Guidelines for running the calculations to reproduce the results for the local tomography of the Gakkel ridge area at ~85°E presented in the paper:

Koulakov I., V. Schlindwein, M. Liu, T. Gerya, and A. Jakovlev (2021) Low-degree mantle melting controls deep seismicity and explosive volcanism of the Gakkel Ridge

Introduction remarks:

The tomography model presented in the paper are obtained using the LOTOS code by Koulakov (2009). Here, we present the full version of the code with initial data and parameters used for calculating P and S velocity models beneath Gakkel Ridge at around 85°E. The code was adapted to the case of a moving network installed on the ice floes. In this case, the velocity model contains the water layer with the constant velocity.

This version of the code is adopted for the Windows OS and contains the entire program listing and the full project structure for Microsoft Visual Studio 2010 and Intel Visual Fortran. Detailed description of the code can be found at www.ivan-art.com/science/LOTOS

Data converter from SEISAN to LOTOS format

The initial data include two groups of files:

1. The pick files in the SEISAN format, which are stored in folder "`READ_DATA\Gakkel_85_2\data_in\`". The same folder contains file "`files.txt`" with the list of all files containing picks.
2. Coordinates of stations, which are stored in the folder "`READ_DATA\Gakkel_85_2\data_in\station_info\`". The same folder contains file "`files.txt`" with the list of all files containing coordinates.

The output files in the format of modified LOTOS are written in folder "`READ_DATA\Gakkel_85_2\data_out\`" as "`rays.dat`" and other files, which are not used for calculations.

Structure of the code:

Initially, the root folder contains three subfolders:

`PROGRAMS` contains all the programs used for calculations

`COMMON` includes some service files, such as quick visualization tool and color scales

`DATA` contains all data files.

The `DATA` files have two-level structure. First level corresponds to the dataset (in our case, we have only one dataset, `GAKKEL85`). The name of the dataset should consist of eight characters.

In the dataset folder (`GAKKEL85`) there is a mandatory subfolder `inidata` containing one mandatory file `rays.dat`. The file with bathymetry `topo_ftz.grd` is optional.

Within the dataset, there might be any number of models corresponding to inversions with experimental (real) data and synthetic tests. Names of the models should consist of 8 characters (e.g., `MAIN_MOD`, `BR3_7_3_`). In the case of experimental data inversion, the model folder contains two files: `MAJOR_PARAM.DAT` and `ref_start.dat`. In the case of synthetic models, besides these two files, there should be two other files: `anomaly.dat` and `ref_syn.dat`. For the visualization, it is necessary to create `sethor.dat` and `setver.dat` files in the dataset folder with the parameters of horizontal and vertical sections respectively.

All the files are defined according to the results presented in the paper. In case if one wish to play with parameters and models, it is necessary to create a folder with a new model. The easiest way is just to clone it by Ctrl-C and Ctrl-V and to change the desired values of parameters or starting model.

Note that synthetic tests can be run only after performing full calculations for the main model `MODEL_01`, because they use the locations of events after relocation in the resulting 3D model.

Main steps to reproduce the results:

1. Checking if the data are correct:
   Open file `model.dat` in the root folder and check if the first line contains the area of the dataset corresponding to the Gakkel Ridge experiment: `GAKKEL85`. Then run `check_ini_data.bat`. In the console, the general information about the initial dataset will appear. A file with the corresponding information will be created in `DATA/GAKKEL85/inidata/data_info.txt`.
   In addition, the folder `PICS` will appear in the root folder. This folder contains the dataset folder with the figure `ini_data.png` inside. This figure shows the location of seismic sources and stations for the Gakkel Ridge experiment.
2. Calculation of the main model for velocity based on the inversion of the observed data:
   Open file `all_areas.dat` in the root folder. Check if the names of dataset folder and main model are correct: `GAKKEL85` and `MAIN_MOD`. The last number in the line corresponds to the number of iterations used in the inversion. All calculations of the Gakkel Ridge data models presented in the paper were based on 5 iterations. To start the calculations run the `START.BAT` file. The main steps of calculation process are seen on the console.
   The resulting pictures will appear in the `PICS/GAKKEL85/MAIN_MOD/IT5.`
   In addition, the information about residuals and variance reductions after every iteration will appear in the `PICS/GAKKEL85/MAIN_MOD/info_resid.dat`.
3. Performing the synthetic tests:
   To visualize the synthetic anomalies in horizontal and vertical sections, open file `model.dat` in the root folder and define the name of the corresponding synthetic model, for example, `BR3_7_3_`. Then, run `visual_syn_model.bat`. Figures with the synthetic anomalies appears in `PICS/GAKKEL85/ BR3_7_3_/SYN`.
   To run the calculations, change the name of the model in `all_areas.dat` to `BR3_7_3_` and run the `START.bat` file. The resulting pictures will appear in the `PICS/GAKKEL85/BR3_7_3_/IT5`.

Description of the models:

`MAIN_MOD` – main velocity models corresponds to:

- figure 2 - horizontal sections of the Vp/Vs ratio at 5 and 15 km depth and two vertical sections,

- figure S2 – horizontal sections of dVp anomalies at 5 and 15 km depth and two vertical sections of the Vp/Vs ratio.
- figure S3 – horizontal sections of dVs anomalies at 5 and 15 km depth and two vertical sections of the Vp/Vs ratio.

`BR3_7_3_` – horizontal "checkerboard" synthetic model shown in Figure S4.

`VER1BRD1; VER2BRD1` – vertical "checkerboard" synthetic models corresponding to two vertical sections presented in Figure S5.

<u>To display the results with Surfer Software:</u>

All figures in the paper were created using Surfer-13. All grid files could be found in folders `TMP_files/hor` and `TMP_files/vert` for horizontal or vertical sections respectively. To plot resulting velocity anomalies in horizontal section in Surfer, create a new contour map using grid file `TMP_files/hor/dv25 1.grd`. To display different models, it is necessary to replace the grid with another file in the same folder.
In the file name `"dvKM N.grd"`:

- `dv` means velocity anomalies;
- `K` number of the phase: 1 for P model, and 2 for the S model;
- `M` is the number of iteration;
- `N` is a number of horizontal section, same as listed in `DATA/GAKKEL85/sethor.dat`).

The color scales for visualization are located in `COMMON/scales_lvl`. In the present figures, we used `color_scale_10_10.lvl`.

To create resulting figures for main model in vertical sections, use grid file `TMP_files/vert/ver_25 1.grd`. To display the earthquakes projected to the vertical section, build a post map using the `TMP_files/vert/ztr_1.dat` file. To plot the position of the vertical section in the horizontal map, create a base map using `TMP_files/vert/mark_1.dat` file.

To obtain figure for synthetic model, for example `BRD_1anm`, the procedure is the same. To add the configuration of anomalies, create a contour map using `TMP_files/hor/synM_N.grd` (`M` is 1 for P and 2 for the S model, `N` is the number of depth section).

Note that grid files in `TMP_files` directory correspond to the most recent calculated model. When computing a new model, all the previous grid files are overwritten. To create grid files for any previously calculated model, change the model's name and number of iteration in `model.dat` and run `visual_result.bat` in the root folder.

The output files also contain the grid files with the `".xyz"` extension, which can also be visualized in an alternative software, such as GMT.