WaterAspects Tutorial

Early Access Version 0.11, August 2008

www.wateraspects.org

Table of Contents

If you're viewing this document online, you can click any of the topics below to link directly to that section.

Section 1. Introduction

What is Water**Aspects**?

Water**Aspects** is a flexible and extensible water modelling framework dedicated to both research and practice. Water**Aspects** is motivated by the need for a more flexible and extensible modelling tool dedicated to the water field. With an initial focus on integrated urban water management, Water**Aspects** allows for the modelling of rainfall-runoff, pollutant transport, simulation with long historic time series and event statistics based on user defined event criteria. In the future Water**Aspects** is expected to expand to include processes description allowing users to model chemical and biological processes of for example treatment plants, streams and other surface water bodies. Coming versions will also include features such as a profile based user interface and improved features for results viewing and reporting.

Water**Aspects** is component based allowing the user to configure her/his own water network by combining the many existing water component to best meet the requirements of the problem addressed. As Water**Aspects** is open source users may develop or have developed custom water components in situations where needed. Water**Aspects** is provided "as-is" with no support. **All users** are therefore strongly recommended to participate in the users mailing list where both experienced users and novices can exchange tip, views and ideas. All questions concerning Water**Aspects** and its use should be addressed to the users list. The questions and answers will provide a support pool for the user community. Follow the link on the Water**Aspects** *web* to subscribe to the users mailing list.

Users of the Water**Aspects** community can submit own components/extensions the common Water**Aspects** code pool for inclusion in future versions. We recommend that users or groups of users contemplating code extensions contact the project maintainers in the early stages of their work in order to optimise design and coordinate efforts.

Water**Aspects** project is maintained by PH-Consult, Denmark.

Section 2. Release Notes and Version History

WaterAspects Release Notes

Water**Aspects** Release Notes
An explanation of how to use Water**Aspects** is given in the tutorials accessible on the Water**Aspects** website (www.WaterAspects.org).

Please check version history to know the differences between this version and the previous ones.

Version History

Early Access Version 0.11 (August 2008))

- Reset button on graph viewer allowing to resize graph to initial ranges
- Added a note component that allows users to insert a plain text note at any point in the project tree
- New GIS viewer with high performance for radar image animation
- Improved performance for radar file reading and ability to read zipped DHI radar files
- Auto reading of image geometry defined by export file for background pictures (VisIt Plus format, www.kms.dk)
- Possibility of adding boundary conditions to MIKE URBAN XML model for Mike Urban 2005 (no longer works with Mike Urban 2004)
- Improved file chooser with the ability to select recent files
- Possibility to add units to exported DHI time series
- Export to Mouse ETS text file format (Mike View text file format)
- Project and node templates for SAMBA calculations
- Network import module from Mouse/Mike Urban network files MEX, UND/HGF or SWF (requires SAMBA2005.7 or later)
- On/off variable formulation (e.g. to simulate pump operation)
- Diurnal Variation Variable (e.g. to simulate daily variation pattern of wastewater dry weather flow)
- Moving average variable
- Sum of Squares formulation (e.g. to calculate sum of square errors/difference)
- Dual time step strategy (e.g. a small in wet weather and large in dry weather for improved performance)
- Water phase substance modeling (transport and mixing for e.g. pollutants)
- Summary by year statistics for water and substances
- Notes component (for inserting comments into the model)
- Improved progress indicators
- Mass balance for substances (at component and network level)
- User defined selection

Early Access Version 0.10 (March 2006)

- Bug fix: export to MJL file
- Minor bug fixes

Early Access Version 0.9 (February 2006)

- In the 'View' tab when showing time series' graph, it is now possible to display the accumulated values of the series over a user-defined interval (Ctrl-click, Alt-click)
- New time series variable which value depends on another time series: the value is either the accumulated or the maximum of the linked time series and is reset to 0 when the linked time series value gets to 0
- Possibility to automatically update the Time Space properties based on the input data used in the model
- New data reader which appends newer time stamped values on every reload
- New time series importer that transforms time series values into time stamped data

Early Access Version 0.8 (January 2006)

- Variables and water components now have a geometry (currently only a point) that enables them to be located spatially
- GIS tab displaying components with a geometry. Possibility to have a picture as background
- Animator component that animates the results of a simulation. Animator works both on the GIS tab and on the time series variable graph on the View tab
- New features on Rain Plane: possibility to change rain plane model
- GUI for connecting rain plane to catchments
- Transformation Chooser that makes it possible to have several variables pointing to the same state variable transformation
- Additional performance improvement in calculations and data loading
- In case your Internet connection occurs via a proxy server, opening project files, data input files and image resources from the Internet might not work. Please check with your network administrator
- Update on DHI time series package: importing and exporting time series values to DHI dfs time series format is only possible if the time series package and Mike URBAN are installed
- Possibility to add boundary conditions to MIKE URBAN XML model
- Updated tutorials
- Corrected minor bugs in tutorials

Early Access Version 0.7 (September 2005)

- Major feature change: a component which inner state depends on time (such as a water component or a time series) can now only be added to the project if a time controller is an ascendant of the component in the project tree
- Performance improvement in calculations and data loading
- In Windows, if DHI's time series package is installed on the computer, it is now possible to import and export time series values to DHI dfs time series format. DHI's time series package is installed automatically with many DHI products or can be downloaded from DHI web site (www.dhisoftware.com)
- Time Controller's default name has been changed to Time Space

- Bug fix: changes to the time controller's properties are fired to all related components. It is no longer necessary to save, close, and open again the project to apply the changes
- Bug fix: PDF tutorials are no longer corrupted and can be read using Adobe Reader
- Bug fix: variables values can be exported to KMD even when the time step size is greater than one minute
- Many minor bug fixes

Early Access Version 0.6 (June 2005)

- New component (List of Observations) that makes it possible to combine several time stamped data series into a longer data series
- New conversion type for observation variables (From sample): it is now possible to transform sampling observations into continuous values while conserving the mass balance
- Values of criteria or event series components are displayed in the 'Text' tab
- New components (Average, Minimum, Maximum) showing the average, minimum, and maximum values over the whole simulation of a time series variable
- Bug fix: In Windows after opening the application by double-clicking a project file, it is now possible to use the 'Save' function later on
- Several minor bug fixes

Early Access Version 0.5 (May 2005)

- Bug fix: selection of a property component via the custom editor in the 'Properties' view effectively updates the component's property

Early Access Version 0.4 (May 2005)

- Sensor has been replaced by a new variable formulation and should not be used any longer
- More user-friendly way of dealing with input data
- Data sources automatically get time stamped data attributes when reloaded
- KMD input file is itself time stamped data and does not get attributes when reloaded
- Tutorial on how to import input data
- The application now requires Java Runtime Environment 1.5
- As usual, several minor bug fixes

Early Access Version 0.3 (February 2005)

- Bug fix: it is now possible to directly open a project by double-clicking a local file on Windows
- Bug fix: relative path wasn't working, data file path was lost when *.waxml was reloaded
- Bug fix: error when creating new XBandRadar and UVFFile data sets

Early Access Version 0.2 (January 2005)

- Bug fix: improved performance in user interface

Early Access Version 0.1 (January 2005)

- Detailed example of how to start using WaterAspects

- Enhanced variable editor
- Support for additional variable formulations enabling to set a variable's value according to an interpolated or interval tabular dependency
- Improvement of refreshing/repainting of user interface components
- Ability to open project files, data input files and image resources from local files as well as files on the Internet
- Bug fix: sensor's variable's attributes can now be saved in project file
- Bug fix: after opening a project, the selection view of the window from which the project was opened now updates additions to the project
- Minor bug fixes

Early Access Version 0.0 (November 2004)
- Initial public release

Section 3. Getting Started

Installing and starting Water**Aspects**

Water**Aspects** requires Java Runtime Environment (JRE) version 1.5 or higher. If you do not have JRE installed on your machine you can download it from *Sun's site*.

Installing and starting Water**Aspects** on Windows 2000, XP or higher is explained in section Installing and starting WaterAspects in Windows 2000, XP or higher on page 7 . For other platforms or versions of Windows, the procedure is given in Starting WaterAspects in another version of Windows or another platform on page 7 .

Installing and starting Water**Aspects** in Windows 2000, XP or higher

You just have to download the installation program from *Water**Aspects**'s website*. Then, start the Water**Aspects** setup program by double-clicking its icon. You can decide where you want the application to be installed.

Thereafter, you can start Water**Aspects** either by clicking Start|Programs|WaterAspects or simply by double-clicking the application icon. Getting started with WaterAspects on page 8 explains the next steps.

Starting Water**Aspects** in another version of Windows or another platform

1. Download the application files at *Water**Aspects**'s website*.
2. If your computer's OS is Windows, use WaterAspects.bat, the batch file available in the distribution, after having replaced **`WATERASPECTS LOCATION`** by the path to the Water**Aspects** directory. If java is not among the environment variables, you must replace **`java`** by the path to the Java Runtime Environment.

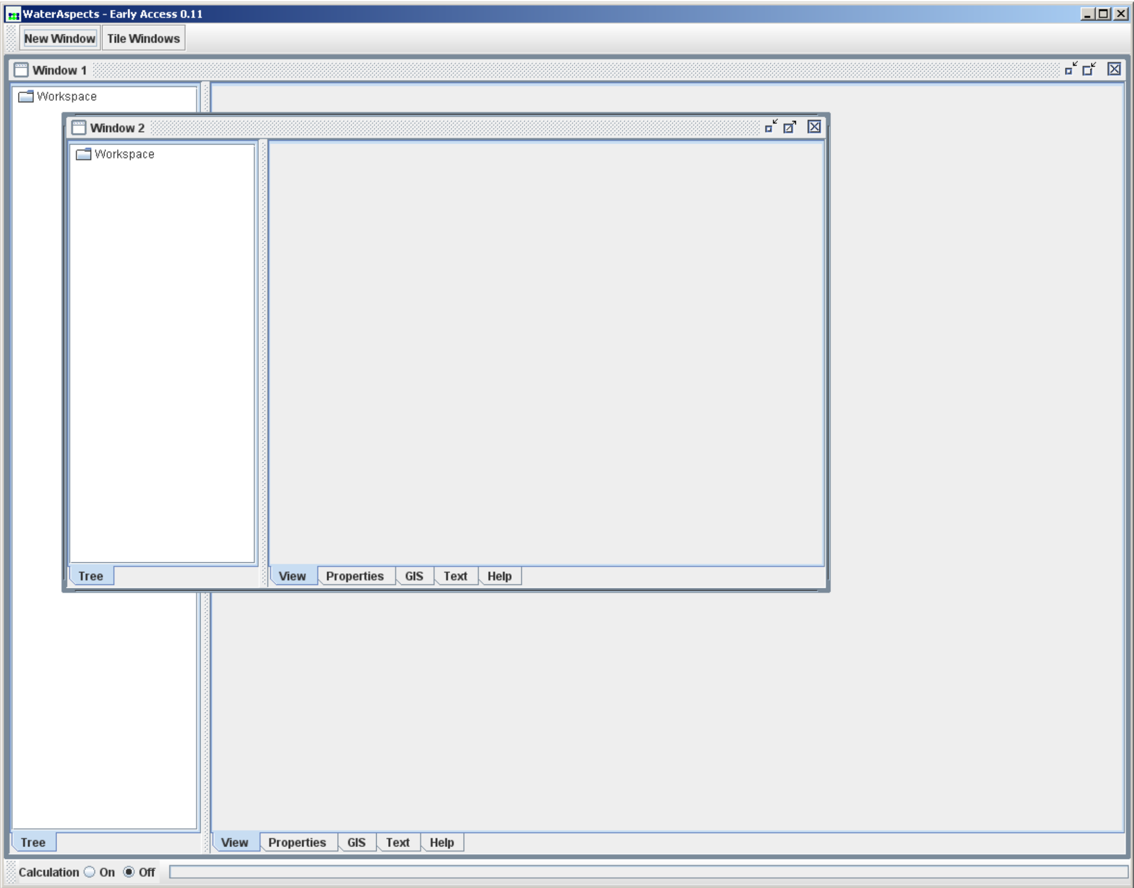
   Run the batch file either via the command prompt or by double-clicking the file on Windows Explorer.

3. If your computer's OS is not Windows, you are likely to know already how to start this kind of application. Open the batch file in a text editor in order to know the classpaths to consider.

Getting started with Water**Aspects**

Water**Aspects** is made of a frame containing several windows of the same type. However, only one window is displayed just after the application is started.

The frame is split into three parts:



- A simple toolbar is displayed at the top of the frame and makes it possible to add extra windows.
- The working area takes the most space and displays all windows. It is described in more details in Description of the application window on page 8 .
- The status bar at the bottom of the frame informs on the status of the application.

Description of the application window

The application window is what is used the most in Water**Aspects**. It is itself split into two panes:

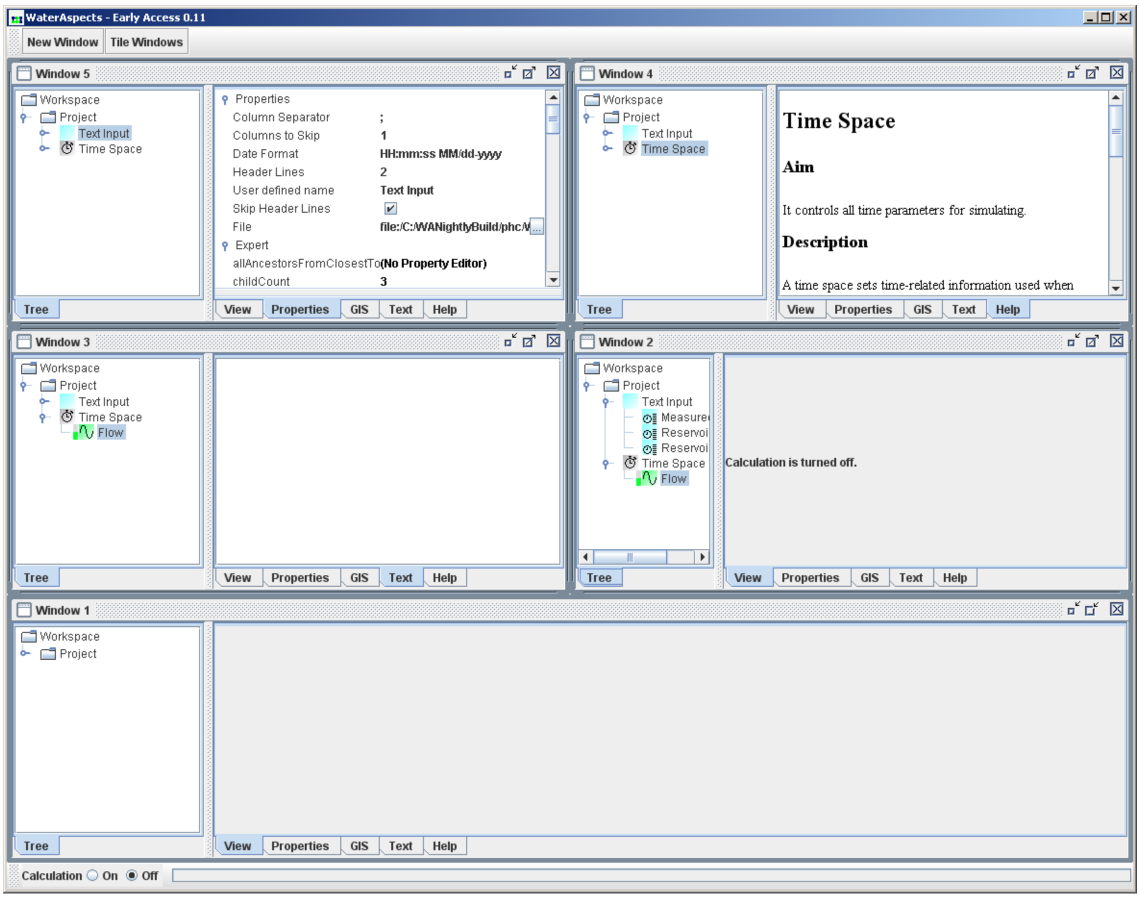
- The left-hand side pane is called the selection zone and displays the project components in a tree structure.

- The right-hand side pane is called the view zone and shows detailed information related to the selected component(s).

As stated earlier, there can be as many application windows as needed in Water**Aspects**. Still, the selection zone is synchronised between all the windows *i.e.* any addition to the project in one window is reflected on the other windows.

The view zone is itself synchronised with the component(s) selected in the particular window and contains four tabs, each of which displaying some different component-related information.

- Generally, the 'View' tab displays graphical information related to the component. For instance, the graphical information can be a plot of the flow against time, a chart of the accumulated volume per month, or a system diagram.
- The 'Properties' tab is used to define and read component properties. Properties are split into two types: Properties and Expert.
- The 'Text' tab displays the results as plain text that can be copied and, for instance, pasted into another application for further data treatment.
- Finally, the 'Help' tab provides help on how to use the component.



The above figure gives an example of displaying several windows with different views for the same project.

Navigating in Water**Aspects**

Access to functions in Water**Aspects** is almost always obtained by right-clicking a component. Here is a list of commonly used functions and how to perform them.

- How to open a project

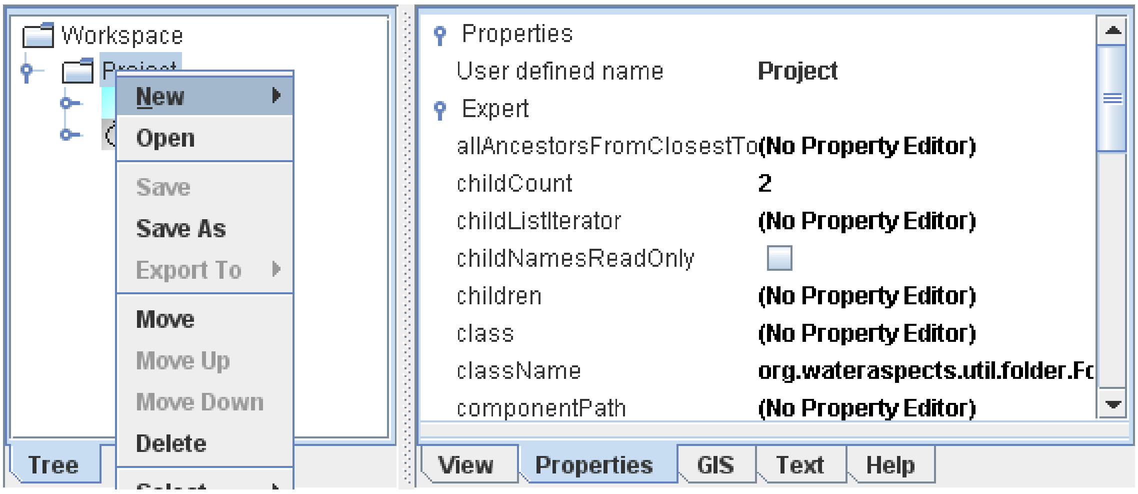
  Right-click 'Workspace' and select 'Open'. A file chooser window pops up. Just navigate through the directories to get to the appropriate Water**Aspects** project file.

- How to save a project

  In the tree, select and right-click the root of the project to save. Decide of the location of the file in the popping up window.

- How to add a component

  Right-click the component that will get the new component as attribute, select 'New' as well as the new component's type.



The figure above shows options that are offered to the users when right-clicking a component.

Uninstalling Water**Aspects**

Under Windows you can uninstall Water**Aspects** by navigating to your control panel and selecting 'Add/Remove Program' in the menu.

If you installed Water**Aspects** using the batch file method described in Starting

WaterAspects in another version of Windows or another platform on page 7 , you only need to delete the jar files in the lib directory under the directory where Water**Aspects** was started.

Acknowledgements

Water**Aspects**was initially developed under the EU sponsored MANTISSA project for the assimilation of a multitude of rainfall and runoff data including data from traditional point rain gauges, weather radar, microwave link precipitation measurements and flow gauges in the runoff system. The very first Water**Aspects** users, Gavin Robbins and Stefan Kr#r, are thanked for their ideas and their patience.

Water**Aspects** is sponsored, maintained and managed by PH-Consult.

Water**Aspects** source code contributions have been made by:

- K#aard Kasper, as a part of his studies on use of radar in urban hyrualic modelling

Water**Aspects** includes some third-party software:

- *GeoTools* (*GNU Lesser General Public License*)
- *HTTP Unit* (*X License*)
- *Jacob* (*BSD License*)
- *Jama* (*Public Domain*)
- *Java Advanced Imaging API Core* (*Java Distribution License*)
- *JEP* (*GNU General Public License*)
- *JEPLite* (*GNU General Public License*)
- *JFreeChart* (*GNU Lesser General Public License*)
- *JGraph 4.0* (*BSD License*)
- *JGraphAddons* (*BSD License*)
- *JTidy* (*JTidy License*)
- *JTS Topology Suite* (*GNU Lesser General Public License*)
- *NetBeans* (*Sun Public License*)
- *Ptplot* (*BSD License*)

Section 4. Modelling with WaterAspects

Introduction

This section describes how to model water transport using Water**Aspects**.

It starts with an overview of those components that can be used for modelling and continues with a detailed description of how to manipulate them. Finally, the section deals with how to actually run a simulation.

Components used for modelling

A simulation requires that data are input to the sewer network or another modelled system and that time is taken into consideration. Therefore, there are three types of components that can be considered for modelling:

- Input data components define the format and the value of the input data. Such a component can point to a file giving an input flow measured every ten minutes.
- Water components simulate water transport in a specific way. For instance, a water component may represent a linear reservoir or a basin.
- Simulation components control time parameters such as time step size.

After the simulation is run, some tools are available for analysing the results.

Input data

Input data are typically rain data. A link between the input data file and Water**Aspects** is created via the Data Source element, which will be chosen according to the rain data format. The input data must then be linked to a time series component. This architecture makes it possible to have e.g. one rain data file associated to several rain gauges. More details are given in the tutorial about adding input data (Introduction on page 49).

Time space

The inner states of components such as water components or time series depend on time. Defining time is ensured by adding a time space component either standalone or as part of a simulator. The time space's properties set the simulation start time, the number of iterations, and the time step size. There might be several time spaces in the same project. However, a component is related to one and only one time space. Water**Aspects** contains the following rule in order to make it easy for the modeller to check which component is related to which time space: components which inner states depend on time must be located in the branches under a time space in the selection tree.

Indeed, the branch under a time space constitutes an independent time space and all components in the branch are related to the time space with respect to e.g. simulation start time and time step size. As a consequence, it is not possible to add time related components to a branch without time space and it is not allowed to add a time space to an already existing time space.

Working with water components

Water components are the elements that will help build the model. Each water component has its own function. An overview of some commonly used water components and their functions is given in the following list:

1. Water components that add water
   - Point inflow: Adds a specified flow
   - Rainfall: Simulates the precipitation defined from a rain gauge
   - Rectangular rain: Models a rain with constant intensity over a period

2. Water components through which water is passed
   - Detention basin: Overflows when its volume and capacity cannot bear the input flow
   - Joiner: Joins all inflows into one outflow
   - Linear reservoir: Outlet volume depends on basin volume. No overflow possible
   - Conduit: Transports water between two locations
   - Basic surface area: Catchment with no water loss whatsoever
   - Splitter: Splits all inflow into two outflows
   - Urban surface area: Simulates a catchment which can be characterized by a total area, an impervious area, and a hydrological reduction. Furthermore, the urban surface area accounts for initial loss as well as transport time

3. A water network may group several of the abovementioned water components and can both add and transport water. What the water network includes is set by the users themselves.

A more detailed description of each individual water component is available on the 'Help' tab of the application.

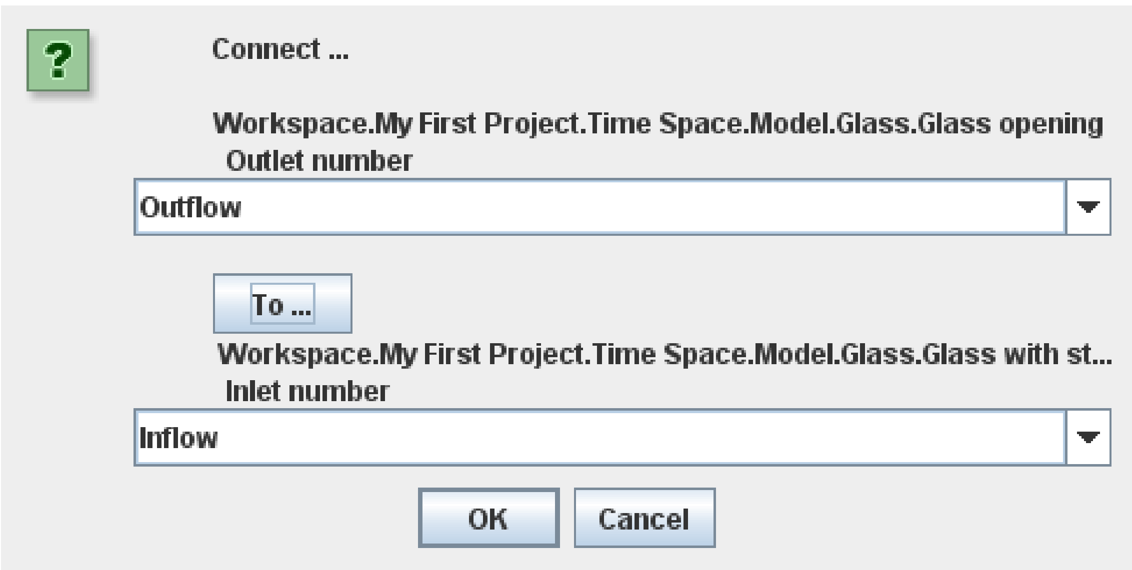
Connecting water components

Water components are added like every other component as described in Navigating in WaterAspects on page 10 . However, water can only flow from one water component to the other after they have been connected.

All water components may have inlets and outlets: water flows into a component *via* its inlets and flows out of it *via* its outlets. If some water is added inside a component it also flows out of it *via* the component's outlets. Water components are connected by linking one component's inlet to another's outlet. In Water**Aspects**, water flows in only one direction: from upstream to downstream.

Water component	**No. of inlets (type)**	**No. of oulets (type)**
Point inflow	0	1 ([m^3])
Detention basin	1 ([m^3])	2 ([m^3])
Joiner	1 ([m^3])	1 ([m^3])
Linear reservoir	1 ([m^3])	1 ([m^3])
Conduit	1 ([m^3])	1 ([m^3])
Splitter	1 ([m^3])	2 ([m^3])
Simple surface area	1 ([m^3])	
Urban surface area	2 ([m^3])	
Water network	User-defined	User-defined

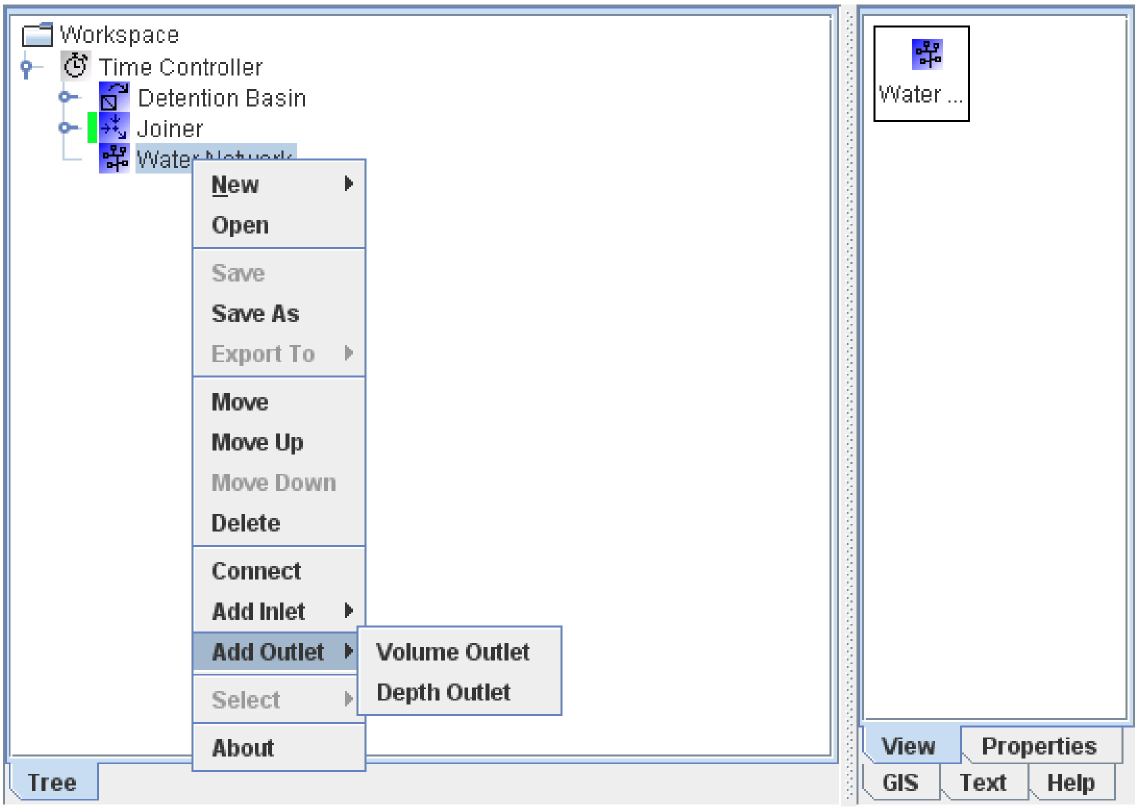
The connection is performed by right-clicking the upstream water component and selecting 'Connect' in the pop-up menu. A window is then displayed that makes it possible to decide which outlet of the component is to be connected, to which downstream water component and to which of its inlets. In order to choose the downstream water component, it is necessary to click on the 'To' button that opens a selection window. It is important to notice that an outlet can only be connected to one downstream inlet but an inlet can be connected to many upstream outlets.



Grouping components in a water network

Connected water components often represent a bigger entity. For instance, an urban surface catchment, a detention basin and a conduit can model a subcatchment with an overflow structure and a pipe. Users might want to group the water components so as to get a better overview of the whole system. To do so users put the water components in water networks. A water network is simply a water component that has other water components as attributes. The other water components cannot have other water components as attributes.

Adding water components to a water network is simply performed like any other addition of component. Connecting a water network to water components upstream and downstream requires that inlets or outlets are created for the water network. This is achieved by right-clicking the water network and selecting 'Add Inlet' or 'Add Outlet'. Then the water component outside is connected to the water network using the procedure explained in Connecting water components on page 13 .



Simulating

Simulating is only possible if a time space is added to the model.

The simulation can be on or off:

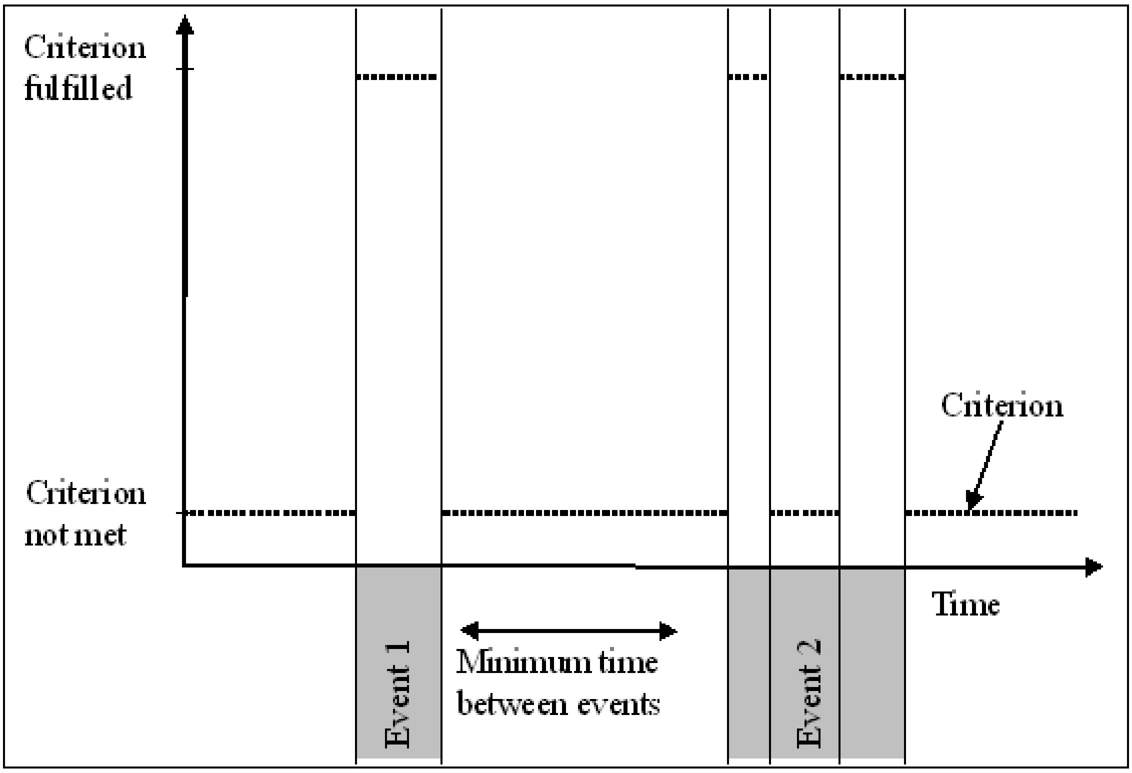
- Selecting 'On' implies that a variable is recalculated as soon as its value might have changed. This occurs when e.g. a water component is connected to another or a parameter such as an emptying rate is modified.
- When the mode is 'Off', no recalculation takes place.

The progress bar at the bottom of the application window informs about the state of the recalculations: if any calculation is taking place, the progress bar will be animated.

Results

After the simulation has ended, graphical results are displayed in the 'Viewer' tab while numerical data are accessible on the 'Text' tab. However, what is displayed depends on the component that is selected. Indeed, when a water component is selected, the 'Text' tab presents monthly summaries of the component's water balance calculated over the whole simulation . Furthermore, whenever variables are selected, the 'Text' tab displays the variables' values at each time step and the 'Viewer' tab shows a graph of the variables' values against time.

In addition, statistics for all variables available in the model can be calculated based on the results of the simulation. Statistics can be either extreme event statistics or monthly or annual summaries. Period summaries are created by adding a summary as attribute of the variable, which values are to be monitored. Similarly, extreme event statistics are set by adding them as attribute of the variable for which statistics are expected. Extreme event statistics require the definition of an event series. An event series is actually a collection of events over the simulation time span. It consists of a criterion (which can itself be made of several criteria) and a minimum time between two events. The relationship between event series, criterion, and minimum time between events is explained in the figure below. The extreme event statistics are such that there is one value per event. The value might be the maximum, minimum, average, or sum of the variable related to the statistics. The reason for such a split between components regarding extreme event statistics is gain in flexibility. Indeed, users can define their own criteria and associate them to several variables.

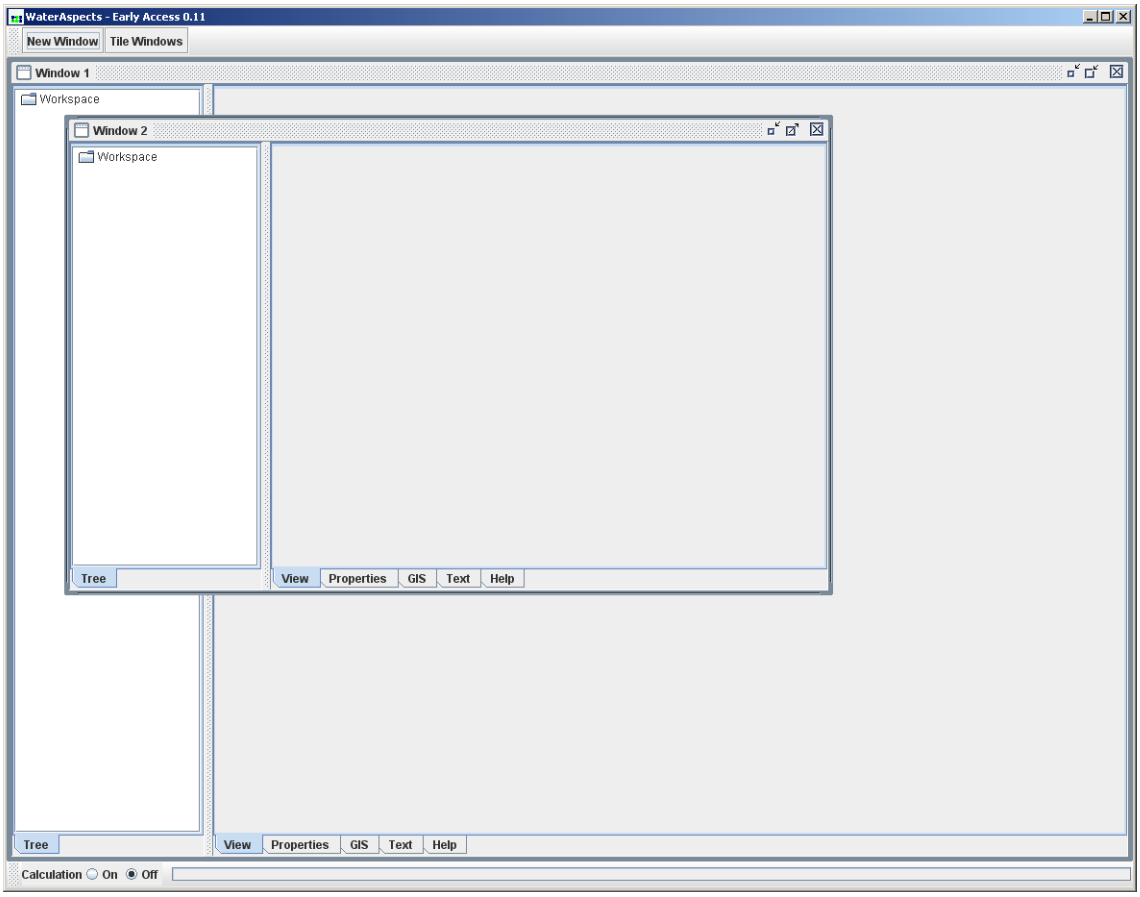

Criterion fulfilled
Criterion not met
Criterion
Time
Event 1
Minimum time between events
Event 2

Section 5. My First Glass of WaterAspects

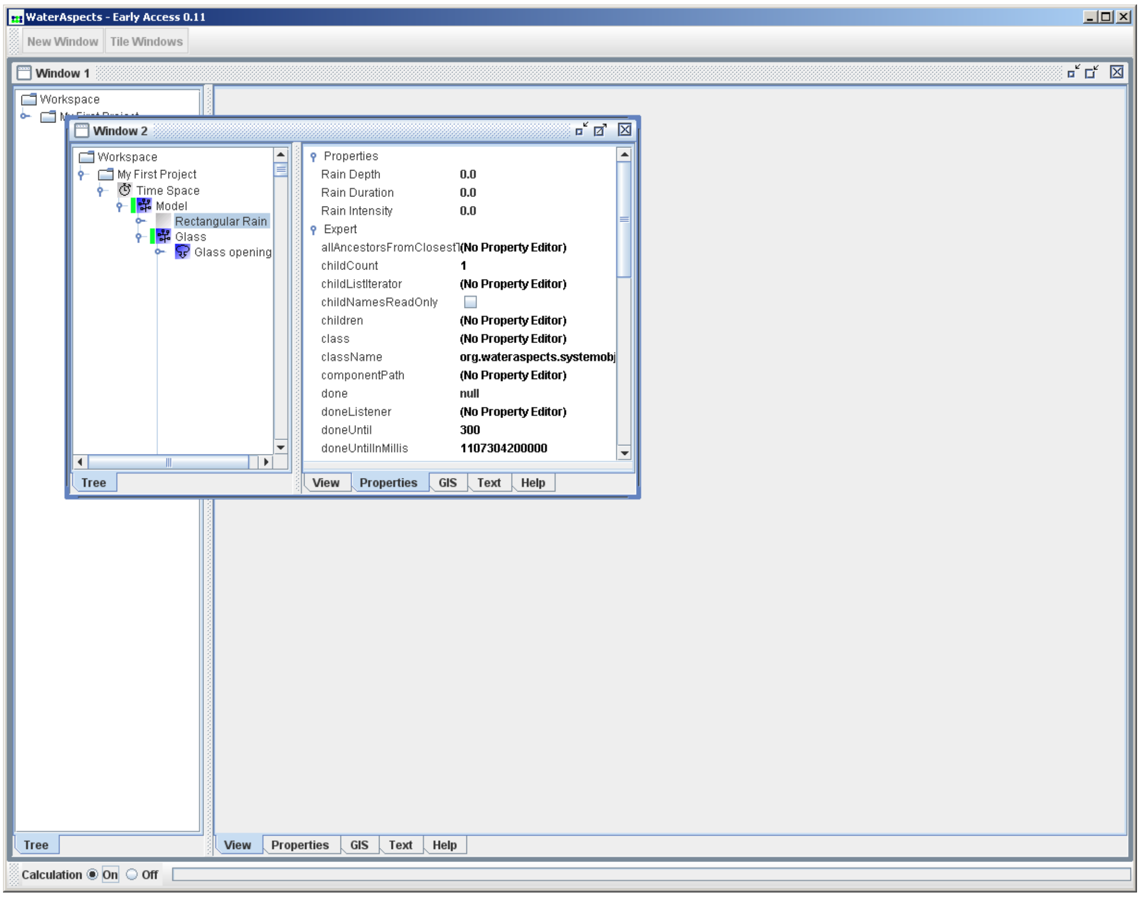
Introduction

This section takes you for a step-by-step tour through many of the basic steps involved in creating a model in Water**Aspects**. You will learn how to create new components, view the component based help, rename components, modify properties, connect water components to one another, run simulations, make variables depend on other variables, view results, copy results to a spreadsheet and finally save and re-open your project. Water**Aspects** has several powerful features that lie beyond this first example. Examples of features that are **not** covered by this first tour are: defining substance and working with substance concentrations, long term simulation, user defined expressions for defining variable dependencies, summary and extreme statistics, Water**Aspects**' powerful event definition facilities, handling missing data, reading your own data files, creating and using templates, optimisation, parameter estimation, discrete time stochastic state-space modelling and how to make your project available in a web page using the Water**Aspects** applet.

The Water**Aspects** application starts up with a single workspace component as show below.



For this small example we'd like recalculation to take place automatically after every change so the **Calculation** mode in the toolbar in the bottom of the application window is set to **On**. Your application window should now look like this ...



The case: a glass of water in the rain

The model created in this example is rather hypothetical but it should be easy to follow for most water modellers irrespective of their speciality or modelling background.

Imagine a glass placed on a table out in the rain. Whilst the rainfall is filling up the glass, you're drinking from it with a straw. In our hypothetical world the rain happens to be falling as a rectangular rainfall event with a constant intensity over a given duration. The glass did contain some water before the rainfall started and we need to consider this in our model. The rate at which you are drinking water through the straw depends on how much water is in the glass. We'd like to know whether the glass gets filled and if so when this happens and how much spills out over the edge of the glass. We'd also like to know when the glass is empty.

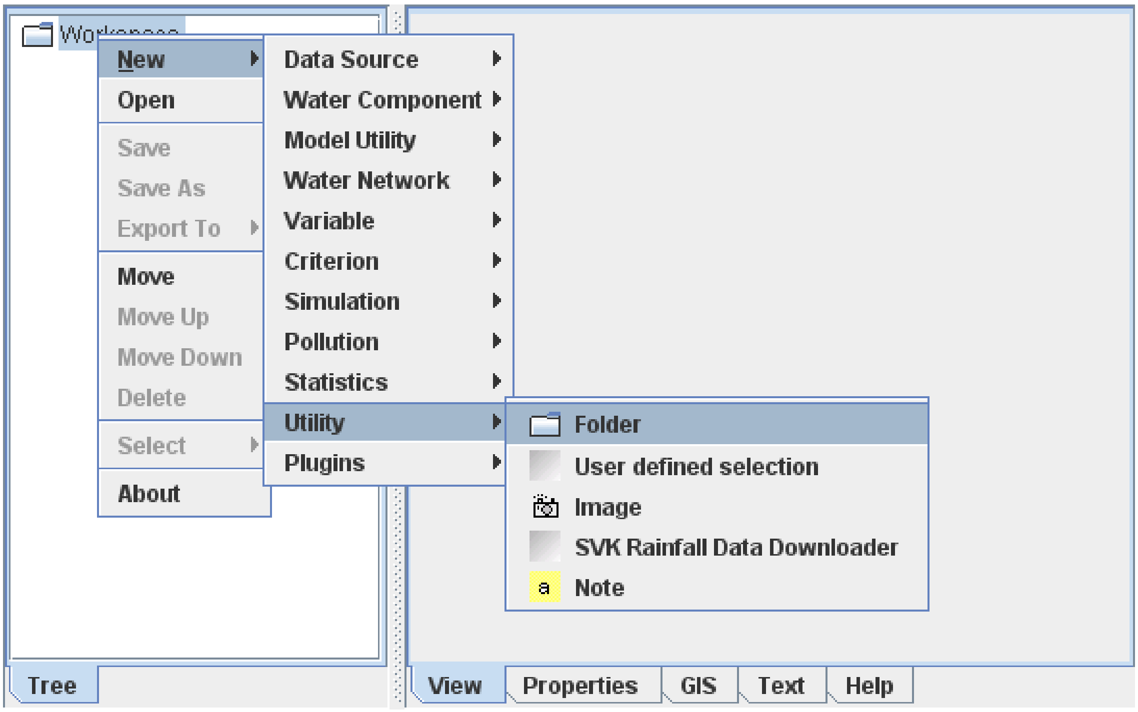
The table below contains the data we need to build our model.

Parameter	**Value**	**Units**
Size of glass (volume)	0.25	l
Diameter of glass opening	6.0	cm

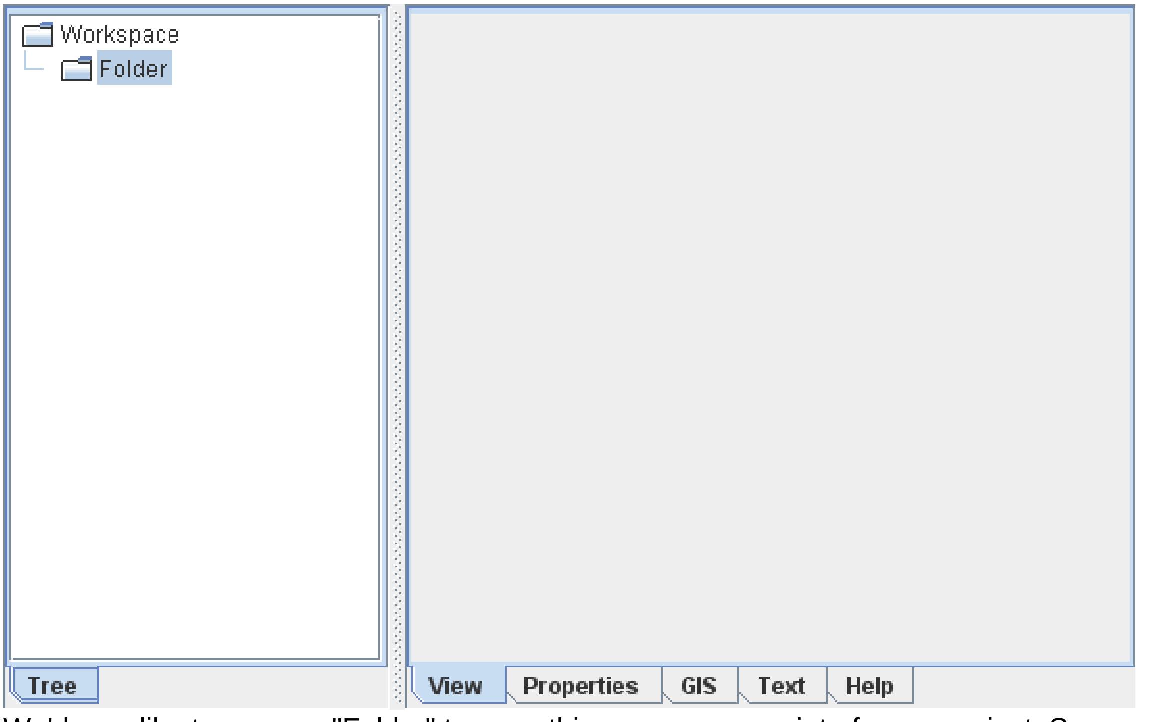
Water in glass at start	0.125	l
Rainfall depth	50	mm
Rainfall duration	120	min.
Flow through straw	1.0e-9	m^3/s

Create your project component

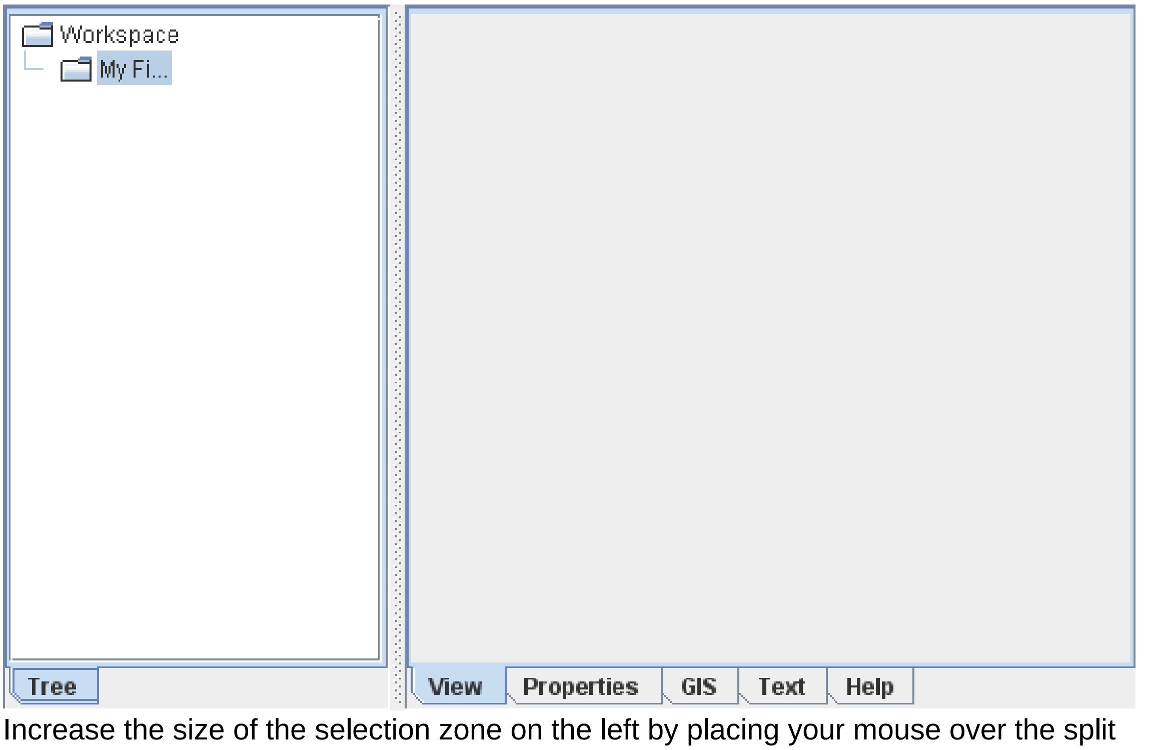
The first thing we want to do is to add a folder component that will be our project folder. Select the workspace component with your mouse and then right-click on the component to get the component specific drop-down menu. Select 'New|Utils|Folder' to add a folder component as shown in the figure below.



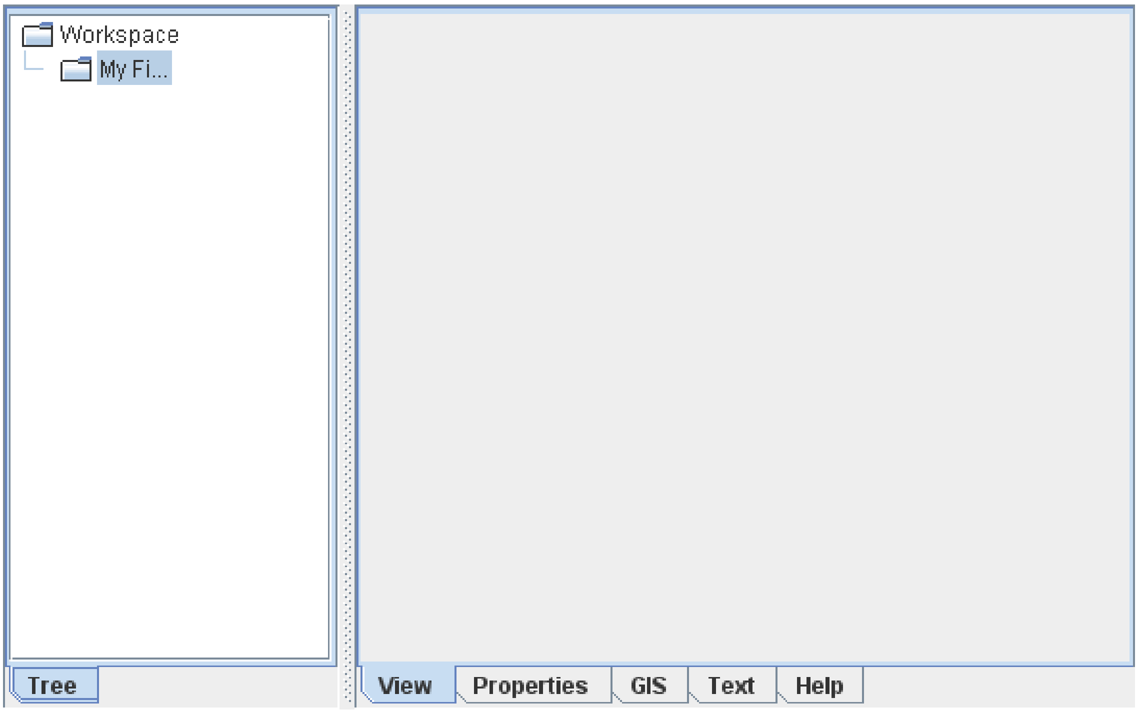
As shown below your workspace component should now contain a new component called "Folder".



We'd now like to rename "Folder" to something more appropriate for our project. Say "My First Project". Slow-click the component to bring its name into edit mode and type in the new name. Remember to press enter to get out of edit mode. You should now see something like this.



Increase the size of the selection zone on the left by placing your mouse over the split line and dragging it to the right. In the current version you need to collapse and re-expand the workspace component to see the full length of project folder's name. Do this and you should see the following.



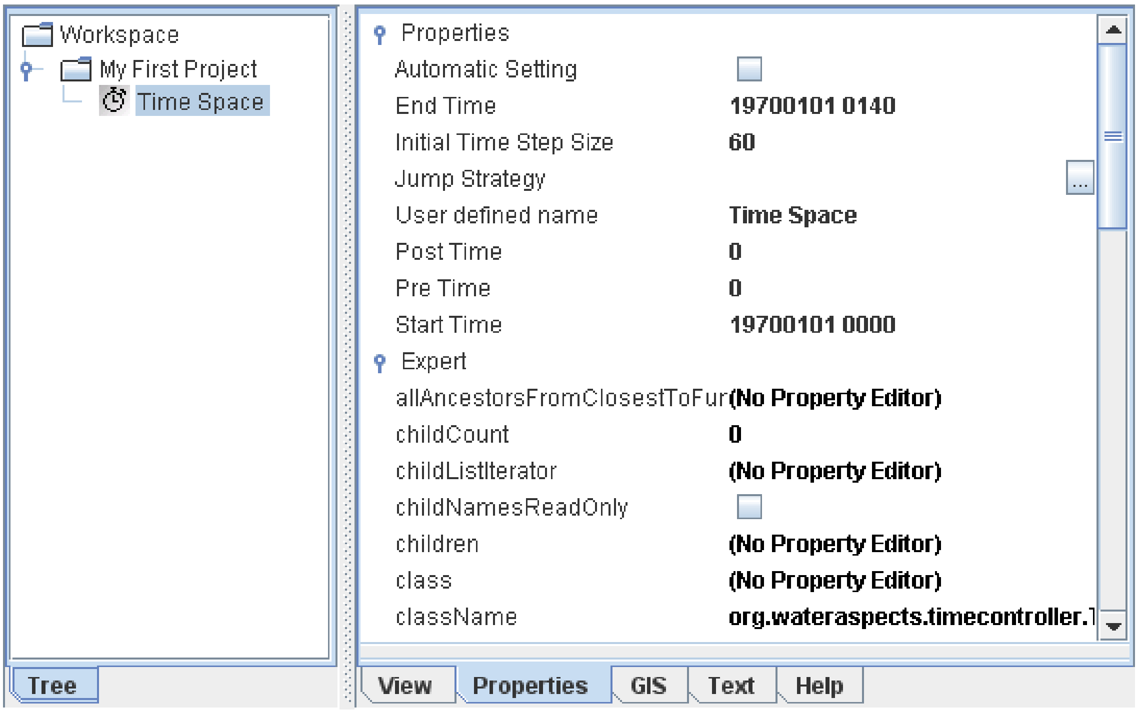
The term "Folder" is user in Water**Aspects** to describe a component whose primary function is to hold or organise other components. Note therefore that a Water**Aspects** "Folder" and all the other components that you see in the tree-view selector zone have nothing to do with folders or directories in the computer's file system.

Add a time space

Water**Aspects** simulations are continuous and with a fixed time step. The time space holds information on:

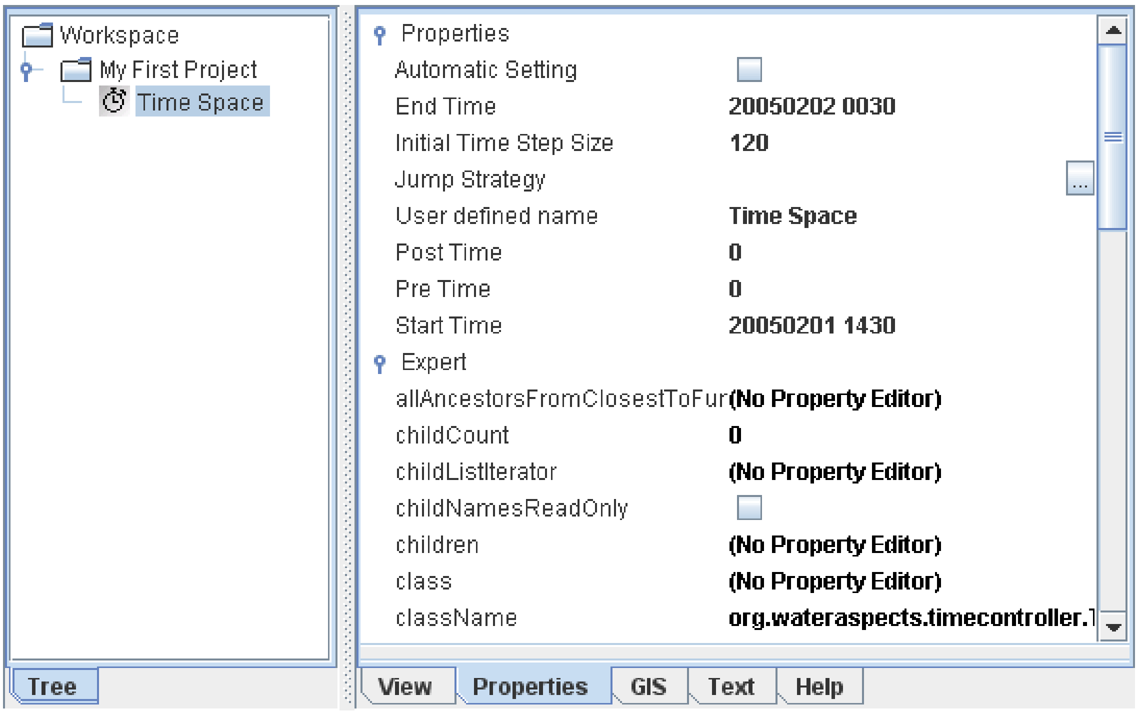
- start time for the simulation
- size of the simulation time step
- number of time steps to simulate

Select the project folder that we have named "My First Project" and add a time space to it by choosing 'New|Simulation|Time Space' in the drop-down menu. Select the new time space component and click the "Properties" tab in the viewer zone on the right side of the window. As you can see below, the viewer on the right shows the above listed time space properties.



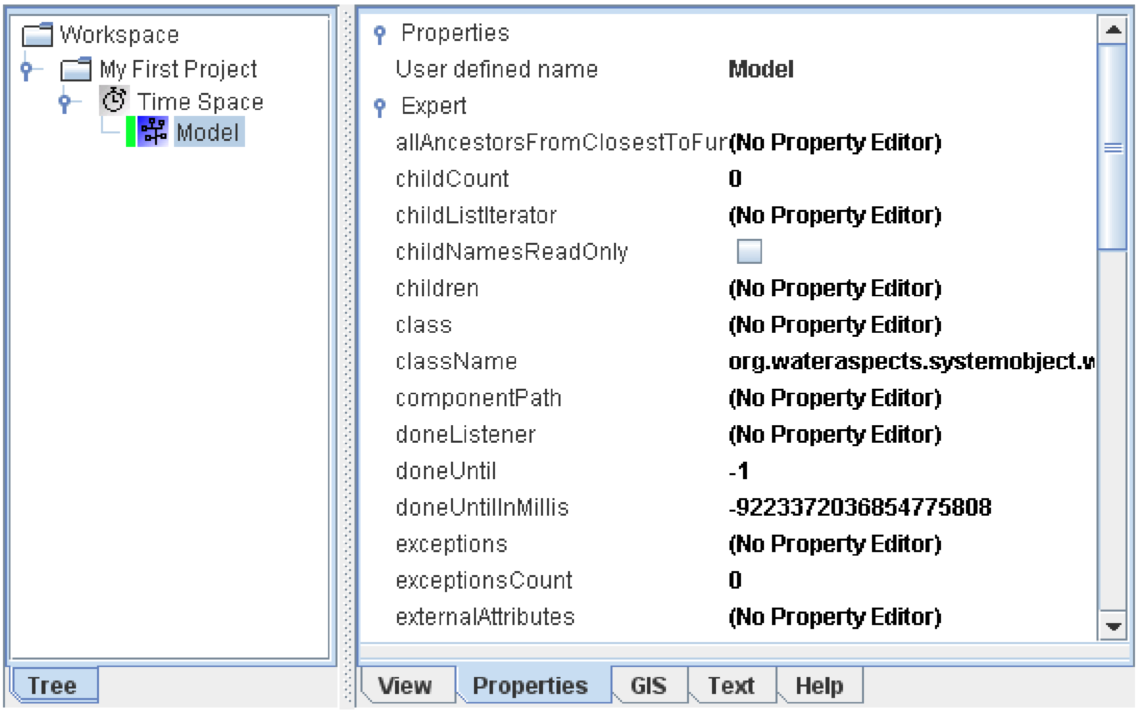
Click the property fields to modify the values. Set start time to 1st February 2005 at 14:30. In the current version the start date needs to be entered in the exact format ddMMyyyyHHmmss (as can also be seen in the tooltip shown when you move the mouse over the property name "Start Time"). For the 1st February 2005 this is "01022005143000".

Once you've similarly set the time step size to 120 seconds and the number of time steps to 300 you should have something like this.



Add a water network in which to create the model

In Water**Aspects** a model should be built up within a water network component. To add a water network select and right-click the time space and then choose 'New|Water Network|Water Network'. Rename it to something suitable. In this case we've chosen to rename it "Model". What we now have is shown below.



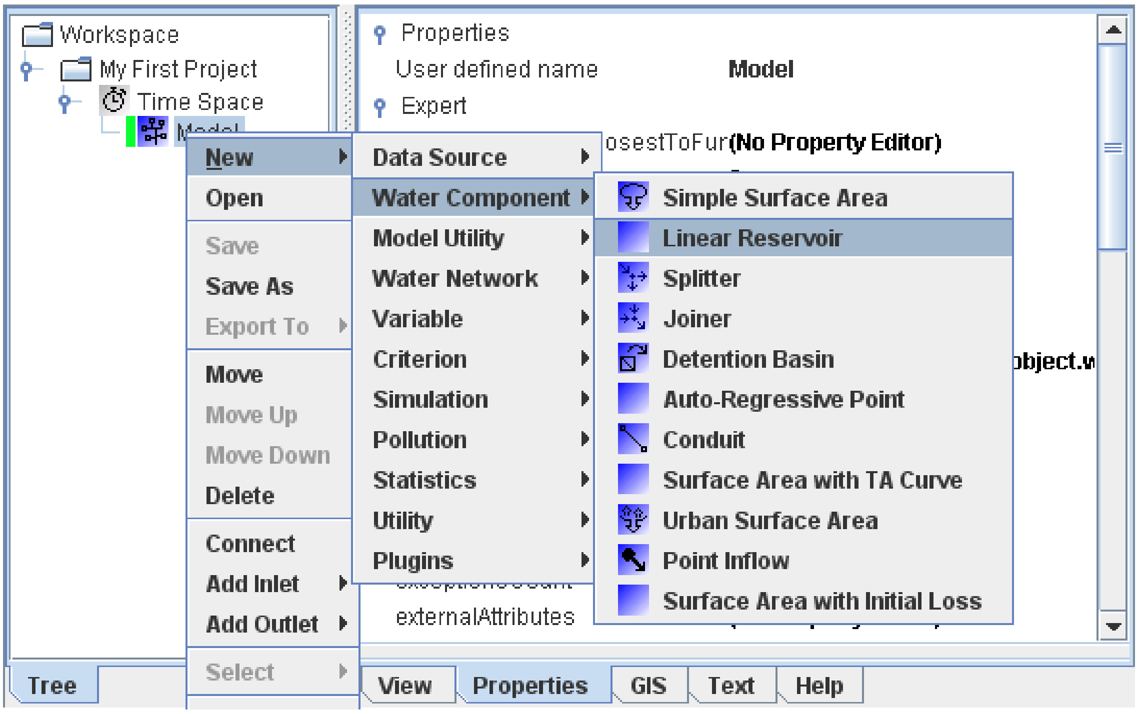
Creating the model

Our model will essentially be composed of three components:

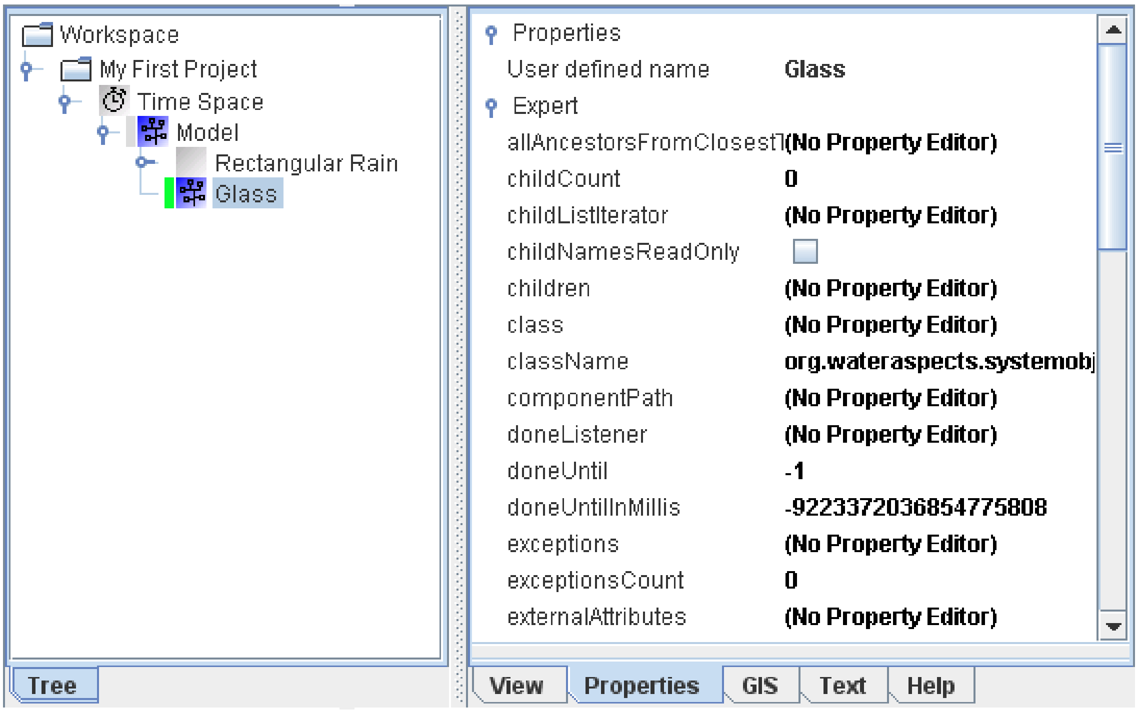
- a **Rectangular Rain** component to model the rainfall
- a **Simple Surface Area** symbolising the opening at the top of the glass
- a **Detention Basin** which we will use to simulate our glass of water and straw

The last two components relate to the glass specifically so we choose to create these within a **Water Network** component that we call "Glass".

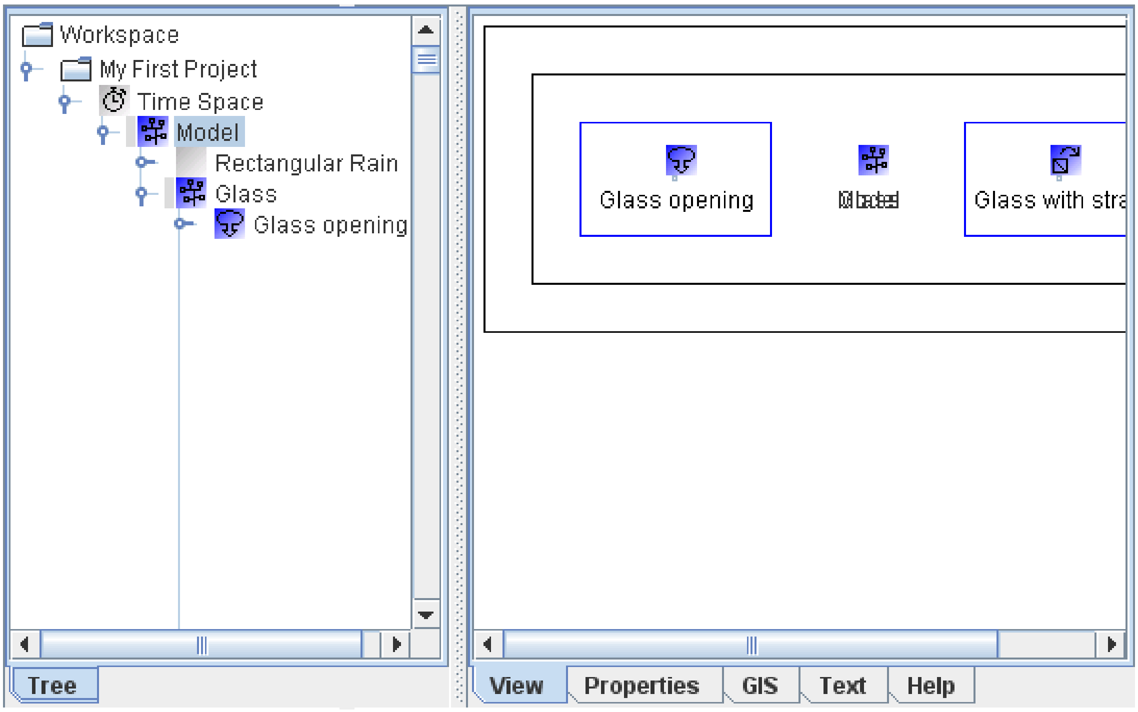
To add a **Rectangular Rain** component to our network follow the same procedure as shown earlier but now choosing 'New|Model Utility|Rectangular Rain' in the popup menu. Make sure that you select and right-click "Model".



If we first add the **Rectangular Rain** components to our network and then a **Water Network** which we rename "Glass", we end up with something like this.



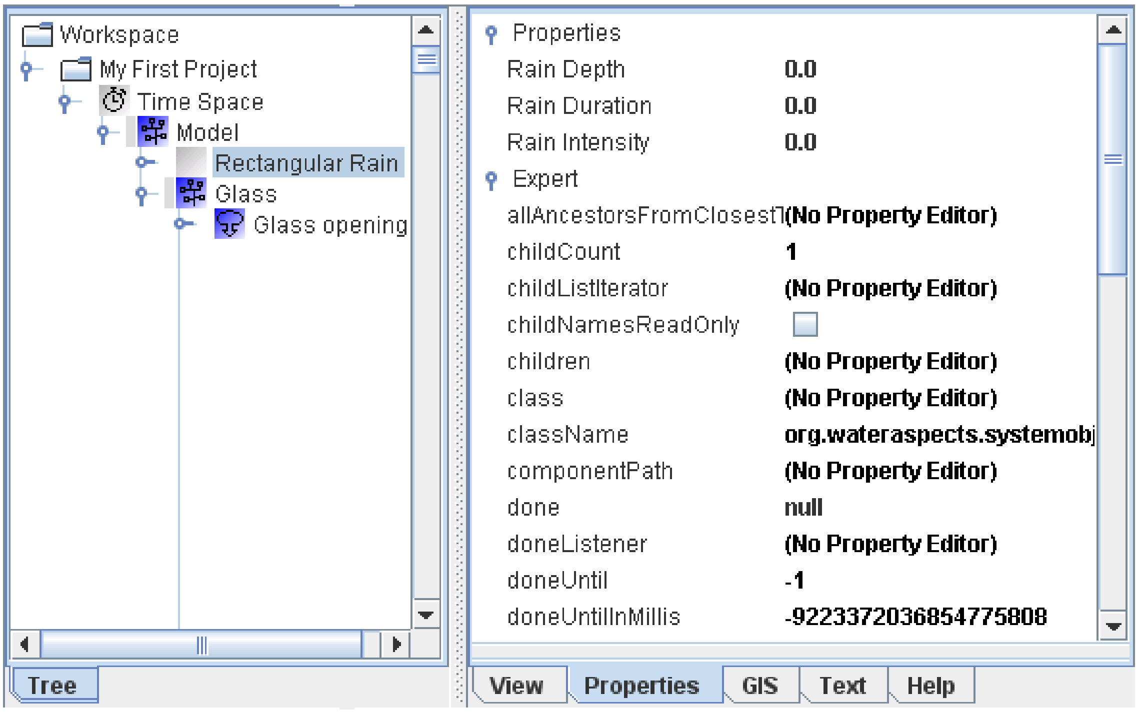
To the "Glass" component we now add a **Simple Surface Area** and **Detention Basin** which we rename to "Glass opening" and "Glass" respectively. Select "Model" in the tree on you left and the 'View' tab on the right to see the schematic diagram of our model. This should give you something similar to what is shown below.



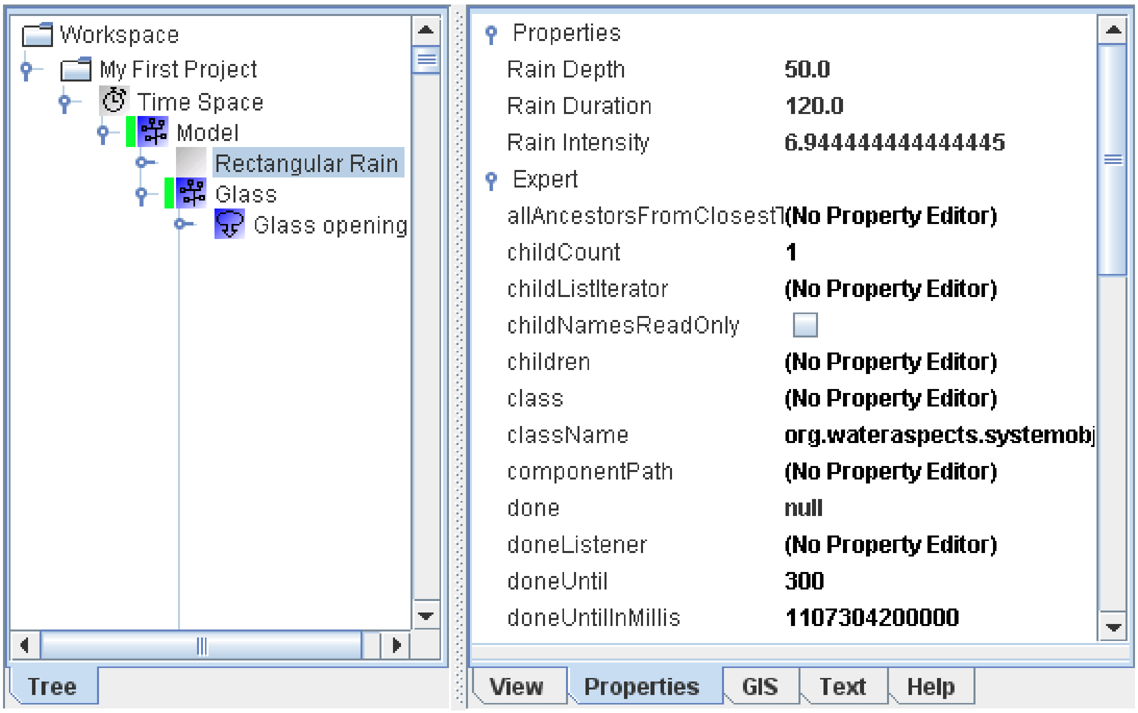
As you can see the system diagram leaves space for improvement. We're at it.

Entering the rainfall data

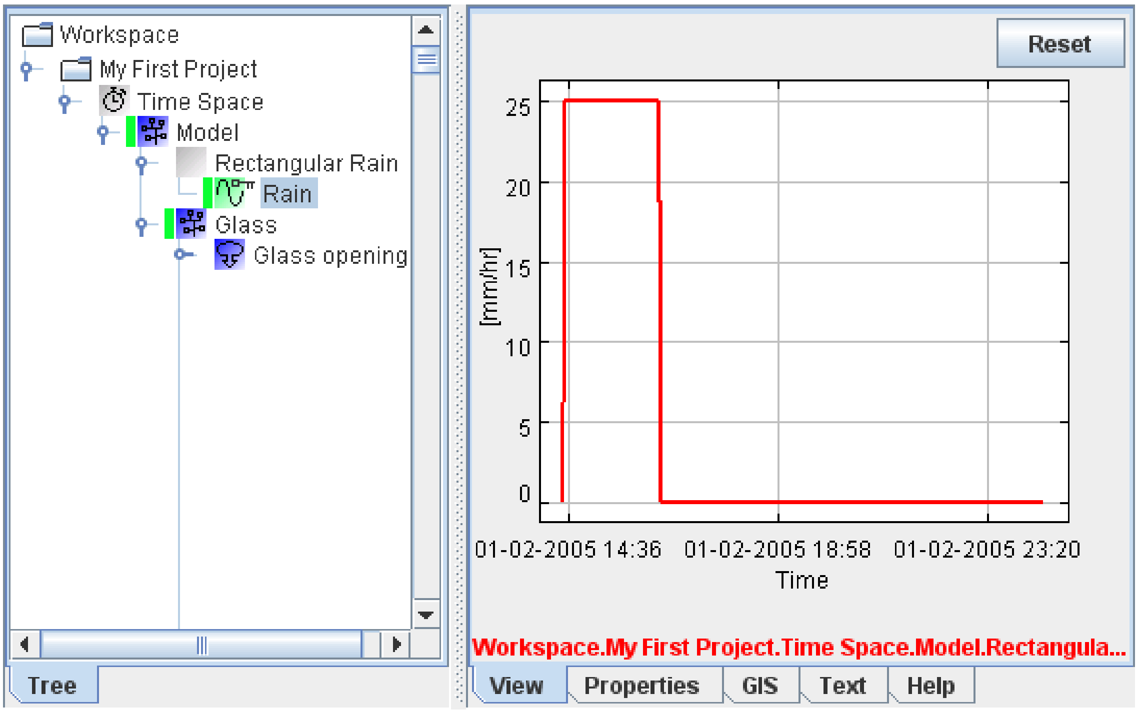
To enter the rainfall data we now go back and select the "Rectangular Rain" component in the tree and again choose the "Properties" tab on the right. You should see something like this. Note that the three properties *Depth*, *Duration* and *Intensity* are all zero.



Modify the duration to 120 minutes and the depth the 50 mm. See the units of these properties by passing the mouse over the properties and reading the tip. When you enter depth and duration, intensity gets calculated as a function of these. If you had entered a different combination the third gets calculated. Now your rectangular rain should look like this...

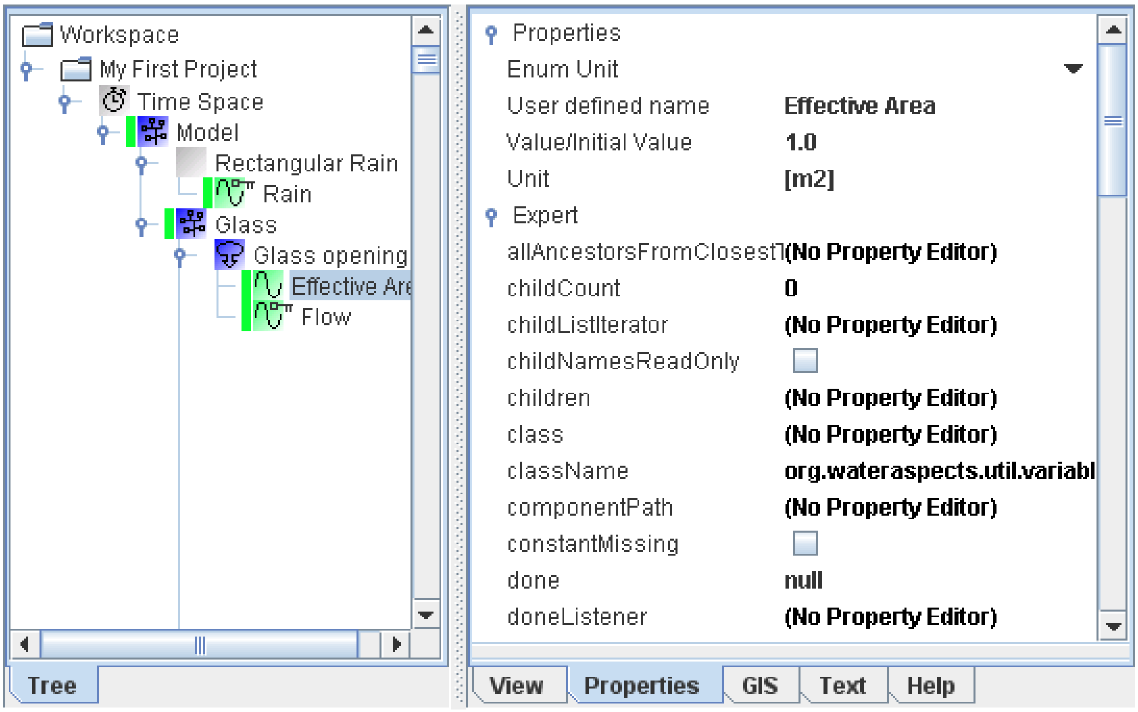


Expand the "Rectangular Rain" node in the tree and select the "Rain" variable. If you have the 'View' tab on the right selected, you will see a plot of the rectangular rain. In the current version rainfall intensity is handle in [mm/hour]; the plan in coming versions is to provide more flexibility with respect to units.

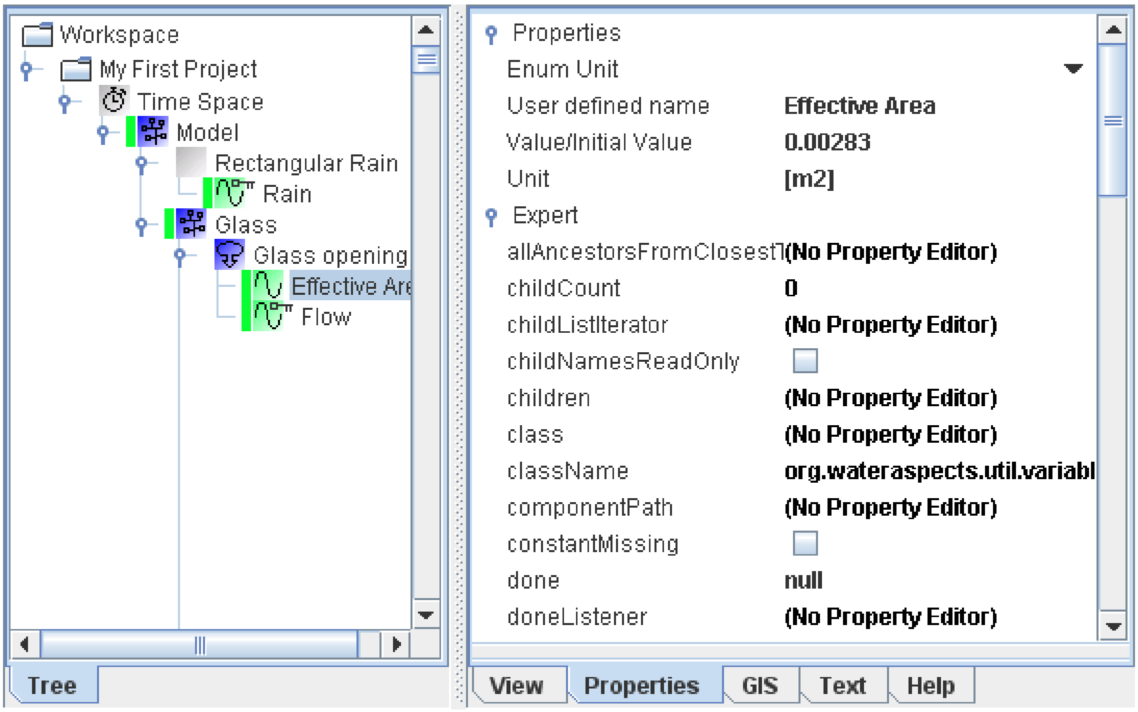


Entering the area of the glass opening

Expand the "Glass opening" component and select the variable component called "Effective Area". This is a **Variable** component (symbolised by the green icon background) which here defines the effective area of our **Simple Surface Area** component that we have named "Glass opening". Select the 'Properties' tab in the viewer zone on the right to show properties of the variable.



Modify the *Value/Initial value* property to 2.83e-3 which is the area of the glass opening in m^2 given that the diameter of the glass is 6 cm. You should now have something like this...



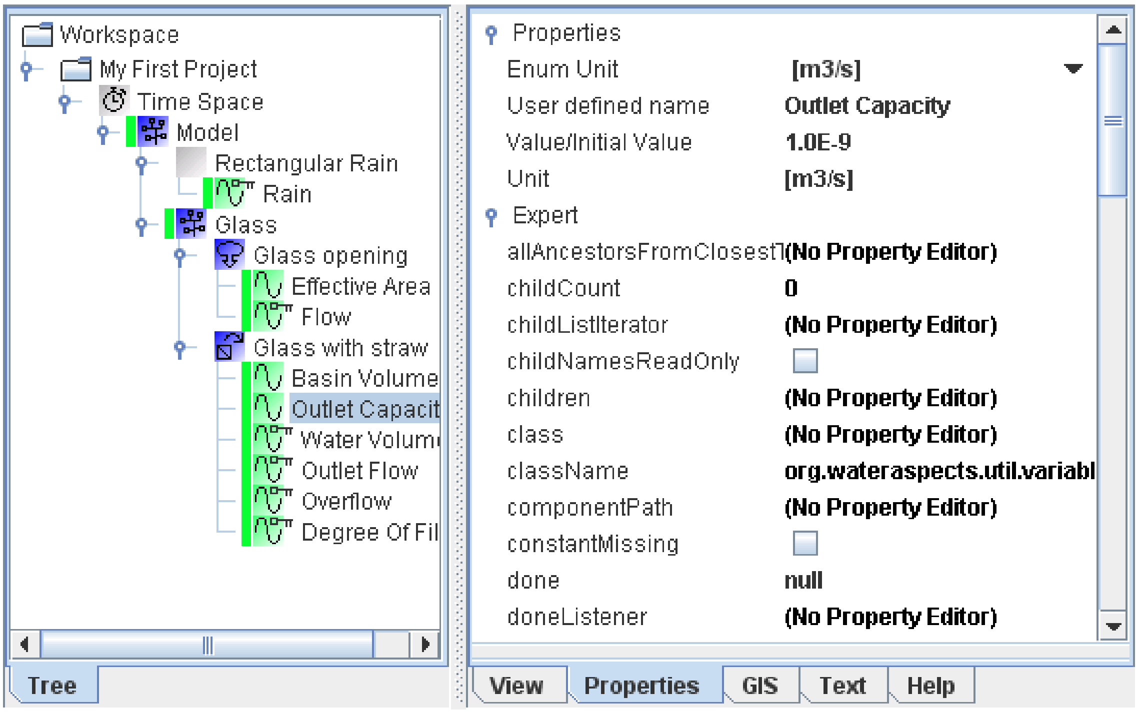
In this example we're assuming that the area of the glass opening is constant in time. This need not be the case. As we will see later on in this example, Water**Aspects** allows the user to change the variable formulation to an arbitrary expression of other variables, to a tabular dependency on other variables or equal to values read from a file (e.g. a measured or simulated series).

Entering data about the glass and the straw

We now need to enter information about the size of the glass, the initial amount of water in it and the flow rate through the straw. Recall that the glass is here simulated using a **Detention Basin**. Expand the "Glass" component in the tree view on the left and choose the 'Properties' tab on the right. Select and modify the *Value/Initial Value* of the following variables:

- "Volume": the maximum volume of water that the glass can contain. In this example this is a fixed value which does not change with time. We therefore set its value to 2.5e-4 m^3 corresponding to 0.25 liters.
- "Water Volume": the initial volume of water contained in the glass. Set this value to 1.25e-4 m^3 corresponding to 0.125 liters given as the volume contained in the glass at the begining of the rainfall event.
- "Outlet Capacity": the flow out of the glass which in this example is the rate at which water is being consumed through the straw. To start with we will assume that water is consumed through the straw with a flow rate of 1.0e-9 m^3/s. Later on in this example we'll take a look at how we can handle situations when the flow isn't constant.

With the "Outlet Capacity" selected you should have something like this:



Connecting the water components

We now have the main components that we need but before we really can call our model a model we need to create connections between the water components. Our model essentially has three base components:

- the "Rectangular Rain": a **Rectangular Rain** base component.
- the "Glass opening": a **Simple Surface Area** base water component.
- the "Glass with straw": a **Detention Basin** base water component.

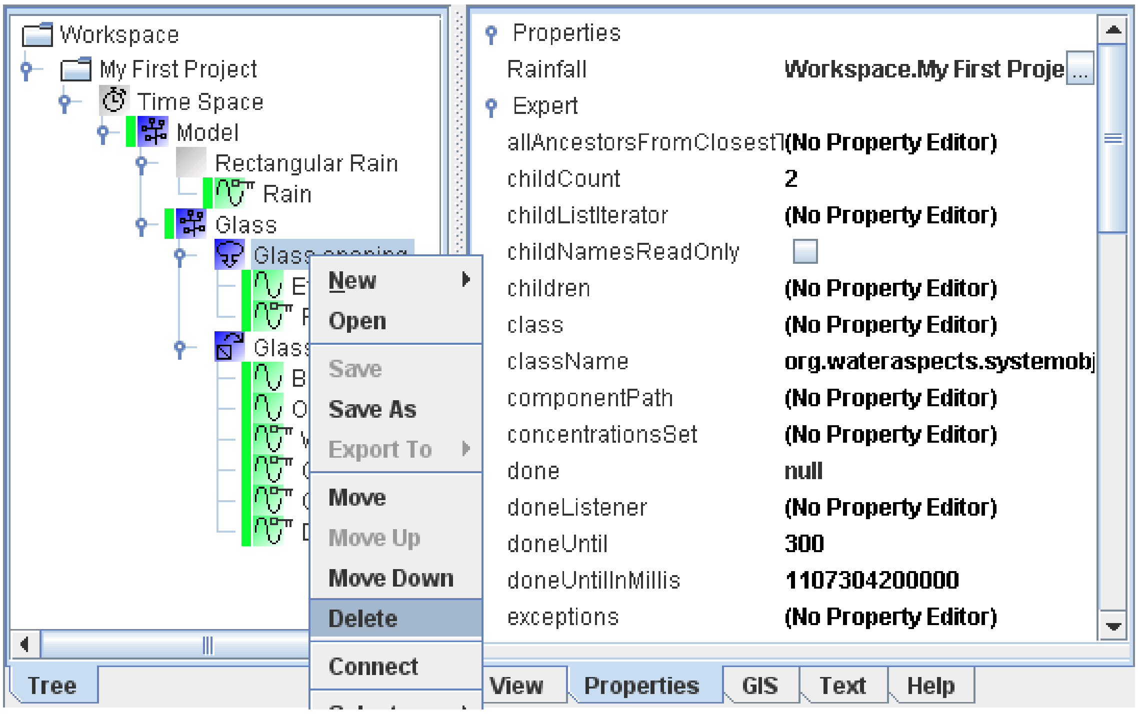
To link the "Rectangular Rain" to the "Glass opening":

- select the "Glass opening"
- in the 'Properties' tab, set the "Rectangular Rain"'s "Rain" as 'Rainfall'

To connect the "Glass opening" to the "Glass with straw":

- select the "Glass opening"
- right-click the selected component

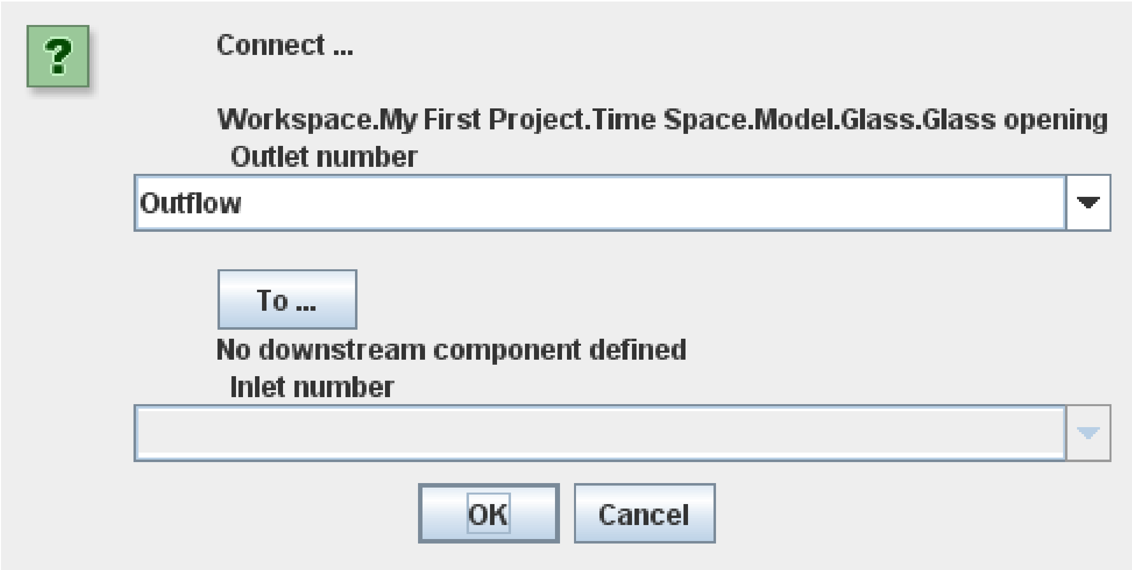
Your popup menu should look like this...



And here you want to...

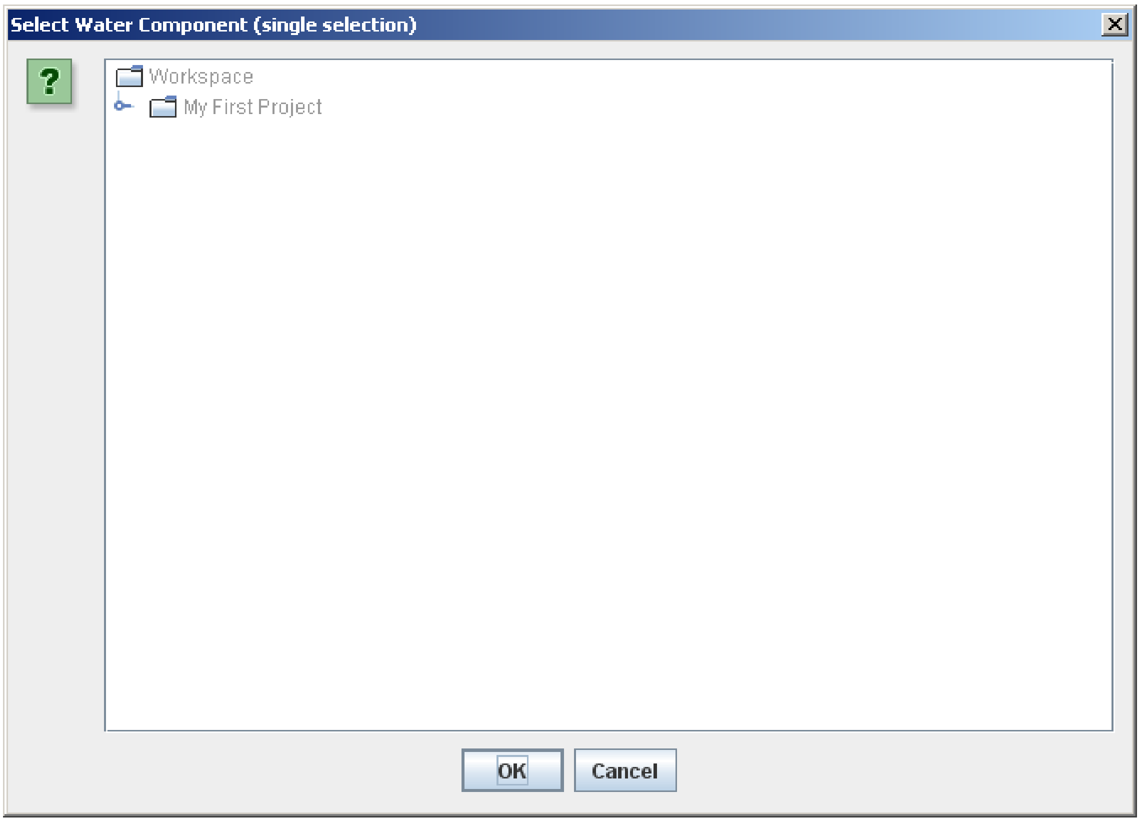
- choose the **Connect...** menu item

This will bring up the connection dialog shown below. First, is the full name of the upstream water component. This is always the component that you had selected when you right-clicked to activate the popup menu. In this case the full name of your "Glass opening" component.

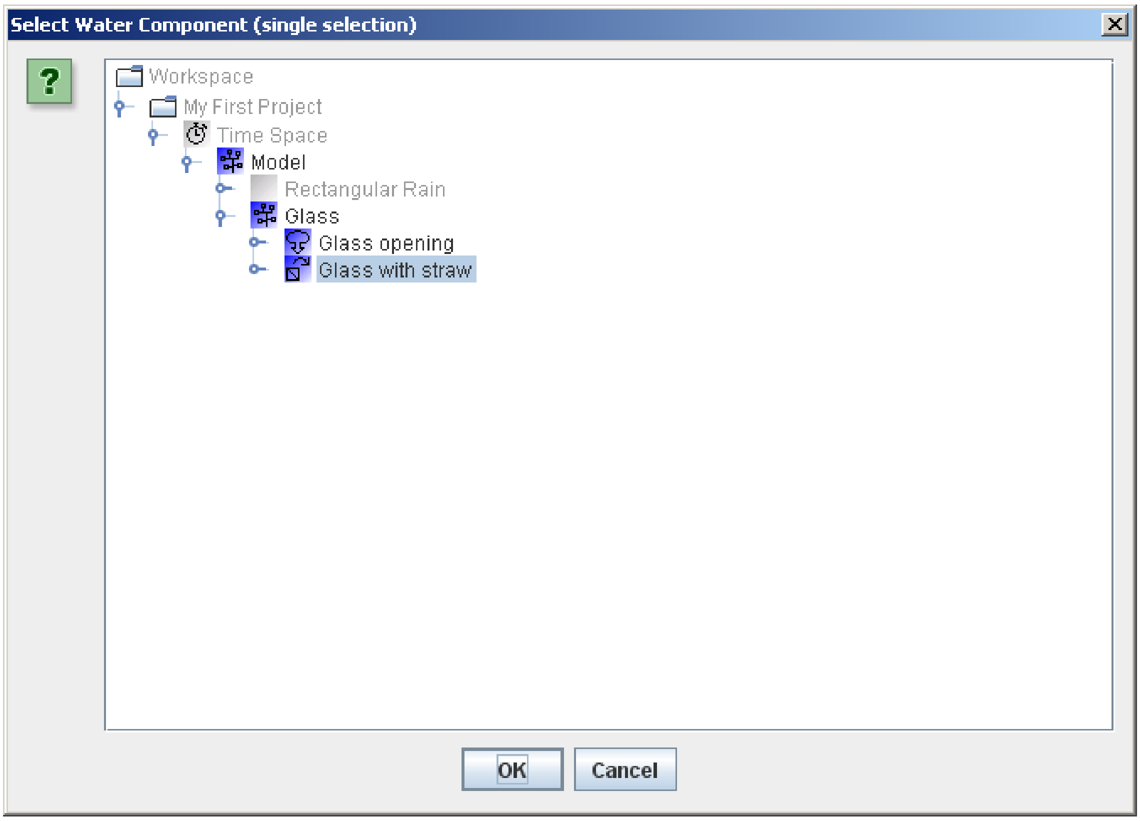


Second, below the name of the upstream water component, is the number of the outlet that you wish to connect. Most base water components, like **Simple SUrface Area**, only have one outlet. However, water components like **Splitter** and **Detention Basin** have two outlets. So in this case we just leave the outlet number unchanged as 1.

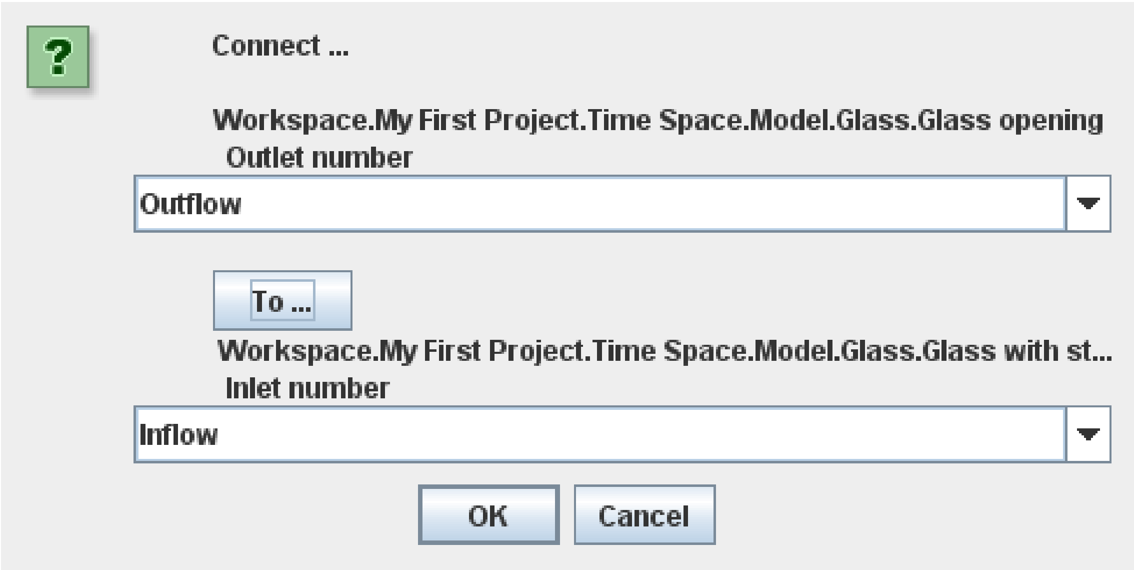
The third item in the connection menu is a 'To ...' which opens a new menu that allows you to select the downstream water component that you wish to connect to. Click the 'To ...' button to get a dialog like this...



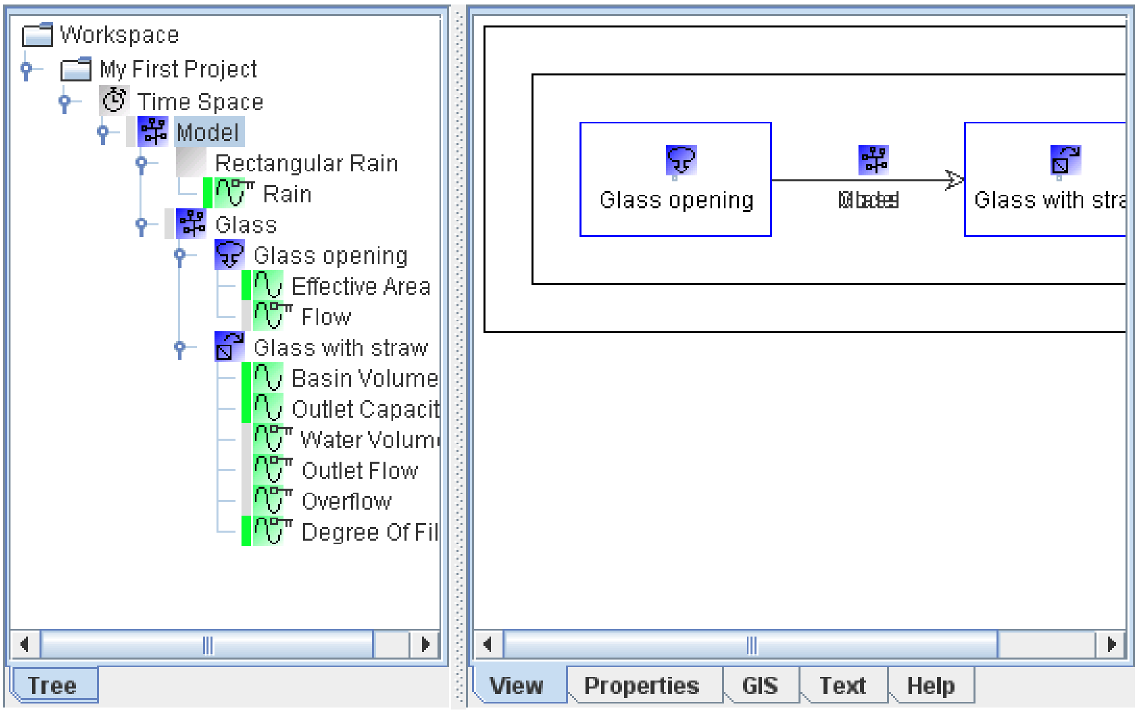
Expand the tree and select the "Glass with straw" component as shown below. Note that the legal selections (water components) are shown in black whilst the others are in light grey.



Click 'OK' to set the selected water component as downstream component. The connection menu should now look like this.



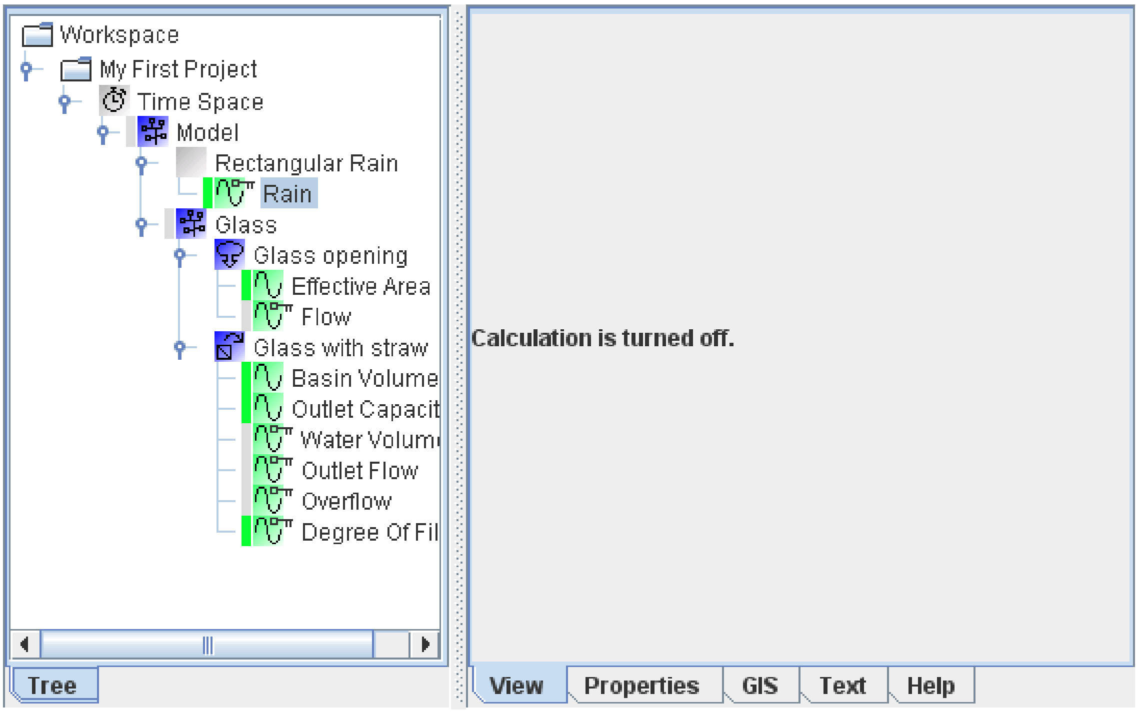
Click the connection menu's 'OK' button. If you select the "Model" component and the view tab on the right you should now see that connection arrows have been added to the system diagram (tentative system diagram).



Let's take a look...

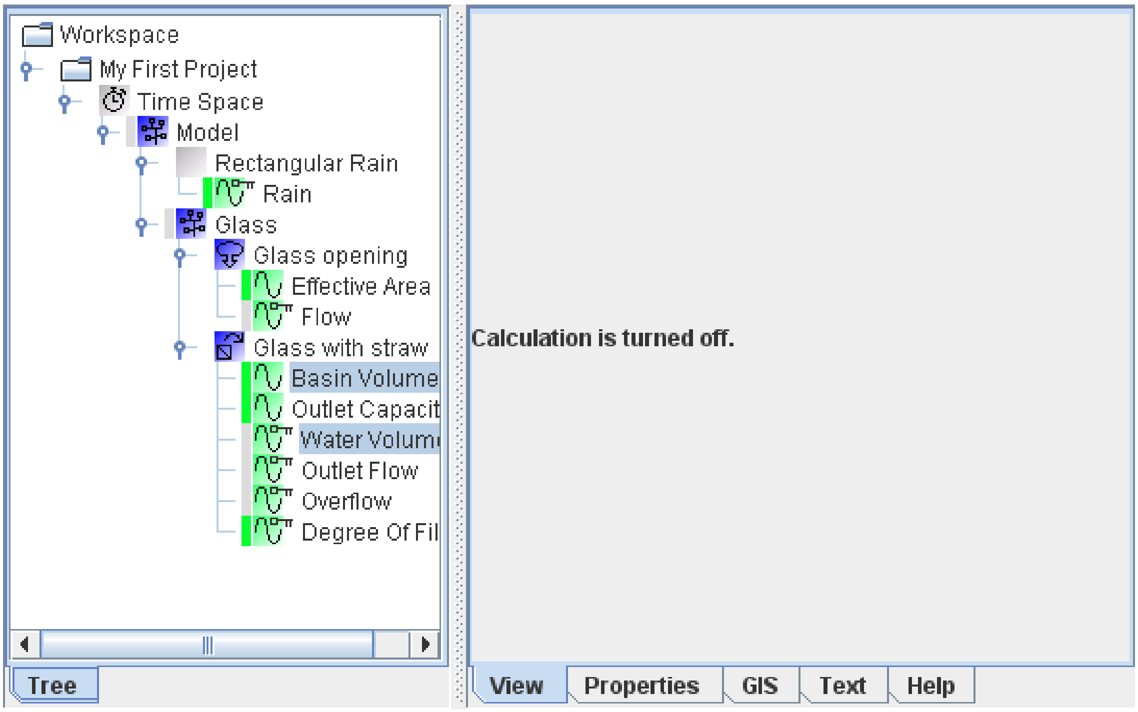
Rain

Let's look at what we have so far. Select "Rain" in the tree on the left with the 'View' tab on top on the right. This shows a plot of the rainfall series against time as shown below. Note that in the current version rainfall is always in [mm/hour].



Water volume

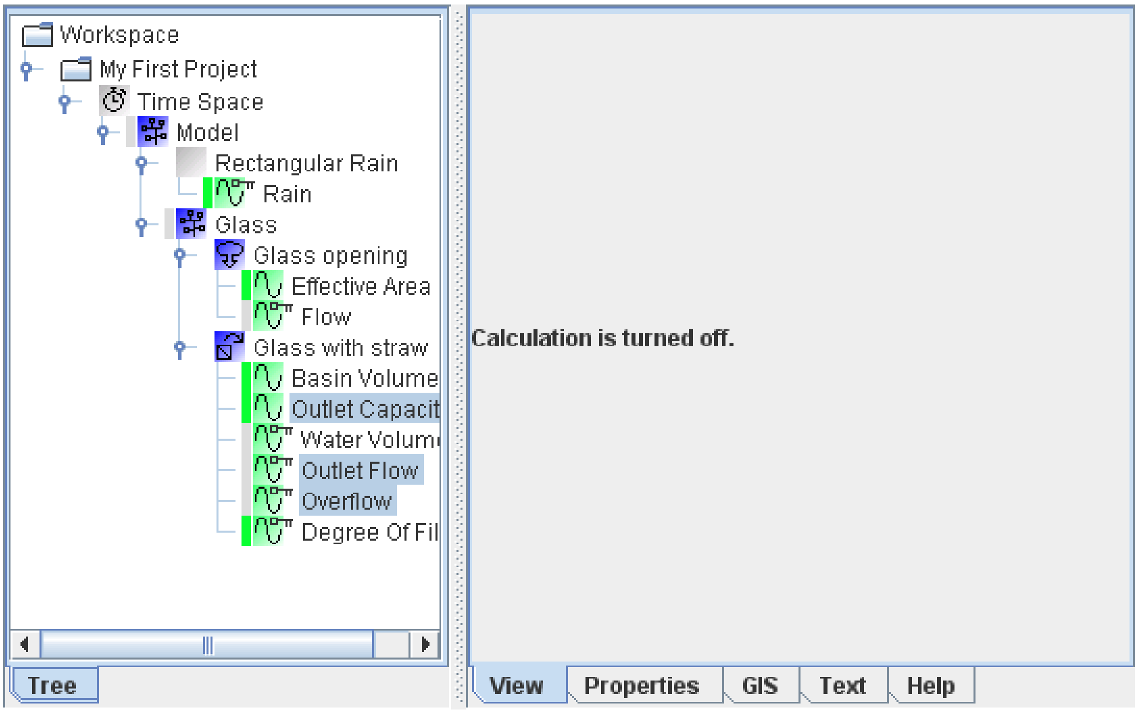
If you now select the "Volume" variable and thereafter select the "Water Volume" variable whilst holding down the 'Ctrl' key you should see something like this:



The "Volume" variable expresses the maximum volume of water that our glass can contain. The size of the glass doesn't change in time and we therefore just see a straight horizontal line (the red line). The "Water Volume" variable expresses the volume of water in the glass at any time and as we'd expect to see the water volume rises until the glass is full.

Flow in, flow out and overflow

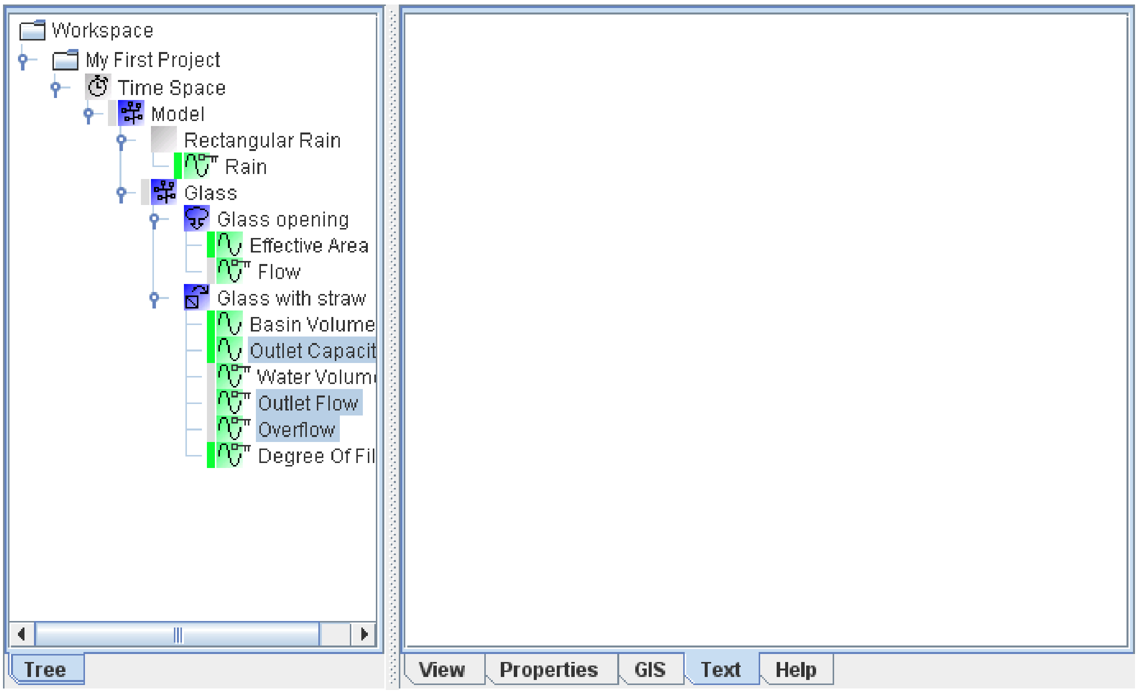
The volume of rain water entering the glass is more than the flow out of the glass through the straw so once the glass is full water flows over the glass edge. We call this flow "Overflow". First select "Overflow" and then with 'Ctrl' held down also select "Outlet flow" and "Flow out" (on the "Glass opening" component) you get the plot shown below. The "Flow out" of the "Glass opening" is the flow into the glass, the "Outlet flow" is the flow out of the glass through the straw and finally the "Overflow" is the flow out of the glass over the edge.



Next we'll see how we quickly can these simulation into other applications like spreadsheets or text editors. We'll keep the current selection.

Copy to the clipboard

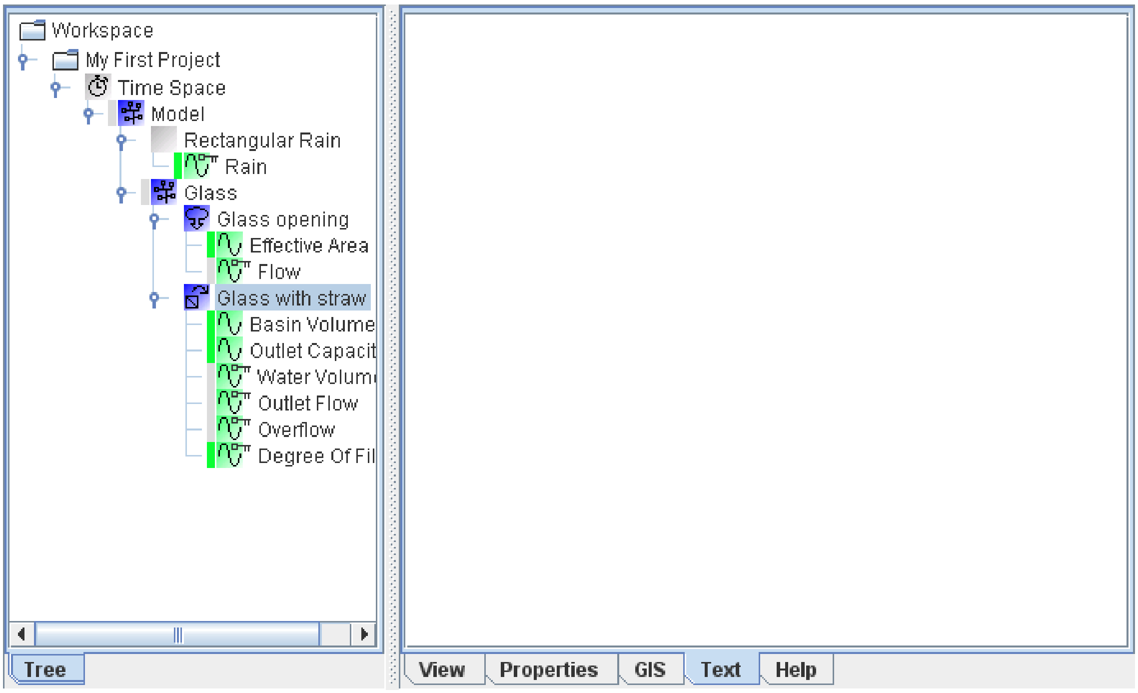
With "Overflow", "Outlet flow" and "Flow" (on "Glass opening") still selected, choose the 'Text' tab in viewer zone to the right. You should now see the variable values as time stamped tab separated columns as below.



If you're really eager you could double-check the Water**Aspects** calculation by selecting "Water Volume" as well as the above three flow variables, copy it all to a spreadsheet and check that the volume balance hold. Alternatively, you could proceed to the next panel where we'll take a look at the volume balance for the glass component.

Volume balance

With the 'Text' tab still on top in the viewer zone to the right, select the "Glass with straw" component in the tree on your left. After a short moment you should see the water balance for the selected component.



This water balance is given for the full simulation period. It lists how much water...

- was in the glass at the start and end of the simulation
- entered the glass as rainfall through the "Glass opening"
- left the glass through the straw ("Outlet flow")
- spilt over the edge of the glass and onto the table ("Overflow")

In this version water component outlets only have a number and no name or text label. So when you look at the volume balance for a **Detention Basin** like the glass you have to know that outlet number 1 is the maximum capacity outlet and that outlet number 2 is the overflow.

Volume dependent outlet flow

Up until now the flow through the straw has been treated as constant but in our case this flow actually depends on how much water there is in the glass. You may recall this from the case description earlier on. Basically when there is little water in the glass the flow is small and as the volume increases so does the flow up to a given point. Let's take a look at how we in Water**Aspects** can define such a dependency between variables.

In this version of Water**Aspects** a variable can have many different formulations:

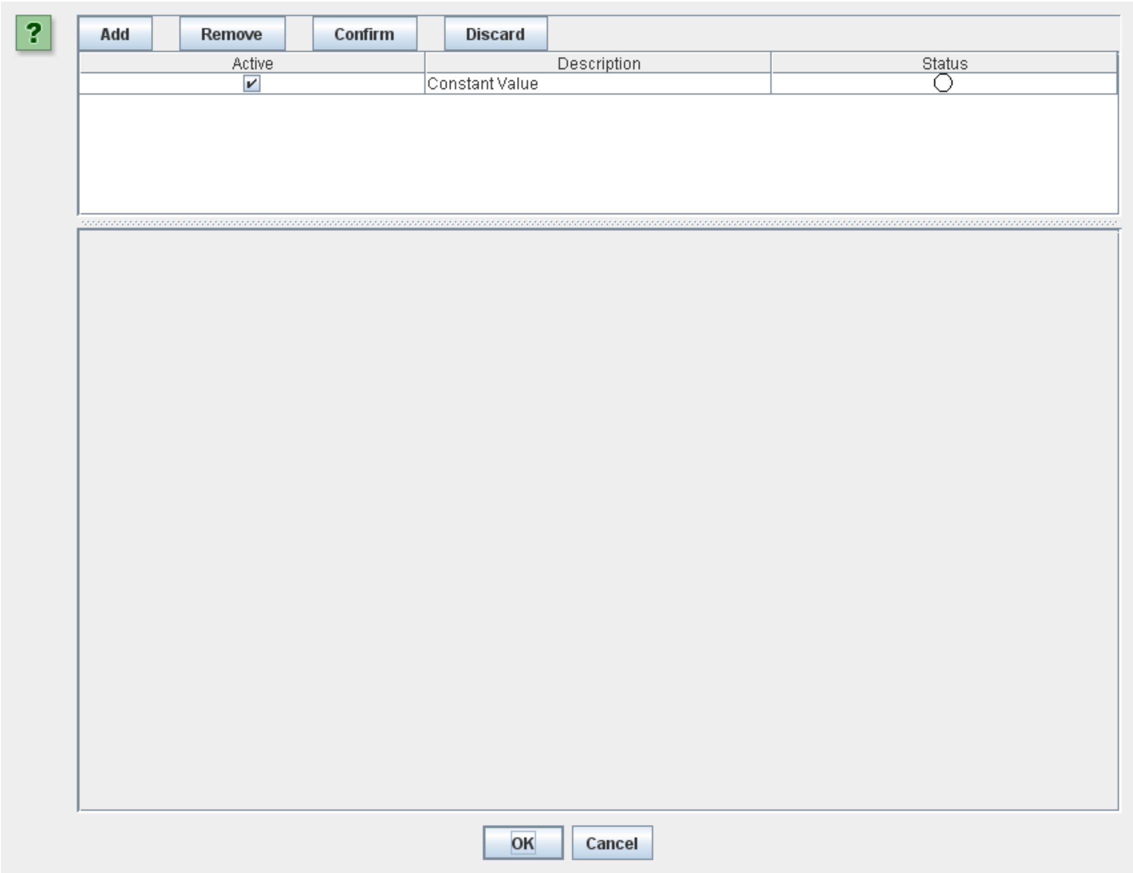
- **constant**: you define a constant value.
- **interval tabular dependency**: where you define the values that your dependent variable should take for given intervals of the independent variable.
- **interpolated tabular dependency**: where you define the values that your dependent variable should take for given values of the independent variable and

WaterAspects interpolates between these points

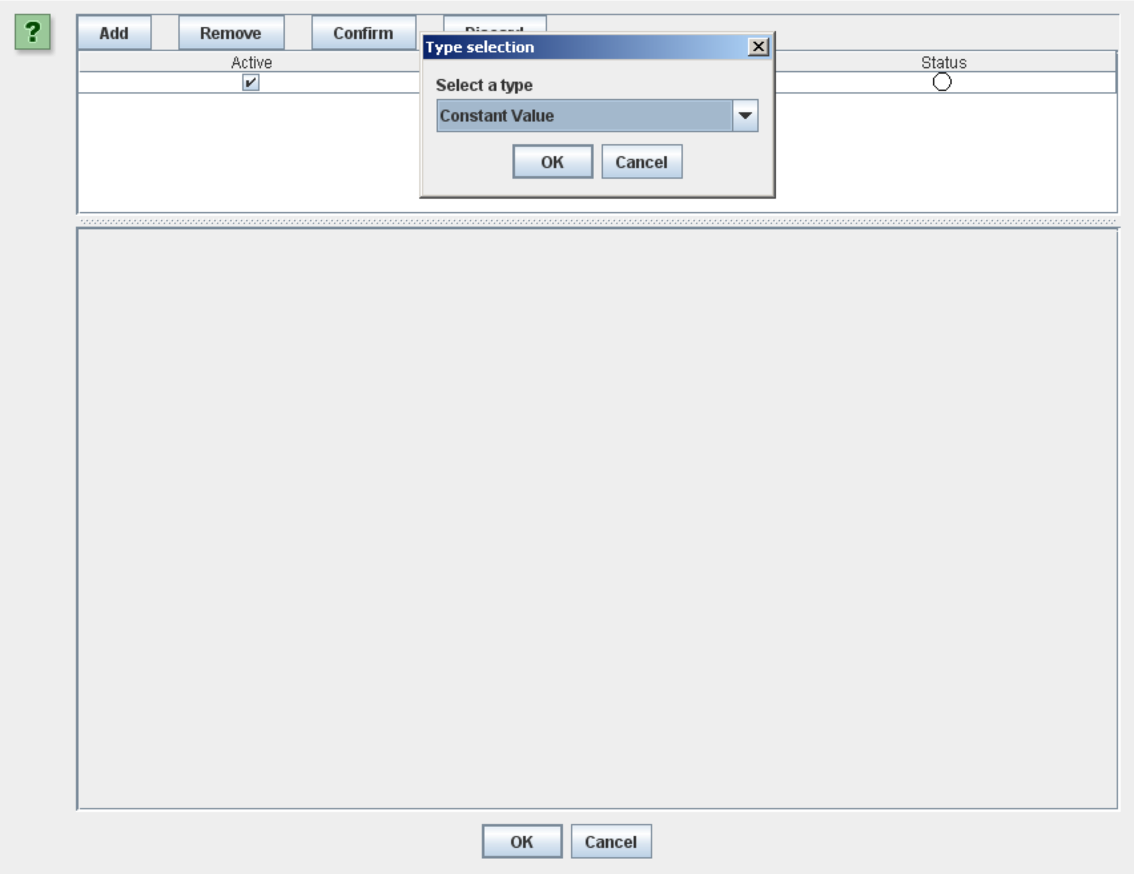
- **variable collection**: where the dependent variable is defined as a standard summary function of any number of other variables. The standard functions currently available include: sum, average, maximum (i.e. equal to the variable with the highest value at that time step), minimum and "value if identical" which results in the value if all values are identical and NaN (not a number) otherwise.
- **expression dependency**: where the dependent variable is defined as an arbitrary expression of any number of other variables (even its own earlier values).
- **observations** and **observations (stochastic)**: where the values depend on time stamped data from observation data. The former is used for deterministic simulations while the latter is used for stochastic ones.

A variable can actually hold several different *formulations* where only one is active for the simulation. This allows you to quickly switch between formulations and thereby evaluate and compare different definitions (for example different control function). Most variables are by default defined as constants with a constant value formulation. On some variables the variable formulation is *locked*. This means that the variable's formulation cannot be changed by the user and a small key is shown on the variable icon. A variable is usually locked because its value is calculated by the component it is on. In our glass case, this goes for, for example, "Overflow" whose value calculation is predefined. For some other locked variables, like "Water Volume", you as user can set the initial value but you cannot change the variable's formulation.

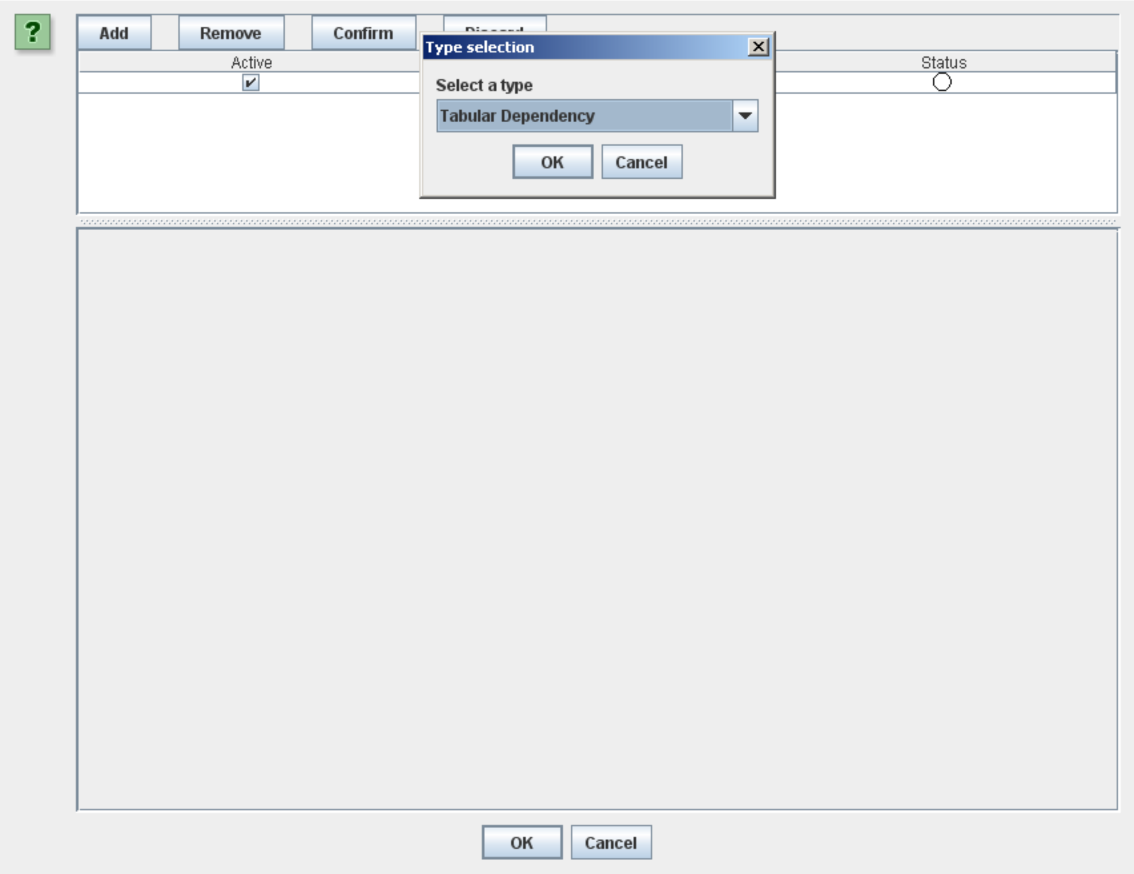
In our glass case we'll use an interpolated tabular dependency to describe the variation of flow through the straw as a function of the volume of water in the glass. Select and right-click the "Outlet Capacity" variable on the "Glass with straw". Then choose the 'Variable editor' menu item to start up the variable editor which looks like this:



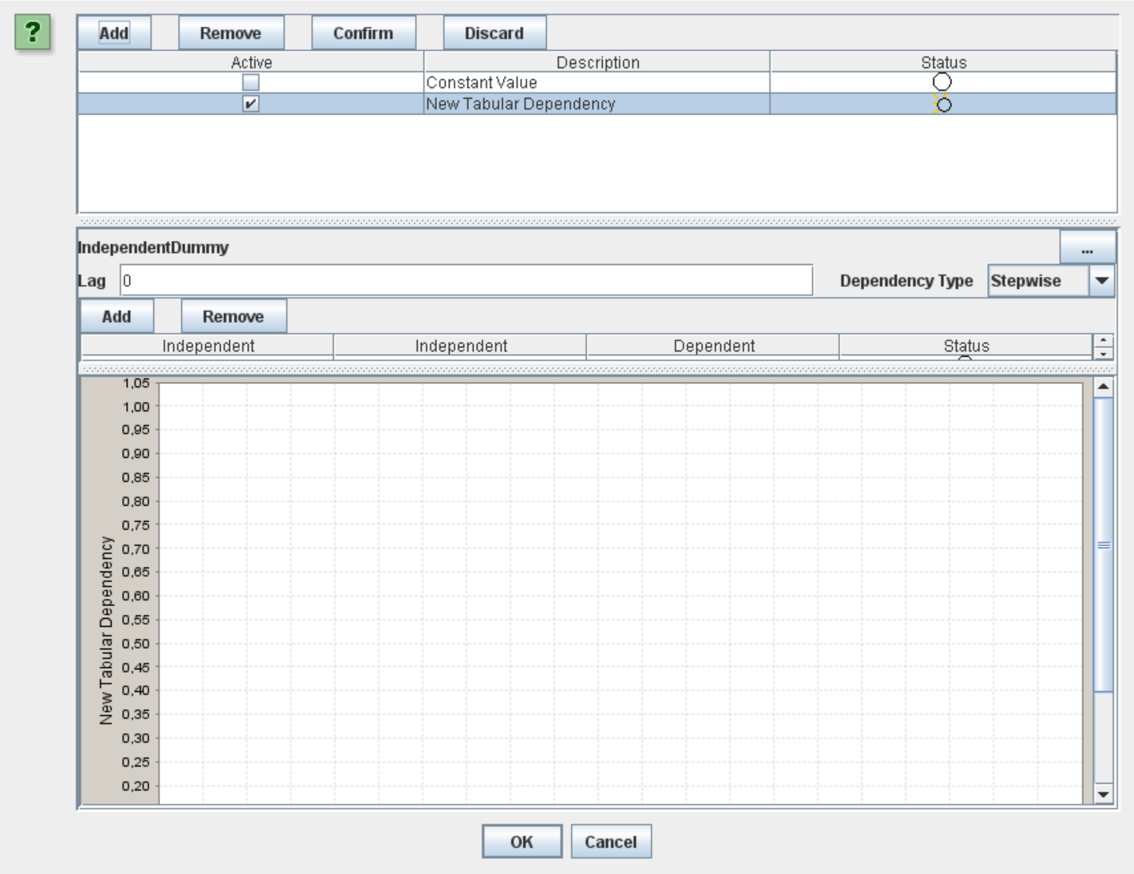
In the top of the menu is a list of the formulations on this variable. So far our list only contains one formulation. To add a new formulation press the 'Add' button which will bring forward a small chooser like this:



Pick 'Tabular Dependency' in the drop down menu and click the 'OK' button.



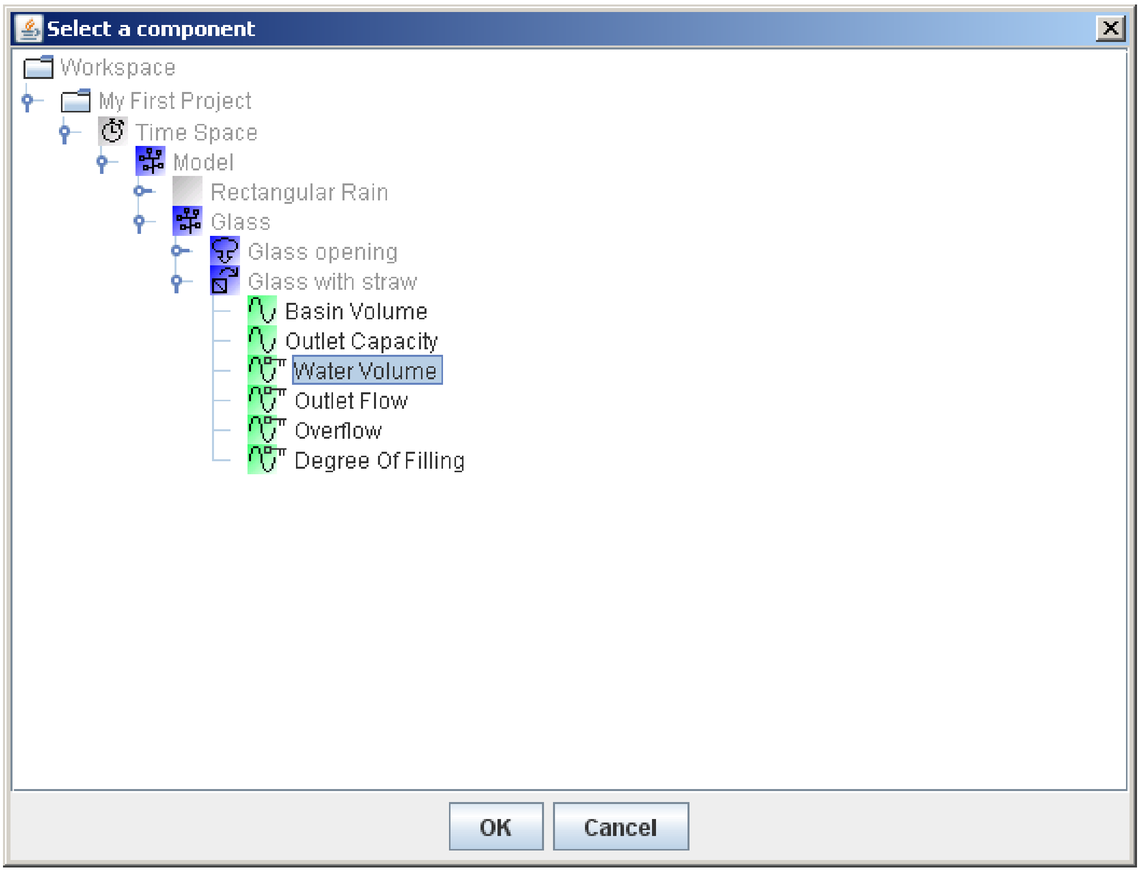
Your variable editor will now have a new variable formulation in the top table. You need to set the new tabular dependency as *Active*. Do this by clicking the checkbox in the right column of the table. You should now have something like this:



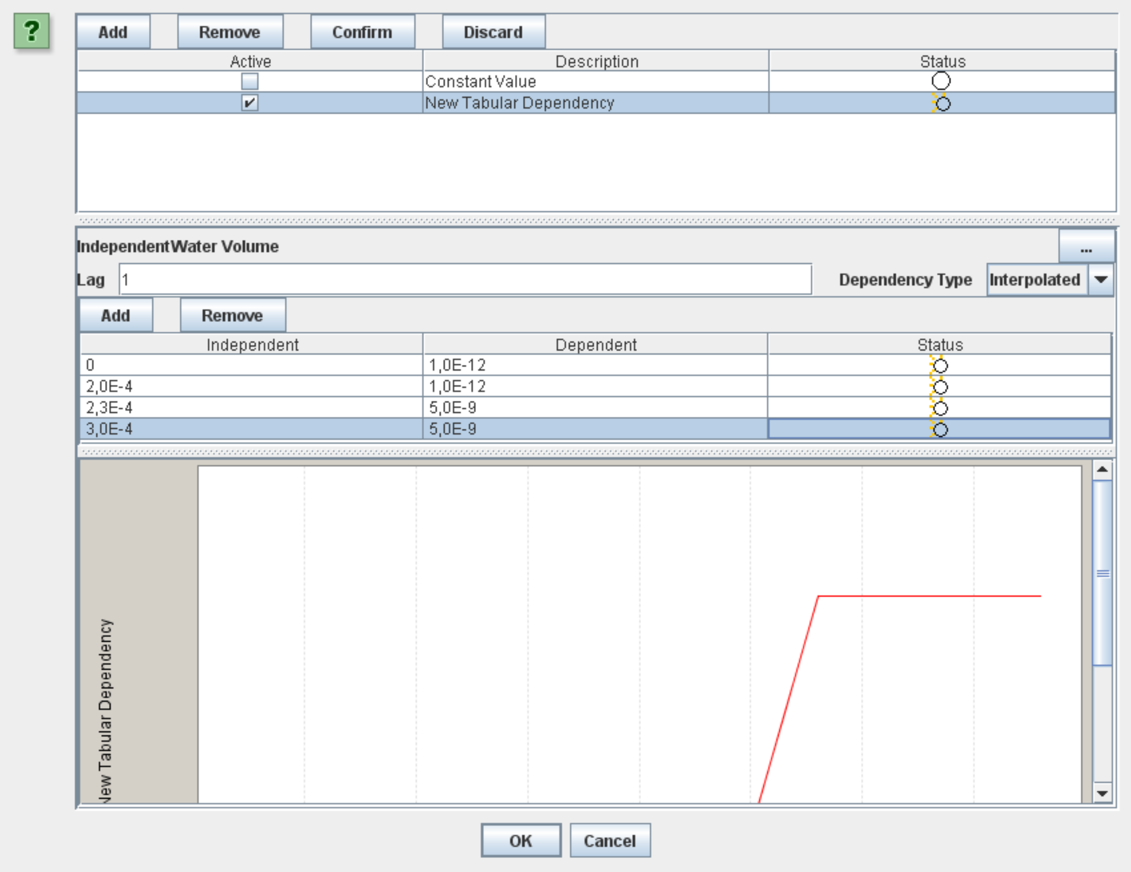
To define the interpolated tabular dependency we now need to:

- select the independent variable "Water Volume"
- set the 'Lag' to 1 (this means that we wish our "Outlet Capacity" to depend on how much water was in the glass in the previous time step)
- set 'Dependency Type' to 'Interpolated'
- define pairs of independent-dependent by clicking the ***lower*** 'Add' button four times and and entering the four data points as shown below.

You can select the independent variable, "Water Volume", by clicking the '...' button and choosing the variable in the tree much in the same way as we selected the downstream water component earlier in this example.

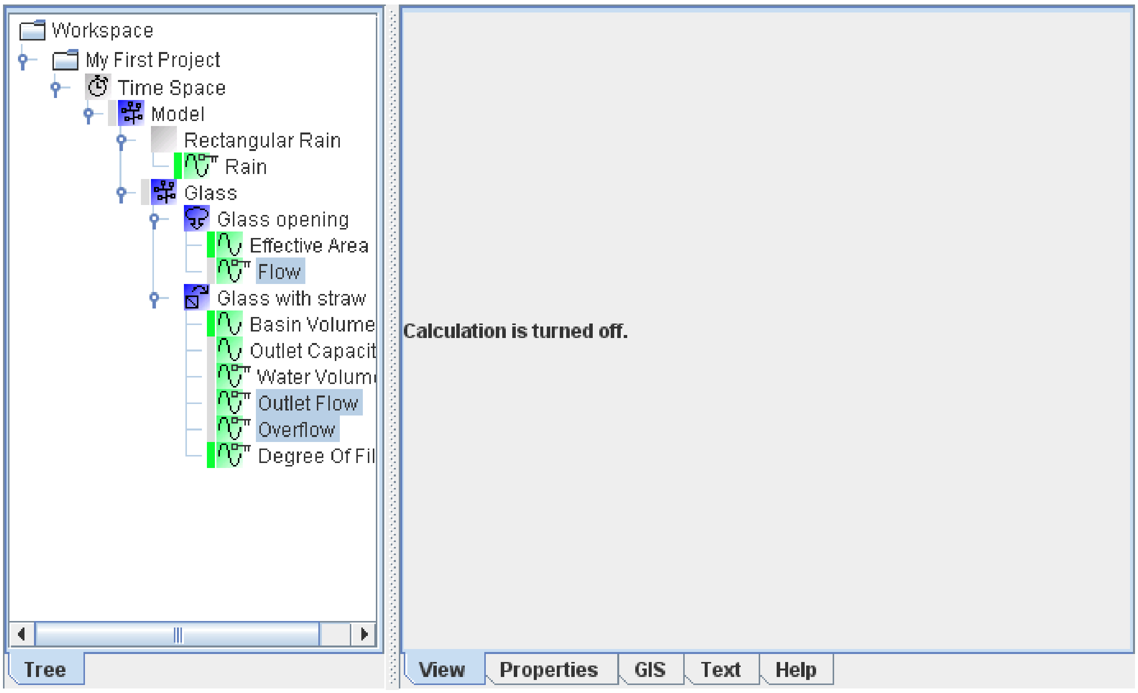


When the above is done our variable editor looks like below. To see the full plot of the entered relationship you need to scroll down using the scroll bar on your right.



Press the 'OK' button to apply your changes and to close the variable editor window.

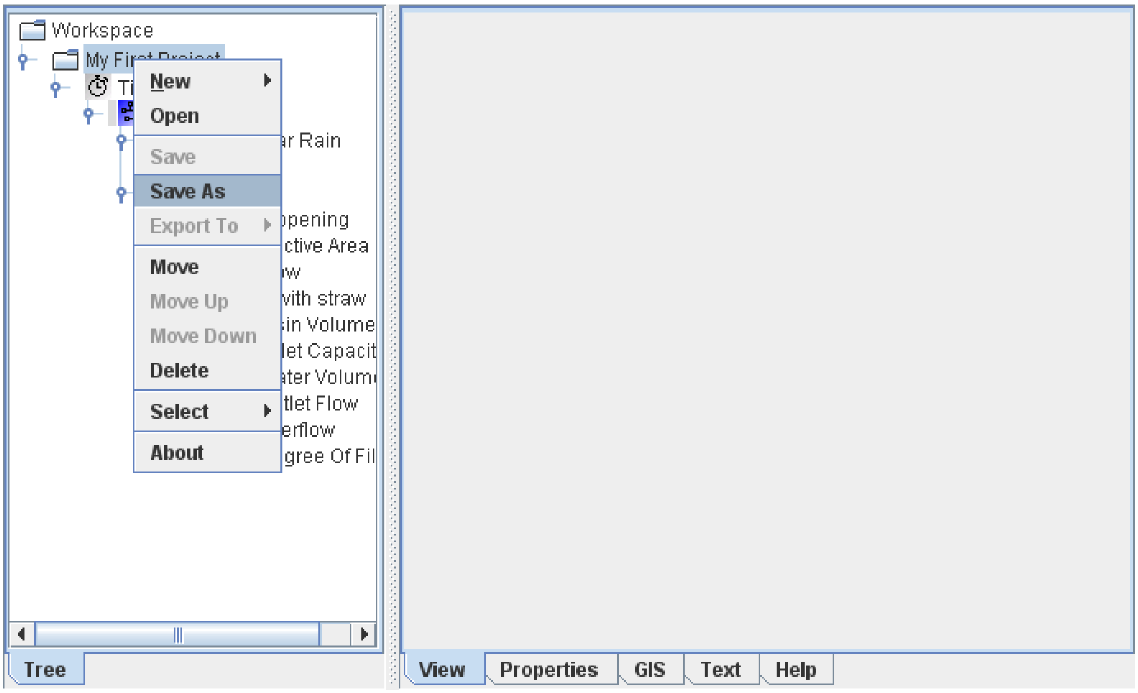
If you now select "Flow" on the "Glass opening" and "Overflow" and "Outlet Flow" on the "Glass" (again using 'Ctrl' to select more than one variable) you should not that the entered relationship has been considered and that your plot looks something like:



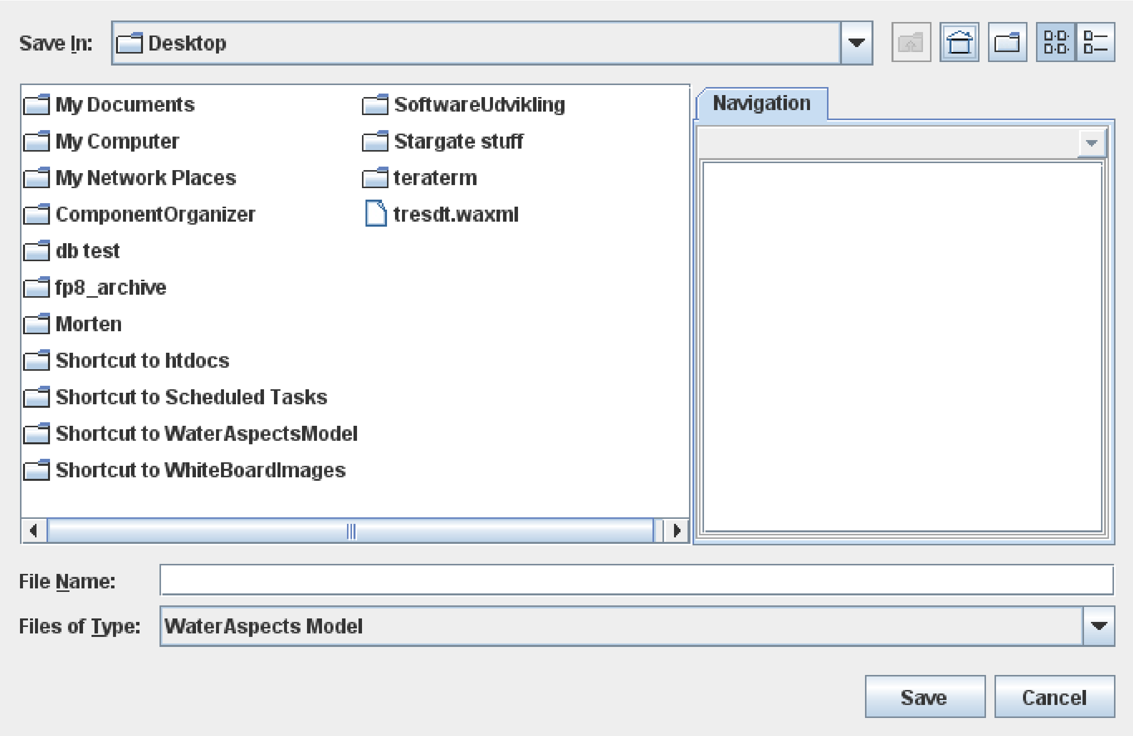
Saving and re-opening your project

Save

To save your project select and right-click the "My First Project" component and choose 'Save As' in the popup menu.



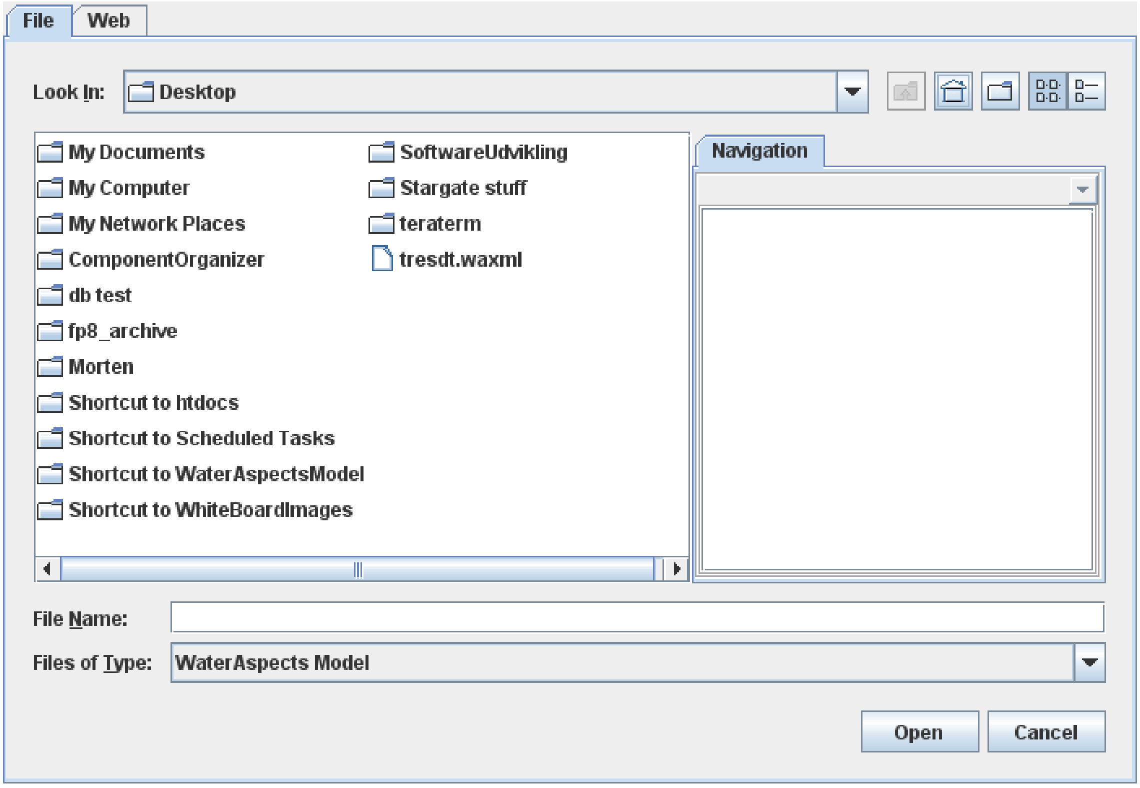
You should see a Save dialog that looks something like this:



In the Save dialog you select a suitable location for the project file, give it a name and press 'Save'. Simulation results are not saved only the data needed to recalculate them on the fly when you open your project again.

Open

The next time you start Water**Aspects** and you wish to re-open your project you right-click the "Workspace" component and and choose 'Open' item in to popup menu. In the open dialog you browse to right location, select your file and press the 'Open' button.



Summary

Congratulations! You have just tasted your first glass of Water**Aspects**! With this somewhat hypothetical example you have been introduced step-by-step to some of the basic logic and features of Water**Aspects**. You are now able to:

- build a model
- define start and end times for the simulation
- add and connect water components
- set model data values
- change a variable's formulation
- run simulations automatically after each change
- view results in a graph or as text columns
- view water balance by component or network
- copy/paste results and water balance to other applications
- save and re-open your Water**Aspects** project file

You are welcome to try some of the many other features. More tutorials are on their way but until then don't hesitate to send questions or comments to the *Water**Aspects** community's mailing list*.

Section 6. Reading My Own Data in WaterAspects

Introduction

Imagine that you've just received measurements of flows that you want to process. The file is typically obtained from a measurement device and the way the data are presented does not necessarily follow any standard.

```
=====================================================================
=====================================================================
M; Time Stamp; Measured Flow; Reservoir Output; Reservoir Volume
AB;  00:00:00 10/05-2004; 0.00204; 0.00250; 50.00000
KP;  00:03:00 10/05-2004; 0.00389; 0.00500; 50.04695
DL;  00:10:00 10/05-2004; 0.00463; 0.00501; 50.16502
MTG;  00:15:00 10/05-2004; 0.00759; 0.00502; 50.29878
K;  00:18:00 10/05-2004; 0.00469; 0.00504; 50.41068
OO;  00:25:00 10/05-2004; 0.00515; 0.00505; 50.51145
1P;  00:30:00 10/05-2004; 0.00726; 0.00506; 50.66789
UU;  00:33:00 10/05-2004; 0.00498; 0.00507; 50.81468
I;  00:40:00 10/05-2004; 0.00298; 0.00509; 50.94598
88;  00:45:00 10/05-2004; 0.00597; 0.00510; 50.99635
AB;  00:48:00 10/05-2004; 0.00623; 0.00511; 51.13434
KP;  00:55:00 10/05-2004; 0.00347; 0.00512; 51.22933
DL;  01:00:00 10/05-2004; 0.00375; 0.00512; 51.21284
MTG;  01:03:00 10/05-2004; 0.00441; 0.00513; 51.39834
K;  01:10:00 10/05-2004; 0.00424; 0.00514; 51.49195
OO;  01:15:00 10/05-2004; 0.00567; 0.00516; 51.62592
1P;  01:18:00 10/05-2004; 0.00501; 0.00517; 51.75030
UU;  01:25:00 10/05-2004; 0.00536; 0.00518; 51.87248
I;  01:30:00 10/05-2004; 0.00374; 0.00519; 51.98502
88;  01:33:00 10/05-2004; 0.00456; 0.00520; 52.09121
AB;  01:40:00 10/05-2004; 0.00558; 0.00522; 52.22922
KP;  01:45:00 10/05-2004; 0.00420; 0.00523; 52.38569
DL;  01:48:00 10/05-2004; 0.00364; 0.00525; 52.52991
MTG;  01:55:00 10/05-2004; 0.00445; 0.00526; 52.61972
K;  02:00:00 10/05-2004; 0.00364; 0.00527; 52.80253
OO;  02:03:00 10/05-2004; 0.00449; 0.00528; 52.80326
1P;  02:10:00 10/05-2004; 0.00390; 0.00529; 52.93401
```

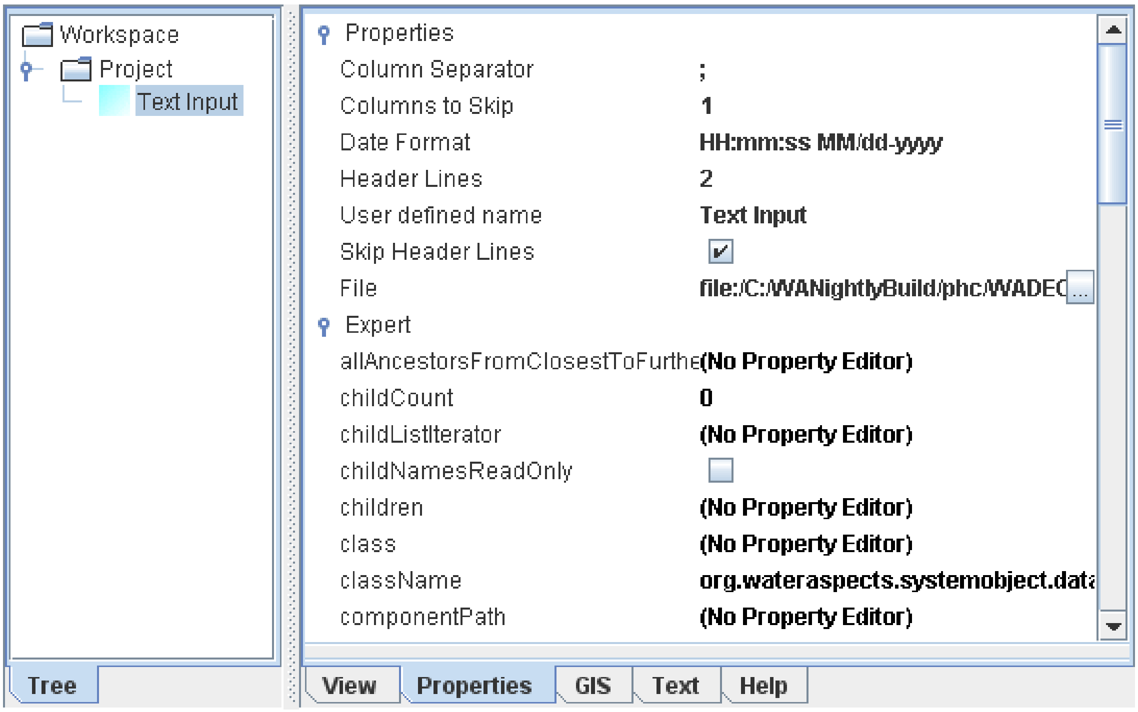
The data file, partly displayed on the figure above, is as follows: the first two lines contain signs that you want to skip; data are separated by ';'; the first column does not have any relevant information; the second column displays the time stamps in an unusual format (hours : minutes : seconds month / day - year); and, the measurements are not taken at a constant frequency.

Addition of a text file input component

The first step is to add in Water**Aspects** a component that links to your input data file. Do so by setting a new **Text Input** in 'New|Data Source|Text Input'. Then define the properties of the text file that is to be read in Water**Aspects**. The location of the file must be set since Water**Aspects** needs to know where to get the data. Furthermore, in order for Water**Aspects** to know how to transform the file information into data, you have to set the properties related to the files particularities: set the date format as HH:mm:ss MM/dd-yyyy (s stands for second, m for minute, H for hour, d for day, M for month, and y for year) and the column separator as ';' (by default it is tab); make sure that the header lines are skipped (Skip header lines set to True) and that there are 2 header lines; finally, set the amounts of columns to skip to 1 so that the first column of irrelevant data is not taken into consideration. Water**Aspects** assumes that the series' names are written in the line immediately after the header.

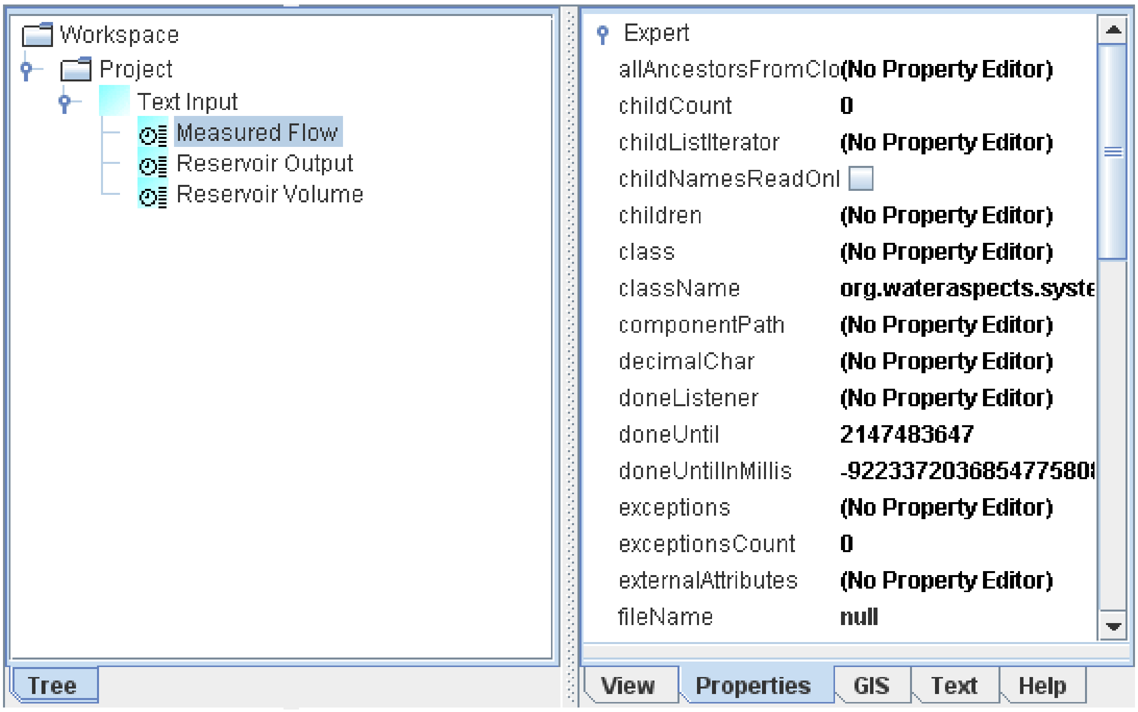
For more information about how to define a date format, click *here*.

"Text Input" properties should be as described by the figure below:



Then right-click "Text Input" and select 'Reload'.

The file is loaded into Water**Aspects** and **Time Stamped Data** components get automatically created and added as attributes of "Text Input". There are as many components as there were time series in the file.

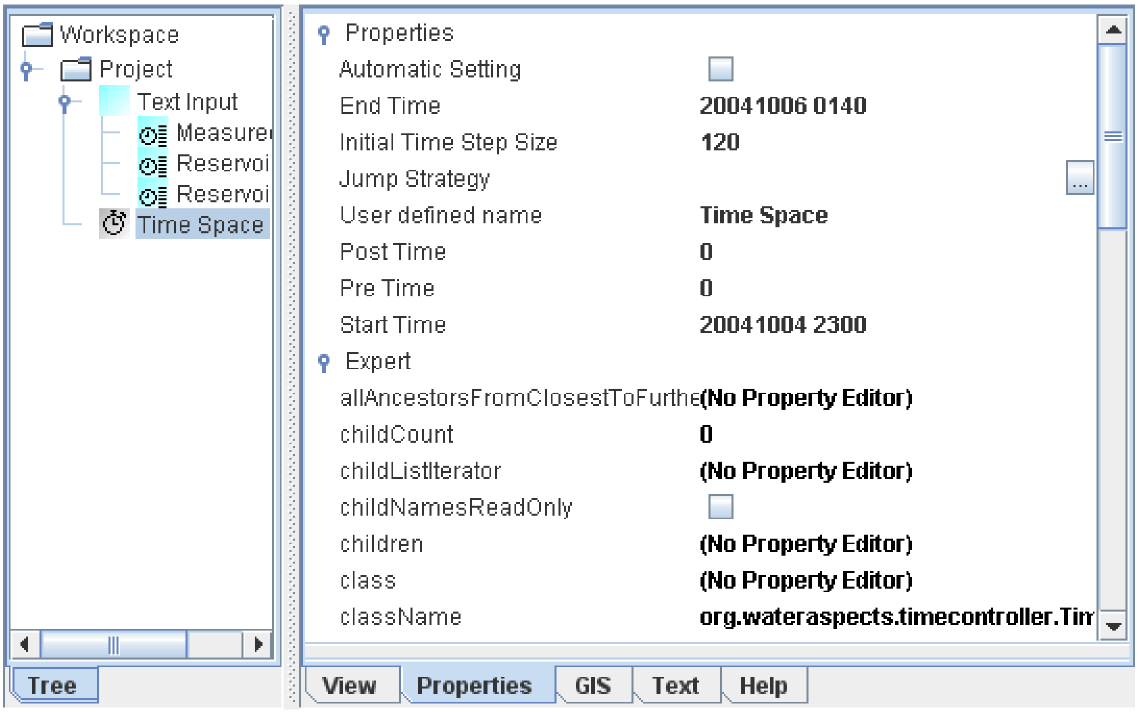


Definition of a variable linked to the flow measurement

Now it is time to process the data. For now we'll only consider the first **Time Stamped Data** component: "Measured Flow".

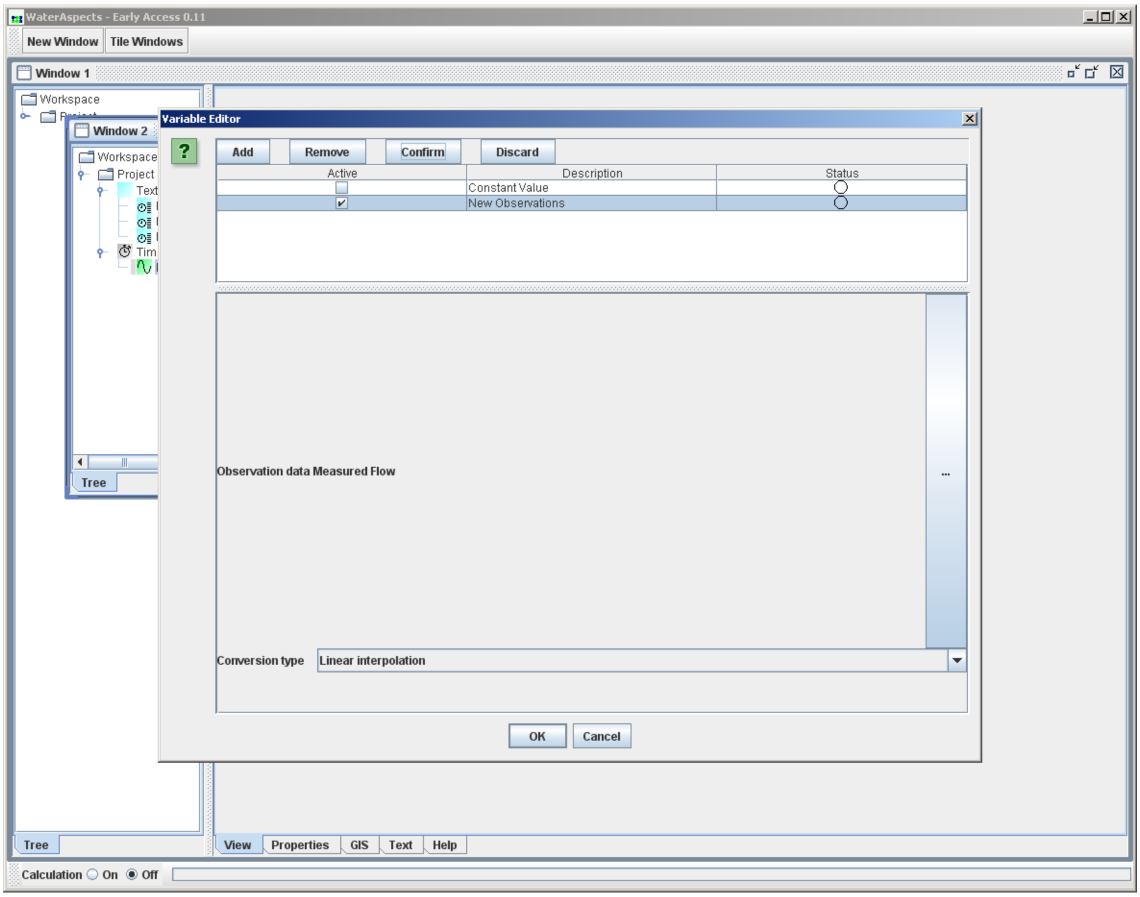
We will link the flow to a variable and have it displayed. Once the time stamped data are related to a variable, all possibilities get open: process data via the Statistics module and e.g. get the monthly average flow or know how often the flow is over a certain value, control the emptying rate of a linear reservoir, etc... Stay tuned to the *Water**Aspects** user's community* to share your ideas and get new ones!

Before linking the Time Stamped Data component to a variable, let's include a **Time Space** component so that we can run simulations. Add the time space by right-clicking "Project" and selecting 'New|Simulation|Time Space'. Set the time space's properties to start around the time for which we have data (otherwise all values will be 0!) i.e. 10 October 2004 11PM. The time step size is fully independent from the measurements frequency. We'll see later how to account for it.

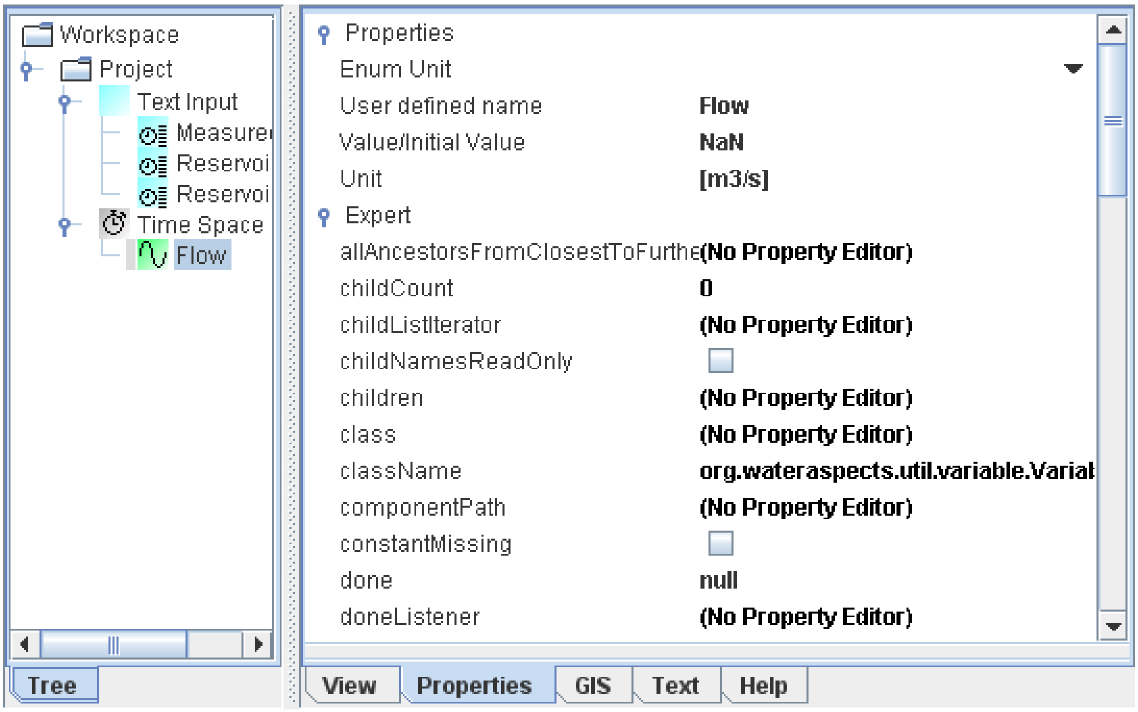


Then add a **Variable** (New|Variable|Variable). The variable will represent the measured flow in the simulations. Therefore, the variable is renamed "Flow". The connection between the time stamped data and the variable is performed in the Variable Editor: right-click "Flow" and select 'Open variable editor'. Add a formulation of type **Observations** by clicking the 'Add' button. Then set this formulation as active. The measurement and the variable are connected by setting "Measured Flow" as 'Observation data'. Finally, how to interpret the observations is defined by the 'Conversion type'. The conversion types are defined in the following table:

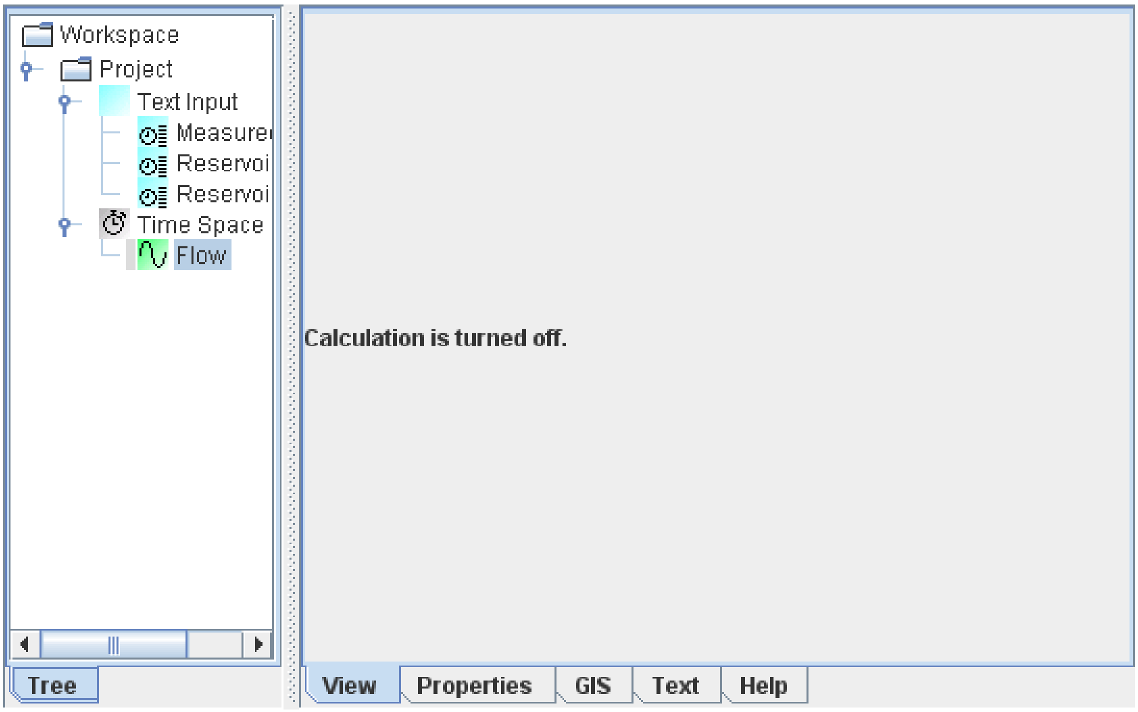
In our example, we choose a linear interpolation as correspondence between the measured flow and the variable. The connection between the observations and the variable is now performed. Just close the variable editor.



The last step is to set "Flow"'s units to [m3/s] (as of now, the observations have no units and units are set at the variable level).



Finally, click on the 'View' tab to display a graph of the flow versus time.



You can now process your measurement data further...

Colophon

This tutorial was written entirely in XML, using the developerWorks Toot-O-Matic tutorial generator. The open source Toot-O-Matic tool is an XSLT style sheet and several XSLT extension functions that convert an XML file into a number of HTML pages, a zip file, JPEG heading graphics, and two PDF files.