The Computer Code for the Evaluation of the Broadband Green's Function of the Range-Dependent Waveguide Based on the Pseudodifferential Parabolic Equation Technique

User's Manual

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The PDPE code computes the broadband frequency-space Green's function of the acoustic pressure in the range-dependent waveguide using the one-way pseudodifferential parabolic equation with the simplified account for the local mode interaction

$$p(z, x+h) = \exp\left(ihk_0 \sqrt{r \frac{d}{dz} \frac{1}{r} \frac{d}{dz} + n^2(z)} \right) p(z,x)$$

For the basic considerations concerning this algorithm see avlv95en.pdf and avlv94en.pdf in the Docs directory.

If you want to make a reference then use, please, the paper from avlv95en.pdf. If you have questions, don't hesitate to contact the author by the above E-mail.

The computation in the frequency domain is made in two stages. On the first stage the input data are checked and rearranged by the FRMEDGEN code. It produces the intermediate files a20.wpr and a21.wpr. On the second stage the Green's function is calculated and memorized in the given region of the waveguide by the code WPRUNI. Thereafter some MATLAB tools are used to produce the time-space Green's function or the time domain signal of the arbitrarily moving source from the computed frequency-space Green's function.

The command string for the execution of FRMEDGEN must have at least one parameter – the name of the text file containing the head part of the input data. It may contain the second parameter – the name of the file for the debugging purpose output of FRMEDGEN. If the second parameter lacks, then there is no debugging output.

The command string for the execution of WPRUNI must have at least one parameter – the name of the text file containing the variable parts of the poles filenames for different frequencies. It may contain the second parameter – the name of the file for the debugging purpose output. If the second parameter lacks, then there is no debugging output.

The head part data file consists of the next data items:

- The upper frequency of the frequency band, Hz. The available pole sets assume the equidistant frequency mesh of the size n=2**m. The upper frequency fr corresponds to the (n-1)-th frequency. This gives the sampling frequency for the time domain 2*n/(n-1)*fr.
- The step on the depth grid, kM. The smaller is this step, the higher is the accuracy of the approximation of the depth differential operator. The value of the one-fourth of the wavelength in water on the upper frequency is sufficient.
- The reference sound speed crf , kM/sec, $k_0 = w / crf$. The highest accuracy of the approximation of the $\exp(ih\sqrt{l})$ occurs in the vicinity of k_0. The horizontal step of integration of the PDPE is proportional to fr / crf . The most common pole set 08!!!!!!.884 provides a good accuracy for $n^2 \in (0.64, 1.21)$
- The final value of the horizontal coordinate for the integration. The medium is given in the fixed Cartesian system. The source position and the direction of the integration can be arbitrary.

The next four data items control the string pattern on the screen

- The ordinal number of the node of the depth grid where starts the display of the excess over cylindrical spreading. This node corresponds to the rightest position on the screen. The node numbering starts from 1.
- The interval of averaging for one symbol position on the screen.
- The number of integration steps after which the string on the screen is displayed. If it is lower or equal to zero then the pattern is not displayed.
- The weight of the one change of the symbol, dB. The symbol scale is ' ','.',':','-','+','=','X','O','Q','0','W'.

The next data items govern using of the pole sets during the calculation. There exist the precomputed pole sets (*.8!!) with the bigger horizontal steps (8 wavelengths) used to cross the section of the waveguide where the interpolation is not necessary. There exist also the pole sets with the horizontal step of one half of the wavelength (*.h!!) used to the integration in those regions of the waveguide where the interpolation is needed.

- The binary logarithm of the size of the frequency mesh for the identification of the pole set. Must be given as the two symbol character string with leading zero if necessary.
- The number of the horizontal intervals of the waveguide where the different pole sets are used.
- The left and the right point of the interval, and the character string – the filename extension, characterizing the pole set. All three items must reside on the one string. The number of such strings must be equal to the number of the horizontal intervals.

The next data items govern the registration of the resulting field.

- The number of the regions of the waveguide where the field is registered in the output files. The region has the form of the trapeze with vertical bases. If this number is lower or equal to zero, then the registration is not needed and the next data item is obsolete.
- The left and right horizontal coordinates of the bases and their upper and lower depths – six numbers on one line. The number of lines must be equal to the precedent data item.

The next data items are the filenames – the character strings.

- The name of the file with the basic oceanological data. This file can contain the sound speed, density and bottom relief data.
- The name of the file with the description of the sound speed in water in the GRD format of the SURFER (Golden Software). Only one such description may exist – in the basic data file or in GRD file. On the same line occur the three coefficients of reduction of units used in the GRD file to the standard units kM, sec for depth, range and sound speed, respectively.
- The name of the file with the description of the bottom relief in the BLN format of the SURFER files. Only one such description may exist also. The coefficients relates to the depth and range units.

If all data are described in the basic data file, then this two filenames must be blank.

- The path to the directory with pole sets including the final backslash
- The string containing the two first symbols of the output filenames. The full filenames consist of these two symbols, the frequency number and the file extension WDX for index files and WLD for the files with the excess over cylindrical spreading.

The next data items describe the sources

- The source type – an integer – 1 or 2.for this version use always 1.
- The horizontal coordinate of the source.
- The maximal value of the phase velocity of the local normal modes at the source. In fact this parameter describes the directivity of the source.
- The number of the sources. For this version use always 1.
- The depth of the source
- The depth step of the vertical array – dummy in thus version.
- The complex amplitude of the source
- The complex ratio of amplitudes – dummy in this version.
- The marker of the end of the data – the negative integer.

The data in the basic data file describe the model of the ocean – the liquid layer with the complex sound speed, the real density both depending on two coordinates and with the plain free boundaries.

The data are grouped in fragments concerning the water, bottom and relief.

- The first line contains the numbers of hydrological horizons for all stations of the sound speed in water, the sound speed in bottom, the sound speed in relief, the density in water, the density in bottom.

The fragments follow

- The type of the fragment – an integer
  1 – sound speed in water
  2 – relief description. The sound speed in relief data is placed only for unification with other fragment types, it is not used in fact. Relief is described as the transition layer. Its depth may be nonnegative arbitrary.
  3 – the sound speed in bottom
  4 – the density in water
  5 – the density in bottom
- The horizontal coordinate of the station. The coordinates of the most right and left stations must be equal for all types.
- The initial and the final ordinal numbers of the hydrological horizons whose depths are changed in the fragment. For the first occurrence of the type all depths must be defined.
- The depths of the horizons
- The real and imaginary parts of the sound speed on consecutive lines or the density. The first two horizons of sound speed in water and the first horizon of density in water are reserved data items. Put the equal to the next one. The same is true for the last two sound speed and last density in bottom. Put them equal to the precedent one.
- The negative integer as the type serves as the end data marker.

The structure of the pole set file.

- The whole number of poles in the set, the frequency ordinal number, the whole number of frequencies (2**m-1)
- The step value in wavelengths, the left and right boundaries of the interval of the squared refraction index with affordable accuracy
- The complex poles

The structure of the file with frequency numbers

- The reserved hex value
- The frequency number with leading zeros and the flag for index file generation 1-yes 0-no

The output WLD files contain the values of
$p(z,r)\sqrt{r}\,\exp(2\mathbf{p} * fr * r / crf)$,where $p(z,r)$ is the acoustic pressure.

The index file has the head record: number of field realizations – 1 for this version, the step on depth, the depth of the ocean surface, the horizontal coordinate of the source, the reference sound speed, the upper frequency, the number of frequencies 2**m-1. It is followed by the set of records of the next structure: the horizontal coordinate of the field slice, the number of the initial and final nodes in the slice, the correspondent position in the WLD file.