

# Automated Tools for Layer Recognition (BMPix) and Counting (PEAK)

The tools presented in this read-me file are detailed in the publication:

“Weber, M.E., Reichelt, L., Kuhn, G., Pfeiffer, M., Korff, B., Thurow, J., and Ricken, W. (2010): The BMPix and PEAK tools: New methods for automated laminae recognition and counting – Application to glacial varves from Antarctic marine sediment. *Geochemistry, Geophysics, Geosystems*, 11(1), [doi:10.1029/2009GC002611](https://doi.org/10.1029/2009GC002611)

The original idea for the tools came from the MSc thesis of Lucia Reichelt:

“Entwicklung neuer Methoden zur hochauflösenden Untersuchung von Umweltvariationen an spätquartären Sedimenten aus dem Weddellmeer, Antarktis. Unpublished diploma thesis, University of Cologne, 123 pp., 2007)”

Björn Korff wrote the original VB source code in 2007 (version 1). Atiullah Faridi updated the software to version 1.5 in 2010. Michael Molz applied further changes for the release of version 2 in 2012.

The software update to version 2 is as of February 2012. It is free of charge and the community is welcome to use it. Although the measuring principal remains the same as in version 1, some of the potential bottlenecks have been omitted, the various parts have been streamlined and simplified, and new and helpful analysis tools are implemented.

Please check the website for the latest updates at: <http://doi.pangaea.de/10.1594/PANGAEA.729700>

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## (1) System Requirements

The tools consist of a set of macros written in Visual Basic. They can only be used in conjunction with Microsoft Excel. Thorough and reliable tests have been performed for Excel 2007 (version 12) through 2010 (version 14) in a Windows 7 environment. Macintosh functionality is currently not given for Version 2 but is desired for an upcoming version. The vertical screen resolution has to be at least 768 pixel. For optimal usage a screen resolution of 1080 pixel and more is advised.

## (2) Introduction

Weber et al. (2010) introduced a software package that combines laminae recognition and counting. It consists of a number of Visual Basic macros – the Macro Toolbox – that are executed from within Microsoft Excel (Figure 1). The BMPix tool extracts color and gray-scale data from BMP images at pixel resolution. The PEAK tool uses the gray-scale curve (or any other data input curve) and performs, for the first time, fully automated counting of laminae.



**Figure 1.** The Macro Toolbox displayed under “Add-Ins” in Microsoft Excel. Toolbox contains all Visual Basic macros that are used by BMPix and PEAK, as well as additional analysis tools (details see text).

Various algorithms allow for the counting of minima, maxima, halfway passages, and positive and negative transitions in the gray-scale (or color) curve. For varves consisting of laminae couplets, this translates into winter maximum count, summer maximum count, seasonal count, and begin and end of seasonal count, respectively. Additional analysis tools help the user to handle the resulting data and to conduct further paleoclimate-related analysis. The software has originally been designed to work with marine and lacustrine varves. However, tests on additional archives such as tree rings and ice cores indicate that the macros can handle virtually any kind of laminated sequence. The only condition is that the image used for the analysis displays the lamination adequately. All aspects of the software, as well as several examples, are detailed in Weber et al. (2010).

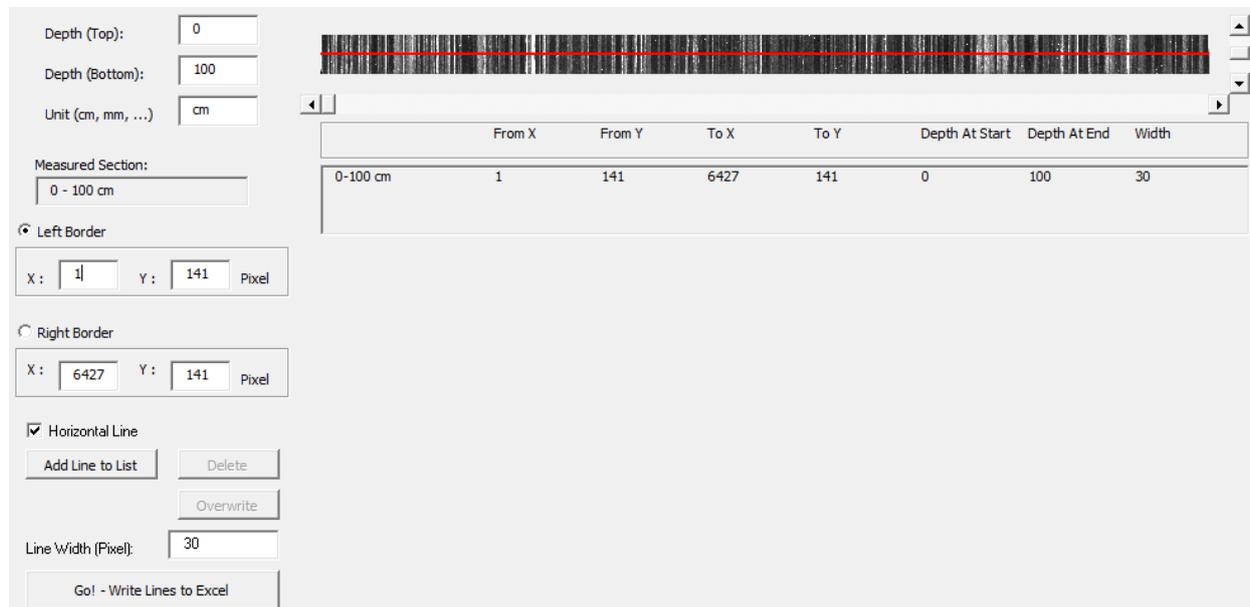
## (3) The BMPix Tool

**General purpose.** The BMPix macro linearly extracts red, green, blue (R/G/B), and gray values at pixel resolution along a profile line between freely adjustable start and end points from any given image that is stored in the BMP file format. This means that color and gray values can be generated along a profile line from surface images (e.g., photos, line-scan images) and from transmitted light images (e.g., x-radiographs, thin sections). Note that

whenever the term “core” is used in the description, it applies to a sediment site (ocean or lake core) since most of the measurements have been carried out on this type of climate archive. However, the same is true if you apply the method to different archives, e. g., ice cores, tree rings, and corals, which have also been tested successfully.

### (3|1) Step-by-step standard use instruction

Double-clicking the “BMPix\_Peak\_Tool\_V2\_2012.xlsm” icon will launch MS Excel. Now you have to allow the Macros to run, which is accomplished by clicking the “Enable Content” button next to the yellow security warning. After that, you’ll find the Macro Tool Box in the new “Add-Ins”-Tab of Excel. It should look like Figure 1. Clicking the “BMPix” macro will open a new explorer window. Browse to the folder containing the image you intend to process and double-click it. Note that, along the process, a number of files will automatically be written to this destination, all of which will rely on the name of the image, followed by an underscore (\_). Now the image will load and the BMPix window (Figure 2) will be displayed with default values. This window will occupy the entire width of the worksheet. We recommend using large, high-resolution monitors to obtain best visual control. The top right section of the window contains the image. On the left side there are a couple of settings that should be adjusted. The measurements are pixel-based. The image in Figure 2 is 282 pixels high and 6427 pixels wide. In order to convert pixel into depth, the user must set initial depth and terminal depth as integer numbers, as well as depth unit (mm, cm, etc.). The box “Measured Section” underneath is generated automatically from the settings defined above. In Figure 2 it is 0 – 100 cm.



**Figure 2.** The BMPix window. Left shows various settings that are adjusted during the analysis. Top shows ice-core image (courtesy of S. Rasmussen) with red lines indicating width over which gray-scale line is generated.

Further down on the left side, the user has to adjust the left and right point of the analysis (i. e., the begin and end of the profile line) either by typing in numerical pixel values or by using the mouse and slider underneath the image. Figure 2 shows that the measurement starts at the first pixel (1) and ends at the last pixel (6427). We recommend to cut the images exactly as they should be used, so the default begin and end values can be used. Clicking “Left Point” or “Right Point” will activate either the left or right side of the slider underneath the image.

Another variable is the “Line Width (Pixel)” over which the measurement is integrated perpendicular to the profile. In Figure 2 it is set to 30 pixels, i. e., centered at pixel 141, between pixels 156 and 126. These upper and lower limits are displayed as the two red lines. Once all settings are adjusted, the user should click “Add Line to List” and all relevant information of the profile lines will be displayed in the list underneath the image. The list allows for multiple entries, so you can perform multiple measurements on a single image. For instance, you can overlap sections, segment the profile into several parts, or add lines from consecutive sections (from images containing more than one core section) in order to achieve a complete profile. This list will be saved as „picture\_name.bmp.liste“ in the folder the image originated from, as will all other files resulting from the analysis. The lines of the list can also be deleted (click “Delete”) or overwritten (click “Overwrite”). When all values appear correct, the user should click “Go! – Write Lines to Excel”.

Now Microsoft Excel extracts one gray-scale (and one RGB) value for every pixel along the profile line (or along multiple profile lines) by averaging 30 pixels perpendicular to the profile line over a total length of 6427 pixel. The data will automatically be written to a separate Excel Workbook in the same folder where the bitmap images are stored. Each spreadsheet contains 6427 data points for X and Y coordinates, the depth that has been linearly interpolated along the profile line between the top and the bottom, extracted gray and R/G/B values, as well as normalized gray values. The format for R/G/B was chosen to allow for direct color or gray-scale visualization in the PANGAEA software PanPlot. The “normalized gray value” will then be used by the various counting macros of the PEAK tool. In addition, the image that was used for the analysis is now displayed in high-resolution as background of a graph (Figure 3), containing the profile line (in red) and the gray-scale curve (in blue). Visual inspection of the curve should be used as quality control, i. e., does the extracted gray-scale curve capture the gray-scale variability of the image adequately?

We recommend leaving all resulting files in the folder where the original image is stored. In case the analysis needs to be modified or redone, all required information is loaded again.

### **(3|2) Trouble shooting**

Although problems may vary depending on the Microsoft Excel version and operation system used, there are a few tips we can provide:

If the input mask or the BMP image is not entirely displayed, try increasing the screen resolution.

If only gray values are extracted, the image is only 8 bit instead of 24 bit. Try converting into 24 bit if desired.

If you experience a runtime error while opening the bmp image, delete the .list file and try again.

If Excel does not open macros you have to change the security setting under Tools/Makro/Security to medium or low, and allow for macros when asked in an opening dialogue (Office 2000-03). Or open Office Button/Word Options/Trust Center/Trust Center Settings/Macro Settings or Add-Ins for allowing and enabling of macros (Office 2007).

## (4) The PEAK Tool

**General purpose.** The PEAK macro is designed to provide automated counts of the overall amount of layers present in an archive, based on the variability documented in gray-scale (or color) curves. In principal, any kind of high-resolution data set that mimics lamination, can be used for PEAK. This also means that the BMPix tool does not necessarily have to be implemented first. However, since the work flow relies on the comparison of image and data set, we recommend to use BMPix first.

### (4|1) Step-by-step instruction

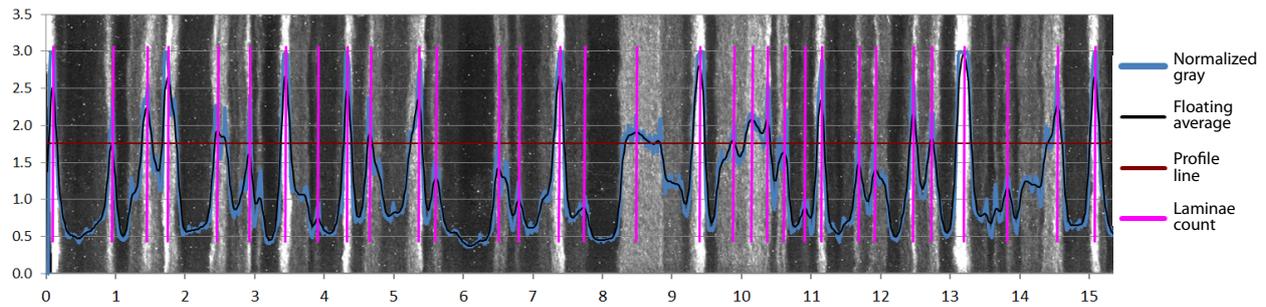
**Measurements on a single core section.** By clicking “Maxima/Minima”, “Count Zero Crossings”, or “Transitions” in the Macro Toolbox (Figure 1) a menu will open and the user has to adjust three parameters:

- “Smoothing Area (Pixel)” – to create a smoothing average (to be precise, the full width half maximum (FWHM) of the Gaussian smoothing)
- “Minimum Width (Pixel)” – defines the minimum thickness of a layer that will be regarded as a lamina
- “Minimum Height” – defines the minimum height of a layer that will be regarded as a lamina.

“Count Maxima” (Figure 1) will count every positive (bright) peak in a curve. “Count Minima” will count every negative (dark) peak in a curve. “Count Zero Crossings” will count every halfway passages of a peak, i. e., it will count the crossing point of the floating average and the gray-scale curve, which is why the default setting for “Smoothing Area (Pixel)” has higher numbers and will therefore produce a much wider floating average. “Count Zero Crossings” will divide the curve into dark and bright units, which translate into seasons in case of a varve. “Counting Transitions” will either count all transitions into bright intervals (“Count Upcrossings”) or into dark intervals (“Count Downcrossings”).

Once the settings – in the case used here for “Count Maxima” – are typed in (or chosen from the default values, which might always be a good start) you should click “Go!”. The PEAK tool will now calculate the amount and occurrence of all laminae that meet the defined settings (in this case the maximum gray scale, i. e., the brightest peak) and add three data columns to the Excel Spreadsheet. The right part of the spreadsheet displays a number of important and helpful statistical parameters such as the “Number Of Layers” counted and how many layers were either “Too Narrow” or “Too Flat” to count as a layer, as well as the “Average Thickness of Layers”.

More importantly, the Excel Spreadsheet displays a graph that contains all relevant results (Figure 3): the underlain core image at high resolution, the normalized gray value (light blue), the floating (FWHM) average (dark blue), the center position of the profile line (dark red), and the position of every layer that was detected with the given settings (pink vertical lines).



**Figure 3.** The PEAK result window (displayed for the “Maximum Count Algorithm”). Underlain image shows upper 15 cm of ice-core image of Figure 1 (courtesy of S. Rasmussen). Light blue curve gives normalized gray value; dark blue curve shows floating average calculated from gray value; dark red line indicates center position of profile line; pink vertical bar indicates position of laminae detected under given settings (details see text).

In case the counting result is not satisfying, you should run “Count Maxima” again and re-adjust the settings accordingly. This way optimization of the setting can be achieved quickly and conveniently because each iteration step will immediately visualize the counting results and display all relevant data. The same routine should be followed if you wish to “Count Minima”, “Count Zero”, or “Count Transitions”.

**Measurements on multiple core sections.** Usually, layer counting includes more than just one core section. Therefore, we have established a workflow that allows for working on multiple core sections. The first step, however, – running the BMPix analysis – will have to be done on every core section individually. All “\_BMPix.xlsx” files of a core resulting from this first step, should then be uploading into Excel. By clicking the macro “Collect Workbooks” (Figure 1), all uploaded core sections will be copied into a single workbook and sorted according to core depth. The user can now define the settings and apply them to all sections of a core by clicking on of the macros “Count Maxima/Minima All Sheets”, “Count Zero Crossings All Sheets”, or “Count Transitions All Sheets” from the Macro Toolbox (Figure 1). This operation may take some processing time and at its end, the total layer count over all individual sections is displayed. Depending on which methods will be used, additional files will be stored automatically in the same destination as the original image file (e. g., “\_MaxCount.xlsx”, “\_MinCount.xlsx”, “\_ZeroCount.xlsx”, “\_UpCount.xlsx”, “\_DownCount.xlsx”).

## (4|2) Trouble shooting

Although problems may vary depending on the Microsoft Excel version and operation system that are used, there are a few hints we can provide:

To change the default thicknesses of the lines displayed in the graph, open the Visual Basic Editor, go to the “PublicModule”, and change the individual “.Format.Line.Weight” to your desired value.

If Excel does not open macros you have to change the security setting under Tools/Makro/Security to medium or low, to allow for macros in the opening dialogue (Office 2000-03), or open Office Button/Word Options/Trust Center/Trust Center Settings/Macro Settings or Add-Ins for allowing and enabling macros (Office 2007).

## (5) Post processing

At this stage, the counting is accomplished and all results are stored in individual Excel Spreadsheets (if there was more than one image analysis) of a single Excel Workbook file. In order to ease successive data processing, we have implemented a number of additional tools (see Macro Toolbox in Figure 1) .Two smaller macros can also be used during the analysis.

**“Total Layer Count In Active Workbook”** will display the amount of laminae counted over all individual sections (all Excel Spreadsheets of a Workbook) independently from executing one of the counting macros.

**“Replot Diagram”** will reposition the graph to its default position and will also apply default settings for all graphical elements. This macro should also be used if the plot is not displayed at all.

Depending on the resolution of the images, and the length of the core, there may be thousands to millions of data points gathered for gray-scale, and hundreds to thousands for counted laminae. This is where another couple of post processing macros come into play, which are accessible through **“Extraction Tools”**.

- **“Extract Columns From Active Sheet”** lets the user define which columns should be exported for further analysis. Executing this macro will extract all marked columns from the active Excel Spreadsheet only. There is an additional option to **“Create .txt File”** that allows for direct compatibility with other paleoclimate-related analysis tools such as **“PanPlot”** and **“Analyseries”**.

- **“Extract Columns From All Sheets”** will extract all marked columns from all Spreadsheets of the Excel Workbook and combine them into a single file. This is specifically helpful if the measurements were distributed over a number of individual images (Excel Spreadsheets) and you intend to plot the composite gray-scale curve or you wish to list all laminae in a single file consecutively for further analysis.

- **“Condense Data”** will open the window **“Columns To Condense”**, where you can define a **“Reduction Factor”** for the data. This is specifically helpful when the original data files contain huge amounts of data points that need to be condensed prior to further processing.

- **“Depth Adjustment”** will merge two or more files and sort the data according to depth.

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