# 1. Introduction

- *scope*
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## 1. Introduction

### *a. Scope*

This course surveys the methodology and tools of experimental research in atmospheric science. This volume, Part 1, treats topics that are general and applicable to most experimental science: how to interpret measurements, test hypotheses, and design experiments. The focus is on the analysis of experimental data, with lesser attention to the design of experiments. Analysis techniques will be treated first, and design of experiments toward the end of the text, because experimental design must take into account the possible ways in which the data can be used.

Most of this material in Part 1 is presented in a format resembling a user's handbook, with corresponding weaknesses in the mathematical justifications and foundations. Some references to the extensive literature on these subjects are included to fill these gaps, but the target audience is those who will use these methods in experimental research so their practical needs are emphasized. This choice has led to a primary emphasis on techniques and methods, in many cases with only enough formal justification to provide a sense of the validity and applicability of the methods described.

*b. Accompanying material*

Part 2 contains brief discussions of some of the primary data sources for research in atmospheric science, and is intended as an introductory guide to common sources of observations in atmospheric science. Part 2 contains brief descriptions of some of the primary sources of experimental data in atmospheric science. The material, prepared by experimental meteorologists, illustrates how data are acquired and used in current research projects, and shows the variety of data sources and approaches that are in current use. This material is based on presentations at the NCAR 1992 Summer Colloquium on Observational Techniques (1–19 June 1992). Notes by the students attending that colloquium and material prepared by the lecturers and participants were used as the basis for Part 2.

*c. Objectives*

The primary objective of this text is to provide a broad background in the methodology of experimental research. Most areas are not covered in great depth, and it is expected that it will be necessary for readers to delve deeper into topics like spectral analysis or the techniques of fitting non-linear parameters before these will become comfortable tools. However, the course should provide a good introduction to the range of approaches available, so that an experimenter can then pursue applicable possibilities in more depth. A material is presented at a level that will permit readers to use the techniques and appreciate their value.

There were some other goals of the Colloquium that carry over to this book:

- We hoped to convey some of the flavor as well as the substance of experimental research. The authors of Part 2 are leaders in their fields who not only provided a state-of-the-art look at their fields, but also showed how observations are driving progress in their areas. Experimentation in meteorology is particularly challenging: It is hard to conduct a controlled experiment, so often other approaches must be used to test theoretical ideas. The concept that knowledge is tested or validated by observation is at the heart of the scientific method. If a task of science is to explain and understand natural phenomena, observations of those phenomena must occupy a central role.
- It is an unfortunate characteristic of meteorological research that experimentalists are often guilty of inadequate attention to measurement uncertainties. It is a goal of this text that the methodology outlined here for characterization of measurement uncertainty might become more widely used in this field.
- Finally, we hope to call attention to the value of careful experimental design. Even though most atmospheric phenomena are complex, uncontrollable, and hard to observe, it is often possible to formulate specific hypotheses, devise critical tests of those hypotheses that distinguish among different competing theories, then make the observations required to test those hypotheses. This can result in faster progress than does the unsystematic collection of data in poorly designed experiments, followed by "case-study" approaches that hope to find something interesting. The latter approach often leads to clues and can support many speculations, but only by chance will it lead to definitive progress.