There is no doubt that the composition of the atmosphere and the Earth’s climate have changed since the industrial revolution, with human activities as the predominant cause. The atmospheric concentration of carbon dioxide has increased by more than 40% since the preindustrial era, primarily from the combustion of fossil fuels for the production of energy. The global mean surface temperature, which has been relatively stable over 1000 years, has already increased by about 1°C since the preindustrial era. If these energy production activities do not shift markedly, these changes will inevitably continue. The global mean temperature is projected to increase by an additional 2°C–3°C during the twenty-first century, with land areas warming significantly more than oceans and the Arctic warming significantly more than the tropics.

The availability of water is also likely to change over the continents. Water will probably be more plentiful in already water-rich regions, increasing the rate of river discharge and frequency of floods. In contrast, water stress will increase in the subtropics and other water-poor regions that are already relatively dry, increasing the frequency of drought. Observations suggest that the frequencies of both floods and droughts have been increasing. Unless dramatic reductions of greenhouse gas emissions are achieved, global warming is likely to exert far-reaching impacts upon human society and the ecosystems of our planet during the remainder of this century and for many centuries to come.

Climate models are the most powerful tools for predicting human-induced global warming. They are based upon the laws of physics and have evolved from the models used for numerical weather prediction. Exploiting the vast computational resources of some of the world’s most powerful supercomputers, climate models have been used to make predictions of future climate change and its impacts, providing valuable information for policymakers. Climate models have been useful not only for predicting climate change but also for understanding it. Serving as
“virtual laboratories” of the coupled atmosphere-ocean-land system, they can be used for performing controlled experiments that have proven very effective for systematically elucidating the physical mechanisms involved in climate change.

The primary title of this book, *Beyond Global Warming*, reflects our strong belief that the greatest value of climate models is not just their utility for making predictions, but also their ability to provide a deeper understanding of how the climate system works. Starting from the pioneering study conducted by Arrhenius more than 100 years ago, this book presents a history of the use of models in studies of climate change. Based upon the analysis of many numerical experiments performed with a hierarchy of climate models of increasing complexity, we seek to elucidate the basic physical processes that control not only global warming but also the changes in climate of the geologic past. It is not our intention, however, to present a comprehensive survey of the literature on climate dynamics and climate change. Instead, we would like to focus on studies in which Manabe was a participant and those that influenced his thinking. We hope to describe the scientific journey that allowed him to develop a better understanding of the processes that underlie climate change. He was accompanied for parts of this journey by Broccoli, who was likewise influenced and informed by the studies described in this volume.

This book has evolved from the lecture notes of a graduate course that Manabe taught in the Program in Atmospheric and Oceanic Sciences at Princeton University. The book may be useful as a reference text for graduate and advanced undergraduate courses in climate dynamics and climate change, but also in other disciplines that involve the environment, ecology, energy, water resources, and agriculture. But, most of all, we hope that this book will be useful for those who are curious about how and why the climate has changed in the past and how it will change in the future.