

Solid Earth Discuss., referee comment RC2
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Comment on se-2021-53

Andres Tassara (Referee)

Referee comment on "Forearc density structure of the overriding plate in the northern area of the giant 1960 Valdivia earthquake" by Andrei Maksymowicz et al., Solid Earth Discuss., <https://doi.org/10.5194/se-2021-53-RC2>, 2021

This paper presents a gravity-based model of the subduction zone anatomy along a segment of the Chilean margin that coincides with the greatest slip patch of the giant Valdivia 1960 earthquake. The authors attempt to interpret their resulting density model in terms of the geological structure of the margin and to discuss the implications of their findings for our comprehension of seismogenic processes leading to the largest earthquake ever recorded.

The work has scientific merit, although the density model is not particularly new (other papers have been published with the topic in the studied area) and the interpretations and conclusions will probably have a moderate impact in the community. This potential impact could be improved if a) more details are offered regarding some methodological aspects that are obscure in the present version (and therefore inhibit a clear interpretation of the results), b) the quality and clarity of figures and text could be augmented, and c) a deeper and complete interpretation can be developed. I expand points a and c below. I also provide a list of many idiomatic points (mostly orthographic and grammar typos and errors) that I identified through the text; this list is not complete, and the authors should take care and be sure that a revised version of the manuscript must have no errors like these in order to be accepted.

- Gaps in methodology.

I found that section 3 Data and Methods is oversimplified and some important gaps can be identified that you should fill in order to provide a better basis for the further interpretation of results. This is a list of my main concerns associated to line numbers on the original pdf.

135-136. Specify the model of the Lacoste&Romberg gravimeter used for the study. What

do you mean with "with a digital upgrade provided by ANID-FONDECYT project No11170047"?

134-140. More details about the processing of gravity data could be useful. How do you ensure that the new data are leveled with the old data compilation? Do you applied any further procedure to correctly merge the satellite data, marine data, old land data and your newly acquired data? Just putting all together as it was provided by different sources could create large problems with different data levels that must be solved before modeling!

171-173, 175-176. It seems that information provided in lines 171-173 regarding the size and geometry of the 3D inversion grid, is in contradiction with information provided in lines 175-176. Please clarify this point.

Instead of gr/cc please use gr/cm^3 in the entire text (which is the correct use of metric units in the SI)

- You mention that "...greater densities than the background below 7500 m depth." What is the background density and its value?

Section 3.2.1. Too few specifications about the method associated with forward gravity modeling. Please provide more information about the basics of the GravGrad modeling scheme of Maksymowicz et al. (2015) and its specific application to the study region, including the original geometry of each section, downward extent, background density structure, how densities of different bodies are assigned and validated, how the constraint information is incorporated into the model, are the geometries of the bodies modified interactively?

Section 3.2.2 3D gravity inversion. I am confused with the target of this model, mostly with the depth of the 3D model and what are you trying to obtain. In addition, with the confusing information noted in lines 171 to 176 regarding the spatial extent of the inversion space, it is not clear what is the maximum depth of the model, it seems to be only few kilometers below Earth surface? If this is the case, can you please justify the application of this tool considering that you are interested in the crustal-to-lithospheric scale structure of the subduction zone?

324-325. How is defined the base of the inversion model at 20 km depth? This is not clear in section 3.2.2 3D gravity inversion, where it seems that the maximum depth is something larger than 7.5 km, but 20 km looks like too deep for this kind of model. Please clarify.

349-365. How do you justify the spatial extent and the resolution of the model? Is there resolution and/or sensitivity test that allows to trust the model results??? This point is important and critical to be solved in a new version of the paper.

- Improve quality and clarity of interpretations and discussion.

Sections 4 and mostly 5 need some improvement in terms of the description, interpretation and discussion of results that for some cases is too confusing. The discussion would benefit from a clear separation of different points, like the geological nature of density anomalies and influence of crustal structure on megathrust seismogenesis.

255-260. Please explain how the gravimetric lineaments were identified; is this just a visual exercise? You would need to justify these identifications, which seems to be quite whimsical. Is it really necessary to include these lineaments? Perhaps a good description of how the recognized (published) crustal faults and geologic lineaments correlate with gravity is a better idea in this case.

280-289. Note that the CBA high called H1 in Fig 3a does not appear in P1, but the modeled density high called H1 in Fig. 4 is present in all the profiles: it is confusing to use the same nomenclature for gravity and density anomalies in this case, perhaps it is better to change these names.

292-295. Why a high-density anomaly shall be related to the volcanic arc? I would expect the opposite since magmatic bodies and the entire plumbing system underneath volcanoes should have a much lower density than the country rock. Please explain this.

- Are you sure Contreras-Reyes et al. (2008 and 2010) mention that the age of the paleo-accretionary prism is Mesozoic to Tertiary? The metamorphic complexes in the region are of clear Late Paleozoic to Triassic age.

444-454. For the discussion about the geological nature of the H1 anomaly you should consider Plissart et al. (2019; <https://doi.org/10.1016/j.lithos.2019.03.023>) and references there in, which shows that the metamorphic basement associated to the WS south of 39°S includes a great proportion of mafic and ultramafic (serpentinites) rocks that were incorporated inside a subduction channel during the Carboniferous. As H1 gravity anomaly in Fig. 3 extends southward into the Chiloe island where only Late

Paleozoic metamorphic rocks has been described (i.e. no Devonian intrusive rocks related to the Chaitenia island arc), one could imagine that H1 (both gravity and density anomalies) are mostly related to the dominance of these lithologies. However, it is important to consider the evolutionary interpretation of Plissart et al. (2019) because they actually link the occurrence of these (ultra)mafic rocks to the creation of an island arc and backarc region disconnected to the main Gondwana margin during the Devonian, similar to the original idea of Herve et al. further south. This could support your interpretation, but you should complement the argumentation already exposed in this section.

456-457. I don't see the supposed correlation between volcanoes and negative density contrast in Fig. 6; please mark clearly the volcanoes in this figure and provide actual values of density contrast to judge about it. This is also in contradiction with what is exposed in lines 292-295, i.e. a correlation between high density and the presence of the volcanic arc and LOFZ. Please clarify.

480-481. A better reference for the Melinka earthquake in terms of describing the physical properties of the forearc is Moreno et al. (2018; <https://www.nature.com/articles/s41561-018-0089-5>). This discussion about the nature of seismic segments along the Valdivia earthquake segment could benefit from including findings and ideas of Molina et al. (2021).

Minor points

27-28. Include Molina et al. (2021)

31-. Reference is Tassara (2010). Add Molina et al. (2021)

34-. Include Molina et al. (2021)

50-. Replace "Fithermore" by "Furthermore"

54-. Replace "at the south of..." by "southward of..."

Fig. 1. Colors of geologic units are somehow masked by topography; perhaps you can

either choose a color table with grey tones for topo/bathy (changing colors for metamorphic units in this case), or to use topo/bathy only in B along with the potential trace of basement domains, leaving in A the geology, structures, slip, fracture zones. By the way, the dashed outline in B is very usefulness and awkward, please remove it.

67-. Solve "Schematic map of map of basement..."

72-. Put "cm/yr" in "convergence rate (6.6 cm, Angermann, 1999)"

85-. Replace "fiction" by "friction"

88-. Replace "...three mayor trenches parallel morphostructural units..." by "...three mayor trench-parallel morphostructural units..."

105-107. Rephrase this sentence, it is awkward.

119-. Replace "Devonic" by "Devonian"

120-. Replace "Ch in Fig. 1b" by "Ct in Fig. 1b"

121-. Remove "Ch in Fig. 1b" (is already indicated in line 120).

120-121. A good and updated reference for this is Rapela et al. (2021, <https://doi.org/10.1016/j.gr.2021.04.004>)

127-. Replace "include:" by "includes:"

147-. Replace "schema" by "scheme"

149-. Replace "...it should be modelling considering..." by "...it should be modelled considering..."

165-. Replace "3.2.1 3D gravity inversion" by "3.2.2 3D gravity inversion"

172-. Replace "...blocks (in X, Y, Z direction), respectively." by "...blocks (in X, Y, Z direction, respectively)."

195-. Replace "3.2.1 Available geophysical information" by "3.3.1 Available geophysical information"

210-. Replace "3.2.1 Electromagnetic methods to constrain gravity measurements" by "3.3.2 Electromagnetic methods to constrain gravity measurements"

Figure 3. Replace "Grvimetric Lineaments" by "Gravimetric Lineaments" in the legend of the figure.

Figure 4. This is a bit confusing, and you could consider some of the following suggestions: 1) Put each gravity profile with the corresponding density profile, so one can appreciate the correlation between anomalies and the modeled density structure. 2) Try to separate or identify the original CBA from the modeled anomaly, since in the current Fig. 4a is impossible to recognize it. 3) Use a different name for H1 and H2 because it is confused with H1 of Fig. 3a although they are not the same. Fig 4d has a problem with numbers in the x-axis, please correct it.

281-282. Replace "... and increase to deep" by "...and increase downwards"

291 and elsewhere. Please do not use "before" and/or "after" to refer to east-west locations with respect to a given feature, better use westward or eastward!

292-. Replace "important toconsider" by "important to consider"

Figure 5. Please include the original CBA and the regional field obtained as a polynomial representation that is extracted from the observed CBA in order to get the residual CBA.

349-. What is the DC? Do you mean CD I guess.

385-. Replace "see and interpretative schema at Fig. 8a" by "see an interpretative scheme at Fig. 8a"

393-. Replace "bangs et al., (2020)" by "Bangs et al. (2020)".

429-. Is there any specific references for this supposed west-dipping reverse fault that puts CC in tectonic contact with CD??

430-. Remove one of both "depth" in the sentence "the depth contact between CC domain and H1 at depth"

449-. Please close the parenthesis after "(Hervé et al., 2016; 2018"

466-. Replace "intreseismic deformation" by "interseismic deformation"

468-. Please provide relevant reference for this sentence.

469-. Replace "fractured and or metamorphic" by "fractured and/or metamorphic"

474-. Replace "...should modified the..." by "...should modify the..."

490-. This is also observed by Molina et al. (2021) and you can used to reinforce this idea. In this line please replace "This siggests oversaturate fluid..." by "This suggests that over-saturated fluid..."

494-. Replace "Several authors have siggested" by "Several authors have suggested"