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Seismic structure of West Africa from surface wave tomography using regional earthquakes and ambient seismic noise.

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Abstract:

Most models of seismic structure of the West African craton come from global-scale studies. With a higher-resolution regional velocity model, we could locate seismic events and calculate regional Green's functions more accurately, thereby improving discrimination between natural earthquakes and man-made events. We aim to produce a 3D regional shear wave velocity model for West Africa, using surface wave tomography, with both regional earthquakes and seismic ambient noise cross-correlation. Using these two types of data we improve azimuthal coverage of the region and therefore hope to produce higher resolution models than possible using earthquakes alone. We presented our preliminary Rayleigh wave group velocity maps obtained from earthquake recordings at the last SnT conference. We now present the results from ambient noise correlation between 25 regional stations and the results from the joint dataset. The results of the tomographic inversion are plotted as dispersion maps that show good correlations with large geological and tectonic features in the study area (craton, shields, sedimentary basins and mobile belts zone).

1- Introduction

The geology of west Africa is characterized by the West African Craton (WAC), which is largely covered by the Neoproterozoic to Paleozoic Taoudeni Basin (Figure 1). Archean rocks are exposed in the Reguibat Rise (Shield) on the north side and the Man-Leo Shield on the south. A series of Pan-African and Hercynian belts rings the WAC: the Pharusian and Dahomeyides Belt along the eastern margin; the Rokellides and Mauritanides Belt run along the western side and the Anti-Atlas Belt along the northern margin. Such different tectonic environments can give strong lateral and vertical variations in the shear wave velocity structure. Surface wave tomography using only earthquakes has limitations: resolution is limited in regions of low seismicity and sparse station coverage; waveform data from distant earthquakes are deficient in high frequencies (due to scattering and intrinsic attenuation), and exhibit strong dependency on the source parameters.

In order to overcome these limitations and improve path density, we used in this study, in addition to the earthquake data, seismic ambient noise cross-correlations to produce Rayleigh wave group velocity map.

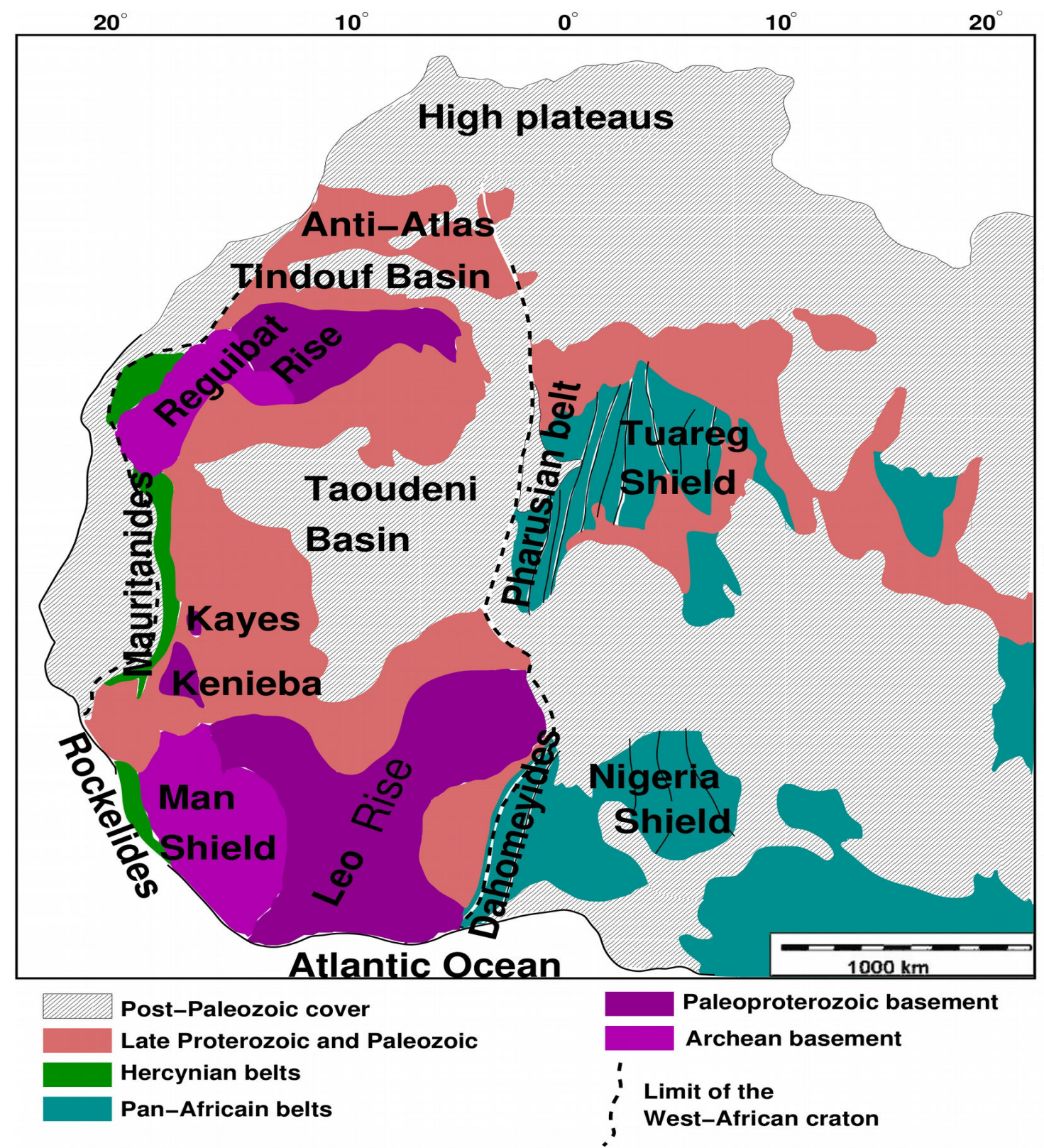

Figure 1: West Africa craton map: Location of the area under study including major geological features

2 - Data and methodology

We analyzed vertical component seismograms (long-period and broad-band) from 342 earthquakes and retained only those for which the surface waves were well distinguished in the dispersion analysis.

In addition to the earthquakes data, we computed ambient noise cross-correlations from continuous noise data recorded by 34 broad-band seismic stations between 1995 to 2015 (the exact number of pairs depends on the availability of data). The obtained correlation functions were then processed to estimate Rayleigh wave Green functions between each station pairs.

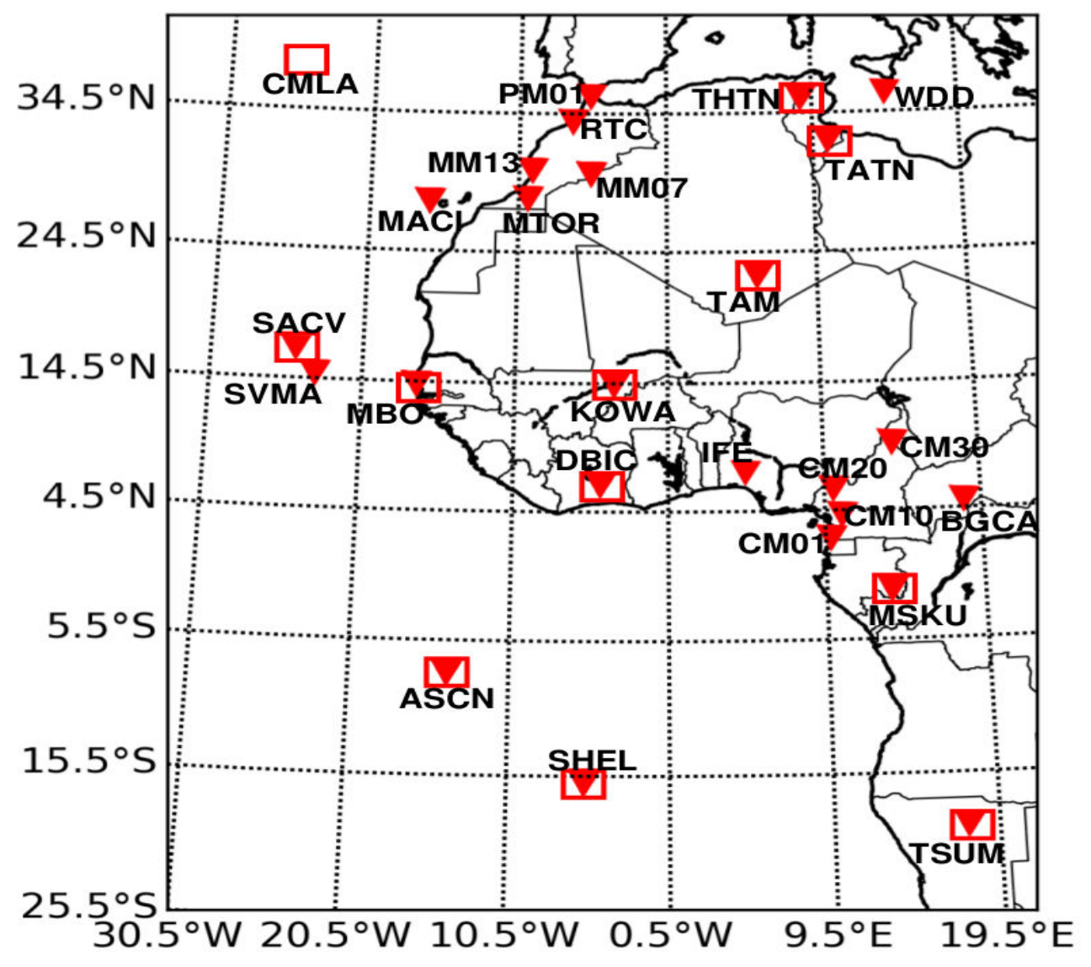

Figure 2: Locations of stations used in this study.

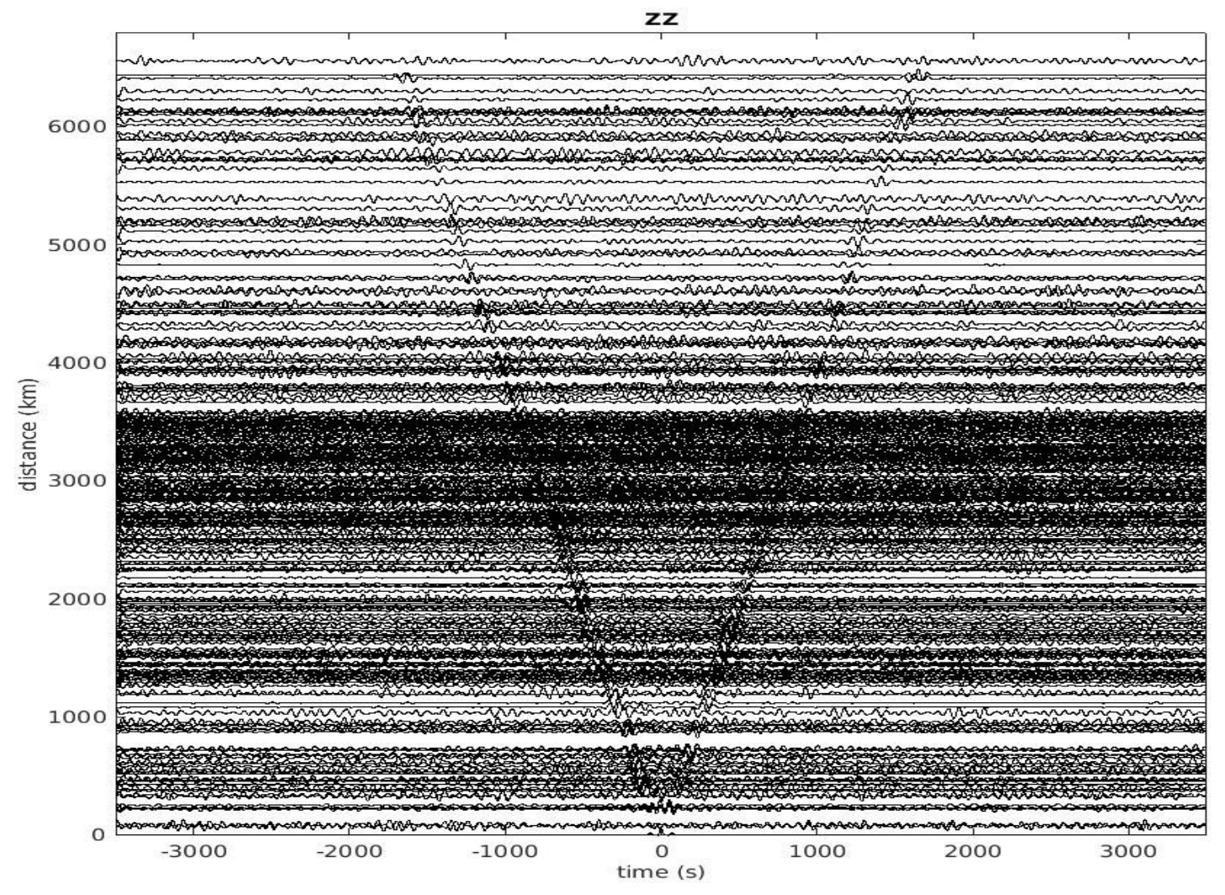

Figure 3: Cross-correlation functions as a function of the distance

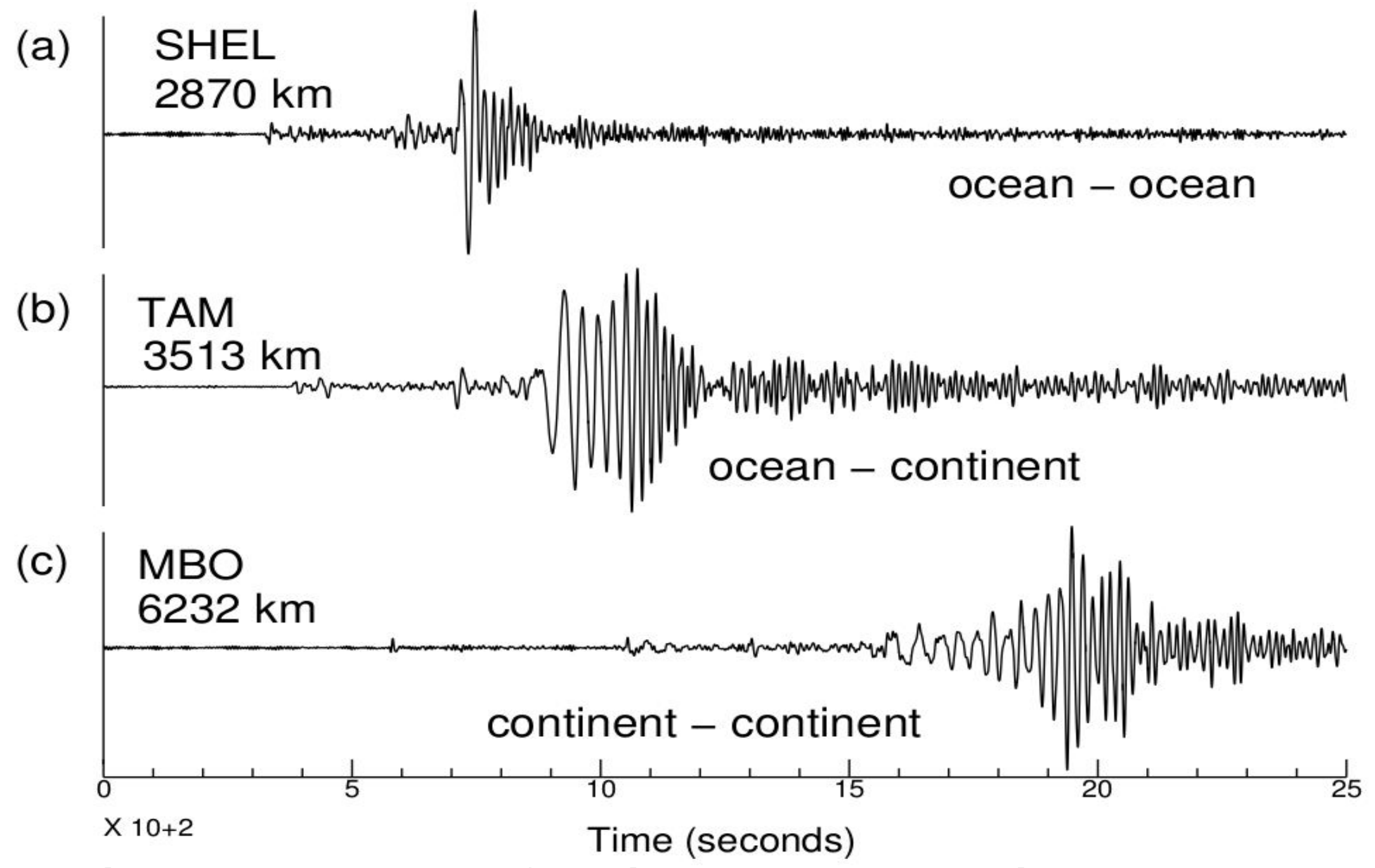

Figure 4: Examples of vertical-component seismograms

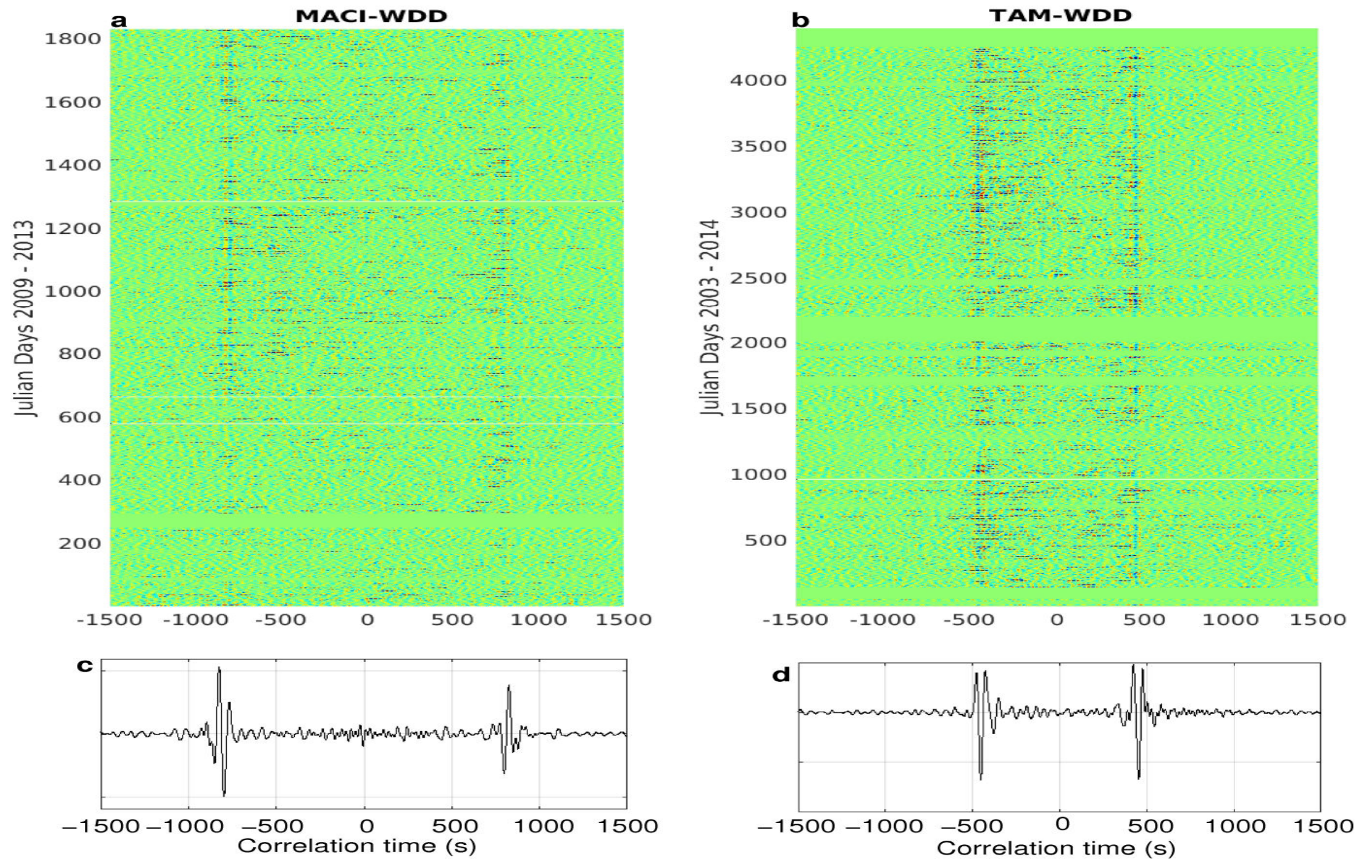

Figure 5: Correlograms (a, b) and Stacked cross-correlation (c, d)

3 - Results

The method used for determining the group velocities dispersion curves is the "Multiple Filter Technique (MFT)". The output of this method is display in Figures 6 and 7. The dispersion curves derived from ambient noise cross-correlation and earthquakes analysis are inverted together to obtain isotropic group velocities maps at different periods.

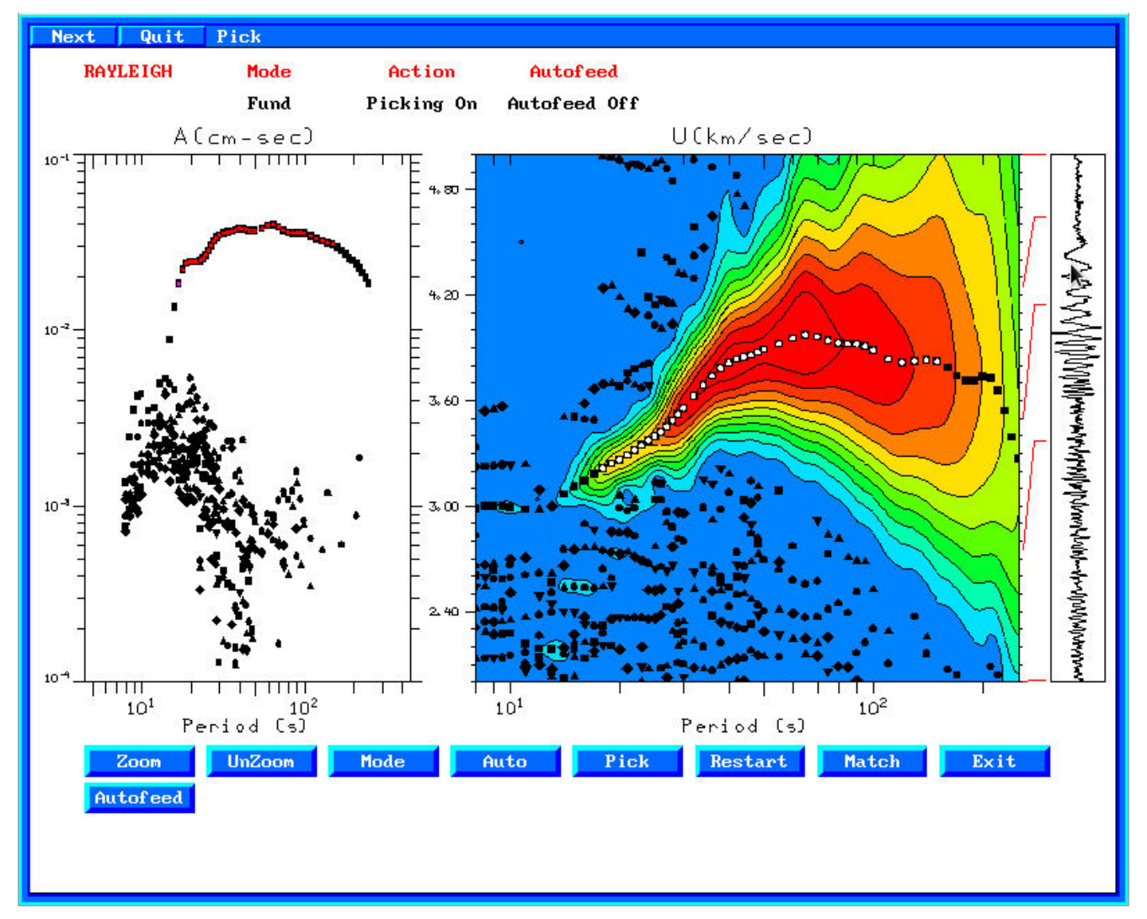

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Figure 6: Earthquake group velocity dispersion and spectral amplitude

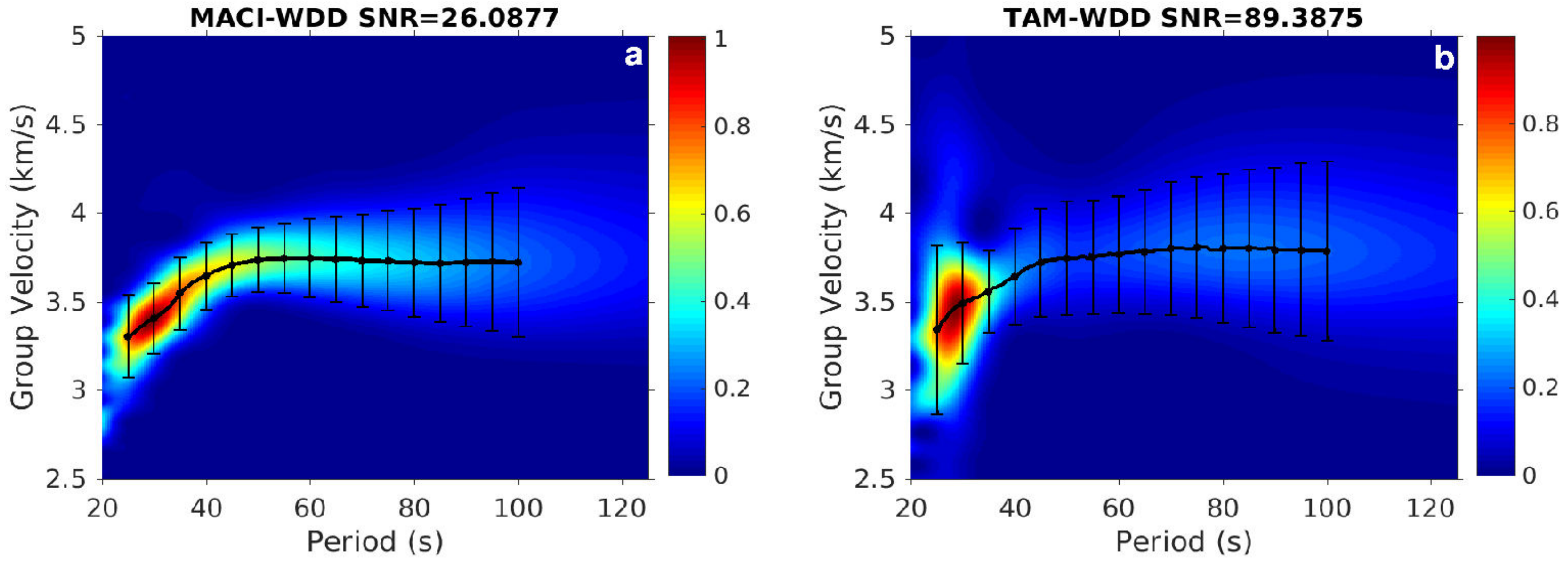

Figure 7 : Ambient noise cross-correlation dispersion curves

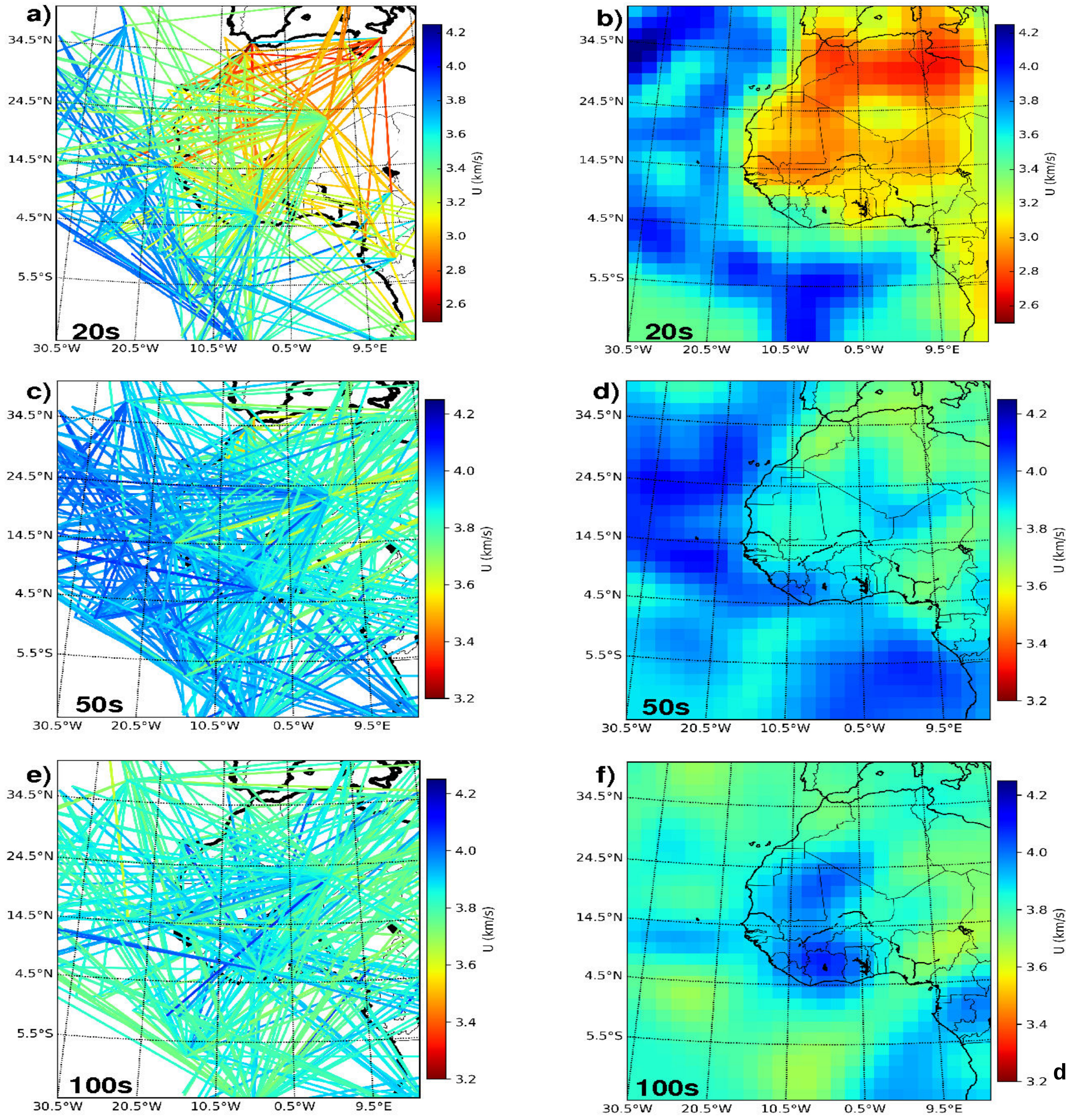

Figure 8: Path coverage (a,c,e) and regionalised group velocities (b,d,f) at different periods combining both earthquake and correlation dispersion measurements.

4 – Conclusion

At short periods the Rayleigh wave group velocity is more sensitive to shallow structure and shows fast velocities for the oceanic crust and slow velocities for the continental crust (differences in crustal composition and thickness). For the same period the thin oceanic crust presents fast velocities compared to the thick continental crust. At intermediate periods the contrast is less pronounced. The boundary with the Pan-African belt bordering the West African craton to the east seems to be well defined. At long period, the roots of the Man-Leo and the Reguibat shields are characterized by fast velocity, showing a cold and thick lithosphere under the craton, while we found lower group velocities under the mobile belt zone indicating thin lithosphere.