

***Interactive comment on* “Effects of Transient Processes for Thermal Simulations of the Central European Basin” by Denise Degen and Mauro Cacace**

Anonymous Referee #1

Received and published: 2 December 2020

I reviewed the manuscript of Degen & Cacace titled “Effects of Transient Processes for Thermal Simulations of the Central European Basin”. The manuscript discusses the influence of transient processes in the subsurface temperature distribution for sedimentary basin systems. The numerical model of the Central European Basin and the sensitivity analysis of its thermal parameters are presented as a case study to evaluate their influence on the temperature field.

The work presents a new methodological approach (i.e., Reduced Basis method) to address the sensitivity analysis in thermal numerical models. This approach has been never tested in this context, and its novelty is well stated in the Introduction and method.

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The results of the model and the sensitivity analysis of the thermal properties are well presented and discussed.

However, the architecture of the model should be described more in detail. The Authors reported the references of the works from which they derived the lithosphere-scale geological model of the CEBS (l. 156-157), its lateral extent, and general, brief, list of the investigated units. However, at l. 169-170, the Authors state that they are investigating the impact of the thermal properties of different chrono-stratigraphic units. At l. 193, the “Upper Crust Baltica and Avalonia” are cited and later on their thermal conductivity is reported as an “influencing thermal property”. How can the Reader understand or partially figure out the extent of these units (i.e., chronostratigraphic or crustal units) and if they are spatially relevant? I suggest to: i) slightly extent the description of the geological model in the text adding some relevant information about the model architecture (for example, the thickness of the model is missing), construction, and the main units geometries, ii) add a brief lithological and spatial (i.e., maximum and minimum depths, geographical position if relevant, total volume, etc.) description of the chronostratigraphic or tectonic units in table form (this would be additionally helpful since acronyms are used to refer to these units in the figures of the results section, but these acronyms have been never explicitly stated), and iii) add a few cross sections of the geological model. I think that the impact of the obtained result would be clearer/more relevant if these data are explicitly stated in the manuscript. Especially the volume of the units could be of interest since, as the Authors are stating at l. 343, “the sensitivities of the steady-state model are mainly controlled by a combination of the volumetric contributions of the individual layers and ...”. Although the information about the model could be gathered from the literature, the work would be more complete and self-standing in my opinion.

In addition, I have a concern regarding the long-term simulation (0 ka – 255.7 Ma). This simulation is divided in 3 periods but it was not specified how the division in periods were performed. In addition, and more important, it seems that all the sedimentary

sequence was used in this model, but it is clear that, for example, the Cenozoic units were not present in the time period 75.8 Ma – 255.7 Ma since the Cenozoic started 66 Ma. Furthermore, the sedimentation of the units was different through time and, for example, the Cretaceous, Jurassic, and Triassic units were progressively not present after a certain simulation time during the time period 75.8 Ma – 255.7 Ma. I suppose that the occurrence (or not occurrence) of some units could change the final result of the sensitivity analysis considering also that the Cenozoic, Cretaceous, and Triassic units generally have the highest sensitivity indices. Was this problem considered during the simulation and eventually how was it accounted? If not, a discussion on this topic should be added.

The language is generally fluent, but some sentences are quite complex and should be simplified to achieve a better readability of the manuscript. I provided a list of these sentences and of other minor language reviews in the COMMENTS part of this letter.

Considering these points, I suggest to accept the manuscript after MINOR REVISIONS.

COMMENTS

L. 13: I am not sure if “where” is correct since the Authors are talking about what is happening in the “case nowadays”. I suggest to rewrite the initial part of the sentence making it more straightforward: “This topic is especially actual since systematic efforts. . .”.

L. 15: delete “their”.

L. 19: “observations” instead of “observables”? It would fit better with the sentence at l. 20: “these datasets are sparse and lacking in coverage”.

L. 24-25: this sentence is not clear.

L. 25-28: I suggest to describe the factors influencing the heat distribution using a list. This would improve the readability of the sentence. In addition, I suggest to avoid

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referring to “the plate” since it could be misleading. The “tectonothermal configuration of the plate” could be changed as “regional tectonothermal configuration”, and the “dissipative processes within the plate” as “dissipative underground processes”.

L. 31: Probably a “and” is missing. Is it “with the square root of the internal period times AND the thermal diffusivity of the plate”? As before, plate could be change with “bedrock thermal diffusivity”.

L. 33-35: I suggest to split the sentence. It could improve the readability.

L. 38-40: I suggest to rephrase or split this long and complex sentence.

L. 41: “require”, not “requires”.

L. 53: I suggest to delete “from instance”.

L. 57: If the original meaning is maintained, I suggest to change with “on the influence of the rock thermal properties”. This would in better accordance with the statement at l. 61.

L. 59: as above.

L. 63-65: I suggest to rephrase this sentence. The expression “from the results of previous efforts by one of the co-authors” sounds a bit strange. I would simply put the reference as reported afterwards in the sentence. I.e: “from Degen et al. (2020)., who demonstrated “.

L. 75: check the style of references.

L. 80: “in Section 3”.

L. 101: I suggest to specify the “many other methods” as done in the Introduction (l. 73). Maybe a brief description about how these other methods constructs surrogate models could be useful. This could be useful to compare with the RB method described in section 2.2.1 of the manuscript and it could highlight/strengthen the novelty of the

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used approach.

L. 103: replace the comma at the end of sentence with dot.

L. 110-113: I suggest to delete this sentence since it is partially repeating previous sentences (l.91 for Sobol and Santelli methodologies; l. 85 for Wainwright et al. comparison; l. 87 for Degen et al.).

Caption 1: use the MPI-ESM abbreviation.

L. 158: A comma is missing. I.e.: “upper and lower crust, and the underlying mantle”.

L. 158: I suggest to detail here the description of the model.

L. 159: I suggest to delete “to assign” or to rephrase the sentence making it more straightforward.

L. 170: this sentence would benefit from the lithological description of the units. Zechstein and Rotliegend are two chronostratigraphic units / periods that correspond to the Middle – Late Permian and Early Permian – Late Carboniferous, respectively. One could argue that they are the same units as the “Permo-Carboniferous Volcanics”.

L. 172: how can we assess that the parameter correlations are negligible from the sensitivity indices? I suggest to specify it, either in brackets or in a subsequent sentence.

L: 179: I suggest to add the acronyms of the units in brackets together with their full name. In my opinion, they should be mentioned at least once when the Authors describe the result referring specifically to a figure.

L. 192-195: as above.

L. 201-206: as above.

Figure 2: what does the numbers in the X-axis mean? Just a consecutive numbering for the variable? I suggest either to remove them or to use 1 as unit for the axis. With the second option, You should get a vertical line for variable favouring the reading on

the vertical axis. If you prefer to maintain a unit different than 1, I suggest to maintain it constant among the figures (i.e., the unit on X-axis in Figure 3 is unit 2).

Caption 2: please report the reference where the Reader can find the acronyms of the different units.

Figure 3: see the comment for Figure 2.

Caption 3: see the comment for Caption 2.

L. 223: I suggest to put the accuracy value in brackets.

L. 225: I suggest to blend the short sentence together with the previous. Otherwise, replace the comma at the end of sentence with dot.

L. 230-231: these two sentences are slightly misleading. Firstly, the Authors say that “the results are the same for all accuracies tested”, but then they state that there are differences among the different accuracies for parameters with low sensitivity. It is clear that the impact of the accuracies is minor since the sensitivity of parameters is low, but the first statement goes in the opposite direction. I suggest to rephrase the sentence at l. 230 describing more in detail the results shown in the figure. A better description of the results will avoid any misinterpretation.

Figure 4: see the comment for Figure 2.

Caption 4: see the comment for Caption 2.

L. 238-239: I suggest to split or rephrase this sentence to increase its readability. The construction of the sentence is quite complex.

L. 240-242: as above.

Figure 5: see the comment for Figure 2.

Caption 5: see the comment for Caption 2.

L. 253-259: as comment for L. 179.

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Figure 7: the title on the Y-axis is missing.

Caption 7: see the comment for Caption 2.

L. 280: I suggest to use “a time-variable scaling factor”. The term “increasing” could be misleading since it is stated that the uncertainties in the temperatures should decrease with time.

L. 293: as comment for L. 179.

L. 296: what does the “the errors in their sensitivities” mean? How can the Reader assess this error? Is it the accuracy discussed in section 3.2 or another parameter? I suggest to specify it and eventually restate the accuracy value of the model.

Caption 11: see the comment for Caption 2.

L. 303-305: why did the Author choose to perform the sensitivity analysis in 4 different periods? Does the segmentation in periods have a geological meaning? These aspects should be specified. In addition, I suggest to start the bullet list from the period 0 – 22.8 ka.

L. 307-308: as comment for L. 179.

L. 321-324: as comment for L. 179.

L. 348: I suggest to put a set of representative values or a reference for validating the sentence “This is caused by the higher radiogenic heat production of the latter rocks”. The same suggestion can be referred to the thermal conductivity of Zechstein (l. 351) and of the lithospheric mantle (l. 352).

L. 353: please specify the percentage of the lithospheric mantle volume with respect of the total volume of the model.

L. 385: check the “to imposed” and eventually rephrase the sentence.

L. 393: “make improve” is not correct in my opinion, I would just keep “improve”.

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L. 430: “an additional”

Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2020-204>, 2020.

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