ACTS PROPAGATION EXPERIMENT AND SOLAR/LUNAR INTRUSIONS

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ABSTRACT

In this paper are described the effects that solar and lunar intrusions have on statistical analysis of the data. The NASA ACTS experiment focuses on the 20 and 27 GHz radiometer and beacon. The experiment is currently compiling a database for the attenuation for these different channels. For the year of 1994 our sight obtained 86.5 hours of attenuation and for 1995 our sight obtained 77 hours of attenuation. The total amount of interference time for sun/lunar intrusions for 1994 and 1995 was respectively, 39 hours and 38.5 hours, which is nearly half the total amount of attenuation due to rain and cloud fades. It is clear to see why this data must be taken out for any type of statistical analysis of the data.

KEY WORDS

NASA ACTS propagation experiment, solar lunar intrusions, rain attenuation

INTRODUCTION

NASA ACTS propagation experiment's main goal is to find a relationship between the noise ratio and attenuation of a signal in the 20 and 27 Gigahertz channels, Another main objective is to build up a propagation database and be able to compare to it to such models as CCIR, CRANE Global, etc... This is done by recording data on the 20 and 27 GHz channels at intervals of I/sec beacon , 1/sec sky temperature (radiometer), and 1/6 sec rain gauge recordings.

The data is processed by NMSU using ACTS software. The program produces an output file which is used for recording keeping and for further analysis of the rain data. Also a record is kept of the plots for the sky temperature and of the signal attenuation plot (for both channels)

PROBLEM STATEMENT AND SOLUTION

The original protocol for processing the data produced in the experiment did not account for sun outages and lunar intrusions. The processing protocol is described in [2]. A solar/lunar intrusion is noticeable when the sun or moon interference is within one degree of ACTS position on the sky. The interference effects the radiometer signal in both the 20 and 27 Gigahertz channels.

Intrusions have a noticeable pattern unlike attenuation caused by rain which is sporadic and has no true shape. Therefore, an intrusion is easy to notice on a plot of the signal, consequently the bad data can easily be removed. This way of finding solar/lunar intrusions events is time consuming susceptible to human error. Although, the error can be corrected though using simple prediction techniques of determining exactly when the event will occur.

The prediction of when an event will occur depends on the relative position of the sun/moon in reference to the incoming signal as seen from the ground base receiving station. Sun intrusions occur twice a year for about a period of a week, which is due to the earth's tilt near the equinoxes. A moon intrusion is due to its rotation around the earth and what side it showing to the receiver during the critical angles. For example, a new moon will give off no radiation, and will not affect the signal. On the other hand, if the moon is in its full moon stage, the maximum amount of interference will be seen in the signal. See Figure 1 for an example of a solar intrusion.

In order to know when these intrusions will occur NMSU created prediction software[3]. The program was designed such that it tells you at what time the maximum angle will occur. This can be used to predict either Sun or moon intrusions, which can then be used to determine the maximum amount of interference which will occur. The programs are based on standard astronomical formulas [4] and validated against known positions [1].

An interference pattern for a sun intrusion is greater than that of a moon intrusion. The effects from the average sun intrusion can be seen from about an hour before and after the maximum predicted time for when the event will occur. Where the effects of a moon intrusion can be seen about thirty minutes before and after its maximum predicted time.

If this data is not removed it will interfere with the data statistics of rain attenuation has actually occurred. This is because a sun of moon intrusion appears to the processing software as an increase in sky temperature which is interpreted by the software as a cloud fade. This is even more harmful to our location, because being in a desert climate the total amount of rain fall is between 12 to 16 inches per year. Meaning that there is only a small amount of time in which we can collect any data on fading events for our database. So any interference such as solar/lunar intrusion will have a significant effect on our total amount of attenuation if it is allowed to remain in our statistics.

As shown in tables 1 & 2, by comparison it is clear to see that if a sun or moon intrusion is allowed to remain as valid data, it would give a totally inaccurate period of the total amount of rain attenuation. Table 1 is the raw data of how many minutes have been lost due to solar/lunar intrusions since the experiment began. We found the total amount of time lost to the interference was 39 hours in 1994 and 38.5 hours in 1995. Table 2 is the total amount of attenuation due to rain and cloud fades. We found the total rain attenuation to be 54.5 hours for 1994 and 36 hours for 1995. The total amount of attenuation for cloud and rain fades for 1994 and 1995 respectively were 86.5 hours and 77 hours. The total amount of interference from the sun is nearly half of the total amount of rain/cloud attenuation. Therefore, it is obvious that if the solar/lunar intrusions are left in, they would have a dramatic effect on any statistics ran on the data.

Using the ACTS software the intrusion data is marked as “bad data” and removed for the given event. Noting that we must allow for even the smallest attenuation, the data must be marked bad or removed well before the effects of the event occurs. The final output file, for record keeping, is absent any solar/lunar event that has occurred and then is stored for our database.

The amount of time lost to solar and lunar intrusions is significant enough to worry about in any study wanting an accurate and correct representation of data. Even sites such as Florida must worry about such type of interference. Since Florida is a tropical climate, the total amount of rain attenuation is much greater than the total amount of outage time due to solar/lunar intrusions. Even though this is true, if you ignore the solar/lunar outage times then you are not obtaining an accurate representation of your data, therefore this data should not be used as any type of database.

TABLES

Table 1

Year	Total Lunar	Total Sun	Total time
1994	11 hours	28 hours	39 hours
1995	10.5 hours	28 hours	38.5 hours

Table 2			
Quarter	Total rain time	Total Cloud Fade Time	Total Attenuation Time
Dec 93 - Feb 94	0 hours	11 hours	11 hours
Mar 94- May 94	23 hours	6 hours	29 hours
June 94 -Aug 94	22.5 hours	No Data	22.5 hours
Sep 94 - Nov 94	9 hours	15 hours	24 hours
Dec 95 - Feb 95	4 hours	7 hours	11 hours
Mar 95- May 95	0 hours	4 hours	4 hours
June 95- Aug 95	21 hours	9 hours	30 hours
Sep 95 -Nov 95	11 hours	21 hours	32 hours
Total	90.5 hours	73 hours	163.5 hours

CONCLUSION

Solar and lunar intrusions play a major role in determining when and what you can do with your antenna. With any moveable ground base receiver it is very important that you take in to account that you can not trust any data obtained in which it contains interference from the sun/moon. In large receivers there is the dangerous possibility of literally frying the components of the receiver.

In conclusion this paper shows the significance of solar/lunar intrusions on data, the need to remove the data, and also how it ruins statistical analysis of the data. A better understanding of the original experiment can now be made through the prediction and removal of solar and lunar events.

REFERENCES

[1] Nautical Almanac Office, The Astronomical Almanac for 1990, Washington: Government Printing Office, 1989.

[2] Feldhake, G.S., Ka Band Satellite Propagation Characteristics Using ACTS Las Cruces: NMSU, 1995.

[3] Horan, S., Acts Propagation Experiment Program Sun an Moon Intrusion Predictions, Las Cruces: NMSU, 1995.

[4] Mecus, J., Astronomical Formulae for Calculators, 4th ed., Richmond: Willmann-Bell, 1988.

FIGURES

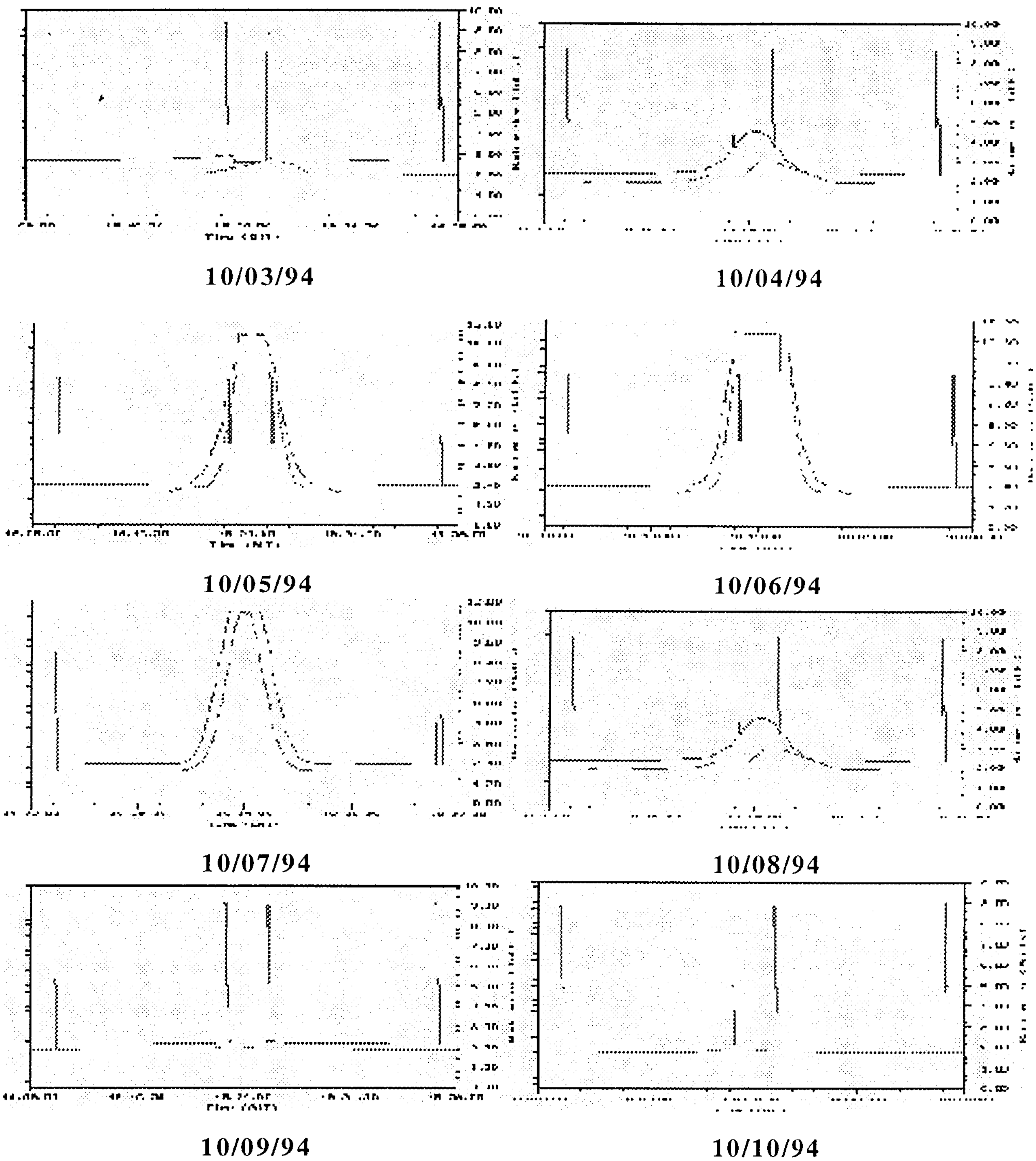

Figure 1. A solar intrusion event sequence. Lunar intrusions appear similar to the 10/03/94 solar intrusion event.