StaTect

user guide

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Introduction

StaTect is a simple application for compass data plotting and statistical analysis. It was created in Object-Pascal using some libraries by doc. Melichar, Masaryk University Brno, Czech Republic (www.ugv.cz) and graphic library GR32 (www.graphics32.org). StaTect can plot data as points (poles), great circles or both ways (used e.g. for faults etc.), compute rose and contoured plots, rotate and generate data. All plots use equal-area projection on lower hemi-sphere and are generated as bitmaps and metafiles.

StaTect can be used and distributed only for non-commercial purposes!
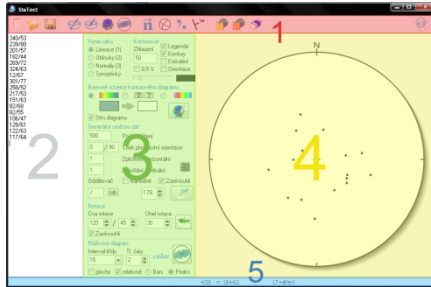
Application use

Input and output as well as the controls can be found on one form:
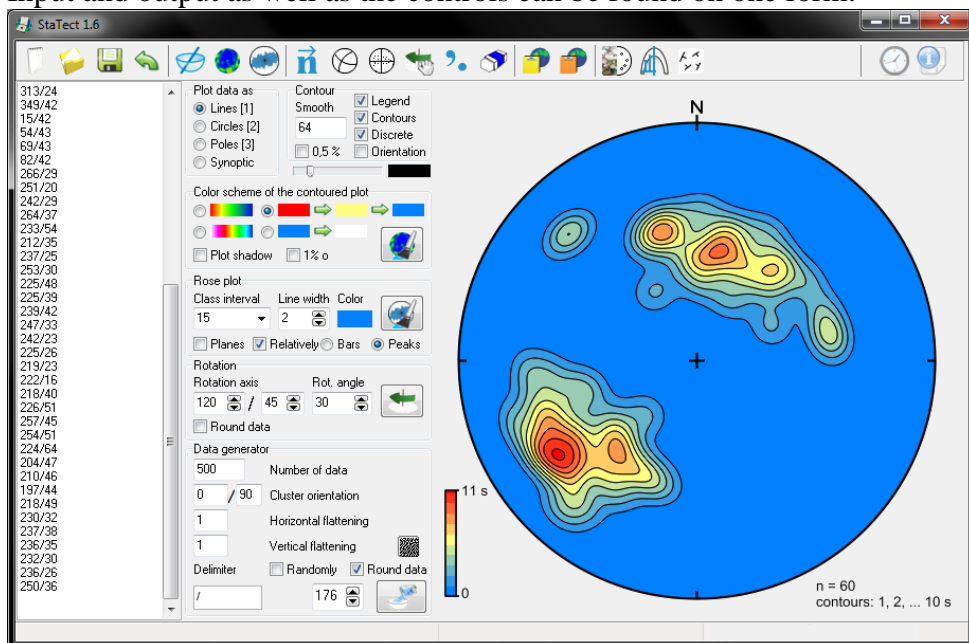
The main form has five parts:

1 – Tool bar – contains the procedures' buttons.
2 – Text field – for the input data.
3 – Settings – contains panels with individual procedures settings.
4 – Plot – is the canvas for output plots.
5 – Status bar – shows mainly the cursor orientation in the plot and densities in the contoured plots.

1. Tool bar

The main tool bar contains buttons for all procedures StaTect can perform and is divided into four parts:

 – data file management

- *New file* – deletes all data, deactivates all tools and clears the plot. No other settings are changed.
- *Open file* – loads selected text file and plots the data according to the settings (see below). Pay attention to the data format!
- *Save file* – saves the contents of the text field into a text file.
- *Undo* – undoes the last change in the text window.
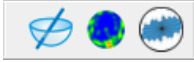
– basic StaTect tools

- *Plot data* – plots the data put in as the Euler angles (α/φ). **Note**: StaTect only accepts the data in the trend/plunge or dip direction/dip format (0..360/0..90)! All other data must be converted elsewhere. The delimiter can be set in the panel Data generator and must be identical in the whole data set. When a file is loaded or data pasted into the text field, StaTect recognizes the delimiter automatically. No header is allowed. The data can be pasted into the text field also as vectors (one vector per line). In such case, the user has to right-click on the button. Data is converted to Euler angles (trend/plunge) on the lower hemisphere.
- *Contoured plot* – calculates and plots the contoured plot. This process is time-consuming (the density function is calculated in extremely dense grid for 40 835 points). The calculation progress is indicated by a progress-bar in the status bar. StaTect uses up to 20 CPU – cores.
- *Rose plot* – calculates and plots the rose plot.

– useful tools:

- *Convert to normals* – converts the dip lines to normals.
- *Calculate fold axes* – calculates a fold axis from two measurements directly one after another in the text field (so sort the data carefully!). If the data are not normals to the planes, you have to either plot the data as poles or great circles or convert them (see above) otherwise the results are completely wrong!
- *Rotate data into the plot axes* – rotates the data, to align the biggest eigenvector with the vertical axis and the smallest eigenvector with the East-West axis.
- *Rotate data manually* – activates manual data rotation (the button icon changes to and the cursor in the plot changes to). The data can be rotated around vertical, arbitrary horizontal or any axis. Possible rotation axes are indicated by red dots with mouse-button hints (see figure-a below): – left button, – right button and – the wheel (clicking, not scrolling!). The starting point of the rotation is the pointing finger of

the cursors hand. During the rotation the button must be held pressed! If the cursor finds itself out of the plot, the data can be rotated around vertical axis by using the left mouse-button. The rotation angle is indicated by a light green circle sector – see figure-b below b). If the cursor finds itself inside the plot, the data can be rotated around horizontal axis by the right mouse-button, around arbitrary axis (but fixed during the rotation) using the mouse-wheel, or around dynamically changing axis using the left mouse-button ( ). The rotation axis is in this case calculated as the vector product of starting and current cursor position vectors. The rotation angle is indicated by a section of a great circle in light green (fig-c).

Results of manual rotation are plot in real-time, data in the input text field are updated every time the user releases the mouse-button. The rotation can be undone (whole, not individual steps) by pressing , which occurs on the tool bar next to the button . The manual rotation tool can be deactivated and the results accepted by pressing which then changes back to .
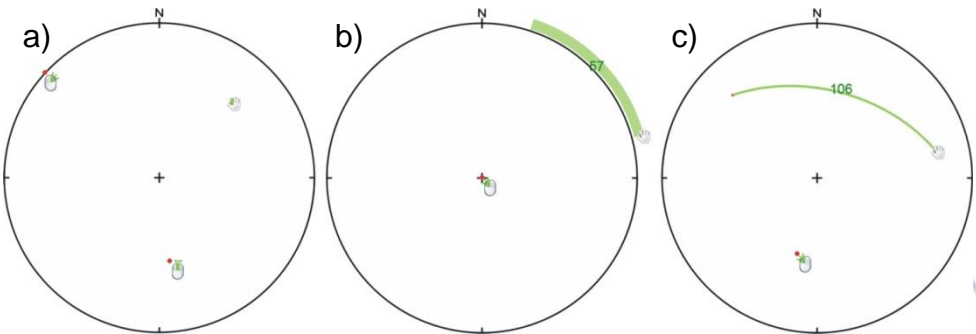
If the user wants to rotate planes, their dip-lines must be converted to normals by clicking on the button $\vec{n}$ or the data must be plot as great circles or poles (by checking the appropriate radio-button on the panel Plot data as). If the data is mixed, the user has to indicate the type of them (see below).

- *Commas to dots* – converts commas to dots
- *Data eraser* – activates manual data eraser (the size can be changed by scrolling the mouse wheel, erasing is ended by clicking on the arrow tool-button).

– copy plot to the clipboard

- *Copy to clipboard* – copies the plot into clipboard in EMF format (enhanced metafile). Note: the process for the contoured plot takes 1-5 sec, depending on your hardware, all other plots are instant. During this time stays the button pressed.
- *Copy to clipboard* – copies the plot into clipboard in BMP format.

- other data analysis tools (descriptions are at the end of the manual)
- *Digitalize data from bitmaps* – tool for digitalizing data from maps (faults, joints) and equal area plots.
- *Fold analysis* – tool for fold classification from photos.
- *Spatial averaged maps* – tool for spatial analysis of structural data by spatial averaging.

– last buttons

- *Tectonic clock* – the only real clock ;-)
- *Information about the application*

2. Text field

The text field contains the input data for all other procedures. The data can be directly written into, pasted from clipboard or loaded from a text file using 📂 button on the main tool-bar (no header!). The data format is important: one measurement on each line, α a φ are separated by a delimiter set in an edit box in the Data generator panel in the bottom part of the form. The delimiter must be only one character and not a number. The delimiter is set automatically if the data is loaded from a text file or pasted from clipboard. Only one delimiter is possible in the input file!

input data example:

34/34
124/45
45/23

StaTect plots the data as lineations, great circles or poles as set on the Plot data as panel. The implicit symbols are dots, the symbol can be altered by adding a delimiter and 1-8 (see below; -1 and -2 plots the datum as a great circle). The poles are plot as unfilled symbols, if the user wants to plot the poles filled, just convert it to normals by pressing 𝐧⃗ on the tool-bar. If the plot is synoptic, the number added to the line tells StaTect how to plot the measurement (the appropriate number is on the Plot data as panel in brackets).

input data example:

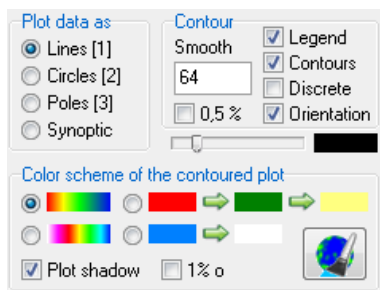|	**synoptic plot**	**point plot**
34/34/1	plots as lineation	1 ● 5 ○
124/45/2	plots as great circle	2 ▲ 6 △
45/23/3	plots the pole to 45/23	3 ■ 7 □
342/65/4	plots as lineation	4 ◆ 8 ◇

3. Settings

This section contains panels with each tool settings. The plot is updated immediately after changing any setting.

Plot data as panel sets the plot type. If ⊙ Synoptic is checked, the input data must be modified (see above). The symbol size can be set by the track bar under the panel Contour, its color by clicking on the black rectangle next to the track bar. If ☐ Orientation is checked StaTect plots eigenvectors of the orientation matrix (as points and also great circles) and writes its characteristics into a text field Orientation matrix, which occurs instead of the Data generator panel. If it is checked using the left mouse-button (☑), the eigenvectors are plot in red, if it is checked using the red mouse-button (▣), the eigenvectors are plot in color: in red the biggest eigenvector, in green the middle and in blue the smallest eigenvector.

Contour and Color scheme of the contoured plot panels set the style and computing method of the contoured plot. When the user wants to contour planes, he has to either check the radio-buttons ⊙ Normals or ⊙ Great circles on Plot data as panel, or convert the dip-lines to normals by clicking on the button $\vec{\mathbf{n}}$. Mixed data cannot be contoured!

The contoured plot can be calculated using either the Watson distribution function (by default) or 1% circle (by checking ☐ 1% o). The smoothing parameter can be set on the Contour panel (the higher the value, the sharper the maxima; 64 gives the sharpness comparable to the 1% circle method). The Watson function gives the values in multiples of the expected density for uniform distribution (s), the 1% circle method gives values in percent.

Panel Contour sets the contoured plot appearance: should the contoured plot contain graphical legend – ☑ Legend (left mouse-button) or only written contours values – ▣ Legend (right mouse-button), should the density function be contoured – ☐ Contours and should the density color fill between contours be smooth or uniform – ☐ Discrete. The step of the contours is set automatically. If the maximum is less than 15, every contour is plot, if the maximum is between 15-30, every other is plot, etc. In any case, the first contour is 1 s (%). If the maximum is less than 5 s (%) one can plot the contours with 0,5 step by checking the ☐ 0,5% in the Contour panel (the EMF is however plot with 1 s (%) or higher step).

Color scheme of the contoured plot sets the color scheme of the plot. The user can choose between two fixed color schemes and customizable two and three colors fills. The colors can be changed by clicking on the colored rectangles on the panel, maximum on the left, minimum on the right. The colors can be easily switched by clicking on the arrow between the rectangles. The color of the contour lines is the same as the dots and great circles and can be changed by clicking on the black rectangle on the panel Plot data as. The changes take place immediately. The button 🖼 redraws the contoured plot (StaTect remembers the densities even if the original input data have been changed). The plot shadow switch on/off control is also located on this panel – ☐ Plot shadow.

Rose plot panel sets the parameters of the rose plot. The class interval can be set in the combo box Class interval: 5, 10, 15, 20 a 30° are for the user's disposal. The colored rectangle Color sets the fill color. If the check box ☐ planes is checked, the strike of the planes is used for the frequency counting. The histogram can be plot as ◉ Bars or ◉ Peaks.

The panel Rotation is used to rotate data, when it is necessary to use a particular rotation axis and angle. The results can be round up by checking the ☐ Round data check box which of course changes the angles between data!
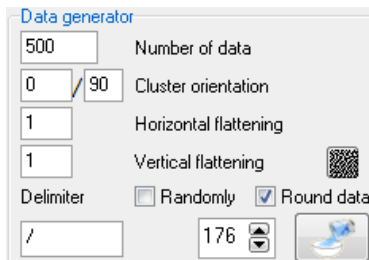
StaTect can generate data in two ways: directly by clicking in the plot and automatically using the panel Data Generator. By default is used an algorithm by Sato, Yamaji, 2006[1], which generates data with uniform distribution. The algorithm can be influenced by changing the value in the spin box next to the button for data generating. Better results can be obtained by unchecking - ☐ Round data. The user can also use random data generation by checking ☐ Randomly. Parameters Cluster orientation, Horizontal flattening and Vertical flattening control the orientation and shape of the data.

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[1] Sato, K. & Yamaji, A. 2006. Uniform distribution of points on a hypersphere for improving the resolution of stress tensor inversion. *Journal of Structural Geology* **28**, 972-979.

4. Plot

The diagrams are plot using Equal area projection (Lambert) on the lower hemisphere. StaTect can plot lineations, great circles and poles, constructs contoured and rose plots as a bitmap, which is shown in the form and as an emf file, which is stored in RAM. Either image can be copied to clipboard by clicking on buttons on the toolbar.
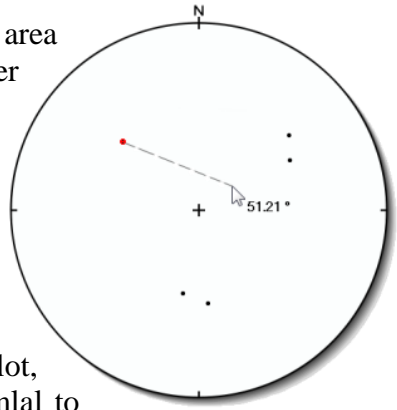
While moving the mouse cursor in the plot, its orientation and the orientation of a normlal to it are shown in the second section of the status bar on the bottom of the form - 293/55 n: 113/35. When a contoured or rose plot is shown, the density in the orientation is shown instead of the normal - 293/55 D: 3,2%.

The use can measure the angle of between two points using the mouse wheel (by clicking). The angle is measured while the wheel is held down (= wheel-click on the first point and hold the wheel while moving the cursor on the second point. The angle is shown in a label next to the cursor).

Data can be deleted in the plot by activating the rubber tool by clicking on 🖐 button. The cursor changes into a red rectangle. The tool behaves as a standard eraser in any graphical editor. Its size can be changed by scrolling the mouse wheel. The rubber tool is deactivated by clicking on ⬡ button.
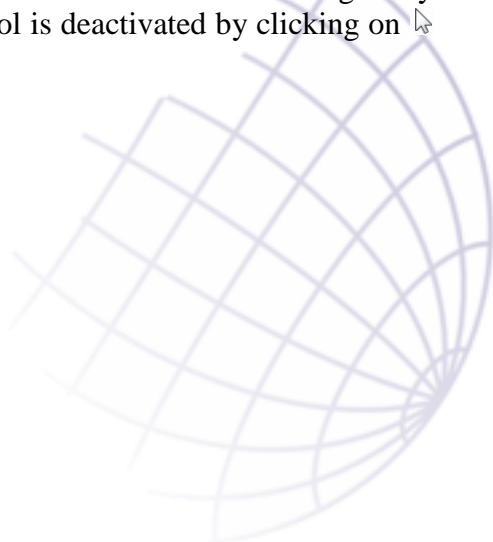
5. Status bar

The status bar shows the file name, orientation of the cursor and normal/density and the number of data. Also the progress-bar indicating the calculation progress is located in the status bar.

Additional tools

• **Digitalize data from bitmaps** – a tool for manual digitalization of trends (faults, joints) from a map and digitalization of raster equal area plots. After pressing the button a new form opens. The bitmap (only in bmp format) can be loaded using ![icon] button or directly from clipboard (*ctrl+v*). The type of data you are digitalizing has to be chosen using radio-buttons, digitalize plots is default. When digitalizing plots, one must set the center point by mouse right click and plot radius by a second right click. For convenience, the outline of the diagram is plotted between the right-clicks. The setting can be repeated until the match is perfect. If the plot is not circular, it has to be edited in a suitable bitmap editor. The data digitalization is done by left-clicking on the data in the bitmap plot. Data is digitalized either as point data or great circles by checking ⊙(. The data is inserted in the main form. If you want to digitalize trends from a map check ⊙ Digitalize trends on map. Then the trends can be "drawn" using mouse left-clicks. The color and width of the line can be set in the top part of the form. The bitmap with the trends drawn can be saved for further use (if you need to pause the process and save your progress) using ![icon]
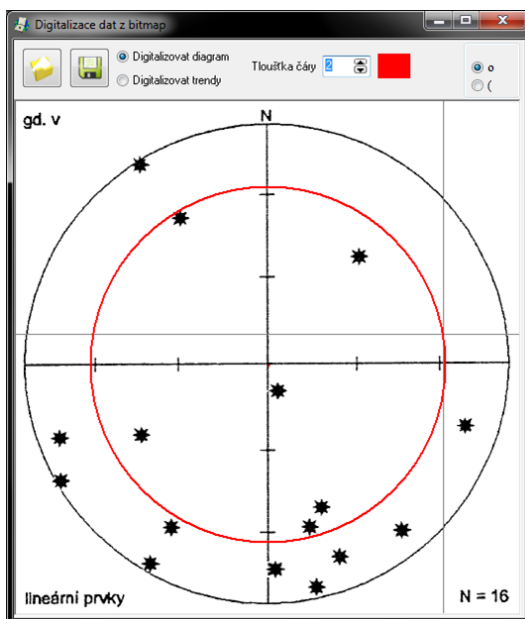
button. The bitmap can be later reloaded. The data set from the main form has to be saved and reloaded manually!

- **Fold analysis** – this tool is for Fouriére and Ramsey fold analysis/classification. It uses field photos of folds, which are digitalized manually. The photos have to be taken parallel to the fold axis! The form consists of a vertical toolbar with data files management and fold digitalization tools, zoom tools and three tabs: Digitalize fold, Graphs and Data table.
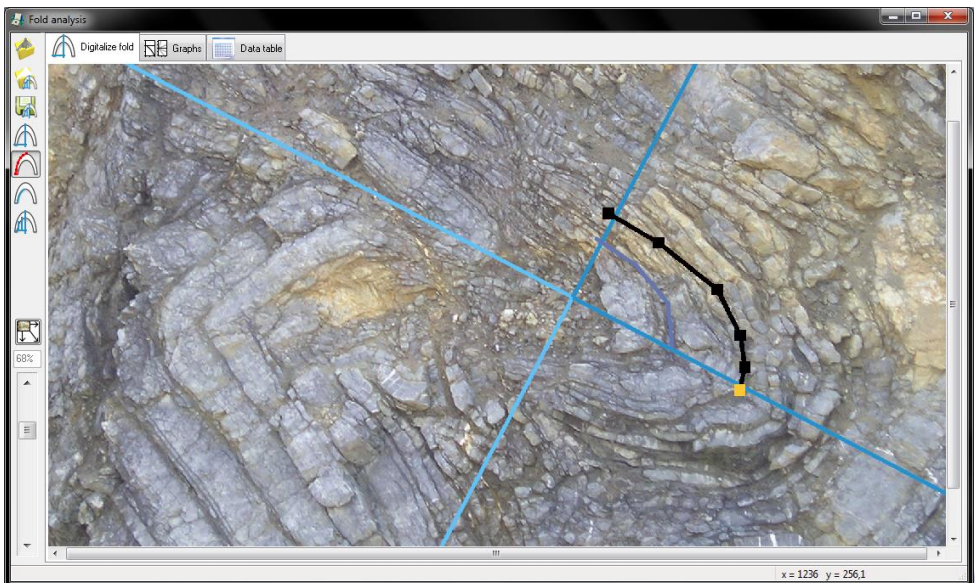

Fold digitalization in Digitalize fold tab has several steps. The photo can be imported into the window either by using 🖿 button, pasting from clip board or dragging directly from a folder. The image can be zoomed and paned using mouse wheel (as in most graphic editors). 🖾 button zooms the image to the width of the window.

Next step is digitalization of axial trace and inflexion line of the quarterwave analyzed. The digitalization is initialized by 🛆 button (hot key A). The axial trace is drawn by first two clicks, the inflexion line by the

third and the quadrant, where the analyzed quarterwave lies, by the fourth click (appropriate quadrant is filled by yellow during clicking). Upper and lower fold plane traces are digitalized after pressing ⌒ button for the upper one (hot key S) or ⌒ button for the upper one (hot key D). The digitalization is terminated by double-clicking or pressing ESC. Digitalized polygons can be edited after right-clicking on the appropriate button. Active polygon node (in orange) can be moved by left mouse button, a node can be activated by clicking on it. Active node can be deleted by pressing Delete, nodes can be added by double clicking on the polygon between two nodes. This tool is deactivated either by right-clicking on the button or by pressing ESC.

The fold analysis is performed by clicking on ⛰ button. Fouriére analysis requires at least one fold plane trace digitalized, Ramsey analysis both. Results are added to the list of documentation points in the Graphs tab, plotted into appropriate graph and added into the data table. Individual analyses can be shown and hidden in the graphs (☑), color can be changed by right clicking on the colored rectangle next to each analysis (||| Set color button in the pop-up menu). Selected analyses can be deleted by ☝ Delete selected in the pop-up menu. Every analysis has a default name which can be changed in the list as in Windows explorer. Ramsey classification graph can be plotted as m'α or M'α, as set in the left-bottom part of the form. Fouriére analysis results can be plotted either as two points (for the upper and lower fold plane trace) or as an average (can be set in the left-bottom part of the form).

All analyses are input into the Data table tab, which can be edited after pressing the edit button in the left top corner of the table. Changes are accepted by pressing save button. The table can be pasted into clip-board by right-clicking on the edit button.

Results can be saved by ⛰ button as *.stctf. Previously saved results can be loaded by ⛰ button. Both graphs are plot as a bitmap and a metafile. Either graph can be copied into clip-board using appropriate button (⬛ bmp, ⬛ emf) on a pop up menu which shows up after right clicking on either graph.
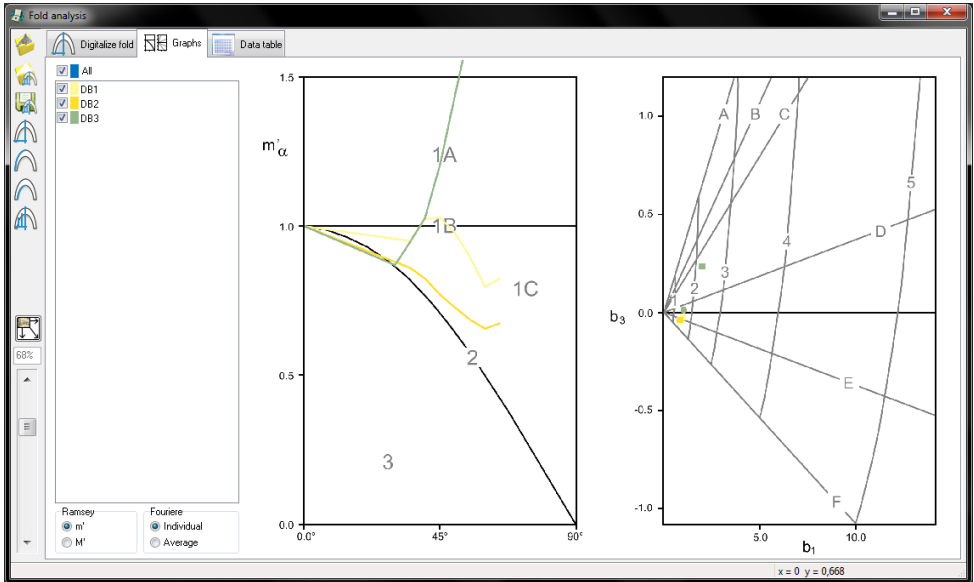
Spatial averaging – this tools is for id-deep spatial analysis of structural data via spatial averaging. Data has to include coordinates.StaTect deals with the coordinates as generic Cartesian coordinates with vertical x axis (positive upwards) and horizontal y axis (positive towards right). It is therefore up to the user to check whether those coordinates are correct and in the right order (mainly which axis is x and which y and above all transformation from geographic coordinates, such as WGS, to cartographical ones!). StaTect does not use WMS services, all base maps have to be loaded as bitmaps and prepared by the user (see below).

Input data can be pasted directly from clip-board (*ctrl+v*) into the text field on the Input data tab. Data have to be in the following format, separated by tabs (can be directly copied from Excel, without any header! the ID must not contain any tab stops!)

ID   x   y   α   φ

Input data example:

| 19 | -1142720 | -585567 | 300 | 40 |
| BA 20 | -1141974 | -585317 | 140 | 20 |

Results of the calculation (in the same format as the input) are displayed in the text field on the Output data tab. All settings and calculations are on the Calculations tab. The top buttons are for the data file management. 🖫 button saves the analysis together with all settings and maps. StaTect saves a *.stctm file, creates a folder of the same name in which it saves all maps loaded by the user. It is therefore necessary when copying the results somewhere to copy not only the *.stctm file but also the folder with maps. 📂 button opens a saved *.stctm file. 🖫 button saves the results of spatial averaging into a text file (to load into some Gis software), 🖺 button savet the map as a *.bmp and 🖺 button copies the map into clip-board.
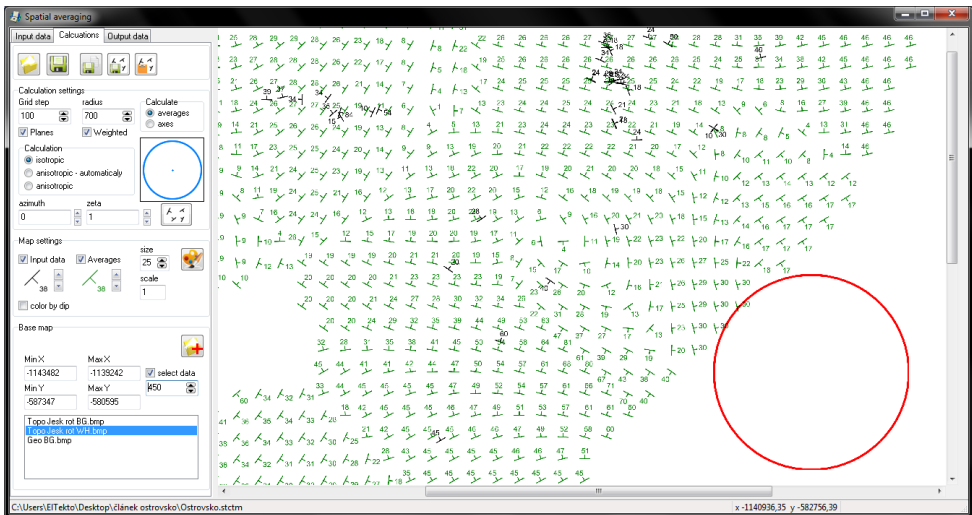
The spatial averaging calculation is performed after clicking 🖺 button. The settings of all parameters are on the Calculation settings panel. The calculation is done in a grid with a given step (edit-box grid step) and only data within a given radius (edit box radius) are used. If the input data is a set of planar features, it has to be indicated by checking the ☑ planes check-box. ☑ weighted check-box determines whether all the data will have the same importance for the calculation or will by weighted by inversed distance from the origin (grid point). On the Calculate panel is set, whether an average value (eigenvector of the highest eigenvalue for planar and

linear data) or a "fold axis" (eigenvector of the smallest eigenvalue for planar data) is calculated. StaTect offers a "classical" isotropic calculation i.e. selection of data in a circle and an improved anisotropic calculation, which selects data within an ellipse. Azimuth of the longer axis of the ellipse and its ellipticity (given by the strength parameter ξ zeta of the orientation matrix) can be set either manually after checking ◎ anisotropic into appropriate edit boxes or by left-clicking and dragging on the picture next to the panel or automatically from the orientation matrix for all data by

checking ◎ anisotropic – automatic. StaTect selects the data based on the settings, the longer axis is equal to the "radius" setting, the shorter according to the ellipticity. The weighting is done the same as for the isotropic option. The anisotropic calculation is very handy in areas with a dominant fold structure with tightly compressed folds.

StaTect can plot both the input data and output averaged data in a map. If no basemap is loaded, an empty white one is created and the data is drawn based on the Map settings panel. Only plotting of the input data is set by default, mainly to quickly check whether the coordinates are correct and also because the plotting of the output data can be very time consuming - first tens of seconds due to antialiasing, so the user has a chance to set everything correctly before committing to a lengthier procedure. Which data is plotted can be set by appropriate check-boxes (☑ input data and ☑ averages). The types of symbols can be selected by up and down arrows next to the appropriate symbol on the panel. The color of the symbols can be changed by left-clicking on them and selecting a different color in the dialog box and the size can be set in the size edit-box. The map can be redrawn by clicking on 🌠 button. Map symbols can be also colored by dip by checking ☑ color by dip (red is dip close to 90, blue close to 0). Edit box

scale sets the "scale" of the map i.e. how many coordinate units make one pixel. The smallest number is 1, if your coordinate system uses meters as units, one meter is one pixel. The scale controls the size of the bitmap and by that the time it takes to plot the map (due to antialiasing of the data symbols). If the user analyses too big of an area and sets the scale too small, the bitmap can get too big for the allocated RAM to handle causing StaTect to crash. If the user uses basemaps, it is necessary to prepare them in advance with the intentioned scale in mind. StaTect does not resample the bitmaps based on the scale!

The basemaps can be added to the „project" one by one using the button on the Base map panel. It is also important to input the coordinates of the corners, or better said, the minimum and maximum x coordinate and the minimum and maximum y coordinate. If the axes of the coordinate system are not parallel with the geographic ones the user has to rotate the map in a graphic of GIS software. The basemap is plotted only if the check-box ☑ plot base map is checked. The user can load several basemeps, but they have to be the same size, it is not possible to load different coordinates for each map! StaTect plots the map which is selected by left-click in the box with loaded maps. If by mistake a wrong map is added to the list it can be deleted by right-clicking on the map and pressing delete button on the popup menu.

Users can select data directly in the map after checking ☑ select data to make a local analysis. Data can be selected either by a circle or an ellipse

based on the settings on the Calculation panel. The diameter of the circle/ellipse can be set in the edit box under the check-box. StaTect selects data only within the circle/ellipse and puts it into the text field on the Output data tab and also into the text field on the main form. If the user wants to select more data than in a single circle it can be done by right-click checking of the ■ select data check-box. In this case, StaTect adds data into the text fields. To help the user not to select data repeatedly, a green circle/ellipse is drawn on the map (StaTect, however, does not check if any data is selected repeatedly!).

It is also possible to get coordinates of a point in the map (used to digitalize data without coordinates using a basemap) simply by left clicking in the map. The coordinates are added in the text field on the Output data tab.

Epilogue

StaTect is meant to be a simple, but freeware alternative to commercially available applications for structural analysis. As mentioned above, some libraries by doc. Melichar, Masaryk University Brno (Czech Republic, www.ugv.cz) were used to create this application as well as GR 32 – a library package for bitmap graphic (www.graphic32.org) mainly due its swiftness and high quality of the graphics. I apologize for any bugs left, and will try to fix them if you contact me: jura@eltekto.cz.

Hail to structural analysis :-)

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