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COMPUTING MAXIMUM USABLE FREQUENCIES

OF RADIO COMMUNICATION LINKS

by V. N. Navysh-Bylinskaya

- USSR -

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COMPUTING MAXIMUM USABLE FREQUENCIES
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[Following is a translation of an article by V. N.
Navysh-Rylinskaya, in the Russian-language work Trudy
Instituta Zemnogo Magnetizma, Ionosfery i Raspro-
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and Propagation of Radio Waves of the Academy of
Sciences USSR), No. 19(29), Moscow, 1961, pages 71-
84.]

Introduction

This study was undertaken to compare the accuracy of two dif-
ferent methods of computation of MPCh [Maksimal'no Primenimaya
Chastota(Maximum Usable Frequency) for the short-wave radio communi-
cation links in order to find out which of these two to recommend as
the most satisfactory method to be used in radio forecasts published
by IZMIRAN [Institut Zemnogo Magnetizma, Ionosfery i Rasprostraneniya
Radiovoln; Institute of Terrestrial Magnetism, Ionosphere and Propa-
gation of Radio-waves]. Only two most widely used methods were com-
pared: The method of "reference points" which is an accepted and
recommended method in "Monthly Forecasts of Radio-Wave Propagation"
(published by IZMIRAN), and the method of "equal jumps" previously
evaluated in work [3] as one of the best methods. Because both
methods are well known we do not describe them here. The examination
of these two methods was done by comparing the calculated values of
MPCh with the actual values observed on several radio communication
links.

1. The Initial Sources

The following are the initial materials used in this study:
Data on the transmission of short radio-waves by several radiocommuni-
cation links published in the pages of 1957-1958 issues of Canadian
Ionospheric Data, and Beobachtungsergebnisse (Observation Results).

Information on radio communication results of various Soviet
radio lines. This information is contained in the materials of the

archives of MDRS' [Moskovskaya Direktsiya Radiosvyazi i Radiovesh-chaniya; Moscow Directorate of Radio Communications and Radio Broad-casting].

Finally the observation results of the ionospheric radio stations are given. These results contained the data necessary for the computation of MPCh between these stations.

The following radio communication links were examined: Washington-berlin 6,600 kilometers long; Washington-Resolution bay (4,100 km); Washington-baker Lake (3,000 km); Washington-Churchill (2,600 km); washington-Ottawa (700 km), and various Soviet radio communication links extending in different directions from 1,600 to 5,400 kilometers.

Experimental MPCh for the above mentioned links were deter-mined by actual measurement of the field strength and according to the results of radio-wave transmissions. Radio transmission data on Washington-berlin link is published in the form of charts containing daily values of field strength for every even hour of reception by berlin on six standard frequencies: 2.5; 10; 15; 20 and 25 megacycles transmitted by the washington transmitter WWV. These charts contain also the diurnal graphs of audibility band of WWV transmitter. On the basis of this data we figured out the monthly median values of diurnal field strength for every frequency above mentioned and also for the upper frequency limits at the threshold of hearing of the transmitter. Finally, according to these median values, the daily trends of MPCh were found out for every month under consideration.

Also was used the experimental data on the reception of radio signals from WWV transmitter by four Canadian stations (Resolution bay; baker Lake; Churchill; Ottawa). This data is published in the form of charts containing hourly and median values of audibility in decibel scale. According to these monthly median values of audibility for every frequency used, the MPCh for every hour of every month was calculated.

The materials on radio communication in the system of MDRSV were in the form of monthly tables of radio transmission using several diurnal operating frequencies. It was impossible to find out for these radio channels the experimental values of MPCh, in-stead, for these channels the monthly median values of the daily trends of an operating frequency were determined.

The calculations of the MPCh for the mentioned radio channels were done using two different methods: by the method of "reference points" and by the method of "equal jumps". The calculations by the

method of "equal jumps" were carried out in conformity with the instructions of NII /Nauchno Issledovatel'skiy Institut; Scientific Research Institute/ of the Ministry of Communications, that is, taking into account the correction factor raising the calculated values of MPCh /3/. The calculations of MPCh were performed either on the MPCh maps, layers E, F1 and F2, or on the maps of the critical frequencies and factors M-3,000 of the layer F2, the maps themselves being made for every month based on the observation data gathered by the ionospheric radio stations. For each radio communication channel a group of the ionospheric stations was assigned. The observations conducted by these stations gave a clear picture of the ionosphere at all points of reflection along a given communication link. Based on this information the maps were made for every radio channel or for the areas adjacent to the points of reflection. When calculating MPCh for the radio channels with one point of reflection during summer months at day time the following layers determined the theoretical values of MPCh: layer E for the radio channels 700 kilometers long; layer F1 for the communication links 2,600 - 3,000 kilometers long; while during the rest of the time the layer determining the MPCh was layer F2. In the case of computing MPCh for the communication links with several points of reflection, provided the method of the calculation was the method of "reference points", the MPCh determining layer was layer F2. If the method of "equal jumps" was applied for computations during the day hours of summer months the deciding layer was layer F1, while for the rest of time the layer F2. In the result for all radio channels under the study, the monthly diurnal trends of the MPCh were calculated theoretically and those were compared with actually observed values of the MPCh for the same periods of time. Comparisons for the radio channel Washington-Berlin were carried out for the period of five months of 1957 (January, June, October-December), and for eleven months of 1958. Comparisons for Soviet radio channels were done for the period of a number of years (1943-1957), including the years of the maximum and minimum solar activity.

2. The Comparison of Computed Values of MPCh with Experimental Data

In order to compare and evaluate the above mentioned methods of MPCh computation it was necessary to find out the rate of the deviation of the theoretical values of MPCh from actually observed values for each hour of operation of each individual radio channel, i.e.

$$\frac{MPCh_{obser.} - MPCh_{calc.}}{MPCh_{observ.}} \times 100$$

Besides that it was necessary to determine the correction factors for
the curves of calculated MPCh for every hour of operation

$$\frac{MPCh_{observ.}}{MPCh_{calc.}}$$

Then the monthly values of deviations and of correction factors were
averaged for the whole period of observations conducted, and also
averaged separately for seasons: Winter, Summer and the equinox.
The values found out for diurnal changes of deviations and correction
factors were scrutinized separately for each individual radio channel
under study.

    We have to mention here that the data available on radio trans-
missions by the channels in the system of MDRSV is not enough to have
a clear picture about MPCh for these channels. These are the operating
frequencies used for carrying out radio communication along these com-
munication links and as such they are below or near frequency limit
of MPCh. Therefore, according to the results of the observations along
these communication links one can have a valid opinion on the devi-
ations only in cases when the computed values of MPCh are below the
operating frequencies, i.e. when the deviations are negative. But,
even the negative deviations do not characterize completely the magni-
tude of the discrepancy between the computed and experimental MPCh
values, because the deviations are limited by the choice of operating
frequencies.

    In order to examine the relative merits of two methods of MPCh
computation we bring here the results of comparison of our findings
on the operations of two radio channels MDRSV: Moscow-Irkutsk 4,200
kilometers long; and Moscow-Vladivostok 6,400 km. The information
is given for the years of the maximum and minimum solar activity.
When computations for both channels were carried out by the method
of "reference points" the frequencies were found out from F2-4,000
MFCh maps, i.e. for a jump distance of 4,000 kilometers. In the
case of using the method of "equal jumps", the jump distance along
Moscow-Irkuts link was 2,100 km., and 2,150 km along the link Moscow-
Vladivostok, when reflecting from ionospheric layers F2 and F.
This discrepancy in jump distances had an effect on the results of
our computations. When computations were made by applying the
method of "equal jumps" the maximum correction factor used was equal
to 1.12, and yet the MPCh were considerably lower than the MPCh com-
puted by the method of "reference points" (for both channels). This
explains why the method of "equal jumps" results in larger number of
cases when the computed values of MPCh were below their experimental

values both from the point of the amount of time and the magnitude of the deviations.

While comparing the computed values of MPCh with operating frequencies used by the radio communication links Moscow-Irkutsk, Moscow-Vladivostok during 1957 it was discovered that the individual small deviations of computed values of MPCh are observed only when applying the method of "equal jumps". The method of "reference points" does not produce the deviations. However, in cases like that, the mere fact of the lack of the deviations does not indicate yet a good agreement between theoretical and experimental MPCh values, for the year 1957 was the year of the maximum solar activity - the time when the values of MPCh calculated by both methods for the day light hours rise beyond the limits of the short wave range. Therefore it is natural to conclude that when communicating by the short waves the operating frequencies can not become larger than the computed values of MPCh.

During the years of the minimum solar activity (1953-1954) little deviations are observed when MPCh computation is made by the method of "reference points"
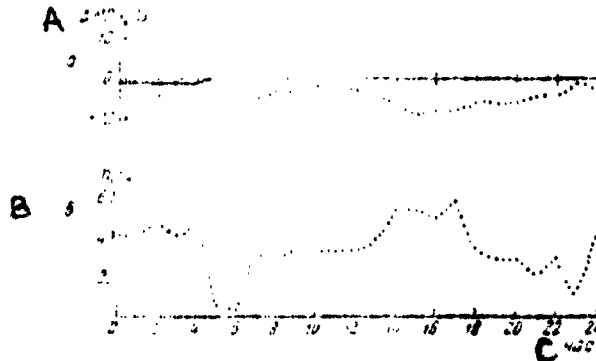

Figure 1. Radio transmission data on Moscow-Irkutsk channel.
(1953-1954)
a - The average variations (deviations) between calculated & observed MPCh values (%)
b - The frequency of the deviations n for every hour (%)
Solid curve - results obtained by the method of "reference points"
Stroked curve - results obtained by "equal jumps" method.
A - Δ MPCh %
B - b
C - hours

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On Moscow-Irkuts link these deviations amount to 3% of time, and on the link Moscow-Vladivostok to 13%. The average values of deviations are negligible, though in the individual cases they may reach up to 45%. When calculations were made by the method of "equal jumps" considerably larger deviations were observed. The calculated MPCh values are below the operating frequencies during 30% of the time for the link Moscow-Irkutsk, and during 60% of the time for the Moscow-Vladivostok link.
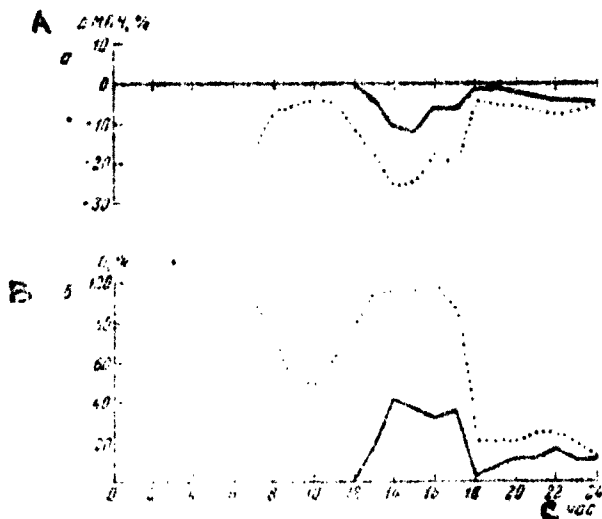
Figure 2. Radio transmission data on Moscow-Vladivostok link.
              (1953-1954)

a - The average variations between calculated and observed MPCh
    values (%)
b - The frequency of the deviations n for every hour (%)
Solid curve - results obtained by "reference points" method.
Stroked curve - results obtained by "equal jumps" method.
A - MPCh
B - h
C - hours

        During the summer months (May-August) the deviations are ob-
served during 70-80% of the time. The average values of these devi-
ations do not go over 25%, but during individual hours they reach up
to 57-60%. The percentage of the average variations for the two
radio links during 1953-1954 calculated by both methods are shown
on Figures 1 and 2. (The time shown is the Moscow Official Time).

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On the same figures are also shown the curves of the percentage of the frequency of deviations for every hour of communication operations. We could not make our comparisons for the link Moscow-Vladivostok from zero to seven o'clock because no communication operation were conducted during these hours. The distribution of the variations (deviations) are the frequency of their indications according to the seasons only for the computed MPCh values by the method of "equal jumps" are shown in Figures 3 and 4. One can see in these figures that the variations occur at any time during twenty four hours, but they are particularly stable during the day time hours in the summer. The results of the comparison of data for the radio communication links Moscow-Irkutsk, and Moscow-Vladivostok bring us to the conclusion that the method of "reference points" is a more satisfactory method for the computation of MPCh for these channels. On Moscow-Irkutsk communication link the method of "reference points" practically does not produce the variations. As for the link Moscow-Vladivostok, again, the magnitude of variations and the frequency of their indications are considerably smaller if the calculations are carried out by the "reference points" method.

But, the major data for the comparisons of these two methods was obtained while studying the results of radio communications of the links Washington-Revolution Bay and Washington-Berlin. In these cases there was the opportunity of finding out for these links the experimental MPCh covering the larger part of the period under our study. This made it possible for us to evaluate the magnitudes of both negative and positive variations. Besides, calculations were performed for the communication link Washington-Moscow for the period of November 1958, but so far as the results of this study are similar to the results of the link Washington-Berlin, and so far as the material about Washington-Moscow link is very small, we do not bring it here separately. Here again, for both of these links, the MPCh curves calculated by the method of "equal jumps" (because of the difference in jump distances) are below MPCh curves computed by 'reference points" method.

The MPCh variations obtained by calculations using both methods for the communication link Washington-Resolution Bay are shown on Figure 5 (Local time: 90 degrees Western Longit.). While computing by "reference points" method the maximum negative variations for the whole period of the examination (23 months) were observed reaching to 15% during the night hours. During the morning and evening hours the variation curve gradually rises approaching the zero level and then becomes positive for the hours of day time, its fluctuations averaging 5%. The average MPCh values computed by "equal jumps" method during all twenty four hour periods of time were negative,

their variation curves reaching to 28-30% during the night hours, and to about 18% during the day time hours.
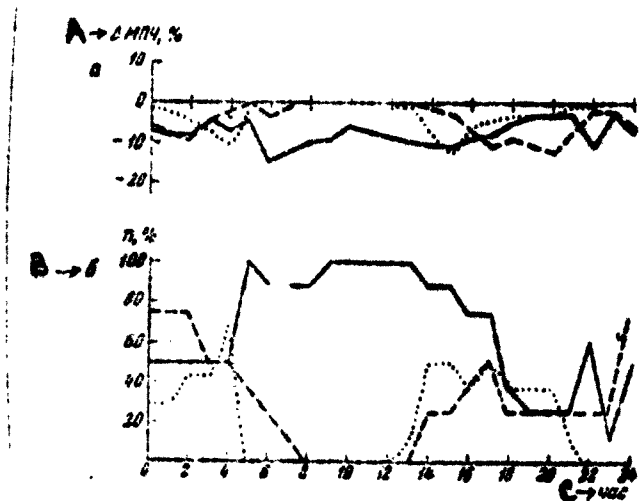
Figure 3. The distribution of the deviations (variations), and the frequency of their indications according to the seasons for the communication link Moscow-Irkutsk (1953-1954)

a - The average deviation of the computed MFCh values by the method of "equal jumps" from observed magnitudes (in %)
b - The frequency of their indications n for every hour (%)
Dotted curves - Winter
Stroked curves - Equinox
Solid curves   - Summer
   A - MFCh, %;   B - b;   C - Hours
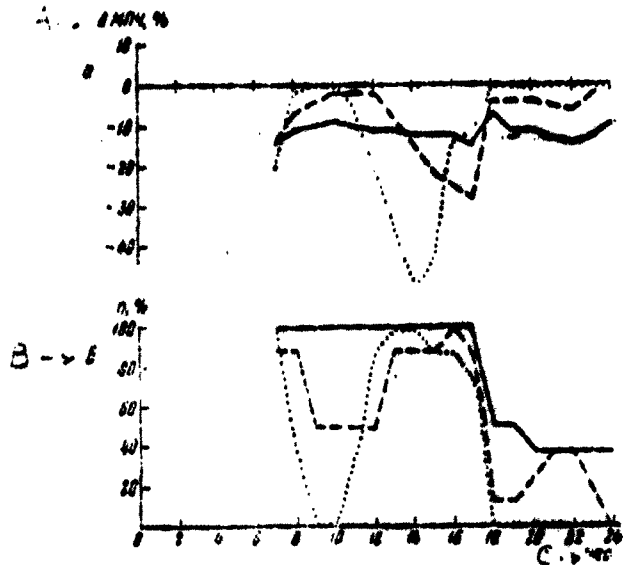
Figure 4. The distribution of the deviations, and the frequency
of their indications according to the seasons for the
communication link Moscow-Vladivostok (1953-1954)

a - The average deviations of MPCh calculated by the method of
"equal jumps" from observed values (MPCh %)
b - The frequency of their indications n for every hour (%)
Dotted curves - Winter
Stroked curves - Equinox
Solid curves - Summer
    A - MPCh, %;   B - b;   C - Hours
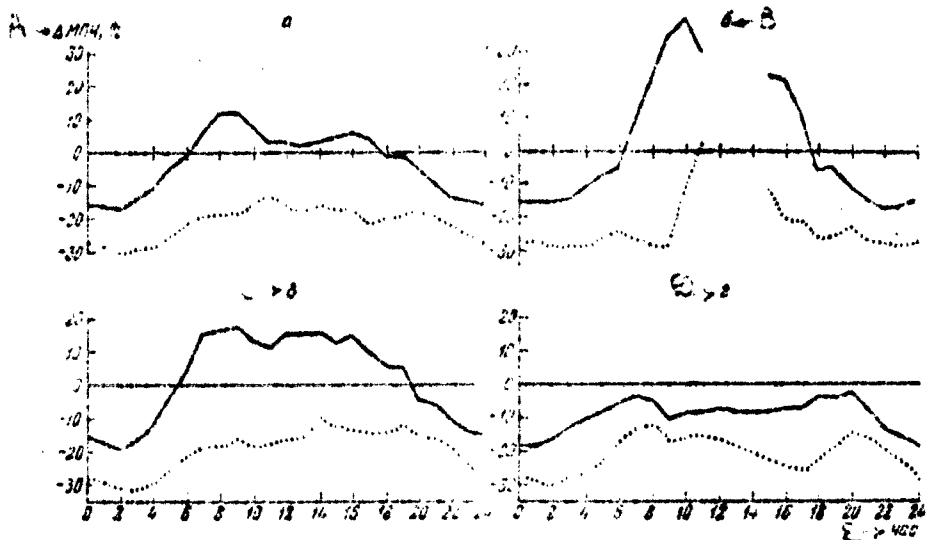
Figure 5. The average deviations of computed MPCh values from
observed magnitudes (MPCh %) for the communication link
Washington-Resolution Bay (1957-1958)

a - For the whole period of observations
b - Winter
c - Equinox
d - Summer
Solid curves - by method of "reference points"
Dotted curves - by method of "equal jumps"
· A - MPCh %;   B - b;   C - c;   D - d;   E - Hours

Below follows the distribution of the variations according to the seasons. In the winter, during the night hours the method of "reference points" gives negative variations up to 15%; during the morning and evening hours the variation curves pass through zero level and at day time become positive reaching considerable values. The variations of MPCh computed by "equal jumps" method during the night and transitional hours keep stable in the vicinity of 28-25% and only during the day hours near noon time pass through zero level reaching small positive values. During months of equinox according to both methods the magnitudes of variations at night hours are almost the same as in the winter, while during the day time hours the method of "reference points" gives variations averaging 15%, and the method of "equal jumps" gives -15%. In the summer the variations are negative by both methods. Their fluctuations during twenty four hours are as shown below: By the method of "reference points", about 8-10%; by the method of "equal jumps" about 20%. Let us mention here that for the day time hours during the winter and equinox in the majority of cases it was impossible to determine the magnitudes of MPCh under examination so far as they were higher than the highest frequency radiated by the transmitter (25 mc). For this reason the deviation curves for the indicated periods are not enough reliable. Also, as the summer time observations constitute the largest number of observations carried out, the curves for the whole period show a somewhat understated value of deviations taking place during the hours close to the noon time. The curves of deviations for the night time hours during the winter and equinox, and for the all twenty four hours during summer are the most reliable curves and the scattering of deviations is small.

The average deviations of MPCh for the communication link Washington-Berlin are shown on Figure 6. (Time-Standard International). The results of comparisons for this link are similar to the results of Washington-Resolution Bay link, but the curve computed by the method of "equal jumps" too, shows the night time (about 35%) average deviations for the whole period of observations. The curve computed by the method of "reference points" gives for the same hours deviations about 20-25%. During the day time hours the deviation curve by the method of "equal jumps" is negative (-10; -15) and the deviation curve by the method of "reference points" is positive (about 5%). However one must talk about day time deviations with some caution, for our remarks about the day-time deviations for the link Washington-Resolution Bay are entirely relevant also to the link Berlin-Washington. For instance the deviations for the night and transitional hours were computed for all sixteen months of observations while the day time (from 13 to 17) computed only for seven months, mainly summer months. Let us analyze the deviations for each season separately. In winter

very large negative deviations were found for night hours by both
methods of computation: 33% by the method of "reference points" and
42% by the method of "equal jumps". In day time both methods give
the positive deviations, but it is impossible to calculate them pre-
cisely because of lack of experimental MPCh above 25 mc. During the
months of equinox at night time the deviations are negative: 20%
by the method of "reference points, and 30% by the method of "equal
jumps". In day time as based on a limited information, the calcu-
lations by the method of "reference points" give deviations up to
+10%, and by the method of "equal jumps" to -8%. In summer the devi-
ation curves of MPCh calculated by both methods are negative (by the
method of "reference points" at night about 15%, during the day time
0-5%; by the method of "equal jumps" at night -28%, during the day
time about 15%).
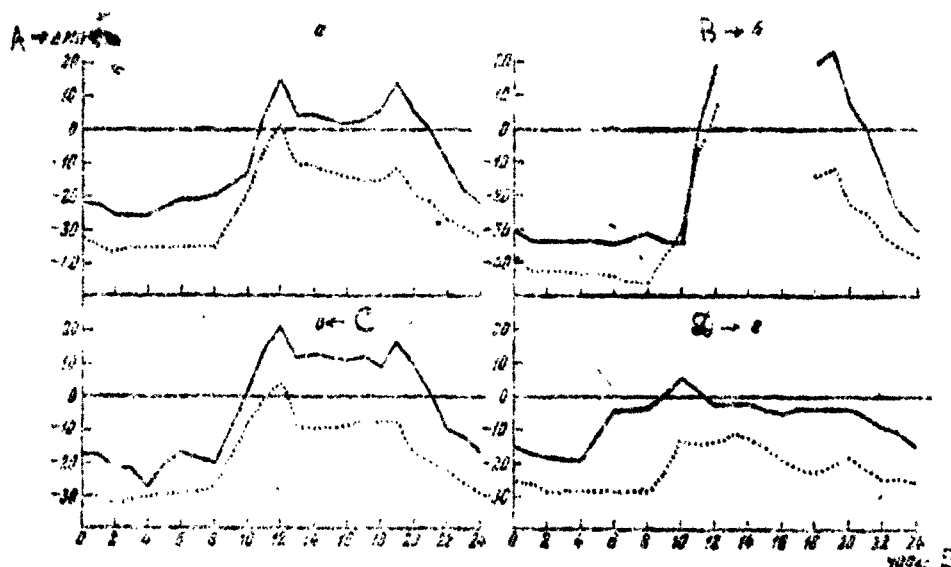
Figure 6.   The average deviations of the computed MPCh values from
            observed data (MPCh) in % for the communication link
            Washington-Berlin (1957-1958)

a - For the whole period
b - Winter
c - Equinox
d - Summer
Solid curves - "reference points" method
Dotted curves - "equal jumps" method
  A - MPCh %;   B - b;   C - d;   D - d;   E - Hours

The graphs of the changes in the values of correction factors calculated for both communication links give the picture which is similar to the graphs of changes in the values of MPCh deviations for the same links. The diurnal magnitudes of the correction factor for each communication channel is not the same for each hour. The magnitude of correction factor has the diurnal trend different for each season. The average magnitudes of correction factors for the whole period of observations and for each season for communication links Washington-Resolution Bay and Washington-Berlin are given in Tables 1 and 2.

Figure 7. Communication link Washington-Ottawa (1957-1958)
The average deviations of computed MPCh from experimental data (MPCh %)

a - For the whole period
b - For separate seasons
Solid curves - Summer;   Stroked curves - Equinox;
Dotted curves - Winter;   Time: 75 degrees Western Latitude
  A - MPCh %;   B - b;   C - Hours

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We have to consider the group of communication channels Washington-Baker Lake; Washington-Churchill, and Washington-Ottawa separately because these are the links with one point of reflection, and therefore there is no big difference in the results when calculations are carried out by above mentioned methods. However there is a small difference in calculations. According to the instructions of the Ministry of Communications while calculating single jump links one has to introduce a correction factor K. When this K was introduced into calculations of above mentioned communication links, the MPCh of Washington-Ottawa was increased by 2%, of Washington-Churchill by 6%, and of Washington-Baker Lake by 8%. Then these increased MPCh were compared with experimental MPCh. The average deviations of those calculated MPCh from experimental values are given on Figures 7, 8 and 9 (Time Local - 90 Deg. W.L.). The decline of the calculated MPCh is common feature for all three communication links. It (the decline) is inversely proportional to the wavelength of a radio channel. The maximum negative deviations for all three channels are during the night. At the day time smaller deviations are found out. Practically there are no deviations during the evening hours for the longer channels such as Washington-Baker Lake, and Washington-Churchill. For the link Washington-Ottawa the night deviations reach 55%, and the day, 20%. Larger deviations occur in summer, smaller ones in winter. The distribution of deviations for the channel Washington-Ottawa for all seasons gives the actual picture because the MPCh for this link do not go over 25 mc., and the experimental data was obtained for the whole period of studies. As for the links Washington-Baker Lake, the Washington-Churchill in day time hours during winter and equinox months there is inaccuracy because of limited experimental MPCh. This feature was mentioned earlier.

About the values of correction factors for these single jump links we can say the same things that we did when discussing the two previous communication links. The values of correction factors for the link Washington-Ottawa are given on Table 3. For the links Washington-Baker Lake, and Washington-Churchill we give one summary table for they are identical from the point of their length and MPCh deviations.
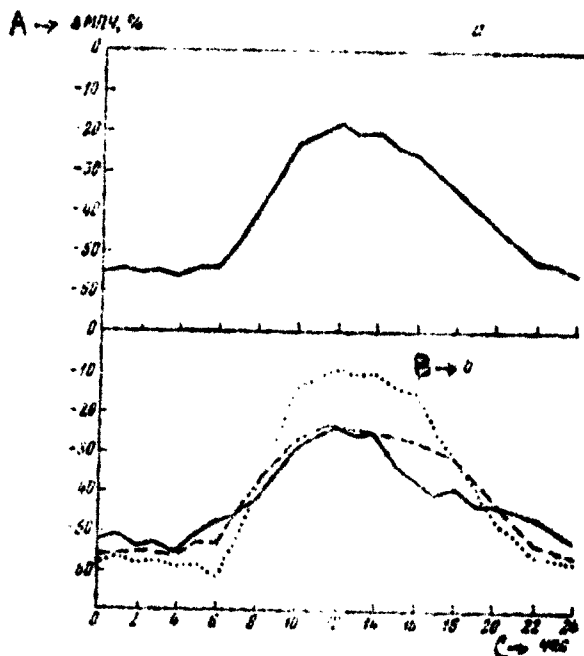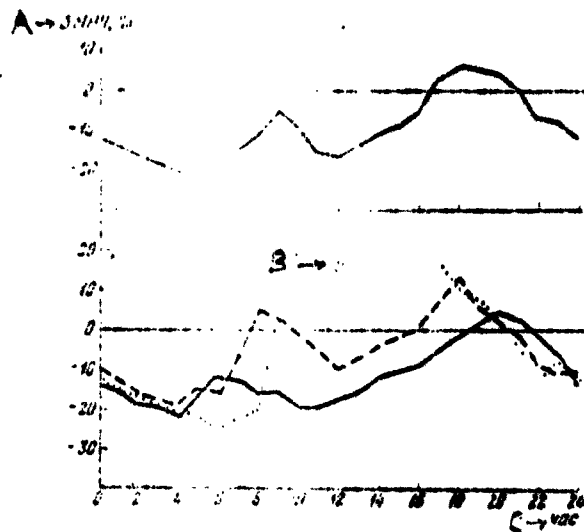
Figure 8. The average deviations of computed MPCh from experimental data (MPCh %). Channel Washington-Churchill (1957-1958)

a - The whole period of observations
b - Seasonal av. deviations
Solid curves - Summer
Stroked curves - Equinox
Dotted curves - Winter
Time: 90 degrees W. L.
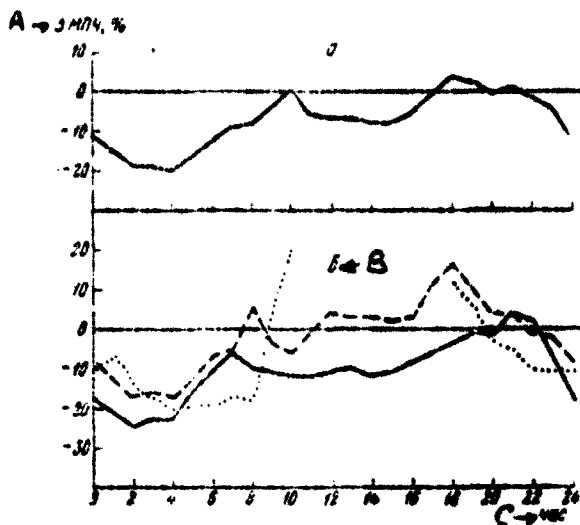   A - MPCh %;   B - b;   C - Hours

Figure 9. Average deviations of computed MFCh values from experimental data (MFCh %). Communication Channel: Washington-Baker Lake (1957-1958)

a - The whole period of observations
b - Seasonal average deviations
Solid curves -   Summer
Streked curves - Equinox
Dotted curves - Winter
    A - MFCh %;   B - b;   C - Hours;   Time: 90 degrees W. L.

TABLE 1

Correction factor values during 1957-1958 for
the link Washington-Resolution Bay

Time: 90° West Longitude	Ave. values whole period observations		Seasonal average values by the method					
	By method "ref. points"	By method "equal jumps"	Pref. points	Equal jumps	Pref. points	Equal jumps	Pref. points	Equal jumps
			Winter		Equinox		Summer	
00	1,22	1,38	1,19	1,38	1,21	1,39	1,24	1,37
01	1,22	1,40	1,19	1,38	1,21	1,41	1,23	1,42
02	1,21	1,43	1,20	1,39	1,24	1,45	1,19	1,44
03	1,17	1,41	1,18	1,41	1,19	1,44	1,14	1,38
04	1,13	1,39	1,12	1,41	1,13	1,42	1,11	1,35
05	1,07	1,32	1,07	1,35	1,03	1,35	1,09	1,30
06	1,03	1,27	1,04	1,33	0,97	1,35	1,06	1,24
07	0,96	1,25	0,89	1,37	0,94	1,24	1,03	1,14
08	0,90	1,28	0,81	1,30	0,83	1,22	1,05	1,14
09	0,91	1,25	0,73	1,34	0,86	1,20	1,12	1,21
10	0,95	1,20	0,68	1,19	0,90	1,24	1,00	1,18
11	1,00	1,17	0,77	1,00	0,92	1,23	1,08	1,18
12	1,00	1,19	-	-	0,89	1,21	1,08	1,19
13	1,00	1,21	-	-	0,80	1,19	1,09	1,22
14	1,00	1,19	-	-	0,83	1,12	1,08	1,24
15	1,00	1,23	0,82	1,17	0,80	1,15	1,00	1,28
16	0,96	1,23	0,82	1,15	0,88	1,16	1,08	1,31
17	0,98	1,26	0,92	1,29	0,91	1,17	1,07	1,34
18	1,03	1,27	1,06	1,35	0,95	1,19	1,05	1,28
19	1,04	1,24	1,11	1,34	0,96	1,15	1,06	1,22
20	1,07	1,22	1,13	1,34	1,04	1,19	1,02	1,15
21	1,12	1,26	1,19	1,38	1,07	1,21	1,00	1,18
22	1,16	1,29	1,23	1,38	1,14	1,28	1,17	1,23
23	1,20	1,34	1,23	1,41	1,18	1,33	1,19	1,29

TABLE 2

Correction factor values during 1957-1958 for
the link Washington-Berlin

Time: 90° West longitude	Ave. values whole period observations		Seasonal average values by the method					
	By method "ref. points"	By method "equal jumps"	"ref. points"	"equal jumps"	"ref. points"	"equal jumps"	"ref. points"	"equal jumps"
			Winter		Equinox		Summer	
00	1.31	1.49	1.45	1.64	1.25	1.41	1.18	1.33
01	1.33	1.52	1.48	1.68	1.28	1.44	1.20	1.36
02	1.37	1.57	1.51	1.73	1.39	1.50	1.23	1.35
03	1.37	1.54	1.50	1.73	1.28	1.45	1.24	1.29
04	1.36	1.56	1.55	1.75	1.29	1.43	1.25	1.40
05	1.34	1.57	1.55	1.77	1.25	1.41	1.15	1.40
06	1.32	1.58	1.52	1.78	1.22	1.42	1.08	1.32
07	1.31	1.57	1.49	1.81	1.24	1.39	1.06	1.38
08	1.30	1.55	1.47	1.82	1.23	1.35	1.04	1.46
09	1.25	1.40	1.50	1.55	1.14	1.22	0.93	1.29
10	1.22	1.25	1.55	1.42	1.09	1.10	0.94	1.13
11	0.97	1.05	1.05	1.07	0.88	1.02	0.90	1.16
12	0.89	1.02	0.81	0.85		0.98	1.03	1.16
13	0.97	1.19			0.90	1.11	1.02	1.14
14	0.96	1.13			0.88	1.11	1.02	1.15
15	0.98	1.15			0.89	1.10	1.03	1.18
16	0.99	1.17			0.90	1.10	1.03	1.23
17	0.98	1.18			0.90	1.07	1.04	1.27
18	0.98	1.18			0.94	1.05	1.04	1.23
19	0.80	1.15	0.82	1.05	0.87	1.05	1.04	1.25
20	0.81	1.21	0.94	1.20	0.92	1.10	1.04	1.22
21	1.02	1.28	1.01	1.35	0.90	1.21	1.08	1.26
22	1.13	1.38	1.10	1.57	1.11	1.29	1.10	1.32
23	1.24	1.42	1.36	1.51	1.11	1.34	1.13	1.32

TABLE 3

Correction factor values during
1957-1958

Time: 75° West Longitude	Ave. value whole per. of observation	Seasonal average values		
		Winter	Equinox	Summer
00	2.27	2.38	2.31	2.13
01	2.23	2.46	2.29	2.06
02	2.27	2.48	2.25	2.17
03	2.24	2.38	2.28	2.15
04	2.32	2.45	2.28	2.23
05	2.20	2.41	2.14	2.04
06	2.22	2.61	2.16	1.90
07	1.95	2.13	1.94	1.86
08	1.68	1.78	1.63	1.75
09	1.42	1.37	1.51	1.57
10	1.33	1.17	1.41	1.41
11	1.28	1.13	1.35	1.36
12	1.25	1.11	1.32	1.33
13	1.26	1.11	1.33	1.36
14	1.26	1.12	1.28	1.33
15	1.34	1.15	1.30	1.48
16	1.39	1.18	1.30	1.30
17	1.47	1.20	1.42	1.65
18	1.52	1.45	1.48	1.66
19	1.67	1.62	1.59	1.80
20	1.80	1.84	1.76	1.80
21	1.91	2.04	1.94	1.84
22	2.09	2.27	2.18	1.86
23	2.20	2.36	2.28	1.97

TABLE 4

Correction factor values during 1957-1958 for the two links:
Washington-Baker Lake, and Washington-Churchill

Time: 90° West Longitude	Ave. values whole per. of obser-vations	Seasonal averages		
		Winter	Equinox	Summer
00	1,1?	1,1?	1,11	1,16
04	1,1?	1,17	1,16	1,23
02	1,2?	1,15	1,20	1,20
03	1,2?	1,2?	1,22	1,28
04	1,2?	1,2?	1,23	1,29
05	1,2?	1,2?	1,16	1,29
06	1,2?	1,2?	1,18	1,13
07	1,1?	1,1?	1,07	1,12
08	1,1?	1,2?	0,95	1,15
09	1,1?	0,?8	0,97	1,16
10	1,0?	0,84	0,97	1,20
11	1,1?	—	0,97	1,20
12	1,1?	—	0,08	1,12
13	1,1?	—	0,06	1,16
14	1,0?	—	0,05	1,14
15	1,0?	—	0,03	1,12
16	1,0?	—	0,01	1,08
17	0,97	0,80	0,90	1,07
18	0,9?	0,?2	0,87	1,11
19	0,1?	0,94	0,92	1,01
20	0,9?	1,0?	0,98	0,98
21	1,0?	1,0?	1,00	0,97
22	1,0?	1,13	1,08	0,94
23	1,0?	1,13	1,08	1,04

Conclusion

The results obtained are concerned with the middle latitude and polar communication links and are right for the periods of maximum solar activity. The period of minimum solar activity is characterized only by data for the communication links of MDRSV. Though these materials give us the right to think that the results obtained for the years of maximum solar activity could be regarded good also for the years of minimum solar activity, for more accurate calculations during the years of minimum solar activity one needs additional data similar to that used for the period of maximum solar activity.

In the result of our calculations and comparisons it is possible to make the following conclusions:

1. There is a difference in the shape of diurnal MPCh trends both for calculated and experimental values, and this difference is especially sharp for winter months. On the day time experimental MPCh curves the deep minimums of the night and dawn hours so characteristic for the curves of computed MPCh are not noticeable. This discrepancy in the diurnal trends is an indication of the inadequacy of both methods of calculation for the night and dawn hours for all communication links. The lack of the above mentioned minimums on the experimental MPCh curves demonstrates the fact that the transmission of frequencies higher than the calculated MPCh takes the place not for the reason of their reflection from layer F2, but because of some other ways of propagation not taken into account by our methods of calculation. A discrepancy is detected between the maximums in the diurnal trends of calculated and experimental MPCh during the winter months, but the experimental information at hand did not permit us to evaluate it quantitatively.

2. While comparing the two methods of computation for the communication links over 4,000 km. long, it is possible to indicate the relative superiority of the method of "reference points". Even for the communication link Washington-Resolution Bay for which one expects a double-jump propagation, and therefore may prefer the method of "equal jumps", the method of "reference points" gave, on the average, somewhat better results. For this channel it is only in winter in the day time hours that the number of positive deviations while comparing computed and experimental MPCh values by the method of "reference points" is more than by the method of "equal jumps".

3. The comparisons of calculated and experimental MPCh values for the single-jump links show that the methods of computation do not guarantee the necessary accuracy. The calculated values are considerably lower than the experimental values and the degree of this reduction increases with shortening of the distance of a communication link. Large reductions of the calculated MPCh values are noticed during the night hours.

4. It was found out that the correction factor K recommended by the instructions of the Ministry of Communication was too low for the calculation of the real communication links. The increase of the value of K could improve the method of "equal jumps" considerably.

5. Contrary to these instructions as shown by calculations the value of the correction factor must not be the same for all hours and seasons. One can see from the tables given above that the values of the correction factor changes diurnally and seasonally. The form of the curve of the diurnal trends of correction factor values is the opposite of the form of the curve of diurnal trends of computed MPCh values, i.e. the maximum values of the correction factor fit the night and morning hours, and the minimum values take place at noon time.

The volume of this material is not considered enough for finding out the new correction factors by statistical methods in order to introduce them into the practice of MPCh computations. Tables 1, 2, 3 and 4 given in this study could be used as a reference material for the areas served by the communication links analyzed here. It is necessary to keep in mind that the values of correction factors given in those tables for the method of "equal jumps" are complementary to the factors which were already used when computing MPCh.

6. The comparisons made have shown that the two methods of computation of MPCh for the communication links with a single or several points of reflection need considerable improvement. The existing MPCh computation methods could be improved by gathering the experimental data on communication links having different lengths and located at the different points on the globe, and by finding out the empirical correction factors, and the steps which could increase the accuracy of our calculations. Simultaneously we have to analyze the reasons for the discrepancies in the relation between calculated and experimental MPCh, and also discover the ways of the transmission of radio waves with a frequency higher than the MPCh.

Bibliography

1. Beobachtungsergebnisse (Observation results), Heinrich-Herz Institute fur Schwingungsforchung DAW zu Berlin, 1957-1958.

2. Canadian Ionospheric Data, Ottawa, Canada, 1957-1958.

3. E. M. Gaspariyants "The evaluation of the methods of the computation of the Maximum Usable Frequencies" Elektrosvyaz' (Electro Communication), No. 11, 1959.

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