<u>Response to Anonymous Reviewer #2</u>

The authors would like to express their deepest gratitude to the reviewer for his/her insightful comments which will surely enhance the paper. We have revised the paper based on your suggestions. Our responses (in black) to the questions (in red) are given below.

1- In this paper, the authors are reporting as they present a new conceptual scheme of coupled MOBIDIC-MODFLOW model. But, in the paper, nothing is said about MODFLOW and how they link the two models.

Thank you for your excellent suggestion. The coupling process of MOBIDIC and MODFLOW will be included in the revised version of the manuscript:

The MOBIDIC and MODFLOW are coupled using the sequential coupling approach discussed in (Guzha 2008). At each time step, the spatial distribution of the groundwater head determined in MODFLOW from the previous time step is transferred into MOBIDIC for calculation of the groundwater recharge in the concurrent time step (equation 12). The calculated groundwater recharge will then be used as the upper boundary condition for the calculation process in MODFLOW for the next time step. This process continues until the last time step.

2- In this study, the MOBIDIC-MODFLOW results were based on the output of MIKE-SHE (e.g. the coefficient of groundwater recharge used by the model is based on the water table of MIKE-SHE) and the result also interpreted again by comparing with MIKE-SHE results. How much this coupled model can stand alone without MIKE-SHE? Why not consider the evaluation of the model result by comparing the measured time series water table of the month considered in the "real" field condition?

Thanks for raising this very important issue. Although the proposed modifications in the model were evaluated against MIKE SHE as the reference model, the model itself can be used independently. The calibration of the coefficient of the groundwater recharge based on the simulation results of MIKE SHE enabled us to propose an alternative model (MOBIDIC-MODFLOW) which is computationally and parametrically simpler. This is important as the developed model is aimed to be applicable at watershed scale simulations where the computational and parametrical efficiency of the model is of great concern.

The comparison of the simulation results against MIKE SHE was made to investigate how the simplifications of in MOBIDIC-MODFLOW can affect the simulated water tables if it applies at the watershed scale. Unfortunately, we didn't have any observations of the water table to test the fidelity of the proposed modifications in MOBIDIC-MODFLOW. Consequently, the simulated water table levels of MIKE SHE was considered as the ''expected'' response of the catchment in absence of the observations.

3- Page 1 (line 21) and page 16 (lines 23-26)- It is reported that in computational efficiency (time efficiency) of the proposed approach, MIKE-SHE took 180 times longer to solve the 3D case than the MOBIDIC-MODFLOW in its application to real catchment case studies. Since MIKE SHE model simulation covers a fully integrated aspect of all important hydrology including groundwater, surface water, recharge, and evapotranspiration, how much the new coupled model is capable in computing all those hydrological processes, and is it acceptable to compare the efficiency of the two models and report theses much gap?

We are very thankful for this insightful question. Same as MIKE SHE, the MOBIDIC-MODFLOW is capable of simulating all aspects of the hydrologic cycle including the groundwater flow, recharge, evapotranspiration, overland, and channel flow. However, the formulations of the hydrological processes in the two models are different. For example, the overland flow and channel flow in MIKE SHE are described using the Saint-Venant equations, whereas in MOBIDIC-MODFLOW these are based on steepest descent and linear reservoir approach.
In terms of subsurface (unsaturated and saturated zone) flow, which is the subject of this paper, the differences are in the conceptualization of the unsaturated zone and its coupling process with the saturated zone. In MIKE SHE the unsaturated zone is extended from soil surface to the water table and it is described using the Richards equation. In MOBIDIC-MODFLOW with the introduced modifications, the unsaturated zone is also extended from soil surface to the water table, however, it is described using the dual reservoir approach. Such conceptual formulation of the unsaturated zone eliminates the fine spatial and temporal resolutions required in the Richards equation, resulting its computational efficiency.
Regarding the unsaturated-saturated coupling procedure, the two models have some differences. In MIKE SHE, the water table level is iteratively corrected within each unsaturated time step which is not the case in sequential coupling

approach implemented in MOBIDIC-MODFLOW (please refer to the question 1 for the detailed description of the method).
Another difference between the two models is in the formulation of the evapotranspiration process. The (Kristensen and Jensen 1975) approach in MIKESHE calculates the moisture extraction for each calculation node in the unsaturated zone. However, in MOBIDIC-MODFLOW, the capillary and gravity reservoirs are not vertically discretized and evapotranspiration loss occurs from the capillary reservoir.
Such differences in the conceptualization of the evapotranspiration process yield a different number of calibration parameters for the description of the evapotranspiration process in the two models. The (Kristensen and Jensen 1975) model have four parameters, however, the magnitude of the evapotranspiration rate in MOBIDIC-MODFLOW is controlled with only one parameter. This is an important advantageous of MOBIDIC-MODFLOW since a low number of parameters makes the calibration process more efficient and reduces the risk of equifinality issue (Beven 2001).
Note that the two models have similar formulation and solution approach for the saturated zone (the Preconditioned Conjugate Solver (PCG) solver in saturated flow module of MIKE SHE is identical to the one used in MODFLOW).
Therefore, similar to MIKE SHE, the MOBIDIC-MODFLOW covers all aspects of the hydrological process, but with different formulations. The comparison of the computational efficiency of the two models enabled us to investigate how much the simplification of the hydrological processes especially in the unsaturated zone can improve the computational efficiency of the model. As it was mentioned in question 2, the computational efficiency is an important factor for watershed scale application of the integrated model.

4- Page 2 (Line 15) "Inconsistency in the conceptualization of the interaction between SZ and UZ" is reported in externally linked models listed. It needs a strong justification. The recently released SWAT-MODFLOW papers could not agree with this idea.

The main problem regarding the application of the externally coupled models in shallow water table cases is the assumption of a constant specific yield. The specific yield decreases nonlinearly as the water table rises. Therefore, the rises in the water table would be much greater than what would be expected using a constant specific yield as discussed in (Abdul and Gillham 1989). Such issue hasn't been discussed in the publications of the SWAT-MODFLOW (Bailey et al. 2016; Guzman et al. 2015; Chung et al. 2010) or

TOPMODEL-MODFLOW (Guzha and Hardy 2010). With modifications in MOBIDIC-MODFLOW, we aimed to address this issue and extend the applications of the externally coupled models in shallow water table cases.

5- There is inconsistence in using the abbreviation for moisture content at saturation which is used in page 5 line 14.

We are very thankful for your careful reading of the manuscript. It was corrected in the revised version of the manuscript.

6- "t" is missed in the ward water table in sentences on page10 line 8 and page 14 line 13.

Thank you for your careful reading of the manuscript. It was corrected in the revised version of the paper.

7- A full stop (.) is missed in the sentence on page 13 line12.

Thank you for your careful reading of the manuscript. A full stop was added to the sentence.

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