

REMOTE SENSING OF ATMOSPHERE, HYDROSPHERE, AND UNDERLYING SURFACE

Multiparameter Technique for Interpreting Ground-Based Microwave Spectral Measurements in the Problem of Ozone Vertical Profile Retrieval

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Abstract—The algorithm for interpreting ground-based measurements of the brightness temperature of downwelling microwave radiation in absorption lines traditionally used for to retrieve ozone vertical profiles is described. The inverse problem is formulated as a multiparameter with respect to ozone vertical profile (target parameter), as well as vertical profiles of the temperature, pressure, water vapor content, and cloud liquid water (controlled parameters). This approach allows one to use independent measurements of atmospheric parameters in different altitude ranges (if available) in any combinations and accounting for physical relationships between the parameters (e.g., the hydrostatic equation for temperature and pressure). Error estimates for retrieving the mean ozone concentration in the 22–30-, 30–40-, 40–50-, and 50–60-km layers are presented for summer and winter conditions (for different tropospheric total water content) and different scenarios of interpreting the downwelling microwave radiation measurements in the 110-GHz ozone absorption line.

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INTRODUCTION

Remote sensing of the ozonosphere at millimeter waves (microwave sensing) from the Earth's surface enables the long-term monitoring of the ozone vertical profile in the stratosphere and mesosphere (at altitudes of about 20–70 km) at a preset geographical point with a high temporal resolution almost independently of the weather conditions [1–4]. At present, these microwave measurements are carried out at some stations of the Network for the Detection of Atmospheric Composition Change (NDACC) International Network [5]. In Russia, ozone microwave monitoring has been carried out for a long time at the Physical Institute of the Russian Academy of Sciences and Institute of Applied Physics of Russian Academy of Sciences (IAP RAS, Nizhni Novgorod) [6, 7].

A widely used technique for processing the microwave spectra for the purpose of ozone profile retrieval consists of estimating the so-called tropospheric absorption and distinguishing the stratospheric component of the radiation, which contains information on the vertical ozone distribution in the stratosphere and mesosphere [1, 2]. In this approach, the optical depth, which is caused by the only ozone absorption, often acts like a measured parameter.

The need for data on the temperature and pressure in the stratosphere and mesosphere and microwave radiation attenuation in the atmosphere is one of the key problems in ground-based microwave ozone sensing. The tropospheric absorption is usually estimated

from measurements in the so-called reference spectral channels, which are characterized by high-frequency tuning out of the center of the line (of several hundreds of megahertz), in order to neglect the radiation formed in the stratosphere.

In this work, we describe and analyze a new multiparameter approach to solving the problem of microwave ozone sensing. The tropospheric attenuation is considered implicitly and simultaneously with the retrieval of the vertical ozone distribution. As a consequence, there are reduced requirements for measurements in the reference channels. In this case, the suggested approach allows the use of all available data on the distribution of atmospheric parameters at various altitudes in any combination, e.g., radiosonde and satellite, and accounting for the correlations between the atmospheric parameters, e.g., the hydrostatic equation for the temperature and pressure.

The algorithm was developed for interpreting spectra in the ozone absorption lines 110.836 and 142.176 GHz recorded by the corresponding instrumentation that was designed at IAP RAS and operates at the Physical Department of St. Petersburg State University [8], as well as by the GROMOS instrumentation operating at Bern University, Switzerland [9]. The results presented in this work have been obtained for the first of the above microwave instrumentation.

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Technique of Microwave Measurements Carol Gray Montgomery, 1964 **Modern RF and Microwave Measurement Techniques** Valeria Teppati, Andrea Ferrero, Mohamed Sayed, 2013-06-20 A comprehensive hands on review of the most up to date techniques in RF and microwave measurement including practical advice on deployment challenges Technique of Microwave Measurements Carol G. Montgomery, 1966 **Technique of Microwave Measurements [prepared Under the Supervision Of] Office of Scientific Research and Development, National Defence Research Committee** Carol Gray Montgomery, 1947 Technique of Microwave Measurements. Edited by C.G. Montgomery, Etc Carol Gray Montgomery, 1947 **Radiation Laboratory Series**, 1964 A New Shunt Technique for Microwave Measurements H. M. Altschuler, 1953 **Microwave Electronics** L. F. Chen, C. K. Ong, C. P. Neo, V. V. Varadan, Vijay K. Varadan, 2004-11-19 The development of high speed high frequency circuits and systems requires an understanding of the properties of materials functioning at the microwave level This comprehensive reference sets out to address this requirement by providing guidance on the development of suitable measurement methodologies tailored for a variety of materials and application systems Bringing together coverage of a broad range of techniques in one publication for the first time this book Provides a comprehensive introduction to microwave theory and microwave measurement techniques Examines every aspect of microwave material properties circuit design and applications Presents materials property characterisation methods along with a discussion of the underlying theory Outlines the importance of microwave absorbers in the reduction in noise levels in microwave circuits and their importance within defence industry applications Relates each measurement technique to its application across the fields of microwave engineering high speed electronics remote sensing and the physical sciences This book will appeal to practising engineers and technicians working in the areas of RF microwaves communications solid state devices and radar Senior students researchers in microwave engineering and microelectronics and material scientists will also find this book a very useful reference Technique Of Microwave Measurement Montgomery C.G., *Handbook of Microwave Component Measurements* Joel P. Dunsmore, 2020-05-13 *Handbook of Microwave Component Measurements* Second Edition is a fully updated complete reference to this topic focusing on the modern measurement tools such as a Vector Network Analyzer VNA gathering in one place all the concepts formulas and best practices of measurement science It includes basic concepts in each chapter as well as appendices which provide all the detail needed to understand the science behind microwave measurements The book offers an insight into the best practices for ascertaining the true nature of the device under test DUT optimizing the time to setup and measure and to the greatest extent possible remove the effects of the measuring equipment from that result Furthermore the author writes with a simplicity that is easily accessible to the student or new engineer yet is thorough enough to provide details of measurement science for even the most advanced applications and researchers This welcome new edition brings forward the most modern techniques used in industry today and recognizes

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Microwave Measurements Edward L. Ginzton,1957 Generation of laboratory signals Detection of microwave power Measurement of microwave power Impedance concepts at microwave frequencies Measurement of impedance Representation and measurement of microwave circuits Measurement of wavelength Measurement of frequency Resonant cavity characteristics measurement of Q Resonant cavity characteristics measurement of R0 Q0 Measurement of attenuation Appendix A Field configurations and cutoff wavelengths for common waveguides Appendix B Formulas and constants

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