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Discussions



# *Interactive comment on* "Lithospheric and sub-lithospheric deformation under the Borborema Province of NE Brazil from receiver function harmonic stripping" *by* Gaelle Lamarque and Jordi Julià

**Anonymous Referee #1**

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Review of Lamarque and Julia, Solid Earth Discussions, 2019

This paper calculates teleseismic P-wave receiver functions to investigate the depth dependence of seismic anisotropy in the crust and lithospheric mantle in NE Brazil. The analysis considers the back-azimuth variations in observed receiver function signal and performs a harmonic decomposition to provide a quantitative estimate of anisotropy in terms of: 1) a plunging axis of symmetry and/or dipping interface; or 2) a horizontal axis of symmetry. The depth decomposition of the anisotropy is able to retrieve the average anisotropy in the crust and lithospheric mantle. The results show consistent anisotropy in the crust and mantle, indicating a control by lithospheric-scale shear zones that develop during the Brasiliano-Pan African orogeny. The lack of well characterized anisotropy at some stations is taken as an indication of re-heating of the lithosphere by an asthenospheric channel. Stations along the Atlantic coast resolve fast anisotropic directions perpendicular to the margin, suggesting lithospheric inheritance during rifting.

General comments:

The paper compiles all available receiver function (RF) data and calculates new RF data for 11 recently installed stations. The RF analysis is adequately described and follows the standard procedures to obtain high-quality data. The novelty of this paper lies in the application of the harmonic decomposition to reveal depth-dependent anisotropy from back-azimuthal variations in the amplitude of both radial and tangential components of RF data, for individual stations. The results are discussed in an appropriate way, although part of the methodology lacks reference to original work that implemented variants of the technique (see specific comments). The condition for rejecting anisotropy (and therefore interpreting the subsurface structure as isotropic) could also be subject to debate. Overall the paper addresses an important question about the structure of fabrics beneath NE Brazil in relation with lithospheric inheritance and the significance of lithospheric-scale shear zones.

Specific comments:

The discussion of RF analysis is appropriate and includes proper referencing up to line 19 on page 7. There the authors describe an additional preliminary step in the harmonic decomposition analysis, where they migrate the time signals to depth using a 1D seismic velocity model to correct for the move-out of teleseismic waves. The migration to depth (before harmonic decomposition) was first proposed by Bianchi et al. (2010), who performed common-conversion (CCP) stacking using a dense line of stations and carried out the decomposition at CCP points. This method was further





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applied in Piana Agostinetti et al. (2011) and Piana Agostinetti and Miller (2015). The step proposed here by the authors (converting time to depth at individual stations, as opposed to CCP stacking), was proposed by Audet (2015) and further applied in Cossette et al. (2016) and Tarayoun et al. (2017). The optimization of energy on one of the k=1 components (as done here) was also proposed by Audet (2015) to retrieve the dominant angle of anisotropy.

On page 10, the authors discuss the reliability of the anisotropic directions using a bootstrap analysis and consider that a measurement is unreliable if the bootstrap uncertainty is greater than 20 degrees. The bootstrap analysis returns an estimate of the standard error on the mean value on modeled parameters (such as the dominant angle of anisotropy), and confidence intervals are normally calculated from the standard error. Is this what is meant by “uncertainty” here? Is it 1-sigma (68% confidence) or 2-sigma (95%)? Furthermore, large variability in the recovered angle might not necessarily imply that the medium is isotropic. Strong structural heterogeneity might produce large-amplitude signal with apparent back-azimuth distribution with k>2. Alternatively, crystal symmetries might not always produce seismic anisotropy that can be modeled with the k=1 or k=2 components. So, it is still of interest to show the strength of the signal on the k=1 and k=2 energy components despite the large variability in bootstrap angles.

Following up from this comment, Figure 6 could be improved by plotting the relative amplitude of the corresponding energy components. On the maps, the anisotropy (length of bars) appears to be equal in magnitude at all stations, though I suspect that the energy components vary significantly from one station to another and regionally. This additional piece of information could also be included in the Discussion and compared with SKS splitting results.

Finally, it would be insightful to look at the receiver functions before application of the harmonic decomposition (e.g., in back-azimuth panels) to see why the “unreliable” stations have large uncertainty in anisotropic direction. This could be added to the Supplementary Information.

Technical corrections:

Page 8, line 3: “presents” -> present

Page 10, lines 6 and 10: the interval “[0,2]” ->. Do you mean [0, 2pi]?

Page 11, line 2: “Realize that” -> We note that

Page 12, line 3: “mantellic” -> mantle

Caption of Figure 6. It’s not clear to me why the direction perpendicular to the fast axis is required in the case of horizontal anisotropy. Is it to differentiate between k=1 and k=2 directions? Which one of the two is the fast axis?

Page 14, line 14: “Bastow et al. (2011); Assumpçao et al. (2011)” -> Bastow et al. (2011) and Assumpçao et al. (2011)

Page 14, line 22: “sensible” -> sensitive

References (not appearing in paper):

Cossette et al.: Structure and anisotropy of the crust in the Cyclades, Greece, using receiver functions constrained by in situ rock textural data, J. Geophys. Res., 121, 2661-2678 (2016).

Piana Agostinetti et al.: Fluid migration in continental subduction: The Northern Apennines case study, Earth Planet. Sci. Lett., 302-267-278 (2011).

Piana Agostinetti and Miller: The fate of the downgoing oceanic plate: Insight from the Northern Cascadia subduction zone, Earth Planet. Sci. Lett., 408, 237-251 (2015).

Tarayoun et al.: Architecture of the crust and uppermost mantle in the northern Canadian Cordillera from receiver functions, J. Geophys. Res., 122, 5268-5287 (2017).

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