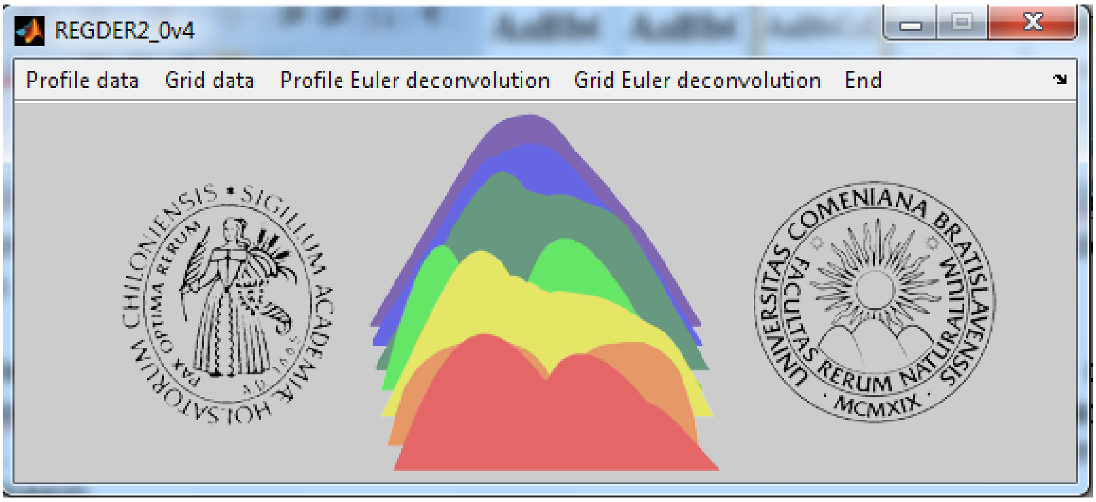
Tutorial – program *regder2_0v5.m*

Matlab script '*regder2_0v5.m*' calculates the 2D and 3D classical Euler deconvolution (Thompson, 1982; Reid et al., 1990) with the utilization of regularized derivatives evaluation (Pasteka et al., 2009).

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 grid '*bram.grd*', which contains the Bouguer anomaly from a selected region in northern Germany basin. All described work-flow steps are connected with the processing of this example. Besides of this, there is also attached a synthetic profile example for 2D Euler deconvolution testing (gravitational effect of a 2D horizontal cylinder in a depth of 21 m, with added 5% normal Gaussian noise) – the file '*cyl5noise.dat*'.

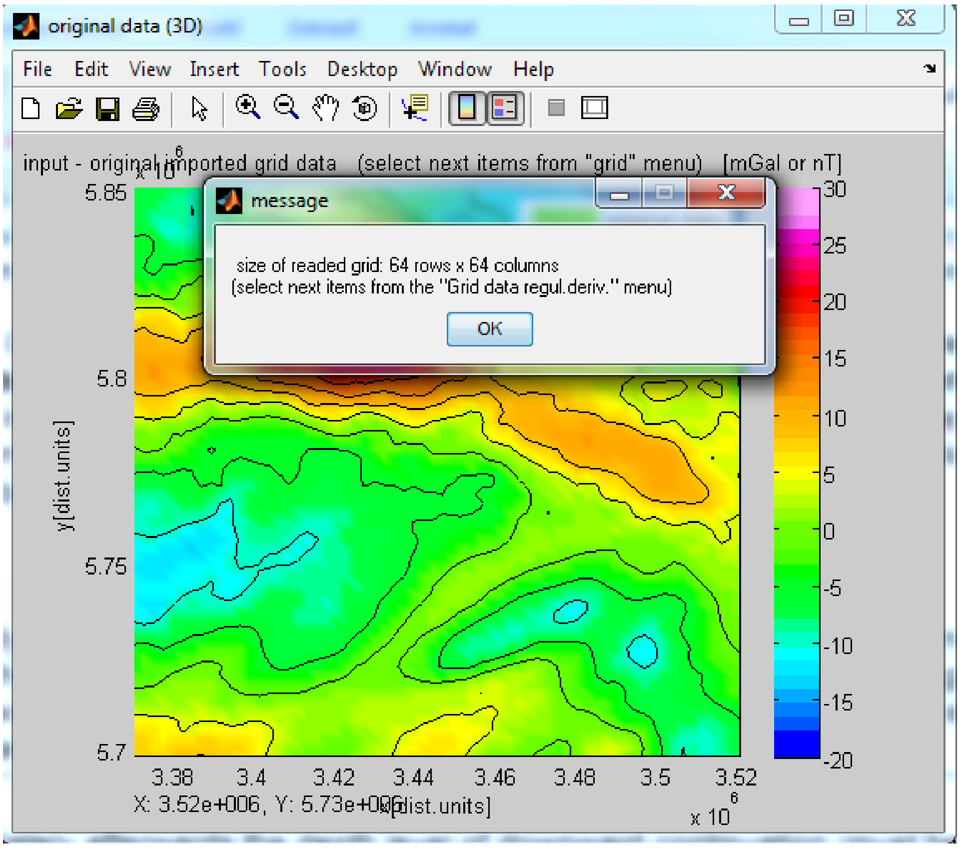
Working steps with '*regder2_0v5.m*':

1. Run the Matlab script file '*regder2_0v5.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:



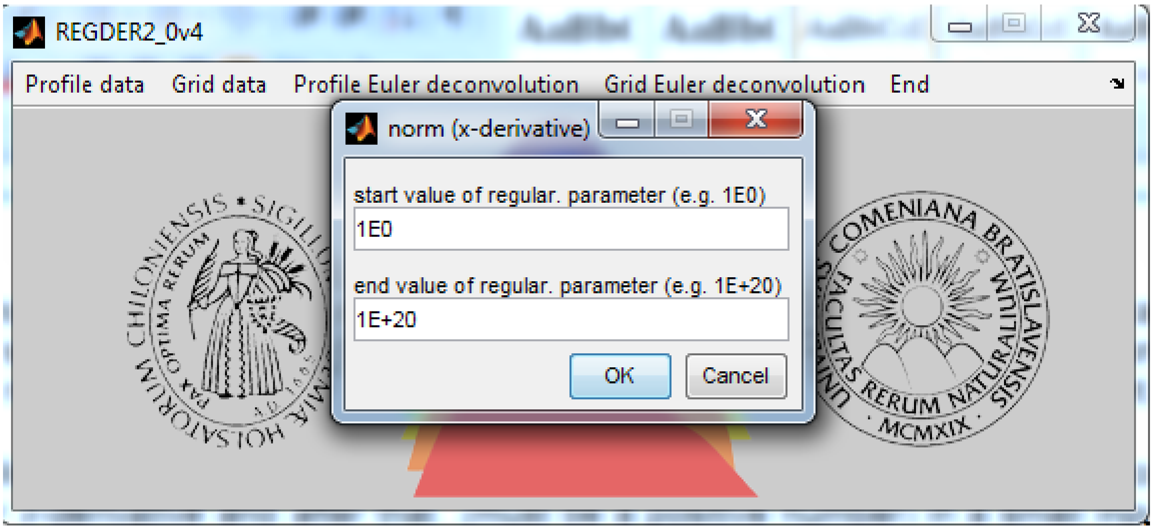
   To process data you have firstly to select *Grid data* menu (or *Profile data*) – this will prepare the regularized derivatives. After passing the most important steps here, you have to switch to *Grid Euler deconvolution* (or *Profile Euler deconvolution*) – this will perform the Euler deconvolution itself and select the most reliable solutions.

2. In the *Grid data* menu select the component *Open grid data file* and select the grid file. **Attention: it must be a Golden Software Surfer ASCII grid format!** After correct import of the grid, you should obtain following windows – a coloured map and an information window about the dimensions of the grid – this information window should be closed using the OK button.



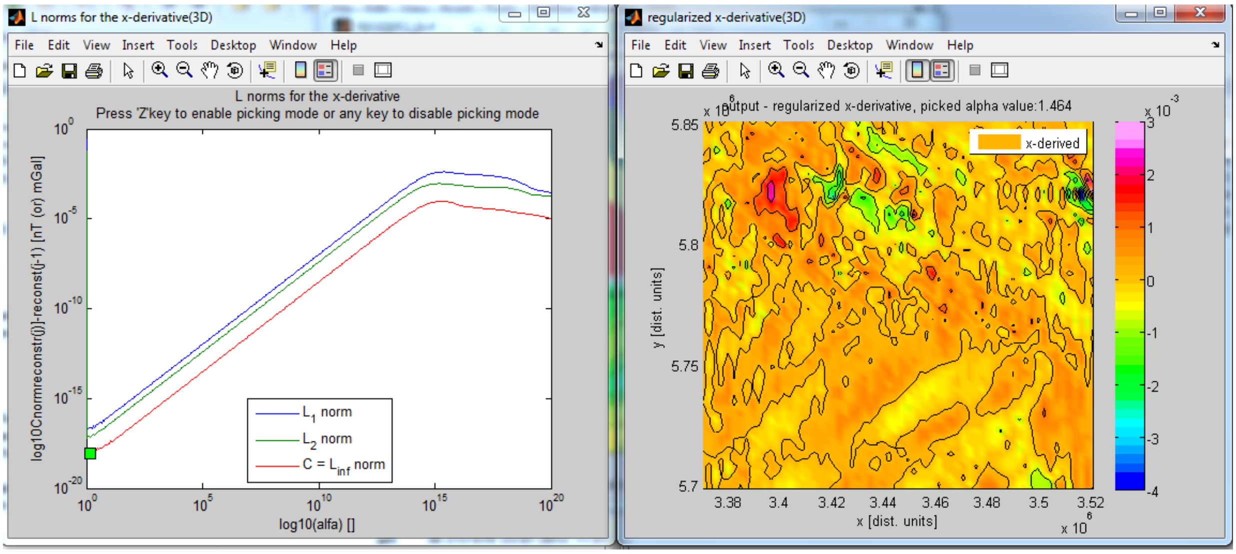
The window with the coloured map of the grid values can stay open and you can move it on your screen to the upper left-hand corner. When this window is open, you don't have to use the next component of the *Grid data* menu the *Display grid data* component.

3. Now follow the most important steps in this section – you have to select the component *Norm for x-derivative* and after that in a small input window have to be entered the limits of the regularization parameter alpha (used for the regularized derivative in x-direction evaluation):

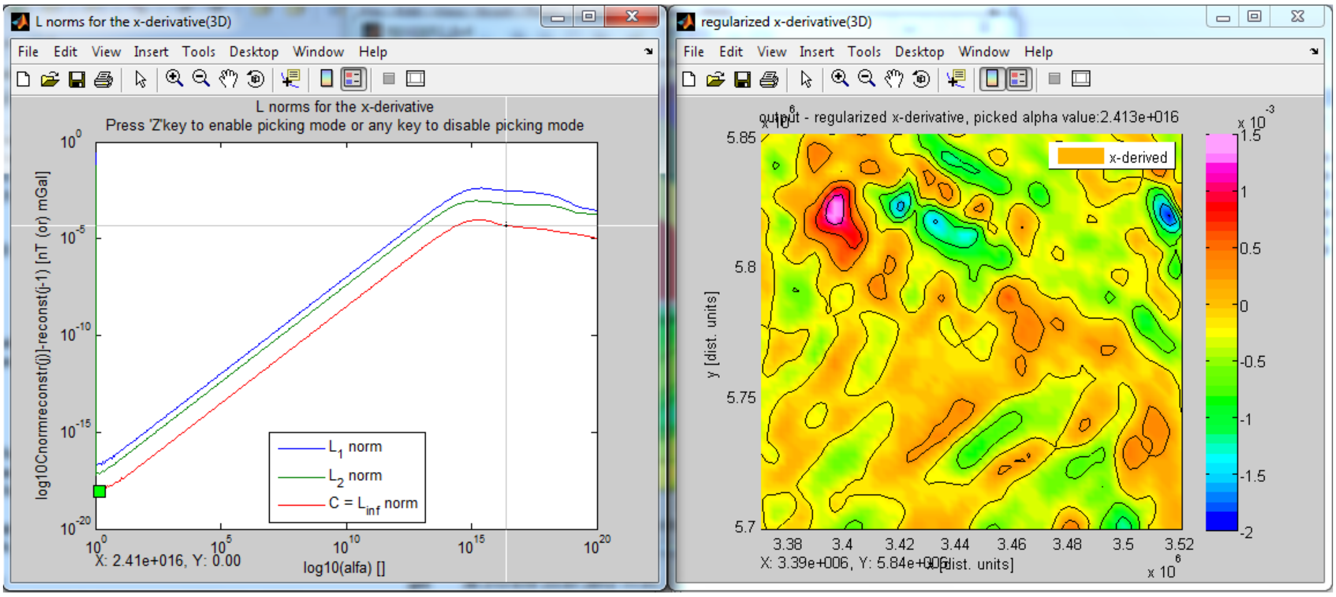


After pressing the OK button, the process of regularized derivatives in x-direction is running – this can take some time (on actual PC computers for grids with 100 x 100 cells some minutes, for larger decades of minutes).

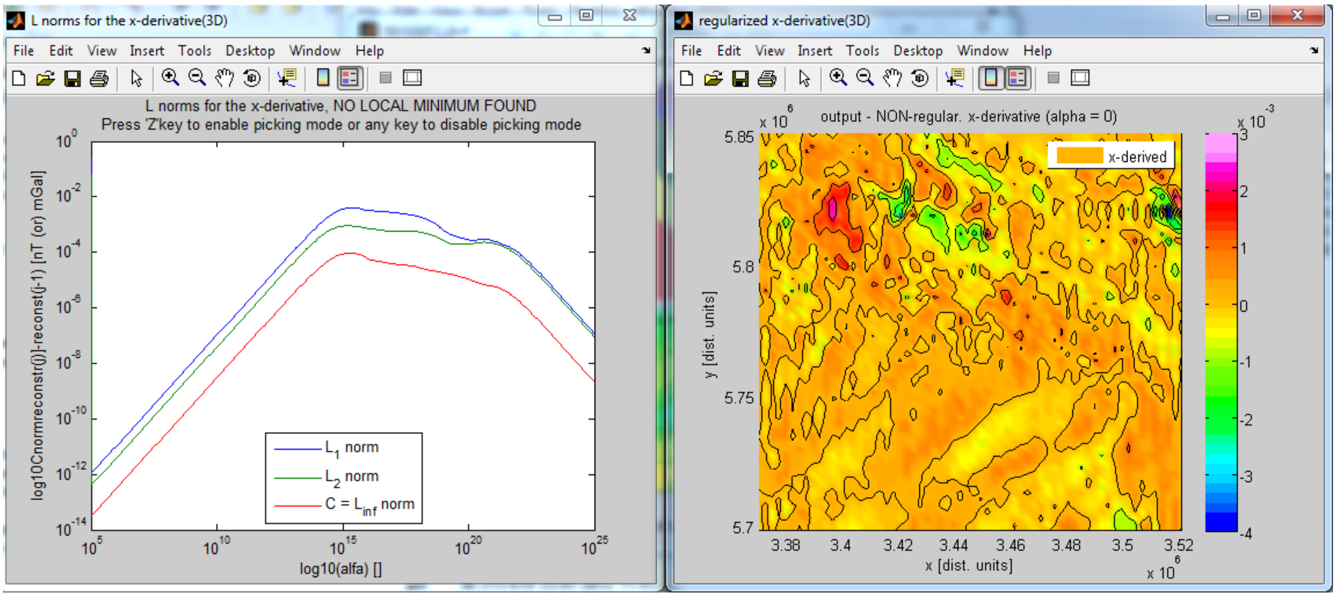
After finishing this process following windows will be opened:



In the left-hand part, there are displayed the norm functions, used for the selection of the optimum regular. parameter alpha value (the most important is the C-norm) and in the right-hand part is the resulting x-derivative for the used regular. parameter value. In this case, the result is not good, because the algorithm was not able to find the optimum parameter value in its correct position – it is the small green square in its left-hand margin. In such a situation, the optimum parameter must be found manually – by making the left-hand window with the norms active (clicking with the left mouse button) and then by pressing the Y button on the keyboard. A thin line bog cross should be active in this window and by clicking a place close to the global maximum of the C-norm we get the correct x-derivative solution – this is immediately displayed in the right-hand window:

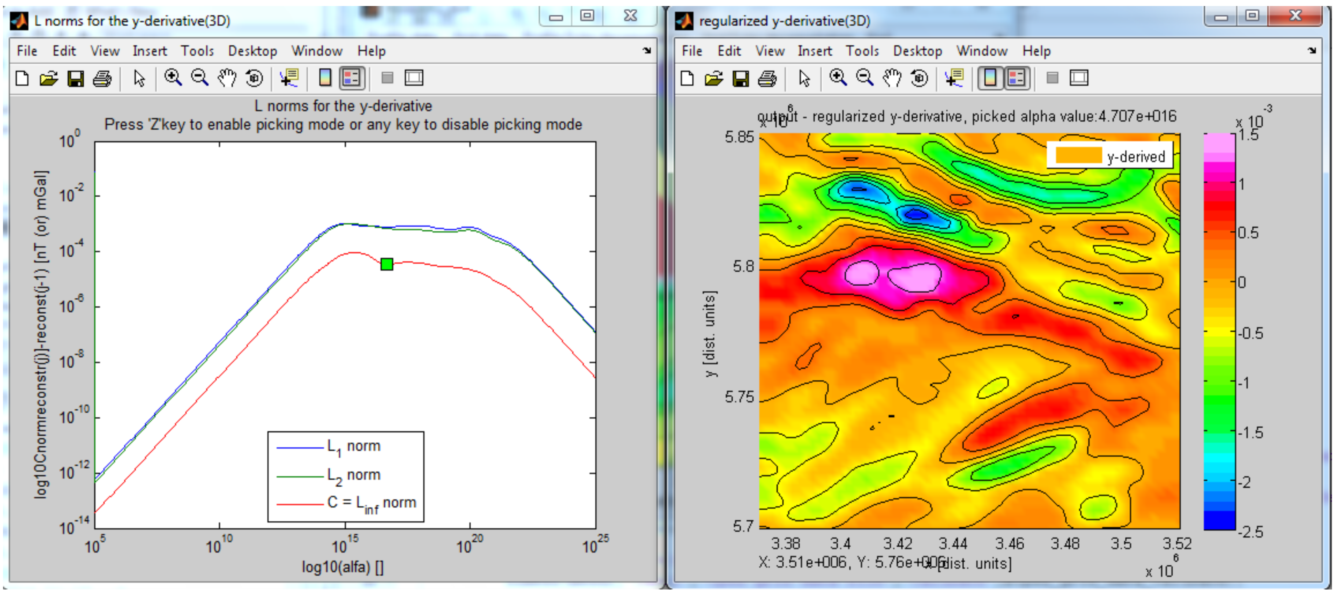


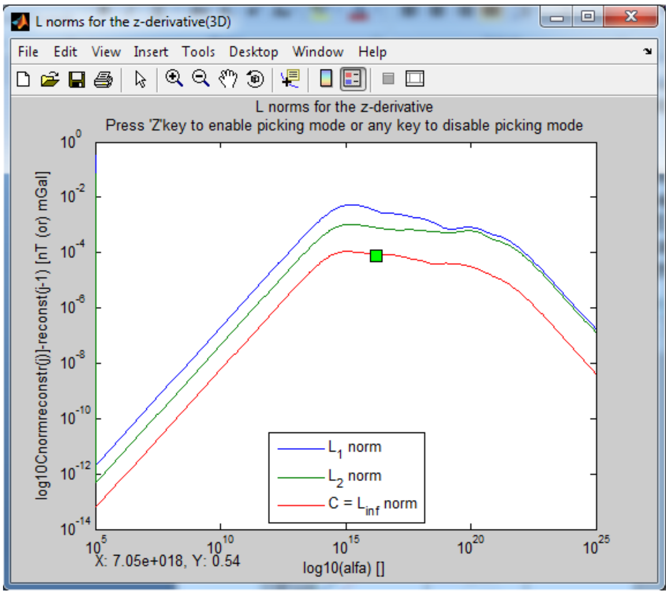
This x-derivative solution will be remembered (always the last used one) and then later on used during the Euler deconvolution algorithm application.
When you are a beginner and you would like to see the whole shape of the norm functions – then it is better, when you close these windows and start with this step (*Norm for x-derivative*) again, but set the limits of the regularization parameter to a different ones – shifted more to the larger ones – e.g. in this case from 1E5 to 1E25:

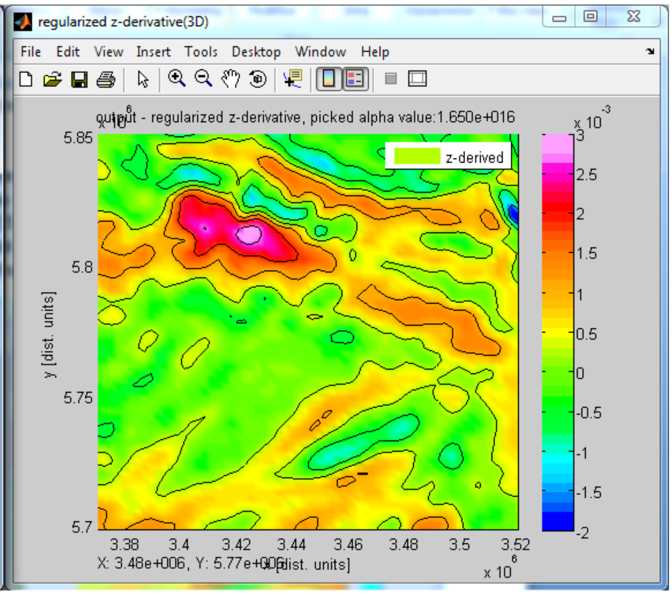


And again you have to use the manual mode for the selection of the correct regularization parameter value. The ideal situation is, when on the top of a concave shape of the C-norm a local minimum is build – then the optimum parameter value is there. But sometimes (as in this situation), it is only something like a "begin of a local minimum" and it is right. And sometimes in happen that there is only a global maximum of a symmetrical concave norm function – then the optimum parameter is on its top. Please, have a look at the examples in Fig. 1 and 4 in our Geophysical Prospecting paper (Pasteka et al., 2009).
When you are happy with the received solution for the regularized x-derivative, you have to press the button A on the keyboard and close both windows – that with norm functions and that with resulting maps.

4. Following procedures should be repeated also in the case of the y-derivative and z-derivatives evaluation, respectively. I give here only the final solutions for them (with the changed limits of the parameter from 1E5 to 10E25). It this cases, the received C-norms have well developed local minima on their tops and the algorithm was able to find the optimum value automatically (the green squares):



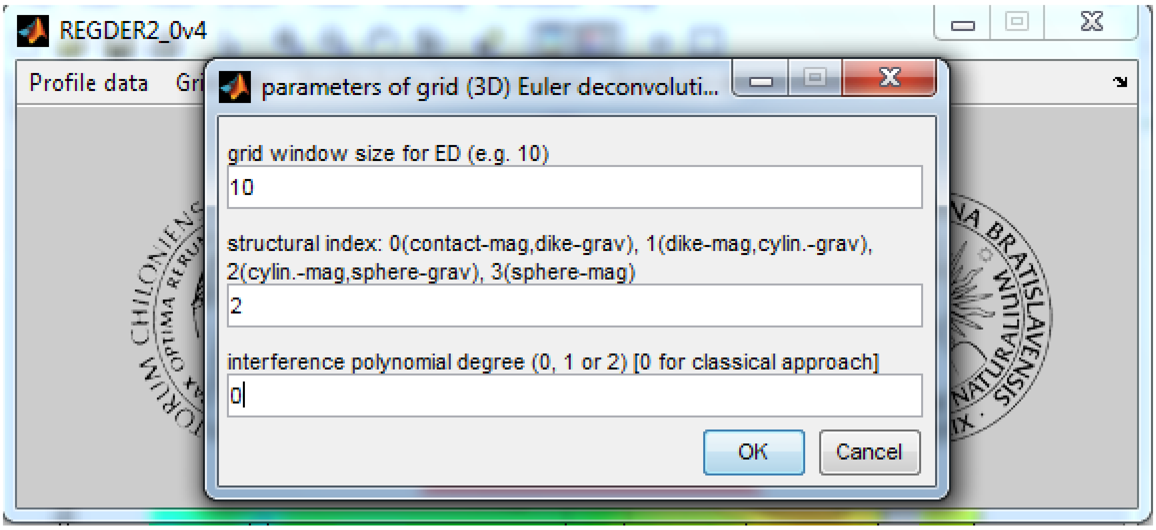




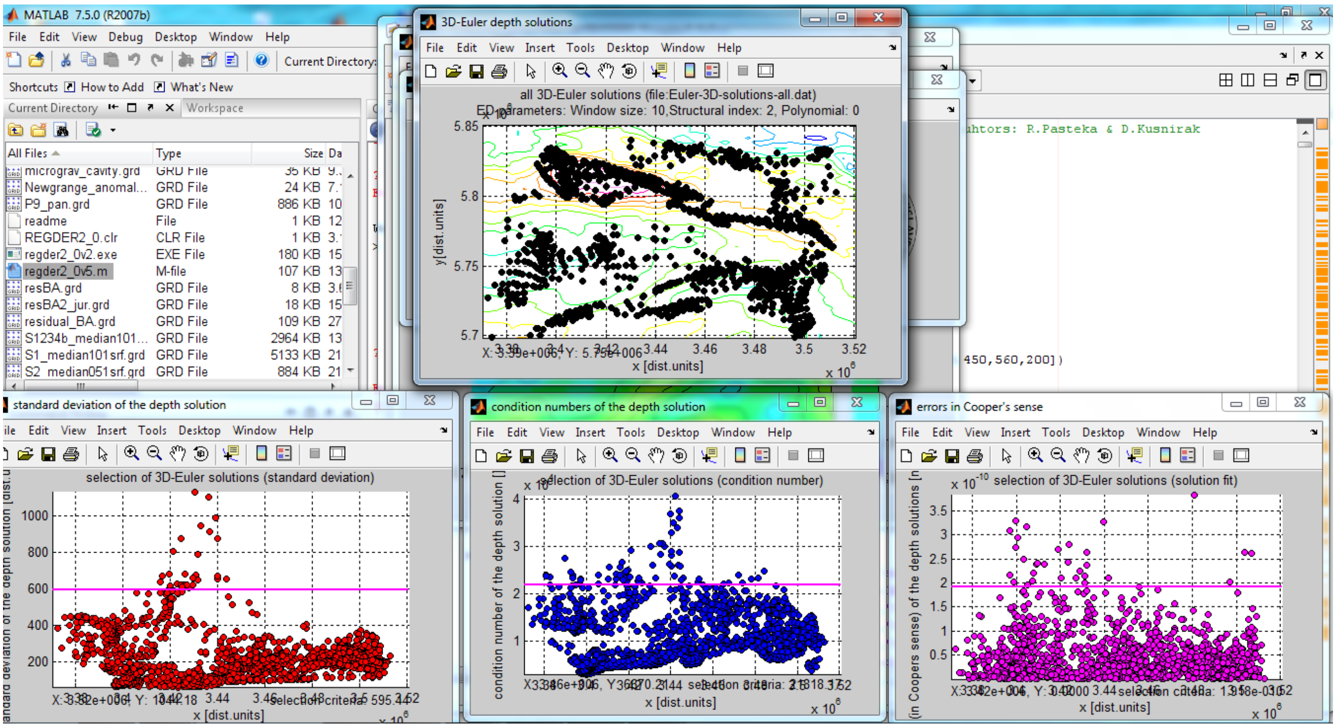
The last three components of the *Grid data* menu (*x-derivative calculation*, *y-derivative calculation*, *z-derivative calculation*) are used in a case, when the user has the knowledge about an exact value of the regularization parameter or wants to use a value of zero. This is not actual in this used example.

Comment 1:
In some cases the predefined values <1E0, 1E20> do not fit to the data processing and the limits must be changed. Mainly, when the maximum limit is too big, small numerical "perturbations" (characterized by oscillations) deform the automatic determination of the local minimum in the norm – one of these small minima is wrongly detected as the optimum one (see the attached figure) and the optimum value must be estimated manually – or by a repetition of the whole calculation (for changed upper limit of the alpha-interval).
Comment 2:
It is always necessary to press the OK button with the mouse, the Enter key is not working well in Matlab scripts).

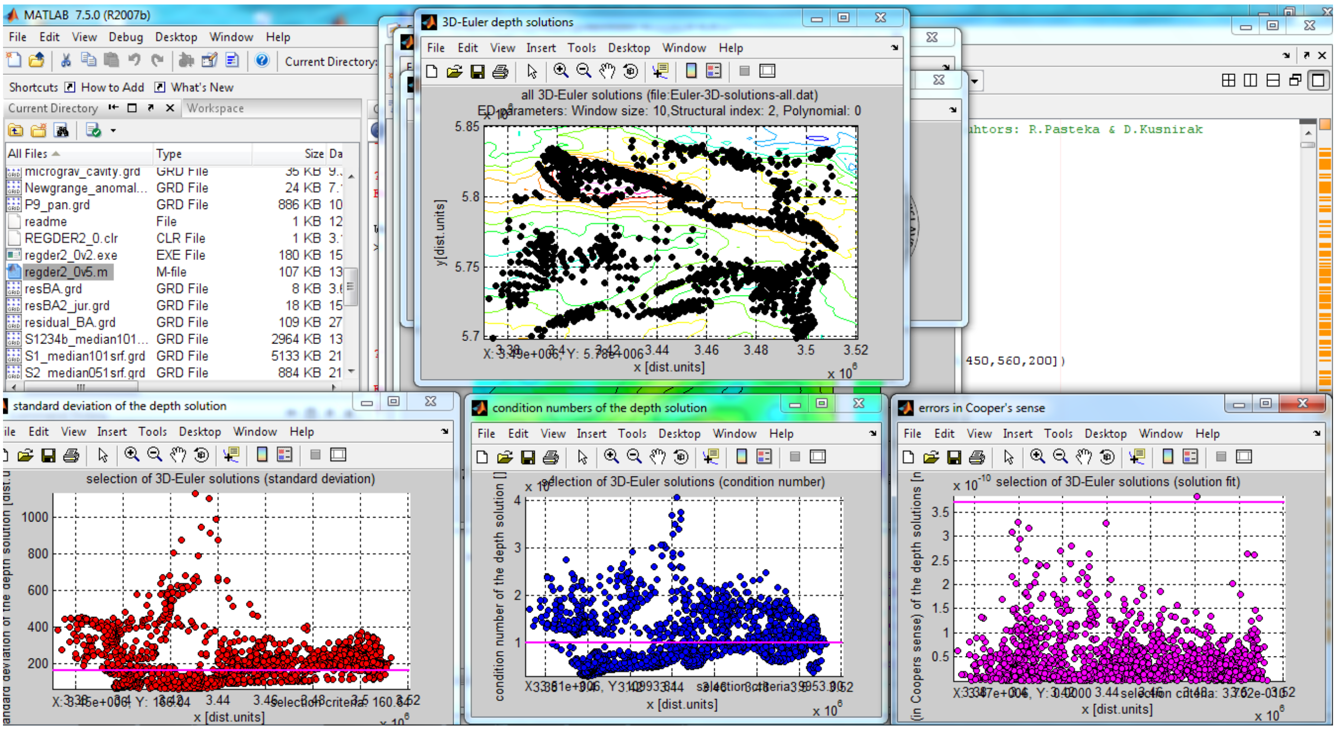
5. After the evaluation of all three regularized derivatives we can switch to the evaluation of Euler deconvolution – selecting the component *Select calcul. param. and START* in the *Grid Euler deconvolution* menu. In the following parameter window:



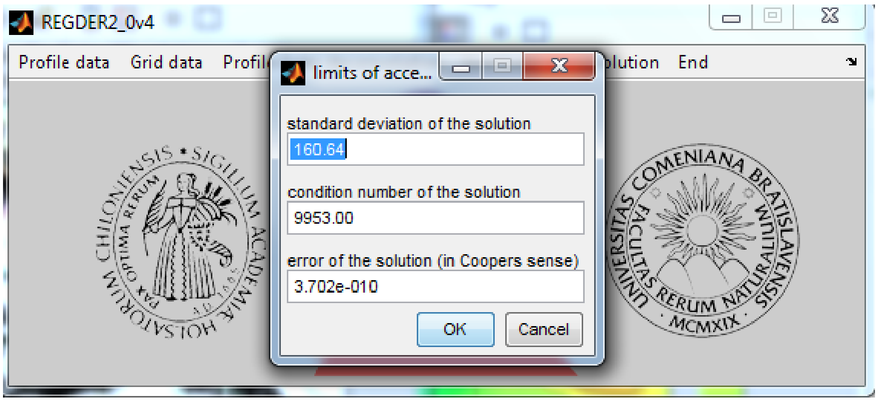
The **windows size** should be selected. Too small window sizes cause defocused (often randomly distributed) solutions, too big windows cause artifacts in the form of “swirls” and “tails”, which are caused by the interference of neighboring anomalies. Next – the **structural index** should be selected (a list of the mostly used values is in the window). Finally, there is an option of a **polynomial interference degree** selection - few years ago, I have experimented with an adoption of the idea from Werner deco into Euler deco, but without any great success in practical application – unfortunately, this adoption has made the solved linear equation system much instable and very hardly solvable. In a case of interest, I can send to you my published paper on this topic in Bollettino di Geofisica Teorica ed Applicata. **So, here the value of zero should be entered**.
After entering all of this values and pressing the OK button the calculations itself are realized and 4 windows are opened. Attention!, they are hidden one below the other, so you have to move them on your screen – I always made them smaller and organize them in this following way:



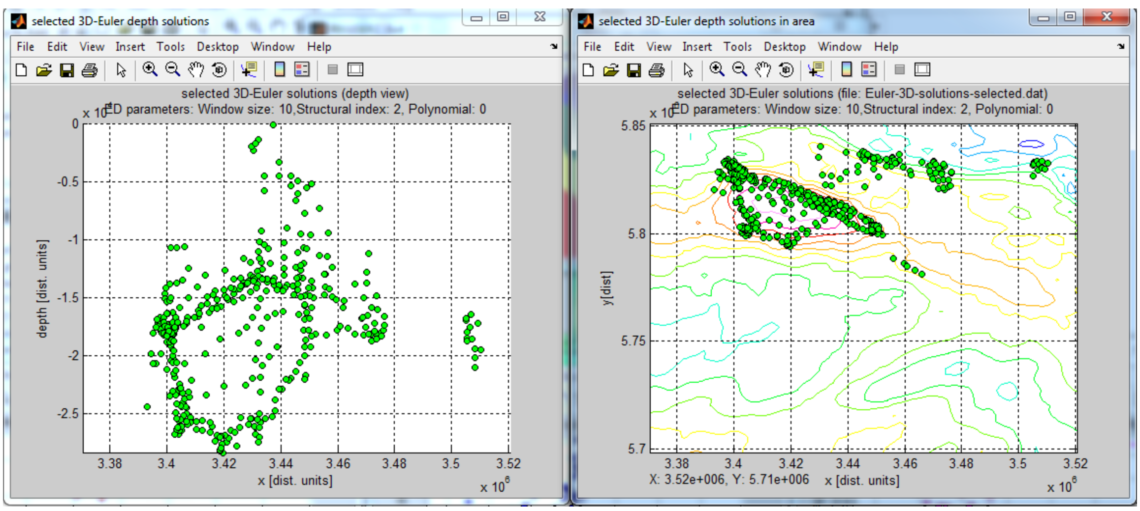
In the upper window – there is a planar view to the received solutions (with a contour map of the interpreted grid values). The three bottom windows contain important statistical parameters of the solutions: **1.** standard deviation (SD) (used also e.g. in Geosoft software solutions), the best solutions have small SD values, **2.** condition number (CD) (a parameter of the solved equation system instability, coming from the Singular Values Decomposition method), the best values have small CD values and finally **3.** The error condition from a paper of Gordon Cooper, where he enters the received ED colution back into the Euler interpretation equation and follows the resulting error from it (when all terms are brought to on side of the equation, on the second side we should get zero). Unfortunately, this criterion do not work well in our script and I do not know why, it is in my opinion a very well defined criterion.
So, for the final selection of acceptable solutions, I use only the first two criterions: SD and CD. With the mouse I select the pink horizontal line in both windows and shift it down – to select only the most important solutions clusters – as you can see it here (to be sure that no wrong influence of the Cooper’s error criterion is caused – I shift the line in this case in the opposite direction – to the top):



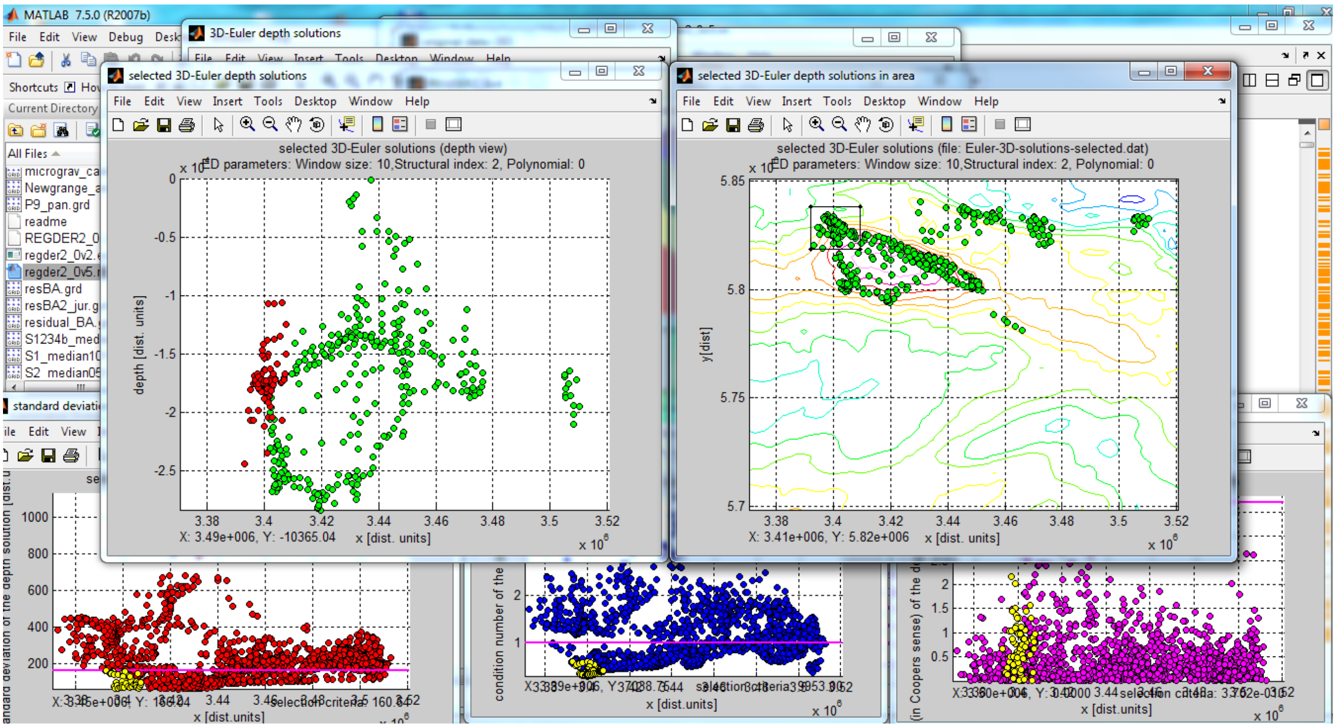
After this, the user has to select the *Select 3D solutions* component from the *Grid Euler deconvolution* menu and she/he receives the information window with the selected values of these three statistical parameters:



After pressing the OK button, we get final two windows (depth and planar view):



Which show the selected solutions. These are also saved in a file in the working directory (signed in the name with the abbrev. 'sel', the file with all solutions has in its name 'all'). We can see in this case that some important clusters are visible in the planar view, but the depth section show relatively large range of depths – this is cause by the fact that we can see in the depth section all solutions (from different corners of the grid). We have one possibility – to select manually some clusters – to see their depths: we can select with the mouse in a rectangle and then see the corresponding solutions in the other windows – also in the windows with statistical parameters (this can be made in the planar or in the depth window):



Unfortunately, these manually selected solutions are not saved in a file, they can be only visualized in these windows.

Final comment: as you can see this program is suitable for the interpretation of not very large grids (maximum 500 x 500 cells), because the selection procedure is very complicated in the case, when there is a huge number of solutions (several thousands). A better way is to extract smaller parts from larger grids.