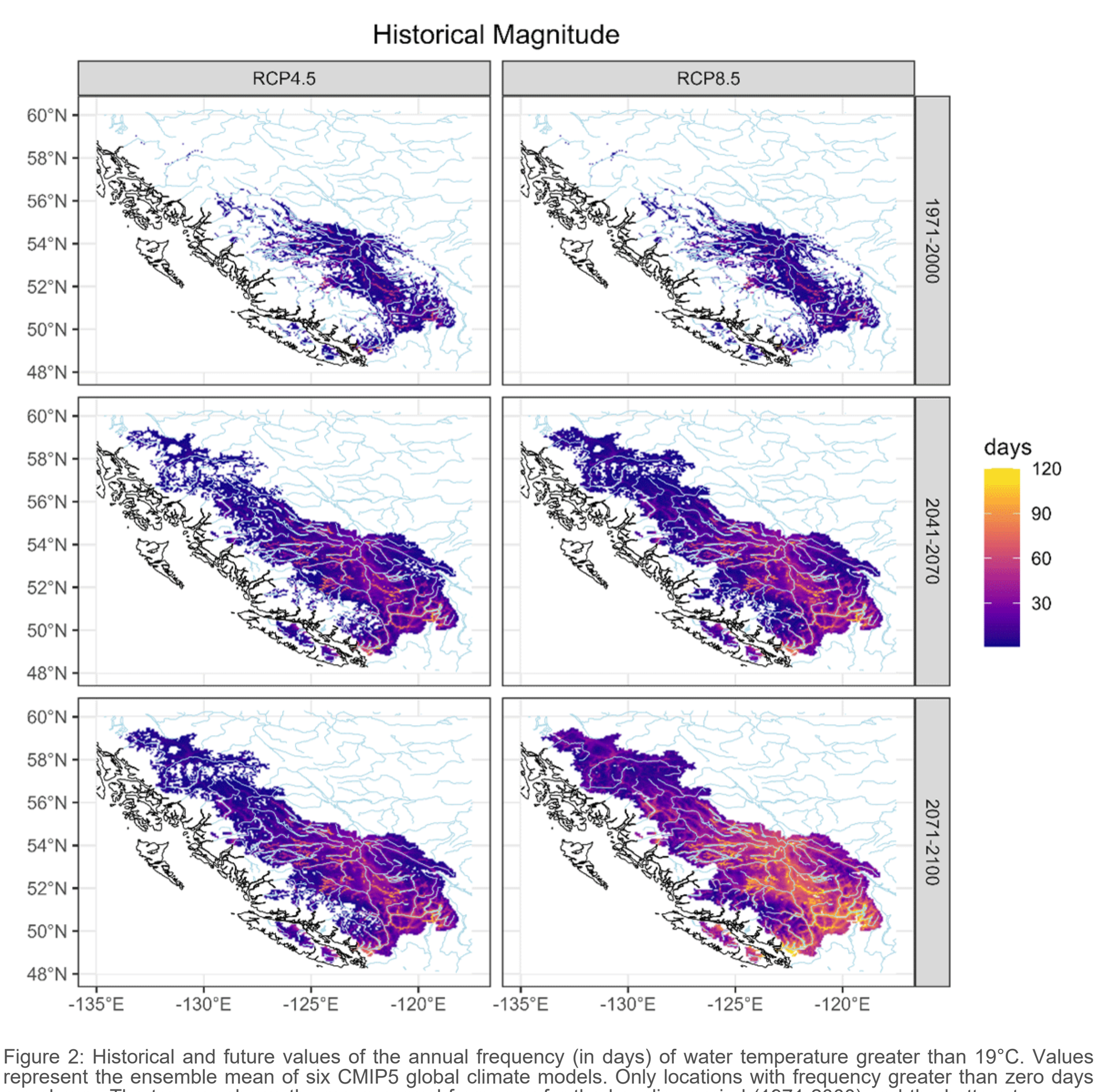

Figure 2: Historical and future values of the annual frequency (in days) of water temperature greater than 19°C. Values represent the ensemble mean of six CMIP5 global climate models. Only locations with frequency greater than zero days are shown. The top row shows the mean annual frequency for the baseline period (1971-2000) and the bottom two rows show the projected values for mid-century (2041-2070) and end-century (2071-2100). Results for RCP4.5 are show in the left column and results for RCP8.5 are shown in the right column.

Pacific salmon are culturally and economically important in British Columbia. They occupy a central position in food webs and nutrient cycling in our province's freshwater and marine ecosystems. Anthropogenic climate change is expected to affect freshwater and marine salmon habitats, impacting the different stages of the salmon life cycle in various ways, including creating heat stress, and streamflow conditions that scour salmon nests, called redds. In partnership with researchers from the Fisheries and Oceans Canada (DFO) and with the support of the British Columbia Salmon Restoration and Innovation Fund (BCSRIF), PCIC has developed a set of exposure indicators that will support the regional management and planning of freshwater salmon habitats that takes climate change into consideration.

Using the Variable Infiltration Capacity hydrologic model with glaciers (VIC-GL) and the dynamical 1-D water energy routing model (dynWat) that is used for high-resolution water temperature modelling, PCIC researchers have simulated streamflow and water temperature under present and future climate conditions in virtually all of BC's gauged river basins that drain to tide water. This represents an area of approximately 400,000 square kilometres. Simulations were forced using output from an ensemble of six global climate models (GCMs) from the fifth phase of the Coupled Model Intercomparison Project (CMIP5) and two emissions scenarios (RCP4.5, a moderate-emissions scenario and RCP8.5, a high-emissions scenario). Results from the simulations have been used to produce exposure indicators that describe potential future flow and thermal hazards during salmon freshwater life stages. These exposure indicators will, in turn, inform large-scale salmon risk-assessment. One example of such an exposure indicator can be seen in Figure 2, which shows the frequency (in the mean number of days per year) of daily water temperatures greater than 19°C. This threshold was chosen because consistent water temperatures above 19°C interfere with salmon migration. The energy requirements for salmon increase at high temperatures, they exhibit early mortality, they reduce spawning and they cease feeding. Figure 2 shows that as the climate warms the frequency with which water temperatures will exceed the 19°C threshold is expected to increase, more so for RCP8.5 than RCP4.5, and that increases will be larger in the southern basins. Additional indicators describe changes to high- and low-flow extremes, and changes to seasonal flow and temperature.

The results of the hydrologic modelling and exposure indicator work will be delivered to fisheries managers and the public via an online tool in 2024 that will inform science-based policies and decisions in support of wild salmon conservation.

New Future-Adjusted Weather Files for Canada

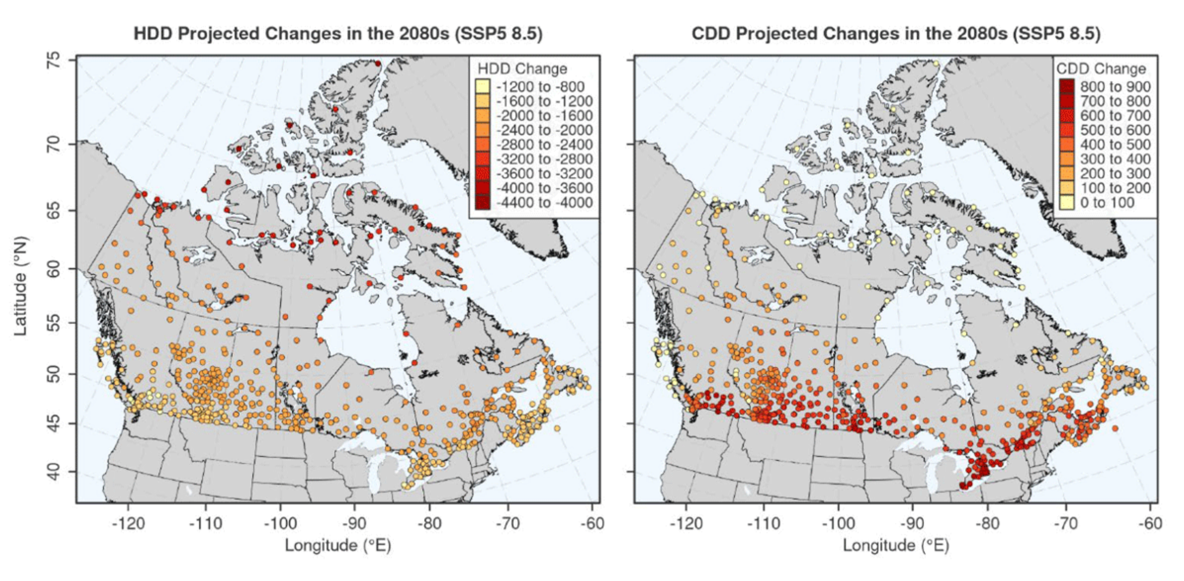

Figure 3: This figure shows the projected changes in heating degree days (HDD, used to quantify energy needs for heating, left panel) and cooling degree days (CDD, used to quantify energy needs for cooling, right panel) for 2071-2100 relative to 1971-2000 for a high-emissions scenario, at all CWEC2020 locations. The patterns clearly show a decrease in heating energy needs (a 33% median decrease in HDD) and an increase in cooling energy needs (a nearly fivefold median increase in CDD—note, however, that CDD has been quite low over most of the country, historically).

Partnering with Environment and Climate Change Canada, PCIC researchers have recently produced a set of weather files that can be used by building professionals across the country to determine the energy needs of buildings for heating and cooling in the changing climate. The files include future-shifted versions of the 2020 Canadian Weather year for Energy Calculation weather files (CWEC2020), for 564 locations across Canada. They were prepared for 30-year windows from the 2040s to the 2080s, and also at different levels of global warming ranging from 0.5°C to 3.5°C. PCIC's team also developed a new method to produce future hourly weather files that overcomes some of the shortcomings of the previous methodology.

This work is part of PCIC's continuing efforts to provide building professionals with information that might be reflective of future climatic conditions. Because buildings are long-lived, the future climate conditions that a building will be exposed to are important factors to consider in its design. The new weather files are based on climate model output from the sixth, most recent, phase of the Coupled Model Intercomparison Project (CMIP6), produced for three distinct future emissions pathways.

As expected in a warming climate, the new future-shifted weather files show a future reduction in heating demand and an increase in cooling demand across Canada (Figure 3). The projected changes are largest in variables derived from temperature, more moderate for relative humidity, and negligible for surface pressure, which displays a high degree of climate variability.

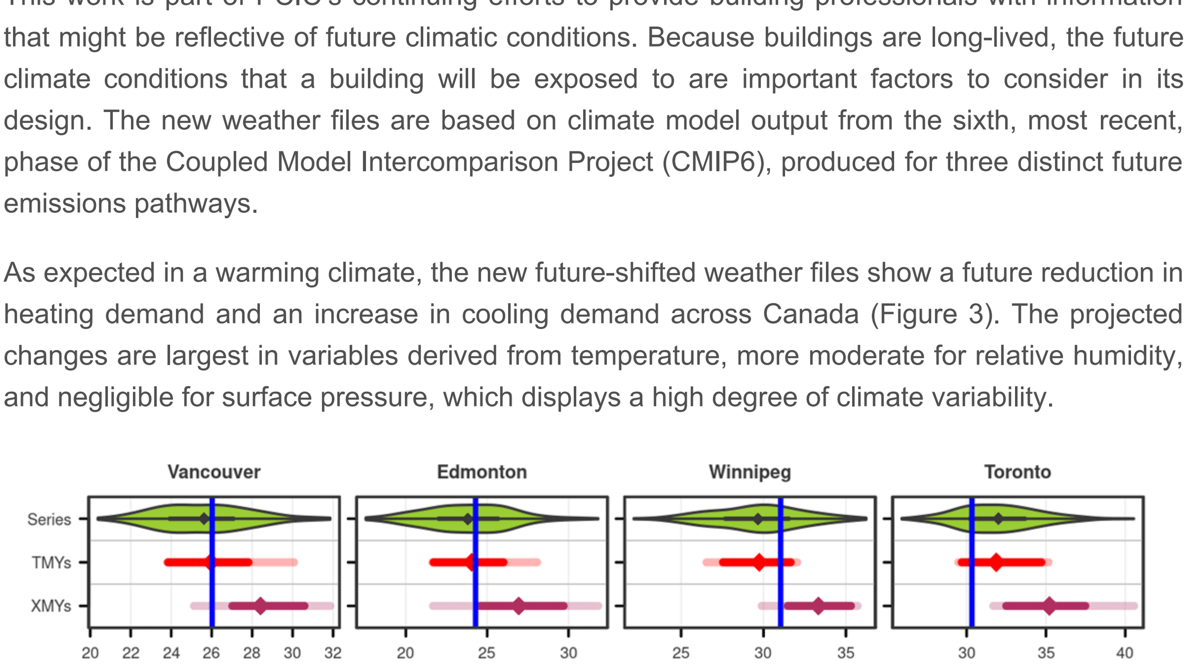

Figure 4: This figure shows the July average Humidex for the 2080s (assuming the moderate SSP2 4.5 emissions scenario) at eight selected CWEC2020 sites. In each panel, the top green shaded area (called a "violin plot") displays the distribution of Humidex values for all 30 years from all 12 downscaled climate model projections. The red bar in the middle shows the results from Typical Meteorological Years (TMYs) while the lower purple bar displays results from Extreme Meteorological Years (XMYs). In each panel, the GCM ensemble spread is indicated by the light-shaded horizontal bars, the 10th to 90th percentile range is indicated by darker bars, and the ensemble average is denoted by a diamond. The vertical blue line displays the result from the future-shifted CWEC2020 file, which can only be expressed as an ensemble mean. Note that the horizontal axis ranges are different for each location, due to their differing climates.

As mentioned, PCIC's team produced the latest weather files using both established and newly-developed methods. In the established methodology, both the CWEC2020 files and their future-shifted versions comprise 12 separate months of hourly weather from station data designated as a Typical Meteorological Year (TMY). However, the TMY approach has certain drawbacks, including the ad hoc joining of climate variables across monthly boundaries and little information about climate extremes, such as heat waves or cold spells. To address these limitations, PCIC's team developed a new method to simulate future hourly series of weather variables. This involved bringing together observations, reanalysis data and climate model output in such a way that continuous, hourly series could be generated for an entire 30-year period. A multivariate downscaling approach was also used, that better preserves the relationships between temperature and precipitation variables. This approach allows not only for the selection of "typical" months as in the TMY method, but also other interesting sampling strategies, such as the selection of extreme months wherein climate variables departed significantly from the norm. This permitted the creation of weather files for Extreme Meteorological Years (XMYs), which could be compared with the usual TMYs. Figure 4 shows an example for the Humidex variable, which captures the joint behaviour of hot and humid conditions, at eight selected CWEC2020 sites. While the TMY results capture the central part of the entire distribution of Humidex over the period shown, the XMY median and range better reflect the extreme values that are projected in some of the future model simulations. This type of information could be used by building practitioners to more thoroughly explore the limits of their designs. We anticipate that these updated weather files will be used by public sector organizations, buildings professionals and others across Canada.

Talks and Training Session

The Pacific Climate Seminar Series is gearing up for the fall semester. Our first speaker will be Dr. Neil C. Swart from the Canadian Centre for Climate Modelling and Analysis. His talk is titled, *Towards Canadian Focused Projections using the CCCma Integrated Climate Modelling System*, and is scheduled for September 27th from 3 p.m. to 4 p.m., Pacific Time. This will be followed by a talk from Dr. John Thompson from the University of British Columbia on November 22nd and a talk by Dr. Erich Fischer from ETH Zurich on December 4th. Stay tuned for more details on these talks.

- Read more about Dr. Swart's talk and access attendance information.

STAFF PROFILE: ERIC YVORCHUK

Eric Yvorchuk is a Programmer/Analyst in the Computational Support Group at PCIC. There he works to help maintain and develop PCIC's applications and climate analysis software, and to provide technical assistance to PCIC's research team. His undergraduate degree was in Physics and Computer Science and he sought career opportunities that would enable him to apply his technical knowledge in a natural science context. He has found this at PCIC, where meeting novel, complex challenges in the development and provision of climate software and cloud-based computing applied to a huge volume of climate data are his day job. Speaking on this, he says, "One of the things I found most interesting about software development here was learning about how complex not only the code for the applications is, but also how these applications interact with other services and the various ways we can detect software/system-related issues."

One of the primary areas that Eric is working on currently is the Data Analytics for Canadian Climate Services (DACCS) project, in collaboration with PCIC's partners, the Canada Foundation for Innovation, the British Columbia Knowledge Development Fund, University of Toronto, Ouranos, the Computer Research Institute of Montréal, McGill University, and Concordia University. The primary goal of this project is to provide a cloud-based web platform in which institutions can integrate their analysis software so that scientists can use it conveniently. Eric explains, "as one example, DACCS removes the need to install the software on one's own machine and deal with possible installation issues." DACCS also allows computational resources (called "nodes") that can serve users' requests, to be located in close proximity to data storage systems. This brings analysis tools to the data rather than moving huge volumes of data to the analyst. PCIC's portion of this project has been wrapping the functionality of its software into Web Processing Services called "birds" and making them usable in the DACCS infrastructure. These can then also be used for other services that PCIC offers, as Eric explains, "I've been making use of these birds in a project called ClimatEx, where the goal is to provide on-demand high resolution downscaled climate data with associated indices." Reflecting on his work, he says that he finds most fulfilling about the DACCS project is gaining experience in maintaining a complex system, and applying the work in collaboration with other members of PCIC's themes.

PCIC STAFF NEWS

This autumn, PCIC will be undergoing a change of leadership, with Dr. Francis Zwiers, PCIC's Director of 14 years retiring and PCIC welcoming its new director, Dr. Xuebin Zhang. It is hard to overstate the impact that Dr. Zwiers has had on PCIC, taking on the growth of a nascent climate impacts group and guiding it as PCIC became one of Canada's leading service providers with a dedicated research team that hits well above their weight. The past 14 years saw a massive expansion of the data, applied research and online tools that PCIC offers and it is with great gratitude that PCIC wishes Dr. Zwiers the best in his retirement. PCIC's incoming Director, Dr. Zhang, is also a renowned statistical climatologist who has contributed substantially to the fields of detection and attribution and extremes analysis, served as the lead author for multiple reports from the Intergovernmental Panel on Climate Change and is Co-Chair of the World Climate Research Program's Grand Challenge on Climate Extremes. Dr. Zhang arrives from his post at Environment Canada, where he served as a Senior Research Scientist.

PCIC welcomed three new members this summer, Dr. Tong Li, Dr. Jingwen Wu and Quintin Sparks. Dr. Li has joined PCIC as a as a Post-Doctoral Researcher, where she will be integrating emergent constraints with detection and attribution methodologies, aiming to deliver more accurate projection and attribution results. Dr. Wu will be working on hydrologic model development, application and related research to quantify future climate-driven changes in river discharge and temperature at very high spatial resolution throughout a region spanning all Pacific-draining watersheds in BC. Quintin has joined PCIC's Computational Support Group where his principal responsibility is to enhance the development and implementation of advanced climate data analytics applications.

This summer also saw PCIC bid a fond farewell to three members, Nina Nichols, Ameneh Mollasharifi and Stacey O'Sullivan. Nina was PCIC's Indigenous Communities Climate Adaptation Coordinator. PCIC appreciates Nina's work in collaboration with Indigenous communities and organizations and wishes her the best in her new position. Ameneh was a Data Analyst on a Co-Op term, during which she worked on deriving streamflow and water temperature hazard exposure indicators from hydrologic simulations and conducting analyses to help PCIC researchers better understand the impacts of future climate change on the habitat of salmon in BC's rivers. We wish her all the best as she returns to her studies this fall semester. Stacey O'Sullivan served as PCIC's Content Development and User Engagement Assistant, a multifacted role in which she provided broad-ranging support for stakeholder engagement surrounding climate data and climate adaptation. We wish her the best as she pursues further studies.

PUBLICATIONS

Larabi, S., J. Mai, **M. Schnorbus**, B.A. Tolson and **F. Zwiers**, 2023: Towards reducing the high cost of parameter sensitivity analysis in hydrologic modeling: a regional parameter sensitivity analysis approach. *Hydrology and Earth System Sciences*, **27**, 3241–3263, doi:10.5194/hess-27-3241-2023.

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