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Book Review of 'Seismic Ambient Noise'

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This book on seismic ambient noise provides a convenient and timely text on theoretical aspects, observations and interpretation of the ubiquitous background signal in continuous seismic time-series collected around the world. The principal editor team managed to commit experts in various complementary fields in ambient-noise research and application to a wide range of frequencies from Earth's free oscillations to ultrasound waves. The product of their efforts is a comprehensive treatise that many have been waiting for. Each of the chapters is well written, and the book could well serve as the principal textbook for a graduate-level course on the topic. The text is dominated by the causes and interpretation of ambient noise in broadband seismic time-series. But the reader will also find the theoretical treatise on and implementation for active and passive ambient noise applications at high frequencies, for example to explore material properties in the laboratory. Because multiple authors contributed to the book, the text is not strictly structured along a main train of thought, and the chapters are largely self-contained. In fact, there is often an overlap, for example on the processing of cross-correlations. This allows an interested reader to select a specific chapter without having to worry about skipping relevant subject matter.

So what is the ambient noise discussed in this book? In broadband seismic time-series, the ambient background noise originates from wind-generated ocean waves that interact with each other and the solid Earth, where elastic seismic waves are generated. These propagate along Earth's surface and through it, and they are observed continuously, even in the interior of a continent. Variations in the strength of the noise are largely associated with the migration of storms. In this environment, ambient noise observations were first recognized and interpreted as propagating intermediate-period Rayleigh waves (at periods between 1 and 20 s) before it was recognized that ambient noise can be excited even at periods in Earth's normal-mode band, at periods longer than 100 s.

Broadband microseism observations have been reported for several decades. But their interpretation and utilization as structural imaging tool has not lastly greatly benefited from the development of the theoretical background and numerical methods at much higher frequencies. The work on acoustic waves, including ultrasonic waves, broke the ground to destruction-free investigation of material properties and structural integrity. This book therefore also includes chapters on high-frequency noise. A short description of each of the chapter follows.

The book first presents a summary of how broadband seismic background noise is commonly processed and visualized in standard seismic data processing that is widely used by the Incorporated Research Institutions for Seismology (IRIS). Explicit case studies are discussed, ranging for the classical seasonal noise variations to recent observations that allow the timing of sea ice cover in the Arctic.

Several chapters detail processing aspects of ambient-noise time-series and juxtapose the analysis of the particle motion against array processing at a wide range of frequencies. For any person analysing noise with a 3-component instrument or with an array of vertical seismometers, Chapter 2 is the 'getting started' chapter.

The following three chapters deal with Earth's ambient noise. Chapter 3 discusses how seismic noise in various frequency bands originates from wind-generated ocean waves. The reader learns that ocean waves interact with each other but also with the topography of the seafloor to generate either travelling or standing waves that are converted to seismic waves at the fluid–solid boundary. A chapter follows that develops the concept of noise interferometry for both acoustic and elastic waves, where the signals are observed at a pair of stations. The chapter explains Green's function retrieval by correlation using three common mathematical models. Interferometry without Green's function retrieval is also discussed. Chapter 5 provides more detail on how surface wave ambient-noise correlations are processed in Earth applications. The authors include details regarding uncertainties and assessing systematic errors. Chapter 7 provides applications towards seismic tomography for both sparse and dense networks.

Chapter 6 deals with coda wave interferometry and presents the theoretical treatment of traveltime changes and implications for structural investigations. Numerical applications are targeted to high frequencies in the ultrasound band to examine rock and material properties. Cases are derived for diffusive acoustic and elastic waves, and acoustic waves that obey radiative transfer. Estimation of elastic property changes can be formulated as a standard linear inverse problem. Structural sensitivity kernels depend hereby on the energy density of the coda waves in space.

Chapter 8 follows on relatively recent efforts to extract body wave information from ambient-noise records. The chapter begins with phenomenological aspects of body wave microseisms, and then elaborates on processing steps to extract body waves from cross-correlations. This chapter concludes with case studies at different geographical scales.

Chapter 9 discusses the observation of ambient noise from a monitoring perspective. It first presents some methodological steps involved to detect and monitor changes in general. Case studies are presented for environmental, volcanic and earthquake processes. The chapter concludes with the use of noise monitoring to assess time variations in seismic material properties.

The book concludes with a chapter on near-surface engineering. After a brief introduction to active and passive surface wave methods, the chapter then details strategies in the experiment design, including array shapes and sizes. A discussion on data processing and inversion follows, including the interpretation of higher modes.

Two specific examples are given, where in one buried channels are delineated. The test site involved a 13.5 × 12 km rectangle in Saitama prefecture, Japan. The other example deals with the effects of basin geometry on the site response, and a specific example is presented for the Hayward Fault in California.

Ambient-noise research has seen a tremendous growth in the last 15 yrs, and some applications are still emerging. The successful extraction of body-wave information is relatively new, and so is the treatment of Love waves and anisotropy. Efforts to locate the sources of Earth's ambient noise are also intensifying. Long-term or repeat seismic deployments provide tremendous opportunities to explore time-varying structural properties and may allow insight that is hard to come by with earthquake seismology. The reader may look forward to a future compendium on ambient-noise research discoveries. This book sets the stage to do the research.

The book is available in print as well as an ebook. The former is printed in black and white and contains colour versions of some of the figures within Chapter 5.