Effect of the water layer on seismic noise cross-correlation across the Northeast Atlantic, from Madeira and Canaries to the Atlas-Gibraltar zone

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Introduction

In the framework of project SIGHT (SeIsmic and Geochemical constraints on the Madeira HoTspot system) we want to obtain a 3D model of SV-wave velocities of the crust and upper mantle of the Northeast Atlantic area encompassing Madeira and Canary Islands to the Atlas-Gibraltar zone, using seismic noise cross-correlations in the period range 2-100 s.

Geological setting

Region of raised seafloors that develops to the NNE (the 1400 km long Tore-Madeira Rise);
Youngest dated eruption occurred 6-7ka ago;
Intraplate active volcanic archipelago;
Lies over a large (2500 x 4500 km) upper mantle anomaly extending down to depths of 500 km – Hoernle et al. 1995 global study.

Key questions

- Is Madeira’s volcanism fed by a deep-seated mantle plume?
- Do the Madeira and Canary hotspots have a common or distinct origin?
- What is the lithospheric nature of the corridor between the Canaries and the Atlas-Gibraltar?

Addressed with

SKS Anisotropy; P and S Receiver Functions; H/V polarization analysis; Ambient Seismic Noise Tomography.
Good azimuthal coverage;
Most of the interstation **paths cross the ocean.**
What is the:
- Effect of the water and sediments in the Empirical Green Functions (EGF) and in the dispersion curves for paths crossing the ocean for short periods?
- Impact on retrieving single mode dispersion curves?

**Dispersion measurements in an oceanic environment – going on study***

Fundamental mode group velocities using:
- S-transform (Ventosa et al., 2017)
  - Velocity range 1.5 - 4.5 km/s;
  - Maximum frequency range 0.3 - 0.5 Hz

Compared with synthetic fundamental mode group velocities in laterally varying media
(Herrmann, 2013)

*Carvalho et al. 2020 in prep.
In the Cape Verde region

**Land**
Lodge and Helffrich (2006), Vinnik et al. (2012)

**Ocean**
Crust to a depth of 20 km - Pim et al. (2008)
Below - Carvalho et al. (2019)
Fundamental mode and overtones in an oceanic environment

- Short period measurements - Madeira to Canaries paths;
- Intermediate periods measurements - between islands and continent.

1D model - Vs
- Water
- Sediments
- Three layer crust
- Mantle

Rayleigh waves → no mode contamination in the short frequency range;
Love waves → contamination in 0.02 – 0.03 Hz.

Rayleigh waves → mode contamination in the short frequency range;
Airy phase frequency related with water layer thickness;
Love waves → contamination between 0.02 – 0.03 Hz.
Computed by normal mode summation (Herrmann, 2013);
Source → vertical force;
\( \Delta = 200 \text{ Km} \)

Synthetic seismograms in oceanic paths – radial versus vertical components

Conclusions

The influence of the water layer on both vertical and radial synthetic Rayleigh waves, as well as on higher-mode conversion and on the group velocities dispersion measurements cannot be neglected;

Although the fundamental mode dominates, the presence of the first overtones at short periods (typically below 8 seconds) show that specifying a given velocity range when retrieving group velocity can result in a mixture of modes.

At short periods, the water has a dominant effect on ocean-continent laterally varying media.
References


