Review: "CropSuite - A comprehensive open-source crop suitability model considering climate variability for climate impact assessment" (egusphere-2024-2526)

General comments

In this manuscript, Zabel et al. describe a new piece of software, CropSuite, that generates maps of crop suitability and related information based on climate, soils, and terrain. This builds on previous work by themselves and other authors to include, importantly, (a) a consideration of climate *variability* in addition to averages and (b) less-widespread but regionally important crop types. Noting that such crops are under-studied but are especially important in Africa, the authors focus their analyses there. The results look reasonable when compared to real-world crop distributions and sowing dates.

One of the goals of CropSuite was to make something that is easy-to-use and flexible enough to be used by a variety of stakeholders, not just scientists. As a scientist, I can't really assess how accessible it is to less-technical users, but the inclusion of a graphical user interface (GUI) is a really important development. I do think, however, that this tool will be useful to scientists and model developers as well. Global gridded crop models and especially integrated assessment models need to be able to endogenously represent things like sowing date, the potential for multiple cropping, and shifts in what crops are planted where; tools like CropSuite can help.

That said, I do have some questions and concerns about the manuscript as currently written. Thus, I recommend it be considered for publication after minor revisions.

Specific comments

- L53: It would be really helpful to have a single place where you briefly list all the new things in this version (other than the GUI). Is it just the addition of climate variability, new crops, and new pre-/post-processing tools? Or are there other things?
- L104: Why change the classification system from 6 to 4? Without a clearly-elaborated reason, a cynical reader might think this was done to make comparisons more favorable.
- How is irrigated area considered in CropSuite? Is there some input dataset about the area equipped for irrigation? I ask because I had thought CropSuite would just run calculations and produce figures for rainfed and irrigated crops separately, but Fig. 7 doesn't say whether it's for rainfed or irrigated datasets, and the associated text suggests discrepancies are due to "different assumptions on irrigated areas." (Later—first in the caption of Fig. 9—I see that "Irrigated areas are considered

according to Meier et al. (2018)." Is that the case for all analyses? This should be explained in the Methods.)

- Comparison to GGCMI sowing dates
    - Dates *must not* be bilinearly interpolated unless the algorithm is smart enough to account for the modulo nature of dates. For example, interpolating between Jan. 3 (day 3) and Dec. 30 (day 364) should give Jan. 1 (day 1), but a not-modulo-capable linear interpolation would give July 4 (day [3+364]/2 = 183.5). Instead of bilinear interpolation to downscale the GGCMI dates, please switch to nearest-neighbor (or explain what tool you're using that can handle modulo interpolation—I'd love to have one!).
    - Alternatively, you could coarsen the CropSuite outputs to match the GGCMI resolution. This would allow you to avoid the interpolation issue: Go one-by-one through the GGCMI cells, modulo-summing all the CropSuite dates, then divide by the number of CropSuite cells in a GGCMI cell. It would also avoid the issue you describe at lines 286–288, of CropSuite simulating a much higher spatial resolution than GGCMI provides.
    - Note also that, according to the supplement of Jägermeyr et al. (2021), the GGCMI crop calendar product contains no interpolation (as you state, "the GGCMI data show the actual sowing date based on interpolated statistics"), but only *extrapolation*.
    - Do there tend to be any patterns in the discrepancies that might explain them? E.g., do the poorly-matching crops tend to have longer growing seasons? Do the discrepancies tend to happen more in certain parts of the world?
- Various figures: Please avoid red and green on the same plot, as that's hard to read for people with the most common form of color vision deficiency. This is less of an issue on some plots than others, with the maps being especially bad and Fig. 10a probably the worst. You can use the Color Blindness Simulator at https://www.color-blindness.com/coblis-color-blindness-simulator/ to check accessibility of color schemes; ColorBrewer has some good suggestions at https://colorbrewer2.org/#type=qualitative&scheme=Dark2&n=3 (make sure to click "colorblind safe). The "Choosing colormaps in Matplotlib" webpage (https://matplotlib.org/stable/users/explain/colors/colormaps.html) also has a lot of good guidance.
    - For Figs. 10(a) and 12(a, d), consider using a qualitative colormap with your three suitability categories instead of a gradient. As it is now, the abrupt changes in the gradient don't really correspond to the boundaries between your categories, and thus it's hard to compare to the text at L300–301. Moreover, it's totally impossible to read with red- or green-blindness.

Minor comments

- For GMD, title must include version number.

- L51: Briefly explain what "fuzzy logic" is.
- L52: Why are they called "membership functions"?
- Table 1: Errors in Latin names—spaces in wrong place, "ti" glyphs missing, italics missing, some other misspellings. E.g., "Chickpea (Cicerorie num)" should be "Chickpea (*Cicer arietinum*)"; "Rice (Oryza sa va)" should be "Rice (*Oryza sativa*)".
- Table 2:
  - Include citations
  - Sodicity row missing "ISRIC Harmonized Dataset of Derived Soil"
- Fig. 1, temperature: Is that mean temperature over the 110 days? Based on later text it looks like yes; maybe this could be mentioned on the figure or in its caption.
- L155–156: What's the difference between sowing and planting?
- Fig. 3: The "climate suitability" plot is hard to read. The "limiting factor" arrow is confusing and should be replaced with a legend instead. ~~Then you could add a dashed black line that traces out the suitability throughout the year, according to which of the three curves is lowest on any day.~~ You basically already have that with the green shading, which I didn't notice before. Again, a legend would have been helpful. And maybe change it from green (which also represents the climate variability curve) to something not already used (e.g., gray).
- Fig. 5: X axis tick labels should be 0, 10, and 20, not 0, 0.1, and 0.2.
- Fig. 6: It would be useful to have a version of this figure in the Supplement that had "proportion of MapSPAM area" on the Y-axis. Would probably want to swap the top and bottom colors for this.
- L233: Why MapSPAM 2020 instead of SPAM 2000/2005/2010? Maybe the latter don't include as many of your crops? But could still be useful.
- L261: "inner tropics"? What about at the southern edge of the Sahara?
- Fig. 8:
  - Why does this plot have gray for "unsuitable and not in GAEZv4" while Fig. 7 had no such color? Also, why is it capped at 30 Mkm2?
  - Does GAEZv4 really not have rice?
- I was pretty surprised after finishing Sect. 3 to see that Sect. 4 was labeled "Results." What does Sect. 3 do if not present results? Please merge these into one Results section and use sub-headings to explain what each does.
- L306: "cultures" is probably not the right word.
- L312 and Fig. 11: Specify in text and caption that Fig. 11 is for Africa only.
- Fig. 12c: "Three harvests" color doesn't seem to appear anywhere and thus should be removed for clarity. Color contrast between one and two harvests is very low, making this map hard to read. Higher image resolution would also help readability.
- L325–327: use of "where" in this sentence is confusing. Suggested rephrasing: "In comparison to the **full** crop suitability **map** (Fig. 12a), more ~~areas are~~ **area is** suitable and suitability is substantially higher~~,~~ ~~where~~ **if** soil and topography ~~do not limit or reduce crop suitability~~ **are not considered**."
- Fig. 13 and related text:
  - Why not consider irrigated areas in (b)?

- o L339–340: "note that climate variability is by definition a limiting factor if precipitation and/or temperature are limiting factors." However, it seems like—when both are 100% limiting—you've chosen temperature or precipitation for Fig. 13a, not variability. This seems like a good choice but is never explicitly stated. Also, this implies that Crop Failure Frequency in Fig. 13b should be plotted underneath the colors for Temperature and Precipitation—it took me a while to realize that the color at e.g. X[30°N to 20°N] x Y[–100 to –80] was orange on top of blue.
  - o Speaking of colors, it's unfortunate that two of the most important limiting factors across the transect in 13b—precipitation and soil pH—have such similar colors. Consider swapping the latter's for something else.
- L365–376:
  - o Refer to relevant sections and figures throughout.
  - o It took me a while to understand the sentence at L370–372. Suggested rephrasing: "In our comparison analysis for maize, reference data showed some cultivation in the regions we identified as unsuitable due to the high recurrence rate of potential crop failures caused by high climate variability (Fig. 7)."
  - o L374: "Though" should be "However".
- L378: Delete comma at end of this line to make sentence easier to understand.
- L379–380: What sorts of biases?
- L383: Start a new paragraph between these sentences to separate discussion of "input data issues" from "fundamental appropriateness of this method."
- L394–395: This sentence is too vague; I don't understand what it means, or why it's set in the middle of a discussion about membership functions.
- L395–397: It's unclear what the first part of this sentence ("Furthermore, … membership function") has to do with the second ("which affect our consideration of climate variability.
- L405: Surely *some* mechanistic crop models consider flooding.
- Comparison_mapspam2020.zip:
  - o "Unuitable" typo in most files under with_climate_variability/.
  - o Why do many files in without_climate_variability/ compare against SPAM2017?
- Consider adding to the User's Guide: advice about which climate interpolation function users should choose.