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FORMATION, DISTRIBUTION AND VARIABILITY IN SNOW COVER ON THE ASIAN TERRITORY OF THE USSR

V. N. Pupkov

Translation of "Formirovaniye, raspredeleniye i izmenchivost' snezhnogo pokrova na Aziatskoy territorii SSSR," Meteorologiia i Gidrologiia No. 8, 1964, pp. 34-40

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FORMATION, DISTRIBUTION AND VARIABILITY IN SNOW COVER ON THE ASIAN TERRITORY OF THE USSR

V. N. Pupkov /34*

The Central Institute of Forecasts has processed materials from snow-measurement surveys on the Asian territory of the USSR from 1935 to 1960. As a result of this work, maps were compiled for the first time for annual and average multiple-year water reserves which were the maximum for the winter in the snow cover, the annual and average multiple-year maximum snow cover height for the winter, extreme values and coefficients for variation in maximum snow reserves, as well as the average multiple-year values of height and snow reserves at the end of each decade. In addition, maps were constructed for normal, average and late dates for establishment and descent of the snow cover, dates of the onset of maximum snow reserves and some others.

These maps were compiled for the entire Asian territory of the USSR, excluding Central Asia, the Kamchatka Peninsulas, and the Sakhalin Islands. They characterize the snow cover on locality to height 1000 m above sea level. The materials are very sparse for the regions above 1000 m.

In the first years (1935 - 1940) snow surveys were made by a very few stations. In the winter of 1935 - 1936, it was possible to use the data only of 50 stations that measured the height and density of the snow cover. By the winter of 1959 - 1960, the number of these stations had increased to 1100. Observations of 1370 stations and posts total were used in the work.

For open regions, results of snow surveys were plotted on the map on the field sections, for forest, the results of snow surveys in the forest under the tree crowns.

*Numbers in margin indicate pagination in original foreign text.

Annual maps for maximum magnitudes of snow reserves and the snow cover height were constructed by the known methods of linear interpolation.

In order to construct maps for the average multiple-year values of the snow cover height maximum for the winter and the maximum snow reserve, the magnitudes were averaged after elongation of the series by taking the insufficient data from the annual maps. After this, the average reserve magnitudes were calculated for each station (post) and the map was compiled.

The other characteristics of the decade height of the snow cover, decade water reserves in the snow cover, date of formation and descent of the snow cover, etc. were averaged for normal calculation of the average magnitude for each station. Analysis of the data and construction of the maps took into consideration the duration of the observations.

The snow cover begins to form in Siberia and in the Far East in September. During this month snow usually covers a considerable territory of the extreme north, the Yenisey lower course, mountains of Putoran, basin of the Alabar River, lower half of the Olenka River basin, lower course of the Lena, Yana and Indigirka Rivers, Kolyma lowland and a large part of the Chukotsk Peninsula. However in early winters, the snow cover was established in these regions even in August, and on the Taymyr Peninsula, in the delta of the Lena River and on the coast of the East Siberian and Chukotsk Seas, the snow cover in some years was present for the entire year, without thawing during the short summer. The materials of snow-measurement surveys show that these years were 1954, 1955 and 1957.

It is interesting to note that the zone where snow is sometimes maintained during the entire year coincides well with the regions in which there is no distinct transition of air temperature within +5°.

During September, there is no natural advance of the snow cover boundaries. Its rapid advance to the south usually begins in October. One could even say that the entire territory of Siberia and the Far /35
East was mainly covered with snow during October. A snow cover has been established in October on almost the entire West Siberian lowland, on the central Siberian high plateau, in the central part of the Krasnoyarsk kray, on the entire territory of Yakutiya and the Magadanskaya Oblast, as well as in the northern half of the Irkutskaya and Amurskaya Oblasts, the Transbaykal and the Khabarovskiy kray. The November snow cover gradually is established in the north and central Kazakhstan and on the remaining territory of Siberia and the Far East.

Only southern Kazakhstan and the plain regions of Central Asia remain uncovered by snow by the end of November. It is very difficult to speak of the average multiple-year periods for establishment of a snow cover in the more southern regions because of its instability. However one can approximately state that by the end of September, the boundary of continuous snow cover most often passes roughly on the line of Volgograd, Kazalinsk, Kzyl-Orda and Tashkent. In the plain regions located to the south of this line, the snow cover is brief and unstable.

These are the average multiple-year periods for the formation of a stable snow cover. As for the early and late periods, their deviations from the normal vary in different regions. The dates for formation of the snow cover in the northern half of the Krasnoyarsk Kray and in the Yakutsk ASSR are the most variable, where the difference between the early and late date is 20 - 30 days. On a large part of the territory of West Siberia and Irkutskaya Oblast, the amplitude for the periods of establishing snow cover is 30 - 35 days; in North Kazakhstan, South Siberia, in the Transbaykal, in the Khabarovskiy and Primorskiy Krays, 40 - 45 days, in the southern half of Kazakhstan, 60 - 70 days.

Release from snow usually begins from the first days of March in South Kazakhstan. However, in March the snow cover boundary

advances to the north very slowly. Snow melt is observed most intensively in April and May, where almost the entire Asian territory of the USSR is free of snow, with the exception of extreme northern and mountainous regions. Thawing in the northern regions ends during June.

Amplitudes of the periods of descent of snow cover are close to the amplitudes of its establishment. In southwest Kazakhstan, in the Transbaykal, and in certain regions of the Far East, they are from 45 to 65 days, and in a large part of West Siberia, in the Central Krasnoyarsk Kray and Yakutiy, 20 - 30 days.

All of these periods characterize the descent of the snow cover on the exposed locality. According to the informational data for 1960 - 1963 available in the Central Institute of Forecasts, it is apparent that the difference in the dates for descent of snow in the field and in the forest fluctuates in West Siberia from 5 to 15 days, in the Krasnoyarsk Kray from 4 to 10 days, Yakutiya from 1 to 6 days, and in the Transbaykal and Primor'ye from 0 to 5 days.

The date of onset of the maximum snow reserve is more stable in time than the date of onset of the maximum height. It is natural that on the territory both of these characteristics change in large limits. It is apparent from the data presented on the map (Figure 1) that if in South Kazakhstan, in the Minusinskiy and Tuvinskiy Basins, in the South Buryatsk ASSR and in the Chitinskaya Oblast, as well as in South Primor'ye, the maximum snow reserve usually occurs in the second half of February-beginning of March, in such extreme northern regions as the Taymyr Peninsulas, North Siberian and Yano-Indigirskiy lowlands, accumulation of the snow cover continues to the end of May.

Figure 1 shows the points for which the average course of the snow reserves is presented in Table 1. It is apparent from these /37 tabular data that the main snow accumulation occurs in the first half of winter. This is explained because cyclonic activity diminishes during the winter on a large part of this territory, and anticyclogenesis gradually becomes more active.

TABLE 1. AVERAGE MULTIPLE-YEAR SNOW RESERVES AT THE END OF EACH MONTH (in mm) IN INDIVIDUAL AREAS OF THE USSR ASIAN TERRITORY

Point	IX	X	XI	XII	I	II	III	IV	V	VI
Kushva	0	5	36	54	72	84	92	0	—	
Karabutak	0	0	6	30	45	66	72	0	—	
Lar'yak	0	12	47	70	95	113	126	62	0	
[illegible]	0	2	48	75	95	112	124	6	0	
Krestv Zavmvrskive	6	34	48	57	70	84	93	110	113	0
Chunskava strelka	3	31	58	88	102	122	137	117	0	—
Maklavan	0	17	29	44	46	46	48	11	0	
Syuren-Kyuel'	3	16	28	38	51	64	71	79	13	0
Kurun-Urvakh	0	10	32	42	41	48	55	19	0	—
Bichevava [illegible]	-	[illegible]	23	37	47	57	17	0	-	-
Krestv Kolvmskive		22	35	50	62	70	80	64	0	-
Gizhiga		21	11	16	20	20	23	25	0	

The snow cover thickness naturally diminishes from the north to the south; it also diminishes from the west to the east, since a western transfer dominates on a large part of the examined territory, while the air masses giving off moisture are gradually dessicated. The latter does not refer to the Far East where the Pacific Ocean has a great effect on precipitation.

However, there is no smooth change in snow reserves over the territory. If we look at the map for distribution of the maximum water reserve in the snow cover (Figure 2), or the map for maximum snow cover height (Figure 3) then we can see that they represent a variegated pattern. This variegation is mainly determined by the influence of relief. The relief acts on the motion of air masses, on precipitation, and also makes a significant correction to the duration of the snow accumulation period. On the western slopes of such mountain massifs as the Ural ridge, the Central Siberian upper plateau, the Altay ridge, the Kuznetsk Altau, the Sayanskiy Mountains, the Baykal and Verkhoyanskiy ridges, the Aldan highlands, etc., usually a thick snow cover is formed.

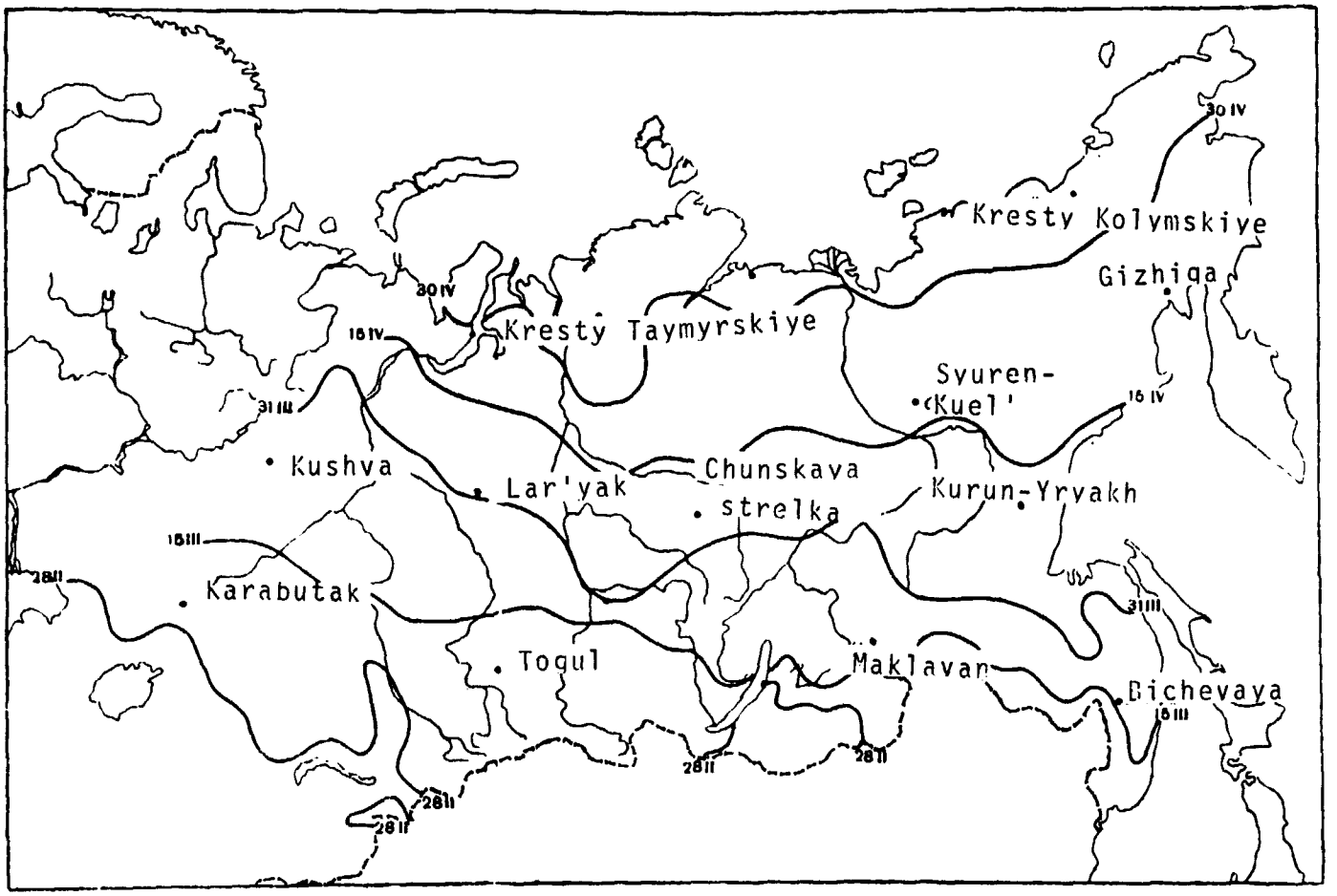

Figure 1. Average Dates for the Onset of Maximum Snow Reserves

At the same time, in regions directly to the east of these mountain chains and ridges, the snow cover is fairly sparse in the majority of cases.

The Ural Mountains, especially their western slopes, as compared to the surrounding region have a lot of snow. By the end of winter, the height of the snow cover in the northern part of the ridge reaches 90 - 100 cm (water reserve 200 - 220 mm), in the southern, 50 - 60 cm (water reserve 130 mm).

A low-snow zone passes directly beyond the Urals in West Siberia parallel to the ridge. In relation to precipitation, this region is

in the so-called "shadow" of the Urals. The influence of the Ural ridge is the sharpest in the extreme north and in the south Transurals. The height of the snow cover in the region of the Ob River mouth diminishes to 30 - 40 cm, and in the upper part of the Tobol, to 25 - 30 cm. At the same time, the influence of the ridge is less noticeable between 60 and 65° n.l. The snow cover thickness in the Transurals diminishes in this place as compared to the snow cover of the European territory of the USSR slightly, to 60 - 70 cm (water reserve to 140 - 150 mm). Increase in precipitation is related to regeneration of cyclones prevailing through the Ural ridge to its lowest part, as well as delay of cyclones before the Putoran Mountains and Yanisey chain.

In the Barabinskiy and Kulendinskiy steppes, the maximum snow cover height for the winter is relatively low (25 - 35 cm). Considerable increase in snow cover thickness is observed with motion from here to the east, initially into the region of the Ob elevations, and then to the western slopes of the Altay and Kuznetskiy Alatau. The height of the snow cover on the western slopes of the Altay (to height 1000 m) is 60 - 70 cm, on the slopes of the Kuznetsk Alatau, 80 - 100 cm (water reserve respectively 160 and 220 mm).

In West Kazakhstan there is a natural decrease in the snow cover height from the north to the south from 30 - 40 cm in the North Aktyubinskaya Oblast to 10 cm in the Caspian lowland. There is little snow in the Tobol and Turgaya basins. Moving to the east towards the Kazakh area of low rounded hills, there is a noticeable increase in the snow cover thickness. It is the most significant on the western slopes of the elevated massifs of the Kazakh area of low rounded hills where the snow cover height usually reaches 30 - 35 cm (water reserve 80 - 90 mm). Along the entire northeast boundary of the area of low rounded hills, partially encompassing the Kulundinskiy steppe, there is a band of very low snow cover. In this region, extending from Kokchetav almost to Ust-Kamenogorsk, little moisture is brought in in winter and summer. The height of the snow cover here is therefore only 12 - 20 cm (water reserve 30 - 45 mm).

There is roughly the same snow cover in the Golodniy steppe and in Balkhashye. The mountain ridges of Karatau, Karghiz, Dzhungarskiy, Tarbagatayskiy and others which are located to the south and east of here are usually covered with a considerably thicker snow cover. The snow cover in Kazakhstan is very nonuniform. Strong winter winds redistribute the snow, blowing it off from the exposed places and transporting it to the protected. The snow surveys which are usually made on a relatively level locality therefore often yield underestimated snow reserve magnitudes.

A band of thick snow cover passes through the entire Krasnoyarskiy kray from the north to the south. In the southern part, this band turns to the west, and bending around the low-snow region of the upper course of the Chulyn, it passes on the western slopes of the Kuznetskiy Alatau and the Altay Mountains. The maximum snow cover height fluctuates here from 60 - 70 to 100 - 110 cm (water reserve 150 - 220 mm). The presence of this band is quite natural. Air masses traveling from the west give off moisture on the western slopes of the Central Siberian upper plateau and the Altay, after which, releasing the moisture, they carry very little precipitation to the actual upper plateau, and a unique minimum snow reserve (65 - 75 mm),(height 35 - 40 cm) is /40 formed here. In the Minusinskiy basin in the Kuznetskiy Alatau, this minimum reaches 40 mm (height 15 - 20 cm).

The considerable increase in the snow cover with movement to the east is related to the Sayanam, the Baykal ridge and the Patomskiy highlands, in the north with the Verkhoyanskiy ridge and the Cherskiy ridge. The network of stations and posts on these mountain massifs is very sparse. The single stations here indicate that on the western slopes of these ridges (to height 1000 m) a snow cover 60 - 80 cm high is formed (water reserve 120 - 160 mm). There is very little snow in the regions lying directly to the east of these mountain systems. To the east of Sayana in the region of Krasnoyarsk and in the south Irkutskaya Oblast, the snow cover diminishes to 20 - 30 cm (water reserve 40 - 60 mm). In the Verkhoyanskiy hollow, in the Momskiy

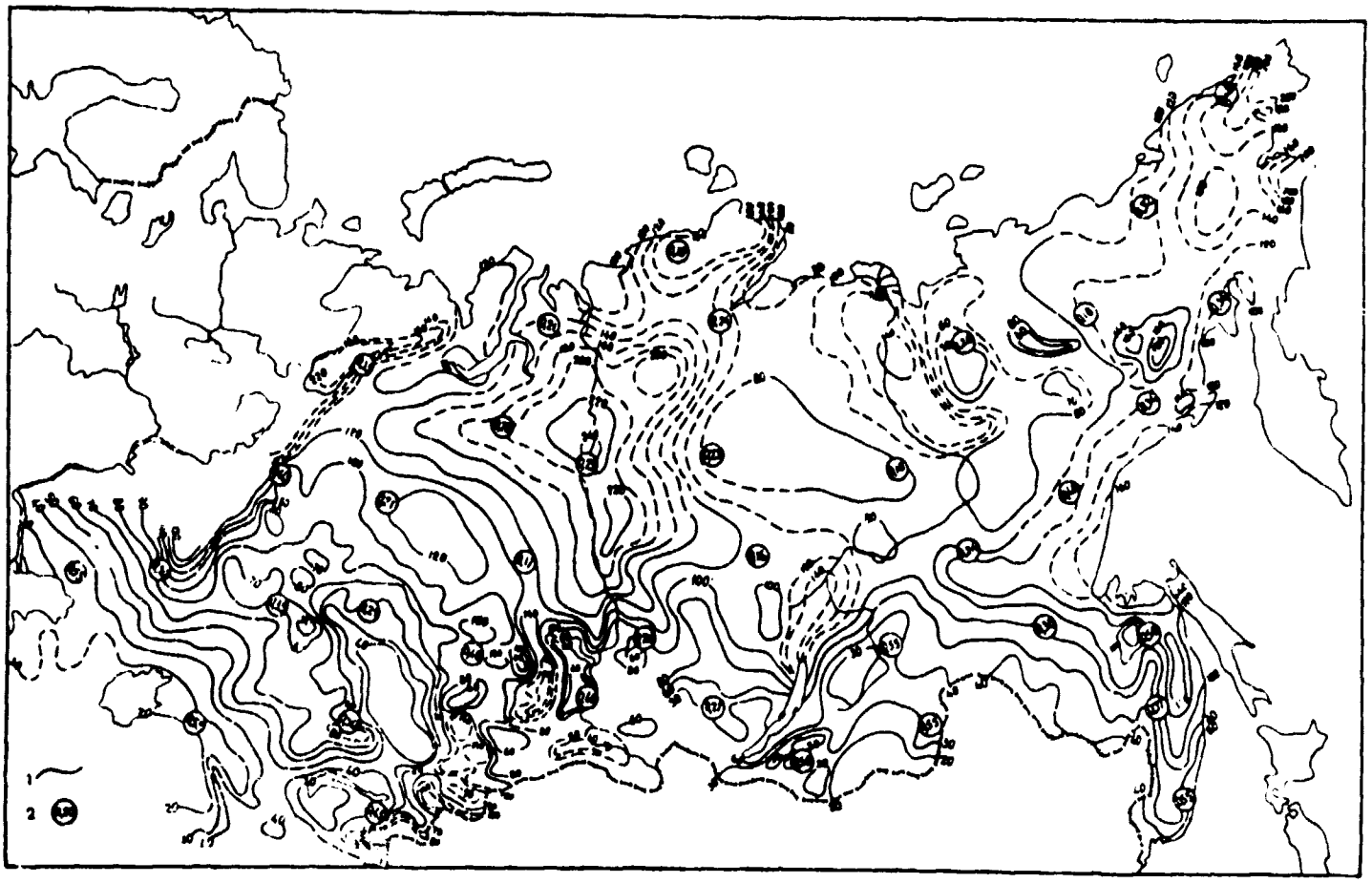

Figure 2. Average Magnitudes of Maximum Water Reserves and Snow Cover from 1941 to 1960 and Their Variation

Key:
1. isolines of maximum water reserves (in mm) in snow cover (dotted line is approximate data)
2. coefficients of variation in maximum reserves

Valley and in the central Yakutiya, the snow cover height is 25 - 40 cm. There is the least snow cover in the Transbaykal where its height in places is only 8 - 10 cm. The central Siberian anticyclone is located above these regions for a large part of the winter, and winter precipitation here is very low.

A large part of the Far East has fairly little snow. The precipitation of the Pacific Ocean is influential here. Materials of snow

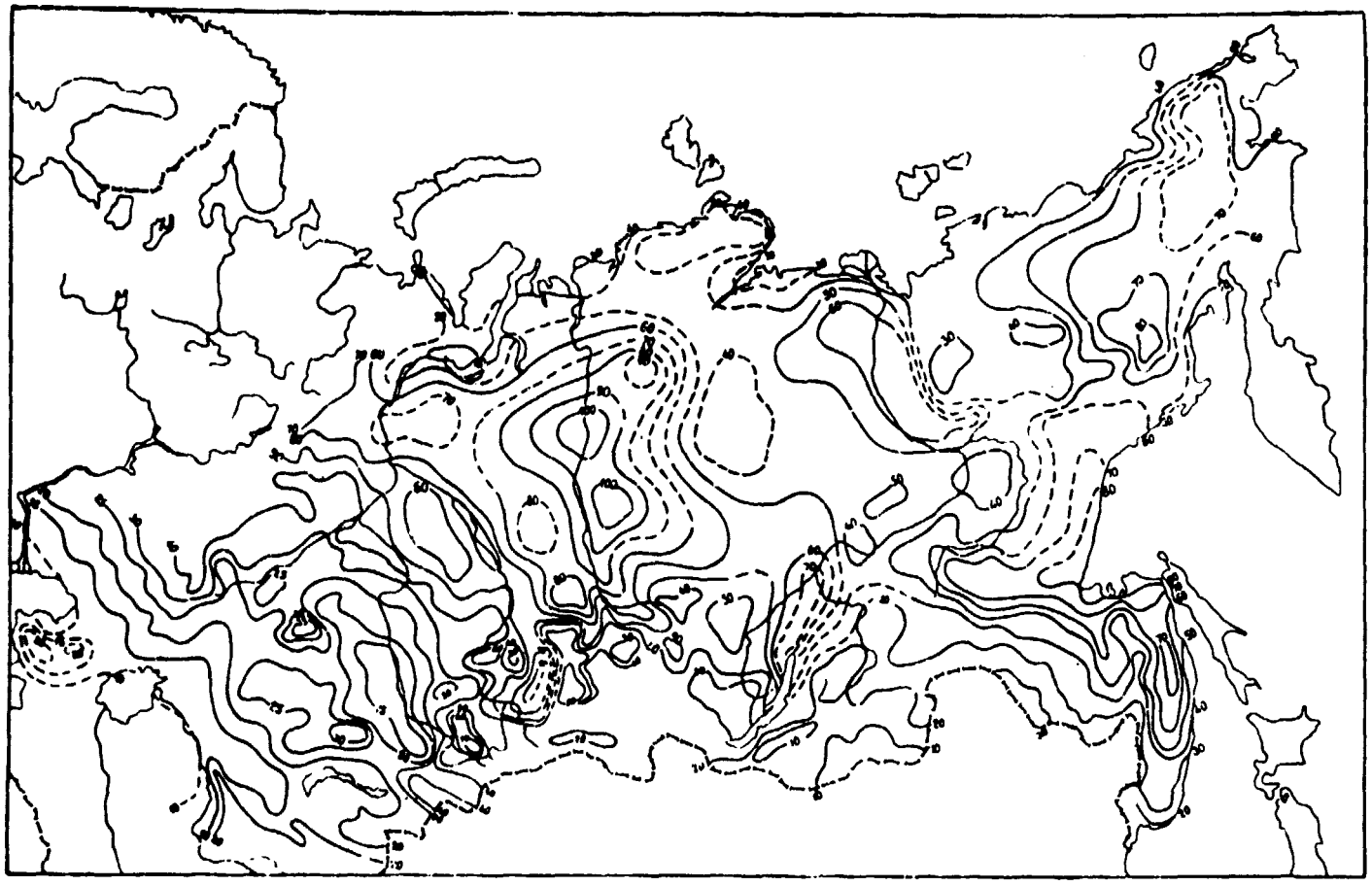

Figure 3. Average Values of Decade Height (in cm) of Snow Cover the Greatest for Winter from 1941 to 1960 (dotted line is approximate data)

surveys show that on the territory of the Magadanskaya Oblast and the Chukotsk national okrug, the height of the snow cover by the end of winter usually fluctuates an average from 50 to 80 cm (water reserve 120 - 160 mm), increasing in the mountainous part of the Kolyma basin and on the Chukotsk Peninsula to 80 - 100 cm. The western coast of the Okhotsk Sea has a lot of snow. On the entire coastal band from Okhotsk to the Tatarsk Gulf, there is a relatively level snow cover 75 - 95 cm in height. This band is fairly narrow, and the deeper into the continent, the thickness of the cover diminishes to 45 - 55 cm. Advancing on the coast to the south of the Amur mouth to Vladivostok,

the snow cover height gradually diminishes from 60 - 70 to 20 - 25 cm. In the mountainous region of Sikhote-Alinya (to height 1000 m) the snow cover thickness is 60 - 80 cm (water reserve 120 - 160 mm).

There is fairly little snow in the Amur basin above Khabarovsk. The least height of the snow cover (15 - 25 cm) is observed in the Amur valley. It slowly increases to the north to 30 - 40 cm, and on the ridges of Stanov, Selemdzhinskiy, Bureinskiy and others, to 50 - 60 cm. The height of the snow cover in the valley of the Amur from Khabarovsk to Komsomolsk is predominantly 30 - 40 cm, below Komsomolsk, it increases to 60 - 70 cm (water reserve to 130 - 160 mm).

It is natural that the magnitude of maximum snow reserve changes from year to year in very large limits. Thus, for example, on the Ural ridge, the water reserve in the snow from winter to winter changes from 100 - 120 to 280 - 320 mm, in North Kazakhstan from 30 - 40 to 120 - 140 mm, in the northern half of the Krasnoyarskiy kray from 160 - 180 to 350 mm, in the Transbaykal from 10 - 20 to 50 - 60 mm, and in the Far East (lower course of the Amur) from 60 - 80 to 300 - 350 mm.

The map of coefficients for variation in maximum snow reserves (Figure 2) provides a graphic idea about the multiple-year variability. Attention is drawn to the trend for decrease in the variation coefficient from the south to the north roughly from 0.45 - 0.50 to 0.20 - 0.25. The fact is that duration of snow accumulation increases in this same direction, and the probability is low that the prolonged period will be very dry or very wet. At the same time, with a short period, this probability is considerably greater. Variability in snow reserves from year to year is therefore greater in the south and lower in the north. However there are occasional exceptions. Regions where the absolute magnitude of snow reserves is low are distinguished by increased variation (lower course of the Ob, Verkhoyanskiy basin and the Momskiy Valley 0.30 - 0.40, Minusinskiy Basin, West Priirtyshye from Semipalatinsk to Omsk, 0.40 - 0.50). This is explained by the fact that with little snow, the role of each individual snowfall is

significant, and variability in the quantity of precipitation which one snowfall could yield is very great. There is little change in the magnitude of snowfall reserves from year to year in the greater part of West Siberia, in Central Yakutiya and on the Kolyma lowland where the variation coefficient does not exceed 0.25.