

# Simulating Realistic Ocean Soundscapes



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## Introduction

High-fidelity soundscape simulations that recreate real-world variability to benchmark detectors and trackers.

- Recreate real-world variability.
- Produce realistic test datasets for detectors and trackers.
- Validate tracking and inform sensor deployment.

## Noise Sources

Biological, anthropogenic and geophysical sources dominate ocean noise.

### 1. Biological

Marine life, such as the cacophony of snapping shrimp or the songs of whales and dolphins.

### 2. Anthropogenic

Human activities, dominated by commercial shipping, but also including sonar, and construction.

### 3. Geophysical

Natural physical processes, including noise from wind-driven waves, rain, earthquakes, and other geological activity.

## Case Study: Snapping Shrimp

### Bursty

Snaps occur in non-independent clusters.

### Heavy-Tailed

Extreme events are more likely than in a Gaussian model.

### Impulsive

Frequent, high-amplitude clicks.

### 1. Snap Timing (When?)

A **Non-Homogeneous Poisson Process (NHPP)** models snap times and burstiness. The snap rate is modulated by water temperature, and rhythmic daily and tidal cycles.

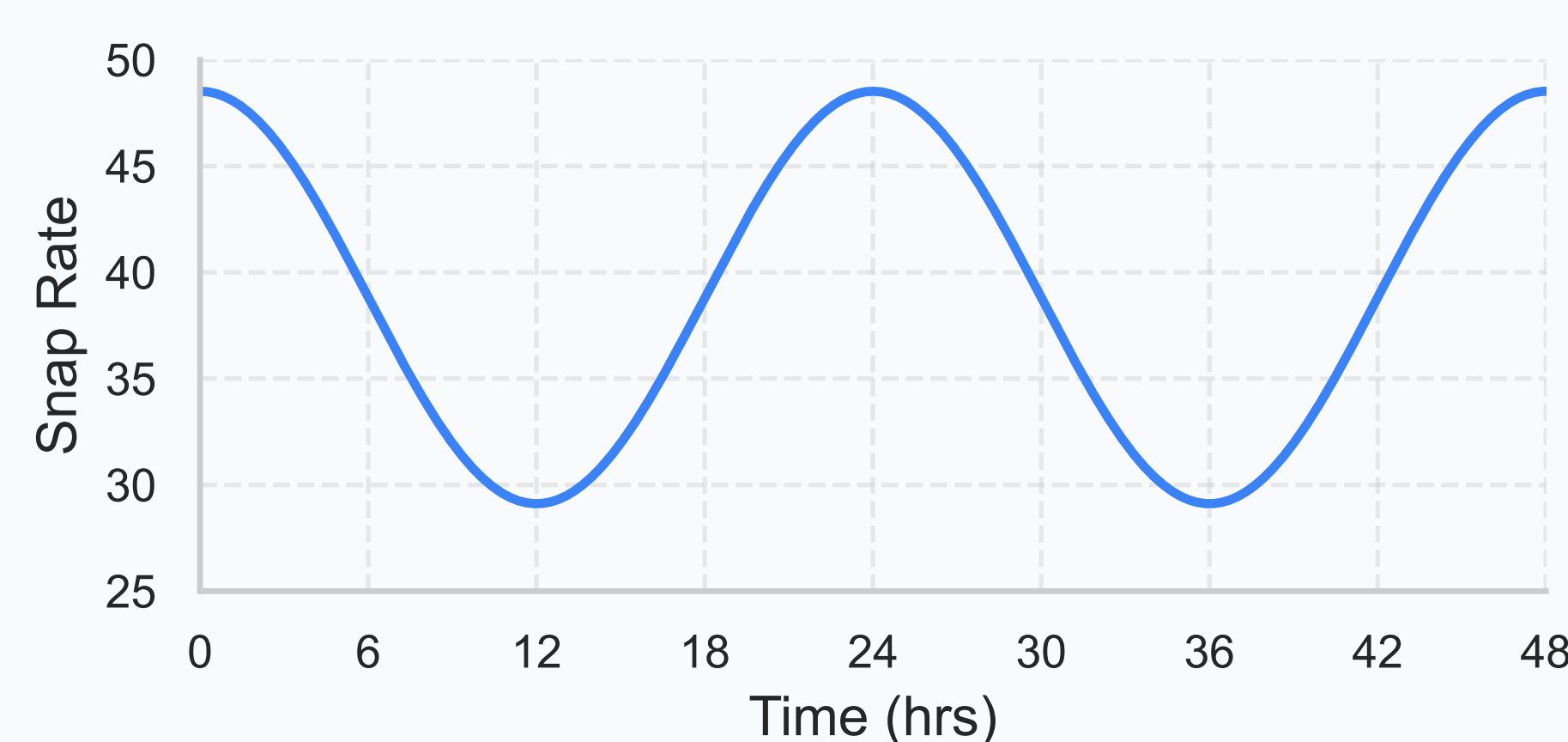


Figure 1. Snap rate variation over 48 hours.

### 2. Snap Waveform (What?)

Each ~2ms snap is built using a **Composite Waveform**, representing the acoustic signature of a collapsing cavitation bubble. This captures the sharp, broadband nature of the sound.

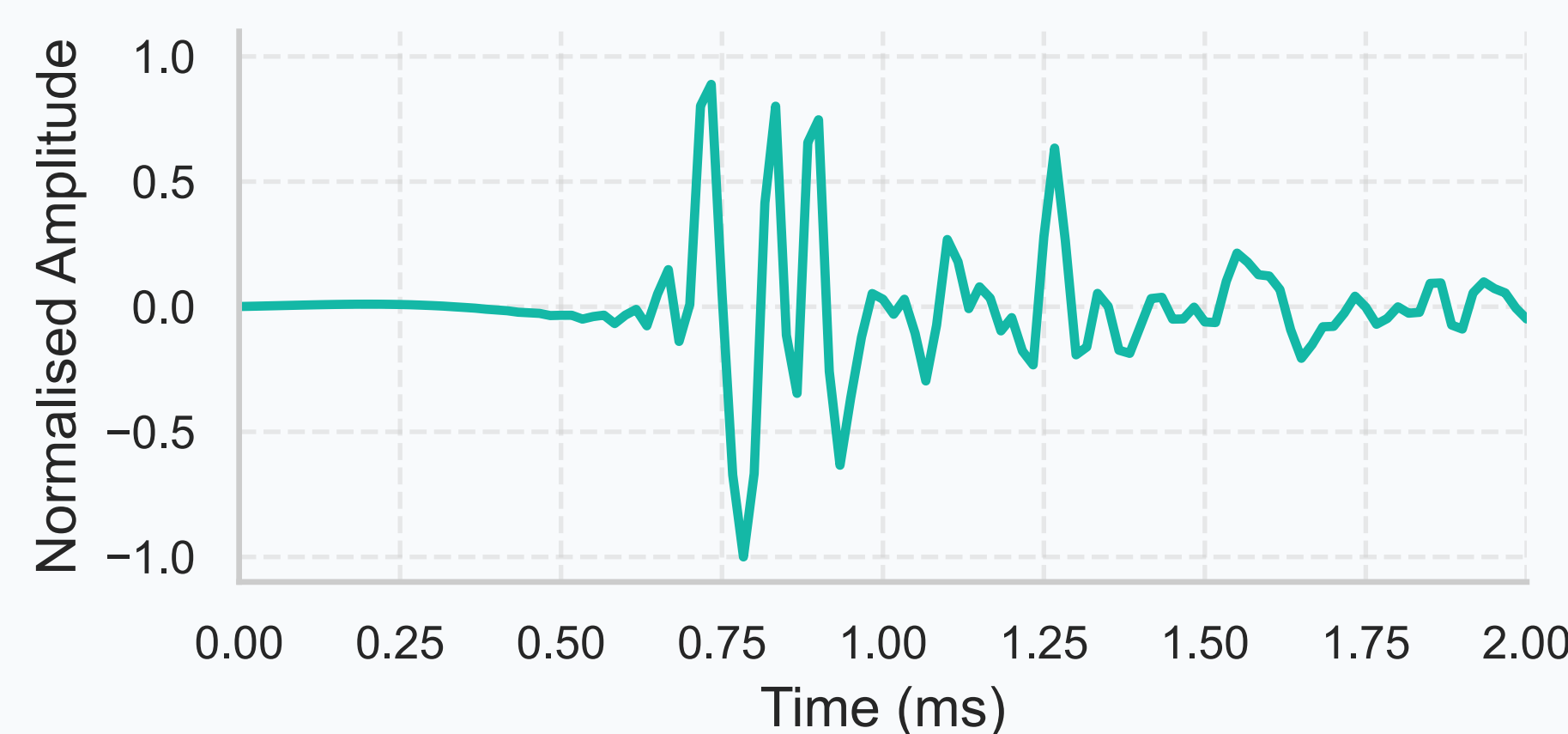


Figure 2. Modelled snap waveform (~2 ms).

### 3. Snap Amplitude (How Loud?)

Loudness is modelled with a heavy-tailed **Symmetric Alpha-Stable (SαS)** distribution. This correctly predicts the probability of the extremely loud snaps that characterise this type of noise.

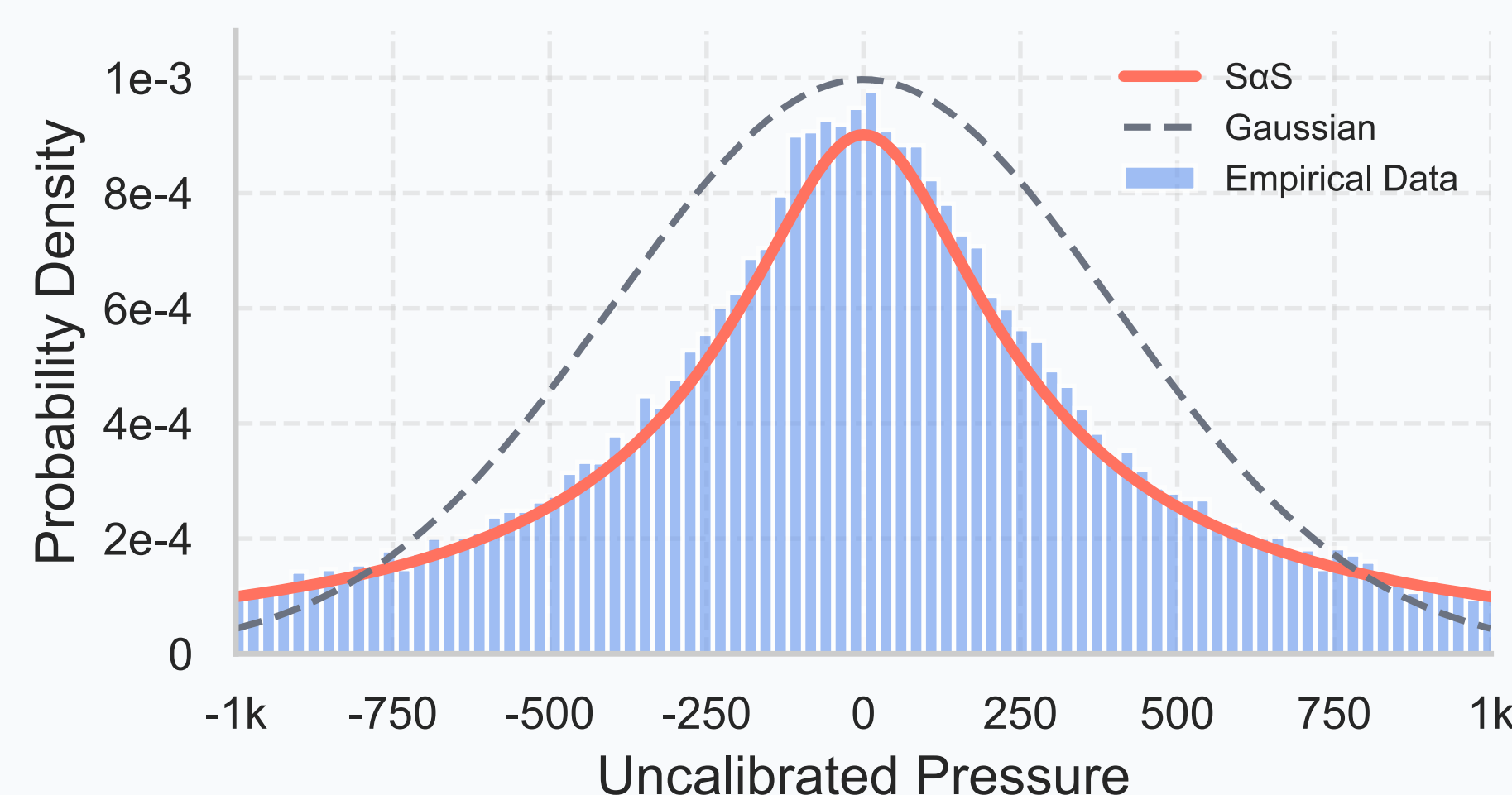


Figure 3. Amplitude distribution: SαS vs Gaussian.

## Detection & Tracking

Use simulations to measure detector and tracker performance across realistic, variable noise conditions.

### Detection

Measure probability of detection and false alarm rate as functions of SNR.

### Tracking

Evaluate localisation error, ID switches, track fragmentation and continuity under variable noise and source density.

### Operational impacts

Distant shipping reduces SNR and detection range; snapping shrimp produce clustered false positives; wind and wave noise increase background noise.

## Key Points

- **Realism:** Models reproduce empirical statistics, specific to each source type.
- **Benchmarking:** Generate labelled datasets to measure detection and tracking metrics.
- **Impact:** Stress-test algorithms; guide sensor placement and processing.

## More Info

Scan for audio samples, references & extra materials



[https://jjwakefield.github.io/snapping-shrimp/snapping\\_shrimp.html](https://jjwakefield.github.io/snapping-shrimp/snapping_shrimp.html)

