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9 JANUARY 1991



# *JPRS Report*

# Science & Technology

## *USSR: Earth Sciences*

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# Science & Technology

## USSR: Earth Sciences

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**Radiation Precursor Phenomena of Earthquakes Studied From Spacecraft**

907N0174A Ashkhabad TURKMENSKAYA ISKRA  
in English 1 Aug 90 p 3

[Article by O. Borisov]

[Excerpt] In 1985, a phenomenon was discovered for the first time in an experiment called "Mariya," which was conducted on board the orbiting station "Salyut-7." The intensity of flows of charged particles with high energies in the earth's radiation belt jumped sharply three times on a day when the geomagnetic field was calm and there were no signs of solar activity. The only exception to the background of general geophysical serenity on the planet that day was heightened seismic activity all over the globe. The question that scientists asked then was: "Is there any connection between this activity and the phenomena in the radiation belt?"

Processing of results of experiments on board the satellite "Meteor-3" (orbit altitude—1,250 kilometers) in 1985-1986 revealed a similar regularity.

The "Mariya" spectrometers installed on the orbiting stations "Salyut" (1985) and "Mir," which have been in orbit from February of 1986 until the present, have repeatedly recorded in the absence of geomagnetic perturbations more than 10-fold increases in the intensity of

particles with an energy of tens of Mev. And again, after 150-180 minutes there were appreciable movements in the earth's interior.

A similar sequence of events was independently observed by associates of the Abastumani Astrophysical Observatory. It turned out that several hours before a subterranean shock there is a sharp increase in the glow of the night sky in the oxygen line (in particular) in the atmosphere over the epicenter at an altitude of the order of 100 kilometers. The Georgian scientists believe that this results from the energy of infrasonic waves, which arise in the earth's interior during a developing earthquake and reach the uppermost layers of the atmosphere. Adapting the 'Abastumani effect' to satellite observations would considerably simplify the problem [of making use of this precursor phenomenon].

Specialists have noted that, shortly before an earthquake, instruments on satellites record electromagnetic radiation over a wide frequency range at the moment of passing through the focal zone. It is the most likely cause of changes in the dynamics of particles in the radiation belt (as is the case during increased solar activity). A. Galper, one of the authors of these studies and a professor at the Moscow Engineering Physics Institute, believes that the discovered phenomenon may become the basis for the development of a method of short-range earthquake forecasting. (SNAP 900817)

UDC 551.583:551.524.34(215-17)

**Structure and Variability of Modern Climate***907N0167A Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 7, Jul 90 (manuscript  
received 18 Oct 89) pp 14-18*

[Article by G. V. Gruza, professor, E. Ya. Rankova, candidate of physical and mathematical sciences, E. V. Rocheva, candidate of geographical sciences, and L. V. Lapayeva, USSR Hydrometeorological Scientific Research Center]

[Abstract] New empirical data on the structure and variability of modern climate (surface air temperature) in the northern hemisphere for 1891-1985 are analyzed. The basic statistics are compared for individual 30-year periods: 1891-1920, 1921-1950, 1951-1980 and for the entire period 1891-1985, with the period 1951-1980 being considered the base period. During 1891-1920 it was colder over the greater part of the northern hemisphere (except for the Atlantic and some regions in Eurasia) than in 1951-1980. During 1891-1985 the mean temperature for the hemisphere in all months of the year (other than October and November) was lower than during 1951-1980, largely due to the temperature of all 12 months in the Pacific Ocean sector and the summer months on the continents. The pattern of spatial distribution of regions of warming and cooling during the last 30-year period was complex and it cannot be said that there has been a global warming as a general phenomenon for all regions. The spatial distribution of the parameters of the linear temperature trend evidently can be analyzed only for the entire period. The stability of these parameters in different time intervals cannot be evaluated due to the short length of the series. During 1891-1985 (during all seasons and for the year as a whole) a stable trend is observed only over the oceans: over the Atlantic—a cooling and over the Pacific Ocean—a warming by the end of the period. Over the northern hemisphere continents against a background of predominant warming there are also zones of cooling: during the warm half-year—only in small regions of Asia, and in the cold half-year—in America, Asia and North Africa. Figures 3; references: 2 Russian.

UDC 551.510.534

**Features of Intraannual Global Dynamics of Total Ozone Content***907N0167B Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 7, Jul 90 (manuscript  
received 14 Aug 89) pp 36-46*

[Article by A. N. Gruzdev and I. I. Mokhov, candidates of physical and mathematical sciences, Atmospheric Physics Institute]

[Abstract] The intraannual features of the global dynamics of total ozone content are analyzed using the

amplitude-phase characteristics method and employing long-term (1973-1985) mean monthly total ozone content measurements at 133 stations in the world ozonometric network. Regional patterns of the leading onset of different phases in the annual variation of total ozone content were detected, including over Northeastern Asia, Central Asia, North America, in the European region and to the southeast of Australia. Both the amplitude and phase characteristics indicate substantial differences in the global dynamics of the field of total ozone content during different seasons. The special features of intraannual evolution of total ozone content in the tropics are discussed. The possible mechanisms of formation of the individual patterns of annual variation of total ozone content also are examined. The correlation between evolution of the field of total ozone content and the evolution of the fields of tropopause characteristics is studied. The "ozone hole" effect over Antarctica is discussed in relation to several aspects of formation of the phase of the minimum of total ozone content in the annual variation. Figures 3; references 29: 15 Russian, 14 Western.

UDC 551.510.41:551.464.34:551.583

**Trace Gases in Atmosphere and Ocean and Greenhouse Effect***907N0167C Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 7, Jul 90 (manuscript  
received 13 Jul 89) pp 77-84*

[Article by O. K. Zakharova and K. I. Selyakov, candidates of physical and mathematical sciences, State Hydrological Institute]

[Abstract] Since the atmospheric content of trace gases experiences considerable changes attributable to both natural and anthropogenic factors the accuracy of climatic predictions to a considerable degree is dependent on the capability to predict their overall atmospheric composition in the future. Accordingly, model computations were made of the absorption of atmospheric trace gases: CH<sub>4</sub>, N<sub>2</sub>O, F11 and F12. The results are compared with computations made for CO<sub>2</sub>. Different scenarios are proposed for the content of such atmospheric trace gases with allowance for possible consequences of a ban on the production of freons. It was found that during the period 1980-2000 the contribution of trace gases to change in mean temperature  $\Delta T$  will be 86% of CO<sub>2</sub> and for the period 2000 to 2020 it will be 108%. The change  $\Delta T$  in 2000 in comparison with 1860 will be 1.7-1.8°C, in 2020—2.3-2.6°C and in 2050—3.2-3.6°C. With allowance for inertia the figures will be approximately: 1.2-1.3, 1.6-1.8 and 2.2-2.5°C. It is emphasized that the  $\Delta T$  values presented here apply to an inertialess planet (a planet without an ocean capable of storing heat for a long time). These warming values are somewhat less than in predictions in which a constant exponential increase in the content of freons in the atmosphere is assumed. Possible changes in ozone concentration were also not

taken into account and there are great uncertainties with respect to these changes during the next 30-70 years. Figures 4; references 15: 7 Russian, 8 Western.

UDC 551.467.3(265.53)

### **Fissures and Leads in Sea Ice Cover**

907N0167D Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 7, Jul 90 (manuscript  
received 16 Mar 89) pp 99-106

[Article by V. A. Kovshov and Yu. N. Sinyurin, candidate of geographical sciences, Odessa Division, State Oceanographic Institute; Main Radiometeorological Center]

[Abstract] On the basis of an analysis of 747 photographs taken from the "Meteor-2" artificial earth satellite covering the period from the third 10-day period of December to the first 10-day period in May during the

years 1977-1986 showing the orientation of mesoscale fissures and leads in the drifting ice cover of the Sea of Okhotsk and the results of research by other authors describing a remarkable selectivity of definite strikes of fissures and leads in the ice cover, it is shown that there is a well-developed polygonal structure of sea ice rupturing. In the sea ice cover (in both drifting and shore ice) the extensive development of this polygonal structure is characterized by four systems of predominant orientation of breaks in continuity: diagonal (NW, NE) and orthogonal (N, E). There is a similarity in the strike of the largest lineaments of individual regions on the Earth's land surface and the predominant orientation of fissures and leads in the ice cover of adjacent sea areas. The existence of a polygonal structure of the ice cover is evidently attributable to general planetary stresses caused by variability of the Earth's rotational regime. A possible reason for the short-period variability of the angular velocity of the Earth's rotation may be variability of atmospheric circulation of a corresponding scale. Figures 3; references: 22 Russian.

### Reconstruction of Radiation Fluxes on the Ocean Surface from NOAA Satellite Data

907N0154A Kiev *MORSKOY GIDROFIZICHESKIY ZHURNAL* in Russian No 3, May-Jun 90 pp 30-36

[Article by N. A. Timofeyev, M. V. Ivanchik, A. I. Sevostyanov and Yu. V. Kikhay, Marine Hydrophysical Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] Total solar radiation and radiation balance fluxes under real cloudiness conditions over an ice-free oceanic surface are reconstructed on the basis of measurements in the near IR in the spectral intervals 0.725-1.1  $\mu$  and the transparency window 10.3-11.3  $\mu$  by means of the very high resolution radiometer on the NOAA satellite. Satellite data was received and processed at the Soviet-Guinean scientific center in Conakry, in Sevastopol, and aboard the research ship "Akademik Vernadskiy." An atlas of charts of total solar radiation and the radiation balance for large sectors of the Atlantic has been compiled. Sheets are based on 0.5 x 0.5° latitude/longitude sectors, averaged from 10-days to a month, with error not exceeding 5%. Algorithms are proposed and recommended as a standard basis for the satellite monitoring of all radiation components of the atmosphere-ocean (ice-free) surface system. The use of these algorithms in the international World Program of Climate Investigations and Tropical Ocean Global Atmosphere programs and in the Soviet Razrezy [Cross-Sections] and SPKOR [Soviet Program on Climatology, Cloudiness, and Radiation] programs. SPKOR, scheduled for 1990, will monitor the radiation fields and cloudiness in the Mediterranean, Black and Caspian Seas, and in the eastern sector of the tropical Atlantic. Data reception and processing will again be managed in the Marine Hydrophysical Institute in Sevastopol, in Conakry, and on the "Akademik Vernadskiy." Figures 4; tables 3; references 8.

### Observation of Anticyclonic Eddy Formation in the Offshore Sector of the Black Sea

907N0154B Kiev *MORSKOY GIDROFIZICHESKIY ZHURNAL* in Russian No 3, May-Jun 90 pp 55-59

[Article by N. A. Panteleyev and A. N. Shcherbakov, Marine Hydrophysical Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] During studies of short-period internal waves in the shelf zone of the Black Sea off the Crimean Peninsula in 1986, an anticyclonic eddy with a horizontal extent of about 20 km was observed moving in a northwestern direction at a speed of 10 cm/s. The passage of the eddy was tracked with current velocity meters and by vertical temperature and salinity profiles. Soundings were made with the "Istok" hydrological probe, two hydrological surveys were conducted, and three autonomous buoy stations, equipped with DISK and DKST current and temperature meters, were deployed. Atmospheric conditions were monitored during the entire experiment. The passage of the eddy

was seen to substantially alter the nature of small-scale hydrophysical processes. It is posited that the cause of the observed eddy formation might have been a dynamic shear instability resulting from a horizontal velocity shear. The Black Sea is characterized by three main types of synoptic changeability of hydrological fields: eddy formations of the Main Black Sea Current, topographic eddies, and frictional eddy formations—the last named being characteristic of the offshore zone. Figures 3; references 2.

### Parameterization of the Dispersion Ratio of Internal Waves Based on Soundings in the Tropical Atlantic

907N0154C Kiev *MORSKOY GIDROFIZICHESKIY ZHURNAL* in Russian No 3, May-Jun 90 pp 59-62

[Article by V. M. Burdyugov and S. A. Grodskiy, Marine Hydrophysical Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] Expressions establishing the relationship between the parameters of the dispersion ratio of the lower mode of internal waves with integral characteristics of the seasonal thermocline are determined. Two models of vertical density distribution—the two-layer and three-layer—are examined on the basis of the Vaisala-Brent  $N(z)$  frequency. Data used to derive the expressions were obtained by the research ships "Akademik Vernadskiy" and the "Mikhail Lomonosov" on various deployments to the tropical Atlantic. The parameterization of the dispersion function obtained provides a convenient way of estimating the relationship of time and space parameters of internal waves for stratification conditions with a clearly expressed pycnocline. This vertical structure of waters is so close to being two-layers that, in the final analysis, the dispersion ratio can be obtained by analogy with the two-layer model. Figures 3; references 3.

### Evaluation of the Parameters of Modulation Instability of Weak Nonlinear Internal Waves in the Ocean

907N0155C Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY IOKEANA* in Russian Vol 26 No 6, Jun 90 pp 633-643

[Article by A. A. Belobrov and A. A. Slepyshev, Marine Hydrophysical Institute, Ukrainian Academy of Sciences]

[Abstract] Within the framework of the nonstationary theory of weak nonlinear internal wave bunches, studies are made of the nonoscillating deformation of the upper and lower boundaries of the thermocline as well as of the dependence of the coefficient of nonlinear self-excitation on wavelength for three model types of stratification and for the real profile of stratification. It is found that the nature of nonoscillating deformation of the thermocline (compression, extension) in a bunch field of short-period



internal waves is essentially dependent on wavelength. The displacement of the upper and lower boundaries of the thermocline in the bunch field is proportional to the square of the wave amplitude, i.e., thermocline deformation is of an inverse character. In the vicinity of the packet group velocity and low-frequency wave phase velocity of a higher mode, a change in the nature of thermocline deformation occurs (extension changes to compression), there is a change in the sign of the coefficient of nonlinear self-excitation, i.e., a stability change in relation to longitudinal modulation. Since the nonoscillating deformation of the thermocline in shallow waters substantially exceeds that in deep waters, the effect under study can be expected to manifest itself mostly in coastal waters. Figures 6; references 9: 8 Russian, 1 Western.

#### Fractal Structure of Surface Wave Collapse Zones in the Ocean

907N0155E Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian* Vol 26 No 6, Jun 90 pp 664-668

[Article by V. Yu. Rayzer and V. M. Novikov, Institute of Space Investigations, USSR Academy of Sciences]

[Abstract] The procedures of fractal analysis are applied to the ocean surface in the state when turbulence develops and the processes of surface wave collapse and foaming intensify. Because the brightness of these features differs from that of the surrounding background and their geometric form does not have smooth features, they readily lend themselves to fractal analysis. A special digital algorithm, which makes it possible to calculate the geometric parameters of the objects with sufficient accuracy, is used for the study. It is found that the field of collapsing surface waves in the ocean does possess a fractal structure, and that the magnitude of dimension depends upon the stage of turbulence development. In different stages of turbulence development, the structure of the wave-collapse field is, on the whole, homogeneous; it possesses definite properties of similarity, and can be described by the methods of the theory of dimension. It is further concluded that the self-simulating spectrum together with the conventional turbulence spectrum can be used as additional measures of the state of the ocean's surface. Figures 4; references 9: 5 Russian, 4 Western.

#### Seasonal Temperature Variations in the Open Ocean

907N0155F Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian* Vol 26 No 6, Jun 90 pp 668-670

[Article by A. S. Monin and I. I. Solntseva, Institute of Oceanology, USSR Academy of Sciences]

[Abstract] Methods for studying the seasonal changeability of ocean surface temperature fields, based on the use of Japanese 3- and 10-day charts of the surface

temperature in the northwestern quadrant of the Pacific Ocean, are described. Seasonal latitudinal variations differ somewhat from sinusoidal: winter minima and summer maxima of latitudes are nonsymmetrical, with the minima notably wider than the maxima, particularly in the isotherms 5, 10, 15°. The winter and summer variations occupy more time than the transitional seasons, suggesting that there are two metastable states of the ocean—winter and summer. The winter decline in surface temperature is accompanied by an increasing thickness of the upper mixing layer of the ocean, both because of cooling upward and convective mixing as well as because of winter storms and the mixing they bring about. The absence of harmony in the seasonal variations is attributed to the mechanisms that cause them, an essential factor in which is the interaction between ocean and continents. The continental effect which evokes the lack of harmony in seasonal surface temperature variations as far as longitude 151° in the northern Pacific Ocean are not insignificant, although diminishing with distance from the continent. Only the axial sector of the Pacific is considered free of continental influences. Figure 1; references 3: 2 Russian, 1 Western.

UDC 551.465.7

#### Coherent Structures in Oceanic Near-Surface Turbulent Boundary Layer

907N0156A Moscow *DOKLADY AKADEMII NAUK SSSR in Russian* Vol 312 No 1, May 90 (manuscript received 21 Jun 86) pp 218-222

[Article by A. V. Solov'yev and V. A. Bezverhnyy, Oceanology Institute imeni P. P. Shirshov, USSR Academy of Sciences; Atmospheric Physics Institute, USSR Academy of Sciences, Moscow]

[Abstract] Until now coherent structures have been observed in the near-surface oceanic layer only in cases of stable stratification associated with a density jump in the near-surface thermocline, that is, arising in the outer part of the turbulent boundary layer, not in the inner part, as observed in the atmospheric boundary layer. On the 41-st cruise of the "Akademik Kurchatov" a new instrument complex was used for research on turbulence in the near-surface layer, making it possible to register organized structures in the unstably stratified near-surface layer of the ocean, the same as observed earlier in the atmospheric boundary layer. At nighttime, after the disappearance of traces of daytime heating, the formation of the structure of the oceanic near-surface layer was related for the most part to cooling of the ocean surface due to evaporation, effective radiation from the ocean surface and contact turbulent heat exchange between the air and water. During nighttime, with cooling of the ocean surface, the upper layer of the ocean was similar to the unstably stratified near-surface atmospheric layer. The observations made of horizontal and vertical structures under conditions of nighttime cooling of the ocean surface are indicative of the possibility of the appearance

of coherent structures in the near-surface turbulent boundary layer of the ocean similar to those in the atmospheric boundary layer. Figures 2; references: 3 Russian, 6 Western.

UDC 551.463.21

### Research on Interference Structure of Acoustic Field in Shallow Sea

907N0157A Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 36 No 3, May-Jun 90 (manuscript received 5 Dec 88) pp 395-398

[Article by S. V. Burenkov, N. L. Dzenis, A. V. Kishko and Ye. A. Rivelis, Acoustics Institute imeni N. N. Andreyev, USSR Academy of Sciences]

[Abstract] The behavior of the power spectra of a wide-band signal in the case of reception by spaced hydrophones in a shallow sea was experimentally investigated, proceeding on the basis of the theory of a space-frequency invariant. An effort was made to clarify whether it is possible to discover experimentally the predicted broadening of the spectrum of a received signal when using an ordinary pulsed sound source, to check how well the behavior of the spectrum is described by the mentioned theory and under what conditions the fundamental computation formula of the theory is applicable. It was found that the field of a real pulsed source in a shallow sea has an interference structure whose behavior is satisfactorily described by the theory of a space-frequency invariant. An algorithm is proposed and a program is outlined which make it possible to trace the behavior of this structure without drawing on detailed information on the spectrum of the radiated signal and on the waveguide properties. It is demonstrated that the proposed algorithm is operable with a spacing of the receivers along the direction of field propagation up to a value  $2.5 H$  ( $H$  is waveguide depth). Figures 4; references: 4 Russian.

UDC 534.28

### Low-Frequency Acoustic Field in Oceanic Waveguide With Irregular Bottom

907N0157B Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 36 No 3, May-Jun 90 (manuscript received 16 May 89) pp 416-422

[Article by N. S. Gorskaya and M. A. Rayevskiy, Applied Physics Institute, USSR Academy of Sciences]

[Abstract] In order to solve direct problems in prediction of the acoustic field and inverse problems in bottom diagnosis it is necessary to have a theoretical model making it relatively easy to relate characteristics of the acoustic field and the parameters of a randomly irregular ocean bottom. This article discusses the statistical characteristics of the normal modes of the acoustic field in a waveguide with an irregular bottom profile. A study was

made of the influence of a smoothly irregular oceanic bottom profile with arbitrary impedance properties with only a single assumption being made: smallness of the Rayleigh parameter and surface slopes. Equations are derived for the correlation function of normal modes and an expression is found for the damping constant of their coherent component. It is shown that an analysis of attenuation of the coherent field of modes can be made using geometrical acoustics methods. The dependencies of the damping constant on the impedance properties of the bottom are discussed. An example of numerical computation of the damping constant is given for the case of an oceanic waveguide of the Pekeris type. The damping constant of the coherent signal component is determined for the most part by scattering effects, not by volumetric losses in the bottom. Figure 1; references 9: 5 Russian, 4 Western.

UDC 551.465.6

### Kinematics and Water Structure of an Anticyclonic Vortex Formation in the Central part of the Black Sea

907N0172 Moscow OKEANOLOGIYA in Russian Vol 30 No 4, Jul-Aug 90 (manuscript received 23 Aug 89, revised 12 Jan 90) pp 575-581

[Article by Yu. N. Golubev, Marine Hydrophysical Institute of the Ukrainian SSR Academy of Sciences, Sevastopol, and V. S. Tuzhilkin, M. V. Lomonosov Moscow State University, Moscow]

[Abstract] A possible source of synoptic variability of the hydrophysical fields of the Black Sea is hydrodynamic instability of the Main Black Sea Current. The baroclinic-barotropic instability leads to the formation of synoptic vortices, similar to Gulf Stream rings. Topographic and shear instabilities also lead to the formation of synoptic vortices.

The temporal evolution of the properties of Black Sea synoptic vortex formations were studied as they displace and interact with large- and small-scale water circulations. Four surveys were made of the central region of the Black Sea at depth of 500-1000 m during June-September 1984.

The horizontal distribution of salinity and its evolution over time was studied and it was found that two separate regions of reduced salinity of meanders of the Main Black Sea Current merged into one large anticyclonic vortex. The vertical distribution of salinity, the evolution of the horizontal and vertical size of the vortex, and its orientation and velocity were also studied. Figures 5; tables 3; references 8: 5 Russian 3 Western.

UDC 551.463.228

### Effect of Wind and Internal Waves on the Parameters of Ocean Noise

907N0171A Moscow AKUSTICHESKIY ZHURNAL  
in Russian Vol 36 No 4, Jul-Aug 90 (manuscript  
received 4 Dec 89) pp 581-585

[Article by A. A. Aredov, G. M. Dronov, A. V. Furdueyev, N. N. Andreyev Acoustic Institute, USSR Academy of Sciences]

[Abstract] This experiment was conducted in a deep part of the ocean from a drifting scientific research ship. Continuous measurements were made of wind velocity, the position and strength of the sound scattering layers, the waves, sound speed profile, and spectrum of internal waves at the thermocline level.

The noise field was received and analyzed by a vertical 32-element antenna and a nondirectional hydrophone. Figures show the effect of wind and internal waves on the spectral levels of dynamic ocean noise. An unambiguous relation is noted between the noise level and local wind velocity.

The passage of internal waves could be detected, and their parameters could be measured from noise field data. Experimental results were found to be in good agreement with ray model theoretical calculations. Figures 3; references 11: 8 Russian 3 Western.

UDC 534

### Possibility and Some Results of Acoustic Mapping of the Ocean Floor

907N0171B Moscow AKUSTICHESKIY ZHURNAL  
in Russian Vol 36 No 4, Jul-Aug 90 (manuscript  
received 31 Jul 89) pp 599-605

[Article by A. V. Bunchuk, V. I. Volovov, D. A. Zhari-nov; N. N. Andreyev Acoustic Institute, USSR Academy of Sciences]

[Abstract] In 1987 research was done in the central part of the Indian Ocean (25 X 25 km test site, 5000 m deep) to determine the spatial variability and temporal stability of the mean amplitude of the reflected signal, the variation coefficient, and the correlation radius, and to determine the possibility of mapping the ocean floor on that scale.

Despite insufficiently accurate surveying of location, the experiment showed significant spatial variability of the parameters and a satisfactory coincidence of values for repeated measurement of the parameters at the same locations, that is, a high degree of temporal stability was noted.

An on-board computer was used to produce maps of the bottom from the data. The algorithms are described in the article.

It was found that the variability of the parameters of the reflected acoustic field exceeds by an order of magnitude the variability of bottom relief, and that parameter variability occurs on much smaller spatial scales. It was also found that it is possible to map the ocean floor in limited regions using some parameters of the reflected signals, and that the detail of this mapping greatly exceeds the detail obtained by mapping from geophysical fields and reflected bottom properties. Figures 4; references 14: 13 Russian 1 Western.

UDC 534.463

### Effect of Wind Waves on Waveguide Propagation of Sound in the Ocean

907N0171C Moscow AKUSTICHESKIY ZHURNAL  
in Russian Vol 36 No 4, Jul-Aug 90 (manuscript  
received 25 Jul 89) pp 767-769

[Article by A. V. Belousov, Yu. P. Lysanov, N. N. Andreyev Acoustic Institute, USSR Academy of Sciences]

[Abstract] This article uses an empirical Pierson-Moskovitz spectrum to describe wind waves, which provides a basis for comparing the results of calculation of the scattered acoustical field with experimental data.

Formulas are developed for the scattering coefficient. It is found that multiple contacts of the sound waves with a rough ocean surface cause a great deal of the scattered energy to leave the surface channel. Incoherent energy captured by the channel will be concentrated inside ray tubes at slippage angles of several degrees or less. The small Rayleigh parameter is the cause for the small amount of energy captured by the surface channel.

A comparison of theoretical calculations and experimental data shows that a consideration of the real scattering index is of primary importance in the interpretation of experimental data. Figures 1; tables 1; references 5: 3 Russian 2 Western.

UDC 534.883

### Effect of Spatial Inhomogeneity and Temporal Instability of the Upper Layer of Ocean on the Acoustic Field in the Neighboring Zone

907N0171D Moscow AKUSTICHESKIY ZHURNAL  
in Russian Vol 36 No 4, Jul-Aug 90 (manuscript  
received 17 Feb 89) pp 771-773

[Article by N. A. Vasilyev, N. N. Andreyev Acoustic Institute]

[Abstract] A detailed description is given of several hydroacoustic experiments conducted in the open ocean,

and how slow changes in signal level were discovered and diagnosed. It is shown that for specific relative positions of a radiator and receiver, one can expect slow changes in the level of received signals due to spatial inhomogeneity and temporal instability of the upper layer of the ocean. Rapid changes are due to surface waves.

Pseudostationary hydroacoustic paths may be used to study internal waves. Figures 2.

UDC 551.511.3

### Asymptotics of the Green Function for the Operator of Internal Waves in a Compressible Medium

907N0181A Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 26 No 8, Aug 90 (manuscript received 31 Jan 90) pp 854-861

[Article by M. Ya. Kelbert, I. A. Sazonov, Acoustic Institute]

[Abstract] This article presents a study of the asymptotics of the Green function for an acoustic-gravitational pulse in a compressible stratified medium. Formulas are obtained which describe the field near acoustic and gravitational fronts. It is assumed that the speed of sound is constant and the sources are point sources. Qualitatively new phenomena are detected, a "break" in the gravity front and "feelers" propagating in front of it. The problem of switching of a harmonic source is also examined.

The acoustic part of the pulse is an oscillating function with variable amplitude and a local frequency. The gravitational part of the pulse is described by an Airy function. Stratification of the medium leads to the dispersion of the acoustic part of the signal. The gravitational part of the pulse enters gradually. Figures 4; references 4.

UDC 551.466.8

### Generation of Vertical Fine Structure by Inertial-Gravity Internal Waves

907N0181B Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 26 No 8, Aug 90 (manuscript received 20 Dec 89) pp 862-870

[Article by A. A. Belobrov, A. A. Slepyshev, V. S. Shamov, Marine Hydrophysical Institute, Ukrainian SSR Academy of Sciences]

[Abstract] Weakly-linear packets of short period internal waves induce non-oscillating deformations of the vertical distribution of the average current speed and density. The deformations are the vertical fine structure

generated by the packet. The deformations are quadratic in amplitude and reversible.

Rotation of the Earth is an important factor which should be considered in the calculations. The fields of the current density and velocity are non-oscillating, and are obtained in this article without the Boussinesq approximation. In this approximation, the induced current compensates the Stokes drift. This finding is evidenced by experimental findings of the research ship Akademik Vernadskiy in an Amazon test site. Figures 7; references 6: 5 Russian 1 Western.

UDC 551.466.8

### Instability of Internal Waves in a Stratified Liquid with a Surface Shear Current

907N0181C Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 26 No 8, Aug 90 (manuscript received 9 Oct 89) pp 871-877

[Article by V. P. Reutov, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] This article studies the instability of two-dimensional internal waves in a two-layer model of a stratified liquid with a shear current near the free surface. The speed profile is similar to that of a boundary layer. The lower layer is considered to be infinitely deep.

This article also considers the possibility of internal wave resonance with the current and waves at a shallow depth, and numerically solves the problem of the instability of internal waves at moderate depths.

In a two-layer model it is possible for there to be a resonance of the internal waves with the fundamental waves of the shallow slow current. However, no reactive instability arises. At moderate depths of the slow current this resonance is not manifested, and there is only a small deviation of the phase speed of the internal waves from the value in an immobile liquid. Instabilities arise when there are discontinuities in the current speed profile, and resonance is reduced to weak instability or weak damping of waves. Nonlinear suppression of the instability of harmonic waves depends on the turbulent viscosity near the critical layer. Figures 4; tables 1; references 18: 11 Russian 7 Western.

UDC 551.466.38

### Manifestation on the Sea Surface of Windfronts in the Presence of Surfactant Films

907N0181D Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 26 No 8, Aug 90 (manuscript received 10 Apr 89) pp 883-886

[Article by S. A. Yermakov, A. R. Panchenko, S. G. Salashin, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] The mechanism of the formation of slicks has been poorly studied. In coastal zones, surfactants play an important role. The redistribution of surfactants and the formation of slicks may be due to inhomogeneous surface currents associated with internal waves, convective motions, eddies, etc. An inhomogeneous wind field may also be a factor.

This work presents the first results of in-situ observations of film slicks in inhomogeneous wind fields. Synchronous measurements were made of the spatial spectrum of wind waves in the centimeter-decimeter range, the surface tension, and wind speed. Results are qualitatively interpreted, based on an analysis of the balance equation for the surfactant concentration.

A characteristic change in the slick spectrum is a complete suppression of ripples in the centimeter range and a rapid decrease in the effect in the decimeter range of the wind wave spectrum.

Equations are developed to describe the redistribution of surfactants, but more detailed research is needed to fully describe the phenomenon. References 10: 8 Russian 2 Western.

UDC 551.596.1

#### **Generation of Atmospheric Infrasound in a Vertical Shift of the Ocean Bottom**

907N0181E Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 26 No 8, Aug 90 (manuscript received 5 Jul 89) pp 886-888

[Article by B. I. Ilin, D. N. Romashko]

[Abstract] Infrasonic atmospheric oscillations may be caused by vertical perturbations of vast areas of the ocean floor. Unlike other works, this work considers the stratification of the speed of sound and its effect on the amplitude of acoustic waves.

The atmosphere is assumed to have no wind, and the sound channel is described by the dependence of the speed of sound on height.

It is found that about 80% of the signal comes from the first mode. The full pressure amplitude is a factor of 1.5 higher than when one does not consider the channel. References 6: 3 Russian 3 Western.

UDC 551.463.5:535.36

#### **Solution of the Problem of Light Scattering by Marine Particle Suspensions in an Approximation of Anomalous Diffraction**

907N0181F Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 26 No 8, Aug 90 (manuscript received 7 Sep 89; revised 20 Dec 89) pp 891-894

[Article by A. G. Zhurenkov, V. A. Yakovlev]

[Abstract] Van de Houlst's anomalous diffraction approximation is virtually the only method of calculating the characteristics of light scattering by marine particle suspensions.

This work proposes a new method of asymptotic expansion of the exact solution of Maxwell's equations with limit conditions which correspond to the scattering of electromagnetic waves on inhomogeneities of dielectric permeability. It is shown that in the first approximation the cross section and intensity of scattering at a zero angle coincide with the results of the anomalous diffraction approximation. However, this method permits theoretical study of its area of applicability.

This article limits itself to an examination of the intensity of scattering. It is found that a consideration of the spatial expansion of oscillators widens the area of application of the new method. Ways to further refine the method are discussed. It is found that the method provides a good description of scattering at small angles for an index of refraction of 1.02. As the index of refraction increases the area of applicability contracts. Figures 1; tables 1; references 3.

### Experimental Investigation of Regular Refraction of Laser Radiation Along Short Horizontal Paths in the Ground Layer of the Atmosphere

907N0151A Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 5, May 90 pp 451-455

[Article by V. P. Lukin and A. E. Melamud, Institute of Optics of the Atmosphere, Siberian Branch, USSR Academy of Sciences, Tomsk]

[Abstract] Several cycles of experimental investigations of the refraction of laser radiation on short horizontal paths in the ground layer of the atmosphere are analyzed for the purpose of determining the feasibility of forecasting refraction on the basis of weather measurements. The effectiveness of algorithms for forecasting the refraction value based on measured meteorological parameters (temperature profiles, wind velocity) was evaluated. Daily cyclical measurements were made of laser beams propagating about 2 m above homogeneous sectors of the ground surface at distances ranging from 100 to 2,000 m. Experiments were conducted in three climatic zones (Volga, Crimea, West Siberia) using a laser emitter having a wavelength of 0.6328  $\mu\text{m}$  and power of 0.5 mWt. Analysis of results shows that the value of regular refraction of laser radiation exhibits a characteristic daily march with maximum amplitude fluctuations of about 1', and that forecasts can be made with some certainty. It is concluded that regular refraction of laser radiation along short ground paths exhibits characteristic features requiring further detailed study. Figures 2; references 5.

### Transmission of Signals from an Isotropic Source of Optical Radiation Through a Cloud Layer

907N0151B Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 5, May 90 pp 538-546

[Article by O. I. Aldoshina, V. V. Bacherikov, A. I. Karkhov and V. A. Fabrikov, All-Union Scientific Research Institute of Opticophysical Measurements of USSR State Standard]

[Abstract] An attempt is made to construct a theoretical model of the transmission path of signals from an isotropic optical radiation source to a remote photodetector, and to find within the structure of this model analytical expressions for pulsed responses and the path transfer function. The model is designed for problems dealing with remote soundings of the surface of the Earth through thick cloud layers. For the first time, an analytical solution is obtained for the problem in the approximate model in which the underlying surface is assumed to be a diffusely scattering Lambertian surface, and the cloud layer assumed to be a thin diffusely scattering screen with a Lambertian scattering phase function. An analytical expression is derived relating the optical source height, cloud layer height, the surface albedo, and the zenith angle of observation. A general expression for an arbitrary number of screens is also obtained. The model may be improved by utilizing known solutions of

the problem of radiation transfer through an optically thick medium with anisotropic scattering. Figures 5; references 12.

### Self-Excitation of a Ring-Shaped Optical Radiation Beam Propagating in a Solid Aerosol

907N0151C Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 5, May 90 pp 559-560

[Article by V. K. Pustovalov and I. A. Khorunzhiy, Belorussian Polytechnic Institute, "Politekhnik" Scientific-Technical Association, Minsk]

[Abstract] The self-excitation of a ring-shaped optical beam propagating in a solid metal aerosol is investigated on the basis of computer solution of a system of equations. The numerical modeling of the beam propagation in this work replicates the conditions in the experiment by N. N. Belov, et al. in "Nonlinear Scattering and Self-Focusing of Laser Radiation in an Aerosol," published in *Kvantovaya elektronika*, Vol 12 No 8 pp 1741-1743, 1985. The numerical modeling of the current authors confirms the possible redistribution of intensity in a ring beam propagating in a metal aerosol, established earlier experimentally by Belov, et al., who also demonstrated that the onset of self-focusing is related to the destruction of particles under the effect of radiation. On the basis of these calculations, it is concluded that the first cause of self-focusing resides in the formation of the responsible refraction field. The destruction of the particles occurs in beam sectors where, as the result of self-focusing, radiation intensity notably exceeds  $I_0$ . Numerical results also show that particle temperature can quickly reach  $T_0 = (3-5) \times 10^5$  K, thus leading to particle destruction. Figures 2; references 8.

### Conditional Albedo for Single Scattering

907N0155A Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSPHERY I OKEANA in Russian Vol 26 No 6, Jun 90 pp 594-601

[Article by O. A. Avaste and Yu. V. Knyazikhin, Tartu State University]

[Abstract] A plane-parallel model of the atmosphere is examined in which radiation transfer is described by an integrodifferential equation. It is assumed that there is no reflection from the underlying surface, while the optical thickness of the layer is taken as infinity. The conditional albedo for single scattering is the probability of particle survival in a scattering event if it is known that event B (angle between the direction of particle motion to and after collision when the scattering event is greater than  $\arccos \gamma$  ( $-1 \leq \gamma \leq 1$ )) has occurred. In other words, within the framework of a model of the radiation transfer process in a plane layer, the dependence of the interval of scattering angles in which the scattering indicatrix is "restored" on the scattering indicatrix is investigated. The results obtained yield additional information on the applicability of the inverse problem of

determining the scattering indicatrix from the distribution of scattered radiation. Figure 1; references 13 (Russian).

### Range of Visibility of Objects in a Turbid Atmosphere

907N0155B Moscow IZVESTIYA AKADEMII NAUK  
SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 26, No 6, Jun 90

[Article by A. S. Drofa, Institute of Experimental Meteorology]

[Abstract] A method is proposed for determining the visibility range of objects in a turbid atmosphere, when observed by the unaided human eye during daytime illumination. Based on analysis of the visual perception of the object image observed through an aerosol medium, it is concluded that image distortions (contour wash out, light aureole phenomenon) caused by light scattering can be disregarded when estimating the visibility range in daytime. The magnitude of the contrast between the image brightnesses of the object and the background, taking into account also the contribution of scattered light to the image brightness, is used as the measure of visibility. It is shown that the effect of this last factor is very significant when observing objects with quite large angular dimensions through a cloudy medium or fog. Most previous experiments in the visual determination of the range of visibility in the atmosphere were not able to identify the effect of this factor because the experiments used objects to observe whose small angular dimensions made the effect negligible. The scattered light on the range of visibility in this study is demonstrated in the theoretically simplest case of observing objects against a sky background at the horizon. It is clear however that in the case of observing objects through a scattering medium against any other bright background, the effect of the factor under examination (especially for cloudy media and fogs), may well manifest itself to a substantial degree and would have to be taken into account in estimating visibility ranges. Figures 2; references 12: 11 Russian, 1 Western.

### Two-Dimensional Spectra of Elevated Surface Waters Based on Aerial Photographic Surveys

907N0155D Moscow IZVESTIYA AKADEMII NAUK  
SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 26 No 6, Jun 90 pp 652-658

[Article by A. N. Bolshakov, V. M. Burdyugov, S. A. Grodskiy and V. N. Kudryavtsev, Marine Hydrophysical Institute, Ukrainian Academy of Sciences]

[Abstract] Data on the background structure of sea surface turbulence obtained by aerial photographic surveys in the western part of the Black Sea in 1987-1988 are presented. For the analysis, measurements made during stable wind conditions were used. The wind velocity in the test range (150 x 150 km; photography at

20 km intervals) and beyond were measured by aircraft scatterometer. Photography was conducted at altitudes of 1.8-3 km by means of an AFA-100 camera. Data on the dimensionless frequency of the maximum, dispersion of the elevations, the form of the spectra of wave numbers and its angular width are presented for dimensionless ranges  $1.5 \times 10^4 < X < 6 \times 10^4$ . Figures 3; references 8: 7 Russian, 1 Western.

UDC 551.510;551.576

### Simulation of Evolution of Atmospheric Optical, Radiation and Thermodynamic Characteristics During Cloud Crystallization. Part II. Cloud Cover Restoration After Dissipation

907N0158G Tomsk OPTIKA ATMOSFERY in Russian  
Vol 3 No 6, Jun 90 (manuscript received  
20 Nov 89) pp 655-661

[Article by K. Ya. Kondratyev, M. V. Ovchinnikov and V. I. Khvorostyanov, Limnology Institute, USSR Academy of Sciences, Leningrad; Central Aerological Observatory, Dolgoprudnyy]

[Abstract] The first part of this article (in this number of the journal, pp 647-654) described a numerical experiment in which by means of artificial crystallization of a supercooled cloud its total dissipation was attained, thereby substantially changing the optical and radiation characteristics of the lower atmosphere. Such a strong effect, however, is not always achieved; the cloud cover may be only partially dissipated or may be restored somewhat thereafter. Particular attention is given to the influence of properties of the underlying surface on cloud cover restoration. It is shown that the rapid restoration of clouds over moistened soil may lessen improvement in atmospheric optical parameters and the desired directed change in optical weather. Thus, although the artificial crystallization of clouds results in a substantial transformation of radiation field parameters in the atmospheric boundary layer, a qualitative change in optical weather and cloud dissipation is not always possible and the properties of the underlying surface are decisive. Numerical experiments confirmed the importance of separation of the liquid and crystalline phases in clouds in such models due to the fundamental difference in their optical-radiation characteristics. These results must be taken into account in planning and implementing cloud dissipation for ensuring favorable conditions for operation of various optical systems and also in predicting optical weather. Figures 4; references 6: 5 Russian, 1 Western.

UDC 535.21:538.97+535.621.33

### Optoacoustic Effects in Aerosols

907N0158A Tomsk OPTIKA ATMOSFERY in Russian  
Vol 3 No 6, Jun 90 (manuscript received  
10 Jan 90) pp 563-578

[Article by N. N. Bochkarev, N. P. Krasnenko and Yu. M. Sorokin, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] This is a review of experimental and theoretical studies on the problem of laser generation of acoustic waves in atmospheric aerosol. A number of effects arising in solid and liquid aerosol are examined. A classification of the developing acoustic waves (AW) is given. The possibilities of remote optoacoustic diagnosis of the parameters of laser radiation and aerosol are analyzed. Remote measurements of the integral energy of AW give an estimate of beam energetics or total aerosol content. The spectral processing of AW yields substantial information on the structure and dynamics of the region of interaction between powerful laser radiation and aerosol under both prebreakdown and breakdown conditions. With an increase in frequency of the received and processed AW lesser space and time intervals become accessible. In the case of long laser pulses of relatively low intensity, the diagnosis of slow collective processes transpiring in an aerosol of high concentration is of considerable practical interest and the effective diagnosis of such processes is possible in the acoustic range. In this case the low-frequency maximum of the acoustic spectrum carries information on the transverse dimension of the discharge region, whereas higher-frequency maxima carry information on the nature of the spatial distribution of aerosol particles. Figures 8; references 39: 36 Russian, 3 Western.

UDC 535.416.3

#### Phase Compensation of Thermal Distortions of Light Beams Accompanying High-Frequency Wind Speed Pulsations

907N0158B Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 6, Jun 90 (manuscript received 20 Feb 90) pp 598-603

[Article by F. Yu. Kanev and S. S. Chesnokov, Moscow State University imeni M. V. Lomonosov]

[Abstract] A numerical experiment was carried out for analyzing the effectiveness of programmed and adaptive control of the phase of a light beam propagating in a medium with large-scale inhomogeneities whose lifetime is comparable to the convection time. The operative element of the control system was a copy of an elastic mirror deformable by transverse forces and bending moments. Comparison of the results of simulation of adaptive and a priori correction indicated that in the case of a weak or moderate mean nonlinearity of the medium or with high-frequency speed pulsations with a particular lifetime programmed correction is a more effective means for the compensation of thermal distortions. In order to obtain reliable information on beam propagation conditions it is necessary to carry out a priori averaging of medium parameters for not less than 30-50 wind speed records. With an increase in radiation power and the lifetime of speed pulsations there is an increase in the relative effectiveness of the aperture sounding algorithm. A distinct advantage of adaptive correction in the considered range of parameters is that

its use does not require a priori knowledge concerning the propagation medium, information on which is received directly during control. Figures 4; references 11: 10 Russian, 1 Western.

UDC 522.617:535.3.087

#### Evaluation of Potential Resolution of Passive Methods for Image Formation Through Turbulent Atmosphere. III. Infrared Speckle Interferometry

907N0158C Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 6, Jun 90 (manuscript received 5 Feb 90) pp 604-608

[Article by P. A. Bakut, I. A. Rozhkov and A. D. Ryakhin]

[Abstract] In earlier articles (OPTIKA ATMOSPHERY, Vol 3 No 4, 1990, pp 394-397, 398-403) the authors evaluated the possibilities of speckle interferometry methods for formation of images from the solar radiation reflected by an object in the visible wavelength range. Continuing this research, expressions are derived for potential resolution in the case of formation of images of an object from infrared radiation emitted by a heated surface using a series of short-exposure images distorted by the atmosphere. It is shown that this observation regime is the best possible for objects whose angular dimensions are greater than the atmospheric resolution limit. In order to achieve a resolution about  $10^{-8}$  rad at a wavelength  $10 \mu\text{m}$  it would be necessary to construct synthesized telescopes with an aperture having a diameter  $10^3$  m, which is presently impossible. However, in constructing synthesized telescopes which at the present time are more realistic, with an equivalent diameter about 25 m, intended for operation in both the visible and IR ranges, due to the great resolution reserve in the latter case it is desirable that the synthesized telescope design be optimized for observations in the visible range. References 8; 5 Russian, 3 Western.

UDC 551.46.08

#### Efficiency of Triangular Method for Determining Ocean Surface Temperature From Remote Measurements of IR Radiation From Space

907N0158D Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 6, Jun 90 (manuscript received 7 Feb 90) pp 622-627

[Article by A. M. Ignatov and V. S. Suetin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] In the approximation of an ideally black surface and a cloudless and aerosol-free atmosphere a



model analysis was made of the comparative effectiveness of two- and three-angle schemes for determining ocean surface temperature. Specific computations were made for the spectral interval  $900-920\text{ cm}^{-1}$  using a radiation model taking into account continuum and selective components of absorption of radiation by water vapor. One of the sighting rays was directed vertically to the nadir and the other two rays were directed at other angles. Estimates were obtained using the method of local linearization of the transfer equation, which makes it possible to take into account a priori information on atmospheric variability in different regions. It is demonstrated that the use of a three-angle scheme is justified provided that the error in registry of IR radiation is reduced to a level about 0.01 K. With real levels of errors in the registry of radiation with modern radiometers, however, the use of measurements at three or more angles cannot be useful. Figures 4; references 13; 9 Russian, 4 Western.

UDC 551.521

#### Remote Method for Determining Path-Averaged Refractive Index of Aerosol Particles

907N0158E Tomsk OPTIKA ATMOSPHERY in Russian  
Vol 3 No 6, Jun 90 (manuscript received  
27 Nov 89) pp 635-638

[Article by V. A. Smerkalov, Applied Geophysics Institute imeni Ye. K. Fedorov, Moscow]

[Abstract] Iteration procedures involving simultaneous search for the optimal value of the refractive index and construction of particle-size histograms are quite unwieldy and require great expenditures of computer time. This definitely restricts the possibilities for practical use of existing methods and programs for processing large files of optical measurements. The solution of this problem is considerably simplified and the required computer time is greatly reduced if the effective refractive index of optically active particles is known (even approximately). In an effort to solve this problem an analysis of 110 models of atmospheric aerosol was made to determine the statistical correlations between the refractive index of aerosol particles, asymmetry coefficient of aerosol light scattering, asymmetry coefficient of the backscattering phase function and Angstrom parameter characterizing the spectral variation of the scattering coefficients (optical depth). The dependencies which were found were approximated by relations making it possible (with an accuracy to 1.3-3.8%) to estimate the mean value of the refractive index of aerosol particles on the basis of its polydisperse characteristics. The estimates of the refractive index which were obtained can be used in inversion of the measured optical characteristics of aerosol into microphysical characteristics. References: 5 Russian.

UDC 551.510;551.576

#### Simulation of Evolution of Optical, Radiation and Thermodynamic Parameters of Atmosphere Accompanying Cloud Crystallization. Part I. Complete Cloud Cover Dissipation

907N0158F Tomsk OPTIKA ATMOSPHERY in Russian  
Vol 3 No 6, Jun 90 (manuscript received  
20 Nov 89) pp 647-654

[Article by K. Ya. Kondratyev, M. V. Ovchinnikov and V. I. Khvorostyanov, Limnology Institute, USSR Academy of Sciences, Leningrad; Central Aerological Observatory, Dolgoprudnyy]

[Abstract] A two-dimensional mesoscale numerical model of cloud and precipitation formation developed by the authors (described in this number of the journal, pp 639-646) was used in investigating the interaction of radiation fields with the microphysical and dynamic characteristics of cloud cover during its artificial crystallization and total dissipation. The results of several numerical experiments are given. The computation results indicate that during the artificial crystallization of clouds in the case of their dissipation it is possible to achieve considerable changes in the optical, radiation and thermodynamic characteristics in the atmospheric boundary layer. The described numerical experiment confirmed that there is a fundamental possibility for modifying optical weather by means of artificial cloud dissipation. A second part of the article (in this number of the journal, pp 655-661) describes a case when the realization of this possibility is made difficult by the restoration of cloud cover after dissipation. Figures 4; references: 7 Russian.

UDC 535.361.1

#### Properties of the Temporal Structure of Radiation in Densely Scattering Media. Part 1. Observations of the Polarization Components of Scattered Radiation

907N0164A Tomsk OPTIKA ATMOSPHERY in Russian  
Vol 3 No 7, Jul 90 (manuscript received 13 Feb 1990)  
pp 691-697

[Article by V. V. Vergun, Ye. V. Genin, G. P. Kokhanenko, V. A. Krutikov, D. S. Mezhevoy, Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk]

[Abstract] This article presents a study of the temporal and polarization structures of pulse radiation in an axial region. The results were obtained in model experiments and using Monte Carlo methods. The effect of geometric parameters on the recorded pulse characteristics is studied and the possibility of using diffusion approximations to describe the temporal structure of the radiation is discussed. This first part of the article describes the shape of the polarization components of the signal.

A self-heating copper vapor laser is used ( $\lambda = 510.6$  nm,  $f = 5$  kHz,  $t = 3-20$  ns,  $P \geq 10$  kW) to irradiate an aerosol chamber ( $l = 26$  m,  $d = 10$  m). A lengthy description of the equipment and experimental method is provided, as well as a diagram of the experiment.

The final result is the pulse transfer function, which characterizes the response of the medium per  $\delta(t)$  pulse.

Solution algorithms are discussed, and graphs show the polarization components of the signal for various optical depths of the scattering layer. A depolarized background is formed by multiple scattering. Figures 5; references 11: 10 Russian 1 Western.

UDC 551.510:621.371

### Two-Way Monostatic Illumination of a Stream of Turbulent Inhomogeneities using a Moving Reflector

907N0164B Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 7, Jul 90 (manuscript received 11 Mar 90) pp 716-722

[Article by V. P. Yakubov, Siberian Physical-Technical Institute of Tomsk State University]

[Abstract] There are two methods of studying atmospheric inhomogeneities: receiving radiation which is diffusely scattered or backscattered, and recording radiation of the direct illumination of the inhomogeneities. In two-way illumination the radiation passes through the medium twice (using mirror reflectors at each end of the path). This article analyzes temporal fluctuations of phase and frequency in the wave using monostatic sensing and a moving reflector.

An auto-correlation function is found for the phase fluctuations in one-way illumination, and a cross-correlation function is found for two-way illumination. These are used to determine the energy spectrum of fluctuations of the full phase.

The case of two-way illumination using a moving radiation source is examined. This method was used to study turbulent inhomogeneities of the solar wind, the two end points of the path being a ground station on Earth and Venera 15.

Monostatic-two-way illumination with a moving reflector may be used to measure the velocity and spatial distribution of intensity of atmospheric inhomogeneities. It can be used in the upper and lower atmosphere, and in interplanetary and near-Sun space in the radio and optical range. Figures 4; references 7.

UDC 535.8

### Study of an Electro-Optical Phase Front Corrector for Adaptive Optical Systems Based on LiNbO<sub>3</sub> Crystals

907N0164C Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 7, Jul 90 (manuscript received 26 Jul 89) pp 723-728

[Article by D. A. Bezuglov, Z. P. Mastropas, Ye. N. Mishchenko, E. N. Myasnikov, S. V. Tolstousov, V. L. Tyurikov]

[Abstract] Existing methods of correcting phase fronts have a number of disadvantages which limit their applicability. One promising method of overcoming these limitations is the expansion of the phase front in spatial modes. This article examines the possibility of creating a corrector for a phase front in the form of a set of pre-determined spatial modes. LiNbO<sub>3</sub> crystals have the desired strong electro-optical effect. To minimize control voltage, the electrodes must be perpendicular to the ferroelectric axis. The optimal configuration of the crystal and electrodes is determined, considering the edge inhomogeneity of the electric field in the corrector.

Experimental models were tested. An advantage of electro-optical crystals is the absence of hysteresis. Optical losses are small. The main disadvantage is low radial stability, which limits the power density. Adaptive optical systems using these correctors are completely independent of control channels.

Figures 5; references 8.

UDC 551.501.7+551.501.8

### Laser-Acoustic Study of Meteorological Conditions and Aerosol Pollution of the Atmosphere over Kemerovo City

907N0164D Tomsk OPTIKA ATMOSPHERY in Russian Vol 3 No 7, Jul 90 (manuscript received 15 Feb 90) pp 729-737

[Article by Yu. S. Balin, T. V. Vilde, V. Ye. Zuyev, N. P. Krasnenko, B. N. Molchanov, I. A. Razenkov, M. G. Fursov, Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk]

[Abstract] The Institute of Atmospheric Optics conducted an expedition to Kemerovo City on 15-29 June 1988 to study the lower atmosphere and its pollutants. This region is noted for prolonged temperature inversions, which concentrate pollutants in low-lying layers of the atmosphere.

The complex of equipment used included lidar (LOZA-3) to monitor the gas and aerosol components, and acoustic locator (MAL-2), and a laboratory aircraft.

Studies were made of the temperature stratification of the atmosphere, the altitude of inversion layers, and the stability or turbulence of these layers. Boundaries of the inversion layers were determined.

Laser sounding of industrially-produced aerosol fields also confirmed the production of smog layers held in place by temperature inversions. While heat released by industrial activity increases the level of the inversion, the concentration of aerosol in lower layers is greater.

Algorithms used to process lidar signals are discussed, as are methods of determining the mass concentration of aerosols from their optical parameters.

Figures 5; tables 1; references 7: 6 Russian 1 Western.

UDC 552.617:535.3.087

#### Resolution of an Adaptive System with Four-Segment Compensation of Random Wave Front Tilts

907N0164E Tomsk OPTIKA ATMOSFERA in Russian Vol 3 No 7, Jul 90 (manuscript received 25 Feb 90) pp 774-776

[Article by P. A. Bakut, I. V. Boyarkina, A. D. Ryakhin]

[Abstract] Various adaptive systems are being studied to evaluate and compensate for atmospheric distortions in received light radiation, in order to form images of the observed object.

One of the simplest is a system based on measurement of the tilts of a wave front from the shifts in short-exposure images, and compensation in the formation of long-exposure images. The method is limited by the small receiving aperture. Resolution can be improved by a factor of 4, but no more. Resolution is a function of the ratio of the aperture diameter to the correlation area of atmospheric distortion of the field of radiation. This article examines a method of expanding effectiveness by determination and compensation of partial tilts of the wave front in individual segments of the aperture.

Various schemes are presented which can further increase resolution of this adaptive system. However, resolution algorithms must be developed. Segmented mirrors are more effective than a continuous flexible mirror. References 5: 2 Russian 3 Western.

UDC 551.508.856:551.521.3

#### Reflection of Picosecond Pulses of Light from a Scattering Medium

907N0164F Tomsk OPTIKA ATMOSFERA in Russian Vol 3 No 7, Jul 90 (manuscript received 15 Feb 90) pp 777-779

[Article by K. P. Burneyka, V. N. Dobrygin, G. I. Yonushauskas, A. S. Piskarskas, V. I. Smilgyavichyus, V. Kapsukas Vilnius State University]

[Abstract] This article examines the experimental results of the dependence of the temporal widening of the reflected signal, the change in intensity of the reflected signal relative to the maximum intensity of the pulse of sounding radiation, and the time delay of the arrival of the maximum (peak) intensity on the extinction coefficient of the scattering medium.

A BeLaO<sub>5</sub>:Nd laser is used to irradiate an aqueous suspension of polystyrene latex microspheres ( $d = 0.14 \mu\text{m}$ ) with a relative index of refraction of 1.2. The pulse duration was 10 ps.

At low densities of the scattering medium the maximum of the reflected signal is weak and blurred over time. As density increases, the ability of the beam to penetrate the medium decreases and multiple scattering increase, as well as singly scattered radiation, which is reflected along the axis of the sounding beam. At maximum density, the ratio of the peak intensity of the reflected signal to the peak intensity of the sounding pulse is about 0.61. The duration of the reflected pulse at half-amplitude is about 40 ps. Figures 4; references 2: 1 Russian 1 Western.

UDC 551.46.08

#### Consideration of Aerosol Absorption of the Atmosphere in Two- and Three-Wave Methods of Determining Ocean Surface Temperature

907N0173 Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOSYEMKA in Russian No 2, Mar-Apr 90 (manuscript received 28 May 87) pp 114-120

[Article by N. A. Skorokhvatov, Candidate of Physical and Mathematical Sciences, Moscow Order of Lenin Institute of Engineers of Geodesy, Aerial Photography, and Cartography]

[Abstract] Ocean surface temperature is determined using two- and three-wave methods and the outgoing infrared radiation of the ocean-atmosphere system.

It has been stated that absorption of infrared radiation by atmospheric aerosol and water vapor are not sufficiently considered, and some authors have stated that it is impossible, in the general case, to use two- and three-wave methods to determine ocean surface temperature to the required accuracy.

This article examines the theoretical bases of two- and three-wave methods considering only continual absorption by water vapor, and the basis of three-wave methods considering aerosol absorption.

When simultaneous measurements are made of the radiation temperature in several close spectral intervals, ocean surface temperature can be determined as a linear regression of radiation temperatures. One must consider in the calculation the actual thermal, moisture, and aerosol stratification of the atmosphere, as well as the coefficients of absorption of water vapor and aerosol.

The author outlines the conditions in which two- and three-wave methods can be accurately used to determine ocean surface temperature. References 9: 8 Russian 1 Western.

UDC 532.528

### **Spatial Variability of Cavitation Thresholds in Some Dynamically Active Zones of the Ocean**

907N0178 Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 312 No 4, June 90 (manuscript received 30 Aug 89) pp 974-977

[Article by Academician V. I. Ilichev, V. P. Yelistratov, V. L. Koretz, G. N. Kuznetsov, N. P. Melnikov, Pacific Ocean Oceanological Institute, Far East Division USSR Academy of Sciences, Vladivostok]

[Abstract] Cavitation is due to variable pressure fields of acoustic and hydrodynamic origin. This article examines the spatial distribution of acoustic cavitation thresholds in sea water in Drake's Bay, at the equator, and in the interfrontal zone of the subantarctic front of the Pacific Ocean. The complex hydrological state of these regions leads to a complex spatial distribution of cavitation thresholds.

Cavitation threshold measurements were made at a depth of 100 m and frequencies of 5 and 15 kHz. In addition to the cavitation threshold, the following parameters were measured: temperature, salinity, total gas content, O<sub>2</sub> concentration, pH, translucence, CO<sub>2</sub> content, total Ca and Mg content, phosphate and N<sub>2</sub> concentration.

Antarctic waters with a small cavitation threshold lie more south than the more stable subantarctic waters. The decrease in the stability of the antarctic waters is due to increased gas content and biological productivity. This leads to an increased concentration of seed cavitation and a decrease in the cavitation threshold.

The equatorial Pacific exhibits a complex surface water structure with spatial and temporal variability. The cavitation threshold varies over relatively small distances. References 1.

UDC 551.46.086:629.78

### **Theory of SAR Image of Sea Waves Propagating in Azimuthal Direction**

907N0182A Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 90 (manuscript received 22 Feb 89) pp 12-18

[Article by M. B. Kanevskiy and L. V. Novikov, Applied Physics Institute, USSR Academy of Sciences, Gorkiy]

[Abstract] A radar with a synthetic aperture (SAR) is capable of registry of sea waves propagating in an azimuthal direction (along or against the direction of

carrier movement). In this case the scattering section may not be modulated at all but images of different surface elements, moving with random velocities, are randomly displaced and superimposed on one another, resulting in modulation of synthesized signal intensity. A theory of this effect is presented. A simple model is employed in clarifying the principal properties of a nonlinear transform converting the spectrum of velocities at the surface into the spectrum of its SAR image. This is examined for the case when a SAR on a carrier moving in a stipulated plane is used in sounding at a given range and with a given glancing angle in the range 20-70° in which Bragg scattering conditions are satisfied without self-shading of the surface. The competing factors operative in signal registry are analyzed in detail and explained. Figures 3; references 5: 2 Russian, 3 Western.

UDC 528.711.714

### **Possibility of Evaluating Surface Roughness Parameters by Sounding With Short Light Pulse**

907N0182B Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 90 (manuscript received 9 Feb 89) pp 69-77

[Article by S. A. Armand, A. L. Surovegin and V. S. Karpov, Geochemistry and Analytical Chemistry Institute imeni V. I. Vernadskiy, Moscow]

[Abstract] One of the possible methods for contactless investigation of surface roughness by means of remote laser sounding is examined. In an earlier study an analytical expression was derived for the envelope of a pulse of a divergent laser beam backscattered by a rough surface, but it was based on qualitative evaluations and intuitive premises. Now the same problem is examined using a rigorous mathematical approach. The accuracy of different approximations is evaluated for a simplified form of the envelope of the backscattered signal. It is demonstrated in the example of a rough surface with Gaussian statistical inhomogeneity that by means of laser sounding with a sufficiently short pulse of a widely divergent beam or a broad parallel beam oriented normal to the surface it is possible to retrieve information on the statistical properties of the surface: rms slope tangent and rms height of the surface. With adequately short pulses the intensity envelope of backscattered radiation is proportional to the distribution function of parameters characterizing roughness. Figures 3; references 21: 14 Russian, 7 Western.

UDC 681.3.01:519.67

### **Interactive Image Segmentation**

907N0182C Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 90 (manuscript received 6 Jun 88) pp 95-101

[Article by D. A. Denisov, V. I. Kharuk, G. M. Tsibulskiy and A. V. Chernyavskiy, Leningrad Electrical Engineering Institute imeni V. I. Ulyanov (Lenin); Wood and

Cellulose Institute imeni V. N. Sukachev, Siberian Department, USSR Academy of Sciences, Krasnoyarsk; Krasnoyarsk Polytechnic Institute]

[Abstract] A variant of interactive image segmentation is described which makes it possible to break down images into sectors allowing meaningful interpretation. The method involves a process of teaching by an algorithmic system in such a way that the taught samples of classes (discriminated features) provide the user with a means for graphic dialogue. Known image recognition procedures are applied. In the method the operator indicates the image fragment representing the feature to be discriminated, thereby fixing the teaching sample of the class. The algorithmic system forms an attribute description of points in the indicated region such that these points are separated from the others by means of some decision rule in attribute space. The operator can interactively adjust the parameters of the decision rule and visually monitor the classification made of elements by the teaching sample. The algorithmic system marks the image points in accordance with the classification made and visualization is by use of pseudocolors. The algorithmic system monitors the appearance of conflicting situations and resolves them by means of a special algorithm. Each of these steps is discussed. The procedures are illustrated by the segmentation of aerial photographs of forested areas. With a very high accuracy it was possible to discriminate conifer, hardwood and unforested areas, forest areas differing with respect to closeness of stand and damaged sectors. Figures 2; references 9: 8 Russian, 1 Western.

UDC 528.72:629.78

**Method for Digital Processing of Aerospace Information for Compiling Soil Maps**

907N0182D Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 90 (manuscript received 7 Dec 88) pp 102-112*

[Article by Ye. V. Shcherbenko, V. V. Asmus and V. L. Andronikov, State Scientific Research Center for Study of Natural Resources, Moscow]

[Abstract] A method is proposed for the digital processing of space information for determining soil cover structure. The method includes: organization of a data bank of surface and aerospace information, digital image processing, interactive processing with visual analysis of initial images and the results of digital processing. The output product is in the form of soil maps and tables of soil cover structural characteristics. A block diagram of the processing and analysis steps is given and each of these is described. A detailed algorithm for cluster analysis by the K-means method used in the digital processing stage is fully described. A new approach, based on the main components method, is proposed which makes it possible to emphasize the local relief on a space image and to detect soil formations homogeneous in spectral brightness. The method was tested in the Trans-Volga area, where it was found that the soil cover in the chernozem zone can be characterized well by this method with respect to humus content, mechanical composition and areal percentage of eroded soils. Figures 3; references: 6 Russian.

**Deputy Geology Minister Discusses Ecology**

907N0108A Kiev PRAVDA UKRAINY in Russian  
12 Feb 90 pp 2-4

[Article by N. M. Gavrilenko, Deputy Geology Minister of the USSR; response to 12th Session of the Supreme Soviet of the Ukrainian SSR]

[Text] Esteemed comrade deputies: Please allow me to disagree with the opinion expressed here in many speeches that there isn't enough money for ecology. I dare to assure you that, in the opinion of many specialists, that there are completely sufficient funds, since losses from ecology substantially exceed the amount that we gain by saving in this area.

In the opinion of Michael Royston, director of the International Institute of Environmental Management (Switzerland), who recently visited the republic, the loss due to worsening of the ecology is 15-25% of the republic's gross national product, and is one of the highest in the world.

And now let's consider what has been reported in the government's report. On the order of 45 billion rubles has been allocated for ecology in the five year plan. Every year the loss of 15% of the gross national product is about 15 billion rubles. In five years this figure, even by conservative estimates, will be much higher than projected. The losses are much higher than we need in ecology. We geologists, who are now studying mineral resources, separate the upper polluted zone of rock from what actually exists in natural conditions in order to solve the main problem. We see that over time, the natural conditions in all regions of the republic are changing exceptionally rapidly.

Due to the effect of waste products and refuse, a number of regions, primarily the region of the northern Donets River, Donbass, and Krivbass, are already in such a state that the system will be doomed to perish without the help of man.

The durability of the upper zone of rock is being disturbed by the effect of mining, industrial city development, reclamation, and hydrotechnical construction with the accumulation of large masses of water, which leads to a drastic activation of various very dangerous geological processes. Judge for yourselves. For example, the number of landslides which are now being observed overall in the republic is 11,000. This number has tripled over the last 20 years. There are about 3,000 sink holes in the territory of the republic. Larger territories, almost a million hectares, are flooded, and there the upper zone of rock is wetted, which overall has significantly increased the seismic danger to the territory of the Ukraine. In the majority of the territory the seismicity is 4-5, in some places, up to 7; considering the increase due to wetting of the upper zone of rock, this seismicity increases by 2 or 3, depending on the underlying rock. This creates extremely serious conditions for the economy.

If all changes are combined, 22% of the republic can be classified as having strong and very strong fracturing. What can be done, from our point of view? First of all, we have approached the exogenic geological processes, considering the changes in chemical content, and modeled the entire Crimean peninsula. We have created a geological model. This is the largest geological model in the world, the first model where all geological processes, subterranean processes, surface waters, karsts, the rise of ground water, and earth creep, have been modeled on a mathematical base. Here we have drilled 900 wells, and their data is concentrated in this model. The stress condition of the tracts of 20 regions is being observed. As a result of the implementation of this program, in the last 5-7 years we, together with the Ministry of Melioration and Water Management and the Academy of Sciences, have developed and partially implemented measures which have made it possible today to confirm that using a scientific approach these processes can be halted. Now, the levels of the subterranean waters have been reduced everywhere. The quality, apparently, will also be restored in 5-7 years. This process is slower.

Such an approach, such a model has now served as the basis for work in the entire territory of the republic. We have isolated three primary regions, the northern Donets, the Dnieper region, and the Carpathians. Then, we think, overall in 5 years we will create a model of the geological environment of the republic, and if the government supports it, we will create in Kiev a republic geological and ecological center. It will have all the information needed for examination, for reaching decisions, and for developing measures.

We have now composed a program for this purpose for the next five year plan. The Committee on Ecology of the Supreme Soviet of the USSR has approved this program. The Ministry of Geology of the USSR has also found funds, and has set aside 68 million rubles in the next five year plan. We are conducting such work in the republic as a whole. We are asking the oblasts and cities to propose to enterprises to order from us an ecological large scale photograph around developments. We have now taken photographs in 50 cities. Then it is possible that the condition can be substantially improved with rather simple solutions. Here, for example, in the city of Kiev, in many areas where children gather, pollution by heavy metals is many times higher than the acceptable concentration limit. The surface layer of soil was removed, and grass was planted (this was accepted with architectural plan decisions) and the situation improved somewhat. Many other cities are in the same situation. We are ready to carry out this work. And I would ask the cooperation of enterprises so that this work could be carried out.

The second aspect. You all know quite well the misfortune that struck Gorlovka. Due to leaks at a chemical industrial complex, poisonous substances entered a mine shaft. A large number of miners were injured. We can now at all chemical enterprises, including those that pollute the environment, drill observation wells. Then

the same thing won't happen. But these enterprises must be forced to carry out the resolutions of the Soviet of Ministers of the USSR on the creation of a secret network of observation wells.

What then can be done to significantly change the attitude toward the use of nature? Primarily economic and legal measures. It must be said that our industry and agricultural industry are somewhat deaf to the many problems of ecology. The problem of obtaining ecologically pure production must be solved. For this production in polluted soil conditions we suggest the use of such nontraditional forms of minerals such as ziolites, glauconites, concrete, saponite, opoka, and sapropel. Use of these materials preserves fertile soils, and significantly reduces the content of harmful chemical substances and even radionuclides in the products.

Globally, these materials are more widely used. In the United States, about 3.5 million tons are used a year. In the Soviet Union, we use 280,000 tons. There are many such deposits in the republic. Some are unexplored. In many cases we are even ready to organize production. Seven foreign firms have turned to us. However, not one agricultural industry in the territory of the republic has come forward as a customer for production or consumption of these very valuable components.

A special problem is the pollution of the environment by mining enterprises. Here there are huge losses. It would be possible to call them that. Seventy percent of explored

deposits of oil, up to 40% of the coal, and up to 25% of the metals remain in the ground. In the extraction of coal, for example, losses due to incomplete excavation per project should be 20%. But in Voroshilograd they have risen by a factor of two in the last 20 years, and are now 40%. These huge millions of masses are expelled onto the surface, piled up, and ground, polluting everything around them. There are huge losses in the reprocessing of mineral raw materials. Twenty-five percent of the manganese is lost in enrichment. The waste products of the production of the Zaporozhye titanium-manganese industrial complex contain a large amount of rare-metal elements. We can develop technology to enrich them, which makes it possible to reprocess 6 million tons of mineral waste products that metallurgists don't know what to do with now. But until the enterprises order this, they calmly extract only the element they need today.

And look what happens to the waste. Only 3% is used. According to a good indicator, 75% is used globally. At Kirvorozhye and Donbass we have already accumulated many tens of billions of tons of waste which will pollute the ecology for many years.

I think what has happened today requires a proposal to draft a resolution of the Supreme Soviet to instruct the Soviet of Ministers of the Ukrainian SSR to develop and submit for examination a draft Law on Mineral Resources.

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