Time-scale slowness adaptive filters

S. Ventosa (1), C. Simon (1), M. Schimmel (2) and JJ. Dañobeitia (1)

(1) Unitat de Tecnologia Marina (UTM-CSIC) Pg. Maritim de la Barceloneta 37-49 08003 Barcelona,
Tel:(+34) 93 230 95 00 Fax:(+34) 93 230 95 55, sventosa@utm.csic.es, csimon@utm.csic.es, jjdanodeitia@cmima.csic.es
(2) Institut de Ciències de la Terra Jaume Almera (ICTJA-CSIC), C/ Lluis Sole i sbarís s/n 08028 Barcelona.
Tel:(+34) 93 409 54 10 Fax:(+34) 93 409 54 12, schimmel@ija.csic.es

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1. INTRODUCTION

In seismic record-section signals are recognised through their lateral coherence. In the present of more than one signal it is possible to distinguish the signals which characterise a set of wavefronts that interfere with each other. One of the characteristics of any wave field is the similarity of the waveforms along the wavefront. This high lateral coherence can be used to separate the waves of interest in function of their slowness (inverse of velocity) in order to analyse them with higher precision.

In geophysics, most of the slowness filters work in the frequency-wavenumber (*f-k*) or the Radon domains [1]. The f-k domain allows to easily filter signals in a constant range of slownesses through the record section but, as it is based on a 2-D Fourier transform, its space resolution is null. The Radon domain is suitable for signals whose wavefront have a known trajectory that varies smoothly with the distance.

2. FILTER DESCRIPTION

With the aim of solving the limitations of the f-k and Radon based filters, we propose the slowness adaptive filters in the time-scale domain. These filters can adapt automatically to variations of the slowness along the wavefronts. In addition, the greater flexibility that this domain provides gives us a higher degree of freedom to design these filters: for example, the slowness resolution can be adjusted optimally at each frequency or, in contrast, can be constant to build filters that do not distort the waveform of the processed seismic signals. Furthermore, it is also possible to adjust these filters to make a great variety of filters in the f-k or Radon domains.

To carry out a slowness adaptive time-scale filter, in the first place, we decompose each trace of the seismic section in slowness in the time-scale domain and we measure the coherence degree of the decomposed section. The slowness decomposition is performed combining the windowed Radon transform with the analytic wavelet transform [2], and the coherence is measured using the phase stack coherence estimators because they are amplitude unbiased and avoid the zero-crossing problems [3]. These coherence measures are used to locate the coherent signals in time, scale, slowness and distance. With this information and the specifications of the filter to design, we can determine the gain of the filter at each slowness component in order to preserve the signals of interest and attenuate the other ones. And finally, we build the filtered seismic section in the time domain using the inverse wavelet transform.

3. RESULTS

In the following we apply the slowness filter to the seismic section shown in Fig. 1 to detect coherent signals with slowness between ±0.2 s/km. The data are recorded by an OBS set in the Cantabric Sea (Project Marconi). In this test, we have decompose each trace of this section in time, scale and slowness using a Morlet wavelet transform and a Hamming window of 15 traces (120 m) long in the windowed Radon transform. As we can notice in Fig. 2, the filter automatically detects the maximum coherent signals in the time-scale domain, and builds the filtered section preserving these signals while attenuating the noise and interferences.

4. CONCLUSIONS

The time-scale slowness adaptive filters are a powerful tool that enables an easy separation of the seismic waves in function of their slownesses in an adaptive way, with a good degree of control of the slowness resolution across the time-scale domain. As interferences are seen in the time-scale and slowness domain, it is possible to isolate them whereas it was not the case in classical f-k or Radon domains. The filters attenuate the incoherent noise which permits to reveal small-amplitude coherent signals otherwise buried in the noise.

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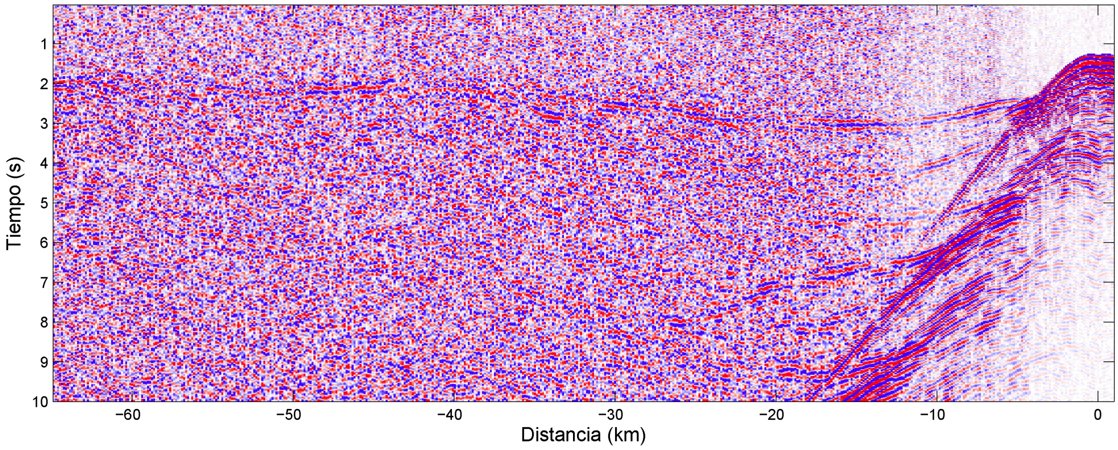

Fig. 1. Original record section.

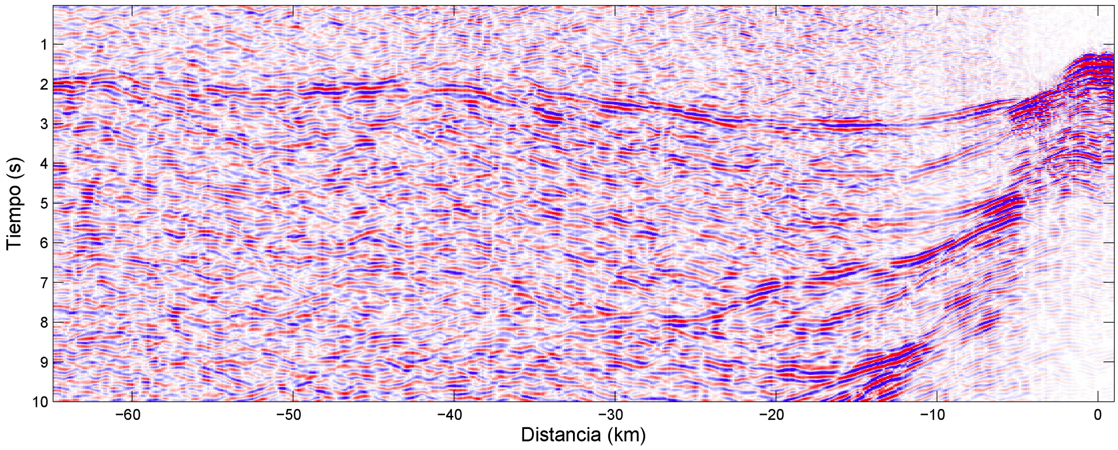

Fig. 2. Filtered record section.