

Preface

The Sun is the most important external driver of climate. Although the total solar irradiance (TSI) fluctuates by less than 0.1 % during a solar cycle, the solar impact on the terrestrial atmosphere can be significant, in particular in the upper atmosphere where the highly variable energetic part of the solar spectrum is absorbed. TSI variations on centennial time scales are of similar magnitude. Unfortunately, the scientific understanding of the variation of solar radiation (and its spectral components) and its impact on the atmosphere is rather limited. This concerns the direct modification of composition by solar radiation, but even more so various coupling mechanisms. For example, photochemically active gases are generated in the upper atmosphere, propagate to lower layers where they substantially alter the composition, e.g., the abundance of ozone. Planetary waves, gravity waves, and tides are excited in the atmosphere and propagate over large distances. They transport trace gases, energy, and momentum. Although these waves are most pronounced in the middle atmosphere, they may modify the background circulation in the entire atmosphere, even in the troposphere. As can be seen in various chapters in this book, major progress has been achieved in our understanding of solar radiation, its impact on the atmosphere, and coupling mechanisms within the atmosphere. Still, various uncertainties exist. For example, the observed solar signal in some parts of the middle atmosphere is larger than can be explained by models.

The purpose of this book is to summarise the scientific results related to a major research program of the international SCOSTEP organisation (Scientific Committee on Solar-Terrestrial Physics) called CAWSES (Climate And Weather of the Sun Earth System). The German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) ran a priority program ('Schwerpunktprogramm', SPP) from 2005 to 2011 focusing on several important science topics from CAWSES. The aim of the CAWSES SPP is a better understanding of the influence of the Sun on the terrestrial atmosphere and the physical/chemical processes involved in various coupling mechanisms within the atmosphere. The DFG spent approximately 10 Million Euro for a total of 25–30 institutes. Most of the financial support from DFG was used for postdoctoral and PhD student positions. In 31 chapters, this book presents the scientific summaries from 28 projects supported under a total of 93 individual

grants. International cooperation was strongly encouraged and supported by funds for travel, etc. At each stage of the proposals, an international team of reviewers assisted the DFG in their selections. Several hundred papers were published in international peer reviewed journals within the priority program.

The book is structured in six parts, namely i) solar radiation, heliosphere, and galactic cosmic rays (Chaps. 2 to 6), ii) solar influence on trace gases (Chaps. 7 to 10), iii) thermosphere, energetic particles, and ionisation (Chaps. 11 to 17), iv) mesospheric ice clouds (Chaps. 18–20), v) gravity waves, planetary waves, and tides (Chaps 21 to 28), and vi) large-scale coupling (Chaps. 29 to 32). The evolution of solar radiation, its effect on galactic cosmic rays (GCR), and their potential impact on cloud droplets in the troposphere are studied in detail. Some chapters concentrate on the direct effect of solar radiation on trace gases, mainly on ozone and water vapour in the stratosphere and mesosphere. Precipitating particles of solar or geomagnetic origin modify the upper atmosphere directly. They also produce photochemically active species which can be transported downward and significantly affect the mesosphere and upper stratosphere. This aspect is studied in several chapters. Results on short and long-term variations of mesospheric ice clouds, as well as related microphysical aspects are presented. Planetary waves, gravity waves, and tides play a key role in distributing and modifying a signal being imposed somewhere in the atmosphere by, for example, the solar cycle. Physical details of this process and implications of wave morphology for the entire atmosphere, from the thermosphere to the troposphere, are presented in several chapters. Finally, results on global aspects of the solar cycle, long-term variations, and comparison with anthropogenic climate change are covered.

This book addresses researchers and students who are interested in actual results on solar cycle and long term variations in the atmosphere. The chapters are written by lead scientists from nearly all major German research institutions where the terrestrial atmosphere is investigated. A brief introduction is provided at the beginning of each chapter to familiarise a broader community with the scientific background. Each chapter was subject to an international peer review process to ensure high quality.

In the name of the German CAWSES community I thank the German Research Foundation for funding the CAWSES priority program. We appreciated the constructive and stimulating support from the reviewers, some of whom accompanied our program for the entire six years. As speaker of this program I would like to express my appreciation for all the activities, excitement, and success being created in various groups. Perhaps most important, many students were involved and contributed to the enthusiasm when working on a wide range of scientific topics of solar-terrestrial physics. I thank Dr. Norbert Engler and Monika Rosenthal for their excellent assistance when compiling this book.

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Franz-Josef Lübken