Geophysical Monograph 139

Volcanism and the Earth's Atmosphere

Alan Robock
Clive Oppenheimer
Editors

American Geophysical Union
Washington, DC

PREFACE

Volcanic activity can have a profound effect on the Earth's atmosphere and environment across many spatial and temporal scales. From being the source of most gases in the atmosphere over geologic time scales, to producing climate change, to threatening aviation, volcanic eruptions as well as non-eruptive volcanic gas and particle emissions provide a strong link between the lithosphere and the impact of the atmosphere on human activities. Since the massive 1991 Mt. Pinatubo eruption we have gained—and continue to gain—greater understanding of the impacts of volcanic eruptions on the atmosphere and climate. Among other things, we have learned about the winter warming effect on Northern Hemisphere continents, about effects on ozone chemistry, and about the impacts of volcanic radiative forcing on the carbon cycle. The importance of quantifying the effects of volcanic eruptions on interdecadal climate change has become more apparent in the context of anthropogenic global warming. New instruments and techniques have strengthened our ability to measure volcanic gas and aerosol concentrations, fluxes, and chemistry in the atmosphere. And new ice cores have allowed us to significantly improve the record of past volcanism.

This book is designed for climatologists, volcanologists, atmospheric scientists, environmental scientists, anthropologists, archeologists, geologists, glaciologists, dendrochronologists, those working on ground-based and satellite remote sensing, atmospheric hazards forecasters, and others interested in the connection between the solid Earth and the atmosphere. Observations of volcanic gas and particle emissions, reconstruction of past emission histories, and quantification of the effects on the biosphere and the climate system bridge a large number of disciplines. Never before has a monograph from so many disciplines been assembled to address the effects of volcanic eruptions on the atmosphere, and this once again emphasizes the value of interdisciplinary work in modern science research.

While this book presents our current understanding of volcanic emissions to the atmosphere, remote sensing of volcanic emissions, ice core records of past volcanism, tree ring records of the climate change following volcanic eruptions, effects of volcanic eruptions on ozone depletion and recovery, volcanic aerosols in the atmosphere, and even taking volcanic eruptions into account when making seasonal forecasts, there remain a number of outstanding scientific issues to be addressed. These include:

- What exactly goes into the atmosphere during an explosive eruption, and where does it go?
- How do quiescent emissions change over time?
- How can we better quantify the record of past climatically significant volcanism?
- Can we design an improved system for measuring and monitoring the atmospheric gases and aerosols resulting from future eruptions—are we ready for the next Pinatubo?
- How can we better model the climatic impact of eruptions, incorporating microphysics, chemistry, transport, radiation, and dynamical responses?
- How do high-latitude eruptions affect climate?
- How much do season, atmospheric dynamics, and other non-volcanic "environmental" factors affect the climatic forcing of an eruption?
- How important are indirect effects of volcanic emissions on clouds?
- Where are the important potential sites for future eruptions?

The chapters in this book serve as an excellent basis for continued work on these topics.

To improve understanding of these phenomena, the International Association of Volcanism and Chemistry of the Earth's Interior (IAVCEI) and the International Association for Meteorology and Atmospheric Sciences (IAMAS) formed the Commission on Volcanism and the Earth's Atmosphere at the AGU Chapman Conference on “Climate, Volcanism and Global Change” in 1992 following one of the largest eruptions of the 20th century, that of Mt. Pinatubo in 1991. To review the progress since then and stimulate new work, the Commission sponsored a 10th anniversary Chapman Conference on the site of one of the most important past volcanic eruptions that profoundly affected civilization, the “Minoan” eruption of Santorini in

the Late Bronze Age. The conference, held in Santorini, Greece, June 17-21, 2002, was attended by 108 scientists. Chapters in this book derive from presentations at that conference. We thank the National Science Foundation, National Aeronautics and Space Administration, and IAVCEI, who provided travel support for many of the participants to the workshop. Ann Singer of the AGU Meetings Department, with the assistance of Ed Lipschitz, provided wonderful support for the organization and on-site operation of the conference. Stephen Sparks' idea to hold the conference on Santorini led to its large attendance and dramatic success. The program committee, Michael Carroll, Paul D. Cole, Hans-F. Graf, Stephen Self, Stephen Sparks, Georgiy Stenchikov, and Gregory A. Zielinski, assisted in the choices of topics and invited speakers. We also thank the numerous reviewers who volunteered their time to help the authors improve the presentations in each of the chapters. All this support resulted in a very successful conference and contributed to the excellence of the chapters in this book.

Alan Robock
Clive Oppenheimer