Supplementary Material

Imaging the subsurface structure of Mount Agung in Bali (Indonesia) using volcano-tectonic (VT) earthquake tomography

Ardianto Ardianto,[1] Andri Dian Nugraha,[2,3*] Haunan Afif,[4] Devy Kamil Syahbana,[4] David P. Sahara,[2] Zulfakriza Zulfakriza,[2,3] Sri Widiyantoro,[2,5] Awali Priyono,[2] Shindy Rosalia,[2]Asep Saepuloh,[6,7] Kasbani Kasbani,[4] Faiz Muttaqy,[1] Puput P. Rahsetyo,[1] Imam C. Priambodo,[1,4] Martanto Martanto[1,4]

[1]Geophysical Engineering Department, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia

[2]Global Geophysics Research Group, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia

[3]Center for Earthquake Science and Technology (CEST), Research Center for Disaster Mitigation, Institut Teknologi Bandung, Bandung 40132, Indonesia

[4]Center for Volcanology and Geological Hazards Mitigation, Geological Agency, Ministry of Energy and Mineral Resources, Bandung 40122, Indonesia

[5]Faculty of Engineering, Maranatha Christian University, Bandung 40164, Indonesia

[6]Center for Remote Sensing, Institut Teknologi Bandung, Bandung 40132, Indonesia

[7]Geology Engineering Study Program, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Bandung 40132, Indonesia

*** Correspondence:**
nugraha@gf.itb.ac.id

Table S1: Locations of Seismic Monitoring Stations at Mt. Agung

No.	Sta Id	Type	Longitude	Latitude	Elevation(m)
1.	TMKS	SP	115^{o} 28.00’	-8^{o} 21.83’	1216
2.	PSAG	SP	115^{o} 29.92’	-8^{o} 22.67’	1306
3.	CEGI	BB	115^{o} 28.30’	-8^{o} 18.13’	966
4.	DUKU	BB	115^{o} 32.07’	-8^{o} 17.75’	630

5.	YHKR	BB	115^o 30.50’	-8^o 22.90’	1196
6.	ABNG	BB	115^o 26.08’	-8^o 17.67’	1535
7.	BATU	BB	115^o 29.97’	-8^o 12.52’	61
8.	REND	BB	115^o 25.50’	-8^o 25.50’	536

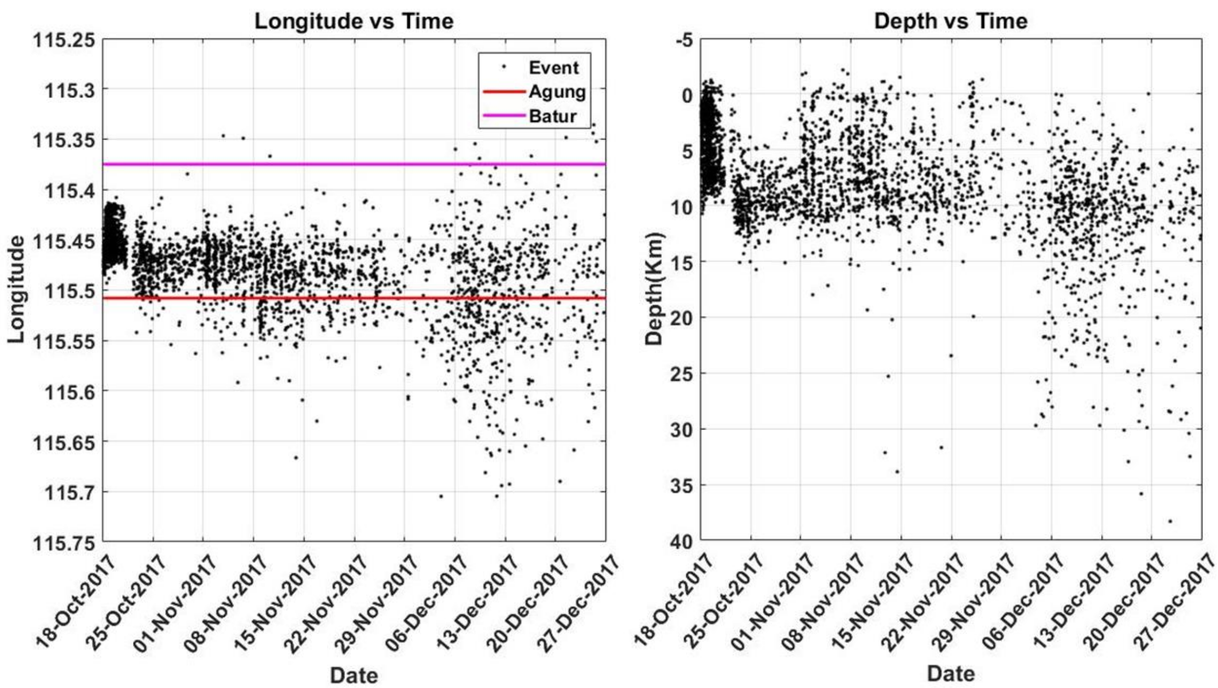

Figure S1. Longitude vs time plots (left panel), and depth vs time (right panel). Red and magenta lines in the left panel show Mt. Agung and Mt. Batur longitude positions respectively.

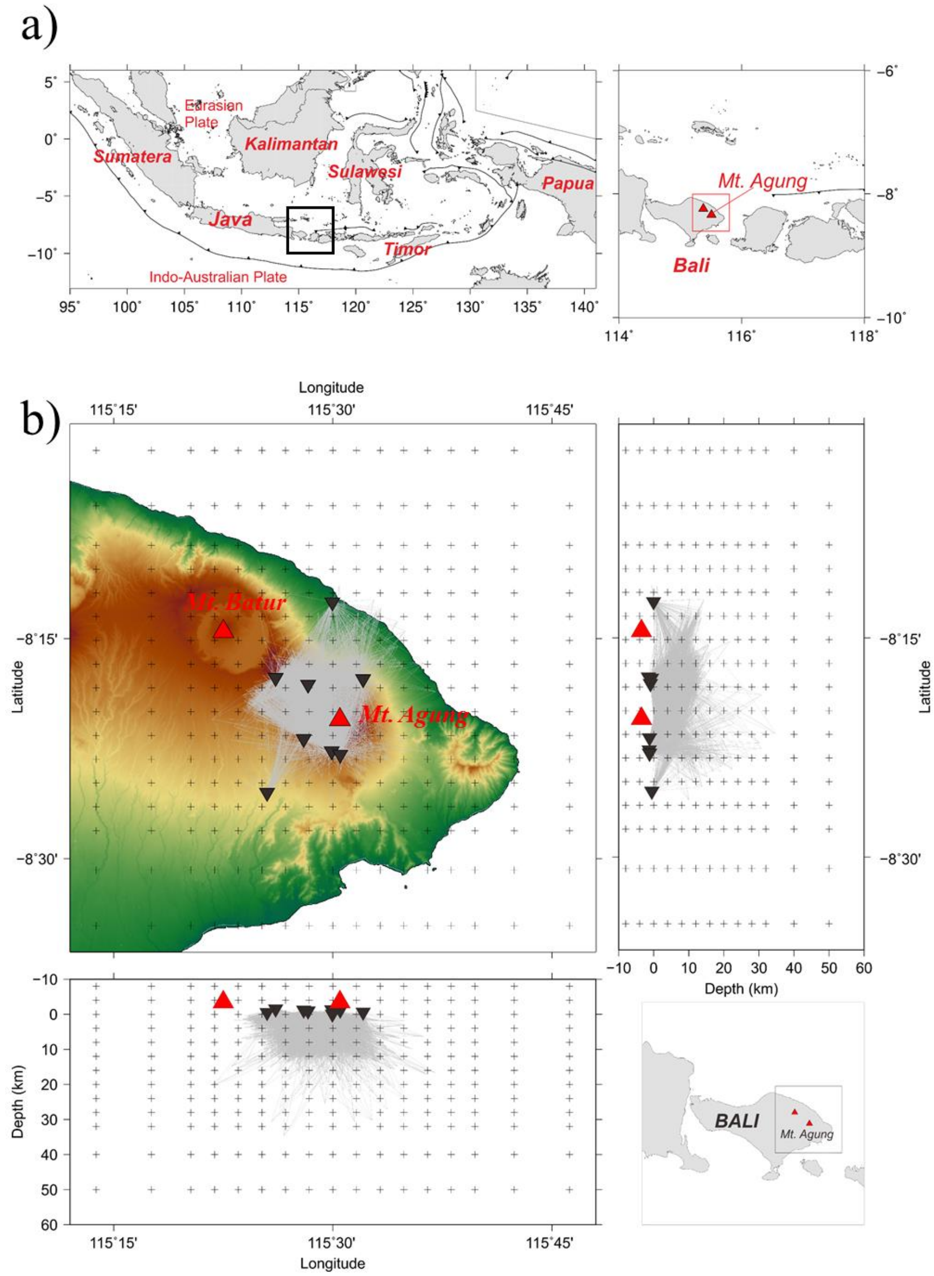

Figure S2. a) The study area of Mt. Agung, Bali, Indonesia; the black jagged lines denote the subduction trench, the black square denotes the local area of the Bali region (right), and the red square in the right image defines the focus of the study area. b) Ray-path through a 3-D seismic velocity model which is calculated using pseudo bending (gray lines). A longitude projection (below) and a latitude (right) image of the ray-path in vertical cross section. The CVGHM seismic stations are shown as black inverted triangles. Red triangles denote Mt. Agung and Mt. Batur. Black plus symbol denotes the grid nodes model parameterization.

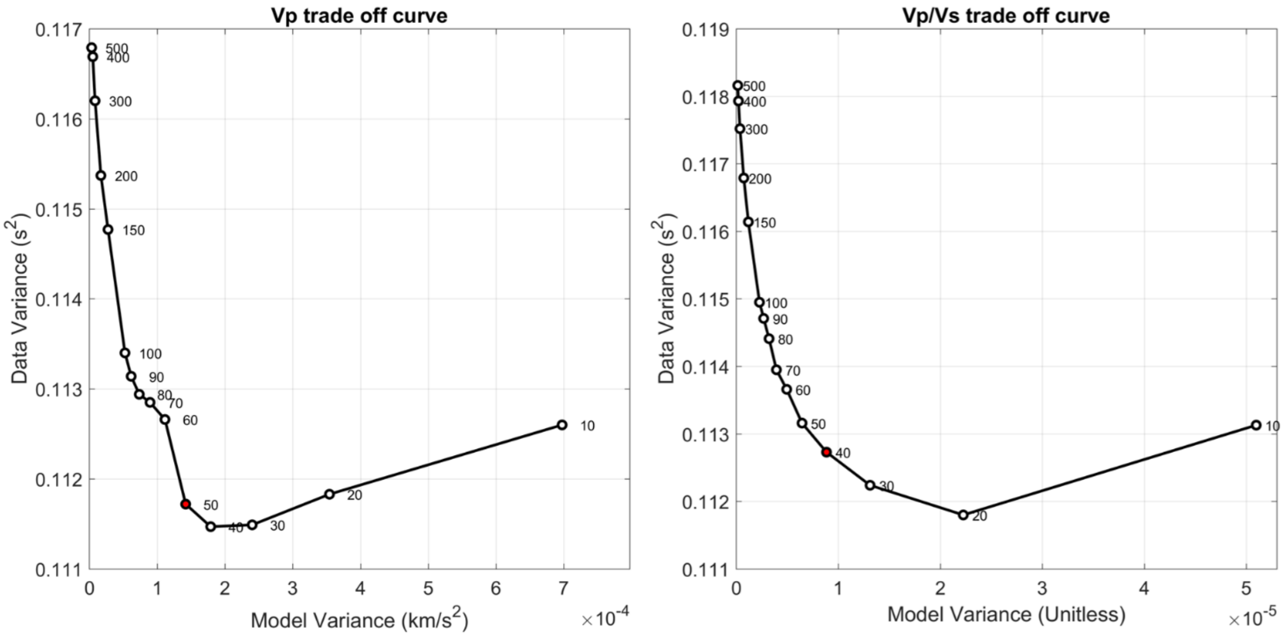

Figure S3. The trade off curve between data variance and model variance plotted for different damping values. Trade off curve for Vp (left) and Vp/Vs ratio (right), the appropriate damping for Vp and Vp/Vs ratios is 50 and 40, respectively.

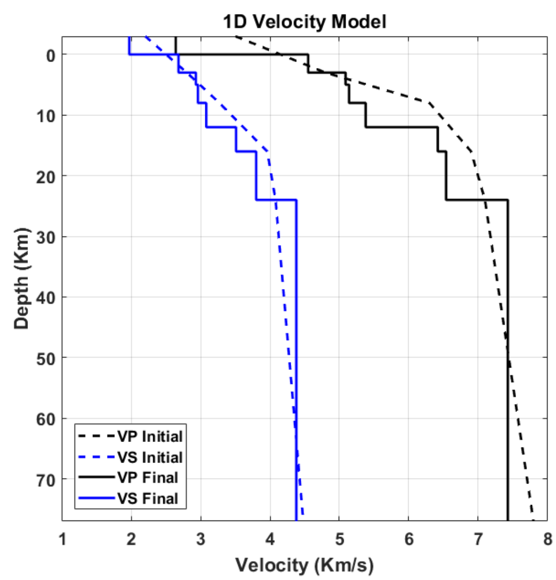

Figure S4. Comparison of the 1-D initial seismic velocity model (Koulakov et al. 2009) with the final 1D velocity obtained, using VELEST. The optimum 1D velocity is used for relocation of VT events (Sahara et al. this issue) and as initial Vp and Vs models for tomographic inversions.

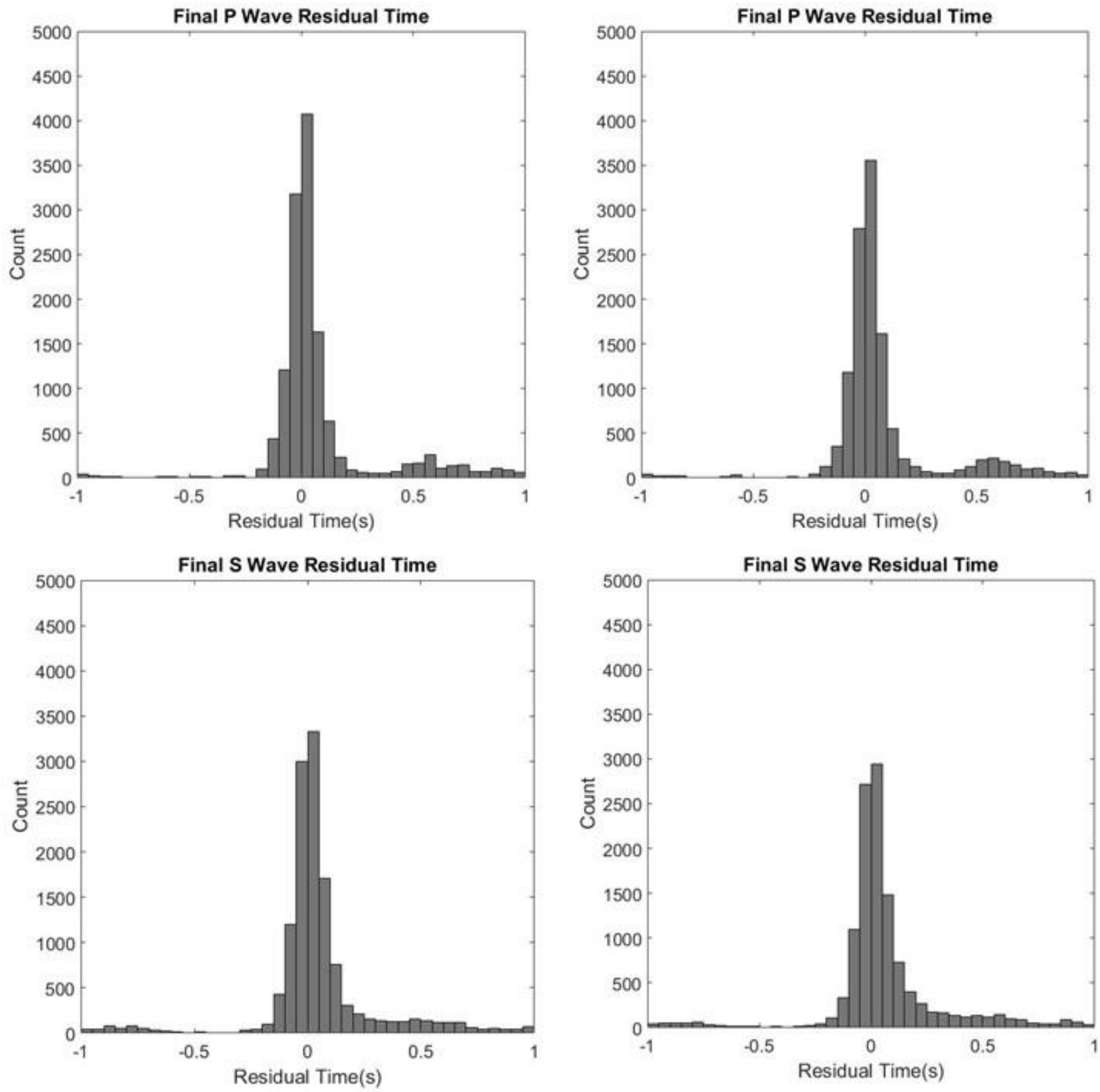

Figure S5. Residual travel time (in seconds) for P-wave (Top) and S-wave (Bottom). The left panel results are obtained by first inversion method as described in text and, the right panel are obtained by directly do simultaneous inversion of Vp and Vp/Vs from 1D initial velocity model.

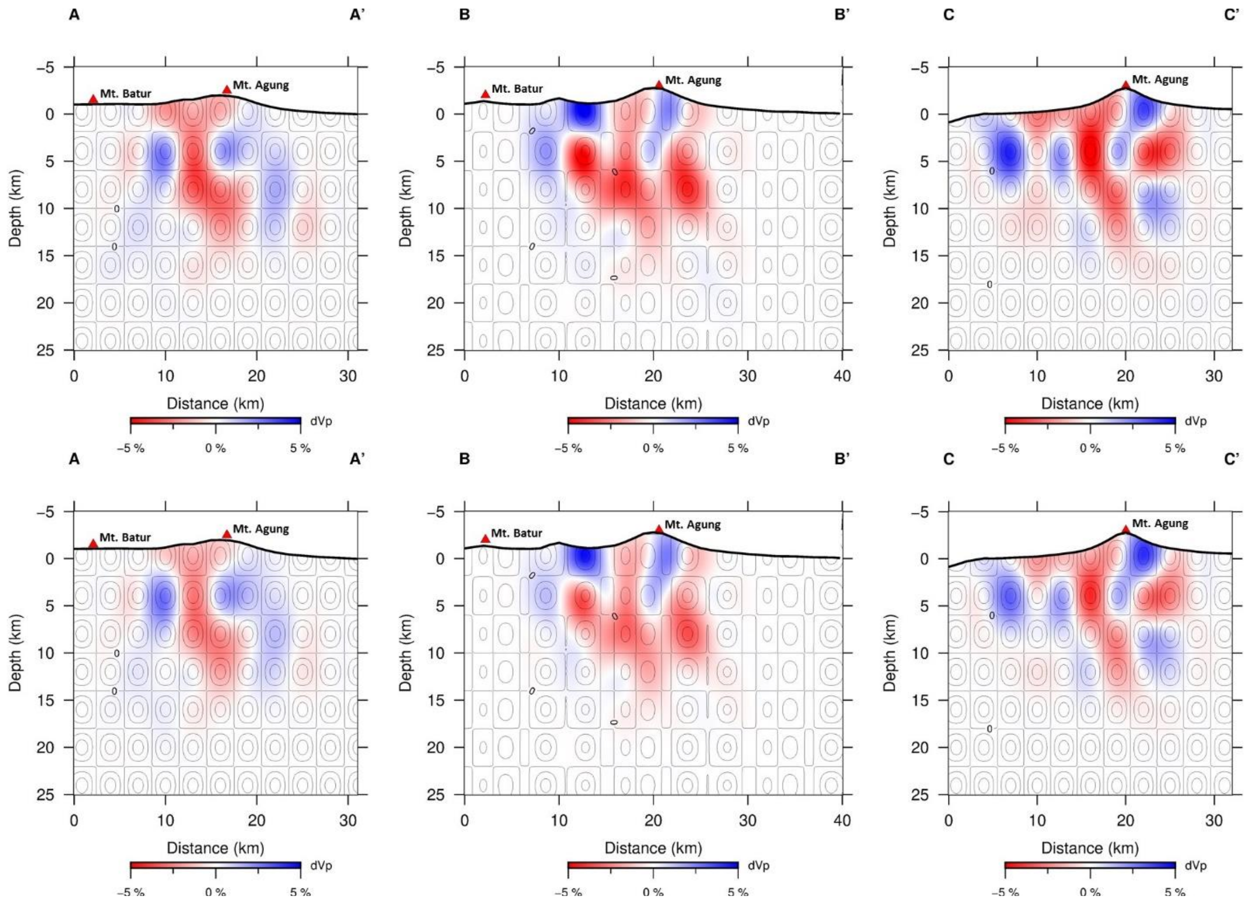

Figure S6. Vertical cross-sections of recovered Vp checkerboard resolution tests (CRT) model obtained by first inversion method as described in text (Top) and obtained by directly conducting simultaneous inversion of Vp and Vp / Vs from 1D initial velocity model (Bottom). Slice A-A′ (first column), B-B′ (second column), C-C′ (third column), the spatial location of each cross-section can be seen in Figure 1c. The thin black line is the contour of the initial CRT model for Vp with interval of 4.

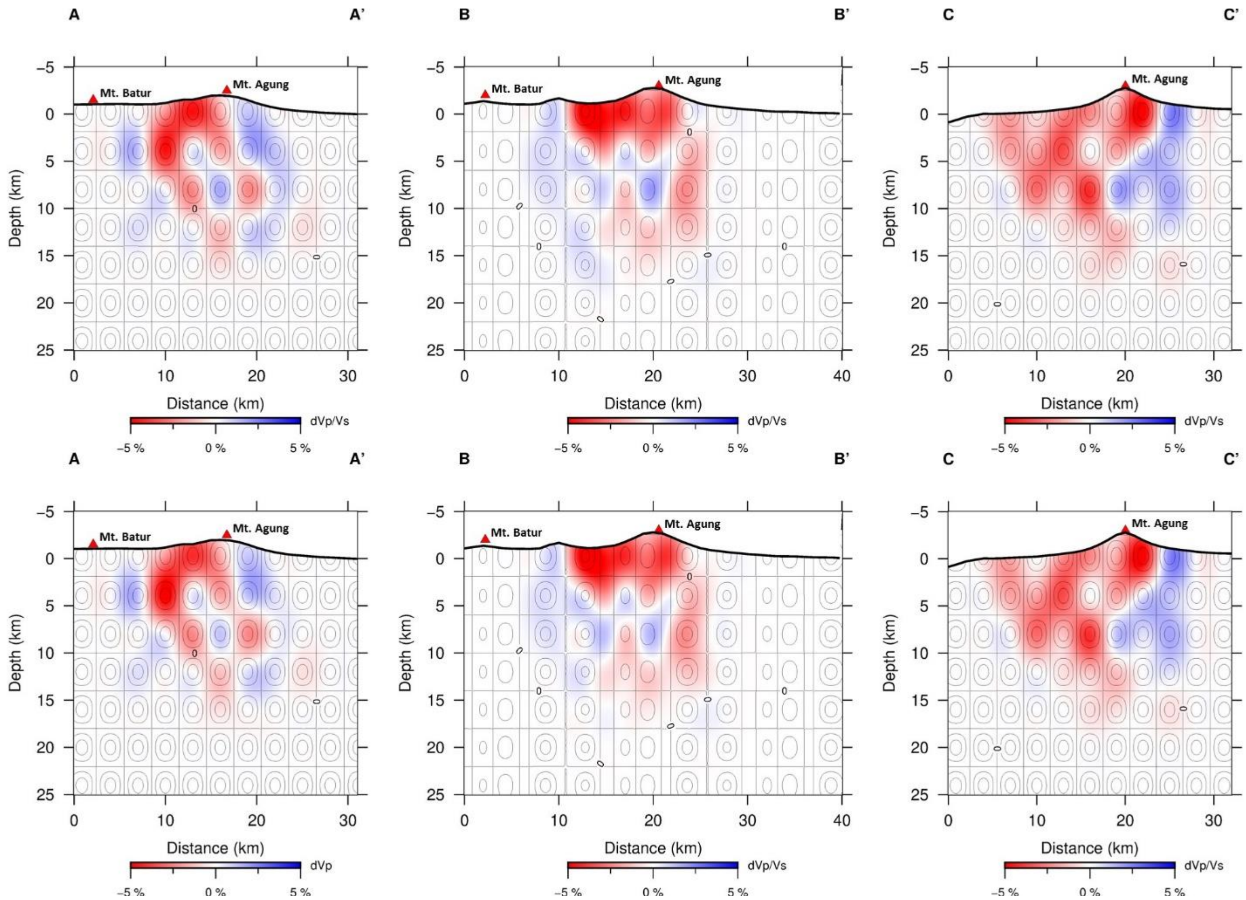

Figure S7. Same as Figure S6 but for Vp/Vs.

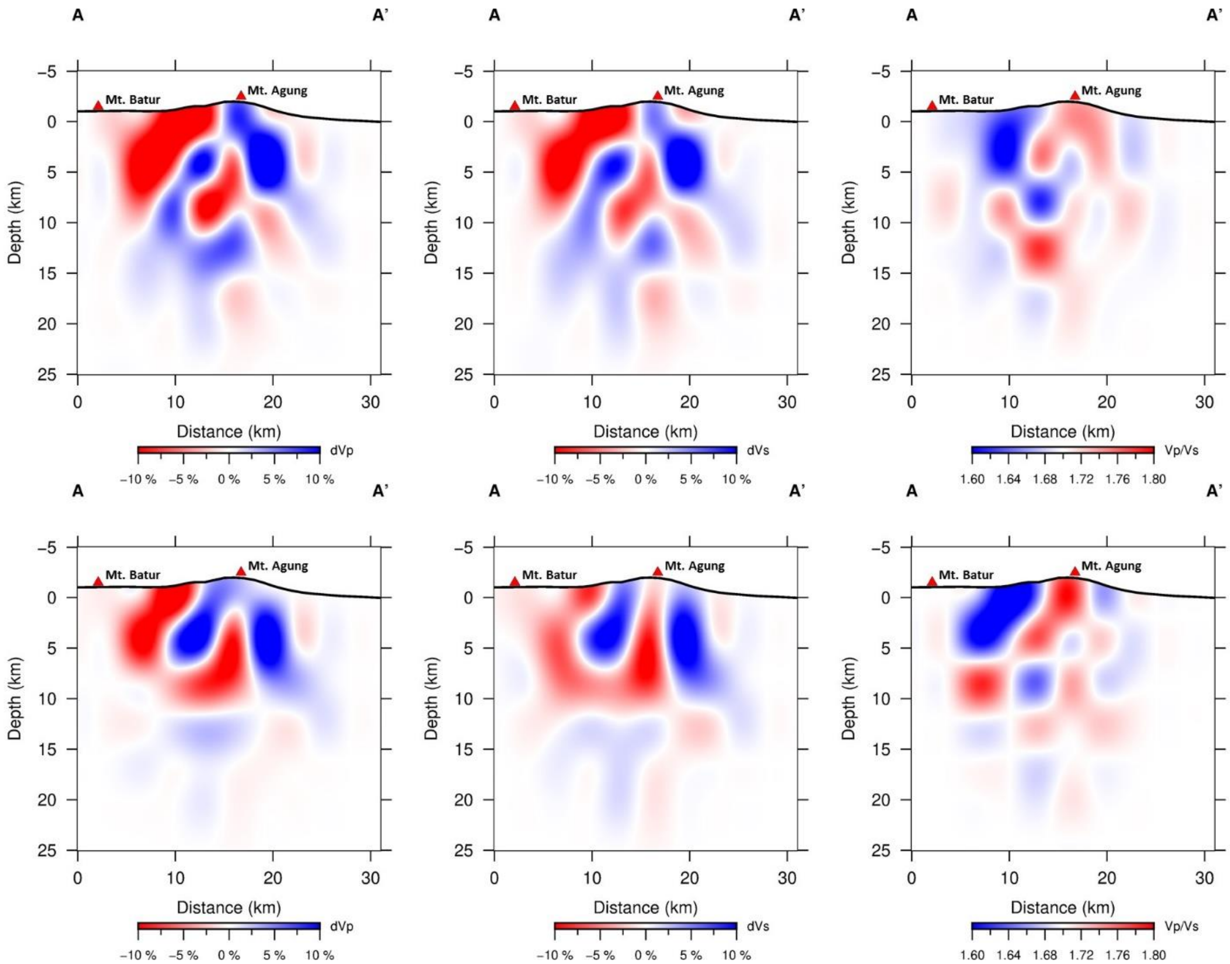

Figure S8. The vertical cross-sections of the Vp, Vs, and Vp/Vs models from left to right, respectively; for slice A-A′ the spatial location of each cross-section can be seen in Figure 1c. Top row obtained by first inversion method as in text and Bottom row obtained by directly conducting simultaneous inversion of Vp and Vp / Vs from 1D initial velocity model.

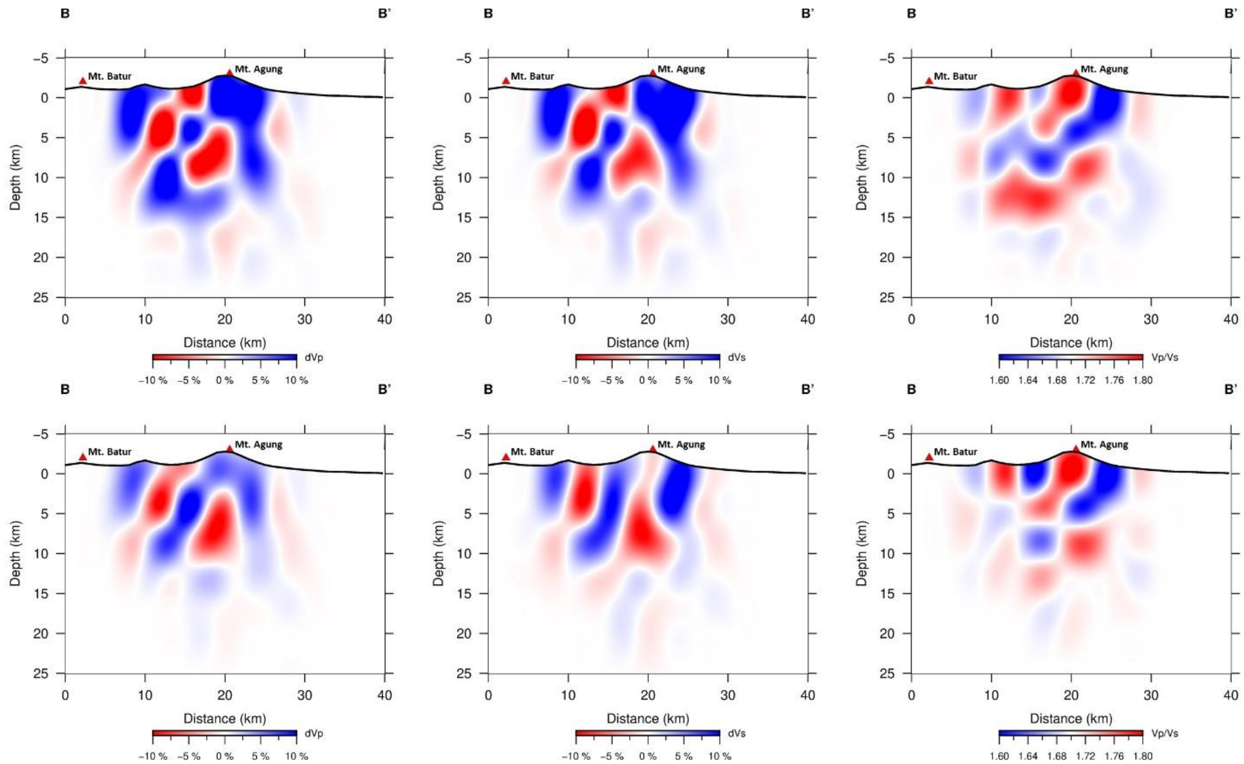

Figure S9. Same as Figure S8 but for B-B′ vertical cross-sections.

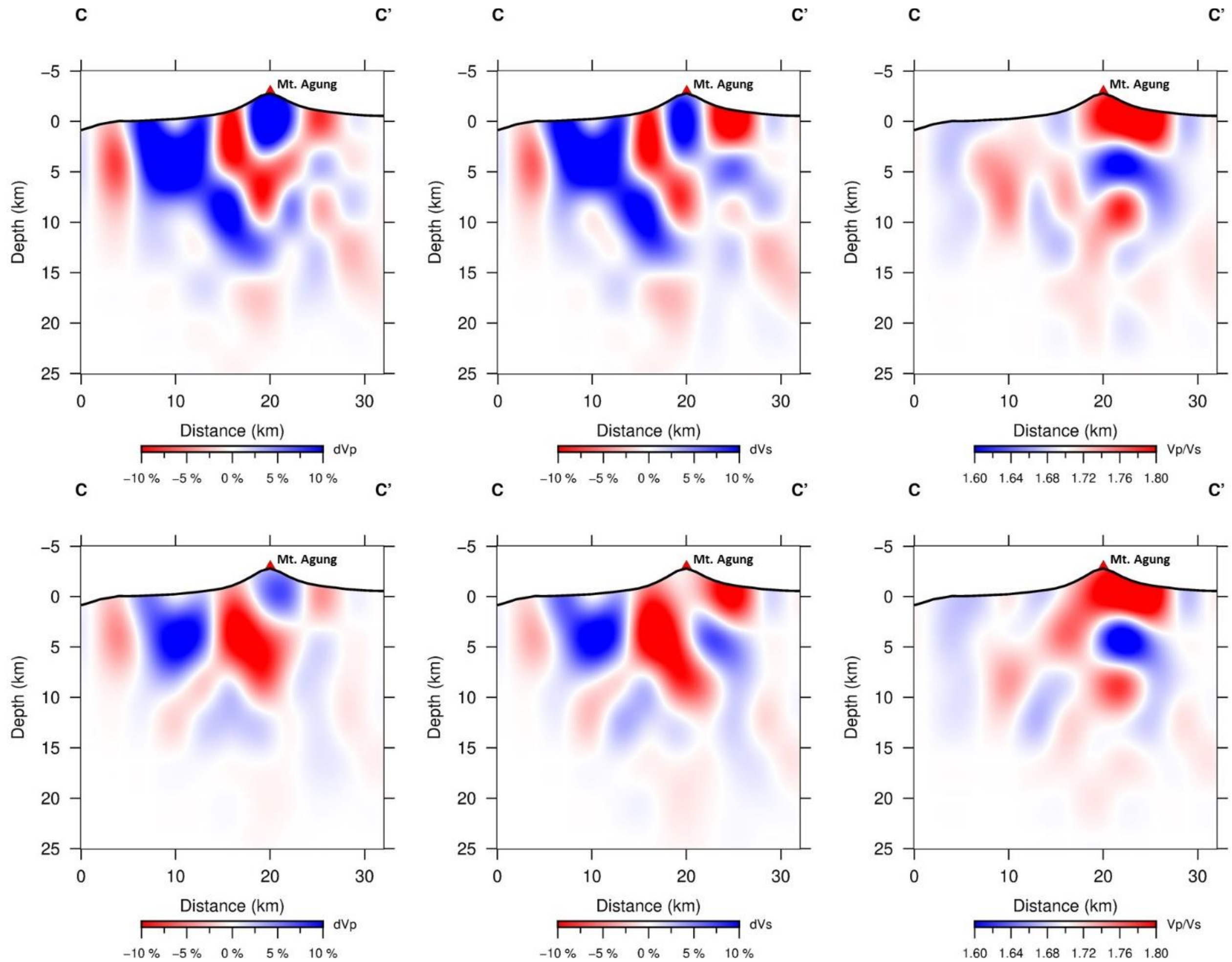

Figure S10. Same as Figure S8 but for C-C′ vertical cross-sections.

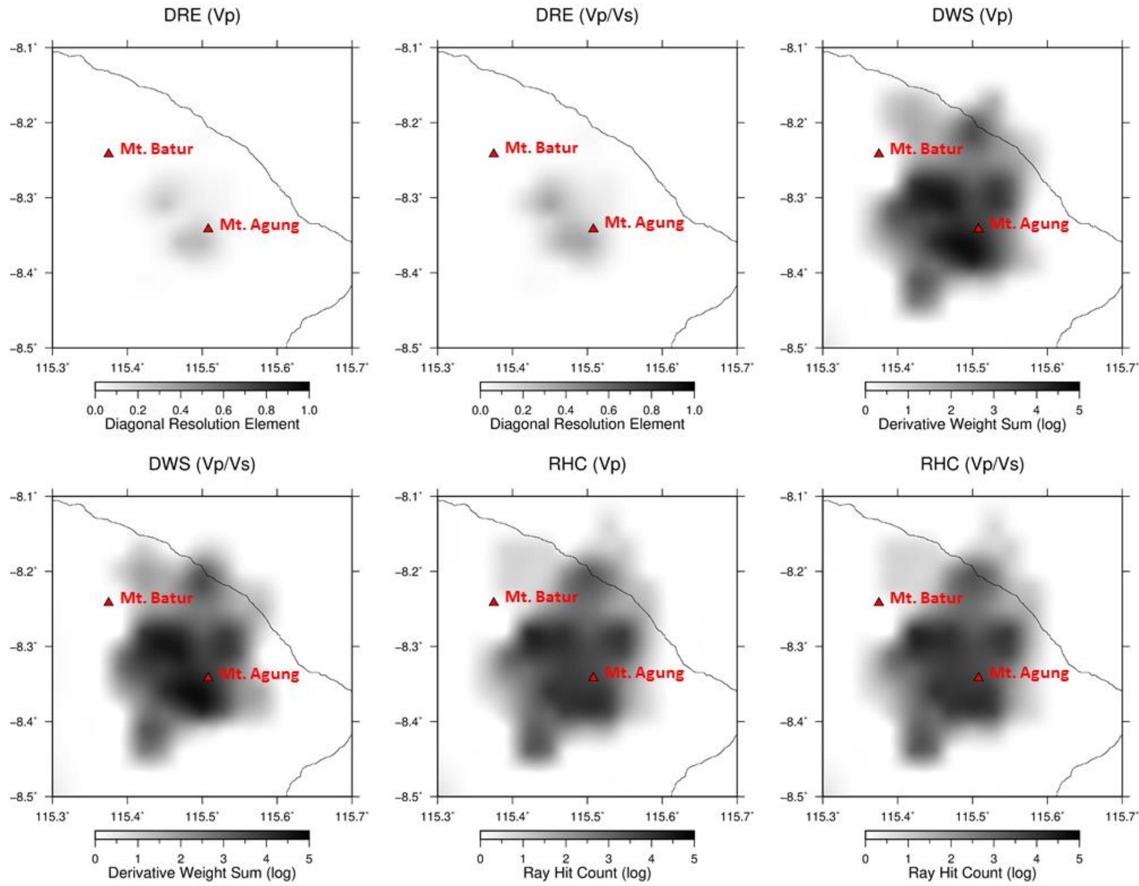

Figure S11. Horizontal slice at 0 km depth for Diagonal Resolution Elements (DRE) of Vp, Diagonal Resolution Elements (DRE) of Vp/Vs ratio, Derivative Weight Sum (DWS) of Vp, Derivative Weight Sum (DWS) of Vp/Vs ratio, Ray Hit Count (RHC) of Vp, and Ray Hit Count (RHC) of Vp/Vs. DWS and RHC are plotted on a logarithmic scale. DRE value varies between 0 (indicating unresolved) to 1(resolved). Darker colors indicate higher RHC, DWS, and DRE values for both the Vp and Vp/Vs ratios.

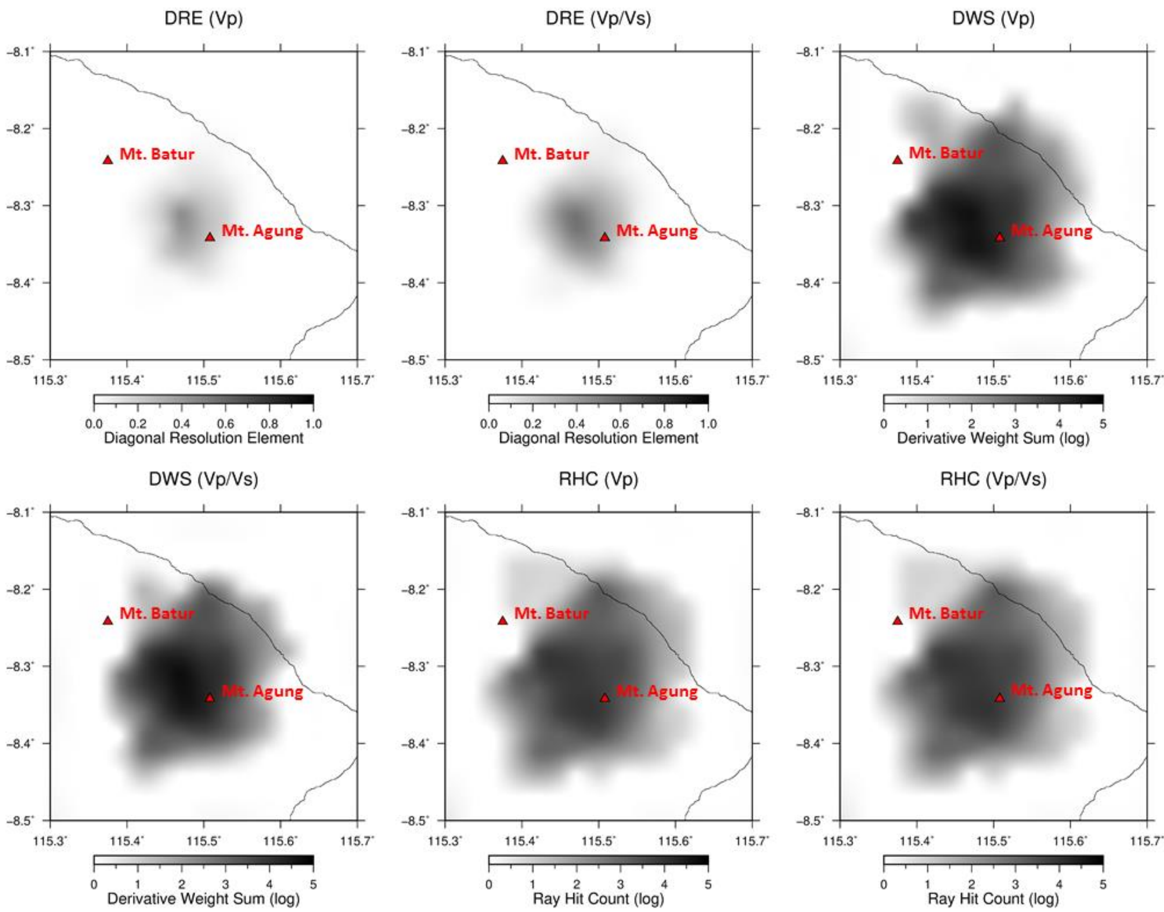

Figure S12. Same as Figure S11 but for a depth of 4 km.

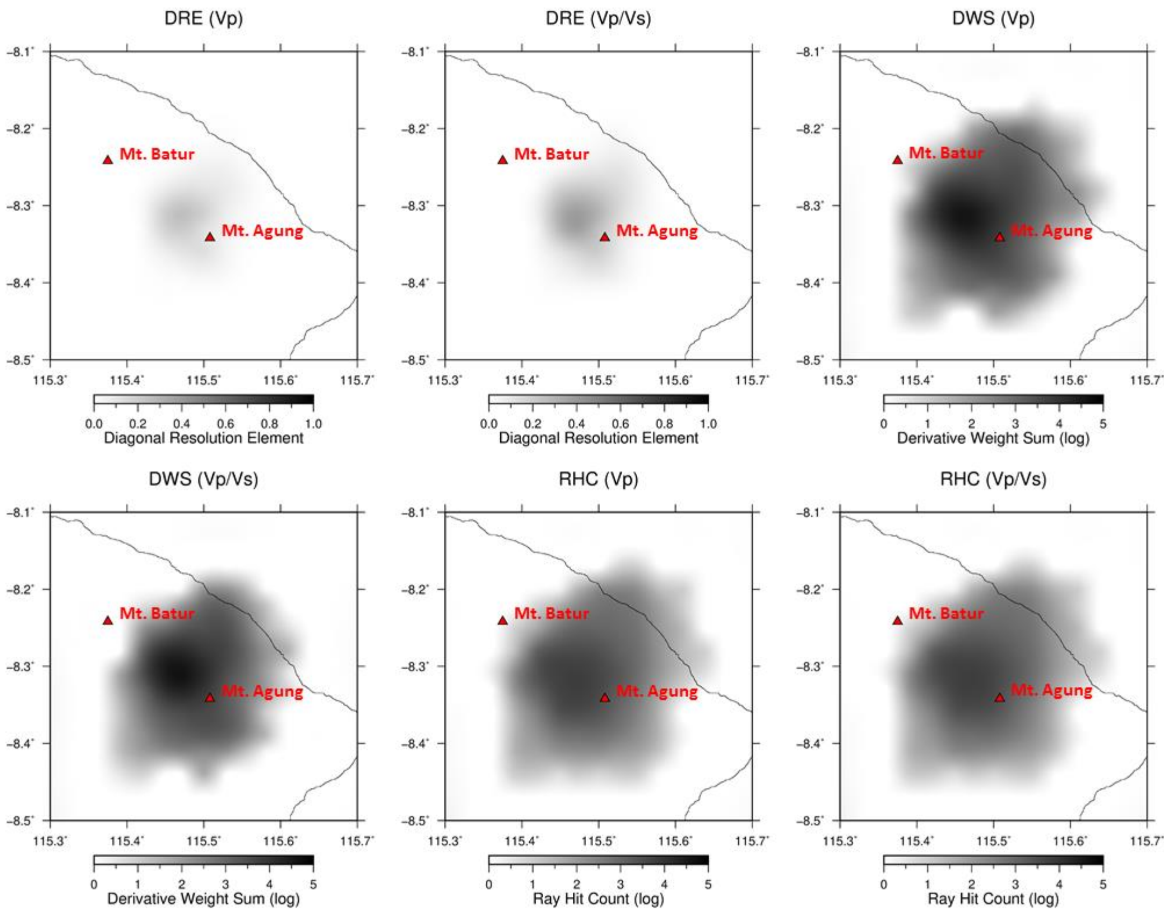

Figure S13. Same as Figure S11 but for a depth of 8 km.

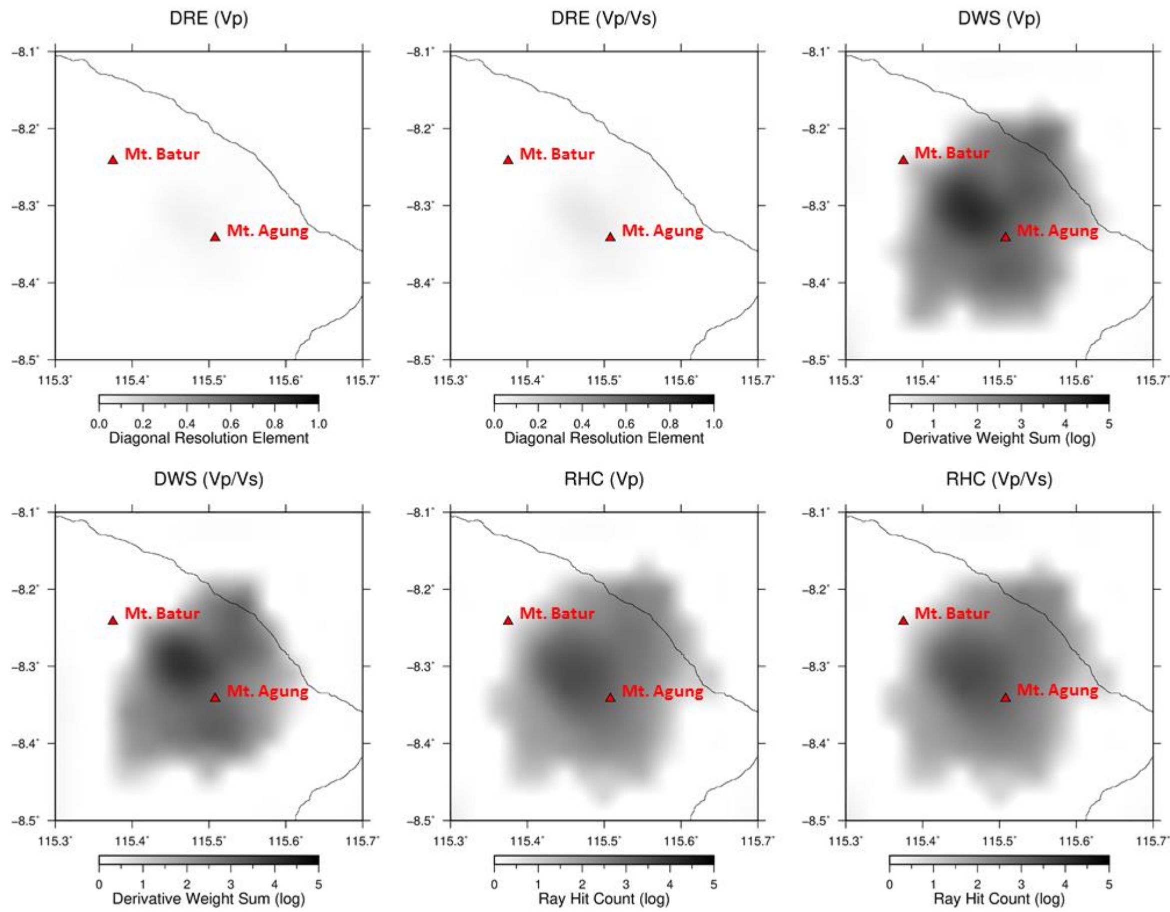

Figure S14. Same as Figure S11 but for a depth of 12 km.

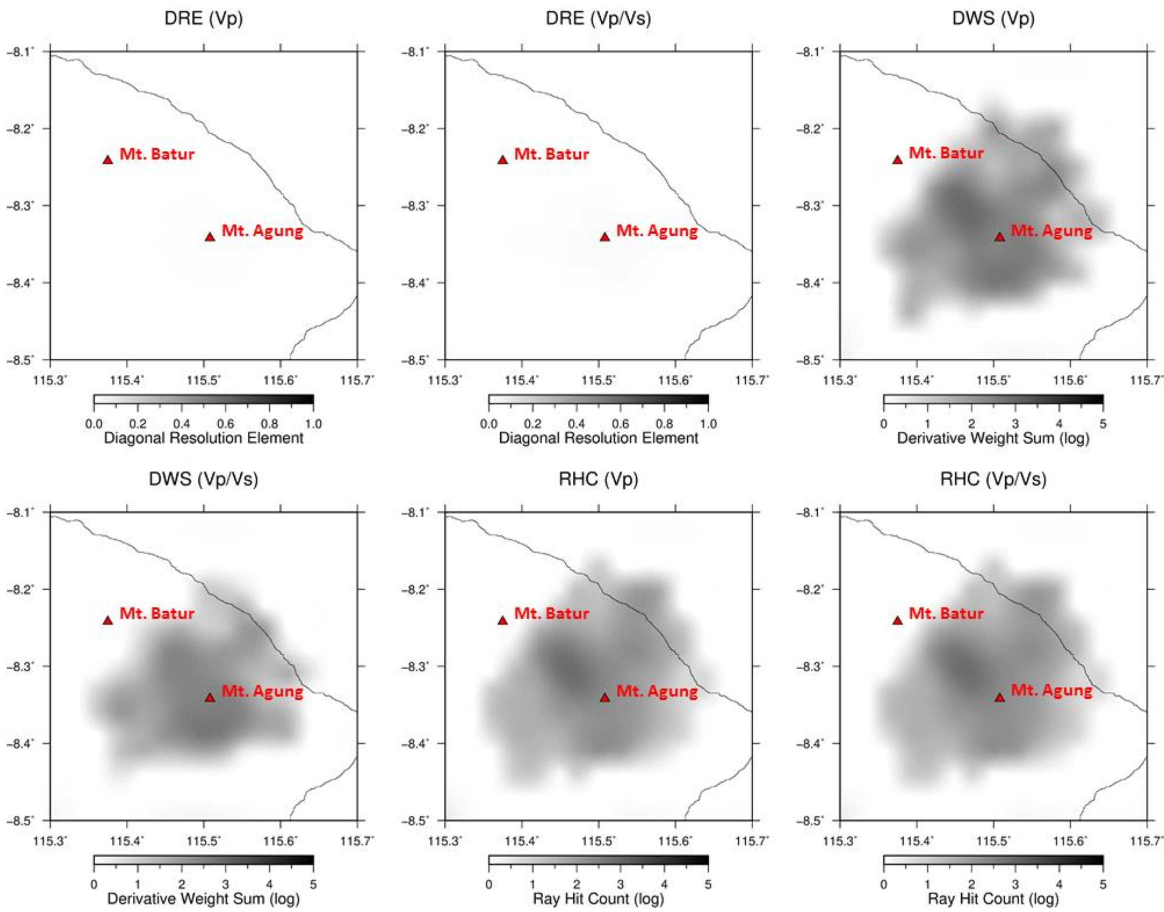

Figure S15. Same as Figure S11 but for a depth of 16 km.

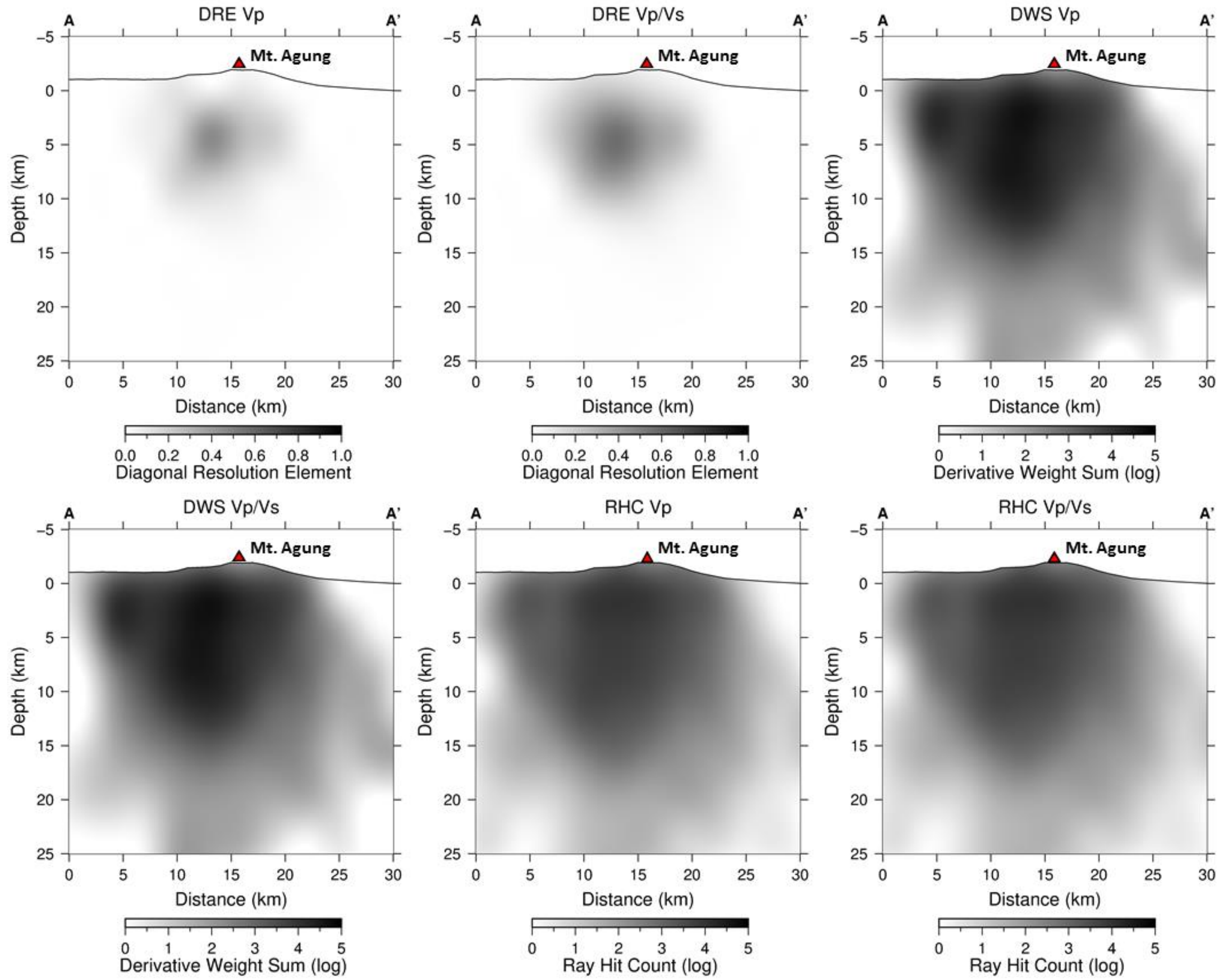

Figure S16. A-A' vertical cross section for DRE of Vp, DRE of Vp/Vs ratio, DWS of Vp, DWS of Vp/Vs ratio, RHC of Vp, and RHC of Vp/Vs ratio. DWS and RHC are plotted on a logarithmic scale. DRE value varies between 0 (indicating unresolved) to 1 (resolved). Darker colors indicate higher RHC, DWS, and DRE values for both the Vp and Vp/Vs ratios.

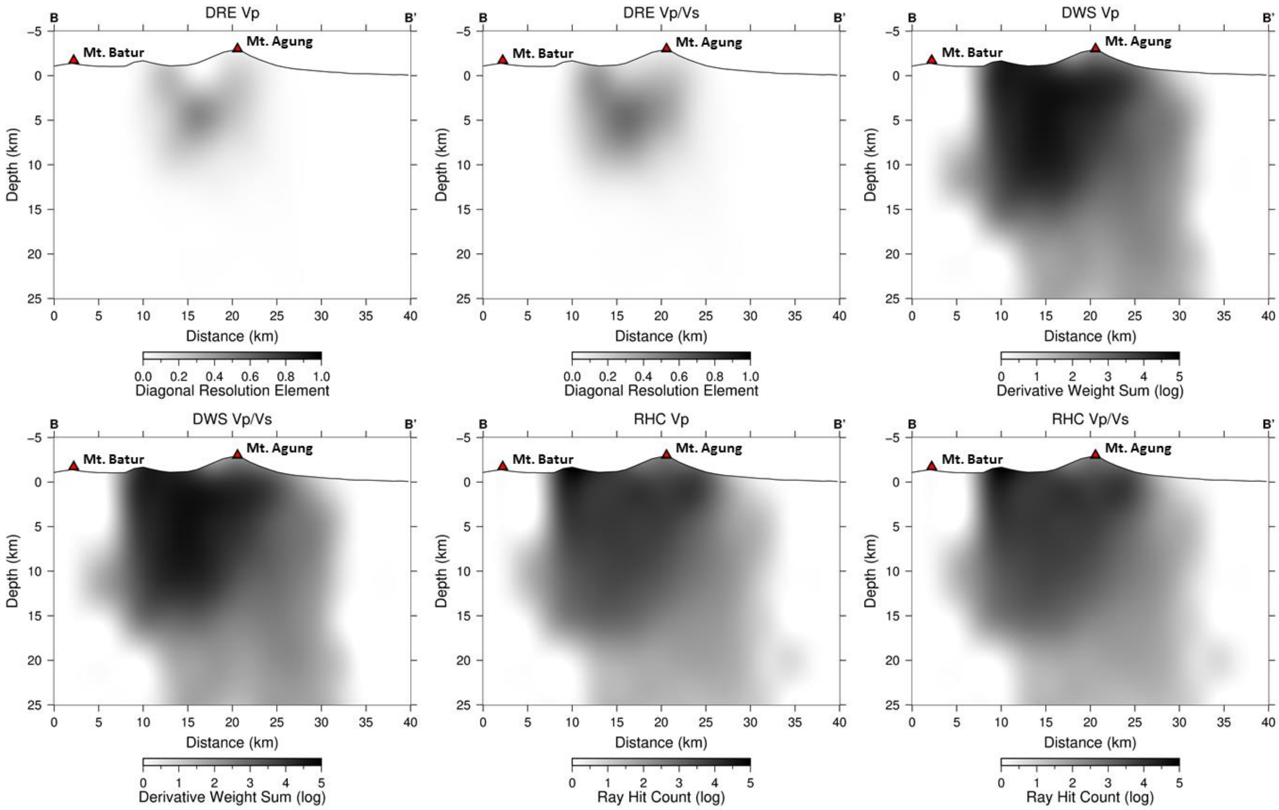

Figure S17. Same as Figure S16 but for B-B’ vertical cross-sections.

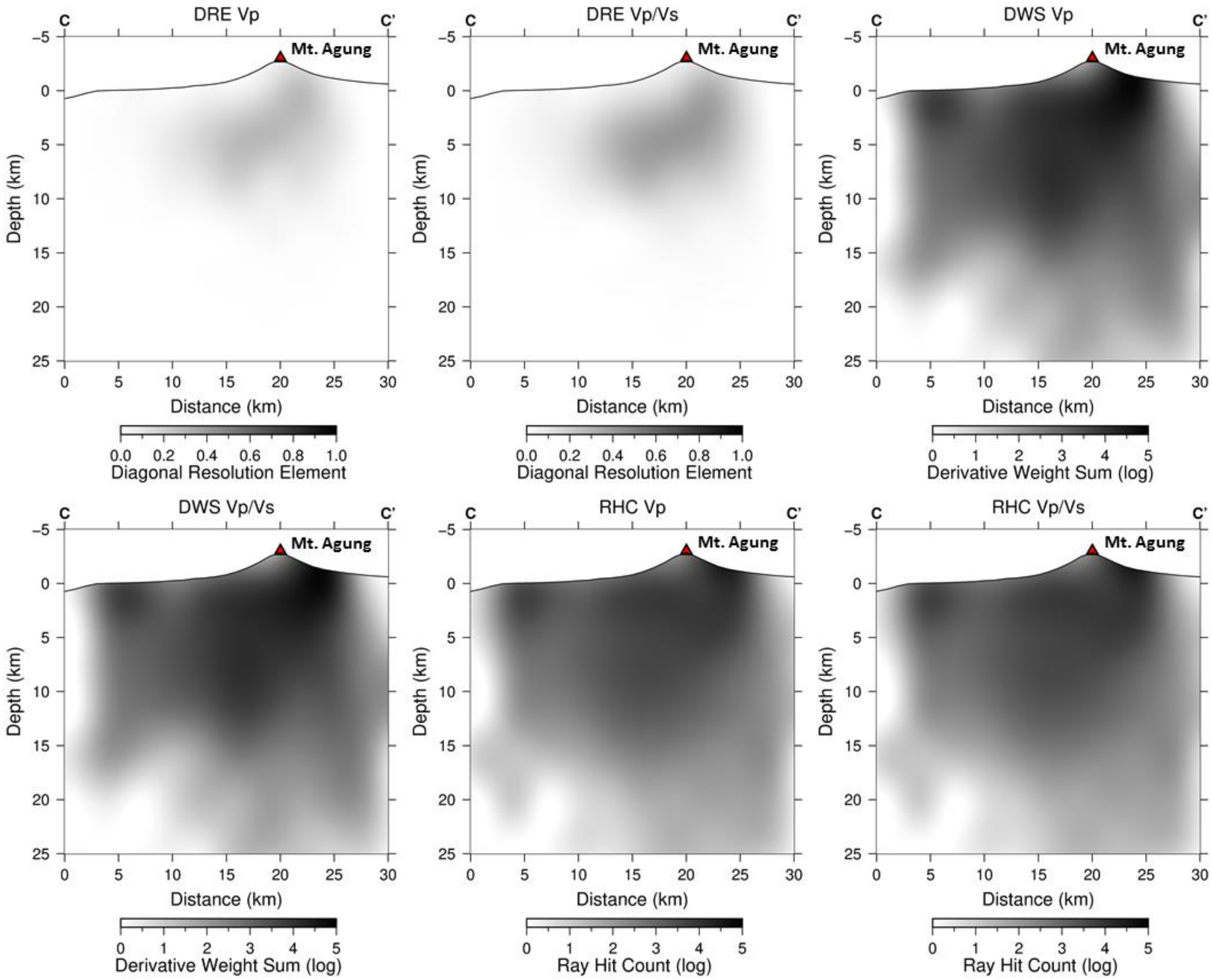

Figure S18. Same as Figure S16 but for C-C’ vertical cross-sections.

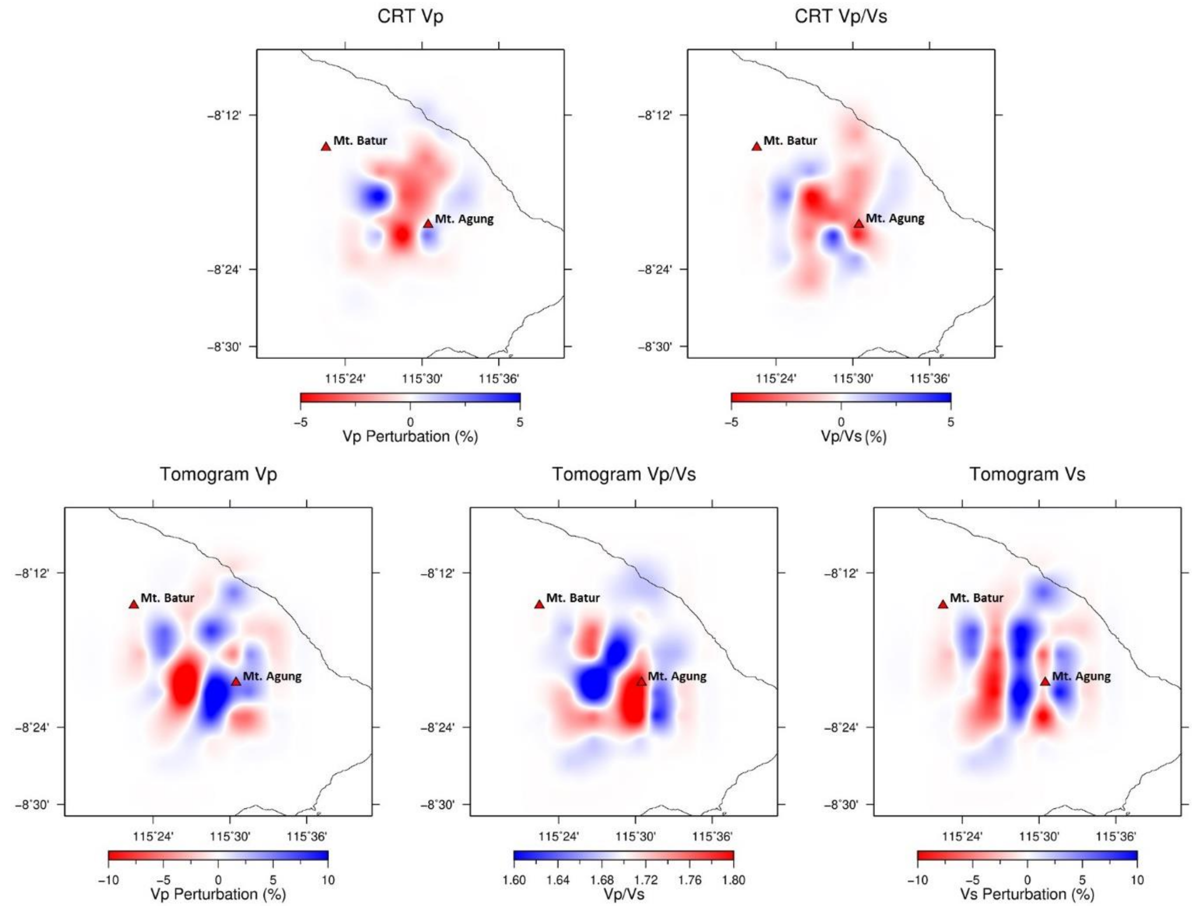

Figure S19. Horizontal slice at depth of 0 km for CRT recovery of Vp (top left) and CRT recovery of Vp/Vs ratio (top right), Vp structure (bottom left), Vs structure (mid-bottom) and Vp/Vs structure (bottom right). Vp and Vs are plotted as percent perturbations relative to the 1-D initial velocity model, and Vp/Vs are plotted as absolute values. Red and blue colors represent low and high velocity anomalies for Vp, Vs, and inverted for Vp/Vs ratios.

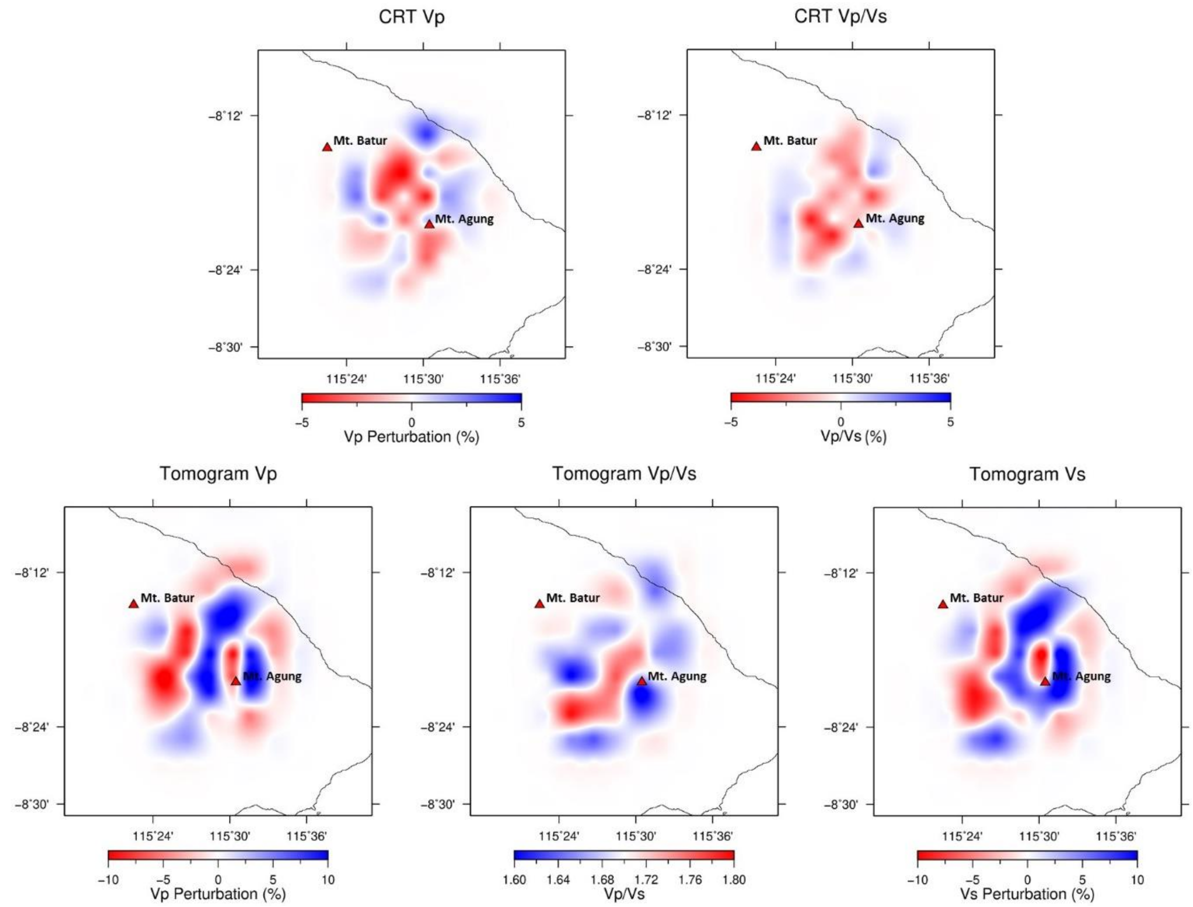

Figure S20. Same as Figure S19 but for a depth of 4 km.

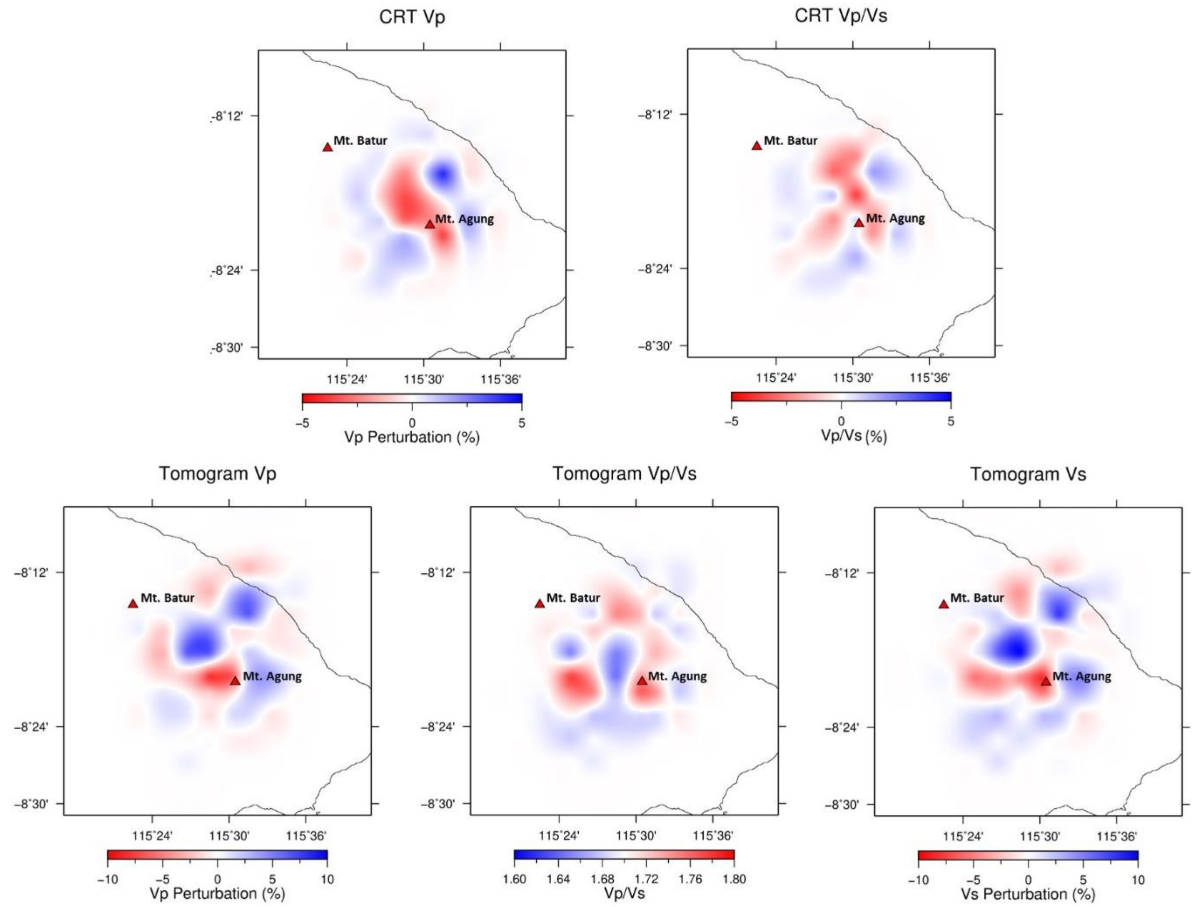

Figure S21. Same as Figure S19 but for a depth of 8 km.

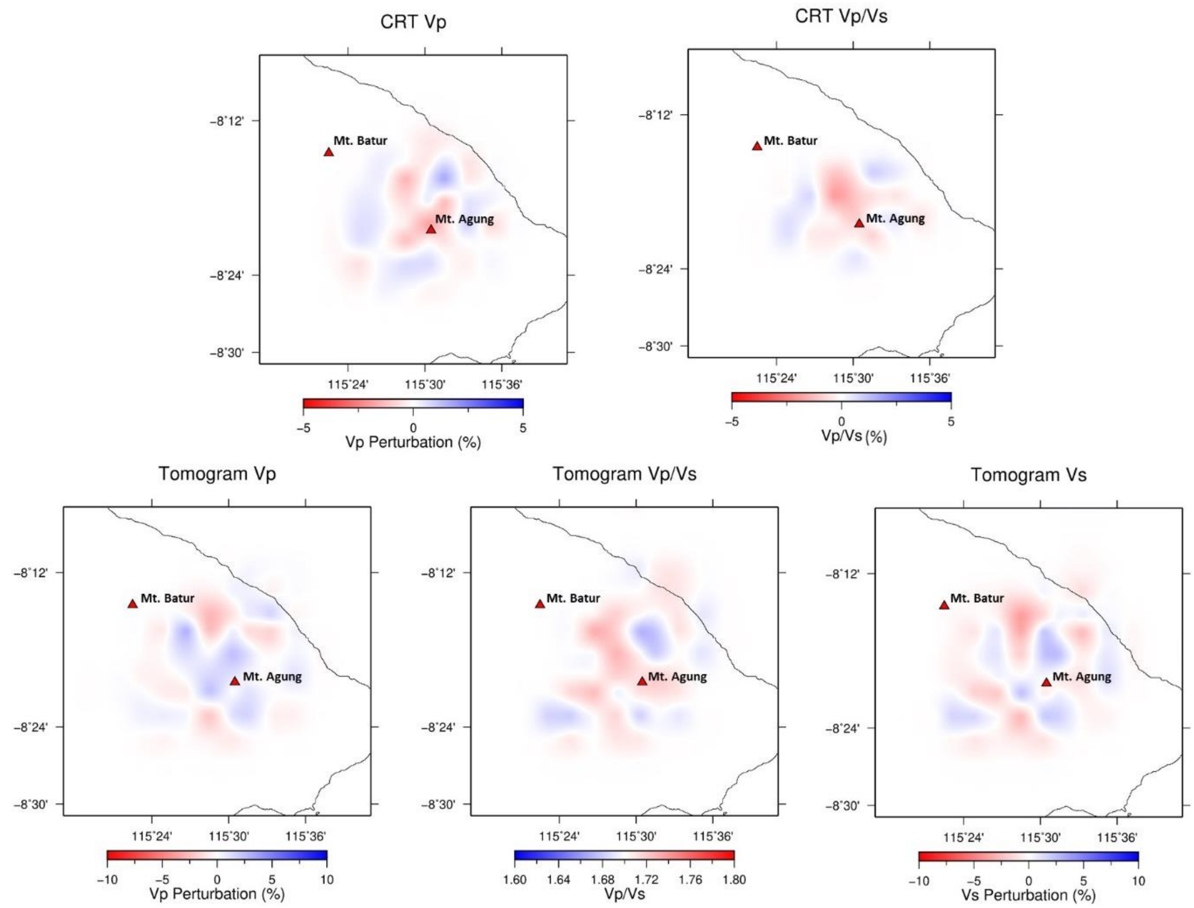

Figure S22. Same as Figure S19 but for a depth of 12 km.

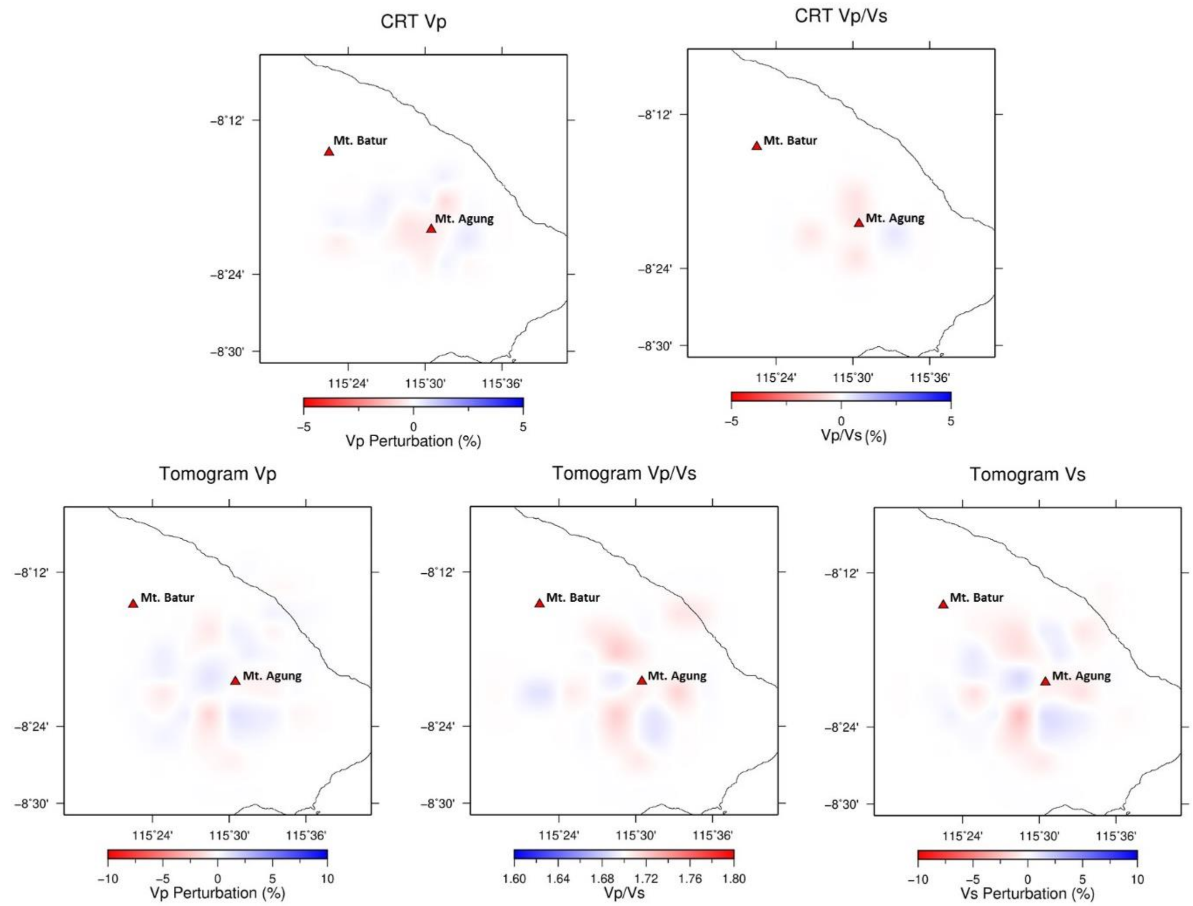

Figure S23. Same as Figure S19 but for a depth of 16 km.

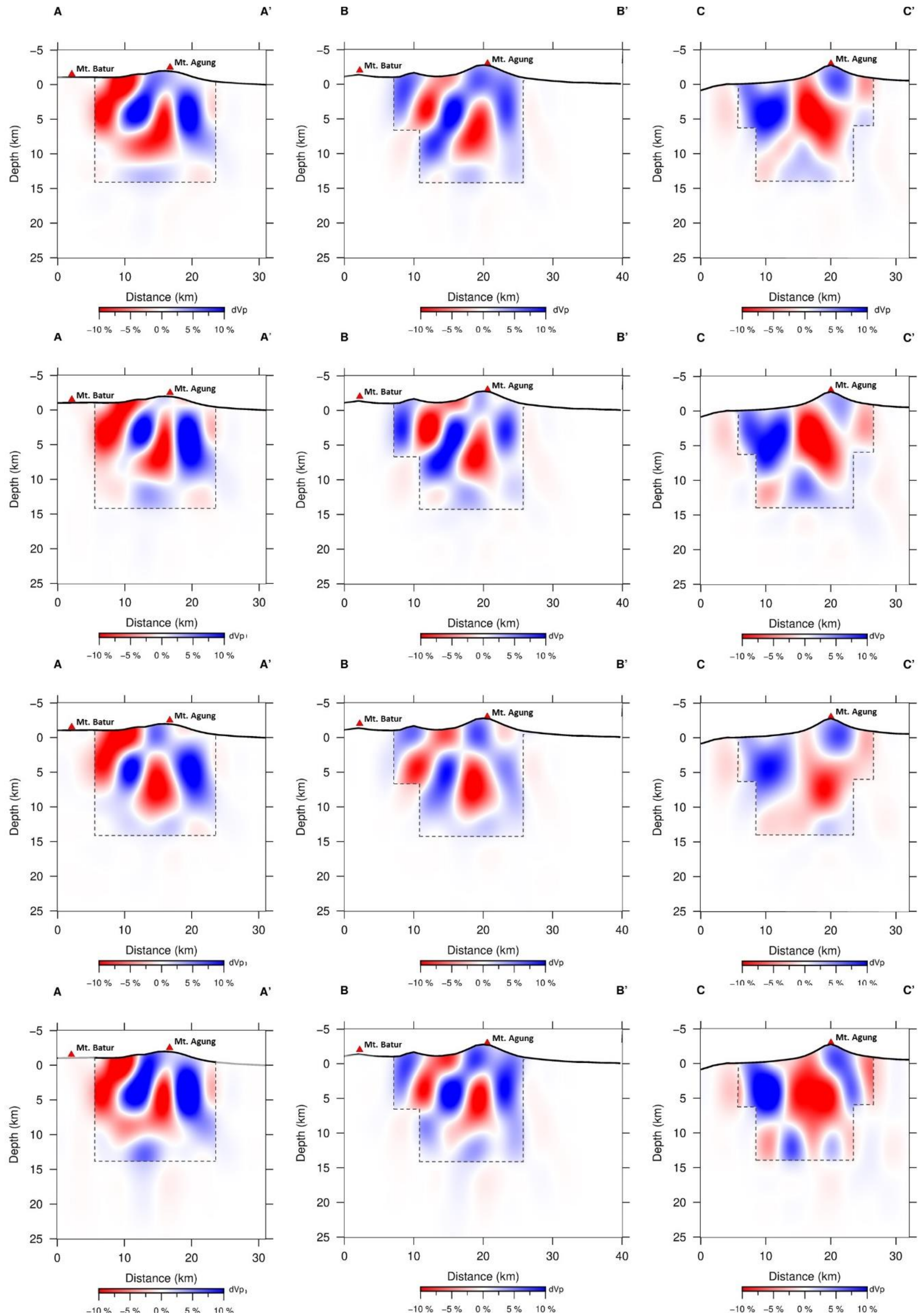

Figure S24. The vertical cross-sections of the Vp, for initial grid position, shifted 1km upward, eastward, and northward from top to bottom, respectively; for slice A-A′ (first column), B-B′ (second column), C-C′(third column), the spatial location of each cross-section can be seen in Figure 1c. Dashed black lines define the area which has a good resolution based on resolution test results.

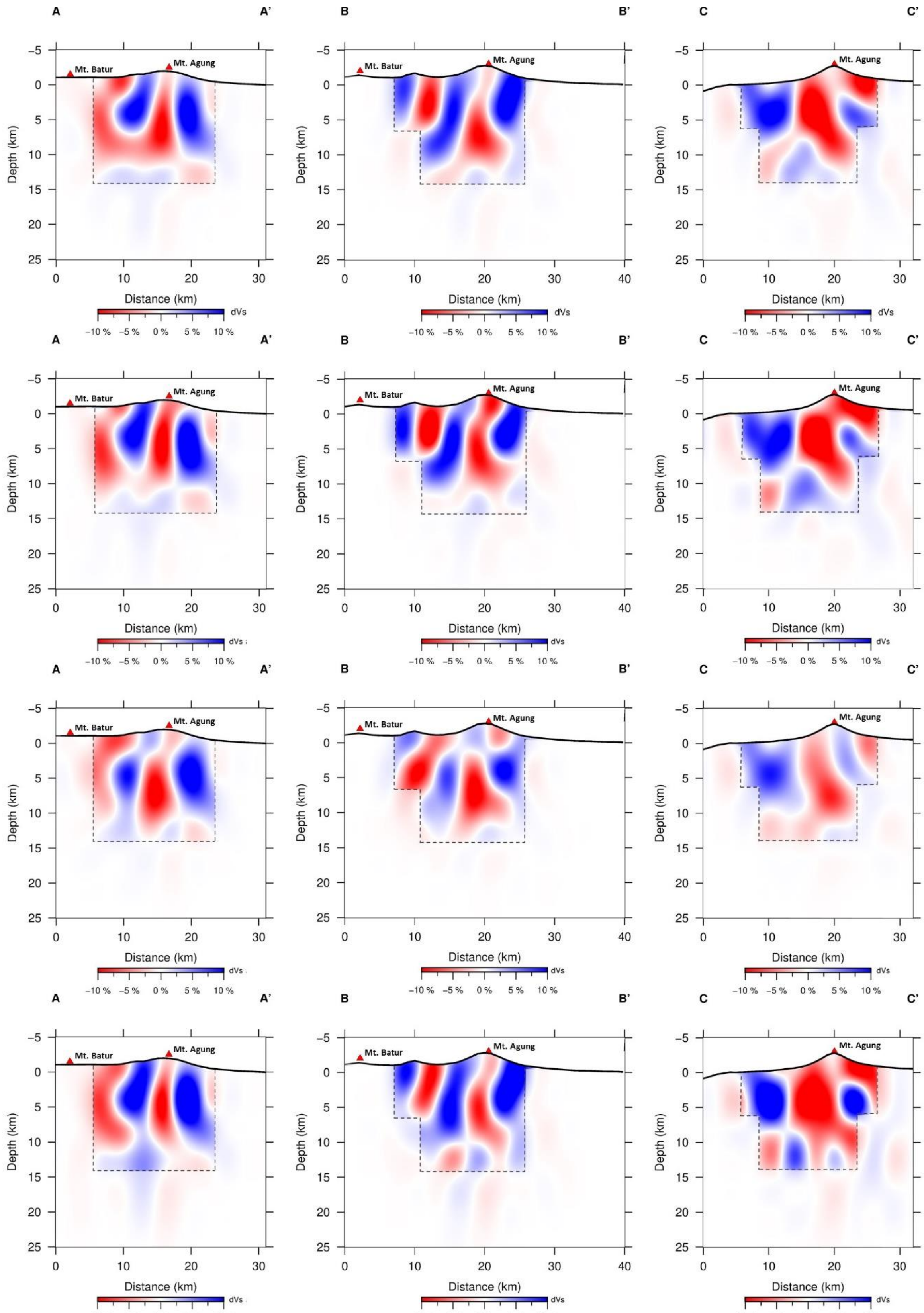

Figure S25. Same as Figure S24 but for Vs.

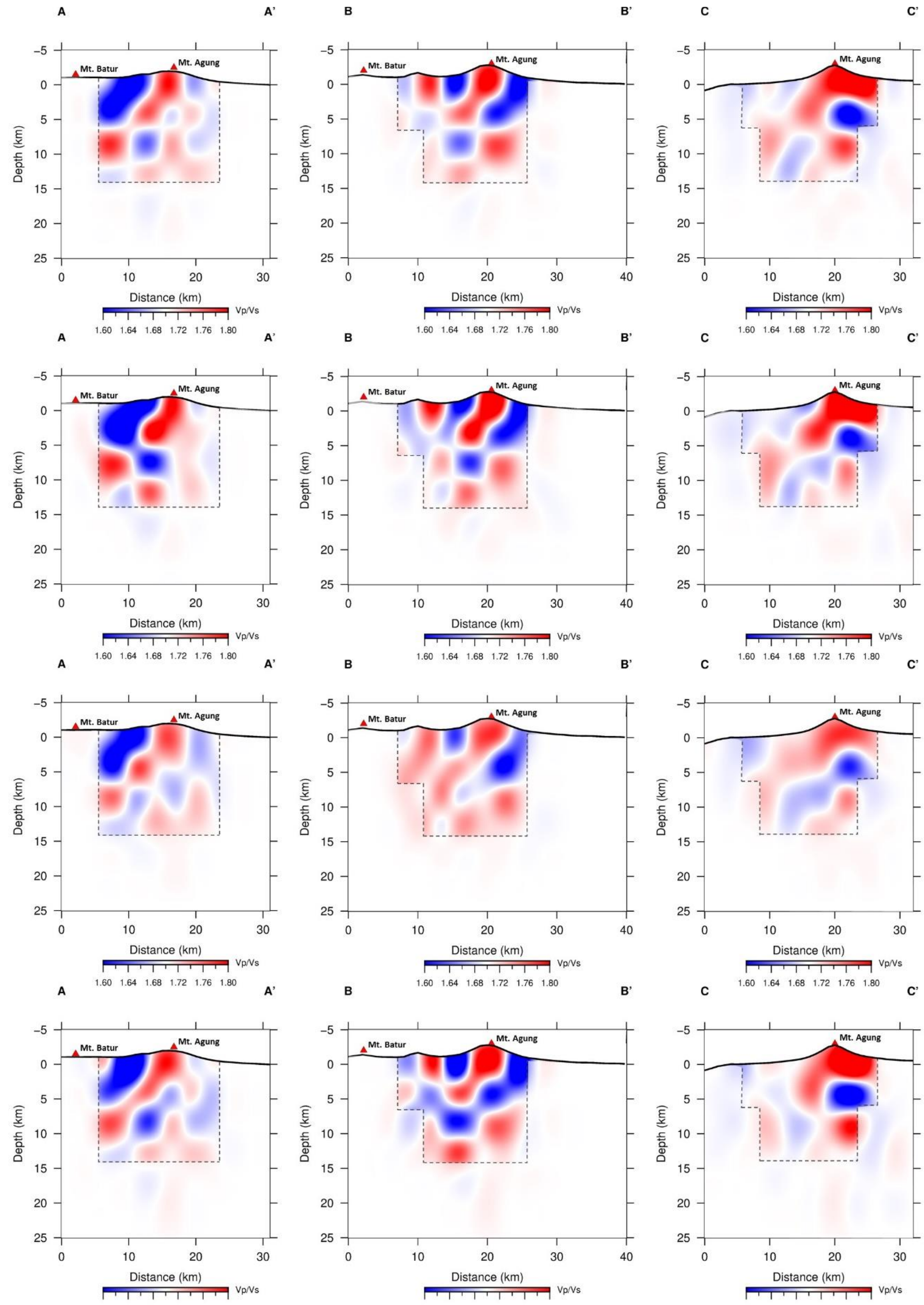

Figure S26. Same as Figure S24 but for Vp/Vs.

Refrences

Koulakov, I., Jakovlev, A., and Luehr, B. G. (2009): Anisotropic structure beneath central Java from local earthquake tomography. *Geochemistry Geophysics Geosystems*. 10(2): Q02011. doi: 10.1029/2008GC002109

Sahara, D. P., Rahsetyo, P. P., Nugraha A. D., Syahbana, D. K., Widiyantoro, S., Zulfakriza, Z., et al. (2020). Analysis of VT Events Preceeding 2017 Agung Volcano Eruption Using Local Network (this issue)