Ref: se-2020-145

Title: Gravity Effect of Alpine Slab Segments Based on Geophysical and Petrological Modelling" by Maximilian Lowe et al.

We thank the referees once again for the constructive criticism and suggestions. All points raised by the reviewer have been addressed. We hope that the new version of the manuscript is improved and can be accepted for publication.

Specific corrections

L. 23: positive gravity signal of up to 40 mGal

-> your modeling shows that the density contrast could also be negative- here it would be more correct to write ..predict a positive or negative gravity signal of up to 40 mGal....?

The LitMod gravity model (approach 3) with a negative gravity signal is a result of the variation in compositional parameters which we tested. We state clearly in the manuscript that we demonstrate the influence of the compositional parameters here. We do not make the claim that a slab with a lower density in respect to the surrounding mantle is likely. We changed the sentence in question to: "Forward calculations predict a gravity signal of up to 40 mGal for the…".

L. 42: Subducting lithosphere has a higher density than the surrounding mantle material at the same depth interval In the modeling you show that density of the slab can be lower than the surrounding mantle, if very old compared to a tecton mantle. So there is the possibility that density can be lower, and is not always a positive contrast, so this sentence is misleading and does not reflect the modeling. Please adjust.

The same response to the previous comment applies here. We changed the sentence in question to: "For lithosphere to subduct, a higher density than for the surrounding mantle material at the same depth interval is required, causing a negative buoyancy for the slab…"

L. 50 Topography-> tomography

Corrected

L. 56: Alpine gravity field have not considered any slab segments, rather they only account for the thickness of the lithosphere (e.g. Ebbing et al., 2006; Spooner et al., 2019; Tadiello and Braitenberg 2020).

-> as it stands the sentence is wrong, because in the recent work of Tadiello and Braitenberg (2021) the subcrustal seismic tomography is converted into densities and the effect is fully calculated down to the depth of the availability of the tomographic model (200 km). The seismic velocity variations have not been interpreted as slabs,

but have been used to calculate the full gravity effect of the mantle. Therefore, I propose to change the sentence to the following:

Secondly, previous Alpine models addressing the Alpine gravity field have considered the subcrustal mantle inhomogeneities in form of lithosphere thickness (e.g. Ebbing et al., 2006; Spooner et al., 2019) or in form of mantle density variations (Tadiello and Braitenberg 2021), but without identifying the isolated effect of subducting slabs segments in the velocity or density variations.

Incorporated the suggested sentence.

L.57/58: If the contribution of the slab is not considered,

-> See above comment: the important thing to consider is the mantle density variation, if it is identified as a slab or not is a matter of interpretation. I propose to make the sentence consistent: If the contribution of the mantle density variations are not considered, a significant part of the gravity field might be attributed to crustal thickness variations or intra-crustal sources.

Incorporated the suggested sentence above.

L. 62: . Therefore,
corrected

L. 67: XGM 2019 -> give reference
Added reference to caption of Figure 1.

L. 76 contrast -> contrasts
corrected

L. 105: approximately -> approximate
corrected

L. 130: We calculated the gravity contribution of the topography and bathymetry
-> give maximum calculation radius of topography for each grid point.
The mass correction for the Bouguer Anomaly map was performed using Tesseroids. No specific terrain correction was carried out. We adjusted the sentence to make it clearer. The new sentence is: “The Bouguer Anomaly is calculated from the Free-Air gravity disturbance with a correction density of 2670 kg/m3 for topography, and a correction density for water of 1030 kg/m3 for the offshore areas using Tesseroids (Uieda et al., 2016). For the tesseroids, we use the topography and bathymetry from ETOPO1 resolution (Amante & Eakins, 2009), which was regridded at a regular grid with a grid space of 25 km to match the resolution of the XGM 2019 model for a maximum degree of 719”

L. 131: Tesseroids -> is this the software name or the object? In either case add reference
Its both the name of the software as well as the object. Added reference here.

L. 134: regridded

Corrected

L. 137: an isostatic compensation of the topography -> without calculating the isostatic equilibrium you don't know if topography is compensated. More precise would be: an isostatic crustal thickening in response to topography
Followed the suggested sentence above.

L. 139: topographic correction for the gravity gradients at a station height of 225…
-> also here please give calculation radius.
Response to comment regarding L 130 applies here as well. We changed topographic correction to mass correction to be consisting with our terminology.

L. 156: b) crustal depth estimation after Grad et al. (2009) -> Please uniform "crustal depth" with crustal thickness used in a) – crustal depth is not the correct word. It would be Moho depth or bottom crustal depth? Geologically crustal thickness and Moho depth are not the same thing.
Corrected. Using now uniform Moho depth in the caption of Figure 2.

L. 163: descripted -> described
Corrected

L. 191: attention, eqt. (2) seems wrong.: a percentage deviation is adimensional. Please check- I suppose you mean:
rhoRel=[Vsvabs(1+delta%)-Vsvabs]*Zeta= Vsvabs* delta% * Zeta
adjusted

L. 193: $divagation$ -> deviation?
corrected

L. 209: please define horizontal extension of the mantle model, and mention how you deal with border effects.
We avoid edge effect or border effects by using relative densities. No significant edge effects are expected and therefore no horizontal extension of the model is necessary. Added following sentence to the manuscript: "No horizontal extensions of the mantle model are introduced because relative densities are used and therefore edge effects are not expected to be significant and would only affect the outer most degrees of the model. The slab segments are located central in the model far away from possible artifact due border effects."

L. 229: Secondly, we create a set of slab models accounting for compositional and thermal variations with depth (approach 3). Those models are created with the software package LitMod 3D (Fullea et al., 2009) -> please add that in approach 3 slabs are strictly vertical due to software limitations. “Those models” is ambiguous- please change to: Secondly, we create a set of slab models accounting for compositional and thermal variations with depth (approach 3). The models of approach 3 are created with the software package LitMod 3D (Fullea et al., 2009) and here the slabs are strictly vertical due to software limitations.
The sentence got reformulated following the suggestions above.

L. 314: Maybe you could mention that calculated field is quite different from the field of the complete mantle density inhomogeneity of Fig. 4, which only reaches a positive mantle effect of maximum 50 mGal.
Included a sentence following the suggestion above.

L. 354: Add hear for clarity that slabs are extending vertically downwards.
Included a sentence following the suggestion above.

L. 384: topography or crustal thickness variation are not considered -> add for clarity: topography, crustal thickness variation and mantle variations outside the slab are not considered.
Incorporated the suggestion above.

L. 390 surround- > surrounding
Corrected

L. 404: Title Fig. 10a,b: profil-> profile
corrected

L. 410: contrast is limit to the -> contrast is limited to the
Corrected

L. 416: significant larger-> significantly larger
Corrected

L. 532: Even though this might be considered as an end of the envelope calculations, -> please revise sentence, not sure what you wanted to say.
Changed sentence to:
“Even though this might be considered as a maximum gravity estimation of slabs, this value is significant, even compared to the observed Bouguer Anomaly low of -200 mGal along the Alps”.

L. 534: Previous studies compensated this effect by lithosphere thickness and/or intra-crustal sources, future studies should incorporate subducting slab structures in order to provide a meaningful representation of the geodynamic complex Alpine area.

-> see comment above- previous works have modelled the mantle densities starting from seismic velocities and inverting the mantle densities. Please reformulate.
-> for instance: The interpretation of density variations in the mantle in terms of subducting slab structures is a means to provide a meaningful representation of the geodynamic complex Alpine area.
Reformulated accordingly the suggestions above.

Missing references in reference list:
El-Sharkawy(2020)
The tomographic model from El-Sharkawy was not published in a peer reviewed journal when the first draft of this manuscript was written. However, the model was published as part of the Doctoral dissertation. In the first draft the model was therefore cited by El-Sharkawy(2019). When the model got published in 2020 the citation within this manuscript was updated to El-Sharkawy et al.,(2020). During the process of updating the citation "et al.," was three times forgotten to add. It got updated now.

Tadiello and Braitenberg 2020->Tadiello and Braitenberg 2021 (accepted in Solid Earth)
Updated

Karusova et al. 2013- > probably Karousova et al?
Corrected

L. 103 Piromallo and Morello, 2003 -> probably Piromallo and Morelli, 2003
Corrected

Check reference Zingerle et al., 2019- webpage? Publisher?
Updated citation