The effect of chalk representation in land surface modelling

This paper proposes the bulk conductivity (BC) model for improving the simulation of chalk hydrology in land surface models. The bulk conductivity model appears a simple approach for simulating both matrix and fracture flow in the Chalk according to the relative saturation. This approach is implemented in JULES (macro) and the results are compared with JULES (default) runs using a typical soil parameterisation, but neither model is calibrated. This is undertaken at the point and, subsequently, catchment scale. The authors suggest that the addition of the BC model in JULES improves soil moisture, evaporation, and runoff simulation.

Major comments

The default soil parameterisation is based on soil texture data from the surface (a loam) down to 5 m depth (Line 164 & Table 2) despite Figure 2 showing that this soil horizon is only 20-30 cm deep, with the remaining profile being chalk. Is it then any real surprise that this uncalibrated JULES model performs worse that a JULES model modified specifically for simulating chalk hydrology? This is not a valid comparison and the conclusions drawn are not valid.

To make any comparison valid the default model runs have to be calibrated, in particular, to achieve a more appropriate soil parameterisation. Currently the default run for the catchment is simulating more than twice the observed runoff for the Kennet, which is not acceptable. Consequently, evaporation is underestimated and soil moisture storage is insufficient. The River Kennet could be used for calibration at the catchment scale and soil moisture data for the point scale.

The macro model appears to be performing reasonably well where described in the text and calibration may not be as essential. However, I would like to see a sensitivity analysis for the BC parameters, which would be very useful for anyone considering implementing this approach for chalk models in the future, particularly when there are so few parameters.

Although the macro model is performing well where explicitly described in the text, Figure 6d asks some serious questions. The macro model is simulating about 0.1 mm/d of potential recharge with the exception of the early 2003 event. This would equate to only c.35 mm of potential recharge a year on a grassland site, on outcrop chalk, in a temperate climate. This seems unrealistically low and the c.200 mm of potential recharge simulated by the default model is perhaps more realistic.

The hypothesis that is proposed and maintained throughout the paper is a minor point, in my opinion, and takes away from the headline story: a simple approach for simulating matrix/fracture flow in the Chalk unsaturated zone, which could be implemented in LSMs.

The abstract needs to be completely re-written and re-focussed on the above comment. There is currently only one sentence (lines 20-23) concerning the results and implications and this is very vague.

The last three paragraphs of the conclusions (lines 385-403) could easily all be deleted or at least only be summarised in a couple of paragraphs. Currently it dilutes the section.

Minor comments

Lines 28-29 – consider rewording

Line 55 – this should be plural

Section 3.1 – the Kennet is a tributary of the Thames

Throughout the paper 'the' is frequently omitted, e.g. 'River Kennet discharges', 'major tributarites of this river are Lambourn, etc

Line 122 – there are 3 years more soil moisture data available at Warren Farm, which CEH collected. These data extend into a wetter period when it would be interesting to see how the models compared.

Line 125 – suggests soil moisture observations only exist to 2.4 m depth but observations in Figure 3 suggest there are deeper data.

Liner 240 – change 'dry' to 'drier'

Section 4.2 – r^2 informs on the fit of the linear regression but perhaps a plot of RMSE over time would be more useful to inform on actual differences between observed and modelled.

Section 4.2 – there appears to be a lot more noise in the modelled LE during Summer?

Figures – blue is not always very distinguishable from black on the comparison plots

Figure 5 – Are the default and macro results from the same depth interval here?