Response to Review Comments by Dr Nataliya Le Vine

We would like to thank the reviewer for carefully reviewing the manuscript and for her comments and suggestions. We address all relevant points raised by the reviewer below, which will be incorporated in a revised manuscript.

1. Novelty and contribution to knowledge

In our current study, we have introduced a new simple parameterization i.e., the Bulk Conductivity (BC) model to simulate the water flow through chalk unsaturated zone in a land surface model (JULES). In addition, the objective of the manuscript is to study the impact of explicit representation of soil-chalk layering features particularly on evapotranspiration (ET) in conjunction with Earth Observations (i.e., MODIS). The reviewer has outlined the similarities between the parameter values between our manuscript and Le Vine et al. (2016). This is due to the fact that our work is motivated by their published study (refer to section 5 in their article), and we therefore decided to minimize differences in other model experimental setups to ensure consistency across multiple configurations in order to better identify the actual impact of our newly proposed BC model. This is a common and expected approach in research practice. Our current study is unique because we introduce the Bulk Conductivity (BC) model (based on the work by Zehe et al., 2001) which is clearly a different approach compared to previous peer-reviewed literature on chalk. Additionally, we investigate the effect of this parameterization on JULES simulated ET in comparison to observations from MODIS.

In conclusion, we strongly believe that our study is novel because of the introduction of the new BC model and the focus on the effect of chalk unsaturated zone hydrology on land surface processes in conjunction with Earth Observations, which has not been discussed explicitly in previous peer-reviewed literature. However, we acknowledge that it is important to refer to other studies that address similar challenges in the region. Therefore we will properly cite the PhD thesis by Bakopoulou (2015) in the revised manuscript.

2. Incorrect model setup for 'macro' configuration at catchment scale

We would like to thank the reviewer again for pointing out this important model setup issue in terms of the spatial distribution of chalk over the Kennet catchment. We agree that a spatially uniform representation of chalk over the catchment is indeed incorrect. We have updated the spatial distribution of chalk in the model using the hydrogeology map provided by the British Geological Survey (http://www.bgs.ac.uk/products/hydrogeology/maps.html). Figures R1 and R2 below outlines the differences between the catchment scale simulation results before and after the modification (related to Figure 8 and 9 in the original manuscript, respectively). These figures will be modified in the revised manuscript.

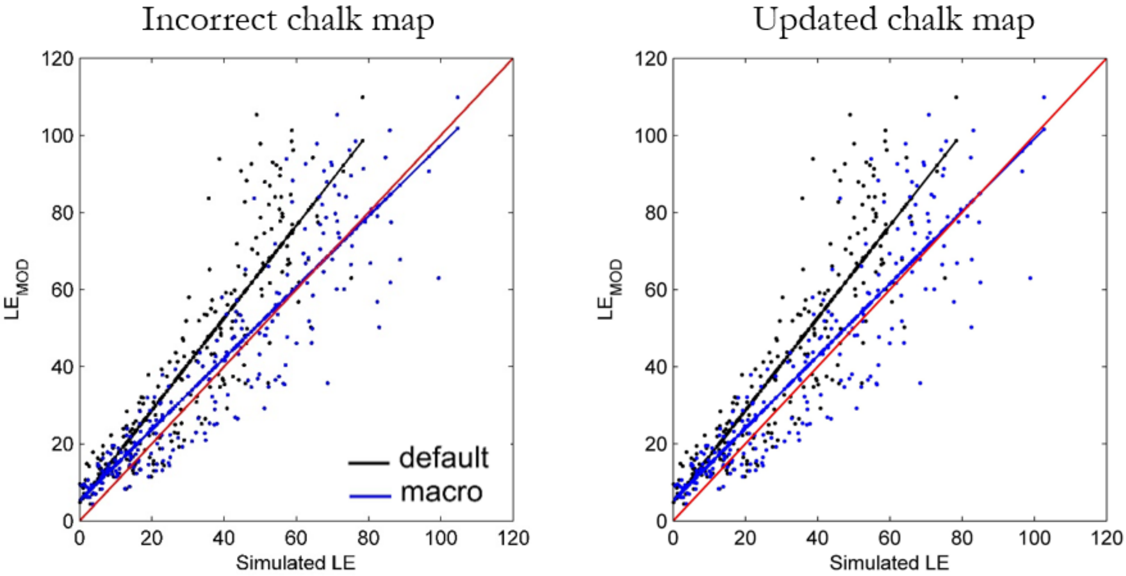

Figure R1. Catchment average 8-day composites of MODIS estimated LE (LE_{MOD}) against simulated LE from *default* and *macro* configurations ($LE_{default}$ and LE_{macro}, respectively) along with the linear models fitted for $LE_{default}$ (black) and LE_{macro} (blue). The 1:1 line shown in red represents the perfect fit between LE_{MOD} and simulated LE. The left and right figures show the results before and after the modification of spatial distribution of chalk over Kennet, respectively.

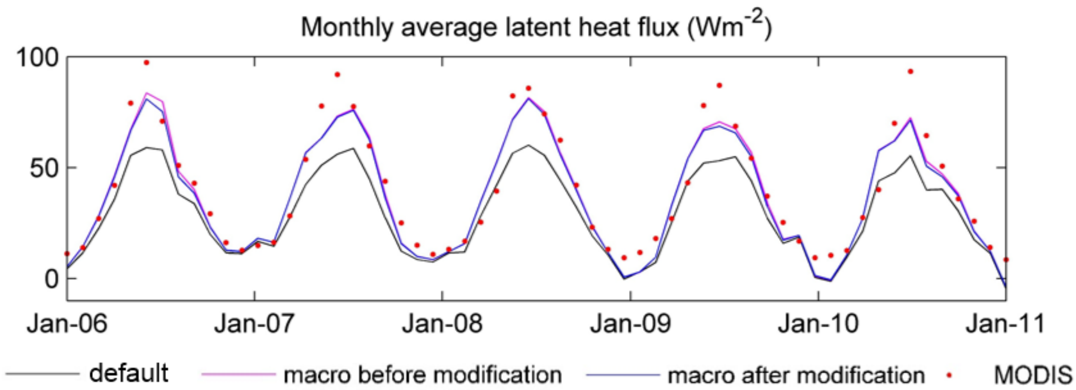

Figure R2. Spatially averaged monthly latent heat flux (*LE*) from MODIS, *default*, and *macro* configurations (before and after modification of chalk spatial distribution) over the Kennet catchment.

3. Activation of Bulk Conductivity model at point- and catchment-scale

The reviewer has mentioned her concern about whether or not the BC model is ever activated at the catchment scale because Figure 9 in the manuscript does not show relative saturation (S) exceeding 0.8 (the threshold chosen for BC model activation). We would like to draw the attention of the reviewer to the fact that Figure 9 shows catchment average relative saturation for the top 100 cm of the profile (please refer to the caption of the figure). The BC model is applied at every grid cell of the model, which is clearly stated in the original manuscript (l. 80-84). Therefore, the catchment average root zone saturation (as shown in the original Figure 9) is not an indicator of the activation of fracture flow through chalk. The intention of this figure is to show that soil moisture affects ET mainly in summer (l. 325-335).

As an illustrative example, Figure R3 below shows the number of instances the BC model (with the updated chalk spatial distribution) was activated at 4th model layer (30-40 cm below surface, the first model layer with chalk) over the entire simulation period. Moreover, note that the mechanism of the BC model at the point scale is discussed elaborately in the original manuscript (Figure 6, l. 246-283), which describes the effect of the new parameterization on water movement through chalk unsaturated zone.

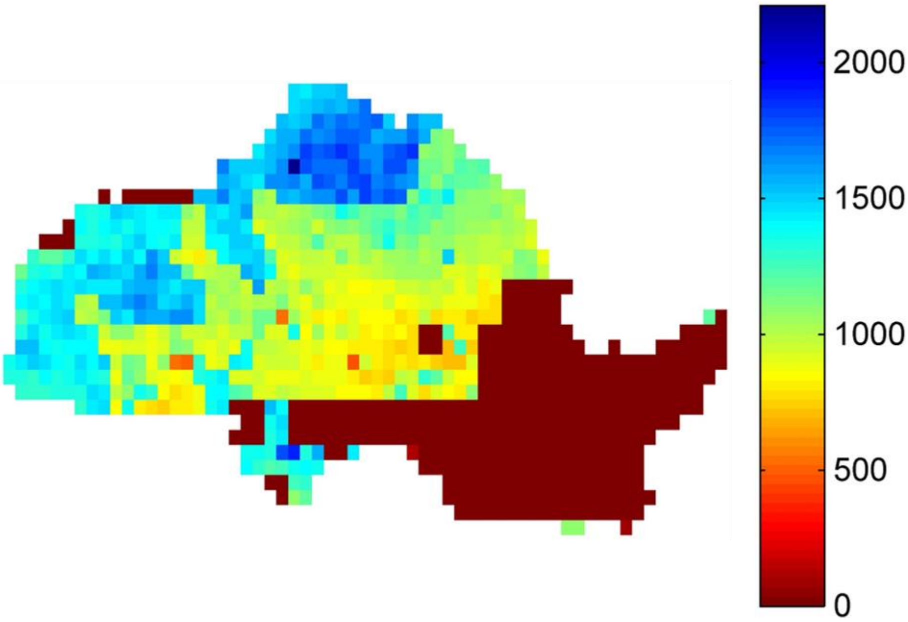

Figure R3. Number of instances of BC model activation (i.e., relative saturation exceeding 0.8) for the 4th model layer (layer between 30-40 cm below surface).

4. River discharge at outlet

The reviewer also commented about the river discharge at the outlet of the Kennet catchment. A description of routing surface runoff to the river network in the model is provided in the manuscript (l. 153-160). We agree with the reviewer that groundwater substantially affects the hydrology over Kennet, and a groundwater representation is certainly needed to better understand river flows in the area, which is also mentioned in our manuscript (l. 397-403). However, such analysis is beyond the scope of our work, as we mainly focus on the surface water and energy partitioning as represented by the interaction between soil moisture and evapotranspiration. The analysis of overall water balance (Table 4 of the original manuscript) corroborates the fact that the overall magnitude of the hydrological fluxes in the catchment is consistent with observations.