We greatly appreciate your thorough review and professional comments on our paper. Thank you for recognizing the intent and significance of our work, while also pointing out the current shortcomings of our manuscript, and providing targeted constructive suggestions. We have carefully considered each of your comments, and we will adopt all of your recommendations. The paper will be revised accordingly, point by point, to further enhance its quality.

Below is our point-by-point response to your comments and our detailed plans for revision.

Comment 1:

This paper aims to study the transferability of calibrated parameters across temporal scales in hydrological modeling using a single model applied to a specific region in China. These limitations, the narrow focus on a specific region and model, restrict the study's scope. Nevertheless, the vision and idea behind the work are valid and highly relevant.

Response:

Thank you for your comments. We fully understand your concern on the narrow scope of the study. Indeed, this research was conducted on a specific model and region. However, this may not limit the generality of our findings; on the contrary, it is exactly one of the main objectives of our study. We aim to validate and expand the generality of existing conclusions through new research under new specific conditions.

As mentioned in the introduction section, the quantitative benefits of high-resolution data in enhancing hydrological model performance remain unclear. Studies on the impact of data resolution on hydrological models have produced inconsistent results. Kobold and Brilly (2006) found that calibrating hydrological models with sub-daily data and time steps can significantly improve the accuracy of flood forecasting. Similarly, Jeong et al. (2011) observed similar improvements. Huang et al. (2019) found that increasing spatial resolution has only a marginal or minimal effect on model performance, while high temporal resolution data leads to a significant improvement in model performance. However, other studies (Kannan et al., 2006; Ficchì et al., 2016) have found that higher data resolution does not always lead to better model performance. Ficchì et al. (2016) reported that as the time scale is reduced, the improvement in model performance becomes limited, and performance may even degrade. Our previous research (Tudaji et al., 2024) in southern China showed that high-resolution data does not always have positive impact on model performance. Nevertheless, we and other related studies acknowledged that further studies across different climate regions and models are necessary to validate and extend the generality of these findings. In fact, the marginal effect of data resolution on model performance is expected. The focus should be on exploring the specific values of the threshold resolution, the underlying causes of performance degradation, and their generalizability across different climate regions and models. This research builds upon this background, aiming to provide new perspectives and data for this field.

We specifically chose northern China as the study area because its climate and runoff generation characteristics differ significantly from those of southern China, which we had previously focused on (Fan et al., 2019; Domrös et al., 2012). Furthermore, other studies exploring the impact of data resolution have not yet considered northern China. Southern China features subtropical and tropical monsoon climates, with warm, humid conditions and abundant, evenly distributed rainfall. Annual precipitation typically exceeds 800 mm (averaging 1500 mm in our study area), classifying it as a humid region. Flood generation is predominantly governed by saturation excess. In contrast, northern China experiences a temperate monsoon climate with lower and more concentrated rainfall. Annual precipitation is generally below 800 mm (averaging 600 mm in our study area), making it a semi-humid to semi-arid region where flood generation is primarily driven by infiltration excess and subsurface preferential flow. By applying a new model to this distinct region, we aim to further validate the previous findings and investigate the role of high-resolution data under different climatic conditions.

In addition, we have broadened the scope of our study by incorporating an investigation into the transferability of model parameters. This aims to provide guidance on using existing parameters across different time scales or selecting appropriate computational time steps in conditions with lack of high-resolution data. Although the model we employed differs in certain aspects, its general structure and computational approaches are similar to those of most hydrological models. For example, it uses linear methods to calculate subsurface runoff and the Muskingum method for routing. Therefore, our findings are applicable to this category of hydrological models and offer valuable insights for practitioners utilizing such models.

We acknowledge that the original manuscript did not adequately explain the background and objectives of this study, nor did it effectively integrate our findings with existing literature. This may have made the study's focus appear overly narrow. In the revised manuscript, we will elaborate on the background and objectives, and discuss the general patterns of how high-resolution data influence hydrological simulations, drawing on findings from studies conducted in different climate zones and with different models.

Comment 2:

The authors should better highlight the novelties of this work compared to the recent study, https://doi.org/10.5194/egusphere-2024-1438. As a consequence, all parts related to model performance across temporal scales should be downplayed, as they currently lack sufficient depth and originality.
The most significant novelty lies in the finding that model parameters are not transferable when the computational time step varies. However, the observation that higher-resolution data produces better results has already been extensively discussed, with numerous examples provided in the ongoing work https://doi.org/10.5194/egusphere-2024-1438, which is openly accessible in the HESS discussion section.

Response:

Thank you for your insightful suggestions. We recognize the inadequacy of not highlighting the novelty of our study. As mentioned earlier, we did not sufficiently elaborate on the progress of existing research and the background of this study, which resulted in the novelty of our work being underrepresented. We believe that the novelty of this study lies in the following aspects:

1. Evaluating the value of high-resolution data in a new climatic region. This study assesses the

value of high-resolution data for hydrological simulations in a new climatic zone, aiming to validate the generality of conclusions drawn from previous studies. The climatic characteristics of the study area have been introduced above. We will add this introduction in the revised manuscript.

2. New findings on the impact of data resolution on hydrological modeling in Northern China. Compared to prior studies, our findings reveal that in northern Chinese catchments, increasing data resolution has a more pronounced effect on reducing peak flow errors. Specifically, for hourly flow simulations, NSE (Nash-Sutcliffe Efficiency) showed no significant improvement when the resolution exceeded 6 hours, whereas REP (Relative Error of Peak Flow) only ceased to improve significantly when the resolution exceeded 3 hours. In southern Chinese catchments, however, the threshold for both NSE and REP was 6 hours. This difference likely arises from variations in runoff-generation characteristics between catchments in different climatic zones.

3. Investigation on transferability of model parameters across various data resolutions and computational time steps. As you pointed out, discovering that model parameters are not transferable when computational time steps change is one of the key novel aspects of this study. Here, we have firstly investigated the value of high-resolution data using a novel model in a new climatic region. The results confirm that our findings align broadly with previous studies and those of other researchers. This supports the generality of the conclusion that "improvements in simulation accuracy become negligible once data resolution surpasses a certain threshold." Building on this understanding, we further broadened the scope of the study to explore the transferability of model parameters, aiming to provide guidance on selecting appropriate computational time steps in environments with lower data resolution. Specifically, we examined the transferability of model parameters under varying data resolutions and computational time steps. The results indicate that parameters remain transferable with changes in data resolution but lose this property when computational time steps change. Based on this finding, we recommend that even in the absence of high-resolution data, hydrological models should be constructed and calibrated using smaller computational time steps whenever possible.

In the revised manuscript, we will update the wording in the introduction and discussion sections to emphasize these points of novelty.

Comment 3:

HESS primarily focuses on generalizable findings rather than region-specific studies. Despite differences in the study areas, the aims of both works, if understood correctly, appear to focus on deriving general conclusions. However, the current discussion does not sufficiently support this objective, making the paper feel more suited to journals focused on regional case studies.

Response:

One of the objectives of this study is precisely to identify generalizable patterns. To this end, we intentionally selected a new climatic zone for our research, complementing previous studies. Although this research was conducted in a specific region using a specific model, our study area represents a typical climatic zone. While the specific equations used in our model differ, its structure and certain assumptions are similar to those of most mainstream hydrological models. Therefore, the methods and conclusions of this study are supposed to be generalizable. Certainly, we need to thoroughly integrate the conclusions of our study with existing research findings.

The title, "A case study," may lead to a misunderstanding that this research is merely a case study of a specific region. If the editor allows, we would prefer to revise the title in the revised manuscript to avoid this confusion.

Comment 4:

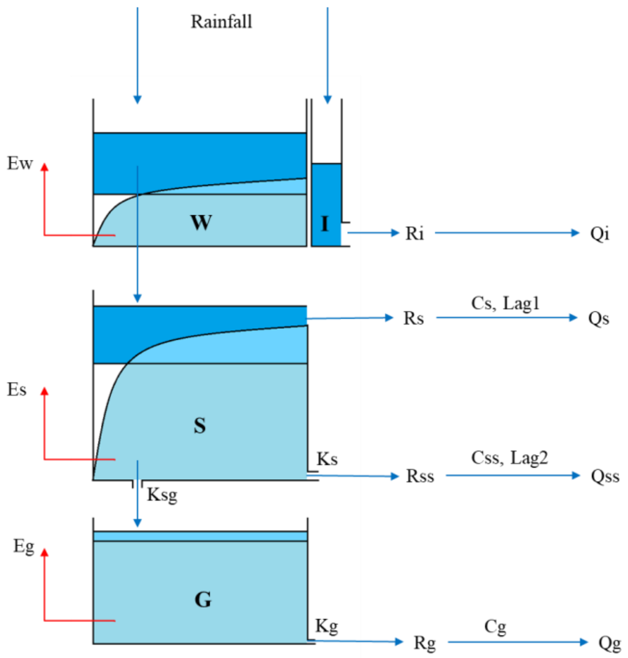
Furthermore, the model is not adequately described. The lack of detailed model descriptions significantly limits the reader's ability to understand the factors that might influence the transferability of parameters across temporal scales. For instance, mechanisms like snow dynamics or evapotranspiration processes could provide valuable insights into why certain parameters can or cannot be transferred. Similarly, a discussion of potential model limitations, perhaps in the modeling of snow dynamics or evapotranspiration, could clarify the conditions under which the model performs better or worse. Unfortunately, these aspects are overlooked, leaving the paper as a lengthy description with insufficient critical evaluation or insight.

Response:

Thank you for pointing out this shortcoming. We now recognize the drawback of not providing a detailed description of the model used in the study. In the methodology section, we focused on describing the experimental design, while the specific equations used in the model were placed in the supplementary section, which led to insufficient explanation of the model itself. Just as you illustrated with examples, our model includes linear assumptions in some modules, such as using a linear reservoir to calculate groundwater runoff, and incorporating lag time in surface runoff calculations. The values of these parameters are related to the time step used, which results in their non-transferability. Although we discussed some variations of these parameters in Section 4.2, we now realize that without a proper explanation of the model, this discussion may not be clearly conveyed. In the revised manuscript, we will provide a detailed description of the model and further specifically elaborate on how the parameter changes with time scales and its (non-)transferability in Sections 4.2 and 4.3, in conjunction with the formula and significance where the parameter is located.

Here is the description of the model that we intend to include in Section 3.1 of the revised manuscript.

The study catchments are located in a rocky mountainous region with severe weathering and high vegetation cover (Zheng et al., 2013; Yu et al., 2017). On the basis of intensive hydrological and isotopic observations from the Xitaizi experimental catchment, Zhao et al (2019) found that preferential flow in the heavily weathered granite and shallow soils makes up the majority of the stormflow. Recent studies also indicate that subsurface flow is a significant contributor to flood generation (Addisie et al., 2020; Xiao et al., 2020; Wang et al., 2022). To effectively capture the hydrological processes within the study area, a four-source hydrological model was developed, designed to represent multiple hydrological pathways. The model's structural diagram (Figure 2) illustrates these pathways.



- I,W,S,G: impervious layer, soil layer, subsurface layer, groundwater layer.
- Ri, Rs, Rss, Rg: runoff in impervious layer, surface layer, subsurface layer and groundwater layer.
- Ew, Es, Eg: evaporation in W, S, G layer
- Ks, Kg, Ksg: linear outflow coefficients from S layer, G layer, and from S to G layer
- Cs, Css, Cg: weighting coefficients of Rs, Rss, Rg
- Lag1, Lag2: lag coefficients of Rs, Rss

Figure 1: The structural diagram of the hydrological model

The hydrological model is semi-distributed, which first divides the watershed into multiple sub-basins based on the DEM data. Within each sub-basin, the model further divides the surface layer into two representative units in the horizontal direction: pervious and impervious layers. The impervious layer (I Layer) includes waterways, compacted rock layers, and artificial covers (such as concrete roads), among others. Rainfall on the impervious layer is directly converted into runoff impervious layer (R_i) for that time step, as follows:

$$R_i = P \tag{1}$$

where P is the precipitation, $Area$ is the area of the basin, imp is the proportion of impervious area, and dT is the calculation time step.

The pervious layer is divided vertically into the capillary water layer (W layer), subsurface layer (S layer), and groundwater layer (G layer). To reflect the spatial variability of water storage capacity in the watershed, the W layer and S layer are enclosed by an exponential curve (Zhao, 1992). Rainfall on the pervious layer is partially routed into the W layer, representing soil moisture, which does not contribute to runoff. Another portion of the rainfall (R) infiltrates into the S layer. Water exceeding the capacity of the S layer is generated as surface runoff (R_s), while the water within the S layer is routed through an outlet, contributing to subsurface runoff (R_{ss}). The equations for surface runoff and subsurface runoff are as follows:

$$\mathrm{WMM} = \mathrm{WM} * (1+\mathrm{B}) \tag{2}$$

$$\mathrm{A} = \mathrm{WMM}\left[1\text{-}(1\text{-}\frac{\mathrm{W}}{\mathrm{WM}})^{\frac{1}{1+\mathrm{B}}}\right] \tag{3}$$

$$R = P - E_w + W - WM, \qquad if\ P - E_w + A \geq WMM \tag{4}$$

$$R = P - E_w + W - WM\left[1 - \left(1 - \frac{P - E_w + A}{WMM}\right)^{1+B}\right], \qquad if\ P - E_w + A < WMM \tag{5}$$

$$\mathrm{SMM} = \mathrm{SM} * (1+\mathrm{EX}) \tag{6}$$

$$\mathrm{AU} = \mathrm{SMM}\left[1\text{-}(1\text{-}\frac{\mathrm{S}}{\mathrm{SM}})^{\frac{1}{1+\mathrm{EX}}}\right] \tag{7}$$

$$R_s = R + S - SM,\ \ if\ R + AU\ \geq SMM \tag{8}$$

$$R_s = R + S - SM \times \left[1 - \left(1 - \frac{R + AU}{SMM}\right)^{1+EX}\right],\qquad if\ R + AU < SMM \tag{9}$$

$$R_{ss} = S * K_{ss} \tag{10}$$

where WM, SM, B and EX are storage of W, S layer and their exponential coefficients.

Water in the S layer infiltrates into the G layer. The spatial variability of the groundwater layer's storage capacity is neglected, and groundwater runoff (R_g) is calculated using a linear reservoir approach. The equations for groundwater are as follows:

$$G = G + S * K_{sg} \tag{11}$$

$$R_g = G * K_g \tag{12}$$

Evaporation occurs in the W, S, and G layers. The evaporation in the W layer is calculated by as follow:

$$E_w = PET * K_{ew} \tag{13}$$

where PET is the mean potential evapotranspiration and K_{ew} is the linear coefficients. E_s, E_g are calculated by similar equations with the linear coefficients of K_{es}, K_{eg}.

Considering the lag time in runoff response to rainfall, the convergence of surface flow and subsurface flow on the hillslopes within a sub-basin is modeled using a lag algorithm. No separate lag time is assigned to groundwater flow, as its runoff response to rainfall is slow, and this behaviour can be captured through other parameters. No lag time is either assigned to the impermeable surface, as the travel time of surface water flow within the sub-basin is relatively short and is assumed to not exceed a single time step. Thus, the equations for the flow from all four pathways are as follows:

$$Q_{i,t} = R_{i,t} * Area * imp/dT \tag{14}$$

$$Q_{s,t} = \left[\, R_{s,t-1-lag1} * Cs\ +\ R_{s,t-lag1} * (1 - Cs)\,\right] * Area * (1 - imp)/dT \tag{15}$$

$$Q_{ss,t} = \left[\, R_{ss,t-1-lag2} * Css\ +\ R_{ss,t-lag2} * (1 - Css)\,\right] * Area * (1 - imp)/dT \tag{16}$$

$$Q_{g,t} = \left[\, R_{g,t-1} * Cg\ +\ R_{g,t} * (1 - Cg)\,\right] * Area * (1 - imp)/dT \tag{17}$$

where $Area$ is the area of the basin, imp is the proportion of impervious area, and dT is the calculation time step.

The total flow from a sub-basin is the sum of the four flows above. The routing process through the river net is modeled using the Muskingum method (McCarthy, 1938; Cunge, 1969), with the equation given as:

$$Q_{i+1}^{t+1} = C_1 Q_i^t\ +\ C_2 Q_i^{t+1} + C_3 Q_{i+1}^t + (C_1 + C_2) Q_L \tag{18}$$

where i is spatial index, t is temporal index, and Q_L is lateral flow.

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