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# WATERMARK: BCH1 Dataset Description

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## I. INTRODUCTION

This document describes the BCH1 dataset that can be used as an input of the WATERMARK simulator developed by FFI [1]. WATERMARK is a benchmark for testing, development, and comparison of physical-layer schemes for underwater acoustic communications.

The BCH1 dataset, provided by Telecom Bretagne, contains four time-varying channel impulse responses (TVIR) measured in the commercial harbor of Brest (France) in the frequency band from 32.5 to 37.5 kHz. The TVIRs were obtained simultaneously with a single-input multiple-output (SIMO) configuration. Each TVIR has a run time of 1 minute. The experiment set-up as well as a description of the TVIRs are presented in the next sections. Please make appropriate references to this document if you use any of these data.

## II. EXPERIMENT SET-UP

Channels measurements were conducted in the Brest harbor in May 2015 [2]. The transmissions were realized between two docks over a 800 m distance, in a 20 m water depth (see Fig. 1). At the transmitter side, an omnidirectional transducer ITC-1032 (resonant frequency: 35 kHz) immersed at a 2 m depth was used. At the receiver side, four broadband omnidirectional BK-8106 hydrophones were vertically deployed at a depth between 3 and 6 m with a 1 m spacing. Estimates of the TVIRs were obtained by successive matched filtering to a known probe signal transmitted repeatedly [3]. The probe signal used during the experiments was a m-sequence of 511 BPSK chips transmitted at a symbol rate of 5 kbps. Such a sequence can capture arrivals delayed up to 102 ms and channel estimates can be updated up to 9.78 times per second. Measurements were made at a carrier frequency of 35 kHz and transmitted symbols were pulse-shaped by a root raised cosine filter with a roll-off factor of 0.1.

## III. DATASET DESCRIPTION

Each TVIR is stored in a Matlab file. BCH1\_001.mat (resp. 002.mat, 003.mat and 004.mat) contains the TVIR measured at the hydrophone located 3 m (resp. 4 m, 5 m and 6 m) below the sea surface. The sampling frequency along the delay and the time axis are  $f_{s\_tau}=20$  kHz and  $f_{s\_t}=9.78$  Hz, respectively. Note that the relative energy between the channels stored in the Matlab files is the same as what was measured during the experiment.<sup>1</sup> Time synchronization between hydrophones is also preserved in the

<sup>1</sup>For instance, the total energy received at the third hydrophone is 8.7 dB lower than at the first hydrophone.



Fig. 1. Brest harbor experiment.

channel files. Various representations of the measured channels are shown next. They show estimates of (see [3, pp 24] for more details):

- the time-varying squared magnitude,
- the spreading function,
- the residual phase of the main multipath arrivals (within 10 dB of the strongest path),
- the power delay profile,
- the autocorrelation function.

All representations plotted in logarithmic scale are given in decibels relative to their maximum value.

## REFERENCES

- [1] P. van Walree, R. Otnes, and T. Jensenud, "Watermark : A realistic benchmark for underwater acoustic modems," in *Proceeding of Ucomms*, Aug. 2016.
- [2] F-X. Socheleau, A. Pottier, and C. Laot, "Stochastic Replay of SIMO Underwater Acoustic Communication Channels," *OCEANS 2015*, pp. 1–6, October 2015.
- [3] P. van Walree, "Channel sounding for acoustic communications: techniques and shallow-water examples," *Research report 2011/00007*, Norwegian Defence Research Establishment (FFI), 2011.

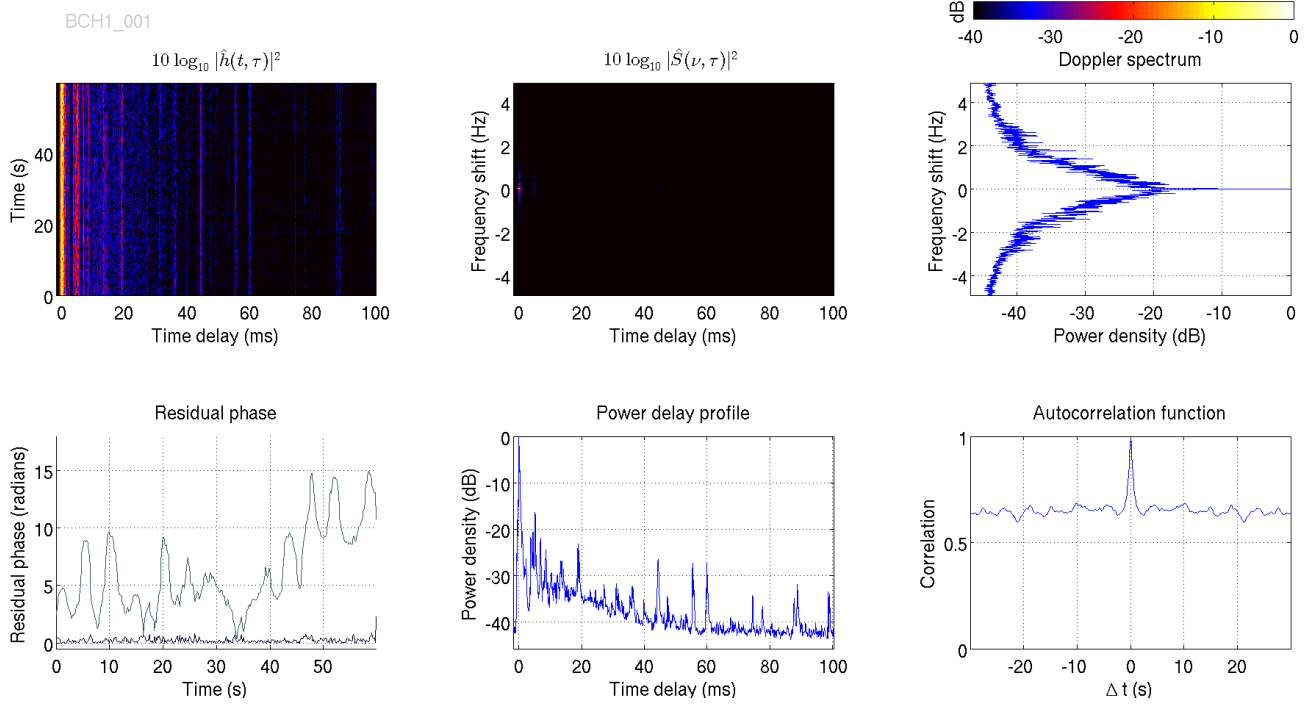


Fig. 2. Channel 1 (BCH1\_001.mat).

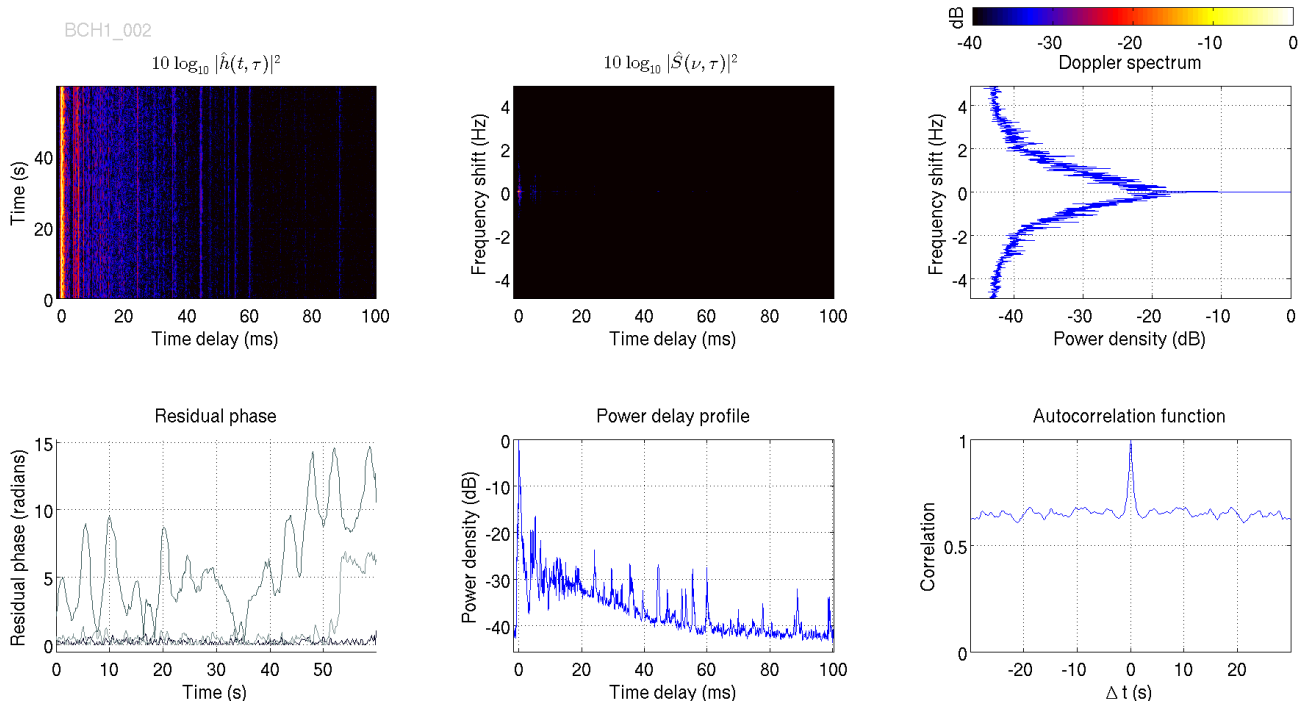


Fig. 3. Channel 2 (BCH1\_002.mat).

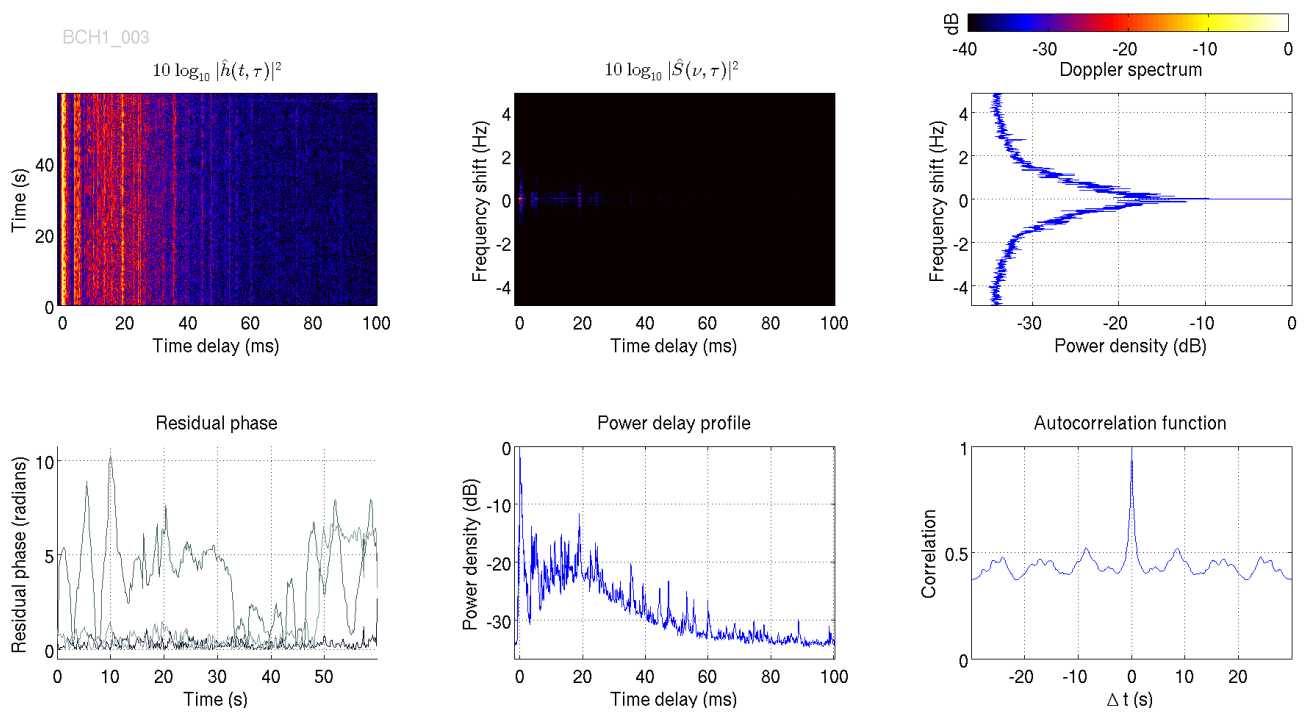


Fig. 4. Channel 3 (BCH1\_003.mat).

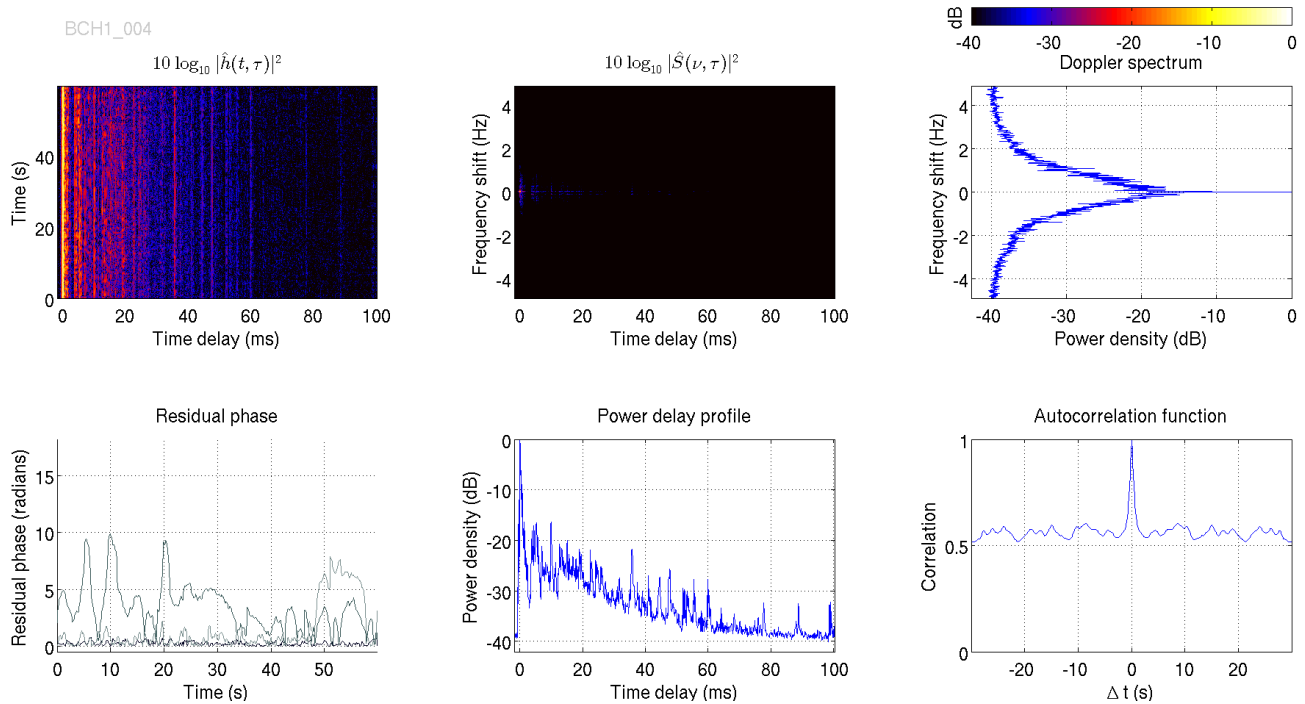


Fig. 5. Channel 4 (BCH1\_004.mat).