

PROCEEDINGS OF SPIE

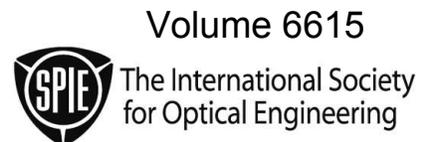
Current Research on

Remote Sensing, Laser Probing, and Imagery in Natural Waters

Iosif M. Levin
Gary D. Gilbert
Vladimir I. Haltrin
Charles C. Trees
Editors

Sponsored by
SPIE Russia Chapter

Published by
SPIE—The International Society for Optical Engineering



Proceedings of SPIE—The International Society for Optical Engineering, 9780819467560, v. 6615

SPIE is an international technical society dedicated to advancing engineering and scientific applications of optical, photonic, imaging, electronic, and optoelectronic technologies.

The papers included 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. The papers published in these proceedings 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 this book:

Author(s), "Title of Paper," in *Current Research on Remote Sensing, Laser Probing, and Imagery in Natural Waters*, edited by Iosif M. Levin, Gary D. Gilbert, Vladimir I. Haltrin, Charles C. Trees, Proceedings of SPIE Vol. 6615 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819467560

Published by
SPIE—The International Society for Optical Engineering
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone 1 360/676-3290 (Pacific Time) · Fax 1 360/647-1445
<http://www.spie.org>

Copyright © 2007, The Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at <http://www.copyright.com>. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/07/\$18.00.

Printed in the United States of America.

Contents

vii	<i>Introduction</i>
ix	<i>From the Editors</i>

SESSION 1 REMOTE SENSING

- 661502 **New approach to atmospheric correction of satellite ocean color data** [6615-01]
O. V. Kopelevich, S. V. Sheberstov, S. Vazyulya, P.P. Shirshov Institute of Oceanology (Russia); I. G. Zolotov, Oregon State Univ. (USA); S. W. Bailey, NASA Goddard Space Flight Ctr. (USA)
- 661503 **Satellite monitoring of spatial variability in the Baltic Sea ecosystem: possible applications of the DESAMBEM algorithm** [6615-02]
B. Woźniak, Institute of Oceanology (Poland); A. Krężel, Univ. of Gdańsk (Poland); M. Darecki, J. Dera, Institute of Oceanology (Poland)
- 661504 **Restoring number of suspended particles in ocean using satellite optical images and forecasting particle fields** [6615-03]
V. I. Haltrin, R. A. Arnone, P. Flynn, Naval Research Lab. (USA); B. Casey, Planning Systems, Inc. (USA); A. D. Weidemann, D-S. Ko, Naval Research Lab. (USA)
- 661505 **Diagnostics of mesoscale water exchange from full normalized radiance spectra** [6615-04]
G. S. Karabashev, M. A. Evdoshenko, S. V. Sheberstov, P.P. Shirshov Institute of Oceanology (Russia)
- 661506 **Measurements of the volume scattering function in a coastal environment** [6615-05]
J-F. Berthon, Institute for Environment and Sustainability (Italy); M. Lee, E. Shybanov, National Academy of Science (Ukraine); G. Zibordi, Institute for Environment and Sustainability (Italy)
- 661507 **Assessment of underwater irradiance and absorption of solar radiation at water column from satellite data** [6615-06]
O. V. Kopelevich, S. V. Sheberstov, V. I. Burenkov, S. V. Vazyulya, M. V. Likhacheva, P.P. Shirshov Institute of Oceanology (Russia)

Pagination: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication.

SPIE uses a six-digit CID article numbering system in which:

- The first four 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. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

- 661508 **Improving regional bio-optical inversion algorithms using state-of-the-art hydro-optical instrumentation** [6615-07]
M. E. Lee, E. B. Shybanov, E. N. Korchemkina, O. V. Martynov, Marine Hydrophysical Institute (Ukraine)
- 661509 **Use of SeaWiFS data to estimate water optical properties of the Black Sea** [6615-08]
V. V. Suslin, V. S. Suetin, S. N. Korolev, A. A. Kucheryavyi, Marine Hydrophysical Institute (Ukraine)
- 66150A **Bio-optical characteristics of the seas surrounding Russia from satellite ocean color data** [6615-09]
V. I. Burenkov, O. V. Kopelevich, S. V. Sheberstov, E. A. Lukianova, O. V. Prokhorenko, P.P. Shirshov Institute of Oceanology (Russia)

SESSION 2 LIDARS

- 66150B **Retrieval of seawater inherent optical properties profiles from lidar waveforms** [6615-10]
E. Zege, I. Katsev, A. Prikhach, B.I. Stepanov Institute of Physics (Belarus)
- 66150C **Inverse problems of lidar sensing of the ocean** [6615-11]
I. S. Dolina, L. S. Dolin, Institute of Applied Physics (Russia); I. M. Levin, P.P. Shirshov Institute of Oceanology (Russia); A. A. Rodionov, St. Petersburg Scientific Ctr. (Russia); V. A. Savel'ev, Institute of Applied Physics (Russia)
- 66150D **Some novel approaches in laser remote sensing of natural waters based on recognition of spectral patterns with the help of artificial neural networks** [6615-12]
T. A. Dolenko, I. V. Fadeeva, S. A. Burikov, S. A. Dolenko, V. V. Fadeev, M.V. Lomonosov Moscow State Univ. (Russia)
- 66150E **Results of Barents Sea airborne lidar survey** [6615-13]
Y. A. Goldin, P.P. Shirshov Institute of Oceanology (Russia); A. N. Vasilev, State Research and Design Institute for Fishing Fleet, GIPRORYBFLOT (Russia); A. S. Lisovskiy, Knipovich Polar Research Institute of Marine Fisheries and Oceanography (Russia); V. I. Chernook, State Research and Design Institute for Fishing Fleet, GIPRORYBFLOT (Russia)
- 66150F **Estimation of the water optical properties and bottom reflectance from SHOALS data** [6615-14]
V. I. Feygels, Optech International, Inc. (USA); Y. I. Kopilevich, St. Petersburg State Univ. of Information Technologies, Mechanics and Optics (Russia); G. H. Tuell, Optech International, Inc. (USA); A. Surkov, St. Petersburg State Univ. of Information Technologies, Mechanics and Optics (Russia); P. LaRocque, A. G. Cunningham, Optech, Inc. (Canada)
- 66150G **Simulation of the performance of ocean imaging lidar with polarization devices** [6615-15]
E. Zege, I. Katsev, A. Prikhach, B.I. Stepanov Institute of Physics (Belarus)
- 66150H **Shipboard polarized lidar for seawater column sounding** [6615-16]
Y. A. Goldin, B. A. Gureev, Y. I. Ventskut, P.P. Shirshov Institute of Oceanology (Russia)

SESSION 3 IMAGING

- 66150I **Image transfer through rough sea surface: computer simulations** [6615-17]
L. Dolin, Institute of Applied Physics (Russia); G. Gilbert, Advanced Coherent Technologies, LLC (USA); I. Levin, P.P. Shirshov Institute of Oceanology (Russia); A. Luchinin, V. Savel'ev, Institute of Applied Physics (Russia); S. Stewart, SPAWAR Systems Ctr., San Diego (USA)
- 66150J **A new method for the observation of underwater objects through rough sea surface** [6615-18]
V. L. Weber, Institute of Applied Physics (Russia)
- 66150K **Correcting images of underwater objects distorted by sea surface roughness** [6615-19]
L. S. Dolin, A. G. Luchinin, V. I. Titov, D. G. Turlaev, Institute of Applied Physics (Russia)
- 66150L **In situ and airborne optical measurements in the surf zone** [6615-20]
G. D. Gilbert, J. S. Schoonmaker, Advanced Coherent Technology (USA); J. J. Dirbas, PAR Government Systems Corp. (USA); N. H. Witherspoon, Naval Coastal Systems Ctr. (USA)
- 66150M **Image transfer through a rough water surface: laboratory experiments** [6615-21]
V. Osadchy, V. Savtchenko, O. Frantsuzov, N. Rybalka, P.P. Shirshov Institute of Oceanology (Russia)
- 66150N **Backscatter corrected Fournier-Forand phase function for remote sensing and underwater imaging performance evaluation** [6615-22]
G. R. Fournier, Defence R&D Canada, Valcartier (Canada)
- 66150O **Secchi disk theory: a reexamination** [6615-23]
I. M. Levin, T. M. Radomyslskaya, P.P. Shirshov Institute of Oceanology (Russia)

Author Index

Introduction

In 2001, a new international conference series on Current Problems in Optics of Natural Waters (ONW-2001) was initiated in St. Petersburg, Russia. Further conferences were held in 2003 and 2005 (ONW-2003 and ONW-2005), also in St. Petersburg. Conference organizers hope that this series will provide a modern continuation of the Plenums on Ocean Optics held in the Former Soviet Union between 1974 and 1990, but now with international participation. Approximately 100 scientists from 10-15 different countries have participated in each conference, stimulating scientific discussion and new, collaborative international research projects.

This volume brings together extended versions of selected papers from ONW-2003 and ONW-2005 that describe significant progress in the topics of passive remote sensing of the ocean; theory and data analysis related to active laser systems; and advances in imaging through the sea surface. One paper describes laboratory measurements that support the sea surface modulation transfer function developed several decades ago by the Russian scientist, Mullaama. Another describes a method to correct image distortion and breakup through the wavy sea surface using auxiliary measurements of the sky radiance. A third details a method for statistically removing the instantaneously curved part of the sea surface, while leaving the flat areas, and then building up an undistorted image of a submerged target by accumulating the image segments through the flat areas.

Other papers address the issues of using laser radars and imagers (LIDARs), including one that discusses work that profiles a water body's optical properties with depth. Other topics pertinent to remote sensing include the use of Secchi disk data to extract inherent and apparent optical properties; measurements of the scattering properties of sea water with newly developed instrumentation; a new and improved mathematical model of scattering; and the use of remote sensing combined with in situ measurements to investigate the rapidly changing dynamic state of the optics of the surf zone. These are only a few examples of the topics that have been covered in ONW conferences. The international flavor of the conference is evidenced by the diverse nationalities of authors in this volume.

Joan S. Cleveland

Office of Naval Research, Arlington, Virginia*

*These comments are the views of the author and do not reflect official ONR opinion.

From the Editors

The first two conferences on Current Problems in Optics of Natural Waters (ONW-2001 and ONW-2003) were held in St. Petersburg during the month of September in 2001 and 2003. These meetings introduced a new international conference series where Current Problems in Optics of Natural Waters were presented and discussed. Historically plenums on Ocean Optics had been held in the Former Soviet Union (FSU) from 1974 to 1990. However due to the world politics of the time a weakness of these plenums was that attendance was restricted to Soviet hydroopticians. Thus there was no interchange of ideas between Soviet hydroopticians and their Western colleagues.

The present ONW series are a modern continuation of the plenums, but with the great advantage that FSU hydro-opticians and their Western counterparts may meet in person to introduce and discuss problems and solutions of common interest. The first two meetings have resulted in collaborative Western/FSU joint projects on issues pertinent to global environmental and oceanographic problems. It is an economic reality that FSU scientists although rich in ideas can seldom afford to attend conferences in Europe or the USA. One great advantage to the advance of the science of hydro-optics is that these conferences foster fruitful discussions between FSU scientists and their international colleagues.

Although the tragic events of September 11, 2001, in the USA reduced the number of American participants, the other nations of the world were well represented in the ONW-2001 and the conference was a success. No such tragedy interfered with the ONW-2003 conference, which was well attended by scientists from the USA as well as Europe and Asia. Personal contacts lead to the mutual exchange of useful and interesting ideas and results. A perusal of the papers submitted for ONW-2005 demonstrate many cooperative efforts between FSU scientists and their international partners. Based on the successes of ONW 2001 and 2003, ONW 2005 has been convened and the plan is to continue the series in successive odd-numbered years as a complement to the ONR-sponsored Ocean Optics conferences held in even numbered years.

The ONW-2005 conference was organized by the St. Petersburg Branch of the P.P. Shirshov Institute of Oceanology, the D.S. Rozhdestvensky Optical Society, and the S.I. Vavilov State Optical Institute, St. Petersburg. The main conference topics are unchanged from ONW-2001 and 2003. They are the fundamental problems of radiative transfer theory and light propagation in water including optical properties of natural waters and their effects on optical remote sensing and underwater imaging. The conference program contains about 90 presentations of authors from 15 countries.

In addition to the organizers previously noted we are grateful to the following organizations for their support and sponsorship: the Russian Academy of Sciences, Russian Foundation for Basic Research, Russian Federal Agency of Science and Innovations, Office of Naval Research, Office of Naval Research Global, National Aeronautics and Space Administration, P.P.Shirshov Institute of Oceanology (Moscow), Institute of Applied Physics (N. Novgorod). Finally we would like to extend our grateful thanks to Vladimir Arpishkin, Vladimir Osadchy, Victor Savtchenko, Tamara Radomyslskaya, and Natasha Rybalka for their strenuous efforts in preparing the conferences.

Iosif M. Levin
Gary D. Gilbert