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Interactive comment on "The Geodynamic World Builder: a solution for complex initial conditions in numerical modelling" *by* Menno Fraters et al.

Menno Fraters et al.

menno.fraters@outlook.com

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We would like to express our gratitude to the reviewer for the very careful reading ofour manuscript. Peer review makes scientific articles better, and this applies to this oneas well – thank you!

The revised paper has been added as a supplement.

This paper presents a tool, the Geodynamic World Builder, allowing the simulation of more realistic tectonic features, e.g., a continental, an oceanic or a subducting plate. The paper explains the philosophy of the tool and the definition of different tectonic settings. The second part focuses on 2D/3D cartesian and spherical examples of mid-ocean ridges and subduction zones models. I appreciate the effort made to simulate

different tectonic context. I have no doubt this tool will be very beneficial and readily usable by the community. The GitHub documentation is also abundant, including a documentation section and a manual.

We appreciate the kind words!

General comments:

[1]Basics information, which could benefit potential users, are missing. The models' parameters are not specified, such as the name of the codes used to generate the figures.

We are not sure what the reviewer is missing. We have provided the GWB input files for all the models and have stated in the introduction that the World Builder can create files which can be visualised by Paraview, and note in the acknowledgements that the data visualization has been caried out by Paraview. We did consider adding the ASPECT example input file, but we think that it would be better fitted as a cookbook in the ASPECT repository than in a paper on the GWB.

[2] The methodology to define complex geometries/polygons could be more explained. For example, figure E1 is useful and could be included in the main text.

Defining complex polygons is just a matter of adding the points of the polygon to a list, we are not sure what extra information the reviewer wants in the paper. We have added figure E1 to the main text (now called figure 8) and use it in section 3.3. We replaced figure E1 in the appendix with the code related to that example.

[3] The authors did not discuss the impact of more realistic geometries on the computational time of the models. Indeed, rapid temperature variation between different materials can induce longer calculation times.

The main author shows in chapter four of his PhD thesis (http://dspace.library.uu.nl/handle/1874/379767), which is a paper in preparation, that this is in practice not a problem. Nonetheless, if needed in some cases, smoothing features could be added to the GWB later, but they would require some careful design to remain efficient. See answer to question [2] of reviewer 1.

Specific comments:

[1] P1, l15: ". . .constrained by boundary conditions, which can be time-dependent, and by initial conditions. . ." you should briefly explain these conditions here and consider adding the parameters of all the models you present in the paper.

We have changed ". . .constrained by boundary conditions, which can be time-dependent, and by initial conditions. . ." to ". . .constrained by boundary conditions (e.g. velocity, pressure, temperature or heat-flux boundary conditions), which can be time-dependent, and by initial conditions. . ."

We did not add the a description of all the parameters of the computations, because the few runs which are shown are just to showcase that the generated initial conditions can be used in geodynamic models in general. We feel that going in too much detail would dilute the message of the paper. For the readers interested in the parameter values use for real computations with ASPECT can look at chapter four of the main authors PhD thesis (http://dspace.library.uu.nl/handle/1874/379767), where a complete input file is given. If the reviewer and the editor feel strongly about it, we can add the ASPECT input file for that specific run as an appendix.

We have also added the sentence: "These examples are intended to illustrate the ease of use in different codes instead of the physics details of the models shown." to section 3, to emphesise the intent of the examples.

[2] P2, l12: "that implicitly define volumes to which temperature and composition can

be assigned." Rough variations of temperature, so viscosity, are hard to solve: Could you add a function to avoid this issue?

It depends on what temperature model is assigned within the volume, and most models do more complex temperature distributions than assigning a uniform temperature to the volume. To highlight this we changed the sentence:

"that implicitly define volumes to which temperature and composition can be assigned."

to

"that implicitly define volumes to which temperature and composition models can be assigned."

This doesn't mean that in complex models, no rough variations of temperature may occur. Especially with the McKenzie (1970) equation, the top of the slab is very hot, while the surface and the continental plate are relatively cold. But we have no experienced problems with running these kind of models, as is also shown in this paper and in the PhD thesis mentioned in the previous comment.

Technically it is possible, but it will require careful design and may significantly increase the computation cost depending on the chosen implementation, because the main aim of the GWB is to provide the answer to 'I am a point, in which temperature/material am I?'. Also see the answer to question [2] of reviewer 1.

[3] P3, l3-4: "but it can be achieved through a sticky air approach, where air is a composition...". Yes for small models, but such an approach is difficult to implement in 3D spherical models because it drastically increases the calculation time.

We agree that this is not an optimal situation for those kind of models yet. We have some ideas of how we could greatly improve the situation, but the first author would be very interested to discuss with people who actually need this kind of functionality to find the best way of parameterizing these problems.

[4] P3, l12-14: "This allows for defining an upper and lower mantle and to insert specific volumetric structures such as Large Low Shear wave Velocity Provinces (LLSVPs) at the core-mantle boundary. In the present version these mantle features can be assigned a radially uniform, linear or adiabatic temperature profile." Could you give an example, it is not clear how you can generate such structures?

We have changed the sentence "This allows for defining a upper and lower mantle and to insert specific volumetric structures such as Large Low Shear wave Velocity Provinces (LLSVPs) at the core-mantle boundary. In the present version these mantle features can be assigned a radially uniform, linear or adiabatic temperature profile." to "This allows for defining a upper and lower mantle and to insert specific volumetric structures such as Large Low Shear wave Velocity Provinces (LLSVPs) at the core-mantle boundary in the same way as for example an oceanic plate, but at depth. In the present version these mantle features can be assigned a radially uniform, linear or adiabatic temperature profile."

[5] P3, l26-30: "Dip angles are linearly interpolated along a segment. The overall direction of slab dip can be to either side of the trench and is selected. . .. varying 3D slab morphology." A figure, like figure E1, could help the reader to understand the method.

We have include figure E1 in the main text and added a reference to it in the first sentence. We also added a reference to the ASPECT figure as an example for the varying 3D slab.

[6] P5, paragraph 3: I encourage the authors to focus on open source software such as CitcomS, CitcomCU, Underworld,....

We agree that this has a large potential, and the first author is very much willing to help the developers of those codes to link the GWB. At the time of writing we have made an issue on the Underworld Github page

(https://github.com/underworldcode/underworld2/issues/393) to see whether there is interest from that community. The response from the developers has been very positive. Although CitcomS and CitcomCU have official repositories, the actual use of the code is much more decentralized. We feel that adding it to one of the official repositories would not necessarily result in it being available to many Citcom users. We think that helping individual groups who use their own version of Citcom to couple that to the World Builder would be more effective and time efficient. Again, the first author is very willing to help those groups, or any other group with a different code, to carry out the coupling.

[7] P5, l17: "The slab temperature is computed using the McKenzie model for a particular slab history." I understand this paper is not on geodynamic interpretations, but it could help the reader to add the model parameters.

We have added the equation (see equation 1) and described the parameters used for the computation of the McKenzie model. The values of the parameters can be found in the world builder files in the appendices, or for the default values in the manual.

[8] P9, l1-2/Fig. 5: "One sided subduction is obtained in a self-consistent way by the presence of a weak crustal layer of uniform viscosity 10^{21} Pa s ËŽus on top of the subducting lithosphere." Is it a self-consistent slab?

In response to the reviewers comment the model description has been rephrased to clarify the role of the weak crustal layer.

The sentence: "One sided subduction is obtained in a self-consistent way by the presence of a weak crustal layer of uniform viscosity 10^{21} Pa s on top of the subducting lithosphere." is replaced by "Subduction is driven in a selfconsistent way by the ridge push resulting from the thickening of the oceanic plate and the negative buoyancy of the subducted slab. Free slip impermeable boundary condition are imposed on the flow. The top of the subducting lithosphere consists of weak crustal layer, 10 km thick and with a uniform viscosity of 10^{20} Pa s. This weak crustal layer plays an essential role in preventing the locking of the subducting lithosphere with the overriding plate that would stop the subduction process (Androvičová et al., 2013)." NOTE: the crustal viscosity value has been corrected with the new value 10^{20} Pa s.

[9] P8-9, Paragraph 3.2 to 3.4: the same comment than before: In order to foster the development of open source tools, it could be relevant to add open source software such as CitcomS, CitcomCU, Underworld,..

We completely agree that this would be very useful and we are we are very much willing to help those open source communities to implement the coupling if there is interest from them. See answer to question 7.

Please also note the supplement to this comment:
https://www.solid-earth-discuss.net/se-2019-24/se-2019-24-AC2-supplement.pdf

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