Dear Editor,

Thank you for passing on the review of our manuscript about the Rayleigh-wave group velocities in Northwest Iran: SOLA Backus-Gilbert vs. Fast-marching methods. We have taken great care to address all of the concerns. The detailed response to the comments from the reviewers is included below (the reviewer comment is in black and our responses are highlighted in green).

Reviewer A:

In the manuscript “Rayleigh wave group velocities in North-West Iran: SOLA Backus-Gilbert vs. Fast Marching tomographic methods” the authors compare two different tomographic methods in Northwest Iran. Overall, this is a very interesting paper, with well-supported analyses and conclusions. The methodology is well-explained and the results are appropriately presented in high-quality figures. Most of my comments are regarding grammatical issues, the conciseness of some paragraphs, or writing style. Nevertheless, some details in the methodology, such as some explanation/justification for the choice of parameters are missing. I also made a few suggestions for improving the figures.

Regarding the grammatical suggestions (most of them concerning the usage of hyphens in compound adjectives), make sure to revise the entire text to catch all the issues and inconsistencies. I’m just mentioning some of them because many occurrences are repeated in the text (e.g. “shear wave velocity” should be replaced by “shear-wave velocity” everywhere, not just in the places I explicitly mention it).

We are very grateful for the positive feedback. The detailed response to the comments is included below.

Comments:

Lines 3-5: “Rayleigh wave group velocities in North-West Iran: SOLA Backus-Gilbert vs. Fast Marching tomographic methods” → “Rayleigh-wave group velocities in Northwest Iran: SOLA Backus-Gilbert vs. Fast Marching tomographic methods”

It is replaced.

Line 12: North-West → Northwest

It is replaced.

Lines12-13: “Rayleigh wave group velocity measurements” → “Rayleigh-wave group-velocity measurements”

It is replaced.

Line 13: “seismic noise correlations” → It’s not wrong, but “ambient seismic noise cross-correlations” or just “ambient noise cross-correlations” is more common. Once you choose a nomenclature, stick to it throughout the entire text. Do not write “seismic noise”, then switch to “ambient noise” or “correlation” and later change to “cross-correlation”, for instance. Be consistent!

It is considered in the whole text.

Line 15: “SOLA Backus-Gilbert linear tomographic scheme” → “SOLA Backus-Gilbert linear-tomographic scheme”

We appreciate your suggestion, but we believe that ‘SOLA Backus-Gilbert linear tomographic scheme’ is correct version.

Line 15: “Fast Marching Surface Wave Tomography method” → “Fast-marching Surface-wave Tomography method”

It is replaced.

Line 22: “strong vs. weak seismic velocity contrasts “→ “strong- vs weak-seismic-velocity contrasts”

We appreciate your suggestion, but we believe that part of it should be changed. It changed to ‘strong vs weak seismic-velocity contrasts.

Line 24: “strong anomaly contrasts” → “strong-anomaly contrasts”

We appreciate your suggestion, but we believe that ‘strong anomaly contrasts’ is correct version.

Lines 27-28: “two and three-dimensional images” → “two- and three-dimensional images”"

It is replaced.

Line 47: Partition Waveform Inversion → “Partitioned Waveform Inversion” or, even better: “Partitioned-waveform Inversion”

It is replaced.

Lines 48-50: 1-D, 2-D, 3-D → 1D, 2D, 3D

They are replaced.

Lines 58-59: “surface-wave studies cited above” → “surface-wave studies mentioned earlier”

It is replaced.

Lines 64-67: There are several reasons for such discrepancies. We have already mentioned the different sources of surface-wave data (earthquakes or seismic-noise) and differences in the tomographic inversion methods; to these we can add differences in uncertainty estimates for the measurements, in model parameterization, in choice of trade-off parameters. → There are multiple factors contributing to these discrepancies. We have previously discussed the diverse sources of surface-wave data (earthquakes or ambient noise) and variations in tomographic inversion methods. Additionally, we should consider disparities in uncertainty estimates for the measurements, differences in model parameterization, and variations in the choice of trade-off parameters.

It is replaced.

Line 71: "full resolution matrix"→ "full-resolution matrix"

We appreciate your suggestion, but we believe that it should be changed to full resolution-matrix.

Line 104-105: "metamorphic region that extends NorthWest into Eastern Anatolia" → "metamorphic region that extends northwestwards into Eastern Anatolia"

It is replaced.

Figure 1: It would be good to add a scale bar on your maps (all of them, not just Fig. 1). That helps when evaluating the distances separating the stations, for instance. Another suggestion would be changing the color you are using to plot the epicenters. They are barely noticeable in black. I would use red for the epicenters and green (or another color) for the IRSC stations. Also, make sure that the two maps are aligned with each other (the second map is slightly below where it should be).

All maps that needed scale bar are updated and figure 1 is aligned.

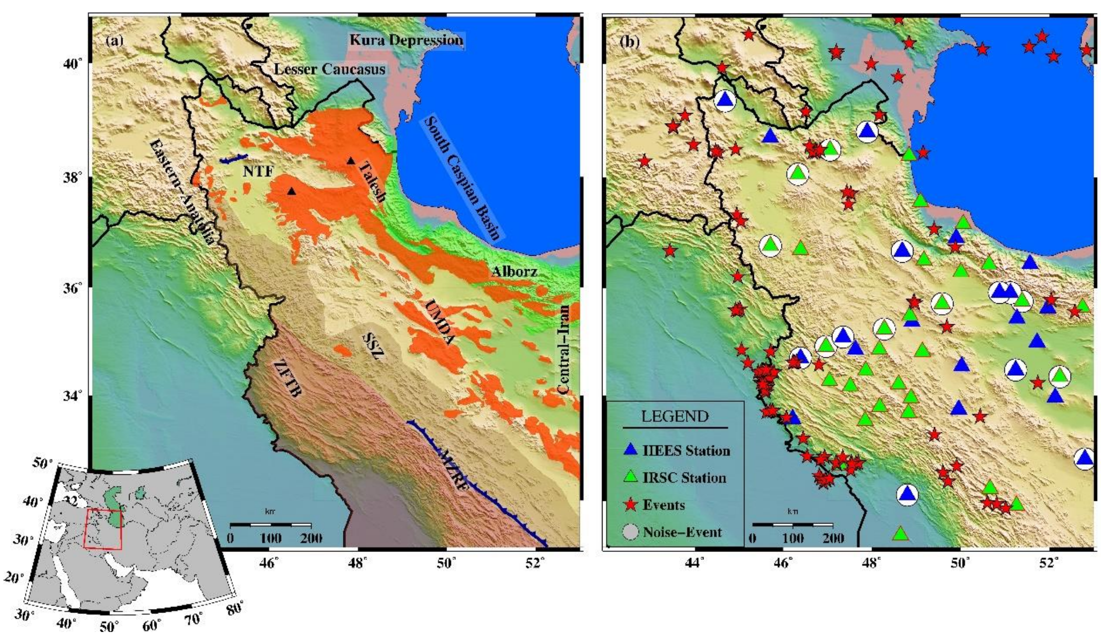
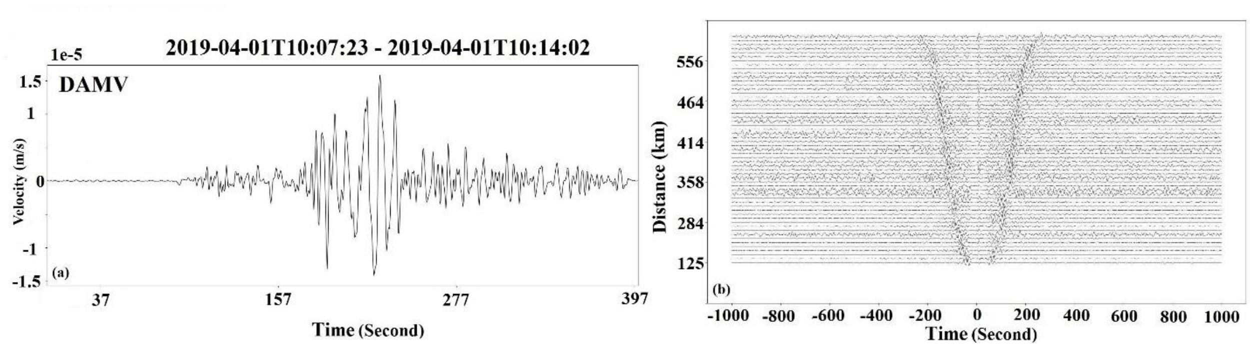


Figure 2: The vertical axis of Fig. 2A has no unit. Is it m/s? Please, indicate in the figure. Also, I would recommend showing the time after the origin time rather than the absolute time in the horizontal axis. “Example of the vertical component velocity seismograms used for dispersion measurements, filtered between 5 s and 120s” → “Example of the vertical component of a seismogram (in velocity) used for dispersion measurements, filtered between 5 s and 120 s.”

The figure updated and text replaced.



Line 135: If your minimum period is 5 s, why do you need two samples per second?

The maximum and minimum frequencies in this study are 0.2 and 0.008 Hz, respectively. Therefore, our sampling rate should be at least more than two times more than minimum selected frequency so value of 2 Hz for sampling rate meets this requirement.

Revised Text: To equalise the sampling frequency and reduce computational time and storage, the data were decimated to 2 Hz.

Line 136: Why did you choose the 5 – 120 s period band? Justify your choice of minimum and maximum periods.

For the lower limit, given the short distances between seismic stations in the region and the complex surface geology, we wished to measure group velocity at 10-seconds period; to ensure we did not measure too close to the filter’s edge, we filtered the data at periods above 5 seconds. For the upper limit of 120s, we considered both the inter-station distance (median distance 506 km) and the responses of the seismometers .

Lines 138-139: Rayleigh waves are observed on both the vertical and radial components of the seismogram. I believe you are using only the vertical components because the radial components were too noisy but, if that was the reason (or if there were other reasons to only use the vertical components), explicitly mention them in the text.

Yes, one reason is that radial component is noisier and the second one is related to a misorientation issue in the horizontal components, documented for Iranian stations by Movaghari et al. (2021).

Revised Text: We only collected vertical component seismograms (due to noisier signal and the misorientation issue in the horizontal components, documented for Iranian stations by Movaghari et al. 2021) with clear surface-waves at distances between 100 and 800~km from 103 M>4.5 earthquakes that occurred between 2012 and 2022.

Line 140: Why one-day segments? Why not more or less time? Justify your choices of parameters.

To ease of storage bulk data and prepare them for implementing whitening step based on Zigone et al. (2015).

Line 145: Why 30% and 10%? Also, explain why it is important to apply the spectral-domain whitening.

As mentioned in the paper, we followed Zigone et al. (2015) for processing the noise data. Based on their study, a 10% gap threshold ensure that sufficient noise data is present in the selected windows before the computation of the correlation function. It avoids to presence of correlation functions computed only on a few minutes of data in the final correlation stack.
Regarding the energy threshold, our choice of 30% was made by experimenting with a representative subset of our data: for larger values, some high amplitudes still remained in the signal and could perturb the correlations; for lower ones, windows without strong amplitudes started to be removed, reducing the overall amount of data available for correlation.

Spectral whitening is a very common noise processing method in noise correlations studies and applied to eliminate imbalances from the cross-correlation spectra (see Bensen et al., 2007 for more details). An isolated and persistent monochromatic noise source can easily disturb the cross-correlation functions. Ambient noise is not smooth in the frequency domain. This means that noise is not spectrally white but has peaks at long periods and at the periods corresponding to the first and second microseisms. In order to overcome these spectral irregularities, the spectrum of noise is whitened. To whiten the noise spectrum, the spectrum amplitude of noise is smoothed, and the original spectrum is multiplied by the inverse of this smoothed spectrum.

Line 145: “spectral domain whitening” → “spectral-domain whitening”

It is replaced.

Line 146: Why one-hour windows?

To increase speed of cross-correlation signal processing time.

Line 147: “stacked the correlation functions over the fullest available time” What do mean by “fullest available time”?

The fullest available time is referring to the entire time range of two signals that coincide in time.

Figure 3: “Diagram (a) was measured from an earthquake waveform recorded at station HSB station at an epicentral distance of 571 km and related to the earthquake on 2020-04-29, 17:01:34” → “a) Dispersion curve for a seismogram recorded at station HSB, 571 km from the epicenter of earthquake occurred on April 29, 2020.” If you believe it to be important to identify the exact date and time of each earthquake, then add a table with all origin times and locations on your supplementary material and assign an index to each event (e.g., #1, #2,…, #103). “The colour scale indicates relative energy” → “The color/colour (regardless of whether you prefer using American English or the British English, make sure your entire text follows it as well) scale represents normalized energy.

The text replaced with British version.

The new table includes earthquakes information is added to supplementary.

Table S3. Information of used events in NW study.

Number	start time	latitude	longitude
1	2012-04-18_18-43-02	32.7	47.21
2	2012-04-20_01-21-10	32.73	47.19
3	2012-04-20_03-05-41	32.48	46.81
4	2012-04-20_15-37-02	32.42	46.85
5	2012-04-20_16-17-50	32.34	46.9
6	2012-04-21_02-39-15	32.39	46.97
7	2012-04-21_05-25-09	32.4	46.95
8	2012-04-21_06-13-28	32.42	47.04
9	2012-08-11_15-43-20	38.48	46.72
10	2012-08-11_22-24-02	38.46	46.72
11	2012-08-14_14-02-25	38.46	46.76
12	2012-08-15_17-49-05	38.45	46.66
13	2012-11-16_03-58-25	38.56	46.59
14	2012-11-27_06-22-26	33.26	49.41
15	2012-12-23_06-38-57	38.5	44.92
16	2013-01-12_03-25-05	31.85	51.02
17	2013-01-26_15-10-49	38.49	46.83
18	2013-03-11_14-57-07	36.674	43.439
19	2013-04-24_03-08-25	33.6	50.44
20	2013-09-16_16-05-02	32.537	49.605
21	2013-09-27_10-02-46	37.33	44.944
22	2013-10-16_08-49-32	35.283	49.692
23	2013-11-05_04-03-39	34.851	45.055
24	2013-11-22_06-51-25	34.44	45.43
25	2013-11-22_18-30-58	34.289	45.555
26	2013-11-23_23-26-20	34.24	45.49
27	2014-01-14_13-54-57	40.238	52.848
28	2014-02-10_12-06-41	40.36	48.84
29	2014-02-20_04-18-36	32.661	49.913

30	2014-06-07_06-05-26	40.3	51.55
31	2014-08-18_02-32-06	32.711	47.638
32	2014-08-18_05-25-51	32.718	47.692
33	2014-08-18_11-01-37	32.733	47.532
34	2014-08-18_18-08-23	32.58	47.52
35	2014-08-18_21-44-29	32.706	47.547
36	2015-01-14_09-48-05	32.837	46.928
37	2015-01-21_13-58-04	38.287	42.866
38	2015-02-15_08-04-40	32.785	46.84
39	2015-03-02_06-08-41	35.752	48.942
40	2015-03-12_00-42-35	38.437	49.157
41	2015-03-22_22-45-23	40.129	52.099
42	2015-05-10_22-08-58	36.744	49.881
43	2015-08-25_17-36-34	35.563	52.579
44	2015-09-04_04-49-38	40.983	47.424
45	2015-09-25_06-10-24	32.849	46.532
46	2015-10-29_09-46-40	39.097	43.776
47	2016-01-12_02-38-37	39.108	48.163
48	2016-03-31_07-15-17	31.932	50.815
49	2016-08-01_04-46-34	40.003	47.981
50	2016-12-13_00-32-59	40.781	48.605
51	2017-02-06_13-46-35	40.253	50.497
52	2017-05-11_03-24-18	39.776	48.592
53	2017-11-15_19-48-02	40.176	47.194
54	2017-11-17_13-27-37	40.218	47.193
55	2018-01-06_15-22-08	34.459	45.736
56	2018-01-10_15-56-26	34.576	46.802
57	2018-01-19_22-17-56	33.709	45.699
58	2018-02-19_19-20-44	36.204	44.969
59	2018-04-01_08-35-26	34.434	45.786
60	2018-06-26_17-57-04	34.624	46.246
61	2018-07-22_10-07-25	34.625	46.293
62	2018-08-25_22-13-25	34.62	46.212
63	2018-09-01_05-31-10	34.344	45.545
64	2018-10-02_02-42-50	31.956	50.604
65	2018-10-17_03-16-55	34.462	45.51
66	2018-11-25_17-09-37	34.301	45.644
67	2018-11-25_23-00-46	34.138	45.601
68	2018-11-26_01-19-42	34.32	45.697
69	2019-01-06_14-15-08	34.062	45.602
70	2019-01-14_18-17-59	34.098	45.583
71	2019-03-12_12-06-06	34.22	45.58
72	2019-03-21_15-43-04	40.47	51.84
73	2019-04-01_10-07-23	33.69	45.62
74	2019-04-17_20-02-49	33.188	46.445
75	2019-05-11_10-28-59	34.82	45.71
76	2019-06-05_03-36-16	34.48	45.61

77	2019-11-07_22-47-05	37.712	47.521
78	2019-11-08_13-51-45	37.74	47.43
79	2019-11-10_02-13-47	37.52	47.47
80	2020-01-28_20-37-18	33.712	45.757
81	2020-01-29_18-07-29	37.21	45.04
82	2020-02-12_10-53-46	37.07	49.404
83	2020-02-23_05-53-00	38.44	44.53
84	2020-02-23_16-00-33	38.44	44.53
85	2020-03-13_07-02-05	32.83	47.34
86	2020-04-03_05-44-23	38.89	43.52
87	2020-04-12_02-23-13	38.464	44.468
88	2020-04-29_17-01-34	35.583	44.973
89	2020-05-07_20-18-21	35.776	52.046
90	2020-06-03_08-16-54	33.58	46.07
91	2020-06-25_10-03-28	38.58	43.97
92	2020-08-09_09-16-19	34.21	45.53
93	2020-10-24_11-34-17	35.72	48.97
94	2020-11-09_23-18-25	35.61	45.02
95	2020-12-14_21-58-45	38.908	43.504
96	2021-02-05_15-36-10	40.509	45.216
97	2021-02-11_22-10-34	34.61	45.2
98	2021-02-13_11-29-24	39.931	44.613
99	2021-12-14_21-23-03	32.37	49.714
100	2021-12-15_08-21-10	32.368	49.718
101	2022-01-10_18-29-48	35.586	44.921
102	2022-01-16_03-25-07	39.164	46.501
103	2022-01-20_01-37-17	34.235	51.743

Line 158: “noise ratios were smaller than 5” → “noise ratios were lower than 5”

It is replaced.

Line 155: “earthquake seismograms” → seismograms / “We measured dispersion curves on the earthquake seismograms and the noise correlation functions in the same way.” → “We measured dispersion curves from seismograms and noise correlation functions in the same way.”

They are replaced.

Line 176: “2D Gaussian distribution” → “2D-Gaussian distribution”

It is replaced.

Line 177: “group velocity estimates” → “group-velocity estimates”

It is replaced.

Line 180: “uncertainties greater than 0.35 km/s” → “uncertainties larger than 0.35 km/s” Why 0.35 km/s? Explain.

We removed all ray paths with data uncertainties greater than approximately 10% of the maximum observed velocity.

Revised text: We rejected group-velocity measurements with uncertainties larger than 0.35 km/s (approximately 10% of maximum observed velocity that is related to 50s data according (Fig. 6)

Line 187: “we refer the reader to the publications cited above” → “we refer the reader to these publications”

It is replaced.

Lines 187 – 190: “However, as one of the aims of study is to compare the two methods on an identical dataset and investigate the advantages and disadvantages of each, we provide below an overview of how each of the two methods approaches the forward and inverse parts of the tomographic problem.”→ “However, since one of the main objectives of this study is to compare the two methods using an identical dataset and explore the respective advantages and disadvantages, we present below an overview of how each method addresses the forward and inverse aspects of the tomographic problem.”

It is replaced.

Line 187: The tomographic forward problem → The forward problem

It is replaced.

Lines 195-196: “However, the paths travelled by seismic waves depend in a non-linear manner on the spatial distribution of seismic velocities. If the spatial variations of seismic velocities are weak, then the path taken by the seismic wave differs little from the path that has the shortest distance between source and receiver, the great-circle path; if the spatial variations of seismic velocities are strong, then the path taken by the seismic wave may differ greatly from the great-circle path.” → “However, the seismic-wave paths have a non-linear relationship with the spatial distribution of seismic velocities. If the velocity anomalies are small, the ray path can be approximated by the great circle connecting the source and receiver. Otherwise, the deviations from the great-circle path may be important and cannot be neglected.”

It is replaced.

Lines 200-203: “The problem arises because we do not know the true path in advance as we do not yet know the spatial distribution of slowness. In practice, therefore, tomographers have to make a hypothesis about the path and the slowness distribution, then use an inverse method to update their hypothesis based on evidence from measurements (in our case group-velocity measurements).” The ray path depends on the slowness distribution, source, and receiver locations. Hence, not knowing the slowness field already implies that you don’t know the ray path. I would rewrite this paragraph as → “Since the slowness distribution is not known a priory, tomographers assume a starting slowness model, then use an inverse method to update their model based on differences (residuals) between the measurements (in our case group-velocity measurements) and the predicted values.”

It is replaced.

Lines 203-204: “In the SOLA Backus-Gilbert tomographic inversion, only the slowness distribution is updated” → “In the SOLA Backus-Gilbert tomographic inversion, only the slowness distribution is updated while the ray path is fixed”

It is replaced.

Line 210: “The tomographic inverse problem is the problem of updating the tomographer’s initial hypothesis about the slowness distribution using the evidence from measurements.” → “The inverse problem in seismic tomography consists in updating a starting slowness model **m** to minimise the residuals between the measurements and the corresponding predicted values.” / “matrix multiplication” → “matrix equation”

It is replaced.

Line 215: “interprets **m** as containing perturbations to an initial hypothesis on the slowness distribution and **d** as containing the differences between the actual measurements and the measurements that would have been made if the initial hypothesis on the slowness distribution were true.” → “interprets **m** as corrections to the starting model and **d** as the residuals”

It is replaced.

Line 216: “This has led to the development of scores of different inverse methods, each with its advantages, disadvantages, and trade-offs” → “This led to the development of various inverse methods, each with its own advantages, disadvantages, and trade-offs”

It is replaced.

Line 227: “The measurements force us to modify our prior beliefs about the slowness distribution” → “The measurements force the model update”

It is replaced.

Line 226: “the prior beliefs are not modified” → “the model is not modified”

It is replaced.

Lines 229-230: “that includes the fit to the data, a damping factor that discourages changes in the initial beliefs about the slowness distribution, and a smoothing factor that constrains the smoothness of the estimated slowness distribution.” → “that includes the residuals, a damping factor that discourages changes in the starting model, and a smoothing factor that constrains the model smoothness”

It is replaced.

Line 233: “fit” → “fits”

It is replaced.

Line 239: “highly efficient method” → “highly-efficient method”

It is replaced.

Line 248: Do not include this link here. Add it to the “Data and code availability” section.

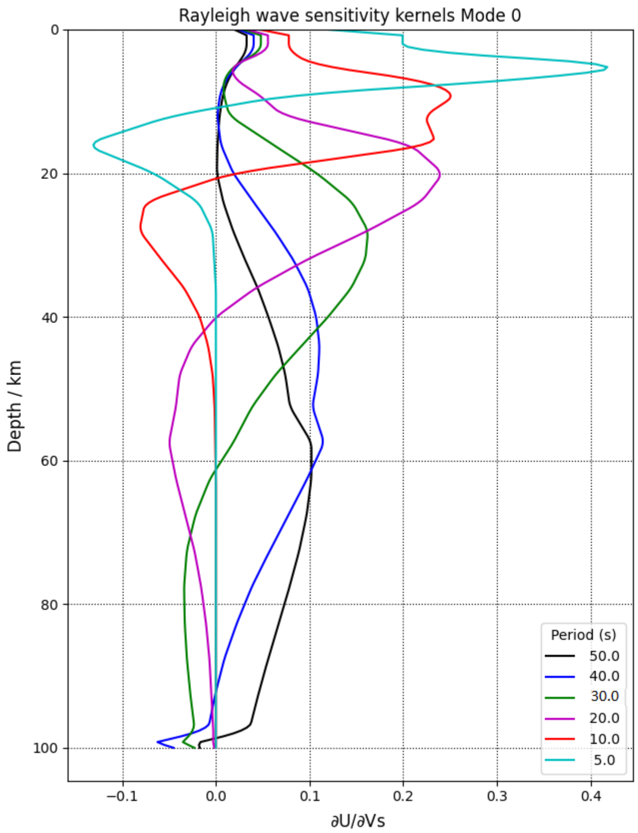
Link is moved to Data and Code availability section.

Line 250: “Fast Marching tomographic method” → “Fast-marching tomography” or “Fast-marching method” (if just say “Fast-marching method”, it is implicit that you are talking about your tomography, but you can also say “Fast-marching tomography”. However, “Fast-marching tomographic method” sounds awkward and redundant)

It is replaced.

Line 270: Since you have a subsection for each surface-wave period, I think it would be nice to start section 5 with a plot of the sensitivity kernels for Rayleigh waves (Sensitivity vs Depth) for the periods you used in your study. Something similar to Fig. 5 in the following paper, but for your periods only: “https://www.researchgate.net/publication/327539991”. Such a figure would make it easier for the reader to identify the depths of maximum sensitivity for each period.

The figure added.



Revised Text:

Figure 10. Sensitivity kernels of Rayleigh wave group velocity at different periods.

Line 269: Figure 10 shows Rayleigh-wave sensitivity kernel at various periods.

Line 274. At periods of 10 s, fundamental-mode Rayleigh-wave group velocities are expected to be primarily sensitive to the upper crust (Figure 10).

Line 300. At periods of 20 seconds, fundamental mode Rayleigh-wave group velocities are primarily sensitive to the average shear-wave velocity of the crust at depths up to 20-25 km for this study (Figure 10).

Line 309. At periods of 30 seconds, fundamental mode Rayleigh-wave group velocities are expected to be primarily sensitive to the shear-wave velocity of the lower crust and uppermost mantle (Figure 10).

Line 323. At periods of 50 seconds, fundamental mode Rayleigh-wave group velocities are expected to be primarily sensitive to the shear-wave velocity uppermost mantle (Figure 10).

Line 274: “fundamental mode Rayleigh wave group velocities” → “fundamental-mode Rayleigh-wave group velocities”

It is replaced.

Line 281: “have been seen” → “were observed”

It is replaced.

Line 292: “have been attributed” → “were attributed”

It is replaced.

Line 301: “shear wave velocity” → “shear-wave velocity”

It is replaced.

Line 318-319: “have seen” → “observed”

It is replaced.

Line 432-433: “to be strong predictor” → “to be a strong predictor”

It is replaced.

Line 462: “strong seismic velocity contrasts” → “strong seismic-velocity contrasts”

It is replaced.

Line 479: The link “http://rses.anu.edu.au/ nick/surftomo.html” isn’t working

Link is corrected in the text.

Reviewer B:

This study is a practical comparison of two "advanced" surface wave tomographic methods (Rawlinson et al.'s implementation of eikonal equation nonlinear tomography and SOLA Backus-Gilbert tomography) using northwestern Iran as a study zone. The authors find that SOLA performs well in most typical use cases (where we think the perturbations are small and ray coverage is poor to reasonable), whereas the eikonal equation-based approach is useful in contexts with very strong anomalies but only if ray coverage is good (and is generally less interpretable). The manuscript is a nice illustration of these properties and should be of interest to practitioners who are deciding on workflows for future tomographic experiments - there is not a great deal of detailed analysis or interpretation of any novel physical structures in the paper. I have one general philosophical issue which may be worth discussion in the paper; SOLA performs well in weak-perturbation contexts (due to the lack of raypath updating), which we have been conditioned to generally expect due to existing tomographic studies. However, as the vast majority of those studies have been produced by tomographic methods that tend to bias the amplitude of perturbations in ways that smooth and weaken local effects, we can't really say with confidence that SOLA is therefore a more appropriate general method for regional or global scale tomography. This is an issue endemic to all seismic tomography, but I think worth perhaps mentioning within the discussion. I also have some issues with the workflow in generating group velocity data (in particular estimating the errors) that may change the quantitative results but I doubt will have much of an effect on the qualitative conclusions reached. Overall, I think this is an interesting paper that is appropriate for publication after revision.

We are very grateful for your review and constructive comments. We have edited and revised the manuscript following your comments. Please see below for a replies to each point.

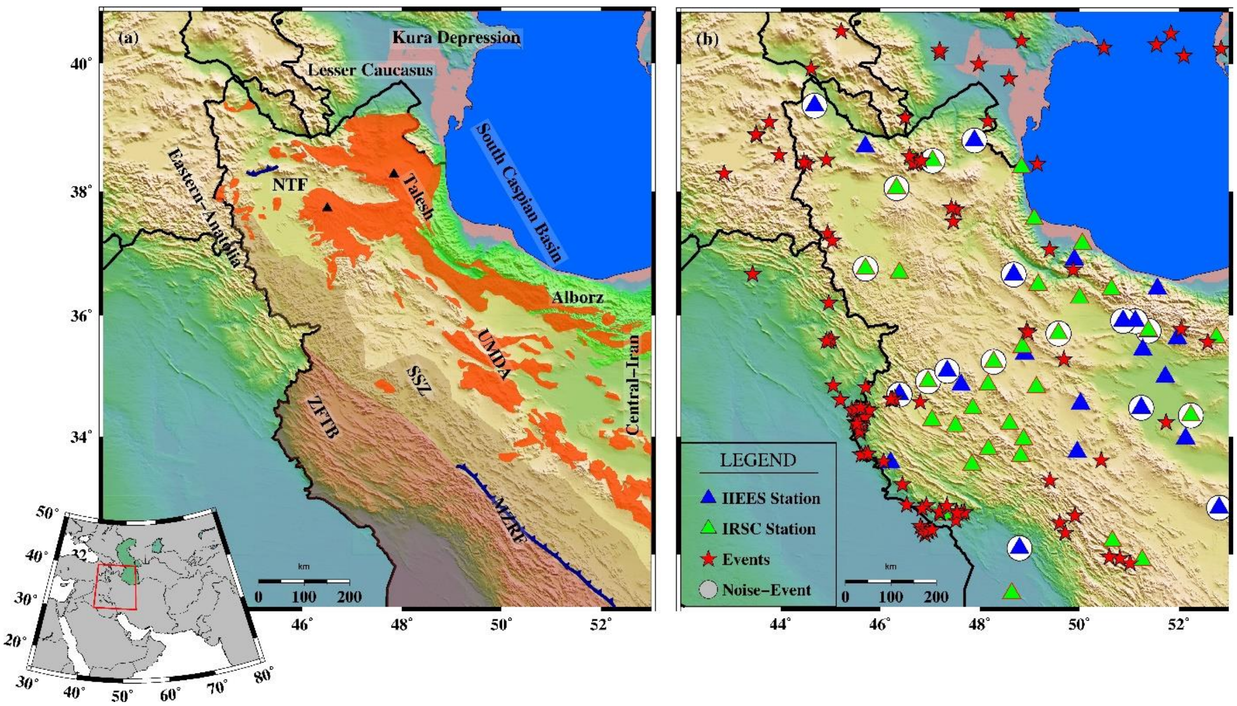
Comments:

Line 83 - it is important to also mention the trade-off between resolution and variance here, lest readers think that SOLA achieves impossible results.

Revised text: The SOLA method not only produces full-resolution and uncertainty information for tomographic models, it also constrains the models to be unbiased, and allows users direct control on the trade-off between resolution and uncertainty. In this study, we apply the SOLA tomographic inversion of Zaroli (2016) to Northwest Iran, using a dataset of Rayleigh-wave dispersion measurements obtained both from earthquakes and from seismic noise cross-correlations, to build a range of models of Rayleigh-wave velocities.

Figure 1 - please increase the visibility of the two fault traces; on first glance I thought that they hadn't rendered for some reason! As a minor aesthetic point, the two map panels are not aligned with each other.

The maps are updated with different color of stations, faults are magnified and two maps are aligned.



Line 113 - reverence to de Voogd should be parenthetical.

Done.

Line 128 - please be consistent throught the paper in they hyphenization of broadband & midband

All of them are revised.

Line 139 - why are only some of the broadband used? It would be useful to add a quick justification here.

At first, we used all broadband stations in NW Iran, but some were eliminated after cross-correlation and calculating SNR. We only had access to continuous data from 2013 to 2015 and some of broadband stations in the IRSC and IIEES networks were deployed after 2015 or at the end of 2014 and did not produce enough continuous data for our study. Moreover, some of stations recorded part of the time as short-period stations and part of the time as broadband stations (instrument updates over the network) which meant we had insufficient coincident recording between two stations to cross-correlate and produce stable surface waves.

Line 144 - why are "impulsive" signals over a 4hr period removed when the data is ultimately cut into 1hr windows? If the increased energy was impuslive it would presumably be mostly over within 1hr (or is this to remove long wavetrains from strong teleseismic events? In general, perhaps a quick word as to why this procedure is used rather than the more standard time-domain normalization with moving averages).

The reason of removing signals over a 4hr period is twofold: firstly, we often saw events that started in one hour segment and continued to the next; secondly, we also saw many aftershocks in the first few hours after larger impulsive earthquakes. Therefore, we decided to use remove a full 4hr period if an impulsive arrival was recorded. Then, we cut the remaining continuous windows to one-hour to decrease calculation time for the correlations themselves as we did not have access to high performance computing assets.

The reason why an energy-based method is used in a wide frequency range is that the ambient noises are parameterized based on the fact that the sources or energy distribution are completely uniform around the pair of stations and the smallest imbalance in the energy distribution causes the obtained results to deviate from the real results while in normalisation with moving averages energy distribution around pairs is neglected. The moving average technique can unintentionally emphasize certain frequencies while suppressing others due to the smoothing process. This could lead to an imbalance in the representation of energy from different frequency ranges, making the resulting tomography less accurate and representative of the subsurface. Also, the choice of the moving average window size is critical. A larger window provides more smoothing, but it can also result in the removal of important short-term variations. Conversely, a smaller window retains more detail but might also preserve more noise. Finding the right balance can be challenging, and the optimal window size might vary depending on the characteristics of the data.

Line 158 - how was the SNR measured for this study?

We measured SNR in the same way as Benson et al. (2007): “the ratio of the peak amplitude within the window of the surface wave signals at a given period to the RMS of the trailing noise for each narrow band-pass filtered waveform”.

Line 173 - is the 90% interval equal to the uncertainty, or is half of the 90% interval the uncertainty; also, why is 90% used rather than the standard deviation of the fitted Gaussian? Overall, I would assume that the standard error in the mean of the fitted Gaussian would be the most meaningful uncertainty in "picking the peak"?

The uncertainty is half of the interval at 90% amplitude. The final data uncertainties for each ray are calculated by sum of energy uncertainties and location uncertainties. If we considered energy related to 1σ that contain 68% of Gaussian plot, as suggested by the reviewer, the values of the energy uncertainties increase dramatically and, after summing with location uncertainties, led to grossly overestimated data uncertainties for each ray path. Furthermore, the use of a Gaussian and its 1σ width to indicate uncertainty would be valid if the Gaussian represented a probability distribution over a statistical variable; here, the Gaussian-type shape is given by physics, not statistics, as it is given by the envelope of a narrow-band filtered seismogram. The time of the maximum of the envelope indicates the time of maximum energy arrival, not the most likely time of a statistical process. There is uncertainty in picking this time (greater when the envelope is flatter, lesser when the envelope is sharper), but it is not related to the overall width of the best-fit Gaussian. The 90% amplitude we chose is indeed somewhat arbitrary but conforms to how analysts routinely pick dispersion curves. To go further (beyond the scope of this paper) we would suggest (a) varying all the filter parameters within reasonable ranges and (b) asking many observers to manually pick each resulting dispersion curve to estimate the true variability (and hence uncertainty) of the resulting measurements.

Line 169 - based on the text, it seems that the location errors & group energy picking errors should be considered to be correlated, as the estimate of the best group velocity depends on the assumed distance between the event and the station; this would tend to increase the overall error in earthquake group velocity picks. Additionally, location uncertainty in the earthquakes is certainly correlated for each of the stations, resulting in a non-diagonal error covariance.

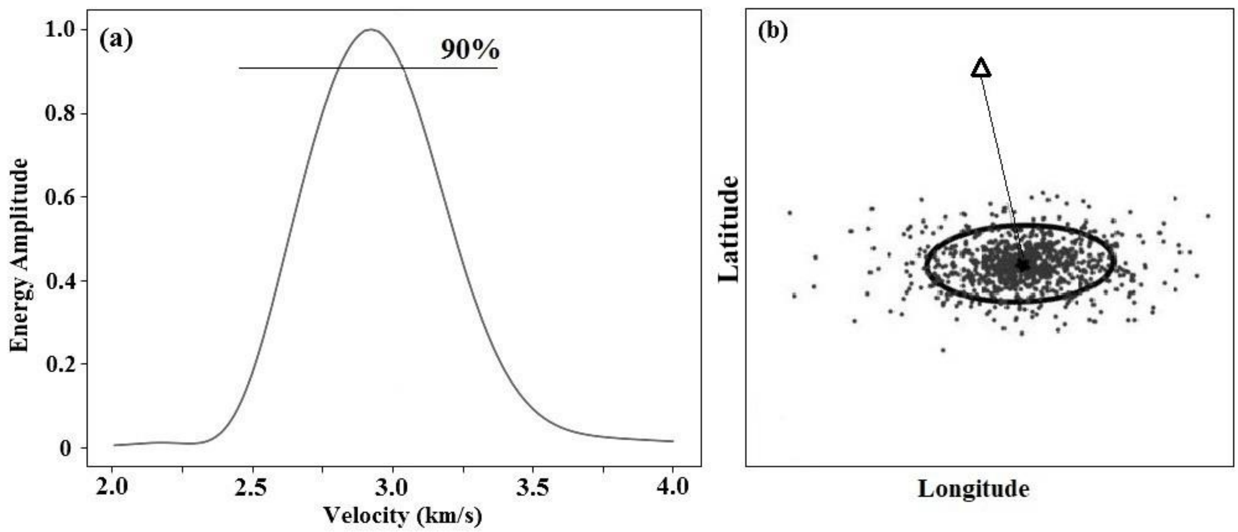
We distinguish two uncertainties: the intrinsic uncertainty involved in measuring a dispersion curve from a seismogram if the epicentral distance is assumed correct (see response to previous question) and the uncertainty in the dispersion curve caused by the uncertainty in the epicentral location. The intrinsic (measurement) uncertainty is not correlated with the epicentral location uncertainty but the two must be combined. For surface-waves obtained by noise-correlation, the epicentral location uncertainty is zero (the stations are at known locations) but the measurement uncertainty remains finite.

Regarding the location uncertainty in the earthquakes being correlated for each of the stations, the reviewer is completely correct, and the true data-covariance matrix should not be diagonal. We agree with the reviewer that the full data-covariance matrix should be used in SOLA, however its current available seismology implementation (Zaroli, 2017) only considers diagonal data-covariance matrices for computational efficiency. We will work with Zaroli to update the SOLA code to be able to take full data-covariance matrices without too much loss of computational performance, but this is outside the scope of this study. We have added to the paper a sentence indicating the probable non-diagonal nature of the true data-covariance matrix.

Line 176 - the text here suggests changes to Figure 4b). As the Gaussian is defined by lat / lon errors, it presumably must be oriented NS or EW for its major axis, so Figure 4b) should be drawn similarly to avoid disengenously implying that covariance in the spatial error is accounted for. The legend in Figure 4b) is also confusing (maybe it was supposed to be for 4a)?). Finally, one can integrate the distances to the station weighted by the PDF of the Gaussian numerically, rather than use Monte Carlo integration as is performed here, which for the smooth integral should converge quickly - why use Monte Carlo integration with its associated error in this case (the number of samples used & hence the associated Monte Carlo error should also be mentioned).

The reviewer is correct in supposing that IRSC and IEES publish uncertainties in the earthquake locations as latitude and longitude uncertainties. We agree that the shape of the ellipse in the original version of Fig. 4b could be misleading and have modified it in the revised version. We used 1000 samples for our Monte Carlo integrations; using more samples did not produce more accurate results but only increased computational time. The uncertainty in the final group velocity caused by the Monte Carlo technique was negligible compared to the location uncertainty of the earthquakes; this is why we did not mention it. We have amended the manuscript to indicate the number of Monte Carlo samples. We chose this technique, instead of the weighted distances suggested by the reviewer, simply for ease of programming.

The figure is updated.



Line 185 - why is the quoted value of 0.35 km/s chosen?

We removed all ray path with data uncertainties more than approximately 10% of maximum observed velocity that is related to 50s data according figure 6. If we rejected all ray paths with data uncertainties more than 5%, we missed several ray paths from our dataset.

Revised text: We rejected group-velocity measurements with uncertainties larger than 0.35 km/s (approximately 10% of maximum observed velocity that is related to 50s data according (Fig. 6)

Line 250 - does it matter at all that the cells are not of constant volume if they are parameterized in lat/lon?

The reviewer is correct in saying that the cells are of different areas. Indeed, in SOLA, we calculate the volume of each cell (area for a 2D inversion such as those performed here) and denote it Vj. These "volumes" are used in the tomographic inversion. We added a mention of this fact in the text.

Figure 10 - this figure is blurry for some reason. Similar figures are also similarly blurry.

They are replaced by high quality versions.

Line 351 - I would appreciate greater discussion about this anomaly discovery workflow; in particular, the workflow sort of implicitly accounts for the importance of the posterior covariance of the model by saying that areas have to both exceed a certain anomaly threshold and also be geographically contiguous; but because of covariance you sort of expect that anomalies are clumped - is there a way to account for this?

Non-diagonal resolution matrices are indeed likely to produce larger, if possibly lower-amplitude, anomalies; it is less clear to us that the same should be true for non-diagonal covariance matrices.

We do not agree that anomalies, normalized by their local variances, will inevitably be “clumped” if the posterior covariances are non-diagonal, as shown by the smaller anomalies in Fig. 15. However, we agree with the underlying idea of the reviewer, that more thought and further study should be put into fully understanding the implications of both resolution and posterior covariance matrices in seismic tomography.

Line 447 - how are you defining "outperform" here?

We define “outperform” as “producing a more-interpretable seismic image”. This means, fewer artefacts (smearing) and/or better resolution of velocity contrasts.

Line 480 - I strongly encourage the authors to provide the full set of scripts used to generate the paper (within the limits of software licensing) for reproducibility and to allow readers to better understand the specifics of the workflow.

The scripts (not the SOLA code) are provided in the zenodo archive mentioned in the data and code availability section, although we forgot to mention this fact in the submitted paper. This has now been corrected.