Preface

In recent years, it has emerged that human activities contribute to the climate changes of our planet. For this reason, it is essential to understand the chemical and physical processes governing atmospheric balance, to determine the concentration of atmospheric constituents and monitor their distribution worldwide. In situ measurements from ground-based instruments can give detailed local information, but only passive remote sensing instruments mounted aboard satellites can generate the global records needed for long-term monitoring of the atmosphere. For these reasons, two schools on remote sensing have been held at the International Centre for Theoretical Physics ICTP at Trieste (founded by the Nobel Prizewinner Abdus Salam) over the last four years. The first school "Exploring the Atmosphere by Remote Sensing" was mainly devoted to atmospheric applications, whereas the second "Inverse Methods in Atmospheric Sciences" focused on techniques to retrieve atmospheric components, gases, aerosol and clouds. More than 140 students from different countries attended the courses and 30 lecturers introduced the Earth Observation missions and the most advanced techniques to retrieve atmospheric components. This book contains the topics underlying each of the two schools.

The first contribution by Paul Simon and Polymnia Skarlas introduce the networks, combining measurements from various instruments, forming an integral part of a general strategy, namely the Integrated Global Observing Strategy (IGOS), which seeks to bring together the major ground-based and satellite components of the Earth's observing system for a better effectiveness in their use and in the study of the environment. This gives a few examples of networks focusing on generating data of known and high quality, to support research related to the Earth's atmospheric environment on the short- and long-term scales, but also assessments on global change and guidance in international policy making.

A second contribution by Martine DeMaziere covers the exploitation of the synergy between ground and space measurements. This contribution introduces some remote sensing ground-based observation methods and highlights some aspects of atmospheric changes. Many references are included for further reading.

A third contribution by Knut Stamnes reviews forward modelling capabilities and requirements in connection with remote sensing of the environment. Emphasis is placed on the formulation of the problem and on discussion of recent developments. The plane-parallel radiative transfer model is used as a specific example of a forward model that is simple but very useful. A solution to this forward model is outlined using the discrete ordinate method. A linearized version of this discrete ordinate solution yielding analytic weighting functions or Jacobians in addition to radiances is also briefly discussed. This provides a framework for a discussion of computational resource and accuracy requirements.

A fourth contribution by Michael Mishcenko and Larry Travis introduce the optical properties of nonspherical particles that are not adequately described by the classical Lorenz-Mie theory and must be determined using advanced theoretical and experimental techniques. This contribution describes how electromagnetic scattering by small nonspherical particles can be computed and measured; the main effects of nonsphericity on electromagnetic scattering is analyzed, discussing the implications of these effects in computations of the earth's radiation balance and atmospheric remote sensing.

A fifth contribution by Rodolfo Guzzi and Oleg Smokty introduces the problem of information content of environment data to be retrieved by a satellite sensor. The retrieval can be modelled on a joint mathematical description taking into account both the satellite sensors and measurement data trend, and the operators set related to mutually linked direct-inverse problem solutions and the input optical models of the "atmosphere-underlying surface system". An example, in which the atmospheric phase function is described by three terms (Rayleigh case) is also reported to show the feasibility of the approach in a particular case.

A sixth contribution by Giuseppe Dalu introduces passive remote sensing of infrared and microwave radiation emerging from the atmosphere, and presents some of the algorithms used to retrieve the following parameters: sea surface temperature, surface winds, surface emissivity, atmospheric water vapor content, liquid water content, temperature and water vapor profiles.

A seventh contribution by Kusiel Shifrin introduces the analytical inverse methods and regularization techniques adpted to retrieve the distribution functions of atmospheric aerosol. The lively interest in studies of atmospheric aerosols has grown in recent years, resulting in the development of many new methods and devices. The main concern of the contribution is to give a clear and concise account of the idea of existing methods, highlighting their advantages and drawbacks, outlining the prospects for their development, and indicating the literature where the reader can find all the details of his/her interest.

An eighth contribution by GianPaolo Gobbi shows how lidars represent an efficient tool to observe minor atmospheric constituents with high spatial and temporal resolution particularly atmospheric aerosols, one of the major unknowns in the Earth's climate system. The fundamental tools for a quantitative retrieval of aerosol extinction and backscatter on the basis of single-wavelength lidar observations are provided. Ground-based lidars only represent a point observation, whereas remote-sensing of the atmosphere necessitates the synergistic contribution of active and passive techniques, operating both from the ground and from space. In this respect, planned space-borne missions including both lidar and radiometric observations (like CALYPSO, expected to fly in 2004) constitute the natural evolution of the application of lidars to the definition of the global aerosol budget.

The ninth contribution by Didier Fussen, Filip Vanhellemont and Cristine Bingen tackle the occultation technique based on recording of sunlight above the horizon. Its benefit resides in the derivation of an absolute quantity (the slant path optical thickness) through the measurement of a relative signal. The ORA experiment is presented together with the inversion method used to retrieve the atmospheric components.

All these contributions cover those topics that can be useful both for students of the atmospheric sciences (as is the case for ICTP students) and also for those wishing to study in depth techniques for exploring the atmosphere by remote sensing.

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