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ABSTRACT

A comparison of two High Frequency background noise measuring systems (BNMS) that employ different hardware and signal processing techniques has been conducted. One system was part of the Frequency Management System at the Jindalee over-the-horizon radar Facility at Alice Springs (JFAS) and the other system was based on a design supplied by the UK's Defence Evaluation Research Agency. The UK BNMS was placed at JFAS so that both systems could independently analyse the same external noise environment. The measurements from both BNMS were compared with the International Radio Consultative Committee (CCIR) HF atmospheric background noise model.

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Executive Summary

HF surface wave radar (HFSWR) predictions require estimates of the local background noise in the HF band to predict the signal-to-noise ratio for a given target. Most HFSWR performance prediction models use the International Radio Consultative Committee (CCIR) HF atmospheric background noise model to provide this data. Comparisons made between the CCIR model and experimentally measured background noise levels in Australia, the USA and the UK, presented at the April 1998 meeting of TTCP SEN-AG-1, have established varying levels of agreement between model and experimental data. It was not clear whether these differences were due to variations in the accuracy of the CCIR model at the various measurement locations or to the inherently different hardware and signal processing used in the various background noise measuring systems (BNMS). In an effort to establish the cause of this discrepancy, it was decided to co-locate the Australian and United Kingdom noise measuring systems to independently analyse the same external noise levels.

The UK Defence Evaluation and Research Agency (DERA) contributed their BNMS design and some hardware and software, so that one of their systems could be installed at the Jindalee Facility at Alice Springs (JFAS) in Central Australia. The Frequency Monitoring System (FMS) at JFAS includes a BNMS, which was the Australian sensor in this comparison. Side-by-side measurements were made during July 1999.

For each BNMS, the measured background noise spectral densities were corrected for the effects of the receiving signal chain and antenna gain to obtain the noise power levels external to the antenna. Estimates of the monthly median background noise spectral density as a function of both time of day and HF frequency were then produced. This allowed direct comparisons between the two systems and the CCIR model output. The two systems used very different techniques for determining the background noise based on the raw measurement data, with the UK method relying heavily on assumptions about the noise and signal environment being sampled.

Despite these differences, there was fairly good agreement between the two systems. Generally, there was a small systematic bias evident with the UK results a few dB higher (median = 2.5 dB) than those for the JFAS FMS, but they rarely differed by more than 6 dB. It is believed that this bias is due to incorrect values for "detection losses" that are employed in the UK BNMS signal processing. Much larger differences were evident when the measurements from either BNMS were compared with the CCIR predictions for quiet rural noise in winter at Alice Springs. For frequencies below

18 MHz during local daytime, the measured background noise spectral density was more than 10 dB lower than the model predictions. It is believed this discrepancy is due to the CCIR model including data from only two Southern Hemisphere sites (compared with 25 in the Northern Hemisphere) and the model not including a solar cycle dependency.

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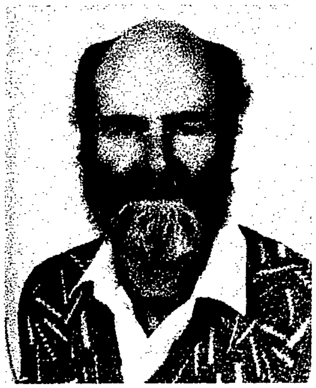
He joined DSTO in 1995 and has worked mainly in the areas of HF background noise and spectral occupancy in relation to the Jindalee over-the-horizon radar Frequency Management System.



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Phil Whitham completed his physics PhD at the University of Tasmania in Hobart in 1979. His field of study was the high frequency radio astrophysics of Jupiter and the galaxy. Since then he has been employed by DSTO where he has been engaged in research on several aspects of over-the-horizon (OTH) radar including radar control, signal processing and ionospheric physics. He currently leads the section responsible for research and development of OTH radar management.

Contents

1. Introduction

1.1 The Requirement for Background Noise Data

High Frequency Surface Wave Radar (HFSWR) performance prediction models require estimates of the local background noise levels in the HF band to compute the signal-to-noise ratio for a given target. The International Radio Consultative Committee (CCIR) provide models of HF atmospheric background noise based on measurements made at twenty seven sites around the world from 1957 to 1968. Members of TTCP SEN-AG-1 (HF Surface Wave and Line-of-sight Radar Action Group) have made their own measurements and, at an April 1998 TTCP meeting, they presented comparisons of their data with the CCIR background noise model data. One member (Australia) reported major differences between the measurements and the CCIR predictions whereas other members (UK and USA) reported reasonable agreement between their data and the CCIR model. It was not clear whether these differences were due to variations in the accuracy of the CCIR model in the members' countries or to the inherently different hardware and software used in the members' background noise measuring systems (BNMS).

To establish the cause of these discrepancies, the June 1999 Annual Report of TTCP SEN-AG-1 stated that members should establish an "inter-comparison" of the noise spectral densities (NSDs) as measured by the various national sensors. This report documents the comparison of the Australian and UK BNMS. (At this stage, the USA and Canada have not been funded for this project.) To facilitate this comparison, the two BNMS had to be at the same location and independently collect and analyse the same external noise levels. The UK Defence Evaluation and Research Agency (DERA) provided their BNMS design and some hardware and software, so that one of their systems could be installed at the Jindalee Facility at Alice Springs (JFAS) in Central Australia. The Frequency Monitoring System at JFAS includes a BNMS, which was the Australian sensor in this comparison.

1.2 Antenna Noise Factors and Figures

The noise power received from sources external to an antenna is commonly expressed in terms of the effective antenna noise factor, f_a, which is defined by

$$f_a = p_n / kT_0b$$

where
p_n = noise power available from an equivalent loss free antenna (W)
k = Boltzmann's constant = 1.38×10^{-23} J/K
T_0 = reference temperature taken as 288 K (i.e. 15 C)
b = effective receiver noise bandwidth (Hz)

The noise factor f_a is often given by the corresponding antenna noise figure, F_a, where

$$F_a = 10 \log f_a = 10 \log (p_n/b) - 10 \log(kT_0) = NSD + 204$$

where NSD = noise power spectral density available from an equivalent loss free antenna (dBW/Hz). This formula shows the relationship between an antenna noise figure (in dB) and the corresponding noise power spectral density, NSD (in dBW/Hz). The CCIR reports publish their noise data as antenna noise figure data, F_a in dB for a lossless short vertical antenna over a perfectly conducting ground plane.

2. Collection and Processing of Data

2.1 JFAS FMS Background Noise Monitor

2.1.1 Measurements

Since 1984, background noise measurements have been made by the Background Noise Monitor (BNM) sub-system of the Frequency Management System (FMS) of the Jindalee over-the-horizon-radar (OTHR), operating near Alice Springs. Earl and Ward (1987) have described the FMS in detail. The background noise measurements for this experiment were made with an omni-directional whip antenna. Prior to each set of BNM measurements, the FMS Spectrum Monitor is used to identify the quietest 20 kHz channel in each 1 MHz band from 5 to 44 MHz. Then for each 1 MHz band, the BNM receiver is tuned to the quietest 20 kHz channel. Ten sets of data are acquired, which after spectral analysis, provide 1000 individual estimates at 200 Hz resolution across the 20 kHz channel. 200 Hz frequency bins contaminated by RFI are eliminated and then any sets containing impulsive interference are rejected. The remaining estimates are averaged to produce a background noise estimate for that 1 MHz band. (The VHF data from 30 to 44 MHz is collected from a separate antenna).

The frequency range 5 to 44 MHz is scanned four or five times per hour. A week's worth of raw BNM data is sent to DSTO Salisbury (South Australia), where it is edited for failures, e.g. any measurements that are below internal noise are rejected. Each day's worth of "good" data is then smoothed, averaged and interpolated to produce "processed" data at time and frequency resolutions of 15 minutes and 200 kHz respectively.

When a month's worth of JFAS FMS processed background noise has been produced, the lower decile, median and upper decile values of background data are produced for each time-frequency bin across the month. This statistical noise data are NSDs measured at the input of the BNM receiver. To convert this data to external noise power spectral densities available from an equivalent loss free antenna, the internal noise component of the NSD at the receiver input is subtracted using measurements of internal noise (obtained by terminating the antenna output in 50 ohms). Then the data is adjusted for the known, i.e. measured, gains or losses between the receiver input and the antenna output. Finally, corrections for the antenna mismatch and ground losses are applied. The ground loss is computed by using a mathematical model of the antenna. Because the JFAS BNM omni-directional whip antenna is almost identical to the antenna used to collect the CCIR data, the JFAS BNM data can be compared directly with CCIR data without the need for an antenna correction factor.

2.1.2 Median Background Noise Data

Our original intention had been to collect DERA BNMS data at JFAS for a calendar month and then compare this data with the median JFAS FMS data for that month. However, due to circumstances beyond our control, the data collection for the DERA BNMS was from June 27 to July 22 1999. Unfortunately, during this period, a major upgrade of the JFAS FMS was in progress, which significantly reduced the volume of FMS BNM data. Consequently, the July JFAS FMS median background noise data could not be computed for a significant number of 15-minute periods. (The DSTO monthly statistics algorithm requires, for any 15-minute period, that data be available for at least 10 days in the month.)

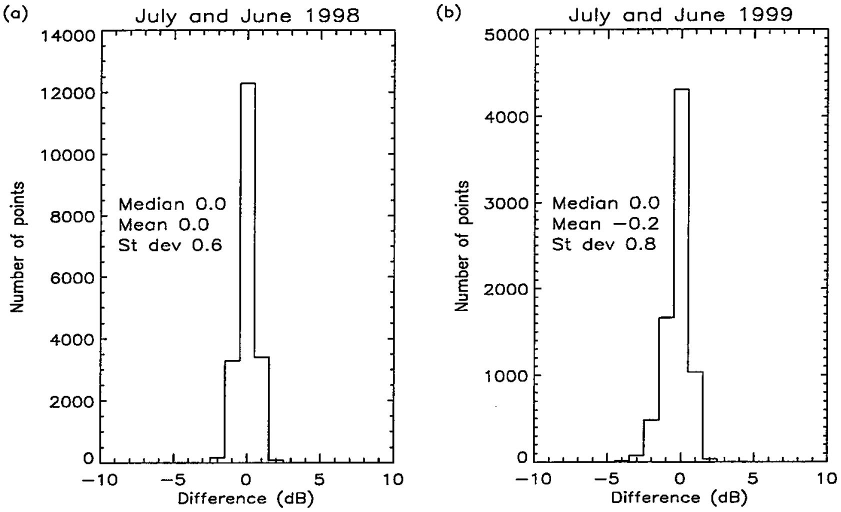

Figure 1: Histograms of median JFAS background noise data, for July minus June, for 1998 (a) and 1999 (b), respectively. The narrow peaks centred on 0 dB demonstrated that there was little difference between the adjacent months, in either year.

Provided there were no significant differences expected or observed between the June and July 1999 median JFAS FMS background noise, we decided our best option was to compare the DERA BNMS data with the JFAS FMS June 1999 median data. To test for such differences, the June and July JFAS FMS 1998 median background noise data were compared by plotting a histogram of the cell-by-cell differences. The histogram (Figure 1a) showed that the median and mean difference were both 0.0 dB and the standard deviation was 0.6 dB. Thus, there was very little difference between the median data for these two months in 1998. This histogram technique was repeated for the JFAS FMS June 1999 and the incomplete July 1999 data, with a resultant median of 0.0 dB, mean of 0.2 dB and standard deviation 0.8 dB (Figure 1b). Again, there were no statistically significant differences between these two data sets. Thus, it was considered acceptable to use the median June 1999 FMS background noise data as the JFAS data set for the comparison with the DERA BNMS data.

2.2 UK Noise Measuring System at JFAS

2.2.1 Measuring System

DERA provided DSTO with their antenna specification, IEEE interface hardware and software, and some processing software. Hereinafter, this system is referred to as the UK Noise Measuring System (UK NMS). The equipment was installed at JFAS and testing took place, including runs terminated in 50-Ohms, and calibration tests using a known noise source.

The UK NMS includes a laptop PC and interface to a Rohde and Schwarz ESH3 receiver, which has a bandwidth of 2.4 kHz. Data collection occurred from 6 to 29 MHz, with 5 minutes spent scanning the first 500 kHz of each MHz (the second 500 kHz was not scanned). The step size was 2 kHz (although the individual measurements were simply collected as estimates of the half-MHz within which they occurred). Thus, the full band of 24 MHz was scanned in a 2-hour period. The system then repeated the process. Gibson and Arnett (1988) have provided a detailed account of how the UK NMS acquires data.

In both the 50-Ohm and noise source tests, the recorded data was lower than expected at all frequencies, with a median offset, with very little variation with frequency, of approximately 4 dB. This effect was traced (Debnam 1999) to inaccuracies in the way the receiver measures noise, as opposed to signals which the receiver measures correctly. The effect was discussed with Clutterbuck (1999), who explained that this problem was appreciated by Gibson and Arnett but at the time of their experiments (circa 1988) there was little other choice for a computer controlled receiver. Clutterbuck also claimed that errors from under sampling the environment would be significantly larger than errors arising from the use of the ESH-3 receiver.

2.2.2 Data Collection and Processing

The data collection period was from 1999 day 178 (June 27) to day 203 (July 22). Data from the UK NMS was automatically stored to the laptop every eight hours (i.e. three times each UT day). At the completion of the trial, the laptop was returned to DSTO Salisbury, where median background noise was produced, for the trial period, using the DERA technique. This involved producing, for each day, a separate file for each frequency and 2-hour block (i.e. 288 files per day) from the three raw data files. The power levels were converted from dBm to dBW/Hz allowing for the 2.4 kHz receiver bandwidth. An Interactive Data Language (IDL) program was written to plot, for any given day, the power level versus frequency for each 2-hour period. These power levels were the median of the individual measurements, for a given frequency and 2-hour period. These measurements included samples of both background noise and transmitted signals. The plots served to highlight when there were serious problems with the data, primarily dropouts where the median fell many decibels (e.g. Figure 2). Dropouts were caused by hardware problems at the recording site. Raw data affected in this manner was noted for exclusion from future processing.

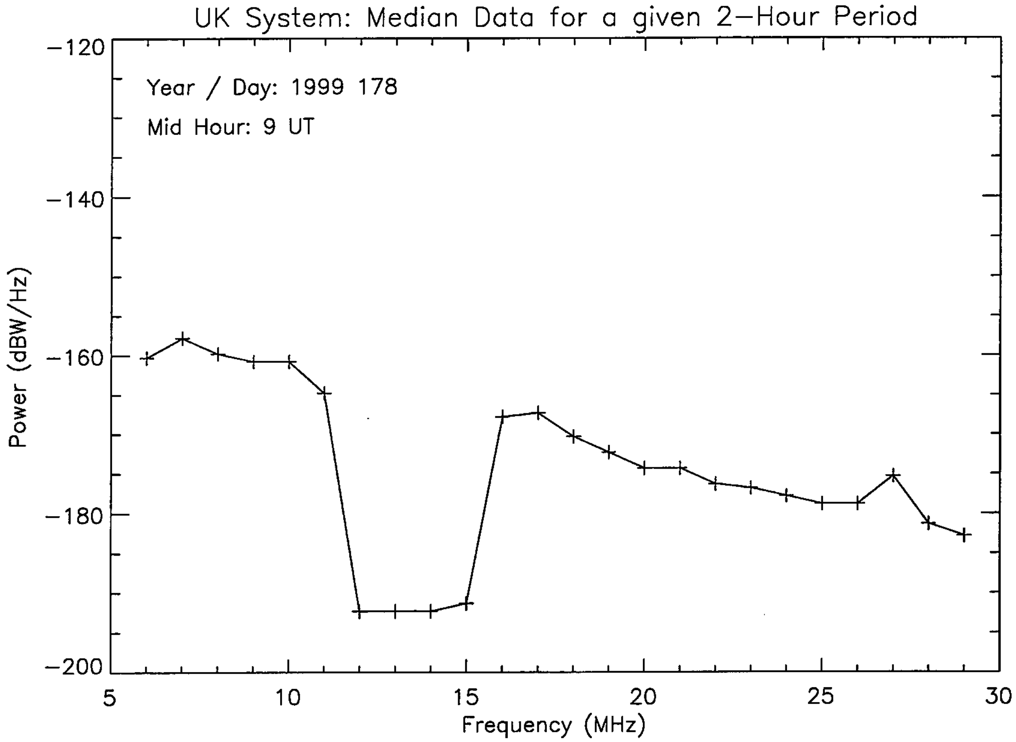

Figure 2: Data collected with the UK Noise Measuring System, for the 2-hour period from 0800 to 1000 UT (i.e. centred on mid-hour 9 UT). Both noise and signals were included in the data, with the median shown for each 1-MHz. The low points at 12 to 15 MHz indicated bad data, which was then excluded from the final trial period data.

Modifications to the DERA-supplied software, to combine all the data from all the days in the trial, allowed an amplitude probability distribution (APD) to be produced for each frequency and 2-hour block combination. The information was stored in ASCII files. The technique used by DERA (Clutterbuck, May 1998) was then applied to each APD to determine the median background noise level at receiver input. This method assumes that the data consists of both noise and signals and that the (higher power) signals will obey a log-normal distribution and appear linear on "probability paper" (cumulative normal distribution). At lower powers, the distribution should be dominated by approximately Rayleigh distributed noise. By plotting each APD on probability paper (e.g. Figure 3 and Figure 4) and fitting a straight line to higher powers, the intercept with the ordinate at the minimum noise level (assumed to be the value at the 99.9% threshold) is found. The midpoint between 99.9% and the percentage at which the intercept occurs is then found, and is considered to be the median of the noise distribution, $P_n(50)$. The main modification to the DERA technique was to automate this time consuming process which DERA had done manually. IDL software was produced to find the line of best fit (Turley 1999). The automation was successful in all but three of the 288 APDs. Those three cases were processed manually.

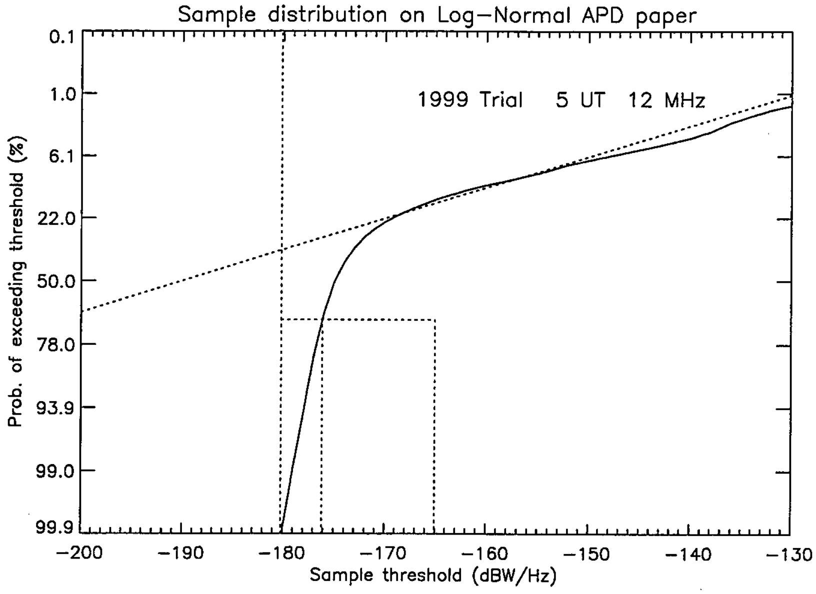

Figure 3: An amplitude probability distribution plotted on log-normal "probability paper". The plot includes all good data for the trial period, for 4 to 6 UT at 12 MHz. The 99.9% ordinate and the line of best fit for the upper section of the curve are both shown. The median percentage for the noise is 68% and the corresponding threshold is -176 dBW/Hz. The detection loss is 11 dB, giving a final median background noise value of −165 dBW/Hz.

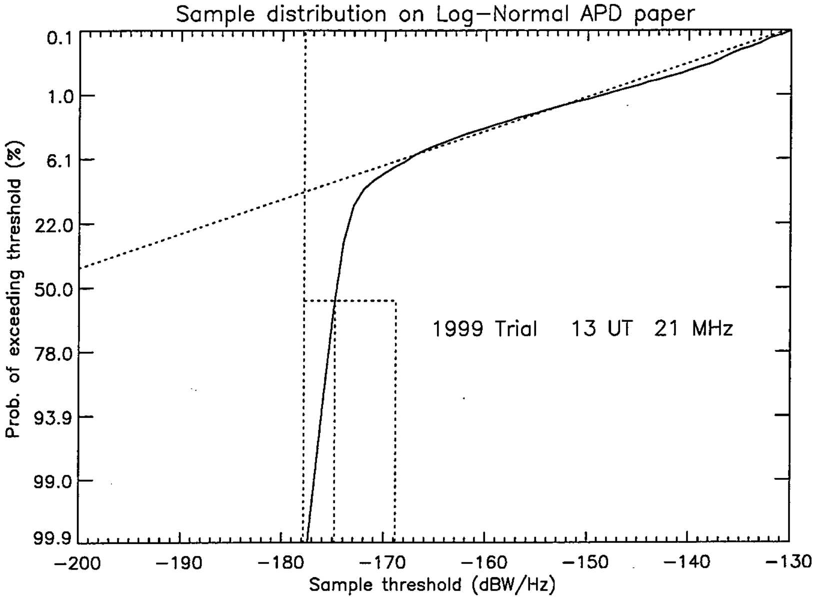

Figure 4: The APD for 13 UT at 21 MHz has a median level of -175 dBW/Hz at 56%. The detection loss is 6 dB, giving a final median background noise value of -169 dBW/Hz.

As noted above, the UK technique involves scaling the value P_n (50) from an APD. P_n (50) is the median value of the data in an APD that is due only to noise. This value will be an under-estimate of the *true* median value of the background noise as consideration of noise values outside of the noise-only part of the APD have been excluded from this process. The difference between P_n (50) and the true median value will be a function of how many of the samples in the APD are measurements of signals – this will vary with frequency, time of day, season, sunspot number and geographic location. The UK algorithm accommodates this expected difference by using "detection loss" corrections (Spaulding et al. 1962). These corrections, published as tables, are functions of frequency, time of day, season, and geographic location (northern or southern hemisphere).

Using the techniques described above, an ASCII file was produced containing the median background NSDs at receiver input, for the trial period, for each MHz and each 2-hour period (i.e. a 24 x 12 array).

As for the JFAS BNM data, the UK NMS data has to be converted to external noise before it can be compared with the JFAS and CCIR data. The external NSD was computed as

$$NSD = NSD_{RX\,I/P} + L - M - G$$

where

L = antenna loss (comprising ground loss, mismatch loss & transformer loss)
M = antenna gain relative to the antenna used by CCIR
G = extra gain in the JFAS implementation of the UK NMS

DERA (Clutterbuck 1998) provided a table of L as a function of frequency. However, we did not have sufficient information to correctly derive M so we could not include this correction factor in our analysis software. We were subsequently advised that M = 0.5 dB.

Because the JFAS UK NMS equipment configuration was different to that used by DERA in the UK, we needed to compute the extra gain in the JFAS implementation of the UK NMS. In the UK, the antenna was connected directly to the ESH-3 receiver via an unspecified (but presumably small) length of URM67 ("N-type") cable. At JFAS, the antenna was connected to a MHW592 amplifier, and then there was approximately 530 m of coaxial cable from the amplifier to the receiver building where a 10 dB attenuator was inserted before the ESH-3 receiver. The gain of the MHW592 amplifier was 34.8 dB at 6 MHz and 35.1 dB at 30 MHz. The cable loss was 4.54 dB at 6 MHz and 11 dB at 30 MHz. Thus, the JFAS implementation of the UK NMS had 20.26 dB (at 6 MHz) varying to 14.1 dB (at 30 MHz) more gain than the way the system was implemented in the UK. Thus, at frequency f MHz, the extra gain in the JFAS implementation of the UK NMS was $G = 20.26 - (f - 6)*6.16/24$ dB.

Using the DERA values for L and the above formula for G, the UK NMS median NSD data at receiver input was converted to external NSD.

2.3 CCIR Model Data

A comparison between JFAS and CCIR background noise data has been carried out previously (Ward 1989). The model data that is used here is from CCIR Report 322-3 (CCIR 1988) and was obtained from the program Spaulding supplied to Ward. An output file was produced that contained CCIR noise estimates as NSDs for Southern Hemisphere winter, at JFAS's location, for 6 to 29 MHz at 15-minute resolution.

3. Results

3.1 JFAS Data Compared with UK NMS Data

The JFAS background noise data is shown as a two-dimensional image of frequency versus mid-hour, with the power level (in dBW/Hz) indicated by the colour scale at the side (Figure 5). The most obvious feature is the onset of higher NSDs around 0800 UT (1730 LT) for frequencies below approximately 18 MHz and the subsequent decrease in NSDs at around 2200 UT (0730 LT). This corresponds to the nighttime decay of the absorptive ionospheric D-layer, resulting in ionospheric propagation from much greater distances and a consequent increase in atmospheric background noise. For these frequencies, NSDs are at their minimum level from approximately 0100 to 0500 UT. At higher frequencies, where the dominant source of background noise is the galaxy, there is very little diurnal variation and a steady fall-off in NSD with increasing frequency.

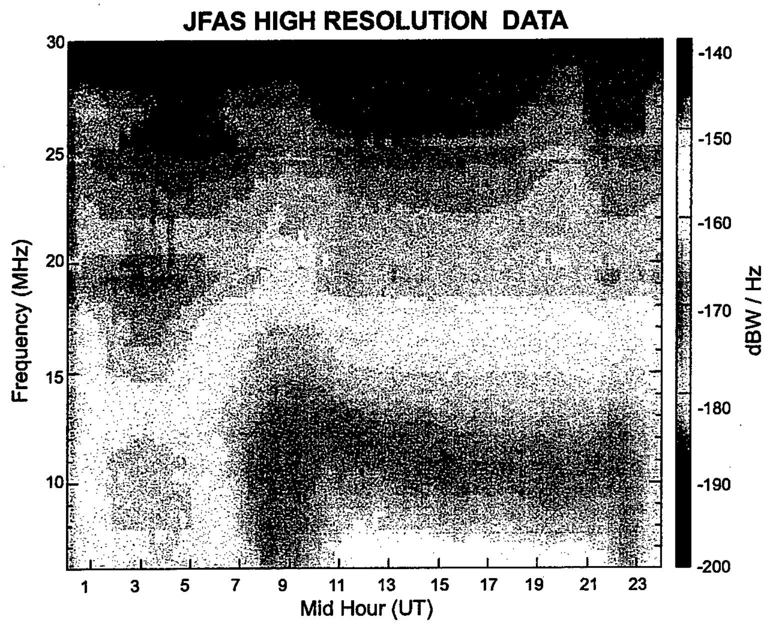

Figure 5: High resolution JFAS BNM median background noise data for June 1999.

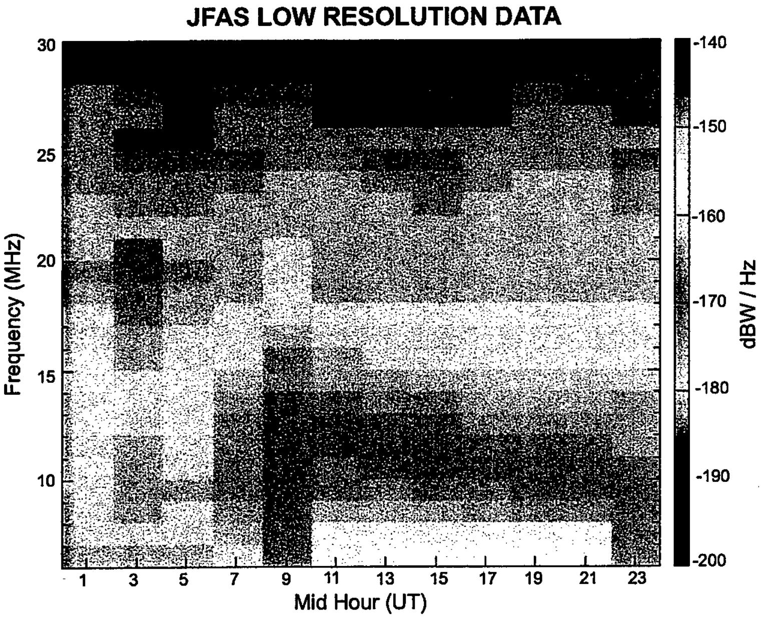

Figure 6: Low resolution JFAS BNM median background noise data for June 1999.

As the JFAS BNM data was produced at greater time and frequency resolutions than the UK NMS data, a change was needed to do a cell-by-cell comparison with the UK

NMS data. The original "high resolution" JFAS BNM data was reduced to the same dimensions as the UK NMS data to produce "low resolution" JFAS BNM data (Figure 6). The time resolution was reduced to two-hour blocks by replacing eight 15-minute bin values with a single median value. Frequency resolution was reduced by replacing the five 200 kHz values in a 1-MHz band with the one which was closest to the centre of the first 500 kHz of the MHz, i.e. f.2 MHz, where f is the integer frequency.

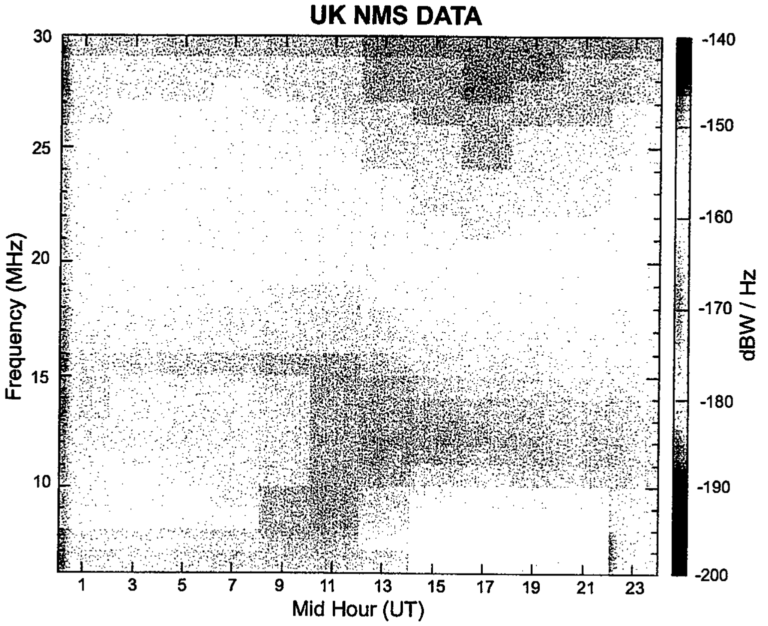

Figure 7: After processing, the UK Noise Measuring System produced median data for the trial period for each 2-hour period at each MHz.

The diurnal and frequency variations in the JFAS BNM data are also present in the UK NMS data (Figure 7). A difference plot (Figure 8) was produced by subtracting, cell-by-cell, the JFAS low resolution BNM data from the UK NMS data. Whilst showing the same general characteristics, the UK NMS NSDs were generally higher than those of the JFAS BNM, with a median difference of 2.5 dB. It is believed that the main reason for this offset is due to incorrect values for the "detection losses" that are employed in the UK NMS signal processing. When the UK NMS data was re-processed without using these detection losses, the UK NMS data was generally lower than the JFAS BNM with a median difference of 5.1 dB; i.e. a net change of 7.6 dB. As noted previously, these detection losses are an attempt to account for the difference between the median value of the noise-only data in an APD and the true median value of the background noise. Whereas this difference would be a function of, inter alia, sunspot number and geographic location, the detection losses have no allowance for solar cycle variation and variations in geographic location are confined to a choice of Northern or Southern Hemisphere.

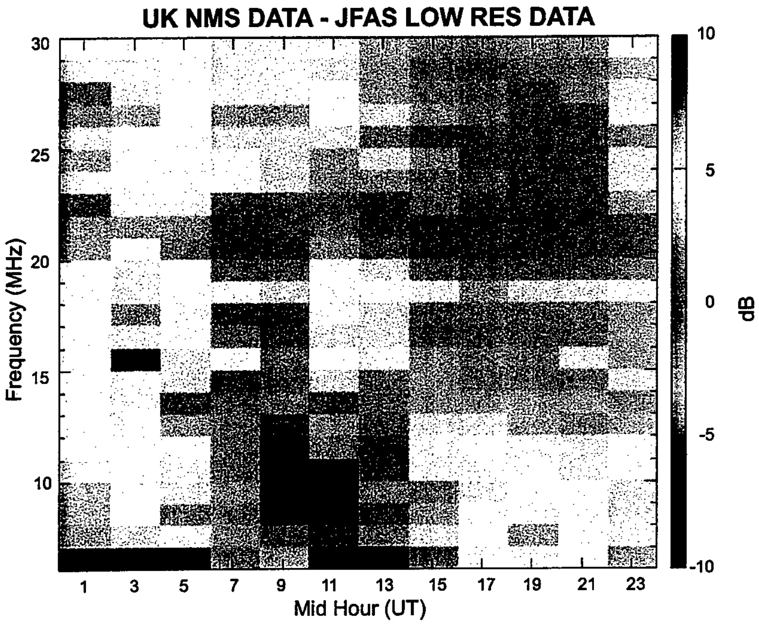

Figure 8: The JFAS BNM low resolution data was subtracted from the UK NMS data. The red regions indicate where the UK NMS data was much higher than the JFAS BNM data. Blue shows the reverse.

Apart from the systematic offset discussed above, the main disparity between the JFAS BNM and UK NMS data occurred at frequencies below 14 MHz in the first four hours after dusk, when higher noise levels were observed by the JFAS BNM. The UK NMS data did not show this increase until approximately two hours after it appears in the JFAS BNM data. Coleman (2000) has advised that the most likely explanation for this effect is the different ground screens employed by the two systems. His modelling has shown that the JFAS BNM antenna is more sensitive to low-angle propagation and thus is capable of detecting propagation from greater distances. For this reason, the JFAS BNM observes the increase in atmospheric background noise due caused by the after-sunset decay of the D-layer earlier than the UK NMS.

The other major difference is at 6 and 7 MHz from 0000 to 0800 UT, where the UK NMS NSDs are considerably greater than the JFAS BNM data. Possible explanations for this difference are that either the UK NMS is internally noise limited or that the UK NMS measurements are contaminated by broadcast band signals (as they are at 15 MHz – see Figure 7). However, neither measurements or theoretical calculations of the UK NMS internal noise support the first explanation and users of the 6 and 7 MHz broadcast bands would not have been able to propagate to Alice Springs at this time (0930 to 1730 LT).

3.2 Comparison with CCIR Model Data

Both data sets were compared with CCIR data (Figure 9).

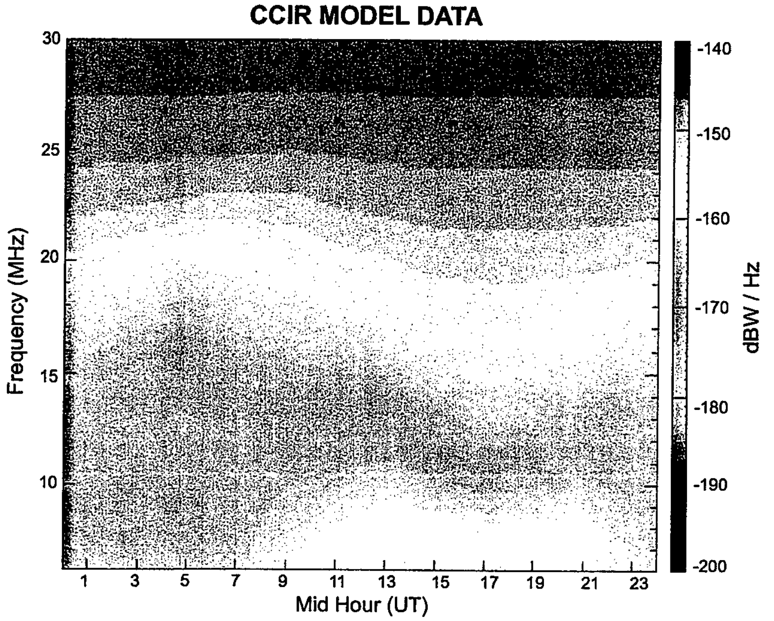

Figure 9: The CCIR model data is based on Report 322-3 (CCIR 1988), and is for the geographic location of JFAS, during Southern Hemisphere winter, from 6 to 29 MHz, in 15-minute bins.

Figure 10 shows CCIR data subtracted from the high resolution JFAS BNM data, and Figure 11 shows CCIR data subtracted from the UK NMS data. For both measurement systems, there is reasonable agreement during nightime (generally within ±4 dB). During daylight hours, the agreement is restricted to higher frequencies (above 20 MHz). For these times and frequencies, the UK NMS data is around 2 dB higher than the CCIR predictions and the JFAS BNM data is around 2 dB lower than CCIR data. There is a large region at frequencies less than 20 MHz during daylight hours, where the measured background noise spectral density is more than 10 dB (up to 15 dB for the JFAS BNM and 12 dB for the UK NMS) lower than the model predictions. The difference, across many MHz and several hours, is evident on both measurement systems and is the major incompatibility with the CCIR results. The CCIR model does not have a solar cycle dependency and only used data from two Southern Hemisphere sites. These two factors are the most probable causes for this discrepancy.

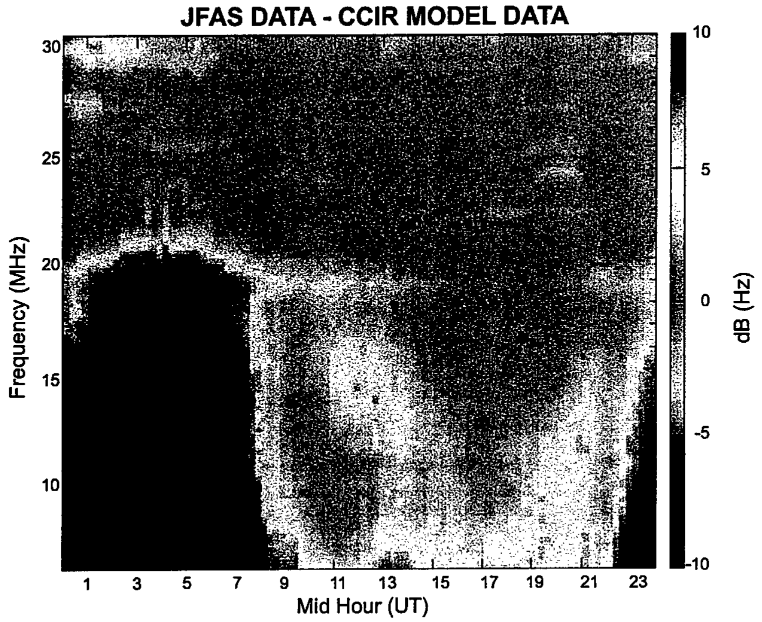

Figure 10: The CCIR model data has been subtracted from the high resolution JFAS BNM data. The CCIR data is significantly higher than the JFAS BNM data during the daytime at frequencies less than 20 MHz.

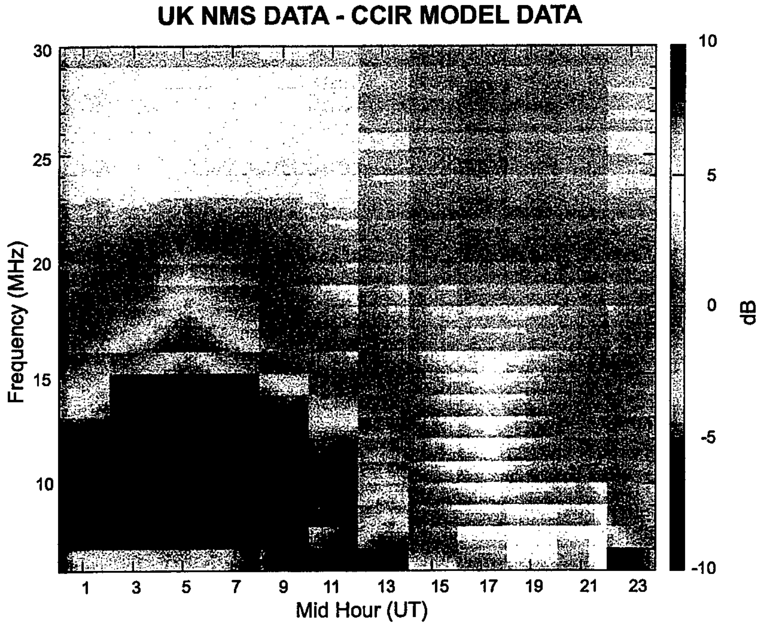

Figure 11: The CCIR model data has been subtracted from the UK NMS data. The CCIR data is significantly higher than the UK NMS measurements during the daytime at frequencies less than 15 MHz, although the difference is not as significant as it was for CCIR data subtracted from JFAS BNM data.

4. Summary

DSTO and DERA background noise measuring systems located side-by-side at Alice Springs in Central Australia have been used to independently analyse the same external noise levels and produce median background noise spectral density data for July 1999. The two systems used very different techniques for determining the background noise from the raw data they gathered, with the UK NMS method relying heavily on assumptions about the noise and signal environment being sampled. Despite these differences, there was reasonable agreement between the systems. However, there was a small systematic difference evident with the UK NMS measurements a few dB higher than those of the JFAS BNM. The major reason for this difference is believed to be the "detection losses" that are employed in the UK NMS signal processing. In contrast to the JFAS BNM which attempts to exclude all measurements contaminated by signals, the UK NMS deliberately measures both signals and noise and requires a model (the detection losses) of the proportion of signals and noise as a function of frequency, time of day, season and hemisphere. For this reason, it is believed that the JFAS BNM measurements are more reliable than those of the UK NMS. It was also noted (Section 2.2.1) that the receiver used in the UK NMS does not correctly measure the output from a calibrated broad band HF noise generator. Apart from this systematic offset, the major difference between the two monthly median data sets was that the higher nightime noise levels at frequencies below 15 MHz were observed by the JFAS BNM about two hours earlier than by the UK NMS. This difference has been accounted for by the fact that the two BNMS use different ground screens with their antennae. Any remaining discrepancies between the two data sets are most probably due to errors in the DSTO and/or DERA mathematical models used to compute antenna ground losses.

The comparison of both sets of measured median July 1999 background noise with the CCIR predictions for quiet rural winter noise at Alice Springs confirmed that there are major differences between the model predictions and actual measurements. For frequencies below 20 MHz, the model does not predict the decrease in noise levels during day-light hours, observed by both the JFAS BNM and UK NMS systems. This discrepancy of more than 10 dB, across many MHz and several hours, is the major incompatibility with the CCIR results. The CCIR model does not have a solar cycle dependency and its derivation included measurements from only two sites in the Southern Hemisphere. Previous JFAS measurements have indicated that the solar cycle is an important factor in propagation conditions (Ward 1989). Thus, the CCIR background noise model should be used with caution in HFSWR performance prediction models, especially in the Australian region. Checking the noise predictions with measurements may allow some estimate of the errors involved in using such models.

5. Acknowledgments

Mr Robert Debnam and Mr Alister Brownrigg assembled the UK NMS and also provided technical assistance during the project. Dr Mike Turley provided the algorithm to automatically scale median noise values from the APDs. Dr Michael Wilson provided the table of gains from receiver input to external noise for the JFAS BNM data. Dr Colin Clutterbuck and his colleagues at the DERA in the United Kingdom supplied the design and analysis technique for the UK NMS.

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19. ABSTRACT

A comparison of two High Frequency background noise measuring systems (BNMS) that employ different hardware and signal processing techniques has been conducted. One system was part of the Frequency Management System at the Jindalee over-the-horizon radar Facility at Alice Springs (JFAS) and the other system was based on a design supplied by the UK's Defence Evaluation Research Agency. The UK BNMS was placed at JFAS so that both systems could independently analyse the same external noise environment. The measurements from both BNMS were compared with the International Radio Consultative Committee (CCIR) HF atmospheric background noise model.