Ground Penetrating Radar Data Processing and Visualization using GPRPy

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Abstract

Allowing near-surface geophysics students to learn ground penetrating radar (GPR) data processing through hands-on exercises poses a challenge because of the high cost of professional GPR software. Free processing and visualization packages are scarce and often either require other commercial software such as Matab, which many students may not have on their own computers, or they are limited to specific operating systems. To allow students to process GPR data on their own computers, for example data collected as part of a class-based research project or online available data, the processing software needs to be (1) free, (2) platform independent, (3) easy to install and use, and should record the steps the students take to obtain their results in order to facilitate reproducibility and grading. GPRPy (https://github.com/NSGeophysics/GPRPy) is an open-source ground penetrating radar data processing and visualization software that has a graphical user interface and which is also scriptable. It is python-based, making it platform independent and independent of commercial programming environments. The graphical user interface allows for writing out humanly readable python scripts that can be run from the command line to automatize the data processing and visualization. GPRPy is hosted on the collaborative software development website GitHub, allowing educators and researchers to create and adapt their own versions to their needs.

Ground Penetrating Radar Data Processing and Visualization using GPRPy

https://github.com/NSGeophysics/GPRPy

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Overview

Hands-on exercises of processing real geophysical data in a near-surface geophysics course is often hampered by

- high cost and complexity of professional software
- platform dependence (e.g. only Windows)
- commercial software requirement (e.g. Matlab)
- lack of easy to use free processing software

⇒ Students processing data on their own laptop computers is almost impossible but would be highly beneficial.

GPRPy is a free, graphical user interface-based ground penetrating radar (GPR) software that is platform independent (Windows, Mac, Linux). It allows for automatically generating scripts, creating a log of the processing steps.

Currently, GPRPy supports GSSI (.dzt files), Sensors and Software (.dt1 files), and ENVI Standard BSQ data sets but other formats can easily be implemented.

Example for automatically generated script

Clicking on the "write script" button at the bottom right of either of the user interfaces shown in Figs. 1 and 2 creates a Python script that can be run from the command line and which shows all processing steps taken in their corresponding order.

Instructors can ask students to hand in plots, together with the script to see the processing steps and the chosen parameters.

The following shows an example of an automatically-generated common-offset profile script `dune.py` for data recorded crossing the Dune of Pilat (France). The resulting profile is shown in Fig. 1. The data set was recorded by a Princeton University freshman seminar field trip taught by Frederik Simons, Christopher Harig, and James Smith.

```
import gprpy.gprpy as gp
mygpr = gp.gprpy2d()
mygpr.importdata('exampledata/GSSI/FILE____032.DZT')
mygpr.setZeroTime(5)
mygpr.dewow(9999999)
mygpr.remMeanTrace(9999999)
mygpr.setVelocity(0.14)
mygpr.fkMigration()
mygpr.topoCorrect('exampledata/GSSI/FILE____032p.txt',
                  delimiter='\t')
mygpr.printProfile('dune1Fig.pdf', color='bwr',
                   contrast=6, yrng=[16.5,19.7],
                   xrng=[0,20.8], asp=2, dpi=600)
```

In this example, the student took the following processing steps:

1. dewow filter with a large running mean window
2. removed the mean trace with large running mean window
3. set a velocity of 0.14 m/ns
4. ran a Stolt f-k migration
5. topographical adjustment using provided topography file

GPRPy graphical user interface

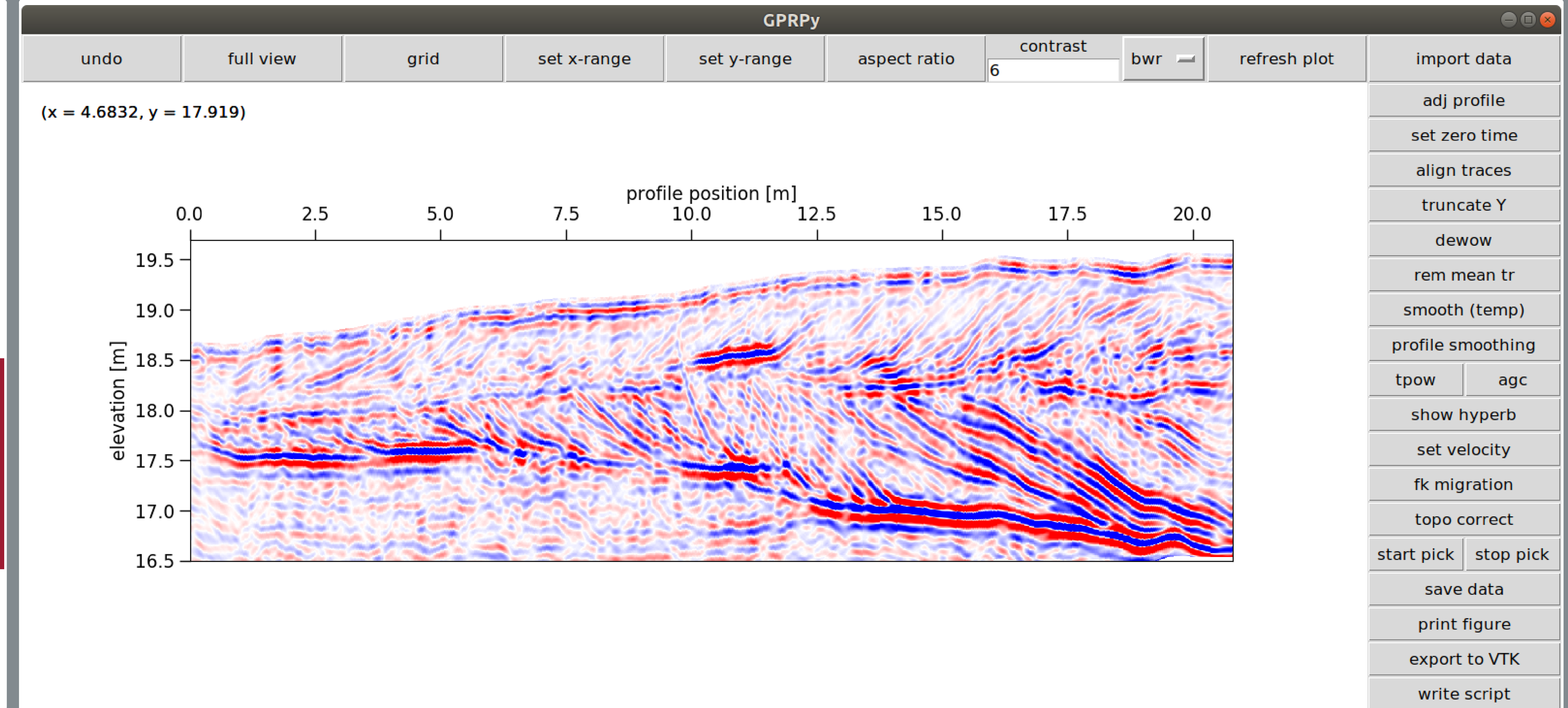

Figure 1: Graphical user interface for common-offset profile data processing. Visualization buttons are on top, processing buttons on the right and ordered in a typical processing workflow from top to bottom. Shown processed data set is included in the software package. Automatically generated script (by clicking on "write script") `dune.py` is given in Section "Example for automatically generated script".

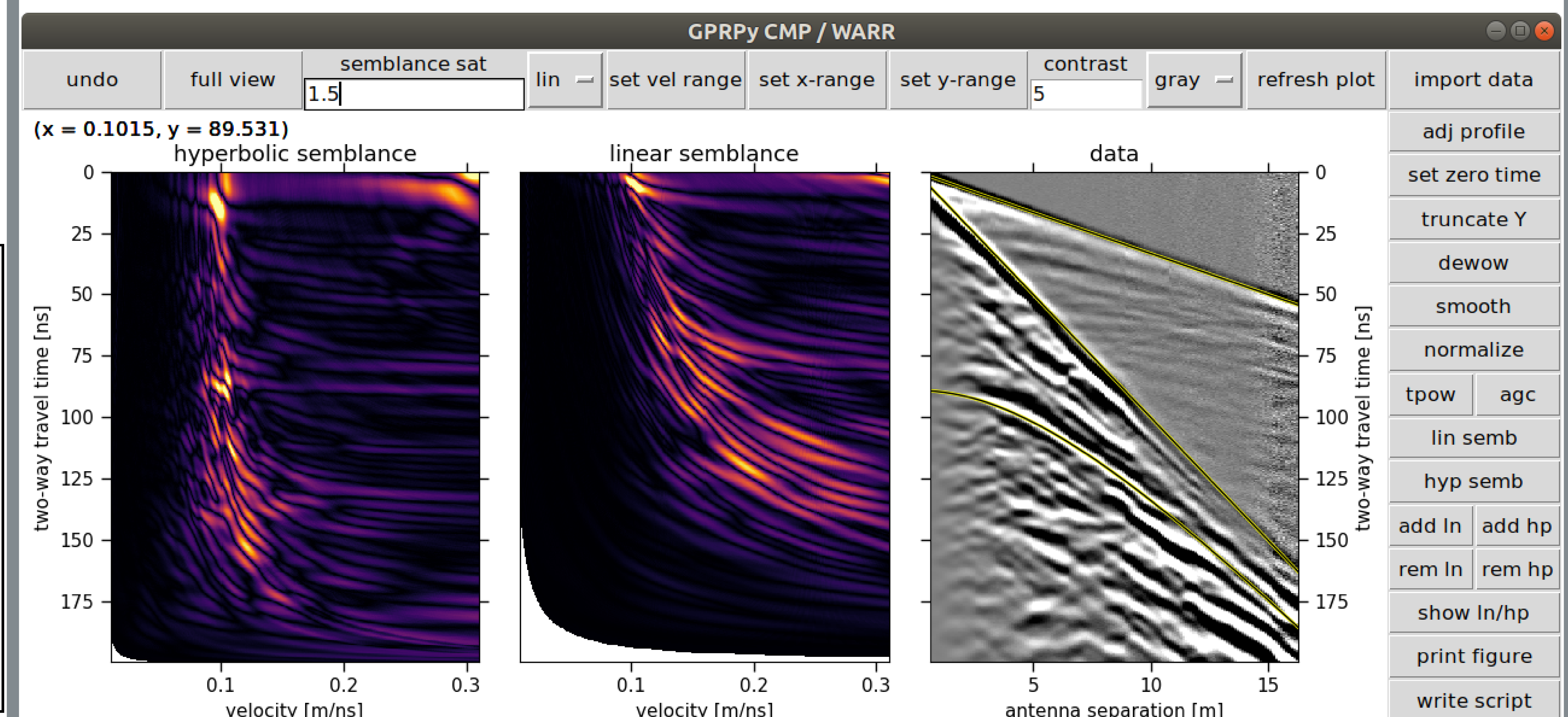

Figure 2: Graphical user interface for velocity analysis from common midpoint or wide angle refraction and reflection data. Visualization buttons are on top, processing buttons on the right and ordered in a typical processing workflow from top to bottom. Right panel shows the data. Center panel shows semblance values for lines depending on two-way travel time intercepts and RMS velocities. Left panel shows semblance values for hyperbolae depending on two-way travel time apexes and RMS velocities. Data set, recorded by C. Liu at Fresno State, is provided with the software.

Teaching suggestions

If a GPR system is available and the class setting provides time for project planning and data collection:

1. Students develop research question that can be answered using GPR.
2. Students design GPR data collection to answer research question.
3. Students collect GPR data.
4. Students answer research question from GPR data using GPRPy on their own laptop computer.
5. Students write report, include figures of data processing steps and result, together with automatically generated script.

If no GPR system is available or the class setting does not provide time for project planning and data collection:

1. Instructor provides raw GPR data together with research question and meta-information.
2. Students answer research question from GPR data using GPRPy on their own laptop computer.
3. Students write report, include figures of data processing steps and end result, together with automatically generated script.

Online available GPR data sets:

- data sets provided with the GPRPy software
- USGS GPR data sets: `https://www2.usgs.gov/climate_landuse/clu_rd/glacierstudies/gpr.asp`

Integration with other methods / data sets.

Besides plotting figures and saving data, GPRPy's common-offset profile graphical user interface allows for two additional ways of exporting data:

Picking points: The buttons "start pick" and "stop pick" in Fig. 1 allow for exporting points as a text file in profile-2D and in 3D coordinates (if easting – northing – elevation information is provided in the topographical adjustment step). This text file can later be used for example as interface data in electrical resistivity tomography using the BERT software (`https://gitlab.com/resistivity-net/bert`).

Export VTK file: If 3D easting – northing – elevation information is provided, then GPRPy can export profile data as a binary VTK file, which can be read using 3D visualization software such as for example Paraview (`https://www.paraview.org/`).

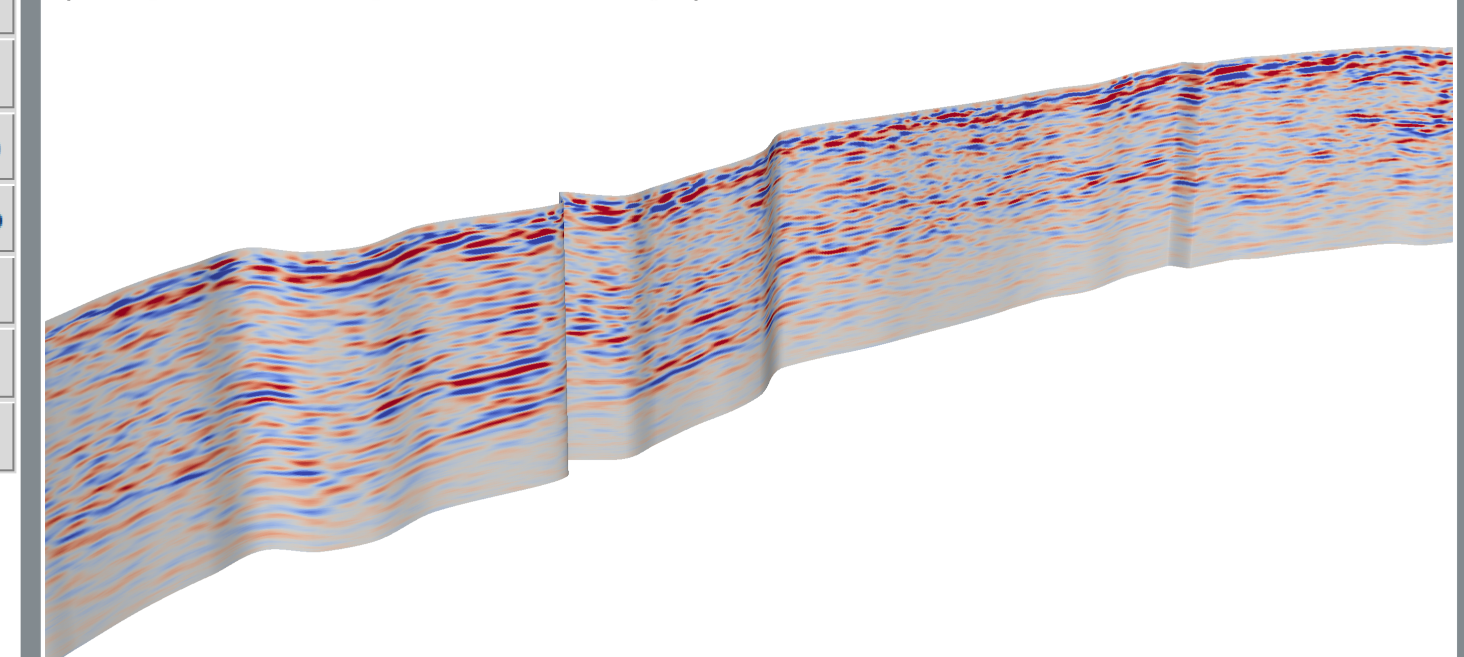

Figure 3: Example of 3D-exported profile data. Data set, recorded by C. Liu at Fresno State, is provided with the software.