Hydrology and Earth System Sciences Discussions

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1
https://doi.org/10.5194/hess-2021-48-RC1, 2021

Comment on hess-2021-48

Anonymous Referee #1

Referee comment on "Climatic expression of rainfall on soil moisture dynamics in drylands" by Isaac Kipkemoi et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-48-RC1, 2021

This paper makes an obvious point, and one that is quite well-known, namely that the temporal resolution of precipitation data can have an important effect on simulated hydrological response. However, this is an issue that is often overlooked in evaluating issues such as climate change, where the models used to represent future climate scenarios may report data on relatively coarse time scales. Hence a paper that reminds the community of these issues and in particular attempts to quantify the associated effects for drylands is in principle to be welcomed.

There are however, important limitations of the present paper. The authors seem to have a very limited understanding of the hydrology of the arid systems they are simulating, and ignore important effects. A general issue for arid climates such as Walnut Gulch, the case study on which the paper is based, is that summer precipitation is based on thunderstorm rainfall, and is therefore highly localized. This is a major challenge for simulating hydrological response, and one that has been quantified for Walnut Gulch in several publications (e.g. Michaud, J.D. and Sorooshian, S., 1994, Effect of rainfall-sampling errors on simulations of desert flash floods. Water Resour. Res., 30, 10, pp. 2765-2775). This effect is also well described in various books on arid zone hydrology (for example the 2 CUP books, Hydrological Modeling in Arid and Semi-Arid Areas, and Groundwater Modelling in Arid and Semi-Arid areas). A major problem therefore arises when grid-square averaged precipitation from a relatively coarse spatial resolution climate model is used. The effects of spatial smoothing of thunderstorm precipitation will bias the simulations in similar ways to temporal smoothing, and is likely to be at least as important an issue. This is not mentioned, let alone addressed, in the current paper. In fact the paper is quite unclear about its treatment of spatial precipitation. line 213 states that an ensemble average of precipitation from 15 grid locations was used, but the details are not specified, and it is unclear why this approach was used, since the soil moisture simulations seem to be a single site and 1D.

It is also well-known that overland flow can be an important process in these areas, and the major mode of runoff generation. This runoff is focussed in the normally dry river channels, and subsequent channel bed infiltration is often a key process for groundwater recharge (and its use by rural communities). However, the conceptual diagram for the HYDRUS model used in the paper (Figure 2) has no representation of overland flow – so it is unclear whether or not this process was represented in the simulations. In addition, intense precipitation can lead to surface crusting (see Morin, J. and Benyamini, Y. ,1977, Rainfall infiltration into bare soils. Water. Resour. Res., 13, 5, 813-817). In the paper, a 1D vertically uniform soil profile is used, and the aggregate soil water response presented in the paper (Fig 6) does not appear to be a particularly good representation of the observations. The 1D assumption may or may not be valid, but more detail of the vertical soil moisture response is needed to convince the reader that the model, on which the whole paper is based, is in fact able to simulate the dynamics of the observed response.

In conclusion, I regret that in my opinion this paper does not warrant publication in its present form. The authors need to demonstrate a better understanding of the hydrology of the region on which their data is based, and hence do a better job in defining and addressing the key issues involved in the approximations inherent in 1D climate models. Temporal resolution of precipitation is an important issue, but one that cannot be addressed in isolation of the other aspects mentioned above.

A few specific comments follow:

Abstract: Note that data resolution does not change soil moisture – it does change simulated soil moisture.

line 46 but is expressed – improper sentence

line 88 insert 'and' soil moisture

line 132 'we divided reported event precipitation depth (mm) by event duration (min), and then aggregated the resulting set of events into hourly precipitation data' not sure what this means in terms of resolution – presumably nothing sub-hourly?

line 193 – note a uniform soil profile was used

line 203 STORM stochastic model used for climate perturbations – method not described

line 205 what is meant by a high resolution grid?

Fig 6 – significant differences in the distribution of soil moisture between observed and simulated – these are not mentioned or discussed

line 213 ensemble average from 15 grid locations was used. Not clear why, since soil moisture simulations seem to be a single site and 1D??