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Interactive comment on "Earth System Model Evaluation Tool (ESMValTool) v2.0 – diagnostics for extreme events, regional and impact evaluation and analysis of Earth system models in CMIP" *by* Katja Weigel et al.

Katja Weigel et al.

weigel@iup.physik.uni-bremen.de

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We thank referee 1 for the time and effort spent on reading the paper and providing helpful comments. A point wise reply is given below, with the original comments in italics.

Overall: This is an overview of what looks like a very useful tool for climate model data analysis. I am not involved in CMIP, but I think this tool is going to be useful beyond CMIP. A paper discussing what the tool is about what would be helpful is making

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awareness of the tool's availability. I have mostly minor comments and some additional comments about how the tool can be improved.

We appreciate the suggestions for new metrics. The ESMValTool is continuously developed further and we welcome any technical or scientific contribution (on Github https://github.com/ESMValGroup). Unfortunately, we cannot include all changes suggested at this stage, but we provide below details about which software changes are planned or done in this respect, as well as the answers to the all other comments.

Comments:

Line 142: "The linear model (lm) function of R is used to calculate trends." One possible alternative is to use Generalised Linear Model (GLM; Nelder and Wedderburn 1972) of R (function glm) instead as GLMs are more flexible (with standard linear regression being part of this approach). The fitting of indices that their values do not follow normal distribution would be made more flexible and easier. It should be a fairly straightforward change to the R code as all R regression modules more or less follow the same standard.

Thank you for the suggestion. In the current implementation we have adopted for now only a simple linear trend line, as commonly used in most climate studies. Indeed a GLM approach could be useful, as you say, particularly for analysing indices with a non-normal distribution and we will consider implementing this functionality in future versions of the code. Please notice that, since ESMValTool produces raw netcdf files with the indices as a function of time, in addition to the plots, this type of more sophisticated analysis can already be performed separately by the user using external tools if they wish.

Section 3.3.3: I would think another related metric would be the annual temperature range (warm season Tmax vs cold season Tmin) could be quite useful along with DTR. If annual temperature range is widening, it may also imply energy use be expected to increase (akin to DTR getting larger).

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There is a function of the ESMValTool preprocessor, which can provide these data, documented at: 'https://docs.esmvaltool.org/projects/ESMValCore/en/latest/api/esmvalcore.preprocessor.html?highlight=preprocessoresmvalcore.preprocessor.amplitude', recipe_wenzel16nat.yml described in Lauer et al., 2020 uses this function to plot the annual cycle of CO2. However, there is no recipe or diagnostic to exploit this function for the annual temperature range, yet, but we will consider an implementation in future releases.

Lines 353-354: Are the CORDEX regions included part of this package? I think doing so will make them more useful to compare with regional climate model results.

It is planned to include the CORDEX regions in the ESMValTool, and the development in this regards has already started, see https://github.com/ESMValGroup/ESMValCore/pull/184 To highlight this in the paper we will included the following: "In addition to the regions described here, the ESMValTool preprocessor can be used to run many diagnostics on distinct regions defined by latitude and longitude limits. We plan to also include regions with more compex boundaries like the CORDEX (Coordinated Regional Downscaling Experiment) regions (Gutowski et al., 2016)."

Section 3.5: More a general comment – this will be a very useful tool in the future to just to avoid data and information overload, considering the volume of multi-model and multi-ensemble data will be involved in future MIPs.

Thanks, there is a lot of effort put into optimizing the data handling, for example by using lazy data evaluation with the Dask python package (https://dask.org/, see also Righi et al. 2020).

Technical comments:

Line 162: May be better to say "Meteorological droughts are negative anomalies in

precipitation." instead.

Changed

Line 173: ". . . which makes SPI incompatible with the concept of hydrological droughts."

Changed

Line 179: "This allows the estimation of surface water retention."

Changed

Line 181: "Evapotranspiration is typically not calculated by climate models." Climate model does output them as part of the land surface model output, but how that is computed are simplistic as in being diagnosed from the variables the authors are mentioning (i.e. surface T and wind). Hence, I am not sure "calculate" is the right word here. Perhaps, "is not prognostic" "is diagnosed simplistically" would be more appropriate.

We changed the corresponding sentence to: "Evapotranspiration is typically not provided by CMIP models, ..."

Lines 224-225: It may be advisable to drop the "computationally demanding" from the sentence as a few hours or days are still short comparing to the wall clock time needed to run the CMIP models.

We dropped "computationally demanding" and changed the sentence to: "Calculating the indices can take several hours up to days, depending on the number of models/observations, length of the time periods analysed and spatial resolution of the datasets as well as the computational resources."

Figure 6, values near year 2000: The ensemble spread around year 2000 is outside of the ensemble mean. Please check what causes this.

The shading does not display the spread around the mean but the area between the

Figure 7, lines 241: For the sake clarity and easy viewing of the figure, indicate which of the 3 indices are for precipitation (the top 3 ones).

We will mark the indices for precipitation.

Lines 256-261: Can you be more specific what the extreme temperature biases are? Do you mean non-bias corrected data has a lot more temperature extremes than in observations (which would be consistent what mortality rates estimates are too high)? If yes, state so directly.

Ouzeau et al. (2016), do not give details on the temperature biases. Nevertheless, bias corrections derived from comparing historical model experiments with reanalysis data applying a quantile-mapping technique can increase the confidence in future simulations.

Figure 9: The font size of the titles for each panel are small, and one can tell the dpi of the image is quite low (which makes the titles even harder to read). I think the dpi issue can be addressed by outputting the figure as a png (or other reasonable lossless format) or pdf.

We will increase the resolution and font size of the figure.

References:

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References in the answers:

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