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Airborne instruments to measure atmospheric aerosol particles, clouds and radiation: A cook's tour of mature and emerging technology

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ABSTRACT

An overview is presented of airborne systems for in situ measurements of aerosol particles, clouds and radiation that are currently in use on research aircraft around the world. Description of the technology is at a level sufficient for introducing the basic principles of operation and an extensive list of references for further reading is given. A number of newer instruments that implement emerging technology are described and the review concludes with a description of some of the most important measurement challenges that remain. This overview is a synthesis of material from a reference book that is currently in preparation and that will be published in 2012 by Wiley.
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Contents

1. Introduction

The fact that global climate is modified as a result of the complex interactions between solar radiation and atmospheric particles is undisputed, but the magnitude and sign (warming versus cooling) of the effects remain a major point of debate. Numerous models have been developed that explore the processes by which aerosol particles interact directly with solar and terrestrial radiation and how some of these particles subsequently form cloud droplets or ice crystals, further enhancing such interactions. The results from these models are often at odds with one another, largely due to differences in how the aerosol and cloud properties are represented in the simulations, differences that are partially attributable to lack of detailed measurements of these properties over a broad enough range of conditions.

The use of satellites, whose measurement capabilities continue to expand with respect to their sophistication, resolution and coverage, has made a significant improvement in the fidelity of the models as the model products can be validated and data assimilated. The advances in satellite technology and associated analysis algorithms have been accompanied by validation programs that compare in situ measurements with satellite products. These types of validation studies are invaluable and many more are needed with even more sophisticated airborne instruments on platforms that can cover larger spatial ranges over many pixels of satellite resolution.

Here we give a broad overview of the sensors that are currently being used worldwide on research aircraft for investigating basic atmospheric processes and acquiring information that expands the data bases of aerosol, clouds and radiation, sources of data that are essential for validating model products and satellite retrieval algorithms. Our objective is to provide sufficient information on operating principles, limitations and uncertainties at a level of detail that will provide

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