Imaging Crust and Mantle Structure beneath the D'Entrecasteaux Islands from Rayleigh Wave Tomography

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Ge Jin, James Gaherty, Geoff Abers, YoungHee Kim, Zach Eilon, Roger Buck, Ron Varave

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Introduction

Ultra high pressure (UHP) terranes are generally considered as continental crustal material being subducted to mantle depth and then exhumed to surface. The youngest UHP rocks in the world are found in the D'Entrecasteaux Islands, Papua New Guinea. These 7-8 Ma coesite-eclogite face rocks indicate different geological history from other UHP rocks for the exhumation process not associating with the subduction either spacially or temporally. The burial of these UHP rocks is thought to be during the arc-continent collision between Australian Plate and Papua New Guinea mainland about 58Ma ago (Lus et al., 2004, Ellis et al., 2011). And afterwards they remained mantle depth for 30Ma before rapidly exhumed to surface from 5Ma at the rate around 1cm/yr (Baldwin et al., 2004; Gordon et al., 2012).
Evidences show strong relation between the exhumation and the west propagation of Woodlark Rift, which is an active transition zone from continental rifting to seafloor spreading. Strong crustal extension may favor the exhumation in two ways: reversing subduction that extract UHP continental crust along the paleo-subduction channel, or thinning the upperplate crust to help the buoyant UHP rocks penetrate through as diapirs.
In this study we investigate the dynamic processes driving uplift and extension using Rayleigh wave phase velocity imaging for both teleseismic and ambient noise measurement to explore the crust and upper mantle structure across this region.

Data

Method

Ambient Noise

Because short intra-station distance violate the far-field estimation of time-domain ambient noise method, we applied the original Aki's spectral formulation which was further developed by Eskström et al., 2009. The key result of these papers can be presented as equation 1:

$$\bar{\rho}(r,\omega) = J_0\left(\frac{\omega}{c(\omega)}r\right) \qquad (1)$$

where $\bar{\rho}$ is the real part of normalized cross-spectrum, $c(\omega)$ is the phase velocity for different frequency ω.
In this study, we fit the whole Bessel function in the interested frequency band instead of counting only zero-crossings of cross-spectrum.

Array-based GSDF

Array-based GSDF method measures the Rayleigh wave phase difference between nearby stations by fitting a five-parameter wavelet to the narrow-band filtered cross-correlation of the seismograms. The wavelet can be presented as (Gee & Jordan, 1992):

$$F_i W C(t) \approx A \exp\left[-\frac{\sigma_i^2 (t-t_g)^2}{2}\right] \cos\left[\omega_i (t-t_p)\right] \qquad (2)$$

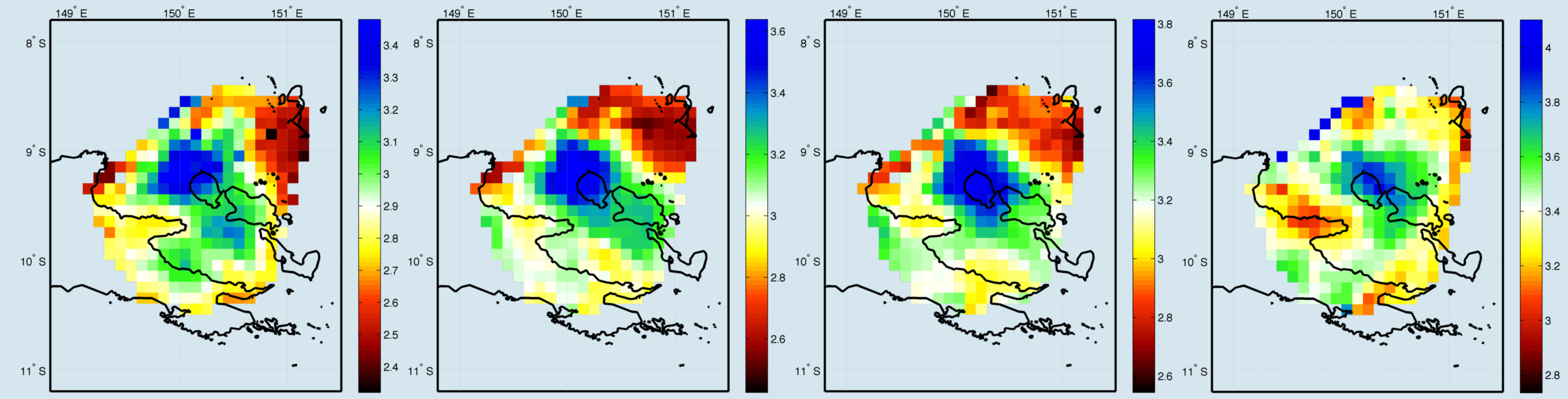
where F_i is the ith narrow-band filter function, W is window function, C is the cross-correlation function, σ_i is the band width of the filter, σ_i is the center frequency of the filter, t_g and t_p are the relative group delay and phase delay between these two stations, perspectively.

Eikonal Tomography

For each "event", Eikonal tomography calculate the distribution of slowness vector based on the phase difference measurement between nearby stations.

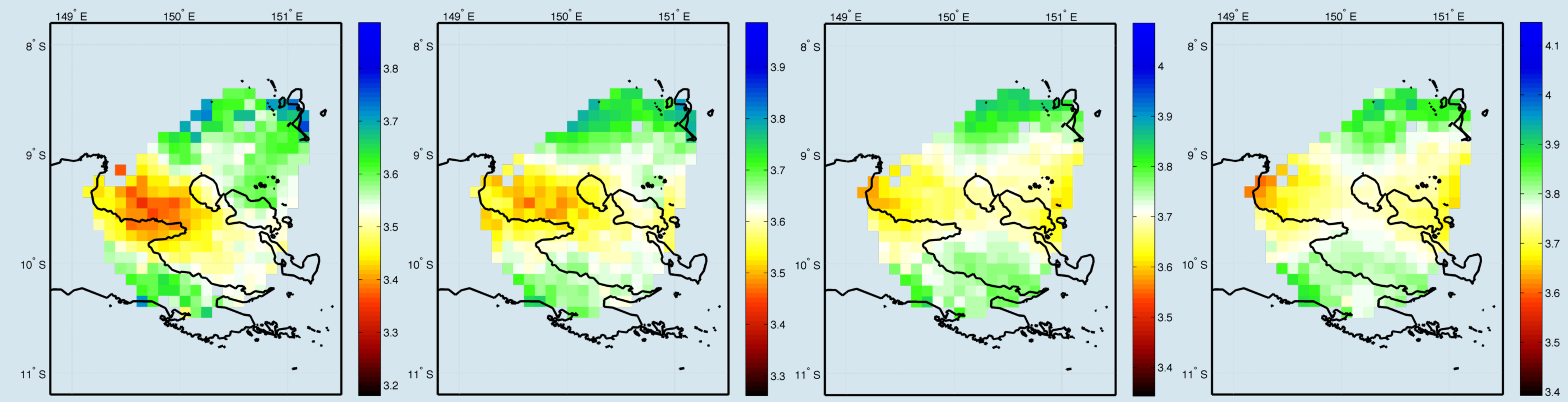
Results

Result from Ambient Noise:



9.1s 10.9s 13.4s 17.4s

Result from earthquake:



20s 25s 32s 40s

Conclusion

Future Work