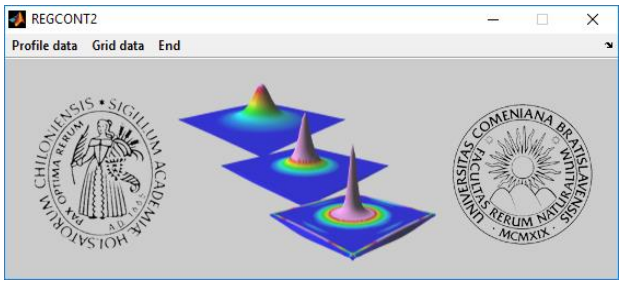
Tutorial – program *regcont2v6.m*

Matlab script '*regcont2v6.m*' calculates the 2D and 3D analytical (upward/downward) continuation of potential fields in spectral domain. For the downward continuation (DC) and source depth estimation (SDE), script applies the Tikhonov regularization approach with L_P-norms and C-norms (Tikhonov et al., 1968; Glasko et al., 1970; Pašteka et al., 2012; Pašteka et al., 2018).

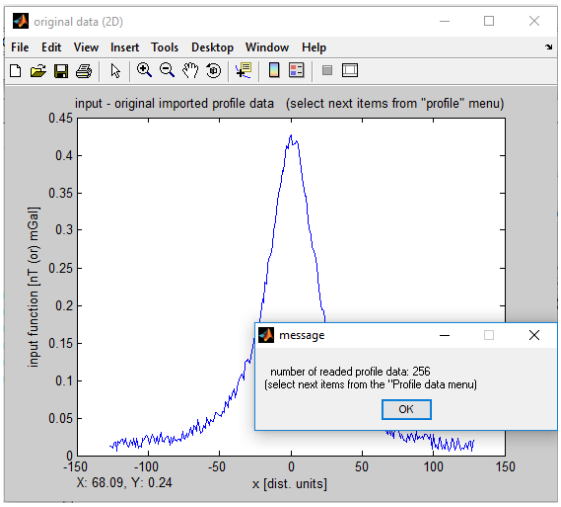
To run the program, the user has to have installed an active version of Matlab (Mathworks). As an example in this tutorial the user can use the attached file file '*Fig1a - horcyl grav 2L_05km dx_100m_depth 1 km.grd*' with synthetic V_z field over a 2D horizontal cylinder in the depth of 1000 m. All described work-flow steps are connected with the processing of this example. Besides of this, there is also attached a synthetic profile example: gravitational effect of a 2D horizontal cylinder in a depth of 20 m, with added 5% normal Gaussian noise, the file '*cyl5noise.dat*' and a next file '*Fig9a-N2niv1_0_dx25_med.grd*', which contains the anomalous magnetic field acquired over an unexploded 100 mm projectile in the depth of 1.0 m below sensor.

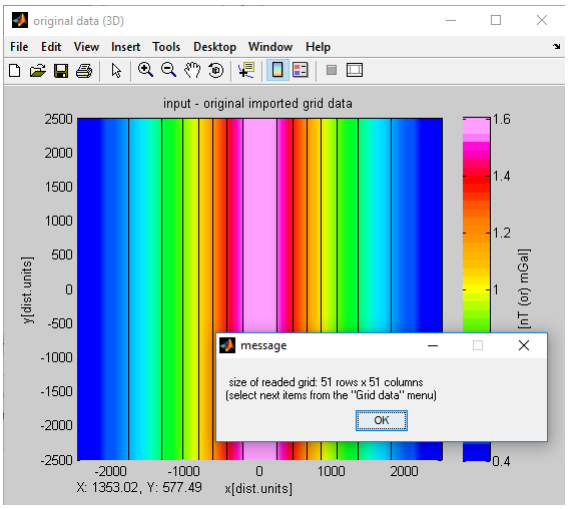
Working steps with '*regcont2v6.m*':

1. Run the Matlab script file '*regcont2v6.m*' in the Matlab environment (opening the script in the editor window and then pressing the F5 button).
   You should obtain the menu of the program:

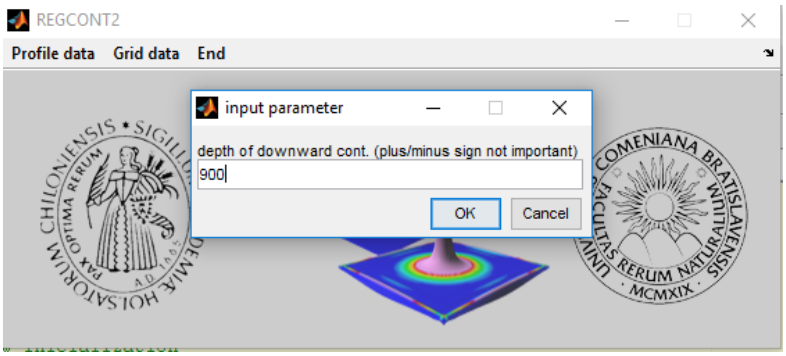


   To process the data you have to work with *Profile data* or *Grid data* menu. In the first step, import your data via the *Open…* items in both menus. The input file with profile data should be an ASCII text data file with two columns (space separated) and the grid must be in a Golden Software Surfer ASCII text format. After importing the input data – these are displayed in a form of a graph or a coloured image map with a displayed information about the number of imported points. You can immediately close this small message window.

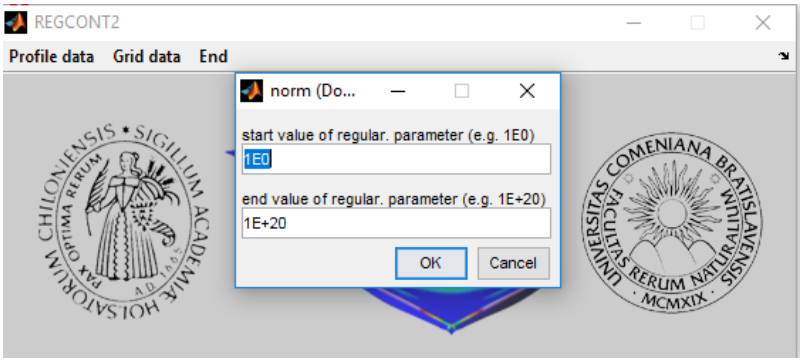




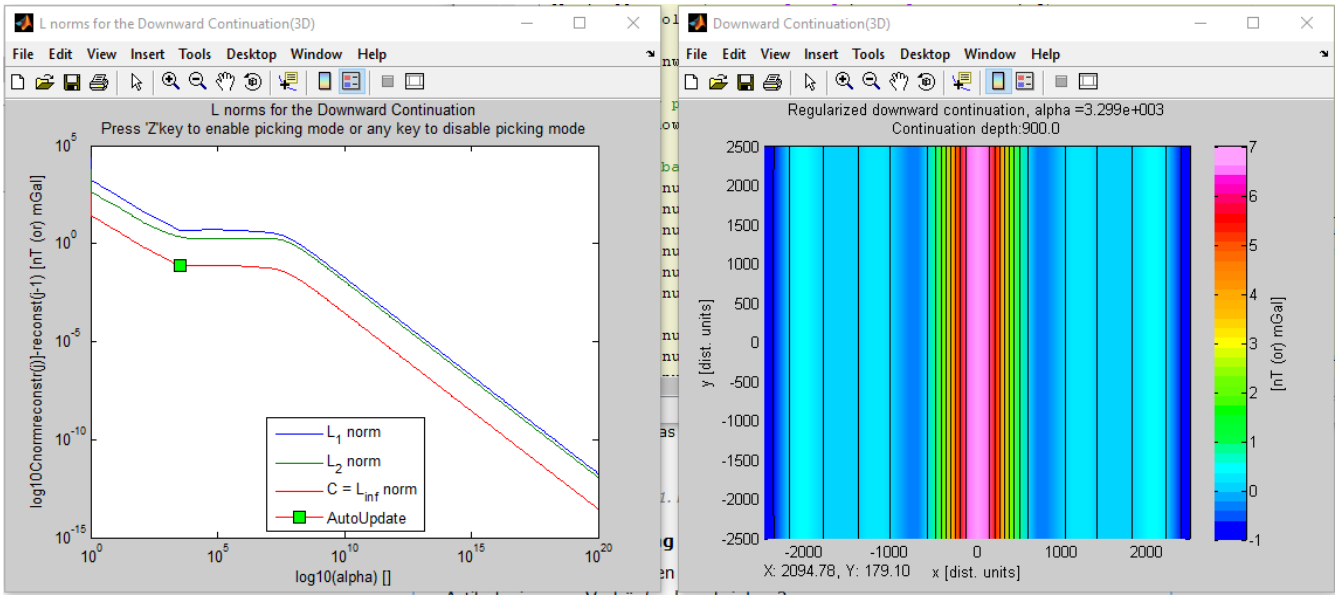
2. As a next step you can select in both *Profile data* or *Grid data* menus the item *Upward continuation* or *Downward continuation*, where you enter the depth of the continuation (the sign of the value is not important, script has an incorporated condition of handling both situations with negative and positive numbers). The depth should be given in the same units, as are the units of the imported data file (meters, kilometers).



In the case of DC transformation you have to enter also the limits of the regularization parameter alpha, which is used during the Tikhonov regularize. procedure, e.g. $<10^{0},10^{20}>$:

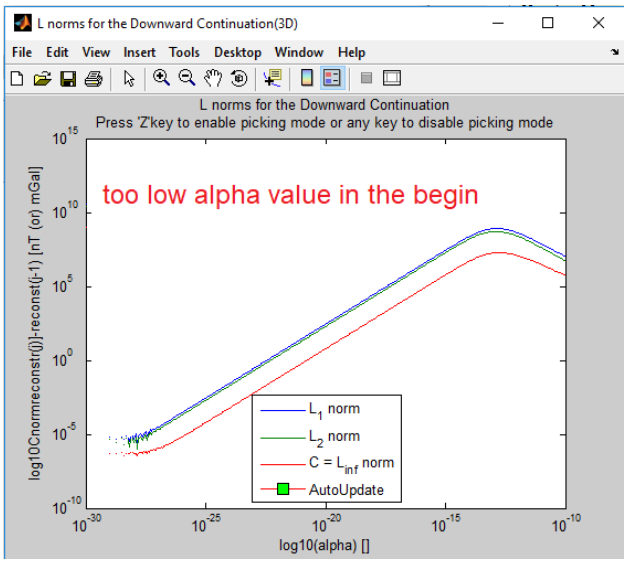


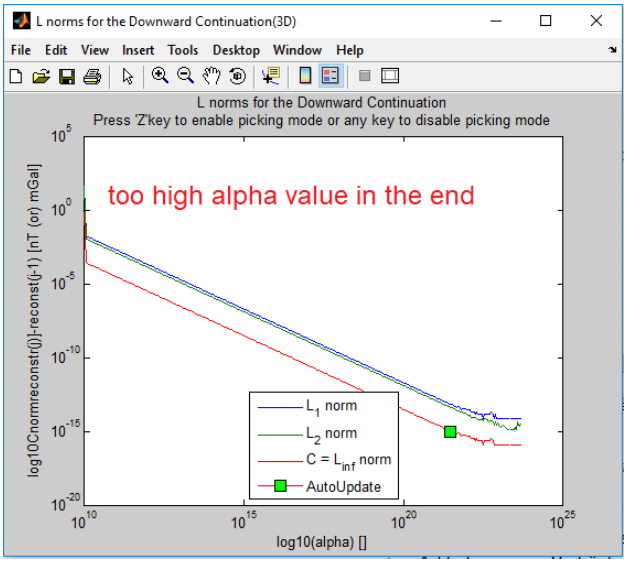
After the realization of the calculation of the DC for all values of the regularization parameter (after pressing the OK button) two windows are opened: left-hand one with norms and right-hand one with the continued field:



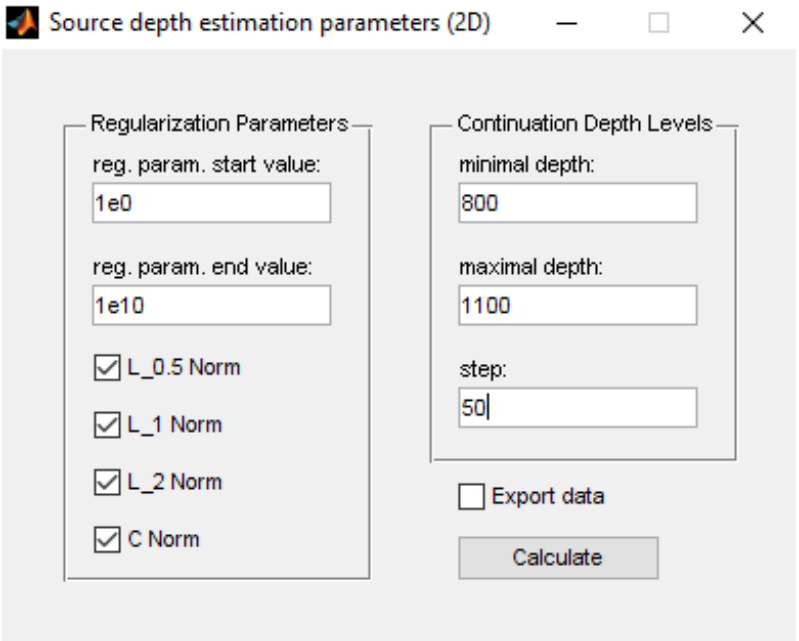
Resulting norms and continued field are also saved in appropriate files.

Script tries to find automatically the local minimum in the shape of the C-norm – its position is showed by a position of a small green square. If this minimum is not found, a non-regularized solution is calculated and shown (user can change it by pressing the key Z and finding its selected alpha value with the mouse in the left-hand window with the norms).
User should be careful of situations, when the limits if regularization parameter alpha are not selected well (two examples are displayed here) and change them in a correct way:

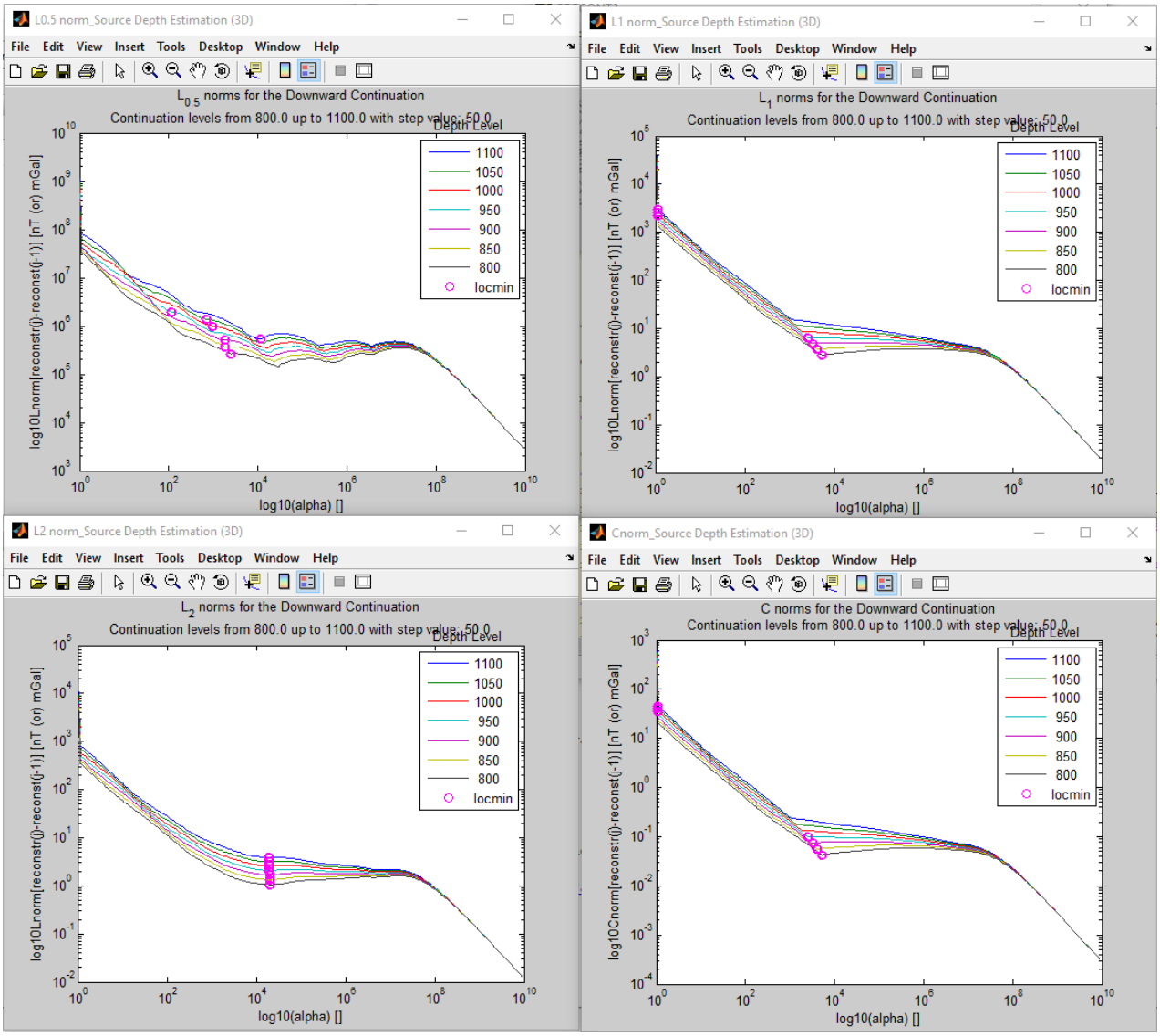




3. To use the Source depth estimation toll, go to the item with the same name in in both *Profile data* or *Grid data* menus. After selecting it you will obtain a window, where you have to enter following parameters: starting and ending value of regularization parameter alpha, type of norm ($L_{0.5}$-norm, L_1-norm, L_2-norm, C-norm), minimum and maximum depth of continuation together with the step of continuation:



After realizing all the calculations (can take a while) several windows are opened (be careful, these windows are one above the other) with all the selested norms:



In the following graphs of norms user can follow positions of automatically detected local minima on different continuation depths and visually find the depth, where the local minimum disappears – this should be the depth of the interpreted source (in this analysis always the interval of used regularisation parameter alpha should be well selected). The best way is to select such type of norm, which has well developed and sharp local minima (in the most of cases these are the C-norms and L_1-norms).

4. To finish the work with the script select the item *Quit* or *Quit inside the Matlab* in the Menu *End*.

Comment:
In the message and parameter windows, it is always necessary to press the OK button with the mouse, the Enter key is not working well in Matlab scripts.