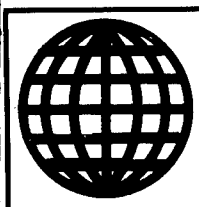
JPRS-UES-90-005
19 APRIL 1990



JPRS Report

Science & Technology

USSR: Earth Sciences

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CONTENTS

PHYSICS OF ATMOSPHERE

ECOLOGY

Towards a New Paradigm

907N0058A Moscow PRIRODA in Russian No 12, Dec 89 pp 4-9

[Article by V. N. Strakhov, Director of Earth Physics Institute imeni O. Yu. Shmidt, USSR Academy of Sciences]

[Text] The catastrophic earthquake in Armenia illuminated a large number of serious problems which had accumulated in different sectors of our society. It also raised, very sharply, questions about the state of applied and basic seismological research.

For applied seismology, understood primarily as the work of routine seismological observations, the Spitak earthquake played the very same role as the sadly famous Tsusimsk battle played in its time for the Russian empire. It is clear that the most urgent, radical measures are required here, of which more will be said later.

It is far more difficult to characterize the state of basic seismology, which is called upon to evaluate the seismic risk for each specific region. Precisely this problem has been the center of public attention. In the very first days after the catastrophy, from various quarters which were investigating the earthquake, the seismologists and other specialists were deluged by a torrent of questions: Why wasn't it foreseen? Is it possible to predict such catastrophies? What are the capabilities of modern science in this area? The questions have still not dried up or diminished, but in addition various sorts of suggestions have rained down, both professional and amateur, as to what more to do, how to develop the science of evaluating seismic risk and predicting earthquakes, which ideas and methods to use. In this ardent desire to help the specialists is seen the highest manifestation of the civic principles of the soviet people. Our wish to somehow respond to the numerous questions and suggestions has caused in part this attempt to analyze the state of basic and applied seismology.

I

The well-known American scholar T. Kuhn in his book "The Structure of Scientific Revolutions" introduced exceptionally capacious and important concepts: "paradigm" and "normal science". A paradigm is a complex and multi-layered concept, including:

a) a great scientific achievement, defining the level of understanding of the nature of phenomena and ways of further developing the given field of knowledge;
b) a system of ideas about which problems need to be solved and how they are to be defined and solved (in other words, the professional orientation of the scientists);
c) the professional association of scientists professing the given system of ideas.

The development of science, according to Kuhn, comprises phases of establishing and replacing paradigms (scientific revolutions) and phases of developing science within the framework of the particular paradigm (Kuhn calls this normal science).

Let us clarify these concepts with an example. Until the famous work of L. Pasteur, the empirical principle predominated in medicine, i.e. the paradigm of observing the symptoms of disease and the effect of one or another treatment on the course of the disease. Pasteur's discovery of the agents of infectious diseases radically changed the conception about the causes of disease and methods of studying and treating them. It created a new and truly scientific paradigm, and modern medicine can basically be characterized as normal science within the framework of this paradigm.

The classic works of seismology and geology on evaluation of seismic risk created a paradigm, which was characterized by empirical synthesis, the logic of retrospective analysis and analogies. Thus modern seismology already has several decades of development as normal science under this paradigm.

Let us reveal the contents of this assertion. Earthquakes are one of the phenomena of life on that supercomplex mechanical system which is the earth's tectonosphere (the layer from the earth's surface to a depth of 600-700 km). The upper part of the tectonosphere is the earth's crust (a layer of rock with a thickness of 7-10 km under the ocean to 50-60 km in the area of mountain systems). It is cleaved by complex fault systems and is comprised of blocks, relatively weakly connected to each other. Each block usually includes smaller and more closely connected blocks, each of which is split by numerous cracks, filled with fluids and gases. The crust is under constant stress; some of the blocks are in a state of compression, others are in tension. Moreover, the deep layers of the crust have magmatic beds, where the rock is in molten and semimolten states.

Under the influence of diverse factors the state of the earth's depths changes, and these changes are usually manifested in various forms at the surface. At the present time, when the number of deep and ultradeep drill holes is small, the life of the tectonosphere is studied basically by its manifestations at the earth's surface and in shallow drill holes. It is also important that the deep processes usually occur extremely slowly and don't make their presence known by sharp changes in magnitude, which are being looked for. But in individual cases the state of the depths changes unevenly, which releases such a great deal of energy that earthquakes occur. Earthquakes are usually considered as connected with the formation of fractures in the earth's depth or with movements of crustal blocks along old fractures, called faults. It is also thought that fractures arise when elastic or elasto-plastic strain reaches (in a region adjacent to a future fracture) the limiting value.

However this is only a qualitative outline. The composition of the earth's tectonosphere (its structure and material make-up) and even more the state of stress at depth is known only approximately. Its behaviour, bearing in mind its slowly occuring processes, also cannot be expressed quantitatively. There are no mathematical relationships allowing us to establish when, in

one or another volume of rock, the slow processes will be interrupted by discontinuous change.

It is just this ignorance of the structure of the earth's depths, its material composition, stress state, and laws governing changes in state, which has caused scientists—geologists and seismologists—to take the path of retrospective analysis of observed events in the matter of earthquake prediction.

Predicting an earthquake means giving its location, strength, and time. In the preceding 2.5-3 thousand years there have occurred tens of thousands of earthquakes. First of all, scientists began to study the pattern of focus distribution for previous earthquakes and discovered that an overwhelming majority of them were connected with deep faults in the crust. However not all faults are fixed by foci of past earthquakes—thus was formulated the concept of active (live, seismogenic) and passive (dead, aseismic) faults. Analysis of earthquake distribution patterns led to seismic risk mapping—a scientific discipline joining geology and seismology. Specialists in seismic risk mapping evaluate the probability of earthquakes occuring in various parts of the earth's surface and their maximum strength (on an intensity scale). This data forms the basis for the seismic-proof construction program.

But although the number of past earthquakes is great and scientists are succeeding in determining their location and strength in not only the historical but also the geological past (paleoseismology), so far there is no unanimous, unified, generally accepted method for evaluating potential seismic risk. Some specialists are disposed to attach decisive significance to seismogenic faults and propose seismic risk mapping (and even long-term prediction of place and strength of earthquakes) on the basis of analysing the structure of such faults. Others associate strong seismicity only with fault tectonics and base themselves on the correlation of seismicity with a number of geological and geophysical indicators, using formalized methods of pattern recognition. On the whole the state of affairs with seismic risk mapping cannot now be considered satisfactory, in as much as the map of seismic districting for the country, compiled at the end of the 1970's and published in 1983, is already outdated, and the demand for similar maps has sharply increased.

The state of affairs with earthquake prediction is similar. Here principal significance is given to indicators of different kinds. The concept of an indicator is entirely based on the logic of retrospective analysis. The essence of the matter is this. Assume we continuously measure some geophysical, geochemical, or other parameter at a given point. If an earthquake has occurred in the area and it was established that the behaviour of the parameter from some time (usually weeks, days, hours) before the earthquake underwent unusually sharp changes, then these anomalies are connected with the earthquake and are called its precursor. If the connection between earthquakes and anomalies of the parameter is solid (confirmed repeatedly), then the precursor can be used for predicting future earthquakes. In other words, if there suddenly occurs anomalous behaviour of a physical parameter, similar to that which takes place before an earthquake, there is a basis for predicting an earthquake in the near future (weeks, days, hours). Thus the ideology of short-term prediction is empirical synthesis, retrospective analysis, and analogy. There is no quantitative physical or mathematical theory here.

Unfortunately, truly solid precursors of earthquakes still have not been found. Therefore seismologists are trying to use a cybernetic approach to the problem of short-term prediction—to construct a dependable whole from a multitude of unreliable elements. In particular, looking back at past events, they search for possible precursors in various geophysical fields: in changes in water level and mud composition in drill holes, the composition of exhaled gases, etc. Moreover, they try to make an integrated use of these indicators. Of course there is still no great science to this, which explains the absence of fully correct short-term predictions.

Speaking of reliability, long-term (several years) and middle-term (less than a year) prediction occupy the intermediate position between seismic risk mapping and short-term prediction. In composing them scientists lean on the sum of the data on deep structure and well- known seismic events from the past. Included here are the fault tectonics of the region, the stress state of crustal blocks, the periodicity of repeated earthquakes, and the empirically established facts on the decrease of seismic activity before strong earthquakes (the so-called seismic hiatus). But in the case of long- and middle-term predictions the judgments are also made by analogy. In so doing, the majority of conclusions are made not on a quantitative, but on an especially qualitative level, because, to repeat, quantitative laws are not yet known.

In recent years a new approach to the problem of prediction has been outlined, based on calculation of cosmic factors influencing earth processes. It passes itself of as completely valid, but here everything is based on extremely vague correlations and considerations of a general character, in short—on hypotheses. Therefore there is no basis to put it at the forefront, as is sometimes done, much less to consider it reliable.

Thus at present seismology is dominated by the paradigm of empirical synthesis, retrospective analysis, and analogy. Empirical synthesis is necessary but, alas, not sufficiently sound for confident prediction. What's missing is the chief factor which defines other sciences (physics, chemistry, biology, etc.)—active experiment.

II

Obviously, it is already clear to the reader that the currently prevailing seismological paradigm is essentially analogous to the one dominating medicine up to Pasteur. Observational (empirical) medicine frequently

successfully treated many chronic diseases, but was utterly helpless before serious infectious diseases—plague, cholera, typhus, tuberculosis, etc. So too the current prevailing seismological paradigm makes possible a sufficiently reliable evaluation of potential seismic risk, but is not, usually, capable of predicting exactly events such as destructive earthquakes. However there is one "but"—much is determined by the level of our information of the structure of the earth's tectonosphere (above all the crust) as well as by the broadness of the observational network, i.e. by the volume of information about the evolution of the system's mechanics over time. In principle even the present paradigm can provide a much more exact earthquake prediction, if the structure of the crust is better studied in seismic risk regions, and if a modern observational network is created in the country.

This last is especially important. Although current seismological observatories and other observation points are not really few (about 400), they are mainly equipped with utterly outdated gear. The main thing is that a system for real-time collection and processing of prediction information is lacking in this country—results from observations are processed with delays of several days to several weeks. True, the service functions promptly for urgent messages about events which have occurred, even fairly weak ones, but for it, as the saying goes, we are none the better.... Not less sad is the fact that there are practically no methods for integrated processing of prediction information by computer.

So then, there is no modern system of seismic observation in the country; its creation still lies ahead. In the shortest term it is necessary to do the following:

expand serial production of modern seismological and other geophysical and geochemical equipment;

radically modernize, and partially construct and equip anew the network of automated observation stations, not only with numerical recording equipment, but also with the means for preliminary processing and telemetric transmission of information;

start up operational collection and transmission of prediction information from observation stations to their processing centers, preferably by means of satellite links;

create data processing centers equipped with powerful computer technology, not only at the republic and regional level but also at the all-union level (only an all-union center will allow generalizing for the country as a whole, taking into account meteorological and other factors);

develop algorithms for integrated processing of prediction information by computer, as well as expert systems, providing for decision making on seismic risk and for earthquake prediction at the earliest possible date and on a strictly scientific basis.

A huge volume of research is necessary for studying crustal structure by geological, geophysical, geochemical and other methods over the enormous area of high seismic risk regions, including Moldavia, Crimea, Caucasia, Central Asia, and significant portions of Siberia and the Far East.

As long as the country does not develop a modern observation system, an effective solution to the problem of earthquake prediction is not possible. This must be clearly understood. And although the creation of such a system will be costly and require a huge amount of labor, it is necessary, bearing in mind not only the enormous human sacrifice and material loss from earthquakes, but also the significance of the psychological factor.

In considering the inescapable cost of labor and material resources for this, it should be understood that within the USSR destructive earthquakes occur about twice a year and that since the turn of the century there have been more than 180 (fortunately many of them in sparsely populated regions); that from 1948 to 1988 (from the Ashkhabad earthquake to Spitak) about 150,000 people have died from earthquakes, and material loss has amounted to more than 25 billion rubles; that in the past few years the total loss has averaged more than 2 billion rubles each year; that with the growth of cities and the increase in numbers of such facilities as high dams, nuclear power plants, etc, the danger has increased sharply.

Therefore the cost of a modern observation network, estimated at approximately 1.5 billion rubles, does not seem excessive. With effective cooperation of science and industry it could be created in 6-8 years.

III

It was noted above that the creation of a modern observation system is necessary, although there are not always satisfactory conditions for predicting earthquakes. But what then would be a satisfactory condition? The answer is obvious—the establishment of a fundamentally new paradigm in this field of science. Here again the comparison with medicine suggests itself—as the paradigm of observational medicine gave way to the paradigm based on the scientific theory of infectious disease, so too the prevailing seismology paradigm of empirical synthesis, retrospective analysis and analogy must give way to a paradigm based on knowledge of quantitative laws which describe the dynamics of the crust and the whole tectonosphere of the earth. There are two ways it is possible to create a new paradigm, as we know from the past. Either a genius appears, about which P. Beranzhe wrote:

> If our sun forgot tomorrow to light the path for our earth the idea of some madman would light the whole universe tomorrow

Such "madmen" might include I. Newton, C. Darwin, L. Pasteur, A. Puankar, A. Einstein. The second way is the purposeful development of basic scientific research in this field.

Since the birth of a genius is an event much more rare than a destructive earthquake, then in my opinion the second way is more realistic.

As experience shows, we must not equate the development of basic research with the tangle of high-priority, all-union scientific programs, with the coordination of work of a multitude of institutes and establishments, with a simple increase in amount of financing, etc. We must not forget that universal laws act upon us too: the number of people employed in science grows more quickly than the square of the number of highly qualified scientists; the difficulties in managing a system grow more quickly than the square of the number of relationships in it. Therefore the level of basic research, the speed with which it can be conducted, and its output is determined not by the number of institutes employed solving problems (they number about 20 in the USSR and republic academies alone), not by the number of workers in them, or the size of their payrolls, etc, but primarily by the level of their instrument and laboratory foundation, by their computer equipment and the working conditions of the leading scientists (right up to their program of administrative and social work).

In this sense the state of basic research on evaluating seismic risk and predicting earthquakes is wholly unsatisfactory. For instance, in the Institute of Earth Physics of the USSR Academy of Sciences, the leader in the country in this field of science, each worker is allocated 2.9 square meters of working space. The specialized design bureau is equipped at the level of the 1950's; far from each laboratory having computers (personal computers, minicomputers), the whole institute doesn't have a powerful computer. We had better not talk about the laboratory base. A similar picture can be drawn for other institutes of this type. Clearly the working conditions of scientists in many respects determines their output, and consequently the rate of solution of the most urgent problems is extremely low.

Thus the necessary condition for progress and effectiveness in basic research is the radical technical rearmament of basic science. As to the chief trends of research in this field, I would select four.

First, development of a single method of seismic risk mapping (including microseismic mapping) that allows seismicproof construction to be raised to a higher scientific level.

Second, creation of new automated methods of processing and interpreting integrated prediction data received from the observation network (not the hopeless old obsolete network, but the future one) and the creation of modern expert systems.

Third, a sharp increase in the volume of work on geologic structure, aimed at the study of deep structure of seismic regions and the peculiarities of tectonic processes in these regions.

Fourth, construction of quantitative physicomathematical models of the evolution of the tectonosphere. First it will be necessary to research the geomechanics of complexly structured fractured and porous media, to study their stress state, etc.

The first three trends are essentially in the spirit of the prevailing paradigm, directed at its improvement. They should lead to a quick practical output, because on the agenda is the creation of new seismic risk maps of the USSR and processing of the material of the observation network. But the third trend is the path to a new paradigm based on the knowledge of the laws which govern the life of the tectonosphere. Without this, foreseeing earthquakes is impossible.

IV

It is impossible not to mention three important problems of a purely psychological sort.

The first of these is the psychological climate surrounding scientists engaged in evaluating seismic risk and earthquake prediction. It is natural to expect that the human character of the problems before them would have united them. In actual fact, there is nothing of the kind. The specialists are fractured into a number of rivalrous groups, busy with endless unconstructive criticism and mutual accusations, and if in public speeches politeness is still somehow observed, in the corridors passions cross all conceivable bounds. Making a more healthy psychological climate among seismologists is one of the foremost problems, the solution of which, it seems to me, is possible only with the use of social pressure.

The second problem is help for science on the part of the industrial ministries. Obviously, the creation of a modern observation network is possible only with their interest and active participation. This relates to serial production of seismological, geophysical, and other equipment, and the organization of information collection and processing, and many other things. One would think that the importance of the problem and its direct connection with the preservation of common human values must guarantee a unanimous and unselfish participation of all industrial ministries and departments in solving the problems that arise. Alas, in reality we run into the primitive desire to get a big order, to push aside competitors, etc. All this severely hurts the cause, and here also is needed the intervention of society.

Finally, the third problem is the moral responsibility of all those writing in different instances and giving advice on earthquake prediction. The difficult task of sorting through all these unthoughtout suggestions lies, in the final analysis, with the small number of highly qualified scientists, who are busy not only with decisions on everyday things, particularly about Armenia, but also

with working out general trends for future work. Everyone who is truly interested in solving the most difficult problem of earthquake prediction would do well to keep this circumstance in mind.

In conclusion I will repeat what are in my opinion the four most important theses.

The state of world science on the topic of seismic risk and earthquake prediction is such that a regular short-term prediction is not possible (it is impractical within the framework of the existing paradigm, especially for us, with an archaic observational base).

The necessary (although insufficient) condition for radical change in the existing state of affairs is the creation of a modern observation network.

The adequate condition for successful prediction must be the broad development of fundamental research, which would be, in essence, inconceivable without a thorough technical reequipping of existing academic institutes.

Progress in the field of earthquake prediction and overall reduction of seismic risk is possible only with a heightened sense of responsibility on the part of seismic specialists and all those who in one way or another provide for the safety of people.

Geochemical Prediction of Earthquakes

907N0058B Moscow PRIRODA in Russian
No 12, Dec 89 pp 60-64

[Article by G. I. Voytov, Doctor of Geological and Mineralogical Science, and Ye. A. Popov, Doctor of Technical Science]

[Text] The tragedy in Armenia again underscored the complex and evidently far from solved problem of predicting earthquakes, that is, determining the location of a future catastrophe, the time of its occurrence, and the strength of its shock. We will not concern ourselves with other aspects of this problem, but here will dwell basically on several geochemical and hydrodynamic effects which precede and accompany earthquakes and which can (and should) become predictive indicators.[1]

For now it must be stated that the observations in seismic regions (including Armenia) on movement and deformation of the crust, variations of magnetic and electric fields, changes in composition of underground water and gases and other so-called precursors of earthquakes (there are considered to be more than 200) have not helped to predict the Spitak earthquake, or, by the way, many others.

However this does not mean that geochemical and hydrodynamic indicators of impending earthquakes cannot be used for prediction. Theoretically this is based on the fact that underground water-gas systems, despite their apparent regional isolation, constitute a unitary whole. Consequently fractures, shears, and faults that arise at the focus prior to an earthquake and in the course of rock transformation are bound to propagate throughout the whole system. Reaching the surface of the earth, they manifest themselves in changes in the chemical composition of water and gases and rate of flow of sources of deep mineralized water.

The first connection between earthquakes and the disruption of deep springs was noted as early as 1912 by the founder of Russian seismology B. B. Golitsyn, who tried to put the problem of earthquake prediction on a systematic basis.[2] He foresaw even then the inevitable gas anomalies and changes in chemical composition of water in springs that are connected with earthquakes. At about this time V. I. Vernadskiy, pondering gas exchange in the earth's crust, formulated the concept of gas plumes, which exist in geodynamically active areas and carry gases from the depths to the surface and into the atmosphere.[3] One of the arguments for this hypothesis is the radioactivity of the near-earth layer of the atmosphere. In seismically active regions (Transcaucasia, Central Asia, and southwest Kazakhstan) it is 10-40 times higher than over the rest of the USSR, despite the soils having about the same content of radioactive elements.

Today, the nature of surface geochemical anomalies associated with processes at depth in seismically active regions is becoming ever clearer. It is known that all geodynamically active zones of the earth are distinguished by a significant tectonic splintering of the crust, high heat flow, the vertical discharge of water and gases in a mixed and time-unstable chemical and isotopic state. This creates the conditions for fluids carrying the chemical and isotopic markers of processes occurring in earthquake focal regions to flow into the underground water-gas systems of higher structural levels of the lithosphere. Moreover the fragmentation (blockiness) of the crustal rocks, especially strongly pronounced in geodynamically active regions, assists the transmitting of fluids along dispersing tectonic structures—faults in the crust—for extremely great distances.

Up till now the single example of successful earthquake prediction by tracking the state of underground water-gas systems has been the Heicheng earthquake of 1975 in China.[4] It was based on peasants' observations over a huge region of water temperature and turbidity, the level of groundwater in wells and boreholes, the behaviour of animals, etc., in conjunction with data from specialists—seismologists and hydrochemists. However this chinese variant, which didn't work in a number of other cases, is hardly acceptable, for example, for our country, where in the majority of high seismic risk regions the population is not so dense. The answer, it seems to us, is in a scientifically based system provided with sensing devices for tracking a predetermined set of geochemical and hydrodynamic parameters (radon content in rock pore space and mineral spring water, geochemical composition of water and gases, groundwater levels, etc).

Examining the data on anomalies from the four largest earthquakes of the last five years gives some hope of success for geochemical prediction. These four are the catastrophes which destroyed the cities of Gazli and Kayrakkum in 1984 and 1985 in Central Asia; a strong earthquake in 1986 with the epicenter in the Vranch mountains in Rumania, and, finally, the Spitak earthquake.

On 19 March 1984 an earthquake with a magnitude of 7.2 (17th energy class) and a focus near Gazli was felt over a large area of the Turan Plate and surrounding territories. The intensity of the earthquake was: at Predkopetdag Basin (550 km from the epicenter) - 5.5; at Tashkent (400 km) - 4; at Bukhara (140-150 km) - 7; at Chardzhoy (175 km) - 7. Naturally, the build-up to so strong a seismic event was accompanied by a restructuring of the underground water-gas systems over a wide region, particularly strong in sensitive zones—zones of active faults. It was recorded by Turkmeni geochemists S. Sh. Sheberdyyev and K. B. Berdyyev, who since 1982 had been making systematic observations on natural gases and water on one of the sections of the Amudarya deep fault, within the Kashabulak tectonic structure.

First, for about 1.5 years before the earthquake the quantity of heavy homologues of methane among the components of hydrocarbon gases began to decline; approaching the time of the earthquake it had become lower than the sensitivity threshold of the measuring device.

Second, hydrogen had been regularly recorded in the composition of gases at the time of earlier earthquakes of energy class 10-14 with epicenter near Gazli. However, from the middle of 1983 the hydrogen progressively decreased as the date of the principle seismic shock grew nearer. It had disappeared by the moment of the earthquake and again appeared in noticeable quantities only after the seismic shock.

Third, in mid-1982 the concentration of helium in the gas composition began to grow. Simultaneously, the argon content of the gases strongly decreased, with the result that the ratio He/Ar rapidly rose, reaching a maximum on the eve of the earthquake of 19 March 1984.

Such changes in the gas composition of underground water-gas systems are evidently associated with the build-up of elastic deformation in the hypocenter zone of the strongest earthquake in Central Asia in recent years, and with the block structure of the crust, which had permitted an increased sensitivity of the observational network built in the Amydarya deep fault zone. This is why the gas geochemical effects were recorded from the relatively weak foreshocks of the Gazli earthquakes, whose epicenters were located 120-130 km from the Kashabulak tectonic structure, not to mention the strongest Gazli earthquake.

Gases from regions of very high temperatures (on the order of 500-600° C), where thermodynamically unstable homologues of methane can no longer exist and the gases are enriched in helium and poor in argon, evidently begin to penetrate into the dispersed structures of the fault in the final stages before a seismic event of this magnitude.

Another effect has been recorded—the long-range effect of the Gazli earthquake. A sensor, recording beta decay of short-lived decay products of argon in the area of the deep Northern Fergana tectonic fault (Leninabad district, 600 km from the epicenter), picked up an anomaly the duration and magnitude of which could indicate that radon at the location of the sensor could only be carried by the flow of other gases from depth, because during normal diffusion such an effect is difficult to explain, considering its half-life—3.825 days. Let us stress that the content of radon in rock pore space (ground atmosphere, by V. I. Vernadskiy's definition) is 10^{-17}-10^{-18} % by volume, which is many orders of magnitude smaller than any other gas.

One more example of long-range effect of the Gazli earthquake is the content of radium in the water of one of the boreholes in the area of the Predkopetdag seismogenic fault, about 500 km from the epicenter. Here at a depth of 1800 m in unusually salty water (mineral content about 45 gm/l), which is apparently drawn along the fault zone from depth, the concentration of radium sharply fell several days before the earthquake, and within two days after it recovered its former values. Such radium content fluctuations were not seen in weakly mineralized water of clearly atmospheric origin from other boreholes. These anomalies could have been used as earthquake precursors, but, regrettably, were not.

But the main shock of the Kayrakkum destructive earthquake on 13 October 1985 (western part of the Fergana valley) had no effect on the "radon field" of the ground atmosphere. This earthquake had an intensity of 9 at the epicenter and wholly destroyed Kayrakkum and buildings of old construction in Gafurov on the western shore of the Kayrakkum Reservoir. It is true that a month before the earthquake geophysicist A. K. Abduvaliyev measured an increased (1.3 times above base) concentration of radon in the ground atmosphere in the same zone of the North Fergana deep fault (Leninabad, 20 km from the epicenter).

On the other hand the clear-cut dips in the graph, radon anomalies in the ground atmosphere resulting from the aftershocks of the Kayrakkum earthquake and associated with the Ura-Tyubin earthquakes of magnitude 4-4.3, were recorded by the same observation station. The earthquakes were preceded by a 4-5 day growth and then a sharp decrease in radon concentrations. In other words, shallow local earthquakes (with focal depths of 10-12 km) were preceded by radon anomalies which could be predictive of earthquakes of magnitude 4-5.

Effects of a similar sort were also typical for deep focus (150-200 km) earthquakes of the Vranch type (magnitude 6.8), which occurred 31 August 1986 in the Vranch

mountains. There was a somewhat weaker than the famous earthquake on 4 March 1977 with the epicenter in the same region, the waves of which were felt even by people in Moscow. The 1986 earthquake was accompanied by various geochemical and hydrodynamic effects, whose scale increased towards the epicenter. Thus, if in "sensitive" surface wells (those wells registering tidal groundwater level fluctuations) in the prediction test fields in the cities of Yessentuki and Kobuleti (1000-1200 km from the epicenter) tidal fluctuations in water level only ceased 6-7 days before a seismic shock, then in Moldavia at the Goteshty station (160 km from the epicenter), located within the influence zone of the Prut deep faults, there was observed a gradual lowering of groundwater level, starting 3-4 months before the shock. At 2-3 days before the shock the levels stabilized, but at 35-38 cm lower than normal. After the earthquake they almost instantaneously returned to normal.

Along with the lowering of groundwater levels, in the influence zone of the Prut deep faults for 3-4 months prior to the 1986 Vranch earthquake the water showed a increase in alkali metal chloride content, an increase in the Ca/Mg ratio; the helium content strongly fluctuated. After the earthquake these parameters of the underground water-gas systems stabilized.

And finally, the Spitak earthquake. Did any geodynamic or geochemical effects precede this catastrophe? One has to be surprised at how, in a district with a relatively high population density, where regular observations on a series of geochemical parameters were being conducted, missing this target proved possible. It is reported that some shepherd in some canyon at two days before the shock saw a violently gushing spring of gas-bearing mineral water, and in the potable water pumphouse on one of the streets in Kirovakan the flow and gas content of the mineral water changed.

As far back as two years before the catastrophe the noted geophysicist G. A. Sobolev warned of the necessity to intensify predictive efforts in specific parts of the Caucasus region, among them the Dzhavakhet highlands in Malyy Kavkaz. A thermal anomaly in the groundwater was noticed at the Institute of Earth Physics' seismic station at Bakuriani on the eve of the earthquake. An analysis of water levels, conducted by G. S. Vartanyan in "sensitive" wells in the observation net of the Geology Administrations of the Georgian and Armenian republics (relatively evenly distributed between both republics), showed that since August 1988 in the area of the future epicenter of the Spitak earthquake water levels had become unstable, attesting to deformational changes in the rock in that area.

After the earthquake the zone of strain deformation attained a length of 400 km in one direction and 150 km in the other. Nine days prior to the event tidal fluctuations in the groundwater ceased in all wells.

A radon sensor at the Institute of Geophysics and Seismology of the Armenian Academy of Sciences in Leninakan picked up an anomaly in the ground atmosphere, discovered 10 days later after the seismic shock by geophysicist V. P. Rudakov. This anomaly resembles the one already mentioned, at Leninabad before the Gazli earthquake of similar energy class. A distinct increase in radon concentration in the ground atmosphere began three months before the Spitak earthquake. Towards the middle of November the radon content stabilized at 30% above base level. The last reading was taken on the morning of December 7, after which the radon was not measured for several days. The measurement on December 15 was close to the base level.

The facts show that the build-up to this earthquake was indeed accompanied by hydrodynamic and geochemical effects in the underground water-gas systems which could be precursors.

Regrettably, the country does not now have multipurpose sensors and processing of recordings is not automated, although attempts have been undertaken to create a fully automatic system with a network of geophysical and geochemical sensors. It was approved for the Leninabad test station of the Institute of Earth Physics in Central Asia and showed its feasibility. There exist neither the universal algorithms for information processing nor the necessary quantity of computer and telecommunications equipment at the prediction center. Then again, at present there is no such center....

Footnotes

1. Voytov, G. I. and Grechukhina, T. G. Geochemical and hydrogeological effects accompanying earthquakes. Priroda, 1980, No 10, pp 90-95.

2. Golitsyn, B. B. Collected works, Vol 2, Seismology, M., 1960, pp 70-72.

3. Vernadskiy, V. I. Izvestiya AN, 1912, T. 6, No 2, pp 141-162.

4. Prediction of the Heicheng earthquake. Eos. Trans. Amer. Geophys. Union, 1977, Vol 58 No 5, pp 236-273.

UDC 504.3/.53.054:539.16:551.551.551.8:621.039.586(477.41)

Evaluating Parameters of Wind Lift of Radionuclides in Zone of Chernobyl Nuclear Power Plant

907N0082A Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 90 (manuscript received 10 May 89) pp 5-10

[Article by Ye. K. Garger, doctor of physical and mathematical sciences, G. P. Zhukov, candidate of physical and mathematical sciences, and Yu. S. Sedunov, professor, Experimental Meteorology Institute, USSR State Committee for Hydrometeorology]

[Abstract] The pollution of the territory adjacent to the Chernobyl nuclear power plant made it a surface source of entry of radioactive aerosols into the atmosphere due to natural wind lift, a process which is one of the principal factors in the migration of radionuclides in the atmosphere. Accordingly, a method has been developed for predicting wind lift, transport and fallout from a polluted area on the basis of physicomathematical models. This is important for formulating practical recommendations on human activity in the polluted and adjacent areas. The wind lift coefficient is computed for three radionuclides. The measurements were made from August 1986 through 1987. It was found that the intensity of wind lift over a field for the isotopes Ce-144, Cs-137 and Nb-95 + Zr-95 is close to 10^{-9} and the wind lift coefficient is about 10^{-8} m^{-1}. For a young pine forest with a mean height of the trees 5-6 m the wind lift intensity for the mentioned isotopes was greater by a factor of 2-9 than for a field. During the mentioned observation period there was no substantial decrease in wind lift intensity and the wind lift coefficient. Figure 1; references: 6 Russian.

UDC 551.511.13:551.583

Characteristics of Static Stability of Atmosphere Accompanying Changes in Global Climatic System

907N0082B Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 90 (manuscript received 30 Nov 88) pp 11-17

[Article by A. A. Arskiy and I. I. Mokhov, candidate of physical and mathematical sciences, Atmospheric Physics Institute]

[Abstract] An analysis was made of changes in the characteristics of atmospheric static stability in the northern hemisphere with both annual variation and year-to-year variability taken into account. The analysis was made using temperature data for 1958-1963 and 1963-1973. The data used were for 11 standard levels in the atmosphere from 1000 to 50 mb. During the period 1958-1973 there were qualitative changes in the global structure of the climatic system and the two periods considered are distinctly different. The first period was characterized by a tendency to general cooling of the atmospheric layer from the surface to 75 mb in the northern hemisphere, whereas the second period was characterized by a regime of temperature variations. A series of maps reveals a large-scale effect of intermittence of horizontal layers with opposite tendencies of change in characteristics of atmospheric static stability. Figures 4; references 11: 7 Russian, 4 Western.

UDC 551.463.5

Theory of Underwater Vision with Arbitrary Radiation Pattern of Radiator or Receiver

907N0012C Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 25 No 9 Sep 89 (Manuscript received 18 May 87; after revision 26 Jul 88), pp 979-987

[Article by Ye. I. Levin, I. M. Levin, Institute of Oceanography, USSR Academy of Sciences]

[Abstract] In the context of underwater vision, studies prior to this one have derived a correlation between the distribution of signal power in an image and the distribution of reflectivity in the plane of the object observed when the radiation patterns of the radiator and receiver are arbitrary. This article studies the transfer of an underwater image for the most general case, when one of the radiation patterns is narrow, while the other is arbitrary. Equations are derived for the calculation of the energy transfer coefficients of a radiator/object observed/receiver system, back-scatter noise, frequency-contrast characteristics, and contrast for underwater observation and observation through a smooth sea surface. The equations can be used to compute the characteristics determining image quality with arbitrary width of "field" radiation pattern when the narrow "element" pattern is aimed at the center of the systems field of vision. Figures 5; References 8 (Russian).

UDC 534.25:551.463.2

Influence of Bottom Rereflections on Sound Pressure Level in Water from Source Located in Air

907N0012D Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 25 No 9 Sep 89 (Manuscript received 29 Apr 88; after revision 3 Feb 89), pp 988-990

[Article by S. T. Zavtrak, A. I. Zaytsev, A. V. Prokurov, Belorussian State University; Scientific Research Institute of Applied Physics Problems]

[Abstract] A study is made of the influence of bottom rereflection on the level of pressure recorded in water from a source of sound pressure located in the air above the water. It is shown that, because of the way sound travels through the air-water interface, the level of pressure of a wave rereflected from the bottom may be considerably greater than the direct-wave pressure if the horizontal displacement of the receiver is greater than the height of the source above the surface of the water, even under unfavorable conditions for reflection of sound from the bottom. Figures 3; References 8: 4 Russian, 4 Western.

UDC 551.463.5

Measurements of Irradiance Attenuation on Narrow Light Beam Axis in Ocean

907N0012F Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 25 No 9 Sep 89 (Manuscript received 20 May 88; after revision 14 Nov 88), pp 996-998

[Article by A. K. Zakharov, Yu. I. Ventskut, S. V. Vashchenko, Institute of Oceanography, USSR Academy of Sciences]

[Abstract] A new method is suggested for measurement of peak irradiance attenuation E_p on the axis of a narrow beam of light in the ocean with hardware described in a previous work ("Optika morya i atmosfery: Tez. dokl.," Leningrad, Izdatelstvo GOI, 1988, pp 251-252). Data are presented from field measurements performed at sea on the 39th cruise of the r/v *Dmitriy Mendeleyev*,and they are compared with Monte Carlo calculations. The method involves a measurement time of several minutes, a period that is longer than the period of roll of the ship, which enables the beam to hit the receiver, yielding a temporary increase in signal amplitude. The measurements are continued until 3-5 values for E_p are obtained that are within 10% of each other. An averaged attenuation value is used for the E_p on the beam axis. The method was used for the first time ever in actual seawater, to study attenuation with depth right on the axis of a narrow light beam from a pulsed, highly directional light source with a pulse length of 15-20 ns. Measurements were performed in transparent, homogeneous waters in the Philippine Sea at depths of 5-250 m. The data obtained were in good agreement with the Monte Carlo computations. Figures 2; References: 4 Russian.

UDC [551.463:532.72].072:504.4.054

Numerical Solution of Problem of Propagation of Passive Impurities in Coastal Zone of Sea

907N0082C Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 90 (manuscript received 19 Dec 88) pp 57-63

[Article by M. A. Nikolskiy, doctor of technical sciences, and A. L. Fedorov and A. I. Dorozhkin, candidates of physical and mathematical sciences, All-Union Planning and Scientific Research Institute for Multisided Electrical Power Engineering]

[Abstract] A solution is found for the two-dimensional equation for turbulent diffusion in a region of arbitrary configuration in the example of mathematical modeling of the propagation of a passive impurity in the coastal zone of the sea. The method employed is essentially that introduced by P. K. Smolarkewicz in J. COMPUT. PHYS., Vol 54, No 2, 1984. The processing was carried out using the MAMO matrix module for a YeS-1055M computer. The latter is a high-speed arithmetical unit, consisting of a set of subprocessors, for performing

element-by- element operations with a large volume of numbers and greatly reduces the processing time. The gradual complication of the computation scheme makes possible a more precise analysis of evolution of a spot of impurity. In contrast to methods used earlier, the proposed full low- viscosity scheme preserves local concentration maxima, but also results in a substantial decrease in blurring of the fronts of pollutant spots. A comparison is made of the usual explicit scheme, an explicit scheme with splitting in physical parameters and the new low-viscosity scheme of increased accuracy and the superiority of the latter is demonstrated. Figure 1; references 14: 9 Russian, 5 Western.

UDC 504.75(26.04)(477.74-25)

State of Marine Ecosystem Under Conditions of Increasing Anthropogenic Pollution in Example of Odessa Bay

907N0082D Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 90 (manuscript received 30 Mar 89) pp 78-85

[Article by Ye. A. Sobchenko and Ye. K. Polezhayev, candidates of geographical sciences, B. F. Bondar, candidate of architecture, and L. A. Vinogradova, candidate of biological sciences, Odessa Division, State Oceanographic Institute; Odessa Civil Engineering Institute]

[Abstract] Data obtained in ecological monitoring carried out in April-September 1988 in Odessa Bay are analyzed. It was found that the assimilation capacity of the ecosystem for these months for readily oxidizable organic matter of anthropogenic and natural origin was considerably increased, which resulted in the formation of a zone of bottom hypoxia and mass death of bottom fauna, as well as bacterial pollution of coastal waters, giving rise to the danger of occurrence of gastrointestinal infections. This situation has evidently prevailed in the bay in summer during recent years. It appears clear that planning organizations voluntarily or involutarily proceed on the basis of the false concept of an unlimited capability of water bodies for self- purification, neglecting their assimilation capacity. This is the principal reason for the uncontrolled and ever-increasing pollution of sea and river basins in the USSR. This dictates a need for computing the assimilation capacity of each specific water body and the organization of ecological monitoring. Figures 3; references 11: 10 Russian, 1 Western.

UDC 551.465

Dynamics of Synoptic Cyclonic Eddy in POLYMODE Test Range

907N0083A Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 1, Jan-Feb 90 (manuscript received 2 Aug 88, after revision 13 Feb 89) pp 3-11

[Article by Yu. M. Grachev and B. V. Kharkov, Oceanology Institute imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] The evolution of a synoptic cyclonic eddy is analyzed using a dynamic baroclinic quasigeostrophic model. The initial field and boundary values which were determined during observations in the POLYMODE test range during the period 24 July-23 August 1978 are used for this purpose. The model satisfactorily reproduces important changes in the horizontal and vertical structure of the eddy field and can be used in predicting synoptic variability for a month in advance. A special feature of the evolution of synoptic currents during this period was the formation of a looplike jet current and changes in synoptic currents associated with it. The looplike current is formed at the levels 100 and 700 m with a time shift of 10-20 days. A cyclonic eddy of small diameter is generated at the 100-m level in the neighborhood of the loop peak. At the 700-m level the interaction of the looplike jet current with a cyclonic eddy in the central region leads to the formation of a single larger eddy formation with cyclonic rotation. A shift in the vertical distribution of the horizontal phase indicates that such synoptic formations probably owe their origin to baroclinic instability. Figures 3; references 14: 11 Russian, 3 Western.

UDC 551.465.432(261)

Vertical Structure of Seasonal Variations of North Atlantic Water Temperature

907N0083B Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 1, Jan-Feb 90 (manuscript received 13 Oct 88) pp 12- 17

[Article by S. G. Boguslavskiy, N. P. Amelchenkova and Yu. P. Krasovskiy, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] The results of research on seasonal variations of the ocean temperature field, constructed using observational data, are given on the basis of a statistical dispersion method. This made it possible to discriminate ocean regions with a predominance of semiannual variations. Estimates of the depth of penetration of the seasonal variation of water temperature are given for different regions of the North Atlantic. At horizons where a predominance of semiannual variations was established there are two distinct maxima falling in the very same months. Closer to the surface the annual variation has only one maximum which is displaced from August to November with an increase in depth. This confirms the widely held hypothesis that the semiannual variations are of advective origin. The described dispersion analysis method makes possible quantitative estimates of the seasonal variability of the water temperature field. Such estimates are not dependent on the possibility of approximation of the annual variation by individual harmonics and therefore are more universal than the estimates based on harmonic analysis. Figures 3; references: 10 Russian.

UDC 551.465:519.24

Evaluating Characteristics of Thermodynamic Structure of Waters of Newfoundland Energy Active Zone on Basis of Results of Four-Dimensional Analysis

907N0083C Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 1, Jan-Feb 90 (manuscript received 7 Dec 88, after revision 20 Feb 89) pp 17-25

[Article by V. V. Knysh, V. A. Moiseyenko and V. V. Chernov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] The results of a four-dimensional analysis of data from 22 hydrological surveys in the Newfoundland Energy Active Zone (NEAZ) carried out during 1982-1986 are given and are used as a basis for a quasigeostrophic dynamic-stochastic model of currents. The features of seasonal and dynamic characteristics of NEAZ waters were clarified. During the period of summer heating there is an increase in heat content of the upper layers of the ocean and an intensification of large-scale circulation. During the time of winter cooling the heat content in these layers decreases and the dynamics of the waters becomes less intensive. In the year-to-year variation of extremal values of heat content and maximal mean volumetric kinetic energy in the layers 0-200 m and 0-500 m there was a tendency in the direction of their decrease in 1982-1986. During this period, for reasons unknown, there was a gradual displacement of the axis of the North Atlantic Current in a southerly direction. The best initial conditions for the T and S fields are asynchronous measurements of these parameters obtained when carrying out a survey and interpolated to the points of intersection of a regular grid. Figures 5; references 6: 5 Russian, 1 Western.

UDC 551.465

Modeling of Upper Quasihomogeneous Layer in Tropical Atlantic

907N0083D Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 1, Jan-Feb 90 (manuscript received 6 Apr 88) pp 38- 47

[Article by E. N. Mikhaylova and N. B. Shapiro, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] A model of a multilayer ocean, including a nonlocal integral model of the UQL (upper quasihomogeneous layer), is examined. Oceanic hydrothermodynamics is described by equations derived by vertical integration of primitive equations within the limits of each layer with a stipulated parametrization of the vertical profiles of temperature, salinity and horizontal current velocity. A method is proposed for computing UQL topography which is used in modeling the formation of hydrothermodynamic fields in the Tropical Atlantic. The three-layer model (UQL, thermocline, abyssal depths) is used in examining the formation of UQL topography from a state of rest, as well as the fields of currents and temperature. In this model it is possible to allow for vertical velocity shear in the UQL, which is particularly important far from the equator. This requires that additional layers be introduced in the UQL for current velocity, applying the equations of motion and continuity equation, integrated within these layers. The thermal conductivity and balance of turbulent energy equations are integrated within the limits of the entire UQL. The method is applicable for large-scale and synoptic variability. Figures 3; references 6: 4 Russian, 2 Western.

UDC 551.46

Observation and Analysis of Solitary Internal Waves in Sea of Okhotsk Coastal Zone

907N0083E Kiev MORSKOY GIDROFIZICHESKIY ZHURNAL in Russian No 1, Jan-Feb 90 (manuscript received 27 Jun 88, after revision 5 Dec 88) pp 54-58

[Article by A. P. Nagovitsyn, Ye. N. Pelinovskiy and Yu. A. Stepanyants, Applied Physics Institute, USSR Academy of Sciences, Gorkiy]

[Abstract] Experimental data are given on solitary internal waves in the coastal zone of the Sea of Okhotsk. The nonlinear and dispersion coefficients of the Korteweg-de Vries equation are determined for slightly nonlinear first mode disturbances. The forms and parameters of solitary waves are compared with the corresponding parameters of solitons. Histograms of the distributions of amplitudes, durations and spatial sizes are constructed for a large number of solitary waves. The results of the study indicate that the observed solitary waves are Korteweg-de Vries solitons of the first mode of internal waves. This conclusion applies to at least 10 of the observed solitary waves. However, the total number of solitons present on the records may be far greater but it is difficult to discriminate them against the general background of internal waves. Further research is required on determining ways to separate solitons from the general field of internal waves, their selection by modes, distribution by amplitudes and calculation of the fraction of energy present in the soliton component of internal pressure. It will then be possible to regionalize zones in oceans and seas during different seasons of the year where solitons are encountered particularly frequently and where they have the maximal amplitudes and steepness. Figures 3; references 5: 3 Russian, 2 Western.

UDC 517.958:532.5

One Abstract Cauchy Problem Arising in Theory of Internal Waves in Presence of Flotation

907N0087A Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 310 No 2, Jan 90 (manuscript received 5 Oct 88) pp 280- 283

[Article by S. A. Gabov [deceased], Moscow State University imeni M. V. Lomonosov]

[Abstract] It was discovered in experimental research on the structure of distribution of water characteristics in

the Black Sea that particles of different materials, whose volumetric density is greater than the density of the upper layer but less than the density of the lower layer, float at the interface between these layers (upper and lower), whose density difference is 20

. This is a manifestation of the "internal flotation" phenomenon, which exerts a quite strong influence on the propagation of internal waves along the interface. The internal flotation phenomenon is modeled, applying the results obtained in two earlier studies by the author (DIFFENTS. URAVNENIYA, Vol 24, No 1, pp 16-21, 1988; ZhVMiMF, Vol 28, No 10, 1988), in order to clarify its influence on internal wave propagation. Two theorems are written for the Cauchy problem which give a solution of the problem as formulated at the end of paragraph 2 in the first of the above-mentioned earlier studies. References 8: 7 Russian, 1 Western.

UDC 534.322:551.463.228

Vector-Phase Structure of Oceanic Noise Field in Sound Channel of New Type

907N0087B Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 310 No 2, Jan 90 (manuscript received 9 Mar 89) pp 458- 460

[Article by V. A. Gordiyenko, B. I. Goncharenko and V. I. Ilichev, academician, Pacific Ocean Oceanological Institute, Far Eastern Department, USSR Academy of Sciences, Vladivostok]

[Abstract] The presence of extended structures of wave guides with closed speed-of-sound isolines, quite stable in space and time (channels of a new type), discovered near frontal zones on the basis of multiyear studies of hydrophysical characteristics, results in the partial capture of lateral acoustic waves so that the fraction of energy from distant sources in the total level of acoustic noise increases. The problem of separating the contributions of individual sources is important in studying the features of noise-formation mechanisms and in developing noise-immune algorithms for the processing of hydroacoustic data. The ratio of the amplitudes of acoustic pressure P, measured at the same point of the medium and averaged in time, to the horizontal V_h and vertical V_z components of oscillatory velocity, can yield much information. Application of this criterion in a study of the vector-phase structure of low-frequency noise fields in the channel of a new type revealed that sources situated in the distant zone play a substantial role in their formation. Figure 2; references: 6 Russian.

UDC 551.465

Nature of Bottom Storm in Equatorial Part of Pacific Ocean

907N0088A Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 310 No 3, Jan 90 (manuscript received 10 Mar 89) pp 706-711

[Article by T. A. Demidova, Ye. A. Kontar and A. V. Sokov, Oceanology Institute imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] A sharp increase in the velocity of bottom currents, a so-called bottom storm, is investigated. A study was made of the relationship between a bottom storm discovered in February-March 1988 and deep currents and processes. The results of synchronous measurements of current velocity at three points in the northeastern equatorial part of the Pacific Ocean were examined together with detailed hydrological and depth measurements made on two cruises. Measurements were made with bottom stations and current meters positioned at different depths; currents were registered at 8 horizons. The observation period lasted 36 days. The studied area was a hill zone between the Clarion and Clipperton faults. The observation period was characterized by two time periods during which currents differed sharply in velocity and direction. The change in current direction was accompanied by bottom storm development. During this time a major anticyclonic eddy was observed in the area and its role, with penetration to the bottom, was evaluated relative to storm development. Figures 4; references 9: 2 Russian, 7 Western.

UDC 551.465

Structure of Bottom Boundary Layer of Ocean in Presence of High- Temperature Hydrothermal Springs

907N0088B Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 310 No 3, Jan 90 (manuscript received 3 Mar 89) pp 712- 715

[Article by A. M. Sagalevich, A. V. Solovyev and N. L. Shashkov, Oceanoloy Institute imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] Although regions with active high-temperature thermal springs occupy but a small part of the bottom area of the ocean they are important in determining geothermal heat exchange with the ocean and also the exchange of chemical elements in local areas where they exist. Although their geological, hydrochemical and biological characteristics have been studied, their hydrophysical aspects have been neglected. Only manned submersibles are effective for such research. Such a study was made from the "Mir-2" submersible during the 15th cruise of the "Akademik Mstislav Keldysh" in the neighborhood of 26°N in the Mid-Atlantic Ridge, where a hydrothermal spring was discovered at a depth of about 3600 m, above which rose a column of black smoke. The submersible surfaced in this column, registering profiles of the vertical distribution of hydrophysical parameters within the convective jet. The influence of this spring could be traced clearly on the T,S curves. The thermal power of the spring was estimated at 90 MW. The convective jet rose to a height of 450 m. Figures 4; references 6: 1 Russian, 5 Western.

UDC 551.464

Mechanism of Formation of Zones of Anomalous Saturation of Oceanic Surface Waters by Atmospheric Gases

907N0089A Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR: GEOLOGICHESKIYE, KHIMICHESKIYE I BIOLOGICHESKIYE NAUKI in Russian No 1, Jan 90 (manuscript received 5 Apr 89) pp 6-9

[Article by A. Kh. Degterev and Ye. M. Filippov, Marine Hydrophysics Institute, Ukrainian Academy of Sciences, Sevastopol]

[Abstract] The advective mechanism of formation of large-scale anomalies of saturation of oceanic waters by atmospheric gases is examined. The effect of this mechanism can be traced most fully within the framework of a numerical model by stipulating the field of surface currents and computing gas exchange between the ocean and atmosphere with allowance for spatial and seasonal variability. This problem was solved for the Atlantic Ocean using a 10° difference grid from 60°S to 70°N with an examination only of the upper quasihomogeneous layer (UQL) with a depth 50 m. Computations were made for nitrogen, oxygen and CO_2. It was found that the advective mechanism leads to the appearance of extensive anomalies and deviations from normal saturation attain +/-10%. The solubility of oxygen in water is twice as great as for nitrogen but the dependence on temperature is close. Accordingly, in a steady regime the patterns of distribution of relative saturation of water by nitrogen and oxygen virtually do not differ. For CO_2, however, due to the Revelle effect the distribution of anomalies is substantially different, their value attaining 30%. Figures 2; references 8: 5 Russian, 3 Western.

UDC 551.521.31

Transmission and Reflection of Light by Homogeneous, Absorbing Aerosol Layer

907N0012A Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 25 No 9 Sep 89 (Manuscript received 8 Jul 88), pp 954-959

[Article by A. S. Ginzburg, I. N. Sokolik, Institute of Atmospheric Physics, USSR Academy of Sciences]

[Abstract] Based on an analysis of the flux of solar radiation by the delta-Eddington method, simple analytic expressions are derived to calculate the transmission and reflection of solar light by a homogeneous layer of absorbing aerosol. The simple exponential approximation of transmission and reflection suggested in this work yields results which are close to calculations by the delta-Eddington method for virtually all types of noncondensation aerosols such as dust and smoke, as well as highly polluted fog. The results diverge at low sun angles. Figures 2; References 16: 6 Russian, 10 Western.

UDC 551.576:551.501.8

Influence of Raindrop Vibration on Polarization Characteristics of Radio Echo

907N0012B Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 25 No 9 Sep 89 (Manuscript received 24 Feb 88; after revision 8 Sep 88), pp 960-968

[Article by A. G. Gorelik, V. V. Sterlyadkin, Moscow Institute of Instrument Building]

[Abstract] Experimental data are used as the basis for analysis of the influence of raindrop vibration on the capabilities of remote sensing of precipitation in the microwave band. The authors note that spectral polarization selection of the signal can be used with selection of the polarization angle to either completely eliminate the influence of vibration or distinguish the contribution made by the vibration and nonsphericity of droplets in the recorded signal. It is concluded that all raindrops experience oscillations, the influence of which on the reflected signal spectrum depends significantly on polarization of the radiation used. The shape of the raindrop-vibration spectrum can be used to determine unambiguously the microstructure of the rain. Microstructure data, plus radar reflection intensity data, can be used to determine the parameters of the *Z-I* ratio (radar reflectivity vs. rainfall intensity) and thus to refine methods of remote determination of rainfall intensity. Figures 3; References 15: 9 Russian, 6 Western.

UDC 551.515.2

Cylindrical Vortices with Horizontal Axis in Equatorial Atmosphere

907N0012E Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 25 No 9 Sep 89 (Manuscript received 6 Sep 88; after revision 17 Jan 89), pp 990-993

[Article by Yu. A. Stepanyants, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] Equations are derived in a study of distributed atmospheric vortices with finite energy, vorticity, velocity field and other geophysical characteristics. Starting with a known system of equations describing the dynamics of the equatorial atmosphere within about 5° of the Equator, the authors obtains results that indicate that the presence of unstable stratification enables the existence of vortices that are stationary in terms of meridional coordinates and whose current fields diminish rapidly with distance from the core of the vortices. Vortex solutions that are constructed are antisymmetric to the plane $z = 0$, which implies restriction to one upper or lower half-plane. The solutions can be easily extended to three or more intervals, in each of which arbitrary constants κ are assigned. Estimates are presented of the dimensions of the vortices for real parameters that characterize the equatorial atmosphere. References 10: 8 Russian, 2 Western.

UDC 621.373

Prospects for Using $Al_2O_3:Ti^{3+}$ Lasers for Atmospheric Research.

907N0013A Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 6 Jan 89) pp 675-698

[Article by G. A. Skripko, Intersector Institute of Continuing Education, Belorussian Polytechnical Institute, Minsk]

[Abstract] In discussing the prospects for the use of solid-state tunable lasers for atmospheric research, the author analyzes the most important features of a new laser medium, $Al_2O_3:Ti^{3+}$, and examines the characteristics of lasers that are based on such crystals. The author draws primarily from research findings at the Belorussian Polytechnical Institute to discuss the most probable directions to be taken in the development of such lasers. Based on the Soviet and Western literature, he asserts that an $Al_2O_3:Ti^{3+}$ laser emitting at wavelengths of 0.65-1.3 μm and supplemented by secondary-harmonic and difference-frequency generators could be used as the base for the creation of a highly efficient source of tunable, coherent radiation in the 0.32—20 μm range, suitable for measuring atmospheric aerosol, for monitoring gases, and for monitoring thermodynamic parameters of the atmosphere. When circumstances dictate expansion of the range toward the shortwave end of the

spectrum—as in studies of atmospheric ozone—a third harmonic of tunable radiation could be effected, shifting the shortwave boundary to 220 nm. Lasers based on $Al_2O_3:Ti^{3+}$ crystals could utilize coherent, lamp or solar light or electron beams for pumping purposes. Figures 10; References 56: 38 Russian, 18 Western.

UDC 551.501+621.396.96

Resonance Scattering of Laser Radiation on Nitrogen and Nitric Oxide Molecules

907N0013B Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 23 Jan 89) pp 699-705

[Article by O. K. Kostko, N. N. Kostko, All-Union State Head Planning-Survey and Scientific Research Institute "Soyuzgiprovodkoz" Moscow]

[Abstract] The first studies of the possibility of using resonance scattering (RS) of laser radiation to determine atmospheric composition were published in the mid-1960s. Although researchers then suggested using RS to determine metastable molecules and ions of nitrogen, nitric oxide, sodium, potassium, calcium, lithium, today's experiments involving determination of the composition of the upper atmosphere are limited to studies of the variation in metal atoms, primarily sodium. Choice of the atmospheric components to be measured with RS is based on four conditions, which the authors here use to study the possibility of determining certain nitrogen components in the upper atmosphere: (1) the concentration of the reradiator and the cross-section of the RS must be such that the backward resonance-scattered signal is greater than the aerosol and molecular scattering; (2) the intensity of nighttime emissions must not exceed the magnitude of the backward resonance-scattered signal at the sensing wavelength; (3) the upper, excited level of transition must have a small half-life; and (4) the laser radiation at the chosen wavelength can be only weakly absorbed by other atmospheric components. The authors examine the Vegard-Kaplan electron transition and electron transitions of the first positive system in determining nitrogen molecule concentrations in the excited and base states. Among the N_2^+ ion transitions, the most perferable turned out to be the transition of the first negative system with fluctuating quantum numbers $\upsilon' = \upsilon'' = 0$. The authors found that a laser sensing equation, tables of the optical characteristics of atmospheric aerosol compiled by Zuyev and Krekov ("Opticheskiye modeli atmosfery," Leningrad, Gidrometeoizdat, 1983), and a model of a standard atmosphere can be used to calculate the minimum concentrations of nitrogen ions that are detectable—$[(N_2^+)_{lim}]$. The possibility of determining the concentration of nitric oxide for altitudes of 100-150 km is also pursued. Figure 1; References 15 (Russian).

UDC 621.373:535.317.1

Experimental Study of Correlation of Space and Specular-Reflected Waves

907N0013C Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 27 Jan 89) pp 710-714

[Article by V. M. Sazonovich, S. M. Slobodyan, B. N. Chen, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk]

[Abstract] The influence of the spatial correlation of space and reflected waves on the variance in optical image shifts is studied experimentally in a simulated thermal convective turbulence. With reflection off a flat mirror, correlation of space and reflected waves quadruples image jitter variance; with reflection off an angular surface, it leads to full compensation for random optical image shifts. Decorrelation of the waves leads to a reduction of image jitter variance (reflection off a flat mirror) and to an increase in variance (reflection off an angular surface) to a magnitude that is the sum of image jitter variances on the source-reflector path and the reflector-receiver path, with the type of specular reflector of little importance. The effect of separation of the axes of space-wave and reflected-wave beams on their correlation to each other was studied experimentally in a randomly inhomogeneous medium. Self-compensation in radiation reflected from a right-angle prism and the fluctuation amplification in reflection from a flat mirror are found to depend on beam axis separation. Figures 3; References 11: 10 Russian, 1 Western.

UDC 535.416:535.31

Numerical Solution of Nonlinear Optics Equation by Fourier-Bessel Transforms

907N0013D Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 4 Oct 88) pp 715-722

[Article by V. L. Derbov. Yu. N. Ponomarev, S. K. Potapova, Saratov State University, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk]

[Abstract] Successful use of an algorithm for a fast Fourier-Bessel transform by Vysloukh and Matveyeva (IZV. VUZOV. RADIOFIZIKA, 1985, Vol 28, No 1, pp 101-106) prompted the authors to create a calculus similar to that advanced by Igumnov *et al.* (Preprint, IN-T. TEORETICH. I PRIKL. MEKHANIKI SO AN SSSR, No 25-83, 1983) with an improved algorithm with radially symmetrical nonlinear wave equations describing the nonlinear propagation of light. The results obtained indicate that cubic nonlinearity has a significant influence on the process of propagation of a Gaussian beam of radiation in an axially symmetrical heterogeneous medium. The results also demonstrate the

possibility of effective utilization of the algorithm developed to model the propagation of light beams in nonlinear heterogeneous media, particularly in problems of laser probing of the atmosphere and atmospheric optics. Figures 5; References 7: 5 Russian, 2 Western.

UDC 535.212

Acoustic Measurement of Energy Distribution in Laser Beam Cross Section

907N0013E Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 5 Apr 89) pp 723-727

[Article by V. V. Vorobyev, M. Ye. Grachova, A. S. Gurvich, V. S. Myakinin, Institute of Atmospheric Physics, USSR Academy of Sciences, Moscow]

[Abstract] Results are presented from a model experiment illustrating the possibility of determining the distribution of energy in light beams by acoustic measurement. The researchers studied the change over time in the pressure in a medium exposed to short laser pulses with a duration τ that was less than the characteristic time of pressure change in an acoustic pulse $\tau_{ac} = l/u$, where l represents the minimal spatial dimensions of light intensity inhomogeneities and u is the speed of sound, with relaxation time τ_{rel} of the light energy absorbed into thermal smaller than τ_{ac}. Distributions measured by the acoustic method are compared with distributions measured photometrically, and there is good agreement of the energy distribution profiles produced by the two methods. The method does not require introduction of measuring elements in the propagation channel, and it permits monitoring of the parameters of radiation in real time. Figures 4; References 3 (Russian).

UDC 551.510.42

Inverse Problem Method in Polarization Soundings of Dispersed Media

907N0013F Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 9 Feb 89) pp 728-736

[Article by I. E. Naats, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk]

[Abstract] This work continues development of the theory of polarization soundings of dispersed media, particularly the extension of the operator approach not only to the joint inversion of the elements of a Muller matrix, but also to their determination in an experiment with sparse data. The author elaborates a method of interpretation that enables the development of practical procedures for studying actual aerosol systems of natural or anthropogenic origin with surface and airborne nephelometers and bistatic lidars. The method is applicable to optical monitoring of aerosol atmospheric pollution. The information capabilities of the approach are illustrated by solving a complex problem of atmospheric optics involving separation of molecular and aerosol scattering matrices on the basis of polarization measurements. References 11: 9 Russian, 2 Western.

UDC 551.591.593

Optical Manifestations of Noncondensation Aerosol Clouds

907N0013G Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 22 Nov 88) pp 737-743

[Article by Ye. Zuyev, V. D. Belan, V. V. Veretennikov, G. D. Zadde, M. V. Panchenko, R. F. Rakhimov, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk]

[Abstract] Noncondensation clouds are localized regions that appear in a clear, dry atmosphere above altitudes of 1 km and have aerosol concentrations 4-60 times greater than that of the surrounding air. They have a relatively high concentration of dust particles 1-4 μm in diameter. Although noncondensation clouds are relatively rare, they are of interest for two reasons. First, regions whose optical characteristics differ from those of the surrounding air can have a great effect on the operation of optical instruments and on the interpretation of the data of optical observations. Second, the nature of the function of particle-size distribution makes the optical characteristics of noncondensation clouds quite different from those used to model atmospheric haze. The authors estimated the optical properties of aerosol noncondensation clouds by examining the results of calculations performed on the assumption of particle sphericity and isotropicity; they used data of microstructure measurements made with a photoelectric counter in the radius range of 0.2-5 μm. They use experimental data on the microstructure and chemical composition of these clouds to compute spectral extinction coefficients constants and lidar ratio. The data indicate that these clouds can be easily detected and identified by multifrequency laser soundings (the most effective being in the near IR area of the spectrum. Figures 4; References 7 (Russian).

UDC 551.521

Optimal Experiment Planning in Upper Atmosphere Sounding Experiments in 15 m Band of CO_2. Temperature, Kinetics, Composition.

907N0013H Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 pp 744-749

[Article by A. I. Demyanikov]

[Abstract] A method is presented for remote determination of temperature distribution $T(z)$ in the region in which the local thermodynamic equilibrium is disrupted. The method does not require *a priori* knowledge of the vertical profile of the probability of survival of quanta in scattering, $\Lambda(z)$, or of CO_2 ratio, q_{CO_2}, and is based on strict solution of the problem of optimal

selection of three spectral channels to provide information on $\Lambda(z)$ and q_{CO_2}, as well as on $T(z)$, when experimental data are processed. The author presents a two-channel version that is said to be superior to an earlier version he proposed for solving the problem of joint retrieval of $T(z)$ and $\Lambda(z)$ when qCO_2 is known. He demonstrates that today's cooled radiation detectors can be used to determine the temperature of the atmosphere at altitudes of up to 100 km, with an accuracy of 1 K. Figures 2; References 13: 8 Russian, 5 Western.

UDC 543.422.4.551.510.522

Laser Device for Measuring Extinction Coefficients at $\lambda = 10.6$ μm

907N0013I Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 30 Jan 89) pp 758-763

[Article by Yu. A, Ivankin, A. P. Cherepanov, R. Sh. Tsyvk, I. Ya. Shapiro, Yr. F. Yatskeyev, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk: "Optika" Special Scientific Instrument Design Bureau, Siberian Division USSR Academy of Sciences, Tomsk]

[Abstract] An attempt is made to summarize the experience accumulated by the authors in the development and testing of a laser device for measuring the extinction coefficient of atmospheric radiation at $\lambda = 10.6$ μm. The authors demonstrated the necessity of complete capture of the radiation flux to decrease the influence on measurement accuracy of flux axis wandering, energy redistribution over the cross section, and flux expansion in a turbulent atmosphere. The results obtained indicate the device, operating over a path of 500 m, can measure the attenuation factor at 10.6 μm within the 0.06-4.00 km^{-1} band with a relative rms error of not over 6%. Figures 2; References 10: 9 Russian, 1 Western.

UDC 551.521:551.576

Numerical Study of Aerosol Extinction of Radiation at $\lambda = 10.6$ μm with Stratus Clouds

907N0013J Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 25 Nov 88) pp 764-768

[Article by V. V. Antonovich, G. O. Zadde, A. V. Podanev, Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk]

[Abstract] A study is made of the dynamics of the aerosol extinction factor of CO_2-laser radiation at $\lambda = 10.6$ μm in a developing cloud layer. The studies were based on a simple hydrodynamic model of the evolution of cloud fields and temperature fields in a moving cyclone, supplemented by assumptions concerning the size distribution of droplets. Variables in the model consisted of turbulence coefficient (k), maximum convective velocity (ψ_m), time constant in hours (t_k), and convective cloud-layer height (H). Calculations were performed for two sets of initial parameters. The first set, borrowed from Bykova and colleagues ("Oblaka i klimat" [Clouds and Climate], Leningrad, Gidrometeoizdat, 1986) modeled the development of dense cloud cover with $H = 11$ km, $k = 5$ m^2/s, $\psi_m = 0.025$ m/s, $f_1 = 0.7$, $r_2 = 0.9$, and $t_k = 24$ hours. The second set consisted of low, mean statistical *St-Sc* clouds with $H = 1.9$ km, $k = 0.9$ m^2/s, $\psi_m = 0.01$ m/s, $f_1 = 0.75$, $r_2 = 0.9$. Figures 3; References 7 (Russian).

UDC 621.373

Laser Emission on $Al_2O_3:Ti^{3+}$ Crystals Excited by Electron Beams

907N0013K Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 7, Jul 89 (Manuscript received 29 Apr 89) pp 769-771

[Article by G. A. Skripko, S. G. Bartoshevich, V. V. Zuyev, A. N. Maltzev, Intersector Institute of Continuing Education, Belorussian Polytechnical Institute, Minsk; Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences, Tomsk]

[Abstract] Previous studies of the generating characteristics of tunable $Al_2O_3:Ti^{3+}$ lasers have centered on optical pumping. The authors here present results from studies of the possibility of creating a tunable $Al_2O_3:Ti^{3+}$ laser pumped by beams of fast electrons. Studies were performed on an installation using a 109 keV electron gun with a beam current density of about 10 A/cm^2, pulse length 50 ns, pulse repetition frequency up to 5 Hz. A second installation was used to study the possibility of achieving generation in an external resonator, using a 600 keV electron gun with current density 150-500 A/cm^2, pulse length at half-height level 25 ns. The possibility is demonstrated of producing stimulated radiation in the red and near-IR region with electron excitation. Total energy efficiency is 4-8%. Figures 2; References 6: 5 Russian, 1 Western.

UDC 551.593.5:510.67

Evaluating Cloud and Post-Volcanic Effects in Computing Characteristics of Field of UV and Visible Radiation in Radiative- Convective and Photochemical Atmospheric Models

907N0077A Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 12, Dec 89 (manuscript received 17 Aug 89) pp 1248-1254

[Article by V. L. Dvortsov and S. G. Zvenigorodskiy, Leningrad Hydrometeorological Institute]

[Abstract] A study was made of the possibility of making allowance for cloud and post-volcanic radiation effects within the framework of two-flux methods for computing the fields of ultraviolet and visible solar radiation in the atmosphere used in radiative-convective and

photochemical models of the atmosphere. A parametrization of the cloud layer is proposed whose principal merits are simplicity and universality, making it possible to compute photodissociation fluxes and constants using any two-flux method for a given optical thickness or cloud albedo. Use of this approach revealed that a sharp increase in the concentration of sulfur dioxide at stratospheric altitudes during the post-volcanic period may result in a substantial reduction of the rates of photolysis of gases optically active at wavelengths less than 300 nm in the zone of localization of a volcanic cloud, but a rapid relaxation of the effect occurs below this layer. It was possible to estimate the changes in the fluxes of solar radiation and photodissociation constants in the presence of cloud cover for different solar zenith angles and also different albedos of a cloud and the underlying surface. The effect of cloud cover on the fluxes of solar radiation is different for the UV and visible spectral ranges. Figures 5; references 12: 1 Russian, 11 Western.

UDC 531:719.24.08

Integral Theorems of Optical Refraction in Three-Dimensionally Inhomogeneous Atmosphere and Their Geodetic Applications

907N0077B Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 12, Dec 89 (manuscript received 12 Jul 89) pp 1260-1264 pp 1260-1264

[Article by A. V. Prokopov, Ye. V. Remayev and A. V. Brazhnichenko, Metrologiya Scientific Production Association, Kharkov]

[Abstract] In earlier studies by A. V. Prokopov (PISMA VZhTF, Vol 11, No 24, pp 1526, 1985; Vol 14, No 2, p 107, 1988) a new approach was proposed for computing atmospheric corrections to the results of optical measurements. This method does not require use of a true or model atmospheric profile and does not require finding of the explicit form of the ray trajectories. In this method ordinary differential ray equations are replaced by equivalent integral relations for some parameters averaged along the rays. These parameters are selected in such a way that they can be represented through experimentally determined values. This approach is used now in new formulations of the laws of refraction of rays in the approximation of geometrical optics in a three-dimensionally inhomogeneous atmosphere and new modified methods for determining atmospheric corrections to range are defined. Figure 1; references: 11 Russian.

UDC 551.594.22

Numerical Simulation of Formation of Ozone and Nitrogen Oxides Accompanying Pulsed Microwave Discharge in Air

907N0077C Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 12, Dec 89 (manuscript received 25 May 89) pp 1273-1279

[Article by V. F. Larin and S. A. Rumyantsev, Polar Geophysical Institute, Kola Scientific Center, USSR Academy of Sciences]

[Abstract] A theoretical study was made of the plasma-chemical evolution of the products of a microwave discharge in the atmosphere at altitudes 30-60 km. It is shown that an intensive dissociation of molecules occurs in the discharge. The frequencies of formation of oxygen and nitrogen atoms are determined. With the temperatures prevailing in the atmosphere at altitudes 30-60 km the atomic oxygen which is the product of a microwave discharge is completely converted to ozone. This is accompanied by the formation of nitrogen oxides. An increase in gas temperature during the absorption of disturbing radiation decreases the efficiency of ozone formation and favors an increase in the concentration of nitrogen oxides. The total annihilation of ozone is possible with an increase in temperature to about 500 K. The results of this research can be used in estimating the ecological effects of the creation of an artificially ionized region in the atmosphere by strong radio radiation. Figures 3; references 16: 11 Russian, 5 Western.

UDC 535.416:535.31

Numerical Simulation of Nonlinear Resonance Spectra in Aperture- Limited Light Beams

907N0077D Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 12, Dec 89 (manuscript received 8 Aug 89) pp 1280-1285

[Article by V. L. Derbov, A. D. Novikov, Yu. N. Ponomarev and S. K. Potapov, Saratov State University; Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] A previously described computation scheme (V. L. Derbov, et al., OPTIKA ATMOSFERY, Vol 2, No 7, pp 715-722, 1989) makes it possible to analyze the behavior of a spatially limited light beam with axial symmetry, in a nonlinear atmospheric channel with absorption experiencing saturation with an increase in beam intensity. Proceeding on this basis, the dependence of the energy losses of a spatially limited beam on frequency is analyzed under strong saturation conditions. The results are in good agreement with experimental data and give a detailed picture of beam evolution in a resonantly absorbing medium. It is shown, for example, that the asymmetry of spectral lines, due to the self-effect, can exert a substantial influence on the results of spectral measurements in the case of high beam intensities. The shift of the absorption line increases considerably with an increase in thickness of the absorbing layer. The size of the radiation detector is of great importance because the total power spectrum is completely dissimilar to the power spectrum of the narrow axial part of the beam. (The latter is especially sensitive to self-effect phenomena.) Its spectrum may be unrecognizably modified by a simple increase in thickness of the absorbing layer. These considerations make it necessary to give close attention to self-effect phenomena in the spectroscopy of saturated absorption, especially in non-Doppler spectroscopy, as well as in the sounding of extended gas media by strong light beams. Figures 8; references 11: 6 Russian, 5 Western.

UDC 538.576.452.1

Influence of Rotational Induced Raman Scattering on Angular Spectrum of Laser Radiation in Atmosphere

907N0077E Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 12, Dec 89 (manuscript received 5 Sep 89) pp 1291-1294

[Article by K. K. Konstantinov, A. N. Starodumov and S. A. Shlenov, General Physics Institute, USSR Academy of Sciences, Moscow]

[Abstract] The distinguishing features of Raman scattering at rotational sublevels in wide-aperture beams in the air are related to a low rotational frequency shift, weak dispersion of the medium, and as a result, great interaction lengths, but such conditions cannot be simulated in laboratory experiments. A study was therefore made of the principal laws governing this phenomenon, including the influence of four-photon parametric processes on the angular spectrum of radiation. The results of numerical computations of the beam profile are given. It is shown that parametric processes can result in a strong change in the angular spectrum of radiation by an order of magnitude and may distort the beam profile during Raman scattering at rotational sublevels in the atmosphere. These processes substantially limit the possibilities of effective directed energy transfer for great distances. Figures 4; references 4: 2 Russian, 2 Western.

UDC 535.34.08

Nonlinear Changes in Air Refractive Index During Ozone Photodissociation and Their Influence on Angular Spectrum of Radiation

907N0077F Tomsk OPTIKA ATMOSFERY in Russian Vol 2 No 12, Dec 89 (manuscript received 5 Sep 89) pp 1295-1298

[Article by A. N. Starodumov and A. V. Shipulin, General Physics Institute, USSR Academy of Sciences, Moscow]

[Abstract] The influence of change in chemical composition of the medium and heat release during the dissociation of ozone on the refractive index, and as a result, the appearance of nonlinear beam refraction, is analyzed. The principal processes transpiring in atmospheric ozone under the influence of radiation in the near-UV and visible ranges are examined in detail. The results of numerical experiments for computing distortions of the beam profile are given, demonstrating the important role of concentration and thermal nonlinearities in the change of the angular spectrum of radiation during passage through the ozone layer. New mechanisms of nonlinear refraction of laser beams in the atmosphere which lead to a substantial change in the angular spectrum of radiation are theoretically predicted: the heating of air results in a change in gas density and accordingly a change in the refractive index and the refractive index changes nonlinearly due to the different polarizabilities of ozone molecules and the products of its dissociation. Figures 2; Figures 6: 4 Russian, 2 Western.

UDC 551.521:551.521.3

Engineering Method for Scaling Atmospheric Transparency Coefficient From One Atmospheric Mass to Another

907N0082E Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 90 (manuscript received 30 Jan 89) pp 103- 106

[Article by Kh. Yu. Myurk [deceased] and Kh. A. Okhvril, candidates of physical and mathematical sciences, Tartu State University]

[Abstract] A reduction formula is proposed for computing the coefficient of integral atmospheric transparency from the intensity of direct solar radiation in order to exclude the Forbes effect to a solar altitude h = 30°. In many situations it can replace the Forbes method, the tables computed by Yevnevich and Sivkov and the nomograms proposed by Myurk (all these methods are time-consuming and the possibilities of their computerization are limited, especially at a meteorological station or on an expedition). The use of tables and manual work is eliminated and all computations can be made with a pocket calculator. The formula coincides with the usually used tables with an accuracy to 2% for transparencies from "very low" to "ideal." The maximal error is observed for cases of normal transition from a solar altitude h = 30° to h = 80°. References: 5 Russian.

UDC 528.87:551.24

Possibility of Tectonofacies Interpretation of Space Survey Materials

907N0092A Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA GEOLOGICHESKAYA in Russian No 1, Jan-Feb 90 pp 41-49

[Article by A. P. Lopatin, A. F. Demenyuk and A. D. Ivzhenko, Branch of Priroda State Center, Krasnoyarsk]

[Abstract] Tectonofacies analysis is one of the newest branches of structural geology, making possible an approximate quantitative evaluation of the degree of deformation of rocks and thermodynamic levels of the dislocation process and a determination of the real width of different fault dislocations. For the first time a study was made of the possibility of using space information in tectonofacies research. The principles for discriminating tectonic formations and defining interpretation keys for exposed regions and those buried beneath sediments are discussed. Examples of tectonofacies interpretation of sectors of epi-, meso- and katazonal regions are given in the example of folded structures along the Yenisey, in the Eastern and Western Sayan, in the Mongolian Altay and on the Iranian Plateau. It is shown that interpretation of space surveys should be a mandatory component among the other types of methods

for tectonofacies research because it favors an acceleration of work and reduction in work input, increases the objectivity and detail of tectonofacies mapping and yields new structural information presently lacking on geological maps. Figures 3; references: 12 Russian.

UDC 551.525.3:535.36

Dependence of Contribution of Multiple Scattering to Lidar Signals on Integral Parameters of Particle-Size Distribution in Cloudy Atmosphere

907N0095A Tomsk OPTIKA ATMOSFERY in Russian Vol 3 No 1, Jan 90 (manuscript received 21 Apr 89) pp 5-11

[Article by V. A. Korshunov, Tayfun Scientific Production Association, Obninsk]

[Abstract] The contribution of multiple scattering to lidar signals from a cloudy medium is computed for different types of particle-size distributions encountered in clouds. The computations were made using a method based on a small-angle approximation for different model spectra close to the real spectra observed in stratiform clouds. It is shown that with some reception angles, regardless of the type of distribution, the contribution of multiple scattering is determined by one of the integral particle-size distribution parameters. With adequately large reception angles the contribution of multiple scattering is slightly dependent on the type of spectrum and particle size. The possibilities of use of these effects in solving inverse problems in laser sounding of a cloudy medium are discussed. Use of reception angles for which the contribution of multiple scattering is maximal makes it possible to sound cloud cover to extremely great optical depths. The problem of spatial resolution is very important because it gradually deteriorates due to the spreading out of a light packet propagating in the medium. Estimates made on the basis of computations by the Monte Carlo method show that prior to onset of an asymptotic regime of radiation propagation the spatial resolution is at an acceptable level. Figures 3; references 12: 11 Russian, 1 Western.

UDC 551.501:551.510.8

Very Simple Interpretation Scheme for Data From Polarization Lidar Sounding of Crystalline Clouds

907N0095B Tomsk OPTIKA ATMOSFERY in Russian Vol 3 No 1, Jan 90 (manuscript received 16 May 89) pp 44-50

[Article by A. A. Popov and O. V. Shefer, Mariy Polytechnic Institute imeni Gorkiy, Yushkar-Ola; Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] A theoretical study was made of the backscattering coefficients of a polarization lidar used in sounding the optical properties of a polydisperse medium. As the latter use was made of a set of oriented circular plates having a complex refractive index. As a result, within the framework of this model the ratios of the backscattering coefficients could be related by simple analytical relations between the Euler angles determining the orientation of the plates and their complex refractive indices. It is shown that by using a single-frequency lidar, without invoking additional information, it is possible to ascertain the orientation and refractive index of platy crystals. It would make sense to use a multifrequency lidar only in those cases when the refractive index and orientation of the particles are known from other measurements. However, the simultaneous use of both types of lidars would make it possible to obtain full information concerning a system of aspherical particles. Figures 3; references 5: 4 Russian, 1 Western.

UDC 621.378.325

Analysis of Some Algorithms for Minimizing Angular Divergence of Partially Coherent Optical Radiation

907N0095C Tomsk OPTIKA ATMOSFERY in Russian Vol 3 No 1, Jan 90 (manuscript received 26 Jun 89) pp 83-89

[Article by V. V. Kolosov and S. I. Sysoyev, Atmospheric Optics Institute, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] During propagation of powerful laser radiation in the atmosphere various nonlinear effects arise which distort the spatial- temporal characteristics of the radiation. An effort is made to obtain the minimal angular divergence in the distant zone of diffraction after beam passage through a thin layer of a nonlinear medium of a given effective thickness. It is assumed that angular divergence attains its minimum when intensity at the reception point is maximal. The conditions for attaining maximal intensity on a target are formulated under conditions of "fast" control of the amplitude-phase beam profile in the radiation plane. Numerical schemes of adaptive and programmed phase control are examined in an aberration-free approximation for a medium with a wind type of nonlinearity. Analysis of the results made it possible to discriminate regions where phase correction is extremely effective and regions where such correction yields only an insignificant gain. Figures 3; references 9: 8 Russian, 1 Western.

UDC 551.521.3:535.36

Pulse Response of Cloudy Atmosphere in Spherical Geometry of Earth With Large Zenith Angles and Optical Depth of Path 1-100

907N0095D Tomsk OPTIKA ATMOSFERY in Russian Vol 3 No 1, Jan 90 (manuscript received 26 Jul 89) pp 90-96

[Article by O. I. Aldoshina, M. N. Gorskov and A. N. Rublev, All- Union Optophysical Measurements Scientific Research Institute, Moscow]

[Abstract] The Monte Carlo method was used in developing a method and program for computing responses of a multilayer spherical cloudy atmosphere to a δ-pulse from a point isotropic radiation source situated beneath the clouds. The following scheme is examined: the atmosphere contains stratiform continuous cloud cover with an optical depth varying from 1 to 100 units; the reflecting properties of the Earth's surface are characterized by the integral reflection coefficient and the Lambert differential law; the reference wavelength of the radiation is selected at the transition between the UV and visible spectral ranges; the radiation source is situated beneath the cloud layer and the receiver is above the cloud layer; the zenith angles of sighting from the epicentral point to the receivers vary in the range from 0 to 85°. In this formulation the pulse responses were determined on both vertical and slant paths. The method and program make it possible to reduce dispersion by a factor as great as 1.3-1.7 and computation time by a factor as great as 3-5. It is thereby possible to construct a qualitative picture of formation of the optical radiation field, which is nonstationary in time. Figures 4; references 15: 10 Russian, 5 Western.

UDC 63:528.88

Estimating Grain Yield of Buckwheat Using Remote Measurement Data

907N0099A Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 310 No 4, Feb 90 (manuscript received 1 Feb 89) pp 829- 833

[Article by P. P. Fedchenko and T. V. Khomyakova]

[Abstract] It has been possible to study biomass, density, leaf cover and other parameters of buckwheat by remote methods only during early development phases because later the soil surface is obscured by the plants. The best possibility for predicting the yield of this crop is a remote study of the planted area occupied by blossoms. This possibility is illustrated by the spectral curves of reflection of blossoms and the leaf-stem system of buckwheat. The spectral curves for blossoms and the leaf + stem system are quite different. The curves for the blossoms have a form close to neutral whereas those for the leaves and stems have a highly selective form with characteristic maxima and minima in the blue, green and red spectral regions, making it possible to discriminate the areas occupied by flowers against the background of leaves and stems. The statistical procedures and algorithm used for this purpose are outlined. The method was tested in 22 sectors with different projective cover of flowers. This revealed that spectrophotometric measurements can be effectively employed in predicting buckwheat yield. Figure 1; references: 5 Russian.

UDC 551.465

Formation and Evolution of Intrathermocline Lenses of Mediterranean Origin

907N0099B Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 310 No 4, Feb 90 (manuscript received 28 Mar 89) pp 980-983

[Article by Yu. A. Ivanov, Yu. G. Mikhaylichenko, S. V. Nikitin, Ye. A. Plakhin, I. S. Podymov and B. N. Filyushkin, Oceanology Institute imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] New information has been collected on the genesis, evolution and characteristics of intrathermocline eddies showing that the nucleus of an anticyclonic lens begins to form against the background of a mushroom-shaped structure. Two hydrophysical surveys were made by the "Vityaz" research ship off the Moroccan coast during the period June-September 1988 for the detection and study of such intrathermocline eddies. The first survey revealed two eddy lenses separated by a distance of 70 km. The nuclei of the lenses with maximal anomalies of characteristics were situated at a depth 1100-1200 m. The lenses had the configuration of ellipsoids of revolution whose axes measured 400 and 45 000 m. By a second survey, 15 days later, it was possible to determine the mean velocity and direction of movement of the nucleus of one of these lenses. Two different periods in evolution of these formations were observed. In the first stage there was an increase in the absolute values of anomalies of characteristics with a decrease in the maximal temperature and salinity values in their nuclei. In the second stage there was a continuing decrease in maximal temperature and salinity but the anomalies no longer increased, eventually leading to their destruction. Figures 2; references 8: 5 Russian, 3 Western.

UDC 551.510.534

Modern Data on Change in Ozone Layer Under Influence of Anthropogenic Factors and Development of Substitutes for Chlorofluorocarbons and Halons

907N0082F Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 1, Jan 90 (manuscript received 19 Apr 89) pp 116- 120

[Article by V. M. Zakharov, professor, and A. A. Chernikov, Central Aerological Observatory, USSR State Committee for Hydrometeorology]

[Abstract] This is a review of reports and communications presented at a conference on evaluation of the present status of knowledge concerning the ozone layer and a seminar on substitutes for chlorofluorocarbons and halons carried out under the auspices of the UN at The Hague during the period 17-21 October 1988. The reports made clear that the predictions of future changes in the ozonosphere on whose basis measures have been developed for restricting the discharge of chlorofluorocarbons and halons still include considerable uncertainties which can be removed only by purposeful theoretical, laboratory and field research. Many problems remain to be solved. Clarification of the reasons for anomalous ozone changes in Antarctica and the Arctic requires an analysis of experimental data for determining correlations between changes in the ozone field and different characteristics of atmospheric dynamics, an examination of new ideas and hypotheses which will make it possible to understand the entire range of observed changes associated with anomalous year-to-year variations of the ozone layer, inclusion of these hypotheses in a model of the ozonosphere for an adequate representation of atmospheric physical processes and additional study of sources and sinks of trace gas components. However, definite progress has been made in developing substitutes for chlorofluorocarbons and halons but many of these have not undergone the entire testing cycle which would make possible their safe use.

UDC 551.588.9

Climatic Effects of the Discharge of Smoke Into the Stratosphere

907N0012G Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 25 No 9 Sep 89 (Manuscript received 30 May 88), pp 998-1000

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[Abstract] Three months after a large-scale nuclear conflict, aerosol pollution of the stratosphere would be the primary source of the so-called nuclear winter. Many researchers have surmised that the aerosol would consist mainly of basalt-laden dust. According to others, however, the climatic effects and the disruption of the radiation balance would be due less to dust than to smoke carried up to the stratosphere by convective flows over burning cities or by flows originating in the troposphere. The vast differences between the optical characteristics of smoke particulate and those of dust particulate prompted the authors here to study the effects a discharge of smoke into the stratosphere would have on ground surface temperature. Calculations are based on a nonstationary seasonal energy balance model in which the mean surface temperature is computed for nine large zones encompassing the entire earth, as well as on generalized models. It is assumed that a large-scale nuclear conflict discharges 11 megatons of a smoke aerosol consisting of soot particles into the stratosphere. In all latitude zones the smoke aerosol in the stratosphere results in an increase in temperature, with a maximum of a 2.8°C temperature rise occurring in the Arctic zone in July. Figure 1; References 12: 7 Russian, 5 Western.

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