Comments from Referees

Comments by review Reviewer #1

“Title: Sedimentary basins of the Eastern Asia Arctic zone: new details on their structure revealed by decompensative gravity anomalies”

A- GENERAL COMMENTS

- The study area of the manuscript is a large area located in the Eastern Asia Arctic zone where it is the inaccessibility territory, rigorous climate and low habitability and geological and geophysical exploration activities are very poor. The author's manuscript based on the well-known interpretation method of decomposition gravity anomaly has been successfully applied in determining the structure of basins in some areas of the world, for example, in the Rio Grande Rift (Cordell et al., 1991), in Antarctica (Haeger and Kaban 2019), in Congo basin (Kaban et al., 2021a), in the Southern Part of the East-European Platform (Kaban et al., 2021b). I believe that authors did a good job in using the decomposition gravity anomaly data to interpret the structures of basins in the Northeastern part of Asia. From calculating decomposition gravity anomalies and analyzing them, the authors have given a more detailed picture of the sedimentary thickness, density and new depocenter position of some basins in the study area. Although the analytical results obtained are more qualitative than quantitative, I highly appreciate the new contributions of the authors on the results of the determination of decomposition gravity anomalies, structures, shapes, thickness and density distribution of the basins in the northeastern part of the Asian where geological and geophysical exploration works are still very sketchy.

However, one of the biggest limitations of the paper is that the research area is very large, the scale of the map showing the results is too small, so the obtained results compared with previous results, as well as the comments of the authors are difficult to follow. I recommend the authors consider zooming in on the necessary figures and providing affirmative independent evidence for your new results.

- The authors use the methods mentioned in Haeger and Kaban, 2019; Kaban et al., 2021a, b, Kaban et al., 2016 for their calculations. However, the presentation of the method in this manuscript lacks creativity and could be unclear for the readers (the papers themselves by Haeger and Kaban, 2019; Kaban et al., 2021a, b, Kaban et al., 2016 are also very succinct). The presentation of the method for correcting the initial model in the "5-New models of the sedimentary thickness and

density" section should be moved to section “3-Methods” and presented more clearly verifiable.

B- SPECIFIC COMMENTS

- Line 219: Is it possible to change “ Intermountane depression” for “Intermontane depression”
- Line 184: “the isostatic correction is estimated following (Kaban et al., 2016, 2017) as” You should be considered change “following (Kaban et al., 2016, 2017) as” by “the following (Kaban et al., 2016, 2017):”.
- Line 185: What is G_{is} (kx, ky)?
- Line 190: “where ρ_s and t_s are the thickness and vertically averaged density”. You should be considered change “where ρ_s and t_s are” for “where t_s and ρ_s are”.
- Line 197: What do you use a Green's function for? Is it possible to change “We use a Green’s function method (Wienecke et al., 2007; Braitenberg et al., 2002; Dill et al., 2015)” for “We use a Green’s function method for calculation of Eq. (1) (Wienecke et al., 2007; Braitenberg et al., 2002; Dill et al., 2015)”
- Line 202 (in formula (4)): What is $G_{is}(x,y,M,Te)$?
- Line 266: “the range 1.9-2.72 g/cm^3“ could be possible “ the range 1.9 – 1.75 g/cm^3”?.
- Line 282: “5. Discussion” should be changed by “6. Discussion”
- Line 283: “5.1 Sedimentary cover: model 1” should be replaced by “6.1 Sedimentary cover: model 1”; and
- Line 377: “5.2 Sedimentary cover: model 2” should be changed by “6.2 Sedimentary cover: model 2”
- Maps in Figures. 8a, b, and 9 have a very small scale, so it is very difficult to follow the descriptions in the text, especially the detailed descriptions in some basins. For example, the Zyryanka basin is divided into 3 parts consisting of Zyryanka depression structures, Myatis zone, and Zyryanka-Silyapsk zone, or very detailed descriptions of its structural units (according to Koporulin (1979)), however, Figures 8a, b, 9 can't show these descriptions, so I recommend that the authors zoom in the maps in Fig 8 and 9 or some basins for readable.
- The location of the Avyon segment (or Avyon basin) in the Chauna basin is not shown in the figures. 3

- “In the continental part, the maximal thickness is shifted to the southeast less than in the first model, but in both cases its position differs from that one in the initial model”.
Do you mean “The maximal thickness in the second model is shifted to the southeast less than in the first model, but in both cases its position differs from that one in the initial model”?
- The color ruler in Figure 9a lacks a density value.
- Line 429 (5. Conclusion): “For the offshore part of the Chauna basin (referred as the Ayon basin), the sedimentary thickness has appeared to be 2-2.5 km in the new model, which is lower than in the initial model (4 km). The new result agrees with the marine seismic surveys, which confirms robustness of the method”.
In the text, you didn't mention the seismic data before. How can say your result agrees with the seismic survey? A short statement should be made on the comparison between your calculation and seismic data in the text
- List of references missing articles:
Hildenbrand et al., 1996; (line 66)
Zinchenko et al., 1987 (line 125)
Drachev et al., 2011 (line 130)
- List of redundant references:
Smelror, M.: Crustal structure and tectonic model of the Arctic region, Earth Sci. Rev., 2016. Vol. 154. P. 29-71.

Comments from Reviewer #2

The research has the goal to revise the sediment cover thickness and density in a remote region of North Eastern Asia, covering both continental and oceanic areas. Depending on a starting model, the gravity field and isostatic considerations are used to define residual gravity anomalies which are used to correct the sediment thickness model. The topic of study is of general interest, and the authors are experts in the analysis of the gravity signal. There are a few general points that should be stated more clearly, as the fact that all residual anomalies are interpreted in terms of the sediment cover, whereas positive density anomalies in the crust, which could affect also the superficial layers are not considered. Another point is data availability- it would be important that the data are effectively available at the time of publication. The present sentence does not allow the reader to access the data, so please make the data files available together with the revised text.

Further issues are listed below.

The text is written clearly and in good English. I suggest the manuscript can be accepted pending minor revision.

Minor remarks:

p.3, L. 79 …and then deformed during a collision between the East Siberian and East Arctic continental lithospheric plates

-> …and then deformed during the collision between the East Siberian and East Arctic continental lithospheric plates

L. 89 - North of the territory is bounded by the Arctic Ocean Shelf of the Laptev Sea, East Siberian Sea, and Chukchi Sea. -> check grammar. You mean: The northern part of the territory….?

P. 6, L. 184- please check reference calls according to SE instructions.

L. 186: M is the depth to the Moho-> M is a single value, whereas Moho depth varies over the window in which the spectral analysis is calculated; define if it is a reference value an average depth, and criterion to define the value.

L. 199-200: The isostatic correction is estimated in a sliding window as a convolution of the

200 adjusted topography with the Green's functions for corresponding M and EET -> please explain in the methodological part how the Moho depth M and elastic thickness EET are set, as needed in the equation 4 and 5.

P. 7, L. 223: For computation of the Bouguer anomalies-> Which maximal radius was used for the effect of topography/bathymetry? Which method to discretize the topography was used? Was the global topography correction used? If not, justify.

P. 8, L. 253: The residual isostatic anomalies are displayed in Fig. 5b-> add for clarity that these are isostatic anomalies corrected for the effect of a starting model of sediments

P. 9, L. 258: Based on computed decompensative gravity anomalies: we have corrected the initial model of the sedimentary cover-> You explain the final anomalies through a correction to sediments thickness and density- but the anomalies could also be due to local densification of the crust, as magmatic intrusions or magmatic deposits, or metamorphic processes. Please explain in the text that the possible densification is not considered, and what uncertainties on the crustal structure may arise. Another question which arises, is whether in the inversion process you control where sediments are present, and how you deal in areas where no sediments are documented.

Data Availability: please make all the data available at the time of revision of the manuscript and specifically indicate the link, according to journal regulations.

Figure 9a: color scale lacks numbers.

Author's response

To Reviewer #1:
Dear Reviewer,
Thank you for your appreciation of our research and for your valuable comments, which helped to improve the manuscript. We have made all necessary corrections.

A- GENERAL COMMENTS

However, one of the biggest limitations of the paper is that the research area is very large, the scale of the map showing the results is too small, so the obtained results compared with previous results, as well as the comments of the authors are difficult to follow. I recommend the authors consider zooming in on the necessary figures and providing affirmative independent evidence for your new results.

Following this comment; we have prepared a set of maps in addition to the main maps for the whole region. The new maps zoom-in several regions including one or two sedimentary basins, in particularly, the Zyryanka, Anadyr and Chauna basins. This improves visibility of small-scale details of the thickness and density of the basins.

- The authors use the methods mentioned in Haeger and Kaban, 2019; Kaban et al., 2021a, b, Kaban et al., 2016 for their calculations. However, the presentation of the method in this manuscript lacks creativity and could be unclear for the readers (the papers themselves by Haeger and Kaban, 2019; Kaban et al., 2021a, b, Kaban et al., 2016 are also very succinct).

Following the reviewer's suggestion, we have extended the description of the method to make it clear to the readers without reading additional papers.

The presentation of the method for correcting the initial model in the "5-New models of the sedimentary thickness and density" section should be moved to section "3-Methods" and presented more clearly verifiable.

Opposite to computation of the decompensative anomalies, which are described in section 3, the description of the procedure for correction of the initial model is directly related to the obtained results. We believe that this is important for their correct understanding and clarity. Therefore, we prefer to keep this part in section 5.

B- SPECIFIC COMMENTS

- Line 219: Is it possible to change " Intermountane depression" for "Intermontane depression"

Done (this was line 119, not 219, and in the revised paper it is line 120)

- Line 184: "the isostatic correction is estimated following (Kaban et al., 2016, 2017) as" You should be considered change "following (Kaban et al., 2016, 2017) as" by "the following (Kaban et al., 2016, 2017):".

Changed to "using the following equation (Kaban et al., 2016, 2017)" .

- Line 185: What is Gis (kx, ky)?

G_{is} is the Green's function. Added to the explanations.

- Line 197: What do you use a Green's function for? Is it possible to change "We use a Green's function method (Wienecke et al., 2007; Braitenberg et al., 2002; Dill et al., 2015)" for "We use a Green's function method for calculation of Eq. (1) (Wienecke et al., 2007; Braitenberg et al., 2002; Dill et al., 2015)"

Done

- Line 202 (in formula (4)): What is Gis(x,y,M,Te) ?

This is the Green's function depending on the Moho depth M and effective elastic thickness Te. We have changed the corresponding explanations before Eq. (4), so that the Green's function is explicitly defined as Gis(x,y,M,Te)

- Line 266: "the range 1.9-2.72 g/cm3" could be possible " the range 1.9 – 1.75 g/cm3"?.

1.9-2.72 g/cm3 is the correct density range.

The corresponding article:

Kaban, M.K.; Mooney, W.D.: Density structure of the lithosphere in the Southwestern United States and its tectonic significance, J. Geophys. Res., 106, 721–740, https://doi.org/10.1029/2000JB900235, 2001,

– has been added into the reference list.

Line 282: "5. Discussion" should be changed by "6. Discussion"

- Line 283: "5.1 Sedimentary cover: model 1" should be replaced by "6.1 Sedimentary cover: model 1"; and

- Line 377: "5.2 Sedimentary cover: model 2" should be changed by "6.2 Sedimentary cover: model 2"

The section and subsection numbers have been fixed.

- Maps in Figures. 8a, b, and 9 have a very small scale, so it is very difficult to follow the descriptions in the text, especially the detailed descriptions in some basins. For example, the Zyryanka basin is divided into 3 parts consisting of Zyryanka depression structures, Myatis zone, and Zyryanka-Silyapsk zone, or very detailed descriptions of its structural units

(according to Koporulin (1979)), however, Figures 8a, b, 9 can't show these descriptions, so I recommend that the authors zoom in the maps in Fig 8 and 9 or some basins for readable.
Following the reviewer's comment, we zoom in several regions in additional figures as mentioned above.

- The location of the Avyon segment (or Avyon basin) in the Chauna basin is not shown in the figures.
The Ayon segment location is now shown in the figure for the Chauna basin.

- "In the continental part, the maximal thickness is shifted to the southeast less than in the first model, but in both cases its position differs from that one in the initial model".
Do you mean "The maximal thickness in the second model is shifted to the southeast less than in the first model, but in both cases its position differs from that one in the initial model"?

We have revised the sentence following the reviewer's comment.

- The color ruler in Figure 9a lacks a density value.
Thank you, we have improved the figures and added all necessary notations, including the color scales.

- Line 429 (5. Conclusion): "For the offshore part of the Chauna basin (referred as the Ayon basin), the sedimentary thickness has appeared to be 2-2.5 km in the new model, which is lower than in the initial model (4 km). The new result agrees with the marine seismic surveys, which confirms robustness of the method".
In the text, you didn't mention the seismic data before. How can say your result agrees with the seismic survey? A short statement should be made on the comparison between your calculation and seismic data in the text.
A description of the seismic data for the Chauna basin and for the Ayon segment has been added in the Section 2.2. Furthermore, the comparison has earlier been added in Section 6.1 (lines 334-335 in the revised manuscript)

List of references missing articles:
Hildenbrand et al., 1996; (line 66)
Zinchenko et al., 1987 (line 125)
Drachev et al., 2011 (line 130)
- List of redundant references:
Smelror, M.: Crustal structure and tectonic model of the Arctic region, Earth Sci. Rev., 2016. Vol. 154. P. 29-71.
Hildebrand et al., 1996 – added in the References
Zinchenko et al., 1987 – removed (irrelevant paper)
Drachev et al., 2011 – added in the References

The reference
Smelror, M.: Crustal structure and tectonic model of the Arctic region, Earth Sci. Rev., 2016. Vol. 154. P. 29-71. –
is not redundant. This is an article by Petrov et al., 2016. We refer to it in Section 6.1 (line 362)

To Reviewer #2

The research has the goal to revise the sediment cover thickness and density in a remote region of North Eastern Asia, covering both continental and oceanic areas. Depending on a starting model, the gravity field and isostatic considerations are used to define residual gravity anomalies which are used to correct the sediment thickness model. The topic of study is of general interest, and the authors are experts in the analysis of the gravity signal. There are a few general points that should be stated more clearly, as the fact that all residual anomalies are interpreted in terms of the sediment cover, whereas positive density anomalies in the crust, which could affect also the superficial layers are not considered. Another point is data availability- it would be important that the data are effectively available at the time of publication. The present sentence does not allow the reader to access the data, so please make the data files available together with the revised text.

Dear Reviewer,

Thank you for your appreciation of the results of our study and for your valuable comments, which helped to improve the manuscript. We have made all necessary corrections. In particular, we have extended the discussion about possible effect of density anomalies in the crystalline crust and put all the results in a public repository.

p.3, L. 79 …and then deformed during a collision between the East Siberian and East Arctic continental lithospheric plates

-> …and then deformed during the collision between the East Siberian and East Arctic continental lithospheric plates

Corrected.

L. 89 - North of the territory is bounded by the Arctic Ocean Shelf of the Laptev Sea, East Siberian Sea, and Chukchi Sea. -> check grammar. You mean: The northern part of the territory….?

Yes, we meant this. We have clarified this issue.

P. 6, L. 184- please check reference calls according to SE instructions.

These links are correct.

L. 186: M is the depth to the Moho-> M is a single value, whereas Moho depth varies over the window in which the spectral analysis is calculated; define if it is a reference value an average depth, and criterion to define the value.

Yes, in Eqs 1 M is a constant value. Therefore, it is not possible to apply the spectral method for the variable M. Instead, we use the Green's function technique, which provides a possibility to take into account variations of the Moho depth within the study area. In Eqs. 4 M depends on the location. We changed Eqs. 4 to clarify this.

L. 199-200: The isostatic correction is estimated in a sliding window as a convolution of the adjusted topography with the Green's functions for corresponding M and EET -> please explain in the methodological part how the Moho depth M and elastic thickness EET are set, as needed in the equation 4 and 5.

In Eqs. 4, M and Te are variable and depend on the location. This is clarified.

P. 7, L. 223: For computation of the Bouguer anomalies-> Which maximal radius was used for the effect of topography/bathymetry? Which method to discretize the topography was used? Was the global topography correction used? If not, justify.

The gravity effect of the topography/bathymetry has been calculated within the radius 333.6 km (3 degrees) based on the initial topography/bathymetry grids. The increase of this radius would produce only long-wavelength anomalies, which are not considered as described in the manuscript. This is clarified.

P. 8, L. 253: The residual isostatic anomalies are displayed in Fig. 5b-> add for clarity that these are isostatic anomalies corrected for the effect of a starting model of sediments

The statement has been added.

P**. 9, L. 258: Based on computed decompensative gravity anomalies: we have corrected the initial model of the sedimentary cover-> You explain the final anomalies through a correction to sediments thickness and density- but the anomalies could also be due to local densification of the crust, as magmatic intrusions or magmatic deposits, or metamorphic processes. Please explain in the text that the possible densification is not considered, and what uncertainties on the crustal structure may arise.**

This aspect has been already mentioned in the results section. Following the reviewer's comment, we have extended the discussion of this effect.

Another question which arises, is whether in the inversion process you control where sediments are present, and how you deal in areas where no sediments are documented.

We cannot be sure that the existing maps correctly show the position of sedimentary basins since this territory is not studied in many places. Therefore, we assume that our results should also indicate some new sedimentary deposits, which were not documented previously.

Data Availability: please make all the data available at the time of revision of the manuscript and specifically indicate the link, according to journal regulations.

The obtained results, including the new sedimentary thickness and density models, can be downloaded from the World Data Center for Solid Earth Physics. The corresponding statement with the link has been added in the 'Data Availability' section.

Figure 9a: color scale lacks numbers.

The figure has been revised.

Author's changes in manuscript

Subsection 2.1

Line 79: "then deformed during a collision" changed to "deformed then during the collision";

Line 89: "North" changed to "The northern part";

Subsection 2.2

Line 120: “intermountane”changed to “intermontane”;

Zinchenko et al., 1987 – deleted;

Line 151: “overlying the folded Early Mesozoic basement” inserted;

“overlying the folded Early Mesozoic basement” deleted;

Line 153: “2.2 to 2.5 km thick, according to the marine seismic survey (Gresov and Yatsuk, 2020)” inserted;

Section 3.

Line 184: “By applying this correction, it is possible to remove the effect of deep density anomalies compensating the near surface load (chiefly topography) (e.g. Simpson et al., 1986). This correction is especially useful when we have only a little knowledge about deep structures of the lithosphere. In this case, it is just assumed that the near surface load is compensated according to a plausible isostatic compensation scheme” inserted;

Line 188: “using the” inserted, “equation” inserted;

Line 189: “as” deleted;

Line 192: "$G_{is}(k_x, k_y)$ is the Green’s function (its introduction is explained below)” inserted;

Line 196: “ρ_s and t_s” changed to “t_s and ρ_s”;

Line 198: “It has been demonstrated that the main parameter, which control the style of isostatic compensation, are the average compensation depth (usually associated with the depth to the Moho) and elastic support of the surface load by the lithosphere.” Inserted;

Line 205: “since” changed to “instead of” ;

Line 206: “in the spectral domain, since the direct application” added;

Line 208: $G_{is}(x, y, M, T_e)$ added;

Line 209: (x_0,y_0), ($T_e(x_0,y_0)$). added;

Line 210: $G_{is}(x, y, M, T_e)$ changed to $G_{is}(x, y, M(x_0, y_0), T_e(x_0, y_0))$ in Eq.4;

Line 216: “By applying this correction, it is possible to reduce the effect of compensation of the unknown density anomalies in the upper crust, which are still missed in the initial model. Otherwise the total effect of the upper crust anomalies and their compensation tends to zero already for the basins with a horizontal size of several hundred kilometres or more (e.g. Kaban et al.. 2021a)” added;

Subsection 4.1.

Line 237: “ The gravity effect of the topography/bathymetry has been calculated within the radius 333.6 km (3 degrees) based on the initial topography/bathymetry grids. The increase of

this radius would produce only long-wavelength anomalies, which are not considered in the manuscript as described above.” added;

Subsection 4.2.

Line 267: “corrected for the effect of the initial model of sediments” added;

Section 5 changed to Section 6;

Subsection 5.1 changed to Subsection 6.1;

Line 301: “To display these details, we have prepared a set of the maps zooming up some important regions. In Fig. 9, we provide a comparison between the initial sedimentary model (in the left) and two new models (the first model in thecenter and the second one in the right).” added;

Line 311: “(Fig. 9a, center)” added;

Line 323: “(Fig. 9b, center)” added;

Line 329: “(Fig. 9c, center)” added;

Line 330:“(Fig. 9c, left)” added;

Line 332: “(Fig. 9c)” added;

Line 337: “(Fig. 9d)” added, “(Fig. 9d, center)” added;

Line 340:“(northwestern one)” added, “(southeastern one).” added,“contoured with dashed lines on Fig. 9d” added;

Line 347:“(Fig. 9e)” added;

Line 366: “(Fig. 9e, center)” added;

Line 374: “(Fig. 9e)” added;

Line 375: “Fig. 2b” changed to “Fig. 9e, left”, and “Fig. 8a” changed to “Fig. 9e, left”;

Subsection 5.2 changed to Subsection 6.2;

Line 407: “(Fig. 9c).” added;

Line 408: “In the continental part, the” deleted, “(Fig. 9a, right). The” added, “in the second model” added;

Line 423: “(Fig. 9b, right)” added, “(Fig. 9b, left)” added;

Line 425: “(Fig. 8a)” changed to “(Fig. 9b, left).;

Line 426: “(Fig. 9b, right)” added;

Line 431: “(Fig. 9a)” changed to “(Fig. 9a10a)”;

Line 432:“(Fig. 9b)” changed to “(Fig. 10b)”;

Line 435: “(Fig. 11)” added;

Line 437: “(the corresponding zones are contoured by dashed lines in Fig. 11).” added;

Line 438: “(Fig. 9b)” changed to “(Fig. 10b)”;

Line 442: “The new sedimentary models were calculated based on the assumption that the decompensative anomalies are exclusively induced by changes in the sedimentary basins’ structure (thickness in the first model and both, thickness and density, in the second one) by applying the approach of Kaban et al. (2021b). Another possible source of the decompensative anomalies, especially in the case of positive ones, could be local densification of the upper crust due to intrusive rocks or metamorphism, which effects were not considered in this study. Therefore, the resulting models may include possible local uncertainties in the vicinity of the intrusions related to the OCVB structure. However, for most of the sedimentary basins in the study area, these uncertainties are generally local and, therefore, minor with respect to the large-scale structures” added;

Data availiability section:

Line 491: “The new sedimentary thickness and density models will soon be available at the GIS portal of the Geophysical Center of the Russian Academy of Sciences” changed to

“The obtained results, including the Bouguer gravity anomalies, residual gravity field, adjusted topography, isostatic and decompensative corrections and anomalies used for their calculation, new sedimentary thickness and density models. are available at the World Data Center for Solar-Terrestrial Physics website http://www.wdcb.ru/arctic_antarctic/arctic_grav_1.html”.

References:

Line 535: “Drachev, S. S. Tectonic setting, structure and petroleum geology of the Siberian Arctic offshore sedimentary basins, in: Geological Society London Memoirs, 35(1): 369-394, https://doi.org/ 10.1144/M35.25, 2011.” added;

Line 552: “Hildenbrand, T. G., Griscom, A., Van Schmus, W. R., Stuart, W. D.: Quantitative investigations of the Missouri gravity low: A possible expression of a large, Late Precambrian batholith intersecting the New Madrid seismic zone, J. Geoph. Res., 101(B10), 21921–21942, https://doi.org/10.1029/96JB01908, 1996.” added;

Line 571: “Kaban, M.K.; Mooney, W.D.: Density structure of the lithosphere in the Southwestern United States and its tectonic significance, J. Geophys. Res., 106, 721–740, https://doi.org/10.1029/2000JB900235, 2001” added;

Figure 1 revised (legend lable fixed);

Figure 5 revised (grid labels fixed);

Figure 5 caption: “. (also implying the the effect of the initial model of sediments).” added;

Figure 6 revised (grid labels fixed);

Figure 9 New figure added. Caption “Comparison between the initial sedimentary model (left) and the new sedimentary cover models, 1 (center) and 2 (right) for several basins: Anadyr (a), Penzhin and Pustorets (b), Chauna (c), Zyryanka (d, dashed lines show the Lower Cretaceous coal-bearing zones), Primorsk and Tastakh (e).” added.

Figure 9 changed to Figure 10, as the new figure has been inserted before it;

Figure 11 new Figure added. Caption: “Figure 11. New density model zoomed in on the Zyryanka basin. Dashed lines show the Lower Cretaceous coal-bearing zones.”