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SOVIET CLIMATOLOGY

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This report surveys Soviet developments in climatology and climate modification during the period from mid=1972 through November 1973. The selections were chosen primarily from regular Soviet scientific journals; several popular science sources were also surveyed. The abstracts are roughly classified into five general categories; (1) recent climate trends, (2) paleoclimatology, (3) meterology, (4) climatology of Eurasia and (5) climate modification.

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SOVIET DEVELOPMENTS IN CLIMATOLOGY

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INTRODUCTION

This report surveys Soviet developments in climatology and climate modification during the period from mid 1972 through November 1973. The selections were chosen primarily from regular Soviet scientific journals; several popular science sources were also surveyed.

The abstracts are roughly classified into five general categories:

I. Recent Climate Trends
II. Paleoclimatology
III. Meteorology
IV. The Climatology of Eurasia
V. Climate Modification

M. I. Budyko's prominence in the climate research field is reflected by his three wide-ranging papers in the opening section on Recent Climate Trends. In particular he examines man's increasing impact on global climate and the critical problem of climatic stability. Due to the large number of papers exploring solar-climatic cycles, a sub-section on this subject was introduced.

Section IV, The Climatology of Eurasia, is comprised of studies on the longstanding climatic problems of Siberia and Central Asia: drought patterns, the continental thermal regime and precipitation distribution, and the present state of glaciation in Central Asia.

Section V, Climate Modification, describes significant climatic transformations which have either been initiated or are considered to be in the realm of technical possibility by the Soviet author: foremost is a recent, highly favored draft of the comprehensive plan for the diversion of surplus North Siberian river water to the arid south. The two concluding abstracts include speculations on methods of moderating the lunar climate for man's purposes.

TABLE OF CONTENTS

I. Recent Climate Trends

Berlyand, M. Ye., M. I. Budyko, and K. Ya. Kondrat'yev. Urban climate and the problem of global climate modification. Meteorologiya i gidrologiya, no. 1, 1973, 3-14.

The global climatic effects of thermal, gas and aerosol pollution of the atmosphere are discussed with liberal reference to Western as well as Soviet research.

Thermal pollution is still chiefly a local phenomenon. However, if the present rate of energy development continues, "within 100 years the thermal pollution level could be comparable to the influx of heat from the Sun". Concerning gas pollution, the article reviews the literature (chiefly U. S. and Soviet sources) on the increasing concentration of CO_2 in the atmosphere and cites the projections of Manabe and Wetherald (J. Atmospher. Sc., no. 3, 1967) on a possible 0.5-0.8° C temperature increase by 2000 A.D. (if CO_2 concentration increases 20% as calculated) and the work of Rasool and Schneider on the CO_2 "saturation effect" (Science, v. 173, 1971). Further research is necessary, in particular more sophisticated quantitative assessments of the climatic effects of variations in the atmospheric CO_2 concentration.

The bulk of the paper is devoted to aerosol pollution, its nature and the special problems arising from the increasing rate of industrial aerosol pollution. The authors emphasize the need to obtain further data on the optical properties of aerosols, aerosol microstructure, and the vertical profiles of aerosol concentrations. In particular they call for the development of a generally accepted, uniform quantitative system for more accurately assessing the role of aerosols in the absorption and emission of atmospheric radiation. The paper of one of the authors, K. Ya. Kondratyev, "Spectral Radiative Flux Divergence in the Troposphere" (in Perenos izlucheniya v atmosphere, Leningrad, 1972) is cited as offering the first experimental data on the true absorption of short wave radiation by aerosols.

Acknowledging the importance of W. J. Humphreys' work on the relationship between atmospheric dust and decreased surface air temperature, Budyko states that in two of his own works, "Climate and Life" (Leningrad, 1971) and "Man's Impact on Climate" (Leningrad, 1972), he confirmed Humphreys' hypothesis on the increased albedo of the Earth due to the scattering of solar radiation by solid particles, and established the close relationship between the secular pattern of direct solar radiation in a cloudless sky and the mean planetary temperature at the Earth's surface.

In Budyko's view the main factor responsible for the warming trend during the 1920's and the 1930's was the reduced concentration of volcanic dust in the lower atmosphere due to the absence of any major volcanic eruptions in the preceding few decades. The authors consider that other hypotheses on the causes of climate change in the 20th century are not soundly based on quantitative calculations and in several cases are refuted by existing calculations.

The relative impact of man's activity on climate is closely related to the problem of the stability of modern climate. If modern climate has a low degree of stability, slight initial changes in the temperature field can result in significant changes in the large-scale heat exchange processes, thus leading to an increase in initial temperature variations, i.e. to their spontaneous development.

Numerical models of the highly sensitive Earth-atmosphere-ocean system, developed by Budyko in the U.S.S.R. Main Geophysical Observatory and by A. Faegre and by W.D. Sellers in the United States, are discussed. Budyko concludes that the Earth-atmosphere relationship is so sensitive that a 2% reduction in the influx of solar radiation could result in the complete stable glaciation of the Earth. Conversely a slight increase in the influx of radiation could thaw the polar caps. Both Faegre and Sellers have arrived at similar conclusions, according to the authors.

Budyko has calculated the thermal conditions for the complete glaciation of the Earth, using the existing magnitude of the solar constant. The mean latitudinal temperatures for the "white Earth" ranged from (-) 68° C at the equator to (-) 73° C at the poles (Budyko, Climate and Life, 1971). Although the compiled temperature depends considerably on the choice of albedo for the Earth's ice-covered surface, the mean latitudinal temperatures remain below zero for any plausible albedo. Thus, the "white Earth" is the second type of climate which is possible under existing conditions.

From Budyko's thermal regime model the authors have concluded that a third climatic variant is possible; the development of the partial glaciation of the Earth and lower temperatures than at present. (Budyko, Man's Impact on Climate, 1972). However this version of the climatic regime is unstable, i.e. it converts into other substantially different types of climatic conditions through very slight changes in the climate-forming factors.[1]

It is concluded from the foregoing that a comprehensive program on the present and long range climatic effects of man's activity should encompass atmospheric effects both in urban areas and in the atmospheric boundary layer above urban territory. The decisive part of this comprehensive program should be the theoretical simulation, based on the empirical data obtained, of both the urban microclimate ("heat islands", raised inversions, etc.) and of the possible global climate changes caused by air pollution, which is altering optical and other parameters of the atmosphere.

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1. The material above is also presented in Budyko's discussion of Faegre's Earth-atmosphere model: M.I. Budyko, "Comments on an Intransitive Model of the Earth-Atmosphere-Ocean System", Journal of Applied Meteorology, (1972), vol. 11, p. 1150 in reference to Faegre's 1972 paper, "An Intransitive Model of the Earth-Atmosphere-Ocean System", J. of Applied Meteorology, vol. 11, 4-6.

Topics of particular importance in the program would include:

- the physical characteristics of urban gas and aerosol pollution
- global atmospheric dissemination of pollutants
- chemical, spectral and laser analysis of atmospheric turbidity
- thermal pollution, including stereophotogrammetric studies of diffusion processes
- analysis of "heat islands"; determination of their horizontal and vertical boundaries
- cloud studies, since the effect of pollution on cloud formation and cloud characteristics has been virtually unstudied. Thus it is extremely important to study cloud characteristics in industrial areas (including chemical composition, characteristics of condensation nuclei) and radiation characteristics of clouds (especially albedo) in different intervals of the spectrum.
- the radiation regime of polluted air, in particular to obtain data specifying the effect of aerosols on climate with reference to the correlation between the actually encountered albedo values of the underlying surface and the coefficients for absorption and back-scattering by aerosols under different light conditions (i.e. different heights of the sun, different cloud cover conditions). The radiation research program outlined is virtually identical to the radiation unit of the (1970) CAENEX (Complex Atmospheric Energetics Experiment), which included integral (actinometric) and spectral measurements of the flux of short and long wave radiation, the characteristic curves for scattering, and the integral and spectral transparency of the atmosphere.

Budyko, M. I. Climate change. Zemlya i vselennaya, no. 3, 1973, 18-25.

As a result of man's increasing fossil fuel consumption, within recent decades the atmospheric concentration of CO_2 has risen 10 - 15% and now is continuing to increase at a rate of 0.2% per year. Based on present calculations, this will result in a 0.5% warming of the surface air temperature by 2,000 A.D. Eighty percent of man's energy sources (fossil fuels, atomic energy, etc.) discharge additional heat into the atmosphere, thus contributing to a 0.01°C annual increase in global air temperature.

Given the 5 to 6% annual increase in world energy production, Budyko estimates that the mean global air temperature could rise several degrees by the mid-21st century.

The crucial question is the stability of modern climate in relation to slight, initial changes in global air temperature. Satellite studies of the Earth's albedo have raised the possibility of a sudden increase in slight, initial climatic fluctuations due to changes in the size of the polar ice cap.

Incorporating material on the heat balance from Sellers, Faegre, and others, the author has constructed semi-empirical climate models which treat the relationship between the influx of radiation into the outer boundary of the atmosphere and the polar ice cover in the Northern Hemisphere. Given the present influx of solar energy and the sensitivity of the existing climatic regime to slight changes in incoming radiation, three climatic regimes are possible as discussed in the foregoing paper by Budyko et al. The "most stable" of these regimes would be the complete glaciation of the planet which could occur if radiation would be reduced only 2%.

Budyko rejects the hypotheses that changes in the solar constant or climate-forming factors were responsible for the advance and retreat of the glacial cover in the Quaternary period. He asserts that the only indisputable change during the Quaternary period was in the amount of radiation received at different latitudinal zones during individual seasons of the year due to periodic, astronomical changes in the position of the Earth's surface relative to the Sun. (i. e. shifts in the eccentricity of the Earth's orbit, tilt of the Earth's rotational axis, etc., which can be plotted with considerable accuracy for the last 20 to 30 thousand years.)

The author's table "Temperature Fluctuations and the Extension of the Polar Ice Sheet During the Ice Ages", which is based on a semi-empirical model of the atmospheric thermal regime, demonstrates the correlation between glacial periods and periods of decreased radiation (during the warm seasons in the temperate and high latitudes), caused by astronomical factors. (Fig. 1). The extreme sensitivity of the Earth's thermal regime is demonstrated by the fact that during these shifts in the boundaries of the polar ice cap the decline in the mean planetary temperature was no more than 1° C in relation to the present-day mean temperature.

Figure 1.

Temperature Fluctuations and the Extension of the Polar Ice Sheet During the Ice Ages

Time in 1,000's of years before 1800 AD	Mean latitudinal advance of polar ice boundary in Northern Hemisphere relative to its present location $\Delta\varphi_N$	Mean latitudinal advance of polar ice boundary in Southern Hemisphere relative to its present location $\Delta\varphi_S$	Change in mean temperature during warm half year at 65° north latitude ΔT
22.1 (Würm III)	8	5	-5.2
71.9 (Würm II)	10	3	-5.9
116.1 (Würm I)	11	2	-6.5
1[illegible]7.5 (Riss II)	11	0	-6.4
232.4 (Riss I)	12	-4	-7.1

Before the present CO_2 build-up in the atmosphere due to man's industrial activity, the evolutionary pattern of the Earth had shown a continuing decline in atmospheric CO_2, which if unchecked could lead to total glaciation of the planet. Budyko estimates a 0.018% figure for atmospheric CO_2 before human intervention, while the estimated figure at which polar glaciation could have begun to form is 0.042%. The critical level for complete planetary glaciation would be 0.015%: this figure could be reached within one million years, if the estimated 0.014% rate of decline in CO_2 occurring during approximately the last million years were to continue in the future. Moreover, this estimate does not take into account the periodic astronomical factors which in the past have also reduced the insolation at high latitudes.

At present, man's input of CO_2 into the atmosphere is increasing 1,000 times more rapidly than its mean rate of loss during past geological epochs, while energy production is up 5% to 6% per year. The rate of particulate build-up in the atmosphere and its future climatic effects are more difficult to gauge accurately.

Budyko predicts, despite the limitations imposed by the approximate nature of present climatic data, that if present rates of energy production are maintained, the "heat barrier" will be reached within 100 years. At this point polar glaciation would sharply begin to recede and eventually disappear.

Close international cooperation is thus increasingly important in regulating the Earth's climate for the benefit of mankind.

Budyko, M.I., K. Ya. Vinnikov. Recent climate changes. Meteorologiya i gidrologiya, no. 9, 1973, 3-13.

Analysis of the secular trend of atmospheric transparency, the atmospheric thermal regime, and precipitation in the extra-equatorial zone of the Northern Hemisphere indicates that throughout most of the twentieth century, climatic changes were principally caused by fluctuations in the aerosol concentration in the lower stratosphere. These fluctuations correlate with the variations in total solar radiation.

The secular trend of air temperature anomalies from 1881 - 1969 shows a distinct warming trend which culminated in the late 1930's. (Fig. 1).

See next page for figure and explanation.

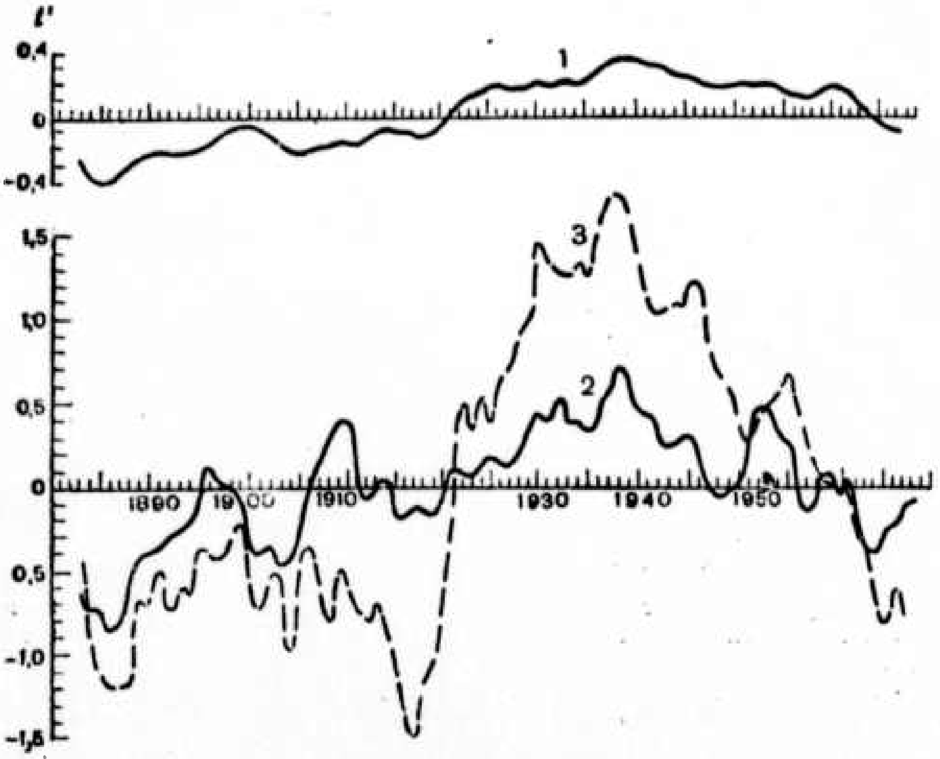


Fig. 1. Secular trend of air temperature anomalies (t', °C), (5-year running means).

curve # 1 = mean annual anomalies for the Northern Hemisphere (with the exception of the equatorial latitudes).

curve # 2 = temperature anomalies in the zone from 70° to 85° north latitude during the warm half of the year.

curve # 3 = the same, during the cold half of the year.

Comparison of the secular trend of anomalous precipitation from November through March in the steppe and wooded steppe zones of the U.S.S.R. (Fig. 2) with the secular air temperature trend (Fig. 1) and the secular trend of the meridional air temperature gradient shows a correlation between increased mean air temperature and decreased precipitation in areas with unstable moisture regimes, (cf. the papers of O.A. Drozdov and A.S. Grigor'yeva, 1963, etc. on the warming trend during the 1930's and the ensuing droughts).

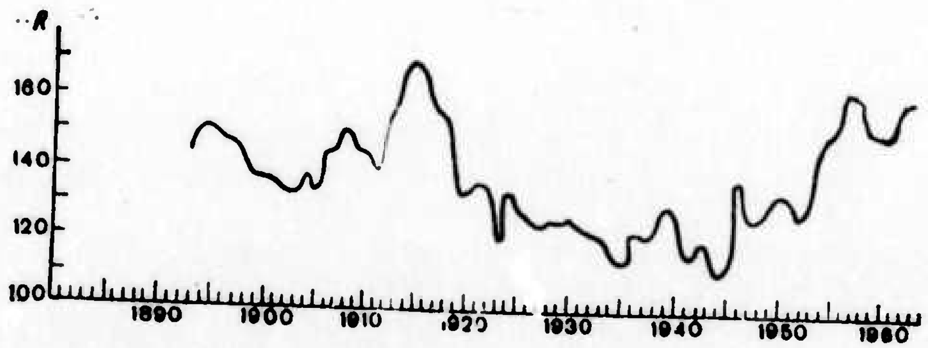
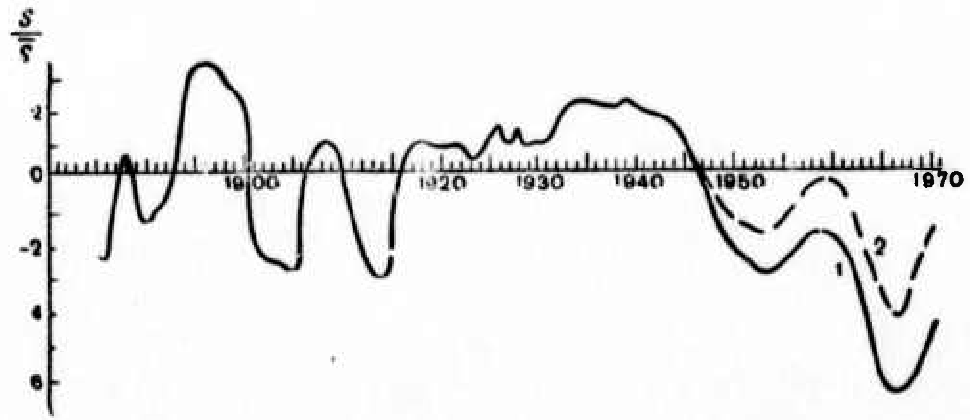


Fig. 2. Secular trend of total precipitation during the cold period (R, mm) in the steppe and wooded steppe zones of the USSR (averaged for 5-yr. periods).

In preceding works (1967, 1968, and most recently in the report, "Man's Impact on Climate," 1972), Budyko developed quantitative explanations for the mean temperature changes in the mid-latitudes during the first half of this century, using a semi-empirical theory of the atmospheric thermal regime. From these results the present authors conclude that the main cause of climatic fluctuations is variations in the intensity of short-wave radiation entering the troposphere, due to aerosol scattering of radiation in the lower stratosphere.



$\left(\frac{S'}{S}, \%\right)$

Fig. 3. Secular trend of anomalies in direct solar radiation (1885 - 1970).

curve # 1 = values for 5-year running means (including effects of anthropogenic aerosols)

curve # 2 = recent trend with correction for anthropogenic aerosols

The decline in radiation during the late 19th and early 20th century is explained by the major volcanic eruptions: Krakatoa (Indonesia), Mount Pelée (West Indies), Katmai (Alaska), etc., which significantly increased the aerosol concentration in the lower layers of the stratosphere, thus affecting atmospheric transparency over the whole Northern Hemisphere.

McCormick and Ludwig (1967), Budyko (1969), SCEP (1970)[1a] SMIC (1971) [1b] and others explain the decline in direct solar radiation since the 1940's by the increased volume of atmospheric aerosols resulting from man's activity.

At the same time, due to the combustion of fossil fuels the CO_2 build up in the atmosphere has been increasing at a rate of approximately 0.2% per year. According to the calculations of S. Manabe such an increase will result in a 0.5° C mean temperature increase by 2,000 A.D. (SMIC, 1971). Thus during the last 20 to 30 years the mean global surface temperature has increased approximately 0.2° C due to the CO_2 build-up. However, the overall mean air temperature in the Northern Hemisphere during this period actually dropped approximately 0.3°C.

In order to ascertain whether the increase in the anthropogenic aerosol volume could lower the mean surface air temperature by 0.5°C, the effect on the surface air temperature of changes in the tropospheric aerosol concentration must be determined. On the basis of the above data, it appears that the increase in the anthropogenic aerosol concentration has reduced direct radiation in the Northern Hemisphere approximately 6%. Given a cloud cover factor of 0.5 this would be equivalent to a 0.5% reduction in total radiation.

1a) Study of Critical Environmental Problems, Man's Impact on the Global Environment, MIT Press, 1970.

1b) Study of Man's Impact on Climate, Inadvertant Climate Modification, MIT Press, 1971.

Using a semi-empirical theory of the atmospheric thermal regime, Budyko shows that a 0.5% decline in total radiation would result in a 0.75° C drop in mean surface air temperature. However this figure does not include aerosol absorption of radiation, which may compensate to a certain degree for the temperature decline caused by radiation scattering.

Comparison of the curve for anomalies in direct solar radiation with the data for precipitation during the cold period of the year in the mid-latitudes for the years 1891 - 1960 shows a correlation coefficient of 0.78. During the 1930's, for example, a period of increased direct radiation coincided with a sharp (~170 cm.) fall in the level of the Caspian and a decline in precipitation throughout the temperature latitudes in both Eurasia and North America. When fluctuations in the U.S. wheat crop yield from 1910 - 1971 are compared with synchronous changes in the level of the Caspian they show a correlation coefficient of 0.74. Thus changes in the radiation balance affect the whole Northern Hemisphere, as shown here by their comparable effect on the temperate zone moisture regimes of different continents.

In regard to the future, an international system of climate control which would reduce the pollution level in the lower layers of the troposphere is imperative. However, in order to accomplish this and maintain the present precipitation level in continent interiors, the transparency of the stratosphere must be regulated by increasing, when necessary, the volume of stratospheric aerosols, as proposed in the recent publication by Budyko, "Man's Impact on Climate", ("Vliyaniye cheloveka na klimat", Gidrometeoizdat, Leningrad, 1972).

Drozdov, O. A. Climatology and forecasting the meteorological regime. Meteorologiya i gidrologiya, no. 12, 1972, 24-29.

Three major series of handbooks on the climatology of the U.S.S.R. are described. The first, dating from the 1930's, was published under the direction of A. A. Kaminskiy and Ye. S. Rubinshteyn. The second series, containing over 100 volumes, was published during the 1940's and 1950's by the climatology department of the Main Geophysical Observatory under Rubinshteyn's direction. The most recent edition (as yet undated), numbering over 170 volumes in 34 series, was compiled by the MGO in conjunction with the area climate sections of the Hydrometeorological Service. Also in progress is an "Agroclimatological Handbook", which includes some of the material in the "Climatic Handbooks of the U.S.S.R.", and already numbers over 130 volumes.

Reviewing the problems in determining the causes of anthropogenic and natural climate changes, Drozdov notes that at present it is only possible to determine statistically the effect of oscillations of the magnetic pole, tidal forces, and solar activity on fluctuations in atmospheric circulation, and by means of all these components obtain the long-term cyclical fluctuations in temperature and precipitation. Moreover such fluctuations are not universally observable, and the spectrum of fluctuations includes all possible frequencies from 2-3 years to 120 years, etc.

The reasons for the long-term secular temperature trend, which during the last two centuries has not shown a substantial correlation with the fluctuations in ice conditions, remain hypothetical. However a "highly probable" explanation is the 1850-year Pettersson-Shnitnikov tidal cycle.

The cause of the fluctuations in the astronomical value of the Wolf number (as the expression of the solar constant) remains unclear. However the fact that its secular fluctuations do not exceed 2% of its value does not minimize its importance, inasmuch as the polar ice sheet is a powerful intensifier of temperature fluctuations, provided they are of sufficient duration. The secular trend of ice phenomena, temperature, and precipitation correlates fairly well with the fluctuations in the solar constant. Since temperature fluctuations radiate out from the areas of the magnetic pole, fluctuations in corpuscular radiation are another possible factor affecting polar ice trends.

Budyko has linked the 80-year trend in temperature fluctuations with decreased solar radiation, which is caused, he maintains, by changes in atmospheric transparency after volcanic eruptions. While Drozdov does not deny the effect of volcanic eruptions on atmospheric transparency, he does question Budyko's thesis that volcanism, rather than fluctuations in the solar constant, is the main cause of the secular solar radiation trend. First of all, the cool period after volcanic eruptions lasts no more than 2-7 years. Secondly, the centers of the cooling trend after volcanic eruptions are not located over Greenland, but over the Kara Sea:

in Greenland zero or even positive anomalies are observed, a fact which does not correspond to the secular trend of temperature anomalies.

Despite the fact that not all the causes for climate fluctuations are established, nor are all fluctuations amenable to physical calculation, the general nature of the future distribution of weather anomalies can be predicted in averaged terms for 5, 10, and more years in advance. For example, the forecasts of the 5-year precipitation mean for the USSR during warm and cold periods of the year, based on calculations of the long-term cyclical pattern for the 1966-1970 period, showed at least a 0.4 correlation upon correction with actual precipitation.

Drozdov, O. A. The relationship of climatic oscillations to the secular trendof the solar constant during the past two centuries. Vestnik Leningradskogo universiteta, no. 24, 1972, 99-102.

Climatic changes during the last 200 years indicate two major trends: (1) a long-term warming trend, based on one of the longest cycles in the post-glacial era, probably the 1850-year [1]

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[1] The 1850-year Pettersson-Shnitnikov tidal cycle is described in Shnitnikov, A. V., "Variability of the moisture balance on the continents of the Northern Hemisphere", Zapiski geograf. obshch. SSSR, nov. ser., v. 16, 1957.

Pettersson-Shnitnikov tidal cycle; and (2) regular, approximately 80-year cylical oscillations, which are superimposed upon the long-term climate trend. With certain localized exceptions, the last two oscillations were clearly observable over broad areas in the Northern Hemisphere. (e.g. Greenland is the center of the modern warm trend from which the 80-year cycles have radiated out with some phase lag and amplitude attenuation.)

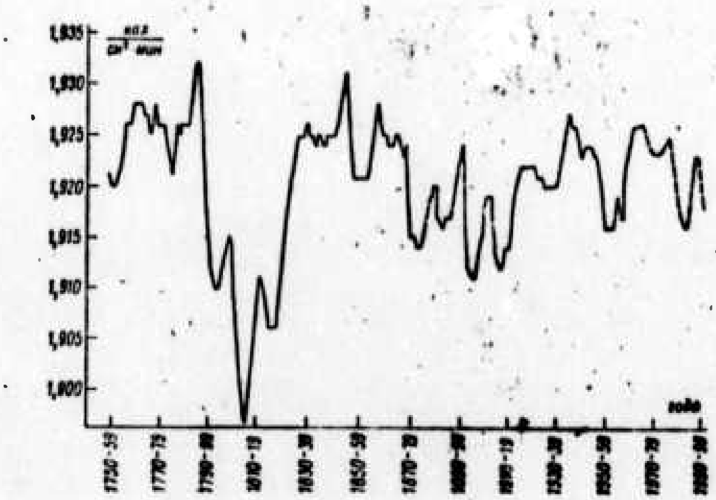

Figure 1. Trend of the solar constant (cal./cm^2/min., derived from Wolfe numbers. (broken line -- extrapolation to the end of the century by A.D. Bonov).

Examining the relationship of the solar constant to climatic characteristics, Drozdov finds that the trend of the solar constant, as established by Wolfe numbers, agrees extremely well with the basic evidence of climatic oscillations both from the mid-18th century to the present and during the immediately preceding period. Significant climatic oscillations which correlate with the secular trend of the solar constant include: (1) the warm trend in the European climate during the second half of the 18th century; (2) the cold trend from 1810 to approximately 1820, accompanied by an increase in the ice cover; (3) a period of low ice conditions in the Atlantic during the 1830's and 1850's, accompanied by a temperature rise and intense aridity in the temperate latitudes of Eurasia, which is confirmed by observational data and by analysis of crop productivity and water basin levels; (4) a relatively cold period from the 1880's to 1920, when low radiation values predominated; (5) climatic warming, decreased ice cover, and increased aridity in the temperature latitudes during the 1930's (to 1950's); (6) a cooling in the high latitudes and a drop in radiation during the 1950's; (7) a certain warming trend in the 1960's and a secondary decrease in the ice cover.

In regard to future climate, the consensus is that solar activity will decline in the course of this century, but there is disagreement on the intensity of the decline. A middle position, held by A. D. Bonov, predicts the solar constant will drop to its level during the 1880's (see figure 1). Thus a substantial cooling and an increase in the western Arctic ice cover should occur, although the cool trend should be tempered by the long-term warming trend dominant in recent centuries. As a result of the cooling trend in the Arctic, a gradual decline in precipitation in the high latitudes and sub-tropic regions, particularly Central Asia, is anticipated.

However as the author and A.S. Grigor'yeva demonstrated in their 1971 monograph, "Long-term cyclical oscillations of atmospheric precipitation in the U.S.S.R.", this precipitation decline will occur at a slower rate than usual due to the prolongation of the secular cycle in Central Asia during the preceding period. Thus, although the secular precipitation decline in the Aral basin has begun, it is still often interrupted by a precipitation increase due to shorter-term cyclical processes. In regard to the redistribution of precipitation, in the southern section of the forest zone in the eastern European section of the U.S.S.R. and in Western Siberia, winter precipitation will slightly increase; while in relation to the aridity of the preceding 30 years, throughout most of the steppe zone precipitation will increase both in winter and summer.

Gedeonov, A. D. Air temperature fluctuations in the Northern Hemisphere during a 90-year period. IAN Seriya geograficheskaya, no. 6, 1972, 102-106.

The author examines the results of a comparison of an 80-90 year solar cycle with deviations of the mean monthly air temperature from the long-term norm during the 9 decades from 1881-1970. The investigation was limited to the area above the 25th parallel north latitude due to the lack of uniformity in equatorial zone data.

During the first 3 to 4 decades negative anomalies predominated, while in the 5th through 8th decades positive anomalies predominated, possibly indicating a sub-cycle lasting 40-45 years. The 9th decade (1961-1970) shows a distinct cooling trend.

Since the progressive rise in the atmospheric CO_2 concentration due to man's industrial activity during the last half century was not matched on the cyclical temperature curve by a significant warming trend, the author excludes CO_2 as the major cause of temperature fluctuations during the 90-year period in question.

The principal causes of temperature fluctuations are rather fluctuations in solar activity (e. g. H. C. Willet's study on the clear correlations in solar-climatic fluctuations between 1900-1959) and fluctuations in atmospheric turbidity (e. g. M. I. Budyko, "Climate and Life"). During the periods from 1881 to 1912 and again from 1953-1956 major volcanic eruptions occurred which correlate with cool phases in the temperature curve. According to Budyko one of the major reasons for the warming trend in the Arctic from 1915-1935 was the low level of volcanic activity and thus of atmospheric turbidity during that period.

The author concludes that long-observed cyclical fluctuations in solar activity are the main cause of climatic change. In recent decades, however, the coincidence between the cool phase in solar activity and fluctuations in atmospheric turbidity may be intensifying solar-climatic effects. The present cool phase in the 80-year solar cycle should last another 10 to 20 years, as postulated by the author (1969), Vitel's (1962), Girs (1971), Maksimov (1952), Mitchell (1966), and Kendall (1935).

Gumilev, L. N. Climate changes and the nomadic migrations. Priroda, no. 4, 1972, 44-52.

The author surveys the major fluctuations of the moisture balance in the Eurasian plain, caused by shifts in the Atlantic cyclone track. During the period from the 3rd century B. C. to the 18th century A. D., Gumilev distinguishes 3 major periods of drought in the Central Asian steppes, each marked by the out-migration of the nomads to find water and grazing lands. When a more humid climate returned, the nomads again settled in the Great Steppe. The major out-migration periods also correlate with the fall of the water level in both the Caspian and Aral Seas (despite their zonally different watersheds).

The alternations in humid and arid periods are not related to global climatic changes, but are the result of zonal shifts in the Atlantic cyclone track which correlate with different intensities of solar activity (and corresponding activity of the Sahara-Arabian subtropical maximum). During low solar activity, the period of most favorable climatic conditions, cyclones cross the Mediterranean and the Black Seas until checked by the Altai and Tyan-Shan' where they release their moisture, thus watering the Aral Sea and Lake Balkhash, while the Caspian Sea, watered (81%) by the Volga, recedes. In the forest zone, the swamp areas become meadowlands, the winters are dry and severe, and the summers very hot.

When solar activity increases, the Atlantic cyclone trough shifts to the north, passing over France, Central Russia and Siberia. The steppes become arid, and the level of the Aral and Lake Balkhash drops. On the other hand, the Volga becomes swollen with additional rainfall and the level of the Caspian rises. In the Volga-Oka river valleys the forest land becomes swampy. There is greater and more prolonged precipitation in both summer and winter.

If solar activity further intensifies, the cyclone track will shift to still higher latitudes, crossing Scotland, Scandinavia, and the White and Kara Seas. The Eurasian steppes then turn to desert. The Volga and, correspondingly, the Caspian return to their banks, while the White, Barents, and Kara Seas thaw, releasing evaporation which shields sunlight from the Earth. The northern climate becomes cold and damp. At the same time a north Iranian cyclone track develops, carrying part of the Atlantic moisture to the mountains of Armenia and the remainder to the Pamir, where it waters the Amudarya and in part compensates for the evaporation from the Aral. However other bodies of water in the Eurasian steppe (Lake Balkhash, Lake Zaisan, Lake Ubsu-nor) continue to recede. Fig. 1 illustrates the three cited cyclone tracks.

Among the supporting geo-historical evidence, the author cites his own archeological investigations at the monumental VIth century Persian wall at Derbent which fix the late VIth century level of the Caspian Sea at an absolute mark of minus 32 meters. Historical documents also record the alternating transgression and recession of the Caspian Sea (ranging from the absolute mark of minus 32 meters during the erection of the Derbent wall to a maximum height of minus 19 meters in the late 13th - 14th centuries, when the Caspian engulfed the port of Absakun, to the current level of minus 29 meters).

See next page for figure.

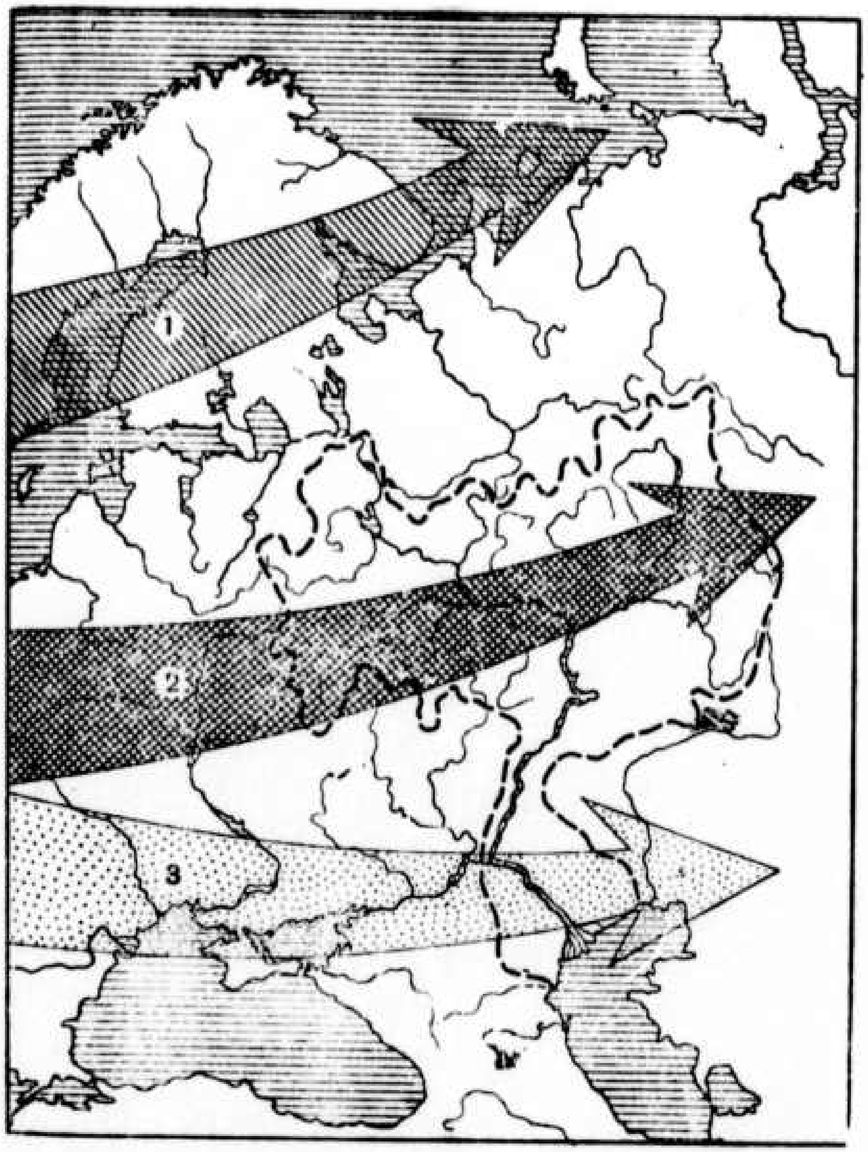

Figure 1. Shifts in the latitude of the European cyclone track:
1. northern position; 2. mid position; 3. southern position.
The boundaries of the Volga basin are indicated by the broken line.

Kupetskiy, V. N. The variability of solar-climatic relationships. Izvestiya vsesoyuznogo geograficheskogo obshchestva, no. 2, 1973, 128-132.

The investigations of V. A. Sleptsov-Shevlevich on the causes for the variability of solar-climatic relationships, and of A. I. Ol' on the nature of 22-year solar cycles, among others, demonstrate that solar activity is too complex to be expressed solely in terms of Wolf numbers. Thus, for the analysis of solar-climatic relationships the more comprehensive Wolfe-Spörer-Hale[1]-Ol'[2] law is indicated, i.e. not only should the Wolfe number in a given year be considered, but also the nature of the solar cycle as determined by the height of the cyclical maximum and the series number (parity), according to the Zurich numeration of 11-year solar cycles.

The author examines Kh. Yu. Myurk's study on the relationship between solar activity and the mean annual air temperature in Tartu from 1867 to 1953 in which the correlation between the mean temperature and the Wolfe number for nine separate 11-year cycles had appeared to be random. However by introducing the maximum amplitude of the 11-year solar cycle into the equation, a clear correlation is obtained between solar activity and annual temperature. (By combining 11-year cycles into 22-year

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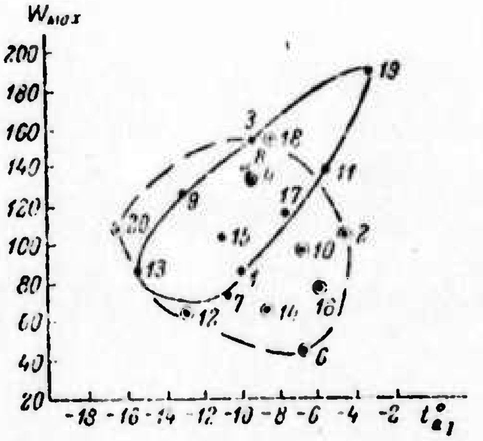
[1] G. E. Hale's law that the polarity of bipolar groups of sunspots changes from cycle to cycle.

[2] A. I. Ol''s rule that the 22-year solar cycle is formed by an even 11-year cycle (generally the low cycle) plus the following uneven (generally the high) cycle.

cycles, in accord with Ol''s rule, the mean temperatures for 22-year cycles are also shown to be directly related to the amplitude of the cycle.)

Solar-climatic relationships have thus been established not only for the 11-year cyclical mean of certain climatic characteristics, but also for mean annual, seasonal, and even monthly climatic characteristics. This is demonstrated by the author's analysis of the relationship between the January mean air temperature in Leningrad during certain years of maximum activity and the amplitude of the corresponding cyclical maximum, based on twenty 11-year cycles (1761-1968), (Fig. 1).



• = odd 11-year cycles

⊙ = even 11-year cycles

Figure 1. The relationship between the mean January air temperature during years of Wolfe number maximums and the amplitude of the 11-year maximum.

Khromov, S. P. Solar cycles and climate.
Meteorologiya i gidrologiya, no. 9, 1973,
93-110.

The author critically reviews the assertions of the increasingly prolific Soviet solar climatologists and geophysicists seeking to establish close solar-climatic relationships. The views of solar geophysicists L. A. Vitel's, I. V. Maksimov, M.S. Eygenson, A. D. Gedeonov, and others, are cited as contrasting with the more conservative views of "official climatology". Countering Eygenson's assertion that the secular solar cycle has been "definitively established", A.S. Monin, corresponding member of the U. S. S. R. Academy of Sciences, wrote in 1969 that the existence of such a solar cycle has not yet been conclusively proven. According to Monin, the assertion by "solar geophysics enthusiasts of the existence of an 80-to 90-year cycle of solar activity, formulated from graphs... describing only 2 such cycles, is certainly unfounded; the known tendency of the human mind to equate the 3-to 5-fold repetition of any cycle with the discovery of periodicity is not statistically valid. Moreover in this case we only know that the cycle has been repeated twice."

Khromov scores the lack of methodological rigor of certain "champions" of solar-climatic cycles. The monographs of Eygenson, Rubashev, Maksimov, and others point to the existence at various times of an extremely large number of solar cycles (periods, rhythms), ranging from several months to millions and even billions of years. Of all these cycles only the so-called 11-year cycle (with fluctuations ranging from 6 to 17 years) can be postulated from direct examination of a series of Wolfe numbers (of the relative numbers of sunspots). Khromov notes that the existence of the 22-year solar cycle is even less obvious, at least in relation to the Wolfe numbers.

Yu. I. Vitinskiy in the 1973 edition of his book, "The Cyclical Nature of Solar Activity and its Prediction", also maintains that the existence of an 80-to 90-year solar cycle is not reliably substantiated by the statistical evidence, even using D. J. Schowe's historical material on northern lights and sunspots during the last 2,000 years; and in any case some degree of uncertainty remains concerning the mean duration of this cycle. Vitinskiy emphasizes the tentative state-of-the-art of long-range solar cycle forecasting as well as the tenuous nature of the statistical evidence.

Khromov stresses the need for a more rigorous approach to the investigation of possible solar-climatic relationships. However, a clear distinction is drawn between the as yet hypothetical solar-climatic cycles and the extremely long climatic cycles, based on astronomical (but not solar physical) causes such as changes in the eccentricity of the Earth's orbit, the inclination of the ecliptic, and length of the perihelion, which clearly affect integral insolation.

II. Paleoclimatology

A New Ice Age? Tekhnika molodezhi, no. 7, 1973, 31.

The present temperate era which has lasted about 12,000 years may be coming to an end. According to recent analyses of sedimentation layers on the floor of the Caribbean, the traditional view of the succession of glacial areas over the last million years should be revised. Instead of 4 major glacial and interglacial periods, each lasting approximately 100,000 years, these findings show that during the last 400,000 years eight intense cold eras and seven very warm eras occurred, not to mention 30 less significant climatic fluctuations. Moreover, the high temperature eras are becoming increasingly shorter.

In early 1973 Dr. Cesare Emiliani suggested at an international climatology conference that a new ice age might occur within 2 to 3 thousand years, possibly sooner due to the harmful environmental effects of human industrial activity. The article concludes noting that if we can not succeed in restoring climatic balance, we may very soon be confronted with an increase in the glaciation of the Earth's surface or, conversely, the thawing of the Earth's glaciation.

Sidorenko, N. S., Do changes in the angle of inclination of the Earth's axis affect the alternation of climatic eras? Priroda, no. 4, 1973, 123-125.

An article by A. V. Orlova, "Precipitation Accumulation and Climate" in Priroda, no. 8, 1972, advanced the hypothesis that in past geological eras significant changes in the Earth's rotational speed caused variations in the inclination of the Earth's axis, thus altering the angle of incidence of solar rays and correspondingly the value for solar radiation in different latitudes.

Sidorenko refutes Orlova's thesis, offering two major counterarguments. (1) The possibility that lunar-solar nutation would have any appreciable effect on climate should be discounted since the amplitude of changes in the Earth's angle of inclination to the ecliptic is too slight (less than 10"). (2) Citing the American geophysicist G. MacDonald's figures, over the last 1.8 billion years the angle of inclination of the Earth's axis to the ecliptic has decreased at a rate of less than 0.004" per century. Such slight, continual changes in the inclinational angle of the Earth's axis could not have caused the climatic fluctuations during the past 0.5 billion years, described by Orlova.

Ustritskiy, V. I. The climate of the Permian period: a comparison of paleobiogeographic and paleomagnetic data. IAN Seriya geologicheskaya, no. 4, 1972, 3-12.

The author discusses the determination of Permian climatic zones in the Northern Hemisphere, and climate change during the Permian period.

Virtually all biogeographic methods (zoogeographic, phytographic, lithologic) used to determine the Permian climatic boundaries in the Northern Hemisphere offer nearly corresponding results. During the Permian period magnetic paleolatitudes in Eurasia and North America, virtually parallel to the borders of the Boreal and Tropical zoogeographic zones, formed an almost perfect semi-circle, centered near the mouth of the Lena River, the probable location of the Permian North Pole. The apparent displacement of the Permian North Pole in relation to its present location was 20° - 25°. This shift was probably caused by the southward movement of the Eurasian land mass during the Mesozoic era.

Climate change during the Permian period, generally regarded as an "Ice Age", resembles the Quaternary pattern in its alternation between glacial and warm interglacial eras. However the duration of the eras was greater during the Permian period. The early Permian period was marked by extremely intense, prolonged cold—a trend originating in the late Carboniferous period. A warming trend followed, apparently thawing all the seas of the Earth. Thirdly a rapid, substantial cooling occurred. During the late Permian period a second warming trend developed, leaving red-soil deposits in Taimyr at 75° north latitude and carboniferous deposits in Verkhoyan' in the areas where glacier sedimentation had accumulated during the preceding cold era (Figs. 1 and 2).

Fig. 1. Paleogeographic plan of the Boreal zone in the early Permian period.

1- boundary of Boreal biogeographic zone; 2- northern limit of evaporites; 3- regions of ice age sediment; 4- Permian parallels and their value according to paleoclimatic and paleomagnetic data; 5- probable position of North Pole in Permian period; 6- modern North Pole.

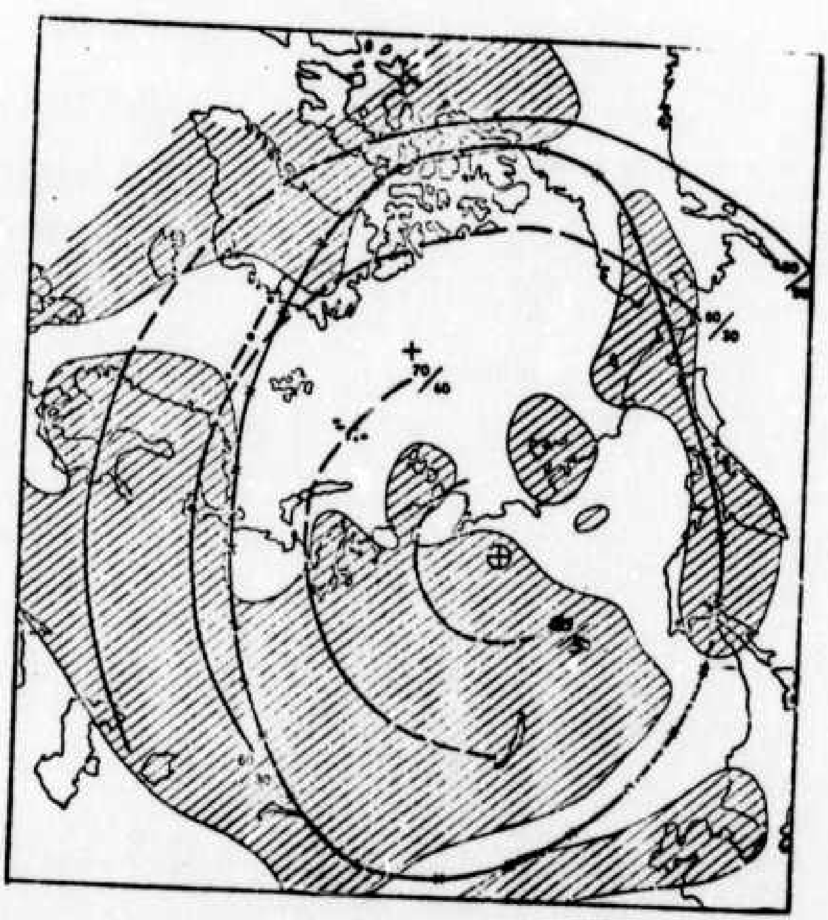


Fig. 2. Paleogeographic plan of the Boreal zone at the beginning of the late Permian period.

(see Table 1 next page)

Divergencies between paleomagnetic data and paleoclimatic data in regard to the distribution of coral reefs are explained by the different temperature tolerance of the reef-building organisms in the different geologic eras. However, Ustritskiy notes that the more significant differences between soil indicator data and paleomagnetic data reveal the paleomagnetic data to be in contradiction with all available data on the Northern Hemisphere, in particular the evidence of tree growth even in the polar region.

Permian climate during the interglacial eras was considerably milder than our present climate, as evidenced by the absence of any traces of sea freezing and the distribution of all the rock indicators of a warm climate 15°-25° farther north than during the modern era.

Table 1

Distribution of Rock Indicators in Permian Sedimentation in Eurasia (according to paleoclimatic and paleomagnetic data)

Time	Rock-Indicator	Distribution Limits		
		according to paleoclimatic data during Permian period	at present	according to paleomagnetic data during Permian period
Maximum Cold (early Permian period)	evaporites	45°	40°	15°
	carbonaceous strata	65°	60°	35°
	reefs	55°	40°	25°
	evergreens	45°	40°	15°
	Ice Age sediment	65°	55°	35°
Maximum Warming (beginning of late Permian period)	evaporites	60°	40°	30°
	carbonaceous strata	75°	60°	45°
	reefs	60°	40°	30°
	evergreens	55°	40°	25°
	Ice Age sediment	-	-	-

Gromova, G. G., and A. A. Akulinicheva. The weather service in the RSFSR. Meteorologiya i gidrologiya, no. 12, 1972, 56-60.

This article surveys the major activities of the U.S.S.R. Hydrometeorological Service, focusing on the areas of collaboration between the RSFSR regional offices and the weather bureaus of the autonomous republics.

In connection with the need to strengthen economic planning throughout the U.S.S.R., the Five Year Plan for 1971-1975 calls for the increased development of analytical techniques for evaluating the economic effectiveness of short-range and long-range weather forecasting.

The authors see the central problem in short-range forecasting as the integration of satellite and radar information into reliable systems for the quantitative forecasting of the barometric field. Stress in the coming 10-15 years will be laid on the refinement of these systems, using increasingly advanced computer technology. New, sophisticated experimental testing stations ("polygons") are being set up for this purpose in Belorussia and on Kamchatka.

The expanded Soviet participation in the international exchange of meteorological information is briefly discussed.

Golovanov, L. Weather waves -- how are they predicted? [An interview with solar meteorologist A. V. D'yakov.] Tekhnika molodezhi, no. 2, 1973, 20-23.

A pioneer in solar meteorology for over 35 years, A. V. D'yakov, the head of the Gornaya Shoriya solar meteorological station (in

Kemerovska Oblast', 53° north latitude, 88° east longitude), was recently honored for the success of his work in long range agricultural weather forecasting. On 10-year projections for Western Siberia, D'yakov is reported to have achieved a record of 90-95% accuracy, while he is credited with an 80-85% record for one- to three-month forecasts.

D'yakov bases his predictions of weather waves on solar-tropospheric laws of resonance. Major cyclone and anticyclone systems are basically viewed as resonance phenomena triggered by the effects of cyclical solar activity. In brief, solar flare discharges of additional energy into the upper layers of the atmosphere create a high pressure ridge over the polar cap. When the air from this anticyclone vortex descends into the troposphere, it moves across Europe from the northeast, in winter sending cold waves over the European territory of the U.S.S.R. and in summer -- stable, hot, dry weather. The pattern is reversed in the tropics. Compensatory air currents are created: the warm air currents rise upward in a northeast flow, forming cyclones which bring stormy weather to Western Siberia and Northern Kazakhstan. During the summer of 1972, for example, this was the dominant weather pattern. Since 1938 D'yakov has been observing the systematic appearance of tropical air masses over the West Siberian plains within 3 to 4 days after intensified solar activity. In 1963 D'yakov published his resonance theory of the weather, which was bolstered by data from the Soviet satellites Luna -2, -3, and Venus-1 (1959-'61).

Evidence of the Earth's sensitivity to solar activity lies in the fact that during periods of intensified solar radiation the atmospheric flow, both warm and cold, increases 40% on the average. D'yakov holds that the principal index of atmospheric dynamics is the kinetic energy of the flow rather than the atmospheric pressure field which is the more prevalent view.

Emphasizing the relationship between fluctuations in the solar corpuscular streams and changes in general atmospheric circulation, D'yakov concludes that knowledge of solar wind periodicity should become a fundamental prerequisite for weather forecasting. However, this is not to deny the extreme complexity of solar-climatic relations. Rather, in D'yakov's view, it is more important to work from a large, if still imperfect, model of the phenomena than to "lose one's bearings in the meteorological labyrinth".

IV. The Climatology of Eurasia

Chichasov, G. N. The space-time structure of the spring thermal regime in Northern Kazakhstan. Izvestiya vsesoyuznogo geograficheskogo obshchestva, no. 6, 1972, 449-454.

For analytical purposes five types of spring regimes are distinguished: normal, warm, cold, -with recurrent cold, and compensatory. Graphic and tabular material for the period from 1881-1970 illustrates the duration of the different types of spring and the spatial frequency of the different spring regimes in Northern Kazakhstan. The section west of the Petropavlovsk meridian shows a 35% frequency figure for "normal" spring as compared to 25% for the eastern section. In contrastive studies for 30-year periods from 1881-1970, the type of spring regime in western and eastern Kazakhstan did not correspond in 51% of the total number of years (Fig. 1).

The relationship between temperature and precipitation is more clearly revealed by a breakdown according to the type of thermal regime (i.e. normal, warm, or compensatory spring, etc). In Tselinograd during spring regimes with recurrent cold, precipitation averages 47 mm. as opposed to 11 mm. during compensatory spring regimes. When corrected for seasonal duration the precipitation during the mean spring with recurrent cold is twice the figure for the mean compensatory spring in Northern Kazakhstan.

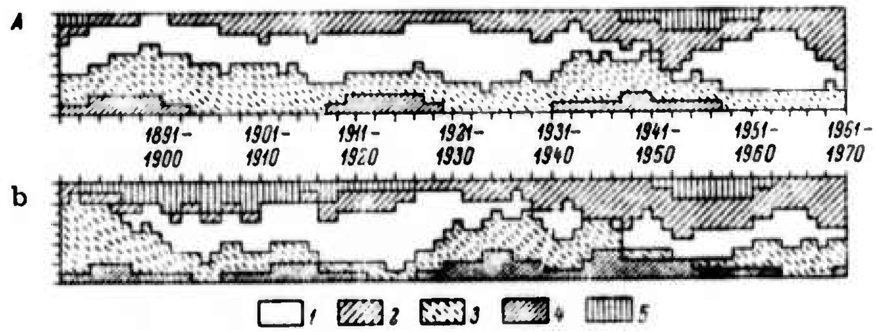


Fig. 1. The frequency of the types of spring regimes in the (A) western and (B) eastern sections of Northern Kazakhstan. Spring regimes: 1- normal; 2- warm; 3- cold; 4- with recurrent cold; 5- compensatory.

A general spring warming trend is currently discernible for all of Northern Kazakhstan. This agrees with the data obtained by Ye. S. Rubinshteyn and L. T. Polozova for the Barnaul and Orenburg vicinities, which indicate about a 5° increase over the mean April temperature at the end of the 19th century. This trend correlates with the warming trend in the Arctic, which has been linked by O. A. Drozdov and A. S. Grigor'yeva to the rise in the frequency of droughts in Northern Kazakhstan since the 1920's.

Gel'mgol'ts, N. F. [review of the book by] A. S. Uteshev, "Atmospheric drought and its effect on natural phenomena". Nauka Publishing House, Alma-Ata, 1972. Meteorologiya i gidrologiya, no. 2, 1973, 116-117.

A. S. Uteshev, the author of "The Climate of Kazakhstan", has studied drought problems for over 20 years. During this period he has been keeping a Calendar of Atmospheric Drought in Kazakhstan, which is proving to be an invaluable source for researchers.

Uteshev's present work focuses on the spells of anomalous atmospheric drought which disturb the natural climatological balance in the Central Asian arid zone. The monograph includes information on drought frequency by months, the characteristic duration, location, etc. It shows that anomalous drought occurs most often in the mid-latitudinal zone along the transformational paths of the air masses from the north.

Synoptic and aerological conditions of atmospheric drought are examined in detail. Uteshev also surveys the work of other authors on air mass transformation, particularly in the free atmosphere, and the aerological structure of the hydrothermic state of the atmosphere. Methods of long-range drought forecasting are discussed. Specific data are given on the relationship between atmospheric drought and soil humidity, forest fires, evaporation, and the water level in lakes, as well as the correlation between the thermal drought component and glacier ablation.

Lovelius, N. V., B. N. Norin, A. V. Knorre. Rhythmic fluctuations in the growth of the Dahurian larch at its northern limit. Izvestiya vsesoyuznogo geograficheskogo obshchestva, no. 5, 1972, 391-393.

The northermost larch forest, described in world literature, is located on the East Siberian island of Ary-Mas, Taimyr, 72° 30' north latitude. In 1934, L. N. Tyulina, one of the first geobotanists specializing in the study of the tundra, reported the improvement of growth conditions along the northern timberline on Ary-Mas and the present advance of the Boreal forest into the tundra.

The rhythm of anomalous tree growth from the mid-18th to the mid-20th century is traced by the authors through statistical analysis of annual tree ring measurements.

A close correlation between temperature maxima, positive extremes in annual tree ring growth, and periods of larch reforestation is demonstrated.

A corresponding synchronic relationship is also demonstrated for the years 1750-1970 between the dates of minimum larch growth on Ary-Mas and in the Putorana Mountains of Siberia, and the secular stages of Northern Hemisphere mountain glaciation, as established by A. V. Shnitnikov.

Krenke, A. N. Climatological conditions for the present glaciation in Central Asia. Izvestiya akademii nauk SSSR, Seriya geograficheskaya, no. 1, 1973, 19-33.

Analyzing precipitation distribution in the Central Asian alpine zone, Krenke derives estimates of the annual precipitation at the altitudinal boundary for glacier alimentation from the figure for glacier snow accumulation. Glacier ablation is derived from the mean summer air temperature, extrapolated for the altitude. Krenke and Khodakov analyzed the relationship between air temperature and glacier ablation, obtaining an empirical formula for the genetic calculation of glacier runoff independent of hydrometric data analysis:

$$Amm = (T_S^0 + 9.5)^3 \qquad (1)$$

where Amm = total seasonal ablation from glacier surface in mm.

T_S^0 = mean air temperature 2 meters above glacier surface during June, July and August.

Air temperature data from past glaciological expeditions are generalized and compared for significant altitudes (i.e. altitude of lowest glacier tongue, mean altitude of alimentation boundary, etc.) on major Central Asian glaciers. Climatic conditions during the ablation season are discussed as well as the existence of different ice formation zones.

Based on the author's analyses, certain previously held conceptions of precipitation distribution in Central Asia should be revised: the most arid Central Asian glacial region is not Eastern Pamir, but the interior of Kirgiziya, in particular the upper reaches of the Karadar'ya and the Lake Chatyr-Kul' area.

Yablokov, A. Reservoirs above the clouds.
Tekhnika molodezhi, no. 12, 1972, 13.

The world's highest hydrometeorological station (4200 meters above sea level), is located at the Fedchenko glacier in Tadzhikistan. For four decades Russian and Central Asian glaciologists have been studying the Fedchenko glacier, the largest in the Soviet Union (over 70 kilometers by 4 kilometers, 1500 cubic kilometer water capacity). Tadzhik glaciologists are also participating in the long-term project of compiling a catalogue of glaciers in the U.S.S.R.

Glaciologists currently note a temporary retreat of glaciation. The proposal has been made to spread a thin film of monomolecular compounds over certain glaciers in order to trap the evaporation from them.

V. Climate Modification

Gerardi, I. A. Rivers will yet flow upstream. Tekhnika molodezhi, no. 9, 1973, 30-34.

In 1966 the May Plenum of the CPSU Central Committee announced a long-range, comprehensive soil reclamation program which included preliminary planning for the diversion of surplus Siberian river water to the arid south. In the following interview, I. A. Gerardi, the chief engineer for the comprehensive Siberian river diversion program, discusses one of the most promising of the major reclamation plans under consideration in 1973.

The main artery of the projected Ob'-Caspian canal would originate at the confluence of the Irtysh and Tobol Rivers. Crossing the Turgay watershed, it would follow the meridian south until it intersects the Syrdarya near Dzhusaly and ultimately join the Amudarya where it emerges from the Sultan-Uizdag mountain range. Later the canal would be extended to the Artek River in southwestern Turkmenistan. In addition a reservoir and west Siberian branch of the trunk canal would be constructed at the Turgay River and extended to the Emba-Ural interfluve.

The engineering solution calls for the diversion of Siberian river water into reservoirs to be constructed near the confluence of the Irtysh and Tobol. The impounded water will then be raised by pumps to a height of 10-16 meters and channeled southward through the Irtysh flood plain to Zavodukovska on the Turgay plateau. There two-stage pumping stations will raise the water an additional 55-57 meters. After the Siberian water has gained an elevation of 70 to 75 meters it will run southward by gravity flow.

In order to meet agriculture's varying seasonal water requirements, a reservoir would be built at Mynbulak or Arys to regulate the flow of water from the canal to southwest Turkmenistan and the Syrdarya and Amudarya basins. In addition water will be pumped via branch canals to the lower reaches of the Chu, Talas, and Assa Rivers as well as into the area of

Chiili and Kyzyl-Kum irrigation systems of the Syrdarya. Inasmuch as a stable flow of water from the Syrdarya into the Aral Sea would be assured, water from the upper Syrdarya could then be both diverted into the basin of the Zeravshan River and used to irrigate the Farish, Nuratau, and Kyzyl-Kum steppes.

During the projected first phase, the volume of water to be diverted southward from the Irtysh and Tobol would be limited to 25 billion cubic meters of water per year. (The Ob' and the Yenisey together carry 700 billion cubic meters per year). During the second phase the volume would be doubled, and in the third phase should reach 75 to 80 cubic kilometers per year. However, in order to maintain the normal flow into the Ob', water from the Yenisey will be pumped into its tributaries such as the Ket' or the Chulym, then into the Novosibirsk reservoir, and from there via the Kulundin trunk canal into the Pavlodar reservoir on the Irtysh. Thus the Irtysh, supplemented by the "Kazakhstan" canal running from the Shul'binsk reservoir to the area of the Ishim, should meet the water needs of north and central Kazakhstan.

In hydrologic and economic terms a "second Volga" would be created: 3,000 kilometers in length, 400-500 meters wide, with a depth of 12-15 meters.

The possible climatological consequences of such large-scale environmental transformations must be weighed. For example, the heat regime of the Kara Sea could be adversely affected by the decreased outflow of water from the Ob'. This could in turn reduce the navigational period in the Ob' Bay. Thus during the first stage of canal construction, water intake would be limited to 2.5% of the total flow from Siberian rivers into the Kara Sea basin. During the second phase the total would rise to 5%.

The establishment of forest zones in the Kazakhstan steppes is an extremely important element in the comprehensive reclamation plan for Siberia. The author estimates that even without additional irrigation such a measure will increase productive grazing land by more than 280 million hectares.

Seregin, Yu. A. How can rain be generated?
Pravda Vostoka, 27 November, 1973, 4.

Artificial rainmaking was one of the central topics at the International Conference on Weather Modification recently held in Tashkent.

Reviewing the history of weather modification programs in the Soviet Union, the author (a member of the conference organizing committee and head of the section on Weather Modification in the U.S.S.R. Main Hydrometeorological Administration), notes that since the late 1940's — early 1950's Soviet cloud modification programs have been essentially based on academician Ye. K. Fedorov's "artificial crystallization" method. Artificial rainfall was first obtained in the U.S.S.R. by seeding supercooled stratus clouds.

According to the author, the U.S.S.R. has developed "a special method of cloud seeding" which introduces the seeding agent directly into the target clouds, "in contrast to the traditional foreign weather modification programs that rely on ground-based or airborne generators." The cited advantage of the Soviet method is that it does not depend on the highly variable vertical air currents.

In 1958 collectives from the Main Geophysical Observatory and the Ukrainian Hydrometeorological Scientific Research Institute helped develop a special meteorological testing ground ("polygon") in the Ukraine. The results of over a decade of meteorological research there show that in the Ukraine cloud seeding yields a 5-10% increase in precipitation during the cold months of the year. However this increase is necessarily localized, being limited to those areas with a certain precipitation potential.

Seeding frontal snow clouds yielded on a localized basis about a 30% increase in supplemental precipitation.

Soviet weather modification research on cumulo-nimbus clouds was also discussed at the Tashkent forum. Preliminary results indicate that the artificial stimulation of cumulo-nimbus clouds could increase precipitation about 15-20%. However further testing is still necessary to confirm these figures.

Rainfall artificially precipitated from convective clouds is being successfully used in combatting major forest fires. The savings to the Soviet economy are estimated at one to two million rubles annually.

<u>What will be the fate of the Baltic Sea?</u>
Komsomol'skaya pravda, no. 14(7132), Jan. 20, 1973, 4.

Oxygen has disappeared from the lower levels of the Baltic Sea. Possible large-scale corrective measures for this are under discussion, and include: (1) closing off the Danish Straits; (2) deepening the Danish Straits. However, non-intervention is also being considered, inasmuch as a longstanding lack of oxygen in the Black Sea has not had serious consequences. The anaerobic layer in the Black Sea extends a kilometer in depth, as opposed to twenty to thirty meters in the Baltic Sea.

Pokrovskiy, G. Climate to order: how to air condition a valley. Tekhnika molodezhi, no. 7, 1973, 18-19.

The ideal type of terrain for this weather modification system is a steep, narrow valley several hundred meters wide which is watered by a mountain river or stream. Water, diverted from the mountainside, is piped downhill to tall, "weather conditioning" columns equipped with nebulizers. The summer columns are situated above the zone being "air conditioned", the winter columns below it. In dry, hot weather several cubic meters of spray per second will remove enough heat from the air to cool the valley approximately 10° C. In winter the water sprayed from the air conditioning columns turns into snow, thus warming the air (given that during the freezing of water sufficient heat is emitted to raise by 10° C the temperature of a volume of humid air 8 times greater in mass).

In the Alma-Ata region, potential sites for this "air conditioning" system include the Medeo gorge and the narrow valley of Lake Issyk.

The Movement of Air in a Steep Valley during the Operation of the "Weather-conditioning" Nebulizer-Towers in Winter (Fig.1). and in Summer (Fig. 2).

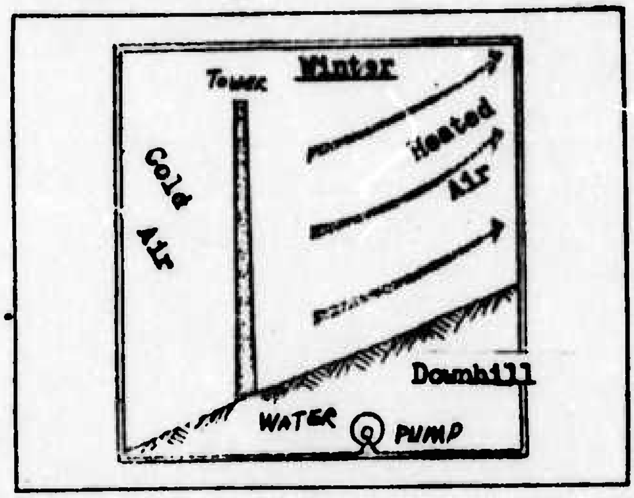


Fig. 1.

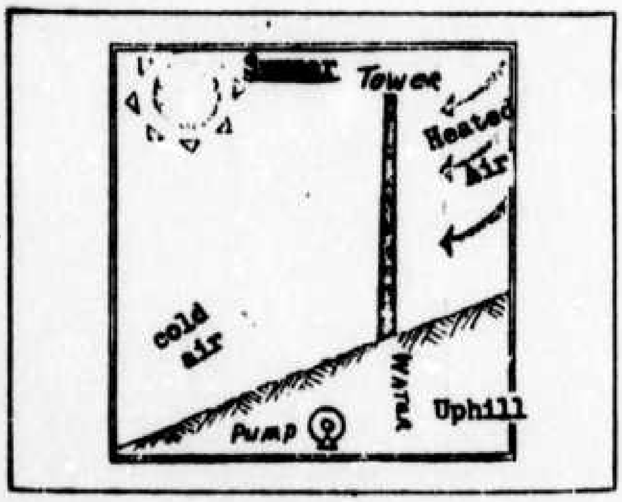


Fig. 2.

Korobkin, V. Cinderella wants to become a princess. [Potential solar climate modification projects.] Tekhnika molodezhi, no. 3, 1973, 26-27.

Economic considerations remain the major obstacle to the development of potential, large-scale solar projects. Projected for possible development by 2050 is an orbiting solar power station with a 10,000 megawatt capacity, sufficient to meet the power needs of a major city such as Moscow.

The development of an "artificial sun", or giant orbiting solar projector, capable of lighting broad areas of the Earth at night, is also technically possible now, according to Professor G. Pokrovskiy. A mirror reflector, three kilometers square, set in stationary orbit, would provide 20 to 30 times more light than the full moon. The size of the area illuminated would depend on the orientation of the mirror. At 60° latitude during the equinox the reflector's rays would cover an area about 350 kilometers across and about 700 kilometers in length. According to calculations, the energy from this reflector would not be sufficient to affect appreciably either the Earth's climate or weather.

Further proposed applications of reflector space technology include the use of a broad, orbiting lunar ring-reflector (possibly composed of lunar rock fragments) to moderate temperature extremes on the lunar surface -- a step toward climatizing the moon for man.

Fedorov, M. Extraordinary projects: what is the Moon's potential? Krasnaya zvezda, March 29, 1973, 4.

In order to make the moon's climate more hospitable to man, Czechoslovak scientists have suggested shortening the length of the lunar day and night. This would be accomplished by setting off controlled, underground explosions at the lunar equator which should cause the moon to revolve more rapidly.

VI. AUTHOR INDEX