Multiple attenuation via Blind Source Separation methods

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ABSTRACT

Multiple elimination is a very important step in seismic data processing. It is commonly undertaken by methods using least squares (LS) filters to perform adaptive subtraction. However, these techniques usually cause some collateral damage on primaries that intersect with multiples. This is due to the LS filters whose optimization criterion relies on removing as much energy as possible around the predicted multiples. Blind Source Separation (BSS) methods have, on the other hand, been recently applied to geophysics and have shown interesting results for multiple extraction. These techniques are able to identify and separate primaries from multiples without any adaptive subtraction, hence minimizing error when primaries and multiples overlap. In view of these initial results, we present in this paper a study on the application of BSS techniques to the problem of multiple extraction. Our study encompasses the analysis of different BSS methods and their application to a number of scenarios, considering both synthetic and real data.

INTRODUCTION

Many popular algorithms in seismic processing, such as various migration and inversion schemes require as input seismic data without multiple reflections. Field-measured seismic data present multiples that interfere with these algorithms and thus constitute a recurrent problem in seismic data processing. The phenomenon can be quite disturbing, especially for shallow water marine data. Several techniques have been applied to try to remove some or all of these multiples. For instance, Verschuur (2006) describes methods based on moveout discrimination to separate primaries and multiples in different domains by applying suitable transforms. Popular transforms for these methods include the parabolic Radon transform, the f–k transform and the linear Radon transform (τ–p transform). Hence, in these domains it may be possible to mute regions associated to multiples and then reverting to the original domain, preserving primaries. However, it is recognized that multiples still leak to the unmuted regions and additional filtering is necessary to improve results with these methods.

A second class of methods is based on a two-folded procedure composed of prediction and extraction of multiples. Currently, prediction can be performed in shallow water by predictive deconvolution. Multiples in data with small offsets (offset $\approx$ $^1/_{10}$ of depth) may be estimated by this technique based on a calculated time shift of data. But more generally, for data with good coverage, surface related multiple elimination (SRME) prediction algorithm is the most precise prediction method (Verschuur et al., 1992).

Once predicted, multiples must be extracted from the original data. Usually this step is undertaken by least squares (LS) filters. Using a minimal energy criterion, SRME prediction is fitted to original data and then adaptively removed. However regions where overlapping of primaries and multiples occur are frequently blurred or totally erased during the extraction phase of processing.

A more recent approach has been introduced by Lu (2006) then developed by Kaplan and Innanen (2008) and Donno (2011) in the past recent years. These approaches suggests that the extraction may be performed by Blind Source Separation (BSS) algorithms with no further need for adaptive subtraction. Results have shown that these methods present better results in primary and multiple overlapping regions (see, for instance, Kaplan and Innanen, 2008; Donno, 2011). Still, the works on this subject have mainly focused on BSS methods based on Independent Component Analysis (ICA). Although this class of methods is certainly the most popular in BSS, recent advances in the area have shown that better performance may be achieved by exploiting prior information that are not taken into account by ICA techniques. In particular, much attention has been paid to methods that work under the assumption that the desired signals are sparse (Comon and Jutten, 2010).

In the search of a better understanding of the application of BSS methods to the problem of multiple extraction, we provide in this paper a set of experiments considering different classes of solutions and their application to different scenarios. Our major goal is to identify which solutions are better suited to perform multiple extraction in the scenarios considered in our study. Moreover, we also aim at analyzing the influence of some practical parameters, such as the size of the windows in which BSS is performed.