TRAVEL TIME EVOLUTION OF P-WAVES RETRIEVALS IN THE SECONDARY MICROSEISMIC BAND USING INTERFEROMETRY

LISA TOMASETTO, PIERRE BOUÉ, PRATUL RANJAN, RUOHAN ZHANG, PIERRICK BLANCHET

INTRODUCTION

Ambient noise spectra show two peaks in amplitude between 3 and 10 seconds of period. The first peak at 7s arises from the interaction of two wave trains travelling in opposite directions, called the double frequency microseisms. The second peak at 14 s is due to the interaction between waves and the coastal seafloor, called the single frequency microseisms. The ambient noise correlations of two seismic stations computed in the 3 – 10 seconds periods are dominated by Rayleigh waves however at greater distances body waves emerge. The double frequency generated body waves carry information about the inner structures of Earth they travel into, and could be used in addition to the usual earthquakes.

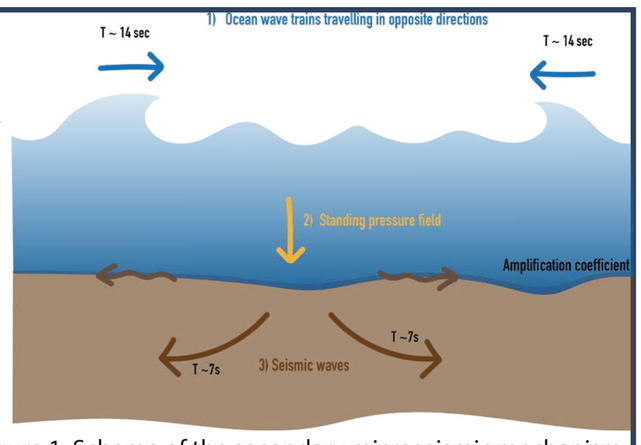

Figure 1. Scheme of the secondary microseismic mechanism.

QUESTIONS

Can we detect body waves from this kind of sources?
What phases? What is the recurrence of these events?
How are the variations of the source affecting the correlation?
How can we quantify the effect of source variations in the data?
What can we learn about the structure?

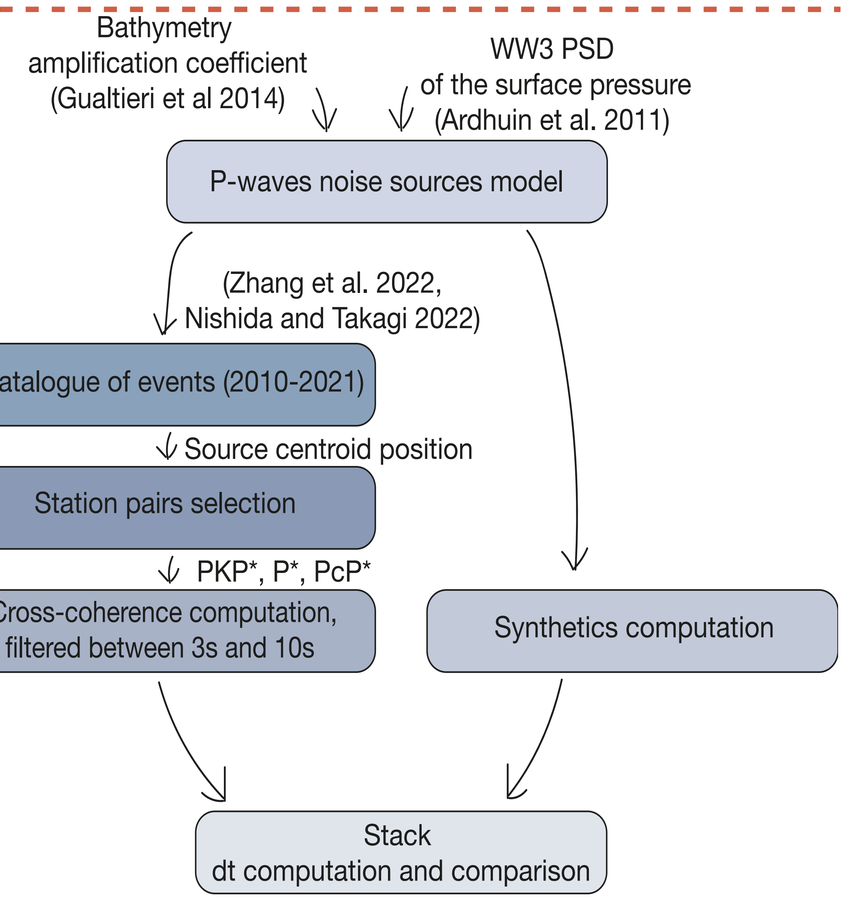

Figure 2. Workflow: A model of P waves noise sources in the secondary microseisms frequency band is built from the WW3 surface pressure data given by Ifremer and the amplification coefficient. From the P-waves noise sources, synthetics are computed every 3 hours. Depending on the target phase (P, PKP, PcP) one select specific station pairs based on ray theory. Cross-coherence method is applied to the data, filtered, stacked, and compared to the synthetics.

MATERIALS AND METHOD

ADAPTATIVE STATION PAIRS SELECTION

A catalog of double frequency microseismic events has been computed using the ocean wave model WAVEWATCHIII (WW3). Using the centroid position of a microseismic source an opportune pair selection, where stations align with the source, is used for cross-correlation.

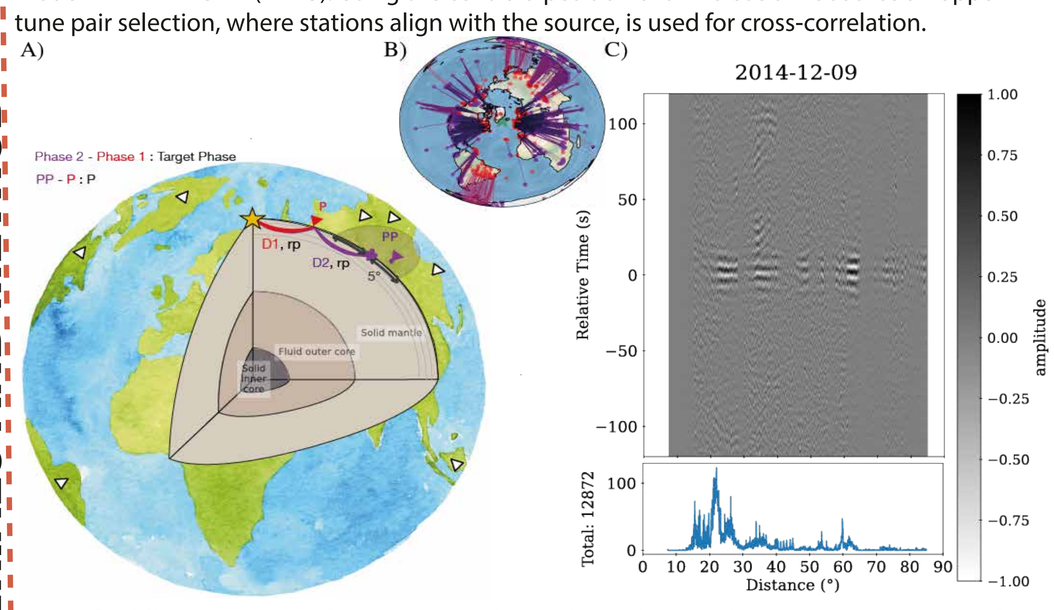

Figure 3: A) Sketch representing the adaptative station pairs selection. The event's centroid is given by the catalogue, then a first station (in red) is selected from the source. A second point on the great circle defined by the source and the first station locations is determined. Given the ray parameter of the P phase at station 1, the distance of phase 2 from the source on the great circle gives the second point (purple cross). Every station within a 5° distance from this point is selected as the second station. B) Selection applied to weather-bomb event on all high gains stations available on the 9th of December 2014. C) Cross-correlations filtered between 3s and 10s of period, stacked in 0.1°bins and normalised. Lag time is relative to the PREM arrival time of a P wave at the given distance.

SIMPLE SYNTHETICS COMPUTATION

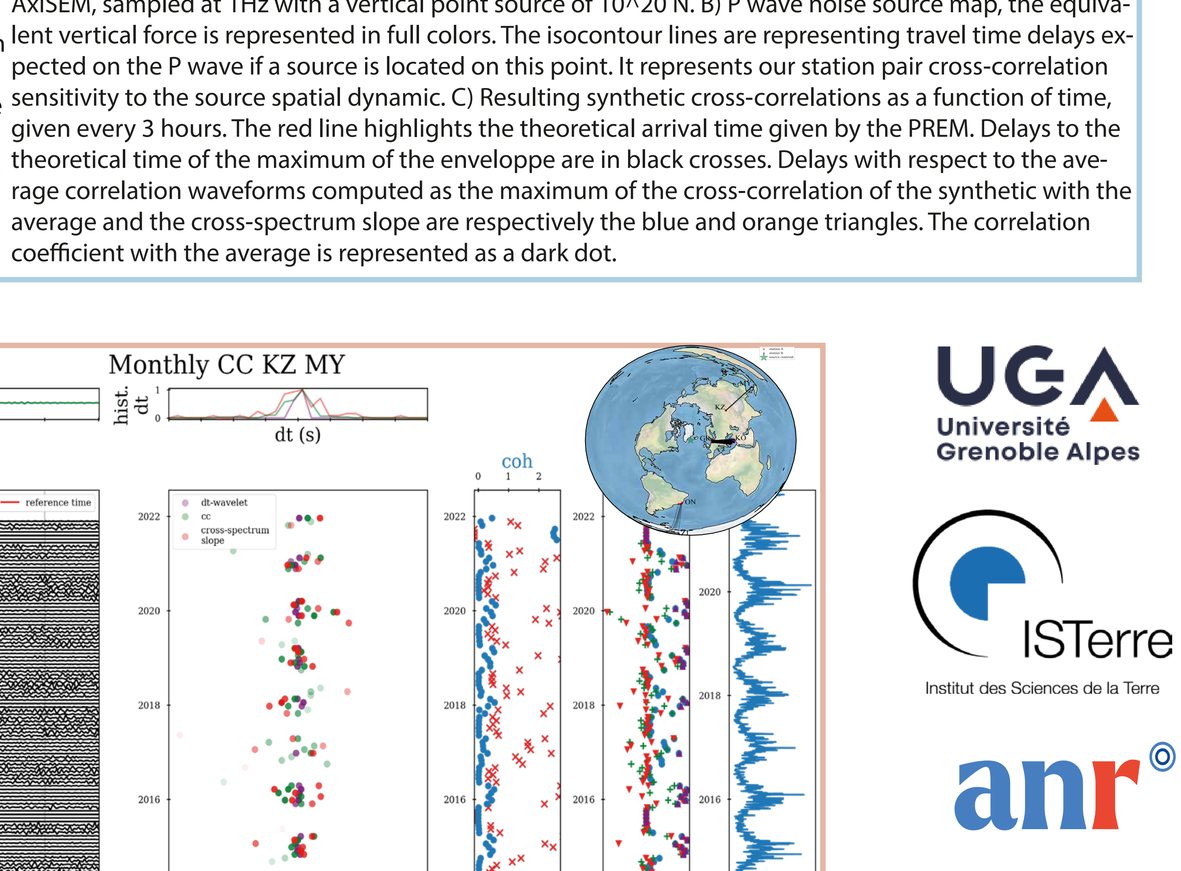

Figure 4. Synthetics computation during the storm Alexandra from the 8th to the 10th of December 2014. A) Windowed Green's functions around the P and the PP phases. Green's functions computed with AxiSEM, sampled at 1Hz with a vertical point source of 10^20 N. B) P wave noise source map, the equivalent vertical force is represented in full colors. The isocontour lines are representing travel time delays expected on the P wave if a source is located on this point. It represents our station pair cross-correlation sensitivity to the source spatial dynamic. C) Resulting synthetic cross-correlations as a function of time, given every 3 hours. The red line highlights the theoretical arrival time given by the PREM. Delays to the theoretical time of the maximum of the enveloppe are in black crosses. Delays with respect to the average correlation waveforms computed as the maximum of the cross-correlation of the synthetic with the average and the cross-spectrum slope are respectively the blue and orange triangles. The correlation coefficient with the average is represented as a dark dot.

RESULTS AND TAKE HOME MESSAGE

- P waves are observed at various interstation distances after computing 24 hours of data cross-correlations.
- Delays to theoretical arrival times using PREM are observed. Our goal is to determine the effect of source variations in time and space on body waves retrieveals in the secondary microseisms period band.
- Cross-correlations computed every 3 hours show variability in delays and can be compared to synthetics.
- Cross-correlations computed daily and stacked monthly show a seasonality of the P wave emergence corresponding to the oceanic source activity.
- Next step in this study is to compare the 10 years of data to synthetics to quantify the source variations impact on travel times.
- This workflow should also be applied to other interferences such as PKPPcP-PcP and PKPPKP-PKP...

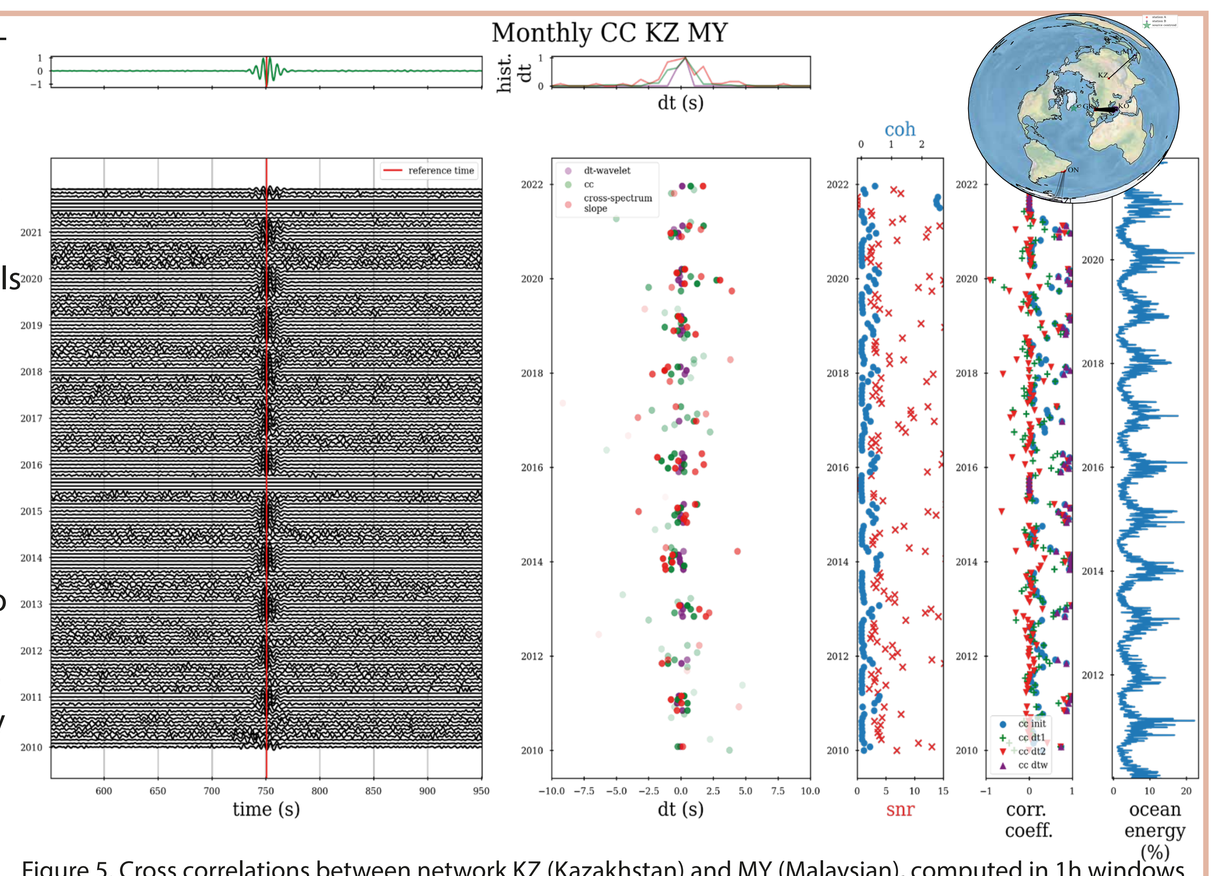

Figure 5. Cross correlations between network KZ (Kazakhstan) and MY (Malaysian), computed in 1h windows for 12 years (2010-2022), phase weighted stacked over 1 months. The overall mean is used to compute travel time delays. Correlation coefficient after delay correction and ocean energy in the source area are computed.

Contact:
lisa.tomasetto@univ-grenoble-alpes.fr