Seismic Anisotropy in Mid-Plate South America: an Updated Model Using Shear Wave Splitting Measurements and Waveform Tomography

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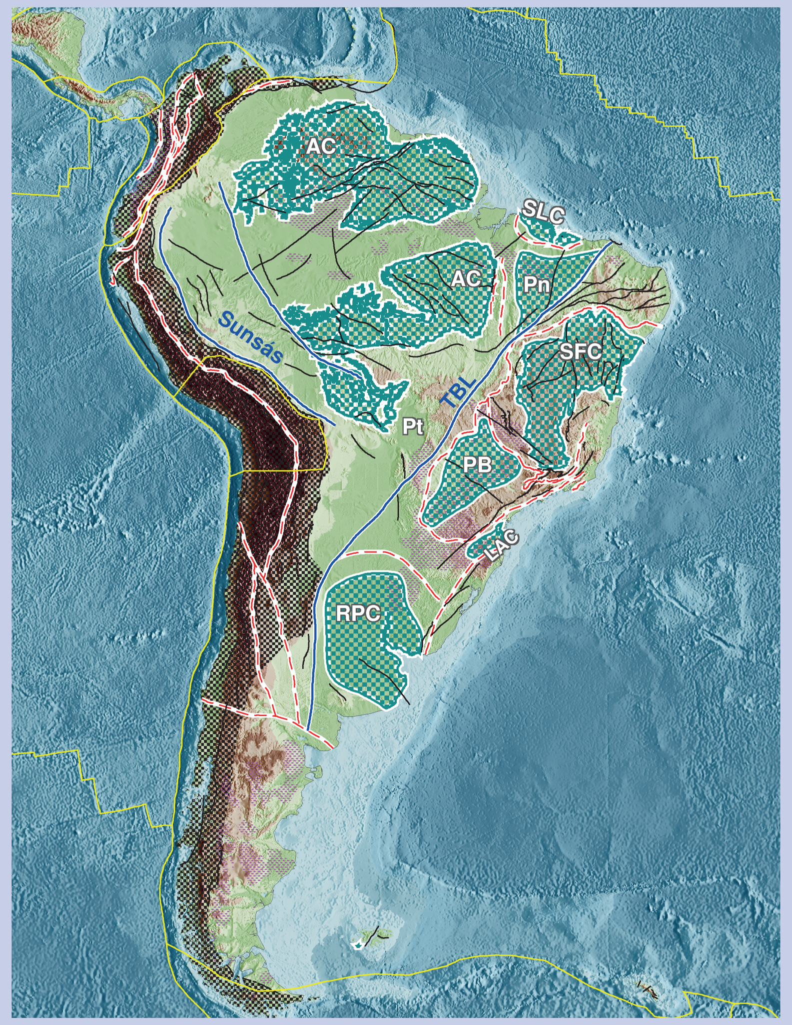
1. TECTONIC SETTINGS

South America is mainly composed of the Andean belt and the stable platform. In the platform, the basement is formed by Archean and Proterozoic cratonic blocks, amalgamated by mobile belts and overlain by sedimentary and intracratonic basins.



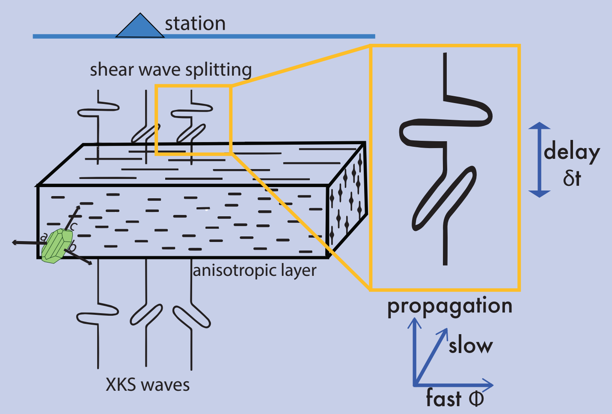
LABELS

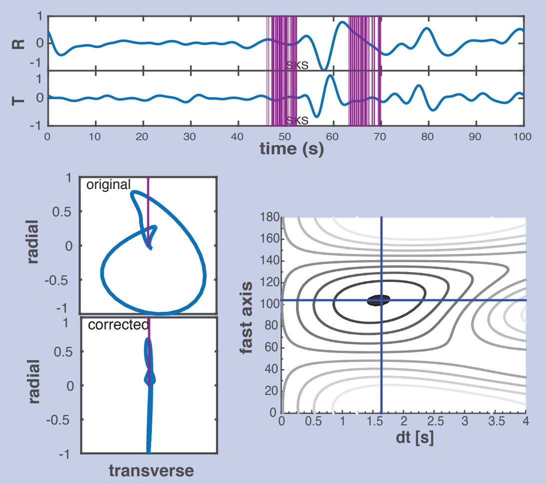
- Andean Belt
- Large Igneous Provinces (LIP)
- Cratonic Blocks (interpreted)
  - AC: Amazon Craton
  - LAC: Luis Alves Craton
  - PB: Paranapanema Block
  - Pn: Parnaíba Block
  - RPC: Rio de La Plata Craton
  - SFC: São Francisco Craton
  - SLC: São Luis Craton
- Lineaments
  - TBL: Transbrasiliano
- Suture Zones within Mobile Belts
- Faults and Magnetic Lineaments

2. METHODOLOGY

When a SKS wave travels through an anisotropic medium, it is split into two orthogonal components with different velocities;

- Φ is the orientation of the a-axis of olivine;
- δt depends on the thickness of the anisotropic layer and/or the strength of anisotropy.

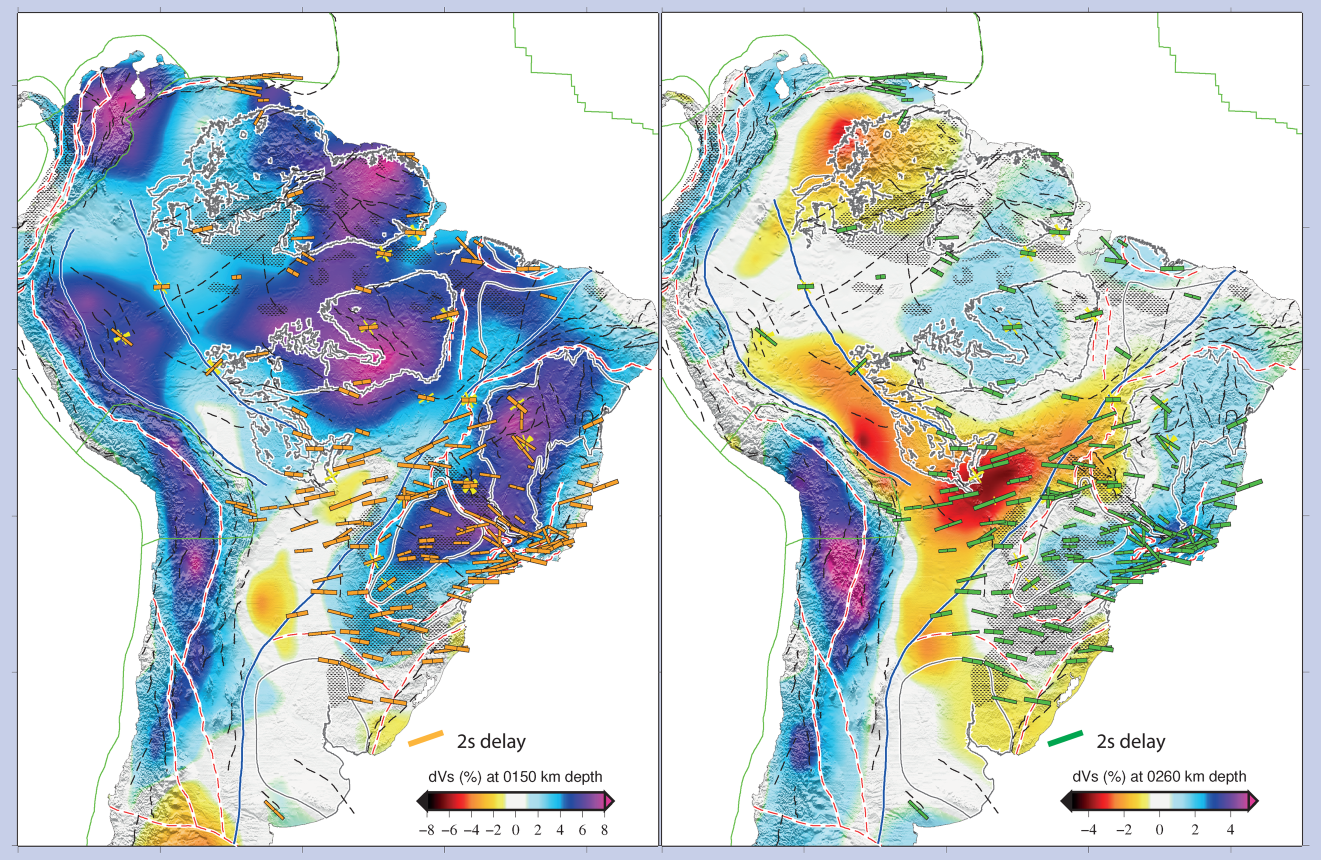




We obtain the anisotropy parameters based on the transverse-component energy minimization method of Silver and Chan (1991). To apply this method, we must know the initial polarization of the wave; for core phases it corresponds to the station back-azimuth. Then it calculates the parameters that best remove the energy of transverse component.

4. RESULTS

4.1 Comparison with the isotropic surface wave tomography model SA2018 [4]



- In general, high velocity anomalies correspond to thicker lithosphere and vice-versa;
- In southeastern Brazil, the anisotropy directions might have mainly asthenospheric source, and are deviated by the cratonic keels of the SFC and PB;
- As seen by the lack of strong, high velocity anomalies, and pattern of anisotropy directions, the southern part of the PB shows no cratonic root; this correlates with the extent of the Paraná LIP.
- Large delays at the Pt and TBL, in agreement with the low velocity anomaly, show that this area has thin lithosphere, and directions are mostly controlled by mantle flow.

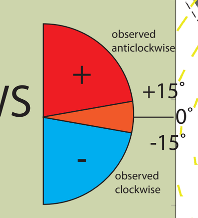
4.2 Comparison with the anisotropic surface wave tomography model SA2018 [4]

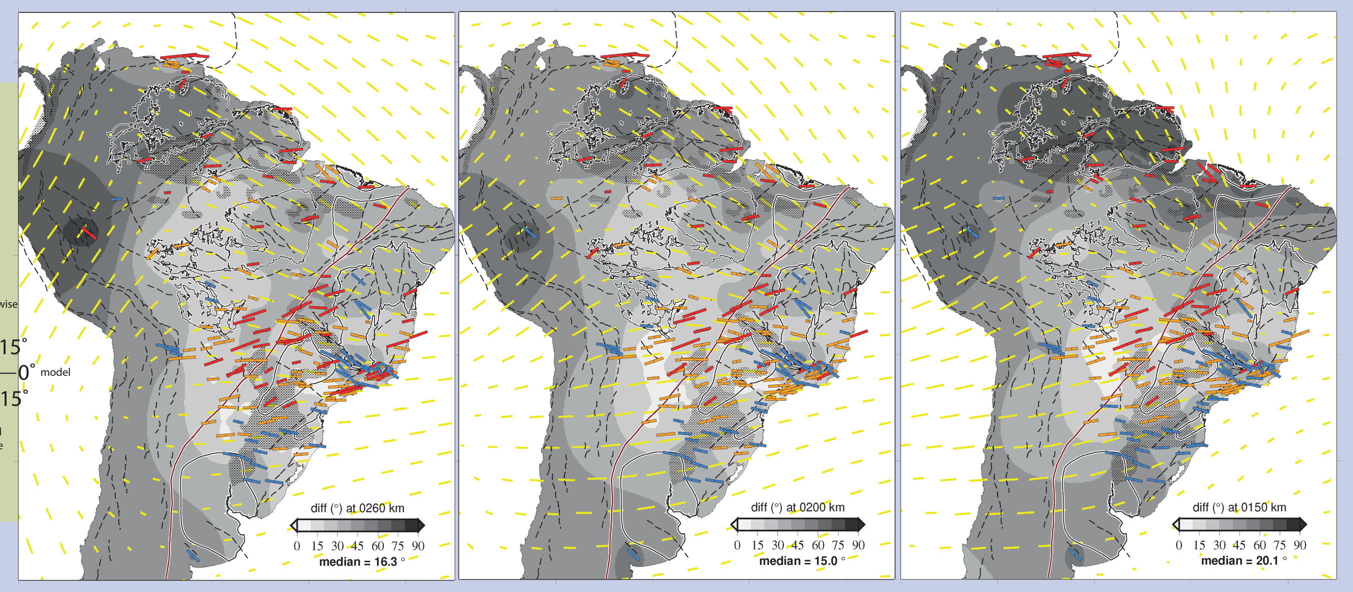
- There is a clear pattern of direction deviation at the TBL and at the southermost part of the SFC and PB;
- The two different direction patterns at the Amazonia craton may be due to two different anisotropy layers:
  - NW-SE, roughly aligned with the lineament trends, from past tectonic events (frozen anisotropy);
  - W-E from mantle flow.

Bar colors are:

SA2018 model

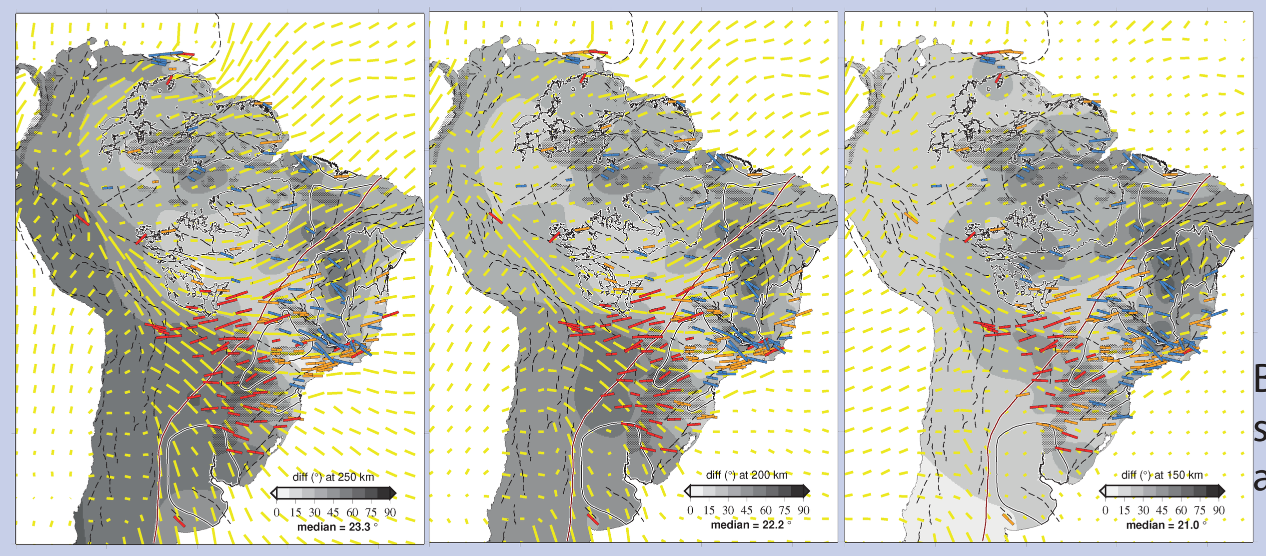
Difference between the model and SWS directions, as follows:



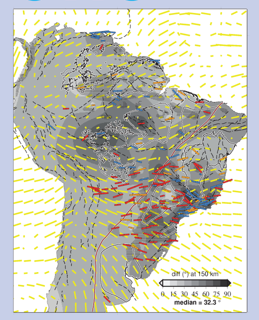


4.3 Comparison with mantle flow model of Hu et al., 2017 [5]

Mantle flow



SWS

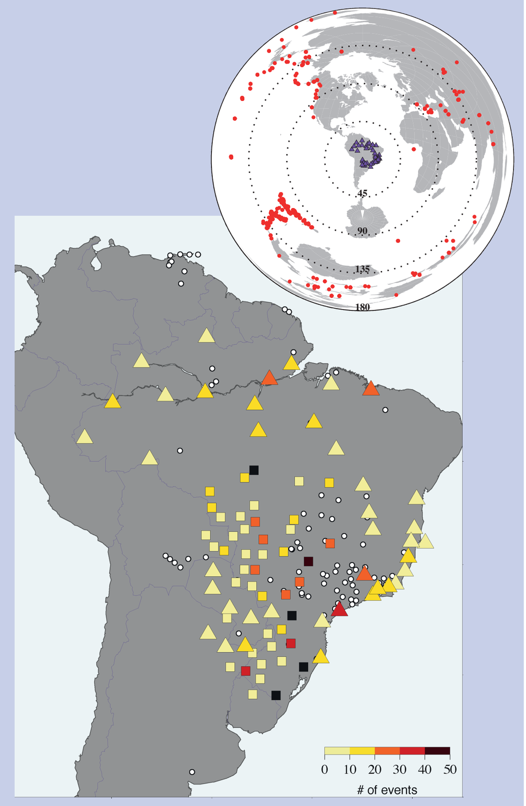


Bar colors are same scheme as above.

- The model only includes the AC area as thicker lithosphere, which could explain the lack of agreement around the SFC and PB.
- There is some agreement with the NEE-SWW directions at the AM, implying these have asthenospheric source.
- The synthetic SWS model has little correlation with our SWS measurements, suggesting uncertainties in the models used.

3. DATA

We add 558 shear wave splitting anisotropy event measurements recorded at 40 stations from the Brazilian Seismograph Network (RSBR), to the stable part of South America, especially in north Brazil and south-eastern coast of Brazil.



LABELS

- Events used in this work.
- New stations added.
- Stations used in previous compilation [2].
- Compilation of Assumpção et al. 2011 [3].

5. SUMMARY

- Seismic anisotropy in the upper mantle causes shear wave splitting.
- We use the split components of the SKS wave to measure orientation and amount of anisotropy.
- We add new data from stations at the north and the SE coast of Brazil, where there was no coverage before.
- In the southeastern area, the anisotropy might have mainly asthenospheric source, and is deviated by the cratonic keels at the SFC and PB.
- Two different patterns at the AC may be due to two anisotropic layers: one lithospheric and one asthenospheric.

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