Review of the Manuscript "Gravity Effect of Alpine Slab Segments Based on Geophysical and Petrological Modelling" by M. Loewe et al, submitted to Solid Earth. Review of First Revision.

Reviewer: Prof. Dr. Carla Braitenberg, Trieste University, Italy.

General Comment

This is the second round of review of the manuscript " Gravity Effect of Alpine Slab Segments Based on Geophysical and Petrological Modelling", Lowe et al.

The aim of the study is to model the gravity field of subducting lithospheric slabs, the geometry and the density of which is formulated assuming different assumptions and hypotheses on geometry and density. The variables that have been studied include compositional aspects, temperature, and geometry of the slabs. Furthermore, a simple first order forward calculation of the gravity effect of the mantle down to a depth of 200 km is made, based on a seismic tomography model. In this case, the density model of the mantle is derived by applying single conversion factor to the percentage seismic velocity variations to obtain corresponding density anomalies. Compared to the first version, the scope and procedure of the work are now much clearer. There are still a few issues, that partly had already been mentioned in the first review, that could be improved for greater clarity. To my view there is an error on Equation 2. Detailed comments are given below.

The manuscript can be accepted pending minor revision.

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....?

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.

L. 50 Topography-> tomography

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.

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.

L. 62: . Therefore,

L. 67: *XGM 2019*

-> give reference

L. 76 contrast -> contrasts

L. 105: approximately -> approximate

L. 130: We calculated the gravity contribution of the topography and bathymetry

-> give maximum calculation radius of topography for each grid point.

L. 131: Tesseroids

-> is this the software name or the object? In either case add reference

L. 134: regridded

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

L. 139: topographic correction for the gravity gradients at a station height of 225…

-> also here please give calculation radius.

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.

L. 163: descripted -> described

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

L. 193: $divagation$ -> deviation?

L. 209: please define horizontal extension of the mantle model, and mention how you deal with 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.

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.

L. 354: Add hear for clarity that slabs are extending vertically downwards.

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.

L. 390 surround- > surrounding

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

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

L. 416: significant larger-> significantly larger

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.

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.

Missing references in reference list:

El-Sharkawy(2020)

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

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

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

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