EGU General Assembly 2021

DIAS
Institiúid Ard-Léinn Bhaile Átha Cliath | Dublin Institute for Advanced Studies

EGU21-13665

Imaging East Asia using waveform tomography with massive datasets

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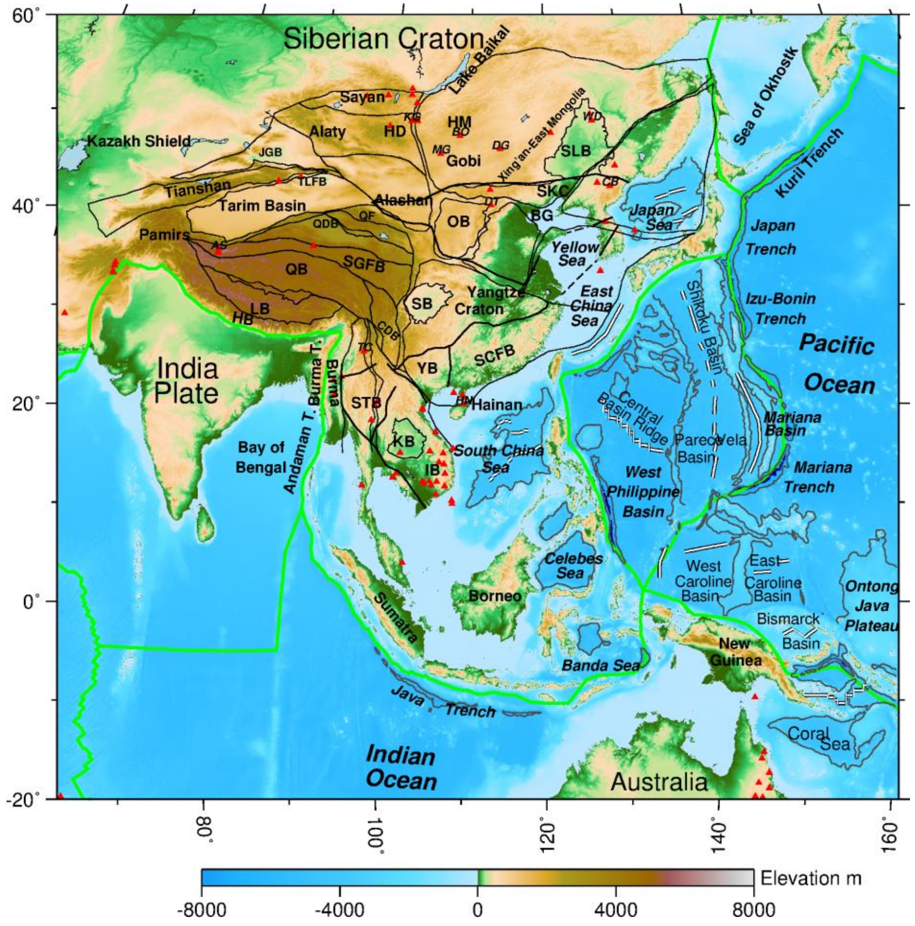
Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

Science Foundation Ireland sfi For what's next

1. Geological background



Tectonic and topographic map of East Asia.
Red triangles represent active volcanoes. Blue lines mark the main tectonic units and basins. Abbreviations are as follows: SB, Sichuan Basin; OB: Ordos Basin; SLB: Songliao Basin; JGB, Junger Basin; HB: Himalaya Block; LB: Lasha Block; QB: Qiangtang Block; SGFB, Songpan Ganzi Fold Block; CDB, Chuandian Block; YB: Youjiang Block; SCFB: South China Fold Belt; STB: Shan Thai Block; KB: , Khorat Basin; IB: Indochina Block.

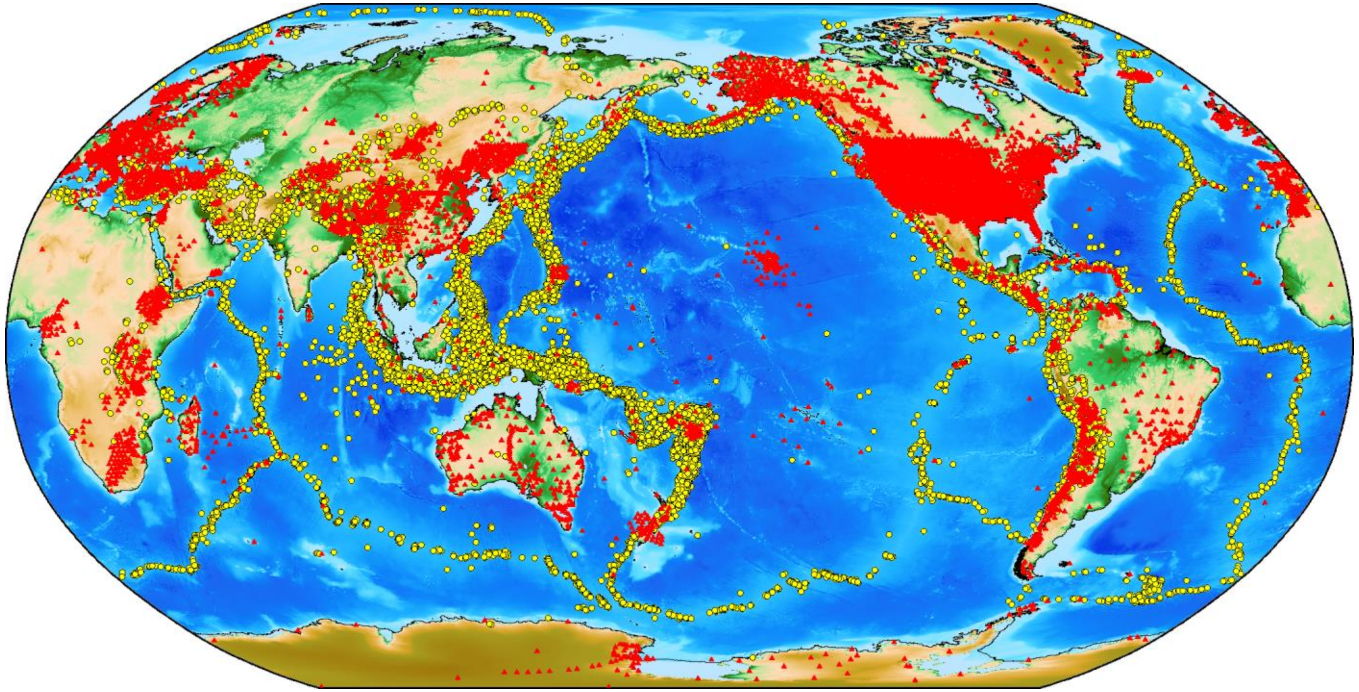
East Asia is a complex region with variety of crustal types and tectonic styles.

Active collision of India-Asia, multiple earlier orogenies, and the current subduction of the Pacific and Philippine Sea plates have produced strong seismic heterogeneities in the crust and mantle beneath East Asia, preserving the record of the deep lithospheric evolution of the region.

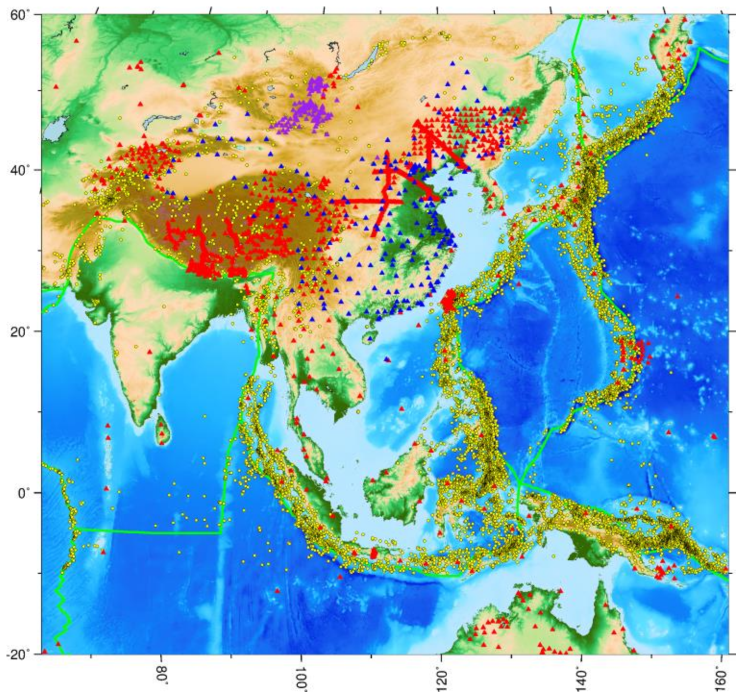
Debate:
The origin of numerous intraplate volcanoes;
The geometry of subducted slab from India, Pacific....

2.1 Data

We collect all the available global records and newly available regional data, like in Mongolia, Northeast China and widely distributed broadband stations from China Earthquake Data Center, to constrain our model.



Distribution of events and stations used in the inversion
Yellow circles and red triangles represent earthquakes and stations, respectively.

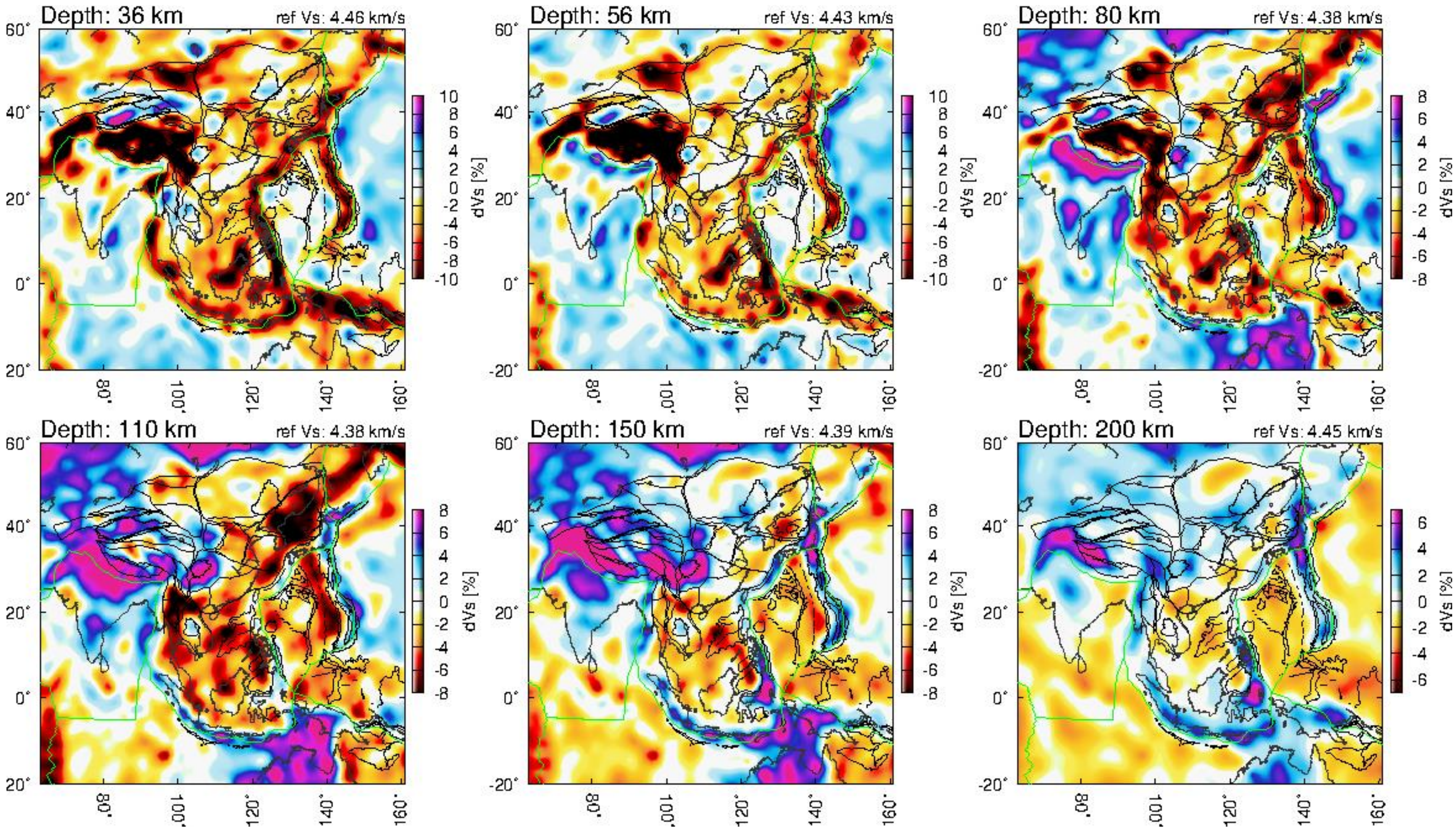


Distribution of events and stations in East Asia used in the inversion
Blue triangles represent the seismograms from China Earthquake Data Center ; Purple triangles represent the new avaliable data from IRIS. The regional dataset amount is comparable to other recently regional tomography models

2.2 Method

- **AMI --- Automatic Multimode Inversion of surface, S and multiple S waves** (Lebedev et al., 2005; Lebedev and van der Hilst, 2008; Schaffer and Lebedev, 2013; Schaffer and Lebedev, 2014).
- **Inversion procedure**
  - **waveform fitting** (filtered, quality control, response correction)
  - **3D tomographic inversion** (path-weighting, regularization, and smoothing, derive a 3-D model of S-wave velocity perturbations.)
  - **outlier analysis** (select posterior the most mutually consistent equations, discard many artifacts in the images(Lebedev and van der Hilst, 2008; Schaffer and Lebedev, 2014). In our inversion, 60 percent waveform fits were kept)
  - **resolution test** (Spike test, (Celli et al., 2020))

3. Model ASIA2021



S-wave velocity anomalies in the map views of East Asia at 10 different depths.
The velocity perturbations are the percentage of the S-wave velocity anomaly refer to the reference model at each depth. Major tectonic plates are plotted as green solid lines.

ASIA2021 is an anisotropic, S-wave model reveal the crust and upper mantle structure beneath East Asia.

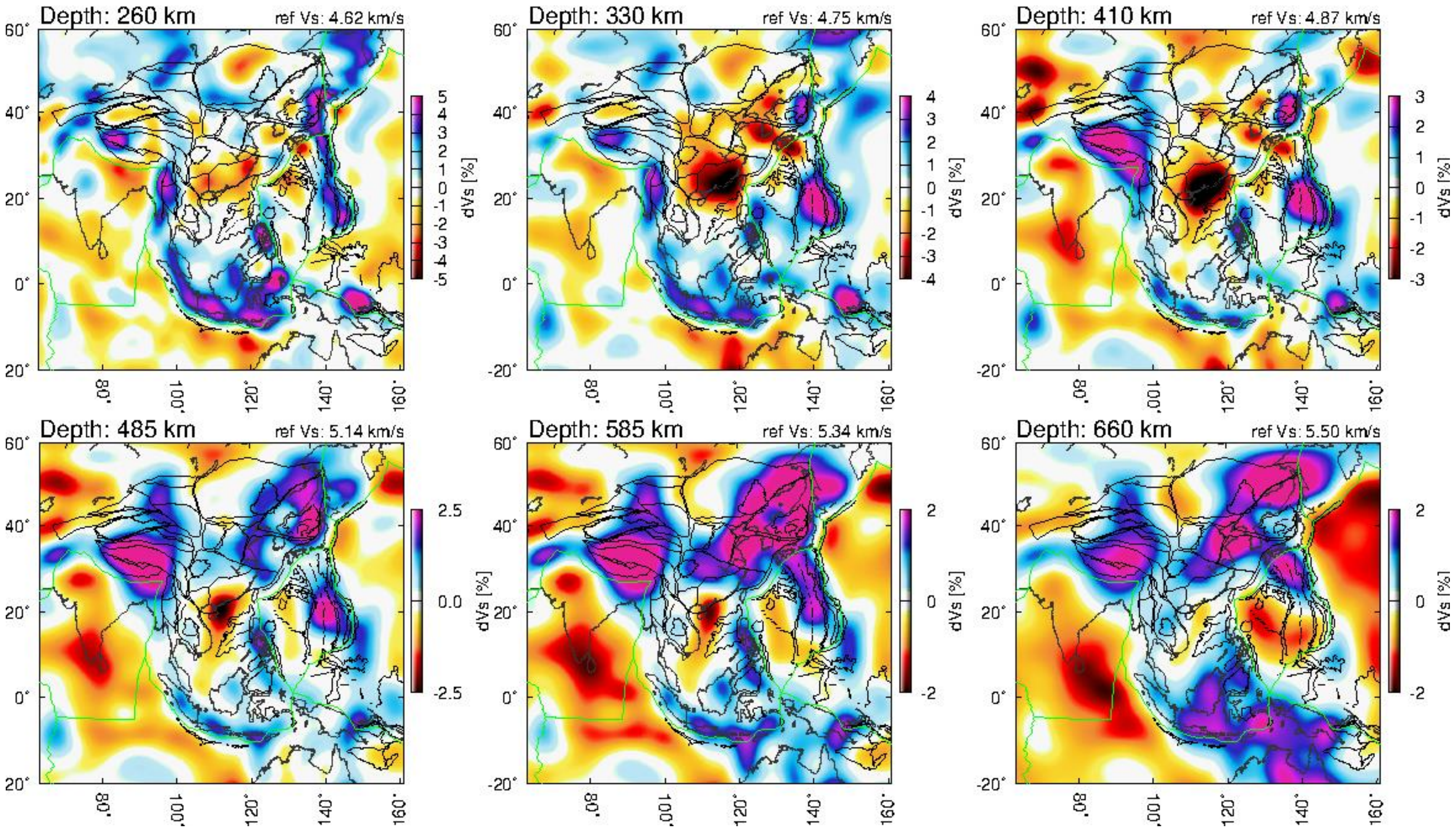
At lithosphere depth:

(1) H-V continent roots down to ~ 200 km depth beneath Sichuan Basin, Tarim Basin, Ordos Block, and Siberian Craton.

(2) Absence of a high-velocity continental root beneath Eastern North China Craton (ENCC), is consistent with the destruction of the Archean nucleus.

(3) Strong L-V anomalies are mapped within the top 100 km beneath Tibet, Pamir, Altay-Sayan area, and back-arc basins.

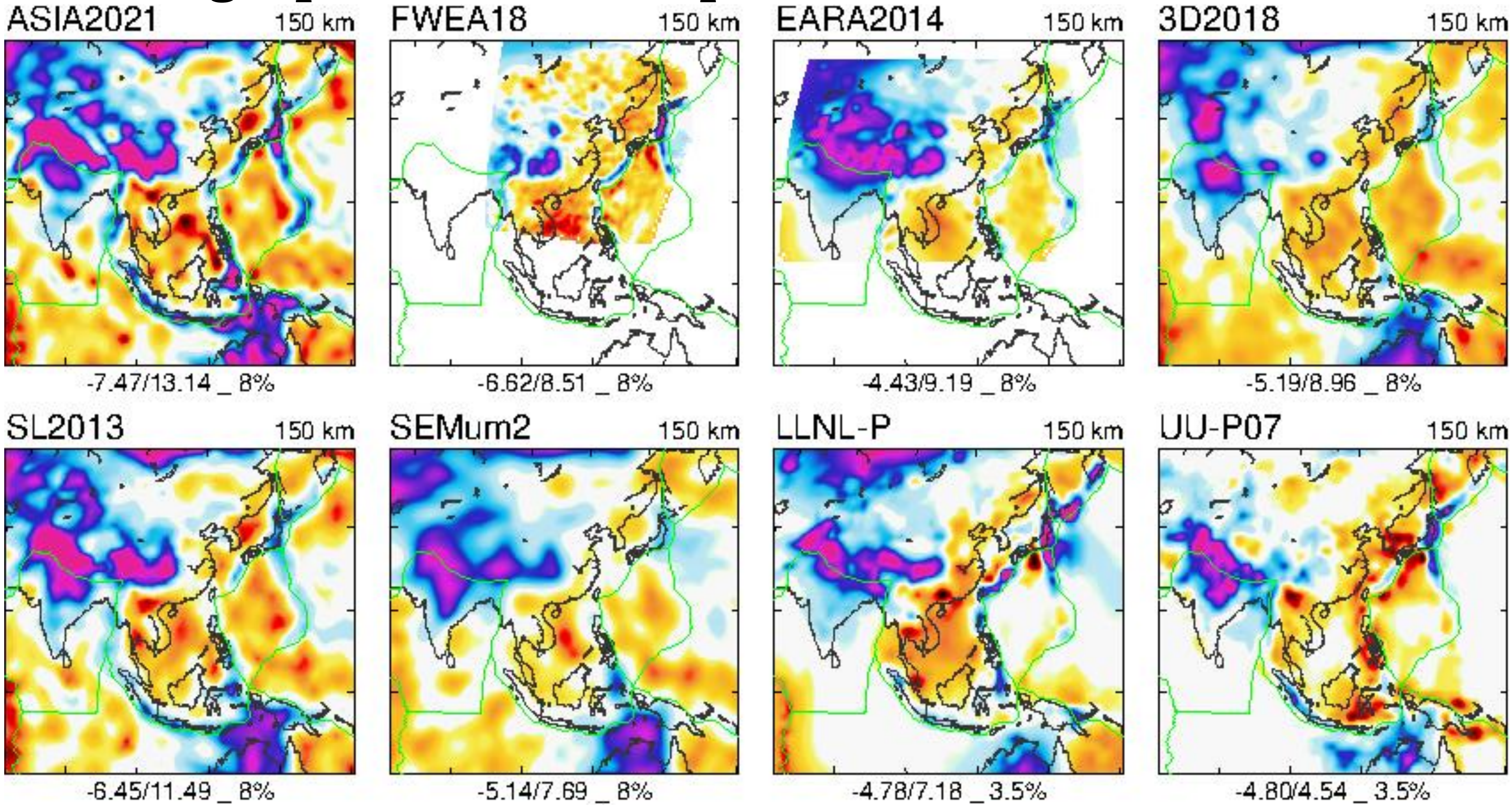
3. Model ASIA2021



Above transition zone: H-V anomalies related to the subducted and underthrusted lithosphere of India beneath Tibet and the subduction of the Pacific and Philippine Sea plate.

In transition zone: H-V anomalies probably related to deflected subducted slabs (Pacific and India) or detached portions of ancient continent cratons (North China Craton) .

4. Tomographic model comparison

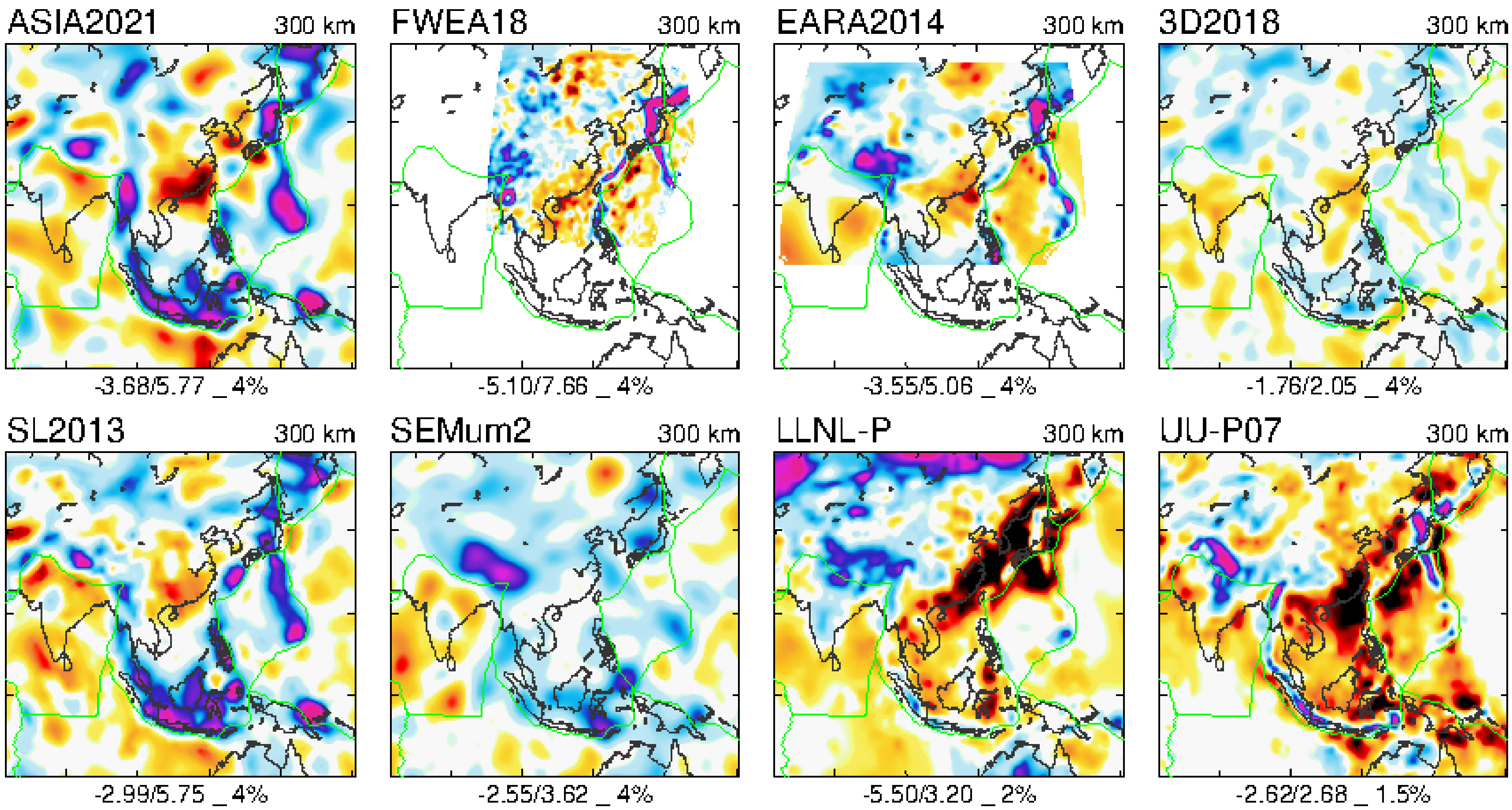


Comparison of ASIA201 with seven recent regional and global surface-wave-tomography models at 150 km depth.

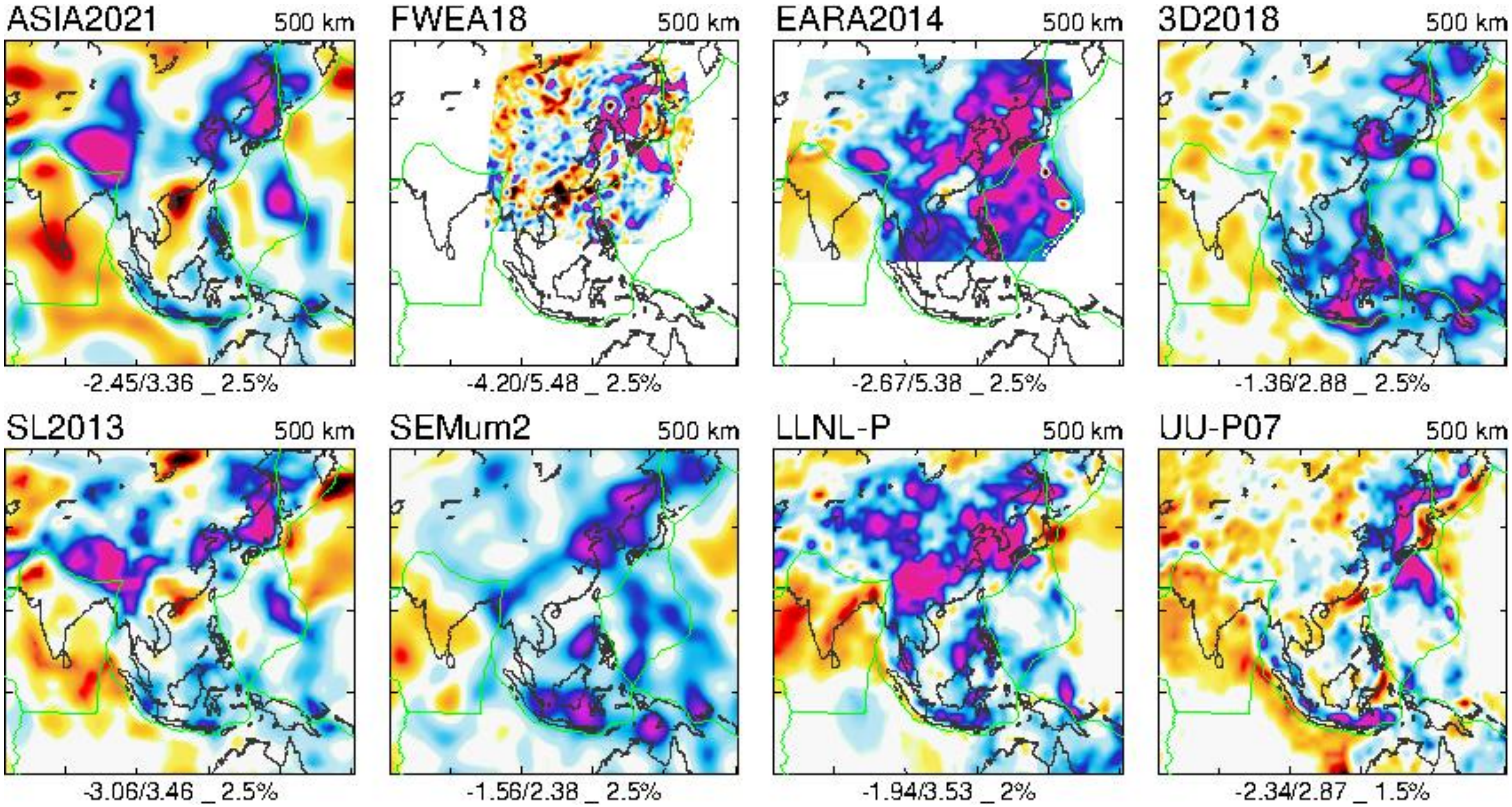
FWEA18 (Tao et al., 2018), EARA2014 (Chen et al., 2015), 3D2018 (Debayle et al., 2016), SL2013 (Schaeffer and Lebedev, 2014), and SEMum2 (French et al., 2013), LLNL-P (Simmons et al., 2015), and UU-P07 (Amaru, 2007).

ASIA2021 shows agreement with previous models at larger scales and, also, sharper and stronger lithospheric anomalies at smaller regional scales.

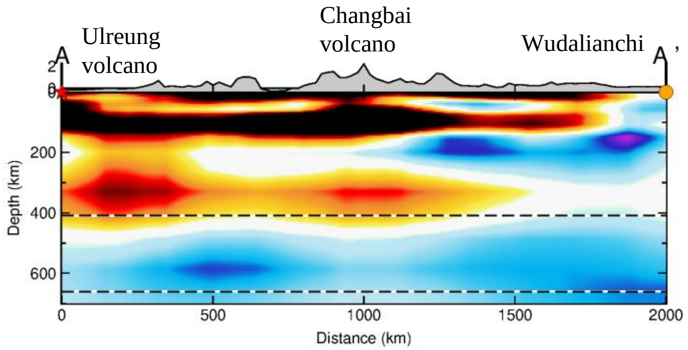
4. Tomographic model comparison

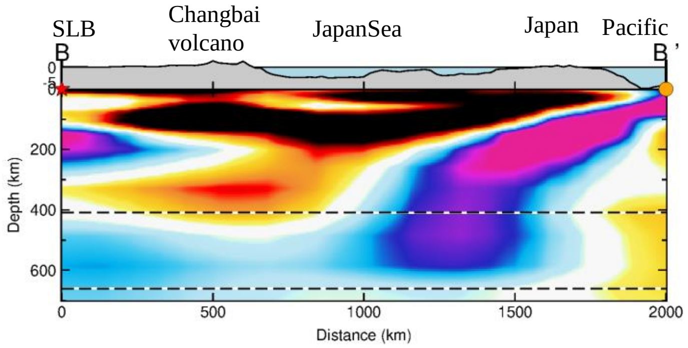


4. Tomographic model comparison

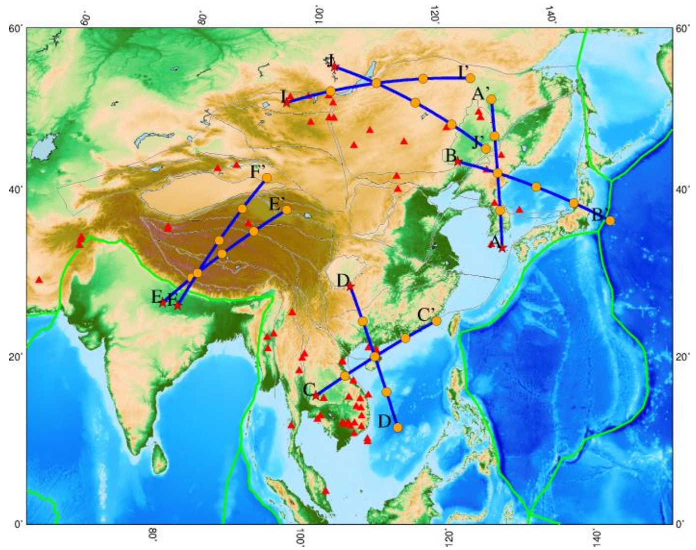


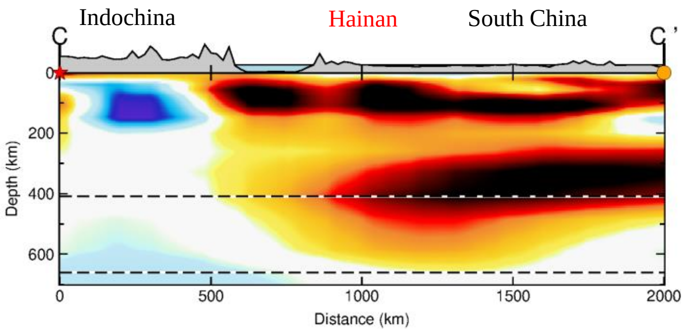
5. Discussion

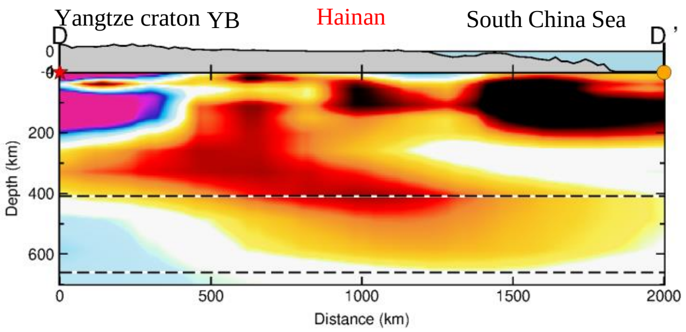




The Pacific Plate subducts beneath the eastern margin of Asia into the MTZ and appears to deflect and extend horizontally as far west as the Songliao Basin. The absence of major gaps in the stagnant slab is consistent with the origin of Changbaishan volcano above being related to the Big Mantle Wedge, proposed previously.

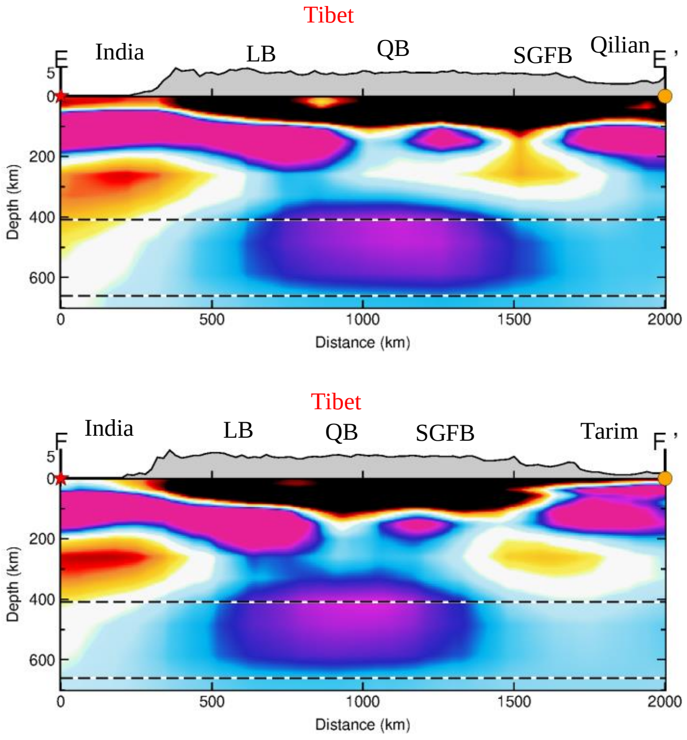


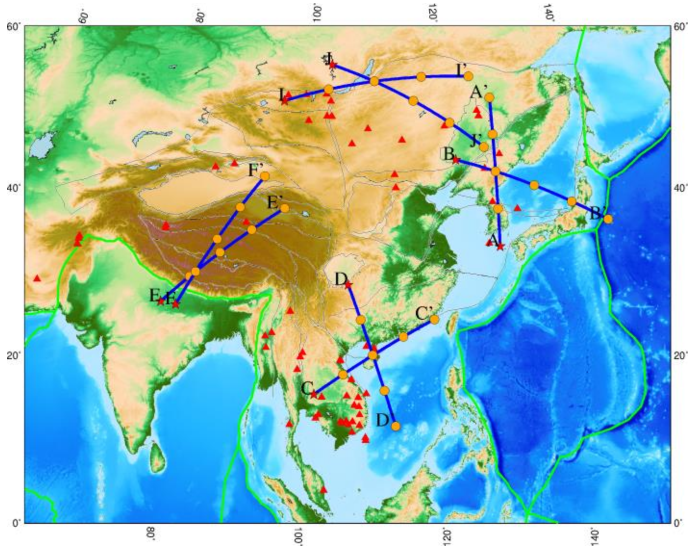


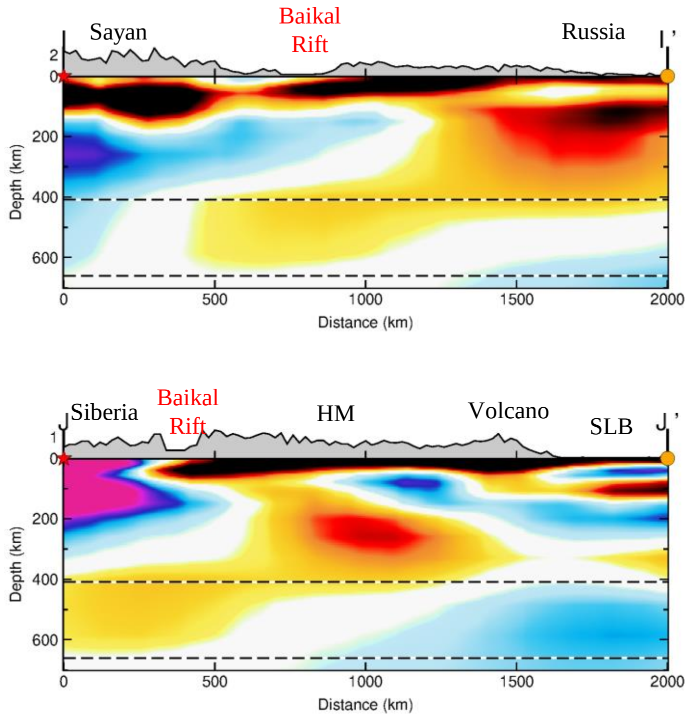


A strong low-velocity anomaly extending from the surface to the lower mantle beneath Hainan volcano and South China Sea is consistent with the hypothesis of the Hainan mantle plume.

5 Discussion







Separate H-V bodies, probably originating from the Indian Plate lithosphere beneath central Tibet, with one at 100-200 km beneath SGFB and the other in the MTZ

L-V anomalies down to ~ 700 km depth beneath the Lake Baikal area, suggest a hot upwelling (mantle plume) feeding the widely distributed Cenozoic volcanoes in central and western Mongolia.

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