AnalySeries User's Guide

Version 2.0.5.2

A time-series analysis software

Available at:
https://github.com/PaleoIPSL/Original-AnalySeries
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1 Introduction to AnalySeries

Welcome to AnalySeries!

AnalySeries is a powerful program designed to assist you in analyzing and visualizing various types of paleoclimatic data, such as analyses on marine sediment and ice cores, but also to calculate parameters such as insolation, obliquity, eccentricity, and precession. Thanks to its user-friendly interface, it makes it easy to correlate different paleoclimatic data and archives, and to make different types of mathematical processing for better interpretations and visualization of your data. Whether you are a professor, a researcher, an analyst, or a student, AnalySeries will provide you with the tools you need to explore and interpret your data effectively.

We encourage the users of AnalySeries to cite the original work of Paillard et al. (1996), as well as each of the respective authors of models and data used by AnalySeries, which can be found in the references of the program or in the references section of this Users' Guide.

This user guide was developed based on the 2.0.5.2 version of AnalySeries, written on C++ for a 32-bit Mac Operation System, but at the end of this guide (chapter 11) other versions are briefly explained too, including a cross-platform version written on Java.

2 Getting Started

2.1 Operating System Requirements

This version of AnalySeries requires a 32-bit macOS prior to Catalina (MacOS 10.15), although the LSCE is currently working on a new Python version, which will be supported on any operational system.

2.2 Installation

1. Download AnalySeries from the official GitHub repository of LSCE at https://github.com/PaleoIPSL/Original-AnalySeries
2. Once unzipped, you can directly run AnalySeries, there is no need to install it.
3. We encourage you to carefully read the **About AnalySeries** section (Figure 2.1), particularly the **Read Me** (Figure 2.2, left panel) and **License** (Figure 2.2, right panel) documentations, and to properly acknowledge and reference AnalySeries, as well as the original references for the datasets and methods used by the AnalySeries' functionalities.

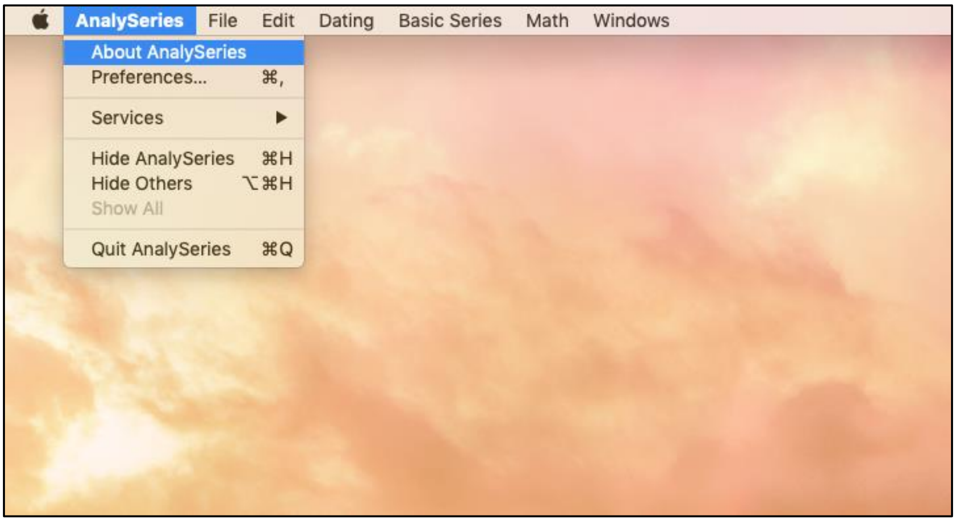

*Figure 2.1: Once downloaded and opened, you can see the Toolbar with the different menus of AnalySeries: **AnalySeries**, **File**, **Edit**, **Dating**, **Basic Series**, **Math** and **Windows**. In the first one, you can open About AnalySeries, where you will find the Read Me and the License (in English and in French), as well as the references and the changes with respect to precedent versions, as illustrated in Figure 2.2.*

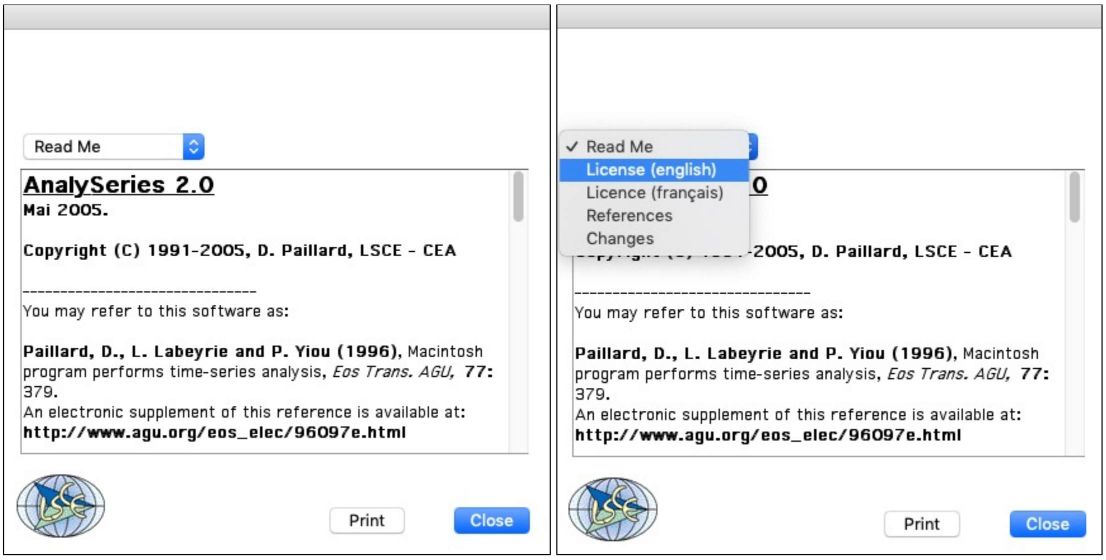

Figure 2.2: Illustration of the About AnalySeries section of the ***AnalySeries*** *menu. The left panel shows the Read Me documentation, while the right panel illustrates the dropdown menu including the License documentation, both in English and in French, as well as the References used for the different functionalities of AnalySeries and the Changes compared to precedent versions.*

3 User Interface Overview

Upon launching AnalySeries, you'll be greeted with a user-friendly interface (Figure 2.1) consisting of various components. There is a main Toolbar with different menus, each one with a series of functions that are indicated here, but further detailed later in the text:

- The **AnalySeries** menu contains the basic documentation, as explained in Installation (chapter 2.2), as well as Preferences, which opens a small dialog window to select the decimal delimiter (point or comma; Figure 3.1), and other functions (Services, Hide AnalySeries, Hide Others, Show All, and Quit AnalySeries; Figure 2.1) related to the interphase.

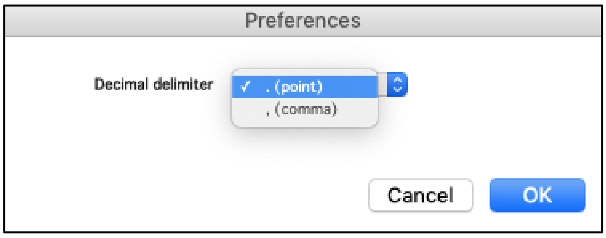

Figure 3.1: Decimal delimiter preferences.

- **File** allows the management of files, worksheets, and data.

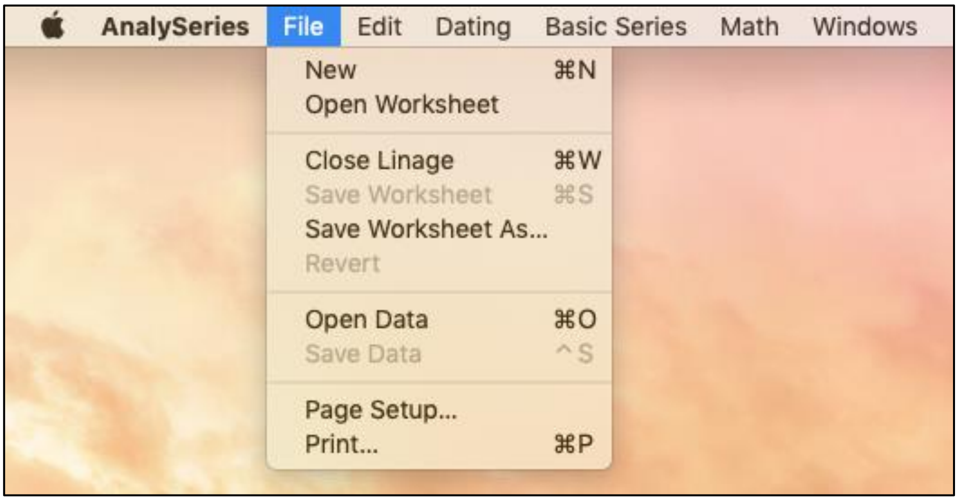

*Figure 3.2: Illustration of the **File** menu and its functions.*

- The **Edit** menu opens a series of functions related to the processing of data (Figure 3.3). Of particular interest are the functions **Draw** and **Info**, which will allow the graphical display of data and its basic information, respectively.

*Figure 3.3: Illustration of the **Edit** menu and its functions.*

- **Dating** offers a series of functions to process data (Figure 3.4), including **Linage** and **Splinage**, which are key functions for the processing of paleoclimatic archives.

*Figure 3.4: Illustration of the **Dating** menu and its functions.*

- The **Basic Series** menu offers several functions to model insolation and orbital parameters, and to generate noise signals and different models of global ice volume (Figure 3.5).

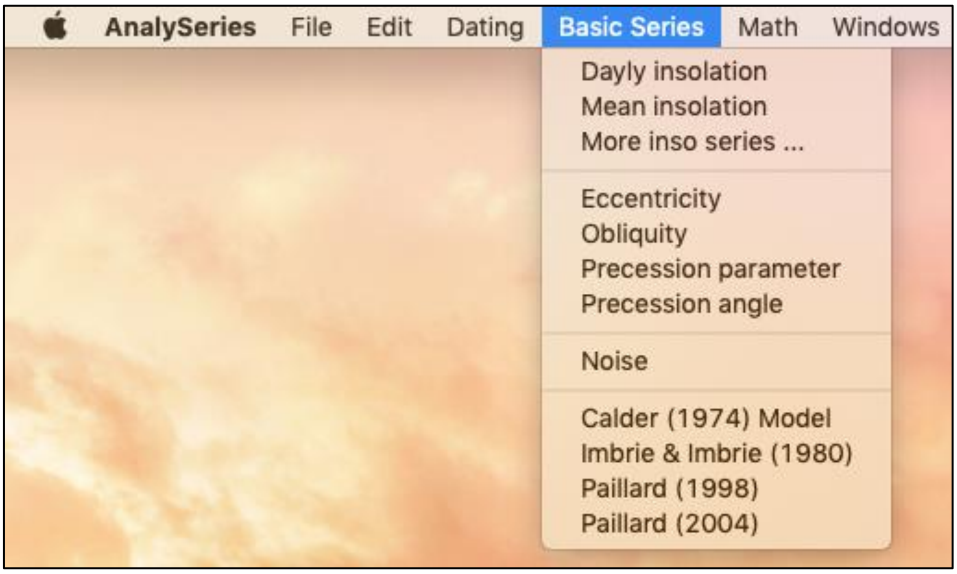

*Figure 3.5: Illustration of the **Basic Series** menu and its functions.*

- **Math** offers a series of mathematical functions to process and analyze datasets (Figure 3.6).

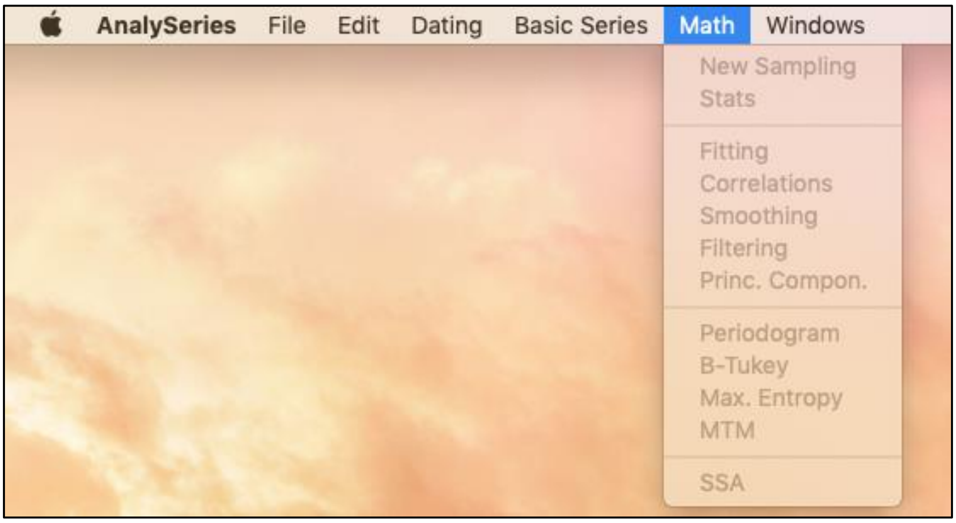

*Figure 3.6: Illustration of the **Math** menu and its functions.*

- Lastly, the **Windows** menu allows to generate new folders (called groups) in a worksheet, open the Clipboard, and navigate between AnalySeries worksheets and windows (Figure 3.7).

*Figure 3.7: Illustration of the **Windows** menu and its functions.*

At this stage, there are several unavailable functions because no worksheets nor data are being used. In the next chapters, each function of AnalySeries will be explained in detail.

4 File menu

4.1 New Worksheet and Open Worksheet

To start working on AnalySeries, a new worksheet must be created by opening the **File** menu, and then clicking (left mouse click) on **New**, or by pressing **Command N**, as illustrated in Figure 4.1.

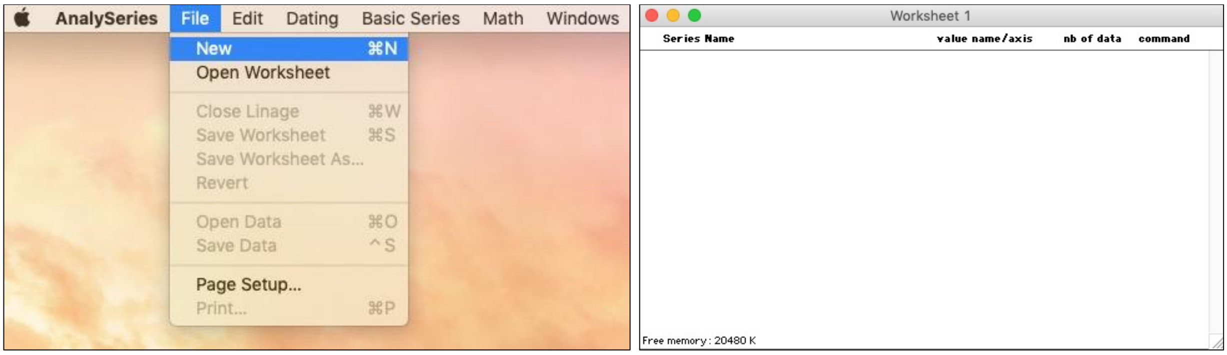

Figure 4.1: Illustration of how to create a new worksheet on AnalySeries (left panel) and the new window created.

Alternatively, an already existing worksheet can be opened by clicking on the option **Open Worksheet**, just under the **New** option. As the new worksheet has been just created, it does not have any content yet, but it is seen that there are already several new options available on the **File** menu (Figure 4.2).

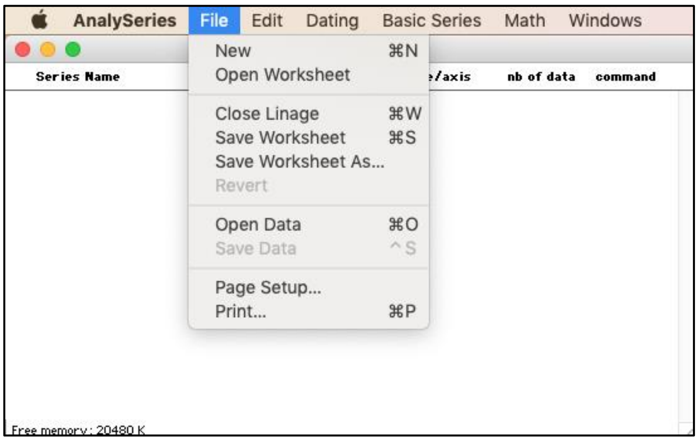

Figure 4.2: Illustration of the new options available once the new worksheet has been created.

4.2 Close Linage and Saving Worksheets

If there is a Linage opened (see chapter 6.1), the option **Close Linage** (Figure 4.2) will close the Linage window, but if there is only a worksheet opened, it will close the worksheet window. As the worksheet has not been saved yet, an alert window will be opened offering the options Save, Don't Save and Cancel (Figure 4.3). The same window will pop up if there are changes that have not been saved before closing the worksheet.

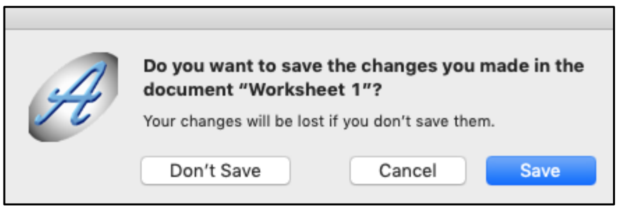

Figure 4.3: Alert window opened if a worksheet is closed without saving the last changes.

The new worksheet can be saved by clicking on the **Save Worksheet** or on the **Save Worksheet As…** buttons, which will open a new window that will allow the user to save the new worksheet with the name, tags, and location wanted (Figure 4.4). Once the worksheet has been saved, the **Save Worksheet** button will be unavailable until new changes are introduced to the worksheet. On the other hand, the **Save Worksheet As…** button will be always available, allowing the user to save the worksheet in a different location, or with a different name and tags.

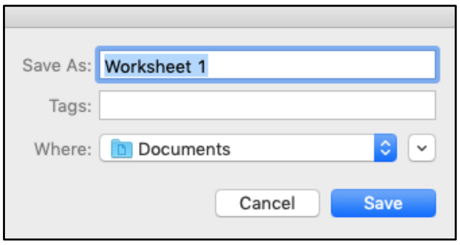

Figure 4.4: Saving dialog window.

For the moment, the **Revert** function has no use.

4.3 Open and Save Data

AnalySeries opens data from texts with columns separated by <u>tabs</u>. The space, comma and semi-colon are not recognized as column separators. It is expected that future versions will be able to directly open Excel files.

For the next examples, we will use data from marine sediment cores. Specifically, we will use the $\delta^{18}O$ from the LR04 stack (Lisiecki and Raymo, 2005) as reference and data from ODP 849 (Mix et al., 1995) and MD00-2374 (Duplessy et al., 2007) marine cores as time series to be processed. To open the data, click **File > Open Data** (Figure 4.5), or press **Command O**, which will open a window to navigate and choose the data file (Figure 4.6).

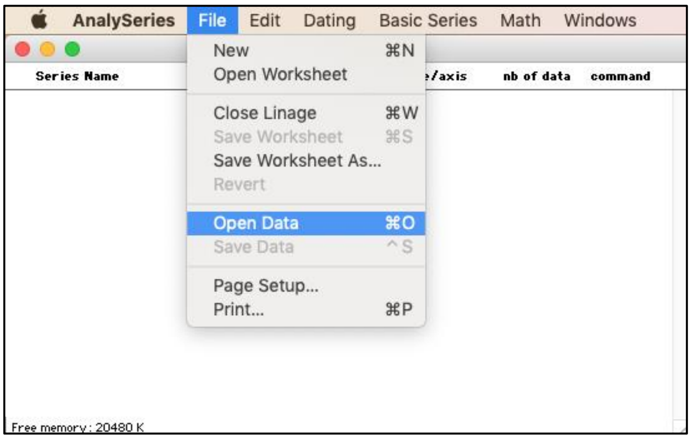

Figure 4.5: Illustration of how to open data.

Once the data have been opened and only if there are no problems with the file, a new dialog window will pop up. In the new window are shown the titles of each column, which will allow the user to select the data to be opened. The unselected columns (time and depth in the example of Figure 4.6) will correspond to the X-axis, and the chosen columns ($\delta^{18}O$, standard error, $\delta^{13}C$ in Figure 4.6) will be in the Y-axis. Note that at the right of the Y-axis, the respective X-axis will be indicated (Figure 4.6), which can be changed by overwriting the number of the column wanted to be the X-axis.

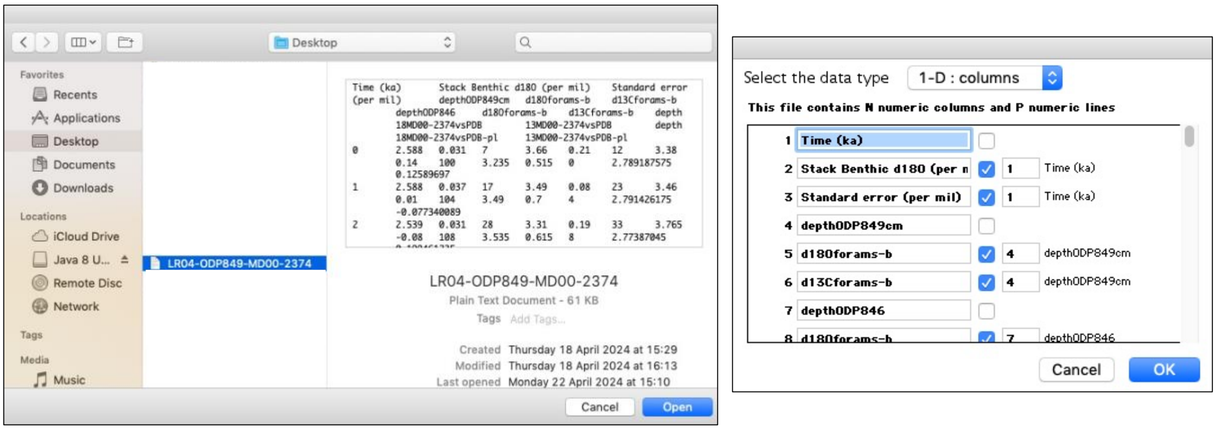

Figure 4.6: Selecting and opening a data file (left panel) and pop-up window after opening the data file (right panel).

Alternatively, it is possible to directly copy the text (**Command C**) and paste it (**Command V**) on the worksheet, which will open the same dialog window. If there is a problem with the data file, an alert message will automatically appear, showing the reason of the problem found while trying to open the data file. For example, Figure 4.7 shows a message indicating that the first column of Y-axis has no data in the first few cells, and the input data file needs to be corrected.

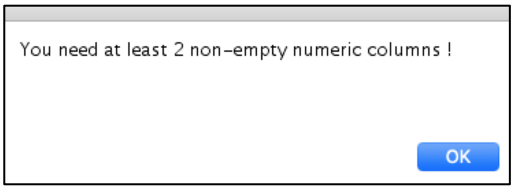

Figure 4.7: Example of an alert message when opening an inadequate data file.

As we introduced changes to the worksheet by adding new data, the **Save Worksheet** option will be available once again (Figure 4.8). Note that the **Revert** button is also available now because we have introduced changes to the already saved worksheet, so now it will offer the possibility of going back to the last saved version of the worksheet.

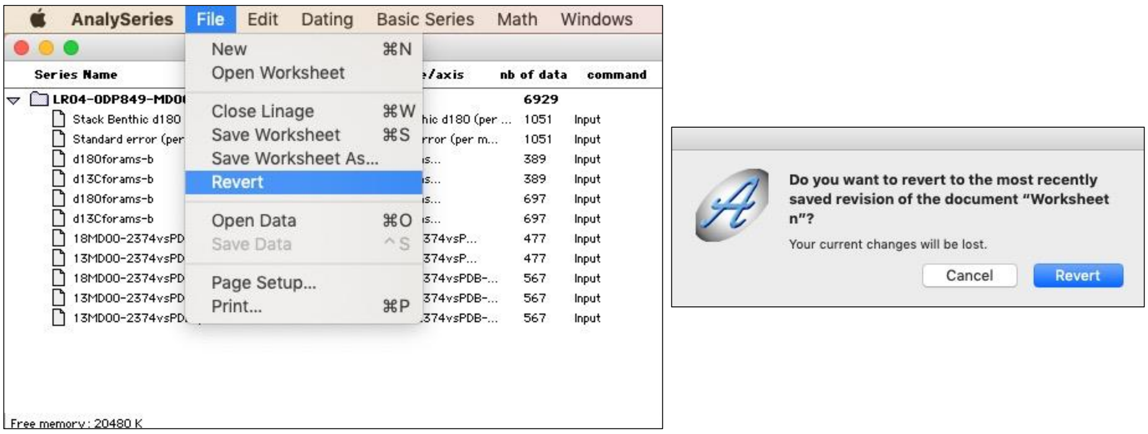

*Figure 4.8: New options available in the **File** menu after having opened the data file (left panel) and pop-up window opened when pressing the **Revert** button (right panel).*

As long as the data remains unchanged, the **Save Data** button will be unavailable. Once there are changes introduced to the data ("+++" was added to the file name, Figure 4.9), it will be possible to save the data by clicking **File > Save Data** or by pressing **^ S** (Figure 4.9).

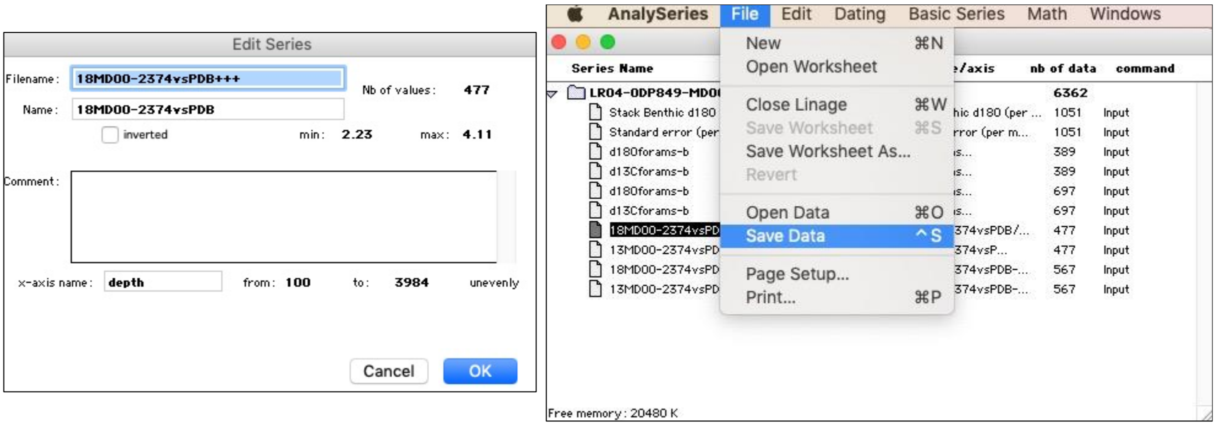

*Figure 4.9: Example of changes introduced to the data (left panel), which enables the use of the **Save Data** option (right panel).*

This will open a dialog window to select the data file name, tags, and location of the data, which will be saved as a text file with columns separated by tabs.

4.4 Opening series with replicates

A useful function of AnalySeries is the possibility to handle series with replicates, i.e., series that have more than one value for the same age or depth. To illustrate this, Figure 4.10 shows a series with replicates of $\delta^{18}O$ for depths of 112.5, 115, 117.5, and 122.5 cm.

	A	B	C
1	depth (cm)	corrected d18O	
37	107.5	4.24648290634155	
38	110.00	4.33362847328186	
39	112.5	4.45088225364685	
40	112.5	3.74879998207092	
41	115.00	4.22130568504334	
42	115.00	4.49148935317993	
43	117.5	4.92203956604004	
44	117.5	3.95486492156982	
45	122.5	4.67720752716064	
46	122.5	4.83645505905151	

Figure 4.10: Illustration of a series with some duplicated $\delta^{18}O$ values over depth after Govin et al. (2014).

As illustrated in Figure 4.11, the series with replicates are distinguished in the worksheet with a different icon (two sheets instead of one).

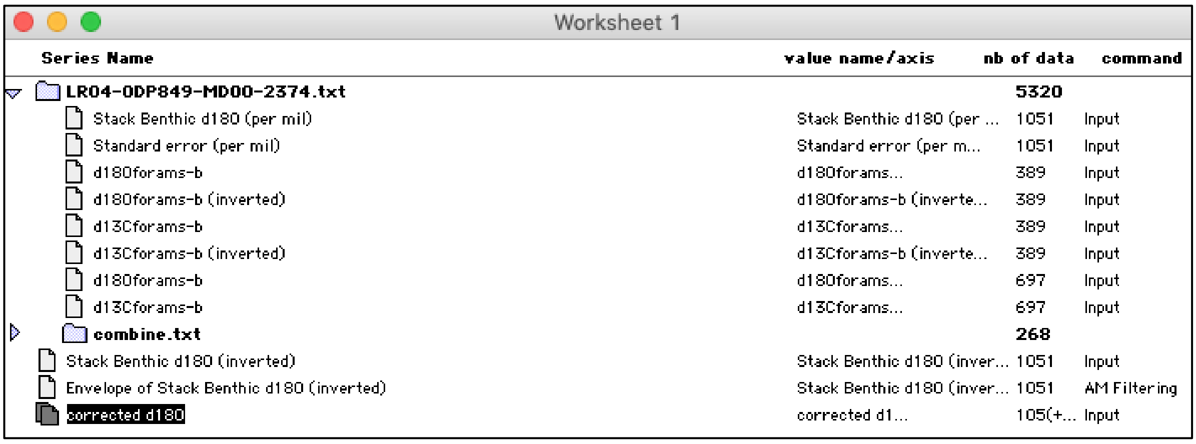

Figure 4.11: Illustration of a worksheet including a series with $\delta^{18}O$ replicates for the same depth ("corrected d18O", selected in the worksheet), as illustrated in Figure 4.10.

When opening a series with replicates, AnalySeries automatically detects the depths or ages with more than one value and generates a new pair of columns with an averaged value for the Y-axis value at the replicated depth/age, while preserving the original dataset. When saving this series, the new dataset will have the double of columns, the averaged pair and the original pair with replicates (Figure 4.12).

2	depth (cm)	corrected d18O	depth (cm)	corrected d18O
35	102.5	3.948010979	100	4.160575924
36	105	3.860017595	102.5	3.948010979
37	107.5	4.246482906	105	3.860017595
38	110	4.333628473	107.5	4.246482906
39	112.5	4.099841118	110	4.333628473
40	115	4.356397519	112.5	4.450882254
41	117.5	4.438452244	112.5	3.748799982
42	122.5	4.756831293	115	4.221305685

Figure 4.12: Illustration of the new series saved with replicates and averaged values. It can be seen that a new pair of columns has been generated with averaged δ^{18}O (two left columns) while preserving the original pair of data (two right columns).

This series can be treated as any other series, and every function will be applied for both the averaged and the original data sets in the same way as for single-value series.

4.5 Page Setup and Print

Those two options will allow the user to select the printing setup of the page and to print it, respectively, but also to save the active window, which will be particularly useful for saving different images as PDF files, which can be further edited in a variety of programs for processing vectorized images.

5 Edit menu

5.1 Basic Edit tools: Copy, Cut, Paste, Undo

If there are no datasets selected, most of the functionalities will be unavailable (Figure 5.1, left panel), but once a dataset has been selected by clicking on it with the left mouse button, most of the functionalities will be enabled (Figure 5.1, right panel).

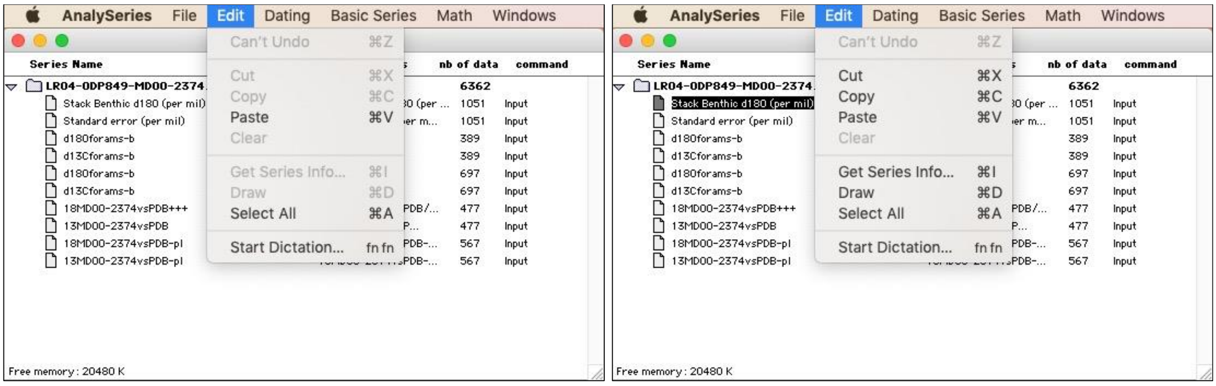

*Figure 5.1: **Edit** menu with (right panel) and without (left panel) having selected a dataset.*

As might be expected, the **Cut** (**Command X**), **Copy** (**Command C**), and **Paste** (**Command V**) buttons will allow the user to cut, copy, and paste the selected dataset(s). Additionally, a data set can be erased by pressing the **backspace** key. Once a dataset has been deleted, cut, or pasted, the **Undo** (**Command Z**) button will be enabled, which allows to undo (revert) the last made action.

5.2 Plotting time series

By pressing the **Get Series Info…** button, **double-clicking** a dataset, or pressing the **Command I** keys, a pop-up window will show the basic information of the series, but it will also allow changing the dataset and the X-axis names, to invert the values of the Y-axis in a plot, and will enable the **Clear** button, which will simply erase the selected text (Figure 5.2).

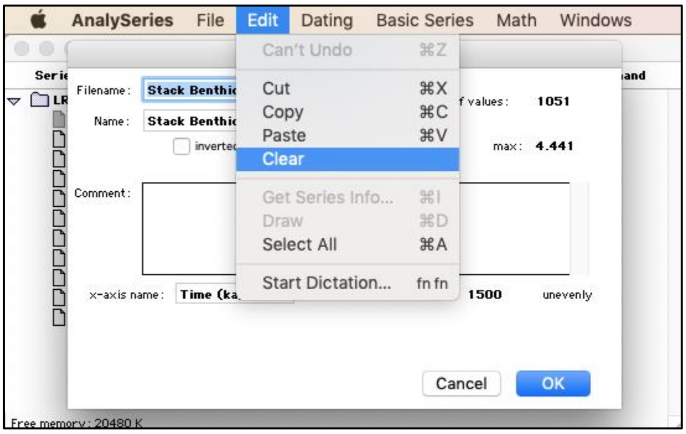

*Figure 5.2: By opening the information of a dataset, a new window with the series information will be opened and the **Clear** button will be activated.*

A series can be plotted by selecting a dataset and clicking **Edit > Draw** or pressing the **Command D** keys (Figure 5.3). As an example, the $\delta^{18}O$ of the reference dataset was plotted with the Y-axis right and inverted (as explained in the previous paragraph) in the upper and lower right panels of Figure 5.3, respectively.

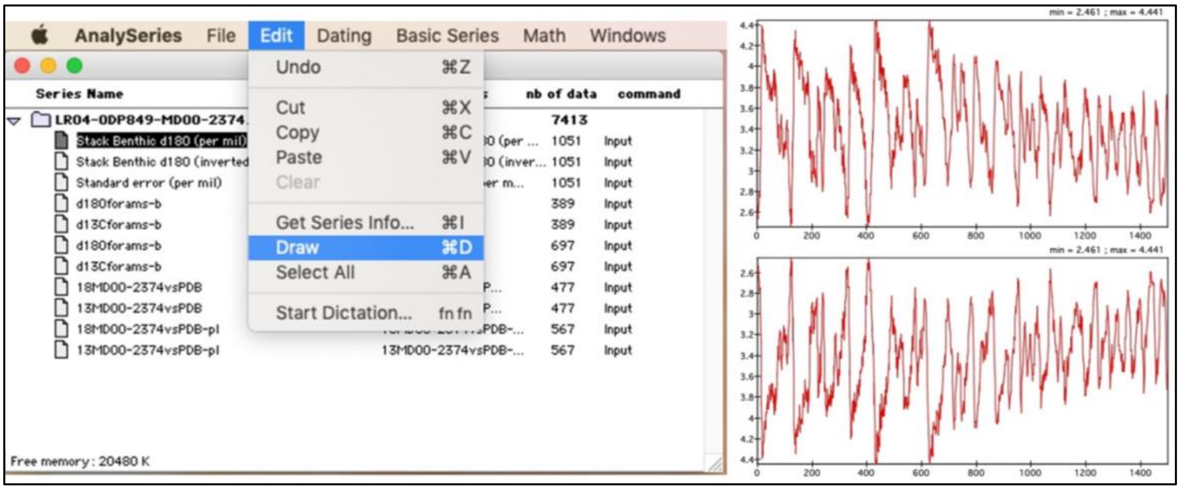

*Figure 5.3: Illustration of how to **Draw** (plot) a dataset (left panel) and the resulting graph (right panels). Two datasets were graphed, both correspond to the $\delta^{18}O$ vs time (ka) of the LR04 Stack (Lisiecki and Raymo, 2005), but the Y-axis of the right-lower graphic has been inverted.*

Several series can be drawn at the same time (Figure 5.4) by selecting all the series that the user wants to plot and using the **Draw** button as previously explained. For the sake of good graphical quality, it is important to draw series with data in the same magnitude order, at least while using the same scale for the axes (see next paragraph).

The window where the data is plotted counts with a series of functions and menus indicated with numbers in Figure 5.4: (1) allows the modification of the scale of the Y (left) and X (right) axes; (2) allows to select between having no scale, having one single scale for all the series drawn, or to have multiple scales, which will generate one scale for each of the series plotted; and (3) allows to see and select the color of the series.

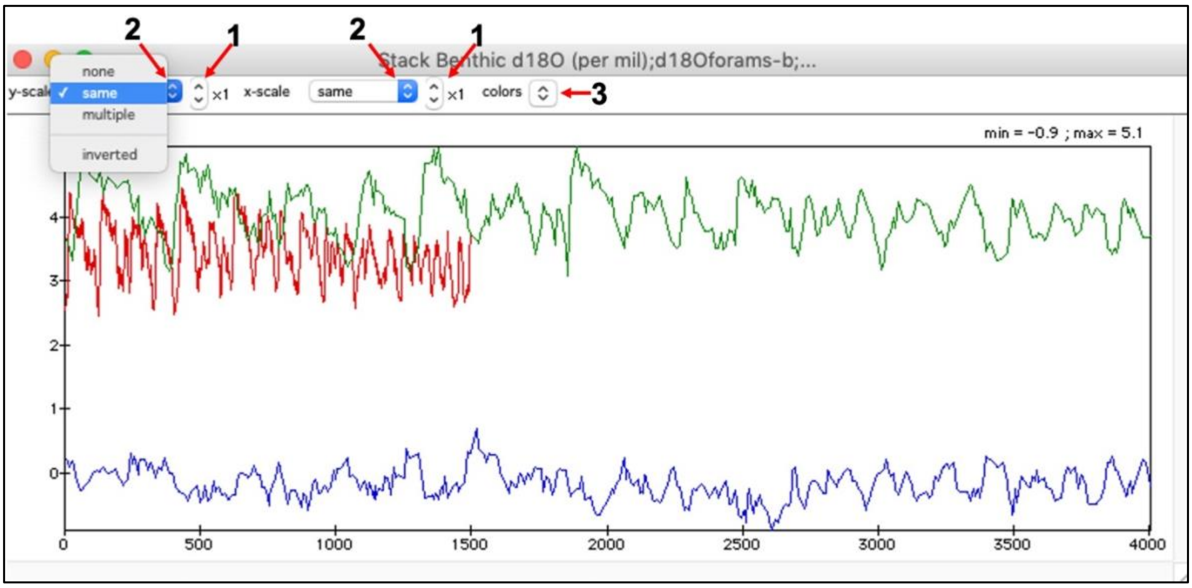

*Figure 5.4: **Draw** of multiple series on a single window. The numbers 1 to 3 show the different options to modify the axes scale and the drawing colors (see main text for details).*

Finally, the **Select All** (**Command A**) button will select all the data in the worksheet, and the **Start Dictation…** (**fn fn**)*[1] button will open a window to start the dictation.

*[1]*At the time of the writing of this guide, the author was not able to use the **Start Dictation…** function.*

6 Dating menu

The **Dating** menu contains some of the central and unique functions of AnalySeries that makes of it such a useful tool, allowing the user to correlate paleoclimatic archives, generate and use age scales, and estimate sedimentation rates. For simplicity, we will first present the **Linage** and **Splinage** functions.

6.1 Linage and Splinage

The functions **Linage** and **Splinage** allow for the definition of an age (or depth) model on a series with unknown age, based on the alignment to a reference series with a well-established age model. The main difference between those two functions is that the first one will generate a linear correlation between the two series (i.e., constant sedimentation rate values between tie-points), and the latter will correlate the series through a cubic spline (the difference is shown later in this text, but the impatient can compare Figure 6.5 and Figure 6.7).

To start a **Linage**, at least two series have to be selected: a reference (reference in right Figure 6.1) and a series to be correlated to the reference (distorted in right Figure 6.1). Then, to start the **Linage,** click on **Dating > Linage** or press **Command L** (Figure 6.1). To start a **Splinage** there are no keyboard shortcuts, so the only way is to click **Dating > Splinage**. More than one series can be selected and correlated to a single reference (or correlate different data from a single core with the reference series), but they must have the same depth/time scale. Alternatively, if there is an already existing file containing a set of tie-points (e.g., ^{14}C ages along a depth profile or a previously created correlation), they can be selected instead of the reference series (pointer in Figure 6.1).

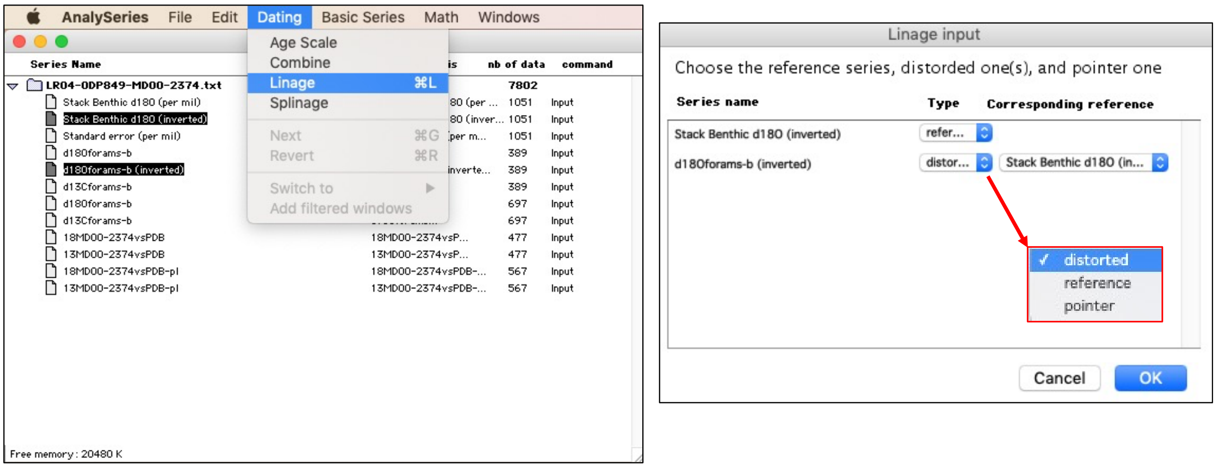

*Figure 6.1: Illustration of the **Linage** and **Splinage** functions, with two series selected: δ^{18}O of the LR04 Stack as the reference, and δ^{18}O from ODP849 (Mix et al., 1995) as the distorted dataset. The left panel shows how to use the **Linage** function, and the right panel the dialog window to select the reference (or pointers) and the distorted series and its corresponding reference.*

After clicking **OK**, a correlation window and three empty windows will be opened: Sedimentation rate, Age scale, and Correlation window (Figure 6.2). The latter is not visible, as it is covered by other windows, but it can be unhide using the **Windows** menu (Figure 6.2), or by hiding the other windows.

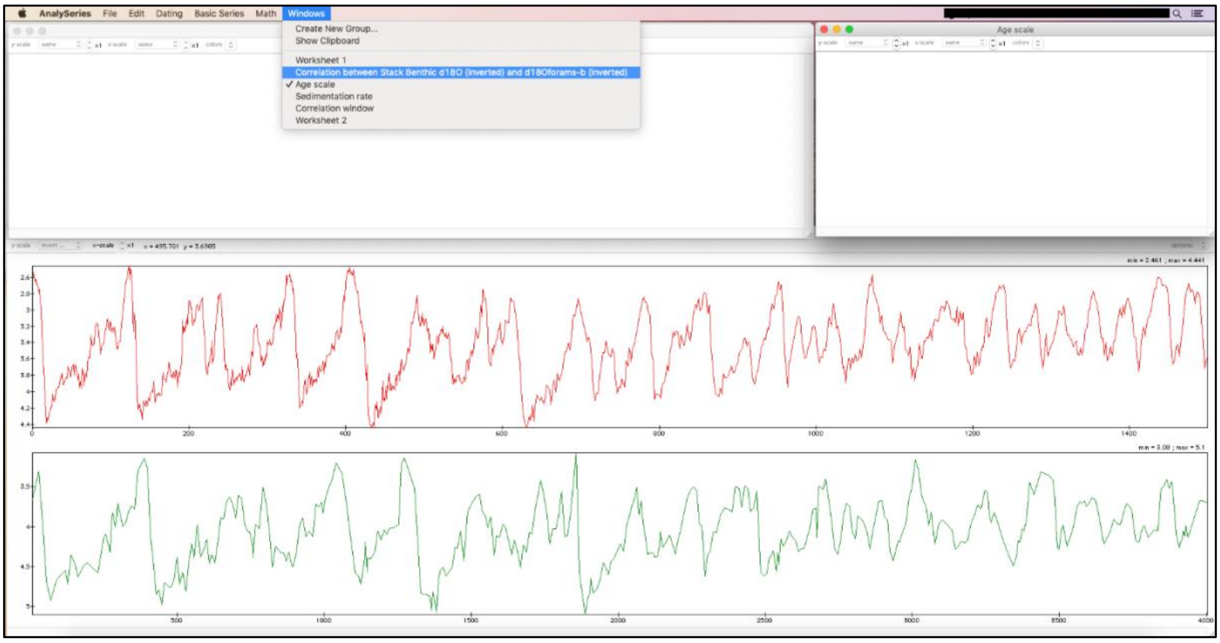

*Figure 6.2: Illustration of the Correlation window opened to start the **Linage**, and two of the empty windows (Sedimentation rate and Age scale). It can be seen the way to open the third empty window from the **Windows** menu, with the correlation between the reference and the distorted curves (this window can be seen in Figure 6.4).*

These empty windows will be filled once the correlation process has started. To do so, two **tie points** must be made by pressing the **left mouse button** in the reference curve and **shift left mouse button** in the distorted curve (Figure 6.3), or vice versa. Each **tie point** corresponds to the correspondence of one depth and one age. After adding the two **tie points** (vertical blue line correlating the reference and the distorted curves in Figure 6.3), a first estimation of Sedimentation rate and an Age scale will be visible in the upper windows of Figure 6.3. In the Correlation window, it can be seen that the lower graphic has already been re-scaled.

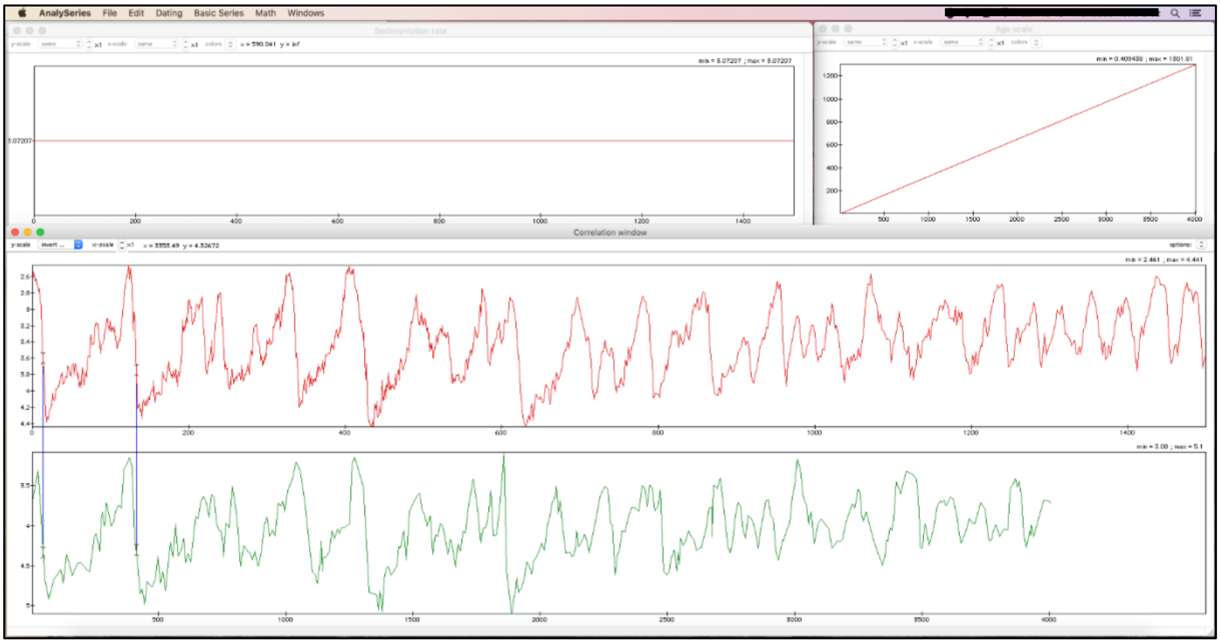

Figure 6.3: Example of the filling of the Sedimentation rate and Age scale windows after adding two tie points (blue lines at the left of the lower graphic).

After adding several **tie points**, the correlation will be improved (Figure 6.4). This can directly be seen in the window “Correlation between Stack Benthic d18O (inverted) and d18Oforams-b (inverted)”, in the upper left panel of Figure 6.4. In the same way, the Sedimentation rate and the Age scale will vary over depth, depending on the **tie points** added (Figure 6.5). **Tie points** (correlation lines) can be erased by pressing **Alt left mouse button**, which will also be immediately seen in the correlation window.

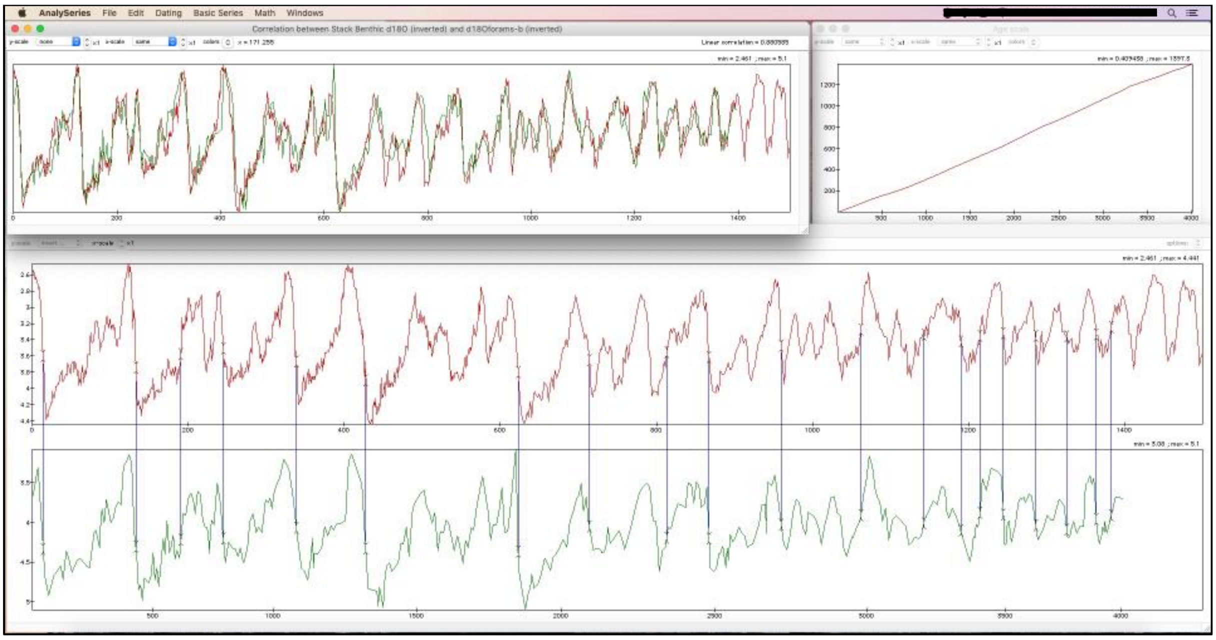

Figure 6.4: Illustration of the correlation between the $\delta^{18}O$ from ODP849 (distorted dataset; Mix et al., 1995) and the $\delta^{18}O$ of the LR04 Stack (reference dataset).

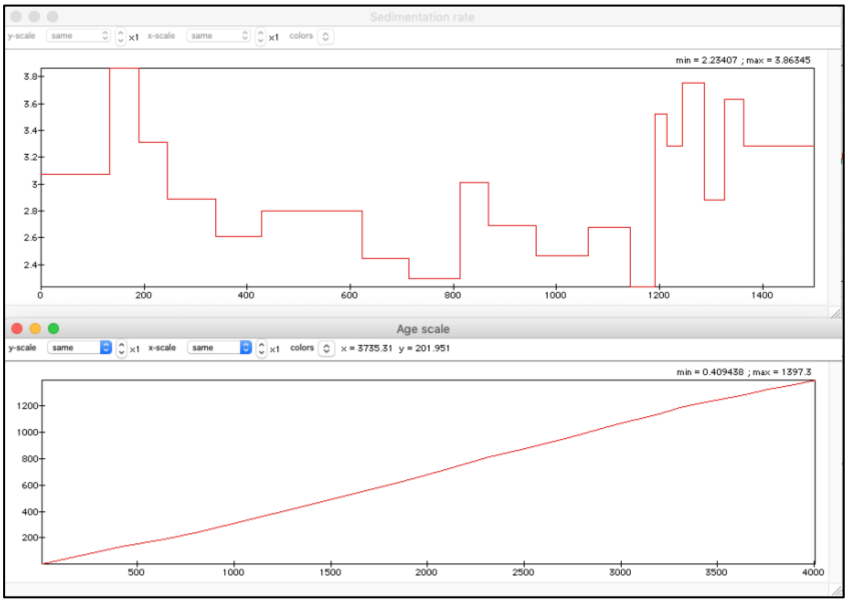

*Figure 6.5: Illustration of the Sedimentation rate and the Age scale windows after adding several **tie points**.*

The X-axis and Y-axis scales can be modified, and the color of the series can be chosen using the same buttons as those of the **Draw** function in Figure 5.4.

In the Correlation window, it is possible to invert the Y-axis (1 in Figure 6.6), and to change the scale of the X-axis. It is also possible to select different options (2 in Figure 6.6), allowing the selection of data points only or allowing interpolations between existing data points, and to select not, half or full interactive. Not interactive will not re-scale the curves in the correlation windows (correlation between series as the upper left window of Figure 6.4 and the Correlation window); half interactive will re-scale the correlation between the series (as in the upper-left Figure 6.4) but not the Correlation window, and full interactive will re-scale both windows. The reader is invited to test these options to have a clearer view of the different outputs.

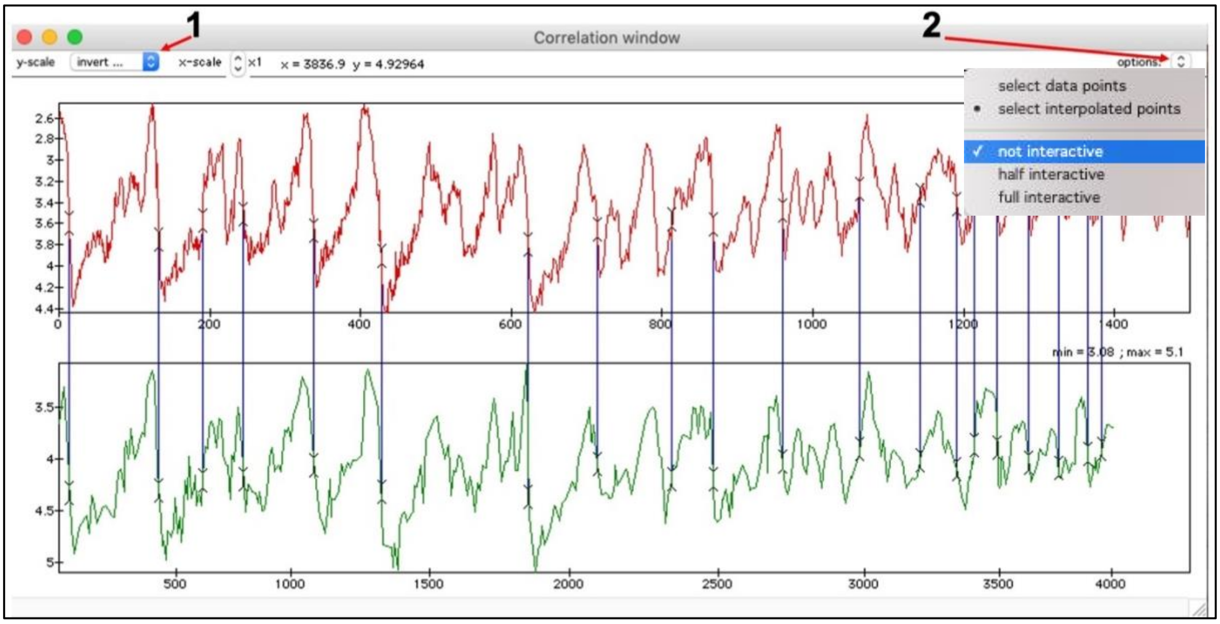

Figure 6.6: Illustration of the axis options (1) and the points selection and interactivity options (2).

After modifying the interactivity, for example from full interactive to not interactive, the **Dating > Revert** (**Command R**) button will bring back the previous mode (full interactive), and the **Dating > Next** (**Command G**) will redo the change (to not interactive). Note that these commands might have some problems (bugs), during some tests they blocked the options button of the Correlation window (2 in Figure 6.5).

At this point, it is possible to select **Splinage**, which will change the **Linage** to a **Splinage**. This will be evidenced more clearly in the Sedimentation rate window (Figure 6.7).

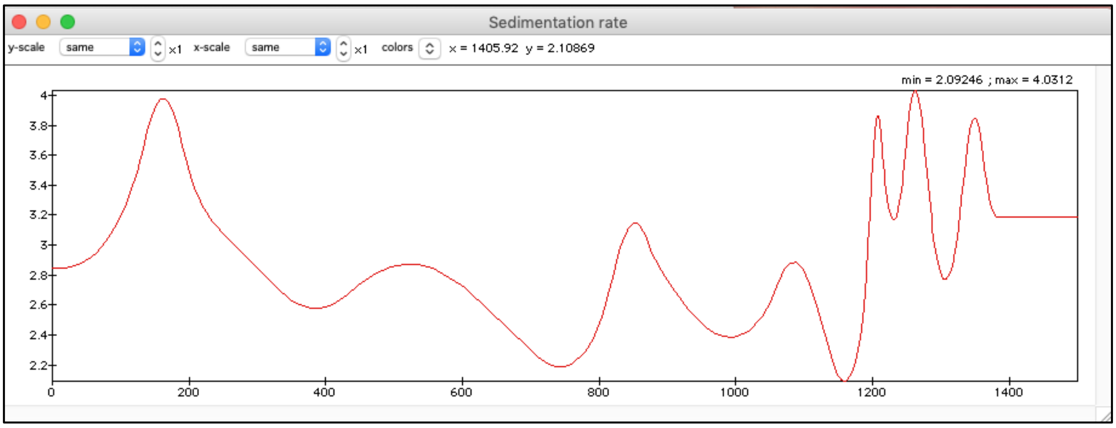

*Figure 6.7: Sedimentation rate window with **Splinage** instead of **Linage** (see Figure 6.5 for comparison).*

Closing the correlation window will open a window to confirm or cancel the action. Selecting **OK** will close the **Linage** and automatically create a folder in the worksheet with the Pointers, the Sedimentation Rate, the Re-scaled series (data now as a function of age instead of depth), and the Scale-map, which is the relationship between the new age model and the original depth (as in the Age scale window of **Linage**; Figure 6.4).

6.2 Age scale and Combine

Now that a new set of Pointers has been created for the $\delta^{18}O$ data of ODP849, it is possible to use this same age model for another dataset, for example, the $\delta^{13}C$ data from that same core. The Pointers and $\delta^{13}C$ data must be selected in the worksheet, and then click on **Dating > Age Scale** (Figure 6.8), which will open a dialog window to select the pointer and series files. After pressing **OK**, a new dataset will be created in the worksheet, named "Re-scaled d13Cforams-b (inverted)". Figure 6.9 illustrates the $\delta^{13}C$ data before and after applying the Age Scale function (see X-axis). Alternatively, this can be made using the **Linage** function, but selecting the pointers as the reference, as illustrated in Figure 6.1.

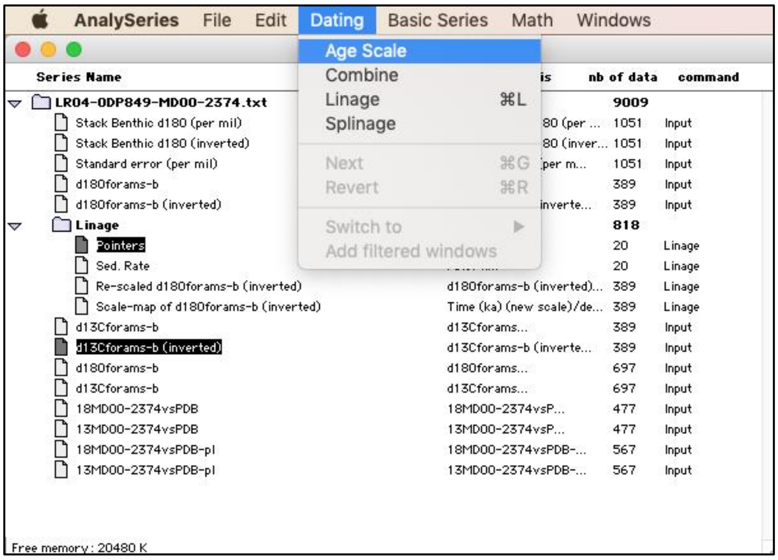

*Figure 6.8: Illustration of how to apply the **Age Scale** function.*

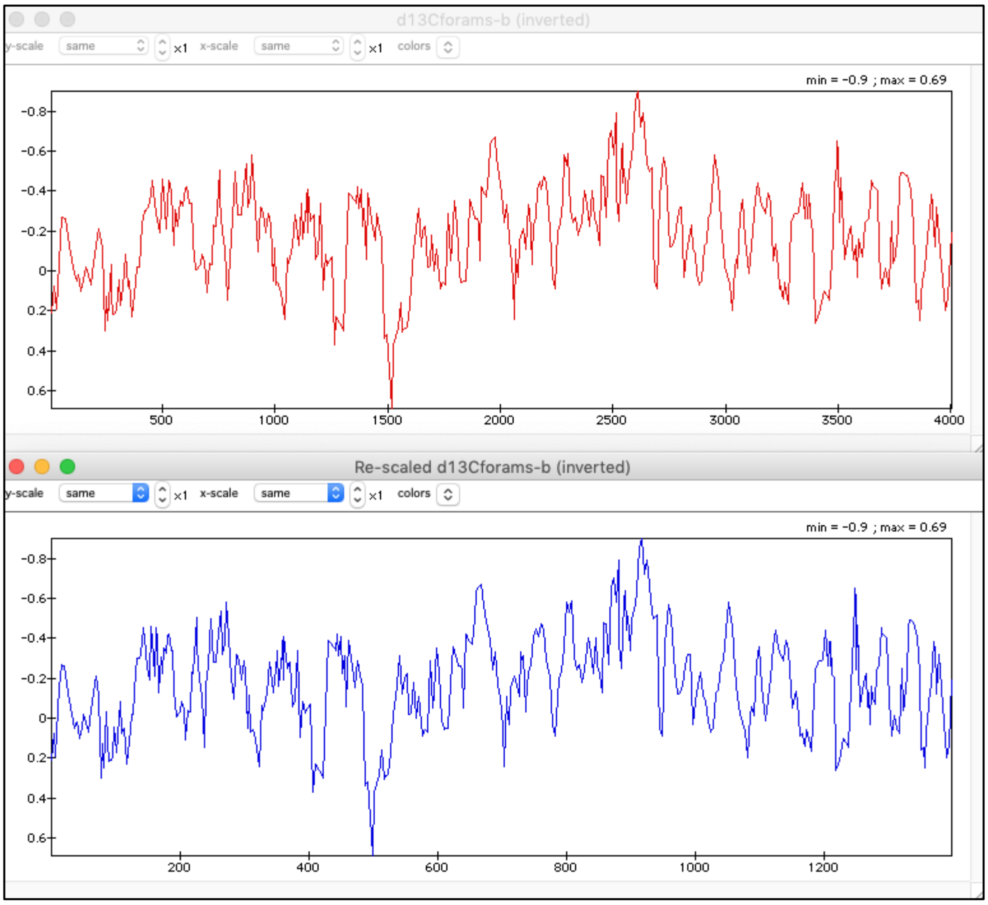

*Figure 6.9: Illustration of the δ^{13}C data before (upper panel) and after (lower panel) applying the new **Age Scale**.*

To present the **Combine** function, we will use a fake dataset with age and depth (cm) in two pairs of columns (Figure 6.10). It is important to notice that the input of the **Combine** function has to be a strictly increasing dataset of two columns, otherwise, an alert will pop up. This means that generally just depths and ages (Pointers) can be combined.

Time (ka)		depth (cm)		Time (ka)		depth (cm)
1	2	134	270			
2	4	136	274			
3	6	138	278			
4	8	140	282			
5	10	142	286			
6	12	144	290			
7	14	146	294			
8	16	148	298			
9	18	150	302			
10	20	152	306			
11	22	154	310			
12	24	156	314			
13	26	158	318			
14	28	160	322			
15	30	162	326			
16	32	164	330			
17	34	166	334			

Figure 6.10: Fake two-column dataset.

After opening the dataset (see chapter 4.3), both series must be selected. Then, pressing **Dating > Combine** (Figure 6.11) will open a window to confirm the pair of datasets to be combined. After pressing **OK**, a new set of pointers (Combined Pointers) will be generated and added to the worksheet.

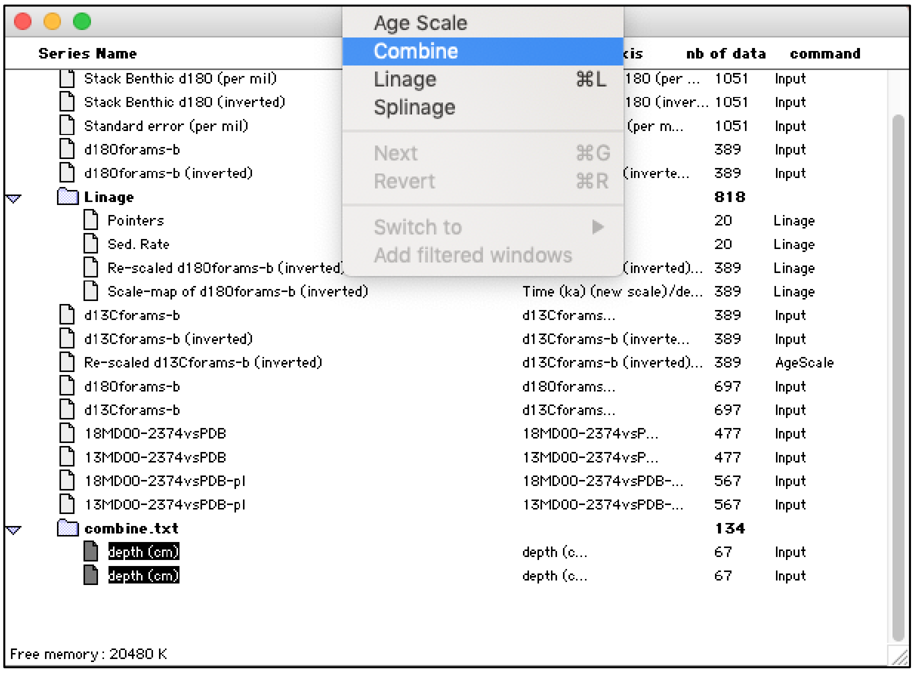

*Figure 6.11: Illustration of the **Combine** function, to combine two pairs of pointers (age and depth, Figure 6.10).*

6.3 Filtered Window

While making a **Linage** (or **Splinage**), it is possible to add a filtered window (Figure 6.12), which eliminates the main trend through a function. This is made by pressing **Dating > Add filtered windows**, which will open a window to select the type of function (Gaussian in the example of Figure 6.13 and Figure 6.14), the frequency and bandwidth, and to select (or unselect) notch filter and the scale (Figure 6.13).

*Figure 6.12: Illustration of how to add a filtered window while making a **Linage** or **Splinage**.*

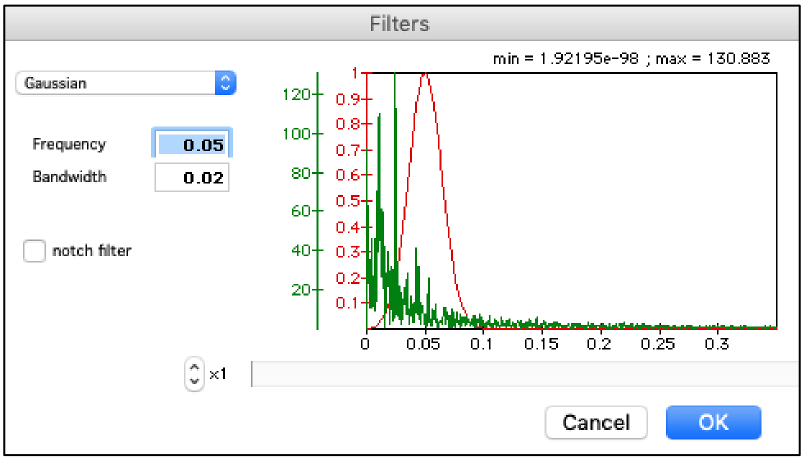

Figure 6.13: Pop-up window to select the type of filter and the wanted parameters for the filtered window.

After pressing **OK**, a new graphic will be opened (Figure 6.14), in addition to the ones opened when starting the **Linage** (see chapter 6.1). This new window will show the filtered correlation between the reference and the distorted datasets. It is possible to continue the **Linage** (**Splinage**) by adding **tie points** in the Correlation window, as explained in chapter 6.1. This will also modify the correlation in the filtered window and improve the correlation between both datasets (Linear correlation in the right-upper part of the filtered window in Figure 6.14).

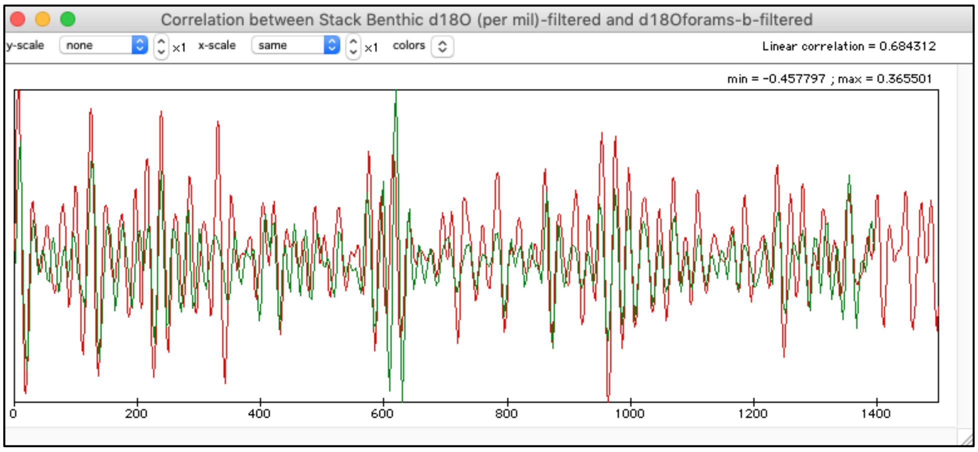

Figure 6.14: Filtered correlation between the reference (red) and the distorted (green) datasets.

6.4 Switch to

The function **Switch to** can be applied during a **Linage** or a **Splinage**. As its name suggests, it allows to switch from one distorted data set to another one of the same archive or to switch from one type of data in the reference series to another one. For example, while doing a **Linage** of $\delta^{18}O$, it allows to **Switch to** $\delta^{13}C$. To do so, we will first apply the reference age model to a series with $\delta^{18}O$ and $\delta^{13}C$ data by selecting three series (the reference, and the $\delta^{18}O$ and $\delta^{13}C$ distorted series) and doing a **Linage** (Figure 6.15).

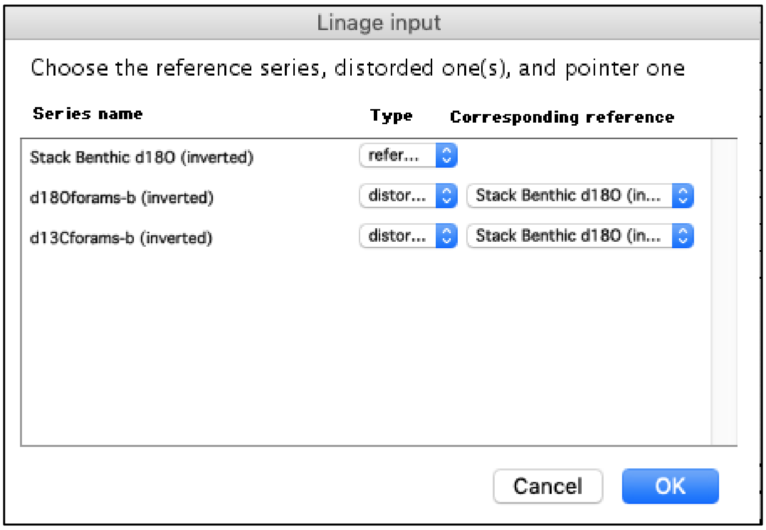

*Figure 6.15: Illustration of a **Linage** using two sets of data from a single core (δ^{18}O and δ^{13}C, ODP 849; Mix et al., 1995) with a single reference dataset (δ^{18}O, LR04 Stack, Lisiecki and Raymo, 2005).*

This will allow to apply the **Linage** (as in chapter 6.1) to both distorted series at the same time. So, by correlating the δ^{18}O of the distorted series with the reference series, the same age model will be applied to the δ^{13}C series. At this stage it is already possible to use the **Switch to** function by pressing **Dating > Switch to > wanted-dataset**, but it would not be correct to correlate different data (O and C isotopes). Instead, we will save this **Linage** and use now the re-scaled δ^{18}O and δ^{13}C data from ODP 849 as the reference series, and the δ^{18}O and δ^{13}C data from MD00-2374 (Duplessy et al., 2007) as the distorted series. As we want to show the utility of the **Switch to** function, we will now select four series from the worksheet (δ^{18}O and δ^{13}C from the reference and distorted series; Figure 6.16).

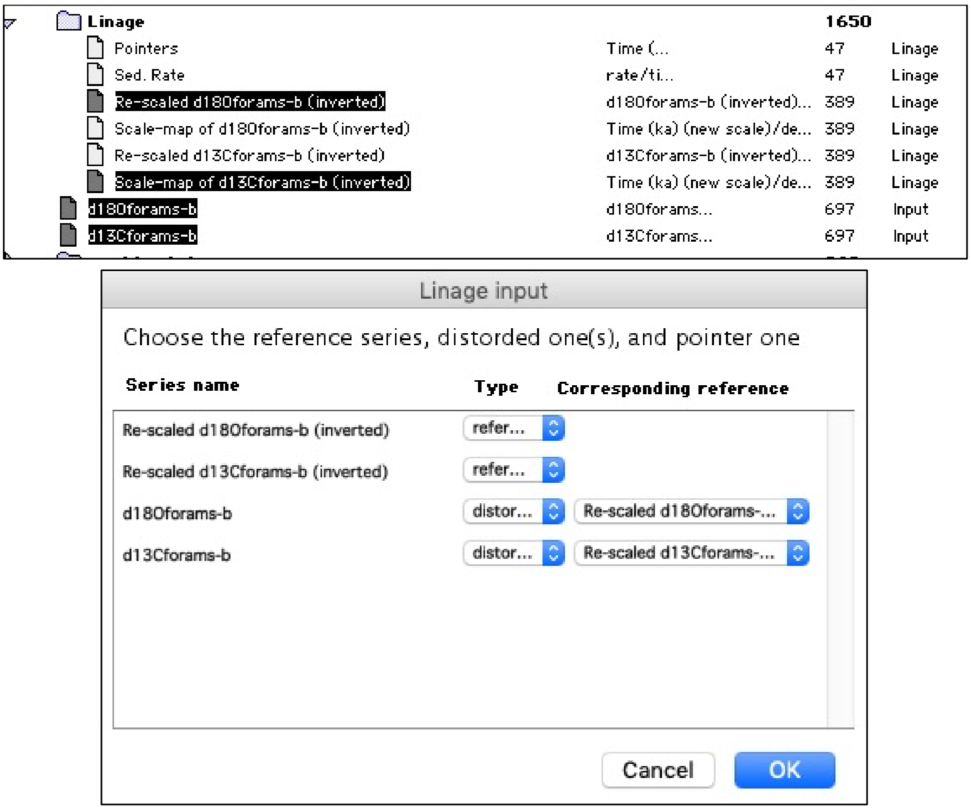

*Figure 6.16: Illustration of the opening of a **Linage** of two distorted datasets and two re-scaled series as references.*

After adding several tie points on the $\delta^{18}O$ Linage between ODP 849 and MD00-2374 (upper Figure 6.17), it is now possible to **Switch to** the correlation of $\delta^{13}C$ of the two cores by pressing **Dating > Switch to > wanted-dataset**. The lower panel of Figure 6.17 shows that the X-axis of the $\delta^{13}C$ over depth has already been adjusted to the age model of the reference series, respecting the **tie points** previously added using the $\delta^{18}O$ curves. If new tie points are added using the $\delta^{13}C$ plots, they will also be taken into account if we switch back to the $\delta^{18}O$ plot.

This functionality is very useful, as in real study cases it is common to have low certainties in some paleoclimatic signals, which sometimes can be better observed in other signals. The advantage is given by the double correlation, as the **tie points** fixed for one dataset will be applied to the other one, and vice versa.

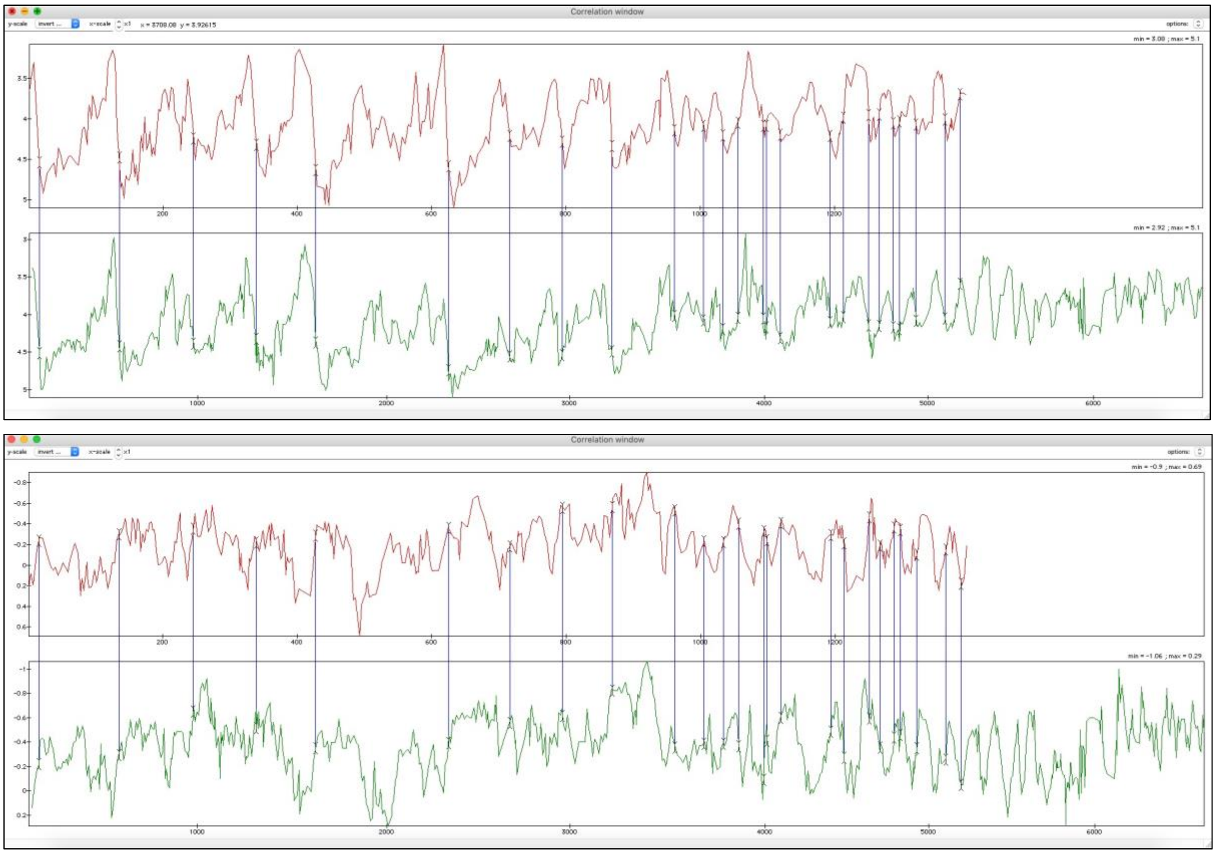

*Figure 6.17: Illustration of the $\delta^{13}C$ plot (lower panel) switched from the **Linage** a $\delta^{18}O$ (upper panel). It can be seen that the X-axis is already modified, respecting the tie points previously added using the $\delta^{18}O$ plot.*

In the same way, the **Switch to** function can also be applied for **Splinage**. Once the **Linage** or **Splinage** is finished and the Correlation window closed, the new data is added to the Worksheet. It is also possible to use several data as reference, in which case the **Switch to** function will allow to change from one reference dataset to another.

7 Basic Series menu

The **Basic Series** menu allows to generate time series of insolation and orbital parameters, a noise signal, and different models of global ice volume.

7.1 Generating Daily and Mean insolation series

There are three different insolation functions: **Daily insolation**, **Mean insolation**, and **More inso series …** (Figure 7.1). Notice that there is no need to select a series in the worksheet to enable the **Basic Series** functionalities, as theywill generate new time series.

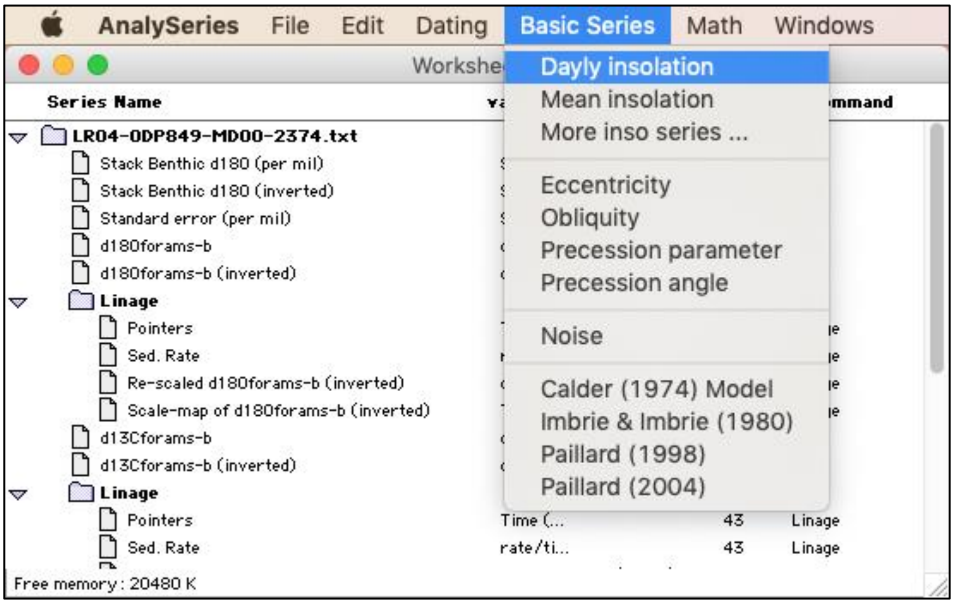

*Figure 7.1: Illustration of the **Basic Series** menu.*

Daily insolation allows to generate a series of daily insolation in a determined latitude and day of the year. By pressing **Basic Series > Daily insolation**, a first dialog window will be opened (Figure 7.2). This window allows to select the period and step of the generated series, its units, time direction and to select among four references to be chosen to reconstruct the **Daily insolation** (Berger, 1978, Laskar, 1990, Laskar et al., 1993, and Laskar et al., 2004; Figure 7.2). Time in the example of Figure 7.2 is positive to the past (right of the X-axis) because a **time direction** with **past > 0** has been chosen. This way, the plotted data will go from the present (0 kyr) to 1000 kyr before present, with a step of 1 kyr. Pressing **OK** will open a second dialog window (Figure 7.3).

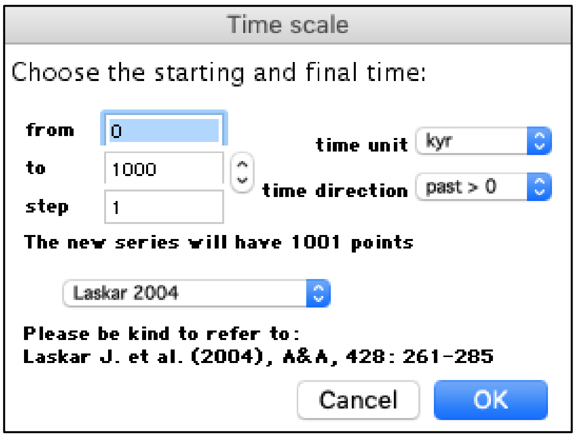

*Figure 7.2: First dialog window to generate a **Daily insolation** series.*

The second dialog window allows to introduce the solar constant (1365 W/m^2 is the default value), the season defined by the degree from vertical point, the date, or by equinoxes or solstices (default values are 90, June 21st and June solstice, respectively), and the latitude (Figure 7.3). Pressing **OK** will generate the new series in the worksheet, which can be processed as a time series in the same way as the examples of the previous chapters.

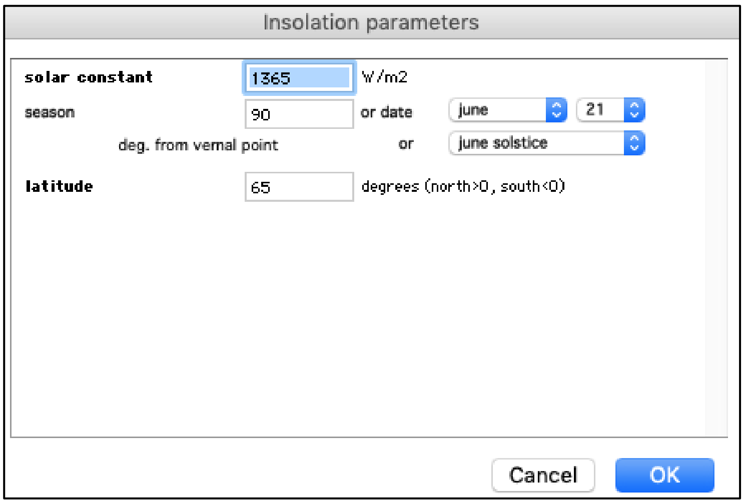

*Figure 7.3 Second dialog window to generate a **Daily insolation** series.*

For example, Figure 7.4 illustrates the **Draw** function of the inverted δ^{18}O data from the reference LR04 Stack (Lisiecki and Raymo, 2005) and the newly generated **Daily insolation** series after Laskar et al. (2004). In this case, a multiple scale was selected for the Y-axis, but a single scale for the X-axis, because the period selected for the insolation series was the same as that of the reference series (1500 kyr).

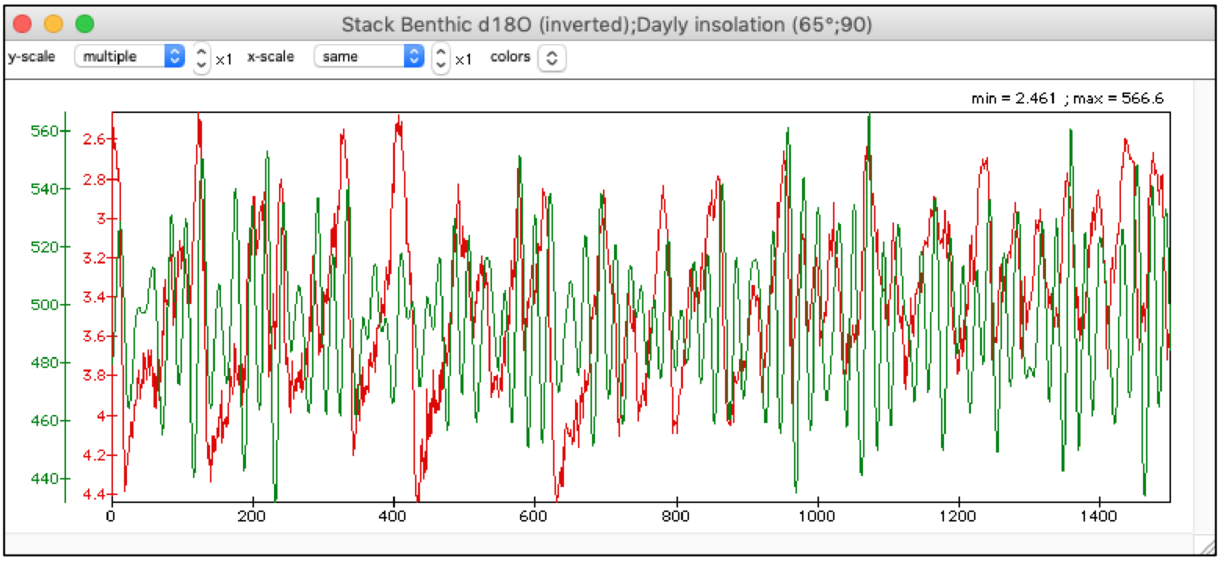

*Figure 7.4: Illustration of the simultaneous **Draw** of the reference δ^{18}O data (red curve) from the LR04 Stack (Lisiecki and Raymo, 2005) and a **Daily insolation** series (green curve) generated after Laskar et al. (2004).*

Creating a **Mean insolation** series requires the same steps (**Basic Series > Daily insolation**), with the difference that the second dialog window will allow to select a period of the year (e.g., several months) instead of a particular day (Figure 7.5).

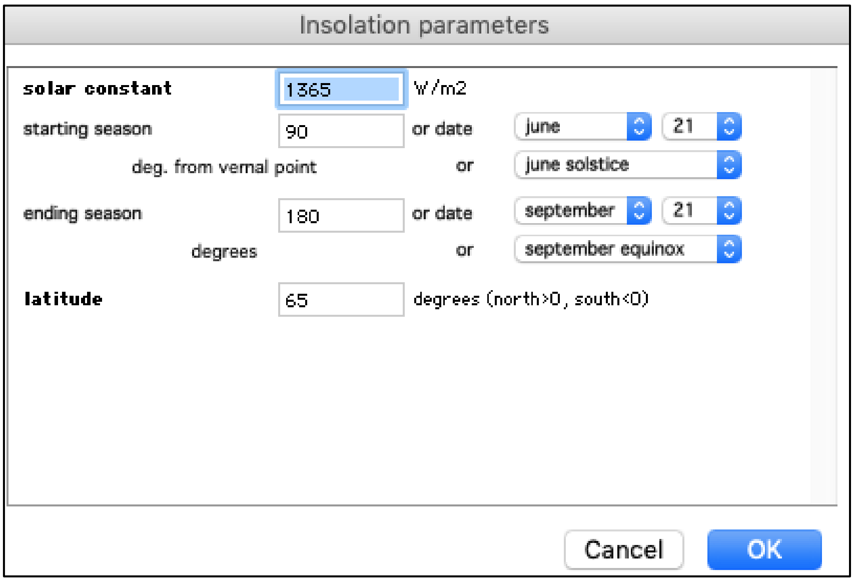

*Figure 7.5: Illustration of the second dialog window opened while generating a **Mean insolation** series showing the option to select a period of the year instead of particular day.*

There is also the function **More inso series …** which allows to generate a variety of insolation series. By pressing **Basic Series > More inso series …**, a first dialog window will pop up (Figure 7.6), which will allow to select the type of function (Instantaneous insolation, Daily insolation, Mean insolation (seas), Mean irradiation (seas), and so on), the parameters on which the function will depend (time, astronomical parameters, or a variety of combinations among them), and to select season or time from reference season. Additionally, it is possible to enable or disable the axes to be shown, and to select the parameters for each axis. If three axes are selected, instead of a graphic, a video with a succession of graphics will be generated.

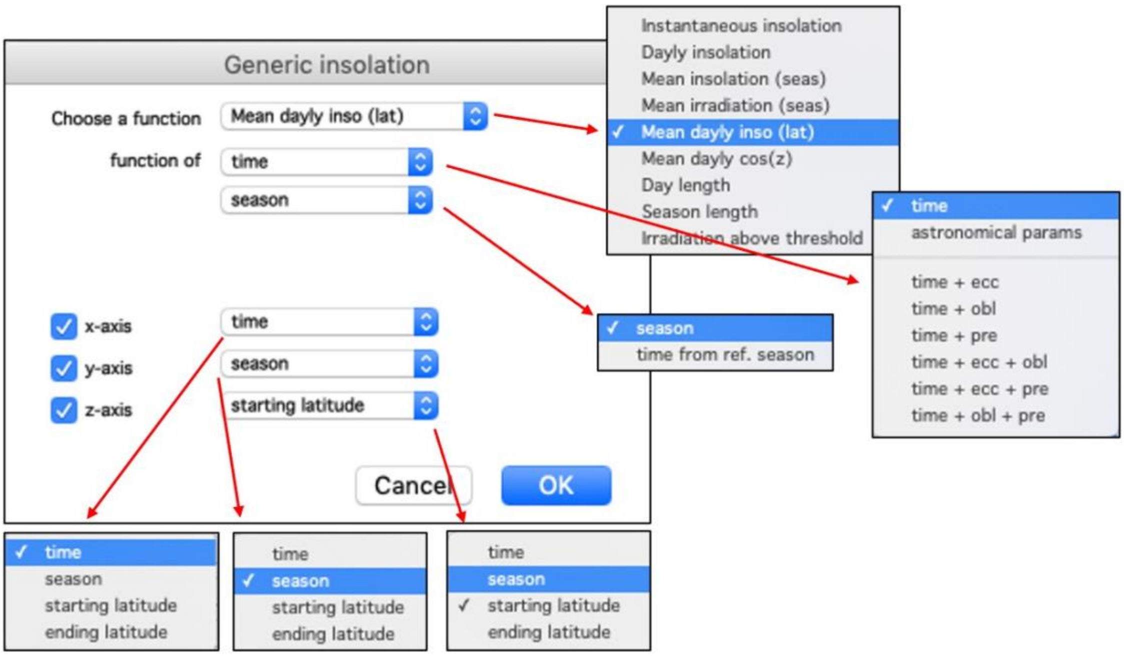

*Figure 7.6: Illustration of the different options of the **More inso series …** function.*

As well as for the mean and daily insolation functions, a second dialog window will be opened after pressing **OK**, which will allow the user to select the different parameters of the function (period and step, solar constant, latitude).

7.2 Orbital parameters and Noise

AnalySeries can generate time series of orbital parameters. To do so, the user just must click **Basic Series > Eccentricity** (or **Obliquity**, or **Precession parameter**, or **Precession angle**), which will open a window to select the period, step, time unit and direction, and reference (identical to Figure 7.2). After choosing the parameters and pressing **OK**, the respective time series will be generated in the worksheet, which can be processed as any time series (for example, using the **Draw** and **Linage** functions). In the case of the Precession parameter and the Precession angle, a second window will be opened, allowing to select different definitions of angle or parameter (upper panel of Figure 7.7). This window also counts with a button to **Show definition**, which opens a window with a diagram showing the Precession parameter definition (lower panel of Figure 7.7).

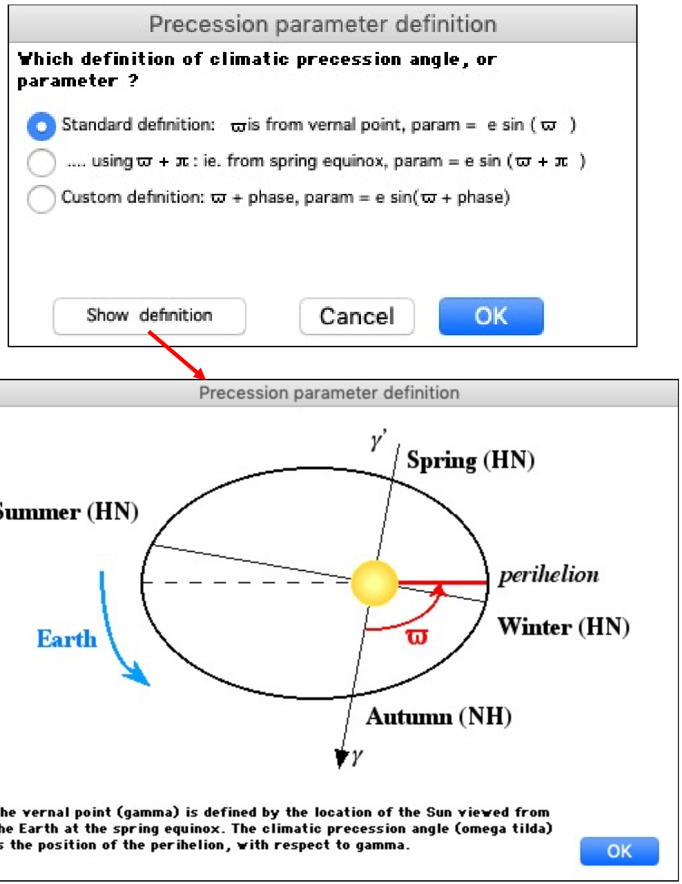

Figure 7.7: Illustration of the second dialog window that opens while creating a precession angle or parameter series, which allows to select the definition of the precession angle or parameter (upper panel), and to see the definition of the precession parameter (lower panel).

A **Noise** signal can be also generated by pressing **Basic Series > Noise**, which will open a dialog window to select the type of noise function (Uniform, Exponential, Gaussian, Double Exponential or Lorentzian) and several parameters, such as the number of points, the center and variance, red noise and its autocorrection, and the number of realizations (Figure 7.8).

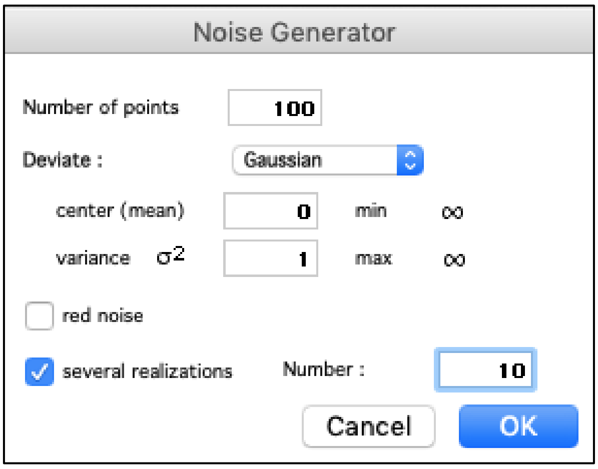

*Figure 7.8: Illustration of the dialog window to generate a **Noise** signal.*

Figure 7.9 shows the plot of ten **Noise** series generated with the parameters selected in Figure 7.8.

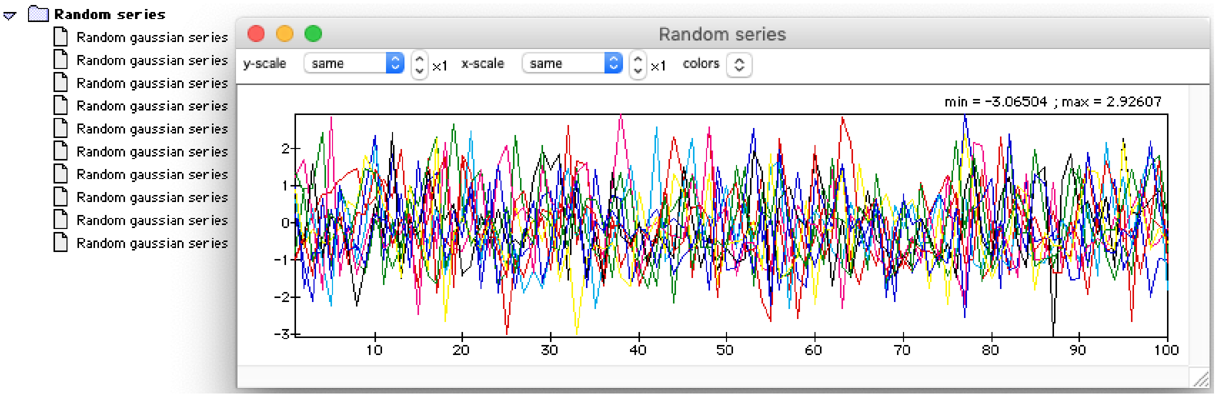

*Figure 7.9: Illustration of 10 randomly generated **Noise** series.*

7.3 Global ice volume models

AnalySeries counts with four different references to estimate past changes in global ice volume: the models developed by Calder (1974), Imbrie & Imbrie (1980), Paillard (1998), and Paillard & Parrenin (2004). To generate the global ice volume series, the user has to select an already existing insolation dataset (to create one, see chapter 7.1), then to open the **Basic Series** menu, and then the respective reference (see Figure 7.1). This will open a dialog window (Figure 7.10) to select the time units and direction, and a series of parameters, depending on the reference selected for the ice volume estimation (the reader is referred to the works of Calder (1974), Imbrie & Imbrie (1980), Paillard (1998), and Paillard & Parrenin (2004) for further details of each parameter). After introducing the parameters or letting the default values (as in Figure 7.10) and pressing **OK**, a new series will be added to the worksheet, which can now be processed as any series.

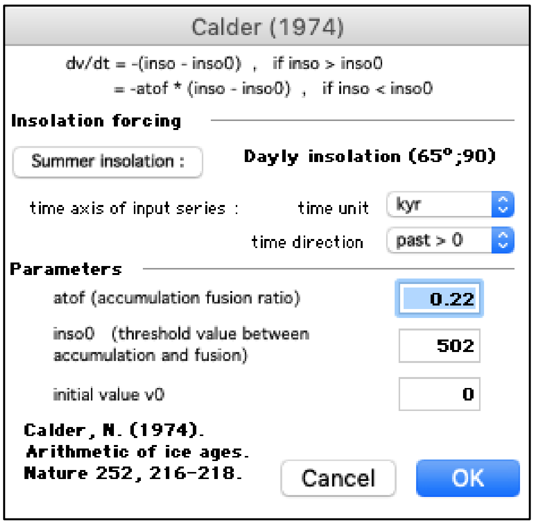

*Figure 7.10: Illustration of the dialog window to generate a **global ice volume** reconstruction after Calbert (1974).*

Figure 7.11 illustrates a plot (with a single vertical scale) of the $\delta^{18}O$ data from the LR04 Stack (Lisiecki & Raymo, 2005) in red and a **global ice volume** reconstruction after Paillard & Parrenin (2004) in green, the latter based on a **Daily insolation** series generated after Laskar et al. (2004).

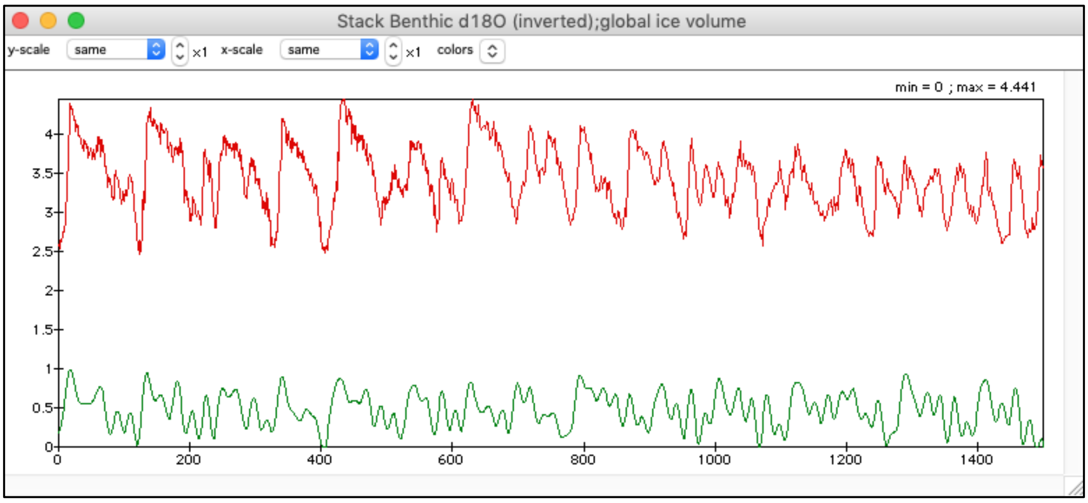

*Figure 7.11: Illustration of a **Draw** of the $\delta^{18}O$ data (red curve) from the LR04 Stack (Lisiecki & Raymo, 2005) and a **global ice volume** reconstruction (green curve) after Paillard & Parrenin (2004).*

Depending on the parameters chosen while creating the daily insolation series, the global ice models will generate different scenarios. For instance, Figure 7.12 shows two different **global ice volume** reconstructions after Calvert (1974), but generated with different daily insolation series. It can be seen that the resulting models vary considerably from each other.

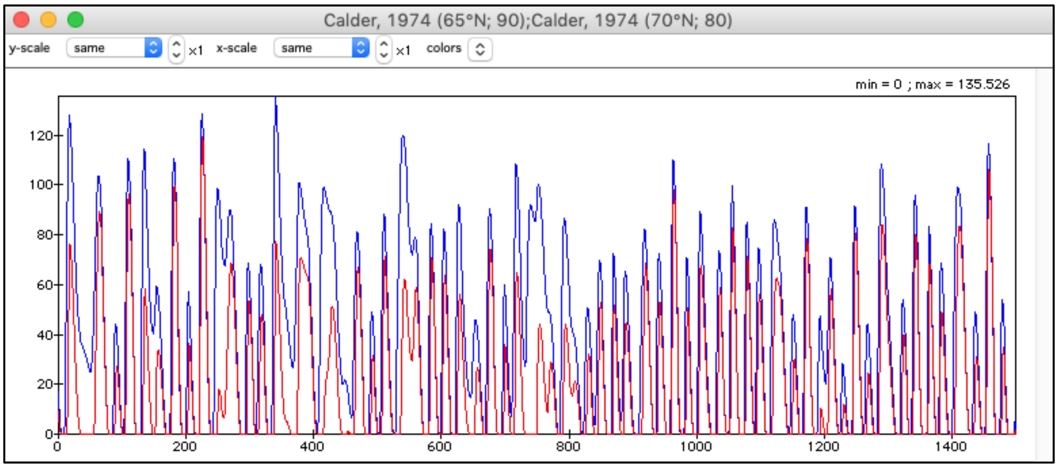

*Figure 7.12: Illustration of two **global ice volume** reconstructions after Calvert (1974) based on two different daily insolation series, generated after Laskar et al. (2004) at 65°N of latitude and 90° from the vernal point in blue, and at 70°N of latitude and 80° from the vernal point in red.*

For some daily insolation series, it is possible that the generated ice volume reconstructions are not realistic. To illustrate this, the upper graph of Figure 7.13 correspond to a global ice volume reconstruction after Calder (1974) based on a daily insolation series after Lasker et al. (2004) at 60°N and 50° from the vernal point. This results in a linear increase of ice, reaching extremely high values at the present. Instead, by using the model of Paillard (1998) to reconstruct the global ice volume, with the same daily insolation series as input, a much more realistic global ice volume model is generated (lower graph in Figure 7.13).

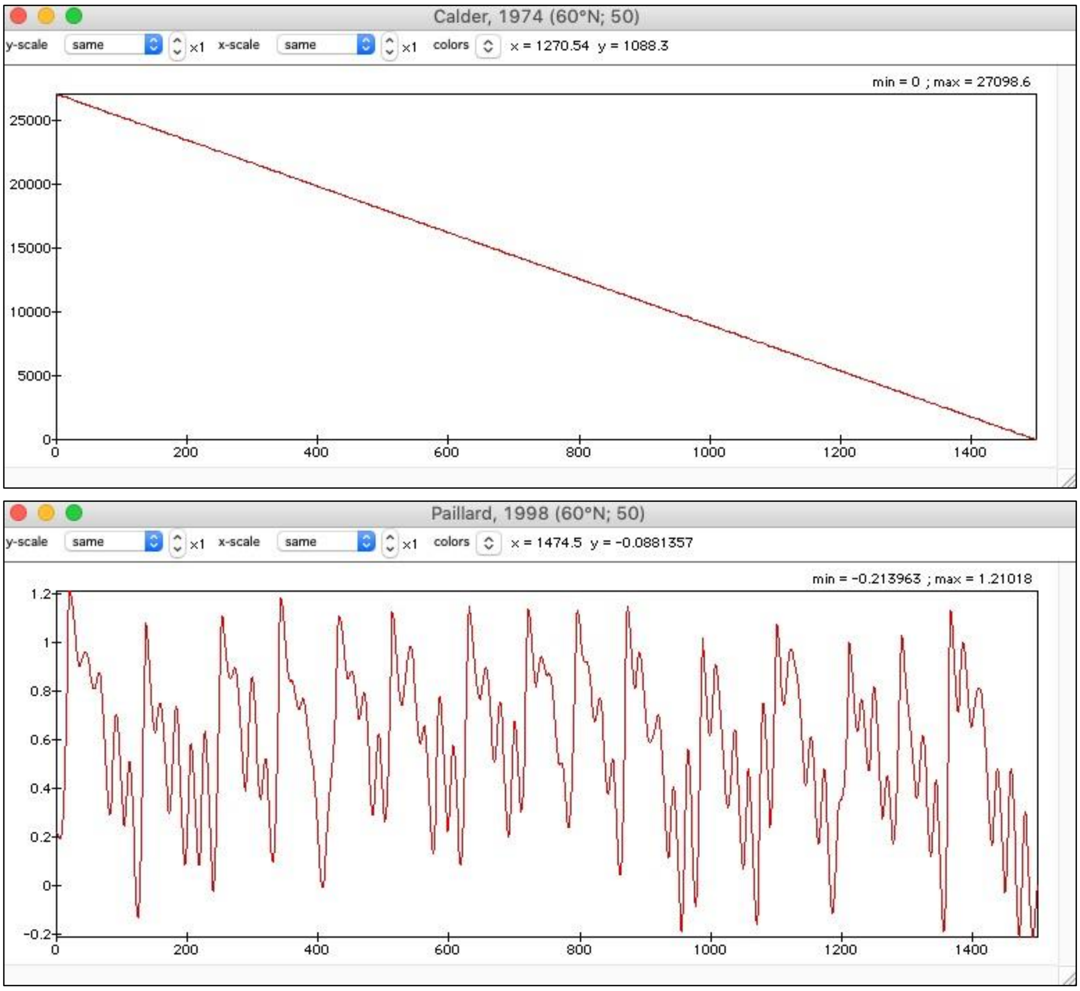

Figure 7.13: Illustration of the application of two different models to reconstruct global ice volume, based on the same daily insolation series after Laskar et al. (2004) at 60°N and at 50° from the vernal point. The upper panel correspond to the model of Calvert (1974), which results in an unrealistic model of global ice volume, and the lower panel correspond to the model of Paillard (1998), that generate a much more realistic ice volume reconstruction.

8 Math menu

The **Math** menu allows to apply a series of mathematical functions and analyses to a single or several time series. For instance, Figure 8.1 illustrates how the function "Principal Component" is not available, because it must be applied to more than one series but just one series is selected in the worksheet.

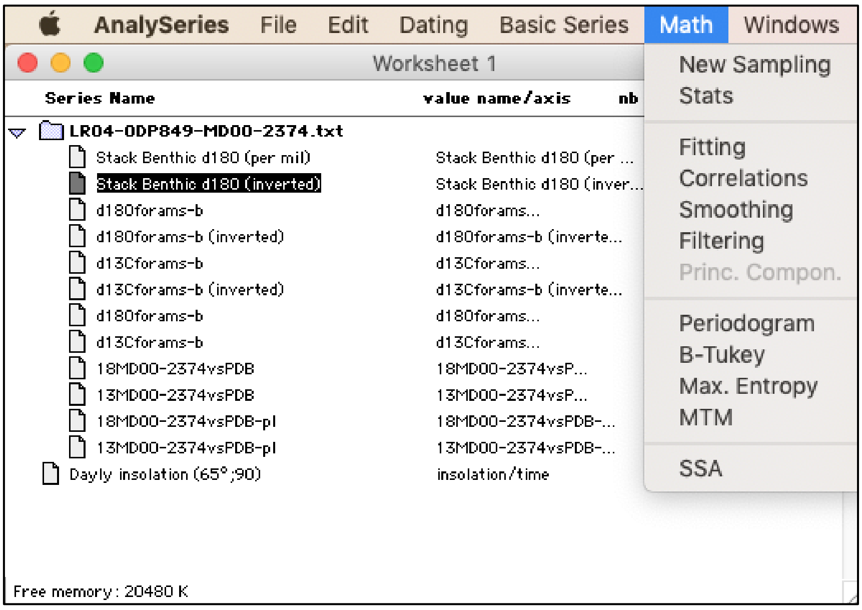

*Figure 8.1: **Math** menu with almost all functionalities available.*

8.1 New Sampling and Stats

It is possible to resample a time series by opening **Math > New Sampling** (Figure 8.1), which will open a dialog window to select the resampling parameters (Figure 8.2). The user can do a new **evenly sampled** series by selecting the desired values for the beginning, end, and step of the depth/age scale. Alternatively, it is possible to use the scale of a previously existing series by pressing the **using scale of …** button of Figure 8.2. The user can also choose among different types of interpolation (Simple interpolation or Integration) and functions (Staircase, Linear, and Cubic spline). Pressing **OK** will generate a new series in the worksheet with the **New Sampling** of the original series.

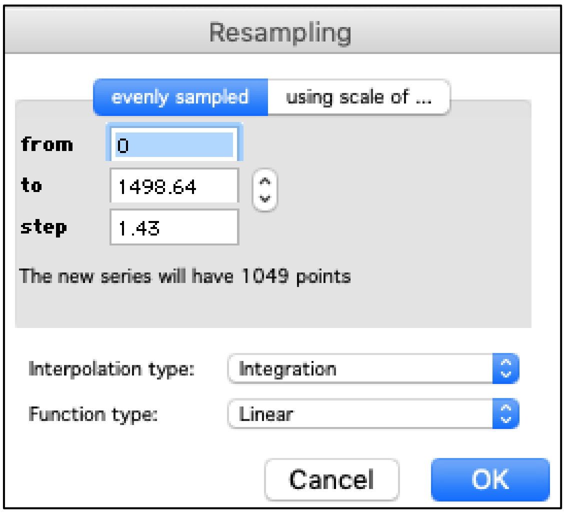

*Figure 8.2: Illustration of the dialog window to select the type of **New Sampling**.*

The **Stats** function of the **Math** menu will generate a folder with statistical information of the time series (Figure 8.3). Those statistics include the Mean, Median and Variance for the Y and X axes ($\delta^{18}O$ and time in the example of Figure 8.3), as well as two types of correlation between the axes and the probability of correlation:

- Mean: average of the data, calculated as the sum of each individual value, divided by the number of observations (or counts).
- Median: the middle value of a dataset when the numbers are arranged in ascending order.
- Variance: measure of how much the values in a dataset differ from the mean. It quantifies the spread or dispersion of the data. A higher variance indicates that the data points are more spread out from the mean, while a lower variance indicates that they are closer to the mean. It is calculated as $\sigma^2 = \frac{1}{N}\sum_1^N(x_i - \bar{x})$, with σ^2 the variance, N the number of observations (or counts), x_i each individual value and $\bar{x}$ the mean of the dataset.
- Pearson's Correlation Coefficient measures the linear relationship between two variables, in this case the X and Y axes.
- Spearman's Rank Correlation Coefficient measures the monotonic (linear or not) relationship between two ranked variables.
- The probability of zero of each correlation calculates the likelihood that the respective correlation does not occur at all within the given time interval of the series.

All these statistics are explained in detail and can be studied in dedicated literature elsewhere.

Stats of Stack Benthic d180 (inverted)		**10**	
Mean of Stack Benthic d180 (inverted) values	3.42002	1	Stats
Median of Stack Benthic d180 (inverted) values	3.41286	1	Stats
Variance of Stack Benthic d180 (inverted) values	0.168486	1	Stats
Mean of Time (ka) (abscissas)	749.32	1	Stats
Median of Time (ka) (abscissas)	749.32	1	Stats
Variance of Time (ka) (abscissas)	187696	1	Stats
Linear (Pearson's) correlation coef. of Stack Benthic d180 (inverted)	-0.298342	1	Stats
Probability of zero lin. correlation of Stack Benthic d180 (inverted)	5.23446e-23	1	Stats
Rank (Spearman's) correlation coef. of Stack Benthic d180 (inverted)	-0.303145	1	Stats
Probability of zero rank correlation of Stack Benthic d180 (inverted)	9.7734e-24	1	Stats

*Figure 8.3: Illustration of the folder with statistical information generated after applying the **Stats** function of the **Math** menu to a time series dataset.*

8.2 Fitting, Correlations, Smoothing, and Filtering datasets

The **Fitting** function generates a mathematical function with the best fit to a selected dataset. This is made by pressing **Math > Fitting**, which will open a dialog window to select the type of fit and a series of parameters, which will depend on the type of fitting function selected. For example, if the polynomial function is chosen, it is possible to modify the degree of the function, the errors, and the fitting (Figure 8.4).

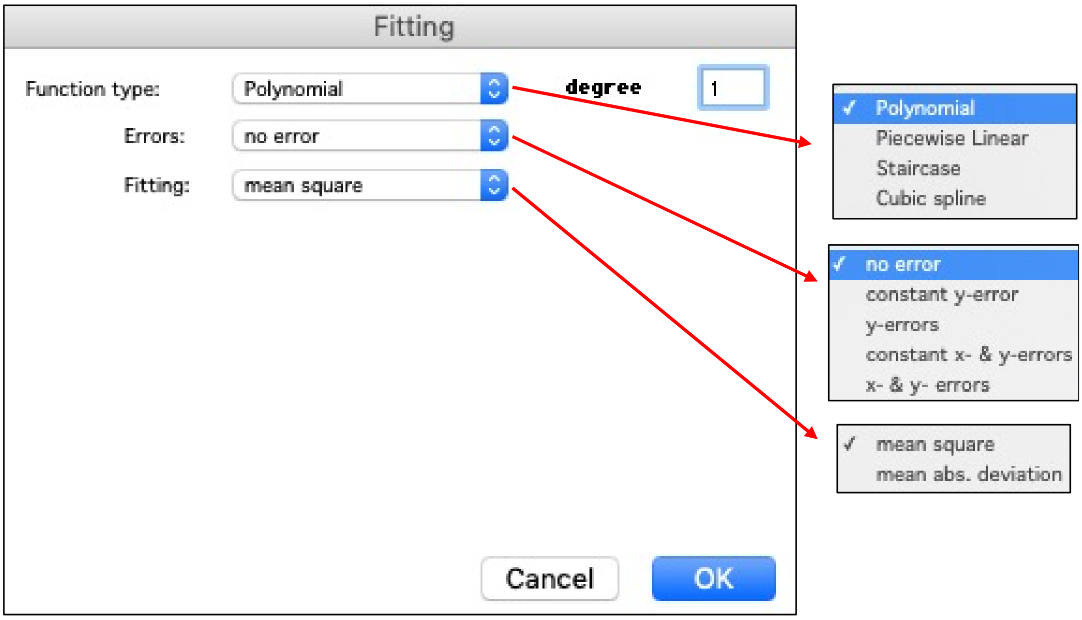

*Figure 8.4: Illustration of the dialog window to choose the type of **Fitting** function.*

If another type of function is chosen (Piecewise Linear, Staircase or Cubic spline; Figure 8.4), it will be also possible to choose the period and the pacing, and between using a new sampling or using the scale of a previously existing set of pointers, as illustrated in Figure 8.5.

*Figure 8.5: Illustration of the additional options for the three other types of **Fitting** functions.*

To illustrate this, the Figure 8.6 shows a plot of a Staircase Fitting of a daily insolation series (90 from vernal point; 65°N) for the last 1500 kyr with a 3 kyr step.

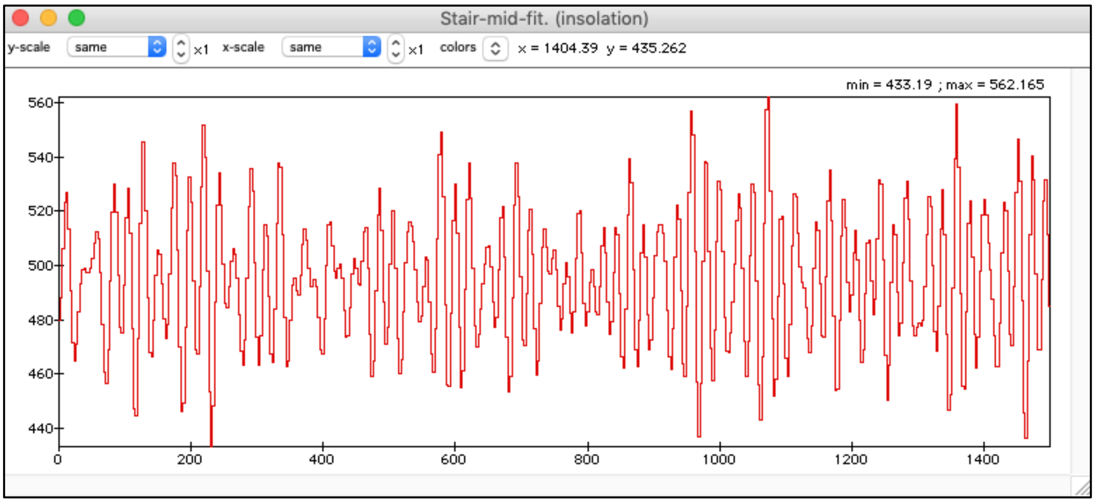

*Figure 8.6: Example of an evenly sampled Staircase function **Fitting** applied to a daily insolation series, using a step of 3 kyr between 0 a 1500 kyr, and a mean square fitting with no error.*

The **Correlations** function returns the correlation of data on a single dataset or between two different datasets. If just one series is selected, the function will make and autocorrelation over time (or depth, depending on the type of data on the X-axis). By selecting a dataset and opening **Math > Correlations** (Figure 8.1), a dialog window will be opened to select the type of correlation (correlation, covariance, or crossproduct; upper panel of Figure 8.7). If correlation is selected, it is possible to select whether to use or not a Fast Fourier Transform (FFT), but the other two menus will be blocked (upper Figure 8.7). If covariance is selected, the normalization option will be enabled (middle panel of Figure 8.7), and if crossproduct is selected, all the options will be enabled (lower Figure 8.7). After pressing **OK**, the new correlation dataset will be added to the worksheet.

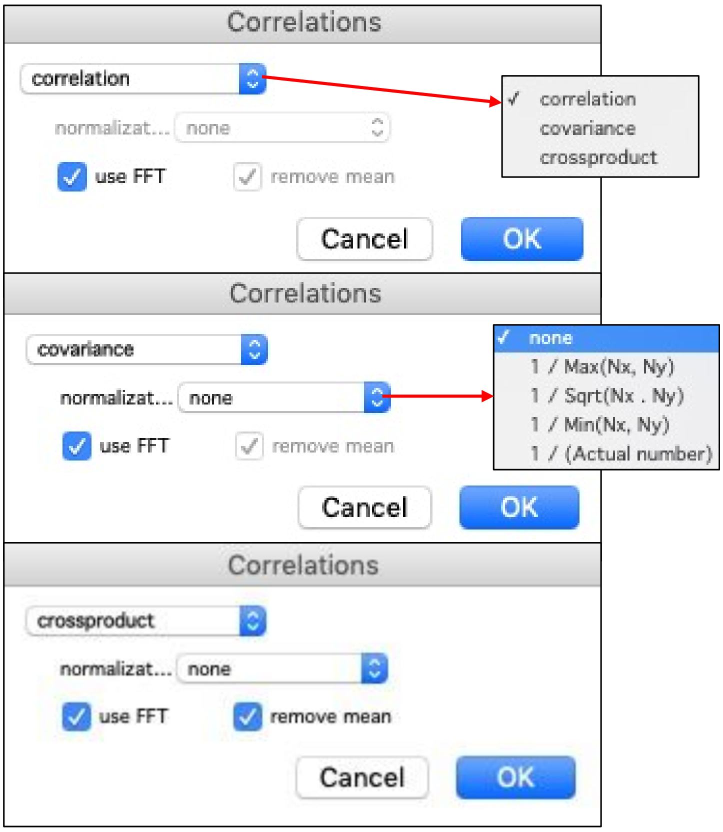

*Figure 8.7: Illustration of the **Correlations** dialog window.*

Note that the **Correlations** function requires the dataset to have an evenly spaced X-axis. If this is not the case, it will automatically create an evenly spaced **New Sampling**, as explained in chapter 8.1. Figure 8.8 illustrates the auto-correlation of one single daily insolation series and Figure 8.9 illustrates the cross-correlation of two different daily insolation series. In both cases, the maximum correlation (1 or 100%) occurs for 0 kyr, as both daily insolation series depend on the same functions. As both are dependent of cyclic functions, high correlations are reached when cyclic peaks are coincident, and minimum values are reached when peaks and lowest values coincide. Near the extremes (e.g., > 1000 kyr), the correlation is much lower, as the superposition of the curves decreases.

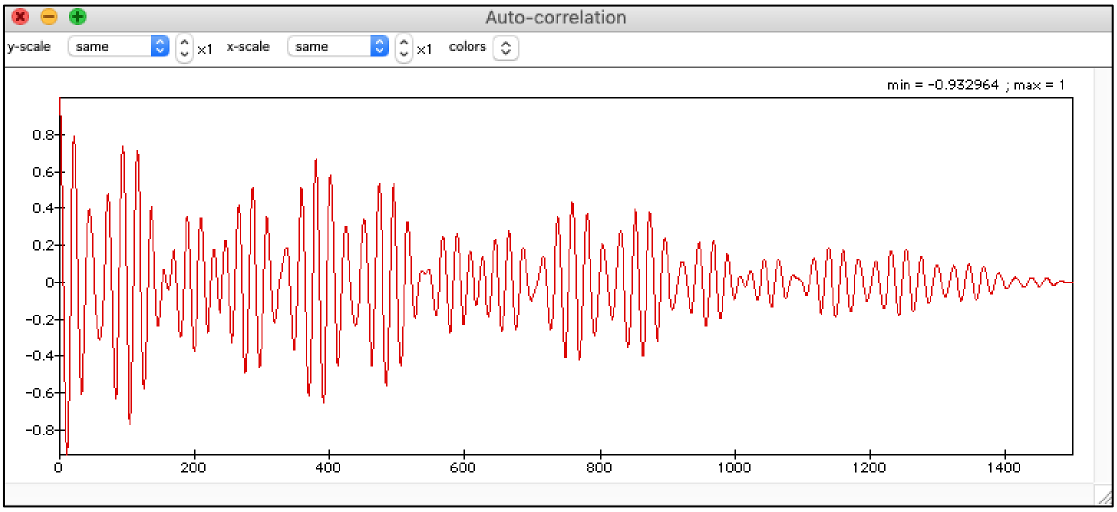

Figure 8.8: Illustration of the Auto-correlation of a daily insolation series.

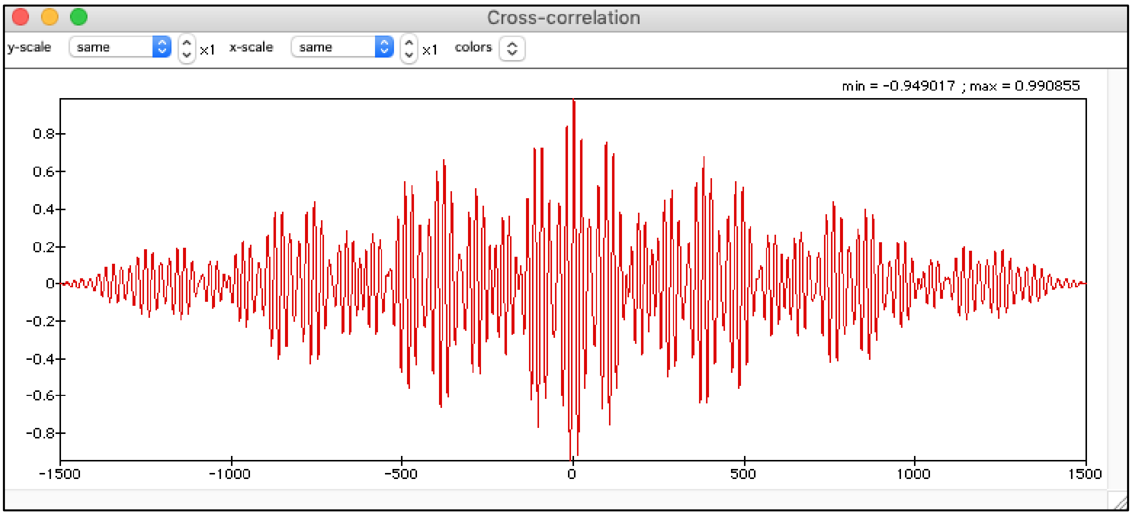

Figure 8.9: Illustration of a Cross-correlation between two different daily insolation series for a period of 1500 kyr.

The **Smoothing** function returns a smoothed dataset with data filtered by considering points in the vicinity. By pressing **Math > Smoothing**, a dialog window will be opened to select the smoothing filter to be applied to the selected series (Figure 8.10). Depending on the type of filter selected, different options will be available in the dialog widow. If the time series is not evenly spaced on the X-axis, an alert message will pop up (lower right panel of Figure 8.10), but an evenly spaced series is not required, so the filter will be applied anyway. After pressing **OK**, a new series will be created in the worksheet with the filtered (smoothed) data.

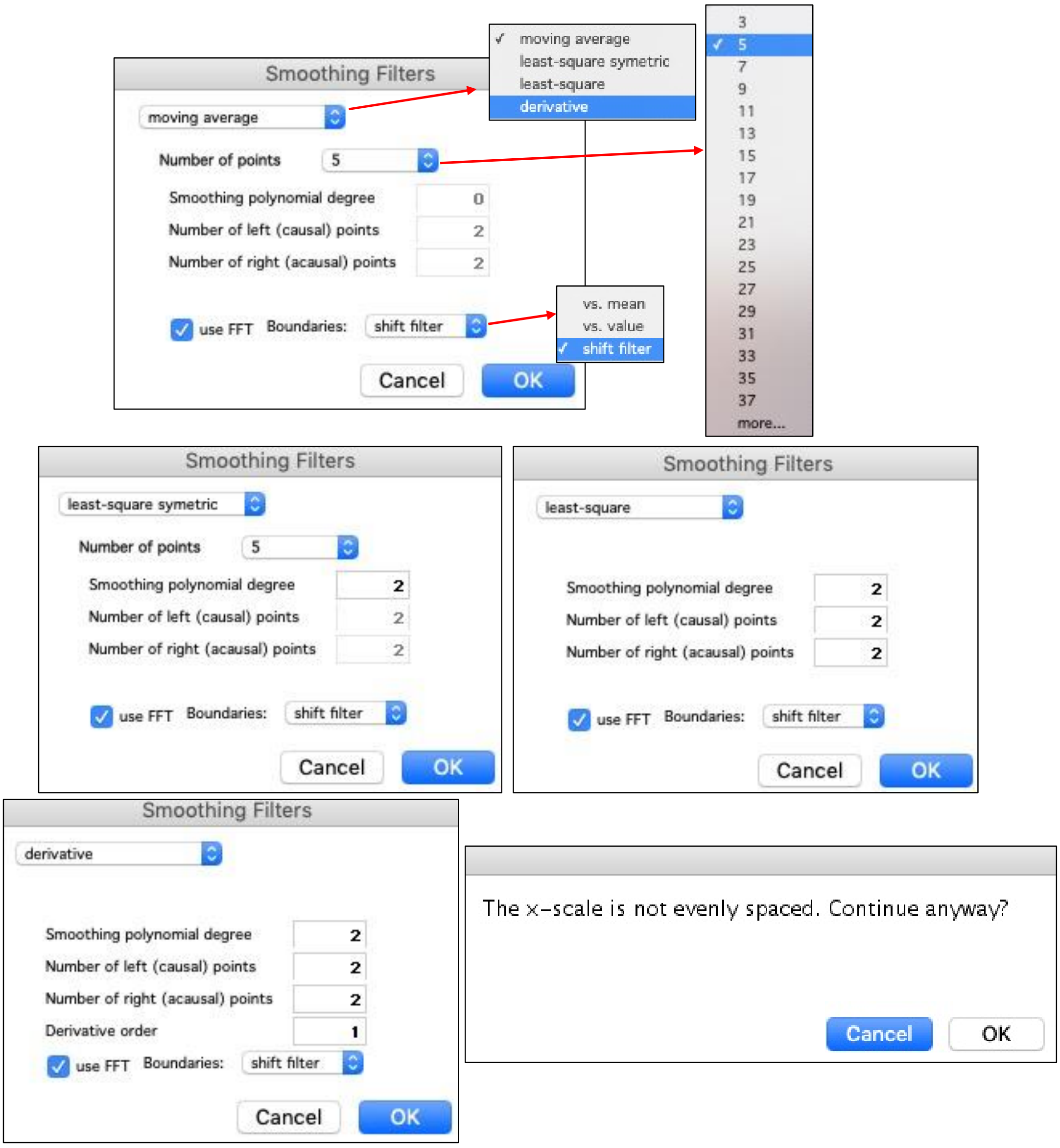

*Figure 8.10: Illustration of the **Smoothing** dialog window and the different filters available. The right-lower panel corresponds to the alert window that pops up when the series is not evenly spaced on its X-axis.*

Figure 8.11 illustrates the difference between the original series (LR04 Stack of Benthic $\delta^{18}O$ in red; Lisiecki and Raymo, 2005), and the smoothed series (green curve). It can be seen how the non-smoothed curve (in red) reaches higher and lower values and has a greater variability than the smoothed (green) curve.

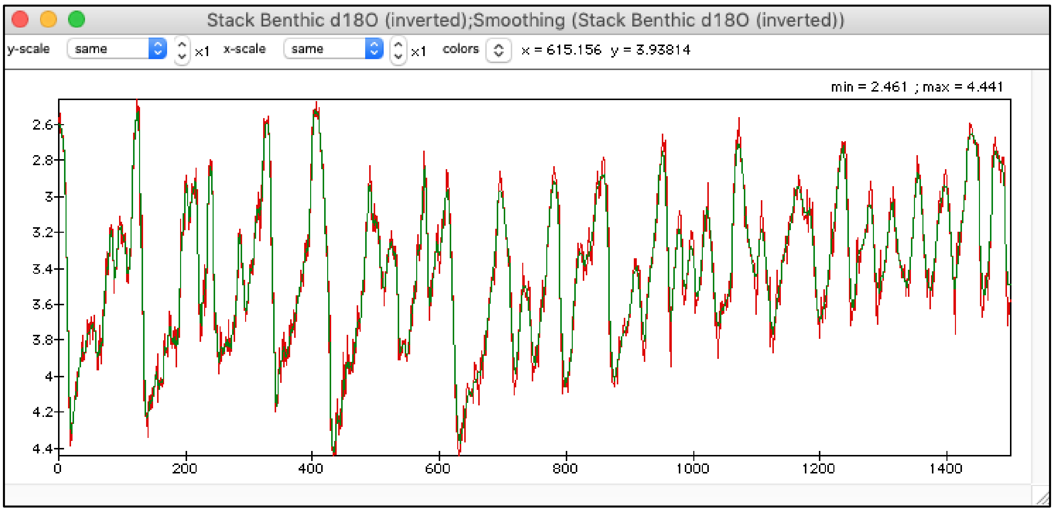

*Figure 8.11: Comparison between the Benthic δ^{18}O of the LR04 Stack (Lisiecki and Raymo, 2005) in red, and a smoothed curve created with the **Smoothing** function with a moving average in green.*

The **Filtering** function allows the user to observe the variations of data by keeping only downcore changes within a specific range of periodicities/frequencies, as previously seen in chapter 6.3. Pressing **Math > Filtering** will open a dialog window as the one of the **Dating** menu, which permits to select the type of filter, the frequency, the bandwidth, whether to notch filter or not, and to select the slope width if the Piecewise Linear filter is selected (Figure 8.12).

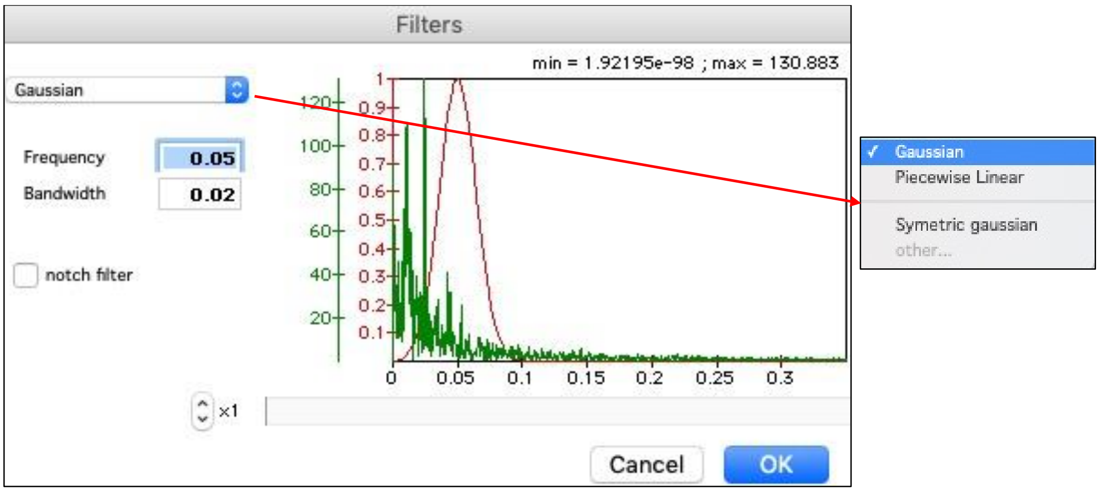

*Figure 8.12: Illustration of the dialog window of the **Filtering** function. The red line corresponds to the applied filter and the green line to the spectral curve of the series being filtered.*

By pressing **OK**, the filtered dataset will be added to the worksheet. Figure 8.13 illustrates the resulting filtered series (green curve) in comparison with the original dataset (red curve).

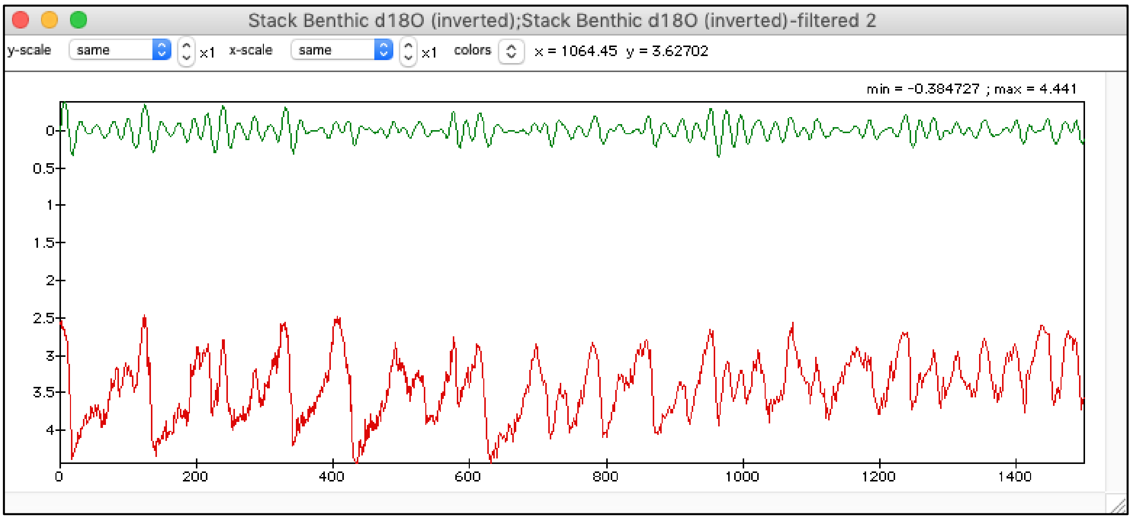

Figure 8.13: Illustration of the filtered series, in green, based on a reference curve of Benthic $\delta^{18}O$ (LR04 Stack of Lisiecki and Raymo, 2005), in red.

Finally, the **Princ. Compon.** function applies a Principal Component Analysis, a statistical technique used to reduce the dimensionality of a dataset while preserving as much variability (information) as possible. It transforms the original variables into new uncorrelated variables (principal components). These principal components are ordered such that the first few retain most of the variation present in the original dataset. In this case, an evenly spaced X-axis is required, and so by pressing **Math > Princ. Compon.** with a couple of non-evenly spaces series will automatically generate a **New Sampling** (Figure 8.14), as in chapter 8.1. After pressing **OK**, two new series will be added to the worksheet.

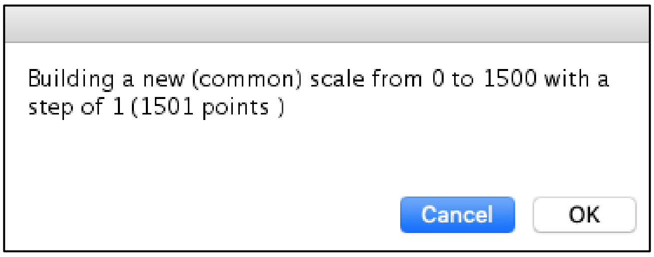

*Figure 8.14: Illustration of the automatic **New Sampling** message that pops up when applying the **Princ. Compon**. function to a couple of no-evenly spaced series.*

Figure 8.15 illustrates a daily insolation series (red curve) compared to its principal component (green curve); Figure 8.16 shows the Benthic $\delta^{18}O$ series (in red) compared to its principal component (green curve); and Figure 8.17 corresponds to both principal components of the original series, with a multiple-scale Y-axis.

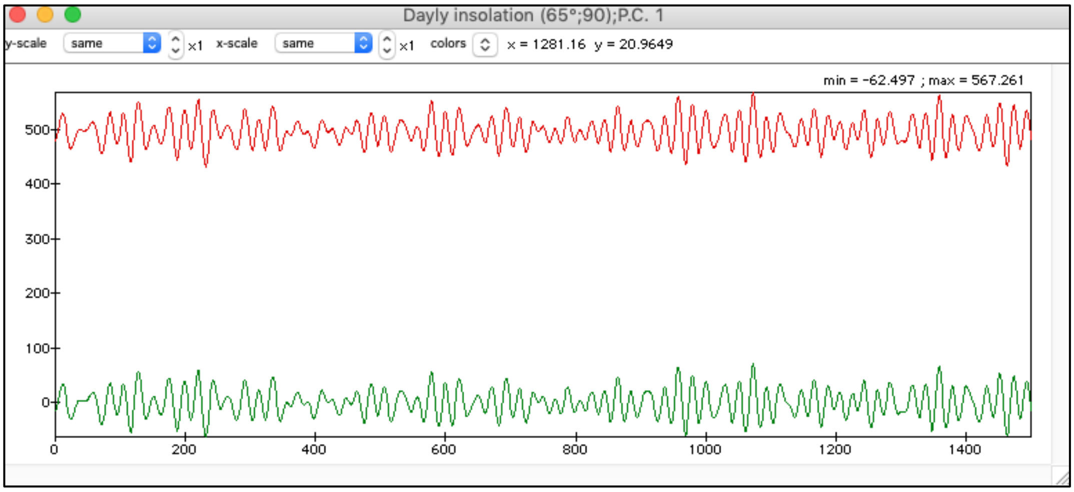

Figure 8.15: Illustration of a daily insolation series (red curve) and its Principal Component (green curve).

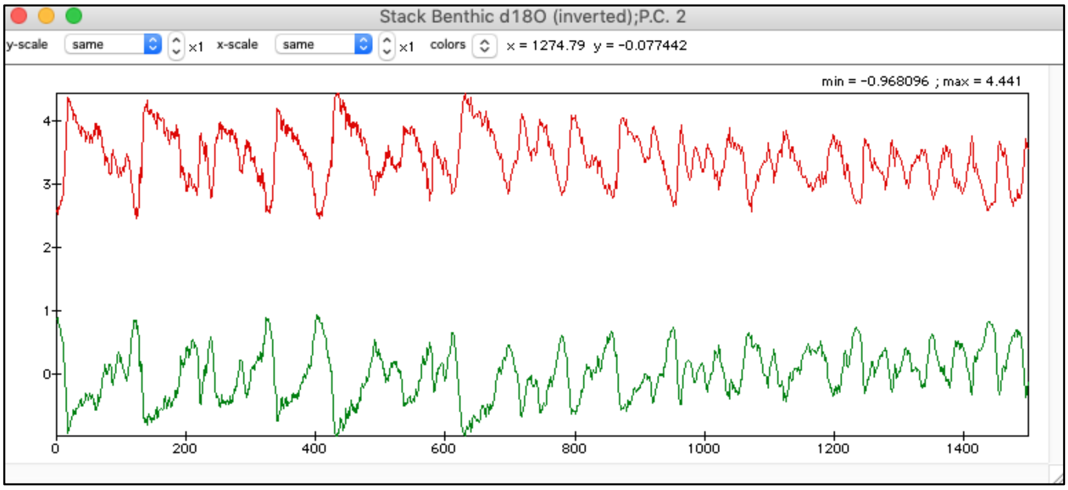

Figure 8.16: Illustration of a Benthic $\delta^{18}O$ series (red curve) and its Principal Component (green curve).

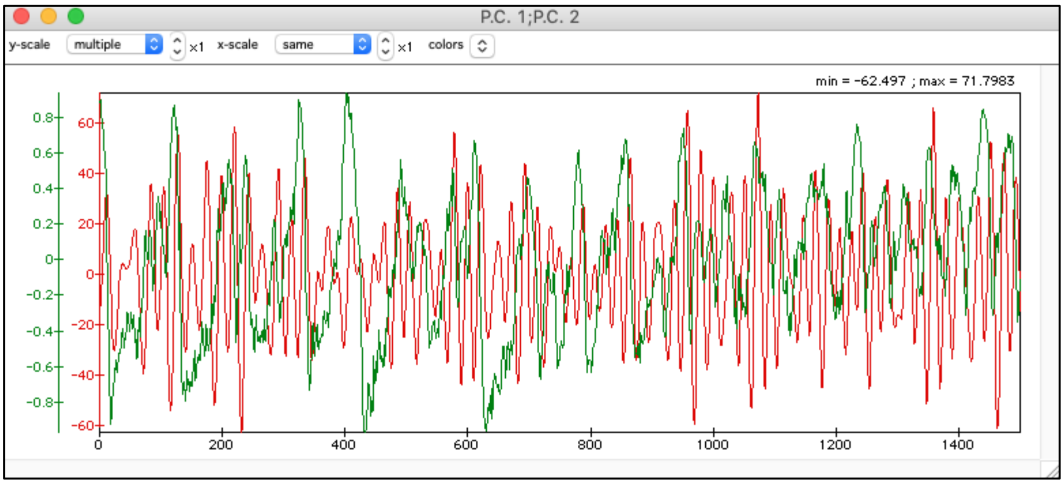

Figure 8.17: Illustration of the principal component series generated through the ***Princ. Compon.*** *function applied to two series of daily insolation and a Benthic $\delta^{18}O$ (red and green curves, respectively).*

8.3 Spectral Analysis

AnalySeries has four functionalities for **Spectral Analysis**: **Periodogram**, **B-Tukey**, **Max. Entropy**, and **MTM** (Figure 8.1). As well as the **Princ. Compon.** function, the **Spectral Analysis** functions require a series evenly spaced on its X-axis, so if a not-evenly spaced series is used, it will automatically generate a **New Sampling** (Figure 8.14).

The **Periodogram** function applies a Fast Fourier Transformation (FFT) to the selected series. By pressing **Math > Periodogram**, a dialog window will be opened (Figure 8.18), which will allow to select a series of options, such as the type of taper to limit the border effect of the FFT (upper panel of Figure 8.18). Depending on the input options selected, more (or fewer) options will be available, as illustrated in the lower panel of Figure 8.18.

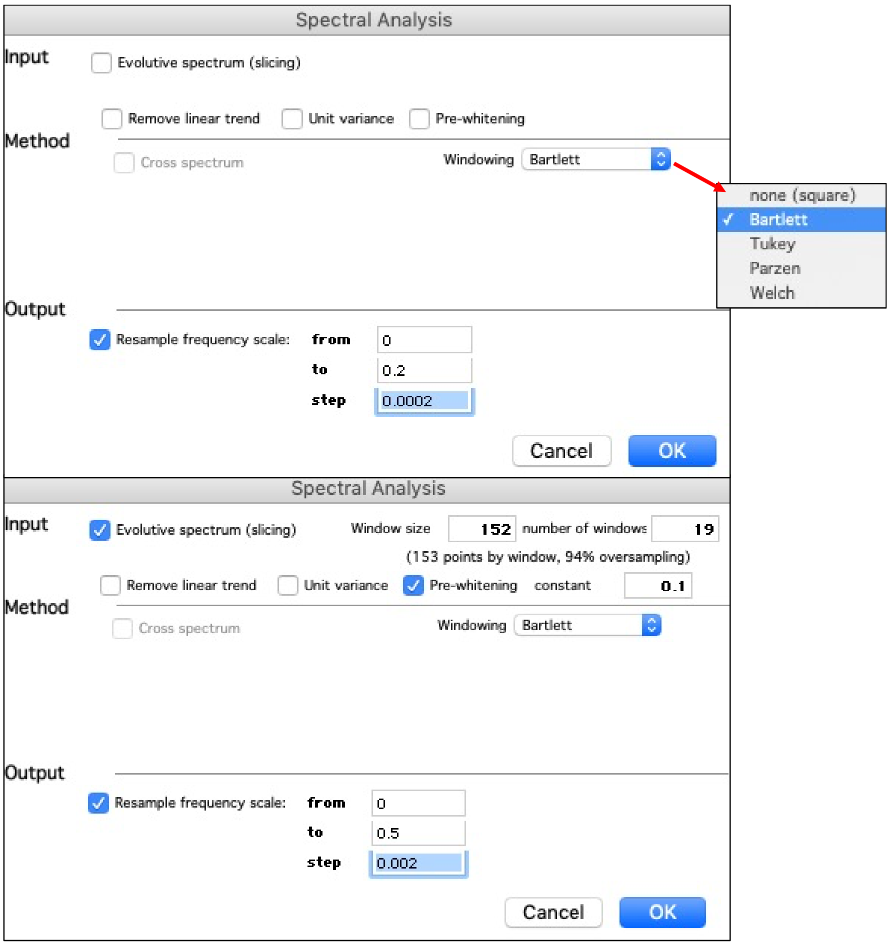

Figure 8.18: Illustration of the dialog window of the ***Periodogram*** *function.*

Figure 8.19 shows the drawing of the series generated by the **Periodogram** function, applied to the $\delta^{18}O$ data of the reference series, using the parameters of the upper panel of Figure 8.18. To observe the application of the “Evolutive spectrum (slicing)” option, see Figure 8.20.

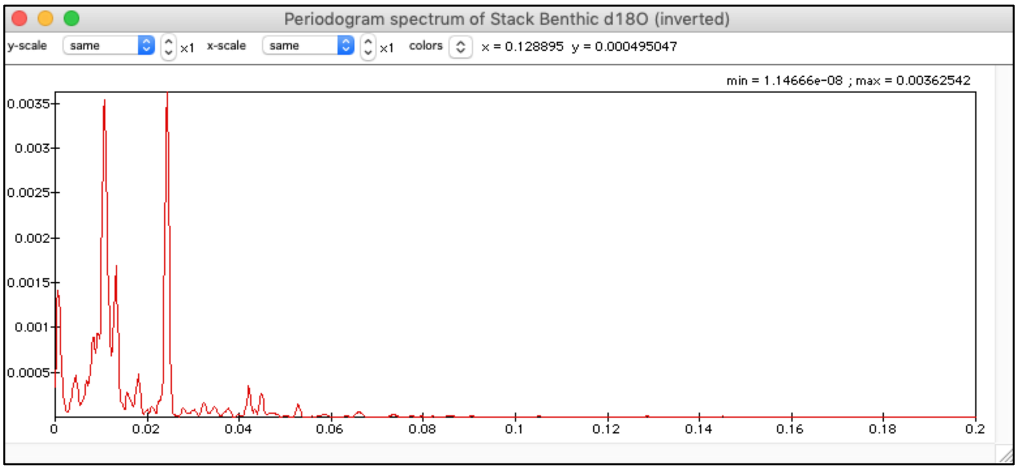

*Figure 8.19: Illustration of the **Periodogram** function applied to the Benthic $\delta^{18}O$ LR04 Stack (Lisiecki and Raymo, 2005).*

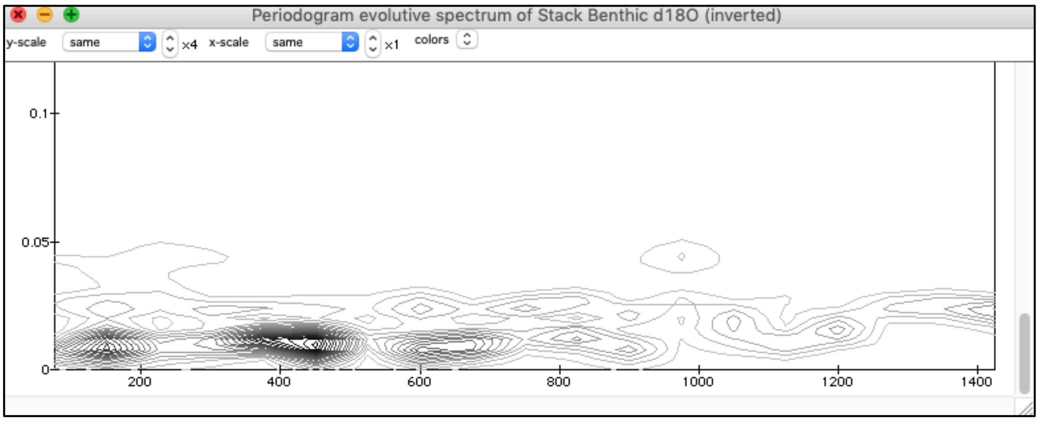

*Figure 8.20: Illustration of the **Periodogram** function applied to the Benthic $\delta^{18}O$ LR04 Stack (Lisiecki and Raymo, 2005), but with the "Evolutive spectrum (slicing)" option of Figure 8.18 selected.*

The **B-Tukey** function applies the Blackman-Tuckey method, which allows the user to obtain a confidence level associated with the power spectrum (see Jenkins et Watts, 1968). Pressing **Math > B-Tukey** will open a dialog window to select the parameters for the **Spectral Analysis** (Figure 8.21), in the same way as for the **Periodogram**.

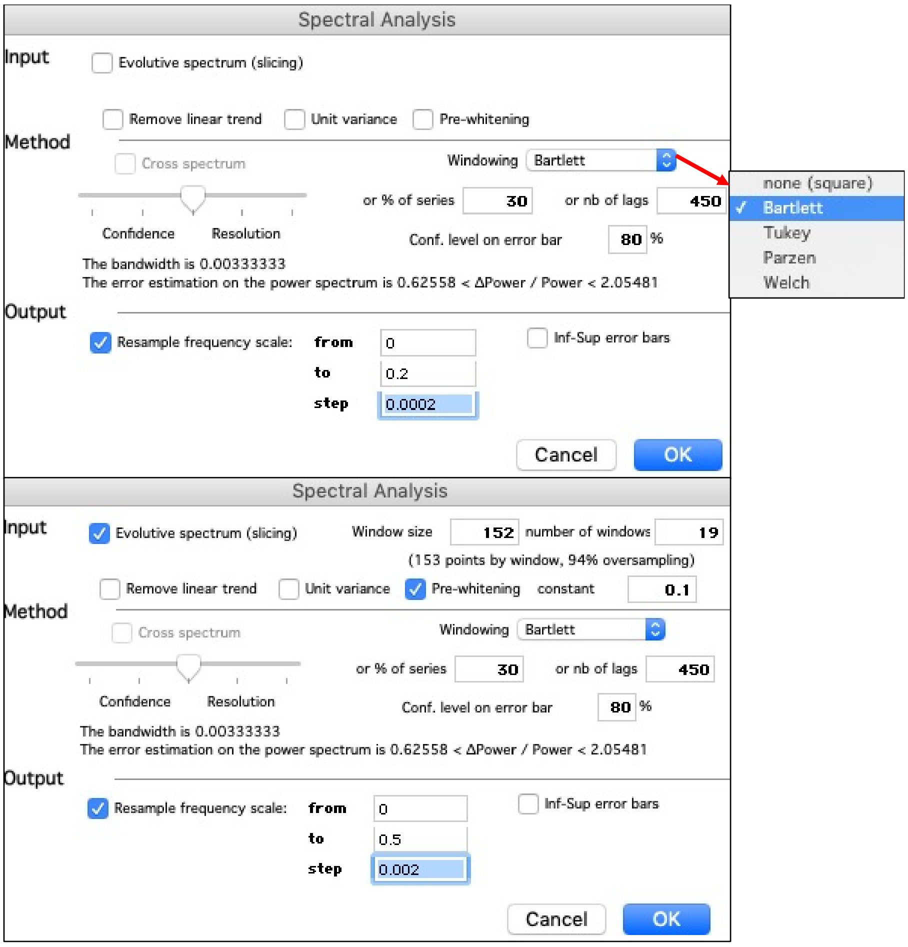

*Figure 8.21: Illustration of the dialog window of the **B-Tukey** function.*

Figure 8.22 illustrates the series generated employing the **B-Tukey** analysis.

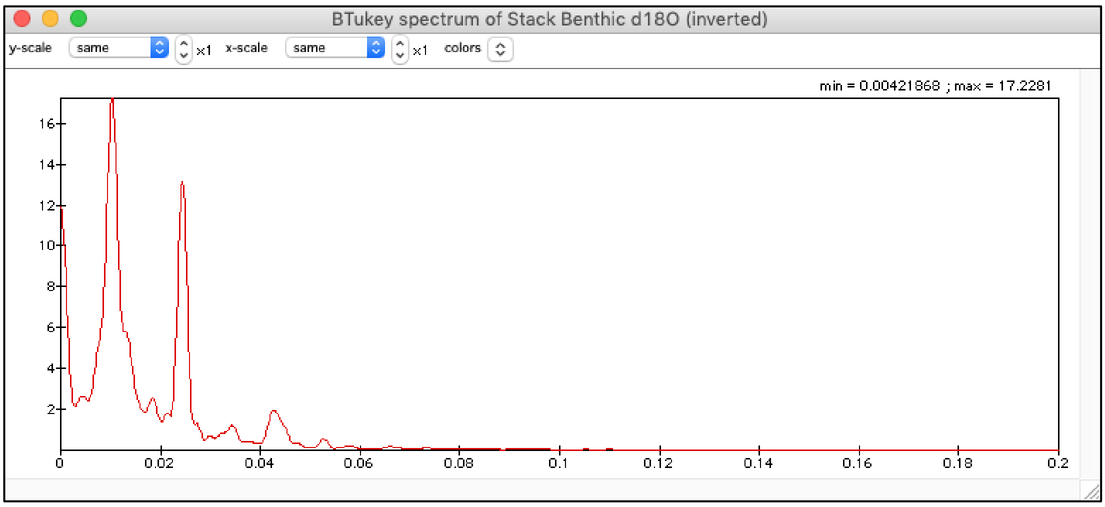

*Figure 8.22: Illustration of the **B-Tukey** analysis applied to the Benthic $\delta^{18}O$ LR04 Stack (Lisiecki and Raymo, 2005).*

Note that in the "Output" part of the dialog window of Figure 8.21 it is possible to select the option "Inf-Sup error bars", which will add to the worksheet two other series, corresponding to the inferior and superior errors at the confidence level previously chosen. Figure 8.23 illustrates the resulting plot (**Draw**) of the original **B-Tukey** spectral analysis (in red) together with the lower (green) and upper (blue) error envelopes.

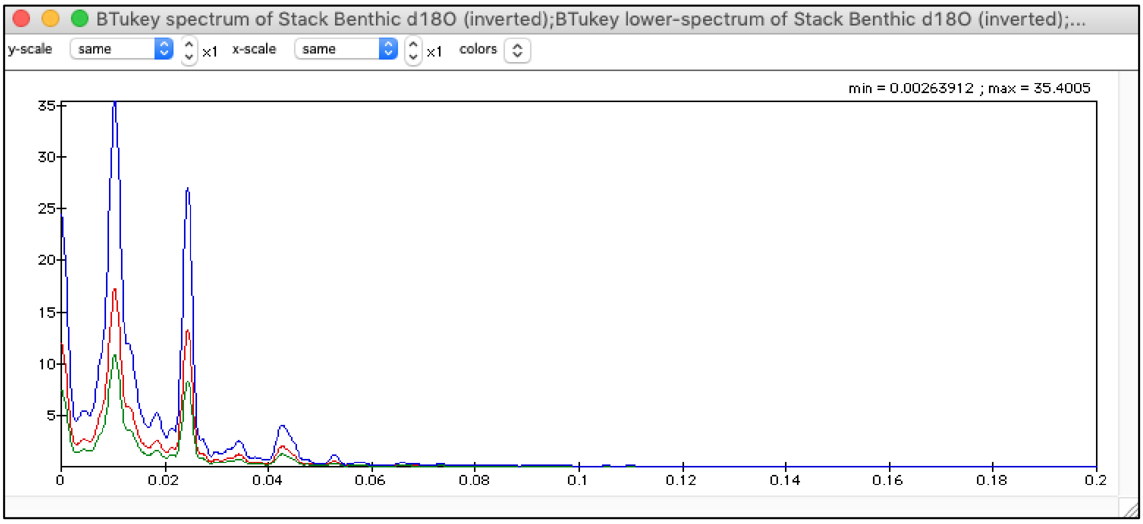

*Figure 8.23: Illustration of the **B-Tukey** analysis applied to the Benthic δ^{18}O LR04 Stack (Lisiecki and Raymo, 2005) and both the inferior (green) and superior (blue) envelopes of the error bars at the confidence level previously chosen.*

The **Max. Entropy** function also allows the user to select the spectral resolution, although in this case it is not possible to export the error bars. As well as for the previous **Spectral Analysis** functions, by pressing **Math > Max. Entropy**, a dialog window will be opened (Figure 8.24), in which it is possible to select several parameters for the analysis.

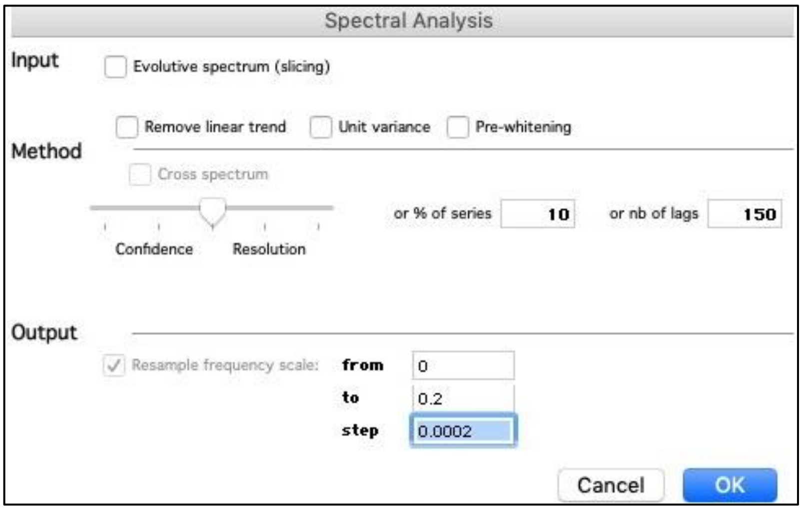

*Figure 8.24: Illustration of the dialog window of the **Max. Entropy** function.*

Figure 8.25 illustrates two drawing of the **Max. Entropy** analysis applied to the reference series of Benthic δ^{18}O data at low (upper panel) and high (lower panel) resolution.

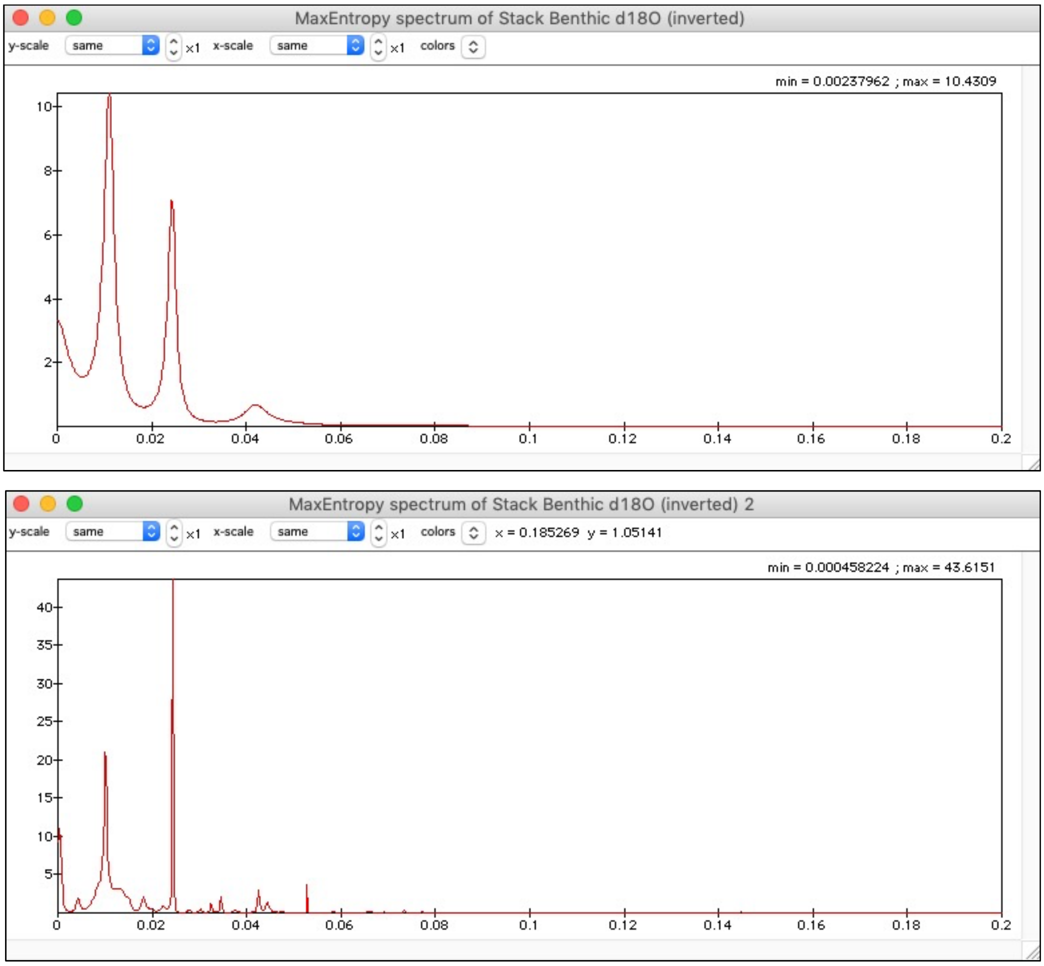

*Figure 8.25: Illustration of the **Max. Entropy** analysis applied to the Benthic $\delta^{18}O$ LR04 Stack (Lisiecki and Raymo, 2005) at low resolution in the upper panel and high resolution in the lower panel.*

The **MTM** (multi-taper method) function also allows the user to select the confidence level (resolution) independent of the power spectrum (Paillard, 1995). This method is better than other spectral analyses because it runs a statistical test, while allowing to select resolution (Yiou et al., 1994 and references therein). As well as for the three previous spectral analyses, by pressing **Math > MTM**, a dialog window will be opened to select the parameters of the **Spectral Analysis** (Figure 8.26).

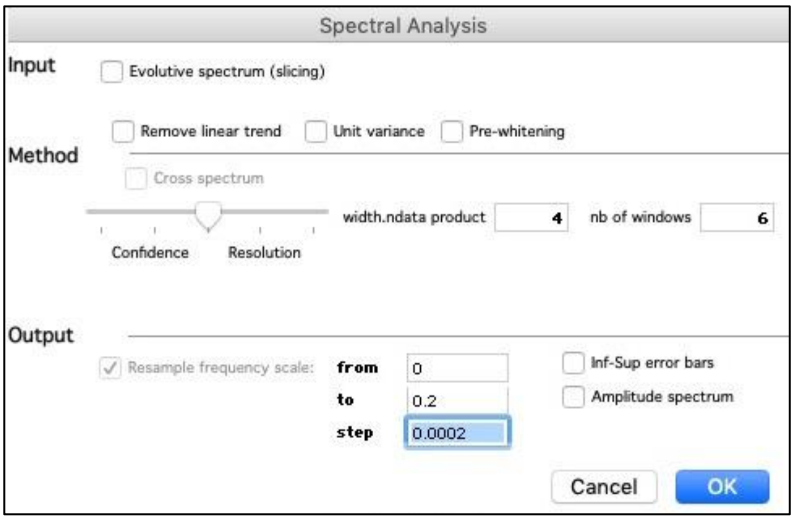

*Figure 8.26: Illustration of the dialog window of the **MTM** function.*

In this case, after pressing **OK**, two new series will be added to the worksheet, one with the **Spectral Analysis** (red curve in Figure 8.27), and one with its spectrum of significance (green curve in Figure 8.27). The latter correspond to a statistical test over the series, ranging between 0 and 1, with the values closer to 1 the more probable scenarios.

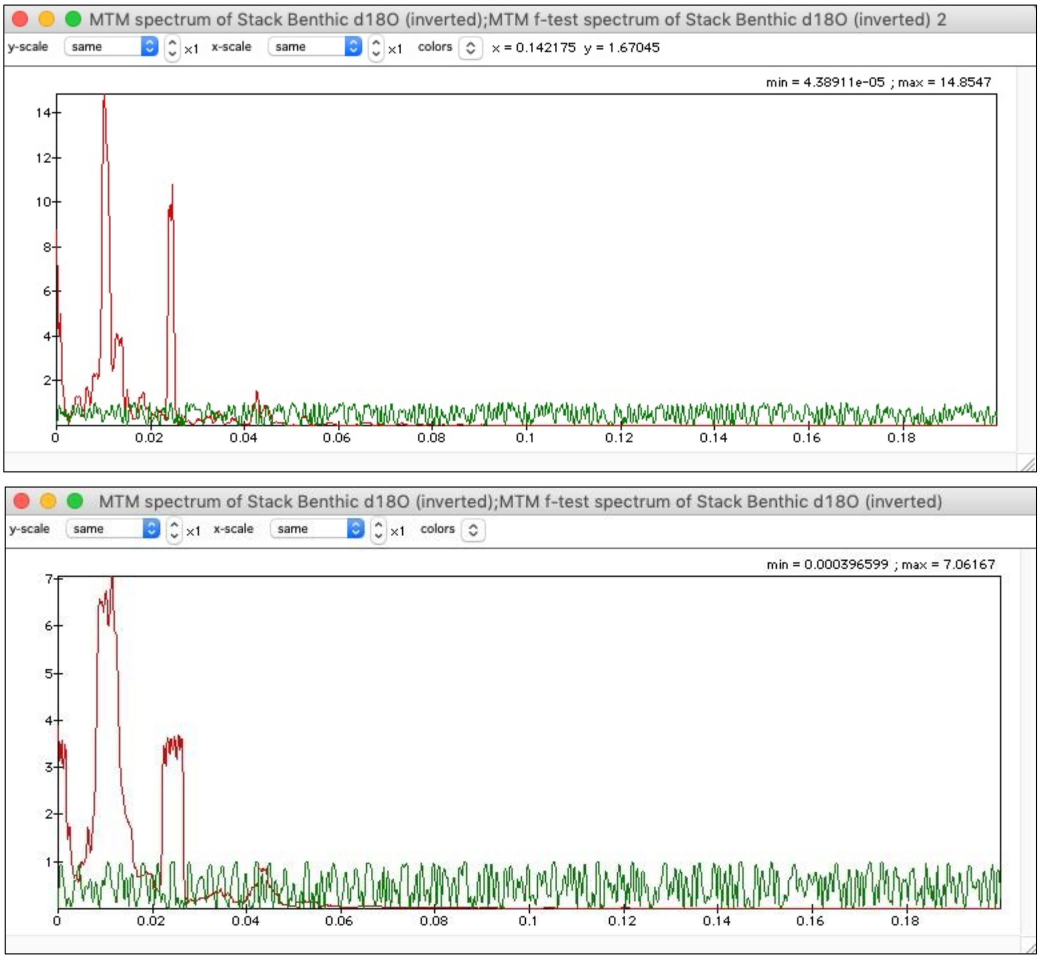

*Figure 8.27: Illustration of the **MTM** analysis applied to the Benthic δ^{18}O LR04 Stack (Lisiecki and Raymo, 2005) at higher resolution (narrower data) in the upper panel than in the lower panel.*

For all these methods, the generated series contain the information of the **Spectral Analysis**, which can be seen by double clicking on the generated series, by pressing **Command I,** or by opening **Edit > Get Series Info…**

8.4 Singular Spectrum Analysis (SSA)

Additionally, the **Math** menu counts with a Singular Spectrum Analysis function (Figure 8.1). This function allows the user to decompose the signal into principal components and then recompose them, but also to filter the signal and to examine the behavior of a particular component (Paillard, 1995, and references therein).

By opening **Math > SSA**, a dialog window will be opened, which allows to select the embedding dimensions, the type of autocovariance estimation, the number of principal components (PCs), and to include (or not) the Eigenvalues and PCs in the output series (Figure 8.28). After pressing **OK**, the new series will be added to the worksheet.

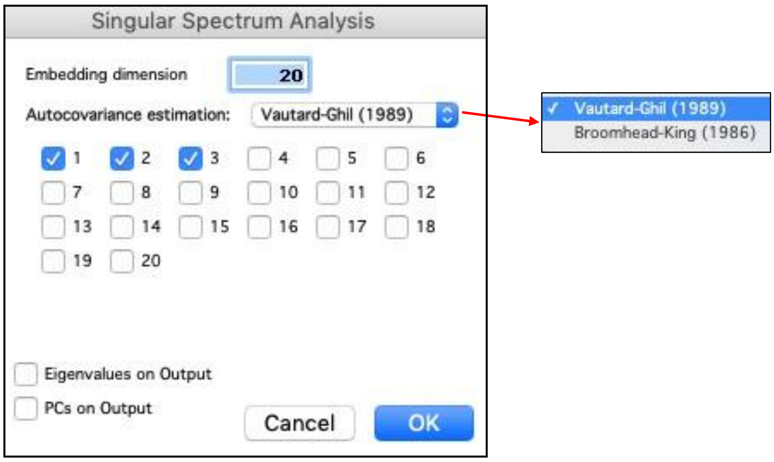

*Figure 8.28: Illustration of the dialog window of the **SSA** function.*

Figure 8.29 illustrates a drawing of the **SSA** applied to the reference Benthic $\delta^{18}O$ series.

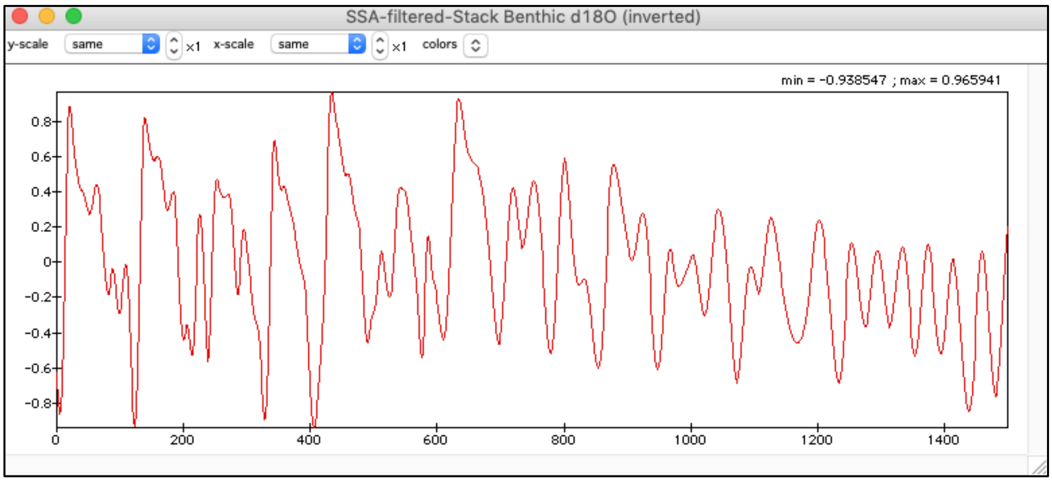

*Figure 8.29: Illustration of the **SSA** applied to the Benthic $\delta^{18}O$ LR04 Stack (Lisiecki and Raymo, 2005).*

If the Eigenvalues and PCs on the output options are selected in the **SSA** window of Figure 8.28, the respective series will also be added to the worksheet.

9 Windows menu

The content of this menu will vary depending on the number of windows being used. For example, if more than one worksheet is opened, a **Linage** is being done, and there is a **Draw** window opened, all of them will be available in the **Window** menu, in addition to the functions **Create New Group…** and **Show Clipboard** (Figure 9.1).

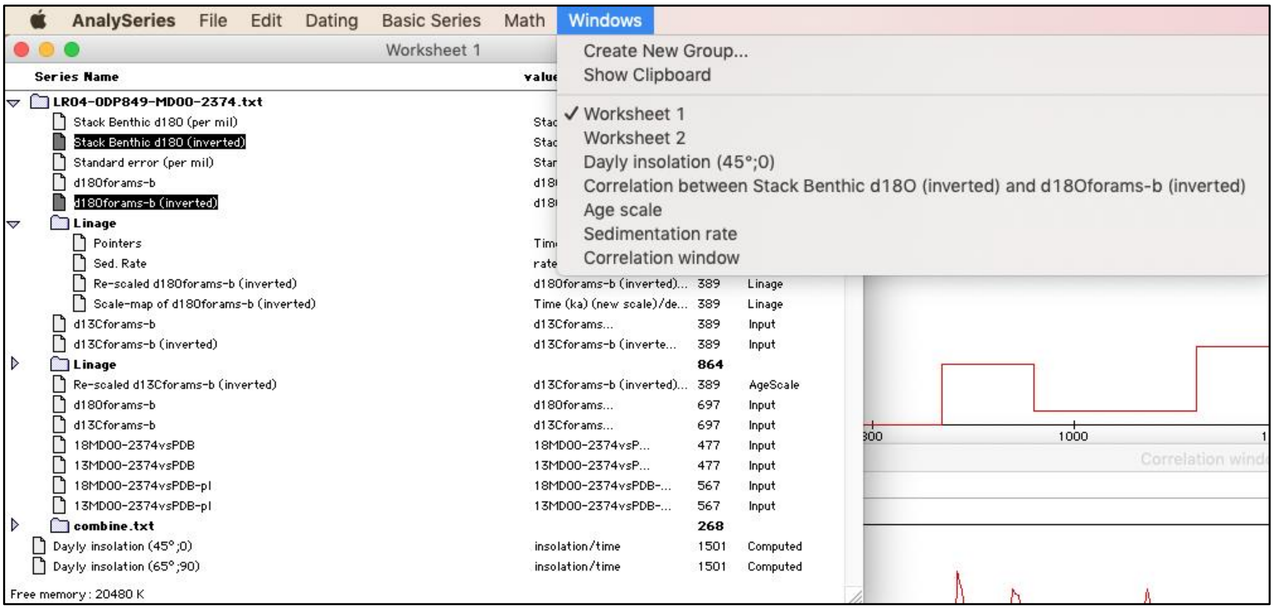

*Figure 9.1: Illustration of the different functionalities of the **Windows** menu.*

As their names indicate, the **Create New Group…** function (**Windows > Create New Group…**) allows to create a new folder (or group) on the worksheet, and the **Show Clipboard** function (**Windows > Show Clipboard**) opens a window containing the series that has been copied or cut.

10 Keyboard shortcuts

Command , : preferences

Command H : Hide AnalySeries

Command alt H : Hide Others

Command Q : Quit AnalySeries

Command N : New Worksheet

Command W : Close Linage

Command S : Save Worksheet

Command O : Open Data

^ N : Save Data

Command P : Print

Command Z : Undo

Command X : Cut

Command C : Copy

Command V : Paste

Command I : Get Series Info …

Command D : Draw

Command A : Select All

fn fn : Start Dictation

Command L : Linage

Command G : Next

Command R : Revert

Shift left mouse button : add tie point

Shift alt left mouse button : delete correlation line

Backspace : delete

11 Other versions of AnalySeries

There are several predecessors, and some successors, of version 2.0.5.2 used for this guide, but they are generally very similar, so this guide should include most if not all their functionalities. In the next section, we show some additional functions of version 2.0.8.

11.1 AnalySeries 2.0.8

This version of AnalySeries has almost the same functionalities as version 2.0.5.2 (used to write the present Users' Guide), except for the **Math** menu, which count with several new functionalities: **Select Parts**, **Histogram**, **Simple Function**, and **AM Filter** (Figure 11.1).

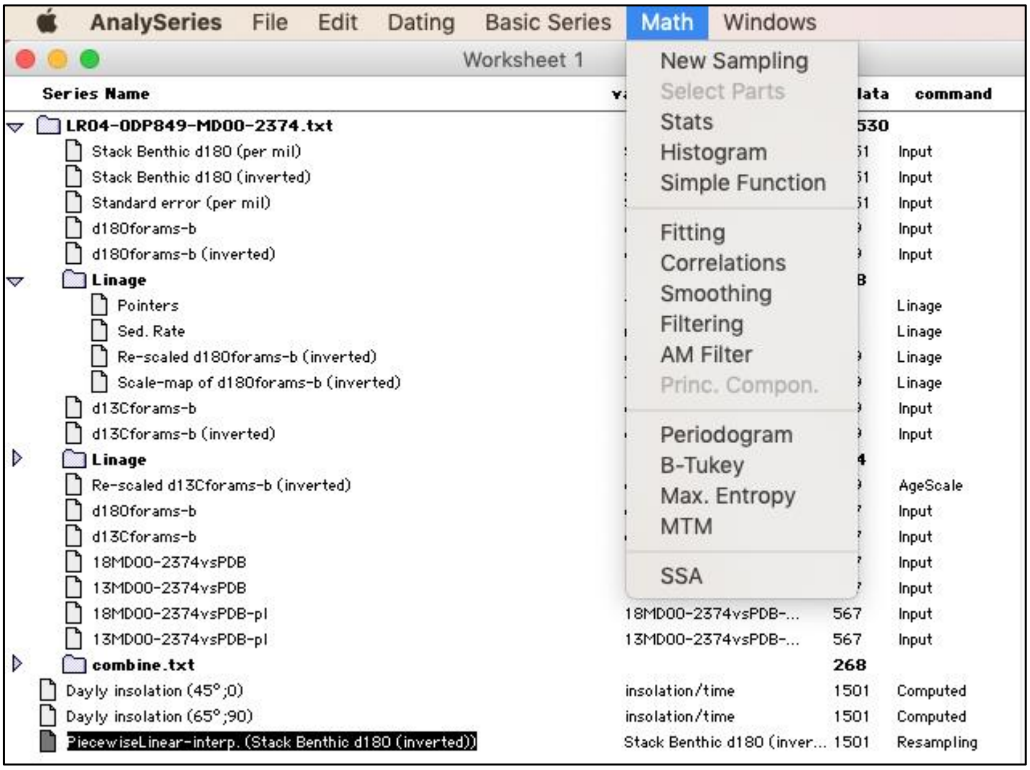

*Figure 11.1: Illustration of the **Math** menu of AnalySeries 2.0.8, showing more functionalities than the precedent version 2.0.5.2.*

The **Select Part** function allows, as its name suggests, to select a part of a time series. It requires two series to be selected, both with the same evenly spaced X-axis. If this is not the case, an alert window will pop up. By pressing **Math > Select Part**, a dialog window will be opened, allowing to select the series to be evaluated and the corresponding data series (Figure 11.2), as well as the part of the series that the user wants to select (e.g., Y larger, lower, or equal than a certain value, Figure 11.2).

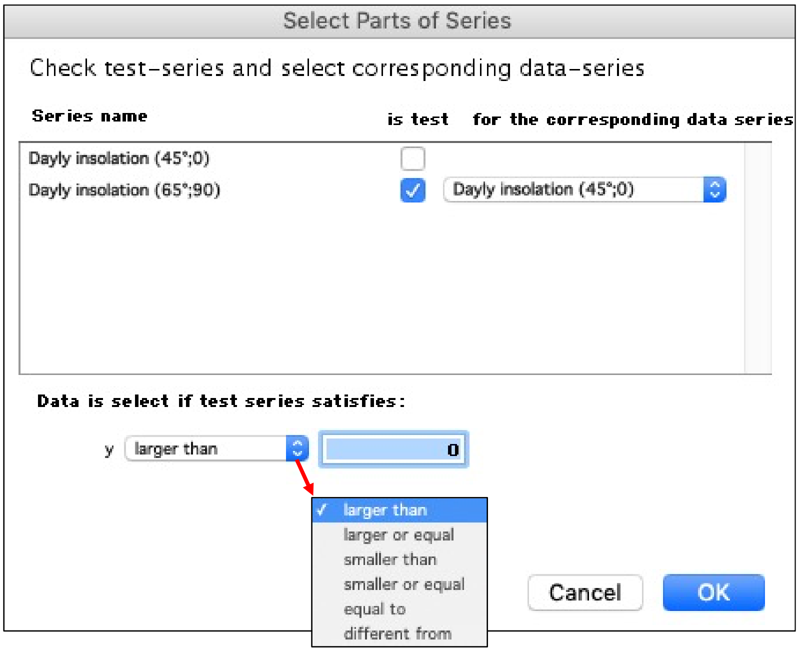

*Figure 11.2: Illustration of the dialog window of the **Select Part** function.*

After pressing **OK**, the new series will be included in the worksheet. Figure 11.3 correspond to the **Select Part** plot with the parameters of Figure 11.2. The upper segmented curve (of Figure 11.3) shows the part of the Daily Insolation (65°;90) series over the time intervals for which the Daily insolation (45°;0) series has Y-values larger than 300 (lower segmented curve of Figure 11.3).

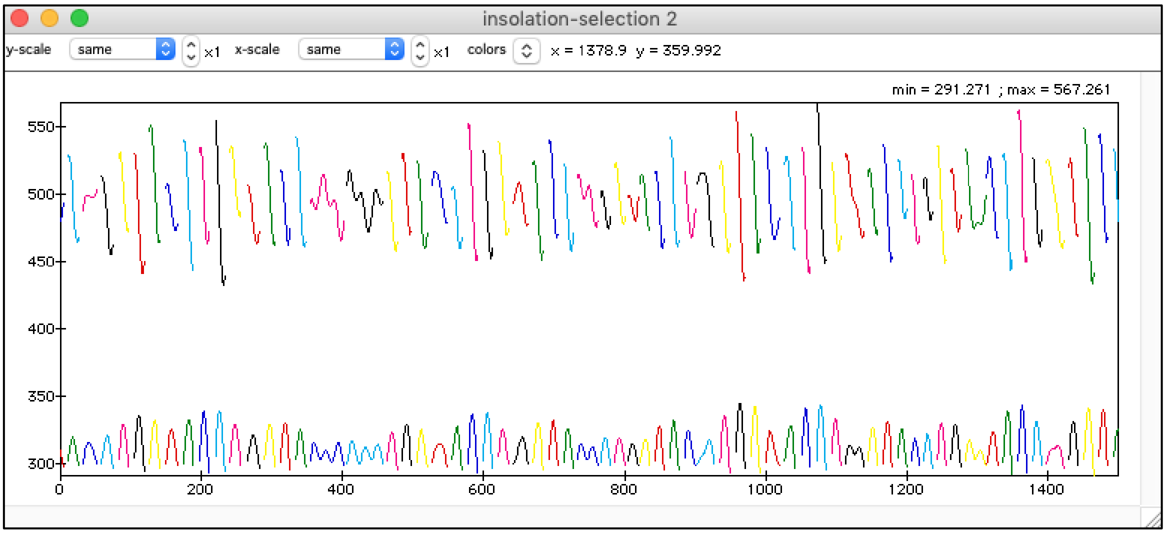

*Figure 11.3: Illustration of the **Select Part** function applied to both series of Figure 11.2. The lower segmented curve corresponds to the series of Daily insolation (45°;0) with Y-values larger than 300, and the upper segmented curve corresponds to the series of Daily insolation (65°;90) over those same time intervals.*

The **Histogram** function, as its name indicates, generates a histogram based on a data series. By pressing **Math > Histogram**, a dialog window will be opened (Figure 11.4), which allows to select different options for the histogram, such as the data range, step, filter size, enable or not the resample, cumulate across series, 2D output, and to choose between cumulative probability, probability density (as in Figure 11.4), or specific values. If the latter is selected, the specific values can be selected, as illustrated in Figure 11.5.

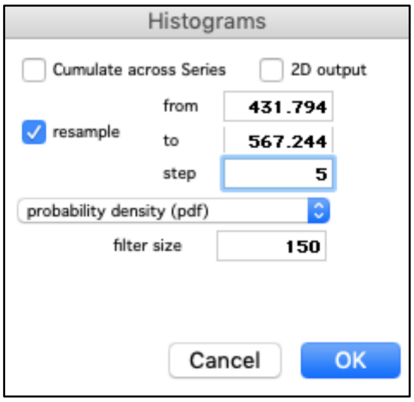

*Figure 11.4: Illustration of the dialog window of the **Histogram** function.*

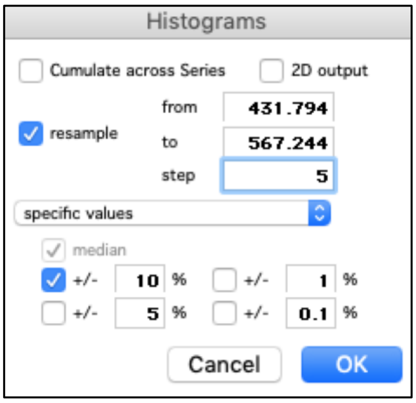

*Figure 11.5: Illustration of the dialog window of the **Histogram** function with specific values selected.*

After pressing **OK**, a new dataset will be added to the worksheet. Figure 11.6 illustrates a histogram of a daily insolation dataset, with the options shown in Figure 11.4.

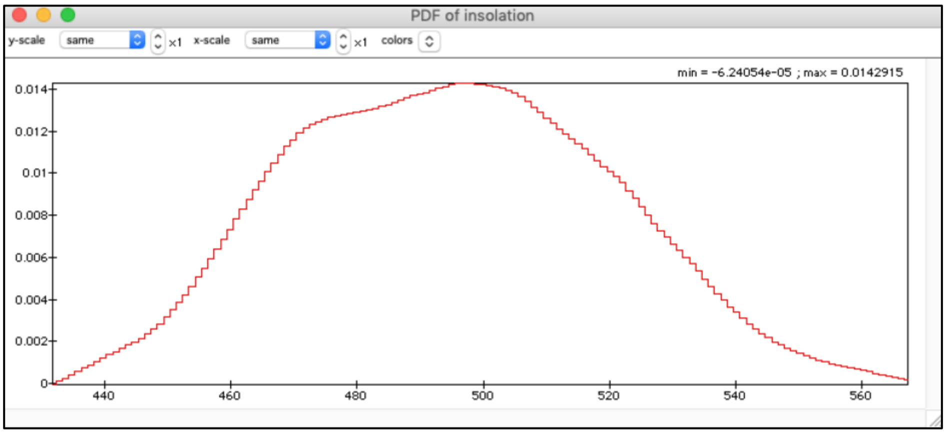

*Figure 11.6: Illustration of the **Histogram** generated for a daily insolation series with the options of Figure 11.4.*

The **Simple Function** allows the user to apply simple functions, such as addition, subtractions, and multiplications, to a time series. By pressing **Math > Simple Function**, a dialog window will be opened, in which it is possible to select a series of options and parameters for the function to be applied (Figure 11.7).

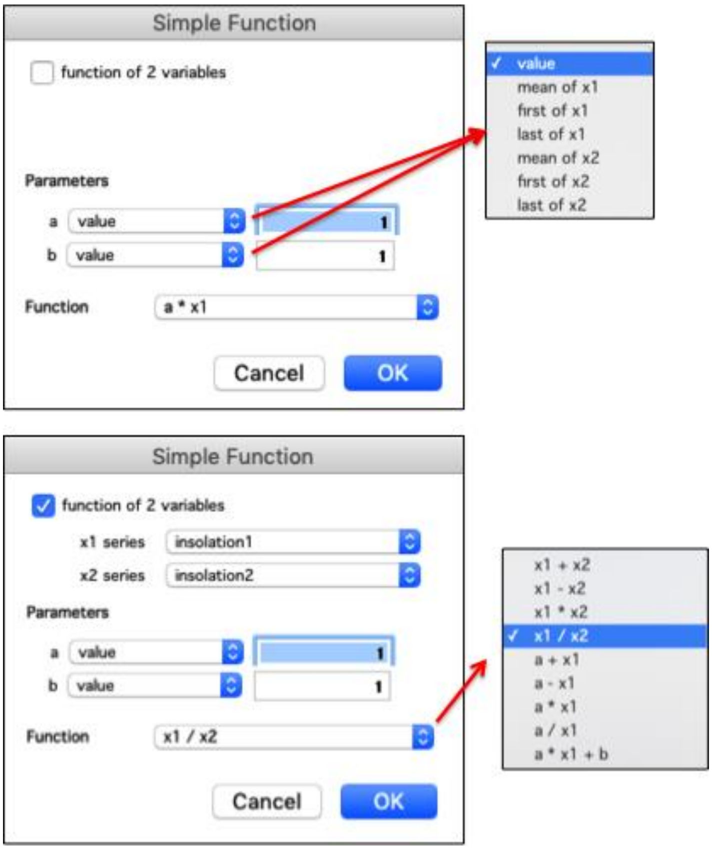

*Figure 11.7: Illustration of the dialog window of the **Simple Function**.*

Figure 11.8 shows the **Simple Function** using the parameters of the upper panel of Figure 11.7 applied to the histogram series previously generated (the one drawn in Figure 11.6).

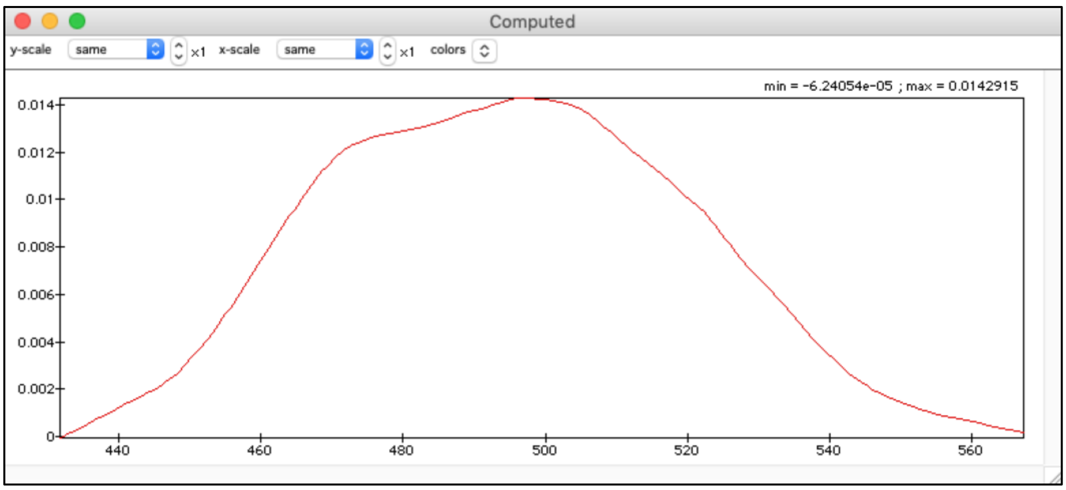

*Figure 11.8: Illustration of a **Simple Function** (a*x1 with a = 1) applied to the **Histogram** previously generated for an insolation series.*

It is also possible to apply this function to more than one series. To illustrate this, the lower panel of Figure 11.7 shows the parameters for a **Simple Function** consisting of the division of two insolation series at different dates and latitudes over the past 1500 kyr. The resulting series draw is shown in Figure 11.9.

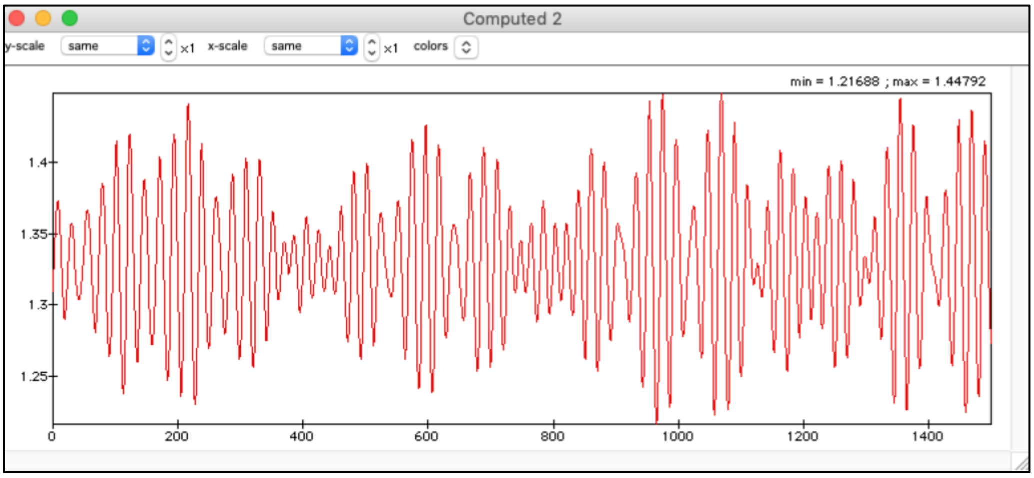

Figure 11.9: Drawing of a ***Simple Function*** *(x1/x2) applied to two insolation series.*

The **AM Filter** function automatically generates a smoothed curve of the original dataset and adds the newly created series to the worksheet. Figure 11.10 illustrates the drawing of an **AM Filter** (green curve) applied to the reference dataset of Benthic $\delta^{18}O$ (red curve).

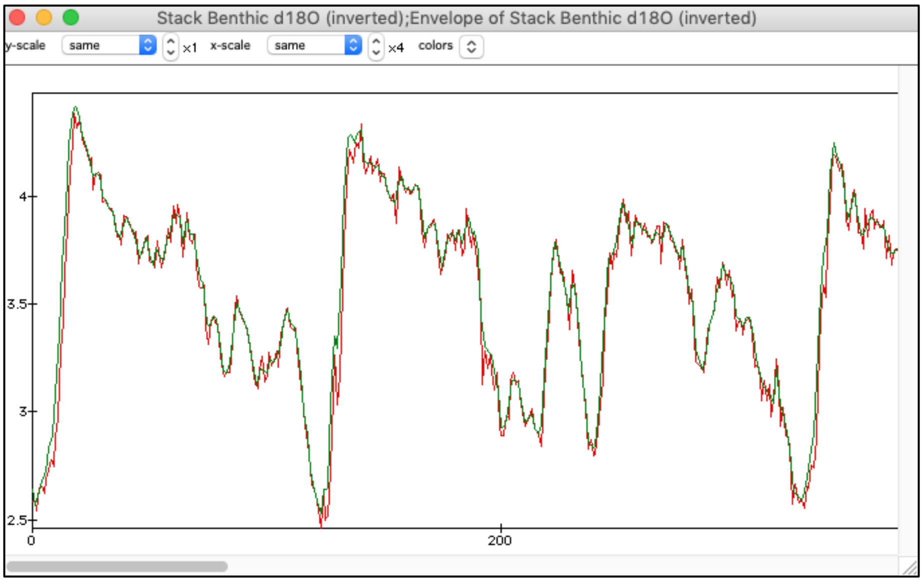

Figure 11.10: Illustration of an ***AM Filter*** *(in green) applied to the reference Benthic $\delta^{18}O$ LR04 Stack (in red; Lisiecki and Raymo, 2005).*

Finally, this AnalySeries version allows to change the scale both axes from linear to logarithmic, which is particularly useful for the visualization of the spectral analyses. For example, Figure 11.11 correspond to the same spectral analysis than that of Figure 8.23, but with logarithmic scale on its Y-axis. It can be seen than the vertical dispersion is much lower in the case of Figure 11.11 (with logarithmic scale).

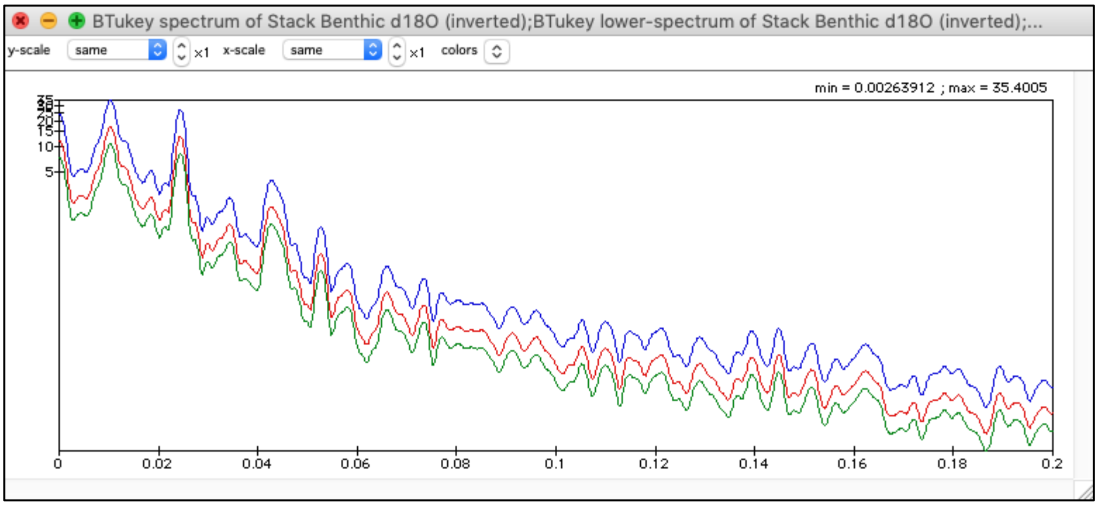

*Figure 11.11: Illustration of the **B-Tukey** analysis applied to the Benthic $\delta^{18}O$ LR04 Stack (Lisiecki and Raymo, 2005) and both the inferior (green) and superior (blue) envelopes of the error bars at the confidence level previously chosen. The scale of the vertical (Y) axis is logarithmic, which is the only difference with Figure 8.23.*

11.2 AnalySeries 3.0 on Java for Mac and Windows

There is a version of AnalySeries written in Java, which works in both Windows and Mac operational systems. This program was written by Roberto Theron, who succeeded in writing several central functions of the original AnalySeries. Nevertheless, it has important limitations compared to its predecessor. In this chapter, we will briefly present a list of the principal differences and problems found while working with AnalySeries 3.0.

1. To install it, make sure you have installed Java. AnalySeries does not require to be installed and can be directly run.

2. To add tie points while using the function **Linage**, the user has to press **Shift A left mouse button**; the keys **Shift D left mouse button** are used to delete tie points.

3. It is very hard to add tie points, as the mouse must be very close to the graphical curve in the **Linage** graphic. As seen in the upper graphic of Figure 11.12, in the first ascending part of the plot, a small cross shows up while adding a tie point, for which the mouse cursor has to be very precisely placed over the curves. Thus, it requires much more time to make a good correlation in AnalySeries 3.0 than in the precedent (C++ written) versions.

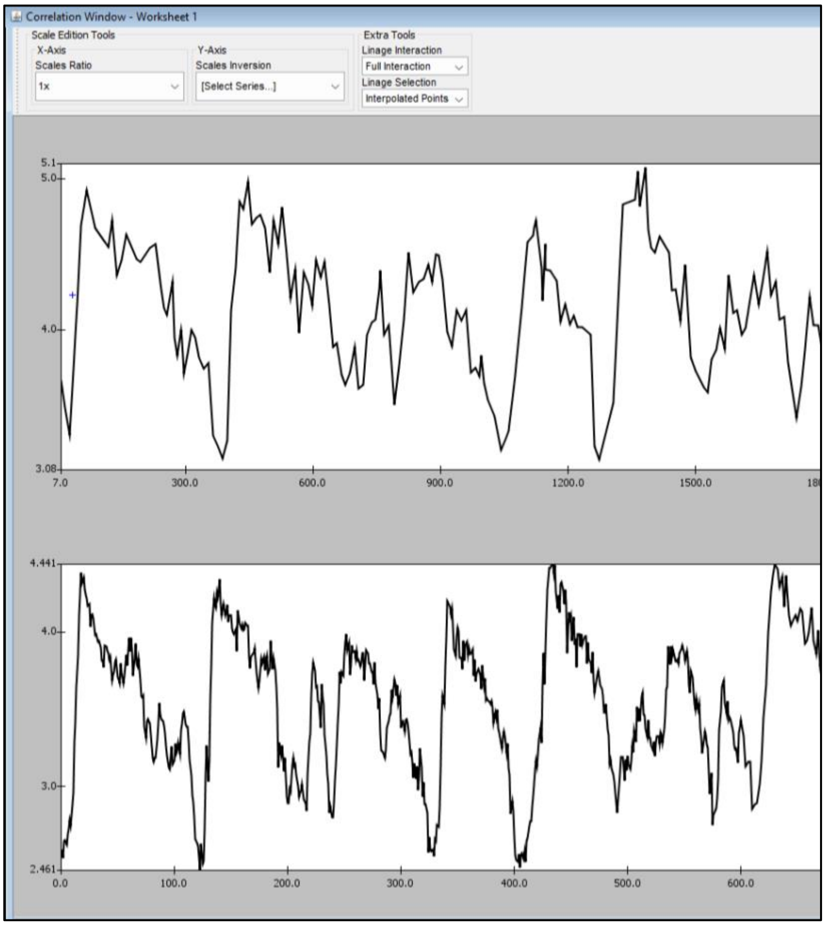

Figure 11.12: Part of the correlation window of the Linage function of AnalySeries 3.0 written in Java and used in a Windows operational system. In the upper curve, a little blue cross indicates the position of the mouse, where the tie point is being added.

4. It does not handle series with replicates (see chapter 4.4). They can be opened, but they are not averaged as in the original AnalySeries.

5. There are several functions that do not work on Windows, such as **Age Scale**, **Splinage**, **New Sampling**, **Fitting**, **Princ. Comp.**, as well as all the Spectral Analyses and the global ice volume reconstructions.
6. It is not possible to work with time series with more than two columns. Consequently, the **Switch to** function does not work either.
7. On Windows, it has no keyboard shortcuts and it is not possible to delete a series from the worksheet. The only way is to delete the last series added, by pressing Edit > Annuler Insert.
8. After adding several (a lot of) tie points, the **Linage** function might bug, decoupling some of the tie points previously added.
9. It has problems to create insolation series: when creating an insolation curve according to Laskar et al. (2004) it uses the solution of Berger (1978), and vice versa.

Besides all these limitations, AnalySeries 3.0 allows to correlate time series and to assign an age model to an undated paleoclimatic archive.

12 Additional resources and contact information

For more information on how to use AnalySeries effectively, we recommend joining our community forum to connect with other users and exchange tips and tricks at https://github.com/PaleoIPSL/Original-AnalySeries/discussions.

If you encounter any issues while using AnalySeries, please share it at https://github.com/PaleoIPSL/Original-AnalySeries/issues clearly indicating the problem and its context. You can also visit our Forum for additional support resources, information, and exchange with other users. If you have further questions, feedback, or concerns, please don't hesitate to contact our support team at https://github.com/orgs/PaleoIPSL/people. We're here to help you make the most of your AnalySeries experience!

13 References

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