Geophysical Research Abstracts
Vol. 16, EGU2014-3509, 2014
EGU General Assembly 2014

Quadratic Time-Frequency Analysis of Hydroacoustic Signals as Applied to Acoustic Emissions of Large Whales

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In order to enrich the set of attributes in setting up a large database of whale signals, as envisioned in the Baleakanta project, we investigate methods of time-frequency analysis. The purpose of establishing the database is to increase and refine knowledge of the emitted signal and of its propagation characteristics, leading to a better understanding of the animal migrations in a non-invasive manner and to characterize acoustic propagation in oceanic media. The higher resolution for signal extraction and a better separation from other signals and noise will be used for various purposes, including improved signal detection and individual animal identification.

The quadratic class of time-frequency distributions (TFDs) is the most popular set of time-frequency tools for analysis and processing of non-stationary signals. Two best known and most studied members of this class are the spectrogram and the Wigner-Ville distribution. However, to be used efficiently, i.e. to have highly concentrated signal components while significantly suppressing interference and noise simultaneously, TFDs need to be optimized first.

The optimization method used in this paper is based on the Cross-Wigner-Ville distribution, and unlike similar approaches it does not require prior information on the analysed signal. The method is applied to whale signals, which, just like the majority of other real-life signals, can generally be classified as multicomponent non-stationary signals, and hence time-frequency techniques are a natural choice for their representation, analysis, and processing. We present processed data from a set containing hundreds of individual calls.

The TFD optimization method results into a high resolution time-frequency representation of the signals. It allows for a simple extraction of signal components from the TFD's dominant ridges. The local peaks of those ridges can then be used for the signal components instantaneous frequency estimation, which in turn can be used as one of the features in any subsequent classification of the whale signals.