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ABSORPTION AND EMISSION OF THE EARTH'S ATMOSPHERE, REMOTE SENSING OF ITS PARAMETERS

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This report presents a brief review of experimental results and up-to-date models for molecular absorption of millimeter(MM) and-submillimeter(SUBHH) radio waves, achievements on the problem of radio wave attenuation In hydrometeors and dust storms as well as on the solution of basic problems In the area of the atmosphere remote sensing RS) by the methods of ground-based radiometry and refractometry. The above areas are tightly connected, since attenuation and refraction characteristics are Important both for the prediction of propagation effects and for the definition of Inverse problem Kernel. The review Is based on papers recently published In the literature, the essential part of the presented material Is Illustrated by the results obtained by the authors at NIRFI.

In the area of the molecular absorption, the fundamental problem of the spectral line shape and the problem of excessive absorption In water vapor remain actual. In connection with the development of ecological investigations, the problems of the effect of trace gases of anthropogeneous origin on radio wave propagation and of their Indication by RS methods at MM and SUBMH wavelengths /1,2/ are In close relation with these Ideas.

The report presents a comparison between different theoretical and semi-empirical descriptions of 0_2 and H_2O absorption and the experimental data. A good agreement Is noted between the absorption of radio waves by the molecular oxygen in the band λ 5 mm and millimeter-wave propagation model-93 (MPM-93) for a wide pressure interval /3/. Again, it is noted, that in short wave part of MM range this model gives too low (in comparison with the experiment) values of the absorption coefficient. The model

MPH-93 is supplemented at frequencies 57 GHz< ν < 300 GHz by the description of absorption with summation of contribution of O_2 spectral lines and with selection of the empirical coefficient characterizing the absorption level.

The experimental results are given for the absorption properties of pure water vapor in the range of 297 -46O GHz /4/, as well as the experimental results for the estimation of the value and temperature dependence of quadratic over the air humidity component of the atmospheric water vapor absorption coefficient in the range of 14O-410 GHz/5/. We report on the observation of new rather fine effects - the dependence of the quadratic component value on the partial pressure of dry air and the presence of two components of pure water vapor absorption with essentially different temperature dependences. Various versions are considered for the semi-empirical description of the absorption by water vapor /6,7, 8/. The reasons of these version existence are induced by the sampling of reference experimental data for corresponding model formulations. The semi-empirical model of absorption by water vapor in the range of 3-300O GHz /7/ based mainly on new experimental data is given and a comparison is made between this model and the Llebe model /8/.

The experimental results are presented for the dynamics of interrelation between the rain rate and attenuation of the shorter НИ radio waves. We pay attention to a strong temporal variability of this interrelation caused by the dynamics and variety of precipitation microstructure and to the hysteretic effect frequently occurred in it /9/. The data are also given on attenuation by snowfalls and fogs in the range of 140 to 340 GHz. Quantitative characteristics have been considered for HH radio wave propagation in dust storms containing water envelope particles.

The second part of the report Is devoted to a review of the results of atmosphere parameter RS by the methods of radiometry and refractometry. Using the characteristics of thermal radio emission measured from the ground, the atmosphere temperature, total content of water vapor, humidity profiles, liquid water content of clouds, height distributions of 0_2, CO are remotely defined. We consider the state of each problem, the necessary and

realized accuracies of measurements of the atmosphere radio characteristics, height Intervals of RS and the achieved accuracies of meteoparameter retrieval, experimental testing of the results. We par attention to different sets of the problem for the temperature sounding from measurements In the region of the absorption band of 0_2 5 mm in the near-ground layer of the atmosphere /10, 11/, in the troposphere /12,13/, In the stratosphere and mesosphere /14, 15/, which are united by the common Physical mechanism of the radiation transfer. We consider a possibility of the definition accuracy Increase for the humidity profiles by supplementing the widely used radiometric measurements in the line H_2O λ l. 35 cm by measurements in the intensive line of 1.64 mm /16/. The particular interest Is recently displayed to the Investigation of dynamic processes on the basis of RS : phase water transitions, near-ground temperature inversions, Internal gravity waves, etc. Possibilities are shown for the ground refractometrlc methods of RS of the atmosphere parameters-retrieval of the refraction index, temperature, pressure, humidity /17,18/. The results are given for actively developing remote investigations of ozone distribution at HH radio waves /19,20/.

The report is concluded by illustration of the atmosphere RS results in the ecological direction. A feasibility is considered for the remote estimations of minor gas component content in the lower atmospheric layer by the НИ radio emission of these gases. The experimental data are presented for the effect of the temperature stratification on the characteristics of harmful gas impurities of the boundary layer of the atmosphere which were made in one of the diamond mines of Yakutiya. We give the methodic aspects of radio measurements of the atmosphere emission in the region of resonance absorption of $S0_2$ 131 GHz.

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