AD-A191 894 DATA NEEDED TO VERIFY/QUANTIFY MODELS(U) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA A K PAUL AUG 86 1/1

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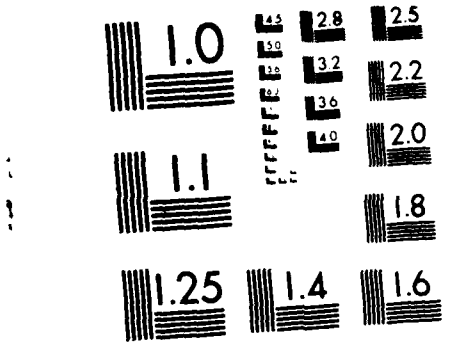

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REPORT DOCUMENTATION PAGE

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1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Ocean Systems Center 6b. OFFICE SYMBOL (if applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) San Diego, CA 92152-5000	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Office of Naval Technology 8b. OFFICE SYMBOL (if applicable) ONT	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code) Arlington, VA 22217	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO: 62759N; PROJECT NO: SXB3; TASK NO: ; AGENCY ACCESSION NO: DN888 715

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MAR 1 1 1988
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11 TITLE (Include Security Classification)

Data Needed to Verify/Quantify Models

12 PERSONAL AUTHOR(S)

A.K. Paul

13a TYPE OF REPORT	13b. TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Journal Article	FROM _____ TO _____	August 1986	

16. SUPPLEMENTARY NOTATION

17 COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Advanced digital ionosondes have two advantages compared with the classical analog systems. They are able to record the full information content of an echo reflected from the ionosphere with high precision in digital form. In many instances, those data can be processed on a computer with little or no interaction by an operator.

An echo is characterized by its frequency, travel time, or virtual height, amplitude, and phase relative to the phase of the transmitted pulse. The frequency is related to the plasma frequency or electron density at the reflection point, the virtual heights are needed for the computation of electron density profiles, while the amplitude is mainly determined by the absorption coefficient along the path of the signal. The most complex information is contained in the phase. The polarisation of an echo can be obtained from the change of the phase with antenna orientation, the change of phase with frequency permits improved precision of the virtual heights. The change of phase with time is the doppler frequency and the variation of the phase with distance over a plane yields the angle of arrival.

The automatization makes the processing more economic, permitting for instance much higher temporal resolution than the standard one ionogram per hour sequence.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION	
☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	UNCLASSIFIED	
22a NAME OF RESPONSIBLE INDIVIDUAL A.K. Paul	22b TELEPHONE (Include Area Code) 619-225-7688	22c. OFFICE SYMBOL Code 544

DATA NEEDED to VERIFY/QUANTIFY MODELS

Adolf K. Paul

Naval Ocean Systems Center, code 544

Ocean and Atmospheric Sciences Division

San Diego, California 92152-5000

Advanced digital ionosondes have mainly two advantages compared with the classical analog systems: they are able to record the full information content of an echo reflected from the ionosphere with high precision in digital form and in many instances those data can be processed on a computer with little or no interaction by an operator.

An echo is characterized by its frequency, travel time, or virtual height, amplitude and phase relative to the phase of the transmitted pulse. The frequency is related to the plasma frequency or electron density at the reflection point, the virtual heights are needed for the computation of electron density profiles, while the amplitude is mainly determined by the absorption coefficient along the path of the signal. The most complex information is contained in the phase, the polarization of an echo can be obtained from the change of the phase with antenna orientation, the change of phase with frequency permits improved precision of the virtual heights, the change of phase with time is the doppler frequency and the variation of the phase with distance over a plane yields the angle of arrival.

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We will see in the following that some of the features mentioned are important for constructing and testing of ionospheric models.

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In figure 1 we show the deviations of individual foF2 values recorded in 15 minute intervals from their mean values over 11 days. The little horizontal bars on the right edge of the figure represent the average deviation for each individual day.Two important facts are evident in this presentation:

1.) The magnitude of the deviations do not seem to depend on the the time of the day,even foF2 is twice as large during the midday hours than during the pre-sunrise hours.

2.) The average day-to-day variation is much smaller than the short term variations with periodicities of two hours and less.The often quoted day-to-day variability based on hourly observations appears to be due to undersampling and aliasing.

The same situation is demonstrated in a different way in figure 2. The upper portion shows a sequence of 7 days of foF2 in 15 minute intervalls, the lower portion the corresponding deviations from the mean diurnal variation which was computed over a period of 20 days.There are definitely differences from one day to the next for a given hour of the day,but the periodicities present in the deviations from the mean are always much shorter than the 24 hours of the day.

Figure 3 compares the deviations from the 20 day mean of the MUF(3000), the maximum usable frequency over a 3000 km path (upper part) with the deviations of foF2 over a 7 day period (lower part).The close correlation of the two parameters which are derived from different portions of the ionogram proves that the variations are due to real changes taking place in the F-region and not due to inaccuracies of the processing methods.

A closer inspection of the two parameters,when high temporal resolution data are available,shows that maximum correlation is obtained for a timelag of approximately 3 minutes,MUF(3000)

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lagging behind foF2.This effect is consistent with the propagation of gravity waves and we can assume that most of the variations observed are caused by gravity waves. This of course means that the observed temporal variations are coupled with spatial variations and correspondingly with local deviations of the ionosphere from horizontal stratification (tilts).The consequences of tilts on ionogram interpretation can best be studied by comparing a sunrise model with observations (Paul,1985).As an example we compare in figure 4 the zenith distance as a function of frequency as it was observed with the data computed from our simulation model.The maximum deviation of the apparent ray direction (observed and simulated) from vertical comes close to 20 degree.This indicates strong bending of the ray inside the F-region coupled with a large increase of the actual and virtual path length. If the virtual path lengths are interpreted as virtual heights for the purpose of electron density profil calculations,the errors can be severe.The same simulation study which produced figure 4 showed that the height of the F-region maximum was overestimated by one scale height. Judging from the temporal variations of F-region parameters,we have to assume that deformations of the F-layer comparable with the sunrise situation can occur any time on days of high variability.In situations like this the profile errors due to tilts are often larger than those due to uncertainties in the parameters for the electron density minimum between E- and F-region (valley).

While temporal variations of F-region parameters provide evidence for the presence of tilts in the layer,this is not true in sporadic E observations.Oblique reflections from a small area of an Es-layer with zenith angles of 20 degree and more have been observed frequently (Paul,1986).Here the measurement of the angle

of arrival is essential for the distinction between range and height.There is sufficient reason to believe that sporadic E statistics involving the socalled virtual heights are significantly erroneous and overestimate the heights of sporadic E-layers and the height range of their appearance.

Another area of interest and in need of improvement is the ionospheric absorption and collision frequency model.It is well known that often several Es-layers can be embedded in the lower E-region with maximum electron densities exceeding the background density only by a small amount.Scanning through this range with increasing frequency results to echoes beeing reflected alternatively from regular and sporadic E-layers showing large differences in their amplitudes (Bibl et al.1965).Separation of the two types of reflections is very tedious when done in analog fashion,but is essential for obtaining a correct description of the regular E-region absorption and collision frequency profile.If amplitude data in digital form (including calibration) are available,the discrimination between the two cases mentioned is relatively simple.Processing the amplitude data of ionograms a few times during the day may be sufficient to obtain the diurnal variation of the absorption.For modelling of special events,like the high absorption caused by X-ray flares,much higher temporal resolution is required.

The few examples shown here demonstrate the progress possible for collecting ionospheric information with modern technology,but also the need for correcting some of our traditional models and modes of operation.It also appears that the improved accuracy of the traditional data plus the new types of measurements may enable us in the near future to include the dynamic of the ionosphere in the models,at least in the form of short term updating.

References

Bibl.K,A.Paul and K.Rawer,Some results of absorption measurements at Freiburg (Germany),J.A.T.P.,27,145-154,1964

Paul,Adolf K., F-region tilts and ionogram analysis,Radio Sci. 20,959-971,1985

Paul,Adolf K.,Limitations and possible improvements of ionospheric models for radio propagation: Effects of sporadic E-layers, Radio Sci.,21,304-308 1986

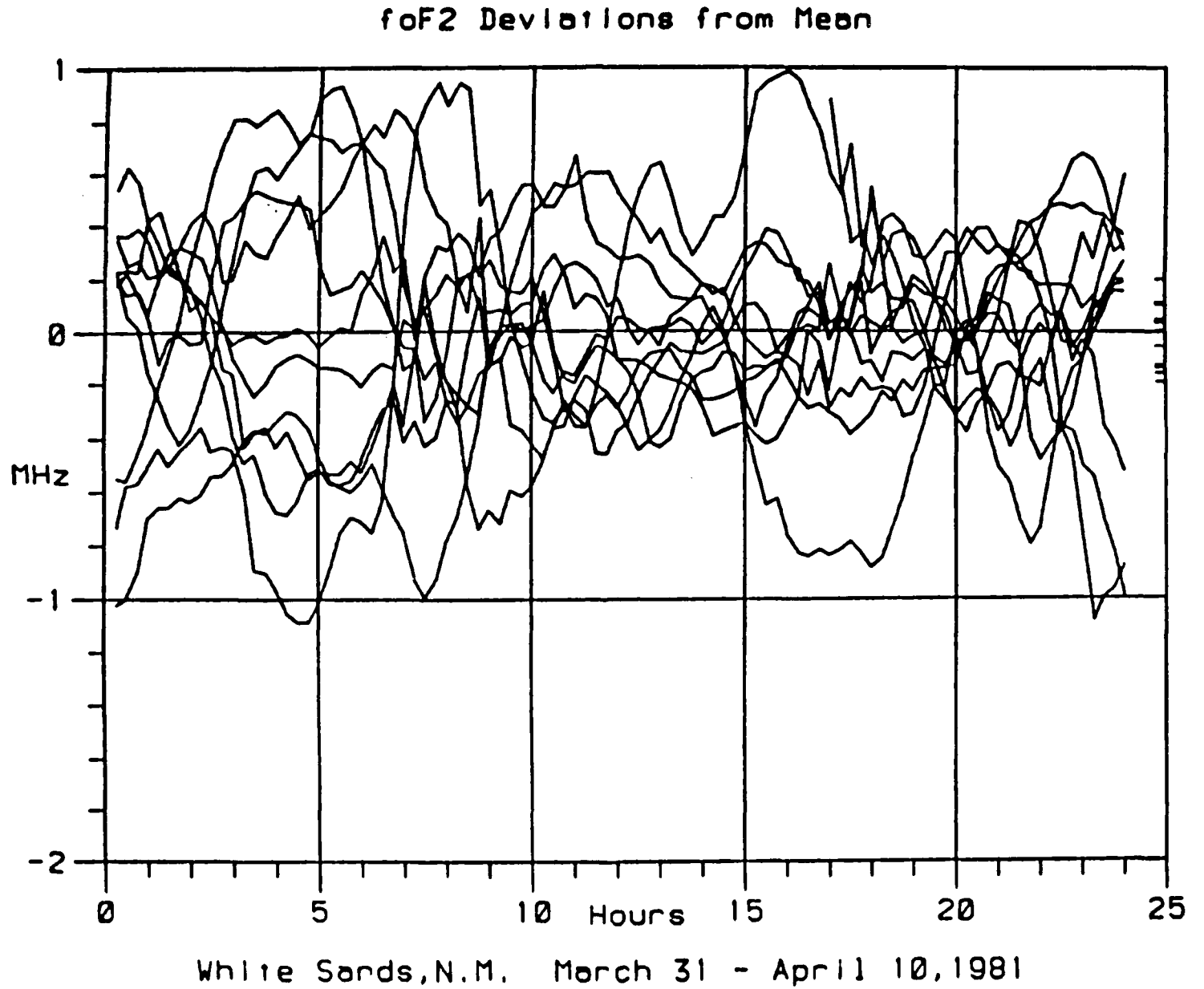
Figure Captions

figure 1 : Superimposed diurnal variations of the deviations from the average foF2. The short horizontal bars on the right side indicate the average deviation for each individual day.(15 minute sampling intervals).

figure 2 : Diurnal variations of foF2 (upper part) and the deviations from the 20 day average (lower part). (15 minute sampling intervals).

figure 3 : Comparison of the deviations from the mean value of MUF(3000) (upper part) and the deviations from the mean value of foF2.

figure 4 : Zenith angle as a function of frequency for sunrise condition observed (top) and simulated (bottom).


foF2 Deviations from Mean
1
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5
10
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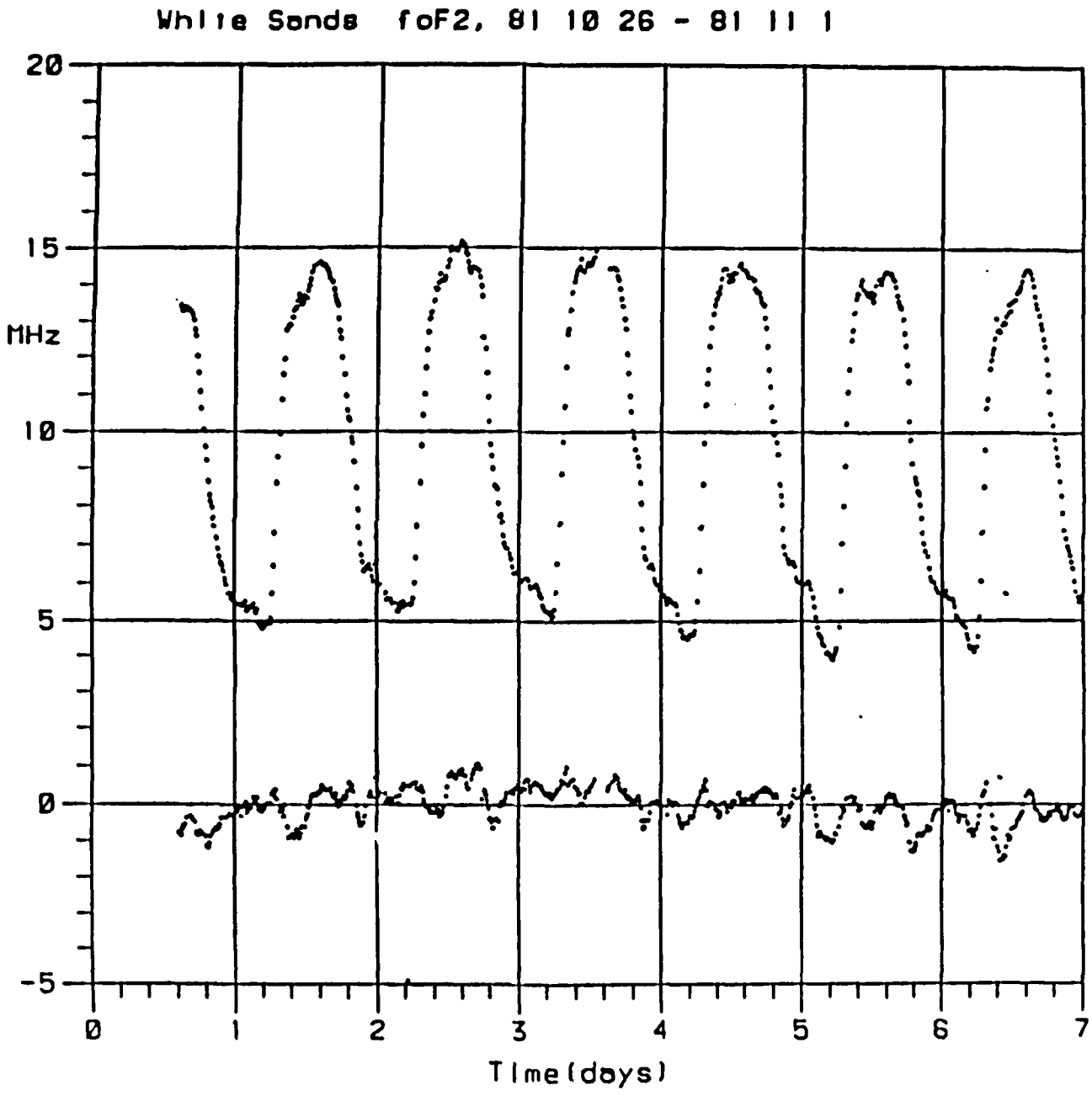
25
Hours
White Sands,N.M. March 31 - April 10,1981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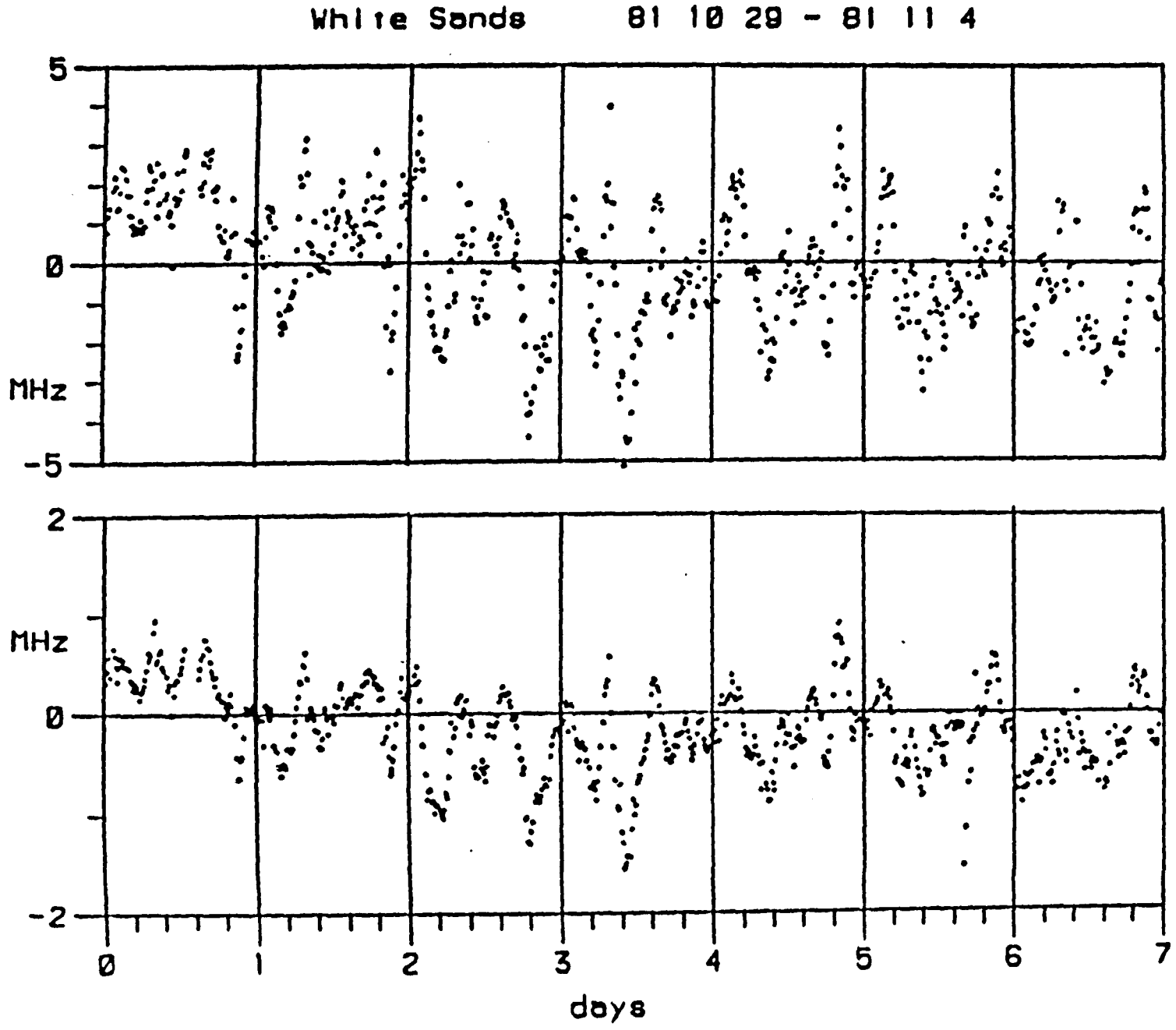
Time(days)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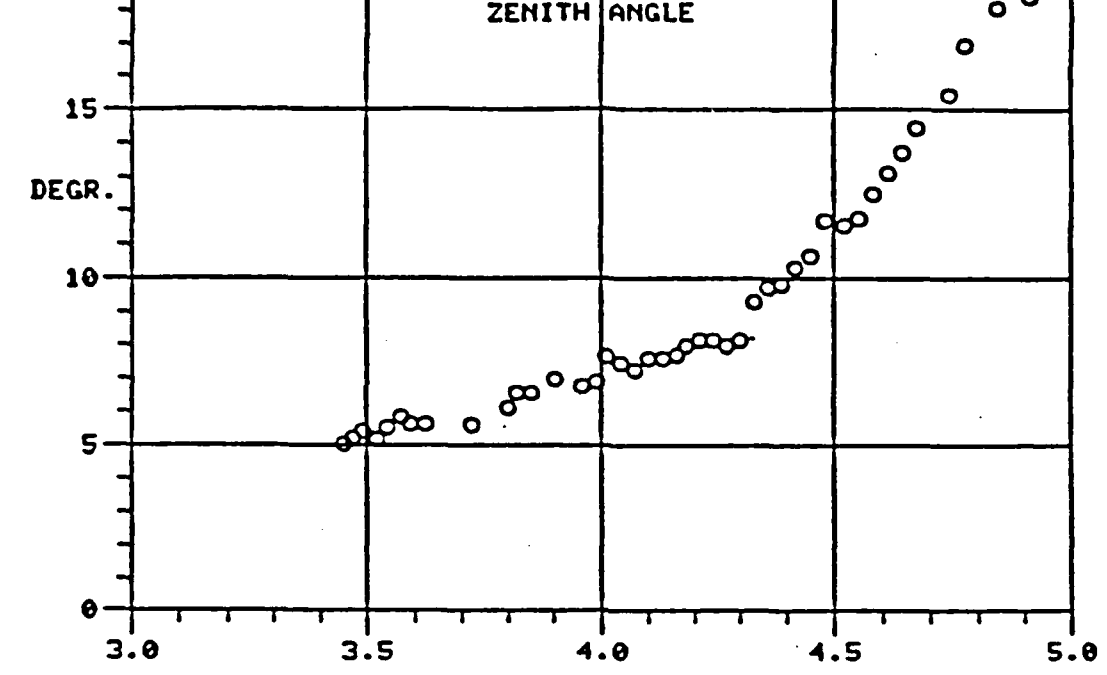
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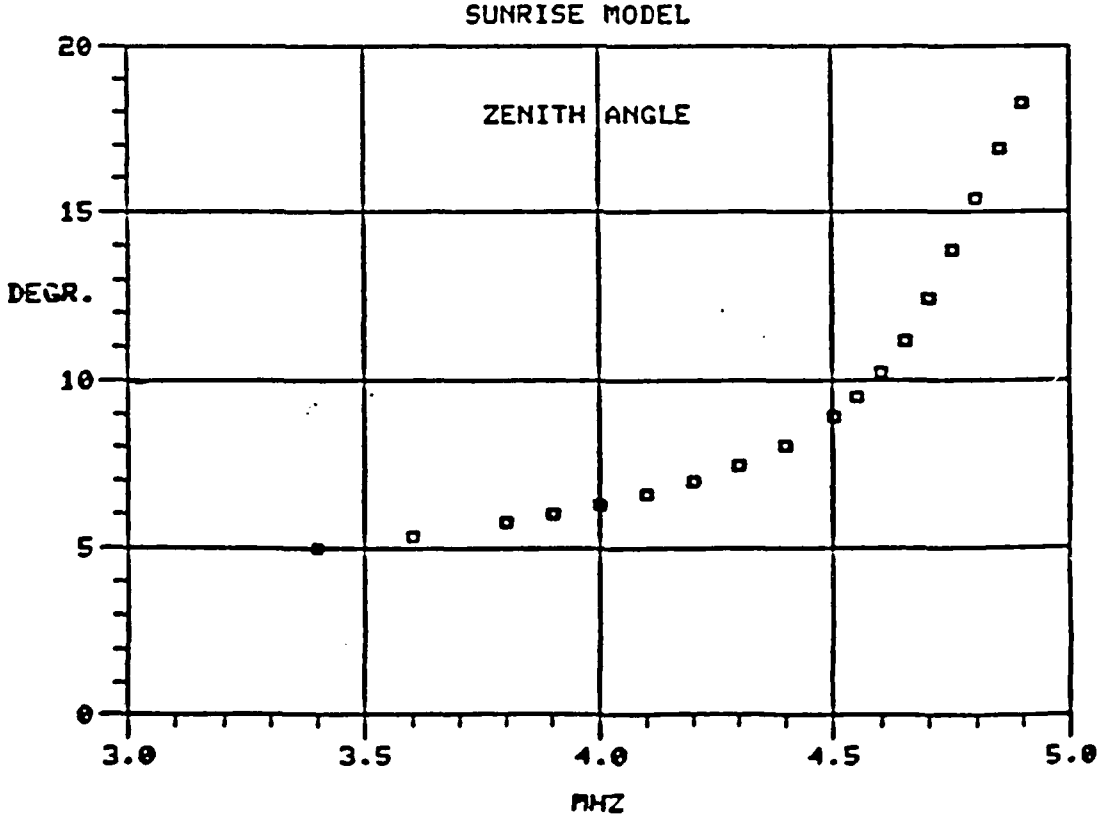
SUNRISE MODEL
ZENITH ANGLE
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