

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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Table of Contents Technique Of Microwave Measurements

1. Understanding the eBook Technique Of Microwave Measurements
 - The Rise of Digital Reading Technique Of Microwave Measurements
 - Advantages of eBooks Over Traditional Books
2. Identifying Technique Of Microwave Measurements
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Technique Of Microwave Measurements
 - User-Friendly Interface
4. Exploring eBook Recommendations from Technique Of Microwave Measurements
 - Personalized Recommendations
 - Technique Of Microwave Measurements User Reviews and Ratings
 - Technique Of Microwave Measurements and Bestseller Lists
5. Accessing Technique Of Microwave Measurements Free and Paid eBooks
 - Technique Of Microwave Measurements Public Domain eBooks
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 - Technique Of Microwave Measurements Budget-Friendly Options

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 - ePub, PDF, MOBI, and More
 - Technique Of Microwave Measurements Compatibility with Devices
 - Technique Of Microwave Measurements Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Technique Of Microwave Measurements
 - Highlighting and Note-Taking Technique Of Microwave Measurements
 - Interactive Elements Technique Of Microwave Measurements
8. Staying Engaged with Technique Of Microwave Measurements
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Technique Of Microwave Measurements
9. Balancing eBooks and Physical Books Technique Of Microwave Measurements
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Technique Of Microwave Measurements
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Technique Of Microwave Measurements
 - Setting Reading Goals Technique Of Microwave Measurements
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Technique Of Microwave Measurements
 - Fact-Checking eBook Content of Technique Of Microwave Measurements
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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