Comment on cp-2021-101

Anonymous Referee #1

Referee comment on "The long-standing dilemma of European summer temperatures at the mid-Holocene and other considerations on learning from the past for the future using a regional climate model" by Emmanuele Russo et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-101-RC1, 2021

Summary: Russo et al. The authors use a regional climate model to investigate the role of spring soil moisture in influencing summer temperatures over Southern Europe and Mediterranean during the mid-Holocene. The authors find that increasing soil moisture generates cooler summer temperatures, identifying a potential source of model bias that may help explain proxy-based paleoclimate reconstructions that show cooler than present mid-Holocene summer temperatures in many parts of the region while models show a uniform warming.

The paper is very well written and the project is well designed. I think that it is eminently suitable for publication in Climate of the Past, and I can thoroughly recommend its publication with only minor changes. The paper provides what I think is an interesting and important contribution to both modern and palaeo climate science.

I have some questions and general comments, as well as a few minor technical corrections.

Q1. What influence could change in soil depth and quality have compared to winter rainfall on soil moisture content? I presume that models use modern soils, but if mid-Holocene soils were better quality and depth then presumably they could create a similar effect since it would allow increased retention of winter/spring rainfall. Model soil hydrology is quite crude (especially in GCM's) but there is also quite a considerable body of evidence that suggests the Mediterranean region lost soil in the late Holocene as a result of natural and anthropogenic aridification. This could mean that better soils in the MH could result in more soil moisture being held in the spring, irrespective of any change in winter rainfall. See for instance https://iopscience.iop.org/article/10.1088/1755-1315/9/1/012011. It may be worth adding a comment on this.

Q2. How does increased soil moisture generate the observed summer cooling? It would be interesting to know to what extent this is a result of, for instance, latent heat, evapotranspiration, clouds or atmospheric circulation changes. Perhaps the authors could add a paragraph on this as it would be interesting to know the degree to which the effects are felt locally (similar to the thermodynamic effect of orbital changes in insolation) or over some distance.

Q3. The authors mention the debate about summer cooling over southern Europe and the Mediterranean during the mid-Holocene. Their experiments show cooling with increased soil moisture, but is this cooling of sufficient magnitude to override the strong warming in the model and therefore cause the negative temperature anomalies shown in the proxy evidence? As far as I understand it, figure 5 shows the effect of soil moisture on summer temperatures relative to the normal model state at the MH, and not summer temperatures as an anomaly compared to the PI. It would be useful to include a comment or figure (even in the supplementary) on this to see whether it is likely to approach the cooler than present summer temperatures shown in the proxy evidence.

Q4. P4 10-14; The authors highlight the importance of the GCM in which regional models are imbedded (eg Armstrong et al 2019). To what degree could the choice and performance of the GCM impact the result? For instance, we know that GCM's have difficulty simulating the mid-Holocene African Monsoon, and therefore probably the Hadley Cell and sub-tropical high pressure over the Mediterranean in summer. This may be related to my Q2, and particularly to what degree the spatial pattern of cooling caused by soil moisture changes could be dependent on the GCM outside of the regional model (eg atmospheric dynamics etc). Maybe a comment would be useful just to say whether this is/is not important, and why.

P5 22-23; The soil in the model is an important part of the story here. Where has the soil data come from that is used in the model? And what are the main variables used? eg carbon content, particle size, permeability etc. There are different sources with different qualities (eg FAO, EU etc)

P9 18 & P11 11-12; See also my earlier comments in Q1 about MH soils in the Mediterranean region being different than the modern soils in the region

Minor technical corrections:

The text has some minor grammatical errors and typos. I highlight some here, but please take time to have another careful read of the text, particularly from section 3 onwards.

P2 28 'Despite different studies have used..' Different studies have used climate models for investigating MH summer temperatures, but no thorough..

P4 2 'stationarity proper of..' stationarity in calibration (?)

P4 6 'In a first place..' Firstly,

P5 9; 'covering entire Europe' covering the whole of Europe

P5 9; 'used as boundary' used as a boundary

P9 5; 'to not appreciable..' to no appreciable..

P9 15; 'The here presented..' The experiments presented here..'

P9 23; 'different forcing.' different forcings.

P9 27, P10 5, P10 12; 'nature' do you not mean 'natural' state?

P9 27-28; 'what would normally' that would normally

P11 17; 'maintain its' maintains its..

Figures

Fig 1; Scale needs attention, blank above 2500m

Fig. 3 'subtracting to the climatological…' not sure what is meant here so no suggested replacement text, but the whole sentence needs another look.

Fig. 3; Convention would suggest using blue for cooler and red for warmer (use green/brown for drier)

Fig 4; 'mea'? not sure what this means.

Fig 6; Can you use a different value on the x axis rather than hours? I have no concept of how long 1000's of hours are (having looked it up, 1000 hours = ~42 days). The y axis would also be better scaled in mm rather than in metres, and it would be easier to understand if the labels for each of the 9 levels included their depths, or at least something to give them more meaning if possible.