Introduction to the SWS Index Model

The following information has been extracted from the Speedwell Weather SWS Help document.

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Background

This document discusses the SWS index model. The pricing of a weather derivative involves the specification of both index and pricing models. An unlimited number of index and pricing models can be created and saved for re-use. The schema below describes their interaction.

Adding/Editing an Index Model

To access: Choose Middle Office / Index and Pricing Models / Index Models. Click the New button.

The following entry form for a new Index Model is generated:

Model Name: A name for the model can be specified here.
Use Backdoor: Use the 'backdoor' facility to price any structure where the user defines the index values outside of SWS (Using the Index Back Door).

Index Always Positive: Makes sure that the Index is always positive. This may be important when detrending positive index close to zero with a negative trend. SWS tries to: Set the negative detrended value to 0 and adjust the other points so that the Mean and Standard Deviation are not modified. NB: This algorithm may generate erratic values depending on the trend strength, the index mean and volatility and the number of zero values of the index.

Partial Index: Options for the Partial Index.

Continued over
No Partial Index: no actual data will be used to adjust the historical index series even if the period of the index has started. This may be used if it is needed to repopulate the historical index series as they were before the index period started.

Auto Recalc: This is the normal option. Any available historical of the index period will be used to adjust the series. This depends on both the pricing date and on the specified historical period end date.

Users Values: this allows the users to force a value for the partial index in the past or in the future

Historical Period: Allows specification of a historical period for the Index data.

Auto Update to Today: Historical Period "To" parameter is automatically set to today whenever the model is used.

Years for Mean and Vol: Allows specification of the number of years to use for the mean and the volatility. As an example when the index mean number of years is set to 10, SWS calculates the historical Mean of the index based on the last 10 index values (after detrending, leap year adjustment, etc).

Index Mean Calculation Options:
- **Auto Estimate**: SWS will automatically estimate the index mean from the index model without any further adjustment (Standard Actuarial Method)
- **User's Value**: SWS will adjust the index distribution so that the average matches the specific user's average value.

Use Swap Level: Use the latest market swap level ([Market Swap Levels](#)) in the pricing irrespective of the historical mean.

Auto Est. - No Detrending: SWS will automatically estimate the index mean from the index model without detrending the index historical values

Index Vol - Calculation Options:
- **Auto Estimate**: SWS will automatically estimate the index volatility / standard deviation from the index model without any further adjustment (Standard Actuarial Method)
- **User's Value**: SWS will adjust the index distribution so that the standard deviation matches the specific user's value (normally used when marking to market).

Auto Est. - No Detrending: SWS will automatically estimate the index vol from the index model without detrending the index historical values

Leap Year adjustment: Allows specification of the method of Leap Year Adjustment. In SWS, several 29th February adjustment methods are available indeed. These adjustment methods correspond to different needs and may not be appropriate for all the cases.
- **No Adjustment**: When selected, SWS will not adjust the calculation. In order for traders to work out the effect of the 29th February this method can be used.
- **Period Day Ratio Adjustment**: The final index is multiplied by the ratio (Number of days in pricing period) / (Number of days in the current previous period)

Continued over
Leap Year adjustments continued

- **Plus/Minus One Day:** One day is added or removed at the end of the period so that the number of days is always equal to the number of days in the pricing period.

- **Twice 28th Feb:** If the deal period contains a 29th Feb and the historical period does not the 28th February value is used twice to “simulate” a 29th February. For all other cases this method uses the plus/minus one day algorithm. Thus if the deal period does not contain a 29th Feb but the historical one does, the 29th Feb is retained, and the last date of the data is discarded, ensuring the same number of days for deal and historical periods.

- **Twice 1st March:** As above, except the 1st March value is used twice to “simulate” a 29th February.

- **Average 28 Feb - 1 Mar:** As above, except the average value between 28th Feb and 1st March value is used to “simulate” a 29th February.

- **Feb Day Ratio Adjustment:** The cumulative index for the February period only is multiplied by the ratio \( \frac{\text{Number of days in February in pricing period}}{\text{Number of days in February in the current previous period}} \)

**Missing Data Method:** Allows specification of the method of filling in any missing data ([Using the Data Auditor](#))

- **Max consec missing data fill:** Allows specification of the maximum number of missing data to fill in for. If a period is made of more consecutively missing day then the data will not be filled.

**Hourly Filling Method:** Allows specification of the method used to fill gaps in hourly data sets ([List of Hourly Filling Models](#))

**Data Type:** Allows specification of the data type used for the Index Model ([Weather Data Types](#))

**Index Weights:** Select which Index Weightings list to use ([List Of Index Weightings](#))

**Use Weight on End Date:** Specify whether the weight is used on the end date (an average is used if this not ticked) ([List Of Index Weightings](#))

**Exclude Year Condition:** Allows setting of the conditions for excluding a year from the index calculations

**Detrending method of the Weather Reference:** Allows specification of the trending method for the weather reference. The data are detrended on a monthly basis to respect the seasonality of trends. Supported detrending models are:

- None

  - **Polynomial** (includes Linear, parabolic, cubic, etc)
    - Sub option: degree. Polynomial order (1 for linear, 2 for parabolic, etc)

- **Bilinear**
  - LOWESS a.k.a. LOESS (Locally Weighted Regression)
    - Sub option: degree. Polynomial order (1 for linear, 2 for parabolic, etc)
    - Sub Option: "Smooth band %". This lets the user specifies the smooth band proportion to take into account when running the local regression. As an example, a smooth band of 60% with 50 years worth of data will mean that each local regression will use 60% x 50 = 30 data points.

- **Exponential**
- **Power**
- **Log**
- **Robust Lowess** (5 pass Lowess)
Sub Option: "Additive Trends?": When ticked (default) the trend correction is applied using an additive shift of the data whereas when unticked the trend correction is applied by using a multiplicative shift of the data. For temperature like data an additive correction is best suited whereas for precipitation data a multiplicative correction (so that 0 values remain 0) may be best suited.

Sub Option: Override Child Index Trend: Specifies whether or not all the child indices use the same weather detrending method

More information can be found on detrending methods in the "Calculation Methods Used" document.

Detrending method of the final Index: Allows specification of the trending method for the final Index values. Supported detrending models are:

- **None**
  
  Polynomial (includes Linear, parabolic, cubic, etc)
  
  Sub option: degree. Polynomial order (1 for linear, 2 for parabolic, etc)

- **Bilinear**
  
  LOWESS a.k.a. LOESS (Locally Weighted Regression)
  
  Sub option: degree. Polynomial order (1 for linear, 2 for parabolic, etc)
  
  Sub Option: "Smooth band %". This lets the user specifies the smooth band proportion to take into account when running the local regression. As an example, a smooth band of 60% with 50 years worth of data will mean that each local regression will use 60% x 50 = 30 data points.

- **Exponential**
- **Power**
- **Log**

Daily Simulation Model: Sets the method by which the daily simulation is calculated. The pricing model of the option must be set to "Weather Daily Simulation".

Forecast Model: Sets the forecast data provider and the method for handling ensemble forecasts ([List of Forecast Models](#))

Scenarios: Allows specification for the use of scenario analysis. Scenarios are used to understand the sensitivity of the contract to the weather element itself and allow to answer questions such as:

- What happens if historically the temperature had been 1 degree warmer/colder ("Bump" parameters)?
- What happens if historically it had rained (in magnitude) say 7% more ("Multiplier" parameter)?
Daily Simulation Model:
SWS supports two daily simulation processes:
- Bootstrap for Temperature like processes
- Markovian with Magnitude for precipitation type series

List of Forecast Models
Please see separate SWS Forecast Model document.

Using the Index Back Door

How to access: Having opened an option in Pricing/Price Weather Derivatives then choose Weather Option/Get-Set Histo Values

For “super-exotic” indices that cannot be automatically generated within SWS it is possible to enter an index through “the back door”. This index is simply a list of period end dates and index values that have been generated outside of SWS. This series can then be used to value the structure and to manage risk on it.

To use this feature, the 'Use Backdoor' option must be ticked from the Index Model tab in the main pricing form.

To do this: save an option (the index description is not material in this case) which is to be priced using the exotic index.

Then choose the Options/Back Door/Set Histo Values menu option. Copy in the index. An example is shown below:

![Example Index Grid]

Now press the Save Values button.

Now choose Options/Back Door/Get values. The data are automatically copied into the left of the index grid. The structure can now be priced using this index.
Appendix

Weather Derivatives Pricing

To call this tool choose the Pricing / Price Weather Derivatives menu option

NB. To price a predefined option access go to the Pricing / List of Weather Derivatives menu. To see the Option Pricing outputs go to the Pricing tab (please see Pricing with a distribution for more information). Click on the required row and press the Edit Option button (List of Weather Derivatives). The full details of the option are now entered into the pricing form.

Entering the contract and index and pricing models details

The Weather Derivatives pricing menu option allows contracts to be priced using different models including burn, simulation and actuarial methods. The underlying weather index can be based on either daily, hourly or up to the minute or a mixture of them and can be Simple or Compound. Compound indices cover those which are based on a relationship between two series (e.g. rain and cold) and/or based on multiple sites (basket or spread options) with no limit on the complexity.

The main pricing screen has two parts: on the left hand side the definition of the deal and the parameters to price it can be entered whereas on the right hand side SWS will display statistical and
Below is a description of the function of each tab under Pricing:

**Index** tab for defining the index of a single site structure.

**Payoff and Position** tab for defining the option or swap.

Index Model tab for defining the determinants of the historical index values.

Pricing Model tab for defining the pricing method and the risk parameters.

**Historical Values** tab to see the values of the index and its payoff in the past.

**Forecast Pricing** to incorporate probabilistic forecasts.

**Pricing** tab use this to price using different distributions.

**Price Matrix** tab: use this to show, for example, option prices as a function of swap level and volatility.

Reverse Pricing tab: Use this tool to calculate a parameter (mean, strike or volatility) for a given price.

The Pricing Date by default is set to the current day. This is the base from which the time-value of money is taken into account. The date can be changed to allow retrospective pricing (i.e. pricing with historical data that was only available up to that date). Just below the Pricing Date on the Payoff and Position tab there is a selection to be made as to the nature of the position. If a weather derivative is being priced, the effect of a short or long position in terms of Premium can be incorporated via this option.

Entering the index and models details should be obvious but if you need additional help please refer to: Setting up an Index and an Option. Once the parameters have been defined, press the Price button (or the F5 key). This calculates the historical index values, the detrended values, the payoff and the detrended payoff and a summary of the period values in the grid to the right. It will also Price the option, using the Pricing parameters under the Pricing tab.

Once a new option has been defined, it can be saved to a portfolio without trading it (for seeing the effect on the portfolio) or it actually be traded. To do this press the Save / Save to Portfolio button. The option can also be traded. Press the Save / Trade button. If none of these are required, the terms of the option can be saved by pressing Save / Save to Options List. If an option has been already defined in the list then the option can be modified by changing the details in the form and then pressing the Save / Save Pricing Param button.

The next section deals with the explanation of the output tabs.
The Historical Values tab displays the historical burn and detrended values of the index and the payoff. A more in depth analysis showing burns with different detrending methods can be performed using the Index Analysis tool **Weather Index Analysis**. Below is shown an ordinary Paris Winter 2004 HDD structure with a 1700 strike with an incorporated -50 Cash Flow and a Long position:

There are a number of outputs on the grid. The Index values are shown with no detrending applied (Index No Det.), with detrending of the weather reference (Index Weather Det.) and with both weather reference and final index detrending applied (Full Det. Index). Next to these columns are the weights (see **List Of Index Weightings**) applied to each Index period. Next to this column is the number of days in the period with the corresponding data types used (Synoptic, Climate, Reconstructed, Settlement and Pricing). Then there is the historical payoff for each period plus the cash flow figure without and with detrending applied in the next two columns. Finally there is a detrended index rank applied for each period.
Charts of the historical values, payoffs and gliding volatilities are shown under the Charts tab. There is also a general summary shown under the Summary tab (this tab is the default once a pricing calculation has been run). Within the Charts tab there are two default graphs available (the Historical Values and the Historical Payoff) as well as the optional selection of the Gliding Volatilities:

As can be seen, the Cash Flow value is incorporated into the Pricing analysis. The Position selection and Cash Flow value will also have an effect on other aspects of the form such as VaR under the Pricing tab.
The Summary tab presents a general summary of all the historical values information generated when a pricing calculation is made. In addition all relevant information pertaining to the calculation is generated into the form at the bottom:

**Pricing Tab**
The Weather Derivatives pricing tab displays prices, Greeks and VaR figures using the currently selected model. A variety of methods can be used to price a contract in addition to the specification of risk premium parameters. Each pricing iteration will move previous results to the right hand side of the grid for easy comparison.

**Forecast Pricing Tab**
The Forecast Pricing tab permits the use probabilistic forecasts for weather derivative structures. There is also a subtab, Ensemble Forecast, that gives a detailed breakdown of any ensemble forecast that is used in the pricing of a weather derivative structure. Please see *Pricing incorporating probabilistic/ensemble forecasts* for further information.

**Price Matrix Tab**
The Price Matrix is a tool that generates that will generate a series of prices based on plotting a series of parameters against each other, commonly Mean and Volatility against Fair Values. Please see *The Price Matrix* for further information.
Pricing using a Covered Capped Call or Put (i.e. swap + option)
When pricing a covered option structure, the layout of the option tab will look slightly different to normal:

Having selected the appropriate covered structure (i.e. a call or a put) the next entry needs to be made under the Strike, Cap and Tick fields. The figures for the Strike, Cap and Tick are laid out as follows: to the left the swap levels must be entered (circled in red) and to the right the structure (call or put) value (circled in blue) needs to be inputted. After this has been done the prices can be generated in the usual fashion.
Many other outputs can be obtained at a click of a button

Displaying the Index historical trajectories and Cone

**Index Cone**: use this to view the history on an index progression. On the form, press the Cone button. The following is generated:

The green line shows the StDev, the yellow the max, the red the mean, and the blue the minimum. It is now easy to put the current season in an historical context. The actual daily values are displayed on the grid below. This shows the minimum, mean, maximum, and standard deviation for each day.

Two grids which are filled with data when the **Index Trajectories** button is pressed. The first is the daily value of the index for every day in the period and for every year of the history selected. The second is the cumulative value for each period.
**Calculate the Partial Index**

*Calculate Partial Index:* Press this button to calculate the Partial Index, as illustrated below:
Visualising Daily simulations

Simulation Process: Press this button to calculate the simulation process and access the tool for running daily simulations:

To run daily temperature simulations, click the Run Daily Sim button. The following will appear:

Simply select the dates that are required for the simulation to be run between and press Next:

The next step is to specify the number of simulations that are required to be run. Then press the
The simulations can either be displayed on a chart or on a spreadsheet - the example shown below uses a chart. Click Next to produce the output of the daily simulations:

Each simulation is displayed as a different series on the graph.
Viewing the Daily Index Values

Viewing the Daily Index Values: Press this button to display a tree view of all the daily index values. The view is shown below: