Surveillance of Environmental Pollution and Resources by Electromagnetic Waves

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CONTENTS

Preface	ix
Participants	xi
Program Committee	xv
HOST NATION ADDRESS	
A. Tonning	xvii
PART I: FUNDAMENTALS	
FUNDAMENTAL BEHAVIOUR OF BIOSYSTEMS IN CONNECTION TO SURVEILLANCE OF ENVIRON- MENTAL POLLUTION AND RESOURCES	
A. Jensen	3
FUNDAMENTALS OF REMOTE SENSING METHODOLOGY	
D.T. Gjessing	13
PART II: THE ATMOSPHERE	
FUNDAMENTALS OF ATMOSPHERIC SPECTROSCOPY	
S. Svanberg	37
SIGNAL-TO-NOISE RATIO OF HETERODYNE LIDAR SYSTEMS IN THE PRESENCE OF ATMOSPHERIC TURBULENCE	
H.T. Yura	67
REMOTE MEASUREMENTS OF ATMOSPHERIC PROPERTIES FROM SATELLITES	
G.E. Peckham	95

INFRARED LASER AUTOMATED FIELD INSTRUMENTATION FOR MONITORING OF THE ATMOSPHERE S.T. Eng	111
REMOTE SENSING IN THE ATMOSPHERE BY MEANS OF FIXED FREQUENCY IR LASER K.W. Rothe	145
MILLIMETRE REMOTE SENSING OF THE STRATOSPHERE AND MESOSPHERE D.L. Croom	155
ACTIVE HETERODYNE SPECTROMETRY WITH AN AIRBORNE CO ₂ LASER SYSTEM W. Wiesemann, W. Englisch, J. Boscher, G. Schäfer	171
HOLOGRAPHIC REAL TIME SEEING THROUGH MOVING SCATTERING MEDIA H. Schmalfuss	183
WORKING GROUP: PROBING OF THE ATMOSPHERE Chairman: K. Rothe	191
PART III: THE EARTH'S SURFACE; LAND - SEA	
SCATTERING OF ELECTROMAGNETIC WAVES FROM THE OCEAN G.R. Valenzuela	199
THE RADAR SIGNATURE OF NATURAL SURFACES AND ITS APPLICATION IN ACTIVE MICROWAVE REMOTE SENSING E.P.W. Attema	227
MICROWAVE RADIOMETRY APPLICATIONS TO REMOTE SENSING E. Schanda	253
CORRECTION OF AIRBORNE IR-SCANNER DATA G.A. Becker	275
LASER - INDUCED FLUORESCENCE TECHNIQUES FOR SOUNDING OF THE HYDROSPHERE F. Günneberg	283
MICROWAVE MEASUREMENTS OVER SEA IN THE NETHERLANDS E.P.W. Attema, P. Hoogeboom	291

CONTENTS

vii

APPLICATIONS OF REMOTE SENSING BY CONVENTIONAL
RADARS

P.D.L. Williams 299

ERICSSON SLAR

B. Ekengren 309

WORKING GROUP: OCEAN WAVES

Chairman: O.H. Shemdin 319

PART IV: METHODS OF INFORMATION RETRIEVAL

THE FOURIER TRANSFORM: PROPERTIES AND
APPLICATIONS

A.G. Kjelaas 329

PATTERN RECOGNITION - WITH SPECIAL EMPHASIS ON
IMAGE PROCESSING

T. Orhaug 353

DIGITAL ANALYSIS OF MULTI-CHANNEL RADAR
DATA AT CCRS

P.M. Teillet 381

EXPERIENCES FROM APPLYING AIRCRAFT AND
SATELLITE MSS-DATA TO EARTH RESOURCES
INVENTORY PROBLEMS IN SWEDEN

T. Orhaug, L.-E. Gustafsson, L. Wastenson,
S.I. Åkersten 387

WORKING GROUP: SIGNAL PROCESSING, PATTERN
RECOGNITION AND IMAGE PROCESSING

Chairman: T. Orhaug 399

PREFACE

These proceedings contain lectures, research papers and working group reports from the NATO Advanced Study Institute on "Surveillance of environmental pollution and resources by electromagnetic waves", held at Spåtind, Norway, April 9-19, 1978.

Remote sensing of the environment has developed into a very complex multidisciplinary field. It encompasses a huge range of different instrumental techniques and analytical methods, designed to provide information about a vast number of environmental parameters. Nevertheless, the approach to solve specific problems and the ways of handling the collected information are to a large extent the same or similar.

This commonality is the basis for the Advanced Study Institute. To provide the best possible background, both tutorially and for a fruitful exchange of research ideas and results, a number of outstanding scientists were invited to review some major fields.

The material presented in these proceedings is certainly not complete in the sense that it covers all aspects of the subject. The selection is deliberately due to the program committee and the editor.

The program committee would like to express their gratitude to Dr. Tilo Kester, head of the NATO Advanced Study Institute Program, NATO Scientific Affairs Division, for his support and encouragement during the organization of the Institute.

Oslo, June 1978.

A handwritten signature in black ink, appearing to read 'Terje Lund', with a stylized, cursive script.

Terje Lund
Proceedings editor

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Dear Colleagues, gentlemen.

I have the great privilege of wishing you all warmly welcome to Norway as participants in this NATO Advanced Study Institute on "Surveillance of Environmental Pollution and Resources by Electromagnetic Waves". I am glad that everyone of you have successfully overcome the communication difficulties and found your way to this rather remote corner of Europe.

If you take a look at the surroundings, here at Spåtind, the snowclad mountains, the spruce trees, you might easily jump to the conclusion that pollution can hardly be the most serious problem for this part of the world. And it is indeed true that our country is thinly populated as compared to the average of Western Europe. There are about 10 Norwegians per square kilometer. In spite of this low population density a part of our industrial activities, our agriculture and the relatively high per capita consumption do cause pollution problems that must be taken seriously. Moreover, and perhaps more important the pollution in the atmosphere and in the ocean show a regrettably poor respect for national boundaries. They spread indiscriminately and rapidly over large distances and are therefore truly international. Hence they must be combated, if at all, by international collaboration.

Since NATO Science Committee was established about 20 years ago its primary aim has been to further international collaboration between scientist from the member countries of the Alliance. The development of general principles for the surveillance of the environmental pollution and resources constitute a logical first step in our common defence against pollution and in our efforts

to preserve resources. It seems particularly appropriate, therefore, that this theme should be chosen for one of the NATO Advanced Study Institutes. I want to express the gratitude of the scientific community of Norway, to NATO and to the NATO Science Committee for financing this meeting. Likewise I want to thank the lecturers and participants for coming so far to take part in its work. I hope that you, in addition to the professional benefits, also will be able to form personal contacts and friendship, and that you will find the nature and the skiing facilities offered an enjoyable recreation.

The theme of the conference specifies electromagnetic waves as the means for carrying out the surveillance. The wide spectrum of electromagnetic waves we have at our disposal to-day is indeed the most natural, and most powerful, diagnostic tool for carrying out surveillance. As long as electromagnetic waves have been known they have been used as a means for exploring the macro-world around us all as well as the micro-world of atoms and molecules. The hypothesis of the existence of ionospheric layers around the earth is about as old as our century. It is worth remembering that its experimental basis was established during the first attempts to communicate by radio-waves across the Atlantic.

At mid-century, when microwave generators and receivers had become easily available, exploration of the atmosphere, of its layers, turbulences and other inhomogeneities became possible. This research field was then pursued with great vigour. At the outset the motivation was again predominantly due to radio communication interests. Scattering from the atmospheric inhomogeneities provided possibilities for long range, over-the-horizon communication. However, one soon realized that the radio waves were a tool of high potential for studying geophysical phenomena such as atmospheric winds, temperature and humidity variations in the atmosphere. The importance for the field of meteorology is obvious and, thanks to the methods of radio science, an improved understanding of the processes in the atmosphere has been achieved.

At the small wave-length end of the spectrum the identification of atoms and molecules by means of spectroscopy was made possible by the work of Kirchoff and Bunsen as early as around 1860, many years before it was definitely known that light is of electromagnetic nature.

The enormous importance of spectroscopy for chemistry and physics in general and for the identification of matter in particular, needs no comments here. During the years after the last war the availability of microwave generators for frequencies beyond 10 GHz made microwave spectroscopy possible, thus allowing for the first time the use of coherent electromagnetic sources

for spectroscopic purposes. The advances of microwave techniques increased gradually the upper frequency limit of microwave generators into the millimeter wave region.

Then a most dramatic change occurred at the beginning of the nineteen-sixties with the invention of the laser. All of a sudden the possibility of having stable, coherent, monochromatic optical sources in the visible region as well as in the ultraviolet and infra-red seemed within reach. This has frequently been emphasized as one of the most important scientific and technological break-throughs in our generation. It is probably also true that the larger part of the possibilities offered by the laser still remains to be exploited.

From the point of view of radio science, faced with the problems of surveillance that concern us here, a number of possibilities appear to offer themselves. The possibility of laser heterodyne receivers creates visions of a dramatic increase in receiver sensitivity, similar to what happened with microwave receiver a generation ago. The advent of tunable lasers that can work dependably also outside of the laboratory might strongly increase the degrees of freedom for designers of systems for laser surveillance.

The use of advanced methods of signal processing has brought marked progress within the field of telecommunications and, still more, within radar techniques and radio astronomy. When the development of electro-optical components have reached a level of perfection that allows realization of similar principles in the optical region, great improvements can be expected. In this country developments in the direction just indicated have been advocated forcefully and eloquently by to-days chairman, the initiator of this meeting, Dag T. Gjessing. I expect that we shall have occasion to discuss them in some detail later in connection with some of his lectures.

Let me, in conclusion, point out that many of the resources we want to preserve are biological resources. Also, the pollution we want to fight very often have biological consequences of a serious nature. This leads to the need for a contact between radio science and the life sciences that up to this time have been rather unusual and that should prove beneficial and stimulating for all of us.

The theme of this conference abounds with problems and possibilities, I wish you all a pleasant stay here and thank you for your attention.