

Chapter 6

Math Functions

The Math functions are available from the **Utilities** menu and are organized into six categories: Arithmetic, General, Time Conversion, Hydrologic, Smoothing and Statistics. Each function category is a tab on the **Math Functions** screen (Figure 6.1). This chapter describes math functions according to these categories.

6.1 The Math Functions Screen

Figure 6.1 shows the basic appearance of the **Math Functions** screen. The HEC-DSSVue Math Functions screen enables the mathematical manipulation of time series and paired data sets selected in the HEC-DSSVue Data Selection List window.

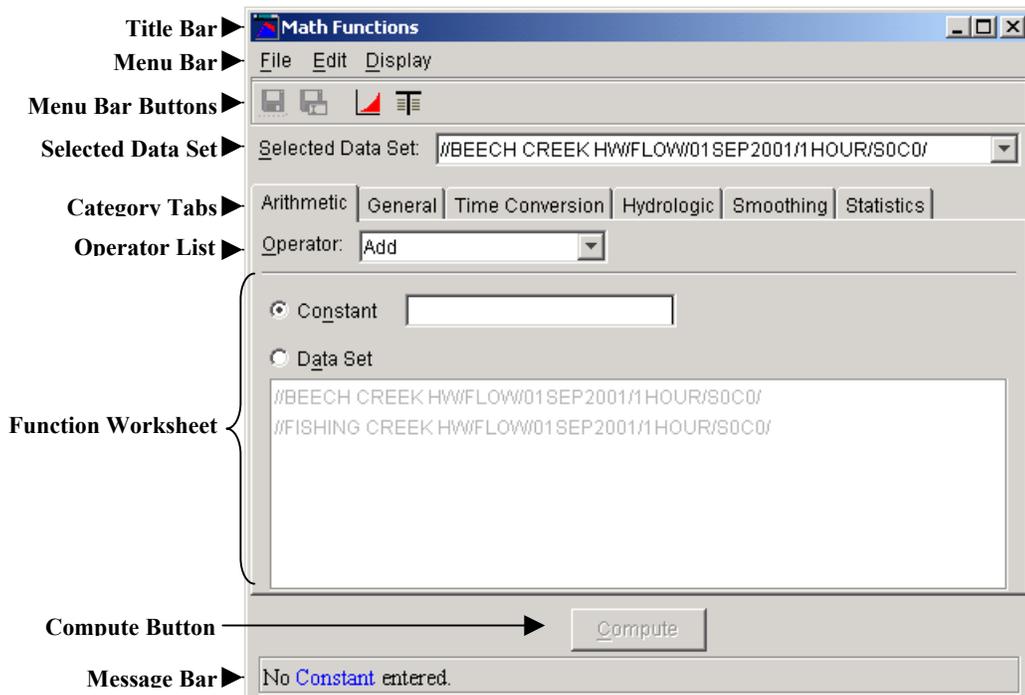


Figure 6.1 Math Functions Screen

6.1.1 Menu Bar

Menu options in the Math Functions screen allow you to save or rename data sets computed with the Math functions, and to display the computed and original data sets in plots and tables. The Math Functions menus are as follows:

- File** File menu commands are **Save**, **Save As**, and **Close**.
- Edit** The **Edit** menu contains the **Restore Original Data** command.
- Display** Use the **Display** menu to open plots and tables with the **Plot** and **Tabulate** commands, and set options for data to display with the **Original Data with computed** and **All Data Sets** commands.

6.1.2 Menu Bar Buttons

Menu bar buttons provide shortcuts to frequently used Menu commands:



Saves a computed data set to a HEC-DSS file (same as **Save** in the **File** menu).



Saves and Renames a computed data set to a HEC-DSS file (same as **Save As** in the **File** menu).



Displays data as a Plot (same as **Plot** in the **Display** menu)



Displays data in Tabular form (same as **Tabulate** in the **Display** menu).

6.1.3 Other Math Features of the Math Functions Screen

The **Operator** and **Selected Data Set** items appear for all function types.

Use the **Category Tabs** to access each of the six categories of math functions.

To select a function, use the **Operator** list.

Use the **Selected Data Set** list to choose a data set to apply each function. This list contains the names of data sets you have chosen in the HEC-DSSVue Data Selection List window.

Use the **Compute** button located near the bottom of the screen to apply a function to selected data sets. If data on the function screen is incomplete, the Compute button is unavailable. A message appears in the **Message Bar** at the bottom of the screen indicating which box is incomplete. In Figure 6.1, for example, the message indicates that no constant has been entered.

6.2 Managing Data

Most functions modify the values in the selected data set. However, the Math Functions screen retains a copy of the original data, which you may use for comparison plotting with the computed result or for “undoing” the compute action. Other functions, such as “Merge Time Series,” may generate a new data set, which is appended to the data set list in the **Selected Data Set** list.

Once a data set has been modified or generated by a function compute, you can save the data to the file, plot it, or tabulate it using the menu options or menu bar buttons located at the top of the Math Functions screen. A computed data set is not automatically saved to the file until you explicitly save the operation.

When you exit the Math Functions screen, if one or more data sets have been modified but not saved, you will be prompted with the **Save Changes** message box shown in Figure 6.2. Save the changes by clicking **Yes**.



Figure 6.2 Save Changes Dialog Box

In plots and tables, the F-Part of the pathname is identified as “MODIFIED-.” This is not retained when the data set is saved to the file and saving the resulting data will overwrite records in the file. In Figure 6.3, the “BEECH CK STATION S0C0T0” time series was added to the “BEECH CREEK HW S0C0” time series. The resulting data set is “BEECH CK STATION MODIFIED-S0C0T0.”

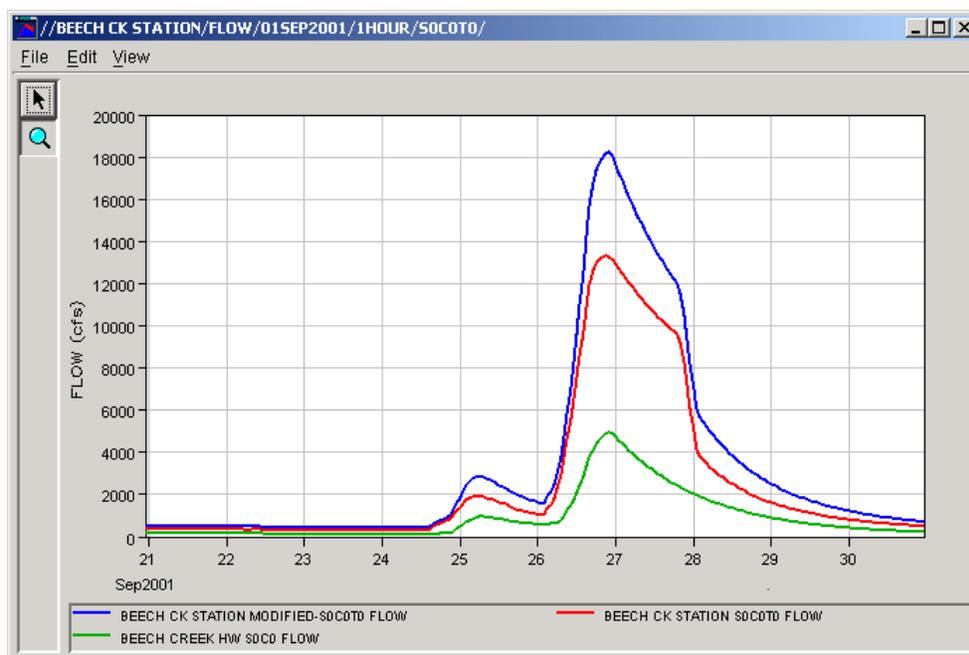


Figure 6.3 Plot of Time Series Data Sets from “Add” Function

6.2.1 Selecting Paired Data Curves for Function Operations

Typically paired data has a set of x-values and a corresponding set of y-values (e.g. a stage-flow rating table). However, a paired data set may have multiple sets of y-values, or curves, which share the same x-ordinates (e.g. frequency-damage curves for multiple categories). Math functions that operate on paired data sets allow the user to select one or all of the paired data curves for the function application. For example, with the Add function, a number may be added to y-values in one curve or to y-values in all curves.

Figure 6.4 shows the appearance of the Math Functions screen when a paired data set is selected for an “Add” operation.

The paired data curve to apply the add function is picked using the **Select Paired Data Curve** list. The list is filled with the paired data curve labels. In this case, there is a curve for each month of the year. The “All” selection in the list refers to the option to pick all curves for the function operation. If the paired data curves are not explicitly labeled in the paired data set, the curve list is then filled with the curve numbers. The **Select Paired Data Curve** list only appears if the selected data set is a paired data set.

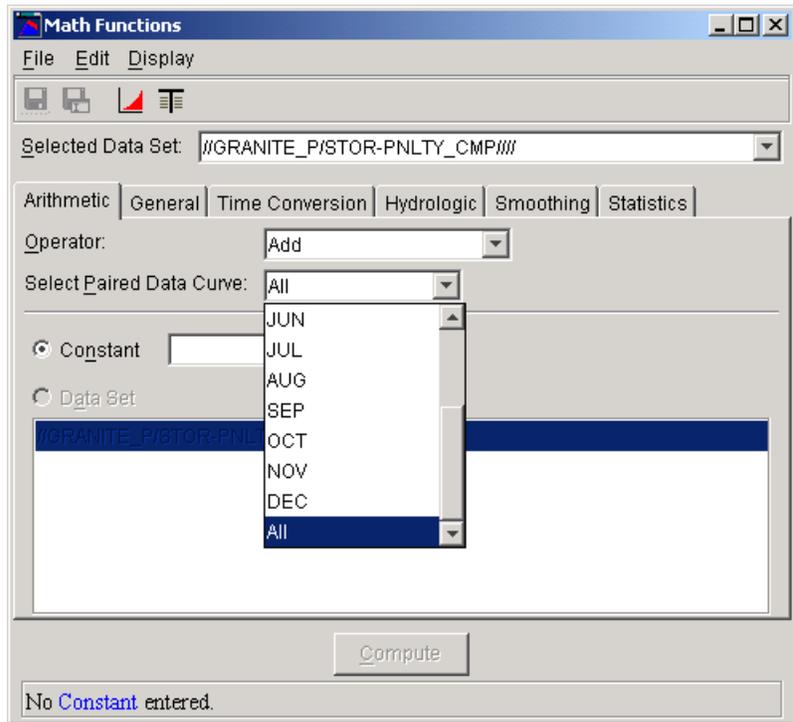


Figure 6.4 Selection of Paired Data Curve.

6.3 Arithmetic Functions

The **Arithmetic** tab (Figure 6.5) contains the functions Add, Subtract, Multiply, Divide, Exponentiation, Absolute Value, Square Root, Log, Log Base 10, Sine, Cosine, Tangent, Inverse (1/X), Accumulation, Successive Differences, and Time Derivative.

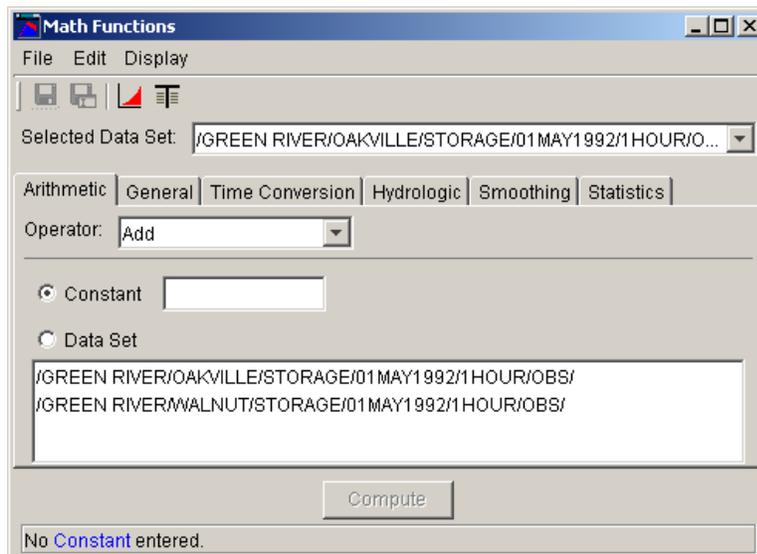


Figure 6.5 Math Functions--Arithmetic Tab

6.3.1 Add

The **Add** function adds a number to all valid values in a time series or paired data set, or adds the values in one data set to the values in another of the same type. For time series data, missing values are kept as missing.

When adding one time series data set to another, times in the two data sets need not match exactly. However, only values with coincident times will be added. Times in the primary time series data set that cannot be matched with times in the second data set result in missing values for those times. Missing values in the primary data set are kept as missing. Either or both data sets may be regular or irregular interval time series.

Presently the Add function does not allow the addition of paired data sets.

This function will not merge data sets. Use the **Merge Time Series** (for time series data sets) or the **Merge Paired Data** (for paired data sets) functions located on the **General** tab for this purpose.

To add a number to all values in the selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Add** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see Section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Constant** and enter the value to add in the box to the right.
5. Click **Compute**.

To add a second data set to the selected data set (time series data sets only):

1. From the **Selected Data Set** list, select a data set to apply the function. This data set will contain the result of the add operation.
2. Click **Data Set**.
3. From the **Data Set** list, select the data set to be added.
4. Click **Compute**.

6.3.2 Subtract

The **Subtract** function subtracts a number from all valid values in a time series or paired data set, or subtracts the values in one data set from the values in another of the same type. For time series data, missing values are kept as missing.

When you are subtracting one time series data set from another, times in the two data sets need not match exactly. However, only values with coincident times will be subtracted. Times in the primary time series data set that cannot be matched to times in the second data set result in missing values for those times. Missing values in the primary data set are kept as missing. Either or both data sets may be regular or irregular interval time series.

Presently the Subtract function does not allow subtraction of paired data sets using another data set.

To subtract a number from the selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Subtract** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Constant** and enter the value to be subtracted in the box to the right.
5. Click **Compute**.

To subtract a second data set from the selected data set (time series data sets only):

1. From the **Selected Data Set** list, select a data set to apply the function. This data set will contain the result of the subtract operation.
2. Click **Data Set**.
3. From the **Data Set** list, select the data set to be subtracted.
4. Click **Compute**.

6.3.3 Multiply

The **Multiply** function multiplies a number by all valid values in a time series or paired data set, or multiplies the values in one data set by the values in another of the same type. For time series data, missing values are kept as missing.

When you are multiplying one time series data set by another, times in the two data sets need not match exactly. However, only values with coincident times will be multiplied. Times in the primary time series data set that cannot be matched to times in the second data set result in missing values for those times. Missing values in the primary data set are kept as missing. Either or both data sets may be regular or irregular interval time series.

Presently the Multiply function does not allow the multiplication of paired data using another data set.

To multiply a number by all values in the selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Multiply** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Constant** and enter the value to multiply by in the box to the right.
5. Click **Compute**.

To multiply the selected data set with another data set (time series data sets only):

1. From the **Selected Data Set** list, select a data set to apply the function. This data set will contain the result of the multiply operation.
2. Click **Data Set**.
3. Select the data set to multiply from the **Data Set** list.
4. Click **Compute**.

6.3.4 Divide

The **Divide** function divides all valid values in a time series or paired data set by a number, or divides the values in one data set by the values in another of the same type. For time series data, missing values are kept as missing.

When you are dividing one time series data set by another, times in the two data sets need not match exactly. However, only values with coincident times will be divided. Times in the primary time series data set that cannot be matched to times in the second data set result in missing values for those times. Values in the second data set form the divisor. Values in the resultant data set are set to missing if there is a zero divisor. Missing values in the primary data set are kept as missing.

Either or both data sets may be regular or irregular interval time series.

Presently the Divide function does not allow the division of paired data by another data set.

To divide all values in the selected data set by a number:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Divide** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Constant** and enter the value to divide by in the box to the right.
5. Click **Compute**.

To divide the selected data set by another data set (time series data sets only):

1. From the **Selected Data Set** list, select a data set to apply the function. This data set will contain the result of the divide operation.
2. Click **Data Set**.
3. From the **Data Set** list, select the second data set. Values in this data set divide the values from the above data set.
4. Click **Compute**.

6.3.5 Exponentiation

The **Exponentiation** function raises values in a time series or paired data set to a user specified power, or exponent. For time series data, missing values are kept as missing.

For exponentiation of the values of a time series or paired data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Exponentiation** operator.
2. From the **Selected Data Set** list, choose a data set for exponentiation.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. In the **Power** box, enter the value for the power, or exponent,.
5. Click **Compute**.

6.3.6 Absolute Value

The **Absolute Value** function computes the absolute value of values in a time series or paired data set. For time series data, missing values are kept as missing.

To compute the absolute value of values in a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Absolute Value** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Compute**.

6.3.7 Square Root

The **Square Root** function computes the square root of valid values in a time series or paired data set. If a value is less than 0.0, the value is set to missing in the resultant data set. For time series data, if the original value is missing, the value remains missing in the resultant data set.

To compute the square root of values in a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Square Root** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Compute**.

6.3.8 Log

The **Log** function computes the natural logarithm (log base “e”) of valid values in a time series or paired data set. If a value is less than or equal to 0.0, the value is set to missing in the resultant data set. For time series data, if the original value is missing, the value remains missing in the resultant data set.

To compute the natural logarithm of values in a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Log** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1, “Selecting Paired Data Curves for Function Operations,” for more details).
4. Click **Compute**.

6.3.9 Log Base 10

The **Log Base 10** function computes the log base 10 of valid values in a time series or paired data set. If a value is less than or equal to 0.0, the value is set to missing in the resultant data set. For time series data, if the original value is missing, the value remains missing in the resultant data set.

To compute the log base 10 of values of a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Log Base 10** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Compute**.

6.3.10 Sine

The **Sine** function computes the sine of valid values in a time series or paired data set. The resulting data set will be in radians. For time series data, missing values are kept as missing.

To compute the sine of values in a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Sine** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Compute**.

6.3.11 Cosine

The **Cosine** function computes the cosine of valid values in a time series or paired data set. The resulting data set will be in radians. For time series data, missing values are kept as missing.

To compute the cosine of values in a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Cosine** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Compute**.

6.3.12 Tangent

The **Tangent** function computes the tangent of valid values in a time series or paired data set. The resulting data set will be in radians. If the cosine of a value is 0.0, the value is set to missing in the resultant data set. For time series data, if the original value is missing, the value remains missing in the resultant data set.

To compute the tangent of values in a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Tangent** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Compute**.

6.3.13 Inverse

The **Inverse** function computes a new value from 1 divided by the value ($1/x$) in a time series or paired data set. If a value is equal to 0.0, the value is set to missing in the resultant data set. For time series data, if the original value is missing, the value remains missing in the resultant data set.

To compute the inverse ($1/x$) of values in a selected data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Inverse** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. If the data set is paired data, use the **Select Paired Data Curve** list to select a single paired data curve or all curves for the operation (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
4. Click **Compute**.

6.3.14 Accumulation

The **Accumulation** function computes a running accumulation of values for a regular or irregular interval time series data set. For a missing value in the time series data, the value in the accumulation time series remains constant (i.e., missing values treated as zero).

To compute the running accumulation of values for a time series data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Accumulation** operator.
2. From the **Selected Data Set** list, select a time series data set to apply the function.
3. Click **Compute**.

6.3.15 Successive Differences

The **Successive Differences** function computes the difference between successive values in a regular or irregular interval time series data set. The time series data must be of type “INSTVAL” or “INSTCUM.” A value in the resultant time series is set to missing if either the current or previous value in the original time series is missing (need to have two consecutive valid values). If the data type of the original data set is “INSTCUM” the resultant time series data set is assigned the type “PERCUM,” otherwise the data type does not change.

To compute the successive differences for a time series data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Successive Differences** operator.
2. From the **Selected Data Set** list, select a time series data set to apply the function.
3. Click **Compute**.

6.3.16 Time Derivative

The **Time Derivative** function computes the successive differences per unit time for a regular or irregular interval time series data set. For the time “t,”

$$TS2(t) = (TS1(t) - TS1(t-1)) / DT$$

where DT is the time difference between t and t-1. For the current form of the function, the units of DT are minutes.

A value in the resultant time series is set to missing if either the current or previous value in the original time series is missing (need to have two consecutive valid values). By default, the data type of the resultant time series data set is assigned as “PER-AVER.”

To compute the time derivative for a time series data set:

1. Choose the **Arithmetic** tab of the Math Functions Screen and select the **Time Derivative** operator.
2. From the **Selected Data Set** list, select a time series data set to apply the function.
3. Click **Compute**.

6.4 General Functions

The **General** tab (Figure 6.6) contains the functions Units Conversion, Round to Nearest Whole Number, Truncate to Whole Number, Round Off, Estimate Missing Values, Screen Using Maximum and Minimum, Screen Using Forward Moving Average, Merge Time Series, Merge Paired Data, and Generate Data Pairs.

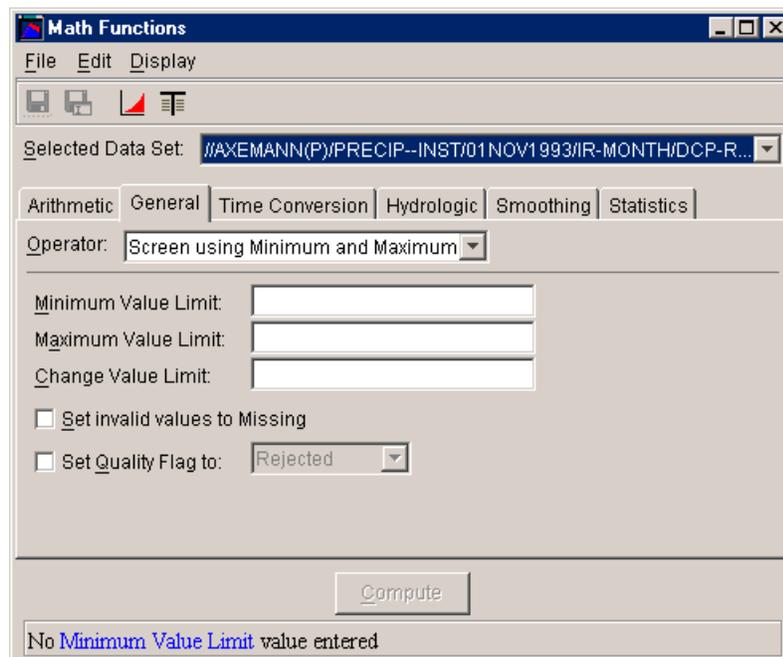


Figure 6.6 Math Functions--General Tab

6.4.1 Units Conversion

The **Units Conversion** function converts SI (metric) unit data to English units, or English unit data to SI units. The Units Conversion function may be applied to either time series or paired data sets.

To convert units for a time series or paired data set:

1. Choose the **General** tab of the Math Functions screen and select the **Time Units Conversion** operator.
2. From the **Selected Data Set** list, select one or more data sets for units conversion.
3. Choose the type of conversion by clicking **Convert to SI** or **Convert to English**.
4. From the **Available Data Sets To Convert** list you may select additional data sets for units conversion. This list is affected by the type of units conversion selected. If Convert to SI is selected, only data sets that are

currently in English units will appear in the list. Similarly, if Convert to English is selected only data sets currently in SI units will appear.

5. Click **Compute** to perform the units conversion of the selected data sets.

6.4.2 Round to Nearest Whole Number

The **Round to Nearest Whole Number** function rounds values in a time series or paired data set to the nearest whole number.

The function rounds up the decimal portion of a number if equal to or greater than .5 and rounds down decimal values less than .5. For example:

10.5 is rounded to 11.

10.499 is rounded to 10.

-10.499 is rounded to -10.

-10.500 is rounded to -10.

-10.501 is rounded to -11.

The x-values in paired data sets are unaffected by the function, only the y-value data are rounded. For time series data sets, missing values are kept missing.

To round values in a time series or paired data set to the nearest whole number:

1. Choose the **General** tab of the Math Functions screen and select the **Round to Nearest Whole Number** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. Click **Compute**.

6.4.3 Truncate to Whole Number

The **Truncate to Whole Number** function truncates values in a time series or paired data set to the nearest whole number. For example:

10.99 is truncated to 10.

10.499 is truncated to 10.

-10.001 is truncated to -10.

-10.999 is truncated to -10.

The x-values in paired data sets are unaffected by the function, only the y-value data are truncated. For time series data sets, missing values are kept missing.

To truncate values in a time series or paired data set to the nearest whole number:

1. Choose the **General** tab of the Math Functions screen and select the **Truncate to Whole Number** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. Click **Compute**.

6.4.4 Round Off

The **Round Off** function rounds values in a time series or paired data set to a specified number of significant digits and/or power of tens place. For the power of tens place, -1 specifies rounding to one-tenth (0.1), while +2 rounds to the hundreds (100). For example, 1234.123456 will round to:

1230.0 for number of significant digits = 3, power of tens place = -1

1234.1 for number of significant digits = 6, power of tens place = -1

1234 for number of significant digits = 6, power of tens place = 0

1230 for number of significant digits = 6, power of tens place = 1

The x-values in paired data sets are unaffected by the function, only the y-value data are rounded. For time series data sets, missing values are kept missing.

To round values in a time series or paired data set:

1. Choose the **General** tab of the Math Functions screen and select the **Round Off** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. In the **Number Significant Digits** box, set digits precision.

4. In the **Power of 10s Place** box, set the magnitude of 10 to which to round.
5. Click **Compute**.

6.4.5 Estimate Missing Values

The **Estimate Missing Values** function linearly interpolates estimates for missing values in a regular or irregular interval time series data set. Linear interpolation will occur for those portions of the time series data set where the number of consecutive missing values exceeds a specified user limit.

If the time series data set has type "INST-CUM", a special check box appears to optionally enable the following rules intended for cumulative precipitation:

- If the values bracketing the missing period are increasing with time, only interpolate if the number of successive missing values does not exceed the value of the user specified limit.
- If the values bracketing the missing period are decreasing with time, do not estimate any missing values.
- If the values bracketing the missing period are equal, then estimate any number of missing values

To estimate for missing values in a time series data set:

1. Choose the **General** tab of the Math Functions screen and select the **Estimate Missing Values** operator.
2. Select a data set to apply the function from the **Selected Data Set** list.
3. In the **Maximum Consecutive Number of Missing** box, enter a value to set the limit for consecutive missing values allowed for interpolation.
4. If the time series data set is of type cumulative precipitation, select **Interpolate Cumulative Precip** to apply the modified rules for the interpolation of missing precipitation data.
5. Click **Compute** to perform the linear interpolation fill of the missing values in the data set.

6.4.6 Screen Using Minimum and Maximum

The **Screen Using Minimum and Maximum** function screens a regular or irregular interval time series data set for possible erroneous values based on user specified minimum-maximum value limits, and maximum absolute change. The maximum absolute change is tested only when the previous time series value is screened as valid.

Data values failing the screening test are assigned a user specified quality flag and/or are set to the missing value. The data set may or may not contain prior quality flags. If the user specifies setting quality flags for screened data, they will be added to the resultant data set if none already exists.

1. Choose the **General** tab of the Math Functions screen and select the **Screen Using Minimum and Maximum** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. In the **Minimum Value Limit** and **Maximum Value Limit** boxes, enter the minimum and maximum valid value limits respectively.
4. In the **Change Value Limit** box, enter a value to set maximum absolute change allowed from the previous time series value.
5. Select the **Set Invalid values to Missing** box if time series values failing the screening test are to be set to the missing value.
6. Select the **Set Quality Flag** box if the data quality flag is to be set for data values failing the screening test. If this box is checked, invalid data will be flagged with the quality selected in the list to the right. The available quality settings are: R(ejected), M(issing) and Q(uestionable).
7. Click **Compute**.

6.4.7 Screen with Forward Moving Average

The **Screen with Forward Moving Average** function screens a time series data set for possible erroneous values based on the change from the forward moving average computed at the previous point.

Data values failing the screening test are assigned a user specified quality flag and/or are set to the missing value. The data set may or may not currently have quality flags assigned. The forward moving average is computed over a user specified number of values. Missing values and values failing the screening test are not counted in the moving average and the divisor of the average is less one for each such value.

To screen data in a time series data set:

1. Choose the **General** tab of the Math Functions screen and select the **Screen with Forward Moving Average** operator.
2. From the Selected Data Set list, select a data set to apply the function.

3. In the Number to Average Over box, enter a value to set the size of the moving average interval.
4. In the Change Value Limit box, enter a value to set maximum absolute change allowed from the forward moving average.
5. Select the Set Invalid Values to Missing box if time series values failing the screening test are to be set to the missing value.
6. Select the Set Quality Flag box if the data quality flag is to be set for data values failing the screening test. If this box is checked, invalid data will be flagged with the quality selected in the list to the right. The available quality settings are: R(ejected), M(issing) and Q(uestionable).
7. Click Compute to apply the function to the selected data set.

6.4.8 Merge Time Series

The **Merge Time Series** function merges data from one time series data set with another time series data set. The resultant time series data set includes all the data points in the two time series, except where the data points occur at the same time. When data points from the two data sets are coincident in time, valid values in the primary time series take precedence over valid values in the second selected time series. However if a coincident point is missing in the primary time series, a valid value in the second time series will be used for the data point in the resultant data set. If the value is missing for both time series data sets, the value is missing in the resultant data set.

The data sets for merging may be either regular or irregular time interval. The resultant data set is tested to determine if the times have a regular time interval. If not, it is typed as an irregular time interval data set.

Data of any type (i.e., "INST-CUM") or units may be merged with data of any other type or units. The resultant time series receives the data type and units of the primary time series.

To merge two time series data sets:

1. Choose the **General** tab of the Math Functions screen and select the **Merge Time Series** operator.
2. From the **Selected Data Set** List, select the *primary* time series data set.
3. From the **Time Series** list, select the *second* time series data set for merging.
4. Click **Compute** to merge the two data sets.

6.4.9 Merge Paired Data

The **Merge Paired Data** function merges two paired data sets. The resultant paired data set includes all the paired data curves from the first data set and a single selected paired data curve or all curves from the second data set. The *x-values* for the two paired data sets *must match exactly*.

To merge two paired data sets:

1. Choose the **General** tab of the Math Functions screen and select the **Merge Paired Data** operator.
2. From the **Selected Data Set** list, select the *primary* paired data set for merging.
3. From the **Paired Data** list, select the *second* paired data set for merging.
4. From the **Select Paired Data Curve** list, set the curve to be merged from the second paired data set (see section 6.2.1 “Selecting Paired Data Curves for Function Operations” for more details).
5. Click **Compute** to merge the two data sets.

6.4.10 Generate Data Pairs

The **Generate Data Pairs** function generates a paired data set by pairing values (by time) from two time series data sets. The data pairs in the paired data set may optionally be sorted by ascending x-value. An example use of the function would be to mate a time series record of stage to one of flow to generate a stage-flow paired data set.

The *times* in the two time series data sets *must match exactly*. If a value for a time is missing in either time series, no data value pair is formed and added to the paired data set.

Units and parameter type from the primary time series data set are assigned to the paired data set x-units and x-parameter type. Units and parameter type from the second time series are assigned to the paired data set y-units and y-parameter type.

To generate a paired data set by pairing values in two time series data sets:

1. Choose the **General** tab of the Math Functions screen and select the **Generate Data Pairs** operator.
2. From the **Selected Data Set** list, select the primary time series data set . Time series values from this data set will comprise the x-values of the resultant paired data set.

3. From the **Data Set** list, select the second time series data set. Time series values from this data set will comprise the y-values of the resultant paired data set.
4. Check the **Sorted** box if the data pairs are to be sorted by ascending x-values.
5. Click **Compute**.

If time points in the two time series data sets do not match exactly, an error message will be posted and the function operation will not be performed.

6.5 Time Conversion Functions

The **Time Conversion** tab (Figure 6.7) contains the functions Transform to Regular, Snap Irregular to Regular, Transform to Irregular, Shift in Time, Extract Time Series, and Interpolate at Regular Intervals.

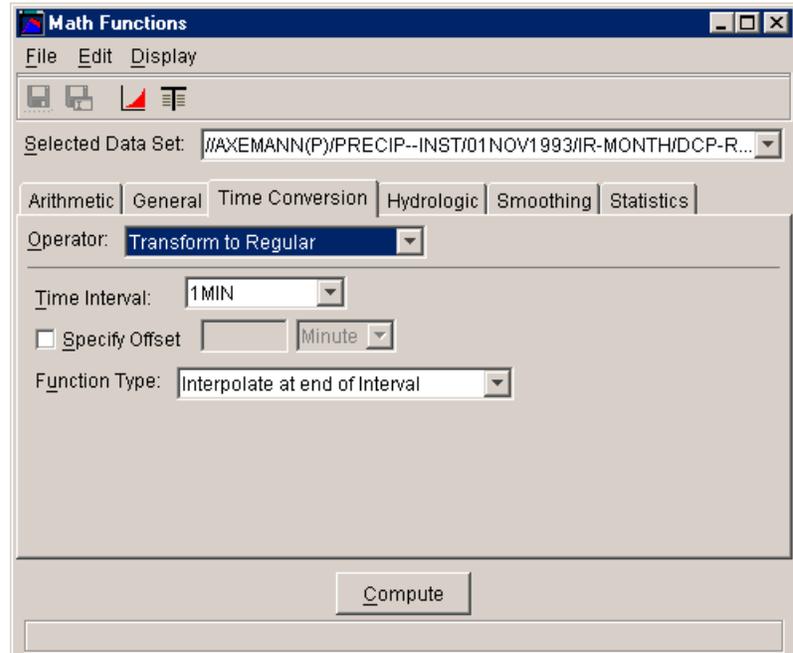


Figure 6.7 Math Functions--Time Conversion Tab

6.5.1 Transform to Regular

The **Transform to Regular** function generates a regular interval time series data set from an existing irregular or regular interval time series data set. Regular interval values for the new time series are computed from the original time series data using one of seven available functions. The functions are:

- Interpolate at end of interval
- Maximum over interval
- Minimum over interval
- Average over interval
- Accumulation over interval
- Integration over interval
- Number of valid data over interval

where “interval” is the regular time interval of the new time series.

The data type of the original time series data governs how values are interpolated. Data type “INST-VAL” (or “INST-CUM”) considers the value to change linearly over the interval from the previous data value to the current data value. Data type “PER-AVER” considers the value to be constant at the current data value over the interval. Data type “PER-CUM” considers the value to increase from 0.0 (at the start of the interval) up to the current value over the interval. Interpolation of the three data types is illustrated in Figure 6.8.

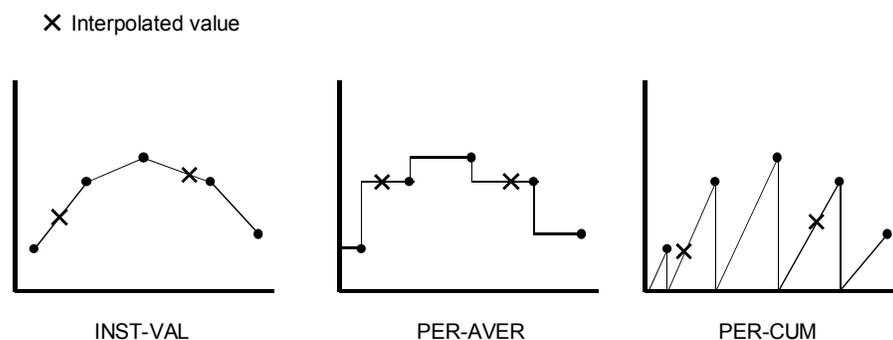


Figure 6.8 Interpolation of “INST-VAL,” “PER-AVER” and “PER-CUM” Data (transform to regular interval data)

How interpolation is performed for a specific data type influences the computation of new time series values for the selected function. For example, if the data type is “INST-VAL,” the function “Maximum over interval” is evaluated by:

- Finding the maximum value of the data points from the original time series that are inclusive in the new time interval.
- Linearly interpolate values at beginning and ending of the new time interval, and determine if these values represent the maximum over the interval.

Referring to the plots in Figure 6.8, the “Average over interval” function is applied to a time series by integrating the area under the curve between interpolated points and dividing the result by the interval time.

Times in the new time series may be shifted (offset) from the regular interval time by a user specified offset. As an example, the offset could be used to shift times in regular hourly interval data from the top of the hour to instead 6 minutes past the hour.

Figure 6.9 shows the appearance of the Math Functions screen for the Transform to Regular function.

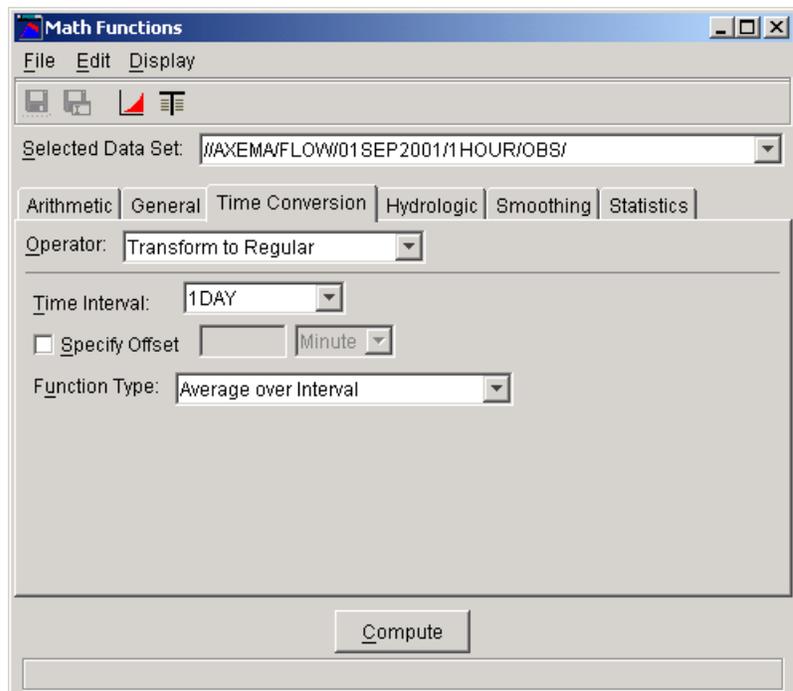


Figure 6.9 Screen for Transform to Regular Function

To transform data to a regular interval time series:

1. Choose the **Time Conversion** tab of the Math Functions screen and select the **Transform to Regular** operator.
2. From the **Selected Data Set** list, select a time series data set to apply the function.

3. From the **Time Interval** list, select the regular interval time period for the resultant time series data set.
4. Select the **Specify Offset** box to shift times in the resultant data set. To set the offset time, enter an integer number in the box to the right and select the **minute/hour/day** time increment from the list further to the right. If the Specify Offset box is unchecked, times in the resultant data set will fall on the regular interval time (typical setting).
5. From the **Function Type** list, select the method for computing new time series values.
6. Click **Compute**.

6.5.2 Snap Irregular to Regular

The **Snap Irregular to Regular** function derives a new regular interval time series data set from an existing irregular or regular interval time series data set. Data from the original time series will be "snapped" to a user specified regular interval time if the time of the original data falls within the time window tolerance set by the user. For example, a time series record from a gauge recorder collects readings 6 minutes past the hour. The Snap Irregular to Regular function may be used to “snap” or shift the time points to the top of the hour.

Times in the resultant time series may be shifted (offset) from the regular interval time by a user specified offset. As an example, the offset could be used to shift times in regular hourly interval data from the top of the hour to 6 minutes past the hour.

By default values in the resultant regular interval time series data set are set to missing unless matched to times in the original time series data set (within the time window tolerance).

Figure 6.10 shows the appearance of the Math Functions screen for the Snap Irregular to Regular function.

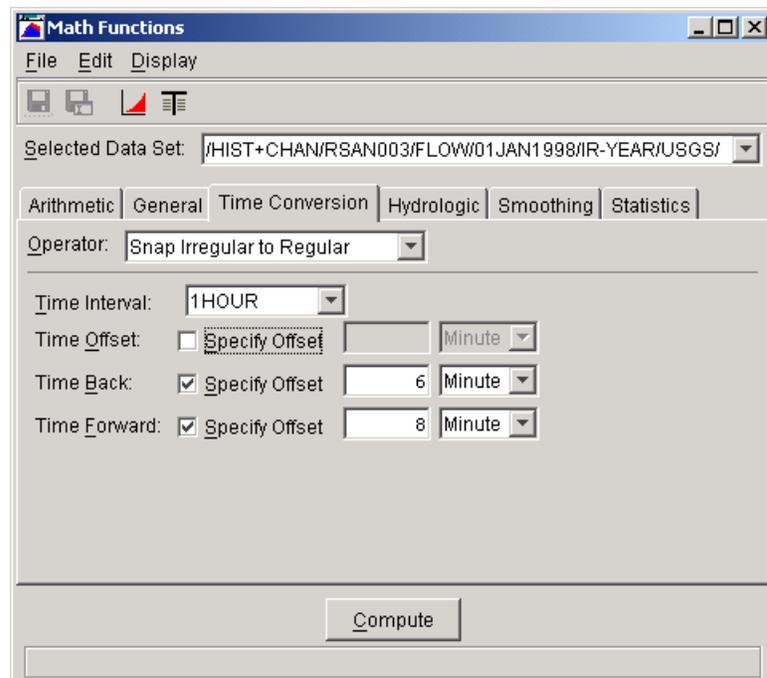


Figure 6.10 Screen for Snap Irregular to Regular Function.

To snap irregular time interval data to regular times:

1. Choose the **Time Conversion** tab of the Math Functions screen and select the **Snap Irregular to Regular** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. From the **Time Interval** list, select the regular interval time period for the resultant time series data set.
4. Select the **Time Offset: Specify Offset** box to shift times in the resultant data set. To set the offset time, enter an integer number in the box to the right and select the **minute/hour/day** time increment from the list further to the right. If the Time Offset box is unchecked, times in the resultant data set fall on the regular interval time (typical setting).
5. Use the **Time Back** and **Time Forward** offsets to define a time window around the regular interval time. If a time point from the selected time series data set falls within the time window, the data value is applied to the new regular interval time point. These offsets are set in the same manner as the **Time Offset** above.

6.5.3 Transform to Irregular

The **Transform to Irregular** function generates a new time series data set from an existing irregular or regular interval time series data set. The times for the new time series are defined by the times of a second time series data set. Values for the new time series are computed from the original time series data using one of seven available functions. The functions are:

- Interpolate at end of interval
- Maximum over interval
- Minimum over interval
- Average over interval
- Accumulation over interval
- Integration over interval
- Number of valid data over interval

where “interval” is the interval between time points in the new time series.

The data type of the original time series data governs how values are interpolated. Data type “INST-VAL” (or “INST-CUM”) considers the value to change linearly over the interval from the previous data value to the current data value. Data type “PER-AVER” considers the value to be constant at the current data value over the interval. Data type “PER-CUM” considers the value to increase from 0.0 (at the start of the interval) up to the current value over the interval. Interpolation of the three data types is illustrated in Figure 6.11

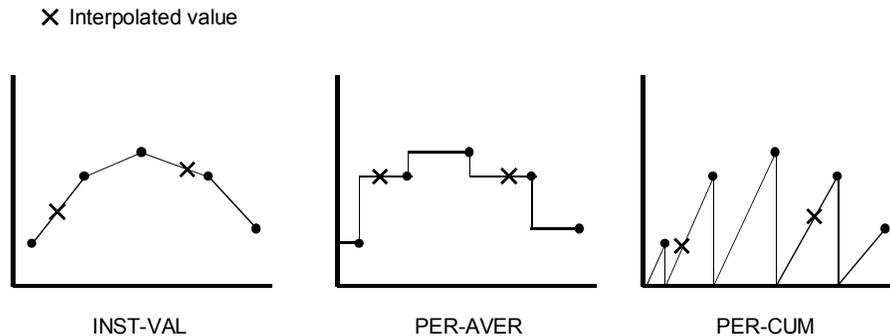


Figure 6.11 Interpolation of “INST-VAL,” “PER-AVER” and “PER-CUM” Data (transform to irregular interval data).

How interpolation is performed for a specific data type influences the computation of new time series values for the selected function. For example,

if the data type is “INST-VAL,” the function “Maximum over interval” is evaluated by:

- Finding the maximum value of the data points from the original time series that are inclusive in the new time interval.
- Linearly interpolate values at beginning and ending of the new time interval, and determine if these values represent the maximum over the interval.

Referring to the plots in Figure 6.11, the “Average over interval” function is applied to a time series by integrating the area under the curve between interpolated points and dividing the result by the interval time.

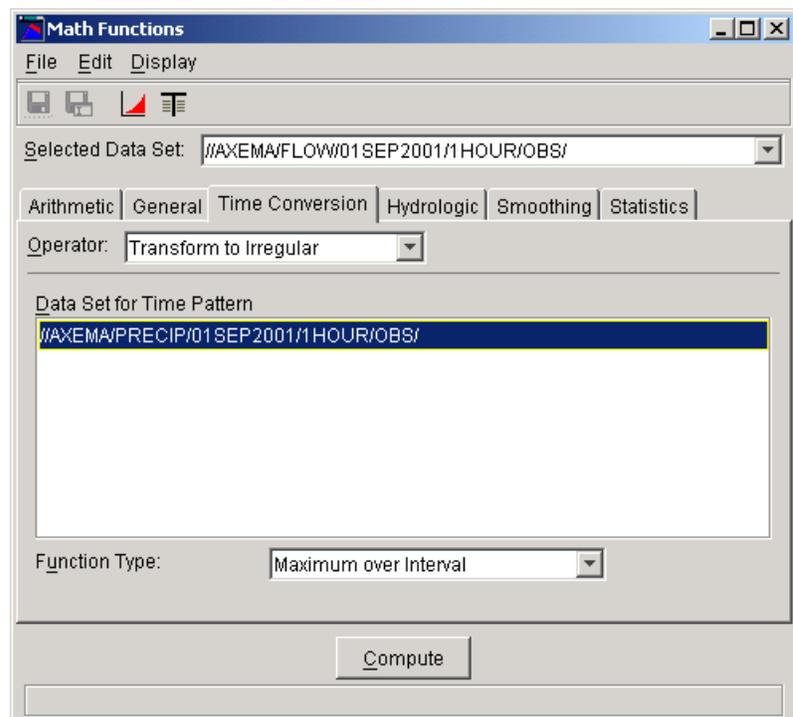


Figure 6.12 Screen for Transform to Irregular Function

Figure 6.12 shows the appearance of the Math Functions screen for the Transform to Irregular interval function.

To transform to an irregular interval time series data set:

1. Choose the **Time Conversion** tab of the Math Functions screen and select the **Transform to Irregular** operator.
2. From the **Selected Data Set** list, select a time series data set to apply the function.
3. From the **Data Set for Time Pattern** list, select a time series data set to provide the time pattern for the resultant time series.

4. From the **Function Type** list, select the method for computing new time series values.
5. Click **Compute**.

6.5.4 Shift in Time

The **Shift in Time** function shifts the times in a time series data set by a specified increment. Data values for the times are not changed. The data set may be regular or irregular interval time series data.

To shift times in a time series data set:

1. Choose the **Time Conversion** tab of the Math Functions screen and select the **Shift in Time** operator.
2. From the **Selected Data Set** list, select a data set to apply the function.
3. In the **Time Shift Interval** box, enter the time shift (integer values only) and select minute, hour, day.

6.5.5 Extract Time Series

The **Extract Time Series** function selects/extracts data points from a regular or irregular interval time series data set based on user defined time specifications. For example, the function may be used to extract values observed every day at noon from hourly interval data.

Data may be extracted on the basis of one of the following time specifications: year, month of the year (January, February, etc.), day of month, day of week (Sunday, Monday, etc.), or time of day.

Figure 6.13 shows the appearance of the Math Functions screen for the Extract Time Series function.

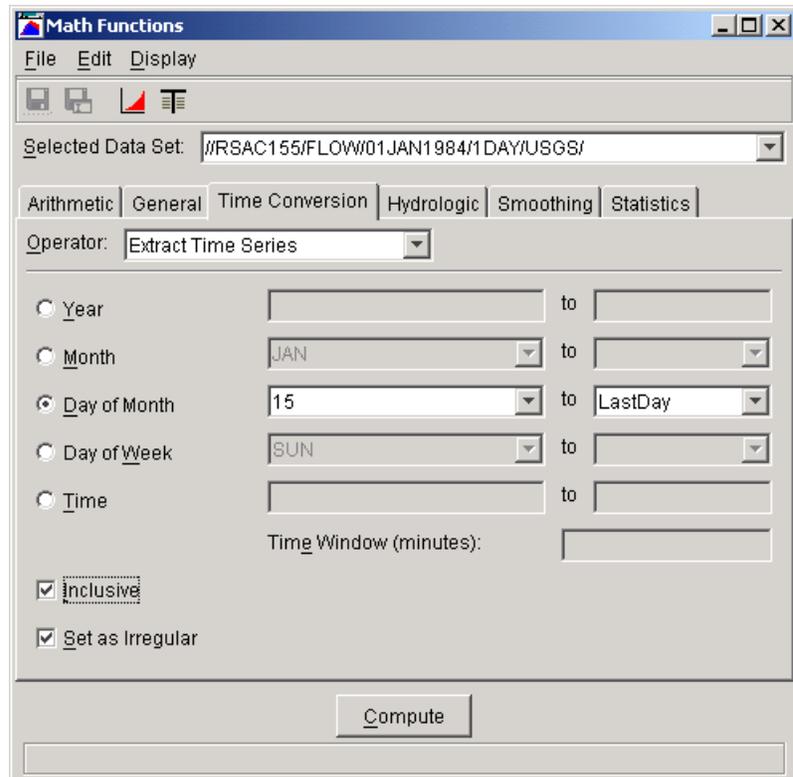


Figure 6.13 Screen for Extract Time Series Function

To derive a new time series data set from the selected times of another time series data set:

1. Choose the **Time Conversion** tab of the Math Functions screen and select the **Extract Time Series** operator.
2. From the **Selected Data Set** list, select a time series data set to apply the function.
3. Choose one of the time levels, **Year**, **Month**, **Day of Month**, **Day of Week**, or **Time** of day, and complete the boxes to the right. Entering or selecting a value in only the left-most box sets a time specification for data extraction to an individual year, month, day, or time of day. Fill in both boxes to specify a time range for data extraction.
4. Click **Year** to extract data for an individual year or range of years. To extract data for an individual year, fill the left-most box in with the desired year. To extract data for a range of years fill the left box with the beginning year and the right box with the ending year.
5. Click **Month** to extract data for an individual month of the year or range of months. Use the lists to set the month boxes. The list contains the months of the year, JAN to DEC. Set only the left-most box to extract data for a single month of the year. Set both boxes to extract data for a range of months. The range of months can be set to encompass the end of the year, that is “OCT to FEB” is a valid setting.

6. Click **Day of Month** to extract data for an individual day or range of day of month days. The days are set using the two lists to the right. As above, the lists can be used to specify a single day of month, using the left-most pull down, or a range of days, using both lists. The day of month values range from 1 to 31, and “LastDay,” the last day of the month, which may vary by month. The range of days can be set to encompass the end of the month. For example, for “27 to 4,” data will be extracted from the 27th of one month to the 4th of the next month.
7. Click **Day of Week** to extract data for an individual or range of day of the weekdays. Select day from the two lists to the right. As above, you may use the lists to specify one day, using the left-most list, or a range of days, using both lists. The day of week values range from SUN to SAT. The range of days can be set to encompass the end of the week; that is, “SAT to MON” is a valid setting.
8. Click **Time** to extract data by the time of day. An individual time is specified by completing the left-most box only. Complete both boxes to specify a time of day range for data extraction. The time specification employs the standard four-digit military style 24-hour format (e.g. “2300” or “0310 to 0600”). The time range can encompass the end of day, that is “2200 to 0330” is a valid setting. The optional **Time Window** box is applied to the time of day extraction only. The Time Window is an integer value in minutes, used to extend the beginning and ending of the time of day period for data extraction. For example, with a time of day extraction time of “0300” and a Time Window of “10 minutes,” data will be extracted from the selected time series if times falls within in the period 0250 to 0310.
9. By default, the data is extracted for the time points falling within the time interval set above. Click to clear the **Inclusive** check box at the bottom of the screen if you want to use the time specifications set above to exclude data for times within the specified range, and to include data falling outside the range. For example, if **Inclusive** is checked and the time range is set to "JAN-MAR," the extracted data will include all data in the months January through March for all the years of time series data. If **Inclusive** is unchecked, the extracted data will cover the period April through December (is exclusive of the period January through March).
10. Select the **Set as Irregular** checkbox (recommended) to ensure the resultant time series data set is identified as irregular interval time series data. If the box is not checked, the function will attempt to determine if the extracted data set can be classified as regular interval time series data.

6.5.6 Interpolate at Regular Intervals

The **Interpolate at Regular Intervals** function interpolates values from an existing time series data set at a specified regular time interval to create a new time series data set. The original data set may be either regular or irregular interval time series data.

Whether the time series data type is “INST-VAL,” “INST-CUM,” “PER-AVER,” or “PER-CUM” controls how the interpolation is performed. Interpolated values are derived from “INST-VAL” or “INST-CUM” data using linear interpolation. Values are derived from “PER-AVER” data by computing the period average value over the new regular time interval. Values are derived from “PER-CUM” data by computing the period cumulative value over the new regular time interval.

For example, if the original data set is hourly data and the new regular interval data set is to have a six-hour time interval:

- The value for “INST-VAL” or “INST-CUM” type data is computed from the linear interpolation of hourly points bracketing the new six-hour time point.
- The value for “PER-AVER” type data is computed from the period average value over the six-hour interval.
- The value for “PER-CUM” type data is computed from the accumulated value over the six-hour interval.

The treatment of missing value data is also dependent upon data type. Interpolated “INST-VAL” or “INST-CUM” points must be bracketed or coincident with valid (not missing) values in the original time series, otherwise the interpolated values are set as missing. Interpolated “PER-AVER” or “PER-CUM” data must contain all valid values over the interpolation interval; otherwise the interpolated value is set as missing.

To interpolate values in a selected time series data set at a regular interval:

1. Choose the **Time Conversion** tab of the Math Functions screen and select the **Interpolate at Regular Intervals** operator.
2. From the **Selected Data Set** list, select a time series data set to apply the function.
3. From the **Time Interval** list, select the time interval for interpolation.
4. Specify the **Time Offset** to offset the interpolated points in time from the standard interval time. For example, if you select an hourly interval for the Time Interval, you may use the option to offset time points from the top of the hour to 6 minutes past the hour. If the **Specify Offset** box is checked, enter an integer number in the box to the right and select the **minute/hour/day** time increment from the list further to the right.
5. Click the **Compute** button to perform the interpolation.

6.6 Hydrologic Functions

The **Hydrologic** tab (Figure 6.14) contains the functions Muskingum Routing, Straddle Stagger Routing, Modified Puls Routing, Rating Table, Reverse Rating Table, Two Variable Rating Table, Decaying Basin Wetness, Shift Adjustment, Period Constants, Multiple Linear Regression, Conic Interpolation, Polynomial, Polynomial with Integral, and Flow Accumulator Gage Processor.

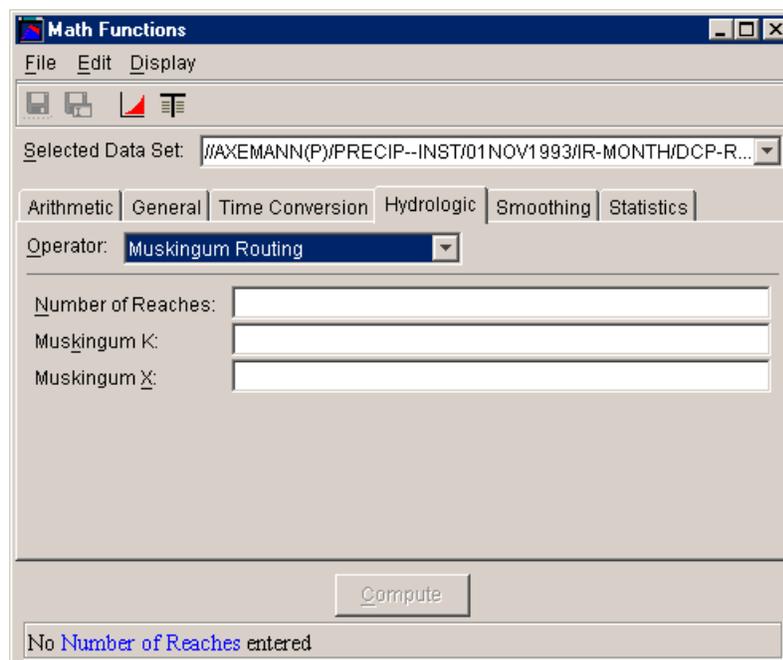


Figure 6.14 Math Functions--Hydrologic Tab

6.6.1 Muskingum Routing

The **Muskingum Routing** function routes a regular interval time series data set by the Muskingum hydrologic routing method.

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Muskingum Routing** operator.
2. From the **Selected Data Set** list, select the time series data set for routing.
3. In the **Number of Reaches** box, specify the number of routing subreaches.
4. In the **Muskingum K** box, enter the Muskingum “K” routing parameter (travel time, in hours).
5. In the **Muskingum X** box, enter the Muskingum “x” routing parameter. The Muskingum “x” value cannot be less than 0.0 (maximum attenuation) or greater than 0.5 (no attenuation).
6. Click **Compute** to route the selected time series data set.

An error message will be displayed if a compute is attempted using an invalid Muskingum “x” value, and no routing will be performed.

The set of Muskingum routing parameters entered may potentially produce numerical instabilities in the routed time series. The parameters are first checked by the function for possible instabilities before the routing proceeds. If instabilities are possible, a warning message box will appear presenting the details of the instabilities. Click the **Yes** button in the message box to proceed with the compute, or click **No** to cancel the operation.

6.6.2 Straddle Stagger Routing

The **Straddle Stagger Routing** function routes a regular interval time series data set by the Straddle Stagger hydrologic routing method.

To route a time series data set by the Straddle Stagger hydrologic routing method:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Straddle Stagger Routing** operator.
2. From the **Selected Data Set** list, select the time series data set for routing.
3. In the **Number to Average** box, enter the number of ordinates to average over (Straddle).
4. In the **Number to Lag** box, enter the number of ordinates to lag (Stagger).
5. In the **Number of SubReaches** box, enter the number of routing subreaches.
6. Click **Compute** to route the selected time series data set.

6.6.3 Modified Puls Routing

The **Modified Puls Routing** function routes a regular interval time series data set by the Modified Puls hydrologic routing method.

With the Modified Puls method, outflow from a routing reach is a unique function of storage. The storage-discharge relationship is entered into the function as a paired data set, where the x-values are storage and the y-values are discharge.

To route a time series data set by the Modified Puls hydrologic routing method:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Modified Puls Routing** operator.
2. From the **Selected Data Set** list, select the time series data set for routing.

3. From the **Storage-Discharge Paired Data Set** list, select the paired data set containing the storage-discharge table. Only paired data sets will appear in this list, and only one data set at a time can be selected.
4. In the **Number of SubReaches** box, enter the number of routing subreaches.
5. In the **Muskingum X** box, enter the Muskingum “x” routing parameter. The Muskingum “x” value cannot be less than 0.0 or greater than 0.5. Enter 0.0 to route by the Modified Puls method, or a value greater than 0.0 to apply the Working R&D method.
6. Click **Compute** to route the select time series data set.

6.6.4 Rating Table

The **Rating Table** function transforms/interpolates values in a time series data set using the rating table x-y values stored in a paired data set. For example, the Rating Table function can be used to transform stage values to flow values using a stage-flow rating table.

The units and parameter type of the resultant time series data set are duplicated from the y-units and y-parameter type of the rating table paired data set. For example, if a stage-flow rating table has a y-data parameter type of “FLOW” and y-units of “cfs”, the resultant time series data set will have the data parameter type “FLOW” and the units “cfs.”

To derive a new time series data set from the rating table interpolation based on the selected time series data set:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Rating Table** operator.
2. From the **Selected Data Set** list, select a time series data set for rating table interpolation. If the selected data set is not a time series, the remaining input boxes on the screen will be unavailable.
3. From the **Rating Table** list, select the paired data set containing the rating table information. Only paired data sets will appear in this list, and you may select only one data set at a time.
4. Click **Compute** to perform the rating table interpolation of the selected time series data set.

6.6.5 Reverse Rating Table

The **Reverse Rating Table** function transforms/interpolates values in a time series data set using the reverse of the rating table stored in a paired data set. For example, the Reverse Rating Table function can be used to transform flow values to stage values using a stage-flow rating table.

The units and parameter type of the resultant time series data set are duplicated from the x-units and x-parameter type of the rating table paired data set. For example, if a stage-flow rating table has a x-data parameter type of “STAGE” and x-units of “ft,” the resultant time series data set will have the data parameter type “STAGE” and the units “ft.”

To derive a new time series data set from the reverse rating table interpolation of the selected time series data set:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Reverse Rating Table** operator.
2. From the **Selected Data Set** list, select a time series data set for reverse rating table interpolation. If the selected data set is not a time series, the remaining input boxes on the screen will be unavailable.
3. From the **Rating Table** list, select the paired data set containing the rating table information. Only paired data sets will appear in this list, and you may select only one data set at a time.
4. Click **Compute** to perform the reverse rating table interpolation of the selected time series data set.

6.6.6 Two Variable Rating Table

The **Two Variable Rating Table** function computes new time series values from the input of two other independent time series data sets. The functional relationship is specified by a table of values contained in a paired data set having multiple sets of x-y curves.

As an example, reservoir release is a function of both the gate opening height and reservoir elevation (Figure 6.15).

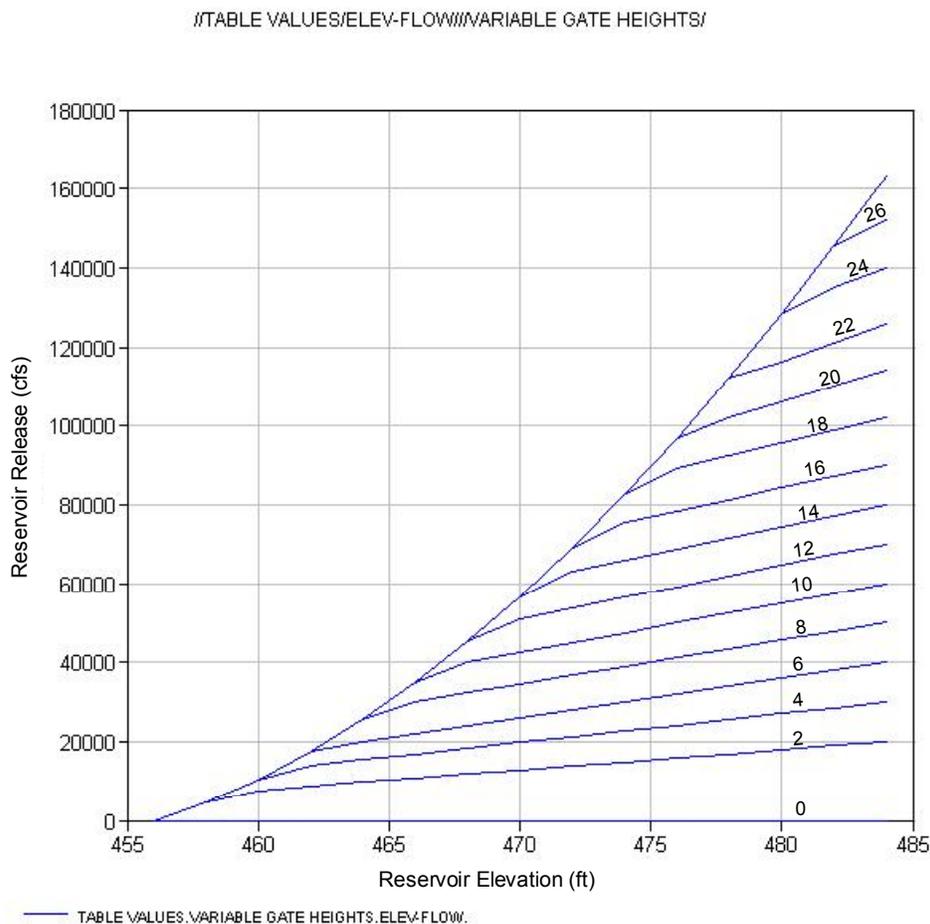


Figure 6.15 Example of two variable rating table paired data, reservoir release as a function of reservoir elevation and gate opening height (curve labels).

For each gate opening height, there is a reservoir elevation-reservoir release curve, where reservoir elevation is the independent variable (x-values) and reservoir release is the dependent variable (y-values) of a paired data set. Each paired data curve has a curve label. In this case, the curve label is assigned the gate opening height. Using the paired data set shown in Figure 6.15, you may employ the Two Variable Rating Table function to interpolate time series values of reservoir elevation and gate opening height to develop a time series of reservoir release.

Times for the two input time series data sets must match. Curve labels must be set for curves in the rating table paired data set and must be interpretable as numeric values.

By default, the units and parameter type of the resultant time series data set are duplicated from the y-units and y-parameter type of the rating table paired data set.

Figure 6.16 shows the appearance of the Math Functions screen for the Two Variable Rating Table function.

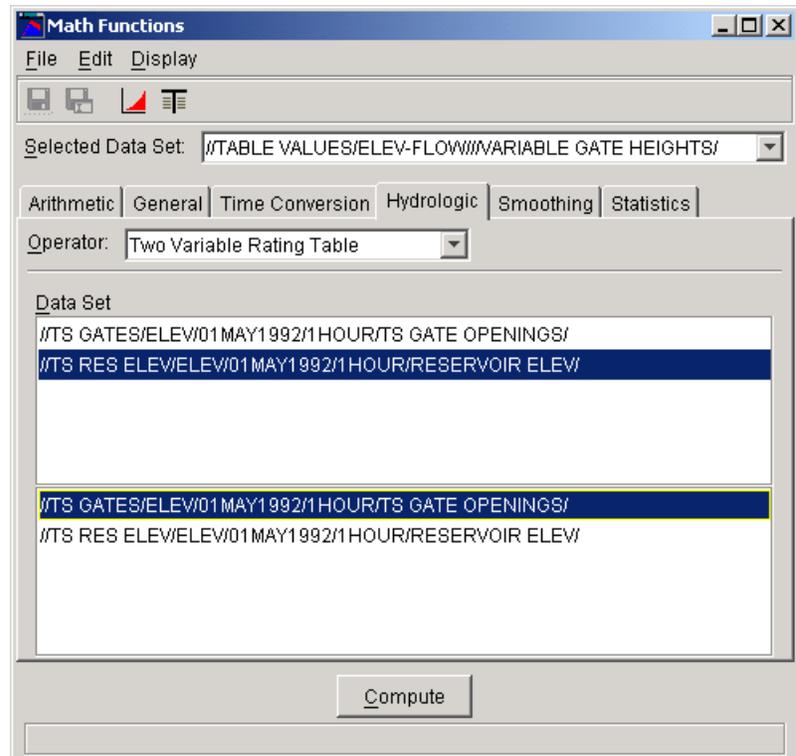


Figure 6.16 Screen for Two Variable Rating Table Function.

To derive a new time series data set from the two variable rating table interpolation of two other time series data sets:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Two Variable Table** operator.
2. From the **Selected Data Set** list, select the paired data set containing the rating table. If the selected data set is not a paired data set, the remaining input boxes on the screen will be unavailable.
3. From the two lists shown below the **Data Set** title, select the two input time series data sets.
 - Use the top list to select the time series data set matching the **x-values parameter** of the rating table. In Figure 6.16, this is a time series data set of reservoir elevation.
 - Use the bottom list to select the time series data set matching the **curve labels parameter**. In Figure 6.16 this is a time series data set of gate opening height. You may select only one data set from a list.
4. Once the data sets are selected, click **Compute** to apply the Two Variable Rating Table function.

6.6.7 Decaying Basin Wetness

The **Decaying Basin Wetness** function computes a time series of decaying basin wetness parameters from a regular interval time series data set of incremental precipitation by:

$$\text{TSPar}(t) = \text{Rate} * \text{TSPar}(t-1) + \text{TSPrecip}(t)$$

where Rate is the decay rate and $0 < \text{Rate} < 1$.

The first value of the resultant time series, $\text{TSPar}(1)$, is set to the first value in the precipitation time series, $\text{TSPrecip}(1)$. Missing values in the precipitation time series are zero for the above computation.

To compute a time series of decaying basin wetness parameters:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Decaying Basin Wetness** operator.
2. From the **Selected Data Set** list, select the time series data set of incremental precipitation.
3. Enter the **Decay Rate**. This value must be greater than 0.0 and less than 1.0.
4. Click **Compute**.

6.6.8 Shift Adjustment

The **Shift Adjustment** function linearly interpolates values in the primary time series data set to the times defined by a second time series data set. If times in the new time series precede the first data point in the primary time series, the value for these times is set to 0.0. If times in the new time series occur after the last data point in the primary time series, the value for these times is set to the value of the last point in the primary time series. Interpolation of values with the Shift Adjustment function is shown in Figure 6.17

Both time series data sets may be regular or irregular interval. Interpolated points must be bracketed or coincident with valid (not missing) values in the original time series, otherwise the values are set as missing.

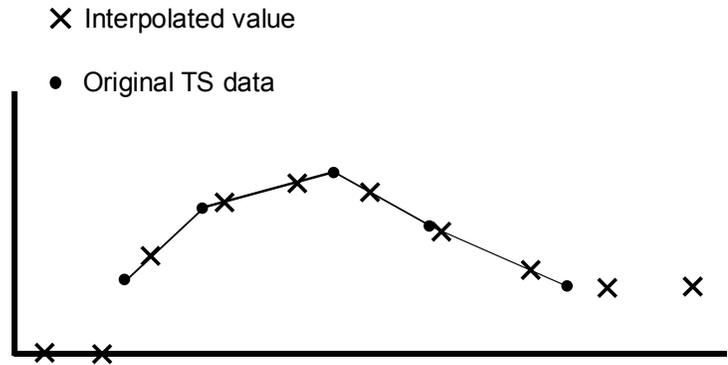


Figure 6.17 Interpolation of time series values using Shift Adjustment function.

To generate a new time series of shift adjustments:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Shift Adjustment** operator.
2. From the **Selected Data Set** list, select the *primary* time series data set. This data set has the *values* for the interpolation.
3. From the **Data Set for Time Pattern** list, select the *second* time series data set. This data set has the *times* for the interpolation.
4. Click **Compute**.

6.6.9 Period Constants

The **Period Constants** function applies *values* in the *primary* time series data set to the *times* defined by a *second* time series data set. Both time series data sets may be regular or irregular interval. Values in the new time series are set according to:

$$ts1(j) \leq tsnew(i) < ts1(j+1), \quad TSNEW(i) = TS1(j)$$

where *ts1* is the time in the primary time series, *TS1* is the value in the primary time series, *tsnew* is the time in the new time series, *TSNEW* is the value in the new time series.

If times in the new time series precede the first data point in the primary time series, the value for these times is set to missing. If times in the new time series occur after the last data point in the primary time series, the value for these times is set to the value of the last point in the primary time series. Interpolation of values with the Period Constants function is shown in Figure 6.18

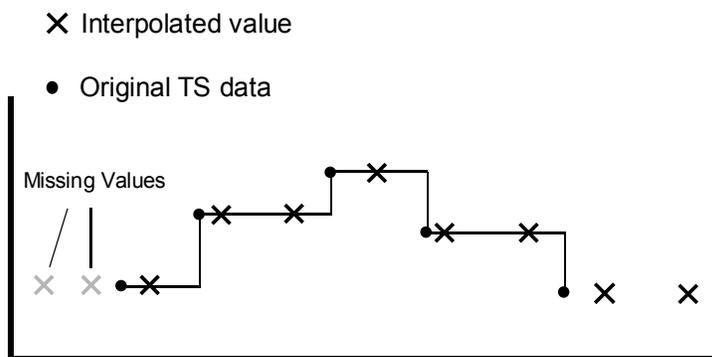


Figure 6.18 Interpolation of time series values using Period Constants function.

To generate a new time series of period constants:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Period Constants** operator.
2. From the **Selected Data Set** list, select the *primary* time series data set. This data set has the *values* for the interpolation.
3. From the **Data Set for Time Pattern** list, select the *second* time series data set. This data set has the *times* for the interpolation.
4. Click **Compute**.

6.6.10 Multiple Linear Regression

The **Multiple Linear Regression** function computes the multiple linear regression coefficients between a primary time series data set and a collection of independent time series data sets, and stores the regression coefficients in a new paired data set. This paired data set may be used with the Apply Multiple Linear Regression function to derive a new estimated time series (see section 6.6.11)

For the general linear regression equation, a dependent variable, Y , may be computed from a set independent variables, X_n :

$$Y = B_0 + B_1 * X_1 + B_2 * X_2 + B_3 * X_3$$

where B_n are the linear regression coefficients.

For time series data, an estimate of the primary time series values may be computed from a set of independent time series data sets using regression coefficients such that:

$$TsEstimate(t) = B_0 + B_1 * TS1(t) + B_2 * TS2(t) + \dots + B_n * TSn(t)$$

where B_n are the set of regression coefficients and TS_n are the time series data sets.

All the time series data sets must be regular interval and have the same time interval. The function filters the data to determine the time period common to all data sets and uses only those points in the regression analysis. For any given time, if a value is missing in any time series, no data for that time is processed. Optional minimum and maximum limits can be set to exclude values in the primary time series which fall outside a specified range.

To compute the set of multiple linear regression coefficients:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Multiple Linear Regression** operator.
2. From the **Selected Data Set** list, select primary time series data set . If the selected data set is not a time series data set, the remaining input boxes on the screen are unavailable.
3. From the **Independent Time Series Data Sets** list, select one or more of the independent time series data sets (by clicking, control-click or shift-click).
4. Click **Compute** to derive new a paired data set containing the linear regression coefficients.

6.6.11 Regression

The **Apply Multiple Linear Regression** function applies the multiple linear regression coefficients computed with the Multiple Linear Regression function (see section 6.6.10). The coefficients, stored in a paired data set, are applied to a collection of independent time series data sets to derive a new estimated time series data set.

For time series data, an estimate of the primary time series values may be computed from a set of independent time series data sets using regression coefficients such that:

$$Y = B_0 + B_1 * X_1 + B_2 * X_2 + B_3 * X_3$$

where B_n are the linear regression coefficients.

For time series data, an estimate of the original time series values may be computed from a set of independent time series data using regression coefficients such that:

$$TsEstimate(t) = B_0 + B_1 * TS_1(t) + B_2 * TS_2(t) + \dots + B_n * TS_n(t)$$

where B_n are the set of regression coefficients and TS_n are the time series data sets.

The number regression coefficients in the paired data set must be one more than the number of independent time series data sets. The collection of selected time series data sets should be in the same order as when the regression coefficients were computed. The displayed list of time series is sorted alphabetically in the dialog. The user should be aware if the names of the time series data sets used for coefficient generation are substantially different from the data names used in this function.

All the time series data sets must be regular interval and have the same time interval. The function filters the data to determine the time period common to all time series data sets and uses only those points in the regression analysis. For any given time, if a value is missing in any time series, the value in the resultant time series is set to missing. You can also set optional minimum and maximum value limits. Computed values in the resultant time series, which fall outside the specified range, are set to missing.

Names, parameter type and unit labels for the resultant time series data set are taken from the first time series data set. The "F part" (Version) in the new data set is set to "COMPUTED."

To apply a set of multiple linear regression coefficients to derive a new time series data set:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Apply Multiple Linear Regression** operator.
2. From the **Selected Data Set** list, select the paired data set containing the regression coefficients. If the selected data set is not a paired data set, the remaining input boxes on the screen are unavailable.
3. From the **Independent Time Series Data Sets** list, select one or more of the independent time series data sets. (You can select a single data set by clicking on it; select multiple contiguous data sets using **Shift+Click**, or select multiple, non-contiguous data sets using **Ctrl+Click**.)
4. Click **Compute**.

6.6.12 Conic Interpolation

The **Conic Interpolation** function transforms values in a time series data set by conic interpolation using an elevation-area table stored in a paired data set. The first value pair in the paired data set contains the initial conic depth and the initial storage volume at the first elevation (given in the next value pair). If the initial conic depth is missing, one is computed by the function. Values in the elevation-area table are stored in ascending order.

The Conic Interpolation function can interpolate a time series of elevation to derive a time series of storage or area. The function can interpolate a time

series of storage to derive a time series of elevation or area. If the output time series is elevation, the output units are assigned from the x-units of the paired data set. If the output time series is area, the output units are assigned from the y-units of the paired data set. If the output time series is storage, the output units are undefined.

Figure 6.19 shows the appearance of the Math Functions screen for the Conic Interpolation function. The Conic Interpolation function is accessed from the **Hydrologic** tab of the Math Functions screen.

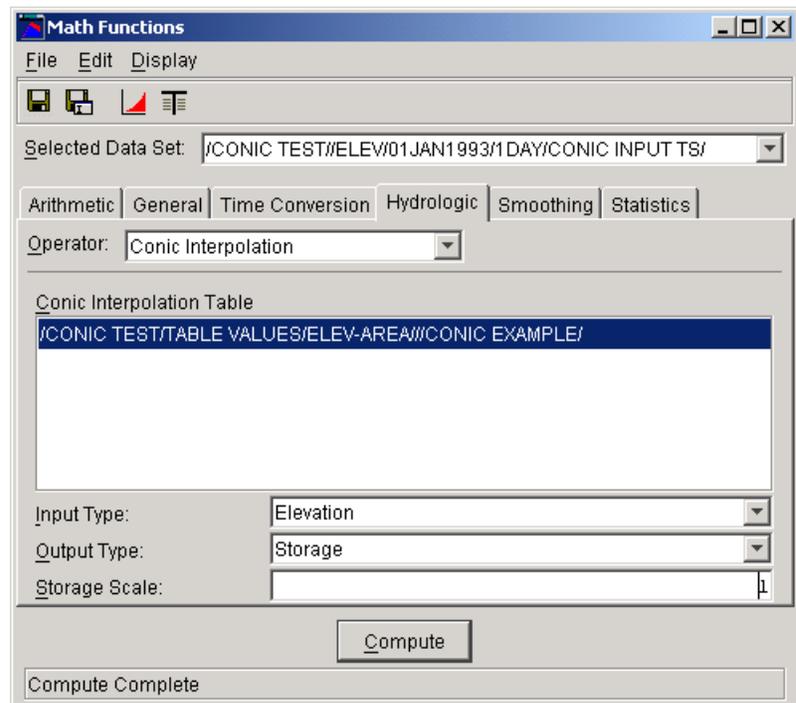


Figure 6.19 Screen for Conic Interpolation function

To perform the conic interpolation of a time series data set of elevation or storage:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Conic Interpolation** operator.
2. From the **Selected Data Set** list, select a time series data set. If the selected data set is not a time series, the remaining input boxes on the screen are unavailable.
3. From the **Conic Interpolation Table** list, select the paired data set containing the conic interpolation table. Only paired data sets will appear in this list, and only one data set at a time can be selected.
4. From the **Input Type** list, select the parameter type of the input time series data (Elevation or Storage).

5. From the **Output Type** list, select the desired output data type (Storage, Elevation or Area).
6. In the **Storage Scale** box, enter factor for the scale of the storage output values. By default this value is 1. The value is used to scale input (by multiplying) and output (by dividing) storage values. For example, if the area in the conic interpolation table is expressed in sq. ft., the storage scale could be set to 43560 to convert the storage output to acre-ft.
7. Click **Compute** to interpolate the selected time series data set.

6.6.13 Polynomial

The **Polynomial** function computes a polynomial transform of a regular or irregular interval time series data using the polynomial coefficients in a paired data set. Missing values in the input time series data remain missing in the resultant time series data set.

A new time series can be computed from an existing time series with the polynomial expression,

$$TS2(t) = B1 * TS1(t) + B2 * TS1(t)^2 + \dots + Bn * TS1(t)^n$$

where Bn are the polynomial coefficients for term “n.”

Values for the polynomial coefficients are stored in the x-values of a paired data set. Before the above equation is applied, values in the input time series are adjusted by subtracting off the paired data “datum” value if defined. The x-units and parameter type from the paired data set are applied to the resultant time series data set.

To compute the polynomial transform of a selected time series data set:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Polynomial** operator.
2. From the **Selected Data Set** list, select a time series data set. If the selected data set is not a time series, the remaining input boxes on the screen will be unavailable.
3. From the **Polynomial Coefficients** list, select the paired data set containing the polynomial coefficients. Only paired data sets will appear in this list, and you may select only one data set at a time.
4. Click **Compute** to perform the polynomial transform of the selected time series data set.

6.6.14 Polynomial with Integral

The **Polynomial with Integral** function computes a polynomial transform with integral of a regular or irregular interval time series data using the polynomial coefficients in a paired data set. Missing values in the input time series data remain missing in the resultant time series data set.

The polynomial transform coefficients are integrated, with the new time series values computed from an existing time series by the expression,

$$TS2(t) = B1 * TS1(t)^2/2 + B2 * TS1(t)^3/3 + \dots + Bn * TS1(t)^{n+1}/(n+1)$$

where B_n are the polynomial coefficients for term “n.”

Values for the polynomial coefficients are stored in the x-values of a paired data set. Before the above equation is applied, values in the input time series are adjusted by subtracting off the paired data “datum” value if defined. The x-units and parameter type from the paired data set are applied to the resultant time series data set.

To compute the polynomial transform with integral of a selected time series data set:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Polynomial with Integral** operator.
2. From the **Selected Data Set** list, select a time series data set. If the selected data set is not a time series, the remaining input boxes on the screen will be unavailable.
3. From the **Polynomial Coefficients** list, select the paired data set containing the polynomial coefficients. Only paired data sets will appear in this list, and you may select only one data set at a time.
4. Click **Compute**.

6.6.15 Flow Accumulator Gage Processor

The **Flow Accumulator Gage Processor** function computes the time series period-average flows from a flow accumulator type gage. Accumulator gage data consists of time series data sets of accumulated flow and counts. The two input time series data sets must match times exactly.

A new time series data set is derived from the time series of flow and counts by:

$$\text{TsNew}(t) = (\text{TsAccFlow}(t) - \text{TsAccFlow}(t-1)) / \\ (\text{TsCount}(t) - \text{TsCount}(t-1))$$

where TsAccFlow is the gage accumulated flow time series and TsCount is the gage time series of counts.

In the above equation, if TsAccFlow(t), TsAccFlow(t-1), TsCount(t) or TsCount(t-1) are missing, TsNew(t) is set to missing. The new time series is assigned the data type "PER-AVER."

To process the flow accumulator type data:

1. Choose the **Hydrologic** tab of the Math Functions screen and select the **Flow Accumulator Gage Processor** operator.
2. From the **Selected Data Set** list, select a time series data set.
3. From the **Data Set Containing Time Series of Counts** list, select the time series data set of counts.
4. Click **Compute**.

6.7 Smoothing Functions

The **Smoothing** tab (Figure 6.20) contains the functions Centered Moving Average, Olympic Smoothing Average, and Forward Moving Average.

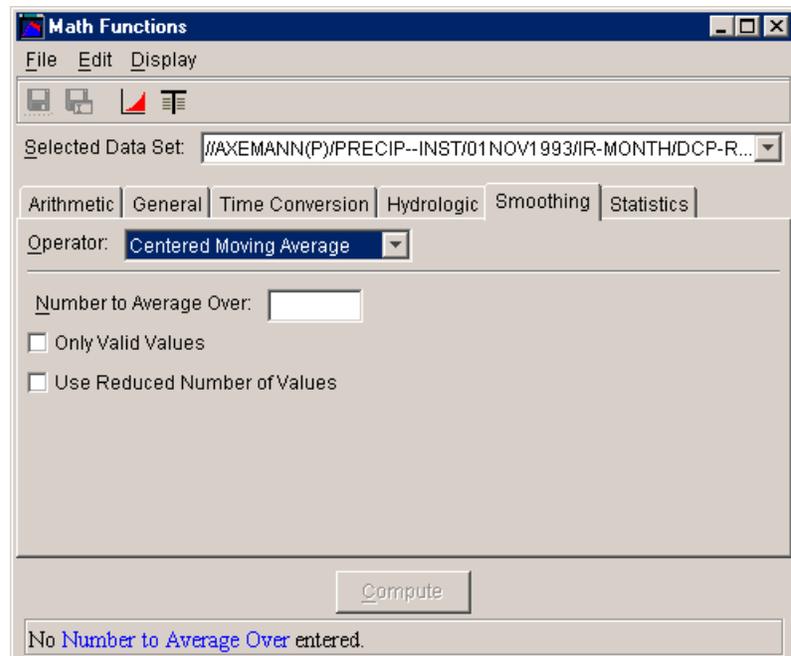


Figure 6.20 Math Functions--Smoothing Tab

6.7.1 Centered Moving Average

The **Centered Moving Average** function computes a centered moving average of “NAVG” values for a regular or irregular interval time series data set. The number of values to average over (“NAVG”) must be an odd integer greater than 2.

The **Only Valid Values** option pertains to when the averaging interval contains missing values. If checked, the option sets the value in the resultant data set to missing. If unselected, the option computes a smoothed value from the valid values in the interval.

The **Use Reduced Number of Values** option pertains to the first and last NAVG/2 values in the resultant data. If selected, the option computes smoothed values at the beginning and ending of the data set from a reduced number of values of the original data set. If unselected, the option sets the first and last NAVG/2 values in the resultant data to missing.

To compute the centered moving average for a time series data set:

1. Choose the **Smoothing** tab of the Math Functions screen and select the **Centered Moving Average** operator.
2. From the **Selected Data Set** list, select a time series data set for centered moving average smoothing.
3. In the **Number to Average Over** box, enter a value to set the number of values for the moving average. This number must be an odd number greater than two (2).
4. Select the **Only Valid Values** box to compute a smoothed value only if all the values in the averaging interval are valid (no missing values). If there are one or more missing values, the value in the resultant time series data set is then set to missing. If the box is not checked, the value in the resultant time series data set is computed using the remaining valid values in the averaging interval.
5. Select the **Use Reduced Number of Values** box to compute a moving average from a reduced number of time series values near the beginning and ending of a time series. At these locations, the moving average interval becomes truncated and there are not “Number to Average Over” values for averaging. If unchecked, values in the resultant time series data set at these locations will be set to missing.
6. Click **Compute** to perform a centered moving average smoothing of the selected data set.

6.7.2 Olympic Smoothing Average

The **Olympic Smoothing Average** function uses the same smoothing scheme as the Centered Moving Average function (see section 6.7.1), except the minimum and maximum values in the averaging interval are excluded from the computation. The input time series may be regular or irregular interval. The number of values to average over (“NAVIG”) must be an odd integer greater than 2.

The **Only Valid Values** option pertains to when the averaging interval contains missing values. If checked, the option sets the value in the resultant data set to missing. If unselected, the option computes a smoothed value from the valid values in the interval.

The **Use Reduced Number of Values** option pertains to the first and last NAVIG/2 values in the resultant data. If selected, the option computes smoothed values at the beginning and ending of the data set from a reduced number of values of the original data set. If unselected, the option sets the first and last NAVIG/2 values in the resultant data to missing.

The span of the averaging interval, “NAVIG,” must be an odd integer greater than two.

Under two conditions there are not NAVG valid values over the averaging interval: if there are missing values in the averaging interval, or if the smoothed point is within NAVG/2 values of the beginning or ending of the time series.

For the first condition, if the averaging interval contains any missing values, the option is to set the value in the resultant data set to missing, or compute a smoothed value from the remaining valid values in the interval.

For the second condition, the option is to set the first and last NAVG/2 values in the resultant data set to missing, or compute smoothed values at the beginning and ending of the data set from a reduced number of values.

To compute the Olympic smoothing average for a time series data set:

1. Choose the **Smoothing** tab of the Math Functions screen and select the **Olympic Smoothing Average** operator.
2. From the **Selected Data Set** list, select a time series data set for Olympic smoothing.
3. In the **Number to Average Over** box, enter a value to set the number of values for the averaging interval. This number must be an odd integer greater than 2.
4. Select the **Only Valid Values** box to compute a smoothed value only if all the values in the averaging interval are valid (no missing values). If there are one or more missing values, the value in the resultant time series data set is then set to missing. If the box is not checked, the value in the resultant time series data set is computed using the remaining valid values in the averaging interval.
5. Select the **Use Reduced Number of Values** box to compute a moving average from a reduced number of time series values near the beginning and ending of a time series. At these locations, the moving average interval becomes truncated and there are not “Number to Average Over” values for averaging. If unchecked, values in the resultant time series data set at these locations will be set to missing.
6. Click **Compute** to perform an Olympic smoothing of the selected data set.

6.7.3 Forward Moving Average

The **Forward Moving Average** function computes a moving average of the last “NAVG” values for a regular or irregular interval time series data set. The number of values for averaging, “NAVG,” must be greater than 2. The first NAVG-1 values in the resultant time series are set to missing.

If the averaging interval contains a missing value, the smoothed value is computed from the remaining valid values in the interval. However, if there

are less than 2 valid values in the interval, the value in the resultant data set is set to missing.

To compute the forward moving average for a time series data set:

1. Choose the **Smoothing** tab of the Math Functions screen and select the **Forward Moving Average** operator.
2. From the **Selected Data Set** list, select a time series data set for Forward Moving Average smoothing.
3. In the **Number to Average Over** box, enter the number of values in the averaging interval. This number must be greater than two (2).
4. Click **Compute**.

6.8 Statistics Functions

The **Statistics** tab (Figure 6.21) contains the functions Basic (statistics), Linear Regression, and Cyclic Analysis.

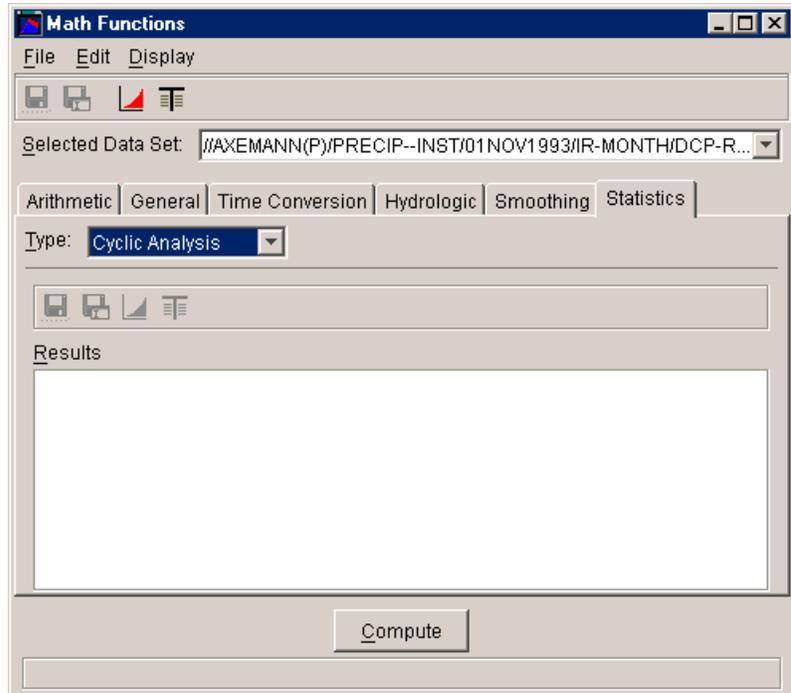


Figure 6.21 Math Functions--Statistics Tab

6.8.1 Basic

The **Basic** function computes the basic statistical values for a regular or irregular interval time series data set. The statistical and informational values displayed are:

- Number of valid values
- Number of missing values
- Last valid value
- Last valid value date and time
- Minimum value
- Minimum value date and time
- Mean value
- Maximum value
- Maximum value date and time
- Total accumulated value for the time series
- Standard deviation
- Skew coefficient

Data type (“INST-VAL,” “INST-CUM,” “PER-AVER,” “PER-CUM”)

Data Units (“ft”, “cfs”, etc.)

To compute the basic statistical parameters for a time series data set:

1. Choose the **Statistics** tab of the Math Functions screen and select the **Basic** type.
2. From the **Selected Data Set** list, select a time series data set.

The statistics are displayed for the time series data set once the data set is selected.

Scripts access the basic statistical functions through a set of calls described in greater detail in Chapter 7:

number of valid values,
number = dataSet.numberValidValues()

number of missing values,
number = dataSet.numberMissingValues()

minimum value,
value = dataSet.min()

minimum value date and time,
time = dataSet.minDate()

mean value,
value = dataSet.mean()

maximum value,
value = dataSet.max()

maximum value date and time,
time = dataSet.maxDate()

last valid value,
value = dataSet.lastValidValue()

last valid value date and time,
time = dataSet.lastValidDate()

total accumulated value,
value = dataSet.sum()

standard deviation,
value = dataSet.standardDeviation()

skew coefficient,
 value = dataSet.skewCoefficient()

units,
 string = dataSet.getUnits()

where number is an integer number, value is a double precision value, time is an integer value in minutes since January 1, 1900.

6.8.2 Linear Regression

The **Linear Regression** function computes the linear regression and other correlation coefficients between two time series data sets. Values in the primary time series data set and the second time series data set are matched by time to form data pairs for the correlation analysis. Missing values are ignored. Times for the two time series data sets must match exactly. The data sets may be either regular or irregular interval time series data.

The correlations statistics computed by the function are:

- Number of valid values
- Regression constant
- Regression coefficient
- Determination coefficient
- Standard error of regression
- Determination coefficient adjusted for degrees of freedom
- Standard error adjusted for degrees of freedom

The primary time series data set forms the values of the independent variable (x-values), while values of the second time series data set comprise the dependent variable (y-values). The linear regression coefficients express how values in the second data set can be derived from values in the primary data set:

$$TS2(t) = a + b * TS1(t)$$

where “a” is the regression constant and “b” the regression coefficient.

To compute the linear regression and correlation coefficients between two time series data sets:

1. Choose the **Statistics** tab of the Math Functions screen and select the **Linear Regression** type.
2. From the **Selected Data Set** list, select the primary time series data set for analysis. Time series values from this data set form the independent variable (x-values) of the correlation analysis.

3. From the **Dependent Data Set** list, select the second time series data set for analysis. Time series values from this data set will comprise the dependent variable (y-values) of the correlation analysis.

The correlation statistics are computed automatically once the two data sets are selected.

6.8.3 Cyclic Analysis

The **Cyclic Analysis** function derives a set of cyclic statistics from a regular interval time series data set. The time series data set must have a time interval of "1HOUR," "1DAY" or "1MONTH." The function sorts the time series values into statistical "bins" relevant to the time interval. Values for the 1HOUR interval data are sorted into 24 bins representing the hours of the day, 0100 to 2400. The 1DAY interval data is apportioned to 365 bins for the days of the year. The 1MONTH interval data is sorted into 12 bins for the months of the year.

The format of the resultant data sets is as a "pseudo" time series for the year 3000. For example, the cyclic analysis of one month of hourly interval data will produce pseudo time series data sets having 24 hourly values for the day January 1, 3000. If the statistical parameter is the "maximum" value, then the 24 values represent the maximum value occurring at that hour of the day in the original time series. The cyclic analysis of daily interval data will produce pseudo time series data sets having 365 daily values for the year 3000. The cyclic analysis of monthly interval data will result in pseudo time series data sets having 12 monthly values for the year 3000.

Fourteen pseudo time series data sets are derived by the cyclic analysis function for the following statistical parameters:

- Number of values processed for each time interval
- Maximum value
- Time of maximum value
- Minimum value
- Time of minimum value
- Average value
- Probability exceedence percentiles for 5%, 10%, 25%, 50% (median value), 75%, 90%, and 95%
- Standard deviation

Figure 6.22 shows the appearance of the Math Functions screen for the Cyclic Analysis function.

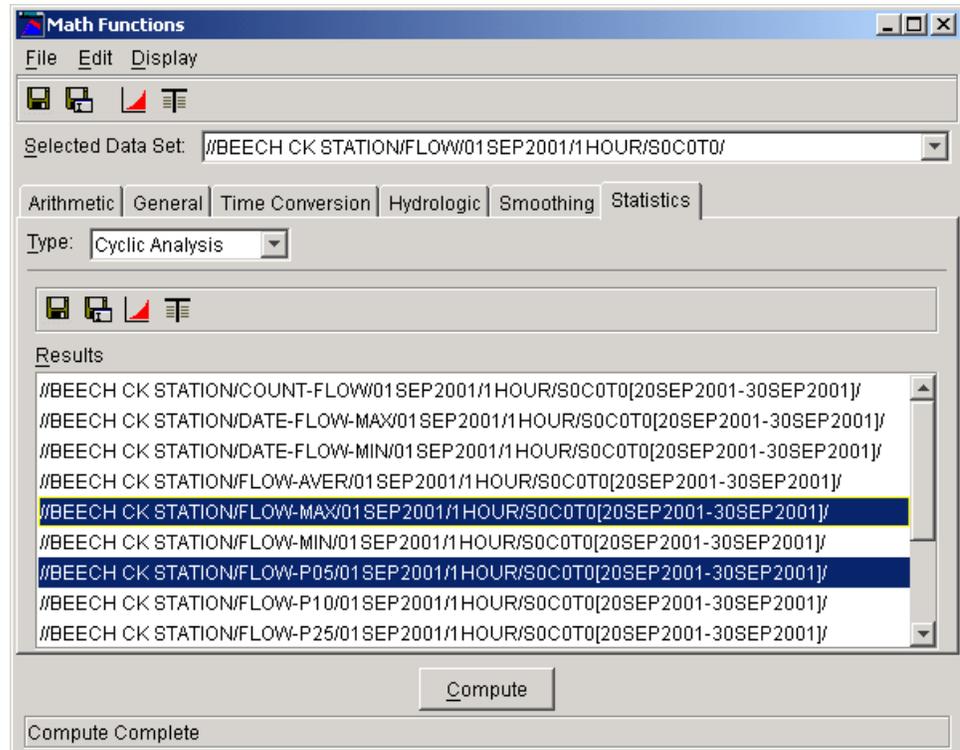


Figure 6.22 Screen for Cyclic Analysis function

To compute the cyclic analysis of a time series data set:

1. Choose the **Statistics** tab of the Math Functions screen and select the **Cyclic Analysis** type.
2. From the **Selected Data Set** list, select a time series data set for cyclic analysis.
3. Click **Compute**.

Once the compute is performed, the resultant 14-pseudo time series data sets appear in **Results** list on the screen (Figure 6.22). One or more data sets in this list may be selected (by clicking, control-click or shift-click) for saving to file, plotting or tabulation by using the **Save**  button, **SaveAs**  button, the **Plot**  button or the **Tabulate**  button from the toolbar located immediately above the Results list.