Aeronomy of the Earth's Atmosphere and Ionosphere

IAGA Special Sopron Book Series

Volume 2

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Aeronomy of the Earth's Atmosphere and Ionosphere

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Foreword by the Series Editor

The IAGA Executive Committee decided in 2008, at the invitation of Springer, to publish a series of books, which should present the status of the IAGA sciences at the time of the IAGA 2009 Scientific Assembly in Sopron, Hungary, the "IAGA Special Sopron Series". It consists of five books, one for each of the IAGA Divisions, which together cover the IAGA sciences:

Division I – Internal Magnetic Field
Division II – Aeronomic Phenomena
Division III– Magnetospheric Phenomena
Division IV– Solar Wind and Interplanetary Field
Division V – Geomagnetic Observatories, Surveys and Analyses.

The groups of Editors of the books contain members of the IAGA Executive Committee and of the leadership of the respective Division, with, for some of the books, one or a few additional leading scientists in the respective fields.

The IAGA Special Sopron Series of books are the first ever (or at least in many decades) with the ambition to present a full coverage of the present status of all the IAGA fields of the geophysical sciences. In order to achieve this goal each book contains a few "overview papers", which together summarize the knowledge of all parts of the respective field. These major review papers are complemented with invited reviews of special questions presented in Sopron. Finally, in some of the books a few short "contributed" papers of special interest are included. Thus, we hope the books will be of interest to both those who want a relatively concise presentation of the status of the sciences and to those who seek the most recent achievements.

I want to express my thanks to the editors and authors who have prepared the content of the books and to Petra van Steenbergen at Springer for good cooperation.

Kiruna, Sweden
October 2010

Bengt Hultqvist

Preface

This book presents a comprehensive set of articles on a series of wide ranging topics in the broad area of the Aeronomy of the Earth's Atmosphere and Ionosphere. Important progress achieved in recent years in our understanding of the field from the lower atmosphere to higher domains of the thermosphere and ionosphere, and extending from polar to equatorial latitudes, is discussed in this book. Overview papers on broader areas are complemented by review papers on topics of specific interest as well as shorter papers of special interest. Together they cover the current status of our understanding of the field in terms of the dynamics, chemistry, energetics and electrodynamics of the atmosphere–ionosphere system and the coupling processes that control the wide ranging characteristics of the system behaviour, and its spatial and temporal variabilities. The scientific results presented at a good number of well focussed Division II and interdivisional symposia held at the 2009 IAGA Sopron Assembly represented the rapid advances in our knowledge of the field achieved during the last few years through observational/experimental studies, sophisticated data analysis techniques and global general circulation model (GCM) and other simulation studies. In an attempt to consolidate these outstanding results in a coherent way in one place, and to mark the progress achieved in recent years in our knowledge of aeronomy, articles from leading scientists in the field who did not attend the Sopron Assembly are also included in the Book. This book is designed to be a useful reference source for graduate students as well as experienced researchers.

The book's content is structured in five sections as follows:

Part I deals with some outstanding problems of the mesosphere and lower thermosphere related to the chemistry and dynamics of the coupling processes, and vertical coupling through tides and planetary waves and climatology of mesospheric temperature, that are addressed in two overview articles. The subsequent articles are concerned with variabilities in ozone, atomic oxygen, aerosols and other minor constituent, and gravity wave effects on noctiluscent clouds.

The coupling processes that involve upward propagating gravity waves and their consequences and manifestations in the mesosphere, thermosphere and ionosphere are discussed in *Part II*. Here the focus is on questions related to upward propagation of gravity waves from sources of their generation in tropospheric convective regions of tropical latitudes, the dissipation of these waves in thermosphere and ionospheric F-region, and their role in providing seed perturbations for instability growth that leads to irregularity development in the post sunset equatorial ionosphere. Some

questions related to atmosphere–ionosphere interaction through upward propagating tides and planetary waves are also discussed.

Part III deals with the electrodynamics and structuring of the ionosphere–thermosphere system. It starts with an overview article on the electrodynamics of the ionosphere–thermosphere coupling and is followed by a series of articles on equatorial vertical plasma drifts, three-dimensional modelling of equatorial plasma bubble development, coupling processes that control the development of equatorial spread F (ESF) irregularities, equatorial bubble development conditions diagnosed from long term optical data set, midlatitude ionospheric irregularities and medium scale travelling ionospheric disturbances (MSTIDs) as studied by radars, optical imagers and GPS receivers, and midlatitude plasma instabilities that arise from E-and F region coupling.

Part IV concerns Thermosphere–Ionosphere coupling, dynamics and trends. The focus here is on ion-neutral coupling and its important role in the dynamics and large scale features, such as the longitudinal wave structure found in this height region. The first article presents an overview of new aspects of the coupling between thermosphere and ionosphere that have emerged from CHAMP satellite mission results. The subsequent articles address the following topics: Influence of thermospheric winds on the Equatorial Ionization Anomaly (EIA) and secular variation (long term trend) of the EIA in the Brazilian longitude, the whole atmosphere model (GCM) simulation of temperature and density structure of equatorial thermosphere, tide induced longitudinal wave structure in equatorial thermospheric zonal wind as observed by CHAMP, connection between such structure in plasma density and the vertical plasma drift of the equatorial ionosphere, longitudinal structure of mid- and low latitude ionosphere as observed by space borne GPS receivers, and ionosphere–thermosphere coupling in low latitudes. This section further presents a tutorial on midlatitude sporadic E layers and two articles on long term trend in the upper atmosphere and on the use of F layer parameters to determine long term trends in the thermosphere dynamics.

Part V on ionosphere–thermosphere disturbance and modelling starts with an overview article on storm time responses of the thermosphere–ionosphere system. Related topics presented in subsequent articles are concerned with outstanding questions on ionospheric data assimilation and limitations on the model due to missing physics, magnetospheric electric field penetration to low latitudes during storms, modelling of the storm time electrodynamics, and a discussion of possible physical mechanism for positive ionospheric storms over low and middle latitudes.

As editors, we wish to thank all the authors of the articles for their dedicated efforts that made possible the realization of this book. We also express our gratitude to all the reviewers listed below for their help in the evaluation of the science incorporated in the present book.

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