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Editors

SCIAMACHY - Exploring the Changing Earth's Atmosphere

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Editorial

In March 2002, the atmospheric science instrument SCIAMACHY was launched on-board ESA's ENVISAT mission into low-Earth orbit. It was, and still is, one of the major current Earth Observation undertakings of Germany, The Netherlands and Belgium, accomplished in cooperation with the European Space Agency (ESA). Today, after successfully monitoring and exploring the Earth's atmosphere with SCIAMACHY for more than 8 years, the involved scientific institutes and space agencies feel that a comprehensive publication describing the SCIAMACHY mission – from the very first ideas to the current results – is worth publishing. The targeted readership shall be not only the existing and potentially new SCIAMACHY data users, from undergraduate student level up to researchers who are new in the fields of atmospheric chemistry and remote sensing, but also anybody who is keen on learning about SCIAMACHY's efforts to study the atmosphere and its responses to natural phenomena and anthropogenic effects.

The first chapter explains briefly why it is necessary to make measurements from low-Earth orbit to study the atmosphere. The global views from an altitude of 800 km open new windows to observe large-scale phenomena which are of prime importance to understand today's changing atmosphere and climate. This introductory chapter sets the stage for the rest of the book. After summarising why SCIAMACHY was selected to be launched into space, chapter 2 takes a closer look at the ENVISAT mission that hosts SCIAMACHY. The purpose of chapter 2 is to describe those aspects of ENVISAT that are of relevance to the SCIAMACHY mission. Its location on the platform, the platform environment itself, and the ENVISAT orbit altogether determine many aspects of the instrument's design and operation. Similarly, the concepts for data downlink and handling in the ground segment specify how measurement data is received, processed and disseminated in general.

A detailed description of the instrument concept is the subject of chapter 3. It permits insight into the optical, thermal and electronic subsystems. Main emphasis is given to the optical paths since they collect and generate the spectral signals containing the information on geophysical parameters, thus being primarily responsible for the achieved data quality. In order to provide the reader with an idea about the challenges of instrument development, chapter 3 also outlines the history of how SCIAMACHY was built. Without a flexible operations concept, however, all the sophisticated instrument functionalities would have been useless. How SCIAMACHY is operated in-orbit is explained in chapter 4. Despite the complexity of the instrument, the chosen operations approach allows full exploitation of its capabilities in a well structured operations environment, thus supporting the need for long, stable measurements as required in atmospheric and climate research. In chapter 5, the various steps necessary to calibrate the instrument, on-ground and in-orbit, are presented. Calibration is required to fully characterise the optical paths. Additionally, chapter 5 also addresses optical performance monitoring which permits quantification of the degradation of optical components. Calibration and monitoring together ensure that the recorded signals are transformed into well calibrated spectra – a prerequisite for retrieving geophysical parameters with high accuracy throughout the mission lifetime.

Chapter 6 brings the more technical part of the publication to a close. It describes SCIAMACHY's in-orbit mission lifetime, starting with the launch and the Commissioning Phase and illustrates now more than 8 years of routine measurements. Various instrument characteristics, derived from the monitoring activities, are presented and show the excellent in-orbit behaviour. We also outline how in-orbit degradation, a phenomenon common to each long duration space mission, impacts SCIAMACHY's measurements, and demonstrate how it can be corrected or compensated.

In chapter 7, the science related information is introduced by summarising the principles and methods for the derivation of geophysical parameters from the measured spectra. During the early years of the mission, retrieval methods relied mostly on standard algorithms. Meanwhile, scientific ingenuity has generated a wealth of novel techniques that allow the retrieval of geophysical parameters even overtaking the original ideas. This chapter can be regarded as the basis for most of the SCIAMACHY data processing and scientific results being described in the next sections.

Operational and scientific data products are the subject of chapter 8. The reader learns which products are generated under ESA responsibility and which are provided by research institutions involved in SCIAMACHY. For the ESA generated products, the strict requirements and implementations of the operational processing environment are outlined. As every geophysical parameter retrieval requires well calibrated measurements, we also elaborate how calibration and monitoring information is used to derive earthshine, extraterrestrial radiance and irradiance data products from the raw signals.

Retrieved geophysical parameters do not necessarily immediately translate into atmospheric science results. It has to be proven first that the data products are of sufficient quality. This process of product validation, subject of chapter 9, was an enormous effort in the first years of the mission and is required, at an adequate level, throughout the mission and even beyond to create long-term datasets of known quality relevant for environmental, atmospheric and climate change research. Chapter 9 explains the selected validation procedures, associated teams and summarises results acquired so far.

Chapter 10 concludes the publication by presenting SCIAMACHY's unique view of the changing Earth's environment. The capabilities of the instrument permit studying phenomena in the different layers - from the atmospheric layer where we live in, i.e. the lower troposphere, up to the mesosphere and lower thermosphere where solar-terrestrial interactions begin to prevail. However, SCIAMACHY's view is no longer just limited to the bottom or top of the atmosphere. Even Earth surface parameters like vegetation or phytoplankton properties are now within reach, and solar activity can be monitored, as well. Finally, SCIAMACHY has proven surprisingly successful in acquiring spectral signals from the atmosphere of our neighbour planet Venus. The content of chapter 10 nicely illustrates the success achieved up to now and justifies continuing investments in the SCIAMACHY mission and data usage. Although we intended to be as complete as possible in the framework of this book, chapter 10 is still only a summary. Therefore, the interested reader is referred to the references given in this book and the websites listed below permitting a deeper look into SCIAMACHY results:

http://envisat.esa.int/
http://www.sciamachy.de/
http://www.sciamachy.org/
http://www.iup.uni-bremen.de/
http://joseba.mpch-mainz.mpg.de/
http://www.temis.nl/
http://wdc.dlr.de/

The SCIAMACHY project is and has been an important milestone in Earth Observation as it has already yielded unique scientific insights into how the Earth system works. Many people have contributed to its success. With the exception of the Principal Investigator John P. Burrows, who pushed the project since over 25 years, they cannot all be named here. But we intend to make clear that the mission is a team effort that combines expertise from agencies, industry and science.

The editors would like to thank all who have been involved in the preparation and careful reviewing of this publication. We hope that the result is well received by the readers.

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