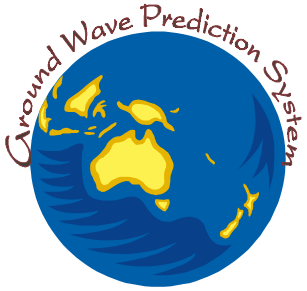
IPS
RADIO AND SPACE SERVICES



GWPS V2

User Guide

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GWPS - General Information

GWPS V2.0 is a program for estimating ground wave range value under specified ground and operating conditions, for transmitter frequencies between 10kHz and 50MHz. GWPS is a DOS based system which can be run in Windows 3.1/95/98 or NT environments.

For a fixed set of conditions, estimates of the range as a function of transmitter frequency, power or time, and estimates of the electric field strength as a function of range, are available. It can also provide estimates of the frequency/time dependence at a given range. The range is the distance from the transmitter at which a signal of a specified quality can be detected.

The user can specify transmitter and receiver operating parameters, ground types, ground losses, the noise conditions and the required signal to noise ratio.

Operation of the program and calculations is controlled by function key selection. The options currently available are listed at the top and bottom of the page. At any time help information can be accessed using the F1 help function key. The help menu page is displayed, and the appropriate subject is selected using the cursor keys.

The ESCAPE key is used to exit from options, displays, etc.

On entering the program, a title banner is displayed indicating the name and version number of the program. Pressing any key other than ESCAPE will then call up the main menu page. The user then adjusts the parameter values as necessary. A description of the cursor control and editing features is given in the CURSOR CONTROL and EDIT MODE help pages.

A calculation is chosen by selection of the appropriate function key sequence. The available options are listed at the top and bottom of the page. If the selected function determines a dependency, then a graph of the data will be displayed. Pressing any key will return the user to the current page. If any graphing options need to be altered, then select the GRAPHING OPTIONS menu. The graphing options page will be displayed, allowing selection of the various options. These options are described in the GRAPHING OPTIONS help page.

Hardcopy of the graph, or a listing of the calculated data is available. These are described in the GRAPH HARDCOPY and DATA LISTINGS help pages.

Descriptions of each variable and function are available in the help listings.

Each data entry is validated against internal checks. If an error is found, then the user is notified. Incorrect data cannot be entered. The current settings can be saved at any time to a configuration file by selection of the appropriate function key. All values that can be altered are written to this ASCII text file. If a save file already exists, then it is overwritten, otherwise a file is created. If it exists, then the default configuration file GWPS.CFG is loaded on execution. This configuration file can be loaded at any stage to reset the variable values.

The Ground Wave field strength calculations are performed using the routine GRWAVE developed by R.S. Gill at Marconi Research Centre. The theory has been developed by S. Rotheram, and reported in IEE Proc. Part F, 1981, 128(5), pp275-284 and ibid., pp 285-295. The calculations are for the CCIR reference exponential atmosphere. Loss curves for particular ground data sets have been processed and placed into a data file. The program GRWAVE was used to generate these data. The model currently in use is for a smooth homogeneous surface with the electrical properties of the ground defined by the relative permittivity and Conductivity. Multiple surface types are not included in this version. Losses arising from a rough sea surface can be included, however losses arising from general surface roughness and vegetative cover are not included. The user should ensure that the conditions approximately match the model. Otherwise meaningful results may not result.

Further information about the GWPS software can be obtained from:

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General Parameters

The following listing gives a brief summary of each variable.

Tx	This is a nametag for the transmitter location. It currently plays no other role.
Antenna	The "type" of transmitter antenna. All calculations are performed for a reference vertical dipole. The reference dipole corresponds to the dipole used in the GRWAVE groundwave calculations.
Latitude & Longitude	These describe the siting of the transmitter. Values are positive for NORTH (latitude) and EAST (longitude)
Length	The length of the transmitting antenna (fixed, 1m).
Height	The height above the ground of the antenna. Valid range 0-100000m.
Frequency	The transmitter frequency (0.01 to 50 MHz).
Efficiency	This is an overall efficiency value for the transmitting system. This is provided so that variations in efficiency may be made without altering the power or signal to noise ratio requirements. It can be used as a way of including other losses that are not accounted for in the program.
Power	The transmitter power (0.001 to 10000 kW).

Transmitter Parameters:

The noise at the receiver is assumed to be the noise at the transmitter location. This will be satisfactory only for short ranges, but this is generally the case with ground wave transmission.

Latitude	-90 to 90 deg
Longitude	-180 to 180 deg
Limits	-20 dB to 0 dB (ie. 1 to 100%)

Receiver Parameters:

Antenna	The "type" of receiver antenna. All calculations are performed for a reference vertical dipole. The reference dipole corresponds to the dipole used in the GRWAVE groundwave calculations.
Bandwidth	The bandwidth of the receiver. The larger the bandwidth, the larger the noise power admitted to the receiver.
Limits	0.001 to 9999 kHz.
Length, Height, Efficiency	As for Transmitter.

Noise Parameters:

The following parameters define the type and magnitude of the external noise signal. The temporal variation in the calculated range is due to the temporal variation in the noise. The T index value determines the contribution from galactic noise. The user, according to the region of interest, sets the man-made noise contribution. These noise levels are broad estimates only. The atmospheric and galactic noise values are taken from the IPS noise model based on CCIR Report 322 (Geneva, 1964).

Month	The month of the year. The month defines the season, for which the noise variation is recorded.
Time	The time of day in Universal Time (0 to 24 UT). The time defines the four-hour block in which the noise variation is recorded.
Atmospheric Noise	This toggles the use of atmospheric noise in the noise calculation. The man-made noise is included as according to the Man-Made Noise setting. The galactic noise is included as necessary.
Man-Made Noise	This defines the level of man-made noise. Either a predefined or a user-defined value can be used.
Signal/Noise Ratio	The required signal strength at the receiving site is specified by the signal to noise ratio. The S/N ratio will depend on the type of receiver in operation, and the current signal noise level. Values for various types of emission and grades are listed in the IPS Explanatory Leaflet #4 (July 1993) "Pathloss, Noise and Noise-Pathloss Predictions". Limits: -99 to 999 dB.
Noise at 3 MHz	This is the noise value associated with a noise type of 'User'. The quantity to be entered is the noise value at 3 MHz. The frequency dependence is determined using the following: Value = Level - 28.0*log10 (Frequency (MHz)/3.0)

Noise Values

The predefined values shown below are the noise in dB (W/Hz) at 3 MHz and include the thermal limit of -204 dB (W/Hz). The values in parentheses are the values above the thermal limit.

None	-204 dB (W/Hz) (0 dB (W/Hz))
Remote	-164 dB (W/Hz) (40 dB (W/Hz))
Rural	-150 dB (W/Hz) (54 dB (W/Hz))
Residential	-145 dB (W/Hz) (59 dB (W/Hz))
Business	-140 dB (W/Hz) (64 dB (W/Hz))
Ship	-130 dB (W/Hz) (74 dB (W/Hz))
User	As specified by the value of the Noise at 3 MHz level (see below). Limits: -204 to 9999 dB(W/Hz).

Ground Surface Description:

At present, the program handles a single surface type. The surface is assumed to be smooth and uniform, with the electrical properties defined by the following parameters. The properties affect the ground wave attenuation.

Relative Permittivity	The dielectric constant (relative to free space) of the surface. Limits: 1 or greater.
Conductivity	The conductivity of the surface (0 to 99 S/m).
Loss	This is an additional loss due to surface roughness or other variation from the homogeneous smooth surface. Currently, only loss corrections for a rough sea are included. This loss is taken from the work of D.E. Barrick, Radio Science 6 (1971), pp527-533. The loss curves as published in this paper have been estimated. These correspond to seawater with a conductivity of 4 S/m and relative permittivity of 80. These are typical values for seawater. The loss depends on the wind speed and the signal frequency. The losses are for frequencies below 50 MHz, with no losses for frequencies below 2 MHz.

The predefined levels are for wind speed and are shown in the table below.

None	(0 knot, 0.00 m/s)
Sea state 1	(5 knot, 0.51 m/s)
Sea state 2	(10 knot, 1.02 m/s)
Sea state 3	(15 knot, 1.53 m/s)
Sea state 4	(20 knot, 2.04 m/s)
Sea state 5	(25 knot, 2.55 m/s)
Sea state 6	(30 knot, 3.06 m/s)

The following gives some average values for the permittivity and conductivity for various surface types. These are reproduced from CCIR Recommendations and Reports of the CCIR, 1986 vol. 5, "Propagation in Non-Ionised Media". Actual values may vary substantially from these values.

Sea water (average salinity at 20 deg C)	80, 5 S/m
Fresh water (at 20 deg C)	80, 0.003 S/m
Wet ground	30, 0.01 S/m
Medium dry ground	15, 0.001 S/m
Very dry ground	3, 0.0001 S/m

Calculation Limits:

The following control the ranges of values used in the calculations.

Minimum Power	When calculating the RANGE as a function of POWER, this sets the lower limit of calculation.
Maximum Power	When calculating the RANGE as a function of POWER, this sets the upper limit of calculation. Limits: From Maximum Power to 10000 kW
Minimum Frequency	When calculating the RANGE as a function of FREQUENCY, this sets the lower limit of calculation.
Maximum Frequency	When calculating the RANGE as a function of FREQUENCY, this sets the upper limit of calculation. Limits: From Minimum Frequency to 50 MHz
Range	When calculating the FREQUENCY as a function of TIME, this sets the RANGE value at which the variation is required. Limits: 1 to 10000 km.

Output:

List file	This is the name of the file for listings. If the file already exists, then the file is opened in append mode, otherwise a file is created.
Graph file	This is the name of the file for bit map images. The file is in POSTSCRIPT format. If the file already exists, then the file is opened in append mode, otherwise a file is created.
Config file	This is the name of the file for the current setup. When saving the current setup, if the file already exists it is overwritten, otherwise a file is created. When loading a setup, if the file doesn't exist then no change is made.

Cursor Control

The following cursor control to position within the menu page is available:

Down Arrow	Shifts to the next row of the current column.
Up Arrow	Shifts to the preceding row of current column.
Right Arrow	Right shifts to the next variable column with an entry on the current row.
Left Arrow	Left shifts to the preceding variable column with an entry on the current row.
Ctrl Right Arrow, Ctrl Left Arrow	Shift between the variable and the units' fields for the current variable. This allows you to vary units, e.g. W to kw, and mm to km.
Home	Shifts to the first row of the current column.
End	Shifts to the last row of the current column.

The cursor movement is cyclical, with the first entry following from the last entry of the relevant row or column.

Edit Mode

There are two methods of modifying a variable quantity:

(1) Position the cursor on the appropriate field and press RETURN. If the quantity can be changed, then the edit buffer with the current value will be displayed. If the quantity is part of a predefined set then the next value in the list will be selected. Otherwise, the operation specified by the field will be performed.

(2) Position the cursor on the appropriate field and start typing the new value. If the variable is of the correct type (numeric or alphanumeric) then this will appear in the edit buffer, with the current data value being ignored. Otherwise no action is taken.

There are two modes of data entry as selected by toggling the INSERT key:

(1) Overwrite mode: The entered characters overwrite the current buffer entry, starting at the cursor position, and form the new value. An underscore cursor will be displayed.

(2) Insert mode: The entered characters are inserted before the character at the cursor position. A solid cursor will be displayed.

To enter the new value, press RETURN. If the value is valid, then it will be accepted, and the edit buffer will be removed. Otherwise, an error message will be given indicating the problem, and the edit buffer will remain, allowing correction.

In summary, the following cursor/edit control is available:

Right Arrow	Shifts one character to the right.
Left Arrow	Shifts one character to the left.
Home	Shifts to the first non-blank character in the edit buffer.
End	Shifts to the last non-blank character in the edit buffer.
Backspace	Deletes the character to the left of the cursor.
F2 Function Key	Clears the edit buffer and positions the cursor at the start of the buffer.
Insert	Toggles between insert and overwrite edit modes.
Esc	Abandons the edit buffer, leaving the variable unchanged.

The cursor movement is not cyclical.

Graphing Options

The following flags determine the format of the graph display:

x(y) Log Scale	Toggles the use of a *Logarithmic* (base 10) x(y) or a *Linear* axis. This option is valid only if the full x(y) data set is positive. If not, then the flag setting is ignored, and a linear scale will be used.
Display Grid	Toggles the display of an x-y grid. If enabled, a grid is overlaid on the graph using the current sub-interval step sizes. This is useful in reading values off the graph.
Data Display Type	Toggles between different types of data display. The available types of display are: (1) Filled circles denoting each data point. (2) Solid line interpolated from the data values (a cubic spline interpolation curve is used). (3) A combination of (1) and (2). (4) A rectangular histogram, where each step represents an average value in the displayed range.
Enable Hardcopy	Toggles the hardcopy enable flag. If this flag is set, then an image bit map will be saved to memory when a graph is displayed to the screen. This can be later saved to a POSTSCRIPT bit map file for later printing. The file is specified by the GRAPH FILE option on the main menu. The image is saved to file using the ALT-F7 key. The image save takes some time and consequently this option should be set only if a graph file is required. Note that there will be a pause between keyboard input and the return from the graphics image.

Data listings

Listings of the current data to the screen and to a file are available. The current data is that data most recently calculated or displayed. The listing consists of the calculated values in tabular form.

(1) To list to the screen, the ALT-F5 key is used.
(2) To list to a file, the ALT-F6 key is used.

The data is listed to the file specified by the LIST FILE variable in the main menu. If a NULL file is specified, no listing is created. To send the listing to a printer, set the file name to the device name, e.g. LPT1. This option lists details of the parameters used in the calculation of the data set, as well as the data set.

Graph Hardcopy

There are two methods of producing hardcopy output of graphs:

(1) Use the DOS screen dump facility (if installed).

This is activated using the SHIFT-PRINTSCREEN key sequence. As the graphs are displayed in colour, the screen dump may give a rendered image of low quality.

(2) Save a bit map image to a file.

Currently, this file is restricted to a POSTSCRIPT format. To do this, the ENABLE GRAPH HARDCOPY flag in the GRAPHING OPTIONS menu needs to be set. A bit map will then be saved to memory. To save this to a file (or to send to a POSTSCRIPT capable printer) the ALT-F7 key is used. The file name is specified by the GRAPH FILE variable of the main menu. If a NULL file is specified, no graph is saved. To send a graph to a printer, set the file name to the device name, e.g. LPT1.

Range Calculation

This option is selected using the F5 function key.

The routine calculates the range of a signal of a given quality as specified by the signal to noise ratio, under the specified operating conditions.

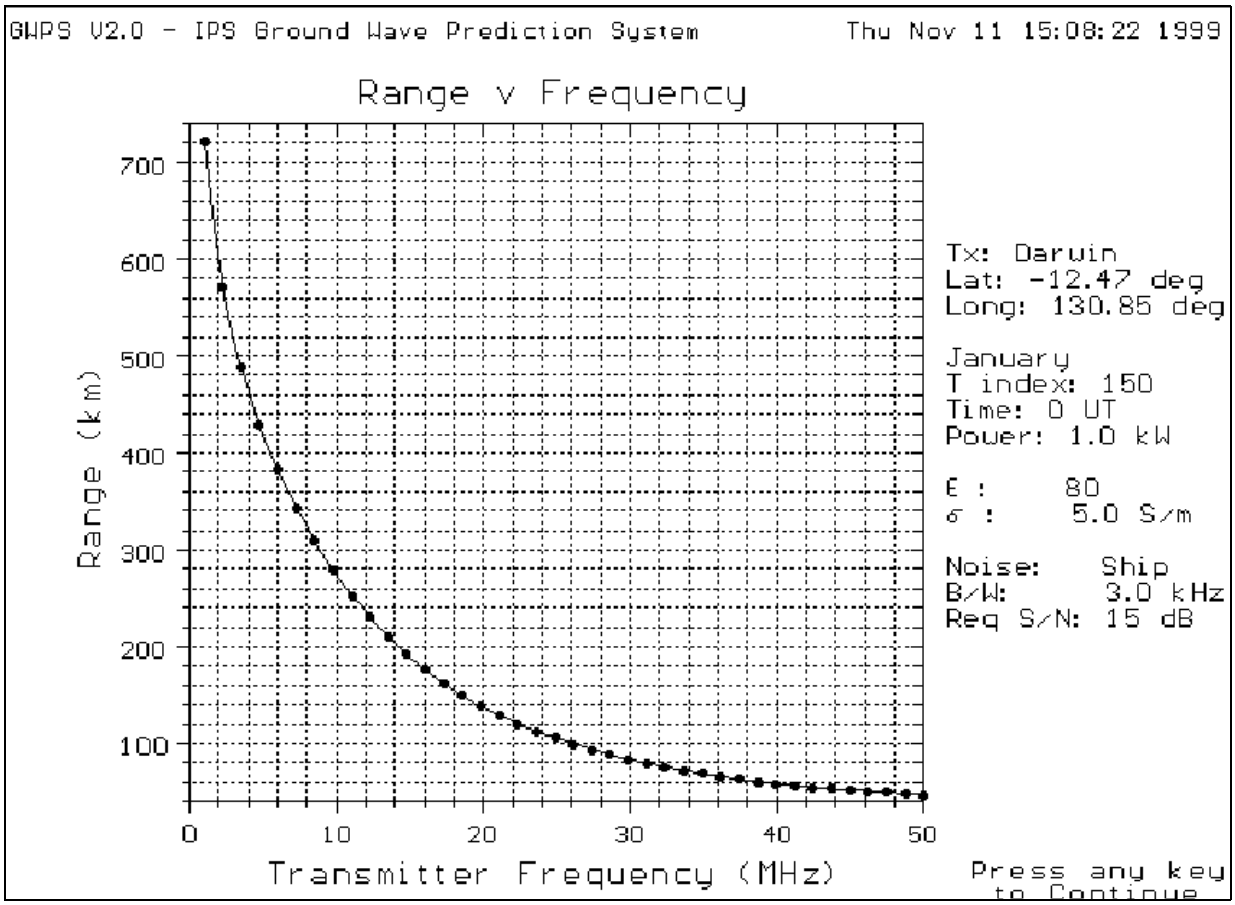
The variables of interest are:

- Transmitter type
- Transmitter geometry (length of dipole element)
- Transmitter efficiency (a total effective efficiency)
- Transmitter height above the surface
- Transmitter location
- Transmitter frequency
- Transmitter power
- Receiver type
- Receiver geometry (length of dipole element)
- Receiver height above the surface
- Receiver bandwidth
- The total noise level as determined by the time of the day, the season of the year, the T index and the grade of the noise. The total noise consists of contributions from the atmospheric noise, galactic noise and man made noise.
- The required signal/noise ratio
- The type of surface over which the signal propagates as specified by the relative permittivity and the conductivity, and any losses associated with this surface.

A listing giving these details and the resultant RANGE is displayed.

NOTE: At present, only a single surface type can be specified, and the only losses are for a rough sea. The groundwave signal is calculated using the routine GRWAVE.

RANGE as a function of FREQUENCY calculation



This option is selected using the F6 function key.

The routine calculates the range of a signal of a given quality as specified by the signal to noise ratio, under the specified operating conditions, for a range of transmitter operating frequencies.

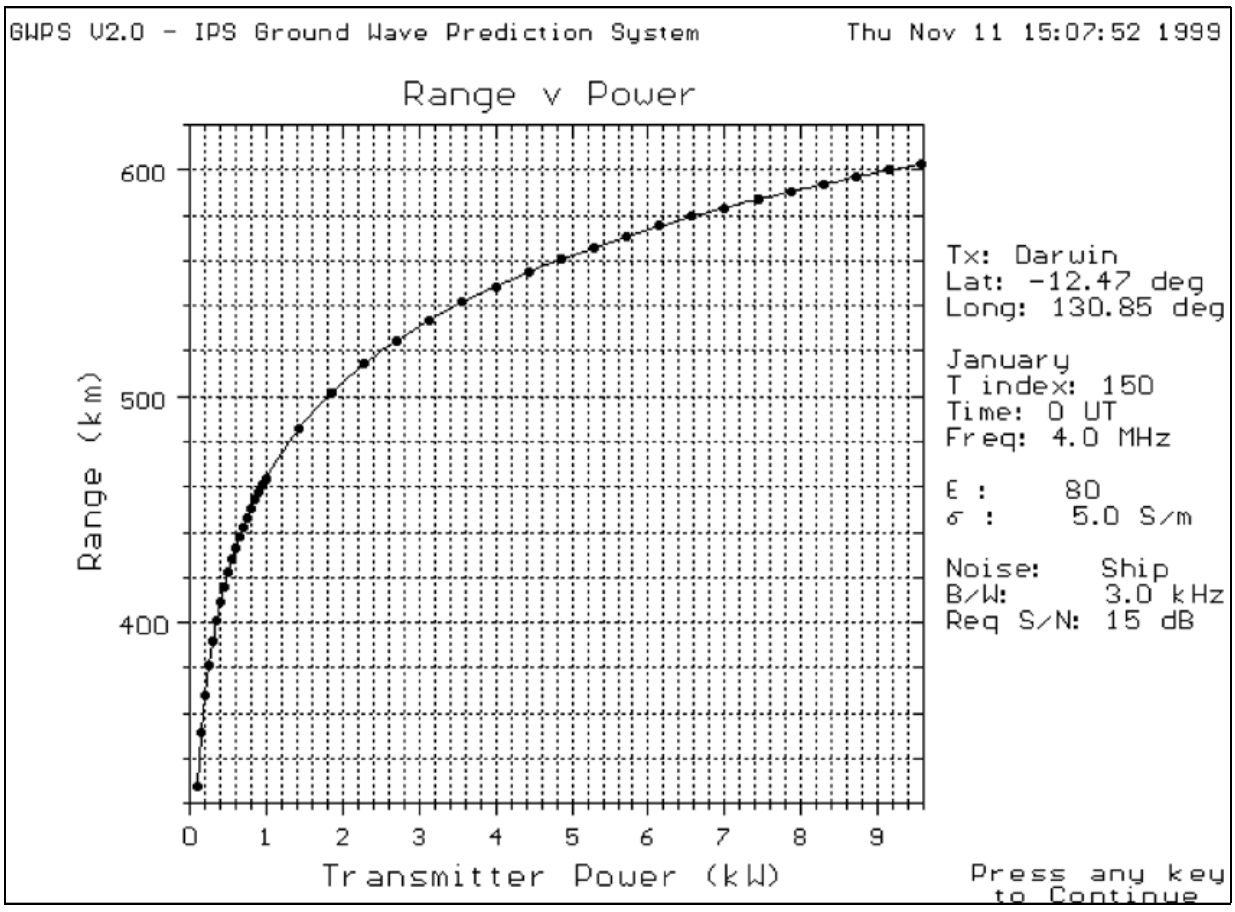
The variables of interest are:

- Transmitter type
- Transmitter geometry (length of dipole element)
- Transmitter efficiency (a total effective efficiency)
- Transmitter height above the surface
- Transmitter location
- Transmitter power
- Receiver type
- Receiver geometry (length of dipole element)
- Receiver height above the surface
- Receiver bandwidth
- The total noise level as determined by the time of the day, the season of the year, the T index and the grade of the noise. The total noise consists of contributions from the atmospheric noise, galactic noise and manmade noise.
- The required signal/noise ratio
- The type of surface over which the signal propagates as specified by the relative permittivity and the conductivity, and any losses associated with this surface.
- The minimum and maximum frequencies at which each range are needed.

A graph of the RANGE at each FREQUENCY is displayed, and may be modified using the GRAPHING OPTIONS menu.

NOTE: At present, only a single surface type can be specified, and the only losses are for a rough sea. The groundwave signal is calculated using the routine GRWAVE.

RANGE as a function of POWER calculation



This option is selected using the F7 function key.

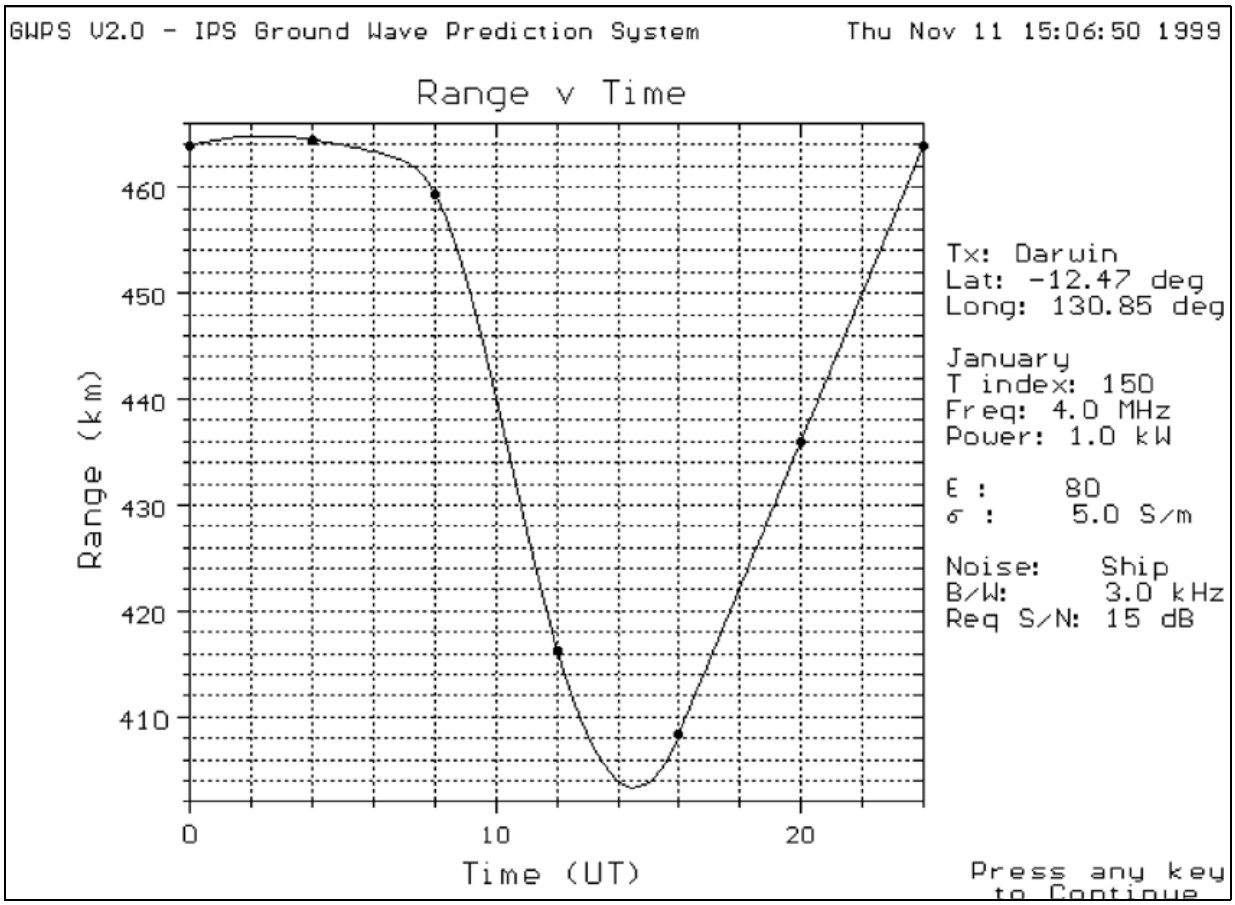
The routine calculates the range of a signal of a given quality as specified by the signal to noise ratio, under the specified operating conditions, for a range of transmitter operating powers.

The variables of interest are:

- Transmitter type
- Transmitter geometry (length of dipole element)
- Transmitter efficiency (a total effective efficiency)
- Transmitter height above the surface
- Transmitter location
- Transmitter frequency
- Receiver type
- Receiver geometry (length of dipole element)
- Receiver height above the surface
- Receiver bandwidth
- The total noise level as determined by the time of the day, the season of the year, the T index and the grade of the noise. The total noise consists of contributions from the atmospheric noise, galactic noise and man-made noise.
- The required signal/noise ratio.
- The type of surface over which the signal propagates as specified by the relative permittivity and the conductivity, and any losses associated with this surface.
- The minimum and maximum powers at which each range are needed.

A graph of the RANGE at each POWER is displayed, and may be modified using the GRAPHING OPTIONS menu.
NOTE: At present, only a single surface type can be specified, and the only losses are for a rough sea. The groundwave signal is calculated using the routine GRWAVE.

RANGE as a function of TIME calculation



This option is selected using the F8 function key.

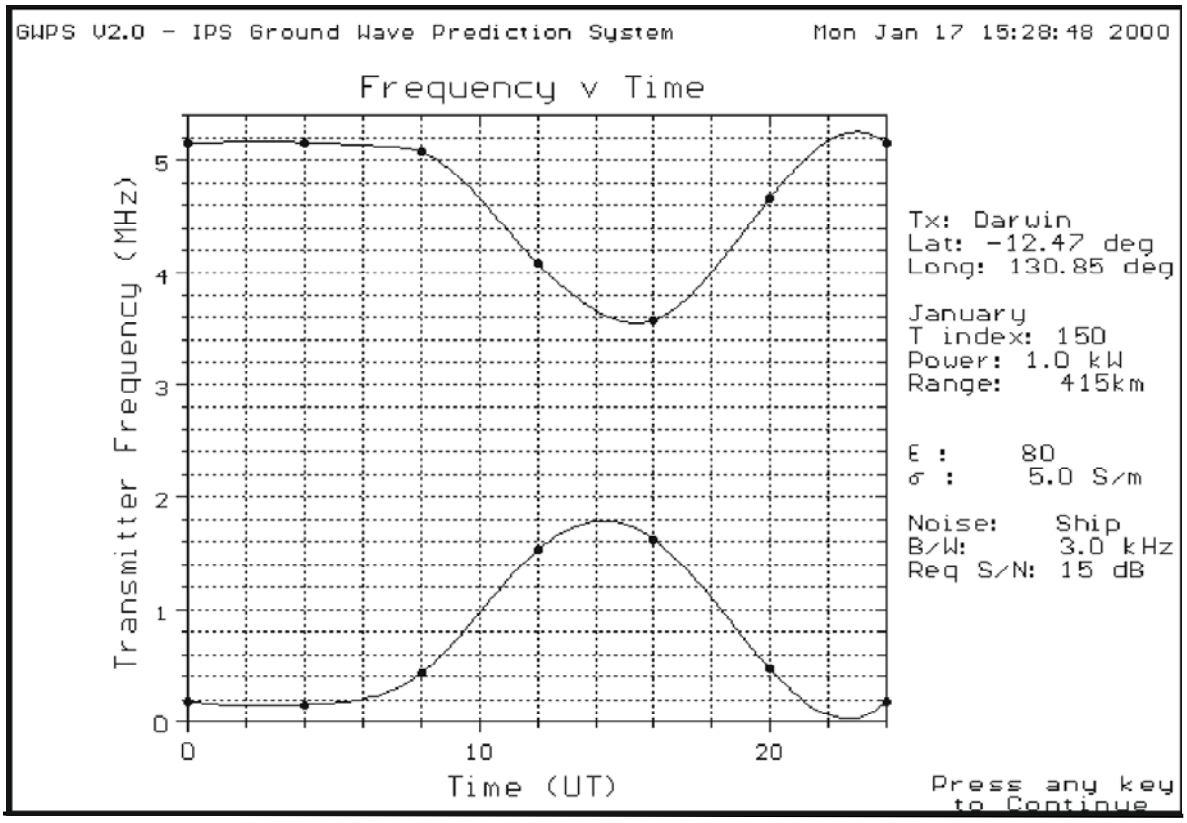
The routine calculates the range of a signal of a given quality as specified by the signal to noise ratio, under the specified operating conditions, for a 24 hour period.

The variables of interest are:

- Transmitter type
- Transmitter geometry (length of dipole element)
- Transmitter efficiency (a total effective efficiency)
- Transmitter height above the surface
- Transmitter location
- Transmitter power
- Transmitter frequency
- Receiver type
- Receiver geometry (length of dipole element)
- Receiver height above the surface
- Receiver bandwidth
- The total noise level as determined by the season of the year, the T index and the grade of the noise. The total noise consists of contributions from the atmospheric noise, galactic noise and man-made noise. (The time of day is varied over a full 24 hour period.)
- The required signal/noise ratio.
- The type of surface over which the signal propagates as specified by the relative permittivity and the conductivity, and any losses associated with this surface.

A graph of the RANGE at each TIME is displayed, and may be modified using the GRAPHING OPTIONS menu.

FREQUENCY as a function of TIME calculation



This option is selected using the F9 function key.

The routine calculates the frequency variation over a day for a signal of a given quality as specified by the signal to noise ratio, and under the specified operating conditions, of sufficient strength to reach a fixed distance. Note that if the required frequency is outside either of the program internal limits, then the frequency is set to that particular limit. These are currently set at 0.01 MHz to 50 MHz. There may possibly be multiple solutions. Each solution is displayed as a continuous line over the appropriate time range. The range/frequency graph can show the frequency bands which correspond to a stronger signal than that specified.

Note that the identification of these bands is limited, so that an incorrect identification may result. Inspection of the Range/Frequency curves at the appropriate times can resolve any problems.

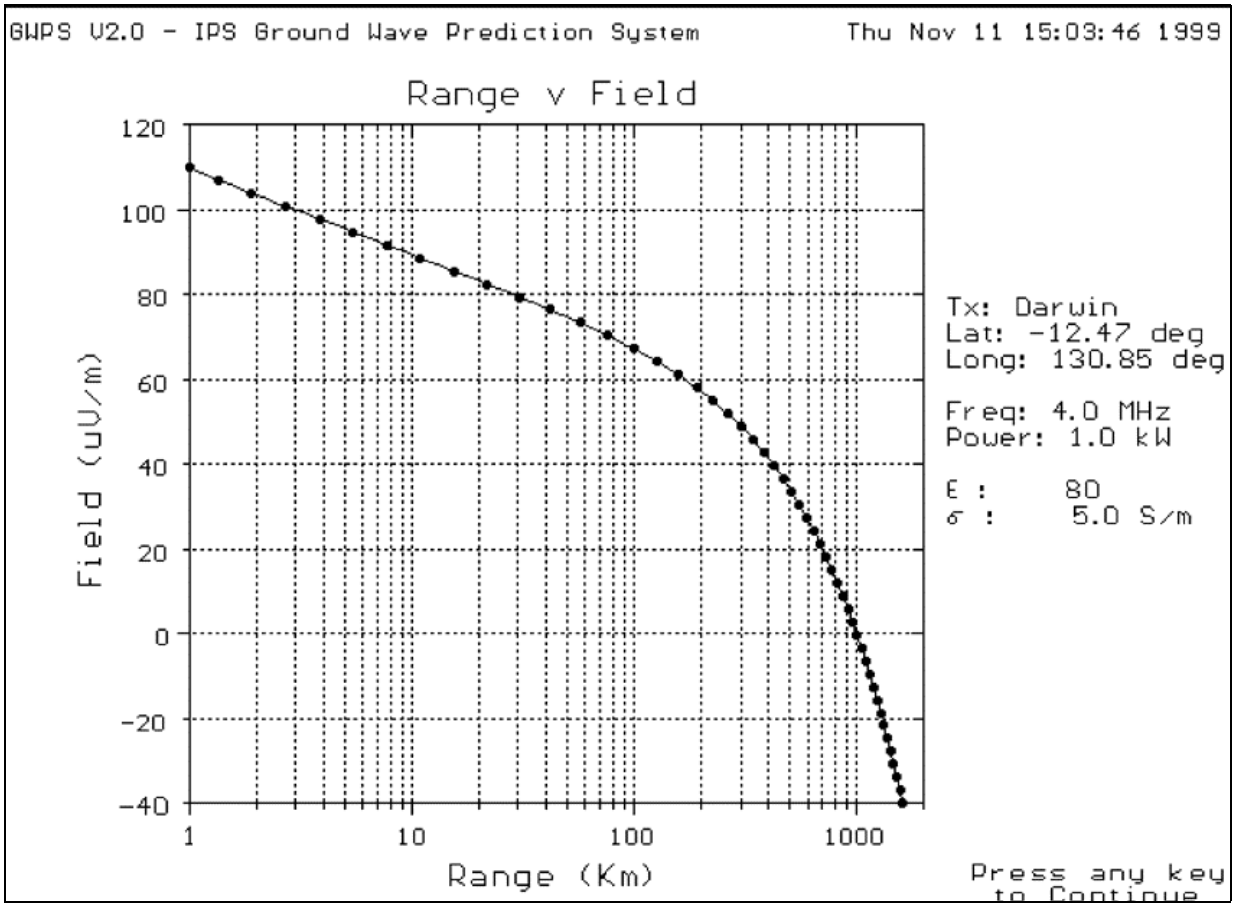
The variables of interest are:

- Transmitter type
- Transmitter geometry (length of dipole element)
- Transmitter efficiency (a total effective efficiency)
- Transmitter height above the surface
- Transmitter location
- Transmitter power
- Receiver type
- Receiver geometry (length of dipole element)
- Receiver height above the surface
- Receiver bandwidth
- The total noise level as determined by the season of the year, the T index and the grade of the noise. The total noise consists of contributions from the atmospheric noise, galactic noise and man-made noise. (The time of day is varied over a full 24 hour period.)
- The required signal/noise ratio.
- The type of surface over which the signal propagates as specified by the relative permittivity and the conductivity, and any losses associated with this surface.
- The range at which the signal is received.

A graph of the FREQUENCY at each TIME is displayed, and may be modified using the GRAPHING OPTIONS menu.

NOTE: At present, only a single surface type can be specified, and the only losses are for a rough sea. The groundwave signal is calculated using the routine GRWAVE.

ELECTRIC FIELD STRENGTH as a function of RANGE calculation



This option is selected using the F4 function key.

The routine calculates the Electric Field Strength for ranges within 1 to 10000 km, under specified conditions.

The variables of interest are:

- Transmitter Frequency
- Transmitter Power
- Transmitter Polarisation
- Transmitter Height above the surface
- Receiver Height above the surface

The type of surface over which the signal propagates is specified by the relative permittivity and the conductivity.
A graph of ELECTRIC FIELD STRENGTH at each RANGE value is displayed and may be modified using the GRAPHING OPTIONS menu.

NOTE: The groundwave signal is calculated using the routine GRWAVE.

Function Keys

The following is a short list of the operation each defined function key performs.

^BREAK	This can be used to interrupt a calculation, as indicated at its commencement. The break will occur at some time after this, depending on what is currently being done. Thus there may be a pause
ESC	This is used to exit from the current option, page, message box, and to quit from the edit buffer
F1	Calls the help menu page
F2	In standard mode, this saves the current settings to the specified configuration file. This file is overwritten if it exists, otherwise a file is created. In edit mode, this clears the input buffer.
F3	Loads the configuration file. If no file exists, then the display is unchanged.
F4	This initiates the FIELD STRENGTH/RANGE calculation. See the description in the FIELD STRENGTH/RANGE CALCULATION help page.
F5	This initiates the RANGE calculation. See the description in the RANGE CALCULATION help page.
F6	This initiates the RANGE/FREQUENCY calculation. See the description in the RANGE/FREQUENCY CALCULATION help page.
F7	This initiates the RANGE/POWER calculation. See the description in the RANGE/POWER CALCULATION help page.
F8	This initiates the RANGE/TIME calculation. See the description in the RANGE/TIME CALCULATION help page.
F9	This initiates the FREQUENCY/TIME calculation. See the description in the FREQUENCY/TIME CALCULATION help page.
ALT-F5	Lists the current data to the screen. The current data is that most recently calculated or displayed.
ALT-F6	Lists the current data to a file. The file name is set on the main menu page. See the VARIABLE DESCRIPTIONS help page. The data is appended to this file if it exists, otherwise a file is created. The current data is that most recently calculated or displayed.
ALT-F7	Puts the current graph to a POSTSCRIPT bitmap file. The file name is set on the main menu page. See the VARIABLE DESCRIPTIONS help page. The data is appended to this file if it exists, otherwise a file is created. The current graph is that most recently displayed.

Running GWPS in Batch Mode

In batch mode GWPS will accept input from a file. If you start GWPS in batch mode, it will read in the following data from the input file gwps.dat:

- permittivity
- conductivity (S/m)
- transmitter frequency (MHZ),
- transmitter power (kW)
- transmitter height (m)
- receiver height (m)

The above data is entered in a line of input in the same order, separated by space. All these values are decimal point numbers. Each line in input file gwps.dat represents a single set of data. Multiple sets of data can be stored in the input file.

Two samples of input data is presented below:

30.0 .01 1.0 1.0 1.0 1.0
80.0 5.0 1.0 1.0 1.0 1.0+

The required command line switch for batch mode is "-B" or "-b". If you type

```
gwps -B filename
```

OR

```
gwps -b filename
```

the program will calculate the electric field strength as a function of Range, store the output in the file "filename", as ASCII, and then quit.