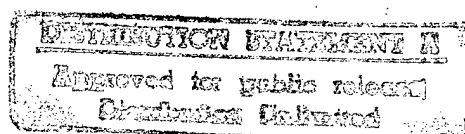


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# ***JPRS Report***



# **Science & Technology**

***Central Eurasia:  
Earth Sciences***

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# Science & Technology

## Central Eurasia: Earth Sciences

JPRS-UES-92-004

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**Influence of Haline and Thermal Stages in Convection on Vertical Hydroacoustic Structure of Upper Layer of Waters in Tropical Atlantic**

927N0094A Kiev *MORSKOY GIDROFIZICHESKIY ZHURNAL* in Russian No 3, May-Jun 92 (manuscript received 29 Jun 90) pp 59-65

[Article by N. P. Bulgakov and P. D. Lomakin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 551.463.21]

[Abstract] The temporal change in the vertical hydroacoustic structure of surface tropical water masses in the Atlantic Ocean under the influence of convective mixing conforms to definite regularities, among which are the following. Convection is accompanied by the formation and disappearance of acoustic waveguides and also jump layers with positive and negative speed of sound gradients and monotonic and nonmonotonic changes in the velocity of propagation of elastic oscillations with time. It is possible to define the characteristics of transformation of the  $C(z)$  profile of three variants of thermohaline structures with a high positive vertical velocity gradient which differ with respect to the sign on the vertical temperature gradient. The haline stage in convective mixing in freshened surface waters with a negative temperature gradient forms a speed of sound jump layer with a negative gradient and a subsurface sound micro-waveguide. These structural elements do not arise in haline convection in waters with a zero temperature gradient. In freshened waters with a positive vertical temperature gradient at the beginning of operation of saline convection a speed of sound jump layer with a positive vertical gradient is formed. In the defined variants of thermohaline structures the haline stage of convective mixing causes changes in the speed of sound profile nonmonotonic with time, weakening and total disappearance of a haline near-surface sound channel which is formed in the rainy season. Thermal convection causes a qualitatively similar form of the  $C(z)$  profile in freshened waters. In the course of development of thermal convection the speed of sound in the convective layer decreases monotonically with time. The near-surface sound channel is intensified. A speed of sound jump layer with a great positive gradient is formed. The thermal stage in convective mixing in highly saline tropical waters with an upper quasihomogeneous layer results in the appearance of a subsurface interlayer with a great positive speed of sound gradient, a clearly expressed subsurface sound channel and a monotonic decrease in the velocity of propagation of elastic oscillations with time. Figures 4; references 7: 6 Russian, 1 Western.

**Measurements of Sea Surface Roughness Parameters With Transition From Calm to Wind Waves**

927N0098B Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA* in Russian Vol 28 No 4, Apr 92 (manuscript received 3 Jun 91) pp 424-431

[Article by G. N. Khristoforov, A. S. Zapevalov and M. V. Babiy, Marine Hydrophysics Institute, Ukrainian Academy of Sciences; UDC 551.466.326]

[Abstract] The results of research on the variability of the parameters of a two-dimensional probability distribution of the slopes of sea wind waves under different hydrometeorological conditions, measured using a laser slope meter from an oceanographic platform erected in the Black Sea, are given. The operating principle of the slope meter was similar to that of the slope meters described by C. S. Palm, et al. and V. A. Hughes, et al. It measures the slope vector of a small (about 2 mm<sup>2</sup>) sea surface area. The range of slope measurements was  $\pm 30^\circ$ , the error was 0.2°, readings were made each 0.02 s and wave heights were up to 1.0-1.1 m. It was found that in situations when there are slicks there are the sharpest changes in the statistical parameters (dispersions of slopes and other third- and fourth-order coefficients). With higher wind speeds, from 4 to 11 m/s, the parameters of the probability distributions are close to those obtained earlier in the studies of Cox and Munk, except for the anisotropy coefficient, which gradually decreases from 2 to 1.5. Figures 2; references 8: 3 Russian, 5 Western.

**Resonance Interaction Between Surface and Internal Waves**

927N0098C Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA* in Russian Vol 28 No 4, Apr 92 (manuscript received 3 Jun 91) pp 439-441

[Article by S. Ya. Vlasenko, Marine Hydrophysics Institute, Ukrainian Academy of Sciences; UDC 551.466.31]

[Abstract] Despite the great interest in the interaction between surface and internal waves in the ocean, the literature usually examines only the mechanism of modulation of the field of surface waves under the influence of a stipulated field of internal waves. However, no allowance has been made for self-consistent changes in the structure of surface and internal waves caused by their nonlinear interaction. One of the few studies taking into account the nonlinear interactions between short surface and long internal waves in a two-layer ocean was made by V. V. Petrov (*IZV. AN SSSR: FAO*, Vol 15, No 7, pp 740-749, 1979), who derived a system of equations which made possible a detailed analysis of the interaction of surface and internal waves and a determination of the parameters and increments of decay and modulation instabilities observable in the interaction process, but it has since been shown that this system is nonintegrable and methods making it possible to construct precise solutions of the Cauchy problem are inapplicable to it. With this taken into account, it is shown that in the neighborhood of resonance, characterized by a coincidence of the phase velocity of an internal wave and the group velocity of a packet of surface waves, the system of Petrov equations can be transformed into a system of Zakharov equations describing long-short wave resonance such as is characteristic for physical processes having dispersion relations with double or multiple branches. Proceeding on this basis, it is shown that the existence of stable and self-consistent wave systems is

possible in the neighborhood of resonance of surface and internal waves. Reference 6: 4 Russian, 2 Western.

### **Wind Role in Variability of Energy of Inertial Oscillations in Black Sea Surface Layer**

927N0098D Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 4, Apr 92 (manuscript received 4 Jul 91) pp 442-446*

[Article by Yu. N. Golubev and A. Yu. Kuftarkov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences; UDC 551.466.3]

[Abstract] It is now well established that inertial movements in the upper layers of the ocean have a predominantly wind origin, but it is unclear why their amplitude so frequently experiences almost harmonic variations with a period substantially exceeding the period of inertial oscillations. A study was made to cast additional light on the mechanism operative in this situation without pretense at an exhaustive exploration of the problem. The study was based on measurements of current velocities made in March 1988 during the 49th cruise of the Mikhail Lomonosov at five buoy stations southwest of the Crimean Peninsula with the current meters positioned at the horizons 10 and 30 m. There were strong inertial oscillations of velocity whose amplitude changed substantially with time, clearly wind-induced. Wind data made it possible to construct the required spectra; an energy peak was registered corresponding to a period of 15.3 hours. Using such data the simple problem of generation of inertial oscillations in the Ekman layer by a wind periodic in time is examined. The results are compared with the findings of other authors. It is shown, for example, that the mechanism described by L. M. Fomin in *IZV. AN SSSR: FAO, Vol 9, No 1, pp 37-39, 1973*, does not fit the particular observational data considered. Figures 3; references 12: 6 Russian, 6 Western.

### **Discrimination of Long-Period Component of Water Temperature Variations in North Atlantic**

927N0100A Moscow *OKEANOLOGIYA in Russian Vol 32 No 2, Mar-Apr 92 (manuscript received 23 Jul 90, after revision 21 Dec 90) pp 219-227*

[Article by Yu. P. Krasovskiy and S. I. Kazakov, Experimental Division, Marine Hydrophysics Institute, Yalta; UDC 551.463.6]

[Abstract] The slowly changing component of multiyear variations of ocean water temperature is determined by a long-period asymptotic form of these variations obtained using thermohydrodynamic equations. Such an asymptotic form contains some number of parameters which are evaluated on the basis of observational data. The resulting dependence has a general character, applies for any moment in time and is related to the used observations only with respect to the accuracy of the

evaluated parameters. The asymptotic form used is described and its application to an analysis of multiyear temperature variations for different regions of the ocean is illustrated. The data presented on year-to-year ocean temperature variations show that the constructed long-period asymptotic form can be regarded as the trend in multiyear variations of this temperature. The small number of characteristics of the air pressure field over the ocean, determining this trend, indicates a considerable synchronism in variations of the slowly changing component of water temperature in different regions of the ocean. Such a synchronism appears to be characteristic of other regions of the world ocean, not only the North Atlantic. It is desirable that this trend be used in an analysis of climatic variations because it reflects the universality of such variations for different regions of the ocean. Figures 5; references 9: 8 Russian, 1 Western.

### **Stratification of Waters in Western Black Sea**

927N0100B Moscow *OKEANOLOGIYA in Russian Vol 32 No 2, Mar-Apr 92 (manuscript received 4 Sep 90, after revision 26 Mar 91) pp 234-240*

[Article by O. R. Andrianova and A. V. Kholoptsev, Marine Hydrophysics Institute, Odessa; UDC 551.465.41:551.463.24]

[Abstract] On the basis of an analysis of more than 20 hydrological surveys (from 1978 to 1989) it was possible to establish the presence of a convergence zone along the continental slope of the Black Sea, into which flow the Dnepr, Southern Bug, Dnestr and Danube, consisting of a chain of anticyclonic eddies. The use of acoustic methods for investigating the structure of these waters, as well as the hydrological characteristics, made possible a more detailed tracing of the paths of propagation and transformation of freshened shelf waters forming in the northwestern part of the Black Sea and also a more precise determination of the characteristics of their seasonal variability. An intensification of anticyclonic activity in this region in May-June was demonstrated. This is attributable to the high waters on rivers in this season of the year. The mechanism of replenishment of the energy of anticyclonic eddies by cold freshened shelf waters is discussed. The cited results indicate that the use of acoustic methods for investigation of hydrological processes in the sea broadens the possibilities of detailed analysis of the nature of transformation of freshened waters and in the future can be used widely in oceanology. Figures 3; references: 8 Russian.

### **Computation of Wavenumber-Frequency Spectrum of Noise From Distant Shipping**

927N0090A Moscow *AKUSTICHESKIY ZHURNAL in Russian Vol 38 No 2, Mar-Apr 92 (manuscript received 14 Feb 91, after revision 8 Aug 91) pp 223-228*

[Article by O. N. Anisimova, Morfizpribor Central Scientific Research Institute; UDC 534.834.1]

[Abstract] A method is proposed for determining shipping noise as the total noise of ships in those areas where the probability of detection of a single ship is less than a stipulated level. In such cases the considered noise generation area is dependent on the hydroacoustic conditions for sound propagation and the critical signal-to-noise ratio at the detector. The case of a flat-bottomed sea is examined and a number of other assumptions are made. If the densities of shipping for all types of ships and the wavenumber-frequency spectrum of fields near ships of each type are known it is possible to compute the mean wavenumber-frequency spectrum of the field of distant shipping using the detector antenna and to estimate the limits of change of this random function. For this purpose it is first necessary for each type of ship to determine the zones in which the probability of ship detection is less than the stipulated level. Then a newly derived formula is used in computing the mathematical expectations of the wavenumber-frequency spectra of the fields for each zone and for all types of ships and by adding them, determine the full mean level of the wavenumber-frequency spectrum of the field. Formulas are proposed for computing the variance, making it possible to determine the total variance of each term of the wavenumber-frequency spectrum and to find the total variance as the sum of the variances of these terms. Figure 1; references: 5 Russian.

#### Sound Scattering by Sphere With Allowance for Energy Absorption

927N0090B Moscow *AKUSTICHESKIY ZHURNAL in Russian Vol 38 No 2, Mar-Apr 92 (manuscript received 16 Apr 91) pp 252-259*

[Article by V. A. Bulanov and L. Bjorno, Problems in Marine Technologies Institute, Far Eastern Department, Russian Academy of Sciences; Danish Technical University; UDC 534.24]

[Abstract] In *J. ACOUST. SOC. AMER.*, Vol 74, No 5, pp 1542-1554, 1983 W. H. Lin, et al. examined sound scattering and absorption on a solid sphere and cylinder with allowance for the thermoviscous mechanism, but the derived system of equations was only solved numerically and no analytic evaluations of the effect were made. In order to fill this gap the scattering of a plane monochromatic acoustic wave by a sphere was examined with allowance for the absorption of energy caused by the thermal mechanism. This energy absorption mechanism is similar to that which is observed with the reflection of waves from plane surfaces (Konstantinov effect). The energy absorption attributable to thermal conductivity is substantial for sound scattering at high frequencies and also for soft objects and for bodies with fixed properties close to the properties of a fluid. It was found that the resonance lines in the scattering function, extremely narrow and great in amplitude, observed in the case of allowance only for radiation losses, with allowance for the indicated energy dissipation mechanism become broader and lesser in amplitude. Some resonance lines in this case disappear with adequately

high  $kR$  ( $S_0kR$  is the sound scattering function) and sound frequency values. Figure 1; references 19: 5 Russian, 14 Western.

#### Geoacoustic Noise of Fast-Moving Craft on Reservoir

927N0090C Moscow *AKUSTICHESKIY ZHURNAL in Russian Vol 38 No 2, Mar-Apr 92 (manuscript received 30 Jul 90, after revision 19 Apr 91) pp 371-373*

[Article by S. V. Merkushev and A. B. Shemyakin, Acoustics Institute imeni N. N. Andreyev, Russian Academy of Sciences; UDC 534.6:550.34]

[Abstract] A study was made of the geoacoustic noise of a fast-moving craft moving across a reservoir using onshore seismic detectors. The noise of hydrofoils of the "Meteor" and "Raketa" types was investigated. Reception of geoacoustic waves was with the standard three-component "Cherepakha-M" seismic detector (three mutually orthogonal velocimeters—two horizontal and one vertical) mounted on the shore and embedded 0.5 m at a distance 200 m from the axis of craft's course. The axis of maximal response of one of the horizontal detectors was oriented parallel to the craft's course. The spectral fast analysis of the geoacoustic noise with an SK4-72 spectrum analyzer with repeated passage of hydrofoils near the detector indicated that characteristic discrete components appear in the frequency ranges 65-75, 130-150 Hz and above. A more detailed spectral analysis of the records of geoelectric noise was with a Buell and Kjer two-channel signal analyzer in the frequency range 50-100 Hz. Using the known speed of hydrofoil movement and Doppler shift of 70-Hz discrete components it is possible to estimate the velocity of propagation of geoacoustic waves. The geoacoustic oscillations generated by such a craft constitute surface waves propagating with a mean velocity 395 m/s with a frequency of the oscillations about 70 Hz. Figure 1; references 4: 2 Russian, 2 Western.

#### Spatial-Temporal Structure of Ocean-Atmosphere Thermal Interaction in North Atlantic

927N0093A Moscow *METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 92 (manuscript received 6 May 91) pp 98-102*

[Article by S. B. Zavertyayev and M. I. Maslovskiy, Leningrad Hydrometeorological Institute; UDC 551.465.71(261.1)]

[Abstract] An analysis was made of the spectra of an 18-year time series of the mean monthly anomalies of ocean surface temperature, air temperature, flows of apparent heat, latent heat and virtual heat for five-degree regions of the Atlantic Ocean from 10 to 60°N. A polycyclic nature of variations of processes of thermal interaction between the ocean and the atmosphere and the spatial distribution of their principal energy-bearing periods was demonstrated. A tendency to a decrease in the period of water and air temperature variations with

an increase in latitude is traced. The instability of the period of annual variation of the thermal state of the two media near the interface caused by oceanic circulation and manifested in dynamically active regions of the ocean forms most of the temperature cycles in the range 8-16 months. The spatial and temporal structures of water and air temperature are similar and differ from the reciprocally similar heat flow structures. More than half the time series of temperatures and less than a third of the heat flow series have strong periodic variations from three to 54 months. Approximately a third of the water and air temperature series are characterized by a coincidence of energy-bearing periods and about 40 percent of the heat flow series also have coinciding variations. Identical cycles of temperatures and flows are observed in individual cases. The intensity of low-frequency heat flow fluctuations greatly changes in dependence on the region and the low-frequency variability of temperatures everywhere bears a considerable part of the energy. Figure 1; references 11: 8 Russian, 3 Western.

#### Diffraction of Surface Gravity Waves on Underwater Obstacle

927N0080C Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA* in Russian Vol 28 No 2, Feb 92 (manuscript received 13 Feb 91 pp 204-208)

[Article by I. S. Dolina and Ye. N. Pelinovskiy, Applied Physics Institute, Russian Academy of Sciences; UDC 551.466.8]

[Abstract] An approximate method was used in solving the problem of diffraction of a surface gravity wave on an obstacle situated at the bottom of a fluid. In an earlier article (DOKL. AN SSSR, Vol 295 No 5, pp 1058-1060, 1987) the authors proposed an approximate method for computing the field of scattered waves and a comparison was made with the results of numerical computations for the case of scattering of a surface wave on a sphere in an infinitely deep fluid. The accuracy of the method in that case was quite high. However, it is clear that in the case of a fluid of finite depth the situation may substantially change and in the limiting case of shallow water the sole characteristic scale is the size of the object, which may be large. Accordingly, the problem was solved of the scattering of a surface wave on an underwater obstacle in the case of an arbitrary fluid depth. The dependence of the reflection coefficient on fluid depth, length and angle of arrival of an incident wave was investigated. A separate study was made of the shallow water approximation and in this case there is a numerical solution of the problem and a comparison of the results made it possible to evaluate the accuracy of the derived formulas. It is shown in a number of commonly observed cases of scattering of a wave on obstacles that the proposed method can be used on a practical basis. Figures 4; references 7: 5 Russian, 2 Western.

#### Possibility of Retrieving Geoacoustic Parameters of Sea Floor Using Experimental Data on Green's Function of Hydroacoustic Waveguide in Broad Frequency Band

927N0086A Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 38 No 1, Jan-Feb 92 (manuscript received 7 May 91) pp 29-33

[Article by I. V. Gindler and A. R. Kozelskiy, General Physics Institute, USSR Academy of Sciences; UDC 534.21]

[Abstract] An algorithm is given for retrieving acoustically significant sea floor parameters by employing the results of wide-band sounding using signals with intrapulse modulation. A numerical-analytic procedure is proposed which rests, on the one hand, on the theory of perturbations for the eigenvalues and eigenfunctions of a plane-layered waveguide, and on the other hand, on a numerical method for solving an overdetermined system of linear algebraic equations. The proposed inverse method has definite advantages in comparison with those previously in use. The experimental method is quite simple, requiring only a wide-band emitter and a single hydrophone. An experiment can be carried out on a quasistationary path with a more or less reliable system for determining coordinates, simple data processing with a fast Fourier transform algorithm, collection of a great volume of data during a short time interval and with availability of information on both field amplitude and phase. The Green's function carries the greatest possible amount of information and with an adequately broad frequency band is a more fundamental source of information than a modal spectrum or the arrival times of a signal in individual modes or along individual rays. References 12: 6 Russian, 6 Western.

#### Generation of Internal Waves by Barotropic Tide in Region of Oceanic Ridge

927N0063A Kiev *MORSKOY GIDROFIZICHESKIY ZHURNAL* in Russian No 5, Sep-Oct 91 (manuscript received 25 Mar 91) pp 3-7

[Article by S. V. Dvogaia and L. V. Cherkosov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 532.59]

[Abstract] Within the framework of the linear theory of long waves, with allowance for the operation of Coriolis force, a study was made of the generation of internal waves by a barotropic tide in a two-layer ocean of variable depth in which a barotropic wave is incident at an arbitrary angle on the axis of an extended ridge whose elevation changes continuously. The examined basin is unbounded in horizontal directions and is filled with a two-layer fluid. In this formulation, a variant of formulations published earlier, the dependence of the amplitudes of the internal waves on the angle of incidence of the barotropic tide and the geometry of the bottom rise are investigated. The analysis indicates that reflected and transmitted internal waves are propagated almost normal

to the ridge, that is, the direction of their propagation is almost not dependent on the direction of onflow of the barotropic tide. However, the amplitudes of the generated internal waves are significantly dependent on the angle of onflow of the barotropic tide. Their maximum values are attained in the neighborhood of the critical angles. Figures 2; references 4: 2 Russian, 2 Western.

**Experimental Research on Hydrophysical Characteristics and Dynamics of Waters in Northwestern Black Sea in Zone of Main Black Sea Current**

927N0063C Kiev *MORSKOY GIDROFIZICHESKIY ZHURNAL* in Russian No 5, Sep-Oct 91 (manuscript received 3 Jul 90, after revision 9 Aug 90) pp 45-50

[Article by V. A. Blinkov, V. A. Dulov, and O. V. Shulgin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 551.465(262.5)]

[Abstract] The results of one of the stages in experimental work in a test range taking in the continental slope of the northwestern shelf and the adjacent abyssal part of the Black Sea are presented. This is a region of interaction of waters forming on the northwestern part of the shelf and main Black Sea waters. The research was carried out from the Professor Kolesnikov research ship operating in a test range located to the southwest of the Crimea. The structure of currents, distribution of zones of subsidence and upwelling and location of mesoscale fronts are discussed. The experimental work, implemented in August 1988, indicated that in the test range, within the frontal zone of the Main Black Sea Current, there are several mesoscale fronts simultaneously present with a convergent nature of circulation. A possible reason for the formation and evolution of these fronts is the onflow of northwesterly waters onto the principal Black Sea waters. In the work area there is an alternation of positive and negative divergence. In August the salinity and temperature fields are spatially well matched; zones where the isolines of these characteristics are close together have a similar configuration and are close geographically. The principal elements of the current field in August are: flow from the northeast, undergoing transition into westerly, along 43°50'N, and southwesterly. Instrumental measurements of currents do not make it possible to regard the Main Black Sea Current as a stable, clearly expressed jet. In the test range there are flows, sometimes with different directions, with a horizontal extent of several tens of kilometers. Figures 5; references: 6 Russian.

**One Method for Retrieving Speed of Sound Profile in Acoustic Sounding of Ocean**

927N0077A Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 37 No 5, Sep-Oct 91 (manuscript received 1 Sep 88, after revision 16 Apr 91) pp 886-891

[Article by S. V. Burenkov and Yu. V. Dudko, Acoustics Institute imeni N. N. Andreyev, USSR Academy of Sciences; UDC 534.22]

[Abstract] Although many methods for determining the speed of sound in the ocean have been proposed which are of theoretical importance, their practical applicability in experimental retrieval of the speed of sound profile is doubtful because: 1) the real ocean at the scales characteristic for scattering problems (fraction of a meter - tens of meters) has little in common with a plane-layered model, 2) for the characteristic speed of sound gradients  $c(z)$  the reflection coefficient is about  $10^{-10}$  and even with emitter operation at the cavitation threshold the level of the reflected signal is much below the ocean noise level. The idea of the proposed method for determining the speed of sound is as follows: the reflection from fluctuations of hydrophysical parameters (most importantly, temperature) is used in retrieving the dependence of their mean values on depth, making use of the fact that the statistical and averaged hydrophysical characteristics are interrelated to one another in a definite way following from the physical essence of the processes transpiring in the water layer. The connecting link between the mean characteristics and their fluctuations is the turbulence of water masses because small-scale fluctuations of oceanological parameters are caused by the mixing of water in the presence of gradients of their mean values. Formulas are derived which express the essence of the proposed method for retrieving the speed of sound profile. Experiments for checking it were carried out in the autumn of 1987 in the North Pacific in regions with typically northern and typically southern hydrologies at depths 5400-5600 m during the daytime when the depth of the sound-scattering layers of biological origin was maximal. The observation procedures, calculations and processing are discussed in detail and illustrated in an example. Figures 5; references: 11 Russian.

**Resonant Amplification of Longwave Disturbances on the Northwest Shelf of the Black Sea**

927N0068 Moscow *DOKLADY AKADEMII NAUK SSSR* in Russian Vol 320 No 2, Sep 91 (manuscript received 13 Feb 91) pp 456-460

[Article by N. Ye. Voltsinger, Ye. K. Demirov, and B. A. Kagan, Leningrad Branch of the Shirshov Institute of Oceanology, USSR Academy of Sciences; UDC 551.465:551.468]

[Abstract] In recent years there has been a drastic worsening of the ecological condition of the Black Sea. In the worst case, coastal regions have sluggish circulation and poor mixing when there are continuous agricultural discharges into the sea. Efforts to improve water quality should use reliable local hydrodynamic models that allow one to calculate and analyze in detail the structural laws governing coastal regions in order to solve diagnostic, planning, and optimization problems. This article states and numerically solves the problem of defining the spectrum of natural oscillations of the Black Sea in a two-layer approximation. Analysis reveals the location of natural oscillations in the spectrum, as well as the possibility of resonant amplification of harmonics with periods of 36.57 and 27.31 hours, similar to the

periods of the periods observed in the flooding of the northwest shelf in February 1979. In order to consider the shallow water dynamics of the northwest shelf one must correctly describe important details of the geometry of the coastal region. This article does not use the

typical approach, in that it uses curvilinear coordinates. The initial equations look like Lamb's equation. This approach may be compared with other approaches using Euler's equation. Figures 2; references 3: 2 Russian 1 Western.

**Allowance for Atmospheric Parameters in Laser Remote Gas Analysis**

927N0098A Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 4, Apr 92 pp 391-397*

[Article by V. N. Arefyev, G. I. Bugrim, K. N. Visheratin and N. I. Sizov, Tayfun Scientific Production Association, Obninsk; UDC 551.510.4:621.375.826]

[Abstract] Although development of systems for the remote monitoring of atmospheric gaseous components and impurities by the differential absorption method is of the highest priority, the role of a number of atmospheric parameters and properties, such as the overlapping of the absorption spectra of different gases and the dependence of the absorption coefficients on temperature and pressure, have not been adequately analyzed or have not been examined at all. Accordingly, an evaluation was made of the role of these factors in the examples of systems with a CO<sub>2</sub> laser whose generation spectrum in the energy transitions 00011-10001 and 00011-10002 coincides with the atmospheric window of relative transparency 8-13 μ and whose individual generation lines overlap with sectors of absorption of atmospheric gases and impurities. The influence of ambient temperature and pressure and the absorption of radiation by different atmospheric components on the error in laser remote gas analysis is analyzed. The results of measurements of the concentration of atmospheric water vapor using a CO<sub>2</sub> laser are presented. Recommendations on remote gas analysis of atmospheric water vapor, ethylene and ammonia are given. Figures 2; references 19: 6 Russian, 13 Western.

**Combined Use of Spectral Brightness and Polarization Characteristics of Upward Radiation in Remote Sensing of Inland Bodies of Water**

927N0089A Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 92 (manuscript received 26 Jul 91) pp 24-29*

[Article by A. A. Buznikov, G. A. Lakhtanov, K. A. Mokiyeveskiy, V. B. Rummyantsev, and S. G. Shvareva, Institute of Electrical Engineering, Institute of Lake Sciences, Russian Academy of Sciences, St. Petersburg; UDC 535.345.1:629.78]

[Abstract] This article presents the results of measurements of the characteristics of upward radiation made on board a ship with a hand-held spectrograph on Lake Onega. Contact and remote measurements were made. It is shown that a parameter such as the effective wavelength, which is based on spectral brightness measurements, can be used with the degree of polarization for remote sensing of inland bodies of water with various optical characteristics. Multiple regression equations are calculated that link the relative transparency of the water with the effective wavelength and the degree of polarization of upward radiation. Figures 5; references 15 (Russian).

**Circulation of the Upper Layer of the Central and Eastern Basins of the Mediterranean According to Data of Ship and Satellite Observations in Winter-Spring 1990 and 1991**

927N0089B Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 92 (manuscript received 28 Aug 91) pp 30-37*

[Article by G. A. Grishin, A. S. Studenetskiy, and N. M. Lets, Institute of Marine Hydrophysics, Ukrainian Academy of Sciences, Sevastopol; UDC 551.501:628.78]

[Abstract] This article analyzes the results of ship and satellite observations of the hydrological structure and large-scale dynamics of water in the central and eastern basins of the Mediterranean Sea during February-April 1990 and January-March 1991, respectively. Maps of the dynamic topography and geostrophic circulation on various levels were compiled. They were then compared with spatial distributions of the surface temperature of the sea. These distributions were constructed from ship and satellite measurements. There was a good agreement of the fields of dynamic topography and geostrophic currents at the surface with composite images of sea surface temperature. The distribution is complex and depends on the circulation of masses of water. Closed systems of circulation in cyclonic and anticyclonic directions were found in the central basin. An intense eastward current was found at a depth of 250-300 m. In the center it weakens, then splits. This is apparently the North African current. Temperature patterns and anomalies are described. Three quasi-stationary eddy formations were found which play a decisive role in circulation. Anticyclonic circulation systems were found to predominate. Figures 6; references 6 (Russian).

**Ecological Monitoring of the Territory of Moscow Using Data From the IR-Heat Channels of an Aircraft Scanner**

927N0089C Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 92 (manuscript received 4 Feb 91) pp 38-40*

[Article by A. A. Feoktistov, Ye. L. Zlobin, A. F. Molchanova, V. A. Zelenin, and V. S. Artemkov, AIUS-Agroresursy Research Center, Moscow; UDC 528.75:681.32]

[Abstract] An aircraft multi-channel scanning system was used over Moscow to study temperature contrasts in the IR channels. Day and night photographs were taken at an altitude of 4 km. In the night photo a resolution of 25 m was achieved. The distribution of large temperature anomalies was evaluated, and the heat losses of individual regions of the city were compared. For quantitative analysis, more detailed digital thermal maps were used. The detection method was able to find 25 previously known sources of discharges into the Moscow River. It was shown that the method can be used practically to evaluate the ecological state of the region. References 7 (Russian).

### Extrapolation of Drilling Data Using Nonlinear Filtering of Aerospace Images of the Earth's Surface

927N0089D Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 92 (manuscript received 18 Jun 91) pp 41-47

[Article by I. V. Kalinin and I. V. Terentyev, Central Surveying Expedition, Yaktuskgeologiya Polar Geophysical Observatory, Yakutsk; Research Institute of Aerospace Geological Methods, St. Petersburg; UDC 528.85:528.8:778.431]

[Abstract] It is shown that it is possible to use nonlinear filtering of aerospace information to increase the accuracy of extrapolation of data from Earth-based measurements. An example is given, two images of one oil and gas bearing region of western Yakutiya. The images were synthesized into one image using various methods. Using a lineaments scheme it was established that, with a simple mask consisting of five points, the coefficient of correlation in a nonlinear third-order transformation could be increased to 0.9. In filtering of part of the image, the coefficient of correlation between Earth-based data and the transformed image of the region reached 0.7-0.8. Figures 7; references 5 (Russian).

### Spectral Studies Using a 8-14 $\mu\text{m}$ Field Spectrometer

927N0089E Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 92 (manuscript received 28 Jan 91) pp 51-58

[Article by V. G. Surin, Research Institute of Aerospace Methods, St. Petersburg; UDC 528.813]

[Abstract] This article describes in detail the basis of a method to conduct spectral studies using a 8-14  $\mu\text{m}$  field spectrometer. The method includes the construction of models of the object and measurement system, verification of the models in field conditions, measurement of radiation, normalization of the data, determination of the energy brightness of the object and background, and determination of the effective radiation coefficient and real radiation coefficient. Quantitative data may be obtained on the radiative characteristics of natural objects. No special temperature measurements are required, because a pyroelectric radiation receiver is used. The method was tested on geological objects in Central Kazakhstan, in particular, diorite rock. This method was also used to conduct spectral studies of other types of rock. The results indicate that the frequency and amplitude anomalies in the spectra recorded by the instrument have a real and specific cause. These anomalies manifest themselves in different ways when the experiment is carried out under different conditions. The deviation increases substantially when the temperature of the object differs substantially from air temperature. A systematic error in the determination of water temperature was also uncovered. Figures 6; table 1; references 14: 11 Russian 3 Western.

### Characteristics of Atmospheric Radiation Regime and Heat Exchange at Ocean Surface Under Continuous Cloud Cover

927N0081B Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 3, Mar 92 (manuscript received 30 May 91) pp 277-282

[Article by Ye. N. Leontyeva, Atmospheric Physics Institute, Russian Academy of Sciences; UDC 551.521;551.465.7]

[Abstract] This is essentially a continuation of an article by the author in the previous number of this journal (IZV. AN SSSR: FAO, Vol 28 No 2, pp 151-157, 1992). Estimates were made of the radiation regime in three atmospheric layers (above clouds, clouds, below clouds) and the heat balance at the ocean surface was determined using in situ data collected on the 35th cruise of the Akademik Kurchatov. Data are given on actinometric observations made by the author in the summer of 1982 in the Middle Atlantic region when predominantly stratocumulus clouds were present. A previously developed model of the aerosol-cloud atmosphere was used in computing the fluxes of short-wave radiation and earlier proposed methods for computing the profiles of thermal radiation made it possible to describe the atmospheric radiation regime. In the method used in computing integral short-wave radiation the optical depth of the cloud layer is first determined from the total solar radiation measured by a selective pyranometer without a filter in the region 0.38-0.71  $\mu\text{m}$ . Then measurements of humidity and aerosol optical depth are used in computing the profiles of descending and ascending integral fluxes. The method used in computing long-wave radiation was the same as in the first part of the study. Since only optically dense clouds are considered, they are assumed to be ideally black emitters. The profiles of atmospheric parameters are determined from the results of aerological sounding. The quantities of heat absorbed by the ocean under different conditions are determined from in situ data on radiation and turbulent fluxes at the surface. Figure 1; references 7: 6 Russian, 1 Western.

### Statistical Properties of Illumination in Image Plane in Lidar Sensing of Sea Surface

927N0081C Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 3, Mar 92 pp 319-324

[Article by V. I. Ivanov and A. N. Lazarchik, Scientific Research Institute of Nuclear Problems; UDC 551.463.5]

[Abstract] The objective of the study was research, within the framework of the first two moments, on the statistical properties of field intensity in the image of a sea surface illuminated by coherent optical radiation and the derivation of simple asymptotic expressions for the indicated moments with different relations of the surface parameters and the sounding geometry. The basis for the

work was a lidar sensing scheme described earlier by the authors in IZV. AN SSSR: FAO, Vol 26 No 11, pp 1205-1210, 1990. A source of coherent radiation at a stipulated altitude above the water surface generates a downward-directed Gaussian beam with a given effective light spot radius. An optical detector positioned coaxially with the radiation source at a different altitude has an optical system consisting of a lens with a pupil function of the Gaussian type which forms a sharp surface image in a plane situated at a given distance from the lens. Formulas are derived for the mean value and intensity correlation function in the image plane. The asymptotic form of the derived formulas for different limiting values of the statistical and geometric parameters of the experiment was investigated. The presented analysis of the statistical properties of illumination in the image plane of the lidar optical system during sea surface sensing shows that under definite conditions these properties can be used in evaluating the statistical parameters of the surface. In particular, the mean intensity in the image plane makes it possible to estimate the density distribution of sea surface slopes if the divergence of the sensing ray considerably exceeds the dispersion of slopes. The derived formulas can be used in determining the accuracy of such an evaluation and in selecting the optimum sensing scheme. Figure 1; references 7: 6 Russian, 1 Western.

#### Television Reporting Aerospace Survey

927N0095A Moscow *GEODEZIYA I KARTOGRAFIYA in Russian No 2, Feb 92 pp 21-25*

[Article by B. N. Rodionov; UDC 528.711.1(202)]

[Abstract] A television reporting aerial survey is a new remote sensing method for monitoring the state of agricultural resources. It involves a survey of agricultural areas from light aircraft using portable TV cameras with registry of images by a portable VCR. Simultaneously the operator-observer dictates and enters on the video-film comments on the degree of development of plants, their damage and anomalies. The videofilm can be played on ordinary TVs. The method combines the reliability of instrumental observations with the on-line character of TV reporting and is available to a wide range of users. The first TV reporting experiments were carried out at the Moscow Institute of Land Survey Engineers in 1980-1982. Later the system was developed at the All-Union Scientific Research Center for Developing and Operating the "AIUS-agroresursy" Data Management System. The survey is made with a constant TV camera focal length; in case of necessity the operator discriminates detail. The great range of available resolutions makes it possible to evaluate the state of both individual agricultural crops and fields as a whole. During 1988-1989 the method was used on an experimental basis from the "Mir" orbital station with direct transmission of the image through space and surface communication lines directly to users. This was done using the "Niva" TV outfit, consisting of a TV camera, VCR, monitor and communication line. The image

detail was 40-50 m on the ground with a swath width 25 km. The resulting TV photographs made it possible to evaluate large anomalies in the development of agricultural crops, seasonal variations of reservoirs and irrigation systems, centers of salinization, zones of pollution around populated places and other ecological phenomena. These experiments were continued in 1991 using devices for compensating image shift, making it possible to obtain a surface resolution of 10 m. Both the small aircraft and spacecraft variants constitute an inexpensive means for on-line remote sensing of agricultural resources. The geometric and brightness characteristics of the TV reporting image are discussed in detail. Factors governing accuracy of the product, processing and interpretation procedures are outlined. Figures 2.

#### Image Spectrum of Sea Surface Formed by Synthesized Aperture Radar

927N0084A Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 pp 32-36*

[Article by M. B. Kanevskiy, Applied Physics Institute, USSR Academy of Sciences, Nizhny Novgorod; UDC 551.46.086:629.78]

[Abstract] In an earlier study (ISSLED. ZEMLI IZ KOSMOSA, No 4, pp 12-18, 1990) the author examined nonlinear transformation of the spectrum of sea waves into their image spectrum obtained using a synthesized aperture radar with numerical computations made using a simplified model function of the correlation of orbital velocities. Now, however, as the basis for computing the spectrum of the SAR image of the sea surface use is made of the spectrum of rises published by K. Hasselmann, et al. (DEUTSCHE HYDROGRAPHISCHE ZEITSCHRIFT, Reihe A, No 12, pp 1-95, 1973), obtained in an in situ experiment, being a generalization of the Pierson-Moskowitz spectrum. It is shown that the mechanism of formation of the sea surface image when using such a radar is nonlinear regardless of the directions of wave propagation, other than those close to radial (this makes problematical a detailed retrieval of the wave spectrum from its SAR image and the possibility of retrieving the parameters of the model spectrum seems more realistic). The spectra of the SAR image of waves propagating in an azimuthal direction, with allowance for speckle noise, are found. A definite approach for solution of the inverse problem is discussed. Figures 2; references 7: 3 Russian, 4 Western.

#### Accuracy in Determining Ocean Surface Temperature and Its Variations by Spectral Methods in Satellite Microwave Radiometry

927N0084F Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 pp 107-121*

[Article by A. G. Grankov and A. M. Shutko, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow; UDC 551.463:629.78]

[Abstract] The effectiveness of microwave radiometry methods for determining ocean surface temperature (OST) based on the spectral regularities in the interrelationship between the field of characteristic microwave radiation of the ocean-atmosphere system in the range of centimeter waves and hydrometeorological parameters is analyzed. OST is determined using the contrast (amplitude) principle for measuring the microwave radiation characteristics simultaneously in several parts of the spectrum. Estimates of the accuracy in determining OST and its variations attained using satellites of the orbital type are given and the conditions under which the potential accuracy can be realized for this range and operating mode are examined. Computed estimates of the accuracy in determining the instantaneous, synoptic and seasonal variations of OST when making observations from geostationary satellites are presented. It is shown that despite the considerable progress attained during the last decade in the field of satellite radiometry methods and apparatus for sensing OST appreciable discrepancies persist between the computed estimates of accuracy in its determination and experimental results. Programs in place in a number of countries indicate that in the early 1990's there should be an activity burst similar to that which occurred in the late 1970's-early 1980's. This should facilitate progress along a whole series of fronts which are defined and discussed in the conclusion. Figures 6; references 104: 62 Russian, 42 Western.

#### **External Calibration of Low-Contrast Microwave Radiometry Measurements From Artificial Earth Satellite and Determination of Ocean Surface Temperature**

927N0084B Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 pp 37-45

[Article by B. Z. Petrenko, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow; UDC 551.521:629.78]

[Abstract] The ineffectiveness of existing methods for the processing of radiothermal measurements in a case when high radiothermal contrasts are absent in the processed file is analyzed. It is shown that the traditional linear external calibration method makes it possible to obtain only biased evaluations of the calibration coefficients. Special indices of the contrast of measurements for individual channels and for the entire processed file of measurements determining the relative bias of evaluations of the scale factors are introduced. This bias is small when processing high-contrast radiothermal measurements well supported by a priori information, but increases with a decrease in the contrast of the measurements due to the exclusion of land regions from the processing. A nonlinear method was developed for processing radiothermal measurements based on the use of a special calibration relation. It is shown that this nonlinear method makes possible the effective retrieval of ocean surface temperature without use of land regions for external calibration. However, if the latter are used,

both methods (linear and nonlinear) ensure an approximately identical accuracy in determining ocean surface temperature. Figure 1; references: 8 Russian.

#### **Adaptive Algorithms for Estimating Content of Chlorophyll 'a' in Phytoplankton Using Remote Sensing Data for Mesotrophic and Eutrophic Water Bodies**

927N0084C Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 (manuscript received 20 May 91) pp 46-51

[Article by I. Yu. Kamov, Hydrochemical Institute, Rostov-na-Donu; UDC 551.46.0:629.78]

[Abstract] The optimum wavelengths for statistical determination of the content of chlorophyll "a" in phytoplankton are those pairs  $\lambda_1, \lambda_2$  of wavelengths,  $680 < \lambda_1 < 720$  nm for which the mean spectral brightness coefficients coincide. Evaluations of the sensitivity and results of application of the formulated algorithms to two files of experimental data are presented. The choice of the optimum wavelengths for the proposed adaptive algorithms is not dependent on the specific form of the dependence of the spectral brightness coefficient on the optical indices: it is only necessary that there be a smoothness of this dependence and a small spectral variability of both the scattering phase functions at angles greater than  $2\pi/3$  and backscattering of radiation by mineral suspensions. Using an expression cited in the article it is possible to evaluate the influence of the spectrally dependent index  $\beta(\lambda)$  on the quality of the adaptive algorithms. The influence of the chlorophyll fluorescence effect (which is dependent on the physiological state of the cells) on the adaptive algorithms is taken into account. The volume of experimental data used in testing the adaptive algorithms was inadequate for reliable confirmation of any theoretical conclusions but provides a basis for further empirical investigation of the proposed algorithms. Figure 1; references 9: 7 Russian, 2 Western.

#### **Analytic Model of Deviations in Coordinates of Points on Pseudoframe Obtained in Scanner Survey of Earth's Surface**

927N0084D Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 (manuscript received 20 May 91) pp 52-61

[Article by V. F. Petrishchev; UDC 528.714.2]

[Abstract] When making a frame survey from an artificial earth satellite the deviations in coordinates of stipulated points on the image are dependent in a general case only on three deviations in the survey camera spatial position and three deviations in the parameters of its orientation along each of the coordinate axes. In a scanner survey the considered deviations in coordinates must also be dependent on deviations in the velocities of translational and rotational motions of the space

camera, that is, must be functions of a 12- (rather than a 6-) dimensional vector of deviations in the elements of outer orientation. The problem of constructing a model of deviations in a scanner survey is therefore more complex than in the case of a frame survey. Taking into account the great diversity of scanner survey methods, as well as the available models of survey camera motion, it must be expected that there will be a corresponding diversity of models of deviations in a scanner survey. This makes it impossible to solve the problem of constructing a unified model of deviations in a scanner survey, in contrast to the case of a frame survey. Accordingly, a quite general approach to solution of the formulated problem is proposed which is applicable to a very simple case of survey camera motion. Only in the presented very simple case is a finalized solution of the problem possible. The proposed analytic model of deviations is represented in a linear discrete form. The constructed linear model of deviations in the coordinates of points on a so-called pseudoframe was possible only by the choice of a simplified model of survey camera motion and the conditions for the scanning of a local sector. This procedure cannot be applied to the case of panoramic scanning. Figure 1; references: 5 Russian.

#### **Global On-Line Space Monitoring of Atmospheric Ozone**

927N0084E Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 92 (manuscript received 7 Jan 91) pp 72-78*

[Article by A. I. Kot, A. M. Lyudchik, A. N. Krasovskiy and A. F. Chernyavskiy, Scientific Research Institute of Applied Physical Problems imeni A. N. Sevchenko, Minsk; UDC 551.510.534]

[Abstract] Data from the Nimbus ozonometric satellite indicate that satellite observation methods are the sole effective means for monitoring the state of atmospheric ozone. However, data of the type supplied by Nimbus have only a local character, limited to the satellite trajectory, and cannot be used in on-line monitoring of the state of the ozonosphere above the Earth's entire surface. Accordingly, a study was made of the possibilities of a method for on-line global monitoring based on atmospheric spectral brightness in the UV spectral range. Since only one spectral interval is used, quantitative information on ozone distribution is largely lost and it is only possible to make a qualitative analysis of the state of the ozonosphere over different sectors of the Earth's surface with detection of regions of significant anomalies, such as the Antarctic ozone hole. The Nimbus system and the new approach supplement one another. The essence of the proposed method is that a satellite in a quite distant orbit carries an optoelectronic instrument forming and registering the image of the visible surface of the Earth in a narrow (several nanometers) spectral interval in the wavelength region  $\lambda$  less than or equal to 300 nm. In this case the fraction of radiation reflected from the Earth's surface is negligible in comparison with the radiation scattered in the atmosphere and the optical

characteristics of the surface exert no influence on the distribution of atmospheric brightness. Under such conditions the brightness of a pixel is determined by the conditions for illumination of the corresponding part of the atmosphere by the sun, vertical distribution of ozone and choice of the observation wavelength. Since the illumination conditions change monotonically from pixel to pixel it is natural to relate all the spatially limited brightness fluctuations detected in the image to anomalies in atmospheric ozone distribution. The effectiveness of the method is illustrated by model computations. Figures 3; references 12: 5 Russian, 7 Western.

#### **Integral Atmospheric Short-Wave Radiation Fluxes Over Continuously Cloud-Covered Ocean**

927N0080A Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 2, Feb 92 (manuscript received 12 Feb 91) pp 151-157*

[Article by Ye. N. Leontyeva, Atmospheric Physics Institute, Russian Academy of Sciences; UDC 551.521.1]

[Abstract] A study was made to determine solar radiation fluxes in the atmosphere over the ocean when there is a continuous cloud cover. Data were used from standard shipboard actinometric and meteorological observations. A method was developed for computing the solar component of the atmospheric radiation regime using these data. In order to solve the formulated problem it was necessary to prepare optical models of an aerosol atmosphere and clouds, then compute the fluxes and compare the results with measurements of the total solar radiation incident on the surface. The total radiation in clouds computed as a function of optical depth and solar zenith angle makes it possible to formulate the inverse problem: by measuring the total radiation and knowing the solar zenith angle, determine the optical depth. On this basis a model of an aerosol-cloud atmosphere was developed for computing the profiles of fluxes of direct, diffuse and total radiation and ascending short-wave radiation in the atmosphere above an ocean with a single cloud layer situated at an arbitrary altitude. The sensitivity of the fluxes at the surface and outgoing radiation at the upper boundary of the atmosphere to the main input parameters was examined. Experimental quantities of total radiation at the ocean surface in the Middle and Tropical Atlantic are compared with data computed using the proposed model under conditions of continuous Sc and As cloud cover. Figures 7; references 7: 3 Russian, 4 Western.

#### **Research on Characteristics of Temperature-Wind Changes in Radiobrightness Temperature of Wave-Covered Sea Surface**

927N0080B Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 2, Feb 92 pp 196-203*

[Article by A. K. Arakelyan, Radio Physics and Electronics Institute, Armenian Academy of Sciences; UDC 551.465.6]

[Abstract] It was shown in earlier studies that in addition to wind speed water temperature exerts a significant influence on the wind wave formation process, making it necessary to carry out research on changes in the radio-thermal characteristics of the sea surface caused by temperature changes in the spatial spectrum of surface waves. Allowance was made for the temperature dependence of the spatial spectrum of wind waves, being a corollary of changes in stratification conditions and the viscous dissipation of short wind waves with temperature. Methods are proposed for microwave radiometry sensing for determining the speed of the near-surface wind and water temperature. It is concluded that the temperature increment of radiobrightness temperature of the wave-covered sea surface is attributable to temperature changes of the permittivity of water and the spectrum of wind waves. The temperature increments of both the radiobrightness temperature and the emissivity of the sea surface are commensurable with the wind increments of these quantities. The maximum of the temperature changes falls in the radio wave range 3-10 cm. For the precise remote determination of wind speed and water temperature by microwave radiometry methods it is necessary to carry out two-position, two-frequency or bipolarization measurements of sea surface radiobrightness temperature. Figures 6; references 17: 11 Russian, 6 Western.

#### **Determining Atmospheric Aerosol Optical Depth From Surface Measurements of Direct Integral Solar Radiation**

927N0039C Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 12, Dec 91 (manuscript received 4 Apr 91) pp 66-71

[Article by T. A. Tarasova and Ye. V. Yarkho, Central Aerological Observatory; UDC 551.521.31]

[Abstract] Simple formulas are proposed for computing atmospheric aerosol optical depth at a wavelength  $0.55\mu\text{m}$  using data on direct integral solar radiation measured with an actinometer. An estimate was made of the possible errors of the method attributable to the inadequacy of data on the spectral behavior of the aerosol extinction coefficient. The use of the results of observations of direct solar radiation  $S$  at stations is difficult due to the lack of precise data on atmospheric moisture content because the actinometric and aerological networks rarely coincide. This problem can be solved using empirical relations between moisture content and water vapor elasticity at the surface in different regions. An error in determining spectral aerosol optical depth of less than 0.05 can be attained when using data on moisture content  $w$  determined with an accuracy to  $0.5\text{ g/cm}^2$  in the dry atmosphere with  $w < 1\text{ g/cm}^2$  and with an accuracy  $2.5\text{ g/cm}^2$  in the moist atmosphere when  $w$  is equal to or greater than  $1\text{ g/cm}^2$ . Determination of the spectral aerosol optical depth with an accuracy greater than 0.05 is infeasible. The method was checked by using 86 instantaneous  $S$  values obtained during a period of an experiment for studying the

radiation properties of cirrus clouds. Four method variants were compared and all gave very close results. The good consistency of the different variants makes it possible to recommend formula (4) derived in this study for the processing of network observations. Figure 1; references: 9 Russian.

#### **Statistical Characteristics of Atmospheric Transparency Coefficient on Slant Paths**

927N0039D Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 12, Dec 91 (manuscript received 24 Jan 91) pp 72-76

[Article by Ye. R. Milyutin and Yu. I. Yaremenko, Leningrad Communications Electrical Engineering Institute]; UDC 551.591.36/6]

[Abstract] The results of actinometric measurements were used in determining the time regularities of change in the atmospheric transparency coefficient on slant paths. Files of data from direct solar radiation measurements made at Voyeykovo during 1980-1982 were subjected to statistical processing. This required computation of the relative transparency coefficient, broken down into 19 intervals. Tabulated data on integral intensity of solar radiation at the ground surface and the transparency coefficient as a function of solar angle of elevation for the ideal atmosphere were used in the process. Tabulated data are given for the monthly and mean annual statistical characteristics of the relative transparency coefficient. During winter the mean value is less than the mean annual value, whereas in spring and summer it is greater. Two characteristic situations with different observation conditions are distinguished. A computer analysis made it possible to determine that with the presence of clouds of any type on a slant path the empirical distribution of the atmospheric transparency coefficient is approximated well by a truncated Rayleigh distribution, but in the case of absence of clouds—by a modified beta distribution. By applying this method it is possible to solve modern scientific problems, such as determining the effective lifetime of modern systems for transmitting information in the optical range. Figure 1; references: 9 Russian.

#### **Thermal Effects of Mixing of Sea Waters With Different Temperatures and Salinities**

927N0054B Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 10, Oct 91 (manuscript received 19 Nov 90) pp 88-93

[Article by A. G. Zatsepin, A. D. Krylov and N. A. Maksimenko, Oceanology Institute, USSR Academy of Sciences; UDC 551.465.4:551.463.6]

[Abstract] The thermodynamics of the process of mixing of sea waters with different temperatures and salinities is examined. An integral equation for the budget of enthalpies is written and solved numerically. The results of computations of the thermal effects of mixing are

approximated by simple polynomials. It was established that the temperature of the mixture may deviate from the arithmetical mean temperatures of the mixing water masses (with allowance for the proportions) by as much as 0.1°C. However, the real contribution of this deviation to the effects of increased density with mixing, as well as ice formation within the water during mixing, is scarcely substantial. The thermal effects of mixing of different water masses in the world ocean are extremely weak, although in some cases they may attain entirely measurable quantities. However, it is impossible to make a direct comparison between the model considered in this article and the results of in situ observations. Under natural conditions in regions with a marked salinity stratification the adiabaticity condition may not be satisfied; an increasing mixing time results in considerable interaction with adjacent layers and the atmosphere and the effects of differential diffusion of heat and salt at different rates become important. These effects are manifested most strongly during the supercooling of the upper layer when it comes into contact with the lower, more saline layers. Figures 3; references 10: 6 Russian, 4 Western.

#### **Some Results of Lidar Determination of Slant Visibility Parameters at Airfield**

927N0047B Moscow *METEOROLOGIYA I GIDROLOGIYA* in Russian No 9, Sep 91 (manuscript received 28 Sep 90) pp 18-25

[Article by Ye. Ye. Rybakov, V. A. Kovalev, A. S. Pak and Ye. E. Mozharov, Main Geophysical Observatory; Zenit Scientific Production Association; UDC 551.591.6:551.501.816]

[Abstract] Practical tests of the "Elektronika-06R" lidar, a modernized variant of a lidar instrument for measuring the range of slant visibility, were carried out in the autumn of 1989 at Ulyanovsk airport. The lidar modernization involved replacement of the analog registry system and processing of the signals in a digital registry system (on-line computer data processing). The objectives of the research were testing of algorithms for processing lidar signals and a method for determining visibility using a lidar directly at an airfield. A direct comparison also was made of the results of lidar measurements of the altitude of detection of airstrip ground reference points and lights with data from visual observations from aboard aircraft at the time of landing and also the results of measurements of the altitude of the lower cloud boundary made with standard cloud altitude recorders forming part of KRAMS meteorological systems. Another objective was refinement of working algorithms and individual parts of the measurement method and gathering statistical data in slant directions under different meteorological conditions. A diagram of positioning of the instruments at the airfield is presented and the results of the comparisons are given. There was a good agreement between lidar sounding data and visual observations from an aircraft. The results are preliminary and require careful checking under a wide range of weather conditions. Figures 5; references 9: 8 Russian, 1 Western.

#### **Simplex Method in the Problem of Optimization of the Phase of a Light Beam in a Nonlinear Medium**

927N0091A Moscow *OPTIKA ATMOSFERY* in Russian Vol 4 No 12, Dec 91 (manuscript received 26 May 91) pp 1249-1253

[Article by I. V. Malafeyeva, I. Ye. Telpukhovskiy, and S. S. Chesnokov, Lomonosov Moscow State University; UDC 535.416.4]

[Abstract] Adaptive and programmatic means of beam control are used to compensate for the distortions of a light wave associated with nonlinear refraction and turbulent fluctuations of the index of refraction of the medium. The problem of control is one of searching for the phase of a light beam at which the quality criterion of radiation in the observation plane acquires an extreme value. Aperture sensing is typically used in quasi-stationary conditions. This makes it possible to optimize any criterion reflecting the control goal. However, gradient procedures typically only find the local extremum of the quality criterion. Phase control methods need to be developed on the basis of procedures which do not require calculation of the gradient of the target function. This article studies the effectiveness of adaptive compensation of stationary wind refraction of a light wave based on the simplex method. Simple optical aberrations are used as the basis modes of control. The control goal function is taken to be the focusing criteria that characterize the concentration of a light field in a given observation plane. The simplex method is found to reach the extremum more quickly, which may further improve the search strategy. The simplex method reliably finds the maximum of the target function with a previously determined accuracy. This makes it possible to increase the speed of adaptive systems without adding more complex equipment. The number of measurements of the target function (compared with gradient procedures) can be reduced by a factor of 1.5-2. Figures 2; table 1; references 3 (Russian).

#### **Some Questions on the Compensation of Nonlinear Distortions of Optical Radiation. Algorithms of Adaptive Control**

927N0091B Moscow *OPTIKA ATMOSFERY* in Russian Vol 4 No 12, Dec 91 (manuscript received 18 Sep 91) pp 1265-1272

[Article by V. A. Trofimov, Lomonosov Moscow State University; UDC 621.373]

[Abstract] This article provides an overview of algorithms presently used to control the parameters of light radiation and their implementation in numerical experiments to compensate for nonlinear distortions. The reasons for the divergence of the phase conjugation algorithm are discussed. The dependence of the results of focusing (according to this algorithm) on the integration step along the longitudinal coordinate is illustrated. Hysteresis dependences are obtained for the strength of optical radiation received at an aperture in relation to the initial strength of the

light pulse. The following issues are also addressed: control of a light beam wave front, delay in control channels, nonlinear interaction of two waves, flexible and segmented mirrors, and selection of an optimal beam profile. A relatively new class of problems is discussed, the distortion of the amplitude-phase characteristics of optical radiation due to a change in the composition of matter through a chemical reaction in the region of the beam. Figures 2; table 1; references: 35 (Russian).

### **Invariant Relationships for the Thermal Blooming of Optical Radiation**

927N0091C Moscow *OPTIKA ATMOSPHERY* in *Russian Vol 4 No 12, Dec 91 (manuscript received 16 Apr 91) pp 1278-1280*

[Article by V. A. Trofimov, Lomonosov Moscow State University; UDC 621.378.326]

[Abstract] Several invariants and invariant relationships are obtained for the thermal blooming of light beams in a moving medium and of light pulses in a stationary medium. The invariants may be expediently used to monitor the results of numerical modeling of thermal blooming of optical radiation. References: 8 (Russian).

### **The Gradient Method in the Problem of Minimizing the Angular Divergence of Light Beams**

927N0091D Moscow *OPTIKA ATMOSPHERY* in *Russian Vol 4 No 12, Dec 91 (manuscript received 2 Oct 91) pp 1281-1283*

[Article by S. S. Chesnokov, Lomonosov Moscow State University; UDC 621.378.3]

[Abstract] The most promising means of controlling the phase front in the transmitting aperture (to decrease angular divergence) is determination of the initial phase profile of the beam while numerically solving the optimization problem using gradient methods. The problem of optimal control consists of the determination of those system parameters which provide the required conditions for the interaction of radiation with matter. One can minimize the angular divergence at a distance by maximizing at a sufficiently remote target the relative proportion of light strength concentrated in a given solid angle using the spectral criterion. Calculations show that the effectiveness of the optimization algorithm depends greatly on the proportion of energy focused in a given solid angle. The peak intensity in the object varies in an iteration process. One can construct an iterative procedure to find the optimal phase using an arbitrary gradient. The effectiveness of the algorithm is demonstrated in the example of compensating for stationary wind refraction. The spectral criterion can be increased by 10-15 percent by varying the proportion of focused energy. The peak intensity can be increased by 20-30 percent. References: 3 (Russian).

### **Possibility of Controlling the Phase of Optically Coupled Lasers**

927N0091E Moscow *OPTIKA ATMOSPHERY* in *Russian Vol 4 No 12, Dec 91 (manuscript received 2 Oct 91) pp 1284-1289*

[Article by V. P. Kandidov, I. V. Krupina, and O. A. Mitrofanov, Lomonosov Moscow State University; UDC 621.373.826]

[Abstract] One promising means of obtaining high-quality strong laser radiation is the use of modularly-constructed multi-beam laser systems. The frequency and phase synchronization of modules enables coherent addition of fields. This substantially increases the power density of total radiation at a distance. Experimental and theoretical studies have noted the strong effect of the scatter of parameters (i.e., optical length) of individual lasers on the effectiveness of phase synchronization. Compensation of distortions and active control of the phase profile is an acute problem. This article theoretically examines the effect of detuning the optical lengths of lasers on the structure and threshold amplification of field distributions of diffractionally-linked lasers. The response function is calculated for the phase of the outgoing radiation. A periodic array of diffractionally-linked lasers is used to analyze the problem. It is shown that it is possible to control the phase profile and the mode composition of the outgoing radiation of optically coupled lasers by varying the detuning of their optical lengths. Figures 4; references: 9: 7 Russian 2 Western.

### **Limits of the Possibilities of Adaptive Correction of Wind Refraction Using Modal Control**

927N0091F Moscow *OPTIKA ATMOSPHERY* in *Russian Vol 4 No 12, Dec 91 (manuscript received 2 Oct 91) pp 1290-1293*

[Article by I. Ye. Telpukhovskiy and S. S. Chesnokov, Lomonosov Moscow State University; UDC 621.378.3]

[Abstract] Based on a numerical model of an adaptive system of aperture sensing, the dependence of the beam focusing criterion on the number of basis modes used in wave front control is analyzed. The problem is limited to compensation of the stationary wind refraction of a Gaussian beam. It is found that the maximum degree of compensation of thermal defocusing is defined by the product of the path length and the nonlinearity parameter. As path length decreases, there is a simultaneous increase in the relative contribution of third- and fourth-order modes. Figures 4; references: 2: 1 Russian 1 Western.

### **Numerical Modeling of a Ground-Based Adaptive Telescope**

927N0091G Moscow *OPTIKA ATMOSPHERY* in *Russian Vol 4 No 12, Dec 91 (manuscript received 26 Sep 91) pp 1298-1302*

[Article by V. P. Lukin, N. N. Mayer, and B. V. Fortes, Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk; UDC 538.566:551.511.6]

[Abstract] Among the ways one can improve the resolution of an astronomical instrument is measurement of distortions of the wave front and correction of these distortions in the process of observation (adaptive technique) This article examines a telescope equipped with a wave front distortion correction system. The effectiveness of phase correction of distortions introduced by atmospheric fluctuations in the refraction index in the formation of images of astronomical objects is studied. Two types of correctors are examined, modal and combined. Two methods of modeling the phase distortions are described. One is based on the generation of a spectral amplitude ensemble, and the other is based on the generation of random aberration coefficients. A combination of these methods was used in the calculation. Figures 3; references 11: 3 Russian 8 Western.

#### **Numerical Study of Phase Characteristics of Reflected Waves in the Atmosphere**

927N0091H Moscow OPTIKA ATMOSPHERY in Russian Vol 4 No 12, Dec 91 (manuscript received 27 Sep 91) pp 1318-1320

[Article by P. A. Konyayev, V. P. Lukin, and S. Yu. Tabakayev, Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk; UDC 621.378.325]

[Abstract] Numerical modeling methods are used to study the propagation of waves in a turbulent atmosphere with reflection off a specular object of finite size. The fluctuation characteristics of the phase of a Gaussian beam are examined. Attention is focused on the effect of amplification of phase fluctuations. The amplitude-phase characteristics of direct and reflected waves, and in particular, the transverse distribution of the average intensity, the dispersion of intensity fluctuations, and the structural phase function are studied using statistical testing by averaging over the solutions of the dynamic part of the problem. The behavior of the amplification coefficient of phase fluctuation depends on the separation of observation points, on the intensity of turbulence, and the reflector. The amplitude curve has two types of behavior: a gradual increase and a saturation section. In the saturation region the amplification coefficient characterizes the ratio of dispersions of phase fluctuations. In the region of high intensity fluctuations there is no amplification of phase fluctuations on a path with reflection. In the region of low intensity fluctuations, the intensity of phase fluctuations is higher for a small reflector and for small separations. The increase in amplitude occurs faster for a smaller reflector. In a region of intermediate fluctuations, the amplitude curve behaves the same as the weak fluctuation section. Figures 2; table 1; references 3 (Russian).

#### **Influence of Conditions for Observing Surface Features on Their Effective Thermal Contrast**

927N0099A Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 12, Dec 91 (manuscript received 17 Jul 90) pp 24-25

[Article by V. A. Ovsyannikov, candidate of technical sciences, R. I. Sitdikov and G. N. Khitrov, State Applied Optics Institute, Kazan]

[Abstract] The  $\Delta T_R$  quantity is the principal parameter determining the possibility of observing objects by means of thermal imaging units. Since the user usually has only data on the temperature difference  $\Delta T = T_0 - T$  and the difference of the radiation coefficients  $\Delta \epsilon = \epsilon_0 - \epsilon$  of the object and the background in the spectral working range  $\Delta \lambda$  of a thermal imaging unit, the objective of the study was a determination of the relationship between these  $\Delta T$  and  $\Delta \epsilon$  values and the corresponding  $\Delta T_R$  quantity for different positions and different conditions for illumination and observation of surface objects with diffusely reflecting surfaces for the most widely used range  $\Delta \lambda = 8 \dots 14 \mu\text{m}$ . A very simple approximate formula is derived for estimating the effective difference of the radiation temperatures of surface objects and the background detected by a thermal imaging unit of any type which can be used in practical work. With approach of the ambient radiation temperature to that for the background of the object the  $v$  quantity in this formula decreases, at the limit attaining a virtually zero value. A table gives  $v$  values which can be used in approximate routine computation of the effective thermal contrast of surface objects for their different positioning and observation conditions (such as in open terrain, in forest glades and amidst trees). References: 5 Russian.

#### **Induced Raman Scattering of Focused Pulsed Laser Radiation Beam in Atmosphere**

927N0096A Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 11, Nov 91 (manuscript received 9 Aug 91) pp 1123-1127

[Article by M. F. Shalyayev and V. P. Sadovnikov, Electronics Institute, USSR Academy of Sciences, Moscow; UDC 538.576.452.1]

[Abstract] A theoretical study was made of the induced Raman scattering (IRS) of focused short pulsed laser radiation beams propagating along atmospheric paths. The focusing of laser beams on atmospheric paths considerably increases the efficiency of IRS. In the beam focal region this results in the total depletion of the incident radiation (IR), blocking its further propagation. In case of necessity it is possible to localize the IRS effect on a stipulated segment of the path, which can be used in a number of practical problems. For example, as in creating a region on the path after which the propagation of radiation of two wavelengths begins; at the wavelength of the IR and the wavelength of the Stokes component (SC), or only the SC. In the atmospheric propagation of laser radiation allowance for the influence of IRS on

nitrogen molecules may be essential not only in problems relating to the transmission of powerful laser radiation, but also in atmospheric sounding problems. A very important consideration is the competition of IRS in the rotational and vibrational transitions of molecules. Whereas IRS in the vibrational transitions of nitrogen molecules exerts an influence for tens of kilometers, IRS in the rotational transitions, for which the Raman scattering section is an order of magnitude greater than for the vibrational transitions, may be manifested for distances of only hundreds of meters. Figures 3; references 4: 2 Russian, 2 Western.

### Laser Radiation Divergence in Regular Nonlinearly Refracting Medium

927N0096B Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 11, Nov 91 (manuscript received 31 Jul 91) pp 1203-1210

[Article by A. A. Zemlyanov and A. V. Martynko, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 621.378.325]

[Abstract] An approach based on use of equations for the effective parameters of a beam is proposed for obtaining quantitative expressions relating the angular characteristics of laser radiation in a nonlinear medium and the beam parameters and characteristics of regular inhomogeneities along the path, as well as for investigating regimes for formation of the directional diagram of the radiation for situations corresponding to manifestation of nonlinear refraction effects in regular homogeneous and inhomogeneous media with linear absorption. The conditions are found for the existence of precise aberration solutions for the effective width, radius of phase front curvature and limiting divergence. A specific form of these solutions is presented. It was established that there is a similarity effect for processes transpiring under conditions of strong nonlinear distortions due to thermal blooming of collimated beams of different classes and different nonlinear interaction mechanisms. The regimes of formation of limiting divergence in initially homogeneous and inhomogeneous nonlinearly refracting media were investigated. Expressions relating the parameters of an inhomogeneous path and the initial parameters of laser beams were determined for a regime of weak nonlinear distortions. Figures 2; references: 11 Russian.

### Correction of Lidar Signals With Their Interpretation Relative to Optical Characteristics of Scattering Media

927N0096C Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 11, Nov 91 (manuscript received 11 Mar 91) pp 1220-1226

[Article by M. M. Kugeyko, I. A. Malevich and D. E. Shipenko, Belorussian State University imeni V. I. Lenin; UDC 551.501.8]

[Abstract] A method is proposed for increasing the accuracy in retrieving the extinction coefficients of layered-inhomogeneous media by correcting the backscattered signals for any change in the lidar ratio. An algorithm is given for determining the correction coefficients. It is shown that the absolute value of the correction coefficient characterizes the degree of change in the qualitative composition of the scattering medium. The effectiveness of the proposed method is evaluated and the results of numerical simulation are presented. The practical significance of the proposed method is evident. Its use makes it possible with the highest accuracy to determine the  $\beta(z)$  profile in all sectors of media with interfaces (both in atmospheric and hydrospheric sectors when sounding from a carrier; in different layers of multilevel clouds, etc.). It is important that the  $\beta(z)$  reference values can be determined in the initial sectors of the sounding path. Moreover, the use of the method for determining the calibration values from the measured backscattered signals described earlier by the authors in IZV. AN SSSR: FAO, Vol 26, No 2, pp 213-216, 1990 makes it possible to automate the experiment and on an on-line basis obtain real-time results. Figures 4; references 5: 4 Russian, 1 Western.

### Study of the Effect of Orientation of Aerosol Particles on Sounding Characteristics of Light Scattering

927N0070A Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 10, Oct 91 (manuscript received 26 Jun 91) pp 1011-1016

[Article by R. F. Rakhimov and D. N. Romashov, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk; UDC 551.510.42]

[Abstract] Aerosol particles may acquire a variety of forms in clouds. Predominance of a particular orientation of the symmetry axes of aerosol particles may have an adverse effect on lidar response. Numerical modeling estimates are used to analyze the effect of a predominant orientation of cylindrical particles on lidar response. The polarization of the sounding radiation is also considered. Similar results are presented for a semi-disperse ensemble of ice crystals with characteristic particle sizes of 1.0  $\mu\text{m}$  and 10.0  $\mu\text{m}$  and a radiation wavelength of 1.06  $\mu\text{m}$ . This article also presents an algorithm to calculate the backscattering inversion matrix for an ensemble of arbitrarily oriented cylinders of finite length. The direction and extent of a predominant orientation of particles provides information on the direction and intensity of air currents, which may be used to develop optical methods to determine the state of the atmosphere at such remote altitudes. Figures 4; references 4 (Russian).

### Resolution-Optimal One-Dimensional Image Filtering

927N0070B Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 10, Oct 91 (manuscript received 8 Feb 91) pp 1030-1034

[Article by V. I. Solodushkin and V. A. Udod, Scientific Research Institute of Introspecty at the Kirov Polytechnical Institute, Tomsk; UDC 535.317.25]

[Abstract] The problem of optimal image filtering for maximum resolution is solved for one dimension. This solution may be used to improve images of objects through signal filtering in a scanning optical system working in a turbulent atmosphere with random refraction. Here a linear image system is used. The model structure consists of an initial image, a distortion filter, additive noise, a correcting filter, and an output image. References 18: 16 Russian 2 Western.

#### **Active Restoration of Coherent Images From Phase-Distorted Signals**

927N0070D Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 10, Oct 91 (manuscript received 12 Feb 91) pp 1054-1060

[Article by R. S. Irgizov, A. A. Kovalev, and V. M. Nikitin; UDC 621.378]

[Abstract] A noniterative method is proposed to restore coherent images distorted by atmospheric turbulence. This method does not require a reference source in the image field. The basic method is space-time modulation of the sounding signal within the time interval of a "frozen" atmosphere. This modulation makes it possible to select phase distortions which do not change over time. Different ways of implementing the proposed active method are examined. One way is illustrated using the results of mathematical modeling. A general method for sounding at great distances and a more specialized approach for short-range sounding are presented. Figures 6; references 7: 5 Russian 2 Western.

#### **Restoration of Two-Dimensional Fields of Atmospheric Parameters Using a Lidar Signal Reflected by the Earth's Surface**

927N0070E Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 10, Oct 91 (manuscript received 10 Jul 91) pp 1061-1065

[Article by V. P. Aksenov, V. A. Banakh, Ye. A. Yefimova, and O. V. Tikhomirova, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk; UDC 551.510.4

[Abstract] It is possible to substantially reduce the power level needed to effectively sense the atmosphere by using a differential absorption signal from on-board lidar reflected from the Earth's surface with a tomographic data processing method. A sounding scheme is proposed and an algorithm is described for inversion of lidar data in order to restore two-dimensional fields of atmospheric parameters. The results of modeling are presented. The sensing scheme is similar to one used in geophysics to study rock massifs. The algorithm is a modification of an algorithm to process seismic tomography data. The modeling process is described. Results are preliminary and implementation of this method requires the development of more efficient algorithms that are more resistant to noise in the initial data. Figures 3; references 9 (Russian).

#### **Power Received by Lidar in Atmospheric Sounding of a Surface With a Combined Scattering Index**

927N0070F Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 10, Oct 91 (manuscript received 7 May 91) pp 1066-1069

[Article by M. L. Belov and V. M. Orlov, All-Union Scientific Research Institute of Marine Fishery and Oceanography, Moscow; UDC 551.501]

[Abstract] Expressions are obtained for the power received during sounding in an optically dense aerosol atmosphere. The sounded surface has a complex scattering index with diffuse and quasi-specular components. It is shown that the received power depends on the ratio of the components. The more transparent the atmosphere, the more strongly the dependence manifests itself. In the calculations it is assumed that there are no changes in the reflectivity. Figure 1; references 7 (Russian).

#### **Comparison of Lidar and Radar Methods of Sensing Wind Velocity**

927N0070G Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 10, Oct 91 (manuscript received 6 Jun 91) pp 1070-1076

[Article by B. D. Belan, G. G. Matviyenko, A. I. Grishin, V. K. Kovalevskiy, and V. Ye. Meleshkin; UDC 551.501.7:551.508.822]

[Abstract] This article examines the determination of the accuracy of an instrument, including instrument error in the standard device and the tested device, as well as the issue of data averaging. Results of simultaneous sounding of the wind vector in the lower atmosphere using three-track lidar and the aerological "Meteor-RKZ" system are compared. Reasons for the selection of these devices are discussed. The lidar implemented a temporal correlation and spectral method of measuring wind velocity by the transfer of aerosol fields between the three sounding tracks. Measurements were made day and night, in various meteorological conditions, and at various wind velocities. The comparison showed a satisfactory coincidence of methods within 2.4 m/s and 32° in direction. Systematic, RMS, and weighted average deviations in speed and direction were considered. The sources of deviations are explained. Suggestions are offered on how to improve lidar characteristics. Figure 1; tables 3; references 14 (Russian).

#### **Joint Interpretation of Lidar and Photometric Data in the Study of Cloud Fields From Space**

927N0070H Tomsk OPTIKA ATMOSPHERY in Russian Vol 4 No 10, Oct 91 (manuscript received 5 Jul 91) pp 1077-1083

[Article by Yu. S. Balin, S. I. Kavkyanov, and S. V. Streptrova, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk; UDC 551.521:629.78]

[Abstract] This article discusses one possible implementation of a complex optical experiment using lidar and a radiometer from space. Lidar and photometric data are linked by models of the vertical stratification of stratiformis clouds. A closed numerical experiment is conducted which simulates a random cloud field on the background of an underlying surface with varied albedo. The results illustrate the possibilities of obtaining information through joint measurement. The vertical profile of the extinction coefficient in the cloud is described by an empirical equation. The algorithm used to interpret the data can determine optical and geometric parameters, distance, surface reflectivity, and the upper boundary and extinction coefficient at the upper boundary of the clouds. Three conclusions are reached. Photometric measurements do not always provide a reliable description of cloud fields. Lidar measurements substantially increase the reliability of the interpretation, but only with a rather high spatial measurement density. Combined use of lidar and photometric measurements permits an acceptable compromise between the required reliability of interpretation and the capabilities of real lidar systems. Figures 3; table 1; references 3 (Russian).

#### Measurement and Calculation System for Lidar Monitoring of Atmospheric Impurities

927N0070I Tomsk OPTIKA ATMOSPHERY in Russian  
Vol 4 No 10, Oct 91 (manuscript received 27 Jun 91)  
pp 1100-1105

[Article by P. V. Golubtsov, Yu. P. Pytyev, and O. A. Filatova, Lomonosov Moscow State University, Moscow; UDC 519.2:551.501:681.3]

[Abstract] This article proposes the creation of a measurement and computing system with the highest possible sensitivity or resolution based on existing lidar measurement systems. Concentrations of atmospheric impurities are determined using differential absorption. In analyzing a large complex nonlinear system one can use series-parallel decomposition into simpler components. An optimal algorithm is constructed for each type of component. The synthesis of an optimal algorithm to process lidar measurements makes it possible to use an existing experimental spectrum to calculate in real time the parameters of the spectral lines with a controlled error level. Figures 3; references 6: 3 Russian 3 Western.

#### Dispersion Method of Determining the Zenith Angle of an Object Moving in the Atmosphere

927N0070J Tomsk OPTIKA ATMOSPHERY in Russian  
Vol 4 No 10, Oct 91 (manuscript received 27 Jun 91)  
pp 1106-1110

[Article by A. N. Shadrin; UDC 528.51]

[Abstract] Optical refraction in the atmosphere, which is manifested in the curvature of the trajectory of beams, makes it difficult to determine the true position of a moving object. In order to account for the effect of

refraction one must know the altitude profile of the index of refraction of air along the propagation path of the beam. One can do this only by measurement or by using various statistical atmosphere models. Measurement is particularly difficult for objects moving along a curved path and an unknown trajectory. Models are rarely used because of error and the computer resources required. Methods using analytical models are similarly afflicted by error. A dispersion method reduces error in determining the true zenith angle. Proceeding from refraction theory for a spherically-stratified atmosphere, assuming the object is located using two-frequency optical radiation, an expression is obtained which makes it possible to estimate the true zenith angle of an object moving in the atmosphere. One must measure the index of refraction of the air at the observation point (or meteorological parameters) and visible zenith angles for radiation at the appropriate wavelength. Appropriate pairs of wavelengths are given for various zenith angle ranges. Error estimates are provided. Figures 7; references 3 (Russian).

#### Measurement of Wind Flow Speed Using Doppler Lidar Based on a One-Frequency TEA CO<sub>2</sub> Laser

927N0070K Tomsk OPTIKA ATMOSPHERY in Russian  
Vol 4 No 10, Oct 91 (manuscript received 27 Jun 91)  
pp 1114-1117

[Article by V. M. Gordiyenko, N. N. Kurochkin, A. V. Priyetzhev, and Yu. Ya. Putivskiy, Lomonosov Moscow State University, Moscow; UDC 551.510]

[Abstract] Doppler lidar using continuous CO<sub>2</sub> lasers can measure wind flow parameters at distances of several hundred meters. Continuous Doppler lidar can be constructed like a Mach-Tsander interferometer with one of the mirrors replaced by a tranceiving telescope. Device parameters are given. Continuous Doppler lidar can be used to a distance of about 1 km. Distance can be increased by using a pulsed TEA CO<sub>2</sub> laser with injection of an external signal and a narrow spectrum of generated radiation. A coaxial bistatic scheme is used for atmospheric sounding. A schematic is given. In sounding at distances over 2 km the problem of a decreasing signal is encountered. This problem can be overcome by using an additive amplifier with a changing amplification. Sensing distance can be increased to over 10 km using a more complex monostatic sounding system. The construction of such a system is described. Wind speed can be determined to within 2-3 m/s. Figures 3; references 5: 4 Russian 1 Western.

#### Vertical Structure of Upper Layer Clouds From Lidar Sounding Data

927N0069 Moscow IZVESTIYA AKADEMII NAUK  
SSSR: FIZIKA ATMOSPHERY I OKEANA in Russian  
Vol 27 No 9, Sep 91 (manuscript received 6 Mar 91)  
pp 924-929

[Article by L. V. Kravets, Central Aerological Observatory; UDC 551.576]

[Abstract] This article presents generalized results of lidar measurements of the altitude and thicknesses of upper layer clouds and the distribution of the extinction coefficient over altitude in these clouds. These measurements were obtained during complex experiments performed in April-June 1986, May 1987, and May-June 1989. Empirical relations are obtained which describe the dependence of cloud thickness on temperature and the vertical profiles of the extinction coefficient. The experiments revealed a relatively uniform distribution of altitudes and cloud thicknesses. Studies of clouds with various lower boundary altitudes revealed that the maximum extinction coefficient varied from the middle of the cloud to near the upper boundary. Analysis showed that the scattering was mainly concentrated directly below the tropopause in a narrow altitude band (on average 400 m below the tropopause). Figures 3; tables 2; references 5: 4 Russian 1 Western.

#### **Parametrization of Filters Retrieving Spatial Spectra of Sea Surface Slopes From Optical Images**

927N0065A Moscow *ISSLEDOVANIYE ZEMLI IZ KOSMOSA* in Russian No 5, Sep-Oct 91 (manuscript received 3 Sep 90) pp 31-38

[Article by A. B. Murynin, Kometa Central Scientific Research Institute, Moscow; UDC 551.46]

[Abstract] Measurements of sea surface spectra from optical images involves definite difficulties due to the nonlinearity of the transfer function relating the slopes of sea surface elements and their brightnesses. A solution was sought for this problem by the author in *ISSLED. ZEMLI IZ KOSMOSA*, No 6, pp 60-70, 1990 and by V. G. Bondur and the author in *OPTIKA ATMOSFERI*, No 4, pp 387-395, 1991. This article is essentially a continuation of these earlier two studies. The method which is developed involves measuring the two-dimensional spectrum of the field of rises of the sea surface from the signal registered in the image with allowance for nonlinearity of the slope-signal transfer function. The method involves discrimination of several fragments of the optical image, formation of the spectra of these fragments and retrieval of the spectra of the fields of projections of the slopes of sectors of the sea surface represented on the optical image fragments from the spectra of fragments of the optical images using nonlinear retrieval operators dependent on optical image formation conditions. The method makes it possible to determine the mean spectrum of rises for several sea surface sectors when using several fragments of one optical image having different signal gradient orientations or the spectrum of a sector of the sea surface from several images registered from different positions. On this basis spatial-frequency filters are found for retrieving the spectra of sea surface slopes. An analytic approximation of these filters is obtained and the dependence of the approximation parameters on image formation conditions is determined. Figures 3; references 14: 12 Russian, 2 Western.

#### **Large-Scale Variability of Circulation and Thermal State of Atmosphere and Ocean in North Atlantic**

927N0063B Kiev *MORSKOY GIDROFIZICHESKIY ZHURNAL* in Russian No 5, Sep-Oct 91 (manuscript received 31 Jul 90, after revision 17 Oct 90) pp 22-27

[Article by A. A. Sizov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 551.465.63(261.1)]

[Abstract] An analysis was made of the large-scale variability of circulation and the thermal state of the atmosphere and ocean on the basis of the year-to-year variability of the Rossby index and the thermal and dynamic characteristics in individual parts of the northern subtropical circulation, with emphasis on relationships to the 22-year solar activity cycle. The 22-year cycle ending in 1986 was characterized by a higher intensity of atmospheric circulation than was the preceding 22-year cycle (1944-1964). The beginning of the current 22-year cycle (in 1990 the large-scale atmospheric circulation over the North Atlantic was characterized by the phase of the first maximum) shows that the intensification of atmospheric circulation is not weakening. Postulating that 1990 belongs to the group of years characterized by the phase of the secular variation maximum in disturbance of atmospheric centers of action, it can be anticipated that an anomalously high atmospheric circulation will persist at least to the end of the current 22-year cycle (the end of this century through the beginning of the next). With these considerations taken into account, it is concluded that there are two limiting regimes in the large-scale circulation of the North Atlantic. The first of these regimes is characterized by a high level of circulation in both the atmosphere and in the subtropical circulation of waters. In the current century this regime has been observed predominantly in years tending to the middle and end of the 22-year cycle. The second regime is characterized by a relatively low level of atmospheric circulation and a weakening of the transport of water masses in the northern subtropical circulation. This regime has predominated for the most part in years tending to the beginning and second half of the 22-year cycle. Figures 2; references 17: 13 Russian, 4 Western.

#### **Distribution Laws of Atmospheric Transparency Coefficient for IR Radiation on Horizontal Paths**

927N0038A Tomsk *OPTIKA ATMOSFERI* in Russian Vol 4 No 8, Aug 91 (manuscript received 25 Feb 91) pp 796-802

[Article by Ye. R. Milyutin, A. I. Serbin and Yu. I. Yaremenko, Leningrad Communications Electrical Engineering Institute imeni Prof. M. A. Bonch-Bruyevich; UDC 551.591.2]

[Abstract] An analysis of experimental data on atmospheric extinction of laser radiation at  $\lambda = 10.6 \mu\text{m}$  made it possible to determine the form of atmospheric transparency distribution functions for this wavelength which were then compared with similar characteristics for

wavelengths 0.55 and 1.06  $\mu\text{m}$ . The extinction of radiation of a  $\text{CO}_2$  laser in the atmosphere was measured using the IKAU-1 IR measuring system. Such a system, by means of multiple reflections, on a 100-m uniform horizontal base makes it possible to obtain a set of paths 400 to 4000 m in length. The measurement method, described elsewhere in the literature, was used in carrying out experiments over a three-year period during different seasons. A total of 19,062 reckoning points were obtained during a total registry time of 170 hours. Each experiment lasted from 30 minutes to six hours. Data files were obtained for three spectral emission lines of the  $\text{CO}_2$  laser:  $P_{20}$ ,  $P_{22}$ ,  $P_{24}$ . It was found that there are stable correlations between the factors determining the state of the atmosphere and the extinction of radiation at  $\lambda = 10.6 \mu\text{m}$ . The distribution laws for the atmospheric transparency coefficient were found for  $\lambda = 10.6 \mu\text{m}$  for the northwestern region of the European USSR. It is shown that a truncated Weibull distribution, approximating well the empirical distribution of the atmospheric transparency coefficient in the visible and IR ranges, also is applicable for describing the atmospheric transparency coefficient in the middle-IR range, governed by the aerosol extinction of radiation. Figures 2; references 16: 13 Russian, 3 Western.

#### Transfer of Radiation of Optical Beam in Spatially Limited Scattering Volume

927N0038B Tomsk OPTIKA ATMOSPHERE in Russian Vol 4 No 8, Aug 91 (manuscript received 29 Nov 89) pp 819-826

[Article by B. V. Goryachev, M. V. Kabanov and B. A. Savelyev, Siberian Physical Technical Institute imeni A. D. Kuznetsov; Tomsk Polytechnic Institute imeni S. M. Kirov, Tomsk; UDC 535.36]

[Abstract] A solution of the problem of transfer of optical radiation in a spatially bounded medium is given. Analytic expressions are derived for different experimental schemes: the radiation source and receiver are positioned on the boundaries of the scattering volume; the radiation source is located within the scattering volume and the receiver is at its boundary, or vice versa. First the intensity of multiply scattered radiation is computed with allowance for source and receiver positioning within the scattering volume and then the intensity of multiply scattered radiation is computed with allowance for the spatial dimensions of the optical beam. The research results ensured a thorough interpretation of the influence of the background of multiply scattered radiation on the brightness contrast of laser sources observed through a scattering medium. In the case of great optical depths a major role is played by the background level of multiply scattered radiation forming the scattering volume outside that illuminated directly by the optical beam. The limiting optical depth  $\tau_{\text{lim}}$  at which the brightness contrast of the observed radiation disappears is dependent not only on the geometric dimensions of the optical beam and scattering properties of the medium, but also on the dimensions of the entire

scattering volume. This is a new and fundamental finding with respect to the dependence of  $\tau_{\text{lim}}$  on the properties of the medium and the geometry of observations. The theoretical results are in good agreement with the experimental data, demonstrating the applicability of the exponential law to description of radiation extinction in disperse media. Figures 4; references 7: 6 Russian, 1 Western.

#### Retrieval of Extinction Index Profile Using Data From Single-Angle Lidar Sounding of Atmosphere

927N0038C Tomsk OPTIKA ATMOSPHERE in Russian Vol 4 No 8, Aug 91 (manuscript received 4 Feb 91) pp 830-837

[Article by V. A. Kovalev, Ye. Ye. Rybakov and V. M. Ignatenko, Main Geophysical Observatory imeni A. I. Voyeykov]

[Abstract] Algorithms are written for retrieving from a lidar signal the profile of the extinction index (or transmission coefficient) in the sounding direction. The processing procedure assumes that the conditions of single scattering and a power-law relationship between scattering and extinction are satisfied. Two different algorithms for determining the extinction index profile are examined. The algorithms were finalized and checked in a large series of experiments. Specific examples of the results are given. The processing algorithm applicable in the case of worsened visibility in most cases ensures a good agreement with data from control instruments, including for slant paths, and is promising for use in retrieving transparency profiles in a wide range of meteorological situations. The good agreement between registered data and the results of processing of lidar signals using the algorithm for a two-layer atmosphere confirms, first of all, the good prospects for its use when there is a strong burst of the backscattered signal at the end of the sounded path from the cloud layer, and second, the need for preliminary identification of the meteorological situation under which this signal is received prior to signal processing. Figures 3; references 35: 13 Russian, 22 Western.

#### Some Problems in Linear Filtering of Images Distorted by Scattering Media

927N0038D Tomsk OPTIKA ATMOSPHERE in Russian Vol 4 No 8, Aug 91 (manuscript received 1 Apr 91) pp 838-848

[Article by V. V. Belov, B. D. Borisov and N. V. Molchunov, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 621.306.61.061]

[Abstract] An in-depth study was made of the possibility of using known methods, some already classical, for the retrieval of images distorted by scattering media. Details of image formation at the registry instrument output with allowance for the transmission of an optical signal through turbid, optically dense scattering formations are

closely examined because the influence of such a medium on image formation is similar to that from the presence of a LF filter. Emphasis is on analysis of the sources of errors arising in computer retrieval of quantized images. Proper retrieval can be compromised by such factors as inaccuracy in stipulation of the point blurring function, quantization range, instrument noise and the spatial limitations on frame formation (each of which are discussed in detail). In the example of a spatially limited object it is shown that for real digital images containing a noise component it is necessary to use a considerable degree of smoothing of the solution for compensating for the quality loss caused by noise, errors in selecting the pulse transient function for the distorting medium and the spatial limitation related to image frame formation. The problems involved are examined in specific examples and special cases are considered. Figures 5; references 7: 6 Russian, 1 Western.

#### **Method for Retrieval of Image From Its Convolution With Unknown Pulsed Response**

927N0038E Tomsk OPTIKA ATMOSPHERE in Russian  
Vol 4 No 8, Aug 91 (manuscript received 18 Dec 90)  
pp 849-851

[Article by D. V. Makarov and A. D. Ryakhin, Astrofizika Scientific Production Association, Moscow; UDC 522.617:535.3.087]

[Abstract] Commonly employed image retrieval methods are based on use of a priori information on an image  $O(x)$  or pulsed response  $H(x)$  or on averaging of a large number of registered images with constant  $O(x)$  and randomly changing  $H(x)$ . Studies were made of the possibility of retrieving the true image directly from the registered image. Although a number of such retrieval methods are known, they are exceedingly sensitive to noise and require a precise knowledge of the image and the pulsed response. The proposed image retrieval method is based on solution of the so-called phase problem, essentially involving retrieval of a spatially limited function from the modulus of its spatial spectrum. It is shown that by using known iteration algorithms for retrieving the spatial spectrum of a finite function it is possible to retrieve the required operational function, usually with 50-100 iterations, with the optimum relaxation coefficient falling in the range 0.4-0.6. The image itself is retrieved using 30-40 iterations. The relative rms error of the retrieved image is about 15 percent. However, this retrieval method as proposed is still inadequately immune to noise. Already with a signal-to-noise ratio 15-20 it no longer gives a satisfactory image evaluation. Therefore, theoretically the proposed method is promising but its practical use is made difficult due to the inevitable noise in image registry. Figure 1; references 7: 6 Russian, 1 Western.

#### **Influence of Grayness of Ocean Surface on Accuracy in Determining Its Temperature From Angular IR Measurements From Space**

927N0038F Tomsk OPTIKA ATMOSPHERE in Russian  
Vol 4 No 8, Aug 91 (manuscript received 21 May 91)  
pp 856-861

[Article by A. M. Ignatov and V. S. Suyetin, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol; UDC 551.608]

[Abstract] The difference of the sea surface from an ideally black radiator was investigated within the framework of an earlier proposed approach to analysis of errors in determining ocean surface temperature on the basis of statistical data on atmospheric variability (V. S. Suyetin, et al., OPTIKA ATMOSPHERE, Vol 2, No 7, pp 750-757, 1989; Vol 3, No 6, pp 622-627, 1990). A more thorough investigation along these lines revealed that allowance for this factor in the radiation model is manifested in an increase in errors and appearance of a minimum on the curves representing error dependence on the sighting angle. The effectiveness of two- and three-angle measurement methods is compared. The analysis reveals the effect resulting from replacement of a single degree of blackness in the radiation model by more realistic values corresponding to a smooth ocean surface. In individual atmospheres with a low moisture content the errors in determining OST increase and their dependence on variations of atmospheric parameters is enhanced. With a realistic level of error in registering radiation 0.1 K the accuracy of the two-angle method falls in the range 0.3-0.5 K; the use of additional measurements in a third angle does not result in any significant improvement. The curves representing the accuracy in determining OST by the two-angle method on the choice of the second sighting angle have a distinct minimum in the region near 55°. Figures 3; references 6: 3 Russian, 3 Western.

#### **Spectral-Angular Parametrization of Satellite IR Measurements of Ocean Surface Temperature**

927N0038G Tomsk OPTIKA ATMOSPHERE in Russian  
Vol 4 No 8, Aug 91 (manuscript received 29 Apr 91)  
pp 862-867

[Article by A. V. Kazanskiy, Automation and Control Processes Institute, Far Eastern Department, USSR Academy of Sciences, Vladivostok; UDC 551.46]

[Abstract] The inadequacy of the linear theory of the multichannel method for IR measurements of ocean surface temperature (OST) through the atmosphere is demonstrated. An effort was made to rectify this situation. Satellite data for the period August-October 1990 were registered in the Philippine Sea region. The survey times were characterized by few clouds and small variability of ocean surface temperature. Ten-day OST charts issued by the Japanese Meteorological Agency and

shipboard observational data were used in the processing, which involved construction of radiation temperature histograms for each satellite revolution. Using a second-order approximation of the atmospheric transmission function in the radiation transfer equation a four-channel parametrization of IR measurements of ocean surface temperature was made using two spectral measurements at two zenith angles. In situ OST data and NOAA-10/AVHRR data in the ranges 3.7 and 10.8  $\mu\text{m}$  were used in testing different two-channel reductions of this parametrization. Data for three surveys were analyzed: the first corresponded to an extremely great atmospheric water vapor content, the third was characterized by an extreme moisture deficit aloft in an extensive zone of air subsidence and the second corresponded to average conditions. Study of these and other data indicate that angular IR measurements, or at least a synoptic adaptation of the angular parameter, are necessary for precise determination of OST. References 12: 6 Russian, 6 Western.

#### **Determining Transparency of Lower Atmospheric Layers From Extinction of Cerenkov Light of Extensive Atmospheric Showers**

927N0038H Tomsk OPTIKA ATMOSPHERE in Russian Vol 4 No 8, Aug 91 (manuscript received 25 Feb 91) pp 868-873

[Article by M. N. Dyakonov, S. P. Knurenko, V. A. Kolosov and I. Ye. Slepsov, Space Physics Research and Aeronomy Institute, Siberian Department, USSR Academy of Sciences, Yakutsk; UDC 551.521.31:551.591]

[Abstract] A method is described for determining the transparency of an atmospheric near-surface layer with a thickness up to 6-7 km for a light source with the spectrum  $d^2W/d\lambda d\lambda$  about  $1/\lambda^3$ , corresponding to the Vavilov-Cerenkov radiation (VCR) of charged particles of extensive atmospheric showers formed as a result of interaction between cosmic rays and air atoms. The observations were made in the Yakutsk extensive atmospheric showers (EAS) registry system, where VCR (Cerenkov light) has been registered since the early 1970's. This radiation is attenuated on its path to the light detector. The structure and functioning of this system, made up of 59 stations, is described. Details are given on signal registry, storage and analysis. The flux of EAS relativistic electrons causes a burst of Cerenkov light for  $10^{-7}$  s. This light pulse can be registered against the background of night airglow using photomultipliers. This constitutes the basis for the described method for monitoring atmospheric transparency. The concept of a "calibration night" is employed. On such a night the light losses on aerosols are minimal and constitute half the losses from Rayleigh light scattering. Data were collected on relative atmospheric transparency as a function of time of day for 15-minute intervals since atmospheric transparency may vary greatly during the course of the night. The values of the mean transmission coefficient are given for an atmospheric layer in the wavelength range  $\lambda_1-\lambda_2 = 300-800$  nm under conditions favorable for optical observations in the Yakutsk EAS registry system. Figures 4; references: 10 Russian.

#### **Optimal Estimate of Concentration of Atmospheric Components by Lidars in Photon Counting Detection Mode**

927N0038I Tomsk OPTIKA ATMOSPHERE in Russian Vol 4 No 8, Aug 91 (manuscript received 30 May 91) pp 883-887

[Article by V. M. Dubyagin and N. A. Shefer, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 535.216]

[Abstract] The problem of optimum estimation of concentrations of atmospheric components is examined. The emphasis is on lidars with event-by-event measurement of the energies of laser pulses by shunting a small part of the radiated flux present in one frequency channel operating in a photon counting mode. Since the optimum estimate in the sense of a minimum of dispersion for these lidars is too complex, two suboptimal estimates of the concentrations of atmospheric components are synthesized which are suitable for elastic scattering, Raman scattering and resonance fluorescence lidars. The change from intuitive estimates, which have commonly been employed, to optimal or suboptimal estimates in many cases requires only an insignificant change in the algorithm for computer processing of lidar signals or a simple improvement in lidar apparatus. Two formulas are derived for the proposed estimates and it is shown in a specific example the advantage of one in comparison with the other and the usually employed intuitive estimation. Figures 3; references: 3 Russian.

#### **Use of Knowledge Engineering Methods for Solving Problems in Atmospheric Correction of Remote Measurements**

927N0038J Tomsk OPTIKA ATMOSPHERE in Russian Vol 4 No 8, Aug 91 (manuscript received 30 Apr 91) pp 888-895

[Article by Ye. I. Pospelova, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 535.96]

[Abstract] This is a review of studies on the application of knowledge engineering methods to the processing of remote sensing data. An expert system is described which takes into account the influence of the atmosphere on the propagation of thermal radiation in the atmosphere-underlying surface system. Particular attention is given to an expert system for atmospheric correction of remote sensing data which involves determination of the vertical profiles of the extinction coefficient, transmission function, optical depth and intensity of outgoing thermal radiation. The applicability of an expert atmospheric correction system in obtaining information on the vertical profiles of temperature, pressure and concentrations of atmospheric gases also is discussed. It is shown how the special features of the subject field exert an influence on realization of the fundamental principle of the system: the need for participation of the user in the

choice of relevant data and research methods. The directions of possible application of prototypes of the represented system for the solution of practical problems are indicated. The use of the artificial intellect method is still in its initial development stage. The concepts of "intellectual" interpretation of remote measurements

are only now being formulated. The basic structures of data and knowledge bases must be worked out and optimum modes of interaction with the user must be studied. All this will be highly useful to researchers with very limited computer skills. References 18: 11 Russian, 7 Western.

### Shoreline Change With Rapid Rise of World Ocean Level Due to 'Greenhouse Effect' Influence

927N0102A Moscow GEOMORFOLOGIYA in Russian No 2, Apr-Jun 92 (manuscript received 25 Sep 91) pp 3-13

[Article by P. A. Kaplin, A. V. Porotov and A. O. Selivanov, Geography Faculty, Moscow State University; Institute of Water Problems]

[Abstract] After examining prevailing concepts on the character of reformation of the coastal zone when there is a rise in sea level, the authors made a reconnaissance study of the possible consequences of a sea level rise in the 21st century for the coasts of Russia and contiguous countries on the assumption of rises by 1 m and 4 m by 2100. These rises are close to the mean and maximum estimates made by many researchers. Sketch maps were prepared showing the consequences of a rise by 1 m for the coasts of Russia and by 4 m within the limits of the Sea of Azov basin. The first of these maps was at 1:4 000 000 and the second at 1:200 000. In the article the first attempt is made at predicting the consequences of a rapid rise in the world ocean as a result of climatic warming. The prepared maps must be regarded as a first approximation. The quantitative estimate of the zone of reworking of shores was based on the approximate formulas of P. Bruun and others and data on the destruction of shores. The paleogeographic analogies method was effective. The quantitative method made it possible to discriminate risk zones (shore destruction and shoreline retreat resulting in catastrophic consequences, inflicting irreversible losses on the mapped natural and economic objects). Natural and economic risk zones can be distinguished. Future directions to be pursued in this field are suggested. Figures 2; references 42: 20 Russian, 22 Western.

### Predictive Estimate of Cesium-137 Field in Black Sea Surface Waters

927N0100C Moscow OKEANOLOGIYA in Russian Vol 32 No 2, Mar-Apr 92 (manuscript received 2 Oct 90, after revision 18 Dec 90) pp 253-256

[Article by M. M. Domanov and A. Ye. Gorbunov, Oceanology Institute imeni P. P. Shirshov, Moscow; UDC 551.465.7]

[Abstract] As a result of the fallout of radioactive aerosols after the accident at the Chernobyl nuclear power plant a specific field of radioactivity was formed in the surface layer of the Black Sea. A prediction of the transformation of this field with time makes it possible to foresee the direction of transport of radionuclides and the rate of elimination of radionuclides from the surface layer and also to detect the position of zones with an increased content of radioactive elements in sea water. It is estimated that the total quantity of cesium-137 entering the Black Sea as a result of the fallout of

products from the accident is about 45 KCi. Such data and published information on the temporal transformation of the cesium-137 field in the surface layer were used in model investigations of structural changes in the cesium-137 field in the Black Sea. The used hydrophysical model was verified by a comparison of the computed fields with in situ measurement data. The mapped fields of cesium-137 distribution indicate the formation of stable zones of nonuniform content of radionuclides. The surface layer is characterized by the transport of radioactive pollutants in a westerly direction. Then the impurity, due to vertical transport, enters into the lower layers and is carried in an easterly direction. A compensating outflow is characteristic for regions lying deeper than 1000 m. Figures 4; references 10: 9 Russian, 1 Western.

### Anticipated Global Anthropogenic Climatic Changes Caused by Joint Influence of Carbon Dioxide and Carbonyl Sulfide

927N0081A Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 28 No 3, Mar 92 pp 227-233

[Article by A. S. Kabanov, Experimental Meteorology Institute; UDC 551.588.7]

[Abstract] The objective of this study was a determination of the joint correlated effect exerted on the global thermal regime of the atmosphere by future anthropogenic changes in the atmospheric content of carbon dioxide and stratospheric sulfuric acid aerosol. As a result of oxidating reactions transpiring in the stratosphere the gas carbonyl sulfide (CSO) is transformed into sulfuric acid vapor. The joint effect of such a singular source of acid vapor, macroturbulent diffusion processes, as well as formation of aerosol on condensation nuclei and growth of droplets, results in formation of a vertical profile of gases, CSO and H<sub>2</sub>SO<sub>4</sub>, and a stationary particle size distribution. Against this background a study was made of three possible scenarios of fossil fuel combustion. It is postulated that there will be a rapid temperature increase in the one- or two-decade period prior to 2150 in two of these scenarios with maximum changes in fuel combustion, that is, up to 2100-2130 there will be a considerable restraint of temperature rise by stratospheric aerosol in connection with the greenhouse effect. After attaining a maximum of combustion intensity in 2100, with its subsequent rapid dropoff and a decrease in the mass of stratospheric aerosol, the temperature will begin to rise rapidly due to the greenhouse effect caused by the accumulation of atmospheric carbon dioxide. Such a characteristic temperature behavior with its sharp increase during relatively short time intervals must be taken into account in the prediction of future changes in climate and in the planning of fuel combustion intensity. Figures 3; references 13: 10 Russian, 3 Western.

### Global Warming and Its Consequences

927N0039A Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 12, Dec 91 (manuscript  
received 4 Jul 91) pp 5-10

[Article by M. I. Budyko, Yu. A. Izrael and A. L. Yanshin, State Hydrological Institute, USSR State Committee for Hydrometeorology and Environmental Monitoring; UDC 551.524:551.583(100)]

[Abstract] Information is given on the accumulation of carbon dioxide and other gases which are intensifying the greenhouse effect in the atmosphere and which are responsible for global warming. Emphasis is on the importance of the increased carbon dioxide concentration for increasing the productivity of agricultural plants. Two rational variants for validating an optimum strategy for contending with global warming conditions are suggested: 1) based on simple economic considerations, 2) based on choice of an optimum strategy for economic development. The following three conclusions are drawn with respect to an effective strategy for dealing with the developing situation. First, there must be a considerable increase in the scientific level of research on all problems related to global warming. This research must take in a far broader range of problems in comparison with the attention now being given to the situation and must be coordinated by the most competent specialists. Second, it is desirable to validate the safest and most economical ways to adapt economic activity to global warming. Third, there is now no adequate scientific validation for changing the prevailing trends in development of global energy production, in particular, for reducing the increasing consumption of carbon fuel. Figure 1; references 10: 9 Russian, 1 Western.

### Programming Complex for Simulating Cases of Strong Atmospheric Pollution at Alma-Ata

927N0039B Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 12, Dec 91 (manuscript  
received 29 Jan 91) pp 11-19

[Article by E. A. Zakarin and V. F. Kramar, Mathematics and Mechanics Institute, Kazakh Academy of Sciences; UDC 551.504.054.001.572 (574.51)]

[Abstract] The development of a system for on-line objective prediction of atmospheric pollution (TOPAZ project), including the software employed in this system, is described. The work was directed to the simulation of processes of transport and dispersal of pollutants in the atmosphere over Alma-Ata. Figure 1 is a block diagram which clarifies the components of the TOPAZ system, its functioning and the research program as a whole; this figure serves as a basis for the textual discussion. A mathematical model is formulated which is based on representation of the computation volume in the form of a system of boxes linked by balance relations of the advective-diffusive transport of pollutants. Within the boxes provision is made for a procedure for detailed examination of concentration fields using the formulas

for Gaussian plumes. Computations were made for a period corresponding to the CO-86 experiment carried out at Alma-Ata. Comparison of the measured and computed data revealed a good agreement with respect to the dynamics of mean values and detailed fields of carbon monoxide concentration. Due to the high degree of automation and ease in adjustment the TOPAZ system can serve as a working tool for a team of experts in planning air conservation measures, in selecting sites for new industrial facilities and in reducing effluent. Figures 3; references 10; 8 Russian, 2 Western.

### Heat Accumulation in North Atlantic and Its Multiyear Variability

927N0039E Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 12, Dec 91 (manuscript  
received 5 Feb 91) pp 77-83

[Article by B. A. Birman and Ye. V. Balashova, USSR Hydrometeorological Scientific Research Center; UDC 551.465.4:551.526.6:551.582.2(261.1)]

[Abstract] Using WDC data, information on heat accumulation in the upper quasihomogeneous layer of the North Atlantic is analyzed. Alternating meridionally oriented regions were discovered in which the annual balance of heat accumulation is impaired (the annual sums  $dQ/dt$  are either positive or negative). In these regions compensation mechanisms are operative in the form of positive trends of heat content in those places where the annual sums  $dQ/dt < 0$  and in the form of negative trends for  $dQ/dt > 0$ . The change in thermocline depth is controlled by this mechanism. The principal features of the seasonal and interannual variability of heat accumulation are discussed. Specific information is given on seasonal changes in heat accumulation for January, March, May, July, September and December. The January field is characterized by heat accumulation over the greater part of the ocean and its losses along the shores of the continents, in the Gulf Stream and in the Norwegian Current. In March the picture changes considerably: heat accumulation occurs in the eastern part of the ocean, especially in the Norwegian Energy-Active Zone, but also in the Sargasso Sea. However, in the central part of the ocean and in the Gulf Stream the upper quasihomogeneous layer loses heat. A generally simple picture is observed in April, but with the difference that the regions of heat loss increase. In May and June the upper quasihomogeneous layer loses heat over almost the entire ocean surface and the losses attain a maximum in the annual variation. In July and August a gradual intensification of heat begins in the coastal regions. September, October and November are months where heat accumulates virtually everywhere in the upper quasihomogeneous layer, which also continues in subsequent months, attaining a maximum in December-January. But regions of heat loss already appear in December, which increase still more in January. Figures 3; references: 7 Russian.

**Second World Conference on Climate. II.  
Evaluations of Global Climatic Changes and  
Measures for Preventing Global Changes**

927N0079A *Moscow IZVESTIYA VSESOYUZNOGO  
GEOGRAFICHESKOGO OBSHCHESTVA in Russian  
Vol 123 No 6, Nov-Dec 91 (manuscript received 20 Nov  
90) pp 473-480*

[Article by K. Ya. Kondratyev, St. Petersburg; UDC  
911:551.58]

[Abstract] The results of the Second World Conference on Climate and work of the Intergovernmental Group of Experts on Climatic Changes are reviewed. High points, achievements and deficiencies are examined. The author has strong negative opinions with respect to many of the reports and theses presented at the conference. The role played by the USSR in this conference also is viewed in an unfavorable light. The work at the national level on preparations for the second conference, directed by the Main Administration for Hydrometeorology, is deemed unsatisfactory. The scientific report of the Intergovernmental Group is virtually devoid of indications that there has been Soviet research in the field of climatology. Although the USSR has a meteorological space system, the report contains no information on this. Even bibliographic references are limited to a few journal articles (there are no references to many recent Soviet monographs on this subject). The Soviet representatives in Working Group 1 evidently did a poor job in a number of ways. Many foreign governmental and nongovernmental agencies prepared numerous monographs, brochures, reports, displays and videofilms for the conference; the Soviet Union made none of these available. Only four speakers were from the USSR, and only one report (M. I. Budyko) constituted a purely scientific report (on climate prediction on the basis of paleoanalogues), but then, among the Soviet participants (a delegation of more than 20) there were virtually no climatology specialists. Ye. P. Borisenkov, director of the Main Geophysical Observatory, the most climate-oriented institute of the Main Administration for Hydrometeorology, was not present and there was only one person representing the Academy of Sciences. It appears that climatic research in the USSR is suffering due to the Main Administration of Hydrometeorology stressing its leading, even monopolistic role. References: 10 Russian.

**Extraction of Oil and Gas With Nuclear Explosions**

927N0078 *Moscow PRIRODA in Russian No 11, Nov  
91 pp 25-33*

[Article by V. I. Musinov, All-Union Scientific Research and Design Investigation Institute for Industrial Technology, USSR Ministry of Atomic Energy and Industry]

[Text] There is no doubt that nuclear explosive devices created during the arms race should not be used for their original purpose. Still, is it worth destroying them and the potential energy they contain without trying to obtain some benefit for humanity?

The search for peaceful ways of using nuclear explosives was begun in the 60s by specialists in the USSR and US working on programs for their respective governments. In 1975 these studies were limited by international agreement, and it was decided to use only camouflaged nuclear explosions of limited strength. This limit was imposed so that the centers of camouflaged explosions were not directly linked (through fractures) with the atmosphere and hydrosphere, including water-bearing strata. Thus, under the defined geological and technical conditions, they were radiationally and seismically safe.<sup>1</sup>

Since the early 80s work on the use of nuclear explosions for industrial purposes was almost completely halted in the US. Negative public opinion played the main role in this decision, as well as the difficulties in financing research which did not yield a rapid economic benefit. This turn of events does not reflect the opinions of American scientists, many of whom are of the opinion that camouflaged nuclear explosions are quite promising, especially in the exploration for and use of natural deposits of hydrocarbons.<sup>2</sup>

In the USSR this type of research was conducted until 1987. Our experience is based on the results of more than 100 peaceful explosions. These results show that such explosions can be used to solve numerous practical problems. Recently this journal discussed how camouflaged nuclear explosions improve the state of the ecology.<sup>3</sup> Here we will speak of the prospects for the use of such explosions in the exploration for and extraction of natural hydrocarbons.

**Explosions to Improve Well Technology**

The energy balance of industrial nations is based on oil and gas. It is also known that oil and gas are nonrenewable natural resources. However, all current well technologies for the exploration for and extraction of these very important products are far from perfect. For example, they do not allow us to develop large deposits of natural hydrocarbons discovered in the lower sedimentary cover of Western Siberia (the Tyumen, Bazhenov and Achimov formations). These deposits of oil and gas are comparable in volume with the deposits which lie above them that have already been developed. The lower deposits remain virtually unused because of the debit of exploratory wells.

Current well technologies do not provide a high yield of oil even at developed locations. On average, the yield does not exceed 40-50 percent, and at the boundaries of gas and oil deposits, this figure is 10-15 percent. Well technologies also do not permit the development of crystalhydrate and bituminous deposits of natural hydrocarbons, which are numerous in our country.

Overall, these technologies permit the extraction of no more than 25 percent of discovered deposits of oil and gas. And if they are not substantially modernized, the energy crisis will become real in the near future (that is, if no alternatives are found to motor fuels based on oil).

The possibility of using camouflaged nuclear explosions to improve well technologies has been studied in the USSR and the US. Here explosions occurred mainly in oil and oil and gas deposits, where the collectors are of very durable carbonaceous rock of varied porosity and permeability. The depth of the deposit and the corresponding depth of explosions does not exceed 1.5 km, and the strength of the explosive devices is from 3 to 15 kt.

American experiments were conducted in gas deposits, where the collectors were very durable terrigenous rock with low porosity and permeability. These explosions

occurred at substantially greater depths (up to 2.5 km) and the strength of the charges used was from 29 to 43 kt.

The results of all these experiments on oil and gas deposits convincingly proved that nuclear explosions improved the operation of the stratum-well system and yielded a significant increase in the debit of stimulated wells (see table). Moreover, a complex of special studies on the physical phenomena which accompanied the explosions made it possible to understand why this occurred and which consequences of the explosion might have an independent technological value.

Technological indicators of experimental industrial objects

Object of investigation	Characteristics of natural collector				Effective depth of explosion, m/kg <sup>1/3</sup>	Number of explosions	Increase in well debit	Additional extraction of fuel per explosion, 10 <sup>3</sup> m
	Rock composition	Porosity, %	Permeability, md	Saturating fluid				
"Butan"	limestone	15-20	4-64	oil and gas	6.5;8	5	1.4-1.5	80
"Geliy"	"	8-10	5-20	oil	10	5	1.6-1	-
"Grifon"	"	10-15	20-40	Water*	7	2	1.5-1.6	120
"Neva"	limestone, dolomite	10-12	0.2-0.4	oil	5.7	6	>20	80
"Gesbaggi"	sandy shale, siltstone	10-12	0.1-0.2	gas	4.2	1	6-8	-
"Rullison"	"	7-9	0.2-0.4	"	6.2	1	10-15	-
"Rio-Blanko"(garland)	"	4-6	0.1	"	5.5;5.9;6.3	3	10-15	-

\*Explosions about 70 m below the productive stratum.

\*\* oil and gas; 1 m<sup>3</sup> of oil is approximately equal to 1000 m<sup>3</sup> of gas.

Of all the physical phenomena which accompany camouflaged explosions, three have been isolated by researchers: mechanical transformation of the surrounding porous medium, stable electric polarization of nearby rock, and consolidation of the main mass (95-98 percent) of radioactive products in the solidified melt.

The region of mechanical transformation of the porous medium around the center of the camouflaged explosion is limited to an effective radius of 80-100 m/kt<sup>1/3</sup> or less. This is a qualitatively inhomogeneous formation which can schematically be represented by several zones, assuming a homogeneous initial medium.

The central zone (I), with a radius of 25-35 m/kt<sup>1/3</sup>, is characterized by a developed system of radial and tangential macrofractures. Due to the abundance of intersecting fractures the rock in this zone is unstable (which leads to its collapse into the explosion cavity); the conduction of fluids is very high. All of this enables us to consider zone I as a large volume (10<sup>4</sup>-10<sup>5</sup> m<sup>3</sup>) suitable for the separation of the arriving liquids and gases and the collection of liquids and solid suspended matter.

The intermediate zone (II) is a shell of residually deformed rock 10-15 m/kt<sup>1/3</sup> thick. The rock here is in a stressed state contributing to the static compression of the shafts of the wells. Large pores and fractures appear in this zone. Zone II, in which the rock of the central zone is relieved of the effect of external pressure, can be considered an additional barrier in the path of fluids moving toward the center of the explosion or from it.

The external zone, zone III, has a radius of 80-100 m/kt<sup>1/3</sup>. Here only individual microfractures are formed, that is, deformation of the rock remains almost unchanged. This zone can be seen as a rock massif adjacent to the center of the explosion. In this massif there is an insignificant increase (by about a factor of 1.5) in the conductance of fluids.

Along with mechanical transformation of the surrounding porous medium, camouflaged nuclear explosions are accompanied by a stable electric polarization of the rock. The region of anomalous electric polarization encompasses the intermediate and external zones, and frequently extends for 200-250 m/kt<sup>1/3</sup>. The voltage of the electric field in the anomalous region is directed

toward the center of the explosion, which provides an additional increase in movement of liquids to the center of the zone broken up by the explosion (reverse displacement is prevented by electrostatic forces, especially in the intermediate zone).

The technological significance of this effect was noted for the first time during experimental industrial work at "Neva."<sup>4</sup> The studies conducted here showed a dependence of anomalous electric polarization on the properties of the rock collector, which makes it possible to plan the use of this consequence of the explosion. The mechanism of its effect on the mobility of stratal fluids was also established, that is, the effect of anomalous polarization on the layer of liquid absorbed by the surface of the filtration channel.

Consequently, the anomalous electric polarization is technologically significant only for rock collectors with fine pores, and the consequences of a camouflaged nuclear explosion will always appear in zone II, where, due to compression the rock acquires the properties of semiconductors. This facilitates the movement of liquid to the center of the explosion. It is for this reason that one can reliably locate liquid in the central zone. This ability confirms the dependence of the rate of filtration on the mutual direction of the vectors of electric voltage and piezometric pressure of liquid observed in experiments at "Neva."

Thus, there is every reason to state that the main transformations of the medium in a camouflaged nuclear explosion are technologically significant. But how can we affect it, how, by changing the parameters of the stratum-well system can we control the process?

#### Specific Technologies

The technological significance of the consequences of a camouflaged nuclear explosion depends not only on the features of the medium transformation, but also on the geological structure of the deposit of natural hydrocarbons and the means of developing them. About 80 percent of the deposits of oil and gas are stratal deposits, for which a large area to thickness ratio  $S/h$  is characteristic, ( $(S/h)^{1/2}$  on the order of  $10^3-10^4$ ). Real mechanical transformation of the rock collectors by a nuclear explosion cannot affect a layer noticeably exceeding the thickness of the deposit itself, because one must preserve the cover of the deposit. Thus, for most deposits explosions should be limited in strength, and should be seen as a means of affecting not the entire deposit, but only the part adjacent to the bottom hole of the well. By the way, American specialists also concluded that the area of the region subjected to the mechanical effect of the explosion does not exceed a fraction of a percent of the area of the deposit.

Experience has shown that camouflaged nuclear explosions are most effective in industrial development (exploration for and development of) deposits of oil and

gas concentrated in low-permeability rock collectors with a complex structure. These deposits have remained, in essence, unused.

Experiments on such deposits were conducted at three American sites ("Gesbaggi", "Rullison", and "Rio-Blanco") and one domestic ("Neva") site. This made it possible to determine the structural principles involved and use two technologies, one of which was to estimate the filtration parameters of the productive stratum, and the other was to intensify the influx of stratal fluids.

As work at "Neva" showed, in the exploration of deposits of oil and gas in low-permeability collectors with a complex structure, one can estimate the filtration parameters of the productive stratum without releasing the stratal fluids to the surface (this estimate is one of the main tasks of exploratory work).

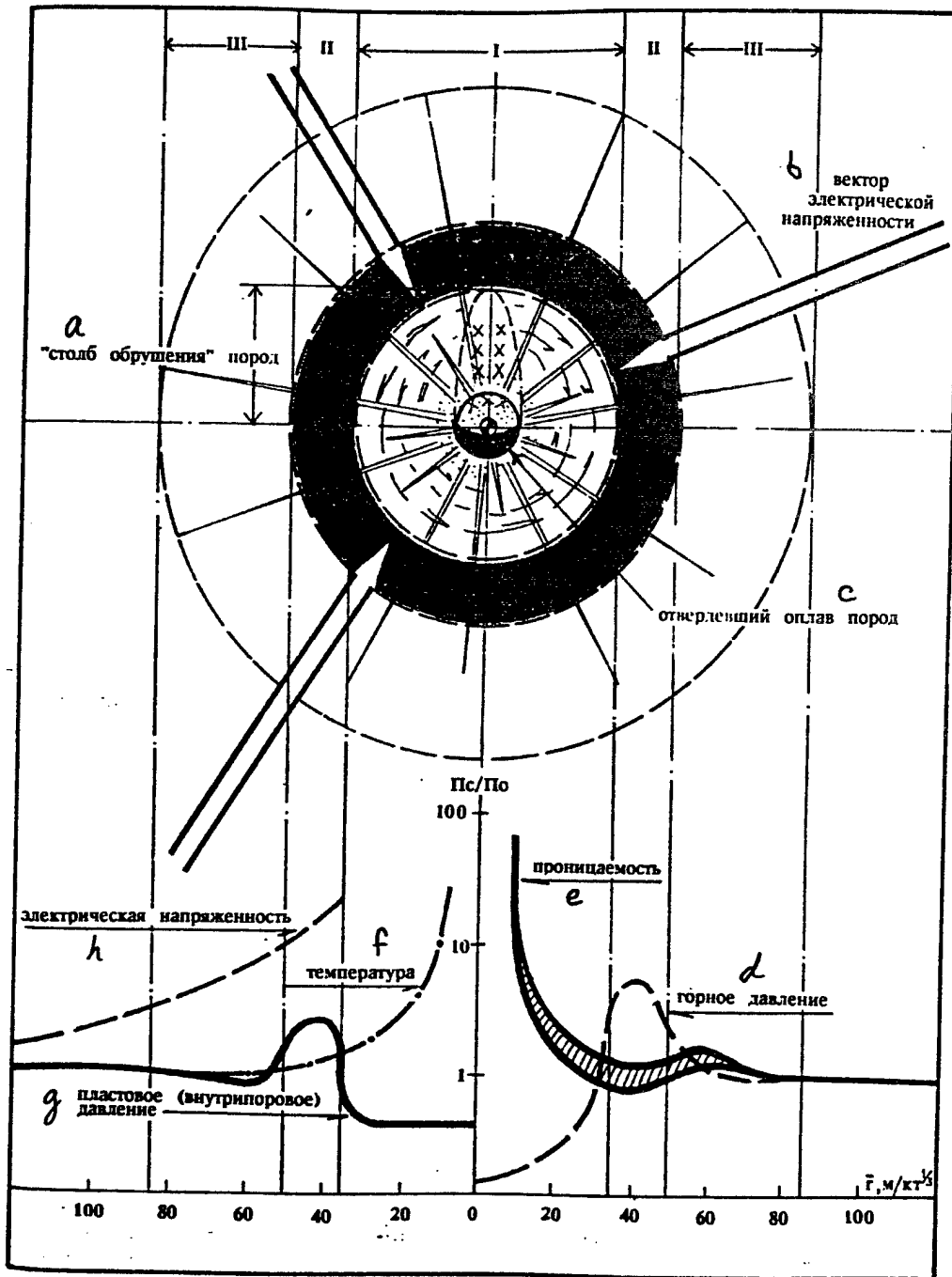
A camouflaged nuclear explosion is necessary in this technology to create a cavity of a specific size in the stratum with a decreased gas pressure. Data from remote measurements of pressure and temperature at the bottom hole of the well stimulated by the explosion were used to construct a curve which describes the restoration of pressure (pressure and temperature changed uniformly due to the effect of the influx of stratal fluids into zone I); then the desired parameters were found.

In verifying this method in practice we were convinced that our estimates of the filtration parameters were close to those obtained in the usual way, in gas dynamics studies of working wells. And although this technology is rather expensive, which has already been discussed, it can be recommended for exploration work in poorly accessible regions and in complex geological conditions.

In low-permeability, fine-pored collectors where deposits are already being developed one can use this technology to increase the influx of fluids. In this case a camouflaged nuclear explosion provides a more complete opening of the deposit and increases the mobility of liquids. In-situ experiments at the listed sites have shown that one can achieve a large (more than a factor of 15) increase in the well debit.

In developing oil and gas deposits, the quality of the opening of the deposit is estimated by the effective radius of the well, that is, the distance from its axis at which the conditions of fluid movement change from a region of high (stratal) resistances to movement to a region of low resistances (in movement along tubes and macrofractures). For any well the boundary of the change in the movement of fluids depends on the condition of the zone surrounding the bottom hole, as well as on how drilling is done, on the properties of the rock composition, etc. The effective radius can be larger or smaller than the radius of the well shaft.

Due to the plane-radial movement to the bottom hole of the well, which is characteristic for stratal fluids, the well's debit is defined by the logarithm of the ratio of the feed contour to the effective radius of the well, log



Above: schematic of physical and mechanical transformation of homogeneous porous rock affected by a camouflaged nuclear explosion. Three zones are isolated (central I, intermediate II, and external III) which differ in the degree of rock transformation, and which are used to achieve various technological ends. The arrows show the vectors of electric voltage in the region of anomalous electric polarization of the rock generated in the explosion. Below: graph reflecting the change in the basic properties of a porous medium (x-axis, effective radius,  $m/kt^{1/3}$ , y-axis, ratio of the "stimulated" parameter to the initial parameter).

Key: a. "collapse columns" of rock; b. vector of electric voltage; c. solidified rock melt; d. rock pressure; e. permeability; f. temperature, g. stratal pressure (intraporous); h. electric voltage.

$(R_w/R_{eff} + 1)$ . This means that an increase in the effective radius by, for example, a factor of 100 leads to an increase in the debit by a factor of two in all.

The effective radius of the well stimulated by the explosion is mainly defined by the size of zone I, where the resistance to the movement of fluids is low. Since the strength of the camouflaged nuclear explosion does not usually exceed 20 kt, the size of this zone and the effective radius of the well is 100-150 m.

It would seem that larger effective radii would be achieved. However, it is frequently inexpedient to increase the debit of a well solely by mechanical transformation of the porous medium through a nuclear explosion. It is worth doing this only in certain types of rock. In these same cases, when the standard methods of developing the well would increase the effective radius only to the size of the shaft (on the order of 0.1 m) and the mechanical action of the explosion provides an increase in the debit of no more than a factor of three to four, the technology becomes unprofitable. The cost of one well stimulated by a camouflaged nuclear explosion is close to the cost of three typical deep wells.

The mobility of liquids can only be increased in the stratum beyond the zone of fracture formation by electrophysical action on the productive layer, and this is achieved only in a fine-pored collector. Due to the features of the structure and saturation of the porous volume in the oil and gas deposit at the "Neva" site, the anomalous polarization of the rock due to nuclear explosions became technologically significant. This provided an additional increase in the debit of wells stimulated by explosions. At American sites where the natural fine-pored collector was primarily saturated with gas, the effect of anomalous electric polarization of the rock was not as significant: the increase in the debit did not exceed a factor of 10-15 (while at "Neva" it was an increase of more than a factor of 20).

Another promising way of using camouflaged nuclear explosions is improvement of the technologies of oil extraction. One of these technologies for increasing the yield of oil is associated with the development of massive deposits in an artificial "gas cap" mode. In this case an explosion is needed to create the pre-condition for gas cap formation and for a normal work mode. This is achieved due to the separation properties of the region of artificial fracturing. To develop this type of deposit into a gas cap, gas is pumped in and oil is expelled. The yield of oil is close to 60 percent, which is about two times higher than in the usual development of such deposits.

As already noted, the yield of oil from the edges of gas and oil deposits is especially low. To increase it, a special technology was developed using nuclear explosions. In this technology oil is recovered in small pressure depressions which are due to the structural properties of the central explosion zone. This oil recovery prevents the formation of breached cones of more mobile fluids (gas and water) to the bottom hole of the well. This stabilizes

the spatial position of the edge and makes it possible to develop it as a typical oil deposit, attaining a yield close to 40 percent (usually 10-15 percent) and providing a total increase in the extraction of oil by more than a factor of two.

Finally, there is another possible application of nuclear explosions. It is associated with the extraction of gas from crystalhydrate deposits, where the gas is in an immobile state in the form of a solid compound with water. The gas can be removed from the crystalhydrate by decreasing pressure or increasing temperature, but to do this one must create a large evaporation surface and insure the separation of the released water and gas within the stratum. An explosion could meet both of these conditions due to the large surface of fractures it forms, and by the separation and collection properties of the central zone of the explosion.

In conclusion we must add that the technologies listed here do not exhaust all the possibilities of using camouflaged nuclear explosions in the exploration for and extraction of hydrocarbons. The experience accumulated in experiments makes it possible to expand this list. But even without this it is clear that the technological possibilities of this type of explosion are extremely broad.

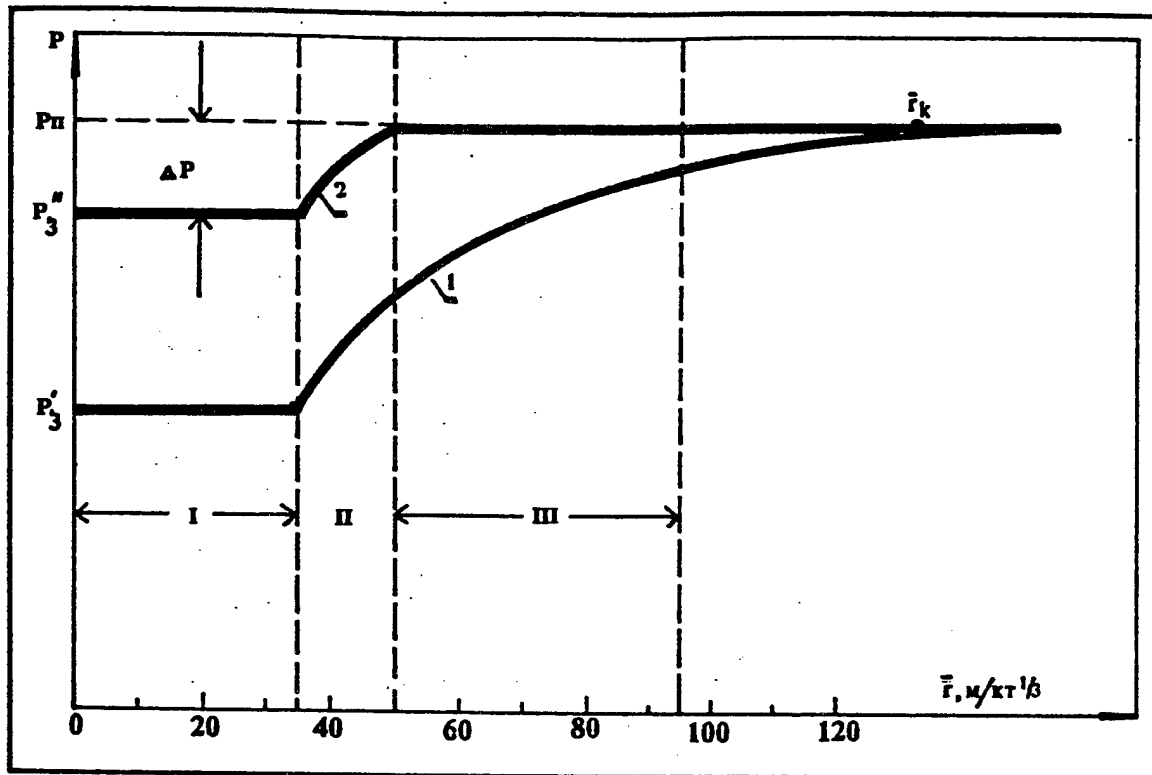
And before we give a final estimate of the prospects for the use of this type of explosion, it is necessary to answer two principal questions: how economically expedient is the use of these explosions, and are they ecologically acceptable?

#### Economic and Ecological Aspects of the Problem

Usually the economic expediency of new developments is judged on the basis of direct calculations using existing methods of determining economic effectiveness. However, in this case we must proceed from extremely uncertain costs for special nuclear products and the changing prices of petroleum products, which are the basic reasons to modernize well technologies with camouflaged nuclear explosions.

According to American data<sup>5</sup> the cost of special nuclear products is 350,000-700,000 dollars, which clearly is close to their true cost. The price of one ton of oil on the international market varies (with a tendency to increase) from 200 to 400 dollars. Given these initial data, direct calculation of the economic effectiveness of new technologies will be very inexact. Consequently, it makes more sense for us to evaluate the economic expediency of using camouflaged nuclear explosions by comparing energy indicators: the energy expended (in the explosion) and the energy obtained (due to the additional fuel recovered).

In in-situ experiments testing the use of wells stimulated by an explosion, in one explosion on average approximately an additional 100,000 tons of conventional fuel<sup>6</sup> was obtained. This is not the limit of the tested special technologies: this result was obtained in the intermediate stage of deposit development. However, even this result is sufficiently convincing: it means that at these sites more than a ten-fold compensation in energy costs has



Distribution of pressure  $P$  in the stratum-well system.

Key: 1. in the recovery of oil or gas from the well; 2. in the shutdown of a well and restoration of pressure in the stratum ( $r_k$  is the radius of the feed contour,  $r$  is the effective radius; I, II, and III are the internal, intermediate, and external zones in rock transformed by the explosion). The pressure at the bottom hole  $P_2'$  and  $P_3''$  in a well stimulated by an explosion is always less than the stratal pressure  $P_\pi$ . The remaining drop in pressure  $\Delta P$  is due to the properties of the intermediate zone, which forms a "barrier" resistance in the path of the stratal fluids. As a result of this pressure distribution, the pressurized movement of fluids from the central zone into the stratum is impossible until the barrier resistance is broken.

been obtained. This makes it possible to positively evaluate the economic expediency of new technologies even monetarily.

In typical estimates of the economic efficiency of new developments one also considers the standard period needed for capital expenditures to pay for themselves (usually five to eight years). Assuming the minimum period and assuming that the cost of one stimulated well (considering expenditures for equipment and use) does not exceed 3-4 million dollars, and that it would operate 300 days a year, we estimate the necessary debit for a minimum value of the additional recovered fuel. Simple calculations show that the additional debit is 12 conventional fuel tons per day.

Thus, the following requirements can be imposed on the criterion of economic expediency of introduced technologies: during the working time of the new technology no less than 100,000 additional tons of conventional fuel should be recovered per explosion; and the established increase in the debit of the stimulated well should be no less than 12 tons of

conventional fuel per day. As in-situ experiments show, these requirements can be fully achieved.

Now, we consider the ecological acceptability of camouflaged nuclear explosions, which is defined primarily by the possibility of overcoming the seismic and radiation consequences of an explosion. The experience of using these explosions in the conditions present in oil and gas deposits shows that the strength of these explosions should not exceed 20 kt, and the depth of the charge should be from 1 to 4 km (it is at these depths that the main deposits of natural hydrocarbons are concentrated). This makes it possible to insure the seismic safety of explosions by selecting strength depending on the depth and geographical position of the deposit.

Radiation safety can also be achieved. In a recent publication in this journal mentioned earlier, there was a detailed discussion of how to insure radiation safety in camouflaged nuclear explosions and how to develop the wells stimulated by them. Only one important question remains: how radiation safety is achieved in technologies

providing for the extraction of oil and gas directly outside the zones transformed by the explosion.

In order to answer this we return to the beginning of the article, where we describe the properties of the medium transformed by the explosion. Especially important are the properties of the central zone, in which all radioactive products of the explosion are concentrated, as well as the properties of the intermediate zone, in which a barrier resistance is created in the path of the movement of fluids.

The features of the central zone make it possible to separate fluids which flow in during the extraction of oil and gas, to extract components separately, to collect the stratal water which enters this zone, which after contact with radioactive products becomes the main source of danger. For example, study of the distribution of pressure in the stratum-stimulated well system at the "Neva" site showed that between the productive stratum and the central zone of the explosion, reduced pressure is retained for a long time (years). This difference of 5-10 atm at "Neva" is explained by the properties of the intermediate zone.

By correctly using the specifics of the medium transformed by the explosion, one can insure radiation safety in the extraction of natural hydrocarbons. But this is possible only before the central zone is filled with accompanying stratal water. After this the extraction of useful products from the zone ceases, and the site becomes a reliable tomb for the contaminated water, which, left to itself (without compulsory destruction of the barrier resistance), cannot leak out.

Thus, in order to insure the radiation safety of the proposed technologies, one must meet two requirements: first, the center of the explosion should be in the productive stratum itself; second, in the extraction of oil and gas, the stratal water should not leave the central zone, and naturally, should not be extracted to the Earth's surface.

In-situ experiments have shown that at all sites where these requirements have been met, radiation safety of the extraction of oil and gas from the wells stimulated by an explosion was insured. This makes it possible to speak of the ecological acceptability of technologies based on the use of camouflaged nuclear explosions.

Thus, the problem of improving well technologies for the extraction of oil and gas with camouflaged nuclear explosions is completely solved. The prospects of this method are confirmed by the results of experimental industrial work at domestic and foreign sites. If the energy problem is to be solved in the future primarily by oil and gas, this research deserves development. Moreover, these peaceful explosions may be seen as an alternate means of destroying nuclear weapons.

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6. Conventional fuel: in technical and economic calculations the standard unit for comparing the thermal value of various types of organic fuel. The heat of burning 1 kg of solid conventional fuel (or 1 m<sup>3</sup> of gaseous fuel) is 7,000 kilocalories.

#### **Definition of the Parameters of Stack Plumes Using Backscatter of Optical Radiation**

927N0070C Tomsk *OPTIKA ATMOSFEREY in Russian* Vol 4 No 10, Oct 91 (manuscript received 1 Jul 91) pp 1048-1053

[Article by V. A. Banakh and I. N. Smalikho, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk; UDC 551.501.7]

[Abstract] The backscatter of a continuous beam of optical radiation is theoretically analyzed for the case of sensing of stack plumes. It is shown that it is possible to determine the concentration of particles in stack plumes and the amount of emissions of local sources of pollution from measurements of the distribution of the intensity of backscattered light in the focal plane of the telescope. First, intensity equations are deduced independent of particle size and radiation wavelength. In later calculations these factors play an important role. Particle concentration is calculated for large particles. The Gaussian model used here cannot be used when there are strong winds and intense mixing because of large variations in particle concentration. However, it can still determine instantaneous emission strengths (number of particles passing through a plane per unit time) if the incident radiation completely encompasses the cross section of the smoke plume. Figure 1; references 8 (Russian).

### Seasonal Characteristics of Distant Transport of Pollutants Toward Central European USSR

927N0054A Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 10, Oct 91 (manuscript received 25 Dec 90) pp 69-74

[Article by A. P. Katsyka, L. G. Bogatova, L. P. Mironova and R. A. Smirnova, Koloma Pedagogic Institute; UDC 504.054:551.511.3:551.509.33(470.3)]

[Abstract] The directions of arrival of pollutants and the frequency of recurrence of individual directions of such transport were determined for the central European USSR at the single point Obninsk (this point is representative for the entire central European USSR) during 1983-1984. The directions of distant transport of pollutants can be roughly determined by evaluating sets of reverse trajectories of arrival of air masses constructed from high-level pressure pattern charts (AT<sub>925</sub> and AT<sub>850</sub>). The accuracy in constructing trajectories decreases with an increase in the duration of the period. An error in position and length of the trajectory results in an error in estimating the location of possible local sources of pollution and for distant transport the possibility of determining such sources is entirely precluded. The study of the directions of transport makes it possible to determine from which sources the greatest quantity of pollutants is transported and for which the concentration of pollutants is maximal. The distant transport method is fraught with many errors and therefore detection of the predominant direction of transport requires a large volume of statistics, prolonged observation periods and allowance for types of weather (circulation), on which the wind regime in the region is dependent. The directions from which pollutants are transported must be determined by seasons since the seasons differ with respect to circulation characteristics and accordingly, predominant transport directions. The seasonal changes in trajectory directions may be the most decisive factor in determining pollution concentrations. The study must be made at several levels. In constructing pollution transport trajectories it is preferable to use data on the actual wind rather than on the geostrophic wind because the actual wind more fully reflects the influence of terrain features, the closeness of shores and the presence of forests. Figures 3; references 11: 10 Russian, 1 Western.

### Influence of Urbanization Process on Global Warming Estimates

927N0047A Moscow METEOROLOGIYA I  
GIDROLOGIYA in Russian No 9, Sep 91 (manuscript received 27 Sep 90) pp 5-11

[Article by P. Ya. Groysman and V. V. Koknayeve, State Hydrological Institute; UDC 551.583:551.588.7]

[Abstract] Estimates of the spatially averaged mean annual air temperature registered in the standard network of the State Hydrological Institute and in a specially selected network for four major continental regions (United States, Western USSR, Eastern China,

Eastern Australia) were compared. The study was based on 301 northern hemisphere stations, 40 percent of them located in populated places with less than 10 000 persons; in the southern hemisphere data were used for 275 stations, 60 percent of them located in populated places with fewer than 10 000 persons. This analysis of the contribution of urbanization to changes in mean air temperature over a considerable part of the most densely populated regions of the extratropical part of the northern hemisphere and one region of the southern hemisphere indicated that in three of the four regions this contribution is negligible and in the fourth does not exceed 20 percent of the observed changes in mean air temperature of the region. It is improbable that the tropical and Western European regions not covered in the analysis could significantly increase the estimate of the contribution of urbanization to the global warming process. Taking into account that over the oceans there may be no such contribution to the estimates of air temperature change, the total influence of urbanization on the global temperature trend does not exceed 0.02-0.05°C/100 years, which is less than 10 percent of the absolute value of this trend. Figure 1; references 10: 3 Russian, 7 Western.

### Reaction of Glaciation to Impending Climatic Changes

927N0055A Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA GEOGRAFICHESKAYA in Russian No  
5, Sep-Oct 91 (manuscript received 14 May 91) pp 35-45

[Article by V. M. Kotlyakov, M. G. Grosvald, M. B. Dyurgerov and V. L. Mazo, Geography Institute, USSR Academy of Sciences; UDC 911.2.551.324:551.583]

[Abstract] The possible changes in glaciation associated with the greenhouse warming of climate are examined. The primary objective is to show that in estimates of the impending rise in ocean level it is necessary to avoid errors related to underestimation of the role which will be played by losses in mass of ice due to the breaking away of icebergs and an illegitimate assumption of a linearity of the correlation between temperature increase and decrease in glaciation (most modern predictions of ocean level changes are based precisely on such an unwarranted assumption). The mechanism of instability of sea glacial formations which may result in their catastrophic decay and a rise in ocean level by 5-7 m in a very short time is examined. (The rate of rising of ocean level was found to be higher than that found by such authors as G. Robin; the discrepancy is attributed to erroneous assumptions by that author.) Detailed computations are given for an extremal regime of mountain glaciation in the temperate and subtropical latitudes with a distinctly negative (as much as -3, -5 m/year) balance of mass, resulting in the rapid disappearance of glaciers. The discussed changes will for the most part have clearly negative geocological consequences. For example, the runoff volume of mountain rivers will be greatly reduced, resulting in negative consequences for agricultural production. Figures 6; references 27: 13 Russian, 14 Western.

### Possible Consequences of Global Climatic Changes for Soils and Their Water Regime

927N0055B Moscow *IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA in Russian No 5, Sep-Oct 91 (manuscript received 31 Oct 90) pp 46-55*

[Article by N. A. Karavayeva and A. F. Mandych, Geography Institute, USSR Academy of Sciences; UDC 911.2:583:551]

[Abstract] Changes in the hydrothermal regime of soils and some of their principal properties with the replacement of natural landscapes by agricultural landscapes were analyzed for the Russian Plain with attention given to increased contrast of the hydrothermal regime, sums of active temperatures and humification. The M. I. Budyko scenario of possible climatic changes was used as a basis for this examination. Qualitative conclusions are drawn concerning possible transformation of such soils as a result of the anticipated climatic changes. Under stationary climatic conditions, in the boreal and subboreal regions, from the tundra to the meadow steppe, the differences between agricultural and natural soils are as follows: in the first there is even now an increase in the contrast of the water and heat regimes, an increase in the sums of active temperatures above 10° and displacement of the moisture balance in the direction of humification for most soils. The following changes in soil formation are observed in cultivated soils in comparison with natural soils: in the soils of the tundra and northern part of the taiga zone there is an increase in the stagnation of moisture, gleyification and a trend to swampification; in the soils of the southern part of the taiga zone there is an increase in eluvial processes, acidification and dehumification, but in meadow steppe soils there is dehumification. For all these soils there is a general trend to worsening of physical properties. These changes in the hydrological regime and properties of worked soils under stationary climatic conditions in general have the same tendency as the anticipated global climatic changes. But the difference between natural and cultivated soils will be different with global climatic changes. The cultivated soils will be transformed more rapidly than natural soils, which will have an inherent inertia. Under climatic change conditions not all natural and cultivated soils will react the same; different genetic, agricultural and geologic factors also will play a role. Figures 8; references 17: 15 Russian, 2 Western.

### Sequence of Environmental Protection and Technological Measures for Lessening Polluting Loads on Urban Landscapes

927N0055C Moscow *IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA in Russian No 5, Sep-Oct 91 (manuscript received 9 Nov 88) pp 74-79*

[Article by V. M. Khvat and V. M. Moskovkin, All-Union Water Conservation Scientific Research Institute, USSR Academy of Sciences; UDC 628.39]

[Abstract] Measures are proposed for lessening the anthropogenic impact associated with continuing urbanization and reducing the intensity of accumulation of

pollutants, especially solid particles, in urbanized landscapes. Expressions are derived for making quantitative estimates of the impact arising from different sources of contamination. Specific proposals are made for reducing the entry of pollutants into the environment. Recommendations are given on a differential approach to reduction of anthropogenic loads on the environment. The first group of measures includes those for preventing soil erosion from lawns and similar surfaces and regulation of runoff from them. The second group includes technological measures for upgrading the resistance of road surfaces to degradation. With an increase in bitumen content from 5 to 7 percent the wear is reduced by 80 percent; with the use of igneous rocks instead of sedimentary rocks wear is reduced by 60 percent; with an increase in gravel content from 50 to 70 percent wear is reduced by 50-60 percent. The third group includes technological and organizational measures directed to reducing effluent into the atmosphere from both industry and vehicles. The fourth group includes measures for reducing wear on tires. Procedures are suggested for ranking loads on the basis of their intensity and territories with respect to the degree of their pollution. Figure 1; references 8: 7 Russian, 1 Western.

### Monitoring Climatic Changes in World Ocean

927N0056A Moscow *IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 27 No 10, Oct 91 (manuscript received 21 Dec 90) pp 1043-1053*

[Article by S. K. Gulev, S. S. Lappo and V. P. Tereshchenkov, State Oceanographic Institute; UDC 551.465:551.582]

[Abstract] The possibilities of analysis of short-period climatic variations by means of monitoring of energy-active zones within the framework of the "Razrezy" program are examined. It is shown that the energy-active zones are characterized by extremal quantities of heat flows at the ocean-atmosphere interface and their maximum variability. The effectiveness of the energy-active zones for detecting climatically significant changes in the ocean is demonstrated. Data are now available making it possible to formulate a strategy for monitoring climatic changes in the North Atlantic. In the tropical latitudes the principal mechanism of interannual and seasonal variability of meridional transport is the drift component. With this taken into account, in the tropics monitoring should stress observation of the wind field with a high resolution and heat content of the entire Tropical Atlantic. In the middle latitudes the meridional transport of heat for the most part is by a system of boundary currents (in virtually all months northward transport is determined by the Gulf Stream) and monitoring should therefore be concentrated there. In the high latitudes of the Northern Atlantic it is necessary to introduce constant monitoring of the region of possible formation of convective outbreaks for the purpose of determining the influence of deep convection on the heat content of the North European Basin. The principal areas for such monitoring should be the Norwegian and Greenland Seas. Figures 5; references 39: 27 Russian, 12 Western.

**Atmospheric Fallout of Metals at North Pole in Comparison With Background Regions of Northwestern Europe**

927N0074A Moscow *IZVESTIYA VSESOYUZNOGO GEOGRAFICHESKOGO OBSHCHESTVA in Russian* Vol 123 No 4, Jul-Aug 91 (manuscript received 19 Sep 90) pp 316-322

[Article by V. N. Adamenko, K. Ya. Kondratyev and S. A. Sinyakov, Leningrad; Petropavlovsk-Kamchatskiy; UDC 910.551.5+581.5]

[Abstract] The fallout of dust and a number of metals, most of which are heavy metals or trace elements, was investigated in the Arctic and in water bodies of Northwestern Europe. Three hundred samples were analyzed, including 18 from the arctic station SP-28. It was found that the dry and wet fallout of heavy metals from the atmosphere differs by three orders of magnitude, determining the global, regional and local backgrounds. In the central regions of the Arctic and in the industrial and background regions of Northwestern Europe it is possible to identify identical groups of metals arriving from the atmosphere which differ in intensity by 1-2 orders of magnitude. The winter receipts of heavy metals in the Central Arctic are considerably greater than the summer receipts. The spatial changes in the fallout of heavy metals conform to an exponential law of attenuation in the directions of predominant transport from the principal areas of origin. There is a correlation, significant at the 95-99 percent level, between the quantity of dust and each heavy metal, making it possible to write regression equations. Applying these equations, by using the quantity of dust it is possible to estimate the content of each of the identified heavy metals. There is basis for assuming that the determination of the concentration of heavy metals in the snow cover is possible. The present-day level of fallout of heavy metals in the northwest is approximately 1-2 orders of magnitude greater than that which it was 100-150 years ago and it is an order of magnitude less than is characteristic for the Central Arctic. It is important to track atmospheric transport of heavy metals because for several very large internal water bodies the receipt of a number of heavy metals from the atmosphere is comparable to or exceeds the receipt with river runoff by a factor of 3-4. References 9: 2 Russian, 7 Western.

**Influence of Solar System Gravity Field Variability on Earth's Climate**

927N0074B Moscow *IZVESTIYA VSESOYUZNOGO GEOGRAFICHESKOGO OBSHCHESTVA in Russian* Vol 123 No 4, Jul-Aug 91 (manuscript received 5 Nov 89) pp 328-339

[Article by V. D. Kovalenko, L. D. Kizim and A. M. Pashestyuk (deceased), Dnepropetrovsk; Moscow; UDC 521+551.590.23+551.509.3]

[Abstract] A study was made to predict the general nature of climate at the end of the 20th century and during the 21st century and also to clarify the reasons for and the nature of climatic changes during past centuries and millenia. This required a systemic analysis of the motion of solar system celestial bodies, construction of a planetary climatic model and study of secular climatic changes. The nature of a whole group of geospheric processes (1-, 20-, 200- and 2000-year cycles) is explained. The concepts developed in the article indicate that the process of global cooling during the last 200-year cycle, beginning with the second half of the 20th century, will continue to the 2030's. The entire 21st century will be relatively "cold." With an increase in the cooling process there will be an increase in the temperature drop between the polar and equatorial zones. This will result in a change in global atmospheric circulation, including advection and adiabatic processes, and an increase in its instability. The region of unstable phenomena will be displaced into the middle and subtropical latitudes, as has been observed during recent years. The heat supply in growing seasons for surface plants in the northern hemisphere and the duration of these seasons will decrease. In the course of the cooling there will be a rise in the ground water level, runoff of rivers and level of inland undrained water bodies. There will be an increase in the ice content of polar and near-polar seas and oceans. The advance of continental glaciers beginning in the 1960's will continue up to the end of the 21st century. The decrease in the level of the world ocean beginning in the 1960's will continue to the end of the 2020's, after which its rise will begin and by the end of the 21st century will attain the mean long-term level. The possibility is appearing for a scientifically validated prediction of the change of these and other geosphere parameters for years, decades and centuries in advance. Figures 4; references: 17 Russian.

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