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# Laser Monitoring of the Atmosphere

Edited by E. D. Hinkley

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## Preface

There is a growing need for continuous monitoring of atmospheric constituents. This has been emphasized recently by the controversy over potentially adverse effects of high-flying aircraft, space shuttles, and even aerosol spray propellants on the life-sustaining ozone layer in the stratosphere. Moreover, the widespread use of more polluting fuels due to dwindling energy resources may produce serious consequences (such as reducing the amount of useful solar energy reaching the earth's surface, changing the earth's heat balance, and degrading air quality in the lower atmosphere) which have yet to be fully understood. Mathematical models of the atmosphere are needed in order to be able to predict the environmental impact of increased source pollution and take the necessary corrective action in a timely and cost-effective manner. The development of these models and the associated continuous surveillance require a wide range of monitoring capabilities.

Surveillance-type monitoring can usually be performed best, and at least expense, with optical techniques. Laser technology has made great strides recently, and the role of lasers in atmospheric monitoring applications has steadily increased; indeed, all of the major laser schemes proposed for monitoring (based on scattering, fluorescence, absorption, and emission) have now been demonstrated experimentally. It is appropriate, therefore, to devote a volume in this Topics series to the subject of laser monitoring of the atmosphere.

This book describes, in a comprehensive and tutorial manner, the fundamental techniques of laser detection of gases and particles. Each chapter contains basic information such as mathematical expressions for the processes and typical values of relevant parameters, in addition to examples of actual measurements made in the field. Consequently, this book should be a useful reference for working scientists and engineers, and a supplementary text book for graduate and undergraduate courses in environmental studies. The broad scope of laser monitoring can be appreciated if we consider that atoms existing in a layer *above* the stratosphere have been detected and their concentrations measured by ground-based laser systems, and gases have been monitored *within* the stratosphere using a balloon-borne tunable laser system. In

the lower atmosphere, pollutant gases, particles, wind speed, and atmospheric temperature have been monitored remotely using laser techniques; and the development of mathematical models for pollutant transport, dispersion, and conversion has been aided by long-path laser measurements.

Each chapter is devoted to a particular type of laser monitoring; but there is strong continuity between chapters, with many cross-references and a uniform set of symbols, defined in the Introduction (Chapt. 1). Chapter 2 considers the structure of the atmosphere and how laser techniques can fulfill some of the air quality management needs of the future. Chapter 3 discusses atmospheric transmission and the selection of appropriate laser wavelengths. Chapters 4–7 concentrate on specific laser techniques. Safety requirements, which must be considered for active laser monitoring systems, are also discussed.

We now recognize that life on earth is affected, both directly and indirectly, by atmospheric constituents not only near ground level but throughout the rest of the troposphere and stratosphere, and possibly above. For proper surveillance of this vast region at reasonable cost, it is becoming increasingly evident that the capabilities offered by laser monitoring techniques may be the only answer. The authors hope that this book will be a useful guide for the evaluation and development of these future laser monitoring systems.

I am indebted to several colleagues for their helpful ideas and comments; particularly, P. L. KELLEY and W. E. BICKNELL of M. I. T. Lincoln Laboratory, V. E. DERR of the National Oceanographic and Atmospheric Administration, and P. B. RUSSELL of Stanford Research Institute. Sincere appreciation is also expressed to the contributors and their families, and to my own wife and children for their patience and encouragement.

Concord, Mass.  
May 1976

E. D. HINKLEY

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