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FOREWORD

The climatological studies of our country are not yet complete. Although there are statistical data for most USSR areas, in some cases for long periods of time, the above data are mostly averaged results of what has passed, and cannot serve as a basis for climatological considerations of the future. In many cases the statistical data are not supported by physical observations, and no clues are furnished as to the origin and subsequent development of climatological processes. This reduces considerably the reliability of deductions drawn from this data and their usefulness in the evolution of a detailed climatological analysis.

Information on the climate of various Territories of the Soviet Union must be made more precise, not so much by the passive accumulation of observation data, as by the method of physico-geographical study of the natural climatic zones, which are climatic units in our vast territorial expanse.

The purpose of this book is to segregate from the territory of the USSR precisely such natural climatic zones (defined by their climate-forming processes), and the resulting general weather cycles together with the order of values of their meteorological components. The climatic study of a territory is to proceed along these zones.

The climatic zone serves as the basic unit. It represents an area, within the limits of which there is a certain continuity of the meteorological circulation complex, which determines the perennial course of the weather, i.e. its climate.

When adjacent zones have analogous characteristics of prevailing air masses, they are incorporated into climatic units of a higher order of magnitude, i.e. into climatic regions. Thus, the distinguishing feature of a climatic region is the nature of its prevailing air masses, whose circulation pattern corresponds to the zones composing the region.

The climatic region may consist of only one zone if the circulation conditions of the prevailing air masses are homogeneous.

Areas, within whose limits local factors exert a substantial influence on the weather, without causing a change in the general circulation features, are considered as climatic sub-zones. Thus, on windward mountain slopes atmospheric precipitation is often observed on semi-discontinued fronts, where there is no precipitation in the adjacent valley. In other cases, when the same mountain slopes are leeward, a thinning out of cloud formations will take place over them. A locality, in which such variations occur, can be defined as a climatic sub-zone.

Within the zones and sub-zones there is a micro-climatic section with certain individual factors prevailing that do not influence the general evolution of zone or sub-zone weather.

The segregation and description of climatic sub-zones and micro-climatic sections are not within the scope of this book, since this is a subject for detailed climatological research in individual zones.

In the construction of a general zoning diagram, the following materials were utilized:

Climatic atlases /maps/ of the Main Geophysical Observatory (GGO) and the Synoptic Charts of the Central Forcast Institute (Ts IP).

In describing individual zones, the Climatological Handbooks of the Main Geophysical Observatory, plus descriptions by Republics and Regions, compiled jointly by the Main Geophysical Observatory and the Regional Hydro-Meteorological Administrations, and additional monographs and articles by various authors, were utilized.

Examples of the synoptic aspects illustrating the described processes were selected by V. M. Kurganskaya, Candidate in Geographical Sciences.

I take this opportunity to express sincere appreciation to express sincere appreciation to V. S. Volynskaya, Editor for the Publishing House, for her thoughtful and warm attitude, which hastened the appearance of the book.

B. Alisov

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CONVENTIONAL DESIGNATIONS FOR SYNOPTIC CHARTS OCCURING THROUGHOUT THE TEXT

Clear	○
Overcast	●
Light Wind	
Strong Wind	
Gusty Wind	
Lower Clouds	
Low Layer Clouds	
Fog	≡
Rain	⁝
Showers	
Snow	*
Heavy Snow	* *
Snowstorm	
Occluded Front	
Warm Front	
Cold Front	

Figures at Isobars designate barometric pressures in millimeters.

Figures at Stations designate temperatures.

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CLIMATE FORMING PROCESSES OVER THE EXPANSE OF THE USSR

The territory of the Soviet Union occupies an area of some 170 latitude degrees by more than 50 longitudinal degrees. West to east it extends almost from the Atlantic Ocean to the Pacific Ocean, and south to north, from the sub-tropical zone to the North Pole. This vast expanse of land, being summer-heated and winter-cooled, is the determining climatic factor for the greater part of USSR territory. Excepted from the above factor is a wide western belt, which is strongly affected throughout the year by the Atlantic, and a narrower belt in the east, which is affected in the summer months by Pacific air currents. The influence of the Arctic Ocean, facing the continent with its wide front, is, to some extent and in some form, felt throughout the entire territory of the USSR.

The effect of the continent itself, and the surrounding oceans, on USSR climate manifests itself in various ways depending on the season. In summer, the basic process for practically the entire USSR territory, excepting the coastal belt in the north and in the east, deals with the formation of warm continental air from the incoming Arctic, Atlantic and Pacific air masses. This is concerned with the initial warming up of the maritime air and its supplementary humidification. According to calculations, the newly arrived Arctic air over Moscow, in June, has a daytime temperature of around 13 degrees Centigrade and an absolute humidity of 7 grams per cubic meter; the Atlantic air, a temperature of 16 degrees Centigrade and an absolute humidity of 9 grams per cubic meter; the continental air, a temperature of 23 degrees Centigrade and an absolute humidity of 11 grams per cubic meter. However, since the air is warmed at a faster rate than it is humidified, the relative humidity, as a result of the change, is actually lowered. For the Arctic air, the relative humidity at noon is 45 percent; for the Atlantic air, 50 percent; for the continental air, 40 percent. Therefore, both the humidity deficiency and the evaporation rate increase.

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In the southern regions of the USSR, where the warming up process is particularly intense, the continental air of the Temperate zone is transformed into Tropical type air - approximating characteristics of air over Tropical deserts.

Upward transmission of heat and moisture in the changing air is due mainly to ascending currents, which are easily formed in the relatively cold maritime air masses moving over the warmed up continent.

The considerable heating up of the earth's surface and contiguous air over USSR territory during the summer is stimulated by the unusual astronomical conditions and nature of atmospheric circulation. For instance, due to the long day in the north, as in Yakutsk, insolation in clear weather may reach 90 percent as compared to Tashkent. At the same time, due to circulation conditions, cloud formations during the summer over the continental areas of the USSR, particularly the more southern parts, is not extensive. Thus, the astronomical factor - excessive summer insolation - assumes a still greater climatological value than usual. (See Figure 1 below).

In the central parts of the continent, due to prevailing anti-cyclonic circulation, sky cover is not excessive, and winds are not strong. Such conditions are conducive to the heating of the terrestrial surface and of the lower atmospheric strata.

Cyclonic activity in the summer (not counting that in the western and far-eastern areas) is directly connected with the Arctic front. This front is now located along the northern shoreline or recedes in the form of separate outcrops into the depths of the Arctic. Arctic front cyclones pass mainly over the northern areas, while the outcrops of high pressure - which divide them - together with the cyclone series enclosing the anti-cyclones advance into the middle areas. (Figure 2)

Figure 1:

Figure 1: Recurrence of Overcast in the Skies over USSR Territory in July.

Figure 2:

Figure 2: Cyclone Series Enclosing Anticyclone over Western Siberia in the summer (14 June 1937).

The Arctic air entering the enclosing anticyclone has very low moisture content, since evaporation /absolute humidity/ at near-zero temperatures is insignificant. The low-moisture content of the Arctic air and the downward motion in the anticyclones are reasons for the slight degree of sky cover developing over the central belt of the USSR interior.

Over Central Asia, where continental air is transformed into Tropical air, the smoothing out of temperature differentials between the incoming Iranian Tropical air and the local air, leads to occlusion of the fronts, and to a general reduction of cyclonic activity (Figure 3). The cloud formation over these areas during the summer is at a minimum.

Thus, the character of atmospheric circulation, being the cause of slight cloud formation over the area, promotes a greater insolation and accelerates the heat effect of the earth's surface upon the atmosphere. At the same time, the circulation itself depends largely on the warmed under-laying surface of the earth, which, in turn, has an effect on cyclonic activity by creating, in some areas, new seats of cyclonic disturbance, and suppressing same in other areas.

In generalizing, the following points must be emphasized:

1. The process of transformation of the incoming maritime air masses (moving into continental air), embraces, during the summer months, practically the entire territory of the USSR. And in practically every area, the warm continental air mass prevails. Thus, continental summers, even beyond the Polar Circle, are sufficiently warm to permit cultivation of some early-ripening bread and truck garden crops.

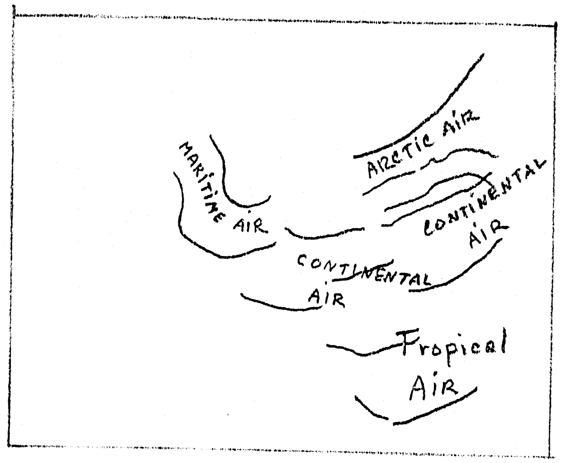

Fig. 3.

Figure 3: The Transformation of Arctic Air into Continental and Tropical Air over Western Siberia, Kazakstan and Central Asia (5 August 1936).

2. As a result of the heat gained in the transformation process, the incoming maritime air is additionally humidified, in terms of absolute humidity, but at the same time recedes from its saturation point. For example, the humidity of Atlantic air during its transformation into continental air, undergoes an average increase of 2 grains per cubic meter, but the saturation deficiency together with the evaporability increase by 8 grains per cubic meter. Evaporation of moisture from the earth's surface and vegetation, which accompanies the process of air transformation, is one of the most important components in the internal humidity turnover over the continent.

3. The summer transformation of the air masses (warming up and additional humidification) is mainly due to the underlaying surface of the earth. In winter the transforming of relatively warm air masses into cold continental air merely begins at the earth's surface, and continues in the free atmosphere under the effect of radiation of the air mass itself. Rising air

currents emerging from the earth's surface heated by the sun, carry the heat and moisture into the upper strata, thereby making the process general and hastening completion of the transformation. Thus, the climatological value of the continent is at its maximum specifically during the summer transformation.

The territory of the Soviet Union is an area of continental air formation during the winter as well. The winter transformation of Atlantic air into continental air consists in the cooling and desiccation of the air over the snow blanket. The transformation of the Arctic air into continental air, on the other hand, consists in warming up and humidification.

Astronomical conditions, which determine possible insolation and warming up of the earth's surface, as distinct from conditions prevailing during the summer, depend to a great degree on the geographical latitude of the area. The possible (in clear weather) insolation decreases rapidly towards the north. In Yakutsk, the maximum insolation in January, compared with same for Tashkent, is only 1 percent instead of 90 percent as in the summer. Therefore, in winter, the temperature drop in the continental air northwards is much more pronounced than in the summer. In Central Asia it is 5 degrees, in Trans-Baykal 25 degrees.

The circulation characteristics [in the winter], as well as in the summer, throughout most of the USSR, are favorable to calm and clear weather, with the exception of the north-western half of the European part, where overcast and winds prevail during the winter (Figure 4).

Figure 4:

Figure 4: Recurrence of Overcast over the Territory of the USSR in January.

In the winter, the effect of the underlaying terrestrial surface upon air masses is mostly limited to the lower [atmospheric] strata, as a result of which the effect upon the weather exerted by the incoming [air] masses is more pronounced and penetrates further inland. For example, in Chkalov the July temperatures, on different days, fluctuate from 15 to 30 degrees Centigrade, and in January from minus 30 to zero degrees Centigrade, or double the range. This is also due to the higher velocity of the air masses during the winter.

The cooling of the Atlantic air over the continental snow blanket is considerable only near the coast line. Within a short time a cold interstratification forms from below. This interferes with the vertical intermixing of the air and with the transmission of the cooling effect into the higher strata. In addition, maritime air over the interior areas is frequently driven upwards by the colder continental air, thereby losing its direct contact with the underlaying terrestrial surface. Subsequent cooling of maritime air is effected by gradual intermixing with colder air masses and radiation. Atlantic air is desiccated by condensation of its moisture on snow surfaces (a process which reverses that of summer evaporation), as well as by the considerable precipitation at the cyclonic fronts.

In its transformation into continental air, Arctic air is warmed rather slowly. This is due to the fact that, of the slight amount of solar radiation available to the middle latitudes during the winter, 70 percent is reflected back by the snow blanket. Humidification of Arctic air is due to snow evaporation — in all the USSR areas the relative humidity in the winter is 70-80 percent over the snow blanket.

However, the thermal effect of the terrestrial surface in the winter may be weakened by two factors: (1) the very low thermal conductivity of snow, which causes it to assume the temperature of the air moving over it; and (2) warm air arriving over the cold surface of the snow frequently forms radiation-retarding fogs. Under these conditions the terrestrial surface practically assumes a thermal neutrality with relation to the warm and cold air masses.

The cooling off of the bottom air layer directly over the snow blanket causes a near-surface inversion of temperature over the entire USSR continental area. This condition is disturbed only from time to time by strengthening of the winds in the wake of cyclones.

Temperature rise with altitude within the lower half-kilometer limit recurs so frequently during the winter, that it even affects the mean temperatures in all the mountainous regions of the Soviet Union, with the exception of Trans-Caucasia and the southern part of Central Asia. This inversion is particularly strong in the most climatically continental part of the USSR — in Eastern Siberia, where it is expressed in 20-25 degrees Centigrade for 1 kilometer of altitude.

The maximum formation of continental temperate air takes place over Siberia in the vast and stable anticyclones (Figure 5).

Figure 5. The Evolution of a Siberian Anticyclone (24 February 1936).

In the northwestern part of the USSR European territory and in the Far East, the migration of air masses and cyclonic activity are of basic importance. Here the part played by the geographical latitude becomes of secondary importance, while first significance is assumed by the circulatory factors of the climate. One look at the chart of winter isotherms makes one realize the climatic significance of advection (transfer) over these areas.

The migration of warm air from over the Atlantic to the European part [of the USSR] compensates temperature differentials due to geographical latitudes. Thus, the mean temperature for January on the Kola Peninsula is the same as in Central Kazakstan; in Leningrad, the same as in Astrakhan'. In Vladivostok, however, neither the geographical latitude (the latitude of Sochi), nor the seashore location, can hinder the effect of the cold East-Siberian air current (rising to an altitude of 4 kilometers), with the result that the January temperatures there are, on the average, colder by 3 degrees Centigrade than the January temperatures in Moscow.

Cyclonic activity as a climatic factor on USSR territory, has great significance, and is closely linked up with the two previously mentioned processes --- the migration and transformation of air masses. Prominent examples of the almost complete absence of fronts are found in the Trans-Baykal area in the winter and the Central Asia deserts in the summer. In both these areas there is practically no precipitation. But for cyclonic activity, other areas, too, would have a snow deficiency in the winter and a rain deficiency in the summer. Cyclonic activity, therefore, is prerequisite to moisture turnover on the continent, since moisture carried in from over the ocean is precipitated principally in cyclones.

Moisture precipitation directly from the maritime air masses takes place over the USSR principally in the winter. During the summer the moisture penetration deep into the continent proceeds first by humidification of the continental air masses, then by precipitation from these as they are carried into the interior by general atmospheric circulation. Only a comparatively small part of the moisture, in the form of so-called "unstable precipitations", is precipitated directly from the maritime air at the rear of cyclones.

Precipitation from continental air in the summer is either in the form of rapid and short convective showers, or long-lasting continuous rains. The latter are most important irrigationally, since the convective showers, although at times of high intensity, are of short duration, and involve only small areas. Furthermore, convective showers usually fall on terrain that has been over heated by the sun, with considerable re-evaporation taking place immediately.

Thermal convective precipitations, unaccompanied by noticeable temperature declines, are to be distinguished from cold front showers, frequently occurring against the background of continuous rains, and creating, together with the latter, long periods of overcast.

Continuous rains, furnishing the basic volume of precipitation on USSR territory, are cyclonic front precipitations. They fall from the continental and Tropical air masses which constitute the warm air of cyclones.

During the summer there are three zones of cyclonic activity over USSR territory.

1. The Arctic Front Zone

This zone is located principally along the northern shores of the Eurasian continent. Depending on the inflow-intensity of Arctic or Continental air masses, the Arctic front may be displaced in two directions. When displaced southward, it reaches as far as the central belt of the USSR, and the Arctic air fills the entire northern half of the European part. This causes a considerable decline in temperature, particularly noticeable at night, sometimes, in the form of light frost. On the other hand, the Arctic front may pass into the depths of the Arctic. In this case the warm continental air penetrates into the Arctic and is accompanied by a temperature rise up to 20 degrees Centigrade for the nearest islands.

In the Arctic front cyclones, Arctic and continental air interact. Atlantic air also is present at times in the European part of the USSR. Front precipitation falls from continental and Atlantic air (Figure 6).

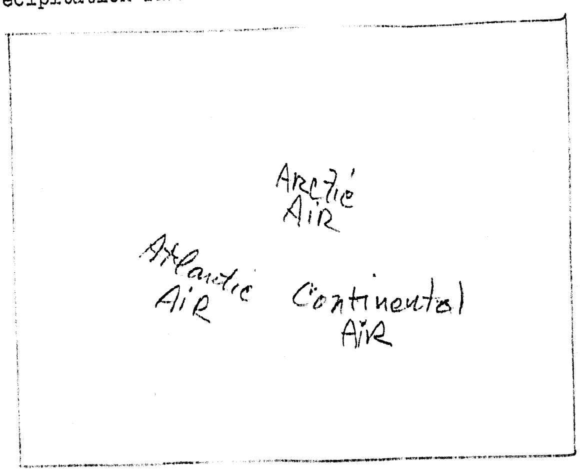

FIGURE 6:

Figure 6: Evolution of a Cyclonic Series at Arctic Front in the summer (9 June 1933).

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2. The Zone of Arctic-Front Occlusions

Occluded front cyclones are not fully independent formations, but represent a secondary form of the cyclo-genesis of the "polar" front. This divides the air of the temperate latitudes from the air of the sub-tropical belt. There are two outcrops of this zone on USSR territory — the European and the Far-Eastern. In occluded front cyclones there is interactivity of the maritime air (Atlantic in the European part and Pacific in the Far East) constituting the cold mass, with the continental air constituting the warm mass. When the warm continental air occupies a considerable area over the European part and overflows into the northern regions, the above mentioned cyclones pass northward and merge with the Arctic front cyclones. When the continental air fills only the southern part, the cyclones move eastward over the middle belt, and the Atlantic air penetrates into Asiatic territory. Since the continental air constitutes the warmer mass, warm front precipitation will follow.

3. Polar Front Zone

The name "polar" has been historically retained for that front which divides the air masses over the temperate latitudes (polar air) from the air masses of the subtropical zone (Tropical air). Over USSR territory in summer the polar front is present in the European part and in the southern part of the Far Eastern Maritime Provinces (Figures 7 and 8).

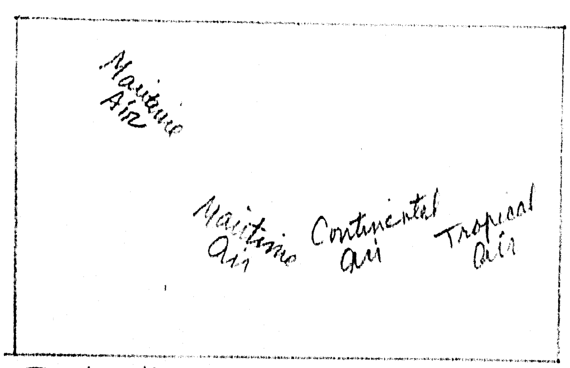

FIGURE 7: [illegible] the USSR (28 July 1935).

The European and the far eastern outcrops of the polar front differ somewhat in nature. The European outcrop is generated from time to time as a result of the double-phase transformation of maritime air, first into continental, and then from continental into Tropical. Between the air masses of the first phase of this transformation and those of the second phase, a new front is generated in conformity with the direction of the air currents. In its medium position, the European outcrop extends from the Crimea toward the Middle Volga. Sometimes the Tropical air reaches the Baltic and the White seas; sometimes it remains within the limits of the extreme southeastern areas without crossing the Volga.

Cyclones at the European outcrop of the polar front are generated primarily over the Ukraine. Precipitation falls from the Tropical air, which is humidified over the southern steppes and the Sea of Azov.

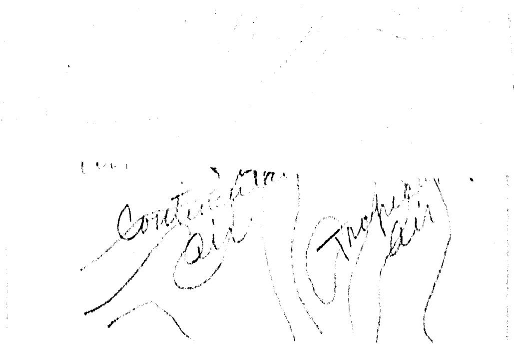

Figure 8: Summer Cyclone over the Far East (17 July 1938).

In summer the southern part of the Far East Maritime area is on the junction of two fronts: the continental East Asiatic Polar front, extending through Mongolia and North China, and the Pacific Ocean polar front, beginning in the Sea of Japan area and extending eastward over the Pacific toward the western shores of America. (Figure 9). During spring and at

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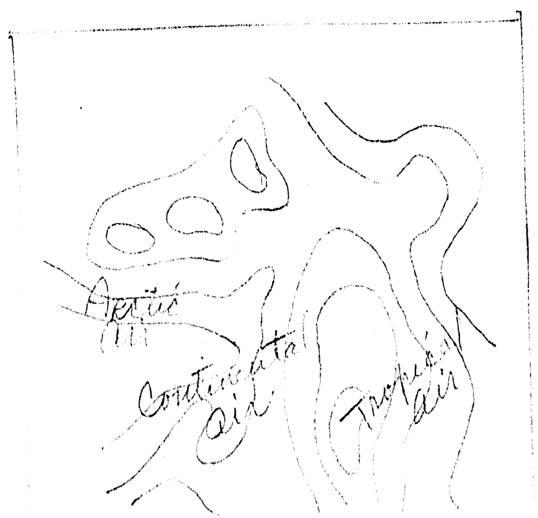

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the beginning of summer, as the subtropical high-pressure belt is displaced northward, and the Tropical air current flowing in the direction of the temperate zone is intensified, both of the above mentioned fronts are shifted from the south into higher altitudes. Toward the middle of the summer, the Far Eastern zone of the Polar front reaches the southern boundaries of Soviet territory.

As they move northward, cyclones of the Far Eastern Polar front are rapidly occluded. Secondary cyclones are frequently generated at these occlusions, since the contrast in temperature between the cold maritime air and the warm continental air of the temperate zone is sufficiently great (greater than at the occlusions of the European part). The distribution of air masses of various types in the Far Eastern cyclones may vary, but precipitation falls mainly from the Pacific Tropical air which is flowing along the western brim of the Pacific subtropical anticyclones. This southeast current of maritime Tropical air moves onto the continent in the form of occluded cyclones at an altitude of two kilometers and supplies the moisture for the monsoon rains

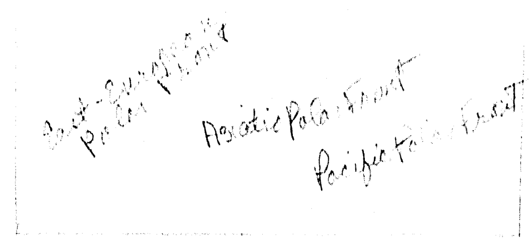

Figure 7.

WINDS:

Recurrence of Winds Within a Quadrant of the Horizon (Arrow points to center of quadrant).

→ 25 to 40 percent of all observations | → 60 to 80 percent of all observations
→ 40 to 60 percent of all observations | → over 80 percent of all observations

—— 760 ISOBARS

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——— 760 ISOBARS

Figure 9: Pressure Areas, Prevailing Winds and Frontal Zones over the USSR in the summer.

In the central part of the continent, over the territories of Kazakstan and Central Asia, the Polar front disperses in summer. This is due to the lack of sufficient temperature contrasts in the expanse of thoroughly heated air mass over the temperate and subtropical latitudes, to the dryness of these air masses, and to the absence of pronounced air currents inside the discontinued baric depressions. However, even in summer, cyclones are passing over Central Asia, but, due to the sluggishness of fronts over the plains, cloud formations in these cyclones are insignificant, and precipitation is rare. Only in mountainous areas, because of the turbulence in air currents caused by terrestrial configuration, the fronts in passing cyclones are reactivated, clouds appear, and moisture is precipitated. The map shows pressure distribution, wind distribution, and the location of frontal zones during July. The Arctic front zone during summer is hardly pronounced and, therefore, does not appear on the map.

During the winter, there are only two zones of cyclonic activity over the USSR:

1. The Arctic Front

The mean location of the Arctic front over the European part is about the same in winter as it is in summer, but the amplitude of its oscillations is greater. In winter the Arctic air sometimes extends as far as the Black Sea, and on rare occasions even penetrates into Asia Minor. Over Western and Central Siberia the mean location of the Arctic front is along the 70th parallel (70 degrees north latitude), but sometimes descends farther into the southern areas of Central Asia. In Eastern Siberia it passes over latitude 65 degrees north; in Kamchatka, over latitude 55 degrees north. Such location of separate outcrops of the

Arctic front is caused by special features of atmospheric circulation.

Two air currents force the Arctic front to the 70th parallel: the powerful southwest current of Atlantic air over the European part, extending along a trough of low pressure, and the southwest current of continental air over Western Siberia, extending along the northern periphery of the Siberian anticyclone. The Arctic air migrates to meet the southwest currents of the temperate zone with their east and northeast winds. Thus, the Arctic front over these areas is rather turbulent.

Over Eastern Siberia the north current prevails, and in the eastern part of the Siberian anticyclone, the Arctic air, too, extends considerably farther to the south. But since there is no stable counter-current from the temperate latitudes, the frontal processes are rather sluggish -- sky cover is slight, precipitation is low, snow blanket insignificant, with an exceptionally deep freezing zone penetration of the earth's surface.

Over Kamchatka, on the approaches to the western brim of the Aleutian depression, migration of air from the north is intensified, and the Arctic front zone descends even farther to the south. At the Aleutian outcrop of the Arctic front, cyclonic activity is re-intensified, due to the southwest counter-current from the temperate latitudes, with an attendant increase in sky cover and moisture precipitation. The southern part of Kamchatka has one of the heaviest snow blankets.

In addition to the self-contained cyclo-genesis at the Arctic front, there is observed a re-generation of semi-extinguished Atlantic and Mediterranean cyclones, after they have passed over the European territory of the USSR. Although these cyclones usually are regenerated while still over European territory, this activity is particularly important to the subsequent development of cyclonic activity over Western Siberia.

Precipitation from Arctic front cyclones falls from continental air as it does in the summer. But in the regenerated cyclones of Atlantic origin, precipitation falls from the Atlantic air. This circumstance also affects the amount of precipitation.

2. Occluded Fronts

Cyclonic activity at polar front occlusions develops during winter over European territory and Central Asia. The occlusions passing over European territory are a part of the Atlantic Polar front, or of the Mediterranean outcrop. In the first case, the occluded front cyclones move from the west; in the second case, from the south and southwest. In both cases the maritime air constitutes the warm front from which precipitation falls, while the continental air constitutes the cold front. This interrelationship is, therefore, the reverse of that observed during the summer (Figure 10).

Figure 10:

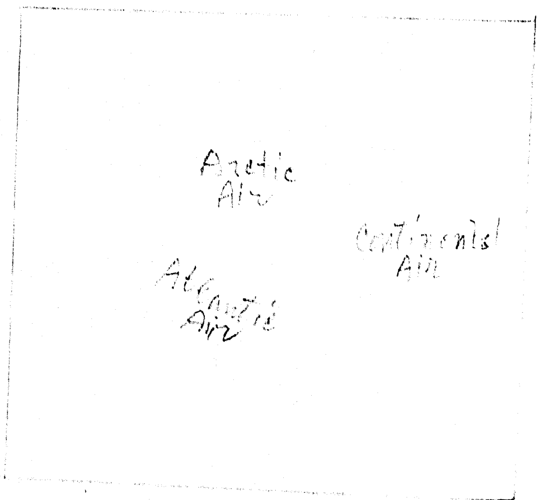

Figure 10: Winter Occlusion Cyclone Over the European Part of the USSR (18 February 1938).

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Figure 11;

Figure 11: The Depth of the Snow Blanket on USSR Territory.

The principal paths of occluded front cyclones over the European part pass from the southwest to the northeast. In connection with this, the amount of precipitation and the depth of the snow blanket decrease in a southeasterly direction. This connection between the depth of the snow blanket and the frequency of the passing of Polar front occlusions carrying maritime air, can be traced throughout most of the USSR territory. An exception is found in the extreme southern areas, where the smaller amounts of snow are due not only to precipitation deficiencies, but also to frequent thaws. (Figure 11).

The snow blanket is light in the northern areas of the Asiatic mainland, where precipitation falls only at the Arctic front from continental air.

In Central Asia, occlusion cyclones are linked with the Iranian outcrop of the Polar front. This outcrop passes over the southern part of Iran in winter. It constitutes the southern limit for the extension of continental air formed in winter over the temperate and subtropical latitudes of Asia. The warm sectors of these cyclones are filled principally with continental air from the southern areas, while the cold sectors contain continental air of a more northerly origin. The temperature differential between the warm and cold masses in these cyclones is small, and moisture content of the continental air is also small. Thus, these winter occlusion cyclones over Central Asia are not very active, and precipitation from them is slight.

Cyclonic activity during winter over USSR territory promotes the external moisture turnover. During summer, on the other hand, frontal precipitations from continental air constitute a phase in the internal moisture turnover. The chart below depicts the distribution of pressure areas, winds, and frontal zones for the month of January (Figure 12).

During spring and fall, cyclonic activity over the USSR undergoes modifications.

In the European part, occlusion activity diminishes in spring and fall, since during the transition seasons a change of algebraic sign in the thermal ratio between the maritime and continental air takes place, with an attendant leveling of temperature differentials between the respective air masses. This transition period is short, lasting only one month in the spring and one month in the fall. April and October are the transition months for the central areas of the European part. With reference to synoptic observations, March is the end of the cold period; May, the beginning of the warm period; September, the end of the warm period; and November, the beginning of the cold period. Characteristic of the cold and warm cycles is the algebraic sign of the temperature differential between the continental and maritime air. In summer the differential is positive, in the winter it is negative. In March the warm sector of the occlusion cyclones is still filled with maritime air from which there is frontal precipitation. In May the warm sector contains continental air from which there is frontal precipitation, and only in the rear of the cyclone there is casual and meager precipitation from maritime air. The same phenomena, but in inverted order, are observed in fall.

The leveling off of temperature differentials at the fronts causes these fronts to become sluggish. Precipitation then assumes a lingering characteristic, particularly in fall when the air masses are gradually cooled off and there

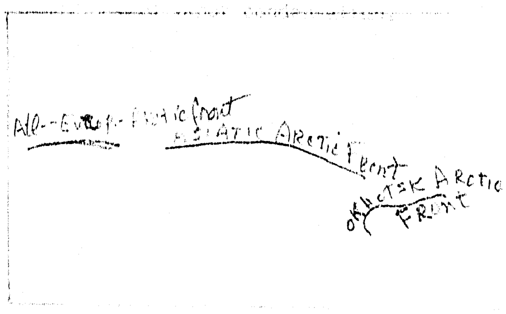


FIGURE 12

Recurrence of Winds Within the Limits of a Quadrant of the Horizon.

→ From 25 to 40 percent of all observations → From 60 to 80 percent of all observations

→ From 40 to 60 percent of all observations → Over 80 percent of all observations

Figure 12: Pressure Areas, Prevailing Winds, and Frontal Zones over the USSR in Winter.

Over Central Asia cyclonic activity reaches its maximum in spring. The highest temperature differentials then prevail between the still cold continental air and the Tropical air arriving from a high-pressure belt. The Iranian Polar front then begins to move north...

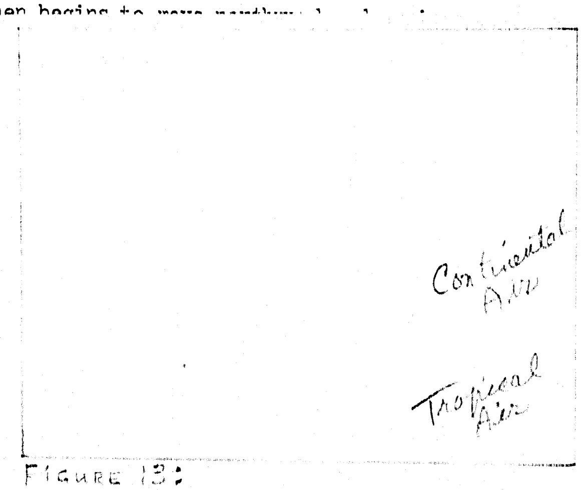
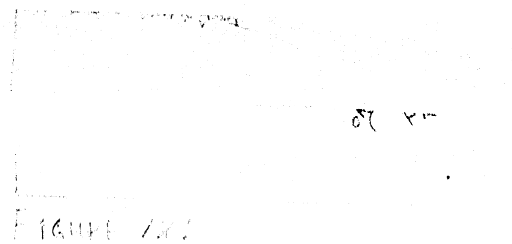


FIGURE 13:

Figure 13: Spring Cyclone over Turkmenia.

The leveling off of temperature differentials at the fronts causes these fronts to become sluggish. Precipitation then assumes a lingering characteristic, particularly in fall when the air masses are gradually cooled off and there is a general tendency toward vapor condensation.



Recurrence of Winds Within the Limits of a Quadrant of the Horizon.

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Figure 12: Pressure Areas, Prevailing Winds, and Frontal Zones over the USSR in Winter.

Over Central Asia cyclonic activity reaches its maximum in spring. The highest temperature differentials then prevail between the still cold continental air and the Tropical air arriving from a high-pressure belt. The Iranian Polar front then begins to move northward and arrives over the territory of Soviet Central Asia (Figure 13).

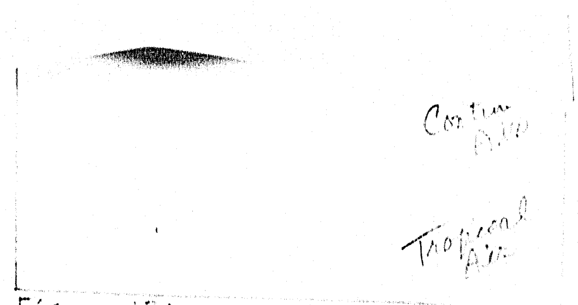

Figure 13: Spring Cyclone over Turkmenia.

The occlusion cyclones which passed in the winter are replaced by the main front cyclones. An increase in temperature variation accompanies this replacement, since continental Siberian or Arctic air with a temperature close to zero degrees Centigrade follows immediately in the wake of the Iranian Tropical air, which has a temperature up to plus 30 degrees Centigrade when it enters the warm sector. The Iranian air after the winter rains in Iran still contains ample moisture, with the result that in the spring there is maximum precipitation over the plains of Central Asia.

In the Far East, there is a gradual discontinuance in the autumn of summer cyclonic activity and the evolution of the anticyclonic cycle. Autumn, moreover, is the most probable period for the appearance of typhoons, which are the Tropical Pacific cyclones regenerated at the Polar front. They are distinguished by winds of exceptional force as well as by abundant precipitation. The central typhoon area passes to the southeast of the Soviet shore, but the related precipitation areas sometimes extend to the southern part of the Maritime Provinces, with abundant showers and, in late autumn, snowfall.

Such are the general conditions of the migration and transformation of air masses and cyclonic activity over USSR territory. We will now turn to the investigation of these processes in individual areas.

THE EUROPEAN TERRITORY OF THE USSR

The European territory of the USSR is not distinguished by diversity of climate, and the regional and zonal segregations are rather large in size. The manner in which climatic conditions are distributed over this territory — a vast, nearly unbroken plain — depends on basic climatological factors, such as radiation balance and atmospheric circulation. Terrestrial configuration and other supplementary factors are not essential.

The inflow and outflow of radiation [the radiation balance] within the limits of the European part, shows little variation, and is predominantly governed by conditions of atmospheric circulation. In the winter, when radiation inflow particularly depends on the geographic latitude, the sky cover over most of the European part is 80 percent. In summer, with considerably less sky cover, solar radiation, for astronomical reasons, depends little on the geographic latitude of a location.

by conditions of circulation, including the migration and transformation of air masses and the cyclonic activity at the fronts, the European part of the USSR can be divided into three climatic regions, as follows:

1. The Northern Atlantic-Arctic Region

In this region, as compared to others, the influence of the Atlantic Ocean and the Arctic predominate. The northern boundary of this region, to the west of the White Sea, lies beyond the continental limits, since, in the winter, the Arctic front passes over the sea of Barentz (Figure 12), and, to the south of this front, air masses of the temperate latitudes prevail. To the east of the White Sea, the boundary runs along the Polar Circle, coinciding with the southern boundary of the tundra. The southern boundary runs from Lake Ladoga to the source of the Pechora River. In the winter it is the region of migration of the air masses and of cyclonic activity at the Arctic front, and in the summer it is the region of progressive heating and transformation of the Arctic air.

2. The Central Atlantic-Continental Region

Here the Atlantic and continental air masses prevail, and cyclonic activity develops at the Polar front occlusions. Its southern boundary runs from the central part of the Dnestr River to the Middle Volga. In the winter the principal /meteorological/ process over this region is the migration /of air masses/; in the summer it is the formation of continental air.

3. The Southern Continental Region

This is the principal region for the transformation of air masses migrating toward the European part of the Soviet Union during the entire year. In the winter, continental air is formed from the Atlantic and Arctic air masses; in the summer, warm continental air is formed as a transitory stage in the formation of Tropical air.

Each one of these three regions is divided meridionally into a west and east zone. In the western zone, those processes prevail that originate over the Atlantic and over Western Europe; in the eastern zone, those processes that originate over the eastern part of the continent prevail. The climatic boundary between the western and eastern zones of the Atlantic-Arctic region coincides with the meridian followed by the Northern Dvina River, nearly bisecting this region. In the Atlantic-Continental, and particularly in the Continental region, this boundary shifts westward, and runs from the source of the Volga to the estuary of the Dnepr. Such shifting of the boundary to the west probably indicates that the continental features of the climate in the European part of the Soviet Union become more pronounced to the south; in this sense, the "mildest" climatic conditions are those prevailing in the Atlantic-Arctic region.

In addition to the western (Atlantic) and eastern (Continental) zones of the continental climatic region, it is necessary to define the Mediterranean zone, occupying the high-altitude part of the Crimea and its southern shore.

The northern littoral of the Caspian Sea, due to circulation characteristics prevailing there, is relegated to the Central Asiatic climatic region.

The zones indicated above are natural climatic zones in the sense that in each one of them definite characteristic cycles of radiation and circulation predominate. These cycles determine the course of the weather and its meteorological components.

The climate governing circulation processes over the European territory of the USSR is of a rather fluctuating nature, particularly, with reference to the location of zones of cyclonic activity and anticyclones. The latter areas, where the transformation of the air masses begins, may shift considerably within the period of a year. Such shifting will cause the boundary lines of climatic zones, situated on a plain unbroken by adequately prominent terrestrial configurations, to become diffused and transformed into wider bands.

The direction of the migration paths followed by the air masses over the European part of the USSR coincides basically with the mean distribution of pressure; this points to the stability of circulation. However, this large scale stability, dependent on the distribution of land and water masses, does not assure the existence of what is usually referred to as stability of climate, of a zone. A slight yearly shifting of the zones of cyclonic activity may considerably affect the weather characteristics of a certain zone or extended belt, without changing substantially the mean distribution of pressure for the same period of time. Generally speaking, the further a given region is from the zones of cyclonic activity, the more stable is its climate. Cyclonic activity is of particular importance over the European part of the USSR, specifically over the more northerly zones; this causes great variability in the climate of the latter.

The distribution of air masses over the European part of the USSR is illustrated by the maps showing recurrence of the basic types of air masses, in accordance with A. F. Dubuque (Figures 14 and 15). These maps were composed from data over a six-year period (1934-1939). Yet, the basic regularities, dependent on the above described circulation conditions are clearly defined even during this comparatively short period.

FIGURE 14: FIGURE 15:

Figure 14: The recurrence of basic types of air masses over the European part of the USSR in winter (from A. F. Dubuque).

Figure 15: The recurrence of basic types of air masses over the European part of the USSR in summer (from A. F. Dubuque).

The Arctic air arrives over the continent more frequently in summer; in winter its entrance is hindered by west and southwest currents. Nevertheless, during the winter the Arctic air penetrates farther south, since during the summer its transformation into continental air proceeds at a more rapid pace. In its migration, the Arctic air is carried more frequently over the eastern zones than over the western zones.

The Atlantic air, similarly, makes a deeper penetration over the continent in winter. This depends, on the one hand, on the value of the pressure gradient force, and, on the other hand, on the more rapid transformation of this air in the summer. The Atlantic air extends mainly over the northern half of the European part of the Soviet Union. In the southern zones, its entrance is observed much less frequently.

Tropical air, migrating from the southeast, is observed over European territory mainly in the summer. The entrance of Tropical air is regularly observed over the Atlantic-Continental region, predominantly over its eastern half.

Continental air is the basic air mass over the major part of the European territory, particularly its southern half. The recurrence of continental air is determined on the above maps as a value complementary to 100 percent /100 percent being the sum total of all the air masses7. The recurrence of continental air over the southern half in summer amounts to 60-70 percent, in winter, 80 percent and more; over the Atlantic-Arctic region it amounts to 20-30 percent in summer, and 40 percent in winter.

Mean temperatures over the European territory of the USSR are to be considered as resultants of the type of recurrence of air masses of various characteristics over the various zones. (Figures 16 and 17)

FIGURE 16:

Figure 16: January Isotherms

FIGURE 17:

Figure 17: July Isotherms

The disposition of isotherms in the winter is characterized by their sharp deflection northward from the lines of the parallels, so that they run from north-northwest to south-southeast. Almost everywhere, with the exception of the southern zones, the deflection angle is above 45 degrees. In the western half, it results mainly from the migration of Atlantic air; in the eastern half, from the migration of continental air from the more southerly zones; in the northern region, from the central region; in the central region from the southern region. In the southern zones, where the continental air either constitutes the local air mass, or is arriving from the east (not from the south), the isotherms show little deflection, and this deflection results not so much from the inflow of warm masses from the west, as from the inflow of cold masses from the east.

In the summer, the isotherms are deflected in the opposite direction, but to a lesser degree than in the winter. The falling of the mean temperature westward, and its rising in an easterly direction, is the result of a dual influence: the entrance of Atlantic air over the west and Tropical air over the east.

The shift in the disposition of isotherms from winter to summer, and vice-versa, takes place more or less simultaneously over the entire territory: in the spring in April, and in the fall in September. In May the continental air is warmer everywhere than the maritime air; in October this is reversed.

The geographical temperature distribution depends on the percentage ratio (recurrence) of the various types of air masses over the zones of a given territory. The distribution of atmospheric precipitation and sky cover depends mainly on the cyclonic activity. Thus, the location of the zones of cyclonic activity, and the intensity of the latter, are reflected in the distribution of sky cover and atmospheric precipitations.

The distribution of atmospheric precipitation for January and July is shown in Figures 18 and 19.

FIGURE 18:

Figure 18: Amount of Precipitation in January.

FIGURE 19:

Figure 19: Amount of Precipitation in July.

In the winter the distribution of precipitation and overcast is more homogeneous than in the summer. Over most of the territory, the recurrence of overcast in January is 70-80 percent, and in a month's time there is 30-40 millimeters of atmospheric precipitation. Only over the southeast zones and over the extreme north is there less overcast and less precipitation. This is due to the fact, that high pressure areas pass over the above zones, and linger over the southeastern zone. Over the rest of the territory, in various places, cyclones pass in the winter (their direction prevailing from west to east and following rather varying paths). Passage of these cyclones results in a rather even distribution of atmospheric precipitation.

In the summer the cyclone paths are more definite; they run predominantly from the southwest to the northeast or directly from south to north. Thus, the southeastern European part remains out of the main path of the cyclones, with a resulting deficiency in atmospheric precipitation.

During the transitional seasons, the most important phenomenon is the thermal upswing in the spring and its downswing in the fall /heat transfer/. Of the processes, which cause a rise in temperature in the first half of the spring, the most important is the migration of warm air from the south. This comes about in the following manner: a low pressure area is over the Baltic, while a high pressure area is over the inland seas of Aral and Caspiy /Caspian Sea/; along the southeastern rim of the low, and the western rim of the high, southwesterly and southerly currents are generated; along these the air of the Atlantic-Continental and the Continental regions flows into the Atlantic-Arctic region, and into the southern zones flows the still warmer air from the south of Europe, Iran, and Central Asia. Figure 20 gives an illustration of such a synoptic disposition.

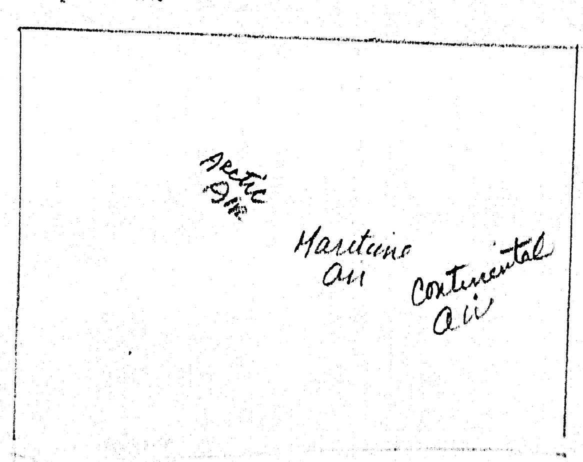

Figure 20: Heat Transfer Conditions in Spring (25 April 1939).

In the autumn the characteristics of the atmospheric processes over the European part are predicated upon the gradual cooling of the continent; this cooling causes an increase in atmospheric pressure and the evolution of anti-cyclones. Over the Asiatic part, the increase in pressure becomes evident as early as September, and over the southern half of the European part, in October; at the same time an intensification of cyclonic activity takes place over the Atlantic-Continental regions. This synoptic situation is illustrated in Figure 21

FIGURE 21:

[illegible]

The Atlantic-Arctic Region

The climate of a region is formed mainly under the effect of the migration of air masses, relatively warm during the winter and relatively cold during the summer, as well as under the effect of cyclonic activity.

Of predominant importance in the winter are the southwestern air currents. These may consist of a current of Atlantic air extending itself along the southern periphery of the cyclones and passing over the Sea of Barents, or they may consist of a current of continental air from the Atlantic-Continental region, flowing in along the northwestern and northern rims of the high pressure areas.

Over the western half of the Atlantic-Arctic region (the Kola Peninsula and Karelia) Atlantic air predominates, and over the eastern part (the territory of the Arkhangel region and the Komi ASSR), continental air predominates. It is easily seen that this is the result of pressure distribution. An example is the synoptic disposition of 2 November 1935 (Figure 22).

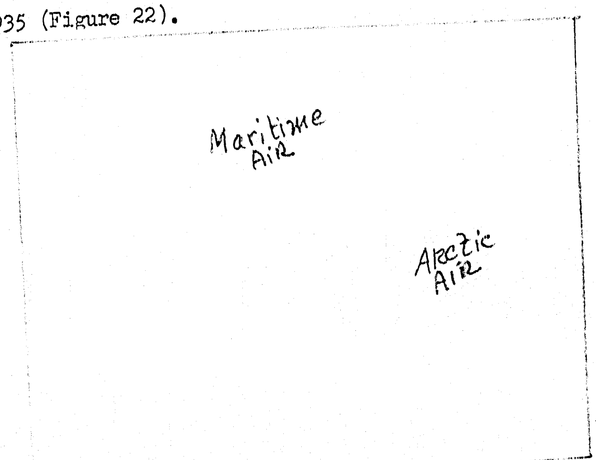

FIGURE 22.

Figure 22: Southwestern Penetrations of Atlantic Air Over the Western Half, and Continental Air Over the Eastern Half of the Atlantic-Arctic Region of the European Part of the USSR (2 November 1935).

The weather in the current of Atlantic air is warm (minus 2-3 degrees Centigrade), windy, overcast, with low-altitude stratified clouds and slight precipitation, as a result of general radiation cooling of the air masses. The temperature in the continental air current is minus 10-15 degrees Centigrade, the sky is predominantly overcast, with occasional clearing, and there is usually no precipitation.

The penetration of Atlantic air is preceded by the formation of warm front sectors, enclosed by cold sectors. At these fronts occurs the basic amount of precipitation upon which the depth of the snow blanket depends.

Particularly striking is the effect of the warm Atlantic air current over the Kola Peninsula, with its greater part beyond the Polar Circle. By the weather characteristics in the winter, the entire territory of the peninsula could be relegated to the middle latitudes. Two outstanding characteristics of the climate in maritime middle latitudes are observed here: ample snowfall and tremendous sleet formation. The generous snowfalls cause snow avalanches in the mountainous regions, similar to those occurring in the Alps and in the Caucasus.

In addition to the Atlantic and continental air of the Central region, the Arctic air also penetrates into the Atlantic-Arctic region. The character of these penetrations depends on the disposition of the Arctic front. When the Arctic front is over the Sea of Barents, the Arctic air mass penetrations into the continent proceed with the active pressure intensification ridges. These penetrations divide the cyclones, and are, therefore, of short duration. Cooling effects alternate with new warming effects, as the [pressure intensification] ridges pass to the east and are replaced by cyclones. The most powerful penetration, in the sense of duration, takes place in the wake of cyclonic series, within the enclosing anticyclones. By the time an enclosing anticyclone is evolved, there is a considerable shift of the front southward, and the Arctic air fills the entire Northern region.

Usually, the Arctic air penetrating into the western and eastern zones of the Atlantic-Arctic region is of different origin and characteristics. In the west it is maritime Arctic air, warmed up in its lower strata over the Greenland Sea and over the ice-free part of the Sea of Barents, coming over the continent with this warm interstratification (the temperature sometimes close to zero). In the east it consists of considerably colder so-called continental Arctic air from the ice fields of the Central Arctic, with a temperature of minus 30 degrees Centigrade or even lower. The synoptic disposition of 21 December 1939 may serve as an example (Figure 23).

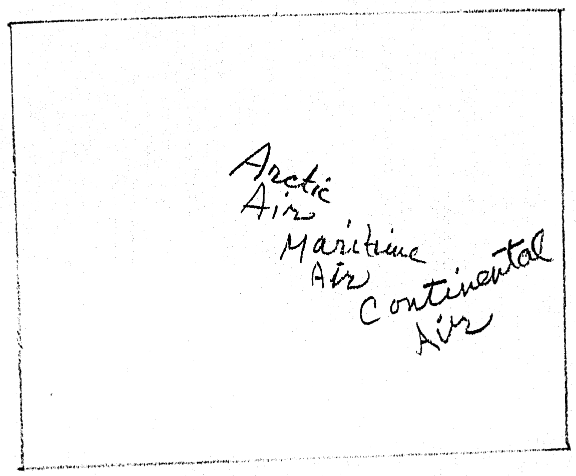

FIGURE 23.

Figure 23: Penetration of Arctic Air into the Atlantic-Arctic Region (21 December 1939).

In the wake of the cyclone departing eastward, cold continental Arctic air moves into the northeastern zones, while the relatively warm maritime Arctic air flows toward the Kola Peninsula.

Typical weather in maritime Arctic air is a turbulently varying sky cover, violent gusts of wind, and short lived precipitations, called "charges" by local seacoast inhabitants. In continental Arctic air the weather is relatively calm, with slight sky cover and strong frost.

The formation of local continental air over the Atlantic-Arctic region is observed rarely, and has no essential climatic significance, since the prevailing conditions of circulation are rather favorable to the inflow of "foreign" air masses.

The mean winter temperature depends on the number and duration of these penetrations. Penetrations of Atlantic air into the western half of the Atlantic-Arctic region are most frequent. To the east the number of penetrations decreases, and is accompanied by a decrease in the mean temperature. Also of considerable importance are the variations in the temperatures of the Arctic air masses. The maritime Arctic air penetrating into the western zones is warmer, on the average, by 25 degrees Centigrade than the continental Arctic air flowing into the eastern zones. As a result, temperature differentials between the western and eastern zones of this region during winter average 5 degrees Centigrade.

As for example:

Mean Temperature

	Dec.	Jan.	Feb.	March
Imaudra (67° 44' N; 33° 2' E)	-11°	-13°	-13°	-9°
Pustozersk (67° 35' N; 52° 11" E)	-15°	-18°	-17°	-14°

The differentials in the maximum low temperatures are more pronounced. In the Atlantic-Arctic region maximum low temperatures are usually the result of local thorough chilling of the Arctic air in clear and calm weather. The longer the duration of this chilling process, the lower the temperature will fall. On the Kola Peninsula, even in the interior, the maximum low is minus 40 degrees Centigrade (except, perhaps, individual non-draining troughs), since calm and clear weather does not last long there. In the northeast of the Komi ASSR the maximum low temperature may descend to minus 50 and even minus 55 degrees Centigrade (when a stable anticyclone is formed). On the other hand the maximum high temperatures, caused by the most intensive penetrations of Atlantic air, may reach 1-2 degrees above zero Centigrade in both the western and eastern zones.

Winter precipitation in the Atlantic-Arctic region, as already mentioned, comes principally from the Atlantic air. Its distribution depends on cyclonic activity, the frequency and basic direction of the passing fronts. Within the limits of the western half of the Atlantic-

Arctic region, the occlusion fronts, at which there is precipitation, predominantly move from southwest to northeast. As the Atlantic air advances in this northeasterly direction, the amount of precipitation decreases. It would seem that the thickness of the snow blanket should be at its maximum in the southwestern zones. The reverse, however, is the case. The thickness of the snow blanket decreases noticeably toward the southwest. In the south of Karelia its average thickness is 50-60 centimeters; on the territory of the Komi ASSR it reaches 80 centimeters. This is caused by the following: (1) in the eastern half of the region the snow blanket gets a head start of a half month due to the earlier arrival of low temperatures; (2) in the western zones the snow is compressed as a result of warm penetrations, and is also partially melted during the winter thaws.

By characteristics of circulation and weather, the duration of the winter in the Atlantic-Arctic region, with the exception, perhaps, of the most southern zones, is from November through March. Circulation conditions vary, not only from autumn to winter and from winter to spring, but during the winter season itself. During the first half of the winter, circulation is characterized by the intensification of the Atlantic air current, during the second half, by the development of high pressure areas over the European sector of the Arctic and the subsiding of the western current. As a result of this, February is frequently colder than January, and sometimes March is colder than February.

Toward the end of the winter, with the development of high pressure areas, sky cover diminishes. During the month of March there is much sunshine accompanied by frost, in contrast to the overcast, windy, and mostly damp winter weather. In general, March has the smallest amount of sky cover.

Spring in the Atlantic-Arctic region is characterized by the intensification of the Arctic air inflow, which is also accompanied by an increase in its temperature. In April the temperature of the Arctic air over the northern zones is about minus 5 degrees Centigrade, and in May, about plus 3 degrees Centigrade; this rise results from the heat the Arctic air receives while passing over the continent, since the temperature over the central Arctic at this time of the year is considerably lower. In the spring the temperature of other air masses increases rapidly; this is particularly true of continental air, which at the beginning of May is already warmer than the Atlantic air.

In the spring, the continental air migrates principally from the Atlantic-Continental region. Therefore, the rise in temperature is to be linked with the beginning of the heating process which the continental air is subject to over this region. The inflow of Atlantic air in the spring is decreased, and is at its minimum in May.

During the month of May the mean temperature level gradually passes across the zero point, and at the same time the snow blanket dwindles. This dwindling of the snow blanket, dependent on the location of zones within the Atlantic-Arctic region, to the north or to the south, goes on for a period of almost a month. In the southern zones the snow disappears by the beginning of May, in the northern zones, by the end of May.

June can be considered, to a considerable degree, a spring month, particularly in the north, where there is still snow in the ravines, and the lakes are just beginning to come free of the ice. Warm weather in June is still not too reliable, and even in the southermost zones penetrations of Arctic air cause overnight freezing which is destructive to many agricultural plants. The day temperature of the Arctic air in June is plus 10 or plus 12 degrees Centigrade. During calm and clear nights, the temperature may drop to zero and even below. Microclimatic conditions decidedly affect these fluctuations. For instance, the temperature will drop below zero, particularly in those locations over which the air is less active, as over depressions and forest clearings. The eastern zones in particular, because of Arctic air penetrations, are subject to these nightly freezes.

The summer season in the Atlantic Arctic region extends from the end of June through July and almost to the end of August. Climatic differences between the western and eastern zones are less pronounced during the summer. From west to east, the warming of the Arctic air and its transformation into continental air constitutes the basic process throughout summer. Isotherms, therefore, are disposed latitudinally, and everywhere temperatures increase to the south. The temperature rise southward is caused not so much by the warm air inflow from the south, as by the warming of the Arctic air moving over the continent, since over this region, northerly winds prevail in the summer, while southerly currents are rare. Sky cover conditions, too, are relatively favorable to the warming of the air masses. Through July and August sky cover is somewhat above 50 percent.

At times, in addition to the continental air from the central region, there are penetrations of tropical air from the southeastern zones, with temperatures reaching 30 degrees Centigrade even in the northernmost zones. Such penetrations are infrequent, yet normal for the Atlantic-Arctic zone, particularly, in the east. As an example, the synoptic disposition of 16 August 1935 (Figure 24) can be cited.

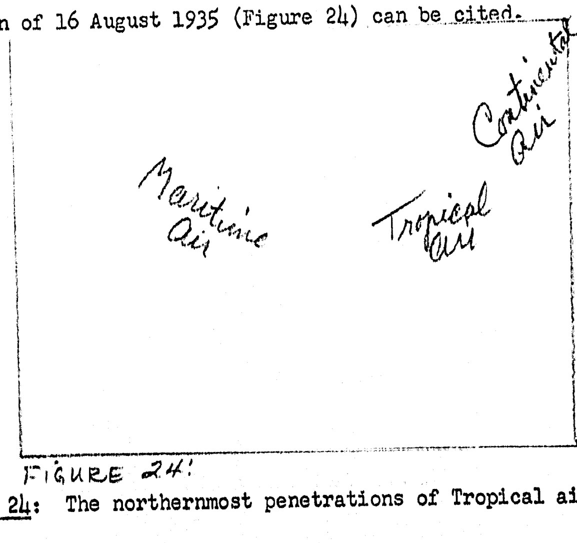

FIGURE 24!

Figure 24: The northernmost penetrations of Tropical air (16 August 1935).

On the whole, summers in the Atlantic-Arctic region are not altogether warm, and the amount of precipitation, although not excessive, is ample. This results in considerable relative humidity, particularly in the northern coastal area, where it can be considered as high. In the southern zones, relative humidity during the day is about 60 percent; in the northern zones it reaches 70 percent. The amount of monthly precipitation averages 70 millimeters. Amount of precipitation increases toward the south and decreases toward the north. From west to east, the variations are insignificant.

In the extreme north only the layer of Arctic air contiguous to the earth is warmed, since the air arriving from the Arctic will sometimes be stratified in stable equilibrium to an altitude of 200-300 meters, and incapable of developing convection. At the same time the damp surface of the earth is a poor absorber of the oblique radiation of the sun (the mean July temperature of the soil at a depth of 10 centimeters is below 15 degrees Centigrade). The Arctic air is warmed here, on the average, to a temperature of 10-12 degrees Centigrade, but the thin layer of this slightly warmed air is washed away by the arrival of new Arctic air masses, or even by a simple increase in wind velocity. Thus, even as low a temperature as 10-12 degrees Centigrade is not stable. The instability of the temperature cycle is further intensified by the relatively warm penetrations of continental air. The mean temperatures for the summer months of July and August are 10-12 degrees Centigrade. Actually, however, the mean daily temperatures [during the same months] oscillate from zero to 20 degrees Centigrade, with a slight tendency to remain within the interval of 10-15 degrees Centigrade. The occurrence of night freezes with temperatures down to minus 1-2 degrees Centigrade is possible throughout the summer. On the other hand, day temperatures sometimes rise to 25 degrees Centigrade.

In the Arctic front cyclones, which pass over the northern zones, the warm mass consists of continental air, the moisture content of which is at its maximum in the second half of the summer, with a resulting maximum in the amount of precipitation. The summer rains are of adequate intensity. Of the total number of rainy days, one half produces not less than 10 millimeters of daily precipitation. The passing of the cyclones is accompanied by considerable sky cover and overcast, which in July and August prevail over two thirds of the time period. In the coastal zone, in addition to sky cover, there are frequent formations of fogs carried by the northerly winds into the interior. Indicative of these general conditions is the considerable humidity, the daily values of which are sustained at about 70 percent.

The arrival of autumn is characterized in the Atlantic-Arctic region by the diminution of northern currents and the intensification of the air mass migration from the Atlantic-Continental region. These changes come about when the cooling process of the continent sets in and high pressure areas form over the southeastern part of the European territory.

From the middle of September rather severe night freezes are possible. These early autumn freezes, unlike those in the late spring, are not always preceded by cold carrying Arctic air penetrations. They can also take place in continental air on clear calm nights.

The migration of relatively warm continental air takes place with southerly and southwesterly winds, and the September disposition of isotherms approximates, in type, the winter disposition, i.e. the southwestern zones are the warmest.

The amplification of currents from the south and the southwest results in the intensification of cyclonic activity at the Arctic front. There is more recurrence of low overcast, with an increase in the number of rainy days. However, the amount of precipitation remains the same, since the temperature drop and the drop in moisture content are simultaneous. In September precipitation falls mainly from the warmer continental air, while in October, and thereafter, precipitation occurs from the Atlantic air. In October, the internal moisture turnover stops, and spontaneous precipitation from the maritime air begins anew. Shortly thereafter, the settling of the snow cover will take place; this process lasts through October, beginning first in the northeastern zones and ending, by November, in the southwestern zones.

Autumn in the Atlantic-Arctic region, by the characteristics of the synoptic processes, is closely related to winter. The basic indication of winter's arrival is the appearance of continental Arctic air, which differs radically from maritime Arctic air. This appearance is noticeable as early as September, but becomes clearly accentuated only in November, which is, therefore, the first month of the winter season.

The Atlantic-Continental Region

Conditions of winter circulation over this region are similar to those of the Atlantic-Arctic region. Here also, the migration of Atlantic air prevails in the western zones, while over the eastern zones continental air prevails. The Atlantic air arrives as a warm mass at the occlusion fronts. Continental air extends from the continental area in the western part of the anticyclones (Figure 22). Thus, here, as in the northern area, both the Atlantic and continental air is carried with the southwesterly winds in relatively warm currents, making the Atlantic-Continental region an area of warm advection (transfer). The main area for the formation of winter continental air is the southeast of the European part of the USSR.

The winter isotherms in the Atlantic-Continental region, like those in the Atlantic-Arctic region, run from northwest to southeast, perpendicular to the southwestern warm currents. Therefore, with relation to mean temperatures, the north and central areas differ comparatively little.

For the area of Kiyev, the mean temperature for the month of January is only 1-2 degrees Centigrade higher than that for the Karelian isthmus. For Saratov and Arkhangel'sk, the January mean temperatures are the same. In the coldest zones of the Komi ASSR, the month of January has a mean temperature of minus 18 degrees Centigrade, while in Kirov (formerly Vyatka) it is minus 16 degrees Centigrade.

The main distinguishing feature of the Atlantic-Continental region is the extremely rare appearance over it os Arctic air -- twice as rare as over the Atlantic-Arctic region.

By conditions of circulation, the Atlantic-Continental region can be divided into two parts: the western part, where the influence of the Atlantic prevails, and the eastern part, where continental features predominate. However, the transfer of Atlantic air eastward is less pronounced here than in the northern region. The climatic boundary, in the specified meaning, between the eastern and western parts lies between Smolensk and Moscow. Zones to the east of Moscow are climatically more continental than those to the west of Smolensk. This becomes evident by comparing the mean temperatures, let us say, for the month of January, which is minus 3 degrees Centigrade and above to the west of Smolensk, and minus 12 degrees and below to the east of Moscow.

The basic air mass over the greater part of the Atlantic-Continental region is the continental air. The properties of the latter, and the circulation conditions in which it is most frequently observed, determine in the main, the features of the winter season in this region. The temperature of the continental air over the central zones in mid-winter is about minus 12 degrees Centigrade. It is encountered in the forward part of cyclones or in the western half of anticyclones, and is usually accompanied by considerable sky cover and moderate winds.

Weather characterized by frost, mild wind, and overcast or considerable sky cover, is the most typical for the winters of this region.

It has served more than once as the /creative7 theme (perhaps sub-consciously) for the paintings of winter landscapes by some of our great masters, such as Perov's "By the Last Tavern" and "The Funeral of a Peasant", and Pryanishnikov's "Empties" /probably empty cars, or empty carts7.

The last painting gives an excellent portrayal of the sensation experienced through sustained exposure to this cold, which, though not too excessive, makes one shrivel, since it is accompanied by wind and dryness in the frosty air. It is this inadequate dryness against the background of rather low temperatures, in combination with a continuous, though mild, wind, that constitutes the most essential climatological feature of the continental air in the winter over the European part of the USSR.

Arctic penetrations are observed predominantly in anticyclones, enclosing a series of cyclones. These penetrations over the eastern part of the Atlantic-Continental region are accompanied by frosts of almost equal intensity as those in the region to the north (minus 40-45 degrees Centigrade). They occur, however, less frequently and do not last as long. In the western zones, the temperature drop does not reach down to minus 30 degrees Centigrade, since the Arctic air arrives with the returning southerly current of the western part of anticyclones, or ridges of high pressure. Skirting from the south an anticyclone, or ridge of high pressure, the Arctic air is somewhat warmed, since, generally speaking, conditions on the western periphery of anticyclones are less favorable to radiation cooling. The result is cloudiness, intensification of the wind, and, frequently, a decrease in the vertical capacity /depth?7 of the cold mass.

Penetrations of Atlantic air, as in the case of the Atlantic-Arctic region, result in abrupt warming and, in most cases, a low overcast; the warming at times becoming a thaw. In some cases, the Atlantic air will extend to the Urals and even beyond, into Western Siberia, but generally speaking it seldom penetrates into the eastern zones. Over Moscow, for example, in January the Atlantic air constitutes 20 percent, and over Kazan', 8 percent of all the air masses. This affects the temperature: in the same month [January] the number of days with a daily mean temperature of over minus 5 degrees Centigrade is nine for Moscow, and four for Kazan'.

Penetrations of Atlantic air into the Atlantic-Continental region during the winter are practically always connected with cyclonic activity and accompanied by precipitation. Precipitation from the Atlantic air continues also in the occluded cyclones, that is, after the Atlantic air near the terrestrial surface has been displaced by cold continental air. Thus, the distribution of precipitation over the territory depends on the general direction of the Atlantic air current in the middle troposphere. A decrease in precipitation takes place in the direction of the migration of Atlantic air, the moisture content of which decreases with the falling of precipitation. This can be seen from the following example.

Amount of Precipitation (in millimeters)

	December	January	February
Minsk	44	46	41
Moscow	39	37	35
Kazan'	33	29	27

The depth of the snow blanket in the Atlantic-Continental region, as well as in the Atlantic-Arctic region, diminishes toward the southwest, although the amount of precipitation increases in the same direction. In the Atlantic-Continental region the consolidation and partial melting of the snow during the thaws occurring in the southwestern zones, affects the depth of the snow blanket to a greater degree than in the Atlantic-

Arctic region. Also of considerable importance is the fact that the snow blanket in the east is established 20 days earlier than that in the southwest (in Kirov, by the end of October; in Kiyev, by the middle of November).

With the penetrations of Atlantic air, particularly in their first phases, sleet is often formed. The most active sleet is formed in the cold wedge of continental air facing the oncoming warm maritime air, when light, supercooled rain is falling through the cold air. The cold wedge [of continental air] is rarely over one half kilometer in a vertical direction, and has a temperature of only minus 2-3 degrees Centigrade. Such a high temperature for winter continental air is due to the following: (1) southerly and southwesterly winds blow in the forward part of cyclones; (2) since the wedge of cold air is thin, it is warmed by the rain falling through it and by mixing with the [oncoming] warm maritime air.

There are several synoptic dispositions favorable to the formation of active sleet. In the central and southern regions it will be formed when the anticyclone is located in the east, and over its western rim the continental air is moving toward the Atlantic air which is arriving in a western or southwestern cyclone. (Figure 25).

Figure 25:

Figure 25: Synoptic disposition during sleet conditions.

Conditions most favoring sleet formation occur in the western zones of the Atlantic-Continental and the Continental region, since, with the subsequent progress of the cyclones eastward or northeastward, the temperature drops too low for sleet formation. In the extreme southern zones, the temperature is too high for the formation of sleet, so that this phenomenon in the Crimea and the Northern Caucasus occurs predominantly in the mountainous zones.

The general character of the winter processes in the Atlantic-Continental region develops under the effect of the transfer of air masses from over the neighboring southern zones, in which the radiation balance is of predominant climatological significance. Therefore, the beginning and the end of winter in this region are determined, to a considerable degree, by the state of the underlying terrestrial surface in the south of the European part of the USSR. Up to the middle of November, the southern, i.e. the Continental region, is still free from snow cover, and, on the average, sky cover does not exceed 50 percent. Up to the middle of November, in the Atlantic-Continental region, warm penetrations may be observed interfering with the establishment of the winter cycle. In the south, during the second half of March, the snow cover disappears, and the underlying surface of the earth begins to heat up rapidly with the ever increasing insolation. This causes ever more frequent warm air penetrations into the Atlantic-Continental region. It can be considered, then, that the winter season here lasts from the middle of November to the middle of March, although the snow cover persists to the beginning of April. In the western zones the winter season is somewhat shorter than in the eastern ones.

Spring in the Atlantic-Continental region is an unstable season, with relation to frequent shifts between cold and warm penetrations and considerable annual climatic variability. Some years the spring season is sunny and warm; some years it is cold, overcast and rainy. All depends on the paths of the cyclones, which may pass over the region with its relatively dry southern half drawing in warm air from the south, or with its rain-carrying northern half drawing in cold air from the north.

The dwindling of the snow cover takes place in the spring and causes a change in the thermal ratio as between the Atlantic and continental air. Until such time as the snow cover is completely gone, the Atlantic air remains warmer than the continental air. After the snow cover is gone, the temperature of the continental air rises rapidly, and is soon above that of the maritime air. In the Atlantic-Continental region the snow cover is gone by the middle of April, by the end of which the warm sector of the western cyclones is already filled with continental air. In the eastern zones of the region the snow cover persists for another half a month, due to the inflow of cold air from the north, along the eastern periphery of the anticyclones.

General melting of the snow cover sets in as a result with the inflow of warm air from the south and the first spring rains, i.e. with cyclonic weather. Following this, the snow will disappear rapidly (will evaporate) with increased insolation, even in clear weather.

The basic synoptic process, causing the transfer of warm air over the Atlantic-Continental region, was described above (Figure 20). There may be another disposition, when, as early as April, there is an outcrop of high pressure (summer process), in which the Atlantic air is warmed and transformed into continental air. The latter, when carried over the region, will induce a rise in temperature. The synoptic disposition for 17 April 1939 is an example (Figure 26).

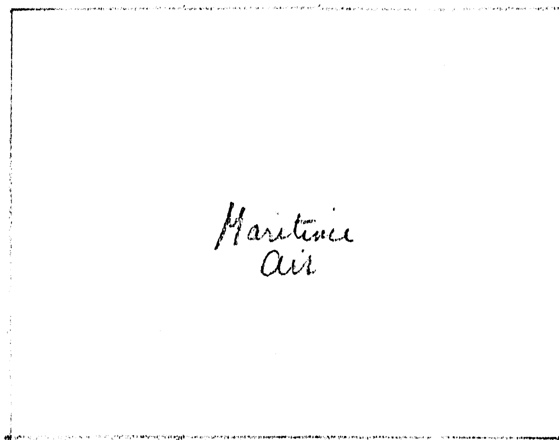

Figure 26:

Figure 26: Spring transformation of Atlantic air into continental air (17 April 1939).

Along with warm weather, of no less importance during the spring season are the considerable chills caused by penetration of either Atlantic or Arctic air. During the spring the temperature of continental air rises rapidly as compared with the temperature of the maritime air masses, and in May the temperature differentials, caused by penetrations of maritime air, can be very considerable. The greatest danger to growing vegetation are the sudden temperature drops to points below zero Centigrade during the second half of spring. As pointed out above, the significance of Atlantic and Arctic penetrations in this respect differs. During the second half of spring, the day temperatures of all the air masses are positive, and freezeovers at the earth's surface occur only as a result of radiation cooling during calm and clear nights. In continental and Atlantic air over the Atlantic-Continental region, the temperature drop under these conditions does not reach the zero Centigrade point. Only in the Arctic air does the temperature drop below zero, not at the beginning of the penetration, but on the second or third day, when calm and clear weather is established in the anticyclone. An example of such "return of the colds" can be seen in the synoptic disposition for 11 May 1939 (Figure 27).

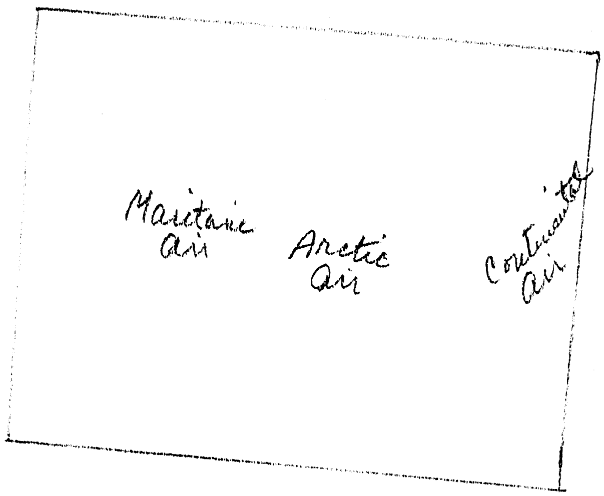

Figure 27:

Figure 27: The spring "return of the colds".

The above example shows that the western zones, with respect to the danger of late freezeovers, have no advantage over the eastern zones. In some cases, the reverse will take place, that is, Arctic air of a more recent origin will penetrate into the western zone and, under corresponding weather conditions, night temperature will reach a negative value sooner.

With the spring rise in temperature, evaporation is accelerated, the moisture content of the air is increased, but relative humidity is reduced. These changes point to the rapid warming of the Atlantic air over the continent. The lowest drop in the mean level of relative humidity occurs in May, when there is the sharpest rise in temperature.

In moving eastward, the inflow of drier air of Arctic origin is intensified, in connection with which the mean moisture content of the air is below that of the western zones, irrespective of the higher temperature. Below is a tabulation of the mean temperatures and moisture content of the air in the spring, which characterize the process of transformation of the air masses over the western and eastern zones:

	Smolensk			Kazan'		
	April	May	June	April	May	June
Temperature (Degrees Centigrade)	4	12	16	3	13	17
Absolute Humidity (Millimeters)	4.5	7.5	10.0	4.5	6.5	9.0
Humidity Deficiency (Millimeters)	3.5	6.5	10.0	3.5	8.5	11.0
Relative Humidity at 1300 Hours (Percent)	65	55	60	60	45	50

Cyclonic activity diminishes toward the middle of spring because of the leveling off of the temperature contrast between the Atlantic air and the continental air. April is not only the driest month of the spring season, but of the entire year. The table below shows the distribution of precipitation during the spring months in the western and eastern zones (in millimeters):

	March	April	May
Smolensk	40	38	57
Kazan'	28	27	33

The western zones have a greater amount of precipitation due to the direction of the cyclones. The number of rainy days (precipitation over 1 millimeter), of which there are, on the average, 10 in the western zone and 6 in the eastern, proves this point.

Summer in the Atlantic-Continental region extends over the months of June, July, and August. By computing the average from observations over a long period

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of years, these months are found to be moderately warm and adequately humid. This, under the conditions of summer circulation prevailing over the region, is determined by the degree of development of two processes -- transformation (warming and humidification) of the air, and cyclonic activity. In addition to transformation, the transfer of recently arrived Atlantic, Arctic, and Tropical air masses will affect the summer temperatures. The circulation conditions, however, are such that transformation of the air masses, as compared to their transfer, is the more important climatological factor. Insolation in perfectly clear summer weather in the latitudinal belt 50-60 degrees North is strong and the heating process in the Atlantic-Continental region could attain even greater significance if it were not at times interrupted by cyclonic activity which reduces the potential insolation in the eastern zones by 40 percent, and in the western zones by 50 percent. This causes the air forming over the Atlantic-Continental region in the summer to be of the continental temperate type, although given a lower degree of sky cover, it could assume subtropical characteristics. Thus, the central region during the summer is a region of formation of continental East-European air, the temperature of which, by midday reaches 24-25 degrees Centigrade, with a relative humidity of 50-55 percent.

The weather in the continental air is characterized, on the whole, by a slight degree of sky cover. The mornings are calm and clear. Light cumulus clouds appear during the day and sometimes almost cover the sky, with winds of moderate force blowing. Toward evening the winds subside and the weather is again calm and clear. Dew sometimes forms at night and toward evening. On rare occasions, the cumulus clouds are transformed into cumulus-rain clouds, and there are short periods of precipitation.

Cyclonic activity over the Atlantic-Continental region, as already mentioned above, regulates transformation in the sense that the transfer of cyclone-carried air masses, intensification of the wind, a higher degree of sky cover, and the falling of precipitation, all tend to retard transformation, which, in the absence of these factors, could develop further. This further evolution of transformation of the air masses does take place over the continental region.

In the course of some years the summer cyclones over the Atlantic-Continental region are particularly frequent; occurring at a series of consecutive fronts, and creating thereby lingering stretches of bad weather. Such was the case in July 1935, during which month Moscow had 26 rainy days. The synoptic disposition typical for such a state is depicted below in Figure 28.

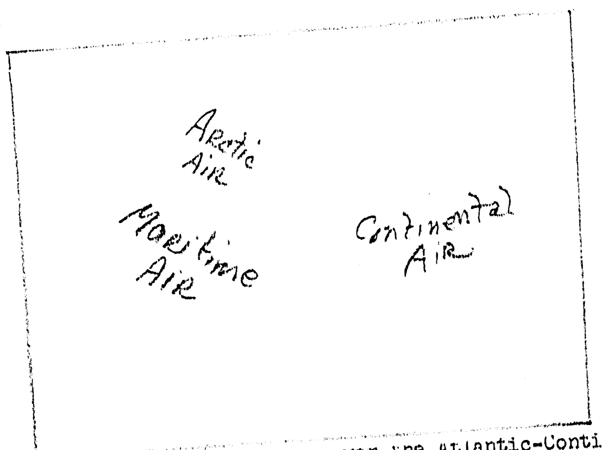

Figure 28: Lingering rainy weather over the Atlantic-Continental region (29 July 1935).

Over the western zones of the Atlantic-Continental region there is transformation of Atlantic air into continental, which transformation is only consummated over the eastern part of the region, since there is more cyclonic activity over the western zones. These processes are reflected in the recurrence of daily temperature values. The mean temperature of continental air may be taken as 20 degrees Centigrade.

Number of Days in July with a
Mean Daily Temperature within Limits of
(Degrees Centigrade)

From 15 to 20	Minsk --- 16	Kazan' --- 11
From 20 to 25	Minsk --- 8	Kazan' --- 12

In the western zones the number of days with a mean temperature of less than 20 degrees Centigrade is twice the number of days with a mean temperature above 20 degrees Centigrade. In the eastern zones it is almost the same. Data on the predominant degree of July daily sky cover recurrence over the eastern zones show the following: for Kazan' -- in the morning 50 percent, during the day 30 percent, in the evening 50 percent. /The Russian text gives the condition of the sky during the day as 20 percent, obviously meaning 20 percent clear, which in terms of sky cover should read 80 percent/. This relatively clear weather during the morning and evening hours, and considerable sky cover during the day is characteristic of continental air.

For the thermal characteristics of the summer continental air, one can again refer to some of the Russian landscape paintings. The "comfortable" warmth one experiences is the most characteristic feature of the complexity of conditions generated by the continental air of our central area. The cumulative effect of all the factors, such as the softness of light, the wind -- not very strong, yet perceptible --, the temperature and humidity in the air which is the kind that does not induce fatigue but is rather bracing because of the sensation of adequate warmth, produces a sense of well-being. Many paintings depict this sensation of well-being, such as: Polenov's "A Moscow Courtyard", Serov's "Girl /basking/ in the Sun", Levitan's "The Little Bridge", and others. However, an oppressive "before the storm" state may also occur, but is less characteristic.

Cyclonic activity is developed predominately over the western zones, since, first of all, the temperature contrast between the warm continental and the recently arrived Atlantic air is more pronounced there, and, second, over the eastern zones relatively frequent penetrations of Arctic air occur which, in moving across the oncoming Atlantic air current, exert a braking effect on the latter and promote the formation of anticyclones. Accordingly, there is considerably more sky cover and a larger amount of precipitation in the western zones.

Recurrence of Sky Cover (in Percent)
and the Amount of Precipitation (in Millimeters)

	Minsk			Moscow			Kazan'		
	June	July	Aug.	June	July	Aug.	June	July	Aug.
Sky Cover	45	48	48	43	41	46	32	33	33
Precipitation	80	90	76	66	82	74	58	60	48

In addition to the passing of Atlantic cyclones over the European part of the USSR during summer, cyclogenesis occurs at the East-European outcrop of the Polar front, at which there is interaction between Tropical air from the southeastern zones and air from the Atlantic-Continental region. These cyclones, too, cause precipitation mainly over the western zones of the Atlantic-Continental and Continental regions.

Frontal cyclonic precipitation in the summer occurs from continental air, which is the warmer one, and the amount of precipitation depends on the additional humidification of the air masses over the continent. This is the main reason for the summer maximum precipitation occurring over the entire European part of the USSR.

Relative humidity is basically governed by the same processes, i.e. transformation [of air masses] and cyclonic activity. The process of evaporation, of course, has some effect, but transformation and cyclonic activity are the predominant factors. Since the warming process is more rapid than humidification, relative humidity will drop as the transformation proceeds. However, under conditions of cyclonic activity, with larger sky cover and precipitation, relative humidity will increase. In the Atlantic-Continental region relative humidity decreases rather rapidly toward the east.

For the Atlantic-Continental region, where transformation of air masses does not attain its highest limit, it is very characteristic that relative humidity is on the increase from May to June and onward, since specifically in May the most rapid rise in temperature occurs, with which evaporation cannot keep pace. During the summer there is, on the one hand, a more pronounced transfer of moisture from the ground into the air in the Continental region proper, and, on the other hand, an increase in the absolute humidity of the Atlantic air arriving over the continent.

Relative Humidity at 1300 Hours

(in Percent)

	May	June	July	August
Minsk	56	59	63	63
Moscow	47	51	54	56
Kazan'	44	48	49	51

Autumn in the Atlantic-Continental region is characterized not only by a general drop in temperature, but also, as in the Atlantic-Arctic region, by a shift in the direction of the air currents and a general intensification of the winds. Thus, the Atlantic-Continental region, which is a region of air mass transformation in the summer, again becomes a region of air mass transfer in the autumn.

Recurrence of Mild and Strong Winds

(in Percent)

	Mild Winds (0-1 meter/per second)		Moderate and Strong Winds (over 6 meters/per second)	
	July	October	July	October
Vitebsk	22	10	11	23
Kazan'	42	24	10	17

The shift in the direction of the wind is less noticeable, since it takes place within the limits of one quadrant of the horizon -- the westerly winds prevailing in the summer shift to southwesterly in the autumn. Also, the continental air gradually becomes colder than the Atlantic air. The dividing moment is usually accentuated by snow precipitation over the central and southern climatic regions. However, if the snowfall is late in coming, the continental air is still colder than the Atlantic air by the end of October. Based on observations over a period of years, the descent of the mean temperature across the zero Centigrade point takes place in the first ten days of November in the western zones, and two weeks earlier in the eastern zones. By this time the snow cover is usually established, although in some years its formation is considerably retarded.

The disposition of isotherms in the Atlantic-Continental region in the autumn gradually approximates their winter disposition. This approximation first occurs in the western zones in September, since over this part of the territory, the transfer of warm air from over Central Europe takes place. In October and November, when the southwestern transfer of air prevails, the isotherms throughout the Atlantic-Continental region are disposed from northwest to southeast. Thus, not only in the winter, but as early as the fall, the western part of this region is warmer than the eastern; this, along with other indications, points to the arrival of autumn.

During the first half of autumn (until the middle of October) the radiation balance of the bottom layer of the troposphere and the underlying ground approximates zero, and the transfer of warm air masses from the south in the anticyclones takes place in clear weather. In connection with this, almost every year, by the end of September or the beginning of October, occurs the "autumnal return of heat", or the so-called "grandma's summer" /Indian summer/, which generates calm, clear, and warm weather -- sometimes for a few days, sometimes for an entire week. It is particularly felt during the day, when the atmospheric layer nearest to the ground is warmed considerably. At night, in many places, particularly lowlands, there are spots of dense creeping fog; in some places this fog lingers into the late hours of the morning, interfering with the warming of the ground and the air, and causing an extremely heterogeneous temperature distribution, which becomes equalized only toward the middle of the day. On such days, the weather is remarkably clear with practically no sky cover. This is due to the fact that the inversion of temperature taking place during the night remains in effect at a certain altitude during the day as well, thereby hindering the development of convection.

The "return of the heat" phenomenon is due predominantly to the air transfer from over Southern Europe along the western rim of the anticyclone which is located over the southern half of the European part of the USSR (Figure 29).

Figure 29:

The passing of cyclones in the autumn is becoming more frequent in connection with the intensification of cyclonic activity over the Atlantic, followed by an increase in the degree of sky cover.

Recurrence of Sky Cover (in Percent)

	July	October
Minsk	48	65
Moscow	46	67
Kazan'	45	70

However, the amount of precipitation as compared to that in summer decreases considerably, since (1) with lower temperatures the absolute humidity of the air masses is diminished, and (2) the fronts over the continent become less active, due to the leveling of the temperature contrasts between the maritime and the continental air. The diminished activity of the fronts is also expressed in their low degree of mobility, which is the reason for fine and long-lasting precipitations so characteristic of the autumn.

The distribution of precipitation over the territory in the autumn is more homogeneous than in the summer.

Amount of Precipitation (in Millimeters)

	Summer (June-August)	Autumn (September-November)
Minsk	246	128
Kazan'	166	117

The contrast between the western and eastern zones during the summer reaches up to 80 millimeters, while in the autumn it is only 10 millimeters.

Rather characteristic of the autumn season are the fogs. Autumn fogs over the Atlantic-Continental region are predominantly of a radiation and advective-radiation genesis, particularly during the first half of autumn. They occur in the central (and even the eastern) parts of anticyclones under the effect of the nightly cooling of the bottom air layer, as well as in the relatively warm air masses as a result of radiation while moving northward along the western periphery of the anticyclones. In the latter case the fogs attain considerable altitude and linger on for several days.

The end of the autumn season gradually merges into winter, and it is rather difficult to isolate any one process which would particularly mark this merger. Sometimes frosts of high intensity arrive as early as November, as in the Moscow region, where the absolute minimum temperature for November is minus 28 degrees Centigrade. In the course of other years, the arrival of winter is considerably retarded -- "nature waited and waited for the arrival of winter, and snow came only in January, on the night of the third."

The Continental Region

As already mentioned above, the Continental region is distinguished by the most continental climatic features, as compared with the rest of the European territory of the Soviet Union.

In the winter, it is the main area for the formation of East-European continental air, in contrast to the central and northern areas, which in the winter are predominantly areas of advection (transfer). The formation of continental air takes place in areas of high pressure (which are either outcrops of the Asiatic anticyclone, or independent anticyclones), along the eastern periphery of which, at times, is established a direct current of Arctic air. Along the southern periphery of these high pressure areas the continental air flows off with the easterly and northeasterly winds into the southern zones. It then skirts the anticyclones from the west, and extends in a southwestern current over the Atlantic-Continental region.

In the process of such circulation, the entire Continental region is filled with relatively cold air. This underlying factor causes the following two characteristic features in temperature distribution over the region. (1) The mean temperature level, as compared to that for the Atlantic-Arctic region, is not as high as would be expected by the difference in latitudes. The mean temperature for January in Petrozavodsk is minus 10 degrees Centigrade, for Poltava -- minus 7 degrees Centigrade, for Kotlas -- minus 14 degrees Centigrade, for Stalingrad -- minus 10 degrees Centigrade. Thus, the temperature rise southward is only one quarter degree of temperature per one degree of latitude, and even on the shore of the Sea of Azov, the mean temperature for January is minus 5 degrees Centigrade. (2) Deflections of the winter isotherms, from a latitudinal disposition to the north, are considerably smaller than in the central and northern areas. The difference in the mean January temperatures between the extreme western and the extreme southern zones is about 4 degrees Centigrade for the south and reaches 8 degrees Centigrade for the north of the European part of the Union.

The relatively low mean temperatures for the winter in the Continental region are a result, not so much of a general temperature decline, as of abrupt temperature drops caused by cold [air mass] penetrations, and along with considerable frost, there are also many thaws. In Rostov-on-the-Don, with a mean January temperature of minus 6 degrees Centigrade, 25 percent of the days of the three winter months have a mean daily temperature above zero Centigrade, and 20 percent of the colder days have a mean daily temperature of minus 10 degrees Centigrade. Minimum annual temperatures everywhere, with the exception of the maritime zones, descend below minus 20 degrees Centigrade. The absolute minimum temperature for Stalingrad drops to minus 35 degrees Centigrade. The lowest temperatures occur in the cold air masses arriving from the north, with additional local chilling taking place on calm and clear nights. Thaws are particularly frequent in the southwestern zones; for instance, in Nikolayev during the winter (December-February) 40 percent of the days have a mean daily temperature above zero degrees Centigrade.

The Atlantic cyclones in the winter predominantly pass further to the north. Those that get into the southern zones are usually moving directly to the east, and precipitations caused by them are evenly distributed over the territory. In addition to the Atlantic cyclones, over the Continental region, pass the Mediterranean cyclones, penetrating here by various routes through the northern coast of the Black Sea, from Odessa to Novorossiysk, proceeding further northward or northeastward. The precipitations caused by the Mediterranean cyclones are distributed over the southern zones more or less evenly. In connection with this, the amount of winter precipitation varies little within the limits of the Continental region, coming to 90 millimeters for the three winter months, and only on the shores of the Caspian Sea does the amount of winter precipitation drop to 60 millimeters.

The snow cover of the Continental region, due to frequent thaws, is small and unstable. A more or less stable snow cover is observed in the northern part of the territory. It is late in taking hold and early in dwindling; in the areas of Kharkov and Stalingrad it is sustained from the beginning of December to the middle of March, reaching a depth of 15-20 centimeters by the end of February. Sometimes the snow cover will dwindle almost completely in the course of the winter and then reestablish itself.

In the western zones, under conditions preceding a thaw, there will be formation of fog and sleet (Figure 25).

Spring in the Continental region arrives mostly with the inflows of warm air from Southern Europe. As an example, the synoptic disposition of 17 April 1939 (Figure 26) can be referred to. The Atlantic air is warming in the outcrop of anticyclones over Southern Europe, and with a westerly current penetrates first over the Ukraine, and then further to the east. Under the effect of the warm air, and sometimes warm rains as well, the slight snow cover disappears rapidly. and from this moment on the territories of the Ukraine and the Lower Volga are in themselves a source for the warming of the air. This process rapidly embraces the entire Continental region, and the snow cover disappears almost simultaneously in the west and in the east during the first twenty days of March, merely lingering on for two more weeks in the northern zones.

In April the continental air over the southern climatic region is colder than that over Central Europe, but the high pressure prevailing in the winter is gradually dropping, and the cyclones begin to penetrate more frequently into the territory of the given region, particularly into its western zones. There is, in connection with this, a slight increase in the amount of precipitation from March to April. The weather in April is very unstable, the absolute contrast between the cold and warm penetrations reaching possibly 40 degrees Centigrade (from minus 10 to plus 10 degrees Centigrade), yet almost yearly there occurs a drop of the mean daily temperature to minus 5 degrees Centigrade and a rise to plus 20 degrees Centigrade. The same occurs with relation to humidity. With the cold penetrations accompanied by precipitations, relative humidity is never below 80 percent even at noon. There are 4-5 such days in a month. Inversely, there are, on the average, four or six very dry days when, toward midday, the relative humidity drops to 30 percent and below, which usually coincides with warm penetrations. In March the temperature oscillations are no smaller, but occur at a lower level, and relative humidity does not drop as low as in April.

In the spring insolation increases with the height of the sun, lengthening of the day, and the decrease in the degree of sky cover.

However, sky cover decreases not as a result of an increase in the number of clear days, but rather of a decrease in the number of days when the sky is overcast. For example, the recurrence of clear and overcast sky over Poltava is (in percent):

	February	April
Clear (0-2 balls)	20	25
Overcast (8-10 balls)	75	50

This arises from the fact that in the spring the formation of the shroud of low clouds, caused by the cooling effect that the underlying ground exerts upon the warm air, is discontinued, and there remain only cloud formations of frontal and cumulus convective origin.

The second half of May in the Continental region, strictly speaking, belongs to the summer season, since it marks the beginning of the process for the formation of Tropical air. This means that the continental air is further heated, not only in its lower stratifications, but also in the middle troposphere. When it meets (in counter-currents) with the air masses of the Atlantic-Continental region, a front is formed which generates cyclonic activity. This warming of the air takes place predominantly over the eastern zones of the Continental region, lying to the side of the principal paths of the cyclones. Correspondingly, the May isotherms in the eastern half, as compared with those in the western half, are shifted considerably to the north, and it is much warmer in the area of the Lower Volga, than it is in the Ukraine. This condition, /as just described above/ does not yet prevail in April.

Mean Temperature in Degrees Centigrade

	April	May
Kamenets-Podol'sk	7.7	14.6
Stalingrad	7.8	17.5

It should be borne in mind, however, that the process of transformation of continental air into Tropical air only begins in the month of May, and the temperature contrasts between the western and eastern zones are caused mainly by the warming of the continental air in its bottom layers. The percentage ratio of Tropical air to the other air masses is still small during the month of May, and its fronto-genetic value is accordingly small. Thus, the increased precipitation in May, as compared with that in April, should be attributed to the frontal precipitation from continental air, which, due to evaporation, contains more moisture than the Atlantic air.

There is also higher pressure over the Continental region during the summer, mainly as a result of the activity of the Azoric anticyclone. Abundant insolation against the background of a predominantly steppe landscape, and in the southeast even semi-desert landscape, causes a considerable heating of continental air and its transformation into Tropical air. This is the basic process of the summer season over the Continental region. However, this transformation does not embrace the entire continental air mass, not even its largest part. According to calculations for the period 1935-1939, the number of days with Tropical air predominating over the southeastern zones for the months of June, July, and August, amounts to 30 percent. Part of it (5 percent) should be attributed to the inflow of Tropical air from Central Asia. The presence of such a relatively small amount of Tropical air seems to constitute the decisive factor for the summer meteorological cycle over the greater part of the Continental region (high temperature, low humidity). The explanation lies in the predominance of anticyclonic circulation (with its mild winds, temperature inversions, which hinder the formation of convective clouds); under the influence of which the bottom layer of continental air is considerably overheated to a state when by temperature and humidity it approximates the characteristics of Tropical air.

The above depicted differences between the western and eastern areas of the Continental region in May become even more pronounced in the summer. The climb in temperature and the drop in relative humidity toward the east are intensified during the summer, as quoted by values in the Table that follows.

	Mean Temperature				Relative Humidity at 1300 Hour (in Percent)			
	May	June	July	August	May	June	July	August
Kamenets-Podol'sk	14.6	17.4	19.4	18.8	49	54	54	52
Akhtuba	17.0	21.7	24.7	23.0	44	44	40	38
Difference	3.4	4.3	5.3	4.1	5	10	14	14

Of particular significance is the relative humidity curve. As already mentioned above, the relative humidity in all zones decreases during the spring. From May on the relative humidity curve of the western part is different from that of the eastern part. In the west the temperature climb from May to June is smaller than in the east, and evaporation raises the relative humidity. In the east the temperature climbs faster, and there is less actual evaporation than in the west, as a result of which relative humidity is constantly dropping. In the east, also, there is more frequent penetration of dry Asiatic air along the western periphery of the anticyclones located over Kazakhstan and the northern part of Central Asia. Toward the end of the summer, the drier air from the eastern half fills the western zones too, where in August, relative humidity is again dropping.

The climatological significance of Tropical air is not limited to its effect on temperature and humidity. Under favorable conditions of circulation, such as the convergence of currents, the Tropical air will form a front with the air from the Atlantic-Continental region.

At this front will develop cyclonic activity, with cloudiness and precipitation. Thus, the process of transformation, creating /a certain degree of/ aridity in the Continental region, carries within itself the cause which retards its rate of evolution. This is the /specific/ feature by which the European territory of the USSR is distinguished from the Central Asiatic territory, where the transformation of the air masses during the summer months attains its ultimate degree of evolution, and is discontinued only under the action of terrestrial factors of general importance.

Frontogenesis and cyclonogenesis in Tropical air over the Continental and Atlantic-Continental regions occurs predominantly to the west and northwest of the center of transformation, i.e. mostly in the western zones of the above named regions. The Tropical air occupies the warm sector in the cyclones moving northward or northeastward over the Ukraine. These cyclones sometimes carry the Tropical air to the northernmost areas of the European part of the Soviet Union. The Tropical air from the southeastern areas penetrates into the Ukraine along the southwestern periphery of the anticyclones. On its way, it is humidified over the lowlands of Kuban' and the Sea of Azov, as a result of which it furnishes much frontal precipitation, frequently accompanied by powerful storms. Figure 24 depicts the development of such a process.

Precipitations from Tropical air are an essential addition to the precipitations brought on by the Atlantic cyclones, so that in June and July there is maximum precipitation over the Ukraine, as compared with the rest of the European territory. At the same time the amount of precipitation in the southeast does not increase:

(in millimeters)

	June	July
Zhmerinka	85	84
Akhtuba	28	22

Very characteristic of the Continental region in the summer are droughts and dry winds.

A drought is the result of precipitation deficiencies over a long period of time. Yet, not every prolonged period of dry weather can be considered a drought. Drought is not only a meteorological, but also a biological concept, and this, mainly, is the reason for its climatological significance. A drought is "a combination of various phenomena occurring in the soil and in the air, and causing a disparity between the indispensable water consumption by plants and its actual delivery to the plants through the soil" (N. V. Bova). Such a condition comes about after some preparatory period, the duration and intensity of which depends upon a whole series of circumstances, such as: the value of the preceding autumnal-winter humidification, the condition and vegetative phase of the plant, etc. The setting in and duration of a drought may vary from year to year. There are spring-summer and summer droughts with a duration of a month or even longer.

Droughts that begin in the spring are usually long, since in the southeastern areas of the European territory the second half of the summer is usually dry. Droughts of long duration are the ones which usually affect the largest areas. This is caused by the fact that the drought is originally brought about by conditions of circulation over a certain area and, given enough time, the surface of that area will itself become a factor which accelerates the intensity of the drought and will, therefore, increase the area of its effectiveness.

The complex of conditions favorable to the setting in of a drought occurs in the southeast of the European territory of the Soviet Union quite frequently. The recurrence of drought (in the sense of the definition above) amounts to 40 percent, as can be seen from the fact that for the period 1890-1939 there were 18 years during which droughts occurred.

One fifth of these droughts began in the month of May, taking in the entire vegetative period and striking the southeastern part of the European territory, the area of the Middle Volga, and the southern part of the Ukraine. The droughts are, to a considerable degree, a result of the transformation of air masses over the continent, particularly the transformation of Arctic air. They are intensified to the east and to the southeast (Kazakhstan, Central Asia). In the European territory they occur frequently, but not annually (with the exception of the Caspian lowland). In Central Asia and in southern Kazakhstan they constitute the most important feature of the summer season.

The dry wind cycle is a phenomenon still insufficiently investigated. It is characterized by a peculiar condition of the air, conducive to extreme evaporation. The temperature by midday is 40 degrees Centigrade, with relative humidity below 30 percent and a wind velocity above 10 meters per second. The basic difference between a drought and dry wind cycle is that in a drought the plants either perish completely, or are partially struck, beginning with the roots, as a result of a moisture deficiency in the soil after a prolonged lack of precipitation, while in a dry wind cycle, the plants are struck by disrupting the process of transpiration for 1-2 days, with the upper parts of the plants cying first.

Dry wind cycles rarely originate in Central Asia. They are more frequently evolved at the periphery of anticyclones over the European territory. In these cases the high temperatures and low /relative/ humidities are due to the adiabatic process, and the dry wind cycle can be considered a descending current, tied in with the katabatic /katafront/. The direction of the winds during the dry wind cycle may vary, but they are predominantly easterly in the southern quadrant of anticyclones. As an example, refer to the synoptic disposition on 21 August 1939 (Figure 30), where the cross-hatched area represents the area affected by dry wind.

Figure 30:

Figure 30: Synoptic disposition during a dry wind cycle (21 August 1939).

During the first half of autumn anticyclonic circulation still predominates, and, while in the Atlantic-Continental region at this time autumnal bad weather sets in, it is still warm and dry in the south. Such a situation is depicted in Figure 21. The anticyclonic characteristics of September and October weather can also be seen from the Table immediately following:

Voroshilovgrad (formerly Lugansk)

	September	October	November
Recurrence of clear Sky (in Percent)	51	40	18
Number of days with Precipitation	7	8	11

The warming process affecting the air over the steppes of the Continental region is discontinued in September, and is gradually changed into a cooling process. Yet, the eastern zones are still warmer than the western zones in September. In October the disposition of the isotherms approximates that for the winter, and even over the southernmost zones the continental air becomes colder than the Atlantic air.

Autumn returns of the heat are sometimes observed rather late in the season. They are caused by the inflow of warm Anatolian air along the western periphery of the outcrop of the Asiatic anticyclone, the formation of which at this time of the year depends to a large extent on the cooling off of the sand steppes of Central Asia and Kazakhstan. This is one of the clear examples of meteorological contradictions, and the specific synoptic dispositions for them are depicted in Figures 31 and 32.

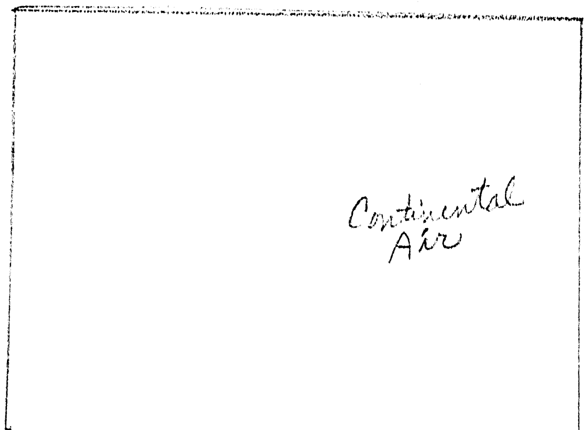

Figure 31: The late autumn return of the heat over the Atlantic-Continental region (23 October 1937).

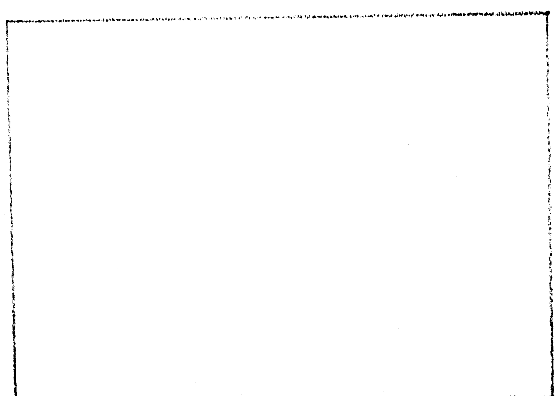

Figure 32: Warm autumn weather in the south (14 October 1935).

The Crimea

By circulation conditions, the Crimea can be relegated almost completely to the Continental region of the European part of the USSR. During the winter the predominant air is the continental air, flowing off with the northeasterly winds along the southern periphery of the areas of high pressure /developing/ over the Continental region. During the summer the northeasterly winds bring the continental air that has been, to a considerable degree, transformed into Tropical air.

The air flowing in from the continent and arriving over the sea, is somewhat warmed in the winter and somewhat cooled in the summer. This warming or cooling process affects the bottom layer only, since the area of the Black Sea is not sufficiently large for the air masses to tarry long enough in their migration to become transformed into maritime air. Additionally, in the winter, when the surface of the sea is warmer than the continental air flowing over it, the air is subject to layer instability, favorable to the development of convectional heat transfer to the overlying layers. The pressure gradient forces are rather strong, and the air masses are carried rapidly accross the sea. In the summer, the winds are relatively mild, and there is stable stratification /layer stability/ in the air, since the sea is colder than the air. Nevertheless, the sea affects the temperature cycle of the coastal belt to a considerable degree.

The land elevations of the southern part of the Crimea are of a magnitude that introduces essential turbulence into the atmospheric cycles developing over the peninsula. This pertains mainly to the extension of cold continental or Arctic air and to the advancing of the fronts. The height of the Crimean mountains is greater than the thickness of the coldest bottom layer of the continental air, and, in the case of Arctic penetrations, it is generally above the vertical capacity of the cold wedge. The cold air, forced to flow around the Crimean ridge, penetrates over the southern coast in a diminished mass and is already considerably warmed from passing over the sea. This is illustrated by the distribution of maximum low temperatures [the Russian text calls them "minimum temperatures"] on the northern and southern slopes and the highest altitude zone (in degrees Centigrade):

	Simferopol'	Ay-Petri	Yalta
The mean of the annual maximum low temperatures	Minus 20	Minus 19	Minus 8
Absolute maximum low temperature (1929)	Minus 32	Minus 26	Minus 15

The lowest temperatures occur to the north of the mountains (Simferopol'). In the mountainous zones (Ay-Petri) it is warmer during the cold penetrations than down below in the steppe, and, finally, on the south shore (Yalta) the mean maximum low is higher by over 10 degrees Centigrade than on the northern slope. In Yalta a minus 10 degrees Centigrade frost occurs only years apart, and a thermometer reading of below minus 15 degrees Centigrade is virtually unknown for the entire period of recorded observations. These figures prove that the land elevations of the southern coast of the Crimea constitute an effective shield against cold air penetration.

No less significant is the part the mountains of the Crimea play in the activation of the fronts that pass over them, particularly in the winter Mediterranean cyclones. These leave in their wake a large amount of precipitation on the southern and southwestern slopes, which are favorably located with relation to the direction of the warm, moisture carrying air current. The summer cyclones of western origin furnish precipitation predominantly on the northern slopes, in amounts, however, smaller than the winter cyclones provide on the southern slopes.

Amount of Precipitation (in millimeters)

	Winter			Summer		
	December	January	February	June	July	August
Simferopol'	39	39	32	71	77	28
Yalta	70	82	56	49	56	27

A considerable effect on temperature and humidity of the Crimean coastal belt is exerted by the proximity of the sea. It was pointed out above, that over the Black Sea, at any rate over its northern half, there is a predominance of continental air with somewhat modified characteristics in its bottom layer, which modifications bring it closer to air of the maritime type. This factor, as related to the temperature cycle, will cause a decrease in the yearly amplitude (by raising the winter temperatures and lowering the summer temperatures) and will also shorten the frost period. The number of frosty days in the central part and the coastal belt is shown below:

Kurman-Kemel'chi	120
Tarkhankut	65
Sevastopol'	53
Yalta	40
Feo-dosiya	71

In order to get an idea of the part played by the land elevations and the sea, with particular reference to the slackening of continental influences in the winter, the mean temperatures for the shielded /from the sea/ and exposed /to the sea/ parts of the coastal area are compared with the mean temperatures for the central zones /the Table below gives the results of the comparison in terms of mean temperature differentials (in degrees Centigrade)/:

	December	January	February
Yalta less Kurman-Kamel'chi	6	6	5
Tarkhankut less Kurman-Kamel'chi	3	3	2

The first line shows the combined effect of the land elevations and the sea, the second line shows the effect of the sea only.

Special features in the conditions of humidity develop mostly in the summer. They pertain to the progress of the daily relative humidity curve, which, in the coastal belt, as compared with the central zones, is very small. This is due to the effect of the breezes, which modify the daily humidity curve in such a manner that the relative humidity during the day is higher over the coastal belt, while during the night it is higher over the central zones.

During the cold season the coastal area is subject to considerable fog, which is generated by the humid air from above the surface of the sea extending over the cold littoral. The characteristics described above do not as yet warrant the segregation of the coastal belt into a particular climatic zone, since the proximity of the sea does not disturb the general progress of the weather in the coastal belt as compared to the interior. It follows that of basic significance in the climatic zoning of the Crimean peninsula is its terrestrial configuration.

The peninsula can be divided into two climatic zones. The first one, comprising the southern part of the Crimea, is of the Mediterranean climatic type. It can be divided into two sub-zones: the southern littoral and the mountainous area. The second zone comprises the rest of the Crimean territory, and, with relation to climate, it blends with the southern part of the Ukraine. The climate of the southern littoral and the mountainous area is integrated not only under the influence of the continent proper, but also under that of the Mediterranean region, since by its location the southern part of the peninsula falls within the sphere of action of the Mediterranean outcrop of the Polar front in the winter, and the Azoric anticyclone in the summer.

The extension of the Mediterranean climatic cycle to as remote an area as the Crimean Peninsula is due to the part played by the Black

Sea, which is, so to speak, a direct continuation of the Mediterranean. The Black Sea undoubtedly exerts an effect upon the paths of the winter cyclones and upon the development of the high pressure outcrop in the summer. The effect of this high pressure outcrop is an abrupt decrease in sky cover during the summer over the Crimea as compared to the southern part of the Ukraine.

The southern littoral of the Crimean Peninsula is one of the zones of the USSR which is most favorable climatically to health and well being. It is frequently rated with the finest Mediterranean health resort areas. Such a rating is due mainly to its mild winters and clear, sunny summers. The mean temperature of the coldest month (January) is plus 4 degrees Centigrade, which is 8 degrees Centigrade warmer than points of the same latitude on the Caspian, 12 degrees warmer than equi-latitudinal locations in Central Asia, and 22 degrees warmer than equi-latitudinal locations in the Far East.

Recurrence of Clear Sky (in Percent)

	June	July	August
Kirovograd (formerly Elizavetgrad)	27	35	48
Kherson	31	46	55
Simferopol'	43	55	65
Yalta	42	57	63
Feodosia	41	56	63

In 1915 the January maximum low temperature was plus 3 degrees Centigrade. In the winter of 1894/95 the temperature was never below plus 4 degrees Centigrade. On the average, there are only six days during the winter without thaws, i.e. only six days with a daily temperature sustained at below zero Centigrade. Out of the entire number of

15 days with precipitation for the month of January, only 5 are with snow, the rest are with rain. The amount of precipitation in the winter is considerable -- twice as much as in any other place within the European part of the USSR. Yet, the number of days with overcast is relatively small. It is of interest in this respect to compare this area with Belorussia, where overcast in the winter is at its maximum:

	Minsk			Yalta		
	December	January	February	December	January	February
Amount of Precipitation (in millimeters)	44	46	41	70	82	56
Number of days with Precipitation	18	17	15	14	15	12
Number of days with Overcast	24	23	15	12	13	9

In Belorussia the overcast weather is only partially connected with the falling of precipitation, since the number of days with overcast exceeds the number of days with precipitation. In Southern Crimea, on the contrary, even the rainy days are not throughout overcast. Not to mention the fact, that in Southern Crimea, with a greater amount of precipitation, the number of days with precipitation is smaller than in Belorussia.

The arrival of spring in the Crimea is connected with the inflow of warm air from the south. These are the warm air masses from the southeast of Europe (the Balkan Peninsula), or more often, the air from Asia Minor. A typical synoptic disposition assuring the transfer of warm air to the Crimean Peninsula and the north coast of the Black Sea in general, is the location over the Caspian Sea of an anticyclone, along the western periphery of which the southerly air current originates. One such case is depicted in the synoptic disposition for 15 April 1938 (Figure 33).

Figure 33:

Figure 33: Transfer of warm air from Asia Minor (15 April 1938).

A similar situation may occur in March also. In addition to the inflow of warm air, the extension of a high pressure area over the Crimea reduces sky cover, which, in turn, results in increased insolation.

In passing over the sea, the air from Asia Minor loses considerable heat. Therefore, the temperature climb in the spring over the southern littoral, as compared to the central area, is at first retarded. For instance:

Mean Temperature Climb (in degrees Centigrade)

	February-March	March-April	April-May
Kurman-Kemel'chi	4.5	6	6
Yalta	2.5	4	6

Yet, spring on the southern littoral is warmer than in the central zone. Below is a tabulation showing dates for the passing of the mean temperature across the indicated levels (in degrees Centigrade).

	Plus 5	Plus 10	Plus 15
Kurman-Kemel'chi	25 March	20 April	12 May
Yalta	3 March	12 April	10 May

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As early as April, but to a greater degree in May, the temperature climb over the southern littoral of the Crimea takes place in connection with increased insolation and the general warming of the air over the peninsula. Insolation during the spring increases very rapidly: on the average, 1 square centimeter [of terrestrial surface] absorbs 4000 small calories in March, 6400 small calories in April, and 9900 small calories in May. The fluctuations of insolation by individual years, as affected by the amount of sky cover, are of minor importance.

During the spring there is a shift in the type of cyclones passing over the peninsula. The number of Mediterranean cyclones decreases, and the Atlantic cyclones take on principal significance. This reduces noticeably the amount of precipitation on the southern littoral, while in the central and eastern zones of the Crimea the amount of precipitation during the spring is somewhat increased.

The summer in the southern coastal area is very warm, yet it cannot be designated as hot, since, with a sufficiently high mean temperature of July and August (24 degrees Centigrade), the maximum high is barely above 30 degrees Centigrade, and this not every year. Daily temperature fluctuations are not great, and, on the average, do not exceed 8 degrees Centigrade. Humidity is considerable, but not excessive, and its daily fluctuations are small, which is due to, not only the small daily range of temperature, but also to the breezes, the force of which is amplified by the winds from the mountain slopes. The daytime humid breeze sustains the relative humidity, which, otherwise, diminishes with a rise in temperature. Inversely, the dry wind, descending from the mountains during the night, stops the further increase of relative humidity. Relative humidity fluctuates daily within a range of several percent, its mean value being 60 percent. Of interest in this respect is the comparison of the range of relative humidity between the southern littoral and the central zones of the Crimea.

Relative Humidity (in Percent)

	July			August		
	700 Hours	1300 Hours	2100 Hours	700 Hours	1300 Hours	2100 Hours
Yalta	60	57	66	57	53	61
Simferopol'	75	45	77	76	41	75

Against the background of the above depicted temperature and relative humidity cycles, takes place the absorption of the abundant insolation, which is a general characteristic of the summer in the Continental region as a whole, and the Crimean Peninsula in particular.

The predominance of clear days points to the dryness of the Crimean summer. In the passing of the season from spring to summer, the amount of precipitation at first increases, then diminishes again in the month of August. The average amount of summer precipitation (40-45 millimeters for June, 55-60 millimeters for July, 20-25 millimeters for August) varies considerably from year to year. There are years when summer precipitation is in excess of that for the winter, accumulating to the extent of 50 percent of the yearly total, with the abundant rains falling during June and July, and the month of August almost invariably dry. The sea breezes in August help sustain the relative humidity almost on the same level, as in June and July.

August in the southern littoral, with rare exceptions, is somewhat warmer than July, and the mean temperature of September is close to that of June.

Mean Temperature (in degrees Centigrade)

	June	July	August	September
Yalta	20	24	24	19

September weather is like summer weather, not only by temperature, but also by relative humidity.

Relative Humidity at 1300 Hours (in Percent)

	June	July	August	September
Yalta	60	57	53	58

Thus, the symmetry of the annual temperature and relative humidity curves is disturbed, and the arrival of the autumn season is to be relegated to October. The shift of the maximum high temperatures to the second half of the summer is due not only to the proximity of the zone to the sea, but also to the general conditions of circulation. This is illustrated by the September and November extension of an outcrop of the Azoric anticyclone over the Southern Ukraine and the Crimea, carrying clear and warm weather in its wake. For an example, refer back to figure 32 (14 October 1935).

The appearance of this outcrop of the Azoric anticyclone is the reason for the prevalence of calm, clear and warm autumnal weather over the Crimea and the Black Sea coastal area of the Caucasus. For this reason, this period is considered the best season of the year. The circulatory process engendering the formation of this Azoric outcrop is not yet sufficiently understood. Possibly this process is to a considerable extent due to the general cooling of the continent, which causes an overcurrent in the middle troposphere from the Atlantic side; in the north at this time there is the beginning of cyclonic activity.

The beginning of the autumn over the southern littoral is indeed the finest time of the year. The temperature drops somewhat, yet is sufficiently high. The mean temperature passes the plus 15 degrees Centigrade level during the "teens" of October, and the plus 10 degrees Centigrade level around 10 November. The amount of precipitation after the month of August increases rather rapidly, yet the number of rainy days increases but little. The number of rainy days in October is smaller than in June. The amounts of precipitation in the autumn, as well as during the summer, vary through individual years, and the autumns are at times very dry.

In the second half of autumn (in November) there is an increase in the amounts of sky cover and precipitation; rainy weather occurs during one third of the month, and on rare occasions (not every year) there is some snowfall. Also in November occur the first autumn frosts, about two or three times during the month, but some years there are none. The most rapid general drop in temperature occurs from October to November, when over the Continental region the formation of winter continental air begins in the areas of high pressure, connected with the Asiatic anticyclones. November over the southern littoral of the Crimea is definitely a winter month, since there is more precipitation on the southern mountain slopes, as compared to the northern slopes, which is indicative of the shifting of the cyclone paths in accordance with the winter circulation cycle.

The mountainous part of the Crimea rises to an altitude of 1000 meters above sea level. The altitude does not essentially affect the conditions of circulation, except that during the winter cold penetrations, the mountainous zones are found in the warmer upper layers of the cold mass. Also, under conditions of local radiation cooling, with the downflow of the cold air over the slopes, it is warmer on the mountain tops than it is below. Yet, the formation of temperature inversions in the mountains occurs rarely, and has almost no effect on the mean temperature differentials. Yet, when compared with the coastal belt temperatures, the vertical temperature gradient becomes considerable, due to the warming effect of the sea. As can be seen from the the tabulation below:

Mean Temperature (in degrees Centigrade)

	December	January	February
Yalta	6.1	3.7	4.0
Ay-Petri	Minus 1.1	Minus 4.2	Minus 3.2
Vertical Temperature Gradient (per 100 meters)	0.6	0.7	0.6

According to observations over a period of years, the number of days with frost is as follows: in December -- 24, in January -- 28, in February -- 26, in March -- 24, with the temperature rising above zero Centigrade during the day in 40 percent of all cases.

The snow cover in the mountains is of considerable depth and is sustained on the average about two months.

Winter precipitation is distributed quite unevenly. In the southern part of the Yayla /mountain ridge/, particularly near the slope facing the sea (Ay-Petri), the amount of precipitation in December, January and February is about 155 millimeters per month. On the northern mountain slopes the amount of precipitation is one third the above volume.

An important climatic feature of the mountainous part of Crimea is the occurrence of strong winds, generating frequent snow storms, which is in sharp contrast with the warm and calm weather prevailing over the southern littoral. With the strong warm winds, there is formation of foehns over the leeward slopes. The Crimean foehns are connected mainly with cyclonic activity. During the passing of the Mediterranean cyclones the southerly and southeasterly winds form foehns over the northern slopes. Cyclones arriving from the west form foehns over the southern coast. The foehns over the southern slopes are not as fully developed as those over the northern slopes, and they occur less frequently. The foehns are most frequent during the winter and spring (March-April).

The summer in the mountainous area is distinguished by lower temperatures and a great amount of precipitation, as compared to the steppe and the southern littoral. The temperature drop with the increase in altitude is particularly pronounced at the slopes, and is due to the powerful ascending currents. The mean temperature gradient between Yalta and Ay-Petri for the entire summer is approximately 0.7 of a degree Centigrade per 100 meters of altitude, with the mean temperature for July at Ay-Petri close to 15 degrees Centigrade, about the same as in Arkhangel'sk. Thus, within the extent of only one kilometer the summer temperature cycle, as related to altitude, will have the same range as the temperature cycle over the entire European territory of the Union, from north to south, from the White Sea to the Black Sea. This is the reason for the maintenance of numerous sanatoria at various altitudes in the southern coastal area of the Crimea, with a choice of favorable climatic features for various convalescent requirements.

Autumn in the mountainous area, as well as throughout the Crimea, is known for its calm and clear weather. The first autumn frosts occur with the beginning of October.

THE CAUCASUS

Among the climatological factors in the Caucasus, terrestrial configuration is of almost first importance. It effects tremendous changes in circulation conditions in the bottom layer of the troposphere, which is of the utmost significance with relation to temperature and humidity -- the two basic factors in the division of a territory into climatic zones. The Caucasus /mountain range/ lies on the boundary between the temperate and subtropical belts, and the system of ridges of the Great Caucasus, by retarding the meridional transfer of the cold and warm air masses, accentuates this boundary and makes it fully unmistakable: Northern Caucasus is in the temperate climatic belt; Trans-Caucasia belongs to the subtropical belt.

Of greatest climatological significance are the ridges of the Great Caucasus, as a hindrance to the migration of the cold air masses from the north. In most cases, when the Arctic air reaches the Caucasus, the high mountainous wall extending throughout the entire width of the Caucasian isthmus, with only narrow passes along the coasts of the Black and Caspian Seas, prevents its penetration into the valleys of the rivers Rion and Kura. And only on rare occasions, which do not recur every year, the cold air flows around the mountain ridge from the west and from the east, enclosing the high-mountain area into a sort of warm island. Such a [synoptic] situation occurred during the first days of December 1938, and it is depicted below in Figures 34, 35, 36, and 37; these show the consecutive stages of the cold Arctic air penetration and its by-passing of the Caucasian ridge.

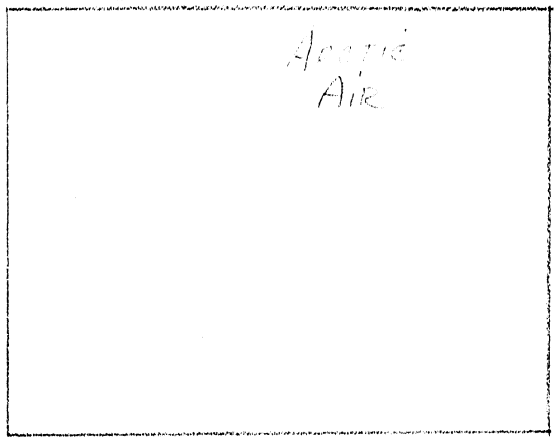

Figure 34:

Figure 34: 700 Hours 2 December 1938.

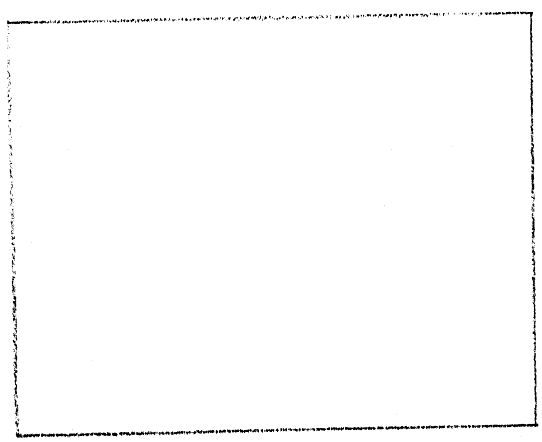

Figure 35:

Figure 35: 700 Hours 3 December 1938.

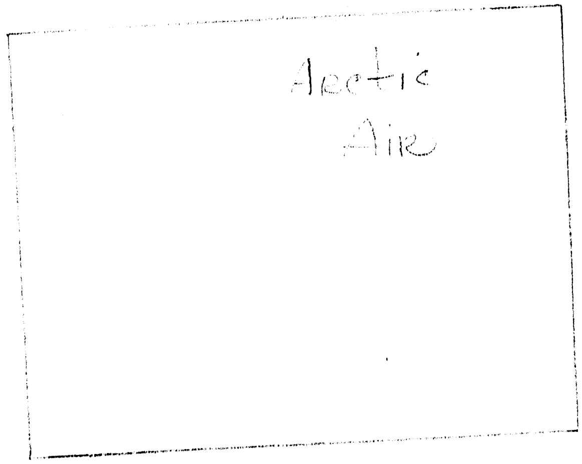

Figure 36: 3 December 1938.

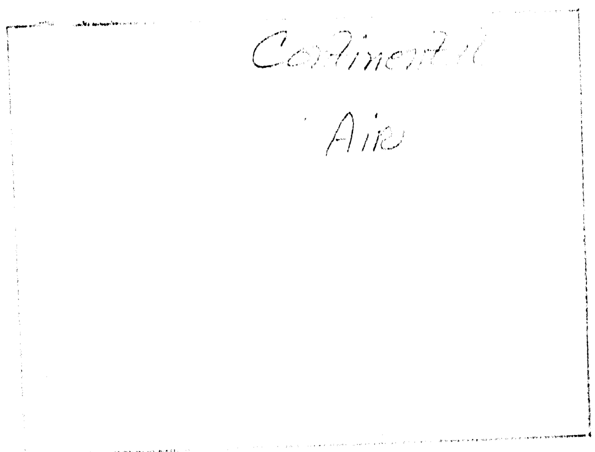

Figure 37: Impedance of the cyclones over Western Trans-Caucasia (11 December 1938).

The general synoptic situation over the continent, under the conditions of which the Arctic air penetrated so far to the south, was as follows: the eastern half of the European part of the Union was dominated by a powerful anticyclone, enclosing a series of cyclones at the Arctic front, with one of these cyclones situated over the area of the lower Irtysh. On 2 December in the morning (Figure 34) the Arctic air arrived over the Sea of Azov. The Northern Caucasus at this time was filled with continental air from Eastern Europe, and Trans-Caucasia, with continental air from Asia Minor. The temperature in Novorossiysk was plus 6 degrees

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Centigrade, in Sochi -- plus 8 degrees Centigrade. On 2 December the Arctic air reached the Caucasian ridge and began to by-pass it, extending along the coasts of the Black Sea and the Caspian Sea. Toward the morning of 3 December, the Arctic air moving over the Black Sea coast passed over Sochi (where the temperature, as compared with the preceding morning, dropped by 13 degrees Centigrade), and the Arctic air moving over the coast of the Caspian Sea passed over Derbent. In the area of Novorossiysk this penetration was accompanied by a powerful gale. Toward the evening of the same day, the Arctic air flowing over the Black Sea arrived over the Turkish coast, and the Arctic air flowing over the Caspian Sea arrived over the Persian coast. In Batum, with a snow storm raging, the temperature dropped to minus 8 degrees Centigrade (a drop of 15 degrees Centigrade as compared to the morning). The cold air filled the entire valley of the Rion and the lower course of the Kura. During the day of 3 December, a snowstorm was raging over the entire coastal area, from Baku to Lenkoran'. Yet, at the northern slopes of the central part of the Caucasian mountain ridge, the Arctic air had only reached the altitude of 1000 meters, and the [cold] front did not get over the mountain ridge.

At other times the cold fronts succeed in getting over the Caucasian ridge, but only in such places where the altitude of the ridge is below 1000 meters. The cold air, upon reaching the mountainous wall, begins to warm somewhat, and the temperature on the slopes, during cold penetrations, is frequently higher than the temperature in an adjacent valley. This is due to the intermixing of the cold lower layers with the warmer upper layers. With the inflow of new masses of cold air, the warm air over it is forced upwards. The result is greater precipitation at the northern slopes of the ridge.

With relation to the warm fronts, the terrestrial configuration also plays an important part, by activating them and thereby causing increased precipitation, as in the case of the substantial rains over the southwestern slopes. Abundant precipitation over the southwestern slopes is due not only to the activation of the fronts, but also to the retardation of the cyclones over the coast of the Black Sea in their movement eastward. This retardation is caused, in addition to terrestrial configuration, by the evolution (particularly in the winter) of an anticyclone over the European territory of the Union, at the same time that cyclones are passing over Trans-Caucasia (Figure 37).

Not only the ridges of the Great Caucasus, but also the mountains of Asia Minor exert an influence over the circulation of the lower /atmospheric/ strata and over cyclonic activity. The Tropical air arriving from Asia Minor, in its descent from the mountains, is very dry, as can be seen from the synoptic disposition for 28 December 1938 (Figure 38).

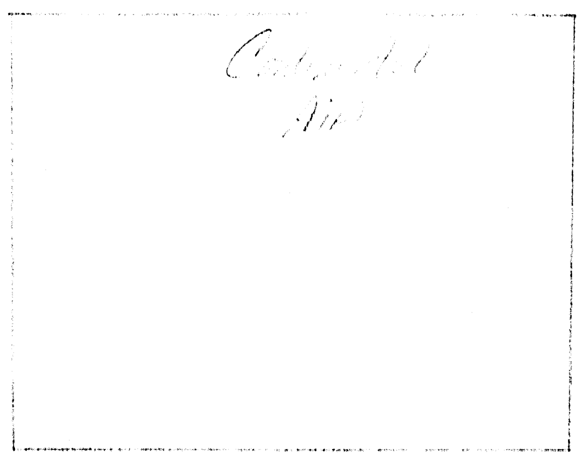

Figure 38.

(29 December 1938).

Such dry adiabatic air extends at times over the Black Sea coast all the way to Sochi. The cyclones arriving over Trans-Caucasia from the south, are also frequently dry. Yet at the same time, if the Tropical air is moving not /immediately/ over the earth's surface, but at some altitude (at the occlusions of the Asia Minor front), it will be a source (in the secondary cyclone) of considerable precipitation

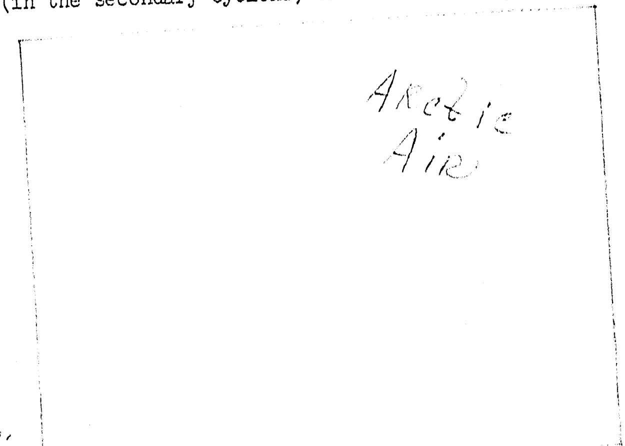

Figure 39: The winter occlusion of the Asia Minor front (23 December 1938).

The climatic significance of the Caucasian Mountains is also accentuated by its vertical zoning, which is due not only to the general temperature and humidity variations with altitude, but to circulation in the free atmosphere. Thus, beginning with an altitude of 2000 meters, the leading part is played by the western current, with the accentuation of the effect of the Atlantic and the Mediterranean.

The Black Sea and the Caspian Sea lying, respectively, on each side of the Caucasus, are not equivalent in their effect upon the climate of the Caucasus. This is due not so much to their individual characteristics, as to their respective locations. The Black Sea lies athwart the westerly air currents flowing toward the Caucasus, while the same westerly winds, dominating the middle troposphere, carry the air from over the Caspian Sea into Central Asia.

These bodies of water are limited in area, and there is insufficient time for the air masses carried over them to become transformed into maritime air. Therefore, the air masses circulating over them are predominantly continental, undergoing certain changes, with relation to temperature and humidity, in their bottom layer only.

In the winter the lowered pressure over the surface of the Black Sea causes the deflection of the Mediterranean cyclones to the northeast from their main path through Asia Minor, with the resulting increase in the amount of precipitation over the seacoast and the western slopes of the Caucasus. In the summer the relatively cold surface of the sea creates favorable conditions for the extension of the Azoric area of high pressure eastward, and for the establishment of weather characterized by a light degree of sky cover. Over the seacoast 50 percent of the summer season is almost completely clear (a particularly large number of clear days occurs in the beginning of autumn).

The predominant circulation over the entire Caucasus in the summer is the transfer of air masses from the north. These northerly currents are connected with the eastern periphery of the Azoric anticyclone outcrop, and with the western periphery of the Asiatic depression. The continental air of the southern steppe belt, in various phases of its transformation into Tropical air, is transferred to the Northern Caucasus. Over Trans-Caucasia the predominant air is Tropical air, which, after it is formed right there, lingers on due to the prevailing wind deficiency.

In the winter, there is a flow toward the Northern Caucasus of continental air from the east and northeast along the southern periphery of the areas of high pressure. Over the coast of the Black Sea, from the southeast, along the eastern brim of the Black Sea depression, extends air of a basically continental type, but with maritime characteristics in its bottom layer. The same kind of air is observed over the Caspian Sea coast. Over the Armenian highland, in the areas of high pressure, there is circulation of continental air of Asia Minor origin, which penetrates into the central zones of Trans-Caucasia.

The Caucasus can be divided into three climatic regions: (1) The Northern Caucasus, which constitutes a part of the Southern Continental climatic region of the European territory of the USSR; (2) The high-altitude Great Caucasus, a territory [constituting the Caucasian ridge proper], with average altitudes from 2000 meters up; (3) Trans-Caucasia, which includes the Kura-Rion corridor and the Armenian highland. The first two regions are in the temperate climatic area, while Trans-Caucasia lies in the sub-tropical area.

Northern Caucasus

The climatic region, of which the Northern Caucasus is a part, borders with its foothills on the high-altitude Great Caucasus, and with its Black Sea and Caspian Sea littorals, on sub-tropical Trans-Caucasia. Along the northern slopes of the Caucasus, the boundary runs at an altitude of 1500-2000 meters, an altitude above which the cold air masses rise only on rare occasions. On the Black Sea littoral, the boundary lies between Tuapse and Sochi, and on the Caspian Sea littoral, in the area between Derbent and Kuba.

With relation to circulation features, there are three distinct climatic zones within the Northern Caucasus:

(1) The northwestern Mediterranean zone, which is a continuation of the Mediterranean zone in Southern Crimea. Its eastern boundary is the river Belaya.

(2) The central zone, which by circulation characteristics is connected with the south of the European territory of the USSR, and may, therefore, be called the East-European zone. It occupies the territory to the east of the river Belaya, the Stavropol' elevation and the adjacent to it central part of the Northern Caucasus up to an altitude of 1500-2000 meters.

(3) The southeastern zone, where the influence of Europe is gradually subsiding, and the effect of the Asiatic land mass is in its

ascendancy. It may, therefore, be called the Asiatic zone -- it occupies the basin of the Terek and the Dagestan.

The winter in the North Caucasus is characterized by continental features, and the predominant air mass is continental of East-European origin. The percent of Atlantic and Arctic penetrations is even lower than that over the Steppe-Continental region, with a subsequent decrease in temperature variation. Thus, the mean January temperature in Pyatigorsk is minus 5 degrees Centigrade, and in 70 percent of all cases the mean daily temperature is actually close to this value (fluctuations do not exceed plus 3 degrees Centigrade). While in the Atlantic-Continental region, the number of cases in which the man daily temperature [during January] is close to the mean monthly value is less than 50 percent. The continental feature is accentuated by the stability of temperature in the above indicated sense, and also by the possible sudden temperature drops in individual cases. Freezing weather in the Northern Caucasus can go down to the same level, as in the area of the Lower Volga, that is to minus 30 degrees Centigrade, but is of shorter duration. Extensive thaws occur rarely. Thus, it is not every winter when days with a mean temperature of over plus 5 degrees Centigrade will occur in Pyatigorsk.

In connection with the orographic lifting of the air in cold and, particularly, in warm penetrations, there is frequent recurrence of compact fogs, enveloping large areas. Under negative temperatures close to zero Centigrade, these fogs, consisting of supercooled drops, often result in intensive hoarfrosts and sleet. According to reported data, the area particularly affected is the area of the Caucasian Mineral Springs (spas). It is reasonable to suppose, however, that other less reported areas on the northern slopes suffer from extensive formation of sleet in the winter months. In the area of the Caucasian Mineral

Springs, the sleet formations are so heavy that almost every year there is disruption of the electric power lines. The sleet intensity depends to a great extent on the local wind intensification, which is due to terrestrial configuration. It is of interest to note that fog and subsequent sleet are formed rarely in localities lying above the 700-800 meter level. For instance, in the same zone of the Caucasian Mineral Springs, the fog is sharply discontinued between Essentriki (altitude 600 meters) and Kislovodsk (altitude 800 meters). And while practically all of the zone is covered with a dense fog (accompanied by a rather strong wind), it is calm and clear in Kislovodsk.

Orographic turbulences connected with the flowing of air onto the mountain slopes, are not always accompanied by the formation of fogs. Said formation depends upon the humidity and temperature of the air mass. Sometimes the process is limited to the development of overcast. The synoptic conditions, under which there is inflow and lifting of air, evolve rather frequently, wherefore the winter months on the northern slopes of the Caucasus up to an altitude of 800-1000 meters are distinguished by a considerable number of overcast days. Below is a tabulation of data on overcast in the area of the Caucasian Mineral Springs.

Number of Days with Overcast

	December	January	February
Zheleznovodsk	16	12	13
Pyatigorsk	17	12	11
Essentuki	15	11	10
Kislovodsk	8	5	3

Of course, overcast in the Northern Caucasus is connected not only with the above described process, but also with cyclonic activity. The overcast is carried by the West-European cyclones, while the Mediterranean cyclones, passing over the Black Sea, generate considerable sky cover over

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the northwestern zones only. At the source of the Kuban', the Mediterranean cyclones are accompanied by foehns, caused by the downward movement of the air after it has crossed the Caucasian ridge. To the east of the Caucasian Mineral Springs area, the Black Sea cyclones are not observed.

Cyclonic activity over the Northern Caucasus during the winter is not of great intensity, and the amount of precipitation is not greater than in the region of the Lower Volga (about 20 millimeters a month). The number of days with precipitation is also comparatively small, somewhat more than half the number of days with overcast, which is due to the above described lifting of the air along the mountain slopes. In connection with the small amount of precipitation, on the one hand, and the frequent thaws, on the other hand, the snow cover is rather light and unstable. On the average, it is sustained for about two and a half months (from the middle of December to the beginning of March), attaining a depth of 10-15 centimeters by the end of February.

The winter season in the area of the Kuban' and on the Black Sea littoral (Novorossiysk, Tuapse), constituting the Mediterranean climatic zone of the Northern Caucasus, is considerably milder. The Kuban' area has a mean January temperature of about minus 2 degrees Centigrade, i.e. 3 degrees Centigrade warmer than that for the central East-European zone [of the Northern Caucasus] (Stavropol', Pyatigorsk). This cannot be explained by lower altitude, since in the Northern Caucasus in winter, up to an altitude of 800-1000 meters, the mean temperature does not drop with altitude, but rather increases somewhat, as a result of the atmosphere over the Kuban' lowland being filled with cold air. The gradual temperature increase during the winter, northwestward along the Caucasian ridge, is due to the more frequent penetrations of maritime air which is carried from the Black Sea with the passing of the southwesterly Mediterranean cyclones.

It is still warmer than that on the littoral, which may be considered as a sub-zone of the Kuban' zone. The mean January temperature in Novorossiysk is plus 2 degrees Centigrade, in Tuapse, plus 4 degrees Centigrade. Such a comparatively high temperature is due, first of all, to the direct proximity of the sea, and, second, to the presence of the mountain ridge. This ridge acts as a barrier hindering the continuous inflow of the cold continental air from the northeast, toward the littoral, and allowing it to pass only in those cases when the vertical depth of the air mass exceeds the altitude of the ridge. In line with such accentuation of the respective effects of the sea and the continent, the temperature fluctuations during the winter are sharper on the littoral than on the slopes of the Northern Caucasus. Cold air penetrations sometimes result in a temperature drop to below minus 10 degrees Centigrade, while with warm air penetrations the temperature rises to plus 10 degrees Centigrade. This 20 degree temperature jump sometimes takes place within a period of only 2 to 3 days. Another feature of the thermal cycle over the littoral is that the winter frosts are accompanied by strong winds, reaching at times the strength of a gale, which aggravates greatly one's sensitivity to the cold. These cold northeasterly gales are known as BORA. This phenomenon is also known in other areas of the USSR, such as Novaya Zemlya, Balkhash /lake/, Baykal /lake/, and the littoral of the Sea of Okhotsk. The BORA sets in at the moment a cold front passes over a mountain ridge. Its subsequent evolution is due to the overflow of cold air spreading behind the front. The bora continues until such time as there exists above the ridge a cold air current of sufficient force, which, in striking the mountain barrier, begins to pulsate, imparting to the wind a peculiar gustiness, a characteristic distinguishing the bora from other winds. Since the air currents are descending, the passing of the front is not accompanied by cloud formation and precipitation. The sky during the bora is clear, with the exception of a characteristic dloud bank extending along the mountain ridge. This cloud bank remains stationary regardless of the powerful, wind, which clearly demonstrates the fact that the place occupied by it is merely the place of intensive cloud formation. At all times pieces of this cloud mass are torn off by the wind and fade away, with new cloud sections appearing. The formation of the cloud bank is due to condensation of vapor in the rarefied air, which is formed as a result of the turbulent backwash at the summit of the ridge.

The evolution of the bora can be studied from Figures 34, 35, and 36 above. As soon as the front has moved across the ridge, the mild southwesterly wind (Figure 34) shifts to a northeasterly wind of gale proportions (Figure 35), with a sharp drop in temperature. On 3 December the bora continues (Figure 36), since there is still present over the ridge a strong easterly current, conditioned upon a considerable pressure gradient force at the boundary between the continental anticyclone and the trough of depression over the Black Sea.

The bora attains its maximum force over the zone of Novorossiysk. The wind descending from the mountains causes tremendous agitation in the bay below. In the winter, during the periods of the bora, the Bay of Novorossiysk resembles a boiling cauldron, over which rise clouds of vapor. The vapor clouds are the condensations in the frosty air of the air moisture evaporated in the strong wind. The waves are broken into spray by the wind, and the supercooled drops settle in the form of heavy sleet on the hulls and the rigging of ships in the bay, and on the walls of buildings located on the southwestern side of the bay.

The bora frequently causes the spontaneous rolling of loaded railroad cars [waiting at sidings] and at times even overturns them, breaks power and communication lines which are heavy with sleet, upsets and breaks poles, etc. The air current descending from an altitude of 600-700 meters is adiabatically heated, but the temperature increase of 6 degrees Centigrade does not compensate for the general temperature drop caused by the cold penetration. Beyond the mountain ridge the temperatures of the cold air run to minus 20 degrees Centigrade and below. The adiabatically induced temperature rise of 6 degrees Centigrade establishes the temperature on the littoral within the range of minus 10 to minus 15 degrees Centigrade. This temperature combined with the powerful wind (mean wind velocity about 20 meters per second) will cause the same sensation as the severest frosts of Yakutia. The bora usually lasts a few days, but at times lingers on for over a week. In Novorossiysk, for the three winter months, there are, on the average, 10 days during which the bora predominates, with a mean daily temperature below minus 5 degrees Centigrade. Toward the south, with higher altitudes of the mountain ridge, the bora occurs less and less frequently, and fades away completely between Tuapse and Sochi.

The combination of calm and frosty weather is practically unknown on the littoral, since, with calm, a strong effect on the temperature of the air is exerted by the direct proximity of the sea, with the additional protection of the coastal belt from the inflow of cold continental air, afforded by the mountain ridge.

In addition to the part played by the continental air masses, the transfer of maritime air carried by the Mediterranean cyclones is also of great significance. As mentioned before, the cyclones of the Mediterranean front reach the shores of the Crimea and of the Northern Caucasus already in a state of occlusion. These cyclones move, in the majority of cases, from southwest to northeast, and the maritime air arrives over the littoral with the southwesterly winds, frequently of gale proportions. These gales, however, in contrast to the cold and dry northeasterly gales, have a positive temperature and are accompanied by precipitation.

Thus, the inflow of the cold air masses and the transfer of the warm ones are accompanied by strong winds, frequently assuming gale proportions. The zone of Novorossiysk in the winter is the windiest zone of the entire Union. The recurrence of strong winds (over 10 meters per second) amounts to more than 20 percent, out of which one half may be designated as gales (above 15 meters per second). The mean velocity of the wind for the three winter months is about 7 meters per second, and over the ridge proper it is considerably higher.

During the periods of relative calm in the atmosphere, which periods constitute 30 percent of all days, there is a prevalence of mild southeasterly winds, which carry the relatively warm air from southern Trans-Caucasia at a temperature which at times is several degrees above zero Centigrade.

Cyclonic activity in the winter brings a considerable amount of precipitation, and the winter is the most humid season, since the ridge slope facing the sea is windward of the saturated southwesterly air currents. The effect of the presence of the mountain ridge with regard to precipitation becomes clear by comparing the amounts of precipitation (in millimeters) for Novorossiysk and for Anapa:

	December	January	February
Novorossiysk	82	74	62
Anapa	50	45	38

Toward the south, the amount of precipitation on the littoral increases, which is mainly due to the rising altitudes of the ridge. The cumulative amount of precipitation for the three winter months is as follows: 218 millimeters for Novorossiysk, 384 millimeters for Tuapse, 497 millimeters for Sochi. Snow occurs on relatively rare occasions, and liquid precipitations predominate.

In Dagestan, regardless of its more southern location, the winter is not any milder than in the area of the Caucasian Mineral Springs and on the Stavropol' Plateau. This is due to the almost continuous inflow of continental air, at times even of Asiatic origin, with the northeasterly anticyclonic winds. Only in the direct proximity of the Caspian Sea does the temperature rise somewhat, yet remain negative in its mean value. In Makhach-Kale the month of January is 6 degrees Centigrade colder than in Sochi. The same sharp contrast between the Black Sea littoral and the Caspian Sea littoral prevails with relation to precipitation: the amount of precipitation for the December-February period in Sochi is almost 500 millimeters; in Makhach-Kale it is 110 millimeters.

The summers in the Northern Caucasus, in the low-lying zones with steppe characteristics, are rather hot with little rain. On the mountain slopes, however, with rising altitudes, the temperature drops, and the amount of precipitation increases. For instance:

Mean Temperature (in Degrees Centigrade) and Amount of Precipitation (in Millimeters)

	June	July	August	June	July	August
	(Temperatures)			(Precipitation)		
Novo-Romanovskoye (Altitude 100 Meters)	21.8	24.8	24.0	59	35	30
Dzandzhikan (Altitude 680 Meters)	17.6	20.4	19.7	154	126	80

Novo-Romanovskoye lies on the plain to the north of Dzandzhikan, at a distance from it somewhat over 200 kilometers. Such a considerable increase in the amount of precipitation over the slopes, as compared to the plain, is due not only to the intensification of the passing active fronts under the influence of the [terrestrial] relief, but also to the regeneration of semi-discontinued occlusions, which, over the plain, have already ceased to produce precipitation. Thus, the mountainous zones receive not only a greater amount of, but also more frequent, precipitation than does the adjacent plain. In the beginning of the summer, the number of days with precipitation amounts, on the average, to 15, while in August it is decreased to 10. In the process of the orographic regeneration of occlusions, and, generally, in the intensification of fronts under the influence of /terrestrial/ relief, of great importance are the thermally ascending currents /convection currents/, evolved during the day over the slopes. This explains why in the falling of frontal precipitation over the slopes of the Northern Caucasus there is clear evidence of a daily cycle -- precipitation occurs predominantly during the second half of the day. Thus, in addition to frontal precipitation, the mountain slopes also receive local convective rains.

The summer rains over the mountainous zones are intensive. During the summer there are, on the average, 15 rains in excess of 10 millimeters per day, while over Moxcow there are only six such rains. Not infrequently the amount of precipitation rises to 20 millimeters a day, and on rare occasions as high as 200 millimeters in one day.

The temperature cycle shows more stability in the summer than in the winter. At an altitude within the range of from 500 to 700 meters, the mean daily temperature in 90 percent of cases remains close to 20 degrees Centigrade. At night it descends to 15, and only in exceptional cases to below 10 degrees Centigrade. However, temperatures during the daylight hours often rise to 30 degrees Centigrade.

In the area of Krasnodarsk, the summers are hotter and dryer, particularly in its eastern part, adjacent to the Stavropol' Plateau. This is partly due to the effect of the foehns evolving in the down-slope air current, in the presence of easterly and southeasterly winds, which presominate in the summer. In this area precipitation increases only in the mountains.

Summer on the Black Sea littoral is little different from the summer of the continental steppe-like zones of the Northern Caucasus, except that the daily temperature and /relative/ humidity fluctuations are, naturally, smaller. At the seashore it is warmer and dryer at night, less warm and more humid during the day.

Summer precipitations in the northern part of the littoral occur predominantly with the passing of the northeasterly cyclones, the paths of which coincide with the [geographical] direction of the mountain ridge, this being the reason for practically the same amount of precipitation on the southwestern and the northeastern slopes. There is some decrease in the amount of precipitation on the coast during the summer, as compared with the winter months (when the cyclones arrive from the southwest), which, as was shown above, is due to the development over the Black Sea of an area of somewhat increased pressure. However, the dryness of the summer here is predicated not only on the extension of the Mediterranean area of high pressure, but also on the inflow of dry continental air from the southeastern regions of the European territory of the Union. The close tie-in with the continent is demonstrated also by a sharp reduction in the amount of precipitation by the end of the summer. This characteristic feature of the continental cycle gradually disappears toward the south, and in the zone of Sochi is hardly noticeable:

Amount of Precipitation (in Millimeters)

	June	July	August
Novorossiysk	62	56	31
Tuapse	85	100	66
Sochi	78	94	82

The inflow of continental air over the littoral is much more even during the summer than during the winter, since the vertical capacity of the continental air current is always considerably in excess of the mountain ridge altitude, and the pressure gradient forces are smaller than in the winter. Yet, every year, specifically in the summer, there is the recurrence of the bora. The summer northeasterly storms, as well as the winter ones, accompany the cold penetrations and are observed upon the passing of the cold front. The temperature differential in the bottom layers, as between maritime air and continental air, is small during the summer, and the diabatic warming of the air, in its descent from the mountain ridge, may even cause a rise in temperature as compared to the day before. In this case the bora assumes the characteristic of a foehn, i.e. the temperature rises to 25 degrees Centigrade; its daily fluctuations disappear; relative humidity drops to below 30 percent. If the bora occurs in the middle of the summer, it is as if it breaks it in two halves. During the first adequately humid half, grasses and trees, although not very abundant in this part of the littoral, look fresh and green. After the bora everything dries out, becomes yellow, and lingers in this state until the end of the summer, since during the second half, the amount of precipitation, in general, drops abruptly.

From the above it becomes clear that the bora cannot exactly be considered a beneficial climatic phenomenon. Yet, there is a positive side even to the bora. It serves as an excellent natural disinfectant for the northern part of the littoral, and has great value as an air stagnation inhibitor. It is largely the bora that makes the area Novorossiysk-Tuapse the most beneficial to health, as compared to the rest of the littoral, which is oppressive and humid. This was recognized by A. I. Voeykov. However, the actual blowing of the bora is difficult to take, particularly for people suffering from neurological disorders. Some neurologists ascribe this to the rapid minute fluctuations in pressure, caused by the above indicated pulsations of the wind [bora].

Dagestan is the hottest and dryest part of the Asiatic climatic zone of the Northern Caucasus. In the foothills, where the temperature begins to descend with altitude, the summer temperatures are analogous to those over the Kuban' plain. At an altitude of 500 meters the mean July temperature is 23 degrees Centigrade, while down below, even at the seashore, it is close to 25 degrees Centigrade. The amount of precipitation in the mountainous zones is approximately the same as in the foothill plain in the northwestern part of the Caucasus, while the littoral is clearly dry; there is only 150 millimeters of precipitation for the period June-September in Makhach-Kale.

The basic cause of aridity and high temperatures is the intensification of the anticyclogenesis, which is characteristic for the southeast of the European part of the USSR and for the area north of the Caspian Sea. In addition to abundant insolation, there takes place in the anticyclones a transfer of Central Asiatic air, which in its relatively short path over the Caspian Sea hardly has an opportunity for cooling.

The High-Altitude Area of the Greater Caucasus

To the High-altitude area of the Greater Caucasus is relegated the territory, the climatical conditions of which are resolved to a considerable degree under the influence of a free atmosphere. Notwithstanding the fact that essential climatical differences are observed in the High-altitude part of the Caucasus, the area in its entirety can be considered as one climatic region, since there are some general characteristics pertaining to it as a whole. The location of the mean level, at which this region begins, can be tied in with the altitude, at which, in the surrounding free atmosphere, the change of direction of the basic transfer of the air masses occurs. Over the Caucasus, beginning with an altitude of 1500-2000 meters, the westerly transfer of air masses predominates, while below the winds are predominantly easterly. Approximately, beginning with the same altitude, the maximum value in the annual temperature cycle is shifted to the month of August, which is characteristic for the temperature cycle of the free atmosphere. Thus, the bottom limit for the High-altitude climatic region in the Caucasus, is the already mentioned 1500-2000 meter altitude.

The character of the terrestrial configuration of the High-altitude region of the Greater Caucasus is such (the absence of large plateaus), that the underlying surface affects comparatively little the temperature of the air flowing over it. In addition, it is necessary to remember that the degree of sky cover is comparatively low over the central Caucasus only in the winter, when the cooling air, flowing downward, is replaced by warmer air from the surrounding atmosphere. Sky cover is considerable in the summer, and there is little insolation of the terrestrial surface and the adjacent atmospheric layer. The temperature change, with relation to altitude, within the limits of the High-altitude region, is very close to the change taking place in the free atmosphere, and can be easily computed without direct observations. The mean temperature of the coldest month (January) at the altitude of 2000 meters, is around minus 8 degrees Centigrade, the mean temperature of the warmest month (August) is around plus 13 degrees Centigrade. The daily temperature fluctuations, caused by advection, as in the free atmosphere, are not smaller than over the plain adjacent from the north, and are greater than in the protected zones of Trans-Caucasia.

Relative humidity in the High-altitude region is generally higher than in the free atmosphere, particularly in the summer months, when there is moisture condensation in the currents rising from below, attaining a mean of 80 percent. The products of condensation, fog and clouds, which, in these altitudes, hardly differ one from the other, are predominantly local formations, tied in, to a smaller degree, with the processes in the free atmosphere. The fluctuations in humidity, as well as those in temperature, depend on the changes in the free atmosphere, and are more frequently observed by their absolute values, than they are in the areas located below.

The activity of the fronts over the High-altitude region, as compared with same over the lower zones, is increased, and with it there is an increase in the amount of precipitation. There is, however, a limit to this increase, since with the increase in absolute altitude, the moisture content of the clouds is decreased. This becomes evident at such altitude, where the clouds become predominantly snow clouds. This explains, incidentally, why the zone of maximum precipitation is clearly in evidence only in the summer, while in the winter, with snow precipitation, it is not in evidence -- a phenomenon generally observed in mountainous locations, particularly in the Caucasus. These relationships allow the indirect determination of the altitude of the zone of maximum precipitation by the altitudinal changes in the character of falling precipitations (rain, snow). The increase in summer precipitation with altitude in any zone is observed for as long as the falling precipitation remains liquid. Beginning with the altitude where, together with rain, there is snow, the amount of precipitation, with the further rise in altitude, is decreased. This is not in contradiction with the increase in the snow cover with altitude (up to a certain altitude,of course), since the increase in snow cover depends not as much on the amount of precipitation, as on temperature conditions.

As much as it is possible to judge by the meager observational data, mixed precipitations (rain with snow) begin to occur at an altitude of 3000 meters. This level, then, is the altitude of maximum summer precipitation, which fact is roughly confirmed by direct observational data. As to the volume of the snow cover, it depends not only on the amount of precipitation, but also on the duration of its existence, which is rapidly increasing with altitude.

The High-altitude climatic region, like the region of the Northern Caucasus, can be divided into two zones: the western or Mediterranean zone, where the influence of the Mediterranean climatic region is still present, and the eastern or Continental zone. Basically, the difference between these two zones, lies in the character of cyclonic activity taking place over them. The occluded cyclones of the Mediterranean front predominate over the western (Mediterranean) zone, while over the eastern (Continental) zone, the occlusions of the western European cyclones and the Iranian front cyclones predominate, advancing at times almost exactly along the meridian, from south to north, over the Caspian Sea. The circulation peculiarities of the western and eastern zones create differences in the annual cycle of precipitations and their distribution over the slopes. There is more precipitation in the winter than in the summer in the western zone, even though during the summer there are, in addition to frontal precipitations, local thermal convection precipitations. The maximum amount of precipitation falls on the windward southwestern slopes. In the eastern zone, there is, on the average, half as much precipitation as in the western zone, as a result of which the snow line in the east lies 500-1000 meters higher than in the west. Precipitation falls predominantly in the summer, with greater quantities on the northern and northeastern slopes. The climatic boundary between the western and eastern zones passes approximately along the upper course of the Kuban' River.

Trans-Caucasia

By conditions of circulation, Trans-Caucasia can be divided into three climatic zones. The first one, or Western Trans-Caucasia, basically occupying the Valley of the Rion, can be called the Black Sea zone. The second one, or Eastern Trans-Caucasia, occupies the Valley of the Kura River and the lower course of its tributaries. The influence of the continent is felt strongly, and the zone is known as the Continental zone. The third zone, containing the Armenian upland, is called the Armenian Highland Zone.

Western Trans-Caucasia (the Black Sea zone) is an area characterized by the stagnation of air masses. The mountain ridges surrounding the Lowland of Kolkhida on three sides, weaken the air currents, by inducing the generation, over the windward slopes, of ascending currents, which are retarding the horizontal air transfer. In the saturated air, while it is ascending along the slopes, there is easy formation of clouds, and the ascending currents are accelerated because of the saturated air instability. This occurs with particular frequency in Western Trans-Caucasia, when westerly winds are blowing, since the Valley of the Rion is open mainly to these winds. Thus, the considerable degree of saturation of the air over the Valley of the Rion, is conducive to wind retardation, causing thereby the stagnation of air masses, with additional subsequent saturation.

The local climatic conditions over Western Georgia are so unique, that they impart to this area characteristics entirely strange to the continent, but very similar to those of the humid sub-tropical climate of the islands of Southern Japan. Western Georgia is, perhaps, the only place where the effect of local factors upon the climate is so strong. At one time some thought was given to the existence of so-called "climatic spheres" in the Caucasus. This idea, although true in part, has little local significance.

In addition to the vertical currents, generated when the westerly winds blow over Western Georgia, there is always the tendency, as over any mountainous country, toward the evolution of a local thermal circulation. This, however, is also observed in other areas of the Caucasus.

The winter in Western Trans-Caucasia is predominantly mild, with little difference in the mean winter temperatures between south and north.

Mean Temperature in Degrees Centigrade

	December	January	February
Sochi	8	6	6
Batum	9	7	7

Only on rare occasions will the temperature descend to minus 10 degrees Centigrade, and the synoptic situation, as presented in Figures 36-39, although typical for the given process, does not recur with every winter. The temperature fluctuations, generally, are not considerable, since cyclonic activity, which is the main cause for variations in weather, takes place mostly at the occlusions, where the Tropical air is cut off from the terrestrial surface. The temperature fluctuates within the limits of the temperature differentials inside the continental air masses, as between its Black Sea, Asia Minor, and Trans-Caucasian varieties. As to the Arctic front, it is usually situated only over the northern part of the sea (Figure 39).

There is also another reason for the winter temperature rise in Western Trans-Caucasia. It is the adiabatic heating of the air in its descent along the slopes of the Meskhian and Gurian ridges, with easterly and southeasterly winds. The easterly winds predominate in the winter over the Valley of the Rion, and, on the average, are warmer than the westerly and southwesterly winds.

The easterly winds are frequently very strong, and form foehns. This occurs, when over the Caspian Sea develops an area of high pressure, over the Black Sea -- a trough of depression, and along the corridor formed by the Greater and Lesser Caucasus is established a southeasterly wind current. This current, after crossing the Meskhian and Imeretian ridges, forms foehns over the western slopes of the latter and over the upper part of the Rion Valley. The foehns frequently pervade all Western Trans-Caucasia in the form of warm and dry winds. In the upper part of the valley (as in Kutais), the foehn assumes an intermittent character, and, like the bora over Novorossiysk, has the same kind of a depressing effect on the nerves. The number of days during the year with strong foehns exceeds 100, out of which 40 percent falls to the winter months (December, January, February), 35 percent to the spring (March, April, May). Figure 40 shows a typical synoptic disposition for Western Trans-Caucasia, with the foehn blowing as on 16 April 1937.

The foehns (gusty, dry, warm in the winter, and torrid in the summer), and the entire synoptic disposition during the foehn (brought about by the slow descent of the air), recur so frequently in the winter over Western Georgia, that the mean values for temperature and humidity are affected. Poti is warmer by 6 degrees Centigrade than Tbilisi in the winter, although the difference in altitudes is only 400 meters. And while it is true that part of the warmth is attributable to the sea, this effect is hardly sufficient to account for a temperature rise, since the winds prevailing over the coastal belt are from the continent. Relative humidity in Sukhumi, Poti, and Batumi is lower in the winter than in the summer, a circumstance that has been noted for quite some time.

Figure 40:

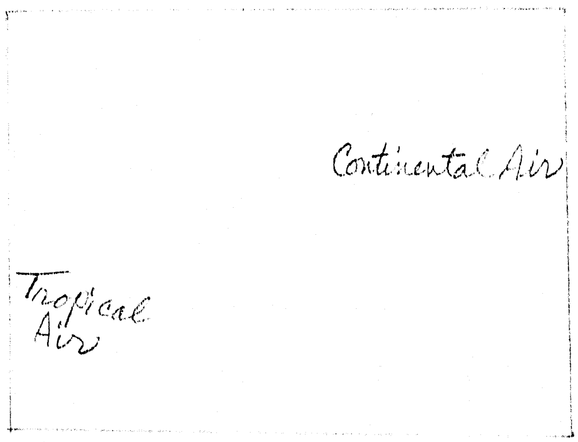

Figure 40: Synoptic Disposition During the Foehn in Western Georgia (16 April 1937).

Intensive cyclonic activity is generated during the winter, mainly in the form of occlusion cyclones at the Asia Minor Polar front outcrop. Rain in December, January and February takes up 50 percent of all days, sky cover cuts off 70 percent of the sunshine, and the mean amount of monthly precipitation for the same months is 100 millimeters for Sochi, and 220 millimeters for Batumi. Rain usually falls with westerly winds, which at times attain such velocities, that west and southwest walls in buildings have to be protected with light sheet iron.

Throughout most of Western Trans-Caucasia, the winter is the rainiest season, by the number of days as well as by the amount of precipitation. Only in the southernmost areas, such as Batumi, is there an equal amount of rain in the winter and in the autumn.

The distribution of winter precipitation in the Rion Valley shows one unique characteristic, and that is that precipitation decreases with distance from the sea in the direction of the Main Caucasian ridge, even though the southwestern slopes are favorably exposed with relation to the fronts moving from the west. This is a result of the impediment of the cyclones occurring exactly over the coastline, as shown in Figure 37. The main reason for the pause, and at times the discontinuance of the cyclones over Western Georgia, is the area of high pressure generated over the central part of the Caucasus and the Armenian Highland similar to the winter anticyclones over the Alps. Climatological maps do not show with adequate clarity the area of high pressure over the Greater Caucasus, on account of the discrepancy in reducing it to terms in relation to sea level, but the above area can be easily traced by following the wind distribution in the free atmosphere and by the conditions of sky cover. Sky cover in the winter (particularly in the first half of it, when most of the precipitation falls on the coast) over the high-altitude zones of the Caucasus is insignificant, and the high mountain resorts of Georgia, in this respect, are similar to those in the Alps. Toward the north (Sukhumi-Sochi), the distribution of precipitation with altitude becomes normal. The winter precipitation over Western Georgia are of a different origin, and their distribution over the territory is of a unique character as compared with the origin and distribution of precipitation over the northern part of the Black Sea littoral, from Novorossiysk to Tuapse.

The basic process during the summer over Western Trans-Caucasia is the saturation of the air. Mean relative humidity, under conditions of stagnation of the air masses, attains a value of 80 percent near the sea and over the lower part of the Rion Valley. Temperature fluctuations are also insignificant during the summer, since the air migration comes predominantly from the north, or with the outcrop system of the Azorean anticyclone, or with the Asiatic depression, warming up on the way and acquiring a homogeneous thermal structure. Local conditions have practically no effect on temperature, but they do affect humidity. Typical in this sense is the synoptic disposition of 25 June 1939 (Figure 41).

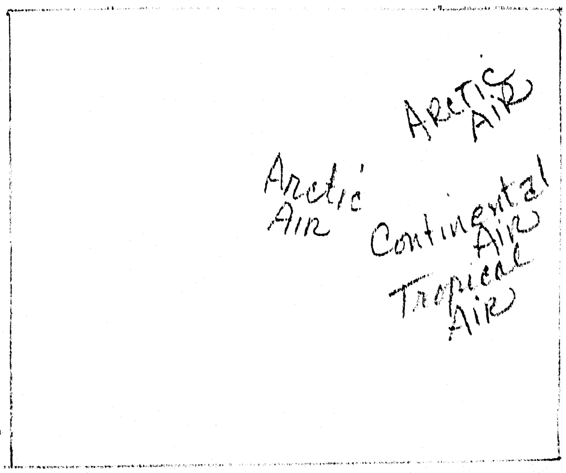

Figure 41: Synoptic Disposition Creating the Stagnation of Air Masses Over Western Trans-Caucasia (25 June 1929).

As a result of some loss of heat through evaporation, the temperature decreases, and the mean level for July and August on the coast becomes 23 degrees Centigrade, with some fluctuations either way. During the day, the temperature frequently goes up to 30 degrees Centigrade, descending to 18-17 degrees Centigrade at night.

Cyclonic activity does not essentially disturb the homogeneous temperature cycle. In most cases, the summer cyclones, passing over the Black Sea littoral of the Caucasus, are connected with the East-European outcrop of the Polar front, in which the relatively cold mass is constituted by what was previously the Atlantic air, now warmed through over the continent. As an example, see the synoptic disposition of 7 August 1936 (Figure 42).

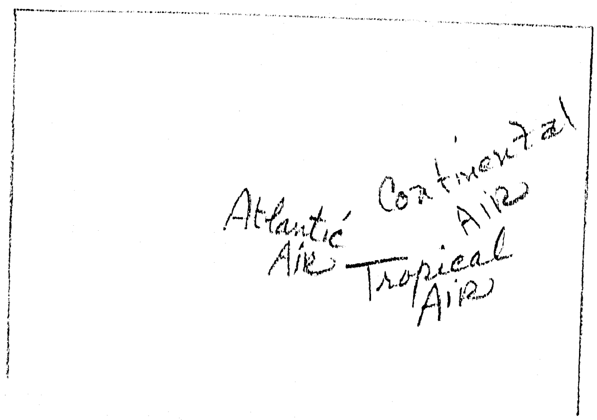

Figure 42: Cyclonic activity at the East-European Front (7 August 1936).

Although in this part the East-European front is not sufficiently active, the local air is saturated to such a degree, that there is much precipitation in the passing cyclones. Furthermore, the summer cyclones, too, frequently linger over Western Georgia if a sufficiently powerful anticyclone develops over Central Asia. The amount of precipitation increases during the summer, and over the southern zones it reaches 250 millimeters in August, and as high as 300 millimeters in September.

At times precipitation takes the form of abundant cloudbursts, attaining a daily amount of over 200 millimeters. The cloudbursts are accompanied by powerful thunderstorms, which is indicative of the ample saturation of the air. The cloudbursts are mostly of a frontal origin, the latter being fronts of warm penetrations of Asia Minor Tropical air, having considerable saturation stability, which causes cloudbursts and thunderstorms even at the warm fronts.

During the first half of autumn (in October), when the East-European front is discontinued, and cyclonic activity over the Mediterranean, Asia Minor and Iran is not yet adequately developed, there is a relatively dry period over Western Trans-Caucasia. Rains are less frequent, sky cover is diminished, yet relative humidity is as high as before, which is due to a general decrease in temperature, thus confirming indirectly the thought about the effect of the foehns on the evolution of the winter minimum in the relative humidity cycle.

Eastern Trans-Caucasia (the Continental zone) occupies most of the Kura-Rion depression, lying to the east of the watershed ridges connecting the Greater and the Lesser Caucasus.

Eastern Trans-Caucasia, with relation to the basic atmospheric processes, has a lot in common with the western part. Yet, even the similar features are so peculiarly refracted under the effect of local conditions that the climate of the Valley of the Kura is in direct contradistinction to the climate of the Rion Valley. Since Eastern Trans-Caucasia forms essentially a single corridor (although divided in two by the Meskhian and Adzhar ridges) with Western Trans-Caucasia, between such gigantic, solid masses of mountains as the Greater and Lesser Caucasus, it cannot essentially differ by general circulation conditions from Western Trans-Caucasia.

Over the Valley of the Kura, as well as over the Rion Valley, in the winter, the basic air current is southeasterly. Due to terrestrial configuration, the current over Eastern Trans-Caucasia is an ascending one, while over Western Trans-Caucasia it is descending. During the summer, inversely, western winds are predominant, and the current becomes ascending over the Valley of the Rion, and descending over the Valley of the Kura. This circumstance has an essential effect on the relative dryness of the winter in the Rion Valley, and the dryness of the summer in the Valley of the Kura.

The cold northern penetrations in the east and the west of the Kura-Rion corridor take place by flowing around the ridge, except that the Kura Valley penetrations occur more easily, and are less subject to the warming effect of the sea, and, in addition, are cooled by local radiation. Local cooling also takes place in the Valley of the Rion, but to a lesser degree because of a greater degree of saturation in the air.

Although there are many common features with relation to cyclonic activity, there are also essential differences. The winter cyclones usually move from Western Georgia into Eastern Trans-Caucasia, but to the east of the watershed the fronts are occluded in connection with the air current descending along the declivity of the valley, and the amount of precipitation decreases abruptly. The amount of precipitation for the three winter months in Kutaisi is over 500 millimeters, while in Tbilisi it is only about 50 millimeters. The paths of the cyclones of the East-European front very seldom pass over Eastern Trans-Caucasia in the summer, since the front is usually situated along the meridian

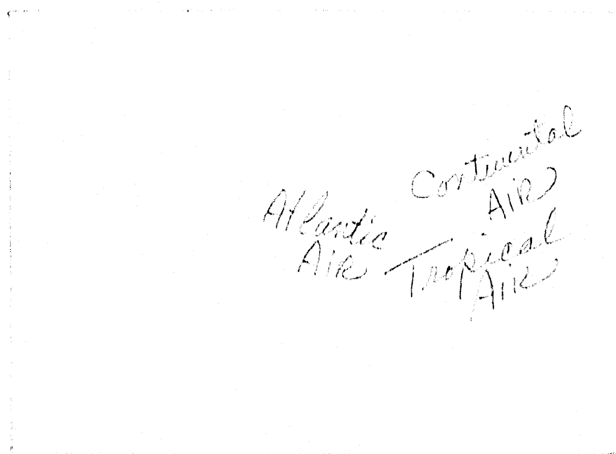

Figure 42:

Figure 42: Cyclonic activity at the East-European front (7 August 1936).

In addition to the diffusing effect of the Meskhian ridge, which becomes pronounced during the passing of the westerly cyclones, the Main Caucasian ridge exerts no less an effect during the movement of the fronts from the northwest to the southeast. A similar effect is exerted by the mountains of the Lesser Caucasus during the passing of the cyclones over the Kura Valley from the southwest to the northeast, or, generally, from south to north.

The foehns, so frequent in Western Georgia, are less important in Eastern Trans-Caucasia, and are generated under different synoptic dispositions. They recur predominantly in the winter over the northeastern and eastern slopes of the Lesser Caucasus, during the westerly winds at the periphery of the Armenian anticyclone, while the cyclone passes over the Caspian Sea. Foehns are also generated over the southwestern slopes of the Main Caucasian ridge, at various places along the entire Valley of the Kura, during the development of an anticyclone over the Lower Volga and the Caspian Lowland, with the simultaneous passing of the cyclones (from the northwest to the southeast) over the Kura-Rion corridor. At times the foehn is not accompanied by a rise in temperature, but only by a drop in relative humidity, which is due to the insufficiently high potential temperature of the air flowing over the ridge, which in its descent has only enough time to warm up to the temperature of the local air. Such a variety of foehn is, so to speak, in between the typical foehn, which is a descending current of a warm mass, and the bora, which is also a descending current, but of a cold mass.

At the southeastern terminal of the Main Caucasian ridge, there is frequent generation, during northerly cold penetrations, of a local acceleration of the wind, due to the one-sided narrowing down of the channel of the air current. This effect extends itself over the entire Apsheron Peninsula, and is known as the Baku nord, which, with relation to force, competes with the Novorossiysk bora. By its conducive synoptic background, and by its very nature, the nord has much in common with the bora, although it is not a "falling" wind. This is the same cold anticyclone over the southeast of the European part of the USSR, and the trough of depression over the southern part of the Caspian Sea, similar to the depression trough over the Black Sea during the bora. The Baku or Apsheron nords, as well as the Novorossiysk boras, usually occur in the winter, but will sometimes be observed in the summer also.

Several climatic sub-zones may be segregated in Trans-Caucasia. Of particular importance is the Talysh sub-zone situated at the extreme southeast of Trans-Caucasia. By its humidity and vegetation it resembles Western Georgia. It occupies a narrow strip between the sea and the Talysh ridge, also the lower part of the ridge slopes up to the altitude of 500-600 meters. By conditions of circulation, the Talysh sub-zone differs little from the remainder of Eastern Trans-Caucasia, but the effect of terrestrial configuration upon the climate is even more pronounced here than in Western Georgia. This is particularly emphasized by contrast with the arid Mugan Steppe and the subtropical forests of Lenkorania which lie alongside.

The Talysh mountains do not protect the coastal belt from cold air penetrations, but they do affect conditions of precipitation. Precipitation occurs predominantly in the autumn when, after the summer interval, cyclonic activity is renewed over the southeast of the European part of the USSR, and the East European continental air, which is just beginning to cool, penetrates into Eastern Trans-Caucasia, forcing the warm Trans-Caucasian air upward (Figure 43).

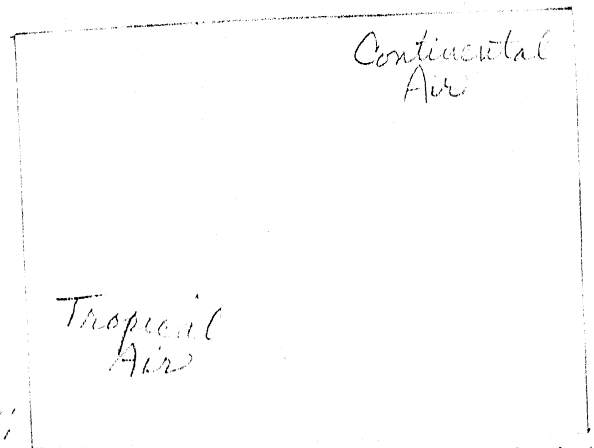

Figure 43: The synoptic disposition conducive to abundant precipitation in the Lenkorania zone (24 October 1939).

In following this process, the falling of precipitation from the Trans-Caucasian air is induced mainly by terrestrial configuration. On the leeward slopes of the Greater Caucasus facing the Kura Valley, and on the Apsheron Peninsula, there is no precipitation, or very little precipitation, under this disposition. But in the Lenkorania zone and further south, where the mountains come face to face with the fronts, abundant showers occur. The process described is basic for this zone, and determines for many years the mean cycle of precipitations and their distribution along the coast.

Amount of Precipitation (in Millimeters)

	July	August	September	October	November	December
Baku	6	7	15	24	29	206
Lenkoran'	16	67	168	236	166	1125

Relative humidity on the Talysh littoral is high the year round, particularly during the autumnal rains.

The winter is somewhat colder in the eastern part of Trans-Caucasia than it is in the western part. However, the general thermal reserve in the soil is so considerable, that the cold continental air from the European part of the USSR arriving here is rapidly warmed through its lower layers. This is helped along by considerable insolation and the absence of a stable snow cover. In connection with this, near-the-surface temperature inversions occur rarely, and, in general, low places are warmer than high places. Thus, on the Plateau of Kakhetia, there are some winters with considerable frosts and with deep snow cover.

The winter is only somewhat milder in the Talysh sub-zone than in the rest of the territory, seemingly not in keeping with its southernmost location, and with what would appear to be its isolation from the continental part. The Talysh coast is open to cold penetrations, and the protective effect is exerted only by the sea, with a considerable thermal reserve available in its deep-water southern part.

The summer in Eastern Trans-Caucasia is hot and arid. The Valley of the Kura during the summer is to a certain degree an area of stagnation of the air masses, since at this time of the year the northern meridional transfer of the air masses predominates over the Caucasus, and the pressure gradient forces are insignificant. Sky cover is small, and insolation abundant. As a result, the mean temperature for July and August over the plain attains, and in spots exceeds, the level of 25 degrees Centigrade, and even on the littoral the proximity of the sea hardly reduces the temperature of the air. The mean temperature for July and August in Baku and in Lenkoran' is about 26 degrees Centigrade.

The causes of this aridity were analyzed before. The climate of Eastern Trans-Caucasia, when the analysis of it is based on formal considerations, such as the arid summers, may be relegated to the Mediterranean type. This, however, is genetically untrue. By the characteristics of the processes taking place over Eastern Trans-Caucasia in the summer, this area can be relegated to the Central Asiatic region of the transformation of the air masses. The meteorological cycle of its summer tribution of temperature is very uneven and spotty. Also, when the atmosphere over Iran and Asia Minor is filled with Tropical air, the latter in most cases also extends over the Armenian Highland.

The saturation of the air masses circulating over the Armenian Highland, is somewhat lowered, partly because of their considerable height over sea level, and partly because of their origin. The winter continental air in the Armenian anticyclone has, near the earth's surface, a relative humidity close to 75 percent, which is due, in particular, to the presence of the snow cover. Generally this air is rather dry, since it does not contain air masses of maritime origin, and, in addition, it moves still further away from a state of saturation by descending in areas of high pressure. In the summer these air masses are fully continental, forming over Iran and Asia Minor. In its layer contiguous to the earth's surface, the mean relative humidity in the summer is maintained around 50 percent, which, combined with a mean temperature for July of 17 degrees Centigrade, is indicative of the dryness of the climate. In the Moscow oblast, for example, the same temperature is accompanied by a relative humidity of 60 percent. The summer deficiency in humidity is also indicated by insignificant cloud formation, which assures abundant insolation.

Cyclonic activity over the Armenian Highland is not very intensive. It extends further south in the winter. In the summer it is somwhat abated, in connection with the formation of Tropical air over the vast expanse of all Southwest Asia. And only in the spring, when the Iranian front is progressing northward and the temperature differentials between the continental air from the temperate latitudes and the Tropical air are not yet sufficiently great, is there a frequent passage of cyclones, which induce the spring rainy season, so common to the entire Lesser Caucasus. Sometimes, similar conditions occur in the autumn with the developing accentuation of the frontal zone, and its subsequent displacement to the south toward Iran.

The annual cyclonic activity cycle over the Armenian Highland, and the cycle of precipitation tied in with it, can be relegated, to a great extent, to the Central Asia type.

As already mentioned above, the Yerevan Hollow and part of the Valley of the Araks up to Nakhichevan', can be considered a sub-zone in which the climate characteristics of the Armenian Highland are particularly accentuated because of certain peculiarities in terrestrial configuration.

The sharp continental features of the climate here are manifested by high temperatures and aridity in the summer. The mean temperature for July at the altitude of 900 meters is 25 degrees Centigrade. The relative severity of the Armenian winter in this hollow is modified by the fact that the cold air, flowing off the surrounding mountains, is warmed in its descent. On the slopes of the hollow, as in the area of Yerevan, the mean temperature for January is only minus 5 degrees Centigrade. Also of great importance is the fact that the cold air is flowing down along the Valley of the Araks.

The vast hollow is conducive to the diffusing of the fronts that pass over it, and there is very little precipitation over the Yerevan sub-zone. The mean amount of precipitation is somewhat above 200 millimeters per year, which, against the backdrop of extreme summer heat, makes it practically a desert climate. This sub-zone has a spring rainy season, which is due to the intensification of cyclonic activity over the Armenian Highland.

CENTRAL ASIA

The territory of the Central Asiatic Republics, and also the southern part of the Kazakh SSR, are situated in the sub-tropical zone. The air masses of the Temperate latitudes predominate over these regions in the winter, with the exception of individual penetrations, while in the summer, it is the Tropical air masses that predominate.

At the same time, the entire territory lies in the belt of the seasonal migration of the Western Asiatic (Iranian) outcrop of the Polar front. Cyclonic activity in this frontal area is generated primarily during the cold part of the year, since it is at this time that the Tropical Iranian air moves in a current directly facing the cold Siberian air masses migrating from the northeast. During the summer, over the vast expanse of the interior of Asia, the air, due to intensive heating, is far from a state of saturation, even at great heights, which diminishes its ability to rise. And only in mountainous areas, where terrestrial elevations activate the surfaces of the fronts, does cyclonic activity manifest itself with adequate force during the summer. However, summer drought, induced by diminished cyclonic activity, penetrates, toward the end of the summer, even into the mountainous areas.

The territory of Central Asia can be divided into two climatic regions: (1) the Lowland and Medium-Altitude region, and (2) the High-Altitude region. The first region contains two zones: the Sub-tropical Iranian located roughly to the south of Parallel 40 North, and the Turanian zone, which is a transition from the Sub-Tropical to the Temperate belt, and is located to the north of the first zone. Over the Iranian zone meridional penetrations predominate, manifesting themselves by the replacement of the Iranian Tropical air with local Central Asiatic and Siberian air. Local Central Asiatic air masses are formed over the Turanian zone, with the number of western penetrations of European air increasing toward the north. Abutting these two zones, lies the Medium-altitude zone, up to the height of 2500 meters, in which can be segregated a whole series of climatic sub-zones. The characteristics of the circulation processes over these sub-zones is the same as over the Plain, yet the weather may change under the influence of terrestrial relief. For example, precipitation may occur when there is no precipitation over the Plain, or, inversely, a foehn effect may be generated, or the temperature background changes with altitude (during the winter there are frequent temperature inversions, within the limits of this zone), or there is the evolution of mountain-valley winds, which are not felt over the Plain, or there are essential changes in insolation, dependent on the slope exposures.

The High-altitude climatic region falls into the sphere of influence of the westerly air currents of the middle troposphere. These air currents, while forming a continuous complex with the air currents below, may have an entirely different direction with relation to the currents in the lower layer.

Many of the phenomena, taking place in the middle troposphere, such as the shifting of air masses and its effect on the weather of the high-altitude areas, either reach the Plain in an abated condition, or do not reach it at all, which is due to the leveling effect of the underlying surface. Therefore, the weather is more changeable at high altitudes than it is below.

The Lowlands and Medium-Altitude Region

The Iranian zone embraces all of Turkmenia, half of the Tadzhik SSR and the southeastern half of Uzbekistan.

The weather over the southern part of Central Asia is very unstable during the winter. Two typical /synoptic/ dispositions prevail. When the frontal zone is basically situated over Iran, the cold continental air pours in over the entire territory, extending from the northeast, from the vast anticyclone situated over Siberia (see Figure 44). In this case, the mean temperature level descends to several degrees below zero Centigrade, reaching at times minus 10 degrees. When the front is displaced northward, and the Iranian air penetrates over the territory of Central Asia, the temperature rises to 10 degrees above zero Centigrade. However, before long, cold air flows in again in the wake of the departing cyclone (see Figure 45). These rear cold penetrations are accompanied in most cases by strong winds with some rain and snow. The temperature range for the winter months attains 50 degrees Centigrade (plus 25 - minus 25), with the mean level somewhat above zero Centigrade. But even the mean temperature level oscillates considerably, by individual years. The mean January temperature for Ashkhabad fluctuates within the range of 13 degrees Centigrade (from minus 6 to plus 7). All depends on the frequency of the cold penetrations, the number and the intensity of which is increased with the acceleration of cyclonic activity over Iran.

The cold half of the year (October - March) is the rainiest season. Even at that, the total amount of precipitation is only 100-150 millimeters.

Figure 44: Northeastern penetration of cold Continental air over Central Asia (24 December 1937).

Continental Arctic Air

Cont. Pol. Air

Figure 45:

Figure 45: Penetration of Arctic air over the territory of Central Asia in the wake of the cyclone (7 January 1935).

Over the Medium-altitude zone of this area, as compared to [conditions over] the Plain, two particular conditions occur: (1) during cold air penetrations, the air usually does not reach above the 500-600 meter altitude, thus exerting a cooling effect upon the relatively low areas, with a temperature inversion taking place as the altitude increases; (2) During the passing of the cyclones, the amount of precipitation on the southern and southwestern slopes is increased, while on the northern slopes foehns are generated. In particular, a considerable amount of precipitation (up to 500 millimeters) occurs over the southern slopes of the Gissar ridge during the three winter months (December - February).

Cyclonic activity is accelerated toward the spring, and attains its highest intensity in March-April. During the same months, the Iranian frontal area, in its gradual northward shift, passes over the southern part of Central Asia. Figure 46 (synoptic disposition of 23 April 1934) shows two areas of cyclones, one at the Arctic front, and the other at the Polar front (the Polar front cyclonic area occupies a somewhat more northward position, than usual). Sometimes the Arctic front progresses far to the south, and practically joins up with the Polar front. When that occurs, the cold air penetrates into the southernmost zones, lowering the temperature to zero Centigrade, from a Tropical air temperature of 25 degrees Centigrade, which prevailed the day before the cold penetration took place. The Arctic air penetration in the spring is accompanied at times by snowstorms, with the snow covering trees in full bloom.

Figure 46:

Figure 46: Cyclonic series at the Arctic and Polar fronts (23 April 1934).

March and April are the months of maximum precipitation. Spring is a short season in the Sub-tropical area of Central Asia. In 40 percent of all days, the mean daily temperature over the Plain in March is maintained at plus 5 - 10 degrees Centigrade. In May, 40 percent of all days have a mean daily temperature of over 25 degrees Centigrade. With relation to precipitation and humidity, the changes are just as rapid. In March-April, with a mean temperature of plus 10 - 15 degrees Centigrade, the amount of precipitation is 40 millimeters a month, and relative humidity, even during the day, is above 50 percent. In May, with a mean monthly temperature of 23 degrees Centigrade, the amount of precipitation is less than 15 millimeters /for the month/, and the relative humidity during the day usually falls down to 30 percent.

There is much rain during the spring in the mountainous part, with the amount of precipitation in many localities for the month of April up to 150-200 millimeters, and over the Gissar ridge -- over 300 millimeters. In May the amount of precipitation, even in these areas, decreases, but is still considerable.

Conditions for the growth of vegetation in the mountains during the spring are very favorable, what with abundant precipitation, a mean temperature not exceeding 20 degrees Centigrade, a daily humidity of about 50 percent, and considerable insolation. Even during the rainiest month of April, the probability of overcast is less than 50 percent, and the probability of clear weather more than 30 percent. The rains frequently take the form of rapidly passing showers, and are accompanied by thunderstorms.

The summer everywhere is extremely dry. As early as May there is a sharp decrease in the rainfall over the Plain, and from June to September inclusive, there is practically no rain at all. The aridity in the air attains its highest limits, with mean relative humidity during the day dropping to 20 percent, and, in some cases, considerably lower. During the month of July, in more than half of all days, the mean daily temperature is 30-35 degrees Centigrade, with the absolute maximum attaining the level of 50 degrees Centigrade. The air, heavily laden with dust, extends upward to a height of several hundred meters. All these phenomena are tied in with the intensive heating, to which the air masses of the Middle latitudes arriving from the north are subjected, and with their transformation into Tropical air.

Conditions for the transformation of air masses over Central Asia during the summer are very favorable. The transformation takes place either in the ridges of accelerated pressure, progressing southward between the cyclones and passing over the lowland of Western Siberia, or in the outcrop of the East European anticyclone. The synoptic disposition with relation to the latter, is presented in Figure 47.

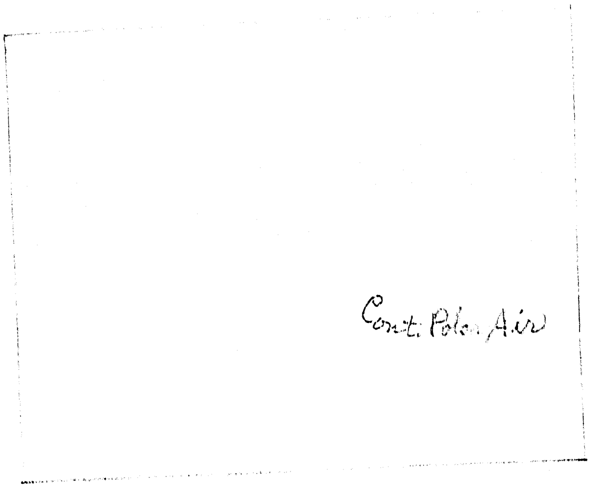

FIGURE 47:

Figure 47: The transformation of East European air into Tropical air over Central Asia (2 July 1936).

As a result of this transformation, there is a drop in relative humidity, a rise in the condensation level up to several kilometers, and a diminution of cyclonic activity. There is no precipitation, and the passing of the front is not always marked by increased cloud formation. However, temperature fluctuations caused by cold penetrations, may amount to 10 degrees Centigrade even in the middle of the summer. Figure 48 shows an example of a Siberian air penetration over the territory of Central Asia: there is no precipitation, the sky is clear on both sides of the front, but the break in temperature is considerable.

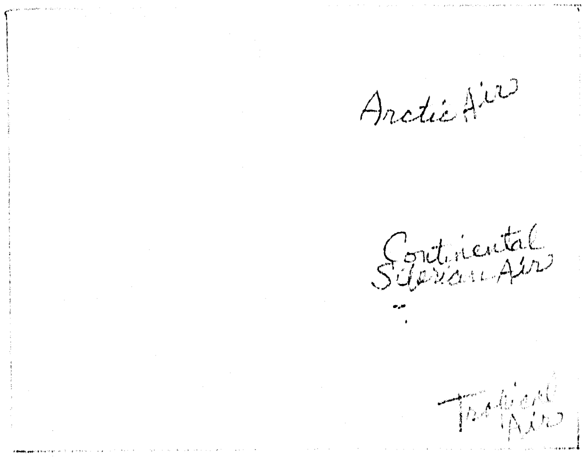

Figure 48: Penetration of Siberian air over Central Asia during the summer (22 July 1934).

The period of summer drought in the mountains is shorter, yet it is just as sharply accentuated. Even in the zones of maximum precipitation there is, on the average, not more than 10 millimeters for August and September, i.e. less than one percent of the annual amount. The beginning of the drought in the mountains, as compared to the Plain, lags behind, and occurs during the second half of the summer. The gradual decrease in precipitation upon the arrival of summer is partly compensated by abundant dew, settling not only on the grass, but also on brushwood and trees. The cause of this abundant dew formation lies not only in the considerable daily temperature range, but also in the high humidity of the air. With the arrival of the arid period, the falling of the dew is discontinued, and the mountainous areas are gradually filled with dry air, the volume of which is ever increasing throughout the summer. However, even during the drought period, rains of short duration, accompanied by thunderstorms, at times occur in the mountains.

The arrival of autumn is marked by intensified rainfall, which is a result of the accentuation of cyclonic fronts and their more frequent passage over the southern part of Central Asia. At this particular time of the year, it is the Polar front that is passing, in its displacement from the northern areas toward Iran. The accentuation of the fronts takes place as a result of the more rapid cooling of the Siberian and Central Asiatic air masses, as compared to the Iranian air masses, increasing thereby the temperature contrast between them. It is also a result of increased pressure gradient forces, with the development of the winter Asiatic anticyclone. However, there is less precipitation in the autumn than in the spring, since the level of condensation in the Iranian air, although it has been somewhat cooled, is still at a very high altitude. The amount of precipitation begins to increase in November. Thus, in desert zones, where the annual amount of precipitation is about 200 millimeters, the amount of same for the month of November is 10 - 15 millimeters, while in the mountains the [annual?] amount is from 100 to 500 millimeters.

Beginning with October, the pressure rises considerably over the Sub-tropical and Temperate latitudes of Eastern Asia, and there is the evolution of stable anticyclones, which are transformed during the winter into an almost stationary anticyclone. With the development of areas of high pressure, reduced cloud formation, and reduced wind velocity, the air begins to cool rapidly, and soon a considerable temperature differential is established between Eastern and Western Asia. Cold penetrations, not only from the north, but also from the east, occur over Soviet Central Asia as early as the beginning of October (as illustrated in Figure 49). However, in the autumn, following directly in the wake of an extremely arid summer, the moisture content of the air masses cannot be high, and there is less precipitation than in the spring, the latter being another period of accelerated cyclonic activity, when the Iranian front is moving across Sub-tropical Asia toward the north.

Figure 49:

Figure 49: Cold air penetration from the east over Central Asia in the autumn (31 October 1934).

The Turanian climatic zone, which is a transition zone to the Temperate latitudes with regard to temperature, precipitation, and circulation conditions, embraces the remainder of the territory of Central Asia, to the north of Parallel 40, the southern part of Kazakhstan up to latitude 48 degrees north, the area of the Lower Volga, and the mountainous territories of the Kirgiz SSR and Southeastern Kazakhstan.

This zone is a focal area for the formation of local Central Asiatic air masses, such as Tropical in the summer, and continental in the winter. At the same time, an essential part is played by the transfer of European air masses in the westerly cyclones and anticyclones. The effect of this westerly transfer, as was pointed out above, is generally accelerated toward the north. The synoptic disposition of 25 February 1934, as presented in Figure 50, can serve as an example.

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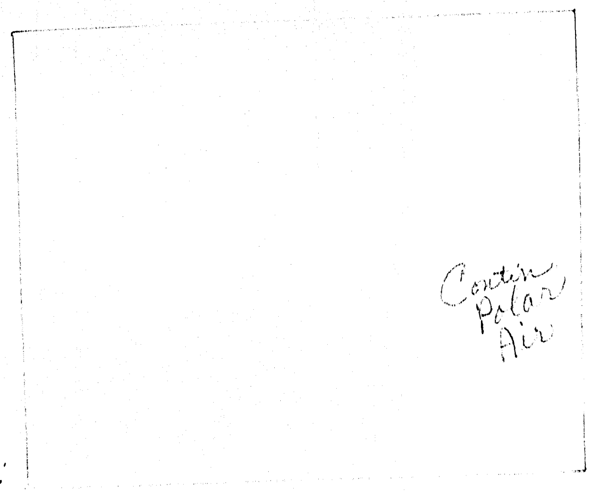

Figure 50:

Figure 50: The Eastern European cyclone over Central Asia (25 February 1934).

The mountainous part of this zone must be considered a special sub-zone, in which the general circulation conditions are practically the same, yet weather conditions vary in response to the effect of terrestrial configuration. There is less precipitation here in the winter, as compared with the Sub-tropical Medium-altitude zone. The Iranian front cyclones pass considerably further south, while the westerly cyclones are mainly significant for the mountainous areas of the Kirgiz SSR and Eastern Kazakhstan. The temperature cycle is of great variability and considerable severity. The mean January temperature in the steppes and semi-deserts of Kazakhstan, at a latitude corresponding to that of Rostov-on-Don, is almost the same as in Kirovo (formerly Vyatka), i.e. minus 14 degrees Centigrade, which, on the average, is 15 degrees Centigrade colder than the southern Sub-tropical zone. There are days when the frost descends to minus 30, minus 35, and, in exceptional cases, to minus 40 degrees Centigrade. A fine dry snow, hardly covering the ground, is easily blown off by the wind. Easterly winds carrying cold air from Eastern Asia, prevail.

With the spring, the Iranian front cyclones pass more frequently, first over the southern part of Central Asia, then extend into the northern areas. In May, when the Central Asiatic front becomes abated, and precipitation is diminished in the south, the passage of westerly cyclones over the northern part is accelerated, with resulting maximum precipitation. However, even in the northern part of Central Asia, over the plains, the summers are very arid, although not to the same degree as in the south.

Distinct from its winter distribution, the summer temperature within the entire territory of Central Asia varies little with relation to latitude, and midsummer in the northern part is almost as torrid as in the Sub-tropical part. The differential in the mean July temperatures is not more than 2 - 3 degrees, but the number of hot days with a mean daily temperature of over 20 degrees Centigrade is half as large. The hot weather period (in the above sense) lasts 4 months in the southern Sub-tropical part, and 2½ months in the northern part.

Within the boundaries of the Turanian zone, the Medium-altitude area differs much more from the steppe and desert parts than does the respective area within the boundaries of the Iranian zone. With reference to the winter temperature cycle, the differentials are the same as in the Iranian zone of Central Asia, i.e. up to an altitude of 1.5 - 2 kilometers, there is a temperature inversion. The area of Lake Issyk-Kul' is of particular interest in this respect, since at the altitude of 1500 meters the winter is warmer than at the same latitude below, at the mouth of Amu-Dar'ya. One of the reasons for such warm winters is the lake itself, radiating into the air a considerable amount of heat. In addition to it, there occurs in the mountains of the Kirgiz SSR, the evolution of general conditions, causing the temperature to rise with altitude. In some cases it is the result of cold penetrations that do not always reach the higher altitudes, but extend mainly below. In others, inversely, it is the result of a warm penetration at higher altitudes not reaching the low-lying spots.

The general circulation characteristics are basically the same over the plain and over the mountains. Yet, against this general background, terrestrial configuration at times causes unique modifications in the various cycles, as, for example, the intensification of fronts in the European cyclones arriving from the west, with attendant considerable snowfall over the windward western mountain slopes and over the valleys facing to the west. When passing over the plain, these cyclones are abated and produce little precipitation.

In the spring and, particularly, in the summer, the falling of precipitation over the mountains of the northern part of the Kirgiz SSR, and along the entire northern Tyan' Shan', is also tied in with the passage of the westerly cyclones. Thus, instead of the summer drought, which is a characteristic climatic feature of the plains and mountains of the Sub-tropical part of Central Asia, the summer here is the maximum precipitation season. The moderately warm and humid summer and the relatively mild winter of this area, with considerable snow cover in some places, does not fall in with the general sharply continental climate of Central Asia, but rather resembles, climatically, the Atlantic-Continental region of the European part of the Union.

High-Altitude Region

The circulation of the atmosphere over the High-altitude region of Central Asia was studied very little. In addition to air currents of general significance, a large scale thermal turbulence, generated between the mountainous part of the territory and the plains, should be of great importance. This [thermal] turbulence should be particularly intensive in connection with (1) the massive bulk of the mountainous elevations, comprising a conglomeration of great mountainous junctions and vast lofty plateaus (particularly in the southern part), and (2) little cloud formation and the intensive evolution of radiation processes. Thermal turbulence is of particular intensity during the warm seasons, but even in the winter there is frequently weather with little cloud formation, and mountain-valley air currents (in a large sense) are generated.

Accelerated precipitation during the summer, over all the High-altitude part of Central Asia (the reverse is taking place over the plain), is a characteristic feature of the precipitation cycle, and is tied in with the evolution of convection currents over the mountains. Yet, convective precipitation is only of local significance in the mountainous areas, and the feeding of the large rivers of Central Asia is tied in mainly with the snow accumulations in the mountains, resulting from winter cyclonic activity. The snow accumulation is heaviest on the western slopes, facing the westerly and southwesterly air currents.

As proved by aerological observations, over all altitudes in excess of 3000 meters, whether in the south or in the north of Central Asia, westerly air currents predominate throughout the year. This circulation feature unifies the entire High-altitude region, and, to date, there are no essential reasons calling for the division of this region into a southern and northern zone. However, the climate of the High-altitude region is very far from being homogeneous, which is due mainly to the variances in terrestrial configuration. Thus, the climate of the lofty plateaus and some high valleys is arid and sharply continental. The climate of the high mountain ridges is humid, with a more even temperature cycle. The surface of flat topographical formations, under the conditions of a rarefied and dry atmosphere, is subject to intensive heating during the day, and cooling during the night. The flat configurations are not conducive to the intensification of the fronts, and, in addition, there is, at these altitudes, inadequate moisture in the air, which results in little precipitation, in some places less than 100 millimeters for the year, i.e. not more than in a desert area. The mean annual temperature range is about 30 degrees Centigrade, with the diurnal range at times being the same.

Over the Pamir-Alay zone, lying at an altitude of 3000 meters, the mean July temperature is around 15 degrees Centigrade, the mean January temperature is minus 15 degrees Centigrade. Upon [theoretical] reduction to sea level, the respective readings will be 30 degrees and zero Centigrade, counting the mean temperature gradient as half a degree per 100 meters of altitude. However, as per direct observations in the free atmosphere, the summer temperature gradient is higher, and the winter one is lower than half a degree per 100 meters. Thus, the summer is warmer, and the winter is colder than the corresponding altitude over sea level would indicate for this zone. This is due to the effect of vast flat terrestrial surfaces lifted to a considerable height. With all this, the effect of the free atmosphere is felt, manifesting itself by frequent winds of high velocity.

On the mountain ridges protruding into the free atmosphere, the temperature cycle is less continental. The temperature range, annual and diurnal, rapidly diminishes with altitude, particularly the annual range. Over the slopes of the Fergan Ridge, at an altitude of 3000 meters, the mean annual temperature range is less than 20 degrees Centigrade. In addition, completely different precipitation-inducing conditions are evolved over the ridge. The mountain ridges activate the passing fronts and force precipitation even from the rather dry Central Asiatic and Iranian Tropical air masses. In the winter, when Mediterranean and Atlantic air penetrates with the westerly cyclones, there is abundant snow that feeds the vast glaciers of western Tyan'-Shan'. There is no reliable data on the maximum amount of precipitation falling over the mountains of Central Asia, yet, by some observations, it is reasonable to suppose that under the most favorable terrestrial relief, the annual amount of precipitation reaches 2000-3000 millimeters.

In the mountains of Central Asia, in the Sub-tropical part and in the northern areas, many sub-zones can be segregated in which local factors, against the background of the same general circulation, create essential variations in the climatic cycle. These variations, basically, manifest themselves in different amounts of precipitation, and are determined by the macroexposure of the area with relation to the winds prevailing in the western quadrant of the horizon. Under macroexposure is understood the basic exposure of the slope, with which the factual exposure of the various sections of the same slope may not coincide. Slopes generally facing the southwest, west and northwest, and not respectively closed in from these sides by neighboring mountain ridges, receive three or four times as much precipitation as the slopes facing in the opposite direction.

In the generally arid climate of Central Asia, these fluctuations in the amount of precipitation radically change the appearance of a locality. On first sight, it creates the impression of considerable variations in physical and geographical characteristics of wide significance, and only the motley distribution and the restricted boundaries of these variegated landscapes betray their local character.

As a striking example of the diversity of the "local climates" (climatic sub-zones), may be considered the Fergan Hollow. The area of this depression is not extensive enough to allow for the possibility of the existence of essential circulation diversity over it. Yet, the climatic conditions in some of its sections show a considerable range. Even before the valley exit, a unique climatic phenomenon, induced by topographical configuration, is encountered. Southeasterly, and sometimes easterly winds, of extraordinary force are generated almost each time the southerly cyclones pass along the western slopes of the Pamir-Alay Mountain Range. These winds occur predominantly in the winter, but are also known to occur on rare occasions during the summer, and they are equal in force to the northeasterly gales over Novorossiysk. The tabulation on this page is a result of observations made at the station Ursat'yevskaya.

Date	Direction and Velocity of Wind (meters/second)				Temperature in degrees Centigrade				Relative Humidity (in Percent)				Sky Cover			
	0100 Hours	0700 Hours	1300 Hours	1900 Hours	0100 Hours	0700 Hours	1300 Hours	1900 Hours	0100 Hours	0700 Hours	1300 Hours	1900 Hours	0100 Hours	0700 Hours	1300 Hours	1900 Hours
9 Jan 1938	ESE_{10}	ESE_{24}	ESE_{20}	ESE_{10}	6	4	11	9	30	55	45	60	0	0	3	0
5 June 1938	SE_5	SE_{18}	SW_5	-	26	30	33	-	18	13	16	-	0	0	0	-

This phenomenon (like the Novorossiysk bora) is a local intensification of the wind current flowing over the Turkestan Ridge. No special research, with relation to the evolution of these winds, was done. The basic concept, however, can be construed as follows: the southerly, or southeasterly current in the forward part of the cyclone, in colliding with the Turkestan Ridge protruding westward, encounters an impedance to its lower layer, and only the fast-moving upper layers of the current come across and glide down the northern slopes of the ridge. The corresponding location of the ridges at the exit of the valley accelerates the easterly component force of the wind. These winds are usually accompanied by rises in temperature, drops in relative humidity, and almost a complete disappearance of lower stratum clouds, which indicates that the air is moving downward.

The recurrence of southeasterly winds at the exit of the Fergan Valley is around 50 percent, and their mean velocity is 10 meters per second. The temperature during these winds frequently rises a few degrees above the mean level, as a result of which this small zone is distinguished by its higher temperatures, the mean January temperature being the same as in the southern part of the Turkmen SSR.

The climate of the Fergan Valley is extremely arid, and in its central part the annual amount of precipitation drops to 100 millimeters, although on the surrounding ridges it is much more abundant. The Fergan Valley proper does not constitute a separate climatic zone, its climate does not essentially differ from the climate of the desserts, which occupy three quarters of the entire territory of Central Asia. However, the effect of terrestrial configuration upon the climate of the adjacent mountainous areas is striking. The mountain slopes with western and southwestern exposures receive 3-4 times more precipitation than the eastern and northern slopes, or the hemmed-in high-altitude valleys. The amount of precipitation is of paramount importance in Central Asia, since the insolation cycle, temperature, and soil conditions are, as far as they go, extremely favorable to the growth of vegetation. Thus, the southwestern slopes of the Fergan Ridge along the valleys of the rivers Kugart, Kar-Ungur, and others, are covered by almost continuous walnut forests and wild fruit thickets, while the Valley of the Naryn, along its lower flow, which is closed in from the west, is a burned out desert.

It is of interest to note, that in all sections of the Fergan Hollow, from the blossoming ones to the barren ones, with their sharp diversity in the amount of precipitation (from 100 to 1000 millimeters), there occurs, first in the low-lying parts, then in the high-altitude parts, the unavoidable summer period of drought. It serves as a reminder that the favorable climatic conditions in this zone or the other are merely a happy result of local conditions, while the basic background of all is the bleak cycle of the desert.

No less remarkable is the "local climate" of the area of Lake Issyk-Kul', where upon the climatic effect of the general circulation

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are superimposed features induced by the surrounding mountain ridges and the waters of the lake itself.

The distribution of precipitation, falling over the various parts of the lake basin, shows with particular clarity the paths followed by atmospheric moisture finding its way into this basin. The southwestern half of the lake, closed in from the south and the west by mountain ridges, receives very little precipitation. The latter increases at a rather rapid rate toward the northeast, due not so much to the evaporations from the lake being carried in that direction (precipitation over Issyk-Kul' occurs predominantly with westerly winds), as to the fact that the fronts, moving in from the west and the southwest, in their descent from the surrounding mountains, are abated while passing over the western part of the lake, and re-activated when passing over its eastern part.

The most remarkable climatic feature of the Lake Issyk-Kul' area is its very mild winter, contrary to its continental location. Mean temperatures for January and February on the eastern shore are minus 5 degrees Centigrade, and on the western shore they are even higher. In order to properly evaluate the thermal effect exerted by Lake Issyk-Kul', it is best to compare its temperature cycle data with the data for Lake Naryn, lying at an altitude higher by 250 meters, but one degree to the south, and also in a hollow. The mean January temperature for Naryn is minus 16 degrees Centigrade. Counting off one degree of temperature for the absolute altitude differential, it can be assumed that the masses of water, constituting the lake, raise the temperature of the air, on the average, by 10 degrees Centigrade. Such a significant thermal effect, exerted by the lake, can be explained by the fact that the hollow is closed in on all sides by mountain ranges, which, in causing frequent air stagnation, accelerates the features of the "local climate". The still higher temperature rise on the western shore is induced by the foehn effect created by the air, in its descent from the mountains during the westerly winds.

WESTERN SIBERIA

Western Siberia, climatically speaking, embraces a vast geographical region, over which the effect of the Atlantic Ocean is still sufficiently pronounced, but, at the same time, the peculiar characteristics of the vast continent of Asia come into prominent play. This territory contains all of the West-Siberian Plain, the eastern slopes of the Urals, and the western slopes of the Altay Mountains. The effect of the Atlantic over the territory of Western Siberia increases toward the north, attaining its maximum during the winter. The effect of the Continent (in all respects) grows toward the south, and in the southern areas it is equally pronounced during the winter and the summer seasons.

The temperature contrast between the ocean and the continent is particularly sharp in the winter, and, tied in with it, the pressure gradient between the Iceland low-pressure area and the Asiatic anticyclone attains a considerable magnitude. Due to the particular character of the distribution of air currents, tied in with the areas of high and low pressure (Figure 12), the Atlantic air current extends over the continent, predominantly, in the direction from southwest to northeast. Thus, the degree of its effect upon the territory of Western Siberia increases gradually from south to north.

The migration of Atlantic air in the winter toward the continent of Asia takes place predominantly in the Arctic front cyclones, in which the Atlantic air is frequently forced away from the terrestrial surface into the higher strata. Thus, it has little effect on the temperature at the surface. However the continuous cloud formation accompanying the penetration, also the falling of precipitation and high-velocity winds, are factors contributing to a sharp temperature rise over the northwest of Siberia (see Figure 51).

Figure 51:

Figure 51: Recurrence of Sky Cover, Wind velocity, and temperature over Western Siberia in January.

In the majority of cases these cyclones are abated over Western Siberia, coming to an end as they approach the area of high pressure, which occupies all of Central Asia almost continuously during the winter. The abundant snow, which in the north (with the exception of the Kara Sea littoral) accumulates to a depth of one meter toward the end of the winter, is also tied in with these cyclones. The precipitation from the cyclones, regenerating at the Arctic front, comes from the saturated Atlantic air, thus representing the external moisture turnover between the ocean and the continent. The Arctic air, in the wake of the cyclones, extends far to the south without encountering any impedance over the plain, and only the approach of the following cyclone from the west forces this air again to the north. During the periods of interruption in cyclonic activity, the Arctic air generally remains over Western Siberia, is slowly warmed through, and transformed into Temperate latitude air.

Alongside the path of the westerly transfer of Atlantic air, the continental processes, as was already mentioned above, are of great importance. These are, the cooling of the Atlantic air flowing over the

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continent, the slow warming of Arctic air, and its transformation into continental Temperate zone air. The latter air is better defined as Western Siberian continental air, since this air, due to peculiar circulation conditions over Western Siberia, is different from the Eastern European and the Eastern Siberian air.

The main volume of continental air present over the Western Siberian plain comes with the transfer of air masses from the more southern areas with the southwesterly winds along the northwestern rim of the Central Asiatic anticyclone outcrop (see Figure 12 in preceding text). This air is gradually cooled in its northward migration, and is thus distinguishable from the Eastern Siberian air, migrating mostly from the north, and, by virtue of that, being colder and drier. As distinct from the Eastern European air, the Western Siberian air is composed to a lesser degree of Atlantic air, and to a greater degree of Arctic air. The latter is essentially the basic source for the formation of Asiatic continental air, particularly over East Asia.

The southwesterly winds, prevailing during the winter, are tied in with areas of high pressure, which are frequently evolved over Western Siberia, either as an outcrop of an Asiatic anticyclone, or as self-contained anticyclones. This stable anticyclogenesis is also a manifestation of the continental characteristic, and the main cause [of its evolution] is the cooling of the continent. The final stages of transformation of the Atlantic air into continental over Western Siberia take place in the anticyclones. The cooling of the Atlantic air masses occurs as a result of the loss of heat through radiation over the cooled continent. All these processes are accelerated toward the south, as the distance from the main path of the cyclones becomes greater over the northern part of Eastern Siberia.

The inflow of Atlantic air over the continent is diminished during the summer, but is, generally speaking, accelerated toward the south, which is the reverse of what happens in the winter. The predominant migration toward the northern part of Western Siberia is that of the Arctic air, which is rapidly warmed over the continent, and transformed into continental air. The Atlantic air penetrates far to the east with the cyclones, even during the summer, arriving over Western Siberia. In the anticyclones, it is frequently transformed into continental air, while still over the European territory of the USSR.

The basic process in the summer is the formation of continental air, which in its characteristics is little different from Eastern European continental air. It is perhaps somewhat drier, since one of its main components is Arctic air warmed over the continent. This, specifically, is the manifestation of the effect of the continent, and the more active the continental air masses are over an area, (as compared to the Atlantic and Arctic air masses), the more continental the climate of the area. Thus, the continental climatic features of Western Siberia during the summer are accelerated toward the south.

Summer cyclonic activity over Western Siberia is generated in the north, at the Arctic front, in the south, predominantly at the occlusions, and, only in rare cases, at the main Polar front. The predominant warm mass in the Arctic front, as well as in the Polar front occlusions, is constituted by continental air, which is the main source of precipitation. The water vapor quantities in the continental air are replenished, mainly, through evaporation of moisture, and, in this sense, the summer precipitation over Western Siberia is of the internal moisture turnover type. And only in the main Polar front cyclones is the precipitation from the Tropical air advective to a prevailing degree.

Based on general circulation conditions, Western Siberia can be divided into three climatic regions, which are a continuation of the climatic regions of the European territory of the USSR, as follows: the northern or Atlantic-Arctic region, the central or Atlantic-Continental region, and the southern or Continental region. With this similarity there is, however, an essential difference consisting in the fact that climatic variations from west to east are considerably more sluggish over Western Siberia than over the European part of the Union. The winter temperatures are significant in this respect. The difference in the mean January temperatures as between Belorussia and the Middle Volga is about 7 degrees Centigrade, while in Western Siberia the temperature differential, corresponding to the same difference in latitudes and distance, is only 1 degree Centigrade. Over the area of the European part of the Union, the effect of the ocean competes with that of the continent, while over Western Siberia, particularly in the more southerly zones, the effect of the ocean is already attenuated to such a degree that continental features practically predominate to the same extent, both in the western and eastern zones.

Thus, there is no reason for dividing Western Siberia into western and eastern climatic zones, as is the case in the European part of the USSR. The three regions, segregated above, are to be considered, each within itself, as climatically homogeneous, and as representing one climatic zone. However, two climatic zones are segregated within the Continental climatic region, the Continental zone and the Altay zone. In the extreme north of Western Siberia, just as in the European territory of the USSR, a part of the Arctic climatic region is segregated in conformity with the fact that during the entire year there is a predominance of /formative/ Arctic air. As compared to the European part, the boundaries of the respective climatic zones in Western Siberia are displaced 2-3 degrees to the north (see Figure 73 at the end of the book -- Diagrammatic Chart of the Climatic Regions and Zones of the USSR), which is due to the general intensification of the continental features over the territory of Asia. This displacement of climatic boundaries is particularly conspicuous due to the existence of the Ural Mountain Range.

The area of the Urals cannot be considered as a self-contained climatic region or zone. Their western slopes, climatically, belong to Europe, the eastern ones to Asia. The Ural Range merely separates the European climatic zones from the Asiatic ones, but does not, by its effect, create the differences between them. These differences are created by the effect of the powerful factor of atmospheric circulation, which, in its turn, depends on the magnitude, form (in part, on the topography), and the general geographical disposition of Europe and Asia. It is not the Ural Mountain Range that sets a visible boundary to the extension of the oceanic effect eastward, but rather the extensive and complex thermal interrelationships between the [land mass] of Eurasia and the Atlantic Ocean, that predetermine the paths, the forms, and the volumes involved in the transfer of maritime air masses over the continent. Were the Urals not there, the extension of the summer outcrop of the Azorian anticyclone, which controls the migration of Atlantic air masses toward Eastern Europe, would hardly be affected. By the same token, the winter southwesterly air current over Western Siberia, tied in with the Asiatic anticyclone, would hardly become warmer.

Yet, the Urals, although not creating any climatic boundaries in the above sense, do accentuate the existing ones. There is an essential acceleration in summer and winter precipitation over the western slopes, due to the intensification of cyclonic fronts arriving from the west. The reverse is true with relation to the eastern slopes of the Urals. Nevertheless, to the east of the Urals, over the entire Western Siberian Plain, the amount of precipitation remains practically the same as over the eastern slopes of the Urals (see Figures 18 and 19 in preceding text).

Generally speaking, the amount of precipitation over Western Siberia is smaller than that over the European part of the Union, but its acceleration over the western slopes [of the Urals], and its attenuation over the eastern slopes, imparts to the general fluctuation, which is supposed to be gradual, the character of an abrupt change. The same is true with relation to winter temperatures, in which there is a very noticeable difference between the above territories (see Figure 16 in preceding text). Winter in Western Siberia is colder because the continental Asiatic air is colder than the continental European air. The Ural Range merely disrupts the gradation of this transition. When the European air, in flowing over the ridge, comes in contact with the colder Siberian air, it continues its eastward flow above the cold air without descending to the surface of the Plain. This causes the above mentioned abrupt change in temperature.

The Ural Range, by virtue of its disposition in a meridional direction, cannot essentially affect the migration of air masses in northern and southern air penetrations. It also presents no essential impedance to the eastern penetrations of Asiatic air, since the latter current, tied in with the southern periphery of high pressure areas, flows around the mountain ridge from the south.

Nevertheless, the climatic conditions of the Ural Mountain zones have a number of unique characteristics, not only with relation to the cycle of individual meteorological components, but also with relation to weather, which, against the background of the same general circulation conditions, may differ as to the western and eastern slopes, and the ridges and the valleys. In addition, there is a variety of microclimatic sections, tied in with topography and vegetation. The microclimatic variations over the Urals may be considerable by virtue of the general continental features of the climate.

Variations in the amount of precipitation between the western and eastern slopes of the central part of the Urals, reach, in places, 300 millimeters in one year. Thus, the amount of annual precipitation over Kizel', located on the western slopes, is 680 millimeters, while over Chelyabinsk, on the eastern slopes, it is 380 millimeters.

The height of the Urals is sufficient to indicate temperature variations which take place with altitude in the free atmosphere. In summer, this is manifested by a gradual temperature drop with altitude, as in the Southern Urals. At the latitude of Ufa, the mean temperature drop is 7 degrees Centigrade per 100 meters of altitude. Such a considerable temperature gradient indicates the degree to which the Plain is heated during the summer, on the European as well as on the Asiatic side. A considerable number of days with stratocumulus cloud formations is registered over the slopes of the Central and Southern Urals during the summer. This is indicative of intensive diurnal convection.

With the passing of the winter anticyclones over the Urals, the vertical temperature gradient in the mountains frequently becomes negative, i.e. the temperature rises with altitude, which is due to the occurrence in the free atmosphere of temperature inversions. These temperature inversions are frequently accompanied by sudden drops in relative humidity at some altitude which underscores the dynamic nature of the anticyclonic inversions, generated as a result of a descent of air strata. A case of such an inversions, observed at 0700 hours on a December morning, is tabulated below:

Name of Locality / Dates of Month (December)	Temperature (Degrees Centigrade)			Relative Humidity (Percent)		
	2	3	4	2	3	4
Ivanovsk Mine (Altitude 850 meters)	-0.9	-0.4	-5.2	32	38	32
Ufa (Altitude 170 meters)	-11.1	-12.0	-11.3	97	72	87

The above shows that the rise in temperature with altitude comes to 12 degrees Centigrade for 700 meters of altitude differential, i.e.

1.7 degrees Centigrade per each 100 meters of altitude differential. This is a result, not only of dynamic heating of the upper air layers, but also of cooling of the air in the immediate proximity to the terrestrial surface. The latter is particularly pronounced over closed-in valleys. For instance, in Zlatoust, during the same hour /0700 hours in the morning7, and on the same days /as in Table above7 the following temperature readings were taken: 2 December, minus 20.7 degrees Centigrade; 3 December, minus 22.1 degrees Centigrade; 4 December, minus 19.1 degrees Centigrade.

The above indicated features in vertical temperature distribution, also the rise in the amount of precipitation with increased altitude and the formation of cumuliform clouds, are the most essential variations, tied in with the vertical climatic zonality over the Urals.

And now, for the characteristics of climatic zones of the Western Siberian Plain.

The southern climatic boundary of Siberia runs over the territory of Kazakhstan somewhat to the south of Parallel 50 north. The transition from Central Asia to Western Siberia is marked by intensification of summer precipitation to such a degree, that in approaching Parallel 50 north, it becomes the maximum annual precipitation. From there on, to the north, precipitation still continues to increase, thus affecting the annual amount. This change in the precipitation cycle is generally tied in with the more frequent passage of European cyclones over the Atlantic-Continental region of Siberia, and also with the lower level of condensation in continental air, which, in this region, is subject to less heating than in the south. Penetration of European cyclones over the Atlantic-Continental region of Siberia, and the abatement of the summer transformation of the air masses, indicate a relaxation in the continentality of the climate, although the annual temperature range, as compared to

Subtropical Central Asia, rises considerably. For example, the annual temperature range over the south of Central Asia is 30 degrees Centigrade, while over Central Siberia it is 40 degrees Centigrade, this increase being accounted for by the accelerated temperature drops in the winter. The relaxation of continentality is manifested during the summer months, since in the winter the Atlantic air extends over Siberia in the upper layers, while the layers contiguous to the terrestrial surface contain, practically at all times, cold continental air.

The southern climatic zone, or the Continental Western Siberian zone, is basically similar to the southeastern part of the European territory of the Union (the Middle and, partly, Lower Trans-Volga), particularly during the warm months, the winter being somewhat colder. The northern boundary of this zone in the western half of the territory passes near Parallel 57 north, and in the eastern half of the territory, near Parallel 60 north.

The warming of continental Temperate air, and its partial transformation into Tropical air, takes place over this zone in the summer, similarly to the process over the Trans-Volga area. The full development of this process (as is the case over Central Asia) is impeded, not only by the difference in latitudes, with which potential insolation is tied in, but also by the accelerated (as compared to Central Asia) cloud formation, the inflow of formative air masses from the north, and the fall of precipitation. During the winter, the anticyclones or high pressure outcrops generating over Southern Siberia, also extend over the southeastern European part. In the eastern section of these outcrops, that is over Western Siberia, it is always colder, than in their western section over the Trans-Volga area.

The transitional seasons [of the year, pertaining to the above mentioned areas], show sharper contrasts yet. The spring temperature rise occurs later, and the autumn temperature drop occurs earlier, over

Western Siberia than over the European part, since a southerly air current predominates along the periphery of the spring anticyclones over the European part.

The amount of precipitation in the southern part of Western Siberia, as compared to the northern zones of Central Asia, rises sharply. The amount of annual precipitation in Akmolinsk is in excess of same in Kazalinsk by 200 millimeters, with the differential attributable mainly to the summer, which radically changes conditions with relation to the growth of vegetation.

In the southeast, the Continental Western Siberian zone borders upon the Altay zone. The Altay [Mountain Range] lies between two climatic regions of the first order of magnitude: Western Siberia and Central Asia. The climate of Central Asia is continental to the highest degree, while, from the west and the northwest, cyclones are moving in, carrying occluded Atlantic air masses. As a result, the cyclones, half extinguished in their long paths over the continent, are reactivated over the Altay Range, with attendant winds of higher velocities, accelerated cloud formation, and precipitation. Thus, heterogeneous factors clash over the Altay Range, by virtue of which its climate is noted for great contrasts, particularly in the winter. Precipitation is rather ample over the western and the northwestern slopes of the Altay, the annual amount in some northwestern localities being in excess of 800 millimeters. Two thirds of all precipitation falls from July to October, out of which amount the July-August acceleration is tied in with the general summer precipitation maximum over the European part, the Urals, and Western Siberia, which, in turn, is dependent on the Atlantic cyclones and local convection. The September-October precipitation is induced primarily by Arctic cyclones, manifesting themselves only to a small degree over the European part and the Urals. A snow blanket of considerable depth is accumulated in the northwestern part of the Altay, in sharp contradistinction with the almost snowless Khakassiya. Several climatic subzones, in which local factors induce particular weather conditions, can be pointed out in the mountainous part of the Altay Kray, such as the area of Lake Teletskoye and the upper parts of the valleys of Katun' and Biya rivers.

The next climatic zone northward, the Atlantic-Continental zone, is a continuation of the Atlantic-Continental Eastern European region. It occupies the central area of Western Siberia and the forest zone. In the west, this area borders upon the eastern slopes of the Central Urals, in the east it tapers out far to the north. This /northern wedge/ is mainly a result of winter circulation conditions, by virtue of which continental air is carried even beyond the Polar Circle by the prevailing southerly and southwesterly winds.

Summer in the Atlantic-Continental region of Western Siberia, as compared to the European part, is rather hot, although of shorter duration. July temperatures are somewhat higher than in the central section of the European part, but May and September are colder. The high summer temperatures are tied in with penetrations of Central Asiatic air and, also, with the local heating cycle, which is more intensive over Western Siberia than over the European part, due to lesser cloud formation, i.e. less intensive cyclonic activity. For comparison, see synoptic chart of the recurrence of July overcast over the European part and over Western Siberia (Figure 52).

FIGURE 52:

Figure 52: Recurrence of July overcast over Western Siberia.

If comparison between the Eastern European and the Western Siberian zones of the Atlantic-Continental region is made with relation to maximum temperatures, it will be seen that maximum temperatures are higher in the eastern area of the European part (see Figure 53).

FIGURE 53:

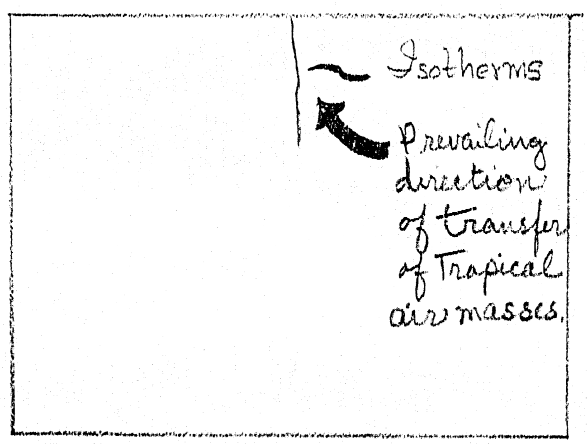

Figure 53: Maximum air temperature and prevailing direction of transfer of Tropical air masses.

This is very significant, and is due to the fact that the transfer of Central Asiatic Tropical air, with which the maximum temperatures are tied in, takes place along the western periphery of high pressure areas in a direction predominantly toward the eastern part of the European territory of the USSR. During the summer, within the limits of the Atlantic-Continental region and the forest zone, there is transformation of Arctic and Atlantic air masses into continental air. In addition to the warming of the incoming air masses, they undergo additional humidification in their passage over the vast masses of forest. Therefore, the relative humidity of the continental air remains rather high during the summer. Its mean value at 1300 hours (i.e. at the moment approximating its minimum value in the daily cycle) is 65 percent, somewhat above that over the European part. Relative humidity drops to its lowest value in May, when the continent receives its initial warming, while the Arctic air [over it] is still very cold, and contains little moisture.

Summer cyclonic activity over the Atlantic-Continental region of Western Siberia is tied in primarily with the Arctic front, which, at this time, is activated over the northern coastline of the continent. Precipitation occurs during the passing of the cyclones, mainly from the saturated continental air, as the relatively warmer mass. Therefore, the greatest amount of precipitation occurs over a belt, where frequency of the passage of cyclones and saturation conditions of the air combine most favorably. This belt of maximum precipitation passes near Parallel 60 north. To the north of it, precipitation is reduced, since the moisture content in the continental air becomes less. To the south of it, precipitation is also reduced in connection with the less frequent passage of cyclones, even though the moisture content in the air is increased with the rise in temperature. The amount of summer precipitation is the same as over the Atlantic-Continental region of the European part.

The winter, on the average, is 10 degrees Centigrade colder than in the same latitude in the European part. Severe frosts, with temperatures down to minus 55 degrees Centigrade, are a result of the thorough chilling which the Arctic air strata, contiguous to the ground, undergo in calm and clear weather. The initial temperatures of the formative Arctic air, in its winter penetration over the territory of Western Siberia, is usually somewhat below minus 30 degrees Centigrade, and only subsequently, with the drop in wind velocity and the clearing of the sky, do its near-the-ground temperatures begin to drop rapidly.

Alongside of these sudden cold waves, considerable warm spells may occur. However, only on rare occasions, during Atlantic air penetrations, do these warm spells attain the nature of a thaw. Cyclonic activity is very intensive in the winter, and the snow blanket, particularly in the northeast, attains a somewhat greater depth than in the European part, which is due not as much to the frequency of snowfall as to its aging on the ground and the absence of thaws. Snowfall occurs mostly during low temperatures, since the Atlantic air in the cyclones may be occluded. The falling snow, therefore, is dry, consists of small particles, and is easily lifted by the wind, which leads to frequent snowstorms. The snowstorms over Western Siberia differ from those over the European part by the low temperatures and the nature of the whirling snow, which is dry and stabbing to a point that it penetrates through all small openings and even through seams of garments. It resembles in this respect the Arctic snowstorms /in Russian, it is the Arctic PURGA, probably from purgatory/, and is fully as menacing and dangerous. Southerly (southeasterly, southwesterly) winds, corresponding to the forward part of the cyclones, predominate during these snowstorms. Figure 54 depicts an example of a synoptic disposition conducive to a snowstorm. /In studying the chart/, the low temperatures accompanying the snowstorm should be noted.

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The transitional seasons are characterized by rapid variations in the temperature level: a potent rise in the spring, and a drop in the autumn. Sudden temperature leaps, caused by Arctic air penetrations, occur frequently against the background of the general variations. Particularly unfavorable are the spring chills when, after relatively warm periods even though for only a short time, there is a recurrence of severe frosts (see Figure 55).

Figure 55:

Figure 55: Arctic air penetration over the territory of Western Siberia in the spring (21 April 1937).

The northern or Atlantic-Arctic zone of Western Siberia is a continuation of the Atlantic-Arctic region of the European part of the USSR. Its southern boundary, as compared with the respective region in the European part, is displaced somewhat to the north. Thus, it is half as large as the respective Eastern European area, and is really a warmer belt separating the interior of Western Siberia from the littoral, the latter being already a part of the Arctic region.

The regeneration of European cyclones at the Arctic front is typical for the winter over this zone. The Atlantic air in these cyclones is, in most cases, already driven off into higher atmospheric strata, yet considerable cloud formation and precipitation are specifically tied in with it. During regeneration of cyclones, there occurs at its rear a sudden break in the Arctic air masses accompanied by squalls and snowstorms. In general, the winter weather over this zone is very unstable.

Extensive cloud formation, precipitation, high-velocity winds in the cyclones, and, on rare occasions, the direct effect of warm masses of Atlantic air, result in considerable warm spells during the winter months, but not to the same extent as over the European part. The November to March isotherms, within the boundaries of this zone, lie in a meridional direction, and the temperature decreases directly eastward. The mean January temperature at the Polar Circle, over the western part of the zone, is minus 22 degrees Centigrade, while over the eastern part it is minus 28 degrees Centigrade.

The predominant air currents during the summer are from the Arctic. The beginning of transformation of Arctic air masses into continental air over the Atlantic-Arctic zone, is indicated by a rather warm summer, moderate humidity, and moderate cloud formation. The mean July temperature at the Polar Circle is 14 degrees Centigrade, relative humidity (at 1300 hours) is 65 percent, and the recurrence of overcast is 60 percent. The passage of summer cyclones reduces the temperature considerably, since at the rear of the cyclones the inflow of formative Arctic air is intensified. The amount of precipitation, although generally decreasing northward, is still considerable here, accumulating to the extent of 50-60 millimeters for July and August.

EASTERN SIBERIA

Eastern Siberia comprises the vast territory lying between the Yenissey River on the one hand, and the Stanovoy Mountain Range on the other hand. In the north it faces the Arctic Ocean, although the tundra belt of the northern littoral belongs, climatically, to the Arctic region. In the south, the territory of Eastern Siberia is enclosed by the Sayan Range and the Trans-Baykal Mountains.

Circulation conditions over Eastern Siberia are such that neither the Atlantic nor the Pacific air masses ever reach the lower strata of its atmosphere. The only source of replacement is constituted by the Arctic air masses, which, upon arriving over the continent, are transformed into continental air.

During the summer, this transformation process embraces almost the entire territory. Already at the Arctic Circle, the former Arctic air masses are warmed through in the diffused and almost windless baric /barometric/ areas to such a degree that its mean July temperature reaches 14 degrees Centigrade. Over the south, the Arctic air is completely transformed into continental air, and its temperature ascends to 20 degrees Centigrade.

A mighty outcrop of the Asiatic anticyclone is situated over Eastern Siberia throughout the winter. The initial formation of winter continental Eastern Siberian air masses, the coldest of all continental air masses over the land mass of Eurasia, takes place in this outcrop. The formation of continental air is accomplished by the warming of the Arctic air masses present, and by the cooling of the Atlantic and Pacific air masses, flowing into the upper troposphere strata, and also by the cooling of the Anti-Tradewinds air masses, some limited volumes of which reach these latitudes. The duration and the intensity of the cooling process, and the vastness of the area involved, also the low initial temperature of the Arctic air being transformed, result in very low temperatures.

In cases of enduring stagnation, the air over the continent is at times colder than the formative Arctic air, which affects the lower layer only.

A characteristic feature of the winter continental air is the presence in its lower layer (up to a height of 1000 meters) of potent temperature inversions. Therefore, the phenomenon of temperature rising with altitude in the mountainous areas of Eastern Siberia is very pronounced. Even its mean value is as high as 2 degrees Centigrade per 100 meters of altitude.

The direction of the air currents has a significant effect upon the temperature of the continental air. In the western half of the Eastern Siberian anticyclonic outcrop, the transfer of the air masses takes place from southwest to northeast. In the eastern half of the outcrop -- from north to south. As a result, the temperature of continental air over the eastern half of the territory is lower by 10 degrees Centigrade than over the western half.

Thus, the transfer of the Arctic air masses and their transformation into continental air is the basic climatological factor over Eastern Siberia. Over the northern half of the territory, this transformation takes place during the warm part of the year only.

Based on the above, Eastern Siberia (with the exception of the northern littoral) can be divided latitudinally into two climatic regions: the Sub-Arctic and the Continental. Each one of these regions is divided longitudinally into a western and eastern zone. The location of the boundaries between the regions, as well as the zones, is determined basically by conditions of circulation. The northern boundary of the Sub-Arctic region, separating it from the Arctic climatic region, is tied in with the evolution of the summer transformation of Arctic air masses as they arrive over the continent. Its demarkation line here, as in Western Siberia, is the line of the tundra. The southern boundary of the Sub-Arctic region is determined by the predominance over the given territory of Arctic air in the winter. In the west it touches the Arctic Circle, then, curving in a general eastward direction, it passes below Yakutsk, close to Parallel 60 north. Due to the inadequacy of scientific observations in this little explored area, this boundary can be considered merely as roughly approximate to establish the fact that southerly air currents, carrying continental air far to the north, predominate over the western part, while over the eastern part, Arctic air masses are carried southward with the prevailing northerly winds. Thus, over Turukhansk, at latitude 66 degrees north, the mean January temperature is minus 30 degrees Centigrade. In Yakutsk, at latitude 62 degrees north, it is minus 43 degrees Centigrade. It must, however, be taken into account that in Yakutsk it is generally colder, not only because of the Arctic air over it, but because the temperature of the continental Siberian air in the eastern half of the anticyclonic outcrop (over Yakutsk) is lower than same in the western half (over Turukhansk). The evolution of the Okhotsk orographic front serves as a confirmation of the fact that during the winter Arctic air masses are predominant over western Yakutia, down to Parallel 60 north.

The eastern boundary of both climatic regions comprising Eastern Siberia, and separating the latter from the effect of the Pacific Ocean, runs along the Stanovoy and Yablonovyy Mountain Ranges. The boundary then turns to the Greater Khingan Ridge, which, together with the Yablonovyy Ridge, retards the extension over the continent of the summer Pacific monsoon.

The southern boundary with Central Asia, over which the formation of continental air takes place under different conditions, is also determined to a considerable degree by orographical phenomena.

In establishing meridional boundaries between the western and eastern halves of the high pressure outcrop, the most reliable index is the extent of cloud formation, which diminishes sharply with the shifting of the prevailing winds toward the north (see Figure 4 in preceding text).

The boundary, as can be seen, may be laid out along the course of the Lena River. Orographical phenomena are not essential here, since the distribution of pressure areas and the main air currents depend on conditions of a more general nature. The decrease in cloud formation is tied in not with the direction of the wind, and not even with the characteristics of the air masses, but with the sudden predominance of high pressure. Most of the westward moving cyclones become extinguished over the Central Siberian Plateau, and, during the winter, they practically never get across the Lena River.

It follows from the above, that the territory of Eastern Siberia, with relation to climate, is subject to entirely different factors than the adjacent territory of Western Siberia. The climatic boundary dividing these two territories is the first great climatic boundary /of the first order of magnitude/ on the tremendous west-to-east expanse of the USSR. There are only two such important lines of demarcation running in a meridional direction. The second one separates the Far-Eastern Monsoon region, an area that is subject to the effect of unique climatological factors, not encountered anywhere else in the USSR. The climatic boundary, running along the course of the Yenisey River, is of a larger order of magnitude than the one running along the Ural Mountains. The Urals separate the Western Siberian climatic zones from the European climatic zones, within the /overall outlines/ of three climatic regions, which stretch in belts from the European part of the Union into Western Siberia. The climatic boundary running along the Yenisey River is of greater significance than the one running along the Urals, since it marks the end of the effect of the Atlantic and the beginning of the domination of the Arctic. The difference does not lie in the varieties of the air masses, since over both Western and Eastern Siberia, continental air is predominant, but rather in the initial sources from which these air masses are transformed. The air masses over Western Siberia contain a considerable amount of Eastern European air. The air masses over Eastern Siberia are formed almost exclusively from Arctic air. It can be said that Eastern Siberia is an area of initial (in a large sense) Arctic air. Therefore, the names of the climatic regions within this area deviate somewhat from the usual.

Sub-Arctic Region

The Western Sub-Arctic zone, which may also be called the Central-Siberian zone as compared with the Eastern zone of the same region, is displaced northward. This is due, on the one hand, to the shape of the continent, and, on the other hand, to the peculiar characteristics of winter circulation. The northern boundary of the zone, marking the summer limit to the extension over the continent of formative Arctic air, as indicated by the tundra belt located here more to the north, has been moved back in connection with the northward widening of the continent at these longitudes. The southern boundary in the west runs more to the north, than in the east. This is due to the winter transfer of continental air with the southwesterly winds, as already mentioned before. In the west the zone borders on the Yenisey River, and in the east, on the Verkoyanskiy Mountain Range.

The western zone is, climatically, an area of transition from Western to Eastern Siberia. The temperature cycle is characterized by a general temperature drop from west to east, reaching its maximum value in the east. Alongside of the temperature drop, there is a decrease in cloud formation and the amount of precipitation. At the latitude of the Polar Circle, the mean January temperature ranges from minus 30 degrees Centigrade in the west to minus 45 degrees Centigrade in the east (see Figure 16 in previous text). An index of particular importance is the diminution of the snow blanket, which in Western Siberia attains its maximum depth, and in Eastern Siberia its minimum depth (see Figure 11 in preceding text). This is a result of the intensification of anticyclones, which, in the winter, points to the intensification of continentality, not only because under anticyclonic conditions the effect of the underlying terrestrial surface is more pronounced, but because such intensive evolution of anticyclones, induced by the cooling of the continent, occurs in its central areas only. Also, the lowest winter temperatures occur in the anticyclones. With relation to this, it is necessary to differentiate between the limit to which the temperature can descend, and the recurrence of severe frosts. The first, under similar conditions of topography, depends mainly on the geographical latitude, and, therefore, shows little variation within the boundaries of the Sub-Arctic region (minus 60-65 degrees Centigrade). The recurrence of severe frosts is tied in with circulation conditions, and shows an increase toward the east.

Winter cyclonic activity, as follows from the above, is diminished from west to east, and the western zone is to be considered the most cyclonically active of all other zones of Eastern Siberia, as indicated by the distribution of cloud formation and the snow blanket (see Figures 4 and 11 in preceding text).

The winters here are very long. A mean daily temperature of minus 10 degrees Centigrade is sustained for $5\frac{1}{2}$ months in the southern part of the zone, for 6 months in its northern part, and the snow blanket is on the ground about 8 months. The transitional character of winter conditions is also reflected in the attenuation of the wind, which, under generally low temperature conditions, is very essential. Wind velocity is gradually extinguished together with the attenuation of cyclonic activity, with the northern part of the zone less favorable than the southern part. With the abating of the wind, the number of snowstorms, known as the scourge of Northern Siberia, is diminished.

Summer climatic conditions are distributed more evely. The decisive factor is the warming of the continent, just as is the cooling of it in the winter. The warming of the continent generates a temperature contrast, and accentuates cyclonic activity at the boundary of the Arctic. Over the interior, however, it results in the diminution of pressure gradient forces and cloud formation, which, in turn, induce more favorable conditions for ground and air insolation. The summers are short, but warm. The isotherms are disposed latitudinally, the temperature rising somewhat toward the east, due to the intensification of continentality. The mean July temperature over the north of the zone, that is at Parallel 70 north, is about 14 degrees Centigrade; in the south, it is 18 degrees Centigrade. Summer is at its warmest in the southeastern part of the zone, over the Valley of the Lena River, where the mean temperature for July reaches almost 20 degrees Centigrade, i.e. the same as for Omsk and Novosibirsk, and above that for Moscow. During the summer, there are, on the average, 15 hot days, with a daily temperature above 20 degrees Centigrade. Maximum temperatures of 35 degrees Centigrade are registered. On the whole, the summers are short, with relatively warm days, when the daily temperature is above 10 degrees Centigrade, accumulating, on the average, for a period of 2 months. The summer is somewhat longer in the southern part of the zone.

The summer appears to be short, mainly because the period of "hot" weather (mean daily temperature over 20 degrees Centigrade) is short by comparison with locations more to the south, where it is of the same intensity, yet of considerably longer duration. In Omsk, for example, there are twice as many hot summer days, as in Yakutsk, even though the mean daily temperatures for both localities are the same. The effect of the relatively high summer temperature is usually accelerated by the prevailing dry weather. July precipitation amounts to 30-40 millimeters only, and the humidity of the air does not exceed the humidity over the black soil belt of the European part of the Union. Cloud formation is not intensive, with middle and higher clouds predominating, which, generally speaking, do not retard insolation. Cloud formation is relatively heavy in May and October. These months of maximum overcast occur between the summer, with a slight degree of sky cover, and the winter, with still clearer weather prevailing.

The eastern, or the East-Yakutian zone, is bound by the Verkhoyanskiy and Kolymskiy Mountain Ranges, and from the north, by the tundra belt. The topography of this zone is heterogeneous: valleys exposed northward, rise in altitude toward the south into a large plateau, and they are divided by small and larger ridges, running basically in the same meridional direction. The topographical disjunction of this area retards the movement of air in the layer contiguous to the earth, thereby increasing the thermal effect of the underlying terrestrial surface.

All the climatic features of this zone pertain predominantly to the winter, when a high-pressure area develops over Eastern Siberia. It is to be noted that this zone is practically always within the eastern half of the high-pressure area, and, thus, within the northerly current of Arctic air, which fills up the valleys exposed northward, and is subject to further cooling over the valleys, as well as over the higher Oymekon Plateau. Since only the eastern half of the Eastern Siberian outcrop lies over the zone, cyclones rarely pass there in the winter, and the sky is as clear as during the summer over Central Asia.

The air, which is almost at a standstill in its lowest layer, is cooled in this clear weather down to its maximum low temperatures for this zone, which, incidentally, are the lowest temperatures occurring anywhere within the northern hemisphere. The mean January temperature in the Verkhoyansk-Oymensk "cold pole" zone is at times minus 50 degrees Centigrade, with the absolute minimum reaching down to minus 70 degrees Centigrade. The only other place with similar conditions is in the center of the Greenland Ice Plateau. Since the cooling of the air occurs predominantly in its bottom layer, it is specifically over this zone that the winter temperature inversion, embracing a large part of Siberia, attains its maximum intensity. Although observations are relatively few, it may be assumed that the mean negative temperature gradient is 2 degrees Centigrade per 100 meters of height, i.e. at the 1-kilometer altitude, it is warmer in the mountains by 20 degrees Centigrade than over the valley. The winters are longer than in the western zone: the period with a mean daily temperature below minus 10 degrees Centigrade is six and a half months; the snow blanket is on the ground from the beginning of October to the middle of May. The tardiness of spring and the earlier arrival of autumn are due to the peculiarities of circulation. While in the western half of the anticyclonic outcrop, in the spring and in the autumn, the southwesterly winds carry the warmer air from the south, where the snow blanket is either gone [spring], or was not yet formed [autumn], a general northerly air current, from the Arctic, predominates over the eastern zone.

The summers over the eastern zone differ little from those over the western zone; they are warm and just as short. There is somewhat more precipitation, which is due mainly to the effect of terrestrial configuration.

Continental Region

The western or Predbaykal zone is characterized by the predominance, throughout the year, of Central Siberian continental air. The continental air is both initially formed over the zone during the winter, and is carried by the southwesterly winds of the western half of the anticyclone from Central Asia. Summer continental air over this zone is to a greater degree a "local" air mass, forming in the attenuated low-pressure areas accompanied by gentle shifting winds. Summer sky cover is low, and there is intensive convection through the bottom air layers over the super-heated terrain. The rising convection currents carry dust particles floating in the air, as a result of which there is frequently a haze in the bottom layer of summer continental air. This is a general characteristic for continental air masses during the warm part of the year. The presence of this haze in the air is always a sign of stable dry weather and stable (uninterrupted by wind) convection.

The northern half of this zone differs from the zone adjoining it, by higher temperatures only, which is due to its more southern location. In its southern half, local factors cause some variations in general conditions of circulation. The local physical and geographical factors, exerting a powerful effect on the climate, are the Sayanskiy Mountains, delimiting the zone from the south, and Lake Baykal, with the mountains exerting the greater effect, and the lake having merely a narrow local significance. The effect of the Sayan Range upon the climate of adjacent localities, manifests itself differently in the winter than in the summer. During the winter, the center of high pressure is to the south of the Sayans, and there is a slow air current across and northward. Descending along the northern slopes of the ridge, the air is warmed, and noticeably raises the general temperature level for a considerable area, modifying thereby the low winter temperatures. This factor has more to do with the higher temperatures of Predbaykal, as compared to Trans-Baykal, than the warming effect of Lake Baykal, which is frequently overestimated. During the summer, the Sayanskiy Mountains and their northern foothills accelerate precipitation from the cyclones arriving from the northwest. Over the southern part of Predbaykal there is 100-150 millimeters more precipitation than over Trans-Baykal, irrespective of the fact that the Eastern Asiatic front cyclones, passing in the summer over Mongolia, penetrate over Trans-Baykal and deposit precipitation, while in the Sayans the precipitation from these cyclones remains on the southern slopes.

The effect of Lake Baykal is limited to a narrow belt, and is hardly felt beyond the ridges surrounding it. The reasons are as follows: (1) the area of the lake is not sufficiently large, (2) it is surrounded by mountains, practically on all sides, and (3) perhaps the most important reason, there are no stable air currents which could promote a more intensive heat exchange between the lake and the surrounding territory. Local winds, although of high-velocity at times, and individual gales raging over the lake, have no wide climatological significance. A sensitive index of the effect exerted by Lake Baykal is the temperature cycle. The mean December temperature over the lake is minus 9 degrees Centigrade, and only 170 kilometers away, over Verkholensk, it is minus 25 degrees Centigrade. The mean July temperature over the island of Ushkan'yem is 10 degrees Centigrade, while 70 kilometers away, over Barguzin, it is 16 degrees Centigrade. Figures 56 and 57 show the temperature distribution around Lake Baykal for December and July.

FIGURE 56:

Figure 56: Temperature distribution in the area of Lake Baykal in December.

FIGURE 57:

Figure 57: Temperature distribution in the area of Lake Baykal in July.

Lake Baykal has no effect on the general circulation over the zone, and therefore, does not change the general characteristics of the climate. Yet, against the background of large-scale circulation processes, under the influence of this large and deep body of water, there occur variations, not only in the cycle of individual elements (temperature, humidity), but in the emergence of unique phenomena.

These manifest themselves during the winter by fogs and severe hurricanes over some localities along the western shore. Fogs are formed under the direct influence of the lake. Powerful winds are induced as a result of the general atmospheric pressure distribution, and are accelerated to hurricane proportions by local factors, such as terrestrial configuration and the high (relative to the air) temperature of the water surface. During the winter, fogs are generated mostly over the southern part of the lake (free from ice the longest), as a result of evaporation of water into the cold air. In December and January the temperature differential between the water and the air is 30 degrees Centigrade, and sometimes more. Such late /in the season/ complete solidification of the ice over Lake Baykal is a result of its great depth and

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great thermal reserve. The area Listvenichnoye-Irkutsk is particularly subject to the winter fogs during December and the beginning of January. These fogs are generated by the Angara River, which usually does not freeze over before the middle of January.

A cruel wind, known as "sarma", occurring in the area of Ol'khon, predominantly in the autumn, is a peculiar variety of the bora. The sarma, a northwesterly wind, is evolved in the cold eastern periphery current of the Western Siberian anticyclone, with the acceleration of the pressure gradient force, as the cyclone approaches from the east. However, the hurricane force (up to 40 meters per second), and the characteristic gustiness (as in the bora) become a part of this wind only as it flows over the shore mountain ridge, and also as the pressure gradient force is accelerated under the influence of the relatively warm lake surface. The sarma attains its maximum force at the estuary of the Sarma River as it passes through the canyon and flows into Lake Baykal. For the synoptic disposition during a cruel sarma attaining a velocity of 40 meters per second, see Figure 58.

Figure 58.

Figure 58: Synoptic Disposition during a cruel sarma 29 October 1901 (From L. S. Berg).

Lake Baykal also induces fog formation during the summer. These summer fogs evolve in the warm continental air extending over the cold lake. The summer temperature differential between the air and the water is at its highest in the northern half of the lake, since in its southern, and particularly southeastern part, the temperature of the water is considerably higher due to the warm water inflow from the Selenga River running from the south along the open steppe plain. Thus, the summer fogs recur most frequently over the northern part of Lake Baykal.

In addition to fogs, summer breezes of a peculiar cycle are to be noted. Only the day breeze from the lake is well pronounced, since at night, due to the generally low temperature of the water (about 9 degrees Centigrade in July), there is no adequate temperature contrast between the water of the lake and the surrounding land. In some localities, night breezes from the shore occur, but these are the winds that descend from the mountains, and the presence of the lake makes no difference.

In addition to the breezes, there is sometimes a strong gusty southeasterly wind that causes a considerable swell. This wind is not tied in with the lake proper, but is of cyclonic (Mongolian) origin, and its gustiness is induced by the effect of the southern shore mountain ridges, over which the air passes.

With relation to precipitation, the effect of the lake is small. Maximum precipitation occurs over the southern shore (500 millimeters as against 200 millimeters over the northern shore). The abrupt rise in precipitation to its maximum value occurs during the second half of the summer (July-August), coinciding in time and in character with the precipitation maximum over the south of the Buryat-Mongol ASSR (Kyakhta, and other localities), where the effect of Lake Baykal is, of course, no longer felt. For example:

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Amount of Precipitation (in Millimeters)

	May	June	July	August	September
Mysovaya (Baykal)	45	60	103	93	50
Ansha (Buryat-Mongolia)	30	45	100	95	45

The summer precipitation maximum over Trans-Baykal and over the southern shore of the lake is tied in with the Mongolian cyclones. The lake can hardly accelerate the summer rains, since the air over it is always colder in its bottom layer than in the one above, which circumstance would considerably retard the rising of the air, even though the wind may force it to ascend the mountain slopes on the shore.

The eastern or Transbaykal zone occupies the southern half of the Aldan Basin, and all of the mountainous area generally known as Trans-Baykal, with the exception of its southernmost part which is situated along the line of the Selenga River, and belongs, climatically, to Central Asia. The predominant air mass over the Trans-Baykal zone during the entire year is continental Trans-Baykal air, which, in the winter, is considerably different from the Predbaykal continental air. Winter Trans-Baykal continental air originates from the transformation of Arctic air taking place in calm and clear weather. Since the Arctic air is heated slowly in the winter, the [formative] continental air has a low temperature. Of all winter air masses of the Temperate latitudes of the northern hemisphere, the Trans-Baykal air is the coldest. The mean January temperature in the north of the zone is minus 35 degrees Centigrade, in the south, minus 25 degrees Centigrade, which is 10 degrees colder than in the Predbaykal zone. It is of interest to note that, with such low mean temperatures, the absolute minimum temperature is not below the absolute minimum over Western Siberia at the same latitude. This further underscores the low winter temperature level over Trans-Baykal, and the fact that radiation cooling in the anticyclone is a normal everyday process here. Anticyclonic clear weather is sharply predominant throughout winter and spring.

Winter and spring are very dry, there is very little snow, and bare soil is encountered frequently. This unique aridity is accelerated southward. In Chita, for instance, from October to April, there are more than 3 days with precipitation in a month, the amount of precipitation being insignificant. The snow deficiency, against the background of severe frost, promotes a deep freezing-through of the soil, creating a Perma-frost zone. Such islands of permanent frost are encountered in large numbers even in the southernmost areas of the region. Spring, too, is an inclement season, dry, cold, with strong northerly winds, under the effect of which the already dry soil is further frost-dried. The mean temperature for April is about zero Centigrade, for May it is below 10 degrees Centigrade. Even these low spring temperatures are to be considered here as indicative of rapid warming, since the April and May relative humidity during the day is below 40 percent, and, in 30 percent of all days, it is below 30 percent.

A characteristic feature of the climate of Trans-Baykal is that, as a result of the climatological stability of the Asiatic anticyclone, the winter and spring cycles are very stable.

The Trans-Baykal summer, like summer throughout Siberia, is very warm. Even in the northern part of the zone the mean temperature for July is 20 degrees Centigrade, with the temperature maximum exceeding 35 degrees Centigrade. A distinguishing feature for Trans-Baykal, manifested mainly in the southern half, is the sharp rise in summer precipitation, which in no way can be attributed to local factors. Some interpret these as the effect of the Pacific monsoon. Yet, the effectiveness of this monsoon is limited to the Pacific basin, i.e. to the eastern and southeastern slopes of the Yablonovyy Ridge and the Greater Khingan. Summer precipitation over Trans-Baykal is tied in mainly with the Mongolian front cyclones in which the warm mass is constituted by the North China continental Tropical air. The mean daily temperature, in Tropical air penetrations during the summer over the southern part of Trans-Baykal, is sometimes above 25 degrees Centigrade. The mean temperature for July over Kyakhta is the same as over Kislovodsk (which has the same altitude), even though there is a considerable difference in geographical latitude. The amount of precipitation for July and August goes up to 90-100 millimeters, which is considerable when compared with the 3-5 millimeters of precipitation for winter and spring. However, even during the rainiest years, the amount of precipitation is always less than 200 millimeters a month, while in the Pacific monsoon area it may exceed 300 millimeters. Some summers in Trans-Baykal are very arid, while in the monsoon area drought never occurs. All this confirms the above mentioned predominant connection between summer precipitation over Trans-Baykal with the Mongolian cyclones. There are few rainy days in the summer, and precipitation takes the form of short showers. Summer sky cover is relatively light, and the duration of sunshine, even during the rainy season, is 60 percent of the potential.

Autumn arrives rapidly, but the weather remains remarkably dry and clear. The transition to the equally clear and dry winter season is /practically/ unnoticeable. The anticyclonic cycle comes into its own as early as September, and the general temperature level drops rapidly. Mean daily temperatures below minus 10 degrees Centigrade are registered in October, and by the second half of November, the winter cycle with its clear, calm, and severely frosty weather is fully stabilized. (see Figure 59).

FIGURE 59:

Figure 59: Typical weather for the end of autumn and the beginning of winter over Trans-Baykal (24 November 1939).

THE FAR EAST

The areas of the Soviet Union within the basin of the Pacific Ocean are known as the Far Eastern areas. The terrain determining the Far East as a separate hydrological region, plays a decisive part in the establishment of a climatic boundary between the Pacific area and Eastern Siberia.

The circulation processes evolving over the Pacific Ocean affect the Far East only partially, and show no tendency for deep penetrations over the continent. Therefore, the mountain barriers easily arrest their progress westward, and accentuate the boundary of the climatic effect of the Pacific Ocean, and perhaps even displace it somewhat to the east. As to the continental influences, which manifest themselves mainly during the winter, the mountain ridges are no essential barriers, since the vertical depth of the winter continental air masses exceeds by far the altitude of these ridges.

When comparing the vast area affected climatically by the Atlantic Ocean, which effect extends to the Yenisey River,-with the narrow Far Eastern belt, over which the effect of the Pacific Ocean is predominant, one realizes the great physical and geographical significance of the westerly transfer of the tropospheric air masses over the Temperate latitudes.

The climate of the Far East is composed under the alternating effect of continent and ocean. The continental effect predominates in the winter, manifesting itself in a mighty northwesterly continental air current, flowing off along the eastern periphery of the anticyclones, constantly generated during the winter over Central Asia and Siberia. The vertical depth frequently attained by this air current is 4 kilometers. The coldest bottom layer of Eastern Siberian air is retarded in the area of formation, and this air arrives over the Far East with a somewhat higher temperature. However, even this temperature is very low, and is not comformant to the maritime location of the area and its geographical latitude. Thus, for example, the mean January temperature in the Ol'ga Bay, enclosed from the north and the northwest by the Sikhote-Alin' Mountain Range, and lying at the latitude of Tuapse, is minus 12 degrees Centigrade, i.e. one degree below that of Moscow. In Nikolayevsk-na-Amure, where the recurrence of winter northwesterly continental winds is 80 percent, the mean January temperature is 13 degrees Centigrade lower than that in Kuybyshev at the same latitude.

The effect of the ocean is strongest during the summer. It is composed of two basic processes: (1) the transfer of maritime Temperate air with easterly and southeasterly winds in the bottom layer, in the forward part of the cyclones (the mean depth of this layer is 1 - 1.5 kilometers), and (2) the propagation, from over the Subtropical part of the ocean (also in the southeasterly current), of warm humid air. This air, however, is, in most cases, even over the southern part of the area, severed (at the occlusions) from the terrestrial surface, and extends over the top of the colder layer. Summer temperature and humidity over the maritime belt are tied in with the first process, while precipitation is tied in with the second one. Both processes evolve under conditions of cyclonic activity, at the western outcrop of the Pacific Ocean front (see Figure 60).

FIGURE 60:

Figure 60: Cyclonic activity at the western outcrop of the Pacific Ocean front during the summer (23 June 1916).

In addition to the Pacific front cyclones, the Mongolian front cyclones, carrying the dry and hot North China air masses, also penetrate over the southern part of the Far East. The amount of precipitation in these cyclones is small.

The inflow of maritime air in the bottom layer reduces summer temperatures, not only over the littoral, but also over the interior. The warmest summers are observed over the Ussuri River Valley, and along the middle course of the Amur River, corresponding in latitude to the Southern Ukraine. Summer temperatures here are the same as in the Atlantic-Continental region of the European part of the USSR.

Summer precipitation from the maritime Tropical air, which is propagating in the higher layers, amounts to 70 percent of the annual precipitation over the southern zones, and to somewhat less over the northern part.

Over the Sea of Okhotsk, in the summer, is evolved a high pressure area, along the eastern brim of which the air flows off southward, toward the Sea of Japan, then returns to the north, along the western periphery, with the southeasterly current. This air is cooled off over the relatively cold waters of the northern part of the Sea of Japan and the Tatarskiy Strait, as a result of which its relative humidity is considerably increased, with frequent formation of fogs, carried by the winds over the coast. To the north, the temperature differential between the air and the surface of the water is decreased, and there is less fog formation. In July, the number of days with fog over Vladivostok is 15, over Nikolayevsk-na-Amure only 1, mean relative humidity in Vladivostok is 88 percent, in Nikolayevsk-na-Amure it is 77 percent. Thus, the constant inflow of damp air, from over the northern part of the Sea of Japan, is responsible for the excessive humidity of the summer in the Far East.

The seasonally alternating continental and oceanic effects, which determine the dry and cold winters, and the rainy humid summers, constitute the principal characteristic of the monsoon climate of the Far East. The winter northwesterly current of continental air is the winter monsoon. The question is posed, as to which air current constitutes the summer monsoon. Is it the lower current of maritime Temperate air that determines the basic temperature and humidity cycles? Or is it the upper, Subtropical air current, from which precipitation is falling? It is, seemingly, both, yet separated from each other in conformity with the processes and phenomena peculiar to each.

Thus, the basic part in the formation of the climate over the Far Eastern territory of the USSR belongs to circulation factors. Figures 61 and 62 show diagramatically the distribution of air currents and the location of frontal zones over the Far East during the winter and the summer (according to N. V. Stremousov).

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FIGURE 61:

Figure 61: Distribution of air currents and location of frontal zones over the Far East during the winter (N. V. Stremousov).

FIGURE 62:

Figure 62: Distribution of air currents and location of frontal zones over the Far East during the summer (according to N. V. Stremousov).

During the winter continental air is propagated far to the south, beyond the boundaries of the Soviet Union, and cyclonic activity at the Polar front takes place in the Subtropical latitudes over the Pacific Ocean. The Pacific Ocean air of the Temperate latitudes is propagated in the rear of the departing cyclones, and is carried by the latter to the east of the Far Eastern littoral. In connection with this, the recurrence of continental air over the Far East is 60-70 percent in the south and 80 percent over the lower part of the Amur River.

Figure 62 shows two summer outcrops of the Polar front, a continental outcrop over Mongolia, and a Pacific Ocean outcrop. In the cyclones at the continental outcrop of the Polar front, the warm sector is filled with continental Tropical air, while in the Pacific Ocean cyclones, the same is filled with maritime Tropical air. A high pressure area is developed over the Sea of Okhotsk in the summer, and it is mainly from this area that the air is flowing off into the rear of the passing cyclones. The same air masses arrive over Primor'ye and over the Amur Valley, but they are carried by the southeasterly current, which is returning from the south considerably warmed.

Based on the above described circulation conditions, the Far East can be divided into two climatic regions: (1) the Monsoon region, comprising the basin of the Amur River, the Sea of Okhotsk littoral, and the southern half of Kamchatka, and (2) the Pacific Ocean Sub-Arctic region, comprising the basin of the Anadyr' River, and the part of the Kamchatka Peninsula to the north of the mouth of the Kamchatka River. Within the Monsoon region, three zones, differing from each other by conditions of summer circulation, can be segregated: (1) the Amur River zone, (2) the Okhotsk zone, and (3) the Kamchatka zone.

The Monsoon Region

The Amur River zone, which is the southernmost zone of the region, occupies the basin of the Amur River down to the State boundary (with the exception of the lower part of the river course), the southern part of the Tatarskiy Strait littoral to De-Kastri Bay, the southern half of Sakhalin and the southern Kuriles. Southeasterly winds from the Sea of

Japan, the so-called summer monsoons, predominate during the summer. These winds develop in the eastern part of continental cyclones, coming from over Man8chzuriya, and cyclones, arriving from over the Sea of Japan and carrying maritime Tropical air. The cyclones arrive, in most cases, in an occluded state, and the southeasterly winds carry over the continent the maritime Temperate (not Tropical) air, which is somewhat warmed and humidified in its passing over the southern part of the Sea of Japan. In passing over the cold waters of the northern part of this sea, (the part that delineates the Soviet coastline), this air is cooled, with frequent formation of fog which is carried by the same winds onto the coast. The air is warmed over the area of Lake Khanka and the Valley of the Ussuri River, and the fog is rapidly diffused, but over the coasts of Tatarskiy Strait, these fogs, rising along the eastern slopes of Sikhote-Alin', frequently become drizzling rains. The fogs are particularly frequent in June and July. The mean number of foggy days in July over Vladivostok is 15, but in the area of Lake Khanka it is only 1. In August, when the northern part of the Sea of Japan is warmed up, the recurrence of fog is cut in two, and in September they are as rare as in the winter (1-2 days). The temperature over the littoral, with the fog-carrying southeasterly wind, shows a drop with the astonishing feature of a sudden change in weather from warm sunshine to windy and damp, with drizzling fog. In rare cases, the penetrations of damp Tropical air produce a fog, accompanied by a hot and suffocating humidity. All these phenomena are rarely observed in the interior, since the air masses are warmed over the ridge-protected valleys of the Amur and Ussuri rivers.

The summer cyclonic rains, furnishing the basic amount of precipitation over the zone, come predominantly from the maritime Tropical air. The terrestrial relief of the southern part of Sikhote-Alin' accentuates the fronts, and precipitation is accelerated, with the maximum amount falling in the area of Ol'ga Bay (about 450 millimeters for the period June-September). Over the interior part of the area, sufficiently exposed from the south, there is somewhat less precipitation, while over the southern part of the Bureinskiy Ridge the amount of precipitation is again increased. The Pacific Ocean frontal zone is at its maximum proximity to the Far Eastern littoral of the Soviet Union in August and September. This is tied in with the warming of the northern part of the Pacific Ocean, including the Sea of Okhotsk, over which, during the first half of the summer, an area of high pressure is developed.

The summer rains over the Far East are abundant, continuous, and of average intensity. Frequently, there is 10 millimeters of rain in a day, with the absolute daily maximum somewhat over 100 millimeters. The monsoon rains are the cause of annual floods during the second half of the summer, with these floods assuming, at times, the proportions of catastrophic inundations. These are caused, not as much by the intensity of precipitation, as by the rapid run-off of the waters along the mountain slopes. The preceding cycle of precipitation is also of importance. Usually the flood stage is prepared by the preceding rains, which fill the river channels to the brim. The high floods in the Far East are not accidental, but constitute a natural result of the summer climatic cycle, and the years in which they do not occur are exceptions. This characteristic of the hydrological cycle of the rivers pertains to the entire Amur Basin.

The amount of precipitation fluctuates considerably from year to year, depending on the location of the Pacific Ocean front and the intensity of the cyclonic activity developed. During particularly rainy years, the amount of precipitation accumulating in the southern part of the zone, is 1000 millimeters. In dry years, it is 350 millimeters. During the month of August (the rainiest month), there may be over 400 millimeters and not less than 20 millimeters of rain.

Annually, by the end of the summer and during autumn, there are, on the average, 10 typhoons, which are regenerated at the Polar front Tropical cyclones. In addition to great wind velocities, they are accompanied by abundant precipitation. They typhoons usually pass over the zone with their northern parts, and over 50 millimeters of rain falls during the day. When the typhoon occurs at the end of the summer, with the rivers full, the intense rain brings on a flood. During late autumn, the typhoons are not so frequent, and when they occur they are accompanied by ample snowfall.

The winter cycle in the Amur zone resembles that of Trans-Baykal, but temperatures are higher, due to a more southern location, with accelerated insolation and more frequent penetrations of warm air masses. The potential insolation for January in the Primorskiy Kray, with respect to geographical latitude, is twice that of the southern part of Trans-Baykal, which, against the background of equally light sky cover, has considerably higher temperatures. The penetration of relatively warm air masses over the Amur zone may take place, both from the direction of the sea, and from China. But these warm penetrations in the middle of the winter rarely result in a thaw. On the average, during the 3 winter months in Vladivostok, there is one day with a mean daily temperature above zero Centigrade. For the same period, there are 12 days with a mean daily temperature from zero to minus 5 degrees Centigrade, while on the extreme southern end of Trans-Baykal (in Kyakhta), there is none, and only 3 days have a mean daily temperature of from minus 5 to minus 10 degrees Centigrade, the other days all being colder.

In the winter, the maritime air arrives over the zone with the rear winds, passing to the south of the cyclones (see Figure 59, synoptic disposition of 24 November 1939). The relatively warm air arrives from over China, where it is initially formed in high pressure areas over Parallel 30 north (see Figure 61).

The winter temperature rise (as compared to Trans-Baykal) is also due to wind acceleration, which takes place in the belt between the Siberian anticyclone and the Aleutian minimum /pressure/ area.

Winter precipitation is small, and there are winters when the snow does not cover the entire ground. The snow cover is stabilized only late in the season, since even in November the temperature hovers around zero, with the falling snow melting. The dwindling of the snow cover takes place in April, by melting and evaporation, since the weather is rather clear, with sky cover increasing only during the second half of April and in May. As a result, the spring flood stage in the rivers of the Amur zone is not significant, and is accelerated only at the lower course of the Amur, where there is considerably more snow.

<u>The Okhotsk climatic zone</u> comprises the littoral of the Sea of Okhotsk, including the lower course of the Amur, the northern part of the Tatarskiy Strait to De-Kastri Bay, and the northern part of Sakhalin.

The characteristic feature of the Okhotsk zone during the summer, is the evolution over the Sea of Okhotsk of an area of high pressure, from which the air masses, cooled over the sea, flow off towards the littoral (see Figure 62). For most of the littoral, the winds from the Sea of Okhotsk are southerly and southeasterly monsoons, occuring during the warm period, from May to August. They begin almost a month after and end earlier than the southeasterly winds of the Amur zone, blowing from the Sea of Japan. The summer temperature of the air masses, being formed over the Sea of Okhotsk, differs little from the temperature of the water, therefore there is very little fog formation. The fogs here are formed rather in the warm continental air in its migration over the sea, and are carried by the day breezes toward the shore, where they are rapidly dissipated, while lingering rather long over the water. Thus, there is considerably less summer fog over the Okhotsk zone, than in the south of the Amur zone. In Vladivostok, there are 40 days with fog from June to August, in Nikolayevsk-na-Amure only five. Not only is there less fog, but also the relative humidity over the Okhotsk zone is lower. The very late arrival of the summer warmth is due to the same cause, i.e. the prevailing winds from the cold sea. The mean June temperature in Nikolayevsk-na-Amure is 11 degrees Centigrade, in Okhotsk and Okha on Sakhalin it is 6 degrees Centigrade. Generally, the summer cannot be considered warm. Only over the lower course of the Amur the mean August temperature reaches 16 degrees Centigrade, and it is considerably lower in the rest of the zone. In Okhotsk, the mean August temperature is 12 degrees Centigrade. Maximum temperatures over the entire zone (not counting the lower course of the Amur) are not above the maximum temperatures over the Arctic Ocean littoral.

Summer cyclonic activity is tied in mainly with southerly cyclones, but there is also formation of secondary cyclones at the occlusions, where the warm mass consists of continental air. Thus, summer precipitation over the Okhotsk zone comes not only from the Pacific Ocean Tropical air, but also from the continental air arriving from Eastern Siberia, and from the south of the Far Eastern territory. Tropical air penetrations (at the occlusions) become rare toward the north, and precipitation is diminished. Over the south of the zone precipitation remains ample, particularly over the western shore of the Sea of Okhotsk (on the slopes of the coastal ridge), where there is as much precipitation as in the south of Primor'ye (in Vladivostok), but in Okhotsk precipitation has already diminished to about half the amount. The amount of precipitation also decreases toward the east: the annual amount in Nikolayevsk-na-Amure is 450 millimeters, and still less in the northern part of Sakhalin.

In winter circulation conditions, there is also a particular factor that differentiates this zone from the Amur zone, i.e. cyclonic activity at the Arctic front. As mentioned in the preceding text, the location of the frontal zone over Eastern Yakutia is, to a considerable degree, determined by orographical causes, but also by conditions of general circulation. The zone of the Sea of Okhotsk is the natural place where the Yakutian Arctic air and the Pacific Ocean air meet. The Arctic cyclones provide the winter precipitation, considerably in excess of winter precipitation in the southern part of the Far East. The snow cover is also increased. It is of interest to note the distribution of the snow cover over the Amur Valley, and the general hydrological cycle of the river, tied in with it. In the central part of the Amur area, the snow cover is thin, the spring flood stage is practically absent, with only one high flood during the summer. Over the lower river area, the snow cover is 70 centimeters thick by the end of the winter, causing spring floods in addition to high water in the summer. Regarding winter precipitation, tied in with the Arctic cyclones, the western littoral of the Sea of Okhotsk, and its part which has maximum summer precipitation, are in an unfavorable position. The warm season precipitation, induced by the southerly cyclones, with relation to which the eastern mountain slopes are windward, increases from the mouth of the Amur westward. Winter precipitation, induced by the northerly cyclones, diminishes toward the west. Thus, the snow blanket attains its maximum depth at the lower course of the Amur. This is partly due to it being sustained on the ground, from the beginning of November to the beginning of May.

Winter temperature conditions differ little from continental conditions over Eastern Siberia, particularly in the south of the zone. The mean temperature of the winter months over the lower course of the Amur is the same as over the southern part of Trans-Baykal (about minus 25 degrees Centigrade for January). The duration of the period with negative mean daily temperatures is over 6 months, the same as in Trans-Baykal. The only difference pertains to the maximum low temperatures, which, in Trans-Baykal, are tied in with a prolonged period of calm and clear weather. Over the Far East, calm occurs rarely, sky cover is somewhat heavier, therefore the frosts are not as severe as in Trans-Baykal. The northern littoral of the Sea of Okhotsk differs greatly from the continental areas of the same latitude, since the mountain ridge constitutes an impedance to the propagation of the particularly cold air inland. Also, it is here that the effect of the Aleutian depression becomes pronounced. As a result, there is a gradual rising of winter temperatures eastward. The differential in the mean January temperatures as between Yakutia and the Okhotsk littoral is 20 degrees Centigrade, and more in the northeastern part of the zone.

The location of the Okhotsk Ridge and the atmospheric pressure distribution, high over northeastern Yakutia, and low over the Sea of Okhotsk, create favorable winter conditions for the evolution of the bora which attains its maximum force over the southern slopes of the Okhotsk Ridge and the western coast of the Gizhiginskaya Guba.

Northern Sakhalin, although a part of the Okhotsk climatic zone, should really be considered a sub-zone over which local factors play an essential part, with certain peculiarities observed in the general circulation cycle.

The winter activity of the northwesterly Arctic cyclones over the southeastern part of the Sea of Okhotsk is accelerated, which is reflected in the increase of winter precipitation on the Kurile Islands, in the southern part of Kamchatka, and partly on Sakhaline Island. The snow cover over the northern part of Sakhalin is heavier than on the continent. Cloud formation, too, is somewhat heavier, and the recurrence of January overcast is 40 percent.

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Southeasterly winds of the Okhotsk anticyclone predominate in the summer over northern Sakhalin, as well as over the greater part of the Okhotsk zone. But, in addition, Northern Sakhalin is caught by the rear part of the Pacific Ocean cyclones moving over the Kurile Islands toward Kamchatka, with the resulting acceleration of the cold and damp northerly winds. Summer precipitation over Sakhalin, as well as over the lower course of the Amur, is lower than same over the southern part of Primor'ye. The northern tip of the island, in this sense, is subject to particularly unfavorable conditions: over flat shores, surrounded by the cold sea, the vertical temperature gradient is small, and at times has even a negative value, which creates a stable stratification, impeding the rising air currents.

The mountains, stretching along the eastern and western coasts of the island, protect the interior from the damp and cold winds from the sea, as a result of which the summers in the interior of the island are no colder than those over the lower course of the Amur.

The Kamchatka climatic zone occupies the southern part of the peninsula up to the mouth of the Kamchatka River, and up to the Northern Kuriles. During the winter, the effect of the continent over this zone is considerably diminished by the air currents of the western part of the Aleutian depression. In the rear of the cyclones, passing to the east of Kamchatka, northeasterly winds are stabilized, carrying the air from over the Bering Sea, which, even though it freezes over in its western part, is not as cold as the continent. As an illustration, see Figure 63, depicting the synoptic disposition of 9 December 1938.

FiGURE 63:

Figure 63: Inflow of air from over the Bering Sea toward Kamchatka, in the rear of cyclone (9 December 1938).

Two parallel currents can clearly be discerned: (1) the cold continental current (the northern coast of the Sea of Okhotsk, with a temperature of minus 24 degrees Centigrade) and (2) the warmer current from over the Bering Sea (north of Kamchatka, with a temperature of minus 10 degrees Centigrade). Over the south of Kamchatka, the northwesterly wind is shown, tied in not with the continental, but with the maritime air, although, by statistical account of prevailing winds, all northwesterlies are considered continental. Thus, the recurrence of the so-called winter continental monsoon turns out to be exaggerated. However, the sequence of mean temperatures for the winter months over Kamchatka (over the central part, the mean January temperature is minus 18 degrees Centigrade) indicates, that the climatic weight of continental air is essential. By the above mentioned mean temperatures, it can be construed that the continental current frequently extends farther to the east than is shown in Figure 63. The rise in the winter temperature over Kamchatka is also tied in with wind acceleration and relatively heavy cloud formation.

The inflow of air from over the Bering Sea, high-velocity winds, and cloud formation, all indicate the evolution of cyclonic activity. These are either the occlusions of the Pacific Ocean Polar front, or the Arctic cyclones.

The winter cyclones passing close to Kamchatka carry considerable precipitation, which is further accelerated by the orographical conditions of the peninsula so that the amount of winter precipitation is almost equal to that of the summer. The snow blanket in the south of Kamchatka is over one meter thick, it is established in the middle of October, and persists sometimes to the end of May.

The winter temperature cycle is of Eastern European rather than Asiatic characteristics, yet, too continental for its maritime location. In the north of the zone (the central part of the peninsula), the mean January temperature is minus 18 degrees Centigrade; over the littoral, it is minus 16 - 14 degrees. An additional index of continentality is the minimum low temperature: at latitude 55 degrees north, on the eastern shore, the frost may descend to minus 35 degrees Centigrade, and in the interior even to minus 40 degrees.

During the spring, the inflow of continental air subsides, and the peninsula is predominantly subject to the effect of the cold waters of the Sea of Okhotsk and the Bering Sea. The spring is damp and cold, with the mean temperature for May, even in the south, only 4 degrees Centigrade, the recurrence of overcast 70 percent, and an air humidity of 80 percent, even though the amount of precipitation for May is smaller than for other months.

In the summer, the paths of the cyclones lie farther to the north, and southern Kamchatka lies under their forward part, which generates southerly and southeasterly winds. These winds carry the Pacific Ocean Temperate air, which displaces (at the occlusions) the Tropical air from directly over the terrestrial surface. Thus, over Kamchatka, as well as over the Primorskiy Kray /Maritime Provinces7, there are two currents in the summer monsoon: the upper current, from which precipitation occurs, and the lower current, which conditions the temperature and humidity near the terrestrial surface. The air flowing in from the south, is cooled over the cold Bering Sea current, that flows past the east coast and the southern end of the peninsula, resulting in fogs similar to those over the south of Primor'ye. Over the west coast of Kamchatka, facing the Sea of Okhotsk, fogs occur less frequently, and, in most cases, they are carried in by the wind from the open sea.

The amount of precipitation is increased (although to a smaller degree than in the Amur zone), with the maximum precipitation of monsoon origin taking place during July--October. The beginning and the end of the summer monsoon rains over Kamchatka usually lag, as compared to the Amur zone, since the paths of the first cyclones lie to the south of Kamchatka, and the effect of the autumn continental anticyclone becomes pronounced over the Amur zone somewhat earlier than over Kamchatka.

The summers over the littoral are damp and cold, no warmer than those over Murmansk beyond the Polar Circle, as a result of the effect of cold sea currents. In the interior, however, under the protection of the mountains (over the valley of the Kamchatka River), the mean July temperature is 14-15 degrees Centigrade, and the maximum temperature is 30 degrees Centigrade, the same as in the interior of Sakhalin. The high temperatures over Sakhalin are tied in with the transfer of air masses from the continent, while over Kamchatka they are a result of local warming, since Southern Kamchatka lies at the latitude of Orel and Tula.

The Pacific Ocean Sub-Arctic Region.

This region comprises the territory of Northern Kamchatka and the Anadyr zone up to the Anadyrskiy Mountain Range. Conditions of circulation and the characteristics of the air masses are entirely different from those over the Monsoon Region. During the winter, the predominant mass over the region is constituted by Arctic air, which is initially formed over the northern part of the Bering Sea, and is flowing off southwestward along the northern rim of the Aleutian depression. This air is considerably warmer than the continental air over Yakutia. In addition, cyclonic activity, involving Northern Kamchatka and the Anadyrskiy Kray, is developed at the Arctic front, in the northern part of the Aleutian depression.

The variations are less essential during the summer, except that the effect of the Far Eastern monsoon does not reach here, and precipitation is tied in predominantly with Arctic cyclones. The basic air mass in the summer is the air of the Northern Pacific, assuming, over the interior, some continental characteristics, such as higher temperature and lower relative humidity. However, considerable cloud formation and winds essentially retard transformation.

Winters are rather cold, with mean temperatures close to those of Western Siberia at the same latitudes. However, as compared with the adjacent (beyond the mountain ridges) Continental Sub-Arctic region, with its "cold pole", winter in the Anadyr zone and Northern Kamchatka is relatively mild, with the mean January temperature differential between the two amounting to over 20 degrees Centigrade. The Stanovoy Mountain Ridge is an unmistakable boundary /between the two/, and it determines, to a great extent, the direction of the winter isotherms, which are disposed parallel to its course. The absolute minimum temperature (minus 50-55 degrees Centigrade) also corresponds to that over Western Siberia.

Winter temperature increases rapidly toward the east, which, in addition to other factors, is a result of wind acceleration that destroys the lowest film /layer/ of cold air. The mean wind velocity is increased to 6 meters per second, and over the littoral to 7 meters per second, while over the valleys of Kolyma, Indigirka, and Yana, it is less than 3 meters per second. The same cause, i.e. the intensification of the wind, leads to the increased "cruelty" of the weather, with its consequent effects upon humans.

The microclimatic features, conditioned by medium and small terrestrial configurations which are sharply pronounced in the region of the Yakutian high pressure outcrop and in Trans-Baykal, are smoothed out here by the powerful winds.

During the winter, the passage of cyclones over this region occurs less frequently than over Southern Kamchatka, which finds itself under the western branch of the frontal zone of the Aleutian depression. The further to the north, the less the amount of precipitation and the lighter the snow cover, which, in Southern Kamchatka, sets a record value for the entire Soviet Union. In the Anadyr zone, the snow cover is no deeper than in the Atlantic-Continental region of the European part of the USSR (60 centimeters), even though it is on the ground about 8 months, and there are no thaws during the winter. Yet, even the 60 centimeters of snow cover is twice the depth of the snow cover in the "cold pole" zone /which was mentioned above/.

The summers are cool. The isotherms are disposed from northeast to southwest in the summer, but the temperature gradient reverses direction in the summer. Temperature decreases with proximity to the coast. The warmest localities are around the middle course of the rivers Anadyr' and Penzhina. They are protected from the damp and cold southeasterly winds by the Koryakskiy Mountain Ridge. The mean July temperature in Markovo and Penzhino is 14 degrees Centigrade, and the maximum temperature is 25 degrees. The summer, of course, is short even here, yet the mean daily temperatures, over a two-month period, are sustained at above 10 degrees Centigrade.

The amount of precipitation in July and August increases to 50 millimeters, which indicates an acceleration of cyclonic activity, since winter precipitation amounts to only 10-20 millimeters. This is confirmed by the recurrence of heavy sky cover and winds. The recurrence of summer overcast over the area Markovo-Penzhino is 70 percent, and the mean wind velocity is 4-5 meters per second.

THE ARCTIC

Although the Arctic area constitutes a vast expanse (it is almost twice the size of Europe), it can be considered as one climatic region, over which air masses of a single type are formed. Depending on the characteristics of the underlying surface, the air masses formed over the Arctic are of two varieties: continental Arctic, and maritime Arctic. Continental Arctic air is formed during the cold part of the year, when practically all of the Arctic, with the exception of a relatively small part in the Atlantic sector, is covered with continuous ice, and does not differ from the continent. This air is characterized by very low temperatures in its lowest layer (minus 35-40 degrees Centigrade), and by temperature rises which take place with height, within the layer of up to 1.5-2 kilometers. Even the strongest winds cannot fully cancel out this powerful temperature inversion. Maritime Arctic air is formed over the open sea, or over the broken ice floes, which constitute the surface of the Arctic during the short summer season. The temperature of the summer Arctic air approximates zero Centigrade in its lowest layer, and frequently rises with altitude, although to a smaller degree than during the winter.

The radiation cycle over the Arctic is unique. During the Polar night, there is no inflow of solar radiation; what remains is only atmospheric radiation, attributable to the warm air flowing into the Arctic from the Temperate latitudes via the upper layers of the troposphere. The cooling of the underlying surface, under conditions of slight sky cover, is very rapid, and the settling air is continuously cooled, becoming increasingly dense, which induces an inflow of air via the upper layers from the Temperate latitudes, with a corresponding increase in pressure near the surface. This cooling, in turn, causes the diffusion of cloud formations and the subsequent cooling of the lowest atmospheric layer. The intensity and stability of this process is indicated by the powerful temperature inversion in the lowest air layer.

During the summer, solar radiation in the Arctic is of great importance, due to the length of the Polar day. For the June-August period, its value is not below that of the Temperate latitudes, but, due to considerable cloud formation and frequent fogs, it rarely reaches the terrestrial surface in a direct manner. However, the heat inflow is so great that it sets off a mass-thawing of snow and ice. On the other hand, the thawing sets a limit to the potential rise in temperature within a few degrees above zero Centigrade, which, however, is exceptional, with the usual summer diurnal temperatures, in 90 percent of all cases, hovering around zero Centigrade.

During the summer, the continents surrounding the Arctic Ocean are considerably warmer than the Polar Sea, and yet, atmospheric pressure over the Arctic is slightly lowered, as over a relatively warm area. This, seemingly, can be explained as follows: the lowest air layer, cooled off by the thawing of the ice cap, and separated from the rest of the troposphere by dense cloud formations, has no essential effect in the general heat exchange between the Arctic Ocean and its surrounding land masses; while the upper surface of the clouds,warmed by the non-setting sun, imparts the /absorbed/ heat with sufficient intensity to the adjacent air. This explains the summer temperature inversion over the Arctic.

The height of the cold air layer (the layer contiguous to the earth) may reach several hundred meters even in the summer. Diminution of mean pressure is also tied in with cyclonic activity over the Central Arctic.

Thus, atmospheric circulation over the Arctic is dependent, to a high degree, on radiation processes. During the winter, which is the period of sharp cooling of the air masses, an area of high pressure is evolved over the Arctic. This area shows strong deformations from the direction of the Atlantic, and lesser deformations from the direction of the Pacific, both as a result of the inflow of warm air, caused by a number of factors, and, primarily, by cyclonic activity over the Northern Atlantic and Northern Pacific. The subsequent progress of the cyclones into the Arctic is induced by the location of the northern continental coastline and the inflow of warm oceanic waters into the Polar basin from the south. For the January atmospheric pressure and temperature distribution over the Arctic, see Figures 64 and 65.

Figure 64:

Figure 64: Atmospheric pressure distribution over the Arctic in January.

FIGURE 65:

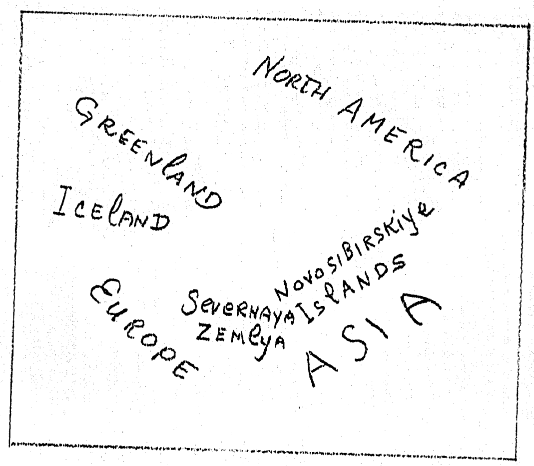

Figure 65: Temperature distribution over the Arctic in January.

The high pressure area shown in Figure 64 is somewhat displaced toward North America. From the direction of the Atlantic, the Iceland depression area extends over the seas of Greenland, Barents, and Kara; from the direction of the Pacific, the Aleutian depression area does not penetrate far into the Arctic. Pressure distribution is in conformity with temperature distribution: the Central Arctic and the Canadian Archipelago comprise the coldest area, while the Atlantic sector is the warmest.

Winter cyclonic activity occurs principally at the periphery of the Arctic, which is also indicated by a corresponding pressure distribution. Cyclonic activity attains its maximum value at the Atlantic and Pacific meridians, where, due to the temperature contrast between the Arctic air and the maritime Temperate air, the Arctic front becomes accentuated. Cyclonic activity over the Asiatic sector is almost extinguished during the winter, with the Arctic and Siberian anticyclones merging into one area of high pressure.

RESTRICTED

During the summer, the mean pressure field is indefinite, there are no clearly delineated areas, either of low or high pressure, yet the summer pressure field should rather be considered as lowered. Temperature distribution does not correspond to such a concept, since the temperature drops from the continents into the depths of the Arctic. The possible explanation for this was given above. The July pressure and temperature distribution over the Arctic is depicted in Figures 66 and 67.

FIGURE 66:

Figure 66: Atmospheric pressure distribution over the Arctic in July.

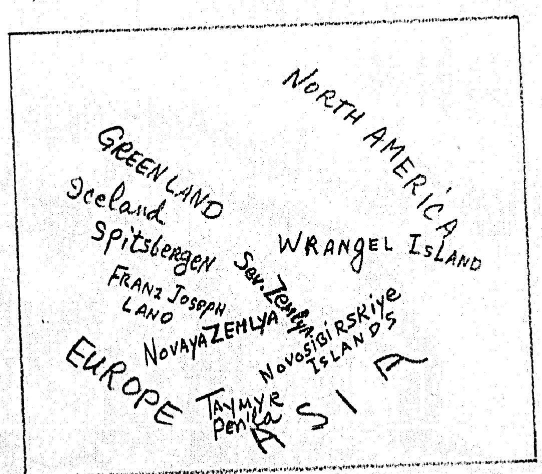

FIGURE 67:

Figure 67: Temperature [illegible]

RESTRICTED

Cyclonic activity at the Arctic front is distributed differently in the summer than in the winter. In the summer, the maximum temperature differentials are observed between the Arctic Ocean and the continents, while the temperatures of the North Atlantic air and the North Pacific air approximate the temperatures of the Arctic air forming over the surface of the Arctic Ocean, which is free from continuous ice fields. In addition, by virtue of a different thermal ratio between the oceans and the continents, the Iceland and Aleutian depressions are filled, and cyclonic activity, tied in with them, is abated. Thus, cyclonic activity at the Arctic front is accelerated over the Siberian littoral, and is abated over the Atlantic and Pacific sectors.

Summer cyclonic activity is not limited to the periphery of the Arctic, but also develops over its central areas, with the Arctic front outcrops disposed meridionally in a direction from the continent into the depths of the Arctic.

The boundaries of the Arctic, as a climatic region, are determined by the predominance of Arctic air masses over it throughout the year. The Soviet sector occupies almost a half of the entire Arctic region. In the west it adjoins the Atlantic sector, and in the east it occupies part of the Pacific sector. Its southern boundary, beginning with the White Sea and further east, runs along the north of the continent, and its location coincides naturally with the southern boundary of the tundra, since the landscape of the coastal tundra is conditioned during the summer by the predominance over it of formative (not transformed) Arctic air. Thus, the southern climatic boundary of the Arctic in Northern Asia depends on the degree of warming of the Arctic air over the continent, with the deficiency in warming indicated by the presence of the tundra landscape. To the east of Kolyma, the boundary for the propagation of formative Arctic air, during the summer, is the Anadyrskiy Mountain Range.

To the west of the White Sea the boundary lies beyond the limits of the continent, since the Arctic front, in the winter, lies over the Barents Sea, and over the Murmansk littoral air masses of the Temperate zone predominate.

Three climatic circulation zones can be segregated in the Soviet sector of the Arctic: the Atlantic, the Asiatic, and the Pacific. The differences between these zones principally pertain to the winter season. The Atlantic and Pacific zones are characterized by a winter acceleration of cyclonic activity, the Asiatic zone, by a winter evolution of a high pressure area. In addition, continental sub-zones can be segregated in the summer, these zones located, as was already mentioned, in the tundra belt on the continent. The distinguishing characteristics of these continental sub-zones are the warming of the lowest layer of Arctic air, and the frequent alternating of maritime and continental air masses, resulting in extreme weather instability.

The Atlantic zone is characterized by the evolution of cyclonic activity tied in with the Atlantic- European outcrop of the Arctic front. It occupies the Barents and Kara seas. It is delimited in the north by the Franz-Joseph Land Archipelago, in the northeast by the Islands of Severnaya Zemlya. On the continent, it occupies the belt of the tundra, to the east of the White Sea and along the Kara Sea littoral.

The Arctic front cyclones over the Barents Sea contain, as their warm mass, Atlantic air, which at times is transferred far to the northwest, and penetrates over the Kara Sea. These cyclones pass into the occlusion stage over the Kara Sea, and are in most cases extinguished over its northeastern part. In a general sense, however, their effect is felt all the way to Cape Chelyuskin. Cyclonic activity at the Atlantic-European outcrop of the Arctic front attains its maximum during the winter, with a sharp predominance of southerly winds from November to March. However, in connection with the rapid formation of occlusions, and the subsequent extinction of the cyclones as they move eastward, precipitation is light, amounting in the winter over the Barents Sea and over the west coast of Novaya Zemlya, to 20-30 millimeters, and over the area of the Kara Sea to about 10 millimeters. It should be noted, however, that the measuring of the winter precipitation (snow) is generally unreliable, particularly in the Arctic because the dry snow is blown out of the pluviometers by the strong winds. Yet, the precipitation deficiency is confirmed indirectly by the shallow snow cover, which, by the month of April, over Novaya Zemlya, the Kara Sea littoral, and the islands, attains a mean depth of only 30 centimeters. The gauging of the snow cover, too, with its non-homogeneous distribution and Arctic conditions, is perhaps just as difficult.

The abating of cyclonic activity eastward is manifested by diminished cloud formation. The recurrence of January overcast over the Barents Sea is 70 percent, over the Kara Sea, 50-60 percent.

The transfer, in the cyclones, of Atlantic and Eastern European continental air results in a sharp temperature rise over the Atlantic zone of the Soviet Arctic. The mean January temperature over Tikhaya Bay, at 80 degrees latitude north, is minus 17 degrees Centigrade, while over the western coast of the Island of Novaya Zemlya, it is minus 11 degrees Centigrade. In 1937, the mean January temperature over Tikhaya Bay was minus 8 degrees Centigrade. Observations made there for the period of December-February, registered on the average, two thaws, and during one January there were even 6 days with thawing weather. The warming effect of the Atlantic Ocean is also indicated by the minimum temperature distribution over the zone (Figure 68).

Figure 68:

Figure 68: Minimum temperature distribution over the western zone of the Soviet Arctic.

The most characteristic winter process is the transfer of warm air masses in the cyclones. Tied in with this, is the presence, in the average atmospheric pressure distribution charts, of a low pressure belt over the Barents and Kara seas. Such a disposition is sustained from November to the middle of April, i.e. during the winter season.

Peculiarly, the end of the winter over the Atlantic zone is frequently colder than the middle of same. By average count, the coldest month of the year is the month of March, not in the sense of the severest frosts then occurring, but by virtue of the frosts of medium severity (minus 20 degrees Centigrade) recurring in a stabilized cycle. There are practically no thaws in March, even though the sun radiates considerable warmth during the day, and sky cover, on the average, is about 50 percent, with 15 clear days registered during this month for some individual years.

Warm spells are frequently registered in the middle of the winter (January), due to the acceleration of warm air transfer into the Arctic, tied in with the accentuation of the mid-winter temperature and pressure contrasts between the Atlantic Ocean and the land mass of Eurasia.

The warm spells that occurred for the last 20 years in the Arctic were particularly pronounced in the Atlantic sector. They are a result of the acceleration of winter circulation over the Atlantic sector and the intensive transfer of the air of the Temperate latitudes into the Arctic.

The recurrence of high-velocity winds during the winter in the Atlantic zone is considerable. The mean wind velocity is 7, and, in spots, 8 and even 9 meters per second. Storms (over 15 meters per second), however, occur frequently only in some localities, under the effect of coastal conditions, while in the open sea they are considerably less frequent. Of particular frequency are the severe northeasterly storms over Matochkin Shar Strait, up to 40 meters per second. Over Yugorskiy Shar such severe gales do not occur, yet the mean wind velocity is higher than over Matochkin Shar. The wind is greatly accelerated as it blows over the mountain range on Novaya Zemlya, assuming the character of an atmospheric avalanche, so typical for the bora. The Novaya Zemlya bora, like the bora over Novorossiysk and Lake Baykal, is a cold air current descending from the mountains, and blowing along the periphery of a high pressure area at the time a cyclone is approaching from the other side of the mountain range. The bora is most frequently induced over the western littoral of Novaya Zemlya, with the evolution of anticyclones over the east, and the simultaneous approach of a cyclone from the Barents Sea. The bora occurs also over the eastern shores when the situation is reversed, that is, when an anticyclone is developed over Spitsbergen, with the simultaneous passing of a cyclone over the Kara Sea. The force of the bora raging over the Island of Novaya Zemlya is as great as the force of the Novorossiysk or Lake Baykal bora, the temperatures, however, are considerably lower, which renders it at times completely unbearable to humans.

In addition to the bora, there are gales of other varieties, in which an important part is played by the wind-accelerating or wind-decelerating coastal conditions. The recurrence of these gales is particularly frequent at the entrances to the Straits of Matochkin Shar and Yugorskiy Shar, also at the northern tip of Novaya Zemlya. During particularly unfavorable years, there were up to 20 days in the month January and other winter months, with a registered wind velocity of over 15 meters per second.

The extensive wind cycle, observed over this zone, considerably reduces the effect of relatively high temperatures and imparts particular severity to the weather. The "cruelty" of the weather in this zone exceeds that of the "cold pole" area of Eastern Yakutia. In connection with the powerful winds, there are frequent snowstorms, which, due to the extreme dryness of the snow and the great force of the wind, frequently assume the characteristics of a scourge, paralyzing all outdoor life. There are, on the average, from 10 to 15, and sometimes 20, such snowstorms per month, during the winter.

Toward the end of the winter (March, or the beginning of April), cyclonic activity is abated, and an Arctic area of high pressure is developed. This coincides with the beginning of spring. It is not clear whether the abating cyclonic activity is tied in with the beginning of spring, or whether it is the end result of the prolonged winter cooling of the Arctic basin. If it is the sign of spring, it is, at any rate, not the Arctic spring, but the spring of the Temperate belt over which there is a shift, at this time, in the thermal ratio between the maritime and continental air masses, and, in connection therewith, an abating of the meridional temperature contrast.

Spring in the Atlantic sector, as through the entire Arctic, is characterized by its long duration, low temperatures and ample sunshine. The gradual shift in the prevailing winds, from southerly to northerly, which is not conducive to a rapid temperature rise, begins in April (see Figure 69).

Figure 69:

Figure 69: Pressure and Prevailing Winds over the Kara Sea (From thesis by N. I. Prik).

Thawing weather is still rare in May, and the snow cover is only beginning to melt, and, even in the southern part of the zone, it only disappears by the middle of June.

The transition to summer is characterized for the entire zone by the abating of the anticyclonic cycle and the regeneration of cyclonic activity taking place in the second half of June. However, during the summer, cyclones are generated predominantly over the Asiatic sector, due to the accentuation of the temperature contrast between the warm land mass and the cold Arctic Ocean. With accelerated cyclonic activity, the amount of precipitation is increased, which is particularly noticeable in the eastern part of the zone (the Kara Sea), where winter precipitation is relatively light. The eastward increase in precipitation pertains not as much to the amount, as to the recurrence of same, plus the cloud formation tied in with them. The number of days with precipitation in August is about 20, and even more over the Taymyr Peninsula. Summer precipitation comes from the relatively warm air masses arriving from the continent. This precipitation frequently (in 30 percent of all cases), in passing through a layer of cold air, /freezes/, and before there is sufficient time for it to melt, it is deposited on the ground in the form of snow. This is most likely to occur over the northern part of the zone.

The second characteristic feature of summer circulation is the condition of the underlying surface, which consists of conglomerations of floating ice floes, shifting in location and dimensions. Masses of melting ice and water, with a temperature hovering around zero Centigrade, impart a particular stability to the temperature cycle, and rapidly diffuse both positive and negative departures.

Over the littoral and the islands along the coast, the transfer of warm continental air causes a considerable rise in temperature. Yet, over the northern part of the zone, the effect of these penetrations can hardly be noticed in the lowest layer. Thus, at Mys Zhelaniye the mean daily temperature during the month of August, in 90 percent of all cases, deviates only by 2 degrees in either direction from zero Centigrade, with a daily range of about 3 degrees. The mean maximum value in July and August is only 4 degrees Centigrade, although in July 1938, when a very intensive transfer of continental air occurred, the temperature once rose to 16 degrees Centigrade.

The proximity of open water and ice fields, which at times occupy vast areas, cause frequent variations in temperature within a range of a few degrees. Since the relative humidity of the air is high, these slight temperature oscillations are sufficient to generate fogs. When the wind blows from an ice field, an "evaporation fog" appears over the open water; when the wind carries relatively warm air from over the open sea, a "condensation fog" appears over the ice conglomerations. These locally generated fogs may be carried by the wind for great distances, thus, appearing and disappearing quite unexpectedly. At any rate, they never last long. Fogs of greater stability are generated with the penetrations of warm continental air. The transfer of continental air into the depths of the Arctic takes place either with the forward part of a cyclone, or along the western rim of an anticyclone (see Figure 70). In such cases, the fogs are very stable, and may sustain themselves for several days on end. They are usually generated over the open sea (not near the shore), mainly, at the brim of the ice fields. These fogs are most frequent in the northeastern part of the zone, where most of the ice conglomerations are found. The recurrence of fogs in July over the eastern half of the Atlantic zone is depicted in Figure 71. The mean July temperature over the littoral approximates 10 degrees Centigrade, and rapidly increases southward with distance from the sea. Over the Island of Belyy, the mean July temperature is 5 degrees Centigrade, and over the Yenisseysk Harbor it is 12 degrees Centigrade. This is due, not as much to local warming, as to the accelerated inflow of continental air from the south. Together with this, there is also a sharp decrease in fog and cloud formation. Over Ust'-Yenisseysk the recurrence of overcast is 40 percent, the recurrence of clear weather

FIGURE 70:

Figure 70: Evolution of fog over the Arctic during the transfer of continental air masses (7 September 1943).

FIGURE 71:

Figure 71: Recurrence of fogs over the area of the Kara Sea in July (From thesis by N. I. Prik).

Autumn arrives in September, and is, first of all, characterized by the change in the condition of the underlying surface. During the second half of September, the complete solidification of the ice fields begins to take place in the northern part of the zone, and, in rapid succession, continental Arctic air, typical for the cold part of the year, is beginning to form.

Considerable frosts occur as early as September, such as minus 10 degrees Centigrade over the southern part of the Novaya Zemlya Island, and minus 15 degrees Centigrade over the northern part of same. Solidification of the ice fields removes the main cause of frequent fogs, while warm air penetrations from the continent are also discontinued. As a result, the number of fogs is rapidly diminished, as follows: over Mys Zhelaniye, there are, on the average, 17 foggy days during the month of August, in September 10, in October only 2. Thus, the recurrence of overcast in the autumn, as compared with the summer, is somewhat diminished, principally as a result of lesser fog formation.

The Asiatic zone comprises the remainder of the Soviet Arctic (except the already analyzed above Atlantic zone and, also, the Sea of Chukotsk), which, in the winter, is within an area of high pressure. The continental part of this zone occupied the tundra belt, from Mys Chelyuskin to Mys Shmidt.

During the winter, the northern part of the zone is within the effective area of the Arctic anticyclone, while its southern part is within the high pressure "bulkhead" between the Arctic and the continental Siberian anticyclones. Cyclonic activity here, as compared to same over the western zone, is much diminished, resulting in less precipitation. Precipitation probability for December and January is about 20 percent, and for February and March even below that. The amount of monthly precipitation is less than 10 millimeters, and the snow cover by the end of the winter is hardly 20-30 centimeters deep, and is unevenly distributed, on account of the dry snow carried by the wind and forming drifts.

The relative "dryness" of the passing cyclones is due to the low activity of the fronts, which is conditioned upon the thermal homogeneity of vast stretches of air chilled to the extreme, and, also, upon the high degree of dryness in the air, as expressed by an absolute humidity of 0.3 millimeter, i.e. 100 times lower than near the equator.

Due to the sharp predominance (to the extent of 80 percent) of an anticyclonic state, the winter in the Asiatic zone is characterized by calm, clear, and very frosty weather, under the conditions of which cooling takes place, principally in the lowest air layer, leading to the formation of a powerful temperature inversion, which, in turn, induces a further reduction in sky cover and further deceleration of the wind. As per observations, the mean daily temperature in January over the Novosibirskiye Ostrova is never above minus 15 degrees Centigrade, and 80 percent of all days have a mean temperature of minus 25 degrees.

In 80 percent of all days the weather is clear (low cloud formation not above 0.2), the recurrence of mild winds (up to 4 meters per second) is 60 percent. The low velocity of the wind makes it difficult to determine its direction. The snow, due to low temperatures, is so dry that even mild winds will cause it to drift, and winds of medium velocity induce a ground snow storm, throwing up the snow from the ground to a height of several meters. When the wind is accelerated to 10 meters per second, the snow is lifted to a height of tens of meters, the snowstorm assuming the character of the so-called "purga", completely drowning out the sun behind its fury. Although calm weather is predominant, there are 4-5 days in a month (15 percent), when 10 meters-per-second winds occur. They are the northerly and northwesterly winds in the rear of the cyclones. Typical of the winter period over the littoral is the southward decrease in temperature, which is tied in with the intensification of the anti-cyclonic cycle over the continent. This is manifested, not only on the average, but in separate cases as well, when southerly winds are blowing from the continent. Thus, in February and even in March, with southerly winds, the temperature, on the average, is minus 30 degrees Centigrade, and with northerly winds, minus 25 degrees Centigrade.

Spring is characterized in this zone by a gradual increase in insolation with its attendant rise in temperature. The first month of spring is April. Although temperatures are still low, the mean daily values oscillate from minus 15 to minus 30 degrees Centigrade, and over the littoral from minus 5 to minus 25 degrees Centigrade. Yet, in the calm sunshine, the snow melts on the steep southern slopes, even though the temperature is minus 15 degrees Centigrade, particularly if it is mixed with sand and pebbles. The weather is predominantly anticyclonic, and sky cover is just as slight as during the winter. In connection with this, the temperature begins to increase southward, particularly over the littoral. The change in direction of the horizontal temperature gradient, and, subsequently of pressure, is the main indication of the approach of the spring season. The month of May is still cold, even though insolation is ample. The temperature is hovering around minus 10 degrees Centigrade, and even mild thaws are rare.

Toward the middle of June, the northern half of the continent is already warmed to a sufficient degree, so that, as a result of the sharp temperature contrast between the continent and the ocean, cyclonic activity is accelerated over the northern littoral. This indicates the end of spring and the beginning of summer.

In the summer, the Arctic front is frequently disposed in the form of separate outcrops, running from the continent into the depths of the Arctic (see Figure 72).

FIGURE 72:

Figure 72: Cyclonic activity at the Arctic front over the Arctic in the summer (From thesis by B. L. Dzerdzeyevskiy).

Acceleration of cyclonic activity during the summer causes increased precipitation, but the amount of the latter is considerable in the continental part of the zone only, while over the littoral the monthly amount of precipitation for July and August is, on the average, 40 millimeters.

The summer cyclonic precipitation over the Asiatic sector of the

Arctic comes from continental Siberian air, and the amount diminishes rapidly to the north, with distance from the coast. The amount of precipitation for July over the Novosibirskiye Ostrova is not more than 20 millimeters, although the number of days with precipitation is about the same /as over the littoral/. These cyclones are occluded by the time they arrive over the interior of the Arctic, and precipitation frequently takes the form of snow, even on the Island of Bol'shoy Lyakhovskiy, which lies close to the continent. Snowfall constitutes about one half of the total precipitation during July and August.

Generally, the summer in the Asiatic zone is little different from the summer in the western part of the Soviet Arctic. The maximum differences occur in the continental belt, during the shifting of the winds from southerly continental to northerly maritime. For instance, the mean July temperature in the Lena River delta during the southerly wind is plus 19 degrees Centigrade, while during the northerly wind it is minus 6 degrees Centigrade.

Summer fogs are as frequent here as they are over the western sector. They are formed during the transfer into the Arctic of warm continental air, and, in connection therewith, are more frequently observed over the open sea, rather than near the coast. The volume of fog is then diminished over the continuous ice fields deep in the Arctic. Such fog distribution is manifested more clearly over the Asiatic sector than over the Atlantic sector, and it is due to the greater stability of the ice pack in the Central Arctic.

The arrival of spring is tied in with the freezing over of the sea, the shift in the direction of the prevailing winds, and the leveling off of temperature differentials between the continental and maritime winds. During the second half of September and October, the temperature of the maritime and continental winds is almost the same, and there is a sharp decrease in the number of fogs. In September, the northerly and northeasterly winds, prevailing during the summer, shift to southerly and southwesterly winds. This is tied in with the beginning of the formation of a climatological anticyclone over the continent.

The Pacific zone of the Soviet Arctic comprises, basically, the Sea of Chukotsk and, on the continent, the Chukotsk Peninsula.

This zone is within the effective sphere of circulation of the Aleutian depression, which, however, does not manifest itself as strongly as the effect of the Iceland depression over the Atlantic zone. Over the southeastern part of the zone, near the Bering Strait, the effect of the Pacific Ocean is strongest, /to the extent/ that southeasterly winds at times induce thaws of short duration. In the western part of the zone (Mys Schmidt, Wrangel Island), the mean daily temperature in the winter, even during warm spells, is about minus 10 degrees Centigrade. The general temperature level is considerably higher, as compared to the Asiatic zone, but lower than over the Atlantic zone. The mean January temperature at 70 degrees north latitude, in the area of the Barents Sea, is about minus 10 degrees Centigrade, while over the Sea of Chukotsk it is minus 25 degrees Centigrade. This differential is due to the different disposition of the Arctic fronts in the west and in the east of the Soviet Arctic. The Atlantic-European outcrop of the Arctic front passes directly over the Barents Sea, and the cyclones generated there pass over the Kara Sea and, at times, even to the estuary of the Lena River. The Pacific Ocean outcrop /of the Arctic front/ lies in the area of the Aleutian depression, to the south of Parallel 60 north, and the cyclones at this outcrop are displaced predominantly toward Alaska, and only some of them penetrate over the Sea of Chukotsk. They are passing over the Sea of Chukotsk with their northern part, and the warm spell, induced by them, is a result, not so much of the transfer of warm air, as of an increase in cloud formation and wind intensification. /The warm spell/ is also tied in with the fact that the transfer of relatively warm air over the Sea of Chukotsk has no clearly accentuated maximum value in midwinter (as over the Atlantic sector), and therefore, January in the Pacific zone is no warmer than February, and the winter temperature range is normal.

By the degree of the oceanic effect, the climate of the Pacific zone in the winter may be compared with the climate of the eastern part of the Atlantic zone, where the effect of the Atlantic is already considerably abated. The "cruelty" of the weather in the Pacific zone of the Arctic is at its maximum as a result of winds of the same force as in the Atlantic zone, and of considerably lower temperature.

The effect of the Pacific and Arctic Oceans is manifested very strongly, since continental air penetrates here only to a small degree. This is evident from the maximum temperature values: the absolute temperature maximum on the Chukotsk Peninsula is below 20 degrees Centigrade, while in other places on the littoral, to the west as over the lower course of the Lena River, or over the Strait of Yugorskiy Shar, it is almost 30 degrees Centigrade. The mean temperature in the area of the Sea of Chukotsk is also considerably below that in the west. Circulation conditions are unfavorable: the warm continental air in the westerly cyclones, as it passes over the Seaof Chukotsk, is forced into the higher layers, while there is an inflow of air into the lower layers, with the southerly winds from the Bering Sea. In the anticyclones, too, the southerly winds carry the air, not from the continent, but from over the Northern Pacific.

Tied in with the fact that the transfer of warm air is rarely observed in the lower layers, there is less fog formation over the sea during the southerly winds, but its formation is accelerated during the northeasterly winds, carrying the cold air masses from over the vast ice fields, which are sustained even during the summer in the eastern sector of the

Arctic. These fogs, evolving through evaporation from the open surface of the sea into the cold atmosphere, are carried by the northerly winds toward the coast, as a result of which the areas of maximum fog over the Sea of Chukotsk are disposed closer to the coast.

The conglomeration of the ice packs, to the north of the Sea of Chukotsk, greatly affect conditions during the summer and the beginning of autumn in the Pacific zone of the Arctic.

Summer precipitation is connected mainly with westerly and south-westerly cyclones, which are accelerated over the Sea of Chukotsk, as a result of the presence of vast ice fields and colder Arctic air masses. The amount of precipitation is rather small, but the probability of their occurrence is twice as great in comparison with other zones of the Arctic. The presence of the ice packs makes the summer over the Pacific zone not only colder, but also shorter, than in the west. The autumn chills arrive early. The mean September temperature is negative (minus 1 degree Centigrade), while, in the continental sector, the same temperature occurs at the latitude of the Novosibirskiye Ostrova, and, in the western sector, even farther to the north, by the Franz-Joseph Land. The prevailing direction of the wind shifts in September to northerly, which is typical for the cold season of the year. All this is due to the rapid dwindling of the open water area under the effect of the enormous refrigerator, the role of which is played, during the summer, by the zone of the so-called "pole of inaccessibility" (or rather the "pole of little accessibility").

In September, there is an abating of cyclonic activity, tied in with the abating of same over the continent. Toward the winter, cyclonic activity is again accelerated as a result of the accentuation of the frontal zone in the Aleutian depression. There is less fog and less cloud formation in September over the Seaof Chukotsk, in comparison with other zones. And, even though the recurrence of overcast is 75 percent, there is intermittent clear weather.

In October, the area of the Sea of Chukotsk is already a lot warmer than the area over the lower course of the Lena River, which indicates the transition to the cold season of the year.

CONCLUSION

In conclusion, a diagrammatic chart of the climatic regions and zones of the USSR (Figure 73), is enclosed. The following text is an analysis of this diagrammatic chart.

(1) Climatic zoning is a part of the complex physico-geographical zoning, but at its base lies the calculation of the effect of geo-physical factors, such as radiation balance and atmospheric circulation. Terrestrial configuration of the first order of magnitude accentuates and somewhat displaces the climatical boundaries projected by atmospheric circulation. Medium and small terrestrial relief, inland bodies of water, vegetation and circulating sea currents, are complementary factors of local significance.

(2) Radiation and circulation processes over the vast expanse of the USSR make for the segregation of 3 latitudinal belts: the Sub-tropical, the Temperate and the Arctic. These belts are the regions, over which the formation of air masses takes place. Over the Subtropical belt, recurs the formation of Tropical air during the summer, and of a somewhat warmer variety of Temperate zone air during the winter. Over the Temperate belt, recurs the formation of air of the Temperate latitudes (so-called Polar air). Over the Arctic belt, the formation of Arctic air.

(3) In the Subtropical and Arctic belts, radiation factors predominate over advection factors, while in the Temperate belt this condition is reversed. In connection with this, it becomes necessary to segregate, within the Temperate belt, three regions of transfer [and transformation] of air masses: the Atlantic, the Arctic, and the Pacific. (see also Paragraph 7 below).

(4) The boundary of the Subtropical part of the Caucasus passes along the southern slopes of the Greater Caucasus, at an altitude of 2000 meters, separating thereby the Armenian Highland from the Temperate zone in Trans-Caucasia. Farther to the east (beginning with the Trans-Volga area), this boundary runs approximately along Parallel 46 north to Lake Zaysan and to the state boundary of the Soviet Union. The location of this climatical boundary in the Caucasus is considerably more to the south than it is in Central Asia, since over the Azov-Caspian Lowland and over the Northern Caucasus, the process of transformation of continental air into Tropical air is attenuated by the proximity of the seas, and over Central Asia, on the contrary, it is intensified by the presence of vast steppes and deserts.

(5) By conditions of atmospheric circulation, the Subtropical part of the Caucasus is divided into 3 climatic zones: (1) The Black Sea zone (basin of the Rion River), (2) The Continental zone (basin of the Kura River), and (3) The Armenian Highland. The first zone is characterized by the predominance of "local" Black Sea air masses, the second one, by the inflow of continental air from the north and from Asia Minor, with the narrow coastal belt, over which there is also felt the effect of the Caspian Sea. The Suramskiy Range is the boundary between these two zones. Over the Armenian Highland predominate the air masses of Asia Minor and Iran. By conditions of terrestrial relief, some sub-zones can be segregated within the above zones.

(6) Sub-Tropical Central Asia consists of 2 climatic regions: (1) the Lowland and Medium-Altitude region, and (2) the High-Mountain region. The boundary between them runs, at an altitude of 2500 meters, along the slopes of the Gissarskiy, Turkestanskiy, Alayskiy Mountain Ranges and along the northern slopes of the Tyan' Shan' Range.

The first region is divided into two circulation zones: the Iranian zone, occupying the southern part of Central Asia up to Parallel 40 north, and the Turanian zone, over which local Central Asiatic air is formed, and at the same time the Eastern European effect is pronounced, it borders in the north on the Temperate zone.

The High-Mountain climatic region is one circulation zone, since at altitudes in excess of 2500 meters here the general circulation conditions are homogeneous.

In the mountains and foothills of Central Asia, several sub-zones can be segregated, as a result of the effect of terrestrial relief and other local factors. Examples of such sub-zones are the Fergan Valley with the adjacent foothills, the area of Lake Issyk-Kul', and others.

(7) The territory located within the Temperate latitudes, which is defined as the zone of transfer and transformation of air masses, climatic zoning is complicated by the introduction of units of a larger order of magnitude, than climatic zones and regions. These are areas of transfer of air masses, and there are three of these: the Atlantic, the Arctic, and the Pacific. Climatic regions and zones are contained within each one of the above areas of transfer.

(8) The area of transfer of Atlantic air masses borders in the south on the Subtropical zone (in the Caucasus and Central Asia), and in the north on the Arctic. The boundary with the Arctic, to the west of the White Sea, passes through the south of the Barents Sea, since the Arctic front at this sector is beyond the limits of the continent during the winter. To the east of the White Sea, the boundary lies on the continent, at the latitude of the Polar Circle, coinciding with the boundary of the tundra. In Western Siberia it follows the line of the coast, deviating to the north, and reaches the mouth of the Yenisey River. The eastern boundary follows the Yenisey River along the western slopes of the Central Siberian Plateau.

(9) Three climatic regions are segregated within the area of transfer of the Atlantic air masses: the Atlantic-Arctic region, where Atlantic and Arctic air masses predominate; the Atlantic-Continental region, where transformation of Atlantic air into continental air takes place, and the Continental region, where continental air masses predominate. These three climatic regions extend in belts from west to east along the European part of the USSR and Eastern Siberia. With the intensification of the continental features of the climate, the belt of the Atlantic-Arctic region narrows down to the east, while the belt of the Continental region becomes wider. The boundary between the Atlantic-Arctic and the Atlantic-Continental region in the European part, runs from Lake Ladoga to the headwaters of the Pechora River. On the eastern slopes of the Urals, the boundary begins at the latitude of Berezovo, makes a sharp break as it crosses the mountain range, and then continues to Turukhansk. The boundary between the Atlantic-Continental and the Continental region runs from the middle course of the Dnyestr River to the Middle Volga, then to the headwaters of the Belaya River. This boundary, too, makes a break as it crosses the Ural Range, and, picking up at the latitude of Sverdlovsk, continues to Podkamennaya Tunguzka.

(10) Each of the above mentioned climatic regions, with relation to the degree of the effect exerted upon it by the Atlantic Ocean, is divided into 3 climatic zones: two zones in the European part of the USSR, and one in Eastern Siberia. Thus, the Atlantic-Arctic region is divided into the following zones: Western European, Eastern European, and Western Siberian. In the European part [of the USSR], the boundary between the western and eastern zones runs from Arkhangelsk through Moscow toward Kherson, and as the continental features are intensified southward, it is continuously displaced westward. The boundary between the European and Western Siberian zones runs along the Ural Mountain Range, and, in

the Continental region, it is considerably deflected to the west, in connection with the intensification toward the south of the transfer of Asiatic air masses along the southern rim of high pressure areas.

Over the western zones of the European territory of the USSR, there is greater development of cyclonic activity, as compared with same over the eastern zones, and basic significance belongs to Atlantic air masses, even though their characteristics were somewhat modified over the continent. Continental air, resulting from the transformation of Atlantic as well as Arctic air, predominates over the eastern zones. The continental characteristics of the climate are further intensified in the Western Siberian zones, by comparison with the Eastern European zones.

(11) In the southern, Continental climatic region, in addition to the Western European, Eastern European, and Western Siberian zones, there are several additional zones. The southern part of Crimea, and also the northwestern part of the Caucasus, constitute a zone that can be called the Mediterranean zone, since the circulation processes generated over the Mediterranean, are predominant here, such as the passage of Mediterranean cyclones in the winter, and the extension of the Mediterranean high pressure area in the summer. Three sub-zones can be segregated here: the southern littoral of the Crimea, the mountain area of the Crimea, and the northern part of the Black Sea littoral, toward (but not reaching) Sochi.

The foothills of the Northern Caucasus and its medium-altitude area (up to 1500-2000 meters) are also a part of the southern Continental region, comprising three climatic zones: the western, or Mediterranean zone, the central, or the Eastern European zone, and the eastern, or Asiatic zone. The western zone, a continuation of the Mediterranean zone of Southern Crimea, has, as its eastern boundary, the Belaya River. The central zone occupies the territory to the east of the Belaya River, the

Stavropol' Plateau with the abutting northern slopes of the Caucasus. By circulation conditions, this zone is tied in with the southern part of the European territory of the USSR. The eastern zone, from the headwaters of the Terek to the Caspian Sea, is frequently subject to penetrations of Asiatic air masses.

In the southeastern corner of the Continental region, within the territory of Western Siberia, lies the Altay climatic zone, which is distinct from the rest of Western Siberia by greater variability of circulation, tied in with the penetrations of Central Asiatic air masses, and with relief-induced intensification of westerly and northwesterly cyclones.

(12) Between the southern Continental region of the European part of the USSR and Subtropical Trans-Caucasia, lies, at a mean altitude of over 2000 meters, the High-mountain climatic region of the Greater Caucasus, from the headwaters of the Belaya River in the northwest to the Samur River in the southeast. Conditions of circulation and characteristics of the air masses over this zone are determined, principally, by the westerly transfer prevailing in the middle troposphere. Within this region, two zones can be segregated: the western, or Mediterranean zone, and the eastern, or Continental zone. The boundary between them is the watershed between the basins of the Kuban' and Terek rivers.

(13) The area of transfer and transformation of Arctic air masses occupies the territory between the Yenisey River in the west, and the Stanovoy and Kolymskiy Mountain Ranges in the east. In the south, it is separated from Central Asia by the Sayanskiy Mountains and the Khamar-Daban and Yablonovoy Mountain Ranges, while in the north it adjoins the tundra. This area is divided into 2 climatic regions: the northern Eastern Siberian Sub-Arctic region, and the southern Eastern Siberian Continental region. The boundary between these two is the Nizhnyaya Tunguzka River in the west, the middle course of the Lena River, above Yakutsk,

and along the foothills of the Aldanskiy Range, up to the Stanovoy Mountains, in the east. This boundary is characterized by the predominance of Arctic air masses during the winter to the north of it. Its more northerly location on the western side is due to the propagation, with the southwesterly winds, of continental air along the periphery of the winter Siberian anticyclone. On the eastern side, the progress of the Arctic air masses southward is limited to a considerable degree by the mountain ranges.

(14) Arctic air masses predominate over the northern region in the winter, while continental air masses prevail in the summer, by virtue of which the region is known as the Sub-Arctic. It is divided into two climatic zones: the Central Siberian, occupying, principally, the Central Siberian Plateau, and the Eastern Yakutian, located to the east of the Lena River, under the eastern half of the Yakutian outcrop of a high pressure area. Such a division is based on circulation conditions during the winter. Over the western Central Siberian zone, southwesterly winds of the northwestern quadrant of the Siberian anticyclone predominate, while over the Eastern Yakutian zone predominate the northerly winds of the eastern rim of the Siberian anticyclone. In addition, cyclonic activity, with attendant heavier cloud formation, winds, and snow cover, is developed over the western zone, while over the Eastern Yakutian zone, there is a sharp predominance of an anticyclonic cycle, with mild winds, little cloud formation, and only slight snow cover. Conditions of terrestrial relief in the Eastern Yakutian zone are conducive to exceptionally intense chilling of the lower air layers, and the "cold pole" of the northern hemisphere is located here.

(15) Over the southern region, continental air masses of the Temperate zone predominate through the year, imparting to the region the name Continental. By conditions of winter circulation, this region is divided into two zones: the western Pred-Baykal zone and the eastern

Trans-Baykal zone. The area of Lake Baykal proper should be considered a climatic sub-zone, which, while standing out sharply against the general background, is still, climatically speaking, conditioned upon local factors, which have no widespread effect. The western and eastern zones differ not only by conditions of winter circulation, but also by characteristics of cyclonic activity. The westerly and northwesterly cyclones from over Western Siberia pass over the western zone, while over the Trans-Baykal zone, the Mongolian front cyclones are developed, almost exclusively in the summer.

(16) The area of transfer of Pacific Ocean air masses occupies a territory, belonging to the Pacific basin, with the climatic boundary furnished by the watershed mountain ranges. This area consists of two climatic regions: the Monsoon region and the Pacific region (or the Aleutian Sub-Arctic region). The Monsoon region is determined by the boundaries, within which the monsoons are effective: through the inflow of continental Eastern Siberian air masses in the winter, and Pacific air masses in the summer. This region comprises the Amur River Basin, Sakhalin Island, the Sea of Okhosk, the southern half of Kamchatka, and the Kurile Islands. Over the Pacific Sub-Arctic region, in the winter, there is a predominance of Arctic air masses, migrating partly from over the Arctic basin, partly from over the Bering Sea, along the northern rim of the Aleutian depression. Cyclonic activity over this area is tied in with the Arctic Aleutian front.

(17) The Monsoon climatic region is divided into 3 climatic zones: (1) the Amur River zone, occupying the basin of the Amur, excepting the lowest part of the river's course, the Tatarskiy Strait coast, to De-Kastri Bay, the southern half of Sakhalin, and the Southern Kuriles. During the summer, there is a development of cyclonic activity, which is generated at the Eastern Asiatic and Pacific Ocean fronts, and the predominant transfer of air masses is from over the Sea of Japan. During the winter,

the anticyclonic cycle of the eastern rim of the Siberian anticyclone is predominant here. (2) The Okhotsk climatic zone, comprising the northern part of Sakhalin, the lower course of the Amur River, and the littoral of the Sea of Okhotsk. By comparison with the Amur River zone, summer cyclonic activity here is attenuated, with the air masses from over the Sea of Okhotsk predominant. During the winter, alongside of an anticyclonic condition, there is observed the passage of Arctic cyclones, at times accompanied by considerable snowfall. (3) The Kamchatka climatic zone, occupying the southern half of Kamchatka, and the Northern Kuriles, differs from the two preceding zones by the development of winter cyclonic activity at the Aleutian Arctic front, and by a considerable abatement of continental effects.

(18) The Pacific Ocean Sub-Arctic region, located within the effective sphere of circulation of the Northern Pacific, occupies the northern part of Kamchatka, and the entire territory to the Anadyrskiy Mountain Range. Circulation conditions over the region are homogeneous, making it a single climatic zone. The territory protected from the effect of the sea by the Koryatskiy Mountain Range, is a sub-zone. The effect of the summer Far Eastern Monsoon does not reach this region, and the effect of the continent is hardly manifested.

(20) The Soviet sector of the Arctic, irrespective of its size, can be considered a single climatic region, since over its entire expanse only Arctic air masses are formed. Its southern boundary extends almost everywhere over the continent, with the exception of the Kola Peninsula, where the southwesterly transfer of air masses of the Temperate latitudes is so intensive that the Arctic front zone is located, on the average, to the north of the continent. Along the rest of the northern littoral of the USSR, Arctic air masses are propagated not only during the winter, but also in the summer. The index of the predominance of formative Arctic air, during the summer, over the continent, is the tundra landscape. The

southern boundary of the Polar tundra is at the same time the boundary of the climatic region of the Arctic.

(21) The Arctic region is divided into 3 climatic zones. (1) The Western, or Atlantic zone, over which cyclonic activity is developed all year round at the Atlantic-European Arctic front. The eastern boundary of this zone is the Archipelago of Severnaya Zemlya /North Land/ and the Laptev Sea. The northern boundary is the Franz Joseph Land Archipelago. (2) The central, or Asiatic zone, over which an anticyclonic cycle predominates in the winter, while summer cyclonic activity is developed at the individual Arctic front outcrops, which are disposed meridionally and extend into the depths of the Arctic. (3) The eastern, or Pacific Ocean zone, occupies the Sea of Chukotsk. During the winter, this zone is within the effective sphere of cyclonic activity of the Aleutian depression. During the summer, cyclones from the continent are pointed in this direction, with the warm continental air, however, almost never reaching this zone. Southeasterly winds, carrying air from over the Northern Pacific, predominate in the lower atmospheric layers, and, in connection therewith, the zone is characteristically oceanic during the summer.

/See attached Figure 73, which is a diagrammatic map of Climatic Regions and Zones of the USSR/.

* THE END *

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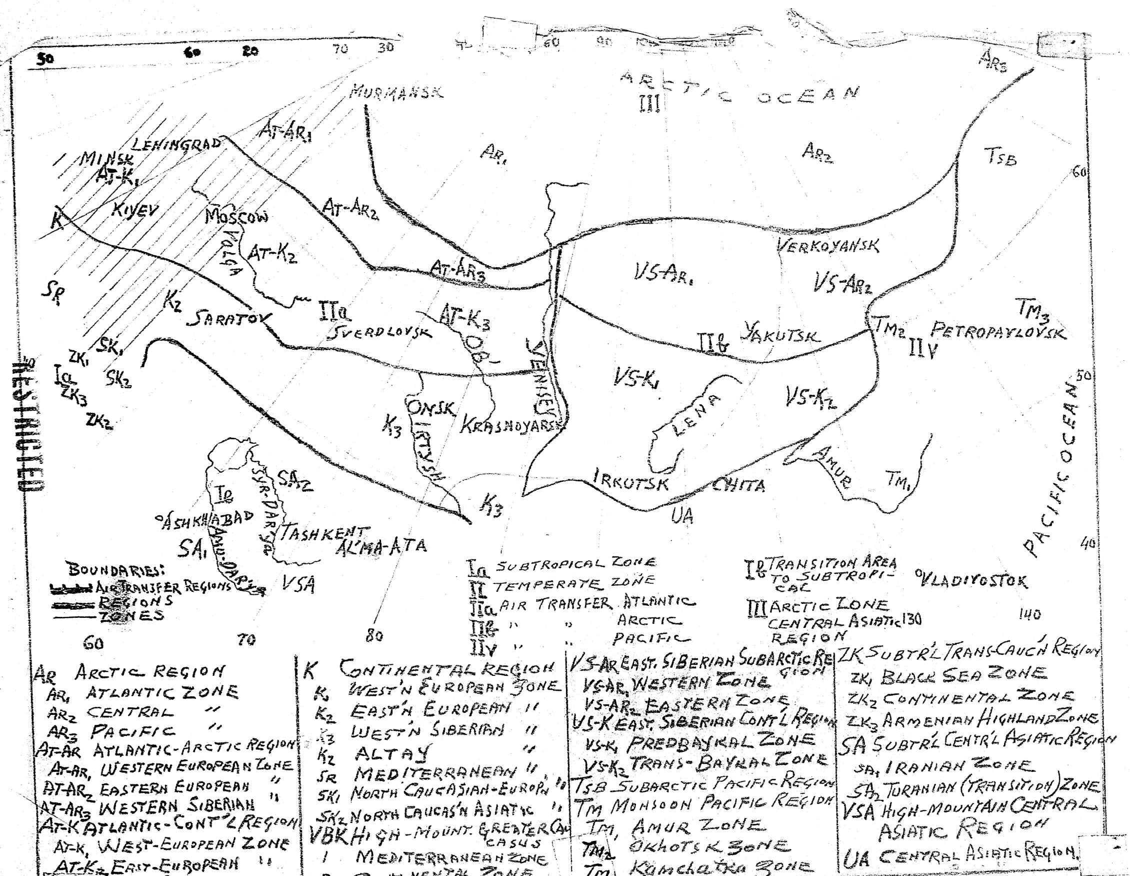

Figure 73. Diagrammatic Map of Climatic Regions and Zones of the USSR

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