Reconstruction of Subsurface Structures from Ambient Seismic Noise in Jakarta Area

Sri Widiyantoro[1]
Andri Dian Nugraha[1]
Zulfakriza[2]
Bayu Pranata[3]

[1] Global Geophysics Research Group, Faculty of Mining and Petroleum Engineering, ITB
[2] Ph. D. student, Faculty of Earth Science and Technology, ITB
[3] Meteorological, Climatological and Geophysical Agency (BMKG), Jakarta

Outline

- Introduction
- Motivation
- Data and Method
- Presentation of Tomograms
- Discussion
- Conclusions
- Further Work

Introduction

- Indonesia is one of regions with high seismic activity in the world.
- Understanding of shallow subsurface structure is necessary to reduce risk of seismic hazard.
- Seismic Ambient Noise Tomography (ANT) represents an efficient tool to image the shallow subsurface structure, especially for Jakarta (as no active seismic sources needed).
- Dense seismographic stations are available in the Jakarta area.

Motivation

- Capital city of the Republic of Indonesia
- Most densely populated territory

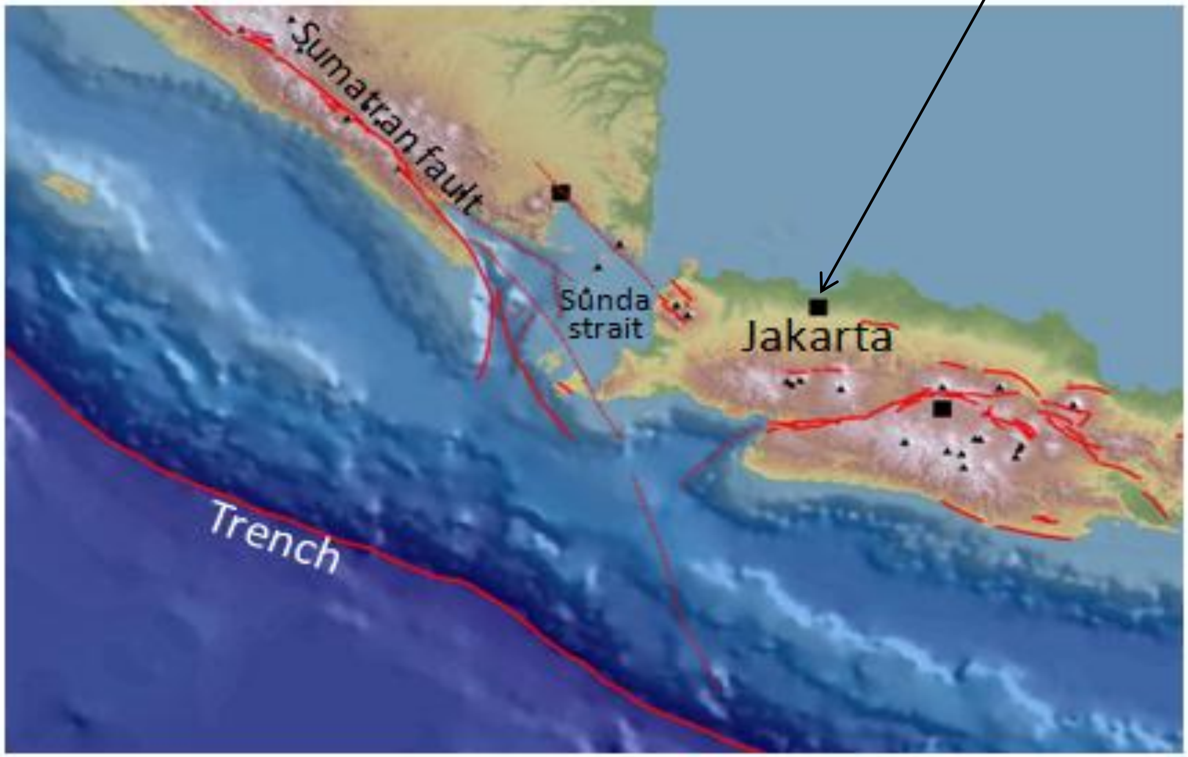


Figure 1. Tectonic complexity of Jakarta and its vicinity (courtesy of Dr. D. H. Natawidjaja, 2013). Thin red lines depict faults in the study region. Thick red line in the ocean depicts the Sunda trench, where the Indian oceanic lithosphere is being subducted beneath the Sunda arc.

Data

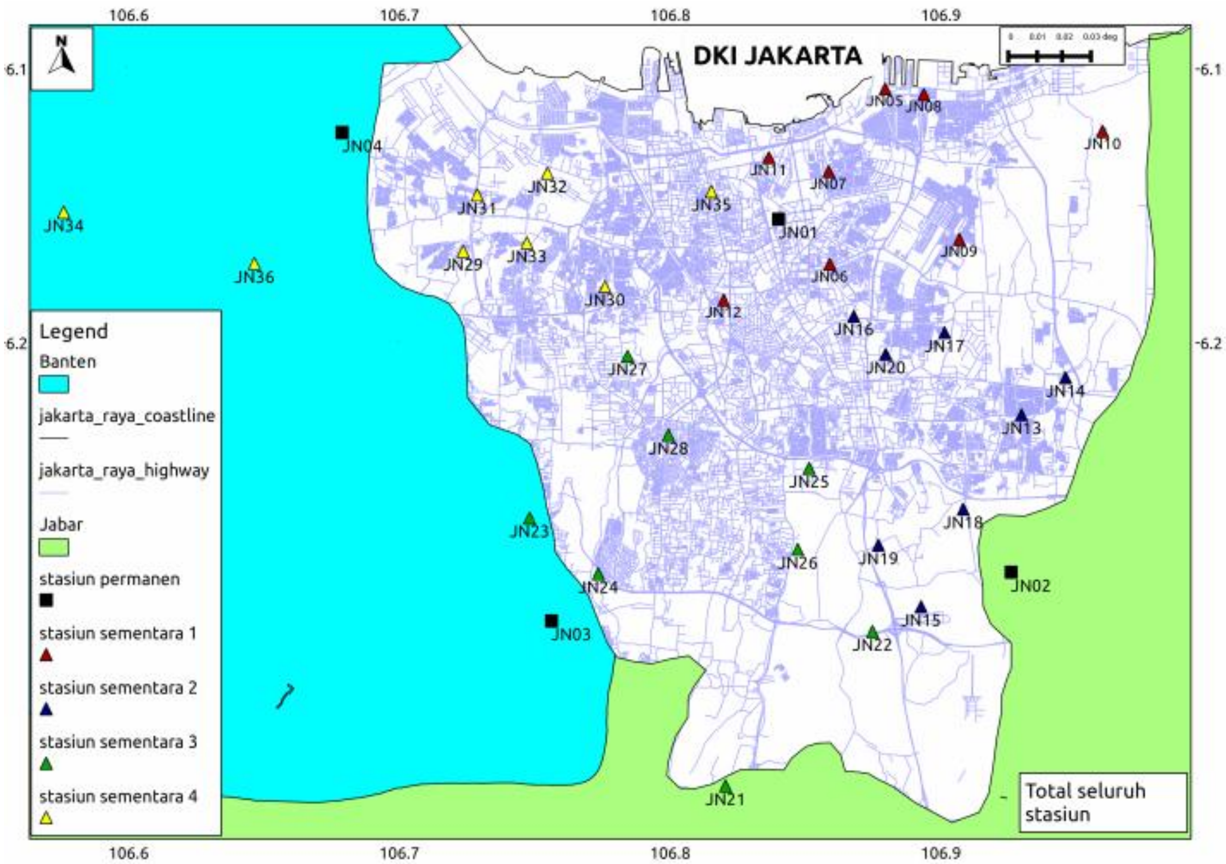


Figure 2. Seismographic station network in Jakarta and its surrounding areas that includes 4 permanent stations (black squares) and 8 temporary stations (colored triangles) that were moved around. The difference in the color of triangles indicates the difference in the period of instrument installation.

Waveform Data

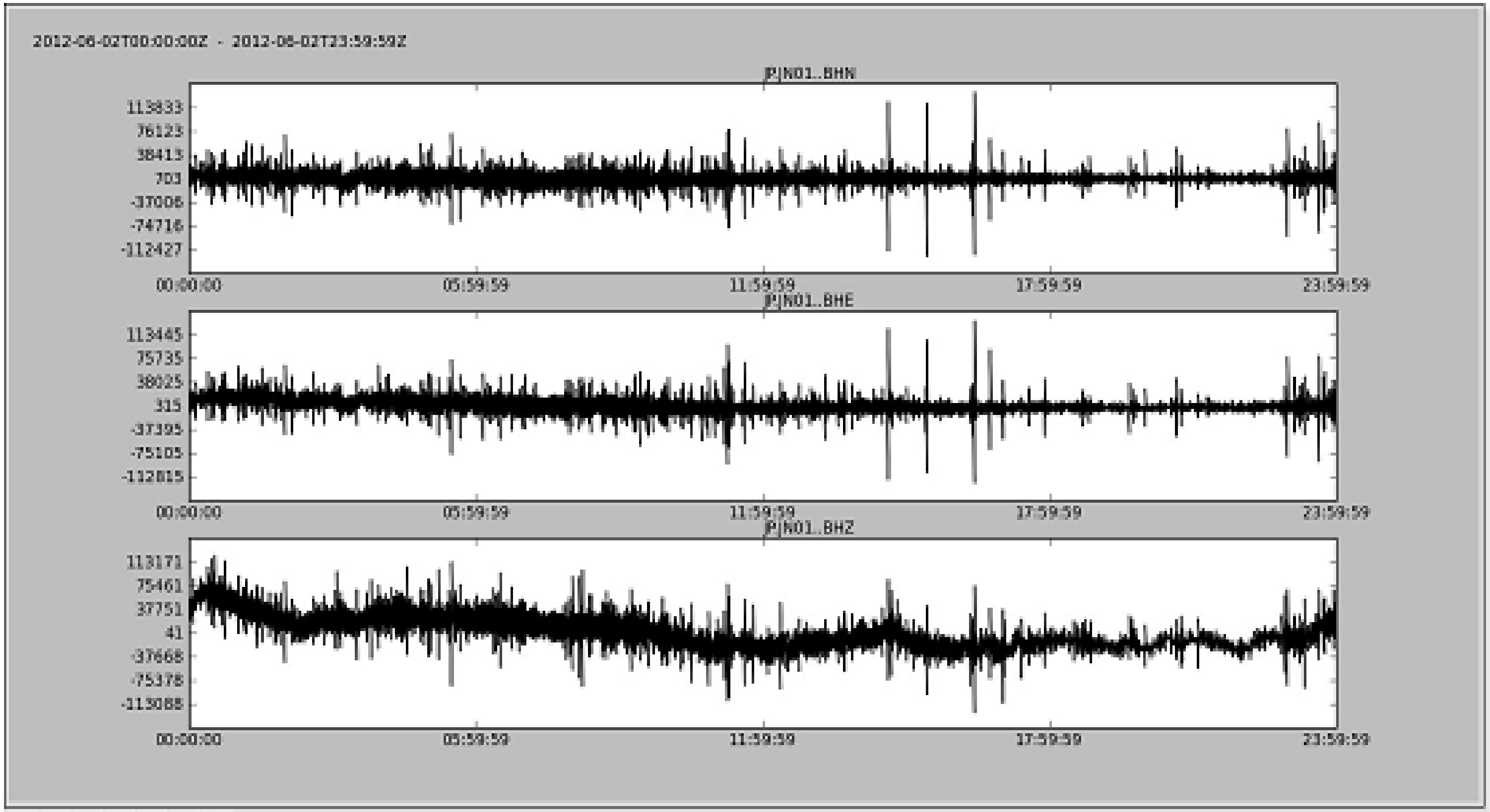


Figure 3. Example of three-component seismographic recordings at station JN01 for 24 hours; N-S component (top), E-W component (middle), and vertical component (bottom).

Instrument

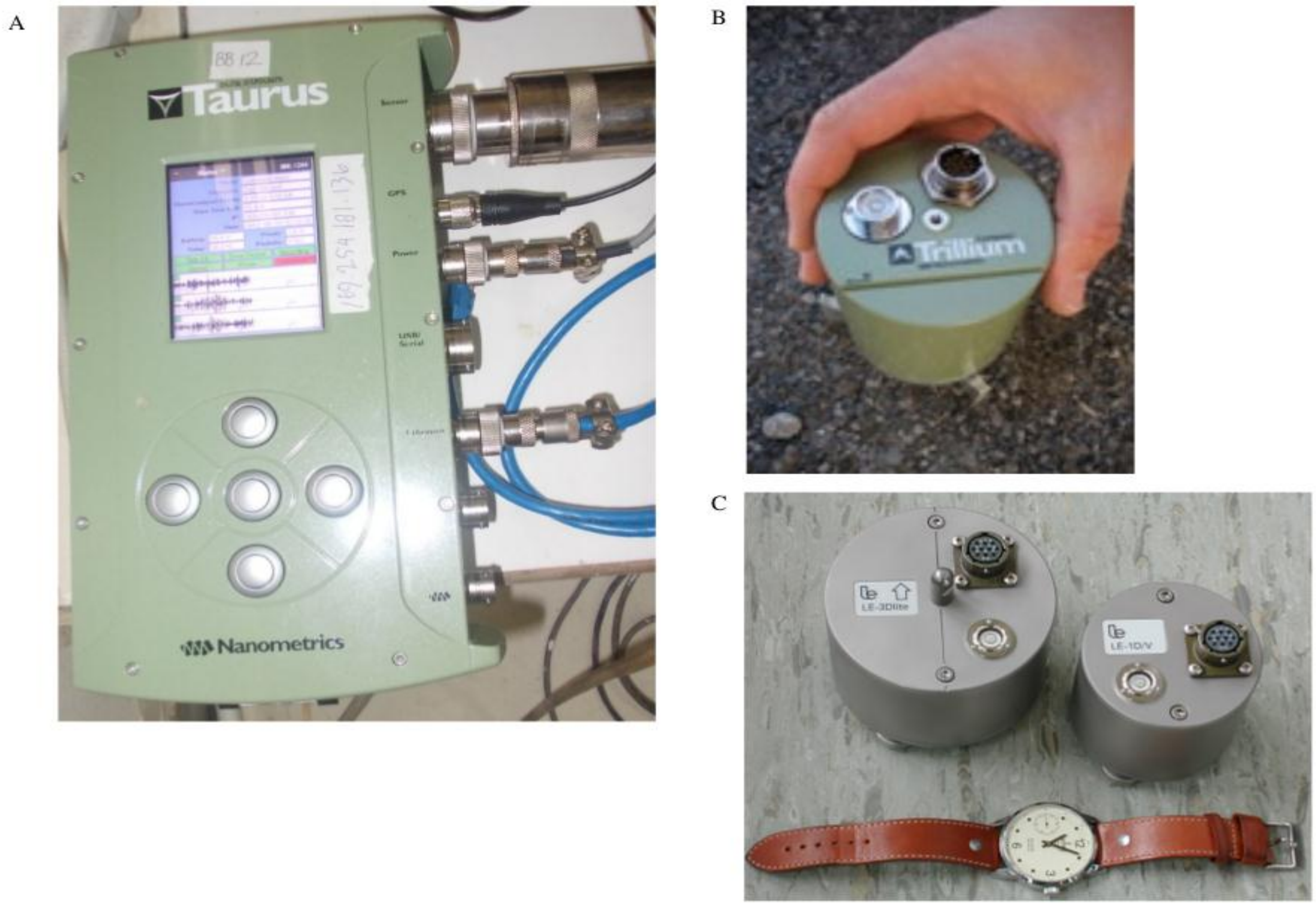


Figure 4. Example of seismometer used in the observation.

Method of Cross Correlation

Prepare daily SAC file for each stations

Create time window and divide it of full day record segment

Average the cross correlation segment to create a daily estimate

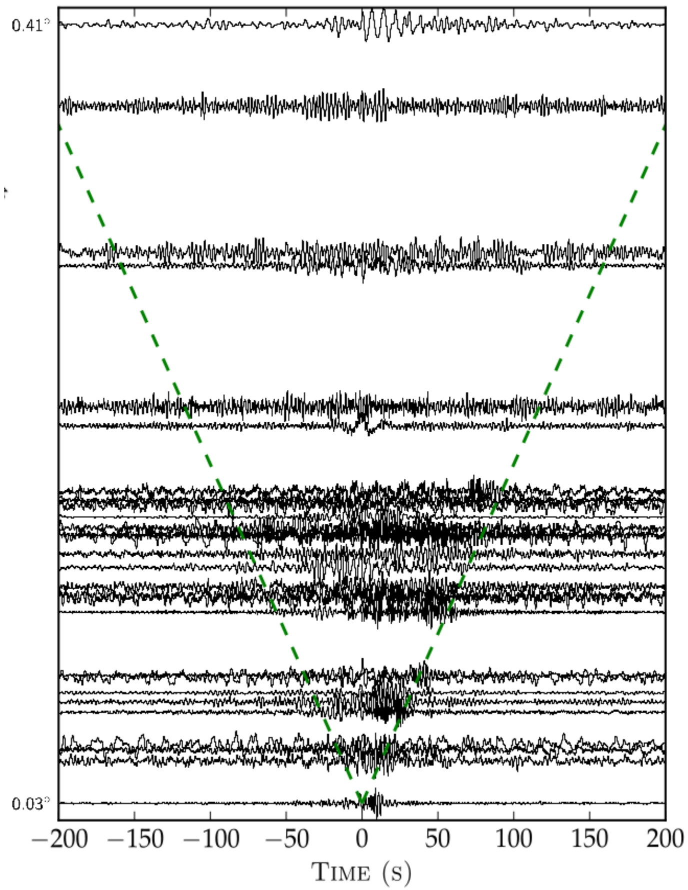
Stack all of the averaged Cross Correlation

Estimated the Green's Function

Compute the group velocity using Multiple Filter Analysis

Waveform Cross Correlation

A



B

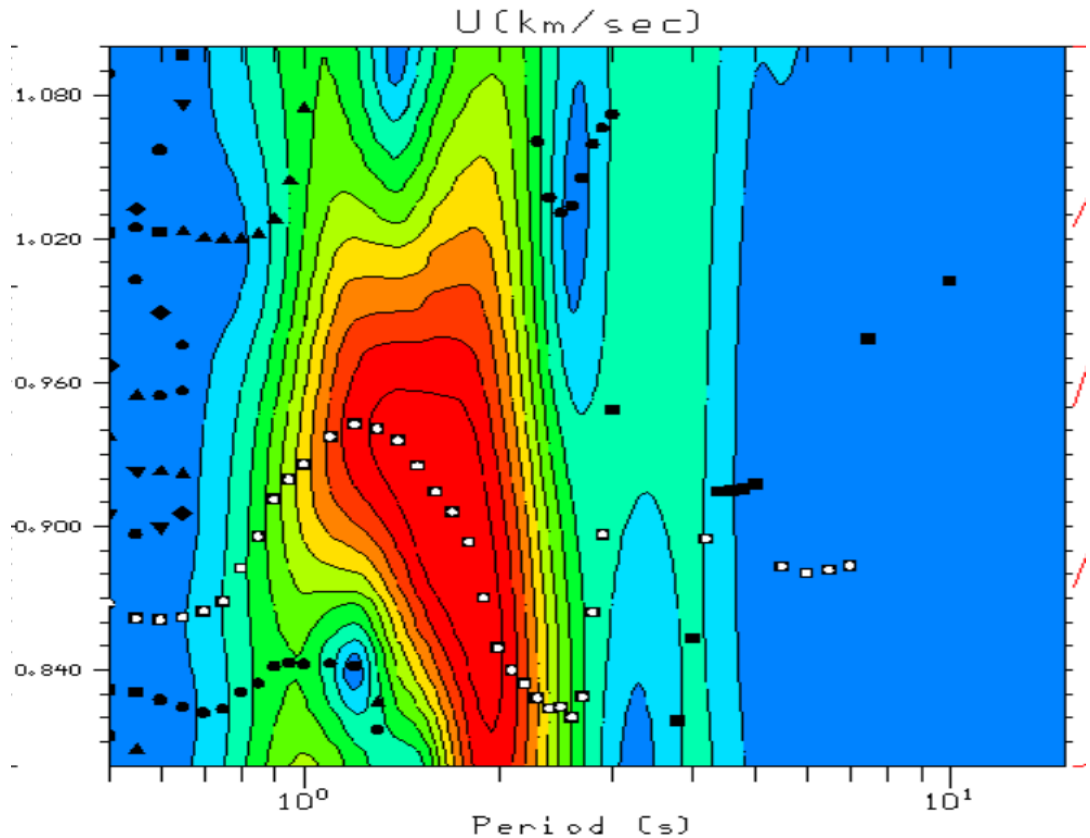


Figure 5. A) Example of waveform cross correlation between station JN02 and other stations. B) Example of dispersion curve of stations JN02 and JN26.

Resolution Test

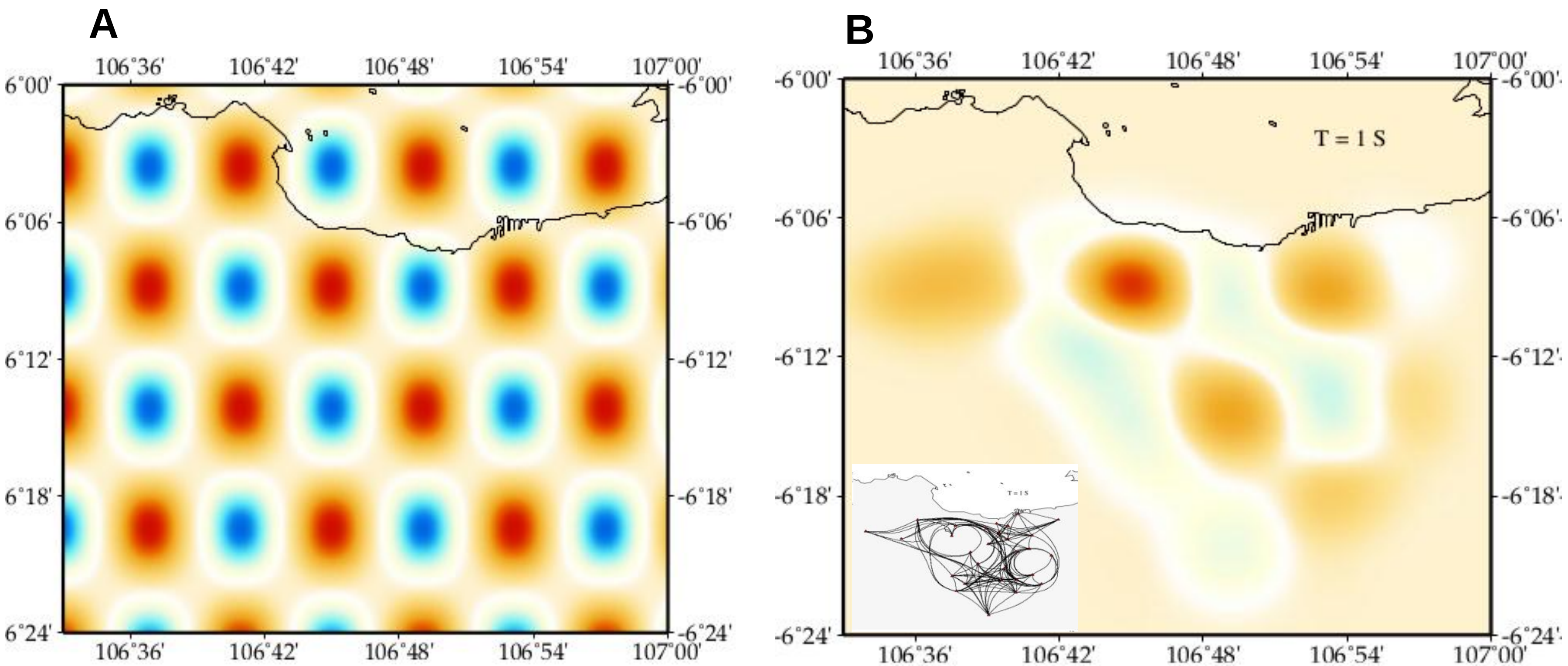


Figure 6. A) Input pattern for checkerboard test using 60 x 60 grid points (cell size = 1.85 km x 1.85 km). B) Recovery of the checkerboard pattern for period = 1.0 sec; ray path coverage (for period = 1.0 sec) is shown in the inset.

Presentation of Tomograms

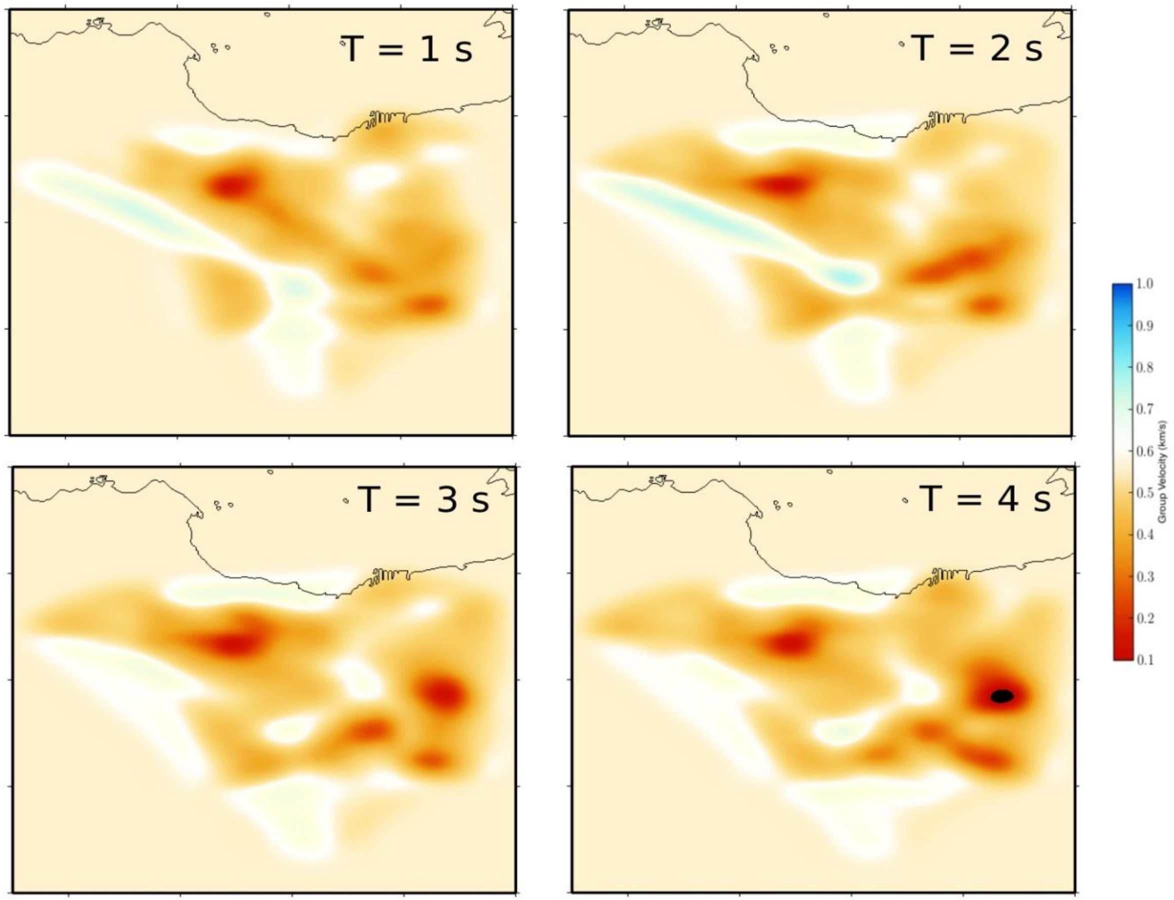


Figure 7. Tomographic images of ambient seismic noise cross correlation beneath Jakarta and its vicinity produced using conventional method for period = 1 sec, 2.0 sec, 3.0 sec and 4.0 sec.

Discussion

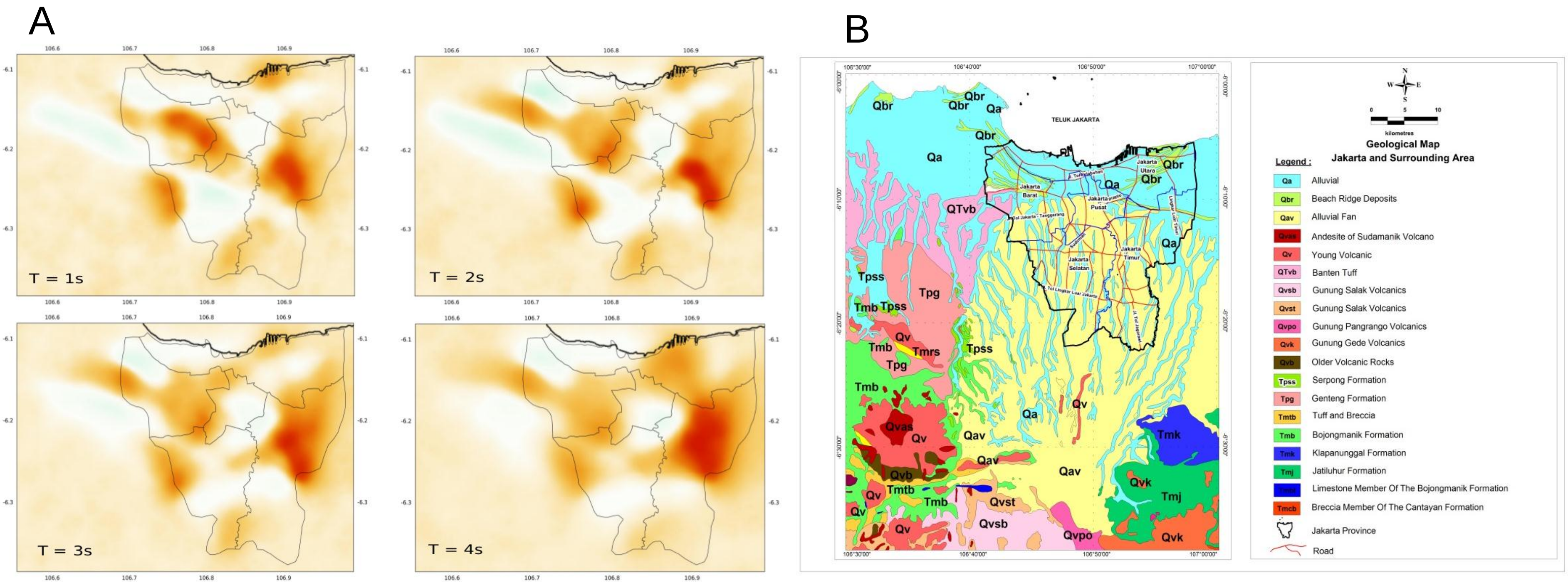


Figure 8. A) Tomographic images of ambient seismic noise cross correlation beneath Jakarta and its vicinity produced using Bayesian trans-dimensional inversion for periods = 1,0 sec, 2.0 sec, 3.0 sec and 4.0 sec. B) Geological map for Jakarta and surrounding area (Modified from Turkandi et al., 1992 and Effendi et al., 1998).

Discussion (*cont.*)

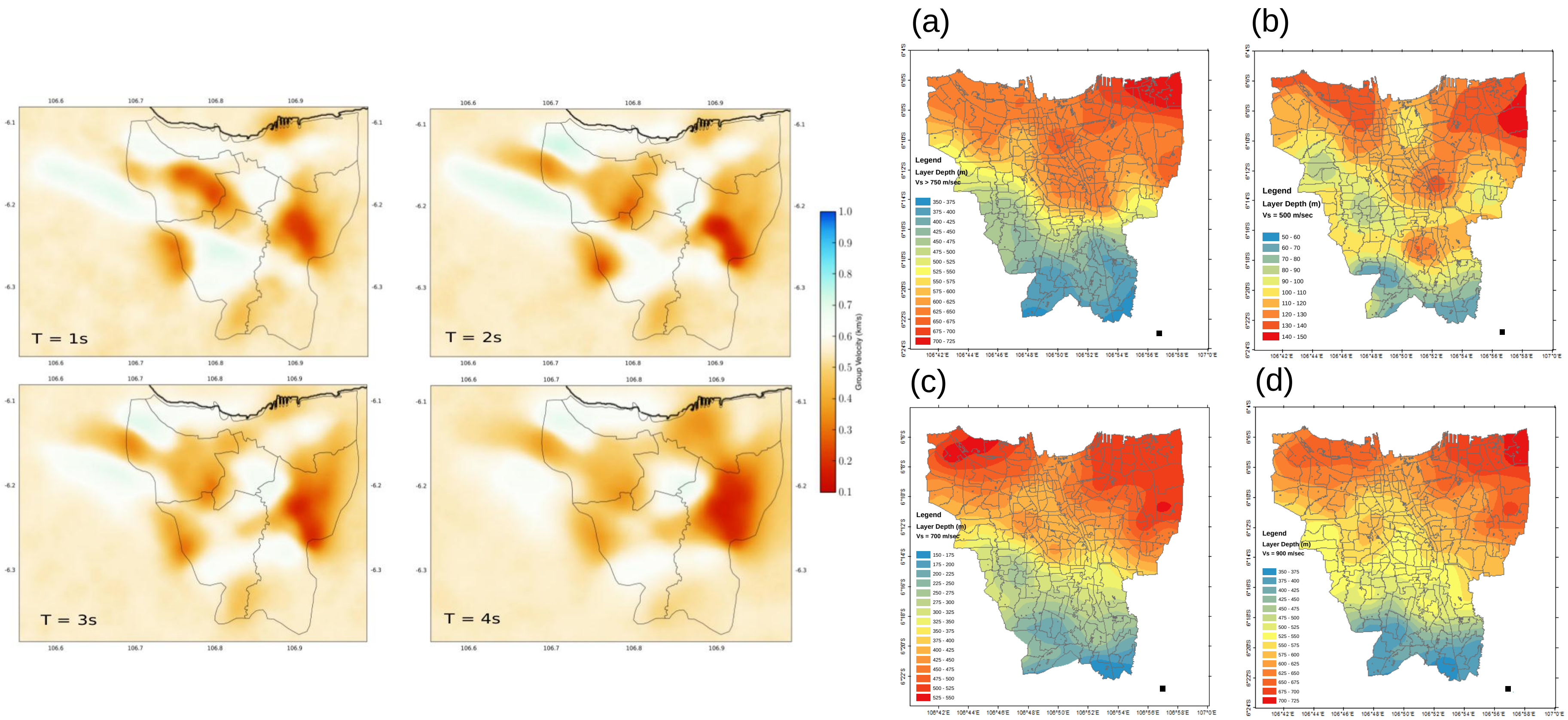


Figure 9. Tomographic images of ambient seismic noise cross correlation vs results of microtremor studies (Ridwan and co-workers, on going project); maps of layer depths for (a) Vs > 750 m/sec, (b) Vs = 500 m/sec, (c) Vs = 700 m/sec, and (d) Vs = 900 m/sec.

Conclusions

- Resulting tomographic images depict that the study region (Jakarta and its vicinity) is mostly underlain by pronounced low velocity anomalies.

- The observed low velocity anomalies are related to thick sedimentary layers, in particular in the northern part of Jakarta.

Futher Work

- Add more seismographic stations in the Jakarta area in order to achieve higher resolution images.
- Conduct more detailed analysis by applying azimuthal anisotropy using Rayleigh wave data.

Aknowledgments

- We thank the Asahi Glass Foundation for supporting this research.

- Thanks also go to P. R. Cummins and E. Saygin for their kind help with the data acquisition and fruitful discussions; M. Ridwan for providing his results from microtremor studies.

Publications (*in preparation*)

- Upper crustal structure of Jakarta and its surrounding areas from trans-dimensional seismic ambient noise tomography
- Azimuthal anisotropic structure beneath Jakarta and its vicinity from ambient noise tomography

Thank you for your kind attention

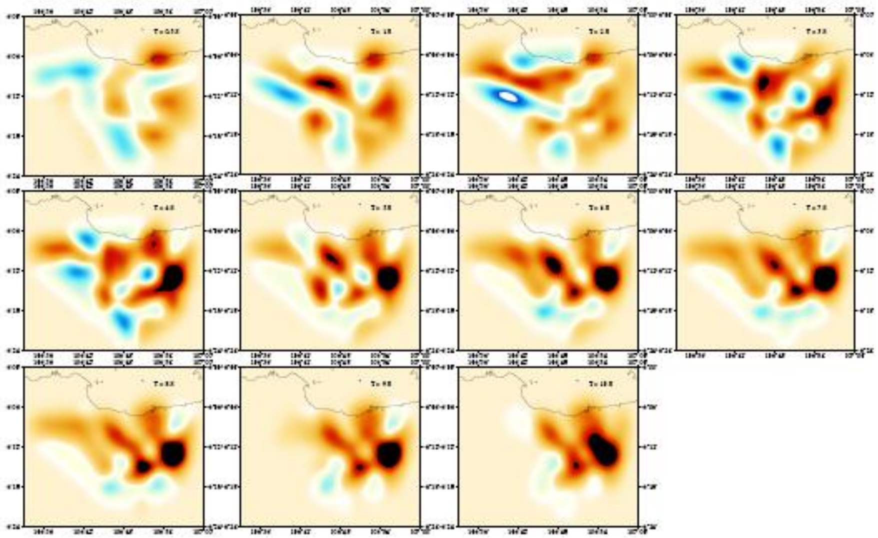
Supplementary Materials

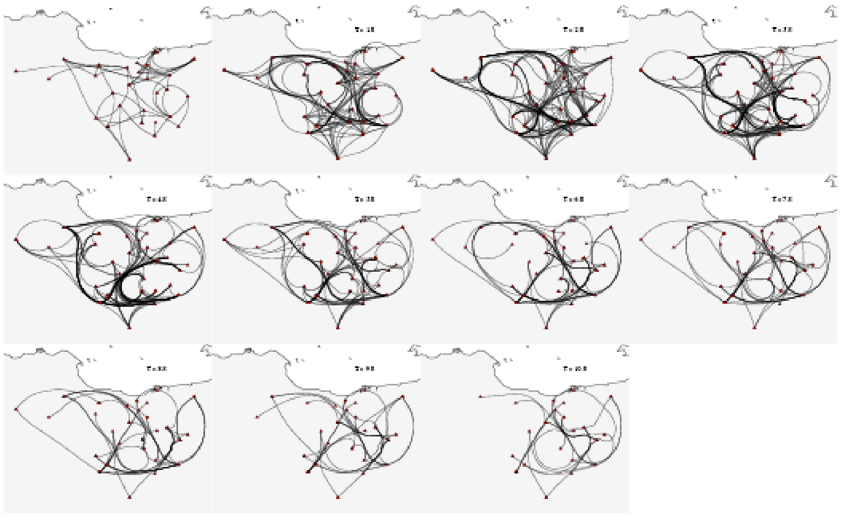
- Tomograms for periods ranging from 0.1 sec to 10.0 sec and their associated ray path coverage

- Checkerboard tests using different cell size, i.e., 1.85 km x 1.85 km, and 2.22 km x 2.22 km

Tomograms and ray path coverage

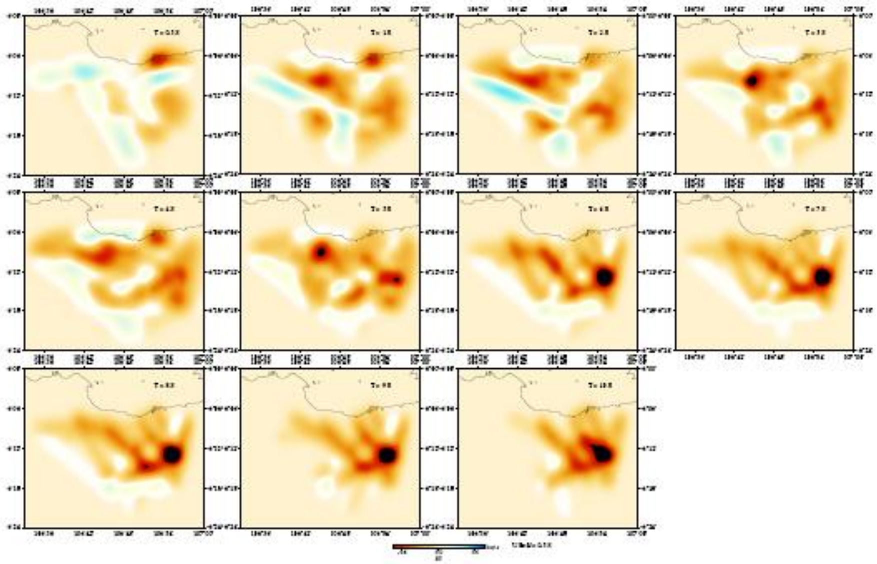
(using 50 x 50 grid points)

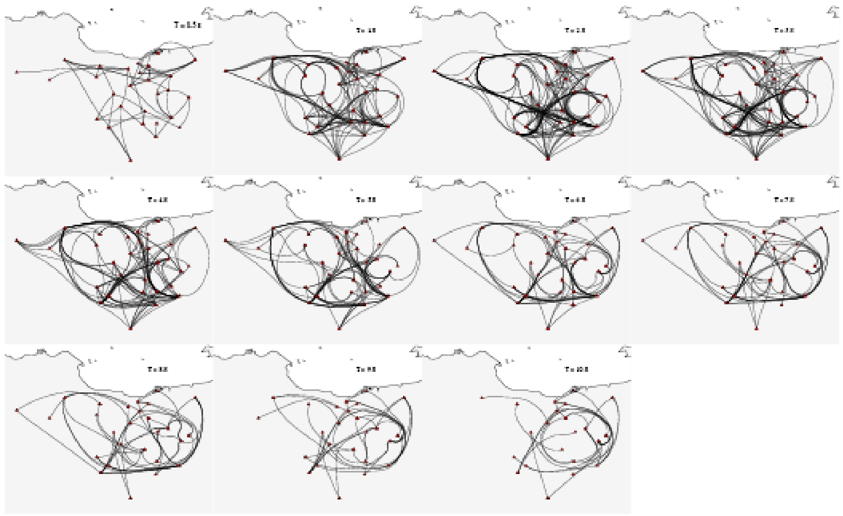




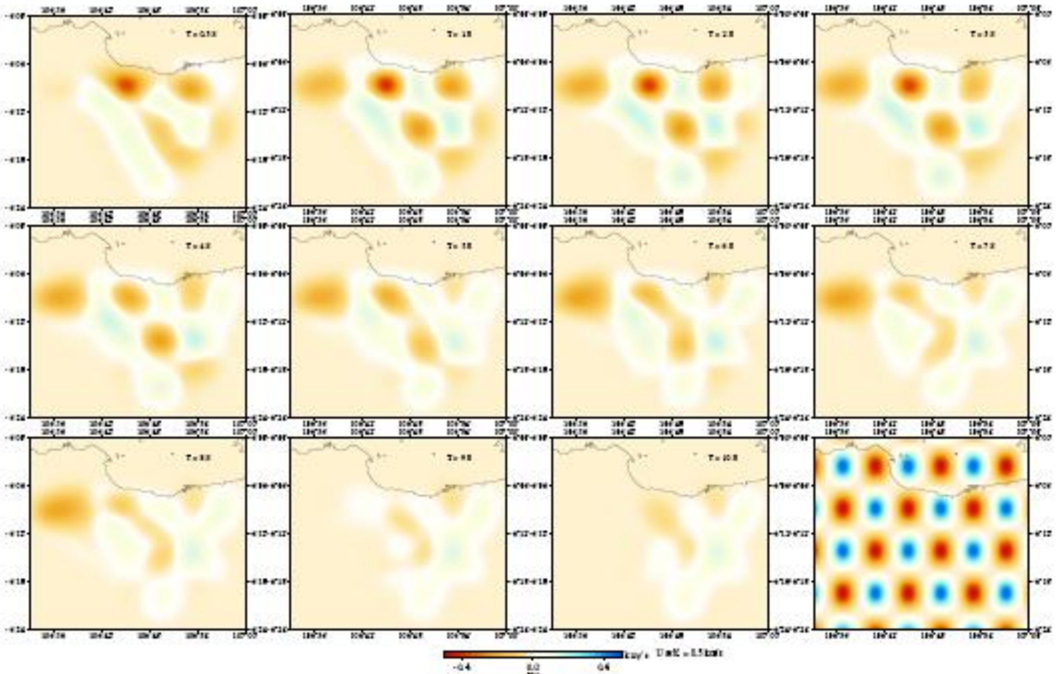
Tomograms and ray path coverage

(using 70 x 70 grid points)



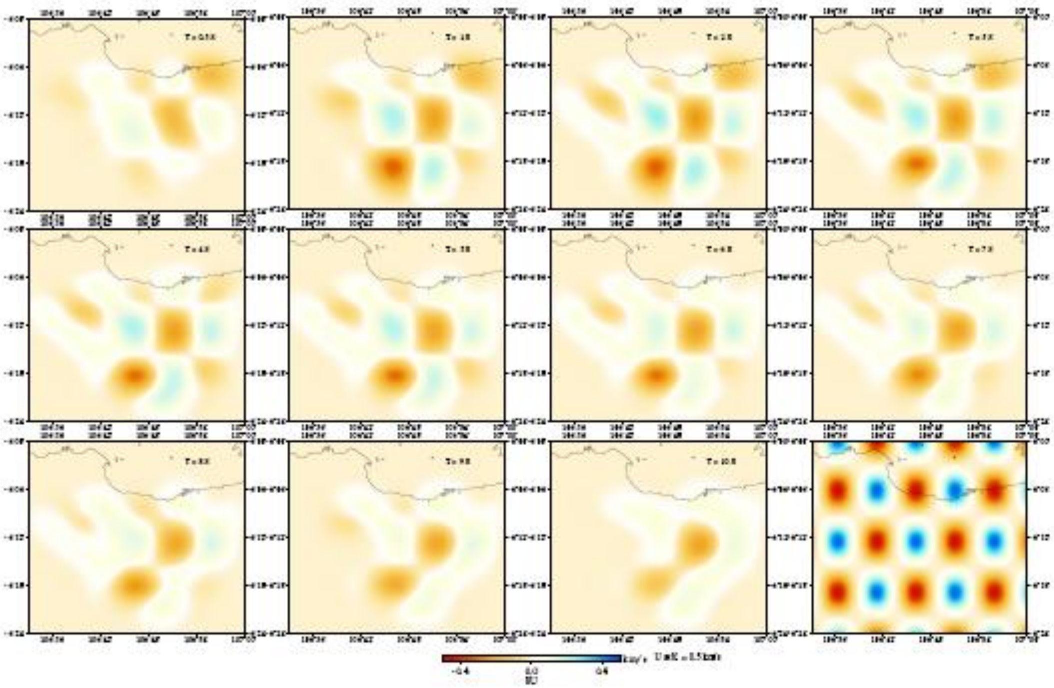


Checkerboard Test



Cell size = 1.85 km x 1.85 km

Checkerboard Test



Cell size = 2.22 km x 2.22 km