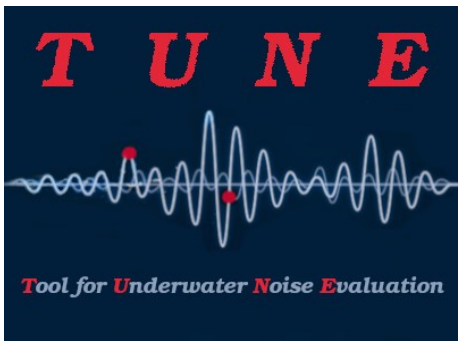

T U N E

Tool for Underwater Noise Evaluation

USER MANUAL

v. 5.14 – 14-feb-2025

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Revision	*Date*	*Description*
5.05	8-mar-2024	First edition for standalone application
5.06	27-mar-2024	Changed to decidecade bands, added multichannel, minor fixes
5.06.1	5-apr-2024	Minor changes to text and format, added flowchart
5.1x	6-dec-2024	Updated with filter and setup save/load options, added quick guide and output file details
5.13	24-jan-2025	Changed program name from “UWNoiPro” to “TUNE” and decidecade PSD to decidecade SPL, revised text
5.14	14-feb-2025	Updated calibration file handling, snapshot options, license details.

1. Overall description

TUNE – **T**ool for **U**nderwater **N**oise **E**valuation – is a program developed as a Matlab® standalone executable for processing audio files in WAV format containing underwater sound recordings to compute any of the following output quantities in dB used in standard analysis:

- Sound Pressure Level (SPL), broadband (BB) and in decidecade bands (DD)
- Power Spectral Density (PSD)

Processing is done in intervals ("snapshots") of given time duration within a given start/stop time range. Data may be highpass/lowpass/bandpass filtered before processing. SPL and PSD are computed and plotted on separate figures for each snapshot, then final results are presented as average (arithmetic mean or median) and percentile plots over all snapshots. Current snapshot waveform is also plotted during processing.

Input data are converted into absolute pressure in pascal using a user provided, frequency dependent calibration table. Processing is done on all valid audio files contained in a user selected input folder. Final figures may be saved to JPEG files, with corresponding data to text files. Program execution details may be logged to a text file. All output files are saved to a user selected output folder.

TUNE is distributed freely under GNU General Public License v. 3.0.

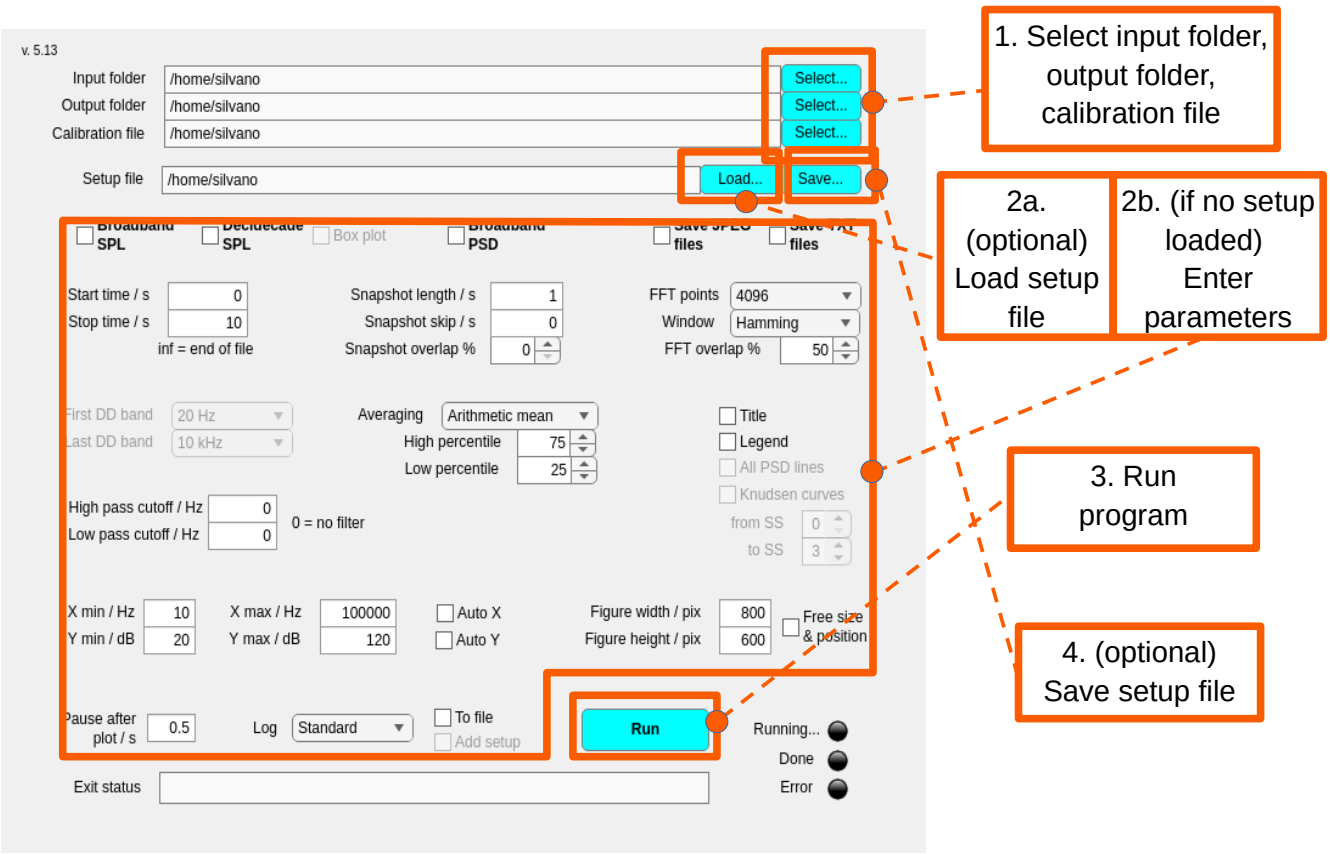
2. Requirements

Input audio file(s): WAV format, single- or multi-channel (e.g. stereo), any sampling rate, any bit depth. Any file length may be processed compatible with system requirements, since file is only read piecewise one snapshot at a time and not altogether. Files in input folder whose names do not end with ".wav" or ".WAV" are ignored.

Calibration file: text format, one [frequency dB] calibration point per row, blank or tab separated. Lines beginning with any non-numeric character and blank lines are ignored. Minimum three points are required, at least partially covering the frequency range of interest. Values used for processing are linearly interpolated between available points, and extrapolated using last value as a constant. Values are meant to be frequency in Hz and sensitivity in dB re 1 V/µPa. Equivalent Scale Factor (SF) values in Pa may also be given instead of dB. The program detects either representation by reading first value: if negative, dB are assumed throughout, otherwise SF. Decimal separator for numbers must be point, comma is not recognized.

System requirements: Matlab runtime for Windows v. 9.5 (R2018b), 8 GB recommended. For additional details see Installation notes or Wiki pages on GitHub repository (https://github.com/sbuogo/TUNE).

3. Quick guide



NOTES

Input/output folders and calibration file may have been automatically selected upon program start from a previous session: anyway, they may be changed as needed.

All valid WAV files in input folder are processed sequentially with current parameter setup and using the selected calibration file. All output files are saved to output folder.

Input waveform snapshots, possibly filtered, are always plotted regardless of SPL, PSD options.

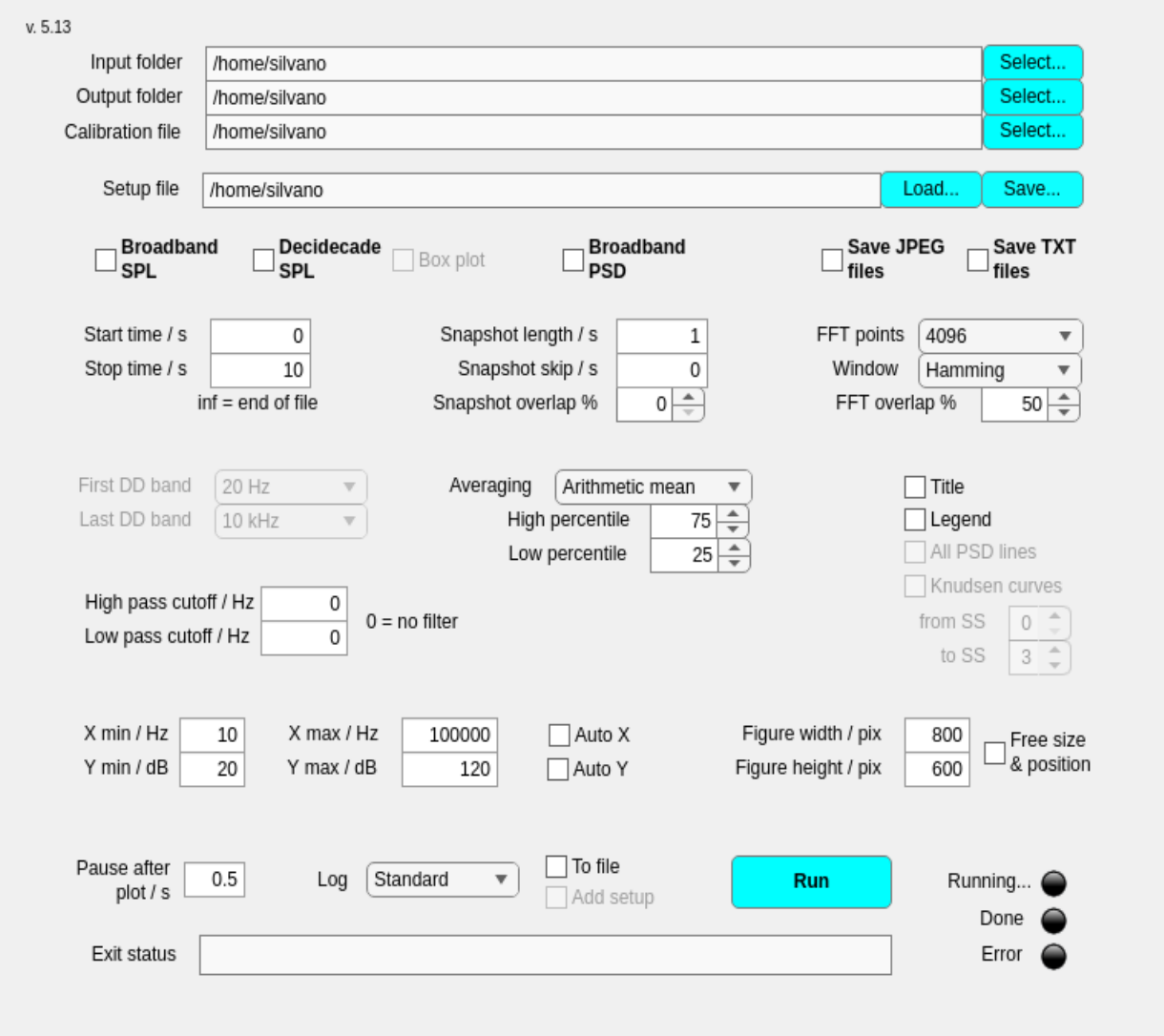
Once a 'Run' command is issued, no user action is required. Execution ends either with normal exit status or an error message, and may be repeated using same or different folders, files, and parameters.

During and after processing, figures may be moved and resized manually.

Closing program window also closes all open figures.

4. Detailed description

A graphical user interface (GUI, see below) pops up at program start, containing all parameters to be sent to processing functions for each input audio file. A description is given below following a top-bottom order which is the normal order for selecting options and parameters.



4.1. Input / output folder and file options

WAV files to be processed are read from input folder. Other files with extension else than ".wav" or ".WAV", if present, are ignored. No action is done if folder is empty. Multichannel WAV files (e.g. stereo files) are read one channel at a time, and "(chN)" identifiers are appended to figure titles and output filenames.

A valid calibration file (see chapter 'Requirements') must be selected to start processing: an error message box pops up to prompt user action to correct a missing or invalid file. Once selected, valid calibration data are plotted on a separate figure.

The program remembers last valid input/output folders and calibration file from last successful session, in which case it is not necessary to enter them again (see chapter 'Execution').

Output folder collects results as JPEG files reproducing final plots and text files containing corresponding numeric data in tabular form. Text file structure is as follows:

Broadband SPL file	Decidecade SPL or PSD file
t(0) spl(0) t(1) spl(1) t(2) spl(2) ...	f(0) avg(0) pct-(0) pct+(0) f(1) avg(1) pct-(1) pct+(1) f(2) avg(2) pct-(2) pct+(2) ...

where t(n) and f(n) are n-th time in seconds or frequency in Hz, spl(n) is n-th SPL in dB, avg(n) is n-th average PSD in dB (arithmetic or median), and pct-(n), pct+(n) are low- and high-percentile PSD values, respectively. Time values in SPL file are actually midpoints of each snapshot. Text files have header lines beginning with '%' to display program version and data names and units.

Each output filename contains audio file name, date-time of creation, and an identifier of processing type. If selected, a logfile in text format is also created in the same folder, containing processing details possibly including parameter setup. If a logfile is already present in output folder, further data are appended to it. Files are created in output folder only if corresponding options for JPEG, TXT, or logging are selected.

4.2. Setup file

The entire set of parameters shown on GUI, with the only exception of input/output folders and calibration file which are managed seprately (see chapter 'Execution'), may be saved to a setup file or loaded from an existing setup file. Setup file name has extension *.mat and is mostly in binary format except first line in text format containing Matlab version, platform type, and date/time of creation.

'Load…' and 'Save…' buttons prompt a dialog window for selecting or entering a *.mat file: the extension is added by default when entering a file name to be saved. Once a setup file is created, it is possible to replicate the same processing by simply loading the setup file at the beginning of a new program session even on a different program installation, provided that program versions are the same. Selecting setup files created with previous program versions raises an error.

Input and output folders or calibration file do not change when loading a setup file, nor they are included in a newly saved setup file. However, the program automatically recalls them from a previous valid session at beginning of a new one (see chapter 'Execution').

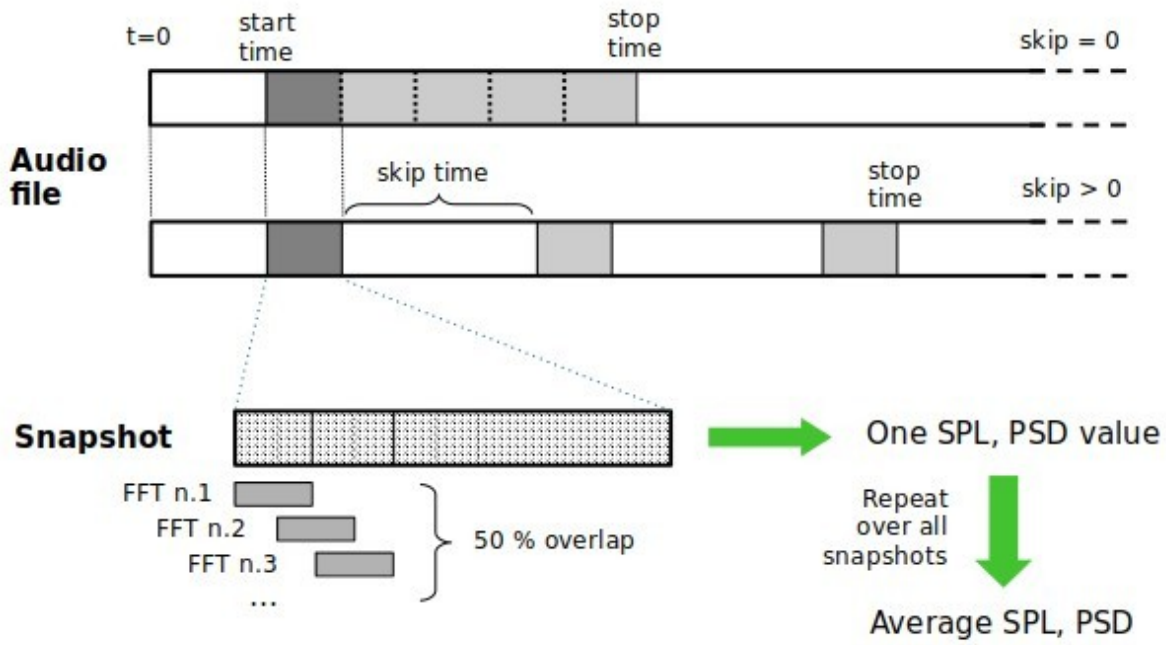
4.3. Processing options (not exclusive, may be selected in any order)

- Broadband (BB) SPL: full-spectrum (unfiltered) sound pressure level in dB re 1 µPa as a function of time, one point per snapshot at midpoint times within each snapshot.
- Decidecade (DD) SPL: as above, computed in a series of decidecade frequency bands with nominal center frequencies selected between 1 Hz and 800 kHz.
- Broadband (BB) PSD: power spectral density in dB re 1 µPa^2/Hz as a function of frequency over full band up to Nyquist frequency (sample rate divided by 2).

Selecting DD, user can choose first and last band in a series, and can select boxplot as output plot instead of bullet plot. Selecting BB PSD, user can optionally add all lines for each snapshot in output plot (default is plot only average and percentiles), and add Knudsen curves for any range of sea states between 0 and 6.

4.4. Defining time range, snapshot, FFT

Start time and stop time define the time range over which one or more intervals named “snapshots” of given duration are considered one at a time. For each snapshot, a number of N-point FFTs (depending on both N and snapshot duration) are computed in subintervals and averaged to yield one single SPL value or PSD spectrum. Values and spectra collected over all snapshots are then averaged, converted to dB and sent to output (see figure below).



To process each audio file up to end of file, set stop time = “inf”. Note that a fixed stop time might cause an error if audio file duration is shorther.

Snapshots may be consecutive (skip time = 0 and 0 % overlap), may have a given skip time between each, or may overlap (overlap > 0 %). For example, set 10 s length and 50 s skip to process only the first 10 s in a minute. Length, skip time and overlap all have an effect on the number of snapshots for a given time range. Skip time and overlap are mutually exclusive.

FFT options include standard options for n. of points (in powers of 2), overlap, and windowing. FFT n. of points must not exceed the n. of samples in a snapshot. Usually, last FFT subinterval does not entirely fit into snapshot (unless snapshot length is an exact multiple related to FFT points and overlap), so it is moved at the end of it by sliding back its starting point by the required n. of samples.

4.5. Averaging and percentiles

Averaging method (arithmetic mean or median) applies both to FFT averaging within one snapshot and to averaging over all snapshots: in the latter case, corresponding averages and percentiles (high from 50 % to 95 %, low from 5 % to 50 %, both in 5 % step) are plotted in final results. If boxplot option is selected, final plot only shows 25 % and 75 % percentiles regardless of user selection.

4.6. Highpass/lowpass/bandpass filtering

Snapshots may be additionally highpass/lowpass/bandpass filtered prior to processing by entering cutoff frequencies in Hz > 0. Filter type is modeled according to cutoff frequencies as follows:

- highpass filter: high pass cut > 0 low pass cut = 0
- lowpass filter: high pass cut = 0 low pass cut > 0
- bandpass filter: high pass cut > 0 low pass cut > 0
- no filter: high pass cut = 0 low pass cut = 0

If no filter is selected, only the DC component is removed. Filter characteristics are: 60 dB stopband attenuation, 0.1 dB passband ripple, transition band = 0.15 * cutoff f. For bandpass filter, stopband attenuation is 30 dB on either side. Note that filtering may consideraby increase processing time especially for long snapshots.

If either low or high pass cut frequencies exceed sampling rate a warning is output to exit status and execution continues with next input file, if any.

4.7. Plot options

Titles and legends may be optionally applied to final plots. Titles include audio file names and major parameters. Options for drawing all BB PSD lines and Knudsen curves are described above in processing options. X and Y axis ranges may be set using fixed values in corresponding units or using autorange. Figures are originally created with fixed size and positioned with a small tile offset near bottom left screen corner. During processing or after it, figures can be freely moved or resized across the screen. If “Free size & position” is selected, on next run figures will keep their current size and position on screen: otherwise, they are reset to original size and position. When saved to a JPEG file, figure size is the same as the one on screen. Figure windows include menus and icons to change plot parameters interactively and save changes on different graphic files.

A variable pause may be added between plots to ease readability before each plot is refreshed with new data.

4.8. Logging

Time-tagged information may be logged to a text file saved in output folder, with options: Standard, Detailed, Debug. Standard option is adequate for most uses, while Detailed adds info on FFT, DD frequencies and intermediate results. Debug adds much more data and requires user action by pressing a key after each FFT plot, which is slow and only recommended for testing on small datasets. The entire parameter setup in GUI may also be added to logfile. A single logfile is created for each folder, and all subsequent processing append further text to it.

Logfile also contains all text Matlab sends to command line including runtime error messages: these may be useful to identify causes of unexpected errors causing execution hangup (see chapter “Execution”).

5. Execution

Once all options have been selected, press “Run” to start processing. From this point on, no further action is required until all files are processed. Visual and text indicators describe exit status: both refer to last error encountered during processing. In case of errors related to global parameters, execution stops before processing first audio file. If errors are encountered in one specific audio file in a set, execution stops but valid results may still be available from previous files.

An “Info” window located near GUI window shows additional information on processing parameters which depend on current audio file and are updated for each file.

Once a measurement run is ended, it may be repeated issuing “Run” again varying input/output folders, calibration file, options and parameters as needed, or loading another setup file. Output will be on different files on a single folder provided that next execution ends at a different time in [hh-mm] format, that is at least one minute later: otherwise, output files will be overwritten.

Note that there will be one logfile for each output folder, which includes information on processing done so far for all output files in that folder.

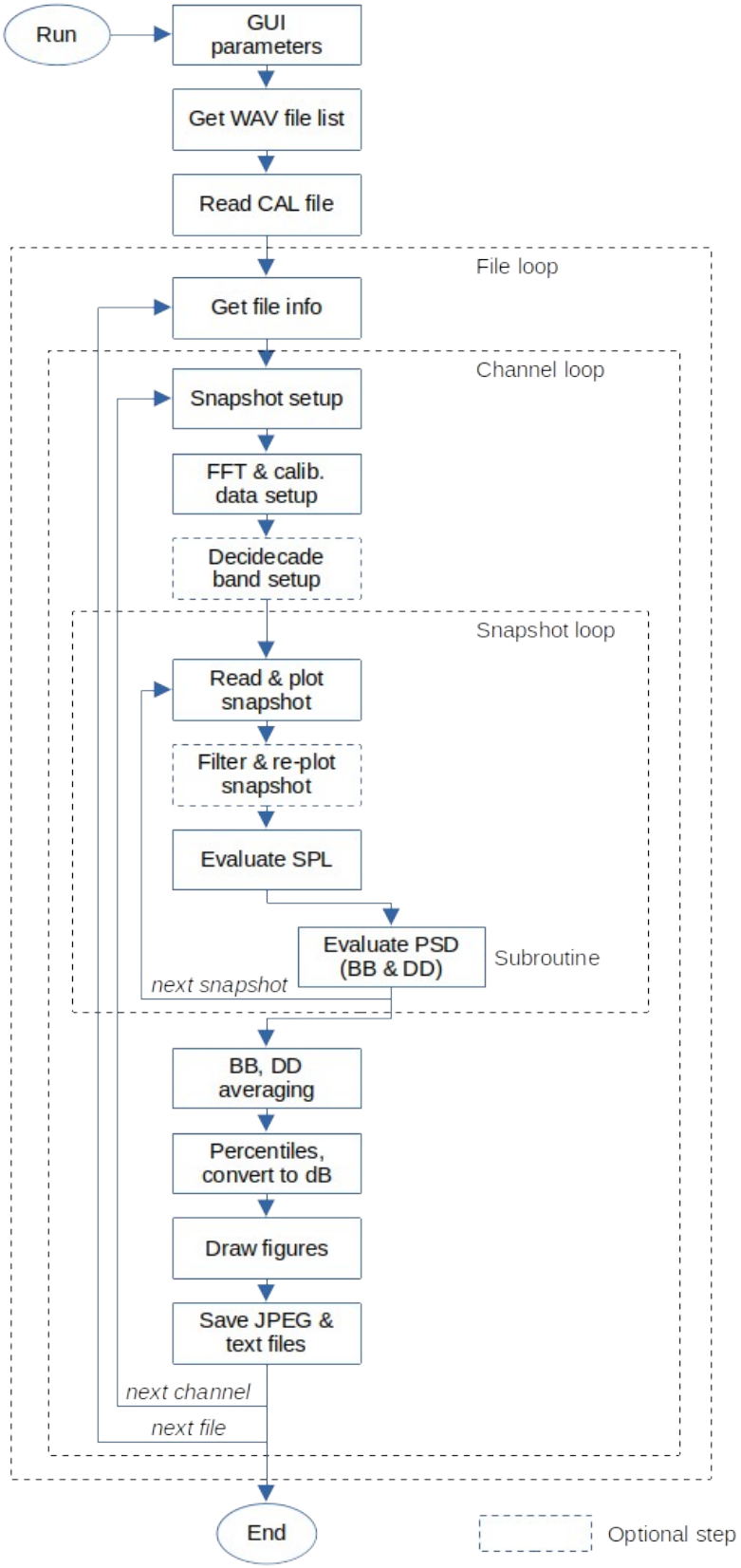
To reuse the current setup in a new session after program exit and restart, or on a different installation using the same program version, a new setup file may be saved and loaded as explained in previous section ‘Setup file’.

Input/output folders and calibration file are not included in setup but are stored in a *.mat initialization file. This file is automatically created in a subfolder named “.TUNE” inside user’s home folder at the end of every successful run, in order to select the last valid input/output folders and calibration file when beginning a new session. If no initialization file is present, folders and calibration file are set to default system folder at beginning of session and must be entered manually before loading or changing setup parameters. Note that the initialization file should not be moved from its location nor it is useful to copy it to another installation, as it contains full paths to local folders which usually differ from those on another PC.

To exit program, click the upper right corner icon in GUI window titlebar. Upon normal exit, all figure windows are also closed.

Most errors cause program stop and show up in a dialog box or in the status bar. However, some might not be caught and may silently cause execution hangup: in this case GUI and figures should be closed manually. Error description usually displays in logfile, and setting logging option to Detailed or Debug may help in identifying its cause.

6. Flowchart


Run
GUI parameters
Get WAV file list
Read CAL file
File loop
Get file info
Channel loop
Snapshot setup
FFT & calib. data setup
Decidecade band setup
Snapshot loop
Read & plot snapshot
Filter & re-plot snapshot
Evaluate SPL
Evaluate PSD (BB & DD)
Subroutine
next snapshot
BB, DD averaging
Percentiles, convert to dB
Draw figures
Save JPEG & text files
next channel
next file
End
Optional step