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Underwater Acoustics with a Single Hydrophone: Propagation, Physics-Based Processing, and Oceanographic Applications

Inferring information from underwater sounds requires robust experimental and numerical methods that account for a complex ocean environment, highly variable in time and space, and only partially known. Further, when considering low-frequency (f<500 Hz) sound propagation in coastal water (water depth D<200 m), the environment acts as a dispersive waveguide: the acoustic field is described by a set of modes that propagate with frequency-dependent speeds. In this context, to extract relevant information from acoustic recording, one needs to understand the propagation and to use physics-based processing. In this presentation, we will review shallow-water acoustics and modal propagation in an ocean waveguide, as well as time-frequency (TF) analysis (real-time spectrogram of ambient sound and attendant voices will be shown). We will then show how modal propagation and TF analysis can be combined into a non-linear signal processing method dedicated to extract modal information from a single hydrophone (i.e., an underwater microphone), and how such information can be used to localize sound sources and/or characterize the oceanic environment. The whole method will be illustrated on several oceanographic examples, including estimation of sediment properties on the US East coast and baleen whale localization in the Arctic.