

Interactive comment on “Incorporation of the equilibrium temperature approach in a Soil and Water Assessment Tool hydroclimatological stream temperature model” by Xinzhong Du et al.

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General comments: In their work, the authors seek to improve the estimation of stream temperature within the SWAT framework by incorporating a model based on the equilibrium temperature approach. By accounting for air temperature, solar radiation, wind speed, and water depth, the authors obtain a more realistic representation of the heat transfer process than the previously used stream temperature models. The paper is well written and very easy to follow. The authors did a nice job at discussing the literature and comparing their contribution to previous work. This helped highlight the novelty in their article. The research is sound and the results brought about by their

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model, based on the equilibrium temperature approach, are clear. I therefore suggest “minor revision” and only ask the authors to address my few comments below.

Response: We would like to thank the reviewer for his/her thoughtful comments. We responded to your specific comments one-by-one below.

Comments 1: Page 3: I agree that the model introduced by the authors represents a trade-off between complex mechanistic models and simple statistical models. However, because of the simplistic representation of the physics, this is an advantage only in long-term analysis, for which complex models would require “intensive data and calibration effort”. On the contrary, for short-term analysis a more realistic representation of the physics, as provided by complex mechanistic models, may be more reliable. I think this needs to be briefly discussed in their introduction. By discussing this, the authors would at the same time provide a range of applicability of their model.

Response to Comments 1: Thank very much for your thoughtful comments. We agree with you that complex mechanistic models might be more reliable by more realistically representing the physical processes despite the fact that they require more intensive data and calibration effort. A brief discussion for this point was added in the manuscript in the section of Introduction – “On the other hand, complex mechanistic models might be more reliable by more realistically representing the physical processes compared to statistical models. Therefore, the equilibrium temperature approach, which can be seen as a compromise between an empirical statistical and a complex mechanistic model, can be used as an alternative for simulating the heat transfer processes.” The discussion of the applicability of the model was added in the section of Conclusion (Line 16-19, Page 16) as “Theoretically, the equilibrium stream temperature proposed in the manuscript can be incorporated in any other hydrological model with the required runoff components and meteorological input data. The required meteorological input data includes air temperature, solar radiation and wind speed. The required runoff components consist of surface runoff (overland flow), interflow, groundwater flow and snowmelt. ”

Comments 2: Regarding the organization of the sections, I suggest moving the description of the study area after the description of the model. This would mark more clearly a distinction between the theory (including the novelty of this work) and the application (which mostly has an illustrative purpose).

Response to Comments 2: Thank you very much for your useful comments. The description of the study area was moved after the description of the model theory to reorganize the section of 'Materials and Methods'. In this way, it marks more clearly a distinction between the theory and the application.

Comments 3: Section 2.2, line 15: Saying that the hydrological cycle is simulated based on the water balance is obvious.

Response to Comments 3: Thank you very much for your useful comments. The expression for "hydrological cycle is simulated based on the water balance" was deleted. Also, the sentence was revised as "The simulated processes of the hydrological cycle in SWAT include canopy interception, surface runoff, infiltration, lateral flow, snowmelt flow, evapotranspiration, deep percolation, groundwater flow and water routing in the stream and other water bodies."

Comments 4: Page 6, equations (4) and (5): can the authors explain why the coefficient of heat transfer should range from 0 to 1

Response to Comments 4: K is a bulk coefficient of heat transfer and ranges from 0 to 1 in equation 4 and 5. The value of K is dependent on the relationship between stream and air temperature within a subbasin. For example, if stream temperature is approximately the same as air temperature, then K is 1. If there is a short travel time or extensive tree shading, then K will be less than 1 but greater than 0. K as 0 means there is no heat transfer between air and water. The above information was added to the manuscript to explain the reason why the coefficient of heat transfer ranges from 0 to 1.

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Comments 5: Page 7: if the authors do not want to use a model for the dew point temperature (such as Lawrence, 2005), why not calibrating directly T_d rather than equating it to $T_{air+\eta}$ and calibrating η ?

Response to Comments 5: Thank you very much for thoughtful comments. The major consideration here is that dew point is not an input to the SWAT model and using dew point as input data will increase the input data requirement of the existing SWAT model. Our goal in this manuscript is to incorporate the equilibrium temperature approach into the SWAT hydroclimatological stream temperature model using the existing input weather data such as air temperature, wind speed and solar radiation. Therefore, dew point T_d is not directly used as model input. Moreover, dew point can be estimated by air temperature based a linear equation using the additive manner (Lawrence, 2005). In addition, the equilibrium temperature can also be calculated using air temperature instead of the dew point temperature (Dingman, 1972). So, air temperature and an additive parameter ($T_{air+\eta}$) are used to replace the dew point temperature to estimate the equilibrium temperature. Reference: Lawrence, M. G.: The relationship between relative humidity and the dewpoint temperature in moist air - A simple conversion and applications, B Am Meteorol Soc, 86, 225-+, 2005. Dingman, S. L.: Equilibrium Temperatures of Water Surfaces as Related to Air Temperature and Solar-Radiation, Water Resour Res, 8, 42-&, 1972

Comments 6: Figure 2 is too small and needs a higher resolution.

Response to Comments 6: Figure 2 was revised to have a bigger size and higher resolution according to your comment.

Comments 7: Why not Arrhenius equation to calculate the change in the reaction rate with respect to temperature? Also, the equilibrium constant too changes with temperature. A more accurate analysis of the effect of temperature on water chemistry would need to account for this (i.e., Van't Hoff equation).

Response to Comments 7: The impact of stream temperature simulated by the different

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models was analyzed using SWAT's exponential correction equation. The temperature correction equation (equation 12 in the manuscript) used in SWAT model is actually the Arrhenius rate function. As the model used in the manuscript is SWAT model, we used SWAT's Arrhenius rate function to analyze the impact of different stream temperature simulations on water quality simulation. Since the stream temperatures simulated by different models are different, the reaction rates would show differences under other correction functions such as the Van't Hoff equation. However, we focused on using SWAT's Arrhenius rate function to investigate the impacts.

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