# *Two-Dimensional Visualizer*



## Summary

The Two-Dimensional Visualizer Statlet is designed to plot multiple time series in a manner that helps users visualize the changes in multiple variables over time. Given *n* time series observed over *p* time periods, the program generates a dynamic display that illustrates how each of the variables has changed over time. Typical applications include plotting:

1. Yearly demographic variables for different countries.
2. Quarterly sales figures for multiple divisions within a company.
3. Monthly economic indices on a state-by-state basis.
4. Daily closing stock prices for multiple equities within a portfolio.

The basic plot shows bubbles plotted on an X-Y display. The positions along the X and Y axes represent the values of two primary data variables. The size and color of the bubbles may be used to illustrate other variables. As time increases, the analyst can follow changes in all of the variables. Various options are offered for smoothing the data and for dealing with missing values.

## Sample StatFolio: *visualize2d.sgp*

## Sample Data

The file *oecd.sgd* contains data for $n = 22$ countries over $p = 31$ years (1980-2010). It was obtained from the Organisation for Economic Co-Operation and Development (oecd.org). Variables in the file include:

- Population
- Central government debt
- Inflation
- Long-term interest rates
- Unemployment rate
- Infant mortality
- Female life expectancy
- Male life expectancy

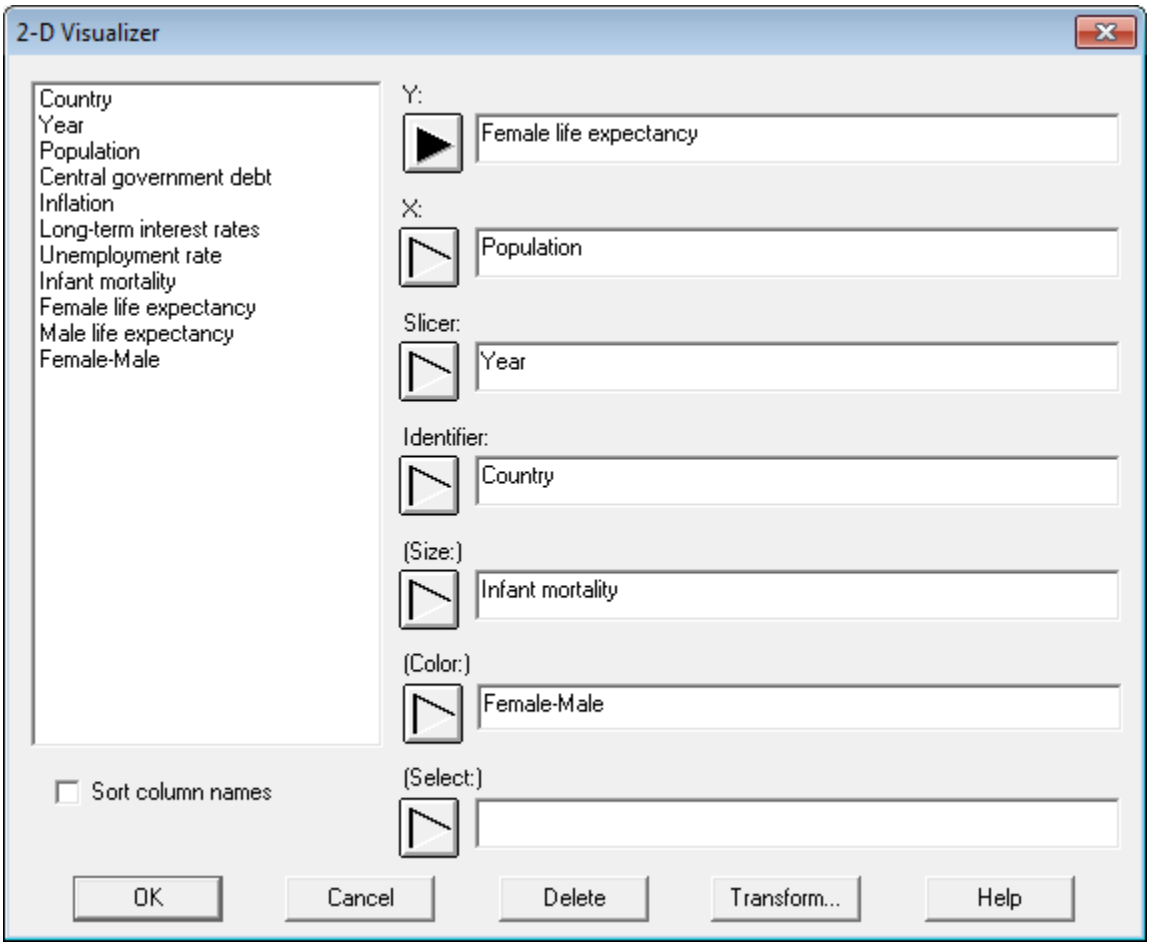
The first several rows and columns of that file are shown below:

| Country | Year | Population | Infant Mortality | Female Life Expectancy | Male Life Expectancy | Female - Male |
|---|---|---|---|---|---|---|
| | | | deaths per 1,000 live births | at birth | at birth | |
| Australia | 1980 | 14695360 | 10.7 | 78.1 | 71 | 7.1 |
| Australia | 1981 | 14923260 | 10 | 78.4 | 71.4 | 7 |
| Australia | 1982 | 15184250 | 10.3 | 78.2 | 71.2 | 7 |
| Australia | 1983 | 15393470 | 9.6 | 78.8 | 72.1 | 6.7 |
| Australia | 1984 | 15579390 | 9.2 | 79 | 72.5 | 6.5 |
| Australia | 1985 | 15788310 | 9.9 | 78.8 | 72.4 | 6.4 |
| Australia | 1986 | 16018350 | 8.8 | 79.2 | 72.9 | 6.3 |
| Australia | 1987 | 16263870 | 8.7 | 79.5 | 73.1 | 6.4 |
| Australia | 1988 | 16532160 | 8.7 | 79.5 | 73.1 | 6.4 |
| Australia | 1989 | 16814420 | 8 | 79.6 | 73.3 | 6.3 |

## Data Input

The data input dialog box requests the names of the columns containing the data values to be analyzed:




- **Y:** name of the numeric column containing the observations to be plotted on the vertical axis. There should be a total of *n* times *p* observations.

- **X:** name of the numeric column containing the observations to be plotted on the horizontal axis.

- **Slicer:** name of the numeric column used to define subsets of the data. This variable, often a measure of time, is changed dynamically to illustrate changes in the other variables. There should be *p* unique values of this variable.

- **Identifier:** name of the numeric or non-numeric column used to define each sample. There should be *n* unique values of this variable. A separate bubble is created for each value.

- **Size:** name of the numeric column used to scale the size of the bubbles.

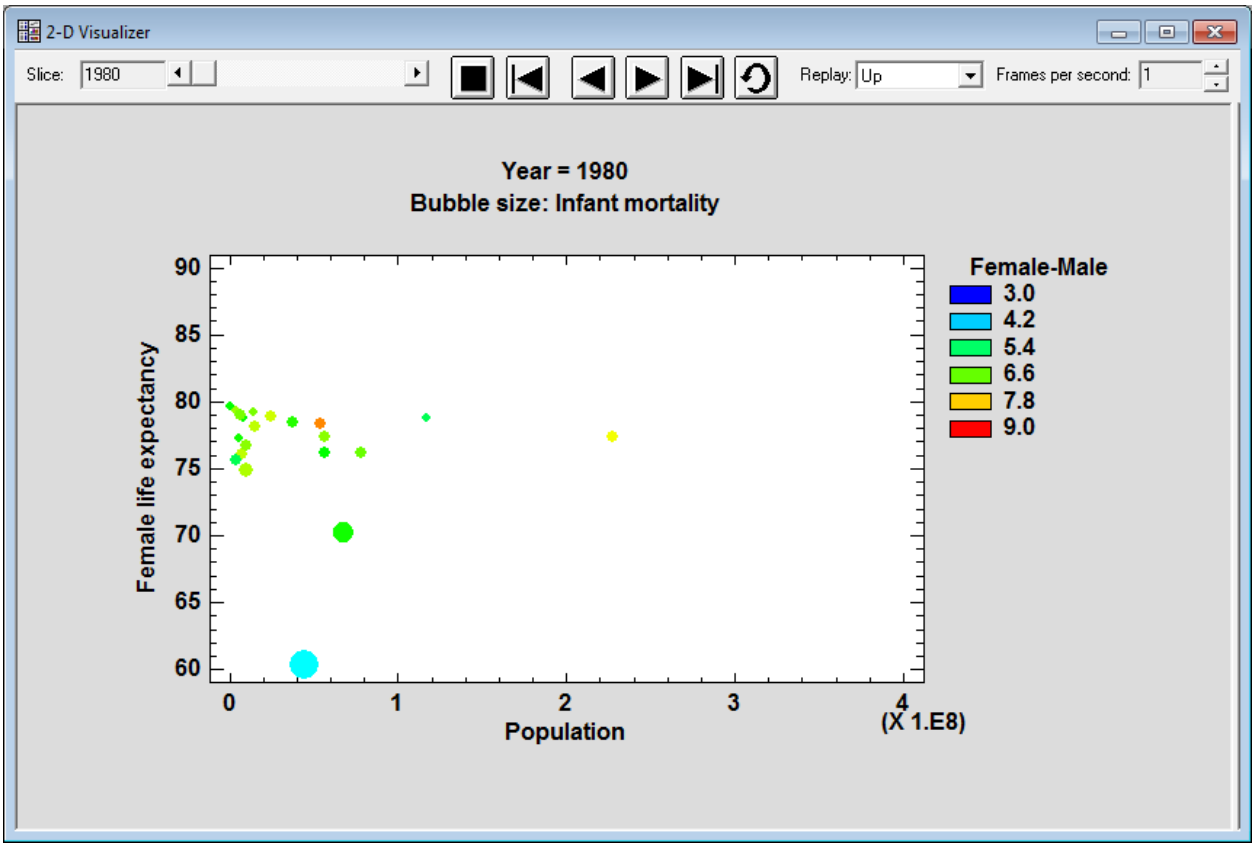
- **Color:** name of the numeric or non-numeric column used to determine the color of each bubble.

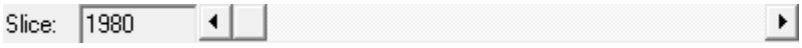
- **Select:** optional subset selection.

## Statlet

The output of this procedure is displayed in a dynamic Statlet window. When first created, the window displays data for the first time period (or first value of the *Slicer*) as shown below:




There is a single bubble for each country in the file. The Statlet toolbar contains the following controls:




**Slice scrollbar**: used to change the time period at which the data are displayed.

**Forward button**: used to start a timer which plots the data for each time period in increasing order.

**Backward button**: used to start a timer which plots the data for each time period in decreasing order.

**Fast foward button**: advances to the last time period.

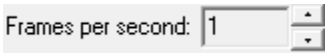
 

 **Rewind button**: rewinds to the first time period.

 **Replay button**: causes the sequence of time periods to be replayed over and over.

 **Stop button**: stops the timer or replay.


**Replay pulldown list**: specifies the direction for the time sequence when the replay button is pushed.

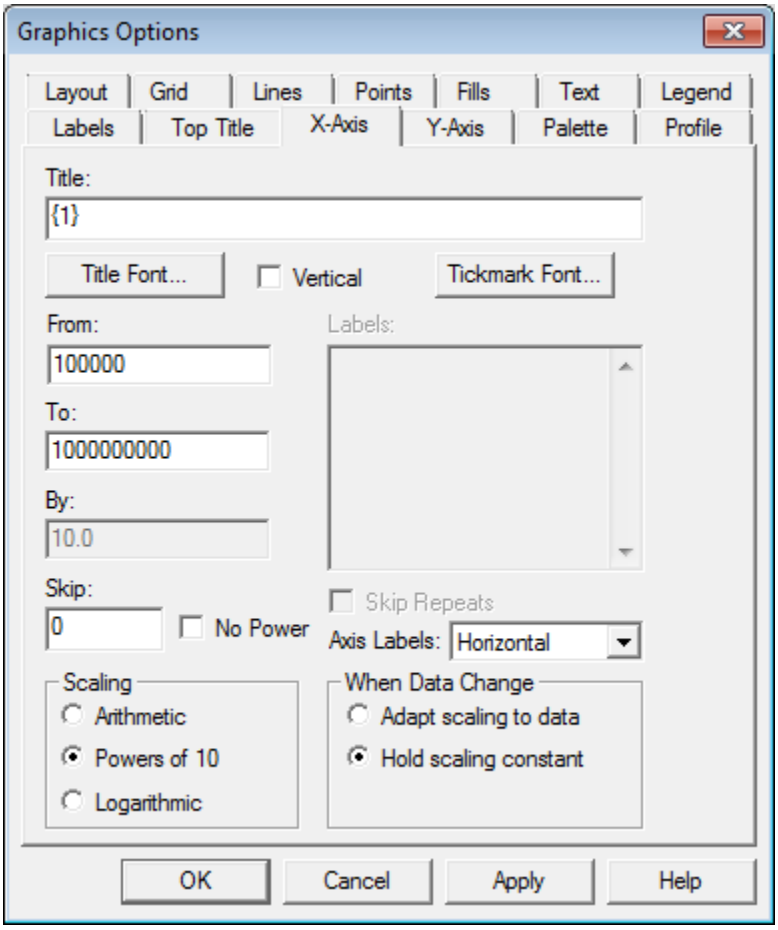



**Frames per second spinner**: specifies the rate at which the time period is changed.

## Graphics Options

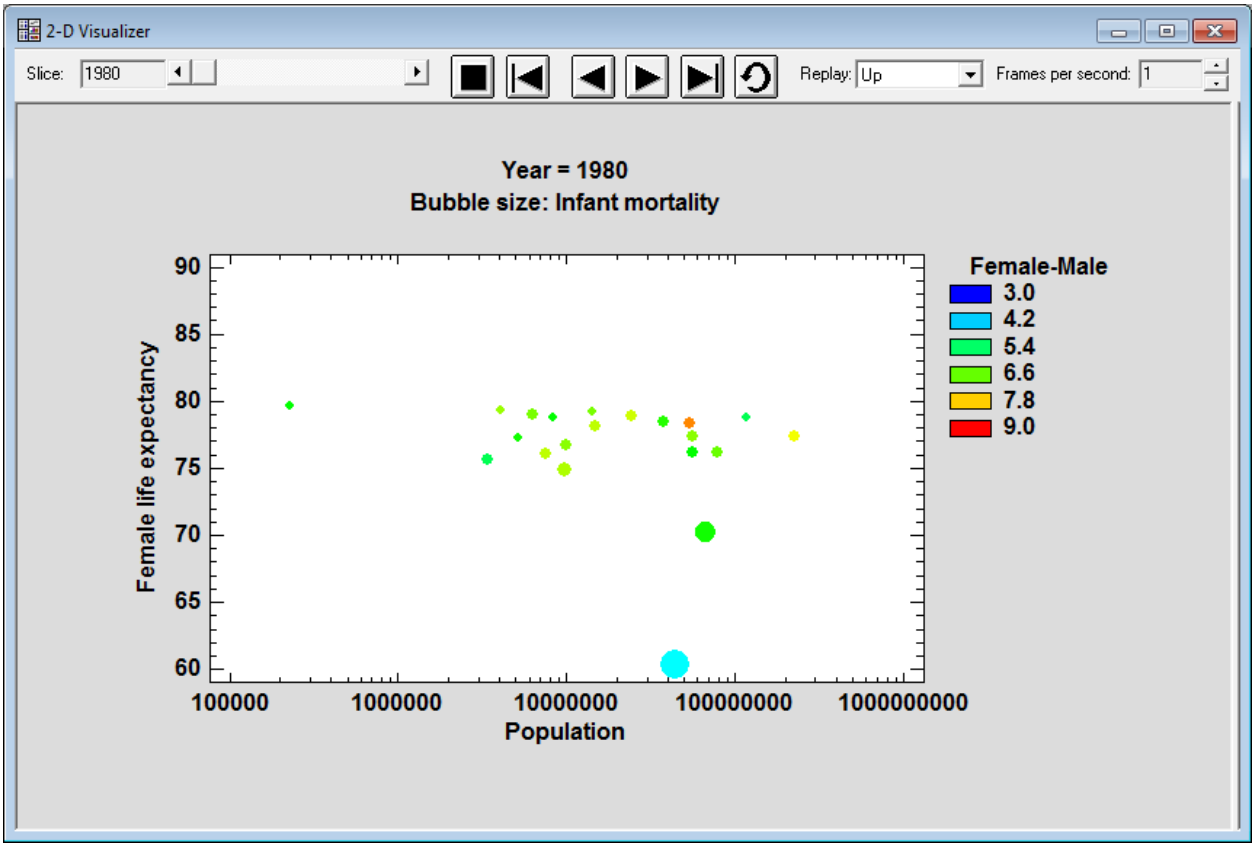
The standard *Graphics Options* tabbed dialog box may be used to change various aspects of the plot. For example, if the variable used to scale either the X or Y axis varies over an order of magnitude, it may be useful to use a logarithmic scale for that axis. Click anywhere on the graph with the right mouse button and select *Graphics Options* from the popup menu. Set the *X-Axis* tab as shown below:




Applying a logarithmic transformation to the X axis for the current example spreads the countries out along the horizontal axis (be sure to check the *Hold scaling constant* checkbox so that the scaling does not revert back to the default settings when the data change).

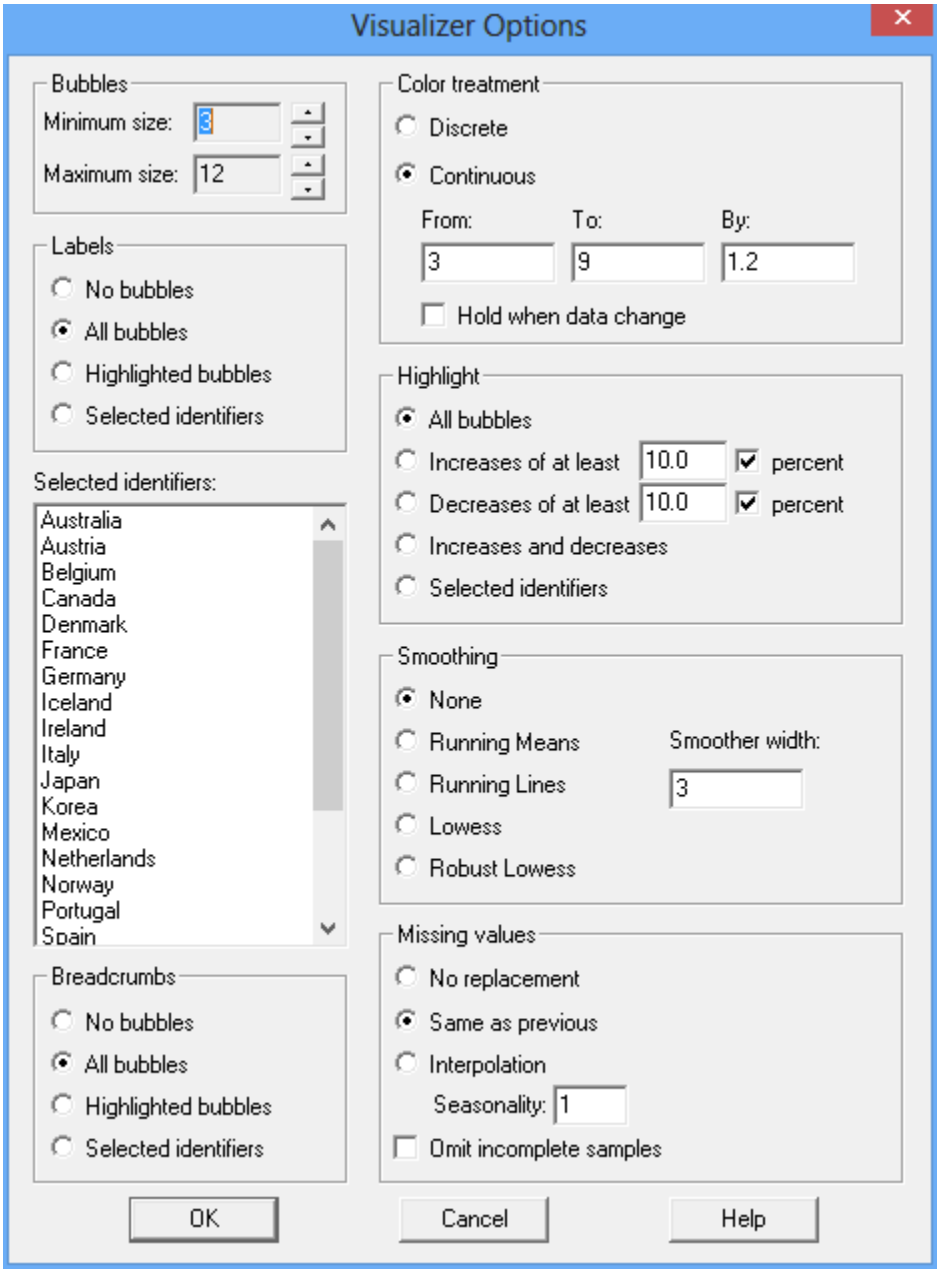
The revised plot is shown below:


2-D Visualizer
Slice: 1980
Replay: Up
Frames per second: 1
Year = 1980
Bubble size: Infant mortality
Female life expectancy
90
85
80
75
70
65
60
100000
1000000
10000000
100000000
1000000000
Population
Female-Male
3.0
4.2
5.4
6.6
7.8
9.0

## Analysis Options

The *Analysis Options* dialog box allows for various special effects to be created:




The following options are available:

- **Bubbles**: specifies the minimum and maximum size of the bubbles. The units are in pixels.

- **Labels**: specifies which bubbles are to be labeled with their sample identifiers.

- **Color treatment**: specifies the manner in which the color variable should be handled. *Discrete* will display a different color for each unique value of that variable. *Continuous*

will color each variable based on a continuous palette, which by default ranges from blue at the lowest level to red at the highest level. *Graphics Options* may be used to change the palette.

- **Highlight**: controls which bubbles are plotted at full intensity. You can elect to highlight a subset of the bubbles in order to demonstrate special features of the data. *Increase* and *decrease* may be used to highlight data which have changed significantly from the previous time period.

- **Selected identifiers**: When labeling or highlighting only selected bubbles, click on each sample identifier that you wish to select.

- **Smoothing**: smoothes each time series using one of four methods. These are the same methods used to smooth X-Y scatterplots as described in the PDF document titled *Graphics Options*. If the data contain a large amount of sampling error, smoothing the time series will cause the points to move more smoothly as time is changed.

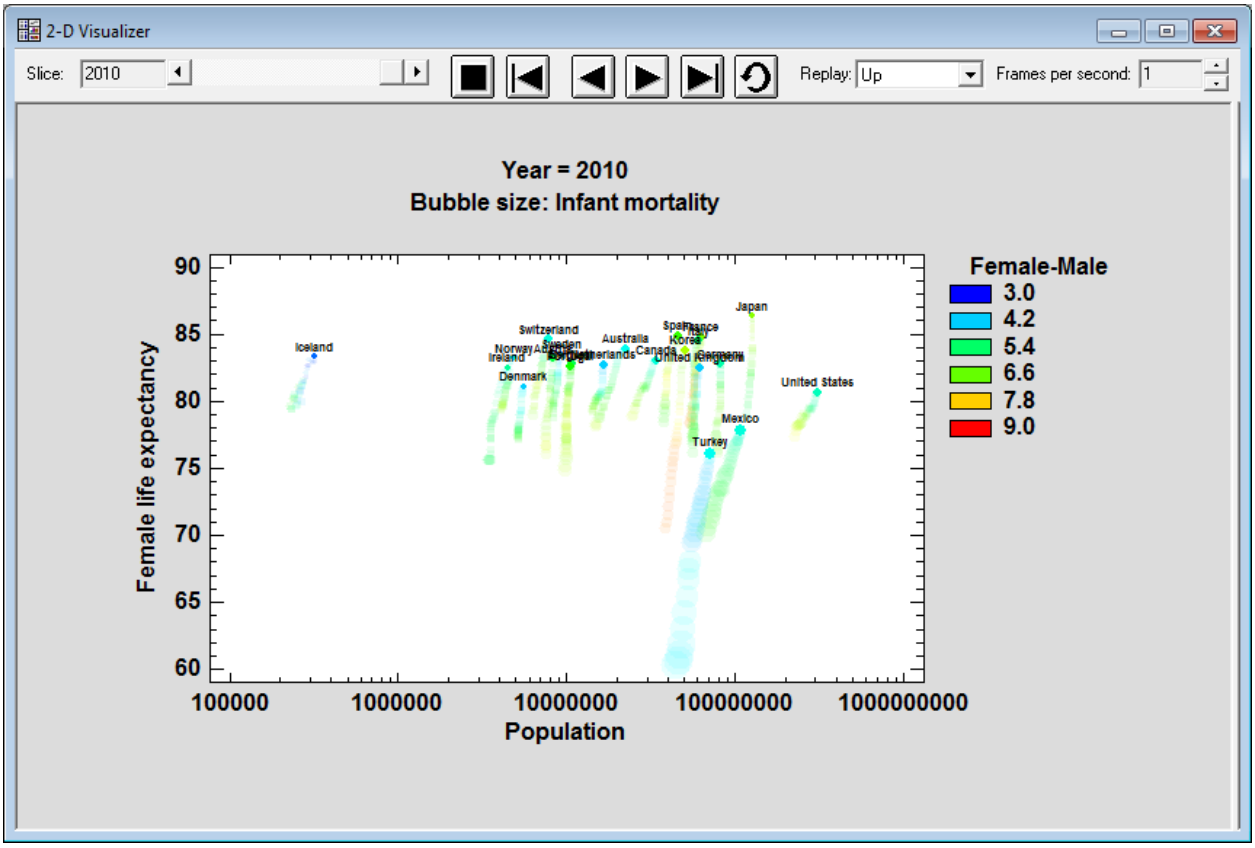
- **Breadcrumbs**: leaves a transparent image of the data at earlier time periods for the selected bubbles.

- **Missing values**: specifies how missing values should be treated. By default, missing values are not plotted, so that bubbles may appear and disappear as time changes. Selecting *Same as previous* will cause missing values to be replaced with the closest previous value which is not missing, which will cause bubbles to pause in one place but not disappear. Interpolation fills in missing values using an interpolation of 4 adjacent values, as described in the *Calculations* section of this document. If the data are seasonal, indicate the length of seasonality *s* to be used in the interpolation (for seasonal monthly data, $s = 12$). For nonseasonal data, $s = 1$.

- **Omit incomplete traces**: plots only time series with no missing data (after the missing value substitution is performed).

The plot below shows the output for the final time period, replacing missing values with the previous values and plotting breadcrumbs.




In all countries, life expectancy has increased significantly between 1980 and 2010. Notice that female life expectancy in Turkey was very low in 1980, but increased rapidly. At the same time, infant mortaility in Turkey declined dramatically. In Korea, the difference in life expectancy between females and males was very large in 1980, but also declined greatly.

## Calculations

The *interpolation* method may be used to replace a limited number of missing values in each time series, provided there are not too many missing values close together. Before the data is analyzed, missing values are replaced by interpolated values, determined using the following rule:

1. If $y_t$, the observation at time $t$, is missing, find the two observations in the same season that precede time $t$ ($y_{t-s}$ and $y_{t-2s}$) and the two observations in the same season that come after time $t$ ($y_{t+s}$ and $y_{t+2s}$).

2. If none of the four observations are missing, then the replacement value for $y_t$ is:

$$y_t = \frac{-3y_{t-2s} + 12y_{t-s} + 12y_{t+s} - 3y_{t+2s}}{18} \quad (1)$$

3. If $y_{t+2s}$ is missing but the other three are not, then the replacement value for $y_t$ is:

$$y_t = \frac{-y_{t-2s} + 3y_{t-s} + y_{t+s}}{3} \quad (2)$$

4. If $y_{t+s}$ is missing but the other three are not, then the replacement value for $y_t$ is:

$$y_t = \frac{-3y_{t-2s} + 8y_{t-s} + y_{t+s}}{6} \quad (3)$$

5. If $y_{t-s}$ is missing but the other three are not, then the replacement value for $y_t$ is:

$$y_t = \frac{y_{t-2s} + 8y_{t+s} - 3y_{t+2s}}{6} \quad (4)$$

6. If $y_{t-2s}$ is missing but the other three are not, then the replacement value for $y_t$ is:

$$y_t = \frac{y_{t-s} + 3y_{t+s} - y_{t+s}}{3} \quad (5)$$

7. If $y_{t+s}$ and $y_{t+2s}$ are missing but the other two are not, then the replacement value for $y_t$ is:

$$y_t = -y_{t-2s} + 2y_{t-s} \quad (6)$$

8. If $y_{t-s}$ and $y_{t+2s}$ are missing but the other two are not, then the replacement value for $y_t$ is:

$$y_t = \frac{y_{t-2s} + 2y_{t+s}}{3} \tag{7}$$

9. If $y_{t-s}$ and $y_{t+s}$ are missing but the other two are not, then the replacement value for $y_t$ is:

$$y_t = \frac{y_{t-2s} + y_{t+2s}}{2} \tag{8}$$

10. If $y_{t-2s}$ and $y_{t+2s}$ are missing but the other two are not, then the replacement value for $y_t$ is:

$$y_t = \frac{y_{t-s} + y_{t+s}}{2} \tag{9}$$

11. If $y_{t-2s}$ and $y_{t+s}$ are missing but the other two are not, then the replacement value for $y_t$ is:

$$y_t = \frac{2y_{t-s} + y_{t+2s}}{3} \tag{10}$$

12. If $y_{t-2s}$ and $y_{t-s}$ are missing but the other two are not, then the replacement value for $y_t$ is:

$$y_t = 2y_{t+s} - y_{t+2s} \tag{11}$$

If more than 2 of the four observations are missing, the missing value will not be replaced.

The interpolated values are designed to perfectly reproduce a quadratic trend (if only one observation is missing) or a linear trend (if two observations are missing), provided no noise is present.