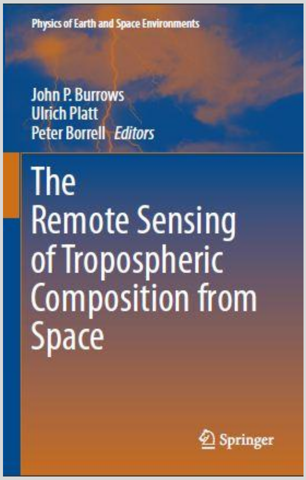
The Remote Sensing of Tropospheric Composition from Space



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John P. Burrows
Ulrich Platt
Peter Borrell

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The Remote Sensing of Tropospheric Composition from Space

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John P. Burrows • Ulrich Platt • Peter Borrell
Editors

The Remote Sensing of Tropospheric Composition from Space

With 158 Figures and 23 Tables

Springer

Prof. Dr. John P. Burrows
Universität Bremen
Institut für Umweltphysik (IUP)
Otto-Hahn-Allee 1
28359 Bremen
Germany
burrows@iup.physik.uni-bremen.de

Prof. Dr. Ulrich Platt
Universität Heidelberg
Institut für Umweltphysik
Im Neuenheimer Feld 229
69120 Heidelberg
Germany
ulrich.platt@iup.uni-heidelberg.de

Dr. Peter Borrell
P & PMB Consultants
6 Berne Avenue
Newcastle-under-Lyme
ST5 2QJ, United Kingdom
peter@ppmborrell.co.uk

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Preface

The impact of anthropogenic activities on our atmospheric environment is of much public concern, and the economic and technical solutions needed to provide a sustainable environment require reliable observations, coupled with a proper scientific understanding. Satellite-based techniques now provide an essential component of observational strategies on regional and global scales.

It is now some 15 years since the launch of GOME, the first satellite instrument designed specifically to retrieve the composition of trace gases and pollutants in the troposphere. Since then the number of satellite instruments has increased steadily, and the availability of satellite data is providing the capability of monitoring the state of the global atmosphere. It is also radically changing the field of atmospheric chemistry.

The purpose of this book is to summarise the state of the art in the field; to describe the technology and techniques used; and to demonstrate the key findings and results. The book has its origins in TROPOSAT, a project initiated within the EUROTRAC framework, to encourage the use and usability of satellite data for tropospheric research; the project was continued within the EU air quality project, ACCENT. Two of the book's editors were proposers of SCIAMACHY and the smaller scale GOME, which initiated European-based remote sensing of tropospheric trace gases from space. The third has coordinated the various TROPOSAT activities, having previously been the Executive Scientific Secretary of the EUROTRAC project. All the contributing authors to this volume are senior scientists actively involved in the field – in satellite data retrievals, in the validation of tropospheric data, in the interpretation of the global and regional results and in the modelling, which relies on the data; most are part of the TROPOSAT community.

The book opens with an historical perspective of the field together with the basic principles of remote sensing from space. Three chapters follow on the techniques and on the solutions to the problems associated with the various spectral regions in which observations are made.

The particular challenges posed by aerosols and clouds are covered in the next two chapters. Of special importance is the accuracy and reliability of remote sensing data and these issues are covered in a chapter on validation.

The final section of the book is concerned with exploitation of the data for scientific and operational applications. These include investigations using individual data products and synergistic studies using a variety of data products. Comparison of global and regional observations with chemical transport and climate models are discussed and the potential added value from the synergetic interaction of model and measurements identified.

The book concludes with scientific needs and likely future developments in the field, and the necessary actions to be taken if we are to have the global observation system that the Earth needs in its present, deteriorating state.

The appendices provide a comprehensive list of satellite instruments, global representations of some ancillary data such as fire counts and light pollution, a list of abbreviations and acronyms, and a set of colourful timelines indicating the satellite coverage of tropospheric composition in the foreseeable future.

The recent impact of volcanic ash on European air transport (Chapter 10) has provided a forceful reminder of the utility of satellite observations in monitoring and understanding the tropospheric constituents in the atmosphere. Thus the book provides a timely account of the developments in a new area of much utility to sustaining a healthy atmosphere.

Bremen, Germany and NERC CEH, Wallingford, UK John P. Burrows
Heidelberg, Germany Ulrich Platt
Newcastle-under-Lyme, UK Peter Borrell

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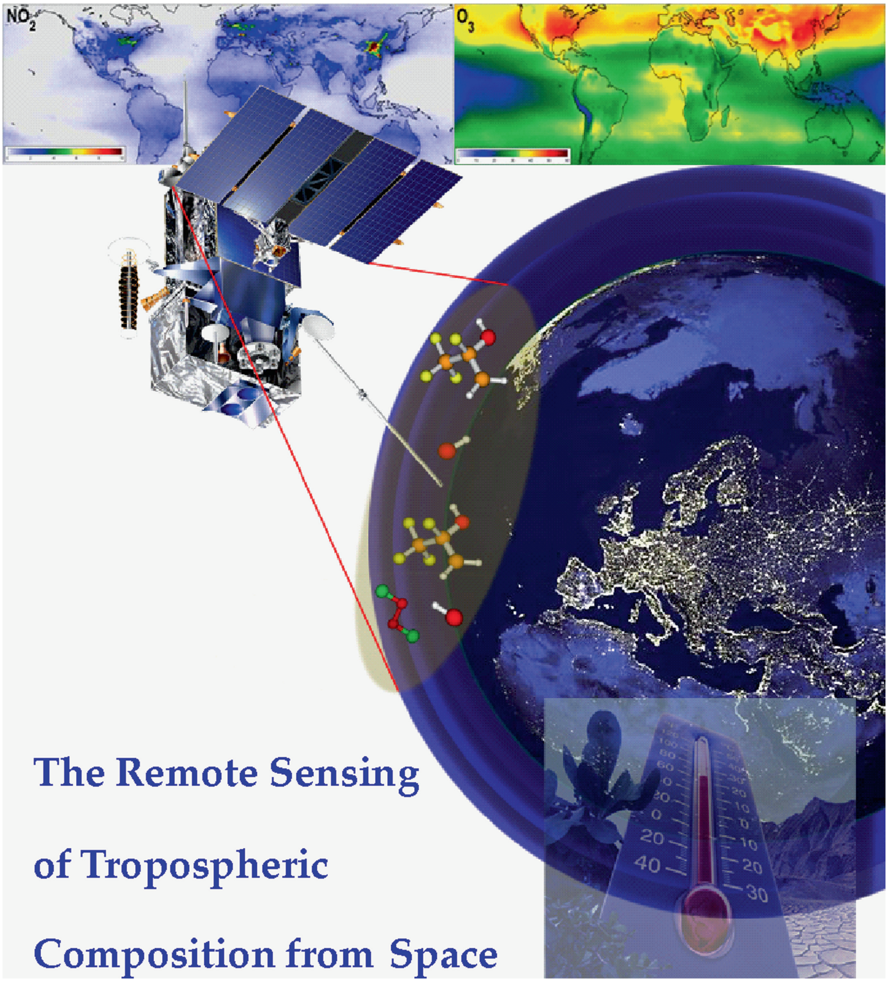
University of Bremen
Bremen, Germany
and
NERC Centre for Ecology and Hydrology
Wallingford, United Kingdom
John P. Burrows

University of Heidelberg
Heidelberg, Germany
Ulrich Platt

P&PMB Consultants
Newcastle-under-Lyme, UK
Peter Borrell



Picture created by Maria Kanakidou and Vassilis Papadimitriou

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Contributors

Dr. Peter Bauer European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, UK

Dr. Matthias Beekmann Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA) CNRS, Université Paris, Est et Paris 7, Créteil, France

Dr. Steffen Beirle Max-Planck-Institut für Chemie, Mainz, Germany

Dr. Peter Borrell P&PMB Consultants, Newcastle-under-Lyme, Uinted Kingdom

Dr. Dominik Brunner Laboratory for Air Pollution Technology, Empa, Swiss Federal Laboratories for Materials Testing and Research, Dübendorf, Switzerland

Dr. Brigitte Buchmann Laboratory for Air Pollution Technology, Empa, Swiss Federal Laboratories for Materials Testing and Research, Dübendorf, Switzerland

Prof. John P. Burrows Institute of Environmental Physics (IUP), University of Bremen, Germany; NERC Centre for Ecology and Hydrology, Wallingford, United Kingdom

Dr. Cathy Clerbaux UPMC Univ. Paris 06; CNRS/INSU, LATMOS-IPSL, Paris, France

Prof. Ronald C. Cohen Department of Chemistry, University of California, Berkeley, CA, USA

Prof. James R. Drummond Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Canada

Dr. Hendrik Elbern Rhenish Institute for Environmental Research at the University of Cologne, Köln, Germany

Dr. Reima Eresmaa European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, UK

Dr. Patrick Eriksson Department of Earth and Space Science, Chalmers University of Technology, Gothenburg, Sweden

Prof. Jean-Marie Flaud Université Créteil Paris 12, CNRS UMR 7583, LISA-IPSL, Paris, France

Dr. Sean Healy European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, UK

Dr. Wolfgang von Hoyningen-Huene Institute of Environmental Physics, University of Bremen, Bremen, Germany

Dr. Michael D. King Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309, USA

Dr. S. Kinne MPI-Meteorology, Hamburg, Germany

Dr. Alexander A. Kokhanovsky Institute of Environmental Physics, University of Bremen, Germany

Dr. Igor B. Konovalov Institute of Applied Physics, Russian Acadamy of Sciences, Nizhnig, Novgorod, Russia

Prof. Klaus Kunzi University of Bremen, Institute of Environmental Physics, Bremen, Germany

Dr. Jean-Christopher Lambert Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium

Prof. Gerrit de Leeuw Climate Change Unit, Finnish Meteorological Institute, Helsinki, Finland; Department of Physics, University of Helsinki, Helsinki, Finland; TNO Environment and Geosciences, Utrecht, The Netherlands

Dr. Jean-Francois Léon LOA, Lille, France

Dr. Nathaniel Livesey Microwave Atmospheric Science Team, Jet Propulsion Laboratory, Pasadena, CA, USA

Dr. Maarten Krol Meteorology and Air Quality, Environmental Sciences Group, Wageningen University, Wageningen, The Netherlands

Prof. Maria Kanakidou Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete, Heraklion, Greece

Prof. Martin Dameris Deutsches Zentrum für Luft- und Raumfahrt, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany

Prof. Paul S. Monks Department of Chemistry, University of Leicester, Leicester, United Kingdom

Dr. Alberto Mugnai Istituto di Scienze dell'Atmosfera e del Clima (ISAC), CNR, Roma, Italy

Dr. Lars Nieradzik Rhenish Institute for Environmental Research at the University of Cologne, Köln, Germany

Prof. Johannes Orphal Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT), Germany

Dr. Jacques Pelon Université Pierre et Marie Curie, Paris, France

Dr. Ankie J.M. Piters Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands

Dr. Steven Platnick NASA Goddard Space Flight Center, Greenbelt, MD, USA

Prof. Ulrich Platt Institute of Environmental Physics (IUP), University of Heidelberg, Heidelberg, Germany

Dr. Catherine Prigent CNRS, Observatoire de Paris, Paris, France

Dr. Andreas Richter Institute of Environmental Physics, University of Bremen, Bremen, Germany

Prof. Daniel Rosenfeld The Hebrew University of Jerusalem, Jerusalem, Israel

Dr. Martijn Schaap TNO Environment and Geosciences, Utrecht, The Netherlands

Dr. Eric A. Smith NASA/Goddard Space Flight Center, Greenbelt, MD, USA

Dr. Piet Stammes Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands

Dr. Graeme Stephens Colorado State University, Fort Collins, CO, USA

Dr. Achim Strunk Rhenish Institute for Environmental Research at the University of Cologne, Köln, Germany

Dr. Pepijn J. Veefkind Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands

Dr. Ben Veihelmann ESA/ESTEC, European Space Agency, Noordwijk, The Netherlands

Prof. Thomas Wagner Max-Planck-Institute for Chemistry, Mainz, Germany

Dr. Michiel van Weele Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands

Dr. David M. Winker NASA Langley Research Center, Hampton, USA

Dr. Folkard Wittrock Institute of Environmental Physics, University of Bremen, Germany

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Chemical Names and Molecular Formulae

Oxygen and hydrogen containing molecules and radicals	
Oxygen	O_2
Oxygen atom	O
Oxygen atom (ground state)	$O(^3P)$
Oxygen atom (first excited state)	$O(^1D)$
Ozone	O_3
Water (Ice, liquid,vapour)	H_2O
Water (Partially deuterated)	HDO
Hydrogen peroxide	H_2O_2
Hydroxyl radical	OH
Hydroperoxy radical	HO_2
Nitrogen compounds	
Nitrogen	N_2
Nitric oxide	NO
Nitrogen dioxide	NO_2
Nitrous oxide	N_2O
Nitrate radical	NO_3
Nitric acid	HNO_3
Dinitrogen pentoxide (nitric acid anhydride)	N_2O_5
Peroxynitric acid	HNO_4
Ammonia	NH_3
Hydrogen cyanide	HCN
Oxidised carbon	
Carbon monoxide	CO
Carbon dioxide	CO_2

(continued)

Organic compounds	
Methane	CH_4
Ethyne (acetylene)	C_2H_2
Ethane	C_2H_6
Ethene (ethylene)	C_2H_4
Methanol	CH_3OH
Formaldehyde	HCHO
Formic acid	HCOOH
Glyoxal	CHOCHO
Acetone	CH_3COCH_3
Peroxyacetyl nitrate (PAN)	$CH_3COO_2NO_2$
Halogen compounds	
Chlorine nitrate	$ClONO_2$
Hypobromous acid	HOBr
Hypochlorous acid	HOCl
Bromine nitrate	$BrONO_2$
Hydrogen fluoride	HF
Hydrogen chloride	HCl
Methyl chloride	CH_3Cl
Halogen radicals	
Chlorine monoxide	ClO
Bromine monoxide	BrO
Iodine monoxide	IO
CFCs	
CFC-11	$CFCl_3$
CFC-12	CF_2Cl_2
CFC-113	$Cl_2FCCClF_2$

(continued)

HCFCs	
HCFC-142b	ClF_2CCH_3
HCFC-22	$CHClF_2$
Sulfur compounds	
Sulfur dioxide	SO_2

(continued)

Hydrogen Sulfide	H_2S
Dimethyl Sulfide DMS	CH_3SCH_3
Carbon disulfide	CS_2
Sulfuric acid	H_2SO_4
Carbonyl sulfide	OCS
Sulfur hexafluoride	SF_6

A Full list of Abbreviations and Acronyms is given in Appendix C.