





MultichannelGPR: A MATLAB tool for GPR data processing

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Summary

Ground Penetrating Radar (GPR) is a popular geophysical method for near surface investigations using high-frequency electromagnetic waves for a broad range of applications such as archaeological prospection (e.g. [Trinks et al., 2018](#)), hydrology (e.g. [Annan, 2005](#)), urban infrastructure detection (e.g. [Pajewski et al., 2019](#)), geological mapping (e.g. [Buck & Bristow, 2024](#)), permafrost investigations (e.g. [Westermann et al., 2010](#)) or soil science (e.g. [Gates et al., 2023](#)). Pulsed electromagnetic waves are transmitted from a transmitter antenna, penetrate into the ground and are reflected and transmitted at interfaces until the reflected waves are recorded by a receiving antenna. For mapping, the transmitter and receiver antenna (=one channel) are mostly carried with a constant small offset between them along a profile. For applications requiring high spatial resolution multi-channel equipment is available collecting several parallel profiles with small profile spacing (e.g. 4 cm or 8 cm) in one swath.

MultichannelGPR is a structured collection of MATLAB scripts and functions for processing, visualization and export of single- and multi-channel GPR data. Although it was originally intended and developed for the processing of multichannel Malå MIRA data, it evolved to a more general processing tool also for data from other systems, e.g. GSSI, and partially Sensors&Software and Radarteam. But as the needed input format is clearly defined, the user can input any GPR data from any system, if the data is converted into the required mat-format. It is structured into various folders containing MATLAB scripts for specific purposes that are mainly data import, processing in 2D and 3D (or cross-channel for multichannel data), visualization and velocity analysis. Some Graphical User Interfaces (GUIs) for processing and visualization are also provided as well as export functionalities for georeferenced radargrams and timeslices for easy import into a Geographical Information System (GIS). A first paper on MultichannelGPR was published initially in 2021 ([Wunderlich, 2021](#)) and the code was available on request from the author. It was used in some publications, mainly for archaeological prospection ([Corradini et al., 2022, 2023](#); [Wunderlich et al., 2023, 2022](#)), but also for infrastructure mapping ([Karle et al., 2022](#)). It is now available on GitHub ([Wunderlich, 2024](#)) including a test data set and tutorial for easily getting started.

Statement of need

MultichannelGPR was designed to overcome the more or less “black-box” commercial software packages provided together with the GPR systems. Although these are mostly complete processing and visualization packages producing nice results, the exact data processing flow is partly obscured and the data can be extracted only at certain stages in specified data formats. Additionally, these programs mostly run only under Windows and/or licensed on single computers. Using closed proprietary software the inclusion of special processing steps by the user is not possible.

42 To my knowledge, there are already following other free software packages available for GPR
43 processing: The Matlab based programs (a) GPR-PRO ([Spanoudakis & Vafidis, 2010](#)), which,
44 unfortunately, is unclear how it can be obtained, (b) matGPR ([Tzanis, 2010](#)), which is only
45 applicable for single-channel data, not multichannel data, and (c) GPRlab [Xiong:2023], which
46 is developed obviously in a similar time range as MultichannelGPR. Two other softwares based
47 on the language R and python are (a) RGPR ([Huber & Hans, 2018](#)) and (b) GPRpy ([Plattner,](#)
48 [2020](#)). Except for matGPR, where it is explicitly mentioned, it is unclear if the programs can
49 handle multichannel GPR data that need special processing steps.

50 Therefore, MultichannelGPR was developed in order to - provide an open source and extendable
51 processing tool for multi- and single-channel data. - provide more control on the used processing
52 steps including documentation for reproducible science. - enabling data export at any stage of
53 the processing workflow for control and visualization purposes. - enabling a possibility (for
54 more experienced Matlab users) to easily implement own processing functions.

55 The input multichannel Malå MIRA data consists of 8 or 16 parallel channels collected with
56 8 cm profile spacing in one swath, a configuration file and a GPS positioning file. After
57 coordinate assignment to each trace, the best flow of processing steps has to be determined.
58 Two GUIs are provided for this task (see [Figure 1](#)): One for the determination of time zero and
59 adjustment between the channels (Check_t0.m) and one for the order of further processing
60 steps (Process_SingleProfile.m). The used processing steps and parameters can be saved and
61 then used for the processing of the complete data set. After determining the processing steps,
62 the main script for Malå MIRA data is Mala3D.m. It reads the data, applies the processing
63 steps and bins the data on a rectangular grid with a defined grid spacing. Some measures for
64 handling data larger than the computer memory are applied. All data is saved as Matlab-files
65 and thus can also be read without the MultichannelGPR software.

DRAFT

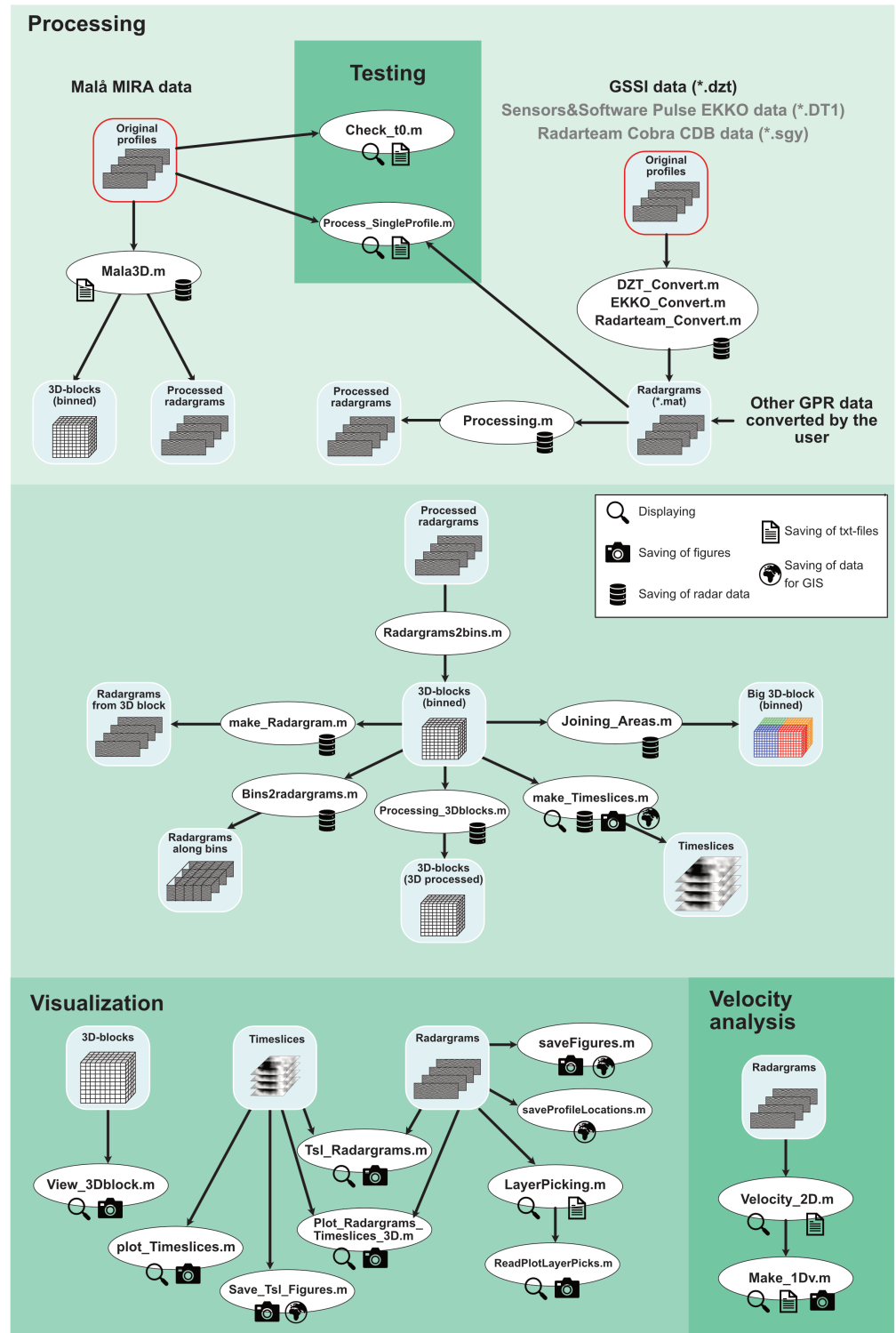


Figure 1: Workflow of MultichannelGPR showing the main scripts for processing and visualization.

Also other single-channel data by GSSI (and Sensors&Software and Radarteam, but not tested too well yet) can be imported and processed. The remaining scripts of MultichannelGPR can be used on the processed radargrams and binned data independently of their origin. Further

69 routines include the creation of timeslices, the extraction of radargrams from the binned data,
70 and 3D processing on the binned data. The 3D blocks can be visualized and sliced in three
71 directions using View_3Dblock.m. Both radargrams and timeslices can be compared using
72 Tsl_Radargrams.m with a visual aid using a copied mouse pointer in both data sets. For
73 picking of layers across the radargrams a script LayerPicking.m is provided. Radargrams and
74 timeslices can be exported as georeferenced PNG images and imported directly into a GIS
75 for producing publication-ready figures. For experienced Matlab users, it is also possible (a)
76 to use single processing functions for own specialised applications that are not covered by
77 the standard processing flow, (b) to include own processing functions or (c) to extract data
78 between processing steps for analysis.

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84 References

- 85 Annan, A. P. (2005). GPR methods for hydrogeological studies. In Y. Rubin & S. S. Hubbard
86 (Eds.), *Hydrogeophysics* (pp. 185–213). Springer Netherlands. [https://doi.org/10.1007/](https://doi.org/10.1007/1-4020-3102-5_7)
87 [1-4020-3102-5_7](https://doi.org/10.1007/1-4020-3102-5_7)
- 88 Buck, L., & Bristow, C. S. (2024). Using ground-penetrating radar to investigate deposits
89 from the storegga slide tsunami and other sand sheets in the shetland islands, UK. *Journal*
90 *of the Geological Society*, 181(1), jgs2023–042. <https://doi.org/10.1144/jgs2023-042>
- 91 Corradini, E., Dreibrodt, S., Lübke, H., Schmölcke, U., Wieckowska-Lüth, M., Wunderlich,
92 T., Wilken, D., Brozio, J. P., & Rabbel, W. (2023). A day at the bog: Preliminary
93 interpretation of prehistoric human occupation at ancient lake duvensee (germany) by GPR
94 structures. *Remote Sensing*, 15(14), 3647.
- 95 Corradini, E., Gross, D., Wunderlich, T., Lübke, H., Wilken, D., Erkul, E., Schmölcke, U.,
96 & Rabbel, W. (2022). Finding mesolithic sites: A multichannel ground-penetrating radar
97 (GPR) investigation at the ancient lake duvensee. *Remote Sensing*, 14(3), 781.
- 98 Gates, Z. W., Galagedara, L. W., & Ziegler, S. E. (2023). Combining ground penetrating
99 radar methodologies enables large-scale mapping of soil horizon thickness and bulk density
100 in boreal forests. *Soil Use and Management*, 39(4), 1289–1303. <https://doi.org/https://doi.org/10.1111/sum.12964>
- 101 <https://doi.org/https://doi.org/10.1111/sum.12964>
- 102 Huber, E., & Hans, G. (2018). RGPR—an open-source package to process and visualize GPR
103 data. *Proceedings of the 17th International Conference on Ground Penetrating Radar,*
104 *Rapperswil, Switzerland, 18–21 June 2018*, 1–5. [https://emanuelhuber.github.io/RGPR/](https://emanuelhuber.github.io/RGPR/2018_huber-and-hans_RGPR-new-R-package_notes.pdf)
105 [2018_huber-and-hans_RGPR-new-R-package_notes.pdf](https://emanuelhuber.github.io/RGPR/2018_huber-and-hans_RGPR-new-R-package_notes.pdf)
- 106 Karle, N., Boldt, M., Thiele, A., & Thoennessen, U. (2022). 3D mapping of buried pipes
107 in multi-channel GPR data. *The International Archives of the Photogrammetry, Remote*
108 *Sensing and Spatial Information Sciences*, XLIII-B1-2022, 85–91. <https://doi.org/10.5194/isprs-archives-XLIII-B1-2022-85-2022>
- 109 <https://doi.org/10.5194/isprs-archives-XLIII-B1-2022-85-2022>
- 110 Pajewski, L., Fontul, S., & Solla, M. (2019). Chapter 10 - ground-penetrating radar for
111 the evaluation and monitoring of transport infrastructures. In S. Persico R. Piro (Ed.),
112 *Innovation in near-surface geophysics* (pp. 341–398). Elsevier. <https://doi.org/https://doi.org/10.1016/B978-0-12-812429-1.00010-6>
- 113 <https://doi.org/10.1016/B978-0-12-812429-1.00010-6>

- 114 Plattner, A. M. (2020). GPRPy: Open-source ground-penetrating radar processing and
115 visualization software. *The Leading Edge*, 39(5), 332–337. [https://doi.org/10.1190/](https://doi.org/10.1190/le39050332.1)
116 [le39050332.1](https://doi.org/10.1190/le39050332.1)
- 117 Spanoudakis, N. S., & Vafidis, A. (2010). GPR-PRO: A MATLAB module for GPR data
118 processing. *Proceedings of the XIII International Conference on Ground Penetrating Radar*,
119 1–5. <https://api.semanticscholar.org/CorpusID:11558802>
- 120 Trinks, I., Hinterleitner, A., Neubauer, W., Nau, E., Löcker, K., Wallner, M., Gabler, M.,
121 Filzwieser, R., Wilding, J., Schiel, H., & others. (2018). Large-area high-resolution
122 ground-penetrating radar measurements for archaeological prospection. *Archaeological*
123 *Prospection*, 25(3), 171–195.
- 124 Tzanis, A. (2010). matGPR release 2: A freeware MATLAB® package for the analysis
125 & interpretation of common and single offset GPR data. *FastTimes*, 15(1), 17–43.
126 <https://api.semanticscholar.org/CorpusID:11558802>
- 127 Westermann, S., Wollschläger, U., & Boike, J. (2010). Monitoring of active layer dynamics at a
128 permafrost site on svalbard using multi-channel ground-penetrating radar. *The Cryosphere*,
129 4(4), 475–487. <https://doi.org/10.5194/tc-4-475-2010>
- 130 Wunderlich, T. (2021). MultichannelGPR – a new MATLAB-tool for the processing of
131 GPR data. *ArcheoSciences*, 45(1), 279–283. [https://doi.org/https://doi.org/10.4000/](https://doi.org/https://doi.org/10.4000/archeosciences.10100)
132 [archeosciences.10100](https://doi.org/https://doi.org/10.4000/archeosciences.10100)
- 133 Wunderlich, T. (2024). MultichannelGPR: A MATLAB tool for GPR data processing. In
134 *GitHub repository*. GitHub. <https://github.com/tinawunderlich/MultichannelGPR>
- 135 Wunderlich, T., Brozio, J. P., Feeser, I., Heumüller, M., & Mohr, C. (2023). Hunte 1
136 reloaded—combining ground penetrating radar, electrical resistivity tomography, corings
137 and excavations at the neolithic domestic site hunte 1, germany. *Advances in on-and*
138 *Offshore Archaeological Prospection: Proceedings of the 15th International Conference on*
139 *Archaeological Prospection*, 305–309.
- 140 Wunderlich, T., Wilken, D., Majchczack, B. S., Segschneider, M., & Rabbel, W. (2022).
141 Hyperbola detection with RetinaNet and comparison of hyperbola fitting methods in GPR
142 data from an archaeological site. *Remote Sensing*, 14(15), 3665.