Reply Referee #1

COMMENT 1: General comments: In the submitted paper, authors investigate the impact of the rainfall seasonality anomalies on the catchment water balance components. For this purpose, a catchment in the southern Italy is selected and SWAT model is applied in order to carry out the investigation. Two different approaches are used in order to define rainfall scenarios. First approaches is based on the standardized precipitation index and second one is based on the duration of the wet season as proposed by Feng et al. (2013). The topic is potentially interesting for the society and HESS readers.

REPLY-1: We thank this reviewer for her/his comments. In the following sections we have tried to provide some preliminary replies to clarify her/his major concerns.

However, two main shortcomings of the paper from my perspective that should be improved are:

COMMENT 2: Firstly, the main focus of the paper is to investigate what is the impact of different rainfall scenarios on the water yield, actual evapotranspiration and groundwater recharge. Thus, for different scenarios changes in these variables are analyzed with respect to reference case. Model calibration is just briefly described and reference to more detailed description is given (Nesta et al., 2017). It seems that model was calibrated using monthly data (?). However, P6, L124 states that daily time step of the SWAT model was used. I think that model should also be calibrated using daily data if authors want to use this time step. Otherwise, I would suggest to aggregate daily rainfall data into monthly and re-run the model with monthly time step (if this is possible or perhaps use a different model). An alternative is, to calibrate the model using daily data if there is a discharge gauging station available near the catchment outlet.

REPLY-2: Nasta et al. (2017 STotEnv) calibrated a few model parameters by comparing measured and simulated monthly water yield values recorded at the dam. Numerical simulations were run at daily time step (the only time step allowed in SWAT). In this study, we followed the same criterion, we run numerical simulations at daily time step (rainfall was randomly generated at daily time step) and aggregated the output fluxes at monthly time resolution. We are aware that calibrating at monthly time-scale might lead to a potential misfit between measured and simulated values at daily time-scale (e.g. Adla et al., 2019, Water). However, our analysis is based on the monthly aggregation of fluxes and we analyzed seasonal patterns of monthly aggregates. This important point will be clarified in the revised manuscript.

Adla, S., S. Tripathi, M. Disse, 2019. Can we calibrate a daily time-step hydrological model using monthly time-step discharge data? Water 11, 1750; doi:10.3390/w11091750.

COMMENT 3: Secondly, when using different scenarios, authors only modified rainfall characteristics, what about air temperature? It is true that in some cases the dependence between these two variables can be low or even none existing. However, is some other cases, some dependence could exist. For example, higher average annual temperature could lead to lower annual rainfall and vice-versa. Or higher daily temperature in summer could cause higher rainfall amounts due to more extreme thunderstorm. Did authors check the relationship for this specific catchment? Moreover, I think that air temperature variability should be included in this kind of investigations. Even if there is no clear relationship with rainfall.

REPLY-3: We fully agree with this comment, which in our opinion is timely. Indeed, the feedback of temperature on precipitation is a widely recognized cause for the increasing frequency of storms and heavy rainfall events under climate change. Unfortunately, we do not have easy access to database of long time series of temperature measurements to reliably evaluate this linkage in our case study, since this analysis cannot be restricted only to the surrounding air temperatures, but should include the change in sea surface temperature and air moisture to correctly frame the analysis. This is certainly an issue that deserves an in-depth analysis, but at this stage it goes beyond the scope of our analysis. We have focused our study only on the long-term (almost one century) daily timeseries of rainfall, yielding interesting outcomes about the sensitivity of catchment hydrological response to seasonal rainfall patterns only. Moreover, for the same reason (lack of temperature data) we could not capture any significant (increasing) trend and assumed temperature stationary in time and so does evapotranspiration. Our analysis addressed only on the impact exerted by rainfall seasonality on water balance components. The availability of adequate datasets should also highlight whether the observed increases in air temperatures impact the daily precipitations, or mostly only the sub-daily and sub-hourly rainfall values.

Specific comments:
I would suggest to add a figure showing the location of the catchment with stations used.
REPLY-4: Actually, the figure with the locations of the two weather stations is already showed in Nasta et al. (2017), so we can easily refer to it.

P6, L130: Please better explain what is meant by the term boundary forcings.
REPLY-5: With the term "boundary forcings", we mean the (input) water fluxes (rainfall and potential evapotranspiration) set on the upper boundary condition of the soil domain.

P7, L142-144: Why did you used only 3 years for simulation and why 2-years warm-up period? How does this selection impact on the results? Moreover, does initial state of the catchment also has impact on the results (i.e. using different initial values of model variables)?
REPLY-6: We decided to run 3 years in each scenario and neglect the model simulations of the first two years to annihilate the impact of initial soil moisture values set in the soil domain. We point out that the soil water content at the initial day of year 1 is set at field capacity (which can be already considered a realistic situation in winter under Mediterranean climate). We also specify that we consider the third year of model simulation. We repeat this exercise 10,000 times such that to organize output fluxes in a probabilistic framework.

P7, L146-149: The data from other station will be used for analyses at monthly time scale but the model will run with daily time step and daily reference evapotranspiration will be calculated? Perhaps you could rephrase this sentence.
REPLY-7: We agree and we reformulate this (unclear) sentence. We have the daily weather values and we use the descriptive statistics of daily values in each month of the year to generate new random daily values of evapotranspiration in each month.

P7, L149: Here reference evapotranspiration is mentioned but in next sections, you only mention potential and actual evapotranspiration. Why was reference evapotranspiration used?
REPLY-8: SWAT uses the weather data to estimate potential evapotranspiration (ET_p). We will replace the word "reference" with the word "potential" to avoid confusion. Thanks for pointing it out.

P9, section 4.3: If I understand correctly exponential distribution was selected only based on the graphical comparison shown in Figure 2 and Figure 3? If this is the case, I would suggest to additionally apply a suitable statistical test.
REPLY-9: The stochastic Poisson point process of daily rainfall occurrences was assumed to represent daily rainfall evolution for its easy reproducibility (L193-196). In a preliminary analysis we tested it and compared it with the best parent distribution, namely the Generalized Pareto Distribution. In this case, we observed a fair agreement between the two models for representing daily rainfall evolution recorded at Gioi Cilento weather station and concluded that the simple-to-use exponential model is suitable (L206-210).
The stochastic Poisson point process is widely used for its simplicity and parsimony as pointed out by Reviewer#2 (we list below the three references reported in REPLY-4 to ref#2)

Rodríguez-Iturbe, I., B. Febres de Power, J.B. Valdés. 1987. Rectangular pulses point process models for rainfall: Analysis of empirical data. Journal of Geophysical Research, https://doi.org/10.1029/JD092iD08p09645

Veneziano, D., V. Iacobellis. 2002. Multiscaling pulse representation of temporal rainfall. Water Resources Research, 38, 1138, 10.1029/2001WR000522

Eagleson, P. S. 1972. Dynamics of flood frequency. Water Resour. Res.,8, 878–898.

P10, L230-231: I do not understand this sentence, if you split the data, how can you then have a drying trend? Only for the second 45 years?
REPLY-10: The frequency distribution of SPI-6 values in the first 45 years is wetter than the one pertaining to the last (more recent) 45 years.

P13, L285 and L294: A statistical test is mentioned here but no information about null and alternative hypothesis is given. Moreover, authors should rephrase these sentences. In statistical hypothesis testing the null hypothesis can be either rejected in favor of the alternative hypothesis or cannot be rejected (with the chosen significance level). Moreover, all the methods used should probably be mentioned and described in the methodology section (and not results and discussion).
REPLY-11: Mann-Kendal test has become a standard test for trend under climate change, it is widely applied in many papers. Therefore, after a discussion among the co-authors, we decided not to describe the Mann-Kendal test in detail and just mentioned the reference.

Sections 5.3 and 5.4 and conclusions: The main results of the paper are somehow expected: dry scenario leads to less runoff, groundwater recharge and also less actual evapotranspiration (compared to reference scenario). On other hand, wet scenario leads to more runoff, groundwater recharge and actual evapotranspiration (compared to reference scenario). Moreover, different rainfall simulation methods yield different results. The actual relationship among variables mostly depends on the rainfall characteristics, especially if variability in air temperature is not considered. Can the authors perhaps somehow enhance the take home message of this paper?
REPLY-12: The target of our study is to evaluate the sensitivity of water balance components to rainfall seasonality only (potential temperature effects are not considered here, partly because of lack of suitable datasets). The take-home message of this paper is that allowing for rainfall seasonality is an important issue because the impact of seasonal duration can be seen in the Budyko plot (Fig. 11). Moreover the assumption of steady-state condition inherent the Budycko approach is questioned. The stationarity/non-stationarity dilemma in hydrological processes is still matter of an open debate in the scientific community (Milly et al., 2008; Montanari and Koutsoyiannis, 2014).

Milly, P. C. D., J. Betancourt, M. Falkenmark, R. M. Hirsch, Z. W. Kundzewicz, D. P. Lettenmaier, and R. J. Stouffer. 2008. Stationarity is dead: Whither water management?,Science,319, 573–574, doi:10.1126/science.1151915

Montanari, A., and D. Koutsoyiannis. 2014. Modeling and mitigating natural hazards: Stationarity is immortal!, Water Resour. Res.,50,9748–9756, doi:10.1002/2014WR016092.