Prediction of solar interference

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Abstract

When the sun, GMS and an antenna at the ground station are located in a line, signal reception from the GMS at the ground station is influenced by the solar noise.

This report describes the simple method, using several charts, of estimating accurate time when solar interference occurs.

1. Introduction

Relative position of the GMS, earth and the sun is important for the steady GMS operational schedule. When the sun, GMS and the antenna at the ground station are located in a line, that is, the sun and the GMS are located the same direction from the ground station, signal reception from the GMS at the ground station is influenced by the solar noise. This phenomenon is called solar interference. Solar interference occurrs for several days about the vernal equinox and the autumnal equinox. During these periods, the ground station can not detect normally the signal of the stretched VISSR or WEFAX from the GMS. Therefore, the time when solar interference occurs is of great importance on the steady communication with the GMS for the data utilization station.

2. Solar Interference and Satellite Eclipse

Like an eclipse of the sun and the moon, there are two types of the situation that the sun, earth and the satellite are located in a straight line : solar interference and satellite eclipse. The concept of solar interference and satellite eclipse is shown in FIGURE 1. Solar interference is caused by the satellite which comes between the sun and the earth, and satellite eclipse is caused by the satellite

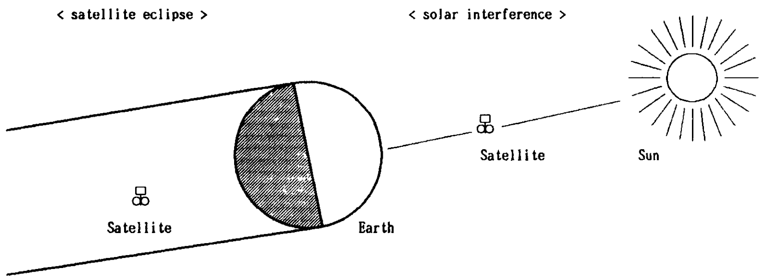

FIGURE 1 Illustration of solar interference and satellite eclipse

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which enters in the shade of the earth. Both are important for satellite operation. In case of a geostationary satellite, such as GMS, both occur in spring and autumn.

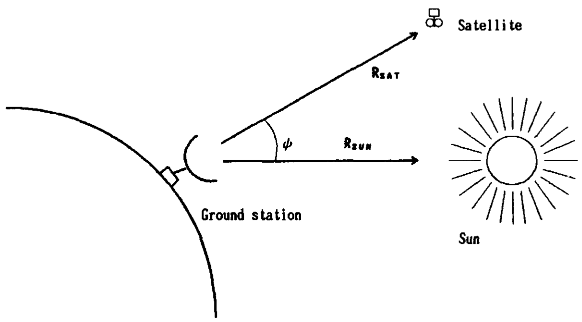


FIGURE 2 Illustration of an angle ϕ

3. Prediction of solar interference

3 − 1. Solar interference

The time and the date when solar interference occurs are determined from the following two elements : 1) the time and date when a satellite-sun digression is minimum and 2) threshold angle.

Referring to FIGURE 2, **R sun** is a vector from the ground station to the sun and **Rsat** is a vector from the ground station to the satellite. A satellite -sun digression ϕ is an angle between the satellite's vector **R sat** and the sun's vector **Rsun**. The method of determining minimum ϕ is described in the next section.

The threshold angle is determined from the maximum digression that solar interference can occur and the threshold angle is affected by the characteristics of the antenna at the ground station.

The concept of solar interference is shown in FIGURE 3. Solar interference occurs when the angle ϕ is less than the threshold angle : the sun locates in the netted area of FIGURE 3.

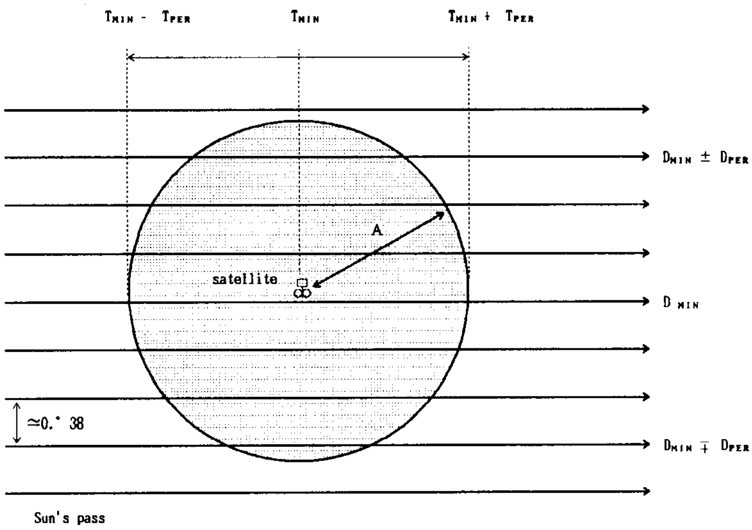
The date when solar interference occurs ranges from D_{MIN}-D_{PER} to $D_{MIN}+D_{PER}$, where D_{MIN} is the date when the angle ϕ is minimum and D_{PER} is the threshold angle ⁄0. 38 in days. 0. 38 deg ⁄ day is the mean change of the Sun's declination in a day about the vernal equinox and the autumnal equinox.

The time when solar interference occurs ranges from T_{MIN}-T_{PER} to $T_{MIN}+T_{PER}$. T_{MIN} is the time when the angle ϕ is minimum and T_{PER} is the threshold angle ⁄0.25 in minutes. 0.25 deg ⁄ min is the angular velocity of the earth.

3 − 2. Prediction chart

The time and the date when the angle ϕ is minimum are determined from prediction charts : FIGURE 4, 5. Dotted lines of FIGURE 4, 5 show the date when the angle ϕ is minimum and solid lines show the time when the angle ϕ is minimum. The date (dotted line) is calculated from the positions of the ground station and satellite relative to the earth center and the sun's declination. The time (solid line) is calculated from the positions of the ground station and satellite relative to the earth center and the sun's right ascension and the Greenwich sidereal time. As FIGURE 4, 5 are calculated on condition that the satellite is geostationary and the sub-satellite point is 0°lat. 140° long., they can only apply to GMS.

The sub-satellite point changes with time because satellite drifts due to external forces. As the result of this effect, the error of the date is within 3 days and the error of the time is within 1 minute. We must take this 3 days and 1 minute error into consideration when we estimate the time



A : threshold angle in degrees
DMIN : date when the angle ϕ is minimum
Dper : A／0.38 in days
TMIN : time when the angle ϕ is minimum
Tper : A／0.25 in minutes

FIGURE 3 Schematic diagram showing the concept of solar interference

and date of solar interference from FIGURE 4, 5.

3 − 4. Verification

Estimation of the time and date of solar interference in TOKYO (35°41'N LAT. 139° 46'E LONG.) in spring of 1989 is shown in FIGURE 6. From FIGURE 4 the time and date when the angle ϕ is minimum are 02 : 51UT, Mar. 6. This determination of the date contains 3 days error in its accuracy and the time 1 minute error. As the threshold angle is 1.2 degrees, for example, solar interference is estimated from Mar. 3 to Mar. 9, and the time when solar interference is estimated ranges from 02 : 46UT to 02 : 56UT.

Precise estimation of solar interference in spring of 1989 using the orbital element is shown in TABLE 1. Comparing the result of TABLE 1 with estimation from FIGURE 4, this simple method, using several charts, has a good accuracy for use to the date utilization station.

4. Conclusion

This report describes the simple method, using several charts, of estimating accurate time when solar interference occurs. This method has a good accuracy for use to the date utilization station.

Reference

Fukui, T. and M. Maeda, 1980 : Solar Noise Interference with GMS Down Link. Met. Sat. Center Tech. Note, 2, 3-14

Hasegawa, I., 1978 : Introduction to astronomical calculation. Kouseisha, TOKYO (in Japanese)

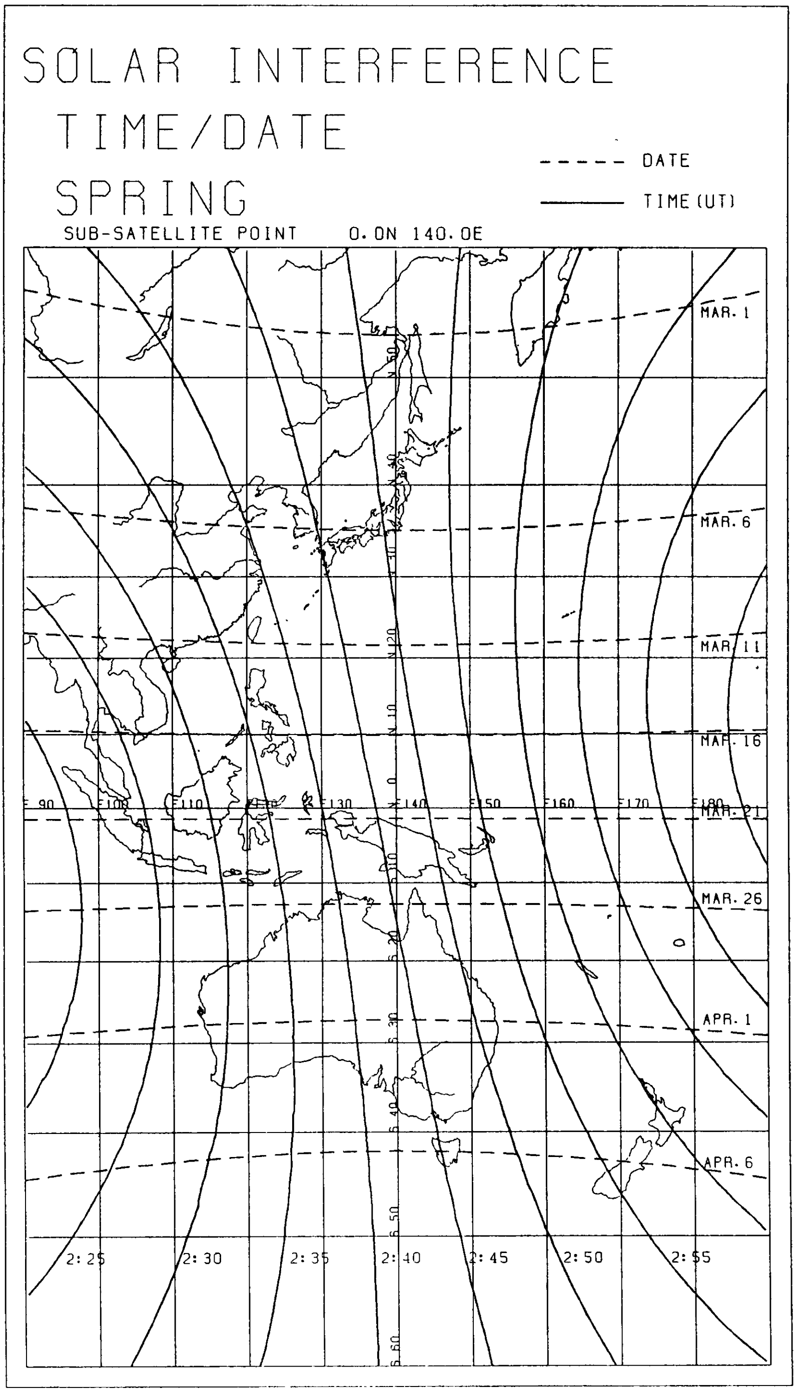


FIGURE 4 Prediction chart of solar interference in spring

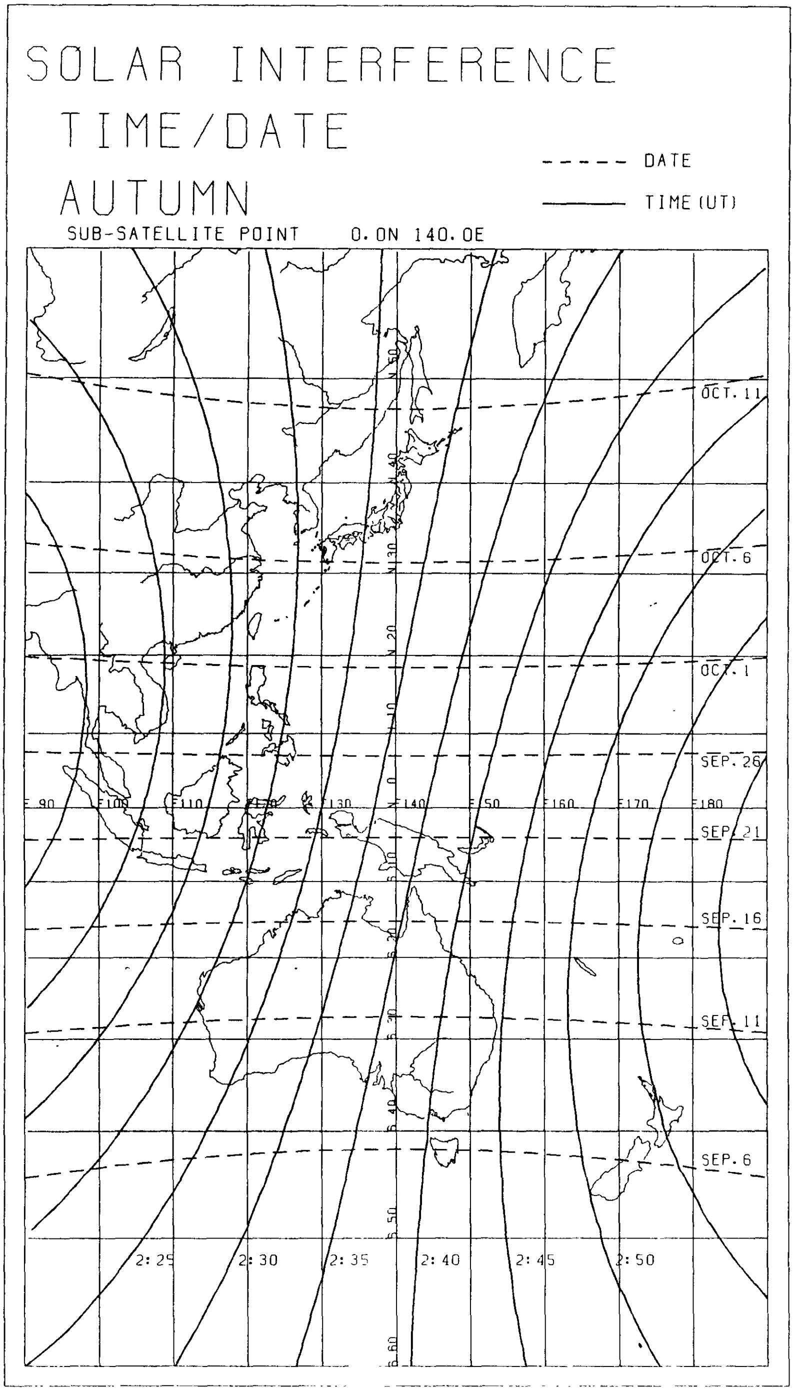


FIGURE 5　Prediction chart of solar interference in autumn

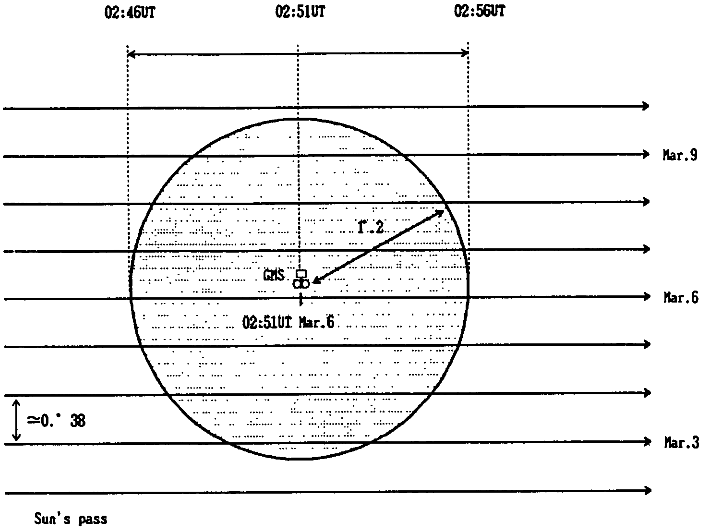


FIGURE 6 Example of solar interference estimation in Tokyo in spring of 1989. The time and date when the angle ϕ is minimum:02:51 UT, Mar.6 have 3 days error and 1 minute error.

TABLE 1 Precise estimation of solar interference in TOKYO

Threshold crossing time information threshold angle=1.200(DEG)

	CROSSING IN	CROSSING OUT
YY MM DD	HH MM SS	HH MM SS
89 02 28	.. .. ..	.. .. ..
89 03 01	02 48 57 UT	02 54 33 UT
89 03 02	02 47 14	02 55 39
89 03 03	02 46 21	02 55 53
89 03 04	02 46 02	02 55 34
89 03 05	02 46 17	02 54 42
89 03 06	02 47 24	02 53 00
89 03 07	.. ..	.. .. ..

太陽妨害の予測

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太陽とGMSと地上局のアンテナが一直線上に並ぶとき、つまり、地上局から見て太陽とGMSが同じ方向に見えるとき、太陽から放射される電波によりGMSからの電波が妨害を受ける。これを太陽妨害といい、春と秋にそれぞれ数日間発生する。太陽妨害により地上局ではGMSから送信されるストレッチドVISSRやWEFAXの信号が正常に受信できなくなることがあり、データ利用局では太陽妨害の発生する日時を正確に把握することが重要である。

ここでは、図を利用した簡単な太陽妨害の予測の方法を紹介する。