Response to comment from Reviewer 2

Dear Reviewer,

Thank you for your review and all your comments and suggestions on the manuscript. Making the required corrections will certainly significantly improve the quality of the article and increase its accessibility to the reader. I agree with all the comments made. Individual issues that I find debatable I will comment below.

In this response, the reviewer's comments are highlighted in **bold** and the author's response is included under each. Due to the large number of revisions required to the text and figures, we have refrained from detailing in this response all the changes made to the manuscript. These will be added and presented in the final version sent after a period of public discussion. Instead, the focus is on the substantive justification for these changes.

Some details on the environment of the water gauges and climatological stations would improve the manuscript. Some examples: How far are the water gauges located from the dam? Are the water gauges located above the dam affected by the backwater of the reservoir? (Backwater has the opposite effect on river ice regime.) Has there been any other anthropogenic influence on the river bed conditions in the river section under investigation? At what altitude are the climatological stations are located?

I agree that adding details about water gauge cross sections and climatological stations will improve the quality of the article. A table with details about the location of the stations (geographic coordinates, elevation above sea level) will be added to the article. A description of potential factors affecting ice cover other than the operation of dam reservoirs will be added to the chapter on the study area. The potential impact of dam reservoirs on cross sections above their locations will also be commented on. At this stage of the study, it appears that the dam reservoirs under study do not seem to affect the occurrence of ice cover at cross sections above their locations (stations C1 and S1). This is due to the large distance from the reservoir (C1: 14.6 km above the reservoir, S1: 28.5 km above the reservoir) and the relatively high longitudinal gradient of these rivers in the sections from the water gauge cross-section to the reservoir (C1: 3.3 meters/kilometer, S1: 3.3 meters/kilometer). Dam reservoirs increase the incidence of ice cover on rivers above their location mainly through the progression of ice cover upstream, resulting from the reservoir's blocking of the outflow of mobile ice from higher parts of the catchment. This process is characteristic of low-gradient river sections with low flow velocities (Prowse and Beltaos, 2002). In the case of the studied reservoirs, ice accumulation most often occurs directly in the reservoir's backwater (at most 1 km above the reservoir), which is confirmed by the author's field observations.

In addition, I would like to point out that the manuscript includes information on the distance of water gauge stations from downstream the reservoir (line 112). Information on the distance of water gauge cross sections upstream the reservoir will be added to the manuscript.

Why was the average air temperature of the 14 days prior to ice cover occurrence used for the modelling? Please explain it more detailed. Had other temperature averages or cumulative temperature sums been tested?

In preliminary analyses, different values of average air temperature (average of 2 to 20 days) were tested. The analysis showed that taking the average air temperature of 14 days most often translated into the highest predictive ability of the model. Information on how this value was adopted will be added to the text of the article.

How have the climatic conditions developed 1950–2020? What kind of temperature trend has been observed? The results shown in Fig.2, 4–5 suggest that there might have been changes in winter temperature conditions, especially since the 1990s.

A subsection will be added to the manuscript on the variability of air temperature over the study period for the stations used. The Mann-Kendall test and the Theil-Sen estimator will be used to detect trends. In addition, air temperature statistics by month will be given for periods before and after the reservoirs were formed.

In case of the San River, the available data set for the pre-dam period is slightly short and incomplete for comparison.

In the case of cross-sections S2, S3, S4, the period of available data on the occurrence of ice cover before the formation of the reservoir is 18 years, which, in the author's opinion, is a sufficient period to generally characterize the ice conditions occurring at these water gauge cross-sections. In the case of cross-section S1, data are only available for 12 years due to gaps. Unfortunately, the data for periods prior to 1950 are characterized by significant deficiencies and high uncertainty, so it is not possible to use them for this type of analysis.

When comparing the results of the 2 dams, it should be taken into account, that the post-dam reference periods are different (Dunajec River: 1993–2020, San River: 1969–2020). Global trends show that winter warming has accelerated since the 1980-90s. If this is also the case here, it should also be taken into account when interpretating and discussing the results.

I agree that additional analysis of air temperature variability and its influence on ice cover occurrence will improve the quality of the article. Therefore, an analysis of trends in air temperature will be presented and its results will be compared with the occurrence of ice cover above the studied reservoirs and the results of modeling. In the discussion chapter, the variability of air temperature will be taken into account when interpreting the results.

Why was it necessary to use satellite data to study the spatial extent of dam effects on river ice regimes? Please justify this more detailed. This could be analysed on the basis of river ice observations at the water gauges. Has the result of the river ice classification been compared with the observational data for the winter of 2016/17? Satellite data could possibly be used to reduce the data gap in river ice observations after 2015.

The use of satellite data resulted from the desire to estimate the spatial extent of the impact of the studied reservoirs. Based on the data from the water gauge cross sections, it is not possible to estimate the section of the river where the ice cover is not present, due to the considerable distances between the various stations. Commentary on this thread will be added in the methodology section.

The results obtained from the analysis of remote sensing data have been compared with the data from the water gauge stations. However, such a comparison is problematic due to the insufficient spatial resolution of the Sentinel-1 satellite for detecting border ice on such narrow rivers as the Dunajec and San. Observational data from water gauge stations contain information on the occurrence of total ice cover and border icing, while the results of radar imaging classification allowed only to determine the sections of rivers covered by total ice cover.

Partial supplementation of ground measurements with remote sensing data is possible, but for an analysis such as the one presented in the manuscript, it would not allow inclusion of such created data in the model and its

subsequent analysis. This is due to the temporal resolution of the Sentinel-1 satellite (maximum temporal resolution of 6 days) as a result of which the satellite data allows only a few days per month to supplement the ground data. Spatial resolution (10 meters) is also a problem, allowing only total ice cover to be identified. Therefore, in the article, only a dataset of field observations, consistent in terms of the methodology of acquiring data on the occurrence of ice cover and boundary ice, was included in the analysis and model, and the periods in which the data were uncertain were excluded from the analysis.

Fig.6 and Fig.7: Please use a thicker line to represent the rivers. Perhaps the inclusion of water gauges would help the navigation on the figure.

Figures 6 and 7 were created in part from raster matrix drawings exported from a GIS program, and thickening the lines is associated with physically increasing the drawing (which already takes up an entire page) or artificially interfering with the results (by drawing a thicker line in a graphics program) which I would like to avoid. Therefore, I ask for the possibility of leaving the thickness of these rivers in the figures. Where possible, a thicker font will be used. In order to better navigate the figures, the locations of water gauge cross sections will be added.

Yours sincerely,
Maksymilian Fukś

References

Prowse, T. D., & Beltaos, S. (2002). Climatic control of river-ice hydrology: a review. Hydrological processes, 16(4), 805-822.