<u>RESPONSE FOR ANONYMOUS REFEREE #1:</u>

COMMENT #1 (PAGE 2):

"…Because of a very low temporal resolution, survey GPS observations cannot catch that. Even if by chance the measurements are made during a transient event, longer measurements ahead would be necessary, in order to have a precise estimation of the trend before any burst, just to be able to detect it. In order to monitor transient aseismic processes, it is necessary to integrate and combine permanent continuous observations…"

Response:

Tectonic movements, like aseismic creep, can be monitored even using long-term campaign observations. Slip deficit is the key factor to determine if creep exists or not. In that case, it's not an essential issue to establish permanent stations. Results would lead us for this kind of permanent continuous observations if necessary. Also, earlier studies which uses space geodesy didn't require or mention permanent GPS stations for this phenomena, and final outcomes of these studies given at Table 1&2 and Figure 6.

COMMENT #2 (PAGE 2):

"…They are correct writing that it is "always related to the geological characteristics and fault geometry", however, I have major concerns about the ability of deciphering between models of slip with measurements so sparse and actually so far away from the fault trace that this network geometry provides."

Response:

Figure 9 includes *Yavasoglu et al. 2015* graphics that shows the optimum perpendicular distances from a creeping fault, 3 and 10 km on both sides. Project mainly maintained on this basis to configure profiles and yearly observations. We try to understand block movements around the region, and results of the TDEFNODE modeling indicates that the distribution of the stations were sufficient to represent blocks along the creeping parts of the NAF.

COMMENT #3 (PAGE 2):

"The authors show on fig. 9 the creep rate profiles. There's a first issue, the axis is labelled "slip rate" with "mm" units: : : is it mm/yr or is it "slip" that is showed?..."

Response:

Figure fixed as "mm/year" for the axis.

COMMENT #4 (PAGE 2):

"…(The location of stations at 3 km and 10km on this graph could be highlighted in order to emphasize their point)…"

Response:

Figure 9 revised as follows:

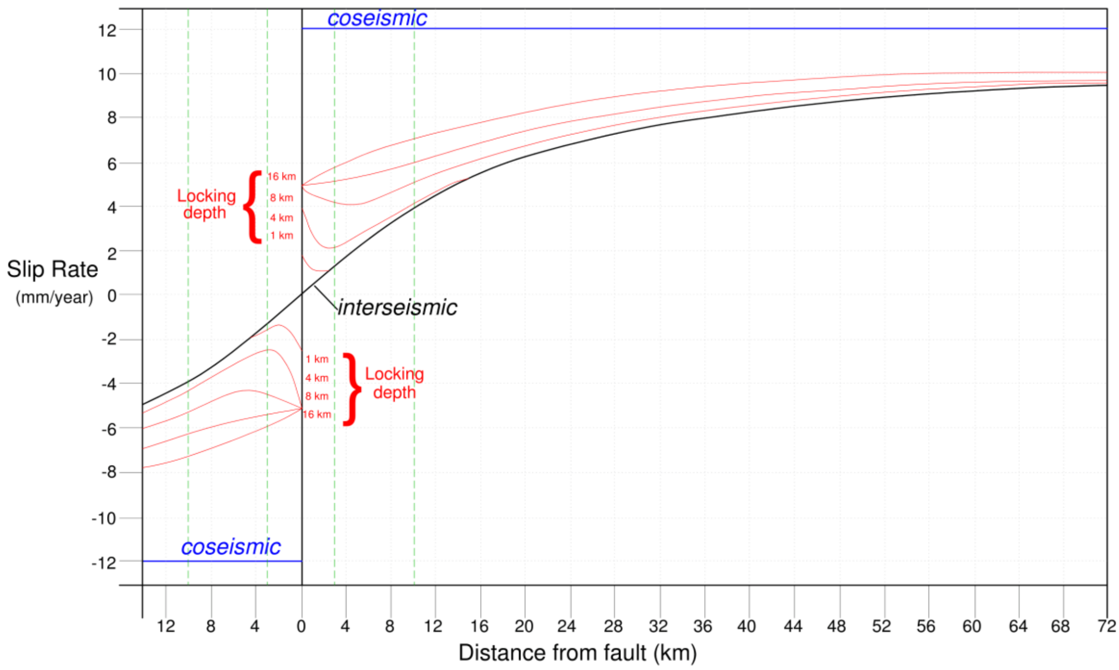


Figure 9. Slip rate along a fault plane during interseismic and coseismic events. Blue lines represents the coseismic, and black line represents the interseismic behaviour, where red lines demonstrates the aseismic creep ratios at two sides of the fault for different locking depths. Vertical green lines indicates 3 and 10 km on the both sides of the fault where the interseismic behaviour disintegrates from aseismic creep (after Yavasoglu et al. 2015).

COMMENT #5 (PAGE 3):

"…- The interseismic deformation is non-unique, it also depends on the locking depth and can show a strong gradient a short distance from the fault.This has to be accounted for in this graph and discussed in the text…"

Response:

By this project, we established GPS networks around the both regions, Ismetpasa and Destek. This gives us the opportunity to monitor a large area. For this reason, several campaign stations established around the NAF to represent the block movements, which based on the theoretical studies.

COMMENT #6 (PAGE 3):

"…Fig.6 shows the offset at the fault, which cannot reproduced by such a simple interpolation. More data at very small scale around the fault appear necessary, for example InSAR or directly surface measurements (offset sidewalk or walls as mentioned in the text l.64)…"

Response:

This project based on GPS observations. InSAR or direct measurements on the field and involving these data with our results is another research issue for the future. Interpolation along the profiles from the GAMIT/GLOBK results gives us a quick overview for the creep behavior, they are not used for final outcomes.

Also, we didn't get any result about the creep rate at the 3rd profile, because it was impossible to estimate the movement using interpolation due to local deformation at the south of the profile, and station velocities removed from the input data used to model the fault and blocks with TDEFNODE. This procedure explained in the text.

COMMENT #7 (PAGE 3):

"…- Fig 11c : there are no data on the first 12 km, meaning on side of the fault according to the model, on what is based this model ?

- Fig 11d : it is in fact possible to draw a single straight line crossing all the points, same question, on what is based the model ?

- Fig 13 : same question, the model is not at all crossing the points on the south side of the fault…"

Response:

Our model based on Figure 9 elementarily but there are some limitations when applied on the field. Also, those fault perpendicular distances are not the exact locations to seize creep; they should be around those locations.

Another issue is that the site selection is heavily relevant with the ground truth. It was not always possible to find out a suitable location for campaign points at the given distances/locations, or they cannot maintain a straight profile on practical applications (inconvenient soil structure, impractical locations for GPS observations due to surrounding obstacles, etc.). For these reasons, we select the closest locations for the stations based on our model.

COMMENT #8 (PAGE 4):

"…Furthermore, the paper does need a lot of work with regards to English language usage to make it readable and understandable by the international scientific community, with recurrent grammar and conjugation mistakes (see details below)."

All of these make the paper very hard to understand. Being a non-native English speaker myself, I do realize how difficult this exercise is, but it should not be the reviewer's burden and I strongly suggest that the authors have a native English speaker help with the manuscript writing before re-submitting…"

Response:

Based on this comment, a total check including proofreading has done.

COMMENT #9 (PAGE 5):

"…Figure 1: it is useful to have a first context figure but it does not seem useful to show it at such a large scale, it could be centered on the NAF between 23 and 40◦E, 35 and 42◦N. I guess everything that is not mentioned in the text, therefore that does not have an influence on the creeping segments, should not need to be on the figure. On the contrary, it misses quite a lot of important information for the understandings of the paper: the very first one being where are the locations of Ismetpasa and Destek ?

Please, more generally, show on the map ALL the location of cities mentioned in the text (Baymoren & Gerede for ex.)?..."

Response:

Following figure prepared for the manuscript. Both segments have their labels according to the nearest villages, thus İsmetpaşa and Destek settlements shown on the figure.

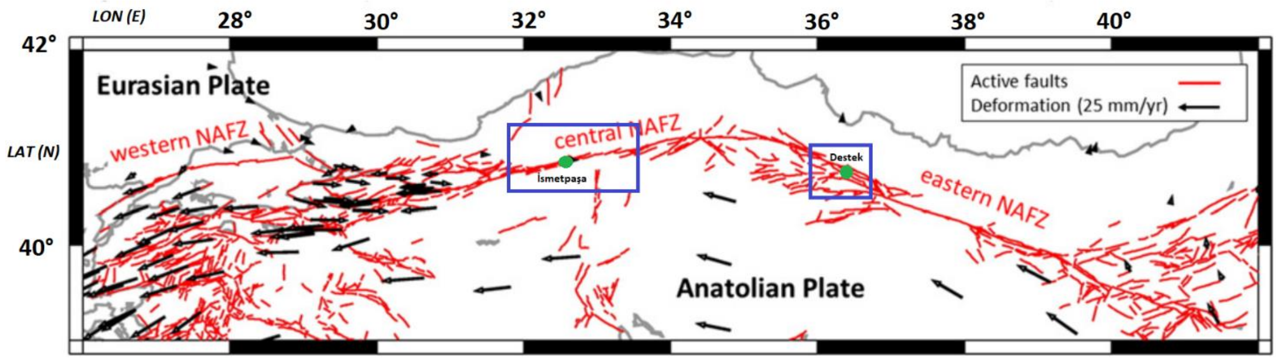


Figure 8. Active fault segments on the North Anatolian Fault (NAF). Blue rectangles defines İsmetpaşa and Destek segments from west to east, respectively (after Bohnhoff et al. 2016).

COMMENT #10 (PAGE 5):

"…The authors also mentioned the historical seismicity along the 2 segments (l.61-68), where did these earthquakes occur exactly respective to the 2 creeping segments? The GPS network at this scale would also be interesting to actually have a sense of its footprint…"

Response:

Following figure added in the manuscript.

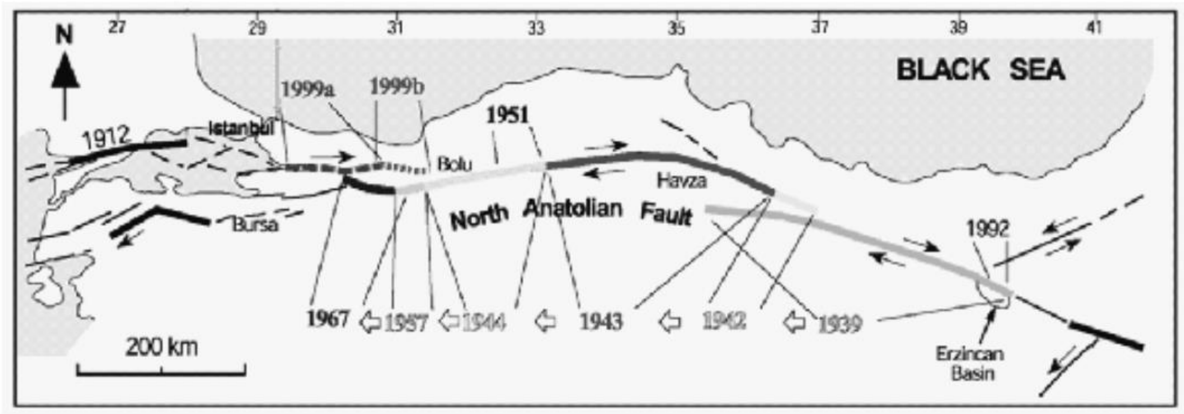


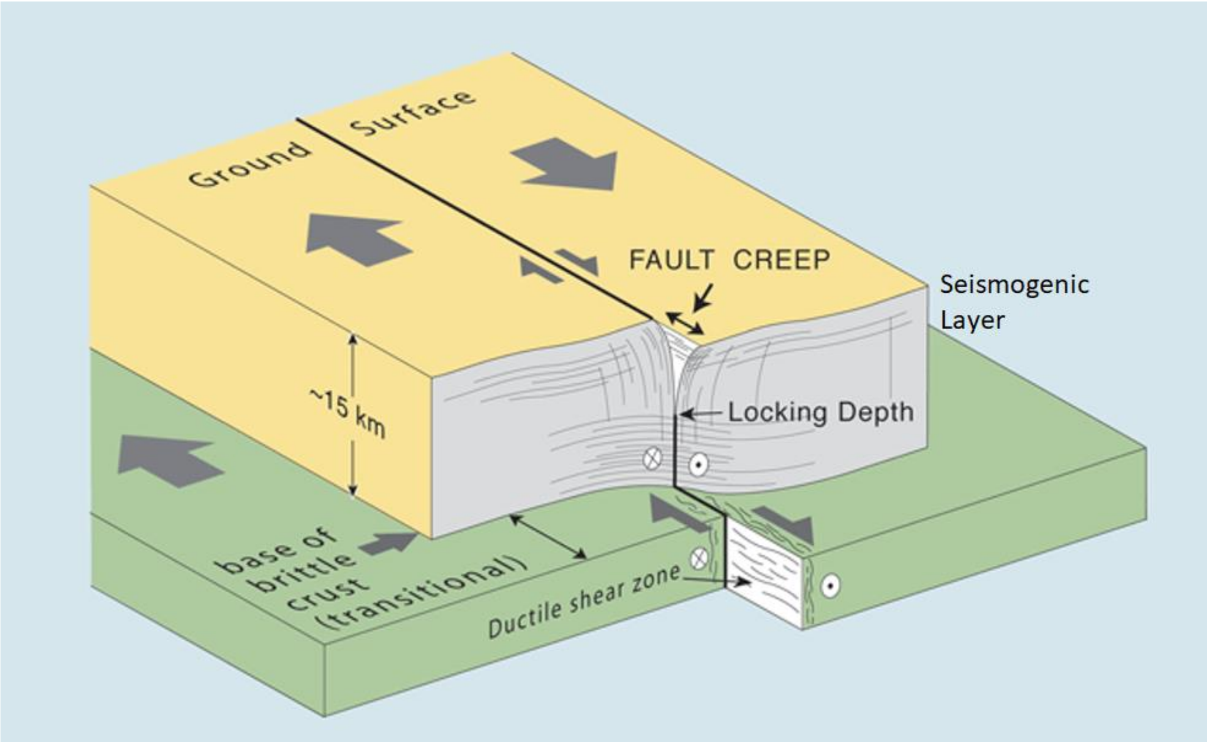
Figure 4. Earthquakes on the North Anatolian Fault between 1939-1999. Both 1943 and 1944 earthquakes suspected to have influence on the creeping phenomena (from Kutoglu et al. 2010).

COMMENT #11 (PAGE 5):

"…Figure 2: the label of seismogenic zone is missing…"

Response:

Figure edited and label added.



COMMENT #12 (PAGE 5):

"…Figure 3: I don't really see the point of this figure, the scale is too small to be able to locate the region on the NAF, and it is too large to see any hints of aseismic creep? Is there any pictures showing the creep ? If so, they could be added as a composite figure showing this pictures and their location ? As it is, this figure is useless…"

Response:

Close up photos for the creeping segments from *Karabacak et al. 2011* added after Figure 3.

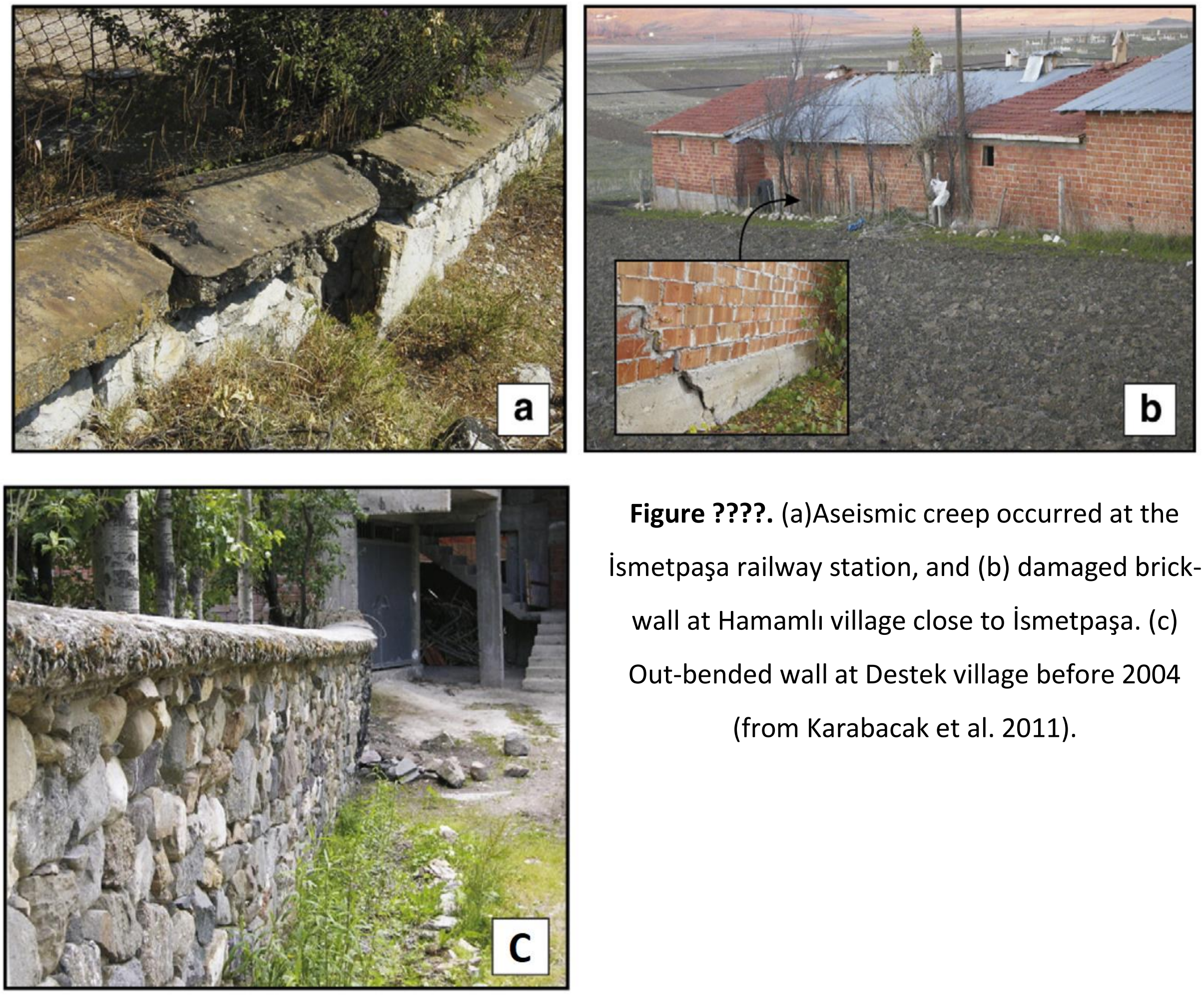


Figure ????. (a)Aseismic creep occurred at the İsmetpaşa railway station, and (b) damaged brick-wall at Hamamlı village close to İsmetpaşa. (c) Out-bended wall at Destek village before 2004 (from Karabacak et al. 2011).

COMMENT #13 (PAGE 6):

"…Figure 4: On sub-figure (b), there are 3 fault trace, the GPS profile only encompasses 2 of them… where is supposed to occur the creep ? Why ignoring the 3rd fault? Discuss that…"

Response:

Profile established according to the observed creep at Destek Village, other fault traces on the south are secondary faults and no creep has not reported around those locations.

COMMENT #14 (PAGE 6):

"…Figure 5: the dataset is quite dense which make this figure difficult to read. Typically, it is hardly possible to read the station codes - which are in fact not needed. There again, rescale the map : there are no data from 26 to 28◦E and from 38.1 to 40◦E. The uncertainty is missing from the arrow legend. The fault trace, even simplified, should appear. Caption: "relative to fixed Eurasia" instead of "when Eurasian plate selected as fixed". Later on: "the westward motion of the Anatolian plate" instead of "the Anatolian plate's motion to the west…"

Response:

Figure 5 represents the all continuous stations(CORS-TR) and contributes a view for the size of project area. Both segments and station velocities detailed at figures 10 and 12.

The uncertainty can be scaled using the current arrow legend.

Figure explanation corrected and fault trace for North Anatolian Fault added as follows:

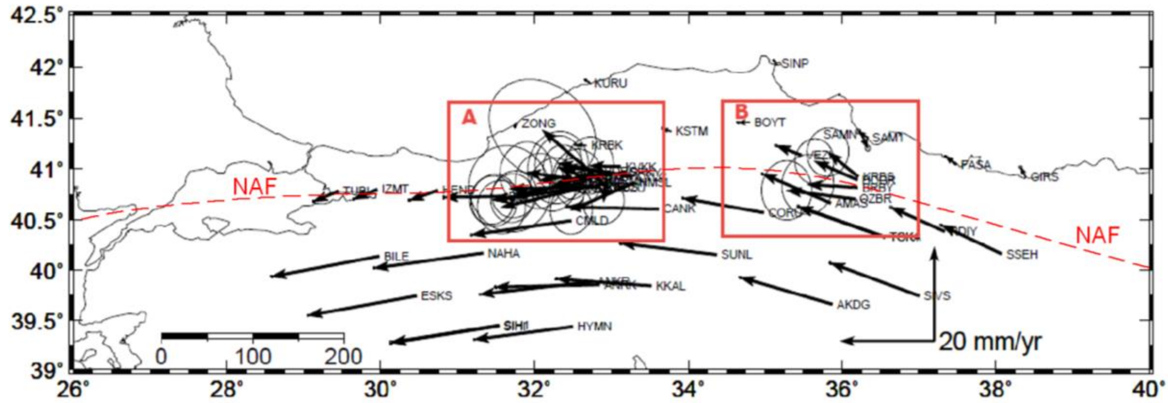


Figure 5. *GLOBK results for station velocities relative to fixed Eurasian. (A) includes the Ismetpasa segment, and Destek segment is inside (B). Dashed lines represents the fault trace of North Anatolian Fault (NAF). Velocities at the north of the NAF are very small as expected, where south velocities indicates the westward motion of the Anatolian plate (after Aladoğan 2017).*

COMMENT #15 (PAGE 6):

"…Figure 6: this figure is very complicated and I am not sure it is really useful. The geological structure is hardly mentioned in the text, and the creep values estimated in previous studies are already recapitulated in table 1. Table 7 and table 1 could be gathered, ordering table 1 as function of profiles and then adding the creep values from this study to compare them ?..."

Response:

This figure is a brief summary of our study after GAMIT/GLOBK evaluation. Approximate profile locations, station velocities, creep interpolation and geological structure of the segments represented in detail. In addition, observations in the history with respect to their method also mentioned in the figure.

Geological structure is responsible for aseismic creep and it's a fact, and this study focused on GPS observations and try to estimate fault parameters caused by this structure in any case.

Figure 6 is an intermediate step to predict creep ratios, but final results gathered from TDEFNODE. Also, it was impossible to predict creep at 3rd profile and this figure shows where we had drawback through the process.

COMMENT #16 (PAGE 6):

"…Figure 7: this is one is directly taken from a PhD unmodified, maybe it can go in supplement?..."

Response:

This figure represent the locking on a fault and outcome of slip deficit between two tectonic blocks. It may remain in the text.

COMMENT #17 (PAGE 6):

"…Figure 10 - 12: why all the white on these 2 figures instead of zooming in on the data ? Add red arrow and the legend "model" / "observed" along with the scale. What are all the squares lying on the fault ?..."

Response:

Dashed lines in Figures 10 and 12 represents the block model boundaries within TDEFNODE. A large scale was necessary to demonstrate the width and length of the creeping segments.

In the explanation of the figures, we explain what those red and black arrows implies. Square on the fault represents the fault and make it easy to observed fault trace and profiles' situations . An explanation added in the explanation under the figures as follows:

"Figure 10. *Model area for Ismetpasa segment with Eurasian plate (AVRA) on the north and Anatolian plate (ANAD) on the south (dashed lines), divided by the creeping segment of the NAF. Black and red arrows represent the observed and modeled velocities respectively, obtained from GAMIT/GLOBK and TDEFNODE. Five profiles are numbered from west to east with 001 to 004, where 005 represents the intermediate profile established during the 1st campaign. Two stations (SLYE and CGCS) on the south-end of the profile 003 removed from the model due to unexpected velocities.* ***Rectangles implies the fault trace****."*

"Figure 12. *Model area for Destek segment with Eurasian plate(AVRA) on the north and Anatolian plate(ANAD) on the south(dashed lines), divided by the creeping segment of the NAF. Black and red arrows represent the observed and modeled velocities respectively, obtained from GAMIT/GLOBK and TDEFNODE. 004 represents the profile in the area* ***and rectangles implies the fault trace****."*

COMMENT #18 (PAGE 6):

"…Figure 11 - 13 : there's obviously no data further than 25 km from the fault, re-scale the profiles. Same remark for the y-axis, the smallest velocity is -2 or -3 mm/yr, re-scale the velocity axis. What are the dashed red lines ? What is the "transverse"?..."

Response:

Profiles rescaled for both x- and y- axis. Dashed red lines represents the block boundaries, explanations are in the statement and "transverse" removed from the figures.

COMMENT #19 (PAGE 7):

"…coordinates of the Euler pole estimated to rotate the velocities in fixed Eurasia…"

Response:

Euler pole coordinates added in the manuscript as follows:

"During TDEFNODE process, one of the tectonic blocks should be chosen as fixed to estimate the fault parameters. Therefore, Euler pole defined as (0, 0, 0) for Eurasian plate and (30.7, 32.6, 1.2) for Anatolian plate. Values represent latitude, longitude and angular velocity, respectively (McClusky et al. 2000)."

COMMENT #20 (PAGE 7):

"…coordinates of all sites (Table 6). In which frame are given the velocities ? ITRF08 or fixed Eurasia ? Indicate it but velocities both in ITRF08 and fixed Eurasia should be given…"

Response:

Those velocities calculated with GAMIT/GLOBK for fixed Eurasia. Explanation for the table fixed as follows:

"Table 6. All cGPS and campaign point with their velocities and location errors (uncertainties) when Eurasian plate selected as fixed."

COMMENT #21 (PAGE 7):

"…Table 5 could be gathered with table 4 with a symbol with stations used for stabilitation…"

Response:

Stations used for GLOBK stabilization are marked and situation added in the explanation for the table:

"Table 5. IGS stations defined in the site.defaults file of GAMIT to constitute reference frame (indicates stations selected for GLOBK stabilization)".*

COMMENT #22 (PAGE 7):

"…l.159-160: "GPS data for cGPS and IGS stations downloaded to cover every six month between August 2009-2016 to increase the stabilisation at the GLOBK step." I don't understand what means "to cover every 6 months" ? The stabilization is important over the campaign dates, then if the stabilisation stations are IGS stations, their positions and velocities are very well known in the ITRF08 : : : Another robust stabilization approach, maybe more efficient than processing data over a longer period than the campaign, is to combine IGS h-files at the dates of campaign in the GLOBK process (to download either from SOPAC or MIT – code sh_get_hfiles in gg)…"

Response:

Observations over the campaign points completed approximately in July – August term at 2014 – 2016. "to cover every 6 months" is an explanation for downloaded and processed cGPS stations' data at campaign observation dates and also every January at those years. So, text has been revised as follows:

"GPS data for IGS and cGPS stations' data processed at campaign observation dates. In addition, observations for those stations during January(for 7 days) included at the GAMIT/GLOBK step to increase the stabilization of the designed networks."

COMMENT #23 (PAGE 7):

"…l.165-167: "Results show that the velocity of the stations inside the Anatolian plate are gathering up to 15- 20 mm/year (Fig 5), which is similar with the previous studies (McClusky et al. 2000, Reilinger et al. 2006, Yava¸soglu et al. 2011)." In what frame ? ITRF08 or fixed Eurasia ? What does mean Âninside the Anatolian plateÂ ´ z ? Located ˙ on the Anatolian plate ? "ranging from 15 to 20 mm/yr" instead of "gathering up to…"

Response:

Addition to the explanation of Figure 5 describes that those velocities calculated when Eurasia selected as fixed. Also, this text changed as follows after the comment:

"Results show that the velocity of the stations located on the Anatolian plate are ranging from 15 to 20 mm/year (Fig 5), which is similar with the previous studies (McClusky et al. 2000, Reilinger et al. 2006, Yavaşoglu et al. 2011)."

COMMENT #24 (PAGE 8):

"…Tables 6 : The uncertainties given in table 6 (of less than 0.1mm/yr in some cases) are totally unrealistic, they must be formal errors from the globk process, in which case it is necessary to precise at how many sigmas. Going further I think the authors are mixing "errors", "uncertainties" and "repeatabilities" (l.179 : "repeatability of the ORMN and KDZU stations indicate abnormal deformation"). They are different things, please clarify what is used, and indicate all the necessary information…"

Response:

At table 6, uncertanties around 0.1 mm/year refer cGPS stations (CORS-TR) at designed network. Also, it can be seen that the uncertainties for campaign stations are much more bigger than those values because data from them are discontinuous and do not cover a complete year.

On the other hand, considering 3 campaign observations for ORMN and KDZU stations, we found evidence for deformations around those locations considering the repeatability graphics after GAMIT step. To clarify the situation, text revised as follows:

"GAMIT process indicates abnormal deformation for ORMN and KDZU campaign stations, so their data removed from block modelling step."