PROCEEDINGS OF SPIE

Remote Sensing of Clouds and the Atmosphere XXI

Adolfo Comerón
Evgueni I. Kassianov
Klaus Schäfer
James W. Jack
Richard H. Picard
Konradin Weber
Editors

28–29 September 2016
Edinburgh, United Kingdom

Sponsored and Published by
SPIE

Cooperating Organisations
Innovation Centre for Sensor and Imaging Systems (United Kingdom)
ADS Scotland (United Kingdom)
The Knowledge Transfer Network (United Kingdom)
Visit Scotland (United Kingdom)
European Regional Development Fund (Belgium)
Technology Scotland (United Kingdom)
European Association of Remote Sensing Companies (Belgium)
European Association of Remote Sensing Laboratories (Germany)
The British Association of Remote Sensing Companies (United Kingdom)
Remote Sensing & Photogrammetry Society (United Kingdom)

Volume 10001

Proceedings of SPIE 0277-786X, V. 10001

Remote Sensing of Clouds and the Atmosphere XXI, edited by Adolfo Comerón, Evgueni I. Kassianov, Klaus Schäfer, James W. Jack, Richard H. Picard, Konradin Weber, Proc. of SPIE Vol. 10001, 1000101 · © 2016 SPIE · CCC code: 0277-786X/16/$18 · doi: 10.1117/12.2264476

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:
Author(s), "Title of Paper," in *Remote Sensing of Clouds and the Atmosphere XXI*, edited by Adolfo Comerón, Evgueni I. Kassianov, Klaus Schäfer, James W. Jack, Richard H. Picard, Konradin Weber, Proceedings of SPIE Vol. 10001 (SPIE, Bellingham, WA, 2016) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-786X (electronic)

ISBN: 9781510604063
ISBN: 9781510604070 (electronic)

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE. DIGITAL LIBRARY
SPIEDigitalLibrary.org

Paper Numbering: *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a six-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

Contents

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Conference Committee

Symposium Chair

Klaus Schäfer, *(Retired)* Karlsruher Institut für Technologie (Germany), Institute of Meterology and Climate Research (Germany)

Symposium Co-chairs

Christopher M. U. Neale, University of Nebraska-Lincoln (United States), Daugherty Water for Food Institute (United States)
Iain H. Woodhouse, The University of Edinburgh (United Kingdom), Geography and the Lived Environment Research Institute (United Kingdom)

Conference Chairs

Adolfo Comerón, Universitat Politècnica de Catalunya (Spain)
Evgueni I. Kassianov, Pacific Northwest National Laboratory (United States)
Klaus Schäfer, Karlsruher Institut für Technologie (Germany)

Conference Co-chairs

James W. Jack, The University of Edinburgh (United Kingdom)
Richard H. Picard, ARCON Corporation (United States)
Konradin Weber, Fachhochschule Düsseldorf (Germany)

Conference Programme Committee

Aldo Amodeo, Istituto di Metodologie per l'Analisi Ambientale (Italy)
Christoph C. Borel-Donohue, Air Force Institute of Technology (United States)
Young Joon Kim, Gwangju Institute of Science and Technology (Korea, Republic of)

Session Chairs

1 Atmospheric Profiling of Aerosol, Trace Gases, and Meteorological Parameters of Remote Sensing
Adolfo Comerón, Universitat Politècnica de Catalunya (Spain)

2 Radiative Transfer
Evgueni I. Kassianov, Pacific Northwest National Laboratory (United States)

Introduction

Remote sensing of clouds and atmosphere from ground, air, and space are central to many climate-related and air quality studies with important and far-reaching societal applications. This volume provides an opportunity for readers to review contributions on new advances in a wide variety of topics related to both passive and active remote sensing. The diversity of participants from Europe, North America, Asia, and Australia reflects the international recognition of the need to design modern instrumentation, as well as to advance retrieval techniques, models, and user friendliness. A strong interrelation with the newly created conference "Remote Sensing Technologies and Applications in Urban Environments" exists, where more specific and object-oriented remote sensing results are presented and discussed.

A healthy mixture of senior investigators and talented young researchers is one of the valuable signatures of this conference. In particular, a distinguished keynote speaker (Dr. Ewan O'Connor, Finnish Meteorological Institute, Finland, and University of Reading, UK) offered an interesting lecture on the current state of ground-based active remote sensing of clouds and aerosols, fast-paced advances in data interpretation, and future directions for addressing long-standing challenges. The Best Student Paper Award (Mr. Thomas Chambers, University of Adelaide, Australia) was recognized thanks to the special financial support from the SPIE Organizing Committee.

The meeting was held in Edinburgh, UK, an attractive city with a long and impressive tradition of scientific and cultural life. We would like to express our most sincere thanks to the SPIE Organizing Committee for creating a pleasant atmosphere and to all the participants for making this conference successful. Also, we would like to acknowledge our colleagues from the University of Edinburgh, UK, and especially Dr. James Jack for hosting this conference and for invaluable support during this international forum.

Adolfo Comerón
James Jack
Evgueni I. Kassianov
Klaus Schäfer
Richard H. Picard
Konradin Weber