

Oriana

Version 4

Users' Manual

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1 Introduction

Welcome to the manual for Oriana, the circular statistics program for Windows. This manual will explain how to use the program, what each menu item does, and gives some background about the statistical analyses and graphs.

The first section, entitled Getting Started, explains the structure of the program, while the second is a tutorial. To get the most out of the program you should work through the samples in the tutorial.

Throughout the text you will encounter symbols like this: . These symbols are page references. They point you towards the section of the manual that gives you more information about the term or concept that you have just read.

We hope that you find Oriana useful.

Suggested Citation

If you have used Oriana in study that you are publishing, the following is a suggested format for the citation:

Kovach, W.L., 2011. *Oriana – Circular Statistics for Windows, ver. 4*. Kovach Computing Services, Pentraeth, Wales, U.K.

We are always interested to see how Oriana is being used. We would appreciate receiving reprints of any papers you have published in which Oriana was used for data analysis. Thank you!

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Note: Please see the technical support section of this manual before contacting us for technical support.

We also maintain a mailing list for notifying customers of new programs and other items of interest. It is a low volume list, with at most one or two messages a month.

To join the KCS-ANNOUNCE mailing list send an e-mail message to:

`listserver@kovcomp.com`

with the following text as the subject or first line of the body of the mail message:

`subscribe kcs-announce`

2 Getting Started

2.1 What is Oriana?

Oriana is a program for Microsoft Windows that analyzes orientations and other circular data. It will calculate a variety of the special types of statistics necessary for working with data measured in degrees, time of day or other circular scales. It will also graph the data in a number of different ways.

Oriana will calculate basic statistics^[63] such as the circular mean and median, various measures of circular dispersion such as mean vector length (r), concentration and circular variance and standard deviation, along with confidence intervals for the mean. A number of single-sample statistics are available for testing whether the data adhere to uniform or other distributions. There are also several multisample tests for determining whether two or more samples differ significantly from each other. Finally the program can calculate correlations between circular samples as well as between sets of circular and linear data.

A number of graph types^[79] are available for plotting the data. These include variants of the histogram for circular data, including rose diagrams, circular histograms, linear histograms and arrow plots, plus raw data plots and vector plots for circular data. There are also distribution plots for comparing data to theoretical distributions, Q-Q plots for comparing the distributions of two samples, and scatterplots for plotting circular as well as linear data.

Oriana has powerful data handling capabilities. It can work with a variety of circular data types^[13] in their native formats: these include angles, time, day of the week, month, day or week of the year, and compass directions. You can also include any type of linear numerical data (for example if you wish to record both wind direction and speed, or direction of movement of an animal and distance traveled), which can then be used in some of the graph types and in the circular-linear correlation. You can also include full dates (which can later be summarized into the various circular types) and labels for each observation. There is also a subgrouping data type which allows you to assign each data point to one of the groups you define, so that you can analyze each subgroup separately as well as all data together.

Data can be entered in a spreadsheet form, with separate columns for each set of data or each variable, as well as in the form of a frequency table. Data sorting, automated filling of data, and search and replace facilities aid in entry and maintenance of your data.

Oriana is designed to be as easy to use as possible and to be compatible with all your other Windows applications. It closely follows the modern Windows standards for menu structures and the behavior of the Windows elements. It also allows you to easily move data, results and graphs between Windows programs, so that you can paste data from another application into Oriana or transfer a table of results and a graph into your word processor. Oriana also tailors itself to the way you work, so that your favorite program options are saved automatically and reinstated later. You can also save whole sets of graphs and results using the KCS Desktop Metaphor^[4], allowing you to return to work at the point where you left off.

This program is meant to be a tool rather than a teaching program; this manual does not purport to teach you about circular statistics. You should make sure you understand the basic theory and assumptions behind the methods presented in this package. There are a number of good books and papers listed in the References^[158] section that will help you in learning about these methods.

2.2 KCS Desktop Metaphor

Oriana uses the KCS Desktop Metaphor. You can spread out your data, the statistical results and the graphs in front of you while you study them, just like paper on your desktop. Each “piece of paper” is collected into notebook-like windows, one for graphs and one for results. These have tabs to access each page. There is also a notepad window that allows you to keep notes about the analyses you are performing. All these windows are contained within the main Oriana program window and they all relate to a single data file.

The windows can each be resized, minimized, or moved around while you study them and generate new pages. Each page can then be printed and/or saved to a file if desired.



You can save your desktop to a file using the **File|Save Desktop** command; later you can restore it to the same state,

using **File|Open Desktop**, so each window is just where you left it with the same contents as before. You can continue working where you left off. Multiple desktops can be saved for different projects.

2.2.1 Windows

The Oriana desktop can have a number of different types of windows open at any one time. These types of windows have different appearances and characteristics, depending on their function. In most cases you need not worry about these differences. For example choosing the “Print” option will print the currently active window, no matter what type it is; you will notice no difference in the procedure.

The different windows automatically save their characteristics for future use. For example, if you resize the status window so that it is small and place it in the lower right corner, new status windows will always be that size and position. Other types of windows can have their own default size and placement.

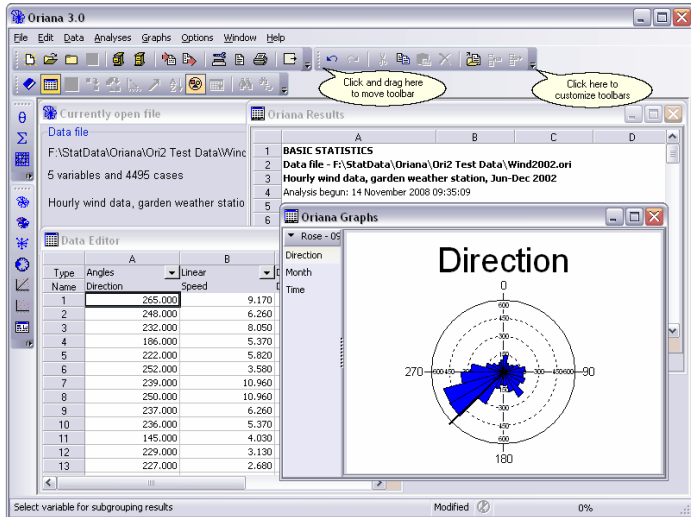
Similarly, each type of window has its own characteristic font  and each can be set up to print to a different printer. 

2.2.1.1 Main window

The Oriana program interface consists of a single main window (a so-called multiple document window). A number of windows can be displayed within this main window, as shown below.

All these windows relate to a single data file; if you wish to have data and results from a second data file on your screen you can run Oriana again to create a second main window.

The image below shows a typical layout of the main window during an analysis session.



Note that most of the commands from the menus are also represented as buttons on the toolbars at the top and left hand side in the image above. These toolbars can be customized to show just the buttons you want, and can be positioned anywhere you would like.

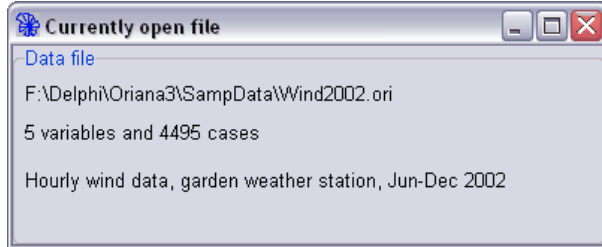
There are eight different toolbars that you can display, one for each top level item in the main menu. You can choose which toolbars to display by right clicking the mouse in an empty area next to one of the toolbars and clicking on the name of the desired toolbar. The buttons displayed on each toolbar can be customized by clicking on the downward pointing triangle on the right hand side of the toolbar, hovering the mouse over the “Add or Remove Buttons” item, then over the toolbar name. A list of all possible buttons for that toolbar will appear, with a checkmark next to those that are visible. You can then click on the items to check or uncheck the desired buttons.

The toolbars themselves can be moved around by clicking and holding the mouse on the bar at the left end of the toolbar (indicated above). The toolbars can be moved around to different positions at the top or left hand side of the main window, as shown above. They can also be placed on the right hand side or bottom of the window by dragging them to those positions. Finally you can drag the toolbar to float over the center of the window, or float outside of the window.

At the bottom of the window is the status bar that provides information about the program. The large section to the left displays hints, giving a fuller description of the menu item or toolbar button currently under the mouse pointer. It also describes the current status of the program when it is doing calculations or other long operations. The next section displays the word “Modified” if the contents of the window that is currently on top (the graph window above) have been modified. Next to this is a button that lights up when the program is doing long operations, such as loading large files or doing long calculations. You can stop the current activity by clicking on this button. Finally there is a progress bar that indicates how much of the current operation has been completed.

2.2.1.2 Status window

The status window is opened every time a data file is opened. It displays some information about the file: its name and title, the number of variables and cases, the current subgrouping variable and defined vector pairs (if any), and the descriptive title. Closing this window causes the data file and all other associated files to be closed.



2.2.1.3 Data editor

This window is a spreadsheet that allows you to edit^[34] your data. The variables are displayed as columns, with the observations for each sample filling the rows. Each column can have different numbers of observations.

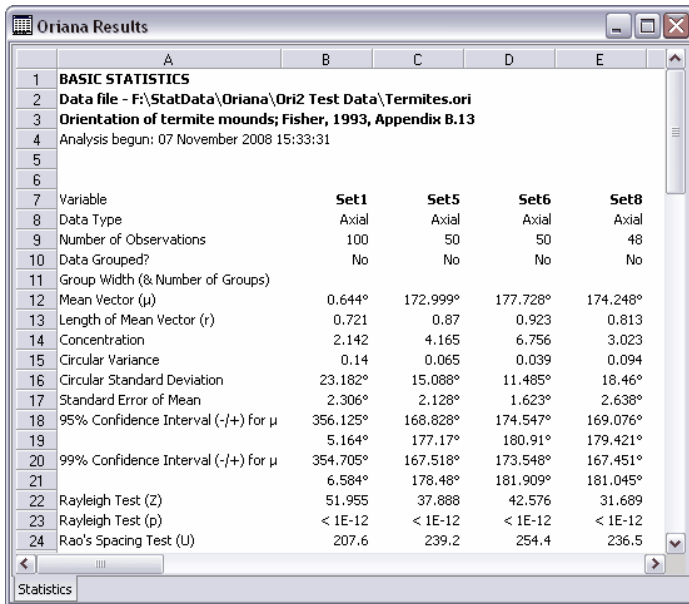
Type	Angles	Linear	Date	Month of year
Name	Direction	Speed		Month
1	265.000	9.171	15/06/2002	June
2	248.000	6.263	15/06/2002	June
3	232.000	8.053	15/06/2002	June
4	186.000	5.369	15/06/2002	June
5	222.000	5.816	15/06/2002	June
6	252.000	3.579	15/06/2002	June
7	239.000	10.961	15/06/2002	June
8	250.000	10.961	15/06/2002	June
9	237.000	6.263	15/06/2002	June
10	236.000	5.369	15/06/2002	June
11	145.000	4.026	15/06/2002	June
12	229.000	3.132	15/06/2002	June

The first row, headed **Type**, displays the data type for that column. You can change the type of the data by simply clicking on the down arrow labeled “Change data type” above.

The data are displayed in a format that matches the data type [12]. You can adjust certain aspects of the format, such as number of decimal places or whether seconds should be displayed, through the **Options/Preferences** [149] dialog box. The display of certain data types, such as date or Day of Week, will be displayed in your local format and language, as set up in the Windows Control Panel.

2.2.1.4 Results window

The results of the statistical analyses are displayed in a tabular format in the Results window. This is basically a spreadsheet and works in a similar way to the Data Editor, except that you cannot change any of the values. Also this single window can contain the results of many different analyses, each on different pages. You can select the page you wish to view by clicking on the tab along the bottom. Double-clicking the tab lets you change the text on the tab.



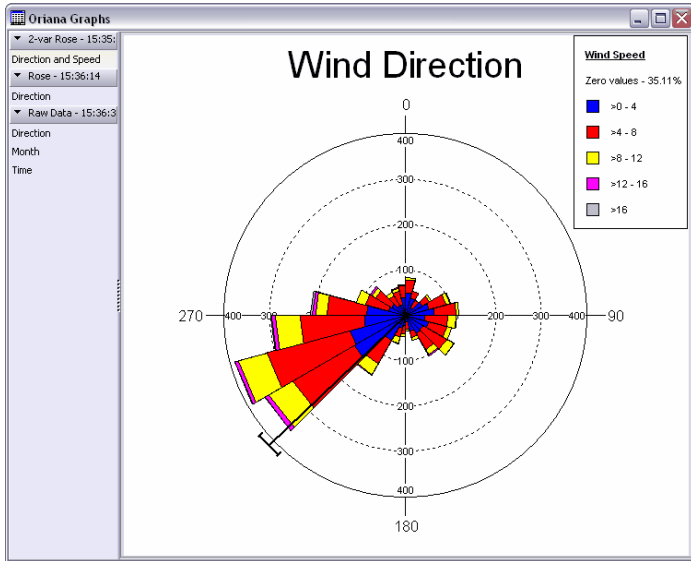
	A	B	C	D	E
1	BASIC STATISTICS				
2	Data file - F:\StatData\Oriana\Ori2 Test Data\Termites.ori				
3	Orientation of termite mounds; Fisher, 1993, Appendix B.13				
4	Analysis begun: 07 November 2008 15:33:31				
5					
6					
7	Variable	Set1	Set5	Set6	Set8
8	Data Type	Axial	Axial	Axial	Axial
9	Number of Observations	100	50	50	48
10	Data Grouped?	No	No	No	No
11	Group Width (& Number of Groups)				
12	Mean Vector (μ)	0.644°	172.999°	177.728°	174.248°
13	Length of Mean Vector (r)	0.721	0.87	0.923	0.813
14	Concentration	2.142	4.165	6.756	3.023
15	Circular Variance	0.14	0.065	0.039	0.094
16	Circular Standard Deviation	23.182°	15.088°	11.485°	18.46°
17	Standard Error of Mean	2.306°	2.128°	1.623°	2.638°
18	95% Confidence Interval (-/+ for μ)	356.125°	168.828°	174.547°	169.076°
19		5.164°	177.17°	180.91°	179.421°
20	99% Confidence Interval (-/+ for μ)	354.705°	167.518°	173.548°	167.451°
21		6.584°	178.48°	181.909°	181.045°
22	Rayleigh Test (Z)	51.955	37.888	42.576	31.689
23	Rayleigh Test (p)	< 1E-12	< 1E-12	< 1E-12	< 1E-12
24	Rao's Spacing Test (U)	207.6	239.2	254.4	236.5

The contents of this window can be saved using the **File|Export** menu item when the window is the active window. The results are written to the file in a tab-delimited plain text (i.e. ASCII) format that can be read into any other program. The columns will be separated by tabs, so that the alignment will be preserved in any program that can interpret these tabs to form a table.

2.2.1.5 Graph windows

The graph window displays all the graphs so far produced, one on each page. When you first create a graph^[47] you can change various settings that determine how the graph is drawn. You can then modify the appearance of the graph by choosing the **Graph|Edit graph**^[147] menu item, or by right-clicking on the graph and choosing **Edit Graph**.

The size of the graph can be changed by resizing the window. Some of the graphs have a fixed length/width ratio, but the shape of others can be adjusted by changing the shape of the window.



The navigation bar at the left side allows you to select which graph you would like to view. Each time you create a graph (or series of graphs) a bar is created giving the graph type and the time of creation. Below this is one or more tabs labeled with the variable(s) used in the graph. If more than one graph is created (because you either have multiple variables selected or you are using subgroups) then these all occur grouped together under the same graph type bar. You can show or hide the individual tabs under each bar by clicking on the downward pointing black triangle on the left hand side of the bar.

If you click the right mouse button over this navigation bar you will see a menu with the options **Open all** (to open up all the bars to show all the tabs) and **Close all** (to close all the bars so all tabs are hidden). There are also options to delete the graph page corresponding to the tab clicked, and to delete the whole group of pages clicked. Right clicking on the graph itself will give a menu with the option to delete that graph.

A graph can be saved to disk, for transfer to another program, using the **File | Export** (97) command. When the contents of this window are saved they are written to the file in one of several graphic formats:

- Bitmap (BMP), Portable Network Graphics (PNG), GIF and

JPEG (JPG) formats save the graph as individual pixels. The resolution is limited to what you see on the screen. Note, though, that the graph is saved at its current size, so if you want a larger bitmap with higher resolution and fewer jagged edges, increase the window to its maximum size. This format can be edited in a painting type of program (such as the Paint program included with Windows), but only on a pixel by pixel basis.

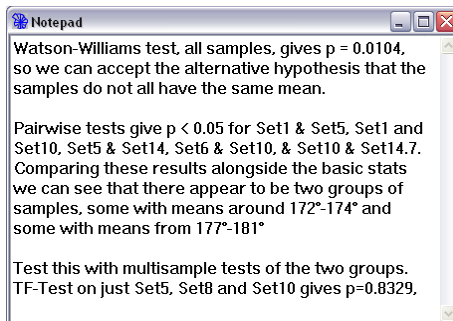
- The metafile formats (EMF and WMF) saves the graph as a vector based drawing. This means that the graphic elements, such as lines and circles, are saved as descriptions of those elements rather than as a collection of pixels. Thus the graph can be resized or printed in another program at the highest resolution available. Also, the graph can be modified in a vector-based drawing package. This would allow you, for instance, to change the dashed line to a dotted one or change the text of the labels.

The format used for saving the file is specified using the **List Files of Type** option on the **File | Export** dialog box.

A graph can also be transferred to another program using the Windows clipboard. Just choose the **Edit | Copy** menu item when the graph window is the active window. You can then switch to another program and use **Edit | Paste** to make the transfer. Oriana places both bitmap and metafile versions of the graph on the clipboard, so you can paste either one into your other program.

2.2.1.6 Notepad

The Notepad window provides a space for you to make notes about the analyses you've done and any trends you've noticed. It is a simple text editor with word wrap.



You can open and close the window through the **Window|Show Notepad** menu option. The text in the window is retained even if you close it, so it reappears when you reopen the window (note, however, that it is cleared when a new data file is loaded or created). The text is saved to the desktop file so that it can be reinstated later when you reload the desktop.

The text in the Notepad can be printed (through **File|Print**) or copied to the clipboard (**Edit|Copy**) for transfer to another Windows program. You can also export the results to a text file, using **File|Export**, for importing to other programs.

2.3 Oriana Concepts

The following section describes some of the basic concepts behind Oriana's data handling.

2.3.1 Circular Data

Oriana is designed to analyze circular data. The fact that circular data are measured on a closed, cyclical scale means that most of the more common types of statistical analyses are unsuitable. Oriana performs analyses designed specifically for circular data.

Many different types of data are circular in nature. Directional or orientation data, measured as angles in degrees, are the most common type. In this case the circular scale ranges from 0 to just less than 360 degrees.

Directional data can be of two types, unidirectional or bidirectional. These are also known as vectorial and axial respectively. Vectorial data consist of a directed line, such as direction of travel or the direction someone is facing. Axial data, on the other hand, consist of an undirected line; either end of the line could be taken as the direction. For instance, a horizontal fracture in a piece of glass could be interpreted as being oriented as either 90 degrees or 270 degrees. The way these two types of data are represented on a graph varies, so that they can be distinguished.

When axial data are analyzed, they are first converted to vectors by doubling each data value and reducing any greater than 360 using modulo arithmetic. The results will be converted back so that they will be in the range of 0-180 degrees.

There are other types of cyclical or circular data. Time of day is another common type; with values measured on a closed scale from 00:00 hours to 23:59 hours. Other variations on chronological data can also be analyzed as circular data (e.g. day of week, month of year, day of year, etc.)

Oriana has a wide range of native circular data types to match the data with which you are working. There are also several other non-circular data types for associating other data, such as text labels or data measured on a linear scale, with your circular data. You can find a summary of the data types in the section entitled Oriana Data Types^[13].

When you create a new data file^[29], you specify the type of data for each variable. You can later change the type of data in a variable using the **Data|Change data type**^[107] menu option.

2.3.2 Oriana Data Types

Each variable in an Oriana file is declared as one of 12 data types. These determine the type of data that can be entered in the data editor. The editor will restrict entry so that only valid data can be entered. It also provides assistance in entering the data, such as automatically entering the separators for times and dates, or allowing you to enter day and month names from a drop-down list or by typing just the first one or two letters.

The data types will also dictate how the data are handled during analyses and graphing. For example, some data types are inherently grouped (see section on Grouped Circular Data^[26]). Oriana will automatically adjust graphs such as the rose diagram to reflect the group width of the data (e.g. Month of Year data will have 12 segments in the diagram, each 30° wide). Some analyses cannot be reliably performed on grouped data, and others must be adjusted to work properly, so Oriana takes this into account.

Variables can be changed^[59] between one type and another, but data that do not fit into the range and assumptions of the destination type may be lost or converted to nonsensical values.

The characteristics of the different variable types are listed below.

Angles

This is the basic circular type, where data are measured within the range of 0° - 360° . The data editor will not allow any values outside of this range to be entered.

Occasionally researchers find it useful to measure angles as a deviation from a home direction. So, for example, if the expected direction of travel is 0° , and one subject travels 10° to the left, then a value of -10° would be recorded. The Oriana Angles variable type will not allow negative numbers to be entered. However, you can get around this by entering the data into a Linear variable (described below), which will accept negative numbers. Once all data have been entered you can change the variable type^[59] to Angles. Any negative numbers will be converted to the appropriate degrees (e.g. -10° will become 350°).

Axial

This is similar to the Angles type, but the data are bidirectional rather than unidirectional, as discussed in the Circular Data^[12] topic above. Data can still be entered in the full 0° - 360° range, but when analyses are performed the data are doubled and then back converted, so that they are within the range of 0° - 180° .

Circular Proportional

This is also similar to the Angles type, but instead of entering data in the range of 0-360 the data are entered as a proportion of the whole circle, ranging from 0-1. So a value of 0.5 would be the same as 180° . The range of 0-1 is also used for labeling graphs and output.

Circular Percentage

This is like Circular Proportional, but the data are on a percentage scale ranging from 0-100.

Compass Direction

This data type presents angular data as directions of the compass. Data are entered into the editor as letters indicating the direction (e.g. N for North, SW for South-west, NNE for North-north-east, etc.). You can use up to 16 compass points (including the three letter ones such as NNE) or restrict the data to the four or eight main points (e.g. N or SW). Oriana will automatically detect which you are using and adjust the histogram bar widths and chi-square class widths accordingly.

The underlying data are still angular, and all calculations are performed on and reported as angles. For mean and median directions the corresponding compass direction is also reported. The actual angle stored is the midpoint of the compass sector, so North would be 0°, East 90°, South-east 135°, etc.

You can customize the abbreviations used for compass points (e. g. NNE) to match your own preferences or local language through the **Options | Preferences** ^[149] menu item.

Time

The Time data type presents the circular data as time in hours, minutes and seconds on a 24 hour scale. The data can range from 00:00:00 to 23:59:59 (or 12:00:00 AM to 11:59:59 PM). The format used to display the time depends on the settings in the Windows Control Panel.

As with other circular data, the data are stored as angles. However, the mean and median times and the confidence limits are reported as time values.

Day of Week (DOW)

This circular type divides the 360° range into 7 groups, representing the seven days of the week. The order of the days follows the ISO 8601 ^[160] international standard, where Monday is the first day and Sunday the last.

As with other circular data the underlying data are in angles, with the midpoint of the sector being the angle stored. Each sector is $360/7$ or approximately 51.4286° wide, so the first day has an angle of around 25.7143° , and day 7 is ca. 334.2857° . Means and medians are reported in angles, but the associated DOW is also reported. The actual text displayed in the results, graphs and data editor are in the user's local language, as set up in the Windows Control Panel, so Monday is displayed for the first day in English, *Lunes* in Spanish, etc. Currently Oriana cannot properly display day names that do not use the Roman alphabet.

Month of Year (MOY)

This data type works in a similar way to DOW, except it is divided into 12 groups for the months of the year, with January first and December last. Each sector is 30° wide, with January being 15°, February 45° and December 345°.

Day of Year (DOY)

This circular type stores the numeric day of the year, ranging from 1 to 365 (or 366 for leap years), with day 1 being 1 January and day 365 (or 366) being 31 December. They are actually entered into the data editor as numbers, and the results are reported as angles (although, as with DOW and MOY the equivalent numeric Day of Year is also reported for means and medians).

By default all analyses assume that there are 365 days in the year, so that each day represents 0.9863° of the circular range. Thus Day 1 would be represented by the midpoint of the sector, 0.49315° . However, if you enter any values of 366 then that is taken as the range, and each day represents 0.9836° . Day 1 would then be 0.4918° .

Week of Year (WOY)

This data type works in a similar way to DOY, with the circular range divided into either 52 or 53 weeks. The calculation of WOY follows the ISO 8601^[16b] international standard. This states that a week is a seven day period, beginning on Monday. The first week of the year is that which contains the first Thursday of the year. This means that Week 1 could contain some days from the end of the previous year; 31 Dec. 2002 was actually in Week 1 of 2003. Likewise, the last week of a year can contain some days from the next year; 1 Jan. 2000 was in week 52 of 1999.

The above standard means that, although we normally think of a year as having 52 weeks, some can actually have a 53rd week. The dates 27 Dec. 2004 to 2 Jan. 2005 were week 53 of the year 2004.

If the data you enter into a WOY variable range from 1-52 then each week represents 6.9231° and Week 1 is 3.4615° . If any week numbers of 53 are included then each week is 6.7924° wide and Week 1 is 3.3962° .

Lunar

This data type is designed for people working with data that might be related to the phases of the moon (e.g. laying of eggs by turtles). The data are entered as dates (see the entry below for the Date variable type for comments about the format). However, when circular statistics are calculated or circular graphs produced these dates are converted into angular data by

calculating the length of the lunar month and the day of the lunar cycle. For example, a date of 3 April 2011 will be plotted on a circular histogram at the top, in the 0° position, since that is the date of a new moon, and 18 April 2011, a full moon day, will be at the 180° position.

Note that all dates are based on the Gregorian calendar, in accordance with ISO standard 8601^[160]. This is the calendar that was adopted in 1582 by the Vatican and many Catholic countries, 1752 by the British Empire, 1918 in Russia, and numerous other dates in other countries around the world. If you are working with dates that were recorded under the Julian calendar before these years they will need to be converted to the Gregorian calendar for the moon phase to be calculated correctly. This can be done by adding a certain number of days depending on the date range. A table in the Wikipedia topic on the Proleptic Gregorian Calendar gives the required number of days.

Note too that you can specify the time zone in which the lunar dates were recorded. The exact point in time at which the moon phase becomes new or full is the same all over the world, but because of differing times zones the clock time and perhaps the date will be different. For example, a new moon occurred on 4 March 2011 at 20:46 UTC. Thus the date of the new moon would have been 4 March in Great Britain. However, when that new moon occurred it was 07:46 on 5 March in Sydney, Australia. The difference in dates can affect how graphs are drawn and statistics calculated.

By default Oriana will use the time zone specified in the Windows system on which it is running (which can be changed through the Control Panel or the clock on the Task Bar). If you are regularly analyzing data from a different time zone you can change the zone that Oriana will use through the **Default Time Zone** option on the **Lunar Phases** tab of the **Options|Preferences**^[149] dialog. You can also change the time zone for individual variables through the **Data|Change Variable Type**^[107] dialog. The time zone for each variable is saved in the data file, so if you send the file to a colleague in a different time zone the original time zone will still be used.

The **Options|Preferences**^[149] dialog also allows you to customize the names used for different phases of the moon. These names are used on the graphs and the basic statistics

output.

Please note that no correction is made for local summer or daylight savings time differences when calculating the dates of the moon phases.

The remaining variable types are non-circular types. They can be used for labeling data cases, specifying subgroups, and providing linear data for correlation with the circular types.

Date

The Date variable type allows you to specify the date on which an observation took place. This could be auxiliary data, which allows you to group your circular data observations according to calendar periods. Or it could be your main data, which will later be summarized into circular types, such as days of the week or months of the year, then analyzed statistically and graphically.

The format of the date (including the order of the year, month and day portions) follows that specified as the short date format in the Windows Control Panel. Normally this would be an all numeric type such as 2003-05-27, 27-05-03 or 05/27/2003. Currently the data editor requires numeric format for direct data input. However, if you are pasting or importing data from another source that is in mixed format (such as 27 May 2003) Oriana will recognize this and convert it to numeric format.

Linear

The linear data type can be used to store any type of numeric data, both positive and negative. These data can then be plotted along with the circular data on the two-variable histograms, circular-linear plots or the two sample scatter plots, and compared to the circular data with circular-linear correlation.

When the linear variable represents the length of a vector (e.g. wind speed or distance traveled) then you can define an angle variable and a linear variable as a vector pair, through the **Data|Define Vector Pair** menu item. This allows you to calculate weighted mean values (where the mean angle is weighted by the length of the vectors) in the basic statistics, as well as add a weighted mean vector to circular plots.

This data type is also used for specifying the frequency of different values when data are being entered in a frequency table format^[22], and for specifying the r value when means and mean vector lengths are being input for second order statistical analysis^[76].

Labels

The label variable type can contain any type of text and is normally used for labeling cases to identify them.

Subgroup

This variable type is similar to the Labels type in that you can type any text into it. However, it is specialized to be used for dividing cases up into subgroups^[43], so that each subgroup can be analyzed separately. When text is entered into a Subgroup variable in the data editor that text is added to an internal list of possible subgroups. That list can be displayed by using the drop-down box that appears in every cell of a Subgroup variable. You can use this drop-down box to enter new data into empty cells, or to change that in existing ones.

2.3.3 Data Structure

Data within Oriana can be structured in several different ways.

Raw Data

The first is the one that was the sole method in version 1 of Oriana. Here each column in the data editor represents an independent collection of measurements. If all your data are repeated observations of a single type of object or event then you would have just a single column of data. Examples might include:

- Directions that pigeons fly after release
- Orientation of tool marks in sedimentary rocks
- Direction of wind at a single station
- Time of arrival of patients at the emergency ward of a hospital

You might also want to divide the data up into different groups so that you can compare the groups and look for similarities or differences. For example:

- Directions that pigeons fly from different release points

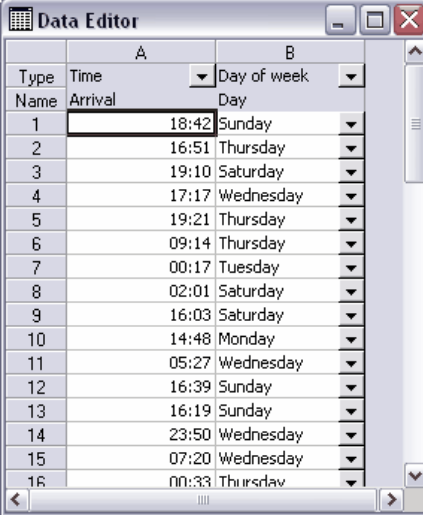
- Orientation of tool marks in different strata of rock
- Direction of wind in different months or seasons
- Time of arrival of emergency patients on different days of the week

In these cases you would have a separate column for data from each release point, strata, month or day. Here is an example of data of wind directions from each month. Notice that each column can have different numbers of observations.

Type	Angles	Angles	Angles	Angles	Angles
Name	January	February	March	April	May
52	3.000	303.000	200.000	205.000	
53	217.000	4.000	251.000	204.000	3
54	54.000	351.000	318.000	280.000	2
55	289.000	356.000	103.000	316.000	1
56	156.000	23.000	119.000	53.000	2
57	69.000	46.000	77.000	114.000	3
58	102.000	64.000	275.000	167.000	1
59	281.000	25.000	113.000	357.000	
60	100.000	243.000	129.000	52.000	2
61	188.000		200.000	187.000	1
62	342.000		128.000	327.000	2
63	223.000		123.000	72.000	1
64	171.000		304.000	100.000	1
65	325.000		310.000	158.000	1
66	257.000			233.000	
67	85.000			5.000	1
68	301.000			3.000	1
69	101.000			208.000	
70	191.000			339.000	3

Paired Data

Oriana version 2 introduced a new method of structuring the data that allows much more flexibility. With this new method each column is a separate variable rather than set of observations. You might have one column with all the directional or time data, plus another with a variable that you can optionally use to divide the data into subgroups. For example, with the arrival time example above, the first column would have all of the arrival times, and the second would have the day that each arrival time was recorded. The data are paired, so that each row of the data matrix gives all the data about a single event. Here is the data matrix:



The screenshot shows a window titled "Data Editor" with a table containing 16 rows of data. The table has two columns: "A" and "B". Column "A" is labeled "Time" and "Arrival", and column "B" is labeled "Day of week" and "Day". The data is as follows:

Type	Time	Day of week
Name	Arrival	Day
1	18:42	Sunday
2	16:51	Thursday
3	19:10	Saturday
4	17:17	Wednesday
5	19:21	Thursday
6	09:14	Thursday
7	00:17	Tuesday
8	02:01	Saturday
9	16:03	Saturday
10	14:48	Monday
11	05:27	Wednesday
12	16:39	Sunday
13	16:19	Sunday
14	23:50	Wednesday
15	07:20	Wednesday
16	00:33	Thursday

Row 1 records the arrival of a patient at 18:42 on a Sunday, Row 2 records an arrival at 16:51 on Thursday, etc. With this format you can, for example, produce a rose diagram of all the arrival times, then produce a series of diagrams, one for each day.

With data of this type each column must have the same number of rows, since the data are paired. However, Oriana can handle missing data, so if one of the variables doesn't have data for a particular observation you can just leave that cell blank. Oriana will deal with the missing data in the most appropriate way for the given analysis or graph. For example, if some of the values in the Day column above are missing, then, when producing graphs for each day, a separate graph will be produced for those where the day is not known. Any missing circular data are just ignored and not included in the graphs or statistics.

With this type of paired format you can also add other variables, allowing you to subgroup the data in different ways, or to correlate the circular data with other types of data. Here is an example of some wind data:

The screenshot shows the 'Data Editor' window in Oriana 4. The window title is 'Data Editor'. The table has 7 columns: 'Name', 'Angles', 'Linear', 'Linear', 'Linear', 'Date', and 'Time'. The 'Angles' column is labeled 'Wind Direction', the first 'Linear' column is 'Wind Speed', the second 'Linear' column is 'Temp', and the third 'Linear' column is 'Pressure'. The 'Date' column is labeled 'Date' and the 'Time' column is labeled 'Time'. The data rows are numbered 1 through 15. The 'Date' column shows dates from 15/06/2002 to 16/06/2002, and the 'Time' column shows times from 12:00 to 02:00.

Name	Angles Wind Direction	Linear Wind Speed	Linear Temp	Linear Pressure	Date	Time
1	265.000	9.171	17.200	1010.043	15/06/2002	12:00
2	248.000	6.263	16.100	1010.043	15/06/2002	13:00
3	232.000	8.053	16.900	1011.043	15/06/2002	14:00
4	186.000	5.369	16.100	1011.043	15/06/2002	15:00
5	222.000	5.816	15.600	1011.043	15/06/2002	16:00
6	252.000	3.579	16.000	1011.043	15/06/2002	17:00
7	239.000	10.961	16.600	1010.043	15/06/2002	18:00
8	250.000	10.961	15.400	1010.043	15/06/2002	19:00
9	237.000	6.263	15.100	1010.043	15/06/2002	20:00
10	236.000	5.369	14.700	1009.043	15/06/2002	21:00
11	145.000	4.026	14.800	1009.043	15/06/2002	22:00
12	229.000	3.132	14.700	1009.043	15/06/2002	23:00
13	227.000	2.684	14.300	1008.043	16/06/2002	00:00
14	211.000	7.158	14.900	1007.043	16/06/2002	01:00
15	232.000	6.263	14.700	1007.043	16/06/2002	02:00

Here each row represents an hourly wind measurement. For each observation we have recorded the date and time of the observation, along with the wind direction at that time, the wind speed, the temperature and atmospheric pressure. We can now analyze all the wind direction data together. We can also use the Date variable for grouping by various methods, such as month of year, day of week or year. Finally, we can use the Wind Speed variable to compare wind speed with wind direction. This can be done with a two-variable rose diagram, ^[86] circular-linear plots ^[87] or by circular-linear correlation ^[76].

You can switch between having the data in the old Oriana 1 format and the new paired format with the **Data | Change Data Structure** ^[109] command. See that section for more details and restrictions. Also, when opening a file created with the old Oriana version 1 you will be asked if you wish to convert it to the paired format.

Note: with paired data it is most suitable to describe each column in the data editor as a variable. However, with the original Oriana version 1 method of structuring the data each column is better thought of as a set of observations. Throughout the program and this document the term variable is usually used for each column, but in data sets using the latter method of structuring the term set of observations can be substituted.

Frequency Data

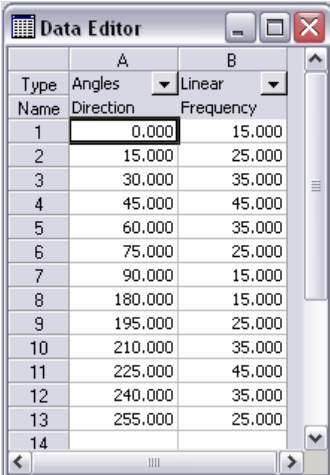
Often data are collected or provided in the form of a frequency table, where the number of times a particular direction was

observed is recorded as the frequency, for example:

Direction	Frequency
0.000	15
15.000	25
30.000	35
45.000	45
60.000	35
75.000	25
90.000	15
180.000	15
195.000	25
210.000	35
225.000	45
240.000	35
255.000	25

Oriana has two ways of dealing with data like this.

1. The first is a special data editing mode called Frequency Editing, which allows you to enter and edit data in this fashion. To enter data in this method you would first create a new data file^[29] as normal, then select a cell in the appropriate column of the data editor and choose the **Data | Edit Frequencies** menu command. This will open a dialog box with a frequency table like the one above, allowing you to enter the observations and their frequency. Once you are done the column of the data editor will be filled with data representing all the observations summarized in the frequency table, in a single column.
2. You can also enter frequency data directly in the data editor. To do this you need to have two variables, the first being one of the circular types and the other a Linear type variable. You can then enter the data in the same form as the table above, as in this example:



The screenshot shows the 'Data Editor' window in Oriana 4. It contains a table with three columns: 'Name', 'Direction', and 'Frequency'. The 'Type' column is set to 'Angles' for 'Direction' and 'Linear' for 'Frequency'. The data is as follows:

Type	A	B
Name	Direction	Frequency
1	0.000	15.000
2	15.000	25.000
3	30.000	35.000
4	45.000	45.000
5	60.000	35.000
6	75.000	25.000
7	90.000	15.000
8	180.000	15.000
9	195.000	25.000
10	210.000	35.000
11	225.000	45.000
12	240.000	35.000
13	255.000	25.000
14		

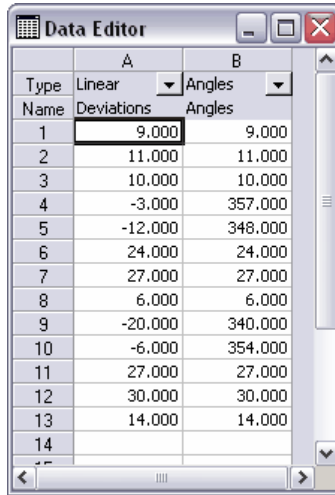
When this method is used for entering frequency data you must specify that the data are in frequency format on the Select page [\[120\]](#) of the Analyses or Graphs dialog boxes.

Note that the second method can only be used for basic statistics and histograms. If you need to do multisample comparison tests then you will need to use the first method, or use **Data|Change Data Structure** to convert the frequency table to raw data.

Deviation Data

Occasionally data are measured as deviations from a particular direction. For example, it might be expected that bees would fly in a particular direction, and observations are made of the actual angle of travel compared to the expected. Thus some observations might be negative numbers (flight to the left of the expected direction) and others positive.

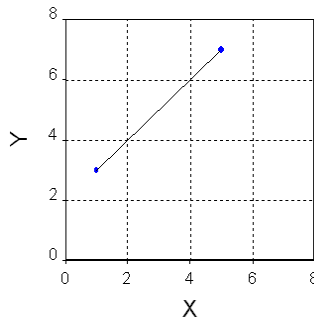
Oriana expects angular data to be in degrees ranging from 0-360, so the data editor does not allow entry of negative data for angular variables. However, this can be worked around by entering the deviation data into a variable of the Linear type, which allows numbers of any type. Once the data have all been entered the type of the data variable can be changed [\[59\]](#) to Angles. When this is done Oriana will automatically convert the negative data to the equivalent on the 0°-360° scale. So -10° would be converted to 350°. The following shows the data before and after conversion:



Type	A	B
Name	Deviations	Angles
1	9.000	9.000
2	11.000	11.000
3	10.000	10.000
4	-3.000	357.000
5	-12.000	348.000
6	24.000	24.000
7	27.000	27.000
8	6.000	6.000
9	-20.000	340.000
10	-6.000	354.000
11	27.000	27.000
12	30.000	30.000
13	14.000	14.000
14		

X/Y Data

Usually circular vector data are entered directly as measured angles and the length of the vector. However, sometimes it may be more convenient to measure and record the X/Y coordinates of the beginning and ending of the vector. For instance, in the following example you may record the X and Y coordinates of the dots at either end of the vector, rather than the angle and length of the vector itself:



If your data are in this format then you can enter them into Oriana as four sets of linear data for the X/Y coordinates, then convert them to angles and lengths, using the **Data|Convert X/Y to circular** command.

2.3.4 Grouped Circular Data

Often circular data can be considered as grouped. This should not be confused with grouping data into different subgroups (such as arrival times on different days or wind direction in different months). Grouped circular data means that the observations have been recorded approximately, to the nearest interval, rather than exactly. For example:

- A rough approximation might be made as to direction of travel (0° , 45° , 90° , 135° , 180° , etc.)
- The direction might be recorded to the nearest 10° rather than a more exact measure (e.g. 20° rather than 21.25°), or time to the closest hour.
- The data might be collated into a frequency table based on intervals, such as 10 observations between 0° and 30° , 12 between 30° and 60° , etc.
- Many of the Oriana circular data types are inherently grouped. Day of Week has seven intervals, one for each day, Month of Year has 12 intervals, and Compass Direction can have four, eight or 16.

This can simplify data collection, but it can also cause problems in data analysis. It can introduce a bias into the results, or indeed can completely invalidate the statistical procedure. Where possible Oriana will attempt to correct for this bias, using recognized corrections or alternative calculations, but some analyses simply cannot be calculated on these types of data.

After you have entered or imported a new set of data, and before saving or analyzing the data, Oriana will scan through them to see if they appear to be grouped. If so, Oriana will prompt you with a dialog box, asking if the data actually are grouped and, if so, what the grouping interval is. If you confirm that the data are grouped then Oriana will record this and will take the grouping into account in all analyses. If you clear the **Data Are Grouped** tick box then Oriana will remember this and will always proceed as if the data are not grouped. You can change this declaration later through the **Data|Change Variable Type**^[107] menu item.

2.3.5 Missing Data

Oriana can easily handle missing data. There is no need to enter a special missing data marker; simply leave a cell in the

spreadsheet blank and Oriana will consider that data as missing.



With all single sample statistics, tests and graphs the missing data are ignored and not included in the results. With pairwise tests missing data are handled by pairwise deletion (leaving out any pair of data where one is missing). For multisample tests listwise deletion is performed (any row that contains one or more missing data is ignored).


3 Tutorial

The following topics give step-by-step instructions on using Oriana.

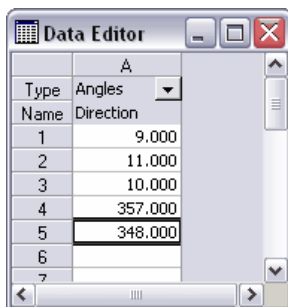
3.1 Creating a data file

The first step in using Oriana is to create a new data file. Do this using the **File|New** command from the main menu. A multi-step “wizard” dialog box will be displayed; this helps you in setting up your data file. You will be asked various questions about your type of data. For now let’s assume we just have one set of circular data. You should:

1. Choose **Angles** as the type of data you are working with, then click on the **Next** button.
2. Choose the **Separate** option on the data layout page, then click on **Next**.
3. Pick **Circular data only** and press **Next**.
4. Make sure **Number of columns** is set to 1.
5. Enter a label for this column of data in the **Labels** box and press **Next**.
6. Enter a descriptive title for the file, then **Finish**.
7. The dialog will close and the status window  and data editor  will appear.

Now you can start entering data. The data editor has a single column for typing in the single set of data. New columns can be added by simply pressing the left arrow key, or using the **Edit|Insert Column**  command.

The spreadsheet will be empty except for two rows of grey cells across the top. One contains the data type, the other the label you entered in the New File wizard. Data can then be typed into the main body of the spreadsheet. The following image shows a new data matrix in which five data points have been entered:



3.2 Entering data

To begin entering data you must open the Data Editor window, if it isn't already. Do this by choosing **Data | Edit Data** from the menu. A spreadsheet-like editor will appear. Initially the cell in the upper left corner will have a dark line around it. This is the active cell and is where any characters or numbers that are typed will appear. You can move the active cell around the spreadsheet, using the mouse to select a new one or by using the arrow keys. Other keystrokes are also recognized for navigating the spreadsheet; see the section on using the keyboard for a full list.

Type	Angles	Linear	Date	Day of week	Time
Name	Wind Direction		Date	DOW	Time
32	208.000	0.026	15/06/2002	Saturday	21:40
33	145.000	4.921	15/06/2002	Saturday	22:00
34	259.000	2.684	15/06/2002	Saturday	22:20
35	194.000	3.132	15/06/2002	Saturday	22:40
36	229.000	3.132	15/06/2002	Saturday	23:00
37	230.000	4.474	15/06/2002	Saturday	23:20
38	253.000	2.684	15/06/2002	Saturday	23:40
39	227.000	5.369	16/06/2002	Sunday	00:00
40	256.000	3.132	16/06/2002	Sunday	00:20
41	192.000	7.158	16/06/2002	Sunday	00:40
42	211.000	6.263	16/06/2002	Sunday	01:00
43	265.000	3.132	16/06/2002	Sunday	01:20
44	231.000	6.263	16/06/2002	Sunday	01:40
45	232.000	8.724	16/06/2002	Sunday	02:00
46	224.000	3.132	16/06/2002	Sunday	02:20
47	248.000		16/06/2002	Sunday	02:40

The spreadsheet has column headers labeled A, B, C, etc. and row headers labeled 1, 2, 3, etc. These headers indicate the position within the spreadsheet and also can be clicked to select the whole row or column for editing purposes.

You can change the width of the columns and height of the rows

by using the mouse to drag the separator between the headers. Normally each row or column is changed individually. However, holding down the shift key while you resize a row or column causes all others to be changed to the same size.

The first two rows are shaded. The first row contains the indicator of the type of the variable. You can change the variable type, say from Angles to Time, by clicking on the little arrow next to each cell (labeled “Change data type” above) and choosing a new type.

The second row contains the name of each variable. These labels are used on the output to identify the variables or sets of observations. New variables are by default given the same name as their data type. You can change these by making the appropriate cell active and typing any characters. Spaces may be included and the labels may be up to 60 characters long (although shorter labels allow you to keep the columns widths narrow and see more data on the screen).

Typing in data


Once labels have been entered you can start typing in the numeric data. This is done by making the appropriate cell active and typing the numbers. You then press the Enter or Tab key or the up or down arrow keys to finish entering the data; the Enter key will also move the active cell to next cell down ready to enter the next datum while the Tab key will move to the cell to the right.

As you type in data, the values are checked to make sure they are valid (e.g. in the range of 0-360 degrees or 00:00-23:59 hours). The program will beep and refuse to accept any values that are not valid. Some data types, such as Day of Week, have a fixed list of possible values. You can choose the desired entry by clicking on the down arrow labeled “Change datum” in the image above. You can also go straight to an entry by just typing the first few characters of the desired entry.

With Date and Time cells a small scroller (labeled “Increment Date” in the image above) will appear next to the cell when you begin typing. You can use this to increment and decrement the date or time. With Date cells, if you double click on the cell when the scroller is visible a monthly calendar will be displayed; you can pick a new date from this.

You can close the data editor at any time by again selecting **Data|Edit Data** from the menu (or clicking on its matching button on the toolbar) or by clicking on the close button (the one with the **x**) in the upper right corner. The data are maintained in memory and will appear when you open the editor again. They are not saved to disk yet, though. You can do this by explicitly saving the data with **File|Save Data**. If you try to exit the program or open/create a new file when the data have not been saved you will be warned and asked if you wish to save the data.

3.3 Selecting spreadsheet cells


Normally the spreadsheet will have a single active cell while you are working on it. The active cell can be selected by positioning the cursor (which is a  when it is over the spreadsheet) over the desired cell and clicking the left mouse button. Alternatively, you can move the selected box around using the arrow keys.

This image shows the active cell in column A, row 2.

	A	B	C	D
Type	Axial	Axial	Axial	Axial
Name	ISOETES	PAXILL	SELAG	ERLAN
1	94.000	112.000	38.000	
2	88.000	102.000	120.000	1
3	88.000	80.000	155.000	
4	94.000	80.000	123.000	1!
5	92.000	110.000	157.000	1!
6	92.000	69.000	54.000	
7	80.000	105.000	84.000	1!
8	87.000	119.000	43.000	

To select a number of cells (in preparation for deleting them or copying them to the clipboard), you can simply hold down the left mouse button and drag the cursor over the desired cells. Alternatively, hold down the shift key while you move the cursor with the arrow keys. The resulting selected block of cells will look like this:

	A	B	C	D
Type	Axial	Axial	Axial	Axial
Name	ISOETES	PAXILL	SELAG	ERLAN
1	94.000	112.000	38.000	
2	88.000	102.000	120.000	1
3	88.000	80.000	155.000	
4	94.000	80.000	123.000	1
5	92.000	110.000	157.000	1
6	92.000	69.000	54.000	
7	80.000	105.000	84.000	1
8	87.000	119.000	43.000	

You can select whole rows or columns by clicking on the row or column headers. Multiple rows or columns can be selected by dragging the cursor across the headers. The current row can also be selected by pressing Shift-Space; a column can be selected with Ctrl-Space. The following images show the result (the  is positioned over the header that was clicked to perform the selection):

	A	B	C	D
Type	Axial	Axial	Axial	Axial
Name	ISOETES	PAXILL	SELAG	ERLAN
1	94.000	112.000	38.000	
2	88.000	102.000	120.000	1
3	88.000	80.000	155.000	
4	94.000	80.000	123.000	1
5	92.000	110.000	157.000	1
6	92.000	69.000	54.000	
7	80.000	105.000	84.000	1
8	87.000	119.000	43.000	

	A	B	C	D
Type	Axial	Axial	Axial	Axial
Name	ISOETES	PAXILL	SELAG	ERLAN
1	94.000	112.000	38.000	
2	88.000	102.000	120.000	1
3	88.000	80.000	155.000	
4	94.000	80.000	123.000	1
5	92.000	110.000	157.000	1
6	92.000	69.000	54.000	
7	80.000	105.000	84.000	1
8	87.000	119.000	43.000	

The entire spreadsheet can be selected by pressing the button in the upper left corner of the spreadsheet. You can also select the whole spreadsheet using the **Edit|Select all** command, or by pressing Shift-Ctrl-Space. The result looks like this:

	A	B	C	D
Type	Axial	Axial	Axial	Axial
Name	ISOETES	PAXILL	SELAG	ERLAN
1	94.000	112.000	38.000	
2	88.000	102.000	120.000	1
3	88.000	80.000	155.000	
4	94.000	80.000	123.000	1
5	92.000	110.000	157.000	1
6	92.000	69.000	54.000	
7	80.000	105.000	84.000	1
8	87.000	119.000	43.000	

3.4 Editing data

There are a number of editing actions you can perform on existing data.

Overwriting old data with new

Make the cell active (click with the mouse or move to that cell with the cursor keys), type the new value, and press the Enter key.

Modifying data within a cell

Make the cell active and press F2 (or double click on the cell with the mouse). This will cause the contents of the cell to be selected. Clicking again or press the right or left arrow keys will cause a caret (vertical line) to appear. You can move this back and forth with the cursor keys.

Any new letters or numbers typed will appear at the position of the cursor. With labels, and the portion of numeric data to the left of the decimal, the new characters will be inserted. With the fractional part of numeric data the typed digits will replace those at the caret (which will be shown as a triangle under the digit).

Some variable types, such as Day of Week, have a fixed list of possible data values. This list can be seen by clicking on the down arrow button to the right of each cell (see below). The

entry for that cell can then be selected from the list. You can also just start typing while the cell is active; the data editor will automatically insert the data value that matches what you have typed so far.

0 Tuesday	▼ February	▼
0 Wednesday	▼ March	▼
0 Thursday	▼ April	▼
0 Friday	▼ May	▼
0 Saturday	▼ June	▼

With time and date variables the separators between elements of the data value are automatically included; there is no need to type them.

Clearing data in one or more cells

Make the cell active and press the Del key, choose **Edit | Delete** from the menu, or choose **Delete** from the context menu.

To clear several cells at once select the desired cells and use one of the above commands.

Pasting data from the clipboard

Make active the cell at the upper left of where you wish the clipboard contents to be pasted. Then choose **Edit | Paste**, press Ctrl-V, or choose **Paste** from the context menu. The pasted data will overwrite existing data.

The data will be validated as they are pasted to ensure they are valid given the variable type. Any data that are not valid are ignored and the cell remains blank. A warning will be displayed if this happens. If the column into which you are pasting does not yet have any data, then Oriana will try to guess the most appropriate data type, given the data on the clipboard. If this guess is wrong you can set the column to the appropriate type, make sure there is data in at least one cell, then try pasting again.

If the data in the clipboard contains more rows or columns than will fit in the spreadsheet then more rows or columns will be added automatically.

Adding new columns and rows

New rows or columns can be added singly by going to the last cell in the row or column and pressing the right or down arrow keys.

To insert new rows or columns in the middle of the spreadsheet select a whole row or column, then choose **Edit|Insert Row/Column** (or **Insert Row/Column** from the context menu). To insert two or more rows or columns select two or more existing ones.

If **Insert Row/Column** is chosen when there are not any whole rows or columns selected a dialog box will appear. This lets you specify exactly what to insert.

Deleting columns and rows

To completely remove rows or columns from the spreadsheet select a whole row or column, then choose **Edit|Delete Row/Column** (or **Delete Row/Column** from the context menu). To delete two or more rows or columns select two or more existing ones. (Note - pressing the Del key while columns or rows are selected will not remove them, but instead will delete their contents).

If **Delete Row/Column** is chosen when there are not any whole rows or columns selected a dialog box will appear. This lets you specify exactly what to delete.

Reversing editing changes

The Oriana data editor keeps track of all changes you have made. Changes can be undone, in the reverse order that they were performed, by choosing **Edit|Undo** from the menu (or pressing Ctrl-Z). The menu item and the hint on the status bar at the bottom of the window will tell you exactly what change will be undone next.

To reinstate a change that you have undone choose the **Edit|Redo** menu item.

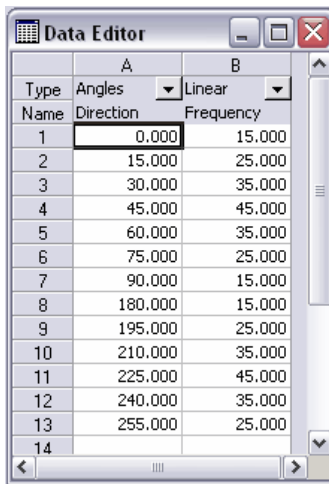
The list of editing changes is only maintained while the data editor is open. If you close the data editor and reopen it you will not be able to undo previous changes.

3.5 Entering frequency data

In most cases you will be entering raw data, the individual measurements collected in your study. However, in some cases you may be provided with data that are in the form of a frequency table, where the number of measurements of each

unique data value are recorded (e.g. 25 observations of the angle 45°). Data in this format can also be entered directly in Oriana by creating two variables, one for your circular data and one, of the Linear type, that is used for entering the frequencies.

You can set up such a data file using **Files|New**. Using the New File Wizard, first choose your data type, then on the next page, where different data file layouts are described, choose the **Frequency** option. Following through the rest of the wizard will result in a file similar to that below, where you can enter your data in the left-hand column and the frequencies in the right.



The screenshot shows a window titled "Data Editor" with a table containing 14 rows and 2 columns. The columns are labeled "Angles" and "Linear". The rows are labeled "Name", "Direction", and "Frequency". The data is as follows:

Type	Angles	Linear
Name	Direction	Frequency
1	0.000	15.000
2	15.000	25.000
3	30.000	35.000
4	45.000	45.000
5	60.000	35.000
6	75.000	25.000
7	90.000	15.000
8	180.000	15.000
9	195.000	25.000
10	210.000	35.000
11	225.000	45.000
12	240.000	35.000
13	255.000	25.000
14		

When analyzing and graphing these data you will need to choose the Frequency option (rather than the Raw option) on the Select page of the analysis or graph dialog box. See the end of the tutorial about Calculating Statistics^[47] for more details.

Note that this method can only be used when calculating basic statistics and plotting histograms. If you need to do multisample comparison tests then you will need to convert the frequency data into raw data (columns of individual observations). You can do this using the **Data|Change Data Structure** command to convert the frequency tables to raw data. You can also use the **Data|Edit Frequencies**^[106] option to enter data as frequencies but have them saved as columns of raw data.

3.6 Saving data

Data are saved through the **File|Save Data** [93] menu item. If you have created a new data file (and the status window says “Unnamed” for the filename) you will then be presented with a **Save As** [93] dialog box. You can choose the appropriate disk and directory, then type a name into the **File name** edit box and press OK.

If the file already has a name (which will appear in the status window) then choosing **File|Save Data** will save any changes directly, with no dialog box.

If no changes have been made to the data the **Save Data** menu item will be dimmed and cannot be selected. You can tell if the data have been modified by looking at the status bar when either the status window or data editor are the topmost window; the word “Modified” will appear in the second panel from the left (note that if the results, graphs or notepad windows are topmost then this modified indicator will reflect their modified status, not that of the data).

To save the data under a new name choose **File|Save Data As** [93], which will produce the dialog box described above. Make sure that the **Save file as type** section of the dialog is set to “Data files (*.ORI)”

3.7 Opening an existing data file

Existing data files can be loaded into Oriana using the **File|Open** [91] dialog box. Alternatively, you can choose a previously used file from the **File|Reopen** [93] menu or use the drag and drop [159] feature of Oriana. You can also load a whole set of windows related to a data file using the desktop [4] functions.

You can keep your data files in any location you wish. The **File|Open** dialog box allows you to switch to any disk or directory accessible to your machine and will remember the last location at which you looked for a data file. If you wish, you can have separate directories for each project.

The Oriana program only allows a single data file (and its related results and graph windows) to be open at any one time. You can start a second copy of Oriana if you wish to have a second data file open. If you already have a data file open when

you choose the **File|Open** command, it will be closed before the new file is opened.

Oriana comes with a number of example data files. You can use these to try out the program or to see the correct format for the data files. They can be found in the SampData folder of the Oriana program directory (usually C:\Program Files\Oriana)

3.8 Importing data

Data can be imported into Oriana from a variety of sources, including many spreadsheet and database formats as well as plain text. See the section on the **File|Import**^[94] command for a full list of formats.

To import a file follow these steps:

1. Choose the **File|Import** command from the menu.
2. An Open File dialog box will be displayed. Use the **Files of type** drop-down box at the bottom to choose the type of file you wish to import. We will choose **Excel** for this example.
3. Now select the file you wish to import. We can try importing the **ImportEx.xls** file that can be found in the **Sample Data** folder of the Oriana data folder (usually found in your My Documents folder). Once the file is selected press **Open**.
4. You will now be presented with an import preview dialog box, which shows a preview of your imported data. You can use this to check that the data are being imported properly. If they are not then you can use the options at the top to adjust various parameters. With this example data set you should see six columns of data, each with a column label (Set1, Set5, etc.) in the shaded portion at the top of each column.

Import statistics					
Columns: 6		Rows: 100		File type: Excel	
Set1	Set5	Set6	Set8	Set10	Set14
161	172	183	166	169	180.5
177	186	194	178	167	174.5
184	174	170	178	184	173.5
163	161	177	168	180	179.5
244	183	201	179	172	173.5
192	186	171	188	176	191.5
215	174	179	177	160	197.5
163	174	191	180	179	179.5
180	190	179	152	173	178.5

5. This is how we expect the data to be imported, so we can press the **OK** button. The data will be imported and the Status Window will be opened. You can use the **Data|Edit Data** command to open the editor and confirm that the data have been imported properly.
6. This example data file has two pages of data. We can choose to import data from the other pages. These pages are accessed by clicking on the tabs just below the data preview spreadsheet. To preview the second page click on the tab named **Intensive**.
7. This time the desired column label (Arrival) does not appear in the shaded area. This is because the file has two extra blank lines at the top of the sheet.

Import statistics	
Columns: 1	Rows: 256
Arrival	
11:00:00	
04:00:00	
11:05:00	
22:00:00	
18:45:00	
23:00:00	

8. To fix this problem change the **Names at row** option to 3, then press **Update Preview**. This tells Oriana to look at row 3 of the worksheet for the column labels. You should now see the Arrival label in the shaded area, and the data will now be imported properly.

Note that if you hadn't changed the row for the column labels Oriana would still have imported this file. However, it would have treated the whole column as text rather than times, and the variable type in the imported file would have been Label.

Cut and Paste

An alternative method for importing data into Oriana is to use the Windows clipboard to transfer data directly between two programs. To do this follow these steps:

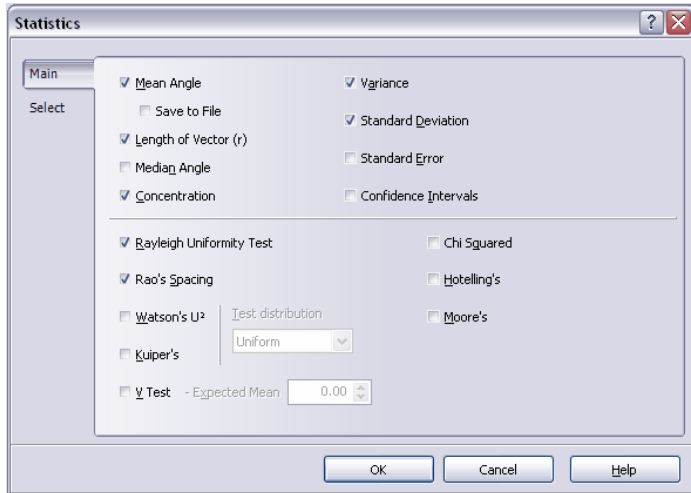
1. Create a new blank file in Oriana, as described in the **File | New** section. You can simply create a file with a single column of any type.
2. Go to the program that you wish to copy the data from (for example, a spreadsheet). Use the mouse to select the data you wish to copy and choose the **Edit | Copy** command for that program (clicking on the upper left corner of the sheet headers will select all data).
3. Switch back to Oriana, place the cursor in the second row of the data editor (the one with the row label **Name**). Then choose **Edit | Paste**. The data will then be pasted into the editor. Oriana tries to guess the correct data type for each column, as described in the section on the **Edit | Paste** command.

3.9 Calculating statistics

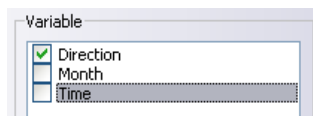
Once a data file has been created or loaded you can then perform analyses. The **Analyses** menu lists the various types of analyses available. Selecting any one of these will cause a dialog box to be displayed, giving the various options for the analysis. When the OK button is pressed a new page will be added to the Results window and the analysis will be performed.

Here is an example of the steps required to calculate basic statistics:

1. Open a data file (the Wind2002.ori example data file distributed with Oriana can be used).
2. Select **Analyses | Stats** from the menu. A multi-page dialog box, with tabs along the side, will appear. The first page contains options to select the basic statistics you want calculated.



3. To discover what each option does you can press the large button labeled **Help** to display a help page describing all the options.
4. By default all circular variables in the file are included in the analyses. If you wish to drop some of the variables go to the **Select** page of the dialog. All the circular variables will be listed on the left, with a tick mark before each. To drop a variable just click the box containing the tick mark so that it is cleared. We want to calculate statistics on just the Direction variable, so clear the checkmarks on the other variables. (Hint: You can clear all checkmarks by right clicking on the list and choosing **Deselect All** from the context menu.)



5. Press **OK**. The Results window will open, if it isn't already visible. A new page will be added, to which the results will be written.
6. Once the analysis is finished you can look at and print the results or export them to a file for inclusion in another program.

Note: if you are working with frequency data (where the data file contains a frequency table summarizing your data) then you will need to select the **Frequency** option on the **Select** page, rather than **Raw**. Then ensure that the variables selected in the Variable and Frequency sections of the page are the desired ones.

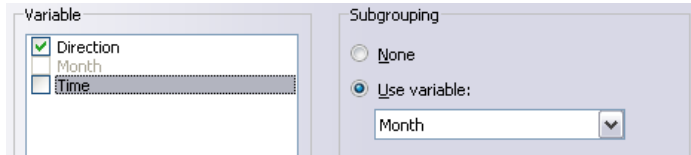
The image shows a dialog box with two radio buttons at the top: 'Raw' (unselected) and 'Frequency' (selected). Below are two sections: 'Variable' and 'Frequency'. In the 'Variable' section, 'Direction A' is selected. In the 'Frequency' section, 'Frequency A' is selected.

3.10 Selecting a subgrouping variable

By default Oriana will calculate statistics and draw graphs using all the data from each variable. However, you may sometimes want to calculate separate statistics and do separate graphs for subsets of the data. You can do this by using a subgrouping variable. This is a separate variable that contains data specifying to which subgroup each case (or row) in the data matrix belongs.

For example, the Wind2002.ori data file has a variable called Month which indicates in which month each observation was made. (See the section entitled Summarizing Data^[60] to learn how this subgrouping variable was created.) To calculate separate statistics for each subgroup follow these steps:

1. Follow steps 1-4 in the Calculating Statistics^[41] section.
2. On the **Select** page of the dialog box go to the **Subgrouping** box and tick the **Use variable:** option.
3. In the drop-down box below this option chose the desired subgrouping variable (Month in this case).



4. Click **OK**. The results page will have a column of statistics for each month.

The **Subgrouping** box also has options for summarizing dates. If the variable you select as subgrouping variable is a Date one then these options are enabled, allowing you to group the data by Day of Week, Month of Year, Day of Year or Week of Year.

3.11 Filtering data

There are often times when you want to analyze just a subset of your data, rather than all of it. You may want to analyze data from just a single month, rather than the whole year, or only those data for which an associated linear variable exceeds a certain value. You can do this through the **Filter Data** dialog box. You can access this in two ways: either choose the **Data|Filter Data** menu item after a data file has been opened, or click on the **Filtering** button on the **Select** page of any analysis or graph dialog box.

To define the subset of data you wish to use you must select a variable that contains the data you want to use to define the subgroup, then declare the criterion to filter on. Lets say we want to calculate statistics of the wind data in the Wind2002.ori example data file in September alone. To do this:

1. Open the Wind2002.ori data file.
2. Choose the **Data|Filter Data** menu item.
3. Click on the **Filter Data** button.
4. Select the variable "Month" in the **Variable** drop-down box.
5. In the **Comparison Type** section click the "Equal" button.
6. In the **Value** box enter "sep" for September.

Filter data

Variable: Month

Comparison Type

Equal Greater than or equal

Not equal Less than or equal

Greater than Contains

Less than Doesn't contain

Value: sep

7. Click **OK**.

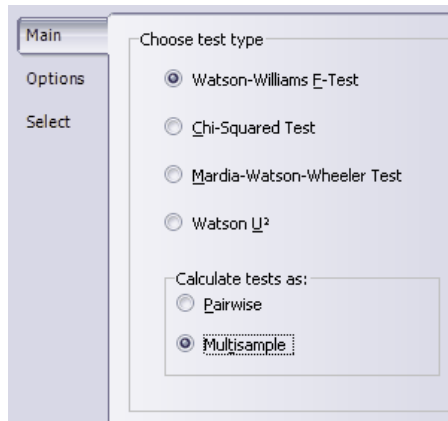
The Status window will now be updated to show you are filtering on the selected criterion. Now when you calculate basic statistics, as in the Calculating Statistics tutorial^[41], only those data recorded in September will be used. The number of observations in the analysis will be just 700, rather than the 4495 in the full data set.

3.12 Comparing samples

Oriana has several different methods for comparing samples within a set of data. Descriptions of each test are given in the Analyses^[63] section.

To perform these tests take the following steps:

1. First open the file. We will use the Termites.ori example data file for this example.
2. Select the **Analyses|Multisample Tests** menu item.
3. On the first page of the dialog box select the desired analysis. We will use the Watson-Williams F-Test here.
4. Most of these tests can be performed in either a pairwise fashion (where the test is calculated for each pair of samples) or multisample (where a single test is calculated for all samples). Let's first choose multisample by ticking the appropriate option in the **Calculate Tests As** section.



5. Press **OK**. The test will be calculated and the results placed in the Results window. In the first column are the names of the samples and the numbers of observations. The F statistic, the associated probability (p) and the two degrees of freedom are in the following columns. A p below your chosen alpha level (usually 0.05) means that the null hypothesis that the samples have the same mean can be rejected. In this case the p is 0.0104, so we can accept the alternative hypothesis that the samples do not all have the same mean.

Variables (& observations)	F	p	df	df2	Est. Mean
Multi-sample test using:					
Set1 (100)					
Set5 (50)					
Set6 (50)					
Set8 (48)					
Set10 (50)					
Set14 (92)	3.0446	0.0104	5	384	*****

6. Let's now investigate each pair of samples. Repeat steps 2-4, but this time choose the **pairwise** option, and press **OK**. The results are reported with a line of values for each pair of variables. The F and p values are also reported in a matrix format at the bottom of the results page, for easier comparisons.

Results in matrix format						
F scores (lower half) and probabilities (upper half)						
	Set1	Set5	Set6	Set8	Set10	Set14
Set1	—	0.0307	0.3811	0.0915	0.0125	0.6631
Set5	4.7624	—	0.0812	0.7147	0.8385	0.0079
Set6	0.7718	3.1037	—	0.2626	0.0134	0.4205
Set8	2.8856	0.1344	1.2697	—	0.5468	0.0548
Set10	6.3883	0.0418	6.337	0.3656	—	0.0007
Set14	0.1903	7.2562	0.6528	3.7527	11.9512	—


We can see that most of the pairs do not have a significant result (so the null hypothesis is not rejected), but there are a few with p values below 0.05. For those pairs where the null hypothesis is not rejected then Oriana also reports the estimated population mean of the two samples.

- Comparing these results alongside the basic statistics (calculated through **Analyses|Stats**) we can see that there appear to be two groups of samples, some with means around 172°-174° and some with means from 177°-181° (note that sample Set1 has the mean reported as 0.6443°, but since these are axial data the mean could also be considered to be 180.6443°).

Variable	Set1	Set5	Set6	Set8	Set10	Set14
Number of Observations	100	50	50	48	50	92
Data Grouped?	No	No	No	No	No	No
Group width (& number of groups)						
Mean Vector (μ)	0.6443*	172.9989*	177.7285*	174.2485*	172.4901*	179.469*

- We can test this by doing multisample tests of these two groups. Again, follow steps 2-4, but this time go to the **Select** page of the dialog box and untick Set1, Set6 and Set14. The results of the F-Test on just Set5, Set8 and Set10 gives $p=0.8329$, so we retain the null hypothesis that these three samples have the same population mean, which Oriana estimates as 173.187°. We can reverse the state of the checkboxes so that we calculate the F-Test on Set1, Set6 and Set14, which gives $p=0.6198$ and an estimated mean of 179.491°.

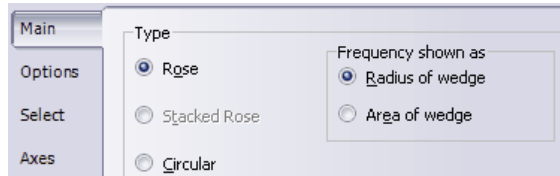
3.13 Plotting graphs

Diagrams are produced through the **Graphs**  menu. We will produce some rose diagrams and a distribution plot of the Wind2002.ori data.

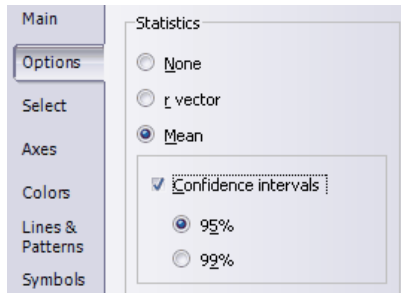
- Open the Wind2002.ori data file.
- Choose the **Graphs|Histogram** menu item. A dialog box

will appear.

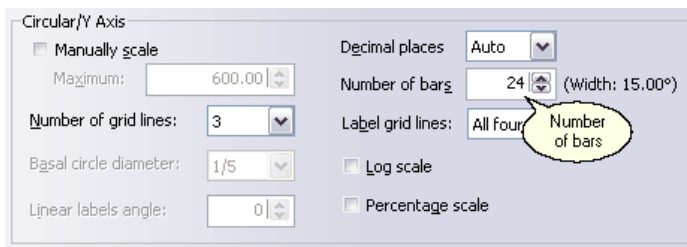
- On the first page make sure that **Rose** is ticked as the graph **Type**.



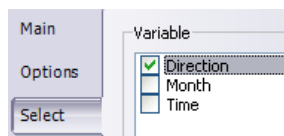
- Click on the **Options** tab to go to that page. In **Statistics** tick the **Mean** option, along with **Confidence Intervals**.



- On the **Axes** page set the **Number of bars** to 24 to produce a graph with 24 bars, each 15° wide.



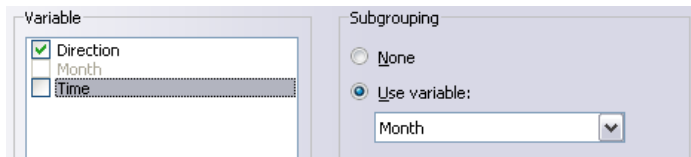
- Click on the **Select** tab, then untick the Month and Time variables, so that only Direction is ticked.



7. Press **OK**. The Graphs window will open, if it isn't already visible. A new page will be added, to which the plot will be drawn.

This diagram shows the wind direction distribution of all the data in the file. Now let's try creating a rose diagram for each month.

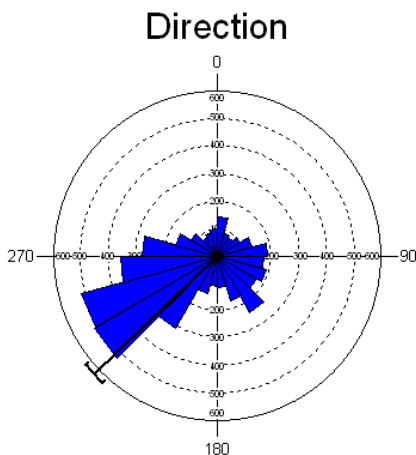
1. Again choose the **Graphs | Histogram** menu item. All the options will be at the same settings used previously, so you don't need to follow steps 3-5 above, unless you wish to change them.
2. On the **Select** page, in the **Subgrouping** box, tick the **Use variable:** button then select Month from the drop-down box below it.



3. Press **OK**. Seven new graphs will be added to the Graphs window, one for each month from June-December. These demonstrate the variation in the wind direction through the seasons, with it being primarily southwesterly in the summer, but more varied in the autumn and winter.

3.14 Adjusting graph axes

Oriana has a wide variety of options that allow you to customize the appearance of the graph. Let's first try out some of the options for changing the axes of the circular graph. Here is what our graph looks like so far:



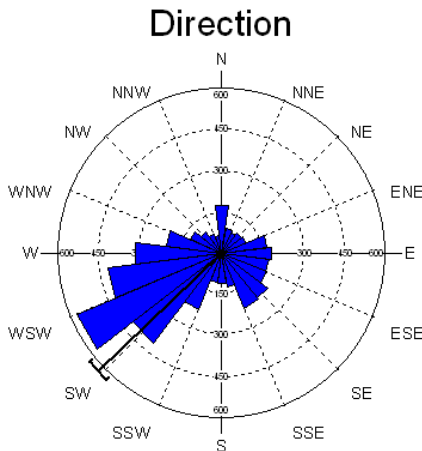
1. With the graph window topmost, showing the graph you want to change, choose the **Graphs | Edit Graph** menu item. The **Histogram** dialog box will appear again.
2. Now go to the **Axes** page. This has two sections, the first for adjusting various aspects of the Angular or X Axis. This is the one around the circumference of the circle, which represents the angles, time of day, or other circular data. In the graph above it is labeled 0, 90, 180, 270. The second section is for changing the Circular or Y Axis. This is the set of concentric rings that provide the grid representing the frequencies in the histogram.

Circular/Y Axis

<input type="checkbox"/> Manually scale Maximum: <input style="width: 100px;" type="text" value="600.00"/> Number of grid lines: <input style="width: 50px;" type="text" value="3"/> Basal circle diameter: <input style="width: 50px;" type="text" value="1/5"/> Linear labels angle: <input style="width: 50px;" type="text" value="0"/>	Decimal places: <input style="width: 50px;" type="text" value="Auto"/> Number of bars: <input style="width: 50px;" type="text" value="24"/> (width: 15.00°) Label grid lines: <input style="width: 50px;" type="text" value="All four"/> <input type="checkbox"/> Log scale <input type="checkbox"/> Percentage scale
--	---

3. First lets change the Angular axis. Notice that the first wedge in the histogram starts at 0° and goes to 15°. With directional data, particular those based on the compass (like our wind direction data) some people prefer to have this first bar centered on 0°, rather than starting there. We can do this with the **Center circular bars on 0** option. We can also tell Oriana to label the axis with compass directions (e.g. N, S, etc.) rather than the actual angles.

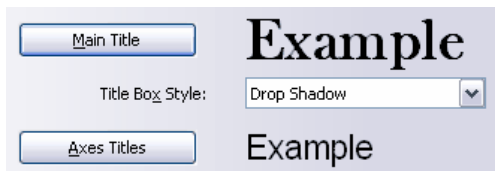
- The **Label angles as compass** option will do this.
- By default Oriana will divide the graph into four sectors, for N, E, S and W. We might want more gridlines than this. We can use the **Minor divisions** option to specify that we want a medium number of divisions. With compass labels this will give us 16 divisions. We can also tick the **Label minor divisions** option so that the compass directions such as NNE and SW are used.
 - Finally we can reduce the number of circular gridlines in the **Circular/Y Axis** section with the **Number of grid lines** option. Let's set this to 3. Now press **OK**. Our graph now looks like this:



3.15 Customizing graphs

- Let's customize other aspects of the appearance of the graph. Choose the **Graphs|Edit Graph** menu item. The Histogram dialog box will appear again.
- If you wish to change any of the options or even the graph type you can do it here. We can change the current graph into a circular histogram type by choosing the Circular type on the **Main** page. Also, on the **Options** page we can change the mean direction indicator into a vector, the length of which reflects the r value for this set of data, by selecting the R Vector option.
- Go to the Fonts page by clicking on the tab at the side labeled **Fonts**. Click on the button labeled **Main Title**. A standard font dialog will appear. Use this to change the

font to be used for the graph title, then press OK. Just below this is a drop-down box labeled **Title Box Style**. Use this to change the box style to **Drop Shadow**.



4. Press **OK**. The graph will now be changed to a circular histogram with an r vector, the font of the main title will be changed to the chosen one, and a box will have appeared around the title. These new settings will have been saved, so all future graphs will be of this appearance, until you change them again.
5. Many other options can be changed to alter the appearance. For example, we can change the text of the title that appears at the top of the graph. By default this is the name of the variable. Choose the **Graphs|Edit Graph** menu item again, go to the **Titles** page and change the **Main Title** to "Wind Direction". You could also remove the title completely by clearing the checkbox next to the title.



6. Now go to the **Colors** page. The bars/segments of the histograms are currently plotted in blue. You can change this by going to the list box titled **Plot Series Colors**, selecting **Series 1**, then changing the color with the drop-down box labeled **Set Series Colors**. If this plot were a stacked or two-variable graph^[54] then you could use the other series to change the colors of other segments of the bars.

The image shows two panels from a software interface. The left panel is titled 'Backgrounds' and contains four rows, each with a label and a dropdown menu: 'Chart' (White), 'Grid' (White), 'Title' (White), and 'Legend' (White). Below this is a section titled 'Plot Series Colors' containing a list box with nine items: 'Series 1 - Blue', 'Series 2 - Red', 'Series 3 - Yellow', 'Series 4 - Fuchsia', 'Series 5 - Silver', 'Series 6 - Lime', 'Series 7 - Aqua', 'Series 8 - Black', and 'Series 9 - Maroon'. The right panel is titled 'Lines' and contains five rows with labels and dropdown menus: 'Axes' (Black), 'Grid' (Black), 'Stats' (Black), and 'Inacc. Stats' (Red). Below these is a checkbox labeled 'Monochrome Graphs' which is unchecked, and a 'Set Series Color' dropdown menu currently set to 'Blue'.

7. You can also use this page to change the background color of various parts of the graph, and also of the lines. Click **OK** to see the results.
8. You may wish to produce a monochrome graph, with shaded areas rather than colored ones, for reproduction in a print journal. You can do this by going to the **Colors** page and ticking the **Monochrome Graphs** option. This will disable the color selection options.
9. Now go to the **Lines and Patterns** page, where you can use the **Plot Series Patterns** and **Set Series Pattern** option to configure the various shading patterns, in a similar way that you did with the colors.

The image shows three panels from a software interface. The top-left panel is titled 'Axes' and has two rows: 'Style' (Solid) and 'Width' (1). The top-right panel is titled 'Stats lines' and has two rows: 'Style' (Solid) and 'Width' (2). The middle panel is titled 'Grid' and has two rows: 'Style' (Dot) and 'Width' (1). The bottom panel is titled 'Plot Series Patterns' and contains a list box with eight items: 'Series 1 - Solid', 'Series 2 - Clear', 'Series 3 - Horizontal', 'Series 4 - Vertical', 'Series 5 - Diagonal Right', 'Series 6 - Diagonal Left', 'Series 7 - Cross', and 'Series 8 - DiagCross'. To the right of this list box is a 'Set Series Pattern' dropdown menu currently set to 'Solid'.

10. This page also lets you customize the lines used in the graph axes and grid. Use the drop-down box labeled **Axes Style** to change between solid and dashed or dotted lines for the axes, and **Axes Width** for the width of the solid lines. Note that the standard Windows line drawing routines do not allow a width to be specified for the dashed and dotted lines, so if you specify a width greater than 1 it will always be drawn as solid.
11. Also on this page you can specify if outlines should be drawn around the bars and symbols of the graph.

3.16 Saving the desktop

Oriana follows a desktop metaphor^[4] in which several windows relating to a single data file can be displayed at once. You can save the position and contents of all these windows to a file, then reload it later. This lets you pick up working where you left off.

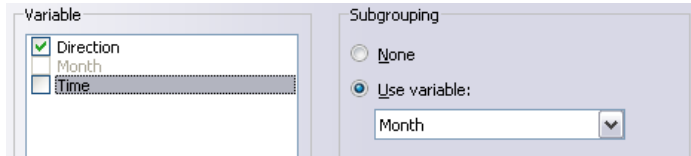
To explicitly save your desktop simply choose the **File|Save Desktop** command. You can save several desktops under different names. You can then restore any of them using the **File|Open Desktop** command.

Oriana can be set up to automatically save your desktop when you exit and reload it next time you run the program. This option can be turned on in the **Options|Preferences**^[149] dialog box.

3.17 Stacked histograms

Data sets that have a subgrouping variable defined can be plotted as stacked or stepped histograms^[85], where a single diagram is produced for all the groups, with each group's portion of the bar depicted in different colors.

1. Open the Wind2002.ori file, if it isn't already loaded.
2. Choose the **Graphs|Histograms** menu item
3. First go to the **Select** page and ensure that **Use variable:** is ticked under **Subgrouping** and that the Month variable is selected in the drop-down box.

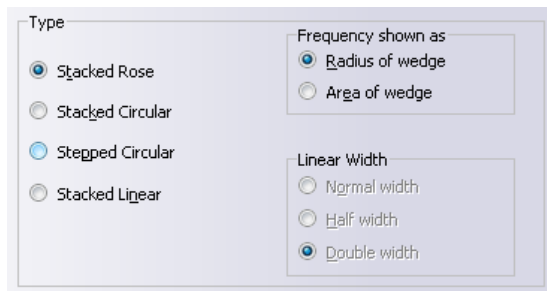


4. Go to the **Main** page and select the type of stacked/stepped graph you wish to produce (say, **Stacked Rose**).
5. Press **OK** and the graph will be produced.

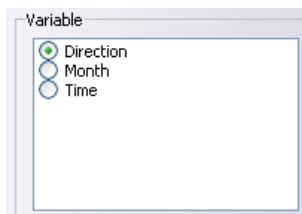
3.18 Two-variable histograms

Let's now try plotting a two-variable ^[86]rose diagram. This is a rose diagram with each bar divided up into segments that represent a frequency table of a second variable. We can use this to show both the wind direction and wind speed from our Wind2002.ori file.

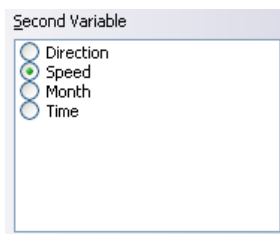
1. Open the Wind2002.ori file, if it isn't already loaded.
2. Choose the **Graphs | Two-Var Histograms** menu item.
3. On the **Main** page of the dialog choose the **Stacked Rose** option (see the section on stacked and stepped diagrams ^[85] for the difference between these).



4. Now go to the **Select** page, where we can specify the variable to be used as the second one. This time the **Variable** box only allows a single variable to be selected. We will select the Direction variable.



5. Below this is a new listbox labeled **Second variable**. Use this to specify the second variable that will make up the segments of each bar in the diagram. We will choose the Speed variable, which represents wind speed.



6. Let's now look at the **Options** page. There is a new option here called **Exclude 0.0 values**. With diagrams depicting wind speed it is customary to not include data when the wind speed is zero; the associated direction could be unreliable as the wind vane could be pointing in any direction in becalmed situations. When this option is ticked any zero values are not included in the rose diagram. Instead the legend box will give the percentage of the zero values in the data set.
7. You can choose to have Oriana automatically divide each wedge of the rose diagram into a certain number of segments, using the **Automatic** option and the **Number of Segments** setting. Each segment will represent that proportion of the total range of the second variable. For example, if the second variable ranges from 0 to 100, choosing 5 segments means that the first one will represent the number of observations between 0 and 20, the second from 20-40, and so on.

Segments

Automatic

Number of Segments: 5

Log scale

Segment for each unique value

Manual

Boundary: 0.0000

Add Remove

8. If you prefer you can set the boundaries between each segment manually, using the **Manual** option above. This lets you enter the exact boundaries for each segment. So, in the above example of a variable ranging from 0-100, if you enter a 15 in this option as the first boundary and a 30 as the second then all values from 0-15 will be in the first segment, all values greater than 15 and up to 30 are in the second segments, and so on.

To build up your list of boundaries tick the **Manual** option, then enter the first boundary into the **Boundary** box and click the **Add** button. This will add the boundary to the box below. Continue doing this for all boundaries. If you need to remove a boundary you can select it in the list and click the **Remove** button.

If your second variable consists of discrete values (e.g. just the numbers 1, 2, 3 and 4) and you want a separate segment for each you can use the **Segment for each unique value** option.

3.19 Circular-linear plots

The process of producing circular-linear plots^[87] is similar to that described in the previous section for two-variable histograms. However, in this case the value of the second variable is represented by the length of the arrows or bars, or by the placement of the points on the graph, each of which represents a single case (or row of the data matrix). We can

demonstrate this graph type by again using the Wind2002.ori file.

1. Open the Wind2002.ori file, if it isn't already loaded.
2. Choose the **Graphs | Circular-linear Plot** menu item
3. On the **Select** page ensure that subgrouping is by Month, as done in step 3 of the Stacked Histogram^[54] tutorial.
4. Also ensure that the primary and second variables are set to Direction and Speed respectively, as in steps 3-4 of the Two-variable Histogram^[55] tutorial.
5. On the **Main** page of the dialog you can choose to have the data represented as a scatterplot, or with arrows, bars or wedges.
6. You can use the **Symbol size** option on the **Symbols** page to determine the size of the scatterplot symbols, and the **Arrowhead size** option on the same page to adjust the arrowheads. If the **Variable arrowhead size** option is ticked then arrowheads closer to the center of the graph will be made smaller. Since shorter arrows have their heads packed more closely together this helps make the individual arrowheads more easily visible.
7. If instead you are using bars the width of the bar is controlled by the **Bar width** option on the **Axes** page. By default this is set to 1 degree wide, but you may wish to make them a bit wider.
8. By default, using Month as the subgrouping variable means that a separate graph is created for each month. If you instead wish to have all data on the same graph, with different colors or symbols representing the different subgroups, you can tick the **Subgroups on single plot** option on the **Main** page. For scatterplots you can choose to use different colors, symbols, or both with the **Represent subgroups with** option on the **Symbols** page.

3.20 Printing graphs and results

The contents of most window types can be printed using the **File | Print** command. You must first make sure that the window you want to print is the currently active window. In the **Print Range** section you can select to have just the current graph printed or all graphs.

You can specify which printer to use and change other options with the **File | Printer setup**^[100] command. The size of the

margins on the printed page can be changed with the **File | Page setup**^[10] command.

3.21 Saving graphs and results to file

The contents of the graph and results windows can be saved to a file using the **File | Export**^[97] command. You must first make sure that the window you want to save is the currently active window and that the page with the graph or results you want to save is visible. If you tick the **Export all pages** option on the dialog all graphs or result pages will be exported. For graphs each file is exported to a separate file. The file names will have sequential numbers appended to your chosen file name to distinguish them. All result pages will be exported to a single file.

Different types of windows have their contents saved in different formats; some may have a choice of formats for saving. See the descriptions of the window types^[5] for more details.

3.22 Changing variable type

You may occasionally find that you need to change the type of a variable. Most often this is when you are creating a new data file in expert mode. In this mode a blank data editor window is displayed with all the variables set to be of the type Angle. You will then need to change the variable types to suit your purpose. You may also decide later, after entering some data, that another data type might be more appropriate.

The simplest way is to use the drop-down boxes at the top of each column. Just click on the small downward pointing arrow and select the new type from the list.

B	C	D	E
Angles	Compass Direc	Time	Date
Direction	Angles	Time	Date
56.0000	Axial	09:20	01/01/2001
55.0000	Time	19:20	02/01/2001
210.0000	Day of week	04:52	03/01/2001
170.0000	Month of year	08:00	04/01/2001
220.0000	Week of year	08:40	05/01/2001
240.0000	Day of year	00:44	06/01/2001
35.0000	Compass Directi	10:40	07/01/2001
	Date	07:20	08/01/2001
	Linear	02:24	09/01/2001
15.0000	Label		10/01/2001
	Subgroup		
55.0000	NE		

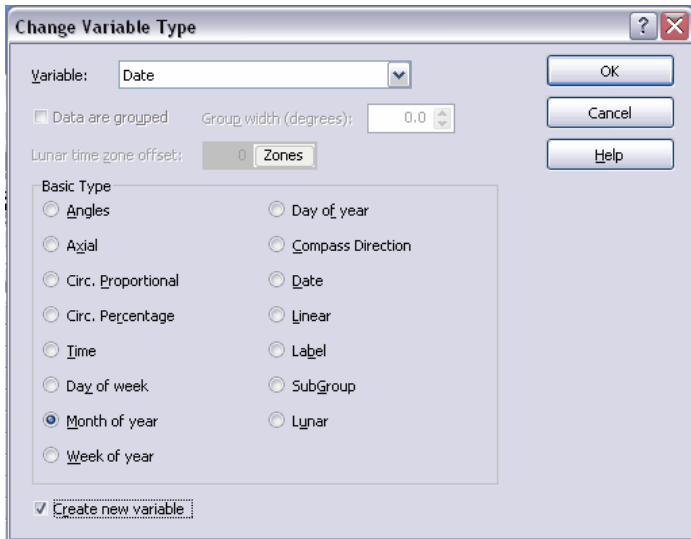
You can also use the **Data|Change Variable Type** menu item. This will display a dialog box with all possible data types. It will also let you change the grouping state of the circular data.

3.23 Summarizing data

You may sometimes wish to summarize a variable to allow for particular types of analyses. For example, if you have recorded the exact date of an event you may wish to summarize these by month, so that you can look at trends throughout the year.

You can do this by creating a new variable from the original date one. This is done with the **Data|Change Variable Type** command.

1. Place the cursor in the column of the desired date variable in the data editor and choose the **Data|Change Variable Type** menu item.



2. In the **Basic Type** section choose the desired type of the new variable (**Month of year** in this case).
3. Ensure that the **Create new variable** option is ticked.
4. Click **OK**. A new variable will be inserted next to the date variable, containing the month of year corresponding to each date.

4 Analyses

There are several types of analyses that Oriana can perform. Some procedures will give you basic statistics on each sample whereas others will allow you to compare samples to test whether they differ significantly.

In the descriptions that follow the basic concept behind the analyses and Oriana's particular implementation is given. For details and a greater understanding of the analyses you should look to some of the circular statistics literature. The references [\[158\]](#) section of this document lists many references, and in the following text page references are given to some of the textbooks that describe the analyses.

4.1 Statistics

Oriana calculates a variety of special circular statistics on each sample. These are mainly descriptive statistics, similar to those provided by other general statistics packages, but they are special versions designed for circular data. There are also a number of one sample tests of probability. The statistics included in Oriana are described briefly in the next two sections. See the section on the **Analyses|Stats** [\[123\]](#) command for details on how to run these analyses.

4.1.1 Basic Statistics

Many of the basic statistical parameters are based on the concept of the mean vector. A group of observations (or individual vectors) have a mean vector that can be calculated by combining each of the individual vectors (the calculations are explained in most books [\[158\]](#) about circular statistics).

BASIC STATISTICS	
Data file - E:\StatData\Oriana\Ori2 Test Data\Wind2002.ori	
Hourly wind data, garden weather station, Jun-Dec 2002	
Analysis begun: 29 May 2003 15:40:28	
Variable	Direction
Number of Observations	4495
Data Grouped?	No
Group width (& number of groups)	
Mean Vector (μ)	226.7189°
Mean Group	
Length of Mean Vector (r)	0.2845
Median	235°
Median Group	
Concentration	0.5936
Circular Variance	0.7155
Circular Standard Deviation	90.8442°
Standard Error of Mean	2.0794°
95% confidence interval (-/+ for μ)	222.6424°
	230.7955°
99% confidence interval (-/+ for μ)	221.3619°
	232.076°

The mean vector will have two properties; its direction (the mean angle, μ) and its length (often referred to using the letter r). The length will range from 0 to 1; a larger r value indicates that the observations are clustered more closely around the mean than a smaller one.

The concentration (κ) is a parameter specific to the von Mises distribution and measures the departure of the distribution from a perfect circle (or a uniform distribution). It is related to the length of the mean vector. The value reported by Oriana is the maximum likelihood estimate of the population concentration, calculated using the formula in Fisher (1993, p.88) and Mardia & Jupp (2000, p.85-6).

The circular variance and circular standard deviation are equivalent to their linear counterparts, but are calculated in a much different way. Variance is calculated from the length of the mean vector through the simple formula $V = 1 - r$; standard deviation is then calculated by $S = (-2 \ln(r))^{1/2}$. The result S , which is in radians, may then be converted to degrees by multiplying by $180/\pi$.

The standard error of the mean is also calculated based on the length of the mean vector (\mathbf{r}) and the concentration, and is calculated using formula 4.42 in Fisher (1993). It assumes that your data adhere to the von Mises distribution. The 95% and 99% confidence intervals are then derived from the standard error as would be done for the normal distribution (i.e. multiplying by 1.9604 or 2.5762). When the standard error is calculated a check is made of the concentration for the sample as well as the sample size. The standard error can be unreliable if the combination of these is low. If this occurs a warning will be printed.

The circular median direction can be difficult to calculate, due to the problem of choosing an appropriate axis on the circular scale, which wraps around. In Oriana the median is calculated by minimizing the function:

$$d(\theta) = \pi - \frac{1}{n} \sum_{i=1}^n |\pi - |\theta_i - \theta||$$

This is from equation 2.32 of Fisher (1993; note that earlier hardback printings of that book accidentally leave out part of this equation) and finds the absolute difference between the test median direction θ and all the data values θ_i . This minimization process can take a long time for large data sets, so it is advised that you leave the **Median** option on the **Analyses | Stats** dialog box unticked unless you need the median.

When circular data are grouped a bias can occur in the calculation of \mathbf{r} . This can be corrected by multiplying \mathbf{r} by a correction term (Zar, 1999, p.601; Mardia & Jupp, 200, p.23), calculated as $\mathbf{c} = (\mathbf{cw}/2) / (\sin(\mathbf{cw}/2))$, where \mathbf{cw} is the width of each class of the grouped data, in radians. For classes less than 30° in width this correction is negligible, so is not applied.

If the variable type being analyzed is Axial then the data are doubled (modulo 360) before being analyzed. The resulting mean direction is then back converted to be within 0°-180°. The other mean-related statistics are also back-converted.

Weighted Statistics

If your data consist of vectors (where both the angle and the length have been recorded) and you have defined vector pairs

using the **Data|Define vector pair**^[114] command, then a weighted mean vector will also be displayed. This is the angular mean, but weighted by the lengths of the vectors. The length of this mean vector is also given, first in the native units of the weighting variable, then scaled 0-1 like the unweighted r . This is followed by the X and Y components (sin and cosine) of the standard deviation ellipse. This is an ellipse depicting the standard deviation that can be drawn around the weighted mean centroid on circular-linear graphs^[142]. Basic statistics about the weighting variable will also be displayed.

Also displayed are two hypothesis tests. **Hotelling's test** (Batschelet, 1981, p. 144) tests whether the centroid of the end points of the weighted vectors differs from the origin - effectively, whether the weighted angles have a significant mean direction. The null hypothesis is that there is no mean direction. A probability less than your chosen significance level (usually 0.05) indicates that there is a common mean direction to the population. It is assumed that the data are not grouped, and that they conform to the bivariate normal distribution. Note that the test is particularly sensitive to departures due to skewness.

Moore's Modified Rayleigh Test (Zar, 1999, p.639-641) is a nonparametric analogue of the Rayleigh test for testing if angles are uniformly distributed around the circle. The null hypothesis is that the data are uniformly distributed. If the p value is less than the chosen significance level (usually 0.05) then the alternative hypothesis that the data are not uniformly distributed is accepted.

4.1.2 One Sample Tests

BASIC STATISTICS	
Data file - F:\StatData\Oriana\Ori2 Test Data\Wind2002.ori	
Hourly wind data, garden weather station, Jun-Dec 2002	
Analysis begun: 21 October 2005 15:26:34	
Variable	Direction
Data Type	Angles
Number of Observations	4495
Data Grouped?	No
Group Width (& Number of Groups)	
Rayleigh Test (Z)	363.8757
Rayleigh Test (p)	< 1E-12
Rao's Spacing Test (U)	331.8087
Rao's Spacing Test (p)	< 0.01
Watson's U ² Test (Uniform, U ²)	23.5836
Watson's U ² Test (p)	< 0.005
Kuiper's Test (Uniform, V)	15.7294
Kuiper's Test (p)	< 0.01
Chi-Squared Test (Uniform, X ²)	*****
Chi-Squared Test (p)	*****
V Test (V; expected mean 225.00°)	0.2844
V Test (u)	26.9647
V Test (p)	< 1E-12

***** indicates that a result could not be calculated.

Rayleigh's Uniformity Test (Fisher, 1993, p. 70; Zar, 1998, p.616; Mardia & Jupp, 2000, p.94) calculates the probability of the null hypothesis that the data are distributed in a uniform manner. The Z value is calculated simply as $Z = nr^2$, where n is the number of observations and r is the length of the mean vector. A longer mean vector (and the resulting larger value of Z) means greater concentration of the data around the mean, and thus less likelihood of the data being uniformly distributed. The calculation of the probability follows Fisher's equations 4.17 and 4.18. A probability less than your chosen significance level (usually 0.05) indicates that the data are not distributed uniformly and that they show evidence of a preferred direction; the preferred mean direction is unspecified, as opposed to the V-test discussed below.

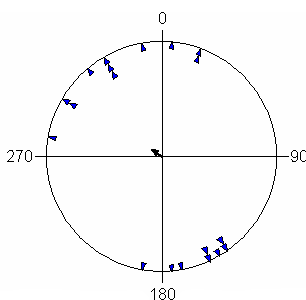
In the above example the Rayleigh Z value is very high and the probability vanishingly small, so we reject the probability that the data are uniformly distributed.

Note that in the Results window a '< 1E-12' (which stands for

$< 1 \times 10^{-12}$) means that the actual value is indistinguishable from zero at the maximum accuracy of the computer (15-16 significant digits). Values that are somewhat larger, but still smaller than the number of decimal places set in **Options | Format | 149**, are given in scientific notation (e.g. 0.0000025, or 2.5×10^{-6} , is displayed as 2.5E-6).

Rao's Spacing Test (Mardia & Jupp, 2000, p. 108; Batschelet, 1981, p.66) also takes as its null hypothesis that the data are uniformly distributed. This is tested by looking to see if the spacing between adjacent points is roughly equal around the circle (using the equations on the above cited pages). For uniform distribution the spacing between points should be roughly $360^\circ/n$. If the actual spacings deviate too much from this value then the likelihood that the data are uniformly distributed is reduced.

This test can be more powerful than Rayleigh's test. For example, the data in the graph below seem to be non-uniform, appearing to be bimodal. However, the length of the mean vector is very small (note the short mean arrow on the graph) and Rayleigh's test gives a non-significant result, with a probability of 0.811. However, Rao's spacing test gives a probability less than 0.01, and the null hypothesis of uniformity can be rejected.



Watson's U^2 Test (Fisher, 1993, p. 84; Mardia & Jupp, 2000, p.104; Zar, 1999, p.657; Batschelet, 1981, p.79) performs a goodness-of-fit test against a specified distribution, either uniform or von Mises. It does this by calculating the mean square deviation for the fitted distribution. If the deviation is too high (resulting in a high U^2 and a low probability) then the null hypothesis that the data fit the chosen distribution is rejected. When the uniform distribution is selected the

modified statistic, as shown in Fisher's (1993) formula 4.36 or Mardia & Jupp's (2000) formula 6.3.36 is used.

This test cannot be calculated on grouped data, nor can it be used for sample sizes less than 10.

Kuiper's Test (Fisher, 1993, p.66; Mardia & Jupp, 2000, p.99; Batschelet, 1981, p.76) takes the alternative approach of directly comparing the distribution of the data to the desired distribution, either uniform or von Mises. It can be viewed graphically by referring to the distribution plots produced by Oriana. The Kuiper's V statistic is based on the largest vertical deviations above and below the diagonal line (representing the desired distribution). Too great a deviation, giving a high V and low probability, leads to rejection of the null hypothesis that the data fit the distribution.

The formula used in Oriana incorporates the correction factor shown in Fisher's (1993) equation 4.12 and Mardia & Jupp's (2000) 6.3.30. As with Watson's U^2 , this cannot be calculated on grouped data.

For grouped data the **Chi-squared Test** (Batschelet, 1981, p.72; Zar, 1999, p.656) is instead calculated. This simply performs a standard chi-squared test based on the expected number of observations in each class given a uniform distribution. A probability below the chosen alpha level (usually 0.05) leads to the rejection of the null hypothesis that the data are distributed uniformly. The sample size must be sufficient so that the expected frequencies in each class are 2 or greater.

If you wish to perform the chi-squared test on data that are not grouped you will have to first declare them as grouped and set the class width, using the Data | Change Variable Type dialog box.

The **V-Test** (Fisher, 1993, p.69; Mardia & Jupp, 2000, p.98; Batschelet, 1981, p.58; Zar, 1999, p. 618) is a variant of the Rayleigh test, but instead of testing the null hypothesis of uniformity against an unspecified alternative, the V-test tests against an alternative hypothesis that the distribution is a non-uniform one with a specified mean direction. The specified mean direction is a hypothetical one chosen in advance (for example, the expected vanishing direction of released homing pigeons).

Note that Zar (1999) calculates V from \mathbf{R} , the total length of the resultant vector of the data, rather than from \mathbf{r} , the length of the mean vector, which is what most other authors (and Oriana) use. However, Zar's formula for \mathbf{u} corrects for this; thus \mathbf{u} and \mathbf{p} will be the same for all methods.

4.1.3 Second Order Statistics

If two or more circular variables are present in the file, or if a subgrouping variable is being used to analyze sets of data, then second order statistics are also calculated. These are statistics that focus on further analyses of the basic statistics for each variable.

Second Order Statistics	
Grand Mean Vector (GM)	171.64°
Length of Grand Mean Vector (r)	0.505
Number of Means	14
95% Confidence Interval (-/+)	217.706°
	175.987°
99% Confidence Interval (-/+)	190.341°
	176.758°
Hotelling's Test (F)	19.776
Hotelling's Test (p)	1.59E-4
Moore's Modified Rayleigh Test (R*)	1.018
Moore's Modified Rayleigh Test (p)	0.1 > p > 0.05

The first statistics are the calculation of the **grand mean vector**, or the mean of means. This is calculated in a similar way to the mean of each variable, with the means for each variable being used as the data rather than the original angles. Also, each mean is weighted by its r value (the length of the mean vector). The result is a grand mean angle and its resulting length r . Also provided are the **95% and 99% confidence limits**, calculated using the method of Batschelet (1981), also described in Zar (1998, p. 611). Note that, unlike the confidence intervals for the sample means, these are not necessarily symmetric around the grand mean. Also, the confidence intervals often cannot be calculated when the number of means are small (e.g. less than 4-5).

Two hypothesis tests are also calculated. **Hotelling's one sample test** (Zar, 1998, p. 638; Batschelet, 1981, p. 144) tests whether the whole population has a significant mean direction. The null hypothesis is that there is no mean direction. A

probability less than your chosen significance level (usually 0.05) indicates that there is a common mean direction to the population. It is assumed that the data are not grouped, and that they conform to the bivariate normal distribution. Note that the test is particularly sensitive to departures due to skewness.

A nonparametric test is also available. **Moore's modified Rayleigh test** (Zar, 1998, p. 641) is an analogue of the Rayleigh test that is based on weighting the mean angles with the rank order of the r values of each. The null hypothesis is that the means of the population are uniformly distributed around the circle. A significant probability indicates that the data are not distributed uniformly and that they show evidence of a preferred direction.

4.2 Multisample Test

The multisample tests in Oriana allow you to compare two or more sets of data to determine if their distributions differ. Most tests can be performed either as pairwise, where each pair of samples are compared, or as multisample, where all samples are compared at once. The tests included in Oriana are described briefly in the next sections. See the section on the **Analyses | Multisample Tests** ^[124] command for details on how to run these analyses.

4.2.1 Watson-Williams F-Test

Watson-Williams F-test (Fisher, 1993, p.126; Mardia & Jupp, 2000, p.129; Batschelet, 1981, p.95; Zar, 1999, p. 625) compares two or more samples to determine if their mean angles differ significantly. The test can be performed in a pairwise fashion, so that the selected samples are compared with each other, a pair at a time, or an overall test can be calculated for all samples.

The F-test basically proceeds by comparing the lengths of the mean vectors for each sample with that for the pooled data of the two or more samples. The resulting **F** statistic is the same as Fisher's variance ratio statistic which is commonly used in linear statistics, including analysis of variance. The **p** value printed for each test is the probability associated with the null hypothesis that the two mean angles are equal. If this probability is less than your chosen significance level (usually 0.05) then the null hypothesis can be rejected in favor of the

hypothesis that the means are different. If the null hypothesis is not rejected (i.e. the probability is greater than 0.05) then Oriana will report the overall mean for all samples in the test, which can be used as an estimate of the overall population mean.

This test assumes that the two samples are independent and drawn at random from a population with a von Mises distribution. It also assumes that the concentrations of the two samples are similar and that they are sufficiently large (>2). If the concentration is too low, a warning is printed. Finally the data may not be grouped^[26].

The formula for the F-test can incorporate a correction factor, based on the concentration, to correct for bias. Some authors only use this when concentrations are low, whereas others use it for all calculations; Oriana ver. 2 takes the latter approach (Oriana ver. 1 only used it for estimated concentrations between 1 and 2).

4.2.2 Chi-Squared Test

Oriana can perform pairwise or multisample **Chi-squared Tests** (Batschelet, 1981, p.109) on the samples. This test determines whether the samples differ significantly from each other in some unspecified way.

The test is the basic chi-squared test as used for a variety of purposes. The data must first be grouped into classes. For data that are already grouped^[26] their specified class width is used; otherwise the class width can be set through the option on the **Options** page of the **Analyses | Multisample Tests**^[12] dialog box. A contingency table is then constructed and the expected frequencies determined (based on the row and column totals). The Chi-Squared statistic is then calculated based on the differences between the observed frequencies of the samples.

The **p** value printed for each test is the probability associated with the null hypothesis that the samples are drawn from the same population. If this probability is less than your chosen significance level (usually 0.05) then the null hypothesis can be rejected in favor of the hypothesis that the samples are from different populations that differ in some way. The difference may be in the distribution, mean direction, or other parameter; further investigation will be needed to determine what the

difference is between the two samples.

The Chi-squared test assumes that most or all the expected frequencies used in the calculation will be greater than 5. This is checked during calculations and a warning is printed if more than 20% of the classes have expected frequencies less than 5. If this occurs you can try using large class widths so that more observations are in each class. You can also use the **Drop Classes with 0 Observations** option on the **Options** page of the analysis dialog box. This will ignore any classes that do not have any observations. This is particularly useful if your observations are clustered fairly closely around the mean, with the result that a large portion of the circle will not have any data.

4.2.3 Mardia-Watson-Wheeler Test

The **Mardia-Watson-Wheeler Test** (Fisher, 1993, p.122; Mardia & Jupp, 2000, p.147; Batschelet, 1981, p.101; Zar, 1999, p. 633), also called the **Uniform Scores Test**, is a non-parametric test for determining whether two or more distributions are identical. The basic idea is that the samples are pooled together, sorted into increasing angles, and are then evenly distributed around the circle by calculating a uniform score (or circular rank). If the distributions of the samples are identical then the new uniform scores for the samples should be evenly interspersed around the circle, and their resultant vector lengths **R** should be short and similar. Any significant difference between the **R**s will lead to a large **W** test statistic and rejection of the null hypothesis of identical distributions.

It is important for this test that any ties between samples (e.g. identical angles, such as 135° , in two or more samples) are broken. Oriana does this by randomly assigning different ranks during the ranking procedure. The actual ranks assigned will be the same for subsequent runs of the test, so long as the order of the original data remains the same. However, if you re-sort the data and run this test again you may get a different result for **W**, because the randomly assigned ranks will differ. If this is likely to cause problems you may wish to break any ranks manually before running the test. You can do this by replacing the identical values with two slightly different values (e.g. replace two 135° observations with 134.999° in one sample and 135° in the other). You must remember, though, that this may cause unwanted effects in other statistical procedures.

This test cannot be performed on grouped data.

4.2.4 Watson's U² Test

Watson's U² Test (Mardia & Jupp, 2000, p.150; Batschelet, 1981, p.114; Zar, 1999, p. 630) is a two-sample analogue of the single sample Watson's U² test; instead of comparing a set of data to a theoretical distribution two sets of data are compared using mean square deviations. The null hypothesis is that the two samples have the same distribution. A significant p value leads to the rejection of this hypothesis and the acceptance of the alternative hypothesis that the samples are from populations that differ in some way. The difference may be in the distribution, mean direction, or other parameter; further investigation will be needed to determine what the difference is between the two samples.

As with the single sample test, the two-sample Watson's test cannot be performed on grouped data.

4.2.5 Hotellings Paired Test

Hotellings Paired Test (Zar,1999, p. 645) compares two samples of paired data using Hotelling's procedure. This tests whether the paired observations differ between the two samples. The null hypothesis is that there is no difference between the two samples. A probability less than your chosen significance level (usually 0.05) indicates that the pairs differ between the samples. It is assumed that the data are not grouped, and that they conform to the bivariate normal distribution. Note that the test is particularly sensitive to departures due to skewness.

Note that this test is for use with paired sample experimental designs and that it is assumed that each row in the matrix is for an individual case (for example, each row contains data for an individual organism before and after treatment or in two different situations). If one sample has more cases than the other all the extra cases will be treated as missing data and will be ignored.

4.2.6 Moore's Paired Test

Moore's Paired Test (Zar,1999, p. 647) is a nonparametric alternative to Hotelling's Paired Test. This also tests whether

the paired observations differ between the two samples, using Moore's modified Rayleigh test. The null hypothesis is that there is no difference between the two samples. A probability less than your chosen significance level (usually 0.05) indicates that the pairs differ between the samples.

As with Hotelling's, this test is for use with paired sample experimental designs and that it is assumed that each row in the matrix is for an individual case.

4.3 Correlations

Oriana provides two different correlation procedures for comparing variables, one between two circular variables and one between a circular and a linear one. These correlations assume that the data are entered in a pairwise fashion; that is, each row in the data matrix contains data related to the same observation or sample. For example, a data set may contain two variables, one the direction of travel of an insect and the other the direction to a light source. Each row would represent the observation of these two directions at a single point in time.

These correlations are described briefly in the next sections. See the section on the **Analyses | Correlations** `[125]` command for details on how to run these analyses.

4.3.1 Circular-circular correlation

The circular-circular correlation coefficient (Fisher, 1993, p.151; Mardia & Jupp, 2000, p.250; Zar, 1999, p. 649) calculates the correlation between two circular variables. This uses the Fisher & Lee (1983) method, which is analogous to the Pearson product-moment correlation commonly used for linear data. As with Pearson's this coefficient ranges from -1 to +1, with the former indicating a perfect negative correlation, the later a perfect positive correlation, and 0 indicating no correlation.

The formula used for the calculation is the alternative form given in Fisher's (1993) equation 6.36. The significance of the correlation is tested by using the jackknife method described in Zar (1999, p.649-650). With this the correlation is calculated multiple times, each time with one pair of data being dropped. The confidence limits of the series of calculated coefficients is then calculated; if 0 does not fall within the limits then the null hypothesis that the correlation is 0 is rejected, and the

alternative that the correlation is significantly different than 0 is accepted.

Note that the jackknife calculation can take a long time for large data sets, so this is an option in the **Analyses | Correlations** dialog box.

4.3.2 Circular-linear correlation

The circular-linear correlation coefficient (Fisher, 1993, p.145; Mardia & Jupp, 2000, p.245; Zar, 1999, p. 651) calculates the correlation between a circular variable and a linear one. Examples of data where one might want to calculate this type of correlation could include wind direction and ozone level, or direction of travel of an animal along with the distance traveled.

This correlation coefficient ranges from 0 to 1, so there is no negative correlation. The calculation of the significance of the correlation follows Mardia & Jupp (2000) in using their approximation of the F distribution in equation 11.2.2.

4.4 Second Order Statistics

The Basic Statistics analysis in Oriana will provide second order stats (e.g. the grand mean) if there are more than one variable of raw data. It will do this by calculating the means and mean vector length for each variable, then calculating the second order statistics.

However, you may already have your data in the form of means and mean vector lengths, so may wish to calculate the second order statistics directly on those means. The analyses in Oriana's Second Order Statistics command will do this. To run these analyses your data file needs to have pairs of variables, one circular and one linear, which contain the polar coordinates of the mean vectors - the means and their associated lengths. You can have a number of pairs of variables, but Oriana will always assume that the first linear variable is associated with the first circular one, the second linear with the second circular, etc.

4.4.1 Basic Second Order Statistics

The first section of the Second Order Statistics output is similar to that produced when calculating the basic statistics on raw data. The grand mean and its length, the confidence intervals,

and Hotelling's and Moore's tests are output. If the data file contains more than one pair of variables containing the means and lengths then a column of results is produced for each pair.

SECOND ORDER STATISTICS		
Data file - F:\StatData\Oriana\Ori2 Test Data\Zar2717.ori		
Analysis begun: 16 August 2011 16:18:07		
Variable	Means1 & Rs1	Means2 & Rs2
Number of Means	7	10
Grand Mean Vector (GM)	152.166*	123.82*
Length of Grand Mean Vector (r)	0.596	0.659
95% Confidence Interval (-/+) for GM	121.423*	110.535*
	186.01*	140.566*
99% Confidence Interval (-/+) for GM	96.366*	105.464*
	216.08*	149.262*
Hotelling's Test (F)	16.663	42.043
Hotelling's Test (p)	0.006	5.70E-5
Moore's Modified Rayleigh Test (R*)	1.428	1.697
Moore's Modified Rayleigh Test (p)	< 0.001	< 0.001

4.4.2 Two Sample Second Order Statistics

If there are two or more pairs of mean and mean vector length variables in the data file then two sample second order tests are also calculated. First in the table of results are the names of the two sets of means/lengths that are being compared, along with the number of means in each sample. This is followed by a number of test results.

Two sample second order statistics	
Variables	
1st sample means	Means1
1st sample vector lengths	Rs1
Number of means	7
2nd sample means	Means2
2nd sample vector lengths	Rs2
Number of means	10
Hotelling's two sample F	4.693
Hotelling's two sample p	0.028
Mardia's two sample U	0.158
Mardia's two sample p	0.1 > p > 0.05
Hotelling's paired F	2.564
Hotelling's paired p	0.171
Moore's paired R'	1.01
Moore's paired p	0.1 > p > 0.05
Number of pairs	7

Hotelling's two sample test (Zar, 1999, p.641-642; Batschelet, 1981, p. 150-154) compares the grand means of two populations. The null hypothesis is that the means of the two populations are equal. A probability less than the chosen significance level (usually 0.05) indicates that the two means differ. As with other variations on the Hotelling test, this assumes that the data are not grouped, and that the data are from a bivariate normal distribution with similar variances. However, this two-sample test is somewhat more robust to departures from normality than the one sample and paired tests.

A nonparametric alternative to the above is **Mardia's two sample test** (Zar, 1999, p.643-645; Batschelet, 1981, p. 154-156). With this test the differences between the individual means and the grand mean for both samples is further analyzed using one of the circular two sample tests. In Oriana Watson's U^2 is used for the analysis. The null hypothesis is that the two samples come from the same population. The alternative hypothesis is that the populations that differ in some way (in the distribution, mean direction, or other parameter). This test cannot be used on grouped data.

These tests are followed by **Hotelling's paired two sample test**^[74], and **Moore's nonparametric alternative**^[74]. These are identical to the paired tests described above in the Multisample Test section, except that they are calculated on samples of means rather than raw data. As with those it is assumed that the data are paired (e.g. each row in the data matrix contains the means for the same population, but measured before and after some treatment or change in circumstances).

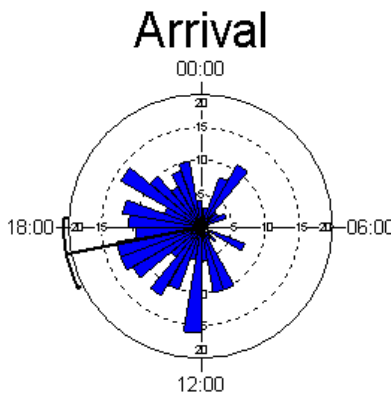
5 Graphs

Oriana allows you to plot your data in a number of ways. There are a variety of circular graphs as well as traditional linear histograms and scatterplots. There is also a graph that plots your data against an expected uniform distribution to allow you to assess whether your data depart from uniformity, and a similar graph that compares two sample distributions.

For more details about how to actually produce these charts, see the tutorial section on graphing your data.^[47]

5.1 Rose Diagrams

This is one of the most commonly used types of graphs for circular data. It is basically a histogram that has been wrapped around a circle. Each section of the histogram, which in this case is wedge-shaped, depicts the number of observations falling within that portion of the range. In the graphs shown below each wedge represents 10° of the total circular range and the length of each wedge (the radius from the center) represents the number of observations falling within that range. The data are tabulated so that the lower end of the range is included in the bar, but not the upper end (e.g. the first bar includes values ranging from 0° to just less than 10° , the second one ranges from 10° to just less than 20° , etc.).

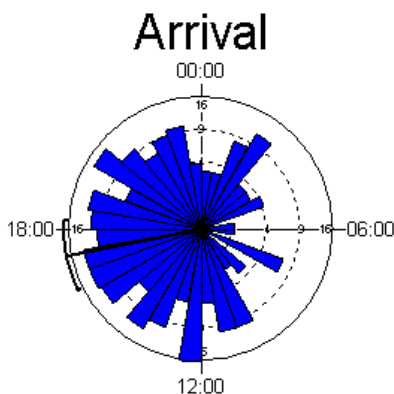


Note that the above graph has a black line running from the center of the diagram to the outer edge, at approximately 17:00. This is the mean angle of the data. The arcs extending to either side represent the confidence limits of the mean. They can be either the 95% or 99% confidence limits, depending on

the setting in the **Graphs|Histograms**^[133] dialog box. Note that sometimes the confidence limits can be unreliable when the combination of the sample size and the concentration is low. In these cases the confidence limit arc can be displayed in a different color. By default this is red rather than black, but the color can be changed with the **Inacc. Stats** option on the **Colors** page of the dialog box.

As an alternative, the mean can also be depicted as an arrow, the length of which represents the value of r (which is described in the section on Basic Statistics^[63^b]).

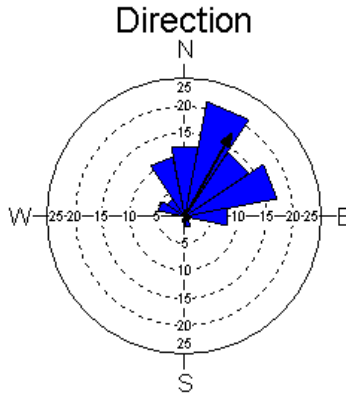
The above type of graph can be misleading, because our visual perception takes the whole area of a wedge into account when comparing them, rather than just its length. A wedge that is one third the radius of another actually appears far less important, since the area of the smaller wedge is only one ninth the area of the larger one. To avoid this problem, the wedges can be drawn so that the frequency is represented by the area of the wedge. The following graph uses the same data as the one above, but the area option has been selected.



Note that the scale is now a squared scale rather than a linear one.

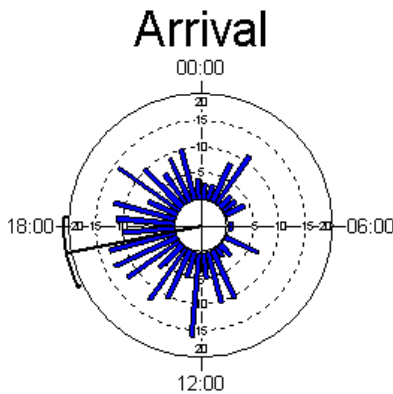
With compass direction data the wedges of the diagram are shifted slightly so that they are centered on the compass direction. For example, in the diagram below the wedge for North directions is centered on the vertical axis (0° or N), rather than having its left edge starting at that point. This type of placement can also be optionally specified for graphs of angular or time data, through the **Center circular bars on 0** option

on the **Axes** page of the **Graphs | Histograms**  dialog box.



5.2 Circular Histograms

These graphs are similar to the rose diagram, but they are made up of parallel-sided bars that show the number of observations within each class range. The actual width of the bars (= the width of the class range) can be set when the graph is drawn. The graph below has a bar width of 10 degrees.

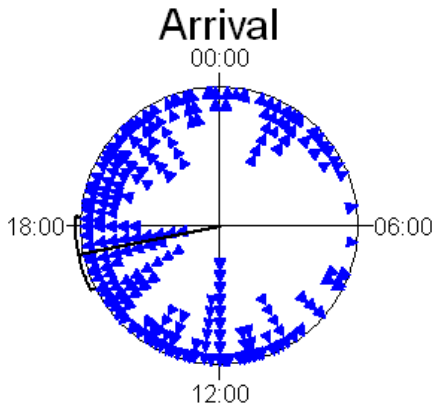


5.3 Raw Data Plots

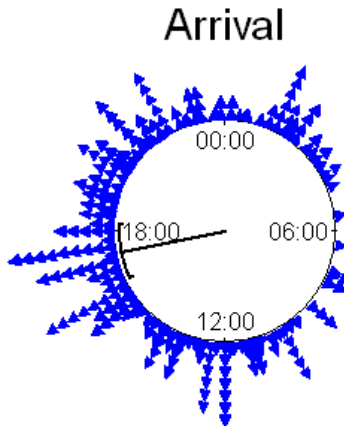
These circular diagrams plot individual symbols for each datum in the sample. This allows you to assess the sample size at a glance as well as seeing the distribution of the data.

Here is an example of one traditional way of presenting the raw data, with the points stacked from the outer rim of the circle

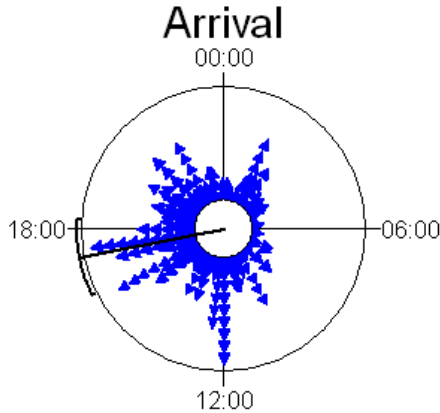
towards the middle:



You can also have the points stacked on the outer rim, pointing outwards:



Finally you can have the points stacked from the middle pointing outwards:

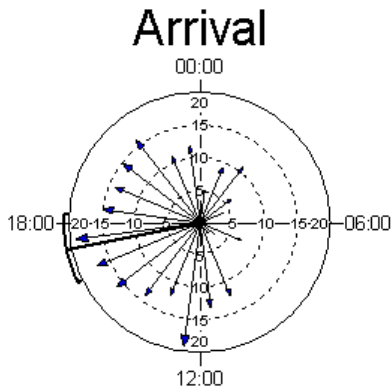


Note: For samples with very large numbers of observations, each symbol may represent multiple observations; a note will be placed on the graph if this occurs. If you want to reduce it to one symbol per observation you can try taking one or more of the following steps:

- Reduce the size of the symbols on the Symbols page of the graph dialog box
- Switch to using a different type of raw plot (e.g. from points arranged margin inwards to margin outwards)
- Adjust the Basal Circle option on the Axes page to make it smaller (for margin outwards and center outwards graphs only).
- Increase the overall size of the graph by making the graph window and/or the whole Oriana window bigger.

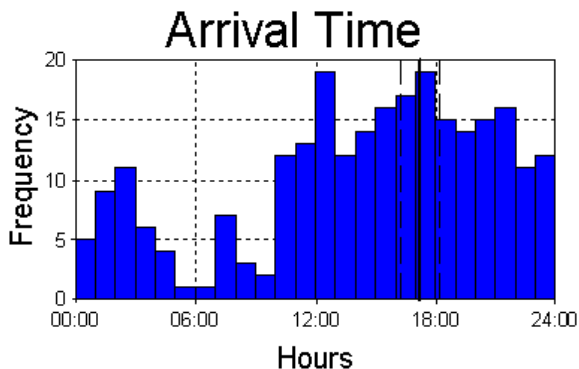
5.4 Arrow Graphs

This graph is similar to a circular histogram^[81], but instead of parallel-sided bars it has arrows indicating the frequencies for each class.

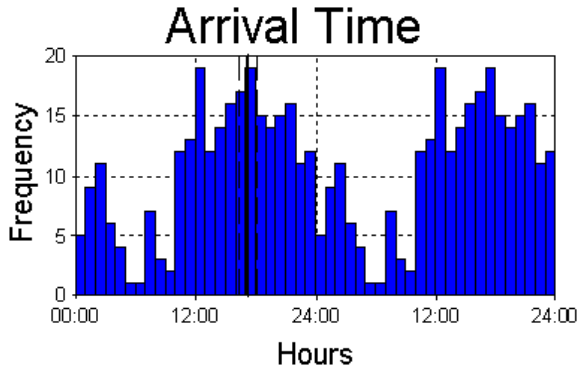


5.5 Linear Histograms

Circular data can also be plotted on linear histograms. In this case the mean vector and the confidence limits are shown as vertical lines.



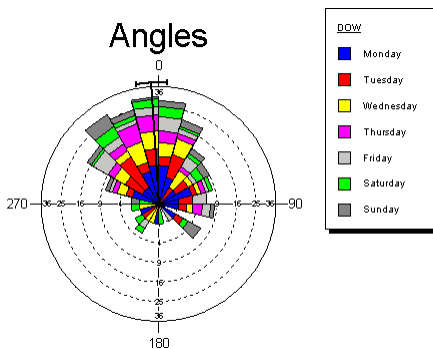
If you wish to emphasize the cyclicity of the data you can choose to have the X axis doubled, so two complete cycles of the data are plotted:



You can also choose to have just half the scale depicted. This is useful if you are working with axial data all in the 0-180° range.

5.6 Stacked and Stepped Histograms

If your current data file has a grouping variable defined then normally separate graphs will be produced for each group. However, you can also produce a single graph that has differently colored segments for each group, showing the relative proportions of each.

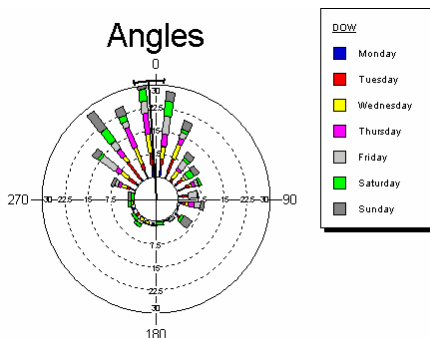


The above graph was produced by first ensuring that a grouping variable was selected (DOW in this case) and then choosing the **Stacked Rose** option on the **Graphs | Histograms** ^[133] dialog box. Choosing **Stacked Circular** will give a similar graph, but with parallel-sided bars, and **Stacked Linear** will give a linear histogram ^[84] with stacked segments.

By default a single mean will be displayed for the whole data set. However, you can optionally specify that the mean for each

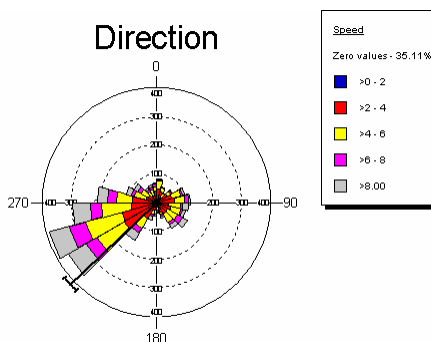
subgroup is displayed by selecting the **Subgroup means** option on the **Options** page of the **Graphs | Histograms** ^[133] dialog box.

The **Stepped Circular** option will produce a circular histogram with each segment being somewhat thicker than the previous one. This type of graph is commonly used for meteorological wind roses.



5.7 Two-variable Histograms

Segmented histograms like the Stacked and Stepped ^[85] ones can also be produced from two separate variables, where one is circular and the other is a set of associated data. Examples would be wind direction and speed, or the direction and distance of travel of an animal. This graph is formed by dividing up the second variable into frequency classes and using those as the segments of the graph.



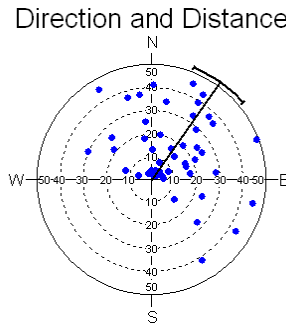
In the above graph zero values for the wind speed are left out of

the graph, as is common in meteorological studies, where the direction measured during becalmed periods could be misleading. This is an option on the **Graphs | Two-Var Histograms** [\[138\]](#) dialog box. Also on this dialog box is the **Subgroup means** option, which specifies that separate means are displayed for each class of the second variable.

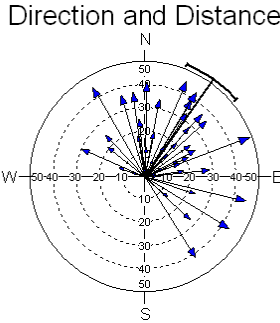
5.8 Circular-linear Plot

This graph type, like the two-variable histogram, also plots two variables, one circular and one linear. However in this case the second variable is depicted not as frequencies in segments of the histogram, but as individual points. Each observation, or row in the data matrix, is depicted as a point, arrow, bar or wedge.

The first type, the scatterplot, has each observation represented by a point. The position around the circular axis represents the circular variable, while the position on the concentric grid represents the linear value. Here is an example:



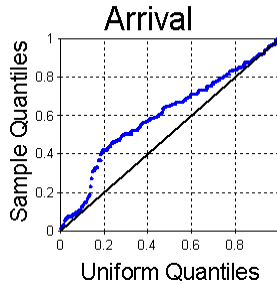
The vector type of circular-linear plot is superficially like the **Arrow Histogram** [\[83\]](#), but in this case each arrow corresponds to a single observation. The direction the arrow is pointing is taken from the selected circular variable, while the length of the arrow is determined by the chosen second variable. So you could, for example, use this graph to plot the direction and distance traveled for each animal observed, or the orientation and length of individual toolmarks in sedimentary rocks.



Instead of arrows, you can also choose to have the linear variable represented by bars or wedges.

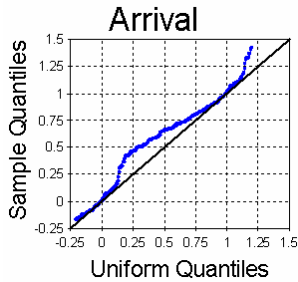
5.9 Distribution Plots

Distribution plots allow you to assess the departure of your data from a certain distribution, such as uniformity. Each datum is plotted against the value expected for that datum given the desired distribution. The points on the plot should lie along a 45° angle; the diagram has a reference line at this angle. Departures from the distribution can be seen as departures from this line. The following graph compares arrival time against a uniform distribution; it is clear that there are departures from uniformity.

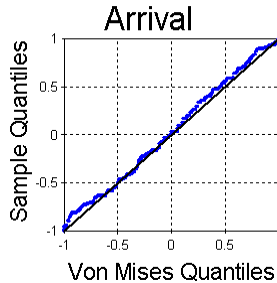


Since the data are circular, and the starting point of the plot is arbitrary you could have important patterns becoming less noticeable if they occur split over the wrapped around part of the plot (i.e. going off the graph at the upper right and wrapping around back to the lower left). This can be alleviated by extending the axes and repeating 20% of the points at either end. The following graph is the extended version of the one

above.

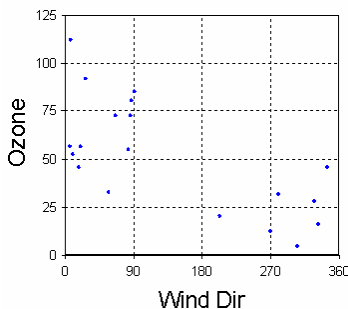


The next graph compares the data to the von Mises distribution. Here you can see a close correlation, suggesting that the data follow the von Mises distribution.



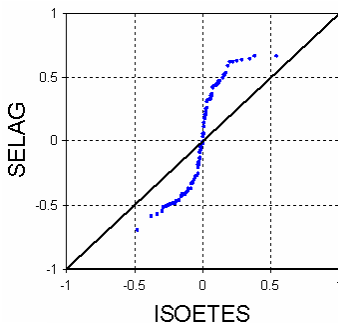
5.10 Two-sample Graphs

The **Graphs** | **Two-sample** ^[145] command produces scatterplots and two sample Q-Q-plots. With the **Scatterplots** option you can plot any two variables against each other. This is useful to give a graphical representation that can be used in interpreting the results of a correlation ^[75] analysis. Options on the dialog box allow you to reverse the X and Y axes, and also to specify whether the whole 0-360 range for circular data is plotted, or only that part of the scale that actually has data.



Q-Q plots are ones that let you compare the distribution of two samples, much like the distribution plots^[88] compare a single sample against a theoretical distribution. They are produced by first centering the data on their medians (so that any differences in the medians do not affect the graphs) and then sorting them into ascending order. These are then plotted against each other. If the two samples have different numbers of observations the number of points plotted is the lower of the two. Observations to be plotted from the larger of the samples are chosen to be evenly distributed throughout the range.

If the two distributions are similar then the points will lie close to the 45° angle reference line. In the following graph the points make a distinct departure from the reference line, and thus it appears that the two distributions are different. This is confirmed by significance levels far below 0.05 for the Mardia-Watson-Wheeler^[73] and the Watson's U^2 ^[74] test.



6 Menus

This section describes the menu structure of Oriana.

6.1 File

The File menu contains the commands for opening and saving data and desktop files, as well as the printer related functions.

All of the save and print functions act on the currently active window.

6.1.1 File|New

This option allows you to set up a new data file. You can specify the initial size of the data file and the types of data.^[12]

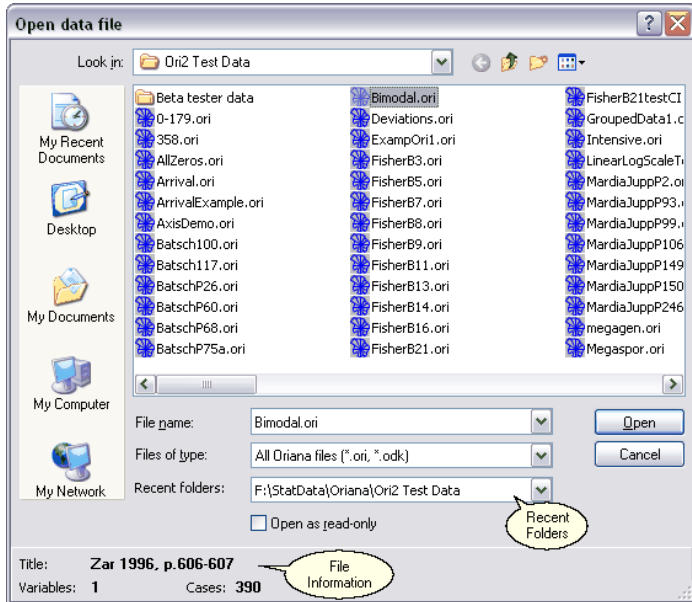
When you choose the **File|New** command, one of two New Data dialog boxes will be displayed, depending on which you used last. By default the New File Wizard is displayed. This takes you step by step through declaring what type of data you are going to enter and how many columns there are, and giving labels to each variable and the whole file. At the end, after pressing the **Finish** button the status window will be displayed and an empty spreadsheet will be opened, ready for you to enter data.

You can also switch to Expert Mode by pressing the appropriate button. In this mode you simply enter the number of columns you wish to have in your file and press **OK**. Once the data editor is displayed you can then declare the type of each variable with the **Data|Change Variable Type**^[10] option, or by using the drop-down boxes in the first row of each column.

6.1.2 File|Open

This command lets you open an existing data file. If another data file is already open it will be closed (after asking if you want to save any changes or results).

When you choose the **File|Open** command, the Open File dialog box will be displayed. This is similar to the standard file dialogs used in many Windows programs, but with some additions:



A panel at the bottom of the dialog shows information about the currently selected file, so that you can be certain you are opening the correct file.

Above this is a **Recent Folders** drop-down list, which shows the most recently visited folders. This makes it easy to move to different folders scattered around your hard disk or network without having to browse through the whole directory structure. Note that this list does not appear under Windows Vista or later, as the standard dialog boxes in these operating systems have their own **Recent Places** folder on the left hand side that performs the same function.

When you have specified a file to open, click on the **Open** button to open the file. Oriana will then check to make sure the file exists, is a valid Oriana file, and can be opened with no problems. The program will then read the data and open a status window telling you some information about the file. Once this is displayed you can then choose one of the data editing, graphing or analysis options.

You can also open a new file using the drag and drop^[159] feature of Oriana.

6.1.3 File|Reopen

When this is selected a submenu is displayed showing the most recently used files. You can reopen one of these files by clicking on it.

The number of recent files displayed here can be changed in the **Options|Preferences**^[149] dialog box.

6.1.4 File|Close

This will close the current data file, along with all other windows containing the graphs and results associated with this data file. If the data have been modified but not saved you will be asked if you wish to save them.

If you have previously opened or saved the current desktop, and have added new results or graphs to it, then you will also be asked if you wish to save the desktop.

6.1.5 File|Save Data

Choosing this option will save the currently loaded data to a file. If you have already specified a filename (by saving it previously) then the file will be saved straight away. Otherwise, you will be asked to enter a file name in the **Save Data As**^[93] dialog box.

6.1.6 File|Save Data As

This option lets you save the currently loaded data to a file, after specifying a filename. When you choose the **File|Save Data As** command, the Save File dialog box will be displayed. It looks much the same as the **File|Open Data**^[91] dialog

Once you have entered a valid file name in this box, click on the **Save** button. Oriana will first check to see if the file already exists; if so you will be asked if you wish to overwrite the existing file. The program will then write the data to the file.

Subsequent saves to the same filename can be done without having this dialog box appear by using the **File|Save Data**^[93] command.

6.1.7 File|Open Desktop

This option allows you to reload a previously saved desktop file. The data file will be reloaded and all the results and graphs windows will be recreated.

When this option is chosen, you will be presented with a dialog box similar to that used in the **File|Open** option. You can choose which desktop file you wish to open. All currently opened data files and results and graphs windows will be closed before the desktop is restored.

You can also open a new desktop file using the drag and drop feature of Oriana.

6.1.8 File|Save Desktop

Oriana uses a desktop metaphor in dealing with data analysis projects. The **Save Desktop** option lets you save your current working environment to disk. The position, size, and contents of each window currently displayed will be saved. Later, you can use the **Open Desktop** option to reload all the windows and their contents, letting you pick up where you left off in your analyses.

You can have Oriana automatically save and restore your desktop each time you exit or start the program. The **Options|Preferences** dialog box allows you to turn this feature on or off. When it is on, your desktop will be saved each time you exit Oriana. When you next run Oriana, the desktop will be returned to the same state.

6.1.9 File|Import

Oriana imports data through an import preview dialog box. This shows you a preview of how the data will be imported and allows you to change various options so that the data are imported correctly. Oriana can import data from the following formats:

- Excel (ver. 2.1 through 2010)
- Lotus 1-2-3 (ver. 1.0-5.0)
- Symphony (ver. 1.0-1.1)
- Quattro Pro (ver. 1.0-6.0)
- dBase (all versions)
- Paradox (ver 3.0-7.0)

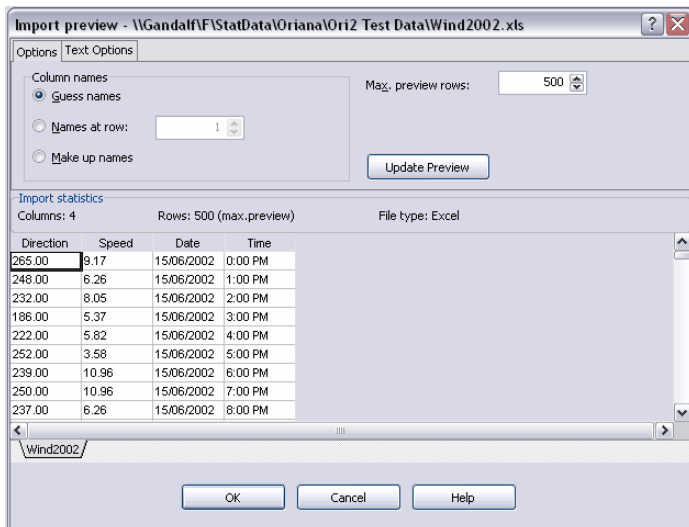
- plain text files

With all these formats Oriana assumes the data are column oriented; that is the data for each variable or set of observations should be in a column, with an optional column label at the top of the column.

When you choose the **File|Import** option you will first be shown a standard Open File dialog box. The **Files of type** section will list all the possible import formats. Set this to the correct format and select a file.

When you press **Open** Oriana will import a portion of the file. You may see a warning dialog box saying that only a certain number of data rows were imported for preview, not the whole file. This is to speed up the preview process; when you actually import the data all rows will be imported. You may simply click **OK** for this dialog box.

You will next be presented with the Import Preview dialog box. This has a tabbed section at the top, with various options that can be changed on different pages (described in detail below). At the bottom is a spreadsheet-like area that shows you how the data will be imported. The portion of the file that will be read as the variable/column labels will be in the shaded row at the top.



The actual data points will be below. At this point you need to examine the previewed data to ensure that they are being imported correctly. If they are not then adjust the options described below to correct any problems. Once you have changed any options you must press the button labeled **Update Preview** to have the data preview pane reflect the new settings.

Below the spreadsheet is one or more tabs. Most modern spreadsheet programs allow multiple pages or sheets. These tabs provide access to each page in the current spreadsheet. When you select a different page by clicking on the tab that page will be previewed. Note that only one page can be imported at a time.

Options

Column names

This tells import where to find the text labels used for each column (variable). The exact options available vary depending on the file type being imported. Some file types don't offer any options here at all; for example, with database files the column names are taken from the field names.

Guess names (for spreadsheets only) will examine the spreadsheet, skip over any blank rows or rows that have text in just a single cell (e.g. titles at the top of a page) and use the first row it finds with text in more than one column as the column names.

Names at row (for spreadsheets only). If the above doesn't correctly find your column labels then you can use this option to specify exactly which row they are in. Data in rows before this are ignored. Note that the labels should have at least one non-numeric character. When importing text files this option becomes **Names at row 1**, and any labels included should be in the first row of the text file.

If your file does not have column labels then you can choose the **Make up names** option to have names, in the form of C1, C2, etc., created.

Max. preview rows

When you change options on this dialog and press the **Update Preview** button the data will be reimported to reflect the new

choices. With large files this could take a long time. To avoid this you can limit the number of rows to preview to a smaller number, such as 500 or 100.

Text Options

These options are only available for text file importing.

Field delimiter

With text files the columns of data must be separated by some character. Oriana will attempt to determine the type of character delimiting the columns, but it may not be successful. If you don't see columns of numbers in the preview box then check the setting of this option to make sure it matches your file. If you aren't sure of the format you can experiment with different options to see which works best. Be particularly aware that, if the numbers in the imported file use a comma for the decimal point rather than a period (full stop) setting the delimiter to a comma will result in the data being imported completely wrong.

6.1.10 File|Export

The function of the **File|Export** command will differ depending on which window within Oriana is the active one. If either the data editor or the status window is the topmost one then this command will export the Oriana data to one of several formats. These include:

- Excel (ver. 97, *.xls, or 2007/2010, *.xlsx)
- Lotus (ver. 1)
- Quattro (ver. 1)
- Symphony (ver. 1)
- dBase II
- dBase III
- Paradox (ver. 4)
- Oriana (ver. 1)
- Comma-delimited text
- Tab-delimited text
- Fixed width text

For many of the formats the data are saved in the earliest file format version possible (as indicated in the list above) so that they should be able to be read by the widest range of program versions.

When you choose the **File|Export** command you will be presented with the standard Oriana save file dialog box. To choose the format you wish to save in use the **Files of type** drop-down list at the bottom of the dialog. You can then switch to the appropriate folder and enter a name for the resulting exported file.

Graphs

If the Graphs window is the active one then this command will let you export the currently visible graph to one of several common graphics formats. By default just the currently visible graph is exported, but if you tick the **Export all pages** option then all graphs will be exported. They will each be exported to separate files. Numbers will be appended to the file names to make them unique.

The available export graphics formats include:

- Enhanced Metafile (*.emf)
- Windows Metafile (*.wmf)
- Windows Bitmap (*.bmp)
- Portable Network Graphics (*.png)
- GIF or CompuServe (*.gif)
- JPEG (*.jpg)

The Metafile options save the graph as lines, symbols and text, so that it can be easily modified and rescaled in a drawing program. The WMF format is an older one that is less flexible and should only be used if your drawing program only imports WMF files; you would normally use the more flexible EMF format.

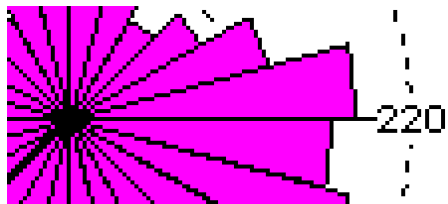
The last four options are bitmap formats, where the file contains an exact picture of what is on the screen, made up of a series of pixels. The elements of a bitmap cannot be as easily modified as a metafile, although you can use a painting program to add new things to the graph or erase some parts.

Note that the size and length/width ratio of the bitmap will be exactly the same size as that of the window containing the graph. If you wish to have a larger bitmap simply resize (or maximize) both the Oriana main window and the graph window so that they are the appropriate size.

The BMP files are Windows native bitmap format. Most programs can import these, although they can't be placed in web pages. The size of BMP files is usually much bigger than any of the other options.

PNG files are in a compressed format and are much smaller than BMP files. Most modern painting programs can import these, but this format isn't as widely used as the BMP format. PNG files can also be used in web pages, but older versions of web browsers may not be able to display them. GIF files are also compressed, and are more widely used, so will work with all web browsers, but have a limited range of colors.

JPEG files can also be used in web browsers, even older versions, and can be imported by most graphics programs. These are also compressed, but the compression method is "lossy", which means it throws away some information in order to compress the image. This method is better suited for photographic images; for line drawings such as produced by Oriana this compression can cause some of the lines to become fuzzy and artifacts to appear in areas of solid color, as demonstrated in the two pictures below (magnified five times).



Windows Bitmap



JPEG

Results

If the topmost window is the Results window then this command will export the results on the current page to a text file or Excel workbook. You can use the **Files of type** drop-

down list at the bottom of the dialog to choose whether you want the results in Excel, a tab-delimited text file (with tab characters between the columns) or comma-delimited text file (with commas between the columns).

By default just the currently visible results page is exported, but if you tick the **Export all pages** option then all pages will be exported. They will all be output to the same file. In Excel each page will become a separate sheet in the workbook, whereas in text files a page break will be used to separate the results pages.

Notes

The contents of the Notepad can also be exported to a plain text file with this command.

6.1.11 File|Merge Files

This option allows you to combine two or more Oriana files into a single one. When the dialog box is displayed you can use the “Folder” control to select the folder containing your files, then tick the box next to each file that you wish to combine. When you press the OK button you will be prompted for a name for the new file.

6.1.12 File|Print

This option allows you to print the contents of the currently active window.

When you choose the **File|Print** command, the standard Windows Print dialog box will be displayed. You may change the required printer, its properties, and the number of copies and pages to be printed. With graphs you can choose to have just the current graph printed, or all graphs in the graph window.

6.1.13 File|Printer Setup

The standard Windows Printer Setup dialog box can be displayed by choosing the **File|Printer Setup** option.

You may choose which printer to use for printing the current window, as well as modify its properties. Each type of window in Oriana allows you to specify a certain printer. So, for instance, you can always have graphics go to a high quality color printer whereas results and data are always printed to a monochrome

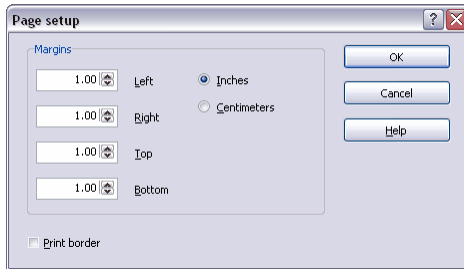
laser or inkjet printer.

The specific printer chosen in this dialog box will apply to the currently active window. These choices of selected printers are saved and restored next time you run Oriana.

6.1.14 File|Page Setup

The **File|Page Setup** command allows you to specify the margins to be used on your printouts. You would normally have margins of about 2-3 cm (or 0.5-1 inch), although you may prefer other settings.

If you wish to have printouts of graphs that do not fill the page, then just increase the margins. For example, if you are using 8.5" x 11" paper and want graphs 2.5" wide, set both the left and right margins to 3" ($3 + 3 + 2.5 = 8.5$).



6.1.15 File|Exit

Choosing this menu option will end your Oriana session. If the data have been changed or new results have been generated but not saved, you will first be prompted to save the files, if you wish.

6.2 Edit

This menu contains functions for editing the current window as well as transferring text and graphics between Oriana and the Windows clipboard.

6.2.1 Edit|Undo

This reverses the last editing action performed on data or graphs. Oriana will save all of your editing actions during the current session, allowing you to undo them one by one. Note that this menu item changes its caption to give a better idea of

what type of action will be undone. When the cursor is over this item the message area on the status bar will give greater detail of the action.


Note that each window maintains a separate list of editing actions that can be undone. Choosing this menu item will undo the last action performed in the currently active window. Also note that, if the data editor is closed and then later reopened you will only be able to reverse actions that have occurred since the window was reopened.

The Undo option will be disabled if there is nothing to undo.

6.2.2 Edit|Redo

If any editing actions have been undone this command will reinstate that action. For example, if some text was deleted, then restored by choosing the Undo item, the Redo item will delete it again.

6.2.3 Edit|Cut

Choosing this option will delete the currently selected  data, leaving the cell or cells blank. Anything deleted will be placed in the Windows clipboard so that it can be pasted into another application or to another spot within Oriana.

If you accidentally delete some data, then decide you want to restore it, choose the **Edit|Undo** option.

The data editor and the notepad are the only windows that allow the user to delete data, so this option is disabled when any other window is activated. Text or graphics from other windows can be placed in the clipboard using the **Edit|Copy** command.

6.2.4 Edit|Copy

Choosing this option will copy text, data, or graphics to the Windows clipboard so that it can be pasted into another application or to another spot within Oriana.

With graphs, the entire diagram is placed in the clipboard in both bitmap and metafile formats. With bitmaps, the graph is copied at its current size, so if you want a larger bitmap with fewer jagged edges, increase the window to its maximum size.

In the spreadsheets used for data editing and displaying the results, the selected $\overline{\text{32}}$ cells are copied.

6.2.5 Edit | Paste

Choosing this option will paste data from the Windows clipboard to Oriana. The data will be inserted at the currently highlighted cell and will overwrite any existing data.

You must have first copied some text or data to the clipboard before choosing this command, otherwise the **Edit | Paste** command will be disabled. The data in the clipboard may have been copied from the Oriana data editor or from another spreadsheet program.

Data may also be pasted from programs such as word processors. However, Oriana expects that the data for different cells are separated by tabs, with carriage returns separating data that belong on a new row. If no tabs or carriage returns are encountered, Oriana will paste as much as possible into a single cell.

When pasting data from other programs into empty columns Oriana will do its best to guess the type of data and convert the variable accordingly. If the column already contains data then the newly pasted data must match the variable type. Any data that doesn't match the type (for example, pasting date format data into an angle variable) will be left out and the cell will remain blank. A warning message will be displayed if this happens.

6.2.6 Edit | Delete

Choosing this option will delete the currently selected $\overline{\text{32}}$ data, leaving the cell or cells blank.

If you accidentally delete some data, then decide you want to restore it, choose the **Edit | Undo** option.

The data editor is the only window that allows the user to delete data, so this option is disabled when any other window is activated.

6.2.7 Edit | Select All

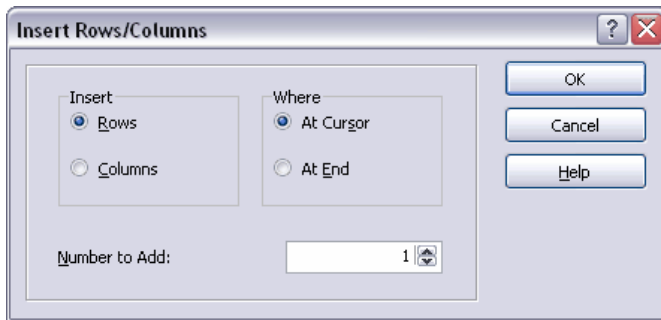
This command will allow you to select all of the text or data in the currently active window in preparation for copying it to the clipboard or deleting it.

This command is disabled when graph windows are active because the editing commands always work on the whole graph window.

6.2.8 Edit | Insert Row/Column...

When the data editor is active, this command can be used to insert new rows or columns into the spreadsheet. The exact function of this command varies depending on how the cells in the spreadsheet are currently selected. ^[32]

If a single cell is selected, the dialog box below will be displayed, allowing you to specify what you want inserted. You can choose to insert either rows or columns and you can specify whether they should be inserted at the end of the spreadsheet or the current location.



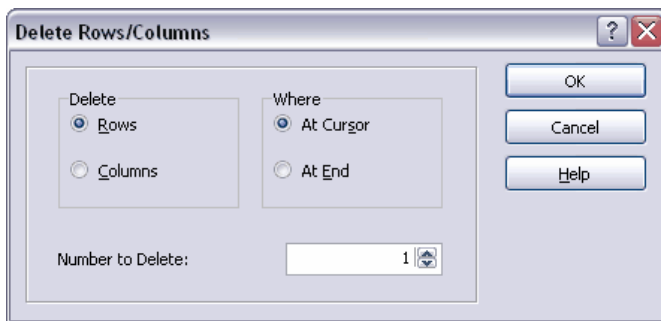
If you have selected ^[32] whole rows or whole columns, then the dialog will not be displayed. Instead, if a whole row is selected, Oriana will insert a new row at that point. Likewise, if a whole column is selected a new column will be inserted there.

If you want to insert more than one row or column then just select the appropriate number of rows or columns.

6.2.9 Edit | Delete Row/Column

When the data editor is active, this command can be used to delete rows or columns into the spreadsheet. The exact function of this command varies depending on how the cells in the spreadsheet are currently selected.^[32]

If a single cell is selected, the dialog box below will be displayed, allowing you to specify what you want deleted. You can choose to delete either rows or columns and you can specify whether they should be deleted from the end of the spreadsheet or the current location.



If you have selected^[32] whole rows or whole columns, then the dialog will not be displayed. Instead, if you have selected a whole row, Oriana will delete that row. Likewise, if a whole column is selected that column will be deleted.

If you want to delete more than one row or column then just select the appropriate number of rows or columns.

6.3 Data

The Data menu contains functions that allow you to make modifications to the currently loaded data file.

6.3.1 Data | Edit Data Title

Each data file has a title associated with it. You can use this title to give your data file a description, so you know what the data are. The title will be printed whenever you print out data or results.

This command will open up a dialog box that allows you to

enter or edit the title for the file.

If you have changed the title but not saved the file, you will be asked if you would like to save it before you exit Oriana or open a new file. If you wish to save the title straight away, choose the **File|Save Data**^[93] command.

6.3.2 Data|Edit Data

Choosing this option will open the Oriana data editor to allow you to enter or modify data. See the section on modifying^[34] data for more details.

6.3.3 Data|Edit Frequencies

Sometimes you may have recorded your data as a frequency table. For example, you may have recorded that there were 20 objects oriented at 10°, 30 at 20°, etc. To enter these data into Oriana you could go to the data editor and type in 20 10s, 30 20s, etc.

However, Oriana has a frequency editing mode that makes it easier to enter this type of data. This allows you to enter the value measured in one column and the frequency of those values in the second column.

	Value	Frequency
1	0.000	1
2	10.000	2
3	20.000	1
4	30.000	2
5	40.000	1
6	50.000	3
7	60.000	2
8	70.000	3
9	80.000	2
10	90.000	3
11	100.000	2
12	110.000	3
13	120.000	2
14	130.000	3
15	140.000	2
16	150.000	3

Once you have entered your data in this form you can press the **OK** button. The current column of the data editor will then be filled with the data.

If you open the Frequency Editor when the selected column in the data editor already has data then that data will be summarized in the dialog box. You can then modify the data as required.

Note that you can now also enter frequency data directly into the spreadsheet. See the tutorial [\[36\]](#) for more details.

Warning - Editing data in frequency mode can change the order of your data values. If your data in the data editor are paired (i.e. each row is a single case and each column contains different data about that case, such as a label, subgroup or linear data) then editing in frequency mode will change the order of one variable so that they are no longer paired. Only use the frequency editor if the columns are independent.

6.3.4 Data | Change Variable Type

This option allows you to change the type of data [\[12\]](#) contained in each column. The following dialog box will be displayed:

The dialog box titled "Change Variable Type" contains the following elements:

- Variable:** A dropdown menu currently showing "Date".
- Data are grouped**: An unchecked checkbox.
- Group width (degrees):** A text input field containing "0.0" with a spinner control.
- Lunar time zone offset:** A text input field containing "0" and a dropdown menu showing "Zones".
- Basic Type**: A group of radio buttons for selecting a data type:
 - Angles
 - Axial
 - Circ. Proportional
 - Circ. Percentage
 - Time
 - Day of week
 - Month of year
 - Week of year
 - Day of year
 - Compass Direction
 - Date
 - Linear
 - Label
 - Subgroup
 - Lunar
- Create new variable**: A checked checkbox.
- Buttons:** "OK", "Cancel", and "Help" buttons are located on the right side.

The **Variable** drop-down box allows you to select the variable to change. You can then use the options in the **Basic Type** box to change the type.

Oriana will do its best to convert existing data to the new variable type. Conversion from angles to other circular types is done by converting to the nearest angular equivalent (e.g. 90° becomes 06:00 or March or week 13 or compass direction E). Conversions back to angles will give the angle that is the mid point for the sector of the circular type (e.g. January will become 15°).

Conversions to and between date summary types tries as much as possible to give a sensible conversion. For example, if you convert a Date variable to Day of Week it will convert each datum to the appropriate day of week for that date. Conversion from less specific to more specific date types is done with reference to the current year, month or week. If you convert from Day Of Week to full Date it will give the date for the DOW in the current week; likewise conversion from Month Of Year to Date will give the date of the first day of that month in the current year).

Conversion of a Lunar variable works in a similar way as the Date type. An addition for Lunar variables is that, if the variable is converted to a Linear type, the result will be the lunar day with a range of 29 or 30, depending on the length of that lunar month. Day 1 represents the new moon day. Also, for each Lunar variable you can set the time zone in which the data were recorded (see the description of the Lunar variable^[16] to find out why you might need to do this). The value entered into the **Lunar time zone offset** option is the number of hours difference (positive or negative) from UTC or GMT (Coordinated Universal Time or Greenwich Mean Time). If you aren't sure of the difference you can press the **Zones** button, which will display a list of time zones from which you can select the appropriate one.

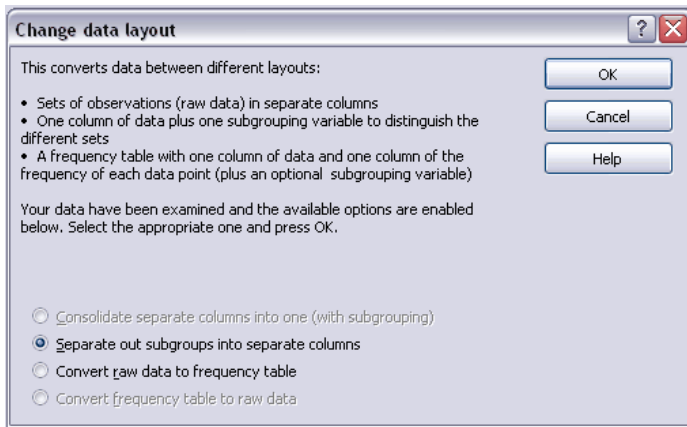
Some conversions can't be made. If you have a Label variable that you convert to Angles only those cells that have numbers between 0 and 360 (or -180 to 180) will be converted. Any cells with textual data, or numbers outside the circular range, will be converted to blank cells (missing data).

If you wish to convert data to an alternative representation, but keep the original data, then tick the **Create New Variable** box. For example, if you have a date variable and wish to have a second one summarizing the month of each date you can use this option.

Finally, you can declare that circular data are grouped^[26] and set the width of the grouping.

6.3.5 Data | Change Data Structure

This command lets you change the structure of the data between different layouts - raw data in separate columns, grouped data in a single column, or frequency table data. For a full explanation of these see the section on data structures^[19].



The dialog box that is displayed gives an explanation of the process that is about to take place. This is so that you don't inadvertently run this command, which makes major changes to your data structure. Your data will be examined to determine which types of changes are feasible and the appropriate options will then be enabled.

Consolidating data

If the current data file has two or more columns of the same data type, with no subgrouping variable, then you are given the option to consolidate the data into a single data column with an associated subgrouping variable. The labels from each of the old columns are used in the subgrouping variable to identify to which group each of the data points belongs.

If you wish to consolidate data but the variables are not all of the same type then you must first convert all data to the same type, or delete the incompatible variables. See the section on changing variable type^[59] for information on how to do this.

Separating data

If the data do contain a subgrouping variable then you will be given the option to convert these to separate columns, with one column for each subgroup. Each column will have a label created by taking the label for the single data column and appending the name of the subgroup. If there are more than one data columns then each will be split into a set of separate columns (e.g. if there are two data columns, plus a subgrouping variable with four groups, the result will be eight separate columns, four for each original data column). If there is more than one subgrouping variable only the first one (counting from the left) will be used; any others will be separated out like the other variables.

If the multiple data columns in a subgrouped data file are of different types then you can still separate them into individual columns. However you will not be able to consolidate them back to their original form. This is because Oriana always consolidates data into a single data column, and will not be able to combine the different data types. You will be given a warning message if you do try to separate out data of different types.

Converting raw data to frequency table

This will take a column of data and turn it into a frequency table, with one column containing the unique data values in the original data, and a second containing the frequency that each of those values occur. So, if the original variable has three 45° values the restructured data file will have one 45° in the data column, and a 3 in the frequency column.

If a data file has more than one variable then each of those will be converted to frequency tables.

If a subgrouping variable is found then that will be used to create a frequency table for each subgroup. The frequency tables will all occur in the same columns and a subgrouping variable will be created next to the frequency variable. For example, if the subgrouping variable has three subgroups, A, B and C, and each subgroup has a single value of 45° then the resulting frequency table will have three entries for 45°, one for each subgroup, with a frequency of 1 for each.

Converting frequency table to raw data

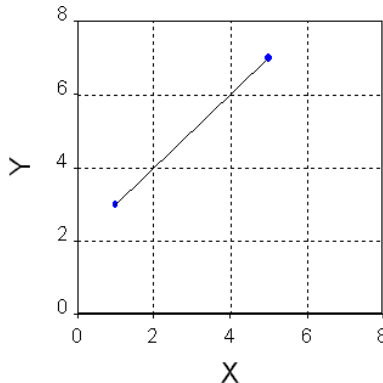
This option will be enabled if it appears that the file contains

one or more frequency tables. To be recognized as a frequency table the file must have one Linear type variable holding the frequencies (which must all be positive numbers), one other data variable of any type, and optionally a subgrouping variable. If the file contains more than one frequency table the variables for all must be in the same order (e.g. if one has the data variable before the frequency one, then all of them must be the same).

When this option is selected each frequency table will be converted into a single data variable, using the frequency column to determine how many of each value are in the column. If a subgrouping variable is also found then a new one will be created and each data value will be assigned to the appropriate subgroup.

6.3.6 Data|Convert XY to Circular

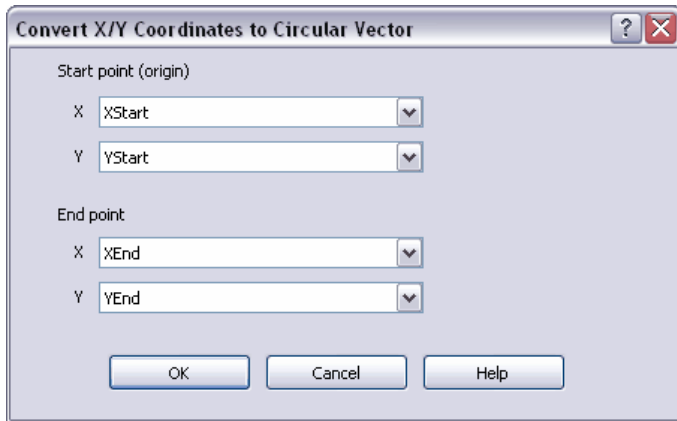
Usually circular vector data are entered directly as measured angles and the length of the vector. However, sometimes it may be more convenient to measure and record the X/Y coordinates of the beginning and ending of the vector. For instance, in the following example you may record the X and Y coordinates of the dots at either end of the vector, rather than the angle and length of the vector itself:



If your data are in this format then you can enter them into Oriana in the following way:

1. Choose **File|New** to create a new file. If the File Creation Wizard comes up switch to Expert mode using the button in the lower left.
2. Set the number of variables to 4 and press **OK**.

3. In the data editor change the variable type of all four variables to Linear.
4. You can now use these variables to enter your data. Put the X and Y coordinates of the start point of the vector in the first two columns, and the X and Y coordinates of the end point in the other two columns.
5. Once the data have been entered select the **Data|Convert X/Y to Circular** menu item. Ensure that the four drop-down boxes contain the names of the appropriate variables for the X/Y coordinates.



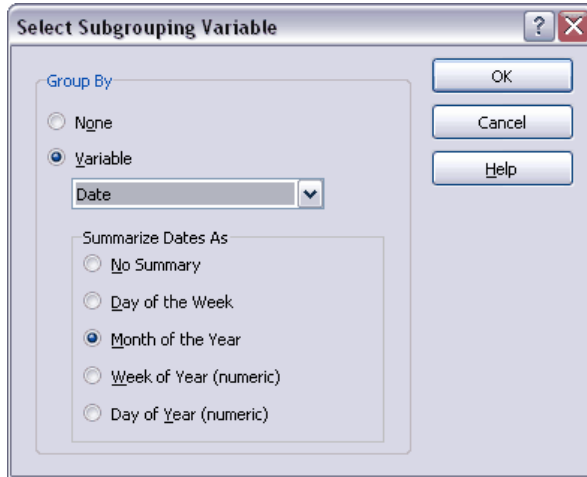
6. Press **OK**. Two new variables will be created, named Angle and Length, that will contain the angle and length of each vector.

Please note that in the conversion process the starting point is translated to the origin of the circular graph, so the angle will be the direction towards which the end point is pointing.

6.3.7 Data|Set Subgrouping Variable

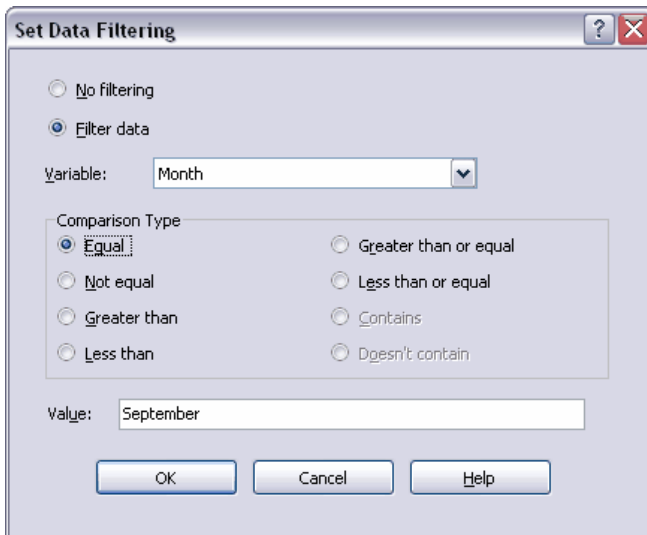
By default Oriana will calculate statistics and draw graphs using all the data from each variable. However, you may sometimes want to calculate separate statistics and do separate graphs for subsets of the data. You can do this by using a subgrouping variable. This is a separate variable that contains data specifying to which subgroup each case (or row) in the data matrix belongs. This dialog box allows you to specify which variable to use for subgrouping. If a date variable is selected then the **Summarize Dates As** section becomes available and

you can choose a variety of ways to have the dates summarized.



6.3.8 Data | Filter Data

This command lets you restrict the analyses or graphs to a certain subset of data.



When you tick the **Filter data** button you can choose a variable to use for selecting the data to analyse. You can then choose a comparison type (e.g. “Equal” or “Greater than”) and enter a

value to use for comparisons in the **Value** box. For example, if you wish to only analyse data from September you would set up the dialog box as shown above, with the variable “Month” and the comparison type “Equal” selected, and the word “September” in the **Value** box. You could also use the abbreviated value “Sep”. If you instead wanted to restrict the analysis to measurements where the wind speed was greater than 20 miles per hour you would select the variable “Wind Speed”, the “Greater than” comparison type, and enter “20” in the **Value** box.

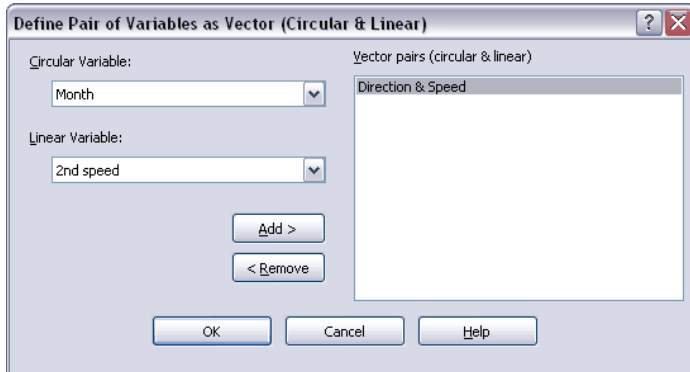
If the variable you are using is a Label or Subgrouping variable then you can use the “Contains” and “Doesn't contain” options to base the selection on a part of the data in that variable. For example, if you had observations labels like “Sample1-1, Sample1-2, Sample 1-3, Sample2-1, Sample 2-2, Sample 2-3” and you wanted to restrict the analysis to just the first three, you would select “Contains” and enter “Sample1” in the **Value** box.

When you press the **OK** button Oriana will check that the value entered in the **Value** box is appropriate given the variable type chosen. If not a message will be displayed and you will be given the opportunity to fix it.

6.3.9 Data|Define Vector Pair

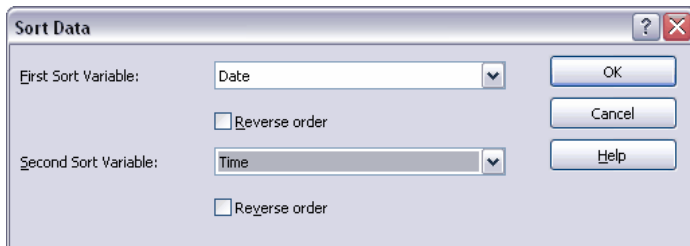
Circular data are often accompanied by a second variable, describing length, speed or other data measured on a linear scale. The two variables together describe a vector. If you have data in this format you can declare which pairs of variables are supposed to be treated together as a vector. These vector pairs can then be used to produce Two-variable histograms^[86] and Circular/Linear plots.^[87] They can also be used to calculate weighted means, where the mean is weighted by the linear variable.

To define vector pairs use the **Data|Define Vector Pair** menu item. The dialog box has two drop-down boxes that list the circular and linear variables. Simply choose the appropriate variables and press the Add button to add the variables to the list of vector pairs. When you press the **OK** button the Status window^[7] will be updated to show the defined vector pairs.



6.3.10 Data | Sort Data

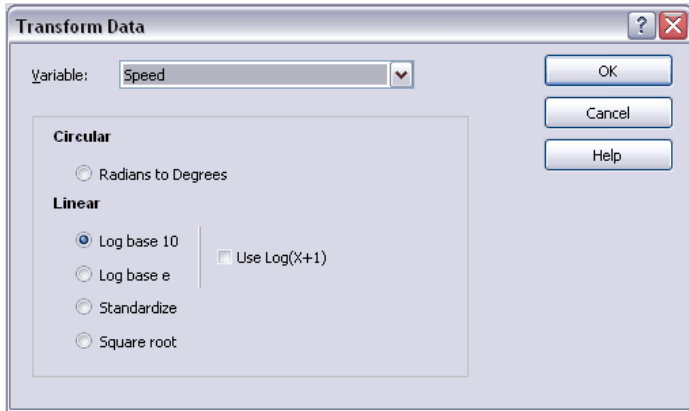
You can use this command to sort your data numerically or alphabetically. You can sort on up to two different variables and can reverse the order of either.



Normally the entire data matrix will be reordered, so that data paired in each row remain paired. However, if just certain columns are selected before choosing this menu item only those columns are sorted.

6.3.11 Data | Transform

This command allows you to perform various transformations on your data. You can transform a single variable by choosing the variable from the drop-down list (labeled "Variable" below), or transform all variables of the appropriate type (either Angles/Axial or Linear) by choosing the "All Variables" option at the top of the drop-down box.



For circular data the only available transformation is from radians to degrees. Oriana assumes that data in Angles or Axial variables are in degrees. However, you may already have data in the form of radians. This transformation will allow you to import or paste radians data, then transform them to degrees so they can be analyzed.

Linear data can have a variety of transformations applied, including logarithmic (base 10 and e), square root, and standardization.

When log transforming data, zero values can cause problems, as the log of 0 is undefined. If your data have zeros you can tick the “Use Log(X+1)” option to add 1 to all values, thus allowing the log transformation to occur. If any negative values are found, for either log or square root transformations, then the transformation will not be performed.

6.3.12 Data|Fill

This command lets you fill a variable with a variety of automatically generated data. You can generate identical data for all rows, or an incrementing series of data. You can also fill the variable with random data or data drawn randomly from a von Mises distribution.

The screenshot shows a dialog box titled "Fill Variable With Data". It has a title bar with a question mark and a close button. The main area contains several input fields and two sections of radio buttons. The "Variable:" dropdown menu is set to "Direction". Below it, "Start Row:" is set to 1 and "Number of Rows:" is set to 100. The "Value:" field contains "90" and the "Increment:" field is empty. There are two sections of radio buttons: "Fill Type" and "Date Fill". In "Fill Type", the "Identical" radio button is selected. In "Date Fill", the "Day" radio button is selected. On the right side of the dialog, there are three buttons: "OK", "Cancel", and "Help".

The **Variable** option above lets you select the variable to fill, and the **Start Row** and **Number of Rows** options let you define what part of the column to fill. If you have a block of cells selected in the data editor when this command is chosen then these two values will match the selected cells.

The two boxes below these change labels and function depending on the **Fill Type** chosen. The Fill Types are:

Identical

This fills the variable with identical data. Enter the value to place in the variable in the **Value** box. The data will be checked for its validity when you press the **OK** button, and an error message will be displayed if the value is not valid for the data type of the selected variable. The program can cope with partial data, so entering “Mon” in a Day of Week variable will fill it with “Monday”, and entering “01/01” in a Date variable will fill it with the date “01/01/2009”, if the current year is 2009.

Incrementing

This fills the variable with incrementing data. When this is chosen the **Value** box above turns to **Start Value** and the **Increment** box is enabled. To fill an angular variable with a series of data such as 10, 20, 30, 40, etc. enter 10 in the **Start Value** box and 10 in the Increment box. With circular data once the data fill reaches the upper limit (e.g. 360 or 23:59) the values will start again at the lowest value (0 or 00:00).

Random

This will fill the variable with uniformly random data. When this is chosen the **Value** box above will become **Min. Value**, and **Increment** will become **Max. Value**. This allows you to specify the range of possible values that are randomly generated. For circular types, if these are left blank then the data are randomly generated from the whole circular range.

von Mises Random

This will fill the variable with random data fitting a von Mises distribution. When this is chosen the **Value** box above will become **Mean**, and **Increment** will become **Concentration**. This allows you to specify the parameters of the distribution. If these are left blank the distribution used will have a mean of 0 and a concentration of 2.

Date

If the chosen variable is a Date variable then the **Date** option will become available in the **Fill Type** box. When this is selected the **Date Fill** box becomes enabled, allowing you to fill the variable with an incrementing series of calendar dates.

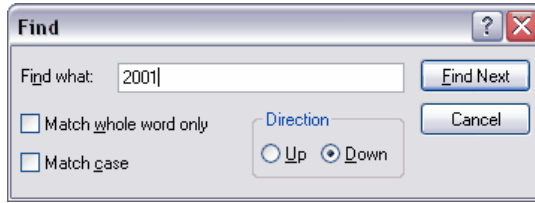
The **Day** option will increment the value by one day for each row, whereas the **Weekday** option will do the same, but skip Saturdays and Sundays. The **Week** option will increment the value by one week (i.e. seven days).

The **Month** option will increment the month by one for each row; If the day portion of the starting date is one that occurs in only some months (such as 31) the day used for shorter months will be the last one (e.g. 28 or 29 for February). The **Year** option will increment the date by a year for each row.

All the above date filling types take the **Increment** value into account (e.g. if the increment is 3 and the fill type is Month, then the dates generated will be three months apart).

6.3.13 Data|Find

This displays a standard Windows find dialog to search for particular data values.



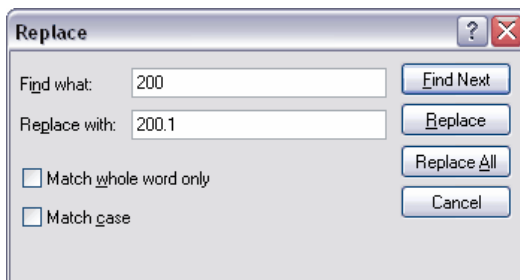
Type in the text you wish to find and press the **Find Next** button. The program will search through the data in the direction chosen, then will highlight that data cell, scrolling it into view if necessary. The search proceeds columnwise, searching either to the bottom or the top of a column before moving on to the next one (to the left if **Up** Direction is chosen, or to the right if **Down** is selected).

Ticking the **Match Whole Word Only** box will restrict the search to only finding a cell if the **Find** text matches the entire text in the cell. The search can be made case-sensitive by ticking the **Match Case** box.

Once a value has been found you can search for the next occurrence by clicking on **Find Next** again. The dialog box remains open until you press the **Cancel** button. The dialog box is non-modal, which means you can switch back to the data editor and make changes if you wish while the Find dialog remains open.

6.3.14 Data|Replace

This dialog box searches for values in the data editor in an identical way to **Data|Find**, and lets you optionally replace the found value with a new one.



Once a data value has been found you can click the **Replace**

button to replace it with the value in the **Replace With** box. The program will then automatically search for the next occurrence. Clicking on the **Replace All** button will cause the program to scan through the entire file replacing all occurrences of the find text with the replace text.

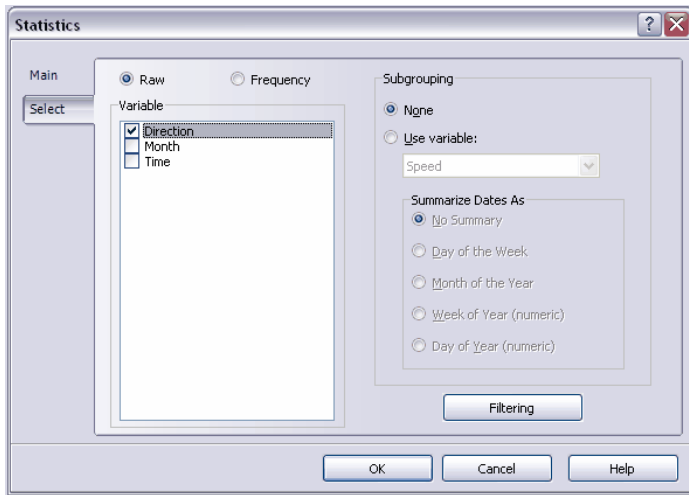
The resulting replacement is first checked for whether it is valid given the variable type. If it is not valid then the value is not changed. For example, replacing “2003” in a date variable with “ABCD” will leave all values as they were, as “ABCD” is not valid in a date. Likewise changing “day” to “dog” will not affect any of the values in a Day of Week variable, as “Mondog” is not a valid day of the week.

6.4 Analyses

This menu contains the analyses functions. When you choose one of these you will be presented with a dialog box that allows you to select the samples to analyze and the options for how the analysis should be performed. A table will be created in a separate window to contain the results.

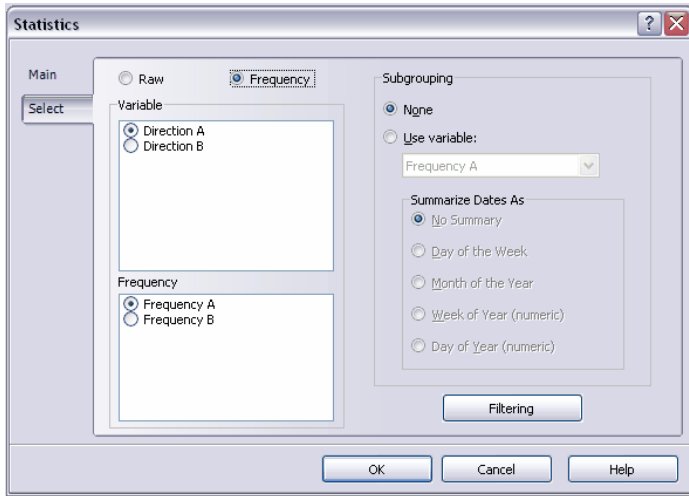
6.4.1 Select page

All the dialog boxes displayed by the commands under the **Analyses** and **Graphs** menus contain a tabbed page entitled **Select**. It allows you to select which variables/sets of observations to analyze, and whether to use a subgrouping variable.



The box marked **Variable** on the left hand side lists all the circular variables in the data file. For most analyses and graphs all of them will initially be ticked, indicating that they will be used in the analysis or graph. You can remove a variable from analysis by clearing the checkbox. Oriana will remember the selection state of the variables during the current analysis session so that you don't need to reset them for every analysis and graph.

In the above example a file with paired data^[20] is being used and the **Raw** option at the top is selected. If your data have been entered directly in the spreadsheet as frequency data^[22] you can select the **Frequency** option, then select the two variables with your circular data and the associated frequencies, like this:



Note that this option will only be available if the data file appears to have frequency table data (defined as pairs of variables, one of which is Linear and contains the frequencies). Also, only one pair of data and frequency variables can be selected at a time. This type of selection is not available for analyses and graphs that are used to compare two or more variables, such as multisample statistics or two sample scatterplots. If you need to do these you can use the **Data | Change Data Structure** ^[109] option to convert the frequency data into columns of raw data.

Subgrouping and Filtering

By default Oriana will calculate statistics and draw graphs using all the data from each variable. However, you may sometimes want to calculate separate statistics and do separate graphs for subsets of the data. You can do this by using a subgrouping variable. This is a separate variable that contains data specifying to which subgroup each case (or row) in the data matrix belongs. You can select which variable to use for this purpose with the set of controls on the right entitled **Subgrouping**.

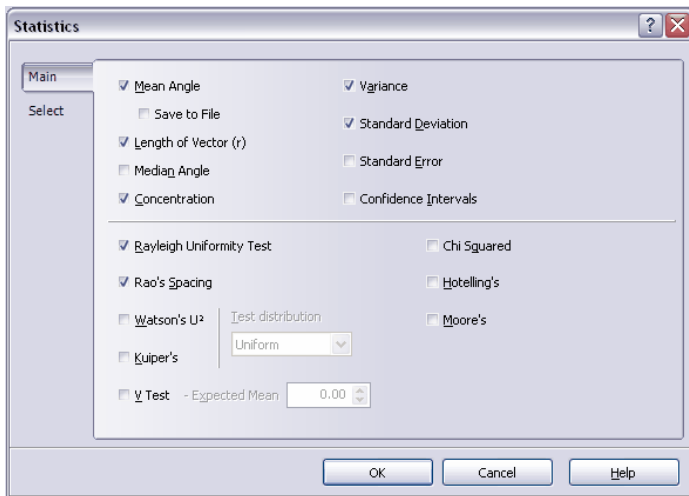
Ticking the **Use variable:** box will allow you to use the drop-down box to select the variable you wish to use as the subgrouping variable. If the selected variable is a date variable then the **Summarize Dates As** section can be used to select the method of subgrouping by date (e.g. by month of year or day

of week).

The **Filtering** button opens the **Filter Data** ^[113] dialog box. This lets you restrict the analysis to a certain subset of data. When filtering is active the caption of this button is changed to **Filtering - Active**. See the description of the dialog box for more details.

6.4.2 Analyses | Stats

This option allows you to calculate a variety of statistics ^[63] on your data. This will cause the following dialog box to be displayed. See the section on Basic Statistics ^[63] to learn more about each option.



Choose the statistics you wish to have calculated by ticking the box before each one. The ones above the horizontal line are basic statistics about the sample, while those below are single sample tests

Most statistics are calculated very rapidly, but the **Median Angle** can take a long time for large sets of data. So, you may wish to leave this one unticked unless you need it.

For the **Watson's U²** and **Kuiper's** single sample tests you must select the desired **Test distribution** from the drop-down box. The **V Test** requires that an **Expected Mean** is entered, as with this test the alternative hypothesis is that the data are

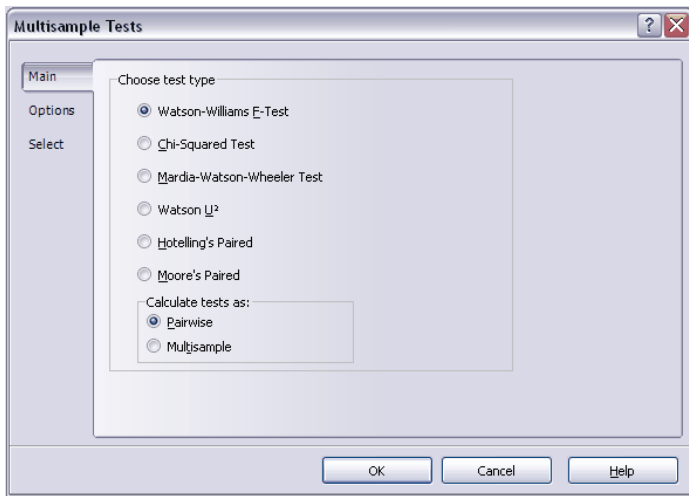
not uniform, but have a certain specified mean.

When you press the OK button the statistics you have chosen will be calculated and the results placed in a table. The results will be printed with the number of decimal points specified in **Options | Preferences** [149].

If you have ticked the **Save to File** checkbox then you will also be prompted to enter a file name. This file will be used to store the means and lengths of the mean vectors in a separate file. You can then use these for further second order analyses [126] (in particular for two sample and paired tests).

6.4.3 Analyses | Multisample Tests

This option allows you to calculate a variety of multisample test on your data. This will cause the following dialog box to be displayed. See the section on multisample analyses [71] to learn more about each test.

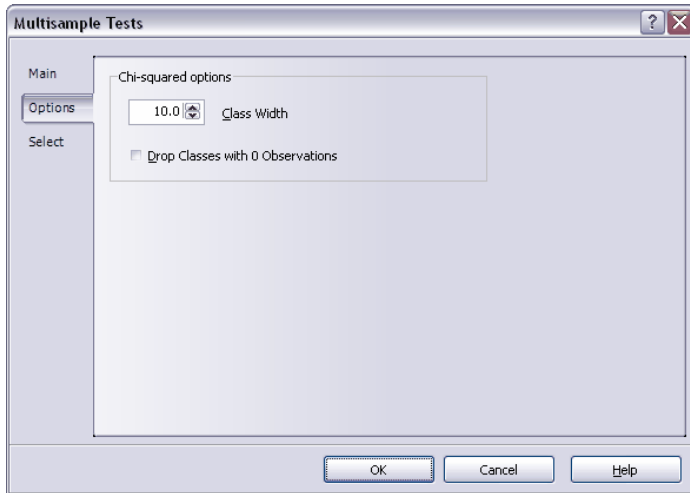


The **Calculate tests as** option lets you decide whether to compare the columns of the data matrix in a pairwise fashion (where each column is compared to one of the others) or multisample (where all columns are compared in a single analysis).

When you press the **OK** button the tests you have chosen will be calculated and the results placed in a table. The results will be

printed with the number of decimal points specified in **Options | Preferences**^[149].

The **Options** page contains two options related to the Chi-squared analysis.

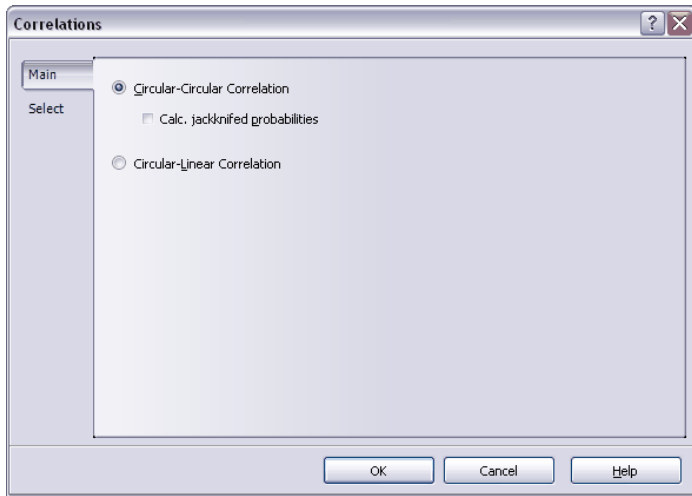


The first option, **Class Width**, lets you set the class width (in degrees) that is used in creating the frequency table for the chi-squared analysis.

The chi-squared test assumes that the expected frequencies in most classes are greater than five (a warning will be printed if too many of them are below this level). However, your measurements may be restricted to a portion of the full circle (e.g. between 45 and 135 degrees). In this situation many of the classes will be empty and the frequencies will be zero. The **Drop Classes with 0 Observations** option lets you automatically drop all classes which have no observations, thus restricting the analysis to that portion of the circle that is of interest.

6.4.4 Analyses | Correlations

This option allows you to calculate correlations between variables in your data. This will cause the following dialog box to be displayed. See the section on correlations^[75] to learn more about each test.



When **Circular-Circular Correlation** is chosen you can also select whether to have probabilities calculated using a jackknifed procedure, using the option labeled **Calc. jackknifed probabilities**. This can take a long time for large data sets, so you may wish to leave it turned off.

When you press the **OK** button the tests you have chosen will be calculated and the results placed in a table. The results will be printed with the number of decimal points specified in **Options|Preferences**^[149].

6.4.5 Analyses | Second Order Stats

This option allows you to calculate second order statistics^[76] on your data. This will cause the following dialog box to be displayed.



The analyses on this dialog box assume that the data consist of pairs of variables, one a circular variable that contains means calculated from samples of raw observations, and a linear variable that contains the length of each mean vector.

You can use these analyses when you have been supplied with data in the form of means, or have calculated them yourself. Note that if your data are raw observations you can use the **Basic Statistics**^[123] command to calculate the means for each set of observations (column in the data matrix). That dialog box has an option to save the means to a file, which can then be opened and analysed with this second order stats command.

6.5 Graphs

This menu contains the graph functions. When you choose one of these you will be presented with a dialog box that allows you to select the samples to graph and the options for how the graphs should be plotted.

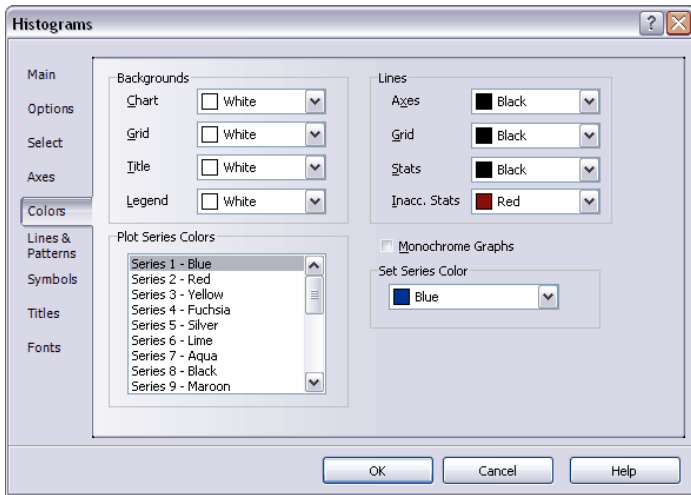
Each graph will be created in a separate page of the graph window. The size of the graph may be adjusted by resizing the window. If you wish to change the type of graph on a page, choose the **Graphs | Edit graph**^[147] option; you will then be presented with the dialog box originally used to create the graph.

6.5.1 Common elements of graph dialogs

All dialog boxes for creating graphs have five pages that control various aspects of the appearance of the graph. The options on these pages are described in the following sections.

6.5.1.1 Colors

This page lets you customize the colors used for various graph elements.



The **Background** section lets you change the color of the background of the whole chart, the gridded portion within the main axes of the graph, the box behind the graph title and the box behind the legend. A new color can be chosen from the drop-down boxes.

The **Lines** section allows you to change the color of the lines used for the main axes, the grid within the axes, and the line used to indicate the statistics of the data (the mean and confidence limits). The **Inacc. Stats** choice lets you change the color that is used for the confidence limits when there is a small sample size and/or low concentration. By default this is red to warn those viewing the graph that the limits may be unreliable.

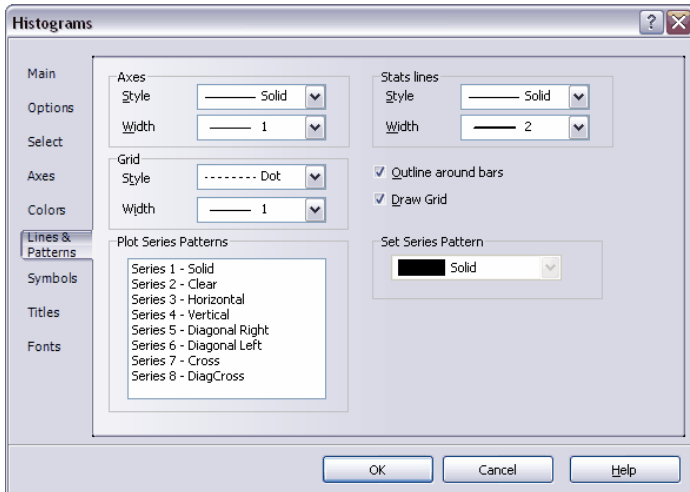
The **Monochrome Graphs** option switches the graph to being produced in black and white, for reproduction in monochrome publications. All lines will be black and the graph elements

such as histogram bars and symbols will be filled with the patterns selected on the **Lines & Patterns** page.

The **Plot Series Colors** section lists the different fill colors used for filling bars and symbols in color graphs. The first color is used in most graphs, and subsequent colors are used for further data series in stacked/stepped histograms. The colors can be changed by selecting the desired series and using the **Set Series Color** option to the right.

6.5.1.2 Lines & Patterns

This page lets you customize the lines and patterns used for various graph elements.



Axes Style changes the style of the lines forming the main axes of the graph, and **Axes Width** changes the width of these lines. Note that width can only be adjusted for solid lines. The **Grid Style** and **Grid Width** options do the same for the grid lines of the graph, and the **Stats lines** options affect the lines drawn for mean, r vector and confidence limits.

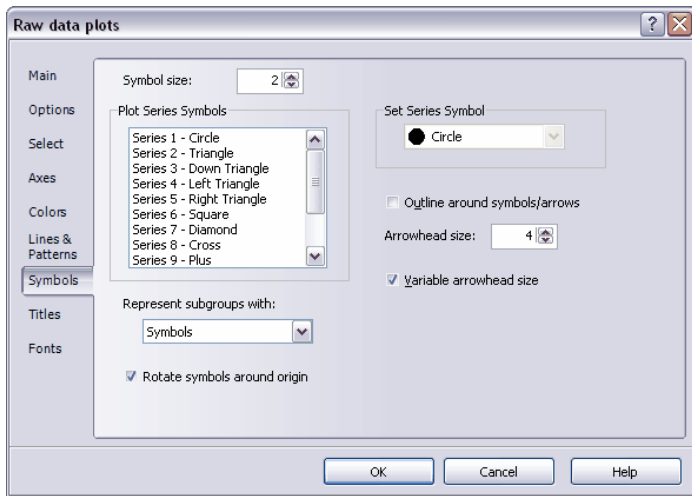
Outline Around Bars sets whether there should be black lines drawn around the bars in a histogram.

The **Draw Grid** option selects whether to draw gridlines on the graph.

The **Plot Series Patterns** section lists the different fill patterns used for filling bars and symbols in monochrome graphs. The first pattern is used in most graphs, and subsequent patterns are used for further data series in stacked/stepped histograms. The patterns can be changed by selecting the desired series and using the **Set Series Pattern** option to the right.

6.5.1.3 Symbols

This page lets you customize the symbols used on raw data and scatterplots.



The **Symbol Size** option changes the size of the symbols used in the plots.

The **Plot Series Symbols** section lists the different symbols used for different groups of symbols on the graphs. The first symbol is used in most graphs, and subsequent symbols are used for further data series when subgrouped data are being plotted. The symbols can be changed by selecting the desired series and using the **Set Series Symbol** option to the right. The **Outline around symbols/arrows** option lets you set whether to have a black outline drawn around the symbol. When this is not checked the symbol will just be a solid color.

The **Represent subgroups with** option lets you decide

whether the different subgroups should be represented by different symbols, or whether the same symbol should be used for all, but with different colors. You can also choose to use both different colors and symbols.

The way the symbols are drawn can be set with the **Rotate symbols around origin** option. With this ticked the symbols will be rotated so that the top of the symbol (e.g. the top tip of the triangle) always points outward on circular graphs. When this is not ticked the symbols will all be oriented the same way.

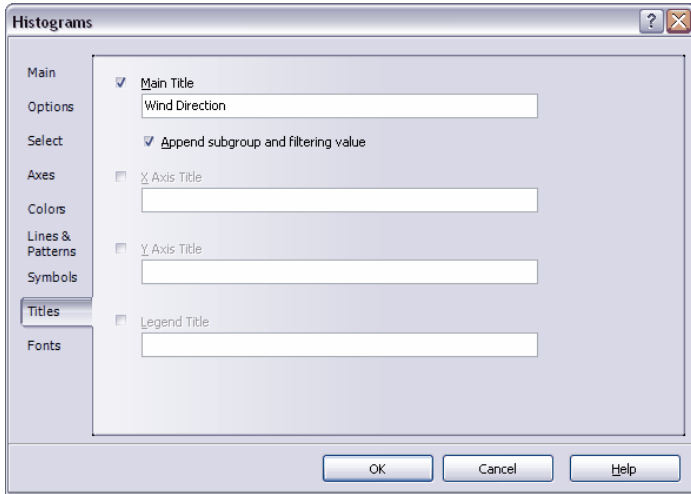
You can change the size of the arrowheads for the r vectors, arrow and vector plots with the **Arrowhead size** option. The **Variable arrowhead size** option makes the arrowheads towards the center of an arrow plot progressively smaller, so that it is easier to see the shorter arrows towards the center.

6.5.1.4 Titles

This page allows you to customize the various titles that appear at the top of the graph, near the axes and over the legend. The tick boxes to the left of each title let you suppress the display of the titles. If the text editing box for a particular title is left blank then Oriana will create a default title, if appropriate.

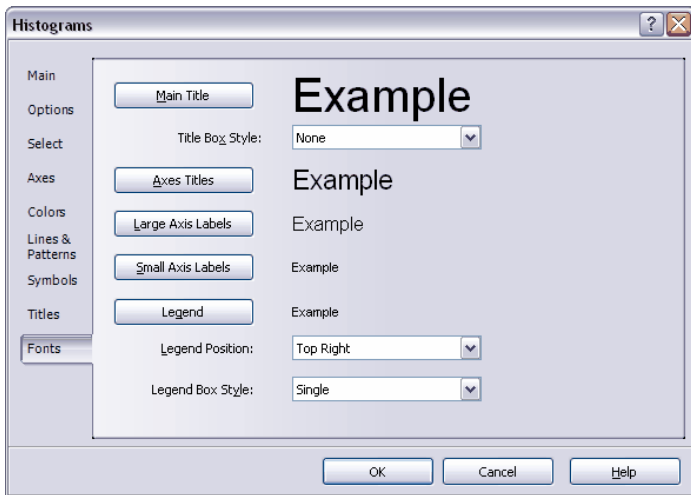
The **Append subgroup and filtering value** checkbox controls whether these values are added to the main title. If subgrouping is in effect the particular subgroup being plotted will be added to the title. If filtering is active the filtering criterion will be added to the title (e.g. "Month = 'June'").

Note that the X and Y axes titles are only displayed on graphs with X and Y axes (e.g. scatterplots, distribution plots, etc.). The have no effect on circular diagrams. The legend title is only displayed on those graphs that have a legend (e.g. stacked plots).



6.5.1.5 Fonts

This page allows you to customize the fonts used for various labels on the graphs. Clicking on any of the buttons will bring up the regular Windows font dialog box^[147], allowing you to select the characteristics of the new font.



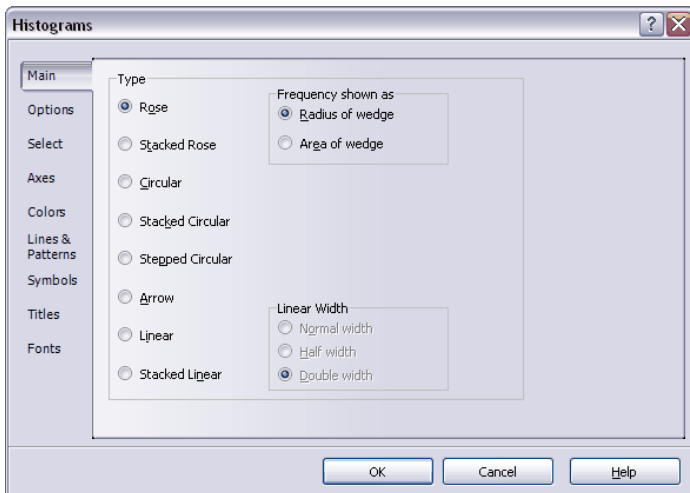
The various graph elements are:

- **Main Title:** The title that appears at the top center of the graph.
- **Axes Titles:** These are the titles that appear alongside the X and Y axes of graphs like linear histograms, scatterplots, etc. They do not appear on the circular graph types.
- **Large Axis Labels:** These are the larger axis tick mark labels. These are used for labeling the tick marks along X and Y axes of scatterplots, etc. This font is also used for labeling the four point on circular diagrams (e.g. the 0° , 90° , 180° and 270° points) and the minor divisions.
- **Small Axis Labels:** These are used for labeling the steps of the circular grid in circular diagrams.
- **Legend:** This is used for labeling the entries in the legend. The title of the legend will use the same font, but in boldface and underlined.

The **Title Box Style** and **Legend Box Style** drop-down boxes allow you to customize (or remove) the box that is drawn around these two graph elements. The **Legend Position** adjusts where the legend is drawn.

6.5.2 Graphs | Histograms

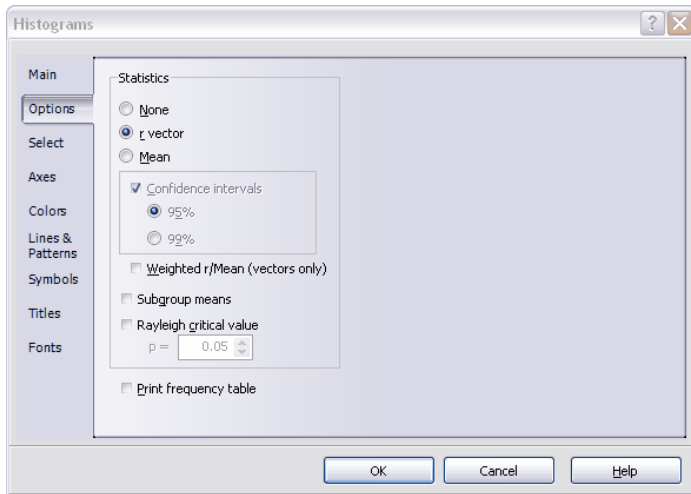
This option allows you to plot a variety of histograms¹⁷⁹. Choosing this option will cause the following dialog box to be displayed:



The first page lets you choose which type of histogram to

produce. They are described in the section about graph types^[79]. For rose diagrams the **Frequency Shown As** box lets you choose between the two methods for producing the rose diagram sections (see the section about rose diagrams^[79] for more details). If one of the linear histogram types is chosen then you can use the **Linear Width** option to set the extent of the X axis.

The **Options** page lets you change a variety of settings that affect how the data are displayed.



You can choose to have the mean and confidence intervals displayed on the graphs. The mean can be depicted either as a line to the edge of the circle, or as a vector, the length of which reflects the r value.

If you have vector data that consist of both an angle and a length or distance, and you have defined the two variables as a vector pair in **Data|Define Vector Pair**^[114] then you can choose to have a **Weighted r/Mean** plotted on the graph. This is the angular mean that is weighted with the second variable. For instance, in wind data you may want to have the mean weighted by the wind speed, so that if higher winds occur predominantly from a certain direction the mean will be weighted more towards that direction. When the “Weighted Mean” option is selected along with the Mean type of statistic then it is depicted by an arrow that extends beyond the edge of the graph. If the “r Vector” type of statistic is selected then the length of the mean

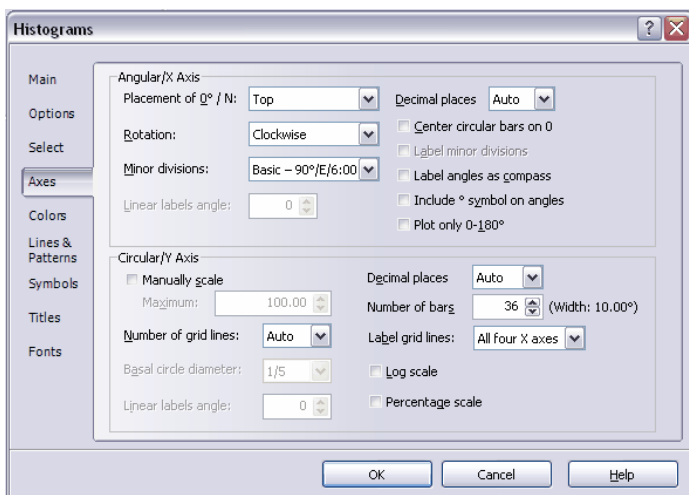
weighted vector will reflect the weighted r of the mean (scaled 0-1).

If the **Subgroup means** option is ticked then separate statistics lines are drawn for each subgroup when a subgrouping variable is in use. Otherwise just a single overall mean is drawn.

The **Rayleigh critical value** option lets you draw a circle on the graph showing the level of the Rayleigh critical value. If the r vector extends beyond the circle this indicates that the Rayleigh test is significant at the chosen p value. This option is only available when the r vector option is chosen, and is not available if subgroup means are being plotted.

When the **Print frequency table** option is ticked a frequency table will be created in the Results window^[8], showing the frequencies for each class that are used to draw the histogram, as well as the percentages.

The **Axes** page allows you to make extensive customizations of the axes in the circular and linear graphs. There are two sections. The first, labeled **Angular/X Axis**, is for adjusting various aspects of the axis around the circumference of the circle, which represents the angles, time of day, or other circular data. The second section, labeled **Circular/Y Axis**, is for changing the set of concentric rings that provide the grid representing the frequencies in the histogram.



Both sections have options called **Decimal places**. This adjusts the number of decimal places used for numeric labels on either axis. When set to “Auto” the shortest number possible will be used (e.g. there will be no decimal portion if the number is a whole number). If set to a specific number of decimal places then all numbers will have that many places.

The second option occurring in both sections is **Linear labels angle**. This only affects linear histograms. By default the labels are oriented parallel to the bottom of the graph. You can use this option to rotate the labels to any angle, up to 90° either way.

Angular/X Axis

By default the Angular grid is oriented so that the 0° or North point is at the top of the graph. In some disciplines it is more usual to have the graph oriented differently, so you can use the **Placement of 0°/N** option to set the position on the circle where the 0° should occur (e.g. to the right or at the bottom). The next option, **Rotation** sets whether the scale should increase clockwise or counterclockwise. With clockwise, and the 0° point at the top, the 90° point will be on the right, whereas with counterclockwise it will be on the left.

By default Oriana will divide the graph into four sectors, with boundaries at 0°, 90°, 180° and 270°. We might want more gridlines than this. We can use the **Minor divisions** option to customize the minor division. You can set the minor divisions to be every 45°, 22.5° or 10° (or their equivalents in Compass or Time variables), or you can leave it at the Basic level (every 90°). You can also turn off all divisions so there is no grid radiating from the center. Note that for Time variables the finest division occurs every 1:00 hour, rather than the time equivalent of 10°. This option has no effect on the date-based variable types (such as Day of Week) as they always have their own angular divisions. If you want the minor divisions labeled you can tick the **Label minor divisions** option.

The **Center circular bars on 0** option specifies that the bars or wedges should be arranged so that the first one is centered on zero (e.g. first bar would range from 350°-10° instead of 0°-20°).

Usually Angle and Axial data are plotted with the actual degrees (e.g. 90°) used as labels. However, if these data

represent geographical directions then you may wish to have the graph labeled with the compass directions (such as E for East) instead. You can do this by ticking the **Label angles as compass** option.

The **Include ° symbol on angles** option determines whether the degree symbol is used when printing angles on the circular scale.

The **Plot only 0-180°** option allows you to create a graph that only plots the data in the 0-180° range, but which cover the whole of the circular graph. This type of graph can be used in fields where data are always measured on a 0-180° scale, such as the axis in ophthalmology. Note that any data values greater than 180° will be ignored.

Circular/Y Axis

Normally Oriana will scale the Circular or Y Axis to the best value to accommodate all frequencies in the histogram. However you may want to produce multiple graphs with the same scaling, for comparison. Ticking the **Manually scale** option will allow you to specify (in the **Maximum** box) the maximum extent of the circular/Y axis.

The **Number of grid lines** option will allow you to specify how many concentric circles grid lines are on the graph. When set to “Auto” it will use the optimum number of gridlines, with the aim of producing a neatly scaled grid with values such as 10 or 25, if possible, rather than 33.33, 24.25, etc. You can set a specific number of gridlines if you desire using this option, or set it to 0 to remove all circular gridlines.

With circular histograms, which use bars with parallel sides rather than wedges, the bars actually extend outwards from a small circle around the middle of the graph rather than from the very center, so that the bases of the bars do not overlap. You can use the **Basal circle diameter** option to adjust the size of this circle. The value is expressed as a fraction of the diameter of the graph, so a setting of 1/5 means that the diameter of the circle will be 1/5 the total diameter. The width of the bars will be adjusted so that they do not overlap.

The **Number of bars** option lets you set the number of bars in the histogram. The width of each bar will also be displayed. Note that this option is not available for data types with fixed

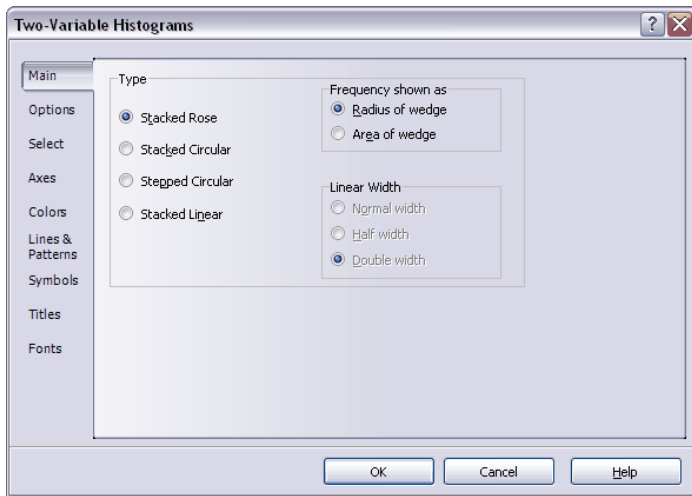
class widths (e.g. Day of Week or Month of Year).

The **Label grid lines** option lets you choose which of the four main angular grid lines have labels for each circular grid line. By default all four angular grid lines are labeled but you can choose to have only a single of a pair of lines labeled, or none at all.

The **Log scale** option lets you choose to have the circular concentric grid (or Y axis on linear graphs) scaled logarithmically (base 10) rather than linearly. The **Percentage scale** option will label the scale with the percentages of the total frequencies rather than the frequencies themselves.

6.5.3 Graphs | Two-var Histograms

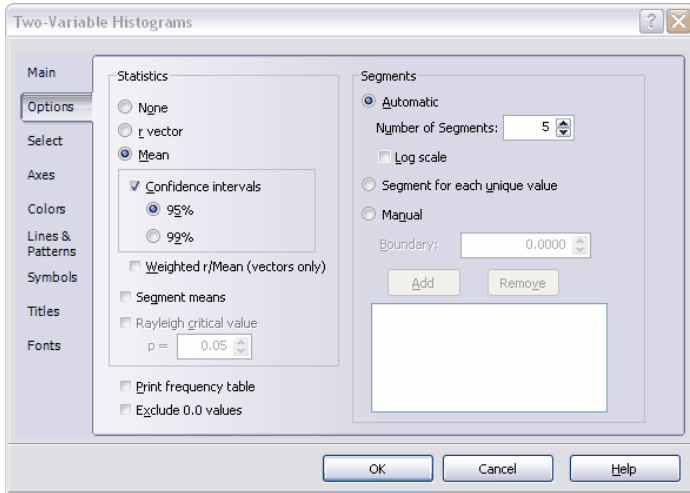
This dialog box allows you to create two-variable histograms^[86], which allow two variables to be plotted together on a single graph, with the second variable being represented as stacked segments of each bar or wedge.



+

The options are similar to those on the **Graphs | Histogram**^[133] dialog box, but with only the relevant graph types listed.

The **Options** page is similar to that for regular histograms, except for the addition of a few new options.



The **Exclude 0.0 values** option excludes any cases where the second variable is 0. This is useful in meteorological graphs. With diagrams depicting wind speed it is customary to not include data when the wind speed is zero; the associated direction could be unreliable as the wind vane could be pointing in any direction in becalmed situations. Instead the legend box will give the percentage of the zero values in the data set.

The **Segments** section allows you to specify the number of frequency classes (and thus segments on each bar) to be used for the second variable. When **Automatic** is selected you can choose to have Oriana automatically divide each wedge of the rose diagram into a certain number of segments, specified by the **Number of Segments** setting. Each segment will represent that proportion of the total range of the second variable. For example, if the second variable ranges from 0 to 100, choosing 5 segments means that the first one will represent the number of observations between 0 and 20, the second from 20-40, and so on. If your second variable is better expressed on a logarithmic scale, with many very large values as well as small ones, you can tick the **Log scale** scale option to base the divisions on a log scale (e.g. 0-10, 10-100 and 100-1000).

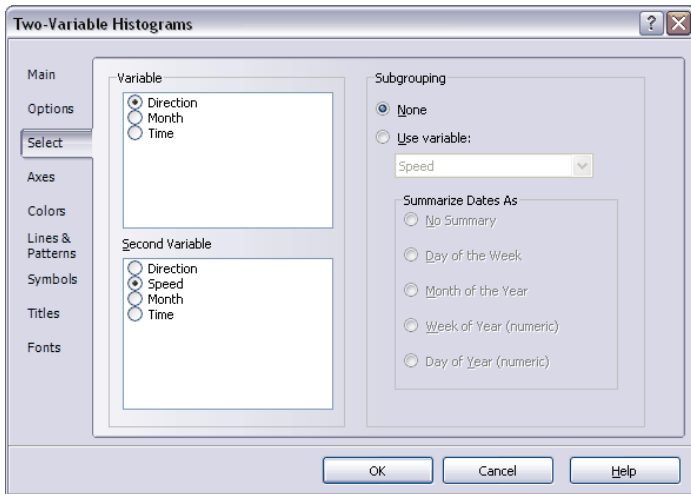
If you prefer you can set the boundaries between each segment manually, using the **Manual** option above. This lets you enter the exact boundaries for each segment. So if you enter a 15 in this option as the first boundary and a 30 as the second then all

values from 0-15 will be in the first segment, all values greater than 15 and up to 30 are in the second segments.

To build up your list of boundaries tick the **Manual** option, then enter the first boundary into the **Boundary** box and click the **Add** button. This will add the value to the box below. Continue doing this for all boundaries. If you need to remove a boundary you can select it in the list and click the **Remove** button.

If your second variable consists of discrete values (e.g. just the numbers 1, 2, 3 and 4) and you want a separate segment for each you can use the **Segment for each unique value** option.

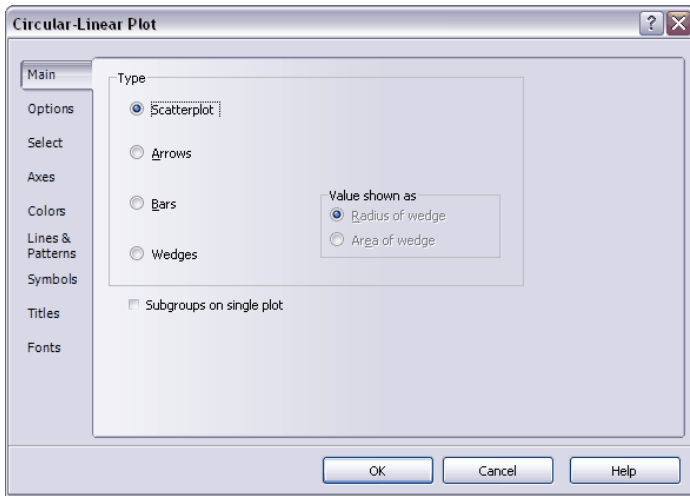
The **Select** page is also slightly different from the **Graphs | Histogram**^[133] dialog box.



The **Variable** box now only allows one variable to be selected. There is also a second box, labeled **Second Variable**, which allows for selection of the second variable.

6.5.4 Graphs | Circular-linear

This dialog box allows you to create circular-linear plots^[87], which allow two variables to be plotted together on a single graph, with the second variable determining the length or placement of each of the graph elements.



The section titled **Type** allows you to specify the graph type. The **Scatterplot** will plot points on the graph so that the positioning around the graph represents the angle, and the distance from the center of the graph represents the second linear variable. You can also have the value of the second variable represented by an arrow, bar or wedge. When bars are used they, by default, are one degree wide. You may use the **Bar Width** option on the **Axes** page to make them wider. For wedges the **Value shown as** option lets you determine how the wedges are scaled, just like in the rose diagrams in the **Graphs | Histogram** ^[133] dialog box.

If you have a subgrouping variable in use then by default a separate graph is created for each subgroup. You can tick the **Subgroups on single plot** to have them all plotted on a single plot, with different colors or symbols for each subgroup, as specified on the **Colors** and **Symbols** pages.

The **Options** page is similar to that in the **Graphs | Histogram** ^[133] dialog box, with two exceptions. The Weighted Mean options works slightly differently. If the weighted option is selected for the “r Value” statistic then the length of the weighted vector arrow will reflect the native units of the weighting variable, so it can be compared to the individual data points on the graph, rather than being scaled 0-1 like the unweighted r. As a result, if you change the scaling of a graph

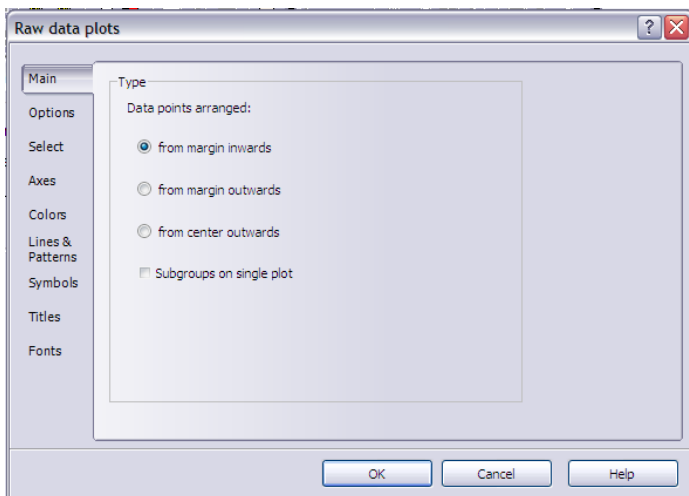
the length of the weighted r arrow will also change to match the data.

Also, there is a new statistics option. The **Standard deviation ellipse** option plots the weighted mean as a centroid point, along with an ellipse that depicts the standard deviation of the data along the two major axes (the exact values of the centroid and standard deviations are given in the **Analyses|Stats**^[123] output as the angle, length and SD of the Weighted Mean Vector). These are calculated from the weighted sines and cosines data. This option, along with the **Plot only 0-180** option on the **Axes** page, is commonly used in ophthalmological studies (see Holladay et. al, 2001).

The **Select** page is similar to that for two-variable histograms^[138].

6.5.5 Graphs | Raw Data Plots

This graph type allows you to plot raw data plots^[81], where each data point (i.e. row in the data matrix) is plotted on the graph with a symbol, stacked up in a histogram-like format. There are three methods of placing the points.



When **Data points arranged** is set to **from margin inwards** then the points start at the outer rim of the circular graph and are stacked inwards. The **from margin outwards** also starts at the outer rim but stacks the points outwards instead. The circle

of the graph is much smaller, with the labels in the inside, to give plenty of room for the points.

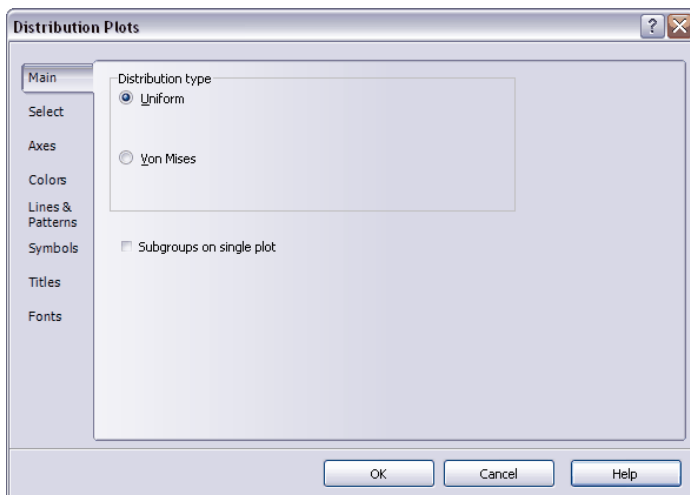
The third option, **from center outwards**, starts from the middle of the graph and stacks the points outwards. The points actually start from a circle plotted a small distance outside the center of the plots, because if all points started at the very center they would overlap too much. You can adjust the size of this circle with the **Basal circle diameter** option on the **Axes** page.

If you have a subgrouping variable in use then by default a separate graph is created for each subgroup. You can tick the **Subgroups on single plot** option to have them all plotted on a single plot, with different colors or symbols for each subgroup, as specified on the **Colors** and **Symbols** pages.

The **Options** and **Select** pages are identical to those in the **Graphs | Histogram** ^[133] dialog box.

6.5.6 Graphs | Distribution

This option allows you to plot two different types of distribution graphs ^[88]. These are helpful for assessing whether your data fit a theoretical distribution. The data can be compared to either the Uniform or von Mises distribution.



If you have a subgrouping variable in use then by default a

separate graph is created for each subgroup. You can tick the **Subgroups on single plot** to have them all plotted on a single plot, with different colors or symbols for each subgroup, as specified on the **Colors** and **Symbols** pages.

The **Select** page is identical to that in the **Graphs | Histogram** [133] dialog box.

The **Axes** page lets you customize the axes of the plot.



The **Extent of Axes** option allows you, for uniform distributions, to have the axes of the graph extended so that any patterns that overlap the wrap-around can be seen more easily (see the section on distribution graphs [88] for an example).

The **Number of grid lines** option will allow you to specify how many grid lines to draw on the graph. When set to “Auto” it will use the optimum number of gridlines, with the aim of producing a neatly scaled grid with values such as 10 or 25, if possible, rather than 33.33, 24.25, etc. You can set a specific number of gridlines if you desire using this option. Since the main purpose of this graph is to compare the distributions on the two axes the same number of gridlines is used for both axes.

The **X Axis** and **Y Axis** sections both have options called **Decimal places**. This adjusts the number of decimal places used for numeric labels on either axis. When set to “Auto” the

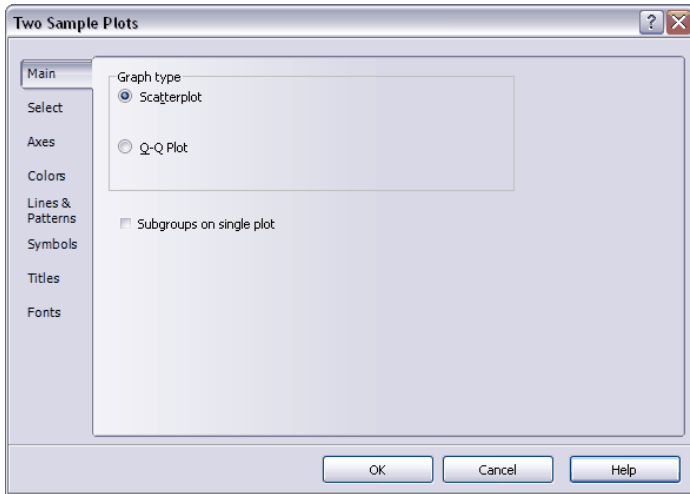
shortest number possible will be used (e.g. there will be no decimal portion if the number is a whole number). If set to a specific number of decimal places then all numbers will have that many places.

The second option occurring in both sections is **Labels angle**. By default the labels are oriented parallel to the bottom of the graph. You can use this option to rotate the labels to any angle, up to 90° either way.

You can use the **Symbol Size** option on the **Symbols** page to adjust the size of the points on the graph.

6.5.7 Graphs | Two-sample

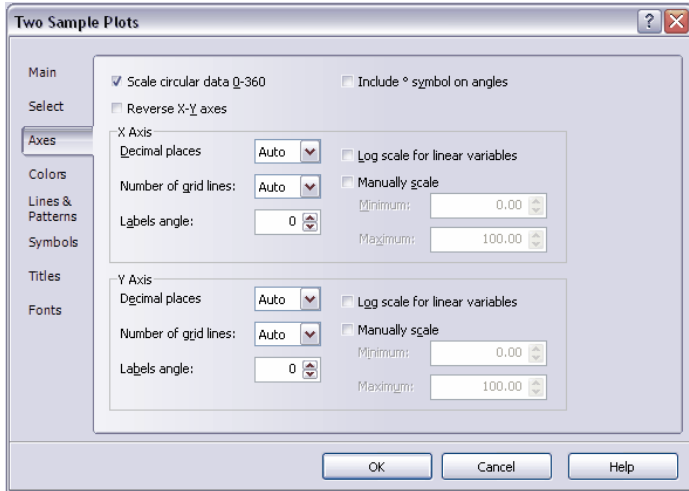
This dialog box lets you create two-sample plots^[89], either a standard scatterplot (using either circular or linear data types) or a Q-Q plot that compares the distributions of two circular variables.



If you have a subgrouping variable in use then by default a separate graph is created for each subgroup. You can tick the **Subgroups on single plot** to have them all plotted on a single plot, with different colors or symbols for each subgroup, as specified on the **Colors** and **Symbols** pages.

The **Select** page is identical to that in the **Graphs | Histogram**^[133] dialog box.

The **Axes** page lets you customize the axes of the plot.



When the **Scale circular data 0-360** option is ticked all axes for circular data depict the whole range, even if the data are restricted to a certain section of the graph. Otherwise the axes are scaled to fit the data range. The **Reverse X-Y axes** lets you change the samples that occur on the two axes. The **Include ° symbol on angles** option determines whether the degree symbol is used when printing angles on the scales.

The **X Axis** and **Y Axis** sections both have a number of options that let you change aspects of either of the axes. The **Decimal places** option adjusts the number of decimal places used for numeric labels on either axis. When set to “Auto” the shortest number possible will be used (e.g. there will be no decimal portion if the number is a whole number). If set to a specific number of decimal places then all numbers will have that many places.

The second option occurring in both sections is **Number of grid lines**. This option will allow you to specify how many grid lines are plotted on the graph. When set to “Auto” it will use the optimum number of gridlines, with the aim of producing a neatly scaled grid with values such as 10 or 25, if possible, rather than 33.33, 24.25, etc. You can set a specific number of gridlines if you desire using this option.

By default the labels are oriented parallel to the bottom of the graph. You can use the **Labels angle** option to rotate the labels to any angle, up to 90° either way.

If you are plotting linear data that are better expressed on a logarithmic scale, with many very large values as well as small ones, you can tick the **Log scale for linear variables** scale option to base the scale on a log scale (e.g. 0, 10, 100, 1000).

Normally Oriana will scale the axes to the best value to accommodate all data. However you may want to produce multiple graphs with the same scaling, for comparison. Ticking the **Manually scale** option will allow you to specify (in the **Minimum** and **Maximum** boxes) the extents of the axis.

The **Symbol Size** option on the **Axes** page lets you adjust the size of the points on the graph.

6.5.8 Graphs | Edit graph


Choosing this option allows you to modify the graph settings for the diagram in the currently active window. A dialog box similar to that used when first creating the graph will be displayed. You can change most of the options; the graph will then be redrawn with the new settings when you press **OK**.

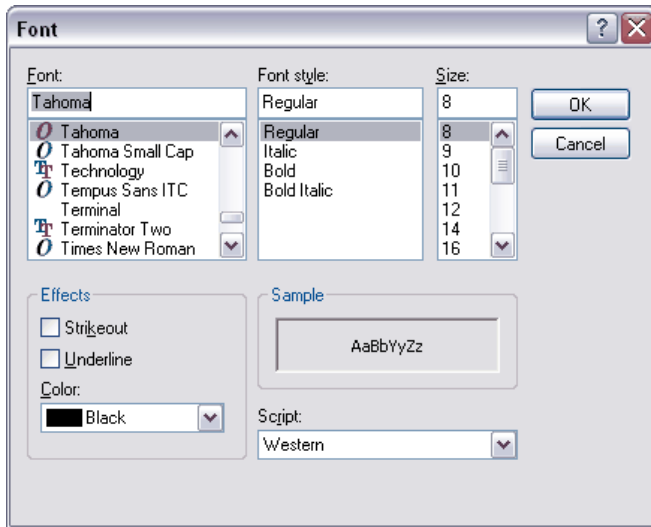
These dialog boxes will not display the **Select** page that allows you to select the samples for plotting. If you wish to plot a different sample then you will need to create a new graph. Also, scatterplot and Q-Q plots cannot be changed from one plot type to the other; new graphs will also need to be created in this case.

6.6 Options

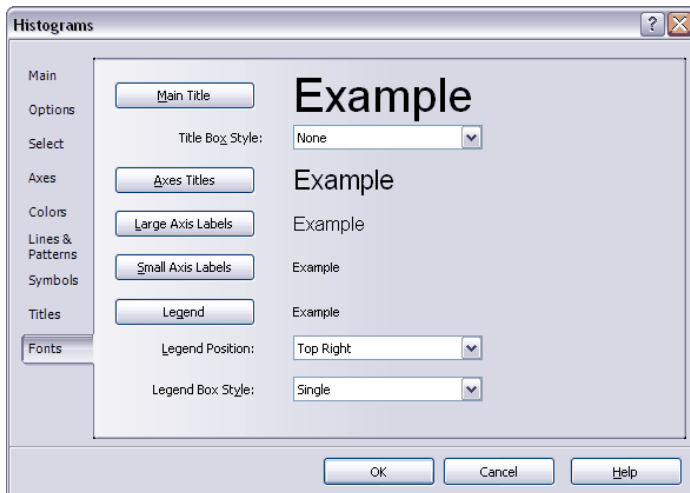
This menu lets you change some of the options regarding how the program acts and looks.

6.6.1 Options | Font

This option allows you to change the font used in the currently active window. It will also change the font that will be used in the future for that particular window type. 

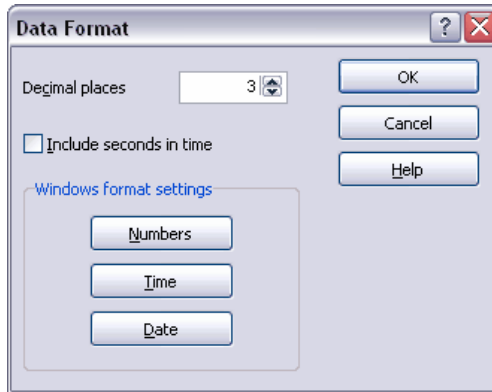


With the graph window, different fonts can be used for the numeric labels on the graphs and the axes labels and title. When this window is active you will be shown the **Font** page of the **Graphs|Edit Graph** ^[147] dialog, which allows you to change these fonts individually. Clicking on each of the buttons below will produce a font dialog like that above.



6.6.2 Options | Format

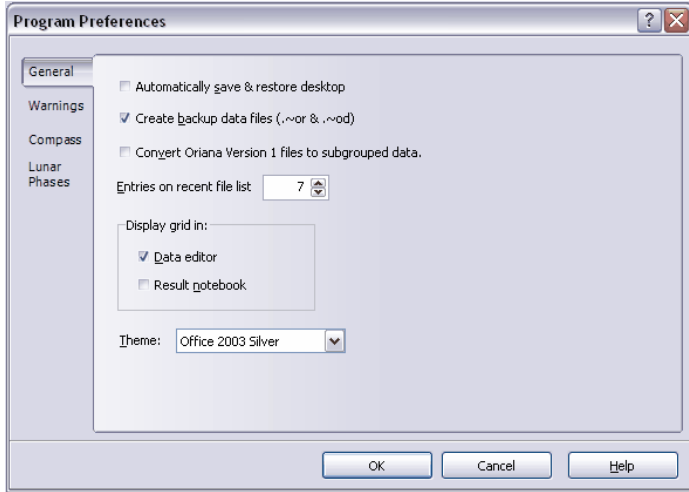
This dialog lets you change the various options for how data are displayed in the data editor and results window.



First is the setting of the number of **Decimal Places** for numeric data, followed by an option as to whether to **Include seconds in time** data. These are followed by three buttons that take you directly to the Windows format setting dialog boxes, for setting the format of **Numbers**, **Times** and **Dates**. Changing these three options will affect how these data are displayed in all Windows programs, not just Oriana.

6.6.3 Options | Preferences

This option lets you change a variety of settings that affect the whole of the program. These settings are automatically saved for future use. When you choose it, the following dialog box is displayed.



Automatically save & restore desktop

If you choose this option your desktop⁴ will be saved when you exit Oriana. It will automatically be restored to the same state next time you run the program.

Create backup data files (.~or)

By default, Oriana makes backup copies of your data files (with the extension .~OR instead of .ORI) whenever you save your data. Desktop files are also backed up to the extension .~OD instead of .ODK. You can turn this off using this option.

Convert Oriana version 1 files to subgrouped data

When selected, any Oriana ver. 1 files that contain multiple columns (samples) will be converted into one column of data and another subgrouping variable, containing the labels of the original samples.

Entries on recent file list

This allows you to set the number of entries on the Reopen menu.

Display grid in:

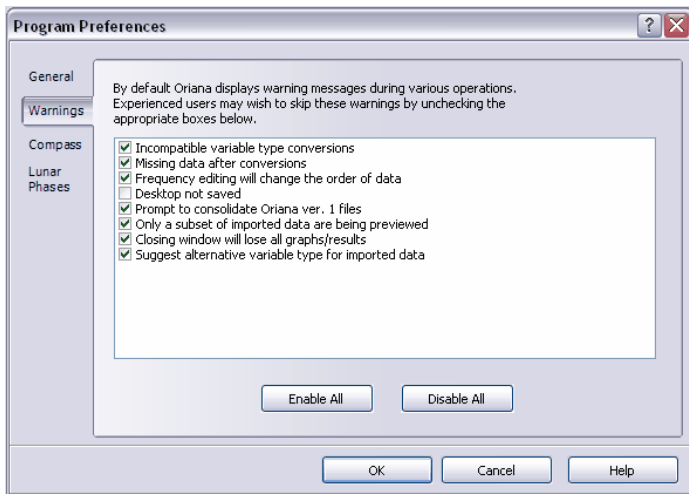
This lets you choose whether to have grids displayed in the data editor and results spreadsheets.

Theme:

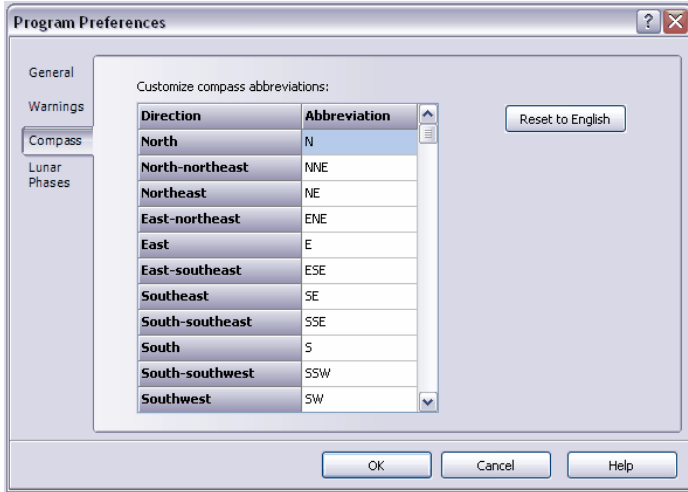
This lets you change the visual appearance of the Oriana

window, including different colors and visual effects. By default a scheme is chosen that will match your current Windows theme as well as possible. The drop down box for this option lets you change it to a different one. The new theme will be applied immediately after you select a new one, so that you can easily see the effects of the different themes, but the change is only made permanent when you press **OK**. If you press **Cancel** the theme will revert to the original one.

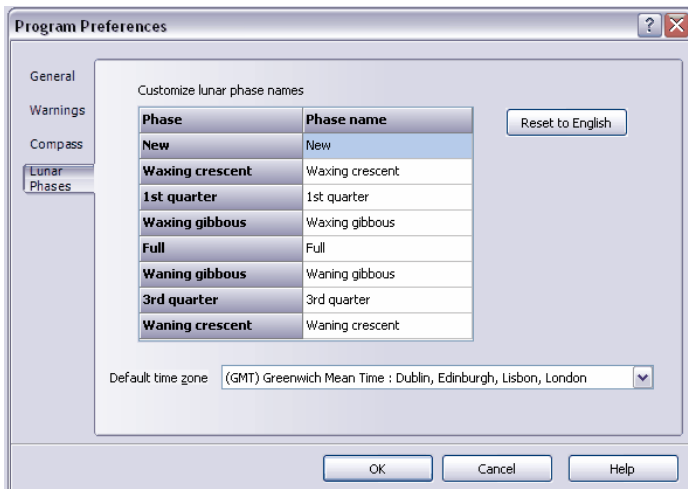
The second page of the dialog box, labeled **Warnings**, lets you set whether certain warning messages are shown. When these warnings are displayed they have a check box labeled **Don't show this again** that suppresses future display of the warning. This dialog box lets you turn them back on again.



The **Compass** page lets you customize the abbreviation used on graphs, results and in the data editor for the compass directions. By default the standard English abbreviations are used (e.g. N for North, SE for southeast). You can change these to the equivalents in your own language by just typing the new abbreviations into the table. You can reset the abbreviations to their defaults with the **Reset to English** button.



The Lunar Phases page contains options related to the Lunar variable type. The table at the top lets you customize the names used for the various lunar phases, in a similar way as the compass abbreviations above. The Default time zone option lets you change the time zone that Oriana assumes when calculating lunar phases (see the description of the Lunar variable [164](#) to find out why you might need to do this). This defaults to the current Windows time zone, but if you change it the new setting will be remembered next time you run Oriana.



6.7 Window

This menu makes it easier to arrange the various windows on the Oriana desktop.

6.7.1 Window | Show Notepad

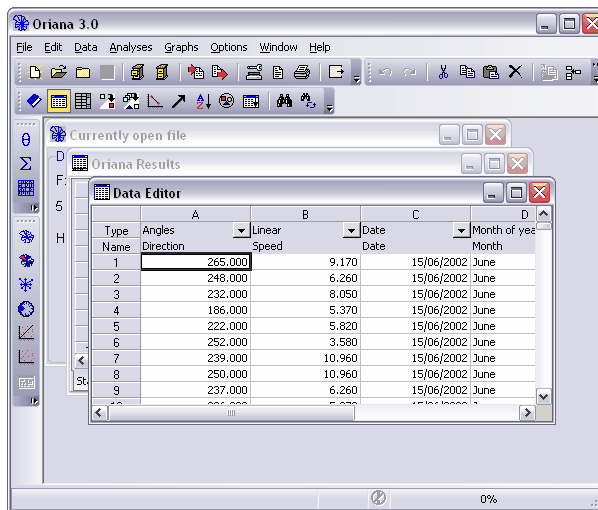
This option will open the Notepad window^[11] for keeping notes about the analyses of the current data file. Selecting it again will close the window.

6.7.2 Window | Arrange Icons

When you iconize windows on the desktop they can be moved around to any point on the desktop. This command will rearrange them so that they are all neatly lined up at the bottom of the desktop window.

6.7.3 Window | Cascade

This command rearranges and resizes the windows on the Oriana desktop so that they are all the same size and are arranged in an overlapping manner, with the title bars of all windows visible. The following picture illustrates this:



Note that any windows that are iconized when the command is chosen remains iconized; the other windows are adjusted so that there is room for the icons at the bottom.

6.7.4 Window | Close all

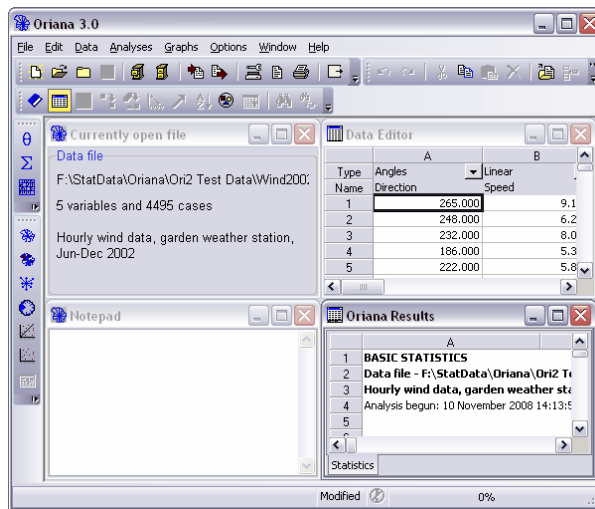
This command will close all the windows on the Oriana desktop. If you have any results or changes to the data that haven't been saved you will first be prompted to save them. The current data file will also be closed.

6.7.5 Window | Minimize All

This will minimize all windows within the Oriana program frame to icons at the bottom of the frame.

6.7.6 Window | Tile

This command rearranges and resizes the windows on the Oriana desktop so that they are all visible at one time. The following picture illustrates this:



Note that any windows that are iconized when the command is chosen remains iconized; the other windows are adjusted so that there is room for the icons at the bottom.

6.7.7 Window | List of open windows

Any windows that are open on the Oriana desktop will be listed at the bottom of the Windows menu. This lets you easily switch between the windows, particularly when you are using keyboard control ¹⁵⁹.

6.8 Help

This menu allows you to look at information about the program.

6.8.1 Help|Index

This command will load the Oriana help file and display the Contents page.

6.8.2 Help|Check for updates

This will allow you to check on the Kovach Computing Services web site to see if a new version of Oriana is available. When you chose this menu item a wizard will appear that will take you through the process of checking over the Internet to see if there is a new version. If there is the new version number and information about the update will be displayed and you can continue on with the wizard to download and install the new version.

By default Oriana will check every month to see if there is a new version. It performs this check when you start up the program. You can change the frequency of the check, or disable it completely, by clicking on the **Options** button on the update wizard.

Please note that Oriana will ask you first before checking for updates, and that no information about your computer or software setup is transmitted to our web site. This update check simply downloads a small file from our web site containing the version number of the latest version and information about the update.

6.8.3 Help|Order Oriana

This menu item takes you to the Kovach Computing Services web site to order a copy of Oriana.

6.8.4 Help|About

This will display a dialog box giving some information about this program, primarily the version number, copyright notice and the address of the author. If you are using the evaluation version of the program it will also tell you how many days or runs you have left in the trial period, and will provide buttons for ordering the program and entering the registration code.

7 Technical Support

7.1 Technical support

Registered users of Oriana are eligible for free technical support on the use of the program for 90 days after purchase. This is primarily meant to answer questions about installation of the program and getting started in using it. Most questions will be answered in the manual and help files, so look at those first before contacting us.

After 90 days we will generally try to help with more technical questions, but we reserve the right to refer users to the Oriana or Windows manuals for more basic queries.

Please note that free technical support only applies to questions on the actual use of the program and its features; it does not extend to help on the statistical techniques themselves or interpretation of the results. The user should refer to the literature^[158] about circular statistics. However, Kovach Computing Services does offer data analysis consulting services at reasonable rates. Please contact us for details.

Bug reports

If you encounter a problem that you think may be a bug in Oriana (yes, all programs have the occasional bug in them!), please contact us so that we can try to track down the cause. Please send as much detail about the problem as possible: what you were doing at the time, the exact wording of the error message, a detailed description of what happened when the problem occurred, details of your system configuration and other software that was running on your machine at the time, and a copy of the data file, if possible.

If the problem involves an error message then the message dialog box will usually have a button labeled “Report”. If you press the button and follow through the steps this will automate the process of sending information about the error to us.

Upgrades

Existing users of Oriana will be eligible for special prices on major new versions of the program (e.g. upgrading from version 3 to 4). Minor upgrades (e.g. from 4.0 to 4.1) can be downloaded for free from our web site.

7.2 Further reading about circular statistics

There are several books that are either dedicated to discussions of circular statistics or have substantial sections about the subject. Many of these books are available from our web site at <http://www.kovcomp.com/books.html>.

Batschelet, E., 1981. *Circular statistics in biology*. Academic Press, London. 372pp.

Davis, J.C., 1986. *Statistics and data analysis in geology*. John Wiley, New York. 646pp.

Fisher, N.I., 1993. *Statistical analysis of circular data*. Cambridge University Press, Cambridge. 277pp.

Jammalamadaka, S. R. & Sengupta, A., 2001. *Topics in Circular Statistics (Series on Multivariate Analysis)*. World Scientific, Singapore. 319pp.

Mardia, K.V. & Jupp, P.E., 2000. *Statistics of directional data. 2nd Edition*. John Wiley & Sons, Chichester. 429pp.

Reyment, R.A., 1971. *Introduction to quantitative paleoecology*. Elsevier, London. 226pp.

Upton, G.J.G. and Fingleton, B., 1989. *Spatial data analysis by example: Volume 2. Categorical and directional data*. John Wiley, New York. 416pp.


Zar, J.H., 1998. *Biostatistical Analysis. 4th Edition*. Prentice Hall, New Jersey. 663pp.

Cabreram J., Schmidt-Koenig, K. and Watson, G.S., 1991. The statistical analysis of circular data. In: Bateson, P.P.G. and Klopfer, P.H. (eds), *Understanding and animal awareness*. Plenum Press, New York.

Fisher, N.I. & Lee, A.J., 1983. A correlation coefficient for circular data. *Biometrika*, 70:327-332.

8 Appendices

8.1 Drag and Drop

Oriana supports drag and drop actions with data and desktop files. This allows you to easily open files by dragging them around the screen, rather than having to navigate the Open File  dialog box.

To do this, simply drag a new data (*.ori) or desktop (*.odk) file from a Windows Explorer window onto the Oriana program window and it will be opened. You can also drag a file onto an Oriana icon on the desktop; this will cause a new copy of the Oriana program to be started. Double clicking on a data file in Explorer or My Computer will also open a new copy of the program and load the file.

8.2 Using the keyboard

Oriana, like most Windows programs, is strongly oriented towards using the mouse to control the program. However, great care has been taken to ensure that all functions can be performed using the keyboard as well.

All main menus can be accessed by holding down the Alt key and pressing the letter that is underlined on the menu. So, to call up the File menu press Alt-F. To access items on each menu, just press the letter that is underlined while the menu is displayed. To save a file, press the “s” key while the file menu is displayed.

All items on the dialog boxes also have underlined letters. You can access them by holding down the Alt key and pressing that letter. Alternatively, the Tab and arrow keys will move sequentially through the dialog box items.

Besides the above principles, you can also use certain other standard keystrokes. The following is a list of the keystrokes that can be used.

Menu Items, etc.

Ctrl-O	Open data file
Ctrl-S	Save current window
Ctrl-P	Print current window
F1	Context sensitive help
Ctrl-F4	Close window on Oriana desktop
Alt-F4	Close Oriana main window
Ctrl-F	Find datum
Ctrl-H	Find and replace data
Ctrl-Tab	Switch between windows within the main Oriana window

Data editor & results window

Del	Delete current cell
Ctrl-Z	Undelete last deletion
Shift-	Cut selected cells to clipboard
Delete	
Ctrl-X	same as Shift-Delete
Shift-Ins	Paste clipboard contents at current cell
Ctrl-V	same as Shift-Ins
Ctrl-Ins	Copy selected cells to clipboard
Ctrl-C	same as Ctrl-Ins
F2	Turn on edit mode *
Esc	same as F2
F3	In date or time fields, when edit mode is on, sets cell to current date or time
F4	In date fields, when edit mode is on, displays calendar

* Edit mode can be exited by pressing Enter, tab or one of the arrow keys. Pressing Esc while in Edit mode will also exit, but the cell will revert to its original value.

8.3 ISO 8601

The International Organization for Standardization has produced a document, ISO 8601, that defines standards related to date and time notations. Different countries around the world traditionally use different methods for these notations, which can cause problems. It is recommended that, particularly for a global audience, the ISO 8601 standard be followed to avoid confusion.

For example, the actual date represented by 5/2/2003 could be

either February 5 or May 2, depending on the country. ISO 8601 recommends representing dates in the unmistakable form YYYY-MM-DD, where YYYY is the year in the usual Gregorian calendar, MM is the month of the year between 01 (January) and 12 (December), and DD is the day of the month between 01 and 31.

Internally, Oriana follows the ISO standard in the way it stores dates and times. However, the format used for displaying dates and times in the data editor and results window follows the regional settings in the Windows Control Panel.

ISO 8601 specifies that Monday is used as the first day of the week. Thus any lists of days of the week in Oriana (e.g. the order they are listed on histograms) follow this standard. Also, the calculation of the week of year follows the ISO standard (see the section on Oriana data types^[13] for details).

An excellent summary of ISO 8601 can be found in the Internet document “A Summary of the International Standard Date and Time Notation” by Markus Kuhn (<http://www.cl.cam.ac.uk/~mgk25/iso-time.html>), as well as on Wikipedia (http://en.wikipedia.org/wiki/ISO_8601).

The full text of the ISO standard can be downloaded from the International Organization for Standards at:

http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40874

8.4 Data file structure

The data files used by Oriana are plain text (or ASCII) files. This has the advantage that you can modify or edit them with a simple text editor, as well as through the Oriana data editor. It also means that it is possible to transfer data from any other program to Oriana, so long as the other program can create an ASCII file.

Header

The first three lines of the file is the header, which contains necessary information about the file. This is an example data file header:

*ORI2 5 4495 Hourly wind data, garden weather station, Jun-Dec 2002

“Direction” “Speed” “Date” “Month” “Time”

“Angles” “Linear” “Date” “Month of year” “Time-15”

The first line gives some overall information about the file.

First is a tag that identifies the file as an Oriana version 2 files:

***ORI2**. If this is not found then Oriana will assume that the file is an Oriana version 1 file and will try to read the header in that format. If the first line does not fit the format of a version 1 file then an error message will be displayed.

Next is the number of columns in the data file, followed by the maximum number of rows (note that for paired data each column must have the same number of rows, whereas with unpaired data the length of each column can differ). Everything after the number of rows is taken to be a descriptive title of the data file; this will be displayed when you load the file and will be placed on all printouts.

The second line contains the labels (or names) for each column. Each label is enclosed within double quotes, so that the label can contain multiple words with spaces in between. Each label is then separated from the next by at least one space or a tab. The number of labels must match the number of columns given in the first line of the header.

The third line contains the data type of the column. These are again enclosed within double quotes and separated by spaces or tabs. The actual text of the data type must exactly match one of the following (including capitalization):

“Angles”	“Day of year”
“Axial”	“Compass Direction”
“Time”	“Date”
“Day of week”	“Linear”
“Month of year”	“Label”
“Week of year”	“Subgroup”
“Lunar”	

If the data within a particular variable are grouped $\sqrt{26}$ then the data type indicator also contains a specification of the class width of the grouped data. For example, if times are recorded to the nearest hour, then the data are grouped with a class width

of 15° ($360^\circ/24$). This would be indicated in the data file as “Time-15”. This is the data type indicator followed by a single “-”, with no spaces, and a number giving the class width in degrees.

For Lunar variables the time zone for that variable is indicated after the data type label in a similar way to the grouping. If the data in a variable were collected in the USA Eastern Time Zone the label would be “Lunar--300”, indicating a time zone difference from GMT/UTC of -300 minutes (- 5 hours).

If any of the columns are of the Subgroup data type then the header will contain further lines giving the actual text for the various subgroups. Subgroup data are entered in the data editor by the user as text (e.g. “GroupA”, “GroupB”, “GroupC”, etc.) but are stored internally and in the data files as integer numbers (e.g. 0, 1, 2, etc.). These extra header lines provide the text for each subgroup. An example subgroup header line is:

```
SubgroupLabels 1 3 GroupA GroupB GroupC
```

The word “SubgroupLabels” indicates that this is a subgroup text line and must be present and match exactly. Next is a number indicating the position of the variable in the file (in the above example the subgroup variable is the first column). Next is the number of different groups (three in the above case), followed by the text for each group. If there are more than one subgroup variables then there will be a similar line for each variable.

Data

The rest of the file contains the data. The variables are arranged in columns, just like in the data editor, and the data are separated by spaces or tabs. Any data that are missing are stored as periods.

Numeric data, such as angles, axial angles and linear data are written as floating point numbers, with a period representing the decimal point. The number of digits after the decimal point is controlled by the setting in **Options|Format** for the data editor. Very large or very small numbers will be represented in exponential form (e.g. 0.0000025, or 2.5×10^{-6} , is stored as 2.5E-6).

Times and dates are stored in ISO 8601  format. The format

for time is “hh:mm:ss” where hh is the hour, mm is the minutes and ss is the seconds. A colon is always used as the separator. Dates are stored in the format, YYYY-MM-DD, where YYYY is the year, MM is the month, and DD is the day.

Days of the week are stored as the ordinal number for the day, with Monday being 1, Tuesday 2, etc. Months are also stored as ordinal numbers: 1 for January, 2 for February, etc. Day of the year and week of the year are stored as the actual number.

Compass directions are stored as the angle of the mid-point of the compass sector (e.g. 45 for NE, 90 for E, etc.). Subgroups are stored as their ordinal number, starting from zero (0 for the first group, 1 for the second, etc.). Finally labels are stored enclosed in double quotes, so that they can contain embedded spaces.

As the data are read they will be checked to make sure they are in an appropriate format for the data type. If any entries are found that are inappropriate that particular cell will be set to missing and a warning message will be displayed.

If a subgrouping variable^[112] has been set then the next line after the data will specify which variable is the subgrouping one. This line begins with the word “SubgroupingVar”, which is followed by the ordinal number of the selected variable (e.g. 4 for the fourth variable). If the selected variable is a date variable and the date is to be summarized (e.g. by day of week) then the variable number will be followed by a dash and one of four indicator of the summary type (“DOW”, “MOY”, “WOY” or “DOY”). An example is:

```
SubgroupingVar 4-DOW
```

If any vector pairs^[114] have been declared then the last line of the file will identify these. The line begins with the word “VectorPairs”, followed by one or more pairs of numbers (separated by a colon) that identify the numbers of the two variables in the vector pair. The line is terminated with a “-1” to indicate that the last pair has been written. So, if the first and second variable in the data file have been declared as a vector pair the last line will look like this:

```
VectorPairs 1:2 -1
```


8.5 Example data files

Oriana includes three example data files. These show you the structure of the data files as well as allowing you to test out the program before entering your own data. These can be found in the folder **SampData** in the Oriana program directory. Oriana should go to this folder first time you run the program.

Wind2002.ori

These are data from a weather station in the back garden of the home of the owner of Kovach Computing Services in Pentraeth, Isle of Anglesey, Wales (current readings can be found at <http://www.anglesey-history.co.uk/weather/weather.shtm1>). They are hourly readings from 15 June - 31 December 2002. The variables include wind direction, wind speed (in miles per hour), date, time and month

Megaspor.ori

These data are from a study by Kovach (1989, Quantitative methods for the study of lycopod megaspore ultrastructure. *Review of Palaeobotany and Palynology*, 57:233-246). They represent measurements of the orientation of the elements that make up the wall of various fossil and modern lycopsid megaspores.

The data are measured in degrees and represent the orientation of the element relative to a base line drawn perpendicular to the spore surface. Measurements were taken from several species of modern *Selaginella* and *Isoetes*, as well as the Cretaceous aged fossils *Paxillitriletes vittatus* and *Erlansonisporites erlansonii*. It was hypothesized that the orientation differed between the modern Selaginellaceae and Isoetaceae and that the fossil spores could be related to one of the two modern groups on the basis of this difference.

Termites.ori

This file has six of the data sets reproduced in Appendix B.13 in Fisher (1993). They are axial orientations of termite mounds of the species *Amitermes laurensis* at different sites in North Queensland.

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