

# **Brief instructions for easy start working with the PROFIT code (version of December 2009)**

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## *Stage 1: Preparation of the code*

**Step 1.1.** Download the file “profit\_exe.zip” from the web site on: [www.ivan-art.com/scence/PROFIT/profit\\_exe.zip](http://www.ivan-art.com/scence/PROFIT/profit_exe.zip) or copy from the CD at “PROFIT/profit\_exe.zip”.

**Step 1.2.** Unzip and copy to any location of your computer. ADVISE: try to use simple paths, (for example `D:/PROGRAMS/PROFIT`) and **avoid** the system paths related to “My Documents” or “Desktop”. This will make operating with files much easier.

**Step 1.3.** Check if visualization tool works correctly in your computer. Go to “/COMMON/visual\_exe” and run “visual.exe”. As a result, a new file “picture.png” will appear in the same directory. In the case of correct working the program, it should be identical to “picture\_correct.png” located in the same directory. In the case if it does not work, the problem can probably be solved if a free package “dotnetfx.exe” is installed. It can be downloaded from [www.ivan-art.com/scence/dotnetfx.zip](http://www.ivan-art.com/scence/dotnetfx.zip), unzipped and executed.

In case of problem, please contact Ivan Koulakov by email [KoulakovIY@ipgg.nsc.ru](mailto:KoulakovIY@ipgg.nsc.ru) or skype [ivan-art.com](http://ivan-art.com). This will help the others to avoid the same problems.

## *Stage 2. Observed data inversion using existing examples*

**Step 2.1.** Define the model to proceed. Open the file “model\_all.dat” in the root directory:

```
/model_all.dat
1: name of the region
2: name of the model
HUL1_p02 R1_V1_A0
```

Starting from line 3, one or several models are defined. The structure of the data has two-steps hierarchy: AREA - MODEL. In this example “HUL1\_p02” means the AREA folder (name of the profile). “R1\_V1\_A0” is the name of the current model.

Check if this model exists in folder “DATA/HUL1\_p02/R1\_V1\_A0”. In the case of observed data inversion, there should be at least two files inside this directory: MAJOR\_PARAM.DAT and velocity\_start.dat.

A scenario of real data inversion or synthetic modeling and number of iteration is defined in MAJOR\_PARAM.DAT in a rubric “GENERAL INFORMATION” as shown below.

```
*****
GENERAL INFORMATION :
1  KEY 1: REAL; KEY 2: SYNTHETIC
10 Number of iterations
```

Any number of iterations from 1 to 99 is allowed.

**Step 2.2.** Run the batch file “START.BAT”. A console with information about running the program will appear. Running the entire inversion procedure (10 iterations) for the selected procedure will take 1-2 hours depending on the computer.

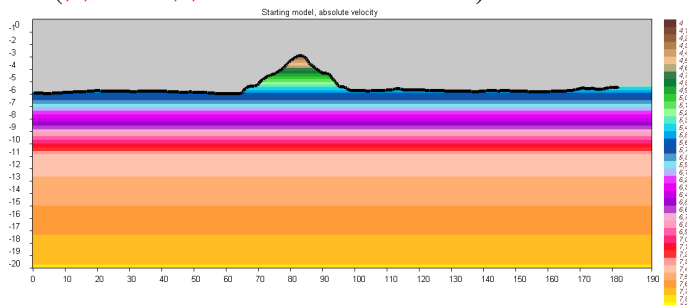
**ADVICE:** We recommend defining larger console buffer to be able to check the course of calculations backward. Click right bottom of mouse on upper panel of console – select Properties – select Position (3<sup>rd</sup> Tab) – update Height of the Screen Buffer (for example up to 3000 lines).

**Step 2.3.** If calculations run successfully and preview tool is available (checked in [Step 1.3](#)), a set of PNG image files should appear in the corresponding folder. In the considered example they will be created in “[PICS/HULA\\_p02/R1\\_V1\\_A0/](#)”.

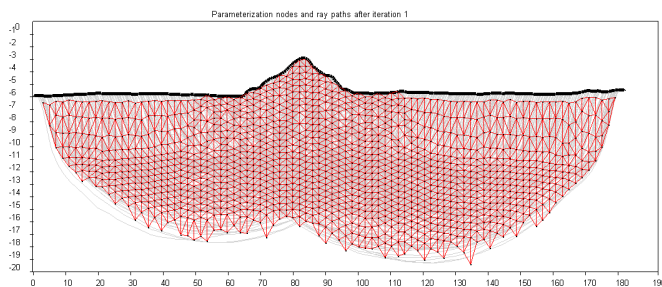
**EXAMPLE 1:** “[HULA\\_p02/R1\\_V1\\_A0/](#)”,

### Preview files created:

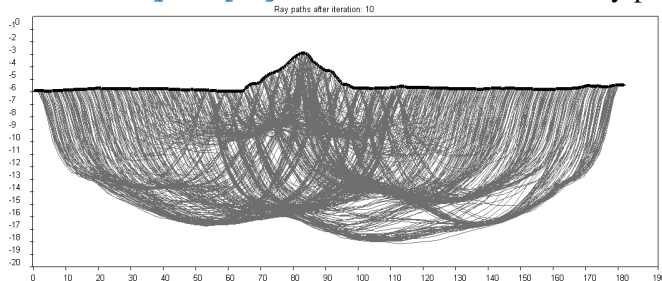
(`///it///` is number of iteration)



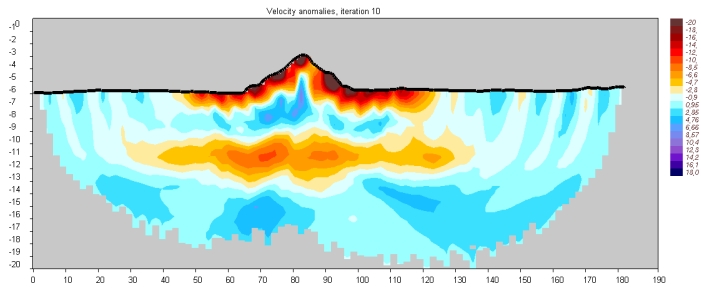
`start_abs.png` : starting model:



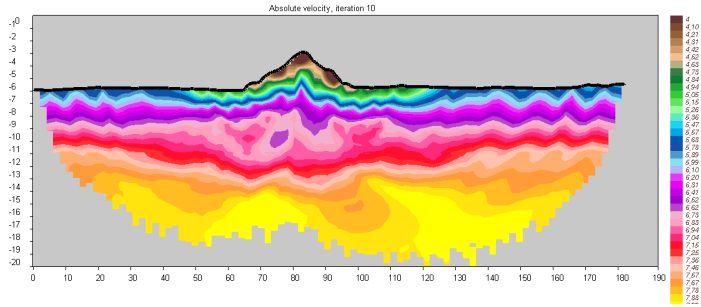
`nodes_rays1.png` : node distributions and ray paths after 1<sup>st</sup> iteration;



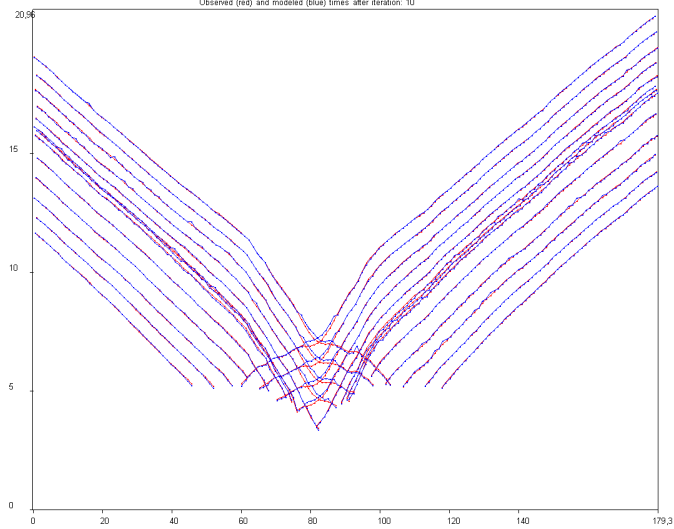
`rays///it///.png` : ray paths after a current iteration (here iteration 10);



`anom//'it'//.png` : velocity anomalies with respect to the starting model after a current iteration (here, iteration 10);



`v_abs//'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):



`times//'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):

`resid_norm.txt` : file with average values of residuals and variance reduction:

1	1873	disp=	0.1992531	red=	0.0000000E+00
2	1873	disp=	7.8441918E-02	red=	60.63203
3	1873	disp=	7.1918942E-02	red=	63.90574
4	1873	disp=	6.9362842E-02	red=	65.18858
5	1873	disp=	6.7084432E-02	red=	66.33205
6	1873	disp=	6.6063881E-02	red=	66.84425
7	1873	disp=	6.5238334E-02	red=	67.25857
8	1873	disp=	6.4746864E-02	red=	67.50522
9	1873	disp=	6.4378731E-02	red=	67.68998
10	1873	disp=	6.4118631E-02	red=	67.82051

The high quality pictures can be created using a commercial tool (e.g. Surfer). The program creates .DAT, .GRD and .BLN which can be used directly in Surfer. The generated files are stored in `FIG_files` directory and they overwrite the older ones.

### List of the main files for visualization:

`FIG_files/result/v_abs0.grd` : starting absolute velocities;  
`FIG_files/result/dv_result/'it'/.grd` : velocity anomalies with respect to the starting model after a current iteration;  
`FIG_files/result/v_abs/'it'/.grd` : resulting absolute velocities after a current iteration;  
`FIG_files/rays/rays/'it'/.bln` : ray paths after a current iteration;  
`FIG_files/rays/nodes.dat` : parameterization nodes;  
`FIG_files/rays/otr.blm` : links between the parameterization nodes;  
`FIG_files/rays/raydens.grd` : grid file for the density of rays in 1<sup>st</sup> iteration;  
`FIG_files/rays/godog_st/'it'/.dat` : travel times with fixed source and variable receivers;  
`FIG_files/rays/godog_zt/'it'/.dat` : travel times with fixed receiver and variable sources;

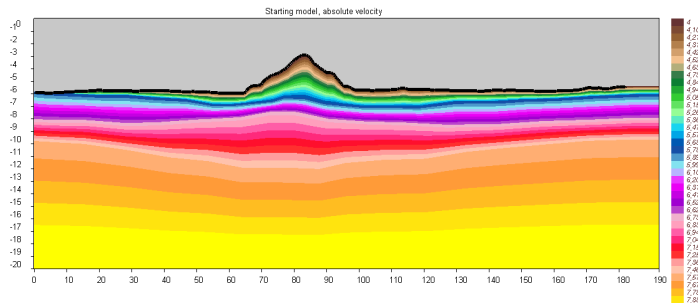
**Step 2.4.** Download the file from [www.ivan-art.com/science/PROFIT/srf\\_examples.zip](http://www.ivan-art.com/science/PROFIT/srf_examples.zip). Unpack this file and use file “`srf_examples/example1.srf`” as a template to visualize the files obtained in Step 2.3.

**Step 2.5.** Create a new model (e.g. “`R2_V1_A0`”) and play with parameters in “`MAJOR_PARAM.DAT`” (e.g. increase or decrease the smoothing or amplitude damping). Produce the results as PNG images and SRF files.

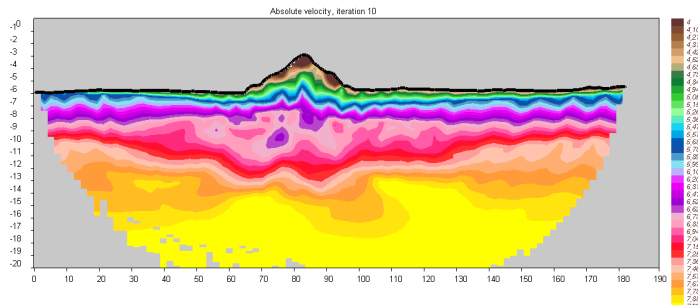
Repeat all the above mentioned steps for other existing examples of real data inversion.

### EXAMPLE 2: “`HULA_p02/R1_V6_A0`”,

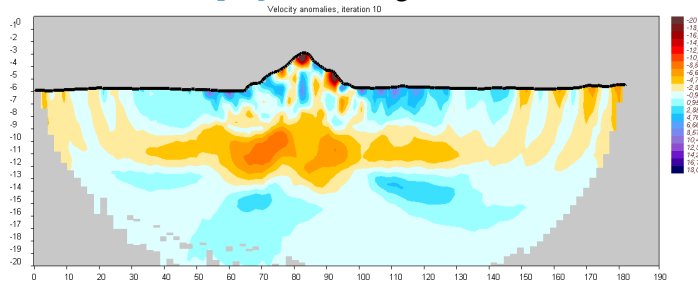
same as “`HULA_p02/R1_V1_A0`”, but with another definition of the starting model. Starting model and result after 10 iterations is shown below:



`start_abs.png` : starting model:



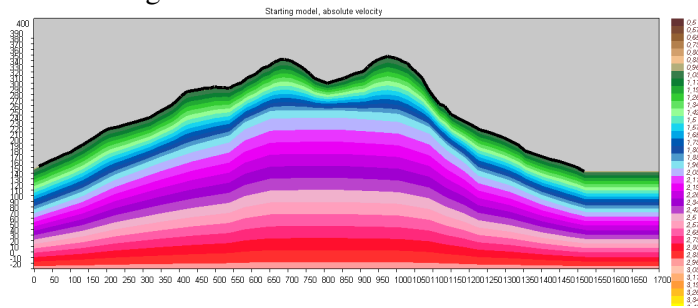
`v_abs//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):



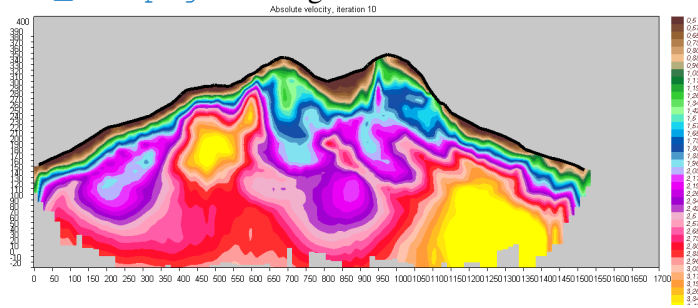
`anom//it'//.png` : velocity anomalies with respect to the starting model after a current iteration (here, iteration 10);

**EXAMPLE 3: “COMPLEX\_/R1\_V6\_A0/”,**

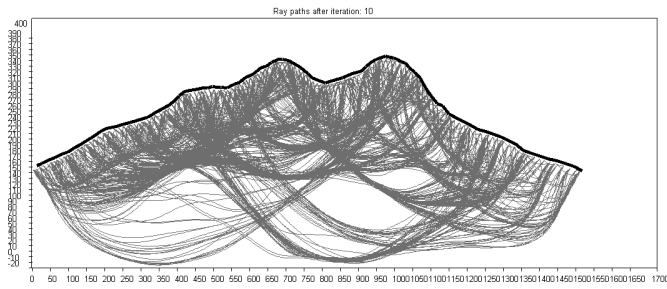
The dataset has been created in a very complex synthetic model and then is used as a blind test for checking the codes.



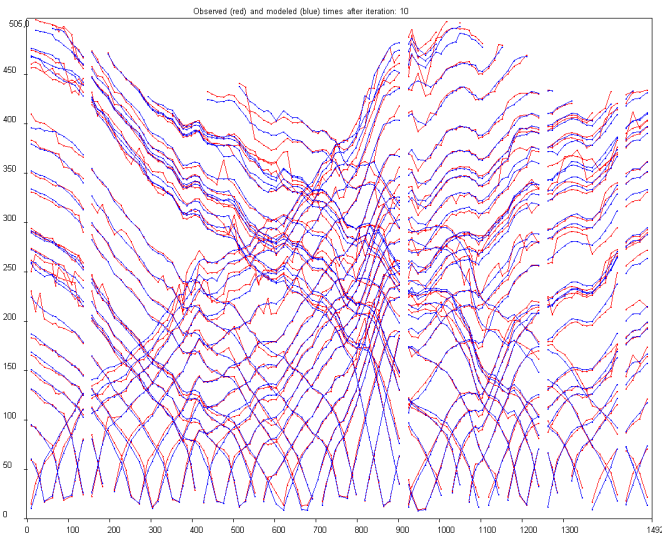
`start_abs.png` : starting model:



`v_abs//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):



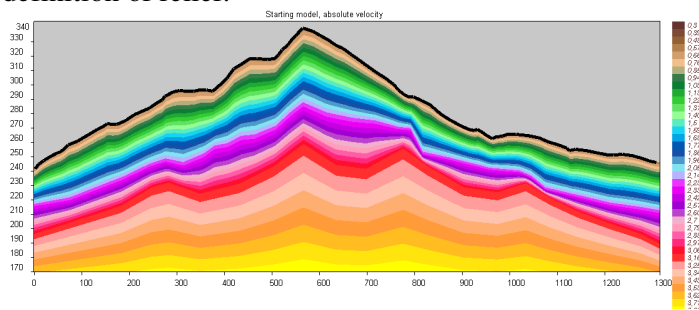
`rays//'it'//.png` : ray paths after a current iteration (here iteration 10);



`times//'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):

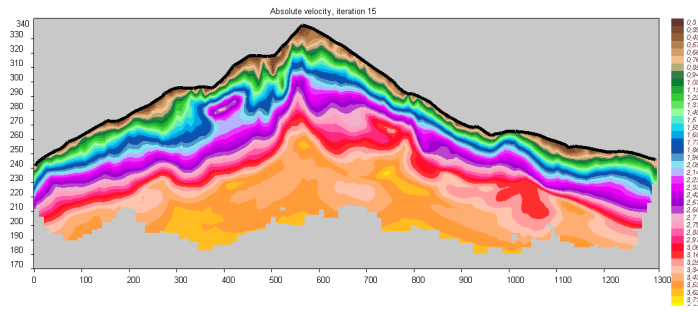
**EXAMPLE 4: “MOUNT\_\_\_/R1\_V6\_A0/”,**

This is a really existing dataset which was collected for investigating a seismic structure inside a hill for constructing a tunnel. Some discrepancies in travel times are mostly due to incorrect definition of relief.

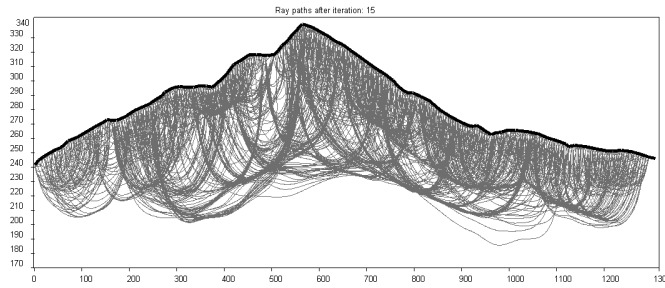


`start_abs.png` : starting model:

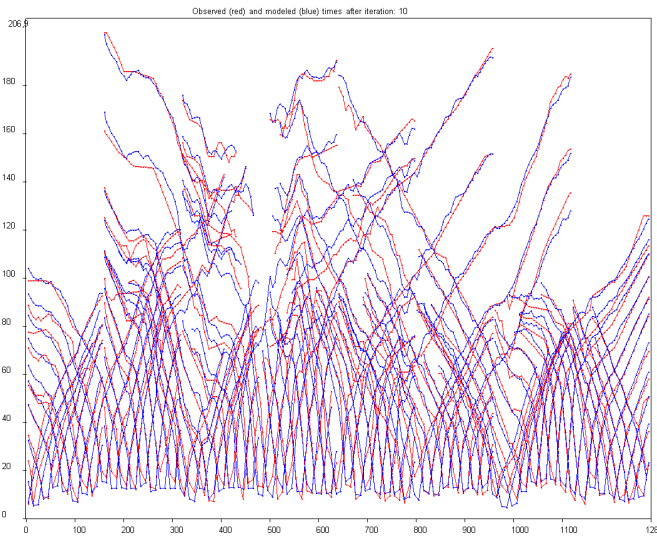




`v_abs//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10)



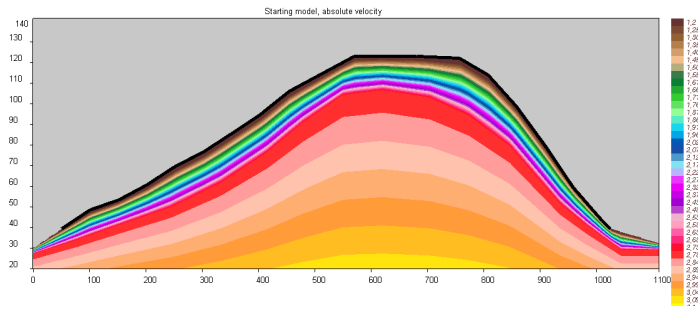
`rays//it'//.png` : ray paths after a current iteration (here iteration 10);



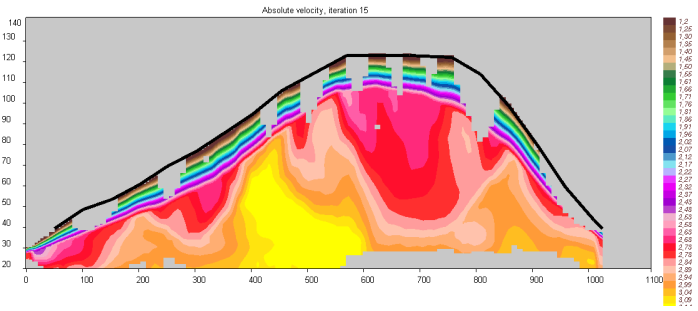
`times//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):

**EXAMPLE 5: “TUNNEL\_/R1\_V6\_A0/”,**

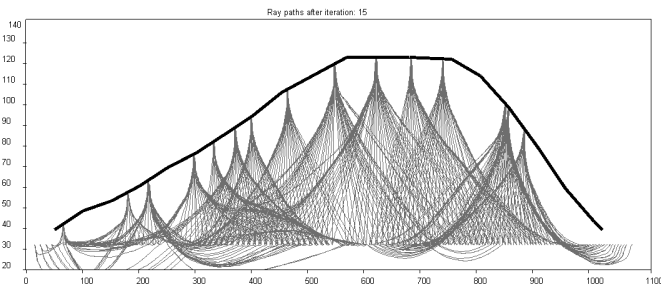
This is a really existing dataset which was collected for investigating a seismic structure inside a hill between a tunnel and surface. The sources on the surface were recorded by receivers in the tunnel.



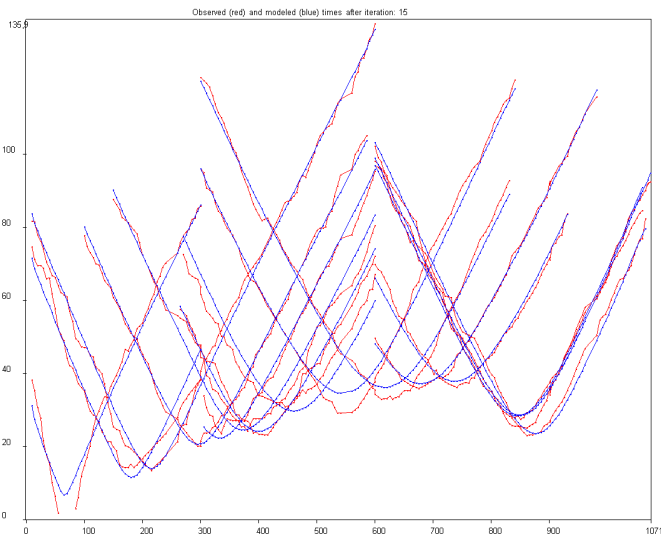
`start_abs.png` : starting model



`v_abs//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 15)



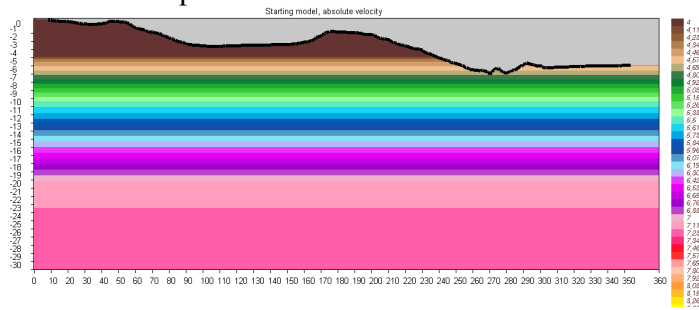
`rays//it'//.png` : ray paths after a current iteration (here iteration 15);



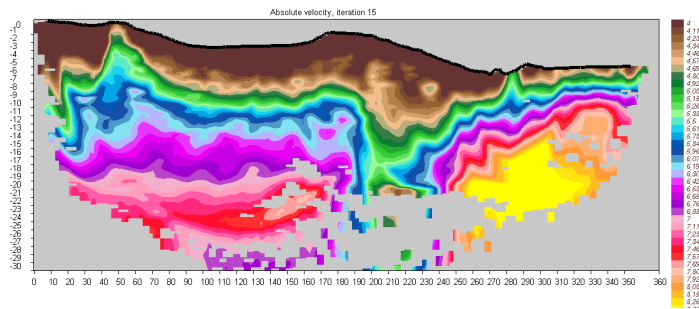
`times//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 15):

**EXAMPLE 6: “[JAVA\\_P18/R1\\_V1\\_A0/](#)”,**

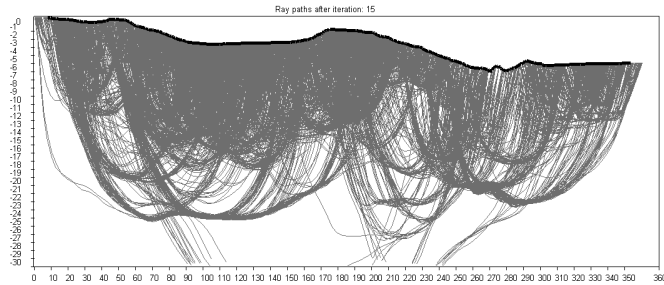
The dataset has been created based on a real distribution of source and receiver. Travel times were computed in a synthetic model which was similar to a realistic distribution. Processing of this dataset is performed in a real data scenario.



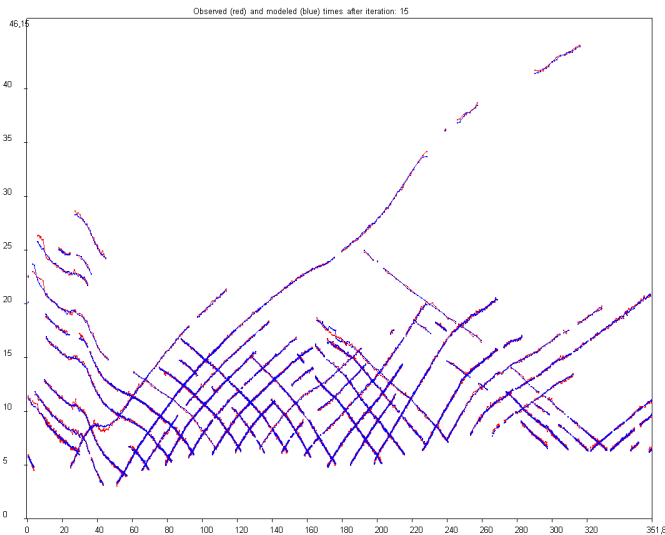
`start_abs.png` : starting model



`v_abs//'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 15)



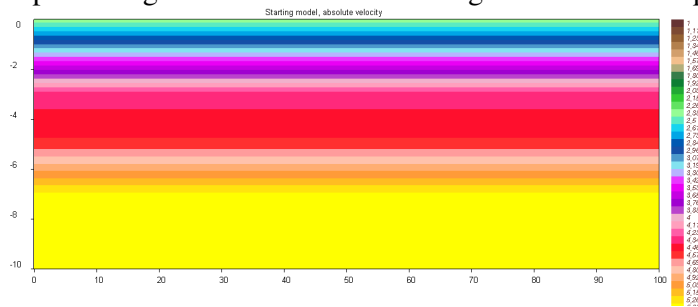
`rays//'it'//.png` : ray paths after a current iteration (here iteration 15)



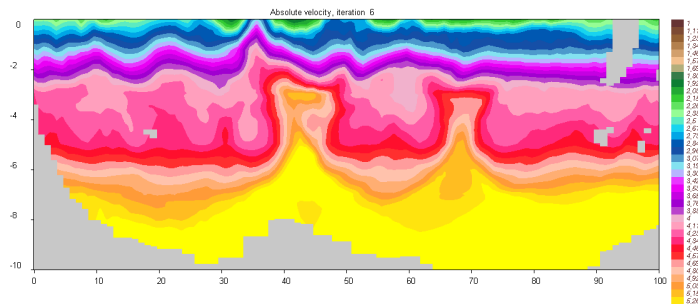
`times//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 15)

**EXAMPLE 7: “SALT\_DOM/real\_001/”,**

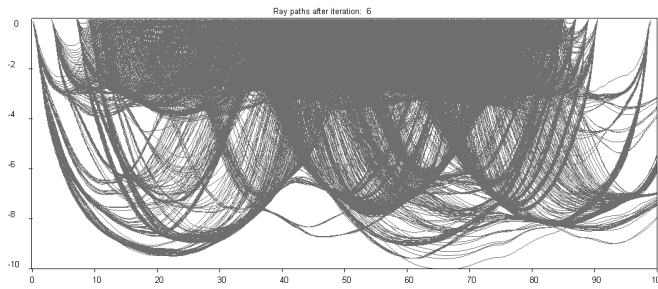
The dataset has been created based on a real distribution of source and receiver in a Precaspian depression. Travel times were computed in a synthetic model with two high velocity bodies representing the salt domes. Processing of this dataset is performed in a real data scenario.



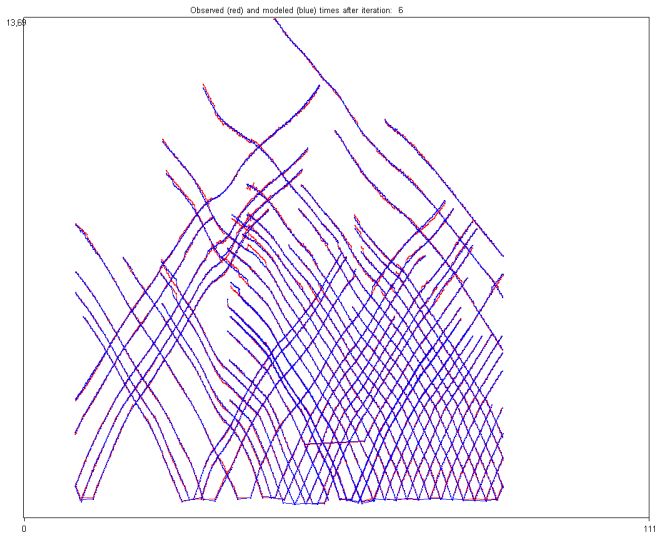
`start_abs.png` : starting model



`v_abs//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 6)



`rays//it'//.png` : ray paths after a current iteration (here iteration 6)



`times//it'//.png` : resulting absolute velocities after a current iteration (here, iteration 6)

### ***Stage 3. Synthetic modeling with existing examples***

**Step 3.1.** The synthetic model is defined in the corresponding MODEL folder in files “`velocity_syn.dat`” and “`anomaly_syn.dat`”. Check if these files exist in the model you wish to proceed.

**Step 3.2.** The configuration of the model can be visualized “`PROG\a_define_model\define_model.exe`”.

Define parameters in two files:

1. Name of the AREA and MODEL folders in file “`model.dat`” in the root directory:

```
/model.dat
```

```
HUL1_p02
S1_V4_A4
9
```

(the last number is not important in this step)

2. Key for visualizing synthetic (2) or starting (1) model in file SET.DAT located in the same directory as visualizing program:

```
PROG\a_define_model\SET.DAT
```

```

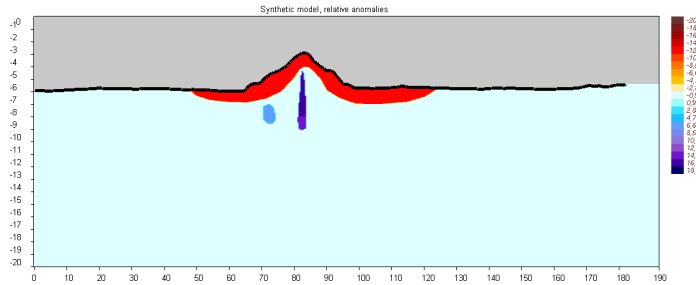
2 1: starting model, 2: synthetic
3  refining the grid for visualization

```

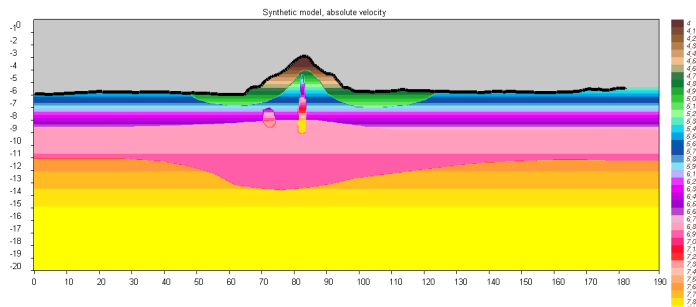
Run the EXE file: “[PROG\a\\_define\\_model\define\\_model.exe](#)”.

**EXAMPLE 1:** “[HUL1\\_p02/S1\\_V4\\_A4/](#)”,

In the considered example two PNG images will be created:



“[PICS/HUL1\\_p02/S1\\_V4\\_A4/syn\\_dv.png](#)”: synthetic anomalies



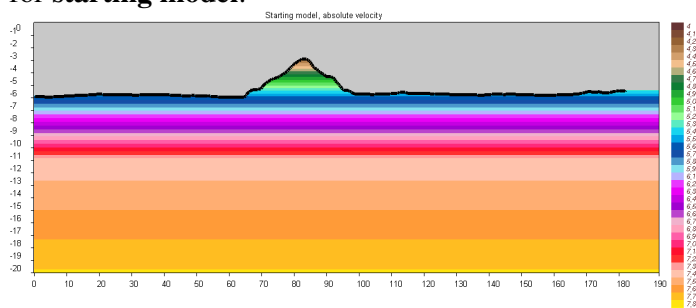
“[PICS/HUL1\\_p02/S1\\_V4\\_A4/syn\\_abs.png](#)”: synthetic absolute velocity.

And the corresponding GRD files which can be visualized in Surfer:

[FIG\\_files/syn\\_mod/dv\\_ini.grd](#) : synthetic anomalies;

[FIG\\_files/syn\\_mod/abs\\_ini.grd](#) : synthetic absolute velocity;

In the case if in [SET.DAT](#) we define the key “1”, the files with the same names will be created for **starting model**:



“[PICS/HUL1\\_p02/S1\\_V4\\_A4/start\\_abs.png](#)”: synthetic absolute velocity.

**Step 3.3.** Define the model to proceed. Open the file “[model\\_all.dat](#)” in the root directory:

[/model\\_all.dat](#)

```

1: name of the region

```

```
2: name of the model
HULA_p02 S1_V4_A4
```

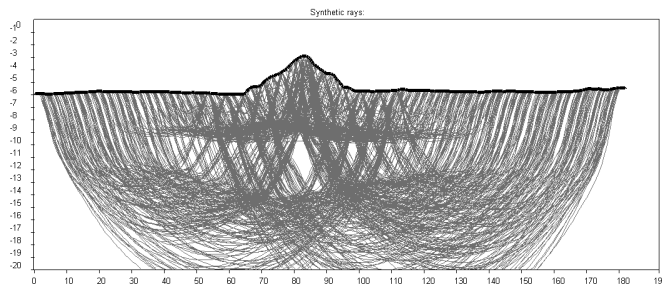
Starting from line 3, one or several models are defined. The structure of the data has two-steps hierarchy: AREA - MODEL. In this example “HUL1\_p02” means the AREA folder (name of the profile). “S1\_V4\_A4” is the name of the current model. Check if this model exists in folder “DATA/HUL1\_p02/S1\_V4\_A4”.

A scenario of real data inversion or synthetic modeling and number of iteration is defined in MAJOR\_PARAM.DAT in a rubric “GENERAL INFORMATION” as shown below.

```
*****
GENERAL INFORMATION :
2 KEY 1: REAL; KEY 2: SYNTHETIC
10 Number of iterations
```

Any number of iterations from 1 to 99 is allowed.

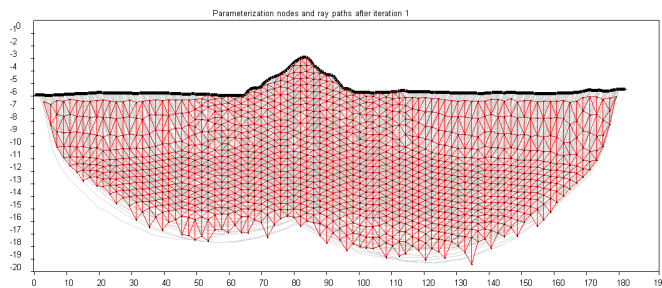
**Step 3.4.** Run the batch file “START.BAT”. A console with information about running the program will appear. First, the code will create the files for visualization for the synthetic and starting models (as in Step 4.2) and will compute the synthetic travel times. Ray paths in the synthetic model can be seen in file:



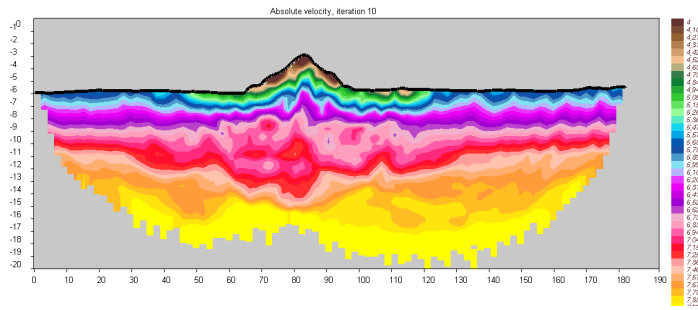
syn\_rays.png : ray paths in the synthetic model

Then it performs the same steps of iterative inversion as for the observed data (Step 2.2)

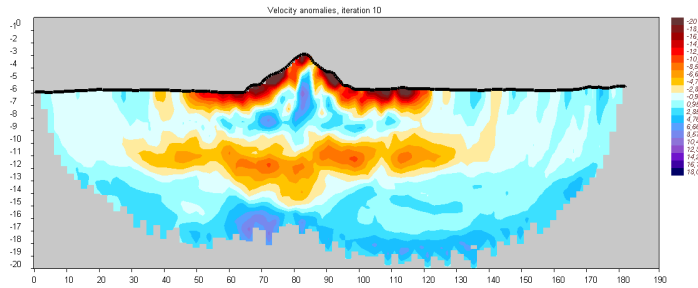
**Step 3.5.** Visualization of the results is the same as for the case of observed data (Step 2.3).



nodes\_rays1.png : node distributions and ray paths after 1<sup>st</sup> iteration;



`v_abs/'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):

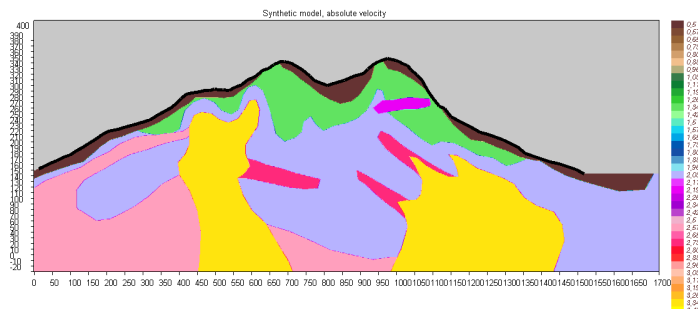


`anom/'it'//.png` : velocity anomalies with respect to the starting model after a current iteration (here, iteration 10);

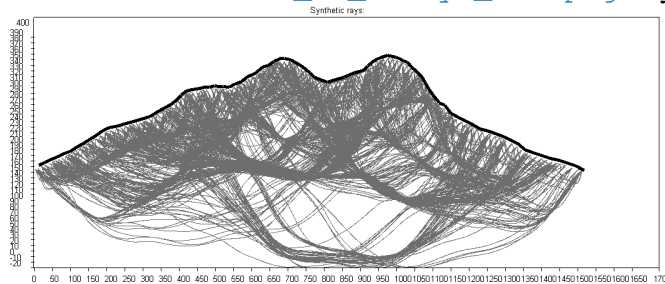
**Step 3.6.** Perform the calculations for other examples of synthetic models:

**EXAMPLE 2: “COMPLEX\_/S4\_V2\_A0”**,

The initial “real” dataset has been created in a very complex synthetic model which was “forgotten”. This dataset is used as a blind test for checking the codes. Here we try to reproduce the velocity distribution which afret performinf FM&TI scheme provides similar results as in the case of “real” dataset inversion.

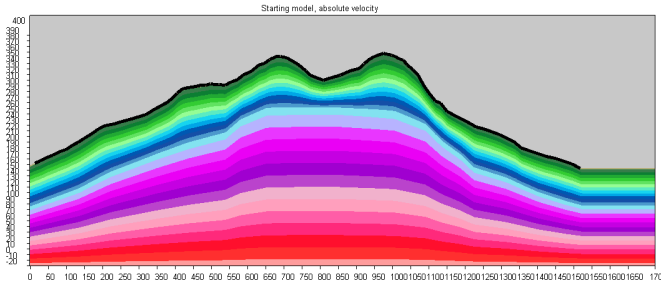


“`PICS/COMPLEX/S4_V2_A0/syn_abs.png`”: synthetic absolute velocity.

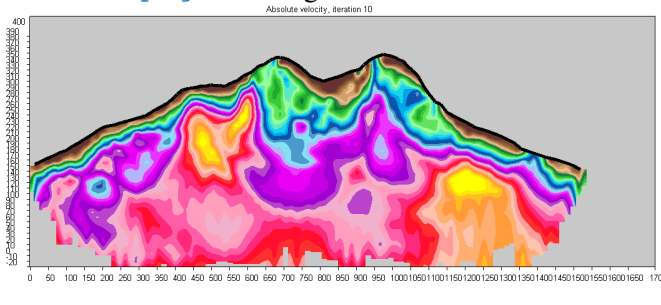


`syn_rays.png` : ray paths in the synthetic model

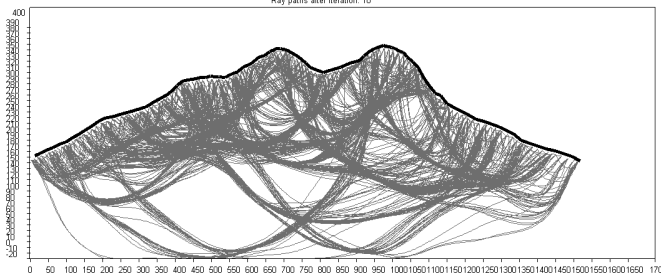




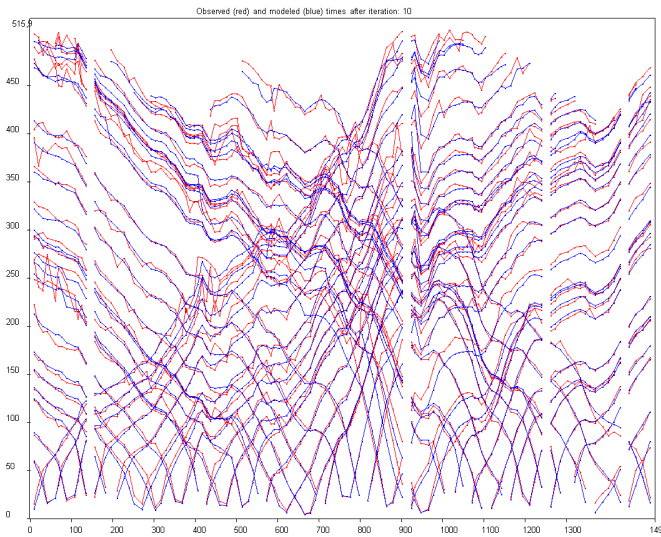
`start_abs.png` : starting model:



`v_abs//'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):



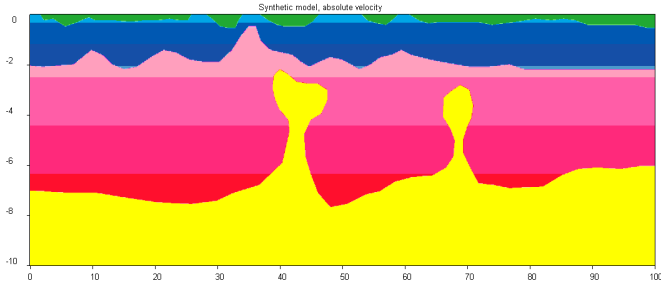
`rays//'it'//.png` : ray paths after a current iteration (here iteration 10);



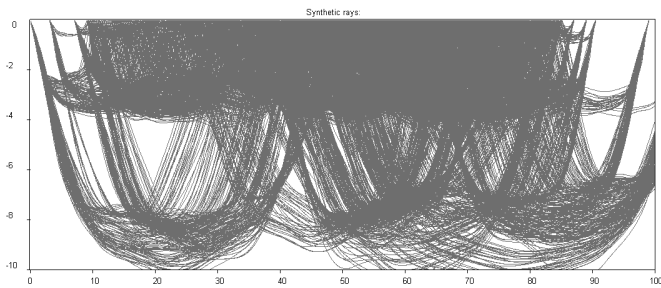
`times//'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):

**EXAMPLE 3: “SALT\_DOM/synth\_02/”,**

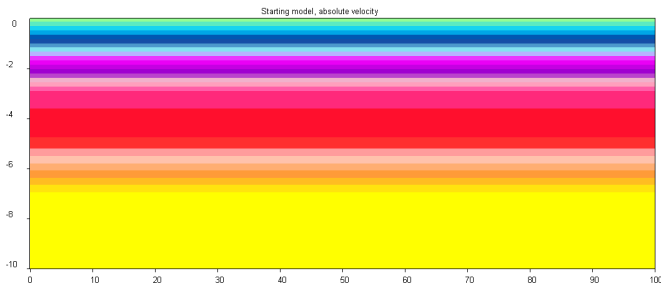
The initial “real” dataset has been created in a very complex synthetic model which was “forgotten”. This dataset is used as a blind test for checking the codes. Here we try to reproduce the velocity distribution which afret performinf FM&TI scheme provides similar results as in the case of “real” dataset inversion.



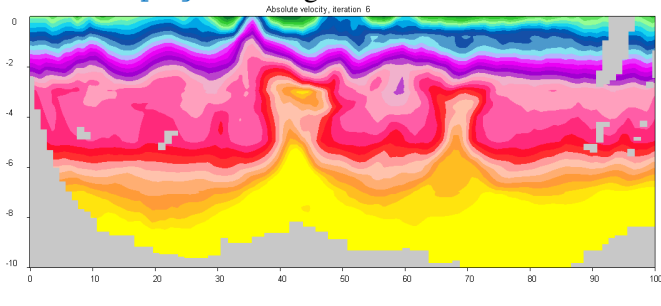
“PICS/SALT\_DOM/synth\_02/syn\_abs.png”: synthetic absolute velocity.



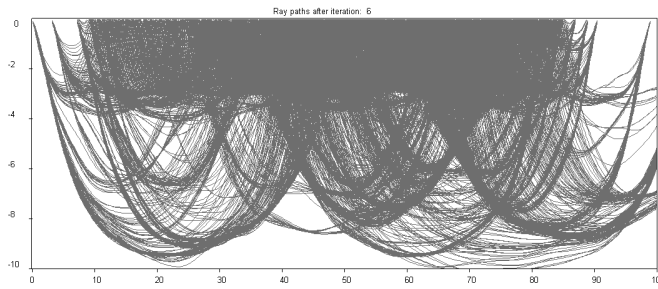
syn\_rays.png : ray paths in the synthetic model



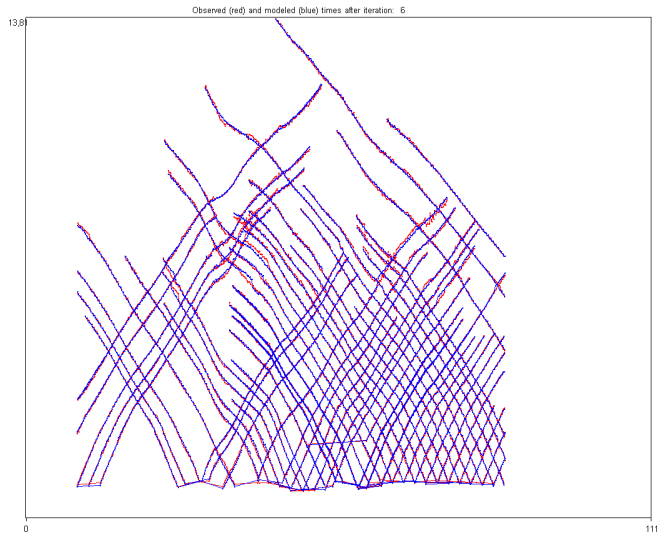
start\_abs.png : starting model:



v\_abs//’it’//.png : resulting absolute velocities after a current iteration (here, iteration 10):



`rays//'it'//.png` : ray paths after a current iteration (here iteration 10);



`times//'it'//.png` : resulting absolute velocities after a current iteration (here, iteration 10):

## ***Stage 4. Start working with own data***

**Step 4.1.** Create a new AREA folder. The name should consist of any eight (8) characters (e.g. “`profile2`”). Inside this folder create “`profile2/inidata`” folder. Inside this folder create files with the initial data “`rays0.dat`” and “`relief.blm`”, as described in Section 2.2.1 of the Manual. (Creating these files is on a responsibility of a user).

In addition, two files used for visualization and previewing should be created:

`DATA/profile2/set_vis.dat` (as described in Section 4.3 of the Manual)

`DATA/profile2/config.txt` (as described in Section 4.2 of the Manual)

These files can be copied from the existing examples and scaled according to the length of the profile.

**Step 4.2.** Create a MODEL folder which should also consist of eight (8) characters (e.g. `DATA/profile2/MODEL_01/`). We recommend fixing the names of the models according to the description of starting velocity description or synthetic model (e.g., `R1_V1_A0` or `S1_V4_A2`) as described in Section 2.2.2 of the Manual.

**Step 4.3.** Create a file

[DATA/profile2/MODEL\\_01/MAJOR\\_PARAM.DAT](#)

This file can be copied from existing examples. Some of the parameters (e.g. grid spacing, and step for tracing) should be scaled according to the size of the profile. The inversion parameters will be tuned during several trials.

**Step 4.4.** Define starting velocity model. In general case, as described in Section 5 of the Manual, velocity model is defined by two files:

[DATA/profile2/MODEL\\_01/velocity\\_start.dat](#)

[DATA/profile2/MODEL\\_01/anomaly\\_start.dat](#)

However, in most cases the second file with anomalies is not used for the starting model, and it might be not existing.

Starting working with a new dataset, it is recommended to use a 1D initial velocity model. In this case, [velocity\\_start.dat](#) has the format described in Section 5.2.1 with the key “1”.

When more complicated models are used (with keys of “2”-“4”), an additional subfolder which contains descriptions of the velocity patterns, is required:

[DATA/profile2/MODEL\\_01/forms/](#)

**Step 4.5.** Define the model to proceed. Open the file “[model\\_all.dat](#)” in the root directory:

[/model\\_all.dat](#)

```
1: name of the region
2: name of the model
Profile2 MODEL_01
```

**Step 4.6.** Run the batch file “START.BAT”.

**Step 4.7.** Produce the results as PNG images and SRF files.

**Step 4.8.** Create a new model (e.g. “R2\_V1\_A0”) and play with parameters in “[MAJOR\\_PARAM.DAT](#)” (e.g. increase or decrease the smoothing or amplitude damping) to find the values which provide the minimum of the residual norm.

**Step 4.9.** Play with parameters in “[velocity\\_start.dat](#)” to find the values of the starting model (namely depths of levels and velocities in the 1D starting model) which provide the minimum of the residual norm.

## ***Stage 5. Creating the own checkerboard test***

Checkerboard test is the easiest synthetic test and it is the most convenient for learning.

**Step 5.1.** Inside the same AREA folder as used in Stage 4, create a MODEL folder for the checkerboard with the name which consist of eight (8) characters (e.g.

[DATA/profile2/S1\\_V1\\_A1/](#)).

**Step 5.2.** Create synthetic velocity model which is described by two files:

[DATA/profile2/S1\\_V1\\_A1/velocity\\_syn.dat](#)

[DATA/profile2/S1\\_V1\\_A1/anomaly\\_syn.dat](#)

Usually in the checkerboard tests, we use 1D reference velocity for both starting and synthetic models, although, this is not strictly required by the algorithm. In general, these files are not

necessarily identical. However, for the first run we recommend using same 1D velocity distributions in the starting and synthetic models. Definition of the checkerboard in [anomaly\\_syn.dat](#) is described in Section 5.3.2 of the Manual.

**Step 5.3.** Perform calculations and visualization of the results as described in **Steps 3.2-3.5**. The particular interest in this case is the relative anomalies.

**Step 5.4.** Play with different parameters of model, for example:

- Tune the smoothing/damping coefficients to obtain the best reconstruction results.
- Try different sized of patterns.
- Try different empty spacing between patterns.
- Try single anomalies (when limits of the board coincide with size of the patterns) located in different parts of the study area.
- Try performing the reconstruction when synthetic reference model is not the same as the starting one.

## ***Stage 6. Creating own synthetic models***

**Step 6.1.** Inside the same AREA folder as used in Stage 4, create a MODEL folder for the synthetic model with the name which consist of eight (8) characters (e.g. [DATA/profile2/S1\\_V4\\_A2/](#))

**Step 5.2.** Create synthetic velocity model which is described by two files:

[DATA/profile2/S2\\_V4\\_A2/velocity\\_syn.dat](#)  
[DATA/profile2/ S2\\_V4\\_A2/anomaly\\_syn.dat](#)

To create these files use descriptions in Section 5 of the Manual.

In this step one may need to digitize polygons and polylines to create patterns for absolute velocity in [velocity\\_syn.dat](#) or relative anomalies in [anomaly\\_syn.dat](#). We propose two ways for doing this task:

1. **With SURFER.** We use the digitizing tool in Surfer which is very convenient for such tasks. To do it in Surfer, make the following steps:

- Open a plot with some results for the current map or profile (e.g. observed data inversion, main results);
- Select the plot;
- Select Menu: “Map – Digitize”;
- Digitize the pattern in the plot (results appear in a separate window);

Save the file in BLN format to subfolder forms (e.g. [DATA/DATASET1/ SYN\\_MOD1/forms/anom1.blm](#)). The name should contain 5 characters.

2. **With our own digitizing tool.**

We offer a free digitizing tool which performs the similar procedure as SURFER. To use this tool, perform the following steps:

- run the program from `/COMMON/digitize_exe/Digitizer.exe`;
- If you want to use any forms in an existing bitmap file, use Menu: “File > Load image” and load the bitmap image (for example `PICS/COMPLEX_/R1_V6_A0/v_abs10.png`. In the screenshot example which is presented below, we create absolutely new patterns and do not load any image;
- If necessary, resize the panel using Menu “Property > Resize panel”. In the presented example the size of the panel is 1000x1000 pixels;
- Set the screen area using Menu “File > set work area” and selecting by mouse from one corner of the plot to another. The frame will be marked with red line. The screen coordinates can be also defined manually in fields Screen coordinates.

xscreen\_min - yscreen\_min

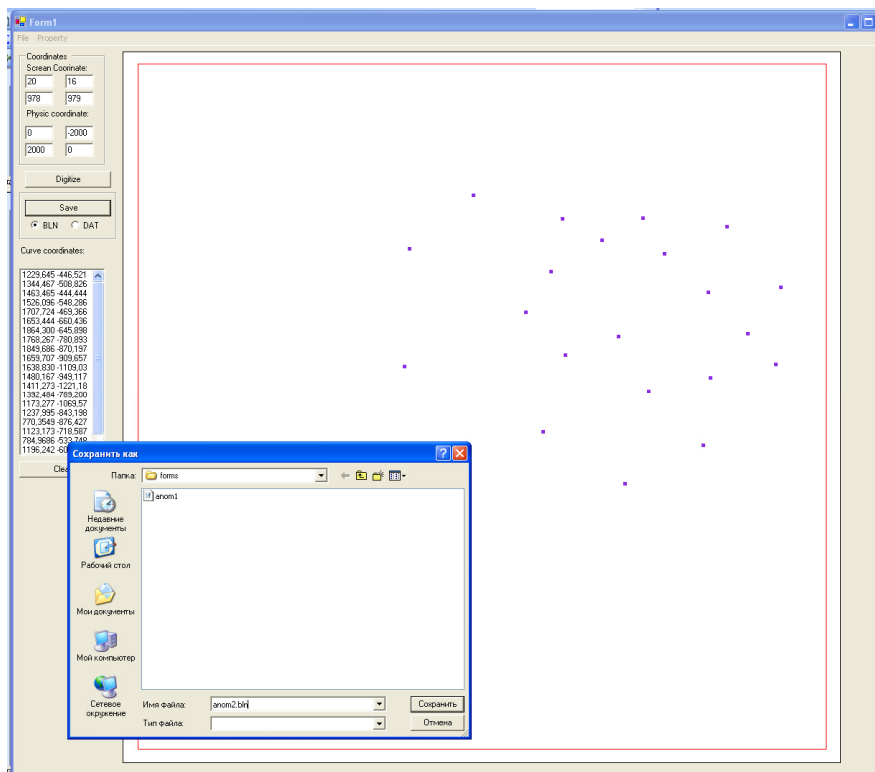
xscreen\_max - yscreen\_max

- Physical coordinates are defined manually in the corresponding fields:

xphys\_min - yphys\_min

xphys\_max - yphys\_max

- Press button “Digitize” and start digitizing



- After finishing digitizing the polyline, save it to the folder “`DATA/profile2/syn_mod2/forms`” in bln format. The name of the file should contain five characters (for example, `anom1.bln`, `anom2.bln`);
- If another polygon should be digitized, press button “Clear” and start digitizing again.
- If necessary, digitize in the same way the interfaces (for example, `surf1.bln`, `surf2.bln`) and save them to the same location;

**Step 5.3.** Check correctness of the model definition using the visualizing program in [PROG\a\\_define\\_model\define\\_model.exe](#) as described in 3.2.

**Step 5.4.** Run the synthetic modeling using the Steps 3.3 – 3.5.

### ***Closing remarks***

If you passed successfully all the steps listed in this document, it would be not a problem for you to perform inversion for observed data and synthetic modeling using the PROFIT code for various profiling datasets.

In case of any problem, please address to Ivan Koulakov ([KoulakovIY@ipgg.nsc.ru](mailto:KoulakovIY@ipgg.nsc.ru)).

Good luck.