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USSR Report

EARTH SCIENCES

(FOUO 5/81)

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USSR REPORT

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CONTENTS

METEOROLOGY

UDC 551.576+551.577+551.578+551.508+551.509+551.511

COLLECTION OF PAPERS ON CLOUD PHYSICS AND ARTIFICIAL MODIFICATION

Moscow TRUDY UKRAINSKOGO REGIONAL'NOGO NAUCHNO-ISSLEDOVATEL'SKOGO INSTITUTA: FIZIKA OBLAKOV I AKTIVNYKH VOZDEYSTVIY in Russian No 178, 1980 (signed to press 15 Sep 80) pp 2-3, 155-161

[Annotation, table of contents and selected abstracts from collection of articles "Transactions of the Ukrainian Regional Scientific Research Institute: Cloud Physics and Artificial Modification", edited by R. A. Bakhanovoy and V. A. Dyachuk, candidates of physical and mathematical sciences, Moskovskoye otdeleniye Gidrometeoizdata, 350 copies, 161 pages]

[Text] Annotation. This collection of articles gives the results of field experiments for the modification of clouds and also field investigations of the structure of clouds and precipitation. The articles give the results of numerical modeling of clouds and fogs and laboratory investigations of reagents for the modification of clouds and fogs. This collection of articles is intended for specialists in the field of cloud physics and artificial modification, meteorologists and graduate students.

Contents

Abstracts

NUMERICAL MODELING OF FORMATION OF A CLEARED ZONE IN A FOG USING MODIFICATION BY A HYGROSCOPIC REAGENT BY THE AIRCRAFT METHOD

[Abstract of article by Bakhanov, V. P. and Manzhara, A. A.]

[Text] A two-dimensional nonstationary model has been developed for describing the formation and evolution of a cleared zone in a fog under the influence of a hygroscopic reagent. Numerical computations were made on an "M-220" electronic computer for determination of evolution of the cleared zone forming in a warm fog with a thickness of 100 m with seeding by monodisperse carbamide along a line near the upper boundary of the fog. It is shown that in a fog with a small liquid-water content (0.05 g/m^3), with a low value of the turbulence coefficient (1 m^2/sec) under conditions close to a calm (wind shear 0.01 sec^{-1}) it is possible to obtain a cleared zone with seeding of a single line. If the problem is to obtain it in 10-15 minutes, it is most effective to use particles with a radius 30-40μm with discharges 200-400 kg/km. Preliminary computations made for greater wind shears (0.05 sec^{-1}) and the turbulence coefficient (5-10 m^2/sec) show that for dense fogs with a liquid-water content greater than 0.1 g/m^3 a clearing could not be obtained by seeding of a single line with pulverized carbamide at the rate of 200-400 kg/km. Figures 4, tables 4, references 31.

UDC 551.521:551.576

COMPUTATION OF LONG-WAVE RADIATION GAINS AND LOSSES IN CLOUD COVER SITUATIONS USING SPECTRAL TRANSMISSION FUNCTIONS AND TRANSFER EQUATIONS

[Abstract of article by Khvorost'yanov, V. I.]

[Text] Using the spectral transmission functions for water vapor, carbon dioxide and water for three models of the atmosphere containing low stratiform clouds the author has computed the spectral gains and losses of long-wave radiation and investigated their spectral and vertical distributions. It is shown that about 90% of the radiation cooling of a cloud and the effective radiation from the upper boundary is formed in the interval of the transparency window 1.84-12.5 μm. This circumstance, in combination with the exponential character of transmission in the window, makes it possible to propose a simple method for computing radiation characteristics when constructing numerical models of low clouds and fogs which is close to the K. Ya. Kondrat'yev schematized spectrum method and which makes it possible to avoid integration in the entire troposphere in each time interval. For narrow droplet spectra at the upper cloud boundary (or in a fog) during cooling $\alpha_{Lc} \sim 600$ cm^2/g; at the lower boundary during heating $\alpha_{Lk} \sim 1000$ cm^2/g. It was noted that the averaging of the absorption coefficients (or sections) for the IR spectrum with a Planck function as the weight considerably exaggerates the absorptivity of water. Analytical estimates of receipts were made by integration of the transfer equations. The following effect was discovered: in the atmosphere there are levels ($\sim$1-2 km) at which the "heat pocket" formed by the cloud has a maximum "depth," that is, the total radiation receipt for the layer is maximum. This effect is intensified with an increase in atmospheric moisture content. Figures 7, tables 3, references 21.

UDC 551:521:551.576

COMPUTATION OF THE SCATTERING AND ABSORPTION COEFFICIENTS FOR SHORT-WAVE RADIATION IN CLOUDS

[Abstract of article by Khvorost'yanov, V. I.]

[Text] Analytical expressions are derived for the coefficients of attenuation, scattering and absorption of atmospheric radiation by a polydisperse cloud medium in which the droplet spectrum is described by a gamma distribution. Use was made of the Van de Hulst formula for the attenuation effectiveness factor in the approximation of "soft" particles and the K. S. Shifrin interpolation formula for the absorption effectiveness factor. This made it possible to generalize the well-known L. M. Levin formula for the attenuation coefficient for the case of presence of absorption. It is shown that the derived expressions acquire an especially

simple form for short-wave radiation. The scattering and absorption coefficients computed with their assistance in the wavelength range 0.4-4 μm differ by not more than 9% from the precise values computed when using the Mie theory. The derived expressions can be particularly useful in constructing microphysical numerical models of clouds and fogs in which the droplet spectrum, as well as the considered coefficients, vary significantly with time. Tables 2, references 9.

UDC 551.509:543.422:541.183

POSSIBILITIES OF MORE EFFECTIVE USE OF AgI AEROSOL DURING ACTIVE MODIFICATION OF CLOUDS

[Abstract of article by Bakhanov, R. A., Kiselev, V. I. and Oleynik, R. V.]

[Text] On the basis of data on radiation fluxes in clouds in the UV spectral region it was possible to estimate the times of irradiation of an AgI aerosol during which the particles can receive an optimum irradiation dose for a maximum increase in their ice-forming activity. On the basis of an evaluation of the mean parameters of convective clouds (altitude of the lower boundary, altitude of the zero isotherm, mean velocities of the ascending fluxes) it was possible to compute the altitudes of the levels at which it is recommended that the aerosol be introduced in the modification effort. The authors give the temperature dependences for the specific yield of ice crystals for aerosols obtained by the combustion of acetone solutions with different weight concentrations C: 1, 5, 20%. With a temperature increase the influence of irradiation decreases for all concentrations. With a decrease in the concentration of the solution the specific yield of the ice crystals increases, which is probably associated with an increase in the numerical concentration of aerosol particles. Figures 1, tables 3, references 7.

UDC 551.509.616

SOME QUANTITATIVE CHARACTERISTICS OF TURBULENCE IN A STRATIFIED CLOUD LAYER AND ZONES OF ARTIFICIAL CRYSTALLIZATION

[Abstract of article by Kudryavtseva, S. K.]

[Text] The author obtained the quantitative characteristics of turbulence in stratiform clouds and zones of artificial crystallization in experiments with the artificial modification of supercooled clouds. The effective velocities of vertical gusts $|W_{eff}|$ in stratiform clouds did not exceed 3 msec^{-1}, in zones of artificial crystallization 2 msec^{-1}. Vertical gusts with $|W_{eff}| < 1$ msec^{-1} in clouds were 95%, in crystallization zones -- 99%. The mean $|W_{eff}|$ values in clouds are 0.46 msec^{-1}, in crystallization zones -- 0.40 msec^{-1}. The maximum frequency of recurrence in clouds and zones is for vertical gusts measuring 60-90 m. The frequency of recurrence of vertical gusts measuring more than 120 m in zones of artificial crystallization is greater than for clouds. The mean dimension of vertical gusts for

clouds was 113 m, for the zones -- 131 m. The mean frequency of recurrence of vertical gusts per unit distance in clouds was 5.95 km^{-1}, in the zones -- 3.61 km^{-1}. The modal probability density of the mean square effective velocities of vertical gusts ($\sigma_{W_{eff}}$) in clouds and zones falls in the gradation 0.26-0.50 $msec^{-1}$. The probability density $\sigma_{W_{eff}} > 0.75$ $msec^{-1}$ in clouds is greater than in zones of artificial crystallization. The maximum frequency of recurrence of the turbulence coefficient (K), characterizing the level of vertical turbulent exchange in the turbulent sectors of the cloud and zone, falls in the gradation 20.1-30.0 $m^2 \cdot sec^{-1}$. Values $K < 40$ $m^2 \cdot sec^{-1}$ in clouds were 86%, in zones -- 91%. The mean value K in clouds was 27.7 $m^2 \cdot sec^{-1}$, in zones -- 25.6 $m^2 \cdot sec^{-1}$. The maximum frequency of recurrence of values of the turbulence coefficient (K^*), characterizing the mean level of vertical turbulent exchange in clouds, falls in the gradation 10.1-20.0 $m^2 \cdot sec^{-1}$, in the zones -- 0-10.0 $m^2 \cdot sec^{-1}$. Values $K^* < 40$ $m^2 \cdot sec^{-1}$ in clouds were 93%, in zones -- 96%. The mean K^* value in clouds is 20.5 $m^2 \cdot sec^{-1}$, in the zones -- 15.0 $m^2 \cdot sec^{-1}$. The maximum frequency of recurrence of the turbulence intermittence coefficient (K_{in}) in clouds falls in the gradation 0.61-0.80, in the zones -- 0.41-0.60. The mean K_{in} value in clouds was 0.60, in the zones -- 0.44. The degree of attenuation of vertical turbulent exchange in the zones of artificial crystallization is dependent on meteorological conditions and cloud parameters. In zones of total scattering of clouds in individual cases all the effective velocity values for vertical gusts were less than 0.2 $m \cdot sec^{-1}$. Figures 5, tables 7, references 15.

UDC 551.501.81

COMPUTATION OF ATTENUATION OF CENTIMETER RADIO WAVES IN RAINS

[Abstract of article by Volynets, L. M. and Zabolotskaya, T. N.]

[Text] Data from the pluviometric network in the Experimental Meteorological Polygon of the Ukrainian Scientific Research Hydrometeorological Institute for July 1974 were used in computing the attenuation of radio waves in precipitation in the range 0.86-10 cm. Attenuation was determined in accordance with its mean monthly duration. The influence of attenuation on the accuracy of radar measurement of the quantity of precipitation was evaluated. The distributions of errors in measuring the layer of precipitation during a rain caused by attenuation at wavelengths 3.2, 5.6 and 10 cm were obtained. The influence of attenuation on the accuracy of measurement of the layer of precipitation during a month is demonstrated. Figures 4, tables 4, references 10.

5303
CSO: 1865/119

UDC 551.508+551.510.42

COLLECTION OF PAPERS ON PHYSICS OF AERODISPERSE SYSTEMS AND INSTRUMENTS

Moscow TRUDY INSTITUTA EKSPERIMENTAL'NOY METEOROLOGII: FIZIKA AERODISPERSNYKH SISTEM I PRIBORY in Russian No 25(93), 1980 (signed to press 20 Aug 80) pp 2, 115-120

[Annotation, table of contents and selected abstracts from collection of articles "Transactions of the Institute of Experimental Meteorology: Physics of Aerodisperse Systems and Instruments", edited by S. P. Belyayev and N. K. Nikiforova, candidates of physical and mathematical sciences, Moskovskoye otdeleniye Gidrometeoizdata, 390 copies, 120 pages]

[Text] Annotation. The articles in this collection deal with some problems of the aspiration of aerosol into different intakes and the influence of hygroscopic particles on the structure of forming droplet fogs. The articles describe a number of instruments and methods for measuring the microphysical and integral characteristics of aerosol media. A number of articles are devoted to an evaluation of different errors of laser photoelectric aerosol spectrometers which recently have come into increasingly broader use for measuring the microstructure of aerosols. The collection is intended for scientific specialists, engineers and other professionals working in the field of the physics of clouds and the mechanics of aerosols.

Contents

Abstracts

UDC 551.509.615:551.574.11

RESTRUCTURING OF THE MICROSTRUCTURE OF FOGS UNDER THE INFLUENCE OF HYGROSCOPIC PARTICLES

[Abstract of article by Smirnov, V. V.]

[Text] The article gives the results of experiments in a cloud chamber with a volume of 3200 m^3 for the modification (by droplets of aqueous solutions of carbamide) of fogs in the initial stages of their formation. In measuring the disperse composition of the fog use was made of the "El'tra" laser particle counter (measurement range $d \sim 0.3$-$30 \mu m$ in diameter, number of analysis channels 64). It is shown that with supersaturations $S > 0.01\%$ and concentrations of condensation nuclei active with $S > 0.01\%$ of the order of 10^3 cm^{-3} the introduction of hygroscopic particles with a "dry" diameter of $1 \mu m$ does not result in an appreciable increase in the large-droplet part of the droplet size spectrum. With a concentration of nuclei greater than $2 \cdot 10^3$ cm^3 and a size of nuclei $0.2 \mu m$ there is formation of stable small-droplet fogs. Figures 2, references 11.

UDC 551.510.42:535.853

CHARACTERISTICS OF LASER SPECTROMETRY OF AEROSOL PARTICLES

[Abstract of article by Petrushin, A. G. and Smirnov, V. V.]

[Text] An analysis of the results of numerical modeling of the characteristics of laser photoelectric counters (LPEC) of aerosol particles in a wide range of sizes (0.05–10μ m) and the refractive indices shows that due to oscillations of the characteristics of known LPEC the errors in measuring sizes can attain 50% and the most satisfactory results are given by LPEC with observation angles 90° and a receiver aperture ±30°. Figures 2, references 11.

UDC 621.383

POSSIBILITY OF REDUCING THE ERRORS ASSOCIATED WITH NONUNIFORMITY OF ILLUMINATION OF THE WORKING VOLUME IN PHOTOELECTRIC LASER AEROSOL SENSORS

[Abstract of article by Kolomiyets, S. M.]

[Text] The article examines the problem of a sensor in which the working volume is formed by a laser beam scanning in a direction perpendicular to the direction of motion of the particles with a repetition period much less than the transit time of the particles through the working volume. It is shown that the errors associated with the nonuniformity of illumination of the working volume in some cases can be decreased by an order of magnitude. References 7.

UDC 551.508.91

INVESTIGATION OF THE CHARACTERISTICS AND MODERNIZATION OF THE AZ-5 AEROSOL PARTICLE COUNTER

[Abstract of article by Belyayev, S. P., Goncharov, N. V. and Dubrovin, M. A.]

[Text] The paper gives the results of an investigation of the principal errors in measuring the sizes and concentration of aerosol particles in counters of the AZ type and describes measures for modernization of the instrument making it possible to transform the AZ-5 counter-indicator into an automated measuring instrument with a measurement range and accuracy increased in comparison with the factory-produced instrument. Also described is a method for calibrating the instrument on the basis of the size of the measured particles and determination of the actual measurement errors. Figures 1, references 6.

UDC 551.508.91

INFLUENCE OF THE THRESHOLD OF RESPONSE OF A PHOTOELECTRIC SYSTEM ON THE ACCURACY IN DETERMINING THE MICROSTRUCTURAL AND OPTICAL CHARACTERISTICS OF AN AEROSOL

[Abstract of article by Nikiforova, N. K.]

[Text] The influence of the threshold of response of a photoelectric aerosol counter (PEC) on the accuracy in determining the concentration and distribution moments for two approximations of the size distributions (gamma and inverse power law) is discussed. It is demonstrated that in the computational determination of the radiation attenuation coefficient on the basis of PEC readings the errors caused by the influence of the response threshold can be small when there are substantial errors in determining the concentration and mean square size. Figures 2, references 3.

UDC 551.574.13:535.8

DARK FIELD METHOD FOR THE ILLUMINATION OF TRANSPARENT SPHERICAL MICROPARTICLES

[Abstract of article by Korovin, V. Ya. and Tolstikov, Yu. V.]

[Text] A rather simple method is proposed for the illumination of transparent spherical microparticles for the purpose of measuring their size. The essence of the method is the irradiation of a microparticle by two light beams with a slight divergence, directed from the direction of the registry system objective, and the measurement of the distance between the luminescent points in the form of which the microparticle image is registered. For the purpose of obtaining the minimum measurement error the angle between the irradiating light beams and the optical axis of the registry system axis is computed in advance from the known refractive index of microparticle matter. It is shown that the total measurement error, without allowance for the error associated with the inaccuracy in pointing the registry system objective on the microparticle, is not more than 2-3%. Figures 1, references 3.

UDC 551.575:621.396.96

EXPERIMENTAL INVESTIGATION OF THE POSSIBILITY OF DETERMINING AN OILY FOG BY THE LIDAR METHOD

[Abstract of article by Yepifanov, V. I., Zhukov, G. P., Korshunov, V. A., Pashkin, Yu. M. and Romanov, N. P.]

[Text] The article gives comparative measurements of the transparency of an oily fog by the lidar (wavelength 0.69μm) and base (wavelength 0.63μm) methods in the range of optical thicknesses 0.1-4. The determined slope of the regression line, equal to 0.78, was caused by the difference in the coefficients of attenuation at the wavelength of the lidar and base apparatus. The relative standard deviation of optical thickness for the lidar measurements is 0.15 and is caused both by errors in the lidar method and comparison errors. Figures 2, references 7.

UDC 551.508.92+551.501.776

MONITORING THE DROPLET SPECTRUM IN THE VERTICAL WIND TUNNEL AT THE INSTITUTE OF EXPERIMENTAL METEOROLOGY

[Abstract of article by Kim, V. M. and Matveyev, V. N.]

[Text] A method is described for monitoring the droplet size spectrum in the core of the flow in the vertical wind tunnel at the Institute of Experimental Meteorology, based on simultaneous measurements of light attenuation and liquid-water content. It is shown that the size of the droplets making the greatest contribution to the liquid-water content varies slightly with a change in the operating regime of the water spraying system and remains constant with a change in the liquid-water content of the fog from 0.3 to 4.0 g/m^3. Figures 1, references 7.

5303
CSO: 1865/130

UDC 551.521+551.501.81(061.6)

ARTICLES ON ACTIVE AND PASSIVE RADAR IN METEOROLOGY

Leningrad TRUDY ORDENA TRUDOVOGO KRASNOGO ZNAMENI GLAVNOY GEOFIZICHESKOY OBSERVATORII IMENI A. I. VOYEYKOVA: METODY AKTIVNOY I PASSIVNOY RADIOLOKATSII V METEOROLOGII in Russian Vol 430, 1979 (signed to press 10 Dec 79) pp 2, 165-175

[Annotation and abstracts from the collection of articles "Transactions of the Red Banner of Labor Main Geophysical Observatory imeni A. I. Voyeykov: Methods of Active and Passive Radar in Meteorology", edited by V. D. Stepanenko, doctor of technical sciences, and G. G. Shchukin, candidate of physical and mathematical sciences, Gidrometeoizdat, 750 copies, 174 pages]

[Text] Annotation. These papers give the results of theoretical and experimental investigations of the meteorological characteristics of clouds and dangerous weather phenomena associated with them by the active and passive radar methods. Methodological studies are presented which relate to improvement of methods for making radar observations of hydrometeor formations in the network of meteorological radars. Problems involved in the construction of radiophysical apparatus are examined. The collection of articles is intended for scientific workers and engineers concerned with physics of the atmosphere, radio physics and radio engineering. It is also recommended for graduate students and students in the advanced courses in the corresponding fields of specialization.

Abstracts

UDC 551.501.81

JOINT DETECTION OF LIGHTNING USING RADARS OPERATING IN THE METER AND DECIMETER RADIO WAVE RANGES

[Abstract of article by Stasenko, V. N., Gal'perin, S. M., Yerov, V. N. and Gonchar, A. F.]

[Text] The parameters of radioechoes of lightning, detectable in the long-wave part of the decimeter radar range of radio waves, are discussed. This is followed by a comparison with the similar parameters of radioechoes of lightning registered with a radar of the P-12 type. Figures 2, references 1.

UDC 551.501.81

MEASUREMENT OF ALTITUDES OF CLOUDS USING A PRV-10 RADIOALTIMETER

[Abstract of article by Alekseyev, V. A., Gal'perin, S. M., Stasenko, V. N. and Tryakhov, A. M.]

[Text] Cases of the detection of thunderstorm clouds with $H_{upper} \geqslant 16$-18 km by means of a radar are discussed. It is demonstrated theoretically that this effect is caused by the picking up of meteorological targets with $Z_{max} \geqslant 10^4$ mm^6/m^3 by the side lobes of the directional diagram of this station. Figures 2, tables 1, references 3.

UDC 551.501.81

ERRORS IN DETERMINING THE BOUNDARIES OF CLOUDS BY THE RADAR METHOD

[Abstract of article by Brylev, G. B. and Ryzhkov, A. V.]

[Text] The influence exerted on the error in determining the upper boundary of clouds Δh in radar sounding at different distances from a meteorological radar by meteorological potential, width of the antenna ray, level of the side lobes and the vertical reflectivity near the upper cloud boundary is examined. A theoretical model is constructed on the basis of which formulas are derived for determining Δh. The strongest effect on Δh is exerted by the gradient of reflectivity at the upper cloud boundary. Tables and graphs of the dependence of Δh on distance of the cloud from the meteorological radar are given for different parameters of the radar and cloud cover. These can be used in practical operational work with a meteorological radar. Figures 4, tables 1, references 3.

UDC 551.501.81

CHARACTERISTICS OF RADIOTHERMAL RADIATION AND ABSORPTION BY THE CLOUDY ATMOSPHERE

[Abstract of article by Bobylev, L. P., Tarabukin, I. A. and Shchukin, G. G.]

[Text] Model computations were made of the statistical characteristics of radiothermal radiation for different types of cloud cover. As models of the cloudy atmosphere use was made of empirical statistical models for stratiform clouds and a jet stationary model was used for Cu. The results are analyzed. The possible ranges of wavelengths and zenith angles for solution of the problems involved in radiothermal sounding of the cloudy atmosphere are evaluated. The required accuracy for measuring the radiobrightness temperature from the point of view of solution of the mentioned problems is also evaluated. Figures 6, tables 3, references 19.

UDC 551.501.81

FLUCTUATIONS OF SIGNAL LEVEL IN THE MILLIMETER AND SUBMILLIMETER WAVELENGTH RANGES DURING PROPAGATION IN A TURBULENT ABSORBING ATMOSPHERE

[Abstract of article by Izyumov, A. O., Bobylev, L. P. and Shchukin, G. G.]

[Text] In the first approximation of the smooth perturbations method a solution was obtained for the problem of the propagation of a single-mode Gaussian wave beam in a turbulent atmosphere. A study was made of the influence of absorption in atmospheric water vapor. It is shown that the presence of absorption can lead to a decrease in the mean square of signal level fluctuations in comparison with propagation in an absolutely transparent medium. The influence of the geometrical dimensions of the wave beam on the magnitude of the fluctuations is examined and the conditions under which a minimum of fluctuations is observed are determined. Figures 4, tables 1, references 12.

UDC 551.501.81

POSSIBILITY OF DETERMINING THE INTENSITY OF PRECIPITATION BY THE PASSIVE-ACTIVE RADAR METHOD

[Abstract of article by Popova, N. D. and Shchukin, G. G.]

[Text] The profile of liquid-water content of a hydrometeor along the sounding line is described. Expressions are derived for the relationship between liquid-water content and the intensity of precipitation for evaluating the instantaneous intensity of precipitation on the basis of the determined liquid-water content. The use of the method for the analysis of passive-active radar sounding of a cumulonimbus cloud with a shower is discussed. Figures 1, tables 2, references 9.

UDC 551.509.6:551.501.81

COMPUTATION OF THE CHARACTERISTICS OF CONVECTIVE CLOUDS USING STANDARD AEROLOGICAL INFORMATION AND THEIR COMPARISON WITH THE RESULTS OF RADAR OBSERVATIONS

[Abstract of article by Brylev, G. B., Vorob'yev, B. M. and Grachev, S. S.]

[Text] The article describes computer modeling of the characteristics of cloud convection on the basis of standard aerological information obtained at a radar observation station. A total of 74 numerical experiments for studying the development of convective clouds during the period June-September 1976-1977 in the Leningrad region are discussed. The statistical characteristics of the parameters of cloud convection, and equations for linear regression between model (computed) and measured (radar) characteristics and also between the maximum values of the model parameters, are both examined. Figures 3, tables 2, references 7.

UDC 551.501.81

METHOD AND RESULTS OF OBSERVATIONS OF POINT RADIOECHOES USING AN AIRPORT RADAR

[Abstract of article by Zavirukha, V. K. and Stepanenko, V. D.]

[Text] Radar observations of point radioechoes are described. The source of these echoes was birds. The repetition rates of the radioechoes, their altitudes, velocities of motion and EPR are given. The feasibility of using an airport radar in evaluating ornithological conditions in the neighborhood of an airport is demonstrated. Figures 1, tables 4, references 7.

UDC 551.501.81

ANALYSIS OF THE VARIABILITY OF RADAR CHARACTERISTICS IN CLOUD FIELD TRANSFORMATION

[Abstract of article by Ivanova, T. V. and Stepanenko, V. D.]

[Text] The article describes the spatial-temporal variability of characteristics of the field of radioechoes of convective clouds at a mesoscale, obtained using AAOM apparatus during summer at Voyeykovo village. Figures 2, references 3.

UDC 551.501.81

APPLICATION OF IMAGE RECOGNITION THEORY FOR ANALYSIS OF RADAR METEOROLOGICAL DATA

[Abstract of article by Solonin, A. S.]

[Text] The mathematical aspects of synthesis of systems for the recognition of meteorological features, capable of functioning under conditions of a priori uncertainty relative to the type of distribution of radar characteristics, are discussed. The author proposes additional adaptation of the system to the peculiarities of the structure of the teaching sample, related to the separability of classes of meteorological features in criteria space. References 3.

UDC 551.501.81

PRINCIPLE FOR USING A SET OF ALGORITHMS IN AUTOMATING THE RECOGNITION OF RADIOECHOES OF THUNDERSTORMS AND PRECIPITATION

[Abstract of article by Brylev, G. B., Zavdov'yev, A. V. and Linev, A. G.]

[Text] This is an evaluation of the effectiveness of individual algorithms for the recognition of thunderstorms and precipitation and the simultaneous use of several algorithms using data from the MLR-2-AAOM instrument complex. The adoption of a decision on the basis of a set of algorithms in order to obtain the overall reliability of the classification of 94-96% is discussed. The effectiveness of the principle for adoption of a decision on the basis of a set of algorithms and ensuring an increase in the probability of a correct classification by 15-20% is demonstrated. Tables 3, references 4.

UDC 551.501.81+551.508.85

INFLUENCE OF A TEACHING SAMPLE ON RECOGNITION OF RADIOECHOES OF THUNDERSTORMS AND SHOWERS

[Abstract of article by Brylev, G. B., Sonechkin, D. M. and Shvedov, V. V.]

[Text] A method for the recognition of thunderstorm and shower radioechoes with use of the technique of quadratic discriminant analysis for the main components is described. Use was made of 9,608 thunderstorm and 3,664 shower radar reflections relating to the observations made with eight MRK radar stations during 1973-1976. The method ensures an extremely high quality of recognition. On the average recognition is unsuccessful for 3.9% of the thunderstorms and 21.3% of the showers are erroneously identified as thunderstorms. Under the condition of equal probability of observation of thunderstorm and shower radioechoes the total recognition error is 12.6%, which is better by 7-8% than the routinely used method. Figures 2, tables 4, references 1.

UDC 551.501.81

DETERMINATION OF THE PARAMETERS OF MOVEMENT OF RADIOECHOES OF CLOUDS AND PRECIPITATION ON THE BASIS OF CORRELATION ANALYSIS

[Abstract of article by Brylev, G. B., Zavdov'yev, A. V. and Nizdoyminoga, G. L.]

[Text] Using 16 trajectories of radioechoes ($S \leqslant 500$ km) a study was made of the possibility of use of the space-time correlation method for determining the velocity and direction of movement. A scheme for computations on an electronic computer is examined and a comparison with other traditional methods for determining V and d is presented. Figures 2, tables 3, references 7.

UDC 551.501.81

SOME PECULIARITIES OF RADAR DETECTION OF RAINS IN THE CUBA REGION

[Abstract of article by Russis, O. N. and Stepanenko, V. D.]

[Text] As a result of computations using experimental data on the relative probability of falling of rains of different intensity for Cuba and Leningrad it was possible to obtain the radioclimatic probabilities of their detection $W_r(R)$ by means of different meteorological radars. It is shown that for Cuba the $W_r(R)$ value at distances greater than 50-100 km is substantially greater than for Leningrad, which makes its use desirable in the organization of a network of meteorological radars in Cuba. Figures 2, tables 1, references 2.

UDC 551.501.81

SOME RESULTS OF INVESTIGATION OF THE STRUCTURE OF THE FOCI OF RADIOECHOES FROM CUMULONIMBUS CLOUDS AND THE DYNAMICS OF THEIR DEVELOPMENT

[Abstract of article by Zhupakhin, K. S., Ivanova, T. V. and Kotov, N. F.]

[Text] The article describes investigations of the structure of foci of radioechoes from cumulonimbus clouds and the dynamics of its development during the summer of 1971 using a meteorological radar and a unit for the processing of a multicontour isoecho, developed by K. S. Zhupakhin and V. S. Zhupakhin. Figures 2, references 5.

UDC 551.501.81

RADAR CHARACTERISTICS OF THUNDERSTORMS IN THE KIEV REGION

[Abstract of article by Brylev, G. B., Sergiyenko, Ye. P. and Shiryayeva, V. I.]

[Text] The change in the maximum altitude of a radioecho H_{max}, radar reflectivity at the level of the zero isotherm ($\lg Z_2$) and at the level of the isotherm -22°C ($\lg Z_3$), the radar criterion of thunderstorm danger Y and the area of the radioecho of thunderstorms, which were obtained using a meteorological radar in a radius of 100 km from the airport at Kiev, are examined in dependence on the altitude of the isotherm -22°C, the level of convection, tropopause and atmospheric stratification. The patterns of movement of thunderstorm radioechoes are considered in dependence on the velocity and direction of movement of the steering current. Figures 1, tables 1, references 5.

UDC 551.501

USE OF INDUSTRIAL COMPUTERS FOR PROCESSING DATA AT A REAL TIME SCALE IN SOLVING STORM WARNING PROBLEMS

[Abstract of article by Gudyma, A. M., Zavdov'yev, A. V. and Linev, A. G.]

[Text] Expressions relating processing time, scanning radius, space factor and the dimensions of representation units for a selected processing algorithm are presented. Figures 1, tables 3, references 2.

UDC 551.501.81

USE OF RADAR STATIONS IN CHECKING THE ACCURACY CHARACTERISTICS OF THUNDERSTORM DIRECTION AND RANGE FINDERS

[Abstract of article by Gal'perin, S. M., Stasenko, V. N., Krokhin, N. N. and Plotnikov, V. D.]

[Text] The authors give a method for checking the azimuth and range of lightning, determined using thunderstorm direction and range finders, on the basis of readings of a P-12 radar station. Figures 1, references 4.

UDC 551.501.81

PROSPECTS FOR THE DEVELOPMENT OF DISPLAY EQUIPMENT FOR SURFACE METEOROLOGICAL RADARS

[Abstract of article by Litvak, B. N., Mel'nik, Yu. A., Petrushevskiy, V. A., Serebrov, L. A., Filaretov, Yu. S., Shavela, G. F. and Shmulevich, V. L.]

[Text] The principal requirements on display equipment are given for mobile and stationary meteorological radars. The implementation of requirements on the basis of color display of the television type, ensuring matching and "brightness" display of signals of different types is discussed. The display of gradations of the intensity of hydrometeors by intermediate colors is described. The introduction of a device for the discrimination of the contours of hydrometeors and the display of the "prehistory" of the meteorological conditions is outlined. Figures 3, references 6.

UDC 551.501.81

INFORMATION CAPACITY OF A METEOROLOGICAL RADAR DISPLAY SCREEN

[Abstract of article by Mikhaylov, V. K., Serebrov, L. A. and Shmulevich, V. L.]

[Text] Expressions relating the information capacity of a display screen to the pip, characteristics of the screen and observation conditions are given. The information capacity of the meteorological radar display screen of the station and the maximum information capacity of a display screen with a pip are discussed. Figures 1, tables 3, references 3.

UDC 551.501.81

APPARATUS FOR DISPLAY OF GENERALIZED METEOROLOGICAL INFORMATION ON COLOR AND BLACK-AND-WHITE TELEVISION SCREENS

[Abstract of article by Litvak, B. N., Mikhaylov, V. K., Novichev, E. A., Petrushevskiy, V. A., Serebrov, L. A., Fedorov, A. A., Filaretov, Yu. S., Shevela, G. F. and Shmulevich, V. L.]

[Text] The article describes the design of apparatus for display on color and black-and-white screens of the information arriving from a meteorological radar, thunderstorm direction finder and unit for automatic data processing. An analysis of meteorological conditions and the transmission of the results of processing to users are presented. Figures 2, tables 1, references 1.

UDC 551.501.81

USE OF METHODS OF OPTIMUM STATISTICAL SOLUTIONS IN THE PROBLEM OF RADIOTHERMAL DETERMINATION OF THE MOISTURE CONTENT OF THE CLOUDY ATMOSPHERE

[Abstract of article by Bobylev, L. P. and Shchukin, G. G.]

[Text] The authors present methods for optimum statistical evaluation for linear models in application to determination of the integral parameters of moisture content of the cloudy atmosphere by means of absolute radiothermal measurements of total absorption. The errors in these methods are considered. The optimum combinations of wavelengths are determined for solution of two- and three-parameter problems in cases when this solution is impossible. Figures 3, tables 4, references 16.

5303
CSO: 1865/138

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000400030025-7

UDC 681.142.37

PAPERS ON COMPUTERIZED PROCESSING OF METEOROLOGICAL INFORMATION

Leningrad TRUDY ORDENA LENINA GIDROMETEOROLOGICHESKOGO NAUCHNO-ISSLEDOVATEL'SKOGO TSENTRA SSSR: AVTOMATIZATSIYA OPERATIVNOY OBRABOTKI METEOROLOGICHESKOY INFORMATSII in Russian No 217, 1980 (signed to press 25 Nov 80) pp 2, 104, 107, 109, 111

[Annotation, table of contents and abstracts from collection of articles "Transactions of the USSR Order of Lenin Hydrometeorological Scientific Research Center: Automation of Operational Processing of Meteorological Data", edited by K. A. Semendyayev, doctor of physical and mathematical sciences, and O. M. Kastin, candidate of physical and mathematical sciences, Gidrometeoizdat, 600 copies, 111 pages]

[Text] Annotation. The monograph gives the results of investigations and also results of development of an automated system for data processing at the USSR Hydrometeorological Center: organization of system control, informational support of the special programs incorporated in the system, primary processing and checking of the operational hydrometeorological information, algorithms for preparing synoptic charts, and also the results of other studies along these lines. This collection of articles is intended for specialists concerned with computerized data processing.

Contents

Abstracts

UDC 681.142.37:551.5

SOME ASPECTS OF DEVELOPMENT OF AN AUTOMATED SYSTEM FOR THE PROCESSING OF OPERATIONAL INFORMATION ON AN ELECTRONIC COMPUTER (ASOOI)

[Abstract of article by Kastin, O. M. and Katayev, V. V.]

[Text] The article gives some characteristics of the set of special programs involved in different links of production of numerical forecasts. The authors set forth the principles for integration of programmed and informational support for operational prognostic problems and the principles of programmed control for the operational processing of data which served as a basis in creating an automated system for the processing of operational information on the basis of a BESM-6 electronic computer within the framework of the OS DISPAK (ASOOI-6) operational system. The structure of the first two variants of the system -- ASOOI-6.1 and ASOOI-6.2 -- is described. Figures 4, tables 2, references 12.

UDC 681.142.37

ASOOI-6 CONTROL SYSTEM

[Abstract of article by Gleyzer, N. Yu. and Katayev, V. V.]

[Text] The control system for the automated system of operational processing of information is described. It was developed on the basis of application of the capabilities of the DISPAK operational system and the "Dubna" monitoring system. Its internal logic and an operational algorithm are described. The makeup and structure, parameters and quantitative characteristics of the ASOOI-6 control system are given. Figures 3, references 6, appendices 1.

UDC 681.142.37

SYSTEM FOR CONTROL OF THE ASOOI-6 DATA BANK

[Abstract of article by Antsypovich, V. A. and Al'tshuler, V. R.]

[Text] The problems involved in the organization of access of special modules to hydrometeorological information with assurance of the nondependence of the modules on structure of the data are examined. The developed algorithm for the system for the control of the data bank and the possibilities of its use are discussed. Figures 6, tables 1, references 4.

UDC 681.142.37:551.5

RECEPTION OF HYDROMETEOROLOGICAL INFORMATION IN THE ASOOI-6

[Abstract of article by Katayev, V. A., Antsypovich, V. A. and Gleyzer, N. Yu.]

[Text] The process of reception of hydrometeorological information in the second variant of the ASOOI-6 system is considered. The creation of mathematical support of the BESM-6 electronic computer for tie-in with the "Minsk-32" electronic computer is described under the conditions of the actually realized means for the tie-in of equipment and the existing technology for the operational processing of data on the "Minsk-32" electronic computer. The possible prospects for the development of tie-ins among the electronic computers at the USSR Hydrometeorological Center are discussed. Figures 1, references 9.

UDC 681.142.37:551.5

PRIMARY PROCESSING OF OPERATIONAL INFORMATION IN THE ASOOI-6

[Abstract of article by Kastin, O. M., Al'tshuler, V. R. and Gural'nik, Ye. M.]

[Text] The general organization of the system for the primary processing of operational hydrometeorological information operating within the framework of the ASOOI-6 is described. The characteristics of the programmed and information support of the system are given. Also examined is an algorithm for the functioning of the operational part of the system for the processing of the initial data arriving from another electronic computer and the capabilities of service programs constituting the nonoperational part of the system. Certain processed information obtained in the course of system operation is given. Figures 1, tables 5, references 16.

UDC 681.142.37:551.5

COMBINED MONITORING OF GEOPOTENTIAL AND TEMPERATURE AT STANDARD ISOBARIC SURFACES

[Abstract of article by Antsypovich, V. A.]

[Text] An algorithm for the combined monitoring of geopotential and temperature at standard isobaric surfaces, applied using a BESM-6 electronic computer, is described. Attention is given to the effectiveness of the algorithm, especially in selecting the influencing stations and the reduction of the number of uncorrectable errors. The algorithm is employed in the operational work of the USSR Hydrometeorological Center. Figures 2, tables 1, references 7 .

UDC 681.142.37:551.5

ALGORITHM FOR COMPUTING AND PLOTTING ISOLINES ON AN ELECTRONIC COMPUTER

[Abstract of article by Semendyayev, K. A.]

[Text] The article describes an algorithm for computing the coordinates of points on field isolines stipulated at the points of intersection of a regular grid in a rectangle and for the plotting of isolines using a two-coordinate instrument. The algorithm was developed for a BESM-6 electronic computer in FORTRAN language. Figures 5, references 3.

UDC 551.5:681.142.37

SOME PROBLEMS IN CONSTRUCTING A DIGITAL FACSIMILE SYSTEM FOR THE TRANSMISSION OF METEOROLOGICAL CHARTS

[Abstract of article by Ovcharov, V. I. and Vakulenko, A. V.]

[Text] The structure of the "Rastr" complex, which is being developed, is described. It is intended for generation of the image of meteorological charts, their storage and transmission in digital form in a communication channel. Proposals are made on the use of the complexes in the network. The need for the considered studies is validated. Figures 1, references 2.

UDC 551.5:681.142.57

METHOD FOR THE PROCESSING OF HYDROMETEOROLOGICAL DATA ON A SCIENTIFIC RESEARCH SHIP

[Abstract of article by Gleyzer, N. Yu. and Katayev, V. V.]

[Text] A possible approach to the combining of programs for the processing of meteorological data into a packet of special programs for scientific research ships on the basis of integration of input and output data is discussed. Also examined is the makeup, structure and functioning of a packet of special programs in the example of computation of the characteristics of mesoscale atmospheric processes. The advantage of this approach for the technology of processing of data is demonstrated in comparison with the traditional single-program method. Figures 1, references 5.

5303
CSO: 1865/170

UDC 551.509.616/617

ARTIFICIAL MODIFICATION OF CLOUDS AND FOGS

Moscow TRUDY TSENTRAL'NOY AEROLOGICHESKOY OBSERVATORII: AKTIVNYYE VOZDEYSTVIYA NA OBLAKA I TUMANY in Russian No 142, 1980 (signed to press 21 Aug 80) pp 2, 129, 131-136

[Annotation, table of contents and abstracts from collection of articles edited by L. P. Zatsepina, candidate of physical and mathematical sciences, Moskovskoye otdeleniye Gidrometeoizdata, 390 copies, 130 pages]

[Text] Annotation. This collection of articles is devoted to problems involved in the artificial modification of clouds and fogs. The articles give the results of experiments for the modification of well-developed convective clouds by pulverized substances and ice-forming reagents. The effectiveness of the method for monitoring the results of modification with the use of a polarization radar is discussed. Also examined are problems related to the artificial regulation of precipitation. A large part of the collection is devoted to the problems involved in laboratory experiments for studying the ice-forming activity of the new reagents and increasing the effectiveness of propane used in the scattering of clouds and fogs near 0°.

The collection is intended for specialists in the field of cloud physics and artificial modification.

CONTENTS

ABSTRACTS

UDC 551.509.61

SOME RESULTS OF FIELD EXPERIMENTS FOR ARTIFICIAL MODIFICATION OF A SUPERCOOLED FOG

[Abstract of article by Dinevich, V. A., Krasnovskaya, L. I., Khizhnyak, A. N. and Shevaldina, T. I.]

[Text] The article examines the results of field experiments for artificial modification of a supercooled fog using a model of a ground propane apparatus developed by the artificial modification section of the Central Aerological Observatory. The experiments were made with temperatures in the fog at the ground from 1.5 to -1.5°C. An 8-mm channel of the MRL-1 radar was used in observing the modification effect. The use of the MRL-1 radar made it possible to determine the extent of the zone of artificial modification at different distances from the source and estimate the velocity of vertical propagation of crystallization in the fog. It is shown that the maximum altitude of penetration of the artificial crystallization effect in the fog is dependent on temperature stratification. The authors make an

approximate estimate of the temperature threshold of the effective action of propane under natural conditions. Tables 1, figures 7, references 8.

UDC 551.509.616

RESULTS OF EXPERIMENTS FOR MODIFYING CUMULONIMBUS CLOUDS BY COARSELY DISPERSED PULVERIZED MATTER

[Abstract of article by Dinevich, V. A., Zatsepina, L. P., Zontov, L. B. and Seregin, Yu. A.]

[Text] The article presents the results of 74 experiments for the modification of cumulonimbus clouds by coarsely dispersed pulverized matter carried out during the summer of 1976/77 in Moldaviya. The experiments are part of a planned long-term randomized experiment (1976-1980) for the regulation of development of convective clouds with the use of high-altitude aircraft. The checking of the results of modification was accomplished using surface 3-cm radar stations of the MRL type. In evaluating the dynamic activity of clouds use was made of a radar with an additional device -- "turbulence indicator." The experiments indicated that in 80% of the cases modification leads to the destruction of clouds or a substantial decrease in their size. In a control series of experiments no effects were noted. Tables 4, figures 5, references 11.

UDC 551.509.616/617

USE OF A POLARIZATION RADAR FOR MONITORING MODIFICATION OF CONVECTIVE CLOUDS BY PULVERIZED REAGENTS

[Abstract of article by Zatsepina, L. P., Zimin, B. I. and Nazirov, Z. N.]

[Text] The results of long-term field experiments indicated that the dynamic effect of modification is essentially dependent on the site of introduction of the reagent into a cloud. For checking and evaluating the accuracy of entry of the reagent into a stipulated part of the cloud specialists have developed an experimental method with the use of a polarization radar and artificial reflectors. Using the station it was possible to accomplish selection of the artificial reflectors introduced into the cloud together with the reagent. Preliminary estimates were made of the velocities of movement of the artificial reflectors in the cloudless atmosphere and in a cloud. Figures 2, references 5.

UDC 551.509.616

EVALUATION OF THE TIME REQUIRED FOR INTENSIFYING PRECIPITATION WITH THE SEEDING OF THUNDERSTORM CLOUDS BY ICE-FORMING AEROSOLS

[Abstract of article by Zimin, B. I.]

[Text] In a number of experiments for the modification of thunderstorm clouds in Moldaviya there was a brief intensification of rain, on the average 11 minutes after the introduction of the reagent into a cloud layer with a temperature less than -6°C. Estimates were made of the time of growth and fallout of particles when there is artificial seeding of a model cloud and a specific thunderstorm. The computed time of intensification of precipitation in the pluviometric network agrees best with the actual time in the case of freezing of large cloud droplets upon contact with lead iodide nuclei. Figures 1, references 18.

UDC 551.557.59

EVALUATION OF CHANGE IN PRECIPITATION OVER AN AREA PROTECTED AGAINST HAIL (BASED ON OBSERVATIONS IN THE MAIN PRECIPITATION-GAGING NETWORK OF THE MOLDAVIAN SSR

[Abstract of article by Dinevich, L. A., Kondratova, A. V., Leonov, M. P., Pozdeyev, V. N. and Seregin, Yu. A.]

[Text] A preliminary evaluation of changes in the quantity of investigated precipitation is given for the territory in the Moldavian SSR protected against hail with the use of the mean areal sums of precipitation during the modification season (May-August) and the same precipitation sums for four control territories on the basis of historical regression equations. The computations included data for the 17 years prior to modification and for 12 years with modification. The averaging of precipitation for a considerable number of stations (over large areas) for prolonged time intervals (four months) and the availability of long series of observations facilitated the elimination of their short-period fluctuations and determination of the patterns of their spatial-temporal distribution. It is assumed that under the influence of hail protection an increase of precipitation by 2-3% is probable, but this value is statistically unreliable. Tables 3, figures 2, references 14.

UDC 551.589:551.576+551.589:551.577

EXPERIENCE IN SYNOPTIC-CLIMATOLOGICAL CHARACTERIZATION OF TERRITORIES INTENDED FOR THE ARTIFICIAL AUGMENTATION OF PRECIPITATION

[Abstract of article by Leonov, M. P. and Trutko, T. V.]

[Text] In this article the authors discuss the synoptic-climatological characteristics of definite regions in Algeria and Spain planned for an artificial augmentation of precipitation (International Project PUOWMO). Emphasis is on processes of atmospheric circulation leading to rainy and "dry" periods and also analysis of precipitation and cloud cover in such periods. Tables, figures 4, references 10.

UDC 551.509.616/617

INVESTIGATIONS OF THE EFFECTIVENESS OF ANTIHAIL MEASURES

[Abstract of article by Dinevich, S. Ye., Medvedev, G. A. and Naumenko, V. G.]

[Text] On the basis of statistical processing and analysis of the results of radar measurements of the characteristics of hail clouds the authors evaluate the effectiveness of carrying out of antihail protection work. The article defines the conditions under which the best effectiveness of protection of agricultural crops against hailfalls is attained. The modification of hail clouds is modeled and the effects of modification are evaluated on the basis of measurements of radar parameters. Figures 2, references 4.

UDC 551.509.616/617

COMPARATIVE ICE-FORMING ACTIVITY OF 1.5-DIHYDROXYNAPHTHALENE AND PHLOROGLUCINOL

[Abstract of article by Aksenov, M. Ya. and Plaude, N. O.]

[Text] In a series of parallel experiments the authors measured the yield of active ice-forming particles for aerosols of 1.5-dihydroxynaphthalene and phloroglucinol generated under identical conditions. In order to obtain aerosols use was made of two types of laboratory thermal generators in which the condensation of vapors of substance occurs during the mixing of an escaping jet of hot steam with the surrounding air. The dispersivity of the forming aerosols was varied by a change in the velocity of the jet and the concentrations of active substance in it. The spectrum of particle sizes was determined using an electron microscope. The resulting sets of temperature dependences for the yield for the two substances indicate that 1.5-dihydroxynaphthalene, dispersed in ordinary thermal generators, has a substantially lesser ice-forming activity than phloroglucinol, especially in the temperature range above -10°C. In the electron microscope investigation of the dispersivity of aerosols of organic substances there is a decrease in the measured number of particles due to the partial evaporation of nuclei. The distortion of the spectrum of sizes and the number of particles increases for substances with a lower melting point. Tables 2, figures 4, references 9.

UDC 551.509.6

INVESTIGATION OF THE ICE-FORMING ACTIVITY OF SOME SOLUBLE SUBSTANCES

[Abstract of article by Plaude, N. O.]

[Text] A study was made of the ice-forming activity of calcium iodide and ammonium fluoride which with a high solubility have parameters of the crystal lattice close to the parameters of the lattice of lead and silver iodide. Due to the strong hygroscopicity of the substances their aerosols were obtained in a flow of dry inert gas and were introduced from a generator directly into a supercooled fog without dilution in an aerosol chamber. Measurement of the yield of active particles indicated that with a decrease in temperature, when there is a decrease in the influence of solubility, the activity of the substances increases. In this case the activity of the calcium iodide attains an activity close in its parameters to the lattice of easily soluble lead iodide. The results confirm the decisive importance of the geometrical correspondence of the crystal lattice of ice for the manifestation of ice-forming activity by the substance. Tables 1, figures 1, references 10.

UDC 551.509.616/617

INVESTIGATION OF ICE-FORMING AEROSOLS OF COPPER ACETYLACETONE OF DIFFERENT DISPERSIVITY

[Abstract of article by Aksenov, M. Ya., Bromberg, A. V., Bychkov, N. V., Kordyukevich, N. G. and Plaude, N. O.]

[Text] Using laboratory generators of two types it was possible to obtain and investigate aerosols of copper acetylacetone with mean cubic dimensions in the range $5 \cdot 10^{-6}$–$2 \cdot 10^{-5}$ cm. It is shown that the ice-forming activity of aerosols in the temperature range of a fog -10 - -20°C is relatively weakly dependent on temperature and for the most part is determined by the supersaturation of water vapor in the zone of action of particles. Variation of aerosol dispersivity exerts no significant influence on the dependence of activity on supersaturation. The maximum yield of active particles, measured for the most highly disperse aerosol, with a computed supersaturation value $\sim$260%, was $\sim 10^{15}$ per gram. Tables 2, figures 4, references 7.

UDC 551.509.616

INVESTIGATIONS OF THE INFLUENCE OF REGIMES OF GENERATION OF AgI AEROSOLS ON ITS ICE-FORMING ACTIVITY

[Abstract of article by Kim, N. S.]

[Text] The author has formulated a mathematical model for describing a variation of the process of formation of AgI aerosols in the operation of full-size generators. Analysis of the derived equations made it possible to ascertain the principal parameters determining the yield of active nuclei. These are: the ratio of the rate of movement of the generator to the velocity of escape of the gas jet from the generator nozzle; the initial concentration of molecules of vapor of the active substance in the hot jet; the coefficient of turbulent diffusion of the air flow surrounding the generator. The results of the numerical solutions agree well qualitatively with the experimental results. On the basis of these investigations the author has formulated requirements on the methods for the testing of generators under model conditions for the purpose of obtaining objective information on the effectiveness of operation of full-size generators. Figures 3, references 10.

UDC 551.509.6

SIMPLE INTEGRAL PHOTOELECTRIC COUNTER OF CONDENSATION NUCLEI

[Abstract of article by Parshutkina, I. P.]

[Text] A photoelectric counter of condensation nuclei has been constructed for use in laboratory investigations of nuclei. The article gives a description of the counter and outlines the method for measuring the concentration of condensation nuclei using this instrument. A Shol'ts counter is used in calibrating the photoelectric counter. With the complete filling of the counter chamber with the investigated aerosol it is possible to measure the concentration of condensation nuclei in the range 10^3-10^4 nuclei/cm^3. The proposed method of small-volume samples makes it possible to broaden the measurement range in the direction of higher concentrations and makes it possible to take air samples from a limited volume. Figures 2, references 4.

UDC 551.509.61, 551.510.42

RESULTS OF MEASUREMENTS OF THE CONCENTRATION OF LEAD IONS IN ARTIFICIAL WATER BODIES IN THE TERRITORY OF MOLDAVIYA IN THE ZONE OF ANTIHAIL WORK

[Abstract of article by Zharinova, Ye. S. and Potapov, Ye. I.]

[Text] The article gives the results of measurements made in September-December 1977. The "plumbon" method was used. There is an increased lead concentration, but the maximum value, equal to 7.6 μg/liter, is considerably lower than the maximum admissible norms. Tables 2, figures 1, references 7.

UDC 551.594.11

EXISTENCE OF ELECTRIFICATION OF WATER DURING EVAPORATION

[Abstract of article by Pokhmel'nykh, L. A.]

[Text] The status of the problem of electrification of water during evaporation is discussed. The author examines the possible consequences relating to atmospheric electricity in good and disturbed weather which follow from the existence of the process of charge separation during the evaporation of water under natural conditions. It is demonstrated that it is possible to develop a noncontradictory formal theory of atmospheric electricity in which the process of charge separation during evaporation plays the principal role. A quantitative and qualitative agreement between theory and existing experimental information can be attained in the case of the transfer of a positive charge by vapor in a specific quantity of about tenths esu/g. Figures 1, references 31.

UDC 551.594.11

EXPERIMENTAL INVESTIGATION OF ELECTRIFICATION OF WATER AND A 0.5 NORMAL SOLUTION OF NaCl DURING EVAPORATION

[Abstract of article by Pokhmel'nykh, L. A.]

[Text] The article gives the results of an experimental investigation of the process of separation of electric charges accompanying the evaporation of pure water and a 0.5 normal solution of NaCl under the conditions of the temperature of an evaporable fluid below 40°C. The registry of this separation was accomplished on the basis of the electric current in the fluid-ground circuit, and also on the basis of the drift of electric potential of the fluid. With a normal temperature of the fluid effects are observed which correspond to the leakage into the air of a positive charge in a specific quantity up to $4 \cdot 10^{-1}$ esu/g. Figures 3, references 6.

5303
CSO: 1865/122

AUTOMATED COLLECTION AND PROCESSING OF METEOROLOGICAL DATA

Obninsk OBZORNAYA INFORMATSIYA: SERIYA AVTOMATIZATSIYA SBORA I OBRABOTKI GIDROMETEOROLOGICHESKOY INFORMATSII. GIDROMETEOROLOGIYA: OBORUDOVANIYE SAMOLETOV-METEOLABORATORIY I METODY OBRABOTKI IZMERITEL'NOY INFORMATSII in Russian No 1, 1981 pp 1-3, 41-42, 47

[Annotation, excerpts from introduction and conclusion, and table of contents from a collection that discusses the research of V.K. Babarukin, V.F. Frakovich, L.F. Grigor'ev, Yu. V. Kopulov and A.V. Litinetskiy]

Annotation

[Excerpts] This work acquaints the reader with problems involving automated measurements from airplane meteorological laboratories. The technical level of equipment for measuring and registering meteorological parameters is given. The results of the authors' work on automating data collection, storage, and processing of airborne experiments using ground and on-board computers is presented. The prospect of creating the technical means and program basis for automated systems to investigate the atmosphere by using airplane meteorological laboraties is shown.

Introduction

The possibility of using airplanes for carrying out aerological observations has attracted the attention of physicists from the birth of aviation.

The modern airplane is capable of carrying numerous meteorological and navigational devices to high altitudes and can combine these devices into an information system using on-board computers. The modern airplane can also provide the measuring process with program, energy, and metrological services. An airplane outfitted in such a way is called an airplane meteorological laboratory (SML).

The SML is used extensively for studying both naturally occurring atmospheric processes as well as for monitoring the influences on the environment. An important function of the SML is its ability to accompany the atmospheric phenomenon under observation for distances of thousands of kilometers, thereby following the evolution of its characteristics.

The large information capability of the SML proves the effectiveness of aeromethods in meteorological investigations. For example, the information capability of the on-board apparatus of the Il-18 SML for measuring low-frequency parameters is estimated at a magnitude of 10 bytes/sec and for high-frequency parameters at 10 bytes/sec. Even though a significant portion of the information flow is redundant from the point of view of the analysis of the processes, there is no doubt of the necessity for the automated data collection and processing of airborne experiments.

The systems for collecting and processing in-flight information, systems created by using Soviet methods of computer technology and registration, are described. Results of the work of the Flight Scientific Research Center (TsAO), work that was carried out with the direct participation of the authors, is the basis of the presented material.

Conclusion

Putting into effect the enumerated measures essentially creates the prerequisites for the transition from an automated ground processing system (SAO) to automated systems of scientific investigation (ASNI) of atmospheric meteorology using airplane meteorological laboratories.

The reasons for creating ASNI are as follows:

1) The impossibility of effectively processing all the SML data without using automation.

2) The existence of a collective need (groups of NIU research facilities of related branches) for the SML information.

3) The on-board, in-flight testing of new meteorological devices and methods for atmospheric investigations.

4) Work for creating a new generation of Soviet SML's.

On the basis of what was expounded in the review of the material, one can say that the following will comprise the technical components of the object subsystems:

1) Complex of on-board devices for measuring meteorological parameters.

2) Radar and television means for obtaining the imaging of objects and results of environmental monitoring.

3) On-board system for collecting and processing information using a general purpose digital computer (UTsVM), which, besides collection, compression, and the express processing of measured information, will resolve part of the problems of in-flight experimental control.

4) An automated data processing ground system which also secures the basic functions of the servicing subsystems of the ASNI.

The existing prototypes of the named components are examined in this review.

The introduction of the ASNI will make it possible to significantly increase the effectiveness and quality of meteorological investigations for resolving economic tasks.

Table of Contents

CSO: 1865/161-P

OCEANOGRAPHY

UDC 550.345

MONOGRAPH ON TSUNAMI CHARACTERISTICS

Vladivostok PARAMETRY OCHAGOV TSUNAMIGENNYKH ZEMLETRYASENIY I OSOBENNOSTI TSUNAMI in Russian 1980 (signed to press 8 Sep 80) pp 2-3, 60-63

[Annotation, table of contents and article from book "Parameters of Foci of Tsunamigenic Earthquakes and Tsunami Characteristics", edited by A. A. Poplavskiy, candidate of physical and mathematical sciences, USSR Academy of Sciences, Dal'nevostochnyy nauchnyy tsentr, Sakhalinskiy kompleksnyy nauchno-issledovatel'skiy institut, 400 copies, 68 pages]

[Text] Annotation. The articles in this collection are devoted to the theoretical and practical results of investigations relating to tsunami focus problems. Also examined are the theoretical aspects of propagation of tsunami waves, the spectral problem, the direction of propagation; new data are given on the relationship between tsunami waves and the parameters of the macroseismic source. This collection of articles is of interest not only for professional geophysicists and hydrophysicists, but also for practical workers involved in the tsunami problem.

Contents

WAVE RECORDER WITH A SET OF COAXIAL SENSORS IN A FIELD VARIANT

[Article by B. I. Basov, B. V. Levin and M. Z. Narbutabekova]

In the investigation of waves in the water in a model water body it is desirable to employ instrument complexes making possible rapid assembly and disassembly of the measurement devices. The latter should be small in size and weight with an adequately high accuracy in measuring the amplitude and velocity of propagation of wave disturbances.

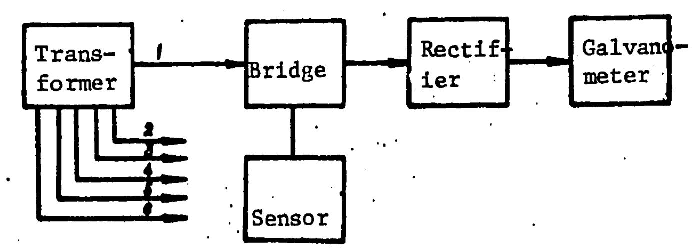

Fig. 1. Block diagram of wave recorder.

The wave recorder developed at the Sakhalin Multidiscipline Scientific Research Institute for the registry of small changes in water level during the passage of surface waves satisfies the mentioned requirements, to wit: is small in size, is compact and convenient to transport, simple to construct and ensures a relatively high accuracy in measuring a wave with an amplitude up to 250 mm ($\sim 4\%$). In addition to six string level sensors whose resistance is dependent on the depth of submergence into the water, and bridge circuits with rectifiers and galvanometers, the system makes use of standard-produced instruments: power transformer and N041U4.2 light-ray oscillograph (Fig. 1).

The level sensor (Fig. 2) consists of a conducting rod (1) with a diameter of 4 mm and a length of 400 mm and four strings (2) stretched along it. These strings are made of thin silvered wire, attached by means of insulating plugs (3). The sensor is cut into the arm of a bridge circuit, which makes it possible to discriminate the useful signal against the background of the constant component. The sensor operates on a variable voltage because as a result of strong electrolysis if a d-c current was used its resistance would become unstable.

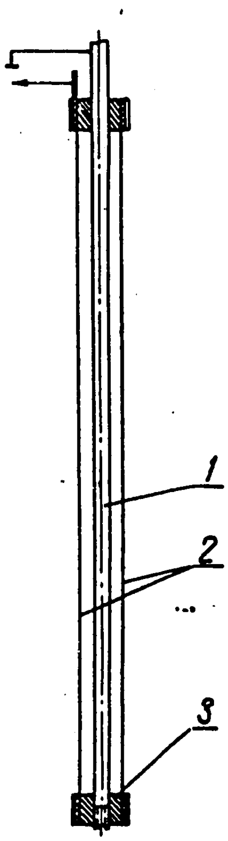

Fig. 2. Level sensor:
1) rod,
2) string,
3) plug

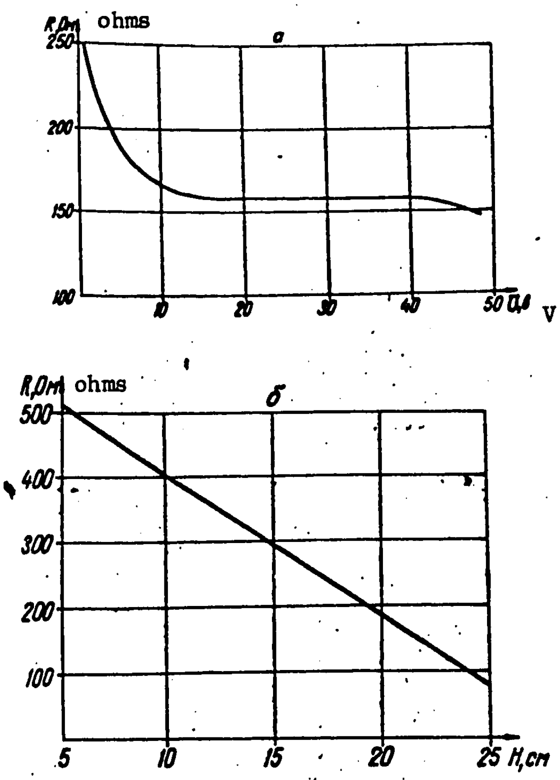

Fig. 3. Curves of the dependence of the sensor on: a) voltage, b) depth of submergence

Prior to the beginning of the experiment remote calibration of all the sensors is accomplished simultaneously from the shore due to bridge symmetry, which sharply reduces the influence of fluctuations of water resistance, simplifies the instrument circuit and reduces the time required for its preparation for operation.

The bridge is fed a variable voltage of 45 V; the voltage across the sensor varies in the limits of the sector of fixed resistance from 18 to 27 V. Figure 3 shows curves of the dependence of sensor resistance on voltage and depth of submergence.

In order to check the accuracy of wave recorder readings we carried out a laboratory experiment with simultaneous registry of fluctuations of the level by the RFK motion picture camera. As a result of interpretation of the wave recorder records and frame-by-frame printing of the kinogram we constructed two pairs of time series with a duration of 12.8 and 25.6 sec (Fig. 4). A cross-spectral analysis was carried out in order to compare the processes (in each pair of records). Computations of the spectral density indicated that with the distribution of energy by frequencies in the low-frequency region there is a good coincidence of the spectra of both processes in each record.

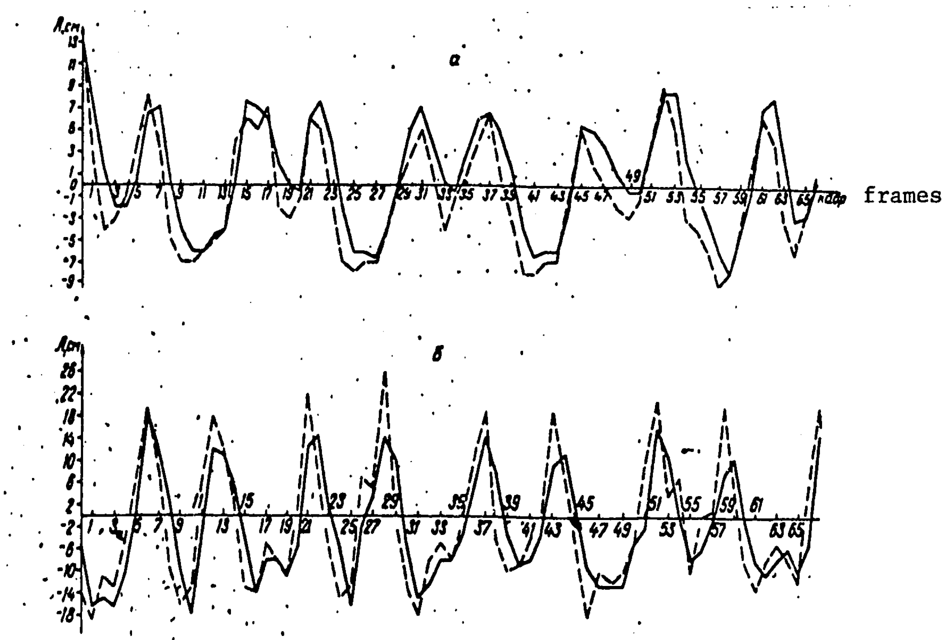

Fig. 4. Records obtained from wave recorder (solid curve) and with printing of kinogram (dashed curve): a) 1st pair; b) 2d pair of records

The coherence functions constructed for them indicated a very high coherence in the frequency range 0-1.5 Hz. At frequencies greater than 1.5 Hz some scatter of the curves can be caused by small differences in the metrological characteristics of the measurement instruments whose refinement is difficult to accomplish at the present time due to the absence of standard instruments.

Figure 5 shows the 95% confidence intervals $\mathcal{E}'$ and $\mathcal{E}''$ of the computed evaluations of the power spectra laid off from zero; $\mathcal{E}'>\mathcal{E}''$ in this case, which is attributable to the lesser duration of the first record.

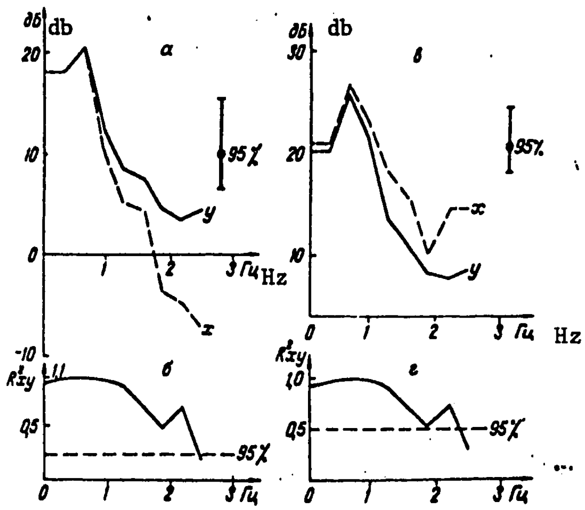

Fig. 5. Spectral density (a, c) and paired coherence (b, d) of fluctuations of level of 1st and 2d pairs of records respectively: x -- RFK, y -- sensor.

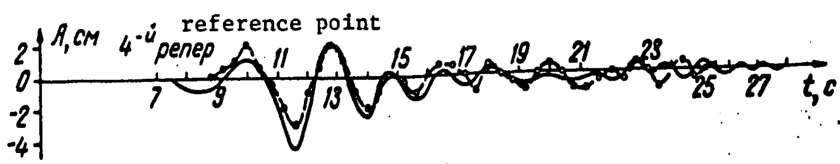

Fig. 6. Processed record of sensor readings (solid curve) and motion picture camera (dashed curve).

In order to determine the integral characteristics of correlation of the processes we computed the correlation coefficients using the formula

$$\tau = \frac{\langle xy\rangle - \langle x\rangle\langle y\rangle}{\sqrt{\langle x^2\rangle\langle y^2\rangle}},$$

where $\langle\,\rangle$ represents averaging for the set. For the first pair of records the correlation coefficient is equal to $\tau'_{xy} = 0.839$, for the second -- $\tau''_{xy} = 0.909$. The coincidence of the spectral curves is evidence of the reliability of the data obtained using this wave recorder. Computations of the spectral characteristics were made on an electronic computer using the fast Fourier transform method.

Field tests of the wave recorder with a set of six sensors were made in a model water body with a depth of 0.6 m and a length up to 60 m on whose shore there were two motion picture cameras of the "Konvas" type. Their use gives a high degree of accuracy in measurements (relative error up to 10%). This is important in investigations of wave processes with a small change in the initial level. Figure 6 is a sample of a processed wavegram.

This laboratory analysis of the records of waves and polygonal tests of the wave recorder indicated that the developed measuring system with a set of string sensors corresponds to all the stipulated requirements. It is quite reliable in operation and ensures the necessary measurement accuracy.

5303
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UDC 551(465.62+466+467)

COLLECTION OF PAPERS ON FORECASTING HYDROLOGICAL CONDITIONS

Leningrad TRUDY ORDENA LENINA GIDROMETEOROLOGICHESKOGO NAUCHNO-ISSLEDOVATEL'SKOGO TSENTRA SSSR: RASCHET I PROGNOZ ELEMENTOV REZHIMA MORYA in Russian No 229, 1980 (signed to press 5 Nov 80) pp 2, 107

[Annotation and table of contents from book "Proceedings of the USSR Hydrometeorological Research Center: Calculating and Forecasting Elements of Sea Conditions", edited by Doctor of Physical and Mathematical Sciences P. S. Lineykin, Gidrometeoizdat, 600 copies, 109+ pages]

[Text] The collection contains articles on calculating and methods of forecasting elements of the hydrological state of the sea (currents, temperature, ice conditions, waves and so on).

Results are also given from numerical experiments on modeling the circulation of the atmosphere and the active layer of the ocean; characteristics of thermal interaction of the ocean and atmosphere are calculated. An examination is made of new approaches to interpreting data of observations in the ocean, and methods of processing these data are proposed.

The book is intended for specializing oceanologists, a wide class of geophysicists and studnets of hydrometeorological institutes.

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6610
CSO: 1865/174

GEOPHYSICAL INVESTIGATIONS OF NORTHWEST PACIFIC

Vladivostok STRUKTURA GEODINAMIKA LITOSFERY SEVERO-ZAPADA TIKHOGO OKEANA PO GEOFIZICHESKIM DANNYM in Russian 1978 (signed to press 25 Apr 78) pp 2, 106

[Annotation and table of contents from collection "Structure and Geodynamics of the Lithosphere of the Northwest Pacific Ocean According to Geophysical Data", DVNTs AN SSSR, 500 copies, 112 pages]

[Text] Annotation. Materials from the geological-geophysical investigations that were carried out by Soviet and Japanese scientists in the preceding five years within the framework of the International Geodynamic Project are presented in the collection. The original experimental material for the construction of the transition zone from the Asiatic continent to the Pacific Ocean is presented along with the theoretical investigations. All the articles were reported at the III Soviet-Japanese symposium in South-Sakhalinsk (1976).

This collection is of interest for specialists in geology and geophysics.

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CSO: 1865/162-P

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INVESTIGATION OF THE DIRECTION OF INTERNAL WAVES OF A TIDAL PERIOD IN 'POLYGON-70'

Moscow OKEANOLOGIYA in Russian Vol 21, No 2, Mar-Apr 81 (manuscript received 26 Feb 80, after revision 1 Sep 80) pp 239-243

[Article by Ye. G. Morozov and S. V. Nikitin, Institute of Oceanology, USSR Academy of Sciences]

[Text]

Abstract: The authors analyze the results of temperature measurements in the thermocline in Atlantic "Polygon-70." The network of buoy stations is regarded as an array by means of which it was possible to study the directional properties of internal waves of a semidiurnal period. There was found to be a system of internal waves generated by different sources. The stability of the directions of internal waves is noted.

Investigations of recent years have indicated that internal gravitational waves with a semidiurnal period carry considerable energy [1, 3]. Observations in Atlantic "Polygon-70" made it possible to detect the existence of quasistationary systems of internal gravitational waves with a tidal period [2]. The purpose of our study was an investigation of the directional properties of these systems of waves by means of evaluations of the spatial-temporal spectra at the corresponding scales.

In the evaluation of the spatial-temporal spectra in our study we used the array method proposed by Barber [7] for determining the direction of surface waves with an arbitrary arrangement of the array detectors. Later Sabinin and Shulepov [6] used a similar method in investigating internal waves.

On the basis of materials from Atlantic "Polygon-70" we selected the 10 variants of arrays listed in Table 1. These arrays consisted of three-seven FT detectors placed at the 200-m horizon on self-contained buoy stations and making synchronous temperature measurements with a discreteness of 30 minutes. All the spectral evaluations were obtained from 12-day records. The numbering of the buoy station points corresponds to [1]. The computations of the spatial spectra for the frequency f_0 of the semidiurnal period were made using the formula

$$E(k_x, k_y, f_0) = 2\sum_{i=1}^{n-1}\sum_{j=i+1}^{n} [P_{ij}(f_0)\cos 2\pi(k_x x_{ij} + k_y y_{ij}) - Q_{ij}(f_0)\sin 2\pi(k_x x_{ij} + k_y y_{ij})],$$

where $k_x^2 + k_y^2 = k^2$ is the spatial frequency; the length of the wave is $L = 1/k$; i, j are the numbers of the detectors; n is the number of the detectors; P_{ij} and Q_{ij} are the real and fictitious parts of the cross-spectrum of the i-th and j-th detectors respectively; $x_{ij} = X_i - X_j$ and $y_{ij} = Y_i - Y_j$ are the projections of the distances between the detectors on the horizontal axes X and Y.

A preliminary determination of the wave length for different modes was made by a numerical solution of the equation for the vertical velocity w of internal waves with zero boundary conditions at the surface and bottom. This equation has the form [2]

$$\frac{d^2w}{dz^2} + \frac{N^2(z)}{g}\frac{dw}{dz} + \frac{N^2(z) - \omega^2}{\omega^2 - f^2} wk^2 = 0,$$

where z is the vertical coordinate; g is the acceleration of gravity; ω is wave frequency; f is the Coriolis parameter. The vertical distribution of the Väisälä-Brent frequency N(z) was obtained by the averaging of 34 hydrological series recorded at a multiday station. The lengths of the internal gravitational waves of the first and second modes computed in this way for the "Polygon-70" region were equal to 113 and 63 km respectively. The evaluations of the spatial spectra were investigated in the range 30-160 km, taking into account that at lesser scales the wave length becomes less than the distances between the detectors and an ambiguity arises in the determination of the wave length, whereas scales > 160 km considerably exceed our estimate (113 km) of the length of the first mode of an internal gravitational wave of a tidal period.

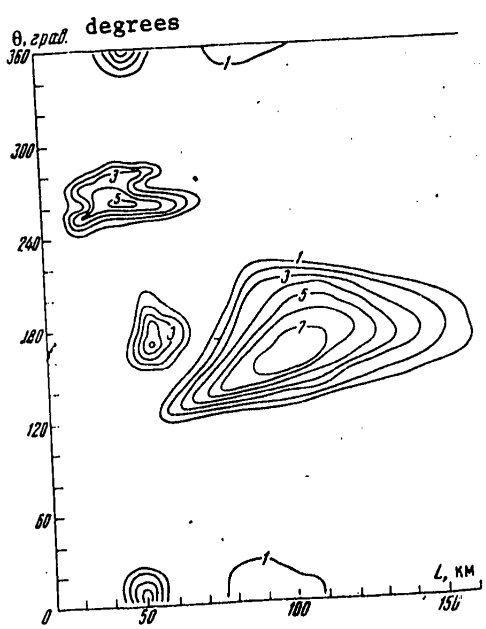

Fig. 1. Characteristic pattern of spatial spectrum for period of 12.4 hours (computation variant 1). The spectral density isolines were drawn on the (L, θ) plane in arbitrary units.

Table 1

Synchronous Measurements in Polygon Used in Making Computations (Length of Series 12 Days)

No of computed variant	Onset of measurements date	time	No of buoy station points
1	2 Mar 70	0200	2, 3, 7, 15
2	6 Mar	0400	1, 2, 3, 10, 15
3	28 Mar	1300	5, 14, 17
4	17 Apr	1000	1, 2, 4, 5, 12
5	1 May	0200	3, 11, 14
6	29 May	0500	1, 2, 3, 7, 11, 14
7	20 Jun	1300	3, 7, 10
8	17 Jul	0630	3, 6, 7, 10, 11
9	8 Aug	1700	3, 6, 11
10	21 Aug	2200	1, 6, 11, 15

A characteristic result of the computations for the spatial spectrum for variant 1 is given in Fig. 1 in the form of isolines of spectral density on a plane (L,θ), where L is the wave length; θ is the direction of the wave in degrees, reckoned from north clockwise). Evaluations of spectral density are given in arbitrary units because they were obtained through the normalized correlation functions.

The most significant "burst" corresponds to the first mode of the oscillations (wave length 105 km) for an internal wave directed in the azimuth 165°. Two less significant "bursts" are determined by second-mode waves (50 and 55 km), directed in the azimuths 260° and 170°.

Table 2

Values of Angles at Which Energy Maxima in the Spatial Spectra Are Observed

No of computation variant	Wave length, km 113 (mode 1)	63 (mode 2)	No of computation variant	Wave length, km 113 (mode 1)	63 (mode 2)
	wave direction, degrees			wave direction, degrees	
1	165	170, 260	6	260	270
2	170	170	7	190	180
3	290, 70	30, 180	8	200	180
4	60, 180	50, 180	9	200	200
5	240, 20	240, 20	10	250	260

Similar computations of evaluations of the spatial spectra, made for all variants, reveal the presence of one, less frequently two directed energy fluxes at the scale of the wave length of the second mode with the mandatory presence of a directed energy flux at the wave length scales of the first mode. As a rule, one of the second-mode bursts coincides in direction with the first-mode burst (Table 2). However, the second-mode oscillations have a lesser energy than the first-mode oscillations (Fig. 1). This is also characteristic for other computation variants.

Table 3

Dependence of Evaluations of Spatial Spectrum on Influence of Individual Records (Computation Variant 2)

Buoy stations used in computations	Direction (in degrees) in which energy maxima are observed
1,2,3,10,15	170
-,2,3,10,15	160
1,-,3,10,15	170
1,2,-,10,15	160
1,2,3,-,15	160
1,2,3,10,-	170

The predominance of the first mode of internal waves in "Polygon-70" coincides with the results in [2, 4], in which, on the basis of study of horizontal coherence and phase shift we detected patterns corresponding to predominance of one mode.

The next stage in the investigation was a study of the dependence of the resulting spectral expansion on the influence of individual records. For this purpose we in turn eliminated individual records from the computations and the computations were made without them. Table 3 gives an example of such a numerical experiment for variant 2.

The table shows that the absence or presence of any point with measurement does not introduce any fundamental change into the computations. However, the position of the maxima and their value can vary insignificantly as a result of elimination of one of the records.

We made a comparison of the results of computations of the parameters of internal waves obtained from spatial spectra and the results of computations on the basis of phase expressions from [2] using these same data. In that study on the basis of phase relationships for series with high values of horizontal coherence it was possible to ascertain the length and direction of waves on the basis of measurements at three points. These computations agree with the spatial spectrum in the presence of a unidirectional wave system.

In analyzing the results we should note two important circumstances. First, the semidiurnal internal oscillations in the polygon are determined not by the passage of one system of waves, but several, generated in different regions. There is a predominance of directions to the south and west (Table 2) (a direction of 180° was also discovered earlier on the basis of phase relationships in [2]). The second significant fact is the stability of the directions of waves over the course of several measurement periods. A conclusion on the stability of directions was also shown in [2] on the basis of computations using phase relationships. A confirmation of this result on the basis of computations of the spatial spectra for a large number of points and for a great number of measurements extending over a period of time, in our opinion, is extremely important.

Proceeding on the basis of the Rattri model [5] of generation of internal waves of a tidal period on the coastal shelf and the Cox and Sandstrom model [8] of excitation of internal tides by a barotropic tide as a result of its interaction with bottom irregularities, it can be assumed that in the polygon there are internal waves of a tidal period of several systems generated in different places. For example, waves directed to the west could be excited near the Cape Verde Islands or on the coastal shelf of Africa. The Mid-Atlantic Ridge girdles the polygon in a semicircle with a radius of about 600 miles on the west from north to south. Accordingly, as a result of interaction between the barotropic tide and the mid-oceanic ridge there can be excitement of waves of different directions, including predominantly southerly. Evidently in some periods of time there is dominance of one system of waves, whereas in others there will be a different direction. It is impossible to analyze the reasons for the predominance of one system of waves over another due to the shortage of data.

The principal conclusion of this study is that a large number of measurements revealed the presence of several systems of internal waves of a tidal period generated by different sources. The greater part of the energy is carried by waves of the lower modes. We also note the constancy of the directions of internal waves over the course of several months. As already noted earlier in [2], in principle there can be computations and prediction of internal waves of a tidal period, since their sources are stationary in space and quasistationary in time. The constancy of the direction of internal waves determined in this study confirms the possibility of prediction of internal waves of a semidiurnal period.

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1865
CSO: 1865/167

UDC 551.465

PHYSICAL NATURE OF 'CALM-WEATHER INHOMOGENEITIES' IN THE OCEANIC TEMPERATURE FIELD

Moscow OKEANOLOGIYA in Russian Vol 21, No 2, Mar-Apr 81 (manuscript received 4 Apr 80) pp 203-210

[Article by K. N. Fedorov, A. I. Ginzburg and L. I. Piterbarg, Institute of Oceanology, USSR Academy of Sciences]

[Text]

Abstract: The article describes thermal inhomogeneities registered in calm weather by a temperature sensor towed near the ocean surface. It is shown that internal waves are a universal mechanism of their formation in different parts of the world ocean. Precipitation and the variability of salinity and also convection exert an influence on the formation and characteristics of these inhomogeneities.

It has been noted by a number of researchers [2, 3, 5] that with intensive solar heating in calm weather the temperature distribution near the ocean surface assumes a complex spotty (sometimes quasiperiodic) character. The typical dimensions of the alternating cold and warm spots fall in the range 1-10 km, the temperature between the spots can differ by 1-2°C, and the temperature gradients at the boundaries of the spots can exceed $1\text{-}2°C \cdot km^{-1}$ [2].

Until now the physical nature of calm-weather horizontal temperature inhomogeneities has not been reliably established. In the literature there have been discussions of the possible local reasons for heating or the loss of heat, which could lead to the formation of temperature inhomogeneities on a kilometer scale [3]. However, it has remained unclear whether these inhomogeneities are created due to local differences in the heat balance or whether their origin is associated with the nonuniform distribution of heat entering the upper layer of the ocean. The lack of information concerning the thickness of the layer affected by inhomogeneities and on the horizontal variability of the vertical thermal structure did not make it possible to draw any definite conclusion. There was also need of assurance that the temperature fluctuations registered by the towed temperature sensors could not be a result of "yawing" of the sensor in depth in the near-surface layer with a high vertical temperature gradient.

The major complex of measurements which we made in the Atlantic Ocean under conditions of calm and with weak winds during the time of the 27th voyage of the scientific research vessel "Akademik Kurchatov" in 1978 gave, it seems to us, a key to understanding the reasons for the appearance of calm-weather inhomogeneities. [The principal measurement methods and instrumentation were described in [1]].

This article is devoted to their detailed description and a clarification of their physical nature.

1. Description of the phenomenon. Temperature inhomogeneities of a kilometer scale (Fig. 1) appear in the near-surface layer of the ocean in calm weather or when there are very weak winds (not more than 1 $m \cdot sec^{-1}$) at approximately 1000-1100 hours local solar time. As a rule they attain a maximum amplitude by 1400-1500 hours, that is, by the time of the maximum heating of the surface layer of the ocean. At the same time, the difference in temperature values between the level of registry with a towed sensor (z = 0.15 m) and a horizon of several meters attains a maximum value. When there is strong heating already at about 1400 hours inhomogeneities of a kilometer scale are also registered at the horizons 3-4 m (Fig. 1,a). The horizontal temperature differences at close points are traced at this time, as indicated by measurements with a floating-up probe ([6], also see below) to the horizon 8 m.

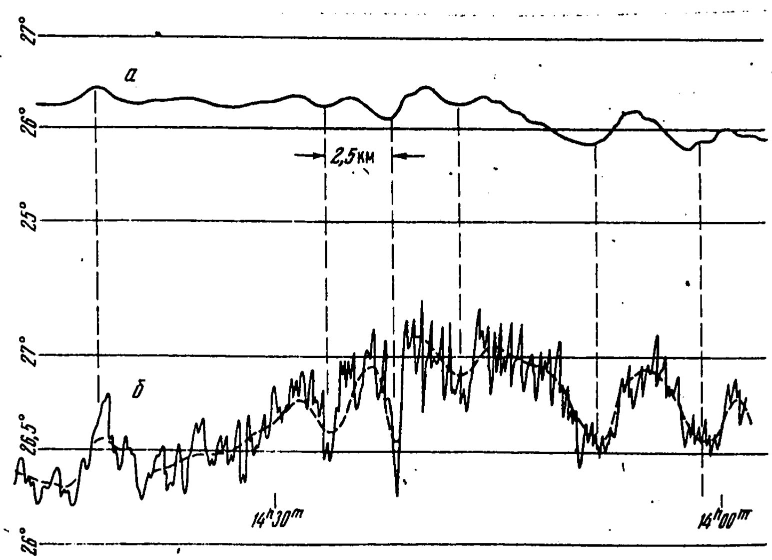

Fig. 1. Simultaneous records of calm-weather thermal inhomogeneities while ship was proceeding on course. a) at level 3.8 m (using temperature sensor in ship's water intake); b) at level 0.15 m (using towed temperature sensor). The dashed lines indicate a phase shift for one and the same disturbances due to inertia of the temperature sensor in the water intake.

Up to 1400-1500 hours on the records near the surface (z = 0.15 m) it is easy to see small-scale temperature fluctuations with an amplitude of several tenths of a degree and with a characteristic horizontal scale of about 100 m (Fig. 1,b). As a rule they disappear between 1400 and 1500 hours LT. Only sometimes, under conditions of extremely strong heating during an absolute calm, they persist to

Table 1

Results of Statistical Processing of Temperature Measurements

No of record	Date and time	$\overline{T}$, °C	σ, °C	a	e	T_{min}, °C	T_{max}, °C	k_{min}, km^{-1}	k_{max}, km^{-1}	$S(k_{min})\cdot 10$, $degree^2\cdot km$	$S(k_{max})\cdot 10$ $degree^2\cdot km$	L, km
1	8 Aug 78 1239–1625	25.03	0.27	−0.50	0.27	24.15	25.75	0.10	0.9	0.852	0.014	102
2	9 Aug 78 1252–1648	26.88	0.30	0.30	−0.57	26.3	27.6	0.10	0.9	1.346	0.007	106
3	24 Aug 78 1340–1608	28.80	0.16	−0.67	1.40	28.5	29.1	0.15	0.9	0.175	0.006	67
4	24 Aug 78 2225–2354	28.20	0.20	−0.18	−0.11	27.7	28.7	0.26	0.9	0.162	0.011	40
5	20 Sep 78 1621–1941	28.60	0.29	−0.05	0.32	27.8	27.8	0.11	0.9	0.572	0.016	90
6	23 Sep 78 1332–1635	28.10	0.25	−0.40	−0.20	27.4	27.4	0.12	0.9	0.690	0.009	82

Notes: The maximum wave number k_{max} for all the records was identical and equal to $1/4\Delta x$, where Δx = 0.28 km is the discreteness of the readings from an analog record (we note that the Nyquist frequency is equal to $1/2\Delta x$). The minimum wave number k_{min} was selected approximately equal to 10/L (where L is the total length of the record) so as to ensure statistically significant evaluations of the spectra.

a later time. Inhomogeneities of a kilometer scale after 1400-1500 hours most frequently begin to decrease in amplitude, but there were cases when they developed in the second half of the day together with the onset of a calm. By 2100 hours the calm-weather temperature inhomogeneities near the ocean surface itself, as a rule, disappear completely. In the deeper layers, and especially after extremely intensive daytime heating, the inhomogeneities of a kilometer scale continue to exist to early in the morning. This is evidenced by records of the AIST temperature flow in a flow-through system with a water intake at the 3-m horizon. With the onset of even a relatively light wind (2-3 $m \cdot sec^{-1}$), accompanied by the appearance of ripples on the ocean surface, calm-weather inhomogeneities at any time of day are destroyed during a time not exceeding one hour. In all cases the lifetime of the calm-weather temperature inhomogeneities does not exceed 24 hours.

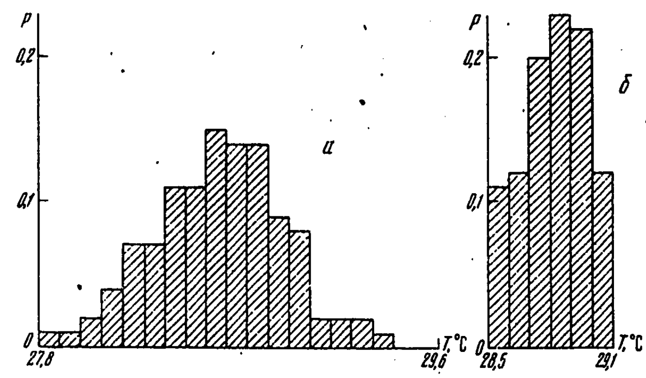

Fig. 2. Examples of histograms (with discreteness interval 0.1°C) corresponding to records of thermal inhomogeneities. 1) a and 5) b. The figures correspond to the numbers in the table.

The data from measurements of thermal inhomogeneities of calm weather were subjected to standard statistical processing. For each of six records of temperature T, °C while the ship was on course, along an arbitrary x-axis we computed the mean $\bar{T}$°C, the standard deviation σ°C, asymmetry a, excess e, and also constructed histograms for P and the S(k) spectrum. Below we give a composite table of the results of computations. Examples of these histograms are shown in Fig. 2, and for the spectra -- in Fig. 3. Among the six constructed histograms we show one with a quasinormal distribution of probability density (Fig. 2,a) and another with a well-expressed negative asymmetry (Fig. 2,b). Among the three spectra represented in Fig. 3 one drops off in conformity to the law k^{-2} (Fig. 3,b), evidently evidence of very sharp boundaries of thermal inhomogeneities; another has a conspicuous peak (close to the "guaranteed"); and the third is characterized by a general very high spectral density level at all wavelengths from 1 to 4 km (Fig. 3,c). It can be concluded from these characteristic examples and the data in the table that the characteristics of calm-weather inhomogeneities are rather diverse. In some cases these inhomogeneities have a character close to random; in other cases they contain a more or less clearly expressed periodic component. It is impossible on the basis of a statistical analysis to make any assumptions concerning the physical nature of the calm-weather thermal inhomogeneities. We will attempt to find a basis for such assumptions by a comparison of the results of measurements made by different methods.

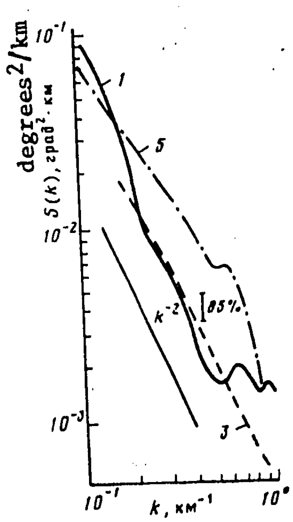

Fig. 3. Examples of spectra of temperature fluctuations for records 1, 3, 5 (the figures correspond to the numbers in the table). The vertical segment corresponds to the 85% confidence interval.

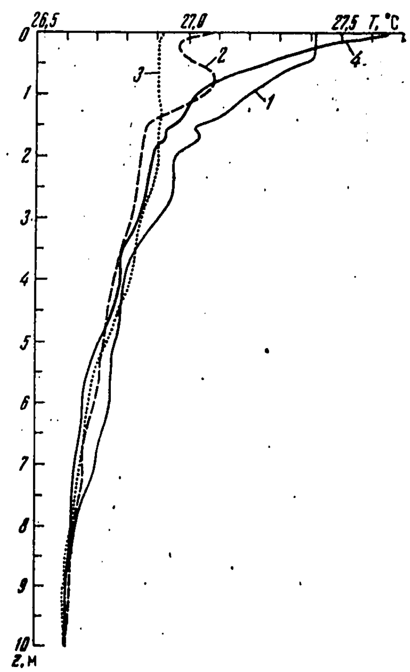

Fig. 4. Vertical temperature profiles obtained in calm weather on 25 Sep 78 using a floating probe. 1) 1311 hours; 2) 1324 hours; 3) 1330 hours; 4) 1332 hours.

The measurements made under conditions of an absolute calm and intensive solar heating in the water region undisturbed by the ship's drift (in the area of prow sighting at a distance of 3-4 m from the ship's stem) revealed a strong variability of the vertical thermal structure of the surface layer. Figure 4 shows four vertical temperature profiles from a series of several tens of profiles obtained on 25 September 1978 in the Sargasso Sea. These measurements were preceded by continuous registry of the surface temperature (z = 0.15 m) by a towed temperature sensor while the ship was proceeding on course. It was also continued upon ending of the station, an hour after measurements with a floating-up probe. A comparison was made of data from continuous registry of temperature with the vertical profiles (Fig. 4), obtained at the station. The minimum temperature in the layer 0-2 m on profile 3 (26.9°C) virtually coincided with the minimum temperature values in the calm-weather inhomogeneities registered about 12 hours before occupation of the station. The temperature sensor, lowered at the station to the horizon 1 m from a boom with a length of 3-4 m from the leeward side, registered fluctuations of about ±0.1°C about this same temperature 26.9°C. The maximum temperature values in inhomogeneities of a kilometer scale, registered while the ship was on course, attained 27.7-27.8°C, which corresponds to the temperature maximum near the surface on profile 4 (Fig. 4). The maximum temperature values in microscale fluctuations with an amplitude of 0.3-0.5°C, observed against a background of changes of a kilometer scale, attained 28.2°C. Accordingly, the profiles obtained using a floating-up probe did not reflect only the "warmest" spots, in which the temperature near the surface should exceed the temperature at the 10-m horizon (26.6°C), common for all the profiles in Fig. 4. Heat content fluctuations above this common level for all the profiles are laid off in the range from 160 to 230 $cal\cdot cm^{-2}$, and with allowance for the maximum temperature values registered while the ship was underway -- up to 280 $cal\cdot cm^{-2}$.

The latter figures and the general good agreement of the results obtained by several independent methods indicate that the variability registered by the towed sensor (Fig. 1) reflects the thermal inhomogeneities of a kilometer scale really existing near the ocean surface which could not be the result of vertical "yawing" of the sensor. In order to obtain any such pattern of temperature fluctuations during registry while the ship was underway that could be attributable solely to "yawing" of the sensor it would be necessary to change the vertical position of the sensor in limits not less than 1 m, which was never the case. With actual deviations of the sensor from the mean level of towing of ±10 cm it could happen, as follows from the nature of the profiles in Fig. 4, that temperature fluctuations could have an amplitude of about ±0.1°C. It is not impossible that the above-mentioned microscale inhomogeneities with a wavelength of about 100 m developed on our records in precisely such a way, although, as will be demonstrated below (see the section on convection) they may also be natural.

2. Discussion of possible reasons for spottiness of the temperature field. a. Internal waves. It is known that apparent manifestations of internal waves can develop on the ocean surface as a result of the modulation of ripples or wind waves by the horizontal components of the orbital motions of internal oscillations [10]. Internal waves can also modulate the fields of a passive admixture (for example, a suspension) in the upper layer of the ocean [7]. The above-mentioned manifestations were noted primarily due to the clearly expressed periodicity of the observed modulations. In a general case, however, in the ocean there is a random field of internal waves which can be described only by statistical methods.

A statistical description of formation of the spotty structure of the field of passive admixtures under the influence of the random field of internal waves was given in [4]. The heated water layer with a thickness of 0.5-1 m during calm weather near the ocean surface can rightfully be regarded as the field of a passive admixture. The temperature spots arising with its modulation by a random field of internal waves must [4] have a characteristic horizontal scale $L \simeq (1.1-1.4)\,\sigma_u/f$, where f is the Coriolis parameter and σ_u^2 is the mean square of the horizontal velocity at the ocean surface. Within the framework of the Garrett-Munk model [12] with a thickness of the pycnocline small in comparison with the ocean depth

$$\sigma_u^2 \simeq \frac{3E}{4\pi} \frac{M^{-3} N^2}{H}$$

(see formula (15) in [4]), where N is the mean Väisälä-Brent frequency in the pycnocline; M^{-1} is the characteristic horizontal scale of internal waves; E is a dimensionless constant characterizing the energy of a column of fluid with a cross section 1 cm^2. With real values H = 5 km, $f = 0.698 \cdot 10^{-4}$ sec^{-1}, $E = 17.4 \cdot 10^{-5}$ and the values $M = 1.22 \cdot 10^{-6}$ cm^{-1} and $N = 0.83 \cdot 10^{-3}$ sec^{-1} recommended in [12] we obtain $900 \leqslant L \leqslant 1200$ m. [The real values were taken on the following basis: the total energy density of internal oscillations 1.06 $J \cdot cm^{-2}$, computed in the POLYMODE polygon on the 27th voyage of the scientific research ship "Akademik Kurchatov," exceeds by a factor of 2.77 the characteristic mean value adopted in [12].] The use of the Garrett and Munk model in this case is justified because it was checked primarily in experiments in the Sargasso Sea. An L value of about a kilometer is also obtained when using the real value $N = 1.24 \cdot 10^{-3}$ sec^{-1}, averaged for the pycnocline layer, computed using data from the 25th voyage of the scientific research ship "Akademik Kurchatov" [9]. Thus, internal waves in the seasonal thermocline in actuality can be the reason for the appearance in calm weather of thermal inhomogeneities of a kilometer scale having a random spotty or quasiperiodic character, depending on the nature of the field of internal waves.

From our point of view internal waves in the considered context are the most universal mechanism for the formation of calm weather thermal inhomogeneities in the near-surface layer of the ocean. The fact that calm-weather inhomogeneities were observed in different parts of the world ocean may be associated precisely with the universality of this mechanism. A number of other factors can also exert an influence on the thermal state of the near-surface layer of the ocean, accentuating the inhomogeneities observed in it and definitely changing the general characteristic pattern. These factors are considered below.

b. Influence of salinity and precipitation. Systematic synchronous measurements of the vertical distribution of temperature and salinity in the upper 30-m layer of the ocean, carried out with the AIST STD probe, in a regime of registry at discrete horizons with an interval 0.5-1 m [1], indicated a strong horizontal variability of the vertical distribution of salinity in the near-surface layer of the ocean. For example, on days with frequent showers we registered the vertical profiles of salinity; these differed by $0.5^o/oo$ in the upper 2-m layer in a distance of only 800 m between the measurement points [1]. The differences in the distribution of salinity are responsible for the temperature variability. Figure 5, for example, shows how the thin precipitation-freshened layer exerts an influence on daytime heating.

The upper extremely heated (to 29.1°C) water layer a meter thick owes its origin to a salinity jump which impedes convective mixing with the lower-lying layers. It is easy to calculate that for creating a freshening by 0.25°/oo in a layer with a thickness of 1 m it is only necessary that 7 mm of precipitation fall, that is, a not very strong shower. In turn, the freshened layer, heated by 0.8°C, contains an excess quantity of heat which on a sunny day can be accumulated in only 1 hour.

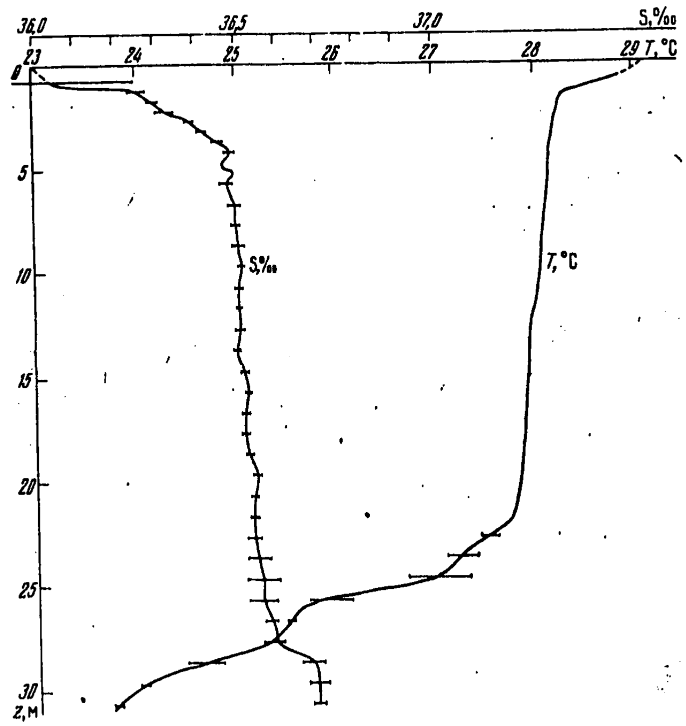

Fig. 5. Vertical profiles of temperature and salinity in the upper 30-m layer under calm weather conditions in the presence of a freshened layer at the surface (26 Aug 78, 1528-1603 hours).

It is evident that the very same quantity of heat with presence of the salinity jump at a greater depth will lead to weaker heating of the above-lying layer. The measurements made during work in the POLYMODE polygon in August-September 1978 indicated that in calm weather the water temperature near the surface in the freshened spots by mid-day attained 29-32°C, whereas at adjacent points, where rain did not fall, in this case it did not exceed 27.5-28.5°C. A negative horizontal T, S correlation, relatively rare for the surface layer of the Sargasso Sea, was observed in this case. Thus, during calm and slightly windy weather precipitation plays an important role in creating the spottiness of temperature difference at the ocean surface. It should be noted that the spatial dimensions of the rain-freshened spots correspond to the dimensions of cumulonimbus clouds, that is, only several kilometers. The development of temperature inhomogeneities of a kilometer scale is also favored by the differences in thermal structure in the surface layer of the ocean persisting from preceding days. Daytime heating, superposed on a structure which is already horizontally inhomogeneous, creates still more clearly expressed calm weather inhomogeneities.

c. Convection. Differences in the intensity and depth of penetration of convection are additional factors involved in formation of spottiness of the thermal field at the ocean surface. In calm weather it is precisely convection which serves as the principal physical mechanism for heat transfer from the surface into the deeper layers of the ocean. Although in summer in the temperate and low latitudes convection usually attains a maximum intensity during the nighttime hours, it can also be operative during the daytime when with an air temperature approximately equal to the water temperature its humidity does not exceed 60-70%. Such conditions are very frequently observed in the Sargasso Sea region. A combination of heat transfer due to evaporation and long-wave radiation with direct radiation (solar) heating can lead to characteristic vertical temperature profiles with an inversion in the near-surface layer and a temperature maximum situated somewhat (from 10 cm to 1-3 m) below the surface. Such temperature profiles, observed earlier as well ([11], Fig. 9,b in [3]), were repeatedly registered on the 27th voyage of the scientific research ship "Akademik Kurchatov." The depth of penetration of daytime convection under the already described conditions, according to the investigations of Solov'-yev [6], has a clearly expressed diurnal variation. During the pre- and near-midday hours the thickness of the convective layer is found in the limits of the upper 10 cm; by 16 hours it attains 1 m and then increases very rapidly, at nighttime, according to our observations, exceeding 10 m. On the other hand, the depth of penetration of daytime convection can be influenced to a considerable degree by spots of films of surface-active substances and local variations of even the weakest wind. In the near-midday hours these factors can cause variations of the temperature field with amplitudes of about 0.3-0.5°C and a characteristic horizontal scale of hundreds of meters due to local differences of about 100-200% at the depth of penetration of convection. These temperature changes are evidently also visible on records near the surface against a background of inhomogeneities of a kilometer scale (together with temperature fluctuations of "artificial origin" due to vertical movement of the sensor). Since microscale spottiness of temperature (true and "artificial") is characteristic for the near-surface layer of the ocean with a thickness of not more than 0.5 m, precisely it is the first to disappear (at about 1500 hours) with deepening of the convective layer. With a further increase in the thickness of the layer affected by convection there is also a decrease in the amplitude of thermal inhomogeneities of a kilometer scale, which at nighttime virtually completely disappear. It is also not impossible that after the onset of a rapid increase of the convective layer there will be development of large cells of convective circulation whose scales for the time being remain unknown.

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MONOGRAPH ON SYNOPTIC EDDIES IN THE OCEAN

Kiev SINOPTICHESKIYE VIKHRI V OKEANE in Russian 1980 (signed to press 12 Sep 80) pp 2, 286-288

[Annotation and table of contents from book "Synoptic Eddies in the Ocean", edited by Boris Alekseyevich Nelepo, Izdatel'stvo "Naukova dumka", 1000 copies, 288 pages]

[Text] Annotation. The monograph gives the results of investigations of synoptic variability of the principal hydrophysical and hydrochemical fields carried out under the international POLYMODE program. Also examined are the background hydrometeorological characteristics of the investigated region (polygon in the Sargasso Sea), mapping of eddy formations, determination of their parameters, thermohaline, hydrochemical and hydrooptical structure. Evolution of the eddies and their interaction with the surrounding medium was investigated. Theoretical models of synoptic formations in a baroclinic ocean are proposed which demonstrate their evolution, as are models illustrating the influence of eddies on processes in the upper quasihomogeneous layer and on the propagation of internal waves. It is of interest for specialists in the field of physical oceanography, dynamic meteorology, hydrodynamics of the ocean, students and graduate students at universities and hydrometeorological institutes. Figures 122, tables 19, references pp 277-285]

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UDC 551.464

INVESTIGATION OF SOME PHYSICOCHEMICAL CHARACTERISTICS OF THE SURFACE MICROLAYER

Sevastopol' MORSKIYE GIDROFIZICHESKIYE ISSLEDOVANIYA: KOMPLEKSNYYE ISSLEDOVANIYA ATLANTICHESKOGO OKEANA in Russian No 2(89), Apr-Jun 80 (manuscript received 27 Nov 79, after revision 8 Feb 80) pp 33-39

[Article by L. V. Yeremeyeva]

[Text]

Abstract: The article gives data on the distribution of pCO_2, ρ, O_2, pH and S in the surface microlayer (SML) in the region of the Guinea sector of the Tropical Atlantic. There were considerable differences in the content of these components in the surface microlayer and at the horizon 0 m; the corresponding coefficients of enrichment of the SML were computed. Within the framework of a film model of gas exchange it was possible to ascertain the rate of CO_2 release from the ocean into the atmosphere for the region of water upwelling.

Recently the attention of hydrochemists has been attracted to the thin surface layer of ocean water at its boundary with the atmosphere, differing substantially in its physicochemical characteristics from samples taken from the "zero" horizon by means of the standard method. The thickness of the surface film can evidently vary under real conditions in dependence on hydrometeorological conditions in the range from tens of microns to several centimeters, which makes it quite difficult to obtain experimental data on its chemical composition. An important factor stimulating study of the SML is its role in the fractionation of elements of the salt composition of waters in the SML, the formation of sea aerosol, evaporation, and also as a result of the concentration of many contaminating and surface-active substances at the ocean-atmosphere discontinuity.

On the 36th voyage of the scientific research vessel "Mikhail Lomonosov" SML samples were taken at 50 stations in the northeastern zone of the Tropical Atlantic using a frame-type sampler with a Kapron sieve No 8 by the method described in [1, 5]. The thickness of the intercepted water layer was not greater than 0.2 mm. At the same time samples were taken with a bathometer from the zero horizon. The following parameters were determined: oxygen, phosphates, salinity. The corresponding analytical methods are given in [4].

In addition, the partial pressure of carbon dioxide pCO_2 was computed on the basis of known formulas [9] with use of the Lyman constants. At ten stations measurements were made of the temperature of the surface microlayer using a calibrated sensor mounted in a foam plastic float. The temperature of the microlayer was lower than at the "zero" horizon; ΔT varied in the range 0.8-1.3°C. Henceforth in computing the pH_{water} values and the CO_2 content in the microlayer at all stations we used the value $\Delta T = 1°C$. The results of the determinations and the computations made on their basis (stations 3210, 3232) are given in Tables 1, 2, and for the section from station 3224 to station 3233 are given in Fig. 1.

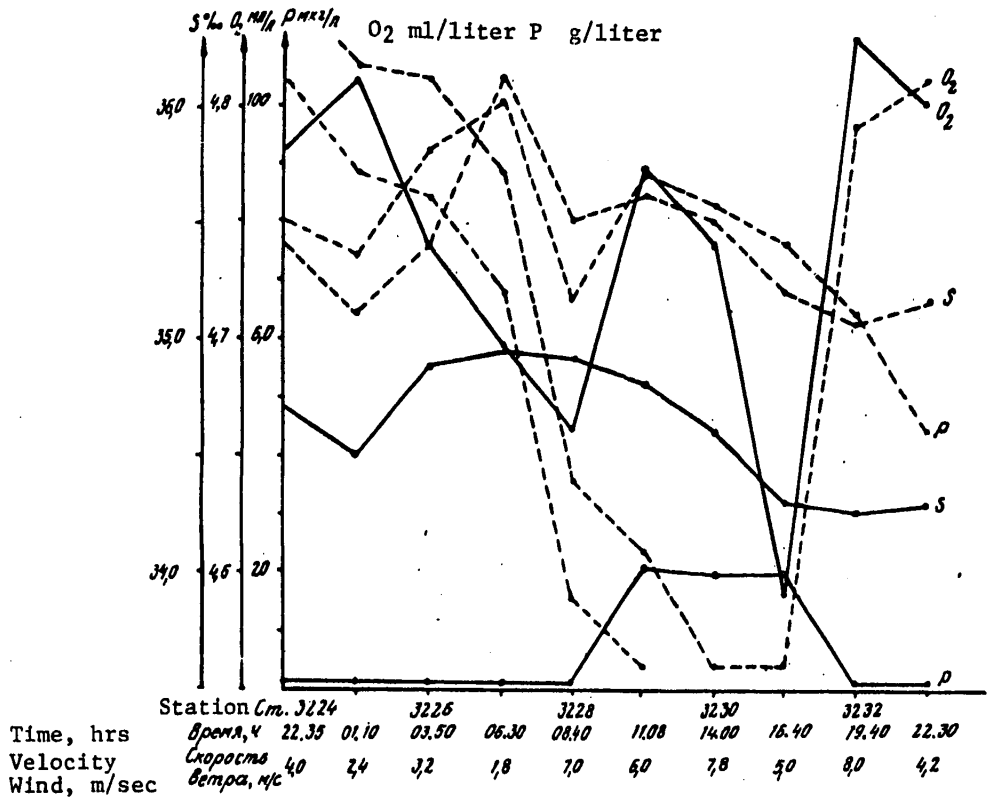

Fig. 1. Comparison of chemical characteristics of SML and 0-m horizon.

The investigated region is characterized by exceptionally complex dynamics. Here there are several zones of upwelling and subsidence of waters, as a result of which the chemical characteristics at the 0-m horizon varied considerably from station to station, as is particularly noticeable from the results of determinations of phosphates, pCO_2 and salinity. The hydrochemical structure of the waters was described in [3]. The distribution of the studied elements in the microlayer correlates with variations in their content (Table 2) at the 0-m horizon and differs only in its absolute values.

Table 1

Percentage of Enrichment of SML Waters Relative to 0-m Horizon (Note 1)

Number of station	δ_S	δ_P	δ_{Alk}	δ_{O_2}	δ_{pCO_2}
3210	2,34	-	1,26	-4,8	-11,3
3211	2,49	567	1,26	0,64	-11,7
3212	2,93	-	1,28	3,02	-11,2
3213	2,54	-	1,28	-1,72	- 9,4
3214	1,58	668	0,85	-0,64	- 9,6
3215	2,15	1 380	0,85	- 7,0	-10,3
3216	1,74	1456	1,68	0,84	8,9
3217	1,74	581	1,25	0,84	6,8
3219	1,97	283	1,27	0,42	- 9,2
3220	2,67	2280	1,31	0,21	13,0
3221	3,30	1192	0,89	-1,47	9,1
3222	2,06	363	0,86	-0,64	-11,3

Note 1: The computations were made using the formula

$$\delta = C_{SML} - C_0/C_0 \cdot 100\%,$$

where C_{SML} is the concentration in the surface microlayer; C_0 is the concentration at the 0-m horizon.

This conclusion evidently cannot be extended to data on the concentration of dissolved oxygen, for which the scatter of experimental values with multiply repeated control samplings of the SML is comparable with the value of the error in the measurement method.

Analysis of the data given in Fig. 1 and in Table 2 makes it possible to draw the following conclusions. The salinity of the surface microlayer is considerably greater than at the 0-m horizon. On the average the difference (ΔS) is about $1^{o}/oo$. The ΔS value varies in the course of the day, increasing during the hours of light, with an increase in $\Delta T°$ between the water and air. It was found that ΔS decreases with an increase in wind force. Since a surface film is created primarily by evaporation [6], this effect can be associated with a decrease in the thickness of the SML with an increase in the wind force and "contamination" of water from the 0-m horizon with sampling by a sieve sampler.

Table 2

Comparison of Hydrochemical Characteristics of Samples Taken by a Bathometer from the 0-m Horizon and the SML

No of station	Time	O_2 ml/liter		S ‰		P µg/liter		pH		Alk meq/liter		$pCO_2 \cdot 10^{-6}$ atm	
		0	SML	0	SML	0	SML	0	SML	0	SML	0	SML
3210	23.00	4,78	4,55	34,97	35,79	0,0	84,4	8,22	8,25	2,38	2,41	386	342
3211	03.30	4,67	4,70	34,89	35,76	12,0	80,0	8,22	8,26	2,39	2,42	384	339
3212	07.30	4,61	4,75	34,70	35,72	0,0	108,4	8,20	8,24	2,33	2,36	399	354
3213	10.40	4,63	4,55	34,63	35,51	0,0	72,0	8,25	8,28	2,33	2,36	358	324
3214	16.30	4,71	4,68	34,52	35,07	10,0	76,8	8,25	8,28	2,35	2,37	354	320
3215	18.30	4,70	4,63	34,36	35,10	6,0	88,8	8,24	8,27	2,35	2,37	367	329
3216	21.40	4,76	4,80	34,96	35,57	4,8	75,2	8,26	8,29	2,37	2,41	338	318
3217	01.00	4,74	4,78	35,04	35,65	8,8	60,0	8,30	8,27	2,39	2,42	306	327
3219	06.30	4,68	4,70	34,50	35,18	19,6	75,0	8,28	8,28	2,35	2,38	324	321
3220	10.00	4,70	4,71	34,50	35,42	4,2	100	8,31	8,27	2,29	2,32	284	323
3221	12.50	4,73	4,66	34,53	35,67	6,5	84	8,31	8,28	2,23	2,25	286	312
3222	16.40	4,64	4,81	34,82	35,54	19,0	88,0	8,24	8,28	2,33	2,35	362	321

In the microlayer there was found to be a concentration of phosphates ~100-200 µg/liter. Frequently at the zero horizon it is close to analytical zero. The maximum difference in the concentration of phosphates between the SML and the zero horizon (Δ P) is observed during the light time of day and is maximum in the first half of day. A wind force in the range 1-10 m/sec and a difference between the air and water temperatures exert virtually no influence on the Δ P value. The relative increase in the concentration of phosphates in the microlayer is evidently attributable to a predominance of mineralization processes over photosynthesis processes.

The CO_2 content in the SML is of special interest. Tables 1 and 2 indicate that the CO_2 concentration in the SML is always closer to an equilibrium value than at the 0-m horizon. Whereas pCO_2 at the 0-m horizon is considerably greater than in the atmosphere, in the surface microlayer this value is reduced. If pCO_2 at the 0-m horizon is lower than in the atmosphere, in the microlayer the CO_2 content is increased. This is reflected in change of the pH value. An increase of alkalinity in the microlayer relative to the 0-m horizon occurs proportionally to salinity. Thus, pCO_2 at the upper boundary of the surface microlayer can be considered equal to atmospheric pCO_2. The collected data confirm the correctness of a film model of the exchange of gases between the ocean and the atmosphere. Since on the voyage investigations of the thickness of the surface microlayer [2] by the radon method were made simultaneously with our experiment, it was possible to compute the rate of transfer of CO_2 from the ocean to the atmosphere. According to the results in [2], the thickness of the SML with a wind velocity up to 5 m/sec was ~110μm. The difference between the pCO_2 of water and pCO_2 of air (ΔpCO_2) in regions of local upwelling of water as an average for the polygon was $40\text{-}60 \cdot 10^{-6}$ atm. The rate of CO_2 release was computed using the formula

$$j = \frac{D\alpha}{Z} \Delta pCO_2,$$

where α is the CO_2 solubility coefficient; D is the diffusion coefficient; Z is microlayer thickness. Using [9] we find the values $\alpha = 2.83 \cdot 10^{-2}$ mol/liter•atm and $D = 1.91 \cdot 10^{-5}$ cm^2/sec. According to our computations, the rate of release of CO_2 from the ocean into the atmosphere in the investigated region was 1.7-2.6 mmol/m^2•day.

It must be emphasized once again that this value was obtained for a wind velocity up to 5 m/sec. With an intensification of the wind the intensity of CO_2 release into the atmosphere can increase considerably.

Summary

1. Use of samplers of the PS type [4, 7] makes it possible to obtain information on the chemical composition of water in the thin surface layer (0.2-0.3 mm), the physicochemical characteristics of which differ from the corresponding data for the 0-m horizon.

2. The distribution of salinity, phosphates and pCO_2 in the SML correlates with the distribution of these parameters at the zero horizon. The maximum coefficients of SML enrichment were registered for phosphorus.

3. The ΔS and ΔP values have a definite daily variation, attaining maximum values during the light time of day.

4. The peculiarities of pCO_2 distribution in the SML can be explained within the framework of film models of gas exchange between the ocean and the atmosphere.

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[Text] CONTENTS

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CLASSIFICATION OF ACOUSTIC CONDITIONS IN THE OCEAN: ACOUSTIC ENVIRONMENT, WEATHER AND CLIMATE

Dushanbe IZVESTIYA AKADEMII NAUK TADZHIKSKOY SSR: OTDELENIYE FIZIKO-MATEMATICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 4(78), Oct-Dec 80 pp 73-76

[Article by V. V. Ol'shevskiy, Acoustics Institute USSR Academy of Sciences and Mathematics Institute-Computation Center Tajik Academy of Sciences]

[Text] The use of statistical methods in a study of acoustic signals in the ocean [1, 2], and also the discussion of the general problems involved in formulating acoustical-oceanological models in recent years [3-6], is making it possible to define a whole series of problems directed to the classification of acoustic conditions in the ocean. These problems are multidimensional statistical problems and it seems to us that in their solution the most effective results will be obtained when employing modern computer image recognition methods [7-10].

In [6] a formal determination of the principal elements of acoustical-oceanological models was given in the form of sets θ_Z, θ_Y and θ_X, whose elements are the corresponding vector functions of vector arguments (vector-functions):

$$\vec{Z}(\vec{\sigma}) \in \theta_Z, \vec{Y}(\vec{\beta}) \in \theta_Y, \vec{X}(\vec{\alpha}) \in \theta_X, \tag{1}$$

these vector-functions describe: $\vec{Z}(\vec{\sigma})$ -- oceanological phenomena, $\vec{Y}(\vec{\beta})$ -- acoustical characteristics of the ocean, $\vec{X}(\vec{\alpha})$ -- acoustical fields in the ocean. Proceeding on the basis of a systemic-physical hierarchy of vector-functions (1), it is possible to write the following operator equations:

$$\vec{Y}(\vec{\beta}) = Q_{YZ}\{\vec{Z}(\vec{\sigma})\}, \vec{X}(\vec{\alpha}) = Q_{XY}\{\vec{Y}(\vec{\beta})\} \tag{2}$$

or in more compact form:

$$X(\alpha) = Q_{XYZ}\{\vec{Z}(\vec{\sigma})\} = Q_{XY}Q_{YZ}\{\vec{Z}(\vec{\sigma})\}, Q_{XYZ} = Q_{XY}Q_{YZ}, \tag{3}$$

where Q_{XY} and Q_{YZ} are operators for conversion from vector-functions of one type to another, Q_{XYZ} is a combined operator for relating oceanological characteristics and acoustical fields in the ocean.

As noted above, modern image recognition methods make possible solution of many problems in the field of acoustical-oceanological investigations, associated, in particular, with determination of empirical patterns, classification of different investigated objects, evaluation of the information content of different criteria, formalization of the description of different hydrophysical phenomena, etc. In these methods (from the point of view of investigation of acoustical-oceanological models) the most important consideration is that in the recognition of images the problems are formalized as statistical and multidimensional and at the present time there is a quite large set of programs for computers making it possible to solve most of these problems on a constructive basis using numerical mathematical methods.

In our subsequent examination we will determine a probabilistic description of the vector-functions (1), that is, their probabilistic models:

$$\Xi_Z(\vec{c}), \Xi_Y(\vec{b}), \Xi_X(\vec{a}), \tag{4}$$

where $\vec{c}$, $\vec{b}$ and $\vec{a}$ are the corresponding arguments of the probabilistic characteristics of the type Ξ. Proceeding on the basis of the systemic-physical hierarchy (2) and (3) of the vector-functions (1), for the probabilistic characteristics (4) we will write the following operator equations:

$$\Xi_Y(\vec{b}) = P_{YZ}\{\Xi_Z(\vec{c})\}, \Xi_X(\vec{a}) = P_{XY}\{\Xi_Y(\vec{b})\} \tag{5}$$

or in more compact form:

$$\Xi_X(\vec{a}) = P_{XYZ}\{\Xi_Z(\vec{c})\} = P_{XY}P_{YZ}\{\Xi_Z(\vec{c})\}, P_{XYZ} = P_{XY}P_{YZ}, \tag{6}$$

where P_{XY} and P_{YZ} are operators for conversion from the probabilistic characteristics of one type to another, P_{XYZ} is a combined operator for relating the probabilistic characteristics of oceanological phenomena to the probabilistic characteristics of acoustical fields in the ocean.

We will introduce the concept of an acoustic environment in the ocean, which we will define in the form of the subset $\Upsilon(V_{t\vec{\rho}})$ such that

$$\vec{X}(\vec{a}/\vec{V}_{t\vec{\rho}}) \in \Upsilon_X(\vec{V}_{t\vec{\rho}}) \subset \Theta_X, \tag{7}$$

here $V_{t\vec{\rho}} = (\vec{\rho}_V, t_V)$ is a quite small region in the space-time coordinates $\vec{\rho}_V$, t_V within which the acoustical fields in the ocean are considered uniform statistically. The description of the fields (7) is stipulated using probabilistic characteristics of the type $\Xi_X(\vec{a}/V_{t\vec{\rho}})$, which correspond to probability distribution laws for acoustical fields "local" in space and "instantaneous" in time.

By the term "acoustic weather" in the ocean we will understand the subset

$$\Upsilon_X(\vec{V}_{\vec{\rho}}, t) \subset \Theta_X$$

such that

$$X(a/V_{\vec{\rho}}, t) \in \Upsilon_X(\vec{V}_{\vec{\rho}}, t) = \bigcup_t \Upsilon_X(\vec{V}_{t\vec{\rho}}) \subset \Theta_X. \tag{8}$$

here $\vec{V}_{\vec{\rho}} = (\vec{\rho}_V)$ is a small region in space coordinates within which the acoustic fields in the ocean are statistically uniform, t is current time. Thus, according to (8), the acoustic weather is determined as a totality of the temporal changes in the acoustic environment characteristic for the particular region of the ocean. The description of the acoustic weather (8) can be made using probabilistic characteristics of the type $\Xi_X(\vec{a}/\vec{V}_{\vec{\rho}}, t)$, which correspond to spatially "local" probability distribution laws for acoustical fields, taking into account all the temporal changes in the characteristics $\Xi_X(\vec{a}/V_{t\vec{\rho}})$.

By acoustic climate in the ocean we will understand the subset $\Upsilon_X(\vec{\rho} \in \vec{R}_K, t) \subset \Theta_X$ such that

$$\vec{X}(\vec{\alpha}/\vec{\rho}, t) \in \Upsilon_X(\vec{\rho} \in \vec{R}_K, t) = \bigcup_{\vec{\rho} \in R_K} \Upsilon(\vec{V}_{\rho}, t) \subset \Theta_X, \tag{9}$$

here $\vec{R}_K$ is a spatial region within which the acoustic weather in the ocean is statistically uniform, $\vec{\rho}$ are the current space coordinates. The description of acoustic climate (9) can be made using probabilistic characteristics of the type $\Xi(\vec{a}/\vec{\rho}, t)$, which correspond to spatial-temporal changes in the characteristic $\Xi_X(\vec{a}/\vec{V}_{t\vec{\rho}})$. The choice of the regions $\vec{\rho} \in \vec{R}_K$ describing regions of the ocean identical with respect to acoustic climate is an important problem in image recognition theory, whose successful solution to a considerable degree will govern the solution of many other problems in the investigation of acoustical-oceanological models.

Now we will enumerate some of the typical problems arising in the investigation of acoustical-oceanological models with use of image recognition methods.

A. Filling of gaps in empirical tables. Problems of this type involve the forming of data banks, that is, sets $\hat{\Theta}_Z \subset \Theta_Z$ $\hat{\Theta}_Y \subset \Theta_Y, \hat{\Theta}_X \subset \Theta_X,$ formed from experimental investigations carried out earlier. Since these data banks have gaps it is necessary that they be filled "in the best way." For this purpose it is possible to use recognition programs [10], making possible the filling of gaps in empirical tables.

The result of solution of this problem will be banks $\hat{\Theta}^*_Z \supset \hat{\Theta}_Z, \hat{\Theta}^*_Y \supset \hat{\Theta}_Z, \hat{\Theta}^*_X \supset \Theta_X,$ which are more complete than the initial banks (it goes without saying, due to the conversion of the excess in the initial banks into informative characteristics).

B. Determination of classes of oceanological characteristics on the basis of acoustic criteria. Problems of this type, in essence, are problems in taxonomy or clustering [8, 9] and the result of their solution is the determination of the classes $\Upsilon_{Zi} \subset \Theta_Z$, $i = \overline{1, N_Z}$ of oceanological characteristics using the criteria $\vec{X}(\vec{\alpha})$ or $\vec{X}(\vec{\alpha}) \cup \vec{Y}(\vec{\beta})$.

The result of solution of this problem should be determination of the classes Υ_{Zi} such that $\bigcup_i \Upsilon_{Zi} = \Theta_Z$.

C. Classification of oceanological conditions (environment). In solving these problems evaluations of the oceanological characteristics $\vec{Z}(\vec{\sigma})$ are stipulated and it is necessary to assign them to one of the classes Υ_{Zi}, $i = \overline{1, N_Z}$, which were determined in problem B.

D. Prediction of acoustic environment. Problems of this type are reduced through $\vec{Z}(\vec{\sigma})$ to determination of the class Υ_{Zi} (problem C) and then to forming of one of the classes $\Upsilon_{Xj} \subset \theta_X$, $j = \overline{1, M}$, which corresponds to Υ_{Zi}. Within the limits of the class Υ_{Xj} it is necessary to reproduce the vector-functions $\vec{X}(\vec{\alpha})$ describing this class (statistical modeling for prediction purposes).

Now we will mention the productivity of use in solving the considered problems of the concepts of acoustic environment in the ocean, acoustic weather and climate. Precisely these concepts, in our opinion, constitute a classification basis in acoustical-oceanological investigations and characterize their general direction.

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INVARIANT SPATIAL-FREQUENCY INTERFERENCE STRUCTURE OF THE ACOUSTIC FIELD IN A LAYERED OCEAN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 257, No 2, 1981 pp 475-479

[Article by S. D. Chuprov and N. Ye. Mal'tsev, Acoustics Institute imeni N. A. Andreyev USSR Academy of Sciences, manuscript received 14 Jul 80]

[Text] A distinguishing characteristic of the acoustic field in the ocean is the level oscillations arising with a change in the coordinates of reception and radiation points or with a change in the frequency of a monochromatic sound source. An approach based on the coherent summation of rays or waveguide modes makes it possible to compute the interference structure of the field and evaluate the anticipated periods of level oscillations. Although the experimentally observed periods of oscillations of the acoustic field usually coincide with the computed oscillations, the experimental and theoretical curves describing the dependence of the sound level on distance, depth of reception or frequency of radiation, usually have little in common even at a rather low frequency of 10 Hz [1]. The latter is related to the impossibility of a sufficiently precise evaluation of the phase difference of the rays or modes at distances of several tens of kilometers due to the inadequacy of information on the spatially and temporally variable medium, and also due to errors in approximate computation methods. Therefore it was deemed improbable that the fine structure of the acoustic field at great distances and at frequencies above 10 Hz could be successfully predicted. However, it was found that the situation in actuality is not so hopeless and it is possible to indicate stable characteristics of the fine spatial-frequency interference structure of the field associated with extremely simple characteristics of the waveguide.

In general form we will write the acoustic pressure at a great distance r from the source in the form of the sum of modes with the amplitudes A_n and the eigenvalues ξ_n

$$P = \Sigma A_n e^{i\xi_n r}.$$

We will be interested in the scalar field with the intensity $I(\omega, r) = |P|^2$ at some horizon in the neighborhood of the distance r_0 and the radiation frequency ω_0.

The conditions for the propagation of sound in a layered ocean are such [2] that the field is effectively formed by a small number of groups of modes with close numbers (corresponding to the rays in geometrical acoustics). We will examine the totality of modes forming several such groups with the phase and group velocities

$c_{ph\ n}$ and $c_{g\ n}$ in the neighborhood c_{ph} and c_g.

We will assume that the group and phase velocities are related by the functional dependence $c_g = c_g(c_{ph})$; in the WKB approximation, and sometimes also in the precise solution this dependence does not include either the mode number or frequency. By expanding $1/c_{g\ n}$ into a series in the neighborhood of the point $1/c_{ph}$ and limiting ourselves to two terms, we find

[Γ = g = group; Φ = ph = phase]

$$\frac{1}{c_{\Gamma n}} \approx \frac{1}{c_\Gamma} + \frac{dc_\Gamma}{dc_\Phi}\left(\frac{c_\Phi}{c_\Gamma}\right)^2\left(\frac{1}{c_{\Phi n}} - \frac{1}{c_\Phi}\right). \tag{1}$$

Computing the derivatives $\partial I/\partial\omega$ and $\partial I/\partial \dot{r}$ with allowance for (1) and the relationship $c_{g\ n} = d\omega/d\xi_n$, we find the direction of the level lines in the coordinate system $\Delta\omega = \omega - \omega_0$ and $\Delta r = r - r_0$:

$$\frac{\Delta\omega}{\Delta r} = -\frac{\partial I/\partial r}{\partial I/\partial\omega} = -\frac{dc_\Phi}{dc_\Gamma}\left(\frac{c_\Gamma}{c_\Phi}\right)^2\frac{\omega_0}{r_0}. \tag{2}$$

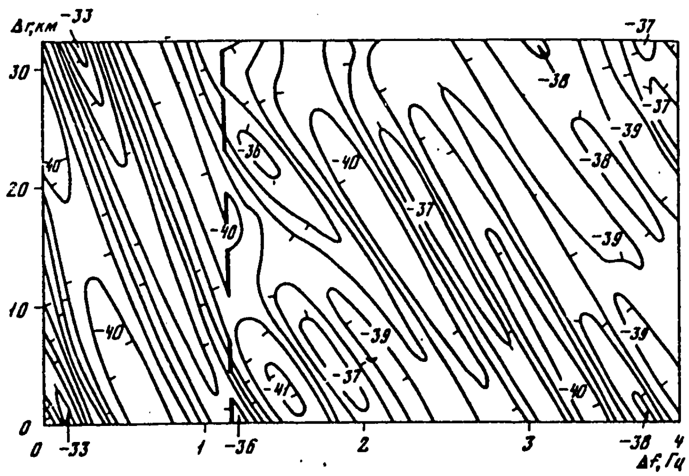

Fig. 1. Curves of equal sound level in neighborhood r_0 = 600 km, f_0 = 5 Hz. The numbers represent the level (in db) for curves near the interference maxima and minima; the zero db is the sound level at a distance of 1 km from the source in a homogeneous unbounded medium. The speed of sound at the surface is 1,505 m/sec, at the bottom at a depth of 2.8 km -- 1,553 m/sec. The bottom is a homogeneous elastic half-space (velocity of longitudinal waves -- 3,000 m/sec, velocity of shear waves -- 1,554 m/sec, density -- 2.2 g/cm³). Depth of radiation 400 m, depth of reception 600 m. The break in the curves with Δf = 1.2 Hz is associated with the "activation" of an additional mode and failure to take dissipative losses into account. Only refracted modes for which $c_{ph\ n} < 1{,}553$ m/sec were taken into account in the computations. The short lines on the curves are directed in the direction of a decrease in the sound level.

It follows from (2) that the following expression is correct for the relative increments of frequency and distance

[Γ = g = group; Φ = ph = phase]

$$\frac{\Delta\omega/\omega_0}{\Delta r/r_0} = -\left(\frac{c_\Gamma}{c_\Phi}\right)^2 \frac{dc_\Phi}{dc_\Gamma} \equiv \beta, \quad (3)$$

which shows that the direction of the level lines β is in some sense an invariant, and specifically, for a group of modes β is not dependent either on the frequency of radiation or on distance, or on depth of radiation and reception, but is determined only by the properties of the medium and some mean value of the phase (and this means the group) velocity for this group of modes.

Expression (3) is approximate since in its derivation use was made of the approximate formula (2) and no allowance was made for the smooth dependence of the amplitudes of the modes A_n on frequency. However, it can be assumed (and this is confirmed by computations of the detailed structure of the field and experimental data) that the general character of the direction of the "crests" of the interference maxima and the "valleys" of the minima will be described by this expression.

For the near-surface channel with a linear law of change of the refractive index $n^2(z) = c^2(z)/c_0^2 = 1 - az$, using the expressions for $c_{ph\ n}$ and $c_{g\ n}$ [3], we have

[Φ = ph(ase)]

$$\beta = -\frac{3}{2 - (c_\Phi/c_0)^2}.$$

Usually $c_{ph} - c_0 \ll c_0$ and $\beta \simeq -3$; this result was obtained by us earlier and is given in [4]. The negative sign of the invariant shows that if there was an interference maximum of the signal with the frequency ω_0 at the distance r_0, with an increase in distance, in order not to "slip" from the maximum it is necessary to decrease the radiation frequency. This is easy to explain. With a change in the distance by r the phase increments of the modes $\xi_n \Delta r = \omega\Delta r/c_{ph\ n}$ decrease with an increase in the phase velocity (and the glancing angle of the modes). Since in this case there is also an increase in the group velocity, it is possible to even out the phases of the modes, reducing the radiation frequency, because this will give additional negative increments of the phases $-\Delta\omega \cdot r/c_{g\ n}$, which also decrease in absolute value with an increase in the phase velocity.

Figure 1 shows the results of computations of isolines of the level of acoustic pressure for the near-surface channel, whose parameters correspond to spring conditions in the western part of the Mediterranean Sea. From formula (3) with $\beta = -3$, $f_0 = \omega_0/2\pi = 5$ Hz, $r_0 = 600$ km we obtain $\Delta r/\Delta f = -40$ km/Hz. This direction of the level lines can be seen clearly in the left part of Fig. 1; in the neighborhood $\Delta f = 3$ Hz the slope of the isolines is also close to the computed value -20 km/Hz.

The dependence $c_g(c_{ph})$ (which is shown in Fig. 2) was computed by the ray method for the vertical profile of the speed of sound measured in early May 1980 in the Mediterranean Sea; for 1,523 m/sec $< c_{ph} <$ 1,553 m/sec $\beta \simeq -3.4$. This value agrees well with the results of acoustic experiments carried out at distances where the main contribution to the acoustic field is from signals arriving along sufficiently deep-water rays (Fig. 3). At distances 22-24 km the reception field point is determined by rays with values of phase velocity less than 1,522 m/sec and the experiment gives a β value in the range from -1.5 to -2.0, which agrees with the steep slope of the $c_g(c_{ph})$ curve (Fig. 2a). We note the stability of the interference structure with time at rather high frequencies of about 1 KHz: the largest details of the pattern "live" for 15-20 min or more. It was also established that with a constant distance (and reception depth) the interference structure does not move along the frequency scale and is only gradually modified due to variations of amplitudes and phases of the arriving signals.

Experimental investigations and computations for different conditions for sound propagation in the ocean indicated a good agreement of the results both with respect to the value of the invariant β and with respect to its sign. The β value assumes a negative sign usually only for purely refracted rays or rays reflecting only from the ocean surface.

In convergence zones, depending on the phase velocity of the rays, the absolute value of the invariant can attain several tens or even hundreds. It is interesting that sometimes in some range of change in c_{ph} even the refracted modes give $\beta > 0$, for example, in the case of a biaxial channel. For modes reflected by the bottom in most cases $\beta > 0$, since $dc_{ph}/dc_g < 0$ (for example, see Fig. 2a). With an increase in c_{ph} the dependence $c_g(c_{ph})$ for any c(z) profile differs increasingly less from the dependence $c_g = c_0^2/c_{ph}$, correct for an ideal homogeneous waveguide (c_0 is the speed of sound in the medium), for which it is easy to obtain

[Φ = ph]

$$\beta = c_0/c_\Phi^2 = \cos^2\chi,$$

where χ is the glancing angle of the mode or ray. For small glancing angles of the modes $\beta \simeq 1$.

It can be assumed that also for more complex models of a waveguide with a layered bottom the indicated expression is a good approximation for the range of high frequencies where stationary values of group velocity are absent and the resonance properties of the layered structure are not manifested and the $\omega(\xi)$ curves asymptotically approach those for an ideal waveguide.

If the sound travels only from above (glancing angle of the rays $\chi > 0$) or only from below ($\chi < 0$) it is found that

$$\frac{\Delta\omega/\omega_0}{\Delta z/r_0} = -\beta \operatorname{ctg}\chi,$$

where Δz is the change in the depth of reception (the z-axis is directed downward). This expression was confirmed experimentally and can be generalized for the case of movement of the reception point in any direction.

It is extremely important that an analysis of the case of a source withdrawing with the velocity v, on the basis of a modal solution [5] and usually satisfying the assumption

$$\xi_n \frac{\partial c_{g\,n}}{\partial \omega_0} \ll 1$$

gives a value of the invariant

[Φ = ph; Γ = g]

$$\beta' = \beta\left(\frac{1+v}{c_\Gamma}\right) + \frac{v}{c_\Phi},$$

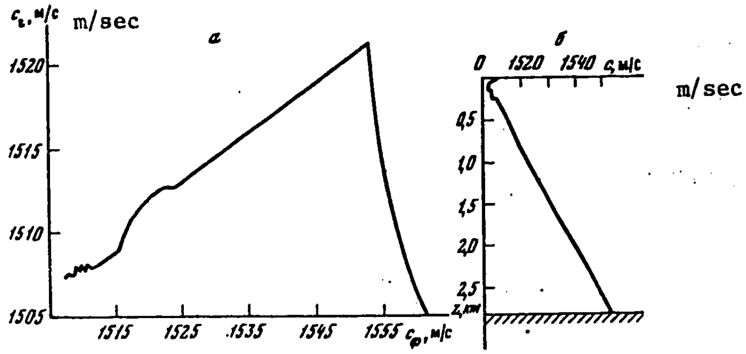

Fig. 2. Curve of dependence of c_g on c_{ph} (a), computed from vertical profile of speed of sound (b).

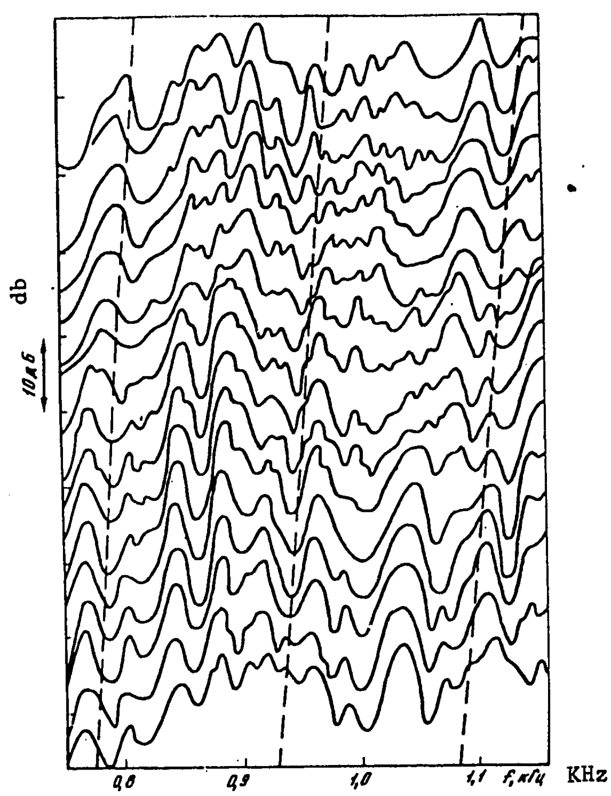

Fig. 3. Frequency spectra of noise signal (resolution of analysis 5 Hz, averaging time 115 sec) in Mediterranean Sea obtained with an interval of 2.48 min during which the distance increased by 42.4 m. The upper curve corresponds to a distance of 54.6 km. Depth of radiation 200 m, depth of reception 10 m. The adjacent curves are displaced vertically by 5 db. The dashed straight lines are the computed slopes of lines of equal level.

which under the condition $v \ll c_g$, c_{ph} differs little from the β value. In particular, for the case of a near-surface channel $\beta' \simeq -3-2(v/c_g)$, and for an ideal homogeneous waveguide $\beta' \simeq \cos^2 \chi + 2\chi(v/c_0)$.

It should be noted that such a structure of the wave field, determined by the correlation between the phase and group velocities of the signals, should be observed during the propagation of waves in any layered medium, in particular, during the propagation of electromagnetic waves in a layered ionosphere.

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VARIABILITY OF VERTICAL STRUCTURE OF THE TEMPERATURE FIELD IN THE UPPER LAYER OF THE OCEAN

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 17, No 3, Mar 81 (manuscript received 28 Dec 79, after revision 25 Feb 80) pp 305-312

[Article by I. D. Lozovatskiy, Institute of Oceanology, USSR Academy of Sciences]

[Text]

Abstract: On the basis of the results of repeated soundings of the temperature field in the thermocline a study was made of its temporal variability in the range of scales of fine-structured and microstructural inhomogeneities. It is shown that relatively long-period internal waves can make the main contribution to variability of the fine structure of the temperature field. The influence of such internal waves can also be reflected in the variability of the mean weighted dispersion of microstructural inhomogeneities $\tilde{s}_{T'}^2$ for the considered layer of the thermocline, an increase in which is accompanied by stratification of the $s_{T'}^2(z)$ profile. Taking into account the vertical variability of the fluxes of heat and momentum, expressions for the mean statistical spectrum of vertical temperature inhomogeneities in the oceanic thermocline are examined.

Short-period variability of the temperature field in the upper layer of the ocean is caused primarily by internal waves and microturbulence. The first results of study of the correlation and coherence of temperature inhomogeneities with vertical scales from a few to tens of meters were presented in [1-3]. However, in actuality there is no information on the correlations between the characteristics of microstructural ($l_z < 1$ m) fluctuations of the temperature field, separated in time and space. In this article we give the results of an analysis of the variability of the statistical characteristics of both fine-structured and microstructural inhomogeneities of the temperature field in the equatorial zone of the Indian Ocean.

On the 19th voyage of the scientific research ship "Dmitriy Mendeleyev" [4], at a point with the coordinates 5°59'N, 87°14'E, specialists carried out a series of soundings of the temperature field and velocity fluctuations in the layer from 25 to 265 m. The time interval between successive soundings was 8 minutes. The spectral characteristics of small-scale fluctuations of velocity and temperature obtained on the basis of data from these measurements are given in [5], which also gives a description of the measurement apparatus. In order to discriminate the fine structure of the $T_j(z)$ profiles they were averaged for the entire set of 23 soundings. From the individual $T_j(z)$ profiles we then subtracted the mean $\tilde{T}(z)$ profile and thus found the profiles of the fine structure of the temperature field $T_j{}^s(z)$ (for more details on the method used for the primary processing of the measurement results, see [3]). We note that such a procedure is justified only in a case when the initial profiles are realizations of one random process. A checking of this assumption was made by an analysis of a set of sample dispersions $s^2_{Tz}{}^j$, computed for each profile of the temperature gradient $T_{zj}(z)$ (j is the number of the sounding). It was found that according to the Cochran test [6], with a probability 95%, the difference in the sample dispersions s^2_{Tzj} can be deemed insignificant and it is possible to consider individual $s^2_{Tz}{}^j$ to be evaluations of the general dispersion σ_{T_z}, whose value is close to $10^{-2}\,°C^2 \cdot m^{-2}$. Statistical computations of the vertical profiles of the fine structure $T_j{}^s(z)$ and the temperature gradients $T_{zj}(z)$ were made with a depth discreteness of 0.5 m. Allowance for the errors caused by the influence of rolling on the rate of lowering of the probe indicated that in the $T_j{}^s(z)$ profiles and $T_{zj}(z)$ profiles inhomogeneities with scales $l_z \geqslant 3.5$ m remained undistorted. As a result of rejection of smaller-scale fluctuations, which was included in the program for the primary processing of the results of fine structure measurements [3], it was found that with $k^{-1} < 7$ m the $E_{TS}(k)$ spectra dropped off sharply with an increase in the wave number k and therefore we will examine the range of scales from 50 to 7 m.

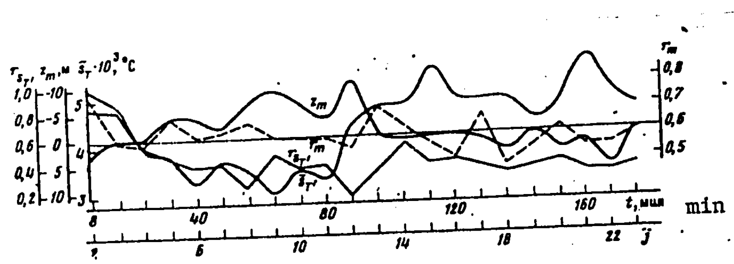

Fig. 1. Temporal change of the maximum values of the cross-correlation functions of the profiles $T_z(z)$-$r_m(z_m)$ and the corresponding vertical shifts z_m, and also the temporal variation of the cross-correlation coefficient for the profiles $s_{T'}(z)$-$r_{sT'}$ and the mean weighted values of temperature fluctuations $\tilde{s}_{T'}$.

Figure 1 shows the temporal change (relative to sounding 1) of the maximum values of the cross-correlation functions of the profiles of the temperature gradients $r_m(z_m)$ and the corresponding vertical shifts z_m. Figure 1 shows that the $r_m(z_m)$ values vary insignificantly, varying between 0.7 and 0.5. At the same time, the change in the vertical shift z_m is extremely indicative: in the course of 80 minutes (soundings 3-13) $z_m < 0$, and from soundings 13-23 (also 80 minutes) there were positive or near-zero z_m values. This fact evidently can be evidence of an appreciable influence on the variability of the $T_z(z)$ profiles by internal disturbances of a wave nature whose amplitude attained 10 m (Fig. 1).

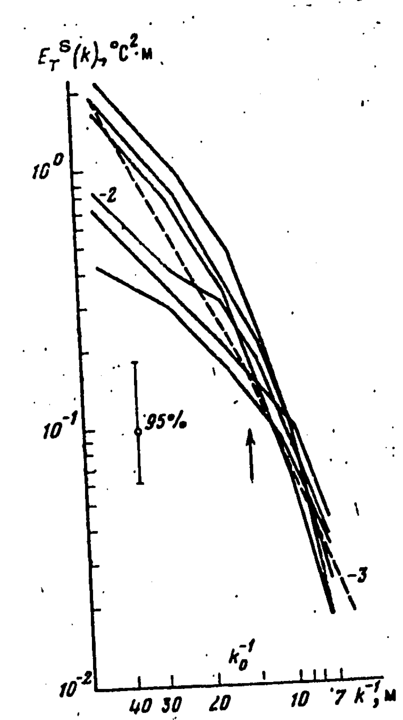

Fig. 2. Examples of spectral densities of temperature inhomogeneities for individual soundings. The dashed curve is for the mean statistical spectrum [13].

Data on the variability of vertical temperature inhomogeneities of individual scales can be obtained in an analysis of the spectra $E_T{}^s(k)$ which were computed from individual $T^s(z)$ profiles with 25 degrees of freedom. A factor which is common for all $E_{Ts}(k)$ spectra (Fig. 2) is that with $k > 0.06$-0.12 cycle/m they are fairly well approximated by a power-law dependence in the form $E_{Ts}(k) \sim k^{-3}$, but with lesser values of the wave number there is some difference in the conditions and slopes of the individual spectral curves.

In modeling the spectra which we observed for fine thermal structure in the thermocline use was made primarily of two approaches which can be defined arbitrarily as statistical and causal. In the first case a suitable statistical model is selected for describing the $T^s(z)$ or $T_z(z)$ profiles, whose parameters are used in constructing the $E_T(k)$ and $E_{Tz}(k)$ spectra. For example, in [7, 8] the profiles of the $T^s(z)$ fine structure were modeled by the random process of alternation of layers and interlayers with the characteristic dimensions $k_L{}^{-1}$ and $k_s{}^{-1}$ respectively with the spectrum $E_{Tz}(k) = \overline{T_z^{s2}}/(k_s - k_L)$ in the range of wave numbers

$k_L \leqslant k \leqslant k_s$, where $\overline{T_z s^2}$ is the dispersion of the fine-structured temperature gradient. The corresponding $E_T(k)$ spectra are proportional to k^{-2}. In [9], within the framework of this model, a more general formula was proposed for the $E_{T_z}(k)$ spectrum:

$$E_{T_z}(k) = Rk^{-r}, \quad R = \overline{T_z'^2} \Big/ \int_{k_L}^{k_s} k^{-r}\, dk \tag{1}$$

with an arbitrary exponent r, which with r from 0 to 2 satisfactorily described many experimental data. It was demonstrated in [10] that in a number of cases the alternation of layers and interlayers in the $T^s(z)$ profiles can be modeled by a Poisson random process with the distribution density

$$p(N, q) = e^{-q} q^N / N!, \quad q = \mu\Delta, \tag{2}$$

where N is the number of interlayers at the distance Δ; μ^{-1} is the mean thickness of the layers. And in [11] for this statistical model of fine structure we obtain the spectrum

$$E_T(k) = (2/\pi)\, \mu a^2 / k^2 (k^2 + \mu^2), \tag{3}$$

where a^2 is the mean square temperature gradient. Formula (3), in particular, indicates that with different μ values the dependence of spectral density on wave number can vary in the range from k^{-2} to k^{-4}.

In contrast to the statistical approach, using for constructing the $E_T(k)$ spectrum the parameters of the fine structure itself regardless of the mechanisms determining it, the causal approach assumes parameterization of the processes exerting a direct influence on the formation of the fine-structured inhomogeneities of the T(z) profiles. In actuality, the only result obtained in this direction was obtained by Garrett and Munk [12], who proposed a formula for the $E_T(k)$ spectrum describing the influence of linear internal waves on deformation of the vertical structure of the temperature field in the thermocline. In the range of vertical scales from a few to hundreds of meters the spectral density $E_T(k)$, according to [12], is proportional to k^{-2} or $k^{-2.5}$. In individual studies the authors have obtained a good agreement between the experimental data and the theoretical spectrum [12]. However, the results of extensive measurements by Gregg, generalized in [13], and also the results of many other authors, and especially the $E_{T^S}(k)$ spectra cited in Fig. 2, indicate that in the neighborhood of the wave number $k_0 \approx 0.1$ cycle/m there is a change in the slope of the $E_T(k)$ curve from -2, with $k < k_0$ to -3 with $k > k_0$. Gregg [13] constructed the mean statistical spectrum $E_T(k)$, which is shown in Fig. 2 by a dashed line. In the range of wave numbers $k_0 < k <$ (1-10) cycles/m this spectrum is approximated by the expression $E_T(k) = A\overline{T}_z^2 k^{-3}$, which for describing the spectra of the fine thermal structure in the oceanic thermocline was proposed for the first time in [14]. The mean value of the dimensionless constant A was equal to $4.5 \cdot 10^3$. The considerable difference of A from unity can indicate the inadequacy of use of the one-dimensional parameter $\overline{T}_z^2$ for for an adequate description of the change in $E_T(k)$ in the considered range of wave numbers. In addition, the $\overline{T}_z$ parameter in no way determines the mechanisms responsible for formation of the observed spectrum of vertical inhomogeneities. Gregg [13] expressed qualitative considerations concerning the possible changes transpiring in the dynamics of internal waves at scales close to k_0. However, if it is assumed that with sufficiently large k these changes are caused by the development of nonlinear interactions in the field of internal waves, leading to the generation of small-scale turbulence, a substantial influence on the formation of temperature inhomogeneities of the T(z) profile can be exerted by turbulent fluxes of heat and momentum. It is known that with a strong stable stratification, which is observed in the oceanic thermocline, the exchange of heat is considerable in comparison with the exchange of momentum (for experimental confirmation of this see, for example, [15]). This means that the main contribution to the heat flux spectrum is from fluctuations with scales l_q, much less than to the momentum flux spectrum l_τ. Therefore, the magnitudes of the fluxes of heat $q = \overline{T'w'}$ and momentum $\tau = \overline{u'w'}$ entering a unit mass will be external determining parameters for inhomogeneities with the scales $l < l_q$ and $l < l_\tau$ respectively. With $l > l_q$ and $l > l_\tau$ the external parameters no longer will be the turbulent fluxes q and τ themselves, but some averaged characteristics of their vertical change, such as the mean values of the gradients

$$\tilde{q}_z = \langle \Delta\overline{T'w'} / \Delta z \rangle \text{ and } \tilde{\tau}_z = \langle \Delta\overline{u'w'} / \Delta z \rangle.$$

Thus, in the range of scales $l_q < l < l_\tau$ the decisive parameters are q_z and τ, but for $l > l_q$ -- $\tilde{q}_z$ and $\tilde{\tau}_z$. Then using dimensionality considerations, we obtain the following expressions for the $E_T(k)$ spectrum:

$$E_T(k) = \gamma_2 \tilde{q}_z^2 \tilde{\tau}_z^{-1} k^{-2} \quad (k < k_\tau), \tag{4}$$

$$E_T(k) = \gamma_2 \tilde{q}_z^2 \tau^{-1} k^{-3} \quad (k_\tau < k < k_q), \tag{5}$$

where γ_1 and γ_2 are some dimensionless constants. Formulas (4) and (5) correctly describe the nature of the dependence of the experimental spectra E_T on k (Fig. 2) with $k < k_0$ and $k > k_0$ respectively. The interpolation formula for $E_T(k)$ in the entire range of scales can be represented in the following way:

$$E_T(k) = \gamma_2 \tilde{q}_z^2 \tilde{\tau}^{-1} k^{-3} \frac{L_0 k}{1 + L_0 k}, \tag{6}$$

where the scale L_0 is determined as

$$L_0 = (\gamma_1/\gamma_2)(\tau/\tilde{\tau}_z). \tag{7}$$

With $L_0 k \gg 1$ the $E_T(k)$ value is described by formula (5), but with $L_0 k \ll 1$, by formula (4). According to available data, L_0 varies for the most part in the range from 10 to 20 m. For a direct confirmation of the possibility of using expression (6) it is necessary to carry out computations of the parameters $\tilde{q}_z$, τ and $\tilde{\tau}_z$ on the basis of experimental data and determine the dimensionless constants γ_1 and γ_2. The first information on the nonuniform distribution of the heat flow in the thermocline, obtained from the results of instrumental measurements, is given in [16]. In [15], by means of indirect computations for individual layers, estimates were obtained for the flux of momentum, which also varied appreciably along z; at the present time, however, there are no direct instrumental measurements of the vertical profiles $\overline{u'w'}(z)$.

The $E_T{}^s(k)$ spectra in the large-scale region ($k < k_0$) represented in Fig. 2 deviate appreciably from the considered universal curve (dashed line), whereas the scatter of $E_T{}^s(k)$ levels, for example, at the scale 7 m, does not exceed the limits of the 95% confidence interval for all soundings. The change in the $E_T{}^s(k)$ levels from

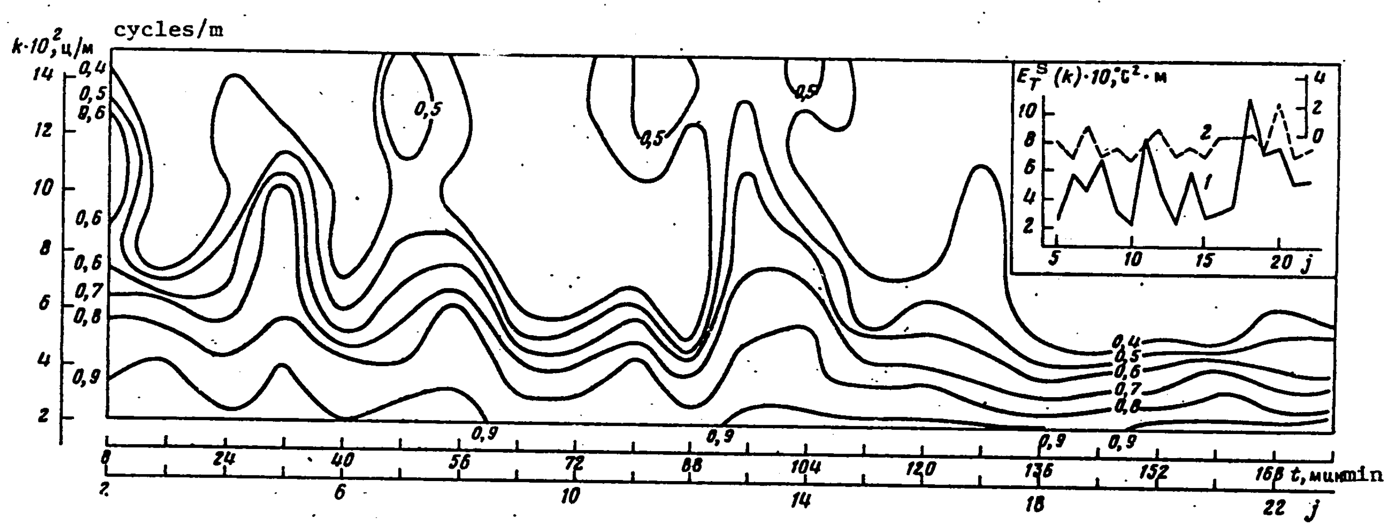

Fig. 3. Isolines of coherence F(k, t) of vertical profiles $T^s(z)$. In insert: change in levels of $E_T s$ spectra from sounding to sounding at scales k^{-1} = 25 m (1) and k^{-1} = 12.5 m (2).

sounding to sounding for temperature inhomogeneities with scales of 12.5 and 25 m is shown in the inset in Fig. 3. For individual time shifts (Δt = 8, 16,...,112 minutes) we determined pairs of soundings for which the difference in spectral levels exceeds the limits of the confidence interval, that is, can be deemed significant. This analysis did not reveal a tendency to an increase in the difference of spectral levels with an increase in the time interval between soundings.

Figure 3 shows isolines of the coherence F(k, t) of the vertical $T^s(z)$ profiles, computed relative to sounding 1, which indicate a rather weak temporal variability of large-scale inhomogeneities ($\ell_z > 17$ m). However, the F(k, t) values themselves in this range of scales are rather great and regularly decrease with an increase in the wave number. We note that the rather great dispersion of evaluations of coherence existing in computations with 25 degrees of freedom does not make it possible to consider the fluctuations of the F(k, t) isolines with small amplitudes to be significant. For inhomogeneities with scales less than 12-16 m there were coherence values exceeding the 95% zero level (F_0 = 0.4) only at individual moments in time. This effect can be associated with deformation of the vertical structure of the T(z) profiles at scales $\ell_z < 12$-16 m by internal waves. With such deformation there can be compression and dilatation of individual layers with subsequent restoration of the initial structure of the T(z) profile (naturally, with some residual deformation). We note that a clear increase in coherence at all scales, observed for sounding 13 (Fig. 3), corresponds to the moment of setting-in of the maximum value of the cross-correlation function $r_m(z_m)$ with a zero vertical shear z_m (see Fig. 1). Thus, the assumption of an appreciable influence of internal waves on the variability of coherence of temperature inhomogeneities is evidently justified.

Our fluctuation measurements made it possible to obtain information on the variability of microstructural temperature inhomogeneities in the range of scales ℓ_z from 1 to 70 cm. Naturally, it is impossible to trace the variability of individual elements of such microstructural inhomogeneities separated by time intervals of several tens of minutes (several hundred meters horizontally). Accordingly, we examined changes in the vertical profiles of the current mean square temperature fluctuations $s_{T'}(z)$, obtained by averaging the T'(z) profiles for a depth interval 1.4 m. Figure 1 shows the temporal change of the cross-correlation coefficient $r_{sT'}$, computed relative to sounding 1. A high value $r_{sT'}$ = 0.82 was maintained during the first 16 minutes. However, if it is taken into account that in these computations the 95% level of zero values of the correlation coefficient was equal to 0.23 [6], then virtually during the entire considered period (170 min) a correlation of the $s_{T'}(z)$ profiles significantly different from zero persisted.

Computations of the matrix of correlation coefficients $r_{sT'}$ for all the soundings gives some idea concerning the frequency of occurrence of different $r_{sT'}$ values and the possible maximum time intervals during which they can be observed. For example, the value $r_{sT'} \geqslant 0.8$ persisted for $s_{T'}(z)$ values separated by the maximum time interval t_m = 16 min and the probability P of appearance of $r_{sT'} \geqslant 0.8$ was 4.2%; P = 2.5% with $0.8 > r_{sT'} \geqslant 0.7$, t_m = 24 min; P = 5.8% for $0.7 > r_{sT'} \geqslant 0.6$, t_m = 40 min, P = 5.8% with $0.6 > r_{sT'} \geqslant 0.5$ and t_m = 1 hour 44 minutes.

The variability of the vertical profiles $s_{T'}^j(z)$ can be characterized by the variability of the mean weighted value $\tilde{s}_{T'}^j$, determined for each sounding j using the formula

[H = in(itial); K = fin(al)]

$$\tilde{s}^j_{T'} = \frac{1}{D^j} \int\limits_{z^j_{\text{н}}}^{z^j_{\text{к}}} s^j_{T'}(z)\, dz,$$

where $z_{in}{}^j$ and $z_{fin}{}^j$ are the initial and final depths of the considered layer in the thermocline, D^j is its thickness. The change in $\tilde{s}_{T'}(t)$ approximately agrees with the change in $z_m(t)$, which, as was noted above, can be associated with the passage of a relatively long-period wave disturbance. In this case the passage of the trough of such an internal wave ($z_m < 0$) led to a general decrease in the intensity of small-scale temperature fluctuations, whereas at the wave crest there was an appreciable increase in $\tilde{s}_{T'}$. Such a pattern of variability of $\tilde{s}_{T'}(t)$ can be attributable to the fact that at the crest of the long-period wave, as a result of the development of hydrodynamic instability, there is formation of short-period internal waves which also cause an increase in the intensity of small-scale fluctuations in the $s_{T'}(z)$ profiles. A definite confirmation of this is a mutual analysis of the change in $\tilde{s}_{T'}{}^j(t)$ and $\varkappa_{T'}{}^j(t)$, where $\varkappa_{T'}{}^j = d^j/D^j$ is the vertical coefficient of field intermittence T', d^j is the sum of the thicknesses of individual interlayers in which the $s_{T'}$ values exceed the doubled noise level $s_{T'}{}^n = 3 \cdot 10^{-4}$ °C. The mean $\tilde{s}_{T'}$ value was equal to $4.1 \cdot 10^{-3}$ °C, and $\bar{\varkappa}_{T'} = 0.69$, with standard deviations $\sigma_{\tilde{s}_{T'}} = 10^{-3}$ °C and $\sigma_{\varkappa_{T'}} = 0.08$. The cross-correlation coefficient between $\tilde{s}_{T'}$ and $\varkappa_{T'}$ had a rather high positive value, equal to 0.76. This means that an increase in $s_{T'}$ is associated with an increase in the layering of the $s_{T'}(z)$ profiles due to the formation of new layers earlier homogeneous with respect to T'. The reason for the formation of such interlayers may be the short-period internal waves arising on the crests of long waves, as was already noted, for example, in [17].

In conclusion, I express appreciation to R. V. Ozmidov for useful discussions and comments. Measurements on the voyage were made by specialists of the Special Design Bureau for Oceanological Thermometry at the USSR Institute of Oceanology under the direction of V. I. Fedonov.

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5303
CSO: 1865/136

COLLECTION OF ARTICLES ON MARINE NAVIGATION AND COMMUNICATION

Leningrad TRUDY TSENTRAL'NOGO NAUCHNOGO ISSLEDOVATEL'SKOGO INSTITUTA MORSKOGO FLOTA: SUDOVOZHDENIYE I SVYAZ' in Russian No 256, 1980 (signed to press 29 Apr 80) pp 107-110

[Table of contents and selected abstracts from the collection of articles "Transactions of the Central Scientific Research Institute of the Merchant Marine: Navigation and Communication", edited by Yu. I. Panin, Leningradskoye otdeleniye "Transport", 1672 copies, 111 pages]

[Text]

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UDC 629.12.053

LASER SYSTEMS FOR SUPPORTING THE TYING-UP OF SHIPS

[Abstract of article by Ignatovich, E. I.]

[Text] Concise information is given on systems for the support of tying-up of ships. The possibilities of creating laser systems for the tying-up of ships are considered as being the most promising. Figures 3, references 3.

UDC 629.12.053.13:550.380.84

ACCUMULATION OF DEVIATIONS CAUSED BY ERRORS IN SHAPING CORRECTION SIGNALS IN GYROSCOPIC COURSE INDICATORS OPERATED UNDER CONDITIONS OF HIGH-LATITUDE SHIP NAVIGATION

[Abstract of article by Filin, V. M.]

[Text] The article defines the errors in course indicators of the "Vega" type in course correction and gyroazimuth regimes. The experimentally measured course correction errors of the "Kurs-5" and "Vega" instruments are analyzed and compared when ships operate in latitudes 70...90°. The limiting latitudes for effective use of each gyroscopic course indicator operating regime are determined. Figures 4, tables 7, references 3.

UDC 621.391.822

SYNTHESIS OF AN ALGORITHM FOR DETECTION OF A PACKET OF FLUCTUATING SIGNALS AGAINST A BACKGROUND OF NOISE FROM THE SEA

[Abstract of article by Komissarov, G. F.]

[Text] An algorithm is given for the detection of fluctuating signals for a Gauss-ian-Markov model of noise which quite precisely takes into account the presence of the coherent component in echo signals from the sea surface. References 3.

UDC 396.676:629

FUNDAMENTAL PRINCIPLES FOR CONSTRUCTING WIDE-BAND ANTENNA APPARATUS

[Abstract of article by Mikhaylov, S. N.]

[Text] Different methods for broadening an antenna operating regime are given. It is shown that they are interrelated. The good possibilities of constructing SW wide-band antennas on the multivibrator principle are demonstrated. References 6.

UDC 621.677:629.12

GENERALIZED TEST FOR EVALUATING THE EFFECTIVENESS OF OPERATION OF SHIPBOARD ANTENNA APPARATUS

[Abstract of article by Vershkov, M. V. and Mirotvorskiy, O. B.]

[Text] An approach to a generalized evaluation of the effectiveness of shipboard antenna apparatus is formulated. The concept of "efficiency factor" is introduced. Examples of evaluation of the operation of shipboard medium- and short-wave antennas are given.

UDC 621.396.674.3

METHOD FOR DECREASING THE SIZE OF LOG-PERIODIC VIBRATOR ANTENNAS

[Abstract of article by Vershkov, M. V. and Mikhaylov, S. N.]

[Text] The authors discuss the possibility of constructing log-periodic antennas of reduced size when using loaded elements and the variable parameter τ. Formulas were derived and graphs are presented which make it possible to determine the necessary τ values for cases of capacitive and inductive-capacitive loads. A method is proposed for computing the geometry of a log-periodic antenna with loaded elements. Figures 5, tables 1.

UDC 621.372.837.621.382

INVESTIGATION OF MIXERS BASED ON DIODES WITH A SCHOTTKY BARRIER

[Abstract of article by Kostylev, O. P. and Li Za Son]

[Text] The paper gives the results of experimental investigations of different designs of annular mixers with Schottky diodes. Figures 7.

UDC 621.391.831

EXPERIMENTAL INVESTIGATION OF THE STATISTICAL CHARACTERISTICS OF PULSED NOISE

[Abstract of article by Arzumyan, Yu. V., Malakhov, L. M., Naumov, A. S. and Sokolov, B. P.]

[Text] The statistical characteristics of pulsed noise in real communication channels are given. The probability of error from the effect of pulsed noise in the reception of binary signals was determined. Figures 8, references 4.

UDC 621.391.837.019.4

NOISE IMMUNITY OF RECEPTION OF WIDE-BAND SIGNALS IN AUTOMATIC SUPPRESSION OF CONCENTRATED NOISE

[Abstract of article by Venskauskas, K. K. and Garbuzov, I. Z.]

[Text] A brief description is given for a method for the automatic suppression of concentrated noise in wide-band communication systems and an analysis of the noise immunity of this method is presented. Curves of the probability of errors under the influence of concentrated noise of different intensity are given. Figures 4, references 6.

UDC 621.391.887

TRANSFORMATION OF THE MULTISIGNAL EFFECT OF THE TOTALITY OF NOISE ON A RADIO RECEIVER INTO THE EQUIVALENT EFFECT OF ELEMENTARY SIGNALS

[Abstract of article by Li Za Son]

[Text] Formulas are cited for computing intermodulation selectivity and adjacent-channel selectivity. Expressions are derived which make it possible to determine the level of the components of cross-modulation and the transformed noise of heterodynes under the influence of sinusoidal noise on the receiver. Figures 4, tables 1, references 9.

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CSO: 1865/159

UDC 551.46

OCEANOGRAPHIC WORK IN POLAR REGIONS OF THE WORLD OCEAN

Leningrad OKEANOGRAFICHESKIYE RABOTY V POLYARNYKH RAYONAKH MIROVOGO OKEANA in Russian 1980 (signed to press 21 Oct 80) pp 2, 237-239

[Annotation and table of contents from book "Oceanographic Work in Polar Regions of the World Ocean" by Nikolay Ivanovich Blinov, Valentin Valentinovich Dremlyug and Vladimir Aleksandrovich Romantsov, Leningrad Gidrometeoizdat, 1000 copies, 240 pages]

[Text] Annotation

The book describes methods of oceanographic work in the polar regions of the World Ocean with the use of new technical equipment. The prospects of their improvement are examined.

Data are presented on estimating the precision of oceanographic measurements and the effectiveness of use of automated oceanographic complexes.

Methods of the computer processing of the results of oceanographic measurements are presented.

The theoretical principles and practical methods of planning oceanographic investigations are examined.

The book is intended for specialists in oceanology and persons engaged in ocean studies. It can be used as a textbook by students of hydrometeorological and marine engineering institutes and universities.

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CSO: 1865/183

UDC 532.528

HYDRODYNAMICS OF DEVELOPED CAVITATING FLOWS

Leningrad GIDRODINAMIKA RAZVITYKH KAVITATSIONNYKH TECHENIY in Russian 1980 (signed to press 28 May 80) pp 2, 235-237

[Annotation and table of contents from book "Hydrodynamics of Developed Cavitating Flows", by Aleksandr Nikolayevich Ivanov, Izdatel'stvo "Sudostroyeniye", 1000 copies, 240 pages]

[Text] An examination is made of particulars of the cavitation effect and artificial cavitating flows. An outline is given of theoretical principles of calculation of developed cavitating flows in nonlinear and linear formulations of problems. Particular emphasis is given to numerical methods of calculating planar and axisymmetric developed cavitating flows of imponderable and ponderable fluids, and also to the use of artificial cavitation for reducing hydrodynamic drag of ships. Major practical problems in the field of cavitation research are analyzed.

The book is intended for specialists in sector-wide scientific research and design organizations dealing with problems of cavitation, and may be of use to shipbuilding engineering students.

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UDC 528.7:330.15

AEROSPACE METHODS APPLIED TO RESOURCE EXPLORATION

Leningrad TRUDY GOSUDARSTVENNOGO NAUCHNO-ISSLEDOVATEL'SKOGO TSENTRA IZUCHENIYA PRIRODNYKH RESURSOV: NEKOTORYYE REZUL'TATY ISSLEDOVANIYA PRIRODNYKH RESURSOV S POMOSHCH'YU SAMOLETNYKH I POLIGONNYKH SREDSTV in Russian No 10, 1980 (signed to press 23 Oct 80) pp 2, 107

[Annotation and table of contents from book "Proceedings of the State Scientific Research Center for the Investigation of Natural Resources: Some Results of Investigation of Natural Resources by Airborne and Proving Ground Facilities", edited by Candidate of Physical and Mathematical Sciences N. K. Vinnichenko and Candidate of Technical Sciences A. P. Tishchenko, Gidrometeoizdat, 500 copies, 107 pages]

[Text] The papers included in this collection deal with studies of the characteristics of natural objects in research using flying laboratories and ground-based facilities.

An examination is made of some kinds of airborne equipment (multizonal aerial cameras and scanning devices), forms of primary processing and imaging of the materials of aerial photography.

A considerable place in the collection is given to the results of combined analysis of proving ground and aerospace data in studying agricultural objects by remote probing methods. The described results were obtained on the Kursk-Belgorod and Ryazan Proving Grounds. Problems of computer analysis of aerospace images are also discussed.

The collection is intended for specialists who deal with problems of using aerospace facilities to study natural resources.

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UDC 551.468

PROBLEMS OF MATHEMATICAL MODELING AND IN SITU STUDIES OF THE BALTIC SEA

Leningrad TRUDY GOSUDARSTVENNOGO OKEANOGRAFICHESKOGO INSTITUTA: VOPROSY MATEMATICHESKOGO MODELIROVANIYA I NATURNYKH ISSLEDOVANIY BALTIYSKOGO MORYA in Russian No 152, 1980 (signed to press 28 Oct 80) pp 2, 129

[Annotation and table of contents from book "Proceedings of the State Ocanographic Institute: Problems of Mathematical Modeling and in Situ Studies of the Baltic Sea", edited by Doctor of Geographic Sciences I. N. Davidan, Gidrometeoizdat, 510 copies, 129 pages]

[Text] The collection publishes the results of theoretical and in situ studies of hydrological processes that occur in the Baltic Sea. The articles contain new data on currents, fluctuations in level, wind-driven waves, water exchange with the North Sea, the influence of atmospheric processes on hydrological conditions, and the role of river runoff in formation of the salt balance.

The collection is intended for oceanologists, biologists and other specialists involved in scientific or practical work with the Baltic Sea.

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6610
CSO: 1865/173

TERRESTRIAL GEOPHYSICS

UDC 550.341,550.31

COLLECTION OF ARTICLES ON COMPUTERIZED STUDY AND ANALYSIS OF SEISMIC DATA

Moscow TEORIYA I ANALIZ SEYSMOLOGICHESKIKH NABLYUDENIY: VYCHISLITEL'NAYA SEYSMOLOGII in Russian No 12, 1979 (signed to press 30 Oct 79) pp 2, 189-191

[Annotation, table of contents and abstracts from collection of articles "Theory and Analysis of Seismological Observations: Computational Seismology", edited by V. I. Keylis-Borok, doctor of physical and mathematical sciences, Izdatel'stvo "Nauka", 1550 copies, 192 pages]

[Text] Annotation. This collection of articles is devoted to the application of modern mathematics and electronic computers in solution of problems in seismology and related disciplines. The articles describe the results of search for earthquake precursors and experimental long-range forecasting in several regions. Work has been continued on the application of recognition algorithms to the determination of places where strong earthquakes may occur. A series of studies is devoted to a determination of the earth's structure on the basis of body and surface waves and corresponding problems in the computation of theoretical seismograms. Long-period seismographs of a new type are described. The collection is of great scientific interest for a wide range of specialists in the field of global and regional seismology, geotectonics, automation of geophysical observations and seismic prospecting.

Contents

ABSTRACTS

UDC 550.341

RECOGNITION OF SITES OF POSSIBLE OCCURRENCE OF STRONG EARTHQUAKES. IX. ITALY. M$\geqslant$6.0

[Abstract of article by Gorshkov, A. I., Kaputo, M., Keylis-Borok, V. I., Ofitserova, Ye. N., Rantsman, Ye. Ya. and Rotvayn, I. M.]

[Text] A study was made of the possibility of predicting the site of earthquakes with M$\geqslant$6.0 in Italy on the basis of a map of morphostructural regionalization and a complex of geomorphological data using recognition algorithms. Figures 4, tables 7, references 16.

UDC 550.341

TWO LONG-RANGE PRECURSORS OF STRONG EARTHQUAKES

[Abstract of article by Keylis-Borok, V. I. and Rotvayn, I. M.]

[Text] The authors investigated the possibility of predicting strong earthquakes using two precursors: swarms of weak earthquakes and calm-activation in opposite segments of a lineament. A retrospective prediction of earthquakes with $M \geqslant 7.2$ is given for the territory of Anatolia, the Armenian Plateau and the Aegean Sea basin. Figures 7, tables 3, references 13.

UDC 550.341

DIFFERENT ALGORITHMS FOR DISCRIMINATING ANOMALOUS CHANGES IN NONCLOSURES OF P WAVES BEFORE STRONG EARTHQUAKES

[Abstract of article by Prozorov, A. G. and Sidorenko, T. V.]

[Text] Different variants of the choice of parameters for an algorithm for predicting the time of earthquakes are considered. The algorithms are based on the discrimination of the time t_ω -- the onset of a decrease in the velocity of P waves in the region of preparation of a future earthquake, that is, a systematic increase in nonclosures. Figures 3, tables 2, references 5.

UDC 550.341

ON ONE ALGORITHM FOR DETECTING MIGRATIONS OF STRONG EARTHQUAKES

[Abstract of article by Vil'kovich, Ye. V. and Shnirman, M. G.]

[Text] The article describes an algorithm for detecting linear migration, that is, the "movement" of the epicenters of earthquakes at a constant rate. The algorithm affords a method not only for finding the phenomenon, but also statistically validating the conclusion that the phenomenon is actually migration. References 3.

UDC 550.341

MASS DETERMINATION OF MECHANISMS OF EARTHQUAKE FOCI ON AN ELECTRONIC COMPUTER

[Abstract of article by Aptekman, Zh. Ya., Zhelankina, T. S., Keylis-Borok, V. I., Pisarenko, V. F., Poplavskaya, L. N., Rudik, M. I. and Solov'yev, S. L.]

[Text] A determination of the focal mechanism for 147 earthquakes in the Far East during the years 1974-1976 was made using an electronic computer. An evaluation of the reliability of determination of the focal mechanism is proposed in dependence on the configuration of the 85% confidence region in which the vector of displacement and the normal to the fracture plane lie. Figures 3, tables 2, references 6.

UDC 550.310

APPLICATION OF THE FOURIER METHOD TO THE EQUATION FOR STANDING SH WAVES IN A HALF-SPACE

[Abstract of article by Markushevich, V. M. and Reznikov, Ye. L.]

[Text] A study was made of the properties of steady harmonic torsional oscillations of a horizontally homogeneous elastic half-space. The Schlomilch transform establishes a mutually unambiguous correspondence between these oscillations and oscillations of an elastic membrane. Formulas are cited and the method for computing the oscillations is given. References 8.

UDC 550.341

PROPAGATION OF LOVE WAVES THROUGH A VERTICAL CONTACT OF TWO QUARTER-SPACES

[Abstract of article by Bukchin, B. G.]

[Text] A numerical method is given for computing the coefficients of reflection and transmission of a Love wave incident normally on the vertical contact of two horizontally homogeneous quarter-spaces. The field of displacements is represented in the form of superposing of the eigenfunctions of a differential operator and the problem is reduced to solution of an integral equation. Figures 5, tables 1, references 7.

UDC 550.341

NUMERICAL SOLUTION OF PROBLEMS IN WAVE DIFFRACTION IN SOME TYPES OF INHOMOGENEITIES

[Abstract of article by Bukchin, B. G. and Yanovskiy, A. K.]

[Text] The article describes a numerical method for solving problems related to the diffraction of acoustic waves in two-dimensional inhomogeneous media, the discontinuities in which satisfy the "conditions of orthogonality": at each point of the continuity the boundary is parallel to one of the coordinate axes. The method is based on a combination of expansion of the field in eigenfunctions of the section orthogonal to one of the coordinate axes (that is, the Thomson-Haskell method) with the Schwarz iteration method in a small region. The authors describe the results of application of the method to solution of the problem of diffraction of a scalar S-wave from a point source in an unbounded two-dimensional elastic medium for a dislocation of the "fractured layer" type. Figures 2, references 4.

UDC 550.341

REFLECTION AND REFRACTION OF SURFACE WAVES WITH SLANT INCIDENCE ON A VERTICAL INHOMOGENEITY

[Abstract of article by Ita, Ye. N. and Yanovskaya, T. B.]

[Text] Using an approximate method the authors derived formulas for the reflection and refraction coefficients for Rayleigh and Love surface waves in the case of slant incidence on a vertical discontinuity of media. Examined separately is the general case of contact of vertically inhomogeneous media and the contact of homogeneous quarter-spaces. Theoretical computations of the dependence of the reflection coefficient of a Rayleigh wave on the angle of incidence were compared with the results of ultrasonic modeling. Figures 1, references 4.

UDC 550.311

INSTABILITY AND GROWTH OF INITIAL PERTURBATIONS IN A SYSTEM OF TWO LAYERS OF A VISCOUS INCOMPRESSIBLE FLUID IN AN IDEALLY FLUID HALF-SPACE

[Abstract of article by Naymark, B. M.]

[Text] Explicit formulas are derived for approximating the growth of initial perturbations in a system of two layers of a viscous incompressible fluid in an ideally fluid half-space. The wave lengths for which the instability is manifested to the maximum degree were determined. Computations were made giving an evaluation of the rate of growth of the initial perturbations in a system with a density inversion. The results of these computations are given. Figures 4, references 5.

UDC 550.341

ASYMPTOTIC INVERSION OF THE FREQUENCIES OF THE EARTH'S NATURAL OSCILLATIONS

[Abstract of article by Belyayev, A. V. and Brodskiy, M. A.]

[Text] The article gives an algorithm for approximating monotonic curves by polynomials. This algorithm was used in asymptotic solution of the inverse and direct problems related to the earth's natural oscillations. Figures 7, references 5.

UDC 550.31

USE OF REFLECTED WAVES WITHIN THE FRAMEWORK OF THE τ-METHOD

[Abstract of article by Molchan, G. M.]

[Text] The inverse kinematic problem in seismology is examined for a horizontally homogeneous medium. The tau method is supplemented by the linear programming method for more complete use of the travel-time curves of reflected waves. Examples of computations are given. Figures 2, tables 2, references 10.

UDC 550.34.012

NOISE OF VERTICAL LONG-PERIOD SEISMOMETERS. METHODS FOR ITS REDUCTION

[Abstract of article by Kolesnikov, Yu. A. and Matsiyevskiy, S. A.]

[Text] The origin of seismic noise on the records of long-period vertical seismographs is examined. The authors describe the mechanism of appearance of noise of a vertical seismometer. An analysis of existing methods for suppressing the noise of long-period vertical seismometers is presented. Figures 21, tables 1, references 15.

UDC 550.344

CHARACTERISTICS OF THE RAY PROPAGATION OF WAVES IN A MODEL OF THE UPPER MANTLE CONTAINING A ZONE OF PLUNGING OF THE LITHOSPHERE

[Abstract of article by Azbel', I. Ya., Gobarenko, V. S. and Yanovskaya, T. B.]

[Text] Computations of rays in a three-dimensional model of the upper mantle are given. The model contains a zone of strong horizontal inhomogeneity in a region of plunging of a lithospheric plate. The wave velocity was assumed to be dependent on two coordinates. In azimuths close to the direction of the axis of structure strike there is a strong horizontal refraction of rays, which can lead to the appearance of a shadow zone in some interval of azimuths. Figures 3, references 7.

UDC 550.31

COMPUTER APPLICATION OF AN ALGORITHM FOR USE IN CONSTRUCTING THE REGION OF ADMISSIBLE VELOCITY SECTIONS BY THE τ-METHOD

[Abstract of article by Bessonova, E. N., Reznikov, Ye. L., Sitnikova, G. A. and Fishman, V. M.]

[Text] An ALGOL program for a BESM-4 electronic computer, making use of an algorithm for solving the inverse problem in geometrical seismics by the τ-method, is described. The method for application of the program is illustrated in a model example of deep seismic sounding. Figures 4, tables 1, references 6.

UDC 550.341

D-WAVES AND EARTHQUAKES

[Abstract of article by Guberman, Sh. A.]

[Text] The article gives the hypothesis and corresponding data on the existence of perturbations (D-waves) propagating along meridians with a constant velocity of

0.15° per year and constituting the triggering mechanism for strong earthquakes. One of the corollaries of this hypothesis is the existence of a discrete grid of latitudes in which there can be strong earthquakes. Figures 20, tables 12, references 28.

5303
CSO: 1865/145

COLLECTION OF PAPERS ON GEOTHERMY

Makhachkala TRUDY VSESOYUZNOY KONFERENTSII "NARODNOKHOZYAYSTVENNYYE I METODICHESKIYE PROBLEMY GEOTERMII": TEPLOVOYE POLE ZEMLI: METODY GEOTERMII in Russian Vol 2, 1979 (signed to press 24 Dec 79) pp 2, 134-135

[Annotation and table of contents from collection of articles "Transactions of the Conference 'National Economic and Methodological Problems in Geothermy': The Earth's Heat Field: Methods in Geothermy", edited by Ye. A. Lyubimova, doctor of physical and mathematical sciences, et al., Dagestanskiy filial AN SSSR, Gosplan DASSR, 500 copies, 136 pages]

[Text] Annotation. This collection of articles, prepared using materials and data from the conference "National Economic Problems in Geothermy," includes articles devoted to such fundamental problems in geothermy as the thermophysical properties of rocks, prediction of deep temperatures, the nature of geothermal anomalies and heat sources. Many of the papers are devoted to the use of the newest geothermal methods for the search for and exploration of minerals in three variants: land, sea and remote, in different geological regions of the USSR. The collection of articles is intended for a wide range of specialists working in the earth sciences.

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CSO: 1865/149

UDC 550.34

PAPERS ON METHODS AND ALGORITHMS FOR INTERPRETATION OF SEISMIC DATA

Moscow METODY I ALGORITMY INTERPRETATSII SEYSMOLOGICHESKIKH DANNYKH: VYCHISLITEL'NAYA SEYSMOLOGIYA in Russian No 13, 1980 (signed to press 12 Dec 80) pp 2, 191, 193-195

[Annotation, table of contents and selected abstracts from collection of articles "Methods and Algorithms for the Interpretation of Seismological Data: Computational Seismology", edited by V. I. Keylis-Borok, doctor of physical and mathematical sciences, and A. L. Levshin, doctor of physical and mathematical sciences, Izdatel'stvo "Nauka", 1150 copies, 196 pages]

[Text] Annotation. The articles describe algorithms and experience in predicting the site and time of very strong earthquakes in a number of seismically active regions of the world. The global and regional migration of the epicenters of strong earthquakes was investigated. New methods for solution of direct and inverse problems in seismology, including at the boundaries of the continents, are examined. An improved statistical method for suppressing seismic noise in multidimensional observation systems is described. The collection of articles is of interest to geologists, geophysicists and engineers concerned with problems involved in the prediction of earthquakes, seismic danger, study of the internal structure of the earth (theory and interpretation of data), and also statistical methods for the suppression of noise.

Contents

Selected Abstracts

UDC 550.341.2

RECOGNITION OF SITES OF OCCURRENCE OF VERY STRONG EARTHQUAKES IN THE PACIFIC OCEAN ZONE ($M \geqslant 8.2$)

[Abstract of article by Gvishiani, A. D., Zelevinskiy, A. V., Keylis-Borok, V. I. and Kosobokov, V. G.]

[Text] The general indicators of the sites of occurrence of very strong ($M \geqslant 8.2$) earthquakes in the Pacific Ocean zone were determined. The indicators were selected in the eastern part of the zone by applying the teaching principle. Their reliability was checked by transfer to the western part of the zone. The results of use of several different recognition algorithms virtually coincide. A total of 45% of the length of the Pacific Ocean zone is assigned to sectors with low seismicity where earthquakes with $M \geqslant 8.2$ are impossible. Figures 5, tables 2, references 20.

UDC 550.341

EFFECTS OF REFLECTION AND REFRACTION OF LOVE WAVES AT THE OCEAN-CONTINENT DISCONTINUITY (COMPUTATIONS)

[Abstract of article by Bukchin, B. G.]

[Text] The paper describes the method used and the results of computations of theoretical seismograms of displacements arising with the normal incidence of a nonstationary Love wave on the vertical discontinuity of two horizontally homogeneous media. Figures 7, references 3.

UDC 550.344

METHOD FOR COMPUTING GEOMETRICAL DIVERGENCE IN A THREE-DIMENSIONALLY INHOMOGENEOUS MEDIUM

[Abstract of article by Azbel', I. Ya., Dmitriyeva, L. A. and Yanovskaya, T. B.]

[Text] The authors examine possible methods for computing geometrical divergence in three-dimensionally inhomogeneous media with curvilinear smooth discontinuities. As a result of computer testing of different methods it was possible to propose the most economical computation scheme for solution of a system of differential equations describing the ray and geometrical divergence. References 17.

UDC 550.34

NEW SYSTEM OF EQUATIONS FOR COMPUTING GEOMETRICAL DIVERGENCE

[Abstract of article by Grinfel'd, M. A.]

[Text] Using the formal approach of covariant time differentiation of tensors determined on a moving surface it was possible to derive a system of ordinary differential equations making possible the simultaneous computation of the ray and geometrical divergence in a three-dimensional inhomogeneous medium. References 10 10.

UDC 550.341

DISPERSION AND ABSORPTION OF ELASTIC WAVES IN ROCKS

[Abstract of article by Levshin, A. L., Ratnikova, L. I. and Saks, M. V.]

[Text] The authors examine the possibilities of applying the G. I. Gurevich theory in describing phenomena occurring during the propagation of seismic waves in absorbing media. Computations of the velocities and decrements of absorption of longitudinal and transverse waves as functions of frequency were made for different rocks. The influence of absorption on the spectral characteristics of body waves registered at the free surface of unconsolidated ground is demonstrated. Figures 3, tables 3, references 16.

UDC 550.341

CHARACTERISTICS OF STRUCTURE OF THE EARTH'S CRUST IN THE SOUTHERN PART OF THE BARENTS SEA SHELF BASED ON SURFACE WAVE DATA

[Abstract of article by Levshin, A. L. and Bertossen, K.-A.]

[Text] A geophysical interpretation of observations of surface waves intersecting the southern part of the Barents Sea was made. There was found to be an anomalously thick low-velocity stratum in the upper part of the earth's crust and a number of vertical discontinuities between individual crustal blocks. Figures 2, tables 1, references 18.

UDC 519.2.550.341

NOISE COMPENSATION IN MULTIDIMENSIONAL GEOPHYSICAL OBSERVATIONS. I. THEORY AND METHOD OF DATA PROCESSING

[Abstract of article by Kushnir, A. F., Pisarenko, V. F. and Rukavishnikova, T. A.]

[Text] A method for compensating additive noise in multidimensional geophysical observations is examined. A recurrent procedure for computing the coefficients of an optimum predicting filter by means of which the compensation is accomplished is generalized for a multidimensional case. References 3.

UDC 550.341

DIGITAL FILTERING WITH ADDITIONAL LIMITATIONS

[Abstract of article by Diasamidze, G. N. and Pisarenko, V. F.]

[Text] The problem of digital filtering with additional limitations on the frequency characteristic of the filter is examined. The limitations ensure suppression of the polynomial trend, the suppression of interfering harmonics and the nondistortion of the harmonics of interest. A method is described for computing the coefficients of the above-mentioned digital filters. References 4.

UDC 550.340

USE OF NONLINEAR POLARIZATION FILTERS FOR DISCRIMINATING EXCHANGE WAVES FROM DISTANT EARTHQUAKES

[Abstract of article by Mikhaylova, N. G.]

[Text] The results of testing of nonlinear polarization-energy filters for discriminating exchange waves with "Zemlya" seismic stations are discussed. The methods of polarization-energy filtering are based on the use of decision functions dependent on the direction of arrival and type of wave polarization. It is shown that the use of polarization-energy filters makes possible the reliable discrimination of exchange waves in subsequent arrivals on the records of distant earthquakes. Figures 4, references 12.

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CSO: 1865/146

UDC 550.34

MEASUREMENTS OF LOW-FREQUENCY ACCELERATIONS

Moscow IZMERENIYA NIZKOCHASTOTNYKH USKORENIY in Russian 1981 (signed to press 18 Dec 80) pp 2, 4-7, 106-107

[Annotation, introduction and table of contents from book "Measurements of Low-Frequency Accelerations" by Vladimir Borisovich Dubovskoy, USSR Academy of Sciences, Order of Lenin Institute of Geophysics imeni O. Yu. Shmidt, Izdatel'stvo "Nauka", 800 copies, 108 pages]

[Text] Annotation

The monograph is devoted to the designing, certification and application of accelerometers of low and ultrahigh frequencies. The main sources of error and methods of eliminating them are discussed. New instruments are described: the accelerometer, the electrolytic tiltmeter, the marine gravimetric complex, the marine gravimeter and a prototype of a stationary gravimeter.

The book is intended for specialists in the area of geophysics and measurement technology.

Introduction

In an overwhelming majority of cases the measurement of accelerations can be reduced to measurement of a periodic process with a given length. During measurement of acceleration of the force of gravity by an instrument on a mobile base (an ocean vessel or aircraft), variations of the vector of the force of gravity are registered with periods dependent on the spatial distribution of anomalies of the force of gravity and the velocity of the mobile base of the instrument.

Instruments of gravity-inertial navigation record accelerations with a period of the order of magnitude of the time interval between reference points. The natural vibrations of the earth and tectonic motion are registered in a wide range of frequencies at fixed stations.

In all the above-cited examples we encounter measurement of low-frequency and ultrahigh frequency accelerations, or infra-accelerations.

Let us examine the most important areas requiring the use of highly sensitive sensors of infra-accelerations.

The elastic reaction of the earth to an earthquake or explosion can be represented in the form of free oscillations with very low harmonics, with a period of 53 minutes. Of great geophysical interest is analysis of the residual fields of strains, displacements and inclinations caused by earthquakes, and also the dynamics of those fields as a manifestation of tectonic processes of strain accumulation. The improvement of the apparatus registering the dynamics of those fields can make a substantial contribution to the analysis of the mechanism of earthquakes, to their prediction and to the analysis of volcanism and orogenic movements.

The seismology of infrafrequencies presents very high requirements for apparatus being designed: determination of residual fields under the conditions of strong disturbances of the source, elimination of the influence of temperature and atmospheric pressure and high temporary stability during periods of several minutes to several years.

Gravity anomalies over oceans can be obtained by satellite observations which characterize the gravitational field of the earth in the form of an expansion in spherical functions of up to the 12th order of magnitude. In studying the higher harmonics of the gravitational field it is necessary to draw in marine gravimetric surveys.

Analysis of gravity anomalies is irreplaceable in estimating the thicknesses of any layers in the upper mantle with anomalous density in those regions where the crust thickness and the velocities in the mantle were determined preliminarily by seismic methods. To solve that problem, at the present time the question arises of creating high-precision gravimetric apparatus with small dynamic errors and the derivation of information directly on machine carriers.

An important source of information about the internal structure of the earth is experimental data on variations of the force of gravity caused by tidal forces, that is, that information permitted selecting the best from all models of our planet obtained by seismic methods [1].

Phase lag of earthly tides permits making a judgment of the rheological properties of the body of the earth.

Increase of the precision of registration of tidal variations and concentration of the tidal station network increase the precision of determination of the δ factor and give information about horizontal heterogeneities in the earth's mantle to considerable depths.

Anomalies in the recordings of earthly tides of both horizontal pendulums and gravimeters when the station precision and density are inadequate can serve as a key for interpretation of the block structure of the earth's crust. Tomashek [10] connects those regional effects with movement of tectonic blocks.

Many interesting effects connected with irregularity of the rotation of the earth, described by N. N. Pariyskiy [2], can be accompanied by noticeable variations of the force of gravity.

Study of the secular deceleration of the rotation rate leads to the conclusion that the reasons for deceleration of rotation of the earth (lunar and solar tides) are known and the reason for acceleration of the earth's rotation by 10^{-5} s/year is unknown. According to [2] it cannot be caused by known "external" causes and is connected rather with variation of the moment of inertia. On the assumption of compression of the earth without change of mass and distribution of density this would lead to change of the planet's radius with a velocity of 0.45 mm/year and of the value of the force of gravity on the surface of $0.14 \cdot 10^{-9}$ g/year.

The rate of irregular changes of the rotation rate can reach values two orders of magnitude larger than the secular deceleration. On the basis of Brown's hypothesis [3] N. N. Pariyskiy examined [2] possible changes inside the earth which can cause that phenomenon and made it clear which changes of the force of gravity on the surface of the planet will accompany that. Without presenting that analysis in detail, we will present only its results. For spherically symmetric strains the changes of the earth's radius amount to 43 to 12 cm for a variable layer of 0.99 to 0.55 earth radius, which corresponds to variation of the force of gravity on the surface of 0.13 to $0.04 \cdot 10^{-6}$ g. During strain distribution (according to a second-order spherical function) for a thickness of the variable layer of 27 m with increasing density by 0.1 g/cm^3 at a depth of 380 km the earth radius change is 0.8 m and the corresponding change of the force of gravity of $0.25 \cdot 10^{-6}$ g. Consequently, small variations at depths of the earth can be registered by high-sensitivity gravimeters. But if irregular rotation of the earth is caused by geological or tectonic features of the structure of the earth's crust, it is described by spherical functions of a higher order and can lead to still greater variations of the force of gravity in time.

Another area of investigations in which the gravimetric method can be used as one of the most sensitive with a largeyield is study of the structure and contemporary movements of the earth's crust, the amplitudes of which are fairly high and can be registered with modern instruments. The velocities of vertical movements fluctuate from 2-3 mm/year in quiet zones to 10-15 cm/year in the seismically very active. For example, the rate of upthrust of Scandinavia according to levelling data amounts to 9-10, at Garm to 16-100 and at the Alma-Ata polygon 50 mm/year.

Darwin assumed that with increase of the precision of tidal and barometric observations it would be possible to estimate the mean shear modulus of the upper part of the earth's crust. According to his computations, fluctuations of pressure of 50 mm Hg can incline the lithosphere sufrace by 0.012", which must be accompanied by change of the force of gravity of 1 to $2 \cdot 10^{-9}$ g. Proofs of the role of active faults in depressions of the earth's crust were obtained by Nishimura. In his investigations the indirect effects were so large in comparison with the direct that the character of the reaction of the earth's crust to them gives interesting information about the microstructure of upper layers of the crust [4].

Besides the registration of tides, of extraordinary interest is interpretation of the instrument drift curve, obtained by Pertsev's method and providing information about sagging of the soil under the effect of overloadings of water masses; of still greater interest is the possibility of registering movement of inaccessible masses, for example, during volcanic events.

To measure strain field dynamics as a manifestation of tectonic processes of elastic energy accumulation it is necessary to use continuous gravimeters, tiltmeters and deformographs, with sufficiently high sensitivity and, what is the main thing, extraordinary stability of zero. The same instruments can be a source of information about residual strain fields. These two questions are extremely important in the analysis of orogenic movements of volcanism and the mechanism of earthquakes, which can help greatly in earthquake prognosis [5].

Observations of the volcano Aso in Japan before and during eruptions show changes of up to 150°. Nishimura et al [6] registered variations in ground inclinations simultaneously at stations hundreds of kilometers apart immediately before earthquakes with an amplitude of 0.03", which ought to be accompanied by change of the force of gravity by a minimum of $(2\text{-}3)\cdot 10^{-9}$ g.

For the registration of relatively slow tectonic vertical movements of 1 to 10 mm/year a fixed gravimeter ought to have a sensitivity of $(1\text{-}2)\ 10^{-10}$ g and a stability of not worse than $3\ 10^{-9}$ g/year.

Much work is now being done, mainly in the readily accessible regions of the Soviet Union (the Crimea, the Russian platform, etc), on the determination of relative variations of the force of gravity [10], but those measurements are being made episodically and without adwquate precision, in the best case $(2\text{-}3)\cdot 10^{-8}$ g, which in displacements amounts to 7-10 mm. It is necessary to develop apparatus of a higher class to solve extremely important questions regarding the connection between observed strains of the earth's crust and seismic phenomena and study of the mechanism of earthquakes and the nature of fault formation.

Connected directly with gravimetry is a number of key questions of theoretical physics, in particular, one of the important questions of the general theory of relativity--verification of the stability of the gravitational constant on the level of 10^{-10} to 10^{-11}/year [17]. Verification apparently is impossible without condiserable improvement of the precision of registration of both tidal variations of the force of gravity and of the absolute value and without drawing in additional information on variations of the mean earth radius and effects caused by them.

Thus, when resolution has been increased and there is long-term stability of the zero point of static gravimeters, possibilities are opened up for the study of phenomena both interesting in themselves and helping to solve questions connected with many areas of geophysics and physics.

Refinement of the model of the earth's internal structure; study of the structure and rheological properties of the crust and upper mantle; vertical displacements of the surface in the epicentral zone as precursors of earthquakes and eruptions of volcanoes; large-scale strains connected with convections in the mantle, phase transitions and variations of the earth radius and its rotation rate; stability of the gravitational constant and an indisputably large number of practical problems--this is an incomplete list of questions awaiting their solution by means of static gravimeters.

Measurement of low-frequency acceleration is of great importance for the solution of many important practical problems, above all in the creation of inertial navigation systems. They are based on the connection, known from mechanics, between accelerations, velocities and the coordinates of moving bodies, consisting of the fact that the velocity is an integral of the acceleration and the travelled path characterizing the coordinates of a body is an integral of the velocity. Thus by measuring the acceleration with which an object moves from the moment of start of motion, and making a double integration of the acceleration, it is possible to find the travelled path in relation to the earth and, consequently, the coordinates of the object.

The prospects of inertial navigation systems are determined mainly by their complete autonomy and an absence of connection with the external world in the determination of current coordinates of the object. In those systems very high requirements are presented for linearity of the acceleration sensors and precision of determination of the absolute values of their sensitivity.

A multiplan program of space research includes as an inseparable part of most experiments the measurement of microaccelerations of orbital stations and satellites. In a number of cases a maximum sensitivity of 10^{-12} to 10^{-11} g must be achieved [8].

The solution of the technical and scientific problems under consideration involves both considerable improvement of the principal technical characteristics of existing acceleration sensors and the development of methods of providing them with a methodology which represent an independent large area of research.

CONTENTS

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CSO: 1865/182

UDC 550.34

COLLECTION OF ARTICLES ON SEISMIC INSTRUMENTS

Moscow INSTRUMENTAL'NYYE SREDSTVA SEYSMICHESKIKH NABLYUDENIY: SEYSMICHESKIYE PRIBORY in Russian No 13, 1980 (signed to press 20 Oct 80) pp 2, 175-184

[Annotation, table of contents and abstracts from collection of articles "Instrumental Means for Seismic Observations: Seismic Instruments", edited by Ye. S. Borisevich, doctor of technical sciences, and D. P. Kirnos, doctor of physical and mathematical sciences, Izdatel'stvo "Nauka", 750 copies, 184 pages]

[Text] Annotation. This collection includes articles devoted to a description of new instruments for the registry and processing of seismic data. The problems involved in the methodology and implementation of observations are considered, as are the metrological requirements on registry systems. The collection of articles is intended for workers in the seismic services, seismologists, geophysicists and specialists in the field of geophysical instrument making.

Contents

Abstracts

UDC 550.34

SEISMOMETRIC CONTACT CONVERTER

[Abstract of article by Rykov, A. V.]

[Text] Among the parametric converters operating on displacement of a seismometer pendulum is a contact converter whose variable parameter is the conductivity of the contact of two conductors which changes in a jump from 0 to ∞. One contact is connected to the pendulum and the other is connected to the seismometer base. By means of an electric circuit in which there are negative feedbacks for the displacement and velocity of movement of the pendulum, the latter is imparted autovibrations at a high frequency and with a low amplitude during which there is an alternate closing and opening of the contacts and accordingly there is pulse-width modulation of pendulum displacements. The converter circuit, in which there is no electronic amplification, gives a response for ground accelerations in the range 0.1-10 W/gal, depending on the parameters of the mechanical part of the seismometer and the nature of the displacement feedback. Figures 3, references 4.

UDC 550.34

STKS SYMMETRIC THREE-COMPONENT ELECTRODYNAMIC SEISMOMETER

[Abstract of article by Shnirman, G. L.]

[Text] The article examines some design and structural characteristics of a symmetric three-component electrodynamic field seismic detector, the STKS, ensuring a high stability and identity of the technical specifications of individual components of each instrument and a series of instruments corresponding in their standard certificate values within the limits of accuracy class 2%. Figures 7, references 5.

UDC 550.34

MULTICHANNEL SEISMOGRAPHS WITH GALVANOMETRIC REGISTRY

[Abstract of article by Mysh, A. G.]

[Text] The author gives the derivation and a brief analysis of the transfer functions and frequency characteristics of seismographs with n degrees of freedom of different configuration using the same converter. It is shown that seismographs with in-series and in-parallel types of channels are described by a common transfer function which includes the ratio of the transfer function of the tied-in seismograph to the product of the transfer functions of galvanometer units without a tie-in, other than the galvanometer unit for the considered channel. Figures 3, references 8.

UDC 550.34

N-052 SEISMIC ENGINEERING STATION

[Abstract of article by Kuchinskiy, Yu. M., Sil'yanov, Yu. M. and Fridman, A. A.]

[Text] A 14-channel station with magnetic FM-registry and intermediate storage of signals on a magnetic drum is described. The station is intended for the registry of local and close earthquakes and can be used under stationary and expeditionary conditions. Figures 18, tables 1.

UDC 550.34

AUTOMATED ENGINEERING-SEISMOMETRIC SERVICE OF THE CHARVAKSKAYA DAM

[Abstract of article by Kvashin, Ye. V., Plotnikova, L. M. and Tilyavoldiyev, U. T.]

[Text] The validation, structure and description of the functional diagram of the automated engineering-seismometric service of the Charvakskaya dam are given. The service is a system consisting of a measuring (23 observation points) communication registry complex, a signaling system and telemetric monitoring of the performance of seismometric channels. The range of observations and registry is 120 db in the frequency band 0.6 20 Hz. There is a centralized standby registry regime. The registry method is digital with data processing on an electronic computer. The format for the registry of information in the system is similar to that adopted in the STsR system. Reproduction of records and input into an electronic computer can be accomplished using the apparatus developed for STsR magnetograms. Figures 3, references 3.

UDC 550.34

RECORDER OF SEISMIC SHOT WAVES ON A MAGNETIC DRUM

[Abstract of article by Dvoyeglazov, Yu. B. and Sergeyev, V. M.]

[Text] The article describes a recorder of seismic shot waves employing a magnetic drum. The authors have determined and computed the principal design parameters of the magnetic drum and the system for the aerodynamic suspension of the magnetic heads. A block diagram of the recorder is given and the requirements imposed on the radioelectronic channel are outlined. Also given are the experimental results of development of the magnetic drum and the radioelectronic channel. It is shown that the use of magnetic recording makes it possible to create a multichannel small-size recorder meeting the requirements of registry of a broad class of seismic shot processes in a frequency band of several hundred KHz ensuring the possibility of automatic processing of the measurement results. Figures 7, references 2. 2.

UDC 550.34

SOME USES OF WIDE-BAND MULTICHANNEL REGISTRY OF SEISMIC SHOT WAVES ON A MAGNETIC DRUM

[Abstract of article by Dvoyeglazov, Yu. B. and Sergeyev, V. M.]

[Text] The authors examine a scheme for the registry of shot waves at different points in an investigated area on a magnetic drum with the transformation of multichannel registry into one periodic process. A scheme for the registry of a single process with a duration equal to the duration of registry of one channel, multiplied by the number of channels with output of this process in a periodic form, is considered. On the basis of the Shannon theorem on the limiting capacity of a channel and the Kotel'nikov theorem on potential noise immunity it was possible to obtain the limiting values of the threshold for frequency-modulated magnetic recording from one side band. Figures 5, references 2.

UDC 550.34

DIGITAL-ANALOG CONVERTER UNIT

[Abstract of article by Grebenchuk, G. S.]

[Text] The article is devoted to a description of the instrumental application of an algorithm for the processing of a digital code for the registry of parallel coded signals by means of narrow-band frequency manipulation and the formation of frequency-separated recording-reproduction channels in one track of a magnetic tape. Figures 3, references 2.

UDC 550.34

DYNAMIC STORAGE SYSTEM FOR GEOPHYSICAL INSTRUMENTS

[Abstract of article by Grebenchuk, G. S.]

[Text] This article is devoted to the use of operational memory units in geophysical recording apparatus. Different types of signal accumulators and delay lines are examined. The design of a dynamic storage system based on annular shifting registers is described and its characteristics are presented. Figures 3, references 4.

UDC 550.34

UNIT FOR CONVERSION OF ANALOG RECORDS OF SELF-CONTAINED BOTTOM SEISMIC STATIONS INTO DIGITAL FORM WITH REGISTRY BY A DIGITAL MAGNETIC RECORDER IN THE YeS COMPUTER FORMAT

[Abstract of article by Bodyagin, A. M., Karman, V. P., Karp, B. Ya., Smolin, V. Ye., Sudakov, A. V. and Chaptsov, R. P.]

[Text] A unit for the conversion of analog signals into digital form in the format of the YeS electronic computer is described. It is adapted to the peculiarities of registry of analog information on the magnetic recorders of self-contained bottom seismic stations. The unit makes it possible to register on a digital magnetic recorder, in the format of the YeS electronic computer, the signals registered in the self-contained bottom seismic station at two levels with a dynamic range of 60 db in three signal channels. The quantization frequency in the unit is fixed by the repetition rate of the synchronizing pulses registered by the magnetic recorder of the self-contained bottom seismic station. This makes it possible to decrease the error associated with the nonuniformity of the rate of movement of the magnetic tape during registry and reproduction. Figures 1.

UDC 550.34

USE OF MATERIALS ON THE BASIS OF ANTIMONY SULFOIODIDE IN PIEZOELECTRIC SEISMOMETERS

[Abstract of article by Arakelyan, G. K., Lyakhovitskaya, V. A., Spitsyna, V. D. and Fremd, V. M.]

[Text] The authors examine the results of an experimental determination of the principal electrophysical parameters of ferroelectric crystalline materials on the basis of SbSI. High values of the spatial piezoelectric modulus and extremely low values of the transverse piezoelectric moduli make it possible when using these materials to create small piezoelectric seismometers with a near-zero transverse response. The peculiarities of possible use of materials based on SbSI in piezoelectric seismometers are considered. Figures 2, tables 2, references 3.

UDC 550.34

METHODS AND SOME RESULTS OF TESTS OF SSRZ-M ACCELEROGRAPHS

[Abstract of article by Kirnos, D. P., Davydov, V. I., Zabelin, M. V., Levin, A. I., Manokhin, A. Ye. and Potapov, S. M.]

[Text] The article gives a brief description of methods for determining the principal parameters (conversion factor, frequencies of characteristic oscillations, attenuation constant, level of starter triggering, time mark values) and characteristics (linearity, transverse response) of SSRZ-M accelerographs. The principal results of accelerograph tests are given. Figures 8, tables 3, references 3.

UDC 550.34

DETERMINATION OF THE POSSIBILITY OF USING ZINC OXIDE ELECTROPHOTOGRAPHIC PAPERS (TYPE EFP-1) IN ELECTROGRAPHIC LIGHT-RAY OSCILLOGRAPHS WITH A STANDBY OPERATING REGIME

[Abstract of article by Begushin, G. K., Borisevich, Ye. S., Mosygina, M. S. and Tsyganov, V. M.]

[Text] The authors give the results of tests of models of Soviet (type EFP-1) and foreign special papers in an N-001 electrographic oscillograph and it is shown that they can be used in the instrument during its operation in a standby regime. References 5.

UDC 550.34

EXPERIMENTAL INVESTIGATION AND COMPUTATION OF AN AERODYNAMIC SUPPORT FOR A MAGNETIC RECORDER OF SEISMIC SHOT WAVES

[Abstract of article by Dvoyeglazov, Yu. B. and Sergeyev, V. M.]

[Text] A method for experimental investigation of an aerodynamic support element for a magnetic recorder of seismic shot waves is presented. Experimental and computed characteristics are given and these make it possible to select the principal construction dimensions of the magnetic drum and suspension for the magnetic heads. Figures 2, references 1.

UDC 550.34

CHOICE OF PARAMETERS OF RADIOTELEMETRIC SYSTEMS FOR SEISMOMETRIC PURPOSES

[Abstract of article by Gavrilov, V. A.]

[Text] The problems involved in choice of the type of radiotelemetric system for the network for collection of seismic information are discussed. The author analyzes the possibility of using a FM-FM system containing input amplifiers with a functional amplitude characteristic and demodulators of subcarrier frequencies with phase-type AFC. Graphs are given for choice of the optimum parameters of the FM-FM system. Figures 2, references 6.

UDC 550.34

ANALYSIS OF SOME CHARACTERISTICS OF SEISMOLOGICAL INFORMATION AND METROLOGICAL REQUIREMENTS ON REGISTRY SYSTEMS

[Abstract of article by Aranovich, Z. I., Melamud, A. Ya., Negrebetskiy, S. A., Trapeznikov, N. L. and Kushnir, G. S.]

[Text] The dynamic and frequency ranges of seismological information in the near ($K \leqslant 13$) and teleseismic ($M = 4-8$) zones are evaluated. On the basis of the collected data and information on the mean frequency of occurrence of earthquakes of different type and duration of their registry it was possible to evaluate the volume and intensity of flows of digital information created by the automated field system in the prognostic polygon. Also considered are the comparative possibilities of four methods for the telemetric transmission of information. Figures 1, tables 5, references 11.

UDC 550.34

METHOD FOR INCREASING RELIABILITY OF PULSED CALIBRATION OF COMPLEXLY STRUCTURED SEISMOMETRIC CHANNELS

[Abstract of article by Aranovich, Z. I., Melamud, A. Ya., Gomzyakova, E. S., Pleshinger, A. and Khoralek, I.]

[Text] In order to increase the reliability of pulsed calibration of complexly structured seismometric channels use was made of the procedure of reducing the number of parameters determined by the minimizing method. The parameters obtained in this way were used in computing the frequency characteristic in the entire necessary range of periods with an accuracy adequate for practical purposes. Figures 2, references 3.

UDC 550.34

OPTIMUM NETWORK OF SEISMOGRAPHS IN AN INVESTIGATION OF SEISMIC DANGER AT THE SITE OF AN ATOMIC POWER STATION

[Abstract of article by Fremd, V. M., Al'vares, L., Rubio, M., Serrano, M. and Chuy, T.]

[Text] The sites for placement of seismic stations in investigations in the neighborhood of the area of the Huragua atomic power station in Cuba were selected by computations of the minimum energy class of seismic events registered by the network of stations. The curves of seismograph magnification were constructed on the basis of measurement of the level of microseismic noise. The investigations were made by three seismic stations situated at the vertices of a triangle with sides of about 30 km; one of the stations had a magnification of about 12 000, and the other two -- about 30 000 with standard amplitude-frequency characteristics of type II. Figures 9, references 2.

UDC 550.34

CHOICE OF CHARACTERISTICS OF SEISMOMETRIC CHANNELS FOR THE REGISTRY OF REMOTE EARTHQUAKES

[Abstract of article by Aranovich, Z. I. and Trapeznikov, N. L.]

[Text] A graph of the dependence of the amplitude and periods of seismic waves on magnitude and epicentral distance was constructed. This makes possible the easy selection of the required characteristics of seismometric channels (response, dynamic range, amplitude-frequency characteristic). Also examined are some variants of sets of channels ensuring the registry of earthquakes with a magnitude $M \geqslant 4$ in the teleseismic zone. Figures 4, tables 1, references 9.

UDC 550.34

SIMPLE HIGH-RESPONSE SHORT-PERIOD ELECTRONIC VELOCIGRAPH

[Abstract of article by Trapeznikov, N. L.]

[Text] An electronic seismometric channel, constructed on the basis of components standard-produced by industry, is described. It is intended for any registry systems, but especially digital registry systems. The values of the parameters and elements of the channel are cited. Figures 2, references 2.

UDC 550.34

ANALYSIS OF OPERATION OF THE DS-BP SEISMOGRAPH AT PETROPAVLOVSK SEISMIC STATION

[Abstract of article by Aranovich, Z. I., Pashkevich, I. K., Rykov, A. V. and Sinel'nikova, A. G.]

[Text] The article gives a comparative analysis of a series of dynamic parameters of seismic waves from strong earthquakes registered at the seismic station Petropavlovsk using the DS-BP long-period seismograph and standard SKD and SD-1 seismographs. A histogram was constructed showing the periods and velocities of body and surface waves and also the spectral characteristics of P waves. It is shown that the DS-BP seismograph has additional possibilities for study of the dynamics of strong close earthquakes for the purpose of a further investigation of the tsunamigenic properties of the northwestern part of the Pacific Ocean zone. Figures 6, references 8.

UDC 550.34

UNIT FOR PROVIDING A 'FLOATING POINT' FORMAT IN DIGITAL SEISMIC RECORDING SYSTEMS

[Abstract of article by Negrebetskiy, S. A. and Turetskiy, I. M.]

[Text] A universal unit has been developed which ensures the registry of seismic information in a format with a "floating point." The unit converts input signals with amplitudes in the range 120 db into the form of an analog mantissa of the number for its subsequent measurement by a 10-digit ATsP and two binary digits of the order of this number. The instrument is assembled entirely from integrated microcircuits. The technical specifications of the unit make possible its use in different geophysical recording systems. Figures 3, references 6.

UDC 550.34

DIGITAL MAGNETIC NARROW-BAND FREQUENCY-MANIPULATION AND SUMMATION (UchMIS) REGISTRY OF STRONG EARTHQUAKES

[Abstract of article by Grebenchuk, G. S.]

[Text] This paper is devoted to a method for digital magnetic registry of strong earthquakes by narrow-band frequency manipulation and summation of multibyte communications. The method makes it possible to form, in one track of a magnetic tape, frequency-separated digital registry-reproduction channels. Also examined are some theoretical problems involved in the choice of digital registry parameters. The registry channel of strong earthquakes is described; this channel was constructed on the basis of the indicated method. A scheme for a digital delay line of the dynamic type, ensuring a standby regime for the registry of strong earthquakes, is presented. Figures 7, references 7.

UDC 550.34

APPARATUS FOR REGIONAL SEISMIC INVESTIGATIONS

[Abstract of article by Brulev, Yu. V., Krylov, G. G., Nersesov, I. L., Rayzman, V. I., Sychev, G. A. and Totmenin, V. F.]

[Text] Apparatus for regional seismic and seismological investigations is described. It contains a three-component short-period seismometer, apparatus with field magnetic registry and apparatus with radiotelemetric transmission of seismic information. The technical specifications of the apparatus and its functional design are given. Figures 12, references 2.

UDC 550.34

TWO OPERATING REGIMES OF A PIEZOACCELEROMETER

[Abstract of article by Arakelyan, G. K. and Uspenskiy, B. G.]

[Text] The operation of a piezoaccelerometer in a no-load regime is examined. A formula is derived for the response of the piezoaccelerometer in a short-circuiting regime with integration. In addition recommendations are given on the choice of the operating regime for a piezoaccelerometer in an industrial antiseismic protection system. Figures 3, references 6.

UDC 550.34

ELECTRONIC TIME MARK FOR LIGHT-RAY OSCILLOGRAPHS

[Abstract of article by Rozenberg, I. M.]

[Text] An electronic time mark, based on integrated microcircuits, is described. It gives marks with a frequency of 10 and 1 Hz, using an a-c current network as a reference frequency source. Figures 1, references 2.

UDC 550.34

INSTRUMENT FOR STUDYING PERIODIC SEISMIC SIGNALS

[Abstract of article by Aleksandrov, A. L., Volodin, A. A., Zelikman, E. I. and Nevskiy, M. V.]

[Text] The article describes a device and the principal characteristics of a 15-channel digital synchronous commutator developed and used for discriminating periodic seismic signals from the Nurekskaya Hydroelectric Power Station. The instrument can find extensive use in study of structure of the earth's crust. Figures 6, references 4.

UDC 550.34

THEORY AND DESIGN OF A SIX-COMPONENT SEISMIC STAND

[Abstract of article by Levshenko, V. T. and Sheyn, B. N.]

[Text] Possibilities of creating a six-component seismic stand, a scheme of one of the designs, and also the mathematical approach making it possible to solve the problems of stipulation and measurement of oscillations on a six-component seismic stand are examined. Figures 2, references 4.

UDC 550.34

MODERNIZATION OF THE APT PIEZOACCELEROMETERS

[Abstract of article by Arekelyan, G. K. and Uspenskiy, B. G.]

[Text] The possibility of decreasing the lower frequency limit of the frequency characteristic of a piezoaccelerometer operating in a no-load regime is examined. A block diagram is given for a modernized piezoaccelerometer which is based on the use of MOS transistors and integrated operational amplifiers. The modernization of the APT accelerometer will appreciably improve the parameters of these instruments and will broaden the range of their applicability. Figures 2, references 1.

UDC 550.34

SIMPLE MECHANICAL EXPRESS-SEISMOGRAPH FOR THE REGISTRY OF STRONG MOVEMENTS

[Abstract of article by Fremd, V. M.]

[Text] The design and operating mechanism of a simple seismograph with mechanical registry for observations in the epicentral zones of strong earthquakes are described. In the seismograph the inertial mass is a drum recording unit with a spring-activated motor. The writing element attached to the housing ensures registry with a magnification equal to unity. A large increase can be obtained by employing a lever-type writing element. Figures 1, references 3.

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PHYSICS OF ATMOSPHERE

UDC 551.510.42+551.521.3

THEORY OF MULTIFREQUENCY LASER PROBING OF THE ATMOSPHERE

Novosibirsk TEORIYA MNOGOCHASTOTNOGO LAZERNOGO ZONDIROVANIYA ATMOSFERY in Russian 1980 (signed to press 16 Oct 80) pp 2, 156-157

[Annotation and table of contents from book "Theory of Multifrequency Probing of the Atmosphere", by Igor' Eduardovich Naats, Institute of Optics of the Atmosphere, Siberian Department, USSR Academy of Sciences, Izdatel'stvo "Nauka", 1350 copies, 159 pages]

[Text] The application of optical lidars to investigation of the space-time dynamics of the atmosphere requires development of a theory of remote optical probing of dispersed media. The monograph deals with the problem of remote determination of the microstructure of aerosols by a method of multifrequency laser probing, and with solution of the corresponding class of incorrect inverse problems. The material is illustrated by examples of interpretation of data of multifrequency probing of aerosols of both the lower troposphere and the stratosphere.

The monograph is intended for specialists on atmospheric optics and computer technology who are interested in optical methods of studying the atmosphere and problems of automating optical data processing.

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UDC 624.371

CHARACTERISTICS OF IONOSPHERIC PROPAGATION OF DECAMETER WAVES IN THE HIGH LATITUDES

Leningrad OSOBENNOSTI IONOSFERNOGO RASPROSTRANENIYA DEKAMETROVYKH VOLN V VYSOKIKH SHIROTAKH in Russian 1980 (signed to press 6 Nov 80) pp 2-5, 97

[Annotation, introduction and table of contents from monograph "Characteristics of Ionospheric Propagation of Decameter Waves in the High Latitudes", by Nikolay Alekseyevich Gorokhov, Izdatel'stvo "Nauka", Leningradskoye otdeleniye, 750 copies, 100 pages]

[Text] Annotation. This book describes the physical mechanisms of ionospheric propagation of decameter waves in the high latitudes. The author examines modern concepts concerning the structure of the high-latitude ionosphere and the course of geophysical processes leading to the appearance of ionospheric characteristics which exert a decisive influence on the operation of radioelectronic equipment. Also considered are experimental methods for investigating radio wave propagation: slant sounding, signal path measurement methods and investigations of the statistical characteristics of a propagating signal.

The book is intended for specialists in the field of radio communications interested in the theory and practice of ionospheric propagation of radio waves. References 96, figures 48, tables 4.

Introduction. According to current concepts, the general problem of propagation of radio waves in the ionosphere must be regarded as two different but at the same time interrelated problems. The first of these involves investigations of the influence of properties of the medium on the parameters of the propagating signal, for example, on the propagation path, the spectral properties of the signal, the statistical characteristics of amplitude and phase. In a rigorous mathematical formulation this problem is reduced to finding solutions of the Maxwell equation (or their asymptotic equivalents) with stipulated parameters of the medium in which the propagation occurs. The second part of the overall problem includes investigation of properties of the medium on the basis of data on the parameters of the signal at one of the points in three-dimensional space. This is the problem of finding solutions of the integral equation, where the unknown functions are the electrodynamic parameters of the medium. Whereas the first part of the general problem is dealt with for the most part in theoretical investigations, for the second part the decisive role is played by experimental investigations because it makes it possible (assuming a correct formulation and solution of the inverse problem) to obtain information on the ionosphere using different radiophysical methods.

In general form the problem of radio wave propagation in ionospheric plasma includes a great diversity of problems of interest in both purely scientific and in practical respects. If these problems are examined applicable to the conditions existing in the high-latitude ionosphere, the most important directions seem to be the following.

1. Investigation of the paths of propagation of a radio signal in an inhomogeneous medium. Even the very formulation of the problem assumes the use of the ray approximation in seeking solutions of interest. In this case specific models of the medium are selected and for these, using numerical methods in most cases, the propagation paths are found for different conditions of radiation and reception of a signal at the ends of the postulated radio path. In its practical aspects the problem is of unquestionable interest because a knowledge of propagation paths is a necessary condition for the effective operation of many radioelectronic systems.

2. Investigation of the amplitude characteristics of the received signal. The signal field level and its variations are important propagation conditions, by investigating which it is possible to ascertain the mechanisms of interaction between the medium and signal. Theoretically, by stipulating the specific type of inhomogeneities in the medium, it is possible to obtain different spatial-temporal distributions of the amplitude of the scattered signal field. These include, for example, the spatial field distributions with the diffraction of a wave on a phase screen, temporal fluctuations with scattering on random inhomogeneities, described by the Rayleigh, Rice, Nakagami and other distributions. In this case it is also of interest to consider the possibility of solution of the inverse problem, and specifically, on the basis of the known characteristics of a signal at the reception point to ascertain the structure and parameters of motion of inhomogeneities. From the practical point of view an investigation of amplitude statistical distribution laws will make it possible to seek optimum methods for the transmission of information for different communication systems, that is, conditions when with a stipulated rate of transmission of information the probability of error will be minimum.

The successful solution of a number of specific problems within the framework of the considered directions will govern any increase in the reliability of many radioelectronic systems using ionospheric propagation of radio waves. A simple enumeration of the problems which are of great practical interest indicates how complex and varied is the formulated problem.

A noteworthy feature of the modern development of society is the intensive development of the Arctic and Antarctica. In addition to factors of an economic and purely scientific nature the exploitation of these regions (especially the Arctic) is dictated by exceptionally important considerations of a practical character. Unfortunately, short-wave apparatus, which has been most intensively developed up to this time, including communication, direction finding and radar, has been extremely unreliable here due to disturbances caused by geophysical processes transpiring in the polar ionosphere. In particular, methods for determining the coordinates of a tracked or ranged object were unsatisfactory when used in high-latitude regions because they do not take into account many characteristics of structure of the polar ionosphere and the characteristics of radio wave propagation associated with them. Among these characteristics are the gradients of ionospheric plasma in the auroral zone, small-scale plasma formations associated with the additional ionization of the atmosphere by injected fluxes of charged particles, and plasma inhomogeneities elongated along the magnetic field. All these factors exert a substantial influence on the conditions for signal propagation, and accordingly, also on its characteristics registered at the reception point.

In an investigation of radio wave propagation in the high-latitude ionosphere in disturbed periods it is impossible to lose from sight the following circumstance of more than a little importance. The fact is that the polar ionosphere consists of nonequilibrium magnetically active plasma in which there are fields, electric currents and beams of charged particles. In the nonequilibrium medium the pattern of propagation of the radio signal differs considerably from ordinary conditions. Here such effects as the interaction of electromagnetic waves and directed corpuscular streams begin to exert an effect, which leads to the pumping of energy from the particles to the field and vice versa. A result of this can be an intensification or collisionless dissipation of the signal, a distortion of its spectrum caused by the movement of plasma inhomogeneities.

In order to realize such an approach to the problem it is necessary to begin to develop a new direction in investigation of the ionospheric propagation of radio waves, specifically an investigation of propagation in a nonequilibrium plasma medium. A logical consequence of such an approach is investigations of nonlinear interactions of electromagnetic oscillations and fields in the ionosphere both at the time of natural disturbances and with its artificial modification. The most important parameters subject to changes due to the above-mentioned factors are: the amplitude of the received signal and the statistical law of distribution of fluctuations of amplitude, the autocorrelation function of signal amplitude (the same also applies to the signal phase), group time for signal propagation and its variation. These characteristics determine the conditions for operation of the radioelectronic systems and the choice of the method for processing the signal against a background of noise of natural origin.

This monograph, while making no pretense at the completeness of coverage of all the scientific problems which relate to the mechanisms of physical processes transpiring in the high-latitude ionosphere, is devoted specifically to those of them which can exert the greatest influence on the characteristics of a propagating radio signal.

It is assumed that the reader is familiar with the principal laws of formation and dynamics of ionospheric layers under undisturbed conditions when the decisive factor is solar UV radiation. One of the arguments justifying the appearance of this monograph is that most of the data on the influence of auroral disturbances on the characteristics of radio wave propagation are scattered in individual articles. Emphasis in these articles is devoted to the study only of the parameters of propagation without regard to the general geophysical conditions in the auroral zone existing at the time of observations. This circumstance determined the structure of the monograph, the form and sequence of exposition of the material. It is based on published foreign data and also some results of individual investigations carried out during the period from 1967 through 1978 at the Polar Geophysical Institute, Kola Affiliate USSR Academy of Sciences under the direction of and with the direct participation of the author and having as their purpose a study of the peculiarities of propagation of radio waves in the decameter range in the auroral zone ionosphere.

The author expresses sincere appreciation to the specialists Ye. L. Boyaintsev, R. A. Pertsovskiy and B. V. Tkachenko, who made a considerable contribution to development of the problems examined in the monograph. G. A. Zazhirilo, T. N. Lipnitskaya and O. A. Patenchinkova gave invaluable assistance in preparing the manuscript for press.

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