

# Preface

Natural hazards and anthropic activities threaten the quality of the environment surrounding the human being, risking life and health. Among the different actions that must be taken to control the quality of the environment, the gathering of field data is a basic one.

In order to obtain the needed data for environmental research, a great variety of new instruments based on electronics is used by professionals and researchers. Sometimes, the potentials and limitations of this new instrumentation remain somewhat unknown to the possible users. In order to better utilize modern instruments it is very important to understand how they work, avoiding misinterpretation of results. All instrument operators must gain proper insight into the working principles of their tools, because this internal view permits them to judge whether the instrument is appropriately selected and adequately functioning.

Frequently, manufacturers have a tendency to show the great performances of their products without advising their customers that some characteristics are mutually exclusive. Car manufacturers usually show the maximum velocity that a model can reach and also the minimum fuel consumption. It is obvious for the buyer that both performances are mutually exclusive, but it is not so clear for buyers of measuring instruments. This book attempts to make clear some performances that are not easy to understand to those uninitiated in the utilization of electronic instruments.

Technological changes that have occurred in the last few decades are not yet reflected in academic literature and courses; this material is the result of a course prepared with the purpose of reducing this shortage. The content of this book is intended for students of hydrology, hydraulics, oceanography, meteorology and environmental sciences.

Most of the new instruments presented in the book are based on electronics, special physics principles and signal processing; therefore, basic concepts on these subjects are introduced in the first chapters (Chapters 1 to 3) with the hope that they serve as a complete, yet easy-to-digest beginning. Because of this review of concepts it is not necessary that the reader have previous information on electronics, electricity or particular physical principles to understand the topics developed later. Those readers with a solid understanding of these subjects could skip these chapters; however they are included because some students could find them as a useful synthesis.

Chapter 4 is completely dedicated to the description of transducers and sensors frequently used in environmental sciences. It is described how electrical devices are modified by external parameters in order to become sensors. Also an introduction to oscillators is presented because they are used in most instruments. In the next chapters all the information presented here is recurrently referred to as needed to explain operating principles of instruments.

Chapters 1 to 4 are bitter pills that could discourage readers interested in the description of specific instruments. Perhaps, those readers trying this book from the beginning could abandon it before arriving at the most interesting chapters. Therefore, they could read directly Chapters 5 to 11, going back as they feel that they need the knowledge of the previous chapters. We intended to make clear all the references to the previous subjects needed to understand each one of the issues developed in the later chapters.

Chapter 5 contributes to the understanding of modern instrumentation to measure flow in industrial and field conditions. Traditional mechanical meters are avoided to focus the attention on electronic ones, such as vortex, electromagnetic, acoustic, thermal, and Coriolis flowmeters. Special attention is dedicated to acoustic Doppler current profilers and acoustic Doppler velocimeters.

Chapter 6 deals with two great subjects; the first is devoted to instruments for measuring dynamic and quasi static levels in liquids, mainly water. Methods to measure waves at sea and in the laboratory are explained, as well as instruments to measure slow changes such as tides or piezometric heads for hydrologic applications. The second subject includes groundwater measurement methods with emphasis on very low velocity flowmeters which measure velocity from inside a single borehole. Most of them are relatively new methods and some are based on operating principles described in the previous chapter. Seepage meters used to measure submarine groundwater discharge are also presented.

Chapter 7 presents methods and instruments for measuring rain, wind and solar radiation. Even though the attention is centered on new methods, some traditional methods are described not only because they are still in use, and it is not yet clear if the new technologies will definitely replace them, but also because describing them permits their limitations and drawbacks to be better understood. Methods to measure solar radiation are described from radiation detectors to complete instruments for total radiation and radiation spectrum measurements.

Chapter 8 is a long chapter where we have tried to include most remote measuring systems useful for environmental studies. It begins with a technique called DTS (Distributed Temperature Sensing) that has the particularity of being remote, but where the electromagnetic wave propagates inside a fibre optic. The chapter follows with atmosphere wind profilers using acoustic and electromagnetic waves. Radio acoustic sounding systems used to get atmospheric temperature profiles are explained in detail as well as weather radar. Methods for ocean surface currents monitoring are also introduced. The chapter ends with ground penetrating radars.

Chapter 9 is an introduction to digital transmission and storage of information. This subject has been reduced to applications where information collected by field instruments has to be conveyed to a central station where it is processed and stored. Some insight into networks of instruments is developed; we think this information will help readers to select which method to use to transport information from field to office, by means of such diverse communication media as fibre optic, digital telephony,

GSM (Global System for Mobile communications), satellite communications and private radio frequency links.

Chapter 10 is devoted to satellite-based remote sensing. Introductory concepts such as image resolution and instrument's scanning geometry are developed before describing how passive instruments estimate some meteorological parameters. Active instruments are presented in general, but the on-board data processing is emphasized due to its importance in the quality of the measurements. Hence, concepts like Synthetic Aperture Radar (SAR) and Chirp Radar are developed in detail. Scatterometers, altimeters and Lidar are described as applications of the on-board instruments to environmental sciences.

Chapter 11 attempts to transfer some experiences in field measuring to the readers. A pair of case studies is included to encourage students to perform tests on the instruments before using them. In this chapter we try to condense our ideas, most of them already expressed throughout the book, about the attitude a researcher should have with modern instruments before and after a measuring field work.

As can be inferred from the foregoing description the book aims to provide students with the necessary tools to adequately select and use instruments for environmental monitoring. Several examples are introduced to advise future professionals and researchers on how to measure properly, so as to make sure that the data recorded by the instruments actually represents the parameters they intend to know. With this purpose, instruments are explained in detail so that their measuring limitations are recognized. Within the entire work it is underlined how spatial and temporal scales, inherent to the instruments, condition the collection of data. Informal language and qualitative explanations are used, but enough mathematical fundamentals are given to allow the reader to reach a good quantitative knowledge.

It is clear from the title of the book that it is a basic tool to introduce students to modern instrumentation; it is not intended for formed researchers with specific interests. However, general ideas on some measuring methods and on data acquisition concepts could be useful to them before buying an instrument or selecting a measuring method. Those readers interested in applying some particular method or instrument described in this book should consider these explanations just as an introduction to the subject; they will need to dig deeper in the specific bibliography before putting hands on.