Reply to comments of Anonymous Referee #1

We thank anonymous Referee #1 for reviewing our manuscript. The authors are grateful for the insightful comments which provide great suggestions to improve the manuscript.

General comment

The paper is interesting and pleasant to read. I have only minor doubts that could be addressed before publication.

Reply: We thank anonymous Referee #1 for the positive feedback and encouragement.

Specific comments

Comment: First of all, in the introduction (lines 33-45) the Authors provide an overview of experimental watersheds dealing with hydrological observations. Although the topic is interesting, I suggest to shorten this paragraph because the cited watersheds are not considered in the present manuscript and the topic could be misleading for the reader.

Reply: We agree with the referee and we will merge the first two paragraphs. We will make the following changes in the manuscript:

Lines 24-45: "Water resource problems, including the effects of urban development, alternative management decisions, and future climate oscillation on streamflow and water quality, require a deep understanding and accurate modeling of earth surface processes at the catchment scale to be addressed (Gassman et al., 2014). In order to understand catchment processes, it is necessary to obtain detailed weather data and catchment observations related to runoff, water stage, erosion, soil moisture, and water quality. Experimental catchments are properly designed and well-monitored catchments that aim to provide databases of long-term historical hydrological data, which help analyze the mechanisms governing surface runoff (Goodrich et al., 2020). In addition, experimental catchments contribute in the development and validation of numerous watershed models and can be used as validation sites for satellite sensors (Tauro et al., 2018). Furthermore, experimental catchments can monitor groundwater and river water quality with the use of tracer experiments which can estimate the residence and travel times of water in different components of the hydrological cycle (Hrachowitz et al., 2016; Stockinger et al., 2016). Bogena et al. 2018 presented an extensive overview of hydrological observatories that are presently operated worldwide with various environmental conditions. Among those, the US Department of Agriculture-Agricultural Research Service's (ARS) Experimental Watershed Network has operated over 600 watersheds in its history and currently operates more than 120 experimental hydrological watersheds (Goodrich et al., 2020)".

Comment: Second, in introduction (lines 72-73) I believe that aims and novelty of the manuscript should be more emphasized.

Reply: We agree with the referee that the aims and novelty of this study should be more emphasized. We will make the following changes in the manuscript:

Lines 72-73: "In this study, the SWAT 2012 model (rev 681) in the QSWAT interface was used to simulate streamflow in an experimental basin using daily and sub-daily (hourly) rainfall observations. The main objectives were to (i) calibrate and validate the SWAT model using streamflow data, (ii) examine which parameters are more sensitive in different time steps, (iii) estimate the influence of rainfall resolution on model performance, (iv) compare the Curve Number method and Green and Ampt Mein Larson method for runoff simulation, (v) examine the accuracy of the sub-daily model and compare the peak discharges and time of peak of the two models in selected rainfall events, and (vi) investigate the suitability of the SWAT model for hourly simulation in a mixed-land-use basin (i.e., blended combinations of land use). Hence, this study will provide essential hydrological knowledge and contribute to the understanding of the earth surface processes of an urban/peri-urban hydrological system with complex land use in order to analyze the mechanisms governing surface runoff at the catchment scale".

Comment: Third, in paragraph 2.2, I found a little confusing the instruments description and the data that later are used in the manuscript. The Authors mention (lines 101-106) water level and water velocity sensor that are installed in the experimental watershed, but specify only units in mm, what about the velocity? Is the sensor present and used?

Reply: We thank the referee for this comment. This paragraph needs more clarification. The river gauge at the outlet of the basin measures water level data at a 15 min time step. Then, using the Manning's equation we calculated the flow velocity and the flow rate.

Manning's Equation:

$$Q = V * A = \left(\frac{1}{n}\right) * A * R^{\frac{2}{3}} * S^{\frac{1}{2}}$$

Where:

Q = Flow Rate, (m^3/s)

V = Velocity, (m/s)

A = Flow Area, (m^2)

n = Manning’s Roughness Coefficient

R = Hydraulic Radius, (m)

S = Channel Slope, (m/m)

We will exclude the reference to the water velocity in the revised manuscript since we didn’t use water velocity in the calibration process. We will also shorten the instruments description.

Lines 95-106: “The study area includes four water level monitoring stations that provide continuous recordings of the river stage at pre-selected time-intervals (15mins time-step) (Fig. 1). The stations were installed at the end of 2017 under the supervision of the School of Mining of National Technical University of Athens (NTUA). The network was developed under the EU H2020 RIA Program SCENT (Smart Toolbox for Engaging Citizens in a People-Centric Observation Web). The station which is located at the outlet of the study area was selected as the most suitable for further analysis in this study, because the three upstream stations experienced some mechanical problems that affected the calibration and validation process. The monitoring stations are part Open Hydrosystem Information Network (OpenHi.net) which is a national integrated information infrastructure for the collection, management and free dissemination of hydrological data (OpenHi.net) in Greece.”

Comment: Fourth (lines 296-297), the Authors mention an interesting effect of precipitation time step that could affect the result, but in my opinion the results could be affected also by the classic difficulty in obtaining reliable estimations of GAML parameters based on the soil type and heterogeneity. Eventually this issue could be discussed here.

Reply: We thank the referee for this suggestion. The GAML method requires indeed detailed soil data which can be difficult to obtain and may affect the accuracy of the model’s results. Hence, we will include the referee’s suggestion in the revised manuscript. We will rephrase lines 296-297 in the following way:

Lines 295-299: “In this study, the daily model produced higher discharge peaks than the hourly model and generally estimated better the observed values. These results could be due to drawbacks of the GAML method, such as the requirement for detailed soil information and high resolution rainfall data in a sub-daily time step (King et al., 1999). The GAML method assumes that the soil profile is characterized by homogeneity and that the previous soil moisture is distributed uniformly in the soil profile (Jeong et al., 2010). Therefore, the uncertainty in the resolution of the rainfall data, the heterogeneity of the soil formations and the upcoming difficulty in determining the parameters' values for parameterization could affect the method's efficiency. The selection of sub-daily precipitation input time step as well as the resolution of the precipitation data have a great impact on model results when using the GAML method and it should be based on the scale and characteristics of the watershed (Bauwe et al., 2016; Jeong et al., 2010; Kannan et al., 2007)."

Comment: Fifth (line 337) the Authors mention observational errors; could they specify if this could be attributed to the estimation of channel and hillslope flow velocities?

Reply: We thank the referee for highlighting this point. In the manuscript we mentioned that several factors may lead to uncertainty in model outputs such as observational errors in model input data (i.e., weather, soil and land use data). These errors could be due to inaccuracies in the nature of the sensor, environmental conditions and data collection (Guzman et al., 2015). Other reasons may be data limitation, complexities of spatial and temporal scales and inaccuracies in model structure (Polanco et al., 2017). We didn't discuss though the observational errors associated specifically with the estimation of channel and hillslope flow velocities during the calibration process.

Channel and hillslope velocities define the time of the peak and the shape of the hydrograph. In the SWAT model, the CH_N2 parameter (Manning's "n" value for the main channel) affects the rate and the velocity of the flow (Boithias et al., 2017). In this study, the CH_N2 parameter showed the highest sensitivity in the hourly model. This outcome is similar to those of previous studies (Boithias et al., 2017; Jeong et al., 2010). In particular, according to Boithias et al. (2017) the CH_N2 parameter is more sensitive at the hourly time step rather than the daily time step, because at the daily time step the flow peak is influenced by other processes decreasing the sensitivity of the CH_N2. Therefore, the lower peak flows of the hourly model comparing to the daily model could be attributed to the different calibrated value of the CH_N2 parameter.

The estimation of the channel and hillslope velocities should be included in the potential observational errors among other errors such as the quality of the precipitation, soil and, land use data. We thank the referee and we will include this suggestion in the revised manuscript. We will make the following changes in the manuscript:

Lines 337-340: "Furthermore, observational errors in the model input data (i.e., weather, soil and land use data) include inaccuracies in the estimation of channel and hillslope velocities and channel geometry, in the nature of the sensor, environmental conditions and data collection (Guzman et al., 2015). These errors can generate variability, lead to undesired trends, and influence the model calibration and validation results (Kamali et al., 2017). In addition, the complex land use characteristics and processes of an urban/peri-urban environment and assumptions made during the model structure/parameterization process (e.g., selection of parameters for calibration, objective function, and conceptual simplifications) increase the uncertainty of the results."

Minor comments

Comment: line 81: route?

Reply: We thank the referee for this comment. We rephrased line 81 in the following way:

Line 81: "The Kifissos River basin occupies an area of 380 km^2. Kifissos River route is approximately 22 km, of which at least 14 km are within an urban area".

Comment: line 97: specify the acronym.

Reply: We thank the referee for this comment. We added the acronym and changed line 97 in the following way:

Line 97: "The stations were installed at the end of 2017 under the supervision of the School of Mining of National Technical University of Athens (NTUA)".

Comment: line 190: changing or constant?

Reply: According to Abbaspour et al. (2017, 2007) the sensitivities are estimated as average changes in the objective function which result from changes in each parameter, while all other parameters are changing.

Comment: line 198: do the numbers refer to discharge?

Reply: We thank the referee for this comment. The numbers refer to discharge. We changed line 198 in the following way:

Line 198: "Mean and standard deviation of discharge for 2018 were 1.25 and 0.46 and for 2019 were 1.42 and 0.74 respectively".

References

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