Interactive comment on "Gravitational and capillary soil moisture dynamics for hillslope-resolving models" *by* A. Castillo et al.

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First of all, we would like to thank Andrew. J. Guswa for his valuable comments which we will take in full consideration in improving our paper.

Comment 1 The paper lacks a clear articulation of the benefits of the dual-porosity approach over a simpler "bucket" model. Many have shown that these simpler models of average soil-moisture can capture the temporal dynamics as well as more complex representations. The current version of the manuscript does not effectively make the case as to why the dual-porosity model is needed – what is gained? What are the advantages over a bucket model? And models such as that of Milly (1993), Rodriguez-Iturbe et al. (1999), and Laio et al., (2001) employ a piece-wise loss function, effectively

changing the dynamics when the soil moisture exceeds critical points, such as field capacity. Those bucket models in some ways already capture the essence of gravity versus capillary water by turning drainage off when soil moisture drops below field capacity. How is the explicit representation of gravity and capillary water, and the exchange between them, superior? Would a bucket model with a single state variable for soil moisture be unable to represent the average soil-moisture dynamics for the two case studies?

Response: In typical non-leaky single bucket models, subsurface lateral flow and percolation do not occur until the bucket is filled i.e. the soil becomes saturated, so the non-linearity in lateral flow and percolation is not captured. Whereas, leaky single bucket models do not capture some essential nonlinear behaviors, such as possible hysteresis (which we will show on another paper that is currently under preparation). Moreover, bucket type models that use single soil moisture state with piece-wise defined functions e.g. using different dynamics when soil is below or above field capacity, are more similar to the conceptual approach of MOBIDIC. One of the advantages of explicit representation of gravity and capillary water is that processes acting separately on the dual reservoirs can occur simultaneously, but not necessarily with predefined relative magnitude. In single bucket models with piece-wise defined function, either but not both slow and fast processes operate.

Comment 2 In equations 4 to 7, can the water available in the gravity store + infiltration be exceeded by the sum of the losses from the gravity water store, i.e. $(Q_{as} + Q_{per} + Q_L) > (W_g + I)$?

Response: In the numerical implementation, Equations 4 to 7 are solved sequentially e.g in a cascade fashion where W_g is updated. In essence, first, infiltration increases W_g, then followed by capillary absorption which has priority over vertical percolation, which in turn has priority over lateral flow. This will be clarified in the revised manuscript.

Comment 3 The manuscript refers to subscripts "*up*" and "*down*", which do not show up in equations.

Response: The schematic diagram shown in Figure 1 is for the full version of MOBIDIC which is intended for distributed catchment modeling. The subscripts "*up*" and "*down*" for surface runoff ($R_{T,up}$ and $R_{T,down}$) and subsurface runoff ($Q_{L,up}$ and $Q_{L,down}$) are defined in the methods section for completeness. Since a 1-D version of MOBIDIC is used in this manuscript, lateral fluxes were not considered.

Comment 4 The authors offer an explanation for the underprediction of soil moisture at Site 2 during the validation phase (Figure 6b, days 850-1100) – that irrigation water may be propping up the observed soil moisture. However, during the calibration phase, the models show the opposite behavior – that is, they show a more muted response rather than the rapid dry-down observed in the measurements. This difference may be worth some additional discussion.

Response: In Figure 6b around day 170-270, the W_c values of both MOBIDIC and SHAW, do not dip down as low as the observations probably because the effect of plant transpiration, through root suction during this dry period, are not correctly captured by both models.