Antarctic Research, Vol. 2, No. 1, 60~67, June 1991

HF FIELD STRENGTH MEASUREMENTS OVER THE VERY LONG DISTANCE

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Abstract It was ascertained that there is a great margin between the theoretical values and experimental medians of the field strength of RWM and RID signals during high solar activity period at Chinese Great Wall Station on Antarctica. The calculated values are, on average, less than the experimental, especially on the propagation path between RID and Antarctica. The field strength by the experiment may be used as the basic data for the research of HF propagation over the very long distance. Because of the large deviation it seems to be necessary to study HF propagation over the very long distance in details, especially the propagation model.
Key words field strength, long distance, RWM, RID, Antarctica

1. Introduction

HF field strength measurements are very important for ionospheric propagation research. For radio-planning purposes, It is desirable to estimate the relationship between the power radiated by a transmitter and the field strength of the signal at a distant receiver. There exist. various methods for predicting. But the most widely adopted is the CCIR interim method for estimating sky-wave field strength and transmission loss at frequencies between the approximate limits of 2 and 30 MHz (CCIR Report, 1970). However, these methods remain partly unproved, through their wide application. In the last years, some measurements of ionospherically propagated HF waves have provided an experimental basis for comparison of low and medium solar activity periods (Bradley, 1971; Tanaka *et al.*, 1978) and also high solar activity period (Gourvez and Sizun, 1981). But all are for propagation over the short and medium distance. Here we give experimental propagation field strength values obtained on two HF radio circuits with two frequencies during the high solar activity period from March of 1989 to February of 1990 (R12=150) and the results of a comparison of experimental data with theoretical values calculated by FTZ method (CCIR Study Groups, 1982–1986).

2. Experimental Procedure

The transmitters were located at Moskva (55°48′N, 38°18 ′E) and irkutsk (52°26′N, 104° 02′ E) and the receiver at Chinese Great Wall Station on Antarctica (62°12′S, 58°54′ W), Some transmitter parameters are listed in Table 1.

The receiver chain consists of a controling computer, a narrowband (100HZ) receiver and a vertical asymmetrical antenna 10 m long. The antenna was set up at 8 m height above the ground for higher output voltage. The signal received at a given frequency is amplitude detected, and digitized by its numerical mean on 220 s (about 20,000 samples) is recorded on

* The research is supported by the National Natural Science Foundation of China and State Antarctic Committee.

Table 1 The transmitter parameters

	Moskva (RWM)	Irkutsk (RID)
Freq. used (MHZ)	9.996, 14.996	10.004, 15.004
Antenna	Horizontal dipole	Horizontal dipole
Carrier Power(Kw)	5, 8	1
Period of Operation	All the Time	All the Time
Dist. to Receiver (km)	15552(S), 24448(L)	18527(S), 21472(L)

floppy disk and printed on paper at the same time. The receiver chain is caliberated with ESH3 Test Receiver (R&S) (Du, 1986), So it can be used to measure HF field strength with high accuracy and with small error.

3. Experimental Data

The measurement of the HF field strength of the transmission from RWM and RID stations was carried out at Chinese Great Wall Station on Antarctica from March of 1989 to February of 1990. The recording was made every hour, every day at each frequency.

Measured values are shown in Fig. 1–8, where monthly median values up decile and *low* decile of *the* records for 4 minutes are plotted at intervals of one hour.

4. Comparison between measured and calculated values

The field strength for propagation over 9,000 km are given as follows: (CCIR Study Groups, 1982–1986)

$$E=E_0\left[1-\frac{(f_m+f_h)^2}{(f_m+f_h)^2+(f_l+f_h)^2}\left(\frac{(f_l+f_h)^2}{(f+f_h)^2}+\frac{(f+f_h)^2}{(f_m+f_h)^2}\right)\right]-36.4+P_t+G_t+G_{ap}-0.8$$

where $E_o=139.6-20\log p$, and the height used in the determination of P is 300 km

G_{ap}: focusing factor

E: received field strength (dB (μV / m),

P_t: transmitter power delivered to the transmitting antenna (kW)

f: operating frequency (MHz)

G_t: power gain of transmitting antenna relative to that of an isotropic antenna in free space

f_l: lower limit frequency

f_h: higher limit frequency

f_m: upper limit frequency. It is determined separately for the first and last hops of the path and lower value is taken.

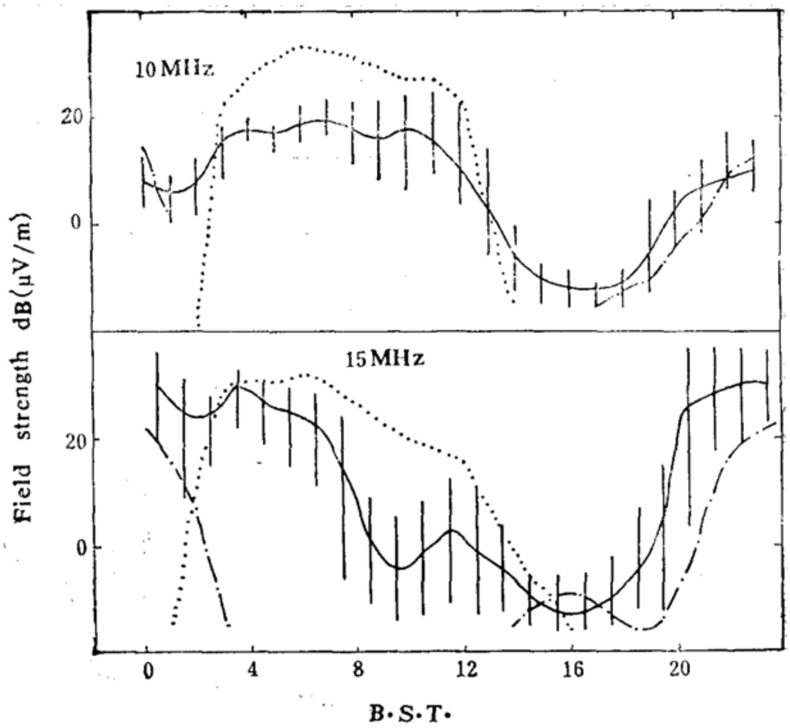

Fig. 1. Field strength of RWM signals at GWS (April, 1989).

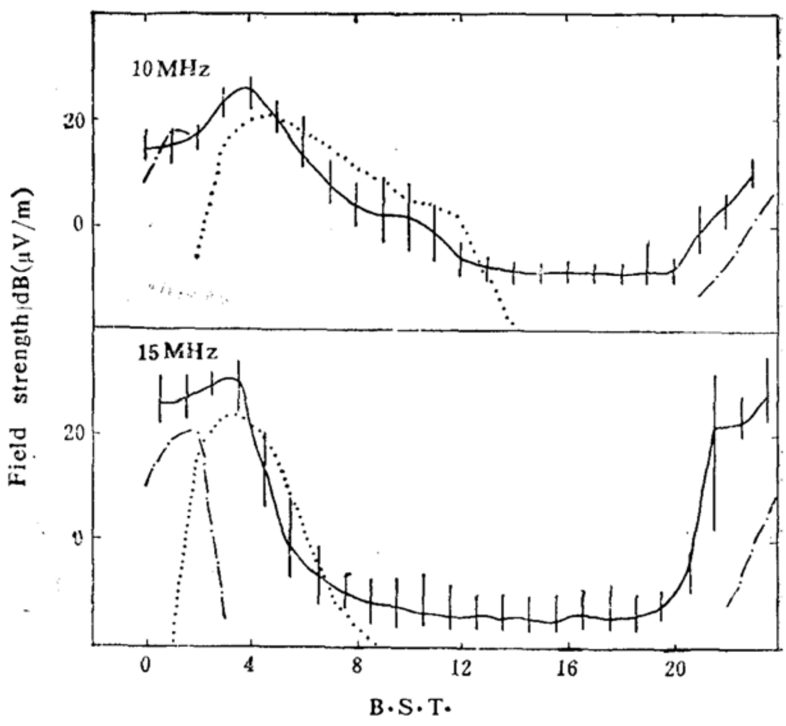

Fig. 2. Field strength of RWM signals at GWS (July, 1989).

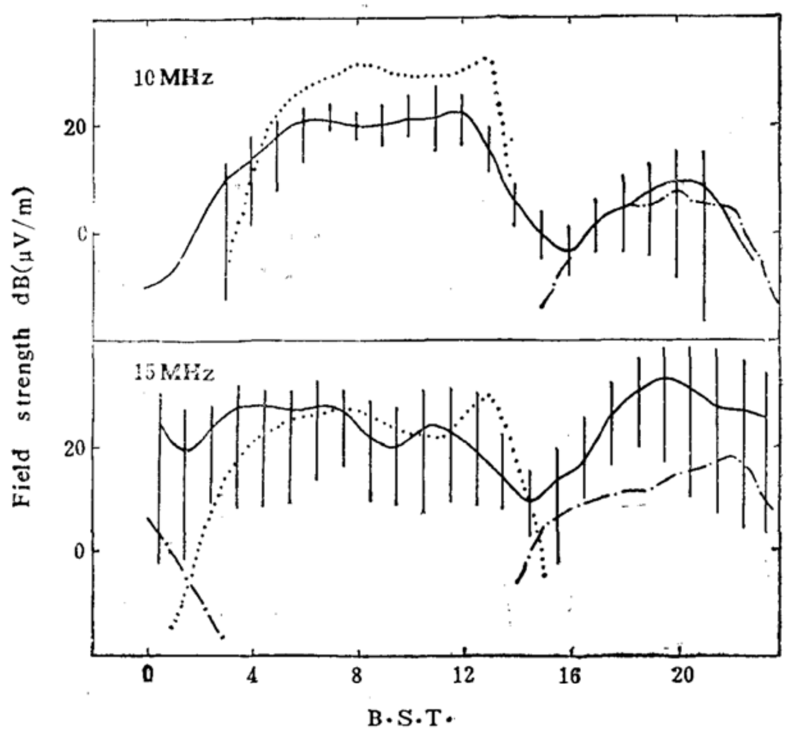

Fig. 3. Field strength of RWM signals at GWS (October, 1989).

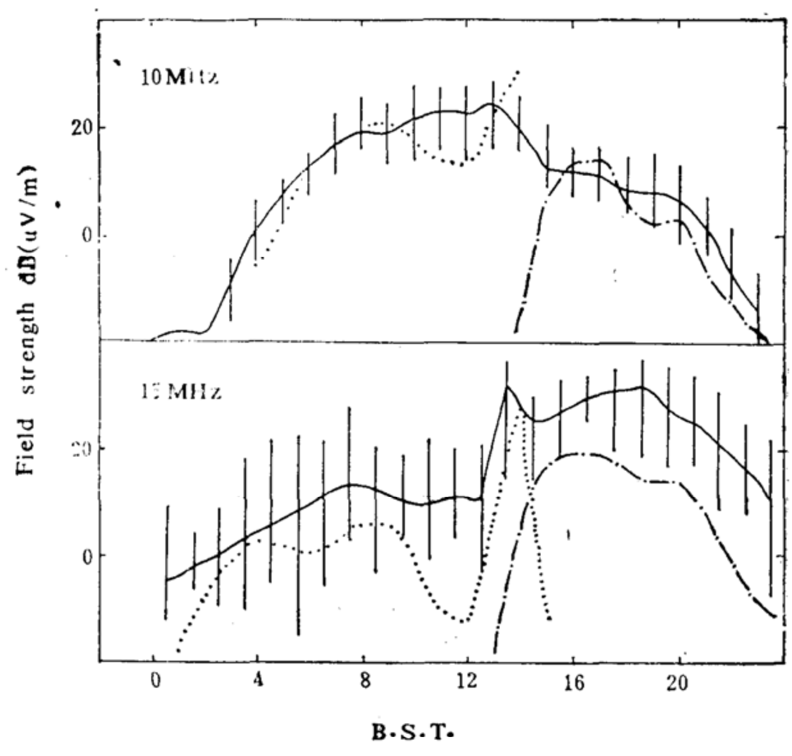

Fig. 4. Field strength of RWM signals at GWS (January 1990).

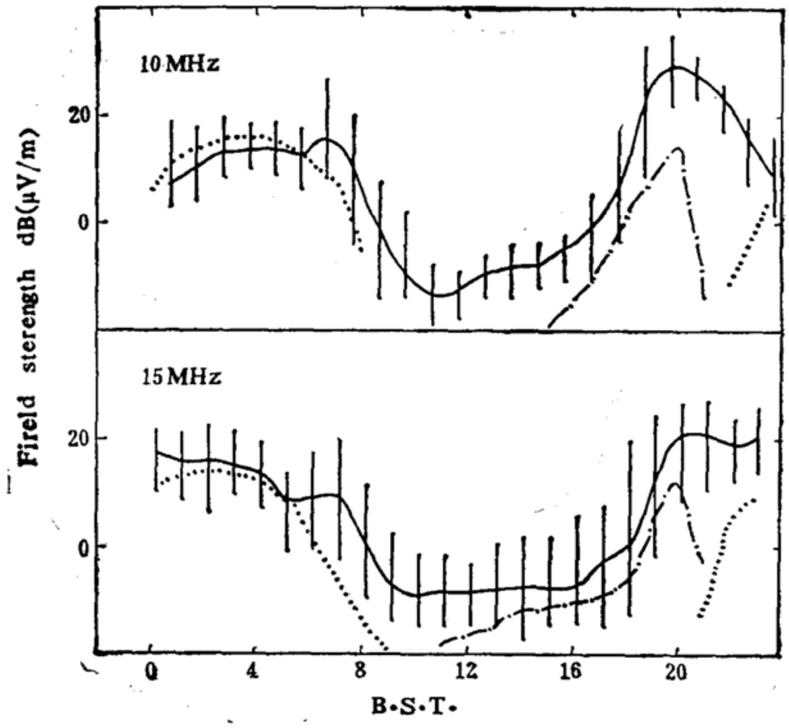

Fig. 5. Field strength of RID signals at GWS (April. 1989).

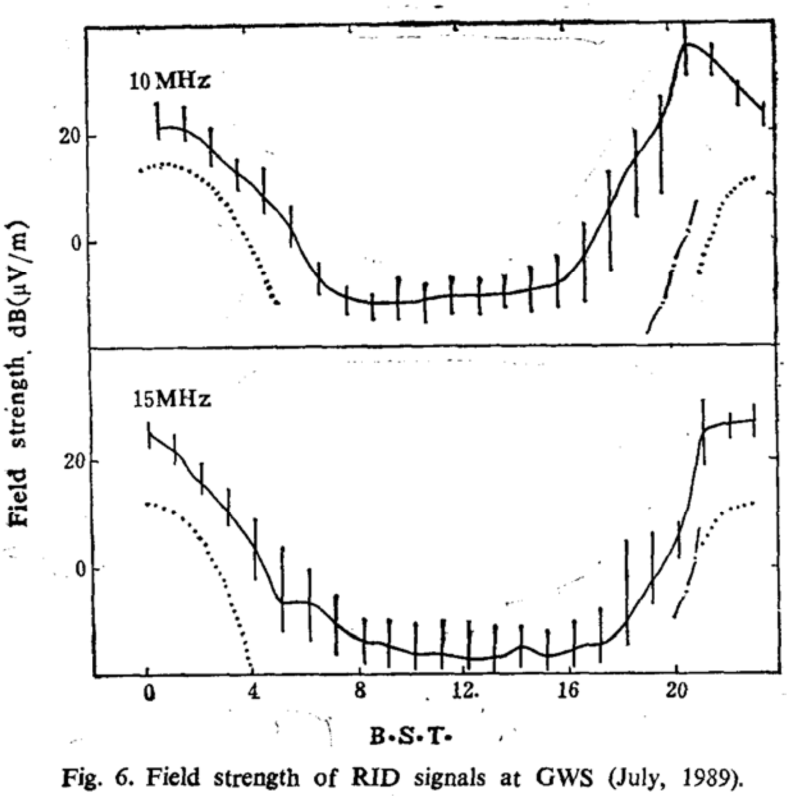

Fig. 6. Field strength of RID signals at GWS (July, 1989).

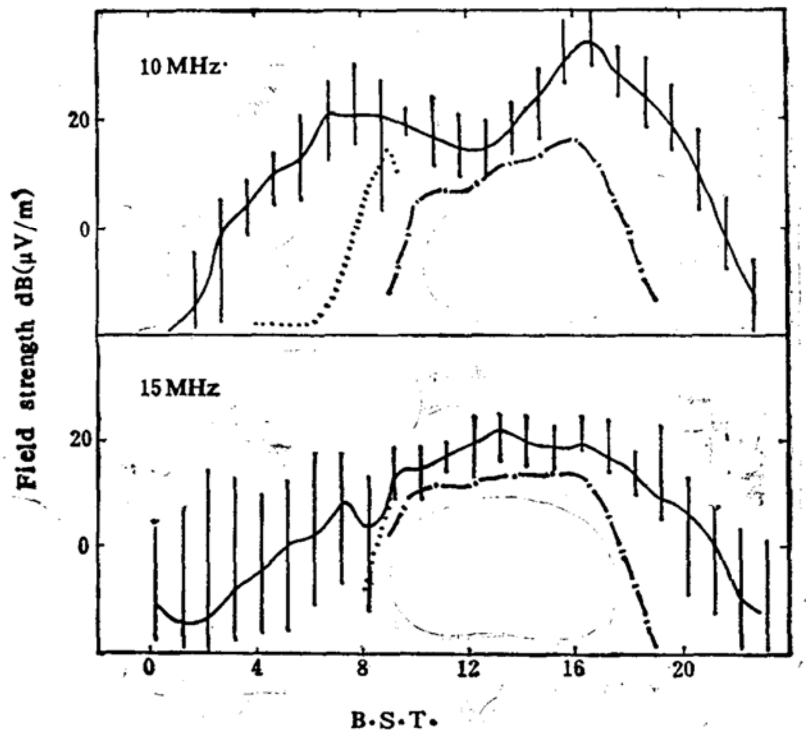

Fig. 7. Field strength of RID signals at GWS (October, 1989).

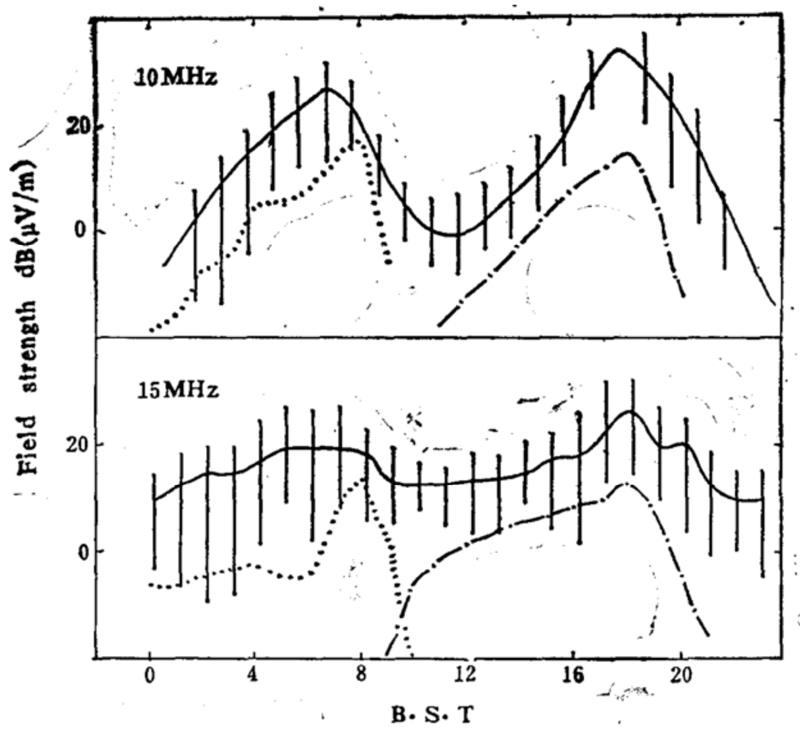

Fig. 8. Field strength of RID signals at GWS (January, 1990)

The calculated values of the HF field strength as well as the measured monthly meadians in April, July and October of 1989 and January of 1990 from Moskva and Irkutsk to the Great Wall station are shown in Fig. 1 through 8 respectively. in which, ... denstes the calculated value for the short great circle path and— • —for long great circle pa'h and——for measured value.

Fig. 1 through 4 show the propagation from Moskva to the Great Wall Station, the deviations of the calculated values from the measured monthly mean values are in a range from 6dB to 12dB for 10 MHz and 12dB to 16dB for 15MHz respectivety. Figs. 5 through 8. show the propagation from Irkutsk to the Great Wall Station, the deviations are in a range from 12dB to 21dB for 10MHz and 9dB to 16dB for 15MHz. Generally the deviaticns on the path from Moskva to the Great Wall Station are smaller than that on the path from Iruktsk to the Great Wall Station, and the calculated values for the latter are too small in comparison with the measured medians nearly all the time. Consequently, significant deviations exist between theoretical and experimental propagation field strengths. The main features are:

a) there is a great margin between theoretical values and experimental medians for both propagation paths.
b) theoretical values are small than experimental ones for propagation from irkutsk to the Great Wall Station.

5. Result and Discussion

It should be considered that there are two great circle propagation paths for the very long distance communication. In comparison with the propagation between BPM Station and Great Wall Station the measured medians are in good agreement with predicticns (Pu and Sun, 1990). there is a great deviaticn in the paths from Moskva and Irkutsk to the Great Wall Station. For the propagation from Moskva to the Great Wall Station. the predictions sometimes are greater than the measurements, but other times less, than the measurements for short great circle path. However predictions for long great circle path are less than the measurements nearly all the time. For the propagation from Irkutsk to the Great Wall Station, the predictions are less than the measurements, even though the great circle path propagation exists. A comprehensive analysis of propagation field strength data from BPM, RWM and RID stations to Chinese Great Wall Station on Antarctica shows that when the propagation distance is more than 17,000 km, the calculated values become less than the measured medians. This phenomena may result from the prediction method itself and the multipath propagation. There are many propagation paths existing in quasiantipode communication. Although the great circle paths are the most important and main ones in most time, non great circle paths also exist and their field strength is greater than that of the great circle paths during some periods of time. This has been verified in some cases (Du and Sun, 1990). Also, ncn "launch" or waveguide propagation model may take place in the very long distance propagation. The more details will be discussed elsewhere.

6. Conclusion

It was ascertained that there is a great margin between theoretical values and experimental medians of the field strength of RWM and RID signals during high solar activity period over the Chinese Great Wall Station on Antarctica. The calculated values are, on average, less than the experiments especially on the propagation path between RID Station and the Great Wall Station.

Then, the experimental field strength may be used as the basic data for research of HF propagation over the very long distance.

Because of the significant deviations between theoretical values and the measured values. It seems to be necessary to study the HF propagation over the very long distance in details, especially the propagation model.

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(*Received Janurary, 1991*)