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Interactive comment on "Resolution-dependence of future European soil moisture droughts" *by* Eveline C. van der Linden et al.

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Comments on "Resolution-dependence of future European soil moisture droughts"

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by E. van der Linden et al.

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1 General Comments

In this manuscript. the authors use a high resolution 6-member ensemble of the general circulation model EC-Earth to get a better and more realistic position of the storm track, which in turn leads to improved representation of the soil moisture (SM) conditions in the future and characterization of SM droughts. The study domain is the central-western Europe under the RCP4.5 emission scenario. One of the major claims of the authors is that high resolution CMIP5 GCMs leads to an underestimation of soil droughts characteristics.

The subject covered by this paper is a highly relevant research topic for practitioners and researchers in hydro-climatology and climate change impacts. I wellcome this study because I am convinced that high resolution GCMs will improve the estimates of future precipitation and temperature patterns because of better parameterization of convective precipitation and land-

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atmosphere feedbacks.

In the present state of the manuscript, nevertheless, there are many shortcomings that have to be clarified before publication.

2 Specific Comments

The following technical shortcomings should be addressed in the revised manuscript:

- The literature of future soil moisture drought projections should be updated and the insights of these studies should be put in context of this interesting study. I recommend to include:

  Samaniego, L., S. Thober, R. Kumar, N. Wanders, O. Rakovec, M. Pan, M. Zink, J. Sheffield, E. F. Wood, and A. Marx (2018), Anthropogenic warming exacerbates European soil moisture droughts, Nature Climate Change, 5, 1117–21, doi:10.1038/s41558-018-0138-5.

  Hanel, M., O. X. I. Rakovec, Y. Markonis, P. M. X. ca, L. Samaniego, J. Kysely, and R. Kumar (2018), Revisiting the recent European droughts from a long-term perspective, Scientific Reports, 8(1), 1–11, doi:10.1038/s41598-018-27464-4.

  Hirschi, M. et al. Observational evidence for soil-moisture impact on hot extremes in southeastern Europe. Nat. Geosci. 4, 17–21 (2010).

  Huang, J., Yu, H., Guan, X., Wang, G. & Guo, R. Accelerated dryland expansion under-climate change. Nat. Clim. Change 316, 847–171 (2015).

  Berg, A., Sheield, J. & Milly, P. C. D. Divergent surface and total soil moisture projections under global warming. Geophys. Res. Lett. 44, 236–244 (2017).

  ... and references therein.

- L7, P4. Parametric uncertainty plays a very strong role in soil moisture predictions and corresponding drought characteristics (see Samaniego et al, JHM, 2013). For this reason, I consider that a ensemble of 6 members and a single land surface model is too small an ensemble to provide conclusive evidence.

- L17 ff P2: Please clarify in the revised manuscript that the PDSI should not be used for climate impact studies because it does not perform well un non-stationary climate. See the explanation provided in the methods section of Samaniego et al. NCC 2018 and in its supplementary information (Fig S8, S9). Contrary to what Sheffield et al. stated in his Nature paper, the reason of the poor performance of PDSI is more likely related to the autoregressive formulation of this index rather than in the temperature-based PET formulation used in the original formulation of PDSI. The text as it written, put in context with these recent insights, is misleading or at least incomplete.

- L30 ff P2: I strongly sugest to avoid comparisons with the PDSI index (see last point) in future projections. EDgE results (http://edge.climate.copernicus.eu), which are based on downscaled CMIP5 forcings and a multi model ensemble, may be more interesting and realistic than the PDSI estimates. Data is available in nc format upon request (contact L. Samaniego if required).

- L35 ff P2: More recent insights on the future soil moisture droughts can be found in Samaniego et al, NCC 2018, e.g., an increase drought area by $40 \pm 24\%$ by an increase of 3 K. This study also offers a regional perspective that can be put in contrast with the present study.

- L9 P4 Why only the RCP4.5 is used in this study? In my opinion RCP6.0 or 8.5 would be more interesting in the context of future impacts.

- L9, P5 I strongly sugest to use the soil moisture index (see Samaniego et al. JHM 2013, code written in Fortran, it is open source) instead of a soil moisture anomaly. The advantage of SMI is that the SM is mapped to a 0-1 space that allows comparison over time and

space. It facilitates the calculation of drought area, duration and magnitude as presented in Samaniego et al. JHM 2013, Vidal et al. HESS 2010, Andreadis et al. JHM 2005, Sheffield et al. JGR, 2004). The index used in eq.3 is difficult to put in context with past studies.

- L10 P7. Please estimate the severity as used in literature (see previos references). Very interesting will be the changes of the curve area-severity relationship with the resolution of the GCM. The code to estimate this curve as presented in Samaniego et al. JHM 2013 is open source.
- L5 P9. The term "anomaly" as defined in this paragraph is misleading. It is an average change over the domain. I recommend to estimate the change is aridity as defined in Samaniego et al. NCC, 2018 since it is a better estimate of the changes in soil moisture under extreme conditions (droughts). A similar index can be develop to wetter events (just the oposite of the distribution function). I recommend to estimate changes over natural regions to avoid compensation. Some regions experience increases in wetting (Scandinavia), others the oposite (Mediterranean).
- L22 P5, the selection of percentiles is a bit ad-hoc. Why not round numbers like 1, 2, 5, 10, 90, 95, 99 percentiles. Remaning analysis should be updated.
- L11 P14, This hypothesis is highly interesting and should be done as proposed in the future. In this study, however, authors should compare the results existing CMIP5 models (e.g., based on EDgE data) to see if the hypothesis holds with present insights (see above).

Based on the comments mentioned above and bearing in mind the HESS publishing standards for a research article, I recommend to return it to the authors for major revisions.

L. Samaniego

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