

## ***Interactive comment on “Recharge estimation and soil moisture dynamics in a Mediterranean karst aquifer” by F. Ries et al.***

**Anonymous Referee #3**

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REFeree REPORT (HESS-2014-304)

Title: Recharge estimation and soil moisture dynamics in a Mediterranean karst aquifer  
Author(s): F. Ries et al. MS No.: hess-2014-304 MS Type: Research Article

General comment The paper deals with an interesting issue, the analysis of the spatio-temporal variability of soil water percolation and estimation of groundwater recharge rates in a Mediterranean karst aquifer, through the study of soil moisture dynamics and modelling of vadose zone flow. The study area, located on the western margin of the Jordan Rift Valley (Israel), covers a small portion of a Mediterranean karst aquifer (limestone and dolomite rocks with alternating marl and chalk layers), highly fractured and permeable. It is characterized by strong climatic gradients and is cov-

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ered by depth residual soils (Terra Rossa and Rendzina), very heterogeneous and complex for their physical and hydraulic features, and by high clay and silt fraction. The experimental field for soil moisture measurements and the hydrometeorological monitoring system set up are very interesting, but the dataset used for the modelling, 3 years of monitoring, is limited to soil moisture data (up to a depth of 80 cm) and precipitations. The water percolation processes in the unsaturated soil zone (extended to 62-years) were simulated by the use of the model Hydrus-1D (numerically solving Richards' equation that governs the groundwater flow). However, the hydrological and hydraulic parameters of the soil zone and other variables relevant to the formulation of the van Genuchten-Mualem model are not physically based, and their calibration was performed using the Shuffled Complex Evolution Metropolis algorithm and Kling- Gupta Efficiency as optimization criteria. Therefore, the model ability to correctly predict soil water percolation and groundwater recharge rates is clearly affected by the reliability of the hydraulic-physic parameters assumed and included in the model Hydrus-1D, which are not physically based. In my opinion, this is a major weakness of the analysis; therefore, the paper can be accepted for publication in HESS, but needs major revisions listed as follows.

Major comments In Section 2 (Study area), Page 4, Lines 1-8 is given a general description of the karst aquifer and soil cover. A more detailed description of the hydrogeological conceptual site model is necessary. In this regard, the Figure 1 is not very detailed, and it should be integrated with: i) a hydrogeological model of the perched karst aquifer (indicating the outcropping lithologies and soils, and the groundwater flow), ii) a schematic cross section, showing soils thickness with the position of the sensors, the unsaturated perched karst aquifer, and the water table of the monitored well. Section 3 (Material and methods). In Section 3.1 (Hydrometeorological measurements). Page 4, Lines 33-37 specify the measurement frequency of the precipitation, air temperature, groundwater levels and water temperature recorded in the monitored well. Section 3.2 (Soil moisture measurements). 1) Page 5, Line 2 specify the area (slope or plain) where there are the soil moisture plots (SM1-SM-3). Furthermore, with reference to

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Table 1, specify if the textural characteristics of the soils are theoretical, or referred to other literature data (in this case, provide the quote), or derived from experimental test. 2) Page 5, Line 19-20 specify the measurement frequency of soil temperatures. Section 3.3 (Modelling of the soil zone). 1) Page 5, Lines 24-25 specify why the water balance equation does not consider the runoff. The tree experimental sites are located in an flat sector or on slope? 2) Is there any experimental evidence confirming that also during rainfall events of high intensity and duration there is no runoff ? 3) Page 6, Lines 1-2 "Potential evapotranspiration was calculated by the Hargreaves-equation (Hargreaves and Samani, 1985)". Why the authors did not calculate the actual evapotranspiration, provided that the peaks in soil water content are only recorded in rainy season and/or during rainfall events of high intensity? Section 4 (Results). In Section 4.3.1 (Parameter optimization, uncertainty analysis and model validation). 1) Page 8, lines 28-29 "The calibrated parameter sets used for further Top assessment of the plot scale soil water balance, are given in Table 3". The values of  $k_s$  included in the model (mm/day), given the textural characteristics of the soils (clays with silt, clays with sand), seem too high (ranging between  $4.94 \times 10^{-4}$  cm/s  $\hat{=}$   $1.15 \times 10^{-2}$  cm/s) and not in line with those reported in the literature for these soil material. The Authors should have at least run the tests in the field or lab, in order to justify the choice of these high values of hydraulic conductivity for the modeling of the percolation flow. 2) Page 9, Lines 7-9 "Water temperatures in a groundwater well near soil moisture plot SM-3". If the variation of temperature is related to flow percolation, it would be interesting to show also the rise of the piezometric levels recorded in the well. To this end, Figure 7 should be modified accordingly. Section 4.3.2 (Plot scale water balance). 1) Page 9, Lines 16-19: "Percolation from the bottom of the soil zone only started after cumulative rainfall during winter season exceeded in an certain threshold. This threshold was found to be approximately 240 mm at plot SM-1, SM-plot at 200 mm 2 and 150 mm at plot SM-3". For the site SM-2 this threshold seems to be in contrast with what is reported in table 4, where it is noted that for 2010/2011 there are rainfall (248 mm) higher than the threshold (200 mm) that did not produce bottom flux (see Table 4).

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Sections 4.3.2, 4.3.3 and 4.34 (Plot scale water balance, Spatial extrapolation of deep percolation and Temporal extrapolation of deep percolation) describe the main results of the water percolation rates provided by model. 1) The groundwater recharge rates calculated certainly deserve some comparison with those already available in the literature, estimated for other karst aquifers of the Mediterranean region. 2) Why are the rates of groundwater percolation determined (up to 66% of precipitation) are not visible in Table 4? Section 5.3 (Spatial and temporal extrapolation of deep percolation). Page 12, Lines 33-36 "These findings are in good agreement with measurements at discharge Auja spring, a large karst spring in the Jordan Valley, where 7 and 8 million m<sup>3</sup> were Measured for the winter seasons 2011/2012 and 2012/2013 respectively, but only 0.5 million m<sup>3</sup> for the 2010/2011 season (Schmidt et al., 2014)". The Auja spring is a large basal karst spring located of the Jordan Valley fed by regional karst aquifers, characterized by dynamics and response time different from the perched karst aquifer of the study area. Conversely, for the study area a more appropriate comparison would be with spring discharges and / or piezometric levels of local perched karst aquifers, in the upper part of the western margin of the Jordan Rift Valley (to see, for example, Peleg and Gvirtzman, 2010, in *Journal of Hydrology*, 388, 13–27, 2010; Weiss and Gvirtzman, 2007, in *Ground Water*, Vol. 45, No. 6, 761–773, 2007). Minor comments Section 1 (Introduction). Page 2, lines 28 to correct the citation Allocca et al., 2014. The correct citation is Allocca et al., 2014. Section 4.3.4 (Temporal extrapolation of deep percolation). Page 10, Lines 12-13 "Percolation at the three plots varied between 0% and 66% of cumulative seasonal rainfall with an average between 16% and 24%". Insert in Table 4 the full range of values. Figure 3: Provide details about station elevation (m a.s.l. and b.s.l.). Figure 8: Improve the editing of the graph at present, is not readable.

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