

## ***Interactive comment on “Global evaluation of nutrient enabled version land surface model ORCHIDEE-CNP v1.2 (r5986)” by Yan Sun et al.***

**Anonymous Referee #1**

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Sun et al., performed a comprehensive evaluation of the nutrient-enabled version of the ORCHIDEE model (ORCHIDEE-CNP). The evaluations were made for biosphere carbon fluxes, N and P cycles, leaf and soil conditions and plant resource use efficiencies. Based on this, the authors were able to provide clear recommendations for future development.

The extensive set of observational data that the authors use, together with the evaluation of different metrics is very powerful. The work provides a complete picture of the model performance. My main concern, however, is that due to the comprehensiveness of the work it is at the same time difficult to grasp the main messages when reading the results and discussion section. When I read the manuscript for the first time I was overwhelmed by all the data and comparisons. I did not get a clear picture of the key

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messages in between the discussion of all the different metrics. The length of the manuscript contributes to this as well (27 pages of text, 18 figures and a table, plus several supplementary documents). Instead of showing comparisons of all available observational datasets, the authors could choose to only show those figures that help to illustrate their conclusion, and move other comparisons to the supplementary material and discuss them only shortly. For example, the authors discuss in sect 5.1.2 that it is difficult to falsify one model version over another based on the comparison of the de-trended anomalies in Fig 4, due to uncertainties in the observed GPP. As this figure did not contribute much to their final conclusion, the authors could choose to leave Fig. 4 out of the main manuscript. I would advise the authors to have a critical look at their figures, and the messages that they convey, to see which figures are really key to bring their message forward in order to condense (and thereby improve) the manuscript.

Moreover, section 2 “Model description” gives an overview of the modifications that were made compared to ORCHIDEE-CNP v1.1, but it does not provide an overview of the nutrient flows of N and P. A brief description of steps in the N and P cycles would be helpful to understand the processes in this nutrient-enabled model version of ORCHIDEE. When such processes are introduced this would also help to understand the evaluation with observations later on. A discussion of Fig. 1 could serve this, as it is a nice illustration of such processes, but this figure is currently hardly discussed in the text.

I provide specific comments below:

P2, Line 49: “this direction of future carbon storage”, what direction? P2, line 58: e? P2, line 70: “should look for” = needs. P2-3, line 75-81: Shorten or break up this sentence for readability. P4, line 118: give full name of SOM. P4, line 140-142: mention here the resolution of the ORCHIDEE run (0.5 degree) that differs from the 2.0 degree for ORCHIDEE-CNP. Otherwise this is only mentioned in the caption of Fig. 3, but it is relevant information. P8, line 277-279: check correctness of this sentence. P8, line 287: its uncertainties were calculated P8, line 290: based on P8, line 291: remove

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“speaking” P9, line 311: twice higher = twice as high P9, line 316-318: The markers in Fig. 2b for temperate and western Europe don't seem to show this? P10, line 345-347: Over the whole range, Eco2 seems to be quite similar for ORCHIDEE-CNP and ORCHIDEE. Is the ORCHIDEE Eco2 higher only because it has more data points in the lower GPP range where Eco2 is clearly higher than those based on Campbell et al. (2017) and Ehlers et al. (2015)? What is the role of the different resolution of ORCHIDEE-CNP and ORCHIDEE here? Does the resolution explain that there are data points in the ORCHIDEE plot below ~400 GPP-296 and in between ~300-1000 GPP-396, that are not there for ORCHIDEE-CNP? P11, line 379: refer to Fig. 6a here already P11, line 381: “... but is close to JENA-inversion estimate during this period”. Can you give the value for the CTracker atmospheric inversion? P11, line 381: Global simulated NBP from ORCHIDEE-CNP.... P11, line 392: avoid the word “cause” here. Better say something like: “Therefore, the underestimation of the global C sink in ORCHIDEE-CNP during the last decades is primarily due to a lower C sink in the NH.” P12, line 13: abbreviation BNF was introduced already earlier. P13, line 457-468: this discussion of literature values is longer than needed, please shorten. P15, line 537-538 it is not entirely clear to me how I can see the net N accumulation of 51.5 Tg N yr-1 from Fig 14a?

Discussion: as there were so many results presented, it is important to reference to a figure or paragraph from the results section that evidences your statements. E.g. in line 631-634; 635-638.

P18, line 643: “all models”, you mean biosphere models? P19, line 676-677: but aren't ORCHIDEE-CNP and ORCHIDEE forced with the same meteorology, and thus the same temperature, precipitation and radiation? P20, line 691: you mean Fig. S7? P20, line 711: “. . .of the land C sink. . .”, you mean “the size of the land C sink”? P21, line 768: is “capital” the right word here? Maybe use “pools”? P23, line 825: “due to that. . .” = “that is because . . .” P23, line 831: model = models P23, line 830-834: shorten this sentence for readability.

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Appendices and Supplementary Material: It is confusing that the manuscript contains Appendices and two supplementary documents. It would be good if all such supplementary material is combined into a single document.

Tables and Figures: Table 1: CMAS inversion = CAMS inversion? Fig 3, legend: Rose lines = Pink lines? Fig 7, complex, consider removing it to the supplementary material. Fig 10, Besides mentioning “model B” and “model C”, also give the reference in the legend (like for model A, Peng et al., 2019 is mentioned). Fig 12, 16, what is red and what is black? Fig 12, is n from the model the number of gridcells with that soil type? Fig 9, 12, 16, 18 add in the legend what the width of the bars indicates. Fig 16, what do a, b, c in the figures mean?

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